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APOLLO TRAINING

SEQUENTIAL EVENTS CONTROL
SYSTEM STUDY GUIDE
(LES, EDS, ELS)

COURSE NO. A-315

FOR TRAINING PURPOSES ONLY



PREFACE

This study guide was prepared to augment the oral presentation of the Sequential Events Control System course, number A-315. It is organized to correspond to the instructor's procedure in presenting the concept of the system's operation and mechanization. The accordant text arrangement affords the student the advantage of review, with printed material, that is in the same sequence as the verbal presentation. Consequently, the format contributes directly to recall memory and is, therefore, conducive to prolonged retention extending the effectiveness of the course.

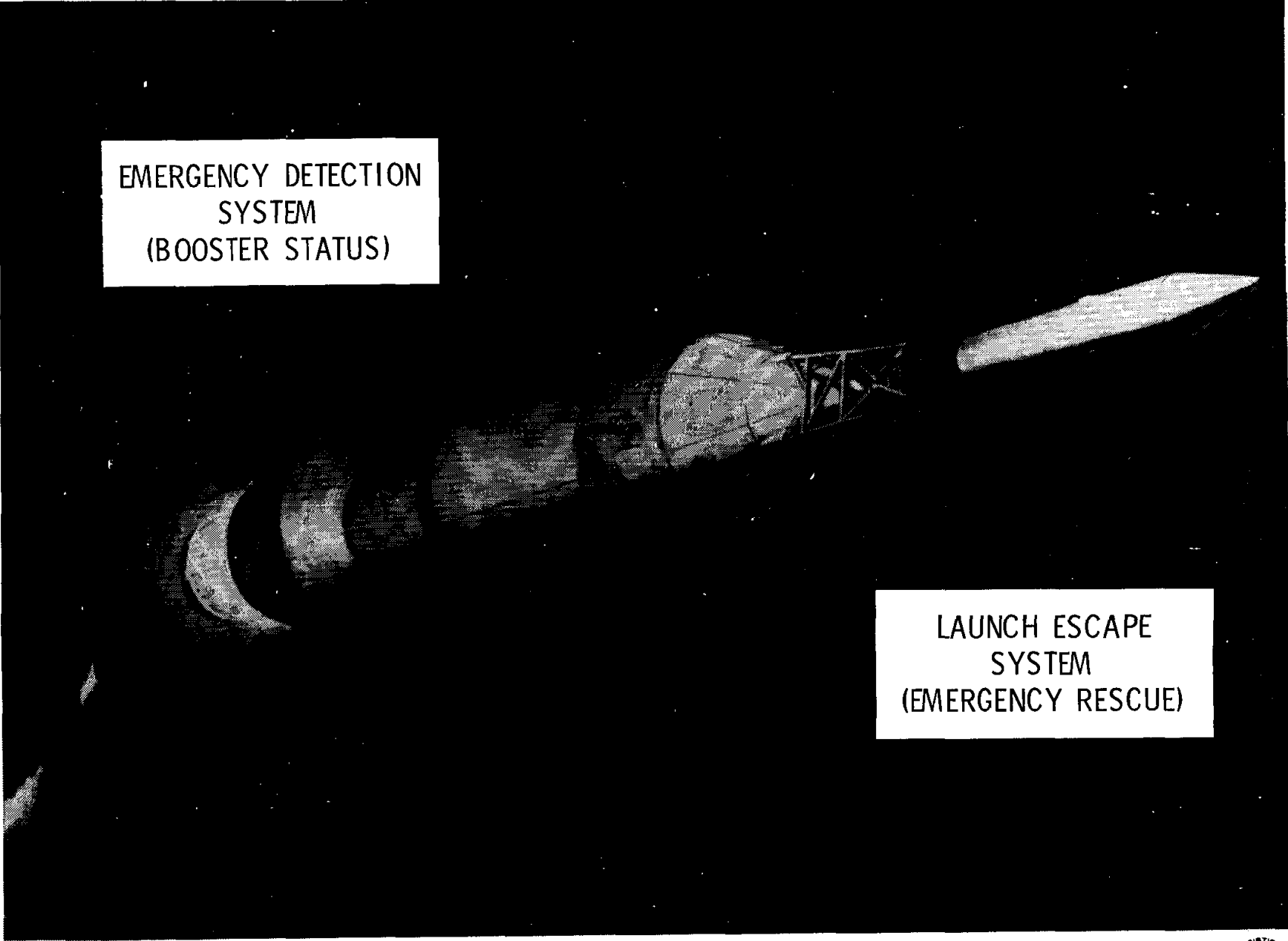
The study guide enhances the course and facilitates further learning by providing the physical convenience of having immediately before the student, the same illustrations and documentation that is utilized by the instructor in the form of transparency projections, charts, and drawings. The necessity for taking notes is minimized, as is the possibility of inadvertently missing portions of the explanation because of the difficulties inherent in distinguishing distant visual aids.

The accounts and descriptions of the Sequential Events Control System, the Launch Escape System, the Emergency Detection System, and the Earth Landing System contained herein are intended to apply only to the first manned flight of the Apollo Spacecraft. Unmanned Boilerplate and Spacecraft flights will, in most instances, have very similar configurations with slight modifications and/or additions depending upon mission objectives and are usually less sophisticated.

This document is intended for training purposes only and is not subject to scheduled revision.

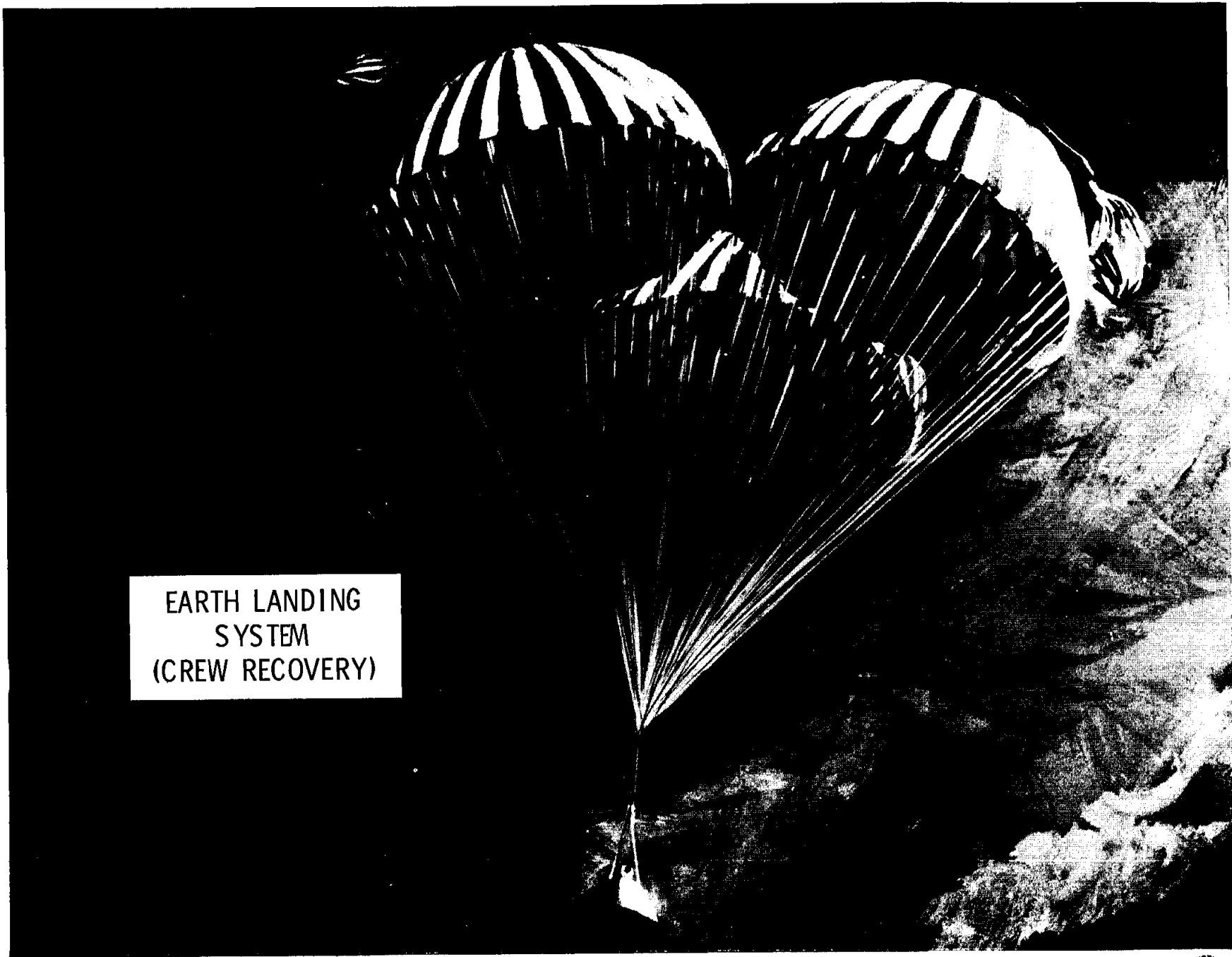
Questions relative to the information contained in this document should be directed to:

W. A. Waddell
T. E. Gilland
Apollo Logistics Training, D/671-142
NAA, S&ID Downey, California
Extension 4325, 6, or 7.



EMERGENCY DETECTION
SYSTEM
(BOOSTER STATUS)

LAUNCH ESCAPE
SYSTEM
(EMERGENCY RESCUE)



EARTH LANDING
SYSTEM
(CREW RECOVERY)

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SECTION I

INTRODUCTION

1.1 SYSTEM DESCRIPTION

The title, Sequential Events Control System (SECS), is the name given to that Apollo Spacecraft subsystem which will control the automatically sequenced functions during any mission abort, normal Spacecraft/Lunar Excursion Module/Adapter (SLA) separation, normal Command Module/Service Module (CM - SM) separation and SM jettison, and earth recovery.

The SECS will act as the controlling agent for the normal, manually initiated Launch Escape Tower (LET) jettison following first stage staging and ignition of the second stage. The SECS will utilize the Launch Escape System (LES) to successfully rescue the Astronauts in case the mission is aborted due to emergency contingencies, either on the launch pad or at anytime up until the time of normal LET jettison. This is normally referred to as an LES abort. An abort may be defined as the premature termination of a mission due to certain emergencies arising within the Launch Vehicle (LV) or the Spacecraft (SC).

Normal separation of the SLA is performed by the SECS following manual initiation at the commencement of the third orbit. Emergency separation of the SLA is performed automatically following the manual initiation of an abort anytime between normal LET jettison (tower jettison) and normal SLA separation (adapter separation or S-IVB jettison). This is normally referred to as a Service Propulsion System (SPS) or a SM abort.

CM - SM separation is also carried out by the SECS after a manual command on a normal pre-entry or

subsequent to an SPS abort. SM jettison is executed simultaneously by the SECS at this time. For an LES abort, this separation of the CM from the SM is performed automatically by the SECS.

The Earth Landing System (ELS) is utilized automatically by the SECS either as subsequent functions to an LES abort, or following an SPS abort, or following normal entry after successfully completing a mission.

The SECS will be armed approximately one hour prior to launch and will remain energized until after normal adapter separation at the start of the third orbit. It will be turned on again for normal CM - SM separation on pre-entry, and remain energized until after the Main Landing parachutes are released after touchdown on the water, at which time it will be turned off for the last time.

The Emergency Detection System (EDS) contained within the LV provides inputs to and interfaces with the SECS. An EDS automatic abort may be voted within the Master Events Sequence Controller (MESC) of the SECS at anytime from lift-off until tower jettison when this capability is automatically switched off or until inhibited by the crew's switching functions.

The MESC, as the name implies, is the master controller of this system. Other controllers are the SM Jettison Controller (SMJC), the CM Reaction Control System (RCS) Controller (RCSC), and the Earth Landing Sequence Controller (ELSC). Numerous relays, time delays, and baroswitches within these controllers

cause certain discrete events to occur in a prescribed order and at specific times or altitudes. Figure 1-1 illustrates the SECS schematically.

The Translation Controller provides the Astronaut acting as the Commander (L.H. couch) with the means to manually initiate an LES or an SPS abort. An LES abort may be manually initiated by the Commander while on the launch pad after the SECS is armed, or at anytime during ascent until the LET is jettisoned. After the LET is jettisoned, there is no longer any possibility for an EDS automatic abort, as previously stated, and therefore an SPS abort must be manually initiated by the Commander. It may be possible to abort to orbit, using the SPS engine of the SC as a booster, or return to earth may be mandatory after the crew selects one of many entry programs.

The SECS depends upon DC power exclusively, being supplied primarily by 5 batteries on board the CM. It also depends upon Main DC Bus power being supplied by the Fuel Cells in the SM for its RCS functions through the CM RCSC. Three batteries titled A, B, and C furnish 3 legs of logic power for the EDS requirements. Batteries A and B provide Logic Bus power for systems A and B respectively of the SECS. These 3 batteries are rechargeable in flight by SC systems.

The remaining 2 batteries, referred to as Pyro batteries, supply power to the Pyro Busses of the SECS. These batteries are not rechargeable during flight.

The SECS is also dependent upon 2 more batteries in the SM to power the SMJC after normal CM-SM separation. These batteries, called the SMJC batteries, are not rechargeable in flight.

The locations of the MESC's and the ELSC's are shown in Figure 1-2, as is the Pyro Continuity Verification Box (PCVB) located directly above or aft of the ELSC's. The purpose of the PCVB is to provide an access point within the CM to verify the continuity of the pyrotechnic hookups in the forward compartment after this compartment has been covered with the Apex Cover during vertical assembly. Space remaining in the PCVB has been utilized to eliminate the single point failures in the ELSC's by installing redundant time delays and relays in parallel to the ELSC's. The electrical connector plugs to this box are left disconnected until after the final pyro continuity verification is conducted and it is desired to complete the hookup of the SECS prior to launch.

The location of the SMJC's and the SMJC batteries is shown in figure 1-3. The location of the RCSC's is illustrated in figure 1-4.

Various circuit breakers, switches, and indicators on the Main Display and Control Panel in the CM's Cabin, or Crew Compartment, are also an important part of the SECS. The above mentioned batteries supply power to these many controls and displays, whose functions are described in the Displays and Controls section.

Acceptance Checkout Equipment (ACE) and various units of Ground Support Equipment (GSE) will be employed for integrated systems checkout of the SECS through the GSE Flyaway Umbilical.

All components of the SECS are inaccessible to the crew for maintenance purposes. Quality assurance and component reliability provide maximum guarantees that the circuitry will operate on demand. Redundancy is accomplished by dividing the system into

MESC & ELSC LOCATIONS

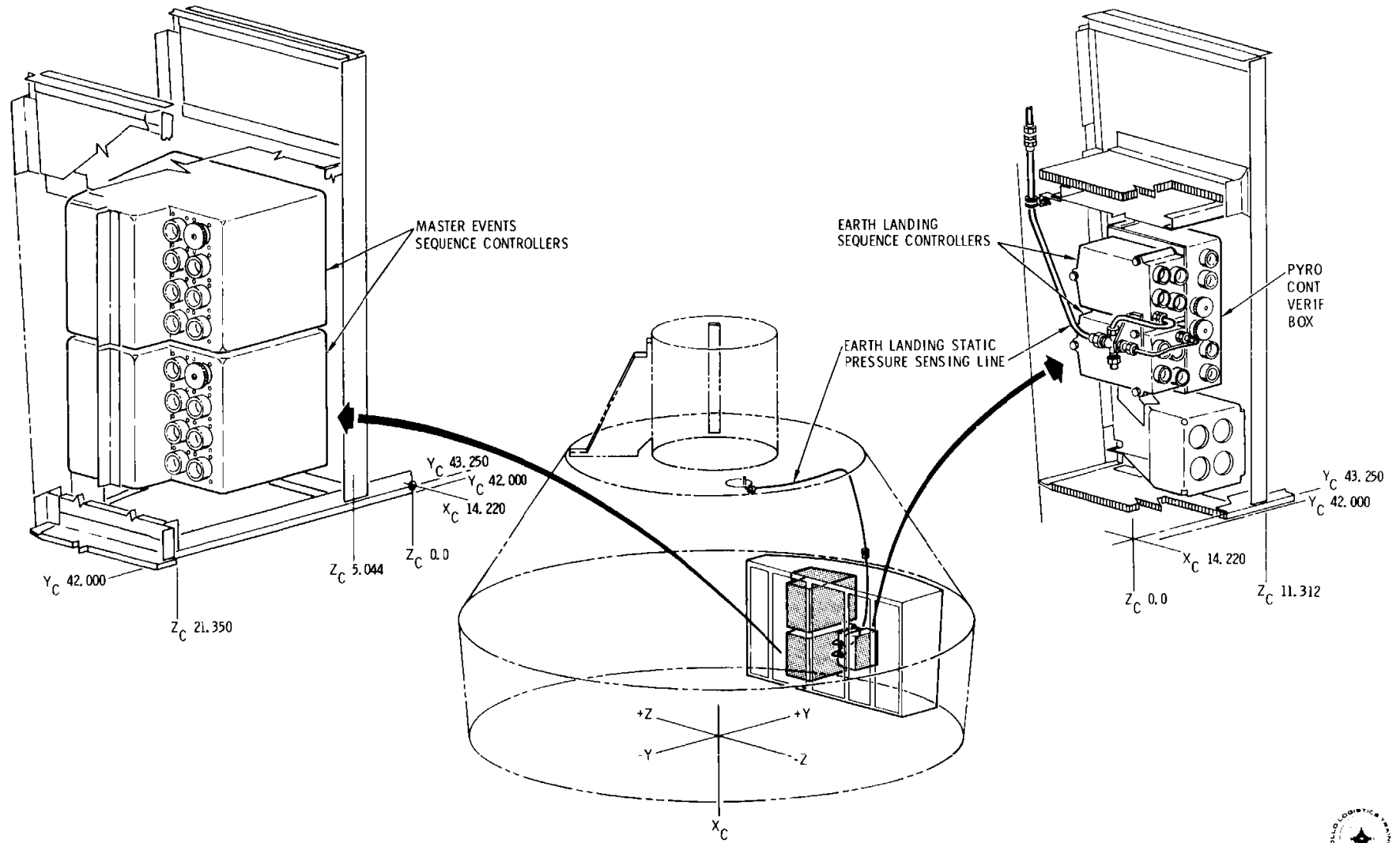
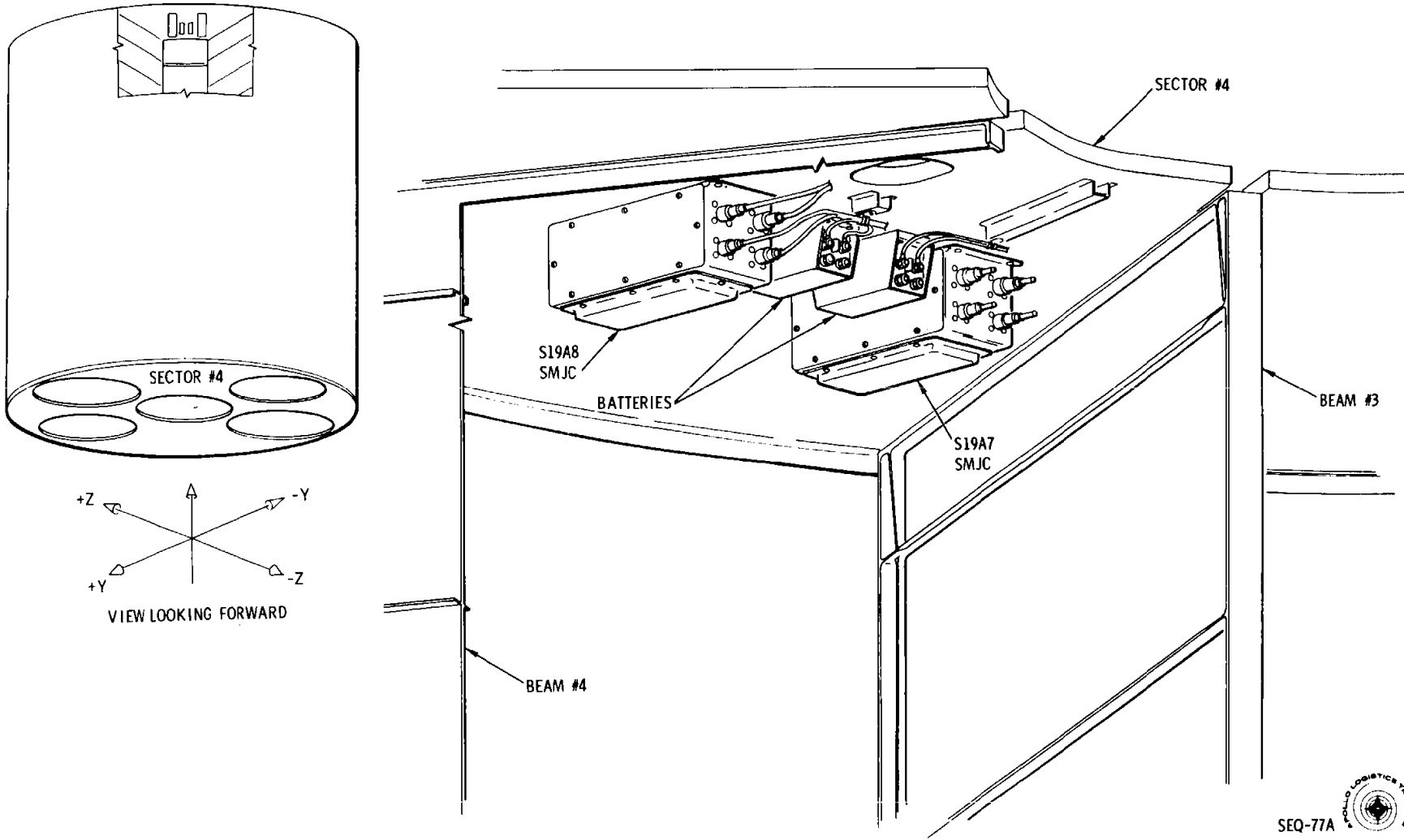


Figure 1-2

SMJC LOCATION



SEQ-77A 

Figure 1-3

CM RCS CONTROLLER LOCATION

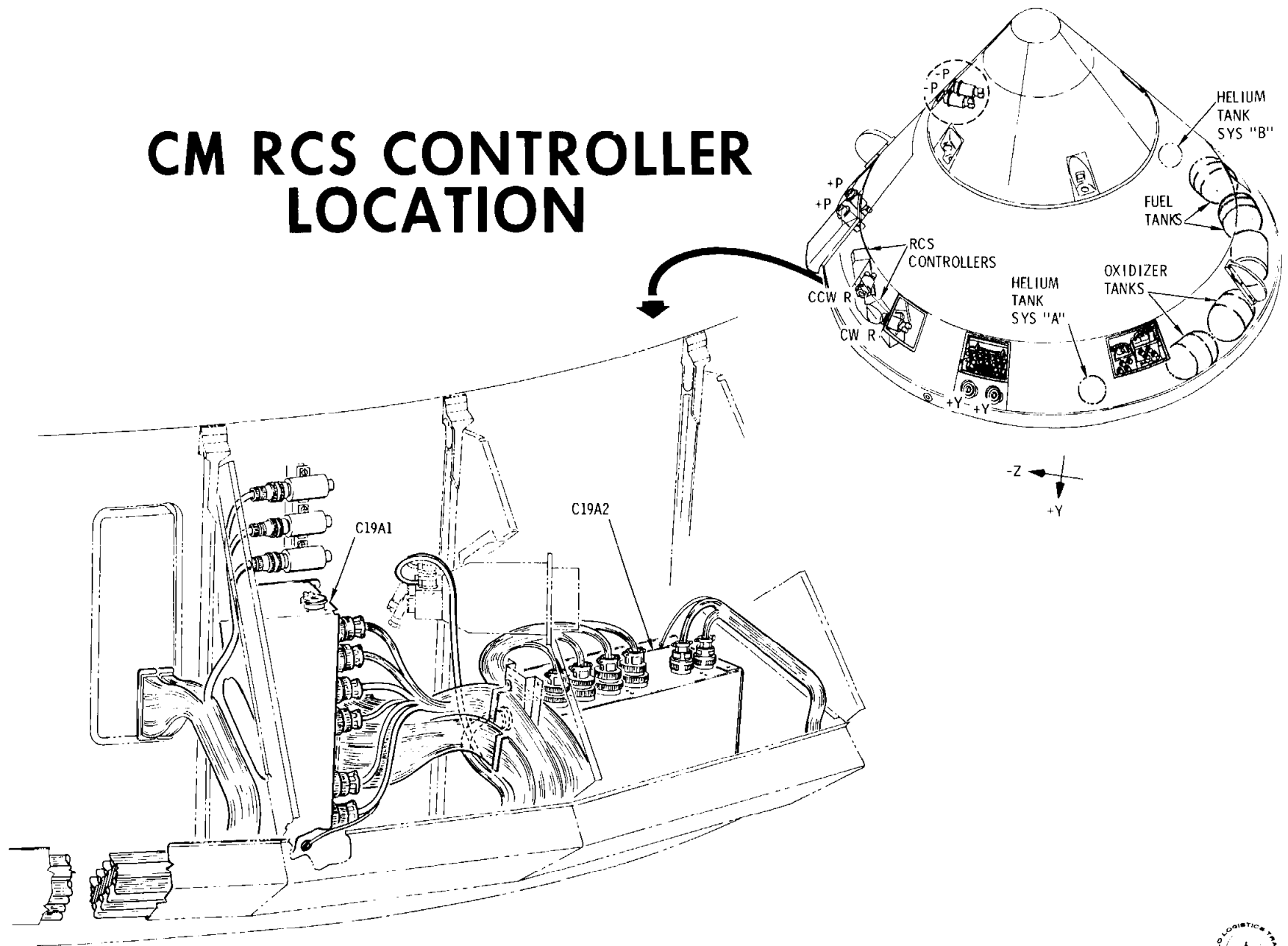


Figure 1-4

2 identical systems (A and B) with numerous power crossovers which will perform functions in parallel simultaneously. Either system A or B has the capability to accomplish system requirements.

1.2 SECS FUNCTIONS

1.2.1 Enables Automatic Abort Capability At Lift-Off

Instantaneously with lift-off from the launch pad, the automatic abort capability is enabled by the MESC. The EDS automatic abort capability is armed by the crew prior to launch, but is not enabled automatically until lift-off.

1.2.2 Votes An EDS Automatic Abort

^{3 prim 1}
_{ok r} An EDS automatic abort is initiated by abort voting relays within the MESC when certain conditions are satisfied within the EDS.

1.2.3 Resets Digital Events Timer Readout At Abort

Upon initiation of an abort, the Digital Events Timer Readout is reset to zero and restarted again to enable the crew to monitor functions during the abort and return to earth. The Digital Readout is started from zero at lift-off.

1.2.4 Initiates Booster Engine Cut Off At Abort

The MESC contains relays which initiate the shut-down of the booster, or LV, at initiation of aborts. Range Safety specifies, though, that for a certain specified amount of time following lift-off, Booster Engine Cut-Off (BECO) will be inhibited, but this is controlled by a time delay in the IU even though the MESC attempts to shut down the booster.

*presently 40 sec. for Range Safety
but may be restricted in time by RSC.*

1.2.5 Deadfaces Certain Electrical Circuits

To open certain electrical circuits known to be hot is a prerequisite to the destruction of the CM to SM wiring umbilical. Circuit interrupters are fired by the MESC to deadface these hot circuits any-time the CM is separated from the SM.

1.2.6 Transfers RCS Control At CM - SM Separation

Whenever the CM is separated from the SM, whether at initiation of an LES abort, or following an SPS abort, or a successful mission, the RCS control is transferred from the SM to the CM by 2 motor switches in the CM RCSC, being driven by a signal from the MESC. Automatic backup switching power for tying the CM batteries to the Main DC Bus is directed across a set of contacts of each of these motor switches to backup the manual switching function of tying the batteries to the Main DC Bus.

1.2.7 Pressurizes the CM RCS

When an LES abort has been initiated, it is mandatory that the CM's RCS be pressurized with Helium, either for disposal of the propellants or for utilizing the RCS for stabilization or orientation. The MESC handles this function immediately upon abort initiation or when commanded manually before CM - SM separation on pre-entry.

1.2.8 Commands CM RCS Oxidizer Dump

Whenever an LES abort has been initiated, an output signal from the MESC is sent to the CM RCSC. If the 61 second timer used for controlling automatic Oxidizer dumping, which is located within this controller, has not timed out after being energized at lift-off, the CM's RCS Oxidizer will be dumped with the energizing of the Oxidizer Dump relays also contained

within this controller. At this same time, the Helium and Oxidizer Interconnect Squib valves between the Oxidizer supply tanks are fired by other relays within this controller to affect this operation thoroughly.

1.2.9 Performs CM - SM Separation

The function of separating the CM from the SM upon the initiation of an LES abort is performed automatically by the MESC. Separation of the CM from the SM following a Service Propulsion System (SPS) abort and a normal mission during entry is also performed by the MESC after receiving a manually initiated command from the crew. This same command also energizes the SM Jettison Controller which affects the retrograde and roll-out maneuver of the SM away from the CM.

1.2.10 Ignites LES Rocket Motors for LES Abort

Immediately following the initiation of an LES abort, either from the pad or up until 61 seconds from lift-off, the MESC ignites the Launch Escape and Pitch Control motors simultaneously to propel the Launch Escape Vehicle (LEV) away from and into a different trajectory than that of the boost trajectory. After 61 seconds from lift-off, however, the possibility for igniting the Pitch Control motor is automatically switched out by the time-out of the 61 second automatic oxidizer dump time delays, thereby making it impossible for the Pitch Control motor to be ignited in case of an LES abort between that time and tower jettison.

1.2.11 Deadfaces CM - SM Separation Pyro Circuits

One and eight-tenths seconds after the initiation of CM - SM separation, whether normal in the pre-entry phase or subsequent to an SPS abort or with an LES abort, the pyrotechnic circuits for separating the

CM from the SM are deadfaced by de-energizing the separation relays. This function prevents any possibility of a high resistance short to ground within the separation system from discharging the Pyro batteries before deployment of the Main Landing parachutes.

1.2.12 Deploys Canards

The Canards are deployed automatically by the MESC 11 seconds after the initiation of an LES abort. The Canards are deployed by a Squib fired gas actuator.

1.2.13 Arms ELS During LES Aborts

automatically During all LES aborts, the ELS is armed *logically* by the MESC 14 seconds after the initiation of the abort and activated with closure of 24,000 foot baroswitches in the ELSC. Subsequent functions of the ELS are dependent upon these 24,000 foot baroswitches, some 10,000 foot baroswitches and time delays. The ELS Logic Bus is armed manually during normal entry, or following SPS aborts with return to earth, prior to descending to an altitude of approximately 50,000 feet, but is not activated automatically until closure of the 24,000 foot baroswitches.

1.2.14 Controls Tower Jettison

Normally (Mission) the manual
The MESC performs the task of jettisoning the LET during normal ascent and ~~high altitude LES~~ aborts after receiving a manually initiated command from the crew. During ~~pad/low and medium~~ altitude LES aborts, the LET is jettisoned automatically by the MESC with the time of jettison being controlled by the 24,000 foot ELS baroswitches.

1.2.15 Enables RCS/SCS During Aborts and Normal Separation

One second following initiation of LES aborts after 61 seconds from lift-off, the CM's RCS/SCS (Stabilization and Control System) is enabled automatically by the MESC for rate stabilization of the CM. Two and one-half seconds following initiation of SPS aborts, the SM's RCS/SCS is enabled automatically by the MESC. For normal SLA separation, present thinking is for the Commander to manually enable the SM's RCS/SCS prior to commanding Adapter Separation manually.

1.2.16 Performs SLA Separation

All SLA separation functions are performed automatically by the MESC if an SPS abort is triggered by the Translation Controller. These functions are:

- (1) BECO
- (2) Direct SC ullage started
- (3) Guidance and Navigation (G&N) signaled of SPS abort
- (4) Event Timer reset
- (5) SLA separated, and
- (6) SM RCS/SCS enabled

Present thinking of how to perform a normal SLA separation alters the above functions somewhat.

For a normal SLA separation, it is thought at this time that the Commander will first of all manually enable the RCS/SCS, then initiate a +X translation with the Translation Controller. Approximately 2 seconds later he would manually initiate adapter separation, which utilizes MESC components.

1.2.17 Jettisons Apex Cover

The Apex Cover is jettisoned automatically by the MESC, but dependent upon the 24,000 foot baro-switches in the ELSC. The Apex Cover is jettisoned .4 seconds after the LET is jettisoned at 14 seconds after the initiation of an abort below 30,000 feet. For any abort above 30,000 feet or for a normal entry after a successful mission, the Apex Cover is not jettisoned automatically until after descending to approximately 24,000 feet.

1.2.18 Deploys Drogue Parachutes

The Drogue parachutes are deployed automatically by the ELSC firing mortars 1.6 seconds after the Apex Cover is jettisoned.

1.2.19 Deploys Main Landing Parachutes

The Main Landing parachutes are deployed by the use of small Pilot parachutes, which are automatically deployed by the ELSC firing mortars. During normal descent, the Pilot parachutes are deployed when the 10,000 foot baroswitches close in the ELSC.

1.2.20 Controls CM RCS Propellant Disposal

During normal descents after Main Landing parachute deployment, the Commander will dispose of all remaining RCS Propellants on board the CM by burning it off through the simultaneous firing of all the RCS engines, except the positive pitch engines. In this manner he rids the CM of all hypergolic propellants prior to touchdown on the water. This is important because if a Fuel and an Oxidizer supply tank should

may change
to 3 sec because
of SLA B Tail Off (per 201)

rupture at touch down allowing the Fuel and Oxidizer to mix, a fire would erupt causing damage to, or loss of, the CM and possibly the crew.

For any LES abort after 61 seconds from lift-off, the full load of Propellants is disposed of by burning, also, following Main Landing parachute deployment exactly as on a normal descent.

For LES aborts from the launch pad or up until 61 seconds from lift-off, however, the Oxidizer is **always dumped** automatically in the first 11-12 seconds during the abort ascent phase.

It is also desired to always dispose of the Helium, either by purging the RCS, as on a normal descent or aborts after 61 seconds from lift-off, or by dumping it directly from the supply tanks when time is critical. Therefore, for LES aborts from the pad up to 61 seconds from lift-off, when time is most critical, the Helium will be dumped automatically 18 seconds after the abort was initiated and the full Fuel load will remain on board the CM. There will be no manual switching functions required of the crew concerning the SECS during this type abort, unless for back-up purposes. Every function is performed completely automatically.

1.2.21 Controls Release of Parachutes

The ELSC fires the parachute release mechanisms. The Drogue Parachutes are released automatically as the Pilot parachutes are deployed, but the Main Landing Parachutes are released only after the crew initiates their release manually after touchdown on the water.

1.2.22 Vital Information Telemetered

The SECS provides conditioned signals to the Telemetry equipment through the Data Distribution Box so that certain vital information may be telemetered to the Manned Space Flight Network (MSFN). This vital information is events which take place from the time the crew activates the SECS until completion of the mission, which is most important to ground personnel in determining the status of the mission.

As previously mentioned, the SECS utilizes the LES and the ELS and depends upon inputs from the EDS. A brief description of the purpose of each of these systems follows:

1.3 LES PURPOSE

The LES provides the means by which the crew may escape instantaneously from the LV by the use of the LET, either while on the launch pad or at any time up until the tower is jettisoned while ascending into space.

1.4 EDS PURPOSE

The purpose of the EDS is to monitor the critical parameters of the LV and to warn the crew by various indicators on the main display and control panel when these parameters are exceeded. Also, with its interface with the MESC, an automatic abort may be voted and Booster Engine Cut-off (BECO) may be initiated.

The EDS is the joint responsibility of the Marshall Space Flight Center (MSFC), the Manned

Spacecraft Center (MSC), and North American Aviation (NAA), since it is primarily built into the LV but must interface with the SC.

1.5 ELS PURPOSE

The ELS provides the capability for a safe recovery of the crew and CM on the water, either after normal entry into the earth's atmosphere following a successful mission, or following an abort.

1.6 LES REQUIREMENTS

To achieve the purpose of the LES, certain requirements are established. The principal requirements are described in the text following. See fig. 1-5.

1.6.1 Abort Capability

The LES is capable of providing an immediate abort at any time until approximately $T = +173$ ", the time of tower jettison. Immediate abort capability is an essential requirement because a delay of a few seconds in initiation of an abort could be catastrophic. There are 3 types of LES aborts, namely; a pad/low altitude abort which ranges from the pad to approximately 30,000 feet, a medium altitude abort, which ranges from approximately 30,000 feet to approximately 120,000 feet and a high altitude abort, which ranges from approximately 120,000 feet to tower jettison.

1.6.2 Abort Initiation

All the functions to be performed for abort are automatically initiated, including tower jettison, ~~with the exception of the high altitude LES abort.~~ Along with this is the requirement for a manual abort initiation capability. The crew can manually initiate the abort command by a counterclockwise twist of the

Translation Controller. The same procedure can be used to initiate an SPS abort. Refer to figure 5-12 for an illustration of the Translation Controller.

1.6.3 Minimum Pad Abort Capabilities

Timewise, the pad abort is the most critical of all aborts. An important requirement then, of the LES, is that it be capable of thrusting the CM away from the LV while resting on the pad, to a adequate altitude for recovery and with a minimum range at apogee of 3,000 feet. This capability is determined by thrust obtainable from the Launch Escape motor and the gross weight of the LEV, plus the thrust alignment setting of the LET.

1.6.4 Non-Thrusting Booster Separation

The capability to separate from a non-thrusting booster is another requirement of the LES. The manner in which this is accomplished varies with the mission and whether it is performed in a normal or an emergency condition. This requirement is primarily applicable to the abort configurations. During a normal ascent, BECO is automatically initiated and separation is manually effected. But when an abort is initiated, either automatically or manually, BECO occurs automatically to enable the CM or Command Service Module (CSM) to separate from a non-thrusting booster, unless inhibited by Range Safety's time delay in the IU for the first 40 seconds following lift-off.

1.6.5 Crew Tolerances

One of the factors considered in the LES design requirements is the extent of physical stresses permitted to be imposed upon the crew. Because of the monitoring and backup functions the crew performs, the forces cannot be in excess of the amount that would

LES REQUIREMENTS

- PROVIDE IMMEDIATE ABORT CAPABILITY FROM PAD TO TOWER JETTISON
- ASTRONAUT INITIATION EXCEPT FOR AUTOMATIC EMERGENCY MODE
- MIN. PAD ABORT CAPABILITIES: 3,000 FT RANGE AT APOGEE, ADEQUATE ALTITUDE FOR RECOVERY
- SEPARATE FROM NON-THRUSTING BOOSTER
- NOT TO EXCEED CREW TOLERANCES *(8-10 g's peak @ coast 4 sec from 0-1)*
- PROVIDE ACCEPTABLE CONDITIONS FOR APEX COVER JETTISON & DROGUE DEPLOYMENT

Figure 1-5

SEQ-21E



1-12

degrade crew performance. This consideration affects the allowable thrust of the Launch Escape motor.

1.6.6 Establish Conditions for ELS Utilization

Another important requirement of the LES is to provide acceptable conditions for Apex Cover jettison and Drogue Parachute deployment in an abort configuration. It is mandatory that the CM be oriented blunt end, or aft heat shield, forward and apex aft in order to make use of the ELS. A Canard, or nose elevator, type of control surface near the Nose Cone of the LET serves this purpose on ~~pad/low and medium~~ altitude LES aborts. The Canard is always deployed automatically 11 seconds after initiation of the abort and this effects the turn-around maneuver of the CM necessary to orient blunt end forward. In the case of the medium ^{near} altitude LES aborts, the LET is retained with the Canard deployed after the turn-around maneuver and will assist in stabilizing the CM as it trails the CM on descent. After descending to approximately 24,000 feet, the LET is jettisoned, immediately followed by the Apex Cover.

1.7

EDS REQUIREMENTS

The EDS must satisfy certain requirements to achieve its purpose. The 6 major requirements are discussed in the following paragraphs. See figure 1-6.

1.7.1 Booster Thrust Status

The EDS is required to display to the crew an indication of whether or not the engines of the LV are maintaining a certain specified percentage of thrust during lift-off and ascent. The crew, by monitoring the displays provided for this purpose can detect deterioration of engine thrust and determine if, and when it is necessary, to initiate an abort.

which displays
in thrust deterioration?

Also, if 2 or more first stage engines are sensed to have degraded below 90% rated thrust, this condition will cause an automatic abort unless inhibited by certain switching functions by the crew.

1.7.2 Excessive Rates of LV

Display to the crew of excessive rates in either roll, pitch, or yaw of the LV is another requirement of the EDS. Three EDS rate gyros on each axis monitor for rates in excess of 20°/sec. in roll and 5°/sec. in pitch and yaw. These excessive rates will activate circuitry which will warn the crew by an indicator light and will initiate an automatic abort up until the time the tower is jettisoned, unless inhibited by the crew by certain switching functions.

1.7.3 LV Guidance Failure

The EDS is also required to monitor the Guidance Unit in the IU for a possible failure. If the attitude reference is lost, an indicator light is illuminated to alert the crew. A guidance failure will not initiate an automatic abort. Instead, the crew will, with ground personnel assistance, decide on a course of action.

1.7.4 Angle of Attack

Angle of attack of the LV is displayed to the crew by a dial and pointer type instrument. Information is transmitted via transducers from a Q Ball located in the nose cone of the LET. A measure of dynamic ram pressure and differential pressure about the pitch and yaw axes is taken to provide the crew with a vectorial display of angle of attack information.

EDS REQUIREMENTS

- MONITOR AND DISPLAY BOOSTER THRUST STATUS
- MONITOR AND WARN OF EXCESSIVE RATES OF L/V
- MONITOR AND WARN OF L/V GUIDANCE FAILURE
- MONITOR AND DISPLAY ANGLE OF ATTACK
- MONITOR AND DISPLAY ATTITUDE ERROR (FDAI)
- MONITOR AND DISPLAY ANGULAR RATES (FDAI)

*Automatic
Abort Features*

*Manual Abort
Monitors*

Figure 1-6

1.7.5 Attitude Error and Angular Rates

Attitude Error and Angular Rates as displayed upon the Flight Director Attitude Indicator (FDAI) are the final requirements of the EDS. Detection of an emergency situation regarding rates and attitude deviations of the LV is of prime importance to the crew. Observance of the FDAI may forewarn the crew of impending breakup of the LV. These indications used in conjunction with the Excessive Rate warning light and the Angle of Attack display will aid the crew in determining the necessity for a manual abort.

1.8 ELS REQUIREMENTS

In achieving its purpose, the ELS must accomplish the following design requirements. See figure 1-7.

1.8.1 CM Orientation and Deceleration

To accomplish the requirement for orienting and decelerating the CM in preparation for earth landing, 2 Drogue parachutes are deployed which are attached to a point at the -Z side of the egress tunnel. Attachment at this point orients the CM with approximately a 15° hang angle during descent. The atmospheric drag on the Drogue parachutes decelerates the CM sufficiently for subsequent safe deployment of the Main Landing parachutes.

1.8.2 Provide a Tolerable Earth Landing

Establishing and maintaining a rate of descent which will reduce the earth impact of the CM onto the water to within the tolerances the crew can withstand is another requirement of the ELS. To accomplish this requirement, 3 large parachutes are used. The impact would still remain within tolerable "g" forces for

the crew if one of the 3 parachutes was rendered ineffective. The 27.5° hang angle achieved by the Main Landing parachute attachment contributes to the crew tolerable impact by ensuring that impact occurs at the specifically designed CM structural attenuation point.

1.9 SPACECRAFT SEPARATION PLANES

Figure 1-8 illustrates the major SC modules and the location of the 4 separation planes that the SECS is associated with. A thorough familiarity with these SC components and their separation planes will be helpful in visualizing events in the various event profiles that will be described later.

1.9.1 LET - CM

This is the plane where the LET is mated to the CM at time of assembly. Frangible nuts and studs are utilized in the tower legs to affect separation of the LET from the CM, either during a successful ascent or during an LES abort.

1.9.2 Apex Cover - CM

The Apex Cover is separated from the CM at this plane whenever the Apex Cover is automatically jettisoned to uncover the parachutes in the forward compartment.

1.9.3 CM - SM

When any LES abort is initiated, separation occurs at the CM - SM separation plane. Separation also occurs at this plane when the crew manually initiates CM - SM Separation prior to entry into the earth's atmosphere after a mission.

ELS REQUIREMENTS

- ORIENT AND DECELERATE C/M FOR EARTH LANDING (Drogue)
- PROVIDE AN EARTH LANDING WITHIN CREW TOLERANCES (Main)

Figure 1-7

APOLLO SPACECRAFT SEPARATION PLANES

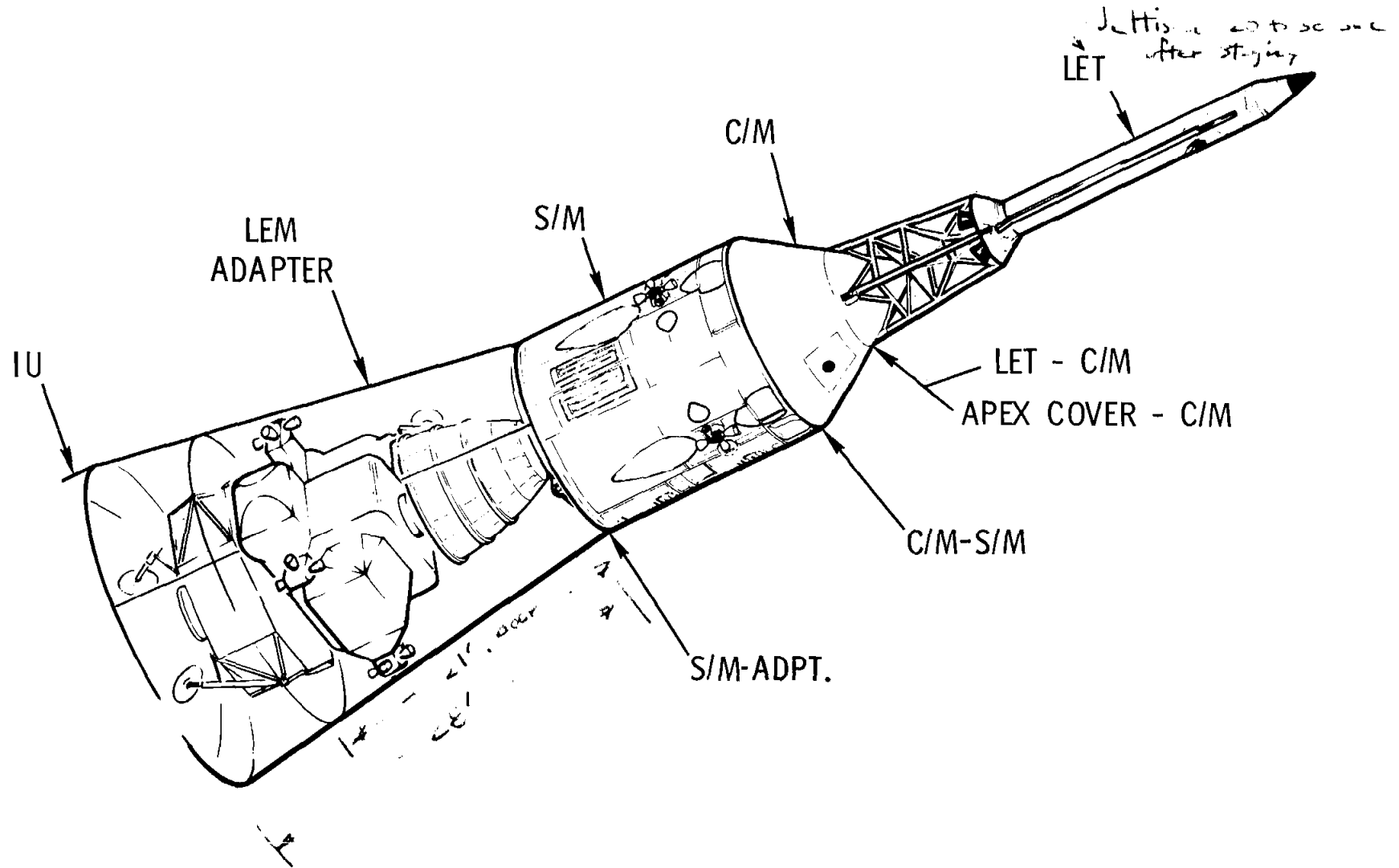



Figure 1-8

SEQ-41D 

1.9.4 SM - SLA

Whenever normal separation of the CSM from the LV or an SPS abort is commanded, separation is accomplished at this plane. The SLA consists of 4 large interconnected panels with each panel having 2 hinges built into the bottom, or aft end. When Adapter Separation is commanded, these panels are separated from each other and from the SM by pyrotechnic devices and are retracted aft and away from the CSM.

1.10 SPACECRAFT WEIGHTS AND DIMENSIONS

For some comprehension of the weights and dimension of the Apollo SC, refer to figure 1-9. Note that the total length of the LET is approximately 34 feet and that the total length of the CSM is approximately 24 feet 8 inches. Note also that the combined weight of the LEV (CM and LET) will be nearly 10 tons, with the LET weighing over 8,000 pounds and the CM weighing approximately 11,000 pounds. This is of interest when the thrust-to weight ratio is considered during LES aborts. For an SPS abort with the CSM, it is readily deducted that the additional weight for a partly loaded SM will be in excess of 10,000 pounds, depending upon the propellant loading. Consider also, that when SLA Separation takes place, 4 large panels measuring 21 feet in length and weighing approximately 3,500 pounds are opened up and retracted away from the CSM for the purpose of separating from the LV and for exposing the LEM ready for pickup ultimately on lunar missions.

1.11 CM COMPARTMENT CONFIGURATION

Figure 1-10 portrays the location of the various compartments of the CM and the axes coordinates relative to the crew facing forward. The forward compartment, which is forward of the crew, contains the

parachutes of the ELS and is covered with the Apex Cover. The Right Hand Equipment Bay contains the MESC, the PCVB, and the ELSC, as shown in figure 1-2. The Lower Equipment Bay contains the batteries which power the SECS. The CM RCSC is located in the Aft Compartment area where most all other RCS components are located.

The longitudinal axis of the SC is designated as the X axis. Translation forward along this axis is referred to as +X translation and in the opposite direction, or aft, as -X translation. Rotation about this axis is roll of the SC and LV and is referred to as the Roll Axis.

The lateral axis is designated as the Y axis, with +Y being to the right and -Y to the left. Rotation about this axis represents pitch of the SC and LV and is known as the Pitch Axis.

The vertical axis is designated the Z axis, with -Z being towards the crew's head and +Z being towards their feet. Rotation about the Z axis is called yaw and is referred to as the Yaw Axis.

For Apollo missions, the LV and SC is stacked with the -Z axis pointed down range. The crew, therefore, will be launched into space in a heels-over-head attitude.

1.12 SPACE VEHICLES

Figure 1-11 is included to show the various LV configurations that will be used to accomplish Apollo missions. It also shows the comparative sizes of the Launch Vehicles as well as the relative sizes of the different sections.

APOLLO SPACECRAFT

WEIGHTS AND DIMENSIONS

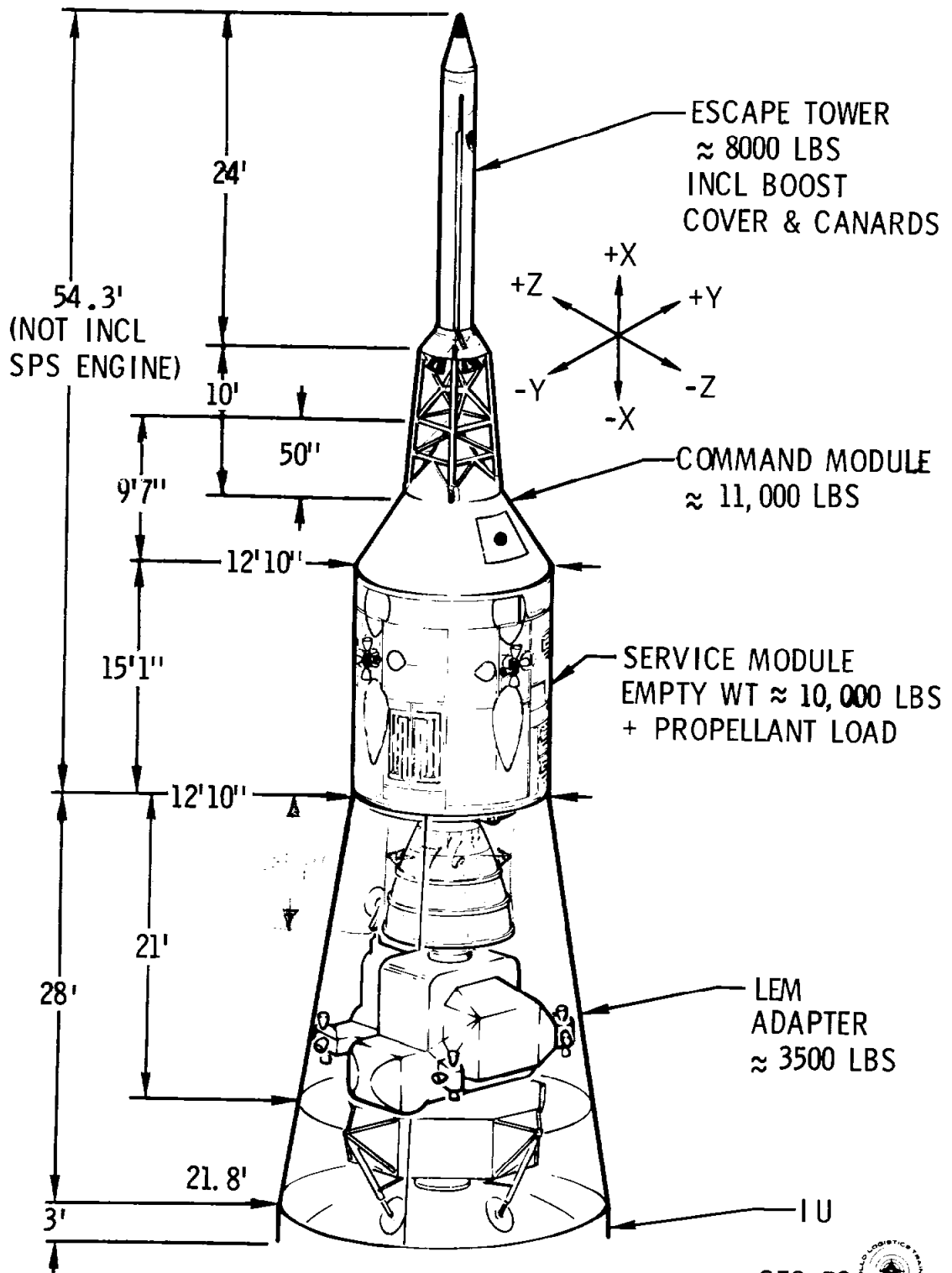


Figure 1-9

COMMAND MODULE COMPARTMENT CONFIGURATION

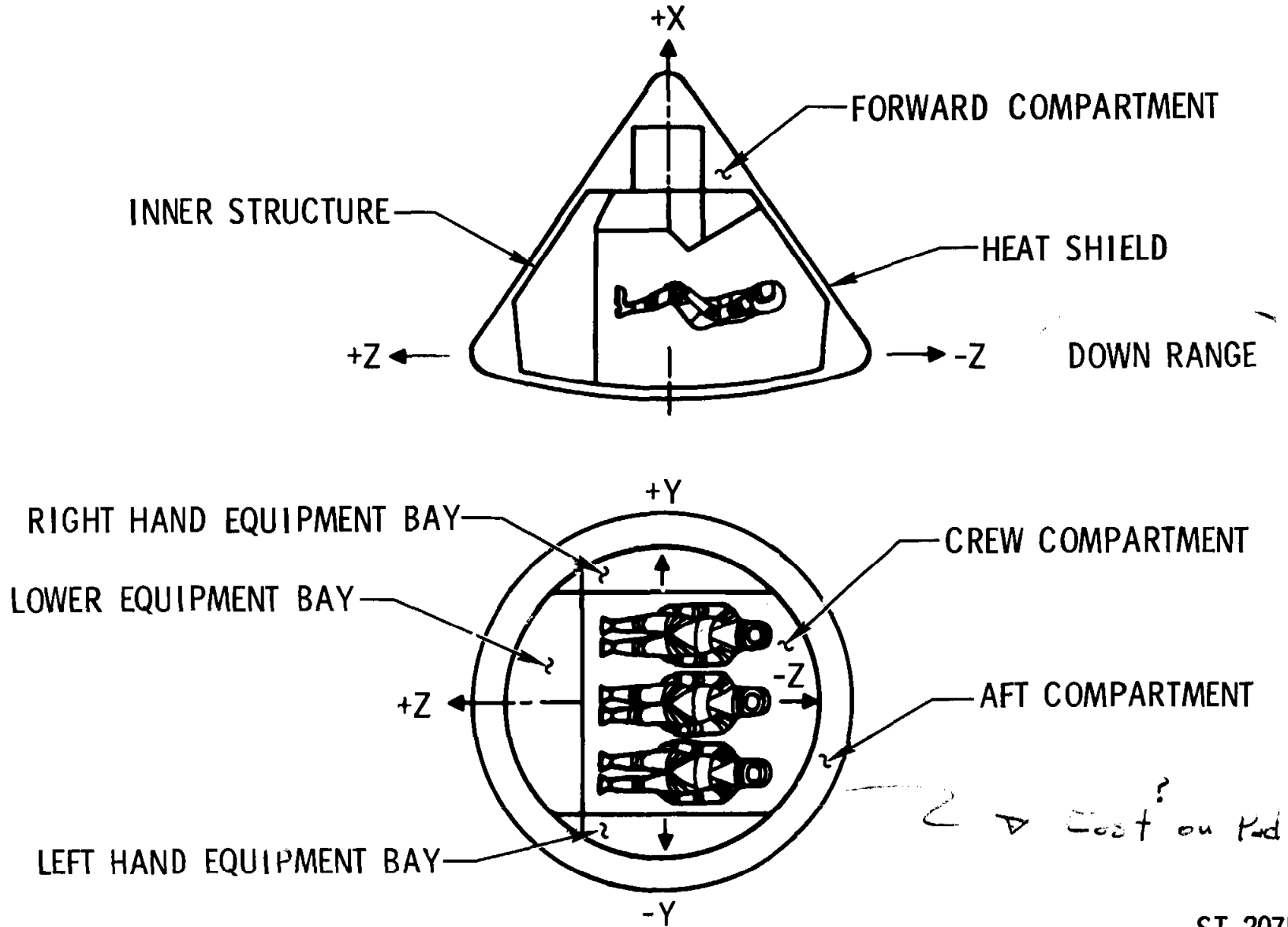


Figure 1-10

SPACE VEHICLES

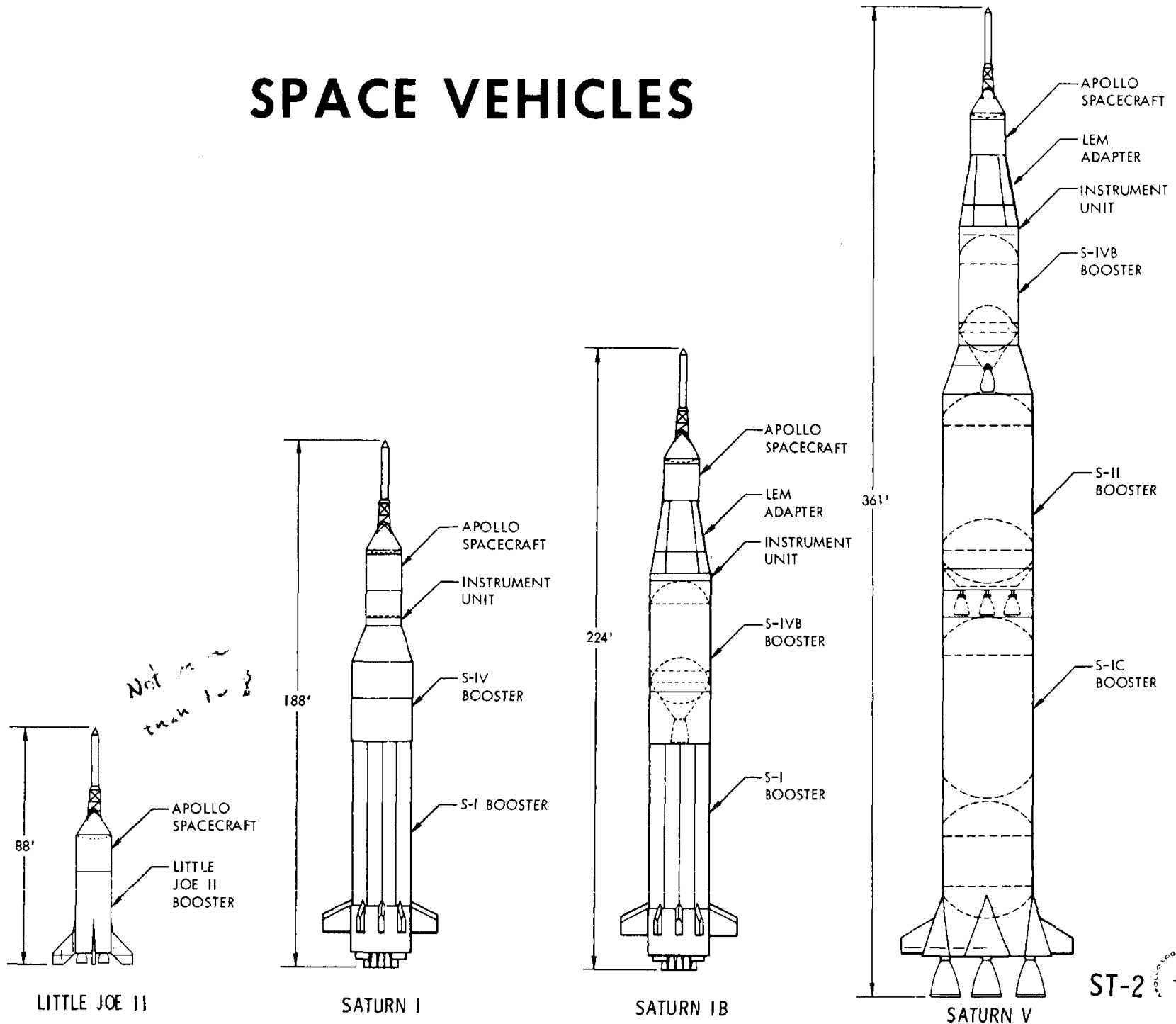
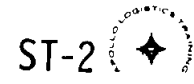


Figure 1-11



SECTION II

LAUNCH ESCAPE SYSTEM COMPONENTS

2

The components of the LES are listed in figure 2-1. These components are the Rocket Motors, the Tower Structure, the Structural Skirt, the Tower Separation Mechanism, the Boost Protective Cover, the Canard sub-assembly, and the Nose Cone - Q Ball. The text that follows describes these components.

2.1 ROCKET MOTORS

The LES contains three separate solid propellant rocket motors. These are the Launch Escape motor, the Tower Jettison motor, and the Pitch Control motor. The overall length is approximately 24 feet and is 26 inches in diameter. Figures 2-2 and 2-3 show their relative positions and sizes in the assembly.

2.1.1 Tower Jettison Motor

Of these 3 motors, only one, the Tower Jettison motor, is used on a successful mission. It provides the thrust to carry the tower assembly away from the SC during the normal ascent. This motor is also used during LES aborts to carry the entire LES tower assembly away from the CM.

Specifications:

The Tower Jettison motor sub-assembly is manufactured by the Thiokol Chemical Corporation. Its overall length, including nozzles and adapter, is approximately 50 inches. It is 26 inches in diameter and weighs approximately 500 pounds. The solid propellant has a 10 point star grain configuration with a burning time of 1 second and develops approximately

_____ pounds of average static thrust, based on a sea level firing at 70°F. Figure 2-4 shows a cross section of the star grain configuration of the propellant. The 2 nozzles are canted 30° from the center line, with 1 nozzle throat area enough larger than the other to establish an off-set thrust vector of approximately 4° to the +Z side.

2.1.2 Launch Escape Motor

The primary function of the Launch Escape motor is to carry the CM away from the LV. It is used in this capacity only if it is necessary to abort the mission on the pad or during ascent. Its secondary function is a back-up for the Tower Jettison motor. If the Tower Jettison motor should fail to ignite at the proper time, the Launch Escape motor may be fired to jettison the tower assembly.

Specifications:

The Launch Escape motor is manufactured by the Lockheed Propulsion Company. It has an overall length, including nozzles and igniter, of approximately 16 feet. It is 26 inches in diameter and weighs approximately 4,750 pounds. The solid propellant has an 8 point star grain configuration with a burning time of approximately 8 seconds and develops an average of _____ pounds of static thrust for the first 3.5 seconds at 70°F and sea level. Figure 2-5 shows a cross section of the star grain configuration of the propellant.

LAUNCH ESCAPE SYSTEM COMPONENTS

- ROCKET MOTORS:
 - TOWER JETTISON MOTOR
 - LAUNCH ESCAPE MOTOR
 - PITCH CONTROL MOTOR
- TOWER STRUCTURE
- STRUCTURAL SKIRT
- TOWER SEPARATION MECH
- BOOST PROTECTIVE COVER
- CANARD SUB-ASSEMBLY
- NOSE CONE - Q BALL

LAUNCH ESCAPE SYSTEM

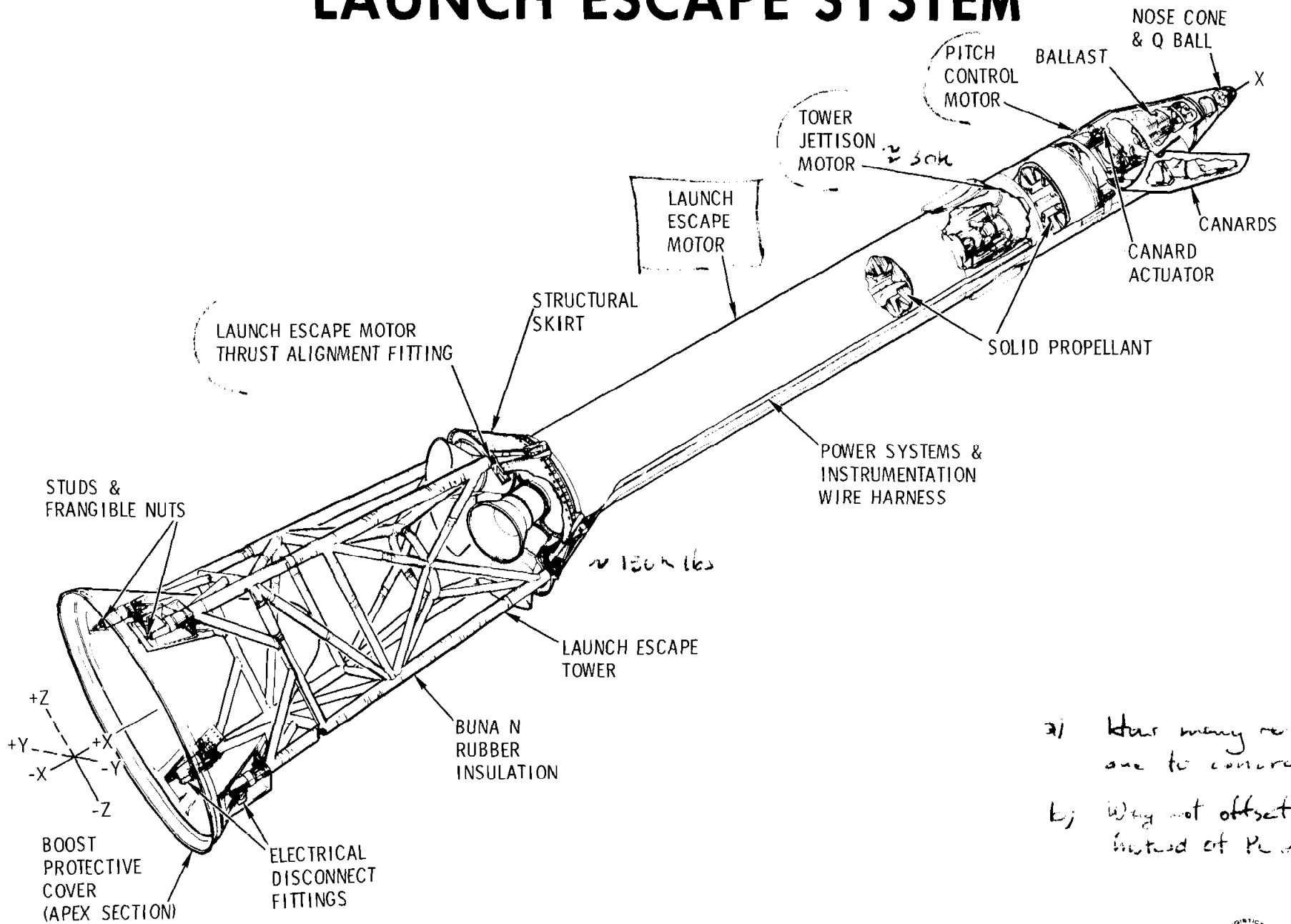
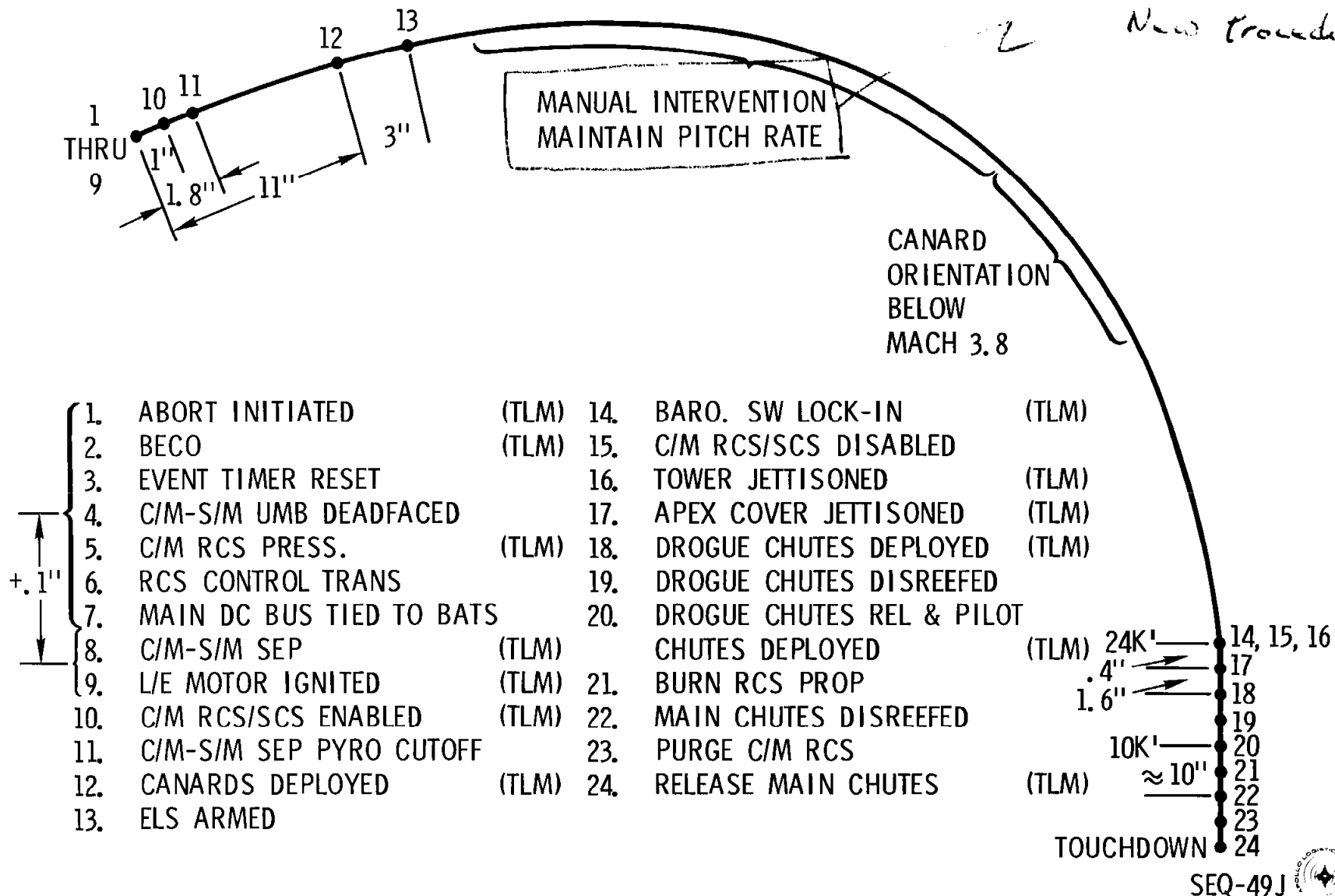


Figure 2-2

EVENT PROFILE

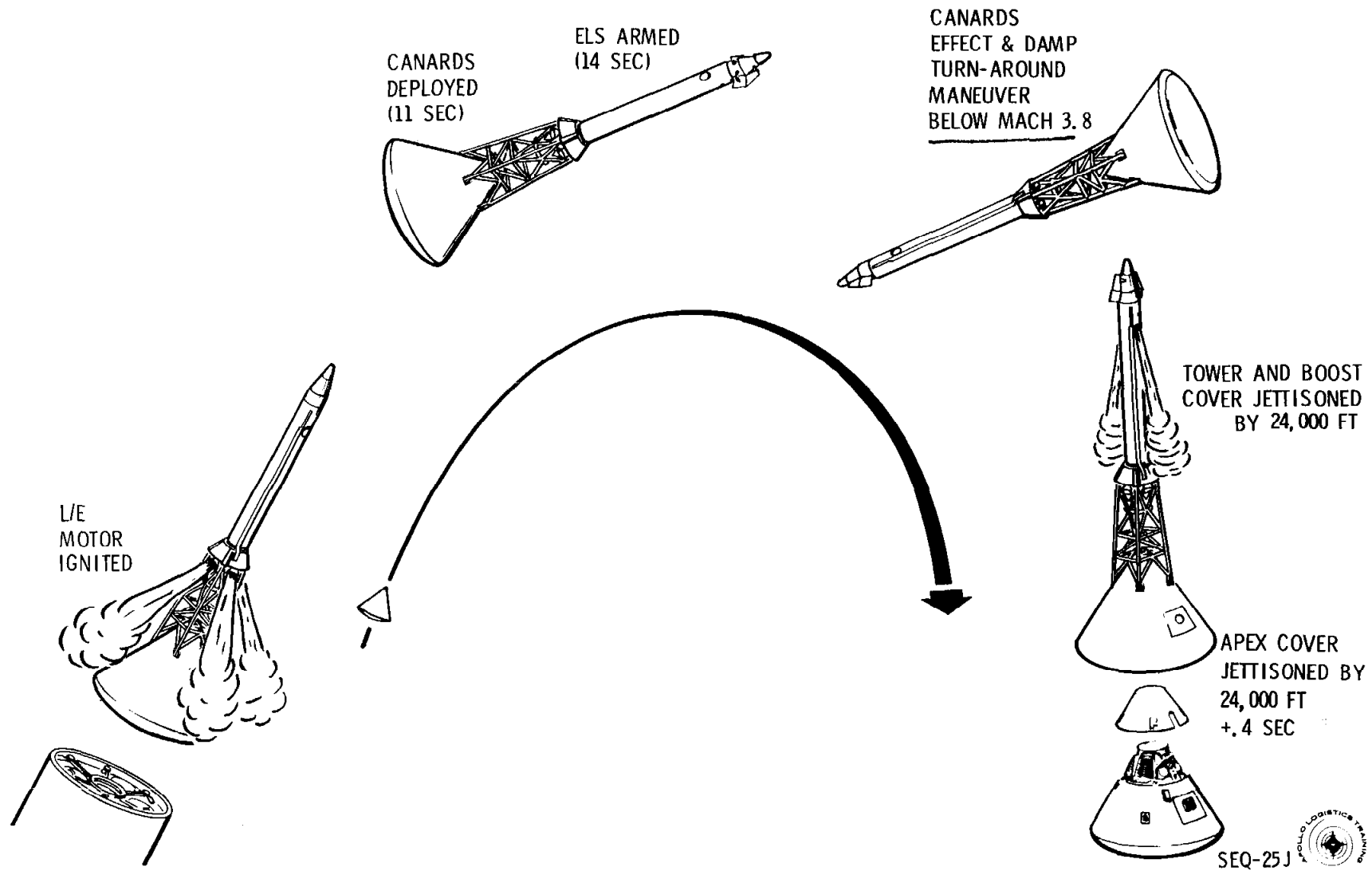
HIGH ALTITUDE LES ABORT

New Procedure



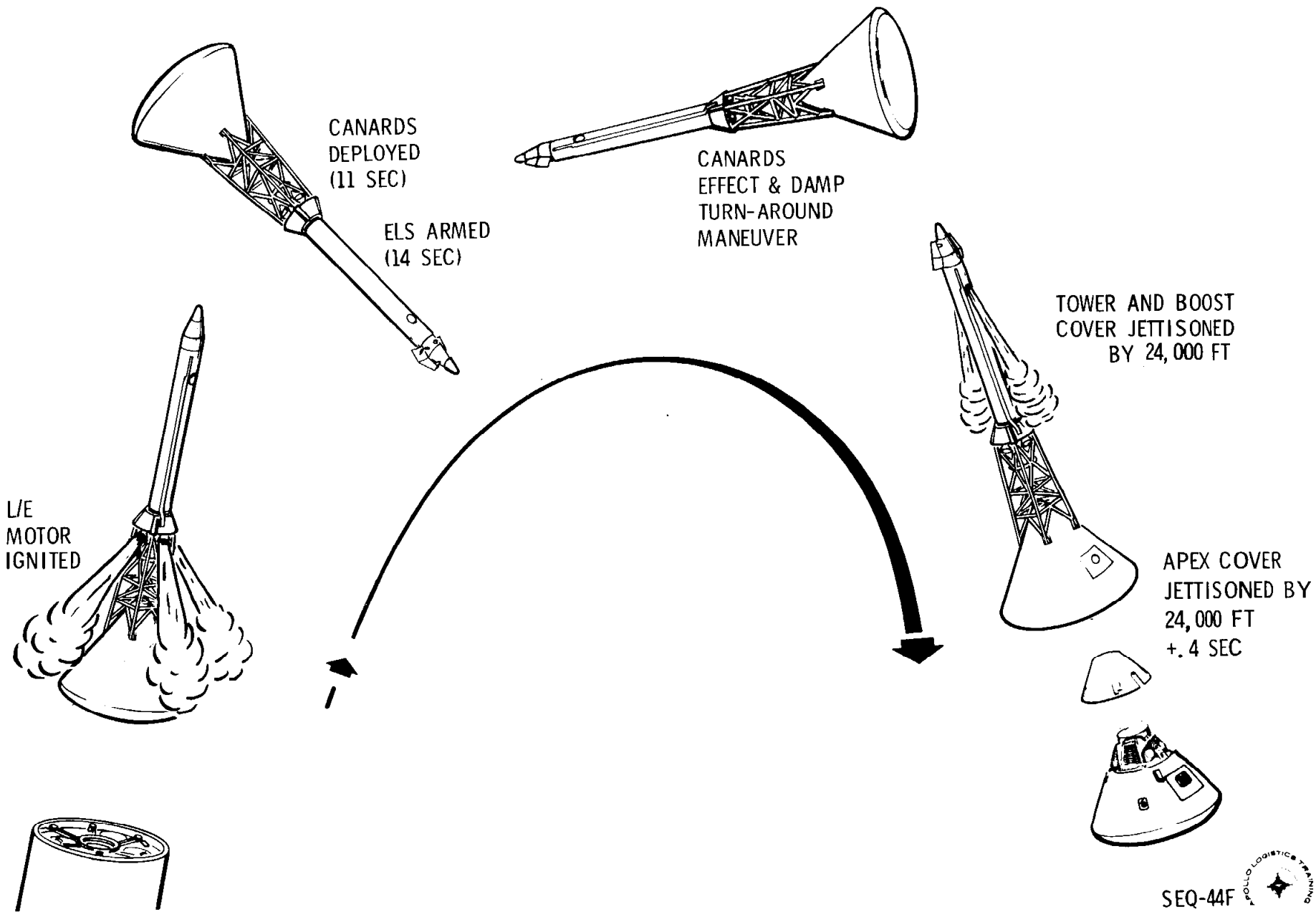
HIGH ALTITUDE LES ABORT

(100,000 FT TO TWR JETT)



MEDIUM ALTITUDE LES ABORT

(30,000 TO 100,000 FT.)



LAUNCH ESCAPE SUBSYSTEM CUTAWAY DETAIL

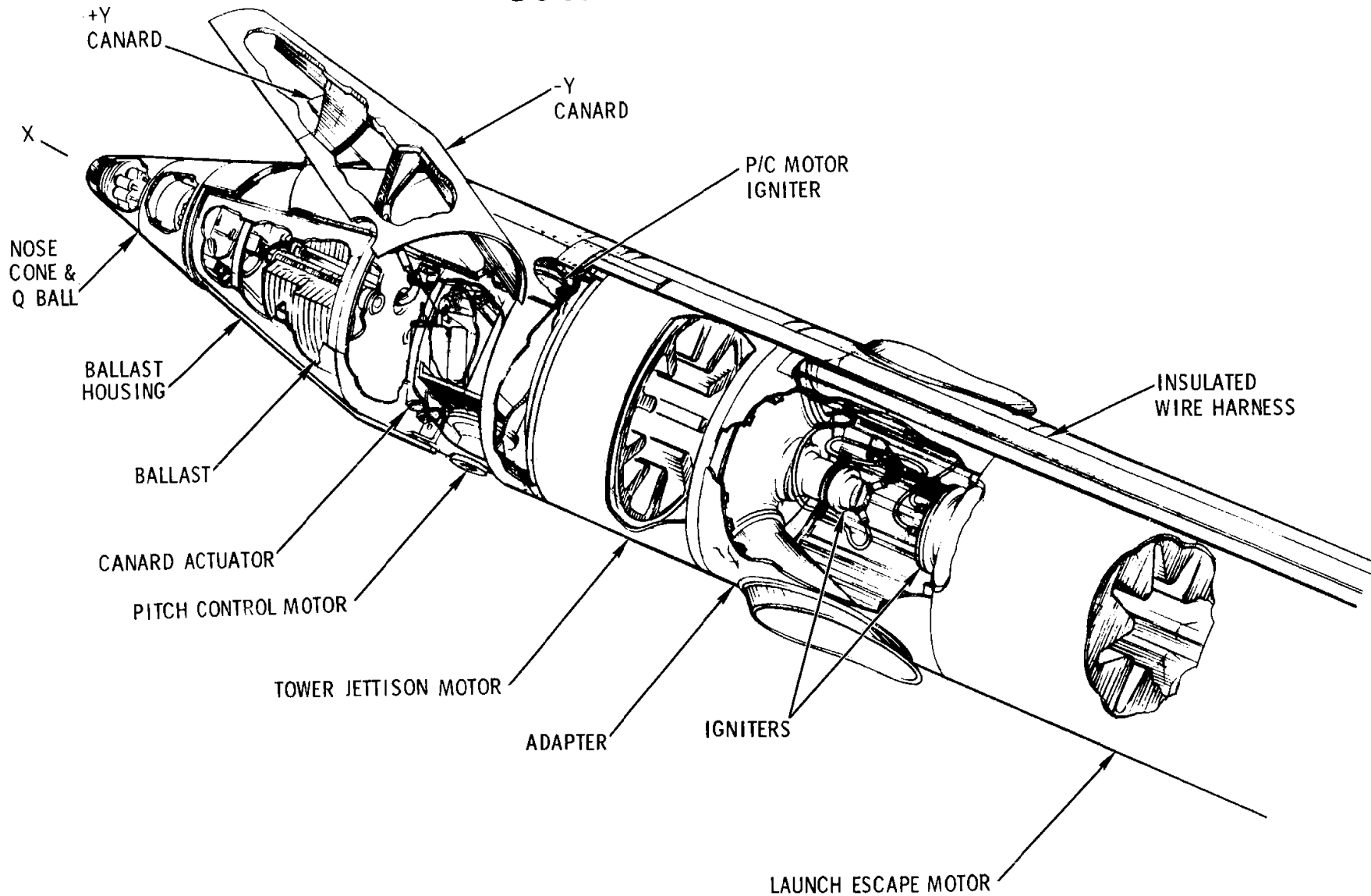
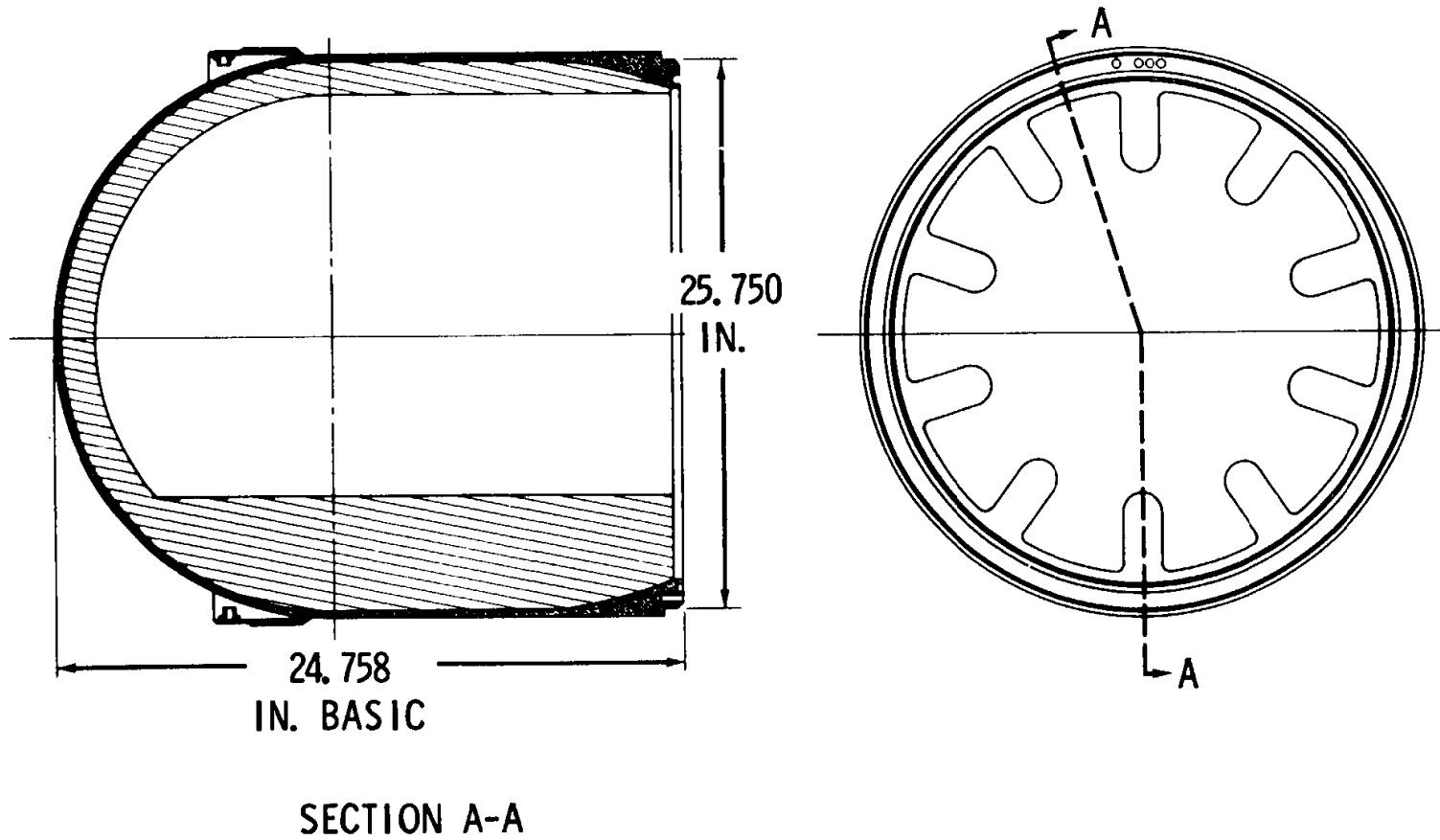


Figure 2-3

GRAIN CONFIGURATION

T/J MOTOR

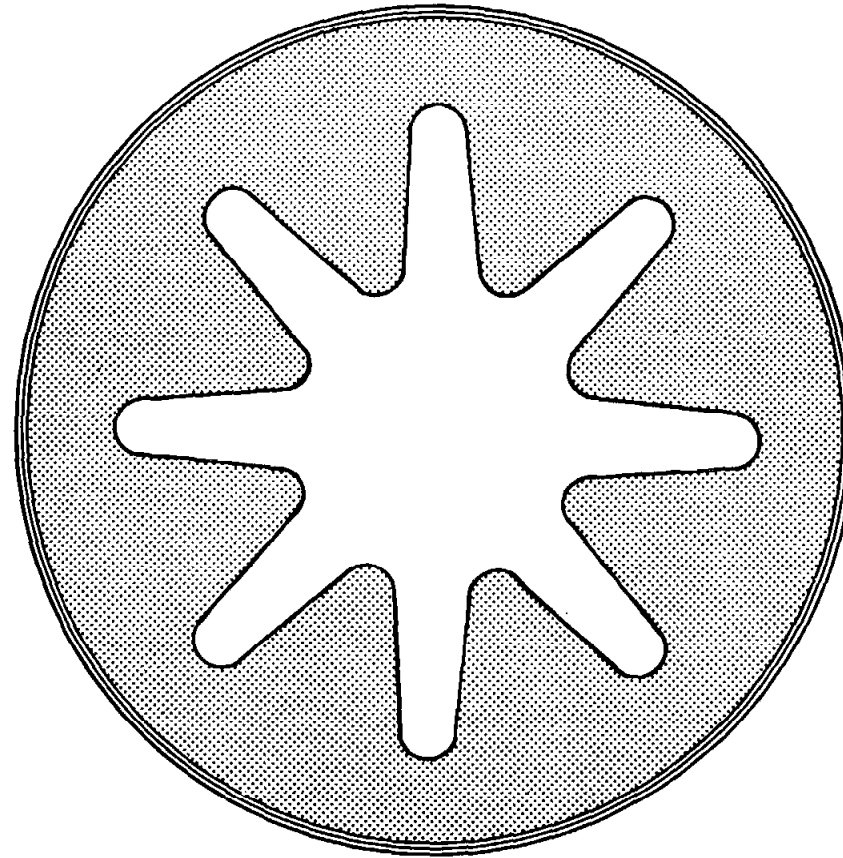


SEQ-27B

Figure 2-4

GRAIN CONFIGURATION

L/E MOTOR



26.000
IN. DIA

GRAIN CONFIGURATION


SEQ-26 C 

Figure 2-5

The Launch Escape motor has 4 nozzles positioned 90° apart. Each nozzle is canted 35° from the X axis. The +Z nozzle has an inside diameter of 5.6 inches as compared to the -Z nozzle's 4.8 inches. The +Y and -Y nozzles are identical, each having an inside diameter of 5.2 inches. This nozzle size variance causes an off-set thrust vector of approximately 2.75°.

2.1.3 Pitch Control Motor

The Pitch Control motor is ignited simultaneously with the Launch Escape motor upon the initiation of any LES abort either from the launch pad or up until 61 seconds from lift-off (approximately 24,000 feet). Its purpose is to establish a 15° to 20° down range pitch-over of the LEV immediately with the initiation of an LES abort. This action effects a tilting break-away from the SM initially and provides miss distance from a thrusting booster by changing the abort trajectory from that of the boost trajectory. Also, lateral displacement towards the Atlantic Ocean for subsequent recovery on the ELS parachutes is gained quickly while in the first 24,000 foot area of the launch and ascent phase which is over land.

Specification:

The Pitch Control motor is manufactured by the Lockheed Propulsion Company. Its overall length is approximately 22 inches, its diameter is 9 inches, and its weight is approximately 50 pounds. The solid propellant has a 14 point star grain configuration with a burning time of one half second and develops an average static thrust of approximately _____ pounds at sea level and 70°F. Figure 2-6 shows a cross section of the star grain configuration of the propellant.

2.1.4 Grain Configuration

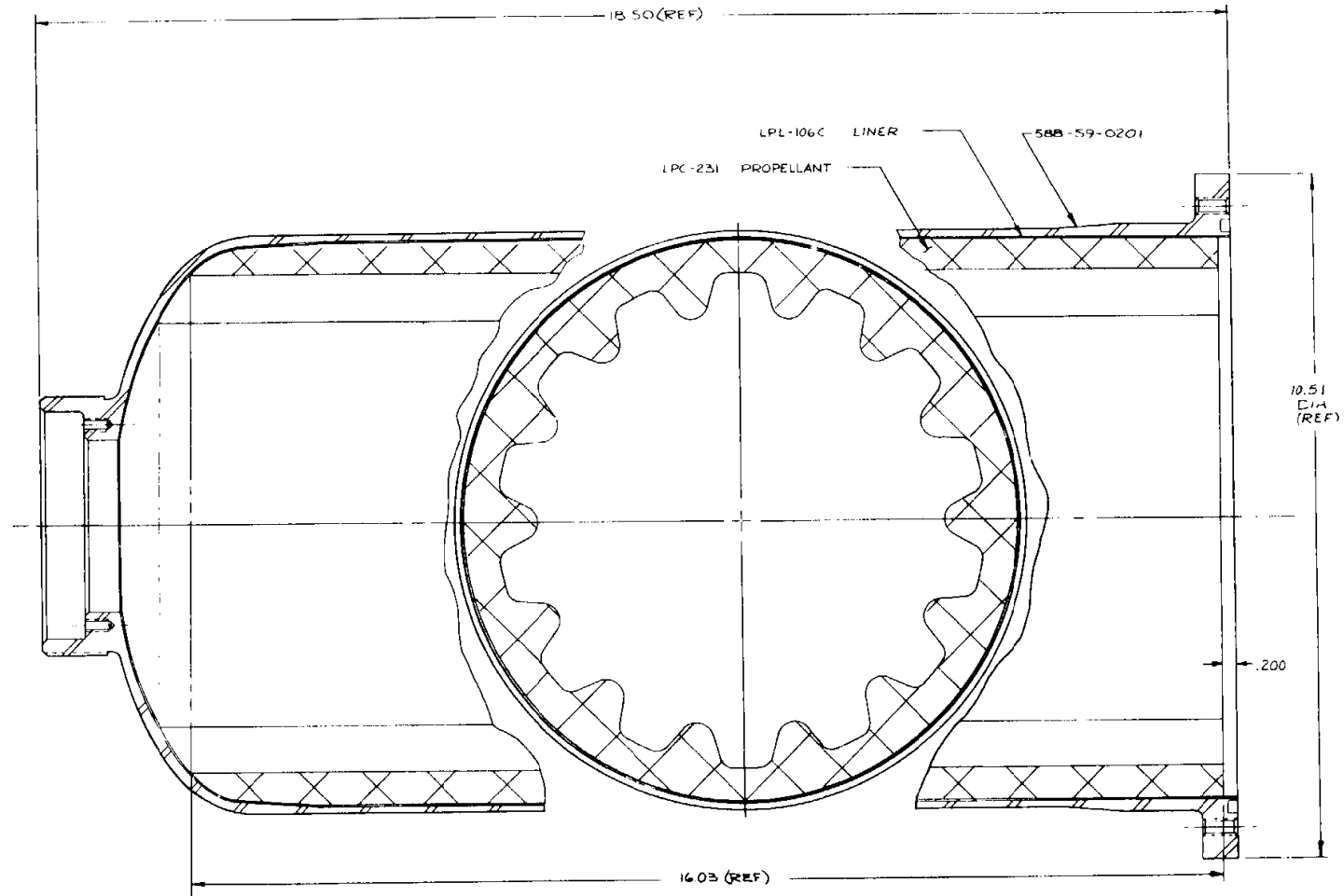
The solid propellant in each of the LES motors is a composite propellant of the polysulfide type. A star grained configuration provides a large surface area for initial burning. The burning of a solid propellant proceeds laterally from the ignited surface in all directions at a uniform rate. The burning of the star grain configuration is divided into two major phases. The first phase occurs from the ignition of the grain until the web is consumed and the flame front reaches the outer wall of the grain. This burning phase is normally classified as web burning. The second phase, known as sliver burning, consists of the burning of the discontinuous portion of the propellant that remains after the web burning. In terms of the motor thrust, the first burning phase is the phase that produces the nominal thrust while the second phase produces the tail-off thrust.

2.2 TOWER STRUCTURE

The purpose of the Tower Structure is to provide a method of attaching the Launch Escape System's rocket motors to the CM. Consequently, its design requirements are governed considerably by the motors. For example, the structure must have a specific strength to support the weight and thrusts of the motors. It must be capable of withstanding various loads, stresses, and strains present during normal ascents and aborts. Yet, the complete structure must be kept as lightweight as possible. The structure must be a certain length to control plume impingement loads to the CM. Finally, it must be constructed of material that can withstand the heat created by the Launch Escape motor in case of an abort.

GRAIN CONFIGURATION

P/C MOTOR



SEQ-28A



Figure 2-6

Specifications:

The tower is constructed of welded tubular Titanium. The main vertical risers are 3.5 inches in diameter, with a wall thickness of 0.125 inch. The inner structure consists of tubes 2.5 inches in diameter, with a 0.050 inch wall thickness.

The overall length of the Tower Structure is 10 feet and it weighs approximately 300 pounds. The entire Tower Structure is insulated with Buna N rubber to protect the wiring from aerodynamic friction heating and the intense heat developed from a burning Launch Escape motor. Also, to prevent weakening the structure during Launch Escape motor burning. This adds approximately 200 pounds to the weight of the tower. The structure tapers from approximately 4 feet square at the CM attach points to 3 feet square where it joins to the Structural Skirt.

2.3 STRUCTURAL SKIRT

The Structural Skirt is an aerodynamically shaped Titanium structure covered with ablative material. The approximately 200 pound structure functions as the adapter between the Tower Structure and the Rocket Motor assembly. The tower assembly is attached to the skirt with 4 Thrust Alignment Fittings after the skirt has been bolted to the Launch Escape motor. This assembly is shown in Figure 2-2.

2.4 TOWER SEPARATION MECHANISM

The Tower Structure is attached to the CM at the base of each tower leg with a frangible nut turned down on a stud that is screwed into the CM's basic structure. The tower is separated from the CM by fracturing the 4 frangible nuts inside each of the tower legs and igniting the Tower Jettison motor.

2.5 BOOST PROTECTIVE COVER

The Boost Protective Cover is an integral part of the Tower Structure. Figure 2-7 illustrates the physical construction of this cover. The purpose of the Boost Protective Cover is to protect the external surfaces of the CM from damage due to thermal heating during the atmospheric boost phase of the mission. Also, in case of an LES abort, the windows of the CM will not become covered with soot from the Launch Escape motor obstructing the crew's capability to orient themselves and to monitor ELS functions visually.

Specifications:

The Boost Protective Cover consists of 10 different sections. One section, the apex section, is commonly referred to as the hard cover. The remaining 9 sections, which make up the skirt and including the hatch, are commonly referred to as the soft cover. The hard cover is constructed of fiberglass honeycomb material and covered on the outside with a cork ablator. The 9 sections which make up the soft cover portion are reinforced Teflon impregnated glasscloth covered with a cork ablator. The soft cover is attached to the hard cover by screws and nutplates. Each section is then fastened together toward the trailing edge with screws and nutplates. One circular fused silica glass window will be installed in the soft cover portion directly over the ingress hatch window.

2.6 CANARD SUB-ASSEMBLY

The Canard sub-assembly is that section between the Tower Jettison motor sub-assembly and the Nose Cone. This sub-assembly consists of 3 distinct sections, those being (1) the Pitch Control motor

BOOST PROTECTIVE COVER BLOCK I CSM

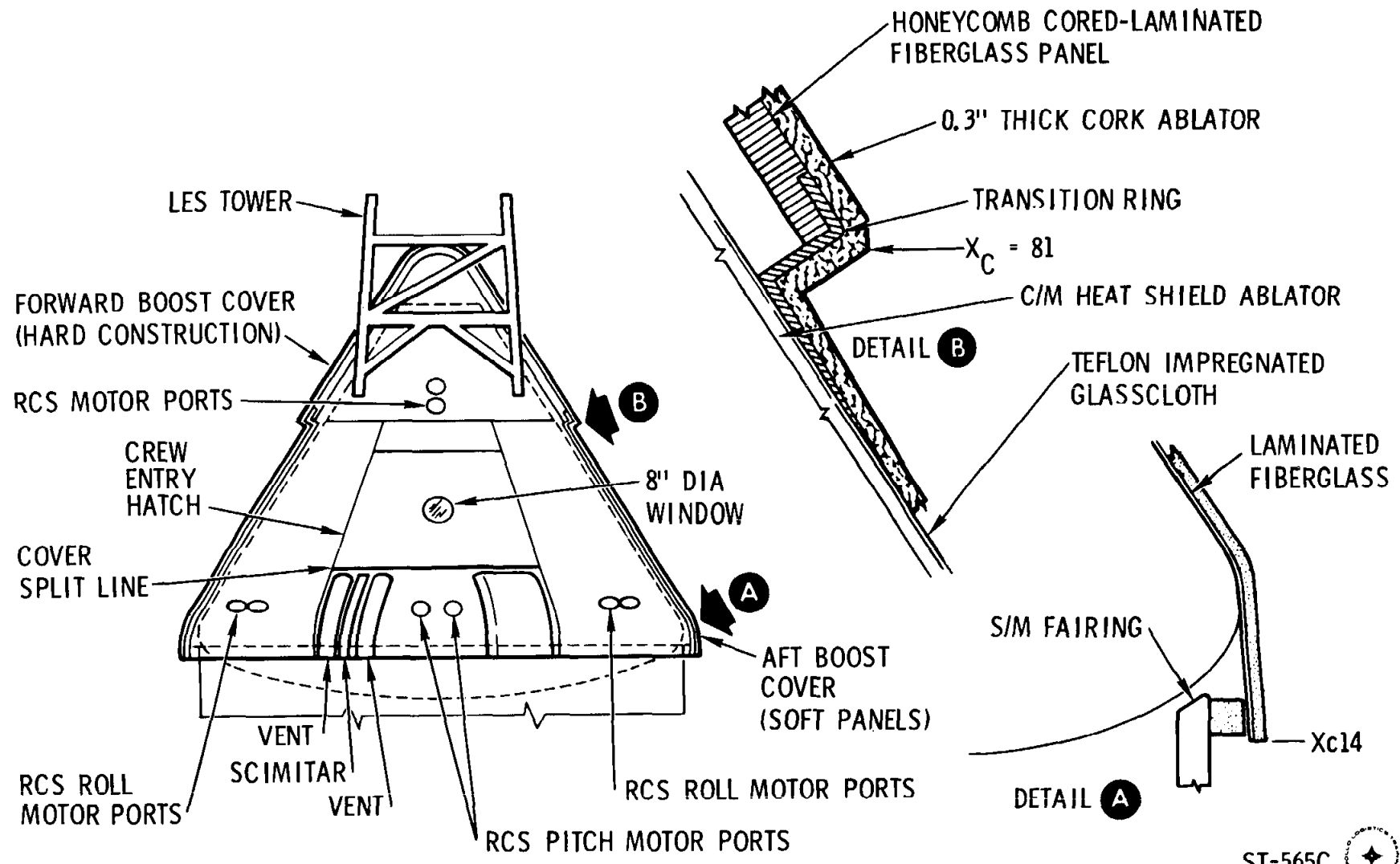



Figure 2-7

ST-565C 

section, (2) the Canard actuator section, and (3) the Ballast section. Figures 2-3, 2-8 and 2-9 show the Canard sub-assembly. The Pitch Control motor is mounted upon channels at either end and these are in turn riveted directly to the ring frames of the Canard sub-assembly. The motor is shimmed into position upon these channels to place the thrust nozzle flush with the outer skin of the sub-assembly. The Canard actuator and its related linkage and locking devices are located in the center section. The Ballast section is the forward section of this sub-assembly. The Ballast section consists primarily of a heavy one and three-quarters inch thick bulkhead permanently attached to the ring frame forward of the Canard actuator section and 3 one and a half inch threaded studs screwed into this bulkhead. A number of lead wafers of varying thickness and diameter is placed upon these studs and tightened down permanently to make up a predetermined amount of weight to maintain aerodynamic stability about the center of gravity of the LEV during an LES abort. This Ballast is enclosed within a cone shaped fairing tapering forward to the Nose Cone of the LET.

The Canards are 2 semi-monocoque constructed semi-circular control surfaces approximately 1 inch thick. When closed, the Canards fair into the Pitch Control motor and Ballast sections. Each Canard has 2 hinges designed and installed in such a manner as to allow these surfaces to deploy approximately 30° from parallel to the longitudinal axis of the LET. The hinges are on the Y axis allowing the Canards to open away from the thrust nozzle of the Pitch Control Motor. The Canards are deployed by a gas operated actuator located in the actuator section of the Canard sub-assembly. All sub-structure under the Canards is enclosed by an inner fairing.

2.7 NOSE CONE - Q BALL

The aerodynamically shaped aluminum fairing at the extreme forward end of the LET is identified as the Nose Cone. In addition to contributing to the aerodynamic stability of the LV, it incorporates the Q Ball, as illustrated in figure 2-10.

Angle of attack is resolved from sensing initially via transducers the differential pressure values obtained from the porting arrangement shown. This information is in turn directed to electronic modules where a vectorial summation of the information obtained is made. This summation is then amplified and sent by electrical wiring down the LET and to the Angle of Attack switch and instrument on the main display and control panel in the CM.

CANARD STRUCTURAL CONFIGURATION

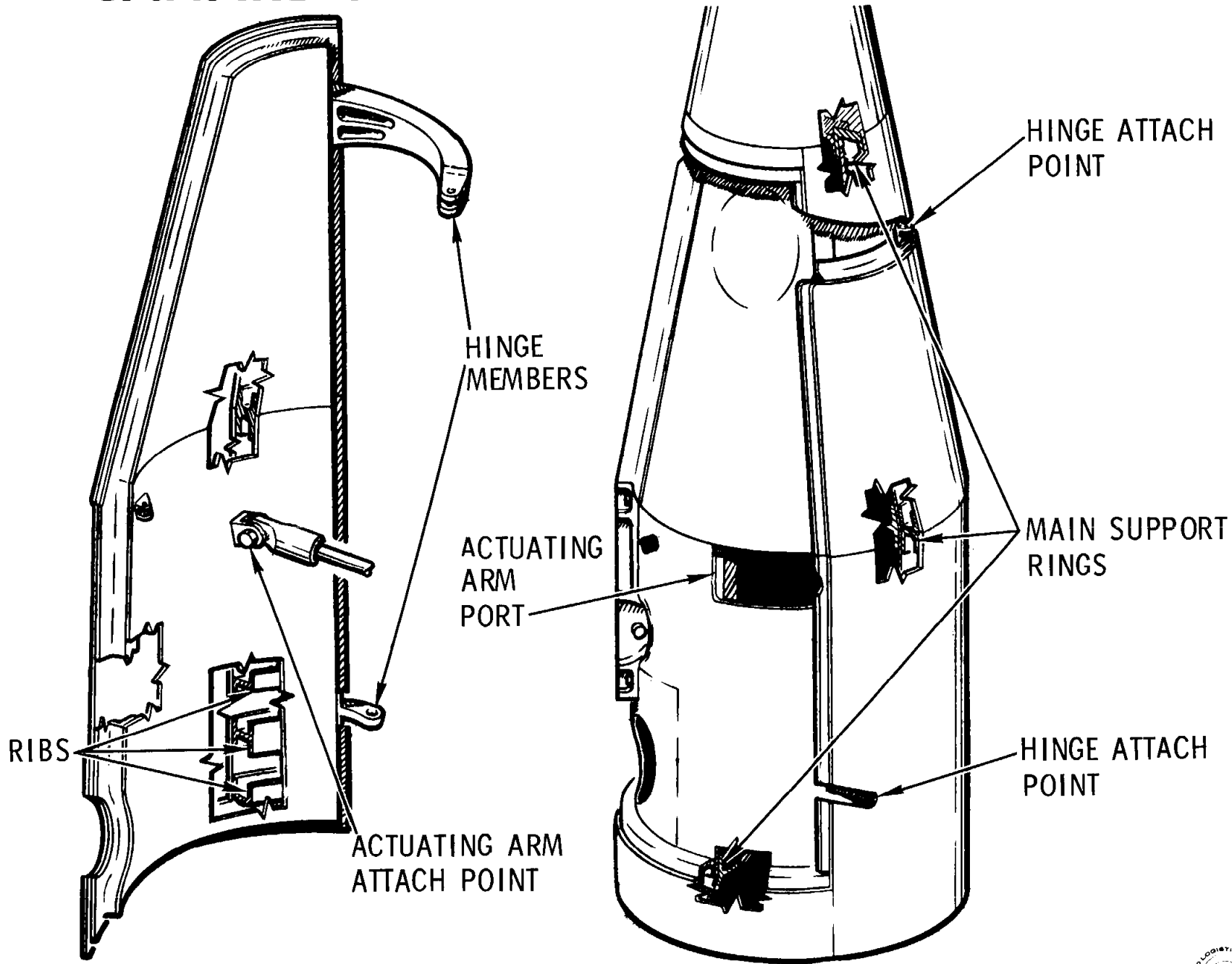


Figure 2-8

CANARD THRUST & LINKAGE ASSEMBLIES

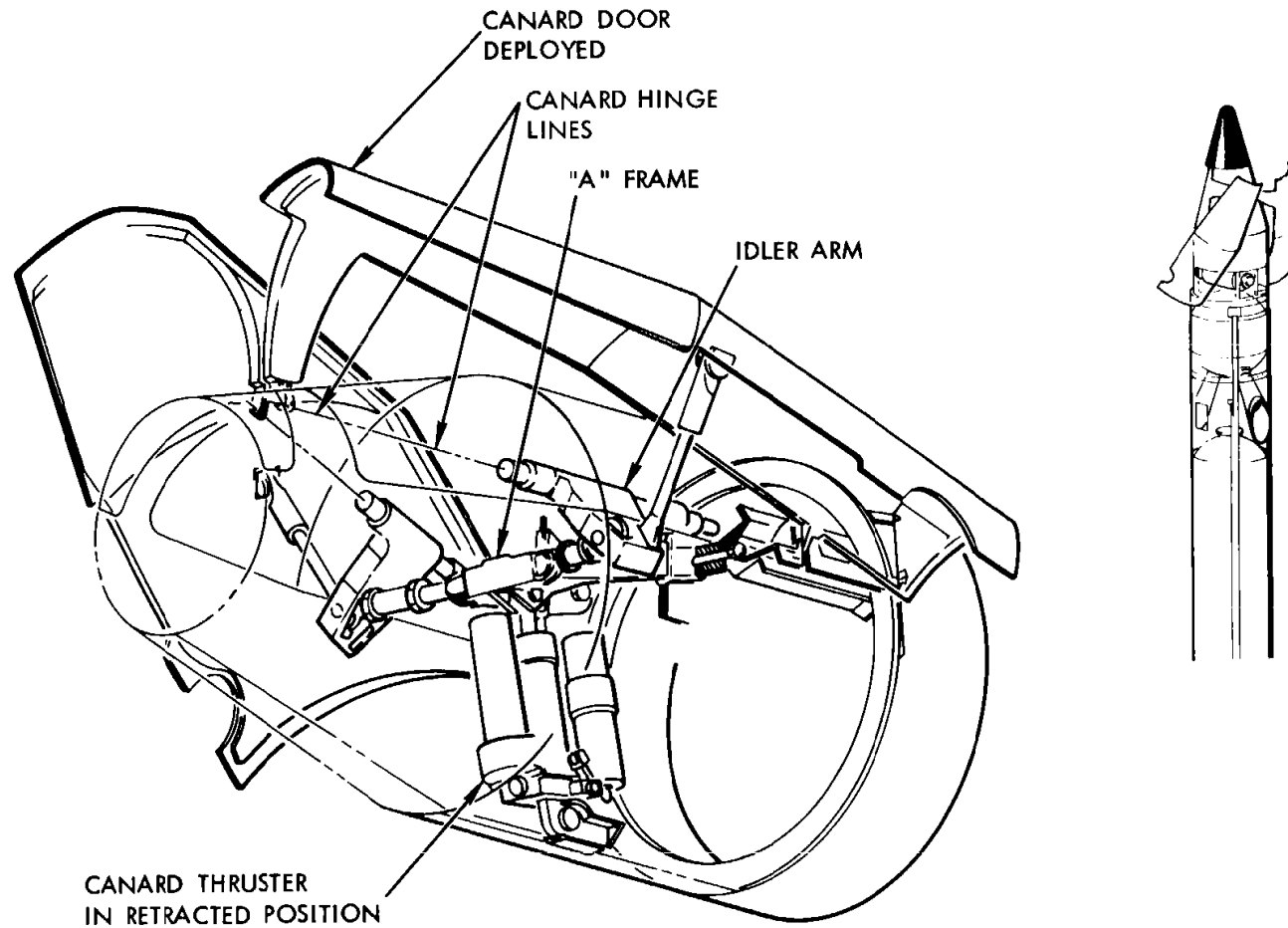


Figure 2-9

EDS Q-BALL

- a) On the end of the LEL
- b) Drives the HCH indicat
- c) HCH ind. reads percent of "red line"
- d) "red line" approx. 2° angle at exten

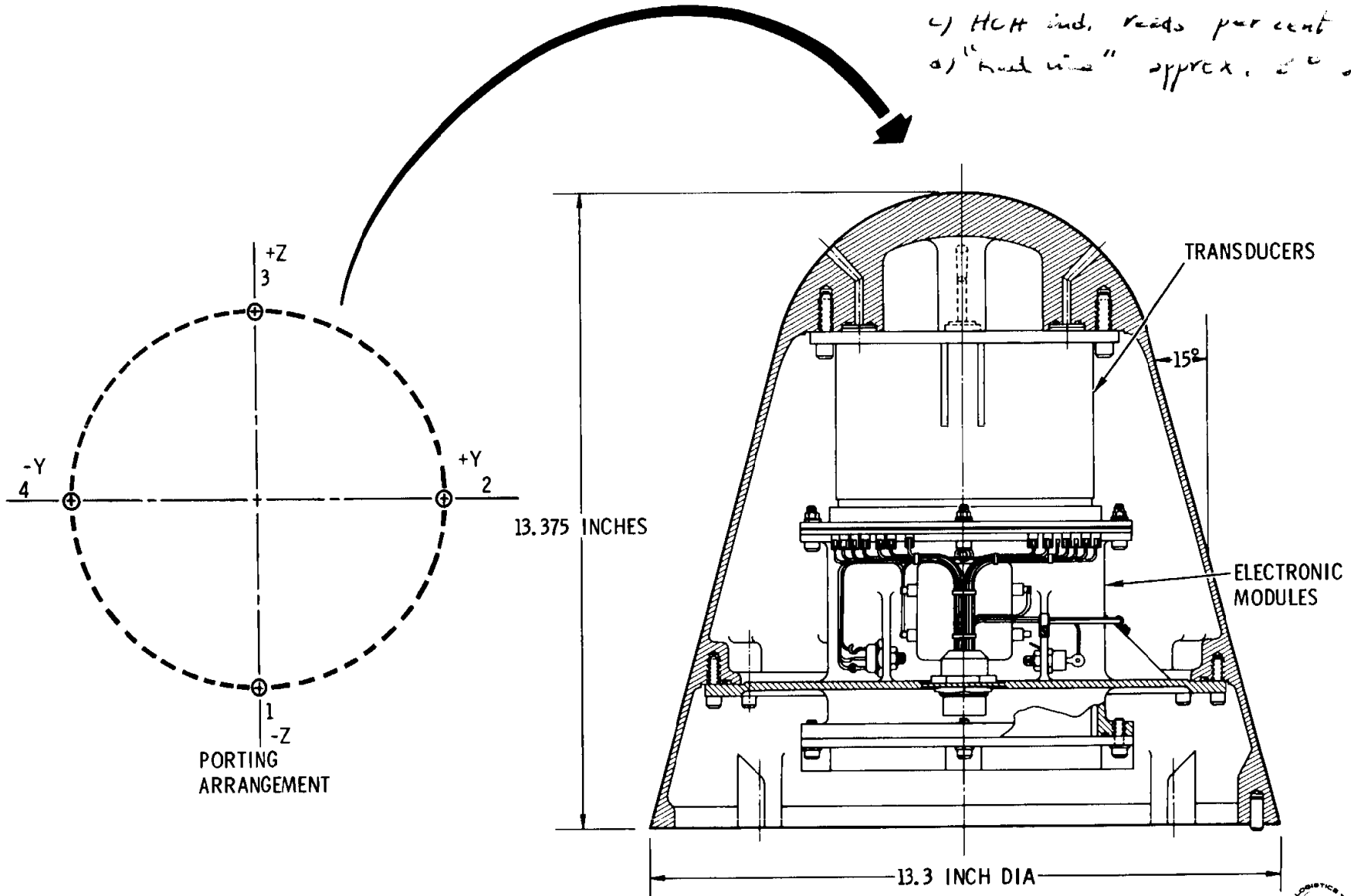


Figure 2-10

SEQ-74A

SECTION III

EARTH LANDING SYSTEM COMPONENTS

Figure 3-1 lists the components of the ELS. These components are the Apex Cover Separation Mechanism and the Parachute Subsystem consisting of 2 Drogue parachutes, 3 Pilot parachutes, 3 Main Landing parachutes, 2 Drogue parachute mortars, 3 Pilot parachute mortars, and are described in the text following.

3.1 APEX COVER SEPARATION MECHANISM

One of the requirements of the LES was to provide acceptable conditions for Apex Cover, or Forward Heat Shield, jettison for subsequent parachute deployment. The mechanism used to accomplish Apex Cover jettison consists of 4 gas actuated thrusters located in the 4 gussets supporting the egress tunnel of the CM shown in figure 3-2.

Opposite thrusters are manifolded together to a common breech assembly in which a Hotwire Gas Pressure Cartridge assembly is installed. This constitutes 2 identical systems which provides redundancy with either system being capable of jettisoning the Apex Cover in case one system should fail. The Gas Pressure Cartridge will generate a gas pressure within the manifold of approximately 12,000 psi when fired by the SECS. This gas pressure enters the thrusters at the lower end through 4 ports causing a 3,500 pound tension tie on the crown of the piston assembly to break. As illustrated in figure 3-2, when this tension tie breaks, it allows the piston to be forced out of the cylinder by the gas pressure. The upper end of the piston is connected to the Apex Cover, or Forward Heat Shield, by a connector link and is, therefore, forced away from the CM. It is most imperative that the CM

be oriented Apex Cover up and aft and not Apex forward and down on descent, or the thrusters will not be capable of jettisoning the Apex Cover, therefore the importance of the LES requirement previously explained.

3.2 PARACHUTE SUBSYSTEM

The Parachute Subsystem consists of 2 Drogue parachutes, 3 Pilot parachutes, 3 Main Landing parachutes, 2 Drogue parachute mortars, and 3 Pilot parachute mortars. Figure 3-3 portrays this ELS equipment and how it is located in the forward compartment of the CM. Figure 3-4 briefly describes the type of each parachute, how each is deployed, and the size of each type parachute.

3.2.1 Drogue Parachutes

As described in ELS requirements, the purpose of the Drogue parachutes is to orient and decelerate the CM sufficiently for the safe deployment of the Main Landing parachutes. The Drogue parachutes are the conical FIST ribbon type as illustrated in figure 3-5 having a canopy diameter of 13.7 feet. They are constructed of nylon ribbons having intrinsic strength in excess of that required to withstand the initial loading shock of deployment at high velocities.

The Drogue parachutes are mortar deployed by a pair of mortars located on either side of the negative pitch RCS engines which are located on the -Z side of the Forward Compartment of the CM. Redundant Gas Pressure Cartridges fired by the redundant circuitry of the ELSC generate gas pressure within the mortar to

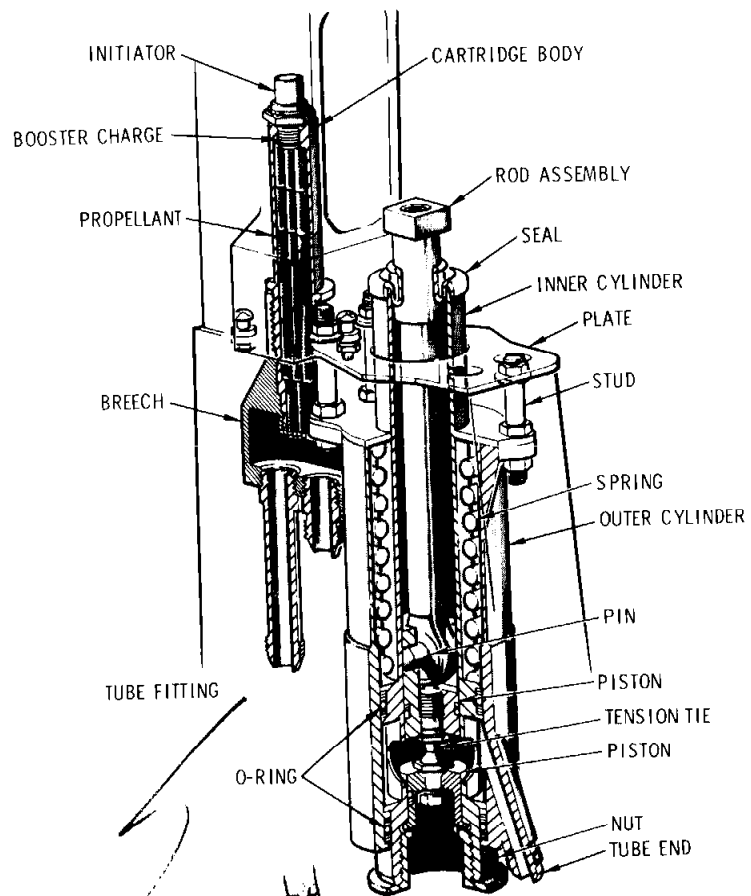
EARTH LANDING SYSTEM COMPONENTS

- APEX COVER SEPARATION
MECHANISM

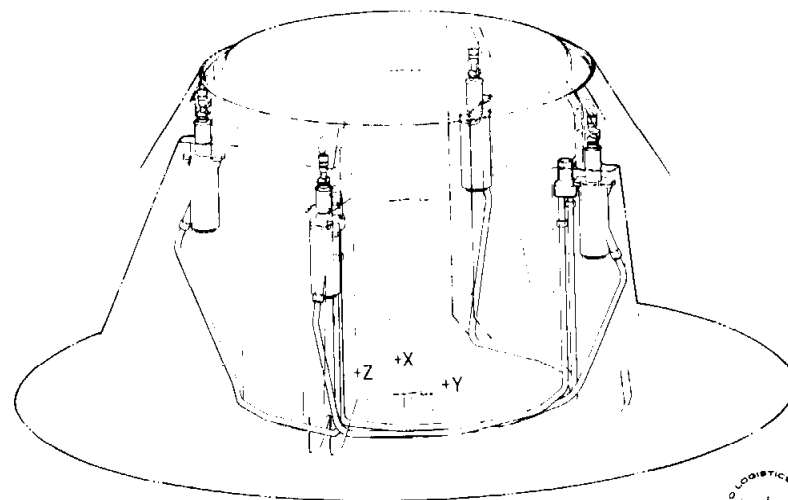
- PARACHUTE SUBSYSTEM
 - DROGUE PARACHUTES (2)
 - PILOT PARACHUTES (3)
 - MAIN LANDING PARACHUTES (3)
 - DROGUE PARACHUTE MORTARS (2)
 - PILOT PARACHUTE MORTARS (3)

Figure 3-1

APEX COVER SEPARATION MECHANISM



*12 psi generated
by 1 gas cartridge*




SEQ-73B 

Figure 3-2

ELS EQUIPMENT BLOCK I

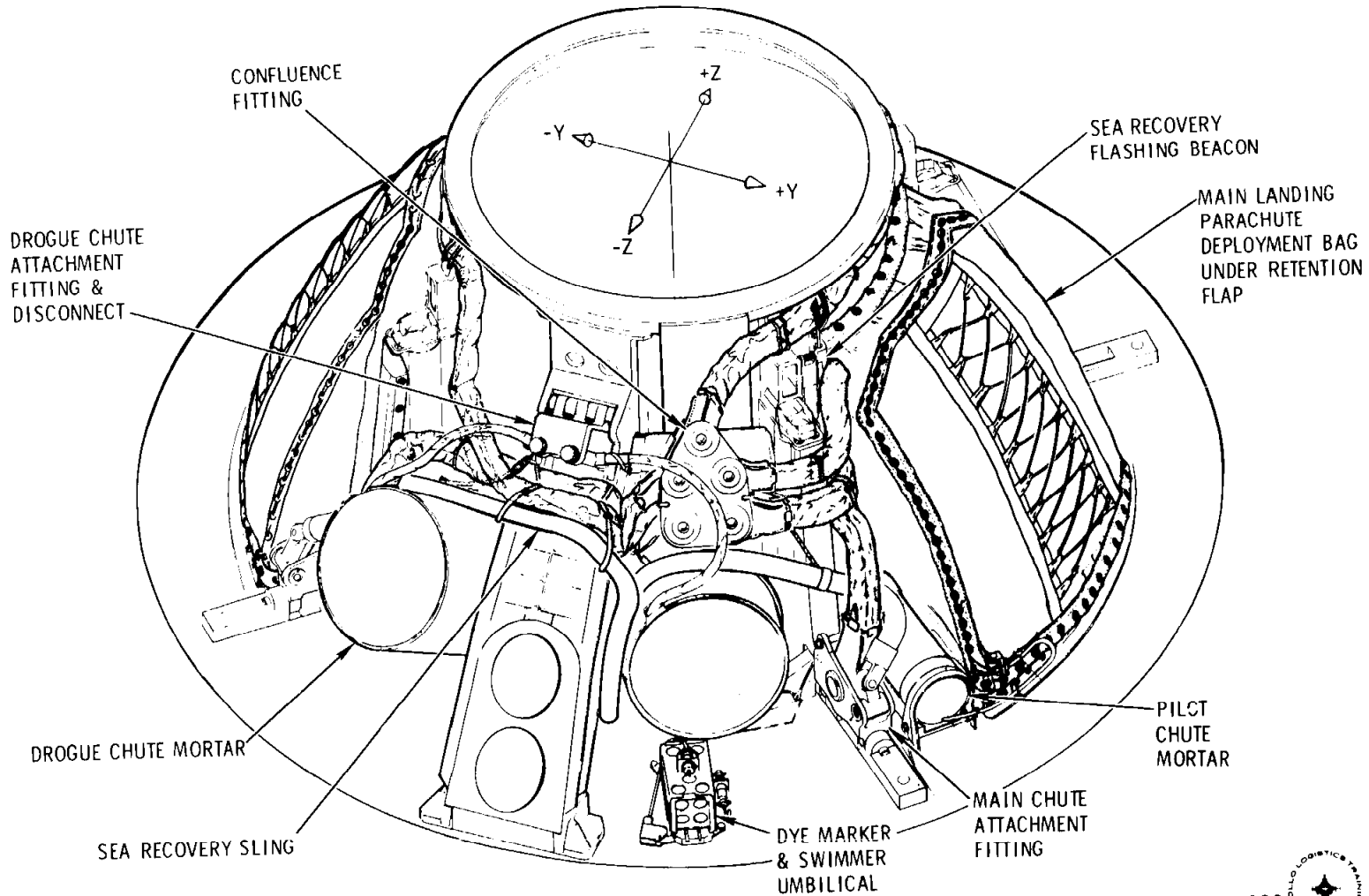



Figure 3-3

SEQ-18G 

EARTH LANDING SYSTEM PARACHUTES

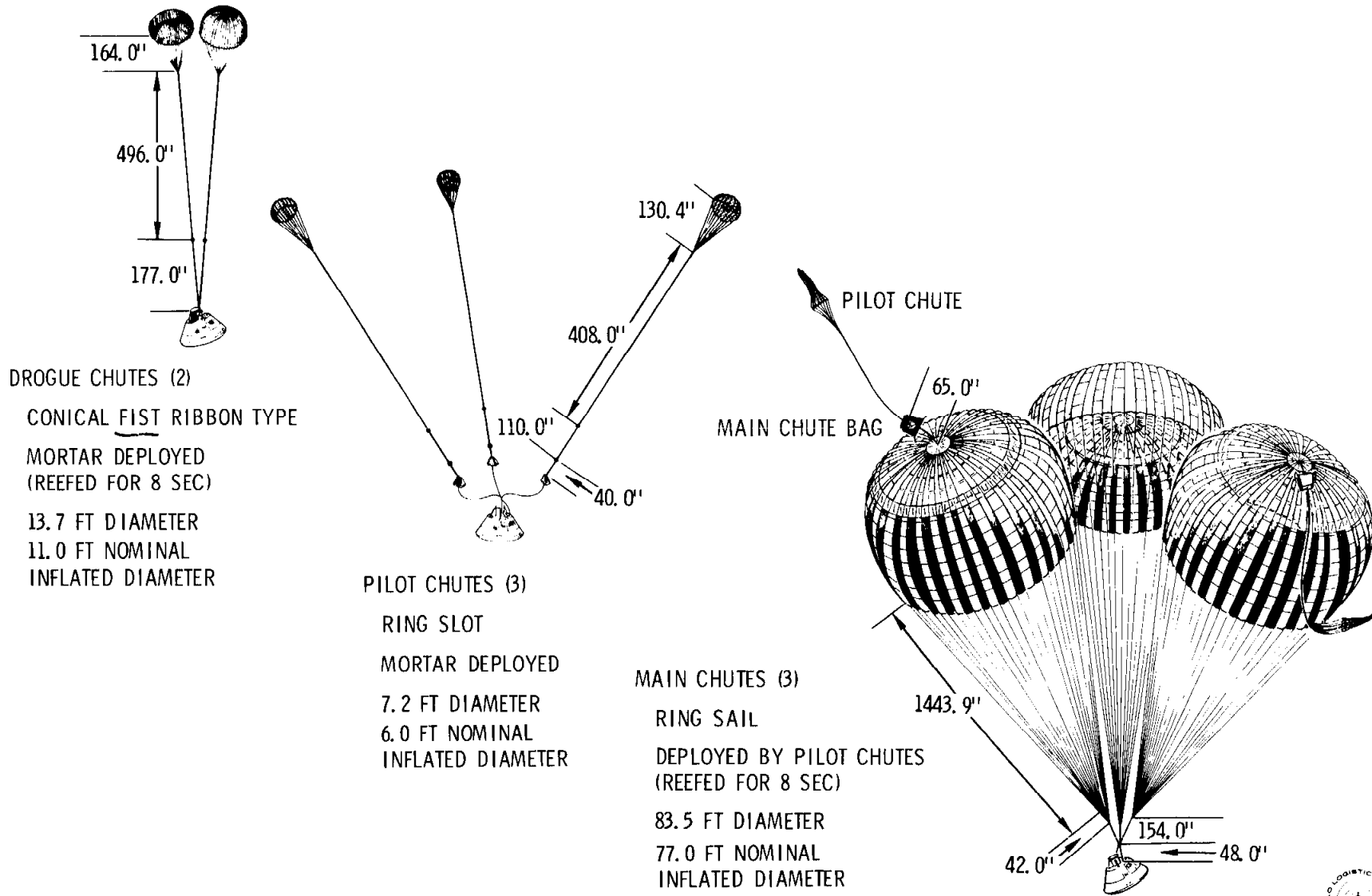


Figure 3-4

FIST RIBBON PARACHUTE

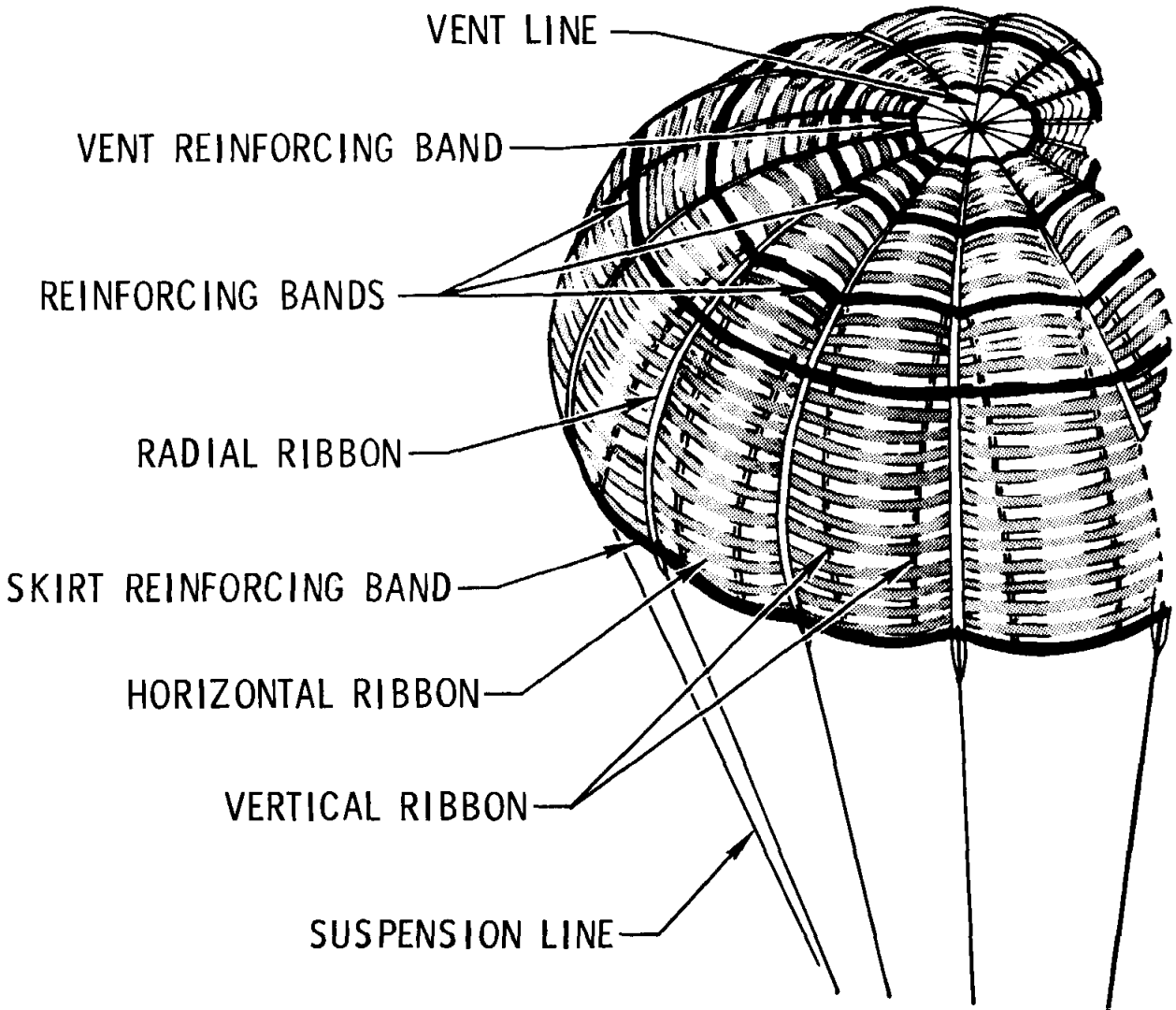


Figure 3-5

SEQ-36

expel the parachute by actuating a Sabot (piston) which forces the parachute to shear the pins that hold the mortar cover in place. Refer to figure 3-6 for an exploded view of the mortar assembly.

These parachutes are deployed and maintained in a reefed condition for 8 seconds when they are allowed to open fully.

Reefed means to take in or reduce in size. This is done by using nylon ropes laced through eyelets around the inside of the canopy skirt which are short enough to allow only partial opening of the parachute initially. For an illustration of Reefing Lines, as they are referred to, figure 3-7.

Each of the Drogue parachutes have 2 reefing lines. As the parachute fills with air, it is allowed to open only partially by the 2 reefing lines to control shock loading of the parachute where tremendous weights and velocities are involved. After 8 seconds has elapsed, the reefing lines are cut in 2 places by the use of 2 Reefing Line Cutters on each line, as shown in figure 3-8. This action then allows the parachute to open fully to a permanently installed restrictor line which maintains a controlled amount of tuck on the canopy skirt to prevent overinflation.

The Reefing Line Cutter is a small device similar in working principle to a hand grenade. When the firing pin is pulled, an 8 second fuse is ignited. After the fuse has burned, it explodes a small charge which drives a cutting blade against an anvil and severs the Reefing Line. To pull the firing pin, a short lanyard is spliced into the suspension line with a slight tuck taken in the suspension line so that when the canopy is fully stretched out after deployment, the firing pin will be actuated. Figure 3-9.

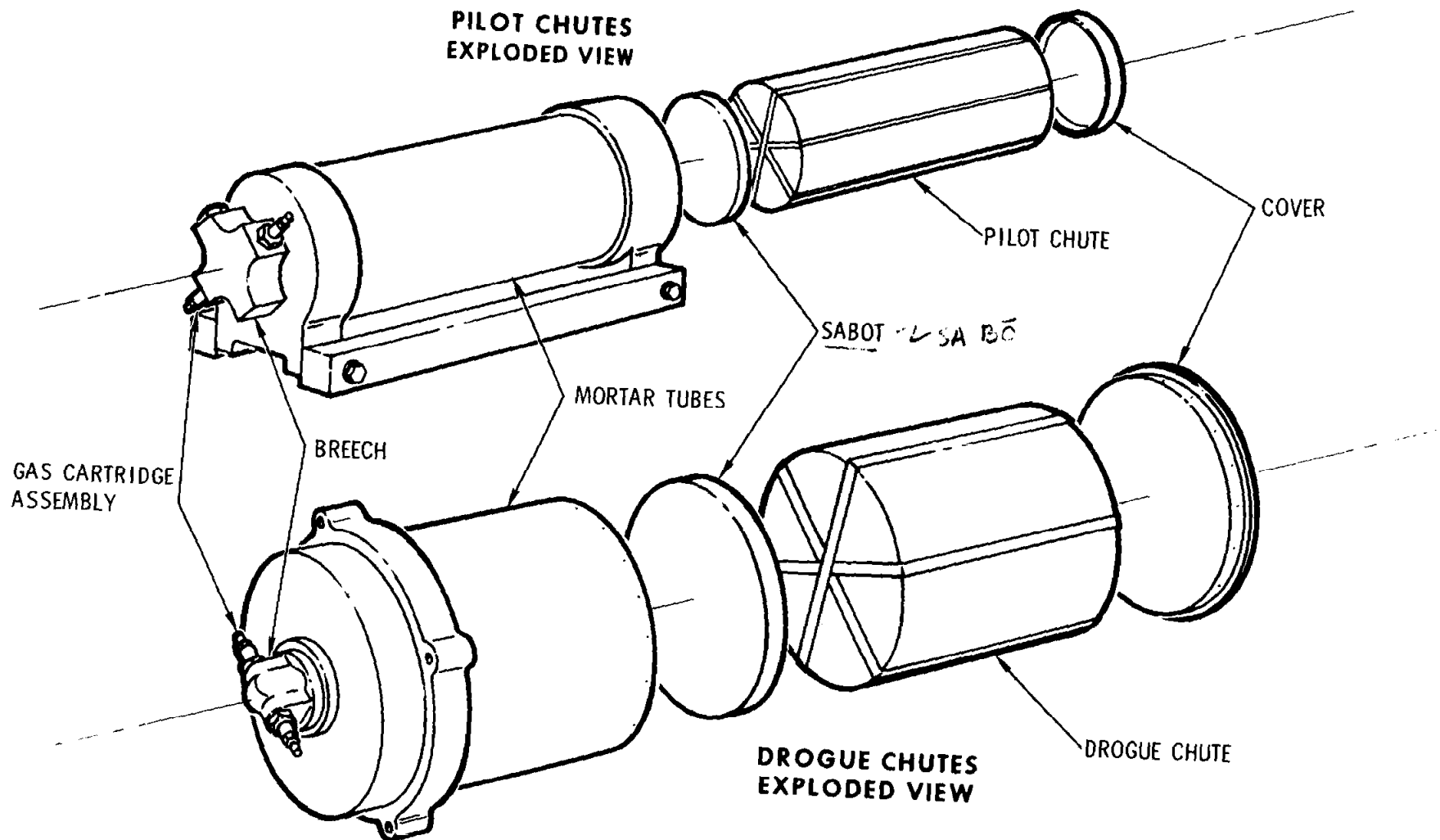
The parachute suspension lines are attached to risers which connect to a common attachment fitting located on the -Z side of the egress tunnel. A flexible linear shaped charge severs the attachment fitting to release the 2 Drogue parachutes together when commanded by the ELSC.

3.2.2 Pilot Parachutes

The Pilot parachutes are the ring slot type with a diameter of 7.2 feet. They are constructed of rings of nylon panels with slot openings between each ring of panels as shown in figure 3-10. These parachutes are also mortar deployed for the purpose of deploying the Main Landing parachutes.


Three Pilot parachutes are packed in individual mortars beside their respective Main Landing parachute. These mortars are fired by pyrotechnic devices and circuitry similar to those used for the Drogue parachutes. The mortars are similar to the Drogue parachute mortars but not nearly as large. Refer to figure 3-3 and 3-6. The Pilot parachutes are deployed outward from the egress tunnel to force them into the airstream about the CM. As they are deployed, their risers pull the lacings off of the retention flaps for holding the Main Landing parachute bags into place in the Forward Compartment. The Main Landing parachute bags are then hoisted out of the Forward Compartment. As the CM continues to descend, trailing the Pilot parachutes behind it, the Main Landing parachute risers are swung up into place from about the egress tunnel and from their attach points at the 2 Main Chute Attachment Fittings. Figure 3-3 and 3-4. When the risers become taut, the Main Landing parachute bags are unlaced allowing the Main Landing parachutes to deploy from their respective bags. As the CM continues to descend, the Main Landing parachutes

MORTAR ASSEMBLIES



3

Figure 3-6

SEQ-64A 

REEFING LINES

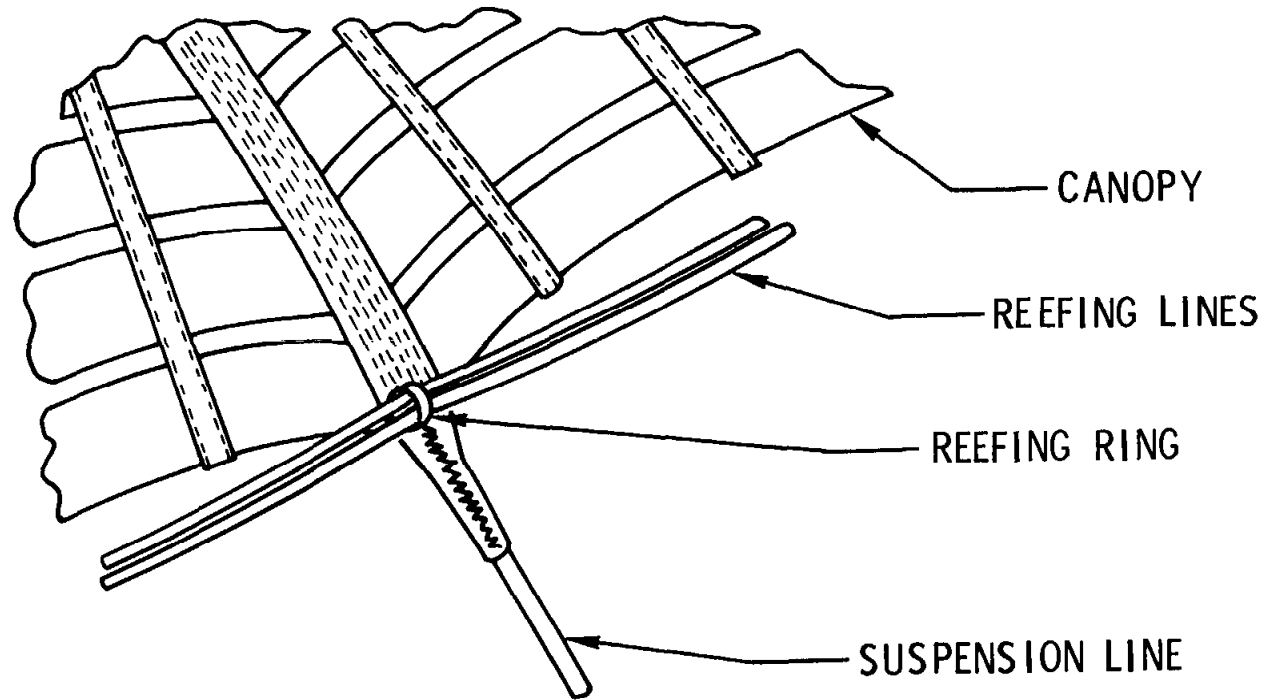
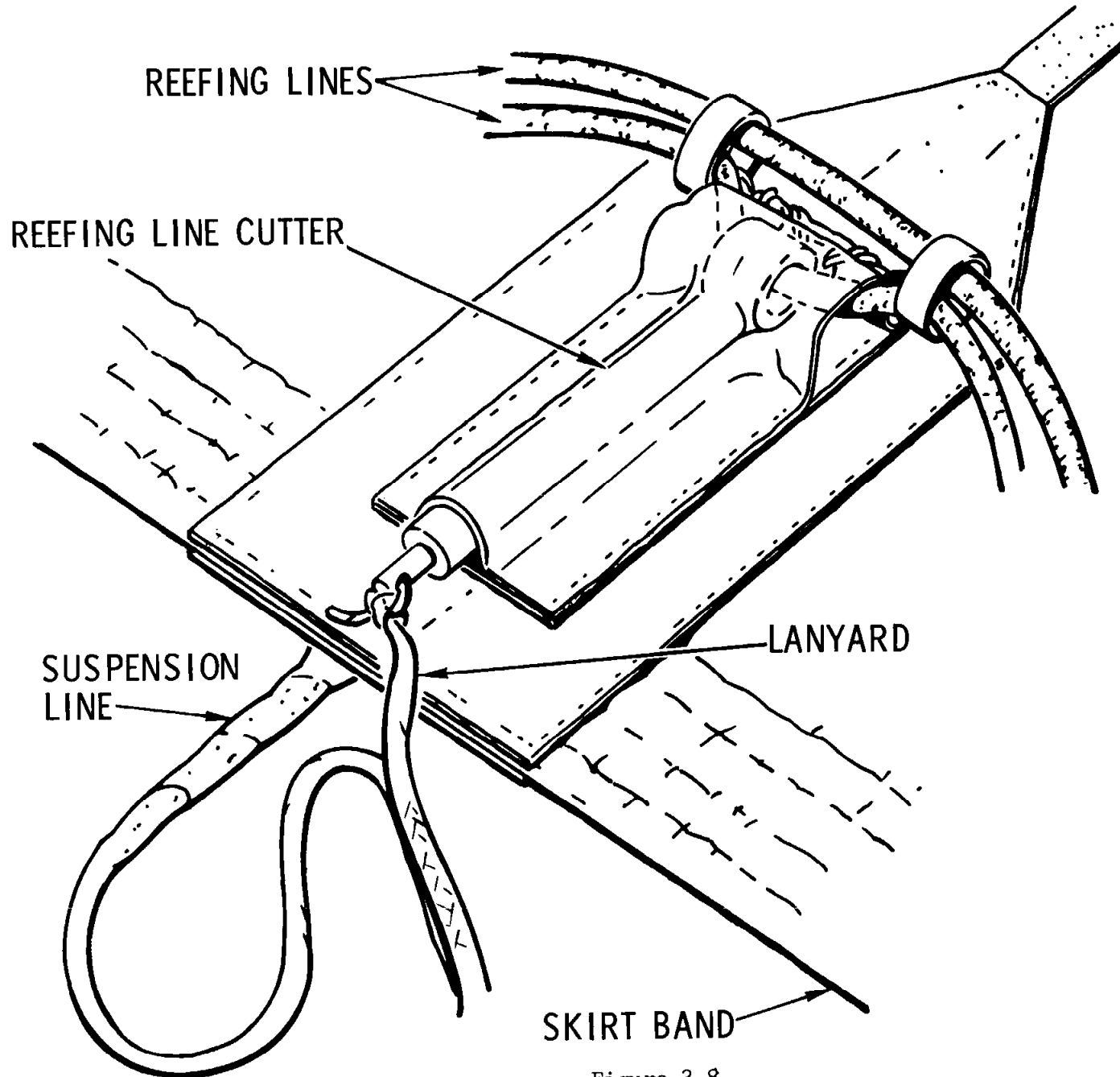


Figure 3-7

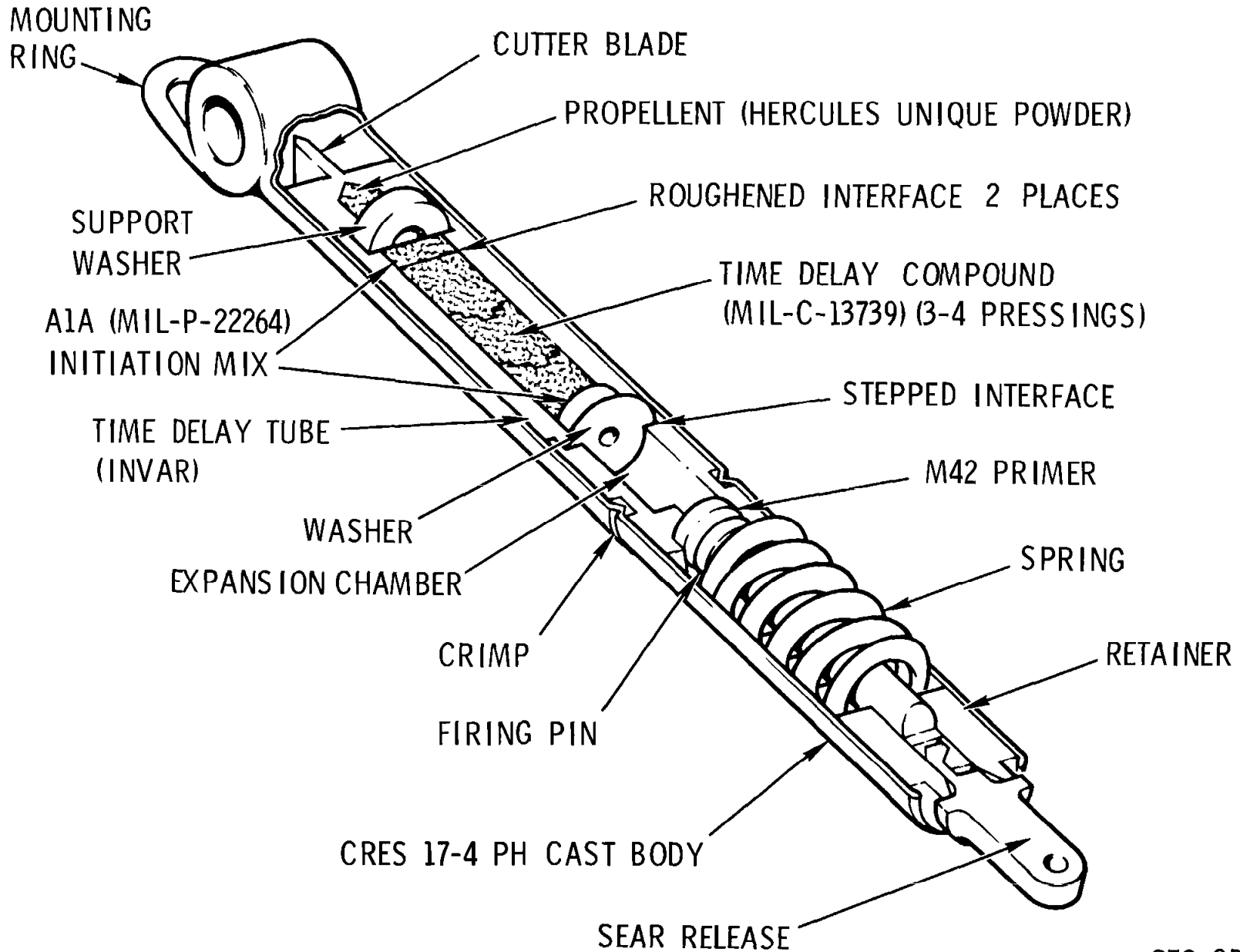
REEFING LINE CUTTER INSTALLATION



3

Figure 3-8

REEFING LINE CUTTER



3

Figure 3-9

RING SLOT PARACHUTE

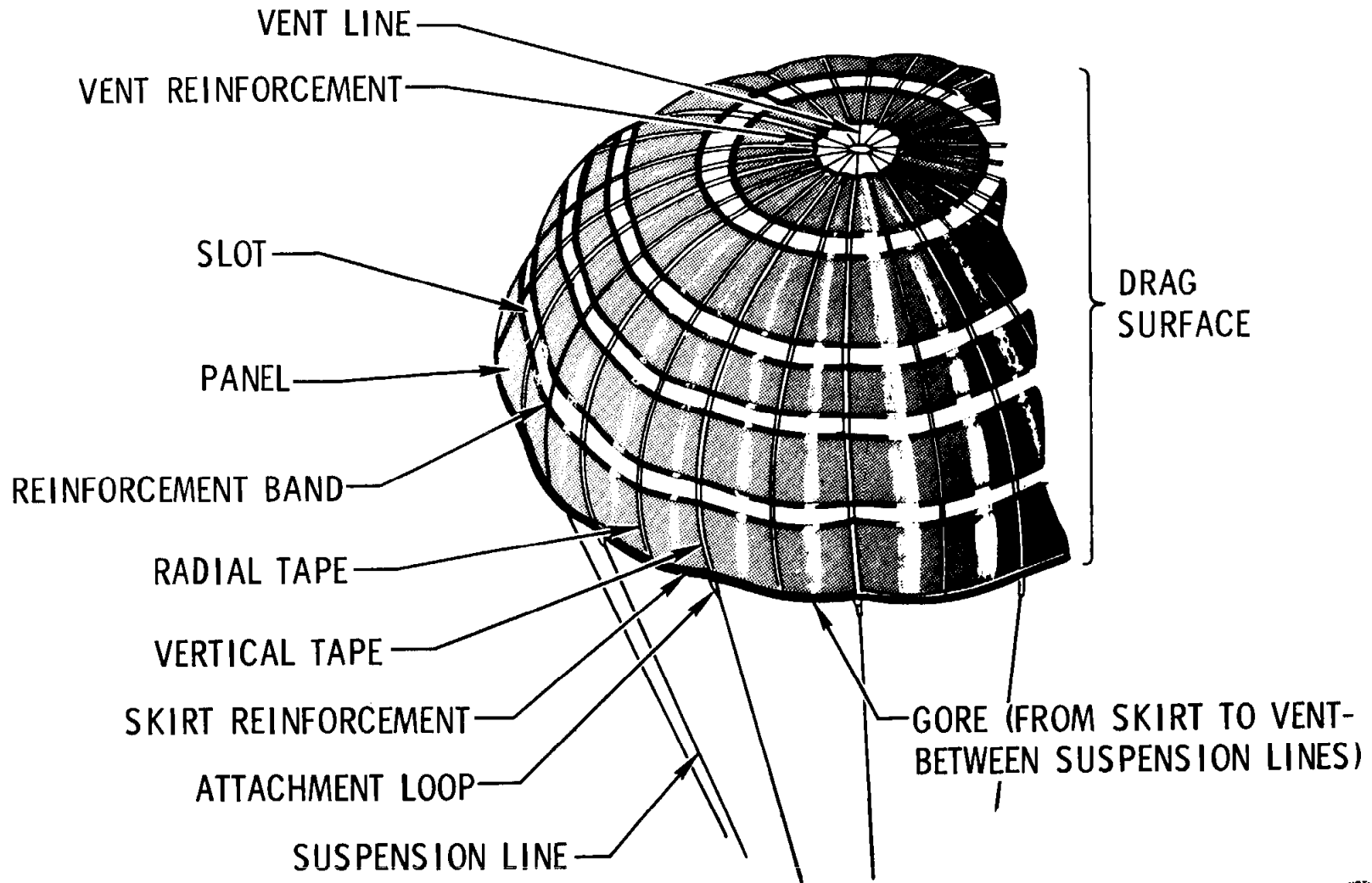


Figure 3-10

SEQ-37



are filled with air and the Pilot parachutes and the Main Landing parachute bags collapse onto the canopies of their respective Main Landing parachute, no longer needed.

3.2.3 Main Landing Parachutes

The Main Landing Parachutes are the ring sail type, as illustrated in figure 3-11, with the diameter of the canopies being 83.5 feet. Excess nylon in the lower portion of each panel allows it to billow out similar to the sail on a sailboat. The canopy consists of 12 rings of these "sail" panels, hence the name ring sail. Seventy-five percent of the fifth ring of panels is removed to provide a large slot in these parachutes.

The purpose of the Main Landing parachutes is to affect an earth landing within crew tolerances. In other words, as softly and as safely as possible. It has therefore been determined to use 3 parachutes, knowing quite well that 2 would be tolerable, but catastrophic if 1 is lost. With this in mind then, 3 parachutes are used in case 1 is not deployed, or is rendered useless in some manner.

The Main Landing parachutes are also deployed and maintained in a reefed condition for 8 seconds to control shock loading. This is mandatory, otherwise, these parachutes could be seriously damaged or completely lost.

Two Reefing Lines exactly the same length are laced through eyelets around the inside of the skirt of each Main Landing parachute for redundancy. Each Reefing Line is laced through 3 Reefing Line Cutters spaced 120° apart. One line of Reefing Line Cutters are rotated 60°, so that there is a Cutter every 60° about the skirt.

The 2 Reefing Line system used on these parachutes prevents premature full inflation of the parachute in case 1 Reefing Line is cut prematurely by a malfunctioning Reefing Line Cutter.

The CM will hang suspended upon the 3 Main Landing parachutes at an angle of approximately 30° from the X axis because of the position of the 2 Main Chute Attachment Fittings on the -Z side of the CM, shown in figure 3-3. These Attachment Fittings were positioned in this manner to guarantee that the CM would impact upon the water in the crushable rib area of the CM on the +Z side. These crushable ribs are the primary shock attenuators at impact. Follow-on shock attenuation from impact is distributed among the crew couch attenuators. The 30° hang angle, the crushable ribs, and the crew couch suspension system is portrayed in figure 3-12.

RING SAIL PARACHUTE

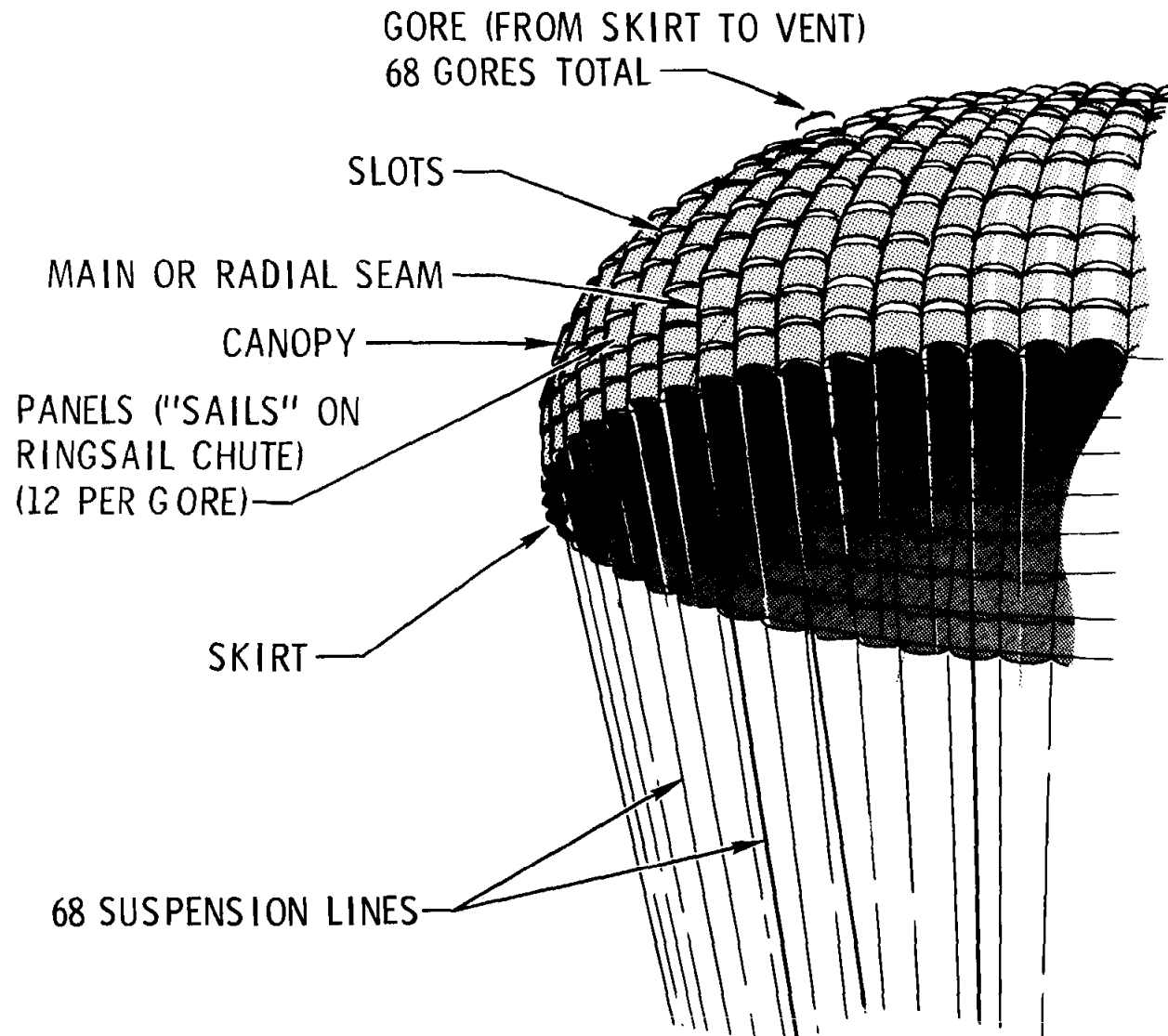



Figure 3-11

SEQ-38B 

EARTH IMPACT SYSTEM

BLOCK I

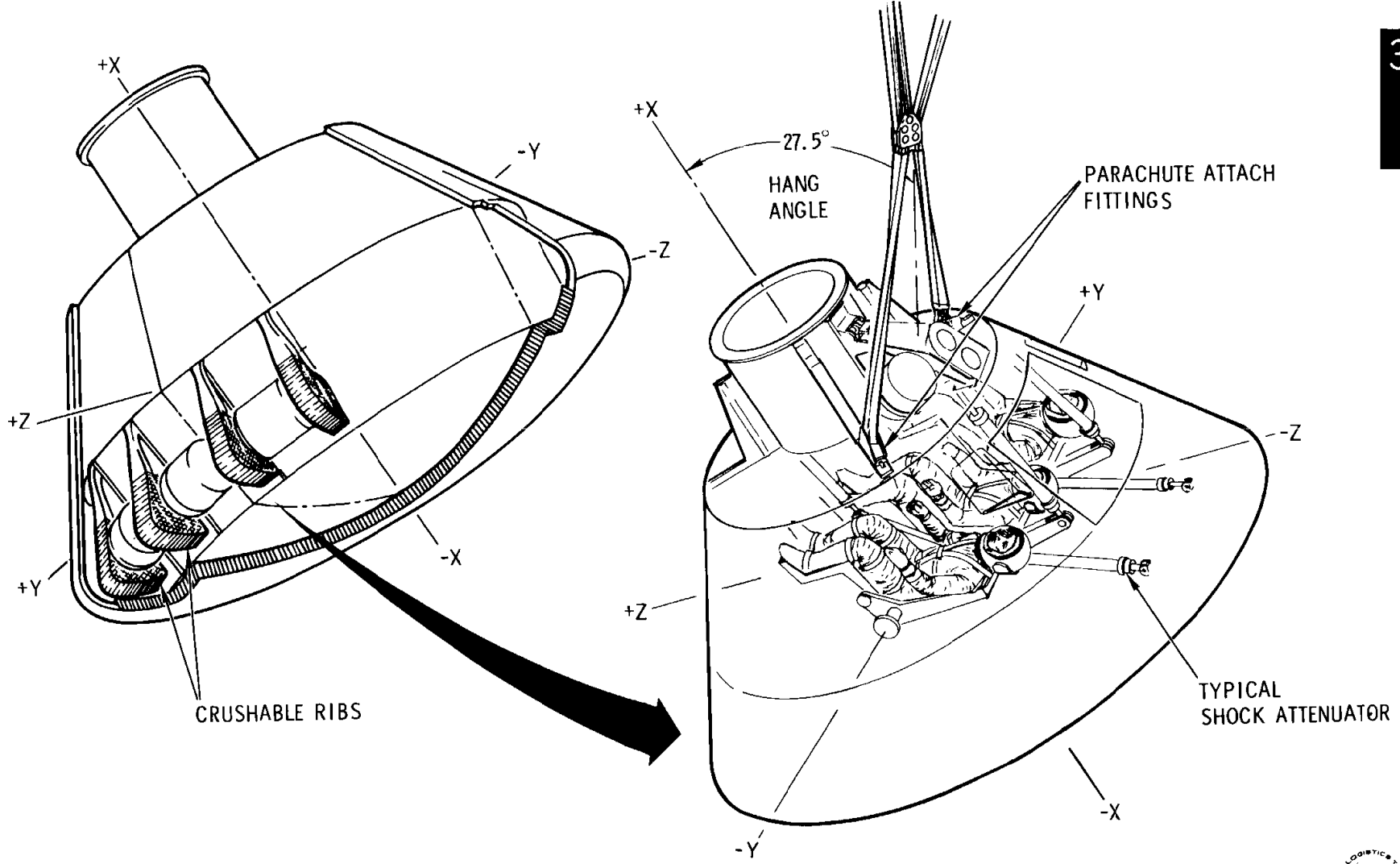


Figure 3-12

SECTION IV

PYROTECHNIC DEVICES

Many operations in the SECS are initiated or accomplished by pyrotechnic devices of various types. This section describes these pyrotechnic devices both functionally and physically and indicates where they are used throughout the SC.

4.1 ELECTRICAL HOTWIRE INITIATOR

Figure 4-1 shows the Apollo Standard Initiator (ASI). This Initiator, because of its simple circuitry, is used throughout the Apollo SC to ignite all pyrotechnic devices. The Initiator acts as the primer, in most all applications, for the main explosive charge.

Each Initiator has 2 pairs of pins, each electrically connected with a 1 ohm resistive wire. It is standard Apollo practice, however, to use only 1 pair of these pins and employ 2 Initiators for each pyrotechnic application for redundancy wherever possible. Exceptions to this practice are in the CM's Reaction Control System. In this system all Squib valves, are equipped with but one Initiator because of Squib valve design, thereby making it impossible to use 2 Initiators.

When a current of 5 amps or 29 ± 2 volts DC is applied, the 1 ohm resistive wire ignites the primary explosive which in turn sets off the secondary explosive and triggers the Igniter, Detonator or Gas Pressure Cartridge.

4.1.1 Launch Escape System Igniters

The LES motors are ignited by the SECS by Igniter assemblies in each of the 3 motors as shown in

Figure 4-2. Each Igniter has 2 Initiators for redundancy installed in them, which when fired, ignites Boron pellets in a primary chamber called the Pellet Basket. These Boron pellets in turn ignite the main charge of Pyrogen which spews flame outward toward the solid propellant of the motor to ignite it.

4.1.2 Squib Valves

Another application of an Initiator is for the CM's RCS Squib valves. Figure 4-3 portrays a typical normally closed Squib valve before and after being fired by an Initiator. When the Initiator is exploded, the gas pressure generated actuates a piston driven cutting blade which shears off the ends of the tubing and allows fluid flow through the port opening of the cutting blade.

In figure 4-4 the various CM RCS Squib valves are located schematically. Note the Helium Isolation valves which are fired every time the CM's RCS is pressurized. Locate the Oxidizer tank's Helium Interconnect valve, the Oxidizer Interconnect valve, and the Oxidizer Dump valves. These valves are fired simultaneously with the Helium Isolation valves in case an abort is commanded on the pad or up until 61 seconds from lift-off to effect the dumping of the Oxidizer. Now locate the Fuel tank's Helium Interconnect valve, the Oxidizer By-pass valves, and the Helium Dump valve. These valves are fired open 18 seconds after an abort that is initiated either from the pad or until 61 seconds after lift-off. For any LES abort after 61 seconds from lift-off when the Oxidizer is not dumped, the Fuel and Oxidizer Interconnect valves are fired simultaneously with the Helium

ELECTRICAL HOTWIRE INITIATOR

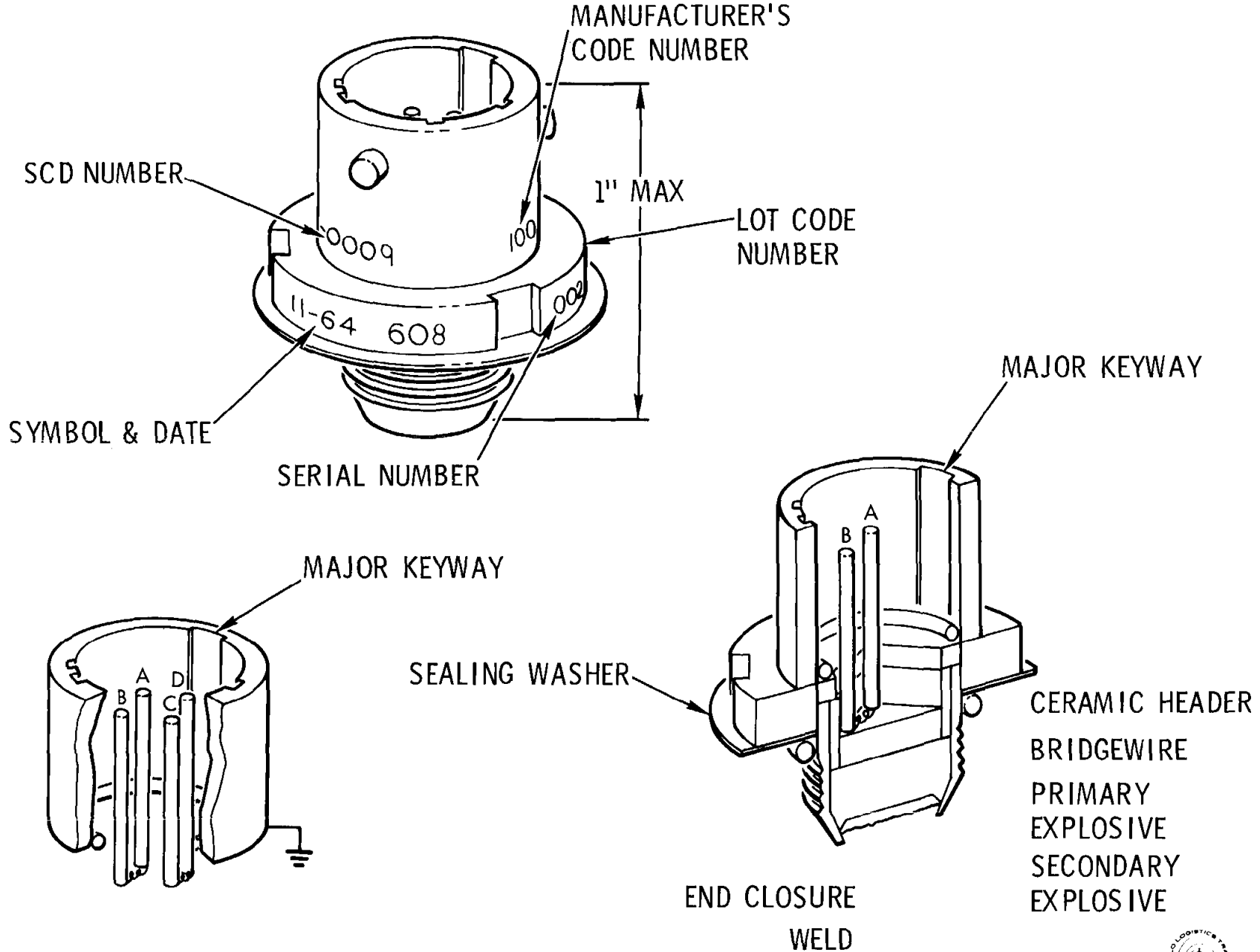
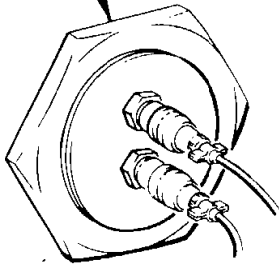


Figure 4-1

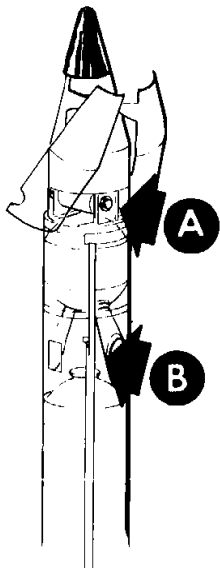
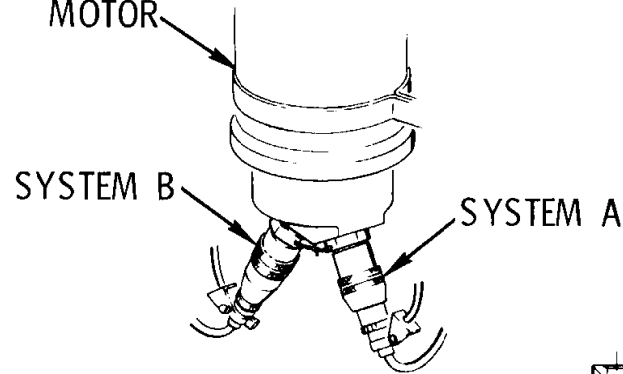
LES IGNITERS

PITCH CONTROL MOTOR



DETAIL A

JETTISON MOTOR



DETAIL B

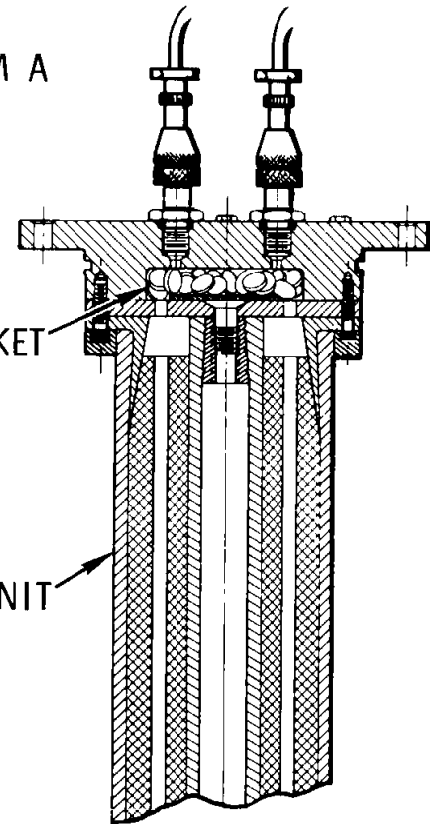
SYSTEM B

SYSTEM A

PELLET BASKET

LAUNCH ESCAPE MOTOR

PYROGEN UNIT



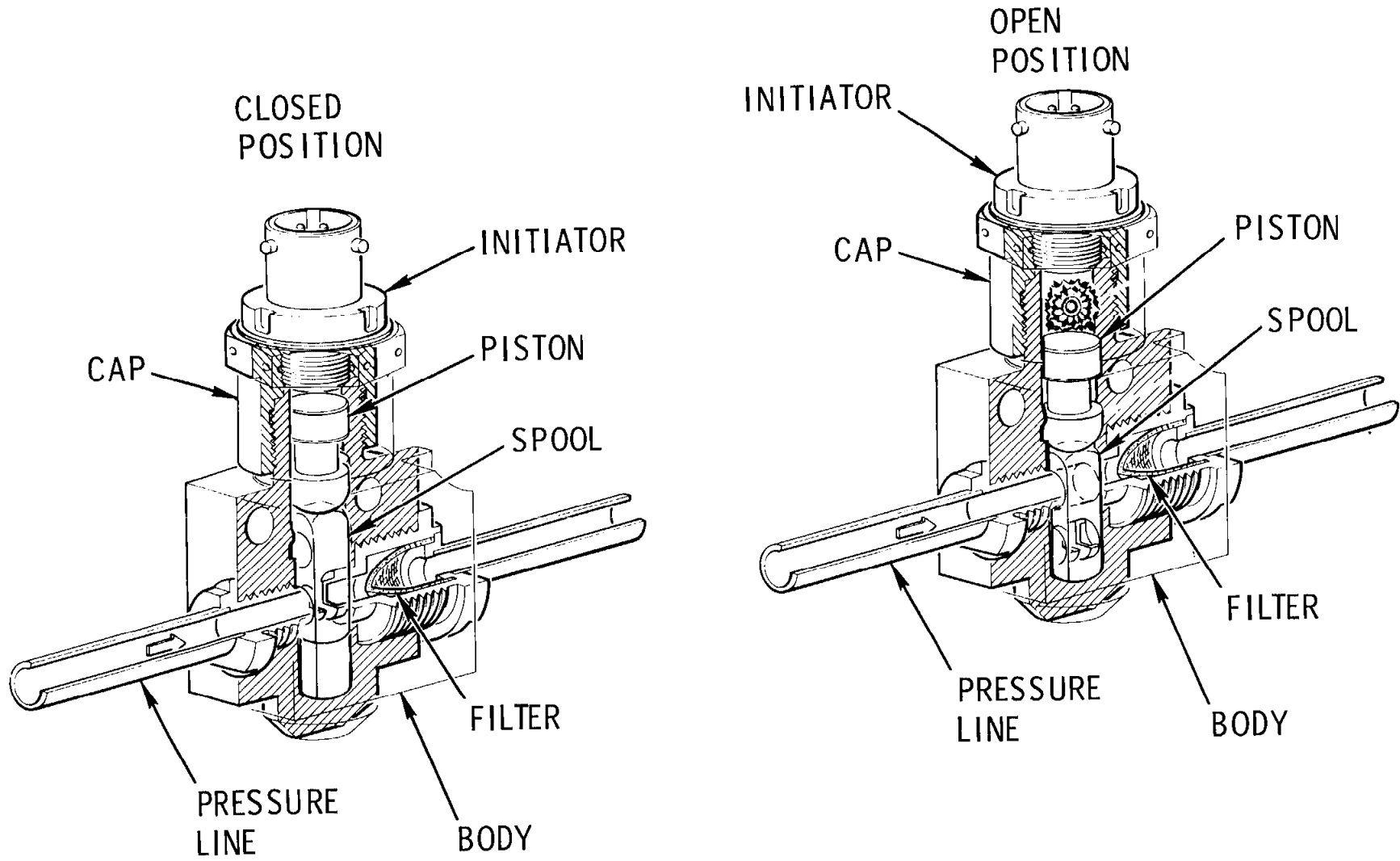
SECTION A-A

SEQ-79



Figure 4-2

TYPICAL C/M SQUIB VALVE

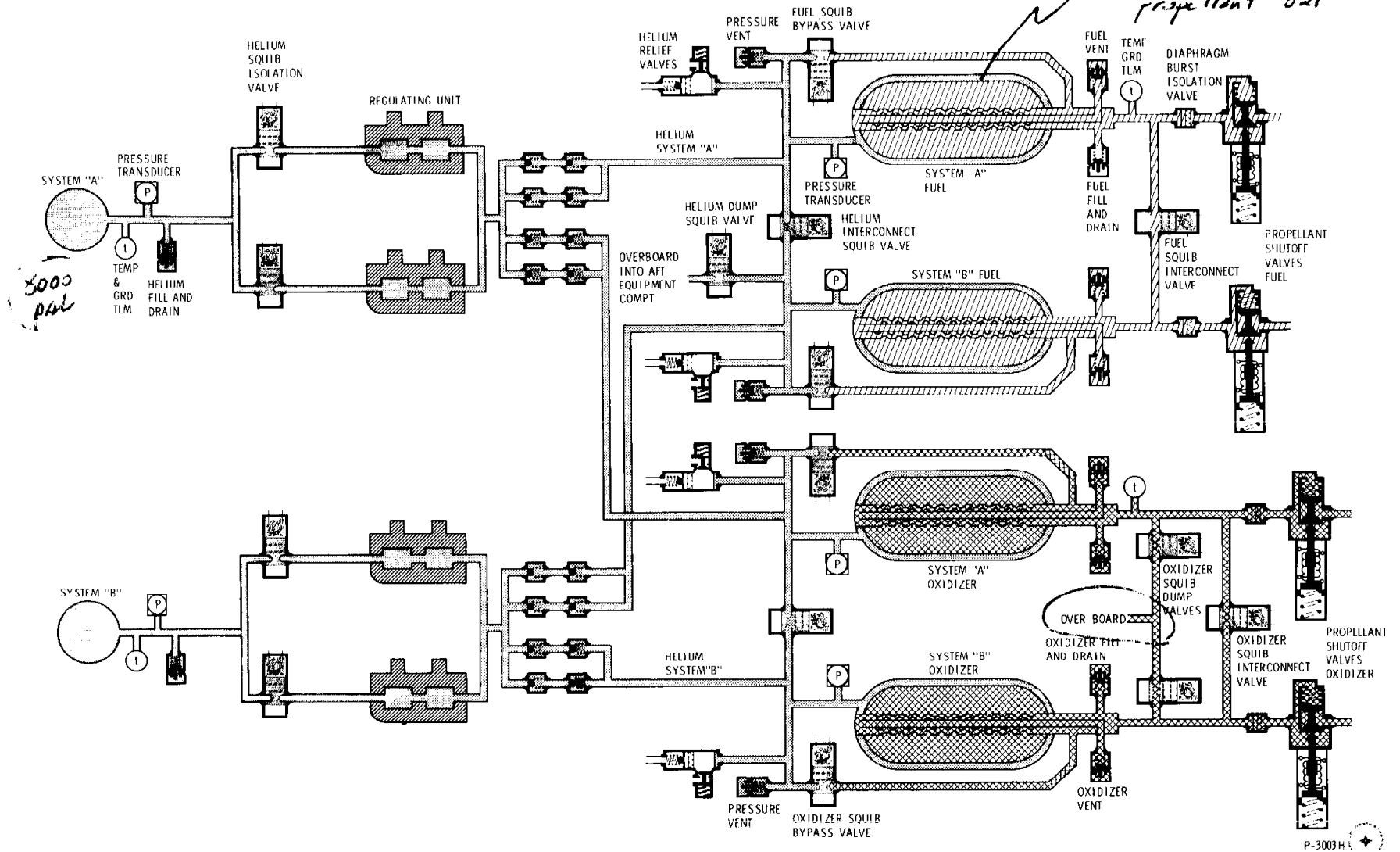


4

Figure 4-3

C M REACTION CONTROL SYSTEM

PROPELLANT FEED SUBSYSTEM A & B



4

Figure 4-4

Interconnect valves when Propellant Dump is commanded after the Main Landing parachutes are deployed. The last Squib valves to be discussed are the Helium Bypass valves which are fired when RCS Purge is commanded by the crew.

Figure 4-5 is a continuation of figure 4-4 to illustrate the solenoid actuated valves at the RCS engines which are operated for Propellant burning.

4.1.3 Circuit Interrupters

Another use for Initiators is for the Electrical Circuit Interrupters shown in figure 4-6. Dual Initiators are installed in each Interrupter, once again for redundancy. When fired by the MESC, the Initiators generate enough gas pressure to force the piston assembly to the left of that illustrated. This action breaks all electrical connections made through the Interrupter, thereby deadfacing the hot electrical circuits routed through it.

Each Interrupter is provided with 2 re-cocking ports so that it may be cycled up to a maximum of 5 times for testing purposes. By removing the re-cocking port plugs and installing union fittings in their place, dry nitrogen under pressure may be used to actuate the piston assembly back and forth making and breaking continuity to the electrical circuits.

Four of these Circuit Interrupters are used on board the CM and 2 on the SM to deadface those certain electrical circuits known to be hot whenever the CM is separated from the SM whether at normal CM - SM separation or for an LES abort.

Other applications for Initiators are for Detonators and Pressure Cartridges. These assemblies are described in the following text.

4.2 DETONATOR CARTRIDGE

A Detonator Cartridge is made up of an Initiator and an additional explosive charge usually composed of Lead Azide and RDX, figure 4-7. Detonators may be used to effect certain functions by themselves or they may be used to affect sympathetic detonation of other pyrotechnic devices by concussion. These other devices, applicable to the Apollo SC, are Flexible Linear Shaped Charges (FLSC), usually assembled into Cutting Charge assemblies, Mild Detonating Fuse (MDF), and Confined Detonating Fuse (CDF).

The one function performed by Detonators by themselves is tower jettison where they are used to fracture the Frangible Nuts that hold the LET onto the CM.

4.2.1 Frangible Nuts

The Frangible Nuts that hold the LET onto the CM incorporate 2 Detonators each to guarantee tower separation whenever tower jettison is commanded. With 1 Detonator wired to system A and the other to system B, fracturing of the Frangible Nut is guaranteed to occur even if one should fail to detonate. Figure 4-8 illustrates the method used to attach the LET to the CM, shows the location of the Detonators, and portrays the manner in which they are wired.

4.2.2 Flexible Linear Shaped Charges

Flexible Linear Shaped Charges (FLSC's) and Detonators are used on the CM - SM separation System as portrayed in figures 4-9, 4-10, and 4-11.

The CM is permanently assembled on top of the SM onto 6 compression pads of which 3 contain Tension Tie Plates that hold the CM tightly to the SM,

C/M REACTION CONTROL ENGINES

SYSTEM A & B

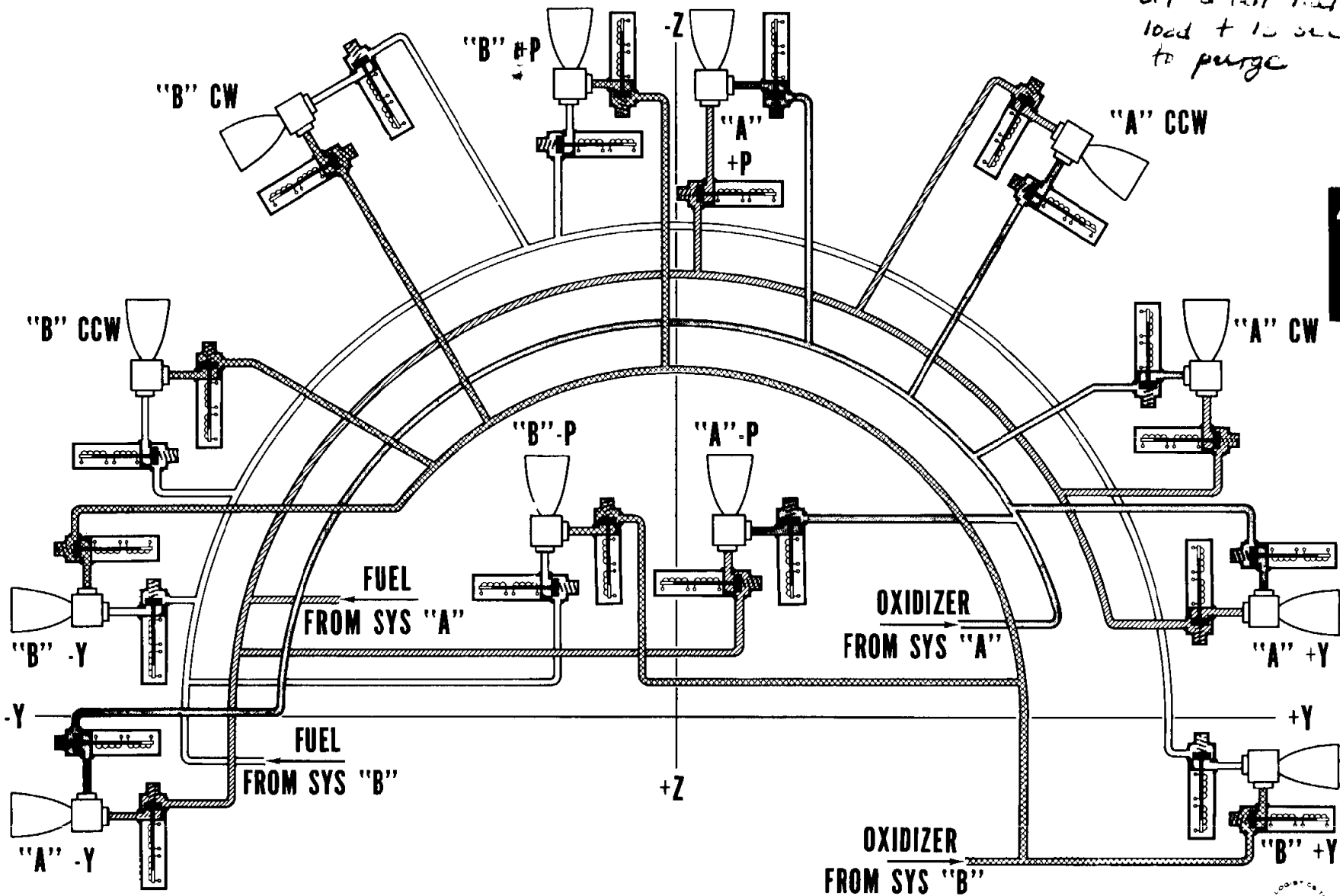


Figure 4-5

P-3004



4-7

4

at 100% is on (includes, no 50 in 100) - - engine multi...
 After 88 sec. to burn off a full fuel load + 10 sec to purge

ELECTRICAL CIRCUIT INTERRUPTERS

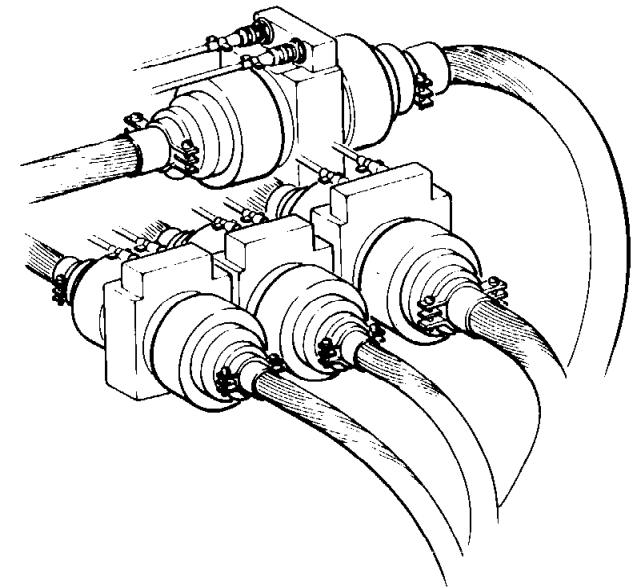
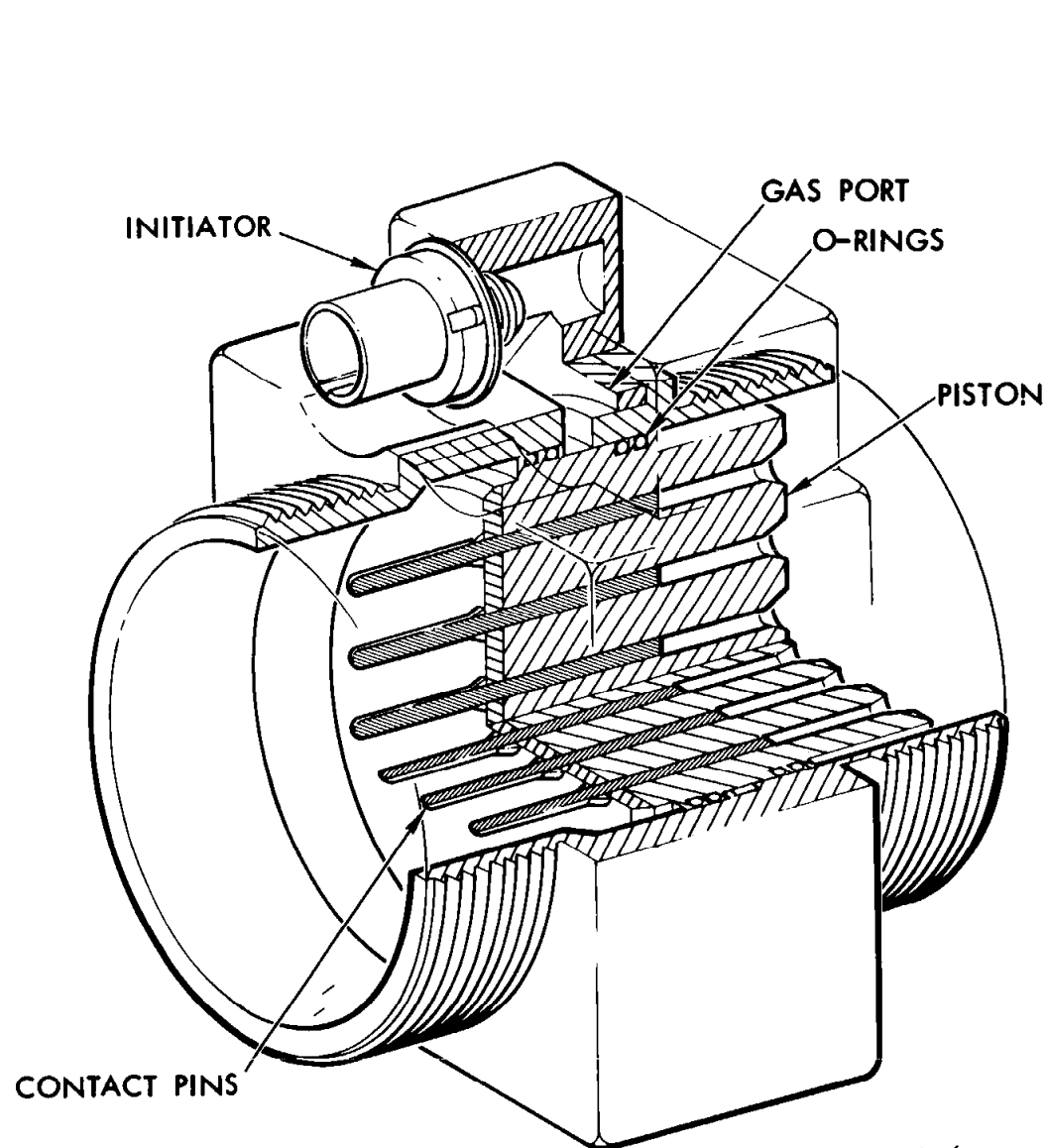


Figure 4-6

ST-9000C



DETONATOR CARTRIDGE ASSEMBLY

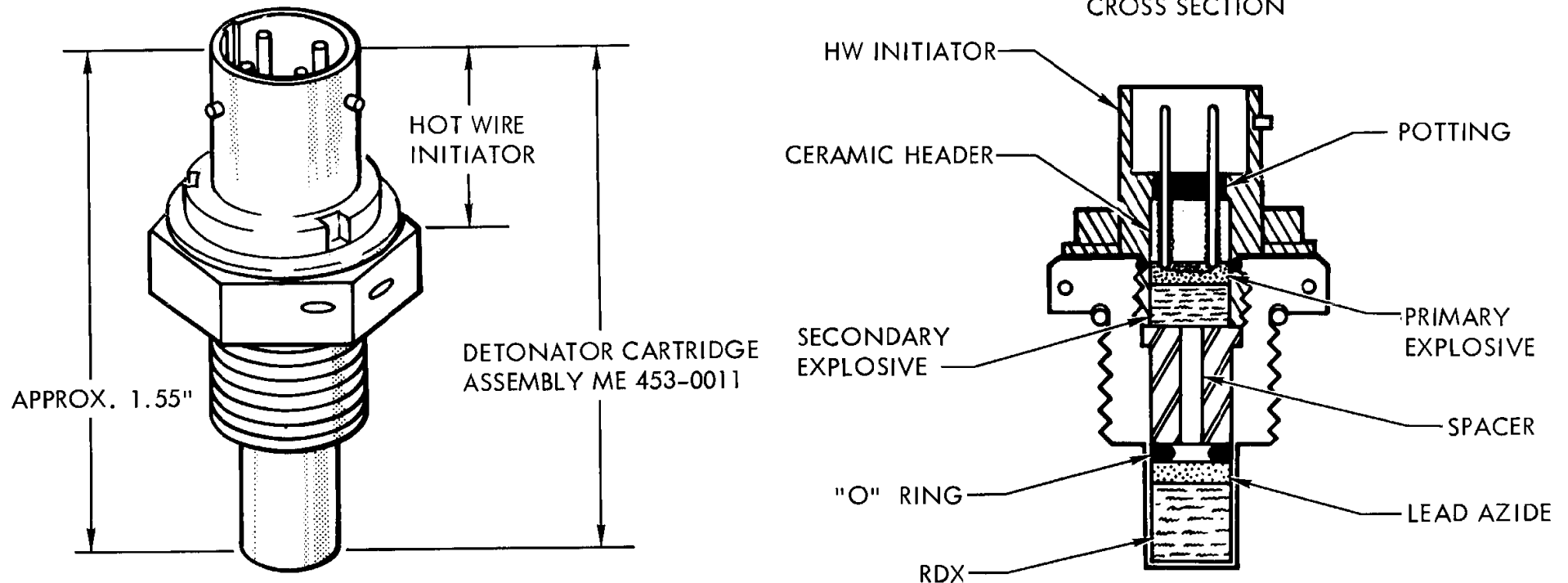


Figure 4-7

TOWER SEPARATION MECHANISM ORDNANCE INSTALLATION

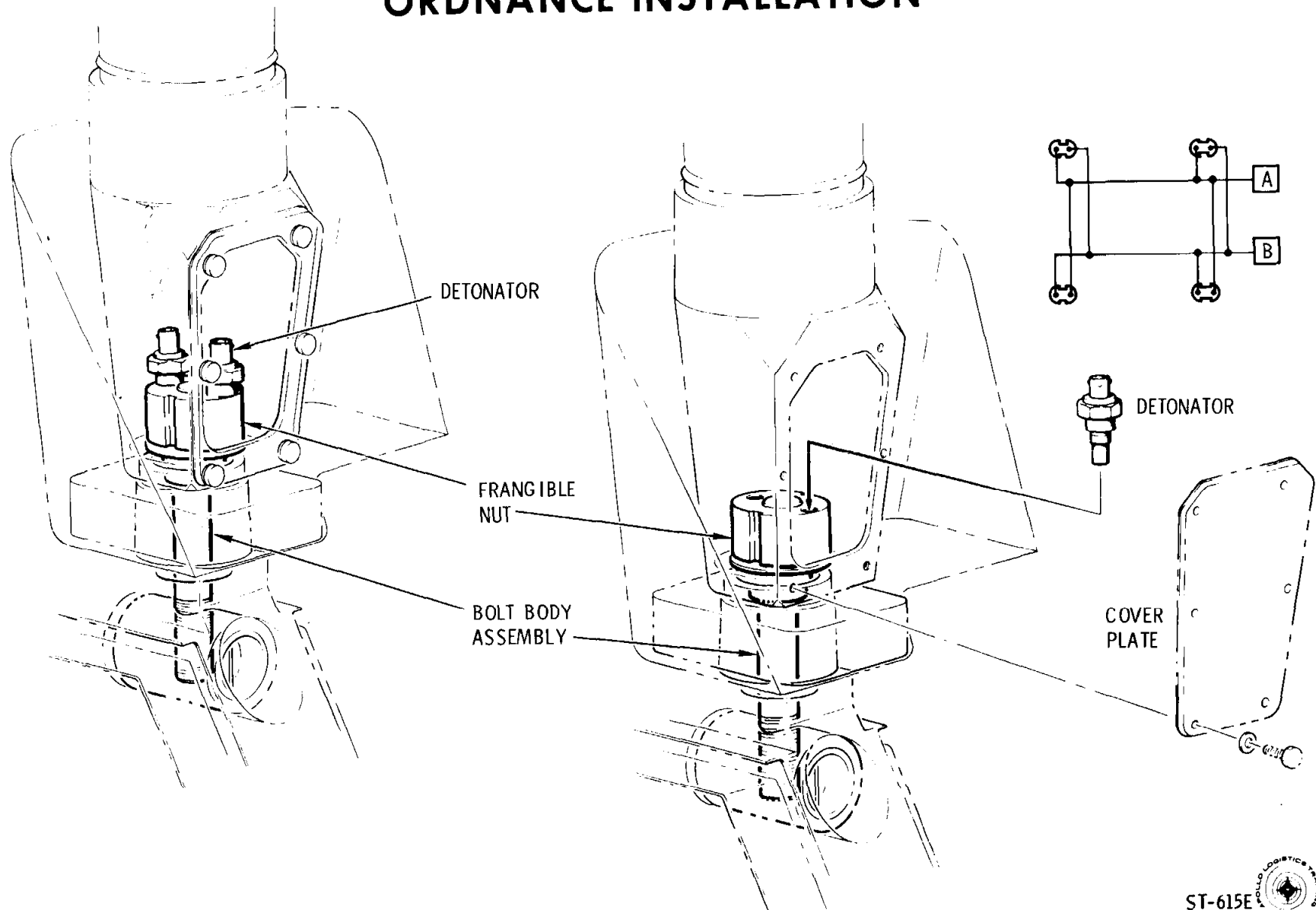


Figure 4-8

Figure 4-9. The Tension Tie Plate is common to a bolt which screws up into the CM structure and another bolt which screws down into the CM support structure on top of the SM as shown in figure 4-10.

After the CM has been bolted down to the SM under tension, an FLSC Cutter Assembly is installed on each of the 3 Tension Tie Plates in the manner shown in figure 4-11. Note the face-to-face mounting of the FLSC onto the Tension Tie Plate and a Detonator provided for each.

When CM - SM Separation is commanded, the MESC fires each of these Detonators simultaneously, one on system A and the other on system B, which in turn fires the FLSC's effecting cutting of the Tension Tie Plate. This is another dual redundant system, for if any one system fails the other system will perform the operation, or if any one Detonator or FLSC fails, the other will operate.

Detonators are also utilized to actuate the guillotine type umbilical separation system shown in figure 4-12. One of these assemblies is installed at the top of the SM adapter with redundant Detonators provided to actuate the dual set of guillotine blades within the housing. At the same time the Tension Tie Plates are cut for CM - SM separation, the electrical cable and hard line umbilical is cut by this separation system immediately following circuit deadfacing.

SLA separation is triggered by redundant Detonator Assemblies located between the hinges on 2 of the Adapter Panels as shown in figure 4-14. The Detonators set off dual trains of MDF installed around the Adapter panels, top and bottom, and between each panel as illustrated in figures 4-13 and 14, which effects separation. Simultaneous with this action, 2 electrical

wiring disconnect plug assemblies mounted on 2 panels are blown apart disconnecting all electrical wiring between the LV and the SC. Also, small thrusters under the corners of each panel is actuated which causes each panel to start opening, hinging on the dual hinges. Refer to figure 4-15. A Negator Spring Reel then retracts each panel outward approximately 45° from its original position.

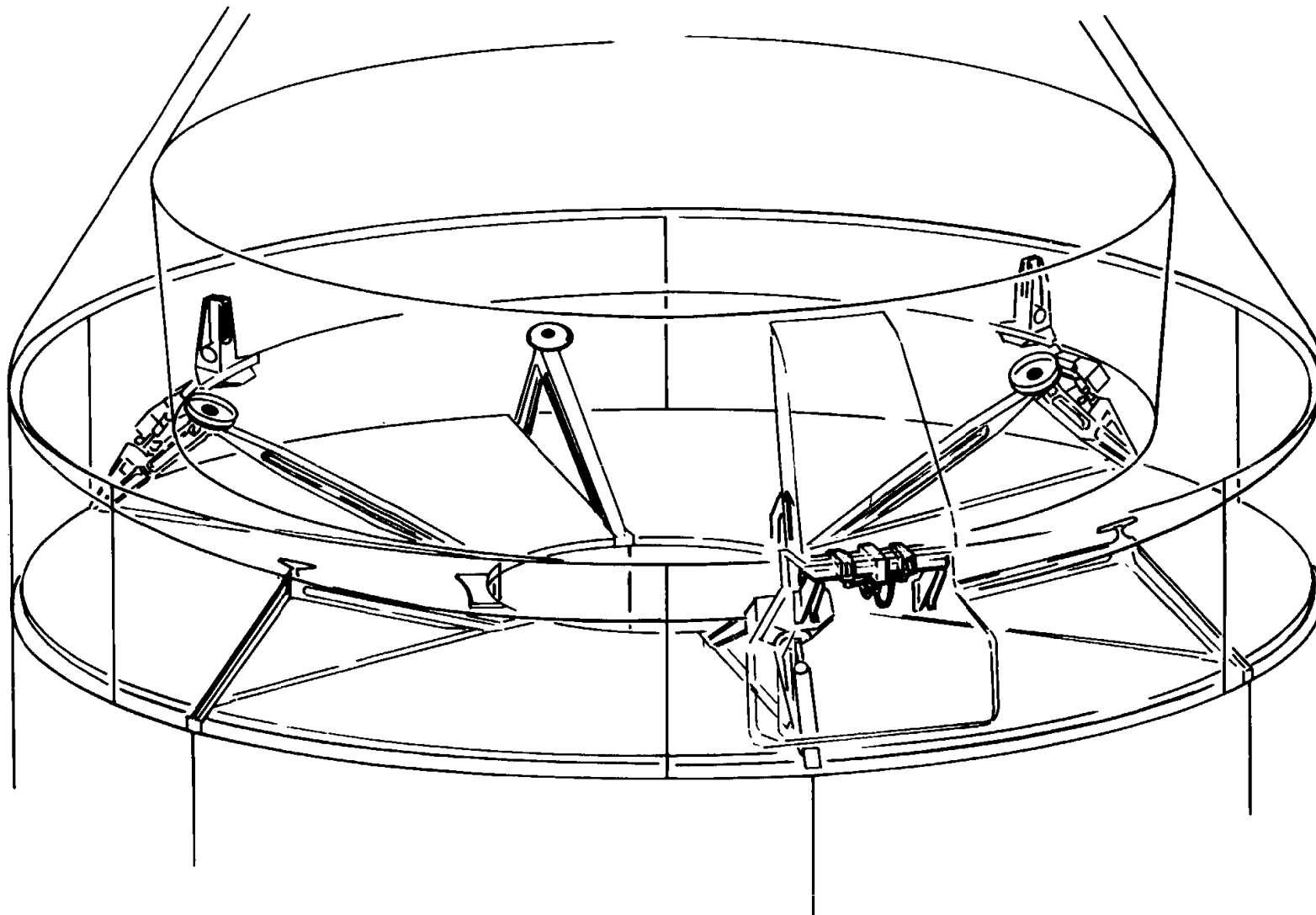
Detonators are also utilized for the release of the parachutes. Figure 4-16 shows the Drogue and Main Landing Parachute Disconnects. When Drogue parachute release is commanded by the ELSC's, dual Detonators are fired which explodes an FLSC Cutter Assembly under the hinge of the Parachute Attachment Fitting. This allows the hinge portion of the Attachment Fitting to slide through the mounting bracket and drift away from the CM on the Drogue parachutes.

After landing, the crew will initiate Main Landing parachute release manually. This will fire the single Detonator shown on each of the 2 Main Landing Parachute Attachment Fittings. The Detonator fires a cutting blade inside the attachment fitting which will cut the nylon harness assembly. The Main Landing parachutes, their risers, the Confluence Fitting, and the harness assembly are then free to drop off the CM into the water.

4.3 PRESSURE CARTRIDGE

The Pressure Cartridge Assembly, or Gas Generator as it is often called, illustrated in figure 4-17, is the electrically initiated hotwire type. The ASI is used to initiate the burning of a booster charge of pistol powder which in turn ignites the main charge of pellets. The fast burning of these pellets

C/M - S/M SEPARATION SYSTEM



4

Figure 4-9

C/M-S/M TENSION TIE

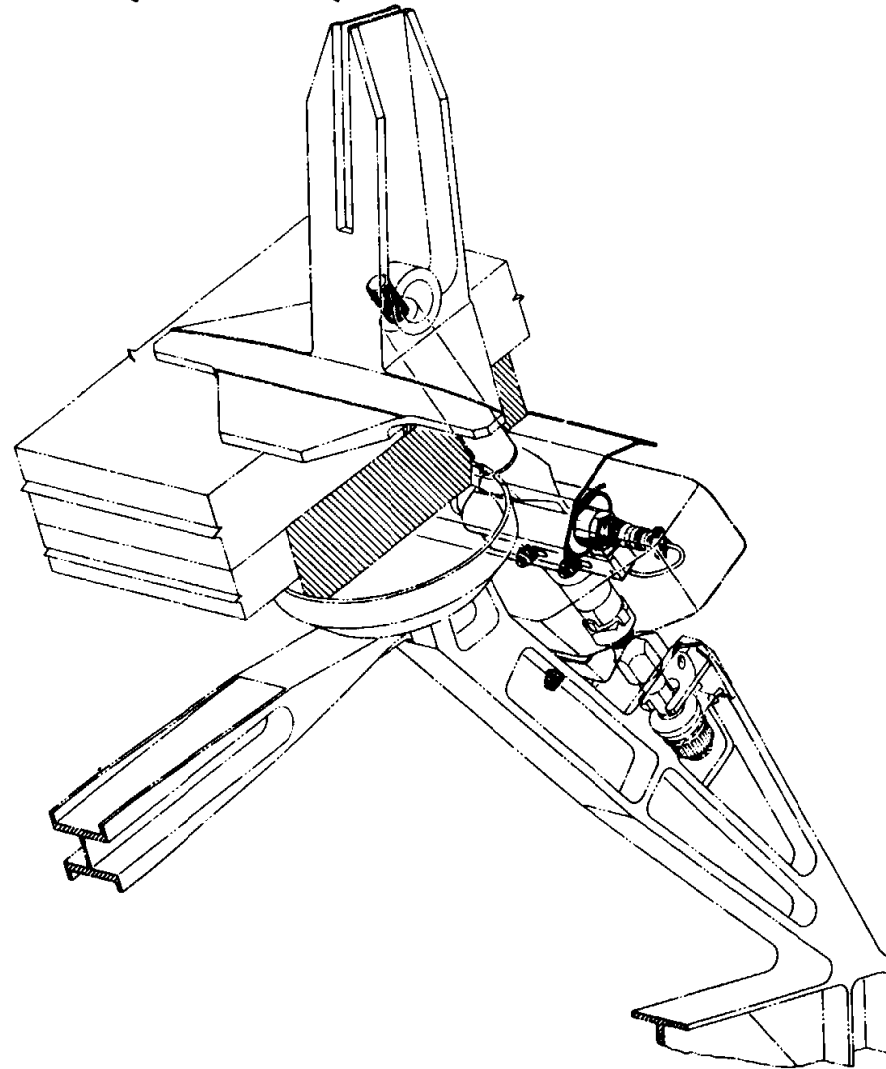



Figure 4-10

ST-601 

C/M-S/M SEPARATION SYSTEM ORDNANCE INSTALLATION

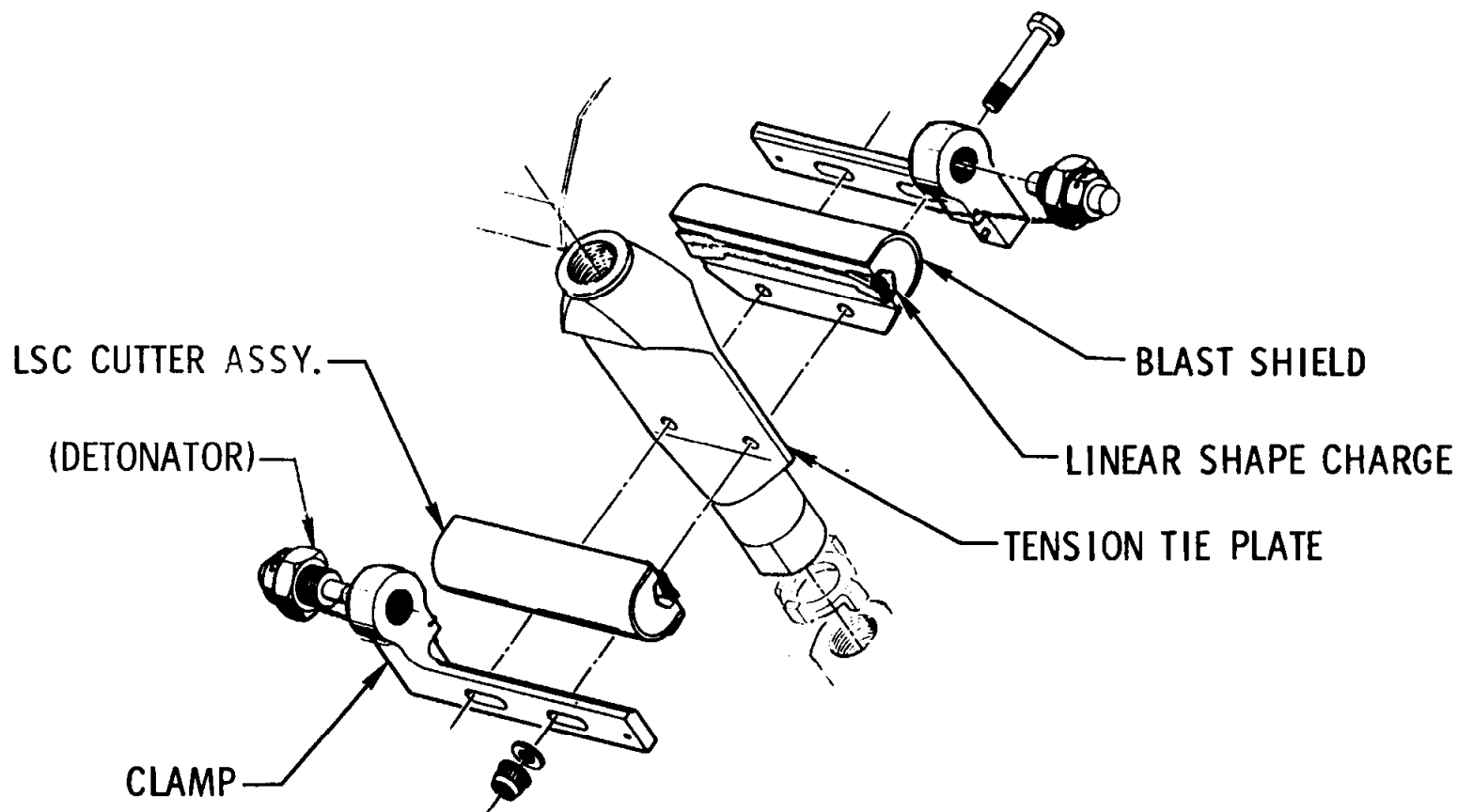

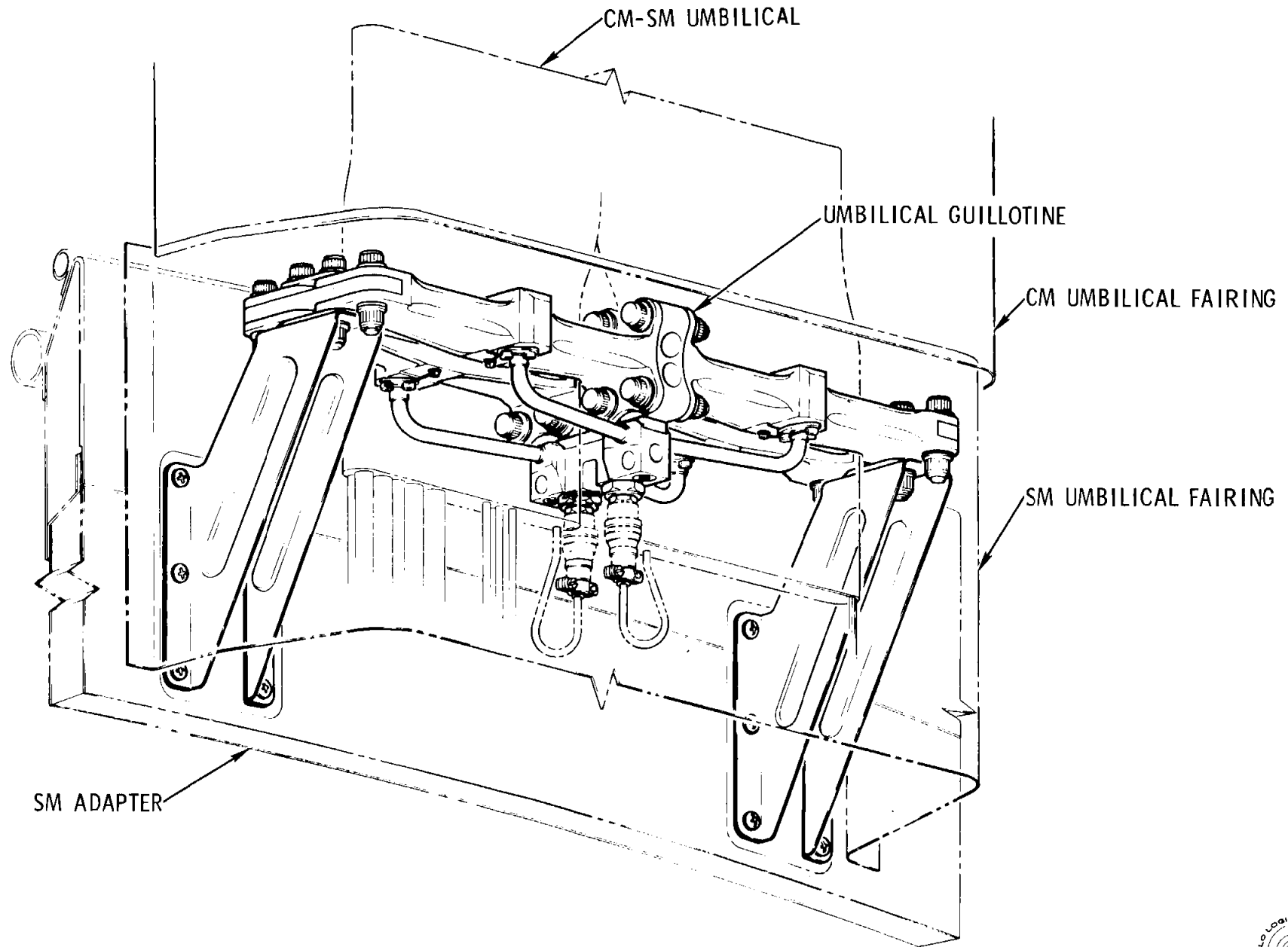


Figure 4-11

ST-602A 

4-114

UMBILICAL SEPARATION SYSTEM



4

Figure 4-12

ADAPTER SEPARATION SYSTEM

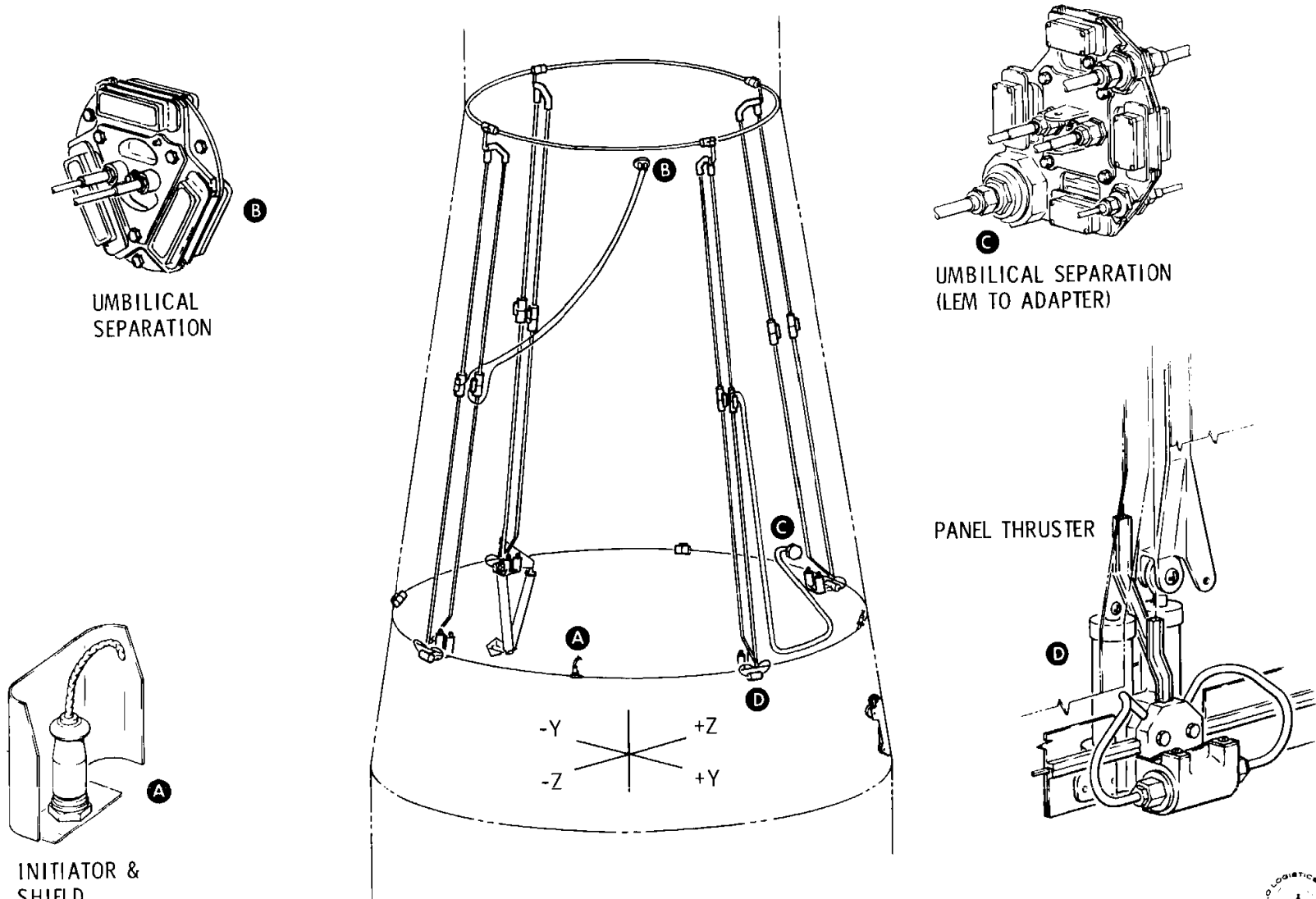
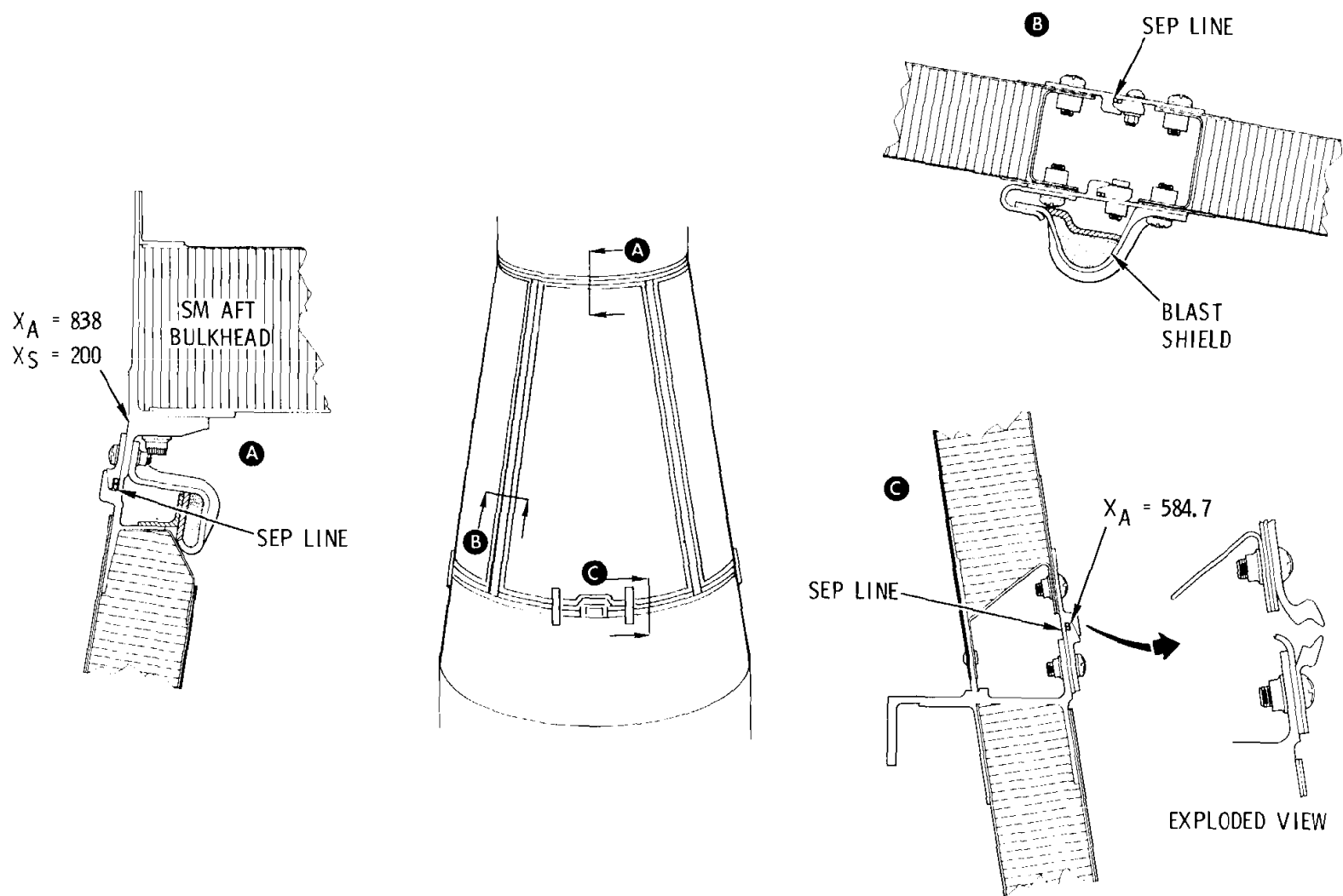


Figure 4-13

ADAPTER PANEL SEPARATION LINE



4

Figure 4-14

SLA PANEL DEPLOYMENT

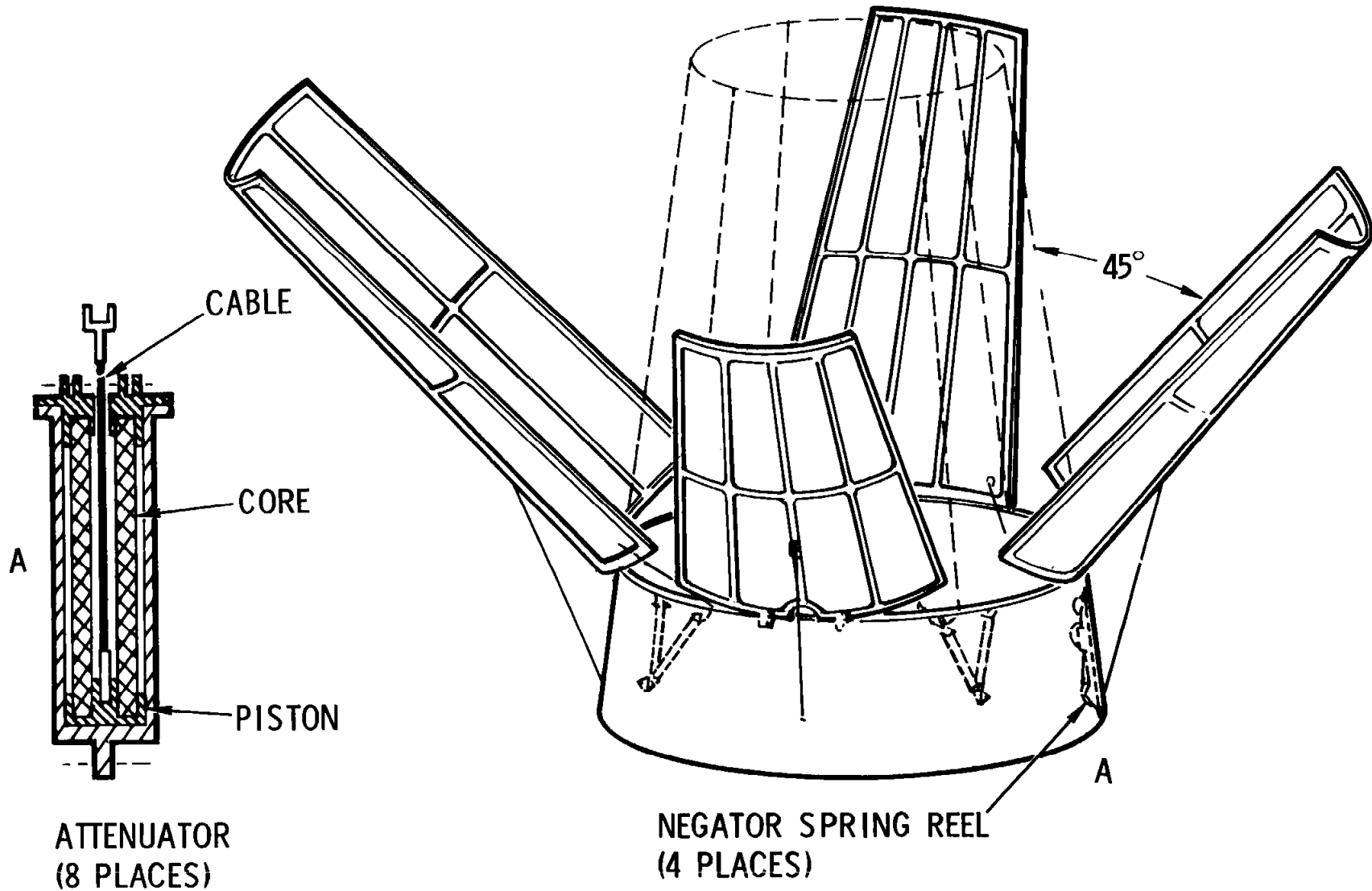


Figure 4-15

ST-3025B



4-18

PARACHUTE DISCONNECTS

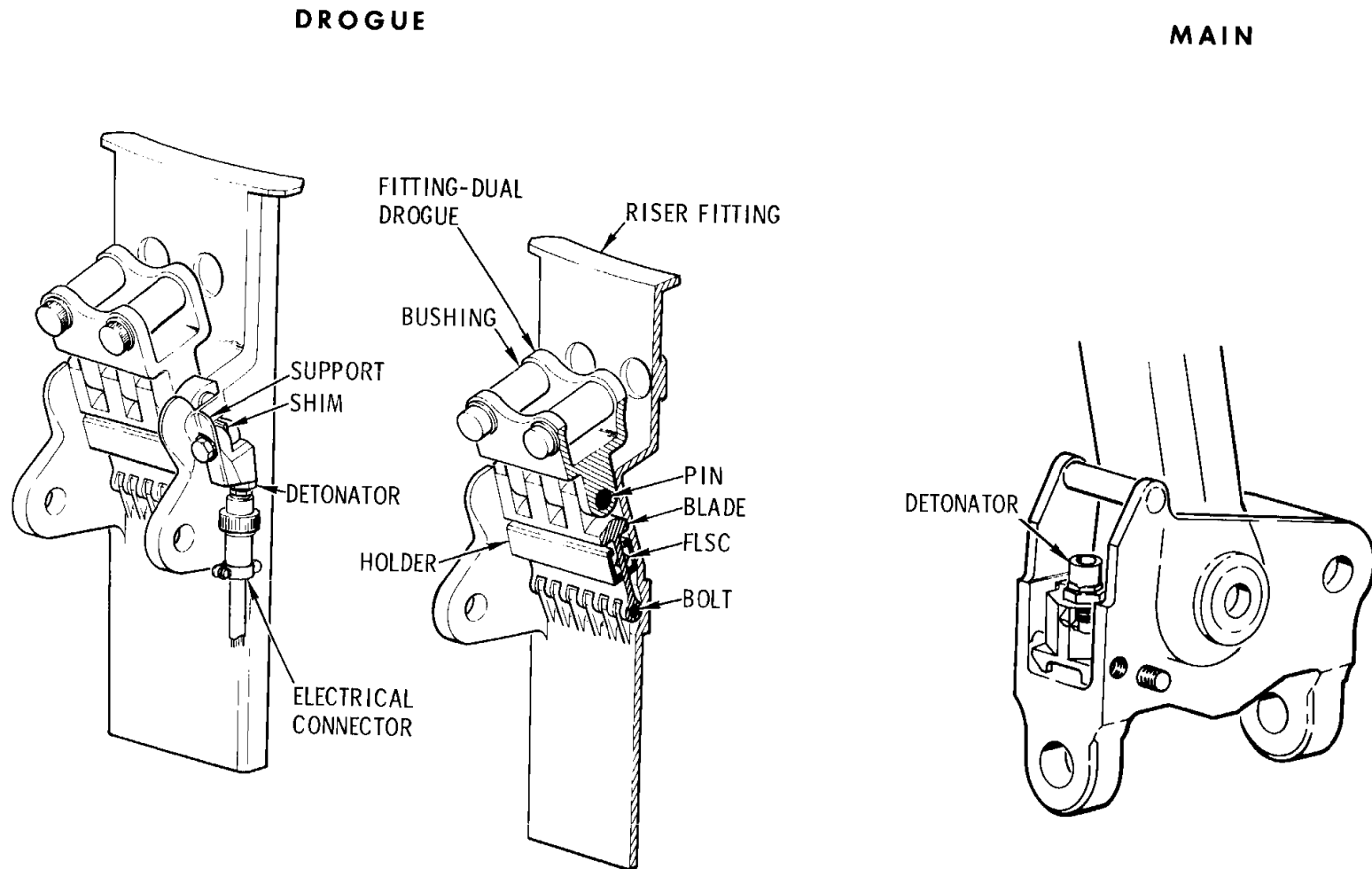


Figure 4-16

HOTWIRE PRESSURE CARTRIDGE ASSEMBLY ELECTRICALLY INITIATED

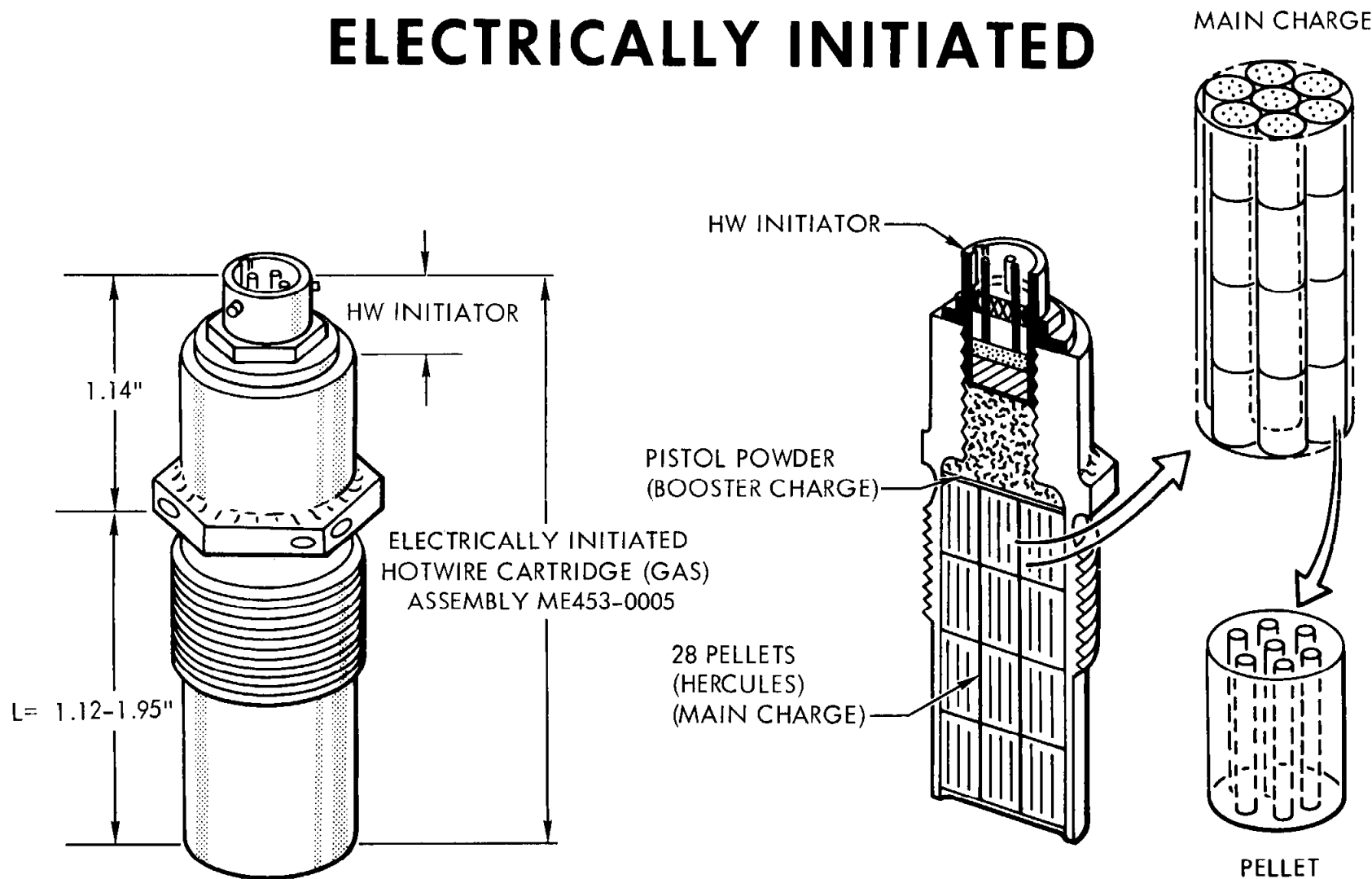

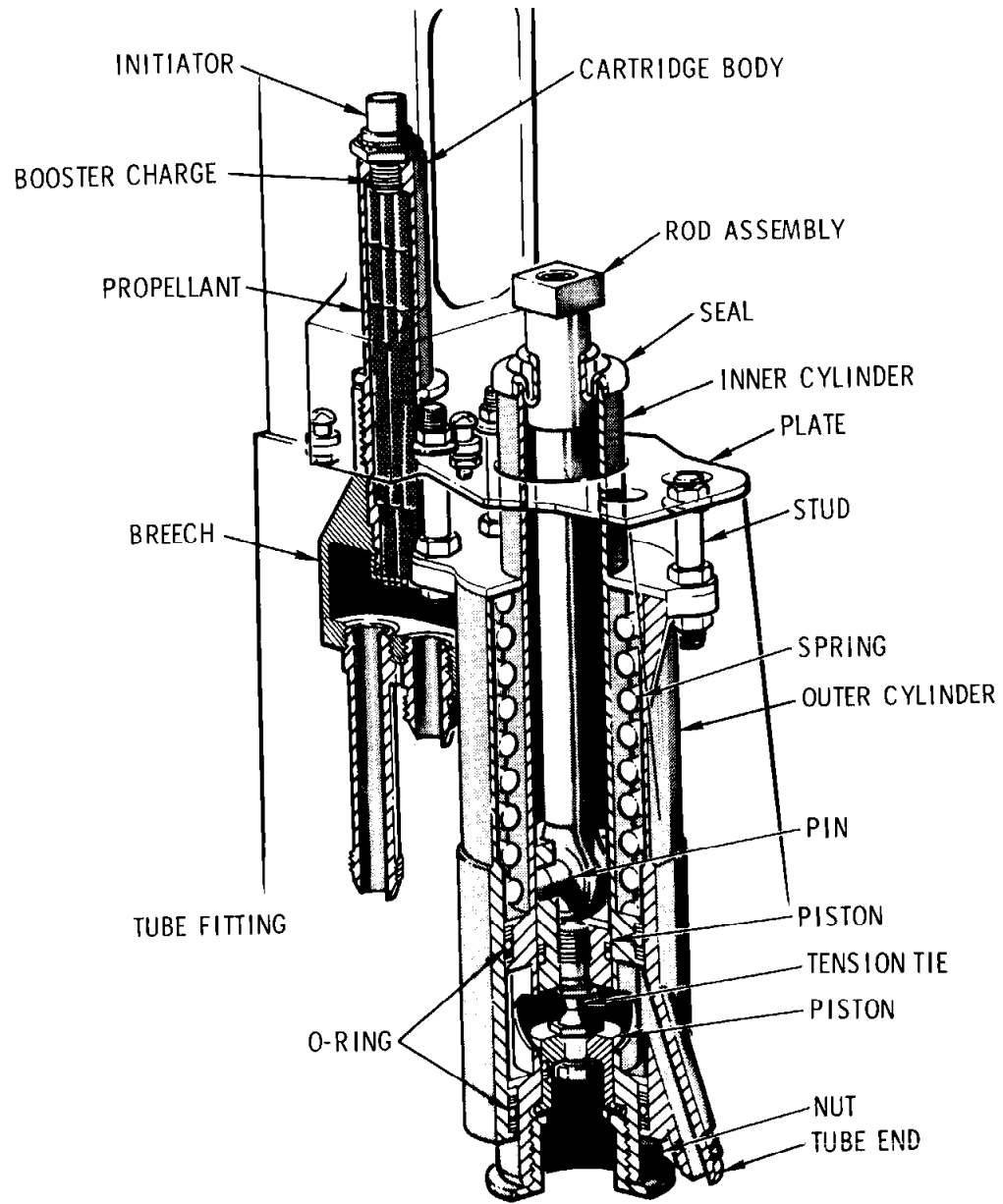


Figure 4-17

ST-9075 

4-20

generates gas pressures, according to the number of pellets in the assembly, to actuate the Apex Cover Thruster Assemblies shown in figure 4-18, the Parachute Deployment Mortars shown in figure 4-19 and the Canard Actuator shown in figure 4-20. Note that in all applications 2 Pressure Cartridges are used for redundancy.



APEX COVER THRUSTER ASSEMBLY

Figure 4-18

PARACHUTE DEPLOYMENT MORTARS

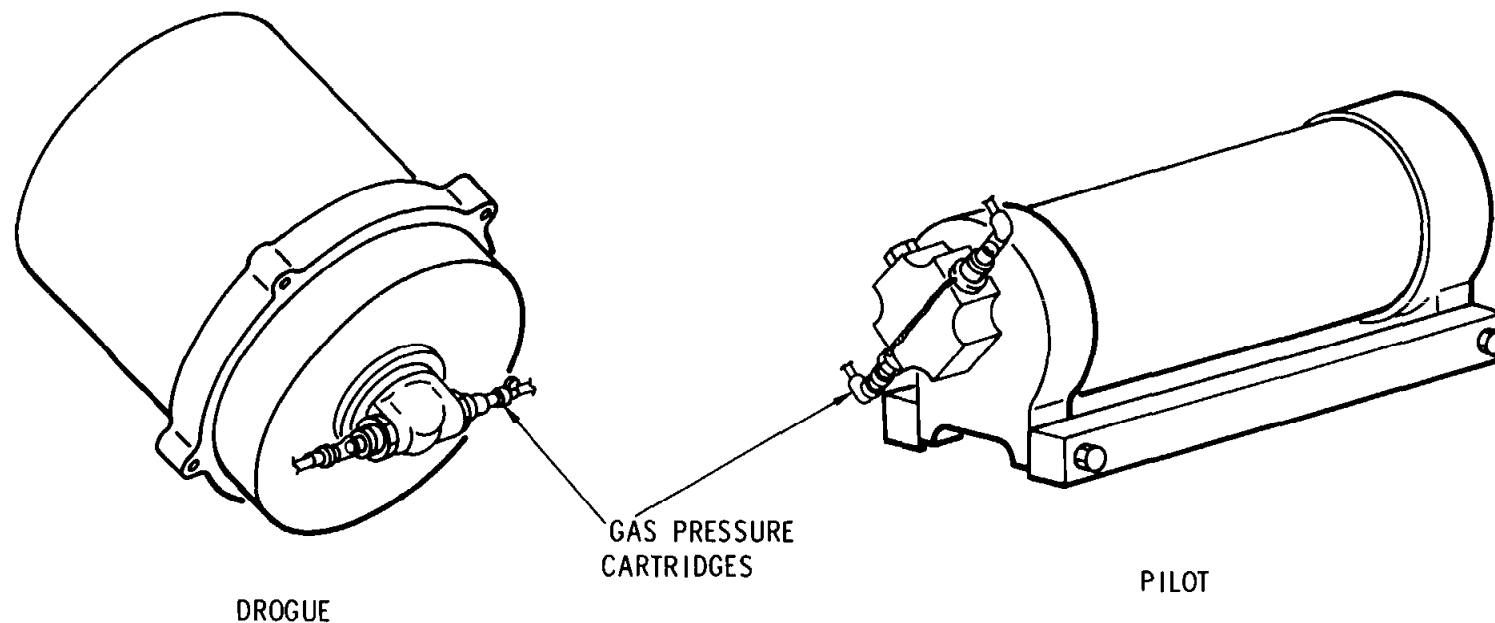


Figure 4-19

CANARD ACTUATOR

actuated 11 sec after
in start

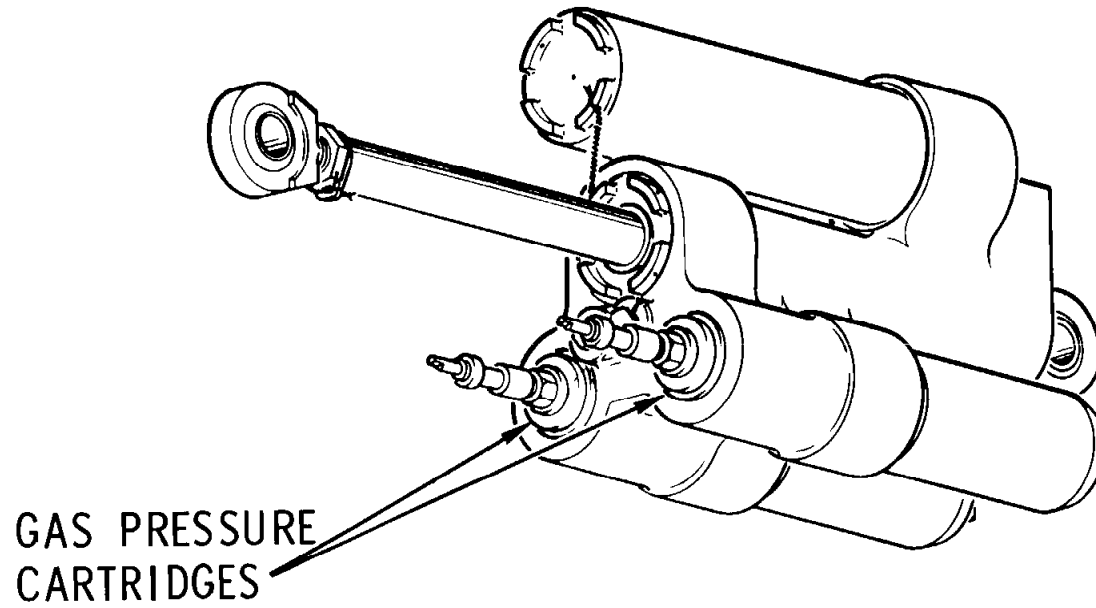


Figure 4-20

SECTION V

DISPLAYS AND CONTROLS

The Sequential Events Control System is directly concerned with certain Displays and Controls on separate panel assemblies located on the Main, Left Hand, and Right Hand Displays and Controls Consoles. Each of these Displays and Controls and their functions will be described in the following text. Figure 5-1 is the complete Displays and Controls layout presently approved for the first manned flight of Apollo. Figure 5-2 is a panel assembly locator designed to aid the student in locating those panel assemblies directly concerned with the SECS. The nine panels which have not been shaded are the ones applicable to the SECS. In addition to the Displays and Controls on the various panel assemblies being described, the Translation Controller is also described.

5.1 PANEL ASSEMBLY 1

Refer to figure 5-3 for an enlarged view of Panel Assembly 1. This panel contains the Barometric Pressure Indicator.

5.1.1 Barometric Pressure Indicator

The Barometric Pressure Indicator, or Altimeter as it is commonly referred to, will display pressure altitude to the crew from sea level to 60,000 feet. Pressure altitude is displayed linearly from 0 to 4,000 feet and logarithmically from 4,000 to 60,000 feet to within $\pm 5\%$, or 100 feet whichever is greater. The best accuracy possible is desired in the 0 to 4,000 foot range for monitoring the deployment of the Main Landing parachutes following a pad or near pad LES abort.

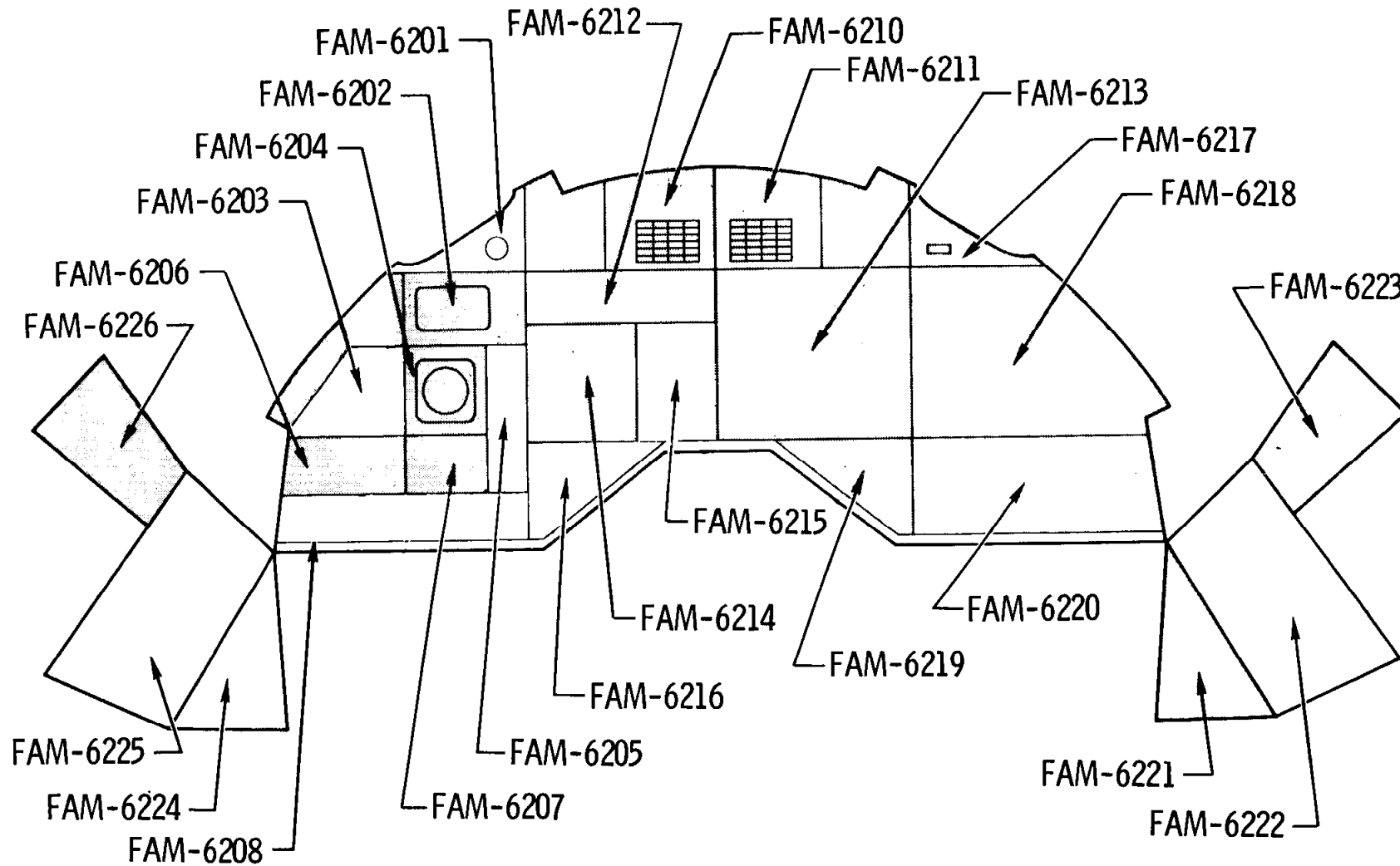
The crew may monitor this indicator on the early ascent phase from lift-off and on the entry phase after descending through 60,000 feet, paying particular attention to it as the pointer nears 24,000 feet, when the Apex Cover must be jettisoned to uncover the parachutes. The crew will monitor this indicator, also, during low and medium altitude LES aborts, if an abort is initiated, and subsequent ELS functions.

If the Apex Cover does not jettison as the CM descends through 24,000 feet, the crew may revert to the APEX COVER JETT back-up switch to effect jettisoning of the Apex Cover. Drogue parachute deployment should follow shortly thereafter, but if it does not, then the crew may revert to the DROGUE DEPLOY back-up switch to deploy the Drogue parachutes.

The Drogue parachutes should release and the Main Landing parachutes should deploy via the Pilot parachutes upon descending to 10,000 feet, as indicated, but if this does not occur, the crew may use the MAIN DEPLOY switch on Panel Assembly 5 to back-up this function.

An alidade assembly is incorporated about the face of this instrument whereby an indicator mark may be rotated to the desired pressure altitude for the manual deployment of the Main Landing parachutes subsequent to a pad or near pad LES abort. Prior to launch the Commander may preset the indicator mark to the pressure altitude, according to the barometric pressure of the launch day, which will prompt him to

MAIN DISPLAY CONSOLE LOCATOR



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Figure 5-2

SEQ-56D



5-3

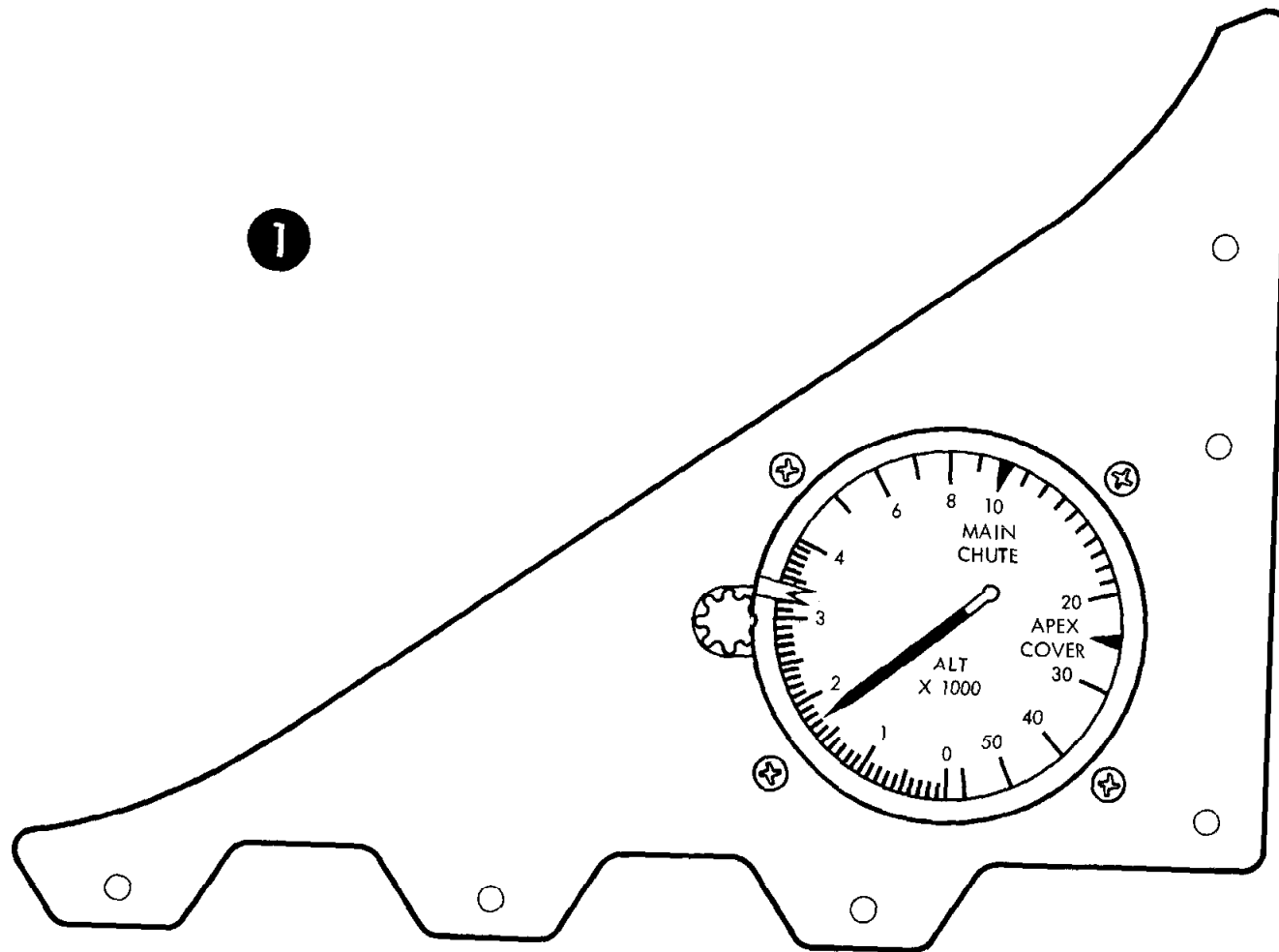


Figure 5-3

manually deploy the Main Landing parachutes when the pointer centers upon this indicator mark on its counter-clockwise rotation during descent from a possible LES abort. As shown in figure 5-3, the indicator mark of this alidade assembly has been set to 3,300 feet which represents a nominal indicated pressure altitude for Main Landing parachute deployment on a standard atmospheric day (29.92 inches of Hg), considering static pressure lag to the instrument and inherent drag within the instrument, that will guarantee that the Main Landing parachutes are deployed at a geometric altitude of 2,500 feet.

5.2 PANEL ASSEMBLY 3

Figure 5-4 is an enlarged view of Panel Assembly 3. This panel contains the LV Angle of Attack/SPS Chamber Pressure indicator and its related selector switch and the ABORT indicator light of the EDS.

5.2.1 Angle of Attack/SPS Chamber Pressure Indicator

The Angle of Attack/SPS Chamber Pressure indicator is a 2-1/4 inch diameter dial and pointer type instrument. This instrument is proposed to be time-shared in the following manner. From lift-off to tower jettison the selector switch to the left of the indicator must be in the LV AOA position in order to monitor Angle of Attack on the indicator as transmitted from the Q Ball. After the LET has been jettisoned, the crew will place the selector switch to the SPS P_c position. In this position the chamber pressure of the SPS engine may be monitored while it is burning. Presently, the dial indicates from 0 to 150% with the normal operating range for the SPS engine lying between 75 and 125%. It is not known at this writing what the limits will be regarding Angle of Attack.

5.2.2 Abort Indicator Light

The ABORT indicator light is a large red lamp assembly containing 4 bulbs. For positive operation (redundancy) there are 2 bulbs on System A and 2 bulbs on System B. These bulbs are illuminated anytime that the Launch Control Center may request an abort via hardwire through GSE for a pad abort prior to launch or via the Up-data Link (radio) for the first 10 seconds of flight. After this time an abort may be requested by the Manned Spacecraft Control Center in Houston at anytime until orbit is attained via the Up-Data Link.

The Range Safety Officer may also cause this light to illuminate anytime from lift-off until the LV is out of his jurisdiction by transmitting a "Destruct Arm" command via radio. If this command is transmitted to the LV prior to the crew inhibiting the 2 Engine Out automatic abort capability, the crew will be automatically aborted because the "Destruct Arm" command also initiates BECO and as soon as the EDS senses 2 engines out an automatic abort is voted and initiated by the MESC. But, if the command is transmitted after the 2 Engine Out automatic abort feature is inhibited, the crew will not be automatically aborted. The booster will be shut down, however, and the abort must be initiated manually as soon as possible. This light will remain illuminated until the CM-SM umbilical is destroyed, if turned on by Range Safety, but if it is illuminated by the Up-data Link, it will remain illuminated throughout descent because the latching relays in the Up-data Link Relay Box are latched on.

5.3 PANEL ASSEMBLY 5

An enlarged view of Panel Assembly 5 is illustrated in figure 5-5. The upper half of this

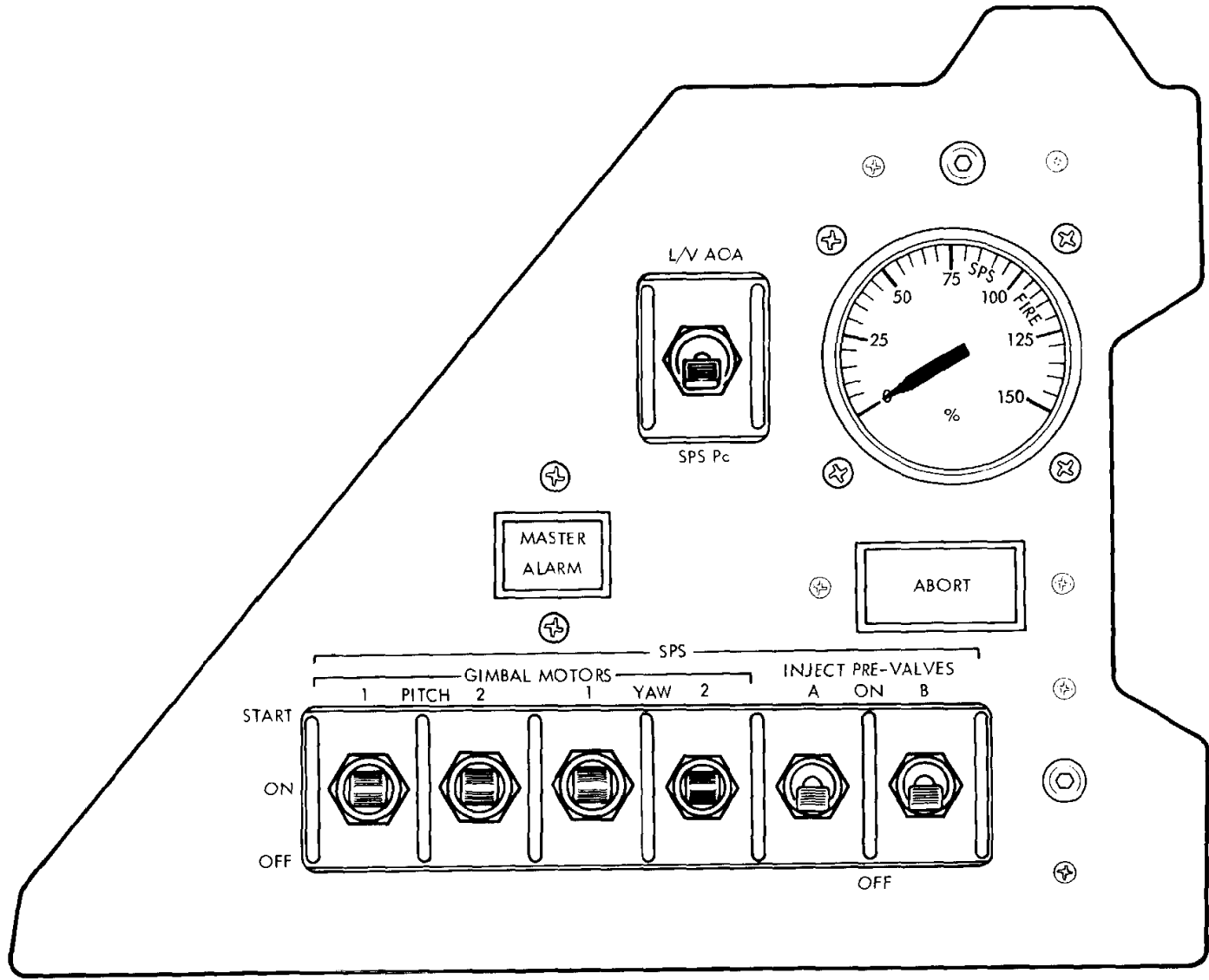
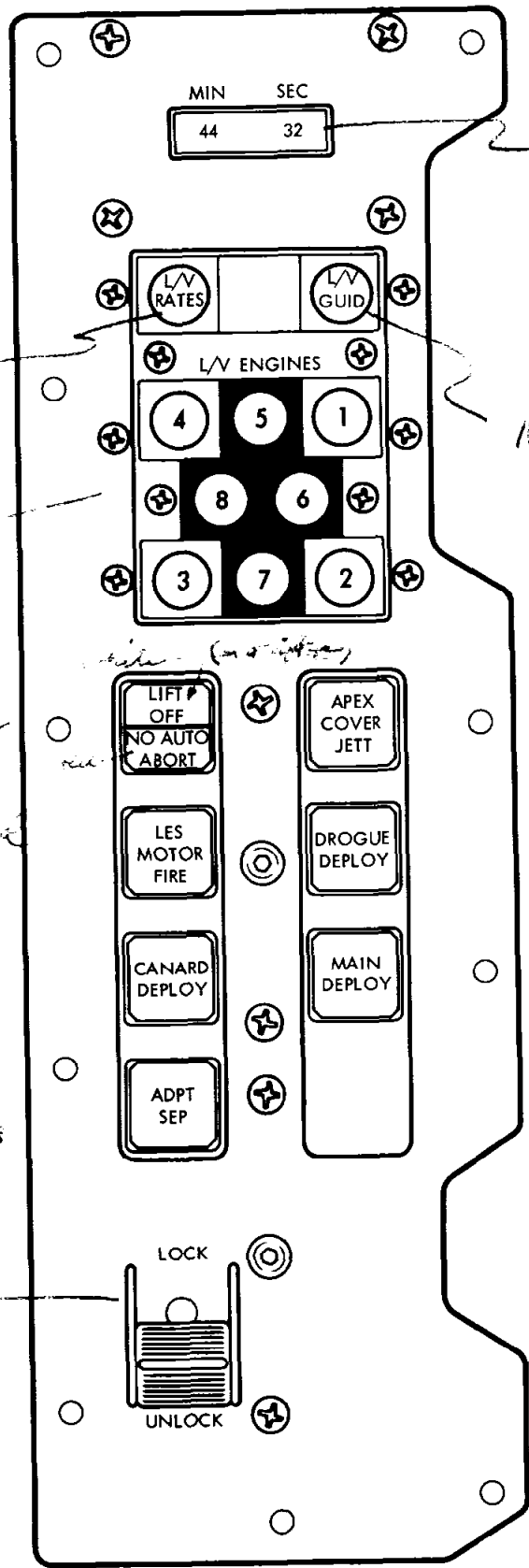


Figure 5-4



Note!

a) Max time 59 min
389 sec

b) Digital counts time which is reset to provide reference for an abort.

No auto abort

subject to auto abort (1 one)

Notes:

a) 8 reactions
H-1 engine
(resistor change process - when below 40% reserve thrust, light comes on)

b) Inbrd. Crisp. auto abort 1st then 4 auto abort

c) Eng. 1 light for 2 lbs calyngue press - 641 auto abort

Prevents all switches except (Lift off) from being changed.

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Note: a) Auto abort for cong. out and/or
b) Excessive rates

panel contains the Digital Event Timer Readout and the various EDS monitor and warning light indicators. The lower half contains 2 vertical rows of switches arranged in a logical sequence for back-up primarily of the major discrete events which occur during a normal ascent, an LES abort, and earth landing.

5.3.1 Digital Event Timer Readout

The Digital Event Timer Readout is a 4 drum readout being capable of presenting a maximum total time of 59 minutes and 59 seconds. It will be started from zero at lift-off and will count and totalize elapsed time in minutes and seconds throughout the ascent phase of the mission. In case of an abort, it will be reset to zero and will start totalizing elapsed time from the initiation of the abort. Switches are provided on Panel Assembly 8 for complete manual control of this Digital Readout and are described in paragraph 5.4. The Digital Event Timer Readout may be used on the ground for checkout purposes, either counting up or down. It may also be used by the crew in a like manner to monitor time functions at anytime during a mission.

5.3.2 LV Rates Indicator Light

The LV RATES indicator light is a red warning light which, when illuminated, will warn the crew of excessive LV rates, either in roll, pitch, or yaw. This warning light will remain illuminated only momentarily in case of an automatic abort because of excessive rates. After the LV Rates automatic abort feature has been inhibited, if this warning light comes on it will remain illuminated until an abort is initiated manually.

5.3.3 LV Guidance Indicator Light

The LV GUID indicator light is a red warning light which when illuminated will warn the crew of a

failure in the LV's guidance system. The Data Adapter of the LV's guidance package in the IU energizes a relay which will illuminate this warning light when a failure is detected. A decision must be made by the crew and ground personnel, if this light comes on, whether or not to initiate an abort.

5.3.4 LV Engines Indicator Lights

Eight LV ENGINE indicator lights, numbered 1 through 8, are provided to monitor the thrust level of the LV's engines. These are aircraft yellow in color and are arranged on the panel to represent the rocket engine arrangement for the first stage of the Saturn IB LV, as viewed looking forward. The outboard engines are numbered 1 through 4 and the inboard engines are numbered 5 through 8. Prior to ignition of the first stage engines on the pad, the LV ENGINE lights will be illuminated. After ignition and a thrust build-up of 90% rated thrust, these lights will extinguish.

If any of these lights illuminate between lift-off and the start of staging at approximately $T = +141$ seconds, it is a warning to the crew of a thrust deterioration below operational parameters of that particular engine. If 2 or more of these lights come on during the first 2 minutes of ascent, an automatic abort will be initiated immediately. After the 2 Engine Out automatic abort feature is inhibited, if 2 or more lights illuminate, a decision must be made whether or not to initiate an abort.

When the inboard engine lights illuminate at approximately $T = +141$ seconds, this signals the commencement of staging. The remaining 4 outboard engine lights will illuminate at approximately $T = +147$ seconds followed in 2 seconds with all but the number 1 light extinguishing as the first stage is severed from the LV and the second stage is

armed and ignited. After the second stage engine is started, and pressure parameters are within tolerance, the number 1 light will extinguish, signaling the completion of staging.

The number 1 light will again illuminate after orbit is attained and with S-IVB BECO. It will be extinguished when the SC is separated from the LV.

5.3.4 Lift Off/No Automatic Abort Indicator Light Switch

The LIFT OFF/NO AUTO ABORT indicator light switch is a spring loaded, momentary on, push button type switch which incorporates 2 individual indicator lights. The upper indicator light is white and is titled LIFT OFF. At lift-off, this light will illuminate for a few seconds to inform the crew of the exact moment of lift-off.

The lower indicator light is red and is titled NO AUTO ABORT. At lift-off, the automatic abort capability should be enabled, but if for some reason it does not, this indicator light will illuminate informing the crew that they have no automatic abort capability. The Commander will then press the indicator light switch which will manually enable the automatic abort capability and the light goes out.

5.3.5 LES Motor Fire Switch

The LES MOTOR FIRE switch is a spring loaded, momentary on, push button type switch and is not lighted. This switch serves primarily as a back-up to normal tower jettison. If the Tower Jettison motor fails to ignite when normal tower jettison is commanded, the Commander will press this switch, which will ignite the Launch Escape motor and jettison the tower.

Secondly, the LES MOTOR FIRE switch will be used to ignite the LE motor following the initiation of an LES abort, if the LE motor fails to ignite.

5.3.6 Canard Deploy Switch

The CANARD DEPLOY switch is a spring loaded, momentary on, push button type switch and is not lighted. The purpose of this switch is to provide the crew with a back-up switch for the deployment of the Canards, which is normally an automatically sequenced function during LES aborts.

5.3.7 Adapter Separation Switch

The ADPT SEP switch is a spring loaded, momentary on, push button type switch and is not lighted. For normal SLA separation, the Commander will press this switch to initiate SLA separation. This switch serves as a back-up for SLA separation following the initiation of an SPS abort, also, in case that the automatic sequence fails.

5.3.8 Apex Cover Jettison Switch

The APEX COVER JETT switch is a spring loaded, momentary on, push button type switch and is not lighted. It serves as a back-up switch in case the Apex Cover does not jettison automatically.

5.3.9 Drogue Deploy Switch

The DROGUE DEPLOY switch is a spring loaded, momentary on, push button type switch and is not lighted. This switch provides the crew with a back-up for Drogue parachute deployment, if for some reason they do not deploy automatically.

5.3.10 Main Deploy Switch

The MAIN DEPLOY switch is a spring loaded, momentary on, push button type switch and is not lighted. This switch provides the crew with a back-up for Main Landing parachute deployment via the Pilot parachutes and for Drogue parachute release, if either the Drogue parachutes do not release, or if one or all Pilot parachutes fail to deploy on a fully automatically controlled sequence. If the Commander chooses to deploy the Main Landing parachutes manually following a pad or near pad LES abort, either ahead of or later than the automatically controlled sequence, he may revert to this switch. To deploy the Main Landing parachutes later than the automatic sequence, however, the Commander must first of all inhibit the automatic sequence by placing the MAIN DEPLOY switch on Panel Assembly 16 to the MAN position.

5.3.11 Panel Lock Button

All of the push button switches except the LIFT OFF/NO AUTO ABORT switch previously described may be prevented from being inadvertently actuated by pressing and sliding the Panel Lock button to the LOCK position. This is a mechanical, sliding lock mechanism.

This panel will remain locked until such time as the Commander wishes to initiate a certain switching function, whether it is a normal manual, or an emergency, or a back-up switching function.

5.4 PANEL ASSEMBLY 8

Panel Assembly 8 shown enlarged in figure 5-6 contains many switches for a number of functions described previously. The Digital Event Timer control switches, the ELS LOGIC arming switch, and the CM PROPELLANT JETTISON switches are located on the right hand half of this panel.

5.4.1 Digital Event Timer Switches

5.4.1.1 Reset/Count Up/Count Down Switch

The RESET/COUNT UP/COUNT DOWN switch is a momentary on towards the RESET position and a maintain on in the other 2 positions. The Digital Event Timer Readout may be reset to zero by momentarily holding this switch to the RESET position. To allow the Readout to count up after lift-off, this switch must be in the UP position. If an occasion arises where the crew or ground personnel wish to make a count down, this switch may be placed in the DOWN position.

5.4.1.2 Start/Stop Switch

The START/STOP switch is a momentary on towards the START position and a maintain on in the other 2 positions. To manually start the Readout, this switch may be held momentarily in the START position, but for a normal automatic start at lift-off or aborts, the switch need only be in the mid position. To stop the Readout at anytime, this switch may be placed in the STOP position.

5.4.1.3 Minute Switch

The MIN switch is a maintain on in the mid position and a momentary on in the other 2 positions. If it is desired at anytime during ground checkout operations, or during a mission after orbit is attained, to set the Readout at some predetermined time before starting a count up or count down, this switch may be held momentarily in either the TENS or the UNITS position to set the exact number of minutes desired on the Readout. For example, if 44 minutes is to be set on the MIN section of the Readout, this switch would be held to the TENS position until 40 appeared on the Readout, then it would be held to the UNITS position until 44 appeared on the Readout.

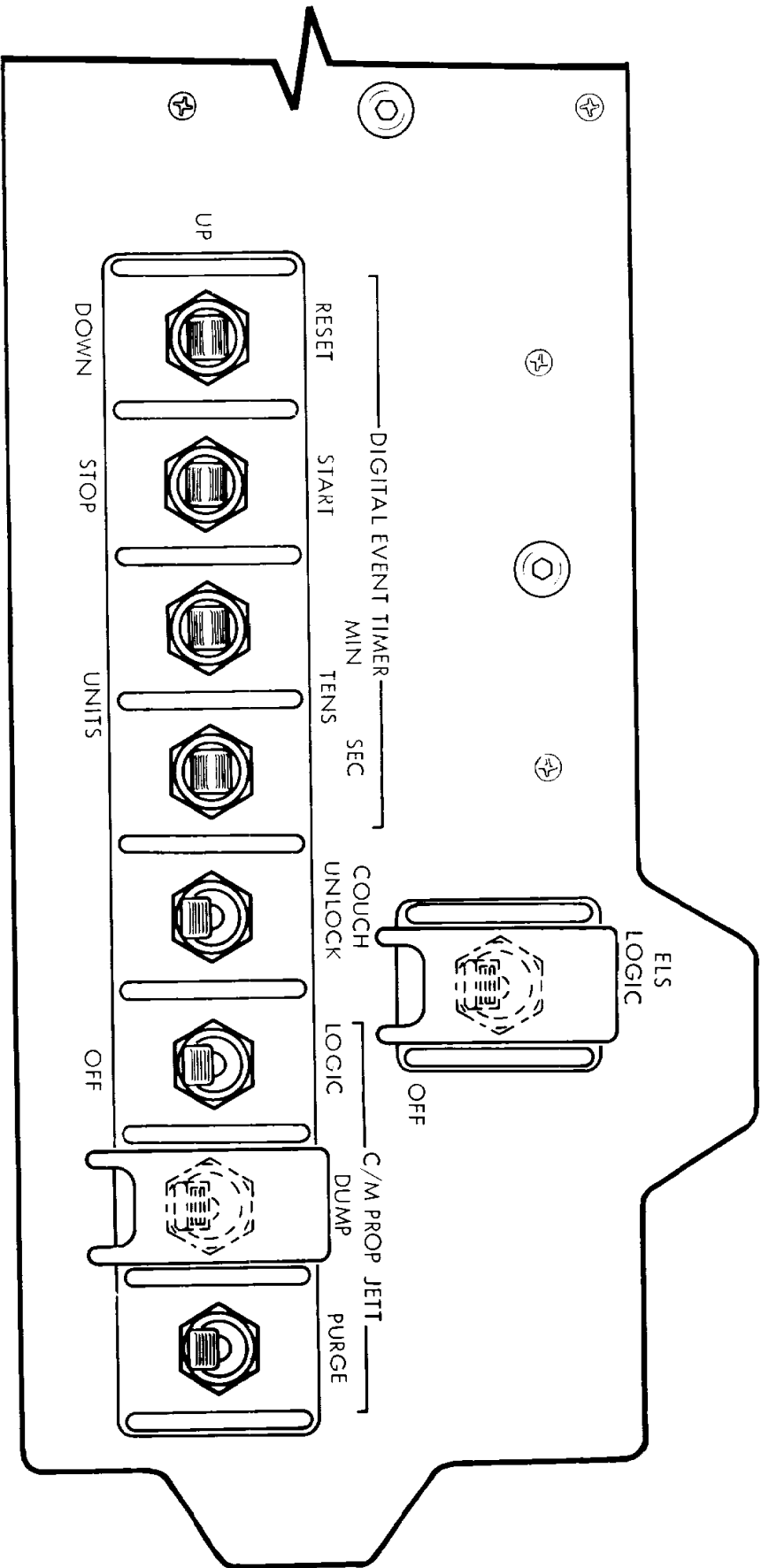


Figure 5-6

FAM-6208C

5.4.1.4 Second Switch

The SEC switch is identical to the MIN switch. If 32 seconds is to be set on the SEC section of the Readout, this switch must be held to the TENS position until 30 appears, then held to the UNITS position until 32 appears.

5.4.2 ELS Logic Switch

The ELS LOGIC switch is a guarded maintain on-off switch. It is guarded with an over center, spring loaded type switch guard. To actuate this switch, the guard must be lifted up into the locked open position. This switch will remain in the OFF position until it is desired to arm the ELS logically, when it will then be placed in the up, or on, position.

5.4.3 CM Propellant Jettison Switches

5.4.3.1 Logic Switch

The LOGIC switch is a maintain on-off switch. This switch will be turned on prior to lift-off to provide power to the 61 second Oxidizer Dump time delays, which are triggered at lift-off. It also provides power to drive the RCS Transfer motor switch whenever CM - SM Separation is commanded, whether for an LES abort or normal CM - SM separation. This switch also provides power to the DUMP switch adjacent to it.

After the LET has been jettisoned on ascent, this switch may be placed in the OFF position and will prevent inadvertent burning of Propellants during the mission, in case the DUMP switch is bumped on. It must be placed on again prior to CM - SM separation and will probably remain on throughout the entire descent. If not, it will have to be placed on again

prior to burning off all remaining Propellants after the Main Landing parachutes are deployed.

5.4.3.2 Dump Switch

The DUMP switch is a guarded maintain on-off switch. Following Main Landing parachute deployment on normal descents and any aborts after T + 61 seconds into a mission, this switch will be placed on to dispose of all remaining RCS propellants by burning it through 10 of the CM RCS engines. The 2 positive pitch engines are inhibited.

5.4.3.3 Purge Switch

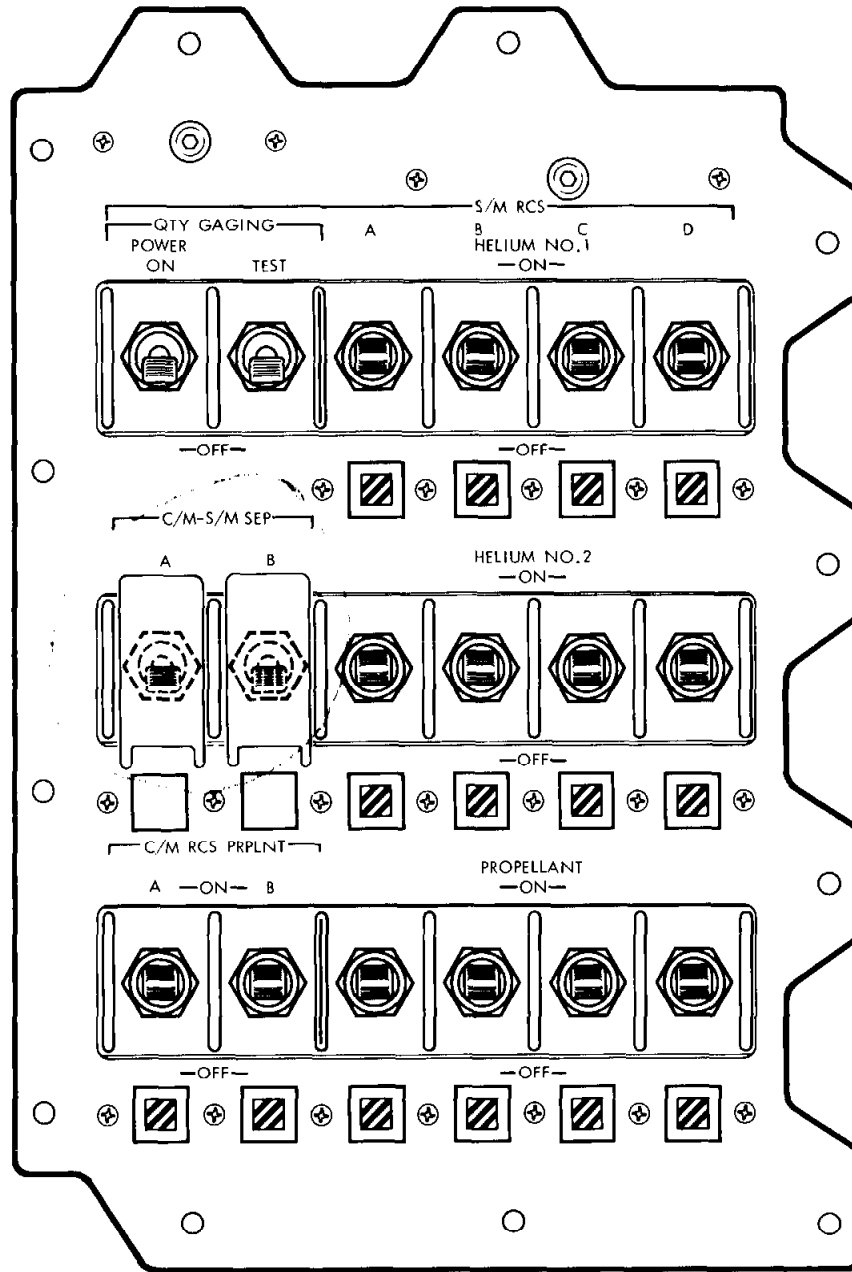
The PURGE switch is a maintain on-off switch. This switch initiates purging of the CM's RCS after the Propellants have been burned. This switch draws its power from the DUMP switch after it has been turned on.

5.5 PANEL ASSEMBLY 15

Panel Assembly 15 is illustrated in figure 5-7 and contains two switches of the SECS. These switches are identified with the nomenclature CM - SM SEP and two switches are utilized for redundancy; one is a system A switch, the other is a system B switch.

5.5.1 CM - SM SEP Switches ✓

The CM - SM SEP switches are guarded, momentary on switches, spring loaded to the OFF (down) position. When the commander wishes to command CM - SM separation, he will raise the switch guards to their locked open position and momentarily hold these switches to the up position. This action will also activate the SMJC.



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Figure 5-7

The CM - SM SEP switches may also be used to initiate an LES abort, in the event of Translation Controller abort signal failure, but the successive events will not be sequenced automatically and must be controlled manually.

5.6

PANEL ASSEMBLY 16

Figure 5-8 is an enlarged view of Panel Assembly 16, which, along with Panel Assembly 5, Figure 5-5, are probably the most involved in discussions and studies of the SECS. This panel contains the automatic or manual control switch for deployment of the Main Landing parachutes, titled MAIN DEPLOY. It contains the ABORT SYSTEM switches, namely; the OX DUMP, 2 ENG OUT, LV RATES, and MODE. It contains the RCS switches that initiate or back-up functions previously mentioned and definitely interface with the SECS. These are the CMD (Command) switch, the CM PRESS. switch, and TRANSFER switch. The EDS switch and the MAIN CHUTE RELEASE switch are also incorporated on this panel.

5.6.1 Main Deploy Switch

The MAIN DEPLOY switch is a maintain on-off switch. It will be normal for this switch to be up in the on position for the automatic sequencing of Main Landing parachute deployment subsequent to an LES abort. Therefore, the up and normally on position is titled AUTO.

If the Commander wishes to delay the deployment of the Main Landing parachutes following a pad to 61 seconds from lift-off LES abort, then deploy them manually later at 2,500 feet, he may place this switch to the MAN position following Drogue parachute deployment and inhibit the automatic deployment of the Main Landing parachutes.

5.6.2

Abort System Switches

5.6.2.1 Oxidizer Dump Switch

The OX DUMP switch is a maintain on-on switch. Prior to lift-off, this switch is placed up in the AUTO position to enable the CM's RCS Oxidizer to be dumped automatically, in case an abort is triggered on the pad or up until 61 seconds from lift-off. After 61 seconds of flight, the Commander will place this switch down to the RCS CMD AUTO position, which will allow the CM's RCS to be automatically enabled after 1 second, if an LES abort is initiated. This action will also inhibit the inadvertent dumping of the Oxidizer and ignition of the PC motor, if an LES abort is initiated, with a 61 second time delay failed closed.

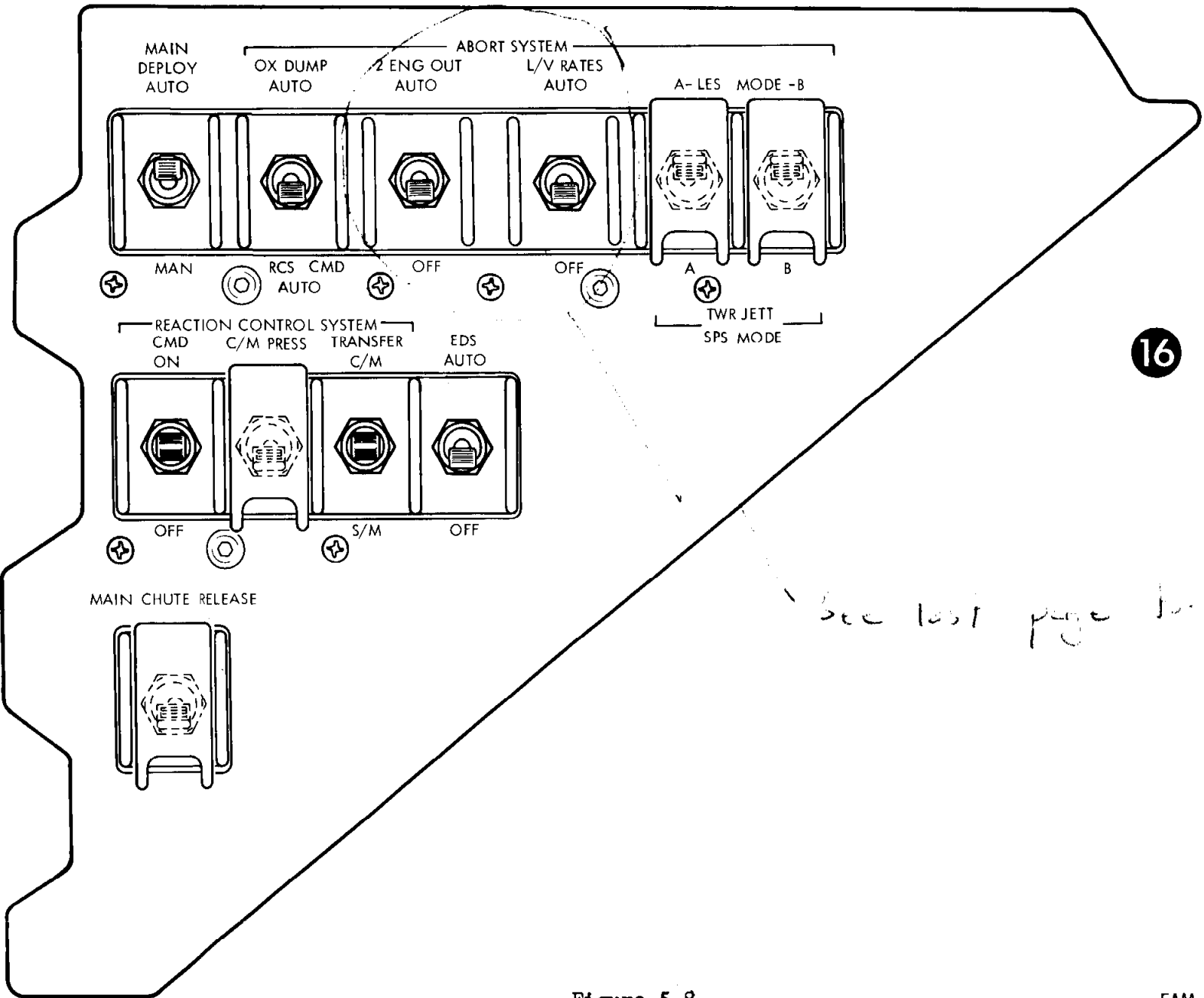
5.6.2.2 2 Engines Out Switch

The 2 ENG OUT switch is a maintain on-off switch. Preceding lift-off, this switch is placed up in the AUTO position to allow 2 or more engines, whose operational parameters have deteriorated to less than satisfactory tolerances, to automatically abort the crew. After 2 minutes of flight, this switch will be placed to the OFF position, which is the "ELECTRICALLY CLOSED" position of the switch, so that the 2 Engine Out Deactivate relays in the EDS is energized inhibiting this automatic abort feature.

5.6.2.3 LV Rates Switch

The LV RATES switch is identical to the 2 Engines Out switch physically and functionally. This switch is placed in the AUTO position before lift-off to permit excessive LV rates to automatically abort the crew. When this switch is placed in the OFF

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Figure 5-8

position after 2 minutes of flight, the Excessive Rates Deactivate relays in the EDS are energized inhibiting excessive rates of the LV from aborting the crew.

5.6.2.4 Mode Switches

The MODE switches are guarded maintain on-on switches. Prior to applying power to the SC's systems, these switches must be in the LES MODE position and not in the TWR JETT SPS MODE position. Two switches are utilized for redundancy; one is a system A switch, the other is a system B switch. Whenever it is desired to jettison the LET, the Commander will place these switches to the TWR JETT position. This position is titled SPS MODE to make it clear to the crew that, once the LET has been jettisoned, the ABORT SYSTEM is in the SPS MODE. The switches being in this position serves no other electrical function other than jettisoning the LET.

5.6.3 Reaction Control System Switches

5.6.3.1 Command Switch

The CMD switch is spring loaded to the center position making the other 2 positions a momentary on. Momentarily holding this switch to the ON position will energize the arming coils of the RCS Control relay, which enables the SCS to control the jet selection logic of the CM's RCS. Momentarily holding this switch to the OFF position will energize the safing coils of the RCS Control relay, disabling SCS control of the RCS.

It is common however, for the MESC to automatically enable the RCS/SCS 1 second after the initiation of an LES abort after 61 seconds of flight, or 2.5 seconds after the initiation of an SPS abort.

The MESC is also depended upon to disable the RCS/SCS automatically on descents with closure of the 24,000 foot baroswitches in the ELSC's. Therefore, this switch serves as a back-up to these MESC functions at these specified times.

Prior to normal SLA separation, however, this switch will be held on momentarily by the Commander to enable the RCS/SCS just before he presses the ADPT SEP switch which will allow the SCS to maintain control of the SC immediately following separation.

5.6.3.2 CM Pressurize Switch

The CM PRESS switch is a guarded momentary on switch, spring loaded to the down and off position. For a normal, successful mission, this switch will be held on momentarily to pressurize the CM's RCS prior to CM - SM separation. Otherwise, it will serve as a back-up to the automatic pressurizing of the RCS by the MESC at the initiation of LES aborts.

5.6.3.3 Transfer Switch

The TRANSFER switch is identical to the CMD switch; being spring loaded to the center position. This switch provides the crew with a back-up to the automatic transfer of RCS CONTROL from the SM to the CM anytime the CM is separated from the SM. It also provides manual back-up to assure SM RCS operation after SLA separation.

If, after SLA separation, the crew determines that there is no RCS response, the Astronaut could momentarily hold the TRANSFER switch to the SM position. If it is determined after CM - SM separation that there is no RCS response, then the Astronaut could momentarily hold this switch to the CM position.

5.6.4 EDS Switch

The EDS switch is a maintain on-off switch. This switch will be kept in the OFF position by the crew until just before lift-off, when it will be placed in the AUTO position. When placed in this position, the EDS automatic abort capability will be enabled at lift-off. The Commander will place this switch back in the OFF position immediately preceding jettisoning the LET, because any possibility for an EDS automatic abort is switched off by relay action within the MESC as the LET is jettisoned anyway.

5.6.5 Main Chute Release Switch

The MAIN CHUTE RELEASE switch is another switch exactly like the CM PRESS and CM - SM SEP switches and is also guarded exactly the same.

This switch has power applied to it anytime that the ELS is armed logically with the 10,000 foot baroswitches closed (below 10,000 feet). It is to be actuated momentarily only after touchdown on the water at which time the Main Landing parachutes will be released from the CM.

5.7 PANEL ASSEMBLY 22

Only SECS panel not on Commander's side of up

Panel Assembly 22 is shown enlarged in figure 5-9. This panel contains 4 circuit breakers vitally important to the SECS. They are the MESC ARM and LOGIC circuit breakers for both systems A and B. All of these circuit breakers are the push-pull, thermal blow type.

5.7.1 Master Event Sequence Controller Circuit Breakers

5.7.1.1 Arm Circuit Breakers

The ARM circuit breakers are rated at 5 amperes. The purpose of these circuit breakers is to

supply 28 VDC from the Battery Busses A and B to the Switch Busses which power many of the switches described in this section.

5.7.1.2 Logic Circuit

The Logic Circuit Breakers are rated at 10 amperes. The purpose of these circuit breakers is to supply 28 VDC from Batteries A and B across the Logic Arming relays to the Logic Busses in the MESC. When the MESC LOGIC switches on Panel Assembly 25, which get their power from the ARM circuit breakers, are locked in the on position the Logic Arming relays in the MESC are energized placing 28 VDC on the Logic Busses.

5.8 PANEL ASSEMBLY 24

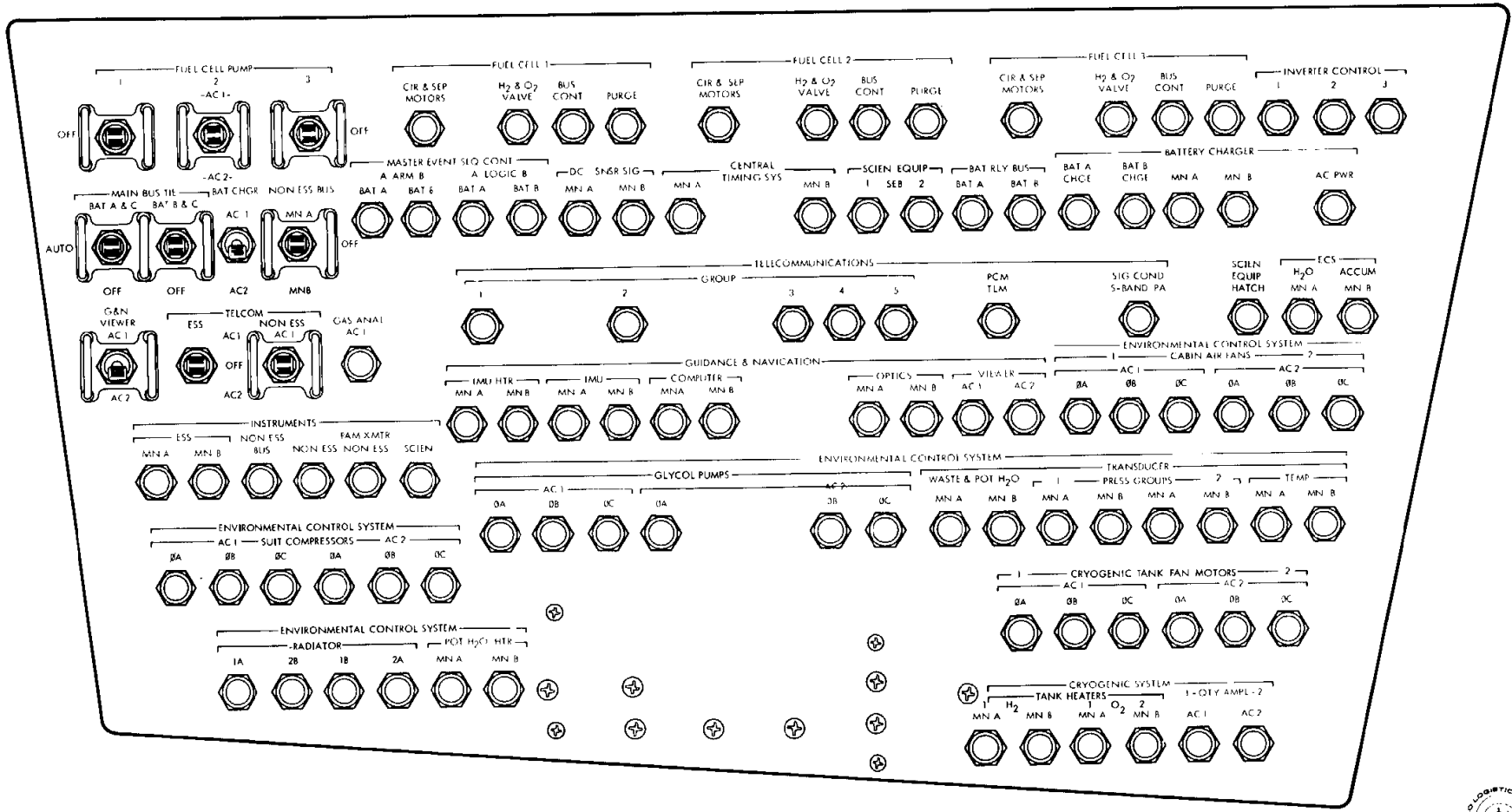
An enlarged view of Panel Assembly 24 is shown in figure 5-10. Three switches on this panel are of prime importance to the SECS. Those switches are the EDS POWER and the MASTER EVENT SEQ. CONT. PYRO ARM switches.

5.8.1 EDS Power Switch

The EDS POWER switch is a maintain on-off switch. When the Commander places this 3 pole switch to the ON position approximately 1 hour before lift-off, 3 EDS busses are energized in the IU and in turn the Abort Voting relays in the MESC. This action forms 3 "hot wire" loops between the CM and IU and establishes the 2 out of 3 voting logic interface between the LV's EDS and the MESC. The 3 EDS circuit breakers, which are described in paragraph 5.9, supply power to this switch.

The normally closed contacts of the EDS Automatic Abort relays in the IU are in these 3 "hot wire" loops. If the Automatic Abort relays in any 2 of the 3 "hot wire" loops become energized during the

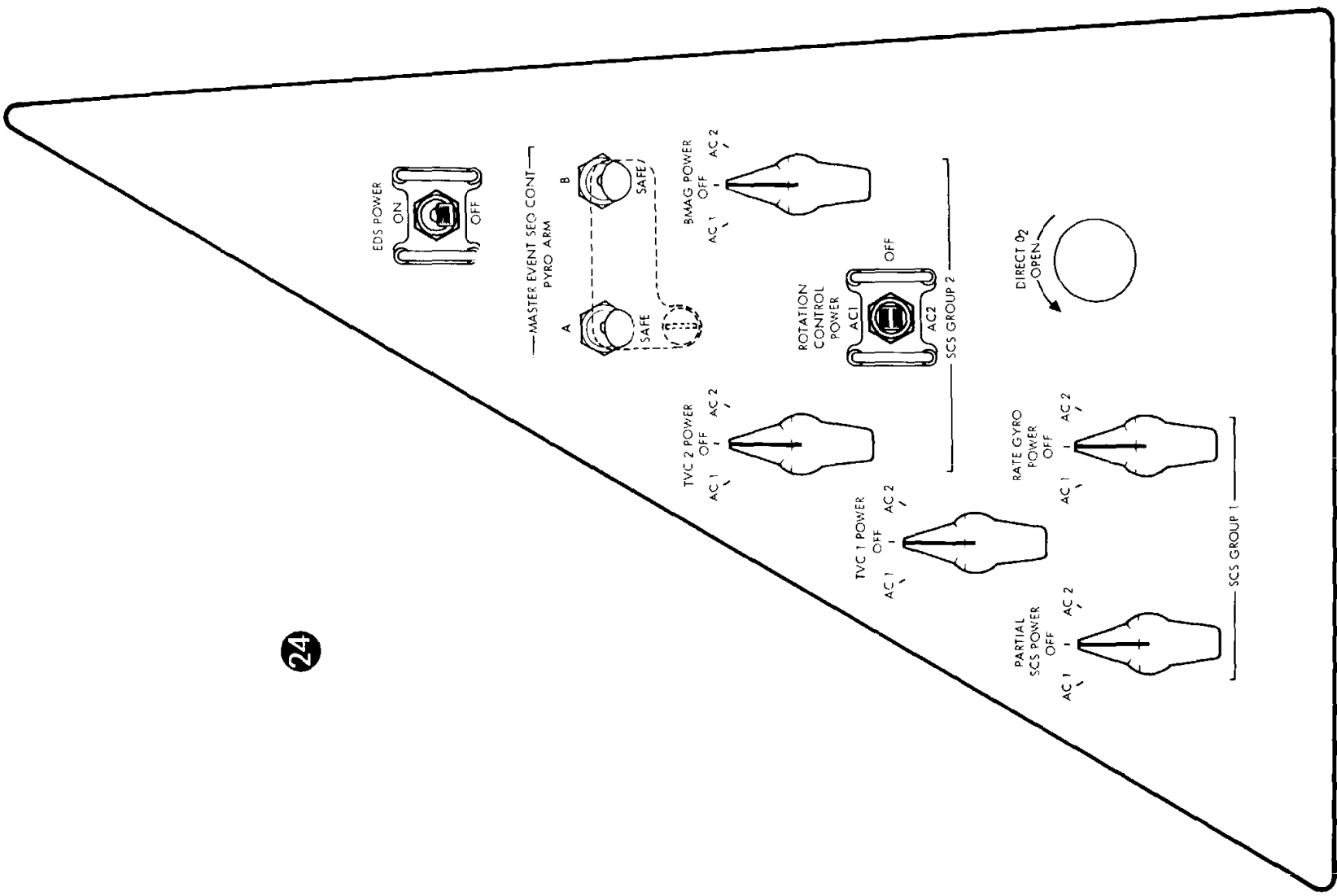
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Figure 5-9





FAM-6224D

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Figure 5-10

5-19

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first 2 minutes of flight, these relay contacts open, breaking those 2 loops and allows 2 pair of Abort Voting relays in the MESC to de-energize. Whenever these 4 of the 6 Abort Voting relays within the MESC become de-energized, an automatic abort is started immediately. With all components functioning reliably, of course, all 3 loops should become de-energized and all MESC Abort Voting relays should de-energize.

After SLA separation, when there is no longer any LV to determine the status of, the EDS POWER switch will be placed to the OFF position, not to be used again throughout the mission.

5.8.2 MESC Pyro Arming Switches

The MESC PYRO switches are maintain on-on lever lock type switch. A lever lock type switch has a spring loaded cap on the toggle, or lever, which allows it to lock into the position selected and cannot be inadvertently bumped out of that position. It takes a positive, deliberate action to change selections on this type switch. Two switches are used for redundancy; one for system A, the other for system B.

A locked cover will be installed over these switches in their SAFE position prior to all pyrotechnic devices being electrically connected before the final countdown on launch day. It is understood at this writing that just before the primary crew for this mission is sealed into the CM that the Pad Safety Officer will hand the Commander a key which will unlock this cover. The Commander will insert the key into the lock, unlock the cover, remove the cover completely, and hand the cover and the key to the Pad Safety Officer. The switches are then exposed for arming the Pyro Busses.

After the crew has been sealed into the CM and the access arm from the umbilical tower to the CM has

been retracted, the Commander will arm the Pyro Busses after arming the Logic Busses of the MESC's by **locking these switches to their ARM position** so that a pad abort may be executed. These switches are powered from the Switch Bus and drive the Pyro Arming relays in the MESC.

5.9

PANEL ASSEMBLY 25

Figure 5-11 is an enlarged illustration of Panel Assembly 25. There are 7 circuit breakers concerned with the SECS on this panel. The MESC LOGIC ARM and ANTENNA DEPLOY switches are also located on this panel.

5.9.1 Antenna Deploy Switches

Redundant ANTENNA DEPLOY switches (A and B) are maintain on-off lever lock type switches. The MESC Pyro Bus provides power to these switches. When the Commander desires to deploy the HF Recovery antenna after touchdown in the water, switch A may be placed to its up position. If the antenna fails to deploy, switch B may be placed to its up position.

5.9.2 MESC Logic Arming Switches

The MESC LOGIC ARM switches are two position lever lock type switches with the up position LOGIC ARM and the down position OFF. These switches must be in the OFF position before power is applied to the SC. To energize the Logic Busses of the MESC, these switches must be locked in the LOGIC ARM (up) position. These switches provide Switch Bus power to the Logic Arming relays in the MESC's which when energized will place power from the MESC LOGIC circuit breakers onto the Logic Busses.

It is suggested that when arming the MESC's that the Logic Busses be energized prior to the Pyro Busses and when turning off the MESC's that the Pyro Busses be de-energized prior to the Logic Busses.

5.9.3 Event Timer Circuit Breakers

The EVENT TIMER circuit breakers are rated at 5 amperes each. They provide redundant power sources from the Main DC Bus to the Digital Event Timer Readout.

5.9.4 EDS Circuit Breakers

The EDS circuit breakers are rated at 5 amperes each. The number 1 circuit breaker supplies 28 VDC from Battery A to the number 1 EDS Bus in the IU through the EDS POWER switch. The number 2 circuit breaker supplies 28 VDC from Battery C, or Post Landing Battery, to the number 2 EDS Bus in the IU through the EDS POWER switch. The number 3 circuit breaker supplies 28 VDC from Battery B to the number 3 EDS Bus in the IU through the EDS POWER switch.

5.9.5 ELS Circuit Breakers

The ELS circuit breakers are rated at 10 amperes each. These circuit breakers provide redundant power sources from Batteries A and B to the ELS LOGIC, DROGUE DEPLOY, and MAIN DEPLOY switches.

5.10 TRANSLATION CONTROLLER

Two Translation Controllers are mounted side by side on the forward end of the left hand armrest of the Commander's couch. A photographic illustration of one of these is shown in figure 5-12.

A 20° counterclockwise twist of the "T" handle will initiate an abort at anytime after the MESC is

armed on the launch pad until SLA separation. The "T" handle is spring loaded to the neutral position requiring a certain amount of torque in order to be rotated. With an additional amount of torque exerted, the "T" handle will latch into a detent.

For an abort, the "T" handle must be rotated counterclockwise into the latched position. The "T" handle must be left in the latched counterclockwise position to maintain a direct ullage on the SC until after the ignition of the SPS engine. After the SPS engine has ignited, the Commander may overpower the latch on the "T" handle and allow it to return to its neutral position to discontinue the direct ullage.

For normal SLA separation, as briefly described previously, the "T" handle will be pushed forward, after momentarily holding the RCS CMD switch to the ON position, to start a +X translation. This will apply tension to the SLA exactly as a direct ullage would do for an SPS abort. Approximately 2 seconds after starting a +X translation, the Commander will push the ADPT SEP switch, which will separate the CSM from the S-IVB. When the Commander desires to discontinue the +X translation, he will return the "T" handle to its neutral position.

The lock shown above the "T" handle locks out translation movements only. It does not lock out the abort capability at anytime.

TRANSLATION CONTROLLER

(2 CONTROLLERS)
L. H. ARM REST

Press to talk
(when connecting)

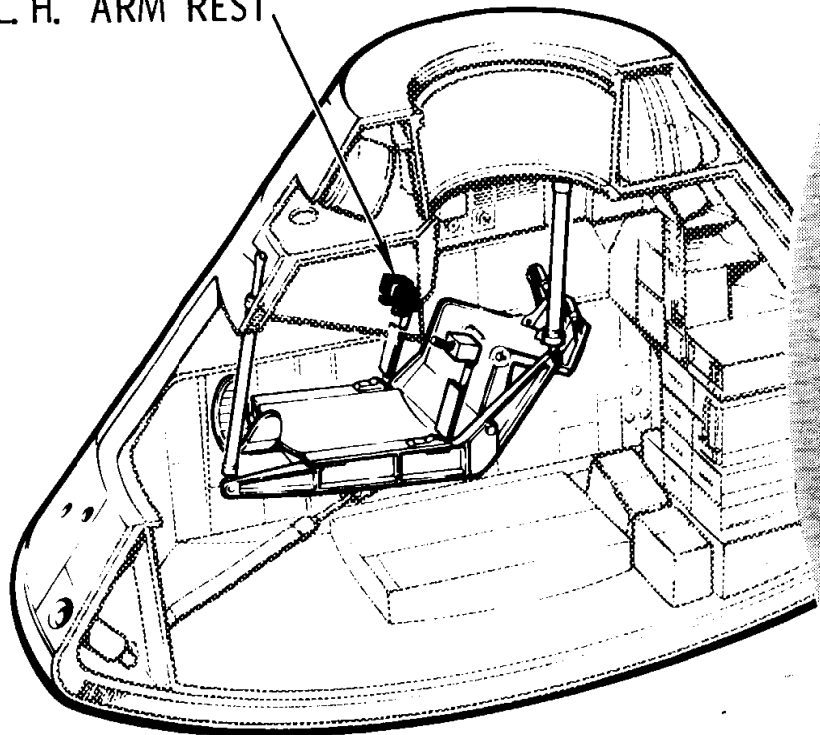


Figure 5-12

SECTION VI

EVENT PROFILES

The major events performed by the SECS on the first manned Apollo mission will be: tower jettison, adapter separation, CM - SM separation and SM jettison, and parachute deployment for earth recovery as depicted in figure 6-1.

The flight path of this mission can be divided into several phases and events. Those phases principally applicable to the SECS are normal launch, ascent, pre-entry, and descent. A typical normal flight path may be presented graphically to illustrate the events in their proper sequence that occur during these various phases as controlled by the SECS. This representation is called an event profile.

If contingencies arise any time during these normal phases, a deviation from the norm is required. Such a deviation would constitute one of several contingency flight paths or abort profiles determined by time factors or by the altitude attained at the time of the contingency. This section describes the various event profiles related to the SECS.

To aid the reader in interpreting the following event profiles, this explanatory statement is made: Whenever the verb in a certain event callout follows the noun, this means an automatic function, but whenever the verb precedes the noun, this means a manually initiated function.

All functions telemetered to the MSFN are indicated by a "(TLM)" callout following the event pointed out in each event profile.

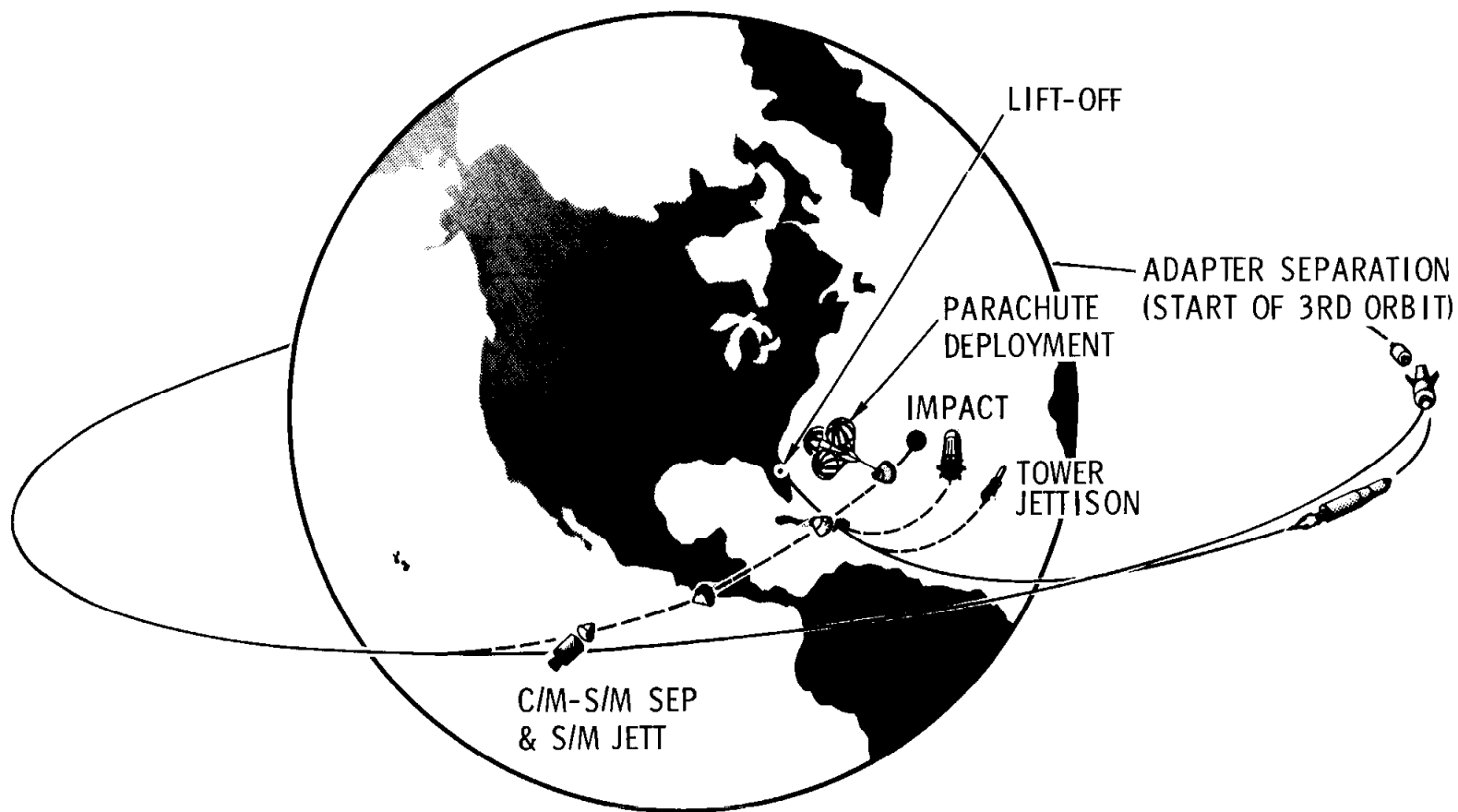
6.1 NORMAL ASCENT

During the normal ascent phase, which begins at lift-off and ends at orbit attainment, the major event handled by the SECS is the jettisoning of the LET. Jettisoning the unused and no longer necessary LET is initiated manually by the crew and performed by functions within the MESC. Present plans call for the crew to jettison the LET twenty seconds after the second and final stage of the Saturn IB LV, the S-IVB, is ignited. Refer to item 8 in figure 6-2. A normal tower jettison is portrayed in figure 6-3.

Another major event handled by the SECS is separation from the LV, normally referred to as adapter separation, at commencement of the third orbit. The events which occur for a normal adapter separation are similar to those which occur for an SPS abort and will, therefore, be described in the SPS abort portion of this section. A normal adapter separation is illustrated in figure 6-4.

Other events which take place during a normal ascent and which has bearing upon, or influences the SECS in some way or another, are also noted in figure 6-2. First of all, lift-off at $T = 0$ is when the automatic abort features of the EDS and its interface with the MESC are enabled. At $T = +61$ seconds (item 2), and when the LV will have attained an altitude of approximately 24,000 feet, the automatic Oxidizer dump feature times out and a switch on the displays and controls panel must be repositioned by the crew from AUTO OX DUMP to RCS CMD (Command) AUTO which will

MAJOR EVENTS PERFORMED BY THE SECS ON FIRST MANNED APOLLO MISSION



6

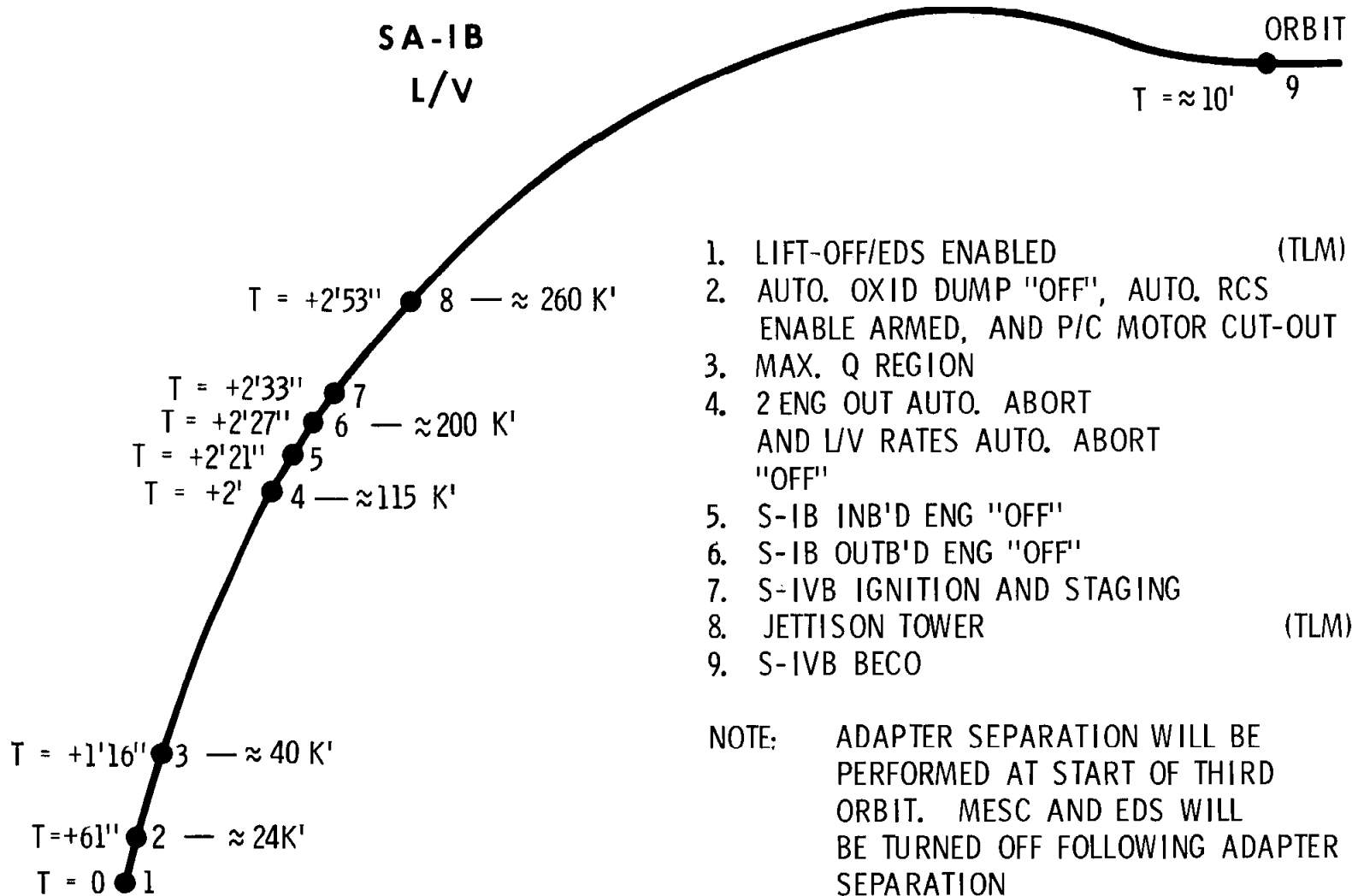
Figure 6-1

EVENT PROFILE

NORMAL ASCENT

SA-IB

L/V



1. LIFT-OFF/EDS ENABLED (TLM)
2. AUTO. OXID DUMP "OFF", AUTO. RCS ENABLE ARMED, AND P/C MOTOR CUT-OUT
3. MAX. Q REGION
4. 2 ENG OUT AUTO. ABORT AND L/V RATES AUTO. ABORT "OFF"
5. S-IB INB'D ENG "OFF"
6. S-IB OUTB'D ENG "OFF"
7. S-IVB IGNITION AND STAGING
8. JETTISON TOWER (TLM)
9. S-IVB BECO

NOTE: ADAPTER SEPARATION WILL BE PERFORMED AT START OF THIRD ORBIT. MESC AND EDS WILL BE TURNED OFF FOLLOWING ADAPTER SEPARATION

Figure 6-2

SEQ-45F



6-3

6

NORMAL TOWER JETTISON

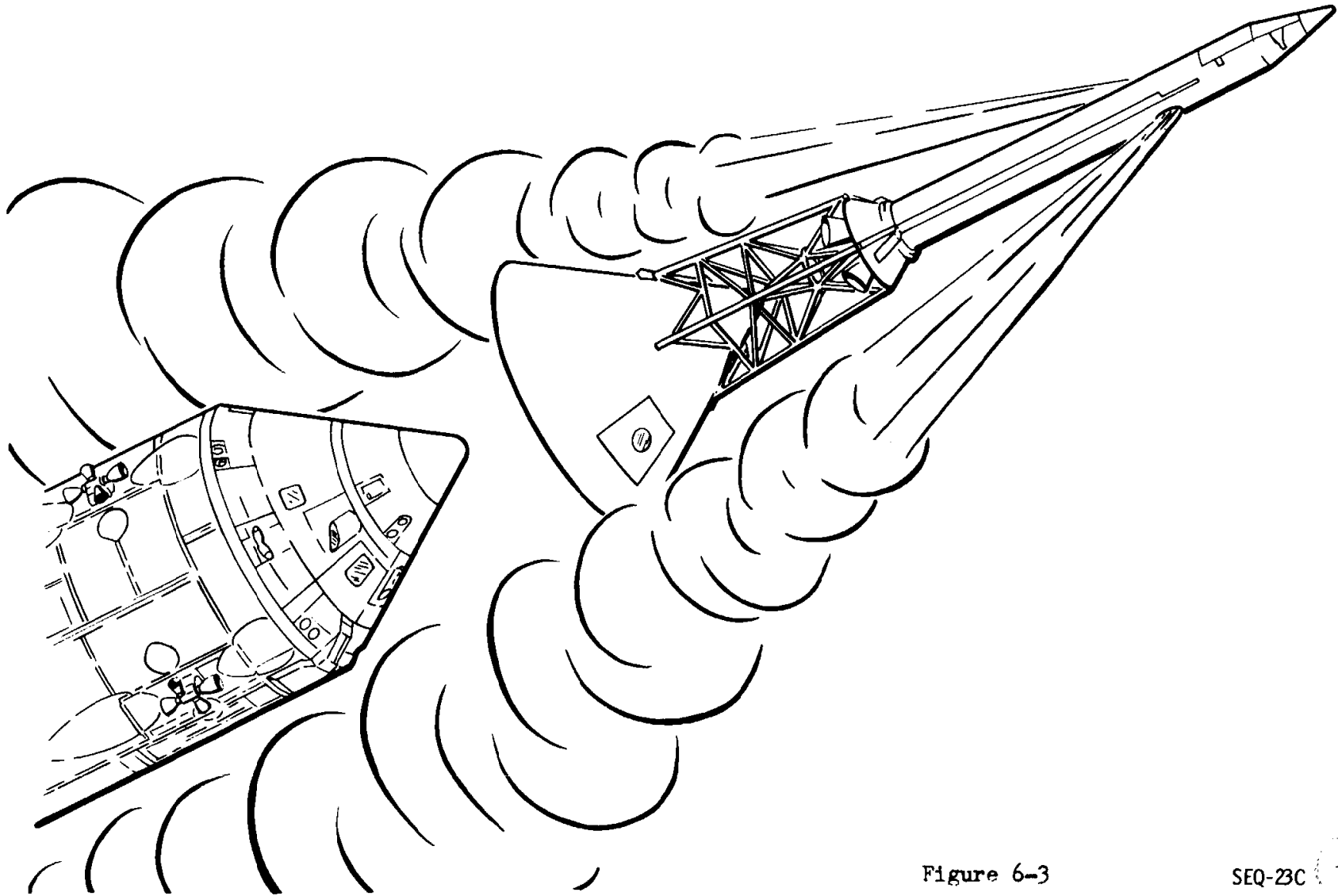


Figure 6-3

NORMAL ADAPTER SEPARATION

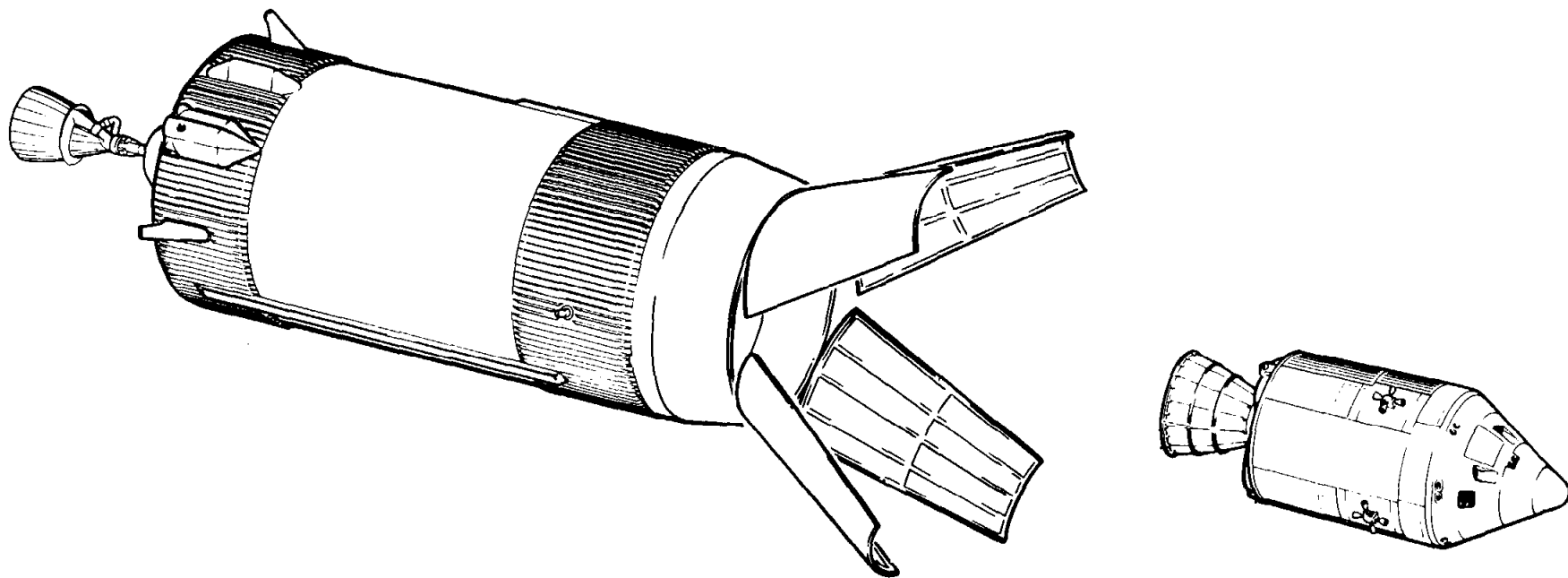


Figure 6-4

SEQ-80



6-5

enable the CM's RCS one second after an initiation of an LES abort, if an abort is initiated.

It is calculated that the Max. Q (dynamic pressure) area will be at approximately 40,000 feet and $T = +1$ minute 16 seconds. Refer to item 3. If LV rates become excessive while ascending through this region an automatic abort may be triggered.

Item 4 at $T = +2$ minutes is the point in time when it is planned for the crew to inhibit both automatic abort features of the EDS, namely, 2 engines out and LV rates, in preparation for first stage staging.

The S-IB (first stage) engines will stop thrusting as indicated by points 5 and 6. The 4 in-board engines will quit thrusting first, then the 4 outboard engines will stop a few seconds later at which time the crew will be at approximately 200,000 feet.

At $T = +2$ minutes 33 seconds (item 7), staging and S-IVB (second stage) ignition and at $T = +2$ minutes 53 seconds and at approximately 260,000 feet of altitude, the crew will initiate LET jettison as previously mentioned.

The S-IVB continues to thrust the SC into orbit in the manner simulated in this profile. This is referred to as a lob shot, shooting high, then diving into orbit to gain orbital velocity. As orbital velocity is attained at approximately $T = +10$ minutes, indicated as item 9, the S-IVB engine is stopped from thrusting (commonly called S-IVB BECO or Cut-off). A few seconds after adapter separation at the start of the third orbit, the crew will turn off the MESC and the EDS.

6.2 NORMAL PRE-ENTRY AND DESCENT

The event profiles for the normal pre-entry and descent phases are illustrated in figures 6-5, 6-6, and 6-7. It will be noted in figure 6-5 that following the final delta V correction (deorbit maneuver) the crew must arm the MESC. The MESC must be armed in order to perform CM - SM separation, as indicated by item 3, after being initiated manually. SM jettison is also performed at this time, as portrayed in figure 6-6, after being triggered by the actuation of the CM - SM SEP switch. Figure 6-6 will be discussed further following the explanation of figure 6-5.

At this writing, it is thought to be most practical for the crew to pressurize the CM's RCS prior to initiating CM - SM Separation, as indicated by item 2, rather than wait for it to be done automatically by the MESC at separation. The crew could actuate the CM RCS PRESS switch and check that the system had pressurized prior to separation rather than having to check on pressurization of the RCS after separation, along with a multitude of other duties being performed at this time.

Immediately following initiation of CM - SM Separation, items 4 through 6 occur and with only 100 milliseconds time delay, item 7 occurs. For instance, the CM - SM wiring umbilical must be deadfaced prior to being cut, or destroyed, in item 7 when the CM is separated from the SM. RCS control must be transferred from the SM to the CM so that the CM may be controlled on entry. One and eight-tenths seconds after initiation of separation, the pyro power to the Tension Tie Plates and the Guillotine is cut-off, indicated in item 8.

EVENT PROFILE

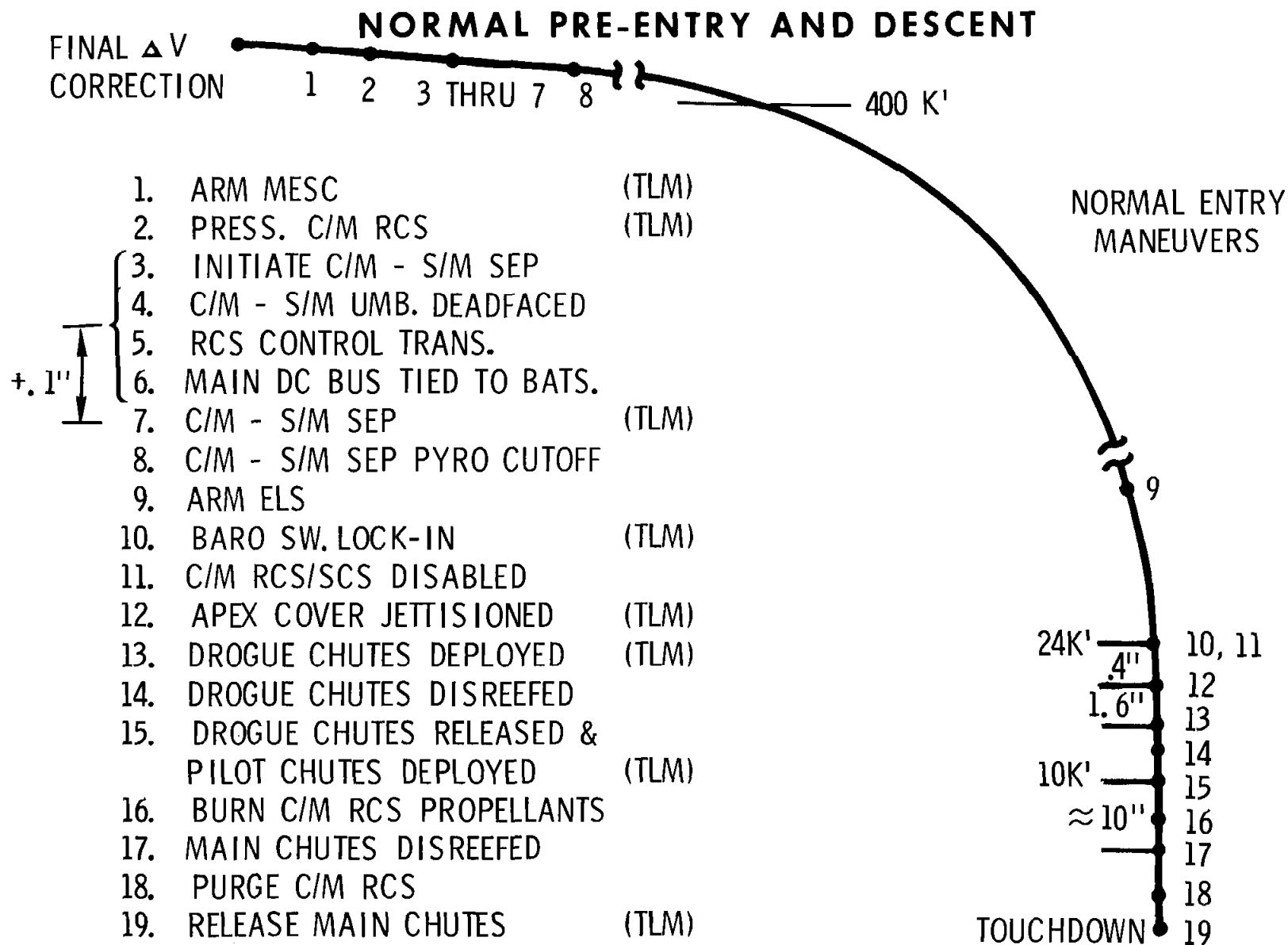


Figure 6-5

SEQ-46J



At approximately 50,000 feet, the crew may arm the ELS logic circuitry by manually placing the ELS LOGIC switch on, shown as item 9.

As the CM descends to approximately 24,000 feet the CM RCS/SCS is disabled, or turned off, as indicated by item 12. Closing of the 24,000 foot baroswitches in the ELSC applies voltage to the safing, or disarming, coils of the RCS Control Latching relay in the MESC effecting this operation.

When the 24,000 foot baroswitches in the ELSCs close baroswitch lock-in occurs (item 10), the CM RCS/SCS is disabled and redundant .4 second, 2 second, and 14 second time delays in both redundant systems of the ELSCs are energized. As the .4 second time delays time out the Apex Cover is jettisoned (item 12). As the 2 second time delays time out, 1.6 seconds after the Apex Cover is jettisoned, the 2 Drogue parachutes are deployed in a reefed condition. Within nine seconds later, the Drogue parachutes disreef. The 14 second time delays in the Main Landing parachute circuitry will time out 14 seconds after the 24,000 foot baroswitches close, then as the 10,000 foot baroswitches in the ELSCs close, the Drogue parachutes are released and the 3 Pilot parachutes are deployed, which in turn deploy the 3 Main Landing parachutes in a reefed condition, indicated as item 15. Approximately 10 seconds after Pilot parachute deployment, the Main Landing parachutes are disreefed, figuring an 8 second reefed condition and approximately 2 seconds of time elapsing while the Main Landing parachutes are being fully deployed and stretched.

Following deployment and disreefing of the Main Landing parachutes, the crew will initiate the burn-off of the remaining CM RCS Propellants by placing the CM PROPELLANT DUMP switch on. After complete burn-off of Propellants, the crew will initiate purging of the CM RCS by placing the CM PROPELLANT PURGE switch on,

shown in item 18. This action will inert the RCS prior to impact as a safeguard against a possible fire if the RCS Propellant tanks should rupture at touchdown. After touchdown, the crew will initiate release of the Main Landing parachutes by placing the MAIN CHUTE REL switch on momentarily.

6.2.1 SM Jettison

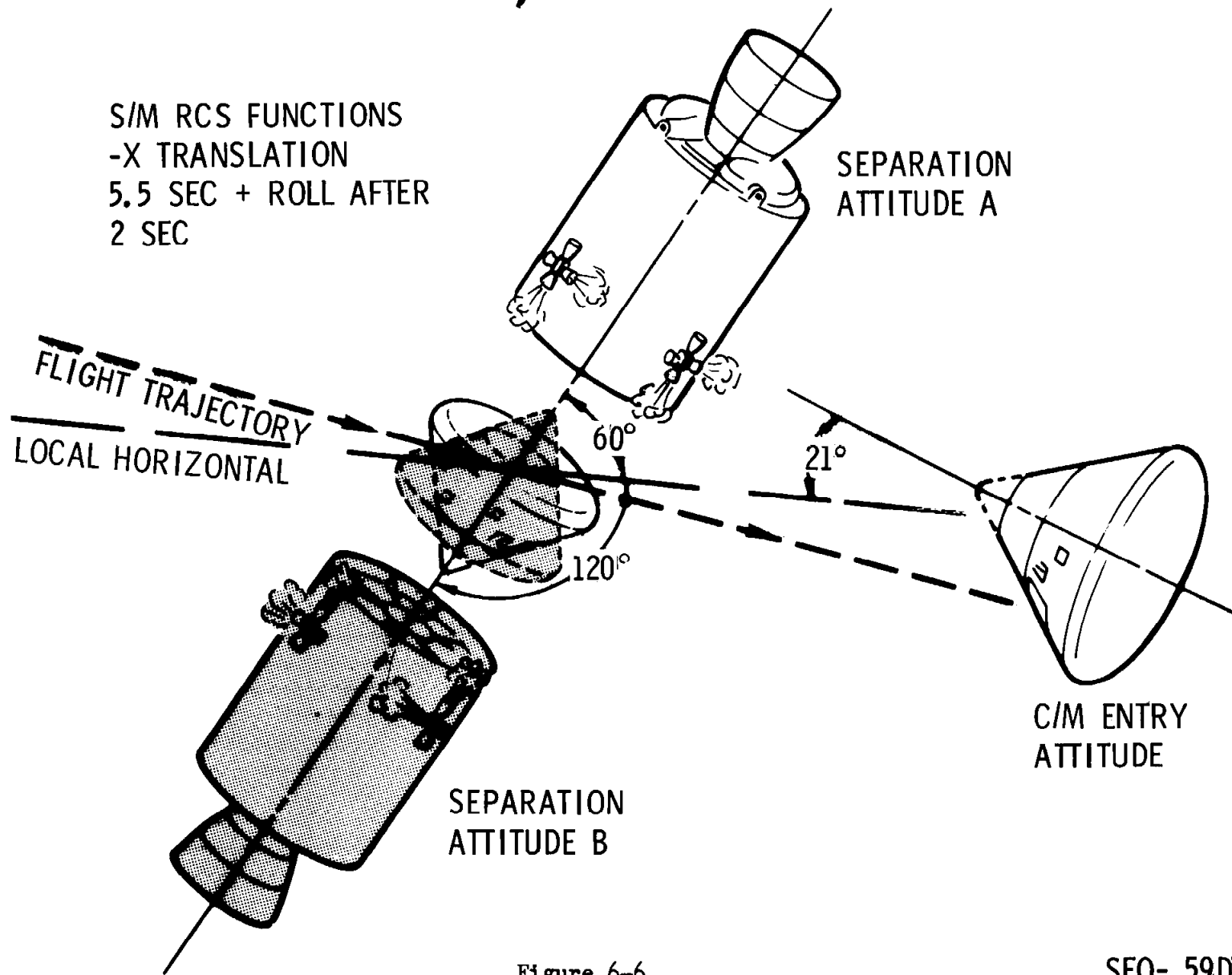
Figure 6-6 depicts the SM RCS functions as controlled by the SMJC for effecting SM jettison, initiated when the crew places the CM - SM SEP switch on momentarily. Note the -X translation which is started immediately. After redundant 2 second time delays have timed out, a 5.5 second positive roll is initiated. The -X translation will continue until depletion of the SM RCS Propellants or until the SM batteries fail. After separation has been effected, the CM will be placed into the normal entry attitude as illustrated.

The reason for jettisoning the SM in this manner is to effect a definite separation away from the CM and to cause the SM to wobble away from the CM on some other entry trajectory from that of the CM. By jettisoning the SM up, or away from earth, it will overshoot the CM on a short range entry and by jettisoning down, or towards earth, the SM will undershoot the CM for a long range entry, when jettisoned approximately as illustrated.

6.2.2 ELS Normal Sequence

Referring to figure 6-7, item 1 depicts Apex Cover jettison .4 second after closure of the 24,000 foot baroswitches. Drogue parachute deployment 2 seconds after closure of the 24,000 foot baroswitches is portrayed in item 2. The disreefed Drogue parachutes are shown in item 3. Item 4 illustrates the

NORMAL C/M-S/M SEPARATION AND S/M JETTISON



6

Figure 6-6

Note: Apex cover
 cover
 can't be
 jettisoned
 until
 48,000 ft

EARTH LANDING SYSTEM

NORMAL SEQUENCE

MAIN CHUTE
 DEPLOYMENT BAG
 MAIN CHUTES
 REEFED

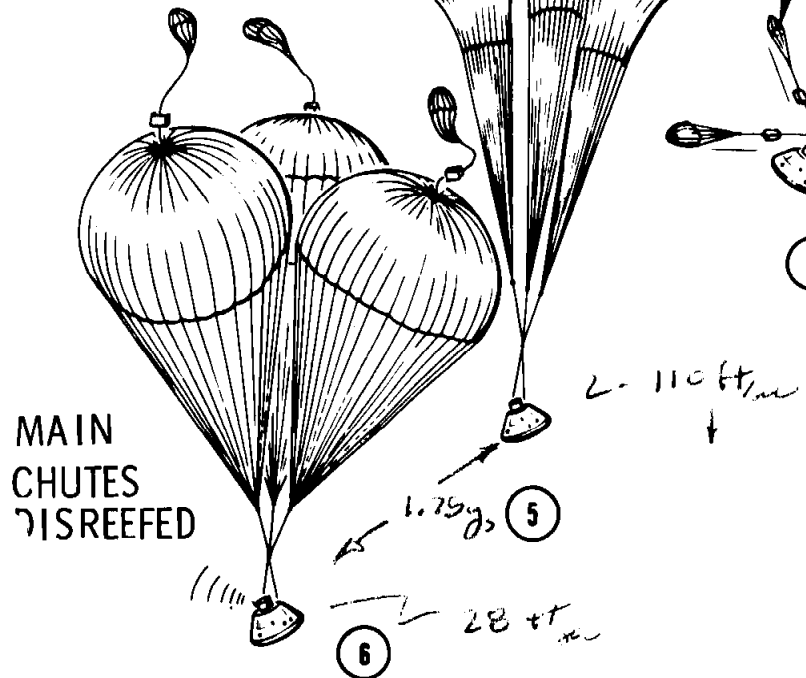
PILOT CHUTES

$v = 425 \text{ ft/sec}$ down

APEX
 COVER

DROGUE CHUTES REEFED

DROGUE CHUTES DISREEFED



1. APEX COVER JETTISONED BY 24,000 FT + .4 SEC
2. DROGUE CHUTES DEPLOYED BY 24,000 FT + 2 SEC (REEFED FOR 8 SEC)
3. DROGUE CHUTES DISREEFED
4. PILOT CHUTES DEPLOYED & DROGUE CHUTES RELEASED BY 10,000 FT
5. MAIN CHUTES DEPLOYED BY 10,000 FT (REEFED FOR 8 SEC)
6. MAIN CHUTES DISREEFED, RECOVERY ANTENNA, & BEACON DEPLOYED
7. MAIN CHUTES RELEASED AFTER TOUCHDOWN

TOUCHDOWN VELOCITIES:
 3 CHUTES - 28 FT/SEC
 2 CHUTES - 33.5 FT/SEC

Figure 6-7

6

release of the Drogue parachutes and the deployment of the Pilot parachutes as the 10,000 foot baroswitches close. Item 5 shows clearly how the Main Landing parachutes are suspended from the Pilot parachutes and deployment bags in the reefed condition. The Main Landing parachutes are portrayed in their disreefed state in item 6. The VHF recovery antennas and flashing beacon are deployed 8 seconds after the deployment of the Main Landing parachutes. Note the collapse of the Pilot parachutes and the deployment bags on top of the Main Landing parachutes canopies. Item 7 illustrates the release of the Main Landing parachutes onto the water. Touchdown velocity on all 3 parachutes is approximately 28.0 feet per second. If one parachute should fail to deploy or is lost, the remaining 2 parachutes will allow the CM to impact at approximately 33.5 feet per second.

6.3 PAD TO T +61 SECOND LES ABORT

The following text describes the sequenced events outlined in figure 6-8 that occur if an LES abort is initiated either while on the launch pad or at any time from lift-off plus 61 seconds. If an abort is initiated within this period, the Oxidizer of the CM's RCS Propellants will always be automatically dumped overboard, as indicated by item 8, immediately following all initial operations. These initial operations are items 1 through 7.

Range Safety's 40 second BECO Lockout time delay prevents BECO from occurring in this profile, even though the MESC attempts to shut down the booster, for the first 40 seconds from lift-off. Otherwise, BECO will occur immediately with the initiation of the abort.

The Event Timer will be reset to zero and started again totalizing time from the instant the abort was triggered.

The CM - SM umbilical will be deadfaced, the CM RCS will be pressurized, the RCS control will be transferred from the SM to the CM, and an automatic backup signal will be generated for tying the batteries to the Main DC Bus.

The CM will be separated from the SM by the cutting of the Tension Tie Plates and the umbilical one-tenth of a second after the initiation of the abort as shown in item 9. At this same instant, the Launch Escape and Pitch Control motors will be ignited as indicated by items 10 and 11. Item 12 points out that 1.8 seconds after abort initiation the separation pyro circuits are cut-off, or de-energized. This is done to prevent Pyro Battery power drain-off in case of a high resistant short to ground at the Tension Tie Plates or where the Guillotine cut the umbilical.

The Canards will be deployed 11 seconds after the initiation of the abort, as shown in item 13. This is approximately 3 or 4 seconds after burn-out of the Launch Escape motor and as the LEV is coasting upwards towards the apogee of the abort trajectory.

Three seconds following Canard deployment, items 14, 15, and 16 will transpire. The ELS will be armed and baroswitch lock-in will occur because the 24,000 foot baroswitches in the ELSC's will be closed. These functions will cause the LET and Boost **Protective Cover (BPC)** to be jettisoned. Simultaneous with these events, the .4 second time delays for Apex Cover jettison, the 2 second time delays for Drogue parachute deployment, and the 14 second time delays for Pilot parachute deployment are energized.

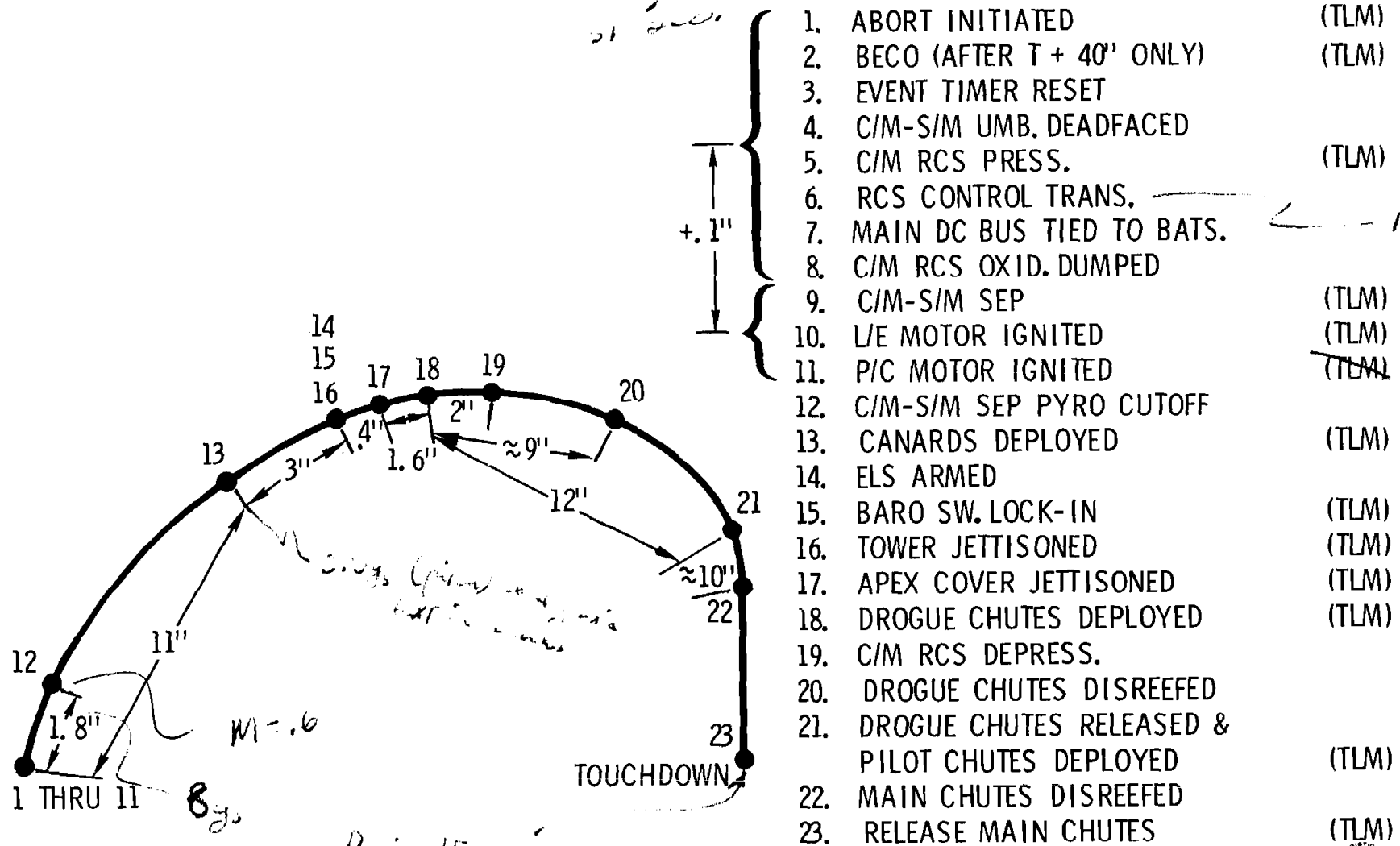
When the .4 second time delays time out, the Apex Cover will be jettisoned as portrayed in item 17. As the 2 second time delays time out 1.6 seconds after the Apex Cover is jettisoned, the Drogue parachutes will be deployed, shown as item 18.

6

Note: NAA guarantees
water landing if
west wind is less than 10 kts

EVENT PROFILE

PAD TO T+61" LES ABORT



6

Design 15yps in coach
7yps normally

Figure 6-8

SEQ-103D



6-12

Eighteen second time delays in the RCSC's are started with abort initiate which will automatically depressurize the CM RCS by dumping the Helium 2 seconds after Drogue parachute deployment. See item 19. In this abort area it has been decided to dispose of the Helium by dumping, because of the tremendous pressure in the Helium supply tanks possibly causing damage to the CM if a supply tank should burst with impact on the water. It has also been decided that the Fuel will not be dumped in this profile. Instead, the crew will land with full Fuel supply tanks because there may not be enough time on the descent phase of an abort to dump the Fuel.

Item 20 points out that the Drogue parachutes will disreef in less than 9 seconds from the time of their deployment figuring an 8 second reefed condition following deployment.

The Drogue parachutes will be released and the Pilot parachutes deployed 12 seconds after the Drogue parachutes were deployed if the abort was initiated below approximately 11,000 feet which will guarantee that the 10,000 foot baroswitches will be closed, and if the Commander allows the automatic sequence of the ELSC's to continue, as illustrated in item 21. The Commander has the option, however, to inhibit the deployment of the Main Landing parachutes via the Pilot parachutes, if he and the monitoring ground personnel think it wise to do so, by placing the MAIN DEPLOY switch on Panel Assembly 16 from the AUTO position to the MAN position. The Commander may then manually deploy the Main Landing parachutes by pushing the MAIN DEPLOY switch on Panel Assembly 5 whenever he desires. The Commander also has the option to deploy the Main Landing parachutes immediately following deployment of the Drogue parachutes by pushing the MAIN DEPLOY switch on Panel Assembly 5. Monitoring the Altimeter on Panel Assembly 1 will aid the Commander in deciding which course of action to take.

It is estimated that approximately 10 seconds will elapse between Pilot parachute deployment and Main Landing parachute disreefing, figuring an 8 second reef and approximately 2 seconds for the Pilot parachutes to fully deploy the Main Landing parachutes. This point is indicated by item 22.

Item 23, indicating release of the Main Landing parachutes, is manually initiated by the Commander momentarily holding the MAIN CHUTE RELEASE switch on after touchdown on the water.

6.4 61 SECONDS AFTER LIFT-OFF TO 30,000
 FEET LES ABORT

Figure 6-9 presents the events which take place during an LES abort sometime between 61 seconds after lift-off and attainment of approximately 29,000 feet of attitude. The major difference in the events occurring in this abort profile, and all other subsequent abort profiles, from the preceding profiles is that the CM Propellants will always be burned off following Main Landing parachute deployment because the Oxidizer does not get dumped immediately following initiation of the abort. Refer to item 21. Approximately 3 minutes 40 seconds of time must be allowed for the burn-off of a complete Propellant load, in case one complete system fails to operate.

After the crew determines that the RCS Propellant has been completely depleted, the Commander will place the CM PROPELLANT PURGE switch on Panel Assembly 8 to its on position to purge the RCS, as called out by item 23.

As was previously described in the normal ascent event profile, the crew will place the OX DUMP switch from the AUTO position to the RCS CMD AUTO position at 61 seconds after lift-off. This will guarantee that the automatic Oxidizer Dump and PC motor ignition circuitry is disabled in case of a

EVENT PROFILE

T+ 61" TO <30,000 FT LES ABORT

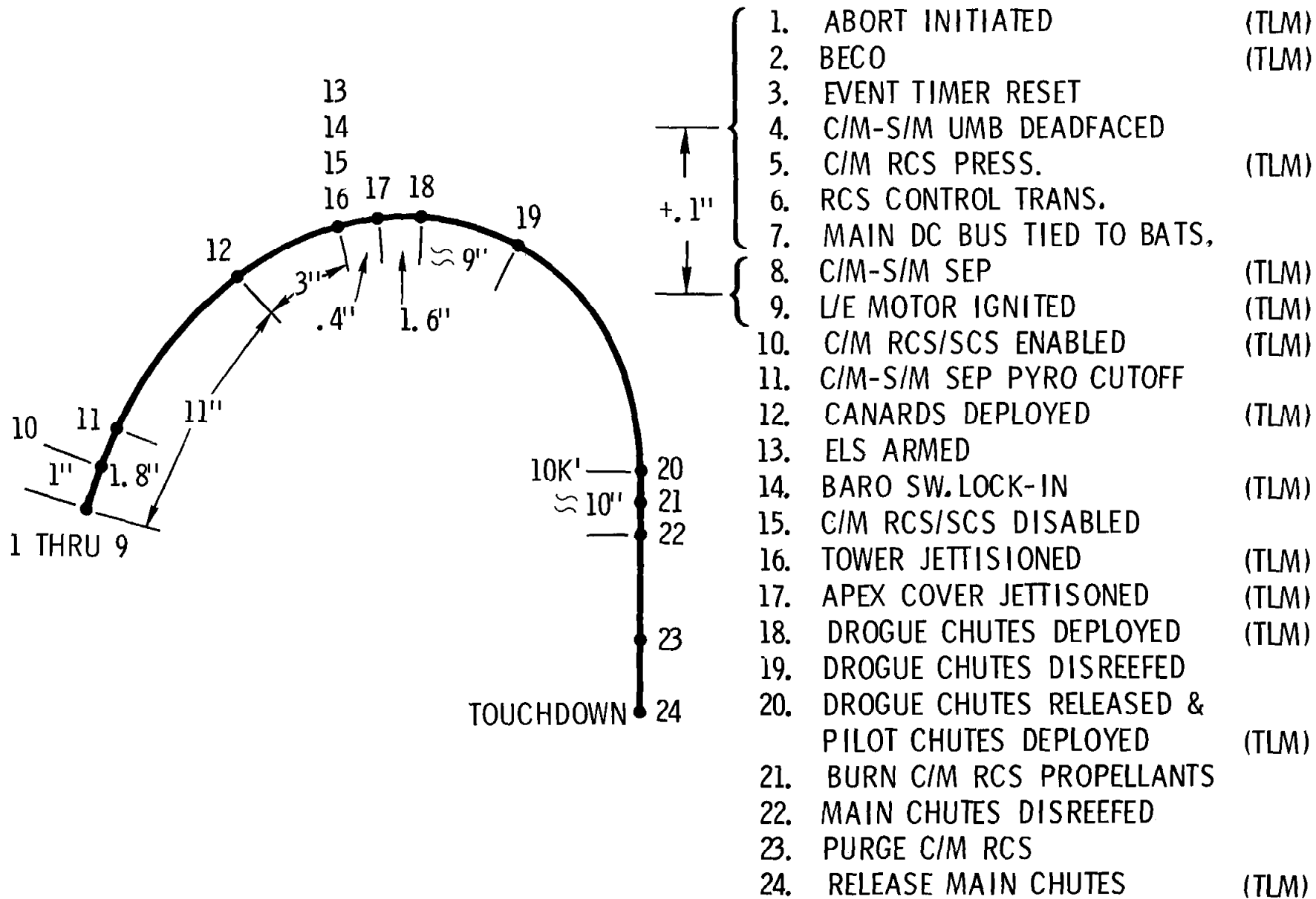


Figure 6-9

SEQ-72H



LOW ALTITUDE LES ABORT (PAD TO <30,000 FT.)

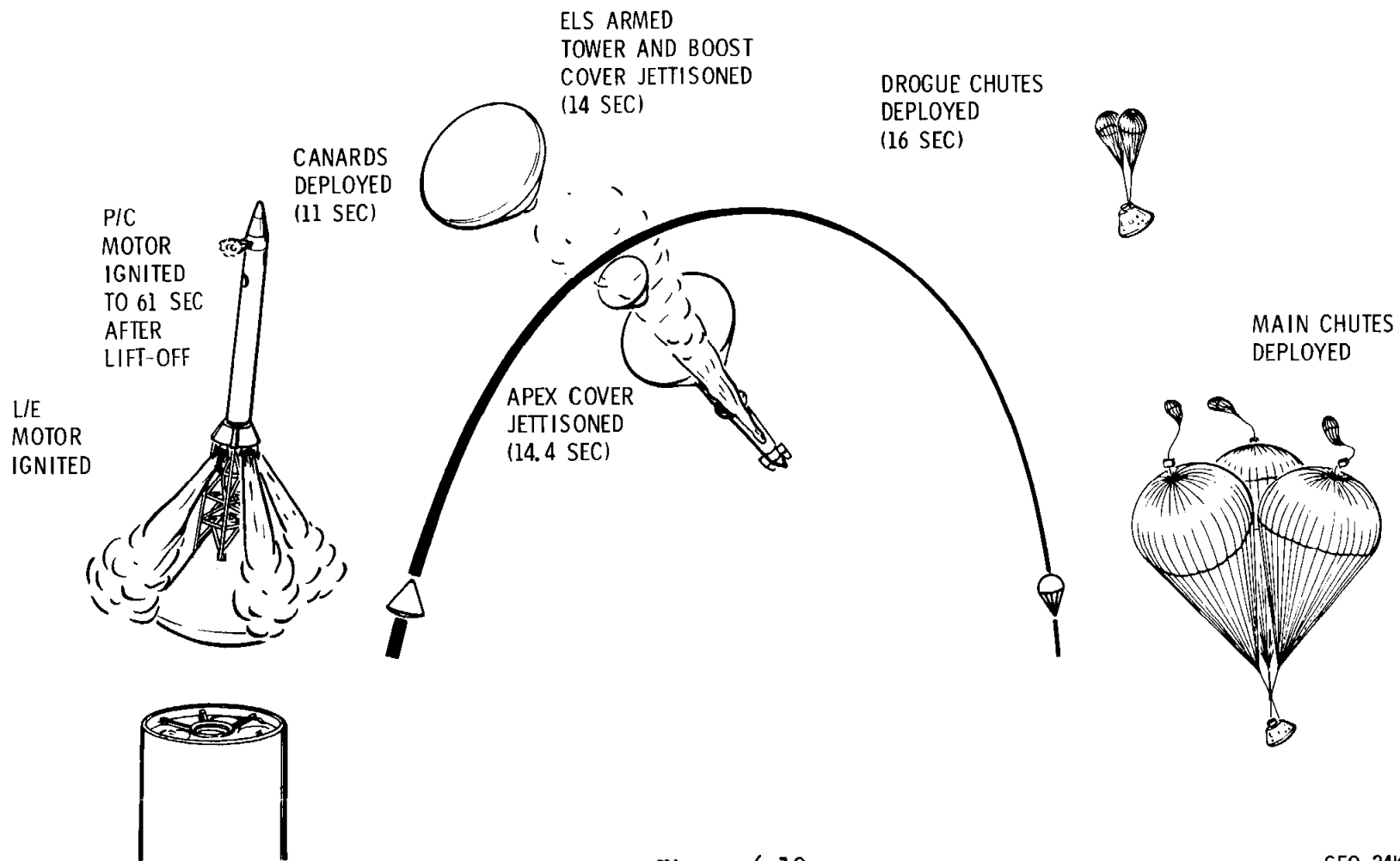


Figure 6-10

malfunctioning 61 second time delay in the RCSC's, and will provide direction for power to energize the 1 second time delays which precede enabling of the CM's RCS/SCS. One second of elapsed time (item 10) is required before enabling the RCS to allow stabilization of pressure throughout the system for all LES aborts. Thirteen seconds later the RCS is disabled automatically when the ELS is armed and with baroswitch lock-in as noted in item 15.

In this abort profile, as in any abort after 40 seconds from lift-off, BECO is effected automatically by the MESC immediately upon the initiation of the abort.

The length of time on the Drogue parachutes is a variable in this abort profile, dependent upon when the abort was initiated. For all aborts above approximately 11,000 feet the time on the Drogue parachutes will exceed the 12 seconds of time illustrated in the preceding profile, because of the 10,000 foot baroswitches opening at approximately 18,000 feet on ascent. The greatest length of time on the Drogue parachutes would be from an abort triggered at approximately 29,000 feet, when the apogee of the abort trajectory will reach approximately 42,000 feet. All other events which occur in this profile are exactly as those described in the preceding profile.

Figure 6-10 illustrates those major events that occur during a low altitude LES abort (pad to 30,000 feet) with relative time from abort initiation.

6.5 MEDIUM ALTITUDE LES ABORT

Figure 6-11 depicts the events which take place during a medium altitude LES abort (30,000 feet to 120,000 feet). The major events that occur during this abort is portrayed in figure 6-12 with their time and altitude relationships.

It has been calculated that an abort initiated at a geometric altitude of approximately 30,000 feet or after $T = +70$ seconds would result in a medium altitude LES abort. The reason for this is the fact that the 24,000 foot baroswitches will open at an approximate geometric altitude of 38,000 feet on ascent of the abort trajectory before the ELS is armed at 14 seconds after the initiation of the abort. Since automatic tower jettison is dependent upon the 24,000 foot baroswitches being closed, in this abort profile the LET will not be jettisoned until the LEV descends to a minimum altitude of 24,000 feet.

All events listed from 1 through 13 occur in exactly the same sequence as in the low altitude aborts after 61 seconds from lift-off. After the turn-around maneuver initiated by the Canards is completed, the Canards will stabilize the CM blunt end forward and apex aft preparatory to parachute deployment, in the same manner as feathers on an arrow. The CM's RCS/SCS will be functioning throughout this period, also, commencing 1 second from the initiation of the abort.

As the 24,000 foot baroswitches close (item 14) after descending to approximately 24,000 feet, the RCS/SCS will be disabled and the LET will be jettisoned as per items 15 and 16.

Items 17 through 22 will be sequenced automatically exactly as during a normal descent, except item 21. The burn-off of all remaining RCS Propellants, the purging of the RCS, and the release of the Main Landing parachutes will be initiated manually by the crew in the same sequence as during a normal descent.

6.6 HIGH ALTITUDE LES ABORT (Updated in lecture)

The high altitude LES abort event profile and portrayal shown in figures 6-13 and 6-14 indicate one major difference between this type LES abort and

EVENT PROFILE

MEDIUM ALTITUDE LES ABORT

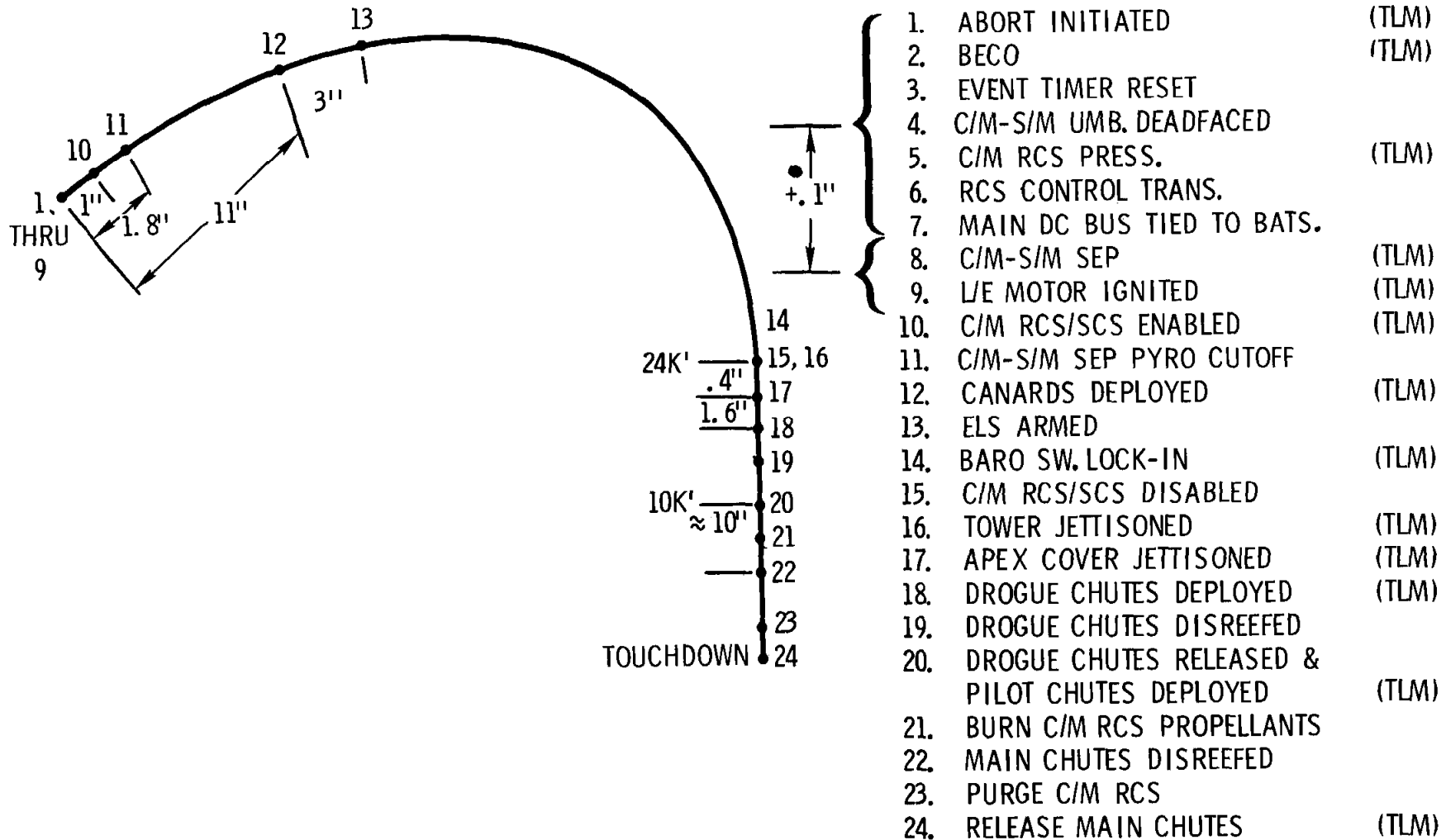


Figure 6-11

MEDIUM ALTITUDE LES ABORT

(30,000 TO 120,000 FT.)

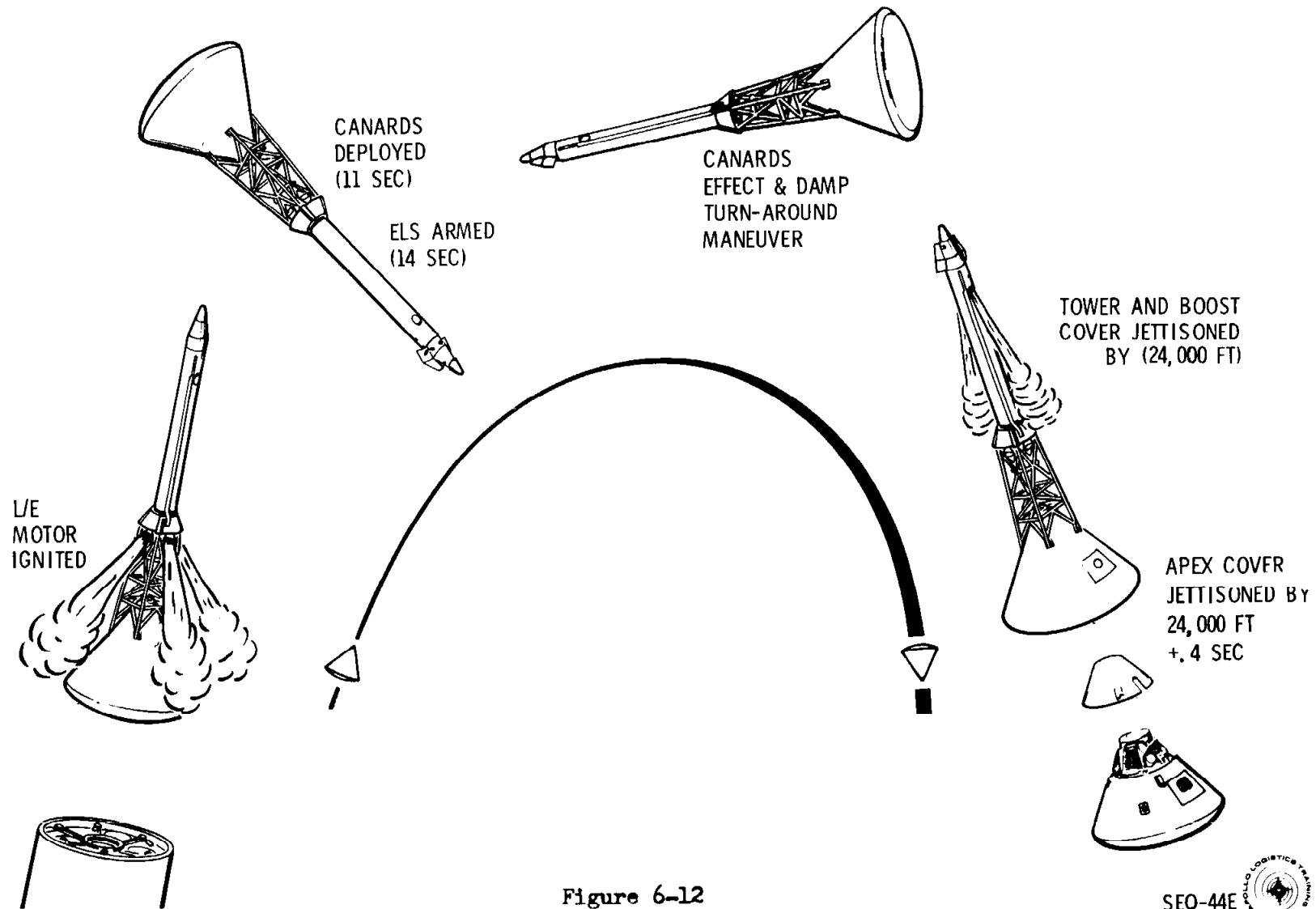


Figure 6-12

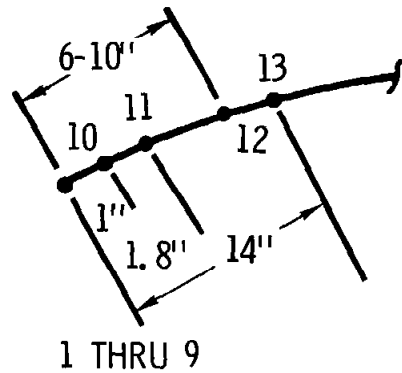
SEQ-44E



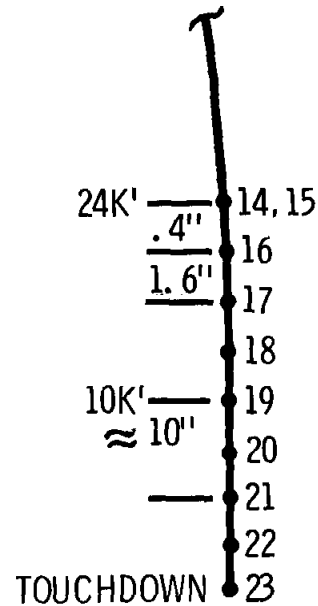
6-18

EVENT PROFILE

HIGH ALTITUDE LES ABORT



- | | |
|--|------------------------------------|
| | 1. ABORT INITIATED (TLM) |
| | 2. BECO (TLM) |
| | 3. EVENT TIMER RESET |
| | 4. C/M-S/M UMB DEADFACED |
| | 5. C/M RCS PRESS. (TLM) |
| | 6. RCS CONTROL TRANS. |
| | 7. MAIN DC BUS TIED TO BATS. (TLM) |
| | 8. C/M-S/M SEP (TLM) |
| | 9. L/E MOTOR IGNITED (TLM) |
| | 10. C/M RCS/SCS ENABLED (TLM) |
| | 11. C/M-S/M SEP PYRO CUTOFF |
| | 12. JETTISON TOWER (TLM) |
| | 13. ELS ARMED |



- | | |
|--------|--|
| 14, 15 | 14. BARO SW. LOCK-IN (TLM) |
| 16 | 15. C/M RCS/SCS DISABLED |
| 17 | 16. APEX COVER JETTISONED (TLM) |
| 18 | 17. DROGUE CHUTES DEPLOYED (TLM) |
| 19 | 18. DROGUE CHUTES DISREEFED |
| 20 | 19. DROGUE CHUTES RELEASED & PILOT CHUTES DEPLOYED (TLM) |
| 21 | 20. BURN C/M RCS PROPELLANTS |
| 22 | 21. MAIN CHUTES DISREEFED |
| 23 | 22. PURGE C/M RCS |
| | 23. RELEASE MAIN CHUTES (TLM) |

Figure 6-13

HIGH ALTITUDE LES ABORT (120,000 FT TO TWR JETT)

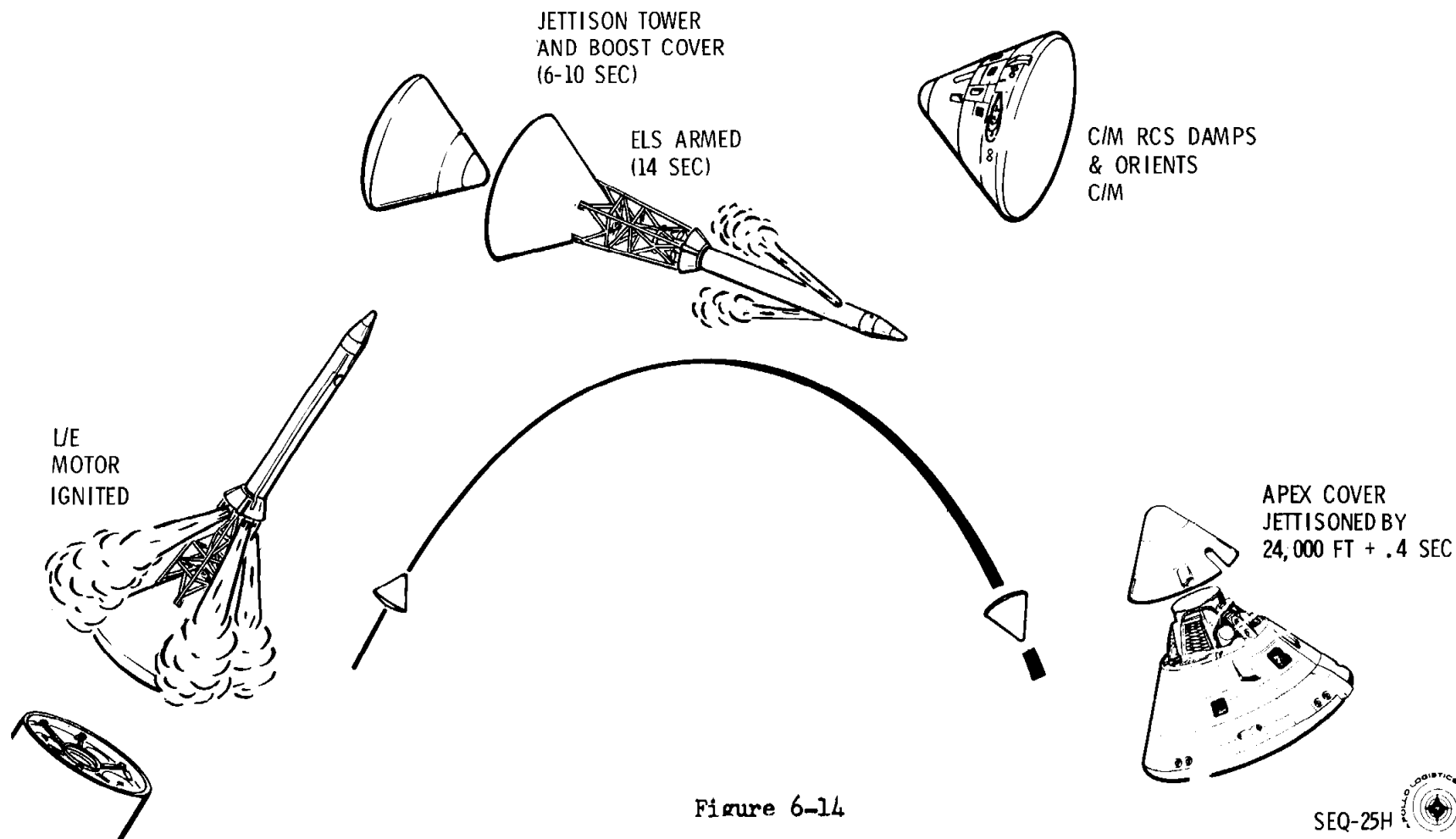


Figure 6-14

SEQ-25H



6-20

the others already studied. This type LES abort occurs between approximately 120,000 feet and when the LET is normally jettisoned. Because it occurs in the area where there is no longer any sensible atmosphere and the velocity exceeds Mach 3.8, the Canards will be ineffective. The crew will, therefore, jettison the LET immediately after its usefulness has terminated and revert to the RCS/SCS as soon as possible to execute the turn-around maneuver and to orient the CM to the desired entry attitude, as indicated by item 12. The RCS is most effective in outer space.

All automatically sequenced items 1 through 11 occur exactly as in all LES aborts after 61 seconds from lift-off. The ELS will be armed automatically 14 seconds from the initiation of the abort as usual. Refer to item 13. From this time until closure of the 24,000 foot baroswitches, the SECS performs no functions.

After the 24,000 foot baroswitches close, all successive functions, whether automatic or manual, will be initiated in the same sequence as during a normal descent. See items 14 through 23.

6.7 SPS ABORT AND RETURN TO EARTH

An SPS abort was defined previously as an abort which is initiated sometime between tower jettison and adapter separation. Once again a decision must be made by the crew and the ground personnel monitoring the mission. It must be decided whether to abort to orbit or abort for return to earth. In either case, however, functions performed by the SECS are identical for separating the CSM from the LV.

Figure 6-15 portrays the three choices the crew has if an SPS abort must be initiated during the launch phase of the first manned mission. If an SPS abort is triggered soon after tower jettison, the crew

will be automatically steered to an altitude above 300,000 feet to a point where CM - SM separation can be commanded manually for a near normal return to earth into the Atlantic Ocean recovery area.

If an SPS abort is initiated in the final few seconds of the launch phase and just prior to orbit attainment, the crew may abort to orbit. On the other hand if it is determined that orbit cannot be attained, then it may become necessary to over-fly Africa for subsequent recovery in the Indian Ocean recovery area.

Reference to figure 6-16 indicates that the first 8 items pertain to those functions performed to successfully separate the CSM from the LV. Items 2 through 7 are performed automatically by the MESC. The Commander manually terminates the direct SC ullage maneuver after the SPS engine has been ignited. See item 8. For an abort to orbit, no other automatically sequenced functions would be required, but for an abort for return to earth, the remaining items shown in this figure must be carried out after the CSM has been steered into the normal attitude for CM - SM separation and for a near normal return to earth somewhere above 300,000 feet of altitude.

Studying items 1 through 8, it is noted that immediately following the manual initiation of an SPS abort that the booster engine is cut-off, the Event Timer is reset to zero to start totalizing the time from the abort initiation, Guidance and Navigation (G&N) System is signaled of the SPS abort, and a direct SC ullage is started by firing the 4 + X RCS engines on the SM, exactly as it was for an LES abort.

The SLA will be separated 1.7 seconds after the abort is commanded by the Commander and the ullage maneuver is started. At the same time that the

SPS ABORTS FROM LAUNCH PHASE

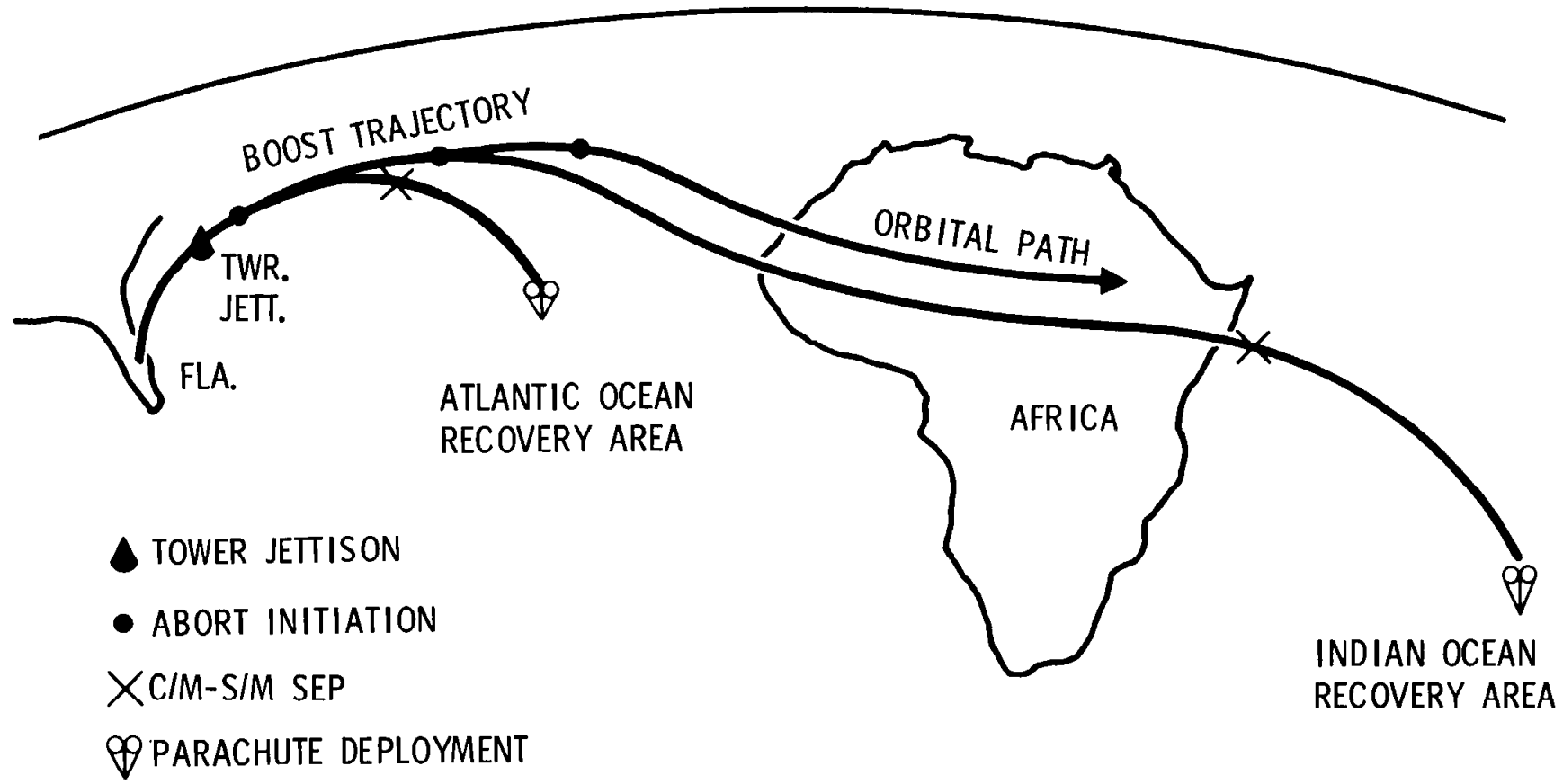


Figure 6-15

EVENT PROFILE

SPS ABORT AND RETURN TO EARTH

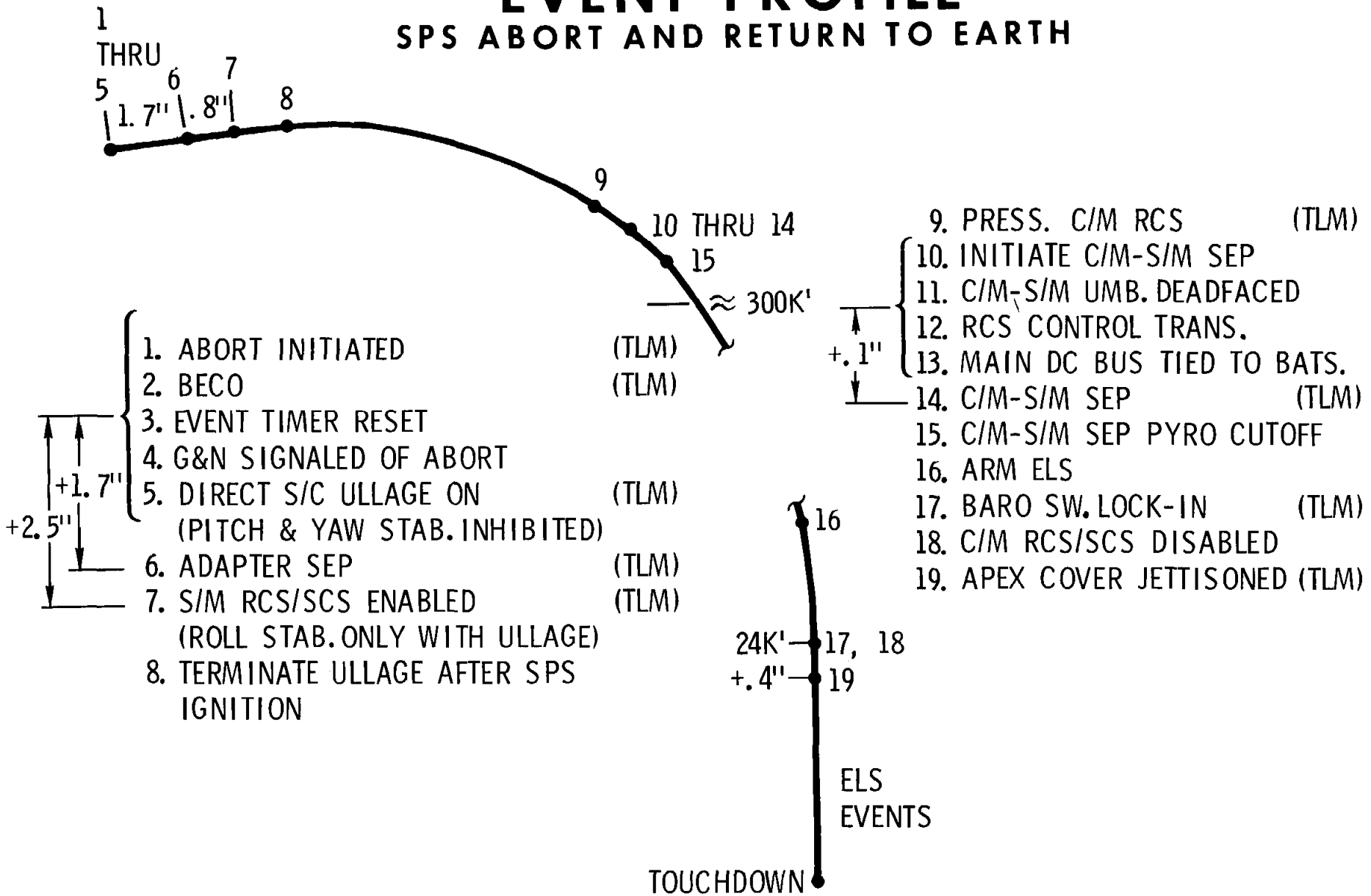


Figure 6-16

SEQ-50J



adapter is separated, an .8 second time delay is triggered which, when timed out, will enable the SM's RCS/SCS for roll stabilization only. Stabilization in pitch and yaw is inhibited as long as the ullage maneuver is on.

At this writing it is felt that the crew will have made their choice of a steering program and that the SPS engine will be ignited manually by approximately 13 seconds from the abort initiation. This is for the purpose of gaining maximum separation from the LV as soon as possible before the possible destruction of the LV.

At some time immediately following the ignition of the SPS engine, the Commander may discontinue the ullage maneuver by rotating the Translation Controller CW, back to its neutral position, after being rotated fully CCW to a holding detent position for initiation of the abort.

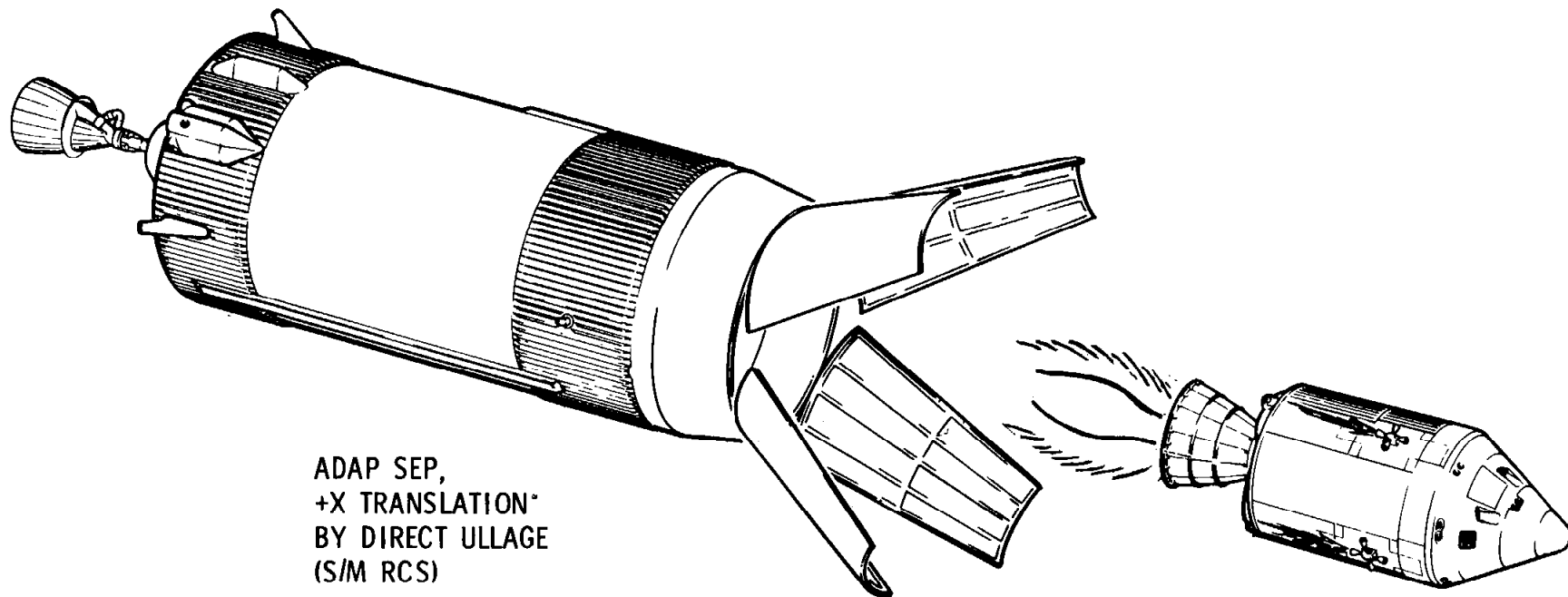
Sometime immediately prior to the crew initiating CM- SM separation, they may pressurize the CM's RCS as previously mentioned and described in the normal pre-entry and descent profile. See item 9.

When the CSM has been steered into the proper attitude and position for CM - SM separation, the crew will initiate this operation in the same manner that was described in the normal pre-entry and descent profile. All remaining events in this abort profile are performed precisely as they are on a normal entry and descent.

Figure 6-17 illustrates that period during an SPS abort when the SPS engine is firing, translating the CSM forward away from the LV and while the direct ullage is still on.

BLK I SPS ABORT

(TWR JETT TO NORMAL ADPT SEP)



ADAP SEP,
+X TRANSLATION*
BY DIRECT ULLAGE
(S/M RCS)

Figure 6-17

SEQ-80-1A



SECTION VII
CIRCUIT ANALYSIS

This section consists of 11 sheets of wiring schematic diagrams included for study by the student for confirmation of statements made throughout the text and for supplemental information in regards to the SECS, EDS, LES, and ELS.

Systems interface, circuit design, power sources, switching **displays and controls**, signal flow, time delays, relay voting logic, system redundancy, telemetered information, and GSE interface may all be studied and analyzed from these schematics.

Statements made regarding RCS functions may be studied and confirmed by referring to the Propulsion Systems Study Guide and the CM - SM RCS Schematic Diagram, number V14-945307.

APPENDIX A - BIBLIOGRAPHY

Specifications

<u>Number</u>	<u>Revision</u>	<u>Date</u>	<u>Title</u>
SID 63-313	(Confidential)	22 February 1965	CSM Technical Specification (Block I)
SID 64-1237	(Confidential)	1 October 1964	CSM Master End Item Specification (Block I)
MC 901-0567 plus PDC	Rev. B 1 2	8 February 1965 5 April 1969 17 June 1965	Master Event Sequence Controller (Block I)
MC 901-0569 plus PDC	Rev. B 1	8 January 1965 5 April 1965	Service Module Jettison Controller (Block I)
MC 901-0002 plus PDC	Rev. E 1	28 May 1964 8 July 1964	Rocket Motor, Solid Propellant, Apollo Launch Escape System
MC 467-0001 plus PDC	Rev. F 1 2	13 August 1964 28 October 1964 26 February 1965	Rocket Motor, Solid Propellant, Apollo Launch Escape System, Tower Jettison
MC 467-0005 plus PDC	Rev. E 1	14 July 1964 19 April 1965	Rocket Motor, Solid Propellant, Apollo Launch Escape System, Pitch Control
MC 901-0001 plus PDC	Rev. E 1C 2C 3A 4A 5A	10 December 1964 10 June 1965 2 August 1965 2 August 1965 2 August 1965 20 August 1965	Parachute Subsystem, Apollo Earth Landing System
MC 453-0009 plus PDC	Rev. C 1A 2B 3A 4A 5A	17 December 1964 18 March 1965 2 August 1965 16 June 1965 12 August 1965 2 August 1965	Initiator, Electrical, Hotwire

<u>Number</u>	<u>Revision</u>	<u>Date</u>	<u>Title</u>
MC 453-0011	Rev. A	21 June 1963	Detonator Cartridge Assembly, Electrically Initiated, Hotwire
MC 453-0005 plus PDC	Rev. F	11 June 1965	Cartridge Assembly, Electrically Initiated, Pressure, Hotwire
	1A	2 August 1965	
	2A	2 August 1965	
	3A	12 August 1965	
MC 111-0004	Rev. B	15 July 1965	Bolt Assembly, Explosive, Dual Mode, Electrically Initiated

A

Drawings

<u>Number</u>	<u>Revision</u>	<u>Date</u>	<u>Title</u>
V14-945018		8 July 1964	Schematic Diagram - Emergency Detection System, Saturn IB
V14-945019		14 July 1965	Schematic Diagram - Launch Escape and Service Propulsion Abort System and Earth Landing System
45604-501	Rev. A	16 July 1965	Schematic - Controller, Sequence, Master Events, Emergency Detection System
45605-501	Rev. A	16 July 1965	Schematic - Controller, Sequence, Master Events, Launch Escape System
45606-501	Rev. A	16 July 1965	Schematic - Controller, Sequence, Master Events, Service Propulsion System
45607-501	Rev. A	16 July 1965	Schematic - Controller, Sequence, Master Events, Telemetry, Ground Support Equipment
40816-306		23 June 1965	Schematic - Controller, Service Module, Jettison
V15-300100	Rev. G	17 April 1965	Tower Assembly, Launch Escape System
V15-300001	Rev. G	13 May 1965	Body Group Installation, Launch Escape System
F01-100056	Rev. C	16 July 1965	Field Site Inst - Parachute Subsystem Earth Landing System, Command Module, Block I
V16-976035	Rev. A	18 August 1965	Design Layout - Main Display Console, AFRMS 12, 14, 17, and 20
V16-540002	Rev. A	22 January 1965	Sequencer Installation, LES and ELS
V17-540001	Rev. A	29 October 1965	Sequencer Installation - Jettison Control System

A

Manuals

<u>Number</u>	<u>Date</u>	<u>Title</u>
SM2A-02	24 July 1964	Apollo Spacecraft Familiarization
NORT 62-190	June 1962	Model F - 16 A Q Ball

NASA Publications

<u>Number</u>	<u>Date</u>	<u>Title</u>
MSC Internal Note No. 65-FM-58	26 April 1965 Rev. 5 Nov. 1965	Preliminary Reference Trajectory for a Long Duration Manned Earth Orbital Apollo Mission SA-204A

A

APPENDIX B

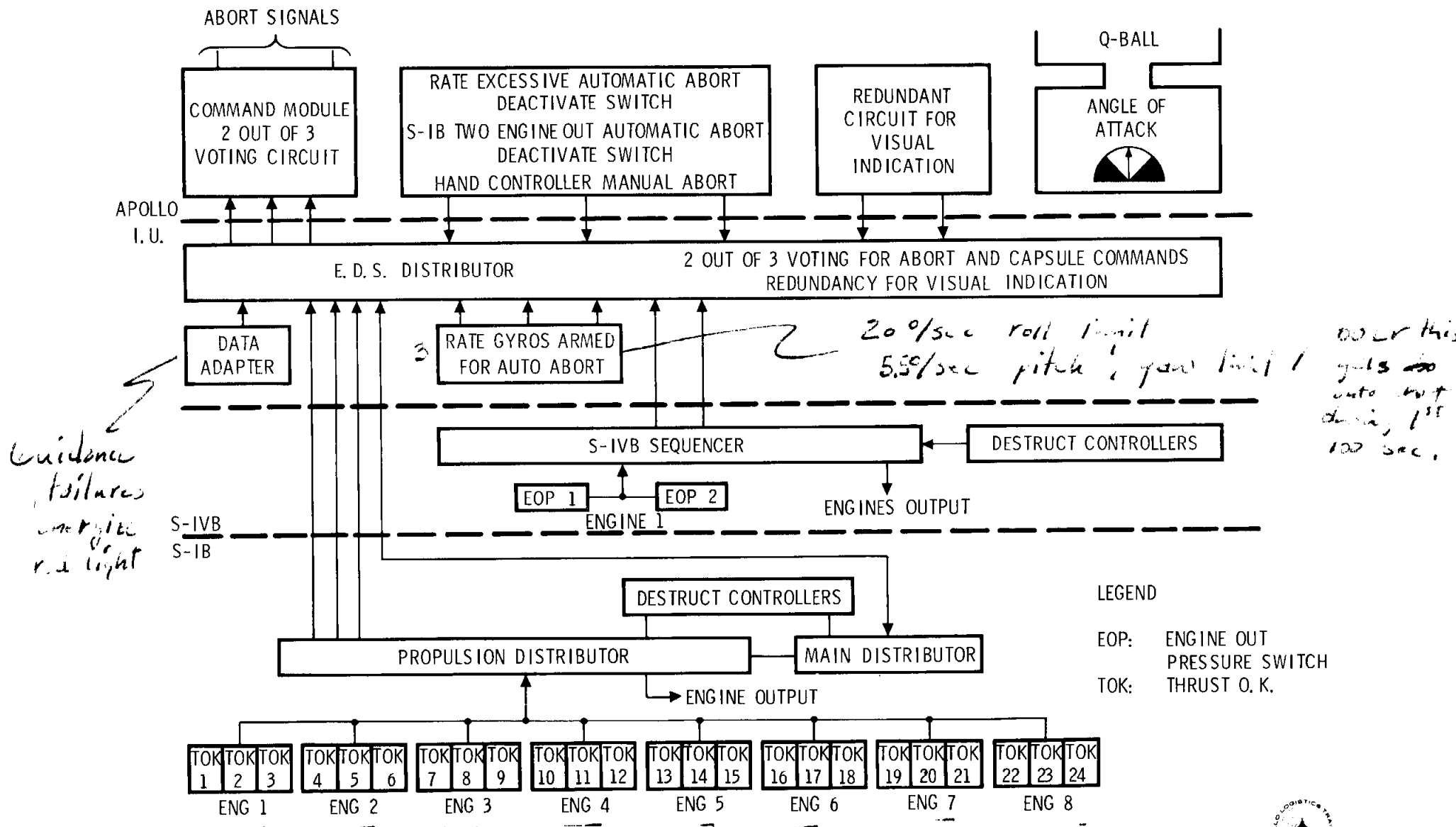
Glossary of Acronyms

ACE	Acceptance Checkout Equipment	MESC	Master Event Sequence Controller
ASI	Apollo Standard Initiator	MSC	Manned Spacecraft Center
BECO	Booster Engine Cut-Off	MSCC	Manned Spacecraft Control Center
BPC	Boost Protective Cover	MSFC	Marshall Space Flight Center
CDF	Confined Detonating Fuse	MSFN	Manned Space Flight Network
CM	Command Module	NAA	North American Aviation
CSM	Command Service Module	PC	Pitch Control
EDS	Emergency Detection System	PCVB	Pyro Continuity Verification Box
ELS	Earth Landing System	RCS	Reaction Control System
ELSC	Earth Landing Sequence Controller	RCSC	Reaction Control System Controller
FDAI	Flight Director Attitude Indicator	RSO	Range Safety Officer
FLSC	Flexible Linear Shaped Charge	SECS	Sequential Events Control System
G&N	Guidance and Navigation	SC	Spacecraft
GSE	Ground Support Equipment	SCS	Stabilization Control System
IU	Instrument Unit	SLA	Spacecraft LEM Adapter
LE	Launch Escape	SM	Service Module
LEM	Lunar Excursion Module	SMJC	Service Module Jettison Controller
LES	Launch Escape System	SPS	Service Propulsion System
LET	Launch Escape Tower	TJ	Tower Jettison
LEV	Launch Escape Vehicle	TLM	Telemetered or Telemetry
LV	Launch Vehicle	UDL	Up-Data Link
MDF	Mild Detonating Fuse		

Notes:
 a) Can tolerate 1 eng. out.
 b) Cannot tolerate 2 engs. out
 c)

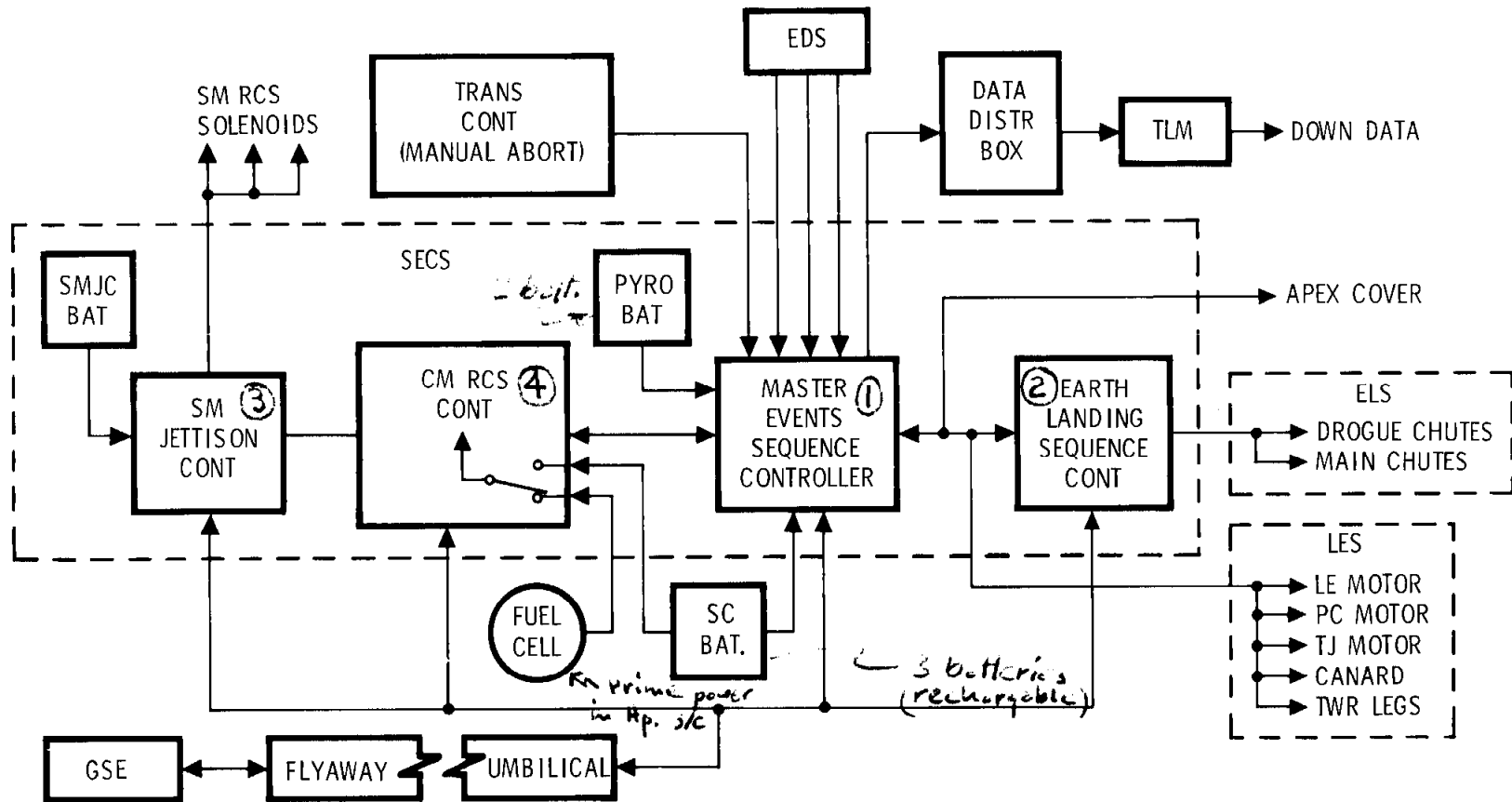
Emergency detection sys.

BLOCK DIAGRAM SATURN **IB** EDS



LEGEND
 EOP: ENGINE OUT PRESSURE SWITCH
 TOK: THRUST O. K.

SECS INTERFACE



Ground Support Equip.

Note: a) Four main parts to SECS (see 1, 2, 3, 4 in "big" dashed box)

SEQ-106



FUNCTIONAL BLOCK DIAGRAM

