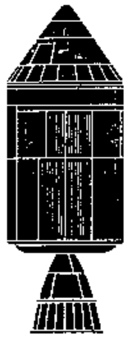

APOLLO TRAINING

STRUCTURES AND MECHANICAL SUBSYSTEMS

COURSE NUMBER A-512S

APRIL 1, 1966

FOR TRAINING PURPOSES ONLY

APOLLO LOGISTICS TRAINING

PREFACE

THIS TRAINING PACKAGE SUPPLEMENTS THE ORAL PRESENTATION OF THE STRUCTURES AND MECHANICAL SYSTEMS BRIEFING COURSE NUMBER A-512S. THE MATERIAL CONTAINED WITHIN THIS PACKAGE ;IS UNCLASSIFIED AND CONFORMS TO THE NASA REQUIREMENT OF DOCUMENTATION OF ALL TRAINING INFORMATION.

IT IS ASSUMED BY THE TRAINING DEPARTMENT THAT PERSONNEL ATTENDING THE STRUCTURES AND MECHANICAL SYSTEMS BRIEFING HAVE ATTENDED THE APOLLO FAMILIARIZATION BRIEFING AND HAVE SOME EXPERIENCE WITH SIMILAR EQUIPMENT.

THE SYSTEMS AND EQUIPMENT DESCRIPTION, INFORMATION, AND DATA APPLY TO BLOCK I SPACECRAFT. BLOCK II CONFIGURATIONS WILL BE EXPLAINED IN THE COURSE AS THE INFORMATION IS AVAILABLE.

THIS DOCUMENT REFLECTS THE CURRENT STATUS OF STRUCTURES AND MECHANICAL SYSTEMS. IT IS A TRAINING DOCUMENT AND THE ATTENDEES COPY WILL NOT BE REVISED.

QUESTIONS RELATIVE TO THE INFORMATION CONTAINED IN THIS DOCUMENT SHOULD BE DIRECTED TO:

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IS ACCESSIBLE THROUGH MAINTENANCE DOORS LOCATED STRATEGICALLY AROUND THE EXTERIOR SURFACE OF THE MODULE. AN AREA BETWEEN THE SERVICE MODULE AND COMMAND PROVIDES SPACE FOR RADIAL BEAM EXTENSION, WHICH ARE STRUCTURAL CONNECTIONS BETWEEN C/M AND S/M. THE ENTIRE STRUCTURAL CONNECTION IS ENCLOSED BY A FAIRING 26" HIGH.

THE SPACECRAFT LEM ADAPTER (SLA), WHICH IS ATTACHED TO THE AFT END OF THE S/M, IS A PRIMARY LOAD BEARING STRUCTURE BETWEEN THE SIVB BOOSTER AND THE S/M, CONSTRUCTED OF ALUMINUM AND WILL HOUSE THE LEM AND NOZZLE OF THE SERVICE PROPULSION SYSTEM. ONCE THE INJECTION INTO EARTH-MOON TRANSIT IS COMPLETE, THE ADAPTER PANELS WILL BE OPENED AND HELD CAPTIVE TO PERMIT COMMAND SERVICE MODULE (CSM) DOCKING TO THE LEM.

THE MECHANICAL SYSTEMS PLAY A VITAL ROLE IN CONNECTION WITH THE MECHANICS OF SEPARATION AND JETTISONING FROM LIFT-OFF TO THE COMPLETION OF THE SPACECRAFT MISSION. THE MECHANICAL SYSTEMS ARE ACTUATED WITH THE USE OF PYROTECHNIC DEVICES. THE MECHANICAL SYSTEMS ARE DEVISED TO GIVE MAXIMUM PERFORMANCE AND RELIABILITY.

A DETAILED EXPLANATION AND DISCUSSION OF EACH MAJOR OR SUBSYSTEM, ITS FUNCTION AND PURPOSE, WILL BE FOUND IN ITS RESPECTIVE SECTION. ALSO, THE VARIOUS SECTIONS SHALL INCORPORATE ILLUSTRATIONS TO FURTHER UNDERSTAND AND HELP EXPLAIN THE OPERATION OF EACH SYSTEM.

1.2 BOOSTER NOMENCLATURE AND BLOCK DEFINITION

FIGURE 1-2 ILLUSTRATES THE LAUNCH VEHICLES USED IN THE APOLLO PROGRAM. THE EARLIER TEST EVALUATION AND QUALIFICATION FLIGHT VEHICLES ARE POWERED BY LITTLE JOE II, SATURN I, AND SATURN IB LAUNCH VEHICLES. THE SATURN V LAUNCH VEHICLE WILL POWER THE APOLLO LUNAR MISSIONS. IT ALSO SHOWS THE COMPARATIVE SIZES OF THE BOOST VEHICLES AS WELL AS THE RELATIVE SIZES OF THE MODULES AND SECTIONS. AS THE APOLLO PROGRAM PROGRESSES, THE PAYLOADS AND DURATION OF THE FLIGHTS NECESSITATES THE USE OF THE SATURN V. THE GENERAL CONFIGURATION OF THE LAUNCH VEHICLE BOOSTERS IS SUMMARIZED IN THE FOLLOWING PARAGRAPHS.

1.2.1 LITTLE JOE II

LITTLE JOE II, OR THE SMALLEST VEHICLE, IS USED FOR ALL TRANSONIC ABORT TESTING ACCOMPLISHED AT WHITE SANDS, NEW MEXICO. THE LAUNCH VEHICLE IS APPROXIMATELY 13 FEET IN DIAMETER AND 29 FEET IN LENGTH. STABILIZATION IS PROVIDED BY FOUR FINS THAT ARE SWEPT BACK FROM THE AFT BODY. LITTLE JOE II, MANUFACTURED BY GENERAL DYNAMICS, CONVAIR USES SOLID FUEL ROCKET MOTORS AS ITS SOURCE OF PROPULSION POWER. THE PROPULSION SYSTEM CONSISTS OF THIOKOL RECRUIT (BOOSTER) AND AEROJET ALGOL (SUSTAINING) MOTORS. THE EXACT NUMBER AND COMBINATION OF MOTORS DEPENDS ON POWER REQUIREMENTS FOR A PARTICULAR FLIGHT.

SPACE VEHICLES

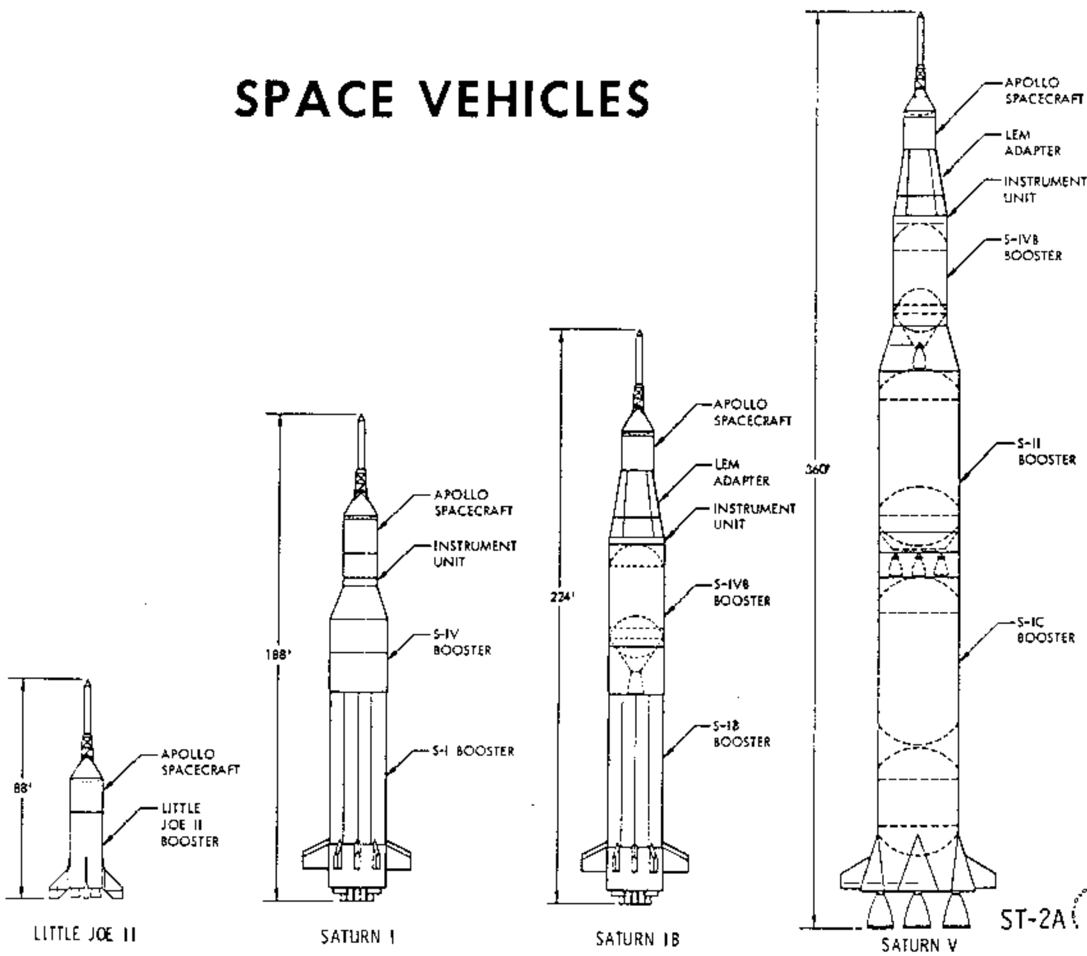

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FIGURE 1-2

1.2.2 Saturn I

Saturn I, a two stage vehicle, has demonstrated the feasibility of clustered rocket boosters and has qualified vehicle guidance and flight control systems. It has tested the Apollo spacecraft's structure and design, physical compatibility of vehicle and spacecraft, and jettisoning of the Apollo launch escape system.

The Saturn I vehicle can send an 11-ton payload, the equivalent weight of six automobiles, into low earth orbit. The first stage, or booster, has a total thrust of 1,500,000 pounds. The second stage develops 90,000 pounds of thrust. An instrument unit, located between the second stage and payload, houses the guidance and control systems and flight instrumentation (telemetry) equipment.

1.2.2.1 First Stage

The first stage is manufactured by Chrysler Corporation. Eight Rocketdyne H-1 engines are used, each producing 188,000 pounds of thrust. They burn kerosene fuel (RP-1) with liquid oxygen. The engines, advanced and compact offspring of earlier military and space programs, were selected because of their early availability and proven reliability.

The four inboard engines are rigidly attached while the four outboard engines may gimbal for control of the vehicle during the booster phase. Tail fins are for aerodynamic stability only.

1.2.2.2 Second Stage

The S-IV second stage is manufactured by Douglas Aircraft Company. Six Pratt and Whitney RL-10-A3 engines are used, each producing 15,000 pounds of thrust. The engines burn liquid hydrogen and liquid oxygen. All six engines may gimbal to control the second stage.

1.2.3 Saturn IB

Earth orbital missions necessary for further Apollo spacecraft development and for astronaut training require payloads beyond Saturn I capability. Saturn IB will be used for these missions. It will employ an improved version of the reliable Saturn I booster, but will have a more powerful second stage. The second stage of Saturn IB will also be the third stage of Saturn V.

The Saturn IB mission in the Apollo program is divided into two phases - unmanned orbital flights and manned orbital flights. Unmanned flights will qualify the Saturn IB and Apollo spacecraft for orbital missions and recovery.

Saturn IB, the second of the class of vehicles, will place 17 tons of payload into low earth orbit,

compared to the 11-ton capability of Saturn I. Its improved booster will develop 1,6000,000 pounds of thrust - 100,000 pounds more than Saturn I. The second stage will develop 200,000 pounds of thrust, or over twice that of the second stage of Saturn I. The instrument unit will be located between the second stage and payload. Saturn IB and Saturn V will have identical instrument units.

1.2.3.1 First Stage

The Saturn IB booster will be essentially the same as Saturn I. Design improvements of the Saturn IB will reduce its weight by more than 16,000 pounds over that of the Saturn I. Eight H-1 Rocketdyne engines are also used on Saturn IB, but an increase in thrust is realized for each engine from 188,000 to 200,000 plus pounds.

1.2.3.2 Second Stage

The S-IVB second stage, manufactured by Douglas Aircraft Company, is of an entirely different configuration than the S-IV; it is longer, heavier, and of a larger diameter. S-IVB employs a single Rocketdyne J-2 engine, burning liquid hydrogen and liquid oxygen to produce 200,000 pounds of thrust.

1.2.4 Saturn V

The Saturn V, the largest of the four vehicles, is programmed for manned earth orbital missions and/or lunar missions. Saturn V is a three stage vehicle consisting of a S-IC first stage, S-II second stage, and a S-IVB third stage.

The huge Saturn V will be capable of injecting a 120-ton payload into low earth orbit and boosting 45 tons beyond the gravitational force of the earth. With the Apollo spacecraft on top, the three-stage vehicle will tower over 360 feet, nearly two-thirds the height of the Washington Monument. Loaded with fuel it will weigh 3,000 tons, about the weight of the nuclear submarine Nautilus.

1.2.4.1 First Stage

The S-IC is manufactured by the Boeing Company, and uses five Rocketdyne F-1 engines. Each F-1 engine, burning RP-1 and liquid oxygen, produces 1,500,000 pounds of thrust for an overall first stage boost of 7,500,000 pounds of thrust. One engine will be rigidly attached at the stage centerline, while the others will gimbal for vehicle control.

1.2.4.2 Second Stage

The S-II, or second stage, is manufactured by Space and Information Systems Division of North American Aviation Inc. The second stage employs five Rocketdyne J-2 engines. Each J-2 engine, burning liquid hydrogen and liquid oxygen, produces 200,000 pounds of thrust for an overall second stage boost of 1,000,000 pounds. The gimballed engines will be

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MOUNTED IN A SQUARE PATTERN, WITH THE FIFTH ENGINE RIGIDLY MOUNTED IN THE CENTER.

1.2.4.3 THIRD STAGE

THE THIRD STAGE OF SATURN V WILL BE IDENTICAL IN ALMOST ALL RESPECTS TO THE SECOND STAGE OF SATURN IB, INCLUDING THE INSTRUMENT UNIT.

1.2.5 BLOCK DEFINITION

THE BLOCK CHANGE CONCEPT. CONSISTING OF A THREE-PHASE PROGRAM, IS USED WHEN DESCRIBING THE DEVELOPMENT AND OBJECTIVES OF THE APOLLO PROGRAM.

1.2.5.1 BLOCK 0

BLOCK 0, OR THE FIRST PHASE, CONSISTS OF THE BOILERPLATE PROGRAM WHICH IS FOR EARLY SUPPORT OF SYSTEM DEVELOPMENT. BOILERPLATES ARE PREPRODUCTION SPACECRAFT SIMILAR TO THEIR PRODUCTION COUNTERPARTS IN SHAPE, SIZE, MASS STRUCTURAL SOUNDNESS, AND CENTER OF GRAVITY. ALSO INCLUDED IN THIS PHASE ARE THE LAND AND WATER IMPACT TESTS, PARACHUTE RECOVERY, AND RPEQUALIFICATION TESTS. IT ALSO SERVES IN SYSTEM DEMONSTRATION TO SUPPORT THE SPACECRAFT PROGRAM, PAD AND HIGH ALTITUDE ABORT TESTS, BOOSTER DEVELOPMENT, AND HELPS IN DEVELOPING APOLLO CAPABILITIES.

1.2.5.2 BLOCK I

BLOCK I, OR PHASE TWO, IS THE BEGINNING OF THE SPACECRAFT COMMAND SERVICE MODULE (CSM) SPACECRAFT LEM ADAPTER (SLA), AND LUNAR EXCURSION MODULE (LEM), DEVELOPMENT PROGRAM FOR MANNED EARTH ORBITAL MISSIONS. IT WILL DEMONSTRATE EARLY SYSTEM OPERATIONAL INCLUDING ALL ABORTS, LAND AND WATER RECOVERY, AND BOOSTER COMPATIBILITY OF THE SATURN IB. IT WILL ALSO HELP IN DEVELOPING APOLLO OPERATIONAL TEAMS DURING CHECKOUT, LAUNCH, MANNED SPACE FLIGHT NETWORK (MSFN) FUNCTIONS, RECOVERY, AND FLIGHT ANALYSIS.

1.2.5.3 BLOCK II

BLOCK II, OR THE THIRD PAHSE, IS THE CONTINUATION OF THE SPACECRAFT PROGRAM, INCORPORATING THE COMPLETE QUALIFIED LUNAR EXCURSION MODULE WITH COMMAND AND SERVICE MODULE. BLOCK II WILL ALSO REDUCE SPACECRAFT WEIGHT WHERE POSSIBLE, IMPROVE COMMAND MODULE CENTER OF GRAVITY, AND IMPROVE ON SYSTEM RELIABILITY. THESE OBJECTIVES WILL CLIMAX A SERIES OF EARTH ORBITAL, CIRCUMLUNAR, AND LUNAR ORBITAL MISSIONS. ALTHOUGH EACH OF THESE MISSIONS WILL HAVE SPECIFIED OBJECTIVES, THEY WILL BE FLOWN PRIMARILY FOR ADVANCEMENT AND QUALIFICATION OF SYSTEMS FOR THE ULTIMATE LUNAR LANDING MISSION.

1.3 MISSION DYNAMIC LOADS AND DESIGN

THE APOLLO SPACECRAFT STRUCTURE IS DESIGNED AND BUILT TO 1.5 TIMES THE DESIGN LIMIT LOAD, WHICH IS THE DESIGN ULTIMATE LOAD. AN EXCEPTION IS THE CREW COUCHES, WHICH HAS AN ULTIMATE OF 1.35 X LIMIT LOAD, THE REASON BEING THE CREWMAN COULD NOT SURVIVE ANY GREATER LOAD.

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1.3.1 MISSION DYNAMIC LOADS

THERE ARE NUMEROUS LOADS TO WHICH THE APOLLO SPACECRAFT WILL BE SUBMITTED. SOME ARE CRITICAL AND WILL DETERMINE THE ULTIMATE DESIGN LOADS WHILE SOME ARE OF INTEREST ONLY. THE MOST CRITICAL LOAD IS AN EARTH IMPACT, ALTHOUGH SIDE LOADS WILL ALSO DETERMINE DESIGN.

LOADS DISCUSSED WILL BE IN TERMS OF G'S, WHERE ONE G WILL BE THE FORCE EXERTED BY GRAVITY AT SEA LEVEL.

1.3.2 LAUNCH

THE LIMIT LOAD DURING LAUNCH IS 1.25 G'S AND OCCURS AXIALLY ALONG THE LINES OF THRUST.

1.3.3 BOOST

AT THE END OF FIRST STAGE BOOST SATURN V, WHEN THE T/W RATIO IS THE HIGHEST, THE ACCELERATION CREATES A LIMIT LOAD OF 5.0 G'S. THIS IS DUE TO DIMINISHING WEIGHT OF THE S/C PROPELLANTS.

THE SECOND AND THIRD STAGE BOOSTERS' ACCELERATIONS WILL BE LESS THAN THE FIRST STAGE.

1.3.4 ABORT LOADS

AN ABORT MAY IMPOSE HIGH LOADS TO THE C/M AND LAUNCH ESCAPE SYSTEM. WHEN THE LES MOTOR IGNITES AND BURNS APPROXIMATELY 10 G'S WILL BE FELT AXIALLY ALONG THE LINES OF THRUST OR DURING THE TURN AROUND MANEUVERS INDUCED BY THE DEPLOYABLE CANARDS.

1.3.5 MIDMISSION LOADS

TRANSLUNAR INJECTION, MIDCOURSE CORRECTIONS, RENDEZVOUS, AND DOCKING LOADS ARE MINOR, NORMALLY BEING LESS THAN ONE G.

1.3.6 ENTRY

A NORMAL 6° ENTRY ANGLE SUBJECTS THE C/M TO A DECELLERATION LOAD OF 10 G'S. A STEEPER ENTRY CAN IMPOSE UP TO 20 G'S.

1.3.7 EARTH IMPACT

A GROUND IMPACT SHALL NOT BE CONSIDERED IN THE DESIGN FOR BLOCK I S/C. UNMANNED BLOCK I VEHICLES MAY IMPACT THE GROUND DURING A LOW ALTITUDE ABORT. HOWEVER A GROUND IMPACT IS NOT A DESIGN CONDITION SINCE MANNED, BLOCK I S/C WILL ALWAYS IMPACT ON WATER.

1.3.8 WATER IMPACT

IN ORDER TO ASSURE CREW SURVIVAL, A WATER LANDING SHALL BE THE PRIMARY MODE. A THREE CHUTE OR NOMINAL 27 FT/SEC VERTICAL VELOCITY AND ABOUT 18 KNOT SURFACE WINDS COULD IMPOSE A LOAD OF 12-40 G'S ON THE STRUCTURE. THE VARIABLE 12-40 G'S IS DEPENDENT UPON OCEAN SURFACE, WAVE CONFIGURATION AND CHUTE HANG ANGLE.

STRUCTURAL CAPABILITY ENVELOPES, BASED ON CALCULATIONS EMPLOYING 90% MINIMUM MATERIAL PROPERTIES, ARE SHOWN IN TABLE 1-1 AND 1-2. IMPACT CONDITIONS WITHIN THESE BOUNDARIES WILL ASSURE C/M AND CREW SURVIVAL. WHEN DESIGNING THE SPACECRAFT A TWO CHUTE DESCENT IS ALSO CONSIDERED. UNDER THIS CONDITION THE IMPACT LOADS WILL NOT EXCEED THE ULTIMATE DESIGN LOAD OF 78 G'S.

A FORCE IN EXCESS OF 40 G'S WOULD SERIOUSLY INJURE OR KILL A CREWMAN AND MUST BE ATTENUATED DOWN TO 20 G'S OR LESS. THE IMPACT ATTENUATION SYSTEM WILL BE DESCRIBED IN SECTION III, AND IN THE CREW SYSTEMS STUDY GUIDE.

1.3.9 ADDITIONAL LOADS

LOADS, OTHER THAN DYNAMIC, ARE FELT BY THE STRUCTURE. THESE LOADS, MAINLY DUE TO HEAT AND PRESSURE, WILL BE DISCUSSED AS SPECIAL LOADS ASSOCIATED WITH THE LES, C/M, OR S/M.

1.4 SPACECRAFT REFERENCE AND COORDINATE SYSTEM

IN ORDER TO DESCRIBE THE SPACECRAFT MOTION, ATTITUDES, AND COMPONENT LOCATIONS, REFERENCE COORDINATES ARE ASSIGNED TO THE THREE SPACECRAFT AXES USING THE CREW POSITIONED IN THE COUCHES AS THE FRAME OF REFERENCE. THE THREE AXES ARE THE LONGITUDINAL AXIS REFERRED TO AS THE X OR ROLL AXIS, THE LATERAL AXIS REFERRED TO AS THE Y OR PITCH AXIS, AND THE VERTICAL AXIS REFERRED TO AS THE Z OR YAW AXIS.

THE CREW, IN A SUPINE POSITION APPROXIMATELY PERPENDICULAR TO THE X AXIS AND FACING FORWARD, IS THE PRIMARY REFERENCE. ALL DIRECTIONS ARE IN REFERENCE TO THIS CREW POSITION. THE ORIGIN OF THE X AXIS, OR LONGITUDINAL AXIS, IS IN THE LAUNCH VEHICLE THIRD STAGE (SIVB). ALL X COORDINATE VALUES ARE POSITIVE - INCREASING GOING FORWARD. THE Y AXIS HAS ITS ORIGIN (0 VALUE) ON THE X AXIS. TO THE RIGHT OF THE CREW MAN IS POSITIVE (+) AND TO THE LEFT IS NEGATIVE (-), INCREASING IN NUMERICAL VALUE AS THE DISTANCE FROM THE X AXIS IS INCREASED. A Y_C DEFINITIVE VALUE, SUCH AS $Y_C = -42$ DEFINES A LOCI OF POINTS 42 INCHES FROM THE X-Z AXIS TO THE LEFT OF THE CREWMAN AND FORMS A PLANE. THE Z AXIS HAS ITS ORIGIN (0) ON THE X AXIS ALSO. IN THE DIRECTION OF THE CREWMAN'S FEET IS POSITIVE, INCREASING IN VALUE AS THE DISTANCE FROM THE X AXIS IS INCREASED. IN THE DIRECTION OF THE CREWMAN'S HEAD IS NEGATIVE (-), INCREASING IN NUMERICAL VALUE AS THE DISTANCES FROM THE X AXIS IS INCREASED.

THE SPACECRAFT IS POSITIONED ON THE LAUNCH PAD SO THAT THE ASTRONAUT'S HEAD IS IN THE DIRECTION OF DOWN RANGE. THE -Z AXIS POINTS DOWN RANGE DURING THE PROGRAMMED PITCH OVER OF THE LAUNCH VEHICLE IN THE ASCENT PHASE, AND THE ASTRONAUT'S FEET WILL ROTATE OVER HIS HEAD TOWARD THE EARTH.

FIGURE 1-3 ILLUSTRATES THE COORDINATES AND SHOWS THE RELATIVE LOCATIONS OF THE C/M COMPARTMENTS. THE NOMENCLATURE FOR THE VARIOUS COMPARTMENTS IN THE C/M CORRESPONDS TO THE FORWARD FACING CREW FRAME OF

TABLE 1-1

APOLLO CM WATER IMPACT CRITERIA

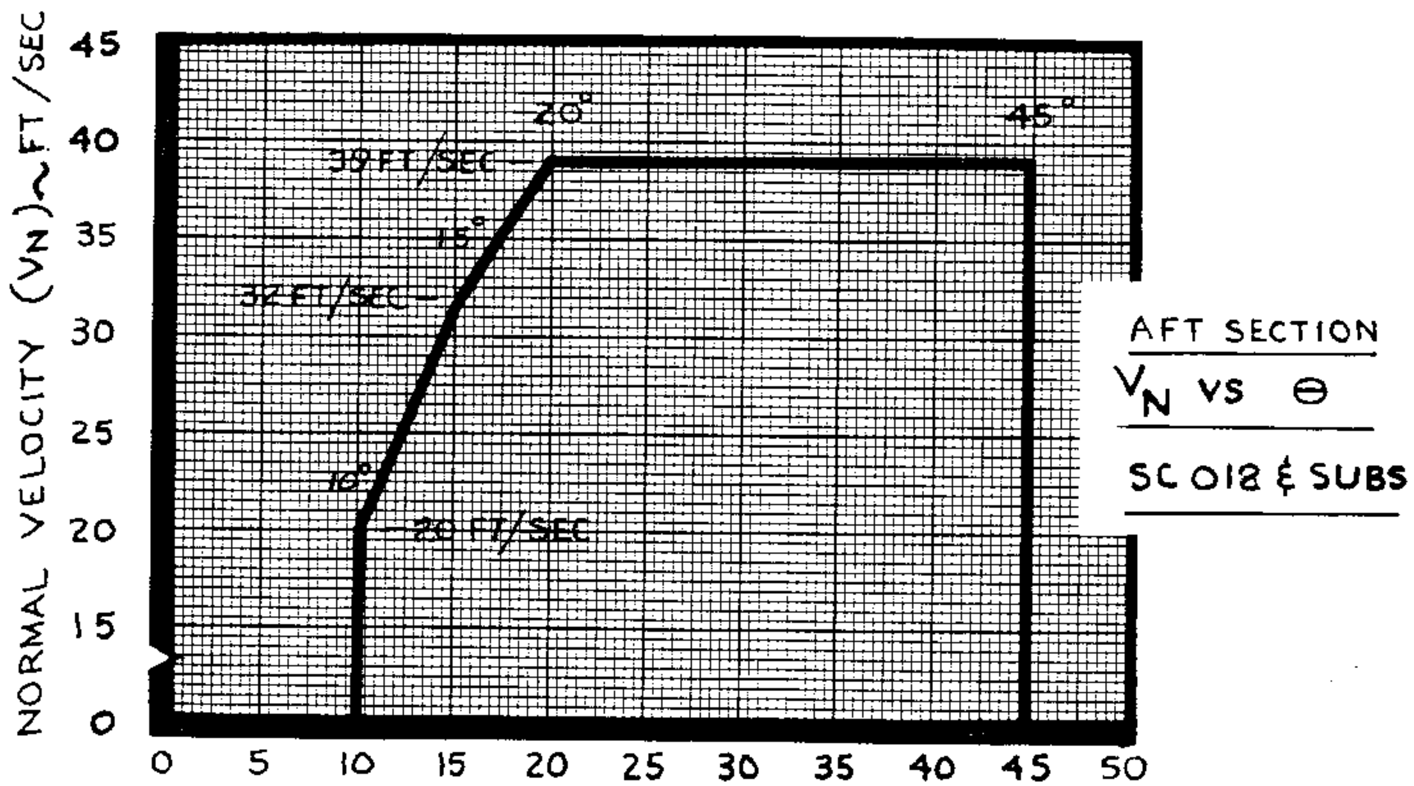

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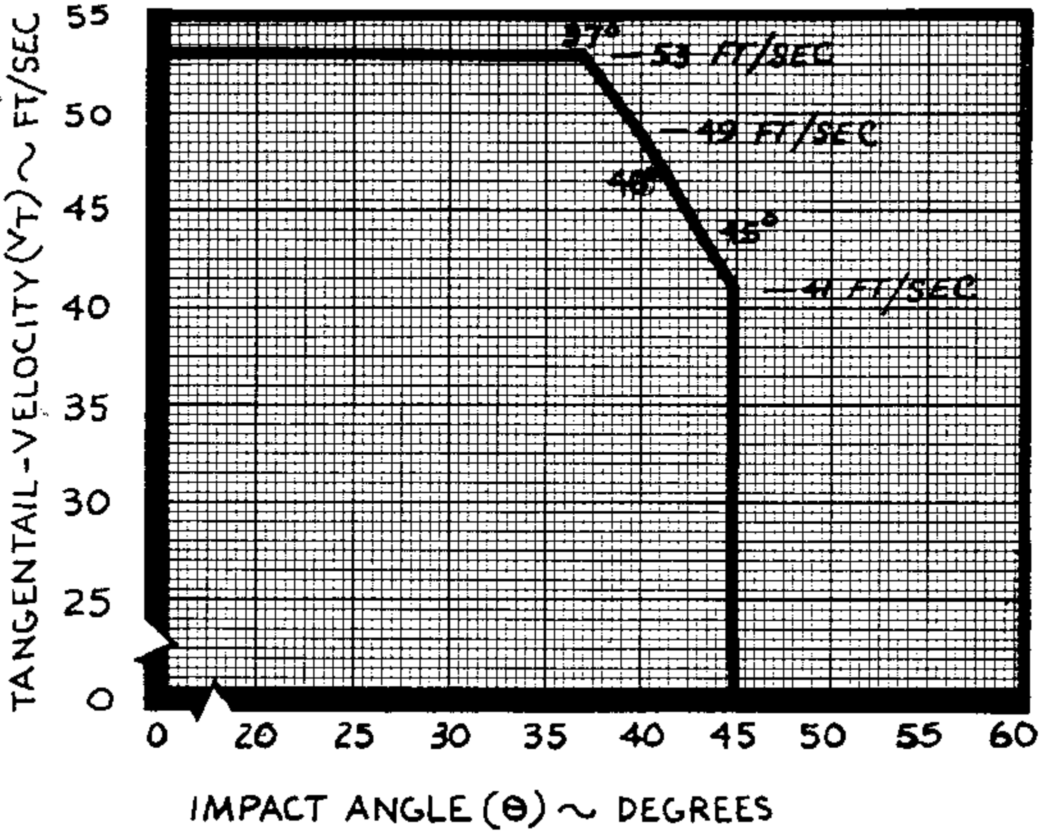
TABLE 1 - 2

APOLLO CM WATER IMPACT CRITERIA



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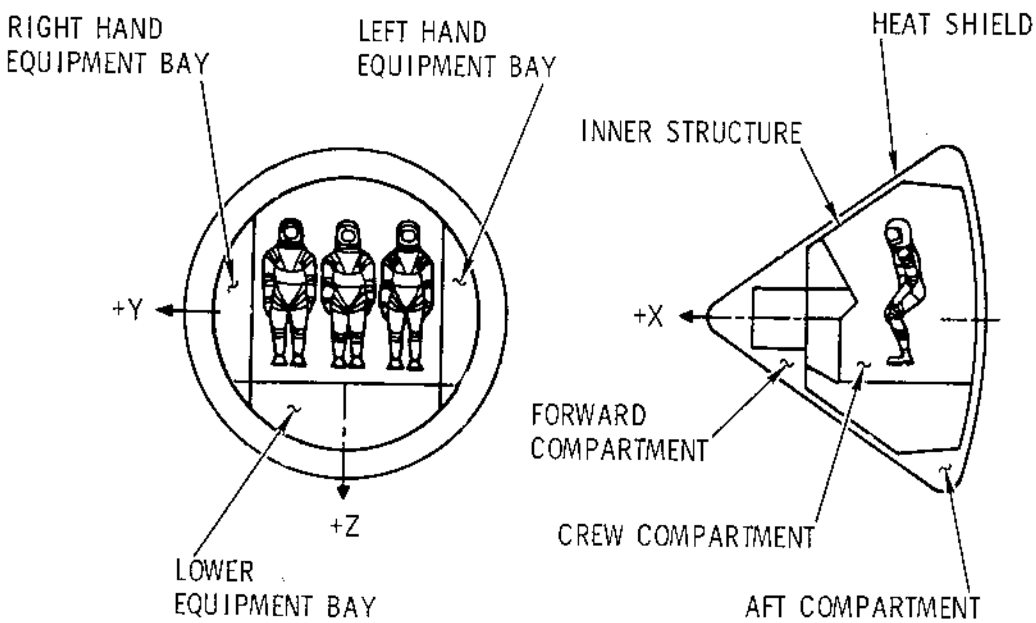
COMMAND MODULE COMPARTMENT CONFIGURATION



REFERENCE. FOR EXAMPLE, THE EQUIPMENT BAY AT THE ASTRONAUT'S FEET IS TERMED THE LOWER EQUIPMENT BAY. THE EQUIPMENT BAY TO THE RIGHT HAND SIDE OF THE CREW IS TERMED THE RIGHT HAND EQUIPMENT BAY, AND USING THE SAME ORIENTATION THE FORWARD COMPARTMENT IS IN FRONT OF THE CREW.

IN ORDER TO DESCRIBE THE STATION NUMBERS (X COORDINATES) ASSIGNED TO THE APOLLO SPACECRAFT, WE LOOK AT FIGURE 1-4. THE LES IS DESCRIBED AS X_L, C/M AS X_C, S/M AS X_S AND THE ADAPTER USING THE APOLLO INTEGRATED SYSTEM WILL BE DESCRIBED AS X_A. STARTING OFF WITH THE LAUNCH ESCAPE TOWER, $X_L = 0$ DENOTES THE BASE OF THE TOWER LEGS AND THE ATTACHING POINT TO THE C/M. THE MOST FORWARD PORTION OR NOSE CONE OF THE LES IS DESIGNATED AS $X_L = 398.5$. THE C/M OUTER FACE SHEET OF THE HEAT SHIELD, EXCLUDING THE ABLATIVE MATERIAL, IS DESIGNATED AS $X_C = 0$ AND THE FORWARD APEX OF THE SPACECRAFT BEING $X_C = 133.5$. THE SERVICE MODULE OUTER FACESHEET OF THE AFT BULKHEAD IS DESIGNATED $X_S = 200$. THIS NUMBER WAS ARBITRARILY PICKED TO PREVENT NEGATIVE STATION NUMBERS, SO, IF THERE IS ANY LENGTHENING OF THE APOLLO SPACECRAFT THE STATION NUMBERS WILL REMAIN POSITIVE. THE OUTER FACESHEET OF THE FORWARD BULKHEAD WILL BE DESIGNATED AS $X_S = 355$. THIS FIGURE DOES NOT INCLUDE THE 26" LENGTH OF FAIRING. THE SLA IS ATTACHED TO THE AFT BULKHEAD OF THE SERVICE MODULE, AND USING THE INTEGRATED SYSTEM, THE DESIGNATIONS WILL BE X_A. THE ATTACHING POINT TO THE S-IVB INSTRUMENT UNIT BEING $X_A = 502$ AND FORWARD ATTACH POINT TO S/M BEING $X_A = 838$.

AN INTEGRATED STATION SYSTEM DESIGNATOR IS X_A AND IS USED FOR LOCATING STATIONS AND MODULES ALONG THE APOLLO LONGITUDINAL (X) AXIS. ITS ORIGIN (0) IS IN THE S-IVB, SO LOCATED, TO MAKE ALL X_A STATIONS POSITIVE. THE PERMANENT REFERENCE POINT IS AT $X_A = 1,000$, WHICH COINCIDES WITH $X_C = 0$.

FIGURE 1-5 SHOWS A COMPARISON BETWEEN APOLLO INTEGRATED STATIONS (X_A) AND THE LAUNCH VEHICLE STATIONS.

APOLLO INTEGRATED STATIONS & AXIS

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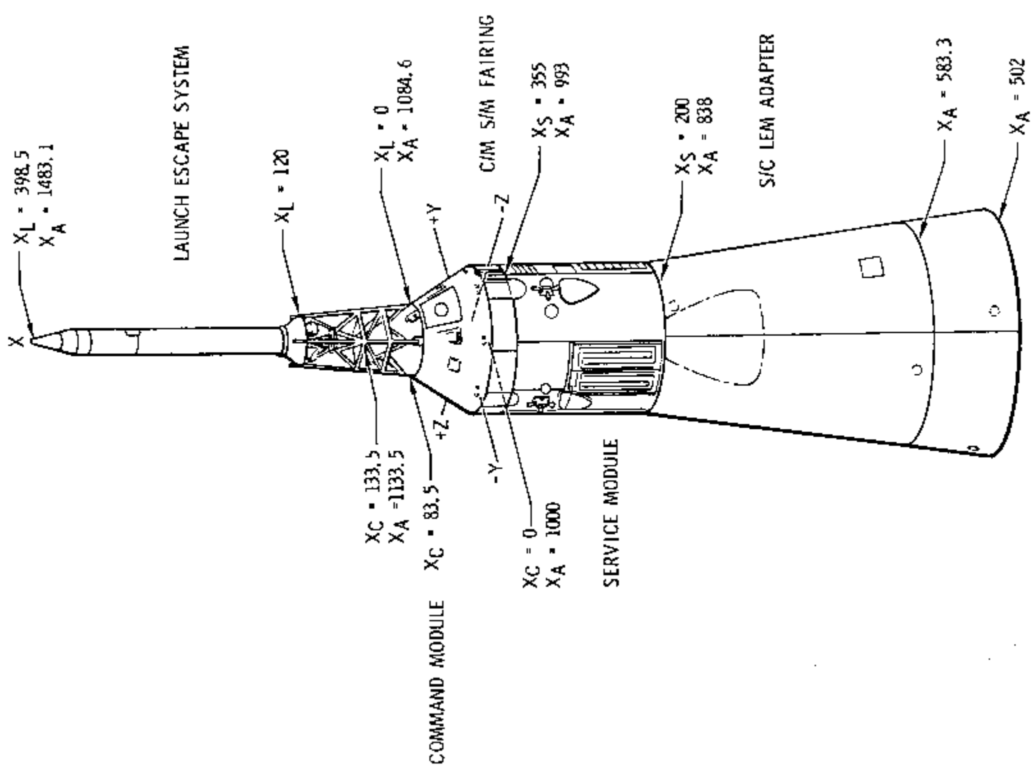

FIGURE 1-4

SATURN APOLLO LAUNCH VEHICLE CONFIGURATIONS

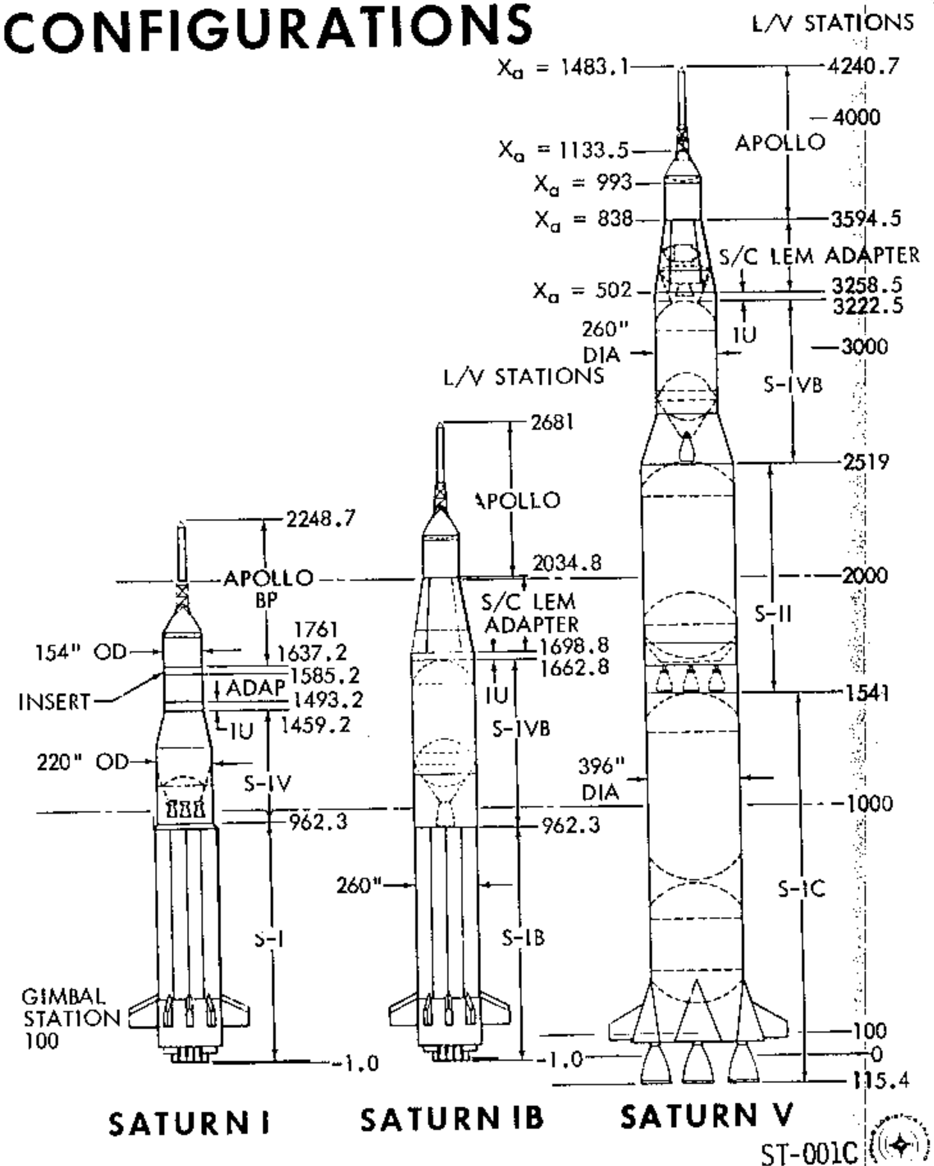

FIGURE 1-5

SECTION II

LAUNCH ESCAPE SYSTEM STRUCTURES

2

2.1 GENERAL

THE LAUNCH ESCAPE SYSTEM (LES) IS PROVIDED FOR THE SOLE PURPOSE OF POSITIONING THE COMMAND MODULE A SAFE DISTANCE FROM THE LAUNCH PAD, OR AWAY FROM THE PATH OF THE LAUNCH VEHICLE IN THE EVENT OF A PAD ABORT OR AN ABORT SHORTLY AFTER LAUNCH. (FIGURE 2-1). UPON THE COMPLETION OF AN ABORT, OR A SUCCESSFUL LAUNCH, THE LAUNCH ESCAPE ASSEMBLY IS JETTISONED FROM THE C/M BY THE JETTISON MOTOR. THE COMPONENTS OF THE LAUNCH ESCAPE SYSTEM CAN BE DIVIDED INTO THE FOLLOWING CATEGORIES; NOSE CONE AND "Q" BALL, CANARD SUB-ASSEMBLY, ROCKET MOTORS, STRUCTURAL SKIRT, AND TOWER STRUCTURE. THE LAUNCH ESCAPE SYSTEM FUNCTIONS ADDITIONALLY IN HELPING TO ORIENT THE S/C DURING THE ABORT BY ITS AERODYNAMIC CANARD SYSTEM.

2.2 STRUCTURE AND CONFIGURATION (FIGURE 2-2)

2.2.1 SPECIAL LOADS AND HEATING

DURING A NORMAL LAUNCH OR WHEN AN ABORT IS INITIATED, THE NOSE CONE MAY BE SUBJECTED TO TEMPERATURES UP TO 1000°F. THIS MAXIMUM TEMPERATURE IS APPLIED DURING THE ASCENT PHASE BETWEEN 30,000 AND 40,000 FEET. HOWEVER, THE TEMPERATURE OF THE "Q" BALL ONLY REACHES APPROXIMATELY 350°F DUE TO THE HEAT ABSORPTION CHARACTERISTICS OF THE ADDED MASS SURROUNDING THE "Q" BALL. THE STRUCTURAL SKIRT, WHICH IS AN AERODYNAMIC SHAPED STRUCTURE JOINING THE TOWER AND THE LAUNCH ESCAPE MOTOR ASSEMBLY WILL REACH TEMPERATURES IN EXCESS OF 500°F APPROXIMATELY 150 SECONDS AFTER LAUNCH. THIS SURFACE WILL BE PROTECTED AGAINST AERODYNAMIC HEATING BY COVERING THE EXPOSED SURFACES WITH AN ABLATIVE MATERIAL.

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 DEGRADE CREW PERFORMANCE.

WHEN AN ABORT IS INITIATED UP THROUGH BURNOUT AND DURING A NORMAL FLIGHT, THE MAXIMUM G FORCES EXERTED ON THE LES STRUCTURE IS 10 G'S. THE G FORCES EXERTED ARE ALONG THE X AXIS OR LONGITUDINAL AXIS. THE PREVIOUSLY MENTIONED FIGURE IS THE MAXIMUM EXPECTED LIMITS, NOT THE MAXIMUM DESIGN. STRUCTURALLY, THE LAUNCH ESCAPE SYSTEM IS DESIGNED TO 1.5 TIMES THAT OF THE EXPECTED G LOADS.

LAUNCH ESCAPE SYSTEM STRUCTURE

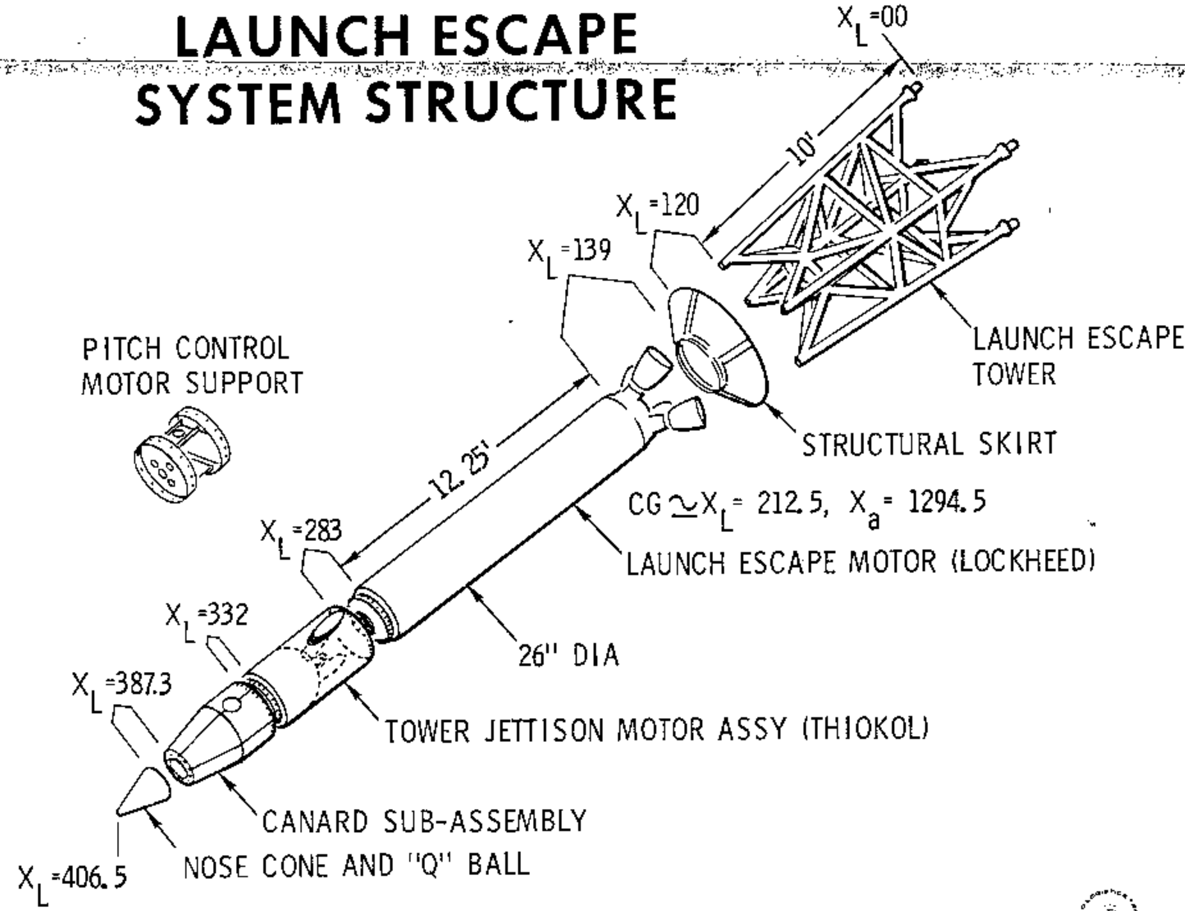

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FIGURE 2-2

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LAUNCH ESCAPE SYSTEM

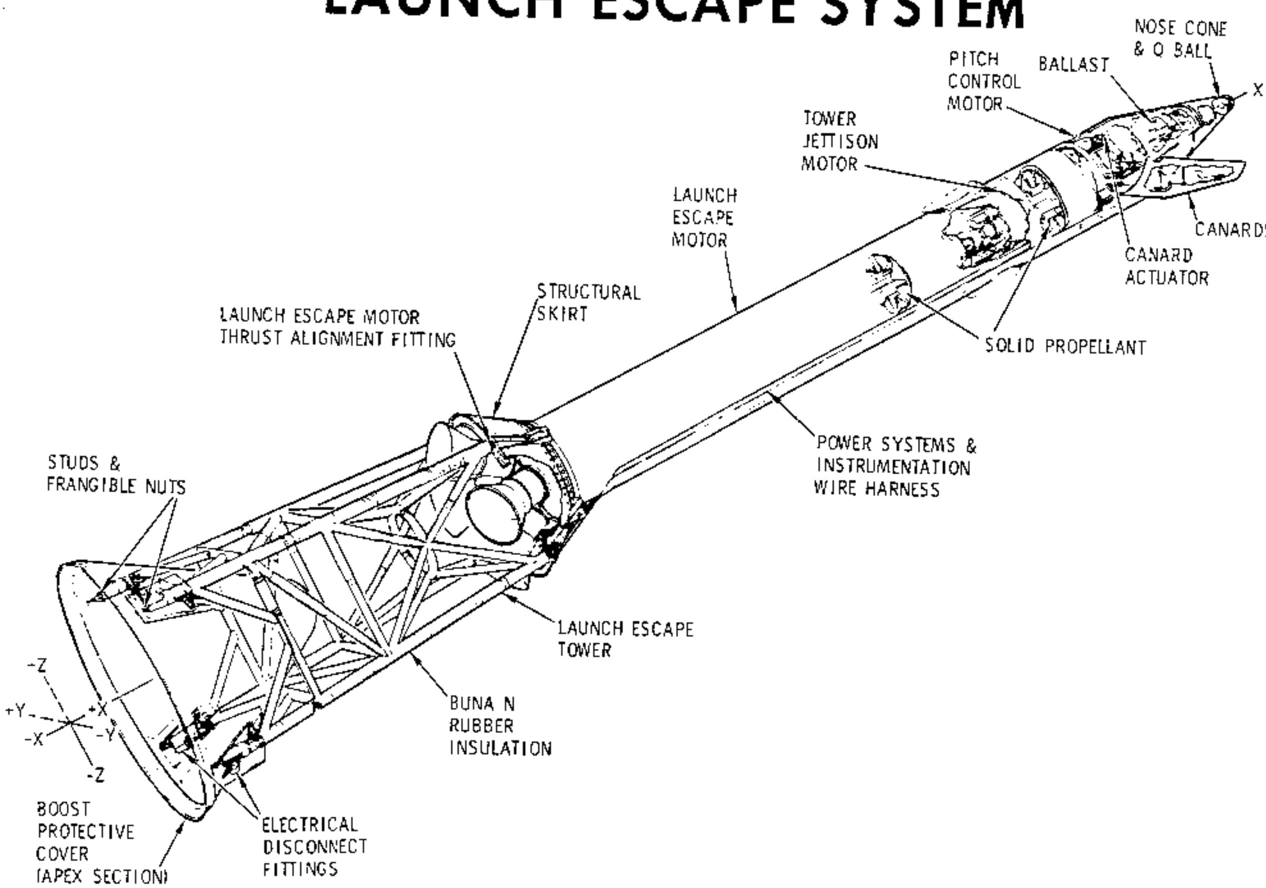

FIGURE 2-1

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2

CANARD STRUCTURAL CONFIGURATION

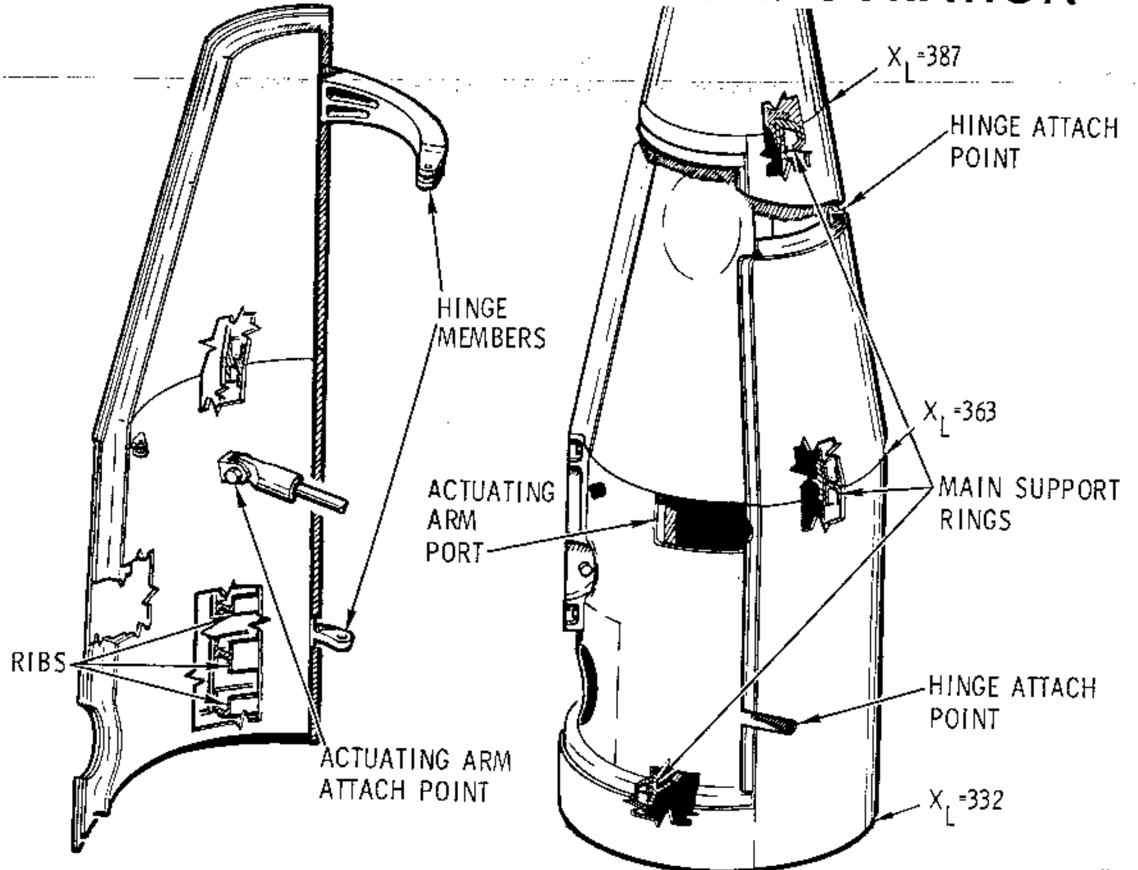

FIGURE 2-3

2-5

2.3 NOSE CONE AND "Q" BALL

THE AERODYNAMIC SHAPED FAIRING AT THE EXTREME FORWARD END OF THE LES IS THE NOSE CONE. THE NOSE CONE 13.3 INCHES IN LENGTH WITH A FOUR INCH RADIUS NOSE IS MANUFACTURED BY (MSFC) MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA. THE NOSE CONE, FABRICATED OF ALUMINUM IS 13.30 INCHES IN DIAMETER AT THE AFT RING. SIX BOLTS AND TWO GUIDE PINS ON THE -Z AND +Z AXES WILL HOLD IT FIRMLY IN PLACE TO THE CANARD SUB-ASSEMBLY. IN ADDITION TO CONTRIBUTING TO THE AERODYNAMIC STABILITY OF THE LAUNCH VEHICLE. THE NOSE CONE WILL HOUSE A "Q" BALL. THE "Q" BALL WILL MEASURE DYNAMIC RAM PRESSURE AND DIFFERENTIAL PRESSURE ABOUT THE PITCH AND YAW AXIS AND PROVIDE THE CREW WITH A VECTORIAL DISPLAY OF ANGLE OF ATTACK INFORMATION. DURING LAUNCH, THE NOSE CONE SURFACE WILL BE SUBJECTED TO THE GREATEST PRESSURE AND HEAT, AND WILL CAUSE THE FORWARD PORTION OF THE NOSE CONE TO ABLATE.

2.4 CANARD SUB-ASSEMBLY (FIGURE 2-3)

THE CANARD SYSTEM CONSISTS PRIMARILY OF TWO DEPLOYABLE SURFACES. THESE CONTROL SURFACES, WHEN DEPLOYED, WILL ORIENT THE LAUNCH ESCAPE VEHICLE IN A AFT HEATSHIELD ATTITUDE PRIOR TO PARACHUTE (ELS) DEPLOYMENT. THE CANARDS WILL BE LOCATED AS A PACKAGE BETWEEN THE NOSE CONE AND "Q" BALL AND THE TOWER JETTISON MOTOR. THE CANARD SUB-ASSEMBLY CONSISTS OF CANARD TOWER STRUCTURE, TWO DEPLOYABLE SURFACES, AN ACTUATING SYSTEM AND NECESSARY STOPS, LOCKING DEVICES, THE BALLAST COMPARTMENT, AND PITCH CONTROL MOTOR ASSEMBLY (FIGURE 2-4).

THE CANARD TOWER STRUCTURE IS A SEMIMONOCOQUE CONSTRUCTION FABRICATED OF INCONEL-X AND CORROSION RESISTANT STEEL (CRES) (FIGURE 2-5). THE TOWER STRUCTURE IS 55 INCHES AT THE FORWARD RING TO 26 INCHES AT THE AFT RING. A FAIRING SURFACE SHALL BE ATTACHED TO THE SUPPORT STRUCTURE WHICH IS NOT OCCUPIED BY THE CANARD SURFACES OR HINGES. THE FAIRING SURFACE MAY BE REMOVED FOR MAINTENANCE AND ADJUSTMENT OF THE CANARD SYSTEM HARDWARE, PITCH CONTROL MOTOR, INSTRUMENTATION AND WIRING, AND ALLOWING ACCESS TO THE BALLAST COMPARTMENT.

THE CANARDS, OR DEPLOYABLE SURFACES, ARE TWO 100 DEGREE ARC SEGMENTS EXTENDING FROM STATION X_L=386.5 DOWN TO STATION X_L=339.6 AND WHEN NOT DEPLOYED WILL FORM PART OF THE TOWER STRUCTURE. THE CANARDS ARE A SEMIMONOCOQUE CONSTRUCTION APPROXIMATELY FOUR FEET LONG AND SIX SQ. FEET EACH. THE INNER LATERAL SUPPORT RIBS AND LONGITUDINAL SUPPORT STRINGERS WILL BE FABRICATED OF INCONEL-X AND WHEN ASSEMBLED WILL BE ONE INCH IN THICKNESS. THE CANARDS ARE CONNECTED BY TWO HINGE MEMBERS, ONE FORWARD AND ONE AFT. THE FORWARD HINGE BEING THE LARGER AND SO ATTACHED THAT WHEN THE CANARDS ARE DEPLOYED, THE CENTERLINE OF THE CYLINDRICAL PORTION OF THE CANARD SURFACE SHALL BE ORIENTED WITH A 30° ANGLE OF ATTACK AND SWEEP BACK ANGLE OF 160 DEGREES (FIGURE 2-6).

CANARD STRUCTURE

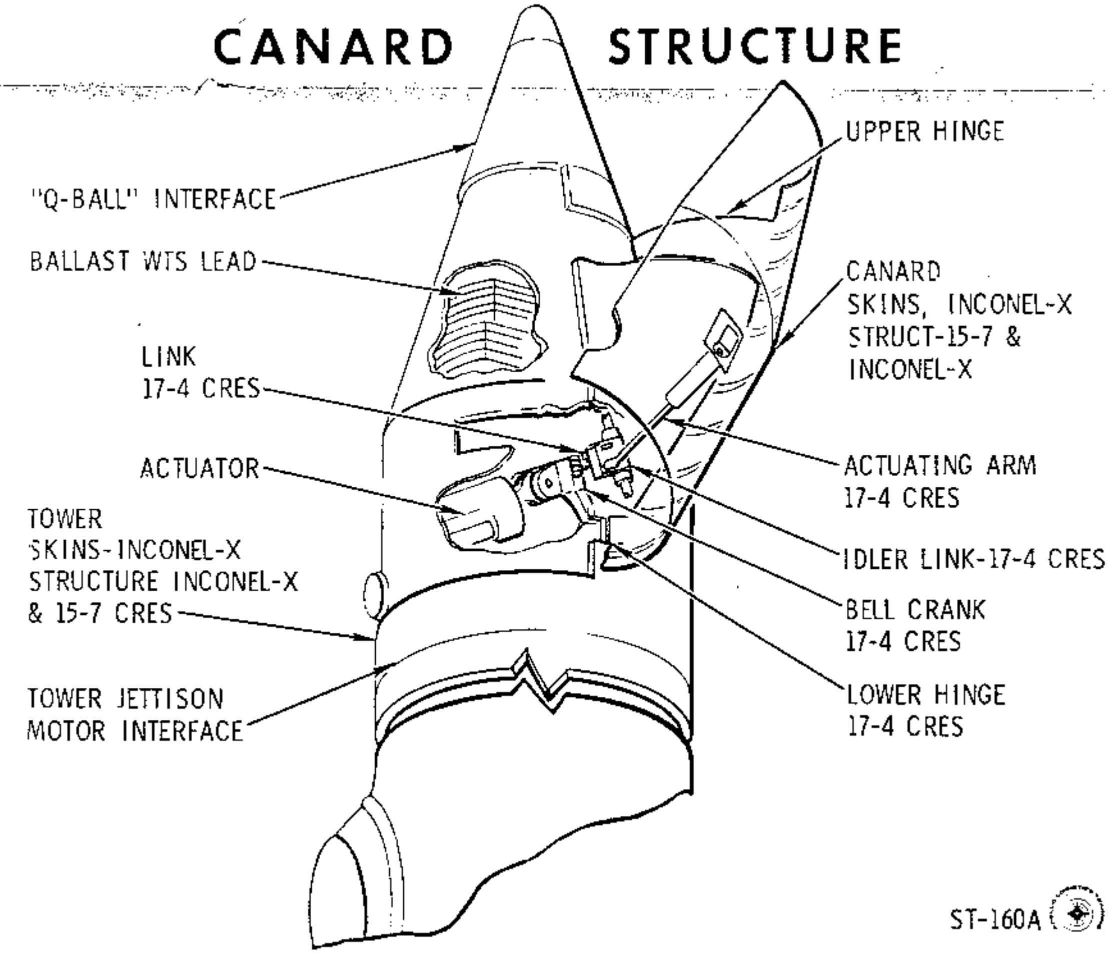

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FIGURE 2-5

CANARD THRUST & LINKAGE ASSEMBLIES

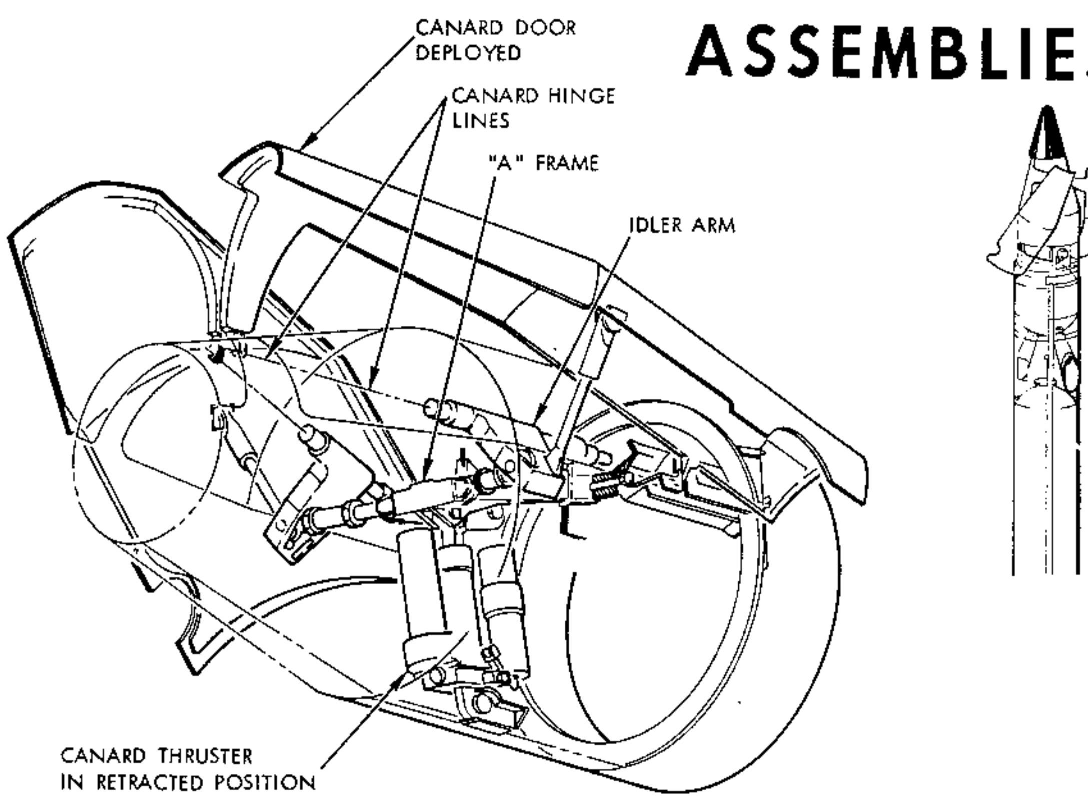

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FIGURE 2-4

2.4.1 CANARD PANELS

THE CANARD PANELS WILL BE DEPLOYED BY A PYROTECHNIC ACTUATED THRUSTER ASSEMBLY (FIGURE 2-7). THIS ASSEMBLY IS MOUNTED TO THE INTERNAL STRUCTURE OF THE TOWER AND CONNECTED TO THE ACTUATING MECHANISM OF THE CANARD PANELS. THE THRUSTER ASSEMBLY IS ACTUATED BY TWO ELECTRICALLY INITIATED PRESSURE CARTRIDGES LOCATED IN THE PLENUM CHAMBER, AND WILL DEPLOY THE CANARDS IN 0.14 TO 0.60 OF A SECOND. THE TWO PRESSURE CARTRIDGES LOCATED IN THE PLENUM CHAMBER, AND WILL DEPLOY THE CANARDS IN 0.14 TO 0.60 OF A SECOND. THE TWO PRESSURE CARTRIDGES WILL GENERATE A PRESSURE FORCING THE MAIN PISTON ASSEMBLY TO RETRACT AND AT THE SAME TIME PRESSURIZES TWO SMALLER PISTONS IN THE PLENUM CHAMBER, ACTUATING THE UNLOCKING LINKAGE. THIS LINKAGE RELEASES THE PANELS FROM THE CLOSED POSITION (FIGURE 2-8). TO PROVIDE REDUNDANCY, EITHER PRESSURE CARTRIDGE HAS SUFFICIENT POWER OUTPUT TO DEPLOY BOTH CANARD PANELS. TO PREVENT THE POSSIBILITY OF THE AIRLOADS OPENING THE PANELS TOO RAPIDLY, A SNUBBING SYSTEM IS BUILT INTO THE THRUSTER ASSEMBLY. THIS SNUBBING ACTION IS ACCOMPLISHED BY FILLING THE VOLUME ON THE UNPRESSURIZED SIDE OF THE MAIN PISTON ASSEMBLY WITH HYDRAULIC FLUID. UPON ACTIVATION OF THE MAIN PISTON, THE OIL IS FORCED THROUGH AN ORIFICE THUS REGULATING THE VELOCITY OF THE MAIN PISTON INDEPENDENT OF THE REACTING LOADS. AFTER THE PANELS ARE FULLY EXTENDED, THEY ARE LOCKED IN THE OPEN POSITION BY A LOCKING DEVICE BUILT INTO THE THRUSTER ASSEMBLY.

2.4.2 BALLAST COMPARTMENT (FIGURE 2-5)

THE BALLAST COMPARTMENT IS LOCATED WITHIN THE CONICAL SHAPED PORTION OF THE TOWER STRUCTURE ABOVE STATION X_L=363. THE BALLAST ASSISTS IN MAINTAINING AERODYNAMIC STABILITY OF THE LES AND C/M DURING AN ABORT. THE BALLAST COMPARTMENT HAS PROVISIONS FOR APPROXIMATELY 960 LBS. OF BALLAST. THE BALLAST MAY VARY IN WEIGHT FROM 0 TO 960 LBS. DEPENDING UPON VARIATIONS IN THE CENTER OF GRAVITY AND WEIGHT OF THE SPACECRAFT. THE DISCS OR WAFERS, FABRICATED OF LEAD, COME IN FOUR SIZES AND WEIGHTS. THESE LEAD WEIGHTS ARE THEN MOUNTED WITH THREE LARGE BOLTS ATTACHED TO THE BALLAST WEB LOCATED AT STATION X_L=363. THE CONICAL SHAPED PORTION OF FAIRING, COVERING THE TOWER STRUCTURE, HAS TO BE REMOVED TO ADD OR REMOVE ANY LEAD WEIGHTS.

2.4.3 PITCH CONTROL MOTOR STRUCTURE ASSEMBLY (FIGURE 2-2)

THE PITCH CONTROL MOTOR STRUCTURE ASSEMBLY AND THE PITCH CONTROL MOTOR IS LOCATED IN THE AFT COMPARTMENT OF THE CANARD SUB-ASSEMBLY. THE PITCH CONTROL MOTOR STRUCTURE ASSEMBLY CONSISTS OF TWO WEB PLATES AND ANGLES WHICH ARE RIVETED TO THE LONGERONS OF THE CANARD SUB-ASSEMBLY. THE PITCH CONTROL MOTOR ASSEMBLY IS MOUNTED PERPENDICULAR TO THE LONGITUDINAL AXIS BY BOLTING TO THE WEB PLATES. TO ASSURE ALIGNMENT OF THE PITCH CONTROL MOTOR, AND THAT THE NOZZLE IS FLUSH WITH THE OUTER SKIN LINE, SHIMS ARE PROVIDED

CANARD SURFACES FULLY DEPLOYED

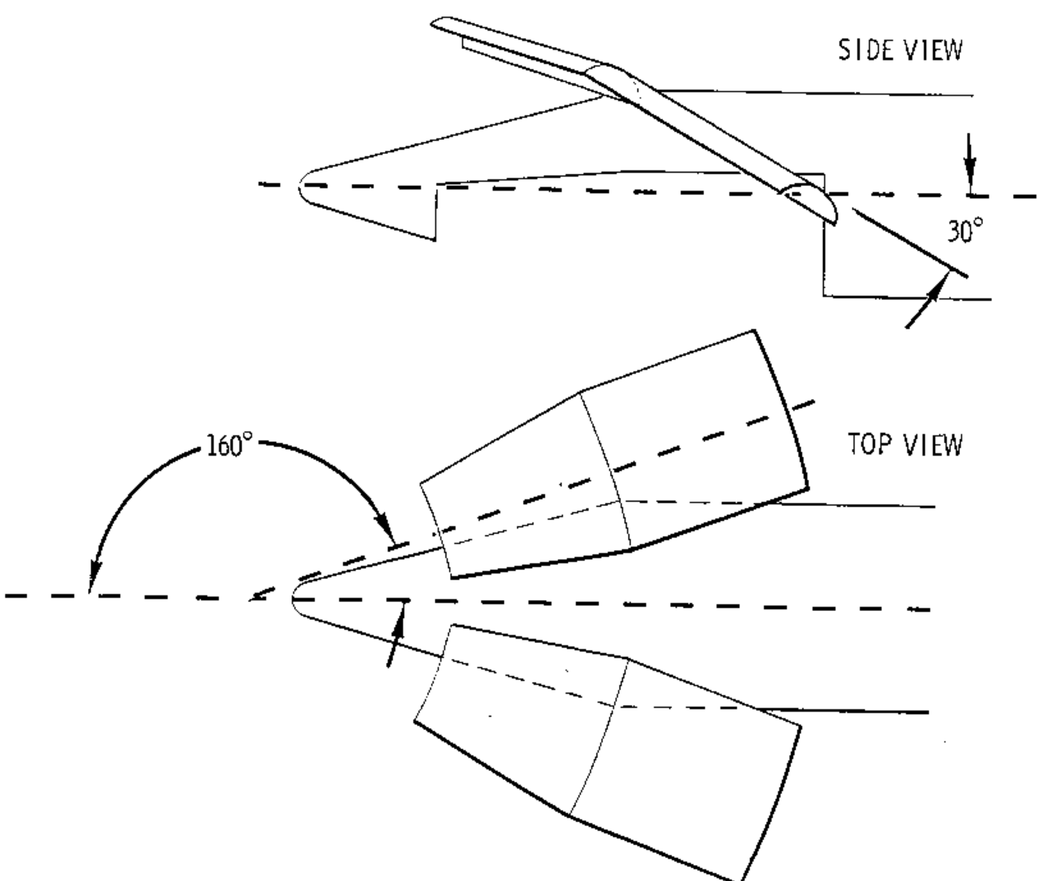

FIGURE 2-6

CANARD LATCH MECHANISM

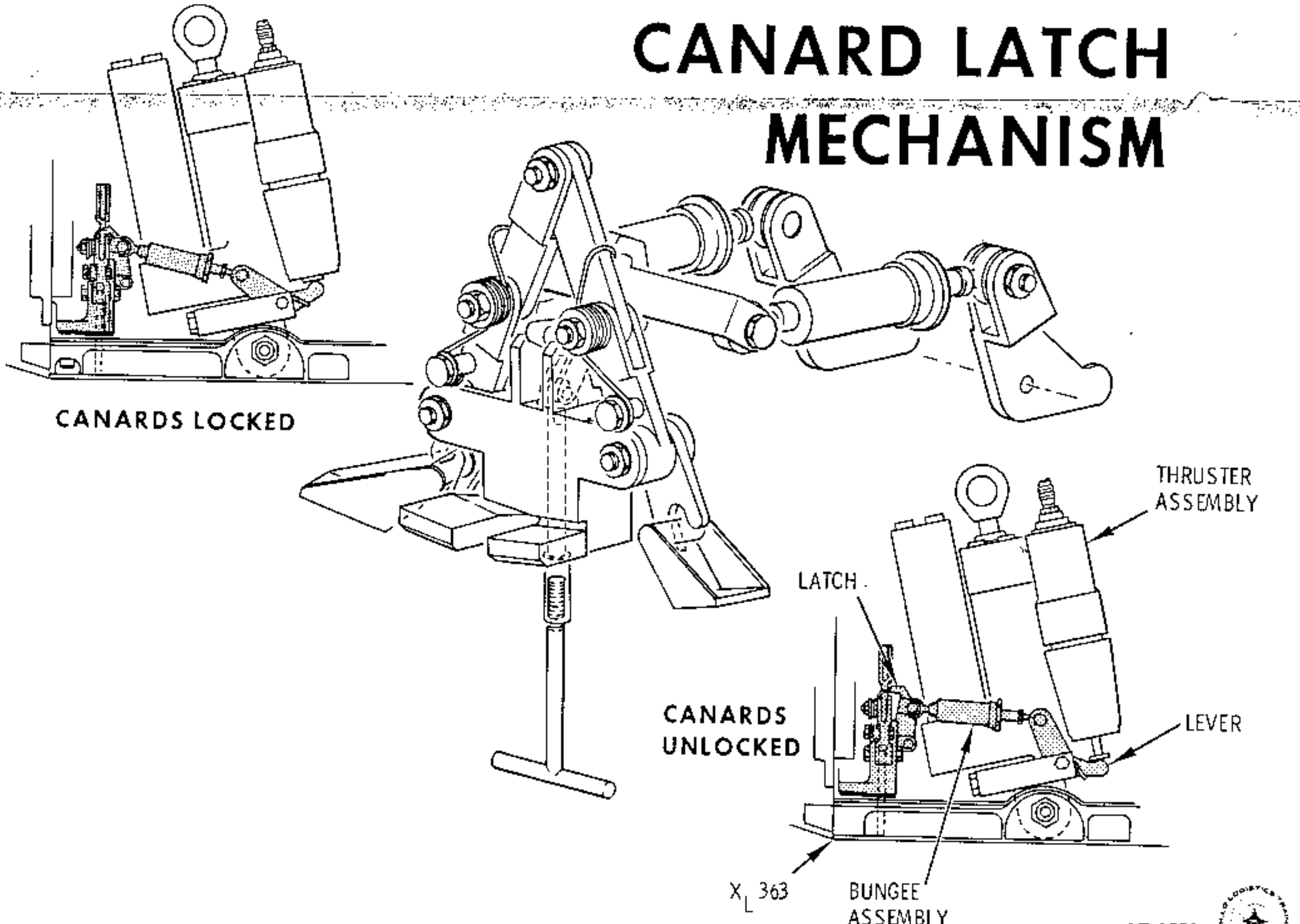

FIGURE 2-8

CANARD THRUSTER ASSEMBLY

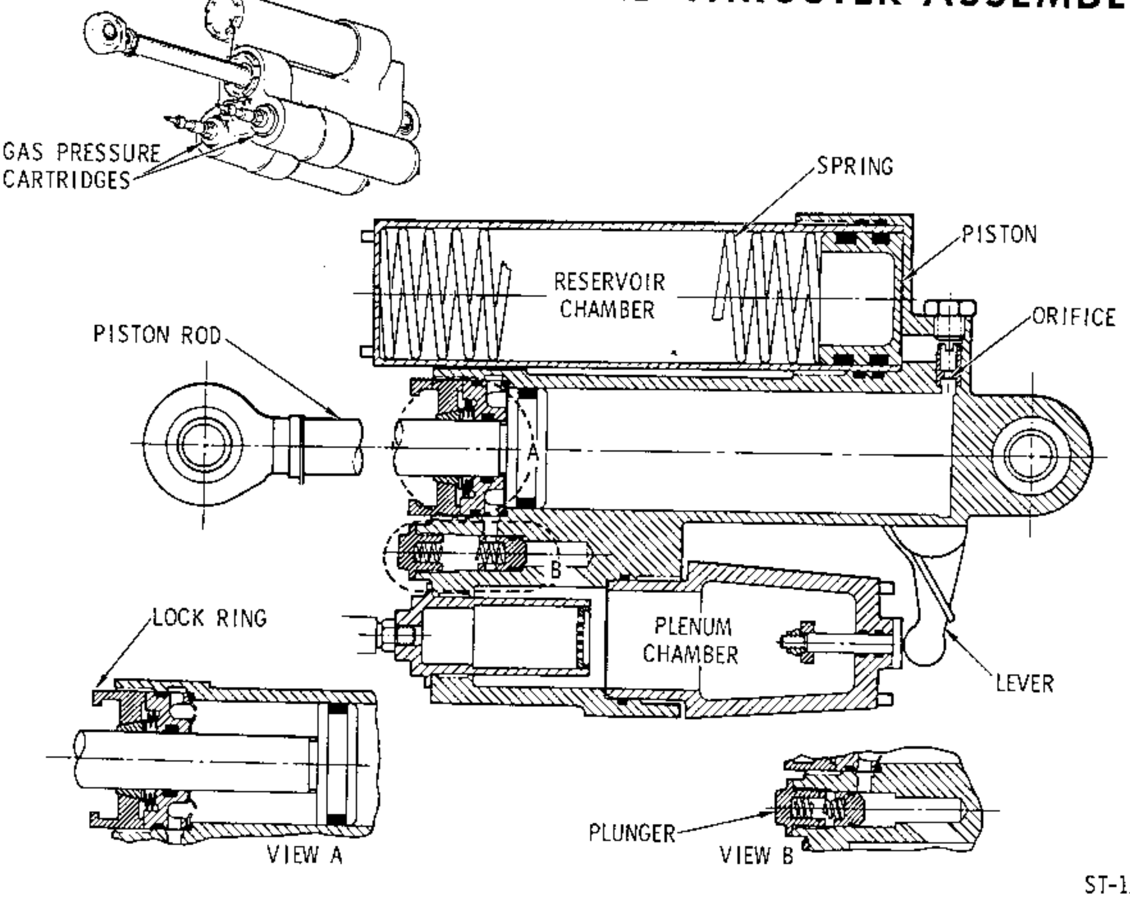

FIGURE 2-7

WHICH MAY BE ADDED OR REMOVED ON THE -Z AXIS PLATE. ALL THE MATERIAL USED IN ATTACHING THE PITCH CONTROL MOTOR WILL BE FABRICATED OF INCONEL AND STAINLESS STEEL.

2.5 ROCKET MOTORS

2.5.1 <u>PITCH CONTROL MOTOR</u>

THE PITCH CONTROL (P/C) MOTOR IS LOCATED IN THE CANARD SUB-ASSEMBLY. UPON INITIATION OF A PAD ABORT, THE PITCH CONTROL MOTOR IS IGNITED SIMULTANEOUSLY WITH THE LAUNCH ESCAPE MOTOR. ITS PURPOSE IS TO ESTABLISH A 15° TO 20° DOWN RANGE PITCH OVER FROM A PAD ABORT. THIS MANEUVER WILL CHANGE THE TRAJECTORY OF THE ESCAPING C/M FROM THAT OF THE LAUNCH VEHICLE.

THE PITCH CONTROL MOTOR IS MANUFACTURED BY THE LOCKHEED PROPULSION COMPANY. ITS OVERALL LENGTH IS 22 INCHES, ITS DIAMETER IS NINE INCHES, WITH AN OVERALL WEIGHT OF 50 POUNDS. THE SOLID PROPELLANT HAS A 14 POINT STAR CONFIGURATION WITH A BURNING TIME OF 0.5 SECOND.

2.5.2 <u>TOWER JETTISON MOTOR</u> (FIGURE 2-3)

OF THE THREE MOTORS USED IN THE LES SYSTEM, ONLY THE TOWER JETTISON MOTOR IS USED IN A SUCCESSFUL MISSION. IT PROVIDES THE THRUST TO CARRY THE TOWER AND MOTOR ASSEMBLY AWAY FROM THE S/C DURING THE NORMAL ASCENT. THIS MOTOR IS ALSO USED, IF AN ABORT IS NECESSARY, TO CARRY THE ENTIRE LES TOWER ASSEMBLY WITH THE BOOST COVER UP AND AWAY FROM C/M.

THE TOWER JETTISON MOTOR ASSEMBLY IS A 26 INCH DIAMETER CYLINDRICAL STRUCTURE. THE TOWER JETTISON MOTOR IS AN INTEGRAL PART OF THE CYLINDRICAL STRUCTURE, HAVING A STRUCTURE PORTION OR SKIRT EXTENDING AFT BEYOND THE NOZZLES. THIS EXTENDED PORTION WILL ATTACH TO THE FORWARD END OF THE LAUNCH ESCAPE MOTOR CASE BY 49 BOLTS AND IS CONSIDERED THE TOWER JETTISON MOTOR MOUNT. EXTENDING BEYOND THE FORWARD END OF THE TOWER JETTISON MOTOR IS A FAIRING THAT IS ATTACHED WITH 32 BOLTS TO THE CANARD SUB-ASSEMBLY. THE TOWER JETTISON MOTOR STRUCTURAL ASSEMBLY IS A SEMIMONOCOQUE CONSTRUCTION FABRICATED OF .080 INCH THICK INCONEL.

THE TOWER JETTISON MOTOR IS MANUFACTURED BY THIOKOL CHEMICAL CORPORATION. ITS OVERALL LENGTH, INCLUDING NOZZLES AND ADAPTER, IS 50 INCHES. IT IS 26 INCHES IN DIAMETER AND WEIGHS APPROXIMATELY 500 POUNDS. THE SOLID PROPELLANT HAS A TEN STAR GRAIN CONFIGURATION WITH A BURNING TIME OF ONE SECOND. THE TWO NOZZLES ARE CANTED 30° FROM THE CENTER LINE, WITH ONE NOZZLE THROAT AREA LARGER THAN THE OTHER TO ESTABLISH AN OFFSET THRUST VECTOR OF APPROXIMATELY 4° TO THE POSITIVE Z SIDE.

2.5.3 <u>LAUNCH ESCAPE MOTOR</u> (FIGURE 2-2)

THE PRIMARY FUNCTION OF THE LAUNCH ESCAPE MOTOR IS TO CARRY THE C/M AWAY FROM THE LAUNCH VEHICLE.

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 BACKUP FOR THE TOWER JETTISON MOTOR. IF THE TOWER JETTISON MOTOR SHOULD FAIL TO IGNITE AT THE PROPER TIME, THE LAUNCH ESCAPE MOTOR CAN BE FIRED TO JETTISON THE TOWER ASSEMBLY WITH THE BOOST COVER UP AND AWAY FROM THE C/M.

THE LAUNCH ESCAPE MOTOR ASSEMBLY IS A 26 INCH DIAMETER CYLINDRICAL STRUCTURE. IT IS CONSTRUCTED THE SAME AS THE TOWER JETTISON MOTOR WHERE THE OUTTER SKIN IS THE MOTOR CASE. EXTENDING BEYOND THE FORWARD AND AFT CONTOUR OF THE MOTOR ASSEMBLY ARE RING FRAMES FOR MATING. THE FORWARD RING FRAME IS ATTACHED TO THE AFT SKIRT OF THE TOWER JETTISON MOTOR WITH A SERIES OF 49 BOLTS. THE FIRST BOLT CCW FROM +Z AXIS AND AN INDEX MARK ON THE -Z AXIS INSURE PROPER MATING AND ALIGNMENT. THE AFT MOTOR RING FRAME IS THEN ATTACHED TO THE FORWARD RING ASSEMBLY OF THE TOWER SKIRT WITH 48 BOLTS. NO MATING OR ALIGNMENT IS NECESSARY AT THIS POINT.

THE LAUNCH ESCAPE MOTOR IS MANUFACTURED BY LOCKHEED PROPULSION COMPANY. IT HAS AN OVERALL LENGTH, INCLUDING NOZZLES AND IGNITER, OF 16 FEET. IT IS 26 INCHES IN DIAMETER AND WEIGHS APPROXIMATELY 4,750 LBS. THE SOLID PROPELLANT HAS AN EIGHT POINT STAR GRAIN CONFIGURATION WITH A TOTAL BURN TIME OF APPROXIMATELY EIGHT SECONDS.

THE LAUNCH ESCAPE MOTOR HAS FOUR NOZZLES POSITIONED 90° APART. EACH NOZZLE IS CANTED 35° FROM THE X AXIS. THE +Y AND -Y NOZZLES ARE IDENTICAL, EACH HAVING A THROAT AREA OF 21.1 SQUARE INCHES AND A DIAMETER OF 5.2 INCHES. THE +Z NOZZLE HAS A THROAT AREA OF 24.4 SQUARE INCHES AND A DIAMETER OF 5.56 INCHES AS COMPARED TO THE -Z NOZZLE THROAT AREA OF 18.1 SQUARE INCHES AND DIAMETER OF 4.8 INCHES. THIS THROAT SIZE VARIANCE PRODUCES AN OFFSET IN THRUST OUTPUT, CAUSING A 2.75° OFFSET IN THRUST VECTOR FROM THE NOMINAL THRUST CENTERLINE.

2.6 STRUCTURAL SKIRT (FIGURE 2-2)

THE SKIRT IS AN AERODYNAMIC SHAPED STRUCTURE WHICH DISTRIBUTES THE LOADS FROM THE FOUR TOWER ATTACHMENT POINTS TO THE LAUNCH ESCAPE MOTOR. THE FORWARD RING FRAME OF THE STRUCTURAL SKIRT WILL MATE WITH A FLANGE ON THE MOTOR AFT CLOSURE. HOIST FITTINGS WILL BE PROVIDED ON THE SKIRT WITH SUFFICIENT CAPACITY FOR LIFTING THE ENTIRE APOLLO VEHICLE.

THE SKIRT ASSEMBLY STRUCTURE CONSISTS OF TWO RING FRAMES, 4 LONGERONS, AND FOUR SKIN ASSEMBLIES OR PANELS. THE AFT RING ASSEMBLY IS FABRICATED OF TITANIUM, VANADIUM, AND ALUMINUM (6AL-4V). IT IS CUT INTO FOUR 90° SECTIONS AND BUTT WELDED TO FOUR LONGERONS FABRICATED OF THE SAME MATERIAL (6AL-4V). RIVETED TO THE AFT RING AND LONGERONS ARE FOUR PANELS FABRICATED OF (6AL-4V) .140 INCH SHEETS. THE PANEL LOCATED ON THE Y AXIS HAS TWO SIX INCH CUTOUTS TO LOCATE THE POWER SYSTEMS AND INSTRUMENTATION WIRE HARNESS. THE FORWARD RING FRAME (6AL-4V) AND FOUR STEEL HOISTING

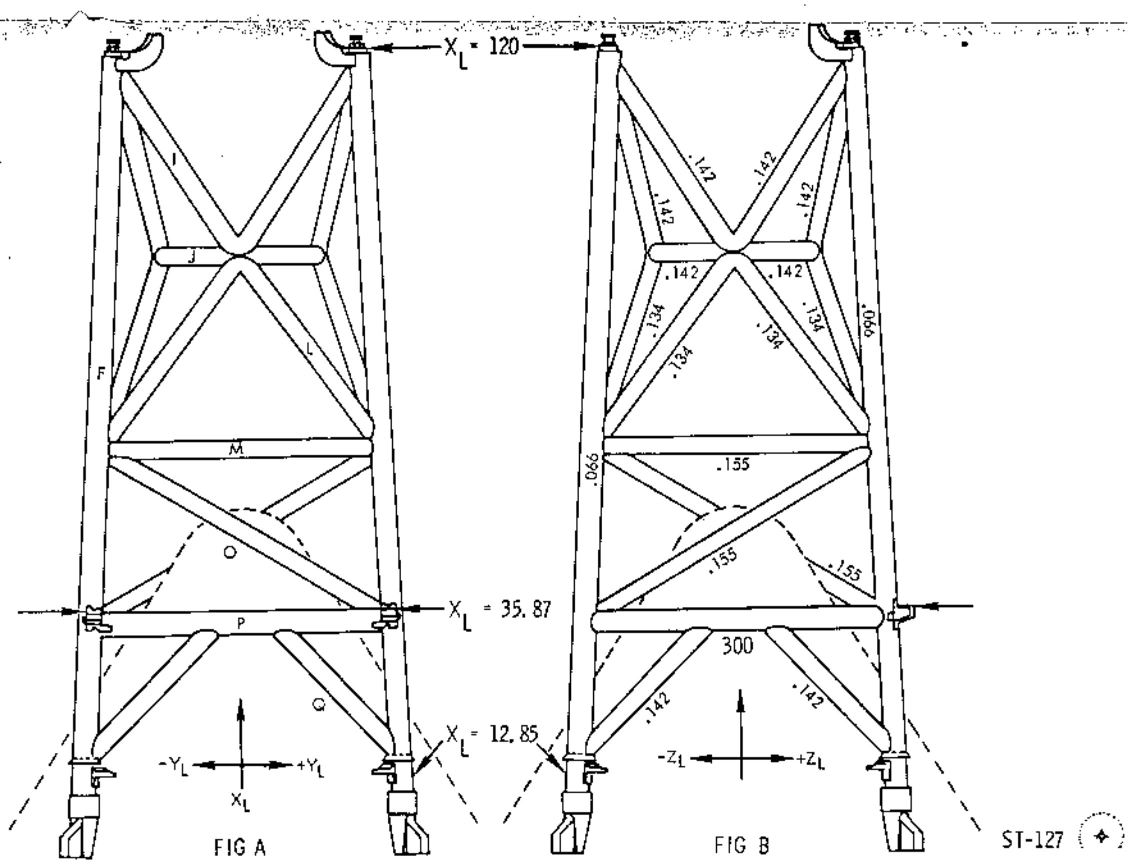

FIGURE 2-9

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FITTINGS ARE BOLTED AND RIVETED TO THE LONGERONS AND SKIN ASSEMBLIES.

AFTER THE TOWER SKIRT IS COMPLETE AND BEFORE ATTACHING TO THE LAUNCH ESCAPE MOTOR, THE SKIRT IS PROTECTED WITH AN ABLATIVE MATERIAL. THE ABLATIVE COATING USED IS THERMOLAG T-500 EX-167 AND RESEMBLES A BLACK TAR AFTER DRYING. AFTER CAREFUL SURFACE PREPARATION THE INSULATION OR ABLATIVE MATERIAL IS APPLIED IN THIN LAYERS BY ALTERNATELY SPRAYING AND AIR DRYING BETWEEN LAYERS UNTIL THE PROPER THICKNESS IS OBTAINED. THE ABLATIVE AND INSULATING MATERIAL SHALL COVER THE INNER AND OUTER SURFACES OF THE TOWER SKIRT, EXCEPT THE OPENINGS AND SURFACES FOR THE INSTRUMENTATION WIRE HARNESS AND THE FORWARD RING FRAME USED TO ATTACH THE SKIRT TO THE LAUNCH ESCAPE MOTOR. THE COMPLETED MULTIPLE COATING SHALL BE .050 INCH THICK, ALLOWED TO DRY THOROUGHLY, THEN HEAT CURED AT A CONTROLLED TEMPERATURE.

THE FOUR TOWER ALIGNMENT/ADJUST BOLTS LOCATED AT STATION X_L=120 ATTACH THE AFT RING OF THE STRUCTURAL SKIRT FIRMLY TO THE LAUNCH ESCAPE TOWER. THESE ATTACHMENTS PROVIDE A CAPABILITY FOR ADJUSTING THE ANGULAR ALIGNMENT OF THE TOWER AND LAUNCH ESCAPE MOTOR. THESE FOUR LARGE BOLTS, HAVING AN ADJUSTMENT OF 1.88 INCHES, PROVIDE A RANGE OF PLUS OR MINUS 1 DEGREE PERMITTING ALIGNMENT OF THE THRUST VECTOR RELATIVE TO THE ABORT CONFIGURATION CENTER OF GRAVITY. AFTER THE TOWER AND LES CENTERLINES HAVE BEEN ALIGNED, THE ATTACHMENT BOLT AND LOCK NUT WILL BE TORQUED AND SAFETY WIRED.

2.7 LAUNCH ESCAPE TOWER (FIGURE 2-9)

THE PURPOSE OF THE TOWER IS TO SUPPORT THE LAUNCH ESCAPE MOTORS. CONSEQUENTLY, ITS DESIGN REQUIREMENTS ARE GOVERNED CONSIDERABLY BY THE MOTORS. FOR EXAMPLE, THE STRUCTURE MUST BE DESIGNED TO SUPPORT THE WEIGHT AND THRUST OF THE MOTORS, THE LOADS, STRESSES, AND STRAINS THAT WILL BE PRESENT DURING ASCENT. THE STRUCTURE MUST BE OF A CERTAIN LENGTH TO PREVENT FLAME IMPINGEMENT OF THE C/M AND CONSTRUCTED OF MATERIAL THAT CAN WITHSTAND THE HEAT CREATED BY THE MOTORS. THE OVERALL LENGTH OF THE TOWER STRUCTURE IS 10 FEET AND WEIGHS APPROXIMATELY 300 POUNDS. THE STRUCTURE TAPERS FROM APPROXIMATELY 4 FEET SQUARE AT THE C/M ATTACH POINTS TO THREE FEET SQUARE WHERE IT JOINS TO THE MOTOR ASSEMBLY.

THE TOWER IS CONSTRUCTED OF WELDED TUBULAR PURE TITANIUM AND (6AL-4V) TITANIUM ALLOY. THE TUBES ARE OF THE FOLLOWING THICKNESS AND DIAMETER:

1. TUBE J-2.5" O.D., 0.15" WALL-COMMERCIALLY PURE TITANIUM
2. TUBES I, L, M, O, Q - 2.5" O.D., 0.05" WALL-6AL-4V TITANIUM ALLOY
3. TUBES F, P-3.5" O.D., 0.125" WALL-6AL-4V TITANIUM ALLOY

CANARD OPERATION

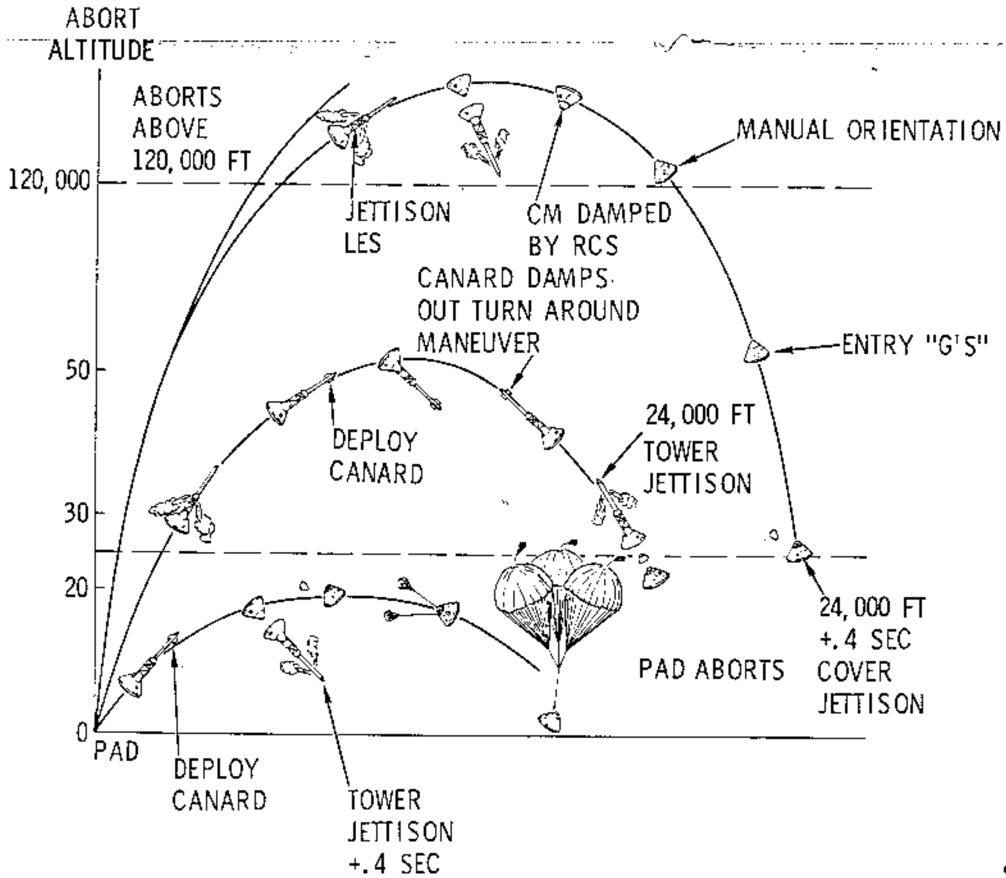

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FIGURE 2-10

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THE ABOVE DIMENSIONS AND THICKNESSES ARE SHOWN IN FIGURE 2-9 (FIGURE A).

MOUNTED TO EACH TOWER LEG AT STATION X_L=12.85 ARE FOUR FITTINGS WHICH PROVIDE AN ATTACH POINT FOR THE BOOST PROTECTIVE COVER. TWO BRACKETS ARE ATTACHED TO THE -Z TOWER LEGS AT STATION X_L-35.87 PROVIDING A STRUCTURAL STOP FOR THE LAUNCH COMPLEX ARM. THIS STOP WILL TRIP A SENSING MECHANISM ALLOWING THE MECHANICAL LINKAGE LOCATED ON THE COMPLEX ARM TO POSITION THE CREW HATCH COVER OVER THE C/M HATCH FOR EMERGENCY EXIT WHILE ON THE PAD.

THE ENTIRE TOWER STRUCTURE IS INSULATED WITH BUNA-N-RUBBER TO PROTECT THE STRUCTURE FROM THE FLAME IMPINGEMENT OF THE MOTORS AND AERODYNAMIC FRICTION HEATING. THE MOST SEVER THERMAL ENVIRONMENT CURRENTLY EXPECTED FOR THE S/C LES TOWER IS DURING A S-V BOOST, 120,000 FT ABORT OR C/M ENTRY TO 24,000 FT. THE INSULATION ON THE TOWER STRUCTURE WILL BEGIN ABLATING AT 550 DEGREES FAHRENHEIT. THE INSULATION ON THE LAUNCH ESCAPE TOWER WILL BE APPLIED UNIFORMLY AROUND THE CIRCUMFERENCE OF ALL TUBES FOR STRUCTURAL DESIGN TEMPERATURES OF 600 DEGREES TO 800 DEGREES FAHRENHEIT. THE VARYING THICKNESSES ARE SHOWN IN (FIGURE 2-9 (FIGURE B)).

THE TWO TOWER LEGS ON THE Y AXIS ALSO CARRY INTERNAL POWER SYSTEMS AND INSTRUMENTATION HARNESS. TO PROTECT AGAINST ANTI-VIBRATION MEASURES WHICH COULD CAUSE CHAFFING OF THE HARNESS, A FOAM IS INJECTED THROUGH A SERIES OF HOLES PREDRILLED IN THE TOWER LEGS. AFTER THE INJECTING OF FOAM IS COMPLETE THE HOLES ARE PLUGGED AND FILLED WITH BUNA-N-RUBBER.

2.8 LAUNCH ESCAPE SYSTEM MODES OF OPERATION

THE LAUNCH ESCAPE SYSTEM WILL CONTAIN A DEPLOYABLE CANARD SYSTEM. THE CANARDS HAVE THE EFFECT OF ORIENTING THE ESCAPE VEHICLE BLUNT AND FORWARD BY THE INDUCED AERODYNAMIC FORCES ON THE CANARD SURFACES FROM THE PAD TO 120,000 FEET. FOR ABORTS AT ALTITUDES ABOVE 120,000 FEET, THE ENTIRE LES AND BOOST COVER IS JETTISONED AND THE ASTRONAUTS WILL PARTICIPATE IN PRECISELY ORIENTING THE COMMAND MODULE IN AN ENTRY ATTITUDE.

THERE ARE THREE MODES OF OPERATION, LOW ALTITUDE ABORT, MEDIUM ALTITUDE ABORT, AND HIGH ALTITUDE ABORT. TO BRIEFLY EXPLAIN THE MODES OF OPERATION, THEY WILL BE EXPLAINED INDIVIDUALLY. (FIGURE 2-10)

2.8.1 <u>LOW ALTITUDE ABORT MODE</u>

FOR THE LOW ALTITUDE ABORT MODE (FROM PAD TO 30,000 FEET), THE CANARD DEPLOYMENT AND SUBSEQUENT LES JETTISON IS BASED ENTIRELY ON TIMED FUNCTIONS WITHIN THE SEQUENCE CONTROLLERS. AN ABORT SIGNAL INITIATES C/M-S/M SEPARATION AND THE FIRING OF THE LES AND P/C MOTOR. ELEVEN SECONDS AFTER AN ABORT INITIATION, THE CANARD SURFACES ARE DEPLOYED, LOCKED IN THE OPEN POSITION, AND A 3 SECOND TIMER STARTED. AFTER THE 3 SECOND TIMER HAS TIMED OUT, THE TOWER JETTISON MOTOR AND TOWER

2

nuts are fired. This occurs with the LEV at apogee or climbing, and as it is turning from Apex forward to blunt end forward attitude. There is a .4 second time delay between tower jettison and removal of the forward heat shield. This delay will prevent damage to the forward compartment with the removal of the boost cover. As the tower is jettisoned, a two second and a fourteen second timer are simultaneously energized. As the two second timer is timed out the drogue chutes are deployed. Twelve seconds later (normal sequence) the drogue chutes are released and the main chutes are deployed utilizing pilot chutes.

2.8.2 Medium Altitude Abort

The medium altitude abort is between 30,000 and 120,000 feet. An abort signal initiates C/M-S/M separation and the firing of the LES and P/C motor. Eleven seconds after an abort has been initiated the canard surfaces are deployed and locked in the open position. The canards will effect and dampen the turn around maneuver, and orient the Command Module in the blunt end forward attitude. As the launch escape vehicle descends, and upon reaching an altitude of approximately 24,000 feet, a baroswitch will close, initiating a signal to fire the tower jettison motor, removing the tower and boost cover. As this function occurs, a .4 second timer is energized, and when timed out will jettison the forward heat shield. As the tower is jettisoned, a two second timer is energized, and when timed out will release the drogue chutes. The drogue chutes will allow the Command Module to decelerate. Upon reaching approximately 10,000 feet a baroswitch will close, releasing the drogue chutes and deploy the main chutes.

2.8.3 High Altitude Abort

The high altitude abort mode is above 120,000 feet and the sequencing is altered by automatic and manual functions. An abort signal will initiate C/M-S/M separation and the firing of the LES and P/C motor. As the G forces decrease and limited motion is possible, the commanders station will manually energize a circuit, firing the tower jettison motor, removing the tower and boost cover. The Stabilization and Control System then provides rate dampening with the use of the C/M Reaction Control System. After the rates have been dampened to zero, the commander orients the C/M into an entry attitude using onboard displays and/or visual cues through the windows. When the Command Module reaches an altitude of approximately 24,000 feet plus .4 second the forward heat shield thrusters are fired. This function is followed by drogue deployment 1.6 seconds later, allowing the Command Module to decelerate. Upon reaching approximately 10,000 feet, a baroswitch will close, releasing the drogue chutes and deploy the main chutes.

2.9 Tower Separation Mechanism (Figure 2-11)

The tower structure is attached to the C/M at the base of each tower leg. The means of attachment at these four points is a frangible nut and stud assembly (Figure 2-12). Each nut shall accept two detonating assemblies, that when fired will fracture the nut at the defined separation plane. The detonator causes the nut to separate due to pressure and shock wave generated Figure 2-13. The frangible nut shall be severed into a minimum of two sections. Both detonators are wired into two electrical circuits A & B (Figure 2-12). If one circuit fails or failure of either cartridge the nut will still separate from the stud. The nut shall be completely free from the stud upon detonation of one or both cartridges. A protective sleeve is provided Figure 2-12 to protect the chute risers. The sleeve shall pop up after tower jettison protecting the chute risers from the sharp threads and prevent entanglement during chute deployment. In a normal ascent, the tower is separated from the C/M by detonation of the four nuts at the base of the tower and the firing of the tower jettison motor.

The bolt body is made from 4340 steel and will withstand a tensile load of approximately 100,000 pounds. Installation of the frangible nut and stud assembly is made during the tower to C/M stacking operation, and explosives are installed just prior to launch.

LAUNCH ESCAPE SUBSYSTEM

FRANGIBLE NUT INTALLATION

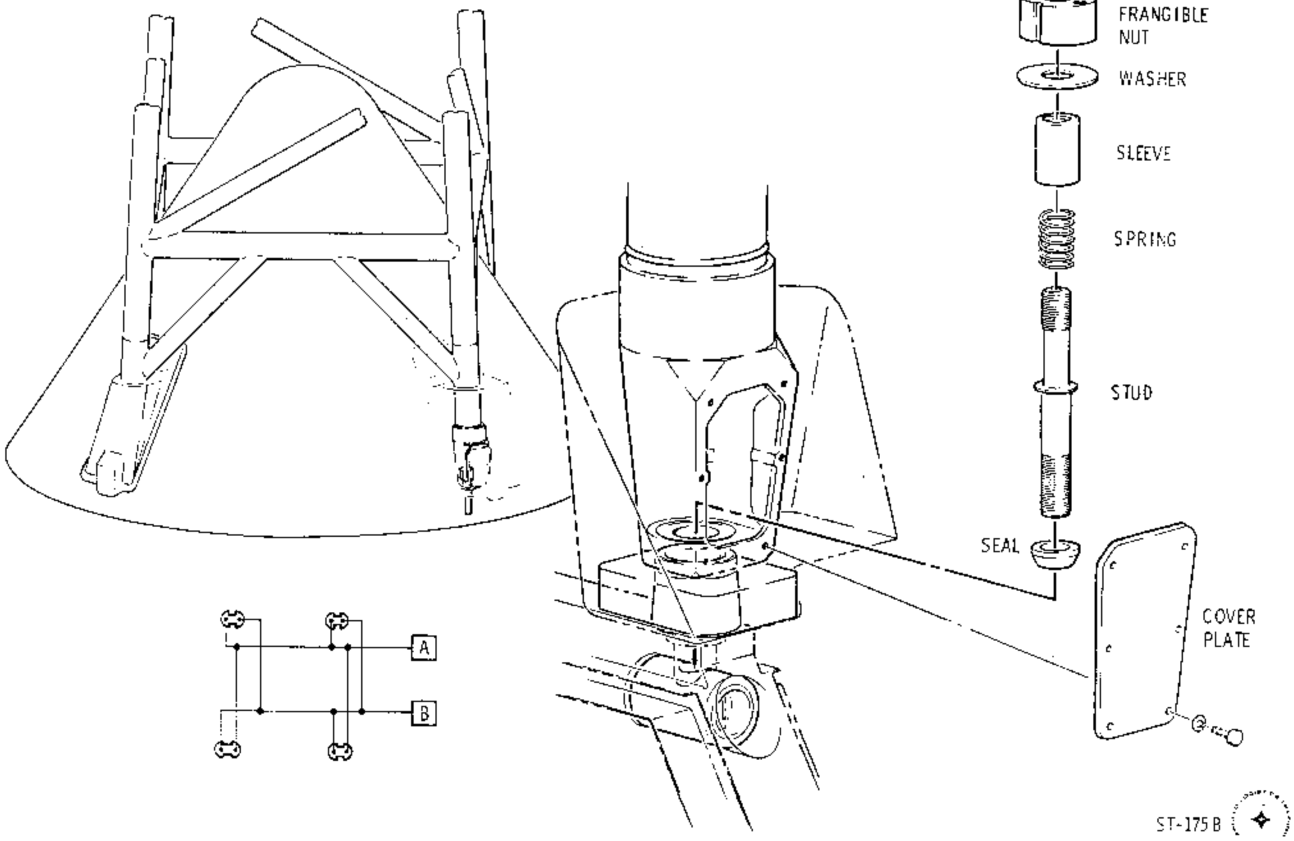

FIGURE 2-13

TOWER SEPARATION MECHANISM

ORDNANCE INSTALLATION

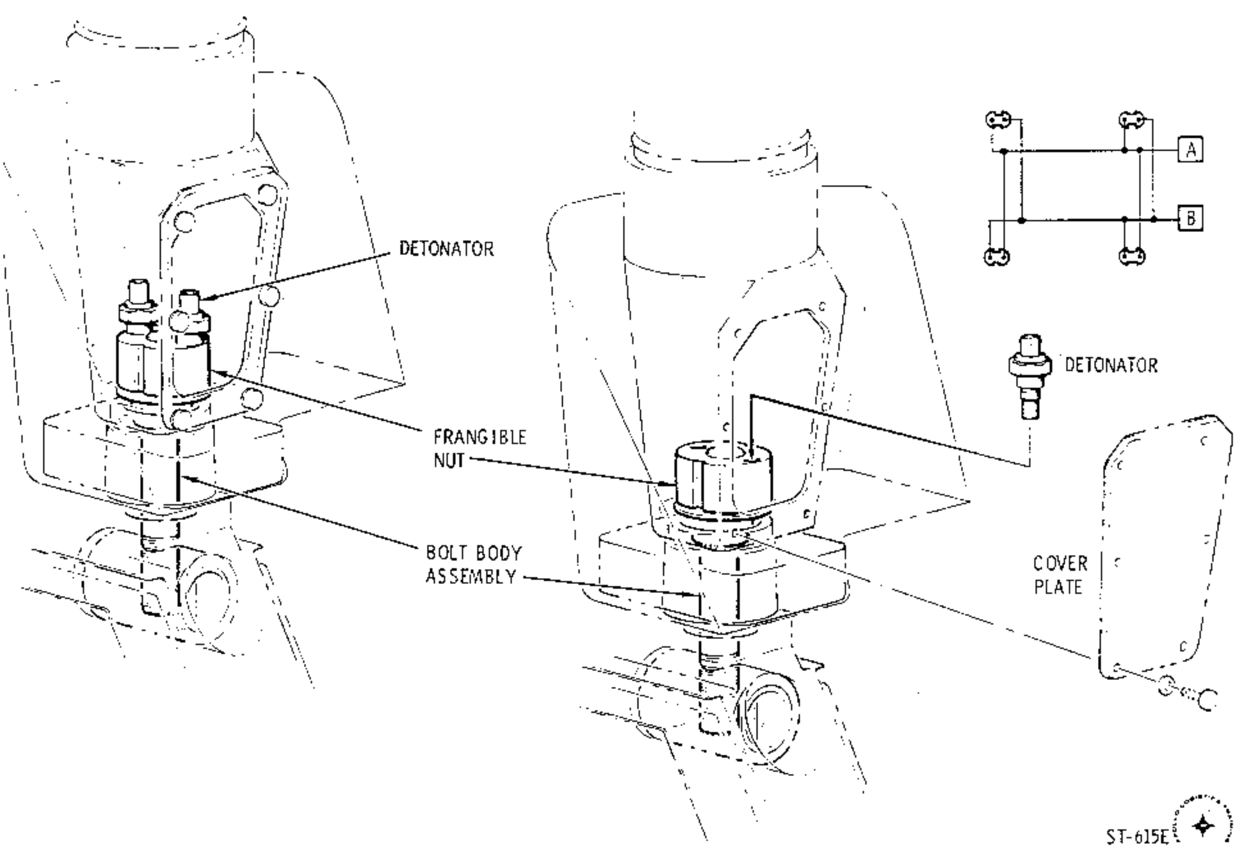

FIGURE 2-11

ELECTRICAL HOTWIRE INITIATOR

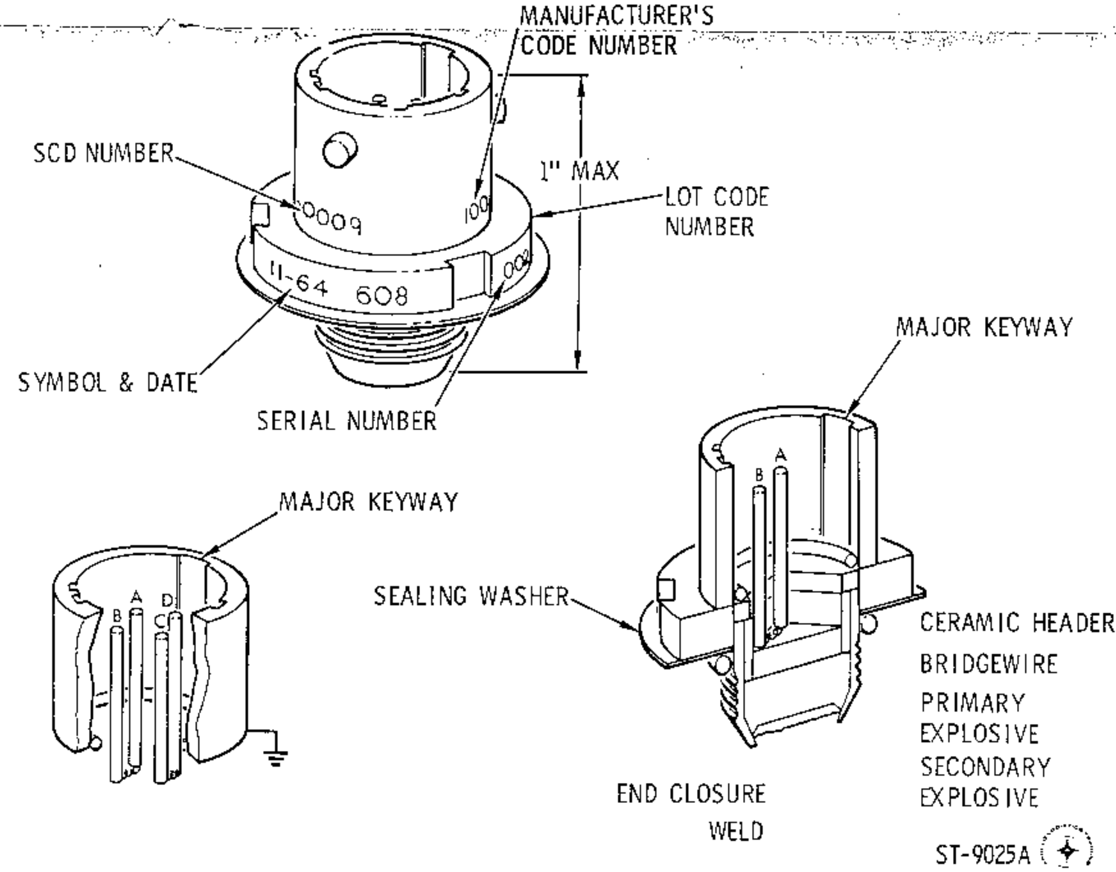

FIGURE 2-14

DETONATOR CARTRIDGE ASSEMBLY

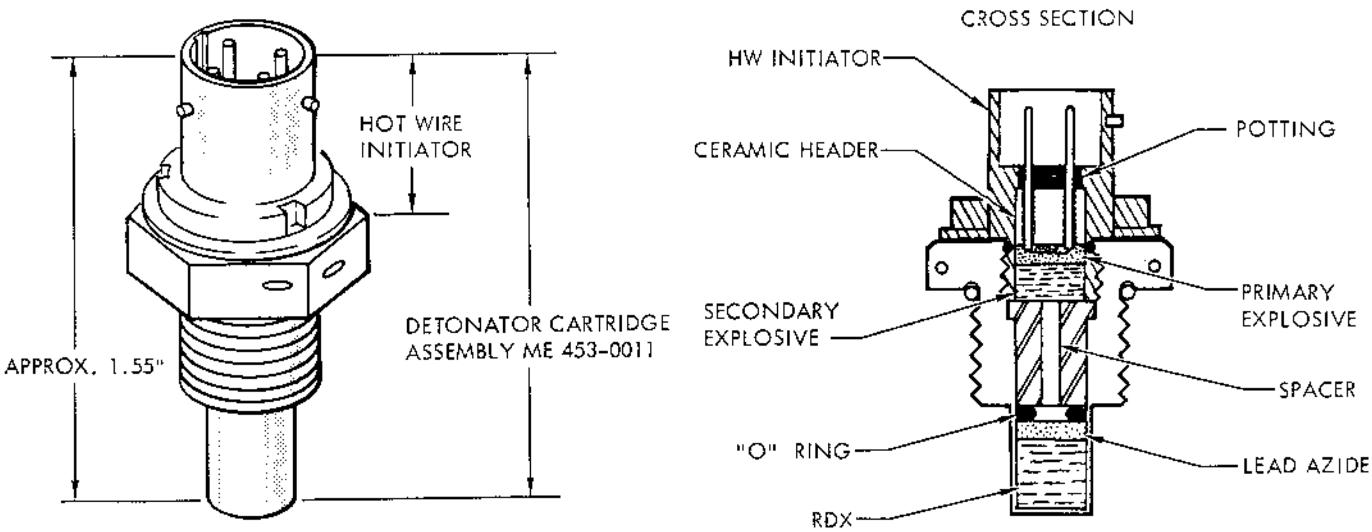

FIGURE 2-12

SECTION III

THE COMMAND MODULE

3.1 GENERAL DESCRIPTION (FIGURE 3-1)

THE COMMAND MODULE IS A CAPSULE HOUSING THE CREW, WEIGHING APPROXIMATELY 11,000 POUNDS. IT IS THE ONLY PORTION OF THE APOLLO SPACECRAFT THAT WILL RETURN TO EARTH AFTER THE LUNAR MISSION. THE COMMAND MODULE IS MADE UP OF TWO STRUCTURES, AN INNER STRUCTURE, THE PRIMARY STRUCTURE OF THE CRAFT, WHICH IS A PRESSURE VESSEL HOUSING THE CREW: AND THE OUTER STRUCTURE, WHICH IS A THREE PIECE HEAT SHIELD CONSISTING OF A FORWARD HEAT SHIELD WHICH IS THE FORWARD APEX OF THE CRAFT, A CREW COMPARTMENT HEAT SHIELD WHICH FORMS THE REMAINDER OF THE CONICAL PORTION OF THE CRAFT, AND AN AFT HEAT SHIELD WHICH COVERS THE AFT PORTION OF THE CRAFT. THE TWO STRUCTURES, HEAT SHIELD AND INNER STRUCTURE, DIVIDE THE VOLUME WITHIN THE COMMAND MODULE INTO THREE DISTINCT COMPARTMENTS. FIRST, WITHIN THE PRESSURE VESSEL, IS THE VOLUME WHICH IS THE ACTUAL LIVING SPACE OF THE ASTRONAUTS AND IS KNOWN AS THE CREW COMPARTMENT. IN THE FORWARD PORTION OF THE CRAFT, A VOLUME BETWEEN THE FORWARD HEAT SHIELD AND THE INNER STRUCTURE, WHICH IS NOT PRESSURIZED, IS THE FORWARD COMPARTMENT AND HOUSES THE EARTH LANDING EQUIPMENT. BETWEEN THE AFT PORTION OF THE HEAT SHIELD AND THE INNER STRUCTURE IS A CIRCULAR COMPARTMENT SURROUNDING THE INNER STRUCTURE WHICH IS KNOWN AS THE AFT COMPARTMENT AND HOUSES MOST OF THE COMMAND MODULE REACTION CONTROL SYSTEM. THE TWO STRUCTURES, INNER AND OUTER, ARE SEPARATED BY A LAYER OF INSULATION. THIS INSULATION COVERS THE INNER SURFACE OF THE HEAT SHIELDS. THERE ARE TWO HATCHES IN THE COMMAND MODULE, A SIDE HATCH AND A FORWARD HATCH. THE SIDE HATCH IS USED FOR EARTH INGRESS AND EGRESS AND THE FORWARD HATCH IS DESIGNED FOR EMERGENCY POST LANDING EXIT. THE BLOCK I COMMAND MODULE HAS FIVE WINDOWS, ALL OF WHICH ARE ON THE UPPER OR HEADWARD PORTION OF THE VEHICLE. THEY CONSIST OF TWO SIDE WINDOWS, TWO RENDEZVOUS WINDOWS AND ONE HATCH WINDOW.

3.2 INNER STRUCTURE (FIGURE 3-2)

THE INNER STRUCTURE IS AN ALUMINUM, SEMI-MONOCOQUE STRUCTURE. IT IS DESIGNED TO HOLD A PRESSURE OF 5 PSI OF PURE OXYGEN WITH A LEAK RATE OF LESS THAN .2 POUNDS PER HOUR AND HAS A LIMIT PRESSURE OF 8 PSI AND AN ULTIMATE PRESSURE OF 12 PSI. THE INNER STRUCTURE CONSISTS OF TWO MAJOR ASSEMBLIES, AN AFT ASSEMBLY AND A FORWARD ASSEMBLY. BEING A SEMI-MONOCOQUE STRUCTURE, IT INCORPORATES SOLID STRUCTURAL MEMBERS WHOSE FUNCTION IS TO DISTRIBUTE POINT LOADS TO THE SIDE WALL OF THE STRUCTURE, WHICH IS THE ULTIMATE LOAD-BEARING PORTION OF THE STRUCTURE. THE SOLID STRUCTURAL MEMBERS ARE OF MACHINED ALUMINUM, WHEREAS THE SIDE WALL IS BONDED ALUMINUM HONEYCOMB SANDWICH MATERIAL. THE INNER FACE SHEETS OF THE

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INNER STRUCTURE

INNER SHELL (BLOCK I)

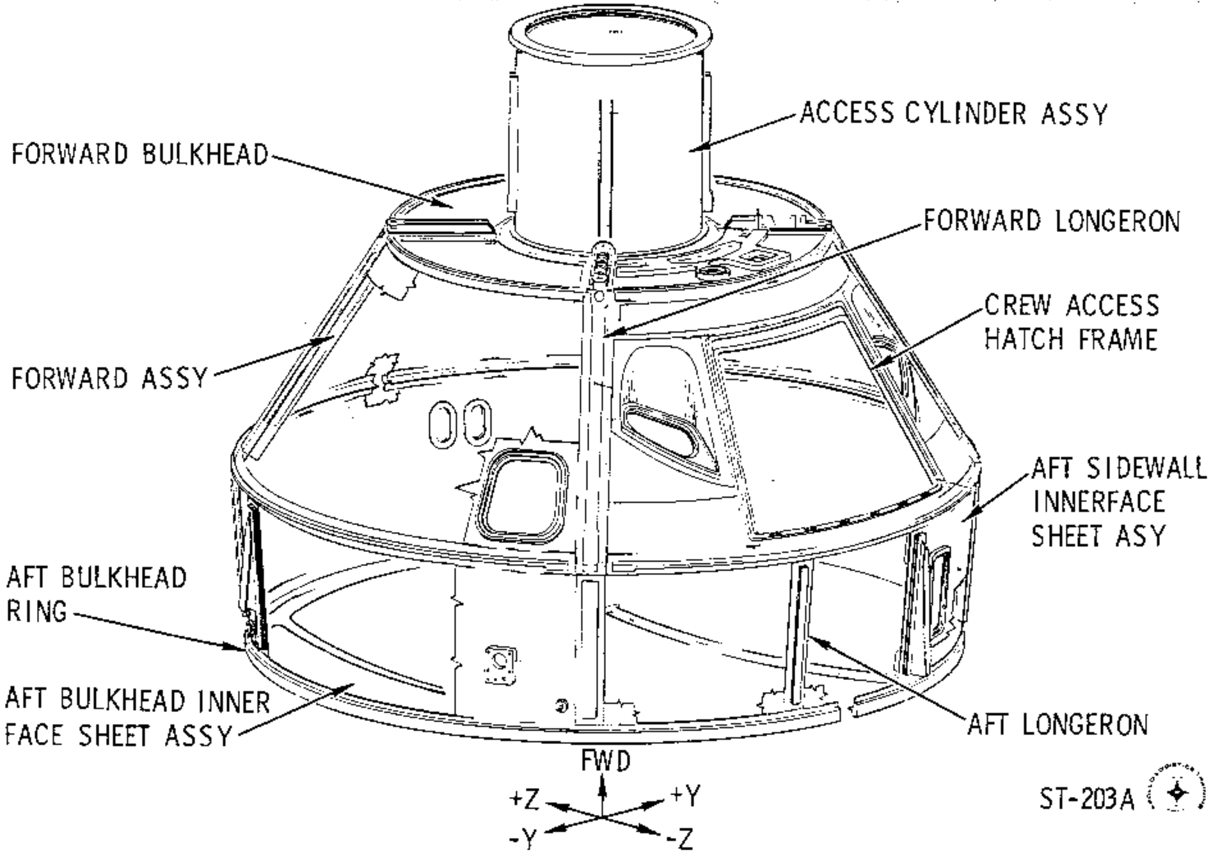

FIGURE 3-2

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GENERAL ARRANGEMENT COMMAND MODULE

(BLOCK I)

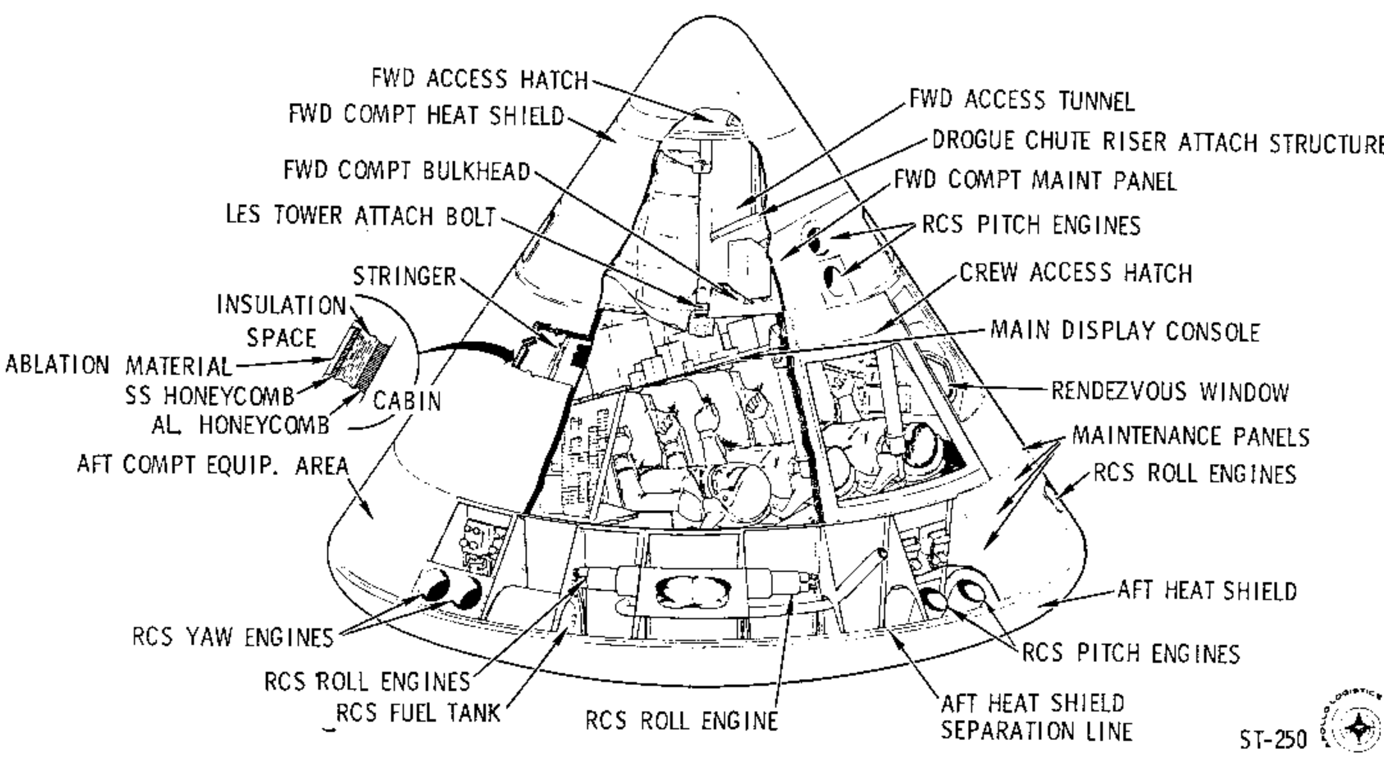

FIGURE 3-1

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INNER STRUCTURE SUPPORT LONGERON'S

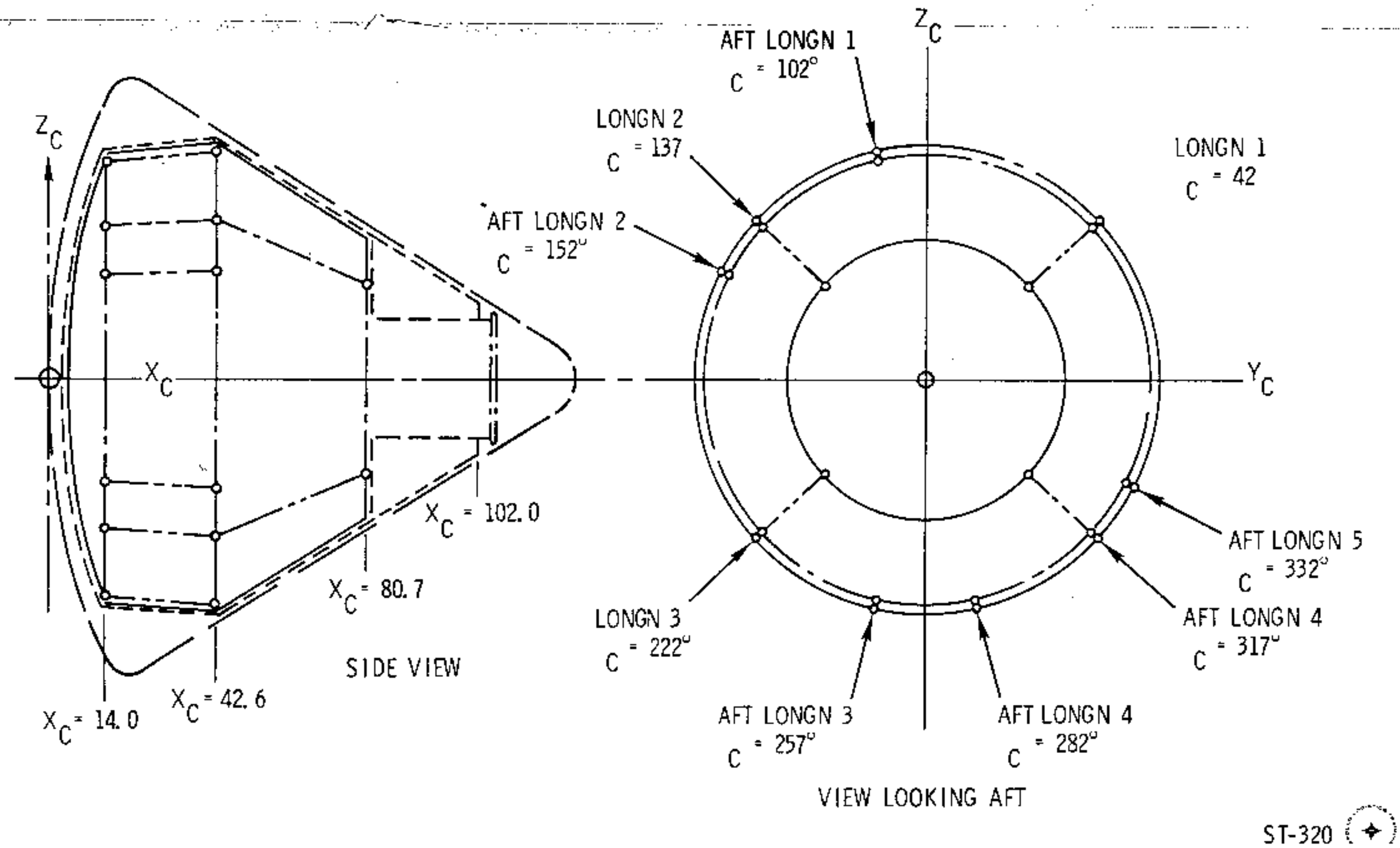


FIGURE 3-3

HONEYCOMB SANDWICH ARE WELDED IN ALL CASES TO THE SOLID ALUMINUM MEMBERS. THUS, THE ENTIRE INNER MOLD LINE OF THE INNER STRUCTURE IS A WELDED INNER FACE MOLD LINE, KEEPING CONSTANT WITH THE PRESSURE HOLDING SPECIFICATIONS OF THE CRAFT. ALUMINUM HONEYCOMB CORE IS THEN BONDED TO THE OUTER SURFACE OF THE INNER FACE SHEETS. IN ALL CASES, THE OUTER FACE SHEETS ARE BONDED TO THE OUTER SURFACE OF THE HONEYCOMB CORE.

3.2.1 AFT ASSEMBLY (SEE FIGURE 3-3)

THE AFT ASSEMBLY CONSISTS OF THE AFT BULKHEAD AND THE AFT SIDEWALL. THE SOLID STRUCTURAL MEMBERS IN THE AFT ASSEMBLY ARE:

(1) A SOLID MACHINED ALUMINUM RING, WHICH FORMS THE AFT EDGE OF THE INNER STRUCTURE.

(2) NINE LONGERONS LOCATED ON THE AFT SIDEWALL OF THE AFT ASSEMBLY.

SEVEN LONGERONS ARE WELDED TO THE INNER FACE SHEETS AND TWO ARE BONDED BETWEEN THE INNER FACE SHEETS AND THE OUTER FACE SHEETS. THE LONGERONS ARE LOCATED IN POSITIONS TO DISTRIBUTE STRESS CONCENTRATIONS EVENLY TO THE SKIN OF THE AFT ASSEMBLY. SIX OF THE NINE LONGERONS COINCIDE IN LOCATION TO THE SIX HARD POINTS ON THE COMMAND MODULE. THESE ARE LOCATED 50°, 60°, AND 70° APART, DIAMETRICALLY OPPOSED. THEY WILL INDICATE THE POSITION OF THE SIX COMPRESSION PADS INTERFACING THE COMMAND MODULE TO THE SERVICE MODULE. THREE OF THE SIX COMPRESSION PAD LOCATIONS ARE ALSO DESIGNED AS TENSION TIES BETWEEN THE COMMAND MODULE AND THE SERVICE MODULE. THE TENSION TIE LOCATIONS ARE SHOWN IN FIGURE 4-4. THE TENSION TIES HOLDING THE COMMAND MODULE TO THE SERVICE MODULE ARE OF STAINLESS STEEL, A DIRECT STRUCTURAL TIE BETWEEN THESE THREE LONGERONS AND THE STRUCTURE OF THE SERVICE MODULE.

3.2.2 FORWARD ASSEMBLY FIGURE 3-4)

THE FORWARD ASSEMBLY CONSISTS OF A FORWARD SIDE WALL, A FORWARD BULKHEAD, A FORWARD ACCESS CYLINDER, AND THE FORWARD HATCH. THE FORWARD ASSEMBLY INCLUDES THE FOLLOWING SOLID STRUCTURAL MEMBERS:

(1) FOUR TOWER SUPPORT LONGERONS. THESE TOWER SUPPORT LONGERONS ARE HOCKEY STICK IN SHAPE, WITH A PORTION COINCIDING IN MOLD LINE TO THE FORWARD SIDE WALL. THEY ARE LOCATED APPROXIMATELY 90 DEGREES APART, STRADDLING THE Y AND Z AXES.

(2) THE MID RING. THE MID RING IS LOCATED AT THE AFT PORTION OF THE FORWARD SIDE WALL. IT IS A TWO-PIECE RING CONSISTING OF A 90 DEGREE SECTION BETWEEN THE TWO UPPER SUPPORT LONGERONS AND A 270 DEGREE SECTION COMPLETING THE RING.

(3) FOUR FORWARD ACCESS CYLINDER LONGERONS. THESE LONGERONS COINCIDE IN LOCATION TO THE TOWER SUPPORT LONGERONS.

(4) A SOLID RING AT THE FORWARD PORTION OF THE FORWARD ACCESS CYLINDER. THIS RING FORMS THE FRAME FOR THE FORWARD HATCH.

THE FORWARD AND AFT ASSEMBLIES, CONSISTING OF THE SOLID STRUCTURAL MEMBERS AND THE INNER FACE SHEETS, ARE WELDED TOGETHER. THE INTERFACE OF THIS WELD IS AT THE FORWARD PORTION OF THE AFT SIDE WALL AND AT THE AFT PORTION OF THE FORWARD SIDE WALL. THIS IS A CONTINUOUS CIRCULAR WELD COINCIDING WITH THE INNER MOLD LINE. AFTER THIS WELD IS COMPLETE, A STRIP OF HONEYCOMB CORE IS BONDED OVER IT, AND FINALLY, AN OUTER FACE SHEET STRIP IS BONDED INTO PLACE. THUS, A CONTINUOUS STRUCTURE NOW EXISTS MADE OF ALUMINUM HONEYCOMB SANDWICH MATERIAL, CONTAINING SOLID, ALL WELDED, INNER FACES WITH CONTINUOUS STRUCTURE MEMBERS AND HAVING ALL WELDED INTERFACES ON THE INNER MOLD LINE. THE THICKNESSES OF THE VARIOUS PORTIONS OF THE INNER STRUCTURE OVERALL WALL ARE AS FOLLOWS: (FIGURE 3-5)

THE AFT BULKHEAD IS 1.5 INCHES THICK
THE AFT SIDE WALL IS .75 INCHES THICK
THE FORWARD SIDE WALL IS .9 INCHES THICK
THE FORWARD BULKHEAD IS .75 INCHES THICK
THE FORWARD ACCESS CYLINDER IS .25 INCHES THICK

3.2.3 PENETRATION FITTINGS (FIGURE 3-6)

3.2.3.1 AFT SIDE WALL PENETRATIONS

IN THE AFT SIDE WALL OF THE INNER STRUCTURE THERE ARE SEVEN PENETRATION FITTINGS. THE PHYSICAL LOCATION FOR THESE PENETRATIONS WILL BE SHOWN IN FIGURE 3-2. THESE ARE ALL ONE PIECE ALUMINUM FRAMES WELDED TO THE SURROUNDING INTERFACE SHEETS.

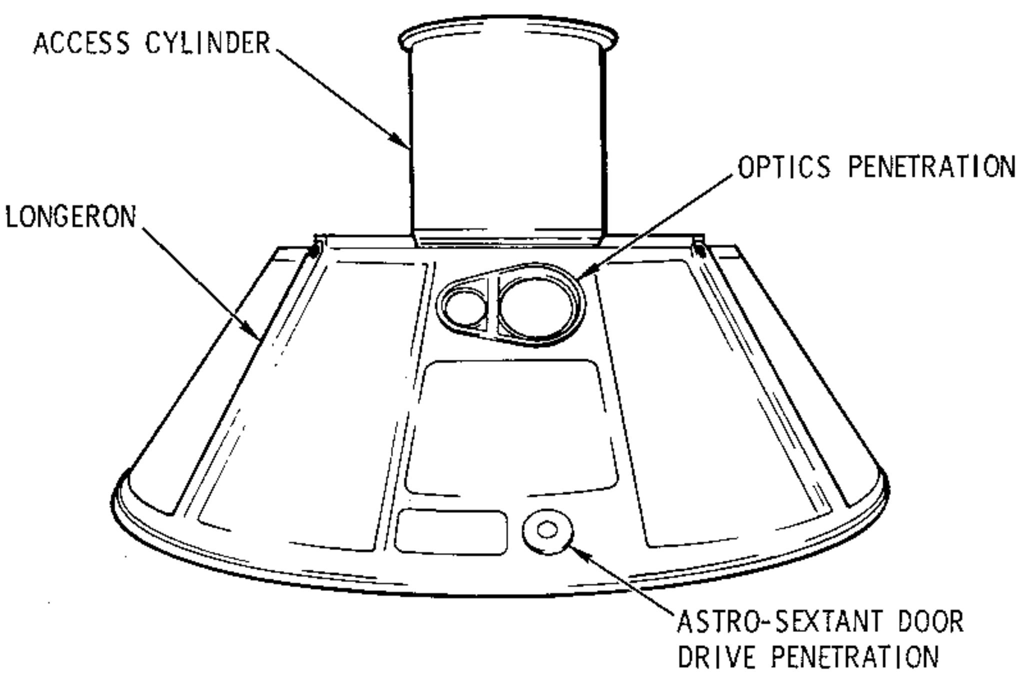
TWO ELECTRICAL PENETRATION FITTINGS ARE LOCATED ON THE AFT SIDE WALL, TO THE RIGHT AND AFT OF THE SIDE HATCH (FIGURE 3-2). THESE PENETRATIONS ARE ALSO SHOWN IN FIGURE 3-6 AS POINTS "D" AND "J". THROUGH THESE PENETRATIONS, APPROXIMATELY 1200 WIRES WILL PENETRATE. OF THESE 1200 WIRES, APPROXIMATELY 1000 WILL BE ROUTED THROUGH THE UMBILICAL TO THE S/M, WHILE THE REMAINING 200 WIRES WILL BE ROUTED TO THE EQUIPMENT IN THE AFT COMPARTMENT.

THREE HARD LINE PENETRATION FITTINGS ARE LOCATED ON THE AFT SIDE WALL TO THE LEFT OF THE CREW HATCH AS SHOWN IN FIGURE 3-2. THE LARGE PENETRATION FITTING SHOWN IN FIGURE 3-6 AT POINT "C" CONSISTS OF EIGHT LINES.

1 STEAM VENT
2 OXYGEN SUPPLY
2 COOLANT SYSTEM (WATER GLYCOL)
1 WATER SUPPLY
2 PRESSURE REGULATOR SENSOR PARTS

INNER STRUCTURE - INNER SHELL

(FORWARD ASSEMBLY)



ST-276

FIGURE 3-4

INNER STRUCTURE PENETRATION DIAGRAM & COORDINATES

PT	X_c	Y_c	Z_c	θ_c	NOMENCLATURE
A	34.1600	24.5000	53.5474	65°24'51.48"	CO-AX
B	18.6856	-48.8943	30.4243	148°06'29.44"	HARD LINE (3 HOLE)
C	26.0000	-51.5856	-26.9500	207°35'02.46"	HARD LINE (8 HOLE)
D	31.6250	19.8750	-55.2046	289°48'00.42"	ELEC. PLUG
E	51.5000	14.8752	-51.8759	286°00'00.00"	PURGE PRES. TEST
F	48.8898	0	-55.6309	270°00'00.00"	CREW HATCH MECH.
G	34.1600	16.3750	56.5636	73°51'15.87"	CO-AX
H	19.2500	-45.0084	-36.0000	218°39'16.62"	HARD LINE (1 HOLE)
J	24.0000	53.1225	-47.6526	304°48'09.04"	ELEC. PLUG
M	47.5930	-4.1250	56.3068	94°11'23.87"	ASTRO-DOOR MECH.
K	80.7500	-6.1000	-29.3000		CO-AX CABLE P/J
L	80.7500	5.0144	-28.6199		ELEC PLUG

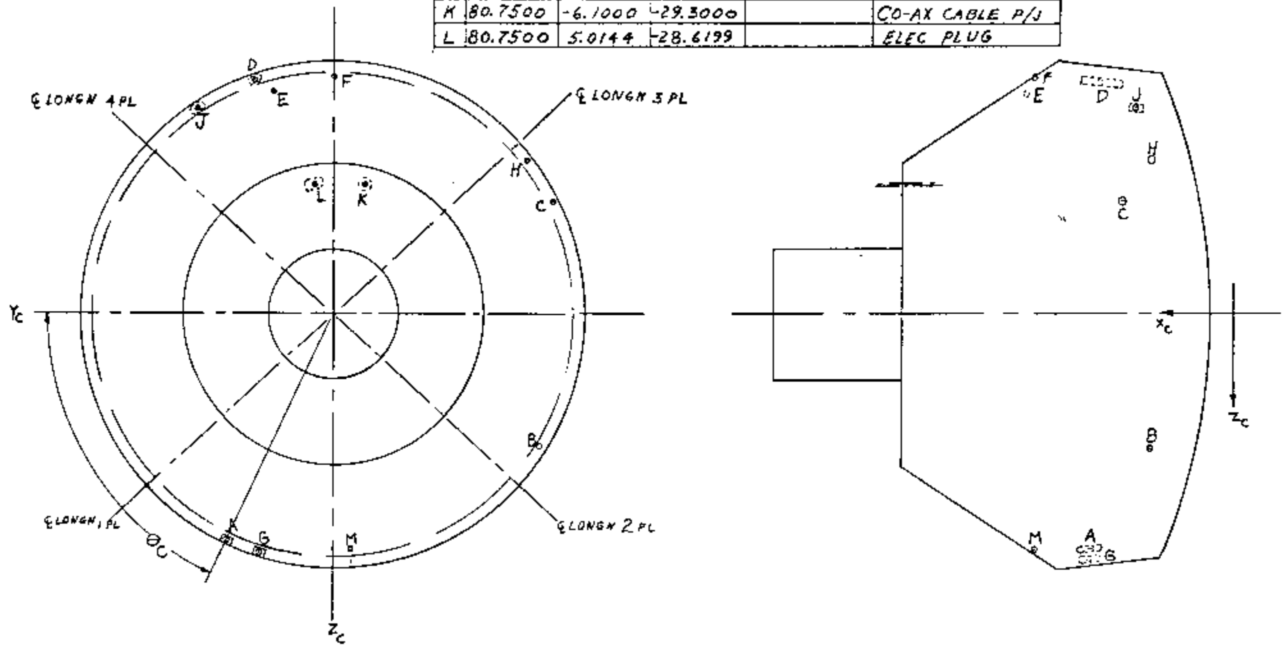


FIGURE 3-6

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COMMAND MODULE INNER STRUCTURE

(BLOCK I)

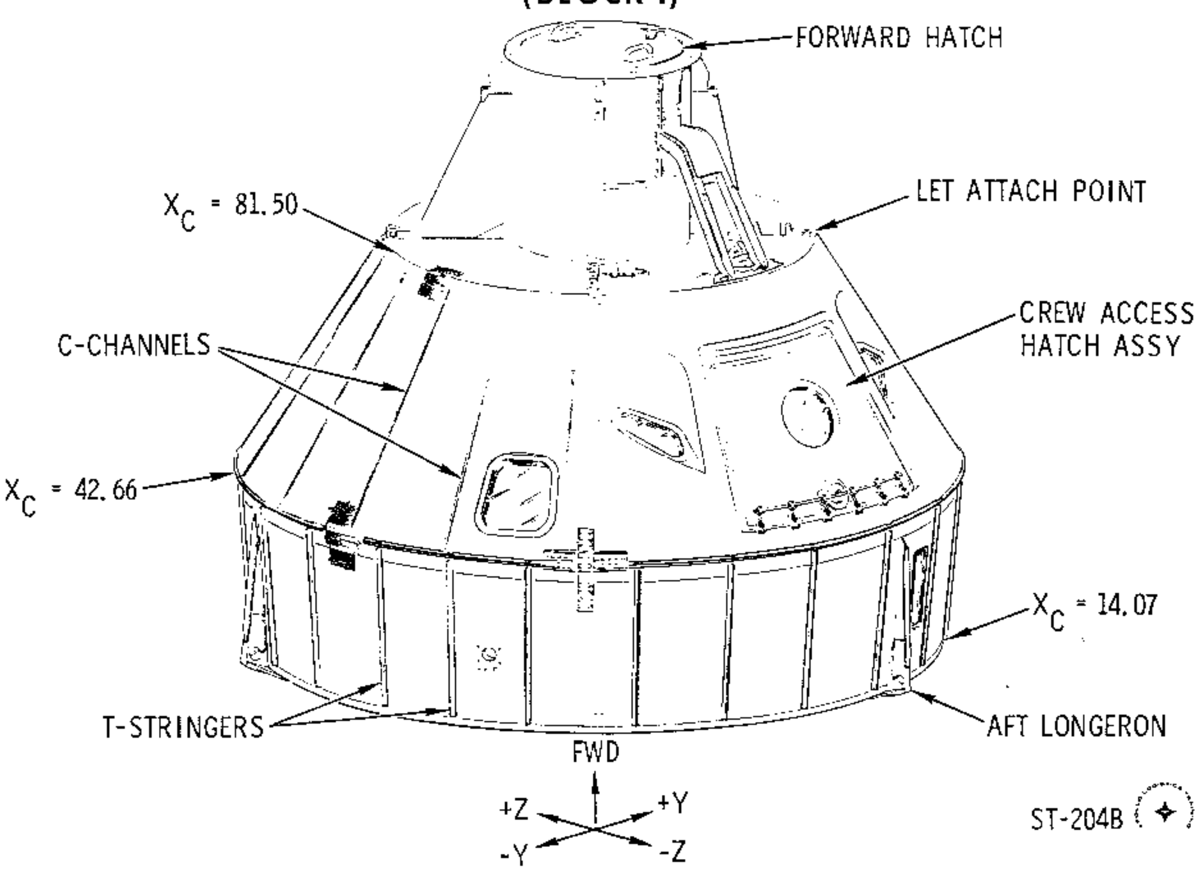

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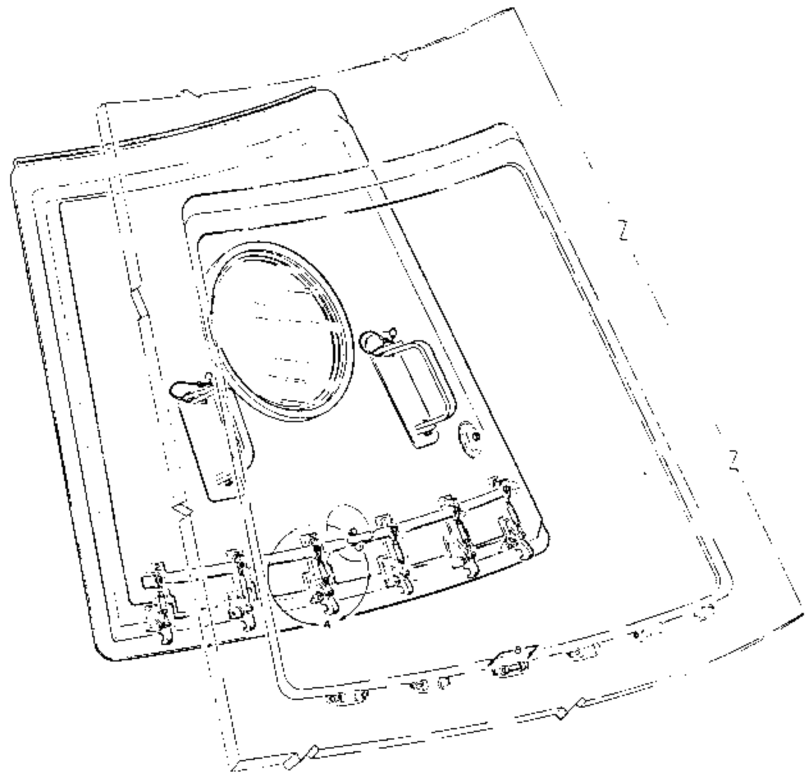
FIGURE 3-5

C/M CREW HATCH

INNER STRUCTURE



ST-605

FIGURE 3-7

3-11

AT POINT "B" THERE IS A SMALL PENETRATION CONSISTING OF THREE LINES.

- 1 OXYGEN SUPPLY
- 1 POTABLE WATER
- 1 WASTE WATER

AT POINT "H" THERE IS A SINGLE PENETRATION. IT IS A STEEL LINED FITTING THROUGH WHICH THE URINE OVERBOARD LINE IS ROUTED. THIS LINE WILL PERMIT URINE FROM THE WASTE MANAGEMENT SYSTEM TO BE DUMPED OVERBOARD. THIS PENETRATION FORMS THE CENTER OF THE STEAM VENT WHEN PENETRATING THE HEAT SHIELD AS SHOWN IN FIGURE 3-14.

TWO COAXIAL CABLE PENETRATION FITTINGS ARE LOCATED BETWEEN THE +Z AND +Y AXES. THESE PENETRATIONS ARE SHOWN IN FIGURE 3-6 AS POINTS "A" AND "G". THROUGH THESE PENETRATIONS ARE THE CABLES REQUIRED FOR THE C-BAND AND SCINITAR ANTENNAS.

3.2.3.2 FORWARD SIDE WALL PENETRATIONS

FOUR OF THE FIVE WINDOWS ARE PENETRATIONS IN THE SKIN IN THE FORWARD SIDE WALL. THE FIFTH WINDOW IS A PENETRATION FITTING IN THE HATCH, WHICH IS A MAJOR PENETRATION OF THE FORWARD SIDE WALL (FIGURE 3-5). THE WINDOW PENETRATIONS ARE SOLID ALUMINUM FRAMES THAT ARE WELDED TO THE SURROUNDING INTERFACE SHEETS. THE RENDEZVOUS WINDOWS PROVIDE A FORWARD VIEW FROM EITHER SIDE OF THE C/M WHILE THE SIDE WINDOWS PROVIDE AN OPENING FOR SIDE OBSERVATIONS. THE WINDOWS THEMSELVES ARE DOUBLE-PANED, EACH PANE BEING .25 OF AN INCH THICK. THE PANES ARE SEPARATED BY A .1 OF AN INCH OF SPACE. THESE PANES ARE CORNING GLASS WORKS NO. 1723 TEMPERED SILICA GLASS. THE SOFTENING POINT OF THE GLASS IS 2000 DEGREES F. THE TEMPERATURE DESIGN LIMITS SURROUNDING THE GLASS PANES IS 200 DEGREES F. THE PANES OF GLASS ARE POTTED INTO THE FRAMES WITH POTTING MATERIAL RTV560 SILICONE RUBBER. AN ALUMINUM RETAINER AND FASTENERS WILL HOLD THE GLASS PANE IN PLACE.

THE OPTICS PENETRATION FITTING IS A SOLID ALUMINUM FRAME WELDED TO THE SURROUNDING INTERFACE SHEETS AND STRADDLES THE +Z AXIS ON THE LOWER SIDE OF THE VEHICLE. THE OPTICAL DEVICES ARE BOLTED TO FLEXIBLE, PRESSURE HOLDING, BELLOWS WHICH ARE BOLTED DIRECTLY TO THE INNER SURFACE OF THIS PENETRATION FITTING, THEREFORE KEEPING THE CONTINUITY OF THE PRESSURE SEAL. JUST BELOW THE OPTICS PENETRATION AT POINT "M" AS SHOWN IN FIGURE 3-6 IS THE PENETRATION FOR THE SEALED DRIVE MECHANISM FOR THE ASTRO SEXTANT DOORS (FIGURE 3-4).

THE SIDE HATCH (FIGURE 3-7) IS FABRICATED OF THE SAME MATERIAL AS THE INNER STRUCTURE AND INTERFACES THE INNER STRUCTURE BY A SOLID ALUMINUM FRAME THAT IS WELDED TO THE INNER FACE SHEETS. HANDLES ARE PROVIDED ON THE INSIDE AND OUTSIDE FOR EASE OF INSTALLATION AND REMOVAL. THE OUTER SET OF HANDLES ARE HINGED, AND MAY BE FOLDED AFTER INSTALLATION. THE SIDE HATCH MAY BE OPENED OR CLOSED FROM EITHER THE OUTSIDE OR THE INSIDE OF THE SPACECRAFT. ALSO, A WINDOW IS

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3

POST LANDING VENTILATION SUB-SYSTEM
FORWARD HATCH

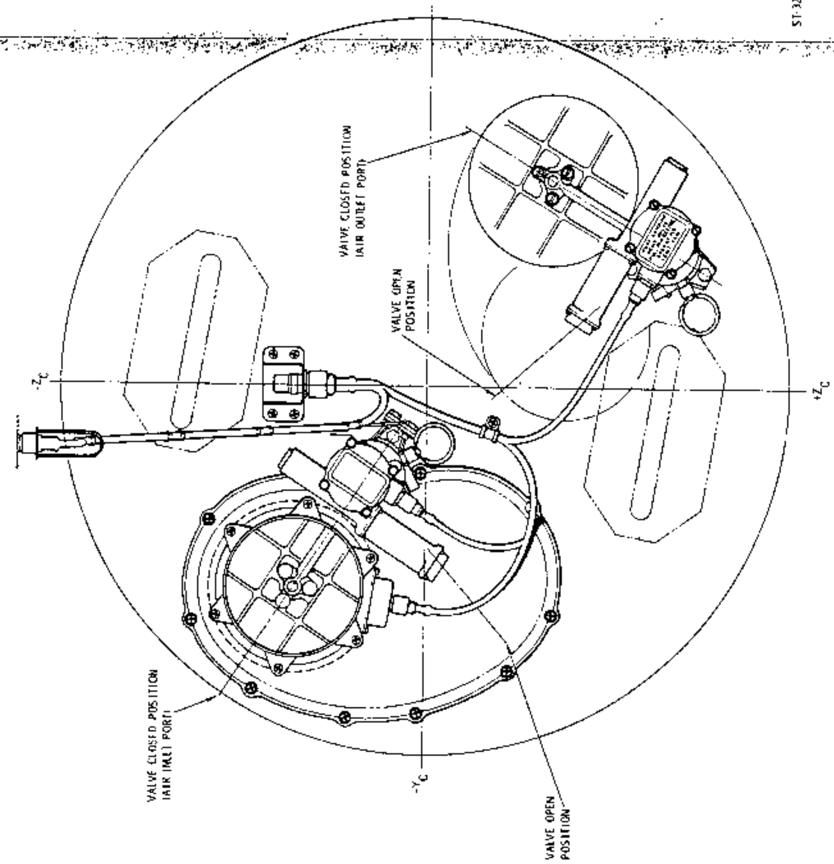

FIGURE 3-8

PROVIDED IN THE HATCH, FABRICATED OF THE SAME MATERIAL AS THE INNER STRUCTURE SIDE AND RENDEZVOUS WINDOWS.

THE CREW HATCH LATCHING MECHANISM PROVIDES THE MECHANICAL SYSTEM NECESSARY TO POSITION AND SECURE THE HATCH DOOR TO THE C/M. THE MECHANISM ALSO ACTS AS A LOAD CARRYING MEMBER FOR STRUCTURAL CONTINUITY WHILE THE C/M IS PRESSURIZED. THE MECHANISM IS MOUNTED ON THE OUTER SURFACE OF THE CREW HATCH DOOR, WITH MATCHING LATCH ASSEMBLIES MOUNTED ON THE SOLID ALUMINUM STRUCTURE. THE MECHANISM IS MANUALLY OPERATED USING THE TOOL SET TORQUE WRENCH. THIS TORQUE WRENCH WILL NORMALLY BE STORED IN A DRAWER, AND JUST PRIOR TO ENTRY INSERTED AND LOCKED IN THE INNER HATCH OPENING MECHANISM. THE INNER HATCH MAY BE LOCKED FROM THE INSIDE BY ROTATING THE TORQUE WRENCH 360° CLOCKWISE AND UNLOCKED BY ROTATING 360° COUNTERCLOCKWISE.

3.2.3.3 FORWARD BULKHEAD PENETRATIONS

THROUGH THE ELECTRICAL PENETRATION FITTING WILL BE ROUTED THE CABLES TO THE EARTH LANDING SYSTEM AND THE LAUNCH ESCAPE SYSTEM. THIS IS SHOWN AT POINT "L" IN FIGURE 3-6.

THROUGH THE COAXIAL CABLE PENETRATION FITTING WILL BE ROUTED THE COAXIAL CABLES TO THE RECOVERY ANTENNAS. THUS PENETRATION IS SHOWN AT POINT "K" IN FIGURE 3-6.

3.2.4 <u>FORWARD COMPARTMENT</u>

THE FORWARD COMPARTMENT IS DIVIDED INTO QUADRANTS BY FOUR GUSSETS (FIGURE 3-5). THESE GUSSETS ARE FASTENED TO THE HORIZONTAL PORTIONS OF EACH TOWER SUPPORT LONGERON, THE FOUR LONGERONS IN THE FORWARD ACCESS CYLINDER, AND STRADDLE THE AXES. THE QUADRANT ON THE NEGATIVE Z PORTION OF THE VEHICLE IS EQUIPPED WITH FITTINGS FOR ATTACHMENT OF TWO DROGUE MORTARS AND A FRAME FOR ATTACHMENT OF TWO PITCH REACTION CONTROL ENGINES. THE REMAINING THREE QUADRANTS WILL HOUSE THE THREE MAIN PARACHUTES, THREE PILOT CHUTE MORTARS, AND THE CANNISTERS STORING THE BAGS FOR THE UPRIGHTING SYSTEM.

3.2.5 <u>POST LANDING VENTILATION</u>

LOCATED IN THE TUNNEL ASSEMBLY IS A FORWARD HATCH. THIS HATCH MAY BE USED FOR EMERGENCY EXIT AFTER POST LANDING FIGURE 3-8 . THE HATCH IS FABRICATED OF ALUMINUM HONEYCOMB SANDWICH MATERIAL APPROXIMATELY 1" THICK. THE HATCH WILL INTERFACE THE TUNNEL BY A SOLID ALUMINUM FRAME WELDED TO THE TUNNEL SIDEWALL. A SET OF HANDLES ON THE INSIDE AND OUTSIDE IS PROVIDED FOR EASE OF INSTALLATION AND REMOVAL. ALSO ON THE MANNED FLIGHTS A POST LANDING VENTILATION SYSTEM IS LOCATED ON THE FORWARD HATCH. THE VENTILATION SYSTEM CONSISTS OF TWO MOTOR DRIVEN GATE VALVES, POST LANDING VENT CONTROLLER (PLVC), MOTOR DRIVEN FAN AND A EXTENDABLE

POST LANDING VENTILATION SUB-SYSTEM

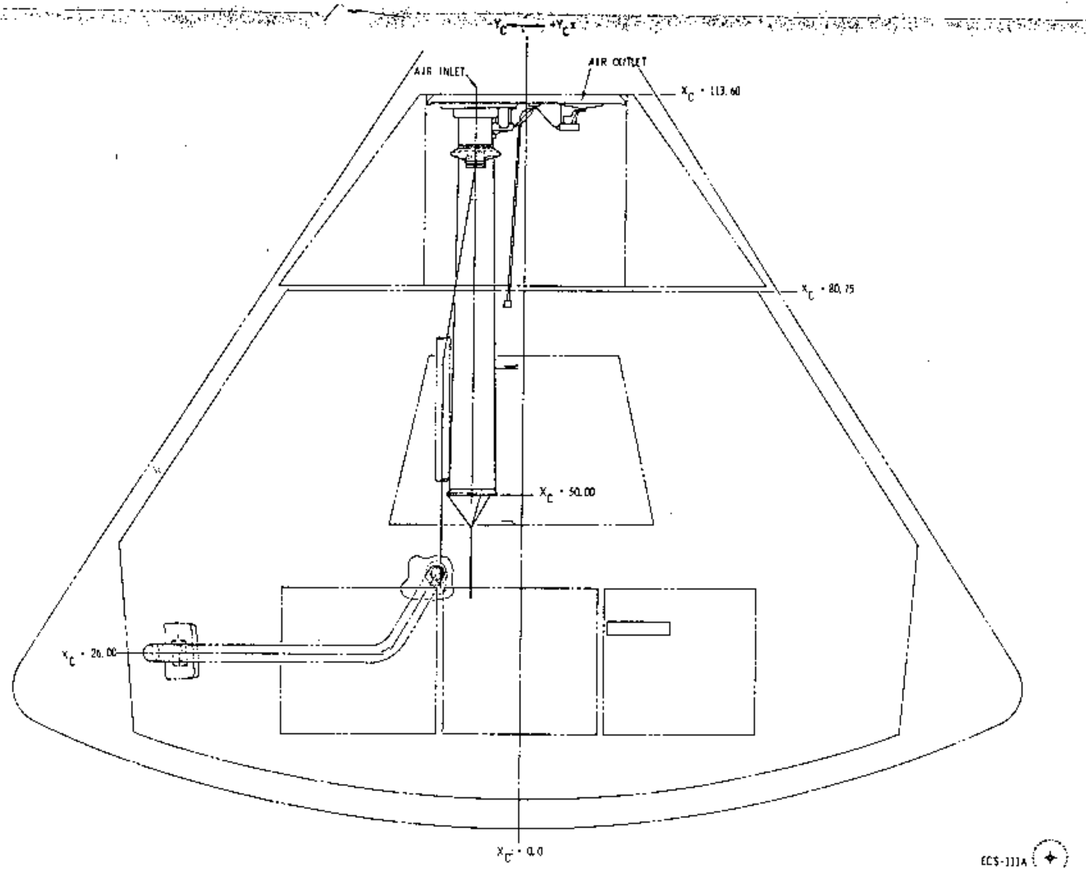

FIGURE 3-9

3-15

DUCT FOR BETTER AIR CIRCULATION. A THREE POSITION SWITCH IS PROVIDED ON PANEL 25 OFF, LOW AND HIGH. WHEN THE SWITCH IS PLACED IN THE HIGH POSITION, THE FAN WILL PROVIDE 150 CFM OF AIR TO THE C/M INTERIOR, WHILE THE LOW POSITION WILL PROVIDE 100 CFM OF AIR. A ATTITUDE SENSOR LOCATED IN THE LEFT HAND EQUIPMENT BAY WILL CLOSE THE VENT VALVES AUTOMATICALLY BEFORE THE C/M HAS TIPPED TO STABLE II POSITION FIGURE 3-9 .

3.2.6 <u>INTERIOR AND EXTERIOR STRUCTURES</u> (FIGURE 3-5)

TO THE EXTERIOR OF THE FORWARD SIDEWALL IS BONDED 21 C-CHANNEL STRINGERS. THESE C-CHANNEL STRINGERS ARE PART OF THE PHYSICAL TIE-IN OF THE CREW COMPARTMENT HEAT SHIELD. TO THE AFT SIDEWALL ARE BONDED 26 T-STRINGERS. THESE T-STRINGERS PROVIDE ATTACH POINTS FOR TRUSSES THAT SUPPORT THE AFT PART OF THE CREW COMPARTMENT HEAT SHIELD. A BULKHEAD IS BOLTED TO THE MID RING INSIDE THE INNER STRUCTURE. THIS IS A BONDED ALUMINUM HONEYCOMB SANDWICH MEMBER DESIGNATED THE GIRTH SHELF ASSEMBLY. THE PURPOSE OF THE GIRTH SHELF ASSEMBLY IS TO PROVIDE LATERAL STRENGTH TO THE SIDEWALL OF THE COMMAND MODULE, PROVIDE STRUCTURAL SUPPORT FOR THE SIDEWALLS, AND THE EQUIPMENT BAYS.

CREW COUCH ATTACH POINTS (6) (FIGURE 3-10)

BONDED TO THE INNER SURFACE TO THE LEFT AND RIGHT HAND SIDE OF THE HATCH ARE HATCH SUPPORT BEAMS. THESE STRENGTHEN THE AREA IN THE VICINITY OF THE HATCH AND ALSO SUPPLY TWO CLEVISES TO WHICH ARE BOLTED TWO (X-X HEAD STRUTS) OF THE SIX SHOCK ATTENUATION CYLINDERS SUPPORTING THE CREW COUCH TO THE COMMAND MODULE INNER STRUCTURE. THE REMAINING FOUR SHOCK ATTENUATION CYLINDERS ARE MOUNTED, TWO (X-X FEET STRUTS) TO CLEVISES WHICH ARE MACHINED ON THE INNER SURFACE OF THE LOWER TOWER SUPPORT LONGERONS, AND TWO (Z-Z STRUTS) TO CLEVISES WHICH ARE MACHINED ON THE INNER SURFACE OF TWO AFT SIDEWALL LONGERONS, AFT OF AND STRADDLING THE SIDE HATCH.

3.3 SECONDARY STRUCTURE (FIGURE'S 3-11, 3-12, 3-13)

THE REMAINDER OF THE INTERNAL STRUCTURAL MEMBERS IN THE CRAFT IS KNOWN AS THE SECONDARY STRUCTURE. THIS FORMS ALL THE EQUIPMENT BAYS INSIDE THE PRESSURE VESSEL. THESE EQUIPMENT BAYS ARE MADE OF SOLID ALUMINUM MEMBERS AND BONDED ALUMINUM HONEYCOMB PANELS. THESE ASSEMBLIES ARE MECHANICALLY FASTENED TO BRACKETS THAT ARE BONDED AND BOLTED TO THE INNER SURFACE OF THE PRESSURE VESSEL.

3.4 COMMAND MODULE OUTER STRUCTURE (FIGURE 3-14)

THE OUTER STRUCTURE CONSTITUTES APPROXIMATELY 30 PERCENT OF THE OVERALL WEIGHT OF THE COMMAND MODULE. IT CONSISTS OF THREE HEAT SHIELDS: THE AFT, THE CREW COMPARTMENT, AND THE FORWARD HEAT SHIELDS.

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3

C/M SECONDARY STRUCTURE

(OUTSIDE VIEW) BLOCK I

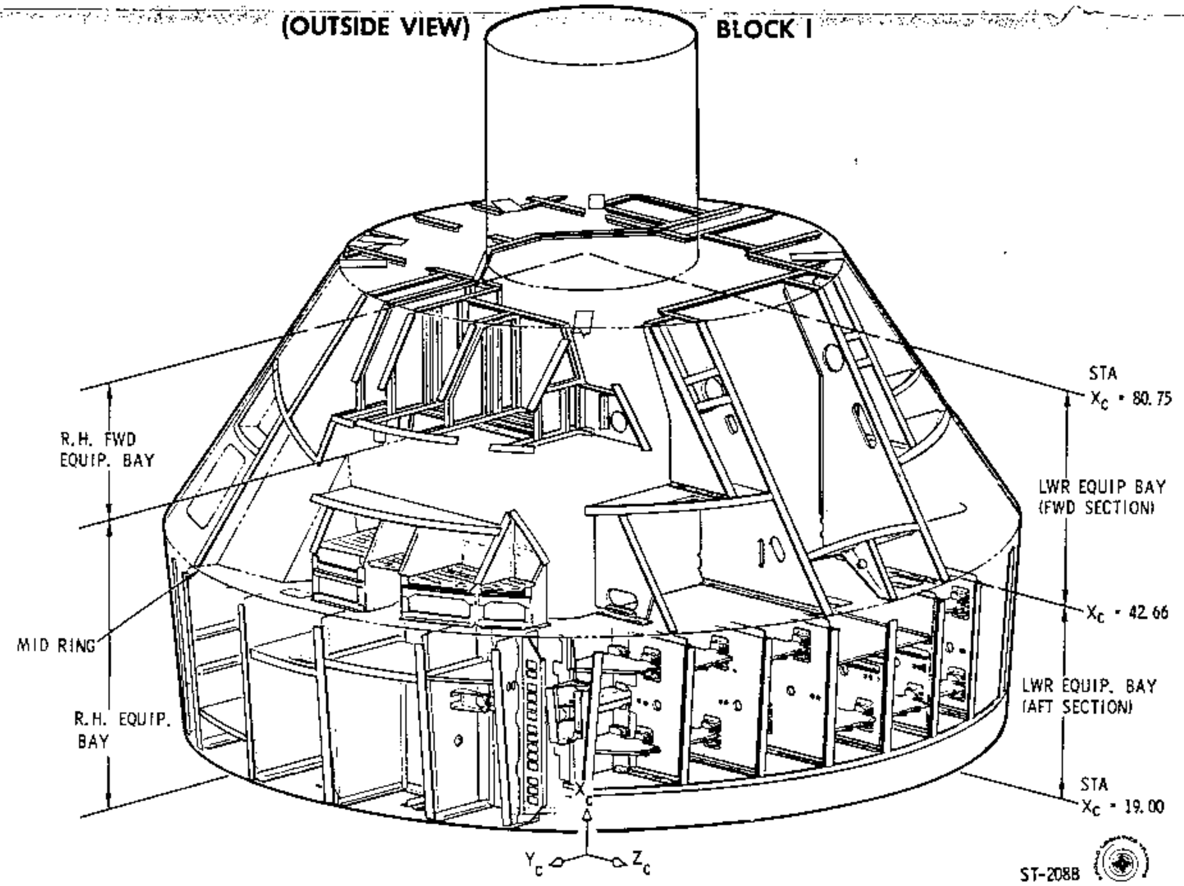

FIGURE 3-11

CREW COUCH ATTACH POINTS

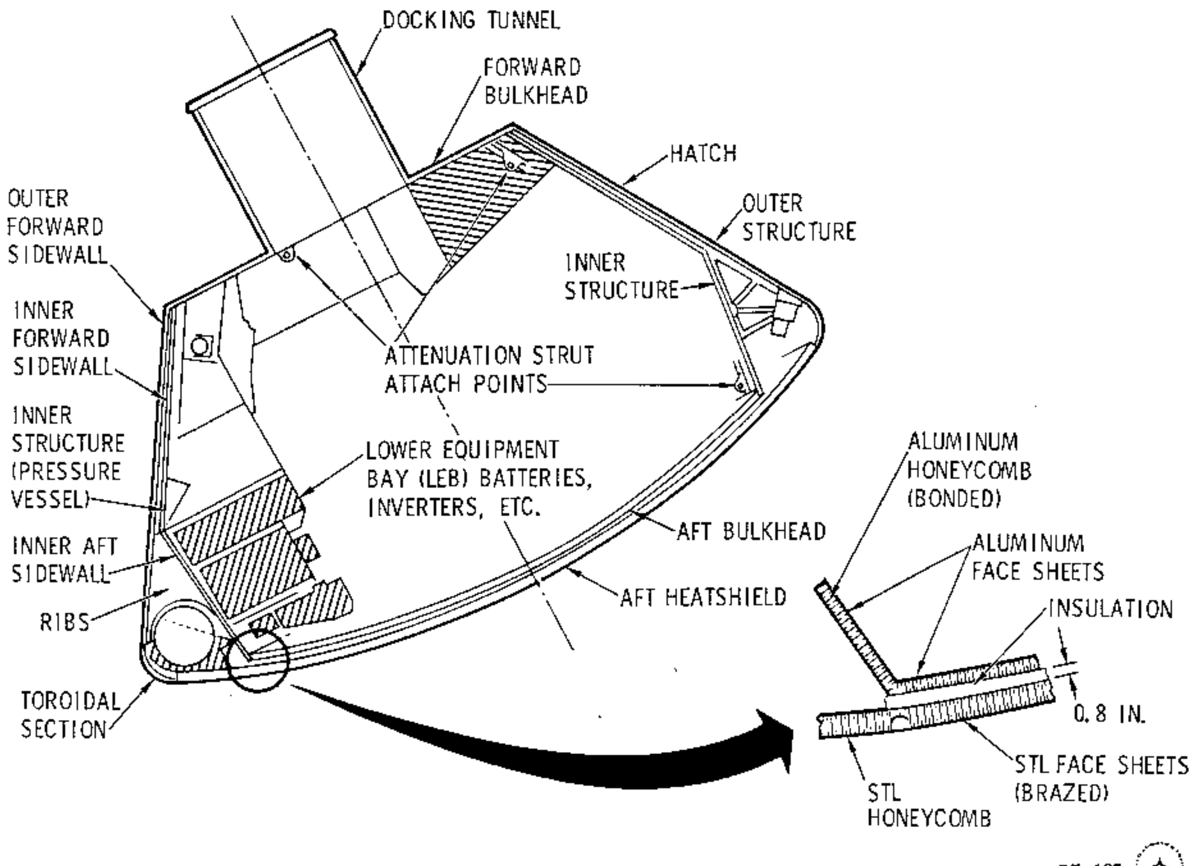

FIGURE 3-10

C/M SECONDARY STRUCTURE

BLOCK I

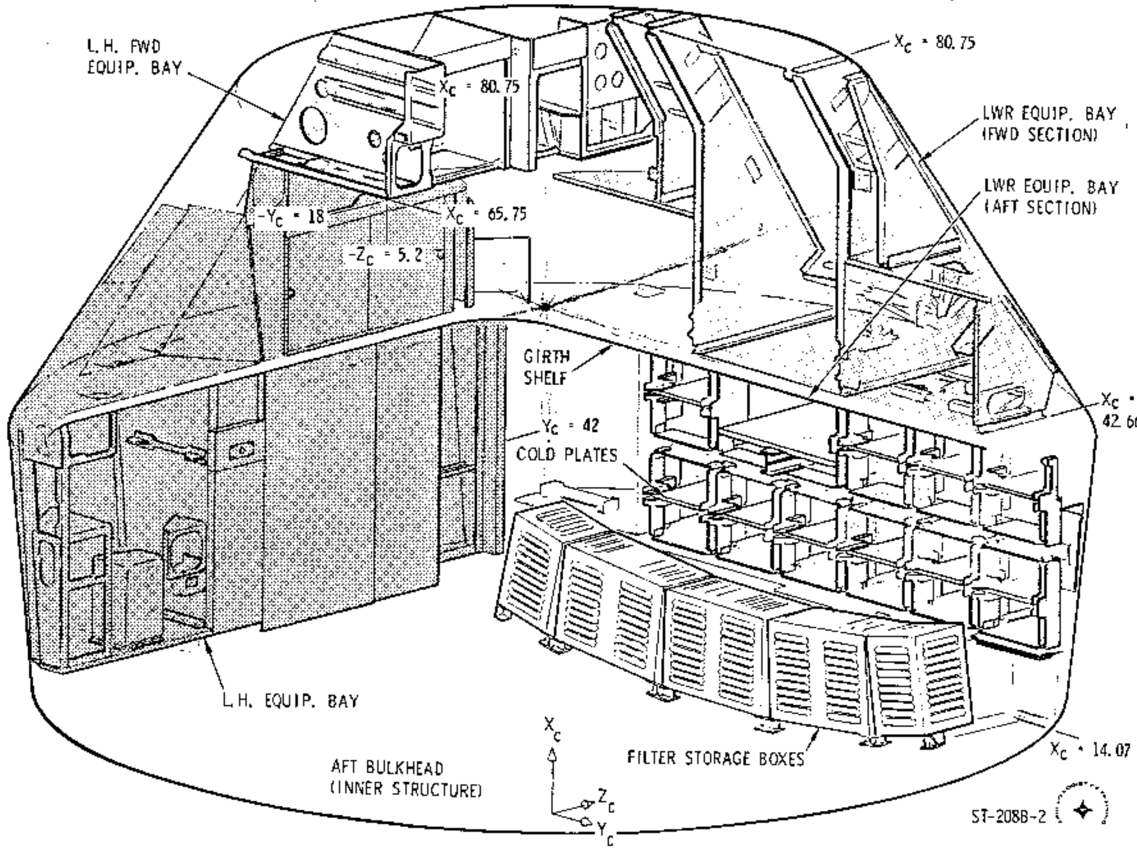

FIGURE 3-13

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C/M SECONDARY STRUCTURE

BLOCK I

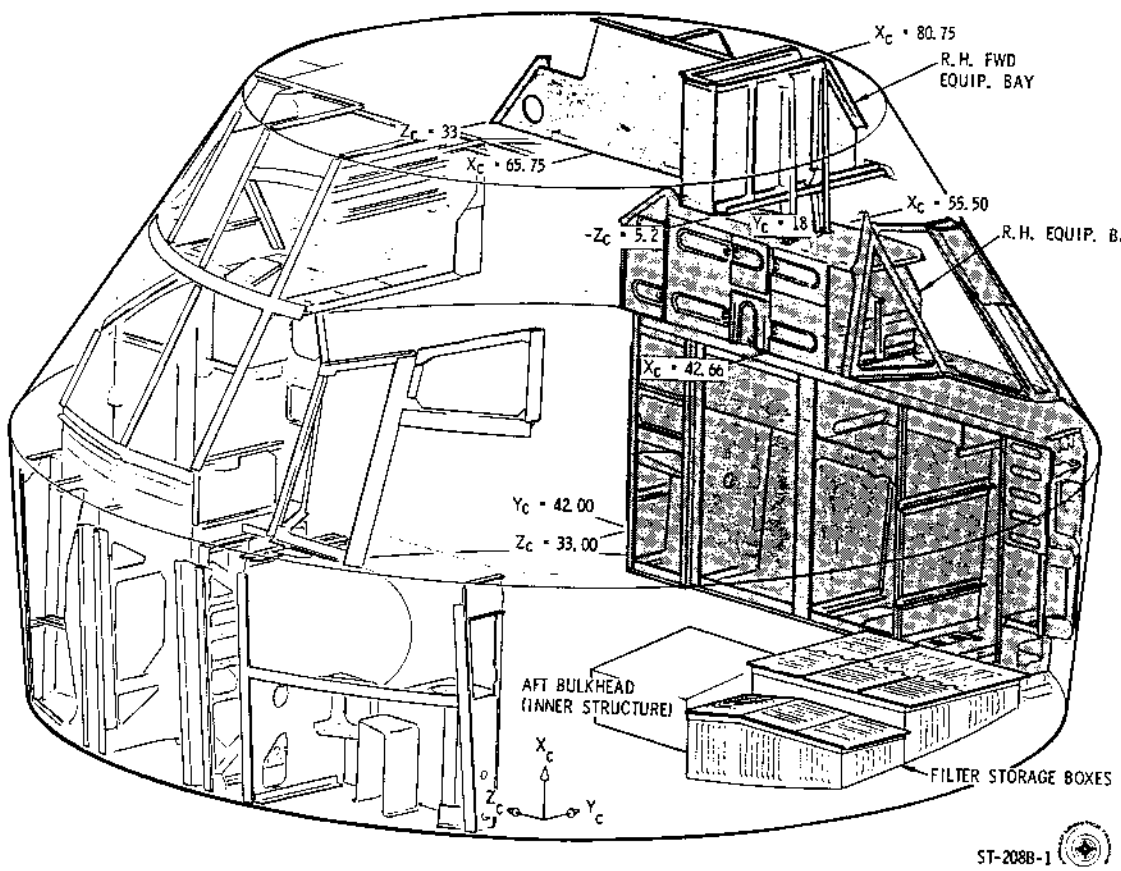

FIGURE 3-12

3

3.4.1 <u>Aft Heat Shield</u> (Figure 3-15)

The aft heat shield is made of brazed steel honeycomb sandwich material and surfaced with ablative material. The types of steel incorporated are 17-4 CRES, 6AL-4V Titanium, and PH14-8 molybdenum corrosion resistant steel. The aft heat shield is made of four 90 degree pie-shaped panels of this material, two inches thick. These panels are butt-welded together, forming the convex portion of the heat shield. The tight radius edge of the heat shield is made of a layer of corrugated steel, surfaced on the outside with a layer of smooth steel. The corrugated sheets are resistance welded to the smooth sheets. The edge is riveted to the honeycomb convex portion of the heat shield. On the forward portion of the aft heat shield, interfacing with the corrugated edge, is a solid steel machined ring. This ring is riveted to the corrugated edge. This ring interfaces a ring on the crew compartment heat shield. The interface is tongue and groove.

From the six hard points of the Command Module, through the aft heat shield, is transmitted the compression loads directly to the compression pads on the Service Module. The aft heat shield is designed to withstand these localized compression forces in the areas of the compression pads. The three tension ties are steel bolts penetrating the aft heat shield and are directly linked to the inner structure. Surrounding the penetration in the aft heat shield through which these bolts are routed is a solid plug of an asbestos type insulating material. The aft heat shield is bolted to the inner structure by 59-3/8 inch stainless steel bolts. These are equally spaced and directly interface the aft ring of the inner structure. The inner structure and the aft heat shield are separated by a .75 inch space. This is accomplished by use of fiberglass aluminum spacers around the periphery in which the 59-3/8 inch bolts are placed. The space between the aft bulkhead of the inner structure and the aft heat-shield is filled by a type II insulation blanket paragraph 3.4.3 having a total thickness of approximately .80 of an inch. A type I blanket 1.5 inches thick is fabricated for the toroidal section. Both types shall be bonded directly to the aft heat shield. (Figure 3-16).

3.4.2 <u>Crew Compartment Heat Shield</u> (Figure 3-12)

The crew compartment heat shield is made of panels of brazed steel honeycomb sandwich material. The overall thickness of these panels is .50 inch. Eight access panels are located in the aft portion of the crew compartment heat shield. These access panels are located in such a fashion as to permit access to the Reaction Control System located in the aft compartment, and also to the hard lines and electrical installations in the Command Module. They are panels of the same material as the crew compartment heat shield and are held in place by captive bolts. Ten reaction control engines are located in the aft compartment. These interface with panels that are part

C/M HEAT SHIELD COMPONENTS (BLOCK I)

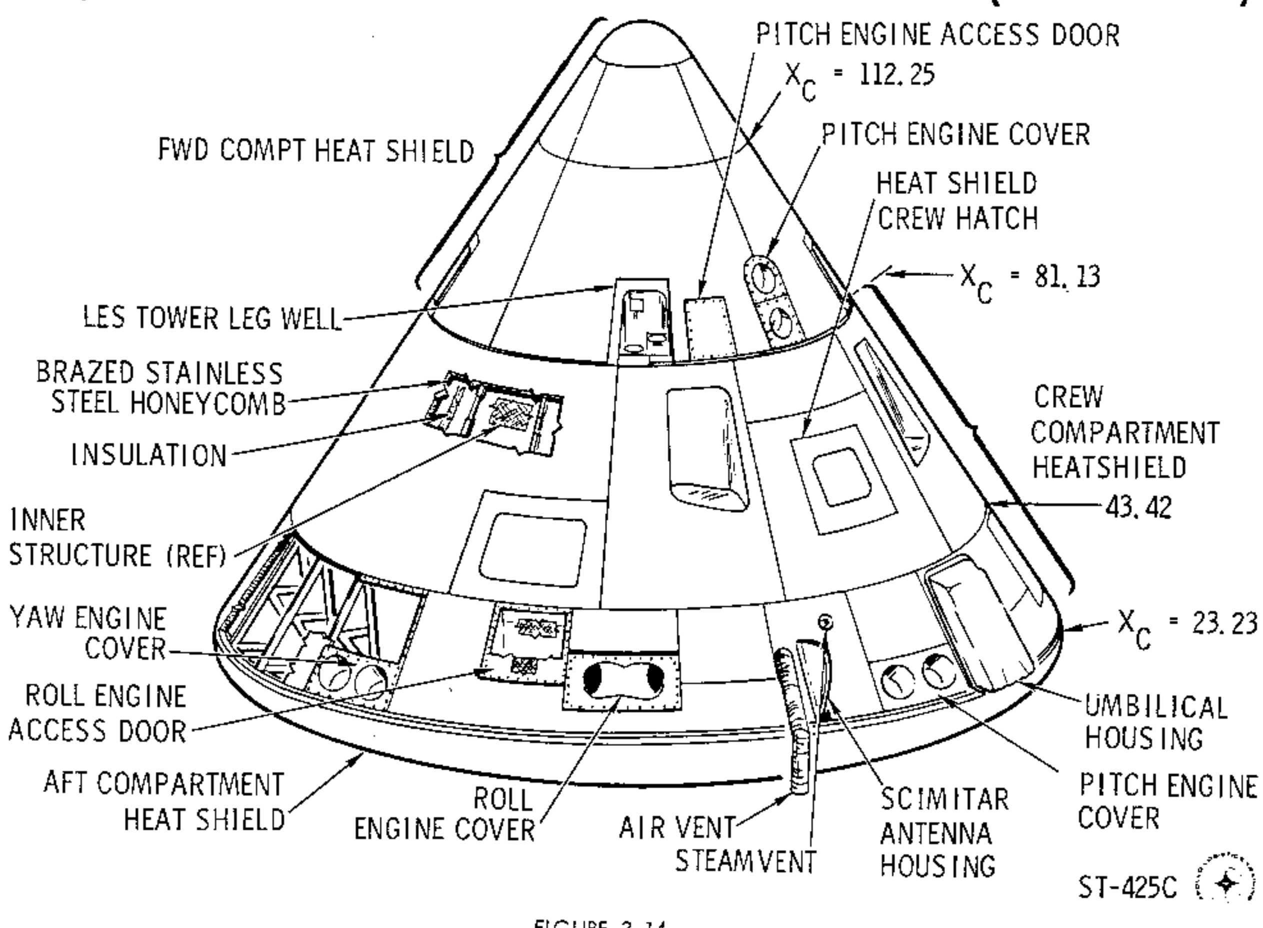

FIGURE 3-14

GENERAL CONFIGURATION CM MODULE INSULATION

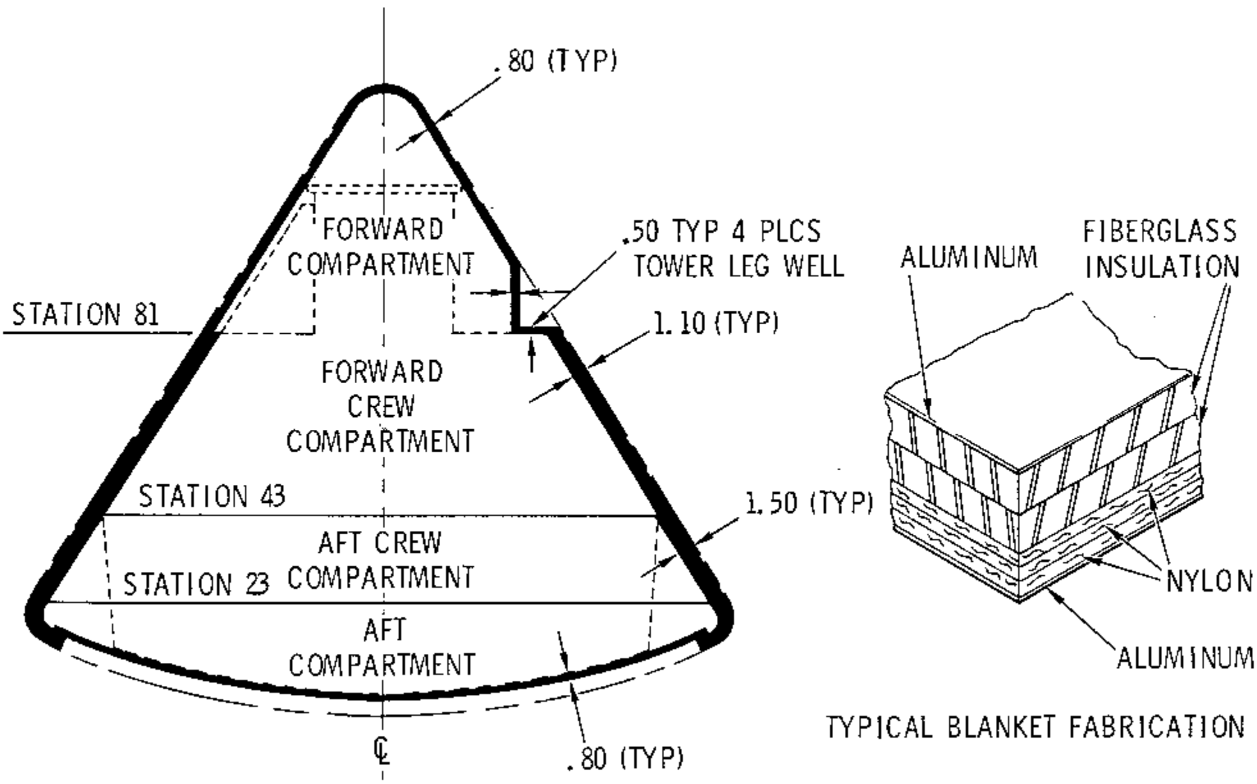

FIGURE 3-16

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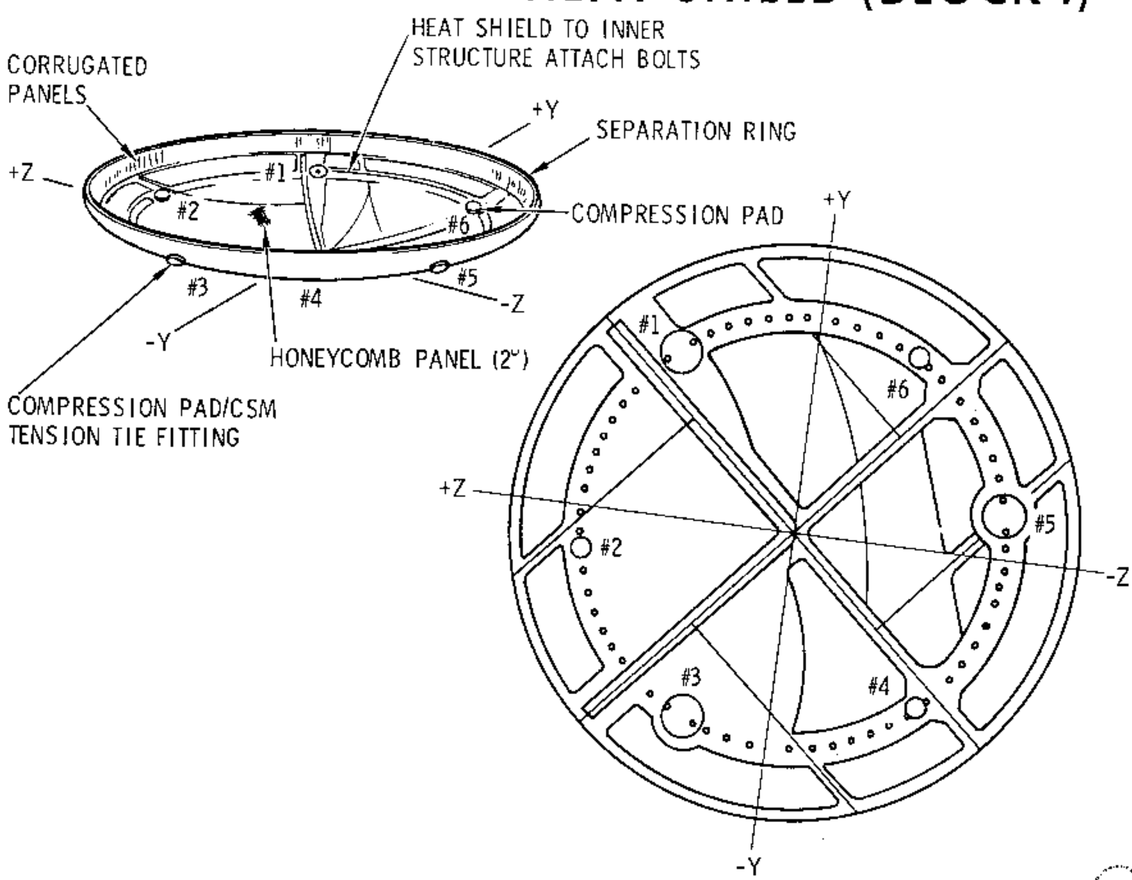
AFT COMPARTMENT HEAT SHIELD (BLOCK I)



ST-427A

FIGURE 3-15

ASTRO-SEXTANT DOOR LATCH MECHANISM

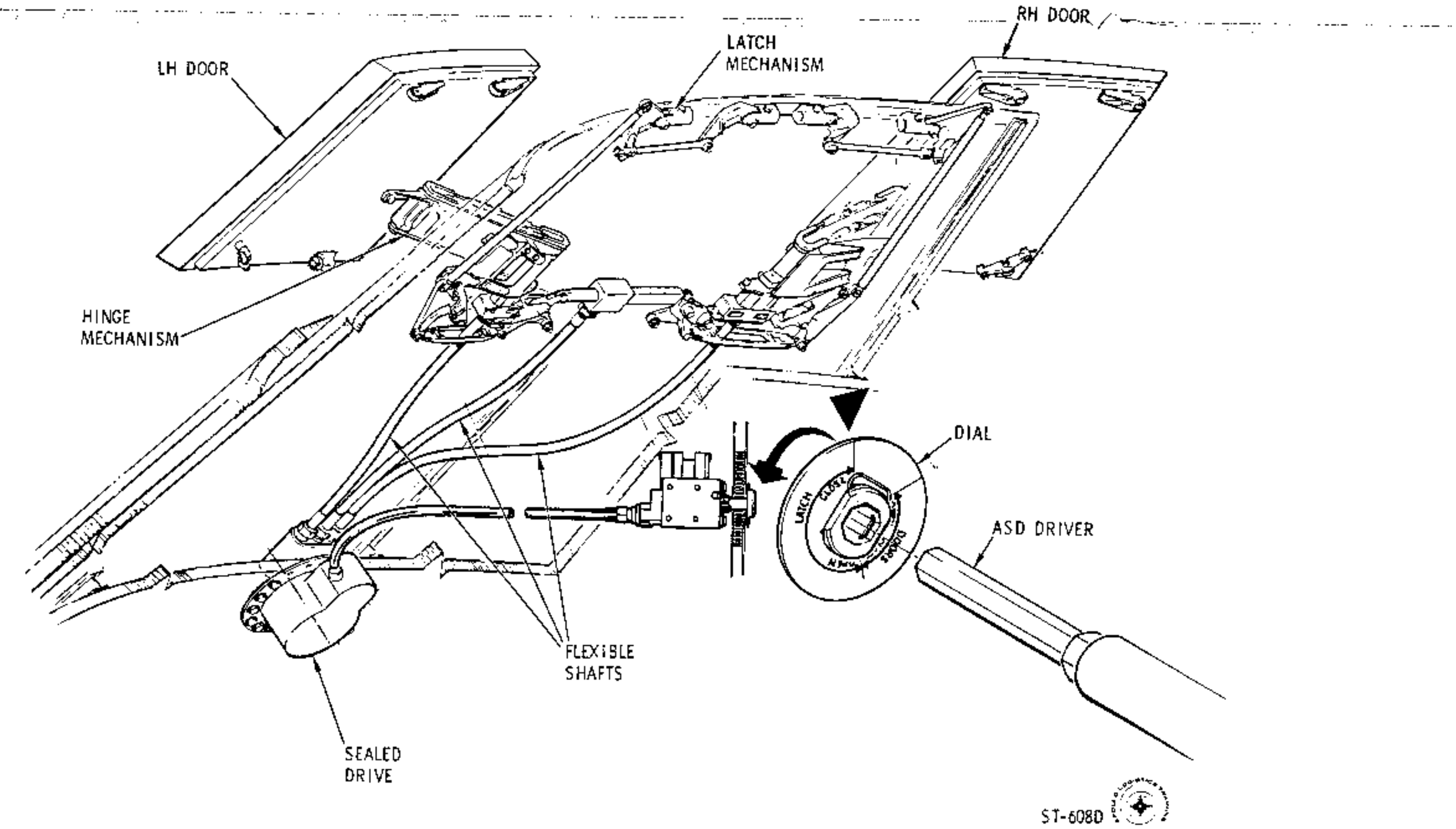


FIGURE 3-17

3-25

of the heat shield. These panels are bolted into place in the same manner as the access hatches. The RCS panels are solid machined steel (6AL-4V Titanium). The crew compartment heat shield is equipped with a 3 inch diameter vent. This vents the space between the inner structure and the heat shield structure allowing no greater than a 1 psi differential in pressure to exist between this and the ambient pressure. The air vent also provides a means of venting fuel or other explosive type vapors that might escape from a possible malfunctioning system.

Located within the vent tube will be eleven copper grid plates that act as a heat sink. These copper grid plates will help in absorbing the hot gas temperatures which may enter the air vent during re-entry. The vent is located toward the aft portion of the crew compartment, directly aft and to the left of the side hatch (Figure 3-12).

Next to the air vent line is the steam vent penetration (Figure 3-12). This is a 2-inch diameter line that interfaces with the inner structure. Through this penetration, the water used in the evaporative process from the suit heat exchanger and the glycol evaporator is vented overboard.

Aft and to the right of the side hatch is located the CSM umbilical penetration. Through this penetration is routed all the electrical and hard lines that interface with the SM systems.

Parallel to the five windows in the inner structure are the crew compartment heat shield windows (Figure 3-12). These are a single pane of glass .7 of an inch thick. The glass is Dow Corning 7950 amorphous fused silicon. Vacuum depositied on the external surface of the glass is a single layer of magnesium floride that is an anti reflective coating. The internal surface of the glass has 42 vacuum deposited layers of blue-red reflective coatings that filter out most of the infra-red rays and all of the ultra violet rays. These panes have a softening point of 2800 degrees F and a melting point of 3110 degrees F. They are surrounded by a steel frame interfacing the heat shield, whose high temperature specifications will be a maximum of 600 degrees F. Between the steel frame and the glass is an insulating gasket. The steel frame is bolted to the adjacent material in the crew compartment heat shield and the entire frame covered with ablative material.

The crew compartment heat shield is equipped with a pair of doors which provide protection for the astro-sextant and telescope lens from environmental conditions expierenced during the mission (Figure 3-17). The two doors are located on the +Z axis of the S/C and are fabricated of brazed steel honeycomb. When the doors are installed and closed they become a part of the crew compartment heat shield substructure. The doors also provide a bonding surface for the ablative material. The door is mechanically operated from inside the crew compartment with the crank handle

C/M OUTER CREW HATCH

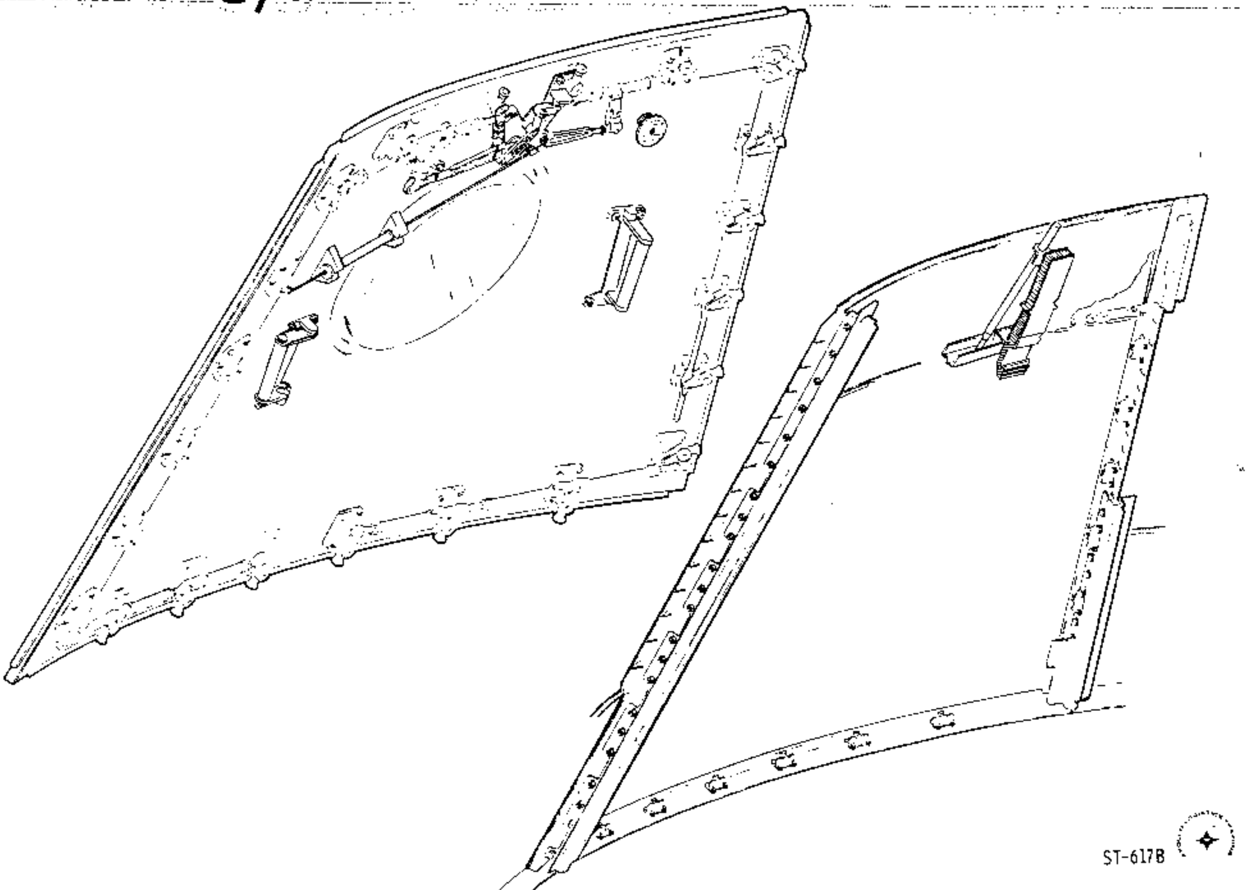


FIGURE 3-18

ASD DRIVER. THERE ARE THREE FLEXIBLE SHAFTS THAT CONNECT THE SEALED DRIVE TO THE LATCH AND HINGE MECHANISMS. THE CENTER FLEXIBLE SHAFT SHALL SERVE TO UNLOCK AND LOCK THE DOORS AFTER THE FINAL CLOSING. THE OUTER FLEXIBLE SHAFTS ATTACH TO THE HINGE DRIVE MECHANISM AND EFFECT THE OPENING AND CLOSING OF THE DOORS IN A PARALLELOGRAM FASHION. THE CRANK HANDLE AND DRIVER ARE INSERTED INTO A HEX DRIVE ON THE INSTRUMENT PANEL, AND SHALL REQUIRE APPROXIMATELY NINE TURNS TO UNLOCK OR LOCK THE ASTRO-SEXTANT DOOR, WHILE THREE TURNS WILL OPEN AND EXTEND OR RETRACT AND CLOSE THE DOORS. A INDICATING DEVICE SURROUNDING THE HEX DRIVE PENETRATION, WILL INDICATE DOOR POSITION DURING OPENING AND CLOSING FIGURE 3-17. THE DOORS WHEN OPEN WILL CLEAR AN ANGLE OF VIEW OF AT LEAST 100 DEGREES. WHEN NOT IN USE THE HANDLE AND DRIVER WILL BE REMOVED AND STOWED.

THE COMMAND MODULE HEAT SHIELD SIDE HATCH PROVIDES ACCESS TO THE INNER HATCH AND INTO THE CREW COMPARTMENT (FIGURE 3-18). THE HATCH IS A TRAPEZOID CONFIGURED DOOR CONSTRUCTED OF BRAZED STEEL HONEYCOMB, THE SAME THICKNESS AND TYPE OF MATERIAL USED IN FABRICATING THE CREW COMPARTMENT HEAT SHIELD. THE HATCH INTERFACES THE CREW COMPARTMENT HEAT SHIELD BY A SOLID STEEL FRAME THAT IS WELDED TO THE SURROUNDING STEEL HONEYCOMB MATERIAL. A LAYER OF ABLATIVE MATERIAL WILL BE BONDED TO THE EXTERIOR SURFACE.

THE OUTER CREW HATCH MECHANISM PROVIDES A POSITIVE METHOD OF SECURING THE CREW HATCH DOOR TO THE C/M STRUCTURE AND RETAINING IT IN POSITION THROUGHOUT THE MISSION. THE LATCHING MECHANISM IS MOUNTED ON THE INNER SURFACE OF THE HATCH, AND THE MATCHING LATCH ASSEMBLIES ARE MOUNTED TO THE STEEL FRAME SURROUNDING THE HATCH. THE HATCH MECHANISM MAYBE MANUALLY OPERATED FROM EITHER THE INSIDE OR OUTSIDE. TO UNLOCK THE HATCH FROM THE INSIDE, A SINGLE HANDLE AND LANYARD IS ATTACHED TO THE LATCHING MECHANISM (FIGURE 3-19). TO LOCK THE HATCH FROM THE INSIDE, THE IN FLIGHT EMERGENCY HANDLE WILL BE INSERTED IN THE HEX DRIVE AND ROTATED APPROXIMATELY 90° COUNTERCLOCKWISE. THE A14-132 C/M HANDLE IS USED TO LOCK OR UNLOCK THE HATCH FROM THE OUTSIDE. THE HANDLE IS INSERTED THROUGH A PENETRATION PROVIDED IN THE ABLATOR, AND WILL INTERFACE WITH THE HEX DRIVE ON THE LATCHING MECHANISM. THE HANDLE IS ROTATED CW TO LOCK THE HATCH AND CCW TO UNLOCK THE HATCH. THIS PENETRATION WILL BE CLOSED WITH AN ABLATOR PLUG AFTER THE FINAL INSTALLATION. TO OPEN THE HATCH AFTER POST LANDING, A ROD ASSEMBLY IS LOCATED BETWEEN THE INNER AND OUTER STRUCTURE (FIGURE 3-18). ONE END OF THE ROD WILL INTERFACE THE SHOE ON THE LATCHING MECHANISM WHILE THE OTHER END IS FLUSH WITH THE FORWARD BULKHEAD. TO OPEN THE HATCH BY THIS MEANS, THE FORWARD HEAT SHIELD WILL HAVE TO BE REMOVED.

3.4.3 INSULATION BLANKETS (FIGURE 3-16)

THE INSULATION BLANKETS USED IN THE C/M WILL CONSIST OF THREE TYPES. TYPE I WILL HAVE FIBROUS INSULATION SANDWICHED BETWEEN TWO RADIATION SHIELDS. TYPE II WILL HAVE FIBROUS INSULATION AND THREE LAYERS OF NYLON SANDWICHED BETWEEN TWO RADIATION SHIELDS. THE TYPE III ASSEMBLY SHALL BE THE SAME AS THE TYPE II EXCEPT THAT FIVE LAYERS OF NYLON SHALL BE USED.

ALL TYPES OF INSULATION BLANKETS ARE ACCEPTABLE FOR USE FROM -300 TO +700°F.

THE FIBERGLASS INSULATION MATERIAL SHALL CONSIST OF GLASS FIBERS CONTAINING A THERMOSETTING SILICONE RESIN BINDER. THE MATERIAL MAY BE PURCHASED IN EITHER A TYPE I 3 POUND DENSITY OR TYPE II 6 POUND DENSITY. THE MATERIAL COMES IN LARGE SLABS 3/16 AND .5 THICK AND IS PRECUT FROM TEMPLATES PRIOR TO INSTALLING ON SPACE CRAFT.

THE INSULATING MATERIAL IS ENCASED BY A ALUMINUM BARRIER OR RADIATION SHIELD. THE BARRIER OR RADIATION SHIELD CONSISTS OF AN ALUMINUM FOIL GLASS FABRIC COMPOSITE BONDED TOGETHER WITH A PRESSURE-SENSITIVE SILICONE ADHESIVE.

THE LAYERS OF NYLON CLOTH SHALL BE CUT FOR INSTALLATION BETWEEN THE FIBERGLASS AND ALUMINUM RADIATION SHIELD. WHEN INSTALLING THE TYPE II OR III BLANKETS THE NYLON LAYERS SHALL FACE THE INNER STRUCTURE.

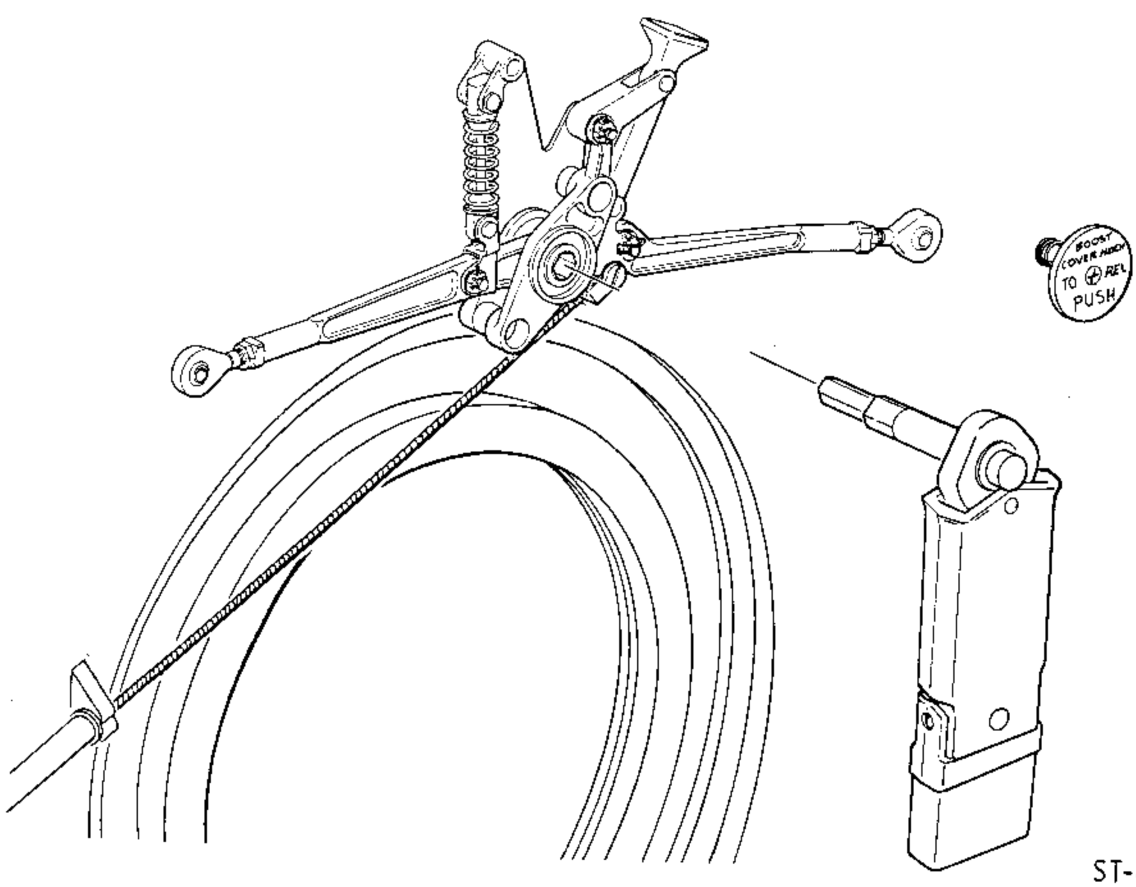
3.4.4 HEAT SHIELD ATTACHMENT

THE FORWARD AND AFT PORTIONS OF THE CREW COMPARTMENT HEAT SHIELD ARE TERMINATED BY A PAIR OF RINGS. THESE ARE SINGLE PIECE FORGED MACHINE RINGS AND INTERFACE WITH THE RINGS OF THE FORWARD AND AFT HEAT SHIELDS RESPECTIVELY. THE INNER SURFACE OF THE CREW COMPARTMENT HEAT SHIELD IS EQUIPPED WITH 24 C-CHANNEL STRINGERS. THESE STRINGERS CORRESPOND IN SIZE AND LOCATION TO THE STRINGERS THAT ARE LOCATED ON THE OUTER SURFACE OF THE FORWARD SIDE WALL OF THE INNER STRUCTURE. THE CREW COMPARTMENT HEAT SHIELD IS FASTENED TO THE INNER STRUCTURE BY MEANS OF I-RAILS THAT INTERFACE WITH THE C-CHANNEL STRINGERS ON THE INNER STRUCTURE AND THE CREW COMPARTMENT HEAT SHIELDS. THESE 2-PIECE I-RAILS PERMIT RELATIVE MOTION BETWEEN THE CREW COMPARTMENT HEAT SHIELD AND THE INNER STRUCTURE. THIS COMPENSATES FOR THERMAL EXPANSION AND CONTRACTION, AND KEEPS THERMALLY INDUCED LOADS FROM ACTING UPON THE INNER STRUCTURE. THE AFT PORTION OF THE CREW COMPARTMENT HEAT SHIELD IS BOLTED TO THE TRUSSES THAT FORM THE AFT COMPARTMENT. THE INTERFACE BETWEEN THE TRUSSES AND THE CREW COMPARTMENT HEAT SHIELD IS BY BOLTING THROUGH OVER-SIZED HOLES, THUS PERMITTING RELATIVE MOTION BETWEEN THE TRUSSES AND THE CREW COMPARTMENT HEAT SHIELD.

THE TYPE III INSULATION BLANKETS (PARAGRAPH 3.4.3) ARE UTILIZED BETWEEN THE CREW COMPARTMENT HEATSHIELD AND INNER STRUCTURE FROM STATION 23.20 TO 81.00. THE INSULATION IN THE FORWARD AREA IS 1.10 INCHES THICK, WHILE THE AFT PORTION IS 1.50 INCHES THICK FIGURE 3-16. THE INSULATION IN THE FORWARD AREA SHALL BE BONDED DIRECTLY TO THE INNER STRUCTURE. CARE SHOULD BE TAKEN TO INSURE THAT NO MECHANISMS, HARDWARE, OR LINES ARE FOULED. WHEREVER POSSIBLE, ALL LINES SHALL BE UNDER THE BLANKETS. THE INSULATION IN THE AFT AREA CAN BE BONDED DIRECTLY TO THE RING SECTION OF THE INNER STRUCTURE STATION 23.20 AND TO THE BLANKETS AT THE TOP OF THE AFT HEAT SHIELD.

3

LATCH DRIVE LINK ASSEMBLY



ST-618

FIGURE 3-19

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ABLATIVE MATERIAL MECHANICS & CONFIGURATION (BLOCK I)

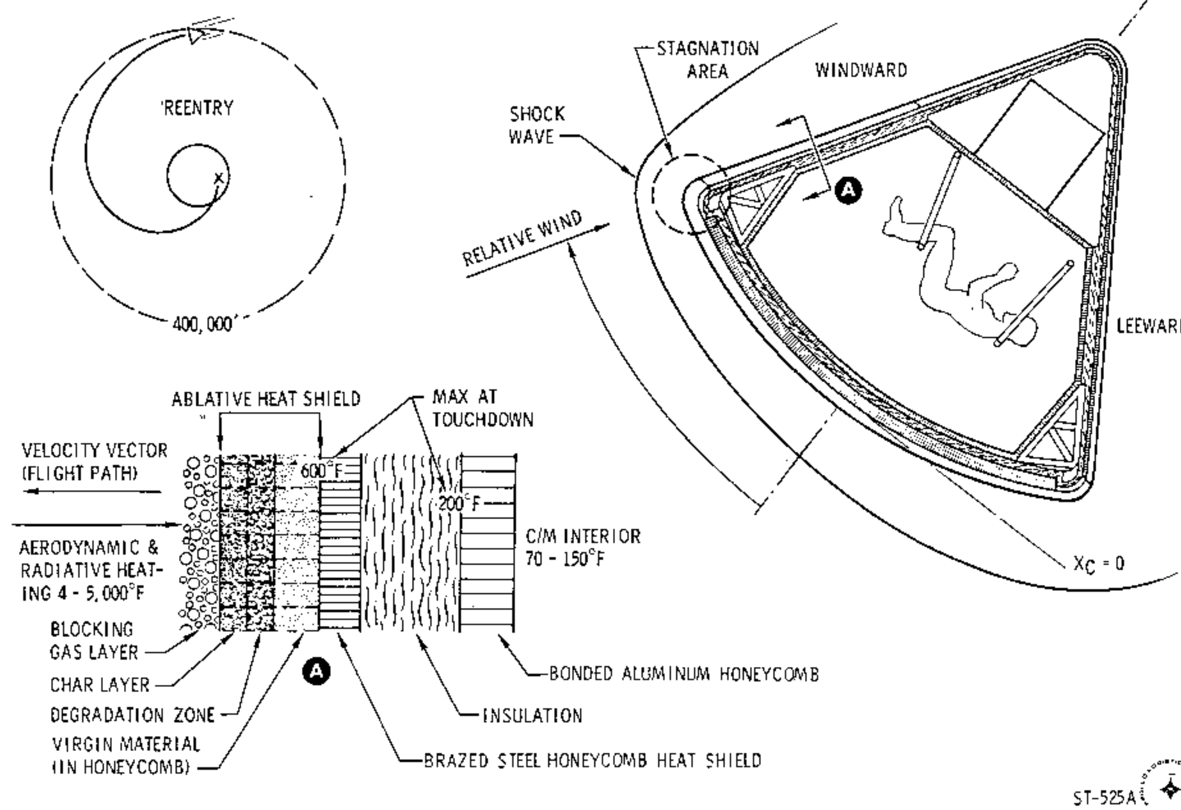


FIGURE 3-20

3-30

3.4.5 FORWARD HEAT SHIELD (FIGURE 3-14)

THE FORWARD HEAT SHIELD IS CONICAL IN SHAPE AND WILL INTERFACE WITH THE CREW COMPARTMENT HEAT SHIELD AT STATION $X_C = 81.13$. THE FORWARD HEAT SHIELD IS .50 INCH THICK BRAZED STEEL HONEYCOMB AND FABRICATED OF THE SAME MATERIAL AS IN THE OTHER TWO HEAT SHIELDS. IN THE AFT PORTION OF THE FORWARD HEAT SHIELD WILL BE A SLOT THROUGH WHICH THE TWO NEVATIVE PITCH CONTROL ENGINES WILL PROTRUDE. THESE TWO ENGINES WILL BE MOUNTED TO THE INNER STRUCTURE OF THE COMMAND MODULE. FOUR SOLID STEEL FORGED MACHINED TOWER WELLS WILL BE WELDED 90° APART INTO THE AFT PORTION OF THE FORWARD HEAT SHIELD. THE HEAT SHIELD PENETRATIONS FOR THE LES TOWER LEGS ARE IN THESE WELLS. THE TWO TOWER WELLS TOWARD THE -Z AXIS WILL BE EQUIPPED WITH ELECTRICAL UMBILICAL PENETRATIONS THROUGH WHICH ALL THE CABLING WILL BE ROUTED BETWEEN THE C/M AND THE LES. THESE TOWER WELL PENETRATIONS AND THE ELECTRICAL UMBILICAL PENETRATIONS WILL BE FLOATING FITTINGS. THUS, THE FORWARD HEAT SHIELD WILL NOT FEEL LOADS INDUCED BY EITHER THE TOWER OR THE ELECTRICAL UMBILICALS. THE FORWARD HEAT SHIELD WILL BE ATTACHED TO THE C/M AT FOUR POINTS. THIS WILL BE A COMBINATION STRUCTURAL TIE OF THE FORWARD HEAT SHIELD TO THE C/M, AND ALSO A THRUSTER SYSTEM FOR JETTISONING THE FORWARD HEAT SHIELD. THESE THRUSTERS ARE LOCATED WITHIN THE FOUR GUSSETS IN THE FORWARD COMPARTMENT. THE THRUSTERS ARE EXPLAINED IN DETAIL IN SECTION IV. INSULATION IN THIS AREA SHALL BE BONDED DIRECTLY TO THE OUTER SHELL IN SUCH A MANNER THAT WHEN THE FORWARD HEAT SHIELD IS JETTISONED FOR PARACHUTE DEPLOYMENT, THE INSULATION IS ALSO REMOVED.

THIS BEING THE TYPE II BLANKET .80 OF AN INCH TOTAL THICKNESS FIGURE 3-16. A .50 INCH THICK INSULATION IS USED IN THE FOUR TOWER LEG WELLS.

3.5 ABLATIVE MATERIAL (FIGURE 3-20)

THE THREE HEAT SHIELDS ARE SURFACED WITH ABLATIVE MATERIAL. WHEN THE HEAT SHIELDS ARE INSTALLED ON THE C/M, THE C/M IS COMPLETELY ENCLOSED IN A SHELL OF ABLATIVE MATERIAL. THE THICKNESS OF THIS ABLATIVE MATERIAL VARIES, THE THICKEST PORTION BEING THE LOWER AFT EDGE OF THE C/M. THIS THICKNESS IS 2.5 INCHES. THIS CORRESPONDS TO THE STAGNATION ZONE DURING ENTRY OR THE HIGHEST TEMPERATURE PORTION OF THE HEAT SHIELD. THE ABLATIVE MATERIAL TAPERS, BOTH LONGITUDINALLY AND LATERALLY, AROUND THE C/M. A THREE DIMENSIONAL TAPERING, DOWN TO A MINIMUM THICKNESS OF APPROXIMATELY .75 AN INCH. THIS THICKNESS OCCURS TOWARD THE SIDE HATCH AREA OR THE NEGATIVE Z PORTION OF THE C/M. THE ABLATIVE MATERIAL APPLIED IS AVCO 5026-39HC. THIS IS AN EPOXY PHENOLIC MATERIAL CONTAINING SILICA FIBERS, GLASS FIBERS, AND PHENOLIC MICRO-BALLOONS AND HAS A DENSITY OF 30 POUNDS PER CUBIC FOOT. IT BEGINS TO ABLATE AT 500 DEGREES F, AND BEGINS TO SURFACE RECEDE AT 2000 DEGREES F. IT IS INSTALLED ON THE OUTER SURFACE OF THE STEEL HEAT SHIELDS BY BEING PLACED IN A MATRIX OF FIBER GLASS HONEYCOMB CORE, WHICH IS BONDED TO THE OUTER SURFACE OF THE HEAT SHIELD. THE CORE IS BONDED TO THE HEAT SHIELD OUTER SURFACE BY USE OF HT 424, AN EPOXY PHENOLIC BINDING MATERIAL. AFTER THIS IS COMPLETE, EACH OF THE CELLS (THE CELL SIZE BEING APPROXIMATELY

BOOST PROTECTIVE COVER

BLOCK I CSM

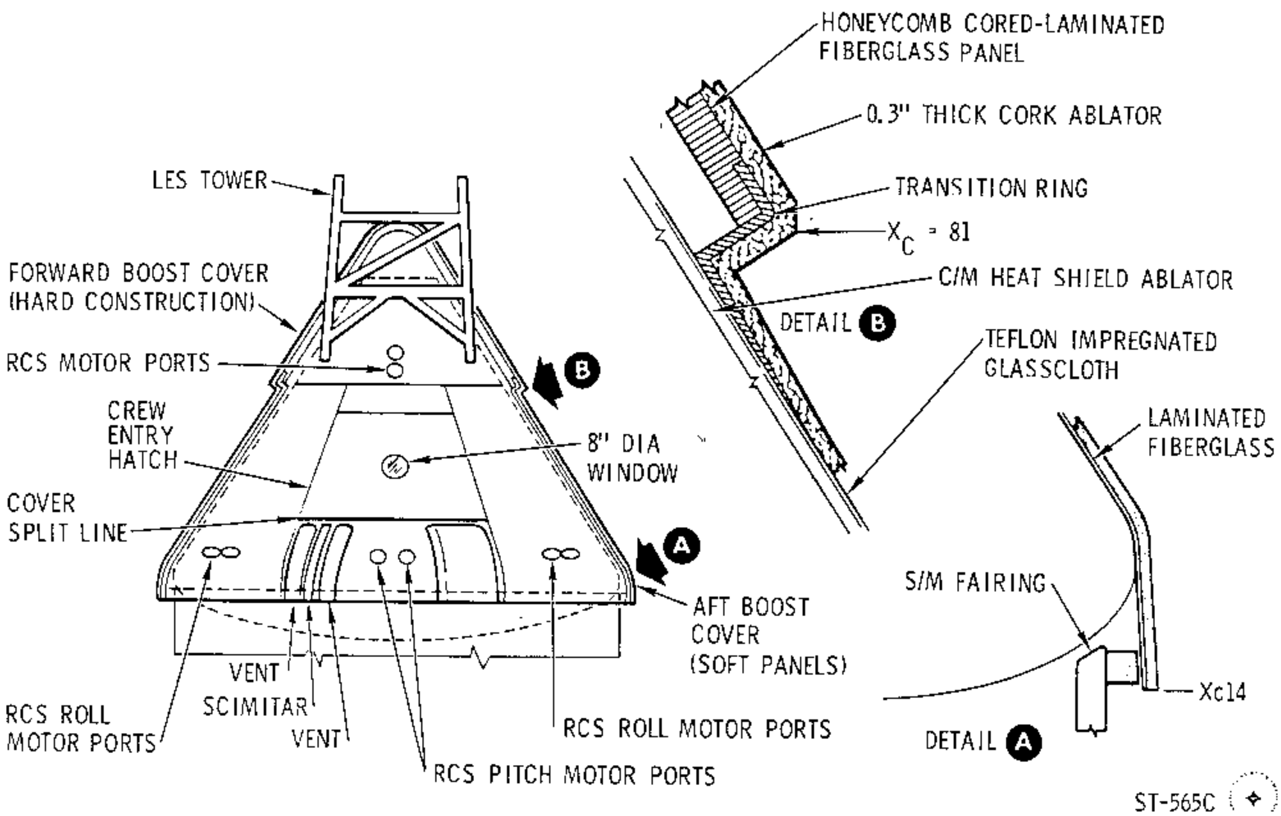


FIGURE 3-21

3-32

3/8 OF AN INCH) IS FILLED WITH THE ABLATIVE MATERIAL. AFTER THE ENTIRE INSTALLATION IS CURED, THE SURFACE IS MACHINED DOWN TO GIVE THE 3 DIMENSIONAL TAPERING OF THE ABLATIVE MATERIAL. THE C/M REACTION CONTROL ENGINES INTERFACE THE HEAT SHIELD WITH A STEEL FRAME AND AN ABLATOR. THE C/M AND S/M UMBILICAL IS ALSO COVERED WITH THE AVCO ABLATIVE MATERIAL.

3.6 BOOST PROTECTIVE COVER (FIGURE 3-21)

3.6.1 GENERAL DESCRIPTION

THE BOOST PROTECTIVE COVER (BPC) CONSISTS OF A CONE SHAPED HARD COVER FABRICATED OF HONEYCOMB MATERIAL, PLUS NINE CURVED PANELS OF TEFLON COATED GLASS CLOTH. THE ENTIRE BOOST PROTECTIVE COVER IS COVERED ON THE OUTER SURFACE WITH AN ABLATIVE PROTECTION MATERIAL. THE PURPOSE OF THE BPC IS TO REDUCE THE AMOUNT OF THERMO COATING AND ABLATIVE MATERIAL REQUIRED ON THE C/M, TO PREVENT THERMO BUILD UP ON C/M SURFACES, AND PREVENT RESIDUE FROM COVERING THE C/M WINDOWS DURING THE OPERATIONAL PHASE OF THE LES. THE BPC SEPARATES FROM THE S/C WHEN THE LAUNCH ESCAPE TOWER IS JETTISONED.

3.6.2 STRUCTURAL DESCRIPTION

THE BOOST PROTECTIVE COVER WILL BE OF HARD CONSTRUCTION FROM THE APEX, AFT TO STATION $X_C = 81$. THE HARD PORTION WILL BE FABRICATED OF FIBERGLASS HONEYCOMB SANDWICH MATERIAL .685 OF AN INCH THICK. COVERING THE OUTER FACE SHEET OF THE HONEYCOMB MATRIX WILL BE A CORK ABLATOR .30 OF AN INCH THICK. THIS HARD PORTION WILL BE ATTACHED TO, AND INSTALLED WITH, THE LAUNCH ESCAPE TOWER. BELOW STATION $X_C = 81$, THE COVER WILL BE A PLIABLE (SOFT) CONSTRUCTION. THE INNER LAYER IS FABRICATED OF .008 OF AN INCH THICK GLASS CLOTH, TEFLON IMPREGNATED ON THE INNER SURFACE. FOR REINFORCEMENT, THE INNER LAYER WILL BE COVERED WITH A THIN LAYER OF HT1-41 "NOMEX" FABRIC .0095 OF AN INCH THICK. COVERING THE OUTER SURFACE, OR "NOMEX" FABRIC, WILL BE A CORK ABLATOR .30 OF AN INCH THICK. THE SOFT PORTION OF THE BOOST PROTECTIVE COVER WILL CONSIST OF 8 CURVED PANELS, ALL REINFORCED AT THE SPLIT LINES AND TRAILING EDGES FOR ADDED STRENGTH. SEVEN (7) OF THE 8 PANELS WILL BE ATTACHED WITH SCREWS AND NUT PLATES TO THE TRAILING EDGE OF THE HARD COVER. AFTER ATTACHMENT TO THE HARD COVER IS COMPLETE, THE INDIVIDUAL PANEL SPLIT LINES WILL BE FASTENED WITH THREADED FASTENERS. THE REMAINING, OR EIGHTH, PANEL LOCATED BELOW THE HATCH WILL BE ATTACHED TO THE TWO PANELS STRADDLING THE HATCH OPENING, COMPLETING THE FOURTH SIDE OF THE HATCH FRAME. THE FOUR PANELS SURROUNDING THE HATCH COVER WILL CONTAIN THE PLATES TO ACCOMODATE THE HATCH LOCKING LEVERS (FIGURE 3-22).

A BOOST COVER HATCH ASSEMBLY IS LOCATED IN THE PANEL ON THE -Z AXIS, ALLOWING ACCESS TO THE CREW OUTER HATCH AFTER THE COVER IS INSTALLED. THE HATCH ASSEMBLY CONSISTS OF A FIBERGLASS PANEL AND SHROUD, LATCHING MECHANISM, AND A SILICA GLASS WINDOW (S/C 012). THE OUTER PANEL AND SHROUD IS COVERED WITH AN ABLATIVE MATERIAL. THE LATCHING MECHANISM IS SPRING LOADED TO THE LOCKED POSITION AND INCORPORATES TWO QUICK RELEASE FEATURES. FROM THE INTERIOR, A "PRESS TO RELEASE"

PLUNGER CAN BE ACTUATED. FROM THE EXTERIOR, A LATCH ASSEMBLY TOOL (G15-B241C5) IS UTILIZED, WHICH IS A PART OF THE A14-183 CANARD ACTUATOR TOLL SET.

3.7 IMPACT ATTENUATION SYSTEM

3.7.1 GENERAL DESCRIPTION

THE COMMAND MODULE IMPACT SUBSYSTEM WILL PROVIDE THE CREW WITH SAFE COMMAND MODULE LANDING CAPABILITIES FOR WATER LANDINGS AT PLANNED SITES, CONTINGENT WATER LANDINGS IN WORLDWIDE AREAS, AND LAUNCH ABORT LANDINGS IN WATER AROUND CAPE KENNEDY.

SUCCESSFUL COMMAND MODULE IMPACT AND FLOTATION IS DEFINED AS ONE IN WHICH THE CREW IS NOT SUBJECTED TO ACCELERATIONS EXCEEDING THEIR EMERGENCY LIMITS UPON IMPACT, AND IN WHICH THE COMMAND MODULE IS HABITABLE FOR 48 HOURS AND RETRIEVABLE FOR 7 DAYS AFTER IMPACT.

THE IMPACT SUBSYSTEM ATTENUATES THE COMMAND MODULE FINAL DESCENT VELOCITY AT IMPACT AND THERE BY DECREASES CREW DECELERATION TO A LEVEL AT OR BELOW ACCEPTABLE HUMAN TOLERANCE. THE STRUCTURE MUST BE DESIGNED TO MAINTAIN STRUCTURAL INTEGRITY DURING THIS IMPACT SEQUENCE AND PREVENT WATER LEAKAGE INTO THE CREW COMPARTMENT WHICH COULD IMPAIR POST LANDING FUNCTIONS (UPRIGHTING, RECOVERY COMMUNICATIONS, POST LANDING VENTILATION ETC.).

THE THREE MAJOR METHODS IN WHICH THIS ENERGY WILL BE ABSORBED ARE DISPLACEMENT OF A VOLUME OF WATER DURING IMPACT, DEFORMATION OF THE CRAFT AND CRUSHABLE ALUMINUM RIBS IN THE AFT COMPARTMENT, AND BY ENERGY ABSORBING SHOCK STRUTS THAT ARE THE STRUCTURAL INTERFACE BETWEEN THE CREW COUCHES AND THE COMMAND MODULE.

THE COMMAND MODULE IMPACT SYSTEM IS DIVIDED INTO TWO SUBSYSTEMS: AN EXTERNAL ATTENUATION SYSTEM AND AN INTERNAL ATTENUATION SYSTEM. THE COMMAND MODULE EXTERNAL ATTENUATION SYSTEM CONSISTS OF CRUSHABLE RIBS AND A 27.5 DEGREE NEGATIVE PITCH ANGLE. THE EXTERNAL ATTENUATION SYSTEM IS STRUCTURALLY DESIGNED TO ABSORB, WITH ALLOWABLE DEFLECTIONS, THE VEHICLE IMPACT ENERGY. WITHIN THE COMMAND MODULE IS AN INTERNAL SYSTEM CONSISTING OF EIGHT ATTENUATOR STRUTS SUPPORTING THE CREW COUCH SYSTEM DURING FLIGHT AND ATTENUATING, IF NECESSARY, DURING IMPACT. (SEE FIGURE 3-23)

3.7.2 EXTERNAL ATTENUATION (SEE FIGURE 3-24)

DURING DESCENT, THE COMMAND MODULE WILL BE INCLINED AT A NEGATIVE PITCH ATTITUDE AS A RESULT OF THE POSITIONING OF PARACHUTE RISER FITTINGS IN RELATION TO THE CENTER OF GRAVITY OF THE COMMAND MODULE. AT THIS ATTITUDE, THE IMPACT WILL BE NEAR OPTIMUM WHEN THE COMMAND MODULE IMPACTS ONTO THE +Z AREA AND PIERCES THE WATER. VEHICLE PENETRATION INTO THE WATER WILL BE HIGH, LEADING TO A TOTAL ENERGY DISSIPATION OVER A LONGER PERIOD OF TIME. THE COMMAND MODULE SIDE WALL AND AFT HEAT SHIELD ARE SUBJECTED TO HIGH PRESSURES, HOWEVER, WHEN PARACHUTE OSCILLATION, WAVE CONDITIONS, AND VEHICLE IMPACT CONDITIONS ARE OTHER THAN OPTIMUM.

BOOST COVER CREW HATCH

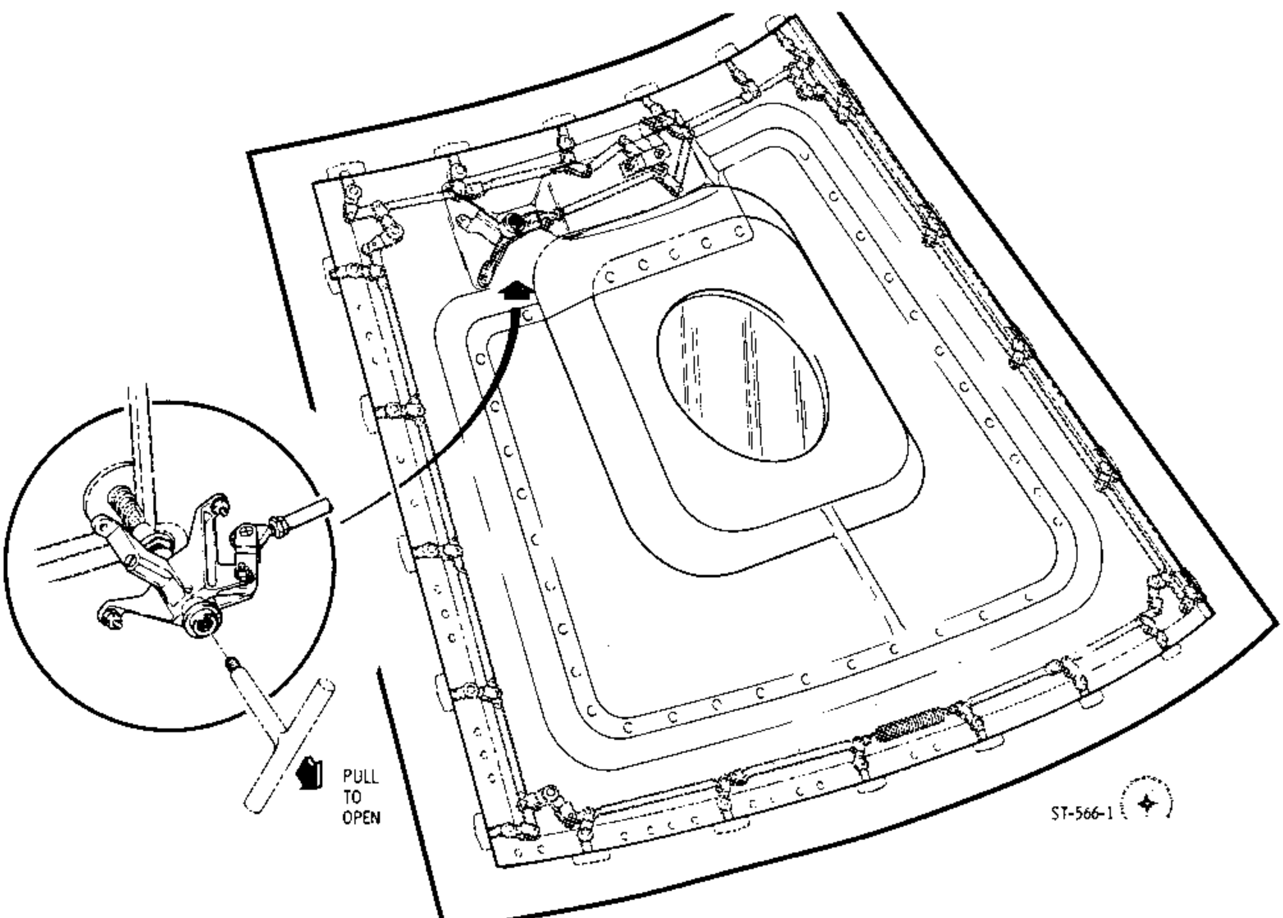


FIGURE 3-22

EXTERNAL ATTENUATION SYSTEM

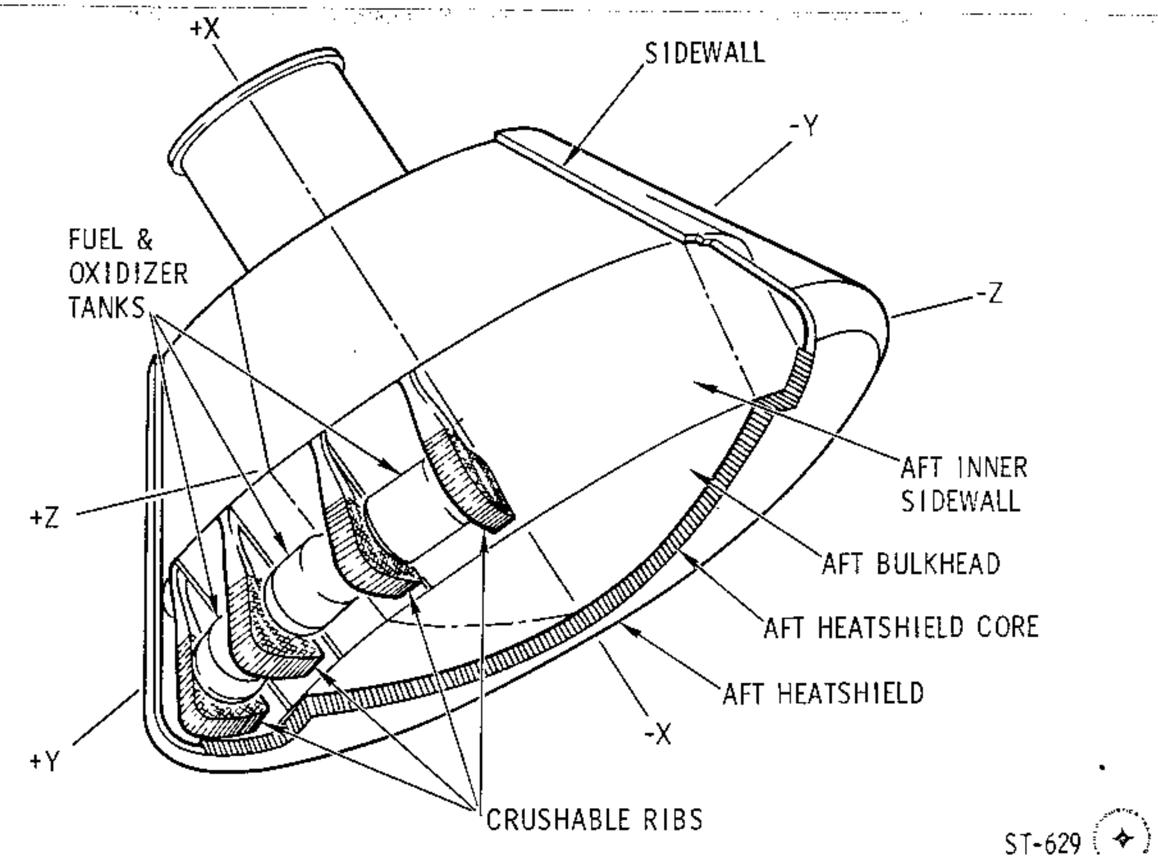


FIGURE 3-24

IMPACT ANGLE (TYPICAL)

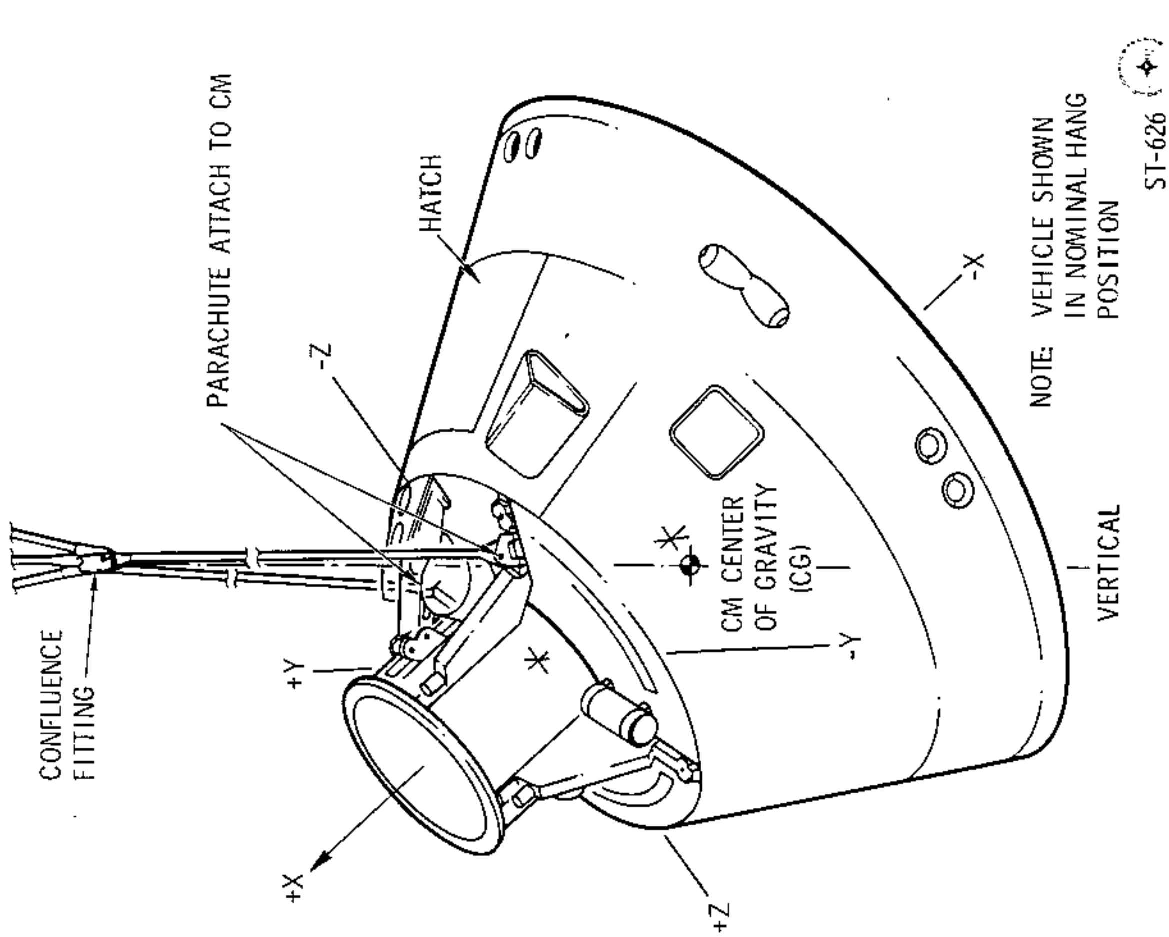
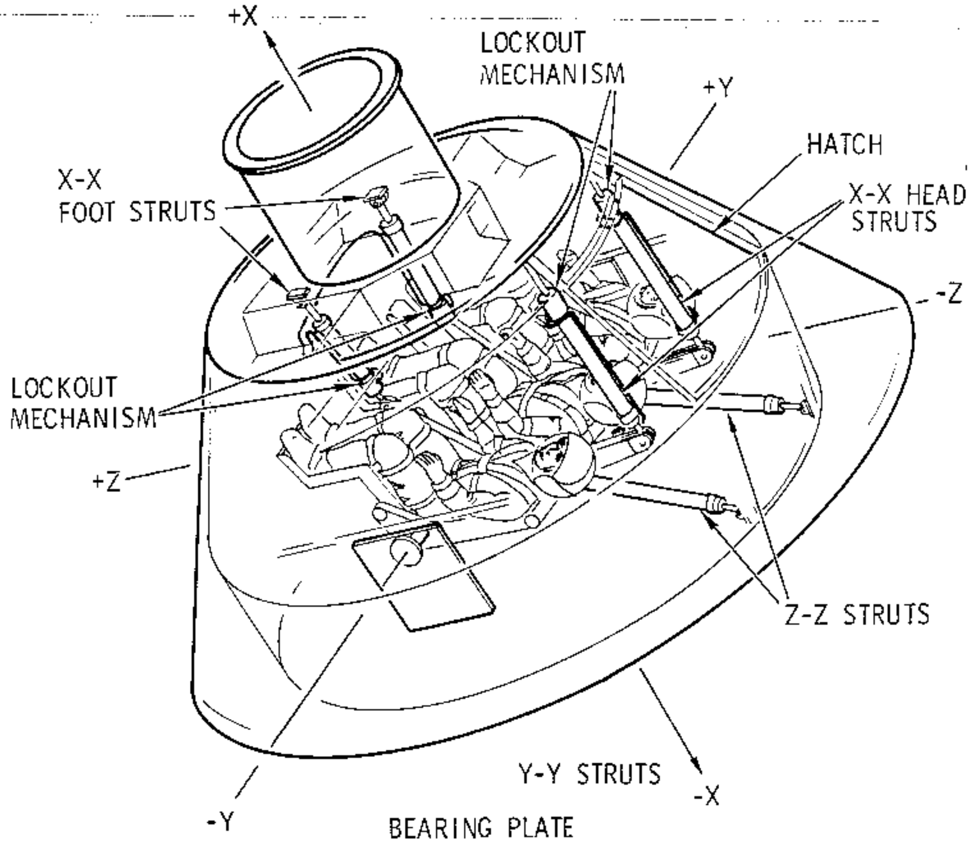


FIGURE 3-23

INTERNAL ATTENUATION SYSTEM



ST-625A

FIGURE 3-25

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For impact, the four ribs installed in the aft compartment at the nominal impact area provide attenuation at known rates. Construction is of bonded laminations of corrugated aluminum which provides attenuation when crushed. These four ribs are located in the vicinity of the +Z axis between the inner structure aft side wall and the torrodial section of the aft heat shield. The four ribs are located approximately 30 degrees apart to allow for parachute oscillation, roll, and local wave slope. These ribs remain inert during the mission.

Also to be considered for water impact, are the vehicle impact conditions including the number of parachutes deployed during vehicle descent, vehicle weight, and wind velocity. Wind velocity results in C/M horizontal velocity, which can effect a more or less severe impact, depending on wave and water motion.

3.7.3 Internal Attenuation

Eight attenuating struts are provided that connect the crew support system to the C/M structure (Figure 3-10). Each strut is capable of absorbing energy at a predetermined rate. The system is shown in Figure 3-25. The struts contain crushable, energy absorbing, aluminum honeycomb cores within the cylinders which are crushed by piston action. During impact, energy is passed through the structure and, dependent on the impact conditions and resultant external attenuation, strokes various struts at known rates. In effect, this action absorbes that part of the energy the crew is not capable of absorbing. Refer to Table 3-1 for Criteria Requirements for attenuating struts.

The requirement of the subsystem is to provide the crew members with a safe impact. Therefore, core strength (hence, the resistant reaction to force) is set so that the deceleration levels and the maximum deceleration are at or below acceptable human tolerance. Each set of struts is unique in design and is described in the paragraphs that follow. The strut names (X-X or Z-Z) refers to the basic direction of motion the strut is capable of attenuating.

3

3.7.3.1 Y-Y Struts

Two Y-Y struts are provided at the outer extremities of the couch at the hip beam. The cylinder end is firmly attached to the couch. The piston end of the strut, consisting of a flat circular foot with a bonded teflon friction surface, is not attached to the structures but reacts against a flat bearing plate attached to the structure. The Y-Y strut acts only in compression.

3.7.3.2 Z-Z Struts (See Figure 3-26)

Two Z-Z struts, located approximately 2 feet apart, are attached to structure just below the hatch at the intersection of the aft side wall and aft bulkhead and are also attached to the couch on the main

TABLE 3-1 CRITERIA REQUIREMENTS FOR ATTENUATING STRUTS

STRUT LOAD VERSUS STROKE

STRUT	TENSION	COMPRESSION
Y-Y	NOTE: NO STROKE IN TENSION	9000 POUNDS 4.5" STROKE TOTAL: 4.5" STROKE
Z-Z	NOMINAL 5249 POUNDS - 18.5" STROKE 2500 POUNDS FRICTION BRAKING TOTAL: 18.5" STROKE	NOMINAL 4680 POUNDS FRICTION AND CRUSHABLE CORE - 5" STROKE
X-X HEAD	NOMINAL 4225 POUNDS - 16.5" STROKE 1470 POUNDS FRICTION BRAKING TOTAL: 16.5" STROKE	1470 POUNDS FRICTION BRAKE NOMINAL 4225 POUNDS - 1" STROKE
X-X FEET	NOMINAL 5130 POUNDS - 16" STROKE 1540 POUNDS FRICTION BRAKING TOTAL: 16" STROKE	1540 POUND FRICTION BRAKE NOMINAL 5130 POUNDS - 1" STROKE

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Z -Z STRUT

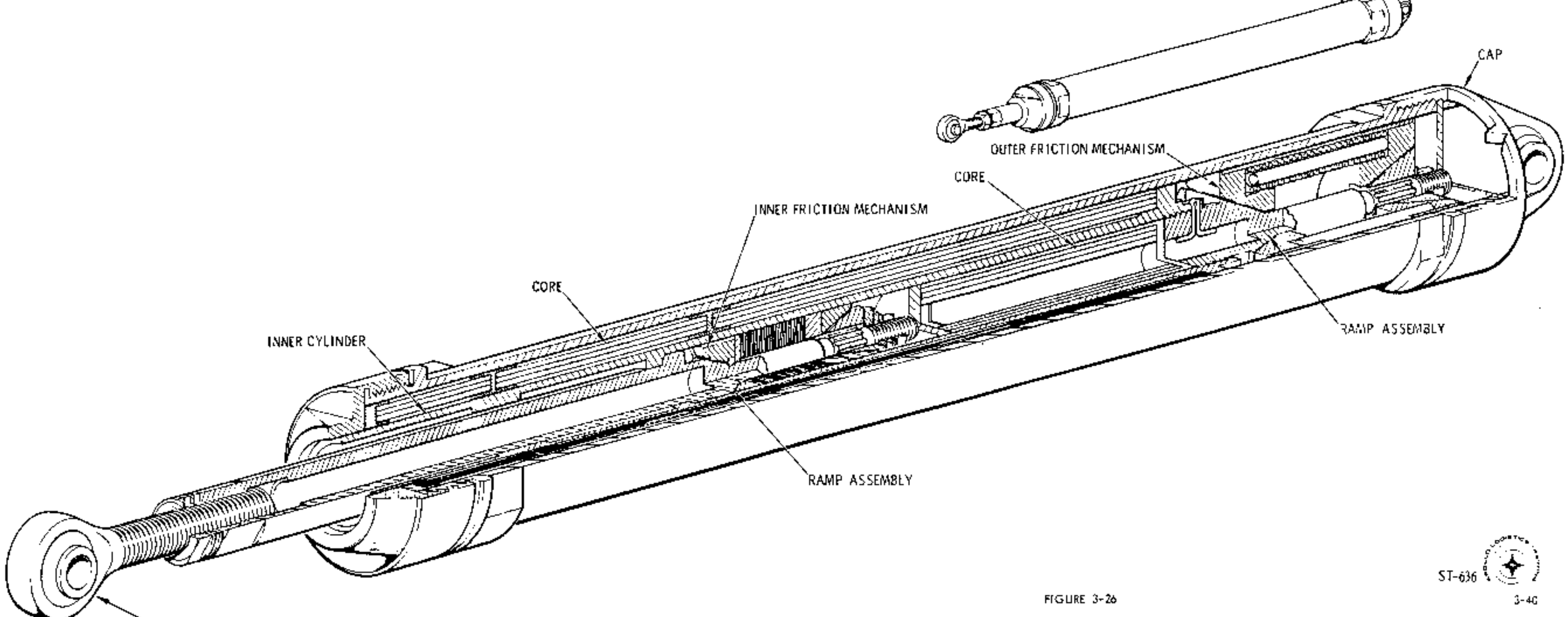

FIGURE 3-26

ST-636

BEAMS BELOW THE CREW'S BACKS. IN ADDITION TO A CRUSHABLE CORE, A FRICTION BRAKE SNUBBER IS INSTALLED ON THE END OF THE COMPLEX PISTON THAT ACTS IN CONJUNCTION WITH THE CORE CRUSHING ACTION WHEN IN TENSION OR DURING THE FIRST REACTION. ON THE COMPRESSION STROKE, THE FRICTION BRAKE SNUBBER ACTS IN CONJUNCTION WITH THE INNER PISTON WHICH IS SIMULTANEOUSLY CRUSHING THE INNER CORE. THE SECOND TENSION LOAD IS A COMBINATION OF THE OUTER AND INNER FRICTION BRAKES COMBINED WITH FURTHER CORE CRUSHING.

3.7.3.3 X-X STRUTS (SEE FIGURE 3-27)

FOUR X-X STRUTS ARE ATTACHED TO THE FORWARD COMMAND MODULE STRUCTURE, AND TO THE BEAM EXTREMITIES OF THE COUCH. THESE STRUTS ARE BASICALLY THE SAME AS THE Z-Z AXIS STRUTS EXCEPT THE ADDITION OF A LOCKOUT MECHANISM. THE LOCKOUT MECHANISM IS PROVIDED ON EACH STRUT TO LOCK OUT ANY STRUT ATTENUATION PRIOR TO IMPACT DUE TO NORMAL MISSION FLIGHT LOADS. PRIOR TO IMPACT, THE MECHANISM IS RELEASED ELECTRICALLY, MANUALLY, OR BY A BUILT IN MECHANICAL OVERRIDE. THE MECHANICAL OVERRIDE IS INSTALLED FOR BACK UP IN THE EVENT THE MECHANISM IS NOT RELEASED ELECTRICALLY OR MANUALLY BY THE CREW.

THE LOCKOUT MECHANISM AND CIRCUITRY CONSISTS OF A SOLENOID, A TWO POSITION SWITCH MOUNTED ON THE INSTRUMENT PANEL, RELAYS, WIRING, AND LOCKOUT MECHANICAL COMPONENTS WITH BUILT IN CREW INDICATION AS TO LOCK OR UNLOCK MODE. THE MANUAL MODE IS PERFORMED BY PHYSICALLY PULLING A PIN AT EACH STRUT SOLENOID WITH THE SAME VISIBLE INDICATION TO THE CREW AS THE ELECTOMECHANICAL MODE OF OPERATION. THE PINS LOCATED ON THE X-X HEAD STRUTS ARE WITHIN REACH OF A CREW RESTRAINT SYSTEM MUST BE LOOSENED TO PULL THE PINS OF THE FOOT STRUTS. THE MECHANICAL OVERRIDE PROVIDES AUTOMATIC BREAKOUT UPON IMPACT SHOULD THE CREW BE UNABLE TO PERFORM THIS FUNCTION DUE TO (1) MECHANICAL FAILURE OF THE NORMAL METHOD (2) THE TIME ELEMENT SHOULD THERE BE AN ABORT, OR (3) THE CREW BEING INCAPACITATED (SEE FIGURE 3-28).

IT SHOULD BE NOTED THAT THE LOCKOUT MECHANISM WILL NOT BE INSTALLED ON UNMANNED MISSIONS SINCE THE EQUIPMENT MOUNTED ON UNMANNED MISSION LOAD PLATFORMS CAN WITHSTAND HIGHER DECELERATION LEVELS THAN THE CREWMAN ON THE COUCHES. THIS ALLOWS HIGHER STRENGTH CORES TO BE INSTALLED WITHIN THE STRUTS AND DELETES THE REQUIREMENT FOR THE LOCKOUT MECHANISM WHICH IN THESE UNMANNED FLIGHTS, WOULD REQUIRE CIRCUITRY FOR ELECTRICALLY SEQUENCED OPERATION.

3.8 UPRIGHTING SYSTEM

3.8.1 <u>GENERAL DESCRIPTION</u>

THE PURPOSE OF THE UPRIGHTING SYSTEM IS TO ACHIEVE AN APEX UP FLOTATION ATTITUDE OF THE C/M AFTER WATER IMPACT. THE INFLATABLE BAGS WILL BE DEPLOYED AFTER TOUCHDOWN AT SEA, ONLY IF THE C/M IS IN A STABLE II APEX DOWN ATTITUDE (FIGURE 3-29). THE INFLATION OF THE BAGS WILL POSITION THE C/M IN AN UPRIGHT POSITION (STABLE I) FOR CREW SURVIVAL AND ESCAPE, AND ASSIST IN RECOVERY BY KEEPING THE HF RECOVERY ANTENNA OUT OF THE

X - X STRUT

TYPICAL

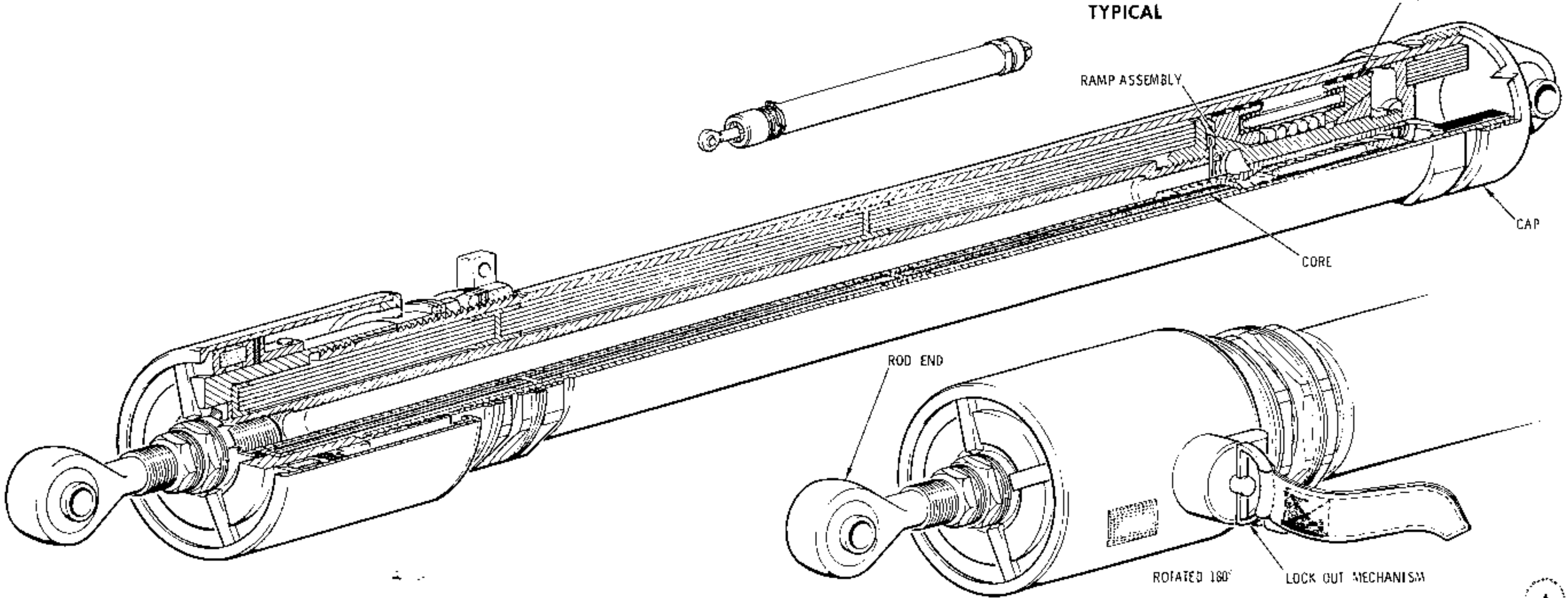

FIGURE 3-27

LOCKOUT MECHANISM

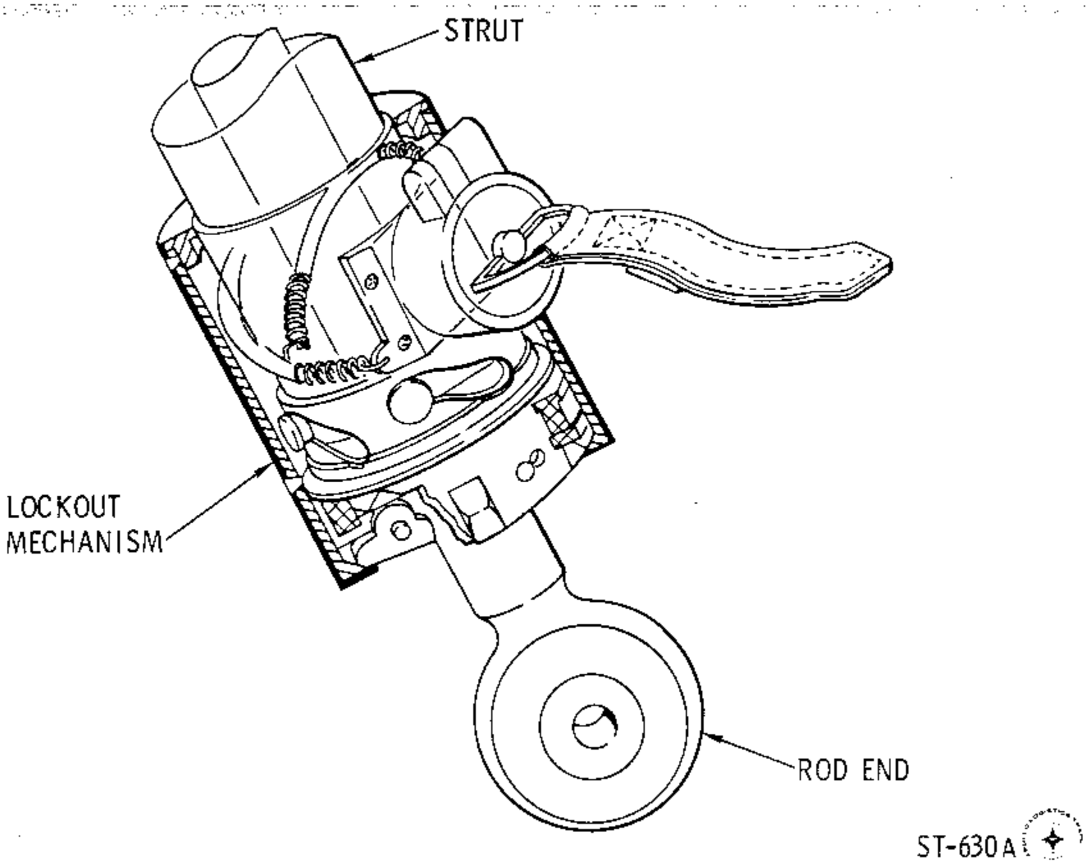

FIGURE 3-28

UPRIGHTING SYSTEM

3 BAG SYSTEM

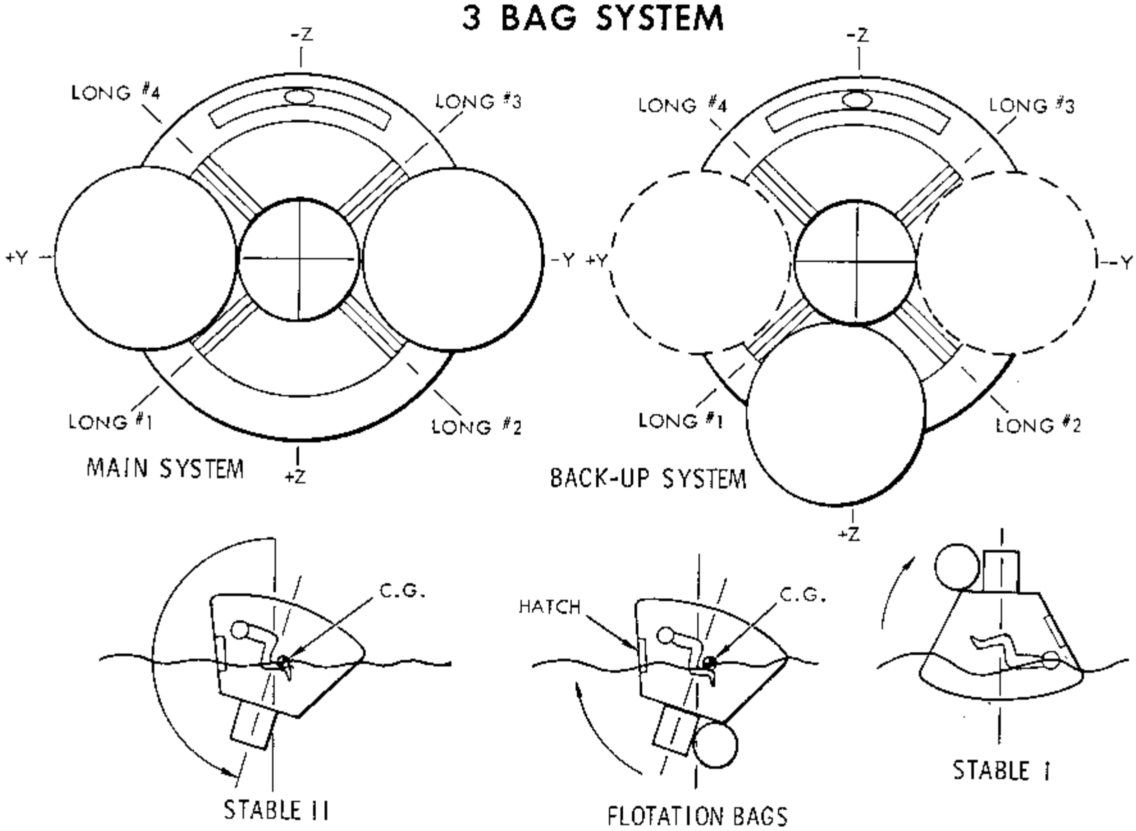

FIGURE 3-29

ST-650B

WATER. THE SUBSYSTEM CONSISTS OF THREE INFLATABLE BAGS, MOTOR DRIVEN AIR PUMPS, SOLENOID VALVES, RELIEF AND CHECK VALVES, TOGGLE SWITCHES, CIRCUIT BREAKERS AND PERTINENT HARDWARE. IN THE MANNED SPACECRAFT, THE UPRIGHTING SYSTEM WILL BE MANUALLY CONTROLLED BY SWITCHES LOCATED ON THE CONTROL AND DISPLAY PANEL. DEVIATIONS ARE REQUIRED FOR UNMANNED MISSIONS AND WILL BE DEFINED FOR S/C 011 FIGURE 3-30.

THE MISSION CONTROL PROGRAMMER (MCP) IS ADDED TO S/C 011 TO PROVIDE FUNCTIONS NORMALLY PERFORMED BY THE ASTRONAUTS. AFTER WATER IMPACT, THE ATTITUDE SWITCH LOCATED IN THE MCP WILL SENSE WHETHER THE C/M IS IN A STABLE I OR STABLE II ATTITUDE. IF IN A STABLE I POSITION NO FUNCTIONS ARE REQUIRED OF THE UPRIGHTING SYSTEM. IF IN A STABLE II ATTITUDE, THE MCP WILL INITIATE SIGNALS AND CONTROL THE INFLATION OF THE AIR BAGS IN THE PROPER SEQUENCE.

FOR S/C 011 AND SUBSEQUENT UNMANNED FLIGHTS, SIMILAR AUTOMATED FUNCTIONS ARE REQUIRED AS THOSE DESCRIBED ABOVE. THEY WILL BE INCORPORATED INTO THE MISSION CONTROL PROGRAMMER (MCP).

3.8.2 <u>COMPONENT FUNCTION AND DESCRIPTION</u>

3.8.2.1 COMPRESSOR - MOTOR DRIVEN

THE FUNCTION OF THE COMPRESSOR IS TO PRESSURIZE THE BAGS THROUGH A SERIES OF RELIEF, SOLENOID, AND CHECK VALVES. TWO COMPRESSORS WILL BE LOCATED IN THE AFT COMPARTMENT BETWEEN FRAMES 2 AND 3 AND 10 AND 11 (FIGURE 3-31). THE AIR LINES CONNECTING THE COMPRESSORS AND BAGS ARE ROUTED BETWEEN THE INNER AND OUTER STRUCTURE ALONGSIDE THE FUEL AND OXIDIZER LINES. THE DUAL PUMP SYSTEM ALSO INCORPORATES CHECK VALVES, PREVENTING BACKFLOW SHOULD EITHER PUMP FAIL TO OPERATE. ATTACHED TO THE INTAKE TUBE IS A FILTER ASSEMBLY TO REDUCE INGESTION OF FOREIGN MATTER. THE COMPRESSOR IS COMPRISED OF A 20 AMPERE, 28 VDC MOTOR AND A POSITIVE DISPLACEMENT SINGLE STAGE PUMP. THE PUMP IS CAPABLE OF PROVIDING 4 TO 5.5 CUBIC FEET PER MINUTE (CFM) OF AIR AT DISCHARGE PRESSURE OF 18 PSIG MAXIMUM. THE VARYING OUTPUT IS DUE TO VOLTAGE DECAY.

3.8.2.2 PRESSURE RELIEF VALVES

THE FUNCTION OF THE FIVE PRESSURE RELIEF VALVES IS TO PROTECT THE UPRIGHTING SYSTEM AGAINST OVER-PRESSURIZATION. THE RELIEF VALVES ARE ACTUATED WHEN THE INTERNAL AIR PRESSURE IN THE SYSTEM IS ABOVE THE RELIEF VALVE CRACKING PRESSURE. THREE RELIEF VALVES (ONE PER BAG) ARE LOCATED IN THE FORWARD COMPARTMENT, FIGURE 3-30). THEY WILL RELIEVE AT 4.5 PSIG MAXIMUM AND RESEAT AT 3.0 PSIG MINIMUM. TWO RELIEF VALVES ARE LOCATED IN THE AFT COMPARTMENT, FIGURE 3-31, ADJACENT TO THE SYSTEM COMPRESSORS AND WILL RELIEVE AT 13.0 PSIG MAXIMUM AND RESEAT AT 11.0 PSIG MINIMUM. THE ASSEMBLY CONSISTS OF A METAL CASE, SEAL, SPRING, SOFT DISC TYPE SEAT, AND ADJUSTING SCREW-PLUG COMBINATION.

UPRIGHTING SYSTEM
AFRM 11 & SUB

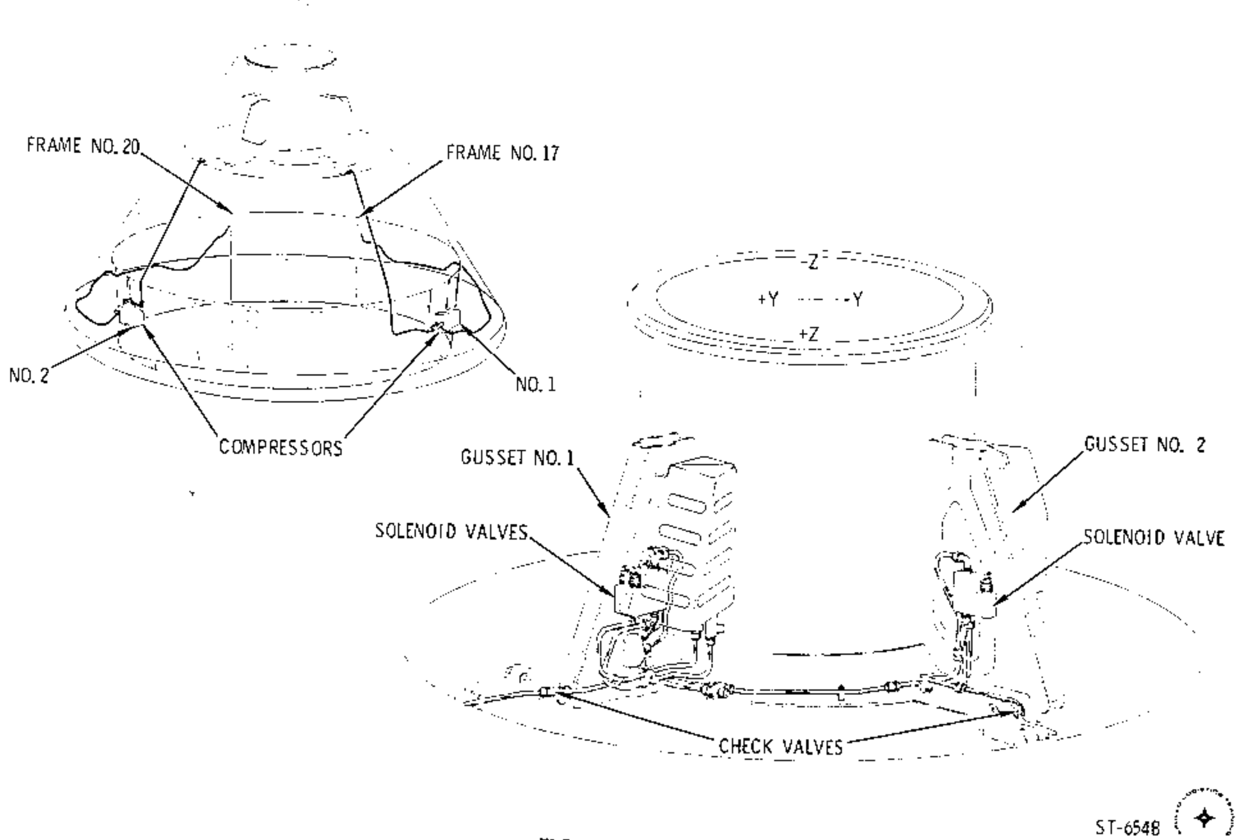

FIGURE 3-30

UPRIGHTING SYSTEM COMPRESSOR AND INLET TYPICAL

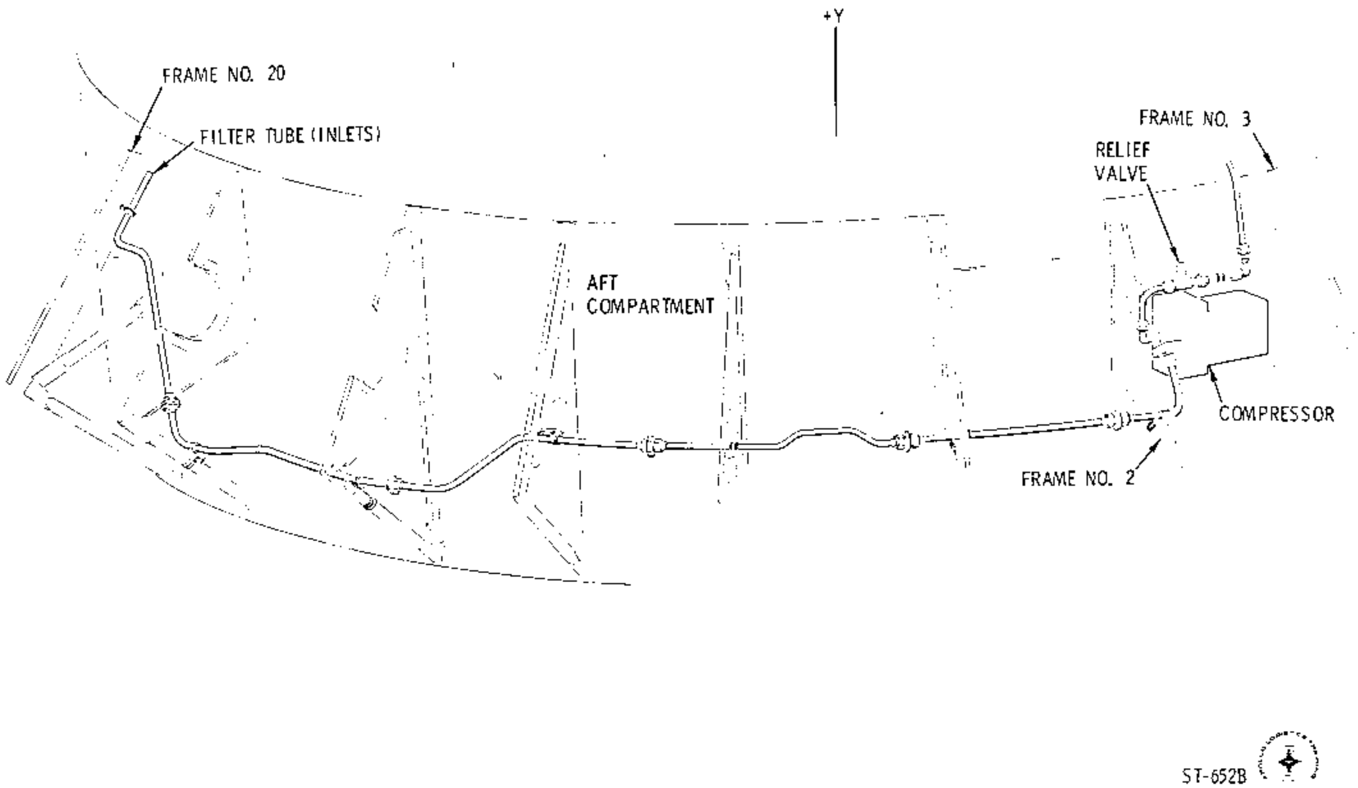

FIGURE 3-31

3.8.2.3 Solenoid Valve - Latching

THE FUNCTION OF THE THREE SOLENOID VALVES IS TO ALLOW THE AIR PRESSURE TO FLOW FROM THE COMPRESSOR TO THE THREE UPRIGHTING SYSTEM BAGS, FIGURE 3-30. THE SOLENOID VALVES ARE ACTUATED BY 28 VDC, AUTOMATICALLY CONTROLLED ON UNMANNED FLIGHTS AND MANUALLY OPERATED ON MANNED FLIGHTS. THE VALVES ARE NORMALLY CLOSED, DIRECT ACTING, IN WHICH THE OPENING AND CLOSING OF PARTS ARE CONTROLLED ONLY BY THE SOLENOID ACTION IN THE VALVE. THE THREE PORTS ON THE VALVE ARE MARKED INLET, OUTLET, AND VENT. THE THREE MODE POSITIONS ON THE SELECTOR SWITCH ARE THE FILL MODE, WHICH FILLS THE BAGS WITH AIR PRESSURE, THE SEAL MODE OR CENTER POSITION, WHICH HOLDS THE PRESSURE IN THE BAGS, AND THE VENT MODE, WHICH RELEASES THE PRESSURE FROM THE SYSTEM.

3.8.2.4 Cannister Assemblies

THE FUNCTION OF THE CANNISTERS, LOCATED IN THE FORWARD COMPARTMENT, IS TO HOLD AND STORE THE THREE BAG ASSEMBLIES UNTIL DEPLOYMENT FIGURE 3-32). THE DOUBLE CANNISTER IS ATTACHED TO GUSSET No. 1 AND WILL HOLD AND STORE TWO BAG ASSEMBLIES, WHILE THE SINGLE CANNISTER ATTACHED TO GUSSET No. 2 WILL HOLD AND STORE A SINGLE BAG ASSEMBLY. THE CANNISTER IS INSTALLED ON THE STRUCTURAL GUSSET REMOVABLE PANEL PRIOR TO THE MAIN PARACHUTE INSTALLATION. THREE SIDES OF THE CANNISTER ACT AS A COVER. THIS COVER WILL INCORPORATE A LATCH ASSEMBLY THAT IS AUTOMATICALLY RELEASED BY AIR PRESSURE. LOCATED ON THE BASE OF THE CANNISTER IS A TEE FITTING THAT CONNECTS THE BAG PRESSURIZING TUBE AND THE LATCH ASSEMBLY BLADDER TO THE PRESSURE SYSTEM'S HARD LINE. THE CANNISTER ASSEMBLY CONSISTS OF A REINFORCED ALUMINUM CASE AND LATCH ASSEMBLY, SUPPORTS, AND RELATED HARDWARE.

3.8.2.5 Flotation Bag

THE FUNCTION OF THE THREE UPRIGHTING BAG ASSEMBLIES IS TO ROTATE THE C/M INTO AN UPRIGHT POSITION IF IT TERMINATES IN A STABEL II ATTITUDE AFTER WATER IMPACT. THE TIME REQUIRED TO INFLATE EACH BAG TO A PRESSURE OF 3.5 PSIG IS APPROXIMATELY 4 TO 5 MINUTES USING 2 PUMPS AND APPROXIMATELY 6 TO 7 MINUTES USING 1 PUMP. THE BURST PRESSURE OF THE BAGS IS 12 PSIG. THE MAXIMUM LEAKAGE OF EACH BAG AT 3.5 PSIG MINIMUM (OPERATING PRESSURE) IS 0.10 STANDARD CUBIC FOOT PER HOUR. THE BAGS ARE FABRICATED OF DACRON, COATED ON THE INSIDE AND OUTSIDE WITH POLYURETHANE. EACH BAG ASSEMBLY CONSISTS OF A BAG AND GROMMETS, CABLES, ATTACH FITTINGS, AND AN INFLATION TUBE (FIGURE 3-33).

UPRIGHTING SUBSYSTEM

CANISTER & BLADDER ASSY

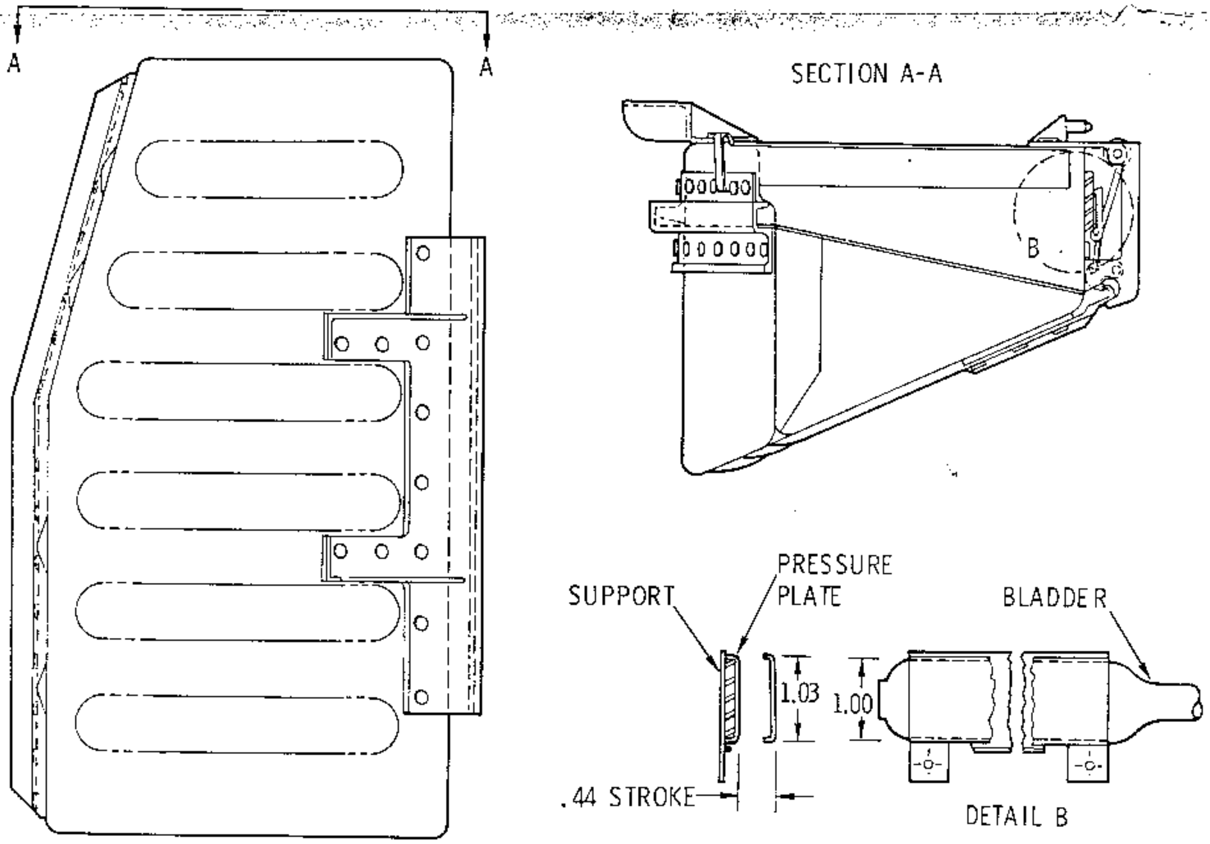

FIGURE 3-32

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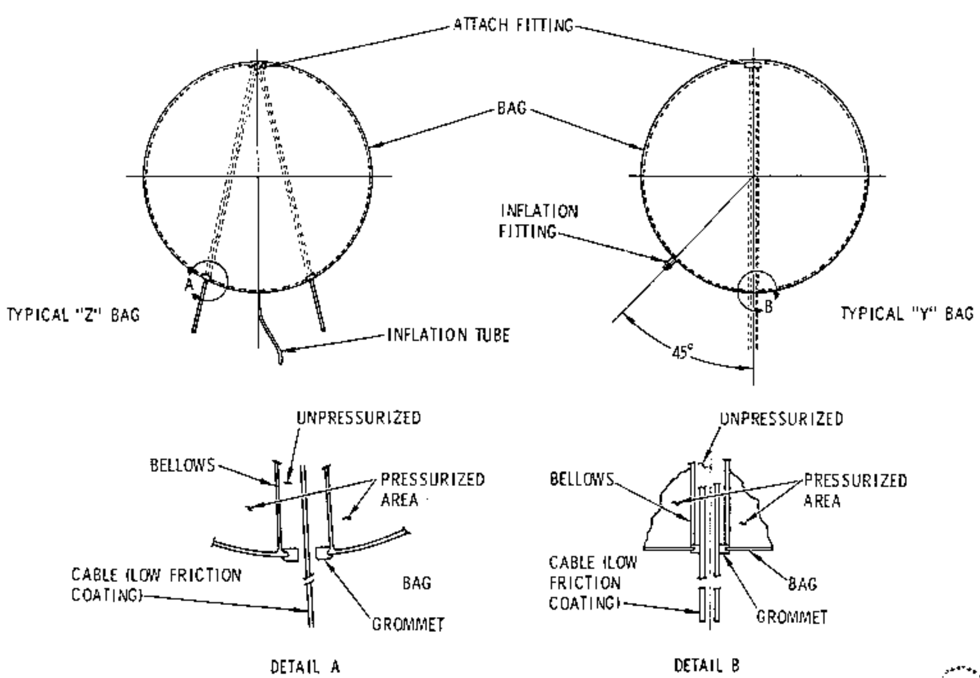
UPRIGHTING SUBSYSTEM

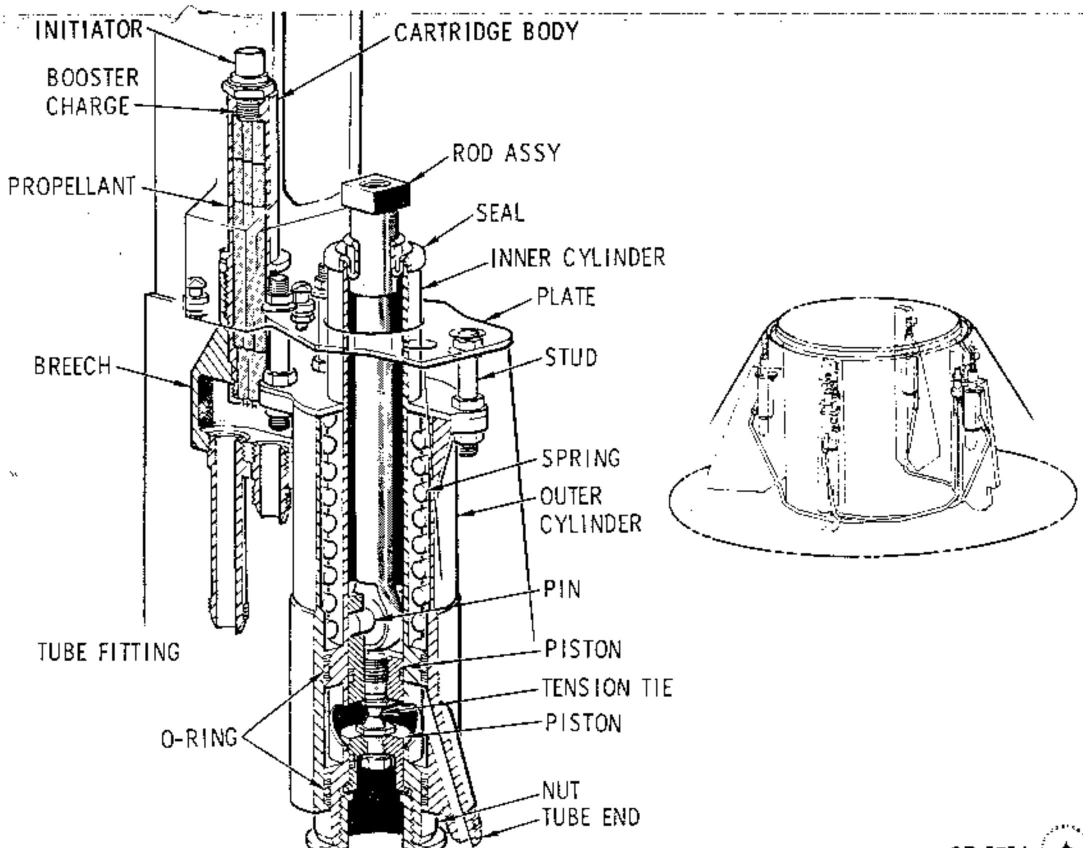
BAG ASSEMBLY



ST-656

FIGURE 3-33

FORWARD HEAT SHIELD SEPARATION SYSTEM



ST-575A

FIGURE 4-1

4-2

SECTION IV

MECHANICAL SYSTEMS

4.1 FORWARD HEAT SHIELD SEPARATION SYSTEM

3.1.1 <u>GENERAL DESCRIPTION</u>

THE FORWARD COMPARTMENT HEAT SHIELD IS ATTACHED TO THE COMMAND MODULE BY FOUR SPRING-LOADED TENSION TIES. SEPARATION IS ACHIEVED BY BREAKING EACH TENSION TIE WITH A GAS-OPERATED THRUSTER UNIT. EACH DIAMETRICALLY OPPOSITE PAIR OF THRUSTERS IS SUPPLIED WITH GAS FROM A SINGLE PRESSURE CARTRIDGE INSTALLED IN A GAS GENERATOR UNIT. IF ONE CARTRIDGE FAILS TO IGNITE, THE TWO THRUSTERS OPERATED BY THE OTHER CARTRIDGE ARE CAPABLE OF BREAKING ALL FOUR TENSION TIES.

THE FORWARD HEAT SHIELD SEPARATION SYSTEM, AS SHOWN IN (FIGURE 4-1), INCLUDES FOUR CYLINDER ASSEMBLIES, AND ASSOCIATED EQUIPMENT LOCATED IN THE FORWARD COMPARTMENT. THE FORWARD HEAT SHIELD SEPARATION SYSTEM SHALL HAVE THE CAPABILITY OF JETTISONING THE APPROXIMATE 300 POUND FORWARD HEAT SHIELD AT A MINIMUM VELOCITY OF 18 FPS. BY JETTISONING THE FORWARD HEAT SHIELD IT WILL EXPOSE THE EARTH LANDING SYSTEM (ELS).

THE FOUR CYLINDER ASSEMBLIES ARE LOCATED IN THE FORWARD GUSSETS AND SERVE A DUAL PURPOSE. THE THRUSTERS PROVIDE A MEANS OF HOLDING THE FORWARD HEAT SHIELD TIGHTLY TO THE CREW COMPARTMENT HEAT SHIELD, AND A MEANS OF JETTISONING THE HEAT SHIELD AT A PRE-DETERMINED TIME.

4.1.2 <u>FUNCTION</u>

EACH THRUSTER (SEE FIGURE 4-2) CONTAINS A DUAL CYLINDER ASSEMBLY, TWO PISTON AND ROD ASSEMBLIES, AND A SPRING ASSEMBLY. THE OUTER CYLINDER IS ATTACHED BY BOLTS TO THE ACCESS CYLINDER LONGERONS AND GUSSETS. THE INNER CYLINDER IS A FREE FLOATING CYLINDER WITHIN THE OUTER CYLINDER. A TENSION OF 500 LBS IS APPLIED TO THE INNER CYLINDER BY A COIL SPRING FORCING AGAINST A FLANGE OF THE INNER CYLINDER. THIS TENSION WILL ASSURE A TIGHT SEAL BETWEEN THE FORWARD AND CREW COMPARTMENT HEAT SHIELDS AT STATION $X_C = 81$, DUE TO EXPANSION AND CONTRACTION OF THE INNER AND OUTER STRUCTURE UPON RE-ENTRY. A TIGHT SEAL AT THIS STATION WILL PREVENT HEAT PLASMA FROM ENTERING AND DAMAGING THE PARACHUTES. A CYLINDRICAL BALL AND BOLT ASSEMBLY WHICH IS FITTED INTO A BRACKET ON THE FORWARD HEAT SHIELD IS THREADED INTO THE INNER CYLINDER PISTON AND ROD ASSEMBLY. THIS BALL AND BOLT ASSEMBLY WHEN FITTED WITH A SPECIAL TOOL AND TURNED WILL APPLY THE TENSION ON THE SPRING ASSEMBLY. DURING A NORMAL TOWER JETTISON (APPROXIMATELY 260,000 FEET) OR DURING AN ABORT

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SITUATION THE TENSION TIES WILL BE BROKEN BY THE GAS PRESSURE ENTERING BETWEEN THE TWO PISTONS. THE TENSION TIE BETWEEN THE INNER PISTON, HAS A SHEAR STRENGTH OF APPROXIMATELY 3300 POUNDS. AFTER THE TIE IS BROKEN THE PRESSURE WILL FORCE THE PISTON AND ROD ASSEMBLY UP AND AWAY WITH THE FORWARD HEAT SHIELD. THE TWO BREECH ASSEMBLIES WILL EACH CONTAIN ONE HOTWIRE PRESSURE CARTRIDGE. A TYPICAL PRESSURE CARTRIDGE IS SHOWN IN FIGURE 4.3. EACH CARTRIDGE ASSEMBLY IS CAPABLE OF PRODUCING 14,000 ± 2000 PSI IN A 21.73 CU IN CHAMBER.

4.2 C/M - S/M SEPARATION SYSTEM

4.2.1 GENERAL DESCRIPTION (SEE FIGURE 4-4)

THE C/M - S/M SEPARATION SYSTEM WILL INCORPORATE ORDINANCE DEVICE'S AT SERVICE MODULE RADIAL BEAMS 2, 4 AND 6 AND C/M TO S/M UMBILICAL SEPARATION SYSTEM. SEPARATION IS ACCOMPLISHED BY SEVERING THE TENSION TIE STRAPS WITH LINEAR SHAPED CHARGES AND SEPARATION OF THE UMBILICAL BY REDUNDANT ORDINANCE GUILLOTINES.

4.2.2 C/M - S/M TENSION TIE ASSEMBLY

THE TENSION TIE ASSEMBLY CONSISTS OF TWO BOLT ASSEMBLIES, TENSION TIE STRAP, LINEAR SHAPED CHARGE SUPPORTS, PROTECTIVE SHIELD AND NECESSARY NUTS, BOLTS, AND WASHERS (FIGURE 4-5). THE FORWARD BOLT ASSEMBLY IS INSERTED THROUGH A HOLE IN THE ABLATIVE MATERIAL AND OUTER HEAT SHIELD AND ATTACHED TO THE AFT COMPARTMENT LONGERON BY A BARREL NUT. THE AFT BOLT ASSEMBLY IS ATTACHED TO THE RADIAL BEAM OF THE S/M. THE AFT BOLT ASSEMBLIES WILL CONTAIN A STRAIN GAGE TO MONITOR THE TORQUE APPLIED DURING STACKING OPERATIONS. THE TYPE STRAIN GAGE USED IS A CONSTANTINE FOIL, EPOXY BASE SINGLE ELEMENT. THE INTERFACE BETWEEN THE TWO BOLT ASSEMBLIES IS ACCOMPLISHED WITH THE TENSION TIE STRAP. THE TENSION TIE STRAP IS 3.4 INCHES WIDE, .132 OF AN INCH THICK, AND IS FABRICATED OF 4340 CRES. THE TENSION TIE ASSEMBLY IS PRELOADED TO 10,000 POUNDS ± 2000. INSTALLING THE LINEAR SHAPED CHARGES IS ACCOMPLISHED BY PLACING THE TWO LINEAR SHAPED CHARGE SUPPORTS ONE ON EACH SIDE OF THE TENSION TIE STRAPS (FIGURE 4-6). THE SHAPED CHARGE SUPPORTS ARE FABRICATED OF FIBERGLASS AND CONTAIN A LEAD AZIDE BOOSTER AND SINGLE LENGTH OF 100 GR/FT OF FLEXIBLE LINEAR SHAPED CHARGE (FLSC). BETWEEN THE FLSC AND THE SHAPED CHARGE HOLDER IS A SILASTIC PAD TO CONTAIN FLYING FRAGMENTS, AND HELP ABSORB THE SHOCK. THE SHIELD, OR CHARGE SUPPORT, IS THEN BOLTED SECURELY WITH A BRACKET ASSEMBLY TO THE TENSION TIE PLATE AND TORQUED. ON EITHER END OF THE BRACKET ASSEMBLY IS LOCATED A APOLLO STANDARD DETONATOR (ASD) FIGURE 2-13).

4.2.3 C/M - S/M UMBILICAL SEPARATION SYSTEM

THE UMBILICAL SEPARATION SYSTEM IS ILLUSTRATED IN FIGURE 4-7. THE SYSTEM CONSISTS OF TWO OPPOSING GUILLOTINE BLADES PER UMBILICAL SECTION. THE GENERAL ARRANGEMENT OF THE SEPARATING DEVICES IS ILLUSTRATED IN FIGURE 4-8. THE MECHANICAL CUTTING ACTION

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FORWARD HEAT SHIELD
THRUSTER ASSEMBLY

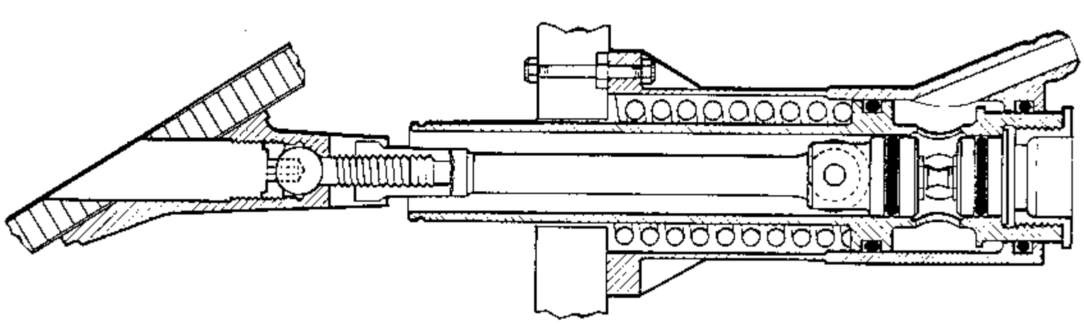

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FIGURE 4-2

C/M - S/M SEPARATION SYSTEM

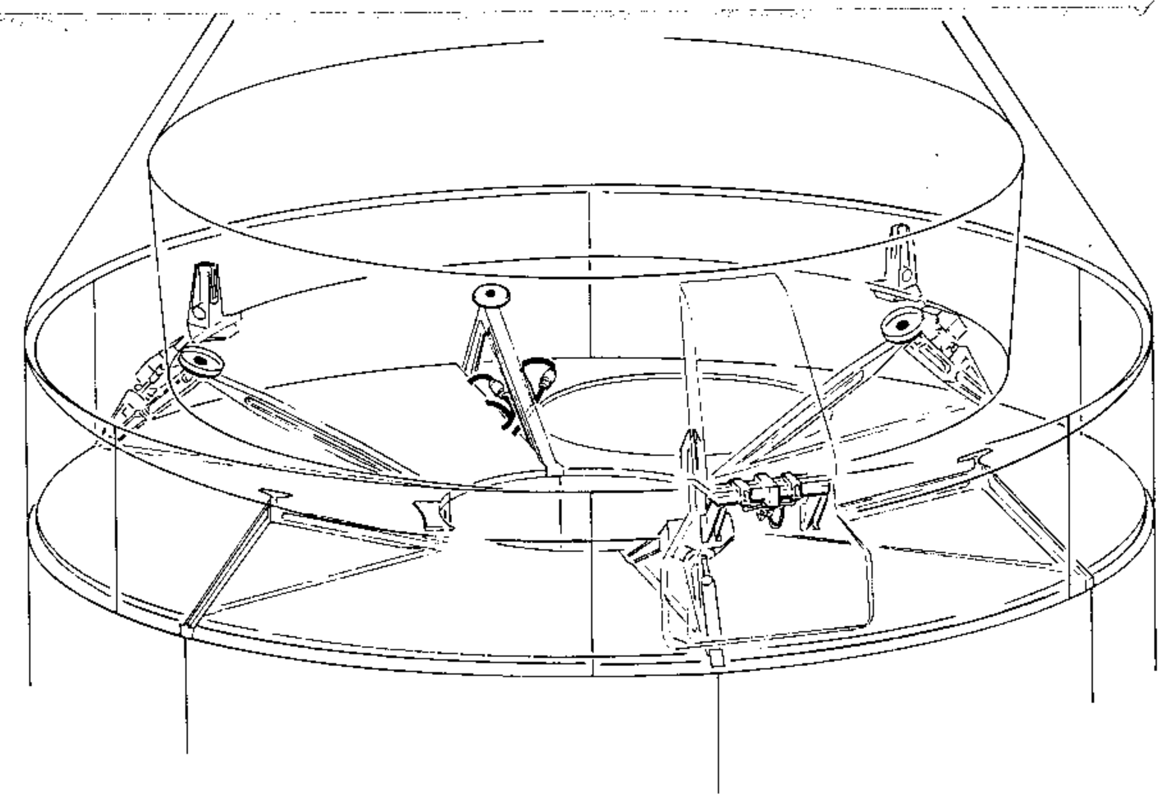

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FIGURE 4-4

HOTWIRE PRESSURE CARTRIDGE ASSEMBLY ELECTRICALLY INITIATED

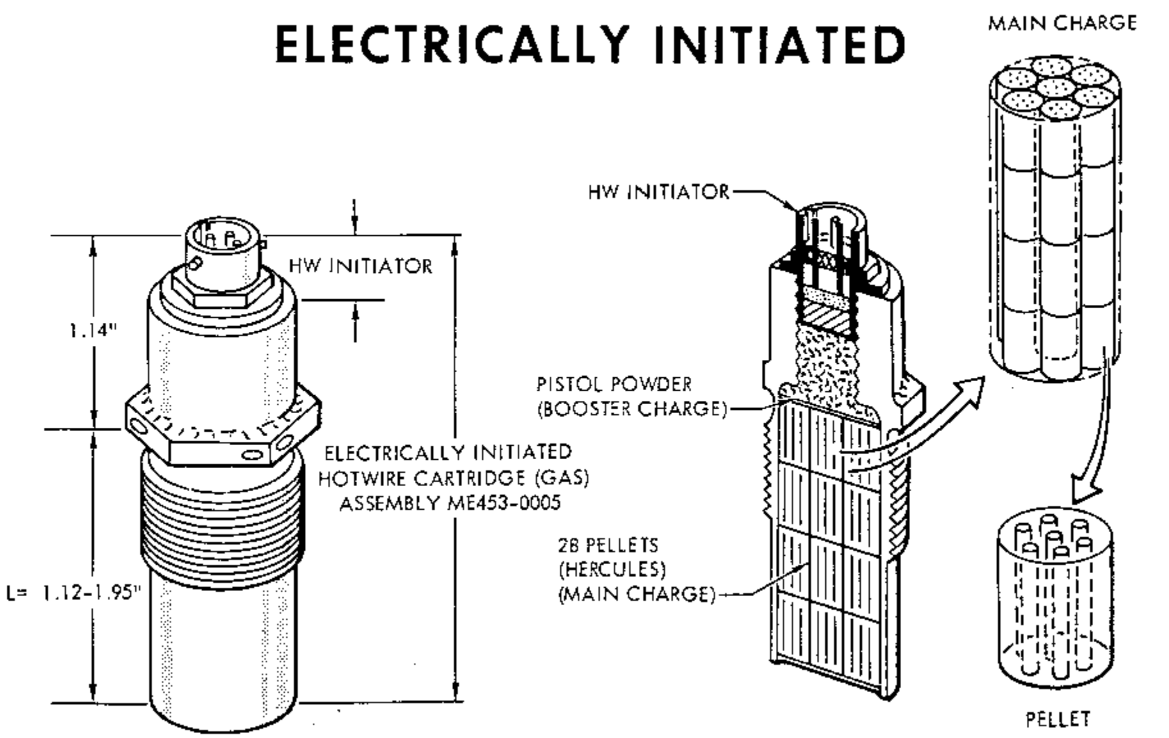

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FIGURE 4-3

ORDNANCE INSTALLATION

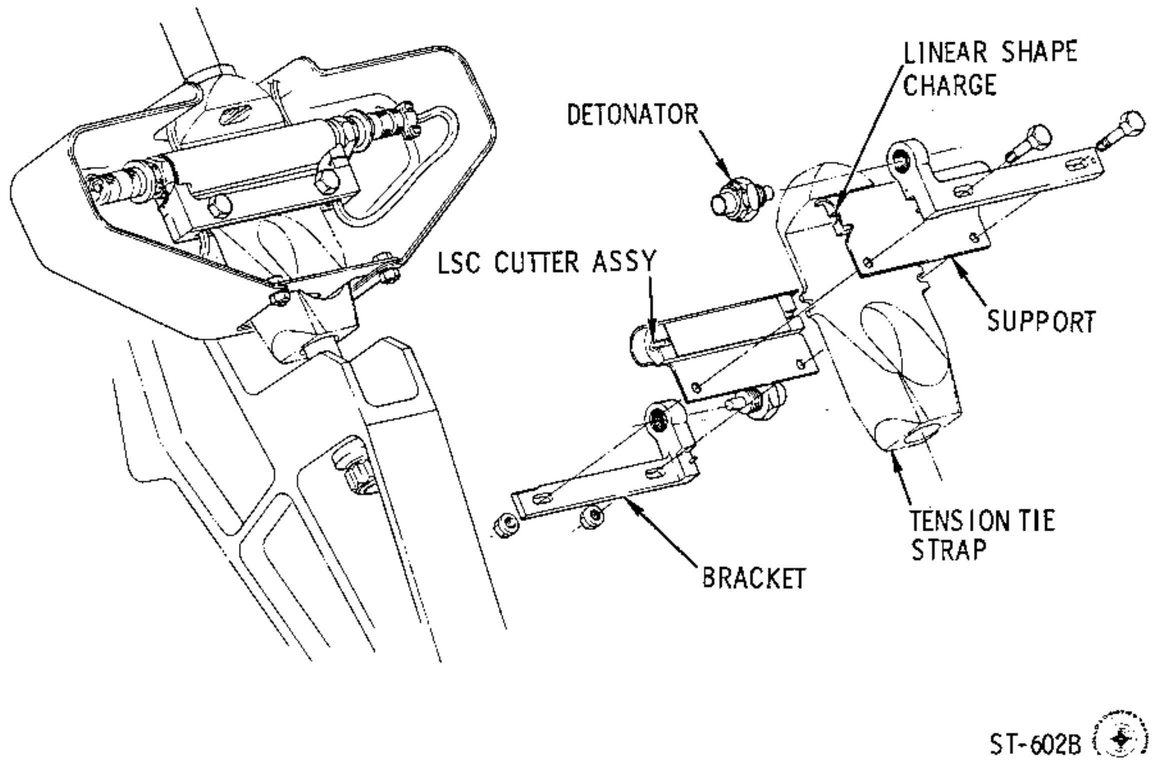


FIGURE 4-6

AFT TENSION-TIE

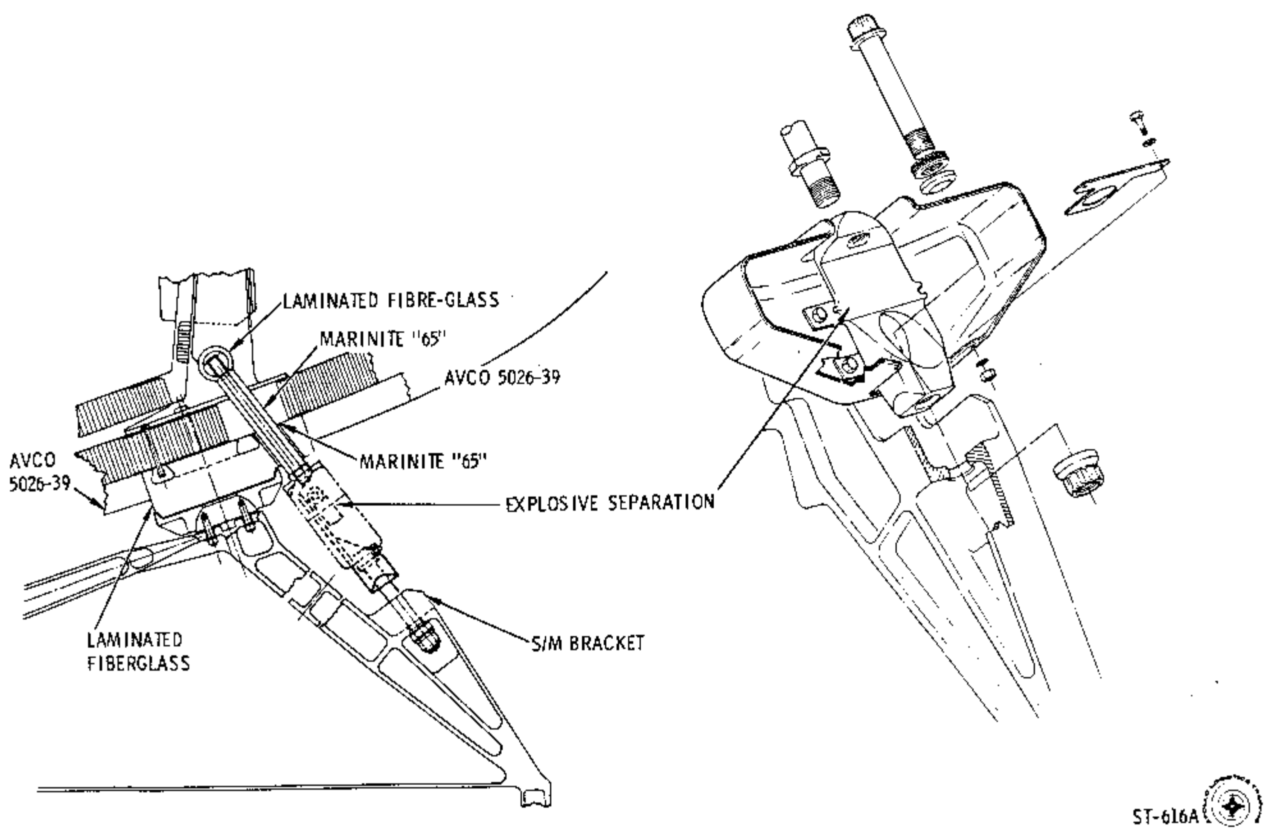


FIGURE 4-5

GUILLOTINE SUB-ASSEMBLY

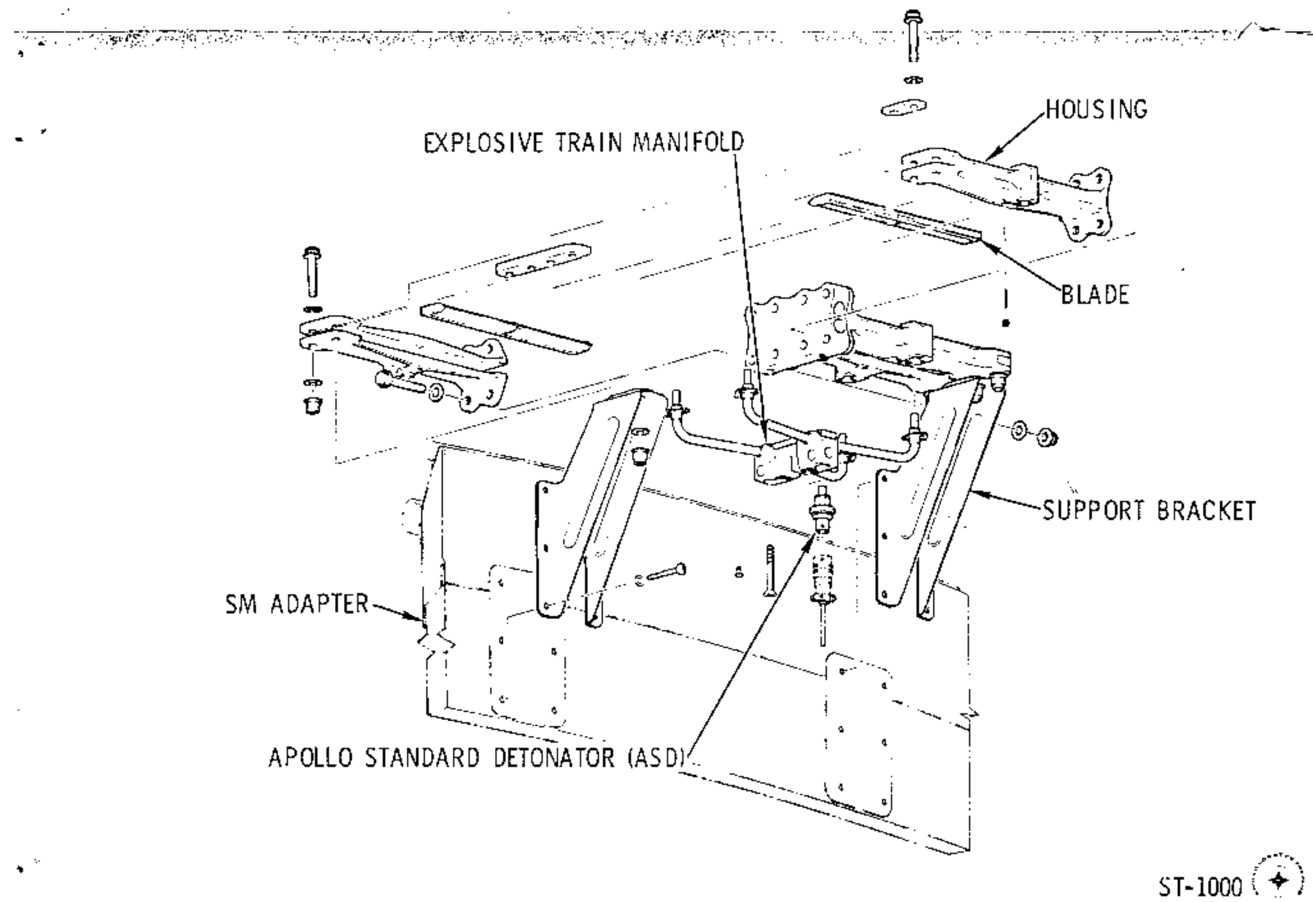


FIGURE 4-8

UMBILICAL SEPARATION SYSTEM

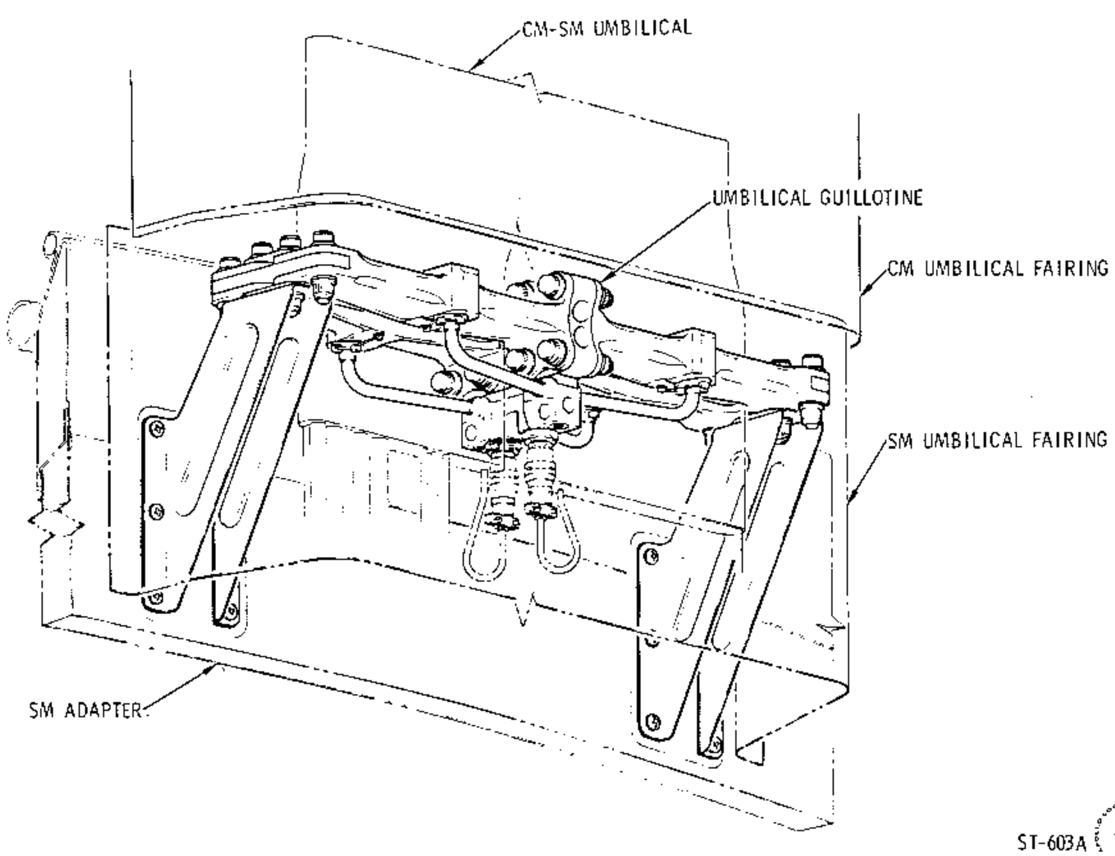


FIGURE 4-7

C/M TO S/M ELECTRICAL CABLE & HARD LINE ASSY

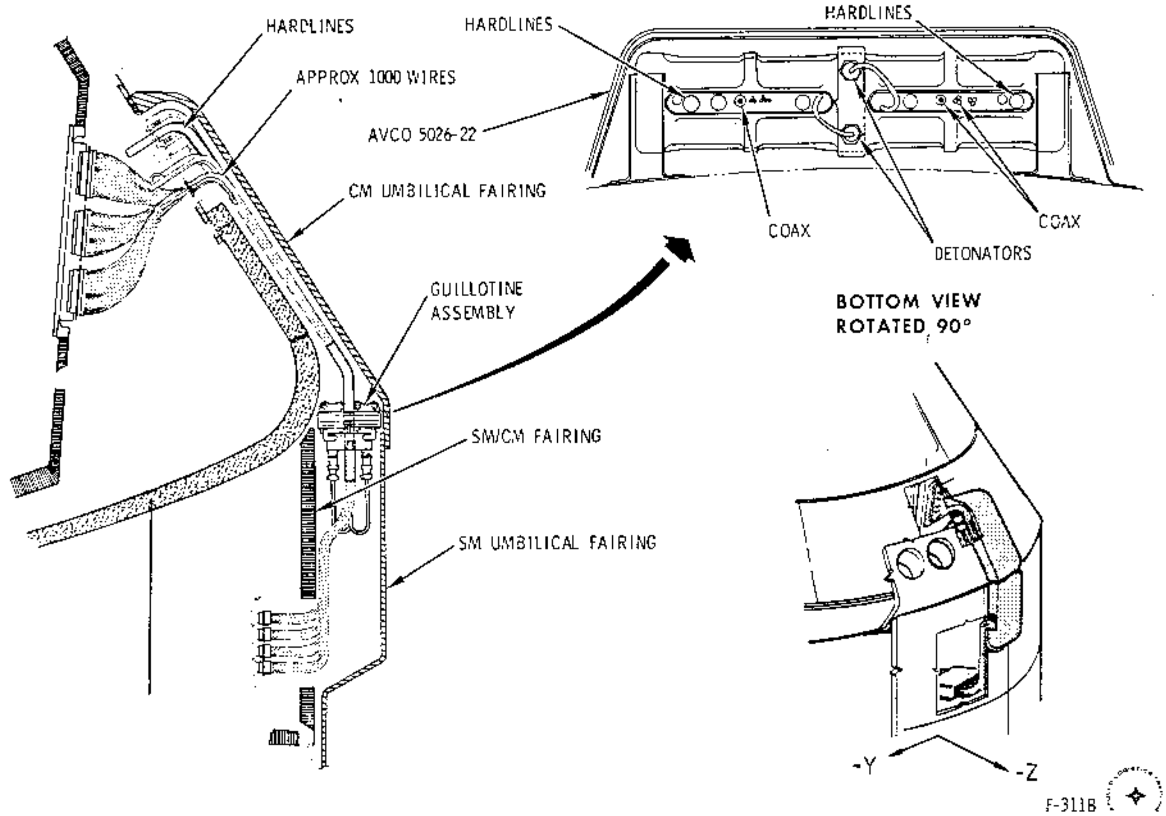


FIGURE 4-9

4-12

OF THE BLADES IS ORDNANCE OPERATED BY TWO APOLLO STANDARD DETONATORS (ASD) SHOWN IN FIGURE 2-13. EACH BLADE IS POWERED BY AN EXPLOSIVE TRAIN CONTAINING MILD DETONATING FUSE, WITH A INTERCONNECTING EXPLOSIVE TRAIN BETWEEN BLADES FOR DUAL REDUNDANT OPERATION.

THE HOUSING AND BLADES ARE MANUFACTURED FROM INCONEL 718. AFTER MACHINING, THE HOUSINGS ARE TO BE MATCHED DRILLED AND SERIALIZED TO MAKE SURE THAT PROPER ALIGNMENT IS MAINTAINED BETWEEN THE BLADE GUIDE RAILS OF OPPOSITE HOUSINGS. TOLERANCES ARE SUCH THAT THIS REQUIREMENT DOES NOT EXIST FOR THE BLADES. THIS DEVICE HAS BEEN DESIGNED TO ALLOW MATCHED SET INTERCHANGE-ABILITY, THEREFORE NO FIT CHECK IS REQUIRED TO INDIVIDUAL UMBILICALS OR S/C PRIOR TO FINAL INSTALLATION. AFTER DRILLING AND SERIALIZING THE INDIVIDUAL FRAMES, THE GUILLOTINE SUB-ASSEMBLY (SETS OF HOUSINGS AND BLADES) ARE SENT TO THE ORDNANCE VENDOR. THE VENDOR WILL LOAD CHARGES INTO THE BLADES AND MANIFOLD, AND SHIP DIRECTLY TO THE LAUNCH SITE. INSTALLATION ONTO THE S/C IS ACCOMPLISHED (BY ATO) AT THE LAUNCH SITE BY BOLTING THE FRAME ASSEMBLY AROUND THE UMBILICAL AND ATTACHING TWO SUPPORT BRACKETS TO THE S/M FAIRING WITH TWELVE SCREWS. THE S/M HONEYCOMB FAIRING WILL HAVE TWELVE FACTORY INSTALLED HOLES, SPACERS AND NUTPLATES TO ACCEPT THESE SCREWS. (SEE FIGURE 4-9)

4.3 CIRCUIT INTERRUPTERS (BLOCK I)

4.3.1 GENERAL

IN CUTTING THE UMBILICAL LINES WITH THE GUILLOTINE SUB-ASSEMBLY, MANY WIRES WILL BE SHORTED. SHORTING WILL RESULT IN ONE OF TWO CONDITIONS; (1) SHORTED POWER LINES WILL DRAIN BATTERY CURRENT; (2) SEQUENCER CIRCUITS WHICH SHOULD BE OPEN MAY BE CLOSED, THUS PREVENTING FURTHER SEQUENCER ACTION. TO PREVENT THIS, CRITICAL CIRCUITS ARE CONNECTED THROUGH THE CIRCUIT INTERRUPTERS. (SEE FIGURE 4-10).

4.3.2 FUNCTION AND DESCRIPTION

THE FUNCTION OF THE CIRCUIT INTERRUPTER IS TO OPEN CRITICAL CIRCUITS 100 MILLI-SECONDS PRIOR TO C/M - S/M UMBILICAL SEPARATION.

THERE ARE FOUR CIRCUIT INTERRUPTERS MOUNTED IN THE RIGHT HAND EQUIPMENT BAY OF THE COMMAND MODULE AND TWO LOCATED ON THE FORWARD BULKHEAD OF THE SERVICE MODULE. THE CIRCUIT INTERRUPTERS ARE CLASSIFIED AS TYPE I OR TYPE II. TWO OF THE CIRCUIT INTERRUPTERS LOCATED IN THE COMMAND MODULE WILL BE A TYPE I AND THE REMAINING FOUR WILL BE OF THE TYPE II CONFIGURATION.

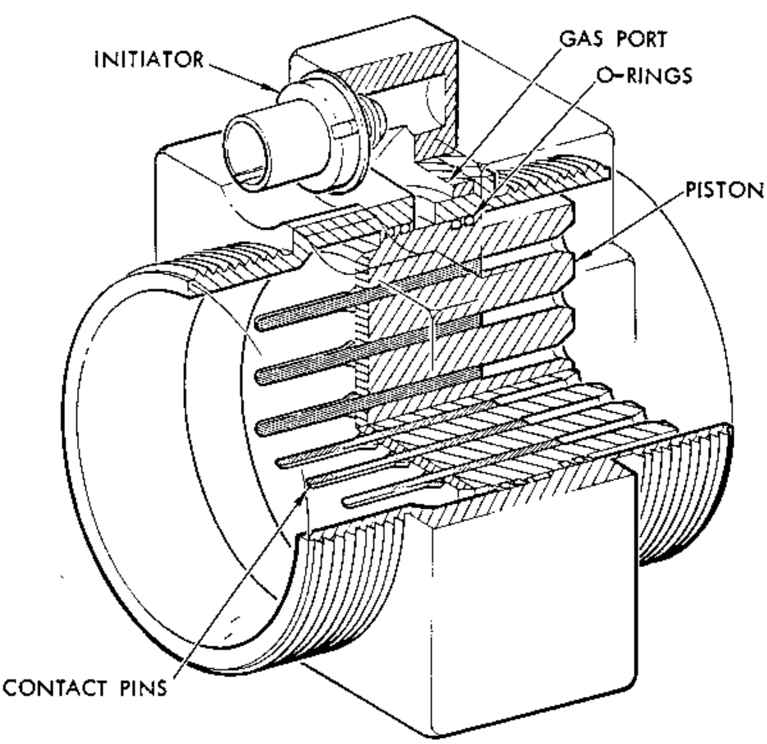
4

A TYPE I CIRCUIT INTERRUPTER CONTAINS 104 PINS, WHILE THE TYPE II CIRCUIT INTERRUPTER CONTAINS 18 PINS. THE CIRCUIT INTERRUPTERS WILL BE EXPLOSION PROOF AND CAPABLE OF FIVE ACTUATIONS OR TEST CYCLES. CAUTION CIRCUIT INTERRUPTERS ARE TO BE CYCLED ONLY WHEN DIRECTED BY APPLICABLE SPECIFICATIONS.

THE CIRCUIT INTERRUPTER CASE IS FABRICATED OF STAINLESS STEEL. LOCATED WITHIN THE CASE IS A MOVABLE PISTON ASSEMBLY WHICH CONTAINS THE VARIOUS NUMBER OF PINS. THE PISTON IS ACTUATED BY AN APOLLO STANDARD GAS PRESSURE INITIATOR REFERENCED IN FIGURE 2-14 WHICH DISPLACES THE PISTON TO THE "CIRCUIT" OPEN POSITION. BEING EXPLOSION PROOF, THE PRESSURE IS CONTAINED WITHIN THE CASE.

4

ELECTRICAL CIRCUIT INTERRUPTERS



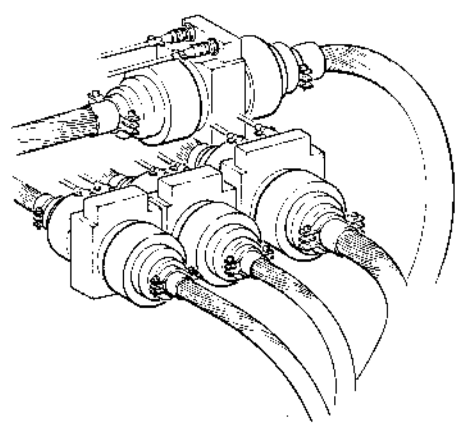


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FIGURE 4-10

SERVICE MODULE STRUCTURE

5.1 ORIENTATION AND GENERAL DESCRIPTION

THE SERVICE MODULE STRUCTURE IS A CYLINDRICAL SHAPED STRUCTURE WEIGHING APPROXIMATELY 10,000 POUNDS WITHOUT THE PROPELLANTS (FIGURE 5-1). IT IS CONSTRUCTED PRIMARILY OF ALUMINUM AND CONTAINS THE SYSTEMS, AND EQUIPMENT TO SUPPORT THE COMMAND MODULE AND SPS ENGINE. THE SYSTEMS AND EQUIPMENT REQUIRE NO CREW MAINTENANCE.

THE MAXIMUM STRUCTURAL LOADS THE SERVICE MODULE WILL WITHSTAND, WILL BE DURING THE BOOST PHASE. THE MAXIMUM EXPECTED IN THE +X DIRECTION IS 5.7 G'S TRANSMITTED FROM THE BOOSTERS, UP THROUGH LEM ADAPTER, TO THE AFT BULKHEAD OF THE SERVICE MODULE. THESE LOADS WILL BE EVENLY DISTRIBUTED TO RADIAL WEB BEAMS, TO THE C/M. THE SIDE LOADS WHICH MAY BE APPLIED IN A HARD PITCHOVER CONDITION WILL BE LESS THAN 1 G.

THE HIGH TEMPERATURES EXPECTED ON THE OUTER PANELS OF THE SERVICE MODULE OCCUR AT MAX Q OR APPROXIMATELY 160 SECONDS AFTER LIFT-OFF. THIS HIGH TEMPERATURE IS FELT IN A BAND, LATERALLY AROUND THE SERVICE MODULE IN THE VICINITY OF THE RCS ENGINE HOUSINGS. THIS HIGH TEMPERATURE ON THE S/M SHELL AND S/M RCS ENGINE HOUSINGS IS DUE TO AERODYNAMIC HEATING DURING BOOST, AND TO HEATING FROM RCS ENGINE FIRING IN SPACE. TO PREVENT STRUCTURAL FAILURE DUE TO EXCESSIVE TEMPERATURES, CORK ABLATOR SHIELDS OF SUFFICIENT THICKNESS TO WITHSTAND A TEMPERATURE RANGE OF APPROXIMATELY 300 TO 1720 F, WILL BE INSTALLED IN THIS HIGH TEMPERATURE AREA. TO HELP IN MAINTAINING INTERNAL TEMPERATURES, THE INDIVIDUAL SECTORS, OR BAYS, WILL BE COVERED WITH AN INSULATING MATERIAL.

THE SERVICE MODULE STRUCTURE IS A CYLINDER FORMED BY SIX PANELS OF ONE-INCH ALUMINUM HONEYCOMB MATERIAL (FIGURE 5-2).

THE INTERIOR AREA BETWEEN THE FORWARD AND AFT BULKHEADS IS DIVIDED INTO SECTORS BY SIX RADIAL BEAMS AND WEB. THESE SECTORS, OR BAYS, ARE ARRANGED IN THREE DIAMETRICALLY OPPOSED PAIRS AROUND A CENTRAL CYLINDRICAL SECTION. EACH BAY OF THE FIRST PAIR (ONE AND FOUR) HAS 50 DEGREES OF ARC AND HOUSES ESSENTIAL AUXILIARY EQUIPMENT. EACH SECTOR OF THE SECOND PAIR (TWO AND FIVE) COVERS 70 DEGREES OF ARC AND EACH CONTAINS ONE LARGE OXIDIZER TANK FOR THE SPS ENGINE. EACH BAY OF THE THIRD PAIR (THREE AND SIX) OCCUPIES 60 DEGREES OF ARC AND EACH HOLDS ONE LARGE FUEL TANK FOR THE SPS ENGINE. THE CENTRAL SECTION HOUSES TWO LARGE HELIUM TANKS AND THE SPACECRAFT PROPULSION ENGINE WHICH IS ATTACHED TO, AND EXTENDS BELOW, THE AFT BULKHEAD. THE ENGINE IS

SERVICE MODULE

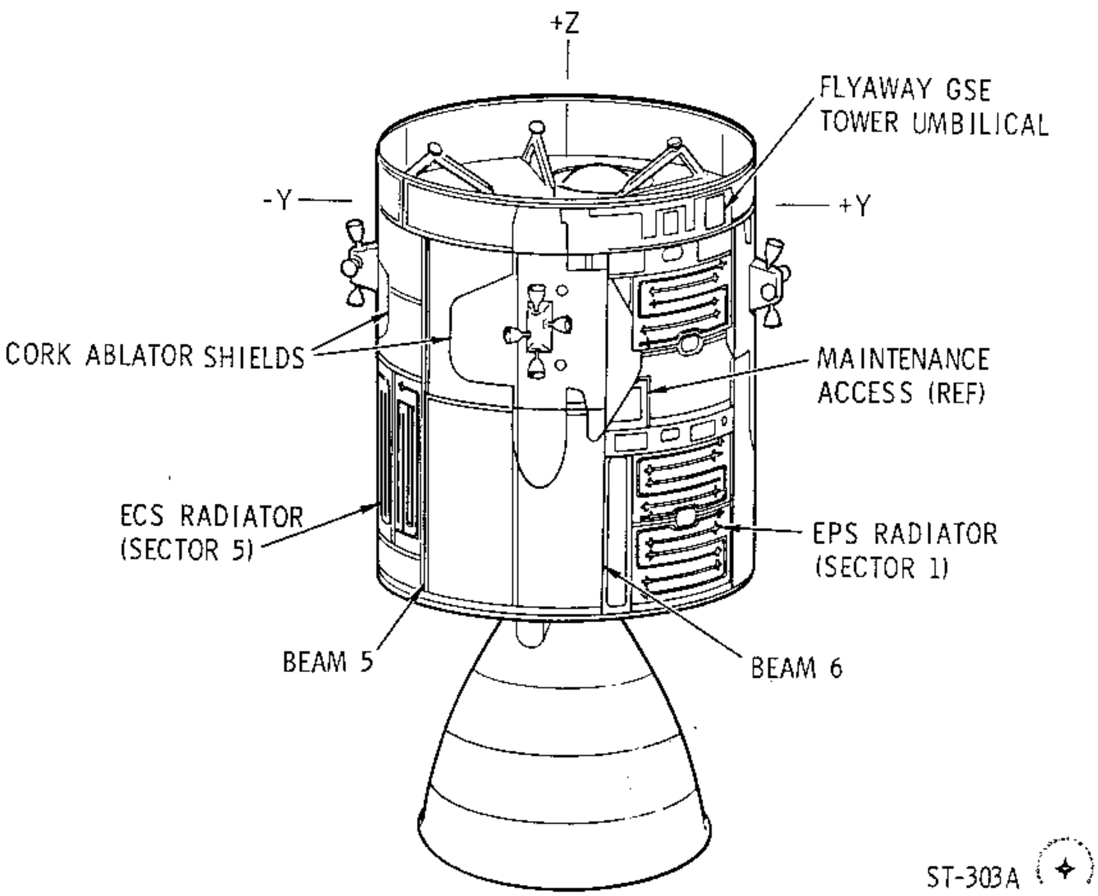


FIGURE 5-1

APOLLO S/M GENERAL CONFIGURATION

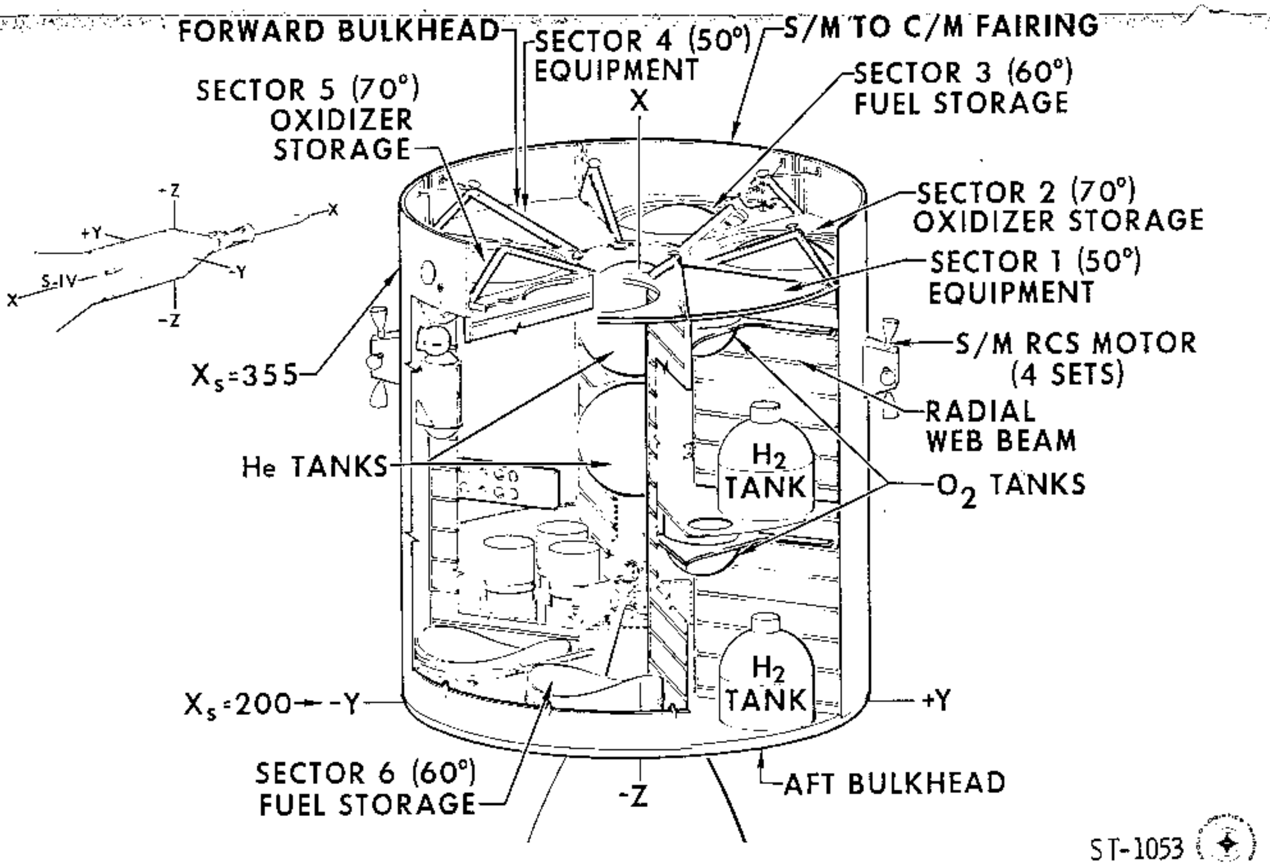


FIGURE 5-2

OPERATED BY FUEL AND OXIDIZER UNDER PRESSURIZATION. BETWEEN THE COMMAND MODULE AND THE SERVICE MODULE IS A FAIRING APPROXIMATELY 26 INCHES IN HEIGHT, ENCLOSING THE FORWARD EXTENSIONS, OR TRUSSES, OF THE RADIAL WEB BEAMS. THREE OF THE TRUSSES (1, 3, 5) HAVE COMPRESSION PADS, AND THREE (2, 4, 6) HAVE SHEAR PADS AND TENSION TIES. THESE (SIX) PADS SUPPORT THE COMMAND MODULE. THE OUTER PANELS OF SECTORS TWO, FIVE, THREE, AND SIX SUPPORT THE FOUR MODULAR PACKAGES OF THE REACTION CONTROL SYSTEM.

THE MAIN SERVICE PROPULSION ENGINE IS ATTACHED TO THE SERVICE MODULE AT THE AFT BULKHEAD. CENTER LINE PLANE OF THE ENGINE GIMBAL IS SET AT STATION X_S= 195.20. ABOVE THE ENGINE GIMBAL, THE COMBUSTION CHAMBER, HARDWARE, AND OTHER EQUIPMENT EXTEND INTO THE CENTER SECTION. BELOW THE GIMBAL, THE ENGINE NOZZLE EXTENDS INTO THE ADAPTER AREA.

THE TWO BULKHEADS, ONE LOCATED FORWARD AND ONE AFT, ARE CONSTRUCTED OF ALUMINUM HONEYCOMB. THE TWO BULKHEADS PROVIDE AN ATTACHMENT FOR THE RADIAL WEB BEAMS AND THE OUTER PANELS.

THE OUTER PANELS OF THE SERVICE MODULE ARE CONSTRUCTED OF ALUMINUM HONEYCOMB MATERIAL. IN FOUR OF THE SECTORS, THE OUTER SKIN IS PARTIALLY FORMED BY TWO RADIATOR SYSTEMS. ALL OF THE PANELS ARE BOLTED TO THE CORE.

5.2 STRUCTURE AND CONFIGURATION

5.2.1 <u>AFT BULKHEAD</u>

5.2.1.1 GENERAL

THE AFT BULKHEAD IS FABRICATED FROM SIX PIE SHAPED SEGMENTS BONDED TO MAKE ONE LARGE CIRCULAR BULKHEAD 3" THICK. THE AFT BULKHEAD IS A PRIME LOAD BEARING STRUCTURE TRANSFERING THE LOADS FROM THE LEM ADAPTER, UP THROUGH THE RADIAL WEB BEAMS, TO THE COMMAND MODULE (FIGURE 5-3).

5.2.1.2 FABRICATION

THE LARGE CIRCULAR BULKHEAD IS CONSTRUCTED OF AN ALUMINUM HONEYCOMB CORE TO WHICH .060 OF AN INCH ALUMINUM FACESHEETS ARE BONDED WITH AN EPOXY RESIN. THE TYPE OF ALUMINUM USED IN FABRICATING THE BULKHEAD IS DESIGNATED 7178. THIS TYPE OF ALUMINUM HAS A VERY HIGH TENSIL STRENGTH. PRIOR TO BONDING THE FACESHEETS TO THE HONEYCOMB CORE, THE FACESHEETS WILL BE CHEMMILLED TO VARIOUS THICKNESSES OF .016 TO .060 OF AN INCH. WHERE ADDED STRENGTH IS NEEDED AT BONDED JOINTS AND ATTACHMENT OF EQUIPMENT, DOUBLERS WILL BE BONDED. BONDED TO THE OUTER PERIPHERY OF THE BULKHEAD WILL BE A .125 OF AN INCH ALUMINUM RING, WHICH PROVIDES AN ATTACHMENT FOR THE OUTER PANELS.

When bonding the six pie shaped segments to make the large circular bulkhead, "T" frames are bonded at the 50°, 60°, and 70° of arc to provide an attachment for the radial web beams. Also, four large circular holes are provided in the aft bulkhead for the fuel and oxidizer tanks.

5.2.2 Radial Web Beams (Figure 5-3)

5.2.2.1 General

The radial web beams are the primary load bearing structure between the aft bulkhead and the forward bulkhead. Also, the forward end of the six radial web beams provide support attachment for the Command Module.

5.2.2.2 Fabrication

The radial web beams are fabricated from a 2.5" thick piece of milled aluminum alloy plate (7078). The 2.5" thick aluminum block is then machined down to 2" at the inner and outer edge. The webbing will be machined and chemmilled down to various thicknesses of .018 to .090 of an inch, leaving 2" thick rails. Mounted to these rails will be 1" honeycomb shelves for mounting tanks and system equipment. The radial web beams will be permanently attached with shear bolts to the "T" frames, bonded to the aft bulkhead.

5.2.3 Forward Bulkhead (Figure 5-3)

5.2.3.1 General

The forward bulkhead is constructed into six individual sections. These six sections provide a structural tie between the six radial web beams.

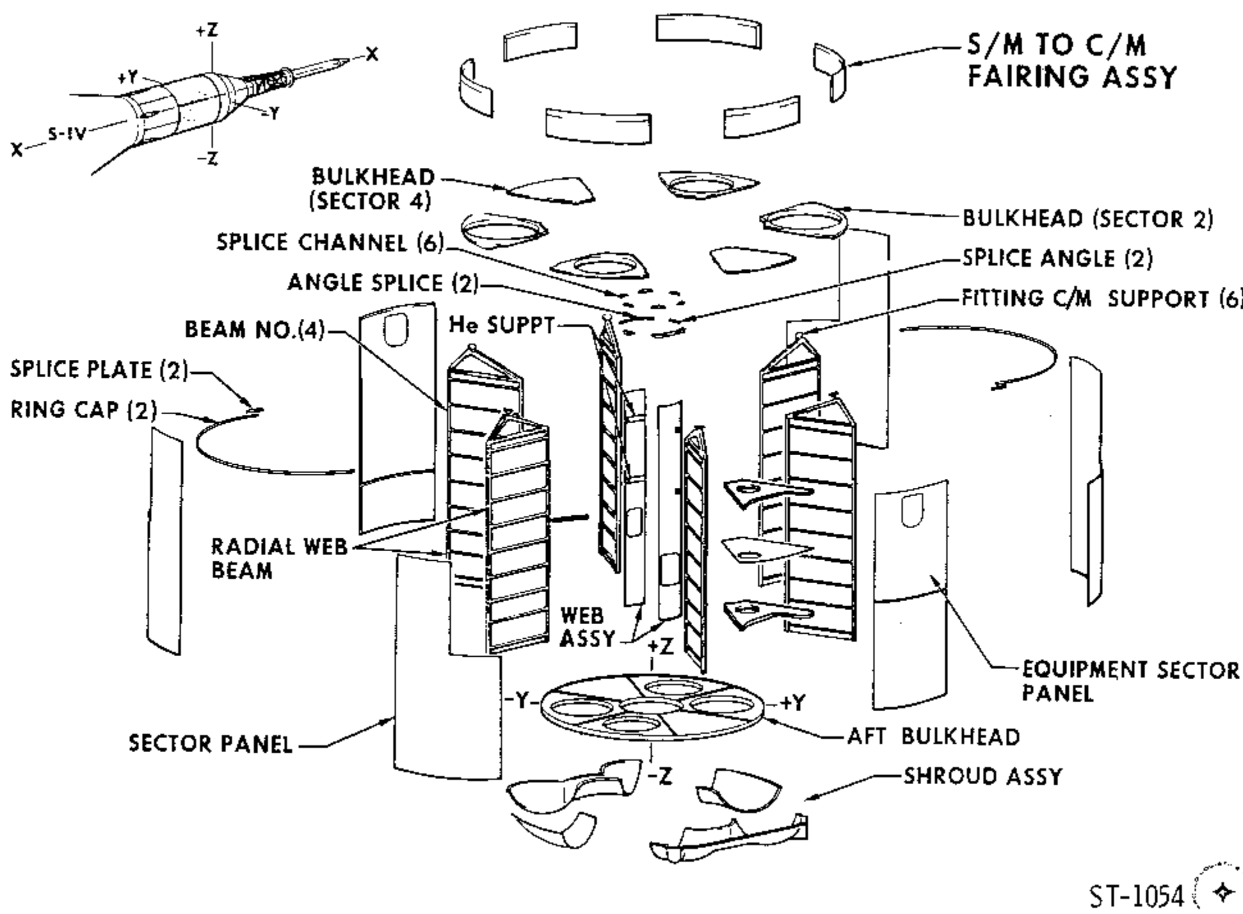
5.2.3.2 Fabrication

The forward bulkhead sections are bonded aluminum honeycomb, fabricated from 7178 aluminum. The facesheets covering the honeycomb core are .060 of an inch, chemmilled to various thicknesses of .016 to .060 of an inch. Where added strength is needed, doublers will be bonded to the facesheets. Two sections of the forward bulkhead are solid, while the remaining four have large circular openings. These four openings provide a means to install or remove the fuel and oxidizer tanks.

The forward bulkhead sections are bolted to the radial web beams. The inner circumferential structure is formed by a number of aluminum angle splice plates and channels, riveted in place, to form the inner ring. (For an overall view, see Figure 5-4).

5

APOLLO S/M STRUCTURE BREAKDOWN



ST-1054

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FIGURE 5-3

5.2.4 S/M TO C/M FAIRING

5.2.4.1 GENERAL

THE S/M TO C/M FAIRING ASSEMBLY CONSISTS OF SIX CURVED HONEYCOMB PANEL ASSEMBLIES (FIGURE 5-3) AND ONE MOLDED PLASTIC LAMINATE FAIRING. THE FAIRING PROVIDES PROTECTION FOR THOSE COMPONENTS LOCATED BETWEEN THE S/M AND C/M. THE SIX HONEYCOMB PANELS ARE BOLTED TO EACH OTHER AND THEN TO A FLANGE ON THE FORWARD BULKHEAD AT STATION $X_S = 355$. ATTACHED TO THE LEADING EDGE OF THE INDIVIDUAL PANELS IS A SLOTTED RING CONTAINING A COMPRESSIBLE SEAL. AFTER THE PANEL INSTALLATION IS COMPLETE THE SLOTTED RING WILL BE POSITIONED TO COMPRESS THE SEAL. THIS PROVIDES THE SEAL BETWEEN THE C/M AND FAIRING. THE MOLDED PLASTIC LAMINATE FAIRING IS BOLTED TO THE OUTER SURFACE OF SECTOR I PANEL. THIS FAIRING PROVIDES A SHIELD FOR ELECTRICAL AND FLUID INTERFACE CONNECTIONS BETWEEN THE C/M AND S/M. SECTOR PANEL ALSO CONTAINS THE CARRY-ON UMBILICAL WITH ACCESS DOOR AND THE GSE FLY-AWAY UMBILICAL (FIGURE 5-1).

5.2.5 CENTER SECTION (FIGURE 5-3)

5.2.5.1 GENERAL

THE CENTER SECTION OF THE SERVICE MODULE HOUSES THE MAIN ENGINE OF THE SPACECRAFT'S SERVICE PROPULSION SYSTEMS, TOGETHER WITH THE TWO LARGE HELIUM PRESSURIZATION TANKS.

5.2.5.2 FABRICATION

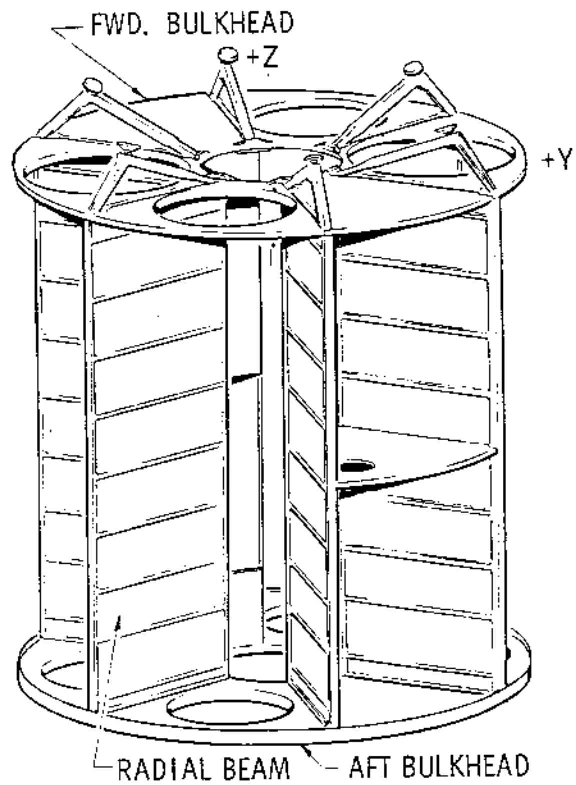
THE CENTER SECTION OPENING IS 44 INCHES IN OUTSIDE DIAMETER AND EXTENDS THE ENTIRE LENGTH OF THE SERVICE MODULE. THE SECTION IS OPEN THE FULL LENGTH ALONG SECTORS TWO AND FIVE. IT IS ALSO OPEN ALONG SECTORS THREE AND SIX, BUT ONLY BETWEEN STATIONS $X_S = 355$ AND $X_S = 227$. ALONG SECTORS THREE AND SIX, AND ONE AND FOUR (BETWEEN STATIONS $X_S = 227$ AND $X_S = 200$), THE CENTER SECTION IS CLOSED BY AN ALUMINUM WEB, OR SKIN, ATTACHED TO BOTH THE AFT BULKHEAD AND RADIAL WEB BEAMS WHICH BOUND THESE SECTORS. THE FORWARD PORTION OF THE WEB, WHICH PARTIALLY CLOSES SECTOR ONE AND FOUR, IS ATTACHED TO THE FORWARD BULKHEAD AND ALSO TO THE RADIAL BEAMS WHICH BOUND THESE SECTORS. ALONG SECTOR ONE, AN OPENING FOR ENGINE ACCESS HAS BEEN LEFT BETWEEN STATIONS $X_S = 225.75$ AND $X_S = 227.06$. ALONG SECTOR FOUR, A SECOND ENGINE ACCESS EXTENDS BETWEEN STATIONS $X_S = 289.04$ AND $X_S = 227.06$. (FIGURE 5-7)

5.2.6 RCS PANELS AND HEAT SHIELDS (FIGURE 5-5)

THE REACTION CONTROL SYSTEM (RCS) IS A REDUNDANT PROPULSION SYSTEM WHICH PROVIDES THREE-AXIS CONTROL OF THE SPACECRAFT DURING MISSION-FLIGHT MODES.

THE RCS CONSISTS OF INTERCHANGEABLE AND REPLACEABLE MODULAR PACKAGES WHICH ARE INSTALLED AT FOUR DIFFERENT PLACES ON THE S/M. LOOKING AFT, THESE MODULAR PACKAGES ARE LOCATED ON A NORMAL REFERENCE SYSTEM 7 DEGREES 15 MINUTES CW FROM THE Z-Z AND Y-Y

SERVICE MODULE
BULKHEAD/RADIAL BEAM ASSEMBLY



ST-301

FIGURE 5-4

AXES. THE CENTER LINE OF EACH ENGINE CLUSTER IS AT STATION X_S - 320.905 AND AT THE MID POINT OF THE MODULE PANEL.

STRUCTURALLY, EACH MODULAR PACKAGE COMPRISES AN ENGINE ASSEMBLY, A TANK ASSEMBLY WITH ASSOCIATED PLUMBING AND WIRING, AND THE PANEL ON WHICH THE ASSEMBLIES ARE MOUNTED.

THE PANEL PORTION OF THE PACKAGE HAS 35.5 INCHES-ARC LENGTH AND IS 67.7 INCHES IN HEIGHT. IT FORMS A PART OF THE OUTER SHELL OF THE SERVICE MODULE IN SECTORS TWO, THREE, FIVE, AND SIX. THE PANEL IS FASTENED TO THE OUTER SHELL BOTH BY PERIPHERAL CAPTIVE BOLTS AND BY HINGES, THUS PROVIDING MAINTENANCE ACCESS.

THE FOUR-ENGINE ASSEMBLY OF EACH RCS PACKAGE IS MOUNTED ON THE EXTERIOR SURFACE OF THE PANEL ON A TEN-DEGREE CANT OUTWARD BY MEANS OF A BOX LIKE HOUSING. THE ENGINE HOUSING, A SINGLE MACHINED FORGING, IS FABRICATED OF ALUMINUM. CORK SHEET WILL BE BONDED TO THE PANEL AND THE ENGINE HOUSINGS PROTECTING THE SURFACE AGAINST AERODYNAMIC HEATING DURING BOOST, AND RCS ENGINE PLUME-FLAME IMPINGEMENT.

THE THREE-TANK ASSEMBLY CONSISTS OF TWO POSITIVE EXPULSION TANKS AND ONE HELIUM PRESSURIZATION TANK. THE THREE TANKS ARE MOUNTED IN A VERTICAL LINE ON THE INNER FACE OF THE RCS PANELS.

THE PRESSURIZATION SYSTEM COMPONENTS ARE MOUNTED ON THE PANEL'S INNER FACE ADJACENT TO THE TANK ASSEMBLY. PROPELLANT AND SERVICING CONNECTORS ARE MOUNTED IN RECEPTACLES WHICH ARE ACCESSIBLE FROM THE EXTERIOR OF THE RCS PANELS.

(FIGURE 5-6 FOR REACTION CONTROL SYSTEM MODULAR PACKAGE.)

5.2.6.3 ACCESS DOORS (FIGURE 5-7)

AN ACCESS DOOR, USED FOR MAINTENANCE PURPOSES ON THE LAUNCH PAD, IS PLACED IN THE OUTER SHELL OF SECTOR ONE BETWEEN STATIONS X_S - 299 AND X_S - 277.5. THE ARC LENGTH OF THE DOOR IS 21 INCHES. ALUMINUM SHEETS BONDED TO THE ALUMINUM HONEYCOMB CORE FORM THE DOOR WHICH IS ATTACHED TO A FRAME OF THE SAME MATERIAL BY SCREWS. THE FRAME IS BOLTED TO RADIAL BEAM 6 AND ALSO TO THE OUTER SHELL OF THE SERVICE MODULE. LOOKING AFT, THE LOCATION OF THE DOOR IS CCW OF BEAM 6.

INBOARD, A 17" DIAMETER CIRCULAR ACCESS HAS BEEN CUT THROUGH THE SHELF AT STATION X_S = 277, ABOUT ONE INCH FROM THE INNER FACE OF THE OUTER SHELL. LOOKING AFT, ITS CENTER IS ABOUT 18 INCHES CW FROM THE CENTER LINE OF SECTOR ONE. ITS CENTER IS 64 INCHES FROM THE CENTER LINE OF THE SERVICE MODULE.

ONE ACCESS OPENING TO THE ENGINE, GIMBAL RING, HARD LINES, AND VALVING HAS BEEN PLACED IN THE INNER

APOLLO S/M STRUCTURE & SYSTEMS EQUIPMENT

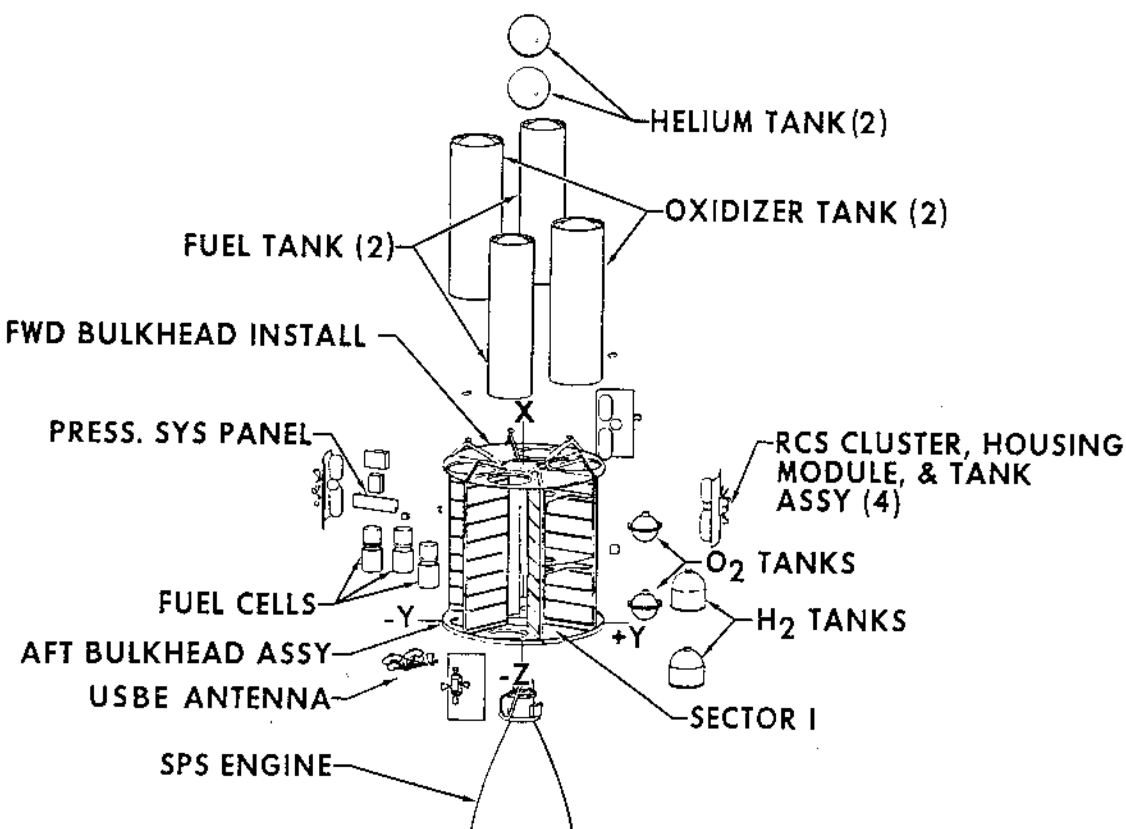


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FIGURE 5-5

SECTOR ONE, SECTOR FOUR, & CENTER SECTION

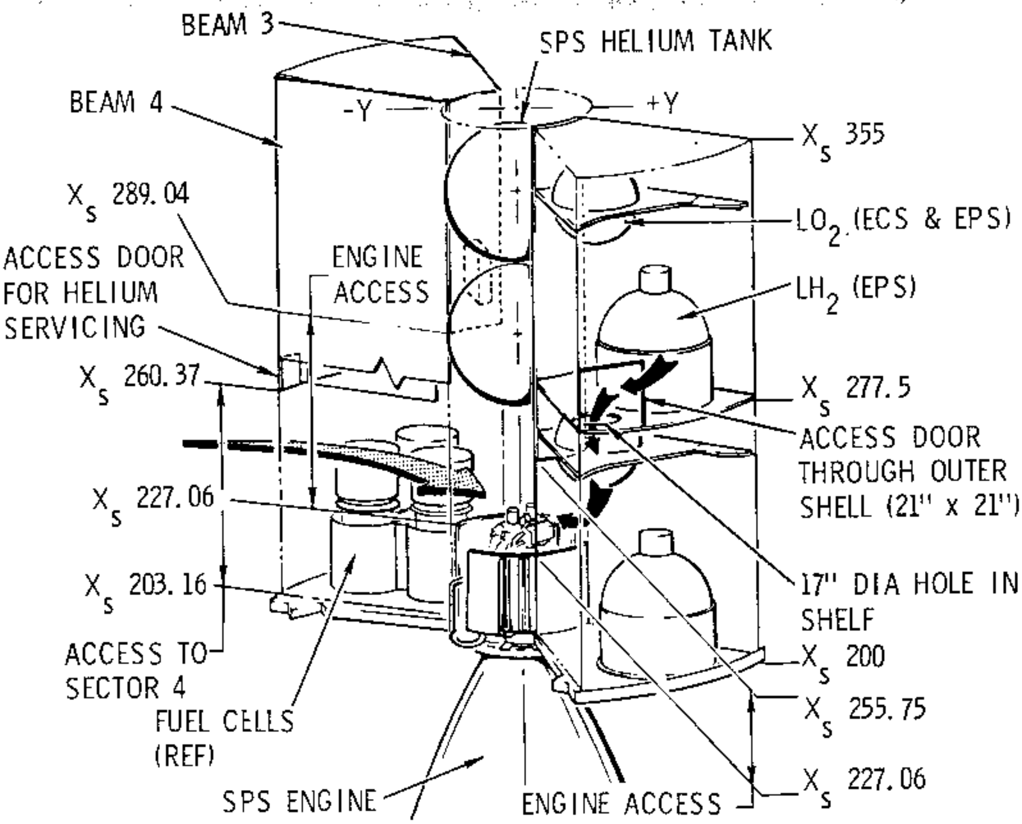

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FIGURE 5-7

REACTION CONTROL SYSTEM MODULAR PACKAGE

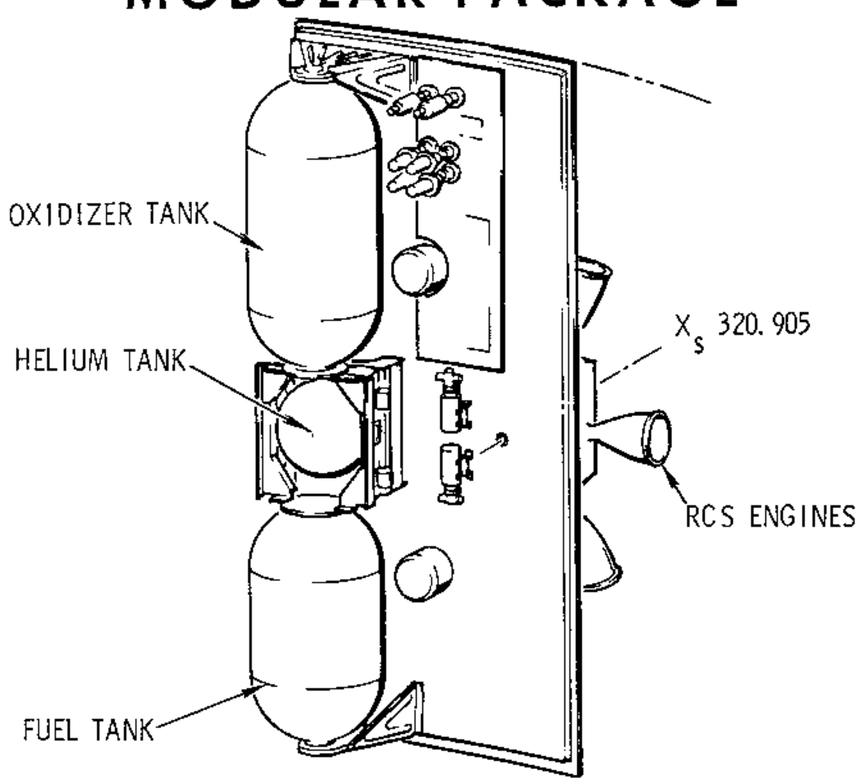

FIGURE 5-6

ST-1200

Other details concerning the fuel tanks are similar to those given for the oxidizer tanks.

5.3.2 Helium Spheres

The two large helium tanks, housed one above the other in the center section, are used to pressurize the fuel and oxidizer tanks of the Service Propulsion System. They are spherical in shape and are fabricated from titanium alloy (6AL-4V).

The helium tanks are suspended by two integrally fabricated bosses which rest in housings attached to radial beams 1 and 4 at Stations $X_S = 329.5$ and $X_S = 286.5$ for upper and lower tanks, respectively. Extensions anchored to radial beams 1 to 6 and 4 to 3 strengthen the housings. These tanks are lowered into place prior to attaching the Command Module to the Service Module.

5.3.3 H_2 and O_2 Tanks

Sector One contains the tanks for the cryogenic (supercritical) storage subsystem which supplies oxygen and hydrogen to the environmental control system and to the electrical power system.

Four spherical tanks comprise the cryogenic storage subsystem. The two larger tanks contain hydrogen (H_2). These are placed near the outer shell: the lower one rests on the aft bulkhead at Station $X_S = 200$; the upper one is on a shelf attached to radial beams (6, 1) and to the inner skin at Station $X_S = 277.5$. The smaller tanks which contain oxygen (O_2) are close to the center well.

Each oxygen tank is suspended within its shelf by means of a circular flange welded to the tank below its equator. The flanges are bolted from beneath to shelves, which are attached to the inner skin and radial web beams at stations $X_S - 332$ and $X_S - 256.5$ for upper and lower tanks respectively. Each hydrogen tank is nested in a circular skirt welded to the tank at its equator. The skirt of one tank is bolted to the aft bulkhead, the other tank is bolted to a shelf at station $X_S - 277.5$.

Replacement of tanks in Sector One is such that any tank may be removed for servicing without disturbing the other tanks.

5.3.4 Fuel Cells

Sector Four houses the fuel cell modules for the electrical power system, which generate the DC power required of the spacecraft for the mission modes.

The fuel cell system consists of three independent modules, each of which contains a group of nonregenerative hydrogen-oxygen fuel cells. Each

One access opening to the engine, gimbal ring, hard lines, and valving has been placed in the inner web of Sector One. The opening has an arc length of about 19 inches. It is located between beams 1 and 6, and between Stations $X_S = 255.50$ and $X_S = 227.06$. It can be reached via the path indicated by the series of three arrows. A second engine access is set in the inner web of Sector Four between beams 3 and 4. It has the same arc length as the first access, but its location is between Stations $X_S = 289$ and $X_S = 227.06$, as shown by the large arrow.

In Sector Four, two maintenance accesses form part of the outer shell. The first is small, about 12 inches in arc length and 15 inches in height. The cover fabricated of aluminum honeycomb, is fastened to radial beam 4 along one edge and attached on its other edges to the outer shell. When the access cover is removed on the pad, the opening permits GSE testing of the helium pressurization control mechanism.

The second maintenance access in Sector Four extends about 67 inches, the entire arc length of the sector, between Stations $X_S = 260.37$ and $X_S = 203.16$. The cover is bolted to both radial beams 3 and 4, to the aft bulkhead, and to the outer shell at the cover's upper edge. This opening will also provide access to the engine, gimbal ring, hard lines, and valving.

5.3 S/M Equipment Installation (Figure 5-5)

5.3.1 Oxidizer and Fuel Tanks

Sector Two and Sector Five contains the oxidizer tanks which store nitrogen tetroxide for the SPS main engine. Figure 5-5 exhibits a typical oxidizer tank with its hemispherical end and cylindrical shape.

Both oxidizer tanks are fabricated from titanium alloy (6AL-4V). A removable door set in the aft end of each tank makes provision for cleaning and maintenance purposes.

Installation of each tank in its sector is achieved by the use of aluminum skirts riveted to the tank and bolted to the aft bulkhead. The forward end is positioned within the bulkhead opening by means of sliding supports attached to the tank skirt. This arrangement is necessary to allow for tank expansion and contraction.

Sector Three and Sector Six house the fuel tanks which contain a hydrazine mixture for the SPS main engine. Both fuel tanks are formed from titanium alloy (6AL-4V).

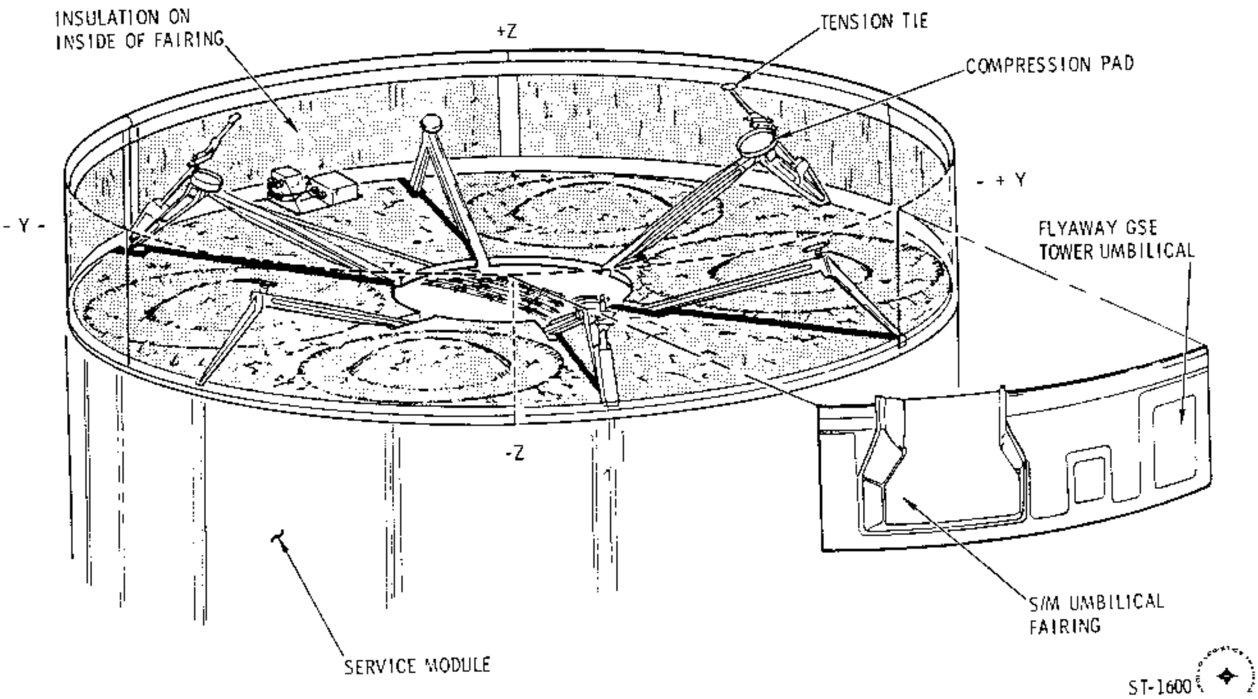

FIGURE 5-8

5-16

MODULE IS A LOW PRESSURE, BACON TYPE CELL, HAVING NICKEL ELECTRODES, USING HYDROGEN AND OXYGEN AS REACTANTS AND POTASSIUM HYDROXIDE AS ELECTROLYTE. THE NORMAL POWER OUTPUT PER CELL IS ABOUT 29 ± VDC.

EACH CELL IS CYLINDRICAL, ABOUT 44 INCHES IN HEIGHT, 20 INCHES IN DIAMETER, AND WEIGHS 250 POUNDS WITHOUT ITS BASE. THE THREE FUEL CELLS ARE MOUNTED WITHIN INDIVIDUAL BASES WHICH ARE ABOUT 24 INCHES IN DIAMETER AND 22 INCHES IN HEIGHT. THE CELLS ARE BOLTED TO SHOCK MOUNTS ATTACHED TO BASES WHICH ARE BOLTED TO THE AFT BULKHEAD.

CELL STABILIZATION IS OBTAINED BY A SHEAR-WEB CONFIGURATION ATTACHED BY TWO ROWS OF BOLTS TO EACH MOUNTING BASE AT THE COMMON CENTER OF THREE BASES. THIS METHOD PREVENTS SWAY AND ALLOWS FOR REMOVAL OF INDIVIDUAL MODULES FOR MAINTENANCE.

AUXILIARY EQUIPMENT INCLUDES ELECTRICAL WIRING, HARD LINES, AND THE CONNECTIONS NECESSARY FOR PROPER SYSTEM OPERATION. THE INNER CAP SIDE OF RADIAL BEAM 4 SUPPORTS THE POWER CONTROL PANEL AT STATION $X_S = 259$. BEAM 3 HOLDS THE HELIUM DISTRIBUTION AND TEST PANEL.

5.4 S/M INTERIOR INSULATION

5.4.1 GENERAL

INSULATION MATERIAL OF CRINKLED, ALUMINIZED MYLAR IS USED IN ALL SECTORS OF THE SERVICE MODULE AND ALSO BETWEEN THE SERVICE MODULE AND THE COMMAND MODULE. THE INSULATION WILL HELP IN MAINTAINING THE TEMPERATURE OF THE PROPELLANTS OF THE TWO PROPULSION SYSTEMS.

5.4.2 FABRICATION AND INSTALLATION

MATERIAL USED FOR INSULATION IS ONLY .0005 OF AN INCH IN THICKNESS PER SHEET. FORTY SHEETS ARE ESTIMATED AS SUFFICIENT THICKNESS TO PROVIDE FOR A TEMPERATURE RANGE OF -420 TO 200 F. RECTANGULAR BLANKETS OF 50 INCHES OR GREATER IN WIDTH ARE CUT TO THE DESIRED LENGTH, SEWN TOGETHER WITH NYLON THREAD. THEN CUT TO PATTERN SIZES BY MEANS OF TEMPLATES. STAPLES MAY BE USED TO AID IN BLANKET ASSEMBLY. INSTALLATION IS ACCOMPLISHED BY MEANS OF HOOK AND PILE TAPE, AND REFLECTIVE BACKED TAPE.

A TYPICAL INSTALLATION OF AN INSULATION BLANKET IS TO BOND THE HOOK TAPE TO THE STRUCTURE, SEW OR BOND THE PILE TAPE TO THE BLANKET AND PRESS THE TAPES TOGETHER. THE ALUMINIZED SIDE OF THE INSULATING MATERIAL MUST FACE TOWARD THE CENTER OF THE SECTOR OR ENCLOSED AREA IN WHICH IT IS INSTALLED.

THE INSULATION BLANKET FOR THE FORWARD BULKHEAD IS MADE IN FOUR SECTIONS. SECTION ONE COVERS SECTOR ONE, SECTION TWO COVERS SECTORS TWO AND THREE, SECTION THREE COVERS SECTOR FOUR, AND SECTION FOUR COVERS SECTORS FIVE AND SIX. THE SECTIONS ARE HELD TOGETHER AND TO THE BULKHEAD BY MEANS OF THE HOOK AND PILE TAPE. (FIGURE 5-8).

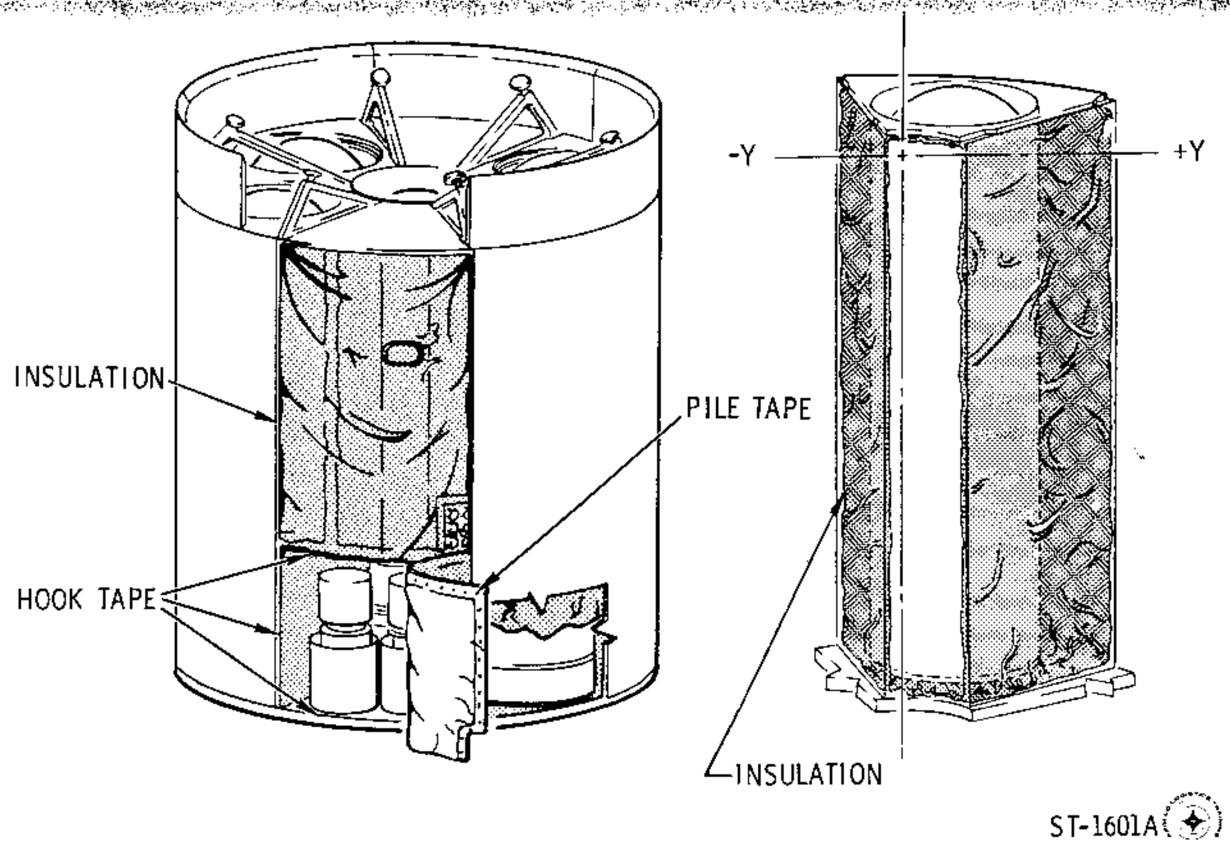

FIGURE 5-9

5-18

THE FAIRING INSULATION IS FABRICATED FROM SIX INDIVIDUAL BLANKETS, ONE FOR EACH FAIRING PANEL. EACH BLANKET IS INSTALLED TO A FAIRING PANEL BY MEANS OF HOOK AND PILE TAPE AT THE FORWARD AND AFT EDGES OF THE FAIRING. (FIGURE 5-8).

USE OF MULTI-LAYER ALUMINIZED MYLAR AS INSULATION MATERIAL FOR THE PROPELLANT TANKS IN SECTORS TWO AND FIVE (OXIDIZER), AND THREE AND SIX (FUEL) IS ESSENTIALLY THE SAME FOR EACH SECTOR.

THE INSULATION SURROUNDING EACH TANK OF THE SERVICE PROPULSION SYSTEM IS FABRICATED FROM THREE INDIVIDUAL BLANKETS. THE BLANKETS FOR THE RADIAL WEB BEAMS ARE TAPED TO THE BEAM AT THE FORWARD EDGE, AND AT THE AFT EDGE. THE RECTANGULAR BLANKET FOR THE INNER SURFACE OF THE OUTER SHELL COVERS THE SURFACE BETWEEN THE RADIAL WEB BEAMS FROM THE FORWARD BULKHEAD TO THE AFT BULKHEAD. THE BLANKET IS FASTENED TO THE INNER SURFACE OF THE OUTER SHELL BY MEANS OF THE HOOK AND PILE TAPE.

THE TANK ASSEMBLIES OF THE REACTION CONTROL SYSTEM (RCS), THE INNER SURFACE OF EACH RCS PANEL, AND THE INNER SURFACES OF ACCESS DOORS OF THE SERVICE MODULE ARE ALL INSTALLED INDEPENDENTLY.

ALLOWANCE IS MADE ON THE INNER SURFACE OF OUTER SHELL FOR THE ENVIRONMENTAL CONTROL SYSTEM'S RADIATOR PANELS IN SECTORS TWO AND FIVE, AND THE ELECTRICAL POWER SYSTEM'S RADIATOR PANELS IN SECTORS ONE AND FOUR.

INSULATION OF SECTOR FOUR IS ACCOMPLISHED BY THREE INDIVIDUAL BLANKETS OF ALUMINIZED MYLAR. ALL THREE BLANKETS EXTEND FROM STATION X_S - 355 TO STATION X_S - 260.37. THE ENTIRE ARC LENGTH OF SECTOR FOUR BETWEEN STATIONS X_S - 260.67 AND X_S - 203.16 IS A REMOVABLE PANEL AND IS INSUALTED SEPARATELY. (FIGURE 5-9)

THE INSULATION FOR SECTOR ONE IS FABRICATED FROM SIX INDIVIDUAL BLANKETS. THIS IS DUE TO THE HYDROGEN TANK MOUNTING SHELF. HOOK AND PILE TAPE IS ALSO USED FOR INSTALLATION OF EACH BLANKET.

THE INSULATION BLANKET FOR THE FORWARD HELIUM TANK IN THE CENTER SECTION, IS MADE TO CONFORM WITH THE SHAPE OF THE TANK, TO WITHIN 4.5 INCHES OF ITS EQUATOR.

THE BLANKET IS HELD IN PLACE BY EQUALLY SPACED STRIPS OF HOOK AND PILE TAPE.

5.4.3 <u>S/M AFT BULKHEAD HEAT SHIELD</u>

5.4.3.1 GENERAL

THE PURPOSE OF THE HEATSHIELD IS TO PROVIDE THERMO PROTECTION FROM THE SPS ENGINE IN ORDER TO CONTROL S/M INTERIOR TEMPERATURE. THE AFT BULKHEAD

S/M SPS NOZZLE AND HEAT SHIELD

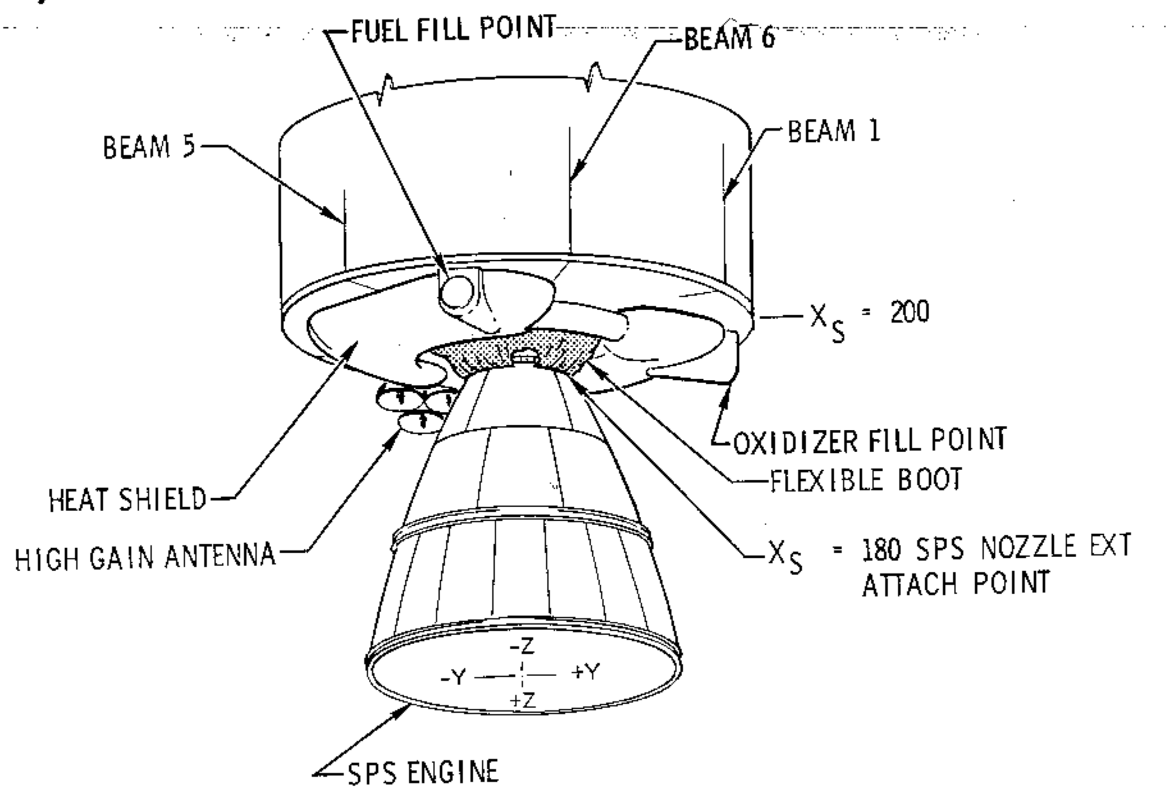

FIGURE 5-10

HEATSHIELD CONSISTS OF EIGHT MOLDED FIBERGLASS SECTIONS, TWO RING SECTIONS AND FLEXIBLE BOOT, AND A MYLAR INSULATION BLANKET. (FIGURE 5-10). THE AFT HEATSHIELD IS LOCATED BELOW THE AFT BULKHEAD AT STATION X_S = 200. ITS LOWEST POINT IS APPROXIMATELY AT STATION X_S = 187.

THE HIGH-GAIN ANTENNA, PART OF THE TELECOMMUNICATIONS SYSTEM, IS STOWED BENEATH SECTOR FOUR AND IS DEPLOYED INTO POSITION ON THE -Y AXIS.

BOTH HEATSHIELD AND STOWED ANTENNA ARE ENCLOSED BY THE LEM ADAPTER PRIOR TO LUNAR INJECTION.

5.4.3.2 FABRICATION

THE SHIELD IS FABRICATED IN EIGHT SECTIONS. EACH MOLDED SECTION IS CONSTRUCTED OF AN INNER LAYER OF FIBERGLASS, MIDDLE LAYER OF Q-FELT, AND AN OUTER LAYER OF 5 MIL NICKEL. ATTACHED TO THE INNER FIBERGLASS LAYER IS A 40 SHEET MYLAR INSULATION BLANKET. THE PERIMETER OF THE HEATSHIELDS ARE PROVIDED WITH BOLT HOLES FOR ATTACHMENT TO THE S/M BULKHEAD, ADJACENT FLEXIBLE BOOT ASSEMBLYS, AND HEATSHIELDS.

FIVE OF THE MOLDED FIBERGLASS SECTIONS CONTAIN PRESSURE RELIEF VALVES TO PREVENT BUILDUP BETWEEN THE S/M INTERIOR AND EXTERIOR. THE VALVE IS A SPRING RETAINED, NORMALLY CLOSED, FOUR SECTION FLAPPER, PRESSURE RELIEF VALVE. IT IS FABRICATED OF ALUMINUM WITH STAINLESS STEEL SPRINGS, ATTACHING HARDWARE, AND A NON METALIC SEAT. TWO SERVICE OPENINGS AND PROPELLANT FILL PORTS ARE PROVIDED AND FURNISHED WITH THE COVERS.

5.4.3.3 S/M FLEXIBLE BOOT

THE FLEXIBLE BOOT ASSEMBLY CONSISTS OF TWO SEGMENTS OF HEAT RESISTANT INSULATION COVERED ON BOTH SIDES WITH HIGH SELICA IMPREGNATED CLOTH. THE REFRASIL CLOTH RING SECTIONS ARE BOLTED TO THE ENGINE HOUSING AT STATION X_S = 190 AND THE INNER PERIMETER OF THE HEAT SHIELD SECTIONS AT STATION X_S = 200. (FIGURE 5-10). AFTER INSTALLATION IS COMPLETE, THE TWO FLEXIBLE SECTIONS ARE BUTTONED TOGETHER, THUS FORMING A FLEXABLE HEAT SHIELD WHICH WILL ALLOW THE ENGINE TO GIMBAL AND PREVENT EXCESSIVE HEAT FROM ENTERING THE SERVICE MODULE INTERIOR DURING ENGINE OPERATION.

SECTION VI

ADAPTER STRUCTURE

6.1 GENERAL DESCRIPTION

THE SPACECRAFT LEM ADAPTER (SLA) CONNECTS THE S/M TO THE S-IVB INSTRUMENT UNIT. THE SLA IS LOCATED BETWEEN STATIONS X_A = 838 AND X_A = 502. IT HOUSES THE LUNAR EXCURSION MODULE (LEM), THE NOZZLE OF THE SERVICE PROPULSION SYSTEM, AND THE HIGH GAIN ANTENNA IN THE STOWED POSITION OF THE AFT HEAT SHIELD (SEE FIGURE 6-1).

6.2 STRUCTURE AND CONFIGURATION

6.2.1 GENERAL

THE SLA IS A TRUNCATED, CONIC STRUCTURE WITH A LENGTH OF 336 INCHES ON ITS X AXIS, A CONE-ELEMENT LENGTH OF ABOUT 349 INCHES, AND A CONIC ANGLE OF SLIGHTLY MORE THAN NINE DEGREES. THE SLA STRUCTURE FORMS TWO SETS OF PANELS, FOUR PANELS PER SET. THE PANEL HEIGHT OF THE FORWARD SET IS APPROXIMATELY 254 INCHES; OF THE AFT SET 82.7 INCHES. THE SEPARATION PLANE IS STATION X_A = 583.2. INTERFACE EDGES OF THE FORWARD SET OF PANELS HAVE THE FOLLOWING ARC LENGTHS: AT FORWARD EDGE-121 INCHES, AT AFT EDGE-184 INCHES. INTERFACE EDGES OF THE AFT SET OF PANELS HAVE THESE ARC LENGTH: AT THE FORWARD EDGE-APPROXIMATELY 184 INCHES, AT AFT EDGE-APPROXIMATELY 204 INCHES.

6.2.2 FABRICATION

THE FORWARD AND AFT PANELS OF THE SLA ARE FABRICATED OF ALUMINUM-ALLOY (2024T-81) HONEYCOMB SANDWICH MATERIAL 1.7 INCHES THICK. BONDED TO THE HONEYCOMB WILL BE FACE SHEETS OF VARYING THICKNESSES. THE FORWARD SET OF PANELS, BECAUSE OF THE SIZE, ARE FABRICATED INTO SECTIONS AS SHOWN IN FIGURE 6-1. AFTER FABRICATION, THE VARIOUS SECTIONS ARE BONDED TOGETHER. THE SPLIT LINES OF THE INDIVIDUAL SEGMENTS WILL BE COVERED WITH SPLICE PLATES BONDED TO THE INNER AND OUTER FACE SHEETS. THE ATTACH POINT TO THE SERVICE MODULE AND THE SEPARATION PLANE AT STATION X_A = 583.2, IS ACHIEVED BY CURVED ALUMINUM SPLICE PLATES WHICH HOLD MDF CHARGES. THE SPLICE PLATES ARE FABRICATED OF ALUMINUM .060" THICK AND ARE BOLTED AND RIVETED TO THE INDIVIDUAL PANELS. THE LATERAL UNION OF THE AFT PANELS TO THE INSTRUMENT UNIT IS BY FLANGES AND BOLTS WITHOUT THE USE OF CHARGES.

6.2.2.1 MAINTENANCE - ACCESS

TWO MAINTENANCE/ACCESS DOORS ARE PROVIDED IN THE FORWARD PANELS ON THE +Z AND -Z AXIS. THE ACCESS PANEL LOCATED ON THE +Z AXIS ALLOWS FREE ENTRY INTO THE SLA AND PERMITS REMOVAL OF GRUMMAN'S SUIT

SPACECRAFT LEM ADAPTER

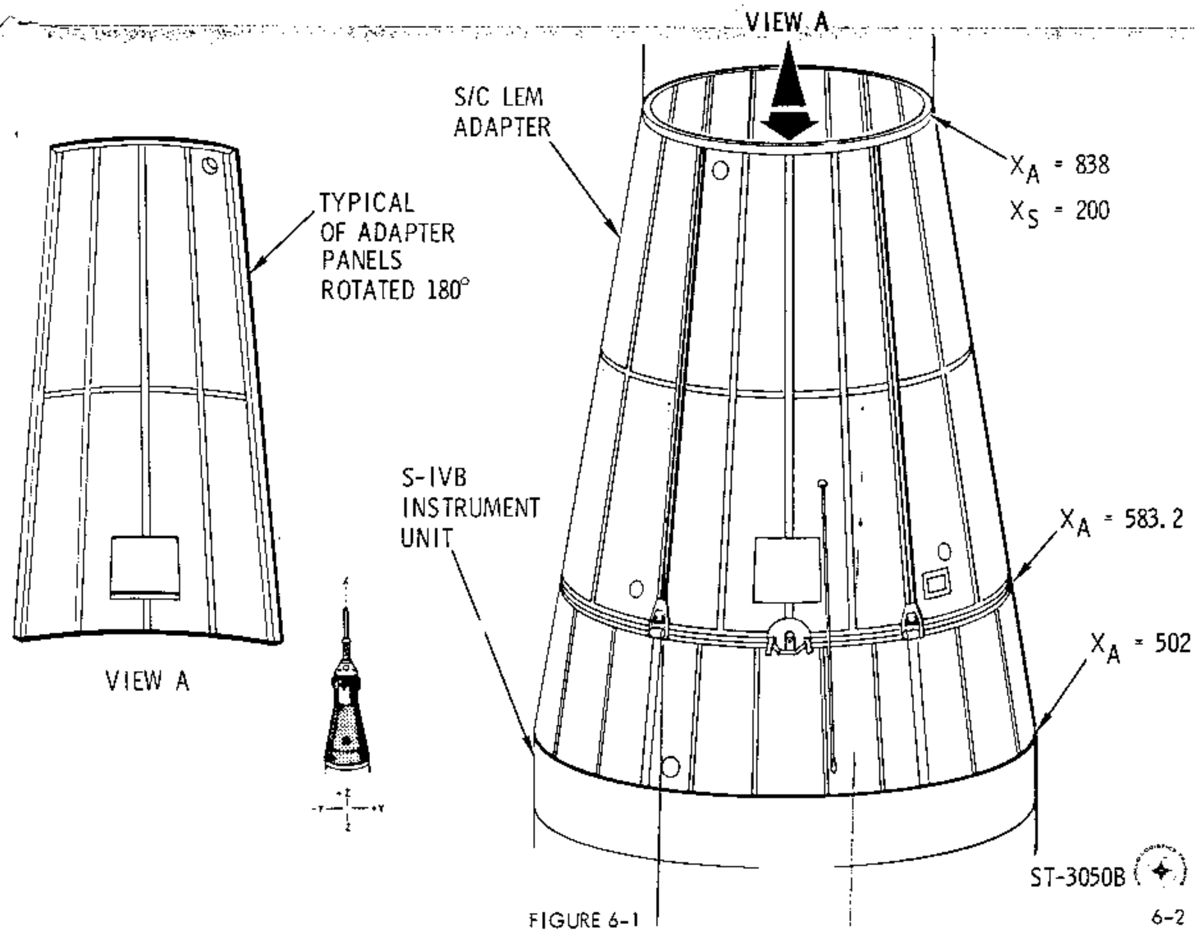

FIGURE 6-1

6-2

COOLING UNIT FROM THE CABIN. THE ACCESS PANEL LOCATED ON THE -Z AXIS SHOWN IN FIGURE PROVIDES ACCESS TO THE SLA AND THE LEMS FORWARD HATCH.

TEN VENTS OR SERVICE OPENINGS ARE PROVIDED IN THE SLA ASSEMBLY. TWO OF THESE VENTS SERVE AS PROPELLANT SERVICING POINTS FOR THE SERVICE MODULE. ONE LARGE PENETRATION IS A FLY-AWAY UMBILICAL DISCONNECT, AND THE REMAINING SEVEN ARE FOR LEM ACCESS AND SERVICING.

6.3 PANEL SEPARATION

THE SPACECRAFT LEM ADAPTER (SLA) TO SERVICE MODULE SEPARATION AND SEPARATION OF SLA INTO FOUR PANELS IS ACCOMPLISHED BY AN EXPLOSIVE TRAIN. THIS EXPLOSIVE TRAIN CONSISTS OF 28 CHARGE HOLDERS, TWO INITIATORS AND SHIELDS, EIGHT PANEL THRUSTERS, AND AN UMBILICAL SEPARATION SYSTEM (SEE FIGURE 6-2). EACH SYSTEM WILL BE DESCRIBED IN DETAIL.

6.3.1 CHARGE HOLDER

EACH CHARGE HOLDER CONTAINS TWO STRANDS OF MILD DETONATING FUSE (MDF), (ONE WILL SEVER THE JOINT, TWO ARE USED FOR REDUNDANCY), WITH BOOSTERS AT THE ENDS. CROSSOVER BOOSTERS ARE USED AT THE CHARGE HOLDER JOINTS TO INSURE DETONATION ACROSS THE JOINTS. THE DETONATING CORD LOCATED WITHIN THE CHARGE HOLDER, IS A METAL CLAD EXPLOSIVE USED FOR BREAKING MATERIALS AND/OR FOR TRANSFERRING DETONATION FROM ONE JUNCTION TO ANOTHER. THIS CORD IS A SEAMLESS, CONTINUOUS LEAD SHEATH SURROUNDING THE EXPLOSIVE CORE. THE EXPLOSIVE CORE IS VIRGIN RDX, CLASS G, AND THE METAL JACKET, OR SHEATH, IS A LEAD-ANTIMONY ALLOY. THE SLA SYSTEM UTILIZES CORDS WITH EXPLOSIVE LOADINGS OF FIVE AND SEVEN GRAINS PER FOOT (SEE FIGURE 6-3).

TWO CHARGES ARE CONFINED BY THE OVERLAPPING OF THE SPLICE PLATE EXTRUSION AND THE CHARGE HOLDER (SEE FIGURE 6-4). UPON DETONATION OF THE MDF, THE EXPLOSIVE FORCE IS CONCENTRATED ALONG A PREDETERMINED LINE AND THE SPLICE PLATE SEPARATES. THE SEPARATION OF THE SPLICE PLATE IS CAUSED BY HIGH SHEAR AND TENSION LOADS. THE DETONATION WILL ALSO TRANSMIT AN IMPULSE TO THE PANEL THRUSTER WHICH ASSIST IN OPENING THE PANELS.

6.3.2 INITIATOR AND SHIELD

TWO INITIATORS ARE USED TO SEPARATE THE SERVICE MODULE (S/M) AND SPACECRAFT LEM ADAPTER (SLA) PANELS (SEE FIGURE 6-2, 6-5). THE SIGNAL TO START THE SEPARATION COMES FROM THE COMMAND MODULE TO THE INITIATOR. THE INITIATOR SETS OFF THE ATTACHED DETONATOR WHICH IGNITES THE MDF ASSEMBLY. ALL THE MDF IS CONFINED, CAUSING THE SPLICE PLATES TO FRACTURE.

6.3.3 PANEL THRUSTERS

THE PANEL THRUSTERS SYSTEM CONSISTS OF A PAIR OF THRUSTERS AT EACH CORNER OF THE LOWER PANEL INTERSECTION. EACH THRUSTER CONTAINS A PISTON WHOSE

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ADAPTER SEPARATION SYSTEM

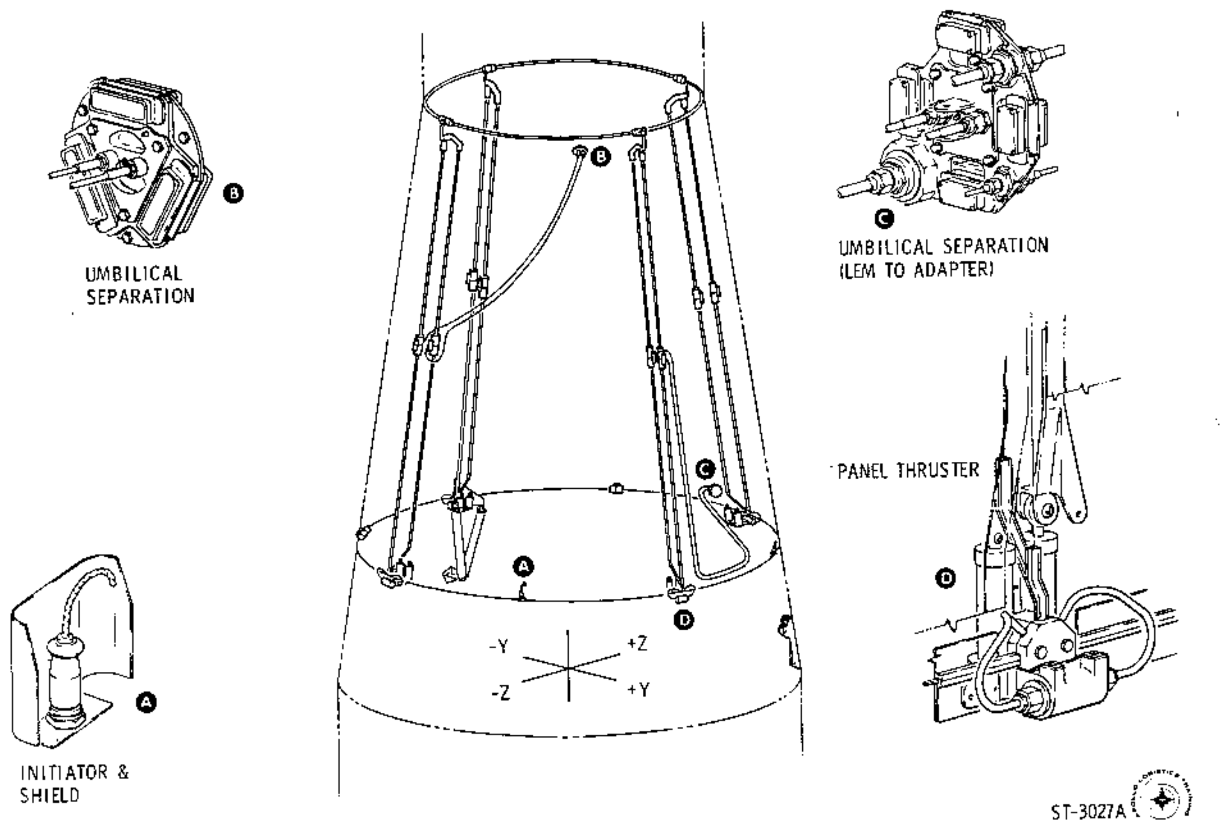

FIGURE 6-2

6-4

SHAPED CHARGES

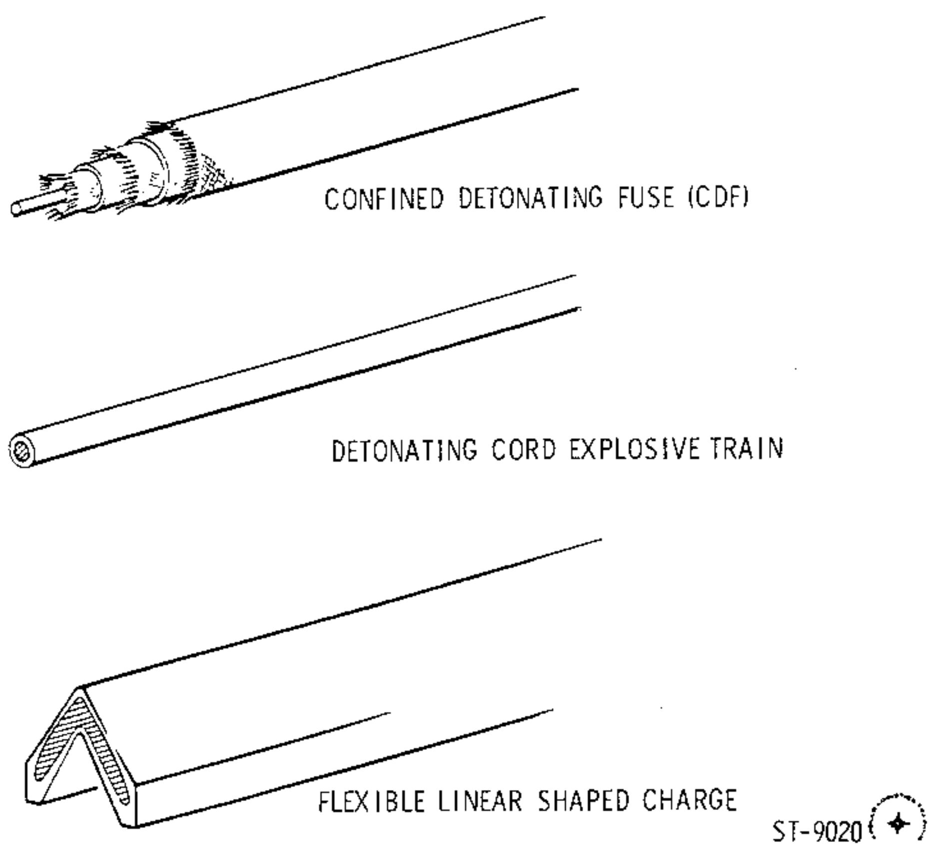

FIGURE 6-3

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ADAPTER PANEL SEPARATION LINE

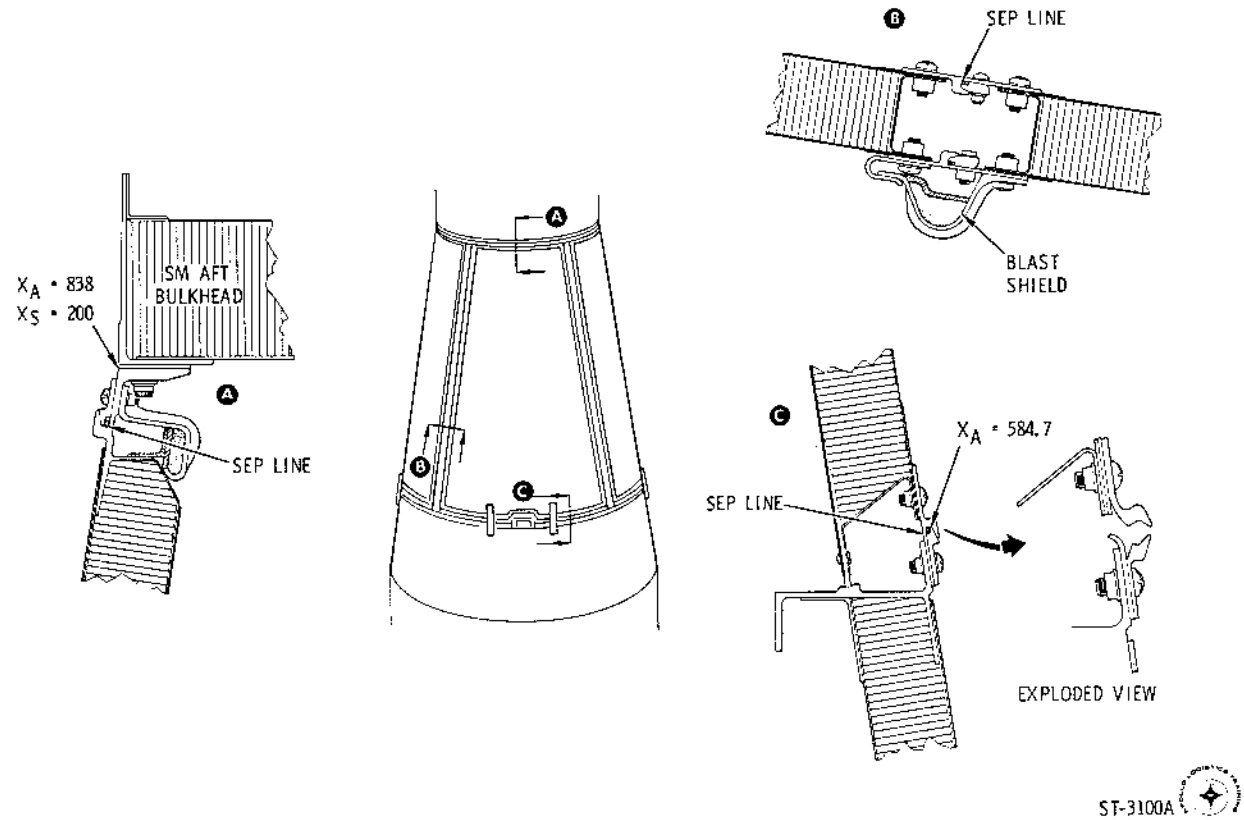

FIGURE 6-4

SLA INITIATOR AND SHIELD

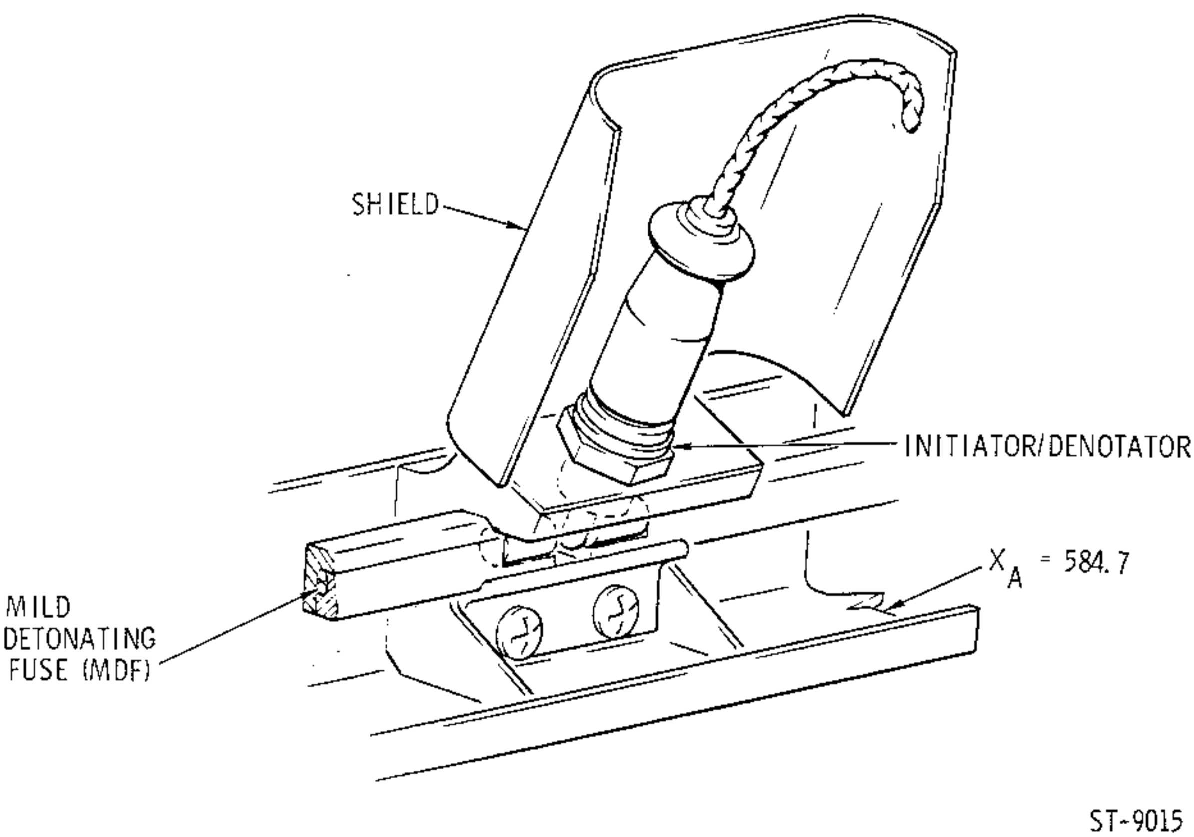

FIGURE 6-5

ROD END IS CONNECTED TO THE SLA PANEL. THE THRUSTER ASSEMBLY CONTAINS TWO PRESSURE CARTRIDGES FOR REDUNDANCY. (SEE FIGURE 6-2 AND 6-6).

THE PANEL THRUSTERS ARE OPERATED BY A THROUGH-BULKHEAD, CONFINED DETONATING FUSE (CDF) INITIATED PRESSURE CARTRIDGE (FIGURE 6-7) WHICH ILLUSTRATES A TYPICAL THROUGH THE BULKHEAD PRESSURE CARTRIDGE. THIS PRESSURE CARTRIDGE DIFFERS FROM THE CONVENTIONAL PRESSURE CARTRIDGE IN THAT A SOLID BULKHEAD WITHIN THE CARTRIDGE BODY PREVENTS ANY BACK PRESSURE. THE CONFINED DETONATING FUSE, WHICH CONTAINS A CORE OF MILD DETONATING FUSE, INITIATES THE "DONOR" CHARGE WHICH TRANSMITS THE DETONATION WAVE THROUGH THE SOLID BULKHEAD. THIS WAVE IS OF SUFFICIENT INTENSITY TO DETONATE A PRIMER OR RECEPTOR CHARGE WITHOUT RUPTURING THE BULKHEAD. THE RECEPTOR CHARGE THEN IGNITES AN INTERMEDIATE CHARGE WHICH IN TURN IGNITES THE PROPELLANT OR GAS PRODUCING GRAINS. EACH PRESSURE CARTRIDGE IS INITIATED BY TWO STRANDS OF MDF WHICH ARE DETONATED BY THE DETONATION OF THE SLA SEPARATION EXPLOSIVE TRAIN.

THE GAS PRESSURE CARTRIDGE PROVIDES THE NECESSARY THRUST THROUGH A 1.5 INCH STROKE TO OPEN THE PANELS. THE ROD SEPARATES FROM THE THRUSTER CYLINDER AND REMAINS WITH THE PANEL.

6.3.4 UMBILICAL SEPARATION (SLA TO S/M)

THE SYSTEM CONSISTS OF THREE SETS OF RECTANGULAR RACK AND PANEL TYPE ELECTRICAL CONNECTORS (SEE FIGURE 6-2 AND 6-8). THE RECEPTACLE PORTION OF EACH CONNECTOR IS MOUNTED TO THE FLANGE OF A CYLINDRICAL CHAMBER. THE PLUG PORTION OF EACH CONNECTOR IS MOUNTED TO THE FLANGE OF A PISTON SHAPED MEMBER WHICH FITS INTO THE CYLINDRICAL CHAMBER. WITHIN THE CHAMBER OF THIS PISTON CYLINDER ASSEMBLY ARE TWO LOOPS OF MDF ATTACHED TO THE PISTON HEAD. THE TWO ASSEMBLIES ARE HELD TOGETHER WITH A FRANGIBLE BOLT. TWO CONFINED DETONATING FUSES ARE ROUTED FROM JUNCTIONS OF THE ADAPTER SPLICE PLATE MDF'S TO THE PISTON END OF THE DISCONNECT. THE BOOSTERS OF THE CDF'S ARE PROJECTING INTO THE FIRING CHAMBER AND ARE IN INTIMATE CONTACT WITH THE MDF BOOSTERS.

THE CONFINED DETONATING FUSE HAS A CORE OF MILD DETONATING FUSE WHICH IS COVERED WITH SEVERAL LAYERS OF PLASTIC TUBING, FIBERGLASS MATTING, AND NYLON COVERS (SEE FIGURE 6-3). IT IS USED TO TRANSFER A DETONATION WAVE BETWEEN TWO OR MORE BOOSTER CHARGES. THE DETONATION IS COMPLETELY CONTAINED BY THE INSULATION BUILD-UP. BECAUSE THE DETONATION IS COMPLETELY CONTAINED, THE CONFINED DETONATION FUSE MAY BE ROUTED IN CLOSE TO SENSITIVE ELECTRONIC TELEMETERING INSTRUMENTS, STRUCTURAL MEMBERS, OR THROUGH CROWDED AREAS WITHOUT DAMAGE.

THEN THE ADAPTER PANEL MDF'S ARE DETONATED, THE CDF'S TRANSFER DETONATION FROM THE ADAPTER PANEL MDF'S TO THE MDF'S IN THE UMBILICAL DISCONNECT. PRESSURE IN THE FIRING CHAMBER PRODUCES FAILURE OF THE INTERCONNECTING FRANGIBLE BOLT ALLOWING THE UMBILICAL HALVES TO SEPARATE. ONE HALF REMAINS FIXED ON THE

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SLA THRUSTER LAYOUT

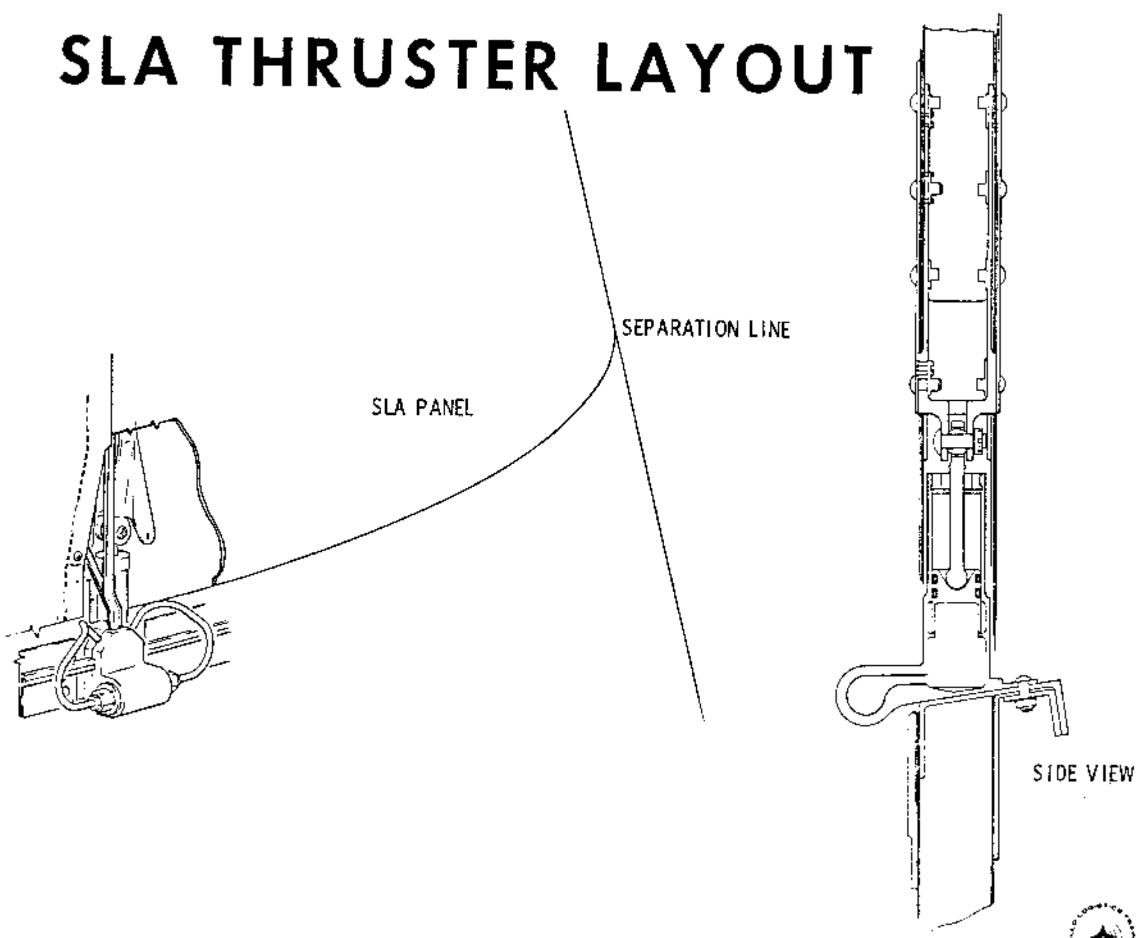

FIGURE 6-6

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THROUGH-BULKHEAD PRESSURE CARTRIDGE

TYPICAL

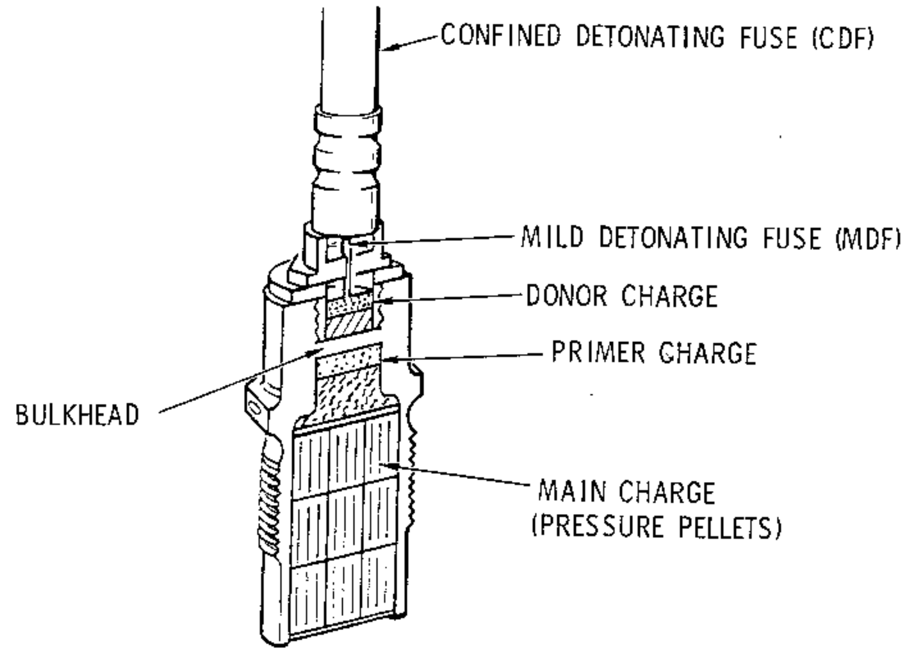

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FIGURE 6-7

S/M TO ADAPTER UMBILICAL SEPARATION

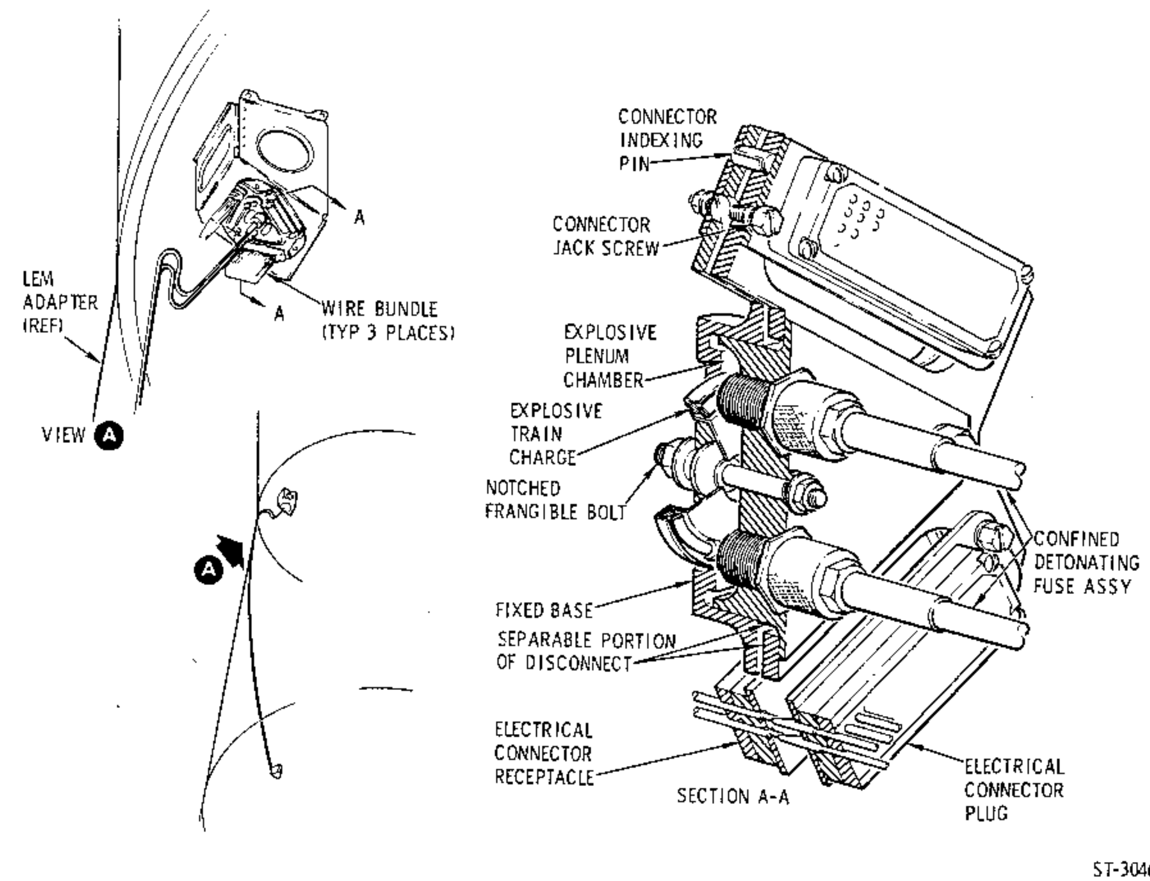

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FIGURE 6-8

SERVICE MODULE AFT BULKHEAD WHILE THE FREE PISTON PORTION IS DEPLOYED WITH THE ADAPTER PANEL. THIS END IS CAPTURED BY THE ADAPTER PANEL AND THE ATTACHED WIRE BUNDLE WHICH MAY CONSIST OF 200 TO 300 NUMBER 20 GUAGE WIRES.

6.3.5 UMBILICAL SEPARATION (LEM TO SLA)

THE DISCONNECT INTERFACE CONSISTS OF FOUR SETS OF RECTANGULAR RACK AND PANEL TYPE ELECTRICAL CONNECTORS AND THREE HARD LINES WITH RADIAL SQUEEZE "O" RINGS IN A SLIP TYPE JOINT (SEE FIGURE 6-9). THE RECEPTACLE PORTION OF EACH ELECTRICAL CONNECTOR AND ONE HALF OF EACH HARD LINE SLIP JOINT ARE MOUNTED TO THE FLANGE OF A CYLINDRICAL CHAMBER.

THE PLUG PORTION OF EACH CONNECTOR AND THE HARD LINE SLIP JOINT ARE MOUNTED TO THE FLANGE OF A PISTON WHICH FITS SNUGLY INTO THE CYLINDER. WITHIN THE CHAMBER OF THIS PISTON CHAMBER ASSEMBLY ARE TWO LOOPS OF MDF ATTACHED TO THE PISTON HEAD. THE PISTON PLUG ASSEMBLY IS RETAINED TO THE CYLINDER RECEPTACLE ASSEMBLY AXIALLY WITH A SINGLE FRANGIBLE BOLT.

TWO CDF ASSEMBLIES WILL RUN FROM THE JUNCTION OF THE ADAPTER SPLICE PLATE MDF'S TO THE PISTON ASSEMBLY. WHEN THE ADAPTER PANEL MDF'S ARE DETONATED, THE CDF'S WILL TRANSFER THE DETONATION TO THE MDF'S SEPARATING THE UMBILICAL HALVES.

ONE HALF REMAINS FIXED ON THE LEM, WHILE THE FREE PISTON PORTION IS ROTATED CLEAR OF THE LEM BY THE ACTION OF THE PANEL OPENING.

6.3.6 PANEL OPERATION

THE FORWARD PANELS ARE INDIVIDUALLY STRAP-HINGED AT THE MIDPOINTS OF THEIR AFT ARC EDGES LOCATED AT THE ENDS OF AXES +Y, -Z, +Z, -Z (SEE FIGURE 6-10). THE HINGES ARE BOLTED TO BOTH FORWARD AND AFT PANELS OF THE SLA. WHEN THE FORWARD PANELS HAVE BEEN OPENED BEFORE DOCKING, THE HINGES PREVENT PANEL DISCARD. THE SIGNAL TO START THE SEPARATION COMES FROM THE C/M TO THE SLA INITIATOR. THE INITIATOR/DETONATOR COMBINATION WILL IGNITE THE MDF CAUSING A TRAIN REACTION. THIS TRAIN REACTION WILL SEVER THE SPLICE PLATES ALLOWING THE PANELS TO SEPARATE, DETONATING MDF, CAUSING THE UMBILICAL TO SEPARATE, AND INITIATING THE PRESSURE CARTRIDGE IN THE THRUSTER ASSEMBLIES. THE THRUSTER IMPULSE ON THE PANEL IS FOR APPROXIMATELY TWO DEGREES OF PANEL TRAVEL. THIS MOMENTUM AND A TENSION CABLE AND PULLEY ARRANGEMENT WILL MOVE THE PANELS THROUGH THE REMAINING REQUIRED TRAVEL.

PANEL DECELERATION IS ACCOMPLISHED BY 8 ATTENUATOR STRUTS LOCATED ON THE FIXED LOWER ADAPTER. THESE STRUTS CONTAIN ALUMINUM HONEYCOMB CORE THAT WILL CRUSH AND ABSORB THE ENERGY FROM THE PANEL (SEE FIGURE 6-11).

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UMBILICAL SEPARATION

LEM TO ADAPTER

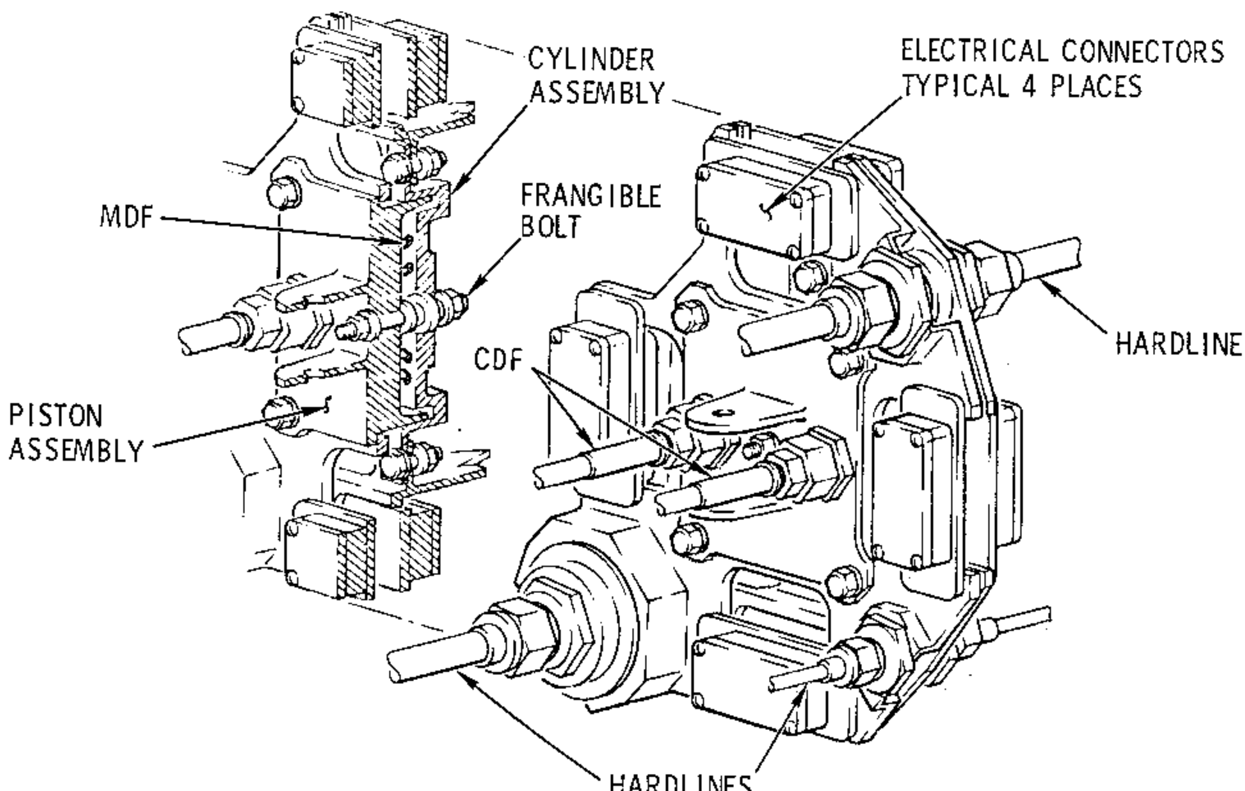

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FIGURE 6-9

SLA PANEL DEPLOYMENT

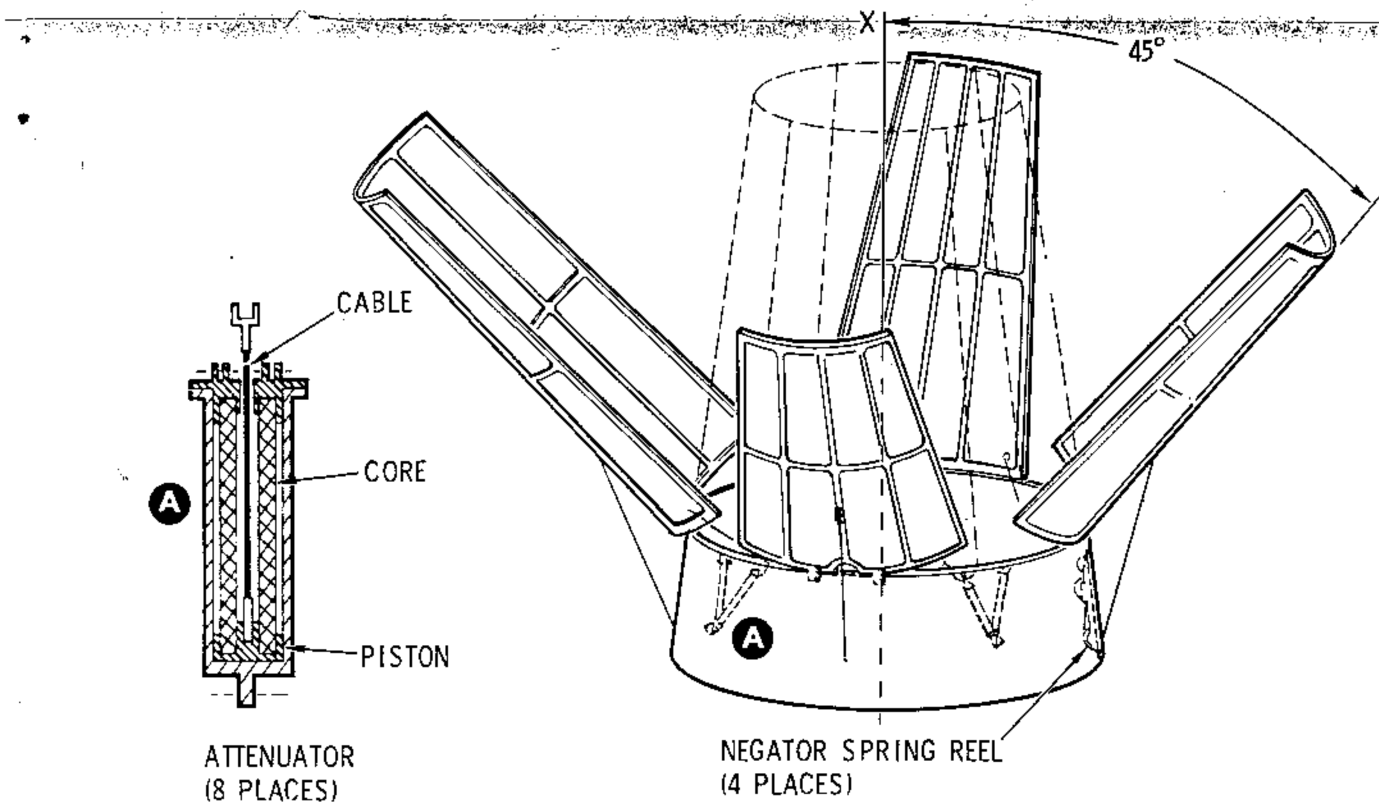

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FIGURE 6-10

SLA PANEL ATTENUATION COMPONENTS

SPRING REEL MECHANISM

ATTENUATOR STRUTS

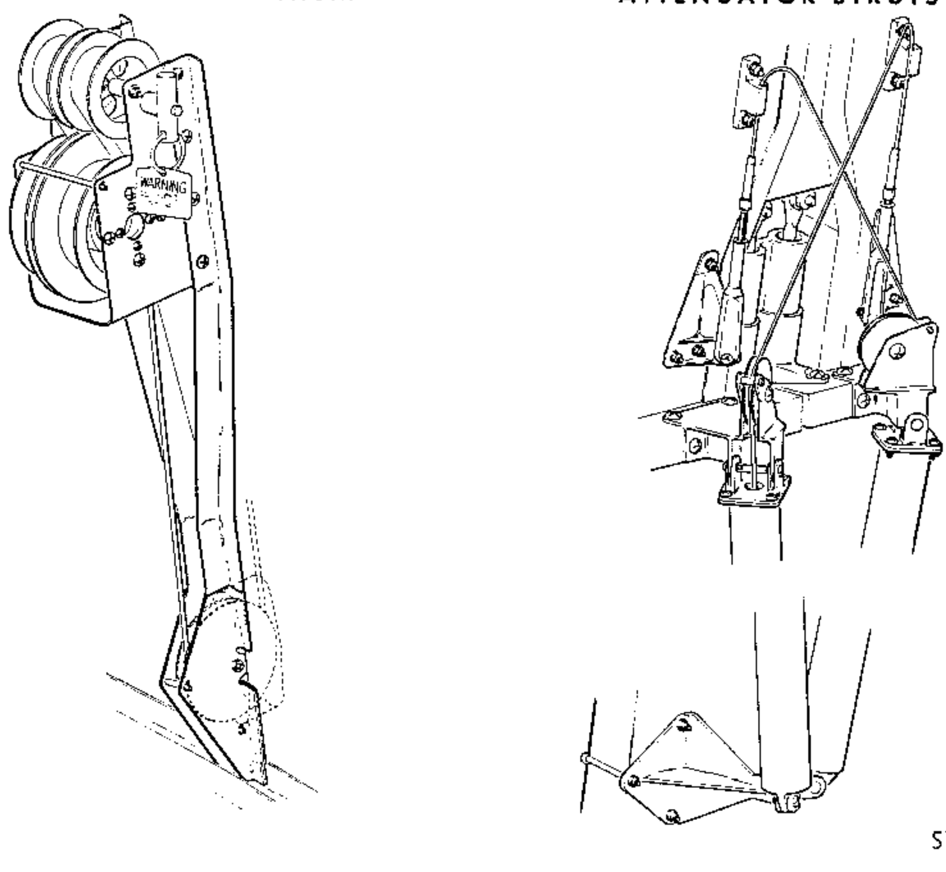

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FIGURE 6-11

After the panels are open they will be retained by a "no back" clutch. This clutch is located within the spring loaded reel and will prevent the cable from extending (see figure 6-11).

6.4 LEM SEPARATION SYSTEM

6.4.1 General

The Lunar Excursion Module (LEM) is attached within the aft adapter at four points which coincide with panel hinge placement. After the forward adapter panels are separated and deployed, the Command Module and Service Module maneuver around and dock with the Lem. A connector for Lem separation is manually mated in the docking tunnel to complete the circuit between the Command Module and the Lem. Two detonators and a frangible link is used to separate the LEM from the SLA attach points see figure 6-12.

A standard detonator, where applicable, is used throughout the Apollo Ordnance Systems figure 2-13. The standard initiator is used as the ignitor for the detonator. The initiator is welded to the detonator and when electrical potential is applied to the bridgewire the primary and secondary charges are ignited. This then ignites the explosive train within the detonator. The detonator explosive train consists of a primary charge of Lead Ozide and secondary charge of RDX.

6.4.2 Operation

Initiation of the detonators is accomplished from a signal in the Command Module. The frangible link is fractured by firing the two detonators. Should a detonator or A or B circuit fail, either detonator is capable of creating enough pressure to fracture the link. A blast shield is attached over the detonators and frangible link to protect the Lem should there be any flying fragments see figure 6-12.

After the strap is severed, two springs hold the tension strap in an open position to provide clearance for the Lem to lift off the fixed adapter.

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LEM SEPARATION SYSTEM

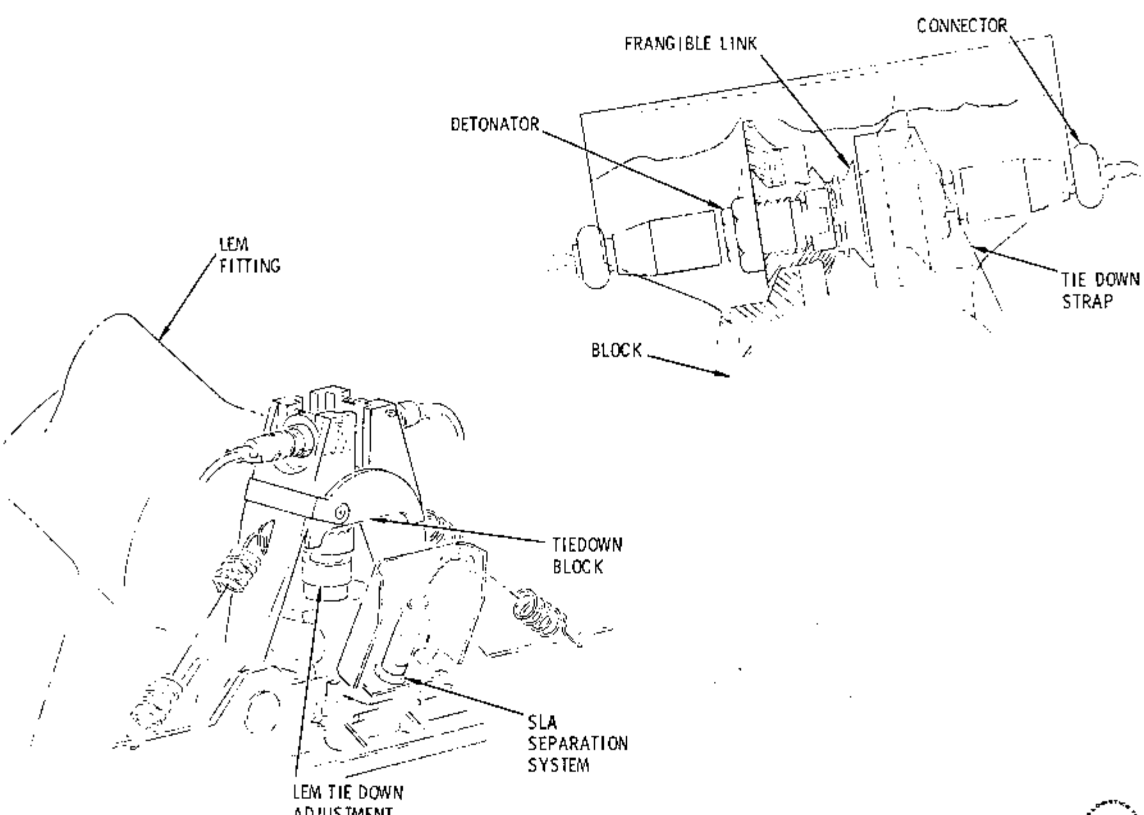

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FIGURE 6-12