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APOLLO RECOVERY OPERATIONAL PROCEDURES MANUAL

DEPARTMENT OF DEFENSE

MANNED SPACECRAFT RECOVERY FORCES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

LANDING AND RECOVERY DIVISION

JUNE 21, 1971

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APOLLO

RECOVERY OPERATIONAL PROCEDURES MANUAL

Prepared by: NASA-MSC Landing and Recovery Division

and

DOD Manned Spacecraft Recovery Forces

APPROVED BY:

Sigurd A. Sjoberg
Director of Flight Operations
NASA Manned Spacecraft Center

David M. Jones
Major General, USAF
DOD Manager
Manned Space Flight Support Operations

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1.0 GENERAL INFORMATION

1.1 SCOPE

This handbook has been prepared jointly by elements of the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA). Although its primary purpose is to inform DOD and NASA recovery personnel of presently accepted recovery procedures, it also provides general information, including descriptions, concerning the Apollo spacecraft, the Saturn launch vehicles, recovery vehicles and recovery support equipment, and specifies safety precautions to be observed in the recovery of Apollo flight crews and flight hardware.

1.2 RESPONSIBLE ORGANIZATIONS

The organizations responsible for the preparation and maintenance of this document are:

(a) Commander, Manned Spacecraft Recovery Force - Atlantic, (CTF-140)

(b) Commander, Manned Spacecraft Recovery Force - Pacific (CTF-130)

(c) Headquarters, Aerospace Rescue and Recovery Service (ARRS)

(d) DOD Manager for Manned Space Flight Support Operations

(e) NASA Manned Spacecraft Center (MSC), Landing and Recovery Division

(f) Commander, Air Force Eastern Test Range (AFETR)

1.3 APPROVAL AND DISTRIBUTION PROCEDURES

1.3.1 Approval of Changes

The DOD Manned Space Flight Support Office (DDMS) will coordinate and approve changes initiated by DOD recovery units and forward them to the NASA-MSC Landing and Recovery Division. The Landing and Recovery Division will transmit NASA-initiated changes to DDMS for concurrence by cognizant DOD units (see flow diagram, fig. 1-1). The following procedure shall be used by all organizations cited in paragraph 1.2 in effecting changes to this document.

(a) Informal technical coordination between the Landing and Recovery Division and applicable DOD units shall be accomplished for all proposed changes, with the exception noted in item (d), prior to the formal transmittal of the changes. After completion of informal technical coordination, the initiating organization shall forward

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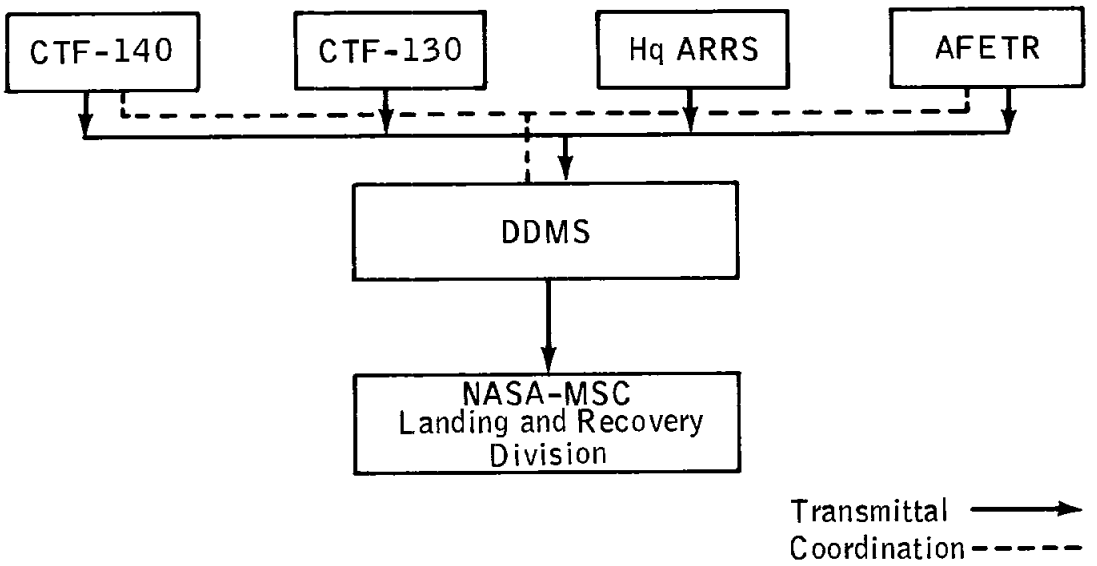
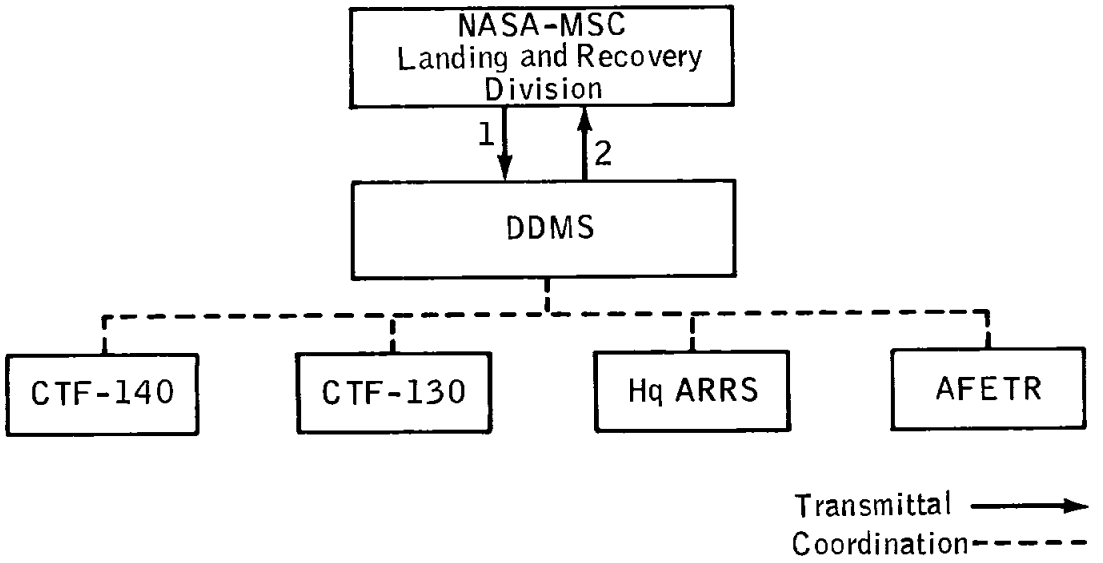


(a) DOD-initiated changes



(b) NASA-initiated changes

Figure 1-1. Change transmittal and coordination flow diagram

correspondence identifying the pages to be changed and giving the existing wording, the proposed wording, and the reason for the change.

(b) DDMS approval will signify concurrence by all cognizant DOD elements, and Landing and Recovery Division approval will signify concurrence by all cognizant NASA elements.

(c) After concurrence on changes by all parties, the changed pages will be published by the Landing and Recovery Division and distributed to DDMS and DOD recovery units. The formal transmittal of approved DOD-initiated changes must be made at least 30 days prior to a scheduled mission to assure adequate time for preparation and distribution of changed pages prior to that particular mission. Changes approved after F minus 30 days will normally not be disseminated in time for that mission. NASA-initiated changes must be transmitted to DDMS for concurrence at least 45 days prior to a scheduled mission to allow adequate time for coordination. If approval of changes has not been completed by F minus 30 days, a determination will be made by the Landing and Recovery Division and DDMS as to the importance of disseminating the information prior to the forthcoming mission and, if necessary, copies of the changed pages will be sent to DDMS and DOD recovery units prior to formal concurrence by all parties.

(d) Sections 1.9 through 1.11 of the document are subject to change without concurrence by all parties. These sections contain general information that does not require change coordination.

1.3.2 Distribution Control

The required number of copies of the basic document and subsequent changes will be sent to DDMS and DOD recovery units. Each organization receiving the documents and changes will maintain its own distribution control.

1.4 APPLICABLE DOCUMENTS

The following documents contain additional information concerning (1) special equipment used in recovery operations, and (2) planning and conducting recovery operations.

1.4.1 Documents Published by NASA-MSC

1. Gemini/Apollo Davit Crane Installation, Operation and Maintenance Manual, April 1966.

2. Inspection, Packing, and Maintenance Instructions for the Apollo Flotation Collar and Apollo Recovery Raft, May 1971.

3. Apollo Spacecraft Transport Dolly Operations Manual, Rev. B, September 1970.

4. Operation, Service and Overhaul Instructions for Kaman K-501 Fire Suppression (Hard-Hose) Kit, May 1968.

5. Operation, Test and Adjustment of SARAH Receiver, Mark III, April 1966.

6. AN/ARD-17 Direction Finder Set, Systems and Operation, April 1967.

7. Packing and Rigging Instructions for Aircraft Delivered Drift Reduction System (Revision 3), October 1969.

8. Recovery Requirements, Apollo (applicable mission).

9. Apollo Command Module Location Simulator (Revision 1), November 1968.

10. Operation and Maintenance Instructions for the Apollo Swimmer Radio, May 1969.

1.4.2 Documents Published by NASA Contractors

1. Apollo Postretrieval Procedures for NASA Recovery Team, Apollo (applicable mission), prepared by North American Rockwell Corporation under direction of NASA-MSC Landing and Recovery Division.

2. Apollo Spacecraft Deactivation Procedures for Landing Safing Team, Apollo (applicable mission), prepared by North American Rockwell Corporation under the direction of NASA-MSC Landing and Recovery Division.

1.4.3 Documents published by the Department of Defense

1. Overall Plan, Department of Defense Support for Project Apollo Operations (Second Edition), dated 29 December 1966.

2. DDMS Operations Order (-), Project Apollo (applicable mission).

3. Commander, Manned Spacecraft Recovery Force Atlantic, CTF-140 Operations Plan 2-68, Project Apollo.

4. Commander, Manned Spacecraft Recovery Force Pacific, CTF-130 Operations Plan 305-67, Project Apollo.

5. Commander, Manned Spacecraft Recovery Force Atlantic, CTF-140 Operation Order (-), Project Apollo (applicable mission).

6. Commander, Manned Spacecraft Recovery Force Pacific, CTF-130 Operation Order (-), Project Apollo (applicable mission).

7. AFETR, Apollo Launch Site Recovery Plan

8. Headquarters ARRS Operations Order (-) Project Apollo (applicable mission).

1.5 SPECIAL NOTATIONS

In order to identify operational procedures and techniques that are (1) hazardous, (2) could result in damage to equipment, and (3) should be emphasized for some other reason, the following notation system will be used throughout this document.

WARNING - Operations which may result in injury to personnel or loss of life if proper procedures, techniques, etc., are not carefully followed.

CAUTION - Operations which may result in damage to equipment if proper procedures, techniques, etc., are not carefully followed.

NOTE - Operational procedures, techniques, etc., that are considered essential to emphasize.

1.6 THE APOLLO PROGRAM

The Apollo program is the major current national space effort. The ultimate goal of the program--to land men on the moon for limited observation and exploration (fig. 1-2) and return them safely to earth--has been accomplished. The findings and experience gained from the program to this point will now be applied to future lunar landing missions. The missions will consist essentially of the events shown in figure 1-3.

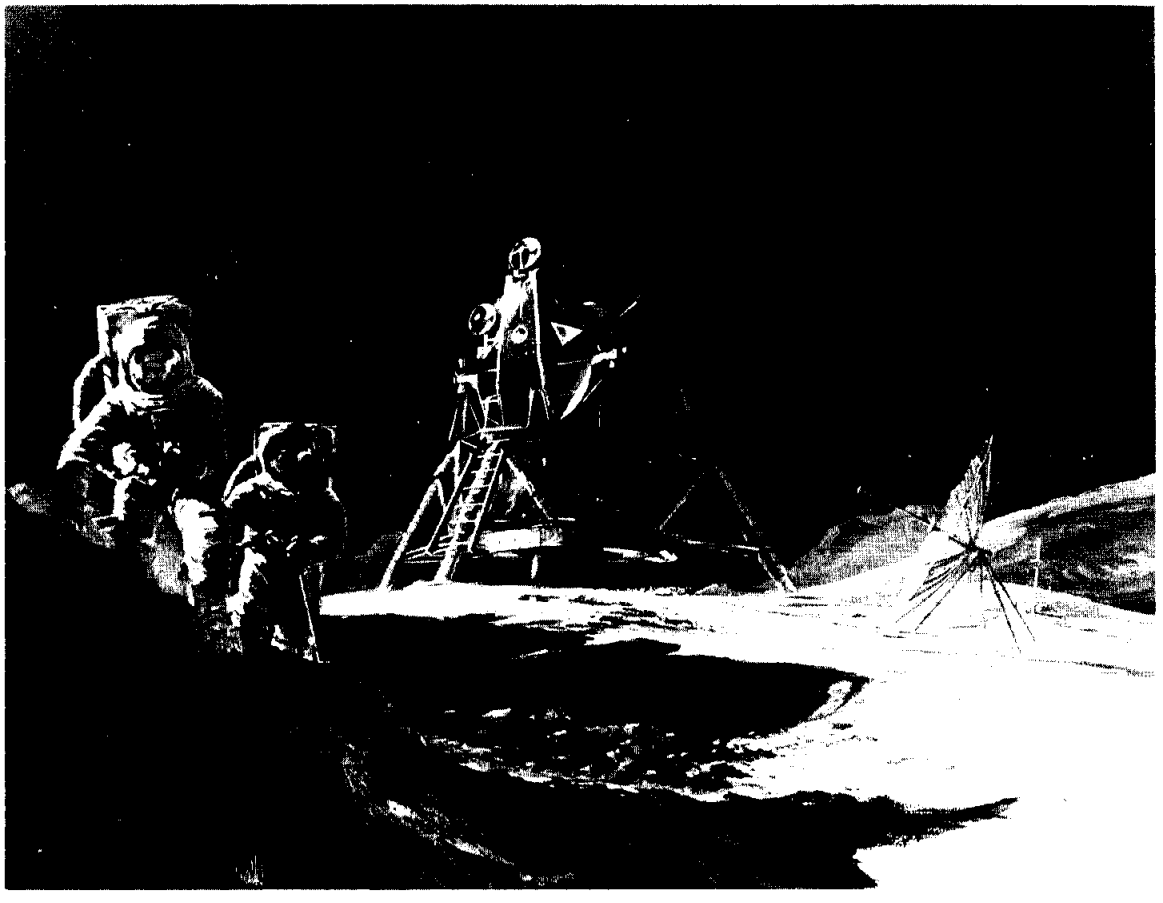


Figure 1-2. - Lunar exploration

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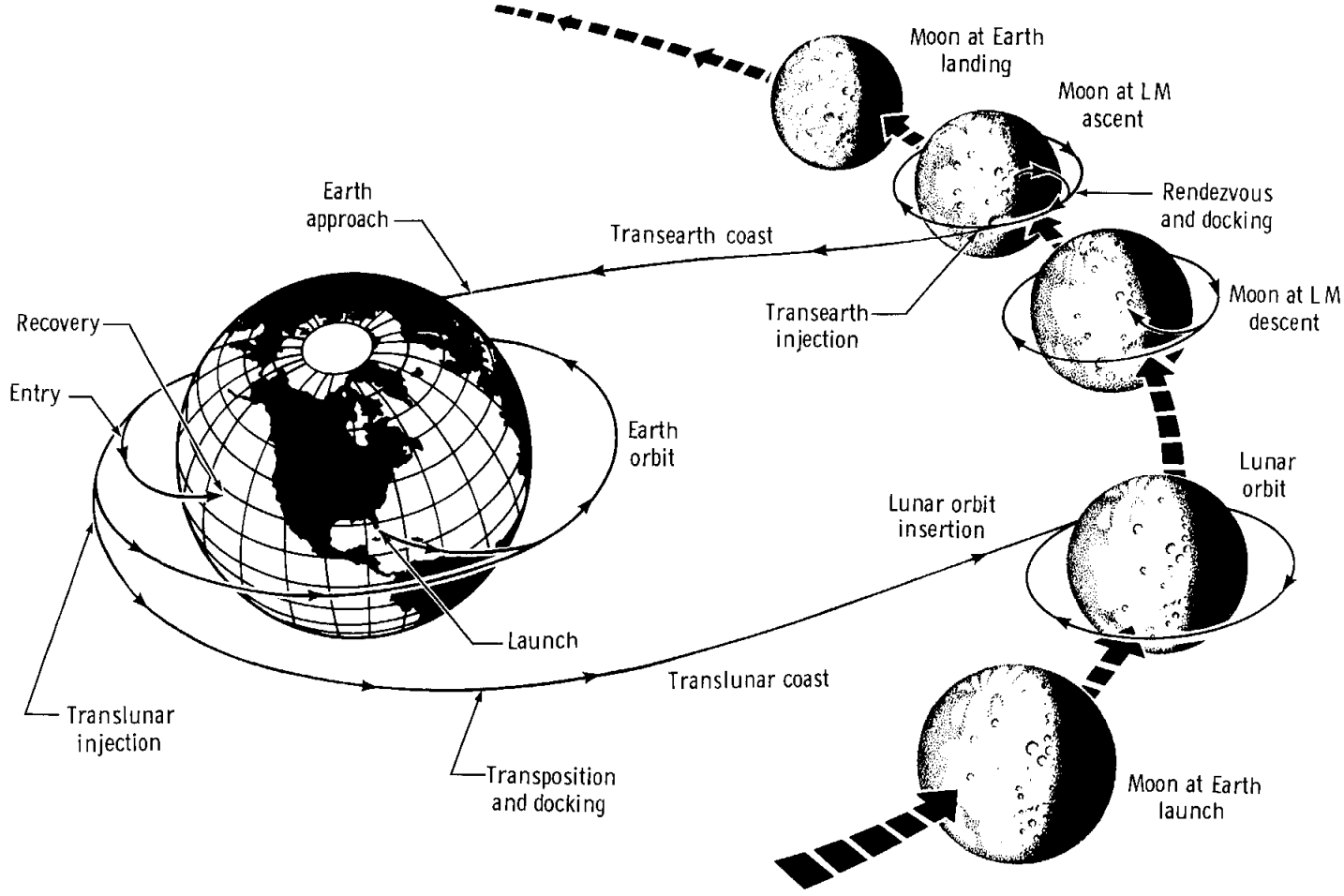

Figure 1-3. - Lunar landing mission profile (typical)

1.7 RECOVERY SUPPORT FOR MANNED SPACE FLIGHT MISSIONS

In formulating a recovery plan, a positive course of action should be provided for every conceivable landing situation. The level and type of recovery support provided in any landing area is determined by the probability of a landing and any unique circumstances associated with that particular area. There are many factors to be considered when planning for a specific mission. For example, rendezvous and lunar missions may require changes in launch azimuth to correspond to the launch time. Although the launch azimuth will be known to lie within certain boundaries, the actual launch azimuth will not be known until lift-off; thus, the exact locations of the landing areas cannot be determined until after lift-off. Spacecraft maneuvers while in earth orbit or deep space flight can also alter the earth ground tracks, and hence, location of landing areas. Weather also influences recovery planning and operations. The spacecraft capabilities and recovery operations must be made as insensitive to weather as possible in order to provide operational flexibility. For long-duration missions, alternate landing areas must be available in order to avoid unfavorable weather. These are a few of the many things that must be studied to properly plan for recovery.

Recovery operations in support of manned space flight missions begin well in advance of launch with the training and deployment of forces. The operations continue through the actual flight and terminate upon completion of certain postlanding operations. Prior to the execution of the actual landing and postlanding operations, recovery involves the usual operational activities such as monitoring the status of forces, making appropriate recommendations, keeping recovery forces informed of mission status, and adjusting the positions of recovery forces as required. The five major phases in recovery operations are: (1) preparation and training, (2) locating the command module (CM), (3) providing on-scene assistance, (4) retrieving the flight crew and CM, and (5) postflight procedures.

The ultimate objective during the locating phase is the visual acquisition of the CM as soon as possible after it lands. When the CM does not land within visual range of recovery forces, electronic aids are the primary means for locating it. Therefore, it is important that personnel be trained on this equipment and that it be checked prior to a mission to ensure satisfactory performance and compatibility of spacecraft, surface, and aircraft systems. Ground-based network stations will track the spacecraft and communicate with it periodically during the course of a mission. However, since the majority of landings will occur in the immediate vicinity of recovery aircraft and ships, the landing point can usually be determined based on information such as electronic bearings or visual sightings by the recovery forces.

Aircraft equipped for radio homing will be airborne in most planned landing areas so that electronic contact will be established with the CM beacons prior to landing. The aircraft can then immediately home on these signals until visual contact with the CM is acquired. In the event of a contingency landing, a general indication of the landing area would be established by surface stations. It is the responsibility of NASA to establish the initial CM target point. Long-range aircraft would then conduct an electronic search along the predicted ground track until visual contact is established.

On-scene assistance should be provided as soon as possible. This support can be provided by helicopters or fixed-wing aircraft. Assistance may be given in the form of providing (1) flotation for the CM, (2) medical aid and additional survival equipment if the anticipated postlanding period prior to retrieval warrants it.

Within the recovery forces, a wide range of recovery methods and capabilities exists. Each of these methods and capabilities is tailored to fit a different set of recovery conditions which depend largely on the anticipated time required to effect the recovery. Under normal conditions, the astronauts and CM will be recovered by the primary recovery ship as rapidly as possible after landing.

In order to accomplish the planning, procedures development, and training programs required to provide recovery support for manned space flights, various organizations have been established within DOD and NASA. The primary agencies for planning and coordinating recovery operations are the DOD Manned Space Flight Support Office and the NASA-MSC Landing and Recovery Division.

1.8 DOD ORGANIZATION FOR RECOVERY

Brief descriptions of the DOD units to provide recovery support are contained in ref. 2. The DOD organization for recovery is shown in figure 1-4.

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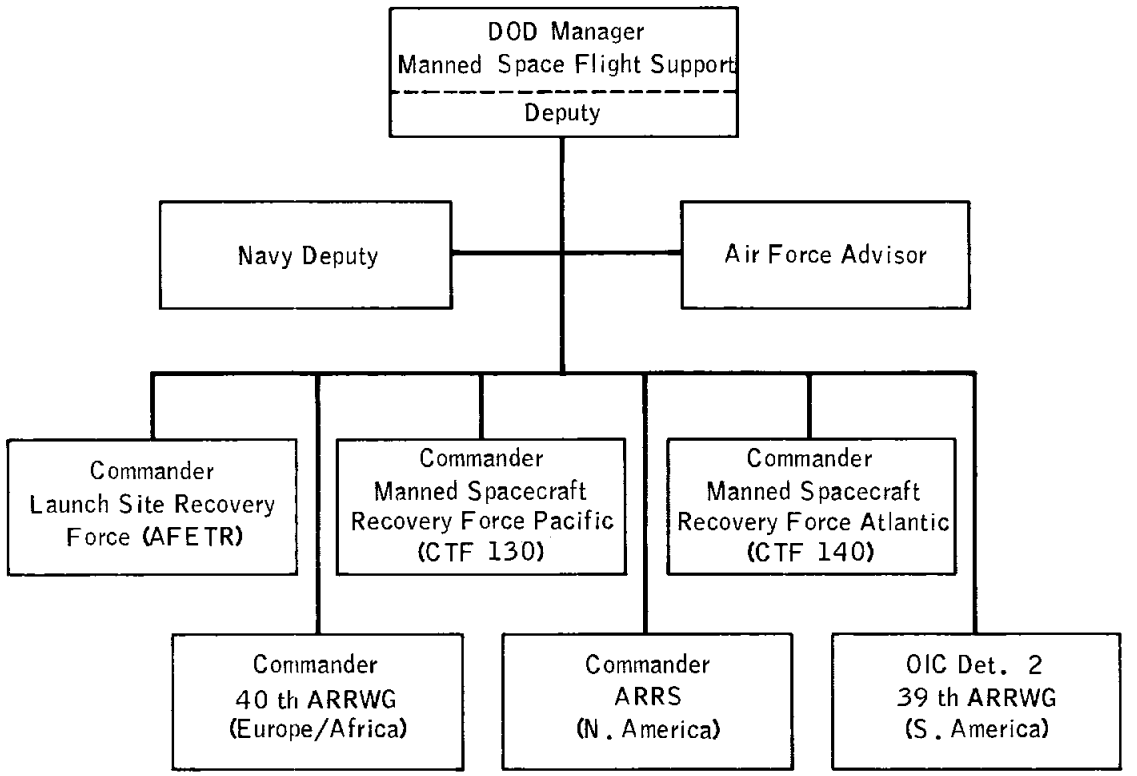

Figure 1-4. DOD organization for recovery

1.9 NASA RECOVERY TEAM

1.9.1 General

During the Apollo Program, personnel of the NASA-MSC Landing and Recovery Division and others will accompany the various DOD forces participating in each Apollo mission. The primary duties of key NASA recovery team members are outlined in the following paragraphs.

1.9.2 Personnel Aboard Primary Recovery Ship

A typical organization of the NASA recovery team aboard the primary recovery ship and its relationship to key ship's personnel is shown in figure 1-5.

1.9.2.1 Team Leader

The senior NASA recovery engineer on the primary recovery ship is the NASA recovery team leader. He will maintain cognizance over and be responsible for the coordination of activities of the recovery team personnel listed in figure 1-5. He will have assistants in the various areas for which he is responsible, and in each area a senior man will act for him in a fashion similar to that in which the ship's chain of command functions. His special duties are to:

(a) Act as technical advisor to the embarked Flag Officer as well as the Commanding and Executive Officers of the ship.

(b) Coordinate the activities and requirements of the various NASA group leaders.

(c) Coordinate all NASA-oriented activities concerning the primary recovery areas and recovery ship with the NASA advisors to CTF-140 or CTF-130 located at Houston, Norfolk, or Kunia, as applicable.

(d) Act as the established liaison point of contact between the recovery team and the ship's command.

(e) Coordinate the scheduling of special briefings for various forces embarked aboard ship. Typical examples of subjects for briefings are:

(1) Program information

(2) Current mission profile, objectives, etc.

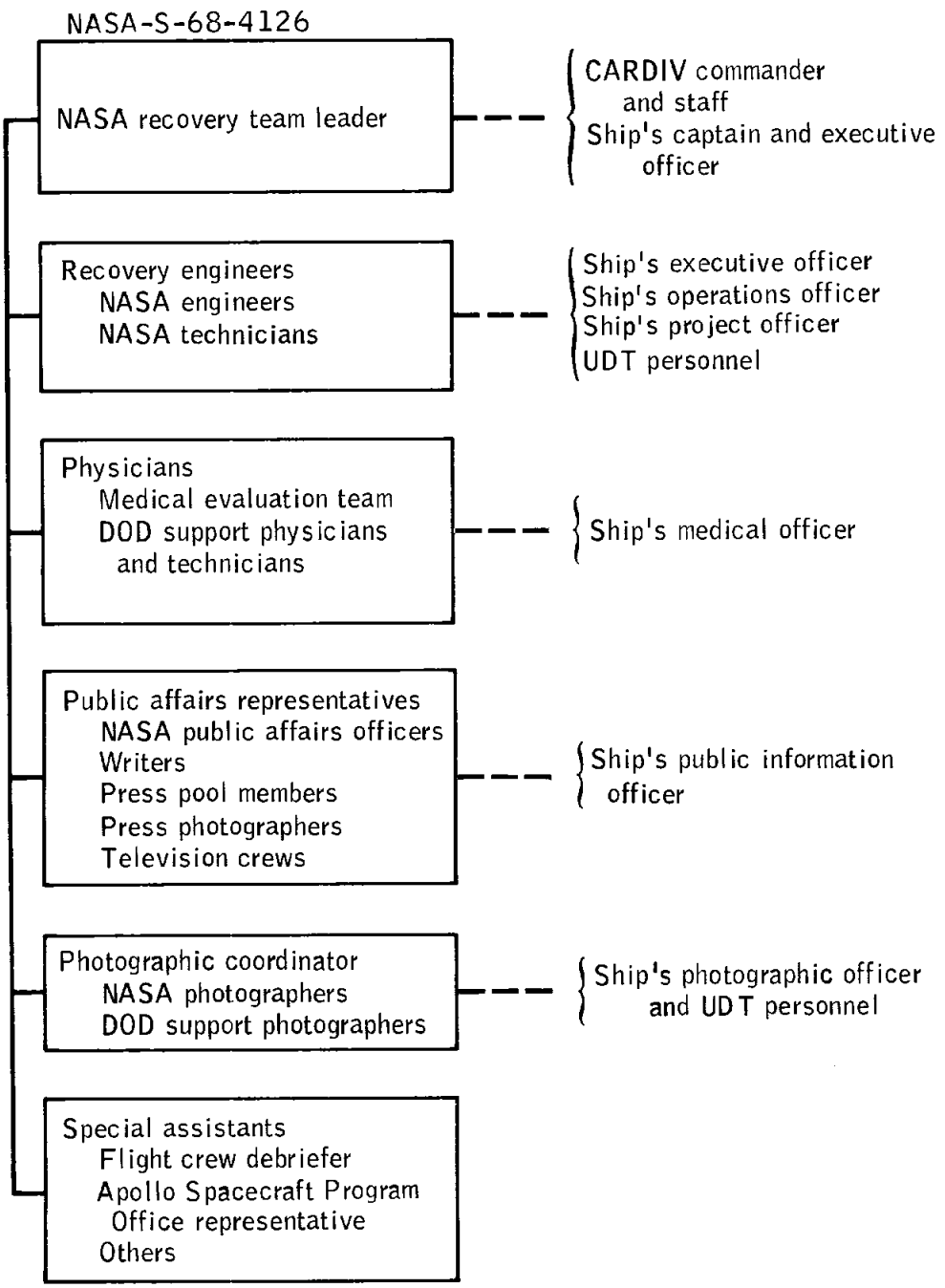

Figure 1-5. - NASA recovery team organization for primary recovery ship

(3) Recovery procedures and equipment

(4) Hazards and safety precautions

(5) Simulations

(6) Security

(7) Astronaut activities

(8) CM handling procedures and general information on post-retrieval procedures

(f) Coordinate preparations for a daily progress meeting with key recovery personnel to evaluate the current day's activities, and to provide changes and schedules for the next day's activities.

(g) Establish a flexible and workable chain of command among the NASA and associated personnel embarked in order to eliminate multiple requests for assistance and equipment and to provide common points of contact for both NASA and DOD coordination purposes.

(h) Provide the ship's command with guidance concerning the security of the astronauts and the CM after retrieval.

(i) Report to the NASA Recovery Coordinator.

1.9.2.2 Recovery Engineers

NASA engineers will assist the team leader. They will:

(a) Participate in all activities involving the planning and carrying out of astronaut and CM retrieval.

(b) Assist in training exercises and simulations prior to a mission, and conduct briefings and critiques for pilots, swimmers, spacecraft handlers, CIC personnel, and lookouts.

(c) Ensure that all NASA-provided recovery support equipment (including helicopter-borne equipment) is aboard ship prior to departure for the recovery area.

(d) Conduct postretrieval procedures and data/sample removal.

Primary points of contact for recovery engineers are normally:

(a) Ship's executive officer

(b) Ship's project officer

(c) CAG or helicopter squadron commander

(d) First lieutenant

(e) CIC or HDC officer

(f) Swimmer team leader

1.9.2.3 Senior NASA Information Representative

The senior NASA information representative is in charge of all PAO activities and news pool operations, and is directly responsible to the Apollo Information Director in all matters pertaining to policy, content, and timing of information to be released aboard the primary recovery ship. In addition, he will advise the NASA team leader concerning all PAO matters and provide him with specific requirements for support and equipment necessary to accomplish his tasks. He will serve as the NASA team leader's representative for public affairs in the dealing with ship's personnel. In accomplishing this, he will be responsible for:

(a) Setting up and operating the shipboard newsroom.

(b) Providing the new pool team with all releasable recovery information.

(c) Acting as NASA spokesman in all matters concerning public release of information.

(d) Managing a staff of NASA and DOD public information personnel in all public affairs matters concerning spacecraft and mission operations information.

(e) Coordinating activities necessary to provide for needs of news pool team writers, television crews, still and motion picture photographers, wire photo and VIDEX crews.

(f) Coordinating NASA and news pool activities in all public affairs matters with the NASA recovery team leader, the U. S. Navy Task Group Commander and ship's company.

(g) Assuring that all news pool copy is submitted to Houston and Cape Kennedy news centers with minimum delay, and that news pool photography is forwarded from the primary recovery ship by ensuring that all concerned are kept informed of communications schedules, COD aircraft data flight schedules, and special aircraft news pool material pickup schedules.

(h) Reporting recovery activities to the public affairs officer at the MCC and to the shipboard news pool team.

(i) Keeping the NASA recovery team leader apprised of all public affairs activities, and any changes or additions to public affairs policies, activities, and requirements.

The senior NASA information representative will be responsible for planning and conducting protocol and news-related astronaut activities. These activities will be coordinated through the NASA recovery team leader who will consider them in relation to post-flight medical operations and astronaut debriefing requirements

Procedures concerning embarkation of press pools on DOD ships in support of Apollo operations are as follows:

(a) NASA Headquarters Public Information Division will organize the onboard news media pool working directly with the media and based on guidelines established in the Apollo Public Affairs Plan.

(b) The Apollo Mission Information Director will forward names of members of that pool to DDMS Public Information Office, Commander of TF-130 and TF-140, the MSC Landing and Recovery Division and the MSC PAO. The pool list will be forwarded no later than seven days prior to the PRS sail date, and no additions or substitutions will be accepted after one day prior to sail date, except in cases of emergency.

(c) After DDMS and the Task Force Commander review the list, the news pool will be authorized to embark by invitation TWX from the area commander with information copies to DDMS, MSC, and NASA Headquarters (code M-H).

1.9.2.4 Photographic Coordinator

All photographers assigned to the primary recovery ship for a mission will be under the direction of a senior photographer who will coordinate the documentary and press photographic coverage of pre-mission simulations and recovery of the astronauts and spacecraft. His primary contacts aboard ship are the senior photographic officer and the helicopter squadron commander.

1.9.3 Personnel Aboard Secondary Recovery Ships and Aircraft

NASA personnel will be aboard ships and aircraft supporting secondary and contingency landing areas (see paragraphs 1.10.1.4, 1.10.1.5, and 1.10.1.6). One NASA-MSC Landing and Recovery Division representative assigned to each recovery unit will be designated to act as technical advisor to the unit commander concerning details of the mission, NASA recovery requirements, retrieval procedures, etc. Each team will generally consist of one or two men; however, these teams will have essentially the same responsibilities as the team on the primary recovery ship. These responsibilities include:

(a) Conducting mission and recovery-oriented briefings and assisting in training, as requested by the unit to which attached.

(b) Inventorying and checking out NASA-provided recovery support equipment.

(c) Providing close coordination with the unit commanders in order to ensure smooth conduct of mission support.

1.9.4 Personnel at Recovery Control Centers

A NASA-MSC Landing and Recovery Division representative will act as technical advisor to the commander of the staff to which he is assigned. In most cases, the NASA representative will stand regular watches in the Control Center at an assigned console. Since he will be in contact with NASA-MSC through his communication facilities, he will be in a position to assist in resolving questions arising during a mission.

In addition to his duties at the Recovery Control Center, the NASA representative will act as senior NASA representative for the area to which he is assigned. He will provide assistance and direction to other NASA representatives assigned to other commands in the area, or who are deployed on ships or aircraft in the area.

1.9.5 Landing Safing Team

The landing safing team has been established to evaluate and deactivate the CM reaction control system (RCS) and pyrotechnic devices, as required, upon arrival of the CM at the port where deactivation will be performed. The landing safing team will carry all equipment required to accomplish CM deactivation. This team will include two NASA-MSC Landing and Recovery Division engineers, two contractor postflight engineers, one RCS engineer and six contractor technicians. One of the contractor engineers will function as the contractor team leader, reporting to NASA team director.

1.10 LANDING AREAS, RECOVERY ZONES, RECOVERY LINES, AND TARGET POINTS

1.10.1 Landing Areas

In the development of recovery plans for manned space flight missions, specific landing areas are identified in accordance with landing probabilities and other factors. The types of landing areas established for earth orbital, deep space, and lunar missions are defined in the following paragraphs.

1.10.1.1 Launch Site Area

This area is in the vicinity of the launch site where a landing could occur in the event of an abort from the launch pad or during the initial portion of powered flight.

1.10.1.2 Launch Abort Areas

These are areas beyond the launch site area in which a landing could occur following an abort initiated prior to orbital insertion.

1.10.1.3 Primary Landing Area

This is the area in which the probability of landing is sufficiently high to warrant the requirement for primary recovery ship support.

1.10.1.4 Secondary Landing Areas

These are areas in which the probability of a landing is sufficiently high to warrant the requirement for at least secondary recovery ship support.

1.10.1.5 Earth Orbital Contingency Landing Area

This is all area outside the previously described areas within which landing could possibly occur during the earth-orbital phase of a mission. The probability of landing in this area is low and only warrants the support of contingency land-based aircraft. For identification purposes, the contingency landing area is divided into four sectors:

Contingency Sector A - from 80°W east to 20°E.

Contingency Sector B - from 20°E east to 120°E.

Contingency Sector C - from 120°E east to 160°W.

Contingency Sector D - from 160°W east to 80°W.

1.10.1.6 Deep Space Contingency Landing Area

This is all the area, exclusive of the primary and secondary landing areas, where a landing could possibly occur after the initiation of the translunar injection maneuver.

1.10.2 Recovery Zones

For the low earth orbital phase of any type mission, primary and secondary landing areas are located within or near general locations designated "recovery zones." The number, size, and locations of recovery zones may vary depending upon mission requirements and recovery force logistics. Presently, two zones are used: the West Atlantic and the mid-Pacific.

1.10.3 Recovery Lines

For returns from deep space, primary and secondary landing areas and target longitudes for contingency landings are located on or near generally north-south lines on the earth's surface designated "recovery lines." The number and location of recovery lines may vary depending upon mission requirements and recovery force logistics. Presently, three lines are used for lunar missions.

Atlantic Ocean Line (AOL)

Mid-Pacific Line (MPL)

1.10.4 Earth Orbital Target Points

For earth orbital flight, target points are selected so that the spacecraft could land in a favorable location if the mission must be terminated early. A preferred target point (PTP) is normally selected for each spacecraft revolution. When possible, a PTP is selected within a recovery zone in order to provide ship support. If this is not possible or feasible, a PTP is selected in the vicinity of an aircraft staging base. PTP's are described by a combination of numbers and letters which identify:

(a) The number of the spacecraft revolution in which the landing would occur.

(b) The recovery zone or contingency sector in which the landing would be made.

(c) The level of recovery support that would be available.

The three support levels defined are as follows:

Support level A - At the predicted time of spacecraft landing, a recovery ship is at or near (within approximately 4 hours travel time) the target point; and aircraft having locating and pararescue capability are at or enroute to the target point.

Support level B - At the predicted time of spacecraft landing, a recovery ship is within approximately 24 hour's travel time proceeding toward the target point; and aircraft with locating and pararescue capability are at or enroute to the target point.

Support level C - The only planned recovery support forces are aircraft with locating and pararescue capability which are at or enroute to the target point at the predicted time of spacecraft landing. Surface support will be provided by a ship of opportunity and will be determined after a decision has been made to land.

Two examples of target points are:

3-1A

28-BC

In the first example, the 3 indicates that to reach the designated target point the landing would take place during the 3rd spacecraft revolution; the 1 indicates that the landing would be made in Recovery Zone 1; the A indicates that recovery support level A would be available at the time of landing.

In the second example, the 28 indicates that the landing would be made during the 28th spacecraft revolution; the B indicates that the landing point is in Contingency Sector B; the C indicates that recovery support level C could be expected at the time of landing. Target point designators are not intended to convey a requirement for support; it is simply a method by which the anticipated recovery support available at target points may be identified.

Prior to a mission, a forecast of the target points for the first several revolutions of the mission may be published.

1.11 APOLLO SPACE VEHICLE DESCRIPTION

1.11.1 Launch Vehicle

The launch vehicle to be used for the remainder of the Apollo Program is the Saturn V. The vehicle in the launch configuration is shown in figure 1-6 and pertinent data is given in Table 1-1.

The Saturn V launch vehicle consists of three propulsive stages and an instrument unit (IU). The first stage, the S-IC, is a cylindrical booster powered by five F-1 engines that develop a total thrust of approximately 7.5 million pounds. A fixed engine is mounted on the longitudinal centerline of the vehicle. The four outboard engines are capable of being hydraulically gimbaled for thrust vector control. The propellants (LOX and RP-1) are stored in separate cylindrical tanks with the LOX tank in the forward position. Eight solid-propellant rocket engines are mounted in pairs under the engine fairings on the aft S-IC stage structure. These engines are used to retard the S-IC stage after S-IC/S-II separation.

The major structural component of the second stage, the S-II, is a cylindrical propellant tank with a common bulkhead to separate the fuel (liquid hydrogen) from the oxidizer (LOX). The stage is powered by five J-2 engines which develop a thrust of 1 million pounds. One engine, mounted on the centerline of the vehicle, is fixed. The four outer engines are capable of being gimbaled for thrust vector control. Eight solid-propellant ullage rockets are mounted at equal intervals around the periphery of the S-IC/S-II interstage structure. These rockets provide positive thrust to settle the J-2 engine propellants prior to engine start. S-IC/S-II separation occurs in two planes. First plane separation occurs prior to S-II engine start. At first-plane separation, the forward ring of the interstage structure remains attached to the S-II and the aft ring remains attached to the S-IC. After S-II engine start, second plane separation occurs and the forward ring of the interstage structure is severed from the S-II stage.

The third stage of the Saturn V is the S-IVB. Its major structural components consist of a cylindrical propellant tank, an interstage structure, a forward skirt, an aft skirt, and a thrust structure assembly to which is affixed a restartable 200,000-lb-thrust J-2 engine. A bulkhead separates the fuel (liquid hydrogen) and oxidizer (LOX) in the propellant tank. The smaller-diameter forward end of the S-II/S-IVB interstage assembly is the separation plane for these two stages, and the interstage assembly remains attached to the S-II at stage separation. Four solid-propellant retrorockets are mounted at equal intervals about the periphery of the S-II/S-IVB interstage structure to retard the S-II stage after separation. Three solid-propellant ullage rockets mounted 120° apart on the S-IVB aft skirt provide positive acceleration to settle the propellant for the J-2 engine. During powered flight, the J-2 engine is hydraulically gimbaled to control the S-IVB stage in the pitch and yaw axes. An auxiliary propulsion system consisting of two hypergolic-rocket-engine modules

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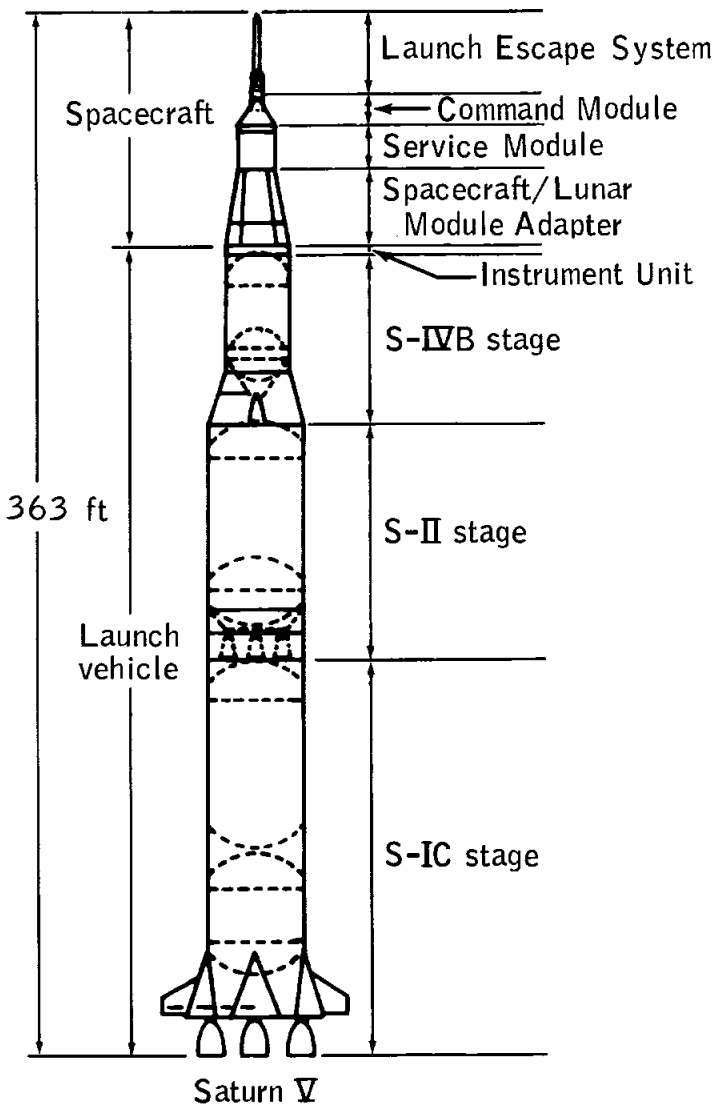

Figure 1-6. Apollo/Saturn space vehicle

Table I-I.- APOLLO LAUNCH VEHICLE DATA

Launch vehicle stage	Diameter, ft	Height, ft	Fueled weight, lb (a)	Engines		Thrust, lb	Propellant	
				Number	Type		Fuel	Oxidizer
S-IC (First Stage)	33.0	138.0	4.7 million	5	F-1	7.5 million	RP-1	LOX
S-II (Second Stage)	33.0	81.5	1.03 million	5	J-2	1 million	LH_2	LOX
S-IVB (Third Stage)	21.7	58.6	260,000	1	J-2	200,000	LH_2	LOX

a - Weights shown are approximate

mounted 180° apart on the aft skirt provides pitch, yaw and roll control during the S-IVB coast mode of operation, and roll control during powered flight.

The IU is a cylindrical structure with interfaces to the S-IVB stage and the Apollo spacecraft. The unit contains the equipment necessary to guide and control the flight of both vehicle stages.

1.11.2 Spacecraft

The Apollo spacecraft and associated major assemblies consist of:

(a) Launch escape system (LES)

(b) Command module (CM)

(c) Service module (SM)

(d) Lunar module (LM)

(e) Spacecraft-lunar module adapter (SLA)

A general description of these assemblies follows. Details concerning the CM earth landing system and recovery aids are provided in section 1.11.3.

1.11.2.1 Launch Escape System

The LES provides two means of separating the CM from the launch vehicle during an off-the-pad or early powered flight abort. If such aborts are initiated, the LES, using the launch escape motors and pitch control motor, will propel the CM to a sufficient altitude and lateral distance away from the danger area to allow the main parachutes to deploy and bring the CM safely to earth. Normally, the LES is jettisoned from the CM shortly after second stage ignition, using the tower jettison and pitch control motors (fig. 1-7).

1.11.2.2 Command and Service Modules

The CM is the only portion of the spacecraft recovered. The basic CM structural assemblies are a conical outer heat shield and an inner pressure vessel which houses a three-man crew. The locations of the heat shield and other external components are identified in figure 1-8. The pressure vessel is made up of three basic structural units: a forward section, an aft sidewall, and an aft bulkhead. A pressure hatch in the forward section provides a means of crew transfer between the CM and LM when the two vehicles are docked. The forward hatch may also be used as a secondary means

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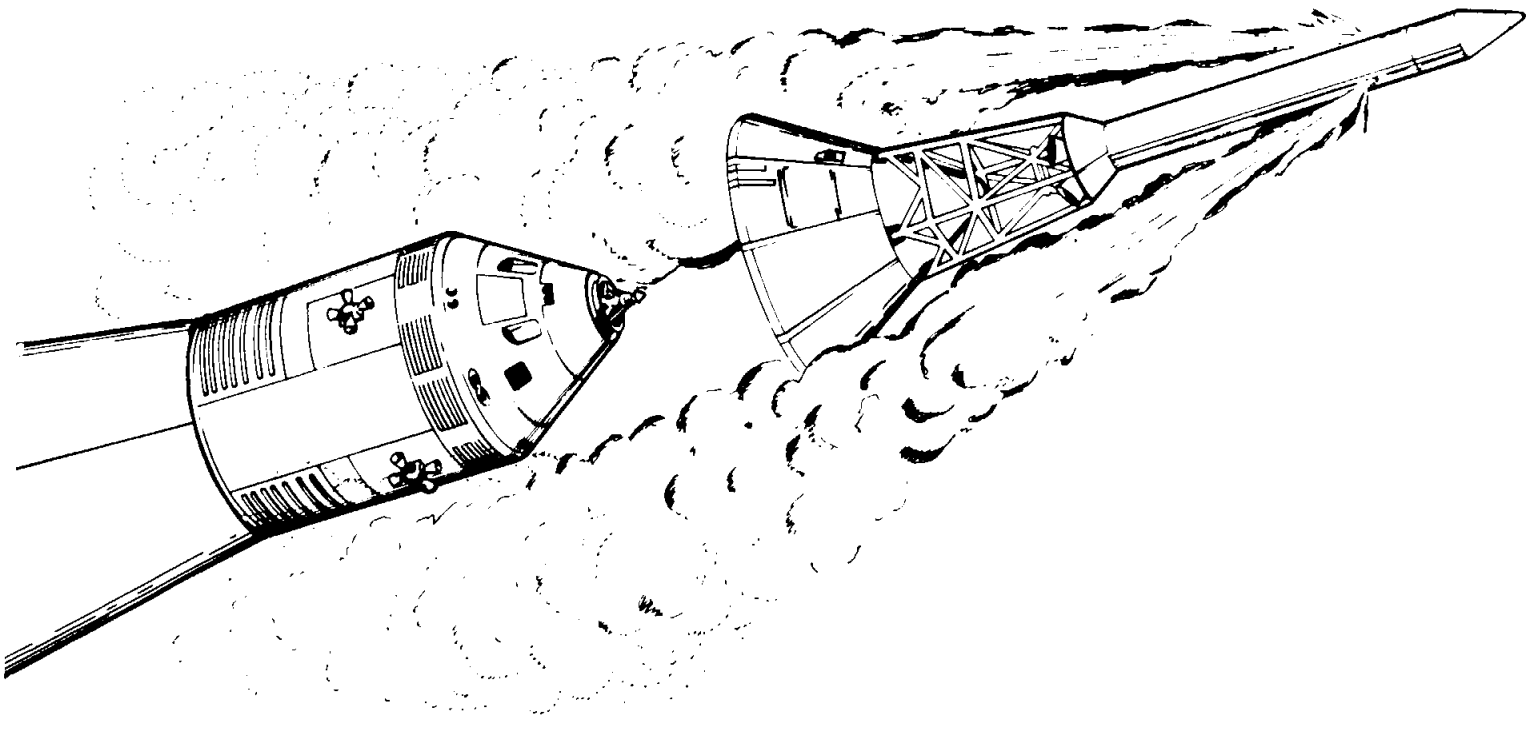

Figure 1-7. - Normal jettison of launch escape system

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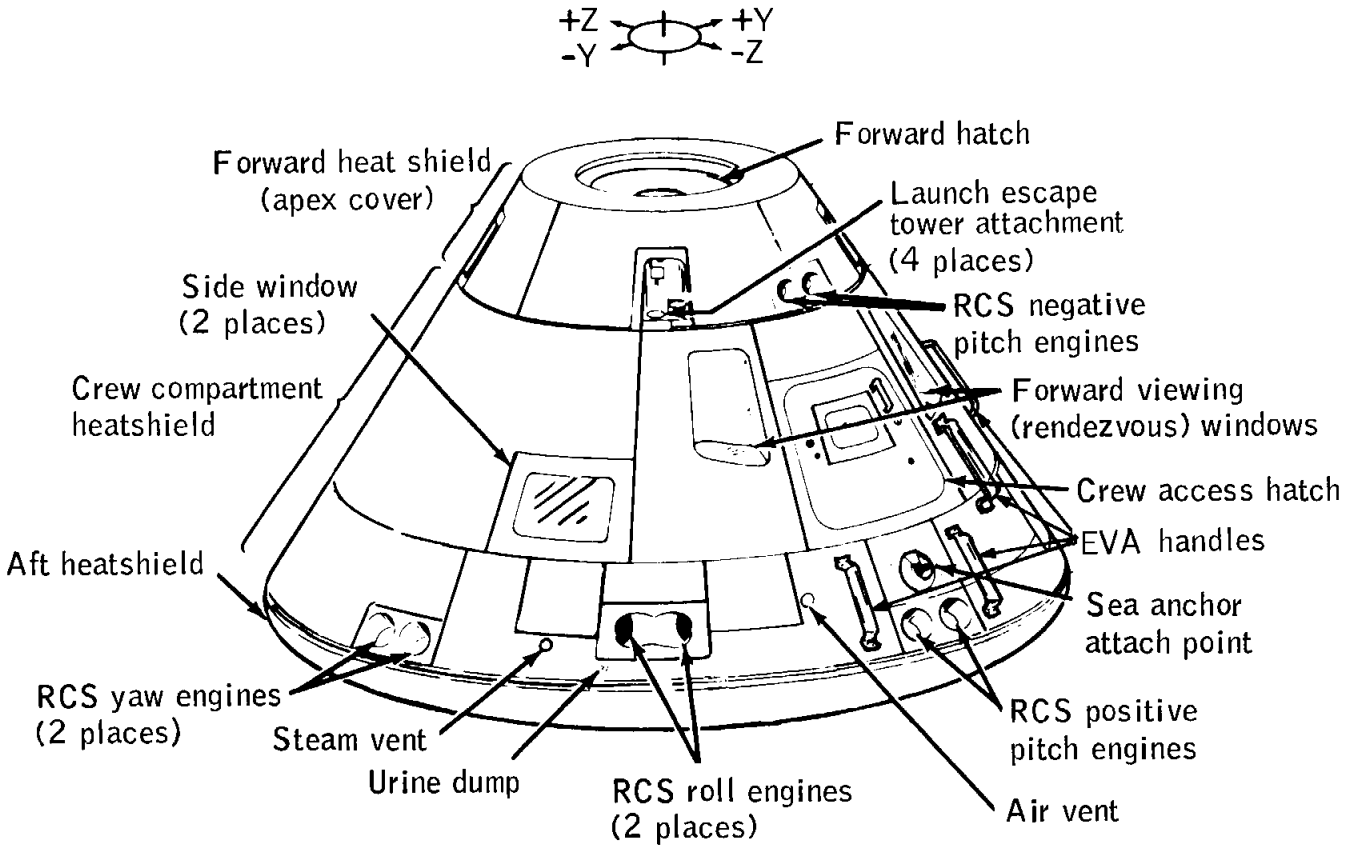

Figure 1-8. Apollo command module prior to entry

of exit from the CM after landing, but the normal means of entry and exit is a hatch on the side of the CM. When the launch escape system is in place, the CM side hatch is covered by a boost protective cover hatch; however, the boost protective cover is jettisoned as a part of the launch escape system during the launch phase.

The area surrounding the forward access tunnel and enclosed by the forward heat shield (apex cover) is referred to as the forward compartment. This compartment is divided into four 90-degree segments which contain the earth landing system, recovery equipment, two reaction control motors, and forward heat shield jettisoning mechanism. Figure 1-9 shows the CM as it would appear after landing and gives its overall dimensions.

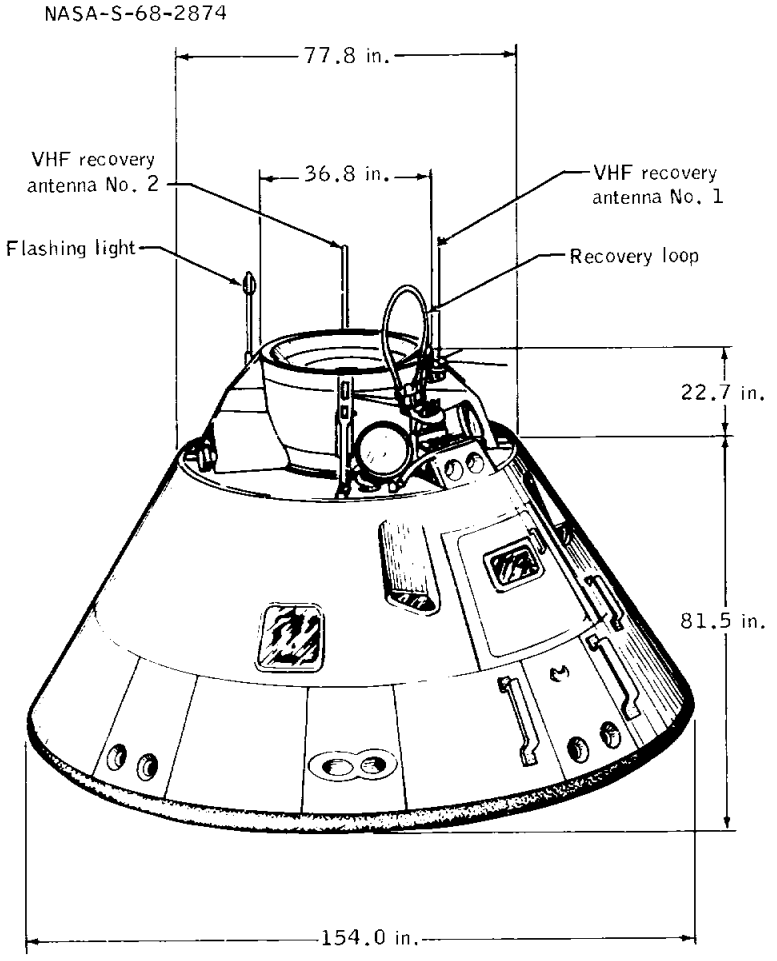

Figure 1-9. - Apollo command module (CM) after landing

The aft compartment of the CM is the area surrounding the exterior of the pressure vessel aft sidewall and enclosed by portions of the aft heat shield and the crew compartment heat shield. This compartment houses reaction control engines; storage tanks containing propellant, pressurizing gas, and water; instrumentation; and structure that would partially absorb the energy of impact if the CM landed on land. At launch the CM weighs approximately 12,300 lb.

The SM is a cylindrical assembly joined to the CM until just prior to entry of the CM into the earth's atmosphere (fig. 1-10).

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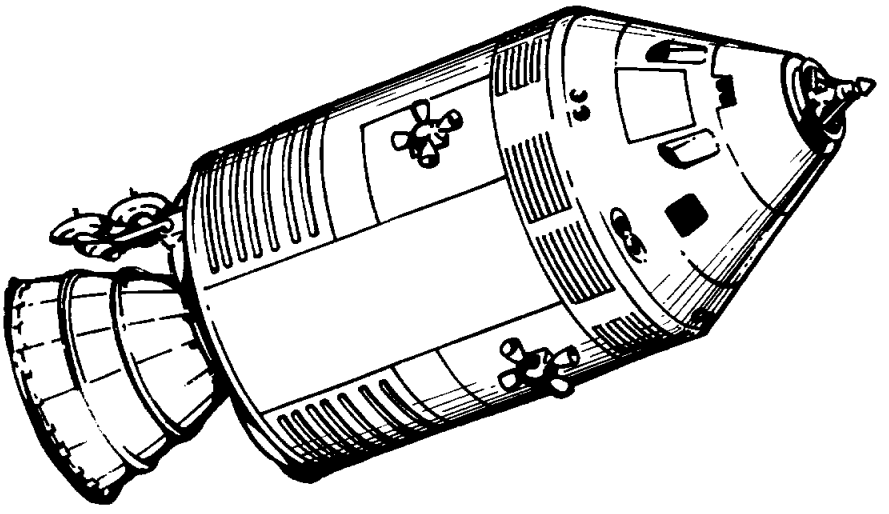

Figure 1-10. - Apollo command/service module (CSM)

Radial aluminum beams divide the interior of the SM into six compartments. The outer surface of the SM is covered with aluminum panels. The SM contains the following major systems and equipment:

(a) Service propulsion system (SPS)

(b) Storage tanks for propellant and other consumables

(c) Components of the electrical power system (EPS)

(d) Four reaction control system (RCS) packages

(e) Components of the environmental control system (ECS)

The equipment contained within the SM is accessible by means of doors around the exterior surface of the module. A view of the SM is shown in figure 1-11. The weight of the SM is about 55,000 lb at launch.

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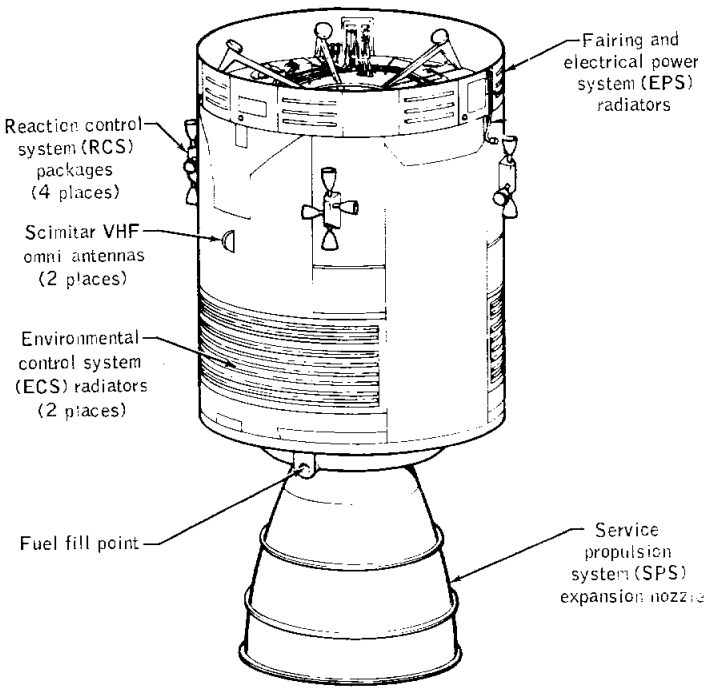

Figure 1-11. - Service module (SM)

1.11.2.3 Lunar Module

The major assemblies of the LM are an ascent stage and a descent stage. They are joined together at four interstage fittings by explosive bolts (fig. 1-12). The ascent stage incorporates a two-man cabin and is the control center of the LM. The stage is powered by a 3,500-pound-thrust ascent engine and also accommodates the reaction control subsystem which includes four thruster packages. The reaction control subsystem stabilizes the LM during descent and ascent, controls attitude and translation, and provides acceleration for settling the main propulsion system propellants prior to engine ignition. The descent stage is powered by a throttleable engine which develops a thrust of 9,870 pounds at full throttle. This stage also contains the landing gear and has support points for securing the LM within the spacecraft/LM adapter. At launch the entire LM weighs about 32,000 lb.

On a manned lunar mission, the two stages will descent as a unit to the lunar surface; at the end of the lunar stay, the ascent stage, using the descent stage as a launch platform, will be launched to rendezvous and dock with the CSM.

1.11.2.4 Spacecraft/LM Adapter

The spacecraft/LM adapter consists of four structural panels which support the CSM and house the LM during launch and the early stages of flight. When the CSM is to be separated from the launch vehicle, pyrotechnic devices are activated that sever, deploy, and jettison the panels (fig. 1-13).

1.11.3 Command Module Systems Information

1.11.3.1 Earth Landing System

The earth landing system parachutes are located in the forward section of the CM enclosed by the apex cover. The parachute landing system consists of two conical ribbon-type nylon drogue parachutes (16.5-ft diameter), three ring slot nylon pilot parachutes (7.2-ft diameter), and three ring sail nylon main parachutes (83.5-ft diameter), deployment bags, bridles, mortars and the necessary hardware for attachment of the parachutes to the CM. The drogue and pilot parachutes are white and the main parachutes have alternate orange and white panels. Figure 1-14 shows the forward section with the parachutes in place.

Apex cover jettison and parachute deployment are initiated at the proper times by sequence controllers. The apex cover is jettisoned at an altitude of approximately 24,000 feet by four thruster assemblies which may be activated either automatically or manually. As the thrusters

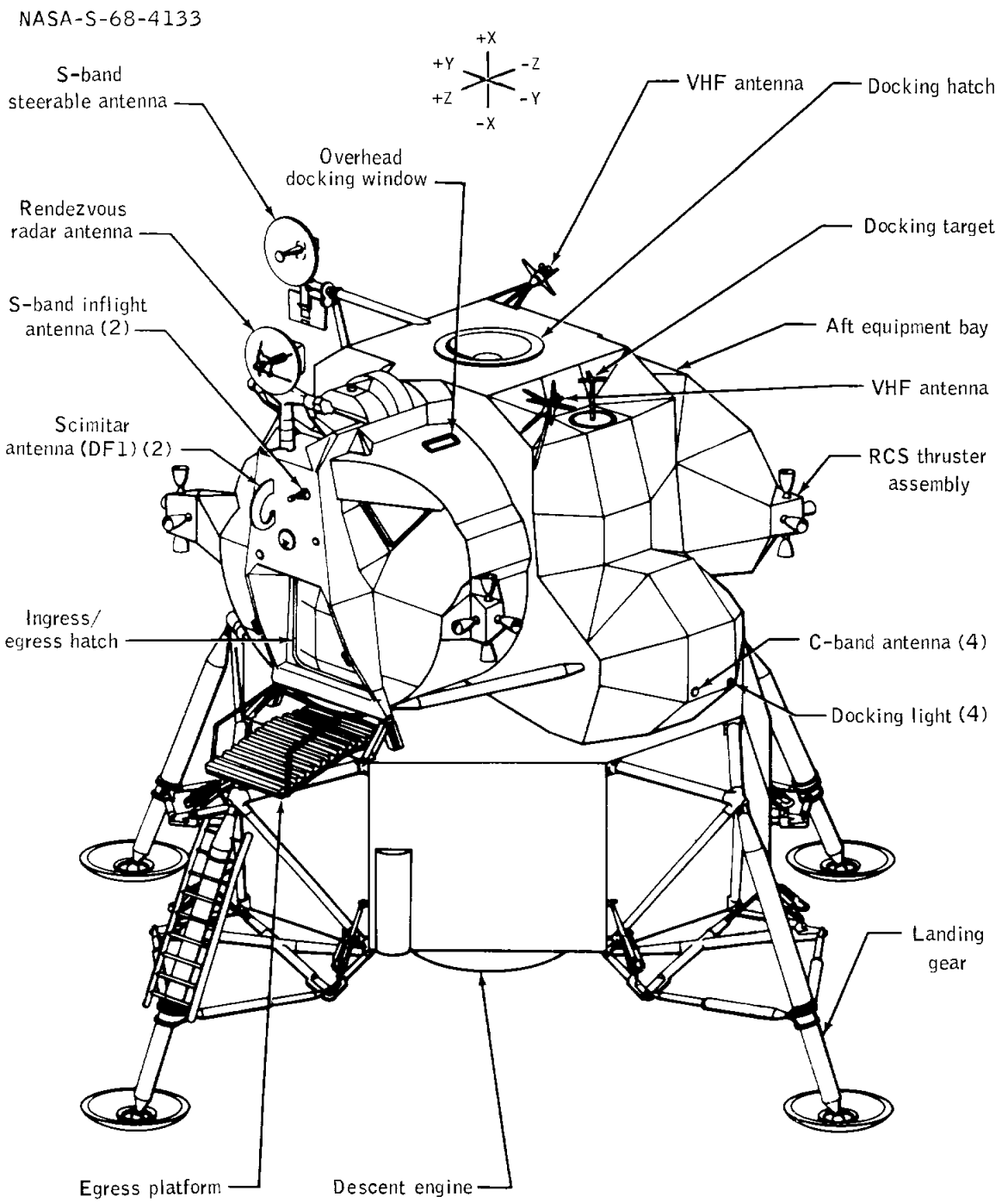

Figure 1-12. - Lunar module (LM)

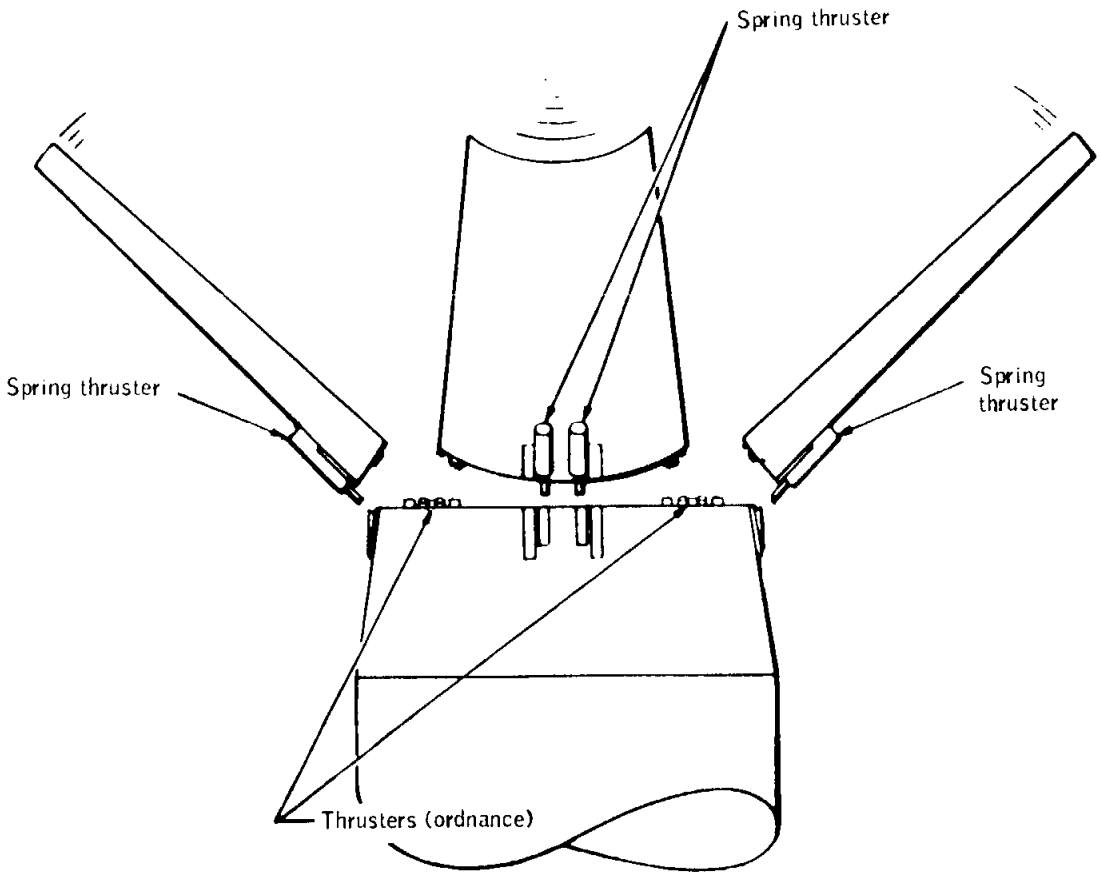

Figure 1-13. Spacecraft/LM adapter panel deployment

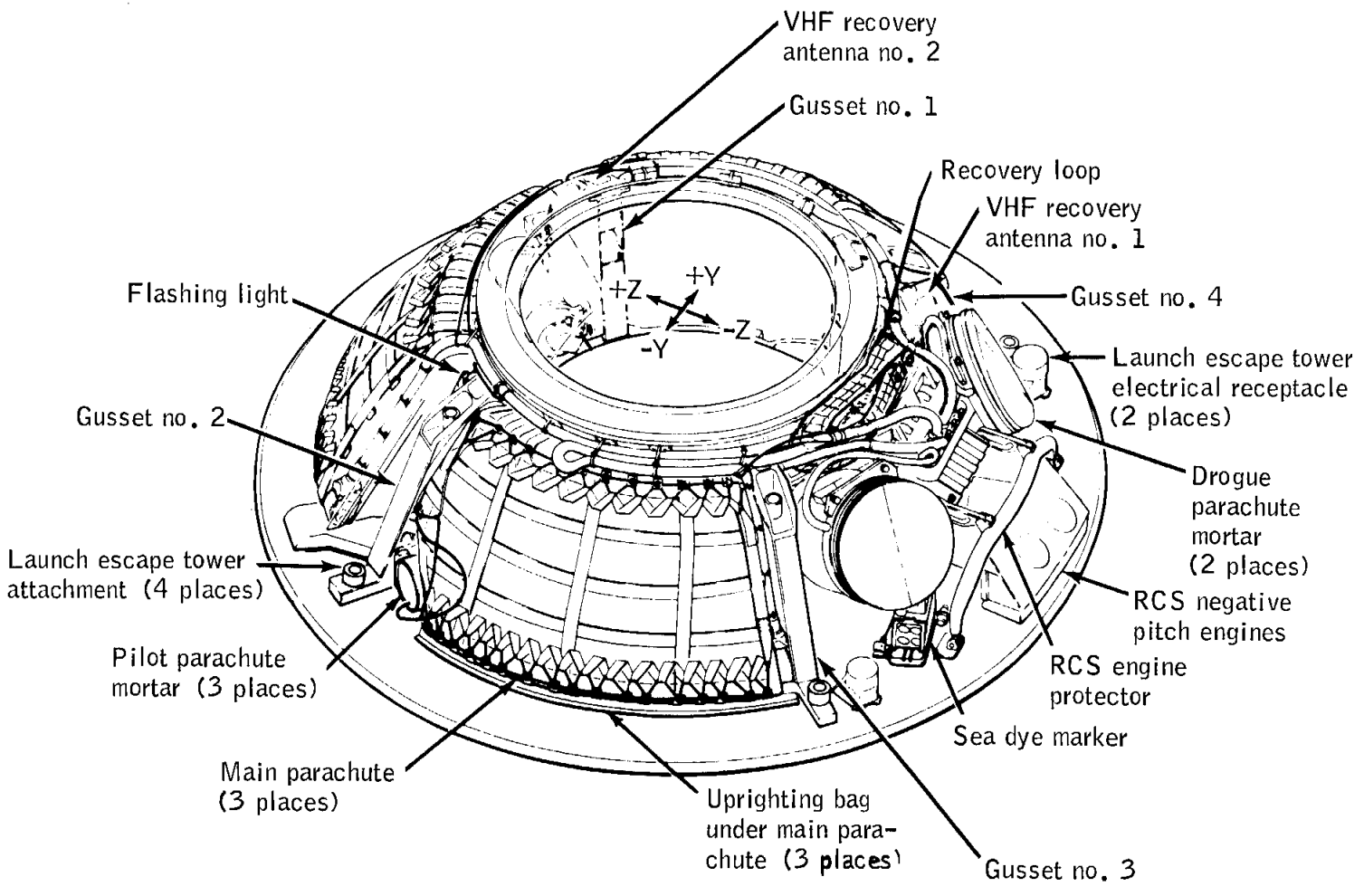

Figure 1-14. Equipment in forward section of CM

force the apex cover away from the CM, lanyard-actuated switches initiate the deployment of a drag parachute from a mortar in the apex cover. Upon deployment, this parachute prevents the apex cover from recontacting the CM. The two drogue parachutes are deployed in a reefed condition about 2 seconds after apex cover jettison, and are disreefed about 10 seconds after deployment. At an altitude of about 10,000 feet, the drogues are released and the pilot parachutes are deployed. These, in turn, deploy the main parachutes in a reefed condition. The main parachutes are disreefed in two stages about 6 seconds and 10 seconds after deployment of the pilot parachutes. The normal sequence of operation of the system is shown in figure 1-15.

The velocity of the CM as it descends on the three main parachutes just prior to landing is about 32 ft/sec. If one main parachute fails to open, the other two parachutes allow the CM to land at a descent velocity of approximately 36 ft/sec.

1.11.3.2 Recovery Aids

This section provides descriptions of CM equipment used during the landing and postlanding phases of a mission to facilitate recovery operations.

Equipment used for locating the command module - Pertinent information concerning the electronic equipment on the CM which is used by recovery forces to locate it during its descent and after landing is given in Table 1-2. The two VHF recovery antennas referred to in the table are 11 inches in length and are installed in the forward compartment of the CM. They are automatically deployed 8 seconds after main parachute deployment. The antennas in the deployed positions are shown in figures 1-16 and 1-17. A flashing light to aid in visual location of the CM is also automatically deployed at main parachute deployment. It is shown in its deployed position in figure 1-18. Both the VHF recovery beacon and the flashing light are activated by the crew. A sea dye marker is also used to aid in visual location of the CM.

Sea dye marker - A perforated housing to the left of the RCS engine panel in the forward section of the command module (fig. 1-14) contains the sea dye marker. This canister, on an 8-foot cable, is ejected into the water on crew command and will provide a yellow-green dye slick for about 12 hours.

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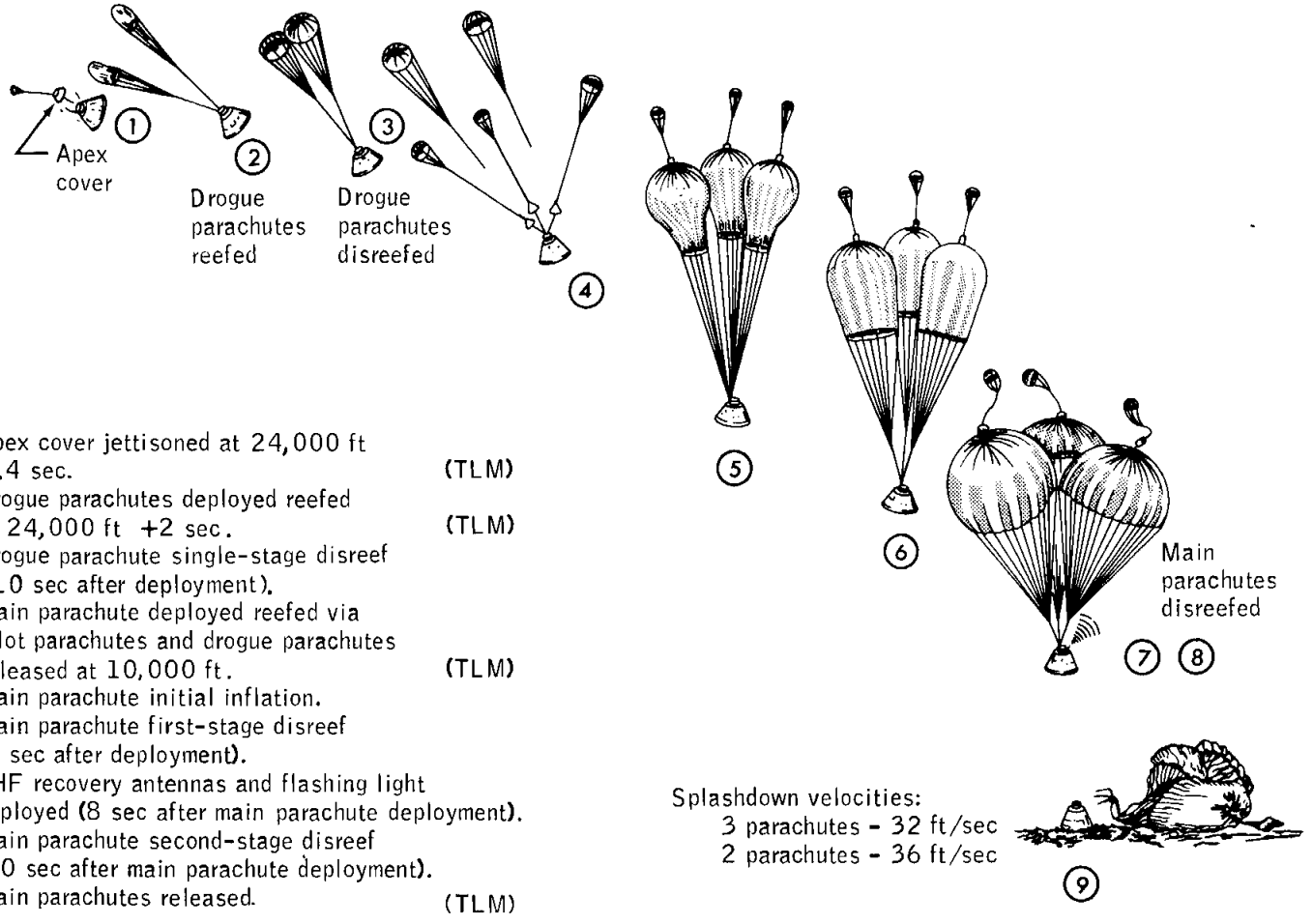


(1) Apex cover jettisoned at 24,000 ft +.4 sec. (TLM)
(2) Drogue parachutes deployed reefed at 24,000 ft +2 sec. (TLM)
(3) Drogue parachute single-stage disreef (10 sec after deployment).
(4) Main parachute deployed reefed via pilot parachutes and drogue parachutes released at 10,000 ft. (TLM)
(5) Main parachute initial inflation.
(6) Main parachute first-stage disreef (6 sec after deployment).
(7) VHF recovery antennas and flashing light deployed (8 sec after main parachute deployment).
(8) Main parachute second-stage disreef (10 sec after main parachute deployment).
(9) Main parachutes released. (TLM)

Figure 1-15. - Earth landing system normal sequence

TABLE 1-2 ELECTRONIC AIDS FOR COMMAND MODULE LOCATION

Equipment	Frequency, MHz	Transmitting power, watts	Duty cycle, sec		Recovery uses	Activation time	Predicted minimum operating life after landing, hr (a)	Other data
			On	Off				
VHF recovery beacon	[b]243.0	3	2	3	Line-of-sight DF	After main parachute deployment	48	Normally turned off after 24 hours.
[c]VHF/AM transceivers: Transceiver A Transceiver B	296.8 259.7	5	---		Voice Communications	Prior to launch	48	Transceivers are not activated between CM/SM separation and main parachute deployment. Primary recovery communications after main parachute deployment will be on simplex A.
VHF survival transceiver beacon	[d]243.0	[e,f]1.25	---		Line-of-sight DF and voice communications	Normally 24 hours after landing or at astronaut's discretion	[e]48	When used inside the CM, the set may be manually connected to either VHF recovery antenna. The unit has its own antenna for use outside the CM.
Unified S-band (USB) transponders (primary and secondary)	2287.5	11.2	---		Line-of-sight DF during entry	Prior to launch	Turned off just prior to landing	
Flashing light	---	---	---		[g]Visual location of CM	Astronaut discretion	24	HI-mode flash rate is 120 to 170 flashes per minute. Lo-mode flash rate is 15 to 20 flashes per minute.

a - Actual operational life depends on usage. Times shown are for continuous operation.
b - Modulated by 1000-Hz square wave.
c - If the astronauts have not obtained voice contact with recovery forces upon landing, both transmitters will be turned off and only receiver A left on.
d - Beacon has swept-tone modulation from 1000 Hz to 300 Hz at 2 1/2 sweeps/sec.
e - Beacon mode.
f - Decreases to 1.0 watt in 24 hours and second battery used.
g - Six to seven miles visibility (both modes).

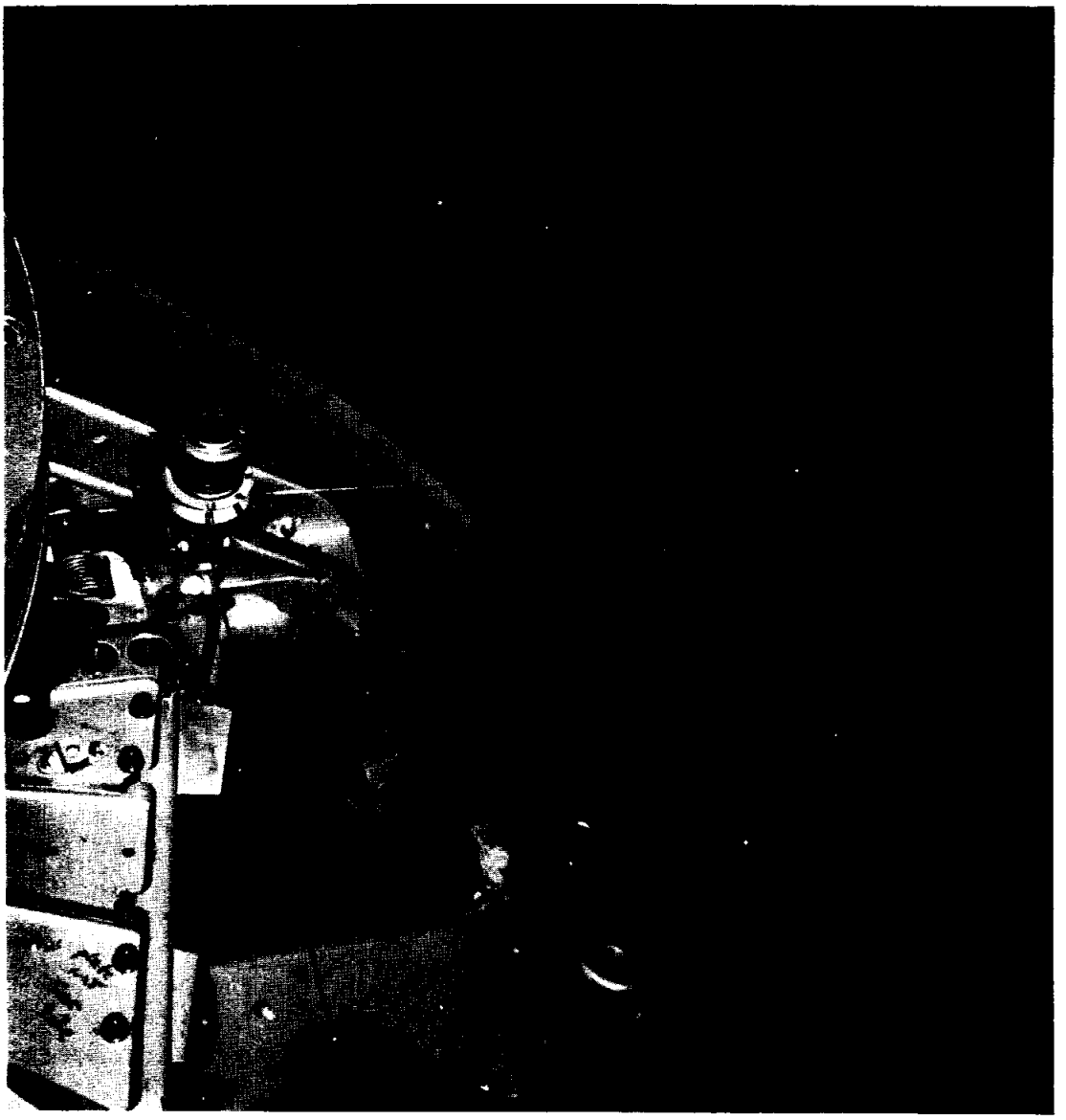


Figure 1-16. VHF recovery antenna No. 1 (Gusset No. 4)

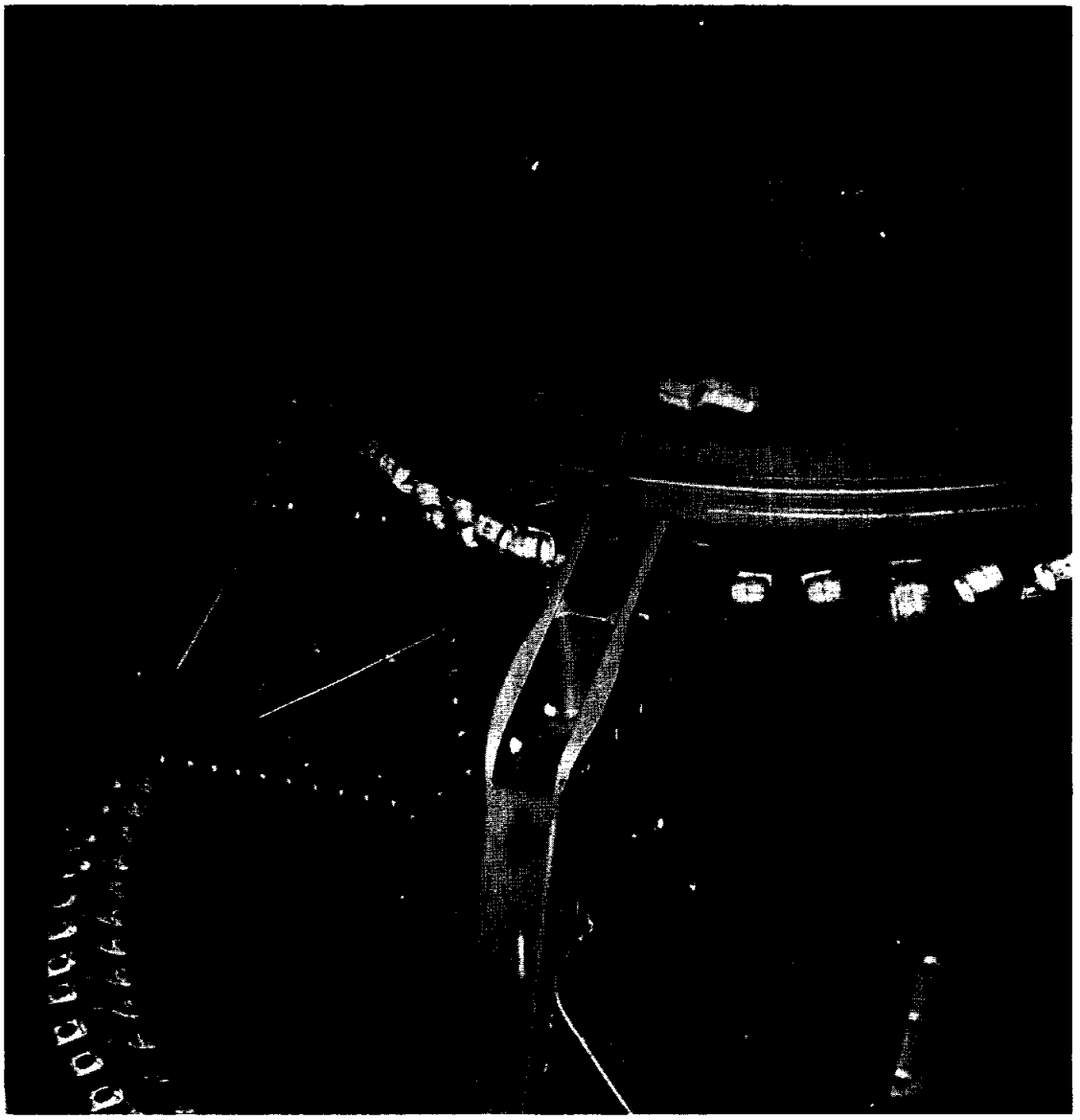


Figure 1-17. VHF recovery antenna No. 2 (Gusset No. 1)

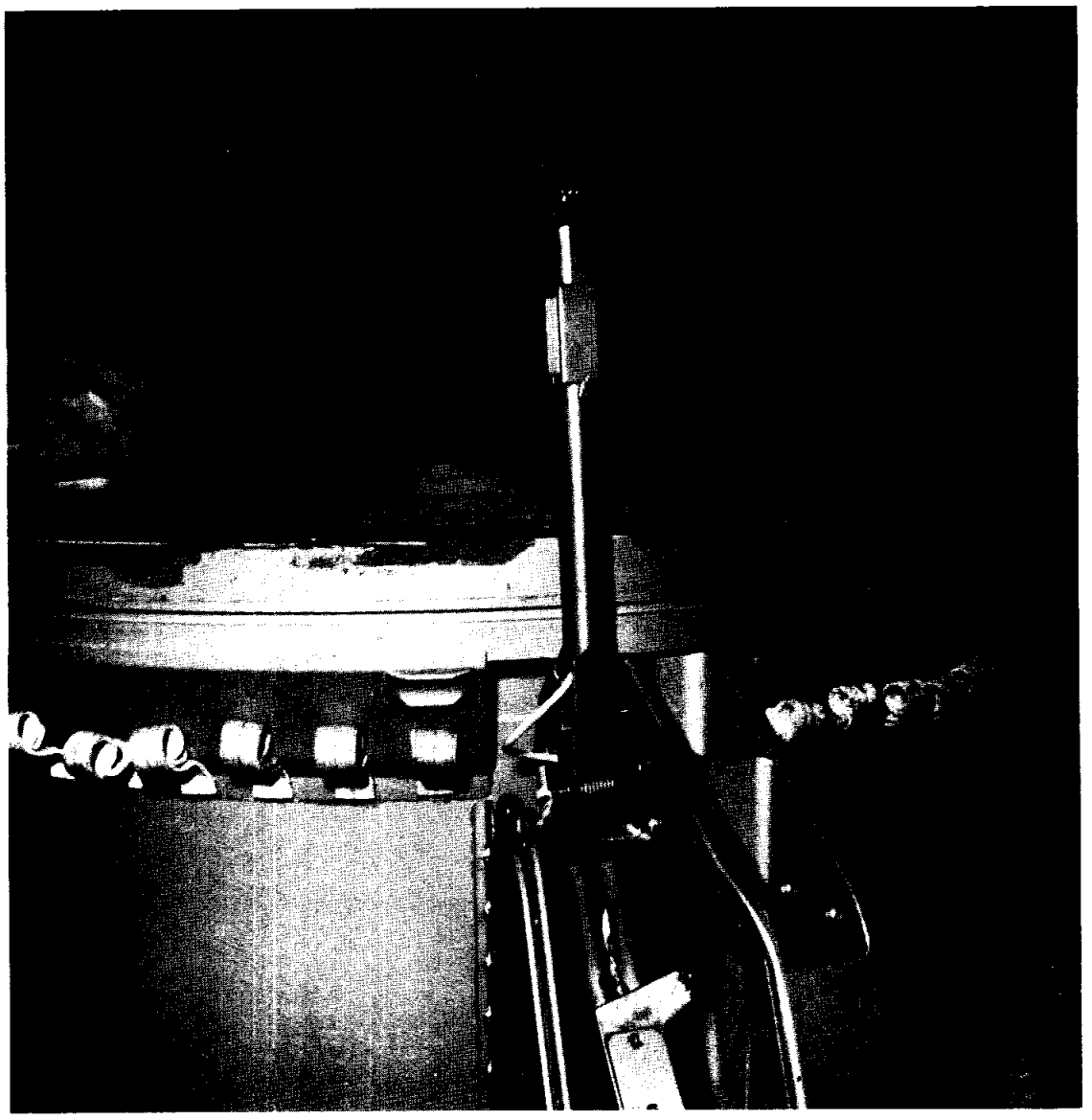


Figure 1-18. Recovery flashing light (Gusset No. 2)

Command Module uprighting system - The major equipment in the uprighting system consists of three inflatable bags stowed under the main parachutes, three solenoid valves on the upper deck gussets, and two air compressors in the aft compartment. After landing, inflation of the bags is activated by manual operation of switches in the crew compartment. If the CM lands in the stable I (upright) attitude, the bags are inflated to prevent the CM from rolling over (the crew waits 10 minutes to allow the upper deck to cool because heat can damage the bags). If the CM lands in the stable II (forward hatch under water) attitude, the bags are inflated immediately to upright the CM. Normal uprighting with the bags inflated should occur within 6 minutes.

Recovery loop - The recovery loop is located in the space between the drogue mortars in the forward compartment. It provides a means for attaching a hook to the CM to hoist it from the water.

Sea anchor attachment ring - The sea anchor attachment ring is used by swimmers (UDT/pararescuemen) to attach a sea anchor (or a line and reserve parachute) to the CM.

2.0 COMMAND MODULE HAZARDS

The potential hazards which may be encountered in working around the CM during recovery operations may be grouped under three main headings:

(a) Unfired pyrotechnic (explosive) devices

(b) Reaction Control System (RCS) hypergolic propellants

This section includes a detailed description of the hazardous areas of the Apollo CM and precautions which should be observed by recovery personnel.

2.1 PYROTECHNIC DEVICES

2.1.1 Hazardous Areas

Descriptions of the hazards from pyrotechnic devices are given in Table II-1. The locations of the devices in the forward compartment and the apex cover are shown in figures 2-1 and 2-2.

2.1.2 Safety

Because of the potential hazards associated with unfired pyrotechnic devices, anyone working in the vicinity of the CM during recovery operations should be aware of these hazards and shall remain clear of the particular danger areas. If any device is seen to be unfired during CM recovery, this information shall be relayed to the NASA landing safing team director at the port where the CM will be deactivated. Any unexpended pyrotechnic device will be safed by the landing safing team at the CM deactivation site.

The possibility of injury to recovery personnel from an unexpended pyrotechnic device is present from the time of CM landing until the time the device is safed. The initial danger is to the swimmers or pararescuemen who will be attaching lines and doing other work. As the recovery ship comes alongside the CM, the shipboard personnel may be exposed if a device is unexpended. While ship's personnel are fending off the CM and getting it oriented for hoisting, an unexpended device could conceivably be hit with a mercury pole, causing the device to fire. After on-loading, the personnel involved in postretrieval operations are exposed to the danger.

Table II-1. HAZARDS FROM PYROTECHNIC DEVICES

Name	Number of hazardous areas	Location	Indications of hazardous condition	Description of hazard
Drogue parachute mortars	2	On upper deck over main hatch	If mortar is not empty, pyro has not fired.	Ignition of charge causes gas to be generated. Gas pressure expells fiber glass parachute container from housing. When detonated, mortar fires a 36-lb projectile at 66 ft/sec for about 75 feet.
Pilot parachute mortars	3	At bases of three of the four upper-deck gussets.	If mortar is not empty, pyro has not fired.	Ignition of charge generates gas which forces parachute container and parachute out of mortar. When detonated, mortar fires a 5-lb projectile at 90 ft/sec for about 60 feet.
Main and drogue parachute disconnects	5	Between drogue parachute mortars	Drogue parachute riser will be connected to CM structure if pyro has not fired.	Ignition of charge forces piston-guillotine against riser, separating riser from CM. Hazard is small because this is a self-contained unit; however, shrapnel-type detonation is possible.

Table II-1. Concluded

Name	Number of hazardous areas	Location	Indications of hazardous condition	Description of hazard
Forward heat shield (apex cover) thrusters	4	Extending from tops of four upper deck gussets	Thruster pistons not extended	Ignition of charges causes gas pressure to force two pistons apart and break tension tie. Lower piston is forced against a stop and upper piston is forced out of cylinder. Hot, high pressure gases escaping from thrusters is the hazard.
Docking ring	1	Top of forward access tunnel	Docking ring will be attached to CM forward tunnel if pyro has not fired.	Explosive device fractures docking ring at circumferential notch. Shrapnel-type hazard.
Apex cover drag parachute mortar	1	Inside apex cover	If mortar is not empty, pyro has not fired.	When detonated, mortar fires a 5-lb projectile at 90 ft/sec for about 60 feet.
VHF recovery antennas and flashing light	3	At tops of three of the four upper deck gussets	Antenna or light will not be erect if pyro has not fired.	Movement of main parachute risers during deployment causes guillotines to cut pin-retaining cords, allowing antennas and light (which are spring loaded) to erect. Antennas and light will whip in arc to upright positions.

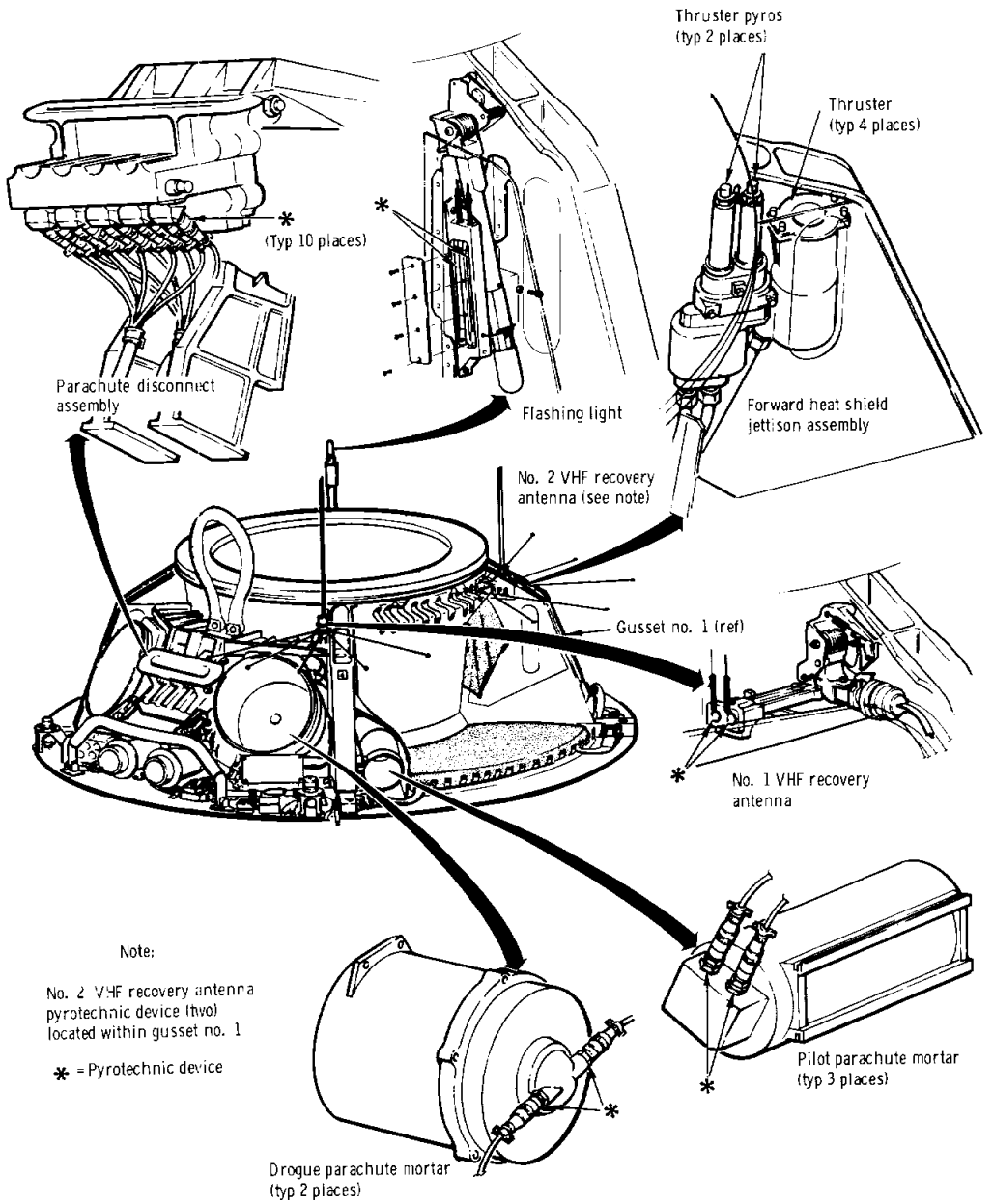
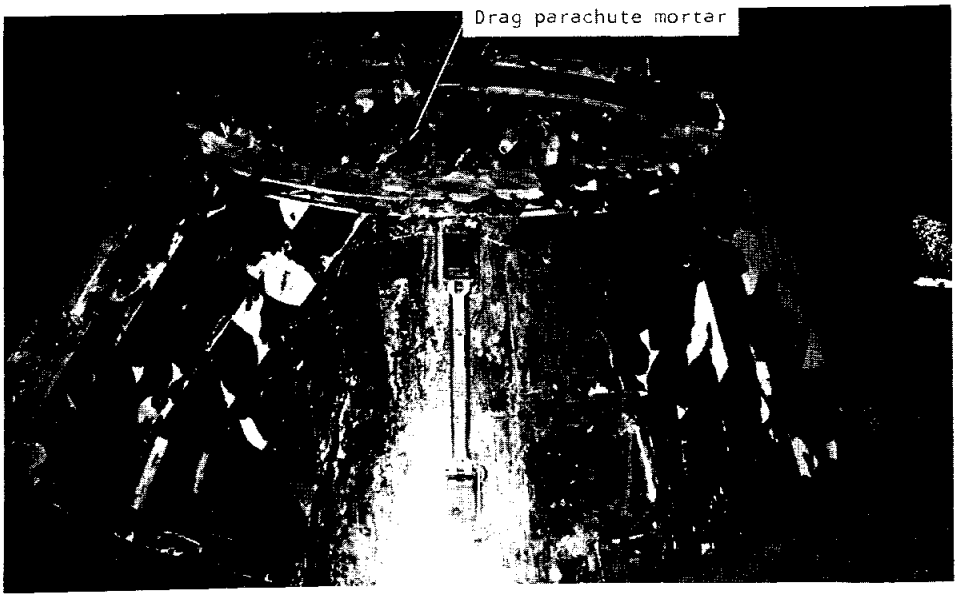
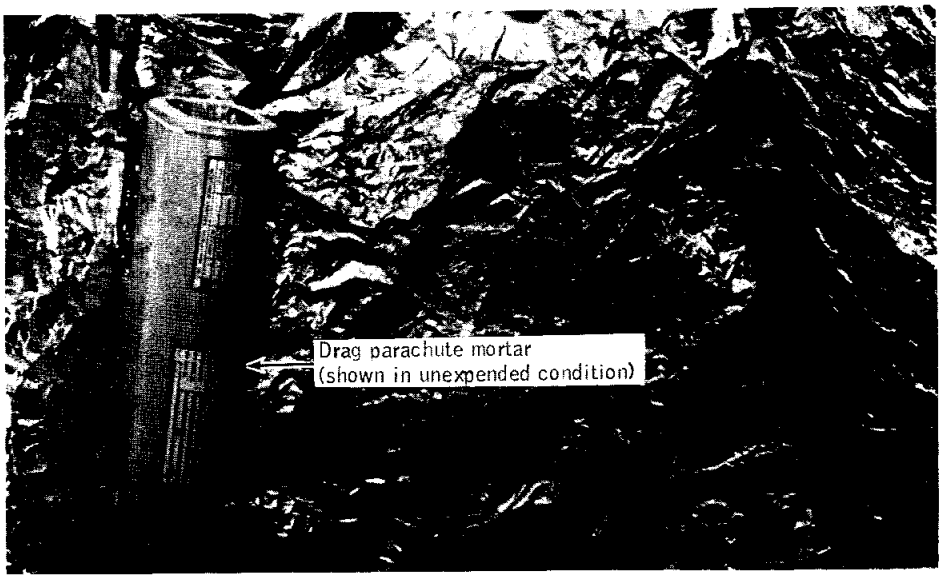


Figure 2-1. - Forward compartment pyrotechnic hazard areas



(a) Exterior



(b) Interior

Figure 2-2. Apex cover pyrotechnic hazard area

If an unexpended device is found, the following precautions should be observed by recovery personnel.

(a) Swimmers and pararescuemen should move cautiously around the CM and not place themselves near the danger area. They should avoid bumping their tanks around and be especially careful in making line hookups in the area of the upper deck.

(b) The retrieval crew should keep all fending poles clear of the unexpended pyrotechnics. The CM should be oriented so that the danger area is outboard. Personnel access to the CM shall be limited and this limitation strictly enforced.

(c) All CM handling by postretrieval operations personnel aboard ship should be done with extreme care. After pictures of the area surrounding an unexpended device have been taken, a mattress should be tied over it. Further protection can be obtained by placing the CM in a position so that the line of fire of the device is in a direction that will minimize the hazard.

2.2 RCS PROPELLANTS

2.2.1 Hazardous Areas

After a normal CM landing, the RCS propellants will have been expelled and the system purged. However, some residuals may remain in the system lines and tanks, and liquid leaks and fumes may be emitted from the engine ports or possibly from ruptured RCS lines or tanks. The RCS danger areas are shown in figure 2-3.

RCS components are located in the aft compartment, with the exception of the two negative pitch engines which are located in the forward compartment. Hypergolic (contact ignition) propellants in the system are monomethylhydrazine (MMH) fuel and nitrogen tetroxide oxidizer.

2.2.2 Propellant Characteristics and Effects

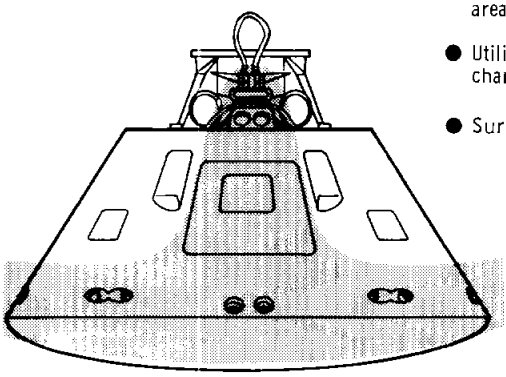
MMH is a clear, colorless liquid with a characteristic ammonia-like odor. It is not sensitive to impact or friction, but is subject to rapid combustion when exposed to an oxidizer or when heated in a confined space. Liquid MMH in contact with the skin results in an intense burning sensation and can cause permanent eye damage, even under short contact conditions. Exposure to moderate or heavy concentrations of the fumes produces immediate violent irritation of the nose and throat and itching, burning, and swelling of the eyes. Dizziness, nausea, and convulsions may follow shortly.

Nitrogen tetroxide is a clear yellow liquid at atmospheric pressure and at temperatures below 70°F. At higher temperatures, the fumes have a sharp, acidic odor, and vary in color from yellow to dark brown and black. It is not flammable, but is hypergolic with MMH and other hypergolic fuels. Contact with moisture in the air or with water produces corrosive nitrous and nitric acid. Because of the reaction of nitrogen tetroxide with moisture, contact with the skin and eyes can result in severe burns. Fume inhalation results in serious delayed effects on the lower respiratory system.

Table II-2 summarizes the symptoms that would result from exposure to RCS propellants and provides suggestions for action to be taken if personnel are exposed.

2.2.3 Safety

With regard to these propellants, the prime hazard is the possibility of leaks during the period of recovery and postretrieval operations. Swimmers and pararescuemen should exercise caution when



- Should propellant leaks or vapors be detected, attempt to establish a safe condition by dousing the contaminated area with large amounts of water.
- Utilize low-pressure water spray to avoid damage to charred areas.
- Surrounding areas should also be washed down.

WARNING

Limit working time in danger areas. The RCS and pyrotechnic devices are to be considered dangerous until verified otherwise.

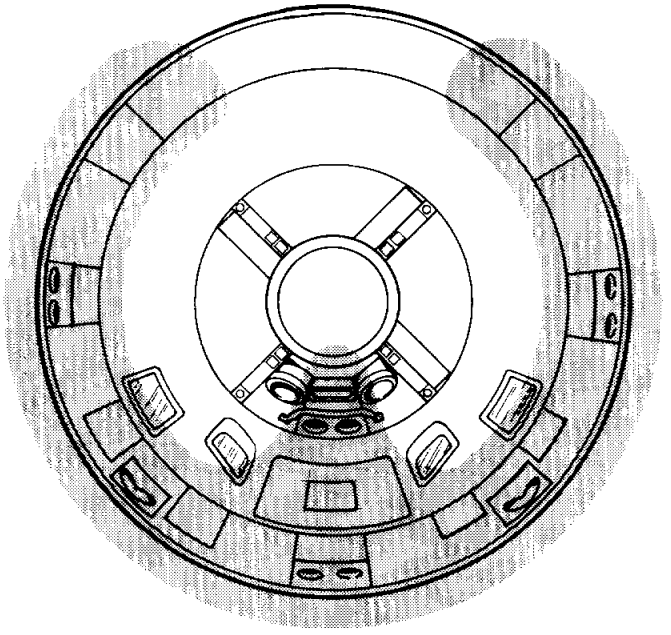


Figure 2-3. Reaction control system danger areas

Table II-2. RCS PROPELLANT EXPOSURE SYMPTOMS AND FIRST AID

Type of Exposure	Symptoms	Action
Fuel		
Local contact (eyes and skin)	Itching, tearing, swelling, stinging pain, temporary blindness	Immediate deluging of affected area with water. Obtain qualified medical advice as soon as possible.
Vapor inhalation	Coughing, choking, difficulty in breathing	Obtain qualified medical advice as soon as possible.
Ingestion	Lethargy, nausea, convulsions	Obtain qualified medical advice as soon as possible.
Oxidizer		
Local contact (eyes and skin)	Stinging, burning sensation itching, possible blindness	Immediate deluging of affected area with water. Obtain qualified medical advice as soon as possible.
Vapor inhalation	Irritation of respiratory system	Obtain qualified medical advice as soon as possible.
Ingestion	Nausea, unconsciousness	Obtain qualified medical advice as soon as possible.

working around the RCS thrusters during collar installation. It is emphasized that there is a set of thrusters on the upper deck. Caution should be exercised when working in this area during line hookups and while doing other work.

When the CM is brought aboard ship, certain RCS safety precautions must again be followed. When a propellant leaks, it vaporizes and the fumes spread rapidly. If a small amount has leaked, it may be allowed to vaporize to depletion. Larger amounts should be hosed down with a low-pressure water spray until completely diluted. Because of the toxic fumes in the air, the contaminated area should be approached from upwind, and personnel involved shall wear self-contained breathing gear.

If both the propellants leak, come into contact, and produce a fire, the same procedure of upwind approach and water dilution should be followed. (Dilution also cuts down vapor flammability.) Since the smoke is toxic, personnel involved in fire fighting shall be properly dressed in protective clothing, wear self-contained breathing gear, and operate in pairs or larger groups (fig. 2-4). Other available fire fighting and safety equipment should be made ready for use.

For the negative pitch thrusters (upper deck) a set of two thruster plugs is used. A plug is placed in each engine port and a small tube connected to each plug carries any leakage away from the CM. The ends of the tubes may be placed in separate buckets of water or other place where the propellants can be diluted safely. On the primary recovery ship, a viton sheet is used to cover the positive pitch thrusters (below the side hatch).

In the case of inadvertent contact with a propellant, the first thing to be done is to flush the affected area with water. First aid or other medical treatment may then be performed.

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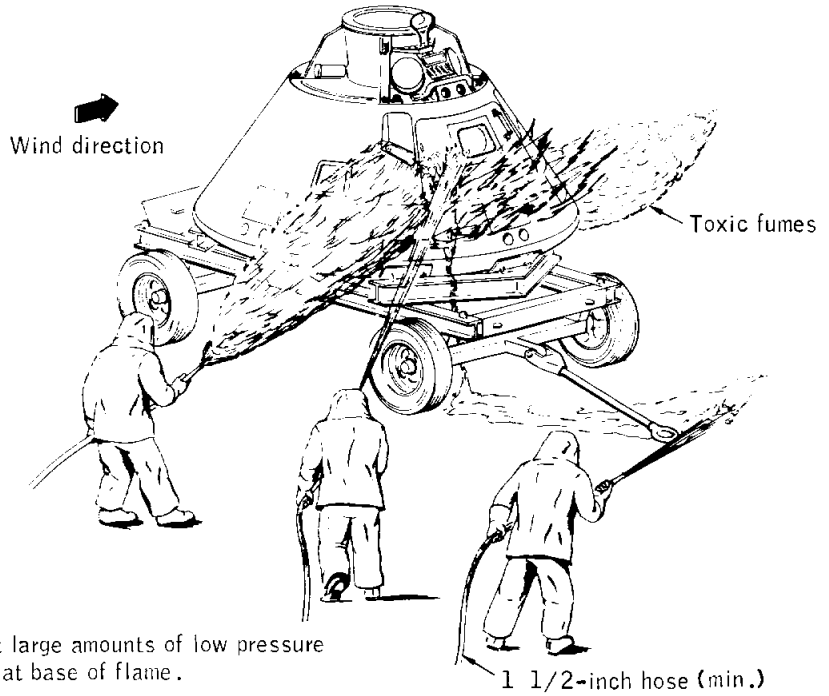

1 Direct large amounts of low pressure water at base of flame.

2 Wash propellants away as soon as possible.

3 Wash down all equipment exposed to propellants.

4 Monitor RCS fumes after fire has been extinguished.

WARNING

- Stand at least 20 feet away from RCS thruster areas.
- Fumes are toxic. Fire fighting crew shall have on self-contained air supply equipment.

NOTE

- Use high-capacity fog nozzle (low pressure) to disperse and absorb vapors.
- Fresh or salt water may be used to combat hypergolic fires.
- Remain upwind when flushing CM with water.

Figure 2-4. Shipboard RCS fire fighting procedures

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III GENERAL RECOVERY OPERATIONS

3.0 PRIMARY, SECONDARY AND CONTINGENCY LANDING AREA RECOVERY OPERATIONS

This section provides information on the equipment and procedures to be used in retrieving Apollo flight crews and CM's in all types of landing areas other than the launch site area. The types of DOD recovery units to which this information applies are:

(a) Primary recovery ship helicopter crews

(b) Underwater demolition team (UDT) swimmer personnel

(c) Fixed-wing search and rescue (SAR) aircraft crews

(d) Pararescue personnel

(e) Personnel aboard primary and secondary recovery ships

Equivalent information pertaining to the launch site area is given in section 4.0.

3.1 PRIMARY LANDING AREA

Normally, an LPH type ship will be on station in the primary landing area. The primary mission of this ship is to recover the astronauts and the CM. Recovery of the CM parachutes and apex cover is highly desirable for postmission analysis; however, their recovery is not to interfere with the primary mission.

Primary recovery ship helicopters are used in the primary landing area to provide rapid location and access to the CM. The recommended number and locations of these helicopters will be included in the applicable recovery requirements document. Upon reaching the CM, the most important tasks of the helicopters are to deploy swimmers to attach a flotation collar and retrieve the astronauts. Other tasks which may be required of helicopters include communications relay/ airboss, CM component recovery, and photography.

Normally, the first helicopter on the scene will assume the role of on-scene commander if the predesignated airboss aircraft is not yet on the scene. Upon its arrival, the airboss aircraft will relieve the helicopter. For the purpose of acting as a communications relay between the on-scene helicopters, the primary recovery ship, and the RCC, a communications aircraft will remain at high altitude over the recovery area. Information flowing through these channels will include a running commentary on the CM/UDT operations, condition of the astronauts, and recovery of any other components.

The photographic helicopter, which carries designated photographers from the primary recovery ship to the scene of recovery, will also carry a flotation collar.

3.1.1 Helicopter Operations

3.1.1.1 Command Module Location

Special Equipment - The search helicopters are equipped with a NASA-furnished homing system consisting of a SARAH receiver and a pair of directional yagi-type antennas (fig. 3-1). The equipment is compatible with the CM recovery and survival beacons (see table 1-2), which operate on a frequency of 243.0 MHz.

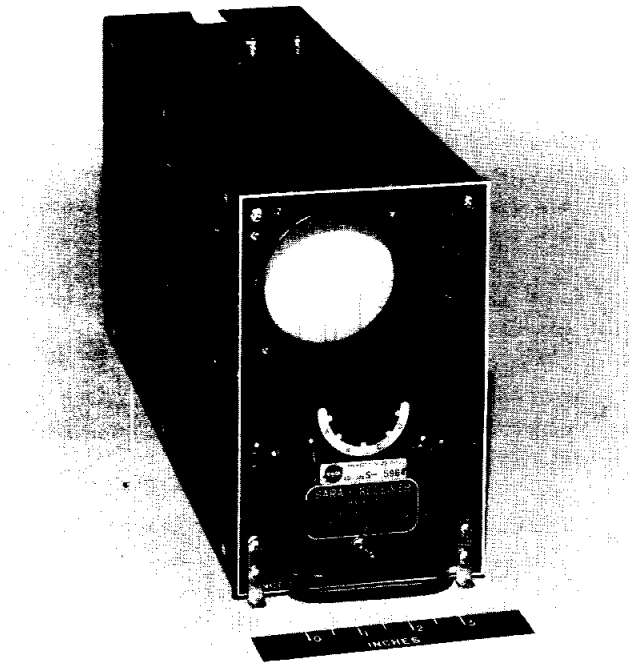
The receiver itself is mounted in a shock rack at the sonar operator's position and the two antennas are mounted on the struts on either side of the helicopter (fig. 3-2). NASA-MSC also supplies connecting cables and special windows (if desired) which allow cable passage through the helicopter fuselage. The expected installation time per helicopter ranges from 3 to 5 man-hours.

The SARAH receiver is used to acquire and home on the VHF recovery and/or survival beacons of the Apollo CM. It provides a visual display of the relative signal strengths at both antennas. It does this by alternately sampling the received signal at each antenna and reproducing the representative signal amplitudes on its cathode ray tube. Details of the operating procedures, theory of operation, and equipment construction may be found in ref. 2. The NASA-MSC representative assigned to work with the helicopter squadron aboard ship will also be available to answer questions concerning this subject.

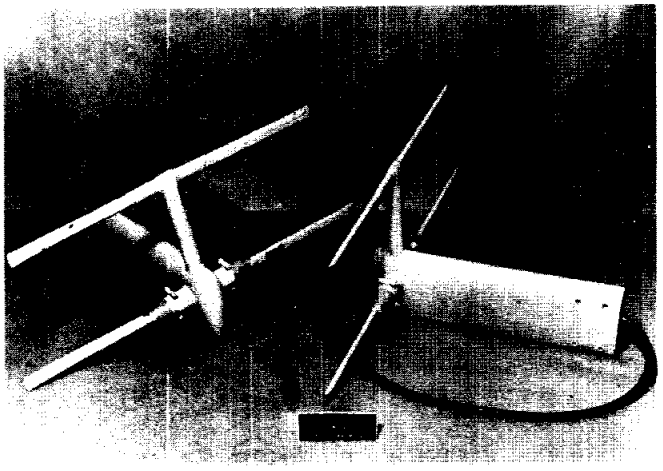
Prior to a search mission, the SARAH receiver should be bench-checked and aligned according to the procedures outlined in ref. 2. After installation in the helicopter, a systems check of the receiver should be performed. An effective test is conducted by positioning a hand-held beacon (which operates on the 241.0 - 245.0 MHz frequency range) to the left, directly ahead of, and then to the right of the helicopter nose. The receiver should correctly indicate left, on-the-nose, and right beacon positions. This "walk-around" test checks out not only the receiver, but also the antennas and the beacon.

Another electronic location aid available on the helicopters is the ARA-25 DF set. It is part of the standard helicopter equipment.

Search Procedures - Prior to CM main parachute deployment, the helicopters should be on station. Tuning procedures for the SARAH receiver should be accomplished before the search is initiated. While on station, at predicted main parachute deployment time, the SARAH-equipped helicopters should periodically vary their heading about 45° to either the right or the left of the expected acquisition bearing. This allows the most sensitive area of the antenna pattern lobe to



(a) SARAH receiver



(b) SARAH antenna

Figure 3-1. SARAH homing system

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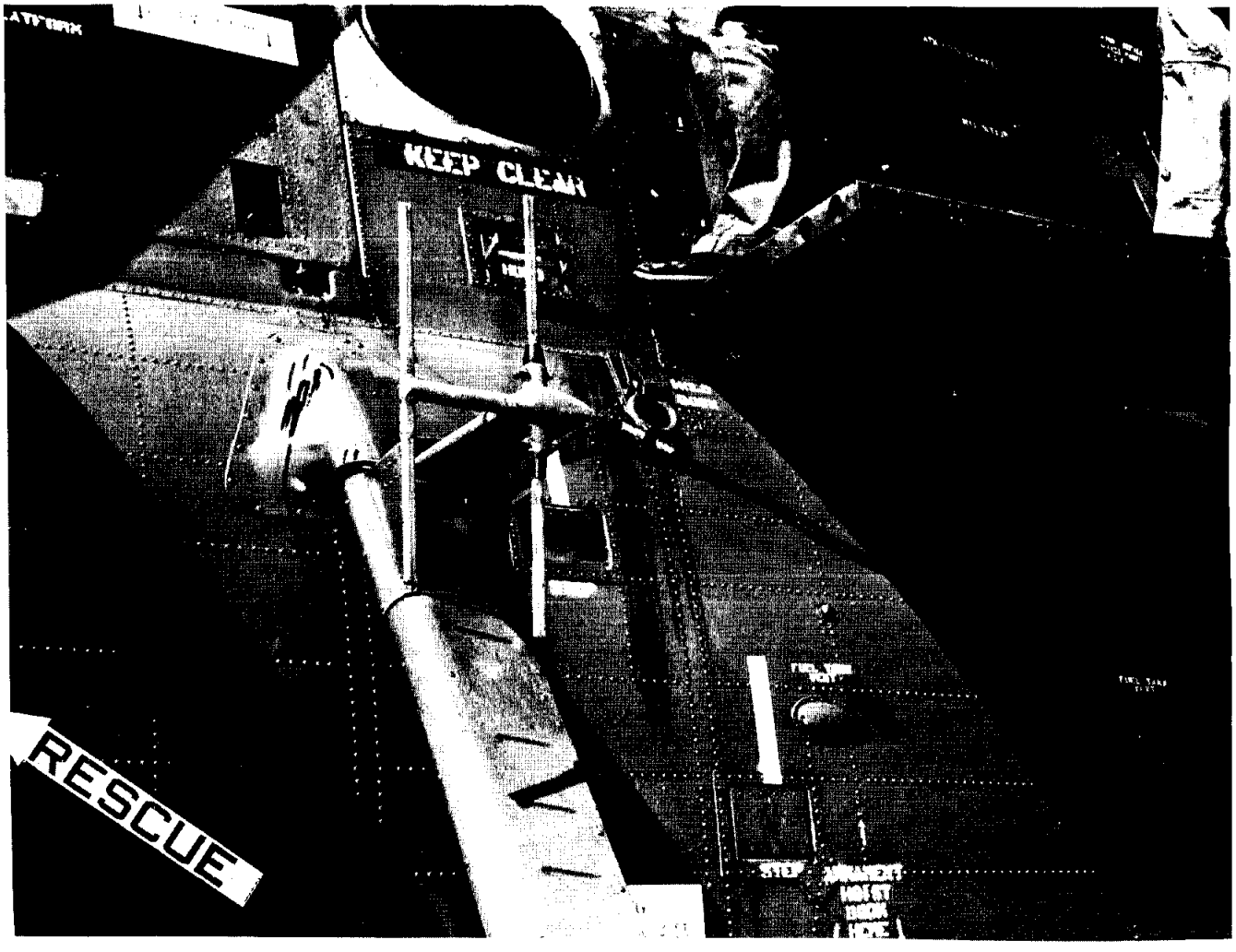

Figure 3-2. Typical SH-3A SARAH antenna installation

sweep the horizon and will afford the earliest possible acquisition of the CM recovery beacon. The recovery beacon is activated shortly after main parachute deployment at 10,200 feet; therefore, first signal acquisition may be expected while the CM is still descending. After splashdown, earliest signal acquisition will occur at a line-of-sight distance dependent upon aircraft altitude (fig. 3-3).

At first signal acquisition, two signal strengths should appear on the scope of the SARAH receiver. The SARAH operator should then advise the pilot to change heading about 45° to the right or left so he may positively determine from which antenna the stronger signal is coming. An increase in size (amplitude) of the signal spike on either side of the scope center-line will indicate that the signal source is on that side of the helicopter. This procedure will resolve any doubt as to whether the signal source is forward or aft of the helicopter on its line of flight. The pilot will then be advised to head in the direction of greatest signal strength. As soon as the two signal strengths on the SARAH scope become equal (signal directly ahead), a rough bearing to the CM may be established. Of great importance to the recovery operation is the immediate transmission of a RECOVERY BEACON ANNOUNCEMENT. A complete CONTACT REPORT (see section 6.0) shall be prepared as soon as possible and will be transmitted upon request. Throughout the homing run, the SARAH operator should keep the two signals on either side of the scope's center-line equal by advising the pilot of heading changes.

Also activated shortly after main parachute deployment is the CM VHF transceiver which operates on 296.8 or 259.7 MHz. The primary frequency is 296.8 MHz. At 10,000 feet, the crew will transmit (on 296.8 MHz) the following:

1. Position — Latitude ±XX.XX degrees
   Longitude ±XX.XX degrees
2. Main parachutes disreefed
3. Range to target point ±XXX.X n.mi.
4. Crew status (exact wording not established)

NOTE

\+ downrange/north/east

\- uprange/south/west

Should the CM assume a STABLE I (upright) attitude upon landing, without voice contact with recovery forces, the crew will monitor the A receiver (296.8 MHz) only. If the CM goes to the STABLE II

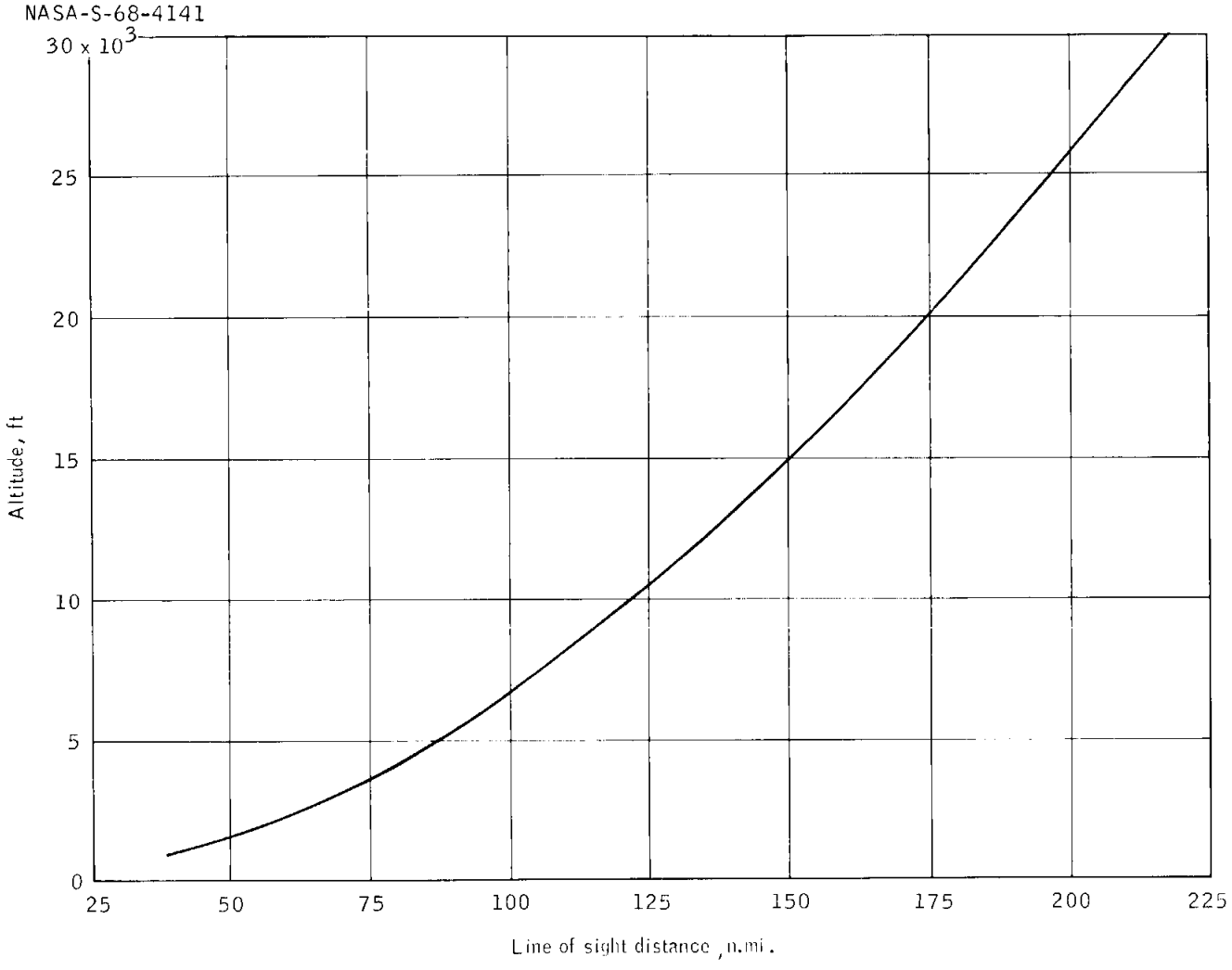

Figure 3-3. Line-of-sight distance versus altitude

(inverted) attitude at landing, it will be about ten minutes after landing before the crew is monitoring the A receiver.

Regardless of which attitude the CM assumes at landing, the search aircraft should attempt to contact the crew on the primary frequency (296.8 MHz), starting at the predicted time of main parachute opening.

The search helicopters homing on the recovery beacon should descend as soon as possible to visually search for the CM. However, with the line-of-sight limitation, the signal may be lost if the descent is too fast.

NOTE

As the CM descends, it may pass out of line-of-sight range, which means that the signal will become weak or even disappear.

The helicopter should then level off to regain the signal before beginning a more gradual descent.

The helicopter crew should be alerted to visually search for the CM at all times during the homing run. When the aircraft passes the CM, "station passage" will be indicated by an elongation of one signal if the aircraft passes to one side, and by a loss of signal for several seconds if it passes directly over. When visual contact is made, a CONTACT REPORT shall be transmitted (see section 6.0).

If no contact is established on 296.8 MHz by the time the CM is visually sighted, the aircraft should transmit in the blind, requesting that the crew switch to 259.7 MHz and that they also turn off the VHF recovery beacon. This is because the beacon interferes with communications on this frequency. The aircraft should then try to make contact on 259.7 MHz.

3.1.1.2 Deployment of Swimmers and Equipment

When the CM is located, the helicopters should proceed to the landing area. The helicopter that is designated for swimmer deployment should take up the "ready" position as shown in figure 3-4.

If the CM is in the stable II (apex down) attitude, follow procedures in section 3.1.1.4. If the CM is in the stable I position, upon approval of the Task Group Commander, commence deployment of swimmers and recovery equipment as shown in figure 3-5. The other helicopters will provide backup personnel and equipment as needed. They are also available for retrieval of other CM components floating in the area, i.e., main parachutes, apex cover and pieces of ablative material. These items will be recovered only if doing so does not interfere with astronaut and CM recovery.

After the swimmer team and flotation collar have been deployed, the swim helicopter should move to the "ready" position so as not to interfere with swimmer operations. All other helicopters should remain far enough away so that they will not interfere with recovery operations (the photographic helicopter should remain close enough to obtain pictures). A designated helicopter should keep the Task Group Commander informed of the status of recovery operations. This information will be relayed to the Task Force Commander and the Mission Control Center.

After the flotation collar has been installed, the swimmers will signal the swim helicopter by means of the swimmer radio (sec 3.2.2.1) or hand signals (sec 3.1.2.6) to deploy the Apollo recovery raft and swimmer raft. After deploying the rafts, the swim helicopter will take up the "standby" position so as not to interfere with swimmer operations and astronaut recovery. The swimmers will attach the Apollo recovery raft to the collar (as described in section 3.1.2.4).

Night deployment procedures for helicopters are adaptations of daylight procedures. The first helicopter at the CM will make a low, slow, identification pass and mark the position with a long burning smoke light. The designated swimmer deployment helicopter will take up the "ready" position; The helicopter designated for CM illumination will take up the "backup" position as shown in figure 3-4. and illuminate the CM with its trainable hover light. Once both helicopters are in position and permission to commence swimmer deployment has been received from the Task Group Commander, deployment can commence using standard deployment procedures.

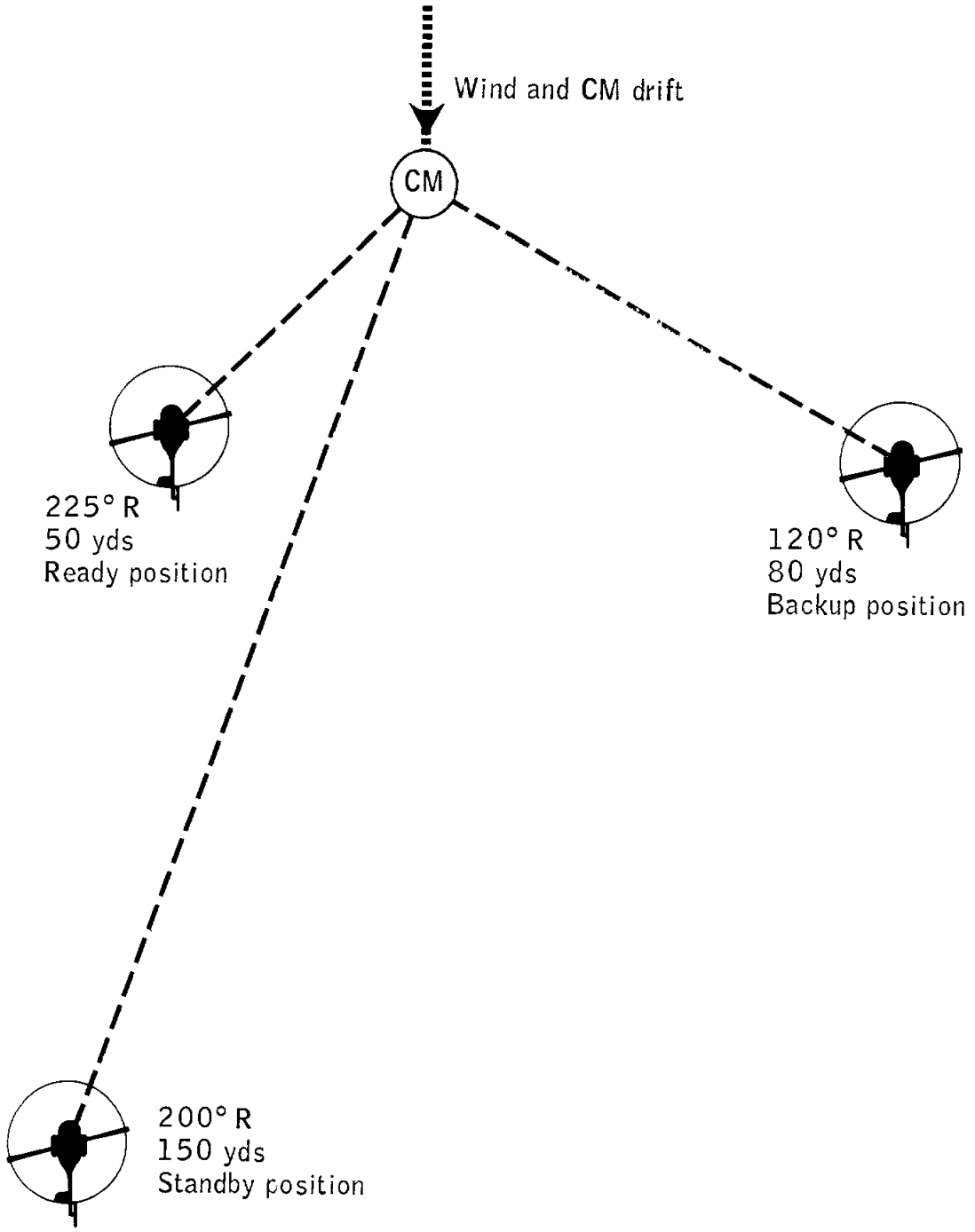

Figure 3-4. Helicopter positions

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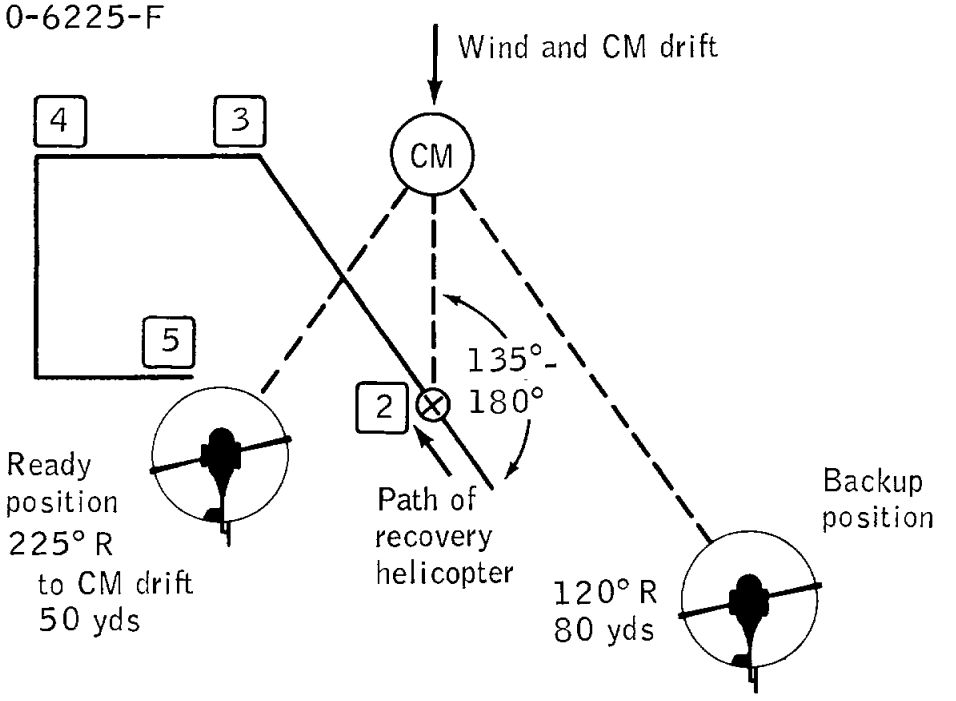


1. Make an approach from downwind 135° - 180° relative to the CM drift at 10 - 15 feet altitude and 10 knots ground speed
2. Deploy the first swimmer (with sea anchor) about 30 yds down the drift line from the CM
3. Turn into wind, climb to 40 feet and begin sideward flight to a distance where rotor wash has no effect on CM
4. Move aft and right to "ready" position
5. Maintain a hover in this position while waiting for the signal to deploy additional swimmers and the flotation collar
6. Once the sea anchor has been installed, repeat steps 1, 3, and 4 deploying the second and third swimmers along with the flotation collar about 15 yds downdrift of the CM
7. Once the collar has been installed, repeat steps 1, 3, and 4 in deploying the Apollo recovery raft about 10-15 yards downdrift of the CM
8. After deployment of the raft , the swim helicopter should take up the "standby" position (see fig. 3-4) and the astronaut recovery helicopter will take up the "ready" position

Figure 3-5. - Helicopter approach for swimmer and recovery equipment deployment

WARNING

IF ONE OF THE SWIMMERS BECOMES SEPARATED FROM THE OTHERS AT THE CM, ONE SWIMMER WILL LEAVE HIS POSITION AT THE CM, SWIM TO THE SEPARATED SWIMMER, AND SIGNAL FOR A HELICOPTER PICK-UP SO THAT THEY BOTH CAN BE REPOSITIONED AT THE CM.

NOTE

All swimmers shall wear personnel strobe lights attached to the back of their life vests to aid the helicopter crew in swimmer location.

3.1.1.3 Astronaut Egress and Recovery

The procedures applicable to both helicopters and swimmers for this phase of the recovery operation are contained in section 3.1.2.4.

3.1.1.4 Emergency CM Uprighting

Should the CM go to the Stable II (apex down) attitude within support range of the PRS, and not be uprighted because of an uprighting system failure, an emergency uprighting method readily available involves an uprighting sling assembly and a Navy SH-3 helicopter.

3.1.1.4.1 System Configuration and Installation

The uprighting sling assembly consists of a $\frac{1}{4}$-inch-diameter cable, a breakaway safety link, 75 feet of $\frac{1}{2}$-inch nylon line, a shackle, and a recovery hook (fig. 3-6). The sling also has a 40-ft tag line tied 20 feet from the $\frac{1}{4}$-inch cable and two brightly colored flays tied 10 and 20 feet from the recovery hook. The flags will aid the helicopter crew chief in judging the amount of slack in the line while the swimmers are making the hookup.

Each sling has been proofloaded to 3,000 lb to insure that the breakaway link will be the weakest system component. This will prevent the $\frac{1}{2}$-inch nylon line from rebounding into the helicopter rotor blades.

Prior to the mission, the helicopter should be configured with a standard Mark 8, Mod. 4 bomb shackle mount. If possible, the bomb load stand-off pads should be installed to prevent the uprighting sling from contacting the helicopter when large roll angle attitudes are assumed. The bomb shackle electrical release should be hooked up

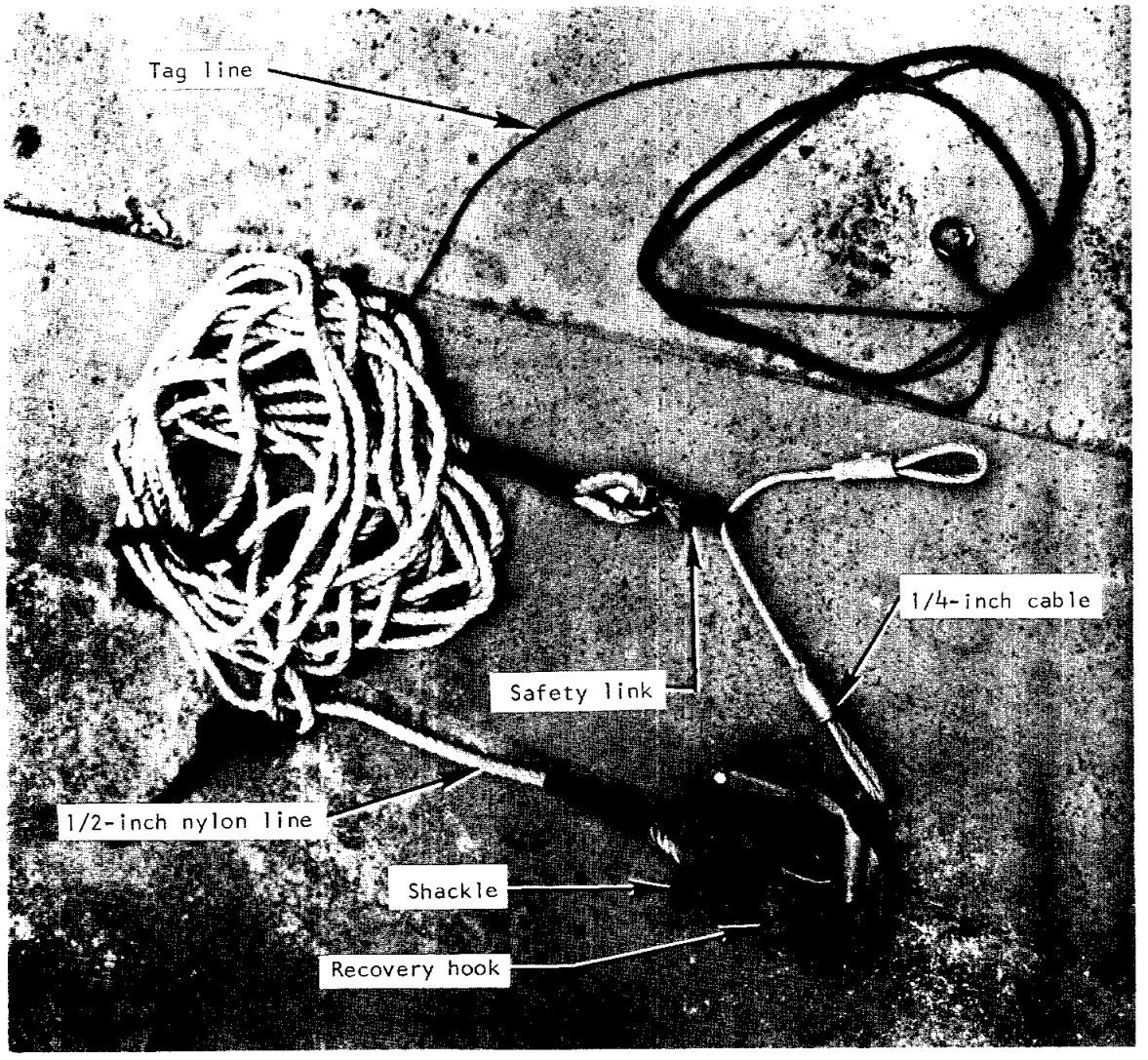


Figure 3-6. Uprighting sling assembly

and functioning properly. It is also desirable to have a backup mechanical release accessible to the crew chief.

The uprighting sling assembly is installed on the SH-3 by first attaching the $\frac{1}{4}$-inch cable to the bomb shackle. The $\frac{1}{2}$-inch nylon line is then fed into the fuselage through the starboard door and laid out so that it does not hinder normal operations and may be easily deployed if needed. The portion of the nylon line between the bomb shackle and the door is then taped along the fuselage to prevent it from whipping around in flight. The tag line is secured within the helicopter. Typical installation is shown in figure 3-7.

3.1.1.4.2 Operation of CM Uprighting System.

If the CM assumes the stable II attitude upon landing, the crew will initiate the CM uprighting sequence. This sequence begins within the first minute after splashdown and requires 4 to 6 minutes to effect an uprighting (see fig. 3-8). The nominal three-bag uprighting sequence is characterized by the appearance of the two large uprighting bags - one on each side of the CM hatch - within 1 to 2 minutes after sequence initiation. The third bag, which is smaller than the other two, is located between these in the +Z upper deck equipment bay (side of CM opposite hatch) and cannot be seen until the CM has uprighted.

Failures in the system can be detected by observing the absence of one of the two bags referred to above or by observing a slow uprighting with the two bags showing; i.e. CM not upright in 6 minutes. If only one of the two main bags is showing, the CM will be in a roll-right or roll-left attitude as shown in fig. 3-9. If two bags are showing and the CM is not upright in 6 minutes, the third (+Z) bag system or one of the two air compressors may have failed. The CM is expected to right itself within 10-15 minutes total elapsed time with any one of these failures. In these failure modes, the crew can assist uprighting by repositioning themselves within the CM. In addition to the previously described modes, there is also the possibility of a complete system failure. If uprighting has not occurred within 15 minutes, it can be assumed that either a stable II crew egress or a CM uprighting by helicopter will be necessary. The latter is greatly preferred.

If it is apparent that uprighting by helicopter is a definite possibility, the swimmers should be deployed using the standard approach and deployment techniques. The flotation collar and raft should not be deployed at this time.

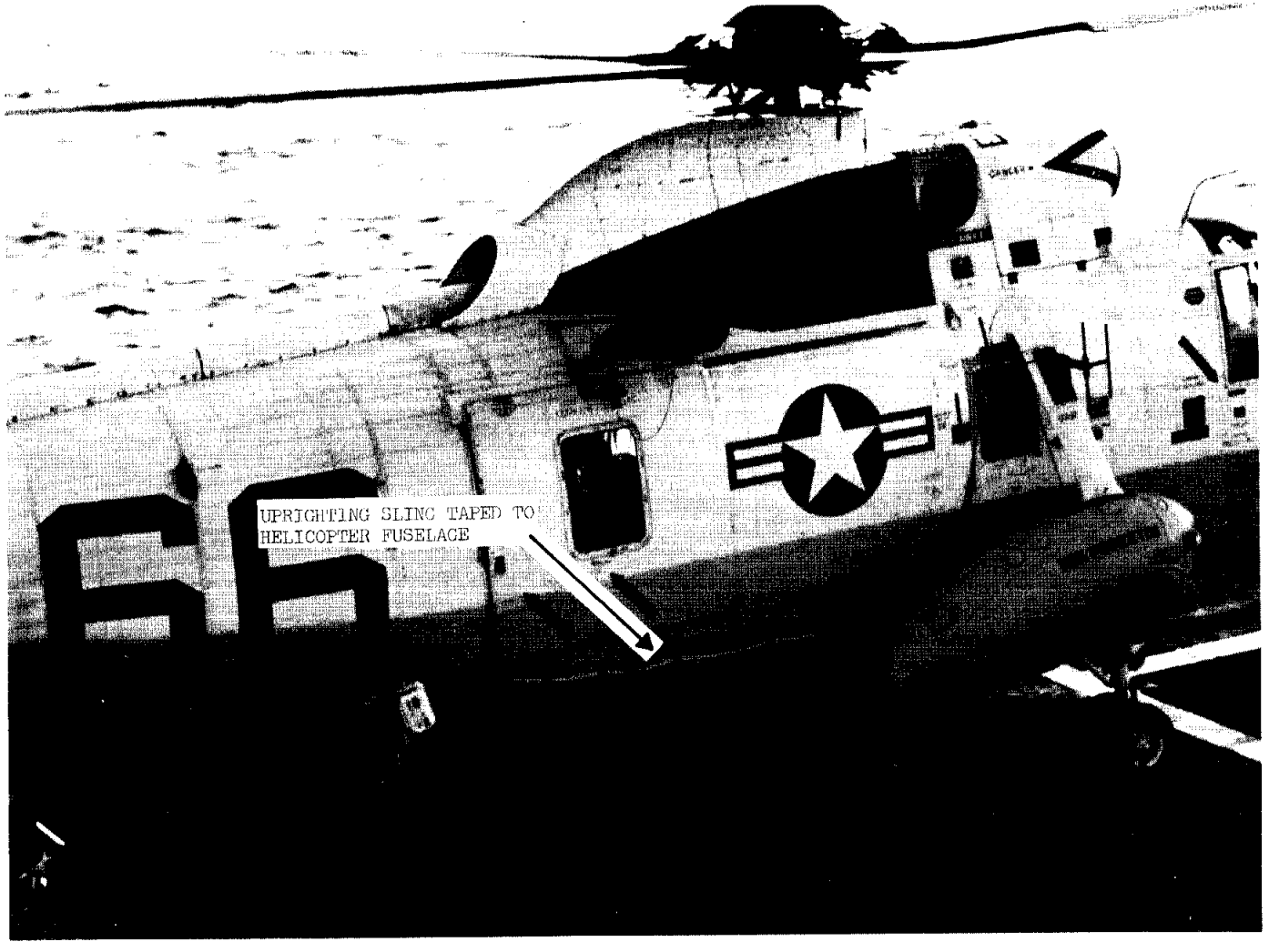
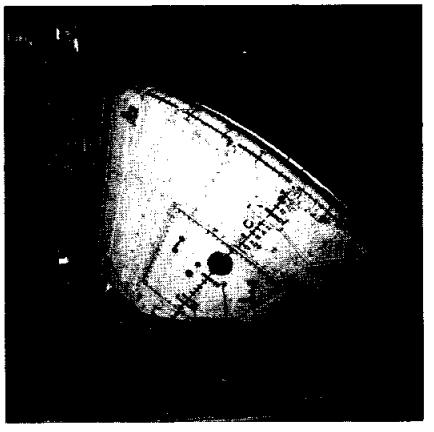
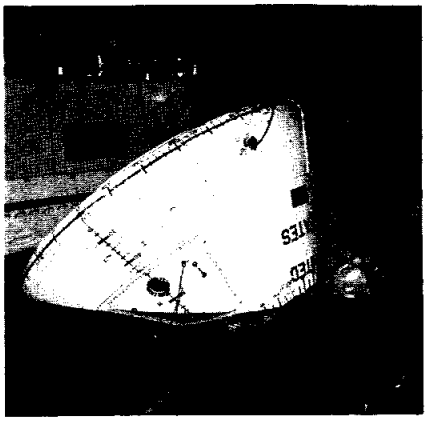


Figure 3-7. Uprighting sling installation

Figure 3-8. CM during nominal uprighting



(a) -Y bag failure - roll left



(b) +Y bag failure - roll right

Figure 3-9. Failure mode uprighting

3.1.1.4.3 Operational Procedures

When the swimmers reach the CM, they should contact the crew by hand signals, grease pencil board, etc. They should find out the crew's condition and what the uprighting situation is. If the astronauts can upright the CM themselves, they will proceed to do so. If not, the swimmers will be in a position to call a helicopter in to do it.

WARNING

UNDER NO CIRCUMSTANCES SHOULD A CM UPRIGHTING BY A HELICOPTER BE ATTEMPTED IF THE FORWARD HATCH HAS BEEN REMOVED AND STABLE II EGRESS PROCEDURES HAVE BEGUN.

After making sure that the crew is aware of the impending uprighting using the helicopter, the swimmers should tie a tether line to the CM upper deck area or sea anchor attach point. They will then signal the helicopter to start approaching.

WARNING

THE UPRIGHTING HOOK SHALL BE DIPPED INTO THE WATER PRIOR TO BEING TOUCHED BY THE SWIMMERS TO PREVENT STATIC DISCHARGE

The helicopter should approach the CM and hover directly over it. The altitude should be such that the CM will not be blown from beneath the helicopter by the rotorwash. The crew chief will then lower the sling to the swimmers. As they are attaching the hook to the CM recovery loop, the crew chief should continue to tend the line and watch the attachment process (figure 3-10).

Figure 3-10. Uprighting sling being lowered to swimmers

WARNING

WHILE THE HOOK IS BEING ATTACHED TO THE CM RECOVERY LOOP, ONE SWIMMER SHOULD CAREFULLY WATCH THE HELICOPTER AND UPRIGHTING SLING TO MAKE SURE THAT THE SWIMMER MAKING THE HOOKUPS DOES NOT GET CAUGHT BETWEEN THE CM AND THE UPRIGHTING LINE.

THE HELICOPTER CREW CHIEF SHOULD WATCH THE FLAGS ON THE TAG LINE TO MAKE SURE THAT THE LINE DOES NOT BECOME TAUT BEFORE THE SWIMMERS CLEAR THE AREA.

After the swimmers make the hookup, they should swim clear. However, it is recommended that they continue to hold the tether line tied to the CM so that they are not blown away from it.

Once the swimmers have cleared the area, the helicopter should move forward to trail the line out in an arc. This will prevent the sling from becoming entagled on the CM upper deck when the line is pulled taut.

The pilot should then begin a vertical lift of the CM (fig. 3-11). As the line slack is taken up, the crew chief should release the $\frac{1}{2}$-inch nylon line and begin tending the tag line.

WARNING

THE TAG LINE SHOULD NOT BE ALLOWED TO BLOW OUT OF THE HELICOPTER; IT COULD FLY UP INTO THE ROTOR BLADES.

CAUTION

The breakaway safety link in the sling assembly breaks in the range of 1,700-2,000 lb. The static force required to upright the CM is approximately 900 lb. Care should be taken to prevent large dynamic loads.

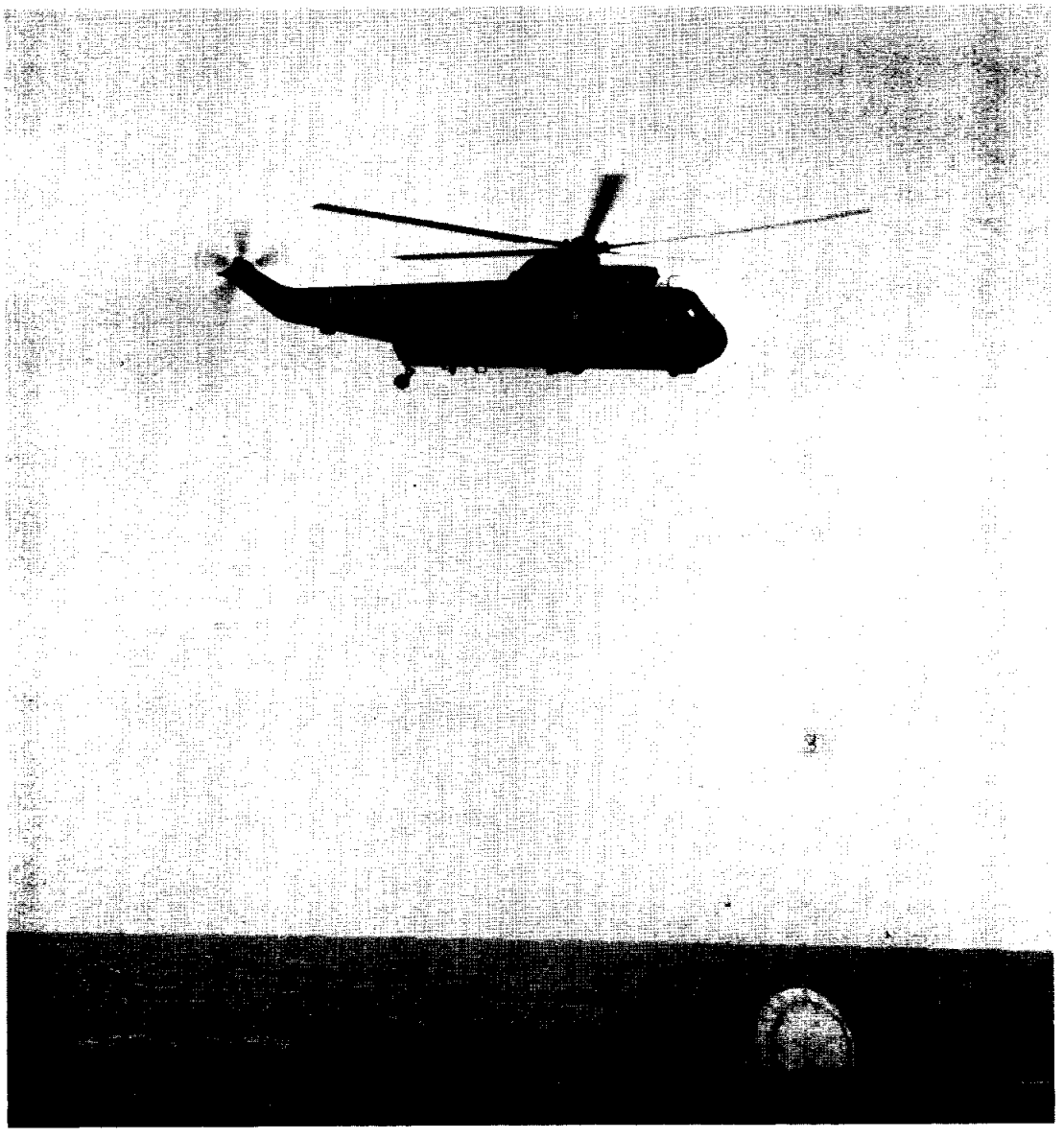


Figure 3-11. Helicopter uprighting CM

After the CM uprights, the helicopter should descend and move to one side. The sling may then be released from the bomb shackle and the standard recovery sequence begun. One of the swimmers should coil the sling and tie it off close to the CM.

3.1.1.5 Summary Report

Upon completion of the recovery operation, each helicopter crew will coordinate and fill out a Helicopter SUMREP, as outlined in section 6.0.

3.1.2 UDT Procedures

3.1.2.1 Special Equipment

In addition to the equipment normally carried by UDT personnel in accomplishing their tasks (SCUBA equipment, etc.) NASA supplies special equipment pertinent to Apollo mission recovery operation as follows:

Item	Number
Apollo recovery raft	2 per helicopter
Apollo flotation collar	6 per PRS
Sea anchor kit	1 per swimmer
Hatch tool	1 per team
Underwater camera	1 or 2 per team
Apollo swimmer radio	2 per team
100-ft line	1 per life raft

Apollo Recovery Raft - The Apollo recovery raft (fig. 3-12 is a raft especially designed for use with the Apollo flotation collar during recovery of Apollo crew and CM. It is constructed to fit the contour of the collar and is equipped to hook on to it. There is also a special flotation section that serves as a rest platform for the rescue net during astronaut pick-up. This raft is for use in the areas of the launch site and the primary recovery ship.

Details concerning the inspection, packing, and maintenance, and use of the recovery raft are contained in ref. 3.

NOTE

Operational recovery rafts will be leak tested and inspected within 72 hours of the planned launch time on the PRS and within 15 days of planned launch time at the launch site.

CAUTION

Use extreme care during the handling/ stowage of the raft to preclude damage prior to use.

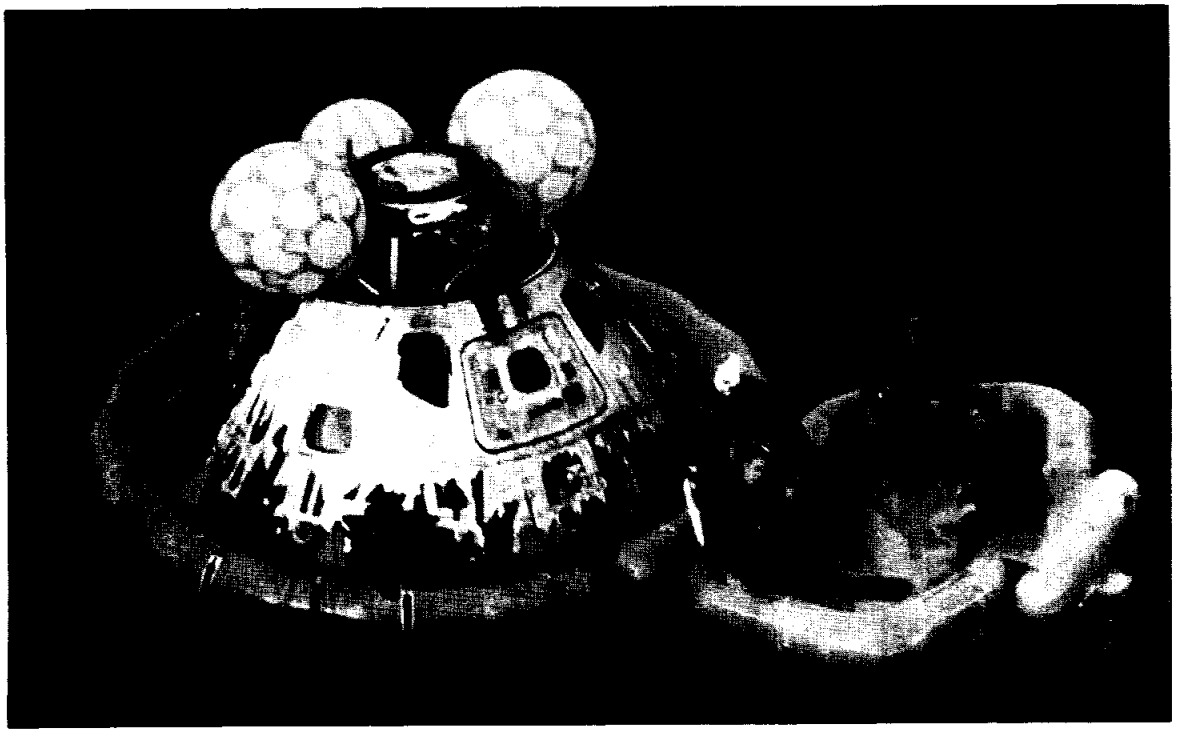


Figure 3-12. Apollo recovery raft.

Apollo Flotation Collar - The Apollo flotation collar (fig. 3-13) was developed to provide additional flotation to the CM and to provide a relatively stable work area around the CM prior to its retrieval. The collar will ensure an extended flotation capability in open seas. For purposes of identification and inventory, each collar has been assigned a serial number. Collars that are to be used for training will have a "T" following the serial number. These collars are for training only and are not intended for use on an actual recovery. Collars designated for operational use should not be used for training. Operational collars will have an "O" following the serial number. Details concerning the inspection, packing, maintenance, and use of the flotation collar are given in reference 3.

NOTE

Operational collars aboard the PRS will be leak tested and inspected within 72 hours of the planned launch time. Operational flotation collars at the launch site and ARRS bases will be tested and inspected within 15 days of the planned launch time.

CAUTION

Use extreme care during the handling/ stowage of the flotation collar to preclude damage prior to use.

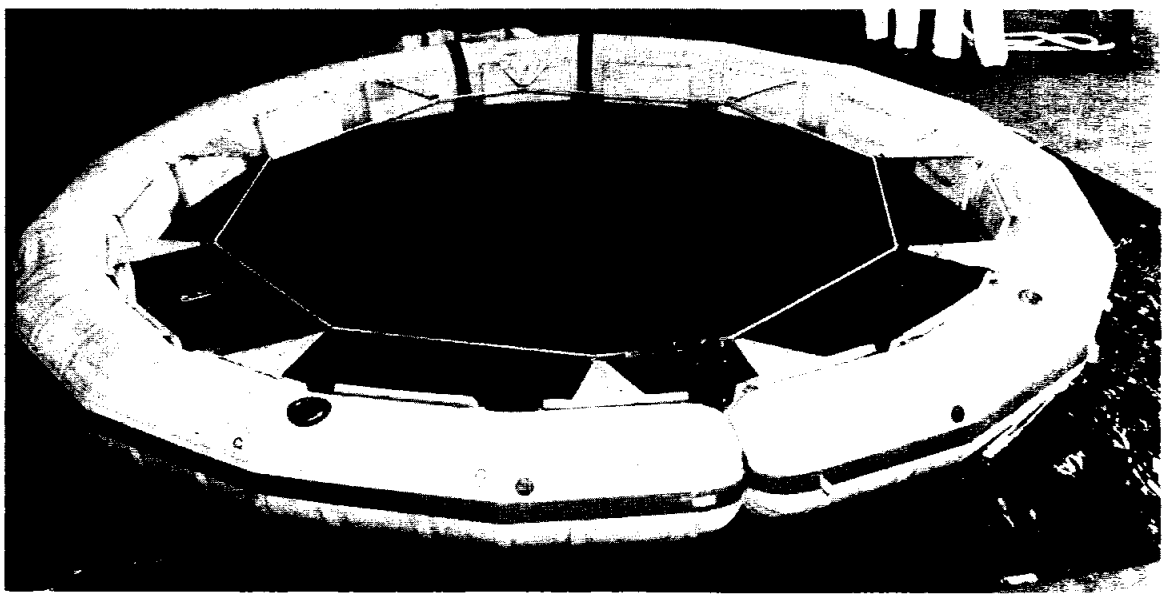


Figure 3-13. Apollo flotation collar.

Sea Anchor Kit - The sea anchor (fig. 3-14) when connected to an attachment ring below the side crew hatch of the CM, lessens the CM drift rate and orients the CM so that the side hatch is generally upwind. It is tethered with a 50-foot length of 2,200-lb test nylon cord. Sea anchor packages are distributed to all U. S. Navy units which install flotation collars and to launch site area pararescue personnel. The sea anchor is not an integral part of the flotation collar package but is carried separately.

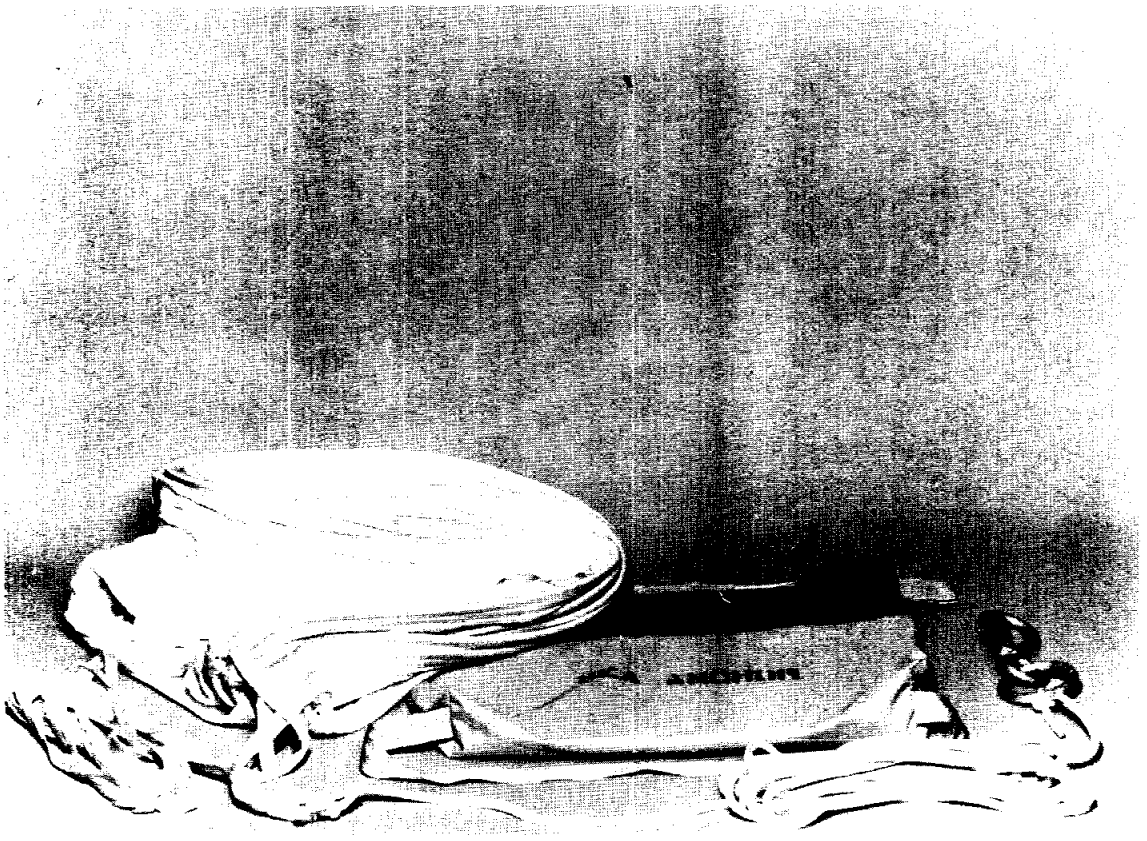


Figure 3-14. - Sea anchor kit

Apollo Hatch Tool - The Apollo hatch tool is shown in figure 3-15. It is of steel construction with a 9-inch handle and a 6-inch shaft. The shaft has a spring-loaded plunger on one end and a 7/16-inch hex head on the other. In the hex head is a ball detent which works in conjunction with the plunger to fit into the hatch latching mechanism. A lanyard extends from one end of the hatch tool to its storage case.

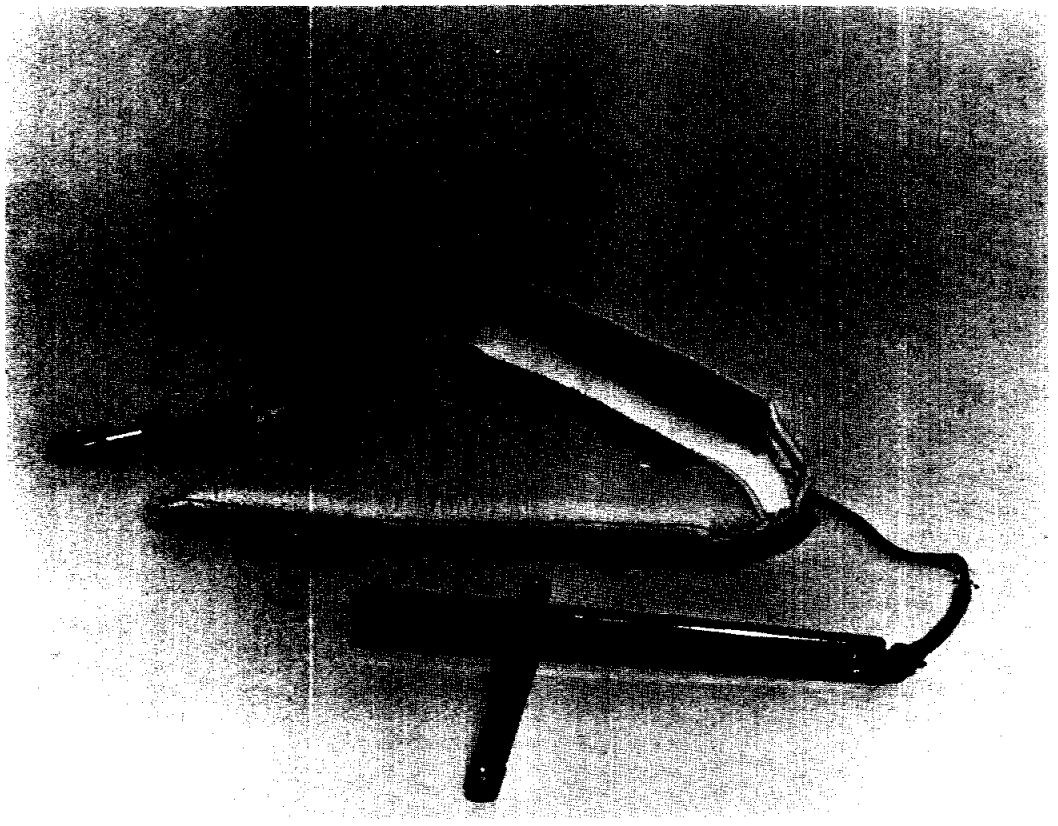


Figure 3-15. Apollo hatch tool

3.1.2.2 Safety Precautions

Prior to a mission, all UDT personnel will be briefed on the CM hazard areas described in section 2.0 of this manual. Additional safety precautions not covered in section 2.0 that should be observed by swimmers during recovery operations are included with the procedures descriptions which follow.

3.1.2.3 Installation of Sea Anchor and Flotation Collar

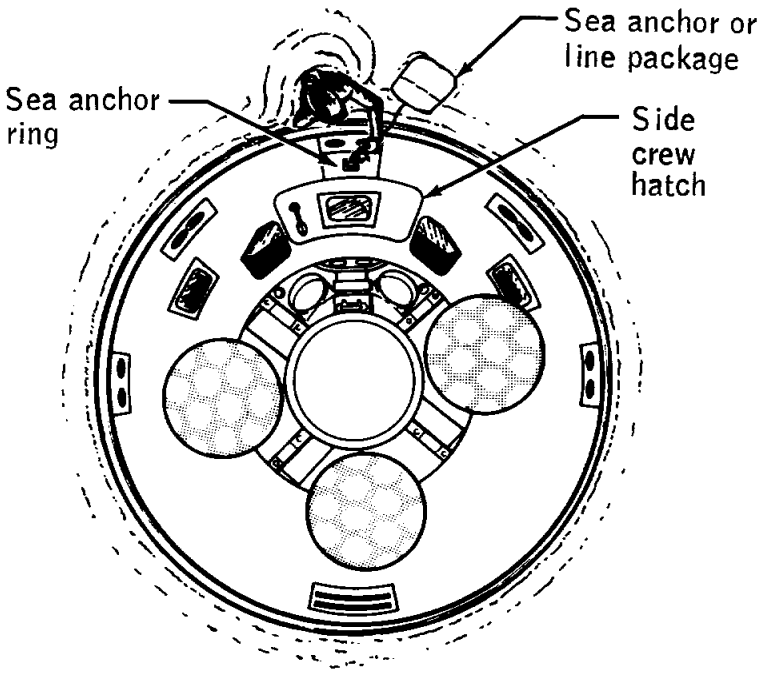
Upon arrival at the CM, swimmers should be delivered as shown in figure 3-5. The procedures for installation of the sea anchor and flotation collar are given in figure 3-16. Prior to collar installation, the CM should be inspected for any damage which might puncture the collar.

WARNING

SWIMMERS SHALL BE CAUTIOUS OF CM ROLLING TO PREVENT GETTING BUMPED, AND SHALL MINIMIZE TIME SPENT IN THE AREAS AROUND THE RCS NOZZLES. FACE MASKS AND FULL SCUBA EQUIPMENT SHALL BE USED UNTIL COLLAR INSTALLATION IS COMPLETE.

NOTE

If the CM main parachutes are still attached, they must be released and recovered, if feasible, as described in section 3.1.2.5 and figure 3-17.



1. The first swimmer reaching the CM connects the hook of the sea anchor or line package to the sea anchor ring below the hatch. If sea anchor, the swimmer then removes the sea anchor from its container. If line package, the swimmer connects his reserve parachute to the line rings and deploys the parachute. If attachment of the sea anchor to the sea anchor ring is not practicable due to heavy seas, deployment of the CM grappling hook (fig. 3-40) by the astronauts should be requested (if not previously deployed). The sea anchor should be attached to it as a temporary measure.

(a) Step 1.

Figure 3-16. Flotation collar installation procedure

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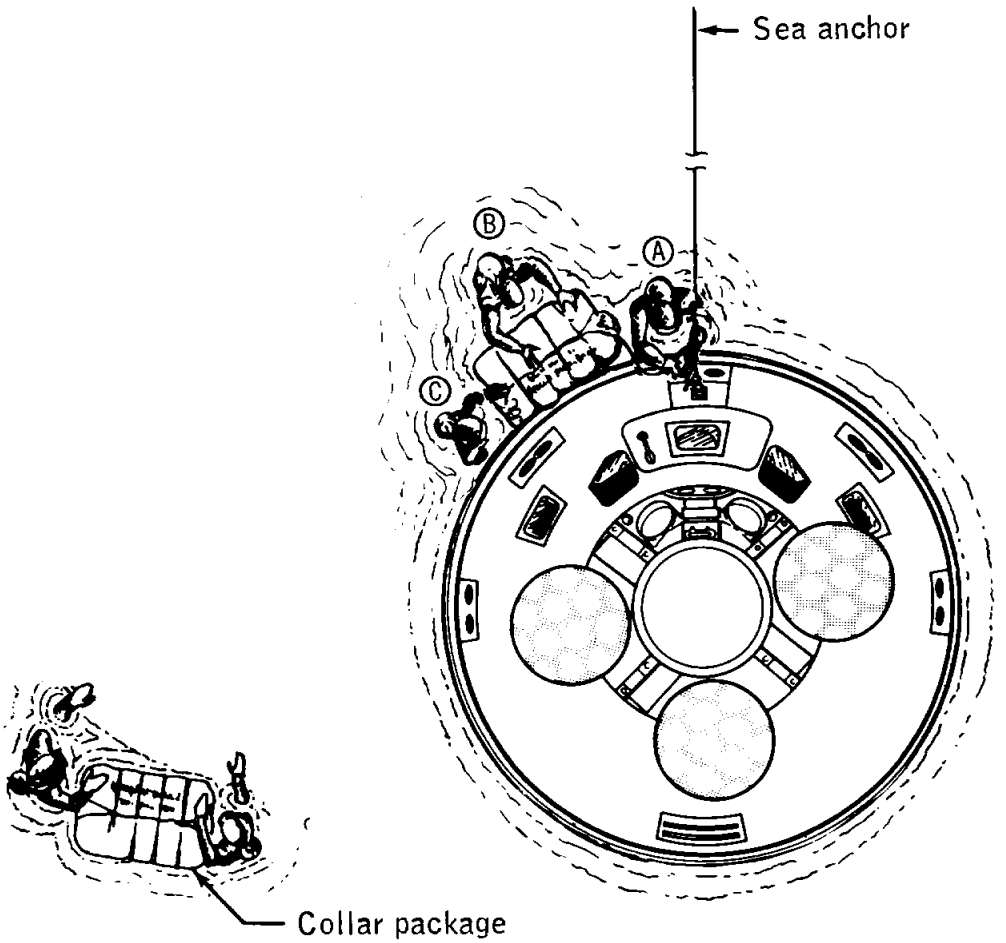
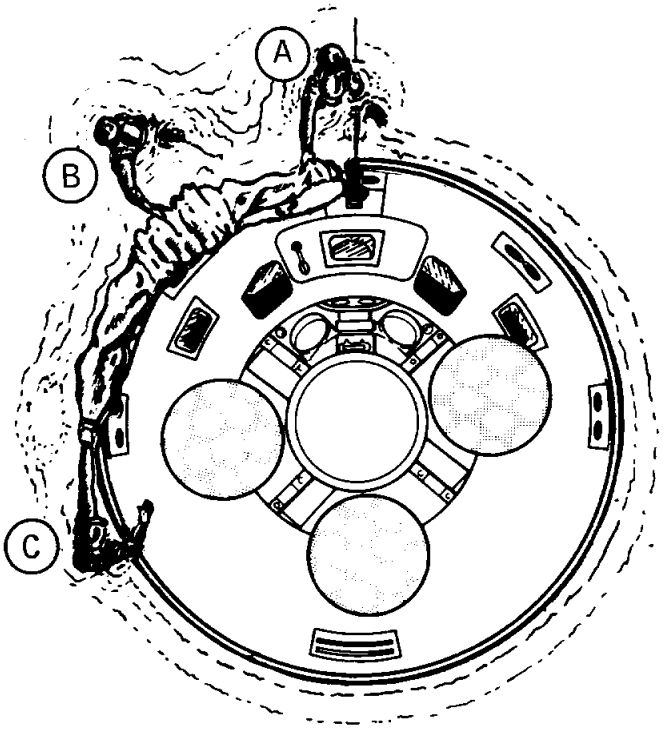


2. Swimmers A, B, and C position the collar immediately to the right (as you face the CM hatch) of the sea anchor ring with the lettering on the collar package toward the CM. Swimmer A unsnaps the left end of the package, grasps the bungee and snaps the hook in the sea anchor hook ring. He then pulls the red striped end of the collar out, unstows the positioning strap, and snaps it in the sea anchor ring (hookup no. 2).

(b) Step 2.

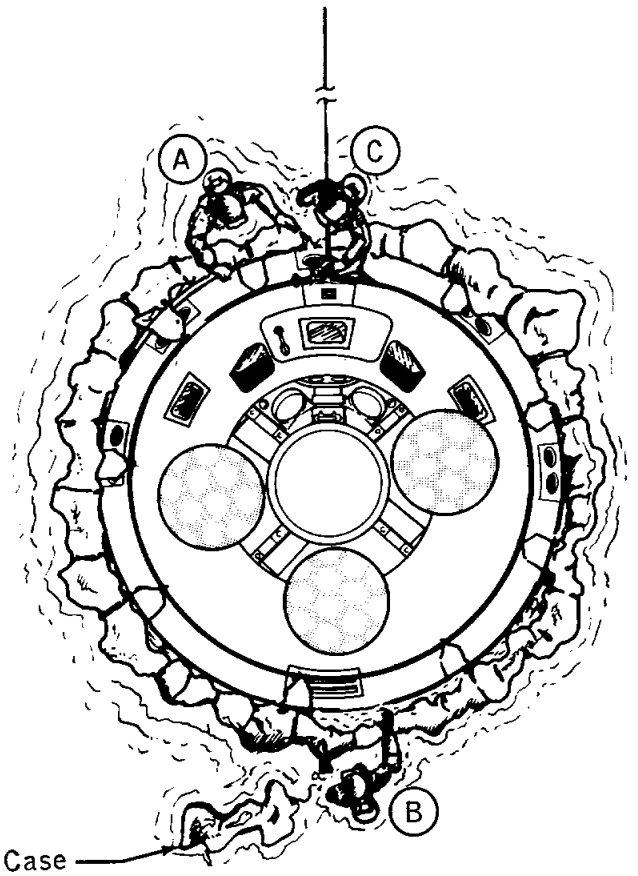
Figure 3-16. Continued



3. Swimmers A, B and C completely remove the collar bag. Swimmer C grasps the right (green stripe) end of the collar and the bungee and begins swimming to his right around the CM. Swimmers A and B help deploy the collar around the CM.

(c) Step 3.

Figure 3-16. Continued



4. Swimmer C, when completely around the CM, snaps the bungee hook (hookup no. 3) in the sea anchor ring. Swimmers A and C then make hookup no. 4 (see step 5).

(d) Step 4.

Figure 3-16 Continued

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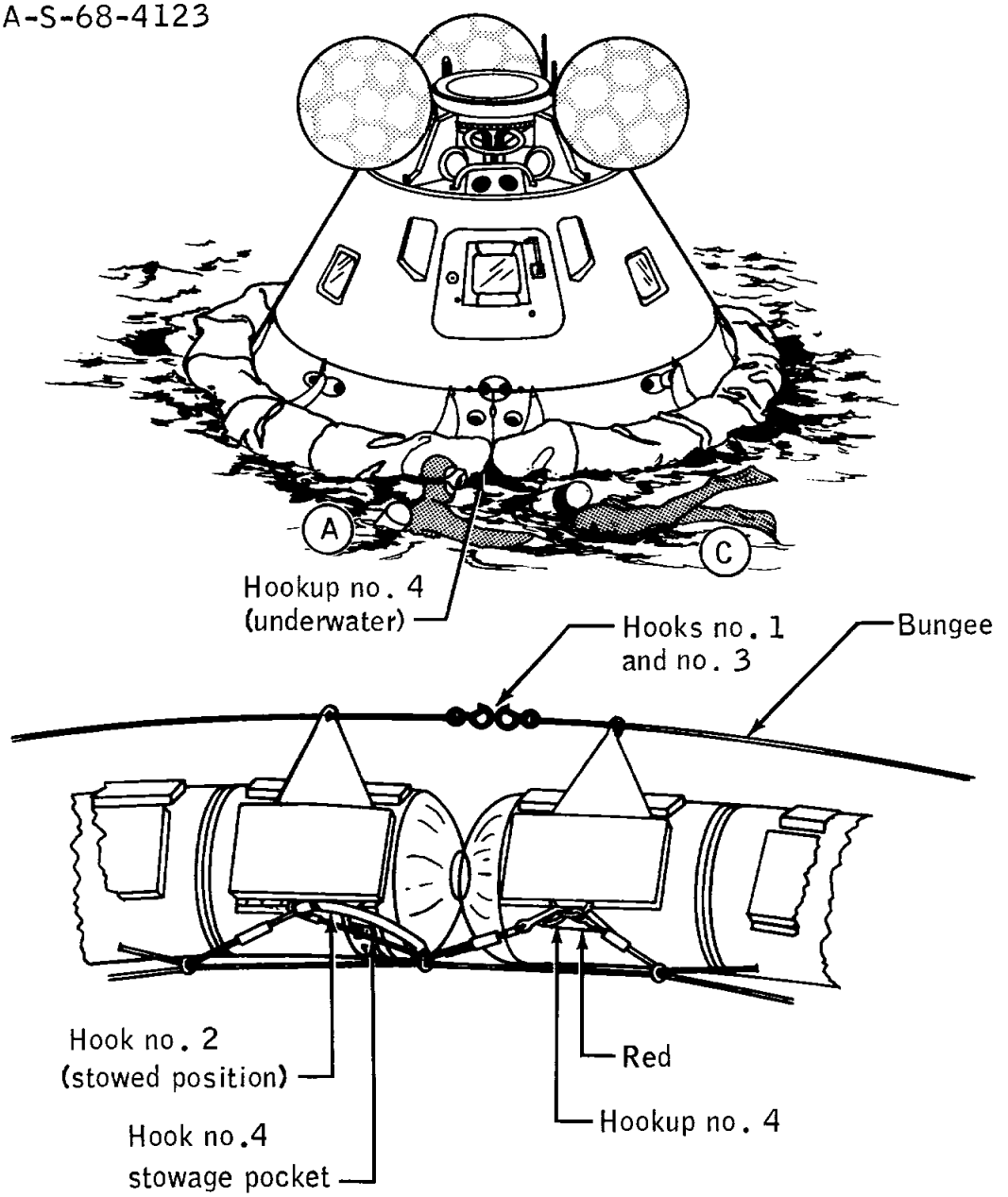
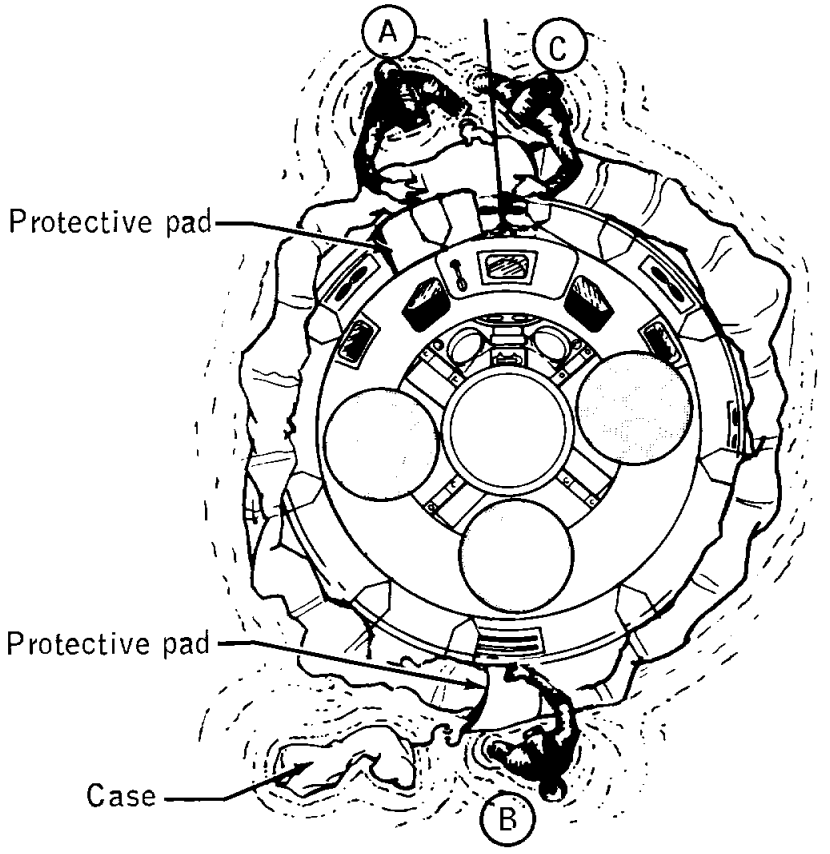


View looking at inboard surfaces at cap ends

Swimmers A and C perform hookup no. 4, this hookup takes place beneath the CM approximately under the hatch.

(e) Step 5.

Figure 3-16. Continued



6. Swimmer B returns to the case (which is attached to the tube by line), and helps swimmer C remove the two protective pads located at the bottom of the case. Pads are used as necessary to protect the tube.

(f) Step 6.

Figure 3-16. Continued

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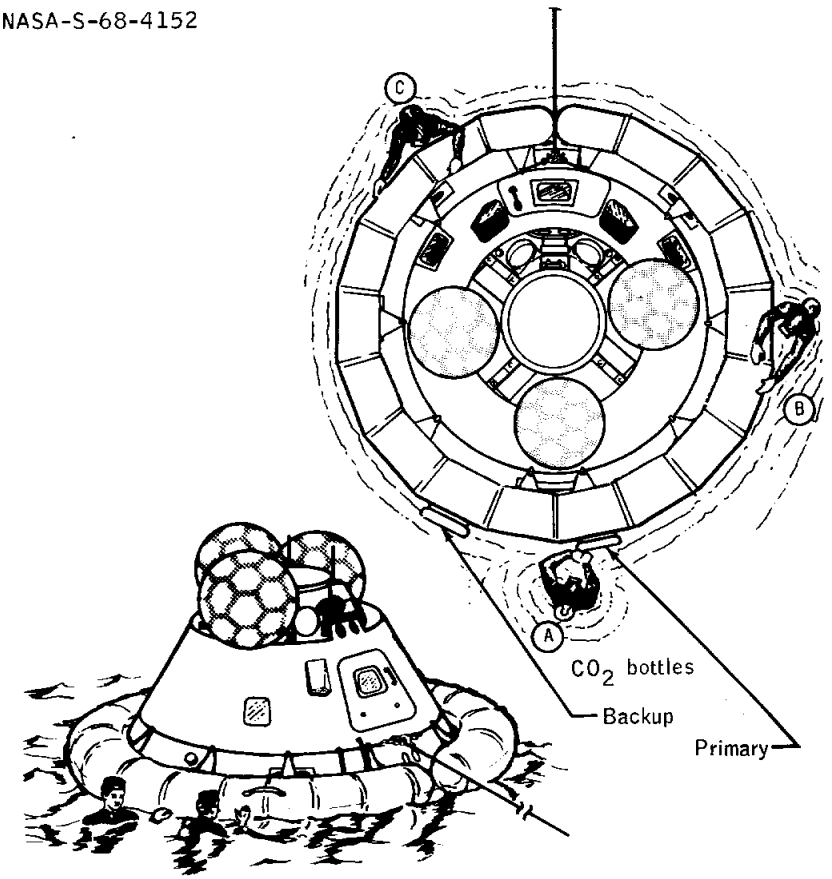


7. Swimmers B and C check sling under CM to make sure it is properly centered. Swimmer A discharges a small amount of CO_2 into the tube.

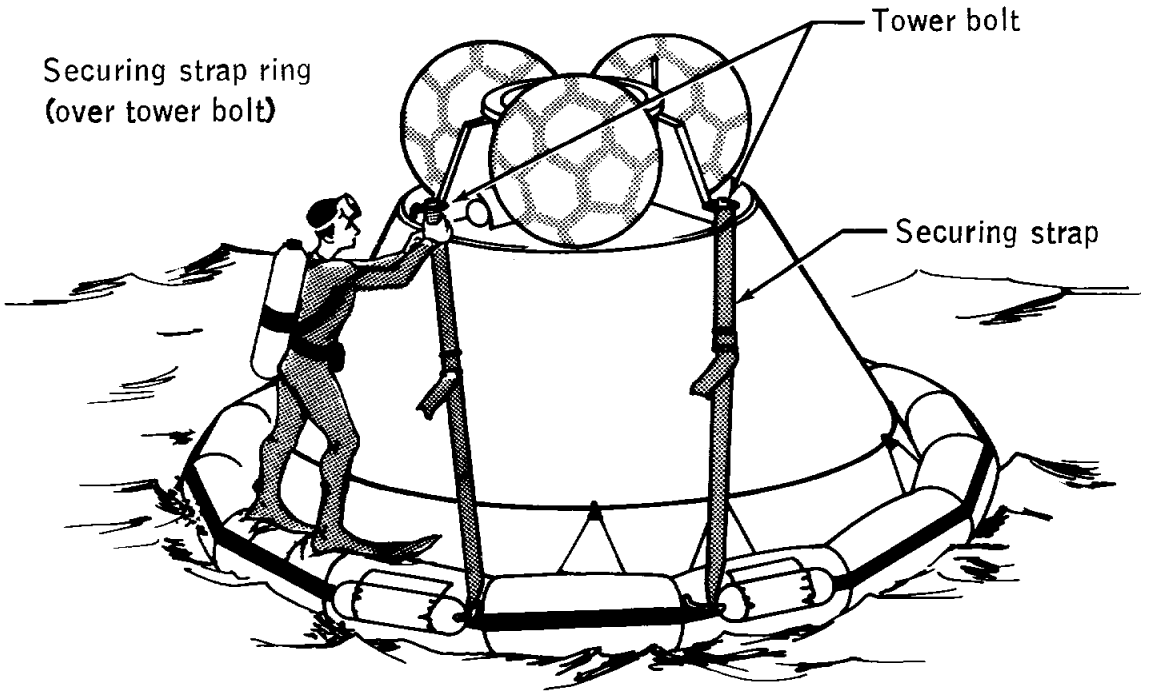
   Swimmers B and C pull up on the tube at several positions around the CM so as to allow an even inflation of the tube.

   Swimmer A continues with the inflation of the tube until it is firm.

8. Swimmers A, B, and C inspect the fit of the tube for points of possible abrasion or puncture and use the padding as needed.

(g) Steps 7 and 8.

Figure 3-16. Continued



9. Swimmer A, B, or C climbs upon the inflated collar and attaches the securing straps to the CM by slipping the securing strap rings over the CM rear tower bolts. The swimmer then cinches the straps taut. The collar is now secured in position and will remain attached to the CM during recovery.

(h) Step 9.

Figure 3-16. Concluded

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WARNING

Use caution when working around RCS and pyrotechnic devices.

1 Secure canopy on parachute riser to a seven-man raft.

2 Attempt to release main parachute risers with upward force (away from command module).

3 If a riser does not release, cut with sharp , heavy-duty knife.

4 If possible, pull parachutes into raft.

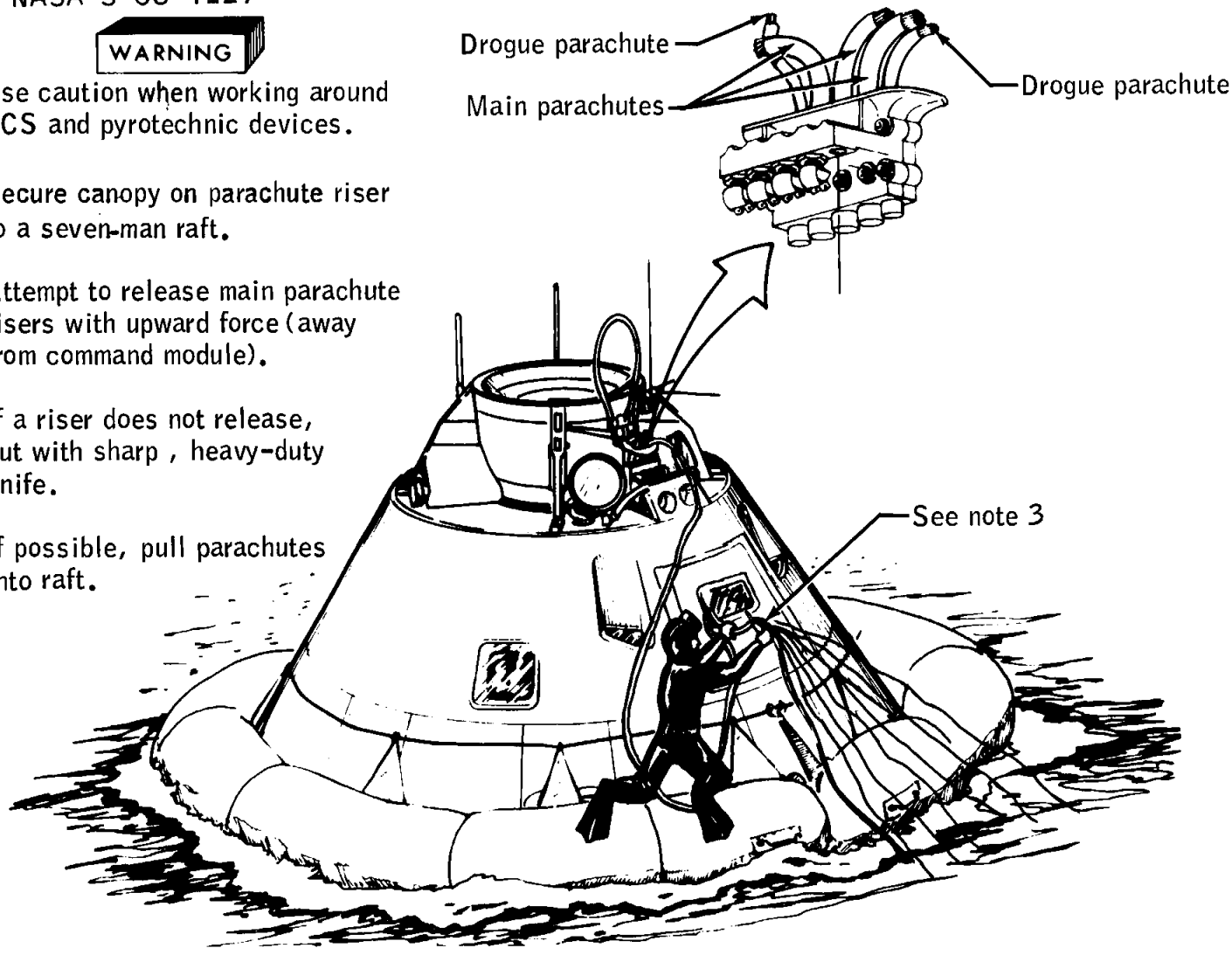

Figure 3-17. Main parachute manual release

3.1.2.4 Swimmer/Helicopter Procedures for Astronaut Egress and Recovery.

After the flotation collar has been installed, the swimmers will contact the crew by swimmer radio. They will find out the crew's condition and inform them of the egress preparations taking place.

One helicopter (in addition to those helicopters designated for swimmer deployment, photo, and air boss) will be dedicated to astronaut recovery. The astronaut recovery helicopter will carry a NASA physician specially trained to aid in astronaut egress in the event his assistance is required. The astronaut helicopter will also carry the astronaut life vests and overgarments, donned before egressing the CM.

After the Apollo recovery raft has been inflated and attached to the flotation collar (fig. 3-18), two of the swimmers will move a short distance upwind and be prepared to assist in the astronaut recovery if required. The third swimmer will place himself in the raft in such a position that he will be able to assist the astronauts during egress and hatch closing.

On signal from the egress swimmer (swimmer in the raft), the astronaut recovery helicopter will lower, via the rescue net, a stowage bag containing the astronaut life vests and overgarments. When the equipment has been delivered to the raft, the helicopter takes up the "ready" position and awaits the swimmers signal to start the astronaut recovery.

With the preparations complete, the egress swimmer contacts the CM crew by means of the swimmer radio or hand signals and requests that they open the hatch. If it is necessary for the swimmer to open the hatch, the procedures on page 3-42 should be used. The egress swimmer then passes the life vests and overgarments to the astronauts and closes the hatch.

Under normal conditions, the astronauts will don the life vests and overgarments in the CM. After these have been donned, the hatch will be opened and the astronauts will egress, inflating their LPU's upon getting into the raft.

NOTE

Before the last crewman egresses, the egress swimmer should verify that: (1) The postlanding ventilation valves are tightly closed, (2) Both latch controls on the hatch are in the neutral (N) position (page 3-46).

If the hatch will not close on the first try, the swimmer should: (1) Verify that the periphery of the hatch is clear of any objects, (2) Verify that the hatch tool is at hard stop in the CCW direction. If the hatch still will not close, the swimmer should bleed off the remaining GN_2 pressure (page 3-47). If further difficulty is experienced, the swimmer may enlist the aid of one of the CM crew.

Upon completion of crew egress and hatch securing, the flight crew is ready for helicopter pickup operations. The egress swimmer then signals the recovery helicopter to move in and recover the flight crew with the rescue net. The egress swimmer will remain in the Apollo recovery raft to insure its stability.

The recommended helicopter approach pattern for astronaut retrieval is also shown in fig. 3-18.

NOTE

Some difficulty may be experienced in holding the helicopter directly over the raft because of CM drift and rotation. Strict adherence to verbal direction by the crewmen operating the hoist is necessary at this point since the pilot has no visual contact with the CM.

WARNING

THE RECOVERY NET (OR SEA ANCHOR TAG LINE) SHALL BE DROPPED INTO THE WATER PRIOR TO BEING TOUCHED BY THE SWIMMERS TO PREVENT STATIC DISCHARGE.

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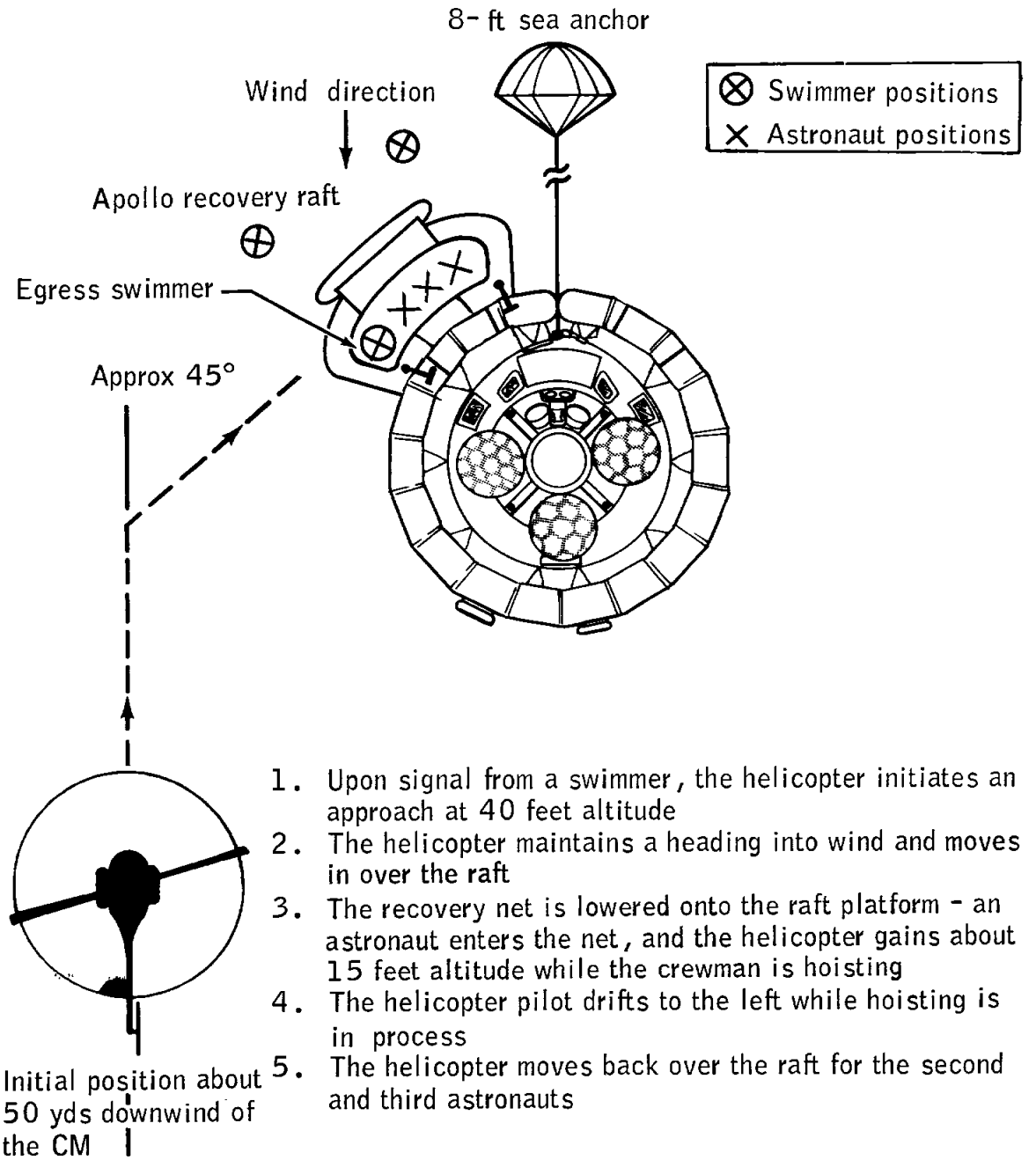

Figure 3-18. Positions and recommended helicopter approach for astronaut pickup

WARNING

THE ASTRONAUTS SHOULD NOT BE HOISTED UNTIL THEY ARE IN THE RAFT, CLEAR OF THE CM. DIRECT PICKUP OF THE ASTRONAUTS FROM THE CM OR FLOTATION COLLAR COULD CAUSE INJURY. IF A SEA ANCHOR OR TAG LINE IS USED ON THE NET, IT SHALL BE PLACED IN THE NET PRIOR TO HOISTING.

The hoist operator should begin lowering the net as the helicopter nears the raft. When the net is on the raft platform, the hoist operator should slack the hoist line and await a signal from the swimmer to begin hoisting. As soon as this signal is received and the helicopter is directly overhead, the hoist operator should begin hoisting and notify the pilot (fig. 3-19). The pilot should then engage the altitude coupler to gain approximately 15 feet of altitude. He should also initiate a left drift to insure that he does not drift over the CM because the crewman will not be able to direct the pilot once hoisting has begun. After the first astronaut is in the helicopter, similar procedures should be used to retrieve the second and third astronauts.

After all astronauts are in the helicopter, the hatch is closed and the helicopter proceeds to the PRS. If sufficient helicopters are available, one should accompany the astronaut recovery helicopter to the PRS and a third should remain on scene to provide swimmer support.

The swimmer and CM should be retrieved, utilizing procedures described in section 3.1.3.3.

Figure 3-19. Astronaut pick-up

Procedure for opening side hatch (pararescue and UDT personnel) - The CM crew will normally unlatch the hatch from the inside. A counterbalance system that is operated by pressurized gaseous nitorgen (GN_2) provides an opening force that will open the hatch when it is unlatched.

WARNING

THE COUNTERBALANCE WILL BE PRESSURIZED AND THE HATCH WILL SWING SLOWLY OPEN. STAND CLEAR OF ITS PATH.

If it is necessary for swimmers or pararescuemen to open the hatch, the following procedure will be used.

Safety - Before attempting to open the hatch, make the following safety checks:

(1) If a drogue or pilot parachute mortar has failed to fire, exercise care and minimize the time spent in the danger area.

(2) If the hatch handle appears damaged, and it is necessary to pull on it, wear some kind of hand protection while doing so.

Equipment needed - Apollo hatch tool (sec 3.1.2.1)

Procedure -

(1) Insert the Apollo hatch tool into the hatch drive hole (fig. 3-20) and engage the latching mechanism.

(2) Turn the hatch tool clockwise to hard stop.

(3) Turn the hatch tool counterclockwise to hard stop.

NOTE

Additional force may be required to fully retract the latches after the hatch tool hits a hard stop.

WARNING

STAND CLEAR OF THE OPENING PATH OF THE HATCH.

(4) Pull or push the hatch to the full open position and secure it there.

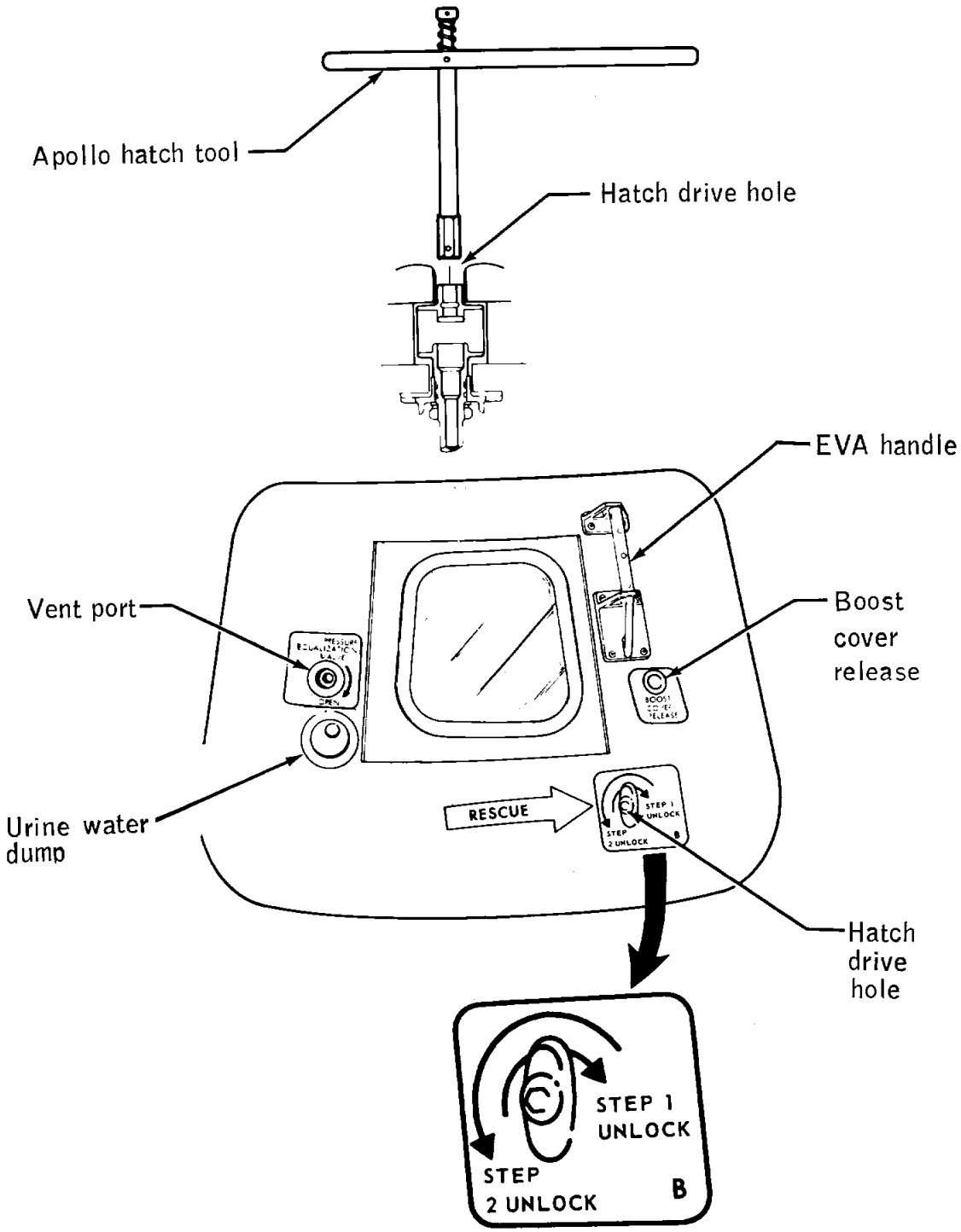

Figure 3-20. Side hatch (exterior)

NOTE

The hatch weighs approximately 250 pounds. If the counterbalance is inoperative, two men will be required to open the hatch.

(5) Pararescue or UDT personnel should assist the flight crew in egress from the CM if necessary.

CAUTION

DO NOT MOVE OR REPOSITION ANY HATCH CONTROLS OR OTHER CONTROLS INSIDE THE SPACECRAFT EXCEPT AS DESCRIBED IN THE HATCH CLOSING PROCEDURE.

Procedures for securing side hatch (pararescue and UDT personnel)

Safety - Before attempting to secure the hatch, make the following safety check: If a drogue or pilot parachute mortar has failed to fire, exercise care and minimize the time spent in the danger area.

Equipment needed - Apollo hatch tool

Procedure

(1) Verify that both control handles are in the "N" (neutral) position (fig. 3-21).

(2) Verify that the periphery of the hatch is clear; e.g., that the postlanding ventilation valve (PLV) cover is not in the way.

(3) Insert the Apollo hatch tool into the hatch drive hole, engage the latching mechanism, and verify that the tool is at hard stop in the counterclockwise direction. The latching dogs should be fully retracted.

(4) While holding the hatch (pulling back), release the overcenter lock (fig. 3-21).

(5) Push and hold hatch closed.

(6) Turn the hatch tool clockwise to hard stop.

Before egressing, the CM crew will have partially depressurized the counterbalance. If the swimmer is not able to close the hatch all the way, he should repeat steps (2) and (3) above. If the hatch still will not close, the swimmer should bleed off the remaining GN_2 counterbalance pressure by:

(1) Reaching inside the CM hatch and gripping the GN_2 vent/ pressurization handle (fig. 3-22).

(2) Pulling this handle toward the inside of the CM until the pressure is bled off.

If further difficulty is experienced, the swimmer can enlist the aid of one of the CM crew in closing the hatch.

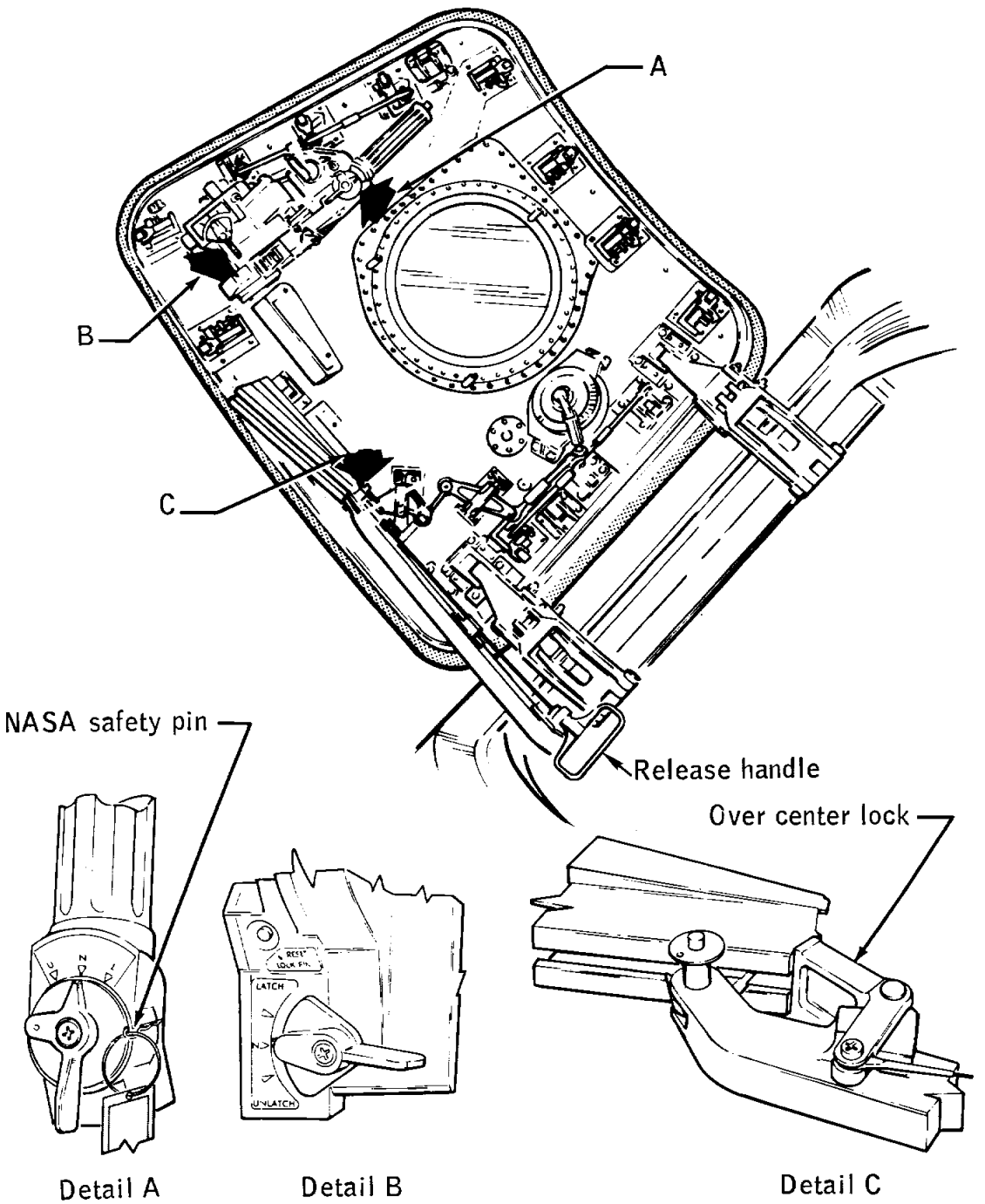

Figure 3-21. Side hatch (interior)

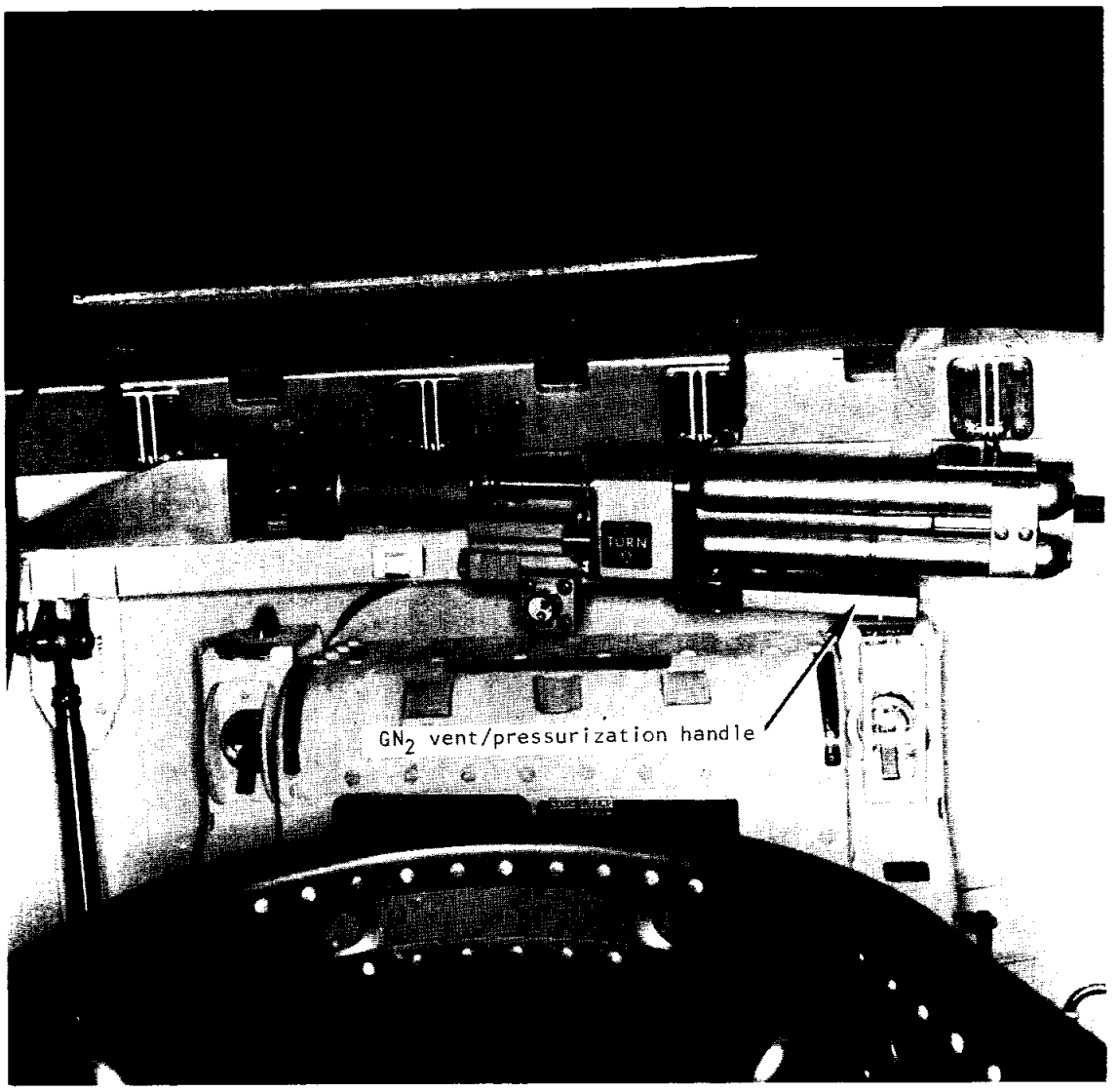

Figure 3-22. Side hatch GN_2 vent/pressurization handle

CM Side Hatch Jackscrew Clamps

Three (3) jackscrew clamps are now stowed onboard the Apollo CM. The purpose of these clamps is to provide an additional or backup means of securing the CM side hatch. At crew discretion, they will be installed following an extravehicular activity (EVA) to assure a good hatch seal.

The clamps fit over bar fittings in the inside hatch and CM structures and then screw on tightly. There is one located midway on the hinged side of the hatch and two located on the opposite side a few inches from each corner. An installed clamp is shown in figure 3-23.

After installing the flotation collar, pararescuemen or UDT swimmers should use the Apollo swimmer radio to verify with the crew that the clamps have been removed. If contact with the crew cannot be established and the side hatch cannot be opened by normal procedures, the swimmers should open the forward hatch. If there is still no response from the crew, one man should enter the CM and remove the clamps. The side hatch must be relatched from the outside before the clamps are moved. The large wing-nuts are rotated counterclockwise until the clamps are free. The hatch may then be opened normally.

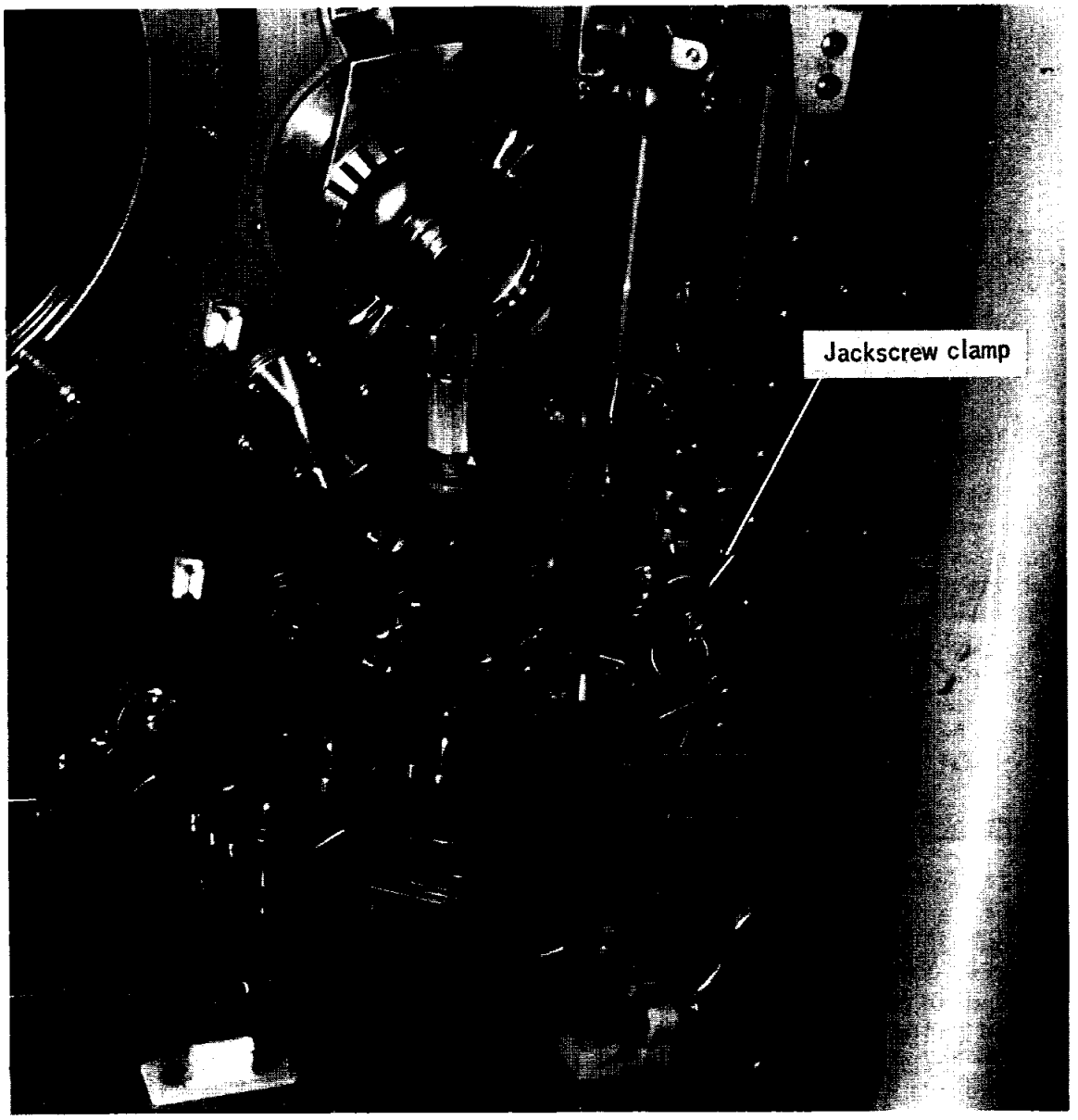

Figure 3-23. Installed jackscrew clamp

3.1.2.5 Recovery of Earth Landing System Components

Recovery of the apex cover, parachutes, and any other items from the CM is desirable on a not-to-interfere basis with recovery of the flight crew.

3.1.2.5.1 ELS Components

Apex Cover

The forward heat shield, or apex cover, (fig. 2-2), weighs about 300 pounds dry and 400 to 500 pounds wet, depending upon sea state and soak time. The apex cover is separated from the CM at an altitude of approximately 24,000 ft and descends on a white parachute (fig. 3-24) at about 150 ft/sec. It will impact in the vicinity of the CM and will sink slowly as it soaks up water.

Drogue Parachutes

The two white, conical, ribbon-type drogue parachutes are used to decrease the rate of descent and stabilize the CM prior to main parachute deployment (fig. 3-25). They are released simultaneously from the CM at an altitude of about 10,000 ft and descend individually at a rate of 15 ft/sec. The parachutes, which weigh 38 pounds each when dry, are attached to 11 pounds of steel riser cable and will sink rapidly after landing. The wind and the slow descent rate can cause them to drift a considerable distance away from the CM landing point. Because of the above factors, their recovery is highly unlikely. For parachute and riser dimensions, see figure 3-25.

Main Parachutes

The three orange and white ring sail main parachutes are deployed at an altitude of 10,000 ft and will lower the CM at a rate of about 31 ft/sec. Immediately after landing, they are simultaneously separated from the CM by astronaut-activated pyrotechnics. They will be found in the immediate area of the CM (fig. 3-8). A deployment bag and pilot parachute are attached to the apex of each main parachute (fig. 3-26). Since the main parachutes are not interconnected and the canopies have slightly negative buoyancy, they will float in the area for only about 10 minutes before sinking. One main and pilot parachute system has a dry weight of 144 pounds.

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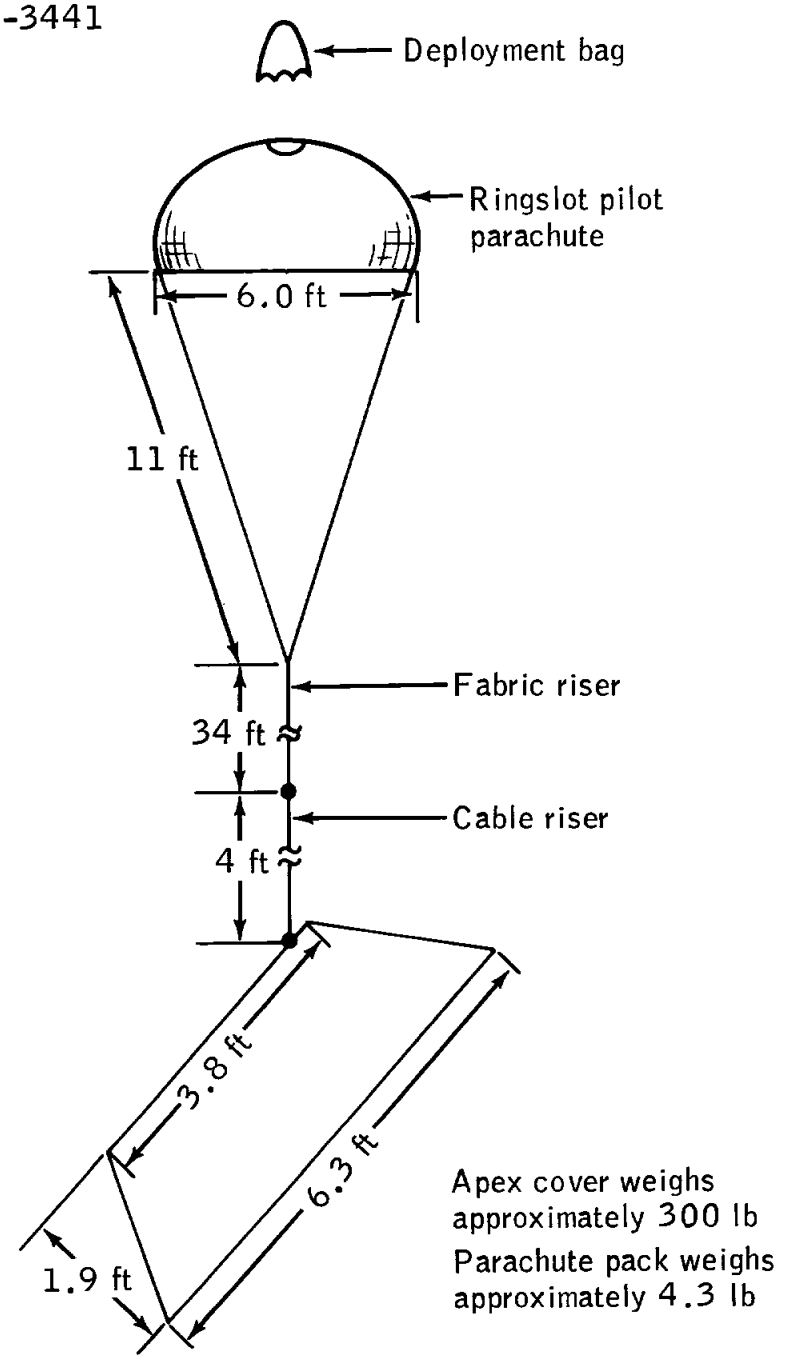


Figure 3-24. Apex cover and separation parachute

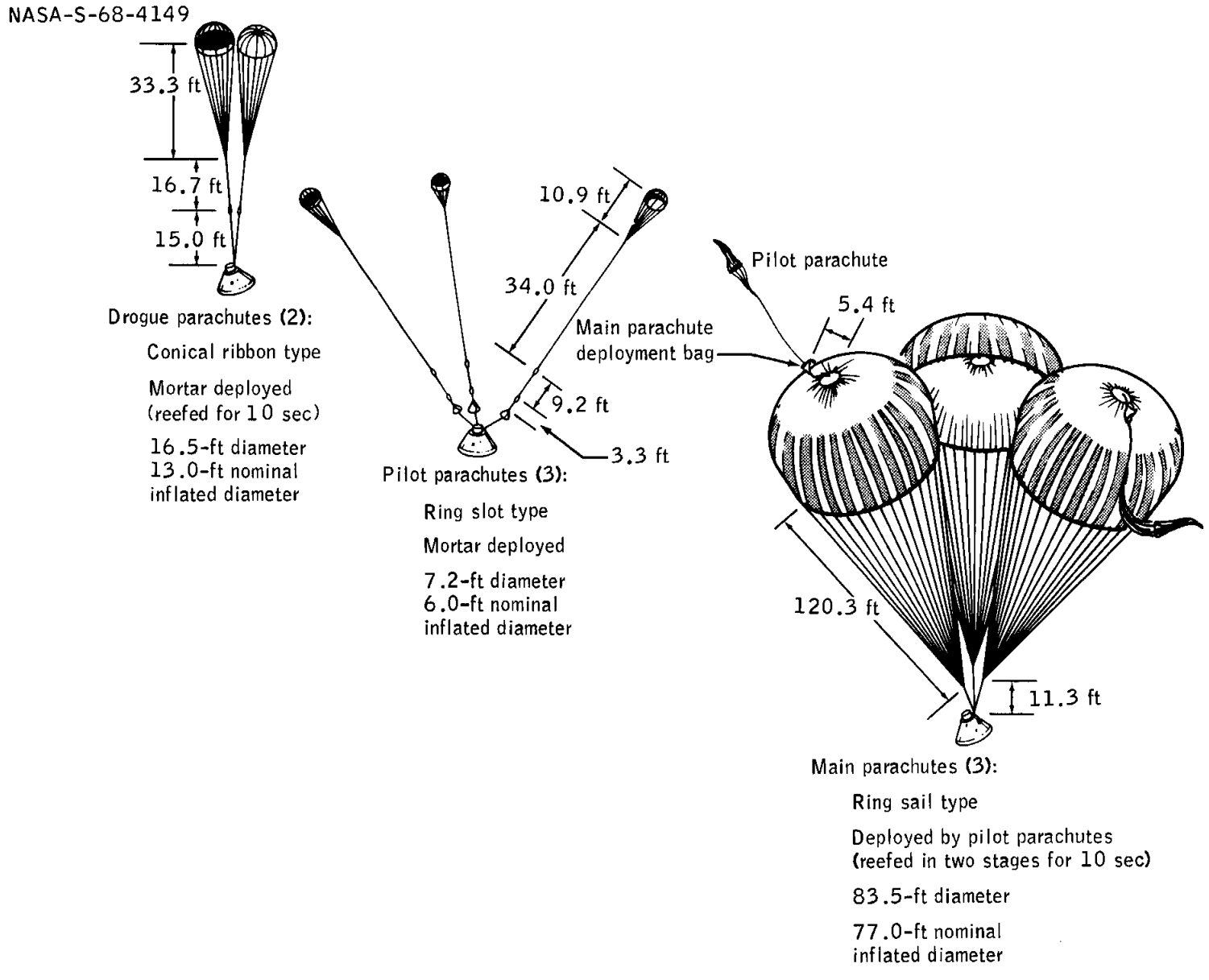


Figure 3-25. - Earth landing system parachutes

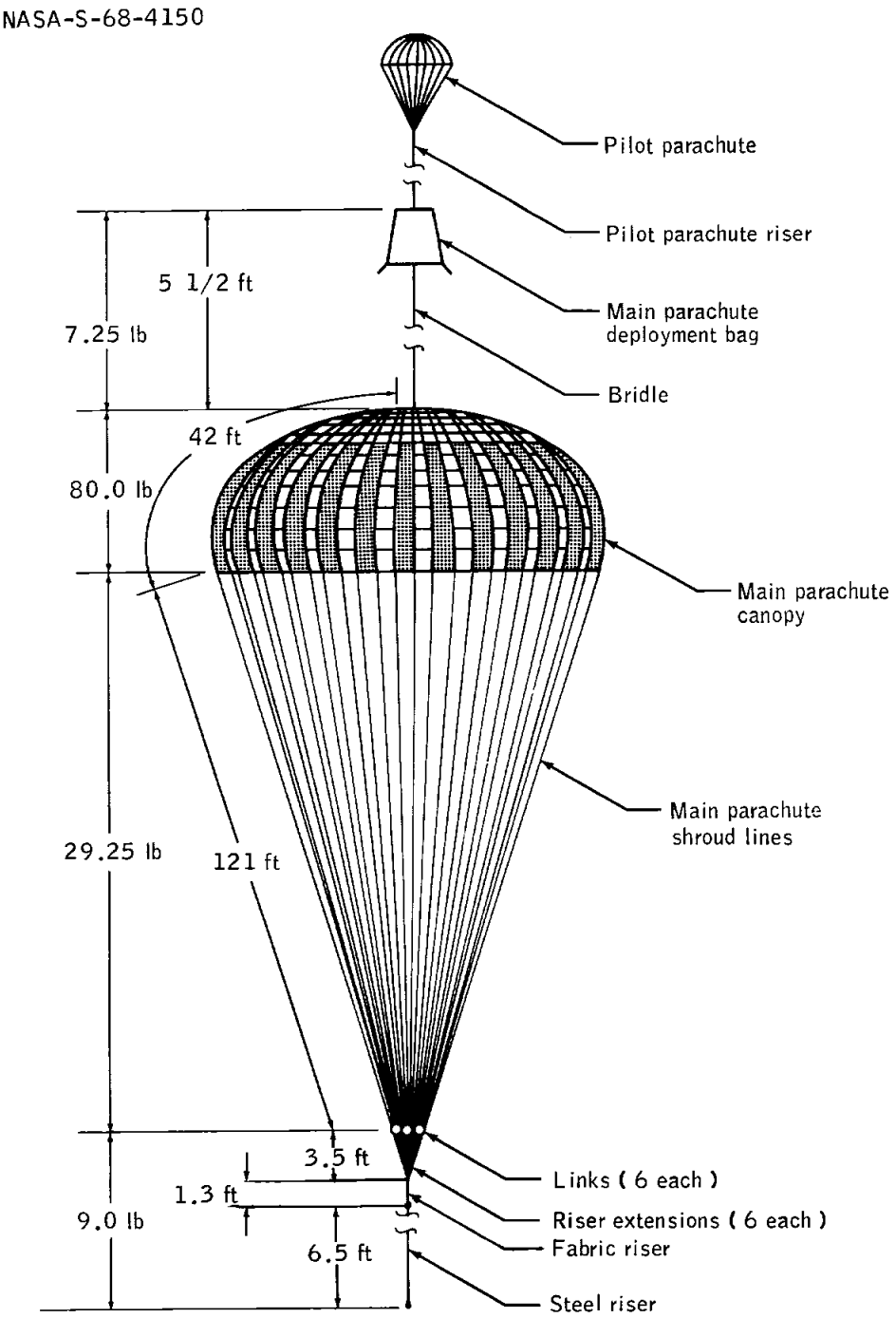


Figure 3-26. Main parachute assembly

3.1.2.5.2 ELS Recovery Equipment and Procedures

The chances for successful apex cover and parachute recovery can be greatly imporved if some kind of flotation device can be attached to them as soon as possible.

Designated helicopters will be equipped with grappling hook/one-man life raft packages. Each package contains a grappling hook and a one-man life raft secured together by a 100' nylon line (Fig. 3-27). Recovery of any ELS component is possible by using the hardware provided in these packages.

Apex Cover Recovery

This operation should not be attempted until notification has been made that the crew is in good condition and that the CM has been collared. After that time, a helicopter may proceed to the apex cover and attach one or more of the one-man life rafts provided in the grappling hook/one-man life raft packages. These life rafts are separately packaged as shown in fig. 3-28. These rafts may be attached to the apex cover as shown in fig. 3-29. The small separation parachute should be collapsed and secured in one of the rafts prior to recovery. Recovery may be accomplished by attaching the retrieval crane hook to a raft loop.

WARNING

IF THE APEX COVER PARACHUTE HAS NOT DEPLOYED, AVOID THE PARACHUTE MORTAR DANGER AREA (FIG 2-2).

Main Parachute Recovery

(a) Since safe recovery of the crew and CM is of the utmost importance, helicopters should become involved with main parachute recovery only to the extent of deploying the grappling hook one-man life raft packages.

(b) As the helicopters approach the CM, they may deploy the grappling hook packages. An appropriate time to do this would be during CM uprighting. Under no circumstance should crew recovery be delayed for ELS component recovery.

WARNING

PARTICULAR CARE MUST BE TAKEN TO AVOID ENTANGLEMENT OF PARACHUTES AND SHROUD LINES WITH HELICOPTER ROTORS.

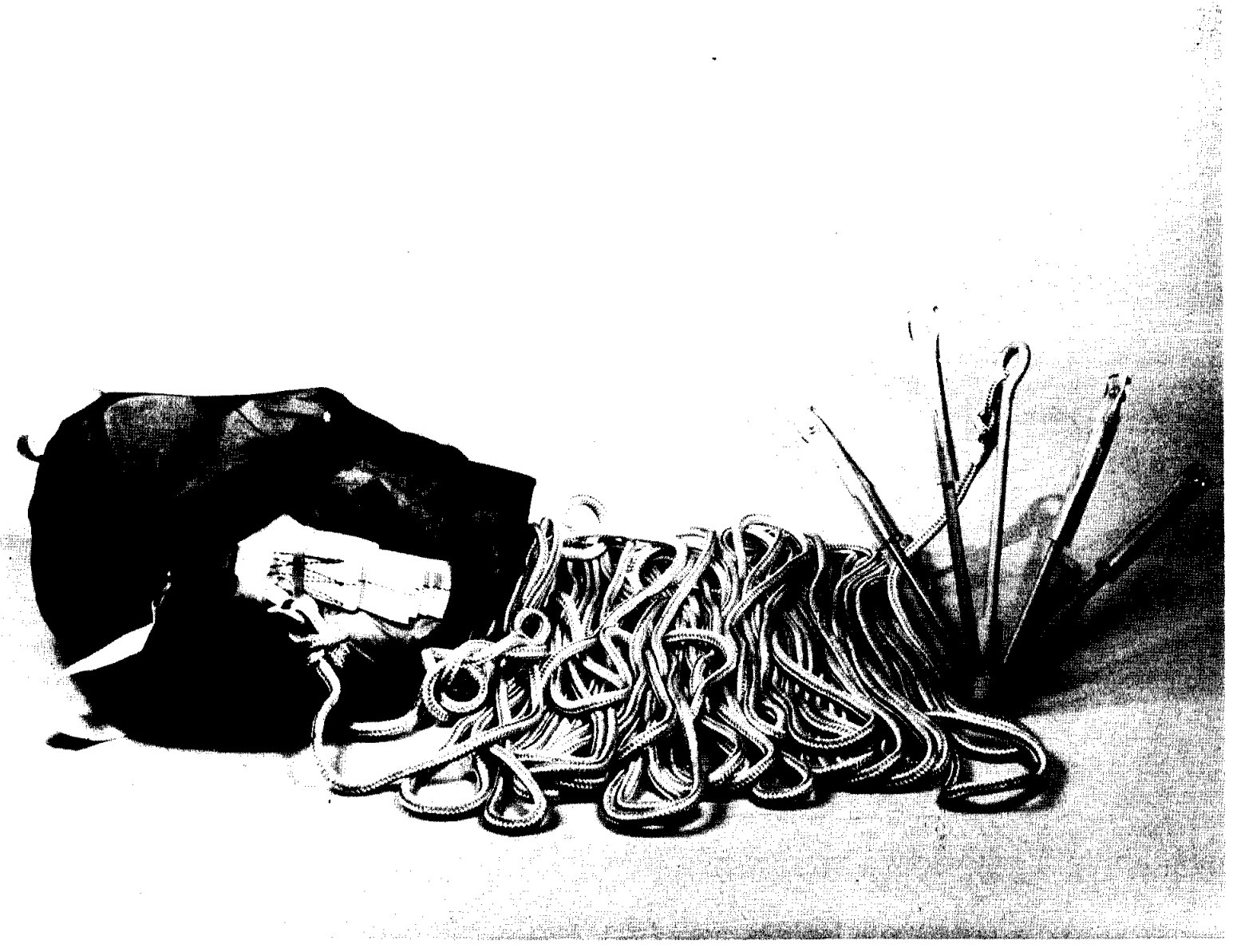
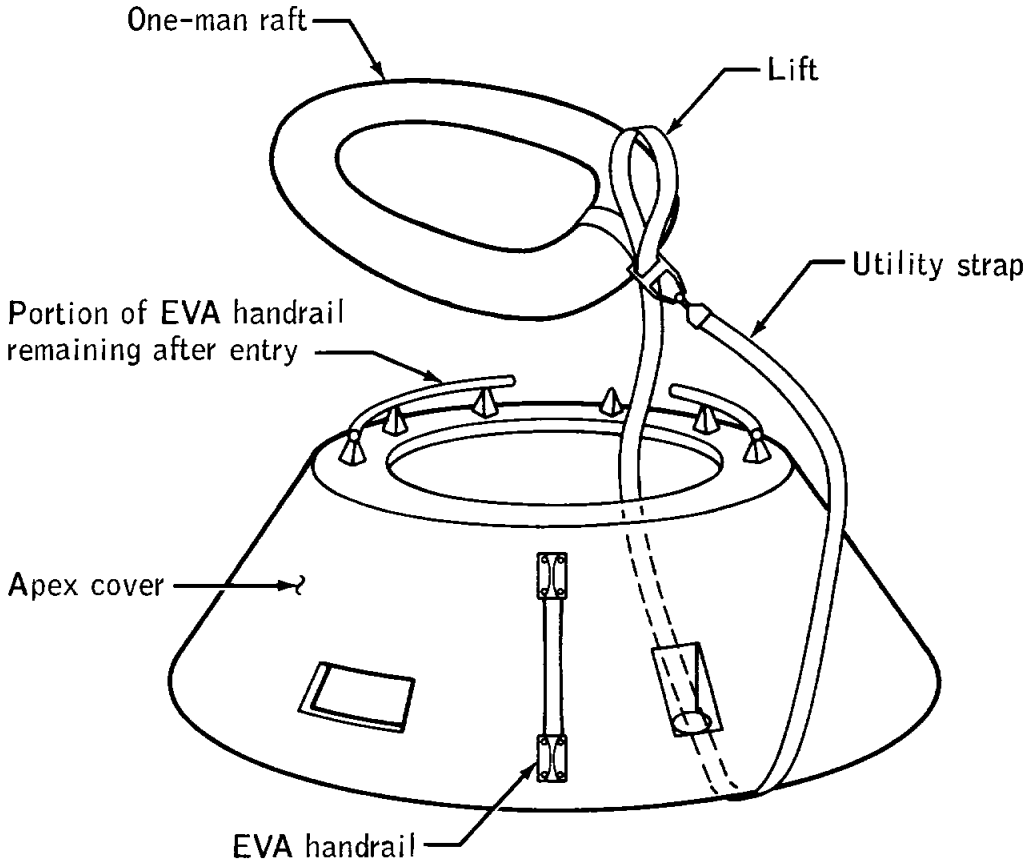


Figure 3-27. Grappling hook/one man life raft package

Figure 3-28. One-man life raft in bag



Caution: Do not lift by
EVA handrails

Figure 3-29. Hook-up of strap to apex cover

(c) As the helicopter is hovering over a visible chute, a crew member opens the grappling hook/one-man life raft package. The raft end is secured within the helicopter and the grappling hook protective covers are removed. The hook is thrown out of the hatch to fall among or below the main parachute shroud lines or, preferably, the canopy. The raft is inflated and deployed.

WARNING

CARE MUST BE TAKEN TO AVOID ENTANGLEMENT OF THE 100' NYLON LINE WITH HELICOPTER ROTORS.

(d) After the flight crew has been recovered, helicopters may direct small boat crews to the snagged main parachutes. Boat crews should attempt to spill the submerged canopies by cutting half of the shroud lines or the adjacent riser extensions. NASA storage bags are provided to stow the parachutes in as they are recovered.

(e) If the main parachute shroud lines have collapsed onto the CM, a one-man raft should be attached to the parachute. Then the shroud lines should be cut near the water--the lines on the CM remaining undisturbed. Should any of the ELS components be damaged during retrieval, it is important that a NASA representative be informed.

3.1.2.6 Swimmer/Helicopter Signals

Signals for use between swimmers and the helicopter crew have been developed on previous missions. They are listed on the following page and several are illustrated in figure 3-30. All signals should be "rogered" for (thumbs up, or during night operations, by turning the helicopter lights off momentarily).

3.1.2.7 Summary Report

The swimmer team leader will record his observations of the recovery by preparing a Swimmer/Pararescue SUMREP as described in section 6.0.

SWIMMER/HELICOPTER SIGNALS

Need doctor in water*	Crossed wrists
Need medical kit*	Crossed wrists
Deploy raft*	Paddling motion
Deploy second flotation collar*	Grab neck
Deploy backup swim team*	Breast swim motion
Lower rescue net	Climbing rope motion, point to astronauts
Lower stretcher or basket (cradle)*	Arms rocking motion
Astronauts OK*	Thumbs up
Helicopter crewman reply, OK, affirm	Thumbs up
Helicopter pilot reply, OK, affirm	Turn forward rotating light off, then on
Helicopter move in or out*	Wave in or out
Sharks	Clap hands

*Signals illustrated in figure 3-30.

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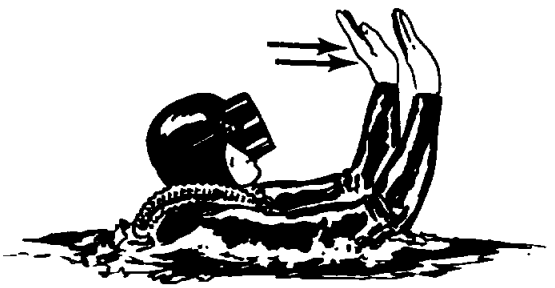
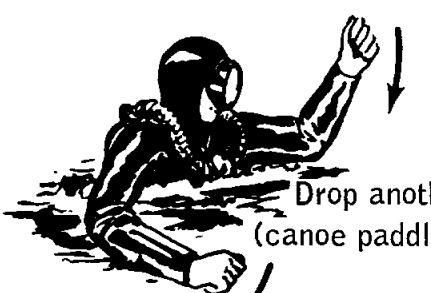


Move away

Astronauts report they are ok

Drop swimmers
(breast stroke motion)

Drop another collar



Drop another raft
(canoe paddling motion)

Drop doctor
if doctor is already in water,
send medical kit

Lower rescue sling for pick-up
(climbing motion)

Lower basket (cradle)
for pick-up
(cradling motion)

Figure 3-30. Swimmer hand signals

3.1.3 Primary Recovery Ship Operations

3.1.3.1 Special Equipment

Brief descriptions of the major items of NASA/DOD-furnished equipment used aboard the primary recovery ship for CM retrieval and handling are given on the following pages.

To help ensure that all required equipment is onboard the primary recovery ship, the following checklist should be used. This is a complete listing of hardware items required for simulation and recovery support.

ITEM	NUMBER
Spare 120' 1 5/8" double-braided nylon line	2
SARAH installation for search helicopters	5 sets
Operational flotation collars	6
Training flotation collars	6
Apollo recovery rafts (operational)	6
Apollo recovery rafts (training)	6
Sea anchor (8-ft. diameter)	15
CM transportation dolly	1
Apollo boilerplate dolly	1
Apollo boilerplate CM	1
Mercury hooks	4
Mercury poles (16 ft.)	2
Recovery hooks for CM (with shackles)	2
Nylon recovery straps (12 ft.)	2
Hatch tools for CM	5
Underwater cameras	3
CW training beacons (modified)(with shorting plugs)	4
CW training beacon antennas	4
CW training beacon batteries	64
Flashing lights	3
Flashing light batteries (12 volts)	2
Beacon/flashing light switchplate assy.	1
Beacon/flashing light wiring harness	1
Two-inch nylon line (1200 ft.)	1
Sea dye packages	12
CM work stand	1
One-man life rafts	18
Window covers	1 set
Took Kit	1
Access Panel Removal Kit	1

ITEM	NUMBER
Thruster plug kit	1
Parachute bags	3
Hook leaders with bolts	2
Uprighting sling assy.	5
Rubber gloves	2 Pr.
Industrial type vacuum cleaner	1
Grappling hooks	9
Compressor for SCUBA tanks	1
Recovery net stiffners	6 sets
Cover for CM	1
CO_2 Absorber bags	24
Plastic Bags:	
Small	50
Medium	100
Large	100
Plastic tape	8 rolls

In addition to the aforementioned items, several items of normal shipboard equipment such as lines, tugs, pallets, etc., will be required These items are covered in paragraph 3.1.3.4

Apollo CM Transport Dolly - The Apollo CM transport dolly (fig. 3-31) is a four-wheeled trailer used in handling the CM aboard the primary recovery ship, on land, and for support of the CM during air transportation. The dolly weighs approximately 3,550 pounds when empty. Its overall length is 205 inches (including the tow bar). With the outriggers extended, the dolly is 127 inches wide and 45 inches high. The wheel base is 135 inches. For more detailed information, see ref. 4.

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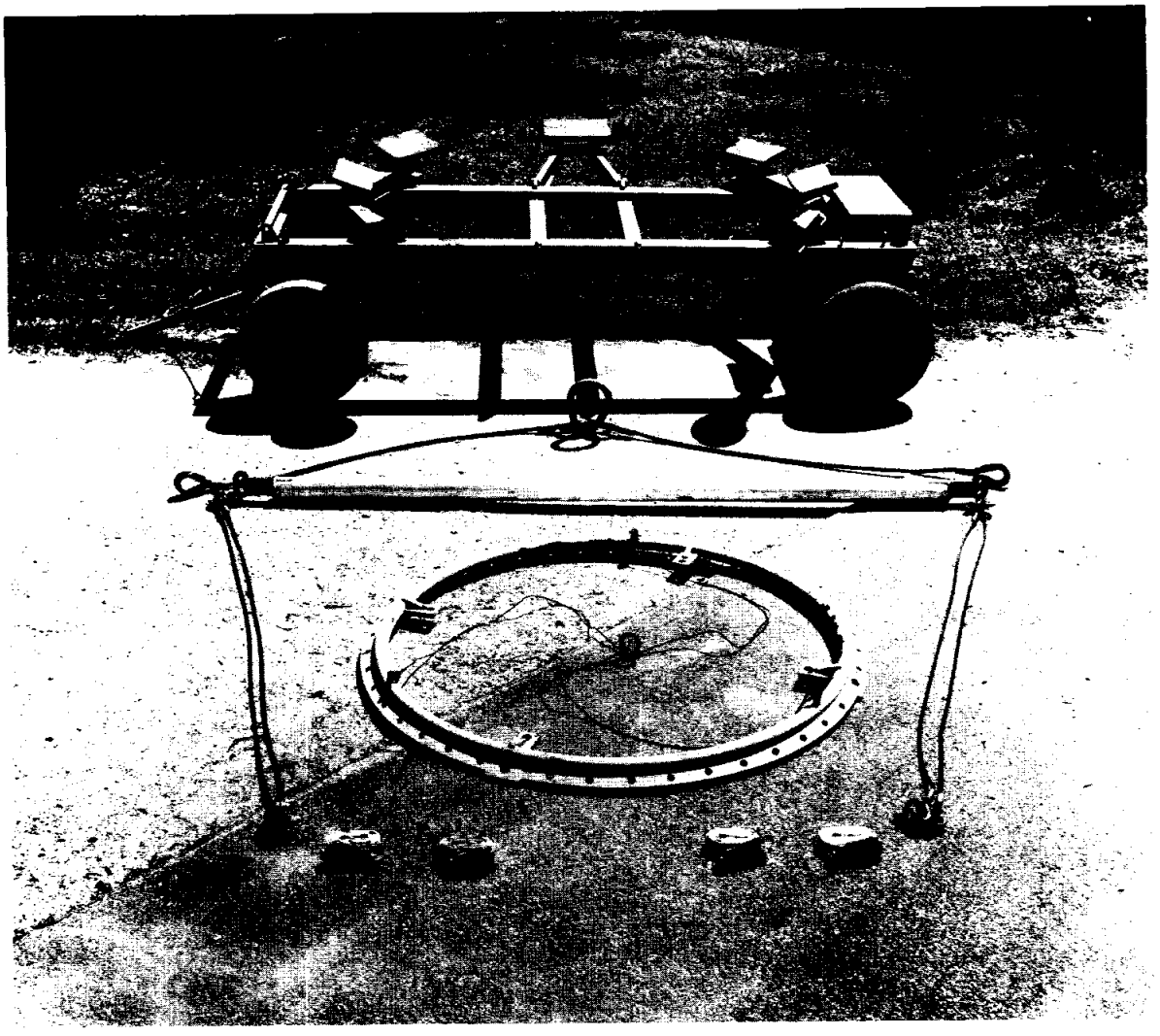

Figure 3-31. Apollo CM transport dolly

Apollo Boilerplate Dolly - The Apollo boilerplate dolly (fig. 3-32) is furnished to facilitate movement of the boilerplate CM on an aircraft carrier hangar deck. The dolly allows the boilerplate to be handled by a limited number of personnel, and also reduces the amount of moving equipment required.

Figure 3-32. Apollo boilerplate dolly

3.1.3.2 Safety Precautions

In addition to the safety precautions given in section 2.0, the following procedures shall be observed on all types of ships involved in recovery operations.

(a) Designated safety officers/observers shall observe the retrieval activity and ensure that safe procedures are used in all operating areas.

(b) All personnel who may be in the vicinity of the CM shall be properly briefed on the CM hazard areas described in section 2.0 of this manual.

(c) All recovery team assignments shall be established prior to the start of a recovery operation.

(d) Communications between the bridge and the recovery crew in the retrieval area should be established prior to the start of recovery activity.

(e) Recovery team members working on deck shall wear life jackets and hard hats.

(f) All personnel not actually participating in retrieval operations should remain clear of the deck areas where recovery teams are working.

(g) Both the boilerplate CM and cradle should be tied down at all times except when the boilerplate is being launched or retrieved.

(h) A properly-equipped fire fighting party should be standing by while the CM is being brought aboard (section 2.2.3).

(i) Portable fenders should be available.

(j) If a ship is in the area of UDT/pararescue personnel operations, small boats should be lowered as safety boats.

3.1.3.3 Rigging and CM Retrieval Procedures

The following rigging and CM retrieval procedures can be utilized by the following types of ships: Aircraft Carrier (CVS); Landing Platform, Helicopter (LPH); and Landing Platform, Dock (LPD).

Rigging - General B&A crane rigging is shown in figure 3-33.

It is recommended that a $1\frac{1}{2}$-inch nylon line be used for the CM in-haul line. The in-haul line must be long enough to allow it to be led out approximately 600 feet from the ship to the CM.

Retrieval

(a) The ship is maneuvered into the wind on a course opposite and parallel to that of the CM so that the CM will be positioned about 100 to 200 feet off the pick-up side of the ship, as shown in part (a) of figure 3-34.

(b) The ship is then maneuvered so that it will ultimately be stopped with the bow approximately 10 degrees to the right of wind direction and with the CM approximately 200 feet off the starboard side of the ship and well forward of the recovery area. This will allow the ship to swing to form a lee during recovery operations and will decrease the maneuvering required with the CM and swimmers alongside. Part (b) of figure 3-34 shows the relative positions, and (c) and (d) show subsequent ship maneuvers.

NOTE

Due to the criticality of positioning the CM for retrieval, the ship should not hesitate to make a second approach to the CM in the event the first approach is not optimum for a retrieval operation.

(c) The swim team leader will position the swimmers to receive a short line after the recovery ship comes alongside. The shot line which is bent to the in-haul line (with mercury hook attached) is fired to the CM. The following warning signals used in sending the shot line to the CM shall be carefully observed by all personnel concerned.

Readiness to receive shot line: UDT personnel at the CM indicate their readiness to receive the shot line by giving a thumbs-up signal.

Readiness to fire shot line: Ship's personnel signal their readiness to fire the shot line by displaying a green paddle or a green light from the bridge area.

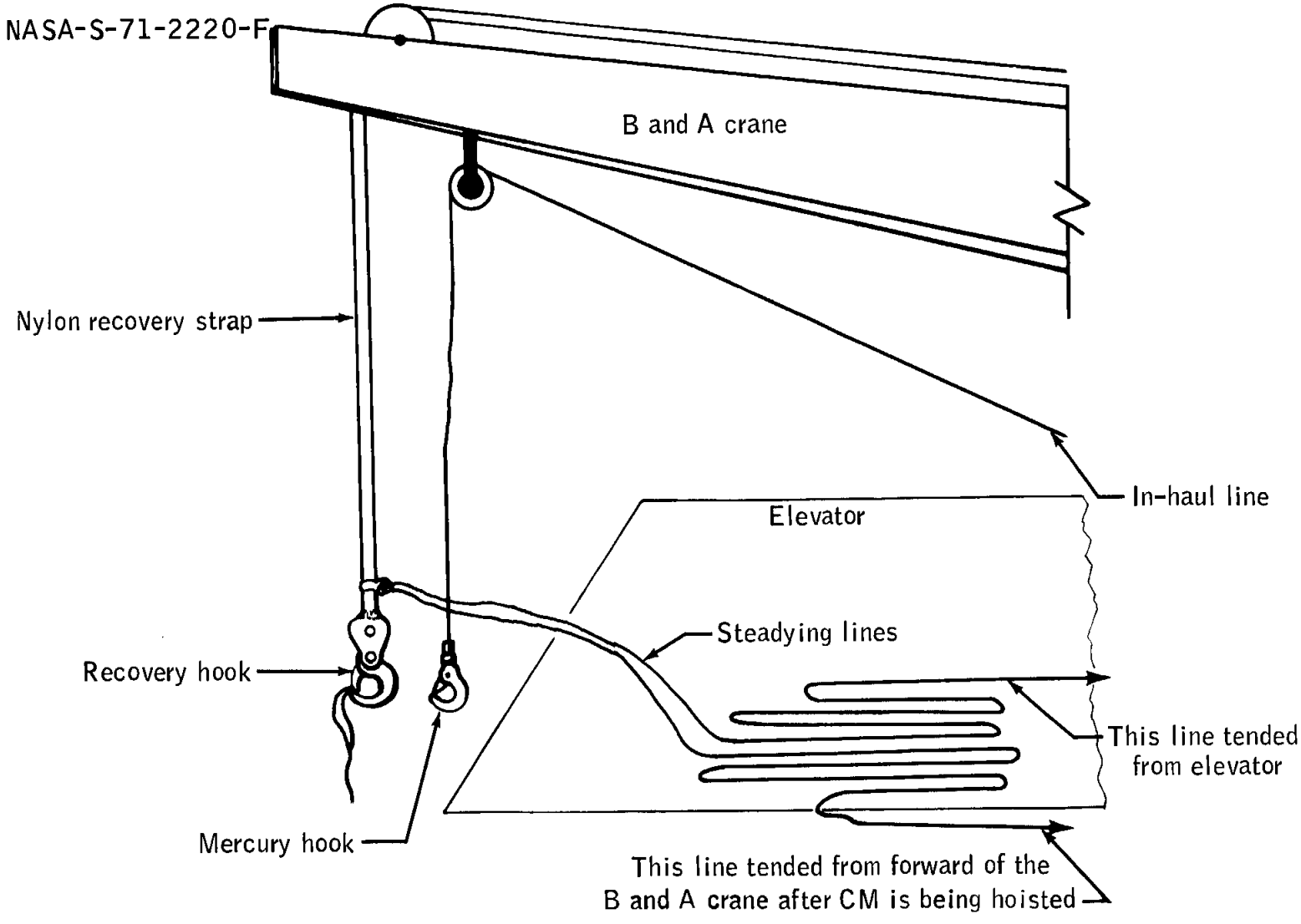

Figure 3-33. Rigging of B&A crane and hooks

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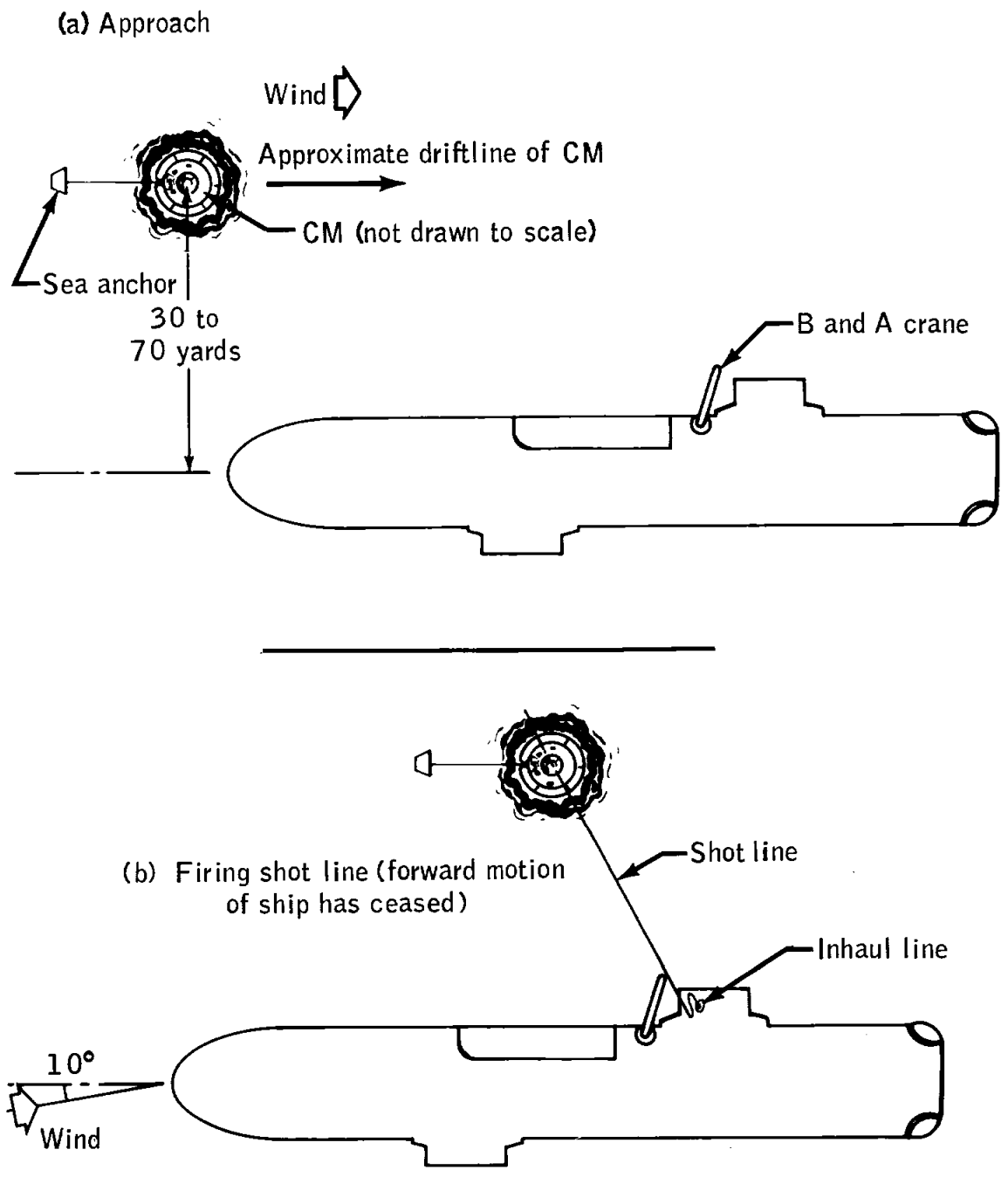
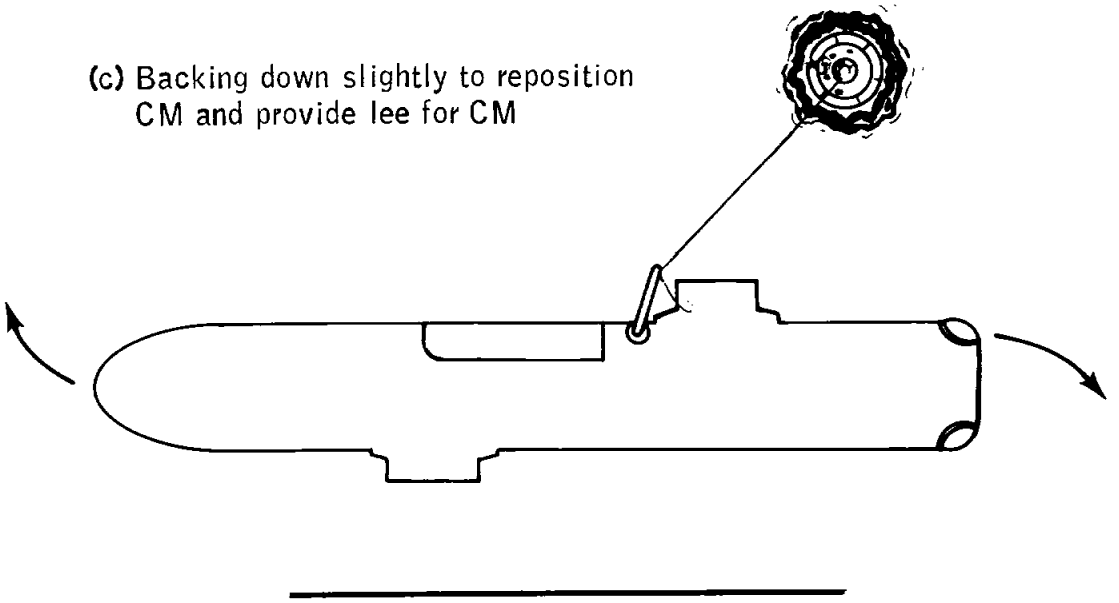


Figure 3-34. Ship approach



(d) Hauling CM into position for connecting recovery hook

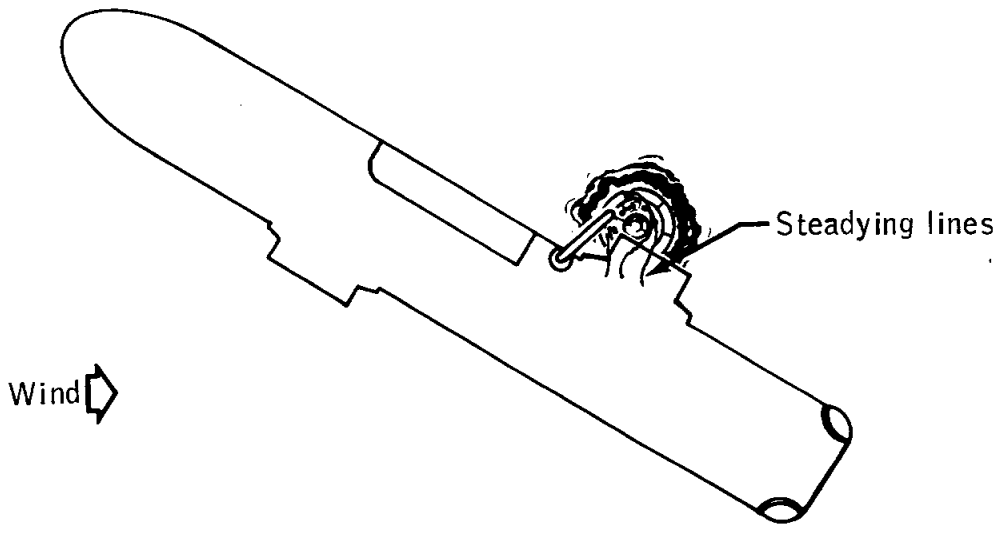


Figure 3-34. Concluded

WARNING

UPON SEEING THE GREEN PADDLE OR THE GREEN LIGHT, PERSONNEL AT THE CM SHALL TAKE COVER BEHIND THE CM.

Firing signals: Immediately before the line-throwing gun is fired, ship's personnel display a red paddle or a red light from the bridge area, and sound three short blasts on a police whistle over the loudspeaker system. If the projectile falls short of the CM or if the gun misfires, the firing signals are repeated and another projectile is fired.

(d) When the shot line is retrieved by the swimmers, they pull the in-haul line out to the CM and snap the mercury hook onto the RCS engine protector. They will then deflate the sea anchor, haul it into a raft, and give a thumbs-up to signal the ship to commence hauling in the CM.

NOTE

During training exercises, the sea anchor should be deflated and hauled into a raft for future use. During mission operations, the sea anchor should be saved on a "not to interfere" basis.

(e) The CM is then hauled into the ship.

(f) As the CM comes under the B&A crane, tension is maintained on the in-haul line while the recovery hook with the steadying lines attached (fig. 3-36) lowered to the swimmer on the CM.

(g) As the recovery hook is received by the swimmer on the CM, he cuts the steadying lines loose and passes them to another swimmer on the collar who attaches them to the CM sea anchor attachment ring. The swimmer on the CM then engages the recovery hook in the recovery loop.

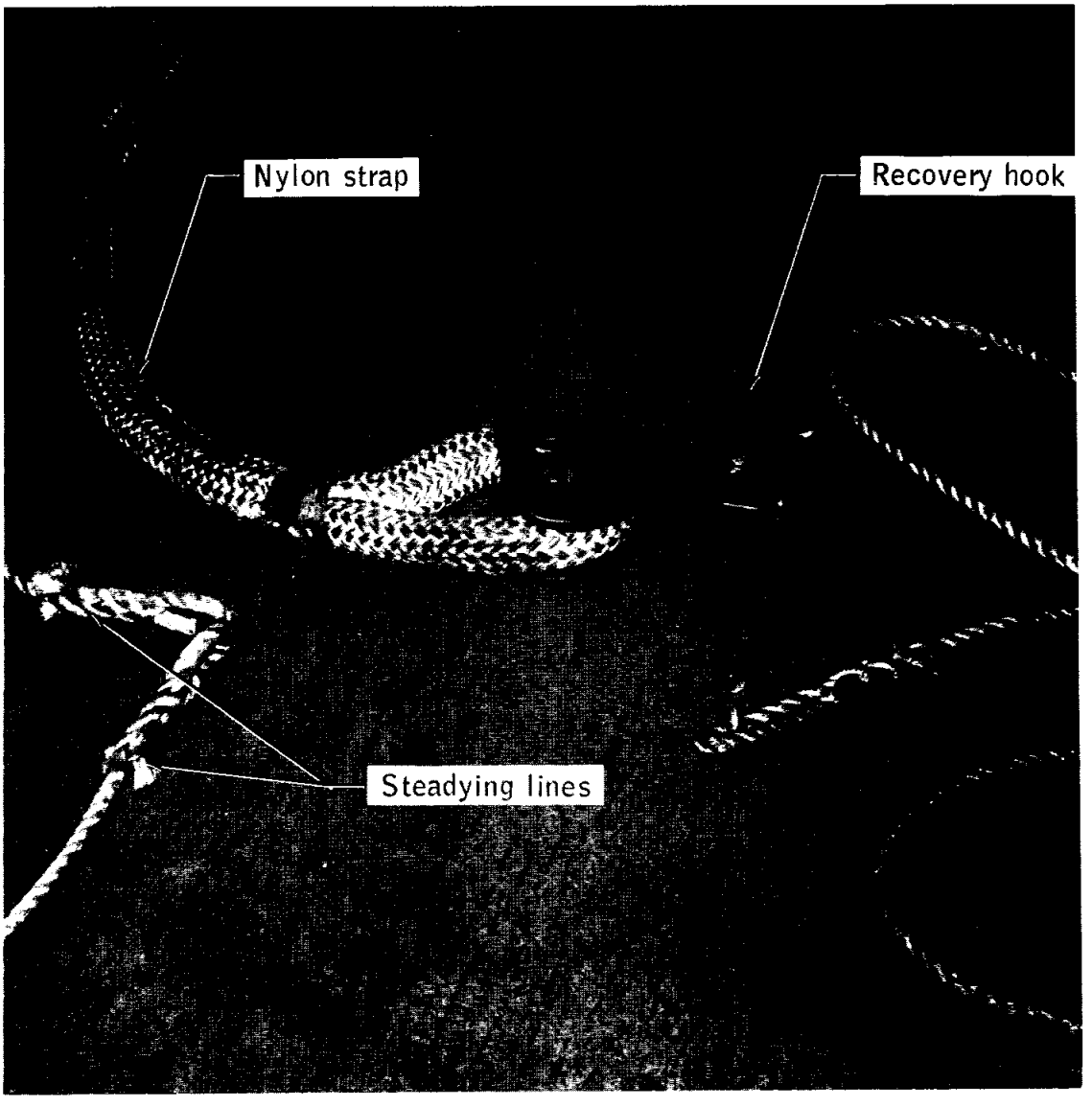


Figure 3-35. Rigging of recovery hook steadying lines

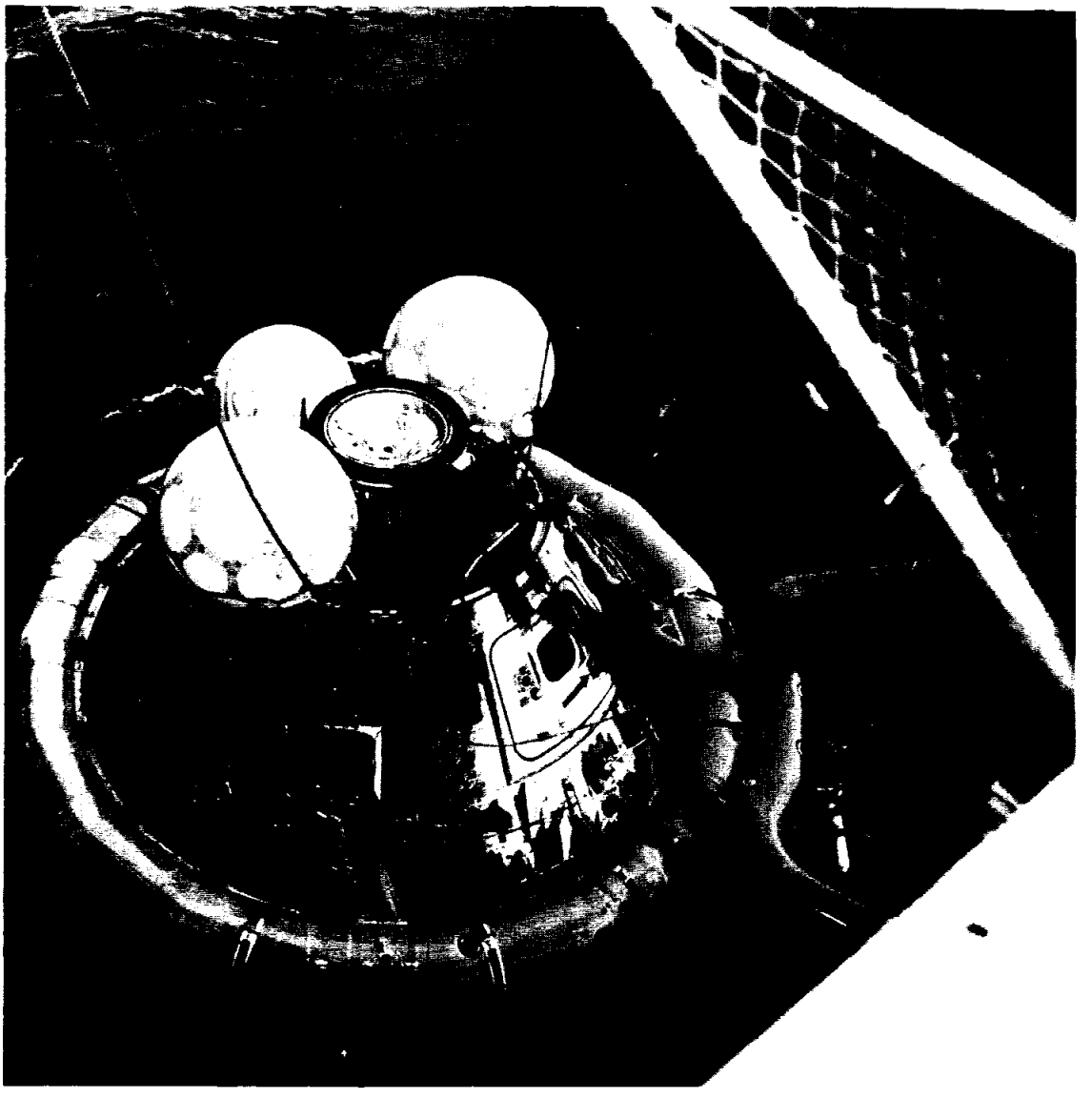


Figure 3-36. Recovery hook being lowered to swimmers

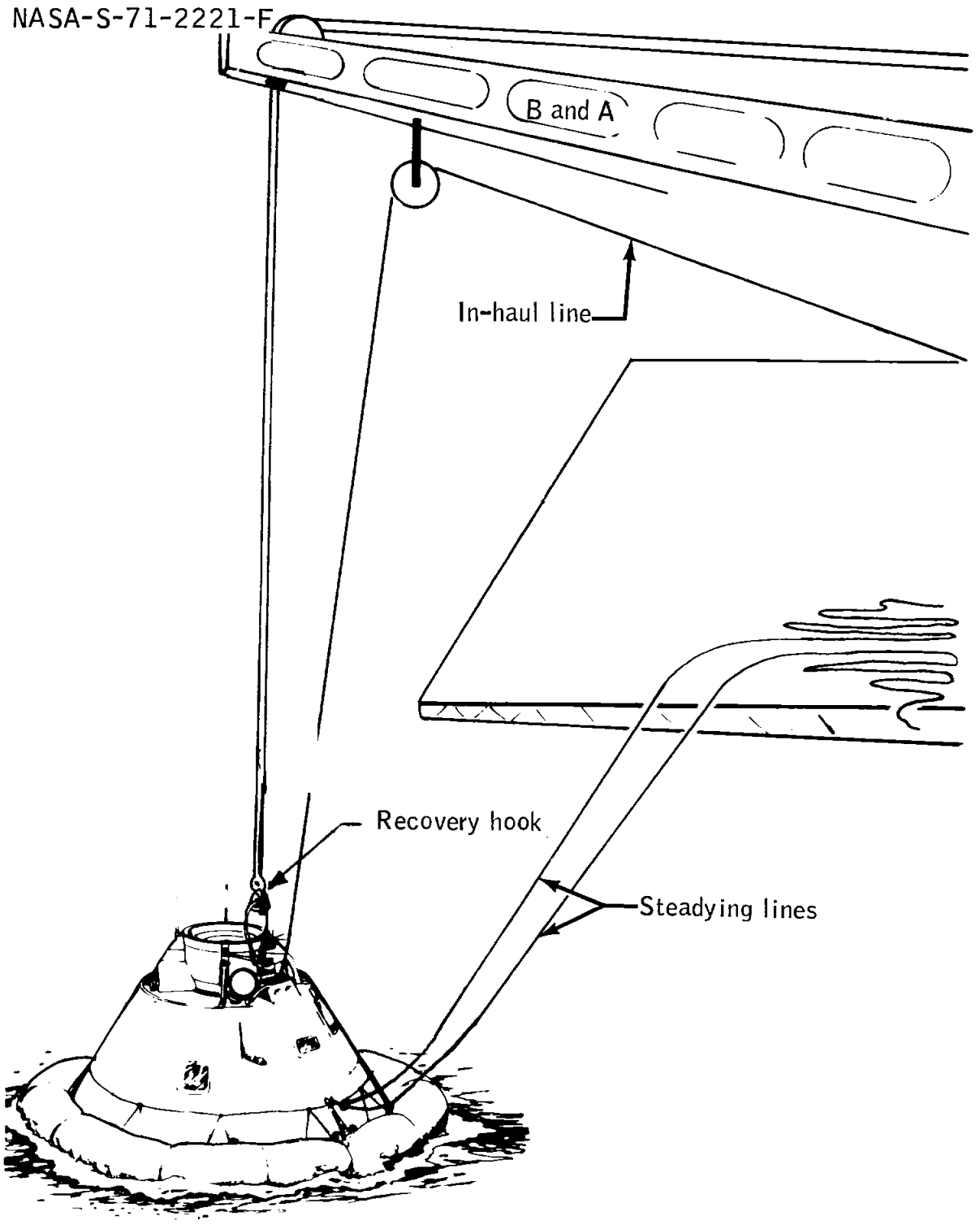


Figure 3-37 Rigging with CM under B&A crane

NOTE

The steadying lines hook must be attached directly to the CM ring, not the sea anchor/collar hooks. The steadying lines are tended from the elevator until the CM is lifted from the water, at which time the lead on one line is shifted to a more favorable position.

(h) Swimmers move clear of the CM before the hoisting operation is initiated.

(i) During the initial phase of hoisting, oscillation of the CM is minimized by the steadying lines. Ship's personnel continue to man the steadying lines until the flotation collar is removed and the CM is placed on the dolly.

3.1.3.4 Postretrieval Operations

CM postretrieval operations are started as soon as practicable after the CM has been retrieved and secured aboard the recovery ship. Step-by-step procedures during postretrieval operations are given in reference 5. A NASA recovery team member will open the CM hatch and perform the postretrieval activities. CM exterior operations and inspection will also be performed by NASA team members.

The major tasks performed are:

(a) Hatch openning.

(b) Recording instrument readings and switch positions.

(c) Systems shutdown.

(d) CM interior inspection.

(e) Removal of lunar samples, experiments, cameras, data recording equipment, and the crew equipment.

(f) CM hatch securing.

(g) CM exterior inspection.

(h) Removal of RCS access panels.

Photographs, both movie and still, are taken during the post-retrieval operations. Photographs are taken of all accessible CM systems, equipment removed from the CM, and any anomalies found.

During this operations, the ship will be requested to provide the items listed as follows:

Item	Number
Telephone at CM area with assigned number	1
Mobile photo platform (platform built on fork lift)	1
Air hose (100 ft)	1
Fire hose with fog nozzle	1
Electrical extension cords (115V ac)	2
Fresh water supply with small garden type hose	1
Trash cans	2
Wooden pallets	2
Voltmeter	1
Work tables (folding mess tables)	2
Chairs	2
Sponges	2
Water bucket	1
Fire extinguisher	1

These requirements vary, and the NASA recovery team leader will coordinate all requests for support with the ship's personnel.

(Additional information will be furnished in reference 6 concerning medical, PAO, communications requirements, etc.).

3.1.3.5 Summary Report

A ship SUMREP (see section 6.0) will be prepared as soon as possible after recovery and forwarded to the designated addresses.

3.1.4 ARRS Aircraft Operations

Near the primary landing area, rescue aircraft will be stationed along the entry ground track. These aircraft will normally play a supporting role in CM location/retrieval operations during the entry and postlanding phases of the mission.

The recommended number, positions, and altitude of these aircraft will appear in the applicable issue of ref. 6. For information on rescue aircraft search procedures and deployment of pararescue teams, see section 3.2.1.

3.2 SECONDARY AND LAUNCH ABORT LANDING AREAS

Secondary recovery ships/refuelable heavy-lift helicopters will normally be available for recovery support in the launch abort and West Atlantic secondary landing area, in the event the CM must land early and cannot reach the primary landing area.

The launch site recovery helicopters are available for recovery support within launch sector A and the Westlant earth orbital landing area. HC-130P/N aircraft will accompany the helicopters to and from the landing area to provide inflight refueling and navigational/communication assistance.

Fixed-wing aircraft are also available to support a landing in the launch abort and secondary landing areas. The primary mission of these aircraft/crew is to locate the CM, installation of the flotation collars, and aid to the astronauts, while awaiting retrieval by recovery ship or helicopter.

3.2.1 Land-Based Air Search Operations

3.2.1.1 CM Location

Special Equipment - The AN/ARD-17 Direction Finder Set (fig. 3-38) is installed in ARRS HC-130 aircraft to provide reception of the CM S-band signal during the entry phase of the mission, and provide reception of the CM recovery beacon for location of the CM during the main parachute/postlanding phase of the mission.

The ARD-17 has two operating frequency ranges (2225-2300 MHz and 225-300 MHz) that are compatible with the CM S-band signal (2287.5 MHz) and the recovery and survival beacons (243.0 MHz). The ARD-17 antenna consists of a pair each of VHF and S-band corner reflectors and monopole feed elements mounted on a common ground plane. The whole antenna system is mounted in a dome on top of the aircraft as shown in figure 3-39. Also shown in this figure is the location of the control set and the printer at the right-side scanner's position.

The ARD-17 equipment provides a printed record of electronic bearing contacts and visual and audible indications of signal presence and strength. For detailed operating, checkout, and maintenance instructions, see reference 7.

The first step in checking out the ARD-17 is boresighting; that is, aligning the control set bearing indicator and the printer readout with the aircraft center-line. A point of reference for all systems is the aircraft center-line. Boresighting must be done to ensure that

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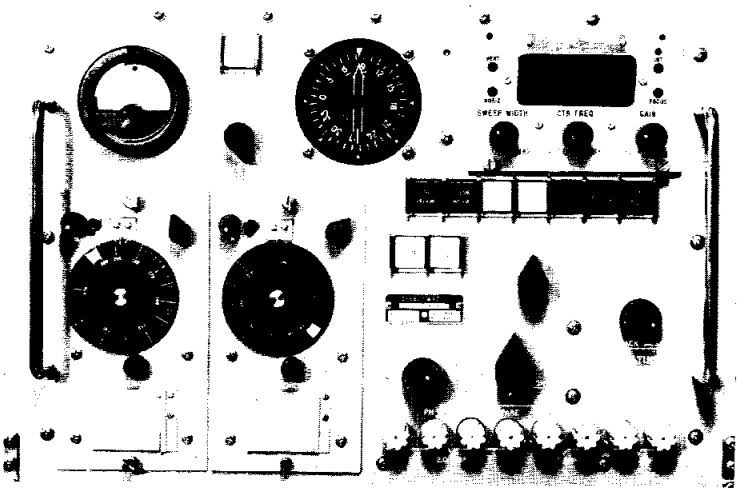

(a) Control set

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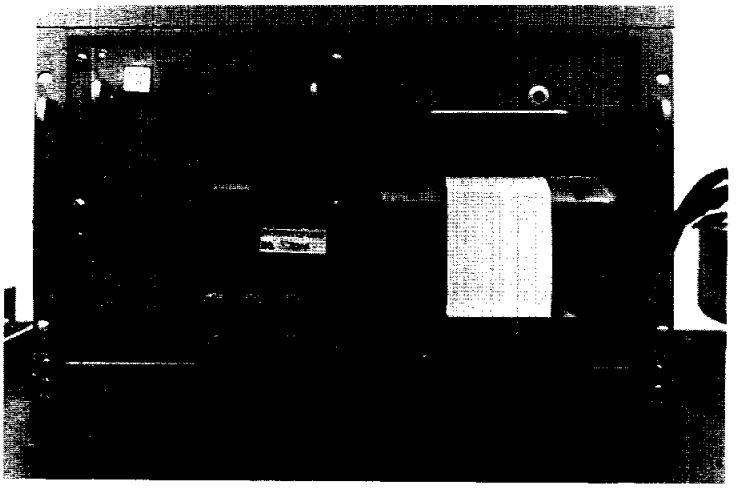


(b) Printer

Figure 3-38. AN/ARD-17 direction finder set

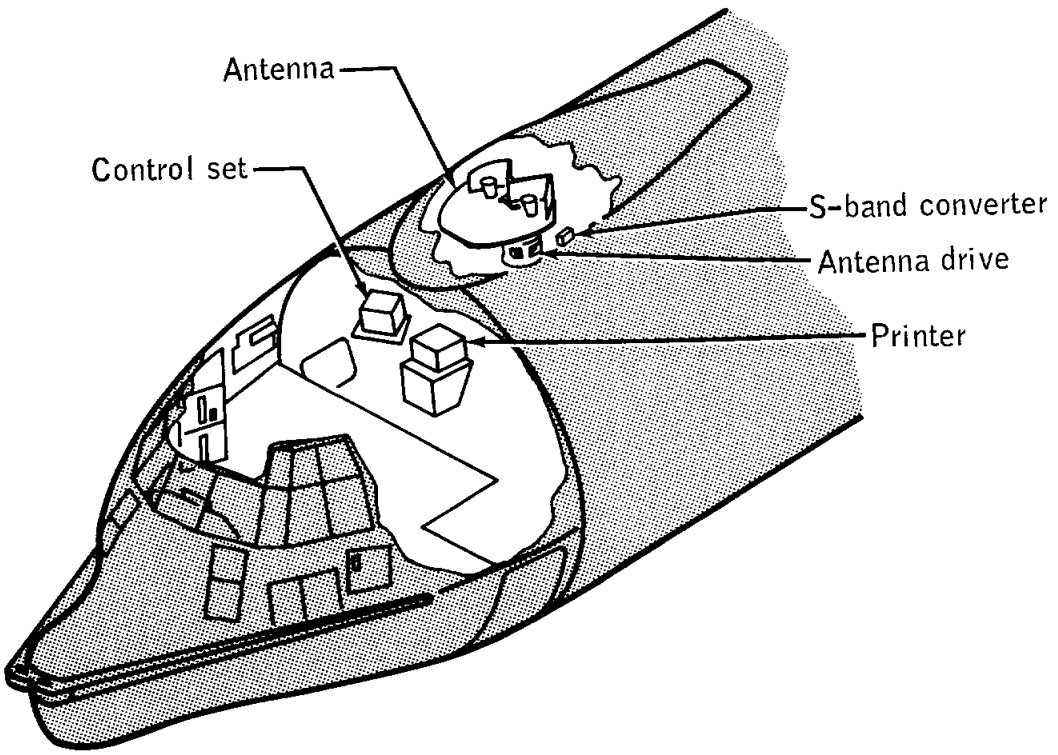


Figure 3-39. AN/ARD-17 installation in HC-130 aircraft

the bearing data provided by the equipment is accurate. Reference 7 also gives detailed instructions concerning the boresight procedure.

Just prior to take-off, a walk-around test should be performed using the AGE item 1 test transmitter. The transmitter is turned on and carried in an arc around the front of the aircraft. The antenna should track it around the arc and produce the correct bearing information. This test should be performed on two frequencies--242.0 MHz and 2287.5 MHz.

A test beacon located on a high point such as a hill or roof top may provide a signal source for a final check of the equipment. (This may be done on any inbound flight just prior to the day of recovery.)

As part of the standard aircraft equipment, the ARA-25 Automatic Direction Finder (ADF) is also available as an electronic location aid.

ARD-17 Search Procedures - Prior to the mission, the rescue aircraft will possess the following information:

(a) Aircraft on-station position and time

(b) Aircraft station departure time

(c) True inbound heading to the ground track

(d) S-band acquisition of signal (AOS) time

(e) S-band AOS bearing

(f) Begin blackout (BBO) and end blackout (EBO) times

(g) VHF recovery beacon AOS time

This information will be updated as necessary prior to CM entry. The best estimate of the CM landing point will be sent to the aircraft as soon as possible.

Before the electronic search is initiated, one receiver should be set for the S-band frequency (2287.5 MHz) and the other for the VHF recovery beacon frequency (243.0 MHz). More detailed tuning procedures are found in reference 7. Recommended search altitude is 25,000 feet. See figure 3-3 for possible signal acquisition ranges.

At the appropriate time the aircraft should depart its station and fly on the predetermined inbound heading which is perpendicular to the predicted CM ground track. Time hacks should be obtained from WWV

and the printer's timer started well in advance of the search run. The actual printout process may start as late as station departure time. The operator should initially utilize the S-band mode of operation and attempt to receive the CM S-band signal. The antenna should be slowly slewed 30° to either side of the given S-band AOS bearing. If there is no signal reception by expected AOS time plus one minute, the ± 30° search sector should be abandoned and, if no further information as to the location of the CM has been obtained (e.e., visual sightings, etc.), a ± 90° search centered about the aircraft's inbound heading should be initiated (with an occasional 360° slew of the antenna).

Once the operator has established contact on S-band and the antenna is tracking, the set should be allowed to stay locked onto the signal. An S-BAND ANNOUNCEMENT should be transmitted and a CONTACT REPORT shall be prepared (see section 6.0) as soon as possible and will be transmitted upon request. Shortly before VHF recovery beacon AOS time, the second receiver of the control set should be activated to receive this signal. At first recovery beacon contact, a RECOVERY BEACON ANNOUNCEMENT should be sent, and a CONTACT REPORT shall be prepared as soon as possible and will be transmitted upon request.

NOTE

See page 3-6 for search aircraft/CM VHF voice communication procedure.

Aircraft near the predicted CM landing point should start a descent as soon as the VHF recovery beacon is acquired. The signal may be lost because of the line-of-sight limitation if the aircraft descends too fast. If this happens, the aircraft should level off until reacquisition occurs, and then begin a more gradual descent to visual search altitude.

NOTE

On VHF, the antenna will track not only the true signal source, but also two false signal points located about 140° on either side of the main antenna pattern lobe. By using the Manual Gain Control (MGC) to set the signal strength of the suspected main lobe at a reference value (i.e. 100 uV), slewing the antenna to the other two lobes, and watching the signal strength meter, the operator can positively determine the strongest signal strength and therefore the true signal direction.

Station passage on the CM will be indicated by a sharp turn of the needle and a drop in signal strength when the aircraft passes abeam, and by a stabilized needle and a drop in signal strength when it passes directly overhead. The printed tape should be marked to indicate AOS and LOS times, frequencies, aircraft call sign, and whether the bearings are true or magnetic. As soon as visual contact with the CM is made, a CONTACT REPORT shall be sent (see section 6.0).

If no VHF signal is received from the CM, the S-band signals received during the reentry can be used to provide location assistance. These will help to determine that the CM has passed certain positions. The landing footprint area to be searched may then possibly be reduced, and the time to CM location decreased.

3.2.1.2 Deployment of Pararescuemen and Equipment

The pararescue recovery team onboard an ARRS HC-130 aircraft will consist of three men equipped with full SCUBA equipment.

Personnel and equipment may be deployed by one of two methods: with or without the Aircraft Delivered Drift Reduction System (ADDRS). (The ADDRS is designed to decrease the CM drift rate prior to pararescue deployment.)

NOTE

If a landing occurs in Launch Abort Sector A, launch site HH-53 helicopters may arrive on-scene before HC-130 pararescue/equipment deployment is complete. Due to the increased speed and safety of helicopter deployment, upon arrival on-scene BEACHBOSS or the senior helicopter pilot will assume on-scene commandr responsibilities, advise the HC-130 aircraft commander to terminate his deployment, and then proceed with pararescue/equipment deployment from the helicopter. Astronaut retrieval will be accomplished in accordance with procedures contained in this Manual.

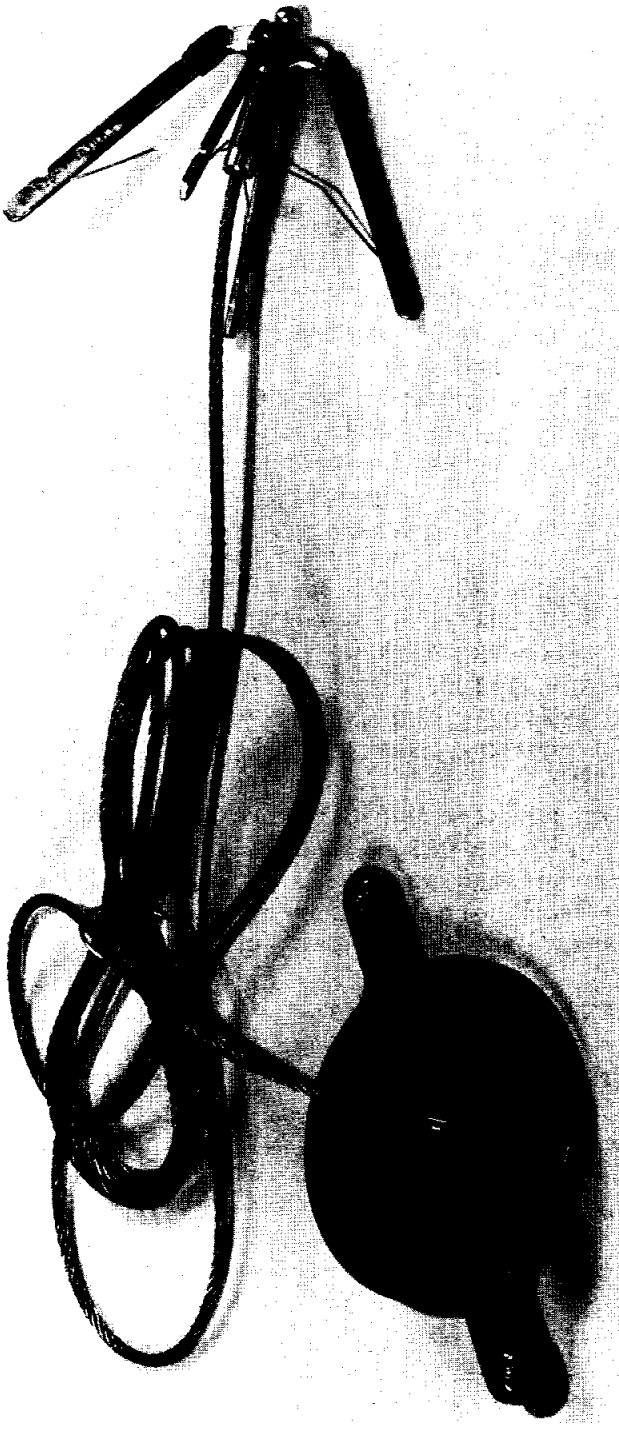


Figure 3-40. CM grappling hook

With ADDRS

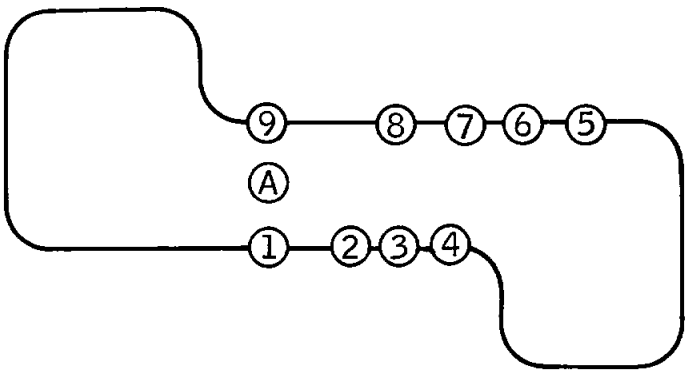
This system consists of two packages connected by 840 feet of buoyant line. One package is a flotation collar, the other is a collar bag containing parts of an MA-1 survival kit (ref. 8). The packages are delivered from an altitude of 300 feet by HC-130 aircraft using ARRS procedures for delivery of MA-1 kits (reference ARRSM 55-130). A small collapsible grappling hook (fig. 3-40) deployed from the CM is used to engage the ADDRS in case the CM drifts over the buoyant line. After receiving word from the rescue aircraft that the ADDRS is to be used, the astronauts will remove the dump valve from the CM side hatch and push out the grappling hook. The hook is attached to the CM by a 10-foot cable secured to the dump valve cover plate. Before deploying the ADDRS, the aircraft crew will verify that the astronauts have deployed the grappling hook.

WARNING

DURING ARRS AERIAL DEPLOYMENT OPERATIONS, ALL OTHER AIRCRAFT IN THE AREA WILL MAINTAIN AN ALTITUDE OF 2,000 FEET, OR ABOVE, AND WILL REMAIN CLEAR OF THE DROP ZONE.

The ADDRS packages are deployed from the rescue aircraft by the overhead delivery system (ODS). There is a time delay of approximately 3.8 seconds between package deployments. The packages are deployed using 15-foot cargo extraction parachutes (ring slot) which are used as sea anchors once the packages are in the water.

During the ADDRS delivery (fig 3-41), the aircraft flies a leg perpendicular to the CM driftline on the updrift side of the CM. When the aircraft is abeam the CM, the pilot starts a count and drops a smoke signal 2 seconds past the CM. After dropping the smoke, the aircraft maneuvers to make a return pass (final, deployment pass) on the downdrift side of the CM. The ADDRS deployment is initiated when the aircraft is abeam the smoke signal (fig 3-42). After deployment, the aircraft will ascend to an altitude of 1,000 feet to observe results of the drop and prepare for pararescue deployment. The packages should be spread so that the drifting CM will contact the buoyant line at its approximate mid-point (fig 3-43). (After contacting the line the CM continues its drift.) The line will either slide up the CM and snag itself under the inflated uprighting bags, or it will pass under the CM and be caught by the astronaut-deployed grappling hook (fig 3-44). The flotation collar and MA-1 kit package then tend to draw together as their parachutes act as sea anchors. When



Driftline

Drop is downdrift of target

A - Position of CM
1 - Note time abeam CM
2 - Drop smoke bomb 2 seconds past target
3 - Smoke bomb impact area
4 - Begin procedure turn immediately after dropping smoke bomb
5 - Notify crew, "30 seconds from target"
6 - Notify crew, "10 seconds from target"
7 - Command, "Ready"
8 - Command, "Drop"
9 - ADDRS deployment

Figure 3-41. ADDRS delivery pattern

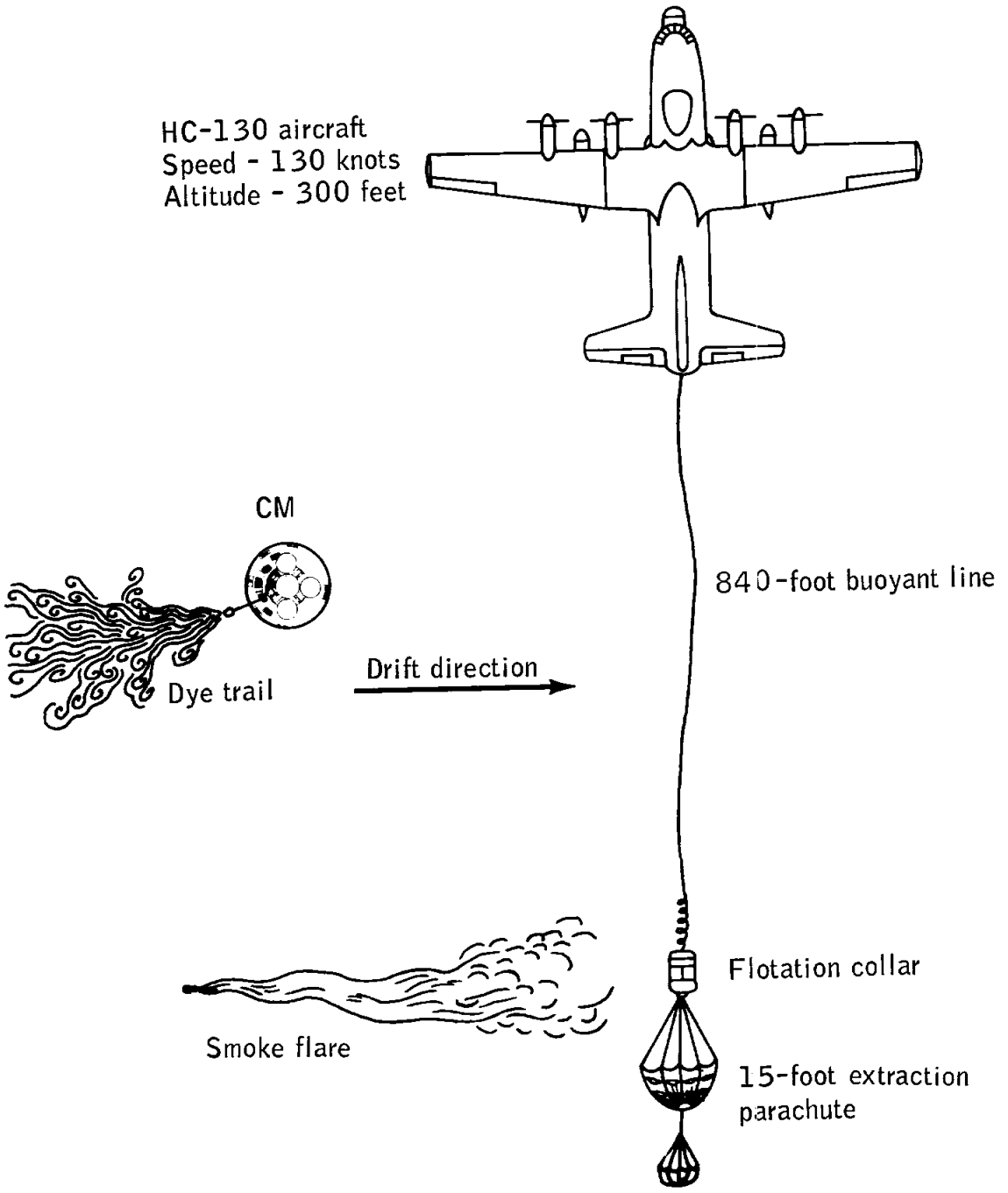


Figure 3-42. Delivery of line/package

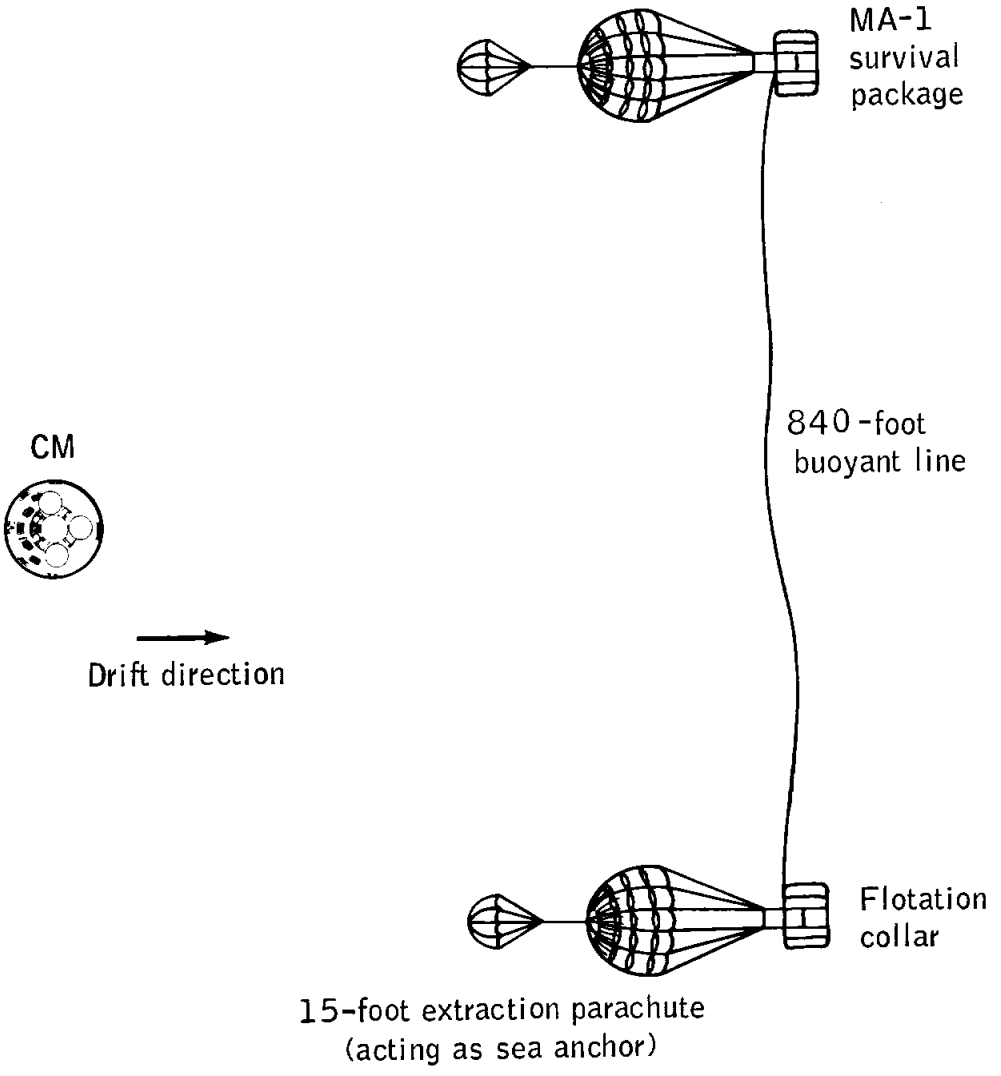


Figure 3-43. Line in place for intercept

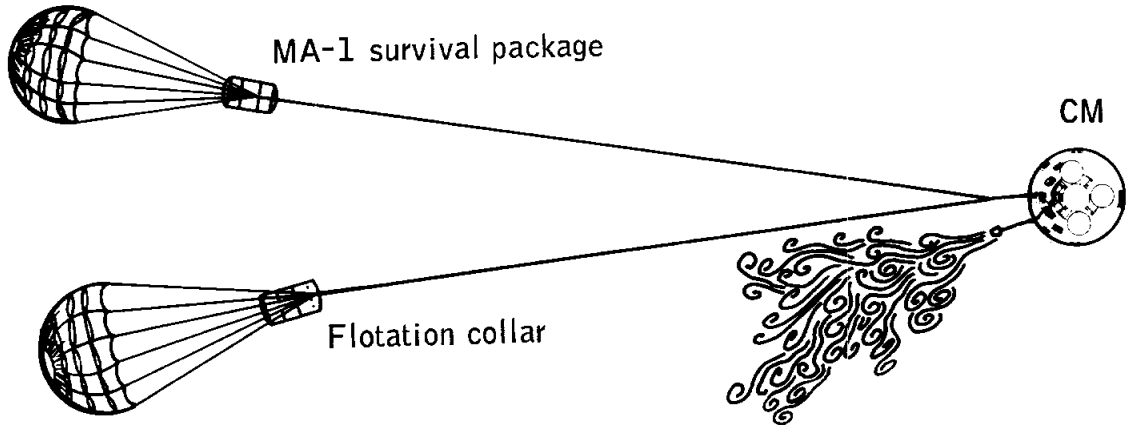


Figure 3-44. Line snagged by CM

the parachutes have slowed or stopped the CM drift rate, the aircraft will initiate pararescue deployment. Pararescue deployment procedures will be as outlined in ARRSM 55 -130. The normal deployment sequence will be: spotter parachute on first pass, two PJ's on second pass, third PJ on third pass.

The first pararescueman to arrive at the CM will attach and deploy his reserve parachute. He will then tie the buoyant line to the grappling hook so that the packages will not become separated from the CM. One of the pararescuemen will swim to the collar package (the package to his left, looking from the CM). He will disconnect its parachute and swim the collar to the CM. The others will assist by pulling in the line.

The flotation collar will be installed using procedures listed in section 3.1.2.3.

After the collar is inflated, one pararescueman will swim to the MA-1 kit package, release its parachute, and swim it to the CM. The others will assist by pulling in the line. All lines and the grappling hook may be stowed on the flotation collar for CM retrieval.

The following procedure is used by the aircraft crew in preparing for deployment of the ADDRS.

(a) The ADDRS packages will be placed on the ODS; the collar on shackle No. 1 and the MA-1 kit bundle on shackle No. 3. (See ref. 8). The loadmaster will advise the pilot when the packages are rigged and ready for drop.

(b) The pilot should set the ODS timing to 1.9 seconds between shackles to give a total of 3.8 seconds between packages.

(c) The delivery pattern flown is the standard for MA-1 kit delivery. The sequence is as follows:

Flaps: 50 percent (70 percent - 130,000 pounds and above)

Altitude: 300 feet

Airspeed: 130 knots

All turns are standard rate

The following procedures will be used for manual delivery of the ADDRS from HC-130 aircraft, if required. This procedure will be used only as an alternate method during mission operations when failure of the ODS has occurred.

(a) The ADDRS and components will be placed on the ramp as shown in ref. 8.

NOTE

Two crewmembers are required for manual delivery. The primary crewmember, Loadmaster no. 1, will ensure that all connections are secure and that the assistant is briefed on all aspects of the delivery method. The restraint harness hookup points will remain the same as for any ramp delivery method (forward of the ramp hinge line).

(b) Upon command of the pilot ("DROP"), Loadmaster no. 1 will deploy the collar package from the end of the ramp and assume safety man duties. The copilot or navigator, upon command of "DROP," will start timing for a 3.5 second interval and give the command "DROP" over the interphone. At this time the assistant will drop the MA-1 kit bag.

CAUTION

SHOULD A FOULED LINE OR CONDITION EXIST THAT MAY CAUSE LINE BREAKAGE, LOADMASTER NO. 1 WILL GIVE THE COMMAND "DROP" FOR THE MA-1 KIT BAG.

(c) Upon completion of the delivery of each package, the static lines will be immediately retrieved.

Without ADDRS

The aircraft, heading into the wind, approaches the CM at pararescue drop altitude which is 1,000 feet. When directly over the CM, a wind drift determination (spotter) parachute, with flare attached, is deployed and a 5 to 9 minute duration race track pattern is established. The final leg of the pattern is flown from the spotter flare to the CM.

As the aircraft passes over the spotter flare, the jumpmaster will start his count. When the aircraft passes over the CM, the jumpmaster will reverse the count, and at the completion of this reversed count, the first pararescueman will jump. Using this technique, the first pararescueman should land downwind of the CM at a distance equivalent to approximately 5 minutes of CM drift time.

NOTE

Because of the high CM drift rate, it is essential to land downwind and/or near the driftline of the CM. The CM will drift at a rate of 10 to 15 percent of the wind velocity or faster.

Upon reaching the CM, the first man will immediately attach the sea anchor line and deploy his reserve parachute as a sea anchor for the CM. He will attach his life raft to the apex of the reserve parachute.

NOTE

Upon adverse wind and sea conditions, a pararescueman may experience difficulty in attaching the sea anchor line to the CM sea anchor ring. If this problem is encountered, the sea anchor line may be attached directly to the grappling hook. The next pararescueman to reach the CM will attach his sea anchor line to the CM sea anchor ring, deploy his reserve parachute as a sea anchor, and then cut loose the line attached to the grappling hook.

After deploying the parachute, the first man will so inform the aircraft using the Apollo swimmer radio (section 3.2.2.1). If this method of communication fails, the flare signals given in section 3.2.2.2 should be used. If the first man is unable to reach the CM, or if he is unable to attach the reserve parachute, he will immediately notify the aircraft of this fact using either radio or flare signal and the second man will jump using an adjusted drop count and the original aircraft heading taken on the moving CM (if the spotter parachute was determined to be a good parachute). If the second man also misses the CM, the third man will deploy using the necessary corrections.

NOTE

If the first spotter parachute is determined to be inaccurate for any reason, an additional spotter parachute(s) will be used as necessary.

As soon as the reserve parachute is successfully deployed as a sea anchor, the aircraft will fly a second wind determination pattern and drop a second spotter parachute directly over the CM. The jumpmaster will take a count between the second flare and the anchored CM on the next pass and deploy the second pararescueman and himself on completion of the reverse count.

After all pararescuemen are in the water and at or near the CM, the aircraft will descend to an altitude of 300 feet and, upon signal from the pararescuemen, drop the flotation collar. The aircraft will then climb to an altitude of 500 feet and maintain an orbit of the CM while monitoring the air-to-ground frequency.

WARNING

IN THE EVENT A PARARESCUEMAN GETS INTO TROUBLE, HIS SAFETY BECOMES THE PRIME CONSIDERATION.

After collar installation is complete, the pararescuemen will signal the aircraft for the MA-1 kit delivery, if desired. The MA-1 kit, (two six-man rafts and three bundles) will be delivered by free fall and in trail from an altitude of 300 feet on a crosswind pass, upwind of the CM. The pararescuemen will secure the two six-man life rafts to the flotation collar. After deployment of the MA-1 kit, the aircraft will again climb to an altitude of 500 feet and orbit the CM.

3.2.1.3 Summary Report

The pilots of on-scene search and rescue aircraft will record their observations of the recovery by preparing a Search Aircraft SUMREP, as described in section 6.0.

3.2.2 Pararescue Team Procedures

3.2.2.1 Special Equipment

Special equipment furnished by NASA is carried aboard aircraft for pararescue personnel, as in the case of the swimmer personnel. Some of this equipment has been described previously. Therefore, to avoid duplication, reference will be made to applicable sections. The following is a list of this special NASA-furnished equipment:

Item	Number
ADDRS kit	2 per aircraft
Apollo hatch tool	1 per team
Sea anchor line package	1 per man
Multilingual retrieval instruction cards	2 sets per team
Apollo swimmer radio	1 per man

The first item is described in reference 8. The second item is described in section 3.1.2.1. The other tiems are described in this section.

NOTE

Certain teams will be requested to carry instamatic cameras with film (4 each cartridges Kodak Kodacolor X CX-126-20) to porvide the photogarphy described in section 3.3.2.3.

Sea Anchor Line Package - The sea anchor line package (fig. 3-45) is carried by pararescue personnel and is to be hooked to the CM sea anchor ring. The reserve parachute is then attached to the other end of the line. When the parachute is deployed, it acts as a sea anchor. The tethering line is a 100-foot length of 1,500-pound test nylon cord. A separate line 6 feet long with two handloops is also attached to the hook to be used as a handhold by the pararescuemen. The procedure for packing the sea anchor line package is given in ref. 3.

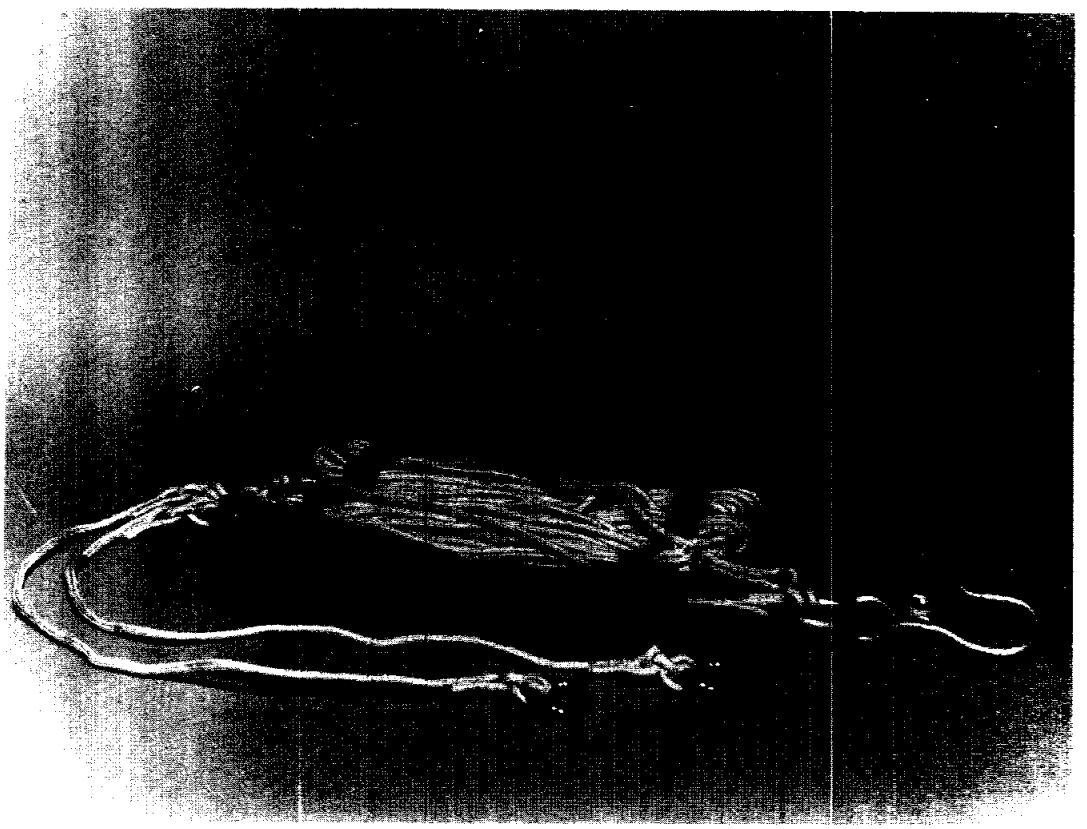


Figure 3-45. Sea anchor line package

Multilingual Retrieval Instruction Cards - These cards (fig. 3-46) are designed to be carried by pararescue personnel for contingency situations wherein a possibility exists that the CM could be picked up by a ship whose crew is not familiar with normal retrieval procedures. For ship's personnel who may not speak English, the cards are also printed in the six foreign languages most likely to be encountered: Russian, Norwegian, Japanese, Greek, French, and Spanish. The cards contain a request for assistance. Following this is a list of recovery procedures pertaining to the astronauts and CM. Also included is a list of hazards in connection with CM retrieval and a list of safety precautions to be followed. Illustrations are included to aid in the understanding of the situation.

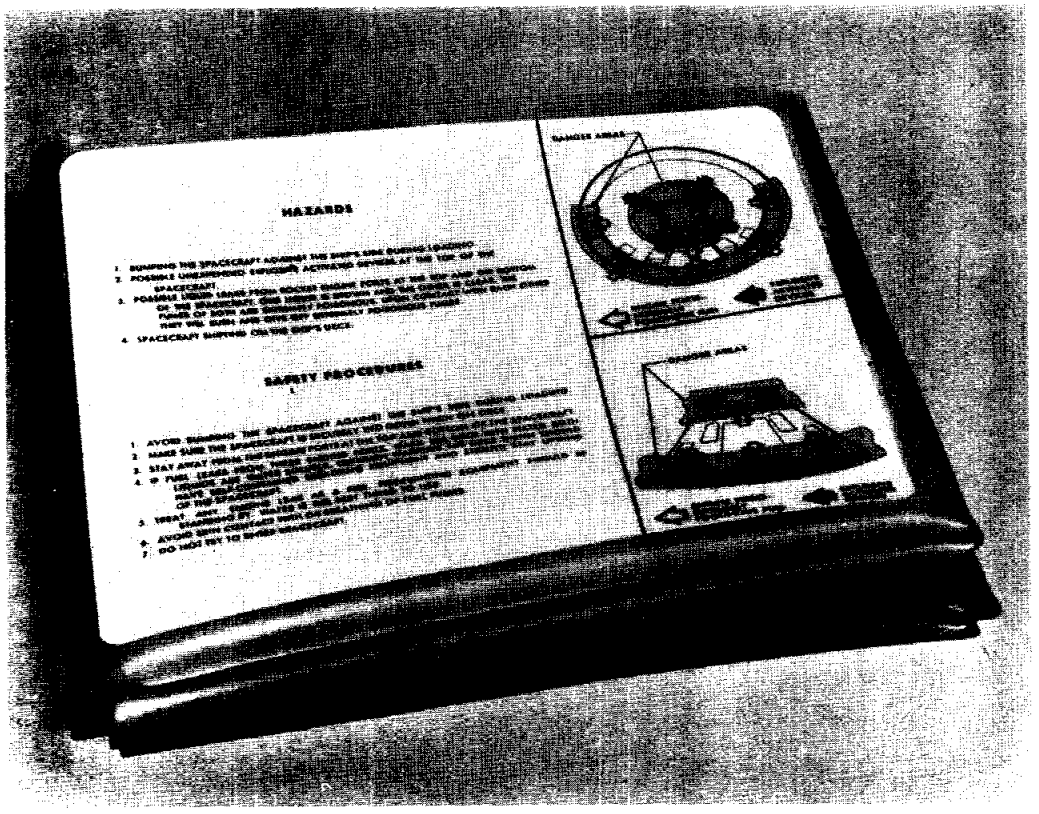


Figure 3-46. Multilingual retrieval instruction cards

Apollo Swimmer Radio - This radio (fig. 3-47) is a small compact package for use by pararescue and UDT personnel in communicating with the recovery ship, aircraft, and the astronauts in the CM. Information on its frequencies and operating modes is as follows:

Frequency, MHz	Mode	Activation
282.8	MCW/voice	Key/PTT*
	Beacon	Continuous
296.8	AM (voice)	PTT

* Push to talk

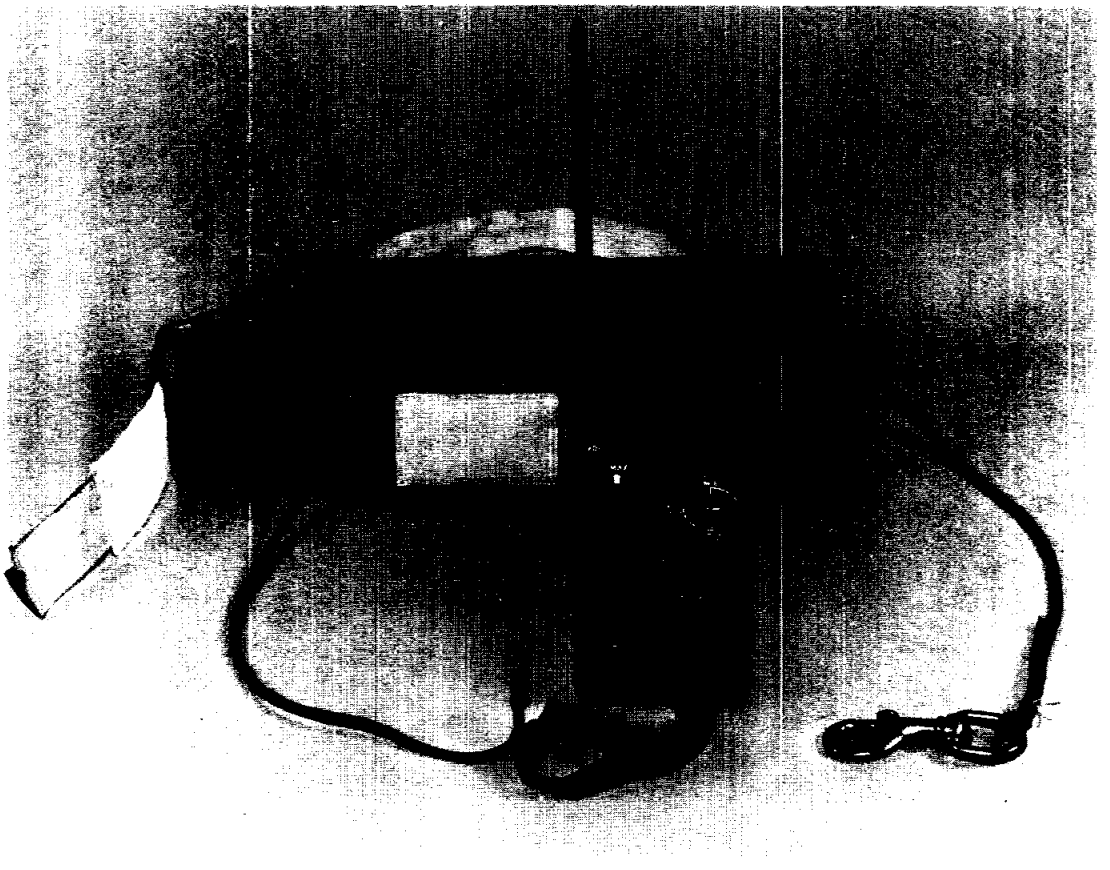


Figure 3-47. Apollo swimmer radio

3.2.2.2 Safety Precautions

Prior to a mission, all pararescue personnel will be briefed on the CM hazard areas described in section 2.0 of this manual. Additional safety precautions not covered in section 2.0 that shall be observed by pararescue personnel are:

(a) The pararescuemen's raft will be attached to the apex of the reserve parachute.

(b) If the Apollo swimmer radio fails, the following flare signals will be used as required.

FLARE SIGNALS

Impossible to proceed as planned	One red
Pararescuemen at CM, astronaut injured; or, pararescuemen at scene, survivors injured. Need doctor; drop medical kit	Two red
Initial notification; all is well	One green
Ready for flotation collar	One white
Ready for MA-1 kit drop	Two white
Flotation device damaged; cannot remove, drop another	One white and one red
Ready for six-man raft	One white and one green
Radio inoperative; drop another	One red and one green

(c) One pararescueman will remain with the CM while the other two retrieve the flotation collar.

3.2.2.3 Installation of Flotation Collar

After the flotation collar has been delivered, the CM should be inspected for any damage which might puncture the collar. The flotation collar will be installed in accordance with the instructions given in figure 3-16.

NOTE

If a parachute remains attached to the CM, it must be released as shown in figure 3-17.

Pararescue personnel will remain with the CM until officially relieved. If sufficient ARRS aircraft are available, the on-scene commander will ensure that an ARRS aircraft is on station at the CM location prior to relief of the original rescue aircraft. If no ARRS aircraft is available, any aircraft with deployable water survival equipment may fly cover on the CM. In this situation, however, the original rescue aircraft will deploy the reserve flotation collar to the pararescue team prior to departing the scene.

3.2.2.4 Astronaut Egress

Refer to paragraph 3.1.2.4 for hatch opening and closing, and astronaut egress procedures.

3.2.2.5 CM Retrieval Assistance and Recovery of Pararescue Personnel

If the retrieval ship is the primary ship with helicopters and UDT personnel, the pararescue personnel will be recovered and replaced by the UDT personnel. When the recovery ship (other than the primary recovery ship) arrives, the pararescuemen should assist in attaching an in-haul line to the CM. As the ship approaches the CM, the pararescuemen should signal readiness to receive the in-haul line by repeatedly giving a thumbs-up signal. The in-haul line will be passed to the CM by means of a shot line. As the ship draws near, a plastic projectile with the shot line attached is fired over the CM. The shot line is tied to a mercury hook on the end of the larger in-haul line. The ship will, in turn, signify its readiness to fire the shot line by displaying a green paddle or a green light from the bridge. When the green paddle or a green light is displayed, the pararescuemen shall take cover behind the CM. Immediately before the shot line is fired, a red paddle or a red light will be displayed from the ship and three short blasts of a police whistle will be sounded over the ship's loudspeaker system. If the line falls short or the gun misfires, the red paddle or red light and three blasts will be repeated and a second line fired.

After the shot line has been fired, the pararescuemen will pull in the line, attach the mercury hook to the RCS engine protector, and cut the reserve parachute sea anchor from the CM. On certain ships with high freeboard and long boom reach, the pararescuemen must stay on the CM and assist the ship's personnel with engagement of the recovery hook after they have attached the in-haul line. However, when this task can be done from the deck of the ship, as with a destroyer and other types with low freeboard, the pararescuemen should leave the vicinity of the CM immediately after attaching the in-haul line and removing the reserve parachute. The pararescuemen will be picked up by the ship's small boat for transfer to the ship. For complete ship retrieval procedures, refer to section 3.2.3.

AFTER THE IN-HAUL LINE HAS BEEN ATTACHED AND THE RESERVE PARACHUTE RELEASED, ALL PARARESCUE PERSONNEL SHALL CLEAR THE CM. PARARESCUE PERSONNEL SHALL NOT RIDE THE CM ALONGSIDE A DESTROYER.

3.2.2.6 Summary Report

The pararescue team leader will record his observations of the recovery by preparing a Swimmer/Pararescue SUMREP, as described in section 6.0.

3.2.3 Secondary Recovery Ship Operations

3.2.3.1 Special Equipment

Brief descriptions of the major items of NASA/DOD-furnished equipment used aboard secondary recovery ships for CM retrieval and handling are given in the following paragraphs. To ensure that all required equipment is onboard, the following checklist should be used. This equipment is common to all secondary recovery ships with the exceptions as noted and will be supplied either directly by NASA or through the Task Force Commander.

Item	Number
Recovery Davit Crane Complete	1
Spare 75-foot nylon whip	1
Spare Recovery Hook and Shackle	1
Ratchet-type tiedown straps	3
Apollo CM cradle	1
Apollo CM boilerplate	1
Line Threaders	3
Line Threader shuttle pins	6
Mercury hooks	3
Mercury poles	3
Fend Devices	3
CM hatch tools	2
CW Training beacons	2
Shorting plugs	2
Beacon antennas	4
Beacon batteries	32
Sea dye packages	3
Flashing light	2
Flashing light mounts	1
Flashing light batteries	2
Beacon/light switch plate assy.	1
Beacon/light wiring harness	1
Tool kit	1
Spare ring lines	2
Plastic bags for lines	4

In addition, the ship will be requested to provide equipment such as in-haul lines, tending lines, etc.

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* Required only if night simulations are planned

Davit Crane - Destroyers deployed for recovery operations will have mounted on the fantail a recovery davit crane capable of lifting the Apollo CM from the water and placing it on deck. The davit crane is an inverted L-type davit with two back-stay supports and is attached to the destroyers by reversible deck bolt sockets (Baxter bolts). Power is provided through an electrical connection from the crane to the ship source. Control of the various components (main hoisting winch, two small winches for positioning hold-off arms and ring, and the training mechanism) is provided by a single operator from a platform bolted to the side of the davit upright structure. Major components of the crane and its rigging are shown in figure 3-48. The crane is designed for operation from either side of the fantail. The location selected for installation of the crane depends on the class and type of destroyer and the location of other installed equipment on the fantail.

A kit containing auxiliary equipment necessary to effect retrieval is provided all secondary recovery ships. A boilerplate CM is also provided so that training can be conducted prior to ship deployment and while the ship is enroute to station. Included in the kit are line threaders and shuttle pins, mercury hooks and poles, CM cradle, other associated equipment, and operating and maintenance pamphlets. Descriptions of the major items are given on the following pages. An item not provided by NASA is the spacecraft in-haul line; at least 350 feet of this line should be available. It is recommended that 2-inch braided nylon, if available, be used.

Hold-Off Ring Padding - The areas of the hold-off ring where pads are to be installed are shown in figure 3-49. The padding consists of four segments which have sufficient thickness so that the hold-off ring seats at the bottom edge of the CM hatch. Padding consists of urethane foam. Grommets and lacing for canvas covers permit them to be tightened so that the pads will not shift position on the hold-off ring. Spare pads will be provided each ship.

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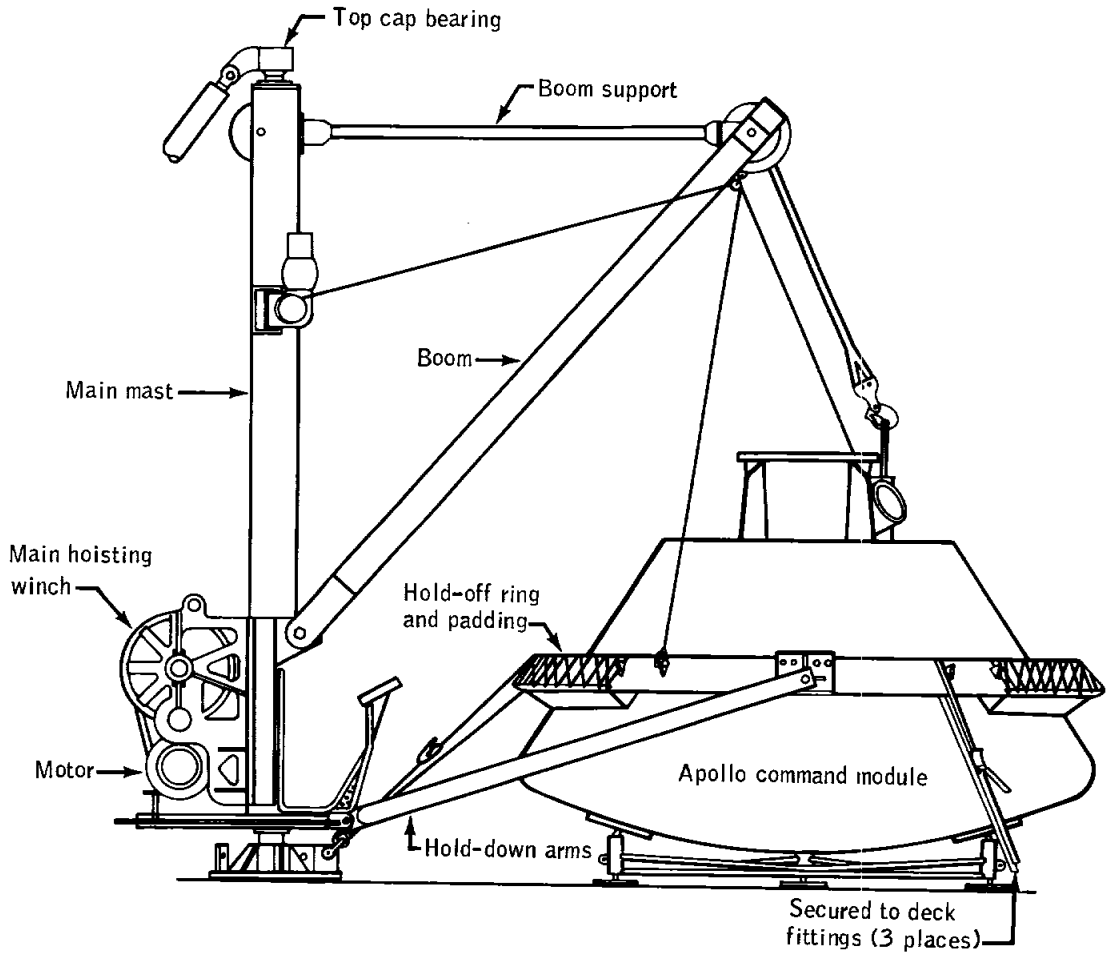

Figure 3-48. Recovery davit crane

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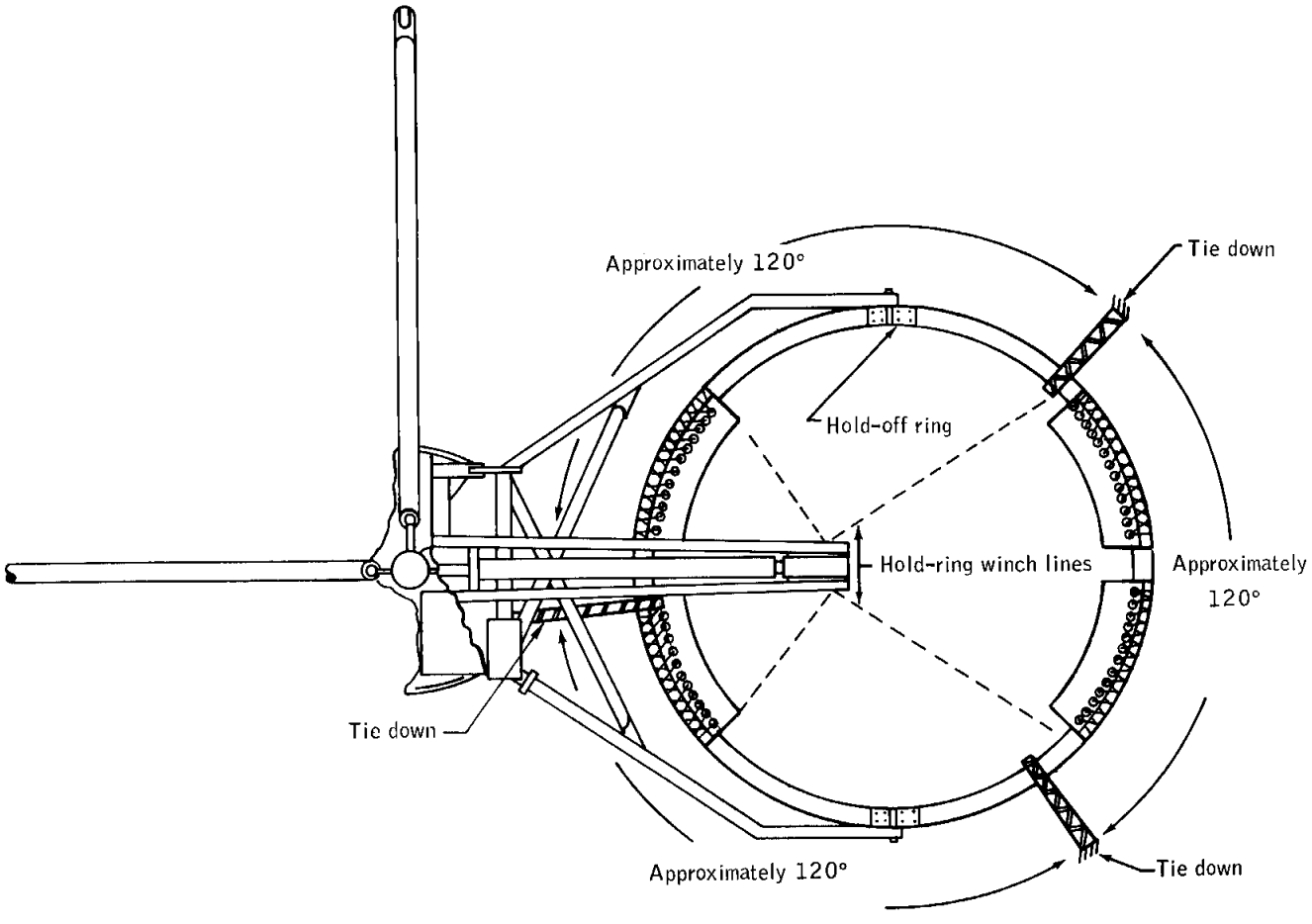

Figure 3-49. Arrangement of padding on davit crane hold-off ring

Apollo Boilerplate CM and Tie-down Ring - The tie-down ring shown in figure 3-50 is used aboard boom-rigged ships to aid in tieing down the CM boilerplate or the CM if it is recovered.

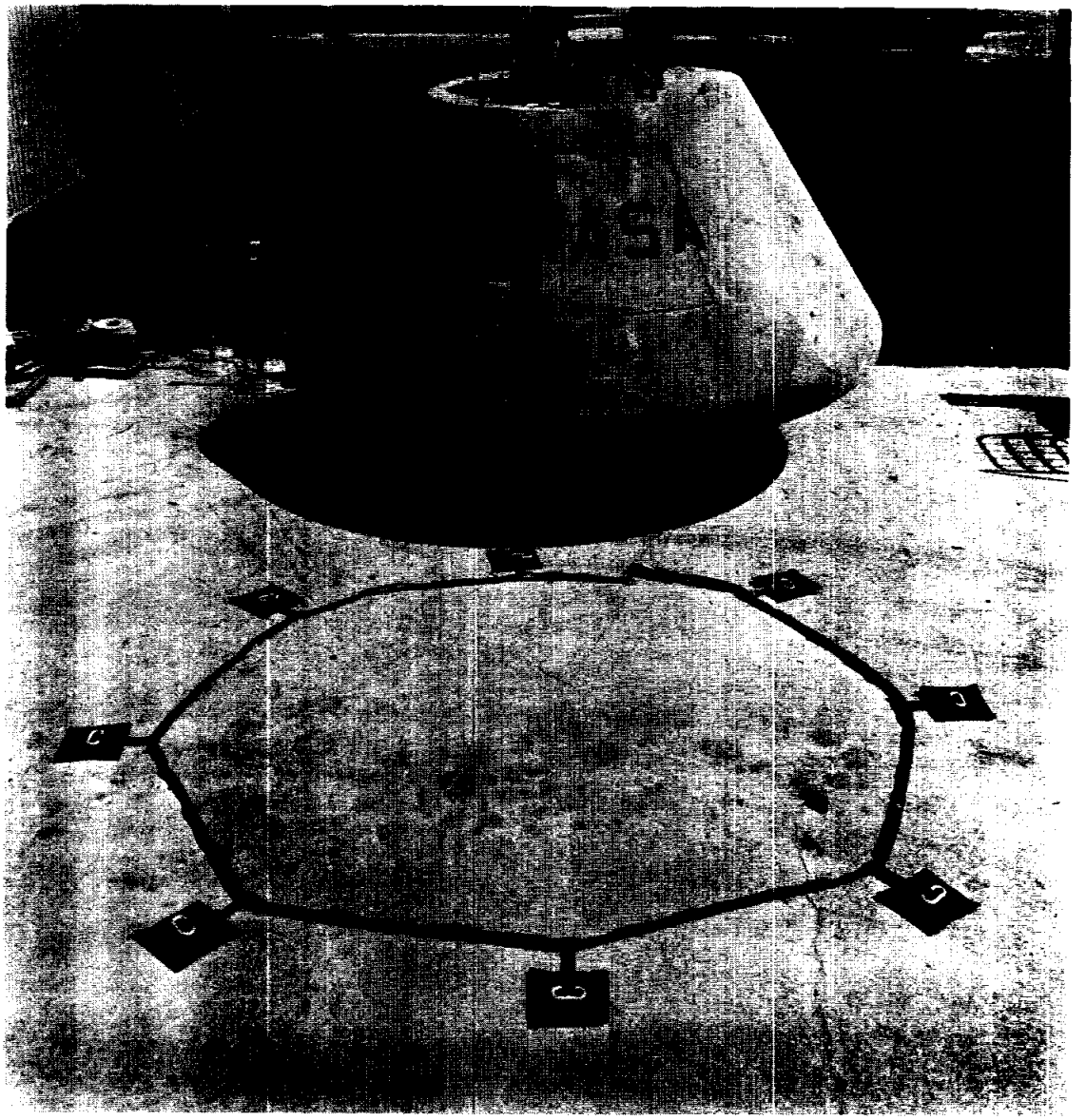

Figure 3-50. Apollo boilerplate CM and tie-down ring

Apollo CM Cradle - The Apollo CM cradle (fig. 3-51) is positioned alongside the recovery davit crane and is used to support the boilerplate or CM after retrieval.

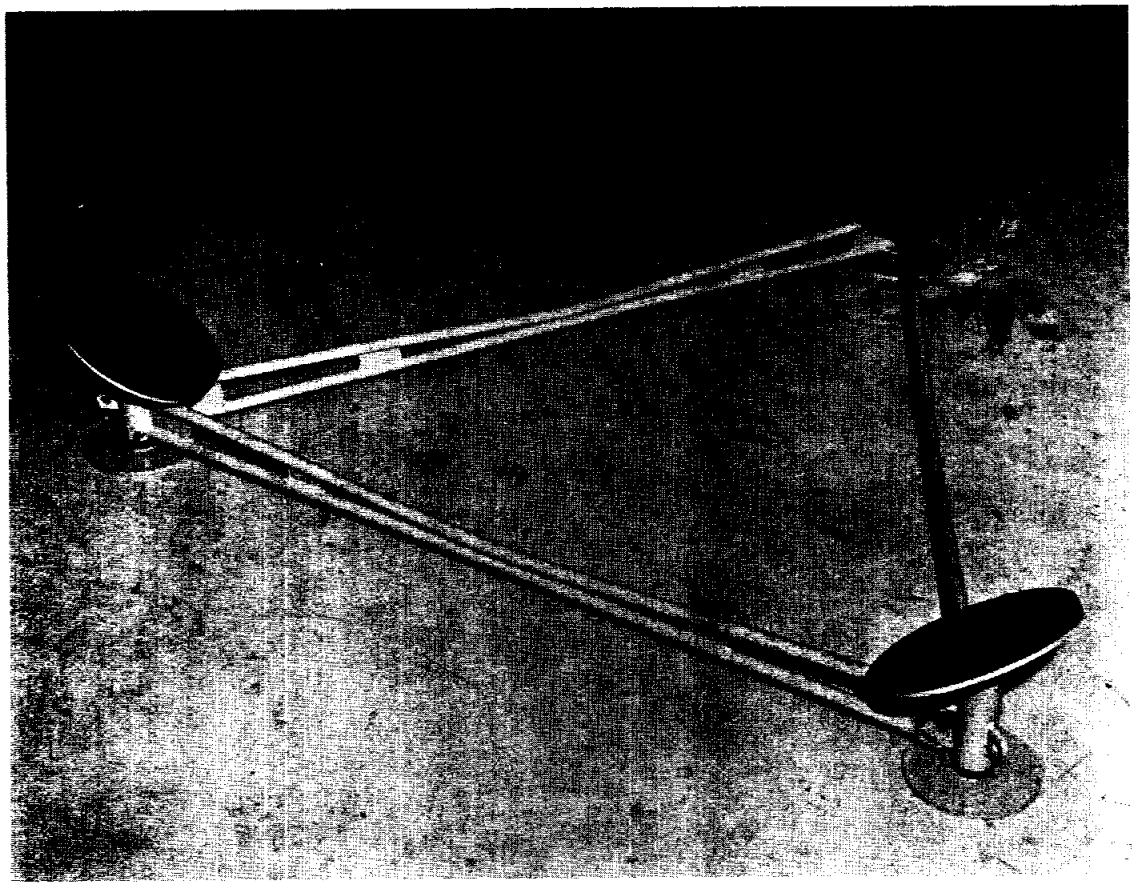

Figure 3-51. Apollo CM cradle

Line Threader - The line threader (fig. 3-52) is used to pass a line through the recovery loop on the CM.

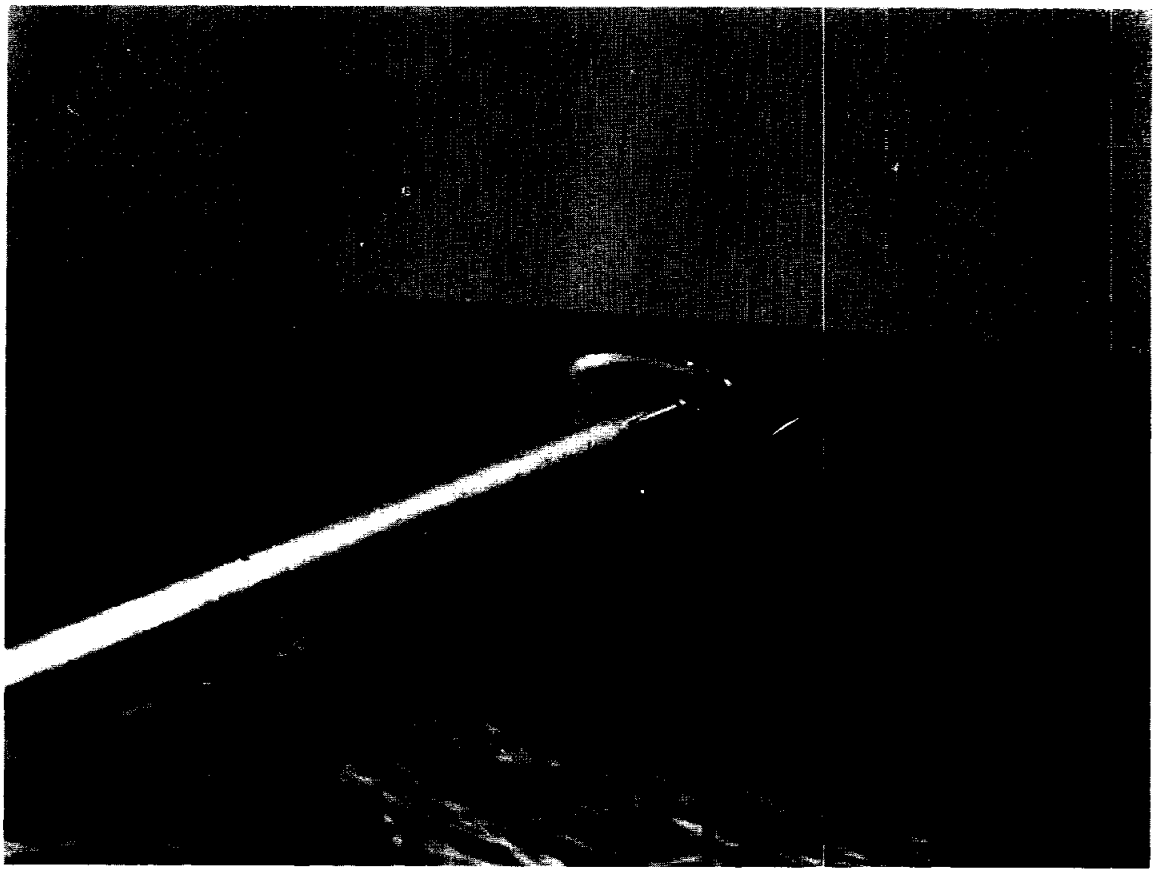

Figure 3-52. Line threader

Mercury Poles, Hooks, and Fending Pads - The mercury poles have a dual purpose. Two adapters are used--the mercury hook for line attachment, and the fending pad for fending the CM off the side of the ship and orienting it prior to hoisting. Sixteen-foot poles are furnished for shipboard use and five-foot poles are provided for use by swimmers. These items are shown in figure 3-53.

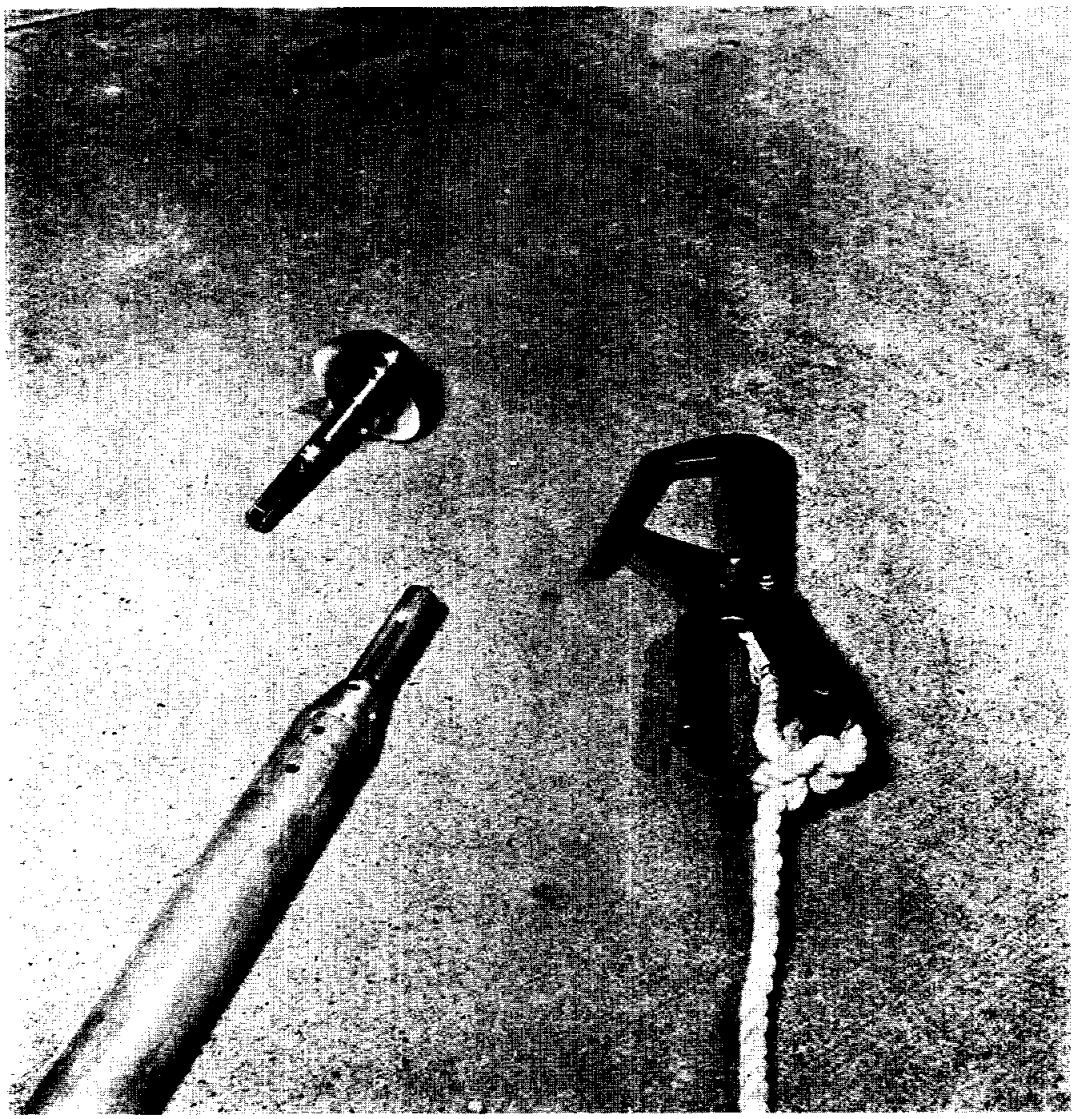

Figure 3-53. Mercury pole, hook, and fending pad

3.2.3.2 Destroyer Procedures

Checkout of Davit Crane - It is recommended that the davit crane be checked out for proper operation prior to any retrieval to be performed. In addition to the procedures in the regular daily davit crane checklist given in the "Operating" section of reference 9 the following procedures should be observed. The operations are accomplished without lifting the boilerplate during the check.

WARNING

WHILE POWER TO THE CRANE IS ON, THE CRANE OPERATOR IS TO REMAIN ALERT AND AT HIS STATION.

(a) Operate the main hoist line up and down at low and high speed.

(b) Rotate the crane left and right for proper braking action.

(c) Raise and lower the hold-off assembly. Tilt it forward and backward.

(d) When involved in an actual recovery operation, a final check of the crane can be made as the boilerplate CM is lowered into the water to make room on deck for receiving the actual CM. If the boilerplate must be abandoned, it must be sunk. It can best be sunk by gunfire.

Equipment to be Available on Deck

(a) One CM cradle

(b) Nylon whip (75 feet) (spare)

(c) Two line threaders (with spare shuttle pins)

(d) Four 16-ft poles

(e) Three mercury hooks

(f) Three mercury pole fending pads

(g) Recovery hook (spare)

(h) CM and cradle tie-downs

(i) Police whistle and red/green paddle (warning device for use with line-throwing gun)

(j) Two fire hoses led out with pressure to nozzle

(k) Fenders and collision mats to be used in crane area

(l) Flotation pack to be attached to the in-haul line mercury hook

Personnel Assignments - The following personnel are required for a retrieval operation:

(a) Three men to handle the padded mercury poles to fend off the CM and orient it to a hatch-outboard position.

(b) One davit crane operator.

(c) One line-throwing gun operator.

(d) One man for shot line signaling.

(e) Three men to handle the CM in-haul line.

(f) One man to handle the threader pole, and an assistant.

(g) Fantail safety officer.

(h) One man (chief boatswain's mate) for deck retrieval operations control (one-point control to give orders to retrieval team).

(i) Two to four fire hose personnel.

(j) Boat crew.

Safety Precautions

In addition to the safety precautions described in section 2.0, the following procedures shall be observed:

(a) All prescribed checks, tests, and inspections of the davit crane shall be performed prior to an actual recovery operation to ensure normal operation.

WARNING

WHILE POWER TO THE CRANE IS ON, THE CRANE OPERATOR IS TO REMAIN ALERT AND AT HIS STATION.

(b) All personnel not actually participating as members of the retrieval team should be cleared from the retrieval operations area, which encompasses the fantail, side passage, and forecastle.

(c) Life lines in the area of the crane will be down during retrieval operations. Safety lines as appropriate shall be rigged. Because personnel will be working near the edge of the ship's deck in all operations, it is imperative that life jackets be worn by the retrieval team. Good safety practice also dictates the use of hard hats when working with heavy equipment, long poles, etc.

(d) Personnel shall not climb on the CM or get between the CM and the davit crane hold-off ring during retrieval operations.

(e) A CM and CM cradle tie-down plan must be worked out on each ship prior to getting underway. The cradle should be secured by line or cable to ensure that there is no movement in any direction. Once the boilerplate CM is set in the cradle, the davit crane hold-off ring shall be lowered on it and tie-downs from this ring to deck supports shall be installed. There should be a minimum of three leads in different directions to ensure that there is no up-and-down or lateral movement. Personnel on each ship will have to survey existing possible tie-down points such as chocks, bits, and deck pad eyes for the arrangement most suitable for their particular case. In the case where there are insufficient points for tie-down, temporary pad eyes shall be welded to the deck to provide tie-down points.

Retrieval - In general, there are several basic retrieval situations a destroyer may encounter. These situations depend largely on the on-scene wind and seas and whether or not pararescuemen have arrived at the CM. The tasks to be accomplished by the pararescuemen are to install the flotation collar, attach a reserve parachute to the CM to act as a sea anchor, and assist the astronauts as well as the personnel making the retrieval.

The step-by-step procedures described in the following paragraphs are based on present knowledge and experience. It is expected that modifications to these procedures will be made as a result of suggestions from observers, operating personnel, and from further experience

encountered during future Apollo missions and training exercises. The procedures recommended for the situations described can be adapted to other situations that may develop in the course of a recovery operation.

Situation 1: Retrieval of CM with collar installed, pararescue personnel on-scene, reserve parachute installed, and weather suitable for small boat operation.

(a) A motor whale boat launched from the destroyer proceeds to the CM to pick up the astronauts after their egress from the CM. The small boat returns to the ship and is picked up and brought to deck level where the astronauts board the destroyer.

(b) The launched motor whale boat stands by to recover the pararescue personnel after CM retrieval.

(c) The destroyer now makes its approach to retrieve the CM as follows (as an illustration, a port side pickup is described): Wind is dead ahead. The ship moves ahead to place the CM 25 to 40 yards off the port bow. As the CM comes into position, the shot line for the in-haul line is passed to the pararescue personnel at the CM and the destroyer is stopped. The procedures for safely passing the shot line to the CM from a position forward of the bridge are the same as those described for the primary recovery ship in section 3.1.3.3.

WARNING

THE FIRING OF THE SHOT LINE IS CONTROLLED FROM THE BRIDGE. APPROPRIATE SIGNALS TO ESTABLISH READINESS AND FIRING WARNINGS MUST BE UNDERSTOOD CLERELY BY PARARESCUEMEN AND SHIPBOARD PERSONNEL.

(d) After the shot line is passed, one pararescueman retrieves the line and returns to the CM. This man passes the shot line to the man on the collar and positions himself to cut the reserve parachute attachment line. The man on the collar pulls in the shot line until the in-haul line and attached mercury hook are received. He snaps the mercury hook into the RCS engine protector on the CM. As soon as this hookup is positively made, the reserve parachute attachment line is cut and all pararescuemen depart the CM, taking their rafts clear of the area. As CM retrieval operations permit, the motor whale boat maneuvers to retrieve the pararescuemen and their equipment.

(e) Ship's personnel handling the in-haul line begin drawing the CM toward the ship. At this time, the ship should be maneuvered to provide a slight way on and to get the wind approximately 20 degrees

off the starboard bow. This maneuver will permit the in-haul line to function as a sea painter and will provide a lee in the crane area.

NOTE

Marking the in-haul line in advance, at a point which will stop the CM just forward of the crane, will be of assistance to the line handling crew.

(f) The recovery hook line is threaded with the threader pole as follows: When the CM is slightly forward of the davit crane, the line threader should be placed in the CM recovery loop. The line must be threaded from beneath to prevent a loop being formed in the threading line around the CM recovery loop (fig. 3-54). The line should be threaded rapidly to prevent the threader hook from becoming fouled in the recovery loop.

NOTE

Padded mercury poles should be used to fend off the CM and prevent it from rotating (fig. 3-55). Rotation will cause the threading line to become fouled in the recovery loop.

(g) At this time, the line handlers on deck should start to slack the in-haul line, thus permitting the CM to move aft under the crane and to allow the recovery hook to be pulled into the recovery loop. The crane operator should be careful to keep the recovery hook slightly above the CM to prevent its fouling on the projections on the top of the CM.

WARNING

DURING CRANE OPERATIONS, LIFE LINES IN THE AREA OF THE CRANE WILL BE DOWN. PERSONNEL WORKING IN THE AREA SHOULD OPERATE WITH CAUTION.

(h) The hold-off ring assembly, when in the outboard position for CM retrieval, should be tilted so that the inboard, or operator's, side is approximately 20 to 30 degrees lower. The assembly should also be hoisted as high as possible to allow the top section of the CM to clear it.

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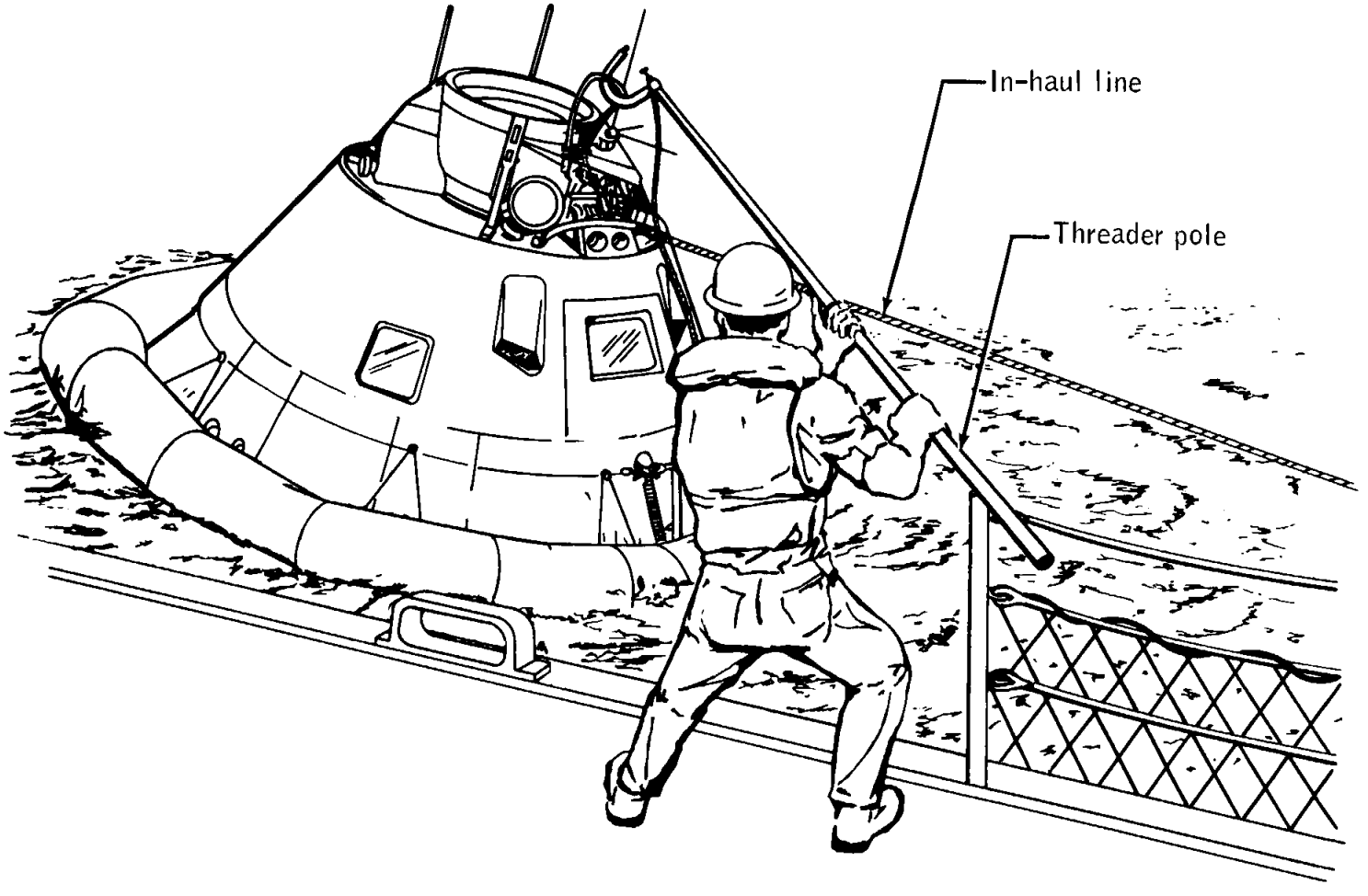

Figure 3-54. Using line threader

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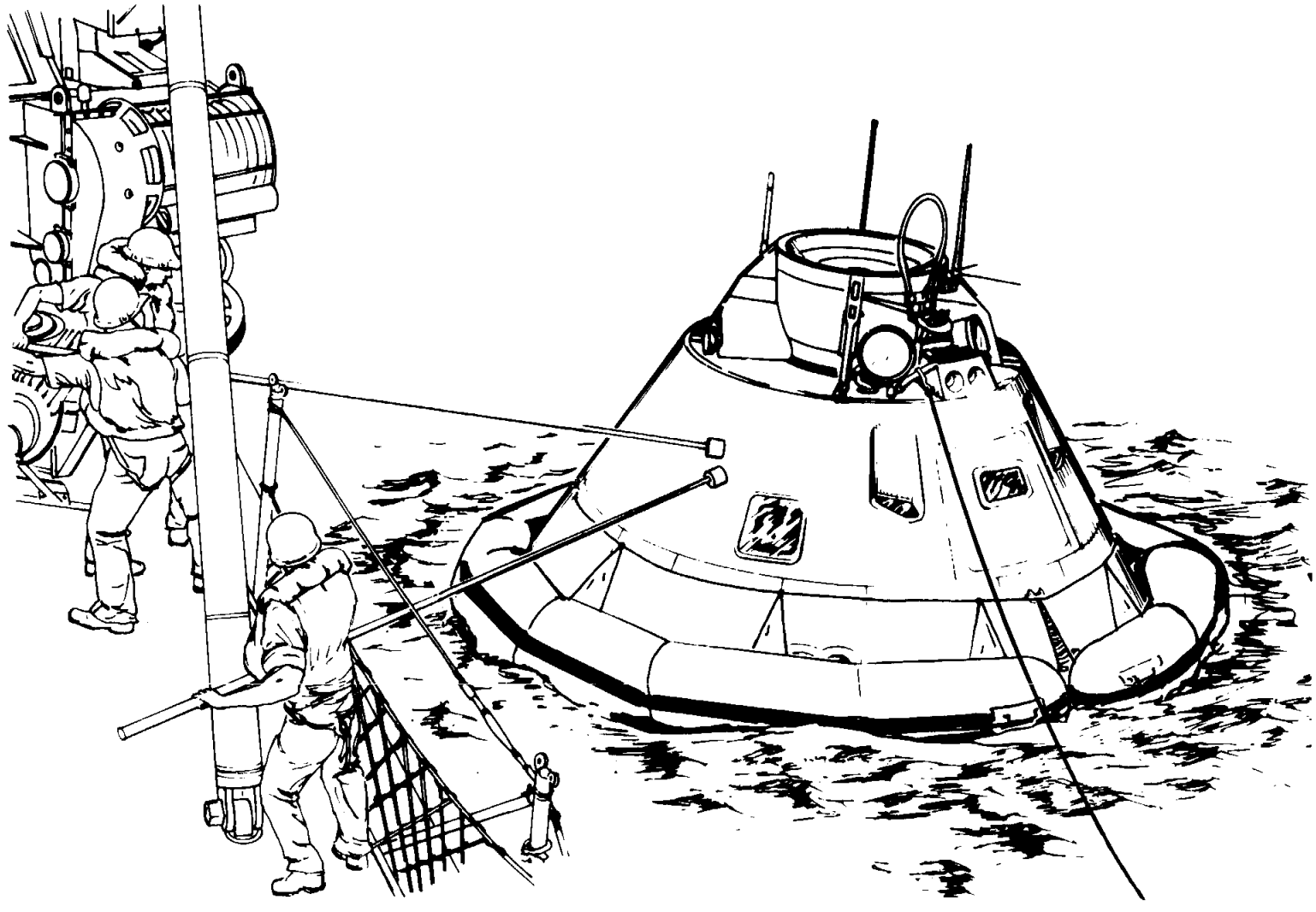

Figure 3-55. Fending CM off with padded mercury poles

(i) Once the recovery hook is engaged, the CM should be oriented hatch outboard by use of the fending poles and the in-haul line. Prior to attempting orientation of hatch outboard, the ship should be dead in the water. This orientation of the CM allows for proper hold-off ring positioning and provides maximum safety for the crane operator.

(j) The operator should raise the recovery hook slowly until the CM is positioned directly under the end of the boom.

CAUTION

OPERATION OF THE MAIN WINCH AT HIGH SPEED AT THIS TIME MAY CAUSE THE CM TO STRIKE THE SIDE OF THE SHIP.

When the CM is centered under the hold-off ring assembly (fig. 3-56), the ring should be lowered. The CM should also be lifted until it is above water and the hold-off ring seating is accomplished. (Actual hoisting of the CM should be accomplished in the high-speed mode.) After the hold-off ring is properly seated, approximately 1 foot of slack in the hold-off ring lines should be maintained. The ring must not be allowed to tilt under the bottom of the CM.

CAUTION

THE SIDE OF THE SHIP IN THE VICINITY OF THE CRANE SHOULD BE PADDED TO PREVENT DAMAGE TO THE CM OR THE SHIP IN CASE THE CM SWINGS WHILE BEING LIFTED.

(k) Immediately after the CM is swung inboard and placed in the cradle, tie-down equipment shall be installed. The flotation collar may be deflated to facilitate installation of tie-downs. This applies in the case of an actual CM retrieval operation.

NOTE

In cases where a training collar is being used during an exercise, the collar should be removed before the boilerplate is placed in the cradle. This is to prevent damage to the collar so that it can be used for future exercises.

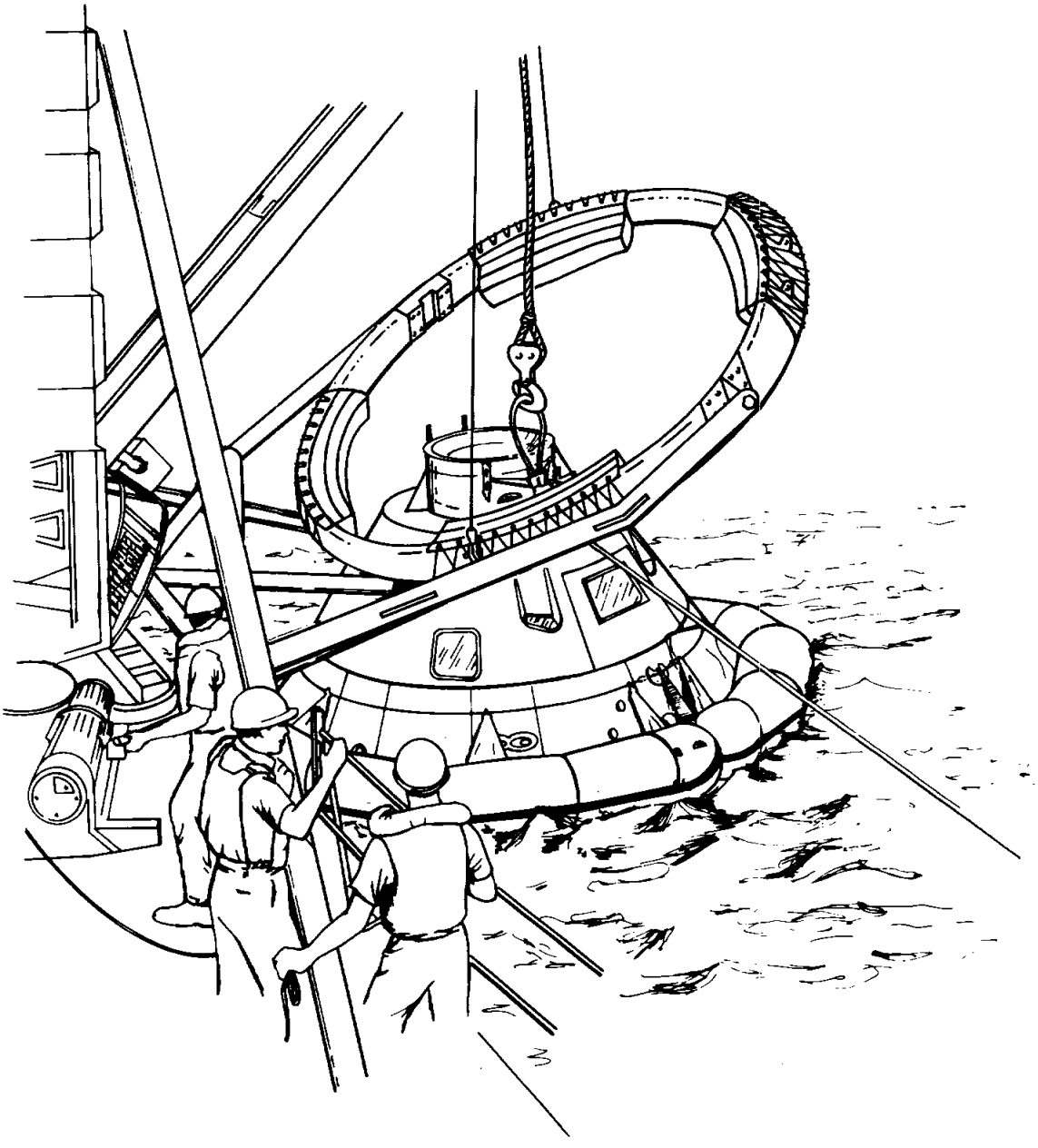

Figure 3-56. CM positioned under padded hold-off ring

WARNING

PERSONNEL REMOVING THE COLLAR SHALL NOT GET BENEATH THE BOILERPLATE OR IN SUCH A POSITION THAT A SWINGING BOILERPLATE WILL PRESENT A HAZARD.

Figure 3-57 provides a diagram and a summary of the Situation 1 procedure.

Situation 2: Same conditions as in Situation 1 except that the weather is unsatisfactory for the use of a small boat.

(a) The rigging and retrieval procedures for this situation are the same as for Situation 1, with the exception of the retrieval of the astronauts.

(b) Two possibilities for astronaut retrieval exist: One is that the astronauts would egress from the CM and return to the ship via raft. The other, less favorable, is that the astronauts would remain in the CM while it is picked up. In the first case, pararescue personnel can assist in getting the raft alongside the ship and the astronauts can board the ship by means of a Jacob's ladder or a scramble net.

Situation 3: No pararescuemen, no collar, no reserve parachute on CM; however, the weather is suitable for a small boat.

(a) A small boat launched from the destroyer retrieves the astronauts who will have egressed from the CM. Astronaut retrieval is accomplished in the same manner as in Situation 1.

(b) After the astronauts are returned to the ship, the motor whale boat is relaunched and stands by to carry the in-haul line to the CM. The ship approaches the CM as in Situation 1 and the small boat comes alongside the destroyer at about the midship position to pick up the end of the in-haul line with the mercury hook attached.

(c) Line handlers on deck feed out the in-haul line as the small boat proceeds to the CM. A mercury pole in the small boat is used to hook the in-haul line onto the RCS engine protector.

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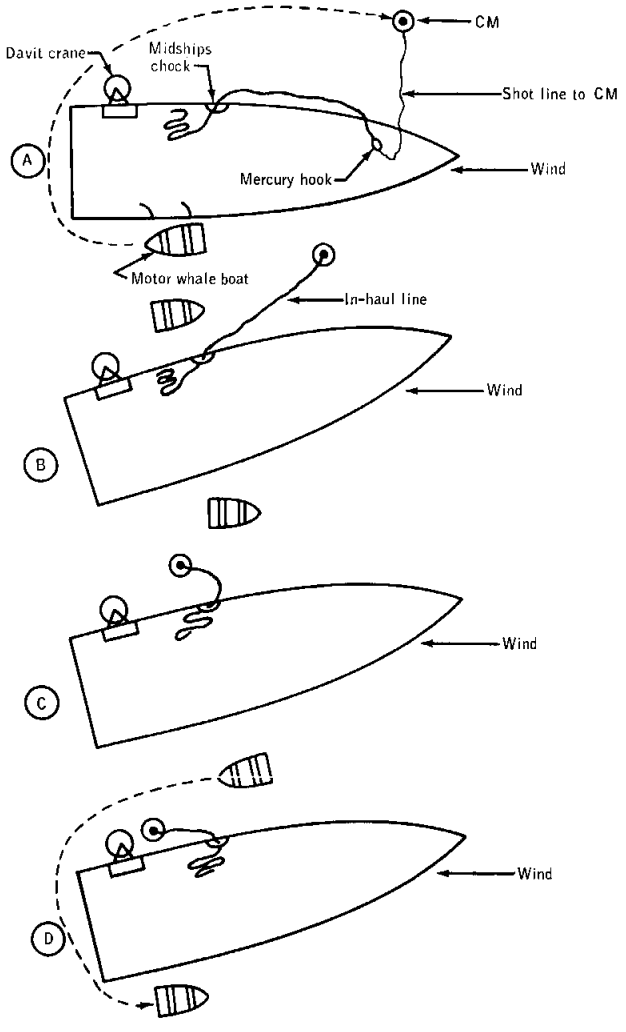

Procedure

1. Launch motor whale boat (MWB) to pick up astronauts. Pick up astronauts and return them to ship. Dispatch MWB to assist pararescuemen (PJ's).

(A) 2. Ship heads into wind so that CM is 25 to 40 yards off the bow.

3. Pass in-haul line to PJ's at CM via shot line. One PJ snaps mercury hook into RCS engine protector. After in-haul line is attached, another PJ cuts and recovers the reserve parachute.

(B) While CM is hauled toward ship with in-haul line, ship moves ahead slightly so that the wind is 20 degrees off the bow opposite the CM.

(C) Continue hauling in CM with in-haul line. (Line should be marked at a point where, if held at the chock, it will hold the CM just forward of the davit crane.)

(D) As the CM approaches the ship just forward of the crane, the man with the line threader quickly threads the line for the recovery hook.

1. Slack in-haul line and allow CM to come under the crane while engaging the hook.

(E) 2. Men with padded mercury poles will rotate the CM so that the hatch on the CM is outboard.

3. Pick up CM with the collar still on it and place it in the cradle, deflating the collar as required.

4. Tie down the CM to prevent any problem resulting from a loose CM on deck.

Figure 3-37. CM retrieval procedures - Situation 1

WARNING

EXTREME CARE SHALL BE TAKEN IN MANEUVERING THE SMALL BOAT IN THE VICINITY OF THE CM. THE HOOKUP SHOULD BE MADE AS QUICKLY AS POSSIBLE AND THEN THE SMALL BOAT SHOULD MOVE OFF AND STAND BY. CARE SHOULD BE EXERCISED TO KEEP THE SMALL BOAT FROM BEING PLACED IN A POSITION BETWEEN THE CM AND THE SHIP.

NOTE

In making the initial approach to the CM, it should be remembered that with no reserve parachute on the CM, its drift rate will be approximately 10 to 15 percent of the wind velocity.

(d) After hookup of the in-haul line, the line handlers on deck will take in the slack. The CM should be moving aft; therefore, it will be necessary for the line handlers to take in on the in-haul line to ensure that the CM doesn't go past a position just forward of the crane.

(e) The remainder of the operation is accomplished as in Situation 1.

Situation 4: No pararescuemen, no collar, no reserve parachute, and weather unsatisfactory for small boat. (This case requires a direct ship pickup with no outside assistance.)

NOTE

The high CM drift rate due to the lack of a reserve parachute is, again, a critical consideration in approaching the CM.

(a) The initial phase of the destroyer's approach is into the wind (fig. 3-58). The ship approaches with the CM just slightly off the bow. At a distance of about 1,200 yards from the CM, speed is reduced to one-third; at about 250 yards, the propellers are stopped and the ship is allowed to coast to a point where it will turn toward the CM

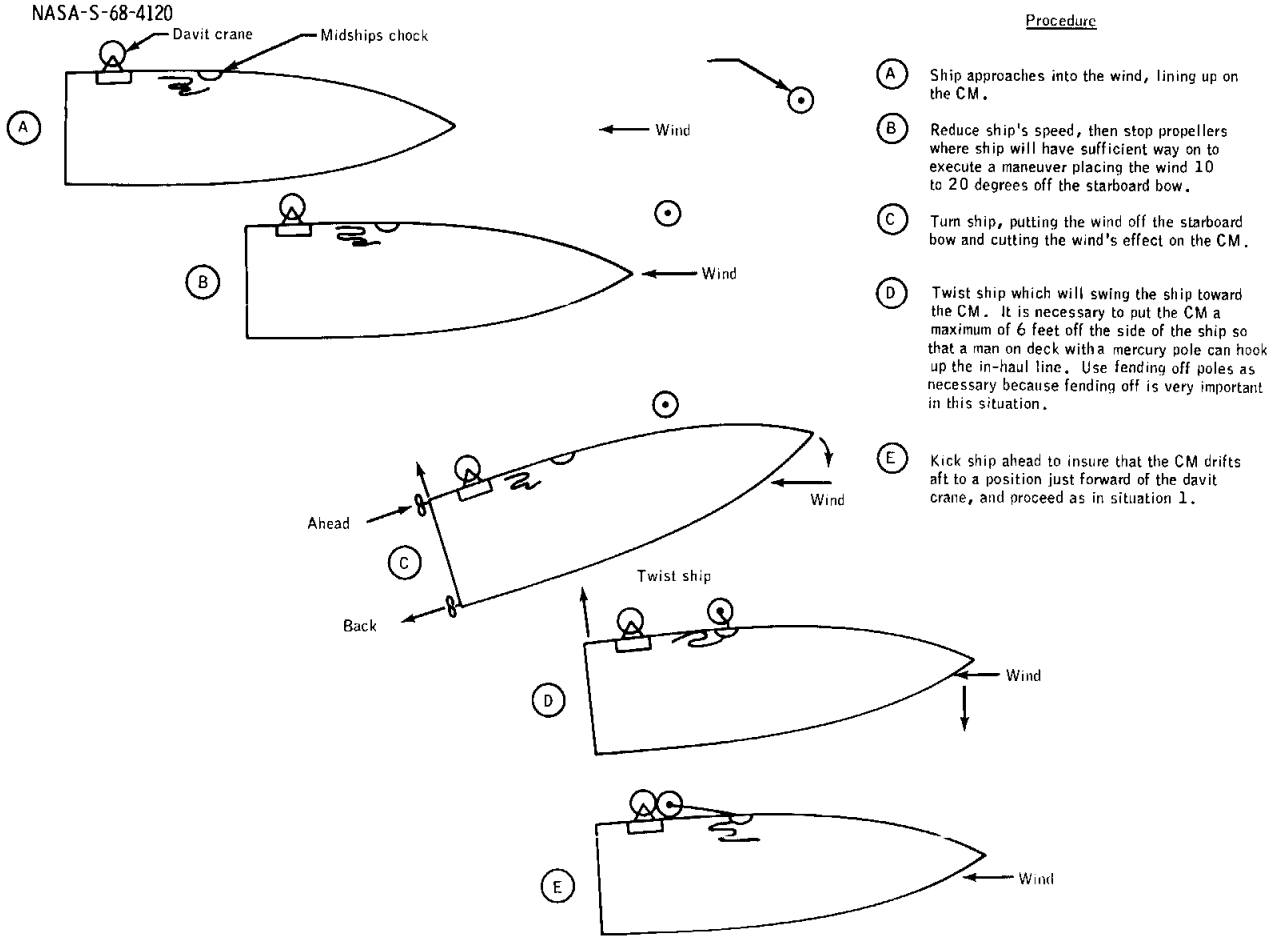

Figure 3-58. CM retrieval procedures - Situation 4

with the wind 10 to 20 degrees off the starboard blow. Then the ship is twisted, throwing the stern toward the CM so that the CM reaches a point that is about 6 feet off amidship. This distance is critical because the hooking-up of the mercury hook to the CM RCS engine protector is accomplished with a pole from the deck of the ship.

(b) Personnel with padded mercury poles should be availavle to fend the CM off the side of the ship as it moves aft toward the crane. A slight way on of the ship will give the in-haul line a sea painter effect.

(c) The remainder of the procedure is accomplished as in Situation 1.

3.2.3.3 Fleet Oiler Procedures

The choice of a boom to be used as the CM retrieval boom will vary frome one class of oiler to another. A typical arrangement is shown in figure 3-59. In choosing a boom, the following guidelines are recommended:

(a) Use the boom with the farthest reach over the side.

(b) Choose a boom located amidship or slightly abaft of beam.

(c) Ensure that the boom selected will be able to sport the CM on a clear deck area, and that the area where the CM will clear the rail is free of obstructions.

Equipment to be Available on Deck

Item	Number
12-ft. nylon sling	2
8-ft. nylon sling	1
Recovery hooks	2
CM boilerplate tiedown rings	2
Ratchet-type tiedown straps	3
Apollo CM cradle	1
Apollo CM boilerplate	1
Line threaders	3
Line threader shuttle pins	6
Mercury hooks	3
Mercury poles	3
Fending devices	3
CM hatch tools	2
CW training beacons	2
CW beacon antennas	4

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WARNING

Minimize work in RCS danger area. Hypergolic propellants burn with a temperature of 5000° F.

1. Connect recovery hook in command module recovery loop.

CAUTION

Command module structure is easily damaged. Do not allow command module to contact ship sides or structure.

2. Hoist command module above deck and position over cradle.
3. Release and remove flotation gear from command module if still attached.
4. Lower command module into cradle.
5. Release and stow recovery hook.
6. Secure command module and cradle to the deck.

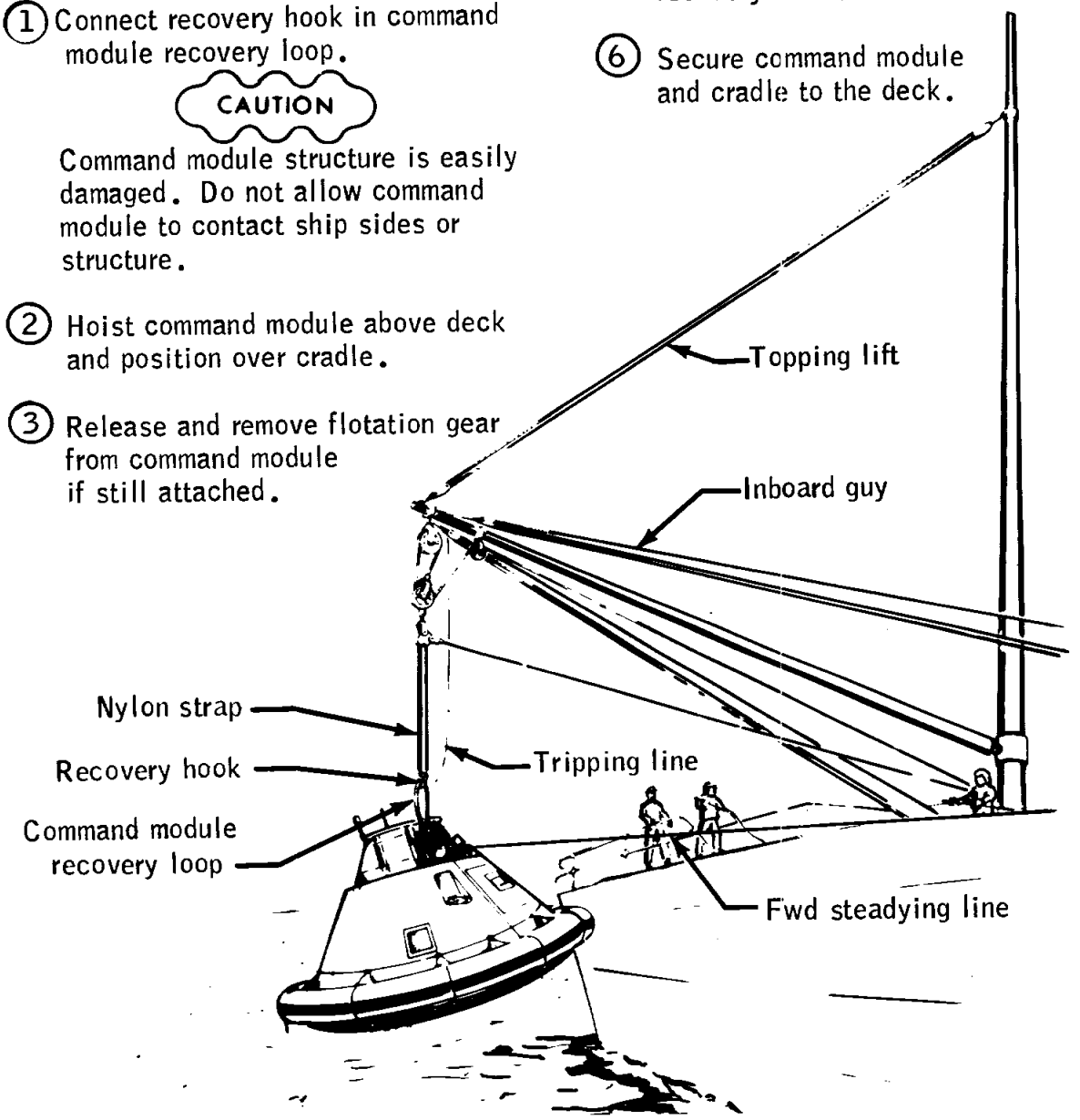

Figure 3-59. Fleet oiler (boom rigged) retrieval operation

Item	Number
Beacon batteries	32
Beacon shorting plugs	2
Sea dye packages	3
Flashing lights	3
Flashing light mounts	2
Flashing light batteries	2
Beacon/light switchplate assy.	1
Beacon/light wiring harness	1
Tool Kit	1
Inhaul line	600 Ft.
Plastic bags for lines	3
Police whistle	1
Red/green paddle	1
Fire hose with pressure nozzle	2
Fenders and collision mats to protect side of ship in boom area	
Flotation pack to be attached to the in-haul line mercury hook	1

Rigging

(a) Rig the boom with a NASA-provided 12-ft braided nylon strap and self-mousing recovery hook.

(b) A 2-inch nylon line that is 400 to 500 feet long will be required as an in-haul line for the CM. A mercury hook shall be spliced to one end of this line to be used for hooking onto the RCS engine protector.

(c) Where possible and feasible, all running rigging, including topping lifts and guys, should be rigged from separate winches to provide maximum flexibility.

(d) Two fire hoses will be run out to the retrieval station with pressure to nozzle to provide large-volume, low-pressure water in case of fire. Fire fighting personnel shall wear protective clothing, use self-contained breathing gear, and operate in pairs or larger groups.

Retrieval - The four situations described for a destroyer are also applicable to oilers utilized for recovery assignments. The same methods of retrieval can also be used, with some modifications.

Situation 1 (same conditions as described for a destroyer):

(a) The layout of the in-haul line is a little different in that it should be led out through the chock just forward of the bridge.

(b) The in-haul line should be led outboard to a point on the forecastle where the man handling the line-throwing gun will operate. As in the case of other-type ships, an alternate method would be to carry the in-haul line out to the CM via a small boat and hook it on the RCS engine protector by the use of a mercury pole.

(c) The in-haul line is used in the same way as described in the destroyer procedures, and the CM is brought alongside the ship just forward of the position where the recovery hook will be lowered from the boom for the hookup.

(d) The threader pole is handled from the jungle deck. The most critical problem that exists in this situation is finding a point from which the threader pole can reach the CM recovery loop.

Situations 2, 3, and 4 (same conditions as described for a destroyer): The general procedures for approaching the CM, retrieving the astronauts, and hauling in the CM described for destroyers (section 3.2.3.2) can be applied to oilers. Since oilers do not have the davit cranes, however, existing booms must be rigged. Also, the freeboard is greater on an oiler, and this makes the tasks of hooking up from the ship and fending off more difficult for oiler personnel.

3.2.3.4 Procedures for Boom-Rigged Ships with High-Freeboard

The boom-rigged ships with freeboard exceeding 18 feet (i.e., amphibious cargo (LKA), amphibious transport (LPA), and tank landing ship (LST)), require a modification of fleet oiler procedures in effecting retrieval of the CM because the mercury and threader poles cannot be used from the on-deck station. The relatively long period of time that the CM would be in close proximity to the ship's side while being hoisted by these ships increases the probability of damage due to the roll of the ship.

Equipment to be Available on Deck

The retrieval equipment required on deck of high-freeboard ships is as listed for fleet oilers plus 125 to 150 feet of 5-inch manila line with mercury hook attached, 75 feet of 21-thread manila with shuttle pin attached, and two standard Navy-type heaving lines.

Rigging

(a) Attach the NASA-provided braided nylon strap with self-mousing recovery hook to the boom hook.

(b) Splice a 25-foot threading line to the recovery hook pig tail with an eye on the bitter end.

(c) Run a tripping line through a block near the boom head and tend it from the on-deck station. Splice a snap-hook to the outboard end. This hook must be large enough to engage the eye attached to the threading line.

Retrieval

The recovery situations described for a destroyer and oiler are also applicable to high-freeboard ships except for Situation 4. Recovery, in the latter case, cannot be safely accomplished by high-freeboard ships because mercury and threader poles are of insufficient length to permit use in CM hookup. The same method of retrieval can be used for other situations, however, with some modifications.

Situation 1 (same conditions as described for an oiler):

(a) The in-haul line is layed out and handled as prescribed under Rigging (a), (b), and (c) for an oiler retrieval. The in-haul line serves as a sea painter and forward steadying line while the CM is alongside and being hoisted.

(b) Since the threader pole and mercury pole cannot be used from the on-deck station, the after steadying line with mercury hook and the threading line (fig. 3-60) are passed to the swimmers by heaving line as the CM drifts into position under the boom. The swimmers connect the after steadying line to the RCS engine protector, unsnap the threading line at the disconnect fitting, run it through the recovery loop and reconnect. The swimmers then move clear of the CM.

(c) As the CM continues to move into position, the boom hook is lowered and the tripping line is hauled in by deck station personnel until the recovery hook engages the recovery loop. The CM is then hoisted from the water.

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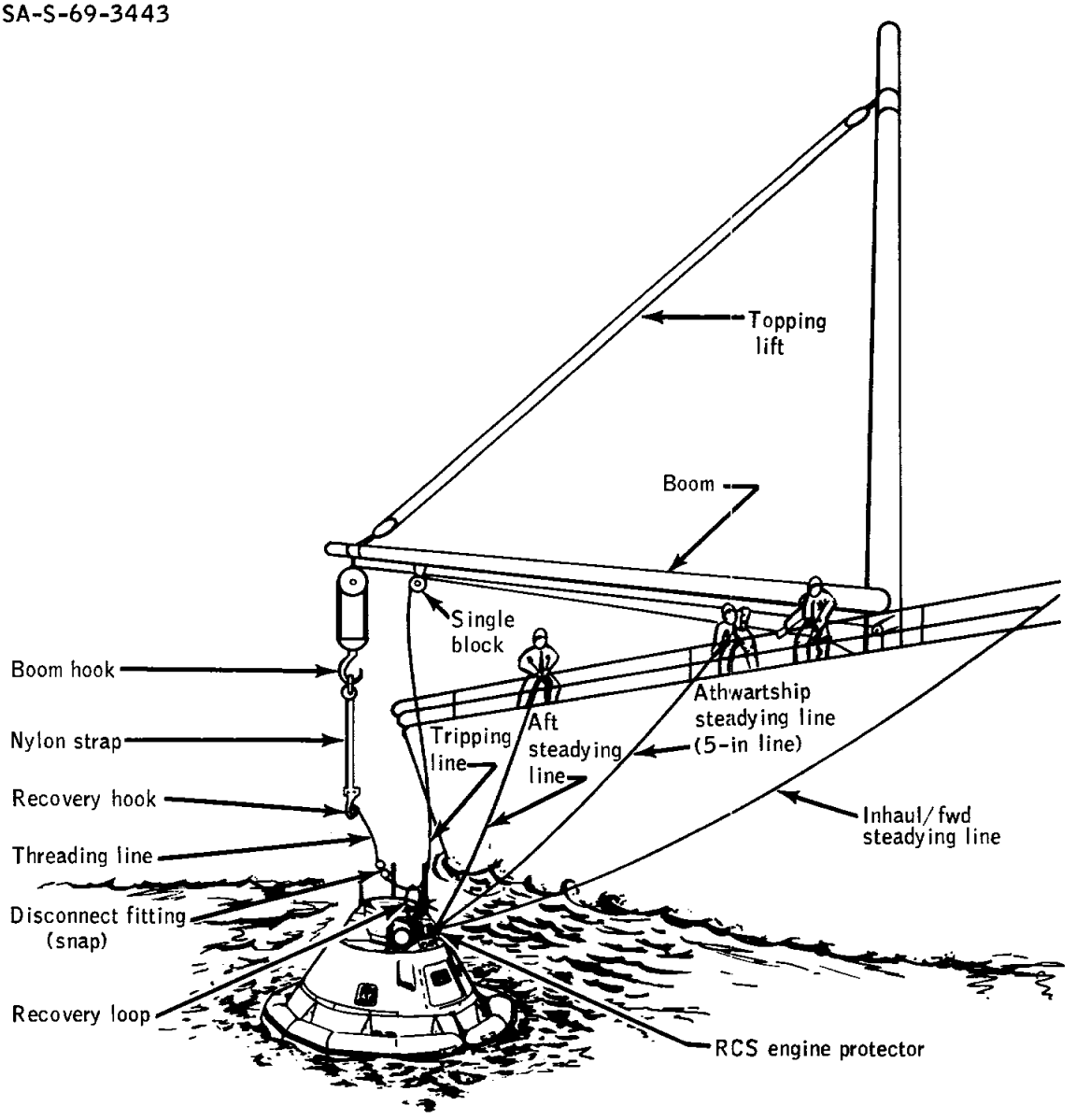

Figure 3-60. Boom rigging for high-freeboard ships

WARNING

IN PASSING THREADING AND AFTER STEADYING LINE TO SWIMMERS ON THE CM, EXTREME CARE SHOULD BE EXERCISED TO KEEP THE RECOVERY HOOK AND BOOM HOOK AWAY FROM THE SWIMMERS.

(d) A third steadying line with mercury hook attached is connected to the RCS engine protector as soon after hoisting commences as reach of mercury pole will permit. This line is tended athwartships from a cleat/bitt on the side of the ship opposite the recovery area. The line is intended to limit the swing of the CM while it is being hoisted in close proximity to the side of the ship during rolls. The pendulum effect is further limited by two-blocking the boom hook as early as possible after CM hookup. The boom hook should be retained in this position insofar as possible while the topping lift, boom and guys are maneuvered to lower the CM to the desired position on deck.

NOTE

In high-freeboard ships it is particularly important that fenders be carefully rigged in the areas where it is possible for the CM to come into contact with the ship's side.

Situations 2 and 3 (same conditions as described for an oiler):

The general procedures used for recovery by oiler are applicable.

(a) The ship's boat is used to effect hookup of the in-haul and steadying lines to the CM.

(b) A 75-foot length of 21-thread line bent onto the eye of the threader line with shuttle pin attached is received by the boat and passed through the recovery loop with a line threader. The recovery hook is then lowered and the threading line is taken in by the boat crew until the recovery hook engages the recovery loop. The CM is then hoisted from the water as for Situation 1.

3.2.3.5 Postretrieval Operations

CM postretrieval operations aboard a secondary recovery ship will be held to a minimum. Generally, they will consist of CM inspection and photography, recording of switch positions, systems shutdown, and removal of specific items that require temperature control or special handling. A 24-hour fire/security watch shall be maintained on the CM at all times after recovery. More detailed information is contained in ref. 5.

3.2.3.6 Summary Report

The ship making the recovery will prepare a ship SUMREP, as described in section 6.0.

3.3 CONTINGENCY LANDING AREA

3.3.1 Water Landing

In the case of a water landing in the contingency landing area, the prime mission of the rescue aircraft is to locate the CM as quickly as possible, commence pararescue operations to install the flotation collar, and give all possible aid to the astronauts until a ship arrives. The nearest ship capable of rendering assistance will be requested to proceed to the landing location and retrieve the astronauts, pararescue personnel, and, if possible, the CM.

3.3.1.1 CM Location

Following notification of a contingency landing, the appropriate Recovery Control Center should supply the rescue aircraft with the most recent information concerning the CM ground track. The exact search procedure to be used will depend on the amount and kind of information which the aircraft is able to get. If part of the ground track is known, the search area may be reduced based on the last known point on the ground track passed by the CM. The aircraft should then fly an electronic search along the ground track using the ARD-17 equipment. If there is time before CM landing, the equipment should be tuned to receive the CM S-band signal. If not, it should be tuned to the recovery beacon frequency. As soon as the signal is acquired, the same procedures used in secondary landing areas may commence.

3.3.1.2 Pararescue Operations

Pararescue operations are the same as for secondary landing area procedures (section 3.2.2).

3.3.1.3 Ship-of-Opportunity (SOOP) Equipment Deployment

As soon as a ship of opportunity can be located, contacted, and its assistance requested in a contingency situation, certain equipment will be transported to the area as rapidly as possible. This equipment falls into two classifications:

(a) Air-dropped SOOP kit for boom-rigged ships.

(b) Air-transportable recovery equipment to augment boom-rigged ships and DD-type ships. In the latter case, DOD and NASA recovery personnel will accompany the equipment.

3.3.1.3.1 Air-dropped SOOP kit for boom-rigged ships

This kit contains the recovery equipment that a boom-rigged ship other than one assigned to the DOD recovery forces would find very helpful in connection with the recovery of the Apollo command module and crew.

(1) The kit will remain at MSC-Houston during the mission.

(2) When a contingency landing occurs, and after a ship-of-opportunity has been designated to make the recovery, the kit will be routed to the scene in the most expeditious manner.

(3) Prior to CM recovery, the kit will be opened by the pararescuemen onboard the ship-of-opportunity and its contents explained to the ship's officers.

(4) The ship's crewmen will be assisted by the pararescuemen and by communications from the DOD recovery forces.

The actual equipment contained in the SOOP kit is:

(a) A recovery hook with an 8 ft., 1-5/8 in. diameter. nylon line attached.

(b) A hatch tool.

(c) A set of multilingual retrieval instruction cards.

(d) A set of instructions pertaining to the equipment.

(e) Any other items which MCC-Houston may see fit to include for crew comfort, CM recovery, etc.

Total equipment weight is about 50 pounds before incidental weight is added and the kit is configured for air delivery from an HC-130 aircraft.

Buoyancy and impact protection have been attained by packing the equipment in two containers - one inside the other. The inner container is a strong, water-tight, independently buoyant, metal or fiberglass case. The inner container, surrounded by shock absorbing materials such as styrofoam and foam rubber, is packed inside an Apollo collar case. If this outer container should split open upon impact, the inner container would remain intact. This combination, along with the ballast or additional equipment necessary to bring the total SOOP kit weight up to 135 pounds, is then compatible with the

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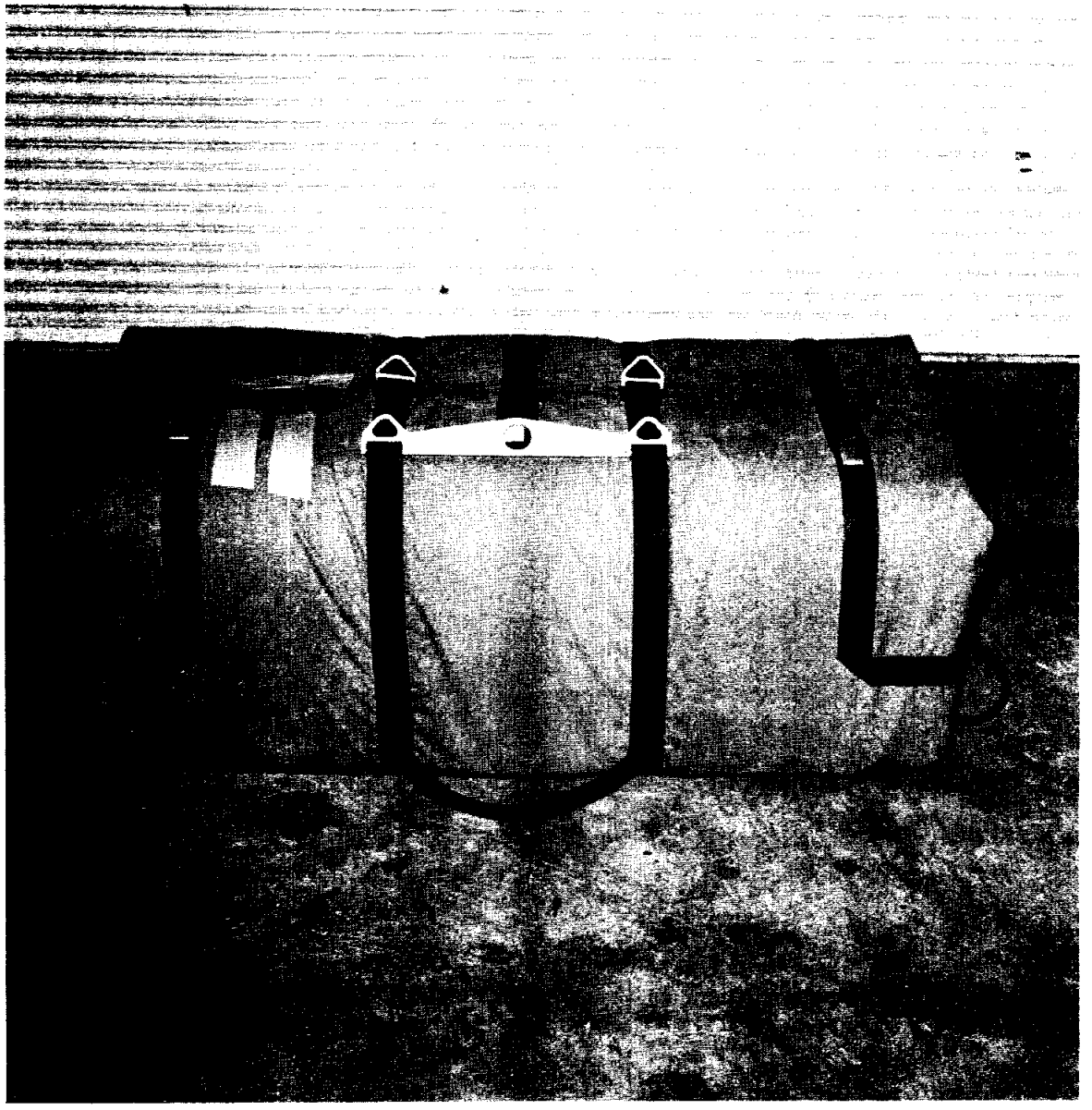

Figure 3-61. Air-dropped SOOP kit for boom-rigged ships ready for deployment

S-70-53197

Figure 3-62. Basic contents of the air-dropped SOOP kit for boom-rigged ships

HC-130 Overhead Delivery System (ODS).

Figure 3-61 shows the SOOP kit as it would be delivered to the ship of opportunity and figure 3-62 shows the basic contents of the kit itself.

3.3.1.3.2 Air-transportable recovery equipment to augment boom-rigged ships and DD type ships.

The following recovery equipment will be available for air shipment to contingency landing area should the need arise:

Item	Number
Recovery Davit Crane (Disassembled for air shipment)	1
Line threaders	3
Line threader shuttle pins	6
Mercury poles	3
Mercury hooks	3
Apollo CM dolly	1
Apollo CM cradle	1
Ratchet tiedown straps	3
Spare recovery hook and shackle	1
Spare 75-ft. nylon whip	1
Fending devices	3
CM hatch tools	2
Inhaul line	600 Ft.
Spare ring lines	2
Took kit	1
Special tools to install Davit	1 Set

A jammed hatch kit vice the shipboard equipment will be included if a land landing occurs.

3.3.1.4 Retrieval Operations

Following a contingency landing and deployment of pararescuemen, assistance will be requested from the nearest ships in the area that have the capability of rendering assistance. Under these circumstances, the pararescuemen must be capable of providing information and assistance for retrieval. The pararescuemen shall be familiar with boom-rigged ship procedures as given in sections 3.2.3.3 and 3.2.3.4. The pararescuemen will be equipped with multilingual CM retrieval instruction cards described in section 3.2.2.1 to assist in communicating with foreign crews. The first concern is for the safe retrieval of the crew of the CM and the pararescuemen; secondly, the CM should be retrieved if possible.

The ship's captain will probably have been in communications with the aircraft and possibly with a Recovery Center before arriving on the scene. He may already have received requests and/or instructions from these sources. If it has not already done so, the ship should attempt to establish communications with the recovery forces or Recovery Control Centers on the recovery frequencies or any other frequency available. If two-way communications cannot be established, the ship should be requested to broadcast in the blind on the recovery force frequencies or on the ship international broadcast frequencies.

Before retrieval of the CM, the pararescuemen should evaluate the weather and sea state and obtain as much information as possible about the ship's hoisting capability. This information will be transmitted to the appropriate RCC for relay to the DOD Manager for a decision as to whether the captain of the ship-of-opportunity will be requested to retrieve the CM.

Prior to beginning retrieval operations, the pararescueman in charge must be sure that the ship's crew are well aware of the precautions and safety measures to be observed. These are covered in considerable detail on the multilingual CM retrieval instruction cards which each pararescueman will carry, but it is necessary to make sure that the instructions on these cards are understood.

He should emphasize that the CM weighs about 13,000 pounds and has a dangerous pendulum swinging action when lifted clear of the water on the end of a long boom. The danger of fire or toxic fumes from the RCS thrusters should be emphasized. The danger associated with each unexpended pyrotechnic device (if any) must be pointed out. Large-volume, low-pressure water fire fighting hoses should be ready prior to attempting recovery. It is highly desirable that suitable padding material (such as mattresses) be provided on which to rest the heat shield. The pararescuemen should also request that the captain launch a small boat, if possible, to assist in recovery.

The pararescuemen should describe the recovery loop and its relation to the equipment in the SOOP kit. They should also assist in making the hook-up with the ship's hoisting cable. Steadying lines should be secured to the CM RCS engine protector to reduce the pendulum action and assist in positioning the CM on the deck padding.

The CM is heavy and inherently unstable when placed on a flat surface. As soon as it is in position on the deck padding, it must be securely tied down. Heavy cargo or anchor lines (1 inch in diameter or larger) should be looped around the CM upper deck tunnel and tied off to strong chocks, cleats, or other securing points of comparable strength.

WARNING

THE SHIP'S CREW SHOULD BE CAUTIONED TO REMAIN WELL CLEAR OF THE RCS THRUSTERS AND ANY POSSIBLE UNEXPENDED PYROTECHNIC DEVICES WHILE RETRIEVING THE CM AND SECURING IT ON DECK.

3.3.2 Land Landing

In the event of a contingency land landing, the prime mission of the search aircraft and their crews is to locate the CM as soon as possible and commence land pararescue operations, giving all possible assistance to the astronauts. Crew transportation from the recovery area and disposition of the CM will be decided after-the-fact.

3.3.2.1 CM Location

Search procedures in this situation will again depend heavily on the latest information available concerning the CM ground track. It is possible that the only CM location aid functioning after a land landing would be the astronaut survival radio.

3.3.2.2 Considerations for Evaluating Flight Crew and CM Condition

In the event of a land landing, the amount of structural damage incurred by the CM will depend on factors such as the type of terrain in which the CM lands, and its angle of impact. A severe landing shock would probably cause severe damage to the aft end of the CM. The heat shield and crushable ribs would assume most of the damage; however, the RCS fuel and oxidizer tanks would most likely be ruptured. The center of gravity of the CM is such that while on the main parachutes, the CM hangs in an attitude whereby the side opposite the hatch would receive the initial shock. This is the area below the feet of the astronaut couches. If the CM should impact at an angle that is flatter (that is, the heat shield more parallel to the ground), the damage is likely to be more extensive. At the time of impact, the CM would be descending at about 31 feet per second on three parachutes or 36 feet per second on two parachutes.

The condition of the astronauts after a land landing will be dependent on several things: the velocity of the CM at impact, the angle of impact, and the precautions which the astronauts themselves take in preparing for a land landing.

3.3.2.3 Rescue Operations and Postlanding Investigation

The action to be taken in providing assistance to the astronauts and protecting the CM will be decided on an after-the-fact basis. Instructions will be provided by the Recovery Control Center or the cognizant sub-Recovery Control Center.

To assist the postflight investigation and/or mission failure boards, as much information as possible should be recorded before the impact site is disturbed. The following checklists should be used and as many photographs as possible should be taken. NASA will furnish cameras to those units providing contingency support of large land areas. Also, it is requested that rescue personnel make written notes of their observations. First priority, of course, is to render aid and assistance to the flight crew as required.

General Instructions

(a) Determine the condition of the flight crew and provide first aid and assistance as required.

(b) Note the location and position of the flight crew.

(c) If possible, take necessary action to secure the impact area to prevent unauthorized disturbance of the vehicle or debris.

(d) Obtain and record the exact location of the impact site.

(e) Note the presence of odors, propellant spillage, etc.

(f) Note indications of rain or other weather effects which appear to have occurred subsequent to impact.

(g) Note the presence of footprints and apparent disturbances of the vehicle or debris which may have occurred prior to arrival of rescue personnel.

(h) After completing an overall survey and photographing the area as it existed at the time of arrival, rescue personnel should attempt to inspect for any damage and obtain photographs of it from various angles. They should look for unusual or significant burning or charring, structural damage, etc.

3.3.2.3.1 Checklists for Photography

Examples of Components to be Photographed

(a) Engines

(b) Heat shield

(c) Parachutes

(d) Suits, clothing, helmets

(e) Suit-to-CM fittings and connections

(f) Seats, seat fittings

(g) Instrument panels and, if possible, instrument readings

(h) Electrical components and connectors

(i) Pipes, lines, joints

(j) Pressure vessels, actuators, valves, tanks

(k) Radios

(l) Position of electrical switches and mechanical control handles

Types of Damage to Include When Photographing Components

(a) Breaks in metal surfaces

(b) Burn marks, soot, melting

(c) Scrape marks, impact marks, dents, punctures

(d) Liquids, spill marks, etc.

(e) Twisted, torn or compressed metals

(f) Electrical burning, condition of wires, etc.

(g) Contrast between damaged and undamaged components/areas

WARNING

DO NOT TOUCH ANY CONTROLS OR LOOSE COMPONENTS. BEWARE OF HAZARDS -- RCS PROPELLANTS, PYROTECHNICS, AND RADIOACTIVE MATERIALS.

3.3.2.3.2 Checklists for Additional Actions

General

(a) Collect charts, recordings, notes, etc.

(b) Note general appearance of cabin interior.

(c) Try to get statements from witnesses.

Impact Area

(a) Note the size and shape of the crater.

(b) Note scatter of debris and distance to objects.

(c) Photograph the impact area before disturbing any parts, if possible.

(d) Look for the initial impact point if it appears that the CM bounced, rolled, or was dragged by parachute to its resting place.

(e) Note the configuration of nearby terrain; hills, slopes, ridges, streams, lakes, rocks, cliffs, buildings, forests, etc.

(f) Establish direction and indicate it on a sketch showing relative positions of the vehicle components.

IV LAUNCH SITE RECOVERY OPERATIONS

4.0 LAUNCH SITE/LAUNCH ABORT SECTOR A/WESTLANT EARTH ORBITAL SECONDARY LANDING AREA (SLA) RECOVERY OPERATIONS

Long range helicopter recovery operations within launch abort Sector A and the WESTLANT earth orbital SLA are to be considered an extension to deep water helicopter recovery operations within the launch site area. Aerial refuelable launch site helicopters and an accompanying tanker aircraft are available to support recovery operations within these expanded areas. This section contains information on the equipment and procedures to be used by recovery forces in the event of an abort resulting in a landing in the launch site area, launch abort Sector A area or the WESTLANT earth orbital secondary landing area. The DOD recovery personnel to which this information applies are:

(a) Launch site recovery helicopter aircrews

(b) Launch site pararescue personnel

(c) HC-130P/N tanker aircrews

(d) Fire suppression kit (FSK) operators

(e) LCU crews

The period in which the launch site/launch abort sector A/WESTLANT earth orbital SLA helicopter recovery forces are responsible for providing recovery support begins at the time of launch escape system (LES) arming and continues until released. Normally, an abort initiated after 90 seconds GET will produce a landing point down range beyond the launch site area and an abort initiated after approximately 6 minutes 30 seconds GET will produce a landing point down range beyond the launch abort sector A area. During nominal lunar mission operations, recovery forces supporting WESTLANT earth orbital target points can expect release after a successful translunar injection (TLI) burn which normally occurs at approximately 2 hours 30 minutes GET (first opportunity) or at approximately 4 hours 05 minutes GET (second opportunity).

In addition to supporting normal recovery requirements, the launch site recovery force should be prepared to support the pad egress team after flight crew ingress.

The suggested general positioning of recovery vehicles at the time of launch is shown in fig. 4-1. A definition of the launch site area, the launch abort Sector A area, the WESTLANT earth orbital target points, and the recovery requirements for each Apollo mission will be included in reference 6.

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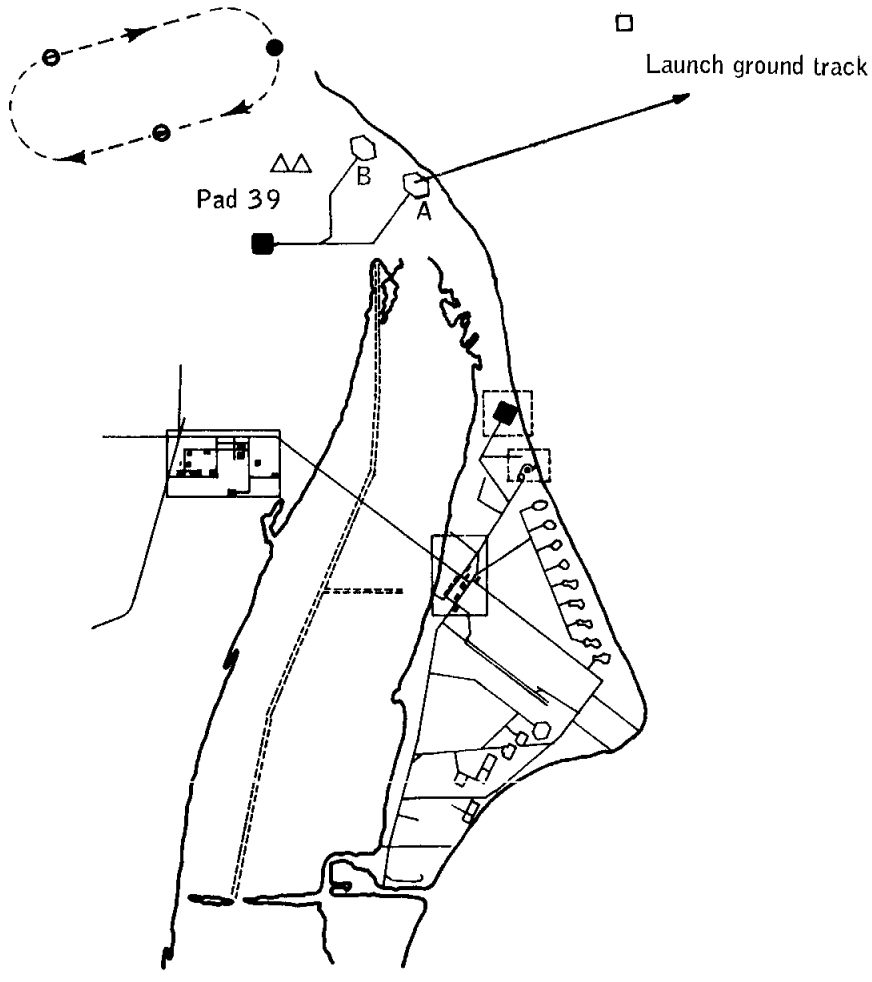

● Recovery commander's helicopter
⊖ HLH recovery helicopters
△ Fire suppression kits
□ LCU

Notes:

These positions are only approximate and not to scale.
CM land recovery vehicles not prepositioned.
After launch, helicopters proceed down range.
They will be flying at pre-assigned altitudes.

Figure 4-1. Typical positioning of recovery vehicles at launch

4.1 RECOVERY SEQUENCE

A typical sequence of activities for recovery and salvage operations in the launch site/launch Sector A area would consist of:

(a) Locating the CM

(b) Retrieving the flight crew and CM

(c) Assisting in postretrieval salvage operations

The general scope of each of these phases of the recovery operation is discussed here. More detailed information applicable to each type of recovery unit is given in the remainder of this section. The procedures described in this section are also applicable to night operations with the exception that the helicopter lights/aircraft dropped flares will provide illumination for recovery operations.

4.1.1 Command Module Location

Visual observation (particularly from helicopters) is the primary method that will be used to locate the CM in the launch site area. This method will be augmented by information obtained from the Launch Abort Range Inspection Surveillance Display System (LARS) in the Range Control Center and by electronic tracking equipment in the Cape Kennedy area. Any abort and relative CM landing point information will be relayed to the Launch Site Recovery Commander in the command helicopter from the Launch Site Range Surveillance Officer (LSRSO). In addition, the helicopters will have SARAH receivers with which to home on the CM if visual contact is lost. On downrange operations, Search and Navigation functions will be provided by the escorting HC-130 P/N aircraft.

4.1.2 Flight Crew and CM Retrieval

The Launch Site Recovery Commander (Beach Boss) will proceed to the landing site to act as controller and communications relay for the recovery force. The course of action that would be taken to retrieve the flight crew and CM depends upon the CM landing location. If wind conditions are such that there is a high probability for a CM land landing. This means that the helicopter will carry a fire suppression kit (FSK), fig. 4-2, a firefighter team, a pararescue team dressed in Nomex suits, a jammed hatch kit (JHK), fig. 4-3, an LRD engineer, and the normal equipment. If a water landing is predicted, the helicopters will be configured for an open-ocean recovery.

The normal procedures to be used for landing on land, in the surf, in deep water, and on downrange astronaut recoveries are briefly described here.

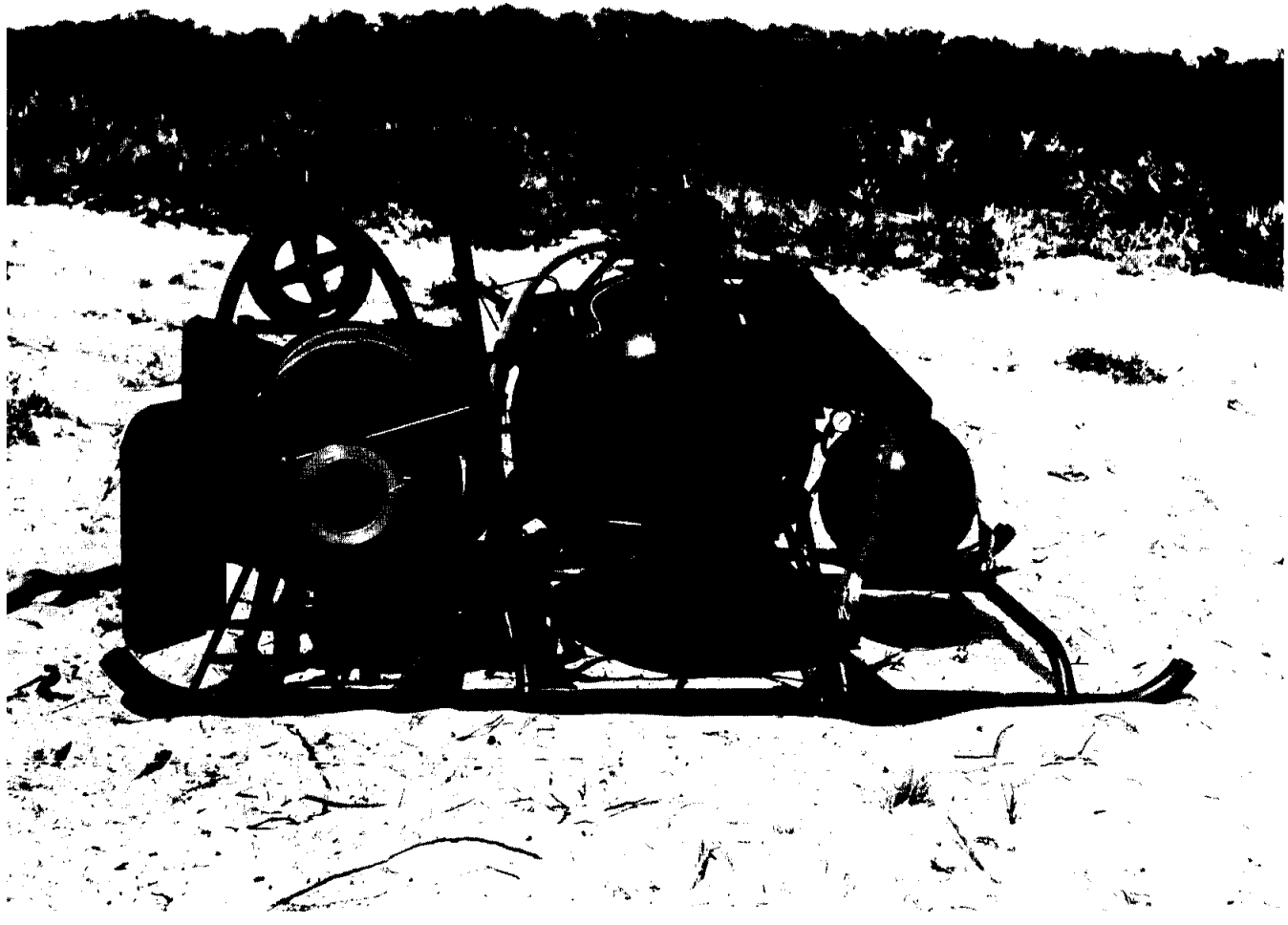

Figure 4-2.- Fire suppression kit

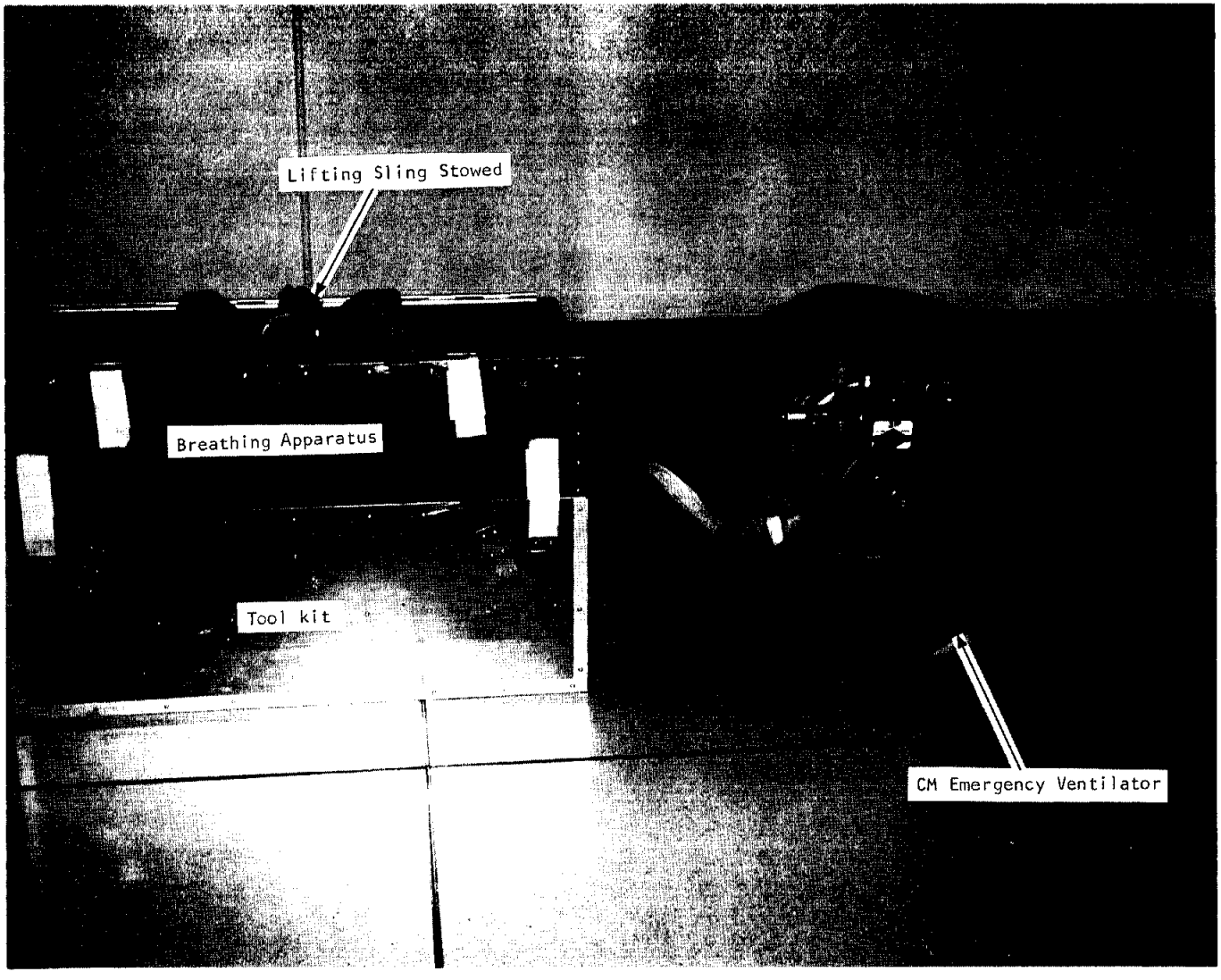

Figure 4-3.- Jammed hatch kit

4.1.2.1 Deep Water

(a) A recovery helicopter will proceed to the landing point and will deploy a pararescue team and flotation collar.

(b) The flight crew will be assisted in egressing, and then taken aboard a second helicopter for transportation to a predesignated medical facility.

(c) The CM will be retrieved and transported to a predesignated transfer point for reception by the postlanding team.

4.1.2.2 Surf

(a) A recovery helicopter proceeds to the landing point and, if the operational area is safe, deploys a pararescue team to assist in the CM/HH-53C hook-up. If the CM is in a surf zone that will be hazardous to pararescue operations, the HH-53C rotor wash will be used to push the CM to the beach where a pararescue team will deploy.

(b) The HH-53C recovery helicopter lifts the CM and proceeds to the nearest beach area.

(c) The second HH-53C recovery helicopter delivers an FSK, a fire fighting team, a JHK and engineer, and a pararescue team to the beach area.

(d) The flight crew is assisted in egressing on the beach and transported by the second recovery helicopter to a predesignated medical facility.

(e) The remaining HH-53C recovery helicopter transports the CM to a predesignated transfer point for reception by the postlanding team.

4.1.2.3 Land

(a) The first helicopter at the CM landing point will deploy an FSK, firefighters, a pararescue team, and a JHK and engineer.

(b) The second recovery helicopter will proceed to the FSK staging point to pick up an FSK, a firefighting team and a jammed hatch team. The recovery team will be deployed if needed.

(c) The firefighting teams, with the aid of the FSK's, will contain any RCS propellant fires while the pararescue team assists the flight crew in egressing.

(d) The flight crew is transported by a recovery helicopter to a predesignated medical facility.

(e) If necessary, the CM will be transferred to a hard surface for reception by the postlanding team.

4.1.2.4 Downrange flight crew retrieval

(a) In the event of an abort in the launch abort sector A and upon commitment of launch site helicopters to a downrange flight crew recovery operation, two helicopters will proceed downrange toward the predicted landing point.

(b) A HC-130 P/N tanker will rendezvous with the helicopters enroute to provide fuel, navigation, and location assistance.

(c) "Station A aircraft also configured as an HC-130P/N will provide backup tanker capability, CM location assistance, and, in the event of night retrieval operations, illumination flare drop support."

(d) Upon arrival at the landing point, Beach Boss or the senior helicopter pilot will assume on-scene command and proceed with whatever phase of operation that is in progress. If the collar is already installed, the helicopter will deploy an Apollo recovery raft and at least one pararescueman to facilitate helicopter recovery operations.

(e) The flight crew will be retrieved and transported to a predesignated medical facility.

(f) The pararescuemen/swimmers will be retrieved by the second helicopter unless a recovery ship has arrived at the scene or is in the area.

(g) The CM will be retrieved by ship and transported to a predesignated port.

4.1.3 Command Module Postretrieval Safing and Deactivation

After the CM arrives at the deactivation site, it is inspected and its condition is evaluated by the landing safing team. The pyrotechnic devices are then safed and the RCS is deactivated in accordance with the procedures given in reference 10. A diagram of CM delivery to the deactivation site is shown in figure 4-4.

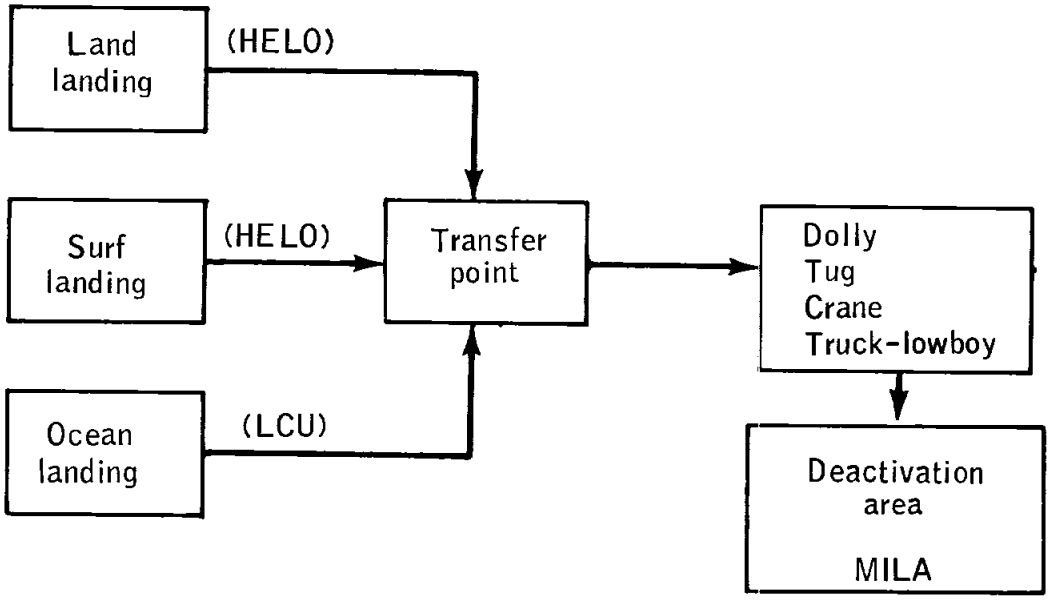

Figure 4-4. - CM transfer to deactivatior area.

4.1.4 Postretrieval Salvage Operations

Once the initial recovery operations have been started and the involved recovery vehicles and crews are executing their assigned duties, the remaining forces may be released to the Recovery Range Control Officer (RRCO) for such tasks as searching for salvageable components, etc.

In conjunction with current and future Apollo lunar missions, a series of experiments will be conducted in which instrument packages will be left on the lunar surface. The power source for these instruments will be a fuel cask attached to the descent stage of the LM and referred to as a System for Nuclear Auxiliary Power (SNAP-27).

4.1.4.1 Responsibilities

The salvage of the SNAP-27 fuel cask will be handled on an after-the-fact basis. In the event of a launch site abort, subsequent salvage operations will be conducted at the discretion of an Investigation Board. If the decision is made to salvage the SNAP-27, the Manned Spacecraft Center has the responsibility of providing the plan for offshore salvage operations. These operations would begin on an assigned priority basis. Responsible organizations, which are on stand-by, will commence their preassigned duties to effect salvage. The salvage plan and description of the duties and responsibilities of each organization are contained in reference 11. In the event the fuel cask lands on land, the Kennedy Space Center will be the responsible organization.

4.1.4.2 Search Procedures

The search operation will be conducted using the Cape Kennedy LCU equipped with MK-16 and PQS-1-B sonar systems and two navy SH-3 helicopters equipped with AQS-13 sonar systems. The LCU and SH-3's will search for pingers located on the Instrument Unit (IU) of the launch vehicle. These pingers are water activated, two emitting a frequency of 37.5 kHz, and two a frequency of 10 kHz.

The LCU and SH-3's will initially search an area prescribed by the Recovery Range Control Officer (RRCO) as the probable impact point of the IU. This information will be based on radar information received at the Range Control Center (RCC) at Cape Kennedy. When a signal is received, the LCU or SH-3's will pinpoint, to the best of their ability, the signal source location. Then divers or underwater photography will confirm the SNAP-27 presence. Once the position is confirmed, the LCU will record its position using LORAC. Based on the local conditions, water depth, debris, currents, etc., a decision will be made by the Investigation Board on whether or not to salvage the SNAP-27.

The primary responsibility of the MSC/DOD is to locate and photograph the cask. From these photographs, the condition of the cask will be determined. When the condition of the cask has been ascertained and the method of salvage determined, the salvage vessel will bring the cask within 3 feet of the surface of the water. (If the fuel cask is damaged, a safe operating distance is approximately 3 feet.) At this point, the AEC/NASA contingency team will assume responsibility for the handling and disposition of the cask. Detailed procedures will be determined on an after-the-fact basis depending upon the physical condition of the cask.

If salvage operations are in water which exceeds the LCU capabilities, naval salvage units will be utilized.

4.2 HELICOPTER OPERATIONS

Air Force HH-53C helicopters are used as part of the launch site/launch abort Sector A recovery force. Normally, the recovery force will consist of a primary recovery helicopter and a secondary recovery helicopter. BEACH BOSS will normally be aboard the primary recovery helicopter.

4.2.1 Personnel and Equipment

Table IV-1 lists the personnel who normally man the launch site/launch abort Sector A recovery helicopters, and special equipment installed on or carried aboard these helicopters. Procedures for checking out the using certain NASA provided equipment are described in section 3.0 of this manual and in references 3, 4, and 12. Check out procedures for the man-rated cargo hook system are included in section 4.8.

4.2.2 Helicopter/Tanker Deployment

Prior to launch, the recovery helicopters will be airborne and in a deployment pattern similar to that shown in figure 4-1. At a predetermined time following lift-off, the helicopters will move downrange parallel to and north of the spacecraft ground track until released from launch abort Sector A coverage. Upon release from launch abort Sector A coverage, at approximately 6 minutes 30 seconds GET, the recovery helicopters will return to the Cape, refuel, and assume a ground alert posture in support of WESTLANT earth orbital target points.

To provide aerial refueling support for the recovery helicopters, one HC-130P/N tanker will be maintained on ground alert at Patrick AFB until the helicopters are released from the mission.

4.2.3 Deployment of Pararescuemen, Fire Fighters, and Equipment

4.2.3.1 Deep-Water Landing

The procedures for helicopter deployment of pararescuemen/swimmers and equipment in the event of a deep water CM landing situation within the launch site area and within launch abort Sector A are essentially the same. The first recovery helicopter on the scene will deploy the pararescue team and flotation collar. During daylight operations, the procedures contained in figure 4-5 apply. During night recovery operations the recovery helicopter commander may elect to maintain a higher altitude and lower the swimmers to the surface by rescue net. In either case, the pararescuemen/swimmers will be deployed downdrift from the CM. Since, during night operations, it is difficult to see if the first swimmer has succeeded in attaching the sea anchor, each swimmer will deploy with a sea anchor kit. The first swimmer will also carry an Apollo swimmer radio. Additionally, during night operations, the flotation collar will not be dropped until confirmation is received that the sea anchor has been installed and all three swimmers are at the CM.

CAUTION

The swimmers must be kept in sight, especially at night. Each swimmer should have a personnel strobe light attached to his back pack so the helicopter crews can locate him at any time. Standard visual and/or radio emergency signals apply. If a swimmer is injured or becomes exhausted, he may be retrieved and replaced by a swimmer from the second helicopter.

If the CM lands in deep water, the first recovery helicopter on the scene will deploy the pararescue team and flotation collar as shown in figure 4-5.

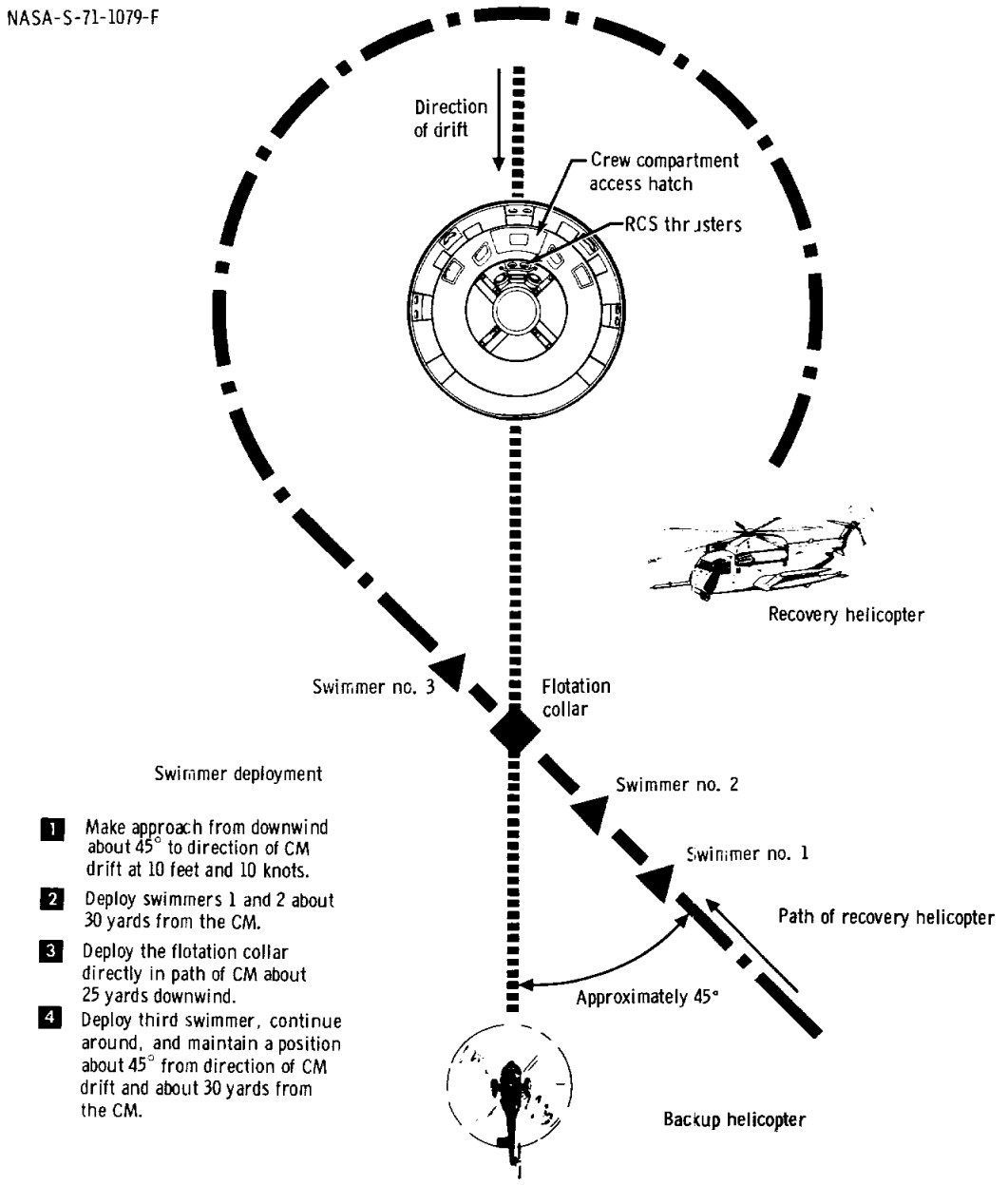

Figure 4-5. Daylight deployment of swimmers and flotation collar

NOTE

An approach from downwind, approximately 45° to the driftline is illustrated. This heading may be varied between 0° and 90° to the driftline at the pilot's discretion.

After deployment of the pararescue team and the flotation collar, the recovery helicopter will circle the CM and fly to a position downwind and on the CM's driftline. The helicopter will maintain this position until called in by the pararescue team to deploy the Apollo recovery raft.

The other two helicopters will orbit the area at discrete altitudes, and be ready to provide personnel and/or equipment as required. During this operation, Beach Boss will keep the LSRSO informed of the recovery operation status. This information will be relayed to DOD Houston.

NOTE

The CM drifts at about 10 percent of the wind velocity. All deployments should be downwind of the CM because of its high drift rate.

In the event the CM is in Stable II, the pararescue team will deploy with an 8-foot auxiliary loop. Uprighting procedures will be identical to those used for surf operations (see sec. 4.3.3.2). Once the CM is uprighted (Stable I), a flotation collar will be deployed.

4.2.3.2 Surf Landing

For a CM landing in the surf, the deployment pattern is the same as in the preceding section, except that the flotation collar is not deployed.

WARNING

EXTREME CARE SHOULD BE USED IN SURF DUE TO THE ROLLING AND PITCHING OF THE CM AND THE POSSIBILITY OF IT HITTING BOTTOM.

TABLE IV-1. LAUNCH SITE RECOVERY HELICOPTER PERSONNEL AND SPECIAL EQUIPMENT

Helicopter designation	Personnel	Special equipment
(2) HH-53C	Normal crew (3 members) Pararescue team (3 members) Photographer Jammed hatch engineer Firefighter team (2 members)	70,000-lb capacity external cargo hook Rescue net SARAH receiver and antennas Stokes litters (3) Slide boards (3) Apollo recovery raft Long-line buoys (3) Flotation collar CM hatch tools (2) Sea anchors (2) 8-ft nylon auxiliary recovery loops (2) 24-ft nylon CM recovery slings (3) Jammed hatch tool kit Boarding ladder

4.2.3.3 Land Landing

Following a land landing, Beach Boss aboard a recovery helicopter will proceed to the CM landing point. The recovery helicopter will deploy its pararescue team, and upon consultation with the on-scene medical personnel, will upright the CM if necessary. In the meantime, the second recovery helicopter will be in the area with an FSK, JHK, firefighter team, pararescue team, and an LRD engineer.

When the first recovery helicopter has uprighted the CM, it will depart the area to pick up the second FSK, firefighter team, JHK, and LRD engineer. Once the first recovery helicopter has departed, the second recovery helicopter will deploy its personnel and equipment.

To deploy their recovery teams and equipment, the helicopters will make an upwind approach 45° into the wind and reduce speed gradually until a hover is attained. The pilot will select a suitable spot and set the FSK down about 75 feet from the CM. When the FSK is on the ground, the helicopter will move several feet laterally and release the sling. The firefighters and pararescue team will be deployed by one of two methods: On a flat, firm surface, the helicopter will land and allow the personnel to jump to the ground; over soft, marshy terrain or tall vegetation, the helicopter will hover at a safe altitude above the vegetation and lower the personnel one at a time by means of a personnel hoist and forest penetrator. The helicopter should be oriented so that the firefighters have both the FSK and the CM in their field of vision as they deploy. After deploying, the firefighters will unreel the hose and activate the unit.

The firefighters will contain the fire and the pararescue teams will commence the crew recovery operation. When all necessary personnel and equipment are on the ground, both recovery helicopters will fly to a nearby position and loiter until called for. The Lanuch Site Recovery Commander aboard a recovery helicopter will act as a command-and-control and communications-relay vehicle.

4.2.3.4 Downrange Flight Crew Retrieval

If a Sector A abort occurs, the launch site helicopters will continue downrange toward the predicted landing point. The helicopters will rendezvous with a HC-130P/N while enroute to the landing point. The tanker aircraft will provide airborne refueling, communications relay, navigation, and CM location assistance.

Upon arrival at the CM, BEACH BOSS or the senior helicopter commander will assume on-scene commander responsibilities, and, if necessary, will advise the HC-130 aircraft commander to terminate his deployment, and then proceed with whatever stage of deep-water operations is

in progress. If the collar is already installed, at least one para-rescueman with an Apollo swimmer radio and an Apollo recovery raft should be deployed to provide assistance in helicopter retrieval procedures.

The flight crew will be retrieved with the rescue net using normal recovery procedures. The second helicopter will recover the para-rescuemen (unless a decision is made to have them remain with the CM) and both helicopters with the escorting tanker aircraft will proceed to a predesignated medical facility.

4.2.4 Summary Report

Upon completion of the recovery operation, each helicopter crew will coordinate and prepare a Helicopter SUMREP, as described in section 6.0.

4.3 PERSONNEL PROCEDURES

4.3.1 Special Equipment

Information concerning the use and care of the flotation collar and sea anchor is given in reference 3. Brief descriptions of these items as well as the Apollo hatch tool are given in section 2.1.2 herein. Instructions for operating and maintaining the FSK are provided in reference 12.

4.3.2 Safety Precautions

Prior to a mission, all recovery personnel will be briefed on the CM hazard areas described in section 2.0 of this manual. Additional safety precautions that should be observed during recovery operations are included where applicable.

4.3.3 In-Water Procedures

4.3.3.1 Deep Water

If the CM lands in deep water, the pararescuemen will be deployed as described in section 4.2.3.1.

WARNING

PARARESCUEMEN SHALL BE CAUTIOUS OF CM ROLLING TO PREVENT GETTING BUMPED, AND SHALL MINIMIZE TIME SPENT IN THE AREAS AROUND THE RCS NOZZLES. FACE MASKS AND FULL SCUBA EQUIPMENT SHALL BE USED UNTIL COLLAR INSTALLATION IS COMPLETE.

Pararescueman No. 1 will swim to the CM with the sea anchor, connect it to the sea anchor attachment ring, and deploy it. After the sea anchor is attached, the remaining pararescuemen will swim to the CM with the flotation collar, staying in the line of drift. The flotation collar will then be installed and inflated in accordance with the procedure given in figure 3-16. When the collar is inflated, the helicopter will be signaled to move in and deploy the Apollo recovery raft and any other equipment needed. The raft will then be tethered to the flotation collar

NOTE

If any main parachutes are still attached to the CM, they should be secured to an additional raft and then cut loose from the CM prior to its retrieval. (See fig. 3-17).

Primary voice communications with the flight crew will involve utilization of the Apollo Swimmer Radio operating on 296.8 MHz. The crew will be kept informed of all events in the recovery. Information pertaining to crew condition will be relayed to the command-and-control helicopter

NOTE

During a nominal launch, the launch site recovery net frequency is 282.8 MHz. If an abort should occur, the launch site recovery force will switch to 296.8 MHz as primary frequency.

The CM hatch will be opened according to the procedures given on pages 3-42 through 3-44 of this manual. When the flight crew has egressed and moved to the raft(s), the hatch will be closed as described in the same section. A second helicopter will then be signaled to move in and retrieve the flight crew. The pararescuemen will assist with the personnel hoist as necessary. Crew retrieval will be accomplished using the recovery net or Stokes litter. A pararescue team will accompany the flight crew to a predesignated medical facility.

The CM will be retrieved by the LCU with the pararescue team assisting in the hook-up. The LCU will also retrieve the flotation collar and other equipment. The pararescue team may be recovered by the LCU or by the helicopters. The LCU will transport the CM to a predesignated transfer point for reception by the postretrieval team.

4.3.3.2 Surf

The normal procedures for assisting in retrieval of the CM after a landing in the surf are similar to those described for a deep-water landing. The major differences are that the flotation collar will not be installed, and the flight crew will remain in the CM until it is transported to the beach.

WARNING

EXTREME CARE SHOULD BE USED IN SURF BECAUSE OF THE ROLLING AND PITCHING OF THE CM AND THE POSSIBILITY OF IT HITTING BOTTOM.

NOTE

If the main parachutes are still attached to the CM, they must be cut loose from the CM prior to its retrieval (see fig. 3-17).

A recovery helicopter will deploy its pararescuemen as applicable before lifting the CM from the surf and transporting it to the beach. if the CM is in a surf zone which would be hazardous to pararescue personnel, the HH-53C rotorwash will be used to beach it. In the event the CM is in a stable II (apex down) position in the surf, the approach and pararescue team deployment procedures will be the same as previously described (paragraph 4.2.3.2), except that pararescueman no. 1 will carry an 8-foot nylon auxiliary loop. As soon as this loop is attached to the CM recovery loop, the HH-53C is signaled in. At the same time, the HH-53C deploys a 24-foot nylon sling which is hooked to the auxiliary loop. The CM is then uprighted and transported to the beach in this configuration. Maximum height above the surface or terrain is to be six feet. The HH-53 releases the 24-foot sling at the completion of this operation. Once on the beach, an FSK will be delivered to stand by in case of hypergolic fires or leakage, and the flight crew will egress. In the meantime, the pararescuemen in the surf will have come ashore or have been picked up by a second recovery helicopter. They will then stand by as required.

The flight crew will be transported to a predesignated medical facility, attended by a pararescue team. The CM will be transported to a point of transfer to a dolly and tug (fig. 4-4) and taken to the MILA deactivation facility.

4.3.3.3 Downrange Flight Crew Retrieval

The normal procedures for retrieving the flight crew on a long-range sector A abort are essentially the same as those for a deep-water launch site recovery. The main difference is that the flotation collar will probably be installed and the flight crew may have egressed prior to the helicopters arrival. The helicopter pararescue teams should be prepared to proceed with whatever phase of collaring or egress that is in progress when they arrive. At least one helicopter pararescueman with an Apollo recovery raft and swimmer radio will be

deployed to provide familiarity with helicopter operations and assistance during the helicopter retrieval. The first helicopter will retrieve the flight crew. The second will recover the pararescuemen (unless the decision is made to have them remain with the CM) and both the helicopters with the escorting tanker aircraft will proceed to a predesignated medical facility.

4.3.4 Land Procedures

The firefighter and pararescue teams and FSK will be deployed as described in section 4.2.3.3. After the FSK (fig. 4-2) has been activated, the firefighters will immediately proceed to contain any fires in the vicinity of the CM. Primary emphasis will be placed on containing fires or toxic fumes from the CM RCS propellant before flight crew egress is initiated (fig. 4-6). The firefighters will spray the CM and pararescuemen as they open the hatch, if necessary. Water will be sprayed from the FSK in the pattern most effective in containing the fire and protecting the pararescuemen and flight crew. Water will be used only as necessary so that it may be conserved.

After the flight crew has been examined by the flight surgeon or pararescue team leader, they will be assisted in egressing as described in the following paragraphs. Then, attended by one of the pararescue teams, they will be flown to a predesignated medical facility. A pararescue team will remain with the CM until it has been recovered or until they are released by the Launch Site Recovery Commander. They will assist in attaching a crane hook to the CM for loading on a flat bed truck and will provide other assistance as required.

4.3.4.1 AIDED EGRESS

It is possible that the flight crew may require assistance to get out of the command module. In the event that this situation arises, the step-by-step procedures for aided egress are as follows.

The following procedures are to be used as a guideline for the launch site recovery forces to follow. Variations from these guidelines will depend upon the operational environment encountered, and the mode of operation will be at the discretion of the Launch Site Recovery Commander.

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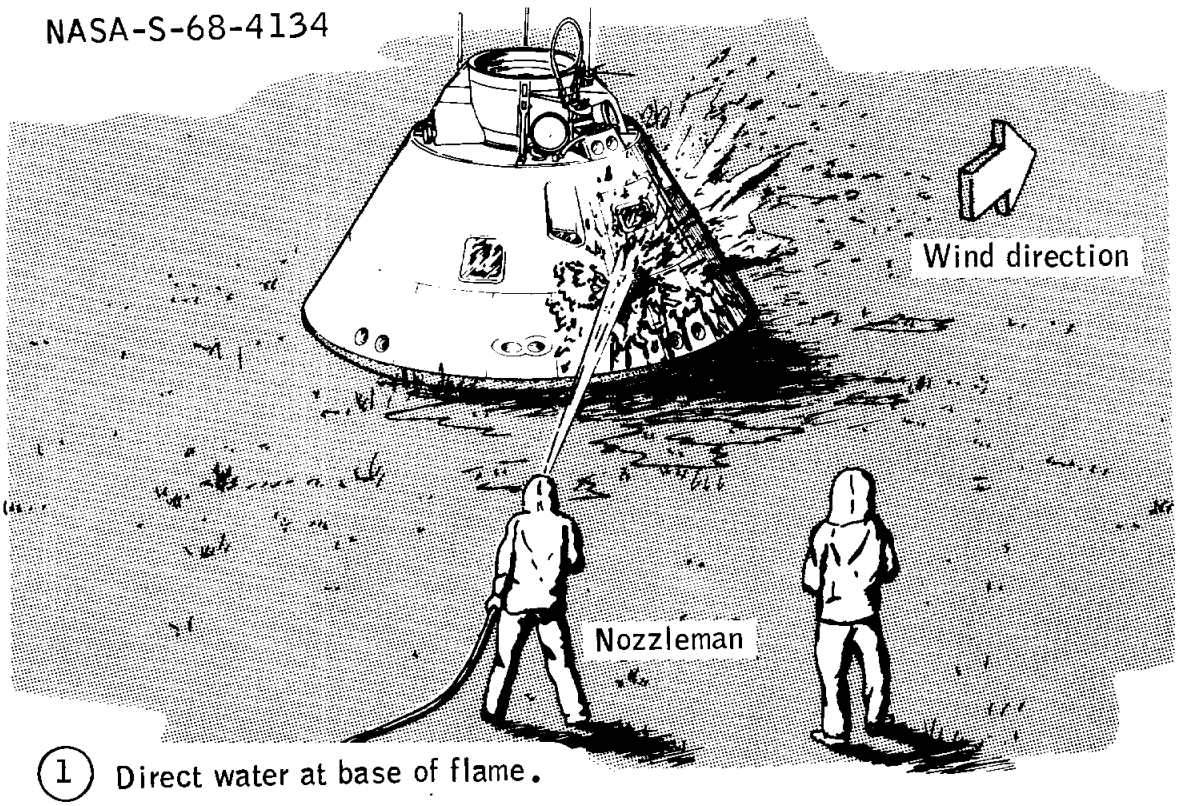

(1) Direct water at base of flame.

(2) Wash propellants away as soon as possible.

(3) Wash down all equipment exposed to propellants.

(4) Observe CM to determine if RCS fumes are present after fire has been extinguished.

WARNING

- Do not stand in RCS thruster area (Approximately 20 feet from the nozzle).
- Fumes are toxic. Fire fighting crew shall have on self-contained air supply equipment.

NOTE

- Use high-capacity fog nozzle (low pressure) to disperse and absorb vapors.
- Remain upwind or crosswind when flushing CM with water.

Figure 4-6. Command module reaction control system firefighting

4.3.4.1.1 Hatch Opening

When conditions permit, egress assistance will begin with the opening of the side hatch by the pararescue team, it will be at the discretion of the on-scene medical officer to determine if the CM should be uprighted before egress of the flight crew is effected. The procedures for this operation are as follows:

(a) One pararescueman will insert the hatch tool in the hatch drive hole as shown in figure 3-20.

(b) He will then rotate the tool clockwise until it stops. This will unlatch the locking mechanism.

(c) He will then rotate the handle counterclockwise until it stops. The hatch will then be ready to open.

(d) The first pararescueman, assisted by the other two pararescuemen if necessary, will open the hatch.

(e) In the event that the hatch is jammed shut, jammed hatch procedures (section 4.3.4.2) will be used.

4.3.4.1.2 Egress Assistance

Once the hatch has been opened, the pararescuemen will ascertain by observation whether or not hazardous fumes or smoke are in the CM. The following procedures will be used:

(a) If the CM atmosphere is safe, the pararescuemen will enter the CM and immediately unfasten the helments from each astronaut (fig. 4-7) and proceed with the aided egress. If the CM atmosphere is hostile, the pararescuemen will don breathing apparatus before entering the CM. Upon entering the CM they will immediately remove each astronaut's helment and attach the forced air breathing device before commencing the egress. An auxiliary air ventilating system will be employed to ventilate the CM.

(b) The pararescuemen that enter the CM will:

(1) Remove the Command Module Pilot's (CMP's) feet from his foot restraint by pulling the heel of his boot out of the restraint.

(2) Remove the CMP's restraint harness.

(3) Remove the CMP's inlet and outlet gas unbilicals.

(4) Remove the CMP's communications line.

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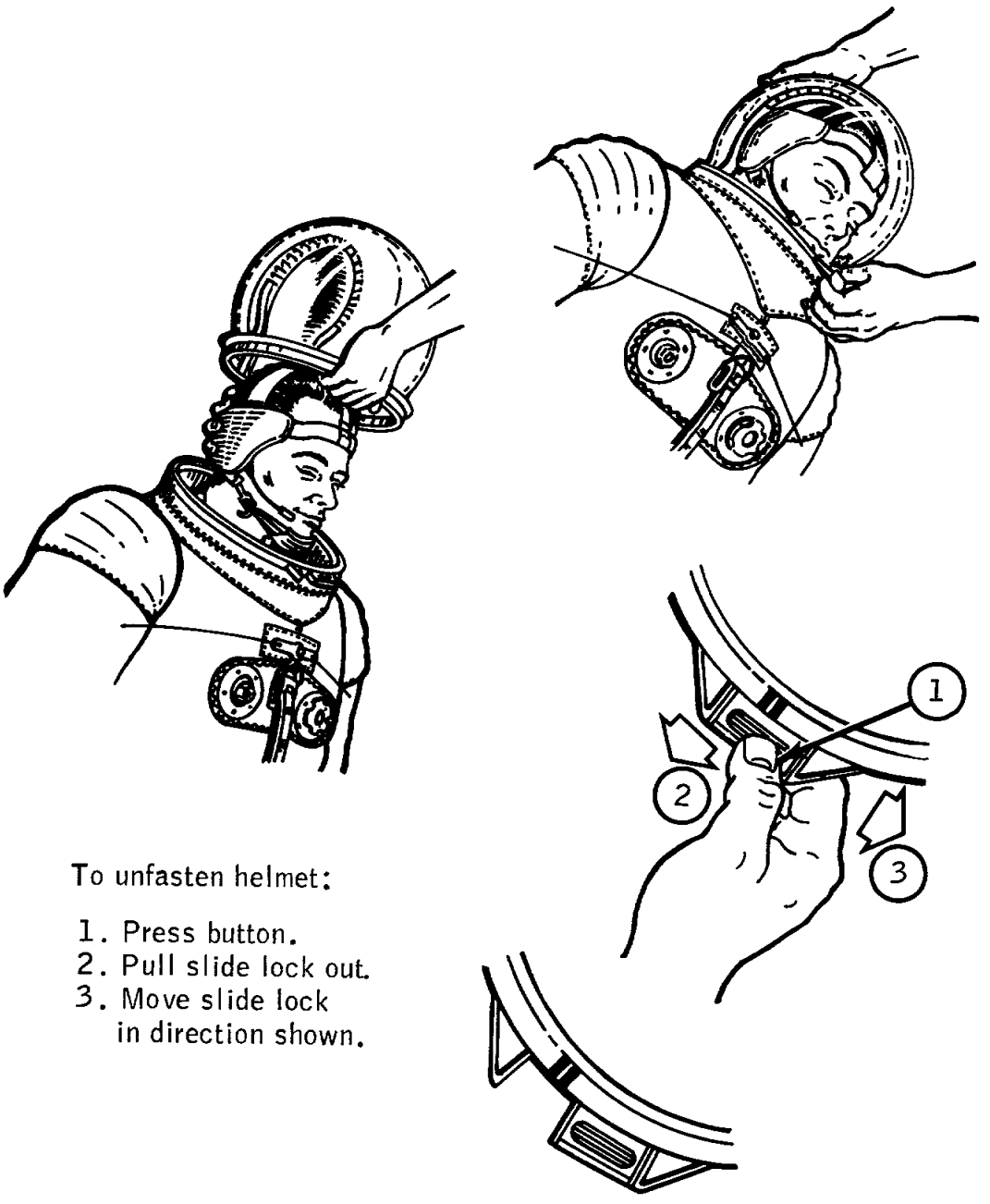

To unfasten helmet:

1. Press button.
2. Pull slide lock out.
3. Move slide lock in direction shown.

Figure 4-7. - Astronaut helment removal

(5) Place the egress strap hook (fig. 4-8) in the upper portable life support system (PLSS) bracket (fig. 4-9).

(6) Slide the CMP's headrest as far back as possible, support his head and guide the slide board (fig. 4-10) lower end into position under his shoulders. The slide board will be handled from the outside by two pararescuemen, aided by the on-scene medical personnel and firefighter if necessary.

(c) The two pararescuemen on the outside will pull the CMP out of the couch, onto the slide board, assisted by the pararescueman inside and available personnel outside (fig. 4-11).

(d) When the CMP is properly positioned on the slide board (secured by safety belt if prescribed by the on-scene medical personnel) the two pararescuemen on the outside will assist the medical personnel or firefighter in transferring the CMP to the helicopter. The slide board may be used as a litter, or the CMP may be transferred into a stokes litter from the slide board, depending on conditions. This decision will be made by the on-scene medical personnel.

(e) Simultaneously, the man in the CM will crawl onto the CMP's couch, stow the Commander's (CDR's) right hand armrest, and lower the center leg pan.

(f) The pararescueman in the CM will then:

(1) Remove the CDR's feet from his foot restraints in the manner described in (b) (1) preceding.

(2) Remove the CDR's restraint harness.

(3) Remove the CDR's suit inlet and outlet gas umbilicals.

(4) Remove the CDR's communications line.

(5) Grasp the CDR's far shoulder and slide his torse into the center couch. The pararescueman will assure that the CDR's head clears the couch strut.

(g) The two pararescuemen on the outside will hand the egress strap (fig. 4-8) to the pararescueman inside the CM.

(h) The pararescueman inside the CM will then:

(1) Attach the egress strap hook to the CDR's upper PLSS bracket strap ring.

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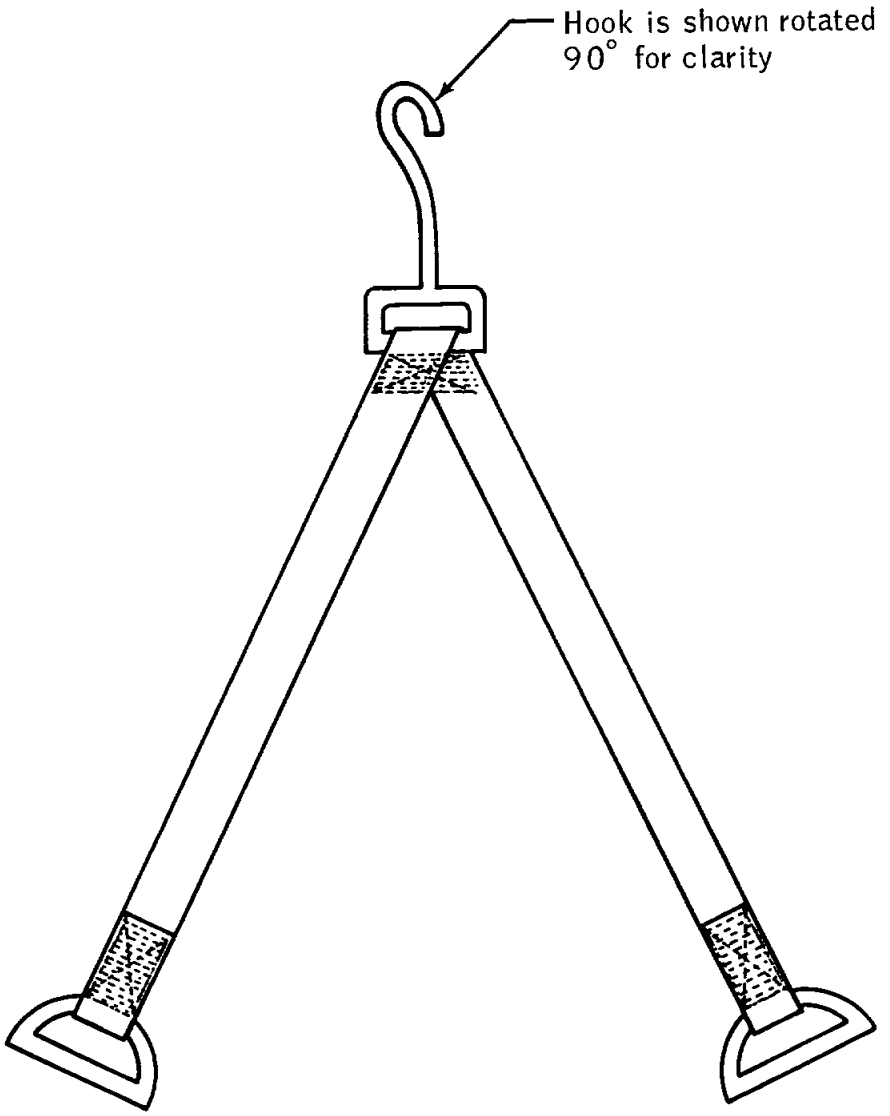

Figure 4-8. - Egress strap

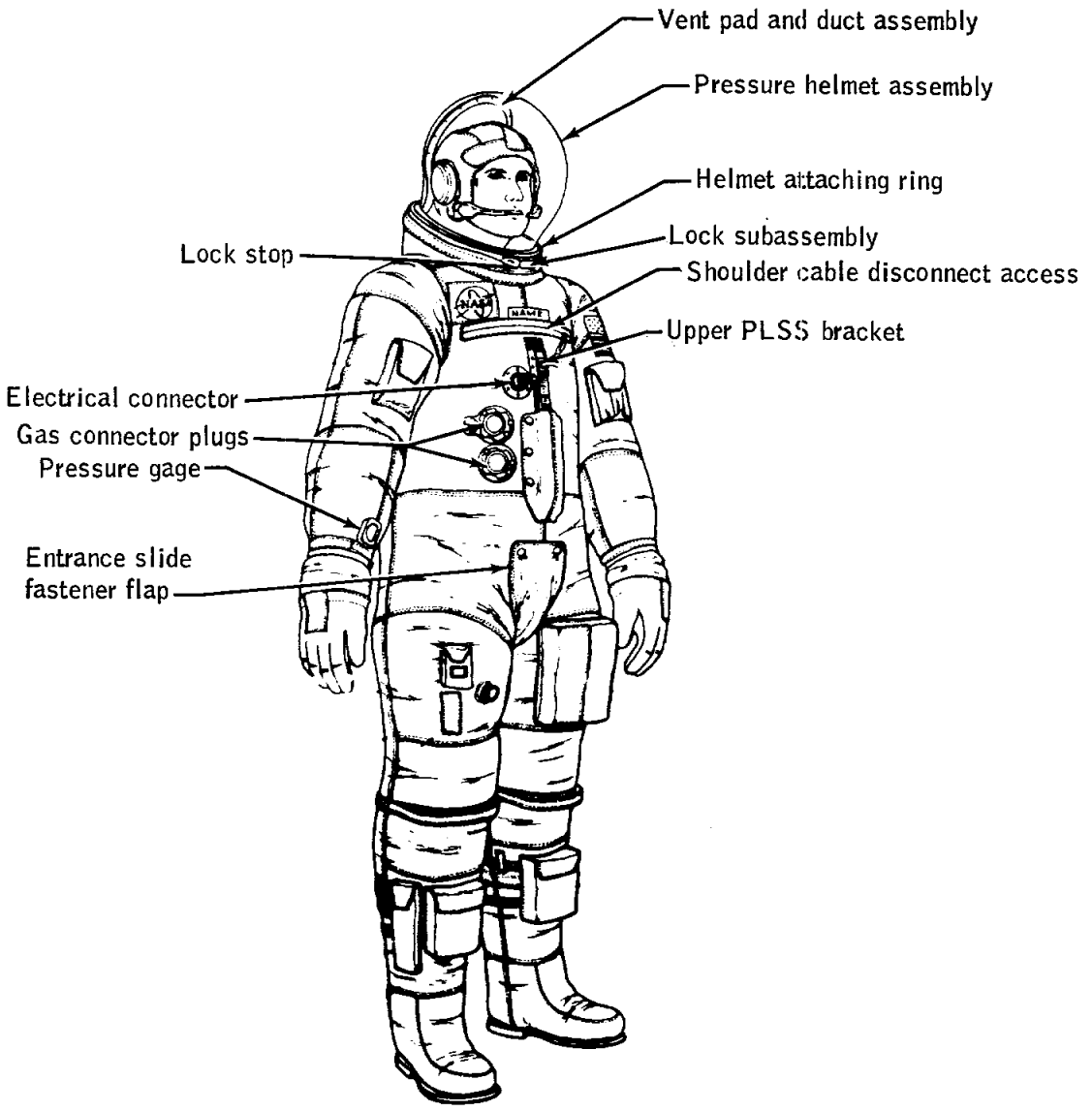

Figure 4-9. Intravehicular pressure garmet assembly

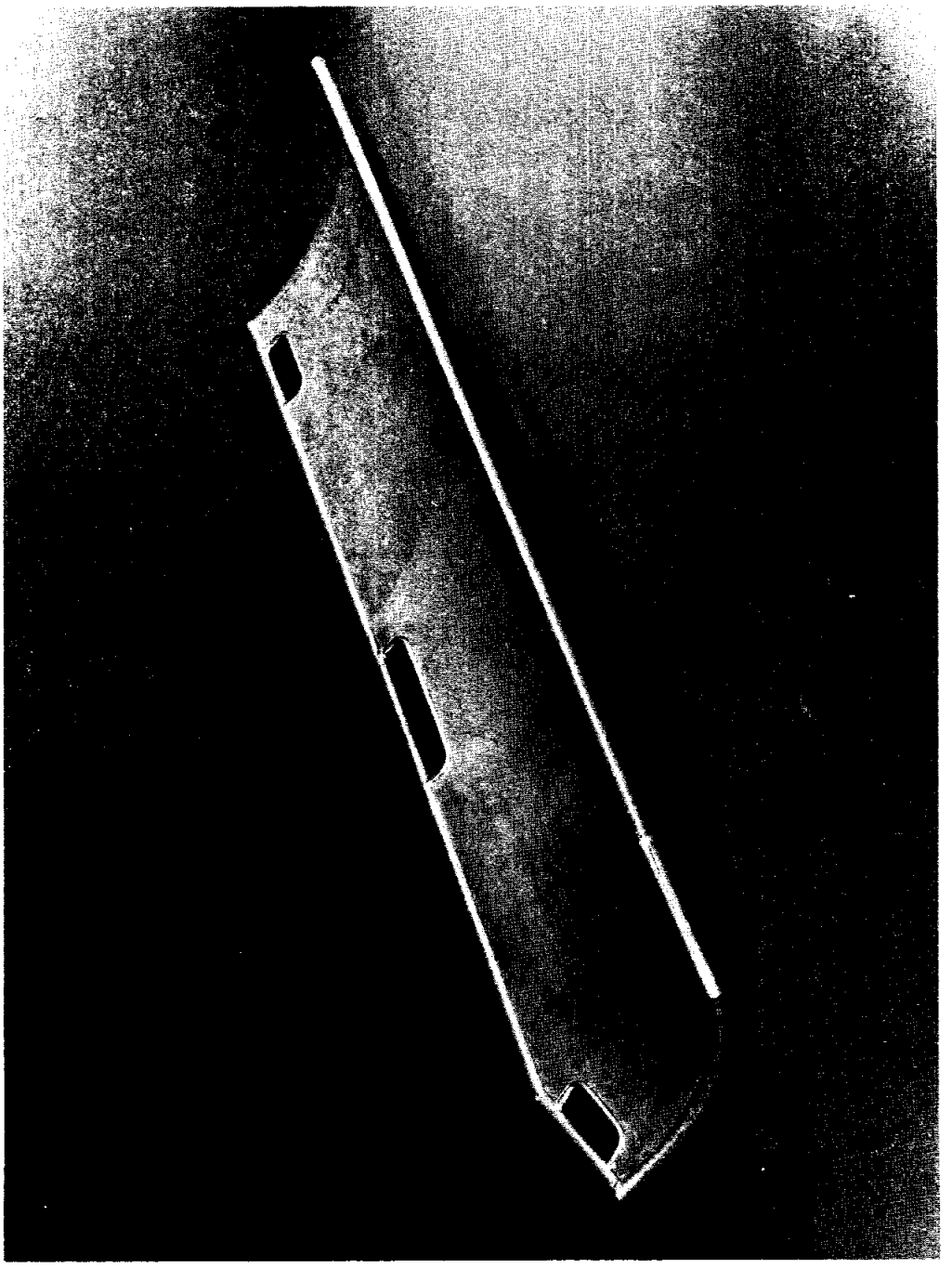

Figure 4-10. Slide board for aided egress

Figure 4-11. Aided egress

(2) Support the CDR's head and guide the slide board as described in step (b) (6), and repeating steps (c) and (d) preceding, as required for the CDR.

(i) Simultaneously, the pararescueman in the CM will again crawl onto the center couch and repeat steps (f)-(h) for the Lunar Module Pilot (LMP).

(j) The pararescue team in the helicopter with the flight crew will remove all crew member's gloves, earphones, and microphones.

4.3.4.2 JAMMED HATCH PROCEDURES

In the event of a CM land landing in the launch site area, the possibility, though remote, of jammed hatches exists. Provisions have therefore been made to enable the recovery forces to gain access to the CM interior and aid flight crew egress.

4.3.4.2.1 Personnel and Equipment

The personnel who perform the CM access operations are pararescuemen who are members of the standard recovery team. They will operate under the supervision of a Landing and Recovery Division (LRD) engineer. The equipment employed for the operation will consist of redundant equipment packages to be transported aboard the HH-53C recovery helicopters. One equipment package and LRD engineer will be aboard the recovery helicopter if it is configured for a land landing. The secondary equipment package and LRD engineer will be staged with the secondary FSK.

The NASA-supplied equipment packages will include the following major items (figs. 4-12 and 4-13):

(a) Pneumatic tool compressed air source.

(b) Pneumatic circular saw with carbide blade.

(c) High pressure hose (25-ft length)

(d) Crash axe.

(e) Single-bit axe.

(f) Sledge hammer.

(g) Two crowbars (36-in length).

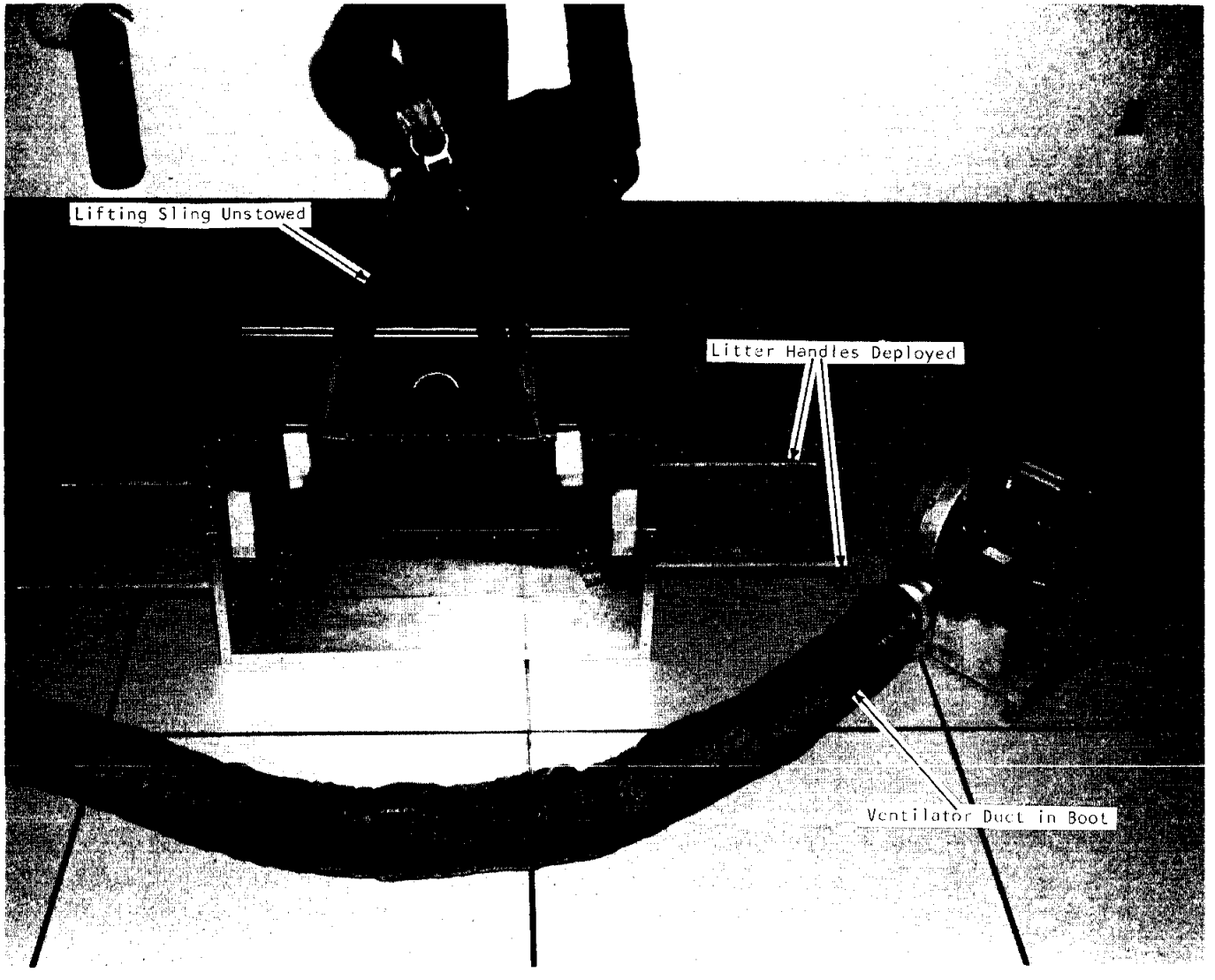

Figure 4-12. - Jammed hatch kit configured for carrying

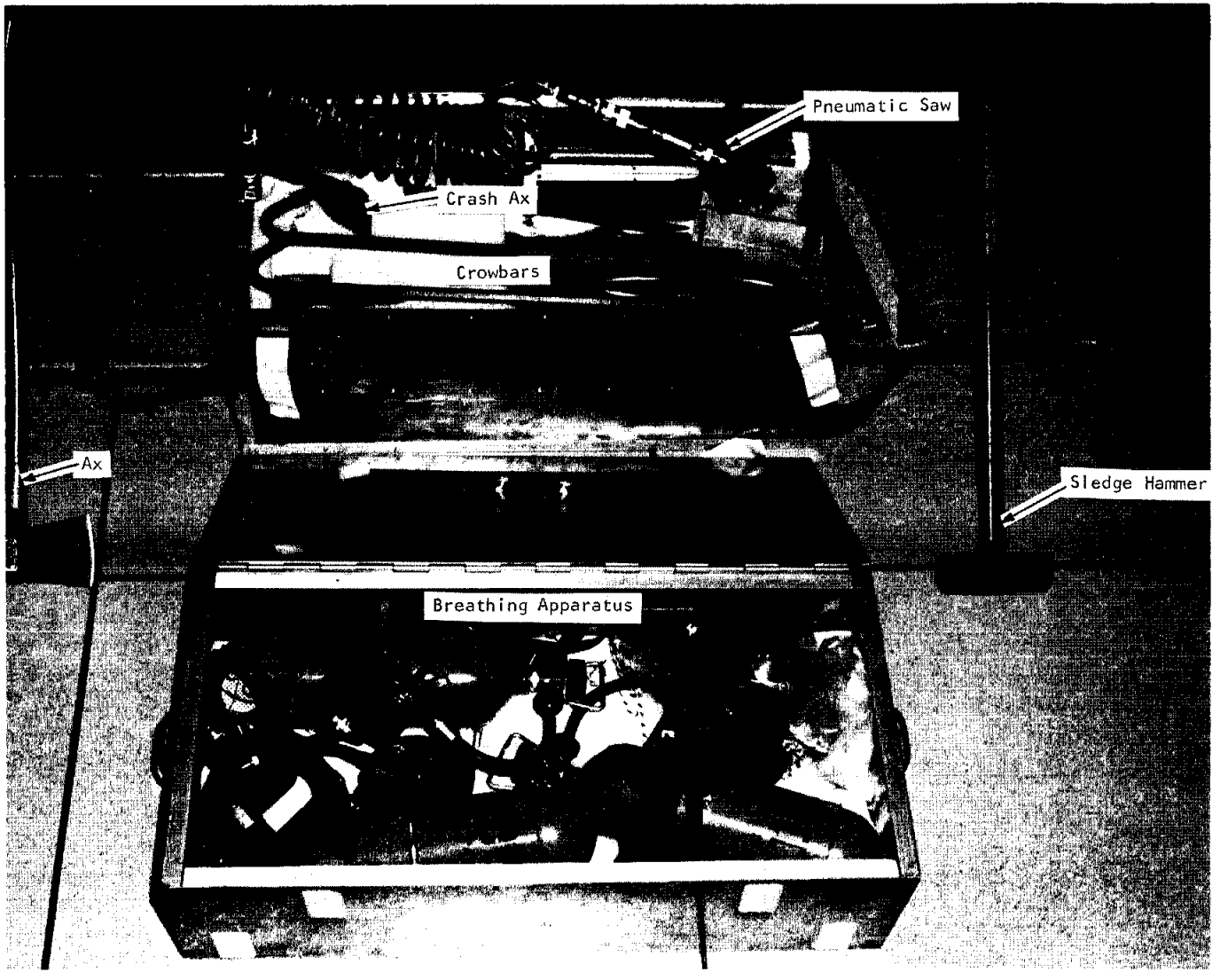

Figure 4-13. - Jammed hatch kit components

(h) Safety goggles.

(i) Cut hose for facing.

(j) Astronaut auxiliary breathing apparatus with voice amplifier (3 units).

(k) Flashlight and pocket knife.

(l) Wrench with 7/16-in hex drive tip.

(m) Aluminum carrying case for preceding items.

(n) Cabin ventilator with 38 feet of collapsible duct.

4.3.4.2.2 Operational Readiness

Prior to a mission, all pararescue and firefighter personnel will be briefed on the jammed hatch access procedure and be familiarized with the tools to be used. They will receive as realistic a demonstration as possible using the training mockup at KSC. Representative blocks of the structure to be cut will be provided, and using the NASA-provided tools, a cutting demonstration will be conducted.

4.3.4.2.3 Operational Logistics

If the launch site recovery force is configured for a land landing, one access kit will be on the heavy-lift helicopter configured for a land landing. If the force is configured for a water landing, the access equipment will be stationed with the FSK's.

In support of a mission, the launch site recovery forces will be deployed as in figure 4-1. One LRD engineer will accompany the FSK's and the other will board the heavy-lift helicopter. One complete set of access equipment will be pre-positioned with each FSK.

4.3.4.2.4 Operations

To support a launch, the recovery forces will be staged as described. If an abort is initiated, the procedures will be as outlined in section 4.2.3.3.

4.3.4.2.5 Access Procedures

If the side hatch cannot be opened, access through the forward hatch should be attempted. It is unlocked by inserting the hatch tool into the locking mechanism as shown in figure 4-14. Tie off the

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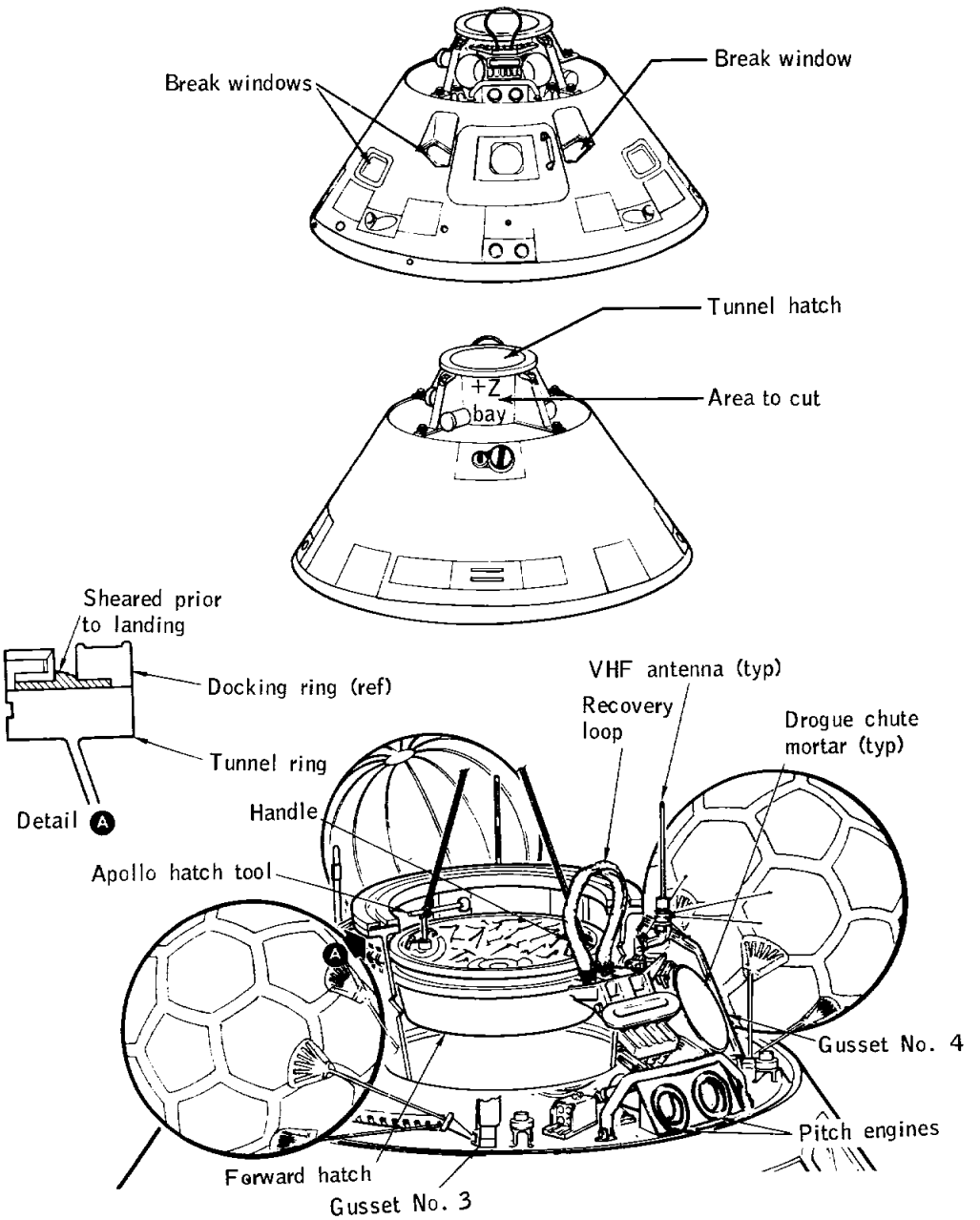

Figure 4-14. Command module access procedure

the hatch to preclude its dropping into the CM once it is unlatched. Turn the hatch tool 167° counterclockwise to unlatch the hatch and lower it into the CM.

WARNING

CAUTION SHOULD BE USED IN LOWERING
THE HATCH INTO THE CREW COMPARTMENT.

If the side hatch or forward hatch cannot be opened normally, two simultaneous access procedures will be performed to gain access to the flight crew.

The simplest and most expedient method will be the breaking of the right hand rendezvous window and side hatch window (see fig. 4-14) and attempting to work the pump handle to open the hatch (see fig. 4-15). Cabin ventilation will be employed as needed through the left side window broken by the pararescuemen.

The more complicated and time consuming procedure will be that of structure cutting. The cut-away area is located on the tunnel wall in the +Z parachute bay, opposite the side crew hatch (see fig. 4-16). The cutting procedure is as follows:

(a) Two pararescuemen will station themselves on the upper deck at all times observing the precautions for unexpended pyrotechnic devices shown in figure 2-1.

(b) To cut the tunnel, penetrations are made and the outline is cut using the pneumatic saw and finishing with the ax and sledge hammer.

(c) When the opening has been cut, facing hose will be placed over the cut edges and secured.

Once access to the cabin is gained, the LRD engineer will enter the cabin and perform the following operations:

Tools: Wrench with 7/16-inch hex drive tip, knife, and flashlight.

(a) The LRD engineer will enter the CM through the tunnel access hole and proceed to the side crew hatch area. He will then take the following action:

(1) Remove the astronauts' helments (fig. 4-7).

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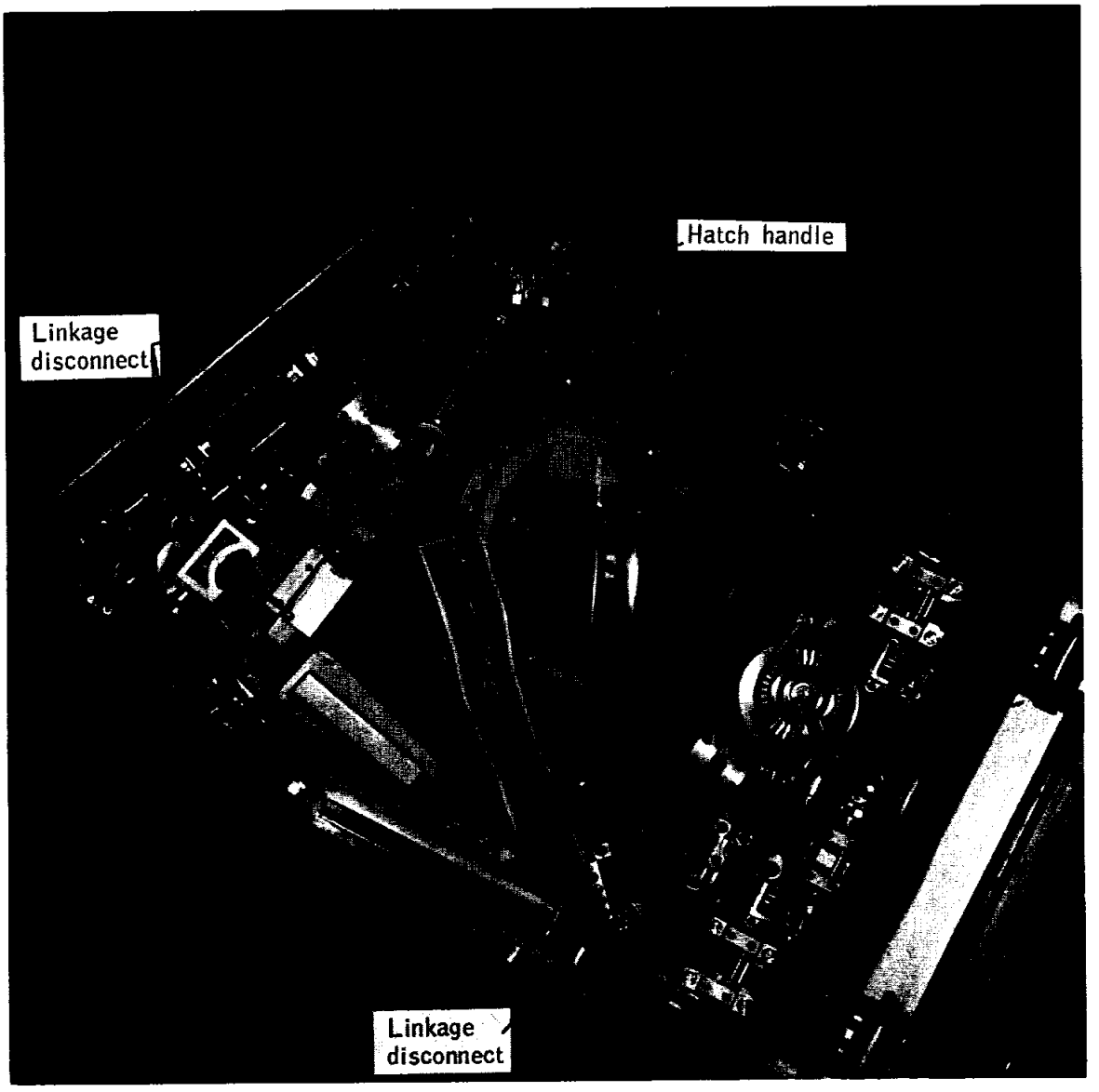

Figure 4-15. Hatch pump handle and linkage pins

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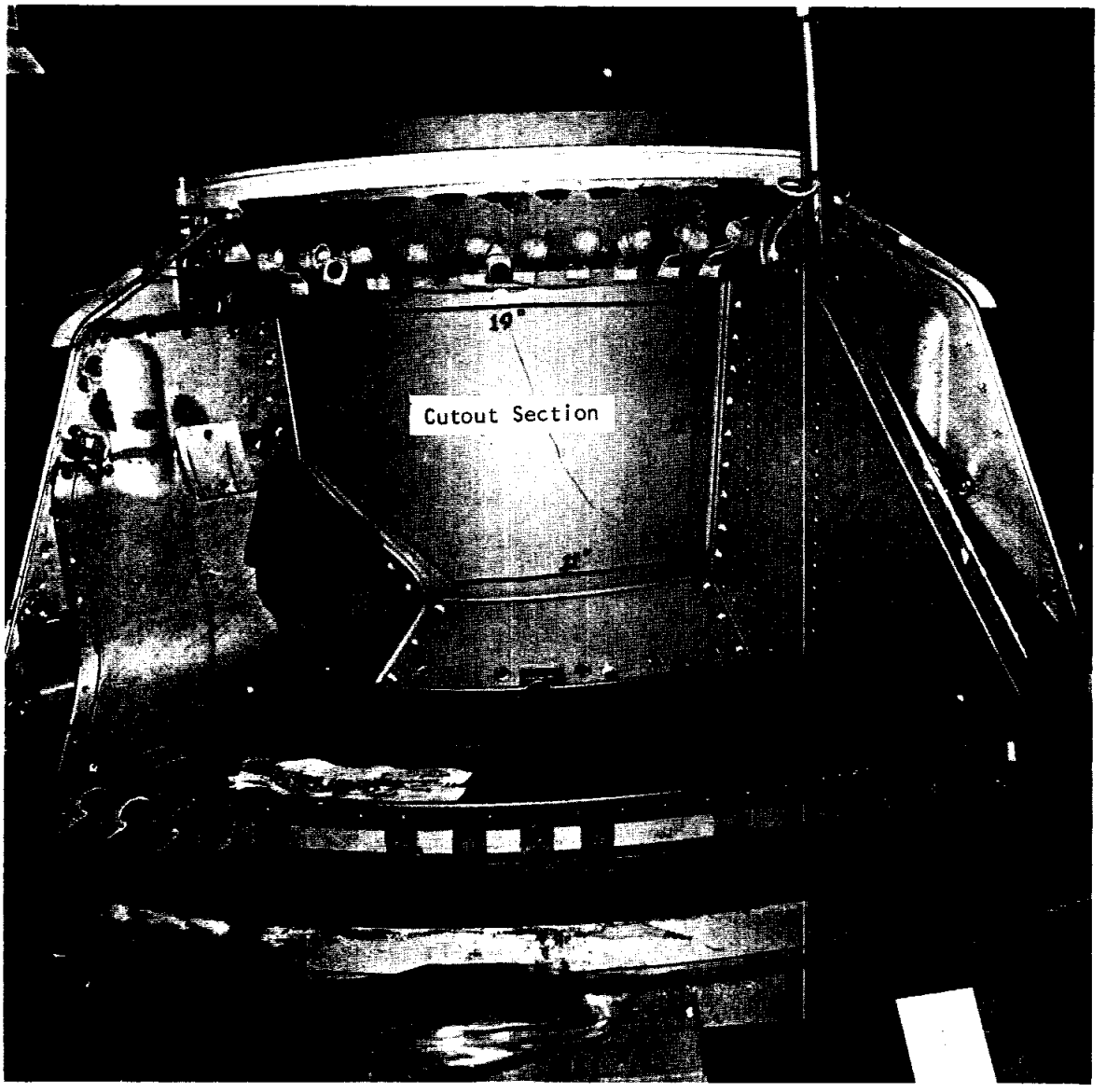

Figure 4-16. Area of CM structure to be cut

(2) Install auxiliary astronaut breathing apparatus, if needed.

(3) Attempt to open the side hatch using the normal method of operating the hatch pump handle and gearbox.

(4) If step (a) (3) preceding is unsuccessful, remove the four hatch linkage pins, thus freeing all linkages and latch dogs (fig. 4-15).

(b) The pararescuemen outside will use crowbars to pry open the side hatch.

When the hatch is open, the medical aid will determine the disposition of the flight crew. If egress is to be performed, the recommended recovery procedures will be followed.

WARNING

ALL PERSONNEL SHOULD REMAIN CLEAR OF THE HATCH IN THE EVENT OF INADVERTENT GN_2 HATCH OPENING ACTIVATION.

4.3.5 Summary Report

The pararescue team leader will record his observations of the recovery and prepare a Swimmer/Pararescue SUMREP as described in section 6.0.

4.4 LCU OPERATIONS

4.4.1 Vessel Description

An LCU is the primary vehicle for deep-water CM retrieval in the launch site area. This vessel is 115 feet long, 34 feet wide, and has a draft of 4-1/2 feet (fig. 4-17). It has a maximum speed of 6 knots and a range of 1,500 nautical miles. The at-sea endurance capability of the vessel is 10 days.

4.4.2 Personnel and Equipment

The LCU is manned by a crew of six and the required number of electronic technicians. Gas masks will be available for use by ship's personnel for protection against propellant fumes.

The LCU is equipped with a crane that has a maximum lifting capacity of 35 tons. A line passing device and two mercury hooks with poles (fig. 3-53) are provided to facilitate CM retrieval and handling. The communications and navigation equipment available on the LCU is as follows.

Communications Equipment			
Type	Band	Frequencies, kHz	Other data
Raytheon 60 transceiver	HF	2031.5/2118 2182 2622 2636 2738 5190 2716	
Collins 32RS-1	SSB	2622 2820 4500	Upper and lower side band
AN/ARD-34	UHF		Frequencies as desired

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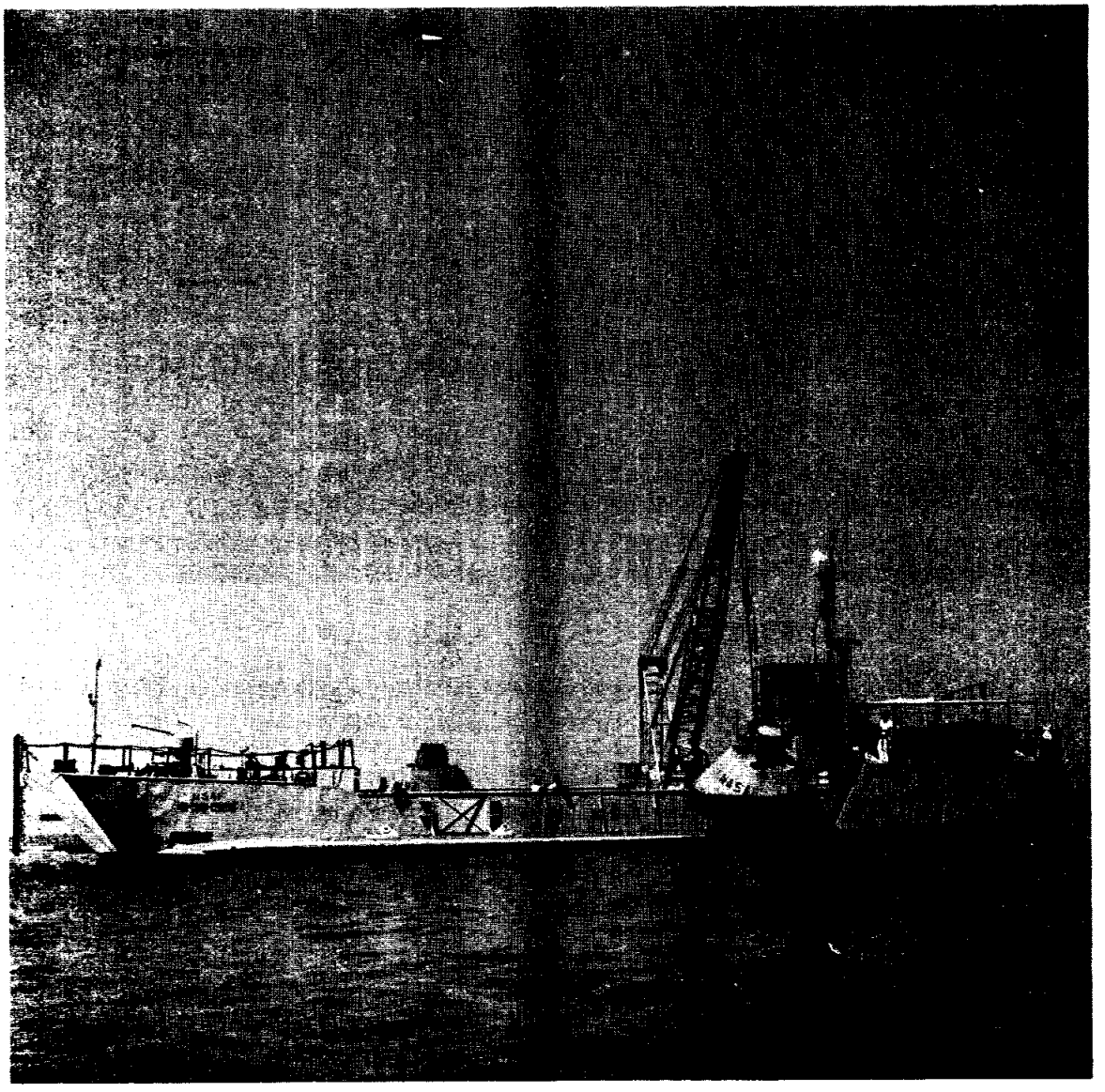

Figure 4-17. LCU (Landing Craft Utility)

Navigation Equipment	
Type	Description
SNR	Lorac receiver with recorder, digital and remote indicators.
AN/SPN-11	Navigation radar
MK-22	Navigation gyro
Raytheon DE-121	Recording fathometer
DX Navigator	Loran A and C

4.4.3 Safety Precautions

Prior to a mission, all LCU personnel will be briefed on the CM hazard areas and precautions described in section 2.0.

4.4.4 Retrieval Procedures

During a launch, the LCU will be positioned approximately 3 miles downrange and 3 miles off the ground track (fig. 4-1). If the LCU is called on to retrieve the CM, an approach will be made to allow transfer of an in-haul line with attached mercury hook to the CM. When the pararescuemen have fastened the mercury hook to the RCS engine protector, the CM will be hauled in so that the recovery hook can be engaged and steadying lines can be fastened to the RCS engine protector. The CM will then be hoisted from the water, placed on sand bags, and tied down securely to the deck. (The collar will remain on the CM during retrieval.) If the pararescuemen cannot be retrieved by helicopter, the LCU will serve as the secondary pararescue personnel recovery vehicle. After returning the CM to the MILA turning basin, the LCU will return to the landing area and commence salvage operations.

4.5 SALVAGE OPERATIONS

If spacecraft parts or booster debris fall in the launch site area, a salvage operation may be required. The LCU will be the primary recovery salvage vessel. Support vessels will be provided on an "after-the-fact" basis. Backup salvage support will be capable of arriving on-scene within 30 hours after notification in the event it is required.

4.5.1 LCU Salvage Personnel and Equipment

Five crewmembers are qualified divers, and SCUBA equipment will be provided.

The following equipment is provided on the LCU for salvage operations:

(a) S-101 shadowgraph

(b) MK 16 passive sonar receiver

(c) AN/SQS-19 search sonar

(d) Unit Mariner crane (35-ton maximum lift)

(e) PQS 1-A hand-held sonar (3)

(f) Low-pressure diving air

(g) High-pressure diving air (K-bottles, manifold and high-pressure air compressor)

4.5.2 Backup Salvage Vessels

Secondary salvage support will be provided by a fleet salvage vessel ARS located at a nearby naval port. It has onboard salvage equipment which includes:

(a) 60,000-lb automatic towing winch

(b) Two 10-inch, four 6-inch and one 3-inch salvage pumps

(c) One 220 cu ft/min, two 105 cu ft/min, one 160 cu ft/min, and three 22.5 cu ft/min portable air compressors.

(d) One auxiliary generator

(e) 7-ton boom

(f) 10-ton boom

The ship has a crew of 85, a maximum speed of 14 knots, and has deep and shallow water SCUBA diving capability. The secondary salvage vessel will remain on call until released by the Recovery Force Commander.

One or two ocean-going tugs (ATF's) based at a nearby naval port may be used as backup salvage vessels. These ships are fitted with salvage pumps, air compressors, and have SCUBA-qualified crewmen. The ships have a maximum speed of 16.5 knots.

4.5.3 U.S. Coast Guard Cutters

The U.S. Coast Guard provides one 82-foot and two 40-foot cutters for range surveillance prior to launch time. These cutters will also be available for search and rescue, logistic, and other support functions as required by the Launch Site Recovery Commander or the Recovery Range Control Officer. Support will be terminated when there is no further need.

4.5.4 Safety Precautions

Prior to conducting salvage operations, personnel who may be required to handle or work in the vicinity of the booster debris will be briefed on the hazards described in section 2.0 herein and in applicable launch vehicle documentation.

4.5.5 Salvage Procedures

In the event that a launch site abort occurs and the debris lands in the water, the LCU, after being released from recovery duty, will proceed to the debris landing area and commence a debris mapping operation or proceed with salvage of components, as described in reference 11. Driving depth is limited to 102 feet by contract; however, this depth can be increased with the permission of the contractor. The maximum operating depth is 180 to 190 feet. Divers will be used after definite contact has been established with an object to be recovered.

4.6 PRELAUNCH LAUNCH SITE LANDING PREDICTIONS

Prelaunch wind profile measurements and Mode 1 abort programs are used to predict Mode 1 launch abort landing points. The abort computations are based on radar-tracked weather balloon releases integrated with flight-programmed events.

These landing predictions are used to determine whether the launch site recovery forces will be configured for possible land-landing or water-landing.

The two weather balloon releases which provide the most timely information with respect to launch site recovery forces occur at approximately T- 6:20 and T- 3:30. Processed results are available approximately one hour after completion of each 55-minute tracking period.

4.7 LAUNCH SITE RECOVERY COMMUNICATIONS

Figure 4-18 illustrates launch site recovery communications and the interface between the various control facilities.

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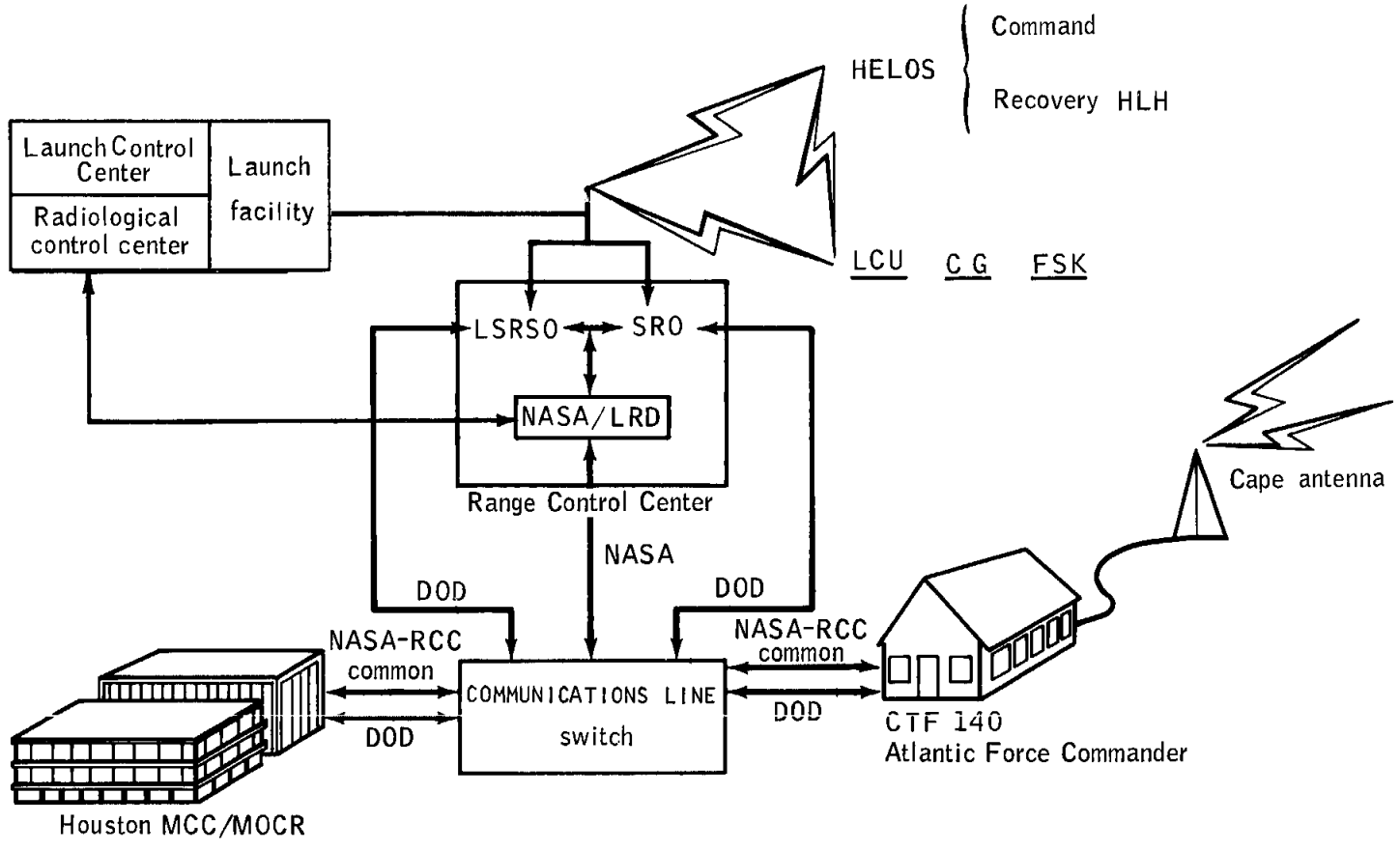

Figure 4-18. Launch Complex communications

4.8 MAN-RATED CARGO HOOK SYSTEM CHECK-OUT PROCEDURES

The HH53-C heavy-lift helicopter uses a man-rated cargo hook in heavy-lift operations. This cargo hook is man-rated to allow safe handling of the CM with the crew inside. Checkout of the system should be performed prior to any mission involving the use of the cargo hook. The man-rating feature of this cargo hook provides a positive mechanical lock which can be operated from the cockpit or from the cargo hook floor well. Release of this lock enables cargo release from the cockpit or the cargo area by either mechanical or electrical means.

Inspection and Check-out Procedures

(a) Release the cargo hook from its stowed position and place it in the vertical position.

(b) With the pilot's emergency release handle in the full down position, insure that a clearance of 0.06 inch exists between the emergency release arm in the hook and the emergency control release rod (view through window in hook).

(c) With the pilot's safety lock handle in the full down (locked) position, insure that the index marking on the hook and the safety lock release lever index tab are aligned.

(d) Insure that the CARGO MASTER switch is in the OFF position and that the pilot's safety lock lever on the cockpit floor is in the down (ON) position. Connect external electrical power.

(e) Position the CARGO MASTER switch to ON and the STATION SELECT switch to ALL. The HOOK SAFETY OFF capsule should be out. Press the CARGO REL. button on the pilot's cyclic stick grip. The hook should not open. Repeat using the co-pilot's cyclic stick grip and the crewman's firing key.

(f) Move the pilot's safety lock lever to the up (OFF) position (leave in the OFF position for operations g, h, and i). The HOOK SAFETY OFF capsule should illuminate. Press the CARGO REL. button on the Pilot's cyclic stick grip. The hook should open and the CARGO HOOK OPEN capsule should go out. Repeat using the co-pilot's cyclic stick grip and the crewman's firing key.

(g) Position the STATION SELECT switch to COCKPIT. Press the CARGO REL. switch on the crewman's firing key. The hook should not open. Press the CARGO REL. button on the pilot's cyclic stick grip. The hook should open and the CARGO HOOK OPEN capsule should illiminate.

The hook should relock automatically and the CARGO HOOK OPEN capsule should go out.

(h) Position the CARGO MASTER switch to OFF and the STATION SELECT to ALL. Press the CARGO REL. buttons on the pilot's and co-pilot's cyclic stick grip and the crewman's firing key. The hook should not open.

(i) Open the access window on the side of the cargo hook. With the EMERGENCY RELEASE TEE HANDLE in the full-down position, insure that a clearance of 0.06 inch exists between the surface of the arm and the dowel in the rod.

(j) Position the CARGO MASTER switch to ON with the pilot's safety lock lever to the down (ON) position. The LOCK SAFETY OFF capsule should be out. Press the pilot's CARGO REL, button on the cyclic stick grip. The hook should not open. Pull the cockpit EMERGENCY CARGO HOOK RELEASE handle. The hook should not open. Press the crewman's CARGO REL. button. The hook should not open. Pull the EMERGENCY CARGO HOOK RELEASE handle at the hook. The hook should not open.

(k) More the pilot's safety lock lever to the up (OFF) position. Pull the cockpit EMERGENCY CARGO HOOK RELEASE TEE HANDLE and release. The hook should open and the CARGO HOOK OPEN capsule should illuminate. The hook should relock automatically and the CARGO HOOL OPEN capsule should go out.

(l) Move the crewman's safety lock lever forward to the OFF position. Pull the crewman's EMERGENCY CARGO RELEASE handle at the hook and release. The hook should open and the CARGO HOOK OPEN capsule should illuminate. The hook should relock automatically and the CARGO HOOK OPEN capsule should go out.

V TRAINING AND SIMULATIONS

5.0 TRAINING AND SIMULATIONS

5.1 TRAINING

5.1.1 General

Minimum training requirements for Apollo recovery operations are outlined in this section. Whenever possible, training in addition to these minimum requirements will be conducted. To allow for crew and equipment turnover, it is desirable to conduct training employing the most representative personnel, ships, and aircraft.

To be assured that the DOD recovery forces can support the manned space flight recovery mission in a professional manner, the DOD Manager has established the following procedures and standards:

(a) DDMS will coordinate with ARRS, CTF-130, CTF-140, and AFETR to determine a time frame in which to conduct joint day and night recovery exercises. Procedures will be reevaluated and updated at this time.

(b) Every effort should be made to select previously qualified ship and air crews to support a manned mission. In cases where it would be impossible to do this, ships and air crews selected should have a minimum of one successful training and demonstration exercise prior to being committed for support of a mission.

(c) Forces responsible for the recovery operation should continually review procedures and safety standards.

Apollo recovery equipment is designed to withstand stresses generated by winds up to 25 knots and wave heights up to 8 feet. Training conducted under conditions exceeding the above may overstress the equipment provided.

Scheduling and conducting of the training described herein is the responsibility of ARRS, CTF-130, and CTF-140 with assistance from NASA and DDMS personnel when required. Unit commanders will determine if additional training is necessary to prepare a unit to perform a satisfactory recovery operation in its assigned area of responsibility.

5.1.2 Special Equipment

Items of special equipment furnished by NASA for both training and recovery support are listed in sections 3.1.3.1 and 3.2.3.1. Several of the major items furnished for training purposes are described on the following pages.

Apollo Boilerplate CM - The Apollo Block II boilerplate CM was designed to simulate the physical characteristics of the actual Apollo Block II CM. This similarity includes flotation and retrieval characteristics as well as dimensions. The weight of the boilerplate is approximately 9,000 lb as compared with 12,000 to 13,500 lb for the actual CM. The Apollo boiler plate is used by recovery personnel for flotation collar installation training as well as for practicing all types of shipboard retrieval procedures. The boilerplate CM may be equipped with a recovery training beacon and a flashing light. Thus furnished, it may provide homing practice for HC-130 and helicopter aircrews, as well as support for practice recovery operations.

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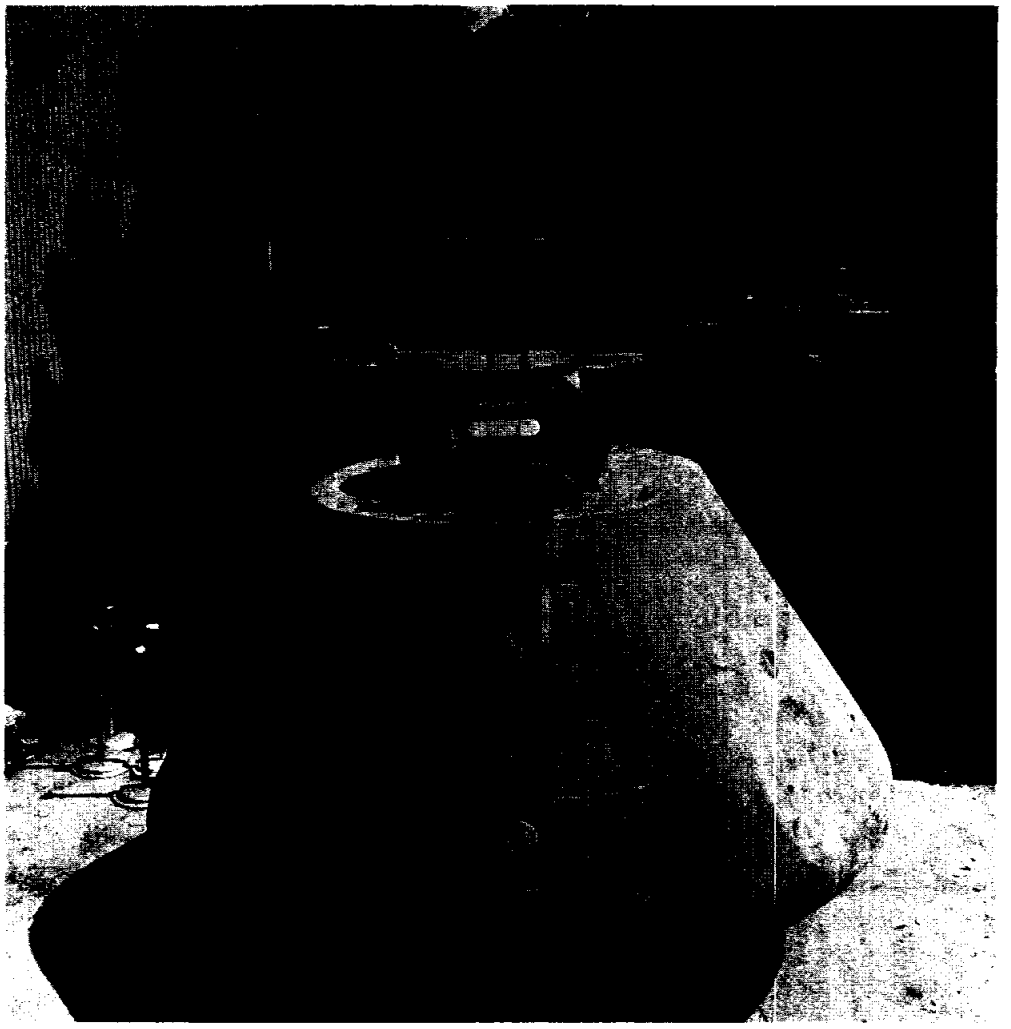

Figure 5-1 Apollo boilerplate CM

Recovery Training Beacon - The recovery training beacon is provided to permit aircraft crews to practice procedures for homing on the CM VHF recovery beacon. The beacon simulates the CM beacon except for frequency and power, transmitting a 1kHz. tone on 242.0 MHz. with a duty cycle of 2 seconds on and 3 seconds off. Power output is 1 watt. It may be installed on the Apollo boiler plate CM, thereby providing the opportunity for a realistic mission simulation. Shown with the beacon is a shorting plug which will activate it when it is used separately from the CM location simulator.

NOTE

Certain beacons do not operate on 242.0 MHz because of local frequency restrictions. These beacons are identified by red markings on the cylindrical portion.

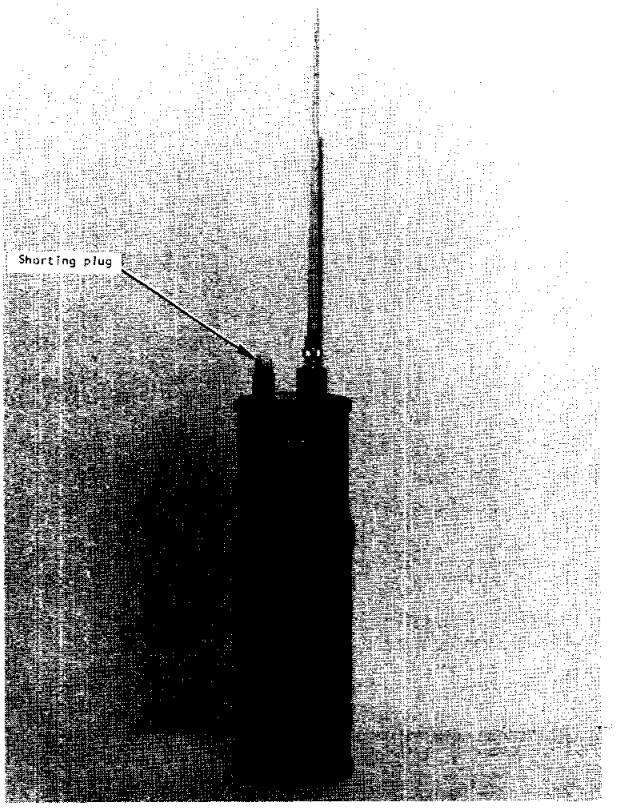

Figure 5-2. - Recovery training beacon

Location Aids Installation - The equipment used to simulate the Apollo CM location aids are depicted below. This installation consists of 1) CW training beacon and antenna, 2) flashing light, 3) flashing light power supply, 4) beacon/light switch plate assembly, and 5) the associated wiring harness. These items simulate the CM recovery beacon and the CM flashing light and are used on the boilerplate CM during training simulations. For detailed installation procedures see reference 14.

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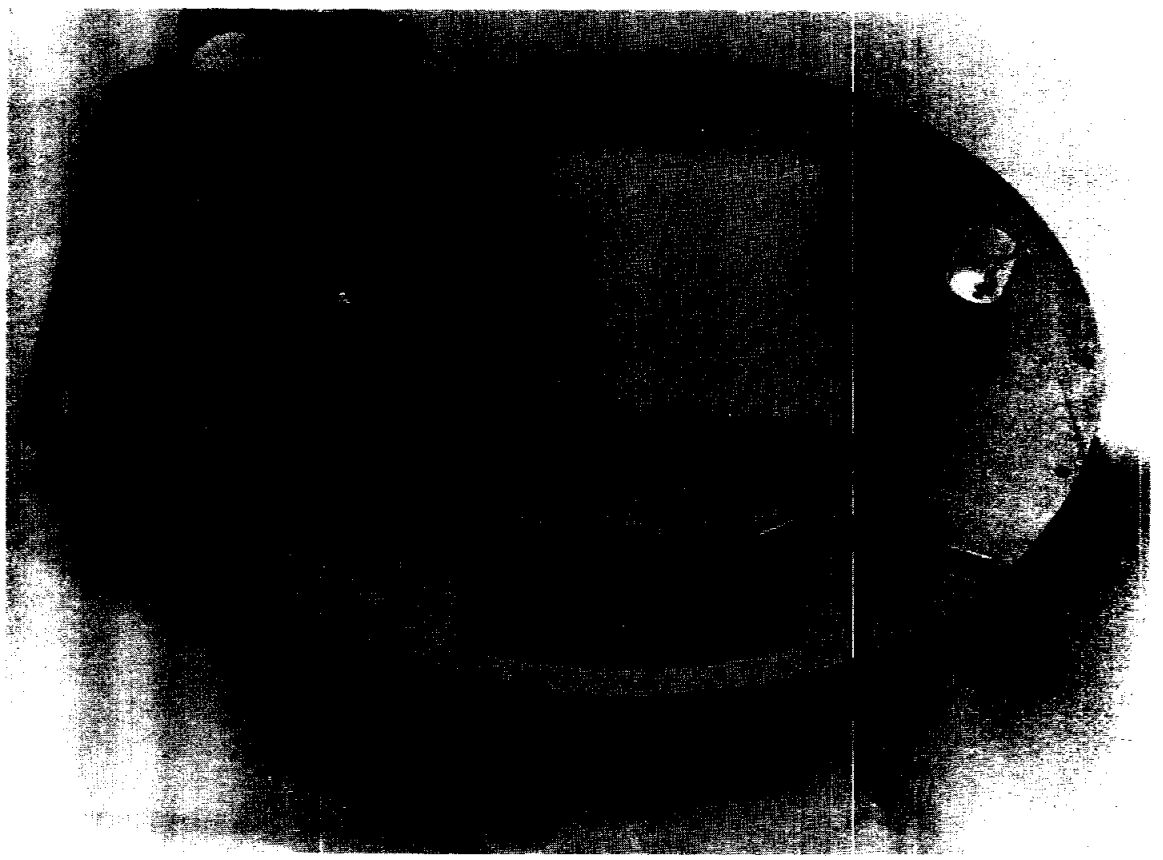

Figure 5-3 CM location simulator

5.1.3 Types of Training

Training can be divided into two major classes, unit training and joint training. Unit training prepares a unit to accomplish its particular mission task. In the joint training concept, participating units are brought together and trained to function as a team under mission support conditions.

5.1.3.1 Unit Training

At this level, units shall receive briefings and instructions in such areas as:

(a) Mission and program objectives, and operational plan

(b) Installation/operation of special equipment peculiar to Apollo recovery operations

(c) Recovery procedures and techniques

(d) CM familiarization

(e) Safety hazards and precautions

(f) Special documentation

These areas of training are expanded in the following outline to show specific areas applicable to individual units. Training will include but will not be limited to the following:

Ship's Personnel

(a) Special recovery equipment to be carried aboard (mercury poles, hooks, rigging, etc.)

(b) Special recovery equipment requiring major installation effort (DD - davit crane)

(c) Onboard recovery team organization, duties and responsibilities

(d) Recovery team safety precautions

(e) CM pyrotechnic and RCS hazards, and associated safety precautions

(f) CM and astronaut recovery procedures and techniques (applicable to the particular unit)

(g) Familiarization of personnel with operations of other participating units

(h) Mission profile, objectives, and planned sequence of events

(i) Reporting procedures

(j) CM configuration and location aids

(k) Security and postretrieval procedures

UDT/Pararescue Personnel

(a) Special Apollo recovery equipment to be used (flotation collar, hatch tool, sea anchors, communications equipment, and rescue net).

(b) Communications and signaling procedures

(c) Hatch opening and closing procedures and astronaut egress.

(d) Mission profile, objectives, and planned sequence of events

(e) Deployment procedures

(f) CM configuration and location aids

(g) CM pyrotechnic and RCS hazards, and associated safety precautions.

(h) Familiarization with procedures of other participating units

(i) Report formats

Aircraft Personnel

(a) Mission objectives and planned sequence of events

(b) Installation, checkout, and operation of specially installed Apollo locating equipment (SARAH, AN/ARD-17)

(c) Special communications and signaling procedures

(d) Reporting and report formats

(e) Pararescue team and UDT deployment procedures

(f) CM configuration and location aids

(g) Search procedures

(h) Mission operational Plan

5.1.3.2 Joint Training

Joint training is that training which requires participating units to work as a team. It may be conducted in the following forms.

(2) Premission training

(b) Simulations

Premission Training - Premission training provides refresher training for units, new training for joint operations, and training for units that have not previously received training because of normal turnover. ARRS, CTF-130, CTF-140, and AFETR will be responsible for the scheduling of this training. It will include RCC, ship, aircraft, pararescue and UDT swimmer unit activation, and will be designed to carry out the joint training operation in accordance with mission recovery procedures.

Simulations - The primary task of units supporting an Apollo mission is to effect the safe recovery of the astronauts and to retrieve the CM; however, the actual mission activity also provides an excellent source of training experience. Simulations conducted by units enroute to mission stations are a form of this training. They will be carried out in a manner that will provide the most realistic conditions and procedures obtainable. Presail briefings should be conducted to insure that all operating units are prepared to participate as members of the overall recovery team.

5.1.4 Training Standards

ARRS, CTF-130, CTF-140, and AFETR will prescribe minimum standards for training. The types of training to which this applies includes but is not limited to:

(a) Pararescue team and UDT water deployment

(b) Collar installation at sea

(c) Boilerplate CM pickup by ships at sea

(d) Safety and equipment familiarization

(e) Mission briefings

(f) Aircraft search, homing, and location practice (including equipment operator training)

(g) Special equipment operator training (e.g., A/C - ARD-17)

(h) Special training that might be required for mission-associated tasks (e.g., special weather observations and operation of specially installed radio equipment)

(i) Night operations

5.2 SIMULATIONS

5.2.1 General

Recovery simulations are conducted in order to thoroughly familiarize recovery personnel with their respective areas of responsibility and to develop proficiency in the procedures and techniques of recovery. This includes specific mission phases, equipment, operations, and information flow formats.

5.2.2 Guidelines

In developing and conducting a recovery simulation, it is essential that certain basic guidelines be followed to assure that recovery personnel understand and gain the maximum benefit from the simulation. As a fundamental guideline, a simulation exercise must be complete enough to accomplish all of its prescribed objectives. For example, for pararescue/collar training, an exercise includes complete installation of a flotation collar; for ship/boilerplate training, it includes the recovery and securing of the boilerplate on the deck of the ship; and for UDT training, it includes the complete installation of the flotation collar. General guidelines for all forces participating in simulations are as follows:

(a) A situation should be made as realistic as possible.

(b) Personnel who participate in simulations should be the same personnel assigned to the actual mission.

(c) Vehicles assigned to recovery operations should participate as prescribed in section 5.3.

(d) DOD-Houston will initiate and coordinate the simulations and will relay lead-in information and current mission status to the RCC.

(e) Time compression for mission periods prior to simulated CM landing time will be allowed only if it is considered essential to the conduct of the simulation. Such time compression will be coordinated by DOD-Houston. Time compression during periods after landing will be at the request of the RCC and will be coordinated with DOD-Houston.

(f) All applicable data formats listed in section 6.0 should be used, and as far as is possible and reasonable, all communication loops and teletype channels should be used in accordance with normal mission procedures. Alternate communication routes should be checked during simulations whenever possible.

(g) All forces participating in the simulation should keep a log of activities, and appropriate SUMREPS should be completed and forwarded to DOD-Houston.

(h) The simulation should continue until retrieval activities are completed.

(i) At the conclusion of the simulation a debriefing will be conducted by DOD-Houston and other RCC's as appropriate.

5.2.3 Recovery Vehicle Posture for Simulations

(a) A boilerplate CM should be equipped with a recovery training beacon, flashing light, and sea dye marker, and be positioned approximately 15 nautical miles from the ship.

(b) Recovery ships (DD, CVS, LST, etc.) should be equipped with appropriate equipment as prescribed in section 3.0.

(c) At the start of a simulation, recovery aircraft (HC-130) should be at an assigned position approximately 225 nautical miles from the boilerplate and at an altitude of 25,000 feet.

(d) Aircraft search should not start until main parachute deployment time is announced by DOD-Houston.

5.2.4 Special Recovery Force Simulations

At certain times prior to a mission it may be desirable to exercise only one unit of the overall recovery force (i.e., DD/aircraft, CVS/helicopter, or RCC). This is very feasible and can be accomplished by following the simulation guidelines described previously.

Whenever a fractional simulation is conducted, local personnel within the exercising unit must generate the required supporting information and broadcast it in a timely manner. For example, if a DD and aircraft are sole participants, shipboard personnel are required to generate CM entry data such as entry time, blackout times, main-chute deployed times, splash time, and reports to an RCC.

For an RCC simulation, RCC personnel are required to generate ship and aircraft information in a timely manner and in a sequence expected from the field forces.

5.3 RECOMMENDED SIMULATIONS

All units should simulate individually at first and then in conjunction with their commanding element.

5.3.1 Launch Site

The launch site forces should exercise recovery team units individually (i.e., helicopters with pararescue swimmers, LCU and boilerplate, and FSK and operators). When each unit has gained proficiency, a launch area simulation should be conducted which integrates all units into a launch site area recovery team.

5.3.2 Secondary Recovery Ship/HC-130

Each ship and aircraft expected to work as a team in the event of an actual recovery operation should conduct joint simulations using prescribed guidelines including reporting to the appropriate RCC. For HC-130 simulations, a simulated timeline for pararescue drops and collar installation should be followed, even though pararescue personnel may not actually be deployed.

5.3.3 Primary Recovery Ship

The primary recovery ship and its aircraft should conduct simulations as a unit to develop a timeline of operation. The ship's aircraft should be deployed as prescribed for a recovery operation, and simulation should include UDT deployment and collar installation. When unit proficiency is gained it should simulate with its RCC.

5.3.4 RCC and Sub-RCC

An RCC should conduct "in-house" simulations and simulations with sub-RCC's and RCC-Houston prior to simulating with field units. The simulation should exercise all communications, including an alternate route, as possible.

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