

LAUNCH OPERATIONS CENTER

TR -4 -4 -2-D JUNE 15, 1963

SATURN V SERVICE ARMS PRELIMINARY ENGINEERING REPORT Complex 39

VOLUME I

LOC-FORM I6B-I

LAUNCH OPERATIONS CENTER

TR-4-4-2-D

SATURN V SERVICE ARMS

PRELIMINARY ENGINEERING REPORT

VOLUME I

SATURN HISTORY DOCUMENT University of Alabama Research Institute History of Science & Technology Group

ABSTRACT

Date _____ Doc. No. _____

This report presents the manufacturing requirements for fabricating Saturn V service arms and contains design and operating details of the service arms and associated equipment.

Part 1 defines the areas of responsibility necessary for the manufacture of Saturn V service arms and associated equipment. Capability requirements, manufacturing processes, special techniques, schedules, and other areas are detailed in Part 1. The manufacturer selected to fabricate the arms and related equipment must meet the requirements stated in Part 1.

Part 2 contains design and operation details of the service arms, Command Module Access Arm, and related equipment used on or in support of the Launcher-Umbilical Tower for the Saturn V Vehicle at Complex 39. The design and construction of all basic arms is similar. Eight service arms are being designed. The arms are being designed to support all umbilical lines necessary to service the various stages of all Saturn V Vehicles. The arms are also being designed to allow personnel access to the vehicle.

Some of the arms must be retracted before vehicle lift-off and others will retract following lift-off. This requirement necessitated the design of umbilical disconnect and arm retract devices which would ensure clearance between the arms and vehicle during lift-off.

The Command Module Access Arm is a separate design concept. The arm is used only for astronaut access to the Command Module.

Part 2 presents the preliminary design directed toward meeting the requirements stated above.

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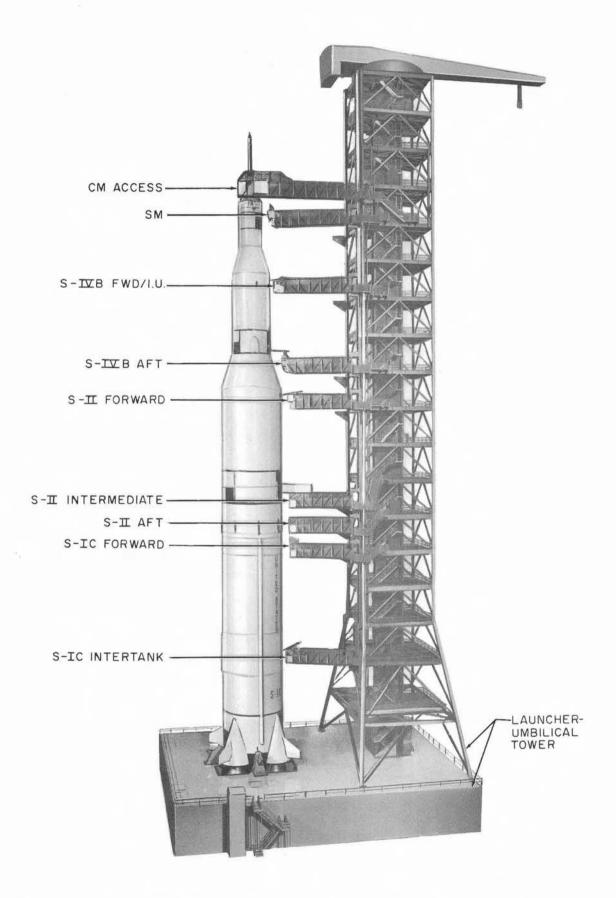
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TR-4-4-2-D July 10, 1963

SATURN V SERVICE ARMS PRELIMINARY ENGINEERING REPORT COMPLEX 39

VOLUME I

LAUNCH EQUIPMENT BRANCH LAUNCH SUPPORT EQUIPMENT ENGINEERING DIVISION LAUNCH OPERATIONS CENTER HUNTSVILLE, ALABAMA



Scale Model of Proposed Launcher-Umbilical Tower (LUT)

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SUMMARY

This volume of the Preliminary Engineering Report presents requirements for fabricating Saturn V Service Arms and contains design and operating details of the service and access arms and associated equipment.

Part 1 defines the areas of responsibility necessary for the manufacture of Saturn V service arms and associated equipment. Capability requirements, manufacturing processes, special techniques, schedules, and other areas are detailed in Part 1. The manufacturer selected to fabricate the arms and related equipment must meet the requirements stated in Part 1.

Part 2 is primarily devoted to the design and operation of the service arms and Command Module Access Arm to be used at Launch Complex 39. Additional information included in this report describes the function of the arms in various prelaunch modes, the location of each arm with respect to the vehicle, and the design criteria. Auxiliary equipment, used in conjunction with the subject arms, is described, and the supporting function of this equipment is explained.

The major assemblies of the service arm include the first and second elements, extension elements, withdrawal mechanisms, and extension platforms. The rotation of the service arm is accomplished by a cylindertype hydro-pneumatic system.

The major assemblies of the access arm include the basic arm structure, an extension to the arm structure, and an environmental cab. Rotation of the arm is accomplished by a hydraulic system using pistonrack type rotary actuators.

PART 1

SCOPE OF WORK

FOR

FABRICATION

SATURN V SERVICE ARMS

RELATED EQUIPMENT

AND

OF

1-1. INTRODUCTION.

The scope of work covered in Part 1 consists of furnishing all plant facilities, labor, material, and equipment necessary for the fabrication and delivery of the Saturn V Service Arms and associated equipment, per provisions stated herein and in Part 2. Figure 1-1 illustrates a portion of the service arms and associated equipment. The arms will provide service and personnel access to the Saturn V Vehicle which will be launched from Launch Complex 39, Cape Canaveral, Florida. Some of the service arms will be retracted prior to launching of the vehicle; the remainder will retract during launch. Complete operational testing of each arm and accessories will be completed by NASA personnel before the equipment is installed on Complex 39.

1-2. DESCRIPTION OF EQUIPMENT.

The contract will include fabrication of the following components:

1-3. ARM BASIC STRUCTURE.

The arm basic structure (Figure 1-2) will be a welded truss composed of round and square tubular shapes of T-1 steel. The maximum chord member is 3×3 inches square, with a wall thickness of 0.188 inch.

Each arm is made up of two structural elements. The first element will be common to all arms. The approximate dimensions for this element are 272 inches long, 60 inches wide, and 98 inches high. The second element varies in length from 146 inches to 182 inches, depending upon the vehicle stage being served. Width and depth dimensions are the same as on the first element.

1-4. EXTENSION PLATFORM.

The extension platform (Figure 1-3) is composed of five major parts as follows:

- a. A basic platform support, similar in construction to the basic arm, of square tubular shapes of T-1 steel.
- b. A T-head service area which is mounted to the basic platform support, and similar in construction to (a).
- c. A bumper assembly which makes contact with the vehicle.
- d. A coupler assembly which connects the bumper to the vehicle.
- e. The drive mechanisms which position the basic platform support and the T-head.

Varying vehicle configurations require modifications to the extension platform. The modifications are detailed in Part 2.

1

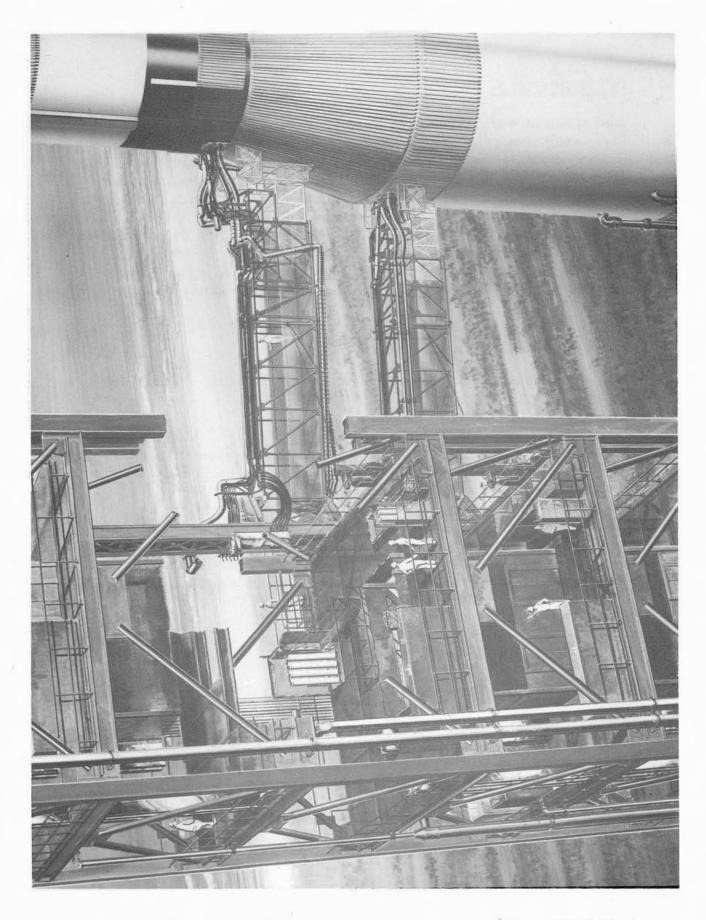


Figure 1-1. S-IVB AFT and S-II FWD Service Arms and Associated Equipment

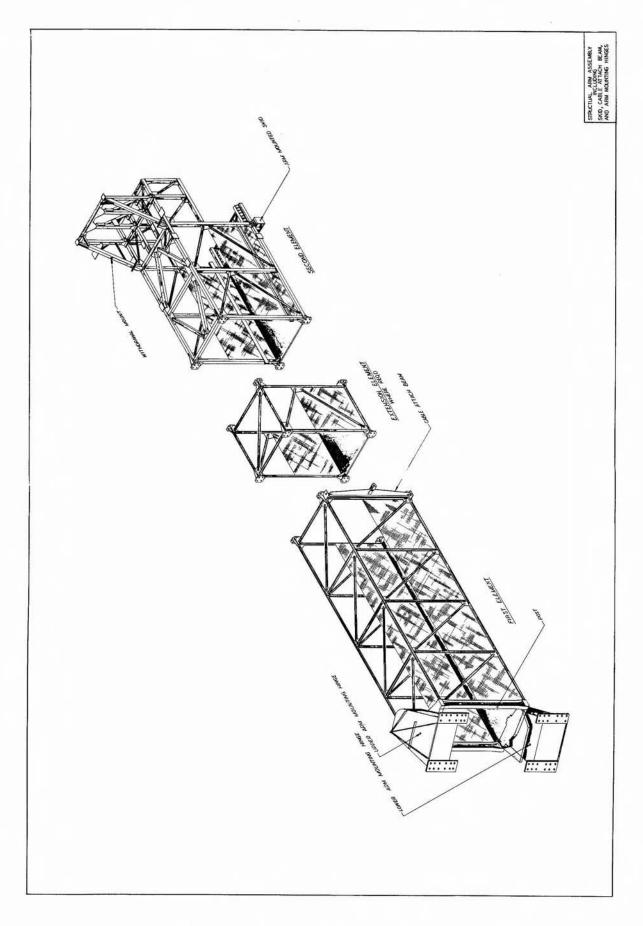


Figure 1-2. Arm Basic Structure

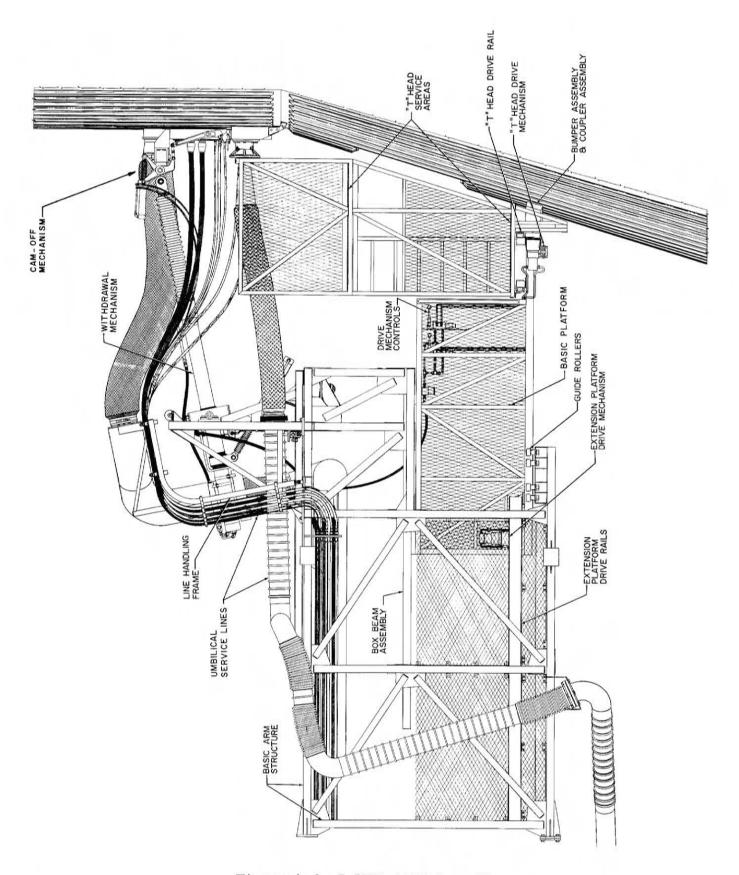


Figure 1-3. S-IVB AFT Arm Tip

1-5. TOWER MOUNTING HINGES.

Two hinges (Figure 1-4), positioned outboard of the arm at the top and bottom chords, house retraction cylinders, valves, and bearing assemblies. The hinges are plate weldments fabricated of A441 steel which varies in thickness from 0.5 to 1.5 inches. Each hinge is fastened to the tower with twenty-three 1-1/4-inch diameter high strength bolts. The hinges are standard for all the arms.

1-6. UMBILICAL SERVICE LINES.

The umbilical service lines (Figure 1-3) which connect the tower piping to the vehicle are supported on the service arms. They are composed of both hard and flex lines of various sizes and materials as follows:

- a. S-IC INTERTANK ARM two 8-inch I.D. stainless steel, vacuum-jacketed LOX lines.
- b. S-IC FWD ARM approximately 16 miscellaneous lines including 0.25-inch I. D. pneumatic lines, two 4-inch I. D. air conditioning ducts, and electrical cables.
- c. S-II AFT ARM one l-inch corrugated stainless steel bleed line.
- d. S-II INTERMEDIATE ARM one 8-inch I.D. LOX line, one 8-inch I.D. LH₂ line, each vacuum-jacketed corrugated stainless steel. In addition there are approximately 37 miscellaneous lines ranging from 0.25-inch I.D. to 2.00-inch I.D., and electrical cables, plus two 10-inch and one 4-inch air conditioning ducts.
- e. S-II FWD ARM two 8-inch I.D. corrugated stainless steel vent lines; twelve electrical cables; six miscellaneous pneumatic lines ranging in size from 0.25-inch I.D. to 1.00-inch I.D., and a 4-inch air conditioning line.
- f. S-IVB AFT ARM one 6-inch I.D. LOX line and one 6-inch I.D. LH₂ line, each vacuum-jacketed corrugated stainless steel, with 19 miscellaneous lines, 0.25-inch to 0.75-inch I.D., and electrical cables, plus one 10-inch air conditioning line.
- g. S-IVB FWD ARM one 6-inch I.D. corrugated stainless steel vent line; 29 miscellaneous lines, 0.25 to 1.50-inch I.D. electrical cables, and one 6-inch air conditioning line. The instrument unit umbilical lines are included in this grouping.
- h. Service Module ARM 12 miscellaneous lines, 0.25 to 1.25-inch
 I. D., and two 6-inch air conditioning lines.

1-7. HYDRAULIC AND PNEUMATIC SYSTEMS.

The major items in the hydraulic and pneumatic systems are the arm retraction systems (Figure 1-4) and the withdrawal mechanisms (Figure 1-3).

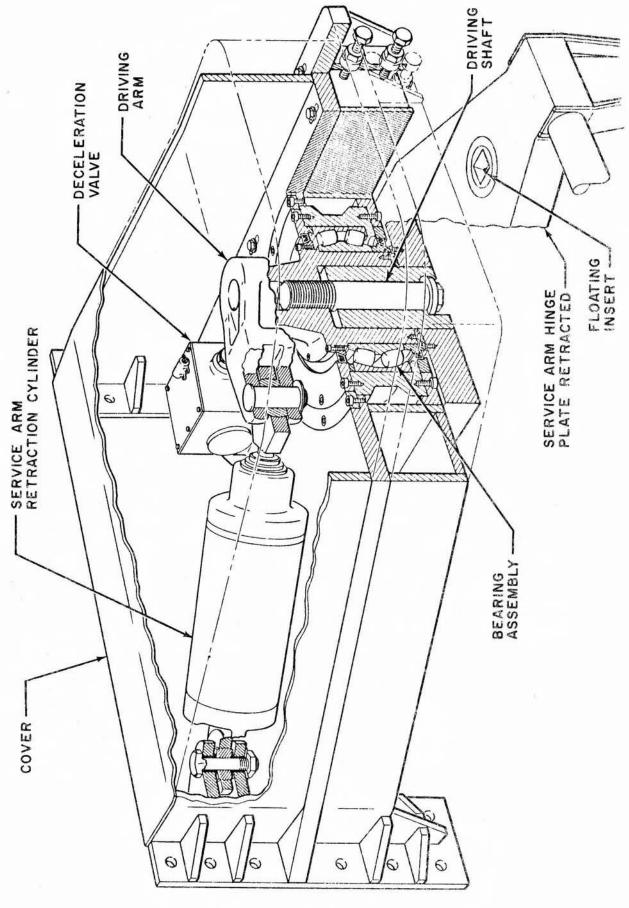


Figure 1-4.

Tower-Mounted Hinge

An in-flight arm retraction system is composed of the following:

- a. Two hydraulic actuators, one in the top and one in the bottom hinge (Figure 1-4). Each cylinder has an 8-inch bore, 14.87-inch stroke, and a 3.5-inch rod, and is mounted within the hinge.
- b. One hydro-pneumatic cylinder, mounted on the tower deck; this cylinder has a 7-inch bore, a 52-inch stroke, with the rod end attached to a 4-pulley block (Figure 1-5).
- c. Primary and secondary pressure supplies, consisting of six 10-gallon nitrogen bottles, and a piston-type 10-gallon accumulator.

The largest withdrawal mechanism is composed of:

- A large cylinder (Figure 1-6) of special design, having a
 5-inch bore, a 4-inch tubular rod, and stroke of approx. 5 feet.
 This cylinder is trunnion-mounted in a universal joint.
- b. A small cylinder, which is a standard high-pressure actuator with a 3-inch bore, 20-inch stroke, and a 1.5-inch rod, trunnion-mounted in a universal joint.
- c. A secondary device for umbilical plate disconnect, which is a small single-acting pneumatic cylinder driving a springloaded linkage (Figure 1-7).

A hydraulic charging unit is mounted in the base of the LUT and supplies hydraulic fluid where required for all systems. It consists of a 500-gallon reservoir with dual 5000 psi, 10 gpm pumps, filters, valving, and controls.

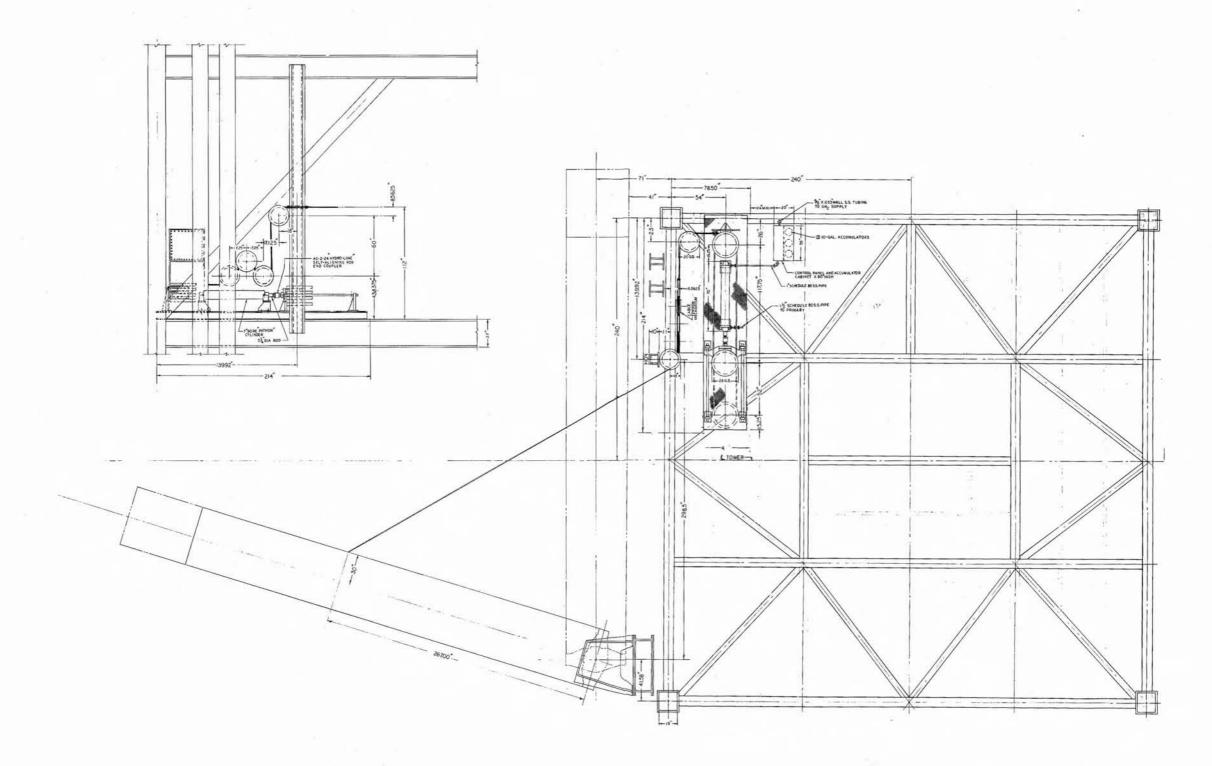
In addition to these items, there are numerous cables, pneumatic lines, hydraulic lines, and associated valves and controls as described in Part 2 and detailed in the engineering drawings.

1-8. ELECTRIC CONTROL AND POWER SYSTEMS.

The electrical portion of the service arm control system will consist of cabinets, panels, and components, both internal and external, at each service arm level, and interconnects between these units. These units will be used for the operational control, monitoring, and signal distribution for the respective service arms.

Lighting on each service arm will provide 20 foot-candle illumination, and receptacles will provide electrical power as required. A Class I, Group B, explosion-proof system will be provided throughout.

All electrical cables from the service arm umbilical plate to the tower distribution box will be provided with connectors at each end. Sufficient cable flexibility to assure proper operation of the withdrawal and retract mechanisms is necessary. These cables will be thermal coated for high temperature exposure. This page intentionally left blank.



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Figure 1-5. Cable Retraction System

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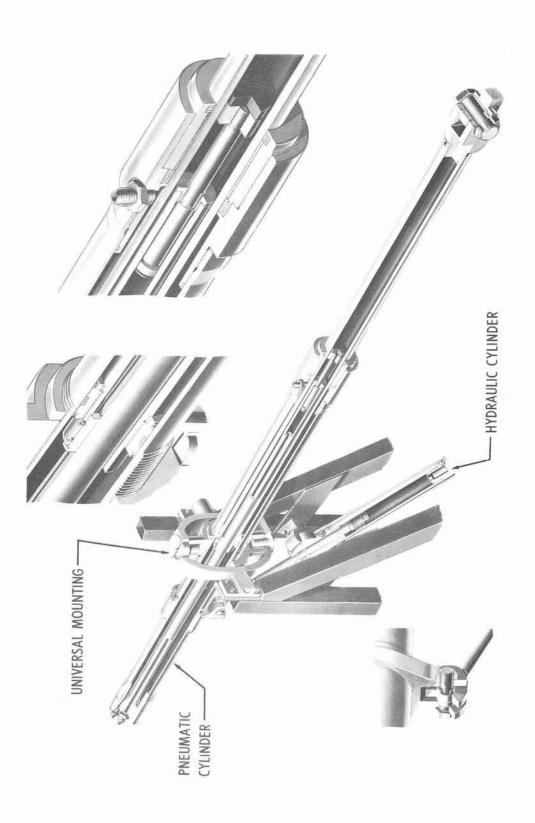


Figure 1-6.

Cylinder-Type Withdrawal Mechanism

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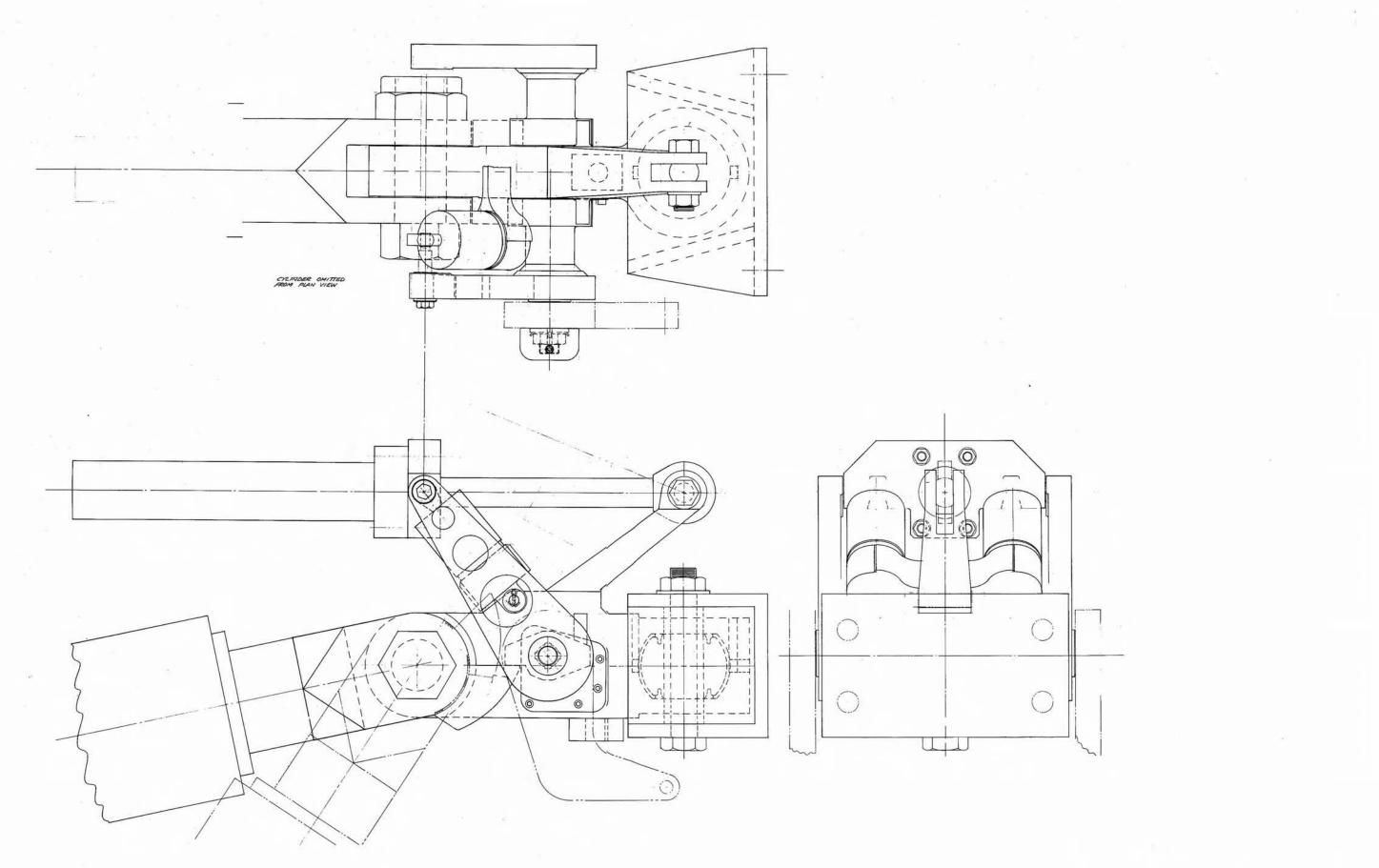


Figure 1-7. Umbilical Carrier Cam-Off Mechanism 13

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Test sets and procedures for complete verification of the satisfactory operation of all units shall be provided to ensure operational reliability.

Control panels and cabinets, with associated instruments and equipment, will be required in the base of the LUT for all service arms to provide interface with the Launch Control Center and for local recording, indication and control.

1-9. WATER QUENCH SYSTEM.

The water quench system (Figure 1-8) consists of header pipe assemblies and spray nozzles mounted on the face of the tower. The spray pipes will tee off the tower headers so that each service arm is covered by two pipes, one above and one below the arm. The pipe used in this system ranges from 2-1/2-inch to 6-inch I. D. Each spray nozzle will be capable of discharging 28 gallons of water per minute, at 70 psi.

The water quench system will operate from an electrical control panel in the LUT.

1-10. TRANSPORT TRAILER UNITS.

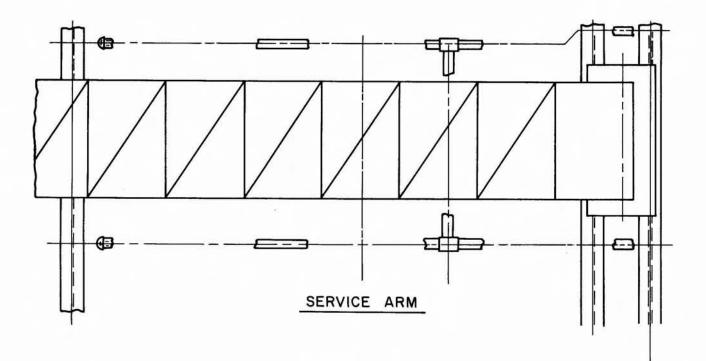
Transport trailer units (Figure 1-9) will be of sufficient size to transport a complete service arm and accessories, and will be capable of highway travel. The drop-deck platform type units will be 10-feet wide by 56-feet long, have removable metal body panels, and will be covered with supported tarpaulin.

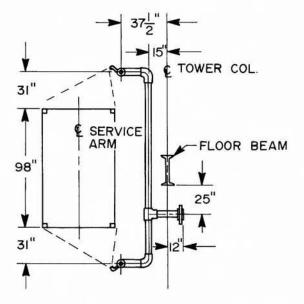
1-11. QUANTITIES TO BE MANUFACTURED.

The quantities to be manufactured under this scope, according to the major divisions, are as follows:

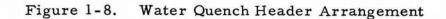
- a. Service Arms there will be four complete sets of service arms manufactured, consisting of eight arms per set. This includes one set for each of the three LUT's of Launch Complex 39, with one set of spares. In addition, there will be provided 10 percent loose spares for all components of the first three sets.
- b. Water Quench System there will be one water quench header system for each arm, making a total of four sets, eight arms per set.
- c. Control panels located remotely from the service arm this includes all control panels outlined in 1-7, 1-8, and 1-9.
- d. Transport trailers there will be eight complete transport trailer units.

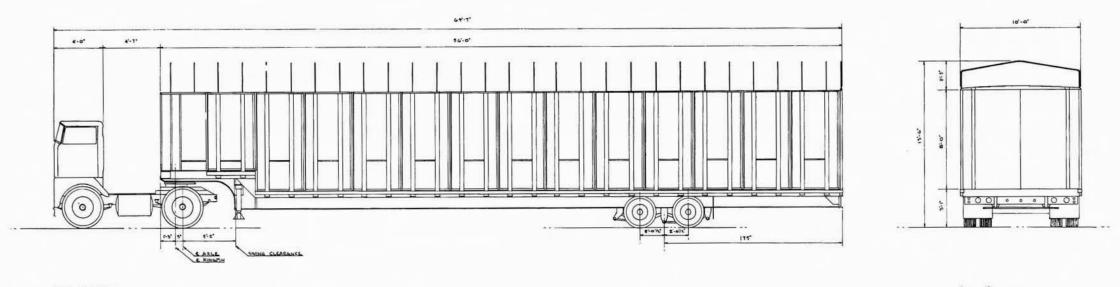
Upon satisfactory completion of the items called for in this scope, the contractor will be given the opportunity to negotiate for the manufacture of four Command Module access arms and their associated equipment.





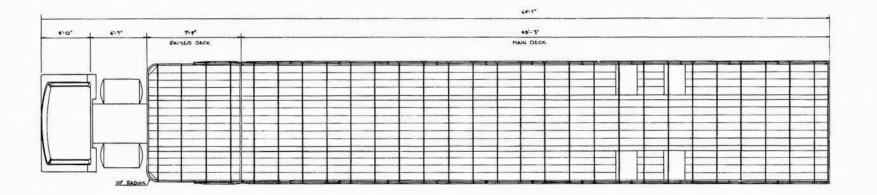
TYP. SECTION THRU SERVICE ARM. FLOOR BEAM VARIES IN ELEVATION WITH RESPECT TO SERVICE ARMS.





SIDE ELEVATION

READ ELEVATION



PLAN

Figure 1-9. Arm Transport Trailer

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If it becomes necessary for an arm to be provided for the Lunar Excursion Module, it shall be within the scope of work to negotiate for the manufacture of four such arms and their associated equipment.

1-12. SPECIAL PROCESSES.

Propellant and pneumatic line cleaning will be required both before and after testing. Refer to Section III for fabrication and special processes details.

1-13. TIME FACTOR.

The first set of eight service arms with their associated equipment, water quench systems, and transport trailers shall be completed and delivered to NASA for operational testing at MSFC seven months after award of contract. For delivery dates of remaining items, see master schedule (Figure 1-10). This page intentionally left blank.

SECTION II. EVALUATION CRITERIA

2-1. GENERAL.

Contractors will be evaluated and selected in accordance with the criteria discussed in the subsequent paragraphs.

2-2. SCHEDULE.

The contractor shall adhere to the schedule established by LOC (Section VI), and to whatever changes that may be required to successfully complete LOC scheduling requirements. The ability and past performance of the contractor to adapt to design changes and modifications in tooling and processes with minimum schedule delay will be evaluated.

2-3. COST.

The contractor shall establish a cost figure for the manufacture of Saturn V service arms and related support equipment, with further cost breakdown as directed by the contracting officer. Although the lowest price will affect the award of the contract, the realism of the cost figures presented will indicate to some degree the experience of the contractor and his grasp of the project, and could result in rejection of a contractor for a deficiency of either.

2-4. MANAGEMENT CAPABILITIES.

Changes or modifications to the basic service arm design may require fabrication, testing, and delivery within an extremely short time. Therefore, the contractor's ability to assign additional personnel to the program and efficiently manage a close schedule is of prime importance. An organization is desired that can properly direct a project of this scope, with emphasis on schedule completion in problem areas. An organization is desired that would also provide a central contact for LOC and subcontractor personnel in obtaining schedules, reports, and project status for proper coordination and direction.

2-5. EXPERIENCE.

Work experience and past projects of the contractor shall be in the manufacturing of equipment similar to that delineated in Section I. This contractor experience should be in, or related to, the fabrication areas listed below.

- a. Umbilical disconnect devices.
- b. Umbilical support structures and retract mechanisms.
- c. Control systems, panels, lines, and cables.
- d. Large launch support equipment (hydraulic, pneumatic, electrical, mechanical).

- e, Test sets to check out complex equipment and systems.
- f. Trailers to transport equipment described in Section I.

2-6. FACILITIES.

Facilities of the contractor and subcontractors must be inspected and approved by LOC (Section VIII) and shall have all equipment necessary to complete the performance of the contract. Equipment and processes that shall be required are defined in Section III.

2-7. PERSONNEL.

Contractor personnel must be experienced in the manufacturing, functional testing, and shipping of equipment described in Section I. Welders shall be certified to NASA requirements as indicated in Part 2. Manufacturing personnel shall be fully capable of successfully performing all functions necessary to complete the services required.

2-8. LOCATION.

The location of the contractor's facilities, in relation to LOC and MSFC, will have a direct bearing on schedules and cost. The contractor shall be in a location to facilitate the following with minimum time and cost.

- a. Transportation of service arms to MSFC for testing.
- Return of service arms to contractor's facilities for refurbishing. (Must be located in the immediate vicinity of Huntsville, Ala.)
- c. Transportation of service arms to Cape Canaveral.

2-9. SUBCONTRACTING.

The contractor shall not exceed 15 percent (paragraph 13-3) of the value of the contract in subcontracted services.

SECTION III. CAPABILITY REQUIREMENTS

3-1. GENERAL

The contractor must show a proven capability for providing adequate fabrication facilities and manufacturing support, and must have experience in subcontracting methods and procedures. This capability and experience must have been directly related to the manufacture of umbilical disconnect devices, service structures, and related systems which have performed satisfactorily during actual launch operations. To effectively provide the required services, the following capabilities are considered necessary.

3-2. FACILITIES AND SPECIAL PROCESSES.

The contractor must be capable of providing facilities and services for the manufacture of service arms, umbilical disconnect devices, and supporting equipment to be used on Launch Complex 39 for the Saturn V Vehicle. These facilities shall be adequate to manufacture the equipment delineated in Section I. The facilities must be adaptable to changes or modifications in the basic design of the equipment. The processes and facilities necessary to manufacture Saturn V service arms and related equipment are as follows:

- a. General and precision machining.
- b. Welding and sheet metal working.
- c. Precision welding jig and fixture fabrication.
- d. Material plating, painting, and finishing.
- e. LOX clean, hydraulic clean, and "clean room" (to MSFC-PROC-166 and MSFC-PROC-164).
- f. Inspection (including X-ray, zyglo, magnetic particle).
- g. Silkscreening.
- h. Functional testing of components and subassemblies.

Element welds shall be inspected as follows:

- a. Connections of the four chords to the arm hinge plates shall be 100 percent radiographically inspected.
- Approximately 16 joints are designated as critical on the drawing 75M-05835 and shall be 100 percent radiographically inspected.
- c. Five percent of the remaining welds shall be radiographically inspected.
- d. The remaining welds shall be inspected by a magnetic particle method.

Adequate facilities to hoist and handle all items and assemblies must be available.

3-3. ENGINEERING.

The contractor must have available a minimum of 10 engineering personnel to support the manufacturing, functional, and quality test efforts. These personnel must have substantial manufacturing production engineering experience. These engineering personnel must be available to either the manufacturing or test areas as required and will be required to determine if the proper fabrication tools, equipment and processes are being utilized. A minimum of three manufacturing engineers will be assigned to the NASA test area at MSFC, as required by the customer, to assist in coordinating or making changes recommended by LOC personnel.

3-4. SUBCONTRACTING.

The contractor must select subcontractors who have adequate facilities for performing the required work. The subcontractor must have experience in the manufacturing and testing of items of a nature similar to those subcontracted. Subcontractors must have facilities and personnel to accomplish the contracted work in an expeditious manner to ensure schedule compliance. The subcontractor must have the ability to quickly adapt processing tools and facilities in the event that basic design changes are necessary. Quality control procedures and methods must meet LOC requirements to facilitate inprocess and end-product inspection (Section V).

SECTION IV. NASA PERT AND COMPANION COST SYSTEM

4-1. REPORTING.

Periodic reporting to NASA by the contractor of time and cost actuals and projections will be accomplished as set forth herein. Contractor reports are required in the operation of NASA's internal project control system called "NASA PERT and Companion Cost". Contractor recognizes NASA's responsibility and authority to establish the type, content, and format of information required. Operation of the system and contractor's obligation in connection therewith are to be as described in the NASA PERT and Companion Cost System Handbook as in effect on the date of this contract.

4-2. IMPLEMENTATION.

Contract requirements under the NASA PERT and Companion Cost System shall be implemented through the operation of an implementation team consisting of representatives of the contractor and of NASA. The NASA Technical Supervisor shall: determine the NASA representatives on the team; designate from the NASA members a team Chairman; and approve contractor representatives on the team. The work breakdown structure to be used by the team as the framework for structuring of the NASA PERT fragnets and corresponding cost reporting categories shall be established by the contractor and approved by the technical supervisor.

4-3. PARTICIPATION.

Fragnets and subdivision of work cost categories (see Handbook) are to be established for each line item or group of line items as indicated by the contractor and approved by the technical supervisor. The contractor's participation, as a member of the implementation team, shall include but not be limited to the following:

- a. Development of the required fragnets.
- b. Interconnecting of fragnets so that data can be processed separately for each fragnet or as a group for the contractor's entire project effort.
- c. Identification of events and activities comprising each of the fragnets required.
- d. Definition of content of each cost reporting category.
- e. Identification of activities chargeable to each subdivision of work cost category.
- f. Establishment of the initial time estimate for each activity.

4-4. REQUIREMENTS.

Lower level time and cost detail, which contractor utilizes for its own management purposes to validate information reported to NASA, shall be consistent with NASA requirements hereunder. Contractor shall exert its best efforts to ensure participation of its subcontractors in implementation and operation of the NASA PERT and Companion Cost System as appropriate.

The approximate scope of each fragnet (in terms of the number of activities) that will be required is also to be indicated by the contractor and approved by the technical supervisor. This number is an approximate estimate included in the contract primarily for purposes of estimating the cost of meeting the requirements under this clause.

Reporting against initially developed fragnets shall commence upon direction by the NASA Technical Supervisor. Frequency of reporting shall be as determined by NASA's Technical Supervisor but not more frequently than every two weeks. Reporting against all fragnets specified by the contractor will be commenced at the time the Technical Supervisor deems appropriate. Reporting against and updating of individual fragnets shall commence as soon as individual fragnets are developed and not until completion of all fragnets. The computer input data reported shall be current as of the reporting date.

Cost reports of actuals and projections shall be submitted by the contractor on NASA Form 533 in accordance with the instructions on the reverse of the form, as supplemented by the work breakdown structure, and in the number of copies set forth in the contract schedule. Reports shall be submitted at the time and in the manner designated by the NASA Contracting Officer provided, if the reporting requirements described above are changed, contractor shall be entitled to an equitable adjustment under the last paragraph hereof. The line items within the work breakdown structure will constitute the subdivisions of work to be reported. The elements of cost to be reported within each subdivision of work will be established by the contractor subject to approval by the Technical Supervisor.

In view of the character of the work under this contract, the initially developed fragnets referred to above need continual updating on a current basis to reflect to NASA a true picture of contractor work plans and status.

To ensure responsiveness and adequacy of reporting requirements, the implementation team will review total content and operation of the system annually.

During the course of this contract, if significant changes, either an increase or decrease, in NASA's information requirements specified in the work breakdown structure above, are directed by NASA's Technical Supervisor (through the NASA Contracting Officer) an equitable adjustment will be made in estimated cost, and fee to be paid to the contractor and in such other provisions of the contract as may be affected.

SECTION V. QUALITY ASSURANCE

5-1. GENERAL.

The contractor shall provide a quality assurance system responsive to the requirements and decisions of MSFC's Quality Division. The system shall meet the requirements of "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services", NASA Quality Publication, National Publication Control 200-3. The system also shall meet the additional requirements specified in 5-2 through 5-17.

5-2. GOVERNMENT SOURCE INSPECTION.

Government source inspection is required on all items manufactured under this contract. The contractor shall provide facilities and other necessary provisions for 12 resident Government source inspectors during the term of the contract. Contractor-owned inspection and test equipment shall be made available to Government inspectors for product verification, if requested. The Government inspectors along with Quality Division and LOC personnel will be given at least 48 hours notice and be present during conduction of end-item subassembly acceptance tests. Inspectors and cognizant personnel also shall be notified before shipment of items.

5-3. ORGANIZATION.

The contractor shall have a quality assurance organization whose past performance proves it to be capable of operating without organizational constraints. The person responsible for directing the quality assurance organization shall have direct contact with contractor top management personnel and shall regularly report on the status and adequacy of the programs. This level of management shall be capable of ensuring compliance with all contractual commitments.

5-4. PLANNING.

The contractor's written inspection and test plan, including the product flow charts for each different end item, shall be submitted to the contracting officer, for review by NASA, within 60 days after contract award. Changes to the written plan shall be submitted at least two weeks before implementation. One-hundred percent inspection is required on all subassemblies and on each end item delivered under this contract.

5-5. DOCUMENTATION CONTROL.

The contractor shall control the distribution of drawings, change orders, control procedures, inspection and test procedures, and procurement documents within his facility. This effort shall include the controlled removal of all such documents from use as they become obsolete. The effectivity of changes, preferably by item as well as date, made to any controlled document shall be clearly defined and complete records maintained.

5-6. SUBCONTRACTOR CONTROL.

All subcontractors shall have inspection programs complying with NPC 200-3. Each subcontractor selected shall either have an acceptable previous quality record with the contractor or shall satisfactorily pass a quality survey performed by the contractor. Subcontractors engaged in this work shall be resurveyed semiannually or more often as quality histories necessitate. Subcontractors shall permit both scheduled and nonscheduled inspection access.

5-7. PROCUREMENT DOCUMENTS.

Purchase orders and subcontracts shall be reviewed by the contractor's quality engineering element to determine the adequacy of the completeness of the technical and quality requirements therein. Only those procurement documents which are approved shall be released for procurement operations. Reports, certifications, and other guarantees of compliance to requirements shall be submitted with any procured item whose important characteristics are not completely reverified by the contractor.

5-8. PRODUCTION INSPECTION AND TESTS.

The contractor's quality engineering function shall analyze all design documents to determine the factors that control the inherent reliability of the design. Based on this analysis, the characteristics to be measured in receiving, production, and shipping operations, shall be determined to assure the achievement of inherent reliability. This data shall be used, in conjunction with the manufacturing plan, to set inspection and test stations, and to comply with the requirements of paragraph 3.6 of NPC 200-3. All procedures shall be maintained current with the effective design documentation and process controls.

5-9. ACCEPTANCE TESTS AND MODIFICATIONS.

After manufacture, the completed end-item will be delivered to Test Division at MSFC for acceptance tests on the service arm and related equipment. The contractor shall supply three manufacturing engineers to MSFC Test Division during acceptance testing. After performance of the acceptance test, the equipment will be returned to the contractor for cleaning and refurbishment. Should acceptance testing indicate that modification of the equipment is required, such modifications shall be swiftly negotiated with the contractor and modified by the contractor at the test site where possible. Further testing will follow to confirm the effectiveness of the changes.

5-10. PROCESS CERTIFICATIONS.

Process certifications shall be provided on all special processes utilized in fulfilling this contract. These processes include welding, soldering, plating, anodizing, heat treating, LOX cleaning, X-ray, magnetic particle and liquid penetrant inspections, and any other processes specified in design documents. Process control procedures shall be generated and utilized. The contractor's quality organization shall conduct audits and reviews of operating processes and shall enforce compliance with the established procedures.

5-11. MATERIAL REVIEW BOARD.

The contractor shall conduct formal material review of any discrepant item that cannot be reworked to conform to design drawings. The material review board (MRB) shall consist of representatives from the quality, engineering, and production elements of the contractor's organization and of a Government representative. Acceptance of nonconforming material shall occur only with the unanimous agreement of the MRB. The contractor's MRB jurisdiction for this contract shall be limited to those discrepancies not affecting reliability, function, interchangeability, life, and safety. Requests for review of discrepancies affecting these areas, and records of all acceptance decisions made on minor discrepancies, shall be forwarded to LOC through the contracting officer.

5-12. TRACEABILITY.

A record of all operations performed on each delivered item, its components, and its sub-assemblies shall accompany each item through production, inspection, and testing. These records shall reference the applicable documents and changes, shall indicate the results of all inspections and tests performed, any MRB actions, and shall indicate operating times or expiration date of any limited-life item. The set of records defining each end item shall be used to permit compilation of all applicable certifications, inspection results, and test reports for any delivered item.

5-13. EQUIPMENT ACCURACY.

The contractor should use inspection and test equipment which has measurement capability of 10 percent of the allowable tolerance of the characteristic it measures. Similarly, the accuracy of standards used to calibrate equipment should be sufficient to measure 10 percent of the tolerance of the equipment calibrated.

5-14. CALIBRATION.

The contractor shall maintain records of the data resulting from calibration operations. Any equipment exceeding its required due date or tolerance shall be suitably isolated, tagged, or otherwise marked to prevent its use without special permission of LOC and/or NASA.

5-15. STATISTICAL TECHNIQUES.

Any sampling performed by the contractor shall be in accordance with MIL-STD-105, MIL-STD-414, or Department of Defense Inspection and Quality Control Handbooks H-106, 107, and 108. If required, other plans may be used with specific prior approval by Quality Division of MSFC. Statistical quality control charts shall be used whenever their use will increase the effective control over the article produced.

5-16. DATA AND ITEM ANALYSIS.

Inspection and test data shall be analyzed for indication of degradation of quality and reliability. If necessary, specific discrepant items shall be given an engineering failure analysis to determine the cause of the discrepancy. If analysis of the data or items indicates a design deficiency, LOC shall be notified and all applicable data, items, and other assistance shall be supplied to aid in design correction.

5-17. HOUSEKEEPING.

The contractor shall establish and maintain high standards for cleanliness and handling practices throughout the manufacturing and test facilities.

5-18. AUDITS.

The contractor's quality engineering personnel shall perform quarterly audits of the operating conformance to all quality requirements specified herein. The results of the audits, with statements of corrective actions taken, shall be submitted to the contracting officer within three weeks of the performance of the audit.

SECTION VI. SCHEDULE

6-1. GENERAL.

The following brief definitions and discussion will make clear the intent of the accompanying schedule charts.

6-2. ENGINEERING.

The engineering required in connection with the manufacture of the service arms shall be that necessary during the manufacturing, testing, and refurbishing processes. Engineering work and guidance shall begin immediately upon award of the contract and will continue until final reprocessing or refurbishing at the manufacturer's facilities is complete.

6-3. FABRICATION.

Fabrication shall include manufacture and/or acquisition of the necessary component parts or materials and assembling these items into finished systems or structures for shipment to the test site. A general breakdown of the sub-assemblies to be fabricated is as follows:

- a. Basic arm structure.
- b. Withdrawal mechanisms.
- c. Extension platforms.
- d. Arm-mounted hydraulic and pneumatic systems and all associated tower and LUT-mounted control panels.
- e. Electrical controls and power equipment mounted on the arm and control panels located on the tower and in the LUT.
- f. Water quench header system and controls.
- g. Arm-mounted platform and stairs.
- h. Hydraulic charging unit mounted in the LUT.
- i. Assembly of vehicle service lines (fuel, electrical, etc.).
- j. Transport trailers.

Note: See Part II for a more detailed description of the service arms and related equipment.

Fabrication shall begin immediately after awarding of the contract. The government will submit a "letter of intent" to the selected contractor so that orders may be placed for the long-lead items required to begin manufacturing.

6-4. TRANSPORTATION.

Transportation refers to moving the service arms, related componets, and equipment as described below:

- From the manufacturer's plant to the MSFC test site at a. Redstone Arsenal, Alabama.
- From the test site to the manufacturer's refurbishing area b. in or near Huntsville, Ala. From the refurbishing area to the AMR at Cape Canaveral.
- c.

6-5. INSPECTION.

Inspection, in this instance, refers to supervisory type inspection by NASA to ensure compliance with contractual commitments. This item, although not actually shown in the chart, will be scheduled on a continuing basis and requires of the manufacturer adequate inspection access.

6-6. TESTING.

All materials and component parts of a non-standard nature must successfully pass all acceptance tests specified in Part II. Standard stock items such as structural steel need not be tested if "Mill Test Reports" are available as specified. This is true for items such as standard valves which have previously been certified by NASA. Following fabrication, the service arm sub-assemblies shall be subjected to a functional test by the manufacturer. This item is scheduled on the chart as testing (manufacturer). Upon completion of the subassembly functional testing and final assembly, the arms will be delivered to Test Division, MSFC, for acceptance testing.

6-7. **REPROCESSING OR REFURBISHING.**

Upon completion of the NASA test program, the service arms will be transported to the manufacturer's facilities for refurbishing. This refurbishing or reprocessing shall include cleaning, descaling, straightening, repainting, and repairing as necessary to prepare the equipment for use. If extensive damage has been incurred, major repairs by the manufacturer will be negotiated.

6-8. DELIVERY OF HARDWARE AND DOCUMENTATION.

This refers to the presentation of the final products, as indicated in paragraph 6-3, to LOC at Cape Canaveral, Florida. At this point, after acceptance of the item by LOC, the responsibility of the contractor terminates. Hardware includes all items manufactured under the contract, generally outlined in paragraph 6-3. Also included is the required 10 percent spare components for all the above items. Documentation shall include such things as:

- a. Test history log.
- b. Manufacturer's shop drawings.

- c. Any documents or data received with purchased materials,
- parts, or equipment, including all manuals.
- d. Operating time, cure date, or expiration date for any limited-life items.

Traceability record, paragraph 5-12, may serve to fulfill part of the above requirements.

6-9. TOTAL CONTRACT REQUIREMENTS.

The previous information in this section on scheduling has been concerned with only the eight service arms of LUT 1; however, the total contract requirements are for the following:

- a. Eight service arms LUT 1.
- b. Eight service arms LUT 2.
- c. Eight service arms LUT 3.
- d. Eight service arms spares.

Note: The contractor will have an option to negotiate for the manufacture of four Command Module Access Arms (see Frontispiece) depending upon his performance, capabilities, and facilities to meet LOC schedule requirements.

The schedule in Figure 1-11 shows the fabrication time permitted for each of the sections of the total contract shown above. This scheduling breakdown of eight service arms, as shown in Figure 1-10, is generally typical of the scheduling for the other sections of the total contract requirements.

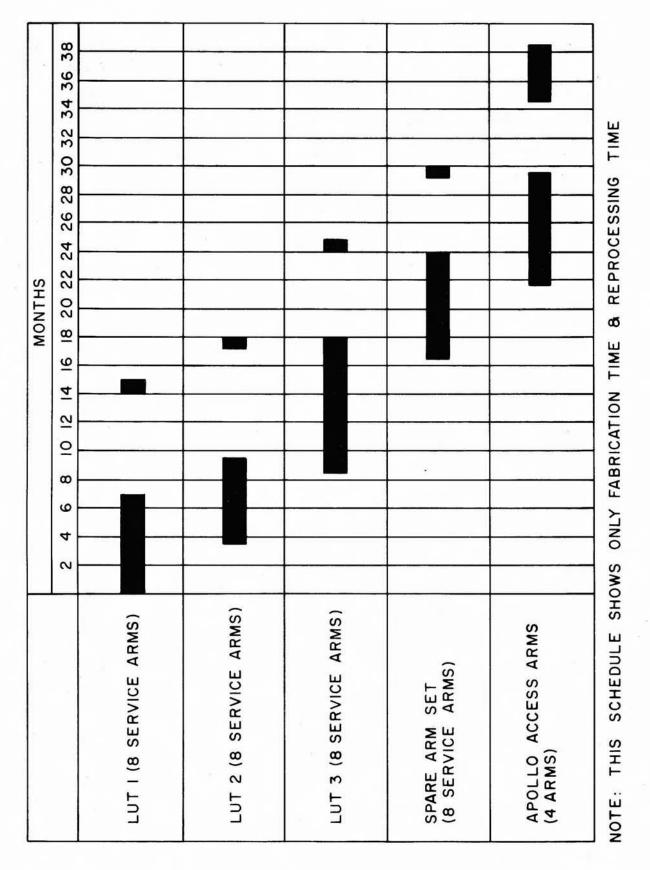
6-10. MAJOR MODIFICATIONS.

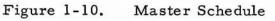
Any major modification requirements will be determined during the manufacturer's functional testing or during NASA's acceptance test program. This will enable modifications on future production to be carried on concurrently with the test programs so that overall schedules can be met. All major modifications so introduced will be negotiated.

6-11. SUBMISSION OF SCHEDULES.

Each bidder shall submit a detailed schedule of each section of the total contract requirements. This schedule shall be similar to that shown in Figure 1-10 and shall adhere to the general requirements of the schedule shown in Figure 1-11.

COMPLEX 39 SERVICE ARMS MASTER SCHEDULE





σ **8 ARMS TO NASA** œ 2 **30 WEEKS** 9 5 4 FOR TESTING DELIVERY OF m 2 SCHEDULE MONTHS = 0 σ ARM ω ~ LUT I SERVICE 9 CONTRACT S AWARD 4 m N DELIVERY OF HARDWARE AND DOCUMENTATION FUNCTIONAL TESTING (CONTRACTOR) ACCEPTANCE TESTING (MSFC) TRANSPORTATION REPROCESSING ENGINEERING FABRICATION



Figure 1-11. Arm Schedule

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SECTION VII. INCENTIVE IDEAS

7-1. GENERAL.

The resultant contract will be of a cost plus incentive fee type.

7-2. OBJECTIVES.

The three prime objectives that should be considered in establishing the basis for determining incentive fee will be as follows:

- a. Delivery final delivery date for the first set of arms (8 service arms), would be the prime milestone. The delivery date for each subsequent arm, according to LOC requirements, would be the next milestones.
- b. Cost Target cost and target fee will be established. The contractor will receive an increase in fee for underrun of costs and/or a decrease in fee for an overrun of costs.
- c. Performance of Contractor All units delivered must adhere to LOC documentation and quality requirements.

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SECTION VIII.

REPORTING REQUIREMENTS AND INSPECTION ACCESS

8-1. REPORTING REQUIREMENTS.

8-2. REPORTING.

Reports will be prepared to reflect status as of the last day of the month reported and will be submitted to reach the NASA Technical Supervisor on or before the 15th of the month following the report period. They will contain the following:

- a. A brief statement of the work accomplished to start of the current report period.
- b. A description of the work performed during the current report period.
- c. A discussion of problems encountered together with recommended resolutions.
- d. A schedule showing the following:
 - 1. Authorized man-hours by individual Schedule Orders including corresponding dollar values.
 - 2. Authorized dollar amounts by Schedule Orders of material estimates.
 - Cumulative total of hours and dollar costs used to date.
 - 4. Forecast of uncompleted Schedule Orders expressed in details of hours and dollars.

The contractor shall be required to submit other reports, either of a recurring or non-recurring nature, as directed by the NASA Technical Supervisor.

8-3. INTERVALS.

A weekly job status report for the preceding week shall be issued to the customer on the first work day of each week. A monthly status report and a monthly financial report shall be submitted to the customer on or before the 15th of the month following the period being reported. They will contain the following:

a. Weekly Status Report - This report shall contain daily labor expenditures for each job; weekly labor hours, labor dollars, and other expenditures by job; and weekly job status reports which compare planned expenditures to actual expenditures and indicate problem areas. The report shall contain all work performed through the last day of the previous week.

- b. Monthly Status Report This report shall contain a brief statement of work accomplished at the start of the current work period; a description of the significant work accomplishment during the current work period; and a discussion of problems encountered, with recommended solutions.
- c. Monthly Financial Report This report shall contain, in appropriate tabulation, the hours expended and dollar costs for the month reported; the cumulative hours expended, dollar costs, and materials; and a forecast to complete the job expressed in terms of hours and dollars, shown on a comparative basis with the amounts authorized, and showing discrepancies between the two as plus or minus.

8-4. INSPECTION ACCESS.

Scheduled Inspection Intervals - The customer shall notify the contractor, in advance, of intended inspections and the nature of the inspections. The contractor shall then advise the affected personnel concerned so they may be available to assist customer inspection personnel. Upon notification of an impending inspection, the contractor personnel concerned shall assemble any engineering drawings or other necessary documents that the customer may request in connection with the inspection tour.

Nonscheduled Inspection - Because the nature of the inspection tours will vary, the preparation period for the contractor will also vary in proportion. Reasonable time notification will be granted the contractor to adequately prepare for the inspection. Frequency of nonscheduled inspection and an appropriate interval of advance notice shall be stated by the contractor before the contract is awarded.

SECTION IX. GOVERNMENT FURNISHED EQUIPMENT

9-1. TEST FACILITIES.

All service arms fabricated under this scope of work shall be given a complete acceptance test to confirm proper operation and performance as scheduled in Section VI. This test will be performed by personnel of Test Division of MSFC. The tests will be made at a Government furnished test facility located at the Marshall Space Flight Center in Huntsville, Alabama. All facilities and personnel required for the assembly, test mounting, operational testing, and disassembly of each service arm at the test site will be provided by the Government at no expense to the fabrication contractor. MSFC will provide office facilities for fabrication contractor personnel required in the test area during operational test periods.

9-2. QUICK-DISCONNECT HOUSING.

NASA will provide ground-half quick disconnect housings, either actual or prototype, for each service arm for alignment purposes and functional checks during testing at the MSFC test area.

9-3. TRANSPORT TRAILERS.

The transport trailers will become Government furnished equipment after LOC acceptance and prior to any service arm transportation by the fabrication contractor. This page intentionally left blank.

SECTION X, PARTS PROVISIONING REQUIREMENTS

10-1. GENERAL.

Spare parts will be manufactured, stocked, and maintained by the manufacturer at the rate of 10 percent. Spare parts manufacture and stocking will be accomplished concurrent with system manufacture. The spares are subject to the same quality control inspections and testing methods employed for the primary parts. In addition, a spare set of arms and equipment to outfit one LUT will be fabricated, inspected, and tested. Ten percent spares will be shipped to MSFC test area and Cape Canaveral concurrent with transportation of the first and subsequent sets of arms. The items which will require spares will be determined by LOC.

Adequate space will be provided by MSFC at the test site for storage of spare parts.

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SECTION XI. TRANSPORTATION

11-1. GENERAL.

The contractor shall furnish transportation of the service arms as follows:

From the contractor's manufacturing area to the test facility at the Marshall Space Flight Center, Huntsville, Alabama.

From the test facility to the contractor's area for refurbishing or modification.

From the contractor's area to the Atlantic Missile Range at Cape Canaveral, Florida.

11-2. TRANSPORTATION.

Transportation of the service arms will be performed using eight semi-trailers to be manufactured by the contractor. The eight semitrailers shall be 22-ton capacity, 10-feet wide by 56-feet long, dropdeck platform type transporters, with removable metal bodies, roof bows, and tarpaulin tops as indicated in Figure 1-9. Acceptance of the trailers will be at the manufacturing area upon completion of manufacture and trailer acceptance test.

11-3. AREAS OF RESPONSIBILITIES.

The Government shall furnish the trailers at the required location for use by the contractor for all transportation of the service arms. The contractor shall be responsible for loading and unloading the service arms from the trailers at his facility, at the test site, at MSFC and at the Atlantic Missile Range.

The contractor shall perform any packaging or dismantling of the service arms in preparation for shipment. The number of parts or assemblies removed from the service arms for transportation will be held to a minimum. The contractor shall be responsible for transportation of all items to Cape Canaveral. Packaging shall be performed in accordance with the American Trucking Association's National Motor Freight Classifications; Rules and Container Specifications. Packaging of system components and assemblies shall, in addition, be in accordance with NASA specifications. This page intentionally left blank.

SECTION XII. COST BREAKDOWN

12-1. SCOPE.

The cost totals for the manufacture of Saturn V service arms and related equipment necessary to outfit one LUT shall be determined by the fabrication contractor, and the information displayed according to Figure 1-12. The total for labor man-hours and materials shall include the contractors overhead costs.

The contractor shall also show costs for arm transportation, liaison, travel, and per diem. These costs will be affected by the location of the contractor's facilities in relation to LOC, MSFC (test area) and Cape Canaveral. This page intentionally left blank.

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SECTION XIII. SUBCONTRACTING LIMITATIONS

13-1. APPROVAL.

The bidder shall specify any subcontractor support required or desired to complete the requirements of the contract. The work required and the estimated cost of such work must be clearly stated. Approval of subcontractors must be obtained prior to awarding of the contract.

13-2. TYPE OF COMPONENTS.

It is anticipated that some components, subassemblies, and services can be provided more advantageously through subcontractors. Typical examples of components or services which could be subcontracted are as follows:

- a. Propellant lines.
- b. Special cylinders and actuators.
- c. Pressure compensating control valve.
- d. LOX cleaning.

13-3. PERCENTAGE OF TOTAL JOB.

The prime contractor will be limited to a maximum of 15 percent on the amount of work under this contract which can be subcontracted.

Generally, the procuring of components which are vendor items will not be considered a subcontract item. Specialty items procured from outside sources, which must be manufactured and/or fabricated in accordance with drawings and specifications furnished by the contractor, shall be considered as subcontracted items. Services of any nature performed, as a part of this contract, by personnel other than regular employees shall be considered as a subcontract.

Questionable items shall be referred to the contracting officer for a decision as to whether or not they constitute a subcontract item. The decision of the contracting officer shall be final in every case.

13-4. WORKING AGREEMENTS.

The subcontractors will adhere to the contract in all respects. Any changes in the original contract by the prime contractor will be subject to immediate negotiation.

Representatives of NASA and the prime contractor will be authorized to inspect work progress at any time during the contract period. Progress reports will be kept up to date and will be presented to NASA and the prime contractor periodically, as stated in Section VIII. All materials and parts furnished by the subcontractor will be accompanied by a written certificate.

13-5. LOCATION.

Subcontracted engineering, fabricating, and testing will be performed only by companies within the United States. All materials and parts used in fabricating will be manufactured in the United States.

13-6. GOVERNMENT SUPER VISION.

NASA installations will invoke the requirements of NASA Quality Publication 200-3 contractually to the extent needed and consistent with program planning for procurements involved. NASA space system contractors will also invoke the requirements of this publication as appropriate.

When revisions or additions to this publication are announced, the prime contractor is encouraged to authorize his subcontractors to follow the applicable portions of the revised publication. However, the contractor is not required to comply with revisions made after the effective date of the contract, except as a negotiated contract change.

SECTION I INTRODUCTION

1-1. PURPOSE

Part 2 of this Preliminary Engineering Report presents data relative to the Saturn V Vehicle service arms and access arm. This part of the report provides detailed engineering data and drawings for use by personnel associated with the Saturn V program.

The information presented in this report reflects the design based on requirements up to 10 July 1963.

1-2. SCOPE

Part 2 contains design criteria, descriptions, and theories of operation for the service arms, access arm, and related equipment used on or in support of the Launcher-Umbilical Tower.

The information is presented according to the following arrangement:

- Section II. Presents information of a general nature. The data given in this section is intended to orient the reader regarding the Saturn V program.
- Section III. Details the criteria by which the present designs were developed.
- Section IV. Provides detailed information on each service arm and major component. Description and theories of operation are contained in this section.
- Section V. Provides the latest engineering data on the Command Module access arm.
- Section VI. Contains descriptions and uses of equipment and accessories used on the LUT. The arm transportation trailer is included in this section.
- Section VII. Presents information and detailed drawings which locate each interface between the arms and vehicle, the arms and tower, and between the arms and Vertical Assembly Building.

The appendices to this volume of the report contain documentation concerning the weight and center of gravity of the arms, the electrical schematics, the interfaces and umbilical requirements, and the drawings furnished by the stage contractors.

The references referred to in Part 2 are listed following the appendices.

SECTION II GENERAL INFORMATION

The Saturn V is a multi-stage, liquid fueled launch vehicle which will be used in the Apollo program. In this program the launch vehicle will boost the spacecraft into the proper trajectory and orientation for lunar and planetary explorations from Launch Complex 39.

The S-IC, first stage of Saturn V, is powered by five engines which operate on a mixture of RP-1 (a kerosene base fuel), and LOX (liquid oxygen). The S-II, second stage, and S-IVB, third stage, are both powered by engines operating on a fuel mixture of LOX and LH₂ (liquid hydrogen). An unpowered instrument unit contains in-flight control and monitoring equipment and is located between the S-IVB stage and the Apollo. The payload consists of the Lunar Excursion Module (LEM), the Service Module (SM), and the Command Module (CM) (Figures 2-1 and 2-2).

2-1. UMBILICAL LOCATIONS

Fuel and oxidizer loading and venting provisions, hydraulic and pneumatic system service connections, and electrical system powering and monitoring connections are contained in vehicle-to-ground umbilical connections at nine locations on the Saturn V stages. A summary of the umbilical requirements for each stage is contained in Table 2-1. Detailed umbilical requirements, service line locations, connector sizes, flow rates, and component weights are defined in Figures A-1 through A-18, Appendix A.

2-2. LAUNCH COMPLEX 39

Launch Complex 39 consists of two or more firing sites, the Vertical Assembly Building (VAB), the Launcher-Umbilical Tower (LUT), the Mobile Arming Tower, and the Crawler Transporter. Assembly and checkout of the erected vehicle on the LUT will be accomplished inside the VAB. The assembled vehicle and the LUT are then moved to the firing site by the Crawler Transporter. After the LUT is positioned at the site, the Crawler Transporter moves the Arming Tower into position for installation of pyrotechnics. If wind in excess of vehicle capability (99.9% probability) are predicted, the vehicle will be disarmed and returned to the VAB for protection.

Placement of the LUT at the firing site will be with the tower north of the vehicle, with position I east, and fin A 45 degrees north of position I. The flame deflector will be directly below the vehicle with the flame exits north and south. The assembled vehicle is supported on the LUT by four holddown _rms during all phases of operation including prelaunch. These holddown arms are oriented north, south, east, and west. The LUT is supported on permanent foundations at the firing site; service lines located at the firing site will be mated to corresponding service lines on the LUT.

The Crawler Transporter lifts the LUT using hydraulic cylinders, The transporter, powered by four crawlers, will transport the LUT between the VAB and the firing site; and will transfer the Arming Tower between its parking area and the firing site. The Crawler Transporter maintains the base of the LUT horizontal within 10 minutes of arc at all times.

All launch operations will be monitored and controlled from the Launch Control Center (LCC) located at the VAB.

2-3. LAUNCHER-UMBILICAL TOWER OPERATIONAL SEQUENCE

The purpose of the following information is to familiarize the reader, in general, with the state of the service arms and the access arm as the LUT progresses from its erection site through lift-off of the Saturn V Vehicle.

The LUT is erected in an open area adjacent to the VAB. Installation of the service arms, access arm, and all auxiliary equipment is performed in this area prior to being transferred into the VAB by the Crawler Transporter.

The following ground rules are applicable for VAB operations:

a. The LUT enters the VAB with the umbilical carriers withdrawn, the service arms retracted against the tower face, and the access arm locked in the extended position.

b. The access arm is rotated to the side to permit stage assembly.

c. As the stages are assembled, the respective service arms are extended (umbilical carriers remain in the withdrawn position). The VAB work platforms for the stages are then positioned.

d. Extension of withdrawal mechanisms and connections of the umbilicals is accomplished from the VAB work platforms.

e. Service Arm Extension Platforms will not be used in the VAB except for fit and alignment checks.

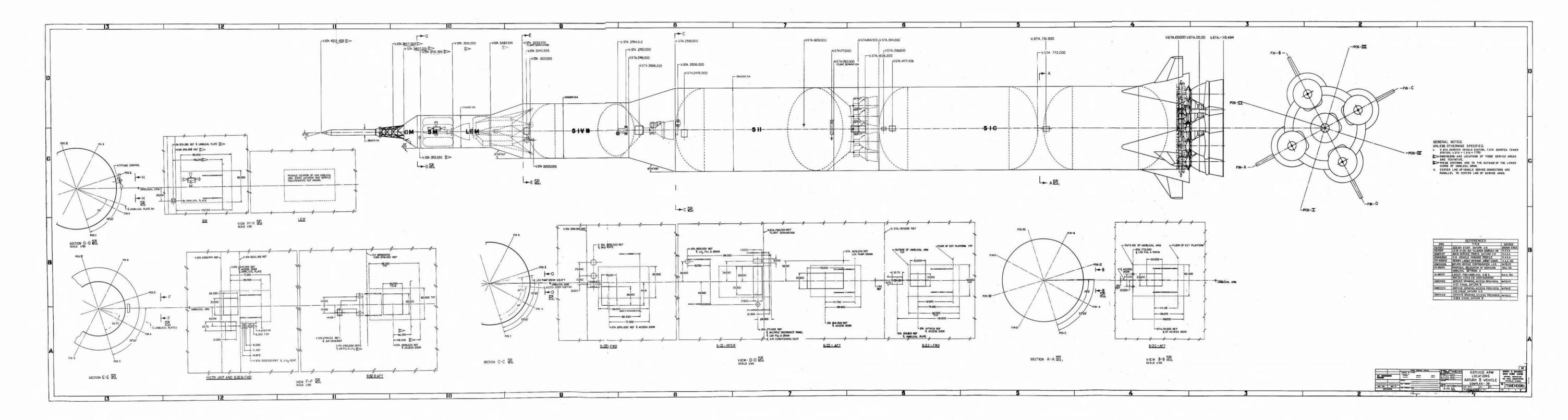


Figure 2-1. Saturn V Vehicle

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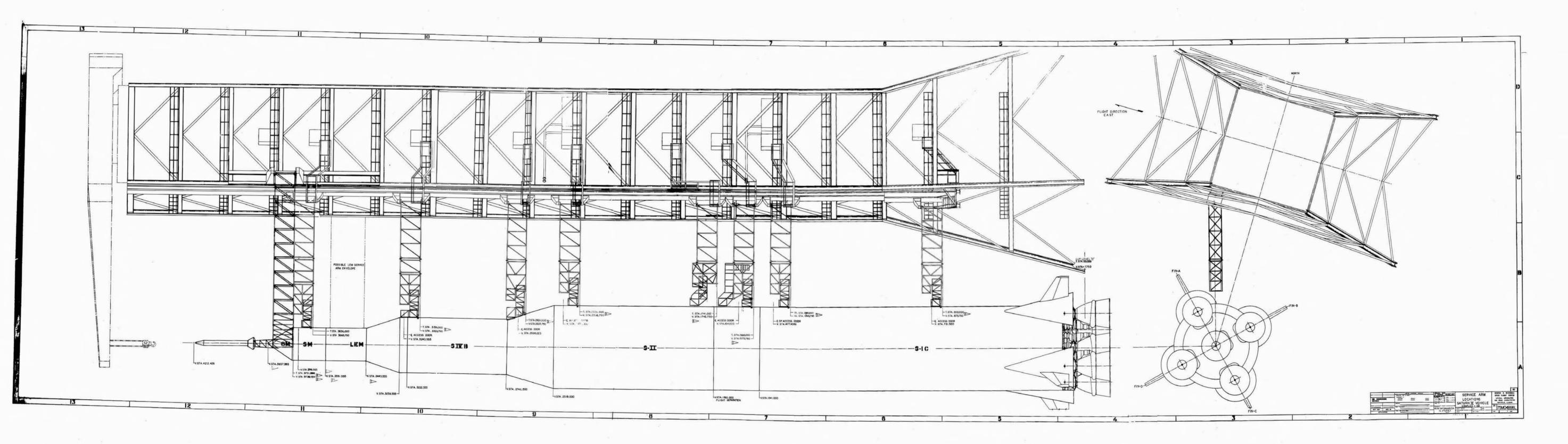


Figure 2-2. Service Arm Locations

Stage	VEH. Station*	Service Provided				
S-IC INTERTANK	772.000	LOX Fill and Drain Couplings				
S-IC FWD	1516.600	Air Conditioning, Electrical, and Pneumatic Services				
S-II AFT	1606.200	LOX Pump Drain				
S-II INTERMEDIATE	1767.000	Instrument Cooling and Purge				
	1771.000	LOX Coupling, Engine Compart- ment Purge, Electrical and Pneumatic Services				
	1905.000	LH ₂ Coupling				
S-II FWD	2506.000	GH ₂ Vent, Electrical and Pneumatic Services				
S-IVB AFT	2760.000	LH ₂ and LOX Coupling, Electrical and Pneumatic Services				
	2794.312	Air Conditioning				
S-IVB FWD	320 3 . 555	GH ₂ Vent				
	3214, 992	Air Conditioning, Electrical and Pneumatic Services				
SM	3721555	Air Conditioning, Vent Lines, Electrical and Pneumatic Services				

Table 2-1. Saturn V Umbilical Requirements

*Stations defined are center lines of umbilical housing.

f. Umbilical carrier disconnect, withdrawal mechanism retraction, and arm rotation for all service arms will have complete functional tests prior to leaving the VAB.

g. Any tests performed on the access arm in the VAB will be limited by the space available for arm rotation.

h. A complete functional test will be performed on the access arm after removal from the VAB and prior to transportation to the firing site.

i. The LUT leaves the VAB, pauses for access arm retraction, and continues to the firing site.

During transportation to the firing site, the service arms remain extended and locked, all withdrawal mechanisms stay extended with the umbilical carriers connected to the vehicle, and all extension platforms are withdrawn and locked. The access arm is in the retracted position locked to the tower.

After the crawler positions the LUT at the firing site, it will then transport the Arming Tower to the firing site and position it on the south side of the LUT. The access arm will be extended and the cab positioned adjacent to the CM hatch. The Arming Tower work platforms will then be moved into position to provide arming service to the vehicle.

After pyrotechnics are installed and other arming services are completed, the crawler will remove the Arming Tower so that propellant loading and final checkout operations can begin. During final checkout, an astronaut crew will enter the Apollo via the access arm and check out the payload. The CM hatch will be closed and the access arm retracted and latched to the tower during this period to allow emergency escape of the CM. After propellant loading is completed, the access arm will be extended for removal of the checkout crew and loading of the flight crew.

The access arm will be retracted at T minus 60 seconds. The S-IC INTERTANK, S-IC FWD and S-II AFT Service Arms will be retracted at T minus 10 seconds.

The S-II INTERMEDIATE, S-II FWD, S-IVB AFT, S-IVB FWD and SM arms will retract at lift-off after receiving a command signal from lift-off switches located on the holddown arms. These switches are activated by the vertical motion of the vehicle. Inspections will be performed on the arms after each launch to determine the extent of damage due to pressure and heat. All major refurbishment will be performed after removing the arms from the tower and transferring them to a separate Refurbish Building. This page intentionally left blank.

SECTION III DESIGN CRITERIA

Design criteria for the service arms and access arm are established by ground operations, and by ground and launch environments during which the Saturn V Vehicle will function.

Wind conditions are expressed in terms of a percentage. This percentage represents the probability that winds not exceeding a certain magnitude will occur during the month when the strongest winds are expected. For example, a 99% probability wind is a wind velocity which will not be exceeded 99% of the time during the strongest wind month.

The Saturn V Ground Rules (Reference 1) state that the Saturn V Vehicle shall have a free standing capability for the 99.9% probability wind. The Saturn V Vehicle shall be capable of launch for the 99% probability wind and capable of flight for the 95% probability wind.

The Crawler Transporter will be capable of transferring the LUT and the Saturn V Vehicle in winds up to 99% probability wind; the LUT must have a free standing capability, without the vehicle, in hurricane winds.

The wind conditions mentioned above establish the vehicle deflections and frequencies that will affect service arm and access arm design.

Prior to launch, the vehicle size and shape will be affected by the prevailing ambient temperatures and by the weight of propellants.

The initial flight path will be determined by the wind velocity and direction and the booster thrust variation. This is one of the criteria which establishes the retraction time for service arms.

Vehicle drift toward the tower will subject all tower mounted components to severe impingement pressures and temperatures. These conditions necessitate the use of high strength steels and a water quench system for the service arms.

Additional criteria are established by maintenance, checkout, and access required into the vehicle at each umbilical area.

Each of the criteria mentioned above will be discussed in more detail in the paragraphs to follow, General design criteria for each major arm component are discussed in paragraphs 3-13 through 3-18, while detailed criteria and design conditions for each component will be presented in their applicable sections of the report.

3-1. SATURN V VEHICLE DEFLECTIONS ON THE LUT

3-2. VEHICLE DEFLECTIONS DUE TO WIND

The Saturn V Vehicle deflections on the LUT due to wind are presented in Reference 2. This data is presented for the 99.9%, 99% and 95% probability wind conditions for both a fueled and unfueled vehicle. Deflection of the vehicle base caused by flexibility of the holddown arms, the launcher deck, and the LUT foundation are also included in this data. The horizontal translation of the launcher will be subtracted from the total deflection presented for a given station since it has no effect on the net deflection between the vehicle and the service arms.

The Saturn V Vehicle frequencies, as given in Reference 2, are 0.80 cps and 0.33 cps for the unfueled and fueled vehicle respectively.

3-3. VEHICLE DEFLECTIONS DUE TO WIND-INDUCED OSCILLATIONS

The Saturn V Vehicle deflections on the LUT due to wind-induced oscillations are presented in Reference 3. This data is applicable to the 99.9%, 99% and 95% probability wind conditions for both a fueled and unfueled vehicle. Effects of the vehicle base flexibility are included in this data.

These deflections are caused by vortex shedding of wind after the vehicle has undergone its maximum displacement due to steady state wind pressure. The oscillations form an elliptical pattern in the horizontal plane. The major axis of this ellipse lies normal to the steady state wind direction. The elliptical pattern will be contained within the maximum vehicle motion envelope.

3-4. VEHICLE DEFLECTIONS DUE TO THERMAL BENDING

The Saturn V Vehicle deflections on the LUT due to thermal bending are given in Reference 4. This data is based on a 25°F temperature differential between diametrically opposed points on the vehicle skin.

3-5. VEHICLE DEFLECTIONS DUE TO PROPELLANT AND STRUCTURAL DEAD WEIGHT

The Saturn V Vehicle deflections on the LUT due to propellant and structural dead weight are given in Reference 4. This data is presented for the most severe conditions that occur simultaneously to produce maximum vertical deflections. The vertical deflections of the LUT and its foundation relative to the vehicle are negligible.

3-6. VEHICLE SHOCK AND VIBRATION CRITERIA

The Saturn V Vehicle shock and vibration criteria are given in Reference 5. The data is presented for the propellant couplings and electrical umbilical connectors of the S-II, S-IVB, Instrument Unit, and SM. The environments considered are:

a. Transient vibration during ignition, lift-off, maximum dynamic pressure, Mach one, cutoff, separation, ignition of second stage, etc.

b. Steady state vibration during the "mainstage" portion of flight.

c. Short time mechanical or electrical shock environment.

3-7. TOWER DEFLECTIONS DUE TO WIND AND TRANSPORTATION

Tower deflections due to wind and transportation are presented in Reference 6. The deflections are given for the following conditions:

a. LUT transporting the vehicle in a 99% probability wind.

b. LUT stationary with the vehicle at the firing site in a 99.9% probability wind.

c. LUT stationary with fixed supports during hurricane conditions.

d. Crawler transporting the LUT and Saturn V Vehicle with a power pulse of 2.6 ft/sec². The combined loads induced in the vehicle due to crawler acceleration and wind will not exceed those induced at the firing site during a 99.9% probability wind condition.

Tower wind deflections will not be combined with vehicle wind deflections for net deflections between the service arms and the vehicle. This is due to frequency conditions and shielding of one structure by the other for the more critical north-south winds.

3-8. SATURN V VEHICLE DRIFT CONDITIONS

The vehicle drift is given in Reference 7. This reference gives the drift of the vehicle nose and base with respect to the tower versus time in seconds and vehicle rise in feet. Curves are presented giving the combined effect of thrust misalignment and variation with 95% and 99% wind probabilities.

3-9. <u>LUT TEMPERATURES AND PRESSURES DURING SATURN V</u> VEHICLE LIFT-OFF

The LUT and all attached components will be subjected to extremely high impingement pressures and temperatures for critical vehicle drift conditions. The stagnation pressures and temperatures versus distance from nozzle exit and engine centerline are given in reference 8.

The vehicle may be committed to flight during a 95% probability wind and can correct for drift with engine gimbal angles up to $5^{\circ}-9^{\circ}$. A combination of the above conditions can place a given service arm in the exhaust stream, thus subjecting it to the temperatures and pressures indicated in Reference 8. These values can approach 4000° F and 85 psig respectively.

Several temperature versus time curves for various locations on the face and top of the tower are presented in Reference 9. These curves indicate the soak time required to stabilize temperatures of 1/4, 1/2, and 1-inch steel plates. The data considered most applicable for design criteria are for a 1/4-inch steel plate located at the south edge of the top of the tower. A stable temperature of 1200° F is accomplished in a soak time of 15 to 20 seconds.

3-10. ASPIRATION EFFECTS INDUCED BY THE SATURN V ENGINE EXHAUST

Data from the Complex 34 Umbilical Tower, obtained during the SA-4 launch, indicated under-pressures of significant magnitude occurred at tower elevations. These under-pressure levels are caused by the jet pump effect of the exhaust gases as they exit from the engine nozzles. Wind velocities developed across the various decks by this under-pressure can slow or prevent retraction of the service arms. Investigation and analysis of this phenomenon has been requested; however, no positive data is presently available for design criteria.

To provide some relief from the aspirated wind effects, all arms are retracted and latched to the tower before the engine nozzle exits are level with the top of the arm.

3-11. CRITERIA BASED ON PERSONNEL AND MAINTENANCE CONSIDERATIONS

Personnel access into the vehicle will be required from service arms. This access is required for installation, checkout, and maintenance of vehicle components and instrumentation.

The anticipated maximum package weight to be carried across the arms is 200 pounds.

Personnel access to each umbilical carrier will be required for routine and emergency maintenance.

Personnel will not be allowed on the extension platforms during winds greater than 30 knots, except for emergency operations.

3-12. DESIGN LOAD FACTORS

The following load factors will be used:

a. Wind Loads = 2

b. Dead Loads = 2

c. Live Loads = 3

d. Inertia Loads = 2

e. Impact Loads = 2

3-13. DESIGN CRITERIA FOR MAJOR SERVICE ARM COMPONENTS

3-14. ARM STRUCTURE

The truss shall be capable of remaining extended and locked during a 99.9% wind condition and must be capable of being retracted during a 99% wind condition.

The truss shall be capable of withstanding loads induced by an angular deceleration equivalent to an eight "g" side load at the arm tip. No load factor will be used for this condition. Design shall be based on ultimate strengths.

Design loads for the vertical direction shall be determined by combining the maximum dead loads with a maximum live load of 1000 pounds. All major structural members that are critical when exposed to exhaust pressures shall be designed to the yield strength of the material at 1000°F. For all other conditions, the major members will be designed to the yield strength of the material at normal ambient temperature. Minor structure such as flooring, personnel safety screen, handrails, etc., will be designed for normal ambient temperature.

Engine exhaust pressures applied to the arm are a function of drift and engine gimbal angle. The maximum drift condition will give intolerable pressures for design purposes. The arm structure will be designed for the following loads:

a. Carry a net pressure of 10 psig on the projected area of the arms.

b. The floor panels can carry 3.5 psig.

c. If the floor panels have failed, the truss members will withstand up to 35 psig before yield.

3-15. EXTENSION PLATFORMS

The S-IC INTERTANK, S-IC FWD and the S-II AFT Extension Platforms do not couple to the vehicle but make contact only through a rubber bumper. The platforms are withdrawn if wind velocities exceed a 95% probability wind. The maximum live load for these platforms will be 1000 pounds. Loads induced by arm retraction will be negligible.

The S-II FWD, S-IVB AFT, S-IVB FWD and SM Extension Platforms are mechanically coupled to the vehicle in wind conditions not to exceed 30 knots. They must remain attached during the 95% probability wind. While coupled, the extension platforms must track the vehicle through an envelope established by combining the effects of a 95% wind, thermal bending, vehicle deflection due to weight, wind-induced oscillations, etc. The detailed criteria is given in Table 3-1. These platforms are withdrawn after vehicle service and prior to lift-off. The platform designs are subject to criteria established by service arm acceleration. The maximum live load will be 1000 pounds.

All extension platforms will be designed to the same criteria for temperature and pressure as stated for arm structure.

ARM	VEHICLE	HORIZONTAL DEFL. (IN.)		HORIZONTAL OSCILL. (IN.)	HORIZONTAL ACCELERATION (IN/SEC ²)	
S-IC INTER'K	692	± .65	+ .65 35	± .10	2,54	
S-IC FWD	1415	± 2.60	+ 1.30 - 3.60	± .55	14.00	
S-II AFT	1590	± 3.20	+ 1.35 - 3.60	± .65	16.50	
S-I INT				<u> </u>		
S-I FWD	2437	± 7.00	+ 2.40 - 5.60	± 1.40	35,60	
S-IVB AFT	2644	± 8.30	+ 2.50 - 5.65	± 1.65	42.00	
S-IXB FWD	3169	± 12.50	+ 3.00 - 7.00	± 2.10	53.40	
S. M.	3614	± 16.80	+ 3.30 - 7.40	± 2.70	68.50	

Table 3-1.Vehicle and Tower Deflections For ExtensionPlatform Design

- INCLUDES SOLAR WARPAGE AT 95% WIND CONDITION. DOES NOT INCLUDE TOWER DEFLECTIONS.
- INCLUDES TOWER DEFLECTIONS, 120° F. TEMP, AND FUELED VEHICLE CONDITIONS.
- RESULT OF VORTEX SHEDDING AT 95% WIND, EMPTY VEHICLE, f = .80
- > PLATFORM DOES NOT FOLLOW VEHICLE MOTION.
- DEFLECTIONS FOR THIS LOCATION ARE APPROX. DEFINITE INFORMATION NOT AVAILABLE.

3-16. WITHDRAWAL MECHANISMS

The withdrawal mechanism shall be capable of tracking the vehicle through an envelope established by the 99.9% wind condition, vehicle deflection due to propellant weight, and wind-induced oscillations. Thermal bending is excluded from this summation because it will not be coincident with a 99.9% wind condition. Detailed design data for each withdrawal mechanism is presented in Tables 3-2 and 3-3.

The withdrawal mechanisms shall be capable of retracting the umbilical carrier to the service arm tip from any point within an envelope established by the 99% wind condition, thermal bending, vehicle deflection due to propellant weight, wind-induced oscillations, and vertical motion of the vehicle during the first few inches of flight. This criteria is presented in Table 3-3.

The withdrawal mechanism shall function while subjected to inertia loads induced by service arm retraction and shall be capable of surviving the following conditions:

a. Impact loads that were described for the service arm structure. Design will be based on the ultimate strength of the material at normal temperature.

b. External design pressure of 35 psig with the design based on yield strength of the material at 1000°F.

c. Inertia loads induced when withdrawing in one second. Design will be based on yield strength of the material at normal temperature.

During LUT transport the withdrawal mechanisms will be extended and attached to the vehicle and must accommodate this motion envelope which shall not exceed the 99 9% condition previously stated.

3-17. ARM RETRACTION SYSTEM

The arm retraction system shall be designed to retract the arm in a 99% probability wind for the most severe vehicle drift condition, and each arm must arrive and latch to the tower face before the bottom of the booster nozzles are level with the top of each service arm. The most critical retraction times for the service arms are given in Table 3-4.

Service Arm	Vehicle Station	Lateral Displacement (Reference 2 & 4)	Vehicle Vertical Deflections		
			+		
S-IC INTERTANK	772	2.5	. 46	1.15	
S-IC FWD	1516	6.8	1.03	3.34	
S-II AFT	1606	7.3	1.06	3.36	
S-II INTERMEDIATE (Lox & Umb.)	1771	8. 3	1.27	3.46	
S-II INTERMEDIATE (LH ₂ Line)	1905	9.3	1.25	3.54	
S-II FWD	2506	13.5	2.12	5.45	
S-IVB AFT	2777	15.8	2.18	5.67	
S-IVB FWD	3222	20: 3	2.64	6.64	
SM ³	3721	26.6	2.98	7.16	

Table 3-2. Vehicle Motion Envelope Prior To Lift-Off

Notes:

- (1) Horizontal Translations given in References 2 and 3 have been subtracted. Reference Design Criteria, Section III.
- (2) Lateral Displacements are the maximum of the two following conditions:
 - (a) 99.9% wind and fueled vehicle.
 - (b) 99% wind and unfueled vehicle plus thermal bending.
- (3) Deflections for this location are approximate. No definite information available.

Service Arm	Vehicle Station	Lateral Displacement (Reference 2 & 4)	Vehicle Vertical Defelctions		
			+	-	
S-IC INTERTANK	772	1.6	0	1.15	
S-IC FWD	1516	4.0	0	3.34	
S-II AFT	1606	4.5	0	3.36	
S-II INTERMEDIATE (LOX & Umb.)	1771	5.2	0	3.46	
S-II INTERMEDIATE (LH ₂ Line)	1905	5.7	0	3.54	
S-II FWD	2506	8.4	0	5.45	
S-IVB AFT	2777	9.5	0	5.67	
S-IVB FWD	3222	11.9	0	6.64	
SM ³	3721	14.5	0	7.16	

Table 3-3. Vehicle Motion Envelope at Lift-Off

Notes:

- Horizontal translations given in References 2 and 3 have been subtracted. Reference Design Criteria, Section III.
- (2) Lateral Displacements are for the 99% wind, fueled vehicle condition.
- (3) Deflections for this location are approximate. No definite information available.

Arm	Tower Station	Retraction Time (Sec)		
S-II INTERMEDIATE	1739.25	6.38		
S-II FWD	2391.25	7.37		
S-IVB AFT	2630.47	7.70		
S-IVB FWD	3155.55	8.38		
SM	3634.80	8.96		

Table 3-4. Maximum Retraction Times for In-flight Arms

Note: Retraction times are based on the travel time required for the bottom of the nozzle (station 115.0) to reach the top of each service arm.

3-18. DESIGN CRITERIA FOR THE COMMAND MODULE ACCESS ARM

The access arm will be latched to the tower during transportation to the firing site.

At the firing site, the access arm can be extended and coupled to the vehicle in wind velocities up to the 95% probability wind (Table 3-5).

The access arm cab must be capable of tracking the vehicle envelope established by a 99% probability wind, thermal bending, vehicle deflection due to propellant loads, and wind-induced oscillations (Table 3-5).

The design temperature for the access arm will be the same as specified for the service arms. The access arm will be retracted approximately 60 seconds prior to lift-off in wind velocities up to 99% probability wind.

More detailed criteria is presented in Section VI for each of the major access arm components.

DECICIL CRITERIA	WIND PROBABILITY CONDITIONS					
DESIGN CRITERIA ITEMS	95%		99%		99.9%	
II EMS	Fueled	Unfueled	Fueled	Unfueled	Fueled	Unfueled
				2	ě.	1
Steady state wind	20.4	20.4	20 7	20 7	10 2	40.2
velocity (knots)	29.4	29.4	38.7	38.7	48.3	48.3
Peak wind velocity						
(knots) .	41.2	41.2	54.2	54.2	67.6	67.6
Displacement of C. M.	-					
induced by wind (in.)	5.7	5.4	15.8	15.5	26.0	24.4
Thermal bending						
envelope (in.)	-	13.3	-	13.3	_	_
onvolope (m.)		10.0		-9.9	2	
Maximum C.M.						
displacement (in.)	5.7	18.7*	15.8	28.8*	26.0	24.4
	<i>R</i>	Š.				
Amplitude of wind						
induced oscillations	2 0	2 0		4 0	10.0	0.0
(cps)	3.9	3.8	7.0	6.3	10.2	9.8
Freq. of wind induced						
oscillations (in. /sec)	. 33	.80	.33	.80	. 33	.80
	a					
Velocity of wind induced						
oscillation (in./sec)	8.1	18.9	14.6	34.2	21.2	49.3
Acceleration of wind						
induced oscillations	16.9	95.0	30.3	173.0	44.1	247.2
		/	ವಿಶಾಸಕ್ ವೇ	1 TAU 7 ATA \$ 1.7	1990 B. 400 B.	
"G" loading wind						
induced oscillations	0,044	0.246	.078	.0446	0.114	0.639

Table 3-5. Command Module Access Arm Design Criteria

*Displacement figures based on thermal and wind induced displacements. Wind induced oscillations occur within the maximum displacement envelope.

SECTION IV SERVICE ARMS

There are eight service arms (S-IC INTERTANK, S-IC FWD, S-II AFT, S-II INTERMEDIATE, S-II FWD, S-IVB AFT, S-IVB FWD, and SM) attached to the LUT mounting beam and extending to within approximately 5 feet of the vehicle (Figure 2-2).

These arms support service lines that are required to sustain the vehicle at the firing site prior to launch. The dimensions of the arms are sufficient to permit personnel passage through the arm to an extension platform. The extension platform provides for personnel entrance into the vehicle and allows access to the various umbilical service areas.

There are two general classifications or types of service arms: preflight and in-flight. The preflight arms are retracted and locked against the tower face prior to vehicle lift-off. The in-flight arms remain extended until the vehicle is launched and are then rotated to the tower before the engine nozzles reach the arm elevation. The S-IC INTERTANK arm must be capable of reconnecting if the launch is aborted during the last 10 seconds of countdown.

The weight and center of gravity has been determined for each arm except the SM and CM arms. This data is presented in Appendix B.

For convenience of presentation, the discussion of the service arms is separated into the arm structure; the withdrawal mechanism and line handling devices; the extension platforms; the arm retraction system; the electrical system; and the service lines. The detail operational sequence is presented in paragraph 4-83.

4-1. ARM STRUCTURE

The complete structural arm assembly consists of either two or three elements (Figure 4-1). The element nearest the tower is designated as the first element and the one nearest the vehicle as the second element. On two arms (S-IVB FWD and SM), the first and second elements are connected by another section designated as an extension element. All elements are of truss type construction employing tubular members and gusset plates. The S-IC FWD, S-II AFT, S-II INTERMEDIATE, and the S-II FWD arms are approximately 420 inches long. The S-IC INTERTANK arm is 13 inches shorter due to tower geometry. The S-IVB AFT, S-IVB FWD, and the SM arms range from 455 inches to 541 inches in length. This additional length is required because of reduced vehicle diameter.

The outside arm dimensions are 60 inches wide and 98 inches high and provide an unobstructed area of 42 by 78 inches for personnel passage. The floor of the arm is constructed of panels which are bolted to angles installed parallel and adjacent to the lower chords. A 1-1/2 inch diameter handrail is provided 42 inches above the floor level for personnel safety.

4-2. MATERIAL SELECTION CRITERIA

During adverse launch conditions, the upper surface of a 1/4 inch thick plate located at the top south edge of the tower will be heated to approximately 1800°F for two to three seconds. This temperature will stabilize at approximately 1200°F for 15 to 20 seconds.

Because of the transient nature of this high temperature, a lesser temperature of 1000°F was chosen as optimum for the accompanying blast loading (paragraph 3-14). To satisfy this requirement, T-1 Type A steel is used for all material thicknesses of one inch or less. For material over one inch thick, T-1 steel is used because T-1 Type A is not available.

T-1 and T-1 Type A steels have yield strengths of 100,000 psi at normal temperatures for plates up to 2-1/2 inches thick and 1 inch thick respectively. For T-1 steel plates over 2-1/2 inches thick and for square tubes, the yield strength is 90,000 psi. At 1000 °F the yield strengths decrease to 73,000 psi. These steels will, upon cooling, regain their original yield strength and modulus of elasticity unless the tempering temperature is exceeded.

As a collateral benefit to the high strengths, T-l has a resistance to atmospheric corrosion four times that of structural carbon steel while T-lType A has a resistance equal to twice that of structural carbon steel. The addition of nickel and copper accounts for the increased corrosion resistance of T-l.

4-3. FIRST ELEMENT

The first element (Figure 4-2) is a truss approximately 272 inches long and is common to all service arms. The interchangeability of this element requires that it be designed for the arm with the most severe loading conditions. It is supported at the tower face by the upper and lower arm hinges. Splice plates are provided on the vehicle end for connection of an extension element or a second element. This element, in elevation, is a Pratt truss with the upper and lower chords connected by members designed for load reversals.

Two wide-flange beams with coverplates, connect the upper and lower hinge plates. These beams transfer the individual bending loads caused by the rotational tendency of the self-aligning bearings. Arm locking devices are incorporated into the hinge plates. For personnel safety and protection of the locking mechanisms, the lower hinge plate is covered with a removable floor grating. The first element is also equipped with a secondary arm lock which is actuated by the movement of a manually operated safety gate (Figure 4-3). The gate occupies a position in the floor, near the hinge plate, and operates a lock to prevent arm rotation. When the gate is in a raised position, barricading the arm, the lock is disengaged.

4-4. SECOND ELEMENT

The second element (Figures 4-4 through 4-7) is the vehicle end of the structural arm assembly. This element, in elevation, is a K-truss design with the lower half of the last panel omitted to accommodate the retracted extension platform and "T" head. The element is of welded construction and framed predominately of square tubular members which furnish additional strength in areas of local bending. Splice plates are mounted on the tower end of the second element for connection to the first element or extension element.

The second element contains brackets for supporting the extension platform box beams. These brackets are pinned longitudinally to prevent transfer of bending loads, caused by deflection of the box beam, into the vertical arm truss. However, the truss does support, in bending, the eccentric vertical shear and the side load induced by the box beams.

4-5. WITHDRAWAL MECHANISM MOUNT

Withdrawal mechanism mounts (Figures 4-8 and 4-9) are provided on the arms to support the mechanisms. The mounts also transfer the withdrawal mechanism loads to the arm structure.

4-6. EXTENSION ELEMENT

The two extension elements (Figure 4-10) are K-trusses fabricated from round tubing and gusset plates. The extension element for the S-IVB FWD arm is 68 inches long; the element for the SM arm is 121 inches long.

4-7. CABLE ATTACH BEAM

The arm mounted cable attach beams (Figure 4-11) are weldments of T-1 Type A steel plate and are supported by self-aligning bearings to allow rotation as the arm is retracted. The beam is mounted at the vehicle end of the first element and transfers the cable tension produced by the tower mounted cylinder into the arm structure. These beams are identical for all arms except the S-IVB AFT. This arm has a special beam to provide clearance for the propellant lines.

4-8. SERVICE ARM MOUNTING HINGE

Two tower mounted hinges (Figures 4-12 and 4-13) located above and below the arm hinge plates support the service arm. Each hinge weighs approximately 2500 pounds and is designed to support the service arms structure under a blast load of 35 psi with the arm in the retracted position.

The hinges are fabricated of welded ASTM A441 steel plate, 1/2 to 2 inches thick, and are bolted to the tower structure with high strength steel bolts.

Each hinge contains a bearing assembly, drive shaft, hydraulic cylinder, and associated piping. The upper and lower hinge assemblies are protected by dust covers which pivot at one corner for access to the equipment. The hydraulic cylinder is clevis mounted to the hinge structure. The piston rod of the cylinder is pinned to a driving arm which transmits torque through the drive shaft to the service arm hinge plate (Figure 4-14).

The differences in the upper and lower hinges are the opposite hand mounting of the hinge components, the secondary lock bracket located only on the lower hinge, and the deceleration valve located only in the upper hinge.

Two adjustable lock mechanisms will hold the service arm in the extended position and are located on the east side of the hinge assemblies. The locking dog is driven by a linkage and a hydraulic cylinder. The dog contacts a floating insert located in the service arm hinge plate ensuring full surface contact.

A secondary locking device prevents inadvertent arm rotation while personnel are on the arm. A floating insert, located in the lower towermounted hinge, receives a key that is pivoted from the arm hinge plate. Personnel entering the arm lower the safety gate, thus engaging the lock.

The upper surface of the lower hinge serves as a continuation of the access platform and is covered with a nonskid coating to provide a safe walking surface. This page intentionally left blank.

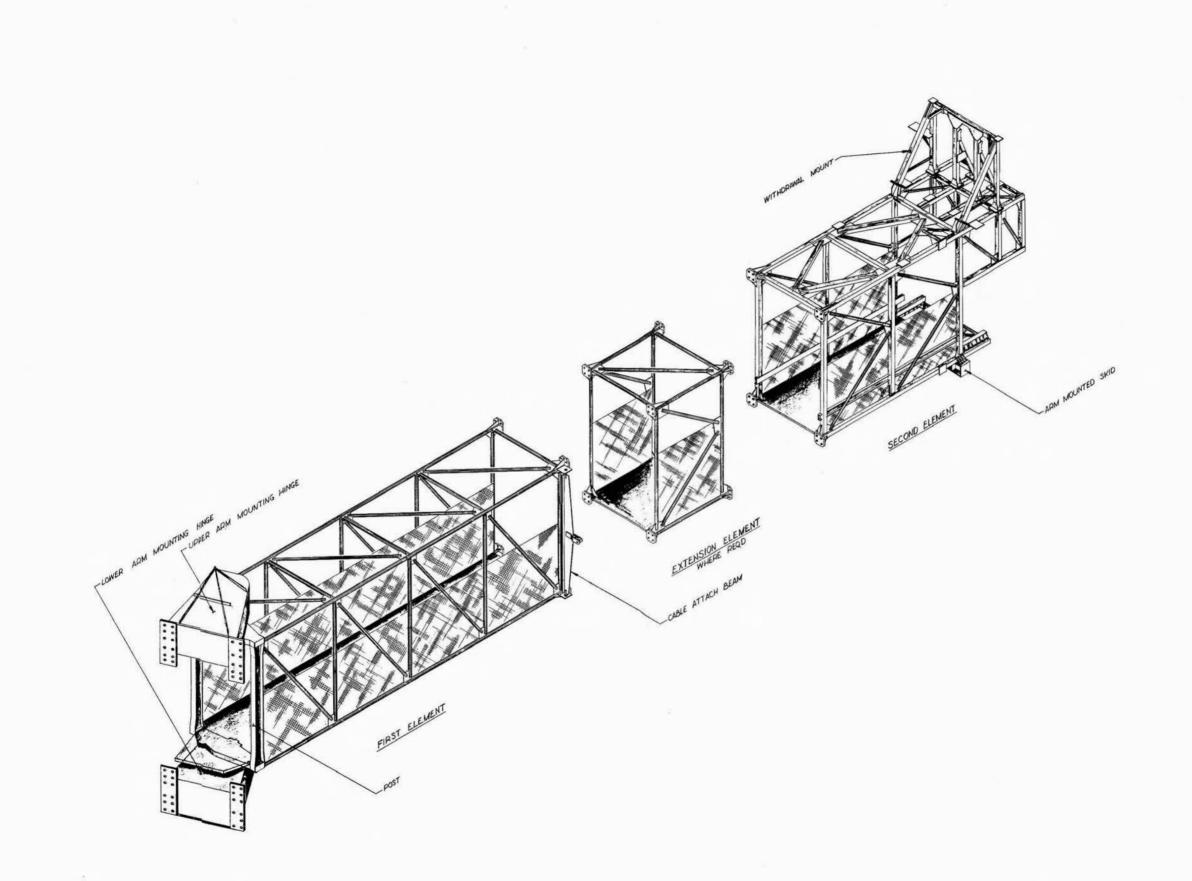
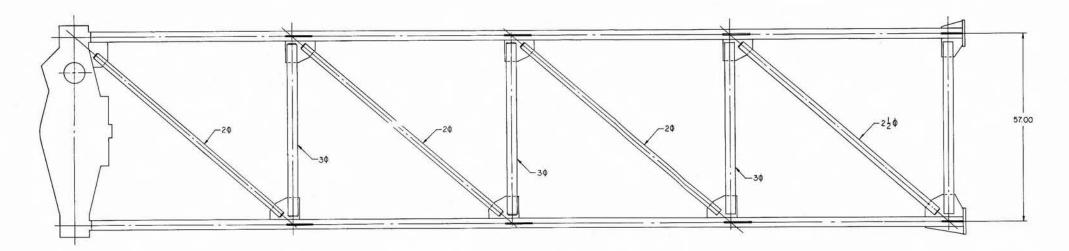
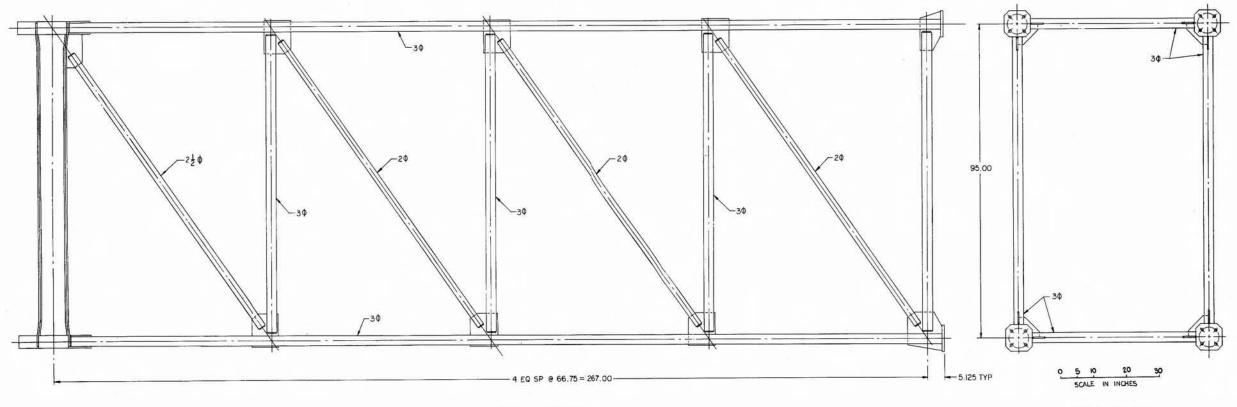


Figure 4-1. Structural Arm Assembly



PLAN - TOP CHORD

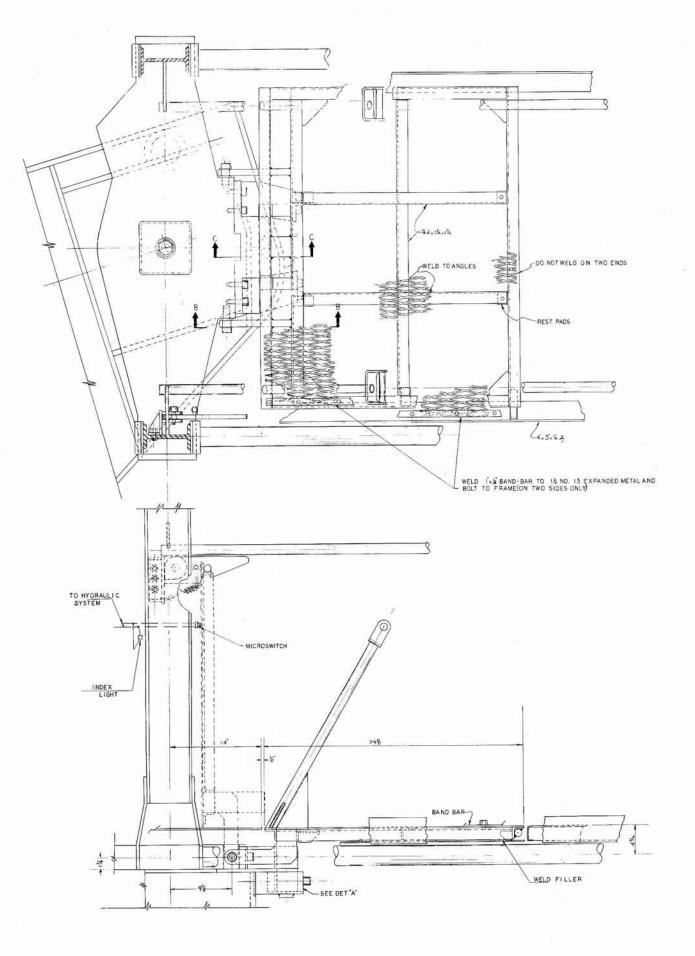


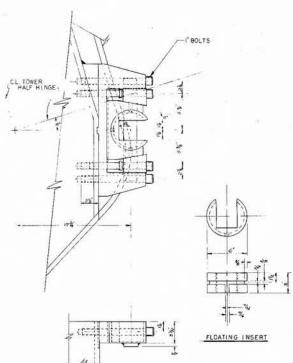
82

SIDE ELEVATION

END ELEVATION

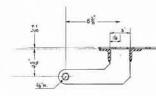
Figure 4-2. First Element







DETAIL A



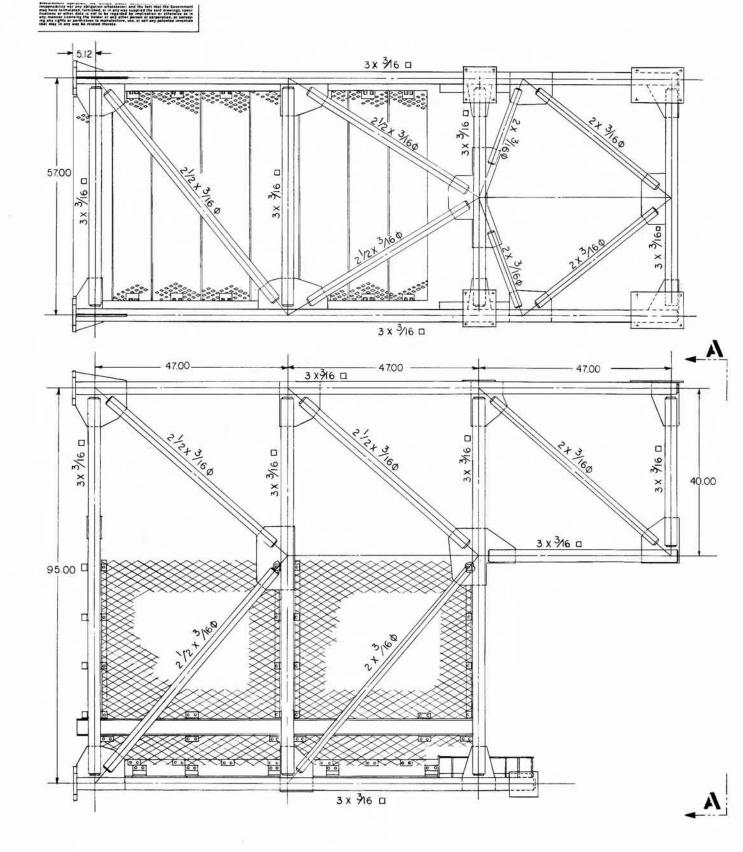
SECTION B-B HINGE

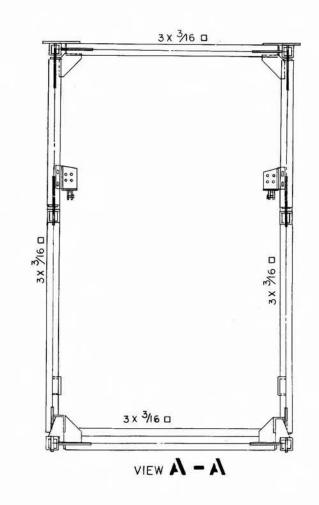


SECTION "C-C"

(GRIND CORNERS - WR APROX)

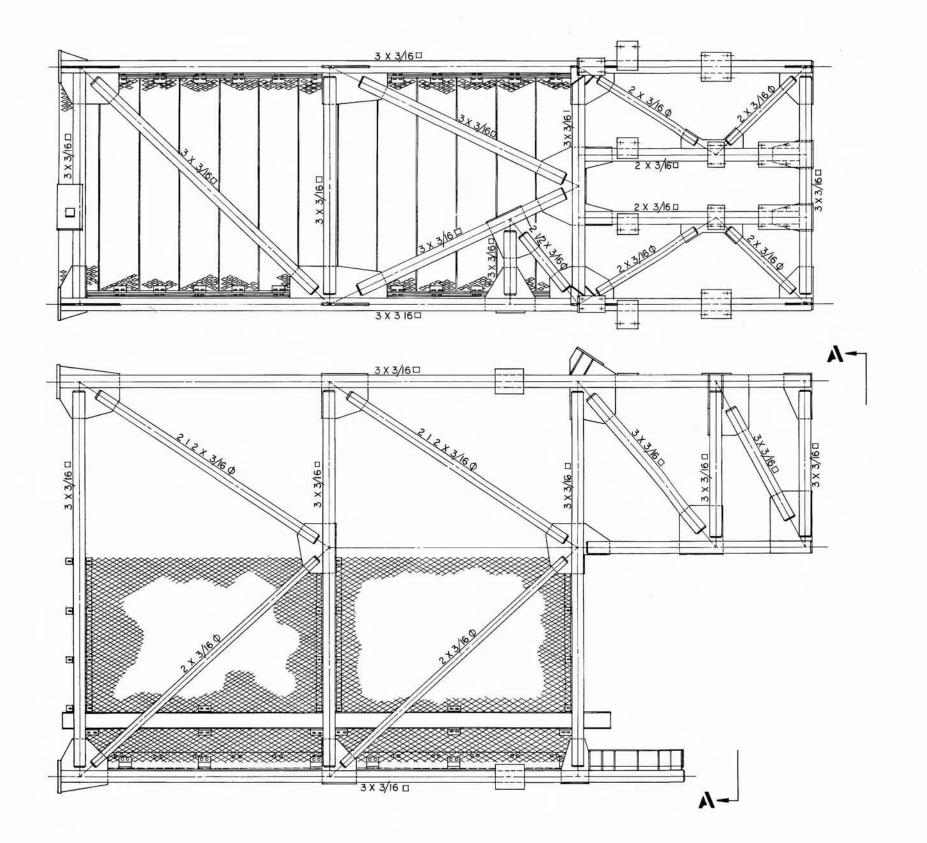
Figure 4-3. Safety Gate





30 õ 20 SCALE-IN INCHES

Figure 4-4. S-IC FWD Second Element



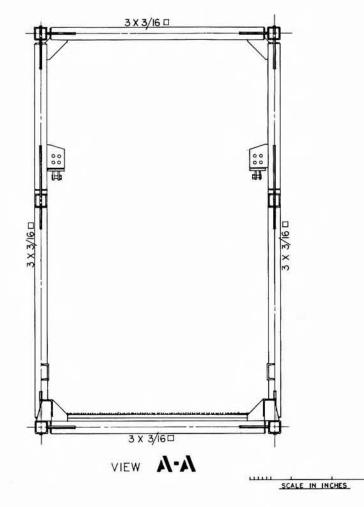


Figure 4-5. S-IVB AFT Second Element 85

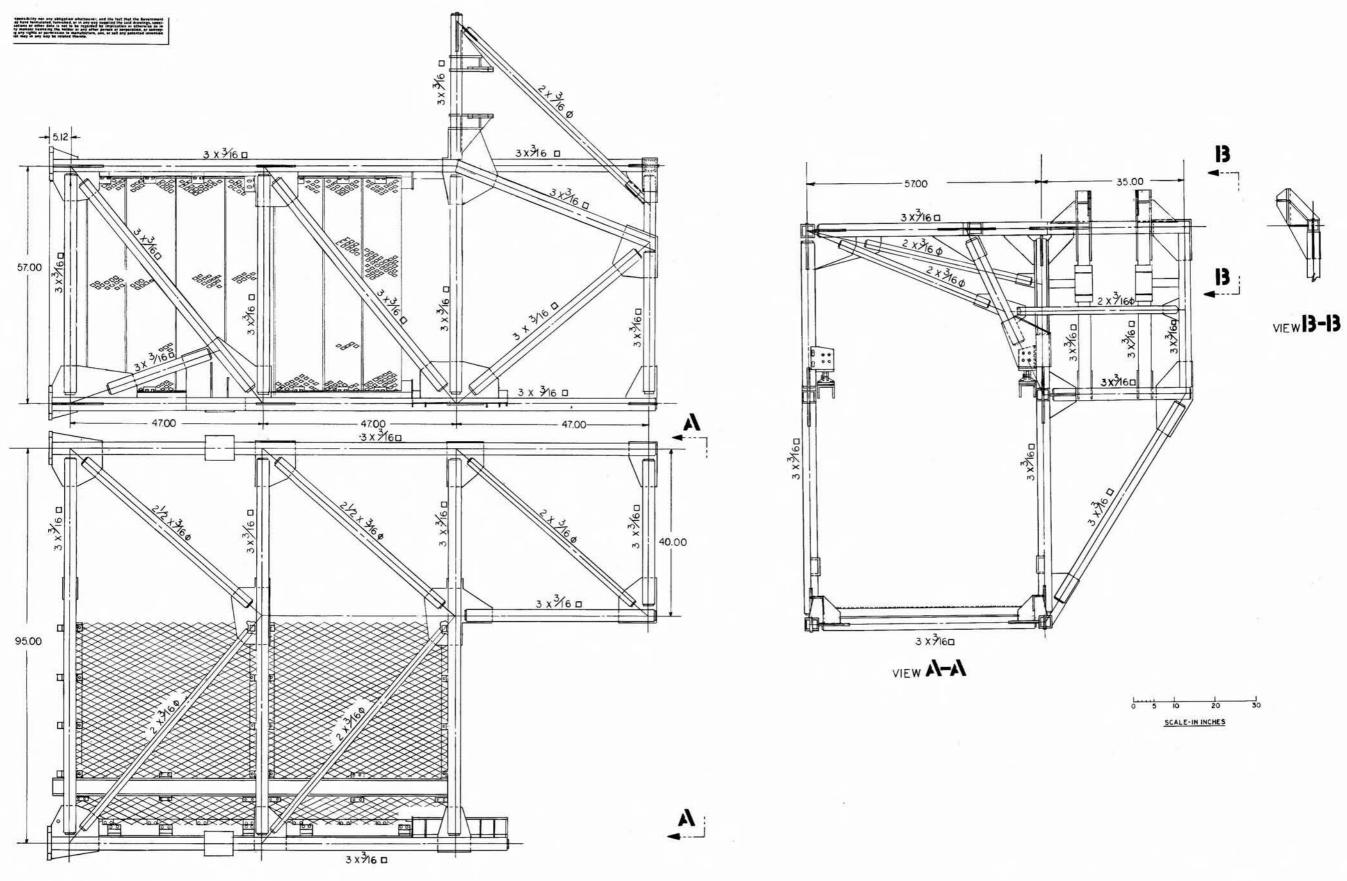
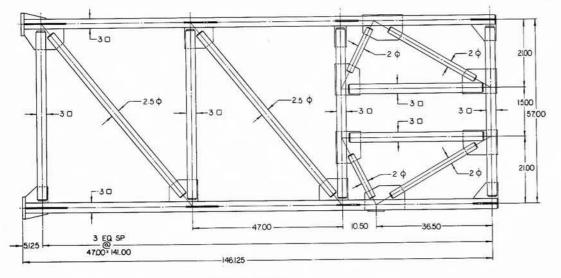
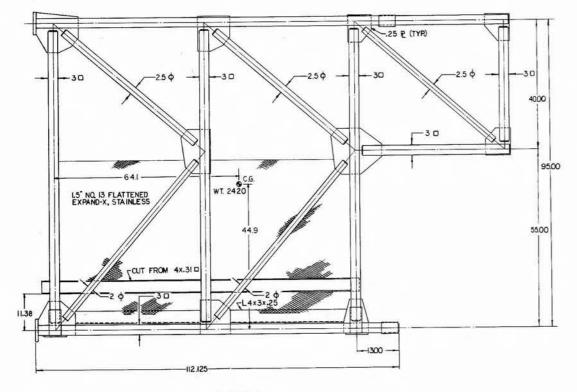


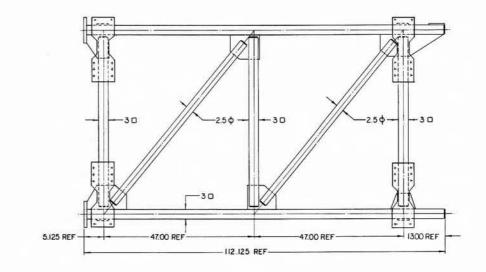
Figure 4-6. S-IVB FWD Second Element



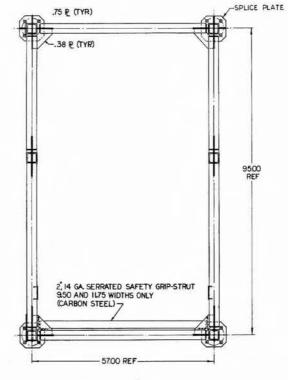
PLAN-TOP CHORD



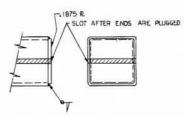
ELEVATION

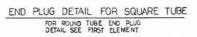


PLAN-BOTTOM CHORD



RIGHT-SIDE ELEVATION

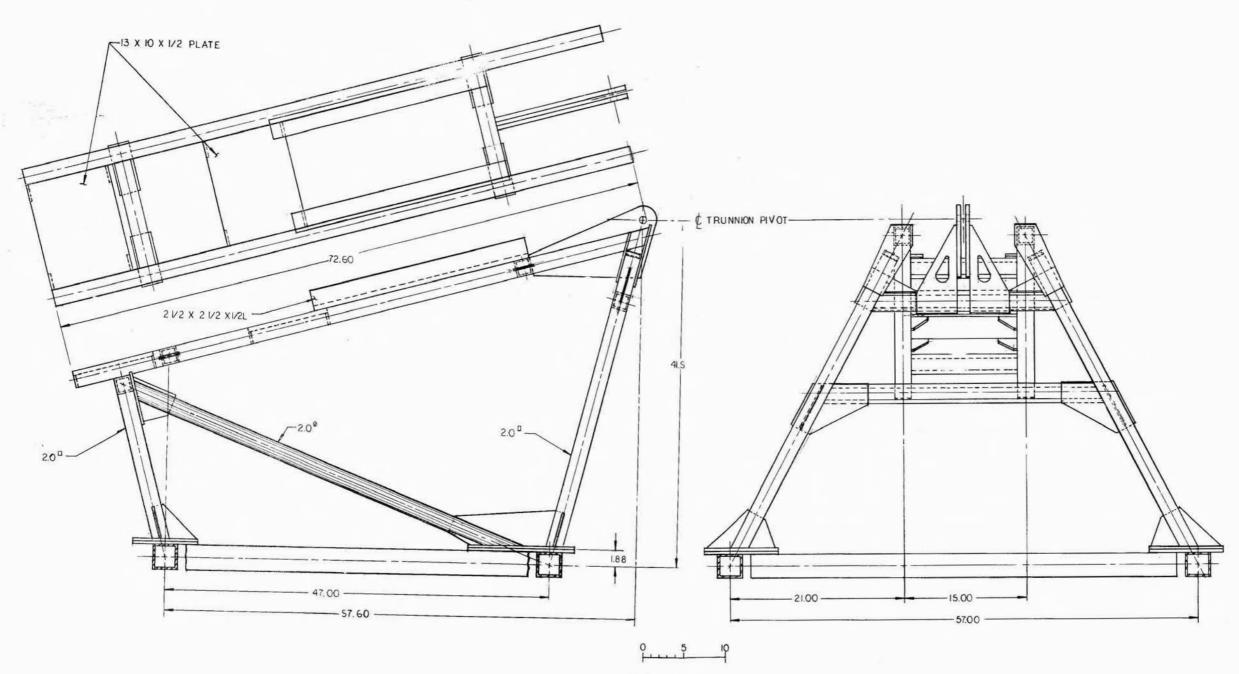




NOTE. FOR JOINT WELDS SEE FIRST ELEMENT

0 5 10 20 30 SCALE IN INCHES

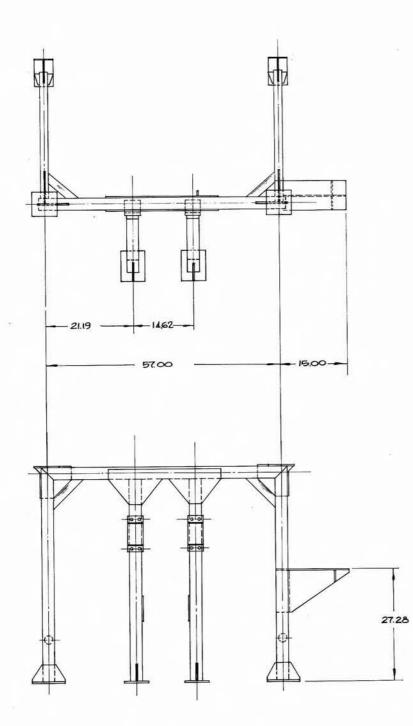
Figure 4-7. Service Module Second Element .



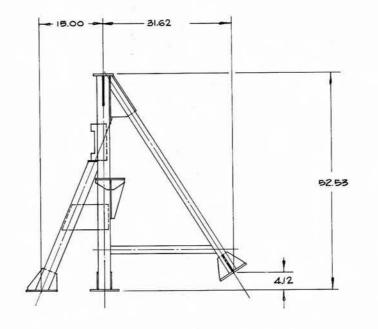
SCALE IN INCHES

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Figure 4-8. S-IC FWD Withdrawal Mount

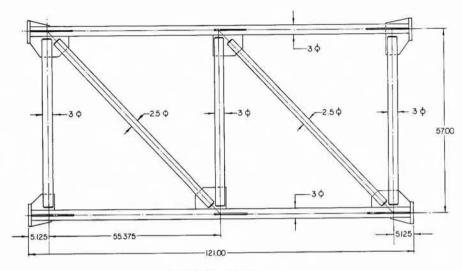


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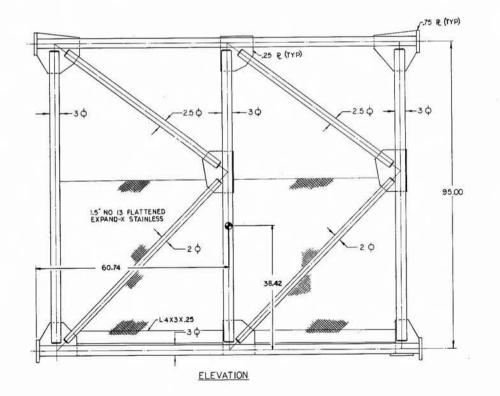


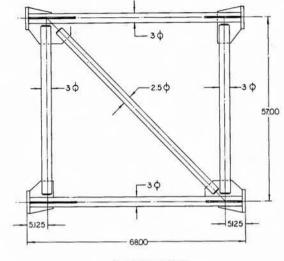
0 5 1 1 SCALE IN INCHES

Figure 4-9. S-IVB AFT Withdrawal Mount

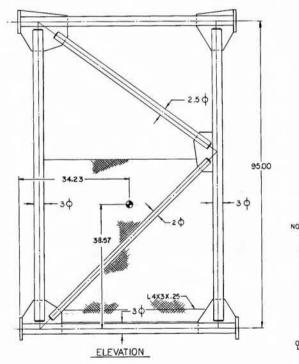


PLAN-TOP CHORD





PLAN TOP CHORD



1

NOTES: 1 FOR CROSS SECTION SEE BASIC FIRST ELEMENT 2 FOR END FLUG DETAIL FOR TUBES SEE FIRST ELEMENT 3 FOR JOINT WELD'S SEE FIRST ELEMENT

0 5 10 20 30 SCALE IN INCHES

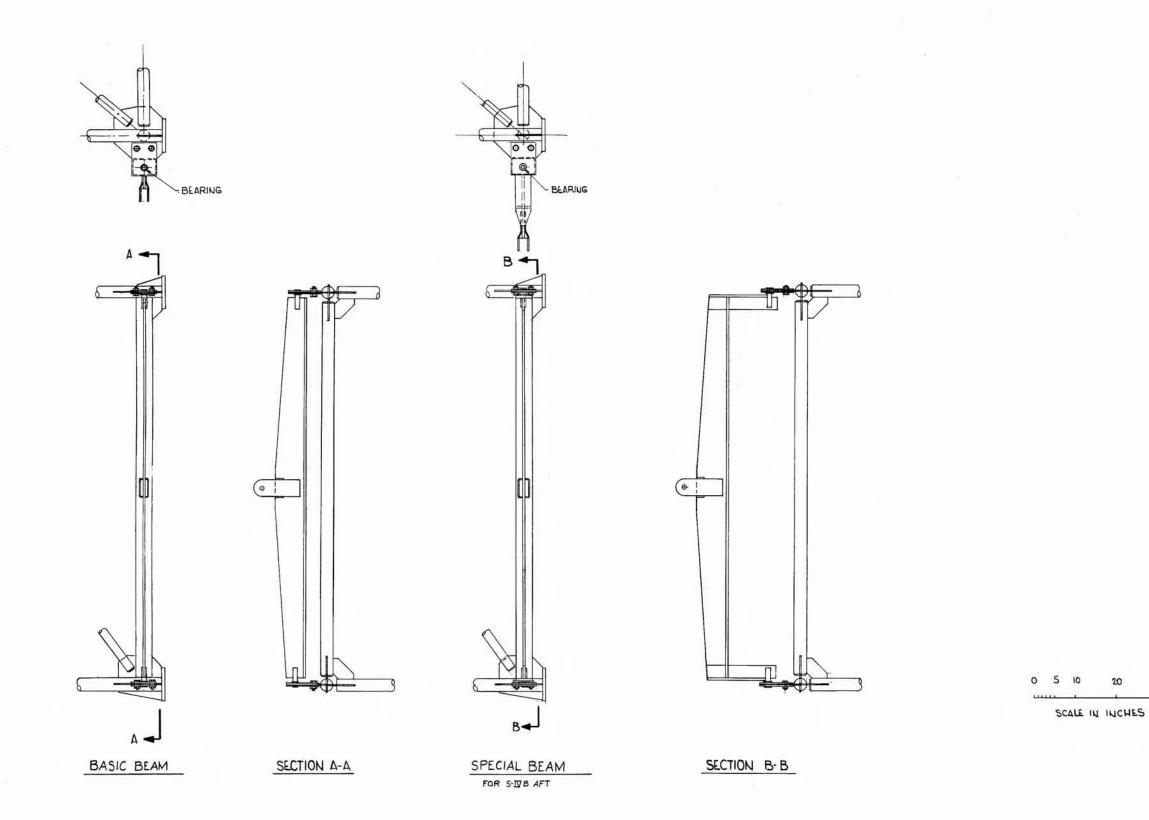
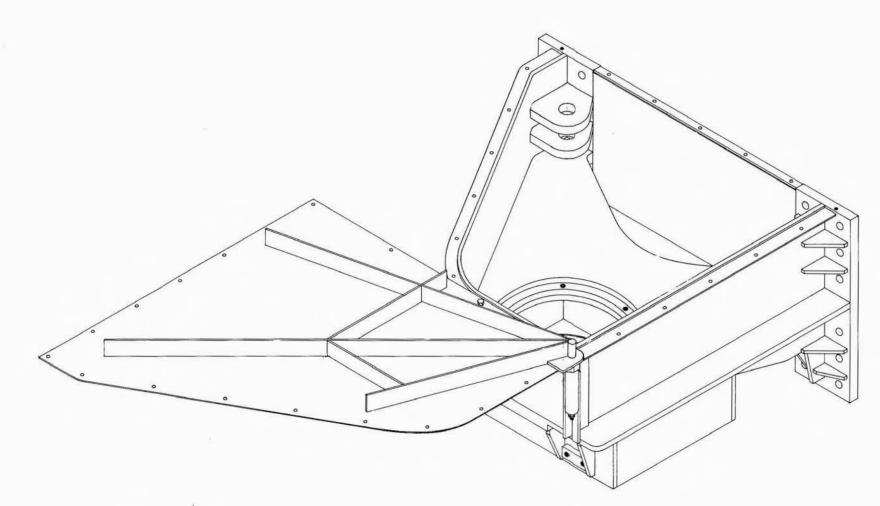
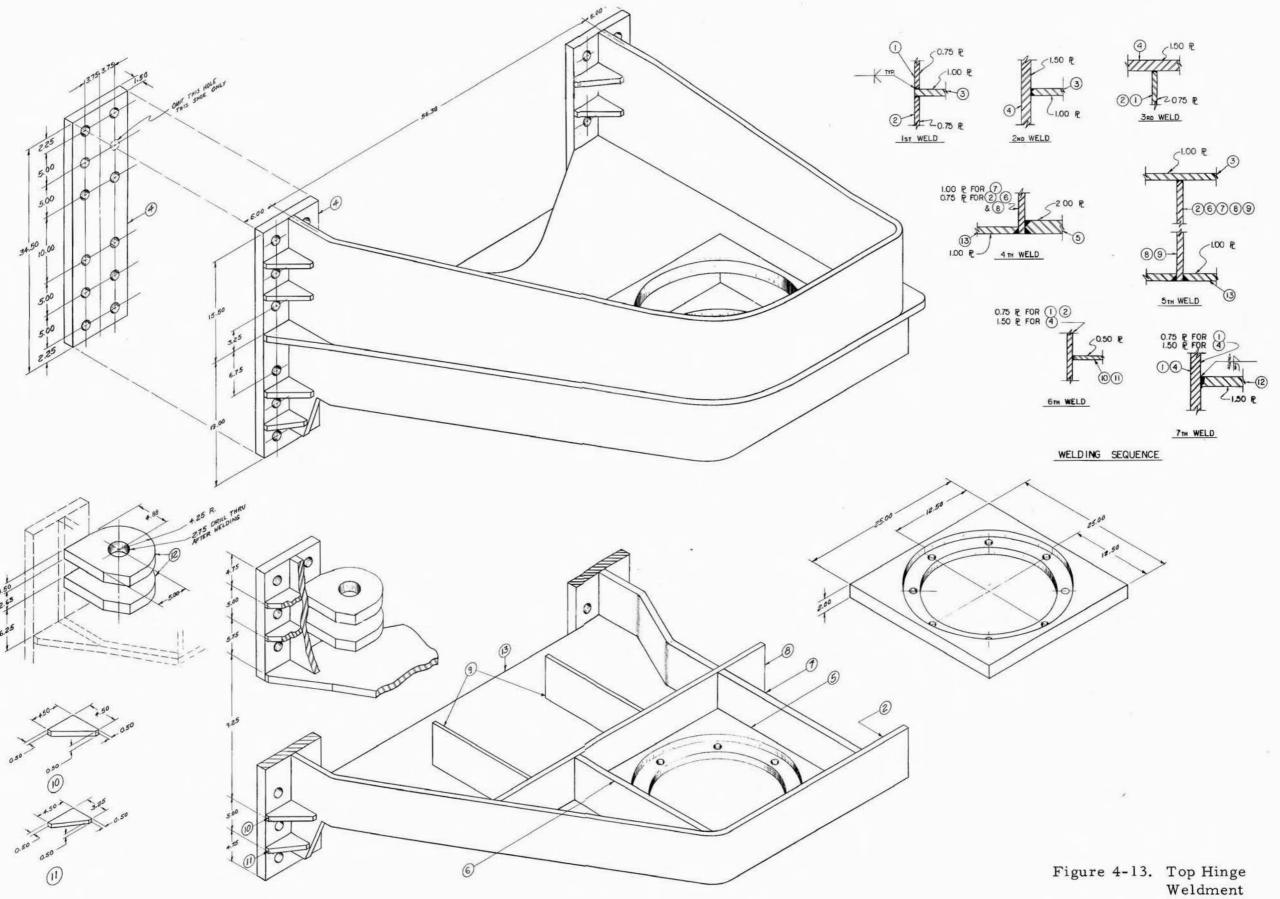


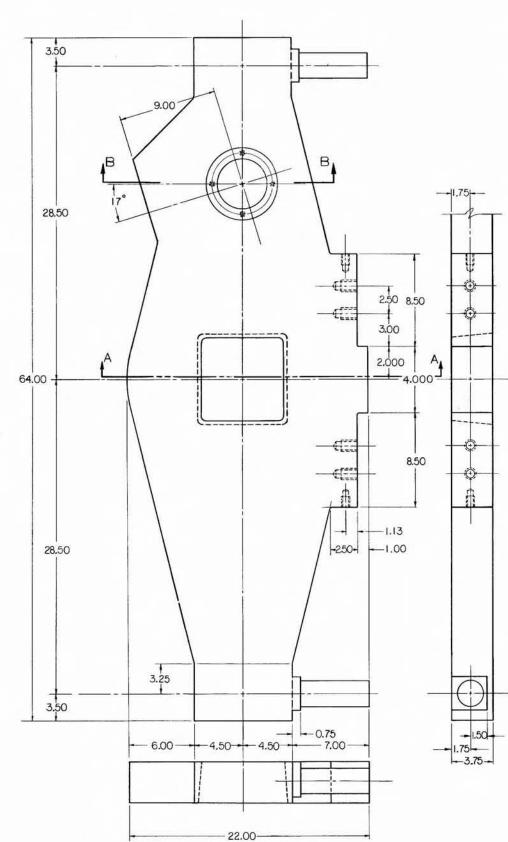
Figure 4-11. Cable Attach Beam

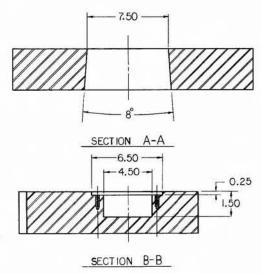


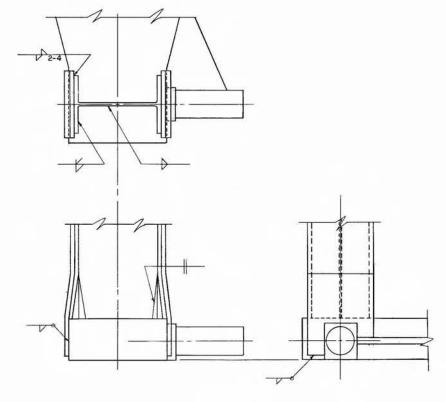
JACKING LUG (TOP HINGE ONLY)

PIVOT DETAIL









TYP. WELD AT POST CONNECTION

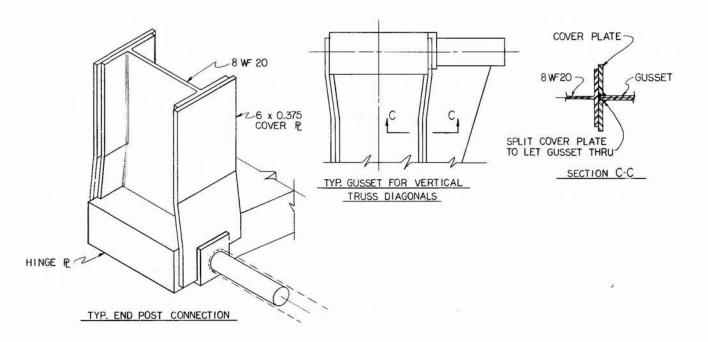


Figure 4-14. Hinge Plate

4-9. WITHDRAWAL MECHANISM AND LINE HANDLING DEVICES

The mechanisms (Figure 4-15) discussed in this section are divided into three general categories: umbilical carrier withdrawal mechanisms, cam-off mechanisms, and line handling devices. The basic function of the withdrawal mechanism is to provide rapid withdrawal of the umbilical carrier from the disconnected position adjacent to the vehicle skin to a stored position near the end of the service arm. The purpose of the cam-off (or disconnect) mechanism is to provide a redundant method of unlocking and separating the umbilical carrier from the vehicle plate. The line handling device operates in conjunction with the withdrawal mechanism to ensure that the line slack developed during withdrawal is accommodated without excessive bending of the lines and without interference with adjacent structures or mechanisms.

The withdrawal mechanism is mounted on the vehicle end of the service arm and is bolted to the umbilical carrier. The mechanism must be capable of following the relative displacement of the vehicle caused by wind loading, thermal bending, fuel weight compression, and thermal contraction due to subzero temperatures of the cryogenic propellants (Tables 4-1 and 4-2).

The "Description of Components" and the "Operational Description" (paragraphs 4-10 and 4-17) are generally applicable to the S-II INTER-MEDIATE, S-II FWD, S-IVB AFT and S-IVB FWD Service Arms.

Some of the detailed descriptions and illustrations used are peculiar to the S-IVB AFT arm. The differences between the mechanisms for S-IVB AFT arm and those for the other service arms are clarified in paragraph 4-19.

4-10. DESCRIPTION OF COMPONENTS

4-11. <u>Umbilical Carrier</u>. The umbilical carrier for the S-IVB AFT (Figure 4-16) is essentially a rectangular housing containing the various line connectors which mate with counter-parts in the vehicle plate. The carrier and vehicle plate are held together until released by a ball-lock assembly. Umbilical carriers for all stages are shown in Figures 7-3 through 7-8.

Primary disconnect is accomplished by energizing small pneumatic push-off pistons which are contained within the housing. These pistons and the ball lock are energized simultaneously. Hockey stick type cam levers are pivoted on each side of the housing and linked to the ball-lock assembly. The levers are driven by the cam-off mechanism and will provide a secondary means of umbilical carrier unlock and separation in case of primary disconnect failure. As the levers are revolved, the ball lock is mechanically disengaged. The lower surfaces of the levers then contact the vehicle to produce

Service Arm	Vehicle Station	Lateral Displacement (Reference 2 & 4)		
C IC INTERTANT		1 (+	
S-IC INTERTANK	772	1.6	0	1.15
S-IC FWD	1516	4.0	0	3.34
S-II AFT	1606	4.5	0	3.36
S-II INTERMEDIATE (LOX & Umb.)	1771	5.2	0	3.46
S-II INTERMEDIATE (LH ₂ Line)	1905	5.7	0.	3.54
S-II FWD	2506	8.4	0	5.45
S-IVB AFT	2777	9.5	0	5.67
S-IVB FWD	3222	11.9	0	6.64
sm ³	3721	14.5	0	7.16

Table 4-1. Vehicle Motion Envelope at Lift-Off

Notes:

- Horizontal translations given in References 2 and 3 have been subtracted. Reference Design Criteria, Section III.
- (2) Lateral Displacements are for the 99% wind, fueled vehicle condition.
- (3) Deflections for this location are approximate. No definite information available.

Service Arm	Vehicle Station	Lateral Displacement (Reference 2 & 4)	Vehicle Vertical Deflections	
S-IC INTERTANK	772	2.5	+ . 46	-
S-IC FWD	1516	6.8	1.03	3.34
S-II AFT	1606	7.3	1.06	3.36
S-II INTERMEDIATE (LOX & Umb.)	1771	8.3	1.27	3.46
S-II INTERMEDIATE (LH ₂ Line)	1905	9.3	1.25	3.54
S-II FWD	2506	13.5	2.12	5.45
S-IVB AFT	2777	15.8	2.18	5.67
S-IVB FWD	3222	20.3	2.64	6.64
SM ³	3721	26.6	2.98	7.16

Table 4-2. Vehicle Motion Envelope Prior to Lift-Off

Notes:

- Horizontal Translations given in References 2 and 3 have been subtracted. Reference Design Criteria, Section III.
- (2) Lateral Displacements are the maximum of the two following conditions:
 - (a) 99.9% wind and fueled vehicle.
 - (b) 99% wind and unfueled vehicle plus thermal bending.
- (3) Deflections for this location are approximate. No definite information available.

a prying action which rotates the umbilical carrier about its support feet. The support feet release completely before an 11[°] rotation angle is attained.

4-12. <u>Cam-off Mechanism</u>. The cam-off mechanism (Figure 4-17) is located on a short link at the vehicle end of the withdrawal mechanism. This mechanism consists of a pneumatic cylinder (2-inch bore and 6-inch stroke), a pair of driving arms, a pair of over-center springs, a splined output shaft, and two small cams. The two small cams are attached to the large clevis at the end of the withdrawal mechanism pneumatic cylinder.

The cam-off cylinder body is trunnion mounted to the driving arms; the piston rod is pinned to a clevis which is part of the support link; and the over-center springs are arranged to prevent inadvertent actuation of the mechanism. When the cylinder is pressurized, the arms are rotated toward the vehicle driving the springs over center and producing a torque at the output shaft. The torque is transmitted through a simple linkage to the cam levers on the sides of the umbilical carrier. The torque and angle are given in Figure 7-1.

A third method of disconnecting the umbilical carrier is produced by the vertical lift-off motion of the vehicle. This phenomenon is known as "Vehicle Motion Cam-off" and is available in case of complete failure of all electrical and pneumatic systems. The method has no effect on normal cam-off operations. When the vehicle has risen past a predetermined level, the angular change between the umbilical carrier and the withdrawal mechanism pneumatic cylinder causes engagement of cam surfaces to drive the cam-off mechanism output shaft. The driving cams are splined to the clevis of the pneumatic cylinder to allow proper adjustment. The driven cams are integral parts of the arms which rotate the output shaft.

4-13. Withdrawal Mechanism. The major component of the withdrawal mechanism is a high pressure pneumatic cylinder (Figure 4-18) of special design which has a 5-inch bore, 4-inch rod, and a stroke of approximately 60 inches. The piston rod is constrained against rotation by a feather key mounted near the piston. The feather key rides in a milled slot in the piston guide rod. The guide rod is keyed to the blind-end cylinder head, extends through the barrel, and telescopes inside the piston rod. The forward end of the piston guide rod serves as a barrel for a 1-1/2 inch bore x 7-inch stroke hydraulic shock absorber. The fluid column contained within the piston guide rod discharges through a metering orifice to provide deceleration during the last five inches of cylinder stroke. The pneumatic cylinder is trunnion mounted in a universal joint located at the cylinder midpoint. A ring-mounted clevis is also threaded to the cylinder barrel to receive a self-aligning bearing on the rod end of the hydraulic cylinder.

The withdrawal mechanism hydraulic cylinder is a standard high pressure hydraulic actuator with a 3-inch bore, 1-1/2 inch rod, and a modified rod-end head which receives a large spherical bushing. The bushing is housed directly below the pneumatic cylinder universal joint and is supported by a common structure which ties the withdrawal mechanism to the service arm.

This dual cylinder combination and arrangement of universal joints allows tracking of vehicle motion while the umbilical carrier is connected. The arrangement also provides a self-centering feature during retraction. Vehicle loading is minimized by the introduction of balancing pressures in both cylinders. The retraction motion is a combination of straight line displacement along the axis of the pneumatic cylinder and simultaneous rotation of this axis is due to the torque applied by the hydraulic cylinder.

4-14. <u>Line Handling Devices</u>. Two types of line handling devices are required on the service arms: propellant line handling devices; and electrical cable, air conditioning duct, and pressure line handling devices. Descriptions of these devices are given in the following paragraphs.

Figure 4-19 shows the propellant line installation on the S-IVB AFT Service Arm. Vacuum-jacketed flex-line assemblies extend from the couplers in the umbilical carrier to flanged joints at the forward ends of the hard line assemblies. The portions of the hard line assemblies on the top of the arm are supported on trolleys which roll along I-beams. Three vacuum-jacketed hinge joints are contained in sections of the hard line assemblies which are suspended on the sides of the service arm. During vehicle motion and umbilical carrier retraction, the hinged joints deflect to allow straight line motion along the I-beams. This arrangement ensures positive drain of propellants throughout the range of vehicle motion. The installation must have enough free motion to extend 16 inches out and 30 inches up from nominal position and yet not allow pockets to form in the lines when the umbilical carrier is 16 inches in and 6 inches down from the nominal position.

A propellant line retract system is installed on top of the arm behind the lines. This system consists of a pneumatic cylinder which drives a 4 to 1 ratio block and tackle. The output cable is connected to a beam which joins the two hard line assemblies. This system provides a pull on the propellant lines during retraction to prevent destructive compressive bending of the flex lines. A second use of the retract system is to provide an adjustment of the tension in the flex line during vehicle tracking. The remaining service lines for the S-IVB AFT arm are handled by a pivoted frame (Figure 4-15) located directly behind the support structure for the withdrawal mechanism. The various lines are clamped to the tubular members of the frame and are arranged to provide proper bend configurations at both ends. The frame follows vehicle motion to some extent since any increase in line tension, as the vehicle moves out, tends to rotate the frame forward. A cable connects the frame to the beam across the aft end of the propellant lines. Thus, as the vehicle moves in and the propellant lines move away from the vehicle, the line handling frame is rotated back. When the umbilical carrier is withdrawn, the frame is rapidly revolved backward by the propellant line retract system. When in final position, the frame is locked in place and is restrained against motion induced by service arm acceleration.

4-15. OPERATIONAL DESCRIPTION

Three possible modes of operation are briefly outlined below. These descriptions are intended to give only a general understanding of the chronological sequence of events. Refer to paragraph 4-83 for detail operational description of the isolated redundant mechanical and electrical systems.

4-16. Primary Disconnect and Withdrawal. Initial vertical motion of the vehicle closes the primary lift-off switch. The closing of this switch completes a circuit to energize a valve which supplies pressure to the umbilical carrier ball lock and push-off pistons. The umbilical carrier is unlocked and ejected from the vehicle. This action closes a switch in the umbilical carrier to confirm release. When this switch is closed, a circuit is completed to energize the valves which supply pressure to the withdrawal mechanism pneumatic and hydraulic cylinders. The umbilical carrier release confirm switch also completes a circuit to energize the service arm retract system. Thus, service arm retraction and umbilical carrier withdrawal occur simultaneously.

Figure 4-20 is a presentation of the combined motions which produce relative displacement of the S-IVB AFT umbilical carrier with respect to the vehicle skin at lift-off. The following phenomena were examined separately as functions of time: pneumatic ejection of the umbilical carrier, withdrawal action of the dual cylinders, retraction of the service arm, rise of the vehicle, and drift of the vehicle toward the tower. The "T" referred to in the figure represents the instant when vehicle rise begins. Many simplifying assumptions were necessary in the preparation of this study. Some of these assumptions were constant accelerations of the withdrawal mechanism cylinders, valve delays, velocity of umbilical carrier acquired by ejection, etc. 4-17. <u>Secondary Disconnect</u>. A few milliseconds after application of pressure to the umbilical carrier pneumatic system, pressure is applied to the cam-off mechanism pneumatic cylinder. Therefore, if the ball lock or pushoff pistons within the carrier fail, release and separation will be accomplished almost immediately by the cam-off mechanism. The sequence of operation after closure of the umbilical carrier release confirm switch is the same as that for primary disconnect.

4-18. Vehicle Motion Cam-off. If both modes of operation described above fail, the vehicle will continue to rise until the cams on the end of the pneumatic cylinder engage the cam surfaces on the driving arms (Figure 4-17). This causes enough rotation of the cam-off mechanism output shaft to unlock the umbilical carrier. Further vehicle rise rotates the withdrawal mechanism pneumatic cylinder away from the vehicle and fully extends the piston rod. When the piston bottoms, the umbilical carrier continues to rotate until all connections are broken and the carrier is free of the vehicle. At this point, the pneumatic cylinder is constrained against rotation toward the vehicle by a ratchet at the trunnion. The pressures in this cylinder are no longer equal due to the increase in the force component along the barrel. Therefore, the pneumatic cylinder will collapse and the carrier will fall away from the vehicle.

4-19. ARM PECULIAR CHARACTERISTICS

As a result of efforts toward standardization, a dual cylinder type withdrawal mechanism (similar to the one described) is used on four of the eight service arms. The large pneumatic cylinder for each of these mechanisms is identical except for the location of the attach point for the hydraulic cylinder. The trunnions for the pneumatic cylinders are identical. The hydraulic cylinders differ only in stroke. The adjustment feature inherent in the cam-off mechanism allows its application to all dual-cylinder type withdrawal mechanisms. A brief description of the mechanisms carried by each service arm is given below.

4-20. <u>S-IC INTERTANK</u>. Addition of a remote connect capability to the S-IC INTERTANK arm allows arm retraction before lift-off and classification as a preflight arm. The exact configuration of the LOX couplers to be handled from this arm is yet to be determined. Present plans call for two 6-inch couplers. The propellants will be carried by two 8-inch lines from the M-P&VE/LOC interface on the arm back to the tower interface. A compound parallel linkage device has been proposed to handle the carrier which contains the couplers. This device is spring loaded to the neutral position and is driven by a single pneumatic cylinder. Two concentric pneumatic devices are provided in the carrier for actuation of the couplers and control of the probe which seats in a funnel in the vehicle. This arrangement provides guidance for remote reconnect of the couplers.

The design of the remote reconnect mechanism has not progressed sufficiently to warrant inclusion of an illustration in this report other than the sketch in Appendix F.

4-21. <u>S-IC FWD</u>. Since the S-IC FWD is a preflight arm, a simple disconnect and withdrawal mechanism is used. Figure 4-21 shows a pivoted device similar to those used on Complex 37. A lanyard is connected to the bar between the umbilical carrier cam levers. This lanyard is routed over pulleys on the boom to a block and tackle retraction device which is driven by a pneumatic cylinder. Initial lanyard travel cams the umbilical carrier from the vehicle (if the push-off pistons have failed) and withdraws the carrier to the end of the boom. Additional lanyard travel rotates the boom away from the vehicle and back to a small structure on top of the service arm where the boom is latched. The service lines are clamped to the pivoted boom thereby obtaining limited guidance during withdrawal.

An alternate mechanism is shown in Figure 4-22. The operation of this device is similar to the one just described except that the pivoted boom is replaced with a simple rigid structure. This mechanism is arranged to prevent the retracted umbilical carrier from contacting the skin of the vehicle as it deflects toward the tower.

4-22. <u>S-II AFT</u>. The S-II AFT disconnect and withdrawal mechanism (Figure 4-23) will handle a single 1-inch diameter flex line. Therefore, a very simple lanyard retract device is mounted on the side of the service arm truss. This device consists of a pneumatic cylinder which reels cable through a block and tackle to disconnect and withdraw the coupler to the service arm.

4-23. <u>S-II INTERMEDIATE</u>. The unique spacing of two propellant lines in addition to a relatively large umbilical carrier dictates the need for three separate withdrawal mechanisms on the special second element of the S-II INTERMEDIATE service arm (Figure 4-24). The arrangement of the mechanisms has been somewhat simplified by placement of an extension platform on the S-II AFT arm for service of the lower umbilicals at the S-II INTERMEDIATE arm.

A dual cylinder type withdrawal mechanism is mounted inside the arm on the bottom cord members to handle the umbilical carrier at vehicle station 1771. The operation and arrangement of the cylinders is similar to that previously described for the S-IVB AFT service arm. All the umbilical lines except the 14-inch air conditioning duct are clamped near the mechanism mount and allowed to sag in the retracted position. Thus, no special handling devices are required. The 8-inch LOX line at vehicle station 1771 is retracted by a lanyard type withdrawal device mounted at the upper left side of the arm. The lanyard is connected directly to the ball-lock pin in the coupler to provide a secondary means of release. The flex line section of the propellant line is supported by rollers to reduce vehicle loading. The propellant line slack generated by vehicle motion is taken up by an arrangement of two hinged joints and a pressure compensated expansion joint. These components are set in their neutral positions at full retraction. Thus, the spring forces generated in the system cause impending motion away from the vehicle. An additional lanyard is connected to the ball-lock pin and anchored to the arm such that vehicle rise past a predetermined level will cause release of the coupler. This corresponds to the vehicle motion cam-off condition previously explained for the umbilical carriers.

The 8-inch LH₂ line at station 1905 is handled by a second lanyard type mechanism. A hard line section rides on a trolley between two sections of flex line. The flex line into the coupler is supported by a band to reduce vehicle loading. The aft flex section is directed down the side of the arm and deflects to allow approximately 40 inches of translation along the trolley. Both the coupler, with attached flex line, and the hard line section are retracted by a single pneumatic cylinder as follows. The cylinder is connected to the hard line section by a 2 to 1 lanyard-pulley arrangement. The lanyard from the coupler is connected to the hard line support by another 2 to 1 pulley system. Thus, one unit of motion by the cylinder produces two units of motion by the hard line and four units by the coupler. This action produces the required bending in the aft section of flex line and simultaneous retraction of the fwd flex line without violating the minimum bend radius of either section.

The systems described above will meet the requirement for positive drain of propellants during vehicle tracking.

4-24. <u>S-II FWD</u>. A dual-cylinder type withdrawal mechanism (Figure 4-25) is mounted off center on the top of the S-II FWD arm to handle the umbilical carrier at vehicle station 2506. The hydraulic cylinder is located above the pneumatic cylinder and is attached to the barrel forward of the main trunnion. The hydrogen vent lines are routed through rollers on the side of the service arm. The remainder of the service lines are routed such that the retraction slack may be accommodated inside the arm structure.

4-25. <u>S-IVB AFT</u>. The withdrawal mechanism for the S-IVB AFT arm (Figure 4-15) has been completely described in "Description of Components" and "Operational Description."

4-26. <u>S-IVB FWD.</u> A dual cylinder type withdrawal mechanism (Figure 4-26) is mounted on the side of the S-IVB FWD arm. This mechanism handles the Instrument Unit and S-IVB FWD umbilical carriers which are held within a common frame. The mechanism employs the "hydraulic cylinder above" configuration and a special bent clevis at the end of the piston rod of the pneumatic cylinder. The special clevis compensates for the geometrical conditions imposed by the off-set location and radial orientation of the umbilical carriers. A pivoted frame similar to the one on the S-IVB AFT is used to handle the service lines. This frame is pulled during retraction by a lanyard connected to the blind end head of the pneumatic cylinder.

4-27. <u>SM.</u> A modified pivoted boom type disconnect and withdrawal mechanism (Figure 4-27) is mounted on top of the SM arm to handle the umbilical carrier at station 3721.555. The boom for this device has a central pivot that allows the boom to collapse as the umbilical carrier is withdrawn. This feature ensures impending motion away from the vehicle skin. A lanyard clamping device is included at the end of the boom to accomplish vehicle motion cam-off within a reasonable amount of vehicle rise. The magnitude of horizontal vehicle displacement at this station prohibits the use of an ordinary cable tension cam-off device. The special device senses the vertical motion of the vehicle and clamps the lanyard so that additional vehicle motion releases the umbilical carrier.

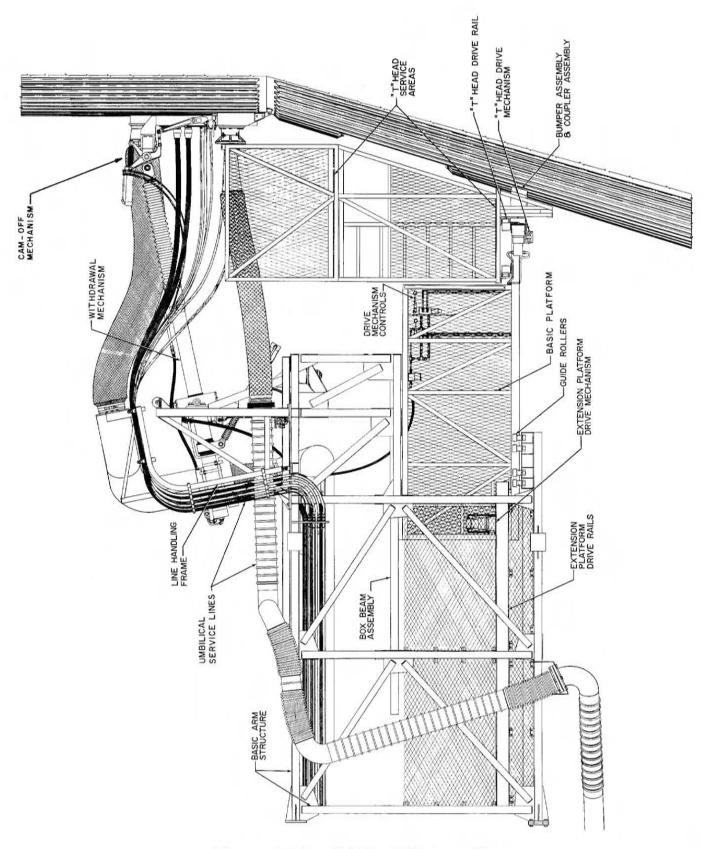


Figure 4-15. S-IVB AFT Arm Tip

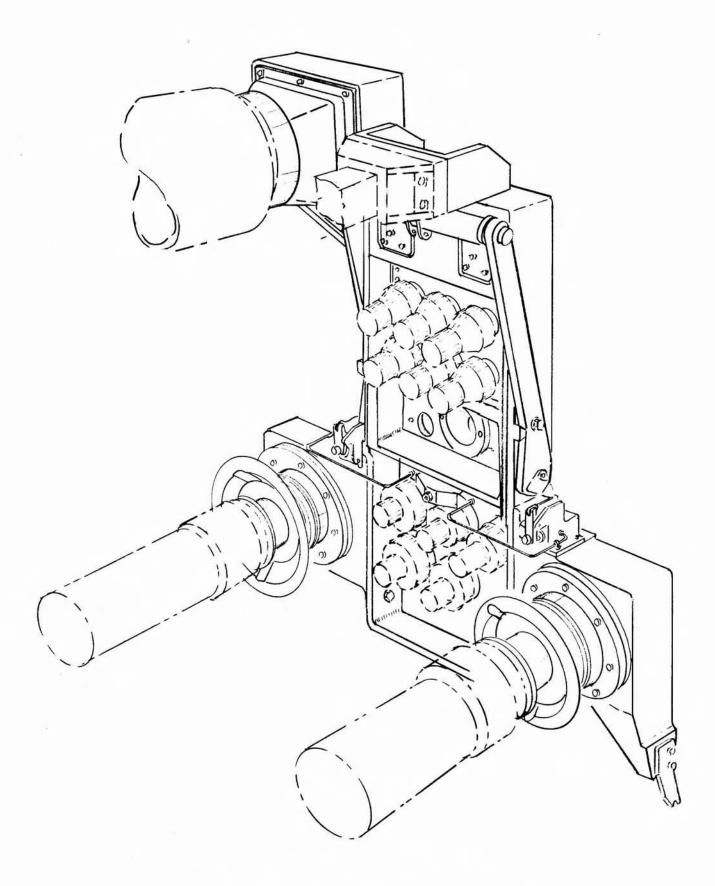


Figure 4-16. S-IVB AFT Umbilical Carrier

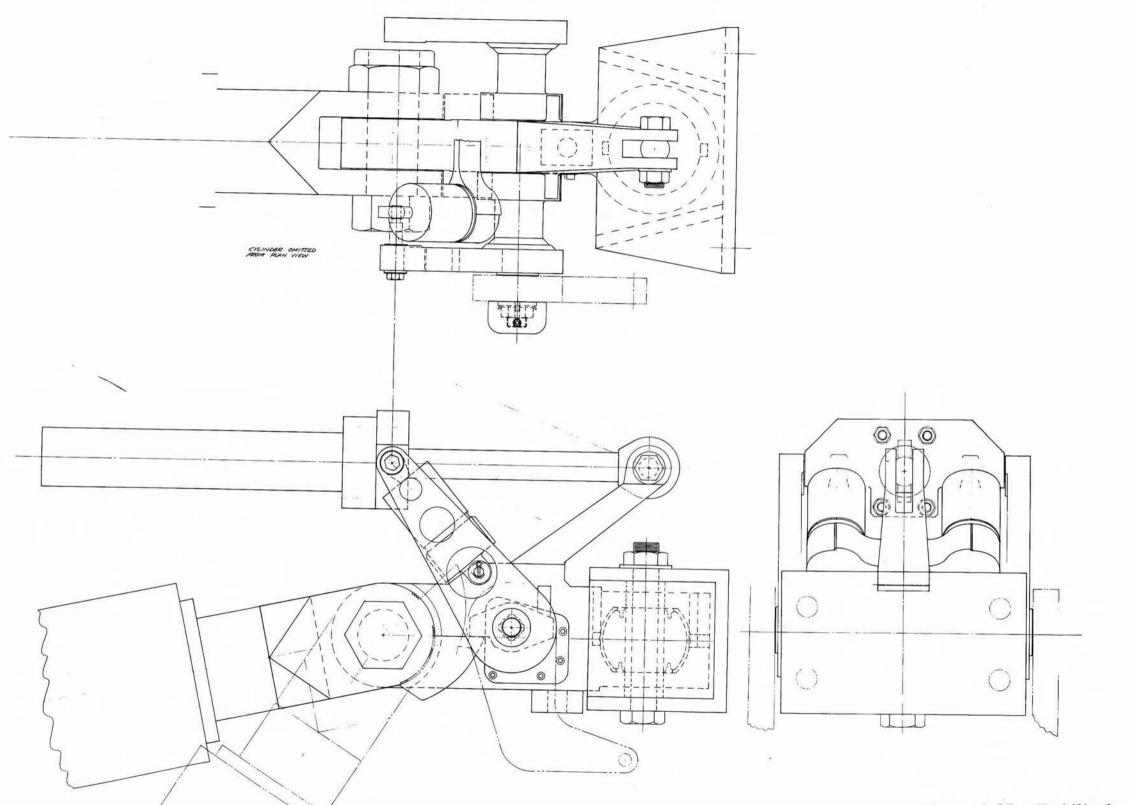


Figure 4-17. Umbilical Carrier Cam-off Mechanism

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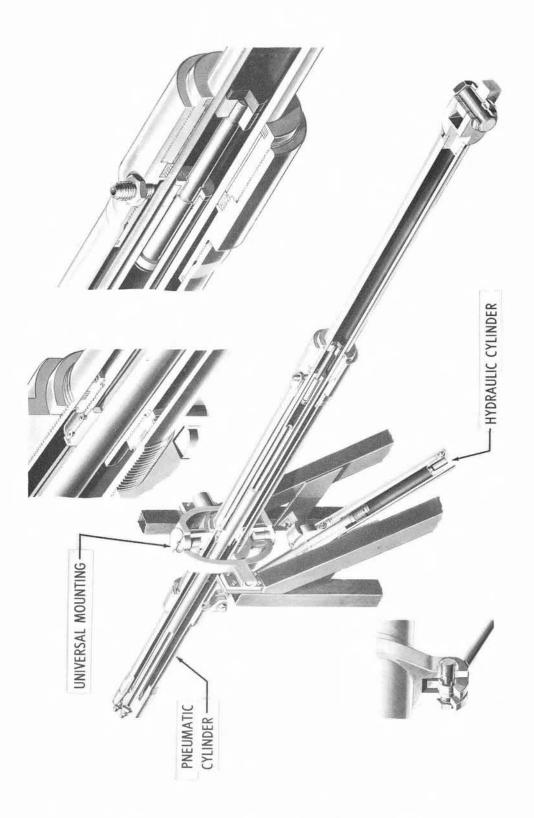


Figure 4-18. Cylinder-Type Withdrawal Mechanism

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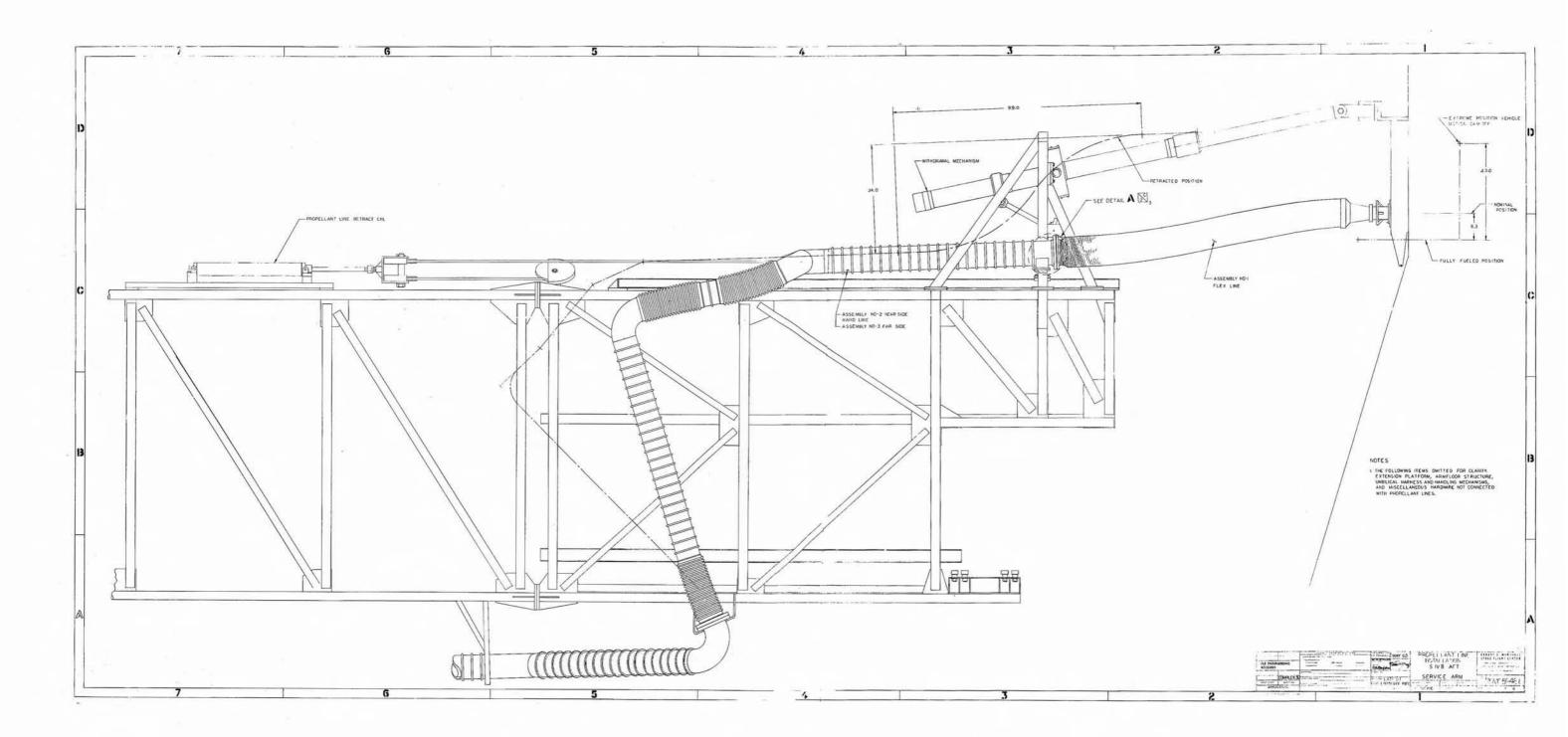


Figure 4-19. Propellant Line Installation -S-IVB AFT (Sheet 1 of 4) 111

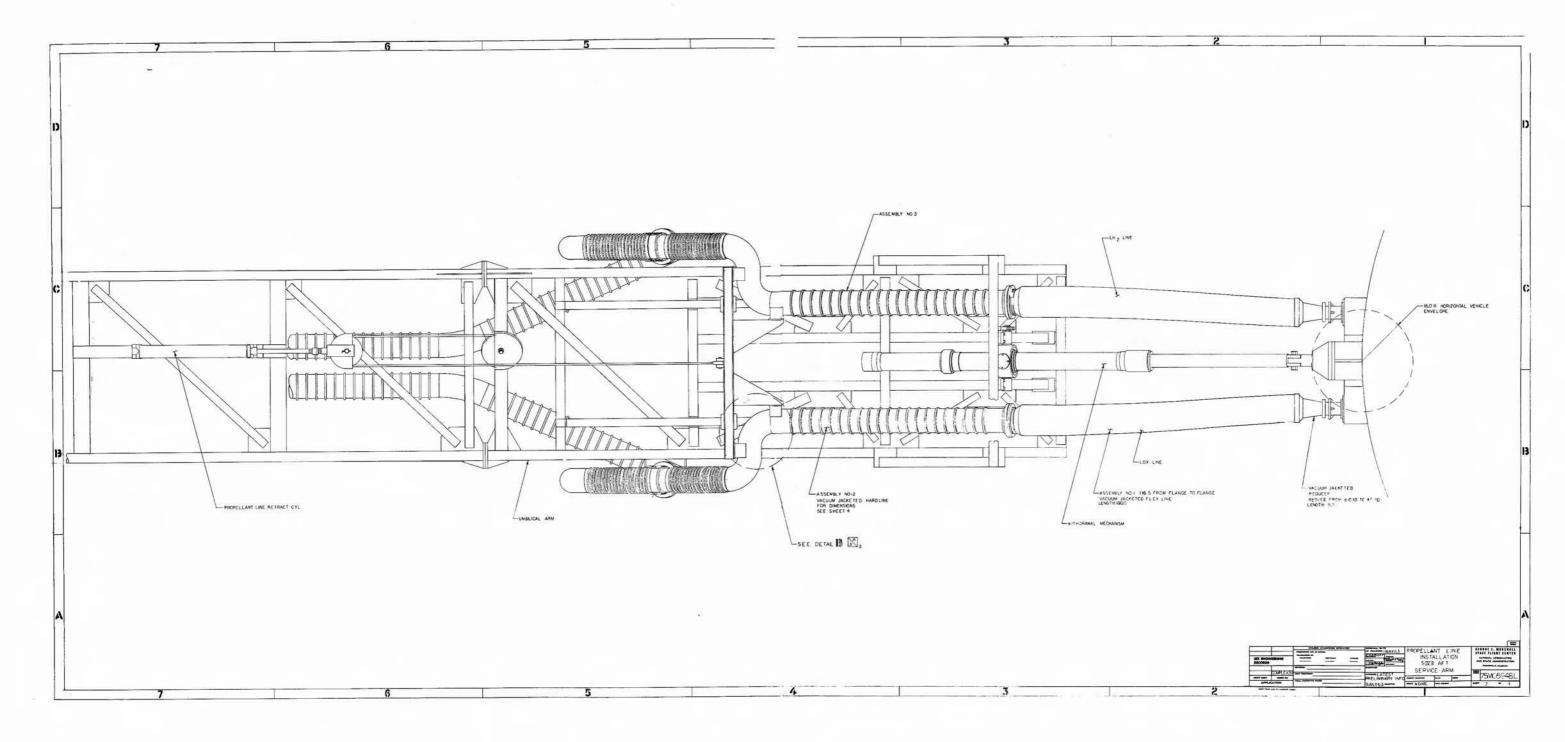
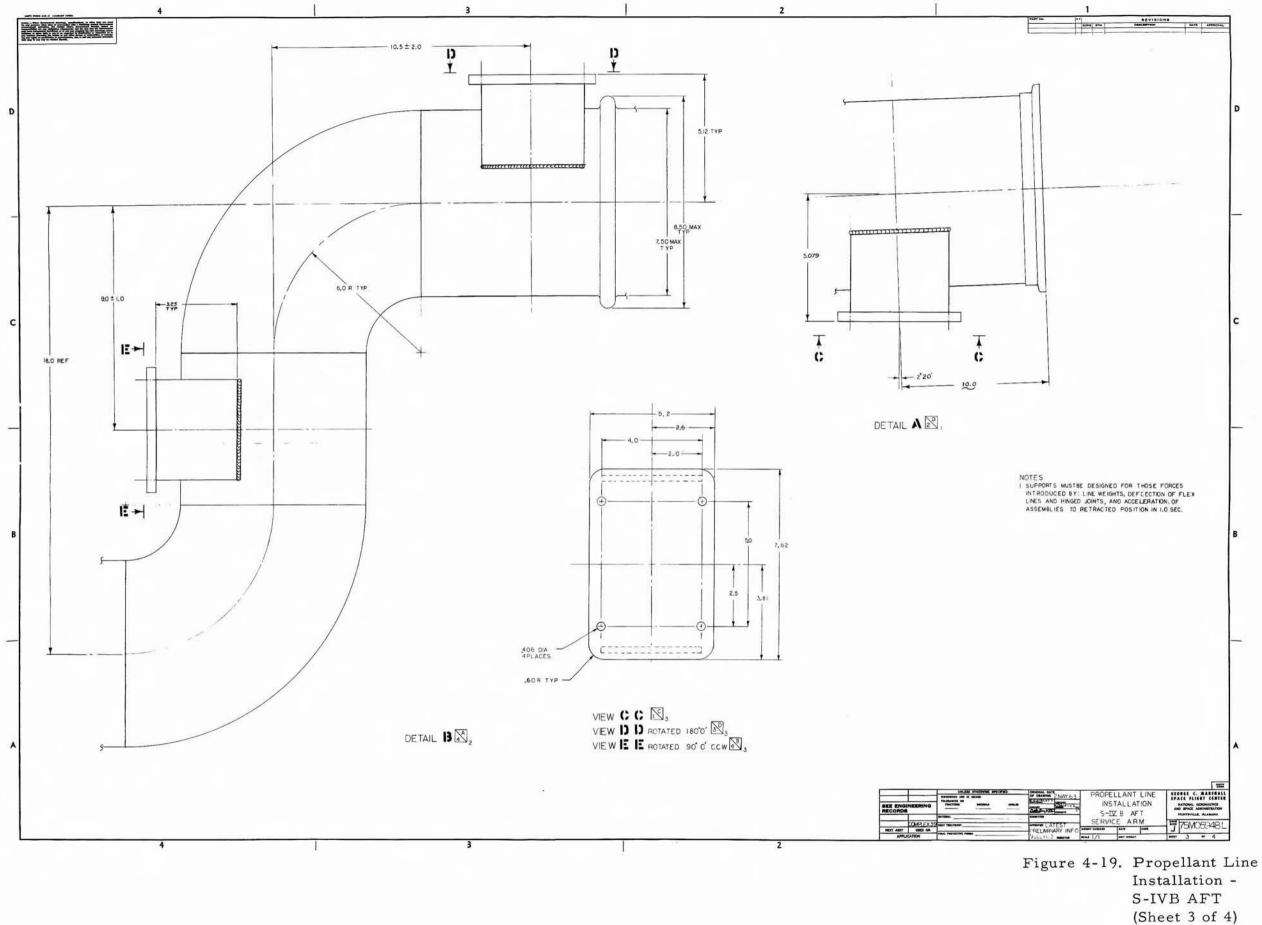
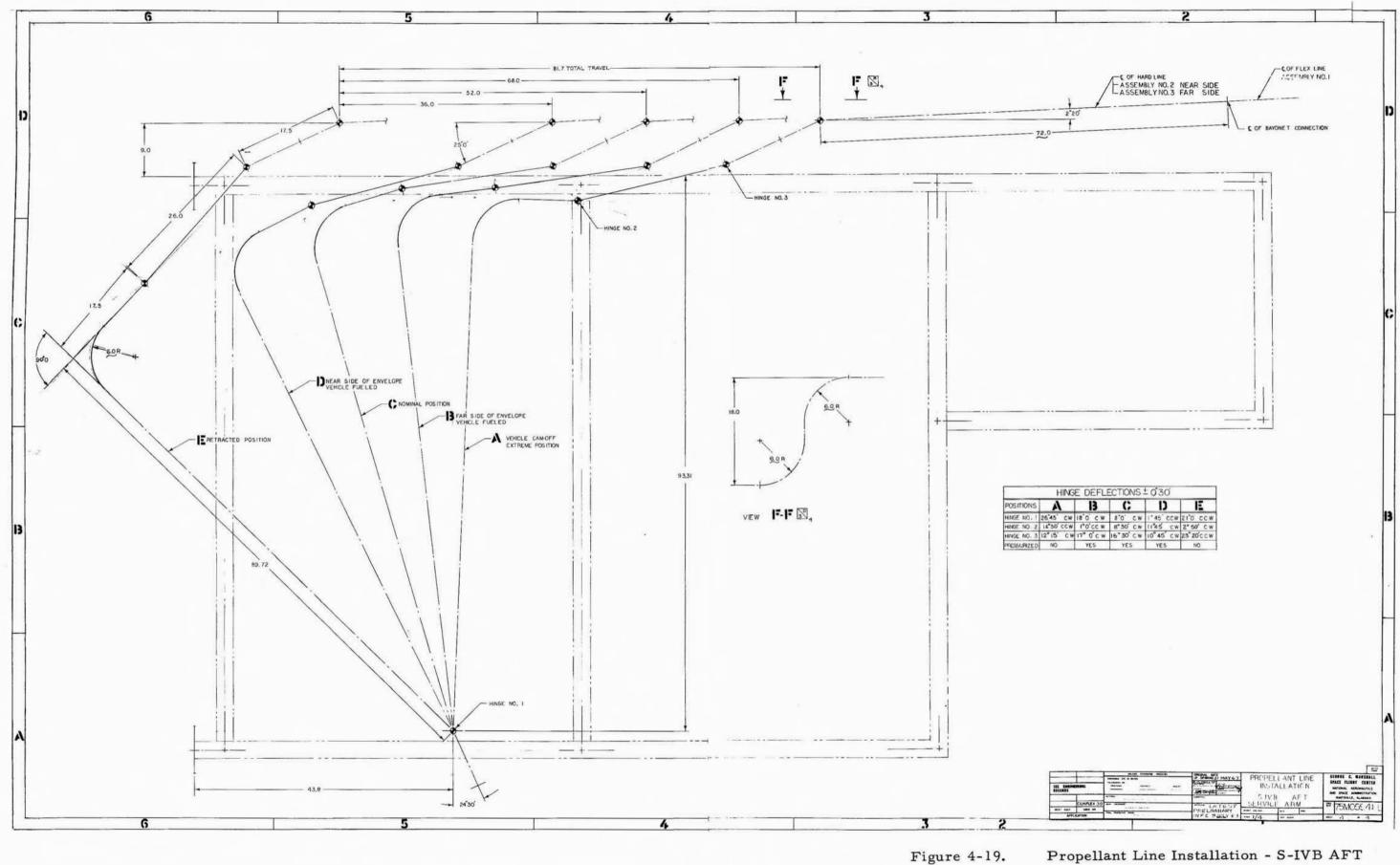


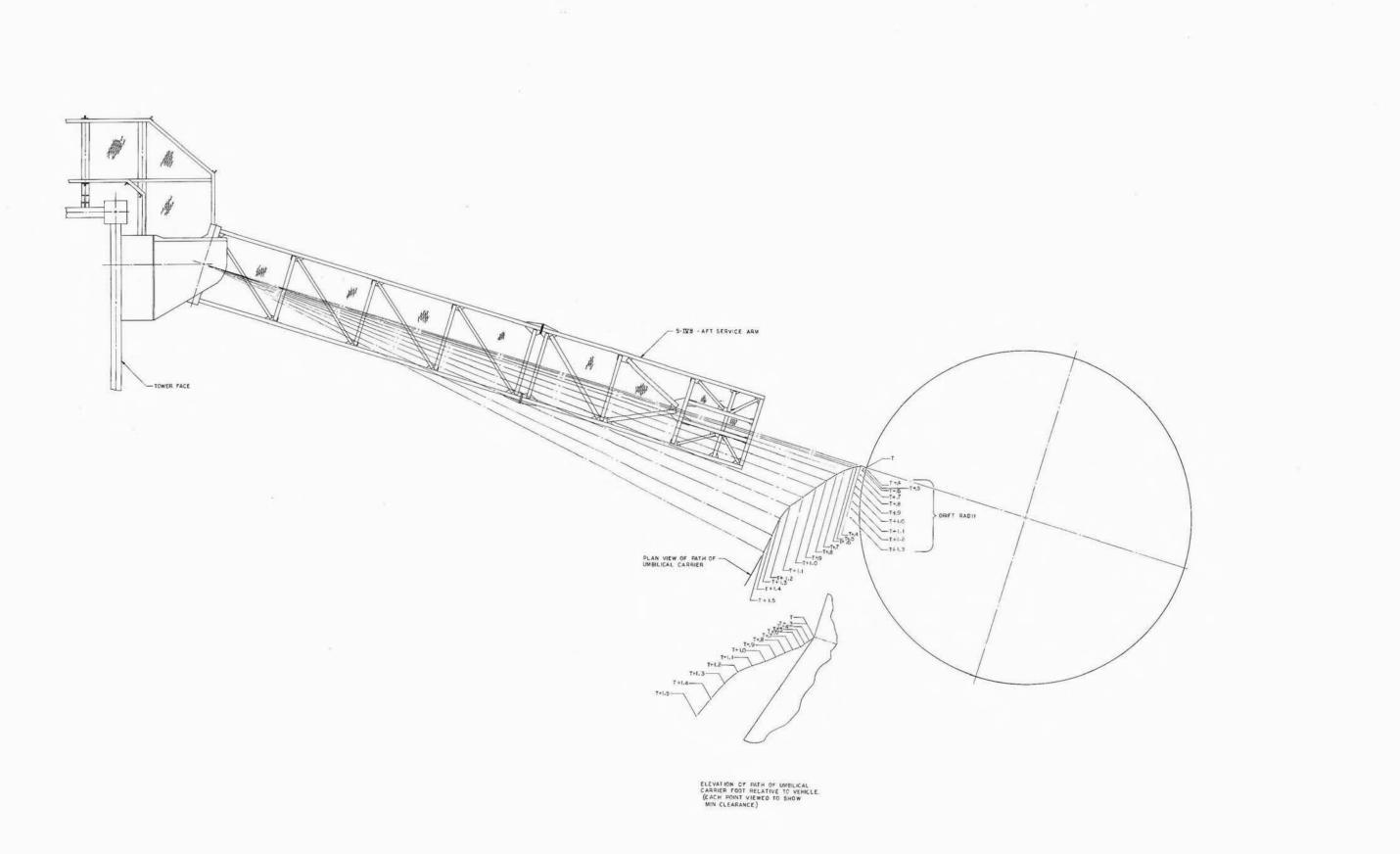
Figure 4-19.

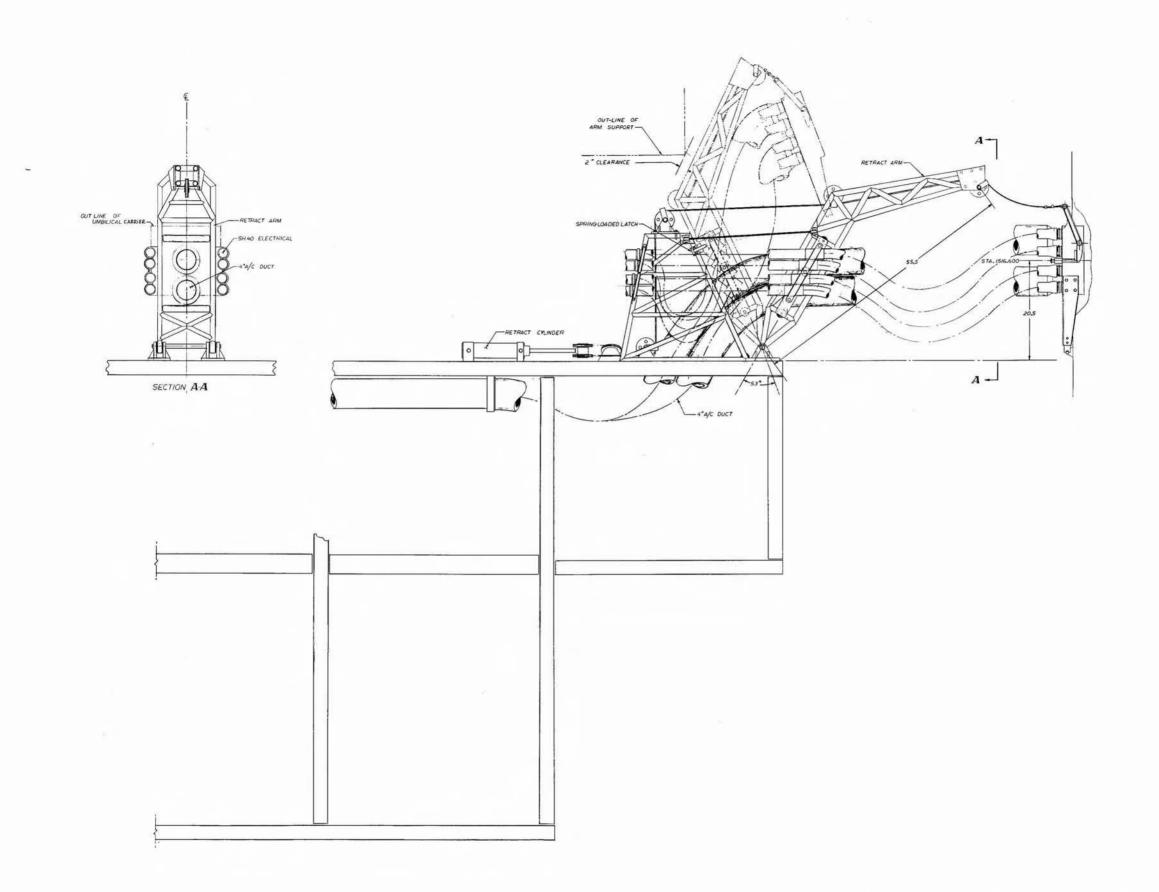
Propellant Line Installation - S-IVB AFT (Sheet 2 of 4)

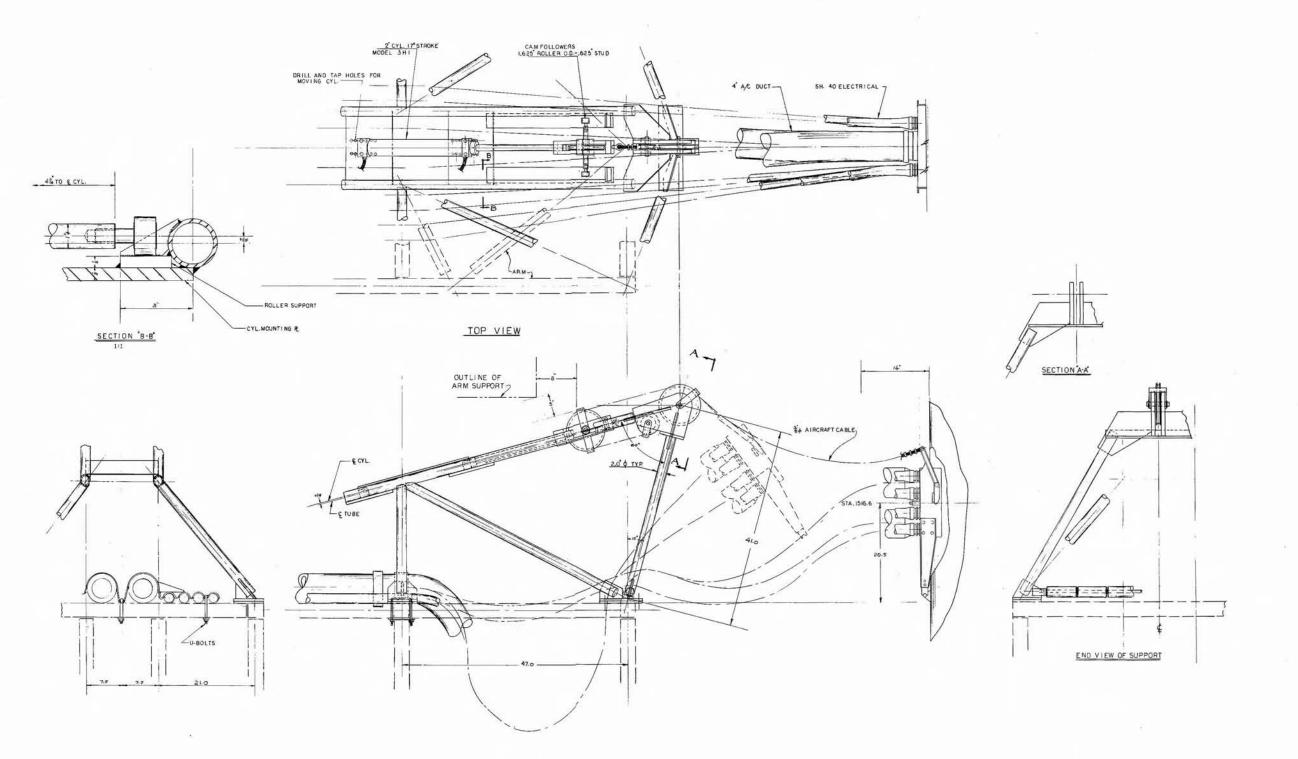




Propellant Line Installation - S-IVB AFT (Sheet 4 of 4)







SIDE VIEW

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Figure 4-22. S-IC FWD Withdrawal Mechanism -Alternate

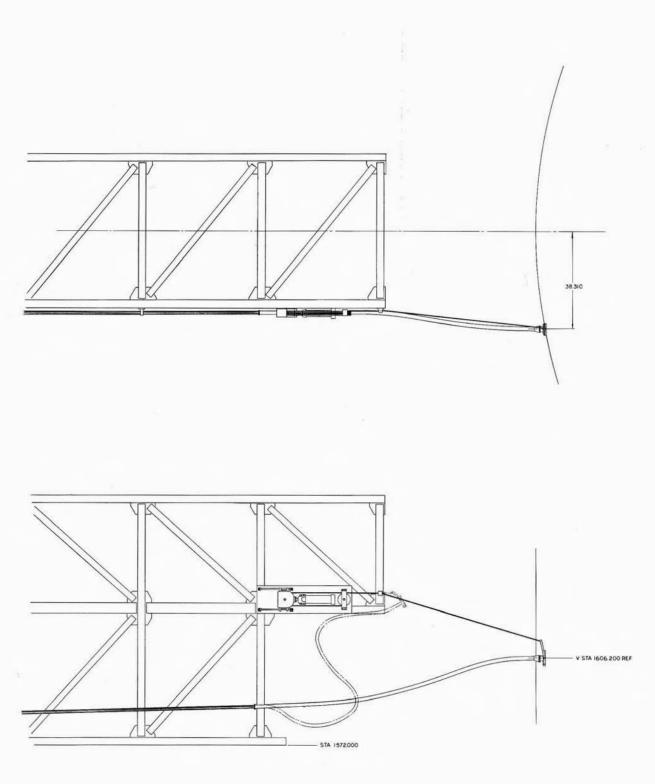
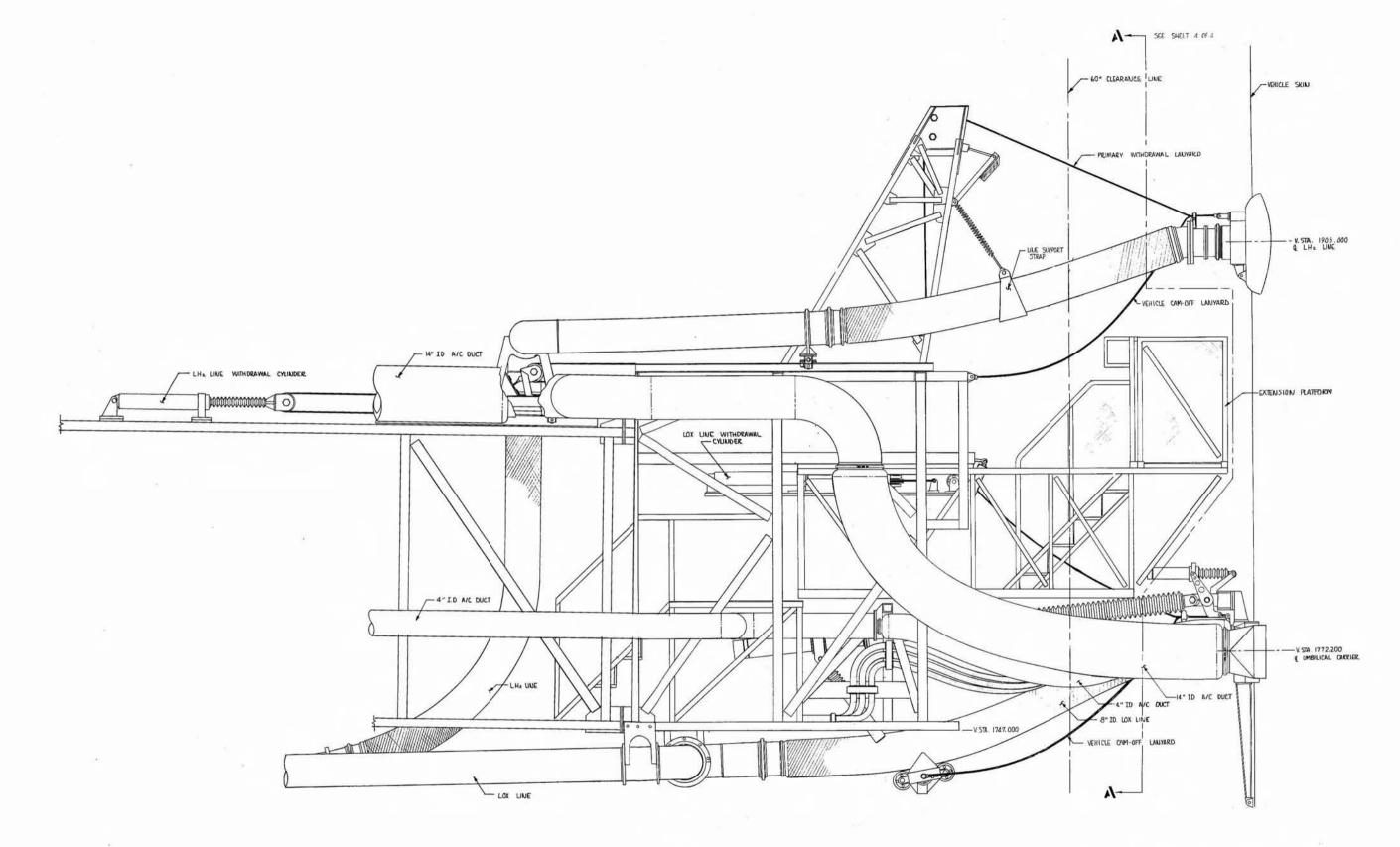
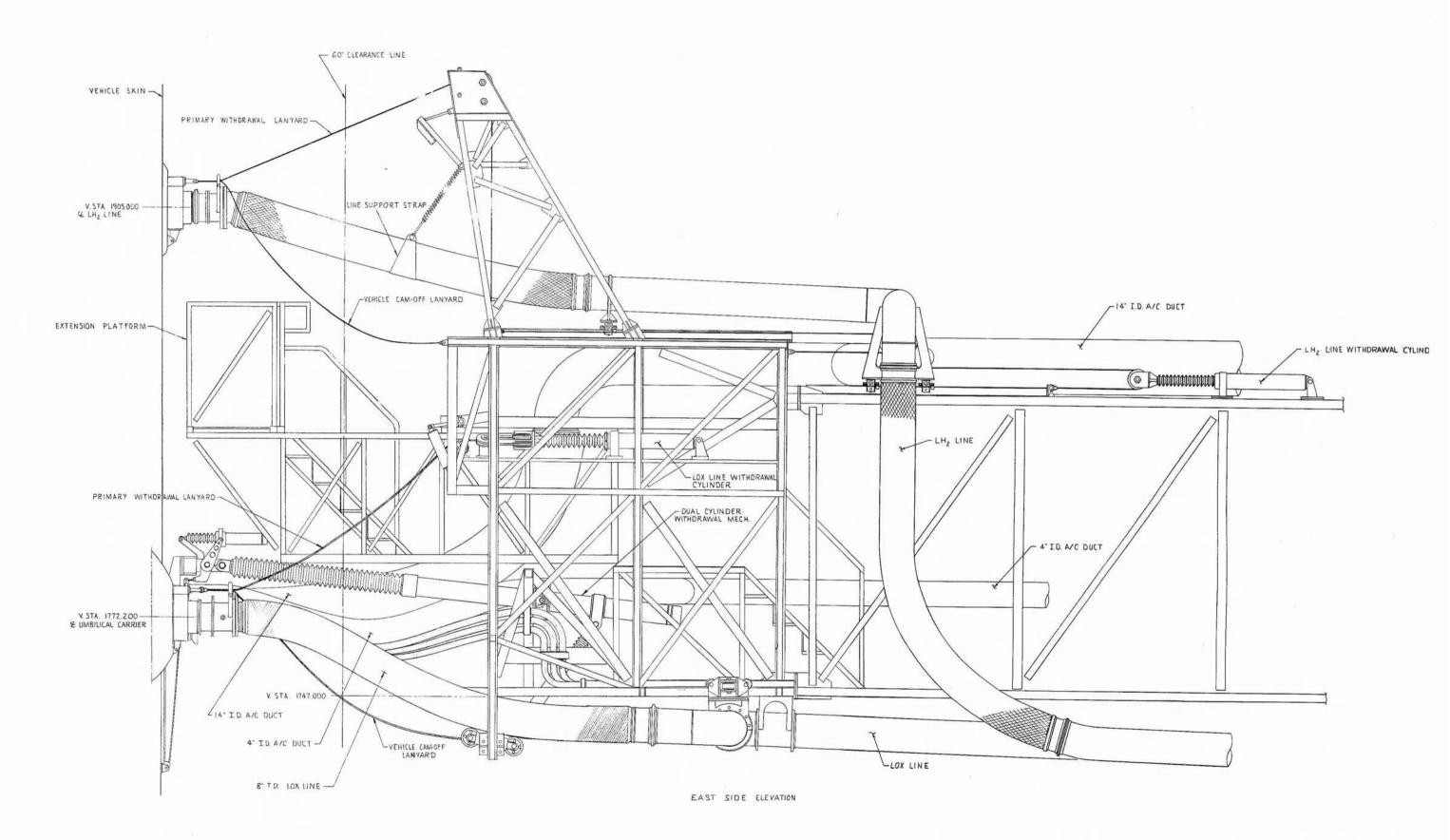


Figure 4-23. S-II AFT Withdrawal Mechanism



WEST SIDE ELEVATION

Figure 4-24. S-II INTERMEDIATE Withdrawal Mechanisms (Sheet 1 of 4) 119



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Figure 4-24.

S-II INTERMEDIATE Withdrawal Mechanisms (Sheet 2 of 4)

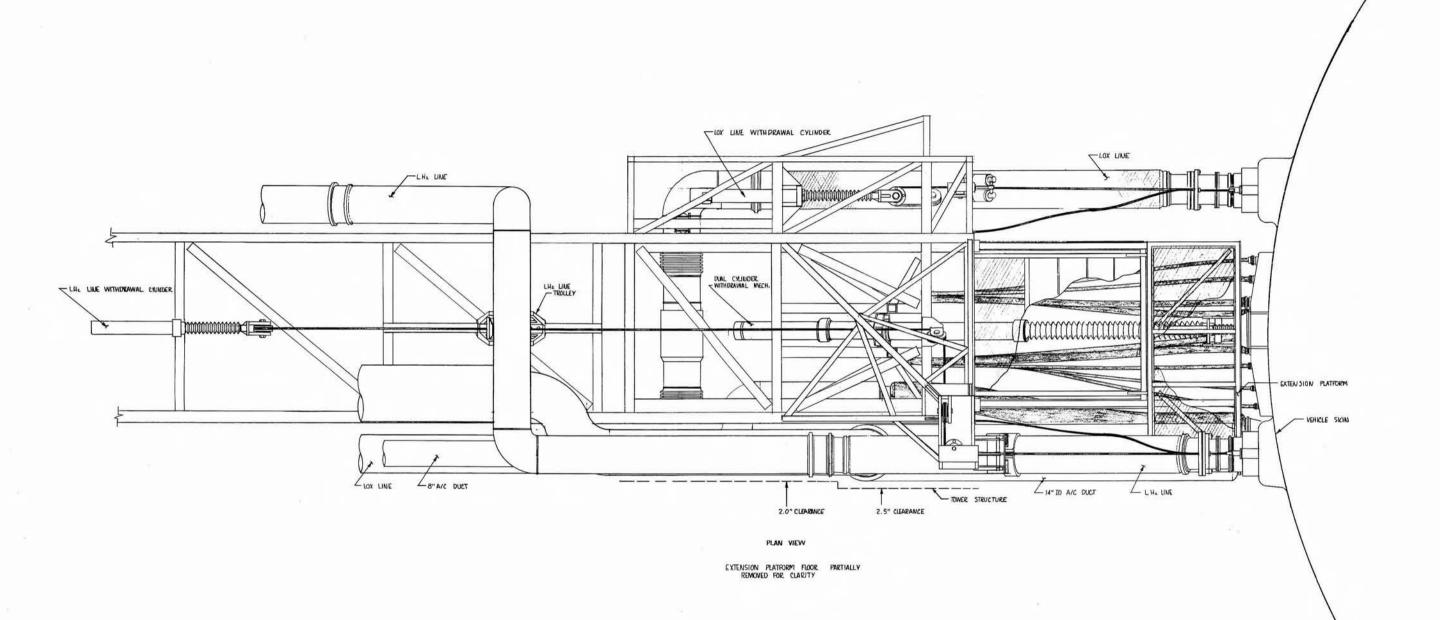
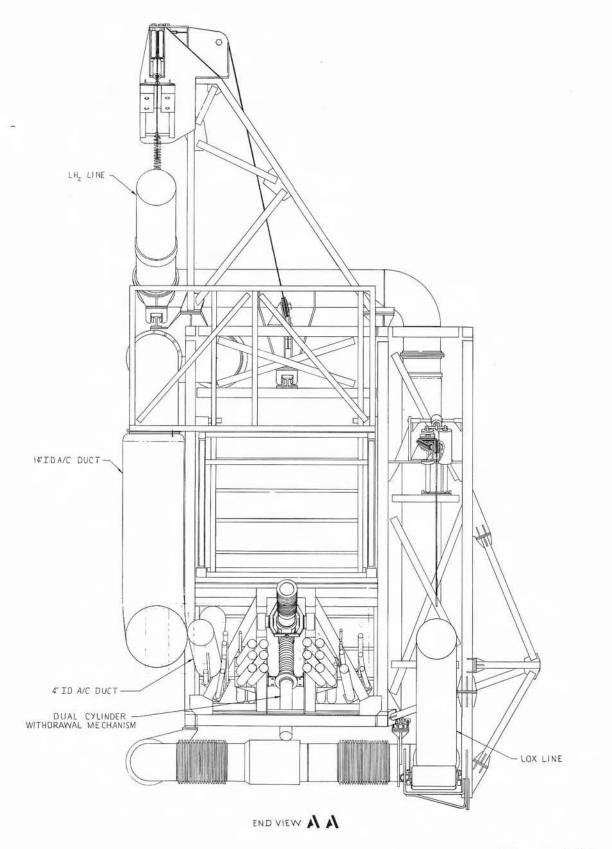
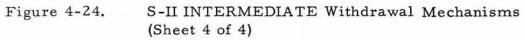


Figure 4-24. S-II INTERMEDIATE Withdrawal Mechanisms (Sheet 3 of 4)





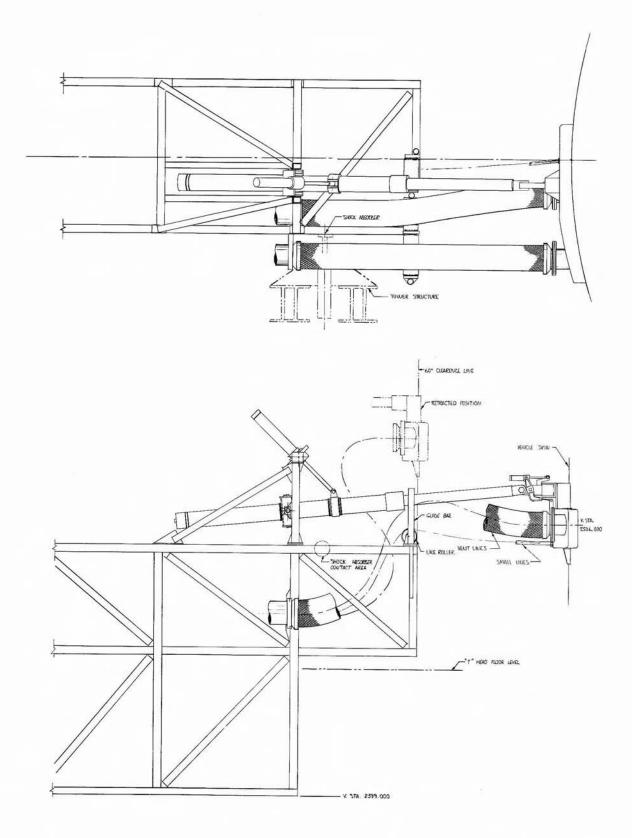


Figure 4-25. S-II FWD Withdrawal Mechanism

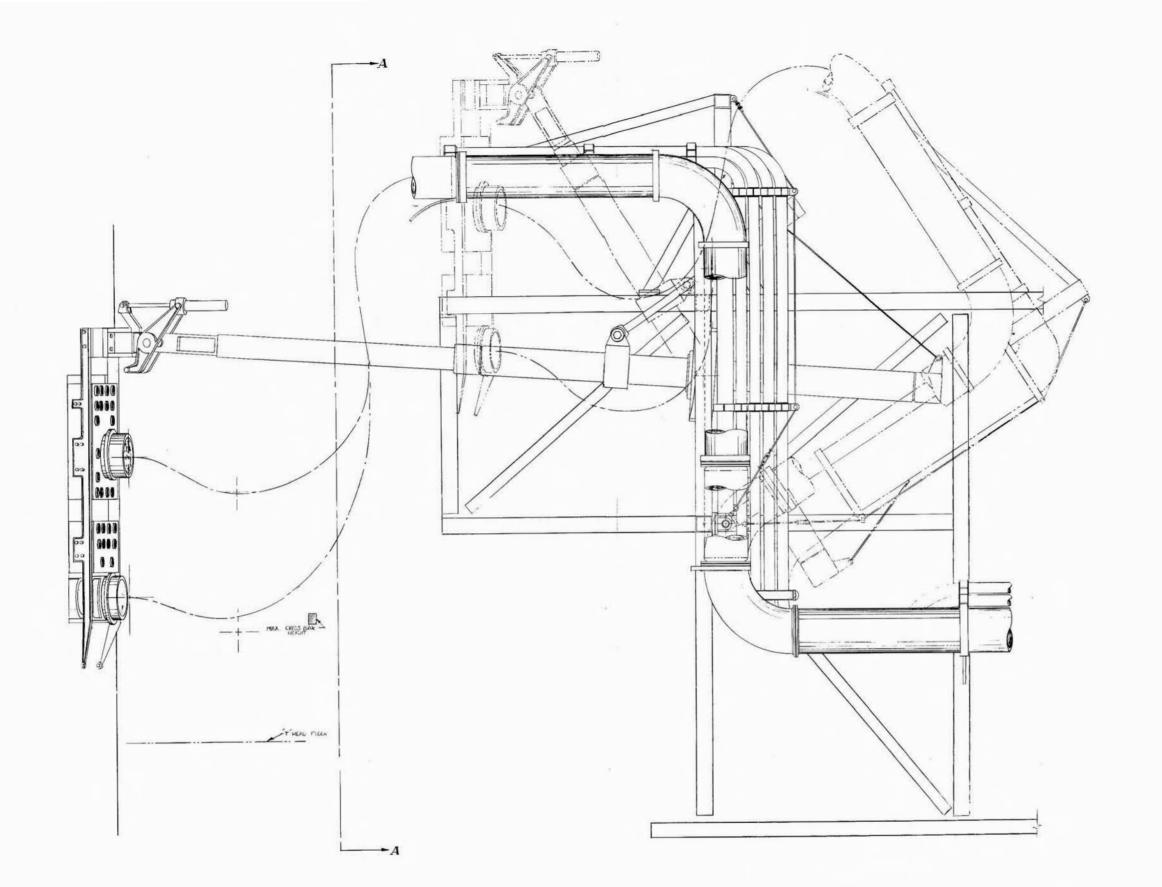
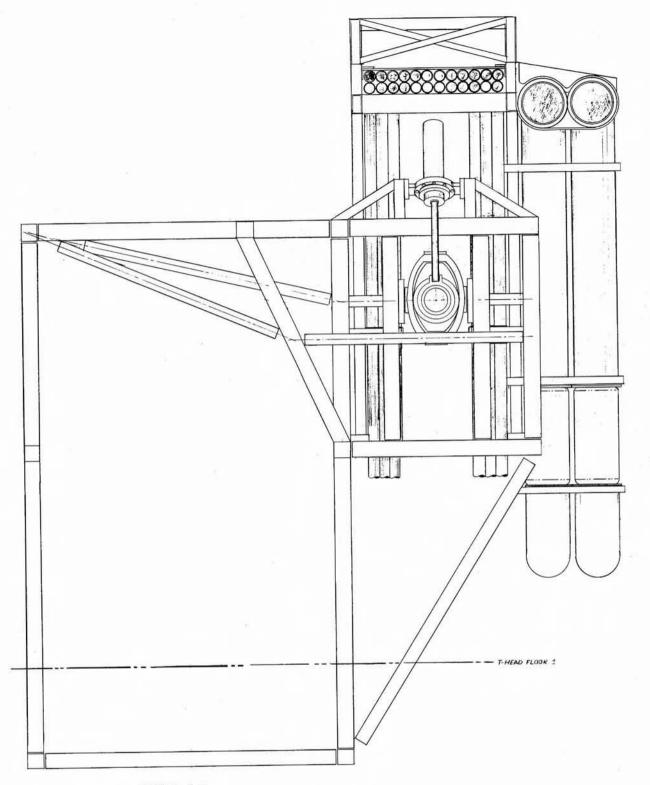


Figure 4-26. S-IVB FWD Withdrawal Mechanism (Sheet 1 of 3)



SECTION A-A

Figure 4-26. S-IVB FWD Withdrawal Mechanism (Sheet 2 of 3)

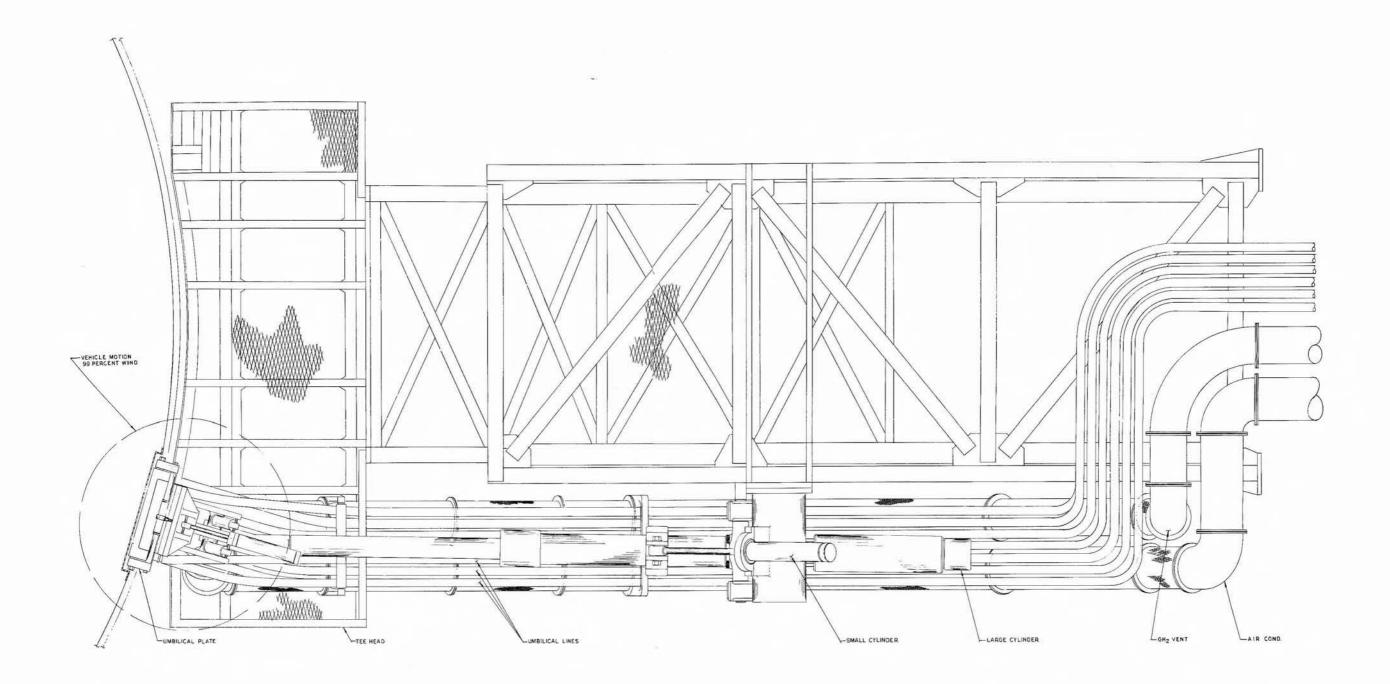


Figure 4-26. S-IVB FWD Withdrawal Mechanism (Sheet 3 of 3)

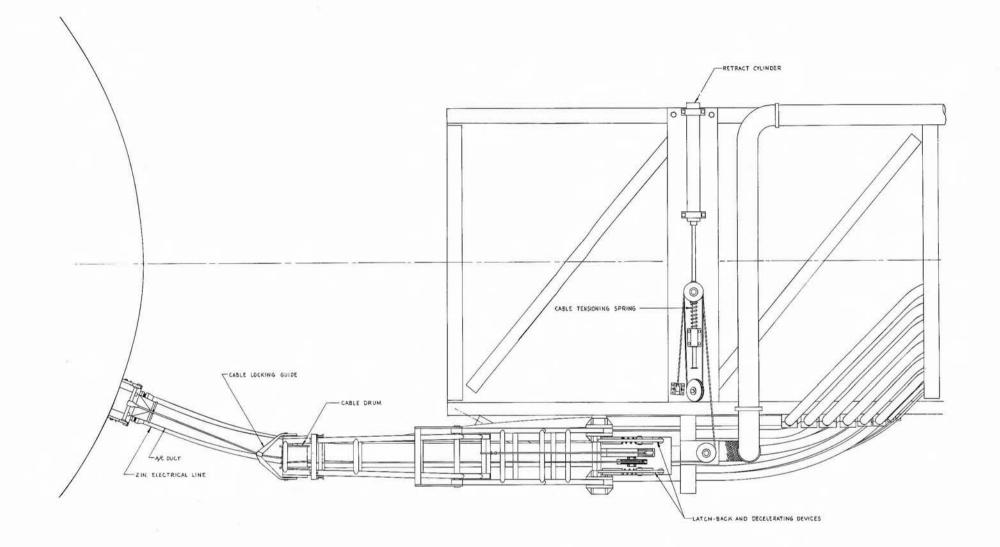
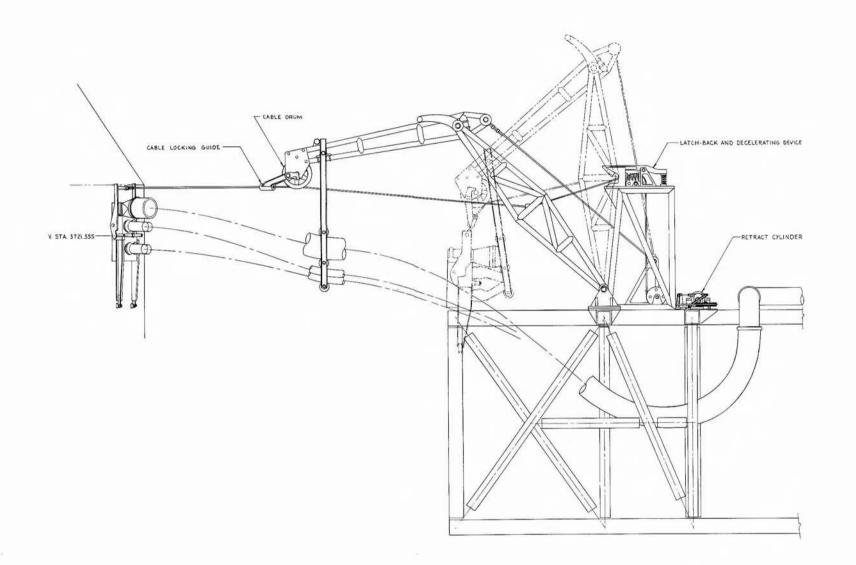


Figure 4-27. Service Module Withdrawal Mechanism (Sheet 1 of 2)



Service Module Withdrawal Mechanism (Sheet 2 of 2)

4-28. SERVICE ARM EXTENSION PLATFORMS

The extension platforms are located at the vehicle end of each service arm. These platforms provide a walkway across the space between the end of the service arm and the vehicle. This distance has been established at 60 inches for all arms except the S-IC INTERTANK which is 45 inches and the S-II AFT which is 36 inches. In addition, the portion of the platform adjacent to the vehicle provides a landing from which personnel can enter the vehicle or service the umbilical areas outside the vehicle.

4-29. DESIGN CRITERIA AND OPERATIONAL REQUIREMENTS

Design criteria established during concept studies and preliminary design of the extension platforms include:

a. All vertical and horizontal motion during prelaunch conditions including a maximum 95% wind condition (Table 4-3) must be accommodated by the platform.

b. The platform must be light enough to minimize the acceleration forces imparted to the vehicle during tracking operations.

c. The platform must retract into the service arm sufficiently to maintain the required clearance between the platform and the vehicle skin.

d. An open structure with good blast survival characteristics is required.

e. The coupling operation must be capable of being performed during winds up to 30 knots.

f. Personnel will not be permitted on the platforms during winds exceeding 30 knots.

g. Vertical movement of the vehicle relative to the platform must be accommodated with minimum forces imparted to the vehicle.

h. The platform structure must allow clearance for all service lines.

i. The maximum acceleration forces exerted on the vehicle by the platform are a result of vortex shedding oscillations (Table 4-3).

ARM	VEHICLE	HORIZONTAL DEFL. (IN.)		HORIZONTAL OSCILL. (IN.)	HORIZONTAL ACCELERATION (IN/SEC ²)
S-IC INTER'K	692	± .65	+ .65 35	± .10	2,54
S-IC FWD	1415	± 2.60	+ 1.30 - 3.60	± .55	14.00
S-II AFT	1590	± 3.20	+ 1.35 - 3.60	± .65	16.50
S-II INT					
S-I FWD	2437	± 7.00	+ 2.40 - 5.60	± 1.40	35,60
S-IVB AFT	2644	± 8,30	+ 2.50 - 5.65	± 1.65	42.00
S-INTR FWD	3169	± 12.50	+ 3.00 - 7.00	± 2.10	53.40
S. M.	3614	± 16.80	+ 3.30 - 7.40	± 2.70	68.50

Table 4-3 Vehicle and Tower Deflections For Extension Platform Design

- INCLUDES SOLAR WARPAGE AT 95% WIND CONDITION. DOES NOT INCLUDE TOWER DEFLECTIONS.
- INCLUDES TOWER DEFLECTIONS, 120° F. TEMP, AND FUELED VEHICLE CONDITIONS.
- RESULT OF VORTEX SHEDDING AT 95% WIND, EMPTY VEHICLE, f = .80
- PLATFORM DOES NOT FOLLOW VEHICLE MOTION.
- DEFLECTIONS FOR THIS LOCATION ARE APPROX. DEFINITE INFORMATION NOT AVAILABLE.

The service arm extension platforms fulfill all the above design criteria and in addition provide practical personnel safety measures and personnel access to the vehicle.

4-30. DESCRIPTION OF COMPONENTS

The basic design of the extension platforms (Figures 4-28 through 4-34) consists of a welded construction of square tubular members, serrated flooring, and expanded metal side screening. The main elements of the platforms are listed below with a brief description of each (Figure 4-15).

4-31. <u>Box Beam Assembly</u>. A box beam assembly (Figure 4-35) is mounted on each side of the service arm just inside the basic structure and approximately 50 inches above the bottom chord of the arm. These two assemblies support the entire extension platform and provide longitudinal motion of the platform with respect to the arm.

Each box beam contains a bearing carrier assembly consisting of recirculating roller bearings mounted on a "T" shaped carrier. The extension platform is suspended from the carriers. Recirculating roller bearings ride on hardened race ways inside the box beam housing and provide low friction movement of the extension platform. The bearings on the carrier assembly must be arranged to react the large moment resulting from the cantilevered extension platform. In addition, a single set of bearings are provided to react reverse loads which may occur during arm retraction.

4-32. <u>Basic Platform</u>. The basic platform, with minor variations, is common to all service arms. This portion of the extension platform provides a walkway across the space between the vehicle and the arm and forms the support structure for the landing outside the vehicle. The "U" shaped structure of the basic platform consists of square steel tubing of welded construction. The approximate dimensions of the platform are: 124 inches long, 52 inches wide, and 45 inches high.

4-33. <u>"T" Head.</u> A "T" head is located at the vehicle end of the basic platform and mounted on ball bearing rollers. The "T" head moves perpendicular to the basic platform on the rollers to accommodate vehicle motion in the lateral direction. A landing for access to the vehicle and/or service areas is provided on all "T" heads. Handrails and screening are an integral part of all "T" heads where personnel are permitted while servicing the vehicle. The "T" head described above is required only on the S-II FWD, S-IVB AFT, S-IVB FWD, and SM arms. A small service platform, to be described later, is used on the remaining arms where access into the vehicle is required.

4-34. <u>Bumper Assembly.</u> The bumper assembly (Figure 4-36) is mounted on ball bushings which move vertically on shafts attached to the "T" head structure. This arrangement permits vertical movement of the vehicle and bumper assembly relative to the "T" head. A rubber bumper is bonded to the bumper assembly structure to protect the vehicle skin while the extension platform is connected. Structure is provided in the center of the bumper assembly for mounting the coupler.

4-35. <u>Coupler</u>. A coupler (Figure 4-37) is mounted on the bumper assembly of each "T" head. The coupler connects to a hard point on the vehicle to form a link between the vehicle and the extension platform. The coupler permits connection to an oscillating vehicle while the extension platform remains a sufficient distance away to prevent a collision. Once the coupler is connected, the platform may be moved out until it is in phase with the oscillatory motion of the vehicle.

4-36. <u>Drive Mechanisms</u>. All extension platforms which require "T" heads are equipped with air motors for positioning both the extension platform and the "T" head. Torque from the air motors is transmitted through a friction wheel to a drive rail. This power moves the extension platform relative to the basic arm or the "T" head relative to the extension platform. The air motors will be powered by pneumatics and will be controlled through manually operated valves located on the extension platform control panel directly behind the "T" head.

4-37. <u>Guide Rollers</u>. Guide rollers are mounted on the bottom chord of the basic arm and bear against the lower members of the extension platform. These rollers transfer wind loads directly to the main structural members of the service arms.

4-38. <u>Uncoupled Warning System.</u> A warning buzzer and flashing red light are mounted on the vehicle end of the basic arm. These devices are electrically connected to a switch located on the coupling mechanism and give visual and audible signals should the extension platform inadvertently disconnect from the vehicle.

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4-39. <u>Safety Panels</u>. Safety panels are installed across the vehicle end of the extension platform when the platform is not connected to the vehicle.

4-40. <u>Service Work Platform</u>. A small service platform (Figure 4-38) replaces the "T" head where horizontal vehicle deflections do not exceed four inches. This occurs on the S-IC INTERTANK, S-IC FWD, and S-II AFT arms. On these extension platforms, the service platform forms a part of the bumper assembly. No hard point on the vehicle is required at these locations. The bumper assembly is spring loaded to maintain pressure against the vehicle skin during all oscillations. The forces imparted to the rubber bumper by the vehicle skin are sufficient to cause the bumper assembly and the attached service platform to follow vehicle oscillations.

4-41. S-II INTERMEDIATE PLATFORMS

The location of umbilical areas at the S-II INTERMEDIATE arm requires two special extension platforms. One platform is located on the S-II INTERMEDIATE arm and provides a service area for the LH_2 umbilical (Figure 4-39). This platform consists of the components described in paragraphs 4-31, 4-32 and 4-37. The platform floor is located approximately 36 inches above the basic arm floor to provide clearance for the withdrawal mechanism.

A second platform is located on top of the S-II AFT arm and provides a service area for the S-II INTERMEDIATE umbilical carrier and LOX umbilical (Figure 4-30). Because of special requirements for this platform, none of the components described in paragraphs 4-31 through 4-40 could be utilized.

There is no contact between either of these platforms and the vehicle since access into the vehicle is not required. Both platforms are extended and locked in position when service is required at the umbilical area.

4-42. PLATFORM OPERATIONAL DESCRIPTIONS

a. Extension and retraction of platforms which do not connect to the vehicle (S-IC INTERTANK, S-IC FWD, S-II AFT).

1. Two men are required for extension. Operator A takes a position on the vehicle end of the platform to move and position the bumper assembly laterally against the vehicle as the platform is extended.

2. Operator B unlocks the extension platform by depressing a foot pedal located at the tower end of the platform and pushes the platform toward the vehicle. Movement of the platform can be controlled by actuating a lever which will apply braking action through two friction blocks pressed against rails on either side of the basic arm.

3. When operator A has positioned the bumper assembly against the side of the vehicle, operator B pushes the platform against a preset stop and locks it in position with the friction blocks.

4. Safety panels across the end of the platform are removed to permit entry to the vehicle.

5. Only one operator is required to retract the extension platform. He releases the friction blocks and pulls the platform into the arm until it locks in the retracted position.

b. Extension and retraction of S-II INTERMEDIATE umbilical service platforms.

The platforms described in paragraph 4-41 will be extended by unlocking the platform retract lock and pushing the platform to a preset stop. The platforms are then locked in the extended position. The platforms are retracted by reversing the above procedure.

c. Extension and retraction of platforms which connect to hard points on the vehicle (S-II FWD, S-IVB AFT, S-IVB FWD, SM):

1. Two men are required for extension and retraction operations. Operator A will assume a position at the air motor controls located on the platform behind the "T" head. Operator B will assume a position on the "T" head above the coupler mechanism.

2. Operator B will remove a section of the "T" head floor to permit access to the coupler and attach the coupler positioning device.

3. Operator A will open the main pneumatic supply valve. This will pressurize both sides of the air motors to provide braking for the platform and "T" head. Next, operator A will move the positioning cylinder valve to "drive" and both friction wheels will be forced against the drive rails.

4. Operator A then moves the lock-pin valve to "unlock" and the extension platform extend-retract valve to "extend". With initial movement of the platform, the lock-pin valve may be released to return to "lock". Platform extension continues until the "T" head clears the basic arm structure. Then operator A unlocks the "T" head lock-pin and moves the platform toward the vehicle while adjusting the "T" head laterally. This operation continues until the coupler and vehicle mounted hard point are in correct position for connecting. Operator A performs these movements by positioning the manual valves which operate the two air motors. One valve extends, retracts, or brakes the platform while the other valve moves the "T" head left and right or brakes it in the desired position. A space of two or four inches now exists between the platform bumper and the vehicle.

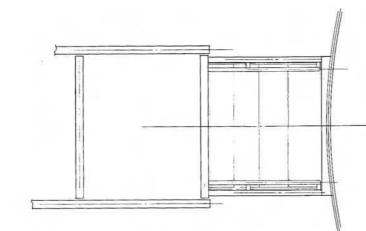
5. Operator B actuates the coupler positioning device extending the coupler across the space between the platform bumper and the vehicle and closing the jaws around the hard point. Operator A extends the platform until the bumper is seated against the skin. Operator B locks the coupler. The coupler positioning device is removed and the floor section replaced.

6. When coupling is complete, operator A moves the cylinder valve to "floating". This pulls the friction wheels away from the drive rails, and the platform and "T" head are released to follow the vehicle movement. Safety panels across the end of the "T" head are removed to permit access into the vehicle.

7. Retraction is performed in the reverse order and the platform and "T" head are locked in position after retraction.

For detail operation of the pneumatic system, refer to paragraph 4-108.

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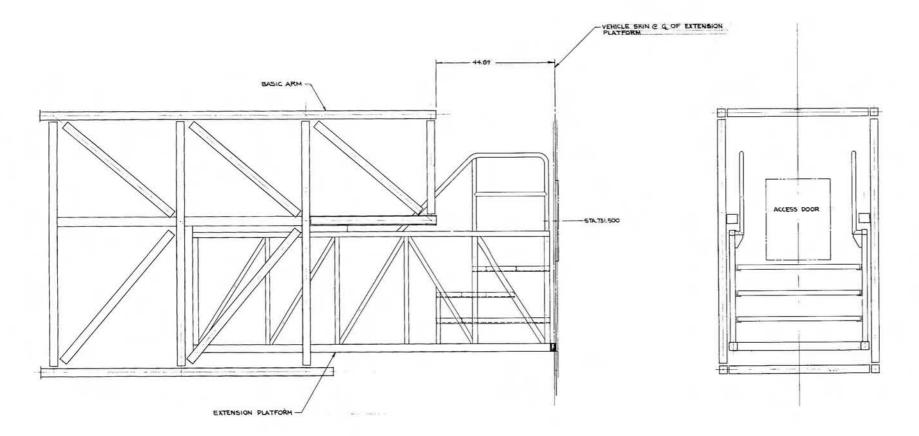
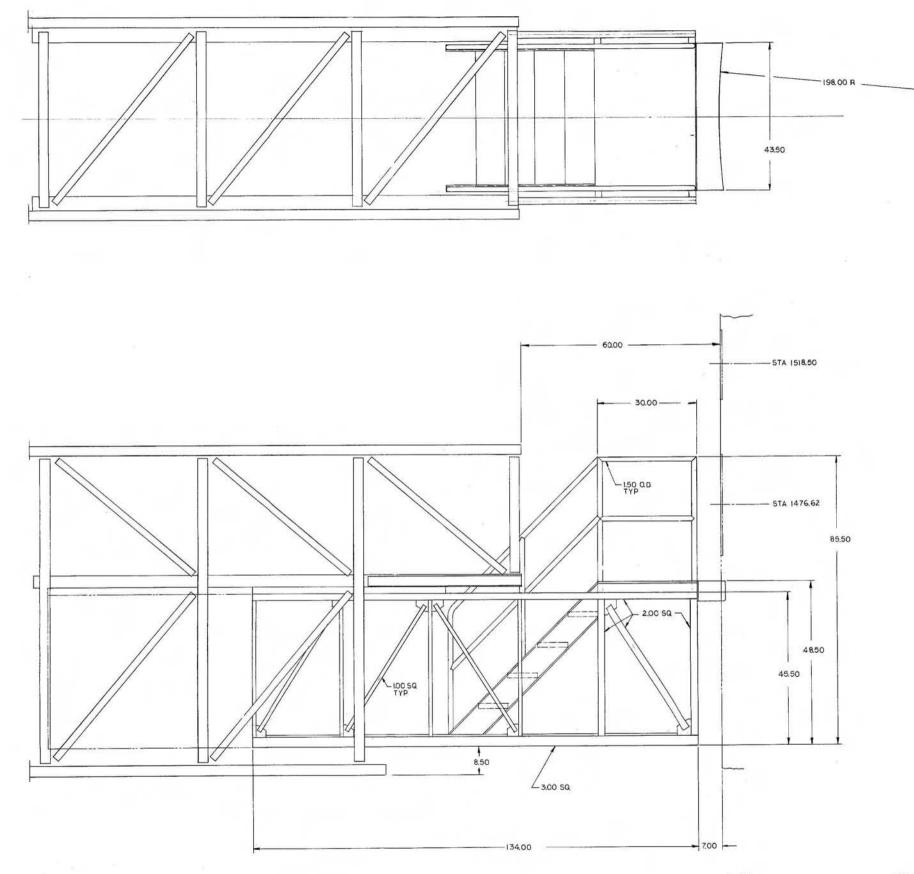


Figure 4-28. S-IC INTERTANK Extension Platform 137



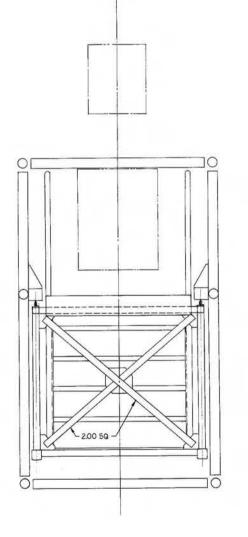


Figure 4-29. S-IC FWD Extension Platform

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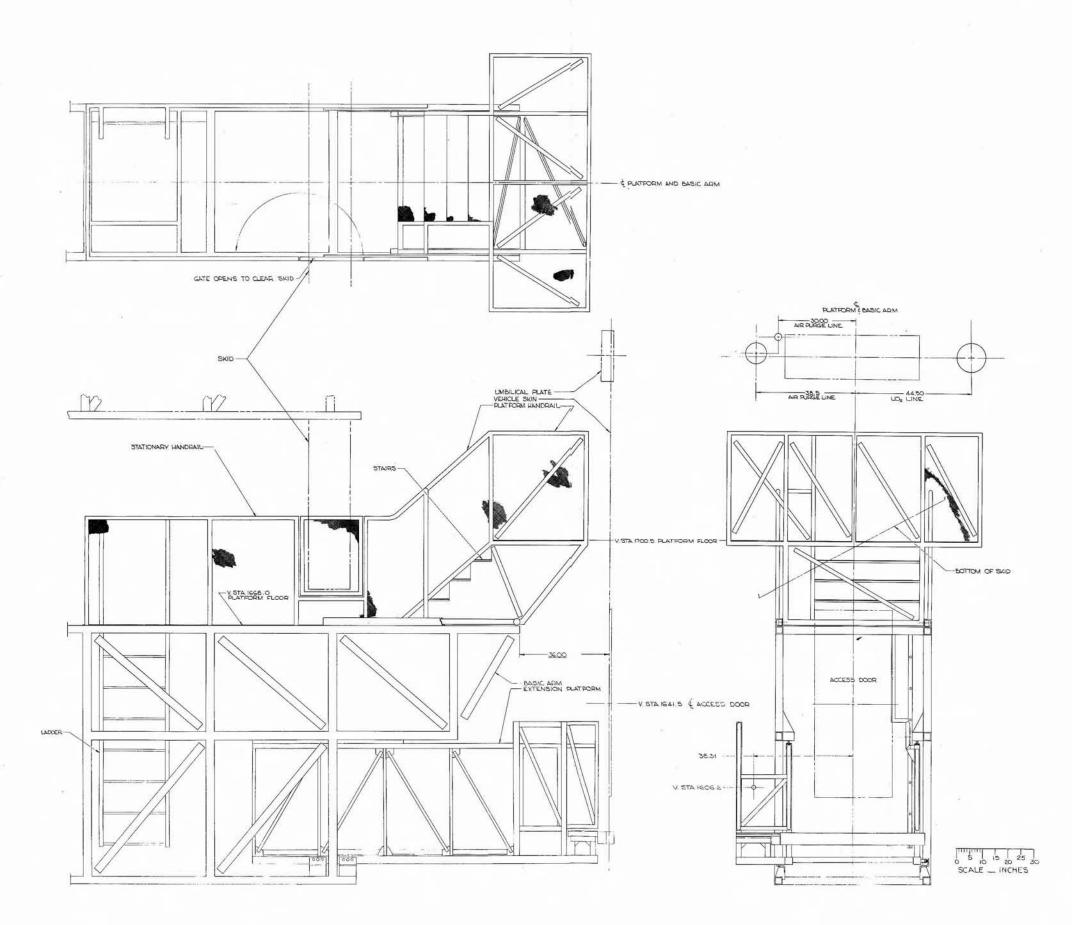
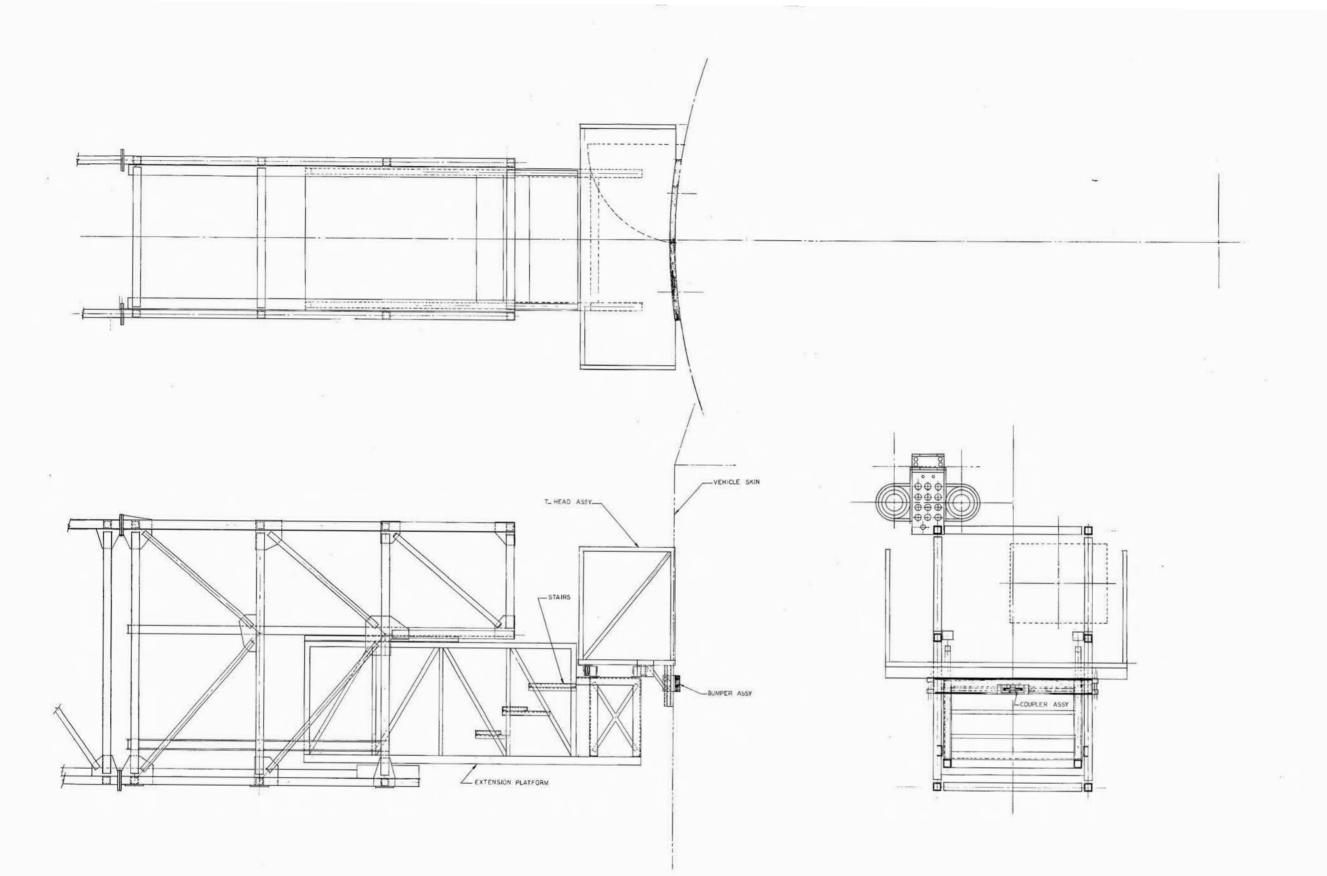
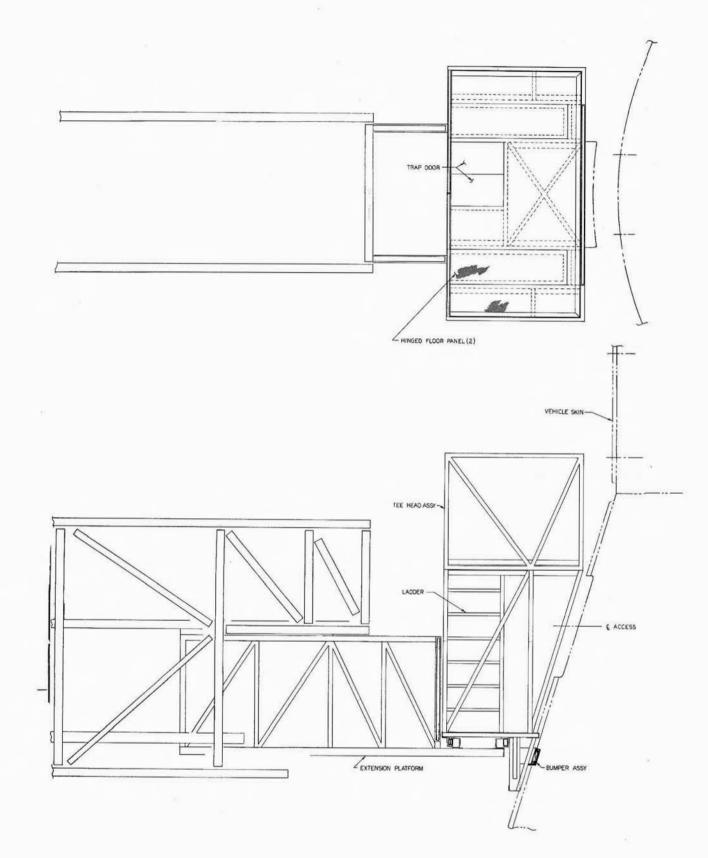


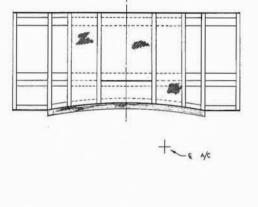
Figure 4-30. S-II AFT Extension Platform

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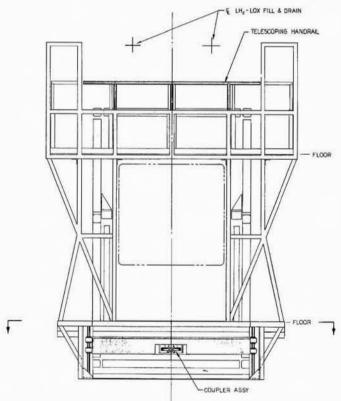


Figure 4-32. S-IVB AFT Extension Platform 141

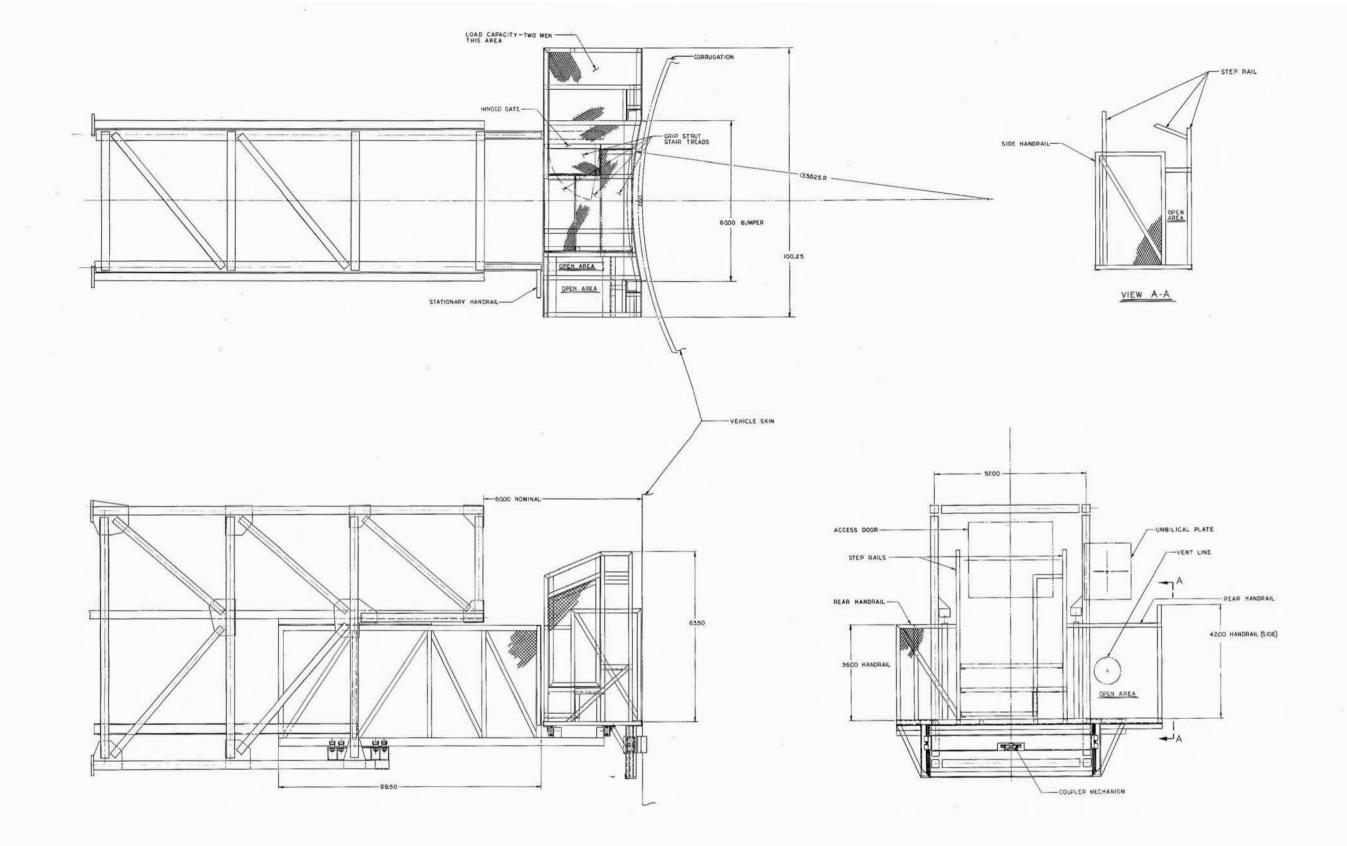
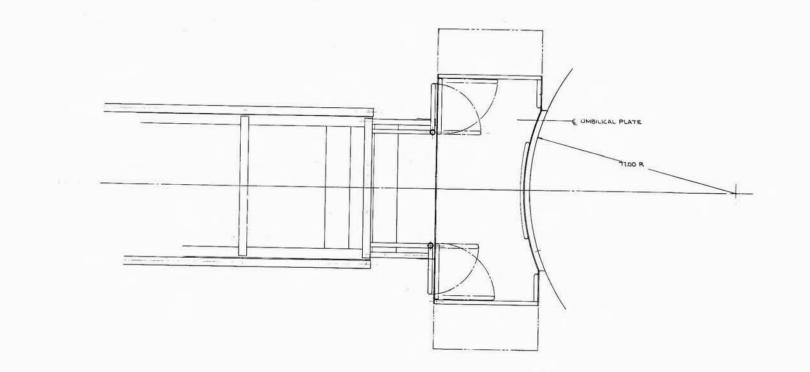
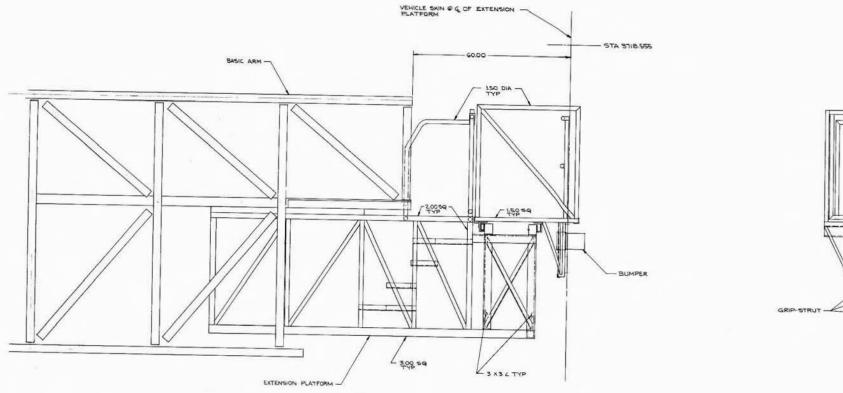


Figure 4-33. S-IVB FWD Extension Platform





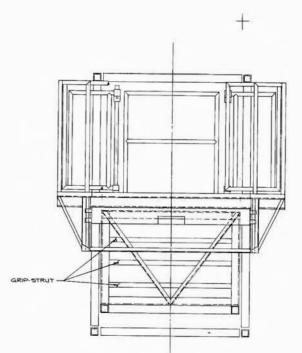
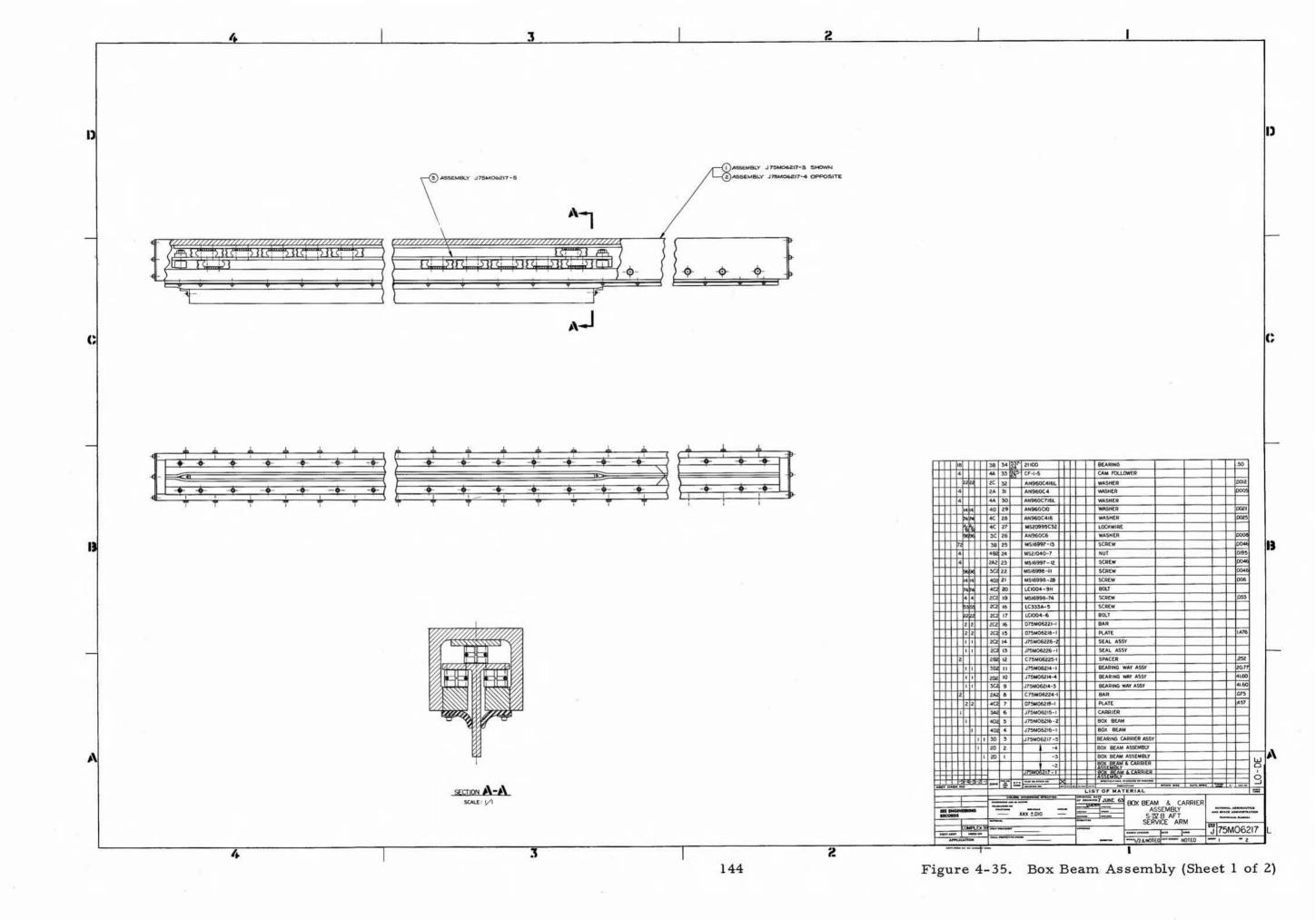
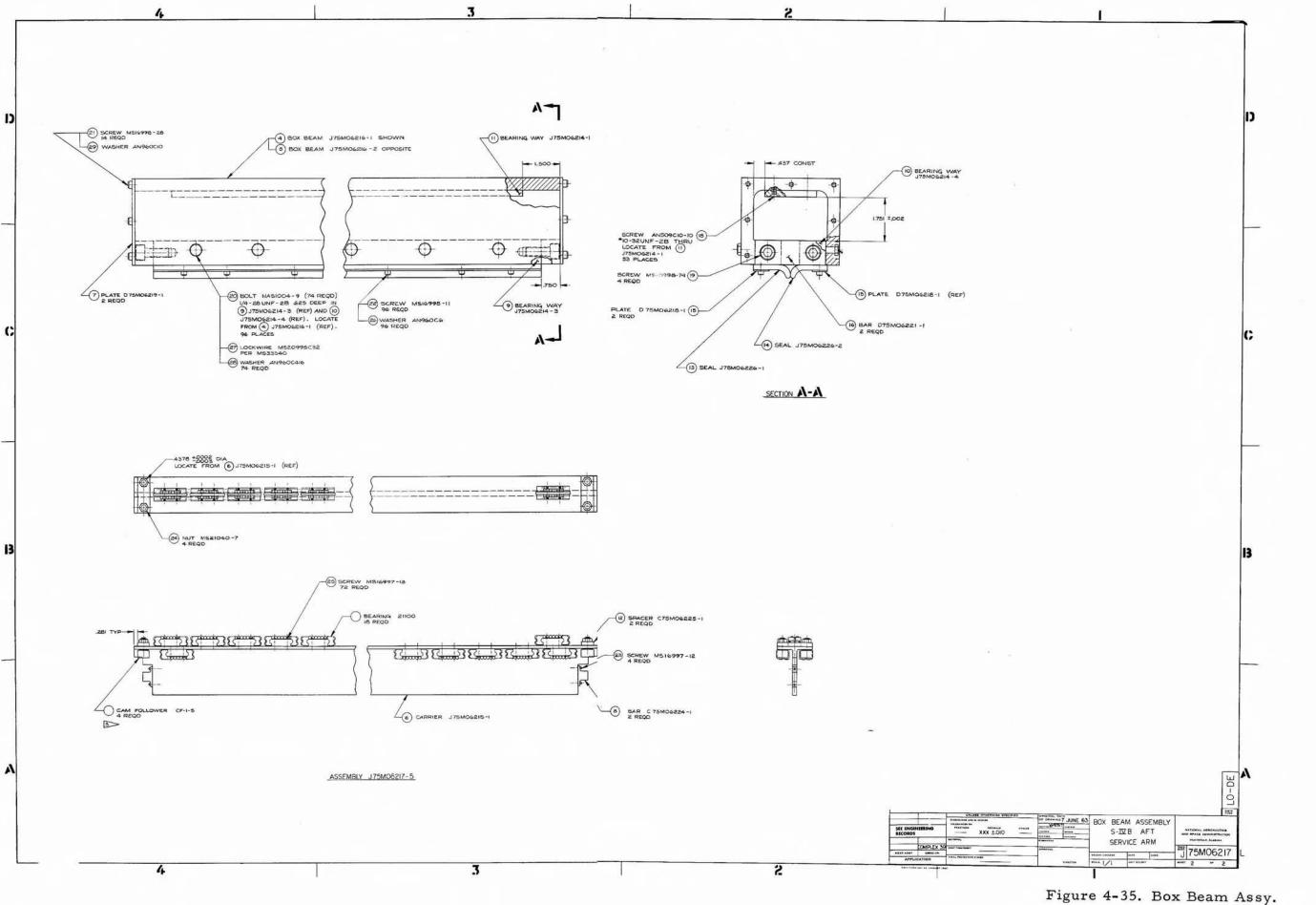
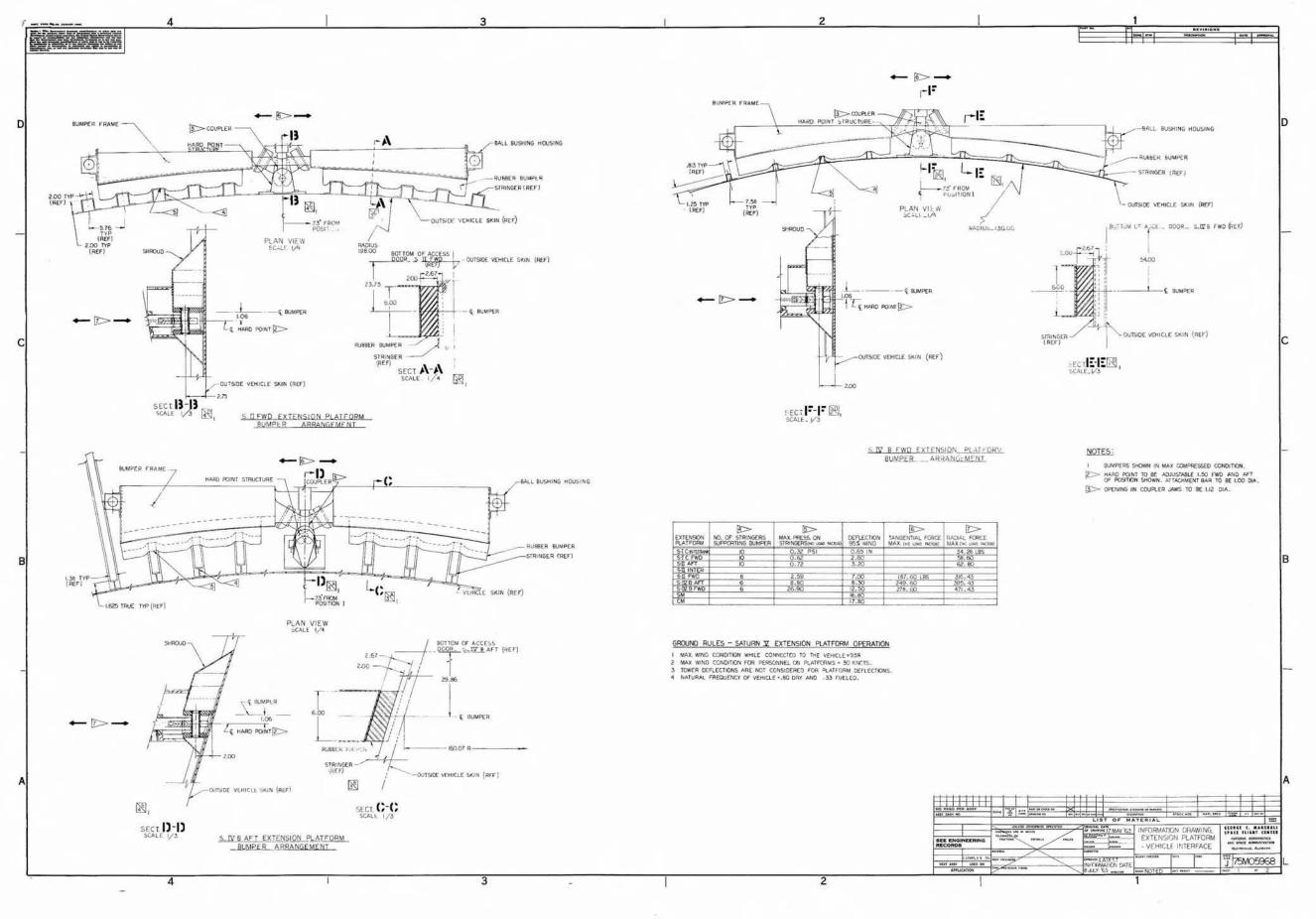


Figure 4-34. Service Module Extension Platform 143

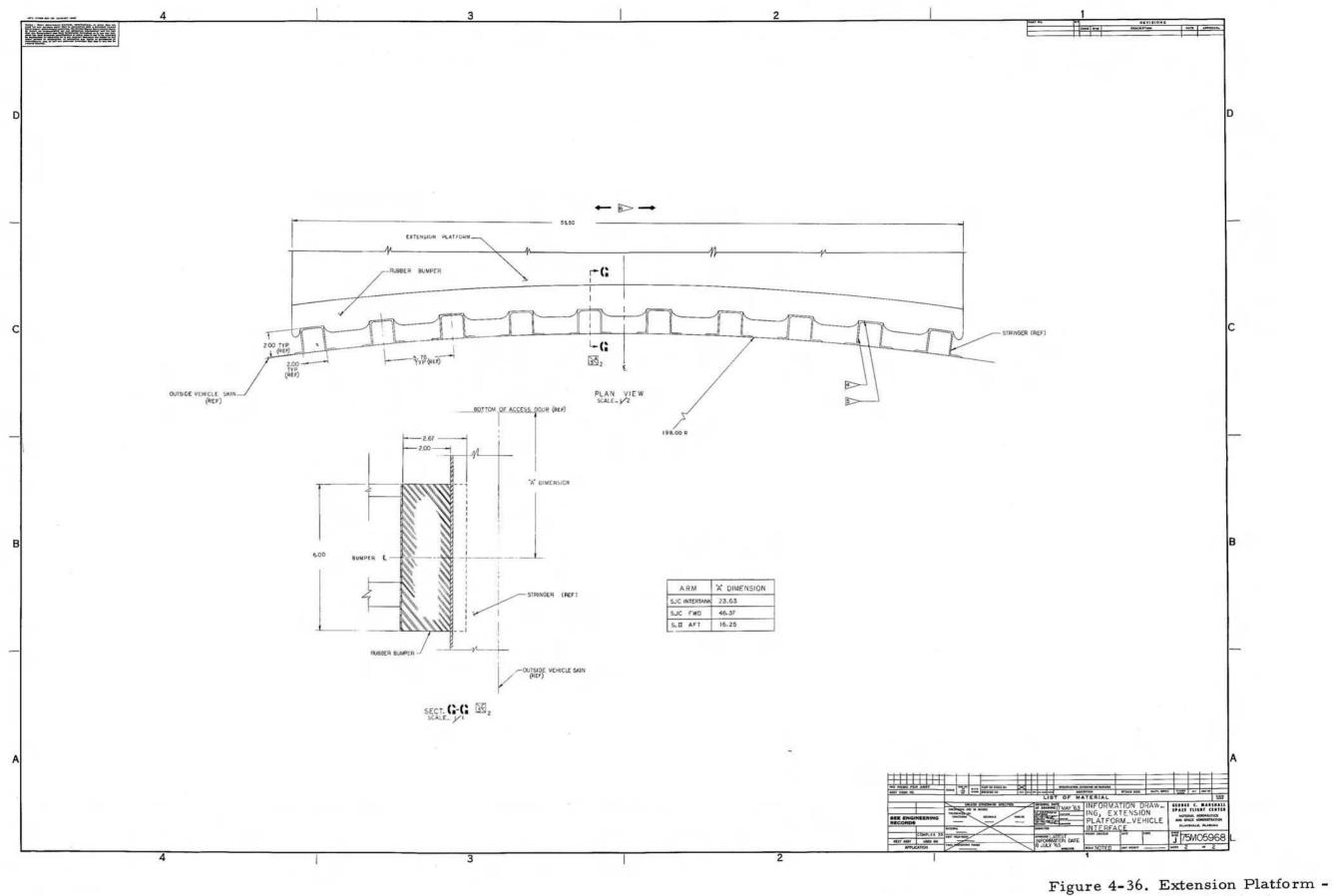




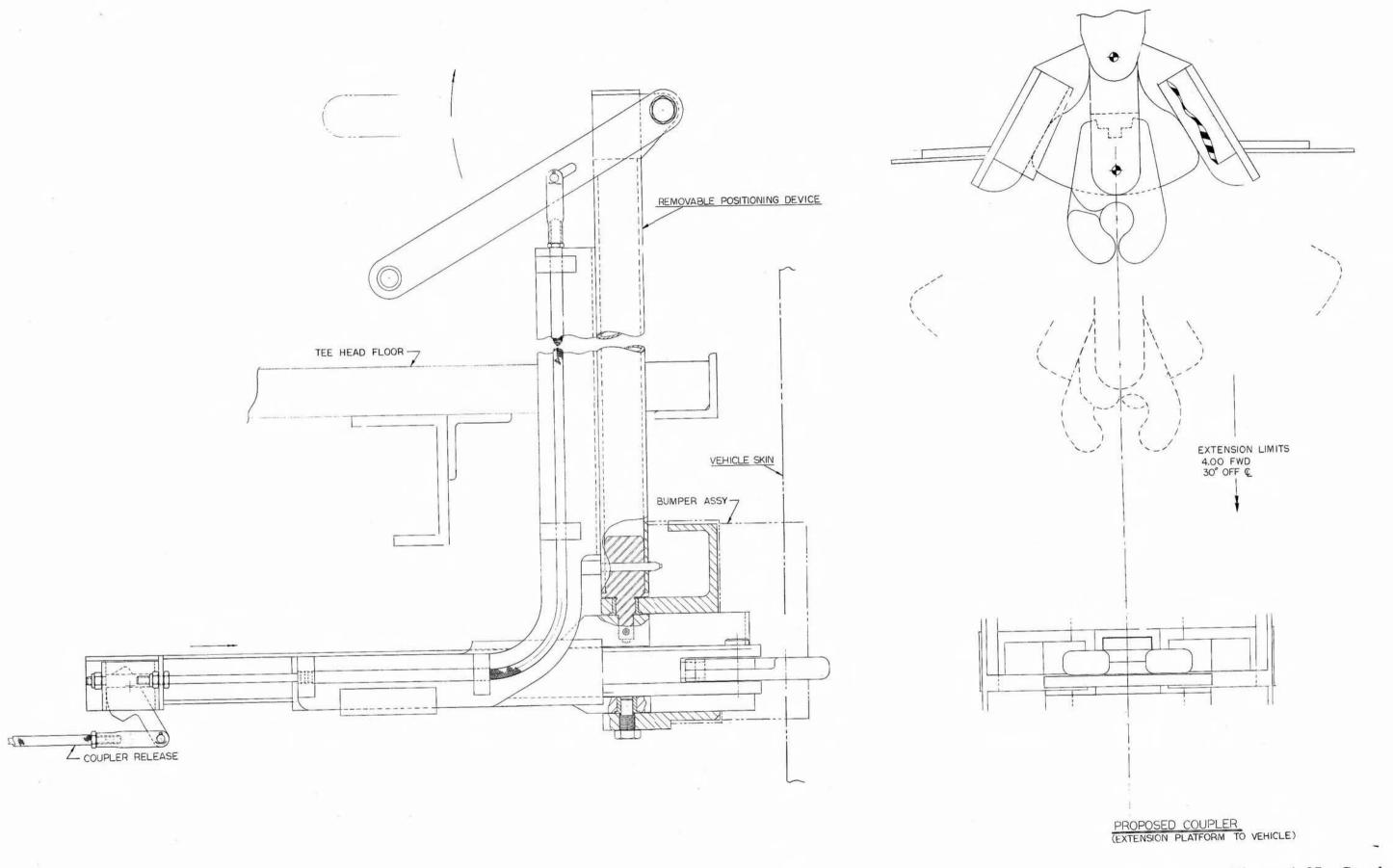
(Sheet 2 of 2) 145

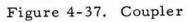


146 Figure 4-36. Extension Platform - Vehicle Interface (Sheet 1 of 2)



Vehicle Interface (Sheet 2 of 2) 147





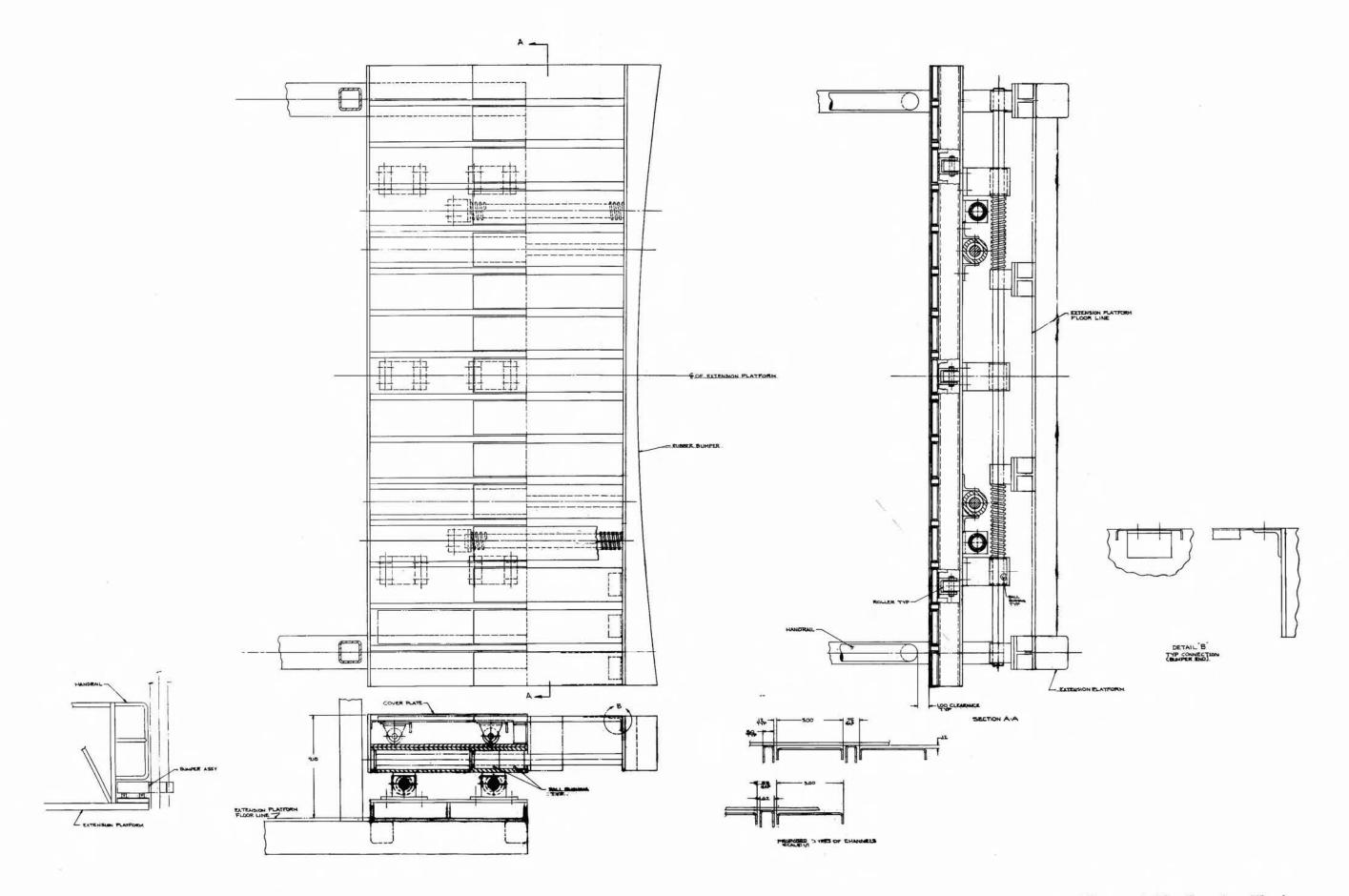
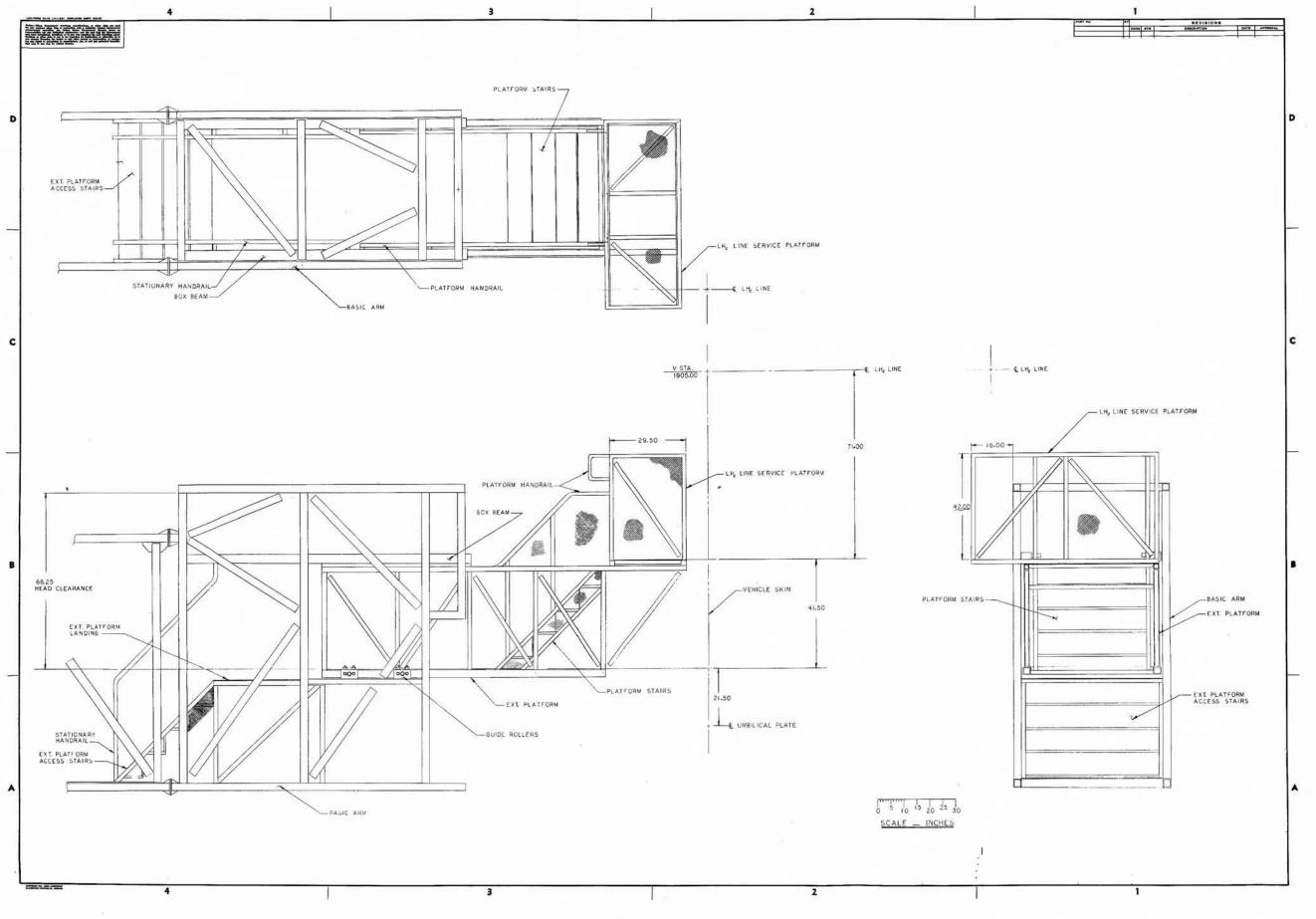


Figure 4-38. Service Work Platform 149



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Figure 4-39. S-II INTERMEDIATE Extension Platform

4-43. ARM RETRACTION SYSTEM

A series of mechanical, hydraulic, and pneumatic features designed into each of the service arms provides a means for rotating the arm horizontally through a 73 degree arc and locking the arm at the extreme positions.

Timing and performance of all components are critical for in-flight arm retraction. The retraction system is capable of unlocking the arm, accelerating it against various wind loads, and decelerating it to a smooth stop.

The arm retraction system differs for preflight arms and in-flight arms. The preflight arms are retracted hydraulically only and do not have the cable retraction system; the in-flight arms are retracted by a hydropneumatic combination system. The hinge-mounted cylinders and associated actuating mechanisms for preflight arms and in-flight arms are the same. The subsequent description is applicable to in-flight arm retraction.

The hydro-pneumatic part of the retraction system is composed of the primary and secondary pressure supplies, valving, and actuators described in the following paragraphs.

The primary pressure supply consists of three 10-gallon nitrogen bottles having a precharge pressure of 2000 psi. The secondary pressure supply is a combination of three 10-gallon nitrogen bottles precharged to 2100 psi, and a piston type 10-gallon hydraulic accumulator. The primary pressure supply and its valving is mounted inside control cabinet No. 2 and the secondary pressure supply in control cabinet No. 1.

4-44. DESCRIPTION OF COMPONENTS

Two tower-mounted hinges (Figure 4-40), positioned outboard of the arm at the top and the bottom chords, house the retraction cylinders, the arm lock, and the bearing assembly. Drive shafts, seven inches in diameter, transmit the torque through the arm hinge plates.

4-45. <u>Hydraulic Retraction Cylinder</u>. Hydraulic cylinders, one in the top and one in the bottom hinge, are connected parallel in the hydraulic circuit. Each cylinder has an 8-inch bore, 14.875-inch stroke, 3.5-inch diameter rod, and is clevis mounted within the hinge. The force developed on the pull stroke of the cylinder is transmitted through a 12-inch driving lever to the drive shaft which rotates the service arm. Two bell-crank type, hydraulically operated arm locks are encased in the hinges. The top hinge contains a special cam-operated decelerating valve and the required valve and cylinder piping. 4-46. <u>Tower-Mounted Hydro-pneumatic Cylinder</u>. One hydro-pneumatic cylinder, mounted on the tower, operates a cable retraction mechanism (Figure 4-41). This cylinder has a 7-inch bore, a 52-inch stroke, and has the rod end attached to a block carrying four pulleys. Four other pulleys are mounted at the rear of the cylinder to form an 8 to 1 block and tackle system. The cable is routed from the system through a tensioning device to a swivel connection 267 inches from the arm pivot (Figure 4-41).

4-47. <u>Control Cabinets</u>. Control cabinets contain hydraulic and pneumatic accumulators and control valves for the arm retraction and withdrawal mechanism systems. The cabinets are made of stainless steel and are located on the tower deck adjacent to the arm. Each in-flight service arm has two control cabinets, No. 1 and No. 2; the prelaunch arms have only control cabinet No. 1. The size of control cabinet No. 1 will be approximately 7 feet long, 5 feet deep, and 7 feet high. The size of control cabinet No. 2 is approximately 2-1/2 feet long, 2 feet wide, and 7 feet high. Each control cabinet contains an electrical distributor box and control cables to the solenoid valves and the position indicator lights.

4-48. Latch-Back Mechanism. Arm supports, mounted on the tower, house the latch-back mechanism. This mechanism must be designed to withstand the load induced on the arm by the aspiratory wind back through the tower (Figure 4-42).

4-49. Linear Shock Absorbers. Two linear type shock absorbers (Figure 4-43) are bolted to the tower-mounted beams at the same level as the top and bottom service arm chords. These shock absorbers have a 4-inch bore, an 18-inch stroke, and are orificed such that a uniform stopping force is provided to decelerate the arm in event of a dual failure of the flow control valve.

4-50. OPERATIONAL DESCRIPTION

The prerequisite for reliable retraction of the service arm dictates the duplication of retraction means and minimum response time between modes of operation. Prior to vehicle launch, the arms are mechanically locked in the extended position. At T minus 10 seconds during the countdown, the preflight service arms are retracted. At T minus 15 seconds, the locks of the in-flight service arms are released; however, the arms are held in position by hydraulically-locked, hinge-mounted cylinders.

Lift-off initiates a rapid but chronological sequence of operations. First, the primary lift-off switch closes and completes the circuit to the umbilical carrier ball-lock release and ejection pistons. When the carrier is unlocked and separated from the vehicle, a limit switch located in the umbilical carrier, closes to initiate action of both the withdrawal mechanism and arm retraction system. The resulting sequential operation of the hydropneumatic retraction system can be described as follows:

NOTE

This system is completely duplicated for redundancy, electrically and mechanically (paragraph 4-96 through 4-100).

The limit switch completes a circuit to open valves located in the supply lines and return line. These valves release the primary and the secondary pressure supplies and open a hydraulic return line from the hinge-mounted cylinders through the flow control valve to the reservoir.

During normal operation of the system, the primary pressure supply delivers nitrogen into the blind end of the tower-mounted cylinder. The nitrogen intensifies the hydraulic pressure on the rod end and forces the flow into the rod ends of the two hinge-mounted cylinders. In effect, the pistons of the hinge-mounted cylinders retract the service arm, and the idling cable is automatically reeled at 8 times the rate of the towermounted cylinder motion. Although blocked by a check valve, the secondary pressure supply is available if the intensified pressure drops below the secondary supply pressure.

The geometry of the hinge cylinder and the cable mechanism is such that for the same angular increments of service arm motion, displacement patterns for hinge and tower cylinders are different. Cable slack is approximately constant for the first 50 degrees of rotation; however, the slack increases in the remaining 23 degrees. A cable tensioner provided at the tower mounted cylinder controls the cable slack and idling tension.

The hydro-pneumatic system (Figure 4-44) offers automatic protection against the consequences of the following types of failure:

a. Gradual or total loss of hydraulic oil in the hinge-mounted supply lines. If a gradual hydraulic leakage develops at the hinge-mounted cylinder, the tower-mounted cylinder, while automatically compensating for oil loss, will extend further and tighten the cable. At the same time, the intensified pressure to the hinge-mounted cylinder will decrease until the secondary supply (hydraulic accumulator) begins to compensate for oil loss. Depending on the leakage intensity, either the cable tension will continue to increase or secondary pressure supply will take over and complete the arm retraction. Sudden loss of all oil due to line failure relieves the pressure in the hydraulic line between the hinge-mounted and tower-mounted cylinders and results in retraction of the arm solely by the cable system. Thus, any loss in torque developed by the hinge-mounted cylinder is automatically supplied through the cable by the tower-mounted cylinder.

b. Loss of Nitrogen Pressure. If there is a complete pressure loss in the GN_2 primary supply, the tower-mounted cylinder will not move and the cable will not be reeled. However, a secondary supply (hydraulic accumulator) will provide pressure and full oil flow to the hinge-mounted cylinders instantaneously. Partial loss of GN_2 pressure will result in either an immediate and complete switch to the secondary supply or a momentary input from the GN_2 primary supply until the secondary supply takes over.

4-51. PRESSURE-COMPENSATED FLOW CONTROL VALVE

For deceleration control of the service arm, a cam-operated, pressure-compensated flow control valve (Figure 4-45) of unique design is located in the return lines from the hinge mounted cylinders. This valve incorporates special features such that it will fail only in the full-flow condition to ensure complete arm retraction within the critical time interval. This valve maintains accurate and reliable speed control of the arm, independent of wind loading conditions, by use of a pressure-compensating unit and a cam-controlled variable orifice. Different retraction times and functions of angular velocity versus displacement may be obtained by changing the shape or angular orientation of the cam or by adjusting the compensator spring setting.

The principle of the pressure-compensator can be summarized as follows: the pressure drop across the compensator is equal to the force exerted by the compensator spring.

The internal design of the flow control valve was dictated by the necessity that the control system must always move the arm from the path of the ascending vehicle; consequently, there must be no valve failure that results in additional flow restriction or in complete closure of the line.

Two types of failure are possible which could jeopardize arm retraction: failure of the compensator spring, or clogging of the camcontrolled variable orifice.

Failure of the compensator spring results in a shifting of the compensator spool to the flow cutoff position. Addition of a sequence valve which, after spring failure shifts the spool to the fully open position, converts the unit into a nonpressure-compensating deceleration valve.

Clogging of the cam controlled variable orifice would close the return line and decelerate the service arm which could result in collision with the vehicle. Orifice clogging causes a rapid pressure buildup that opens a latch-type relief valve allowing full flow through the return line. Incorporation of the two special features satisfies the requirement for a fail-safe deceleration system. However, the failures outlined above could result in the service arm approaching the tower with sufficient momentum to destroy the arm or cause the arm to rebound into the vehicle. The shock absorbers previously described reduce damage from these possibilities.

For detail operational description of hydro-pneumatic system, see paragraph 4-92 through 4-107.

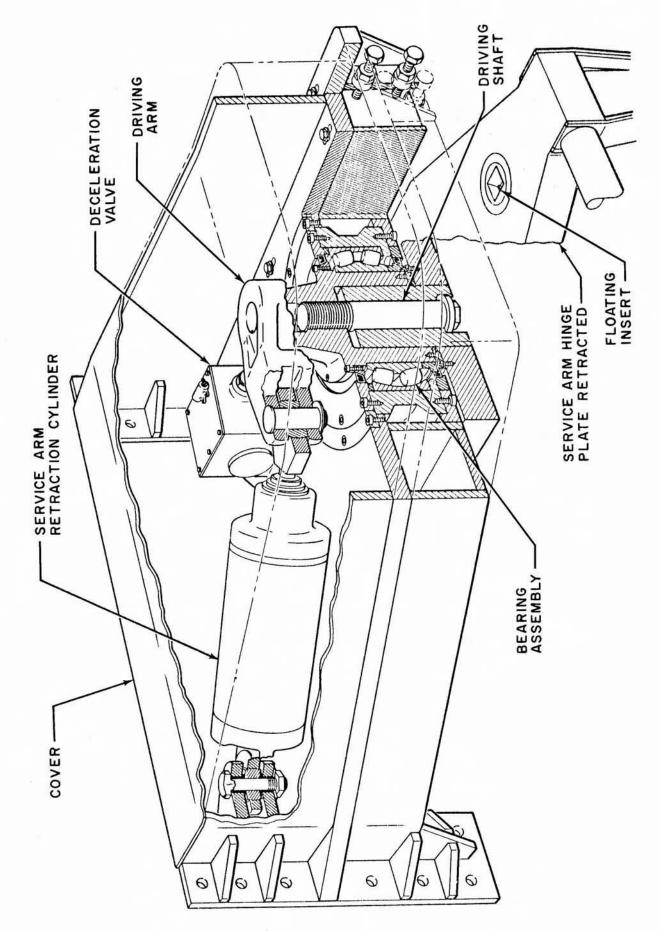


Figure 4-40. Tower-Mounted Hinge

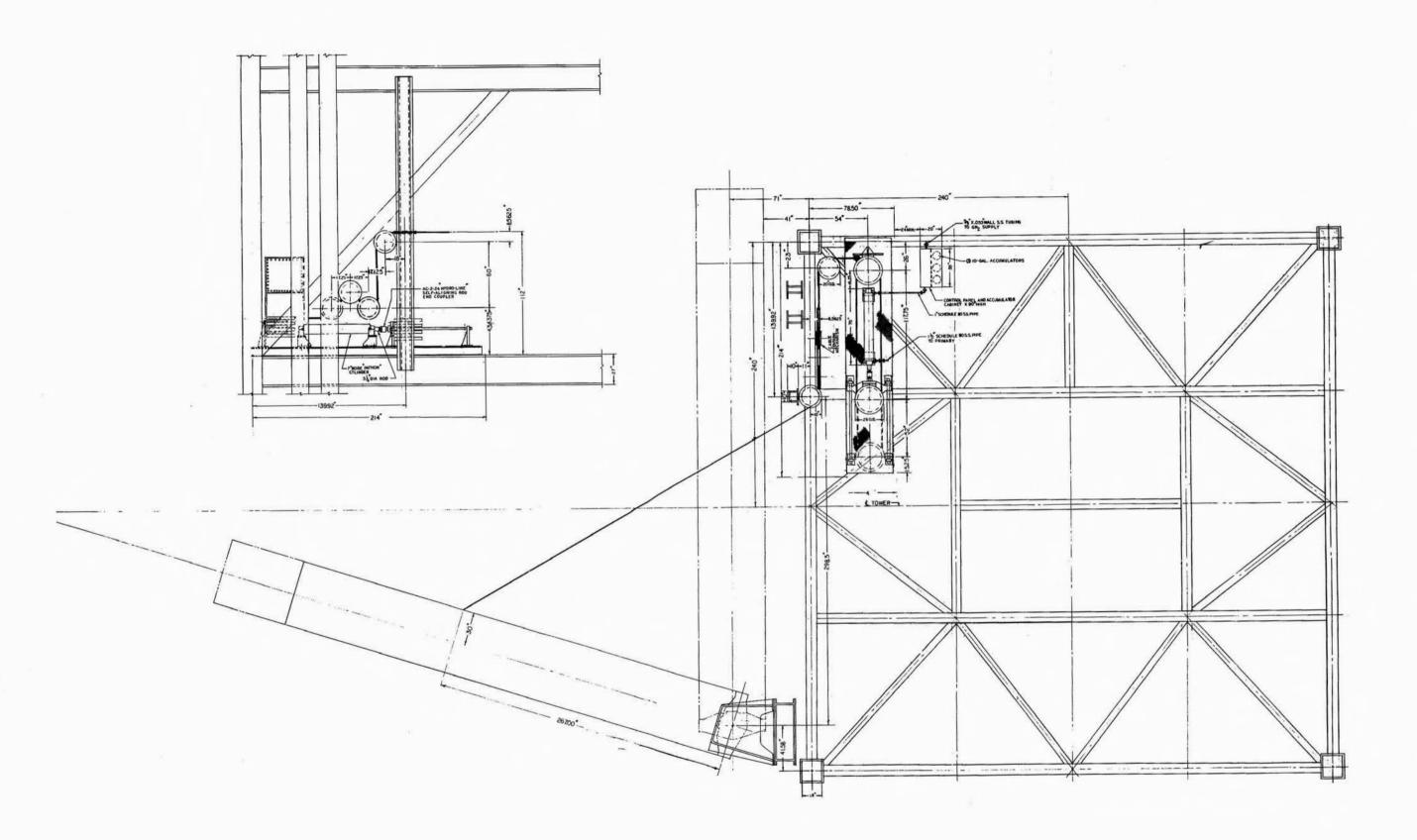


Figure 4-41. Cable Retraction System 157

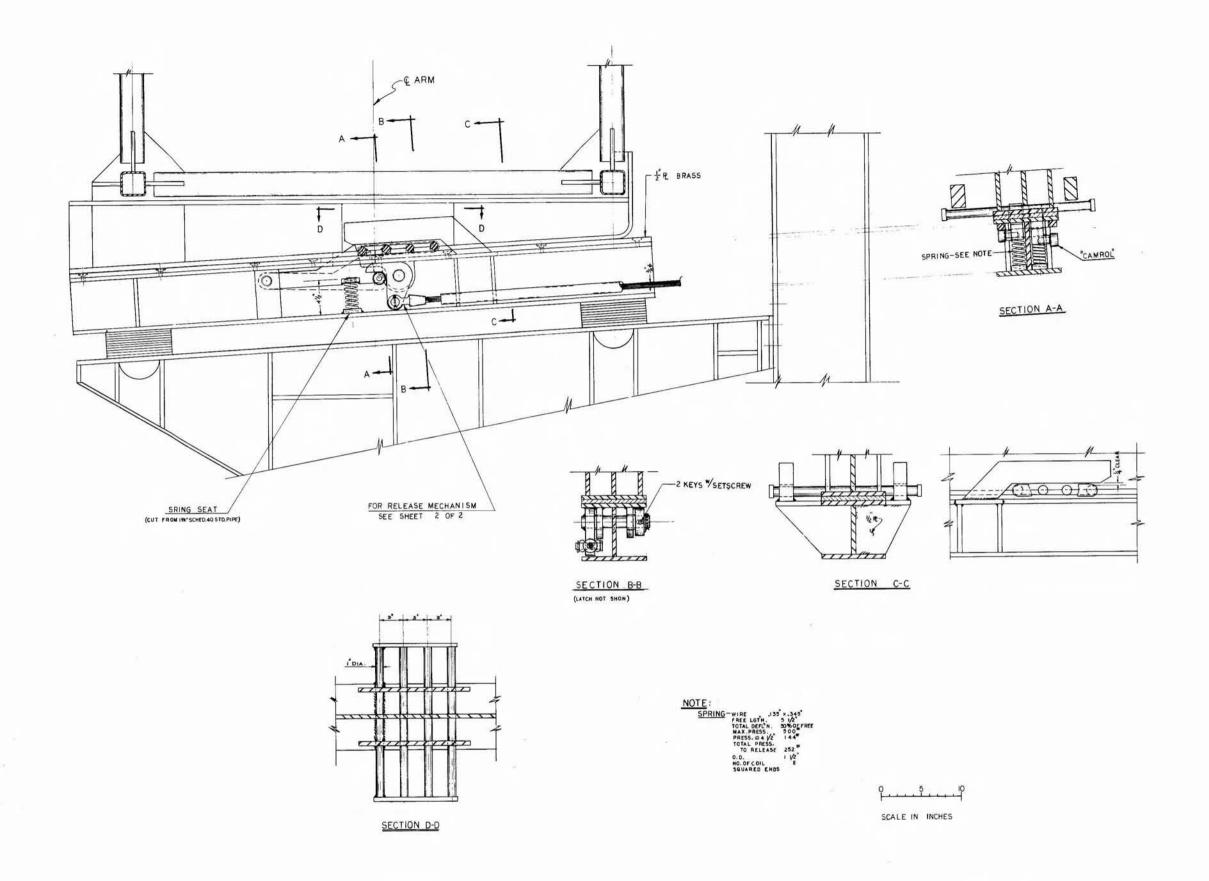
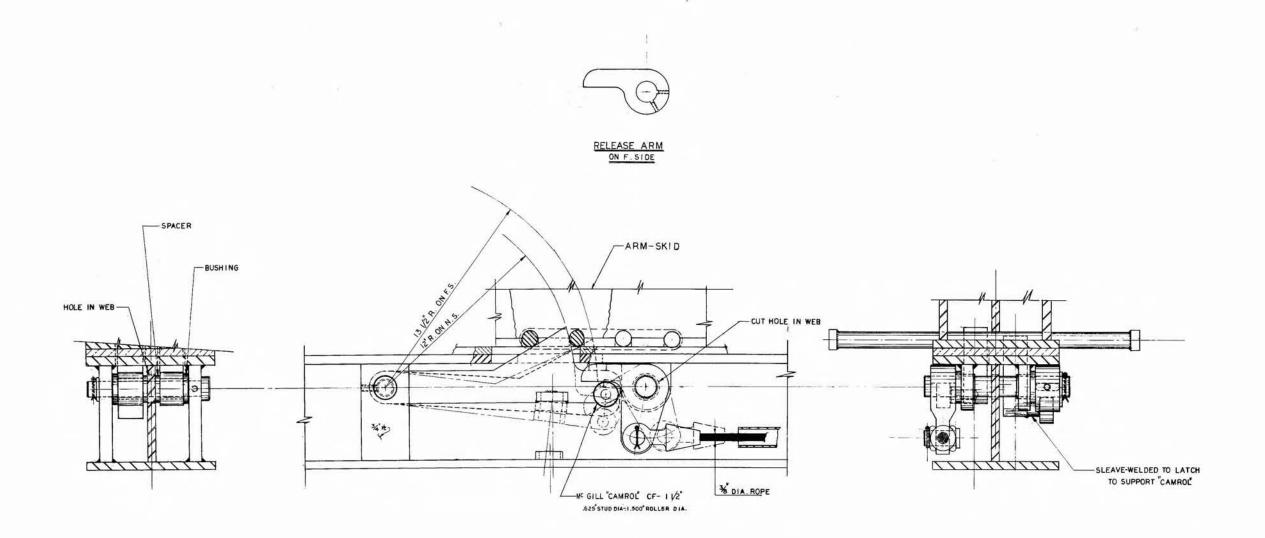


Figure 4-42.

Latch-Back Mechanism (Sheet 1 of 2)

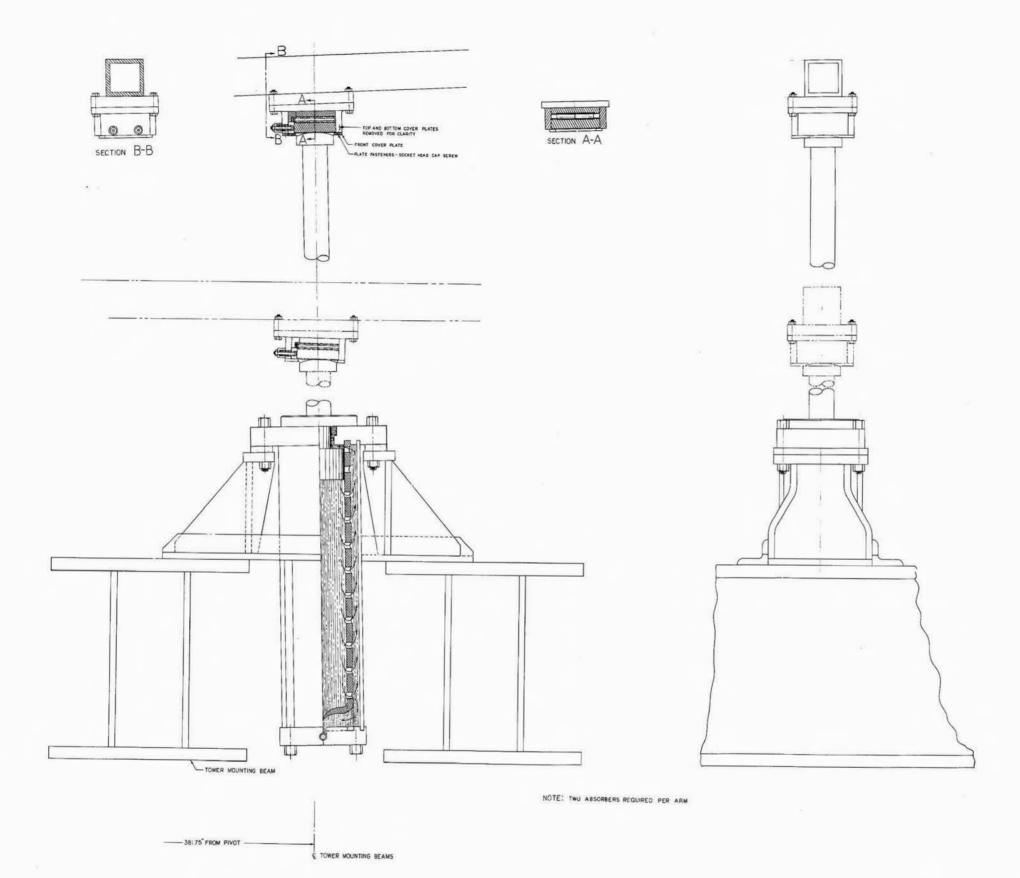
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Figure 4-43. Linear Shock Absorber

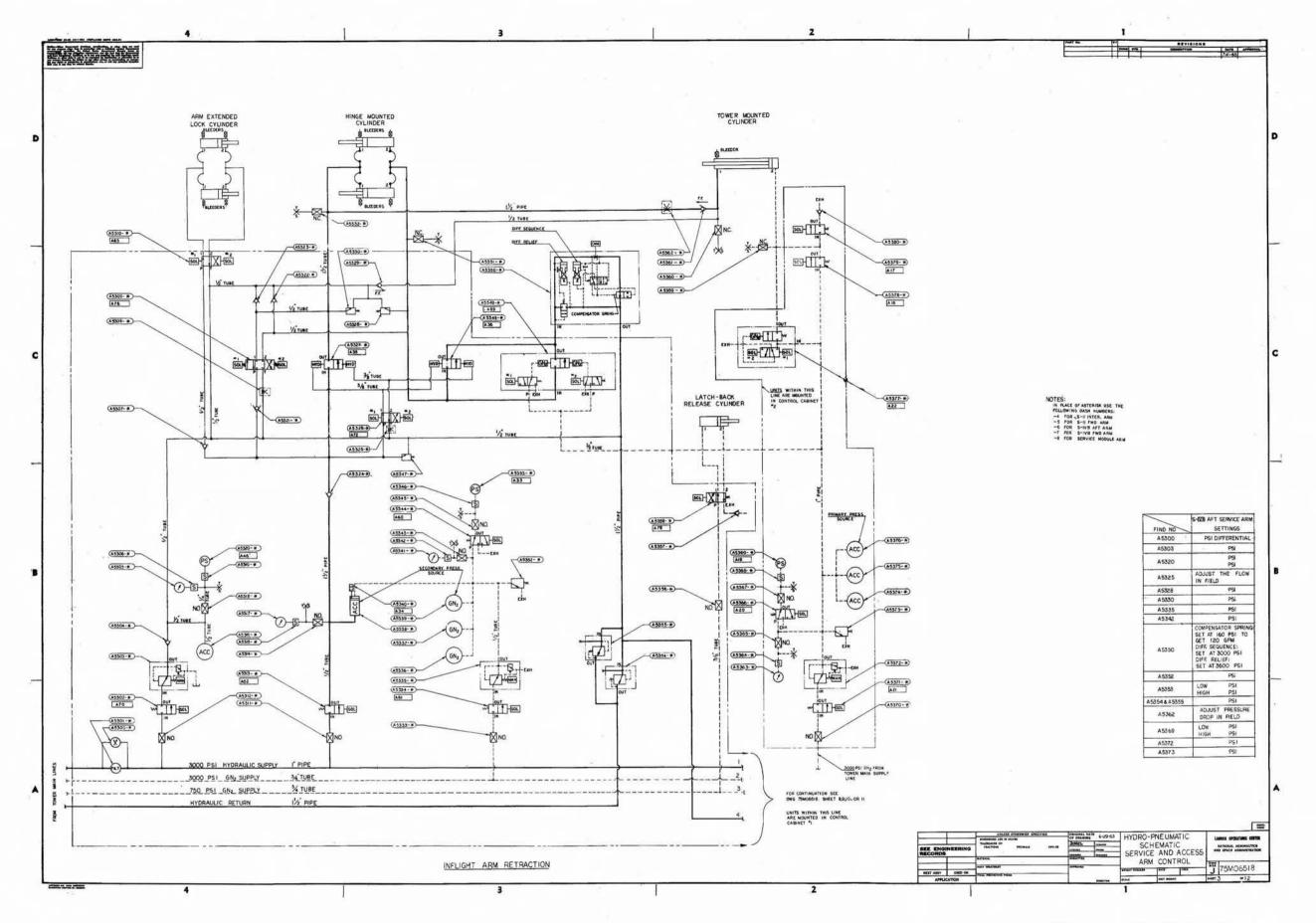


Figure 4-44. Hydro-Pneumatic System Schematic 161 This page intentionally left blank.

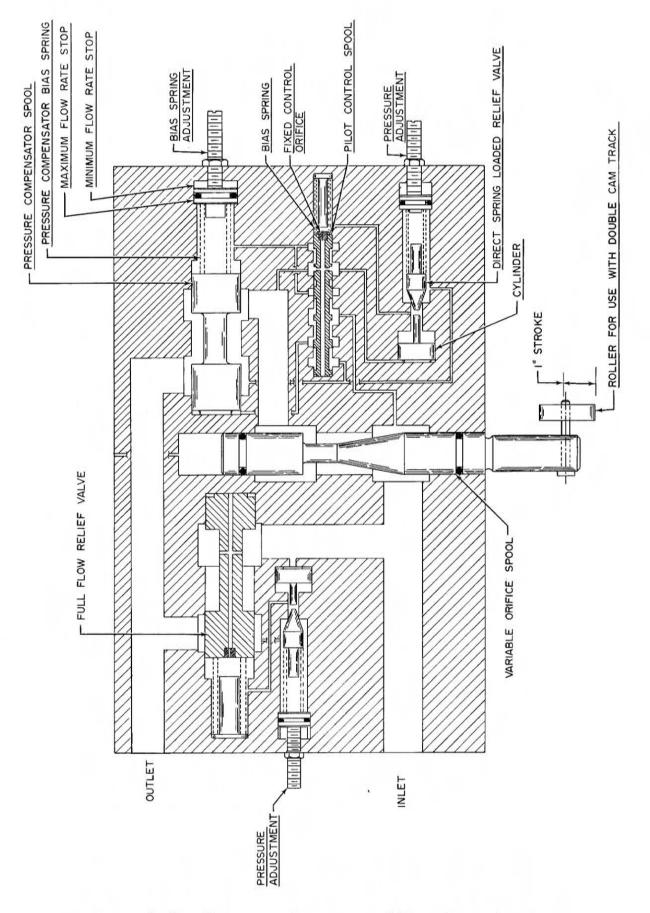


Figure 4.45. Pressure-Compensated Flow Control Valve

4-52. ELECTRICAL SYSTEMS (Appendix C)

4-53. OPERATIONAL DESCRIPTION

4-54. <u>In-flight Service Arms Automatic Operation (Figures 4-55 and 4-56)</u>. The automatic operation of the service arms has the firing circuits isolated from the remainder of the system. There are two 28-volt d.c. power sources, two primary lift-off switches, two secondary lift-off switches, and two carrier release switches. Each power source is used in a similar manner through its respective primary, secondary, and carrier release switch. There is no electrical connection between the two systems, thereby ensuring complete isolation and redundancy.

The primary lift-off signals originate from the two switches located on the vehicle holddown arms which sense vehicle motion. The signal from the primary lift-off switch number one simultaneously energizes solenoid No. 1 of valve number A5520 for all in-flight service arms. The signal from the primary lift-off switch number two simultaneously energizes the solenoid of valve A5524 for all in-flight service arms. When the valves have shifted, the position indicator switches close and energize relays in the relay distributor. Contacts of the relays will close light circuits on the LUT service arm monitor panel to confirm operation. Other contacts of the relays will energize recorder circuits to record the operations of the valves. These valves open pneumatic lines that supply pressure to unlock and eject the umbilical carrier from the vehicle. When the umbilical carrier is disengaged, two carrier release switches are closed to initiate withdrawal and retraction of the respective service arm for each d.c. power source, Carrier release switch No. 1 energizes solenoid No. 2 of valve A5500, solenoid No. 2 of valve A5462, solenoid No. 2 of valve A5451, and solenoid No. 2 of valve A5326. Carrier release switch No. 2 energizes solenoid of valve A5508, solenoid No. 2 of valve A5463, solenoid No. 2 of valve A5413, solenoid No. 1 of valve A5349, and solenoid No. 2 of valve A5377. As the above valves shift, the position indicators of each will close and energize their respective relay in the relay distributor. Contacts of the relays will close a light circuit on the LUT service arm monitor panels to confirm operation of each valve. Other contacts of the relay will energize recorder circuits to record the operation of the valves. Due to the delay in shifting of the valves, the withdraw will begin operation approximately 100 milliseconds before retraction begins.

The secondary lift-off switches are closed by vehicle motion at a position of vehicle travel where any umbilical carrier will have been mechanically disengaged from the vehicle by vehicle motion if any umbilical carrier had failed to be disengaged electrically. Closure of the secondary lift-off switches supplies power to the withdrawal and retraction valves for all service arms without the need for umbilical carrier switches having to close.

When the service arm locks to the tower and the arm has bottomed out on the shock absorber, a retraction-complete switch will close and energize a relay in the relay distributor. Contacts of the relay will energize a light circuit on the LUT service arm monitor panels. Other contacts of the relay will energize a recorder circuit.

The electrical wiring schematics for the service arm control system are shown in Figures C-1 through C-19 and C-23. Figure C-24 depicts this operational sequence. The operational times were based on the best information available from the mechanical, hydraulic, pneumatic, and analysis groups.

4-55. <u>In-flight Service Arms Semiautomatic Operation</u>. This operation is discussed in paragraph 4-83 (Figures C-20 through C-23).

4-56. Preflight Service Arms Automatic Operation. The automatic operation of the preflight service arms will be similar to the in-flight arms. The signal to retract the arms will be given approximately 10 seconds before engine ignition from the countdown programmer; whereas, the primary liftoff switches give the retract signal on the in-flight arms. This will allow the arms time to be retracted and locked against the tower before engine ignition. When all the preflight arms are locked against the tower, a signal will confirm the retracted condition. If any one of the preflight arms is not retracted, the countdown will hold.

The preflight arms will have no redundancy in the carrier kickoff, withdrawal, and retraction systems; whereas the in-flight arms use redundancy throughout. There will be no cable retraction system, and the withdrawal and carrier kickoff valves will be reduced in number; for example, there will only be one supply and return valve for the pneumatic cylinder.

There will be one battery supply and one carrier release switch; whereas, the in-flight has two battery supplies and two carrier release switches. Figure C-31 depicts this operational sequence. 4-57. <u>Preflight Service Arms Semiautomatic Operation</u>. The preflight semiautomatic operation will be the same as for the in-flight arms except for solenoid valves A5377, A5378, A5379, and A5349 of Figure 4-55. These valves will not be in the system since there is no cable retraction system for the preflight arms.

4-58. SERVICE ARM LIGHTING

The lighting system will provide a minimum of 20 footcandles of illumination on each service arm (Figures C-32 through C-36). The system components are hydrogen explosion proof; thus, should the need arise, the lights could remain on during fueling operations. Refer to Figures C-32 and C-33 for an arrangement of overhead lighting for those service arms for which preliminary design is complete. The first element, as shown on the S-II AFT Service Arm, will be typical for every service arm (Figure C-32). The placement of the lights on the second elements and extension elements will vary for each arm (Figures C-32 and C-33). All service arms will also be provided with three-wire, 120/208 voltage explosion proof receptacles.

4-59. DOCUMENTATION

The complete service arm electrical documentation for Complex 39, which includes arm installation, tower installation and LUT base installation in more detail, is shown by the family trees in Figure C-37 and C-38.

4-60. COMPONENT DESCRIPTION (Figure C-29)

4-61. <u>Control Distributor</u>. The primary function of the control distributor is to channel the individual cables from pressure switches, valves, junction boxes, etc., into 60 conductor cables for distribution to patch racks in the base of the LUT. Each distributor is supplied with the same 28 volts d.c. power used in the patch racks to provide a common positive and negative return bus; this reduces the number of 60 conductor cables required to supply indication and controls to the base of LUT.

The distributor will be 10.50 inches high and is designed to mount in a standard 24-inch rack. There will be top and bottom covers which are sealed to provide easy accessibility to the terminal boards and connectors. The front plate will be sealed in order for the distributor to be used in areas that will require sealing. The distributor is versatile and can be used in other GSE. The control distributor will be used on all service arm levels and will be mounted in valve console No. 1 since the majority of valves are located in this console. The six-pin connectors on the rear (Figure C-30) are connected to components in the console with cables which have a sixpin plug on one end and the required plug on the other end. This allows the distributor to be used on all service arms without special modifications for the exact number of 2, 3, 4, 5, and 6-pin connectors required.

The front of the distributor has two 60-pin and one 4-pin connectors. The 4-pin connector is 4-conductor number 1/0 and is used for d.c. power. One of the 60-pin connectors is used for control and indication circuits feeding to the patchracks in the base of the LUT, and one is used for control and indication circuits from valve console No. 2 or circuits from the service arms.

There are two assembly-types of terminal boards inside the distributor: One assembly numbered TBl and TB2 which will be wired number to number to the 60-pin connectors Jl and J2 on the front of the distributor; and the other assembly numbered TBA, TBB, TBC, and TBD, each wired in groups of six terminals to their respective 6-pin connector, letter to letter. For example, TBAl wires letter to letter to connector JAl on the rear. Other terminals will be used for d.c. buses and will be supplied from connector J3 on the front.

The terminal board nomenclature of TBA1, A2 "A10"; TBB1 "B10", D1 "D10" is used in lieu of TB1, 2, 3 . . . 40. It has been common practice to wire each connector pin to a terminal and to keep the terminal nomenclature consistent with that of its connector pin; four mechanically interchangeable terminal boards are used in the distributor for this purpose. Had connectors numbered 1 through 40 been used, then four separate boards which only differ in silk screen markings (i.e., 1-10, 11-20, 21-30, and 31-40) would have to be produced and stocked. By engraving the position of the four terminal boards TBA, TBB, TBC, and TBD, each board only needs to be marked 1-10, thus reducing stocking and manufacturing expense.

4-62. <u>Test Set</u>. The firing system portion of the test set will have four switches. One switch will be used for a lift-off simulator. The other three switches will be used to either arm or disarm the carrier release switch, withdrawal, and retraction circuits, respectively.

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The firing test set will have three modes of operation:

a. Operation of the kickoff cylinders only. This can be done by disarming the carrier release switch, withdrawal, and retraction switches. Then close the lift-off simulator to the firing position.

b. Operation of the withdrawal mechanism. This can be done by arming the carrier release switch and withdrawal switch, and disarming the retraction switch. Then close the lift-off simulator switch.

c. Operation of the retraction mechanism. This can be done by arming the carrier release switch, withdrawal and retraction switches. Then close the lift-off simulator switch.

For safety purposes the operator checking the firing circuit operations must unplug the firing cable feeding the firing junction box from the other LUT firing circuits and then plug the cable from the firing test set into the firing junction box.

Also included in this test set will be the capability of controlling all valves and verifying all component feedback indications, thereby providing complete individual arm checkout capability while isolated from all other systems. This test set is identical for all arms and has switches and lights to command and monitor all functions. When used on an arm not containing certain functions, the switches and lights not used may be noted on checkout procedures and panel overlays.

This test set will be used to check out a single arm at the manufacturer, at MSFC Huntsville Service Arms Test Site, at the completion of installation of an arm on the LUT, at any time a single arm is to be checked out, or for troubleshooting components of an arm.

The test set will have a separate d.c. power connector to enable operation from portable or fixed power sources.

A parallel connector will be provided to allow recording, if required, while testing, or to allow monitoring of checkout in the LUT.

The test set is the suitcase weatherproof type similar to the LO-DE test sets supplied for the Saturn Cl.

All arm test sets are identical and interchangeable. There is only one test set checkout procedure and only one spare test set per LUT. Six test sets will provide one for every other arm plus the one spare per LUT. 4-63. <u>Portable Arm Control Box</u>. The portable arm control box is used to extend or retract each service arm individually. The operator can take a position near the arm with the control box and visually check the arm as it extends or retracts.

There will be six indicator lights and a single-pole double-throw, center off, spring return switch on the top panel. Internally there will be a terminal board and a relay. A 60-pin connector will terminate the control cable from the control box to control console No. 1. Schematics showing the controls for the extension and retraction are shown in Figures C-20 through C-22

4-64. <u>Umbilical Crossover Distributor</u>. The umbilical crossover distributor will be approximately 6 by 3 by 6 feet and will be used only on the service arms that have umbilical cables.

Approximately 70 electrical cables will be required from the vehicle to crossover distributors and approximately 100 cables from the crossover distributors to facility umbilical (U.B.) terminal distributors. The majority of these cables will be 60 conductor No. 16 with overall shields and with certain individual shield requirements. Choices of standard cable configurations will be made when requirements are available from the stage contractors.

The arm cables will be delivered, installed on the arms and tested at MSFC Huntsville. The crossover to U.B. distributor cables will be delivered with the arms so that they can be installed on the LUT as a complete package

4-65. <u>Control Console No. 1.</u> Control Console No. 1 will have most of the hydraulic and pneumatic components, and will be located on each service arm control level. The control distributor, portable arm control box and test set will be either mounted in or attached to the console. There will be approximately seventy-five, two to six conductor component cables from the pressure switches, valves, etc., to the control distributor, portable arm control junction box, and test set which will be installed with clamps, etc.

4-66. <u>Control Console No. 2.</u> Control Console No. 2 will have the hydraulic-pneumatic cylinder controls. This console will only be used on the in-flight arms. This console will have a junction box for portable arm control. There will be approximately fifteen, two to six conductor component cables from the pressure switches, valves, etc., to the junction box which will be installed with clamps, etc.

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4-67. Lighting and Power Distributor. The lighting and power distributor will be approximately 8 by 8 by 8 inches, and will supply three-wire 120/208 volts, 60-cycle power for lighting and receptacles for each service arm. The facilities installation will be phased to provide a balanced load to all service arms, and it will be on a switched circuit similar to that for the tower lighting.

4-68. <u>Service Arm Patch Racks</u>. These racks are used to distribute the control command and feedback signals of each service arm to remote locations such as the Launch Control Center (LCC).

There will be patchboard terminations for all incoming and outgoing lines. In addition, relay and diode modules have patchboard terminations for each relay and diode terminal. These modules are plugged into connectors identical to those which accept the cables on the back of the patchboard assembly. The racks will be 24 inches wide by 86.25 inches high and radio frequency interference shielded. There will be a requirement for seven racks (Figures C-25 and C-26).

Pre-programmed patchboards can be readily installed or existing board re-programmed for several different operations. This will offer versatility with a minimum of wiring changes.

4-69. <u>Service Arm Monitor and Recorder Panel Racks</u>. The service arm monitor and recorder panels will be used to monitor and record operations for each service arm. The panels will monitor the systems at the vertical assembly building, during transit, and during prelaunch and launch operations.

There will be two monitor panels per service arm, each being 24 inches wide and 8.75 inches high. Panels for each service arm are laid out by location of equipment, pneumatic charging, hydraulic charging, and firing systems. The pneumatic charging circuits for each service arm are summed up with relay contacts to a green pneumatic charging "OK" light. The pneumatic charging "OK" light will remain energized until the pressure drops in one of the pneumatic air bottles at which time the respective pressure switch closes and energizes a charging valve. The "OK" light will be de-energized. This will tell the operator the location of the system being charged. This same procedure is performed for the hydraulic charging systems. The firing feedback circuits are summed up with relays to a green firing system "OK" light. This light will remain energized as long as the firing valves are in the proper position. Another light is provided to indicate the firing systems are ready for launch. This light will be energized when the charging systems are blocked, the extension platform locked, and the arm extended-lock unlocked. As the firing valves shift after being energized, relays will be energized and will energize their respective light and recorders circuits.

There probably will be three 100-channel, R. F. I. shielded event recorders used to record charging events and firing events.

The monitor panels will require four 24-inch wide by 86.25inch high R. F. I. shielded racks. The layout of the monitor panels and racks are shown in Figures C-25, C-27, and C-28.

4-70. VEHICLE SERVICE LINES

Service lines described in this section are the cryogenic, air conditioning, pneumatic, and electrical lines servicing the S-IC, S-II, S-IVB, IU, and the SM stages of the Saturn V Vehicle. Electrical lines are described in paragraph 4-52. The lines run from an interface at each tower level, along the service arm, to another interface at the vehicle, either in a combined housing or a single coupling. All lines other than electrical, which are continuous between the vehicle and the tower junction box, consist of a section of flex line at each end of the arm with a section of hard line between. All pneumatic flex lines are extruded teflon tubes wrapped with a stainless steel wire braid. All cryogenic flex lines are corrugated stainless steel wrapped with a stainless steel wire braid. Air conditioning flex lines are silicone and fiberglas supported by a wire helix with the 4-inch, 6-inch, and 10-inch sizes being insulated. The hard line for the air conditioning is an aluminum spiral duct with an external insulation. Propellant fill and drain lines will be vacuum jacketed with a vacuum probe, valve, and burst disk supplied with each assembly. In addition, expansion joints are used to accommodate movement of the propellant lines. The S-IVB AFT propellant fill lines are discussed in paragraph 4-14. A detailed tabulation on function, media, pressure, temperature, flex hose weight, size, etc., and hard line data along with each umbilical carrier location is included in Appendix A.

4-71. S-IC INTERTANK

This arm will carry the S-IC LOX fill and drain lines. The size and number of the lines leading from the remote reconnect mechanism has not been determined. Two 8-inch ID lines carry the propellants from the tower interface onto the arm.

4-72. S-IC FWD

All of the S-IC FWD service lines are terminated in a common umbilical carrier (Figure 4-46) at the vehicle. The lines include two 4-inch air conditioning lines, eight electrical lines, and four pneumatic lines (Figure A-3, Appendix A). Each line consists of a flex section at the arm tip, a section of hard line along the arm, and another section of flex line at the hinge point. The umbilical carrier and the lines are handled by a lanyard withdrawal mechanism (Figures 4-21 and 4-22).

4-73. S-II AFT

A one-inch LOX bleed line will be located on the S-II AFT arm (Figure A-5). Corrugated stainless steel flex lines will be used at the arm tip and hinge point with a section of tubing between. A lanyard attached to a collar on the coupling and actuated by a pneumatic cylinder is used to withdraw the line, (Figure 4-23).

4-74. S-II INTERMEDIATE

The three main groupings of service lines on this arm are as follows.

4-75. LOX Fill and Drain Line. An 8-inch ID, 10-inch OD, vacuum jacketed line interfaces with a lift-off type ball and cone propellant coupling (Figure 4-47) and is retracted by a lanyard withdrawal mechanism. Two hinged joints and a pressure compensated expansion joint is used in conjunction with a corrugated flex hose to aid in retraction.

Another flex hose (Figures 4-48 and 4-49) is used at the hinge point in a traveling loop supported below the arm. Six pneumatic lines will furnish GN₂ and He₂ to purge the line and coupling and to actuate the shut-off valve located between the coupling and flex hose.

4-76. LH₂ Fill and Drain Line. An 8-inch ID, 10-inch OD, vacuum jacketed line (Figures A-7, A-8, and A-9, Appendix A) will interface with a coupling similar to the one used for the LOX line. Six small pneumatic lines will be routed out to the interface between the coupling and the flex hose. The LH₂ line is handled by a lanyard-type withdrawal mechanism as shown in Figure 4-24.

4-77. <u>Umbilical Carrier</u>. All electric lines, air conditioning and purge lines, small cryogenic lines, and pneumatic lines interface in a common carrier (Figure 4-50). The carrier and lines are handled by a cylindertype withdrawal mechanism. The cryogenic and pneumatic lines vary from 3/8 inch to 2 inches in diameter and conditioning ducts vary from 4 inches to 14 inches in diameter.

4-78. S-II FWD

All the lines on this arm interface at the vehicle in a common umbilical carrier. These lines (Figure A-10, Appendix A) include two 8-inch hydrogen vent lines, a one-inch cryogenic line, six pneumatic lines, eight electrical lines, and one 4-inch air conditioning line. These lines are handled by a cylinder withdrawal mechanism.

4-79. S-IVB AFT

All the service lines on this arm interface in a common umbilical carrier (Figure 4-51) handled by a cylinder withdrawal mechanism.

The vacuum jacketed propellant fill and drain lines, a 6-inch ID, 8-inch OD LOX line and a 6-inch ID, 8-inch OD LH₂ line are located symmetrically on either side of the arm (Figure 4-52). Hinged expansion joints are used in conjunction with flex hose at the tip of the arm, and flex hose is used at the hinge point. Another mechanism is used to eliminate pockets in the LOX and LH₂ lines and aid in withdrawal of the propellant lines, 10-inch air conditioning line, six electrical lines, and eleven pneumatic and small cryogenic lines. The line handling mechanism is shown in Figure 4-15. The layout of these lines around the hinge point is shown in Figure 4-19.

4-80. S-IVB FWD AND INSTRUMENT UNIT

The lines on this arm service both the S-IVB FWD and the Instrument Unit (IU). All of the lines interface with two umbilical carriers supported in a common frame (Figure 4-53). Each line is defined in Figure A-14, Appendix A. A cylinder withdrawal mechanism is used to handle the common frame and lines (Figure 4-26).

a. <u>S-IVB</u>. The S-IVB portion consists of a 6-inch hydrogen vent line and eight electrical lines.

b. IU. The IU portion consists of a 6-inch air conditioning line, sixteen electrical lines, a pneumatic line, and two lines for water/ methanol conditioning.

4-81. SERVICE MODULE

The requirements of this arm have not been definitely established at this time. However, all lines will interface in a common umbilical carrier (Figure 4-54). This carrier will be retracted with a lanyard withdrawal mechanism (Figure 4-27) and the tentative lines are shown in Figure A-16 and A-17, Appendix A. The lines include a 6-inch air conditioning line, three electrical lines, five pneumatic and small cryogenic lines, and two coolant lines.

4-82. COMMAND MODULE

At present, a 6-inch air conditioning line will supply the environmental cab at the tip of the access arm.

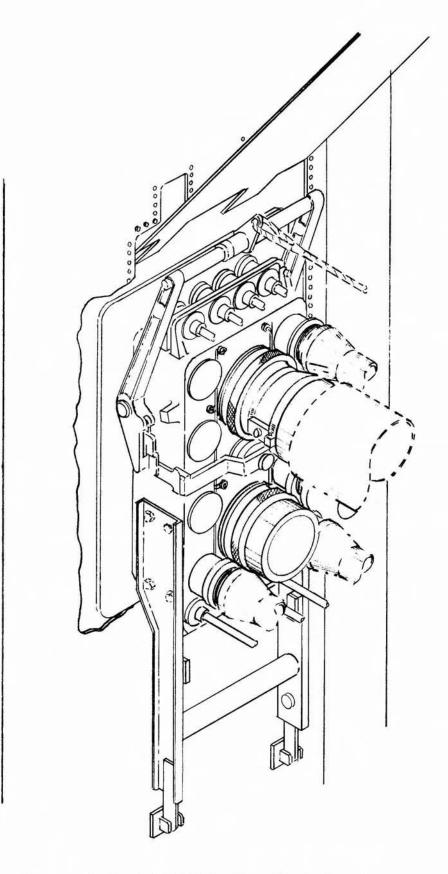
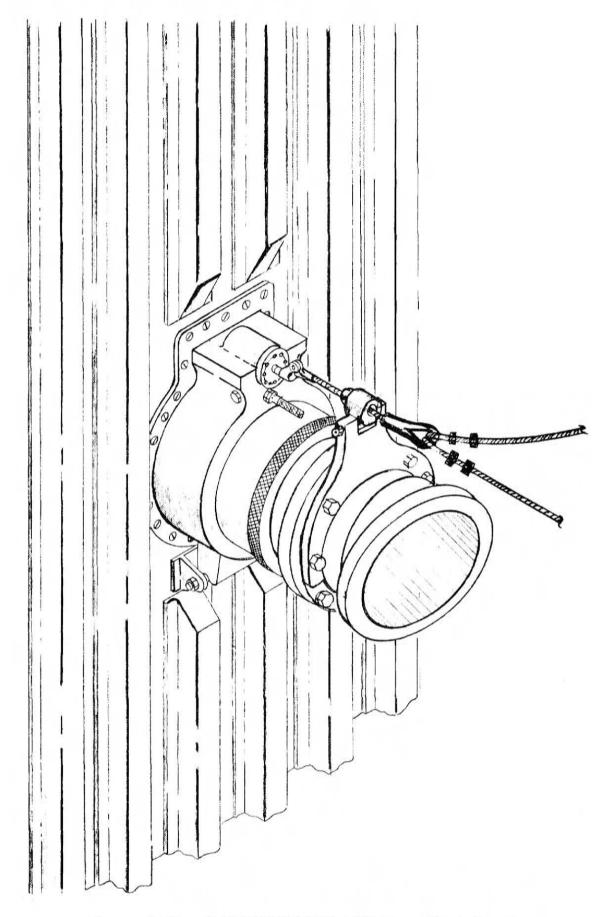
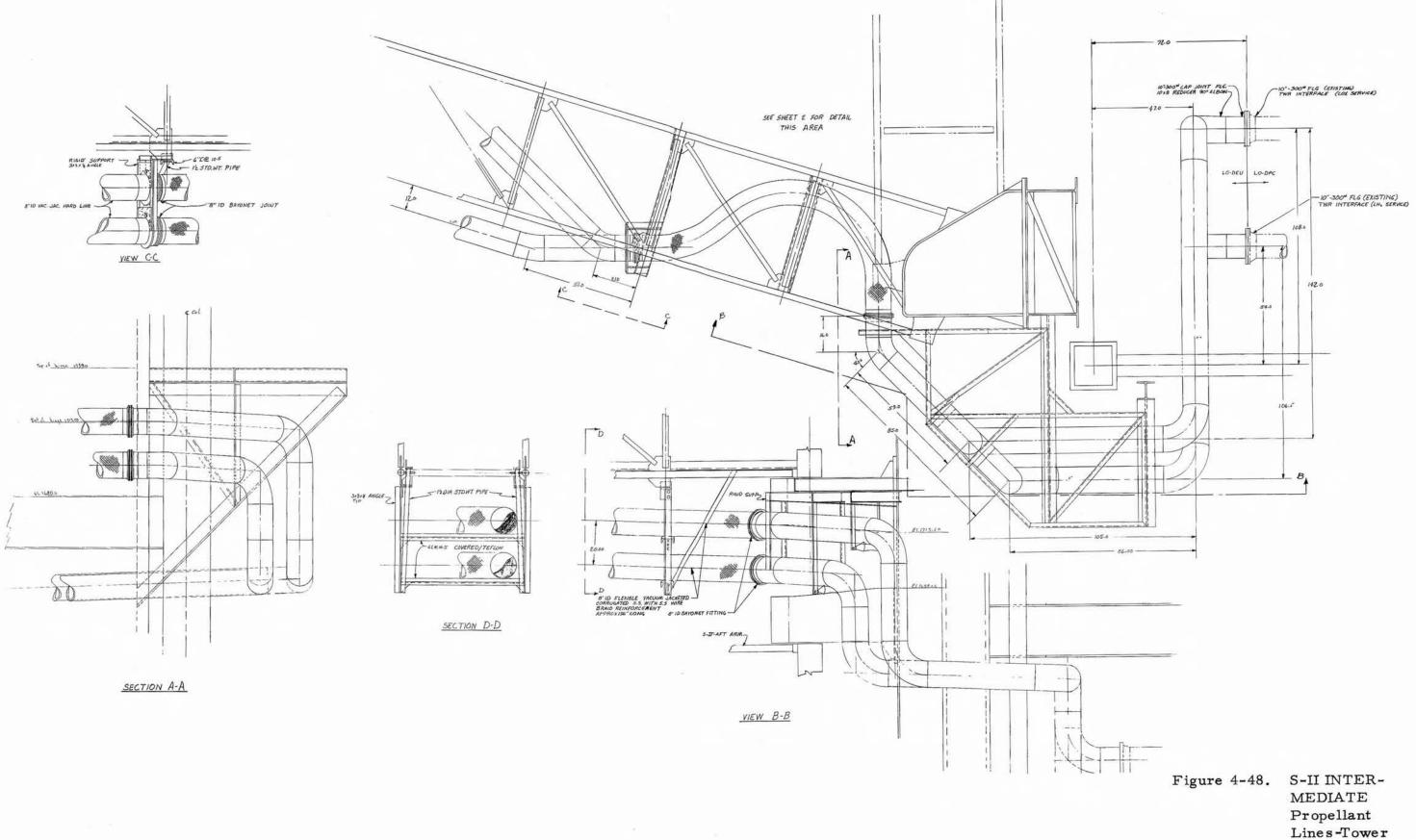


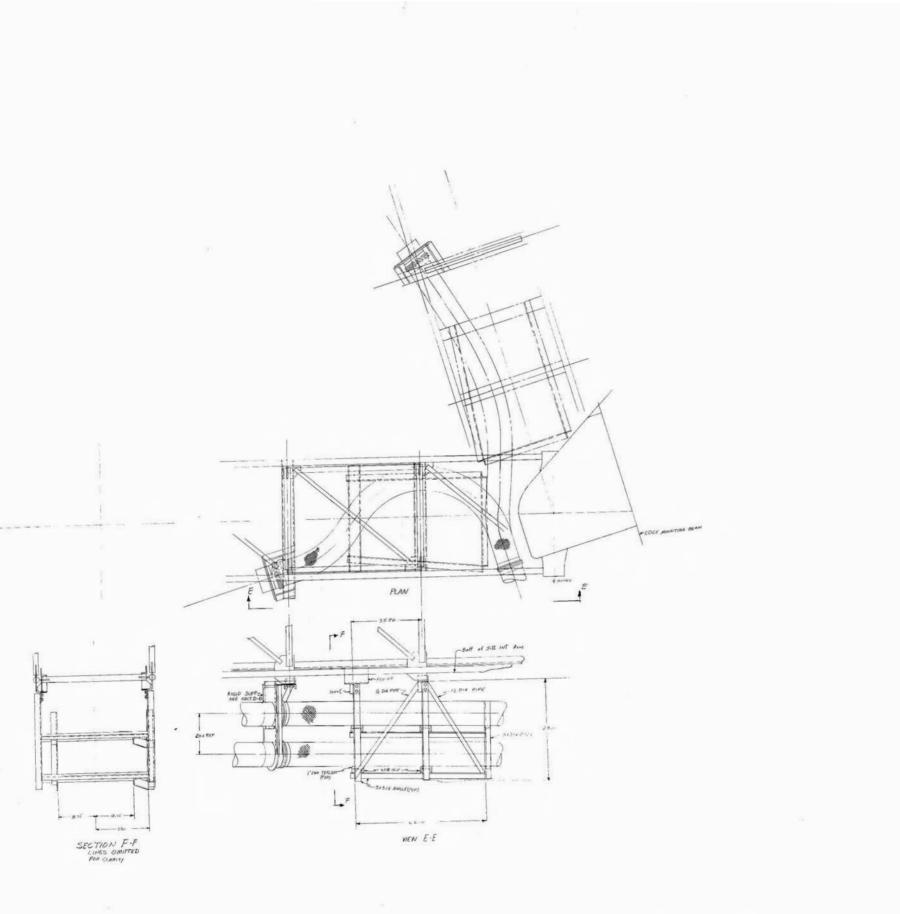
Figure 4-46. S-IC FWD Umbilical Carrier







Interface



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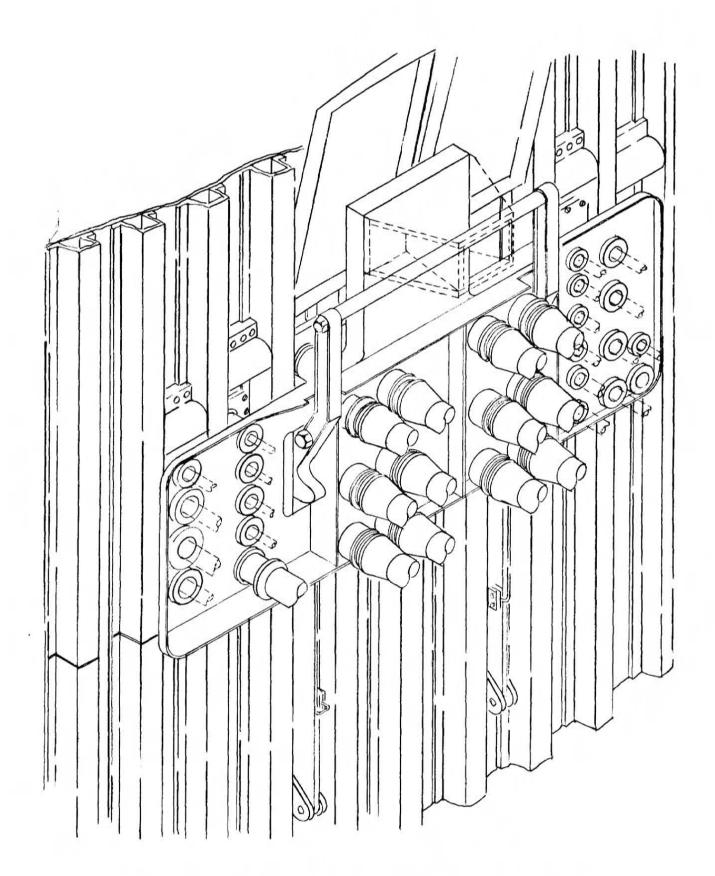


Figure 4-50. S-II INTERMEDIATE Umbilical Carrier

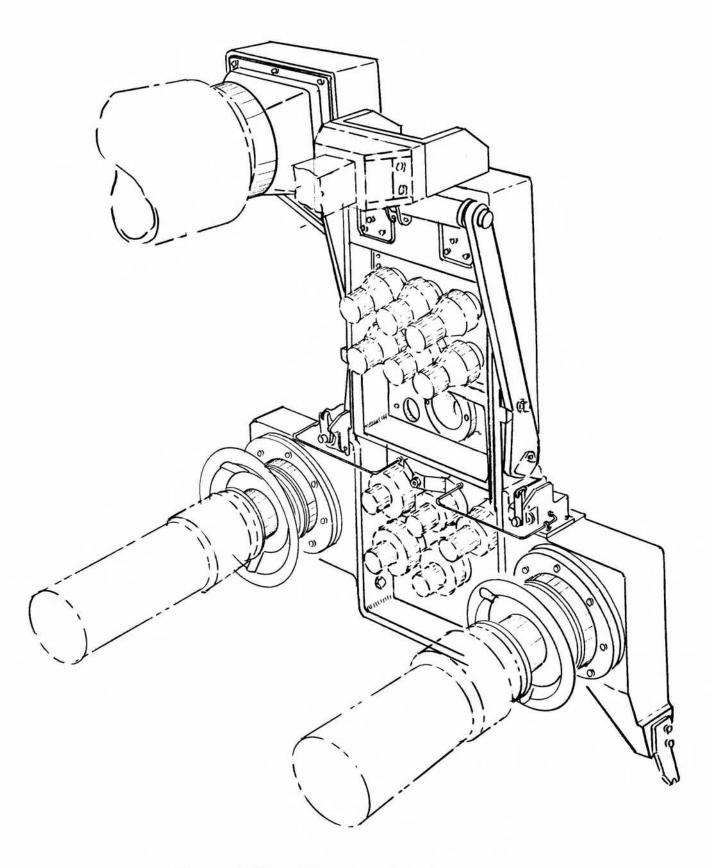


Figure 4-51. S-IVB AFT Umbilical Carrier

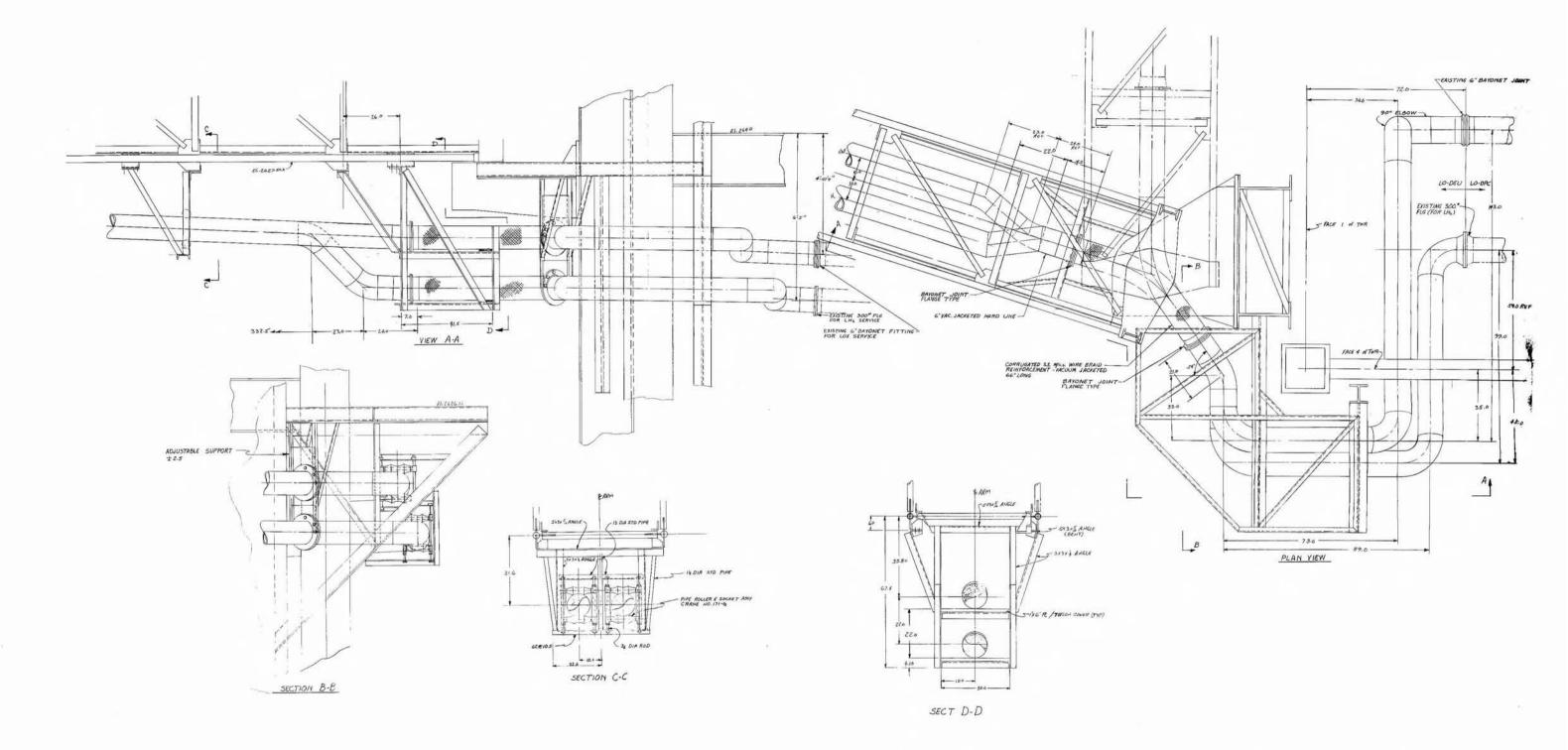
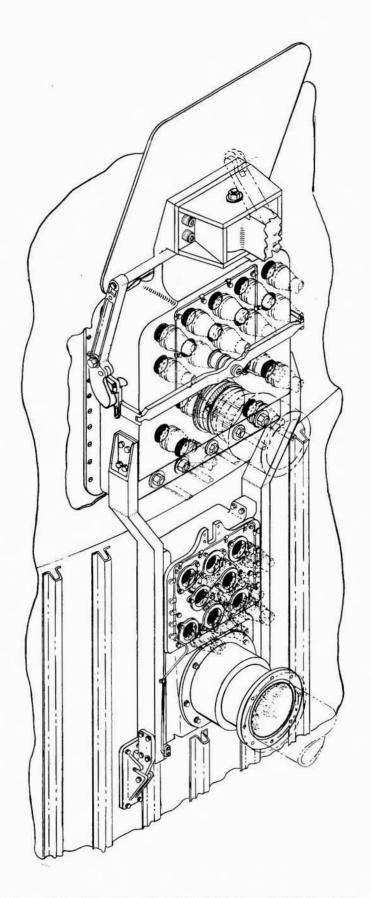
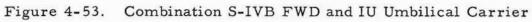
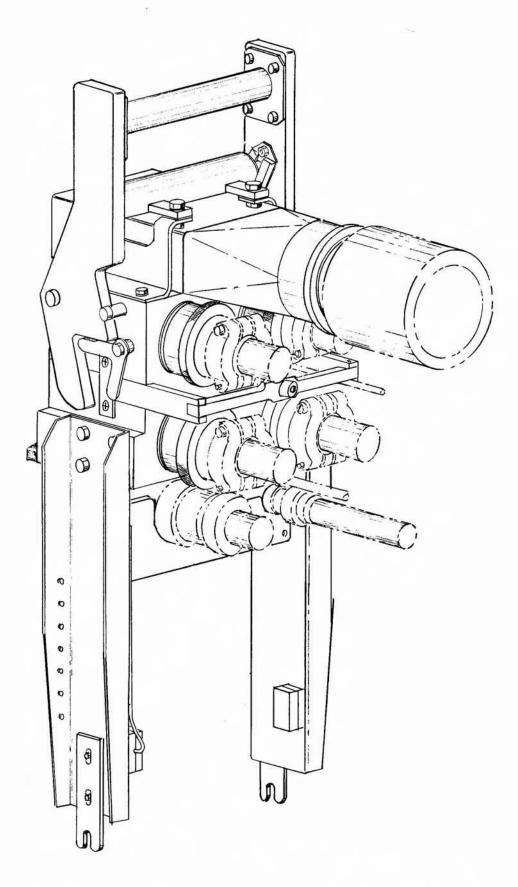
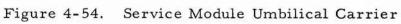


Figure 4-52. S-IVB AFT Propellant Lines - Tower Interface 181 This page intentionally left blank.









4-83. SYSTEM OPERATIONAL DESCRIPTION

Semi-automatic and automatic operating sequences for the withdrawal mechanism, in-flight and preflight service arm retraction systems, and extension platform are presented in the following paragraphs. Semiautomatic operations are those which are initiated by the manual positioning of switches, valves, etc., by personnel on the tower levels. Automatic operations are those which are initiated remotely by the lift-off motion of the vehicle or by the output signal from a countdown programmer.

Each component which appears on the applicable schematic is identified by the number mentioned in the chronological sequence of operations. Additional physical descriptions of cylinders, locking devices, switches, and other mechanisms have been excluded from this section since these are contained in other sections of the report.

4-84. CHARGING OPERATION

Each service arm is provided with the following supply lines:

Hydraulic fluid at 3000 psi; Nitrogen gas at 3000 psi; Nitrogen gas at 750 psi; Compressed gas at 125 psi.

These lines are used to initially charge and to replenish the hydraulic accumulators and gas bottles located in the control cabinets. Pressurized gas bottles, hydraulic accumulators, and their combinations are separated from each other either for redundancy or for accomplishing specific functions.

A typical charging cycle is explained for gas bottles A5374, A5375, and A5376 (Figure 4-55). As the LUT panel charging system switch is turned on, solenoid valve A5371 is energized through action of pressure switch A5369. When the pressure in the gas bottles drops to the low setting of pressure switch A5369, the switch completes a circuit and energizes solenoid valve A5371. The valve shifts to its open position, and gas flows through pressure regulator A5372, which controls the outlet pressure and thus the rate of gas flow into the bottles. Pressure in the bottles rises to the high setting of pressure switch A5369 when the bottles are charged. The circuit then opens and as solenoid valve A5371 is de-energized, the spring shifts the valve to its closed position. A separate standby hydraulic accumulator A5316, charged to 75 psi through its charging components A5302, A5303, and A5320 prevents entry of air into the hydraulic lines.

4-85. WITHDRAWAL MECHANISM

Withdrawal mechanisms may be classified as either lanyard or dual cylinder type. Figure 4-56 shows the schematic for the S-IVB AFT withdrawal mechanism which is a typical dual cylinder type. The schematic for the S-IVB FWD Service Arm (Figure 4-57) is similar to the S-IVB AFT. Valve pressure settings are different, however, and the propellant line cylinder and associated components are not provided.

4-86. Manual Extension. At the start of this operation, the hydraulic and pneumatic cylinders of the withdrawal mechanism are mechanically ratcheted in the retracted position; all the solenoid valves are reset to their pre-launch position; and the hydraulic accumulators and gas bottles are charged. To accomplish manual extension, two operators are required; operator A at control cabinet No. 1, and operator B on the tip of the service arm. Operator A increases pressure on the rod end of the hydraulic cylinder by clockwise adjustment of loader A5406. The resulting pressure change causes an unbalance in the dome of the main pressure regulator A5408 and permits hydraulic fluid to flow into the rod end of the hydraulic cylinder. When pressure gage A5411 indicates approximately 675 psi, operator A stops adjustment of loader A 5406. Operator B then removes the pawl from the ratchet mounted at the trunnion of the pneumatic cylinder. Should the pawl be tight, a higher pressure will be required to permit its release. Once the pawl is removed, operator A adjusts loader A5406 counterclockwise to slowly reduce the pressure. As this pressure is reduced, the net moment about the pneumatic cylinder trunnion causes an unbalanced condition which causes extension of the hydraulic cylinder and allows the pneumatic cylinder to rotate toward a horizontal position. Operator B must judge how much rotation is required in one step and signals operator A accordingly. Operator A adjusts loader A5406 to increase the counterbalancing pressure and stop the motion. Operator A then slowly adjusts the setting of pressure regulator A5477. The pressure increases in the blind end of the pneumatic cylinder and causes cylinder extension. Any extension of the pneumatic cylinder will cause further rotation toward the horizontal position; therefore, operator A must gradually increase the pressure in the hydraulic cylinder to counteract the increasing turning moment. Until operator A becomes familiar with the pressure variations required to extend the umbilical carrier smoothly,

The incremental method outlined above should be followed. After the umbilical carrier is extended about half way, operator A positions valve A5499 to extend the pneumatic cylinder of the cam mechanism. When this action is completed and the springs in the cam mechanism have gone over center, operator A allows valve A5499 to return to its normal position and thus vents the rod end of the cylinder.

Extension is continued until the umbilical carrier is a few inches from the vehicle. The umbilical carrier is manually positioned to contact the vehicle; the ball locks are engaged; and extension is completed.(Coupling of service line connectors is excluded from this report.) Operator A will then adjust all valves and regulators to the original settings.

Should the manipulation of the hydraulic cylinder as described above prove difficult, an alternate method as outlined below may be used.

Operator A adjusts regulator A5406 to increase the pressure to 1600 psi in the rod end of the hydraulic cylinder. After gage A5411 confirms the pressure increase, operator A closes valves A5407 and A5446 and opens valve A5427. Now the hydraulic cylinder can be advanced, blocked, or retracted by positioning spring-centered manual valve A5428. Setting valve A5428 to either position No. 2 or position No. 1 causes the cylinder to advance or retract respectively. The speed of cylinder movement is controlled by valve A5426. Operation of the pneumatic cylinder is accomplished in the manner previously described. After locking the umbilical carrier to the vehicle, operator A closes valve A5427, checks for centering of valve A5428, opens valves A5407 and A5446, and adjusts valve A5406 to its original pressure setting.

4-87. <u>Manual Retraction</u>. Operation of the withdrawal mechanism cylinders may be checked as follows: The pin is removed from the clevis on the rod end of the pneumatic cylinder, and operator A adjusts regulators A5491 and A5406 clockwise. Increased pressures on the rod ends of the hydraulic and pneumatic cylinders cause their retraction. The rate of retraction depends on the degree of regulator adjustment.

4-88. Vehicle Tracking. The system for vehicle tracking requires an adjustment of pressure settings of regulators A5406, A5441, A5477 and A5491 to induce minimum vehicle skin loading.

4-89. <u>Vehicle Motion Away From the Service Arm.</u> Vehicle motion away from the arm causes movement of the withdrawal mechanism cylinders. For the purpose of this description, let us limit the motion to that directed along the longitudinal axis of the arm.

When the vehicle moves away from the service arm, the withdrawal mechanism pneumatic cylinder extends, and pressure increases on the rod end and decreases on the blind end. As soon as the pressure on the rod end increases 5 psi above the original setting of 150 psi, check valve A5495 closes and regulator A5497 opens to maintain constant rod end pressure. Shuttle valve A5509 remains in the position shown on the schematic. At the same time, the blind end pressure is maintained at 175 psi by pressure regulator A5477. The withdrawal mechanism hydraulic cylinder operates on the same regulating principle. The rod end discharges displaced fluid through a 5 psi differential unloader A5450 into the blind end of the cylinder. The difference in volume between rod and blind ends is provided by accumulator A5449.

The propellant line pneumatic cylinder also extends and displaces gas from its rod end through a 5 psi differential unloader A5445 into the line containing check valve A5442. Thus, the blind end of the propellant line pneumatic cylinder is maintained at a pressure slightly above atmospheric pressure by the discharged gas from unloaders A5445 and A5497. A portion of this gas is relieved through check valve A5442.

4-90. <u>Vehicle Motion Toward the Service Arm.</u> When the vehicle moves toward the service arm, the operation is reversed. The blind end of the withdrawal mechanism pneumatic cylinder now discharges through a 5 psi differential unloader A5460, while the rod end pressure is maintained by action of pressure regulator A5491.

The withdrawal mechanism hydraulic cylinder also retracts as the vehicle moves toward the service arm. The discharge from the blind end of the hydraulic cylinder first charges the accumulator A5449 to 75 psi and then discharges any further fluid through system back pressure valves A5354 and A5355 contained in hydraulic return line 4. Rod end pressure is maintained by fluid supplied through pressure regulator A5408.

As the vehicle moves toward the service arm, the propellant line pneumatic cylinder also retracts. Rod end pressure is maintained by pressure regulator A5441 and blind end pressure is relieved through check valve A5442. 4-91. Disconnect and Withdrawal. When the vehicle rises 3/4 inch, primary lift-off switches No. 1 and No. 2 complete electrical circuits; switch No. 1 energizes solenoid No. 1 and de-energizes solenoid No. 2 of inlet valve A5520 while switch No. 2 energizes the solenoid of inlet valve A5524. Both valves shift and provide paths for the pressurized gas stored in the two separate gas bottles A5522 and A5519. Gas from bottle A5522, which is charged to 900 psi, shuttles valves A5506 and A5525 and blocks the flow from bottle A5519 which is charged to 750 psi maximum. This pressure sequencing gives priority to the higher pressure supply and maintains the redundant second pressure source on standby. Since solenoid valves A5524 and A5520 are actuated from independent buses, the redundant system protects against failure of either of the two lift-off switches or electrical power supplies, valves, or stored energy sources. Shuttle valves A5506 and A5525 will permit operation from whichever pressure source is at the higher level.

NOTE

The system described above necessitates a continuous electrical signal applied to one of the solenoids of valve A5520. A similar situation exists in other circuits in the control system. This condition is recognized to be undesirable. Therefore, mechanical latching type valves are under development for these applications.

Pressure build-up will occur sooner in the ball-lock and kick-off pneumatic cylinders than in the cam mechanism pneumatic cylinder, due to the difference in flow settings of valves A5526 and A5507. A slight delay will therefore occur between actuation of the ball lock and kick-off cylinders and the redundant cam mechanism pneumatic cylinder.

The umbilical carrier is ejected away from the vehicle by action of either the kick-off or cam mechanism pneumatic cylinders. Release switches No. 1 (A101) and No. 2 (A102) which are mounted in the umbilical carrier then close. These switches operate independently and complete two redundant circuits to initiate action of both the withdrawal mechanism and the arm retraction system. Operation of the withdrawal mechanism is initiated by the closure of switches No. 1 (A101) and No. 2 (A102). Switch No. 1 energizes solenoid No. 2 and de-energizes solenoid No. 1 of inlet valve A5500. It simultaneously energizes solenoid No. 2 and de-energizes solenoid No. 1 of outlet valve A5462. Switch No. 2 actuates the solenoid of inlet valve A5508 and simultaneously energizes solenoid No. 2 and de-energizes solenoid No. 1 of outlet valve A5463.

Actuation of inlet values A5508 and A5500 provide flow paths for gas stored in gas bottles A5437 and A5438 (precharged to 650 psi maximum) and A5503 (precharged to 1350 psi minimum). The resulting pressure difference shifts shuttle value A5509, which blocks the lower pressure source and permits the gas at the higher pressure to flow into the rod end of the withdrawal mechanism pneumatic cylinder. Thus, bottles A5437 and A5438 become the redundant source. Value A5463 permits flow out of the blind end of the cylinder. Value A5462 also shifts open but does not permit any flow unless value A5463 fails to shift.

During the last seven inches of stroke, the withdrawal mechanism pneumatic cylinder and its moving masses are decelerated by the hydraulic shock absorber which is housed inside the cylinder. The shock absorber hydraulic fluid is forced through the orifice of valve A5465 into accumulator A5466 which is gas precharged to 180 psi.

As the withdrawal mechansim pneumatic cylinder retracts, the withdrawal mechanism hydraulic cylinder swings the pneumatic cylinder upwards. The hydraulic cylinder operation is as follows:

Umbilical carrier release switches No. 1 (A101) and No. 2 (A102) actuate inlet valves A5451 and A5413 respectively of the withdrawal mechanism hydraulic circuit from independent electrical buses.

When valve A5451 shifts, it isolates unloader A5450 from the system and permits hydraulic fluid at 1600 psi minimum to flow from accumulator A5404 into the rod end of the withdrawal mechanism hydraulic cylinder. Hydraulic fluid displaced from the blind end of the cylinder flows to the hydraulic return. Valve A5413 shifts and duplicates the function of valve A5451. At the end of the stroke the hydraulic cylinder is retarded by buffering provided in the cylinder blind end.

During retraction of the umbilical carrier, the propellant lines are pulled back by action of the propellant line retract cylinder. The pressure in the rod end of this cylinder is maintained at 100 psi during motion by regulator A5441.

4-92. IN-FLIGHT SERVICE ARMS

Figure 4-55 shows a schematic which is common to all in-flight service arms. The pressure settings indicated on the schematic are preliminary values calculated for the S-IVB AFT Service Arm. The switches referred to in this description are located in Figures C-20 through C-23.

4-93. Semi-Automatic Operation

Arm Extension. At the start of this operation the service arm is 4-94. in the fully retracted position and is latched to the tower. The cable from J1 of junction box A5 in control cabinet No. 1 is disconnected from J2 of the control distributor by the operator who plugs the portable arm control box into control cabinet No. 1 and then assumes a convenient position near the edge of the tower deck for direct observation of the service arm. The momentary switch S1 on the control box is placed in the EXTEND position and held. Immediately, a circuit is completed through limit switches All0 and All1 to an indicator light on the box which confirms the unlocked positions of the arm extended locks. Simultaneously, a circuit is completed to energize solenoid valve A5358. This valve shifts to the cross-over position and gas from the 750 psi supply line enters the rod side of the latchback release cylinder. The cylinder activates the latch-back mechanism so that the arm is free to swing away from the tower. Limit switch Al04 closes and completes a circuit to a second indicator light on the control box confirming release of the latch-back mechanism. The closure of switch A104 also completes circuits to energize solenoid No. 2 of valve A5309 and the solenoid of valve A5379. As these valves shift, hydraulic pressure is applied to the blind ends of the hinge mounted cylinders from secondary supply A5338; flow is directed away from the rod ends of these cylinders to the hydraulic return line; and the blind end of the tower mounted cylinder is vented. The application of torque by the hinge mounted cylinders rotates the service arm away from the tower. As the arm extends, the cable is reeled out through the block and tackle system thus retracting the tower mounted cylinder. Hydraulic fluid enters the rod end of this cylinder from accumulator A5316 through check valve A5329. Approximately 5 minutes is required to extend the arm. This time may be varied by adjustment of valve A5308. After approximately 73° of rotation, the arm hinge plates contact adjustable mechanical stops on the tower mounted hinges. Limit switch A109 then closes to energize solenoid No. 2 cf valve A5310. This valve shifts to admit pressure to the rod ends of the arm extended lock cylinders from accumulator A5338. These cylinders drive the locking dogs into engagement with floating inserts in the arm hinge plates. Limit switches All0 and All1 in the top and bottom hinges close to complete a circuit through a third indicator light on the control box and thus confirm

the engagement of both locks. The operator continues to hold the arm control switch in the EXTEND position until the 75 psi fluid entering the rod end of the tower mounted cylinder forces the piston to a fully retracted position which ensures proper cable tension. If this pressure is not sufficient to overcome the friction in the system, back pressure regulators A5354 and A5355, regulator A5303, and pressure switch A5320 located in control cabinet No. 1 should be adjusted to higher pressure settings. When the cylinder becomes fully retracted, limit switch A105 closes to complete a circuit to a fourth light on the control box. The arm control switch is released, the portable arm control box is unplugged, and the operation is completed.

The arm may be stopped at any intermediate position during the extension operation by releasing the momentary switch on the control box. If this switch is released, all electrical circuits are opened, and the solenoid valves are de-energized. Valve A5309 returns to the blocked position and the service arm is hydraulically locked. After the arm has stopped, the operator may reverse the original direction of rotation by placing the momentary switch in the RETRACT position.

4-95. Arm Retraction. At the start of this operation, the service arm is in the fully extended position and the arm extended locks are engaged. The operator plugs the portable arm control box into control cabinet No. 1 and takes a suitable position for direct observation of the service arm. The momentary switch is placed in the RETRACT position and held. A circuit is completed to energize solenoid No. 1 of valve A5310. This valve shifts and pressure from accumulator A5338 is applied to the blind ends of the arm extended lock cylinders. The locking dogs are disengaged and the limit switches in the hinges close to complete a circuit to an indicator light on the control box. Closure of these switches also causes solenoid No. 1 of valve A5309 and the solenoid of valve A5378 to be energized. As these valves shift, gas pressure from the primary supply bottles A5374, A5375 and A5376 is applied to the blind end of the tower mounted cylinder. This pressure is intensified by differential piston area and applied to the rod ends of the hinge mounted cylinders through valves A5361 and A5362. Fluid from the blind ends of the hinge mounted cylinders is directed through valve A5309 to the hydraulic return line. Since the intensified pressure keeps check valve A5321 closed, fluid from accumulator A5338 does not flow into the active circuit. The application of torque by the hinge mounted cylinders rotates the service arm towards the tower. The cable is reeled in by the motion of the tower mounted cylinder. Retraction continues until the arm comes into the tower and is automatically engaged by the latchback mechanism. Limit switch A103 closes when the arm has retracted sufficiently for engagement of the latch-back mechanism. This switch completes a circuit to an indicator light on the control box. The momentary

switch is released, all circuits are broken, the portable arm control box is unplugged, and the operation is completed. The same 5-minute operation time mentioned in paragraph 4-9 applies for arm retraction. This time is also subject to the adjustment of valve A5308.

As in the case of extension, the arm may be stopped at any intermediate position by release of the momentary switch. Subsequent continuation of retraction or a change to extension operation may be selected by positioning the momentary switch.

4-96. Automatic Retraction

4-97. Unlocking Operation. At T minus 15 seconds, a signal from the countdown programmer energizes solenoid No.1 of valve A5310. This valve shifts and hydraulic pressure from supply A5338 is applied to the blind ends of the arm extended lock cylinders. When the locking dogs become fully disengaged, a limit switch in each hinge closes to complete a circuit to an indicator light in the LCC confirming the operation. The arm is now hydraulically locked since both sides of the hinge mounted cylinders are blocked by valves A5327, A5348, and A5349.

4-98. Normal Retraction. The operational sequence prior to closure of the umbilical carrier release confirm switches is described in paragraph 4-91.

As the umbilical carrier is ejected from the vehicle, release confirm switch No. 2 closes to energize solenoid No. 2 of valve A5377 and to energize solenoid No.1 of valve A5349. At the same time, release confirm switch No.1 closes to energize solenoid No. 2 of valve A5326 which directs hydraulic pilot pressure to valves A5327 and A5348. Valve A5377 shifts to the straightthrough position and system primary pressure at 2100 psi from bottles A5374, A5375 and A5376 is applied to the blind end of the tower mounted cylinder. This pressure is intensified to 2700 psi by differential piston area and is applied through valves A5361 and A5362 to the rod ends of the hinge mounted cylinders. Valves A5348 and A5349 shift to their straight-through positions and allow fluid from the blind ends of the hinge mounted cylinders to flow through valves A5350, A5355, and A5354 to the hydraulic return line. The torque applied by the hinge mounted cylinders causes the service arm to retract while the cable is automatically reeled in by the motion of the tower mounted cylinder. Although valve A5327 is shifted to the straight-through position, fluid from accumulator A5338, charged to 2000 psi, is blocked by check valve A5324. As the arm retracts toward the tower, its dynamic characteristics are governed by flow control valve A5350 (see paragraph 4-51 for a detailed description of this valve).

For normal operation, the flow through the cam controlled pressure compensated orifice is independent of pressure fluctuations on the upstream and/or downstream side of the valve and, in effect, flow rate depends only on the cross-sectional area of the orifice. The integral sequence and pressure relief valves remain closed during normal operation. Operation of valve A5350 causes angular velocity of the arm to vary as a function of arm angular displacement closely approximating a half sine wave. These dynamic characteristics are dictated by the contour of a cam attached to the service arm pivot. The peak velocity occuring at the half angle of rotation is equivalent to a flow rate of approximately 120 gpm for the S-IVB AFT service arm. The corresponding retraction time, excluding delays due to response time for valves, switches, etc., is approximately 6 seconds. The service arm contacts the tower mounted shock absorber after rotation through a 70° angle and since the velocity of contact is small, an additional time delay included in the 6 seconds is required to collapse the shock absorbers. The latch-back mechanism engages the arm as it becomes fully retracted. A limit switch closes at the completion of the retraction cycle and energizes a relay in the base of the LUT for further distribution, recording, and indication at the LCC.

Relief valves A5328, A5330, A5352, and A5373 are provided for protection against excessive increase in the stored energy pressures which could result from engine exhaust gases impinging upon the tower levels and consoles.

4-99. Redundant Modes of Retraction. Several different intersystem modes of arm retraction are automatically initiated by possible subsystem or component failure. These specific failures have been divided into groups below. Each set of failures is followed by a description of the subsequent system operation.

a. Complete loss of primary supply pressure.

Possible reasons: Gas bottles A5374, A5375, and A5376 not charged; valve A5379 vented; valve A5377 and/or valve A5362 closed; loss of supply line to blind end of tower mounted cylinder; or malfunction of umbilical carrier release switch No. 2 (A102).

Closure of umbilical carrier release switch No. 1 (A101) insures that valves A5327 and A5348 have shifted to their straight-through positions. Since primary supply pressure is absent, flow immediately proceeds from accumulator A5338 through check valve A5324 into the rod ends of the hinge mounted cylinders. This flow is produced by a secondary supply pressure of 2000 psi from gas bottles A5336, A5337, and A5339. The remainder of the operational sequence is identical to that described for normal retraction except that the tower mounted cylinder does not extend, and thus the cable is not reeled in at the normal rate.

b. Gradual or intermittent loss of primary supply pressure.

Possible reasons: Leakage in the supply line, leakage or sticking of valves A5379 and A5377.

A decrease in primary supply pressure will be accompanied by a corresponding decrease in the intensified hydraulic pressure supplied by the tower mounted cylinder to the hinge mounted cylinders. If the initial intensified hydraulic pressure is between 2600 and 2000 psi, the retraction operation will be normal until gas expansion causes the hydraulic pressure to drop below 2000 psi. When this pressure falls below 2000 psi, the secondary supply takes over; fluid from accumulator A5338 feeds the hinge mounted cylinders through check valve A5324; and arm retraction is completed without any time delay. If leakage has been severe enough to diminish the initial intensified pressure below 2000 psi, the retraction operation will be identical to that described in subparagraph a above.

c. Complete loss of hydraulic fluid in the rod ends of the hinge mounted cylinders.

Possible reasons: Loss of inlet line (breakage).

Should the hydraulic inlet line break, all hydraulic fluid from secondary pressure supply accumulator A5338 and from the rod end of tower mounted cylinder will be discharged. Since the blind end of tower mounted cylinder is pressurized by gas, it will extend and force the cable to reel in, thus completing arm retraction.

d. Gradual loss of hydraulic fluid in the rod ends of the hinge mounted cylinders.

Possible reasons: Hydraulic fluid leakage from any line normally carrying intensified fluid pressure or internal leakage through valve A5309.

Should the fluid leak be slight, the tower mounted cylinder will move faster and increase cable tension. The intensified hydraulic pressure will gradually decrease, but the retraction will be continued without delay since the input power available for retraction is nearly constant. The torque caused by increased cable tension will be added to the hinge mounted cylinder torque. Once the intensified pressure decreases below that of the secondary pressure supply A5338, the latter will compensate for the leakage and complete the retraction.

4-100. Redundant Modes of Operation for Flow Control Valve A5350. Since the hydraulic return line plays a vital role in controlling the speed of arm retraction, the special cam operated valve A5350 incorporates several fail-safe features to protect the entire system from possible internal failure of any flow control valve component.

a. Failure of the compensator spring.

Possible reason: Overstressing of the spring.

Should the compensator spring break, the flow will rapidly decrease. As a result, upstream pressure will rise and at 3200 psi will operate the sequence valve to direct high pressure fluid behind the compensator spool and force it to its open position. The resulting flow will no longer be compensated for pressure variations but partial control is still maintained.

b. Restriction of valve main flow channels.

Possible reasons: Clogging of the variable orifice, or sticking of the compensator or sequence valve spools.

Should the variable orifice clog, the upstream pressure will rise rapidly and at 3650 psi, the differential type relief valve will be actuated. The flow will force a normally closed spool into an open position and will unload the flow of 120 gpm at a pressure drop of 160 psi. Pressure drop will be a function of flow rate. Flow and resulting arm motion will be uncontrolled.

4-101. PREFLIGHT SERVICE ARMS

The hydro-pneumatic system to operate the preflight service arms is a simplified version of the system used for in-flight arms. All the redundant features provided for the in-flight arms are not incorporated (Figure 4-58). Therefore, the system is limited to two hinge mounted cylinders (no cable arrangement), and the pressure supply and valving contained in control cabinet No. 1.

4-102. Semi-Automatic Operation

4-103. Arm Extension. At the start of this operation, the service arm is in the fully retracted position and latched to the tower. The operator – plugs the portable arm control box into control cabinet No. 1; holds momentary switch S1 in the EXTEND position, and system operation proceeds in exactly the same manner as for in-flight arm extension. Since the tower mounted cylinder, its control valves, and limit switch Al05 are not included in the preflight system, the operator releases the momentary switch when the limit switches confirm engagement of the arm extended locks.

4-104. Arm Retraction. At the start of this operation, the service arm is in a fully extended position and the arm extended locks are engaged. The operator plugs the portable arm control box into the appropriate jack of the control cabinet, places momentary switch Sl into the RETRACT position, holds it, and proceeds in exactly the same manner described for in-flight arm extension. Since the tower mounted cylinder, its control valves, and the primary pressure supply are not included, retraction is accomplished by the pressurized fluid supply in accumulator A5338.

Control value and electrical interlock operation was explained in the description of the in-flight service arm retraction sequence.

4-105. Automatic Retraction.

4-106. Unlocking Operation. At T minus 15 seconds, a signal from the countdown programmer energizes solenoid No. 1 of valve A5310 and sequences the unlocking operation in exactly the same manner as described for the in-flight arm.

4-107. Normal Retraction. At T minus 10 seconds, a signal from the countdown programmer initiates the sequence of ejecting the umbilical carrier and/or couplings and retraction of the arms. The resulting sequential operation of the hydraulic retraction system occurs in the same manner as for the in-flight service arms, except that all redundant units and their controls do not exist. The possibility of a countdown hold in the event of system malfunction provides a replacement for the redundant system complexities in the preflight systems. The countdown hold is accomplished automatically by failure of any preflight arm to retract fully and close the arm retracted switch at the tower.

4-108. EXTENSION PLATFORM

Flow control valves A6000, A6001, A6013, and A6014 (Figure 4-59) are provided for adjustment of motor speed. Pressure regulators A6012 and A6008 are provided to allow motor torque and friction wheel pressure adjustment.

4-109. Manual Extension, Vehicle Tracking, and Retraction. Operation of the extension platform requires two operators. To extend the basic extension platform, operator A moves the handle of valve A6007 to position No. 2, gas at 90 psi flows into the blind ends of both motor positioning cylinders. The rods extend and friction wheels mounted on the arm motor shafts are forced into contact with the arm mounted rails. Now both motors are ready to drive their respective platforms. Operator A manually positions the handle of valve A6010 to the unlock position. Pressure forces the piston of the lock cylinder upwards and disengages the lock. Operator A next places valve A6002 into position No. 2. Nitrogen gas at 40 psi flows into the air motor, the motor starts to rotate, and through its friction wheel extends the platform. After the platform moves approximately one inch, the handle of valve A6010 is released and the rod end of the lock cylinder is vented through check valve A6006. The spring-loaded lock returns into position ready for the next latching. When the basic platform is extended close to the required position, operator A releases the handle of valve A6002. The air motor is thereby pressurized on both sides to slow down and stop the platform. To position the "T" head, the mechanical lock is first released and then valve A6015 is manually turned into position No. 1 or No. 2 by operator A, depending upon whether the platform has to move left or right. When the handle is released, the "T" head stops. Operator B couples the "T" head to the vehicle and operator A places valve A6007 into position No. 1. The friction wheels are pulled away from the rail and the platform is free to track the vehicle.

To retract the platform, the operation is reversed. First operator B disconnects the coupler, then operator A moves the handles of valves A6007 and A6002 into position No. 1. The friction wheels are engaged and basic platform is retracted and automatically locked.

During platform retraction, operator A moves the handle of valve A6015 as required. The "T" head is locked manually in the centered position.

After retraction is complete, operator A shifts valve A6007 into position No. 1.

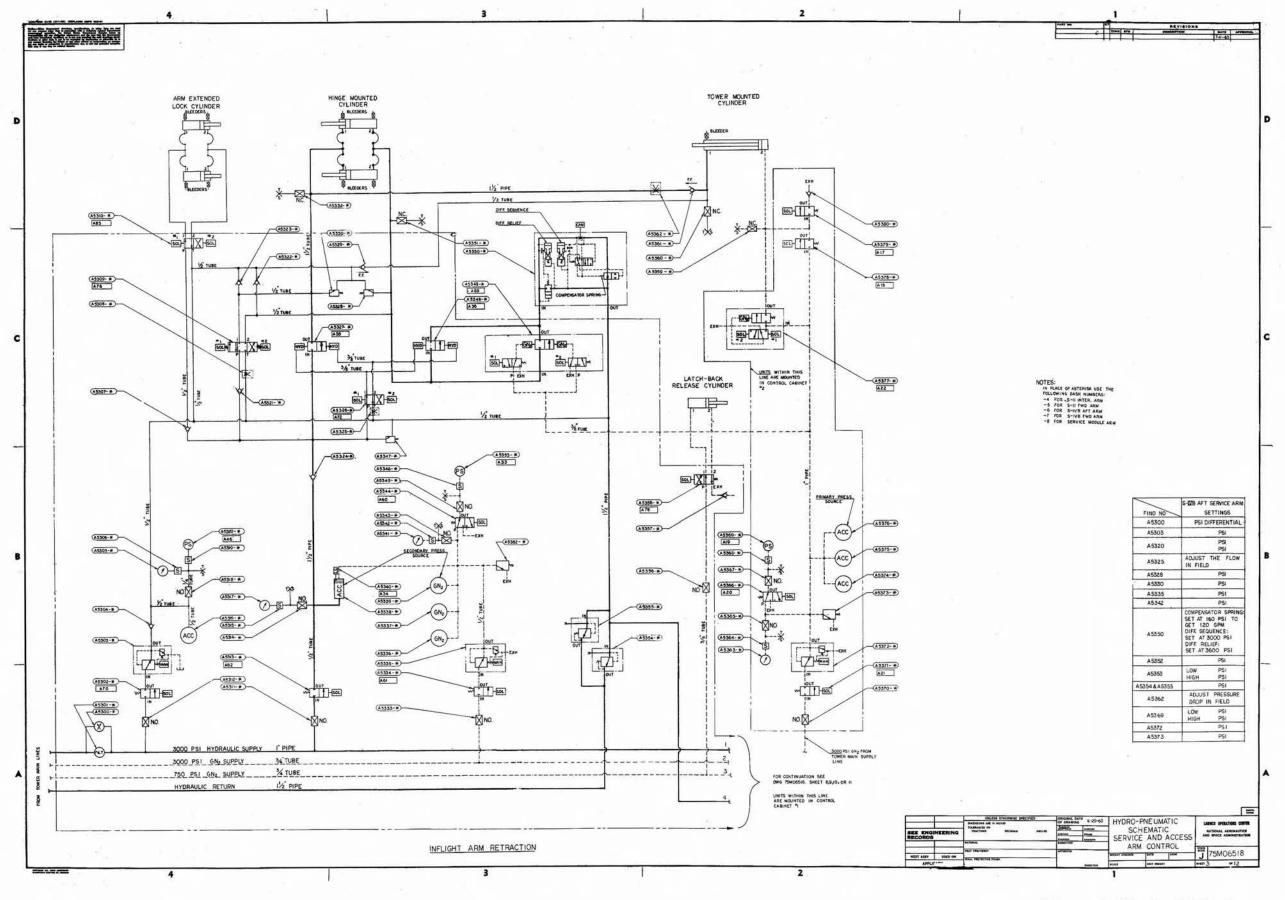
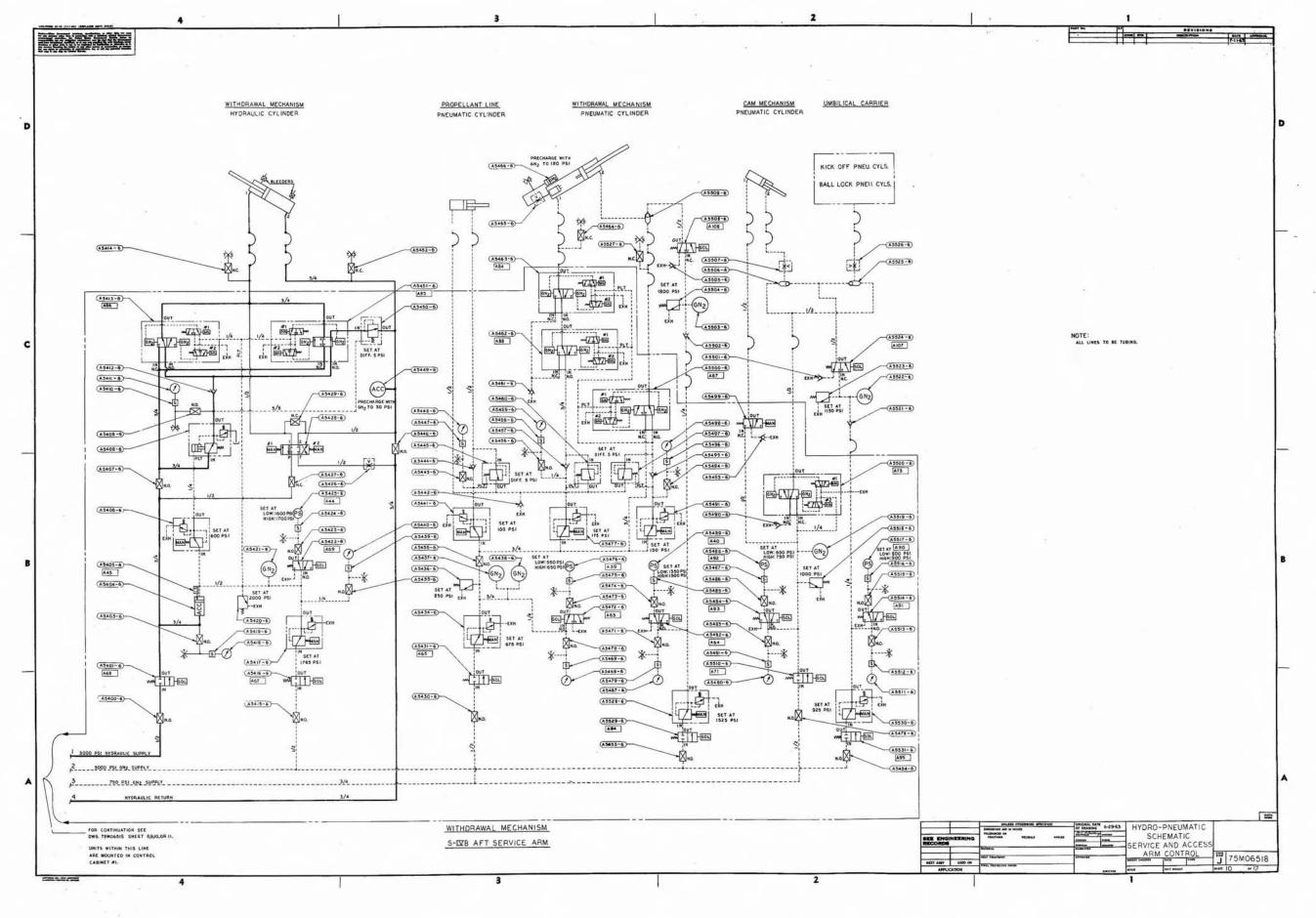


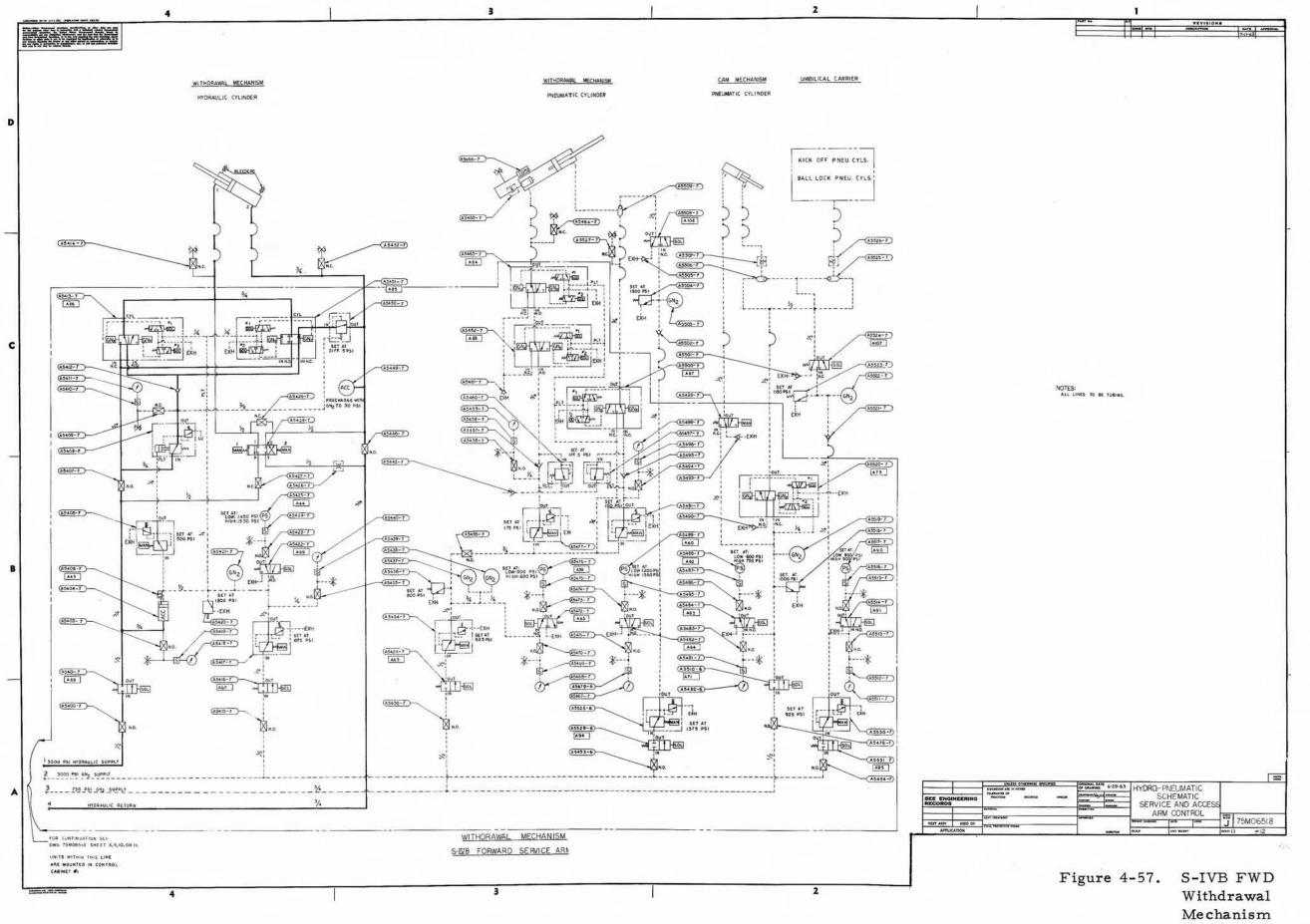
Figure 4-55. In-flight Arm Retraction Schematic

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Figure 4-56. S-IVB AFT Withdrawal Mechanism Schematic



Schematic 201

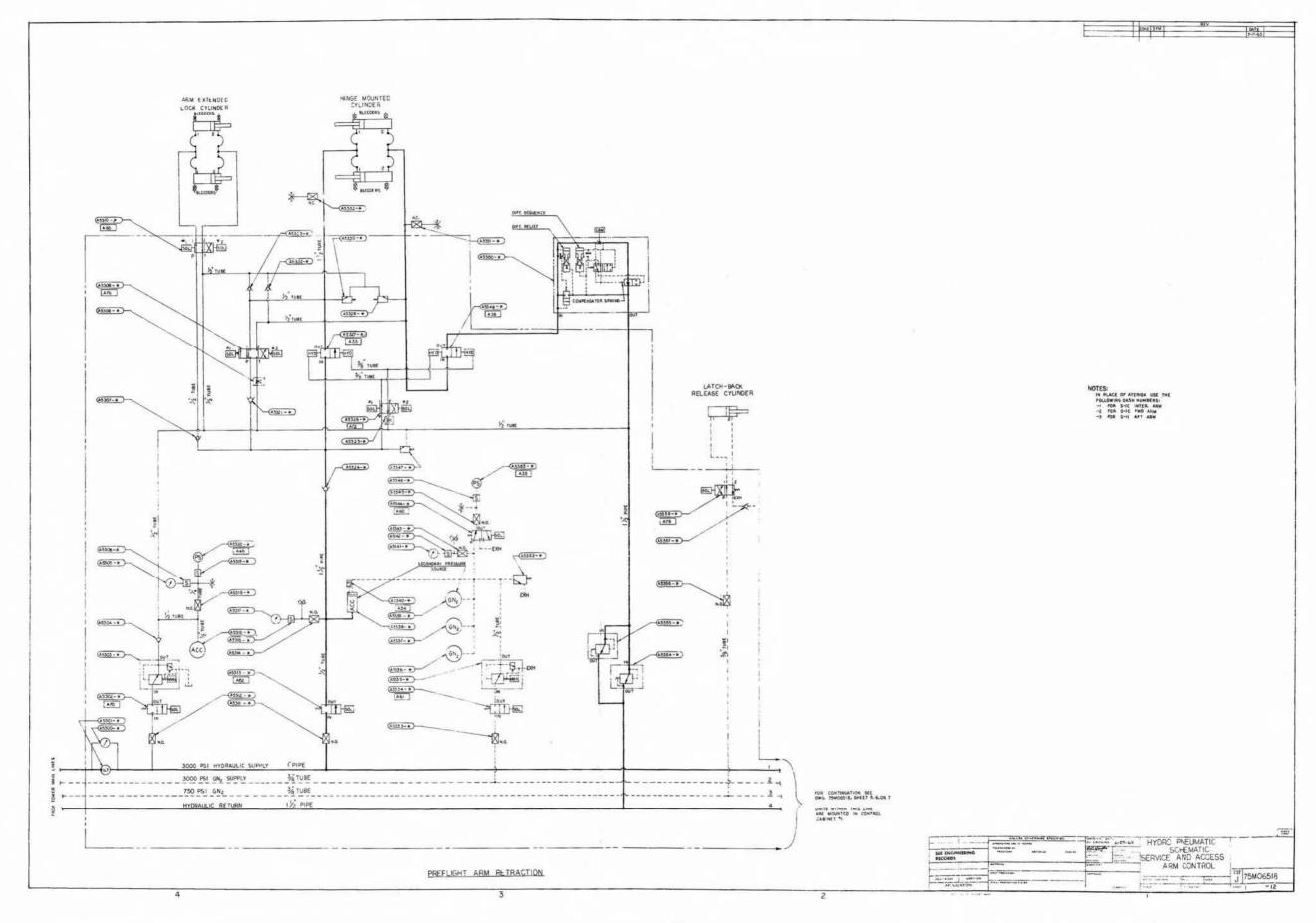
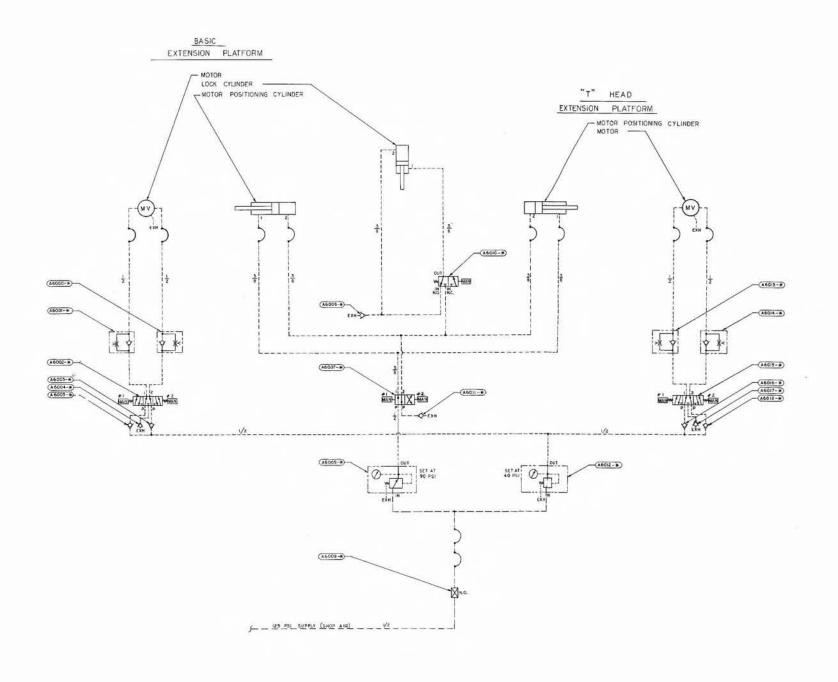


Figure 4-58. Preflight Arm Retraction Schematic



EXTENSION PLATFORMS

5 0 2 Figure 4-59. Extension

IN PLACE OF ASTERISK USE THE FOLLOWING DASH NUMBER: -5 FOR SIT FWD ARM -6 FOR SITE AFT ARM -7 FOR SITE FWD ARM -8 FOR SERVICE NODULE ARM UNSS TO DET TURING

NOTES:

Extension Platform Schematic

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SECTION V COMMAND MODULE ACCESS ARM

The Apollo Command Module Access Arm provides an environmentally conditioned means of astronaut ingress and egress to the Apollo spacecraft. The arm, in normal operating position, is extended toward the Saturn V Vehicle forming an angle of 189 degrees with the east face of the LUT. A hydraulically-actuated locking device restrains the extended arm against motion induced by wind, vibration, and other environmental conditions.

5-1. DESIGN CRITERIA AND OPERATIONAL REQUIREMENTS

Design of the Command Module Access Arm will not start until 1964; however, the following design criteria and operational requirements have been established.

At approximately 60 seconds prior to S-IC ignition, the arm extend lock is disengaged, and the arm is freed to rotate to a locked position, parallel to the east face of the LUT. An arm retract lock and support bracing restrain the retracted arm against the tower face. The complete unlockretract-restrain cycle is accomplished within 30 seconds.

In the event of an abort or hold in the countdown following arm retraction, the arm may be remotely re-extended to contact the spacecraft and relocked in the extended position. The re-extension cycle will also be accomplished within a 30-second time period.

Wind and environment induced displacements, velocities, and acceleration are shown in Table 5-1 for three wind probability conditions. The displacements and oscillations anticipated during transit operations will approximate the same conditions as imposed by a 99.9% probability wind as shown in the table.

The extended access arm will be retracted whenever wind velocities have reached the 95% probability level or more.

The maximum live load imposed on the access arm will be limited to five men. An average weight of 250 pounds for each man and his safety equipment will be used in computing live loads.

DESIGN CRITERIA - ITEMS -	WIND PROBABILITY CONDITIONS					
	95%		99%		99.9%	
	Fueled	Unfueled	Fueled	Unfueled	Fueled	Unfueled
Steady state wind						
Velocity (knots)	29.4	29.4	38.7	38.7	48.3	48.3
Peak wind velocity					20	к. 20
(knots)	41.2	41.2	54.2	54.2	67.6	67.6
Displacement of C. M.			15.0	15 5	26.0	24.4
induced by wind (in.)	5.7	5.4	15.8	15.5	26.0	24.4
Thermal bending		13.3		13.3		
envelope (in.)		15.5		15.5	-	-
Maximum C.M. displacement (in,)	5.7	18.7*	15.8	28.8*	26.0	24.4
displacement (m,)	5.1	10.1	19.0	20.0	20.0	21.1
Amplitude of wind induced oscillations						
(cps)	3.9	3.8	7.0	6.3	10.2	9.8
Freq. of wind induced						
oscillations (in. /sec)	. 33	.80	. 33	. 80	. 33	.80
Velocity of wind induced		i.				
oscillations (in./sec)	8.1	18,9	14.6	34.2	21.2	49.3
Acceleration of wind					5 A A	
induced oscillations	16.9	95,0	30.3	173.0	44.1	247.2
"G" loading wind			2.0.72	~	0.11.4	0 (20
induced oscillations	0.044	0.246	0.078	0.446	0.114	0.639

Table 5-1 Command Module Access Arm Design Criteria

*Displacement figures based on thermal and wind induced displacements. Wind induced oscillations occur within the maximum displacement envelope.

5-2. ARM STRUCTURE

The access arm structure (Figure 5-1) is composed of two basic elements; a Pratt truss constructed of T-1 steel, and a composite truss constructed of aluminum alloy. The Pratt truss is 568 inches long and provides an unobstructed walkway to the environmentally conditioned room. The second element is 231 inches long and provides support for the environmentally conditioned room which is also constructed of aluminum alloy.

Two large hinge plates provide the rigidity required to connect the arm to the hinge, and expanded stainless steel screening provides personnel protection. Arm extend locks are installed in the hinge plate and, as on the service arms, a buffer cylinder and arm retract lock is installed on the LUT. Umbilical connections are not provided from this arm; all lines to the environmental chamber are rigidly attached to the arm structural members. Wind provides the maximum loading condition on the arm.

5-3. ARM RETRACTION SYSTEM

The basic hydraulic and pneumatic components required for system operation are shown in Figure 5-2.

5-4. CONTROL CABINET

A stored-energy system utilizing four air receivers and three hydraulic accumulators is provided to permit use of a small capacity hydraulic charging unit in the base of the LUT and to overcome pressureline losses which would be encountered in transporting fluids to various tower levels from a central supply source. Each of the three piston-type accumulators has a 20-gallon fluid capacity and incorporates an electrical level sensor to provide an indication of full capacity. Pressurization of the fluid is accomplished by expansion of gaseous nitrogen stored at 3000 psi in the four 20gallon air receivers.

5-5. ROTARY ACTUATORS

Arm rotation is accomplished by the application of pressurized hydraulic fluid to the pistons of rotary actuators RA-1 and RA-2. The forces produced by hydraulic pressure acting upon the two opposed pistons rotate a pinion attached to the output shaft. Variable center-depth, involute gear teeth (Figure 5-3) are integrally machined on the sides of each piston. A variable center-depth, tooth configuration provides greater strength than the standard involute tooth profile. The actuator housing is a ductile nodular iron casting incorporating replaceable bronze sleeves in the piston bores. The sleeves assist in reducing piston friction and provide corrosion resistance during periods of system inactivity. Tapered roller bearings support each end of the shaft and absorb both radial and axial shaft loads. Standard elastomer O-rings are used as shaft and moving piston seals.

Each of the two units required in the complete arm actuation system produces 1.55×10^6 inch-pounds of torque at an applied pressure of 2000 psi, is rated at 3000 psi, and weighs 5100 pounds. The shaft extending from the upper surface of the actuator has been modified to permit mounting of a cam which actuates a flow control valve mounted on a support plate spanning the two cylinders. These valves appear in Figure 5-2 as valves VCO-1 and VCO-2.

5-6. HYDRAULIC SYSTEM

Cam-operated, pressure-compensated, flow control valves provide the desired discharge flow rates from the rotary actuators during arm operation. Compensation for the effects of wind loading and other environmental conditions is accomplished in these valves to maintain approximately the same arm rotational time under all operating conditions. Actuator discharge flow control is provided by cam-valve action during the acceleration and deceleration phases of arm operation. The valve is identical in design to that used in the service arm control system.

The back pressure valve (VBP-1) and hydraulic accumulator (HYD ACC-4) maintain a definite pressure level within the system during standby periods to minimize the possibilities of introducing air into the system.

System control values (VA-6 and VA-9) are pilot-operated ball values detented to remain in the last position selected. Pilot pressures are selected by pilot values (VA-10 and VA-11).

5-7. <u>Automatic Arm Extension</u>. In the event of an abort or hold in the countdown following automatic retraction, the access arm may be reextended upon command from the Launch Control Center (Figure 5-4).

Actuation of either the access arm extend switch in the Launch Control Center or the access arm extend switch on the remote hydraulic console in the base of the LUT provides an electrical signal to solenoid valve VA-12. Opening this valve permits pressurized nitrogen to act upon the piston of linear actuator CY-1, compressing the spring and releasing the latch-back device. Upon release of the latching mechanism, an electrical signal will be directed to solenoid 2 of pilot valve VA-11. Hydraulic pilot pressure will then be directed to open control valves VA-7 and VA-9. Fluid under pressure will flow from the hydraulic accumulators through control valve VA-7 to rotary actuators RA-1 and RA-2. Rotary actuator outlet flow will be regulated by cam-operated, pressure-compensated, flow-control valve VCO-2 before flowing through control valve VA-9 and back-pressure regulator valve VBP-1.

Upon reaching the limit stop at the fully extended position, an electrical signal will be initiated to energize solenoid 1 of valve VA-5. This action permits linear actuator CY-2 to position a lock, thereby preventing arm motion caused by wind or other environmental conditions. An electrical signal, to de-energize solenoid 2 and energize solenoid 1 of pilot valve VA-11, is also obtained when the arm contacts the extend limit stop and the lock is in place.

5-8. Automatic Arm Retraction. The bold lines appearing on schematic diagram (Figure 5-5) indicate the portion of the system involved in an automatic arm retraction cycle. At 60 seconds prior to S-IC ignition, an electrical signal is directed to solenoid 2 of valve VA-5. Valve actuation permits pressurized fluid stored in hydraulic accumulators 1, 2, and 3 to actuate cylinder CY-2, thereby retracting the arm extend lock. An electrical signal is provided to indicate either successful accomplishment of the unlocking operation, or to provide an automatic countdown hold in the event of malfunction.

At 45 seconds prior to S-IC ignition, an electrical signal is automatically directed to solenoid 2 of pilot valve VA-10. Valve actuation provides pressure to actuate ball valves VA-6 and VA-8. These valves permit fluid flow from the accumulators to the rotary actuators and from the actuators through cam flow-control valve VCO-1 and the back pressure valve prior to returning to the sump in the base of the LUT.

Upon completion of the 30-second retraction cycle, the arm contacts an arm retract lock. An electrical signal is provided at the completion of arm retraction. Failure to obtain this signal results in an automatic countdown hold.

5-9. <u>Manual Arm Extension</u>. Placing the latch-back release switch on the local control panel in the release position provides an electrical signal to energize solenoid valve VA-12 (Figure 5-2). Nitrogen gas stored in air receivers AR-1, AR-2, AR-3, and AR-4 will then flow to cylinder CY-1 through the circuit indicated on Figure 5-2. Pressure regulator VR-4 maintains pressure in the circuit at 750 psi and needle valve VM-8 permits

an adjustment of cylinder actuation time. An indicator light on the local control panel will indicate when the arm is no longer restrained to the tower by the latch-back mechanism.

Following release of the latching mechanism, the LUT-mounted hydraulic charging unit can be connected to the circuit by placing the local control panel hydraulic supply switch in the on position. Solenoid valve VA-2 is operated by the electrical signal provided. An indicator light on the local panel will confirm the open condition of the valve.

Movement of the manual "RETRACT-EXTEND" valve (VM-6) to the "EXTEND" position will direct hydraulic fluid to rotary actuators RA-1 and RA-2 as shown in Figure 5-2. The arm will slowly extend as a result of the applied actuator torque at a rate of speed governed by needle valve VM-5.

During arm rotation, a continuous monitor signal of arm position is provided to panels in the Launch Control Center and in the LUT. When the arm reaches its fully-extended position and has made contact with a limit stop, the panel-mounted, lock pin control switch is placed in the "LOCK" position; an electrical signal is thereby provided to open solenoid l of valve VA-5 and direct hydraulic fluid to linear actuator CY-2. The actuator extends and positions the locking device to prevent arm movement. An indicator light will verify the arm-locked condition.

The extension cycle is completed by locking the arm and the "RETRACT-EXTEND" valve (VM-6) and returning the HYDRAULIC SUPPLY and LATCH-BACK release switches to their off positions. Upon removal of the electrical stimulation from the latch-back release switch, linear actuator CY-1 is vented to the atmosphere through valve VA-12 and the internal spring returns the latch-back release pin to the locked position.

5-10. <u>Manual Arm Retraction</u>. The retraction cycle (Figure 5-6) is initiated by placing the lock pin control switch in the "UNLOCK" position. Solenoid 2 of valve VA-5 is energized by the electrical signal produced, and hydraulic pressure is directed to linear actuator CY-2. As the actuator piston retracts, it removes the locking device from the arm. An indicator light will verify removal of the locking device from the arm.

Connection to the LUT-mounted, variable-displacement hydraulic pump is obtained when the hydraulic supply switch is placed in the "ON" position to energize solenoid valve VA-2. An indicator light will signify that hydraulic fluid from the LUT pump is available. When an indication of availability of hydraulic pressure has been obtained, "RETRACT-EXTEND" valve (VM-6) can be placed in the "RETRACT" position to direct fluid flow to rotary actuators RA-1 and RA-2, as shown. Arm rotational speed is again determined by needle valve VM-5 and the panel-mounted indicators provide continuous monitoring of arm position.

When the arm has reached the fully-retracted position, it will be mechanically restrained by the panel-type, latch-back device. An indicator light will confirm the restrained position of the arm.

Return of "RETRACT-EXTEND" valve (VM-6) and hydraulic supply valve (VA-2) to the "OFF" position after the arm restrained indication has been obtained, completes the retraction cycle.

5-11. ENVIRONMENTAL CHAMBER

An environmental chamber will be mounted to the aluminum alloy second element of the access arm. Due to the length of the arm, the chamber and associated equipment should be as light as possible. Lightweight construction material such as aluminum alloys aids in reducing inertia forces on the arm rotational drive system which already is subjected to extremely high wind loads.

To provide consistency of arm rotational system methods of operation with those used on service arms, the access arm will incorporate an arm extend lock. All vehicle tracking functions will, therefore, be incorporated in the environmental chamber similar to the manner in which tracking functions are included in the service arm withdrawal mechanisms.

The access arm will be extended toward the command module during VAB assembly operations. It will be retracted to a position along the tower side as soon as the vehicle and LUT have moved from the VAB. This retraction will permit only functional test of the retraction system following vehicle assembly in the VAB. The arm will remain locked to the tower side throughout LUT and vehicle transit from the VAB to the firing site. The locked-to-tower position eliminates the requirements for unreasonably large tracking excursions and a large capacity hydraulic charging unit in the base of the LUT during a period when all electrical power must be self-generated within the LUT. The charging unit would

be required if the arm had to track maximum vehicle displacements during transit. After arrival at the firing site, the arm will be extended toward the command module, and the environmental chamber tracking unit will be placed in contact with the field splice between the command and service modules. A bellows-type shroud and platform will be extended to provide a passage between the environmental chamber and the command module access hatch.

A conditioned air supply duct will be routed along the arm structure to provide cooled, controlled-humidity, salt-free air to the environmental chamber.

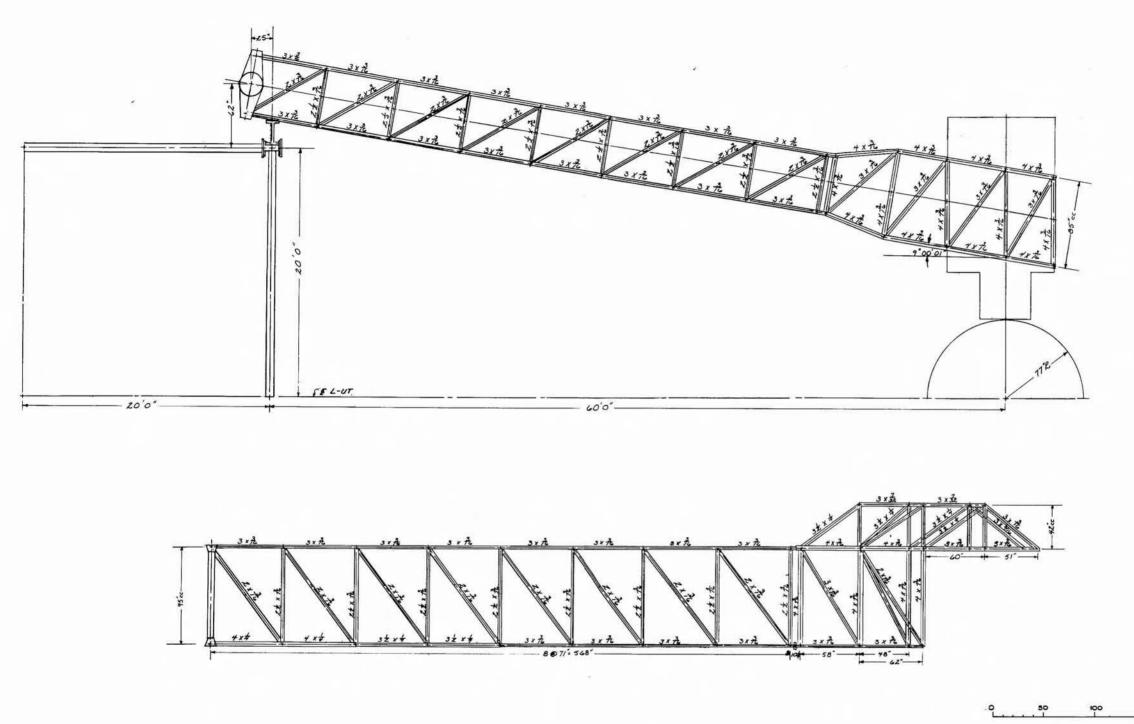
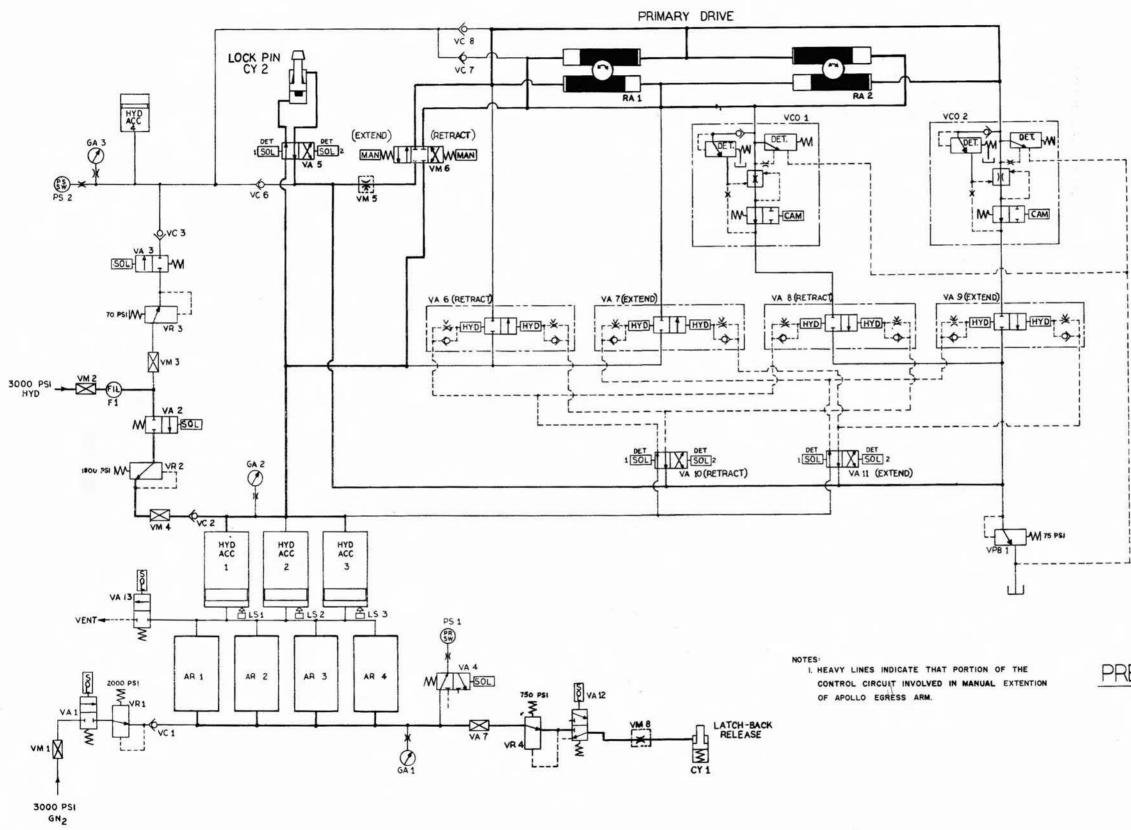




Figure 5-1. Command Module Access Arm Structure 213



PRELIMINARY

Figure 5-2. Manual Extension Schematic



Figure 5-3. Rotary Actuator

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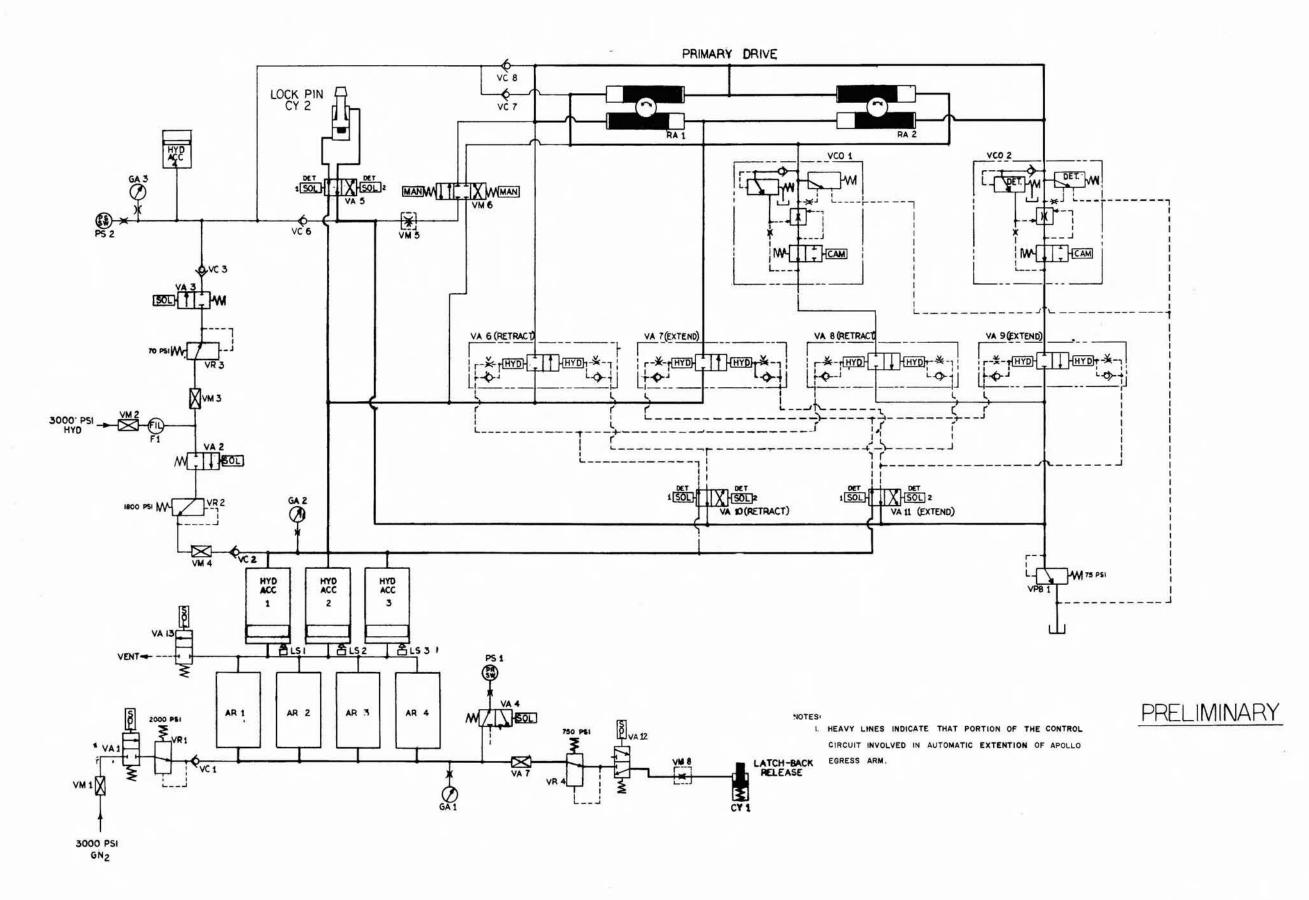
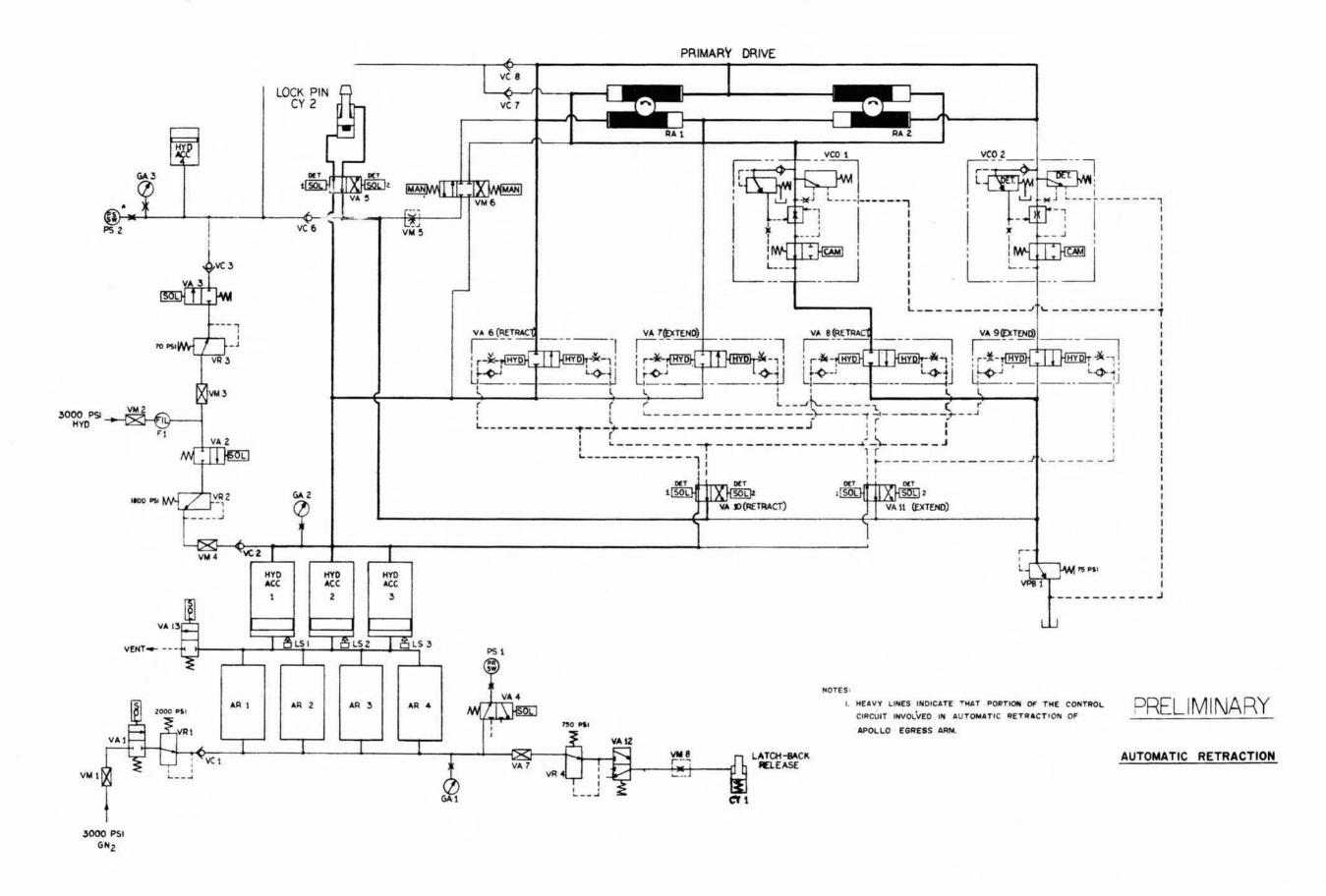
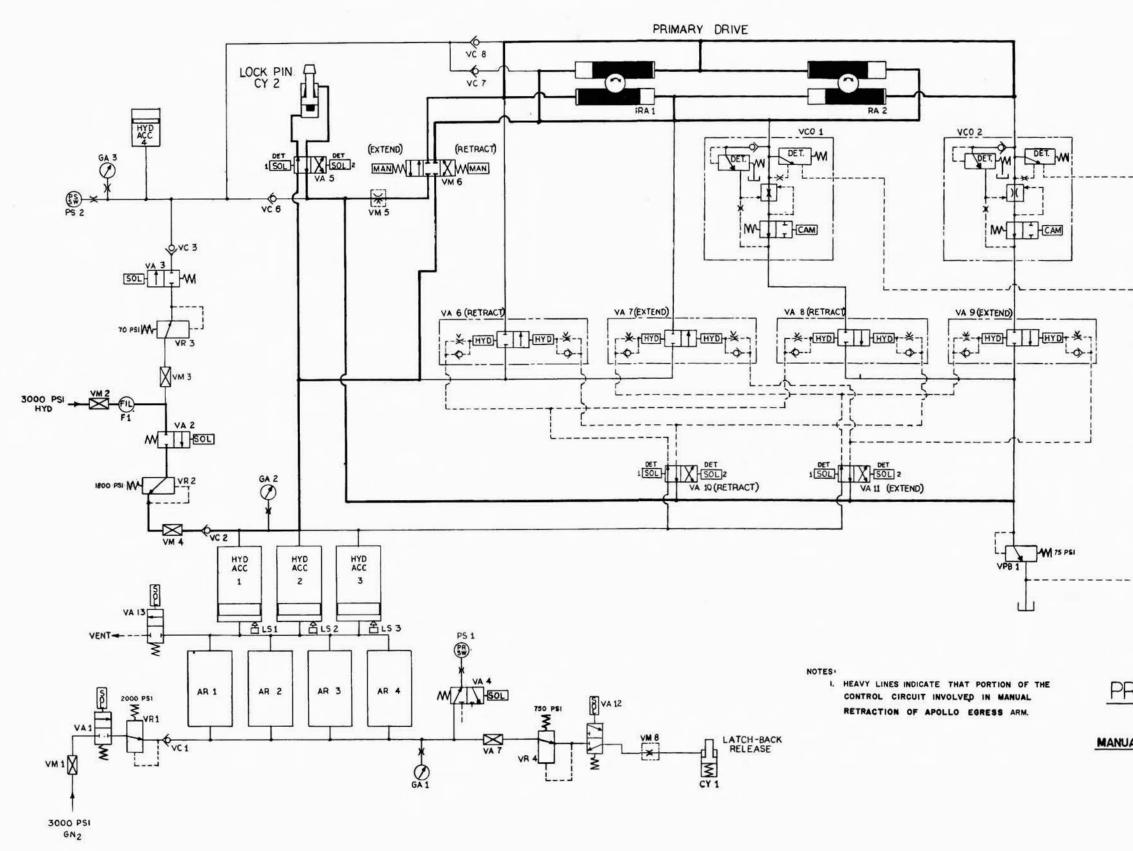


Figure 5-4. Automatic Extension Schematic 217

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PRELIMINARY

MANUAL RETRACTION

Figure 5-6. Manual Retraction 219 Schematic

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SECTION VI AUXILIARY COMPONENTS

Included in this section are the hydraulic charging unit, water quench system, service arm transporter, arm accessways, arm supports, latchback and holddown devices, skids, and tower-mounted secondary retract beams.

The transporter is used in the preassembly and prelaunch phases to transport the service arms from the MSFC Test Area, Huntsville, Alabama, to Complex 39.

The hydraulic charging unit is used to initially charge and to periodically replenish the service arm control system accumulators. The unit is operated under standby conditions during vehicle transport from the VAB to the Firing Site, during checkout operations, and while the vehicle is at the Firing Site. During the final phase of the launch countdown, the unit is inactivated and the launch sequence is completed with energy stored in the system accumulators.

The water quench system is not required to complete a vehicle launch but is used to cool the service arms and permit their reuse with a minimum of repair after exposure to the high temperature engine exhaust gases.

Arm accessways give personnel access onto the arms from the tower for maintenance and checkout.

Arm supports, skids, and tower-mounted secondary retract beams are described in subsequent paragraphs.

6-1. HYDRAULIC CHARGING UNIT

The hydraulic charging unit (Figure 6-1) is used to initially charge and to periodically replenish the hydraulic accumulators which provide sources of stored energy for the service and access arm control systems. This unit also furnishes fluid, under pressure, to permit the umbilical withdrawal mechanisms to track vehicle excursions. The charging unit is mounted in the lower level of the LUT base and is de-energized during the final seconds of launch countdown. The hydraulic charging unit is comprised of three major subassemblies, a reservoir, and two skid-mounted hydraulic pumping units. The system design, as shown in schematic diagram (Figure 6-2), is such that either pumping unit may be readily removed without operational interference with the other unit.

The reservoir shape was dictated by the 5 x 8 foot opening in the LUT decking through which the unit is lowered for installation. The stainless-steel reservoir serves both as a storage vessel for 500 gallons of MIL-H-5606 hydraulic fluid and as a structural support for the skid-mounted pumping assemblies, a gage panel, and associated valves. The tank is internally baffled to reduce fluid foaming and to provide a settling area for fluid contaminations, and vented overboard through the LUT sidewall.

The reservoir is 73.75 inches long, 49.25 inches wide, and 47 inches high. The reservoir is designed to accommodate a 4-inch return line from the tower supplies, two 0.75-inch supply lines, one for each pumping unit, auxiliary 2-inch and 4-inch return lines, and a 4-inch vent line. Dry weight of the complete assembly is approximately 4500 pounds.

The two pump drives, A6044-1 and A6044-2 (Figure 6-2) are 20 horsepower, 220/440 volt, 3 phase, totally enclosed, fan cooled motors operating at 1800 rpm. The aluminum alloy motor frames conform to NEMA classification 286-U and are double-ended with flanges on each end bell to accommodate drive pads for both superchargers and main stage pumps. The motor windings are specially impregnated to permit use in hazardous atmospheres. All motor control equipment is hydrogen ignition proof where NASA LOC qualified components are available. All electrical components not within protected enclosures are either hydrogen safe or capable of being made hydrogen safe if required later by hermetic sealing, encapsulating, or purging. The motors are fastened to skids fabricated from 1020 steel plate and channel sections.

The supercharger pumps, A6011-1 and A6011-2, are fixed displacement units employing 1-inch wide helical gear pumping elements. Each pump will deliver 11 gpm of hydraulic fluid at an output pressure of 30 psi. Supply fluid for these pumps is drawn from the reservoir through 60 mesh monel strainer assemblies A6010-1 and A6010-2. Pump discharge passes through 10 micron nominal, 25 micron absolute, pleated wire cloth filters, A6012-1 and A6012-2, prior to entering the inlet ports of the main stage pumps. Relief valves. A6024-1 and A6024-2, are also included to unload the supercharger pumps when no demand is placed upon the hydraulic system and when the main stage pumps are operating under standby conditions. The valves have a cracking pressure of 30 psi and return to supercharger pump output flow to the hydraulic reservoir.

The main stage pumps A6026-1 and A6026-2, are pressure compensated variable displacement units capable of delivering 9.3 gpm at 3000 psi discharge pressure. Fluid displacement is a function of demand and requires only sufficient power to meet the functional and delivery requirements of the system.

Discharge of the two main stage pumps is directed to a common header through check valves A6034-1 and A6034-2. Header pressure is limited by relief valve A6036 if there is a failure of the pressure compensator which is an integral part of the main stage pump.

The tower header may be drained by block valve A6035 and individual pump unit cycling, under flow conditions, may be achieved by block valves A6032-1 and A6032-2.

Motor control and necessary instrumentation will exist on the charging unit and at both the LUT and LCC service arm monitors.

One pumping unit will be operated continuously while the LUT is in the VAB. A loss of hydraulic supply, in this environment, is not considered critical. Only one pumping unit will be operated during transit, in order to minimize power demand. (Constant monitoring, therefore, should be considered to permit selection of the second unit operation in the event of a pumping unit malfunction). After the LUT arrives at the launch site both units will be placed in operation and remain in operation until launch.

6-2. HYDRAULIC CHARGING UNIT MOTORS AND CONTROLS.

This section generally covers all electrical power and control components required for connecting and controlling the hydraulic pump motors which are used to charge the swing arm hydraulic system.

Each LUT hydraulic charging unit (Figure 6-3) will have 20 hp motors. These motors will be electrically connected and controlled individually. Therefore, all description herein will refer to only one pump motor and system.

6-3. OPERATIONAL DESCRIPTION

The following is a general description of the operational procedures for the electrical system of the hydraulic pump motor.

There are three control panel locations, one in the Launch Control Center, one in the Launcher-Umbilical Tower Monitor Room and one mounted in the Pump Room on the hydraulic instrument assembly. The control panels are used to control and indicate proper functioning of the electrical and hydraulic systems

The main electrical service will be provided by the facility power source through a sight switch. With the sight switch in the "ON" position, the following indicator lights should be lighted on all control panels; "Phase Sequence OK", "AC on", and "DC on" also the "Control" light will be lighted on the controlling panel which has charge of the system. The "Phase Wrong" light should not be lit but if lit, operation shall cease until the wrong phase condition is corrected.

The pump motor is started by the "Start" switch at the controlling location. This switch energizes an autotransformer starter which starts the motor. If the system functions properly the Hydraulic "Pressure OK" light will come on when the pressure operating level is reached. The pressure switch will be adjustable between the operative limits of 2300 to 3000 psi. Additional control panel indicators will be a motor overtemperature light, hydraulic pressure transducer read-out meter and "Protection Control Bypass" switch with danger light. The pump motor will continue to operate until the "Stop" switch is actuated which stops the motor and resets the control system. The indicating lights and autotransformer holding coils will be of the 28 vdc type. All indicating lights will be dual bulb legend type suitable for mounting in panels.

The control panel having the Start - Stop function will be the one connected to the control receptacle on the distributor assembly. All control panel cabling will be interchangeable to facilitate the plug-swap control/monitor functions. Changing of this control from one location to another will require an exchange of plugs. These changes will be made with the power disconnected from the motor. All electrical equipment in the Monitor and Motor Rooms shall be capable of being easily converted to "Hydrogen Ignition Safe". All motor windings and transformer coils shall be vacuum impregnated with G. E. RTV-11 encapsulating silicone rubber compound. Each piece of equipment must be mounted in such a manner that it can be removed and replaced by disconnecting cable connectors, purge lines (if required for hydrogen safing) and mounting brackets or attachments.

All components shall be tested and certified as to their capability of performance under the worst vibrating conditions expected during movement of the LUT or during launch.

6-4. ELECTRICAL CONTROL SYSTEM COMPONENTS.

The control systems will generally include but not be limited to the following number and type of items:

a. One 28-vdc power source.

b. Two phase sequence indicators and relays. One of these is connected for correct rotation and one for incorrect.

c. Three 110-vac relay coils connected through resistors to each phase of the 440 V supply with normally open contacts connected in series ahead of main contactor coil to prevent operation in case a phase failed.

All above items will be provided with a minimum of 2 fuses, sufficiently sized, on the line side.

d. One autotransformer starter as shown on drawing.

e. Three overload relays with heater elements installed in each motor lead, and their contacts connected normally closed in control circuit.

f. Three Start-Stop controls.

g. Eighteen indicator lights suitable for 28 vdc operation with dual 40 ma bulbs

h. One transducer connected to hydraulic system for pressure readout.

i. One overtemperature relay imbedded in motor frame and connected normally closed in control circuit.

j. One 20 hp, 1800 rpm, 440/220 volt, 3 phase, double end shaft, totally enclosed fan cooled (TEFC) with G.E. RTV-11 encapsulated dual winding motor with space heater and drain plugs to alleviate moisture condensation in high humidity environment.

This equipment will be connected generally as shown on Motor Control Circuit Drawings.

All components must have a certified function test of at least 10 cycles of satisfactory consecutive operations before being released from the manufacturer.

The assembled unit will have a checkout procedure including continuity and complete functional performances.

6-5. <u>Power Cables With Connectors</u>. The power cables used for power supply from the sight switch to the starter assembly and from the motor terminals to the starter assembly will be of flexible cable consisting of seven No. 8 tinned-copper stranded conductors with a tinned-copper braided overall shield enclosed with mold-cured neoprene sheath cover. The power cables will conform to NASA specifications of cable drawing No. A75M50222.

6-6. <u>Control Cables With Connectors</u>. The control cables connecting the Distributor to the Relay and control panels shall consist of sixty-one No. 20 conductors with an overall shield which shall conform to NASA cable drawing A75M50223, these cables shall be interchangeable, using similar plugs. Lengths of these cables shall be such as to accommodate the maximum distance between locations of terminals in the LUT hydraulic motor room.

The control cable connecting the starter assembly to the distributor will consist of nineteen No. 20 conductors with overall shield which shall conform to NASA drawing A75M50223.

The cables used to connect the relay assembly with LCC controls shall be as required according to NASA controlling authorities. A 3 wire No. 18 conductor cable shall connect the control panels to a pressure switch sensing hydraulic pressure, connected through the hydraulic unit electrical distributor A1. The cable shall be constructed to conform to NASA LO-DE standard cable subassemblies.

6-7. <u>Receptacles.</u> The receptacles shall be mounted on the assemblies and gasketed to provide a leak proof seal. The connections to the receptacles shall be hermetically sealed by potting between the connecting terminals and the box interior. The control and distributor receptacles shall be according to standard cable subassembly drawings. All component receptacles on Hydraulic Unit Distributor Al shall be MS3100 type. The power receptacles shall be rated for 600 volts and 40 amperes on the power and grounding terminals and 10 amperes on the low voltage terminals.

The starter assembly shall have 2 power receptacles and one 19 pin control receptacle. Distributor assembly Al shall have one 19 pin and three 61 pin control receptacles. Each control panel shall have one 61 pin control receptacle and one DC power 3 pin receptacle.

6-8. <u>Starter Assembly</u>. The starter assembly A3 shall be constructed to house the autotransformer starter, low voltage transformer and 28 vdc rectifier, plus right and wrong phase sequence relays, phase to phase connected 115 volt relay and dropping resistors, line overload relays, fuses, terminal boards and all other necessary equipment needed for mounting and connecting indicated components.

This assembly shall be constructed of rigid sheet metal steel sealed with gaskets and capable of being purged with an inert gas making it hydrogen ignition proof if ever required. The plug-in receptacles shall be installed in the sides or bottom of the assembly. The assembly shall have been protected from rust with galvanized or bonderized paint per NASA standards. All electrical connections shall be made with the applicable connectors. All relay contacts located in the starter section shall be ignition proof or installed in an environmental panel to give explosion proof protection.

The starter and all components shall be of the capacity and size to meet all National Electric Code Safety requirements.

The assembly shall be mounted in a manner to make interchanging of assemblies easy. If any component within the assembly should become faulty the complete assembly could be replaced by unplugging cables and exchanging to a spare starter assembly. The assembly shall be frame mounted as shown on plan. 6-9. <u>Distributor Al</u>. This box will provide the interconnect between the starter, monitor and control panels. The distributor shall have a sufficient number of terminal boards for all present needs plus 20 percent spares.

The terminal boards shall be of the solder type and shall be firmly secured to the distributor.

The distributor shall have three identical sized 61 pin control jacks. One jack shall be labeled "Control" and each of the other jacks shall be labeled "Monitor."

The distributor shall be constructed of rigid sheet steel equipped with a gasket. It shall be of a standard size and shall be protected from rust and moisture accumulations by galvanizing or bonderized paint. It shall be capable of being purged for extra hydrogen safing if ever required.

6-10. Control Panels. All LUT hydraulic unit control panels are to be identical, standard 24-inch rack mount type, shallow depth panels. They may be connected for "Monitor" or "Control" operation by a plug swap into the appropriate control jack at the distributor Al. The local control panel will be located in the area of the pump below the hydraulic gages. The primary purpose will be to start and stop the pump motor and monitor operations. A toggle switch will be used for starting and stopping the motor. Eight indicator lights will be used for monitoring. All components on the local control panel will be per MSFC STD-110 except as specially required for motor control.

All control circuits from the panel will exit through a 61 pin connector.

6-11. LUT Remote Monitor-Control Panel. The LUT remote control panel will be located in the LUT control room. A standard size panel as described above will be used to match existing panels within the area. This panel will be primarily used for monitoring the operations of the pump electrical and hydraulic systems, but when the cable to the distributor box is connected in the "Control" position, the LUT monitor room panel can function as the main control panel. The eight indicator lights on the panel will be 28 vdc Master Specialties, Word Indicator Lite with appropriate legends engraved on each light. 6-12. LCC Control Panel. The LCC control panel will be furnished by other NASA contractors and will probably contain functions similar to LUT panels.

6-13. Motor. The hydraulic electric motor shall be a 30 hp, 1800 RPM 440/220 V, 3 phase, totally enclosed, fan cooled, double end shaft. The shaft shall be hollow with a 1-inch diameter hole and constructed for the installation of the specified pumps on each end.

The motor housing shall have two 1/4 inch drain holes tapped to the stator section of the motor. These drain holes shall be used to remove any condensate or may be connected to a dry nitrogen purge system where hydrogen safing is required. A 200 watt strip heater shall be installed in or adjacent to the inside cooling section to provide above ambient temperature to the internal section of the motor housing and further alleviate condensation.

The motor windings shall be vacuum impregnated and encapsulated with General Electric RTV-11 silicone rubber compound or equal. The motor winding leads shall be according to MIL-W-8777 wire and shall be solder terminated to a Bendix Hus-Key connector anchored and extending through the side of the motor lead terminal box. The leads and soldered end of the connector shall be potted with clear LTV 602 silicone.

The motor shall have a terminal overtemperature switch which will be embedded in the motor winding. The switch shall operate with excessive temperature rise to turn on a warning light when the overtemperature occurs.

The motor shall be made of No. 363 aluminum alloy with not more than 3 percent elongation in 2 inches and a maximum weight of 300 pounds. The motor shall be similar to Reuland's horizontal double end hydraulic pump motor frame No. 286U.

6-14. <u>Hydraulic Pressure Read-Out</u>. Transducers and pressure switches shall be furnished and connected into the indicator system to provide pressure read-out located on all control panels. All equipment will be furnished according to NASA approved components.

6-15. WATER QUENCH SYSTEM

The water quench system will provide for rapid heat dissipation and fire control on the service arms and CM access arm immediately after launch. The limits of design call for tower-mounted headers using 7500 gpm of water and the assumption that wind conditions are nullified by aspiration effects during vehicle ascent.

6-16. OPERATIONAL REQUIREMENTS

The service arm and equipment was considered to be cooled to an average temperature of 212°F in one minute. Even though no appreciable cooling effect could be gained during lift-off, it is desirable to have the water flowing on the arm during firing to insure immediate heat dissipation after blast has cleared the arms. Actuation of the water spray system should take place at lift-off.

Since a uniform water spray must be designed for cooling on a "per unit area" basis, the tubes of the service arm determine the water requirements. In this case a flow rate of one gpm per square foot of projected area was required.

The water quench headers are placed above and below each service arm in positions that will allow clearance of arm hardware and yet provide complete water spray coverage over top and bottom of service arm.

The piping used for the water quench system will be seamless carbon steel, schedule 40. Spray nozzles are the square spray type to provide uniform coverage. Water will be piped as near the center of the tower mounted headers as possible so that spraying will start uniformly. Water pressure at each header will be determined by the number of nozzles per arm and will be regulated by a pressure reducing orifice.

The piping (Figure 6-4) will be supported by brackets attached to the face of the arm-mounting beam, two vertical beams, and to the floormounting beam at each individual arm level. Piping will be fabricated to provide easy installation by tower crane. A flanged interface is provided at each floor-mounting beam.

The piping, nozzles, etc., for the water quench system are standard design and commercially available.

6-17. CONTROL SYSTEM

The water quench control system consists of a control valve located at each arm level, one solenoid valve to supply pneumatic pressure to operate the control valves, and a control panel located in the base of the LUT. The control valves will be located near the tower interface at each arm level so the water is as near the arms as possible.

At holddown arm release, the solenoid valve receives an electric signal which opens the valve and allows pneumatic pressure to actuate the control valves. By opening the control valves at this time, water will reach the arms before they are exposed to the exhaust heat.

A timing circuit in the control panel will determine the length of time the control valves will remain open. The time will be adjustable. Between one and two minutes of quenching is expected to be sufficient. At the end of the desired time, the solenoid valve will be de-energized and the control valves will close and stop the water flow.

A second control system consisting of one large control valve located below the first service arm level was considered; however, it was found that the head of water could not rise as quickly as the vehicle.

6-18. SERVICE ARM TRANSPORTER

The Complex 39 umbilical service arms will require transportation from the Marshall Space Flight Center in Huntsville, Alabama to Complex 39, as well as requiring local transportation at both locations The size of the service arms and the protection necessary preclude the use of completely standard transportation methods.

Transportation by trailers is necessary for local movement and has been found to be the best and most efficient means of transportation from Huntsville to Cape Canaveral. Comparison with barge and rail transportation indicates that trailer transportation requires less handling, coordination, and travel time than the other modes of transportation and provides better protection for the service arms. Minor disassembly of some of the service arm components is required for trailer transportation to provide sufficient bridge clearances. The trailers required to transport the service arms are special drop deck, 22 ton capacity, platform type semitrailers with removable body panels, roof bows, and tarpaulin tops. The trailers are 56 feet long and 10 feet wide and constructed in accordance with NASA drawings and specifications (Figure 6-5). Standard commercial components and practices are used and meet or exceed the requirements of the Interstate Commerce Commission "Motor Carrier Safety Regulations".

6-19. ARM SUPPORTS

Arm supports (Figure 6-6) are provided for the service and access arms against the anticipated vehicle engine exhaust pressure. The supports were designed on the basis of a 10 psi pressure upon the vertical projection of the arms.

The service arm auxiliary supports are always mounted on one of the two vertical beams which are provided specifically for their installation. These double-web beams have mounting holes in their outer flanges in the face nearest the vehicle. The holes are located at the same pitch as the main arm mounting beam (5 inches) and at equal tower elevations. The auxiliary supports will be mounted at least one hole lower than the normal position, due to arm deflection.

The auxiliary arm support (Figures 6-7, 6-8, and 6-9) is made from ASTM A-441 steel, is of all welded construction, and is connected to the tower with two vertical rows of 1-inch diameter bolts. A cutout is provided in the support to allow the passage of a water header for the quenching system. Shims are used to keep the top of the support skid at approximately the correct elevation. The blast load is transferred through the skids to the auxiliary arm support. A complete skid arrangement consists of two skids: an arm mounted skid and a support mounted skid.

6-20. SKIDS

Skids are used to seat the arms in the retracted position where they receive the blast load from the vehicle engine exhaust.

6-21. <u>Arm Mounted Skid</u>. The arm mounted skid (Figure 6-10) is bolted to the lower chords of the second element. The skid is fabricated from plates and has the shape of a wide flange beam with a sloping lower flange that matches the angle of the support mounted skid. The seating of the two sloping surfaces furnishes the automatic vertical adjustment and also a dampening of the linear and rotational vibratory motion as the arm swings to the fully-retracted position. To provide a latch-back mechanism and holddown system, (Figure 6-6), a series of rungs are fabricated onto the bottom flange of the arm mounted skid. These rungs act with a spring loaded latching device, housed in the support mounted skid, providing a ratchet-type lock with several locking positions.

6-22. <u>Support Mounted Skid.</u> The support mounted skid (Figure 6-11) is a constant depth weldment of plates and also has the cross-sectional configuration of a wide flange beam. The top flange will be covered with a sheet of nonsparking material. The top flange is installed on the auxiliary arm support and positioned with a series of shims which provides 5 inches of vertical adjustment. The outboard end of the skid slopes downward from the tower and parallel to the top of the auxiliary arm support. In addition to supporting the arms, the skid is utilized as a housing for the arm latch-back and holddown mechanisms.

6-23. TOWER MOUNTED SECONDARY RETRACT BEAM

A pair of sheaves, one in the horizontal plane and one in the vertical plane, provide the directional change for the secondary cable. The horizontal sheave is mounted on the inboard face of the tower mounted secondary retract beam (Figure 6-12) at approximately the same elevation as the center of the arm. Because of the eccentricity of the retract cable with respect to the beam, considerable torsion is carried by the beam.

Tower connections for the secondary retract beam are furnished at every floor above the 80 foot level and will have common bolting pattern for interchangeability of the beams. The holes for the mounting of the sheaves will be located and drilled during installation. Since the beams are furnished only to meet the present requirements, any subsequent relocation of the arms requires additional field drilling for the mounting of the sheaves.

6-24. ARM ACCESSWAYS

Service and equipment installation for the verticle requires access of personnel from the tower to the vehicle. To fulfill this requirement, accessways (Figures D-11, D-12, D-13, and D-14) leading from the tower levels to the arm levels are provided. All arm accessways, with the exception of the S-IC INTERTANK arm, consist of two landings and at least one arm peculiar transitional section. This section may be a stair, ladder, platform, combination of stair and platform, or a combination of a ladder and a platform. The arm landing and the tower landing, including their supporting structures, are common to all arms except the S-IC INTERTANK. A mounting beam on the east face of the tower provides support for one side of the arm landing.

For the S-IC INTERTANK arm, access is provided through the interior to tower. This route, however, does not allow the walkway clearance of 42 inches by 78 inches that is normally maintained. All obstacles interfering with headroom clearances will be clearly marked in an approved manner.

For personnel protection in the area of the arm mounting hinge and arm landing, a retractable enclosure (Figure 6-13) is provided. This enclosure allows protection for personnel for all positions of the arm.

The design loading for the accessways is a 5 psi blast loading.

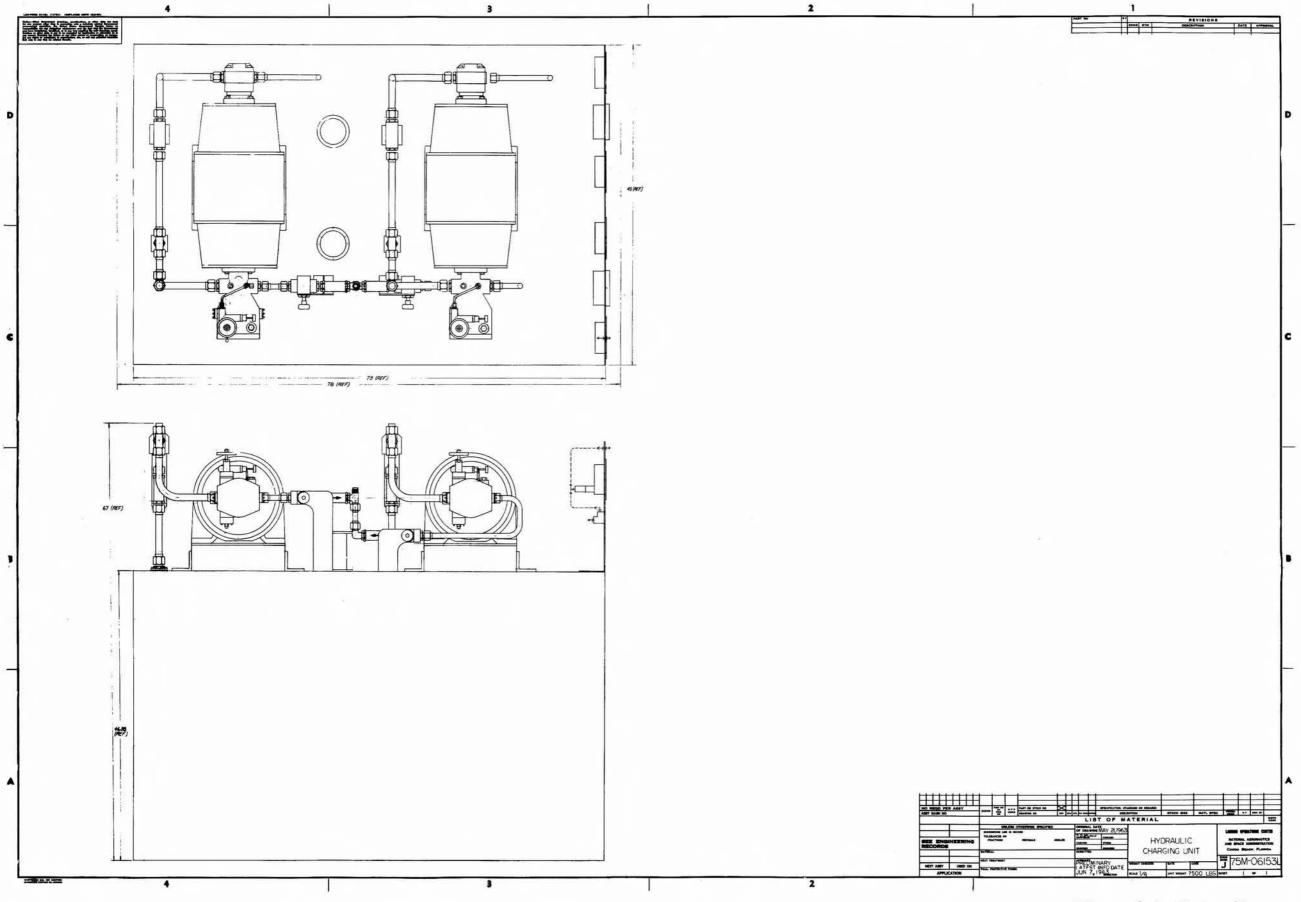


Figure 6-1. Hydraulic Charging Unit

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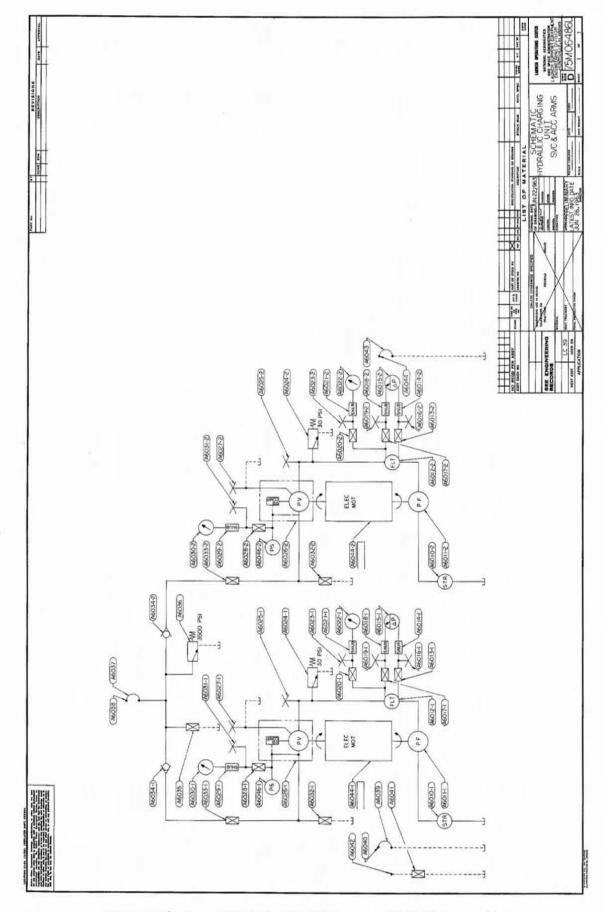
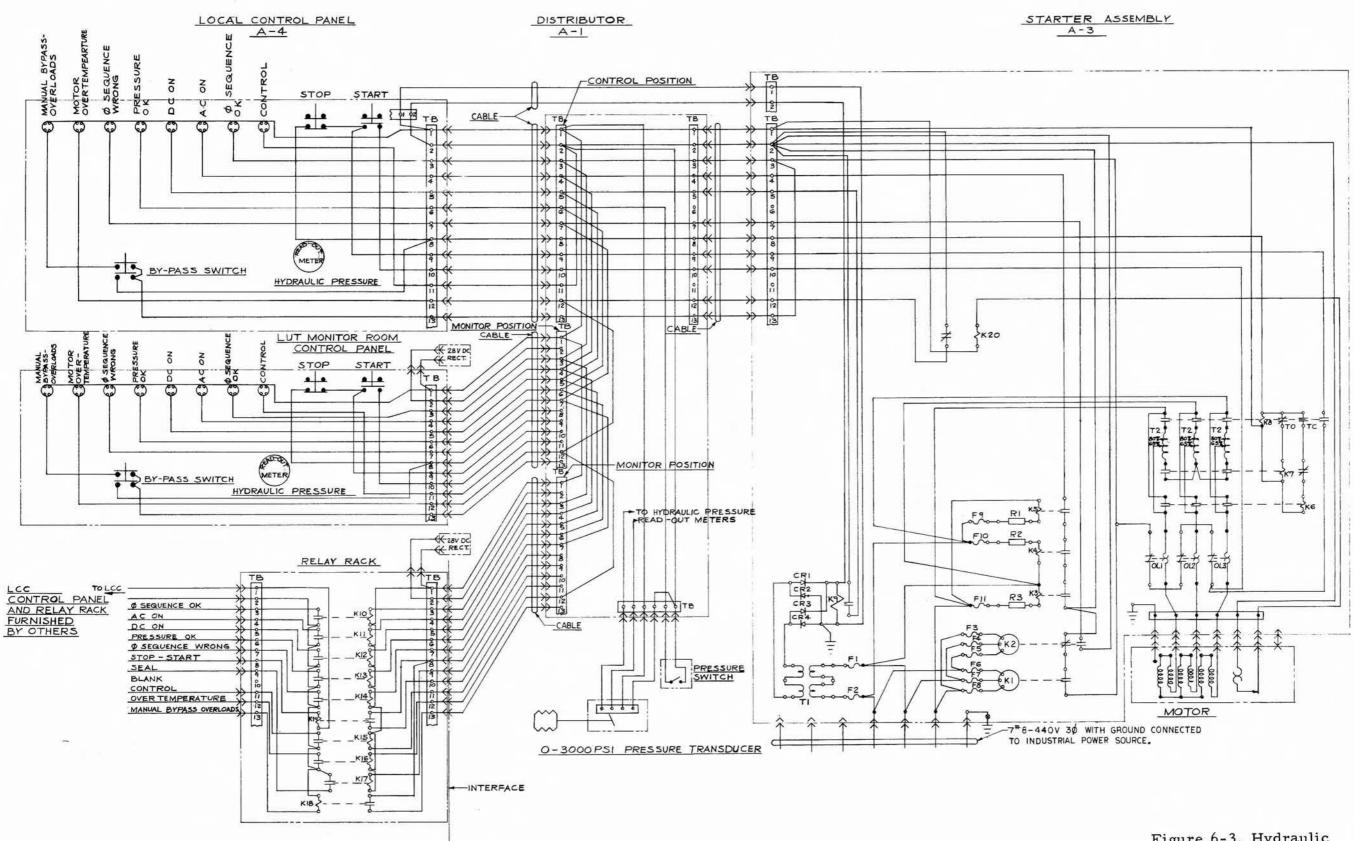


Figure 6-2. Hydraulic Charging Unit Schematic

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Figure 6-3. Hydraulic Charging Unit Electrical Schematic

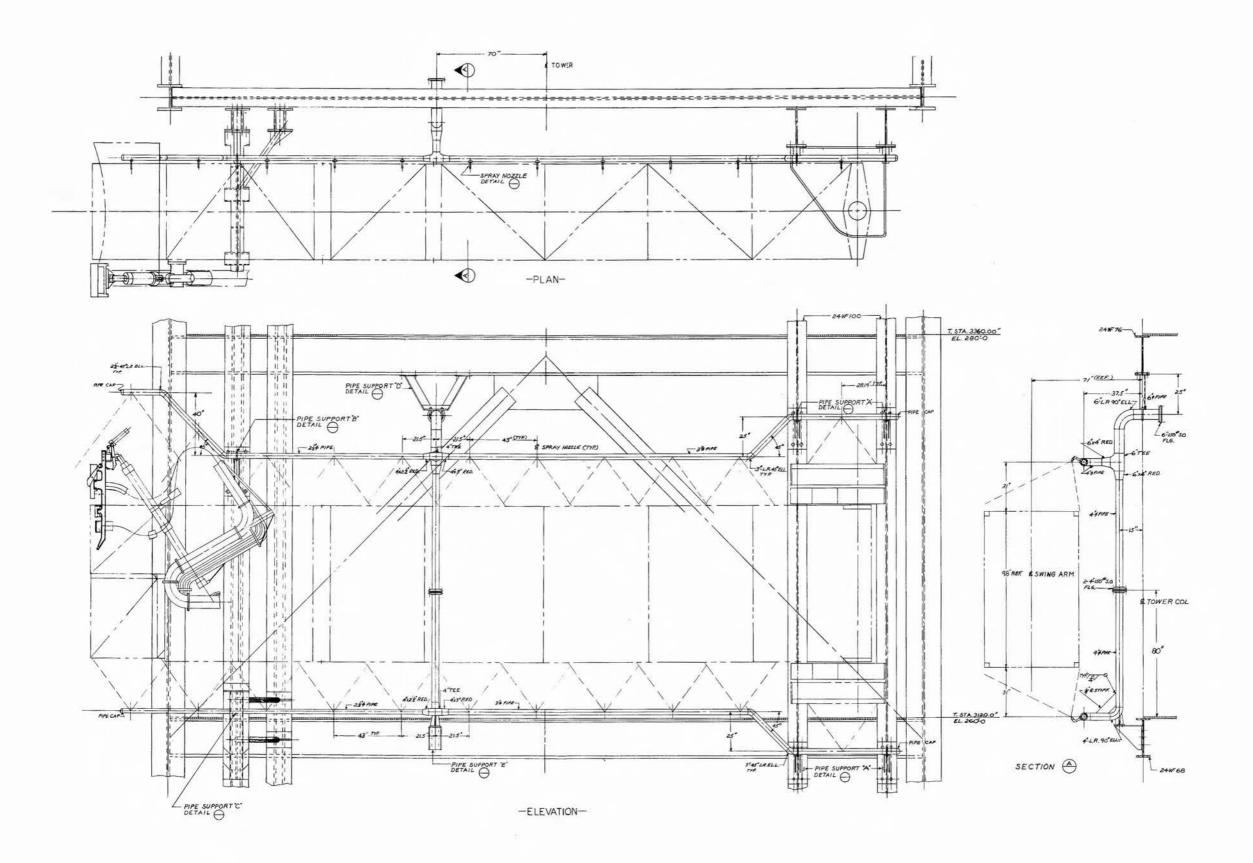


Figure 6-4. Water Quench Piping Layout

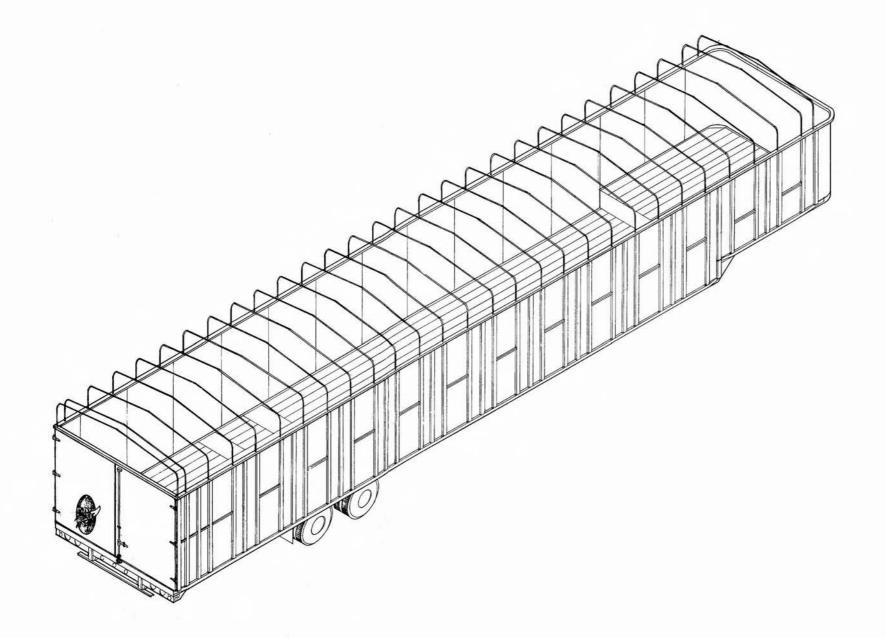
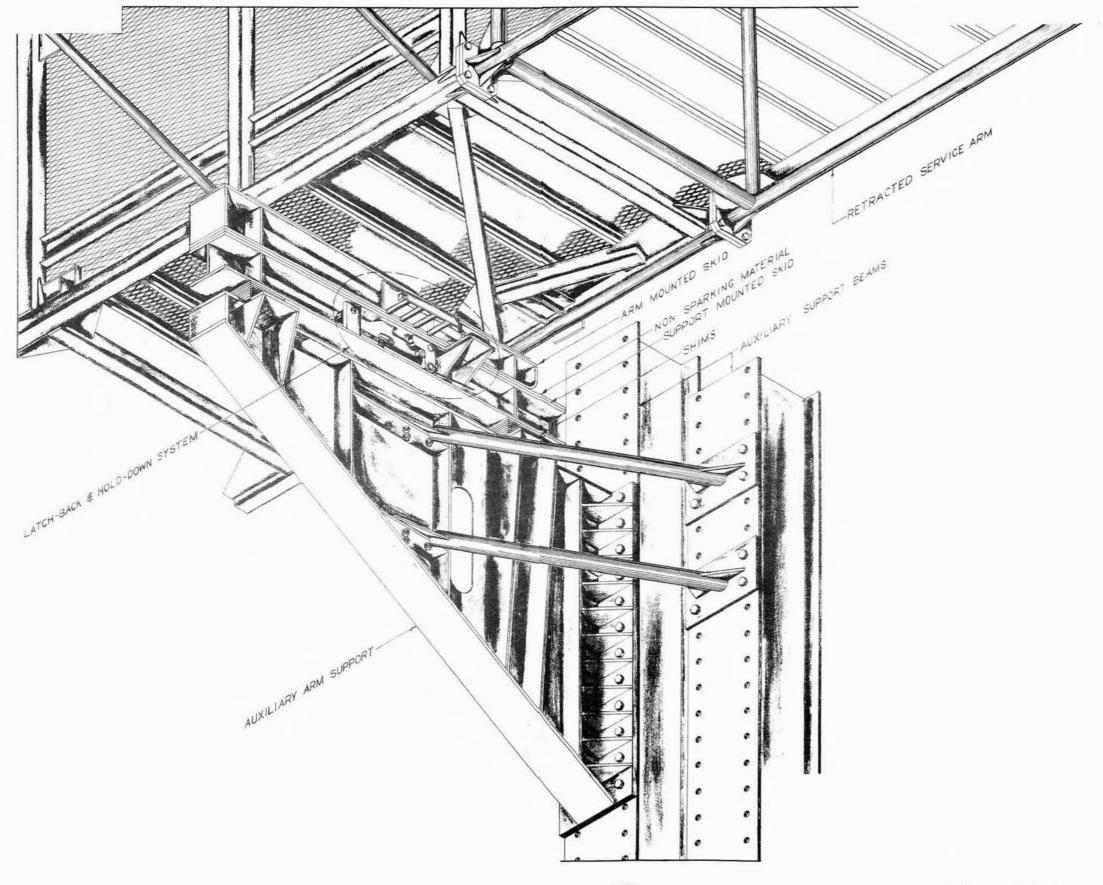
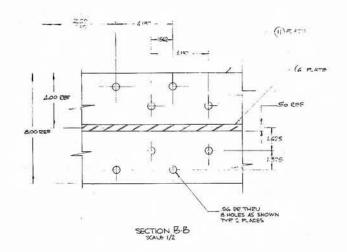


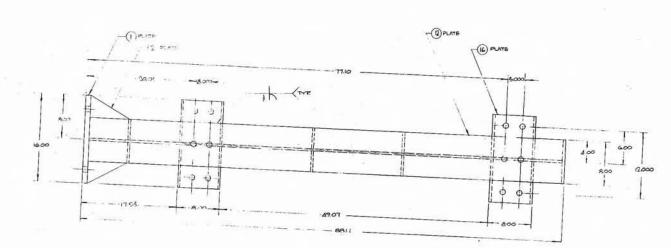
Figure 6-5. Service Arm Transportation Trailer

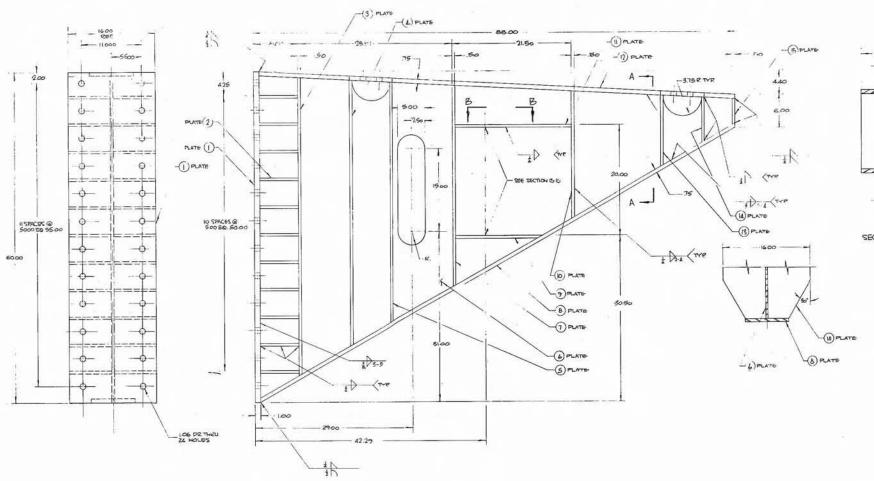
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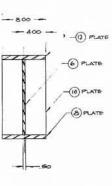
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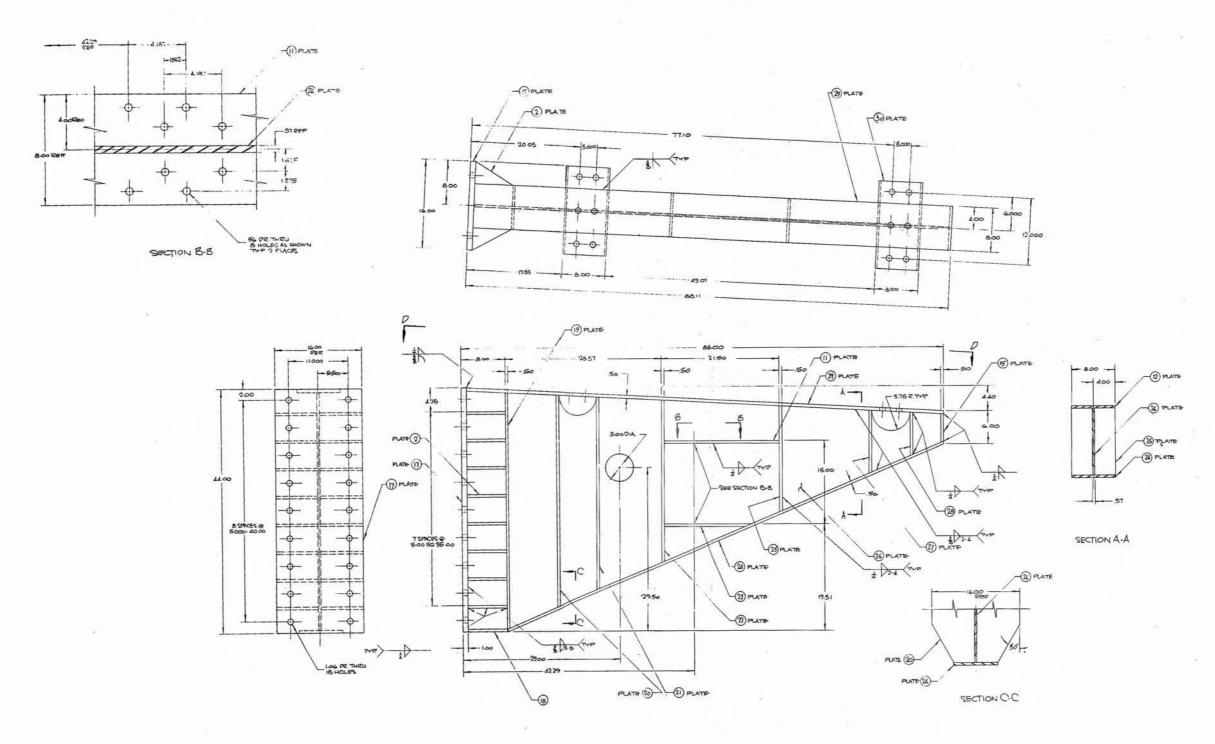






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Figure 6-7. Service Arm Support Bracket - Basic 243



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Figure 6-8. Service Arm Support Bracket S-IC INTERTANK

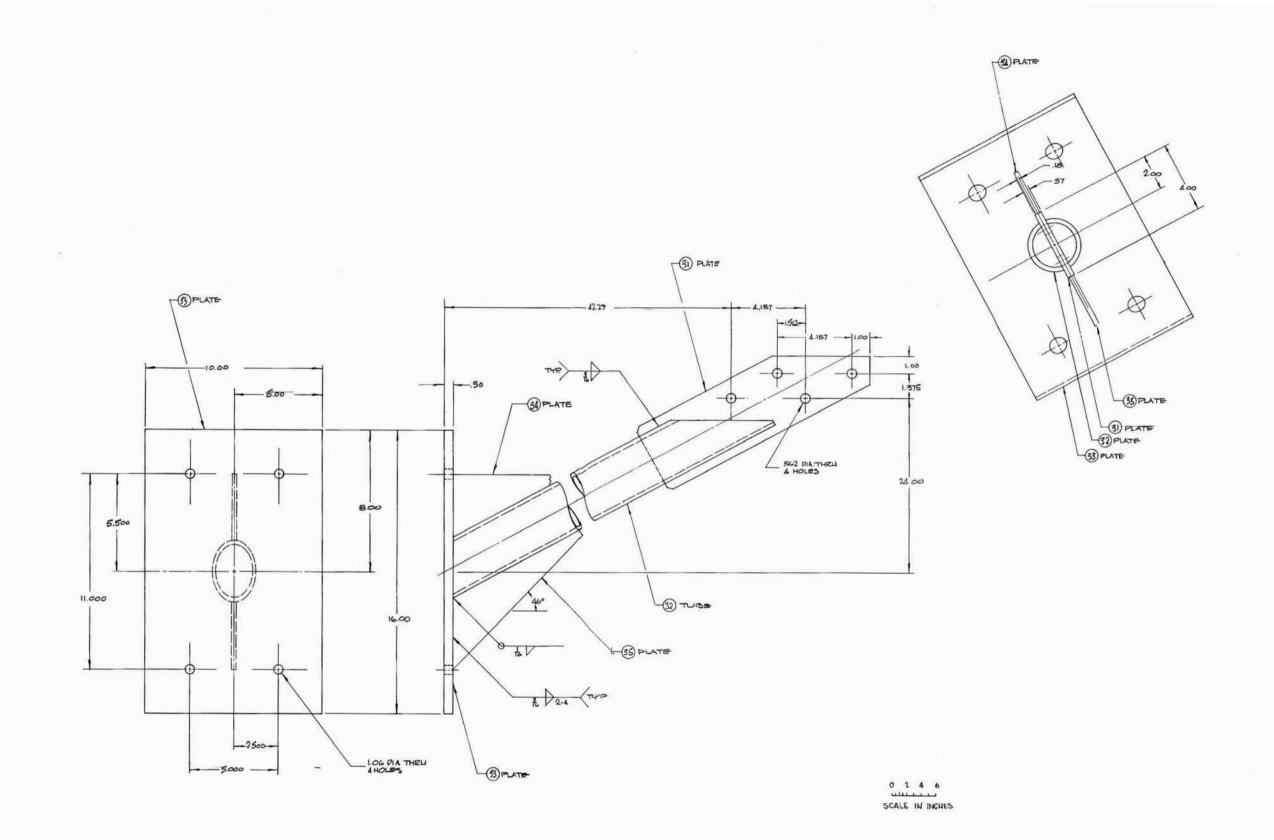
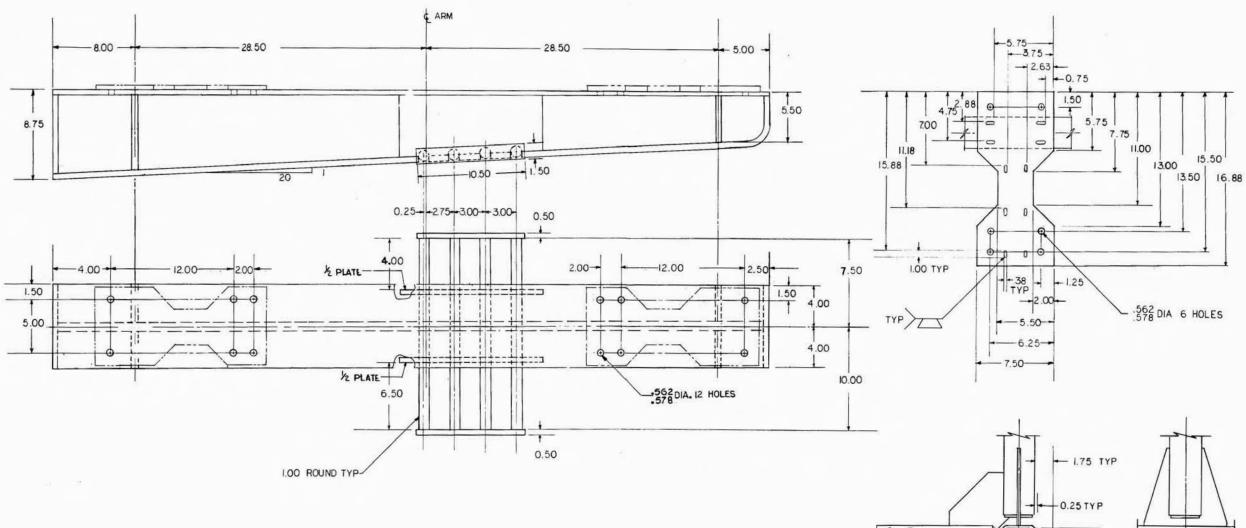


Figure 6-9. Arm Support Brace

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2.75

0.25

- 4.00-

16.88

0.25

SCALE IN INCHES

- 2.25

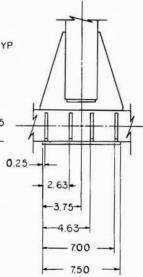


Figure 6-10. Service Arm Skid - Arm Half

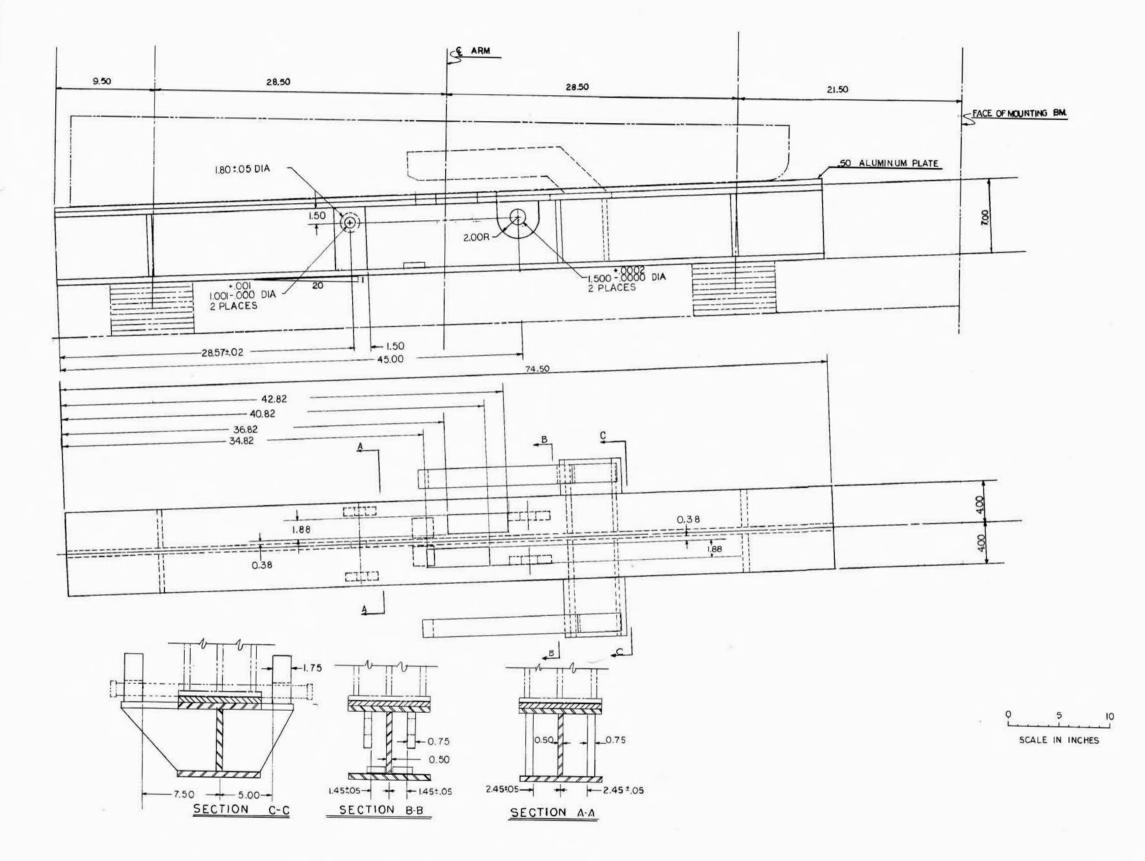
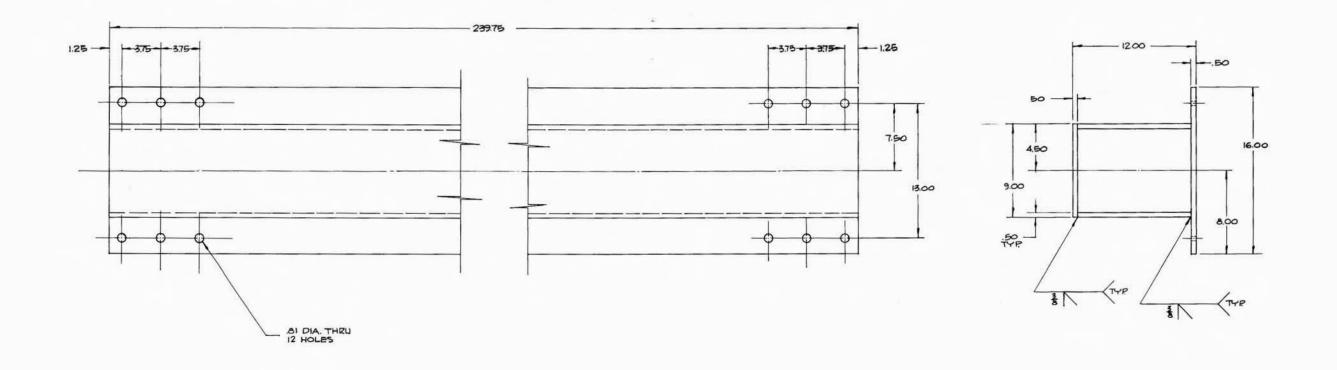
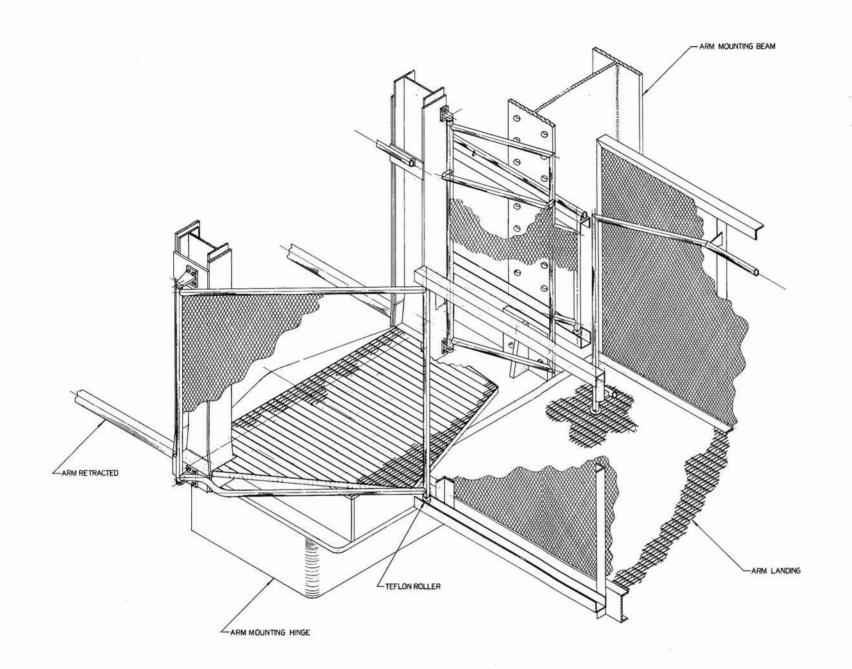


Figure 6-11. Service Arm Skid - Bracket Half 247







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SECTION VII INTERFACES

This section presents the location and definition of each interface affecting the service arms, access arm, and associated equipment. The design responsibility of each affected organization is delineated as the established interfaces are defined.

The interfaces are presented in four general paragraphs entitled:

Vehicle Interfaces Tower Interfaces Arming Tower Interfaces Vertical Assembly Building (VAB) Interfaces

Vehicle interfaces will in general define the design responsibilities of LOC and M-P&VE. Tower interfaces will define the responsibilities of various branches and sections with LOC. Arming Tower and VAB interfaces indicate the necessary structural modifications required on the extendable work platforms to provide adequate clearance and environmental control around the service and access arms.

7-1. VEHICLE INTERFACES

All points of contact and connection between the service arms and the vehicle are defined in this section. The areas include extension platform bumpers and couplers, propellant lines, pneumatic lines, air conditioning lines, electrical lines, and the interface between the umbilical carrier and the cylinder type withdrawal mechanism. The vehicle ground half connectors and the umbilical carriers are the responsibility of M-P&VE. The interfaces covered in this section are as follows:

a. <u>Propellant Lines</u>. These interfaces consist of a LOC furnished vacuum jacketed stainless steel flex line mating with a M-P&VE furnished coupling by means of a floating flange, gasket, and bolts supplied by LOC.

b. <u>Pneumatic Lines</u>. Metal or teflon flex hose furnished by LOC will interface with a M-P&VE supplied quick disconnect coupling by means of tube fittings or flanges. Gaskets and bolts will be furnished by LOC.

c. <u>Air Conditioning Lines</u>. A flexible air conditioning line supplied by LOC interfaces with a M-P&VE furnished vehicle ground half coupling. This interface is a flange or slip-on cuff and clamp. Gaskets, bolts and clamps will be furnished by LOC. d. <u>Electrical Lines</u>. A cable and connector with the pin insert supplied by LOC will mate with a M-P&VE furnished connector located on the vehicle and will mount in the M-P&VE furnished carriers.

e. <u>Umbilical Carrier</u>. The M-P&VE carrier which groups the small lines together in a common housing will have a bolted interface with the LOC withdrawal mechanism. This interface is shown in Figure 7-1. LOC will furnish the bolts.

f. Extension Platform Coupler. Personnel access extension platforms for the S-II FWD, S-IVB AFT, S-IVB FWD, and SM service arms will couple directly to the vehicle. This coupler is detailed in Figure 4-37. Permission for a hard point on the SM for this purpose has not yet been granted by the Manned Spacecraft Center.

g. Extension Platform Bumper. On all personnel access extension platforms, a bumper assembly (Figure 7-2) will be provided by LOC. This resilient bumper provides surface area for contact against the vehicle skin. The bumper is used in conjunction with the coupler discussed in paragraph f on the S-II FWD, S-IVB AFT, S-IVB FWD and SM service arms.

h. Cylinder-Type Withdrawal Mechanism Interface. As shown in Figure 7-1, LOC furnishes the complete assembly including the shock mount joint, small cylinder, springs, and driving linkage connected to the small cylinder. M-P&VE provides the driving linkage for the umbilical carrier cam-off lever. These two driving linkages are keyed to a common spline provided by LOC.

Following is a detailed explanation, by service arm, of the vehicle interfaces.

7-2. S-IC INTERTANK ARM

Two 8-inch stainless steel flex lines interface with M-P&VE vehicle ground half propellant devices (Figure A-1, Appendix A and Figure F-64, Appendix F) with raised face flanges. The extension platform interfaces with a bumper as shown in Figure 7-2.

7-3. S-IC FWD ARM

The extension platform bumper (Figure 7-2) will contact, but not couple with the vehicle. The lanyard withdrawal mechanism (Figures 4-21 and 4-22) will interface with the umbilical carrier on the cam-off lever. All of the service lines (Figures A-3 and A-4) interface at the umbilical carrier (Figure 7-3) as outlined in subparagraphs b through d.

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7-4. S-II AFT ARM

The bumper (Figure 7-2) does not couple to the vehicle. The LOC/ M-P&VE interface is at the ground half of the quick disconnect coupling. LOC furnishes flex line up to the coupling as well as the lanyard for the withdrawal mechanism. This lanyard will be connected to an attachment on the coupling.

7-5. S-II INTERMEDIATE ARM

As there is no personnel access into the vehicle from this arm, neither of the extension platforms contact the vehicle. The M-P&VE umbilical carrier, which will have a mounting pad as an interface, is shown in Figure 7-4. The LOC withdrawal mechanism will bolt to this mounting pad. The service lines (Figures A-7, A-8 and A-9) interface as outlined in subparagraphs a through d. The LOC/M-P&VE interface for the LO₂ fill and drain line is detailed in Figure 7-5. The LOC portion of this interface consists of the vacuum jacketed flex hose with the 150-pound raised face floating flange, bolts, and gasket. LOC also provides the retract and cam-off lanyards and the six small pneumatic and purge flex lines which interface at the coupling valve and flex hose. M-P&VE will supply the coupler, the butterfly shut-off valve, and the support bracket which interface with the LOC retract lanyard. The LH₂ fill and drain line, which is handled by a lanyard device (Figure 7-5) has an interface similar to the LO₂ connector. The LOC flex line interfaces with the M-P&VE butterfly valve by means of a 150-pound floating flange.

7-6. S-II FWD ARM

The extension platform will have a "hard" connection as well as a "soft" bumper. The individual umbilical carrier and extension platform interfaces are discussed in paragraph 7-1 b, c, d, f, g, and h.

7-7. S-IVB AFT ARM

The interfaces for the extension platform coupler and bumper are covered in paragraphs 7-1 f and g. All of the service lines are supported by the umbilical carrier which is handled by a cylinder type withdrawal mechanism. These LOC provided lines interface with M-P&VE supplied quick-disconnect couplings as outlined in paragraph 7-1 a, b, c, and d. The M-P&VE carrier (Figure 7-6) interfaces with the LOC withdrawal mechanism as detailed in paragraph 7-1 e and h.

7-8. S-IVB FWD ARM

There will be a "hard" and "soft" connection between the extension platform and the vehicle. Refer to paragraph 7-1 f and g. The S-IVB FWD and IU umbilical carriers are supported in a common frame (Figure 7-7). M-P&VE will provide an interface on this frame for the LOC cylinder type withdrawal mechanism. Details on this interface are given in paragraph 7-1 e and h. The service line data is covered in Figure A-14 and the interfaces in paragraph 7-1 b, c and d.

7-9. SERVICE MODULE ARM

Although there will be no personnel access into the vehicle from this arm, a coupler will be used, if a hard point can be provided. This coupler is detailed in Figure 4-37. The service line data is covered in Figures Al6 and Al7. The umbilical carrier (Figure 7-8) has an M-P&VE/ LOC interface on the cam-off lever where the LOC lanyard withdrawal mechanism attaches (Figure 4-27). The line interface is outlined in 7-1 b, c, and d.

7-10. COMMAND MODULE ACCESS ARM

There are two vehicle interfaces on this arm. The environmental room bumper(s) as presently considered will contact and track, but not couple with, the vehicle at the vehicle station 3716.555 field splice. An interface also exists between the environmental room seal and the edge of the access door.

7-11. TOWER INTERFACES

All interfaces discussed in this paragraph are those between service and access arms, with their associated equipment, and the LUT. All tower interfaces (Appendix D) are the responsibility of the Launch Support Equipment Engineering Division (LO-D) of LOC. The following branches and sections of the division are affected:

LO-DE -	Launch Equipment Branch
LO-DE5 -	Electrical Section
LO-DE3 -	Pneumatic Section
LO-DE4 -	Umbilical Arm Section
LO-DL -	Launch Transporter Systems Branch
LO-DL3 -	Structures Section
LO-DL5 -	Electrical Section
LO-DP3 -	Mechanical Section
LO-DP2 -	Cryogenics Section

The interfaces established delineate realms of responsibility between the branches and sections of LO-D.

7-12. LO-DE4/LO-DL INTERFACES

7-13. Service Arms and Command Module Access Arm. Each service arm will have two hinges (Figure 4-13) which bolt to the Launcher Umbilical Tower Mounting Beam. The tower elevation at the bottom of the lower chord of each service arm is as follows: S-IC INTERTANK - 666.000, S-IC FWD - 1391.000, S-II AFT - 1566.000, S-II INTERMEDIATE -1741.000, S-II FWD - 2391.000, S-IVB AFT - 2631.000, S-IVB FWD -3156.000, and SM - 3636.000 (Figure 2-2). Details of service arm hinge mounting is given in Appendix D. The Command Module Access Arm interfaces with the Launcher Umbilical Tower in a manner similar to the service arm interface. However, the mounting beam is located on the east face of the tower.

7-14. <u>Control Consoles</u>. Refer to Appendix D for details on the LUT interface with the consoles on tower levels 60, 120, 140, 160, 200, 220, 260, 300 and 320. Another interface exists in the LUT base where the hydraulic charging unit will be mounted.

7-15. <u>Arm Accessways</u>. There are nine accessways between the Launcher Umbilical Tower and the service amrs. The accessways are furnished by LO-DE4 and are detailed in Figure D-11, Appendix D.

7-16. <u>Arm Support, Beam, and Linear Shock Absorber</u>. The tower-mounted service arm skid, support and beam are furnished by LO-DE4. The linear shock absorber used to stop the arm is also furnished by LO-DE4. Refer to Figures D-1 through D-10 for locations at each level of the arm supports and linear shock absorbers.

7-17. <u>Tower Mounted Cylinder</u>. This mechanism is located on tower levels 140, 200, 220, 260, and 300 as shown in Figures D-4, D-6, D-7, D-8 and D-9. It is used in the service arm retraction system as outlined in paragraphs 4-46 and 4-50.

7-18. <u>Water Quench System</u>. A piping system for spraying each arm with water at the tower will be furnished by LO-DE4. This water quench system interfaces with the tower as detailed on the following figures in Appendix D:

S-IC INTERTANK arm - Figure D-2 S-IC FWD arm - Figure D-3 S-II AFT arm - Figure D-4 S-II INTERMEDIATE arm - Figure D-5 S-II FWD arm - Figure D-6 S-IVB AFT arm - Figure D-7 S-IVB FWD arm - Figure D-8 Service Module arm - Figure D-9 Command Module Access arm - Figure D-10

7-19. LO-DE4/LO-DL5 INTERFACES

7-20. <u>Control</u>. An interface will exist between the cables, distributors, and consoles furnished by LO-DE4 and the facility furnished by LO-DL5.

7-21. <u>Umbilical</u>. These are the LO-DE4 furnished shell size 40 cables which supply all electrical service to the vehicle. They are outlined in the following figures in Appendix A:

S-IC FWD Arm - Figure A-3 S-II INTERMEDIATE arm - Figures A-7 and A-8 S-II FWD arm - Figure A-10 S-IVB AFT arm - Figure A-12 S-IVB FWD arm - Figure A-14 Service Module arm - Figure A-16

The cables interface on the tower levels with an umbilical crossover distribution panel.

7-22. Lights and Receptacles. The cables which furnish service to the arm mounted lights and 120/208 receptacles interface with a lighting distributor panel on tower levels 60, 120, 140, 160, 200, 220, 260, 300, and 320. Refer to Appendix C, Figures C-32 and C-36 for further details.

7-23. Firing. LO-DE4 has an interface at tower levels 160, 200, 220, 260 and 300 in the lift-off and umbilical release switch circuitry. A cable from the in-flight service arms interfaces with a distribution panel located on the above mentioned tower levels. Another interface exists with the umbilical release circuitry for the preflight arms. These interfaces are located on tower levels 60, 120, 140, and 320 at distributor panels.

7-24. LO-DE4/LO-DP2 INTERFACES

The interfaces discussed here are between the cryogenic lines and the environmental lines on the service arms and access arm and the tower supply lines.

7-25. LO₂. There are three LO₂ fill lines on the service arms; the S-IC INTERTANK arm (two lines), the S-II INTERMEDIATE arm, and the S-IVB AFT arm. Each of these LO-DE4 lines has an interface with LO-DP2 furn-ished line. The S-IC INTERTANK service arm 8-inch ID lines will interface approximately as shown in Figure D-2, Appendix D. The S-II LO₂ fill line interface is shown in Figure D-3. The S-IVB LO₂ fill line interface is as shown in Figure D-6.

7-26. LH_2 . There are two LH_2 fill line interfaces. These are the 8-inch line at the S-II INTERMEDIATE service arm shown in Figure D-3, and the 6-inch ID line at the S-IVB AFT service arm as shown in Figure D-6.

7-27. $\underline{GH_2}$ Vent. There are two $\underline{GH_2}$ vent areas. One line is located at the S-II FWD service arm and interfaces with tower piping as shown in Figure D-6, and the other line is located at the S-IVB FWD service arm and interfaces as shown in Figure D-8 with the tower piping.

7-28. Environmental Control (LO-DPM). The interfaces discussed here are the connections between the service-arm-mounted and tower-mounted air conditioning and GN₂ purge lines; and between the access-arm-mounted and the tower-mounted lines. These flanged interfaces are located at the S-IC FWD, S-II INTERMEDIATE, S-II FWD, S-IVB AFT, S-IVB FWD, and Service Module arms as well as the access arm.

7-29. LO-DE4/LO-DE3 INTERFACES

The pneumatic section will furnish pneumatics for the vehicle, the umbilical carrier withdrawal mechanisms, and the hydraulic charging unit.

7-30. Service Arm Pneumatics. LO-DE4 will receive at the various tower levels the necessary pressurized air and GN_2 for operation of the pneumatic equipment on the service arms and access arm.

7-31. <u>Hydraulic Charging Unit</u>. There will be several hydraulic interface areas on the tower. One is located in the base of the LUT while the other is located at the consoles on the various levels. LO-DE3 will supply the piping from the LUT up to the control consoles.

7-32. Vehicle Pneumatics. LO-DE4 will interface with LO-DE3 at the tower levels for pneumatic service to the vehicle.

7-33. Vehicle Conditioning Fluids. LO-DE3 will furnish LO-DE4 the water/glycol for the Service Module arm and the water/methanol for the S-IVB FWD service arm from the supply units mounted on tower levels 260 and 300.

7-34. VERTICAL ASSEMBLY BUILDING INTERFACES

As the stages are assembled in the VAB, the respective service arm will be extended. As the service arms are extended, the VAB work platforms will be positioned. There will be provision in the work platforms for openings to accommodate the service arms and associated equipment. These cutouts are defined by the figures in E-2, Appendix E. A recommended universal clearance envelope for the service arm cutout in the VAB wall is detailed in Figure E-4 so that LO-DE4 may provide a standardized diaphragm for environmentally closing the cutout.

7-35. ARMING TOWER INTERFACES

The Command Module Access arm will not be extended until the LUT has been positioned at the Firing Site. Openings or cutouts will be provided in the arming tower platforms in order to accommodate the service and access arms which will be in the extended position. These opening requirements are outlined in Figures E-5 and E-6, Appendix E.

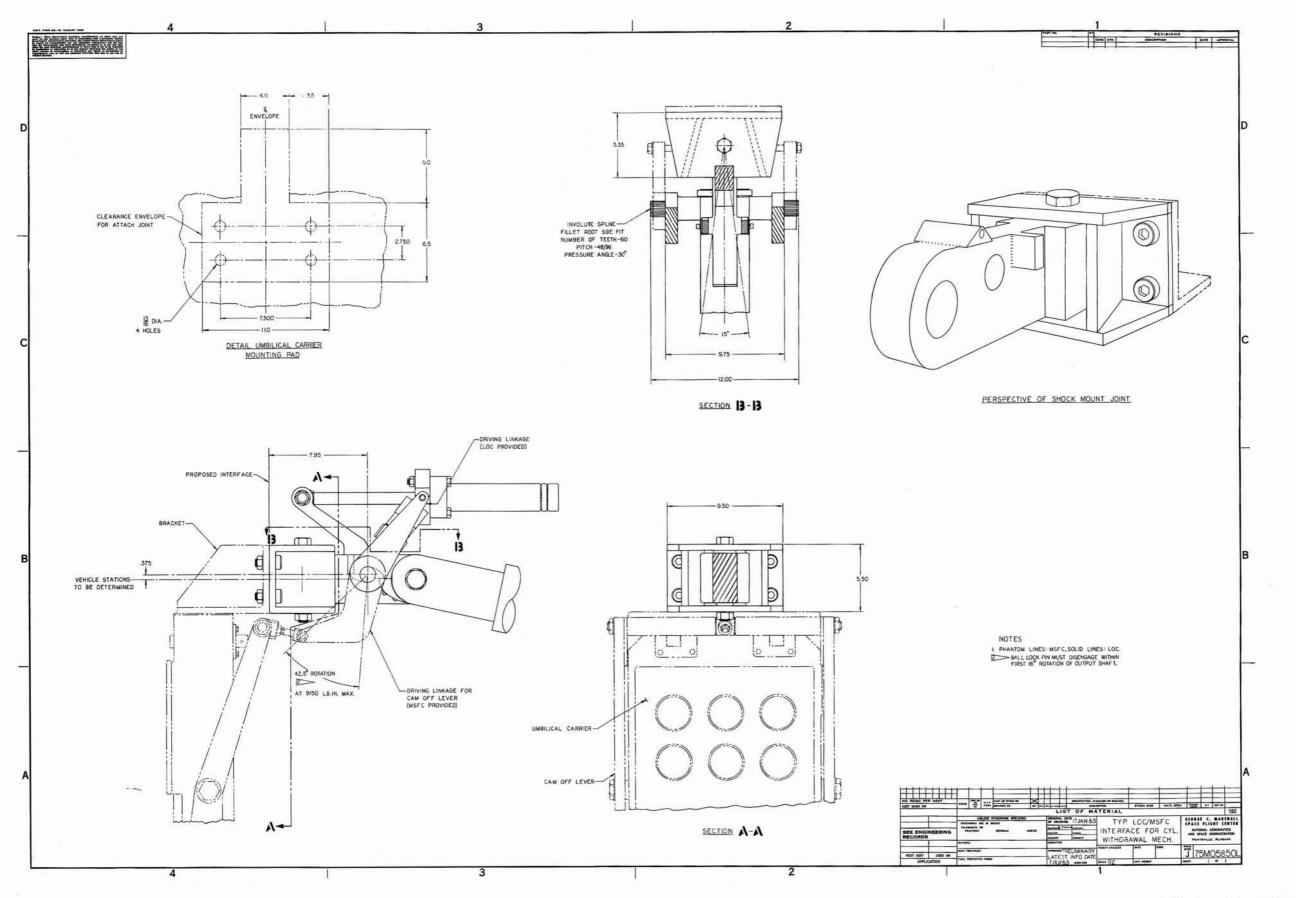
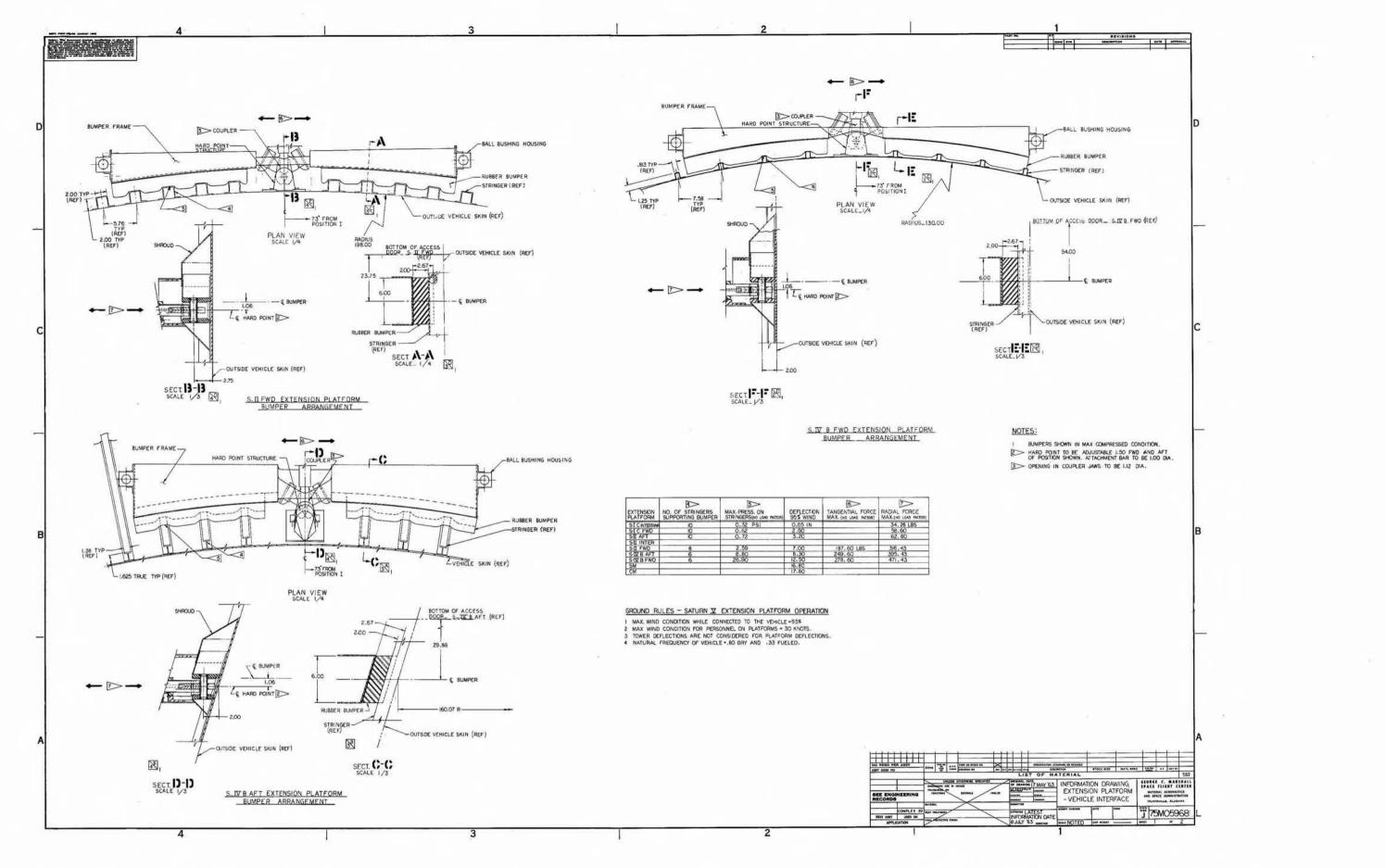
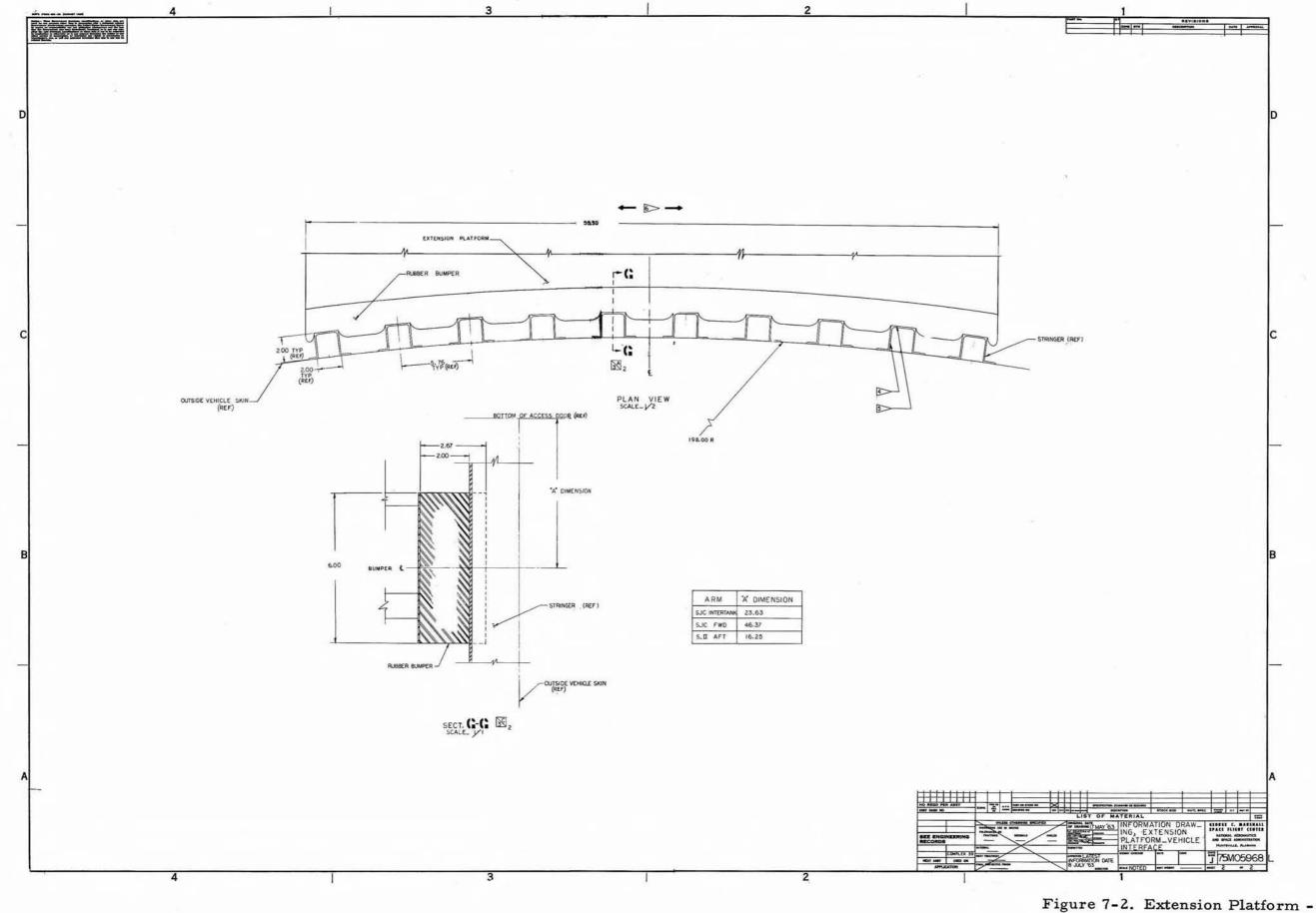


Figure 7-1. Cylinder-Type Withdrawal Mechanism Interface 259



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Figure 7-2. Extension Platform - Vehicle Interface (Sheet 1 of 2)



Vehicle Interface (Sheet 2 of 2)

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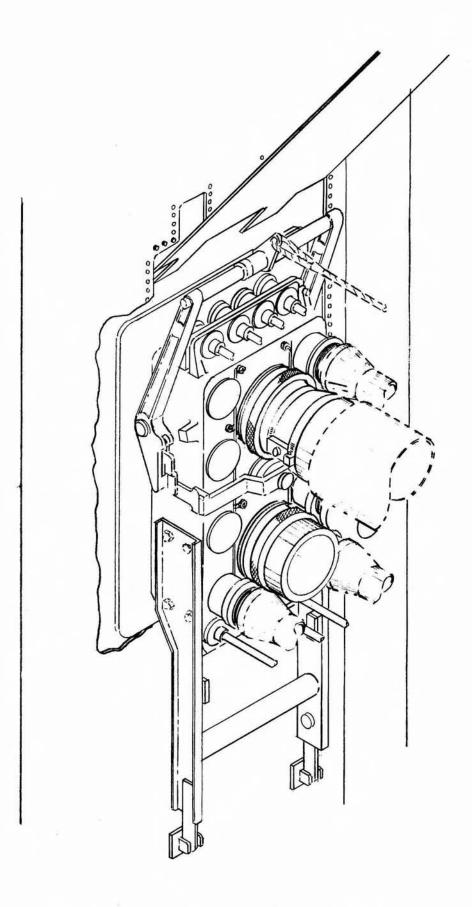


Figure 7-3. S-IC FWD Umbilical Carrier

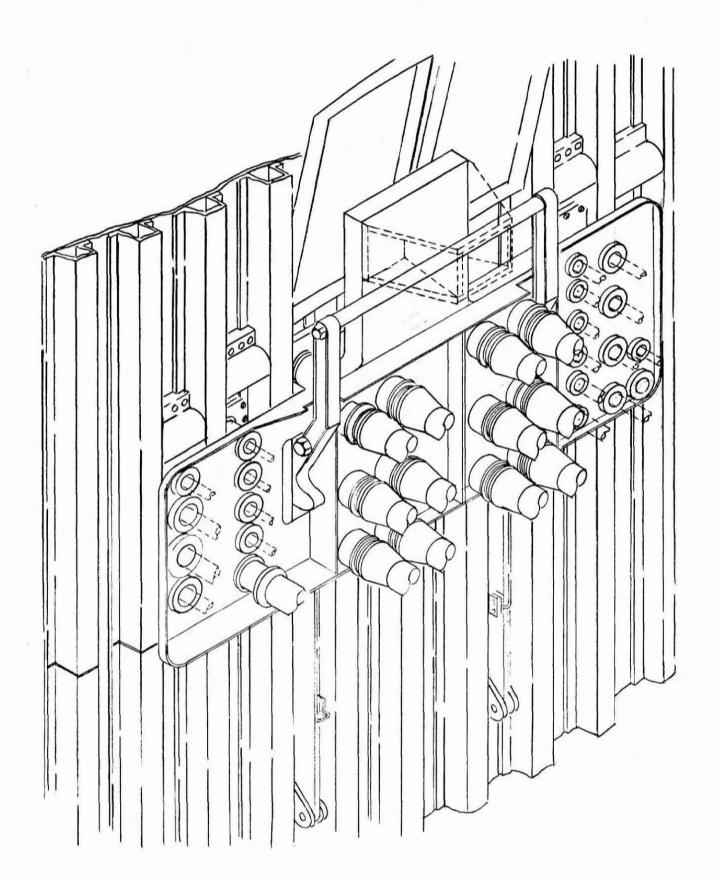


Figure 7-4. S-II INTERMEDIATE Umbilical Carrier

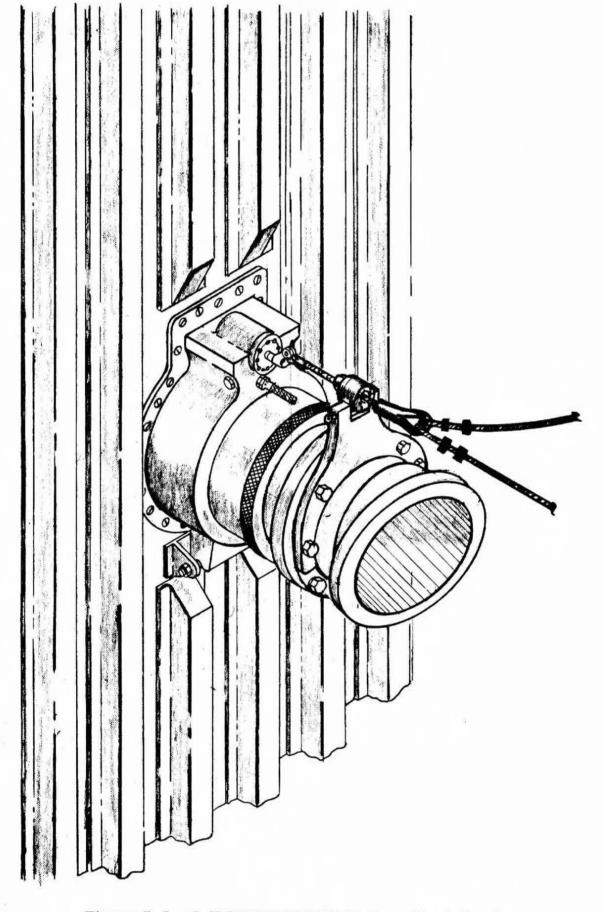


Figure 7-5. S-II INTERMEDIATE Propellant Coupler

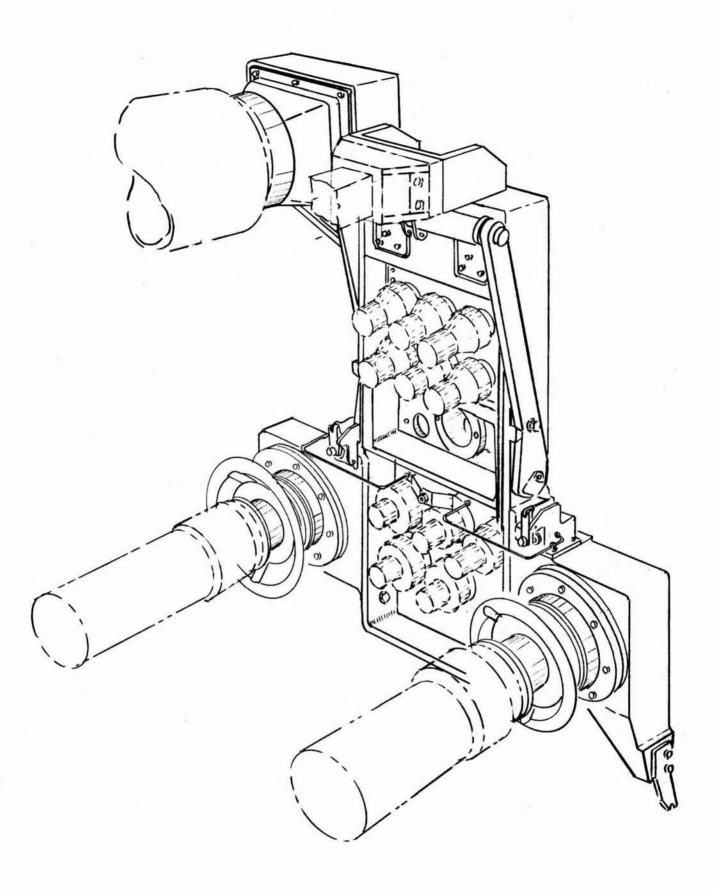
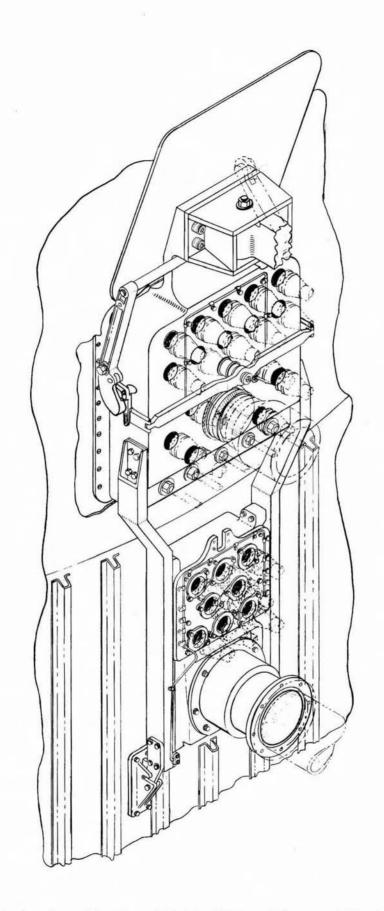
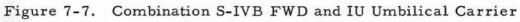
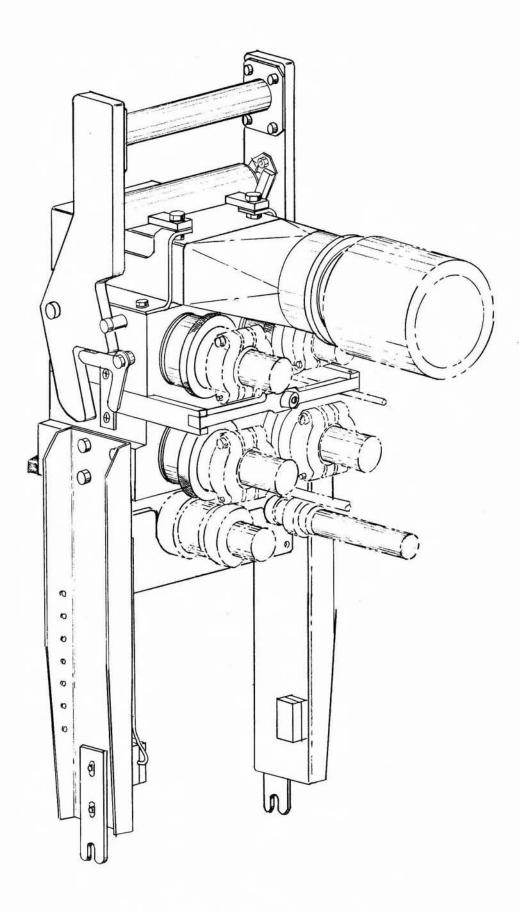


Figure 7-6. S-IVB AFT Umbilical Carrier





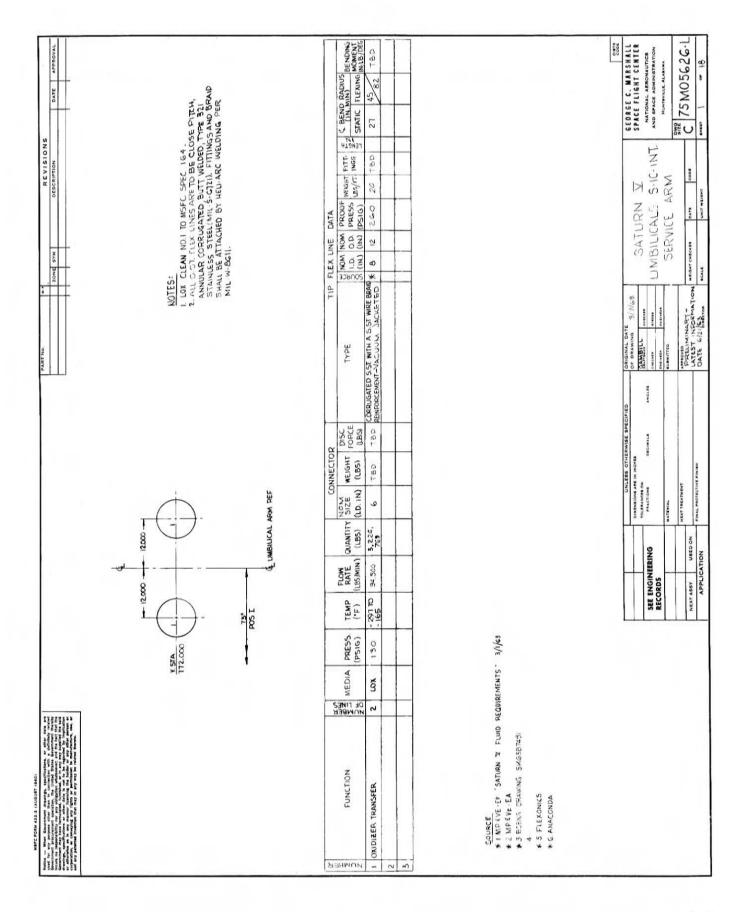




APPENDIX A

Preface

Appendix A contains tabular data on the umbilical service lines, such as specification, insulation, size, type material, source, and bend radii.



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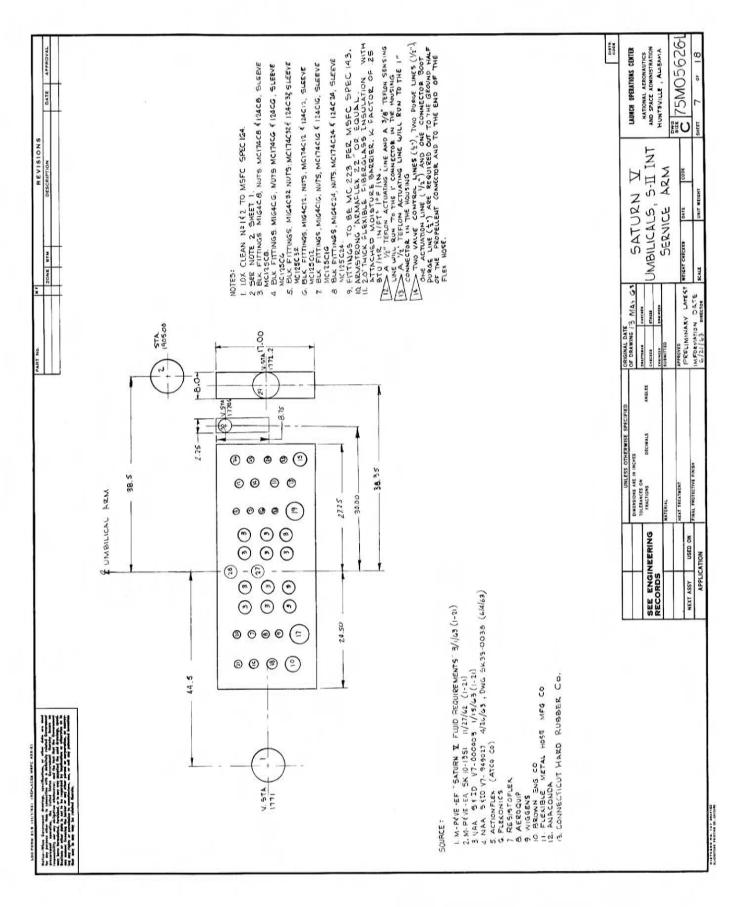
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25 REGULATION PRESSURE I GN.	ŝN.	1000	TBP		TBD	.50	.42	40 780		8.	TBO	2000 T	180	-	A/N		
-	GNL	50	180	•	180	1.00	1.34	40 TBO		1.00	0 780	18	180	-	A/N		
	GNI	2	AMB	180	N/A	50	.42	40 SAME AS 1	NUMBER 4	2 · 50	65. 0	4	· 15	-		4.75	
-	GNI	750	AMB	STATIC	NIN	.50	.42	40 SAME AS NUMBER 4	NUMBER 4	8 .50	59	500	15 Note9		N/A A	4.75	
1	2	2.5 8	80-250	500	NA	8 ×17	TBD	TBD REF DRAWING	NG 751/05693L	5 4.00	-	20 7	TBD 780	-	N A	21	
30 A/C INSTRUMENT COOLING & I GIR	A.R.	9	70-150	25		2%x8%	180 1	TED REF DRAWING	ING 75MO5690L	5 400	00	20 1	1.67 TBP	180	×/1	4	TBD
									* APPROXIMATE L	LENGTH		12 FT.					CODE
					DIMENSIONS	UNLESS OTHERWISE SPECIFIED IS ARE IN INCHES	HERWISE	SPECIFIED	OF DRAWING TO MAY 63	0	CATUDAI	INC.	Þ	-	AUNCH OPE	LAUNCH OPERATIONS CENTER	TER
		18	SEE ENGINEERING	IEERING	TOLERANCE	TOLERANCES ON FRACTIONS DE	DECIMALS	ANGLES	PAUTHAMA CORCUTA CORCUTA TIMER	AM	CIMARII ICALS	7	S-IT INT	-	NATIONAL ND SPACE	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	s
					WATEPOLAL				Distantia Subarreto	S	SERVICE		ARM		HUNTSVILLE	E ALABAMA	VV.
		1*	NEXT ASSY	USED ON	HEAT TREATMENT	Lin I			PRELIMINARY LATEST	WEIGHT CHECKED	CKER	DATE	CODE		75N	75M056261	261
			APPLICATION	TION	FINAL PROTECTIVE FINISH	TINE FINISH				SCALE		ONIT WEIGHT		SHEET	ď	or 18	Γ

responses and the set of the second s										ZONE	7	DESCRI	DESCRIPTION	T	DATE AFFROVAL
and an interview of the second se				Ű	CONTINUED	FROM	SHEET 7								
-	HARD LINE D	DATA					HINGED JOINT	OR BELLOWS		DATA		FLEX HOSE	SE AT	HINGE P	POINT
TYPE	SPECIFICATION	אוכגאנגא אוכגאנגא	INSULATION B	(IN) TENETH SE	END FITTINGS	SOURCE	AVE	SPECIFICATION	(134) (134) MEIGHT ONIT	(NI)	SOURCE	TYRE SHOT	THOISUL	Source	RADIUS REA
T60 14	TBO	180 4.3		90	BAYONET		EXPANSION JOINT	TBD	6	TBD TF	TBD		NONEE 20	156	45 82 600
T80 14	TBD	TBO V.J.		TBO	BAYONET		TNIOC NOISNNAX3	TBD	180 1	T80 T	180	V.J. S.ST. BU FLEX HOSE	DAVIDNES 20	751	45 82 600
SAME AS Nº 3	14	MA THERM	1		10-323C40-59	BENOIX - TOWE	E N/A	M/M	N/A	N/N N/N		SAME ASN'SM	SAME 2 AS	TBD ID	15 T60
TYPE 316	05200	DIS NONE	1	8).	SEE NOTE			-	-		•	TEFLON WISE	SEE .15 Note9 .15	- 87	4.75
5 215 1			T	13	-							-	21. 4	-	4
		640		.50									.25		6.5
	,	044		.50				•	•			-	.25	-	57
TYPE 316	Duc	_	1. Such	8	SEE None		M/A	NIA	MN	N/N N/N	×	TEFLON W/	51.	~~0	4.75
TYPE 316 5CH 405	8020WSL4	133 566		1 6.8			EXPANSION JOINT	TBD		-	00	5.57	1.5	یے۔	SI
101.5 TYPE 316, SCH 805		20 566	0 0	3.63			EXPANSION JOINT	-	-		-	-	4.81	-	000
1 10 TYPE 314	OWG	049 SEE	SEE	3	Sce Nore		EXPANSION JOINT						2.39		8.5
5.51, 108106		NGNE	NE C	-	1 -2		EXPANSION JOINT						.86		0
		NONE	NE		-		EXPANSION JOINT		-			-	1.35	-	12
		ON SEE	5.0.3	20	SEE Note		EXPANSION JOINT	160	180	T80 T80	٥	5.51.	.86	920	ō
		TBO NONE	2		SEE Nore		NA			A/N	Ψ.	TBD	180		TBD
-		670	5	20	See Note		EXPANSION JOINT	TBD	180	180 180	0	5,51,	1.80	922	12
TYPE 314	DWG	083			See Note		EXPANSION JOINT	780	T80	TB0 TB0	a	5, ST,	.86	922	10
18/1.00 5 5T 0105 113	0/000000	.133		1.68			11/14	NIA	¥n	4 V/M	H/4	TBD	TBD		TBD
DELETED							-	-	-						
TYPE 310 S.ST TURING	Durgenge	250,	-	8	See Nore							180	160		TBD
DELETED														1	
Deleted															
W											_				
SIST TURING	ATSM05698	.035	İ	18	See 3					_	_	T80	TBD	-	180
-	-	SEC.	-	8	SEE Nore					-		160	780		180
26.1.00		640'		.50	SEE Note					_		160	TBD		180
		.035	-	18	SEE Note Na 3							S,ST. BRAD	. 15	200	4.75
TYPE 314	DWG M75M05698	D35 NONE		18	See Note							TEFLON WI SI	SEE Nore9, 15	8	4.75
ALUM. SHEET DUCT		ON SEE	2 11 2	5.5	CLAMP		•	•	-	•	-	FIBERGUASS NC	SEE 6.00	s e	12
4 ALUM SHEET DUCT		.04 4"(2	4"(2× 11)	.5 780	CLAMP		MIN	N/A	MA	N/A	N/N	SILICONE/ SEE	EE 1.67	TB0 5	6 TBD
															CODE
						DIMENSIONS AL	INLESS OTHERWISE SPECIFIED RE IN INCHES	OF DRAWING	TE	63	SATI	A N D N D		LAUNCH (LAUNCH OPERATIONS CENTER
				SEE	ENGINEER	0.52	ON DECIMALS AND	ANGLES DAATTERAK			UMBILICALS	an mad	5-TINT	AND SPAC	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
				RECC	RECORDS			ENGINEER	11and		SERVICE	•	ARM	HUNTS VILLE	LLE , ALABAMA
					╢	HEAT TREATMENT		APPROVED PRELIMINARY LATEST	1 1 14	-	WEIGHT CHECKER	Γ	CODE	15	75M05626-L
				NEXT ASSY	ASSY USED ON	D ON FINAL PROTECTIVE FINISH	VE FINISH	IMFORMA	Nol	_					0

and the second state of th	1										1	AUNUS STR		Î	DESCRIPTION	NOI		DATE	APPROVAL
			+		- 38.65		1				H	Ħ	\parallel				Ħ		
and any paintee buries for any 1s any up to stand farms.			ł	- 12.95 -															
	4	70 6	69 6	68 67	7 66	57 .0	- i.	.97											
	5	Г-	н- с-	L				<u> </u>											
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		54	ÞĢ			@	-:-		- 5.00		I. LOX CL	EAN	1-5 \$5	4 01 6-	ISFC	SPEC	64	-	
		+)			 			7	(ERANE)	C- ALL S-SI- FLEX. LINES ANE 10 DE CUUSS FINCH, RANNULAK CORRUCATED BUTT WEDED, TYPE 221 STAINLESS STEEL MINI - S- COTYAL FITTINGE & R RAMIN SHALL BE ATTANDED BY	ATED	BUTT!	NELDED,	TYPE 3	VISI STA	IN LESS S	TEEL	
					6		-(2		HELL-AR	IC WE	DING	PER MIL	O M	1	5		
	4			۵	þ.	\$	9 9-	8	5.00		3. FITINGS FOR Nº 2345 (4.9.0, TO BE PER MC 223, MSF C SPEC 143. 4. BLX FITING MIG4CE NUTS MCIACA (1240A GARVE)	45 F0	R Nº3	2,34558.5	TOT OF	SE PER I	NC 223	, MSF	J
			 -	ц Т	-		<u>.</u>	7			MCI25CB	1/2" - 1/2" - 1/2" -	EFLON	ACI25C8 > A 1/2" TEELON ACTUATING LIN SENSING LINE WILL RUN TO THE THE HOUSING	N LINE	AND A	CI25Ce > A 1/2" TEFLON ACTUATING LINE AND A 3/6" TEFLON SENSING HUE KUN FO THE 1' CONNECTOR IN THE LINGKING	non r	
٤							Š	CONNECTOR	a		TIP	FLEX	FLEX LINE DATA	ATA					
FUNCTION	NBEB	MEDIA	PRESS			7	Size	WEIGHT F	DISC	TYPE		108 CE	NOM NOM PROOF	35	WEIGHT	HISH		RADIUS	BENDING
			(PSI6)	E 1	(LBS/MIN)	-	(11)	(185)		CORRUGATED S.ST. WITH S.ST. WIRE BRAID	- 1		a s		1 Ja	¥	STATIC FLEXING	FLEXING	N-B/DEG
I FUEL IANK YENI		240	12	G74	2.42	VIN	<u> </u>			EINFORCEMENT, REF. RE45 CP	NIDE RDAID	1.9	_	3		_		1	
2 FUEL TANK PRESSURIZATION (PURGE D		GHL	3300	-250°	8	3900	-00	*		REINFORCEMENT SOL MILE BOOK	NINE ONNI	u J	1.000185	6600	3.0	180	4	15	•
3 LH2 TANK PRESSURE SWITCH & VENT	-	μĘ	A3 to 223	AMB	STATIC	N/A	375.	38	0 1	CHUN JUBE WITH 5.51. "			5 .47	8		Ner	∀ / N	4.00	
4 LH2 TANK VENT AND VALVE		He	750	AMB	STATIC	N/N	50	.42	40	SAME AS NO.3		8 50	5	1500	5.	a la	N/A	4.75	
5 REG CHECKON	-	GNL	1000	Teo	180	180	8	.42	40	SAME AS NO 3		20.20	.59	2000	5	N.	A/A	4.75	
6 ELECTRICAL		NA	N/A	A/A	N/A	N/A	SH 40	S"EA	180 6	60 WIRE, REF. 75M02943		N/N 01	2	V/N	N	A/A	12	15	
7 ELECTRICAL EQUIPHENT	-	AIR GN ₁	2	70-150	52	A/A	67)			REF DWG 75M05690-L		4	2	20	1.67		N/N	e	
8 Deceted	-												-		-	-			
	1	GNt	2	AMB	180	Ala	.50	.42	40	SAME AS NO 3		8 .50	-23	4	. 15	減	MA	4.75	-
10 UNBILICAL HOUSING	-	GN,	750	AMB	STATIC	MIN	.50	.42	40	SAME AS No 3		78 .50	-59	1 Soo	.15	會議	AIN	475	180
												-			1				
										*	APPROXIMATE	AATE	LENGTH	- 10	Ŀ		i) Q		
SOURCE			9																
1. MP (VE-EF ' SATURN I FLUID REQUIREMENTS ' 3/1/63 (D REAL	IREMENT	5. 3/1/63	(1-8)															
	(6/63).	SK-33-	9) 6800.	(67)+1															
4. FLEXIBLE METAL HUDE MAG CO. 5. FLEXONICS	MFG	9																	ELLIO Della
6. ANACONDA					$\left \right $	I.	TINIT	UNLESS OTHERWISE SP 6 ANT IN INCHER	AWISE SPE	CIFIED ORIGINAL DATE	317/43		i i				51015	GEORGE C. MARSHALL	SHALL
7. AEROQUIP B. RESISTOFI FX				1	CINEEDIA	Τ	TOLERANCES ON	8	TOWNER	1	Centres		SAL	SALURN			SPACE	SFACE FLIGHI CERTEN NATIONAL AEROMAUTICE	AUTOR
9. WIGGENS				RECO	RECORDS							WD	UMBILICALS	ALS S	See. 11	FWD	WAS DAY	BPACE ADMINISTRA	TRATION
II. ACTO Co					-	*	WATENDAL						SERVICE	CE AKM	¥		DAG		
				NEXT ASSY		NOR				PREUMINARY LATEST INFORMATION	RYATION	NEIGHT CHECKEN	ROOM	DATE	14000		_	M050	15M05626-L
				*	APPLICATION		THE PROTECTION			DATE - 4/2/	teros	BCALE		UNIT WEL	ţ		C/ LINKS	8	18

ROVAL	Γ	587-NI 111 24000	199			F	_					DBT		BITR BITR FICS	JG.	1.070
dav	DATA	BEN D RADIUS	67 67	151	4.00	4.75	4,75	SI	ي		1.1	4.70			ALABA	Sin
DATE		613												LUNICH OFENTIONS EDITER NATIONAL AERONATICS	HUNTSVILLE, ALABAMA	NIVIO.
	POINT FLEX HOSE	(IN) (IN)	7*1	0 440	3 ~ 00	0 ~ 00	80.4	10	1	~	10.01	00				C
z	ч Г Ы	(SBT	1 50	30	-12	.	.15	2	1.67		<u>n</u>	-12				Γ
DESCRIPTION	HOd	SONILL	0	160	SEE 12	-	SEE Note3	A/M	CLIMP	56E	Ten y	2°		Δ 5.IFWD	ARM	CODE
8	HINGE	TYPE	S 51	5.51	TEFLON W	++	LON WI	A6 45 46	FIBERGLASS	M NOT	SSTBRAID VOT	T.BRAID		N ST	J.	DATE
	-	F	0		TEC	'n	1E1 5.5	A.S.	FIB	TEI	S	5.6	-	SATURN	SERVICE	8
WAS	IA	Source			A							N/A		SATURN	SE	WEIGHT CHECKER
ZONE	DATA		5	JWI	N/A							_				
	TNIOL	LIN) ENGTH SE NIT NIT	081 00	TB0 TB0	A/N A		-	-		-	-	N/A N/A	-	D MAY 63	Dent	LATES!
	1000	TIN TIN	TBD	18	N/N				H	•	- 3	z	-	Note of the second s		NARY
	FLEX HINGED	SPECIFICATION	0	00	N/N		_			,	-	N/A		ORIGINAL DE DRAMA	ENGINEED ENGINEER	PRELIN
	FLEX	SPECI	TBO	T80	2											
	OR		TM	TUT												
	BELLOWS	R.	N JOI	07 NO	N/N							N/A		5145 1945		
	100	TYPE	EXPANSION JOINT	EXPANSION JOINT	2						5	z		UNLESS OTHERWISE SPECIFI DIMLESS OTHERWISE SPECIFI		
	SHEET	-	EXE	EX	+			JEE			+	-	-	UNLES UNLES CES A ME IN	THENT	
	FROM	Source						BENDEX - TOMER						Sector 1	MATERIAL. HEAT THEATMENT	
		20						BEND								
	CONTINUED	END	FLANGE	FLANGE		SEE 4	4	3640-53	CLAMP		Nore 4	1£ 4				
	CONT		_		36	E S	SEE	0-32	5 3	2	N SP	2 Z	-			
	NS S	HI9N HI9N) Tan	1.68	£1.	.18	81.	-			81.	-18 TBD	-			
		ATION	2 10		n		-		F1866-							
	A	SPECIFICATION		133 SEE	S NONE 5		~		4"OF FIBER-			S NONE				
	DATA	NO	HL C	13		_	_	0	.04		-	8 .035	-			
H	INF	FICAT			DWG	10569	DWG	2			ATSM05698	10569				
	HARD	SPEC			DWG	ATSN	DWG	NOR		510	ATSM	A75N				
	HA	È	316	SCH 40 S. TYPE 316				SER G	ALUM SHEET DUCT							
		ш	TYPE	JUL SUPE		SNIG	16 IBINIG	WIN S	HEET		S.ST TURNO	UBING				
		τγρε	4 5 S	ST. F	TYPE 314		5T 3	ME A	S NJ	ALC: NO	To To	51. 10				
A set of the provide state of the set of the provide state of the set of the		MO	N) SCI	0 50	375 TYP	5 5.	S TYP	2 SA	4 ALL		-5 5.5	5.5	-			
1166		NOM NOM	S C	2 1.0	1 6	4		6	7 4	00	5	0	1			

(Q141 1000 4137 5 (410001 1440)																	
				V. 51A.	9		- CE UME	UMBILICAL ARM REF	KIN REF		ZONE SYM	2		REVISIONS DESCRIPTION	SNOI	CATE	APPROVAL.
	1			_			+	Г									
					/	7	@			*	1-12 \$	13-17	TO MS	MSFC SPE	SPEC 164.		
					-	90	98 98			2 SEE NOTE 2 SHEET I. 3 C/T SHALL HAVE POLYETHYLENE TUBES. A FUTHALS FOR NAY 2 JI AND ALLI, TO AS	HAVE POLY	T I.	L SHEET I. HAVE POLYETHYLENE TUBES. DE NE 3-11 AND 4-11. TO 1	UBES.		DEP MC 315 MEEC	Sper
						Θ	-@	6		5. BLK FITTINGS V	MC1640	01.60		14C4 & M	C 124C4	SLEEVE	SLEEVE MC1250
ž			274	<u>v. STA</u> 2760.000	\square	3 0 0 	• • • • • •			6. BLK FITTINGS MCIAGG, UNTS UCTAGG & MCI24GG, SLEEVE MCI25GG. 7. BLK FITTINGS MCIAGGE, NUTS UCTAGG & MCI24GG, SLEEVE MCI25GG. 7. BLK FITTINGS MCIAGAG, NUTS MCI74GB & MCI24GB, SLEEVE MCI25GG. 9. ARMSTERUS MCIAGCZ, NUTS MCI74GB & MCI24G12, SLEEVE MCI25GZ. 9. ARMSTERUS ARMAFLEX Z2. OR EQUAL. 10.20. THICK FLENBLE FIGERGLASE INSULATION WITH ATTACHED MOISTURE BARDIEL K FACTOR OC. 25 DTU/HC. IN [FT ¹]"F [IN.	SE MCIGACC, NUTS JUN SE MCIGACC, NUTS JUN SE MCIGACR, NUTS MCI SE MCIGACR, NUTS MCI S ARMAFLEZ, NUTS MCI S ARMAFLEZ, LEFERZCLASE EAZEVEZ, K FACTOZ	C4, NUT C8, NUT C12, NUT C12, NUT C12, NUT C12, NUT C12, NUT C12, NUT C12, NUT	5 MCI740 5 MCI740 5 MCI740 5 MCI740 5 MCI740 5 MCI740 5 MCI740	COST MC	12406, 54 468, 54 4612, 54	174C6 1 M. 124C6, 51 EEVE MC 125C 174C6 1 MC 124C6, 51 EEVE MC 125C 14C8 1 MC 124C8, 51 EEVE MC 125C 15C1 1 MC 124C12, 51 EEVE MC 125C1 15C12 1 MC 124C12, 51 EEVE MC 125C1 100L 22 BTU/HR IN 17T1 1*F (N.	12568. 12568. 25612.
			1	13° (POS I)		- 15,000 -	+++	15000-	++								
213	SZ						Ø	CONNECTOR	X	TIP	FLEX	FLEX LINE DATA	ATA				
FUNCTION	OF LINE NUMBER	MEDIA	PRESS. (PSIG)	TEMP (F)	FLOW RATE (LBS/MIN)	CUANTITY (LBS)	Now Size (I.D.IN)	WEIGHT (LBS)	DISC FORCE (LBS)	TYPE	Sound CE	NON (IZ)	PROOF PRESS. (PSIG)	Меіснт (сыз) гинны	RENGY	C BEND RADIUS (IN MIN) BENDING STATIC FLEXING MOMENT	S BENDING
I MAINSTAGE FUEL TRANSFER	-	ZHJ	20	-423	1108	43059	4	-10	~50	CORRUKATED SST. WITH A S.ST. WIRE BRAID REINFORCEMENT - VACUUM URCKETED -		6	150	I S BWONET	61	7 30 66	TBD
2 MAINSTAGE OXIDZER TRANSFER	1	LOX	18	- 292	9500	193,513	4	01~	~50	SAME AS NO 1 (REF 5- 108091-4)	5 6	6	50	15 Enouer	er 119 27		TBD
3 FUEL TANK PRE PRESSURIZATION	-	HE	200	-360	20	15	.75	88	6	CORRUGATED S.ST. WITH A S.ST. WIRE BRAID REINFORCEMENT REF. R.W. BIL	8 •**=	1.32	000	-86 Nore4	4 230 213	2.00	-
4 LOX TANK PRE PRESS, PRESS & PURGE	1	ΗE	3008	-360	50	225	3	.42	8	SAME AS NO.3 REF RW-BL	200	8	6000	.70	1.50	г 0	
5 TURBINE START BOTTLE GH2 SUPPLY	-	GH2	35	-2501	20	302	ß	42	\$	SAME AS NO.3 REF RW-BIL	-		1600	.45	1	+	_
6 AUX PROP. SYSTEM HE BOTTLE PRESS.	-	HE	3000		S	õ	25	8	\$	TEFLON OR HI-DENSITY POLYETHYLENE WITH A S.ST. WIRE BRAID REINPORCEMENT		8	6000	61	A/z	A 3,25	
7 GHE SUPPLY BOTTLES	-	Hε	3000	AMB	5	8	SS	02	\$	SAME AS NO.6	1 280	8	600	Ø.	1	N/A 3.25	10
8 ENGINE HE BOTTLE PRESSURIZATION	-	ΗE	3000	3000 -2501 50	ю	ъ	25	Ŗ	4	SAME AS NO.3 REF RW BIL	5 250	8	6000	.22	2	5 001	_
9 PELIEF	-	ILE I	808	TO-250	8	180	-50	,42	\$	SAME AS NO.3 REF RW- BIL	4-10 = .	.92	1600	25	1,50		
IO THRUST CHAMBER PURGE & CHILLDOWN	-	HE	25	AMB 70-250	10.5	157.5	.375	.42	4	SAME AS NO.3 REF RW BIL	5 .375	.76	100	.30	· 1.13	3 5.5	
II FUEL PUMP CAVITY DRAIN	1	HE GH2	160	TO T0-425	780	780	52	Q.	\$	SAME AS NO.3 REF RW BIL	\$ 550	8	180	-22 Note		s	
12 AIR CONDITIONING & PURGE	1	AIR \$GN2	25 IN H20	85 TO I25	300	180	\$6x3%.8	480	TBO	REF DRAWING Nº 75M05693L	18 10	14	4	4-17 CLAMP	P 83 4	15	_
13 ELECTRICAL	و	N/A		NIA	N/A	NIA	SHELL SIZE40	3EA	180	60 WIRE, REF. 15M0 2943	N/N OI	2	N/A	200 N/A	NA 12	5	
14 LOW PRESSURE CHECKOUT SUPPLY	- 75	ΗE	50	AMB	160	A/N	.25	.20	40	SAME AS NO. 6	5,250	35	100	DO Note	LE 230	0	
IS HIGH PRESSURE CHECKOUT SUPPLY	- 7	Ηε	3000	AMB	180	AIN	.25	.20	40	SAME AS NO. G	7,250	50	6000	.19 SEE	4 230	2	
K DELETED											_			_	_	_	_
17 UMB. HOUSING ELEC. PURGE	-	GNL	2	AMB	180	A/A	22.	8	8	SAME AS NO 6	14.250	SE. 0	ŝ	.09 See	4 230 N/A	A 2	-
18 DISCONNECT PURGE	-	GN1	750	AMB	STATIC	¥/2	52	.20	40	SAME AS NOC	4.250	35	1500	D9 Note	Nore4 230 N/	A 2	180
SOURCE "SATURN I	D RE	FLUID REQUIREMENTS		3 1 62 ((1-15)						_		1	-	_	-	
5. PUNCLAS UKAWING Nº AGEIESS 5. FLEXONICS		59/2/2			$\left \right $		TOLENSION AND THE TOLENSION	UNLESS OTHERWISE SPECIFIED . MAR IN INCHES 	ERWISE SP	OFFICIAL DAT	0	TAZ	SATURN		5P	GEORGE C. MARSHALL Space flight center	ARSHALL CENTER
6. RESISTO FLEX 7. AEROQUIP 8. ACTIONFLEX (ATCO CO)				SEE E RECO	SEE ENGINEERING RECORDS		-		DACIWAL	ANGLE COLORI COLORI	MU	BILIC	01	AB VI-	AFT	NATIONAL AEROMAUTICS AND SPACE ADMINISTRATION HUMBER ALAND	MAUTICS INSTRATION
9. WIGGENS 3-12-13 \$ 14							THEFT			GELLINGO	5	SERVICE		ARM	SHO		
11. FLEXIBLE METAL HOSE MFG 12. CONNECTICUT HARD RUBBER	3.3	ö		NEXT ASSY		NO	PINAL PROTECTIVE	INC. FUMILIA		PRELIMINARY LATEST INDERNATION	WEIGHT CHECKER	LOOK IN	DATE	CORE	U	DMIC/	2020
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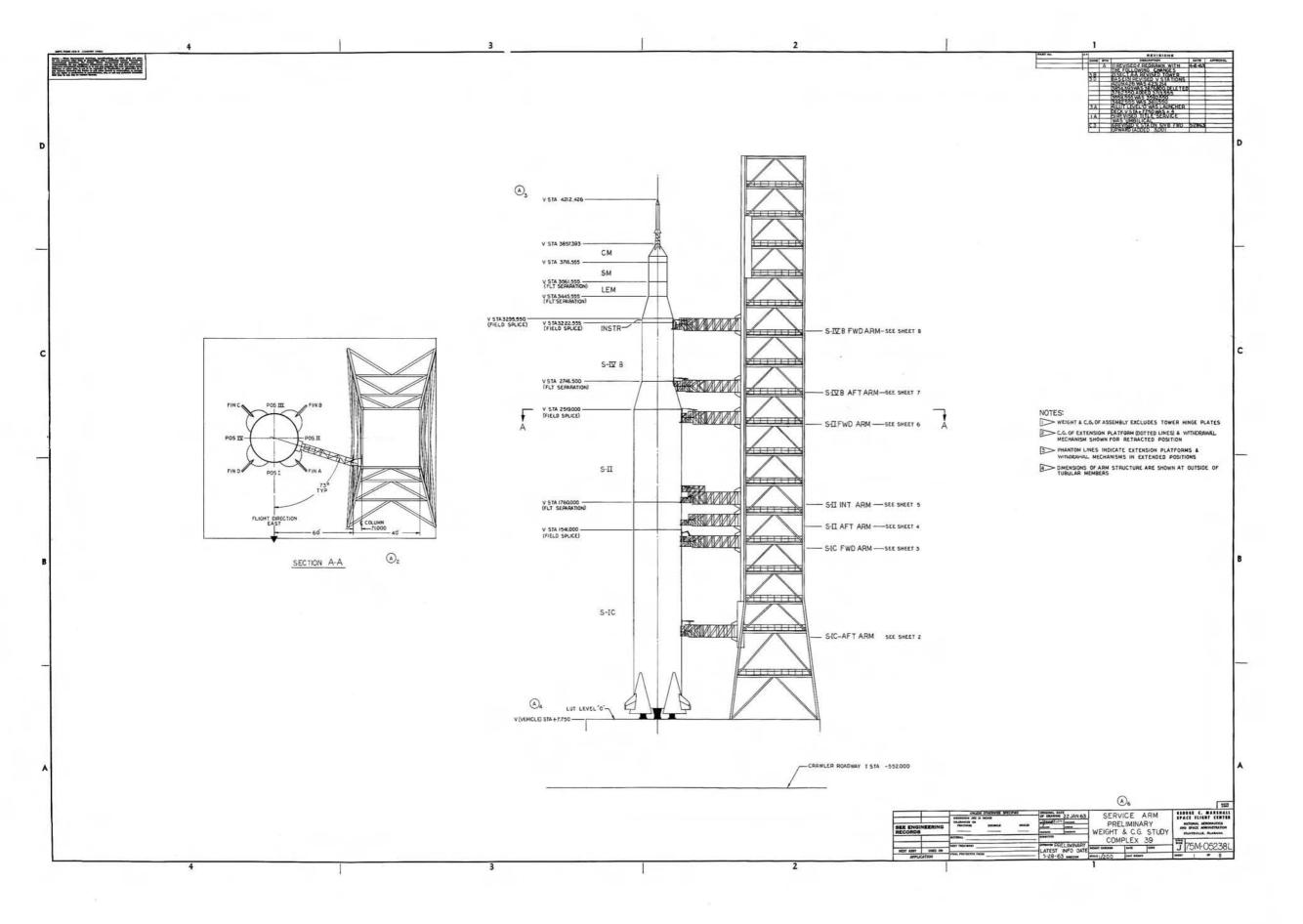
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APPENDIX B

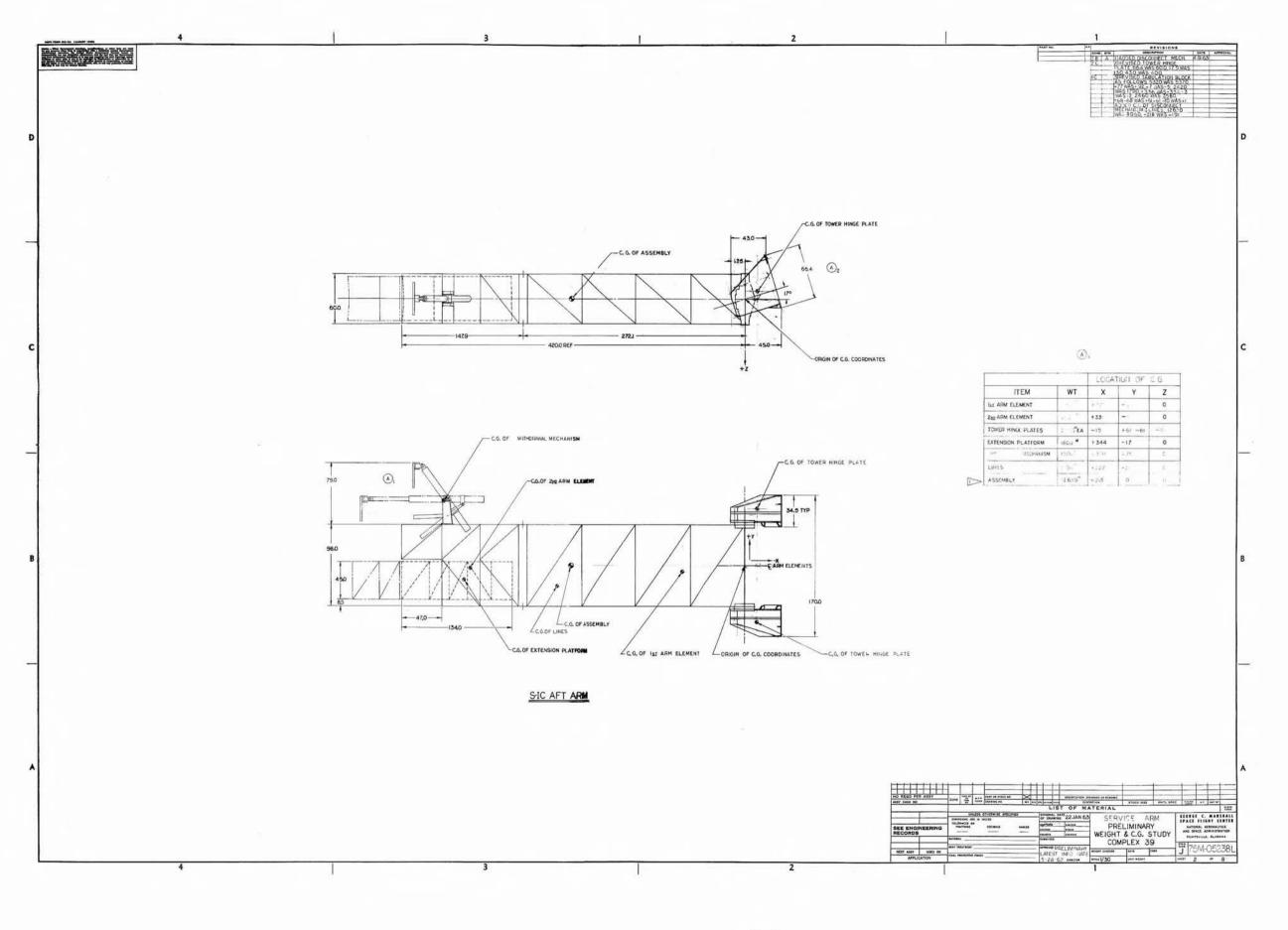
Preface

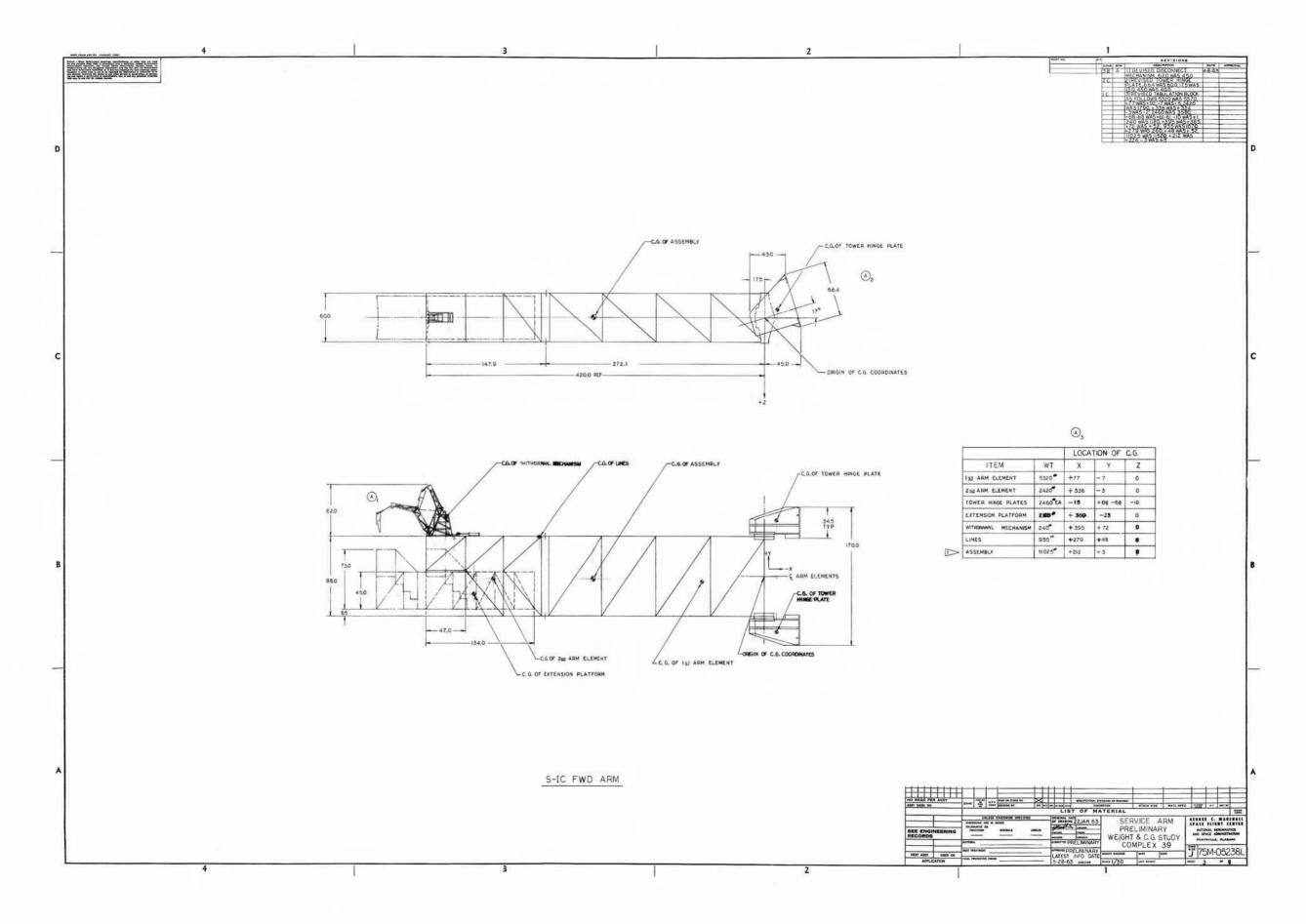
Appendix B contains information on the weight and center of gravity of all arms except the Service Module Service Arm and Command Module Access Arm. The following errors on these drawings are being corrected.

- (1) Sheet 1, vehicle stations are in error.
- (2) Sheet 2, S-IC AFT arm LOX loaders have the wrong configuration.
- (3) Sheet 4, S-II AFT does not show the S-II INTER-MEDIATE service platform, arm length incorrect also.
- (4) Sheet 5, shows incorrect LH₂ withdrawal mechanism and incorrect extension platform.
- (5) Sheet 7, configuration and centers of gravity changed.
- (6) Sheet 8, centers of gravity changed.

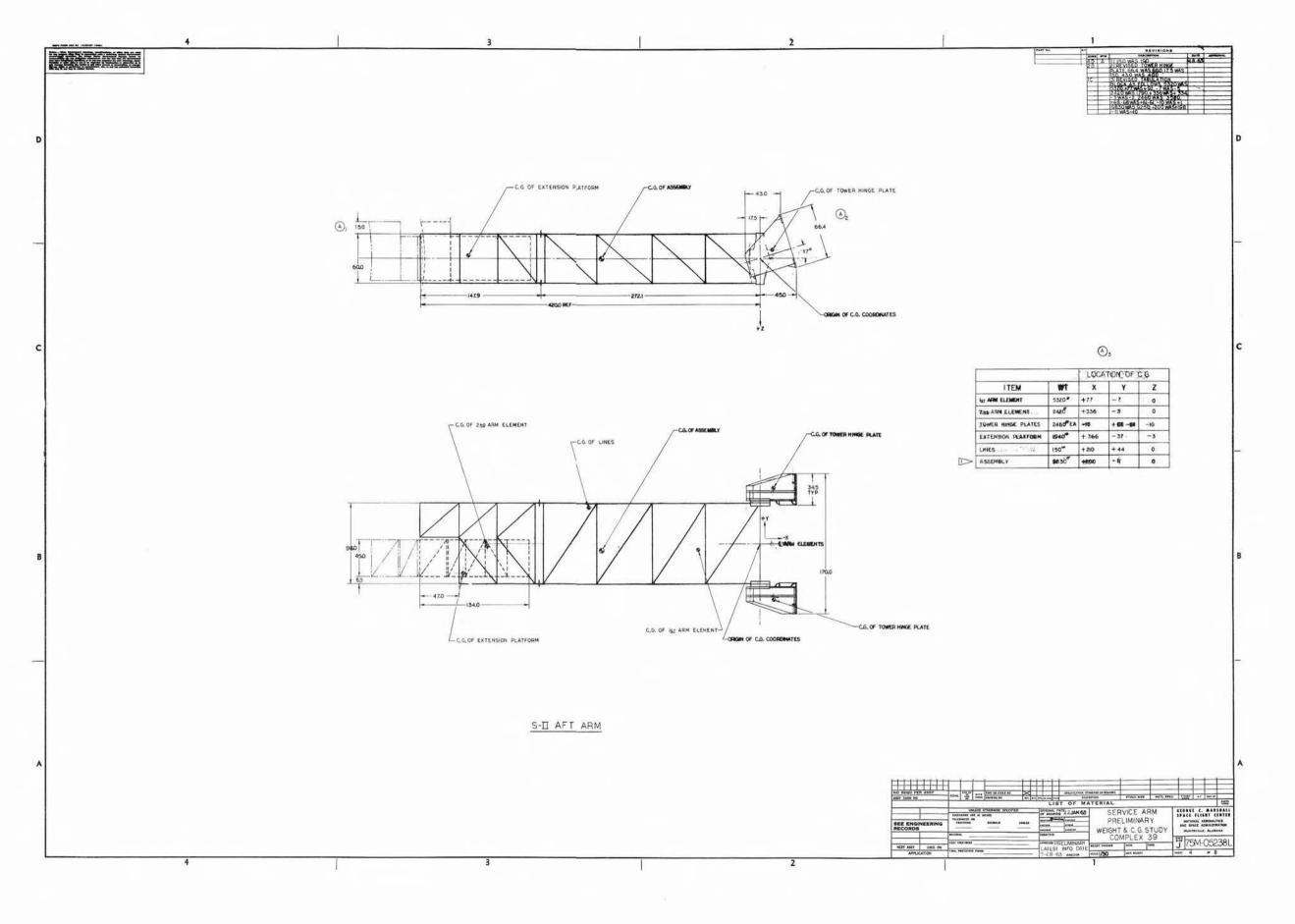


B-1

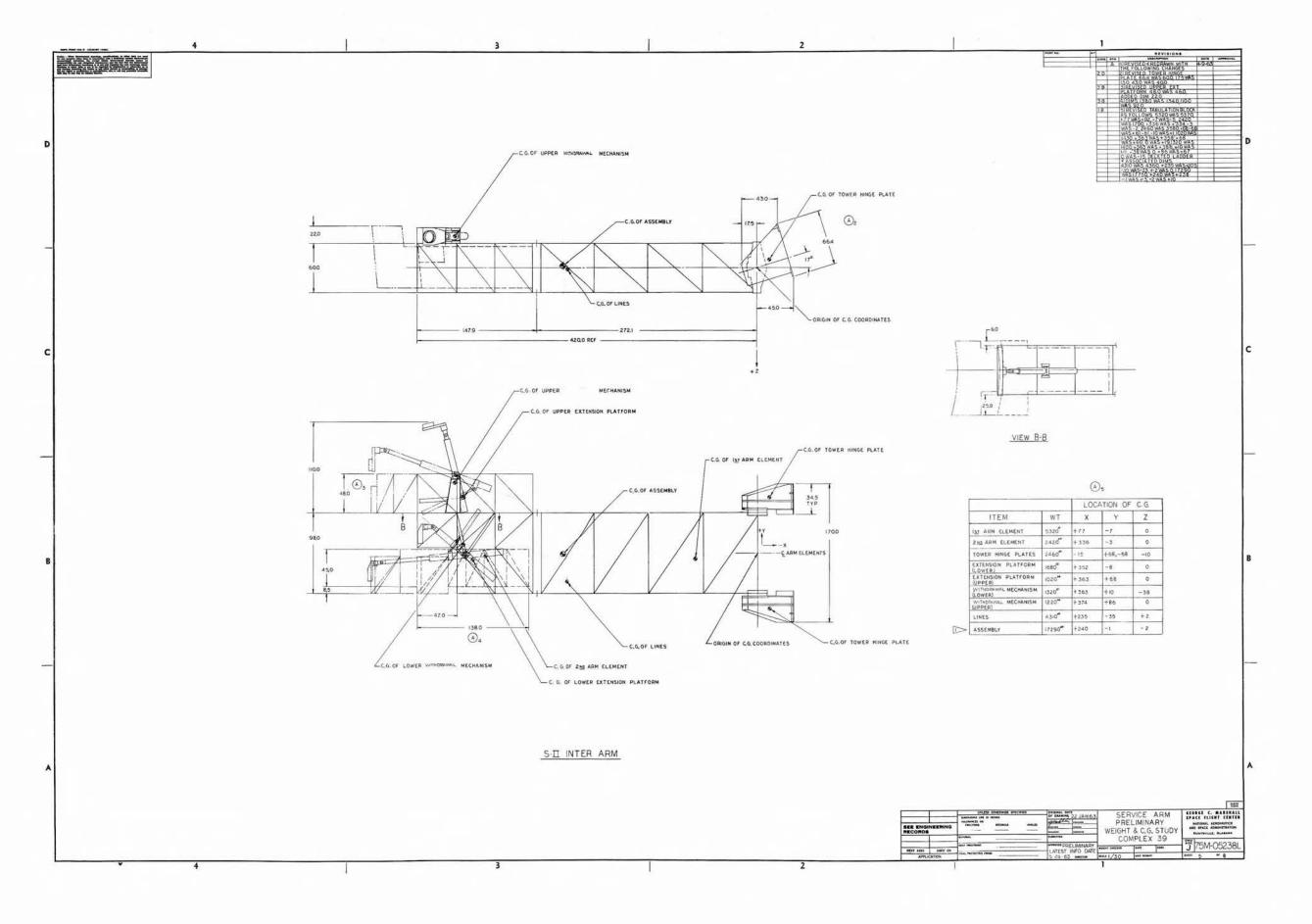


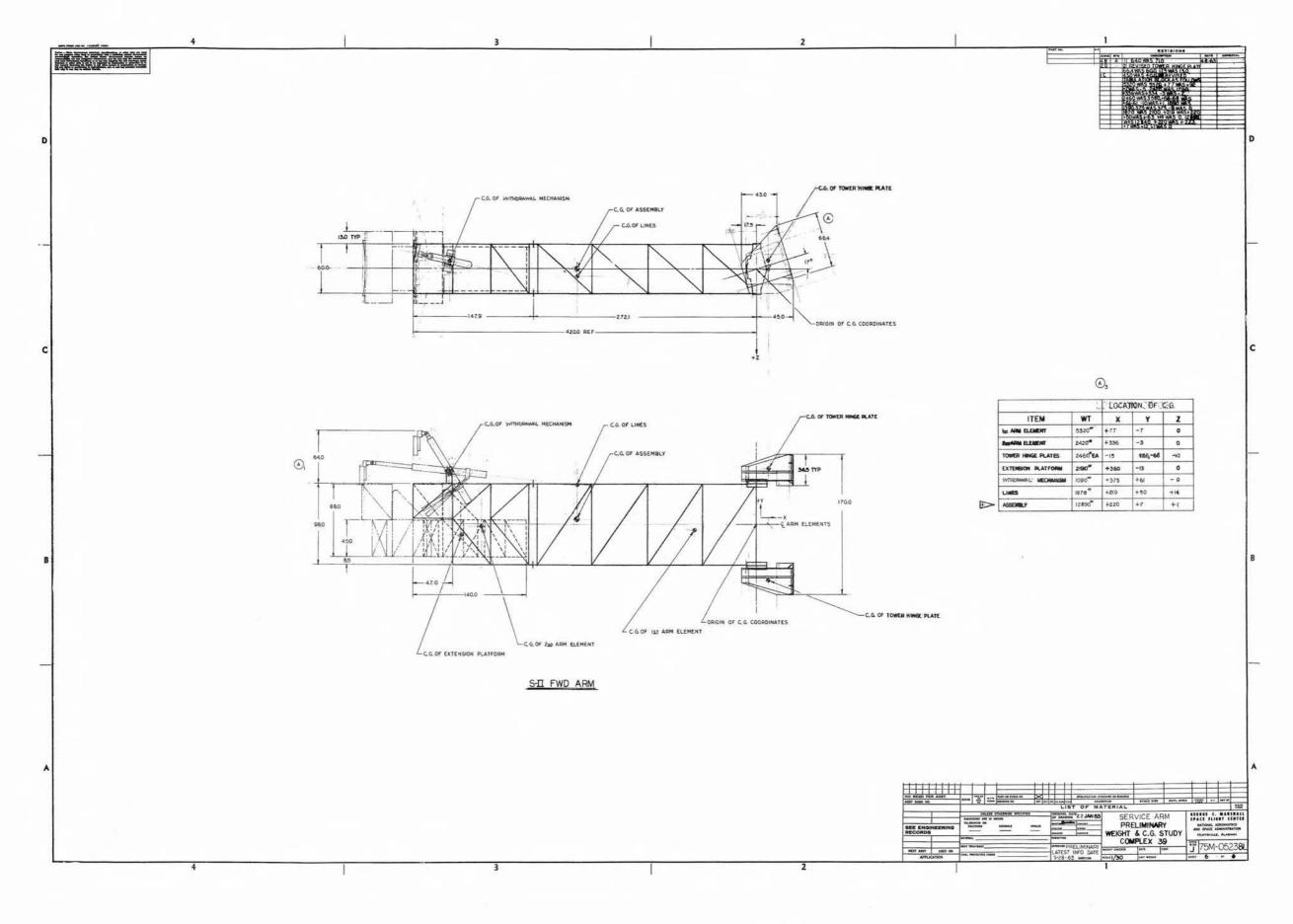


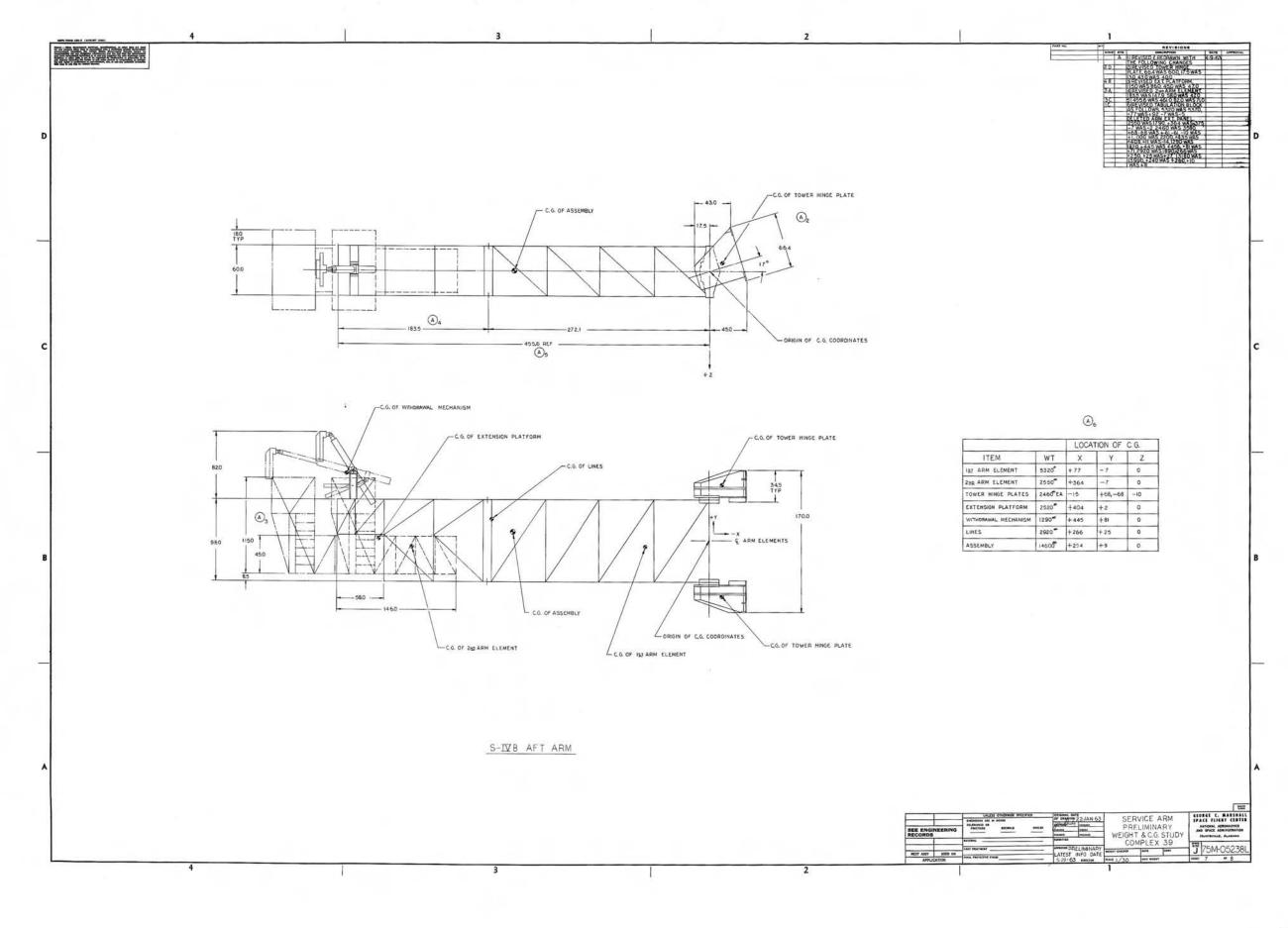
B-3



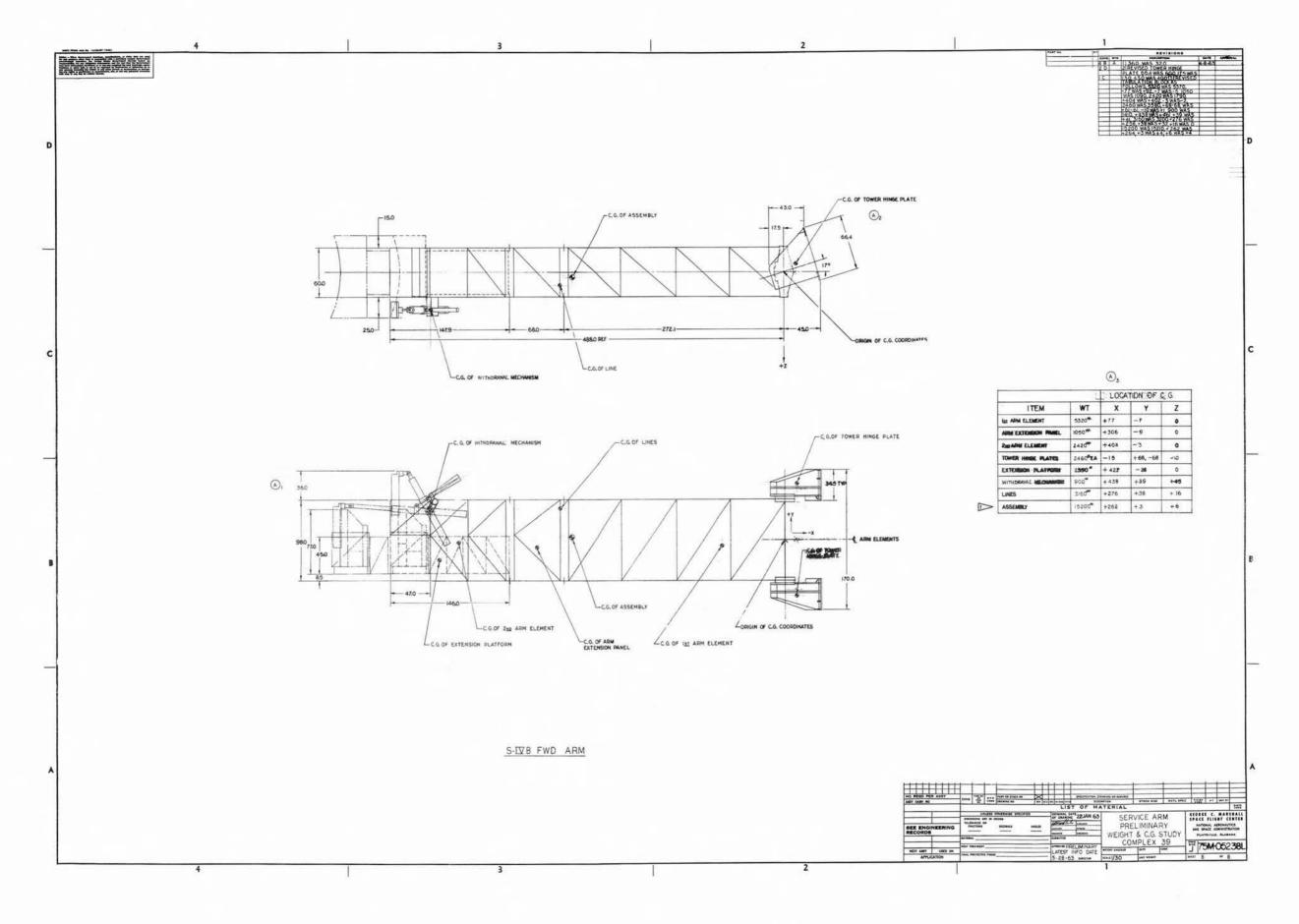








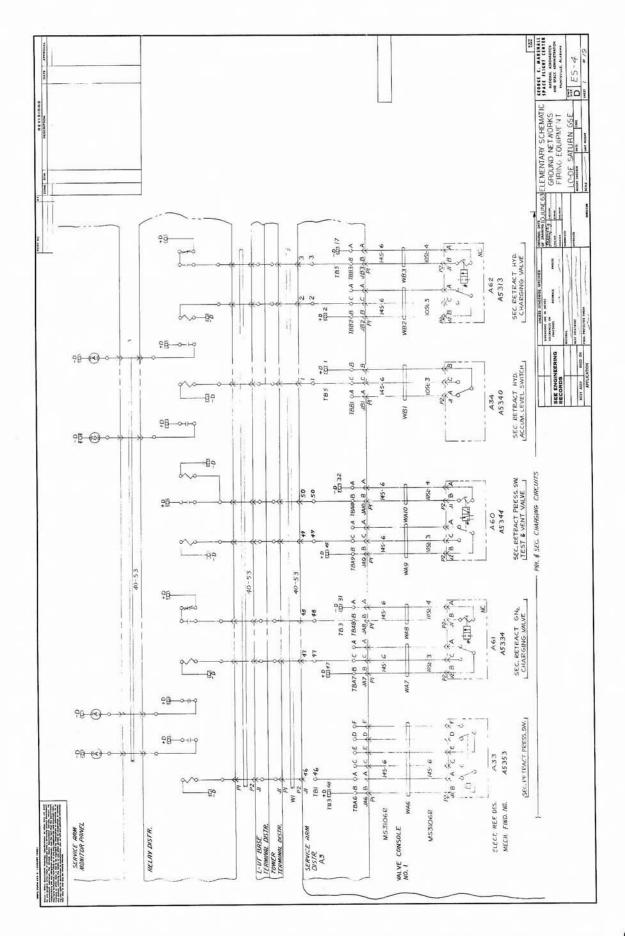
B-7

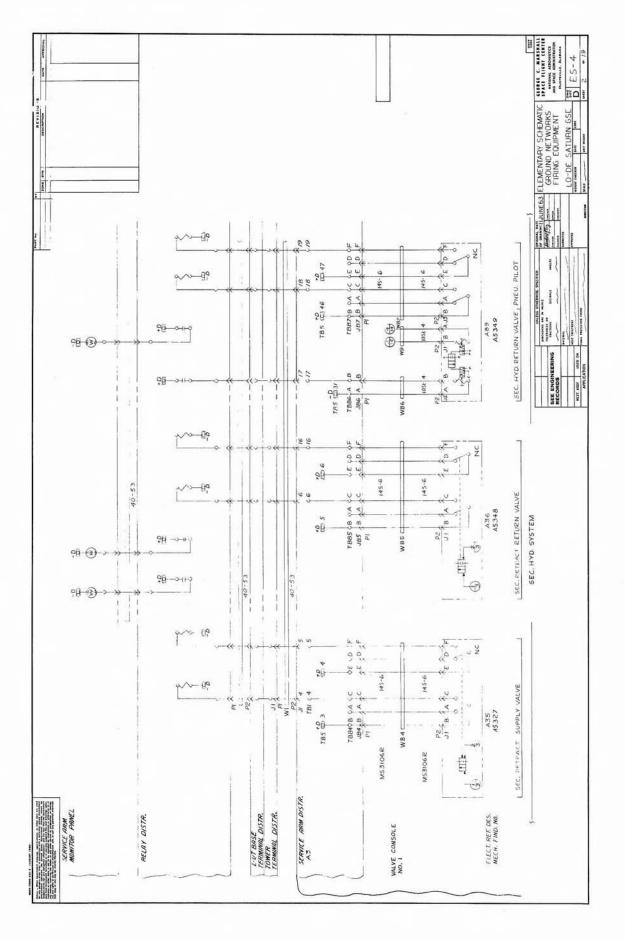


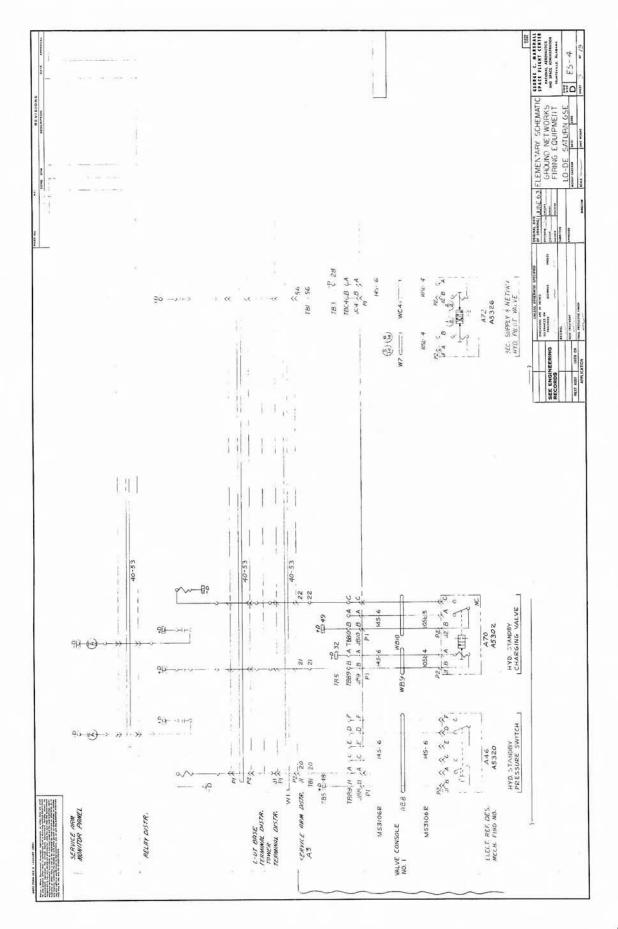
APPENDIX C

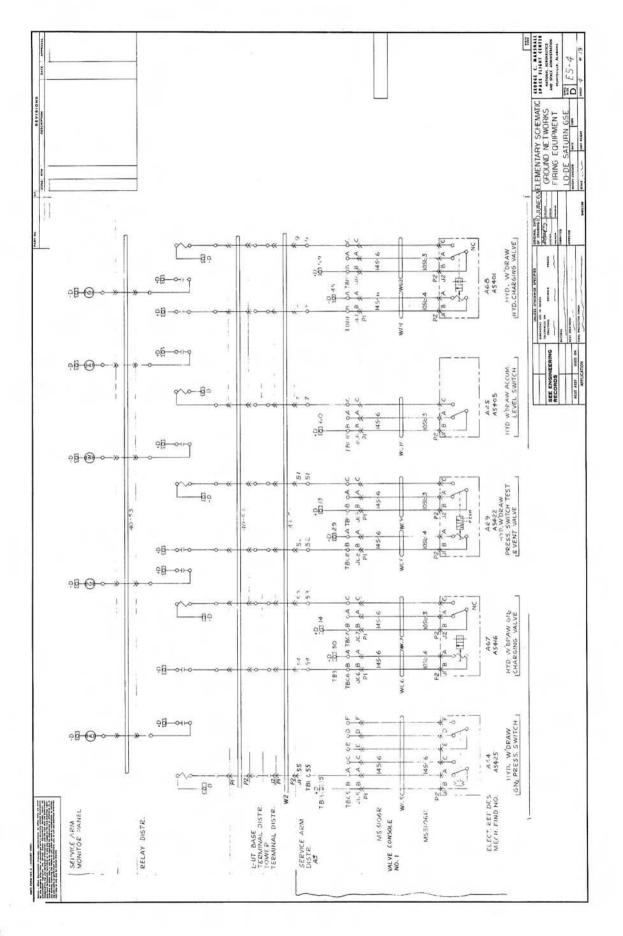
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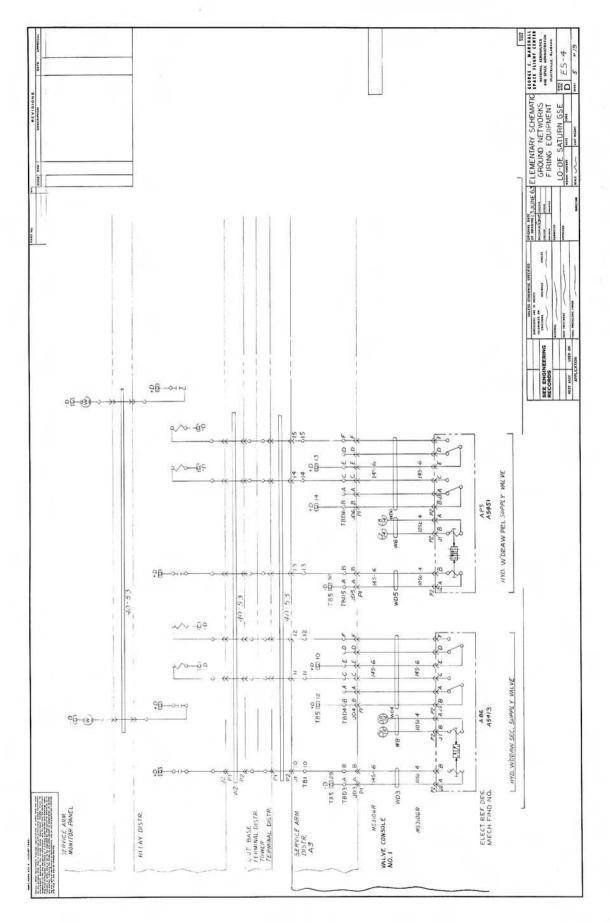
Appendix C contains electrical schematics for ground network firing equipment, service arm monitor cabinet configuration, and a family tree of electrical drawings for service arms. A general equipment layout and arm lighting layout is also included.

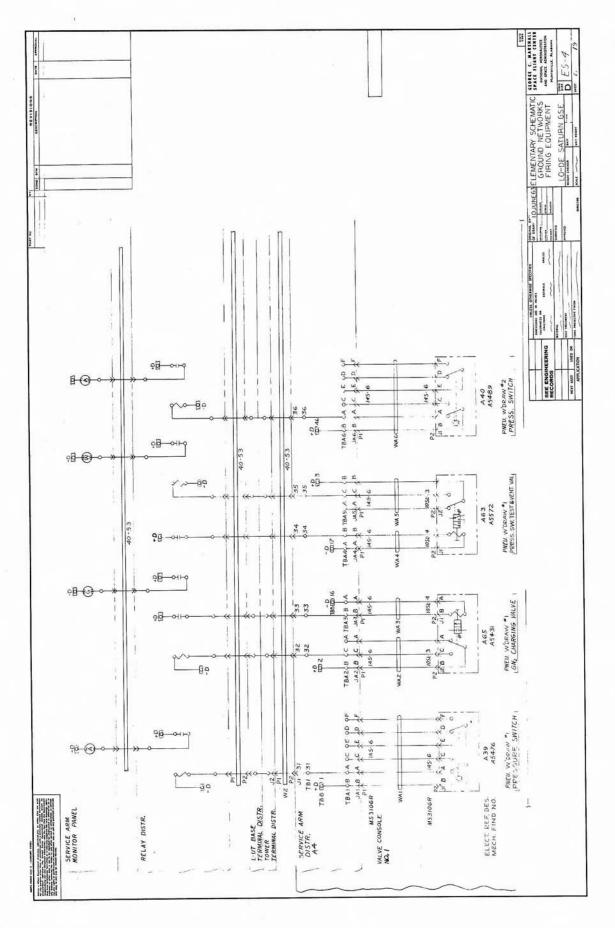


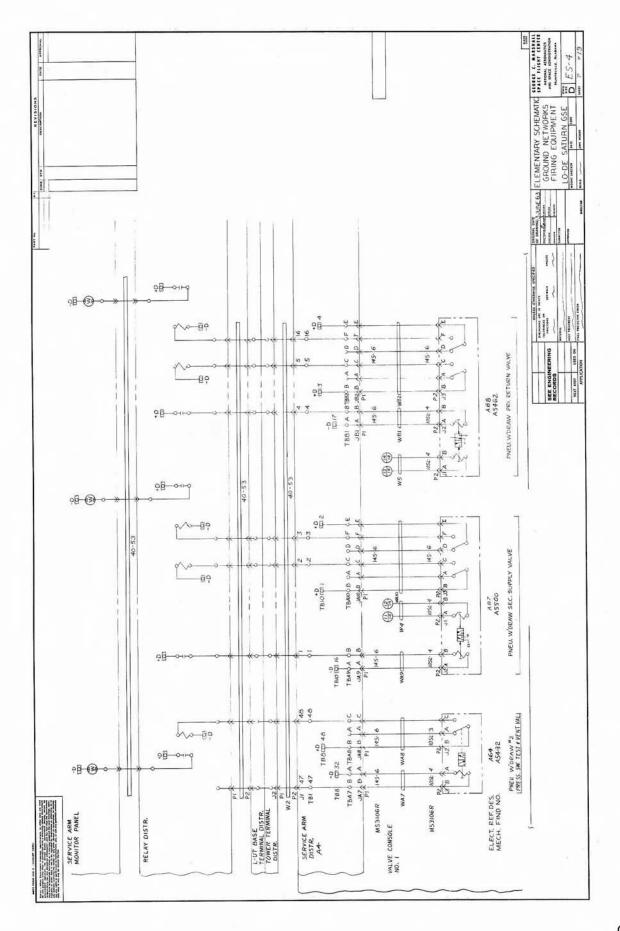


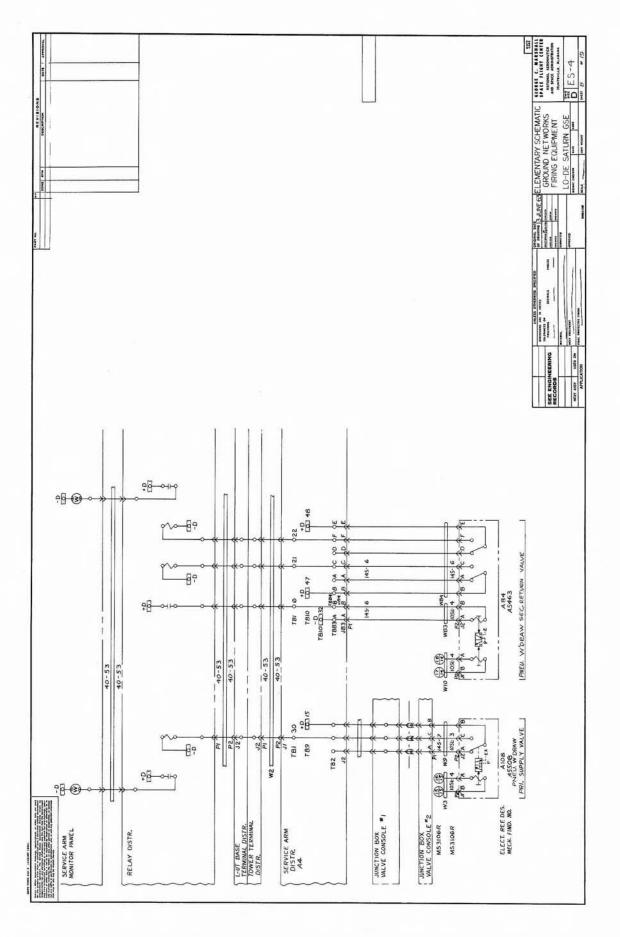


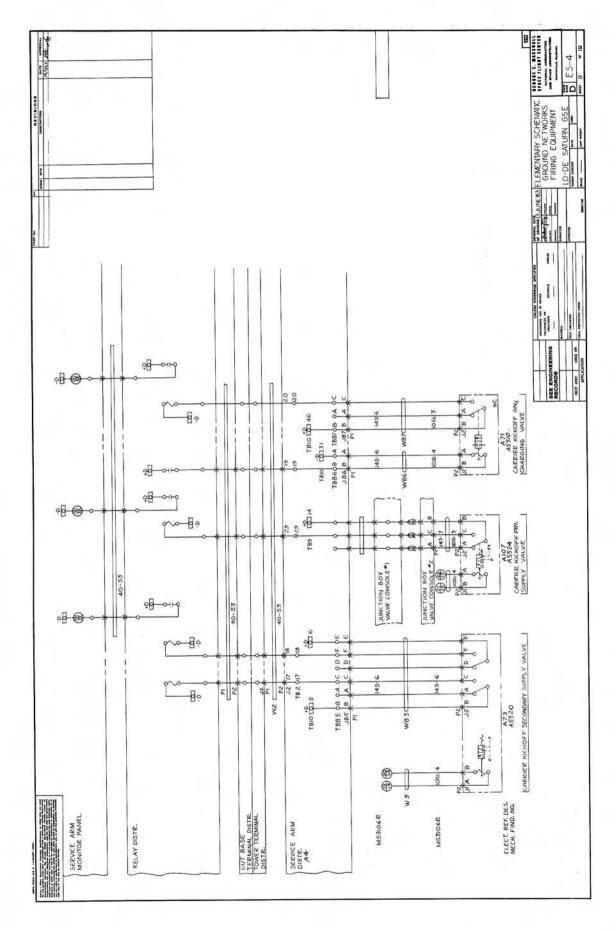


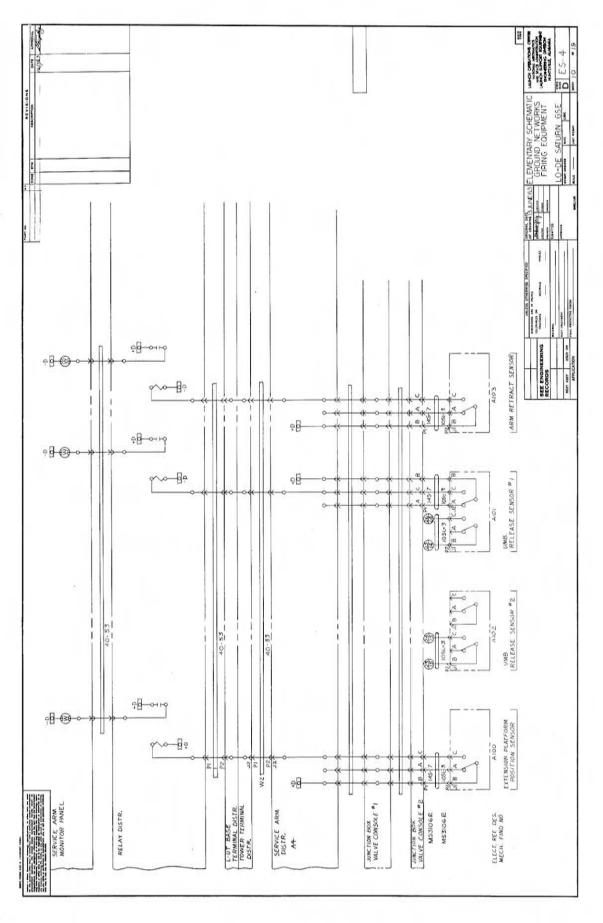


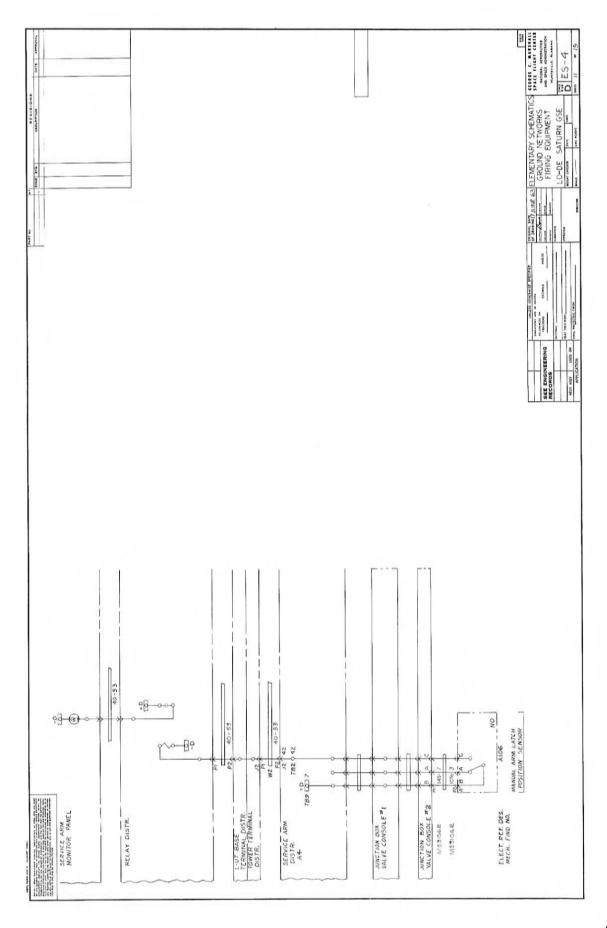


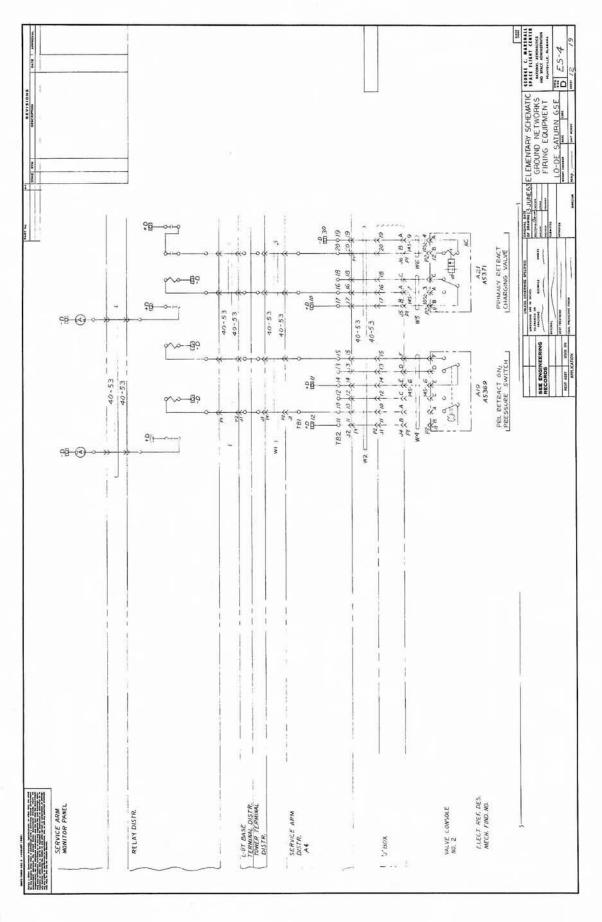


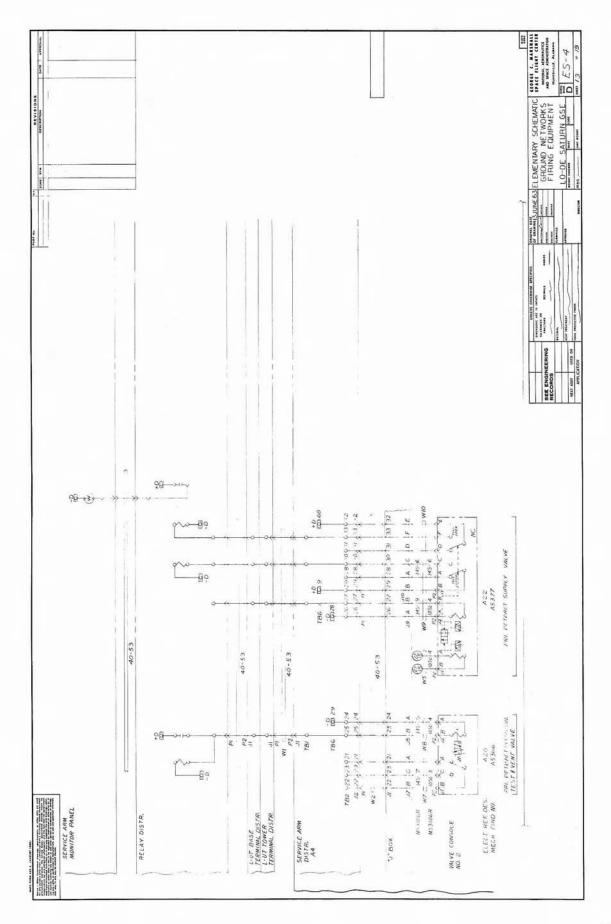


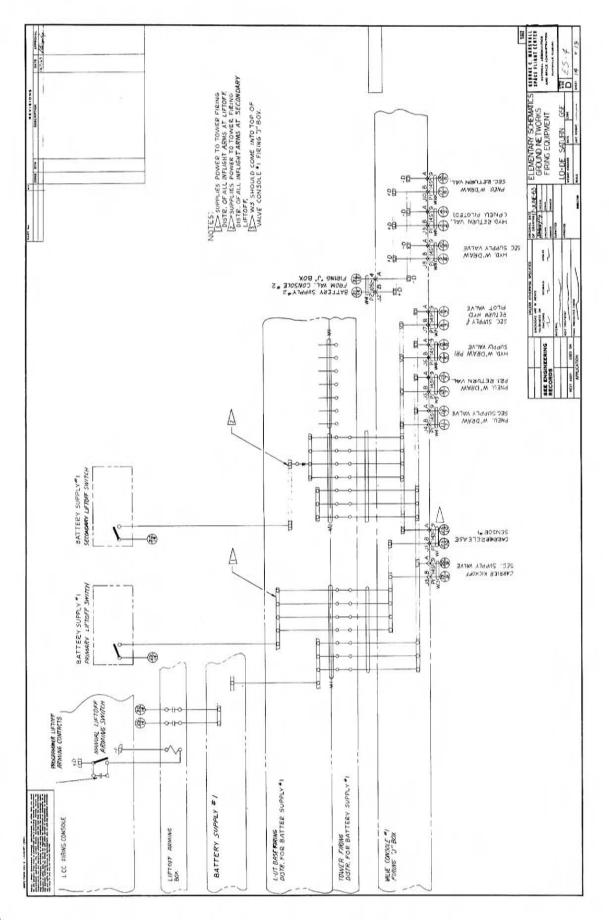


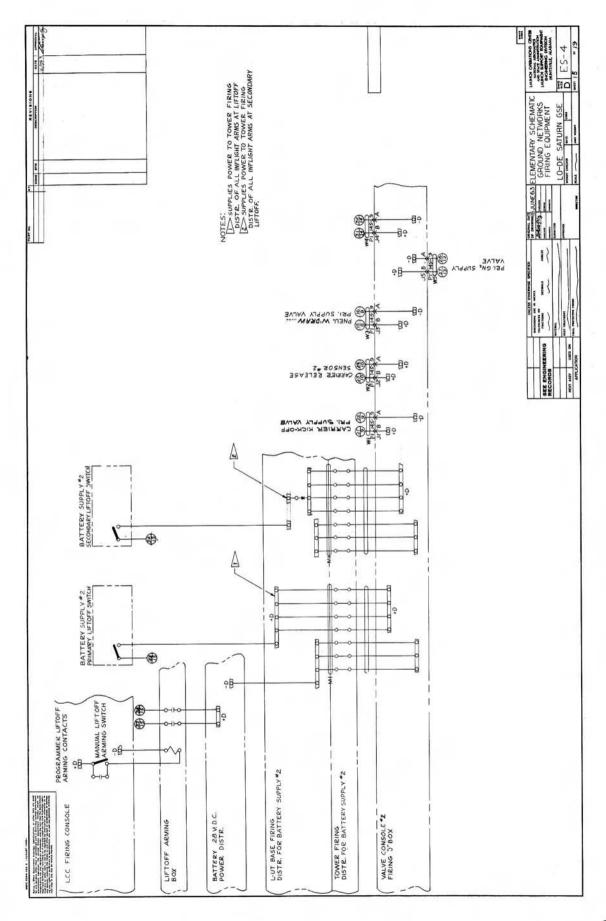


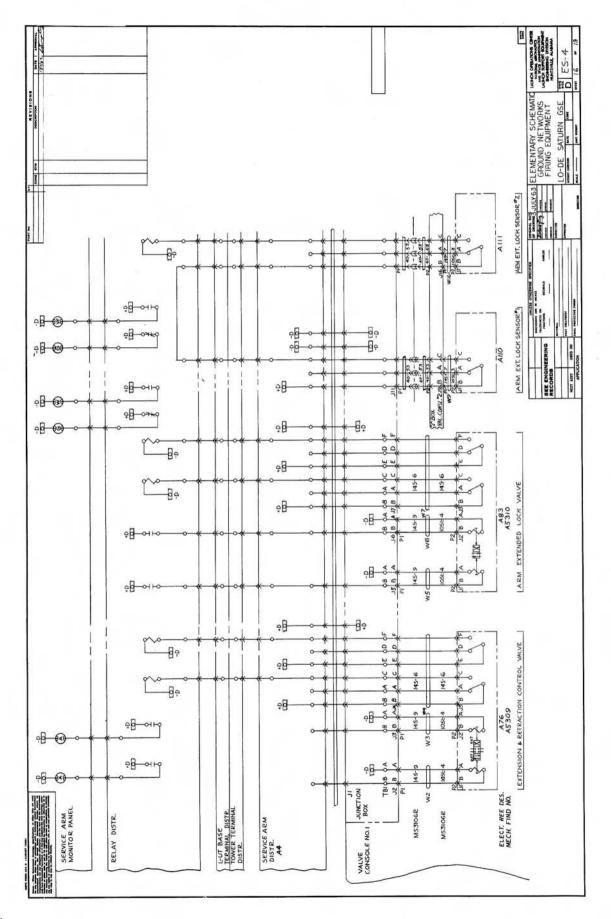


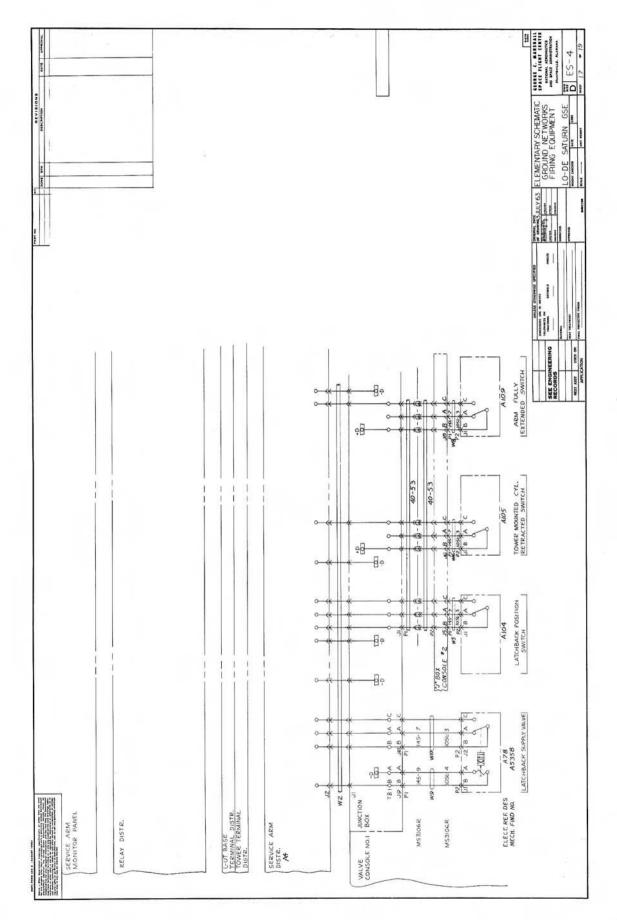


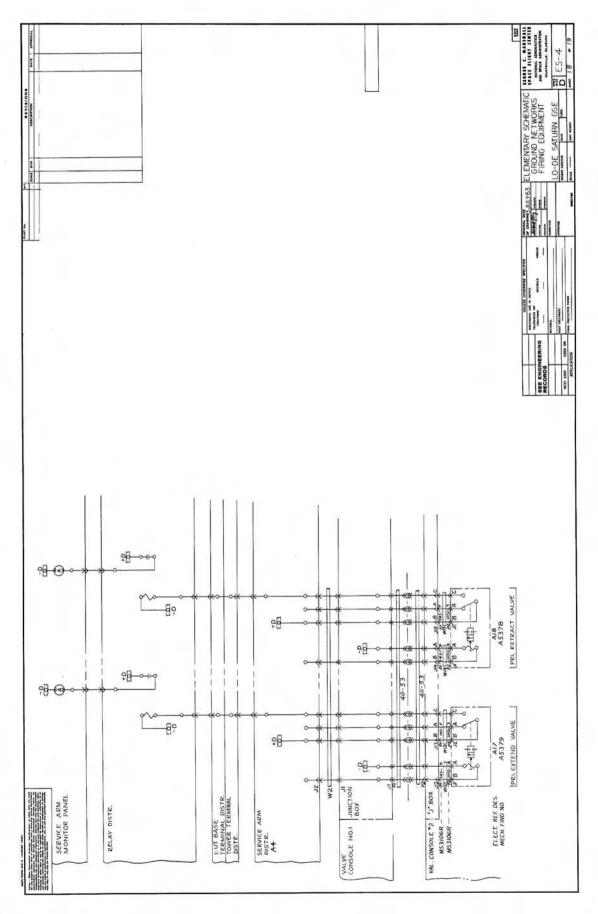


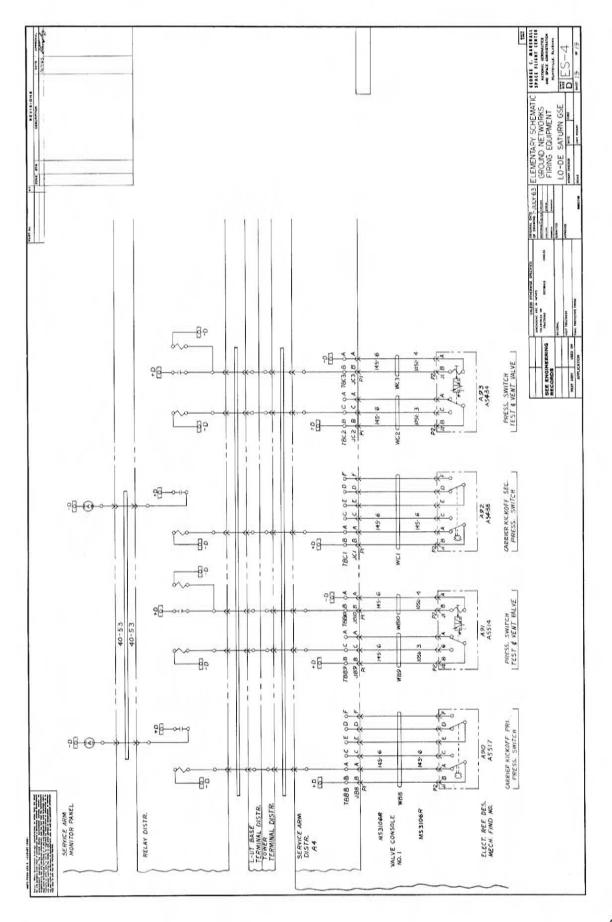


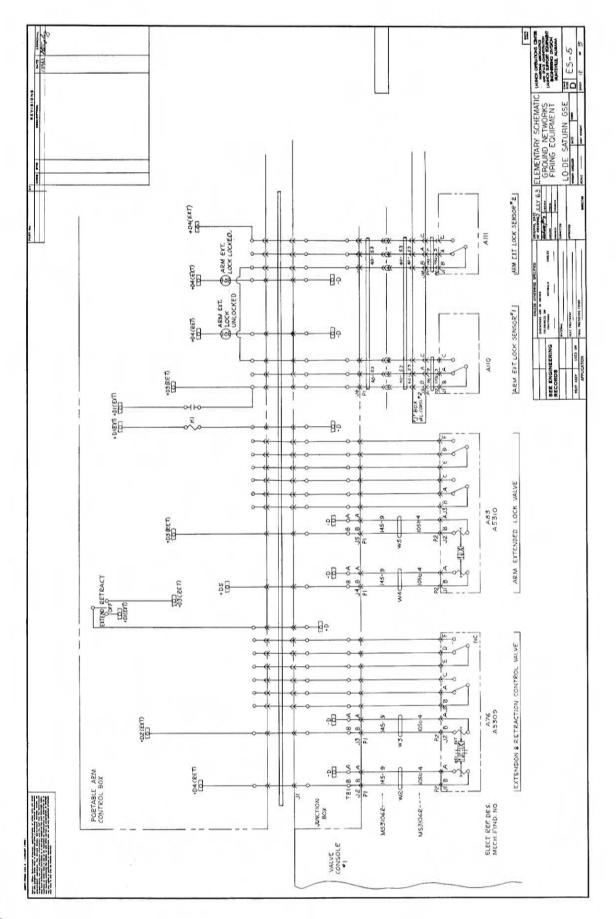


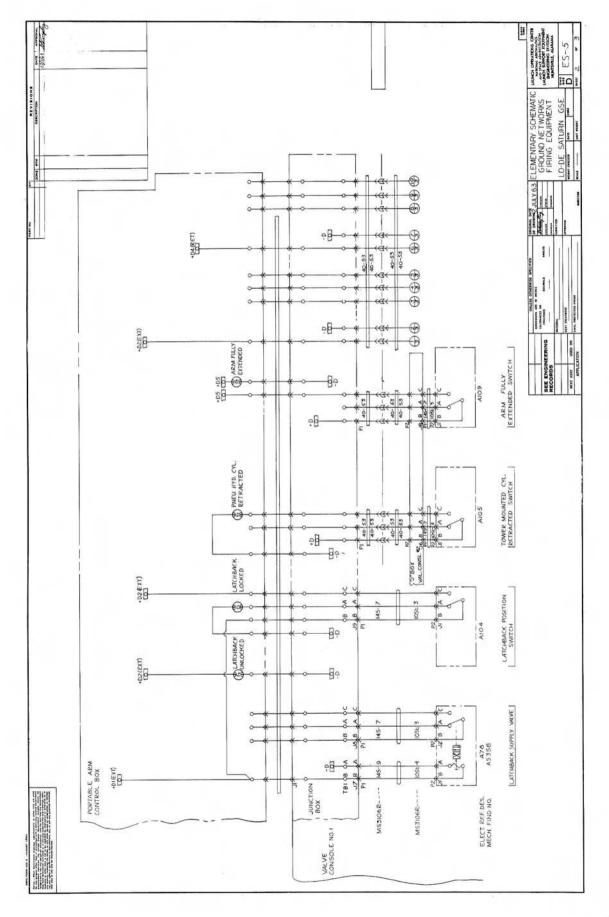


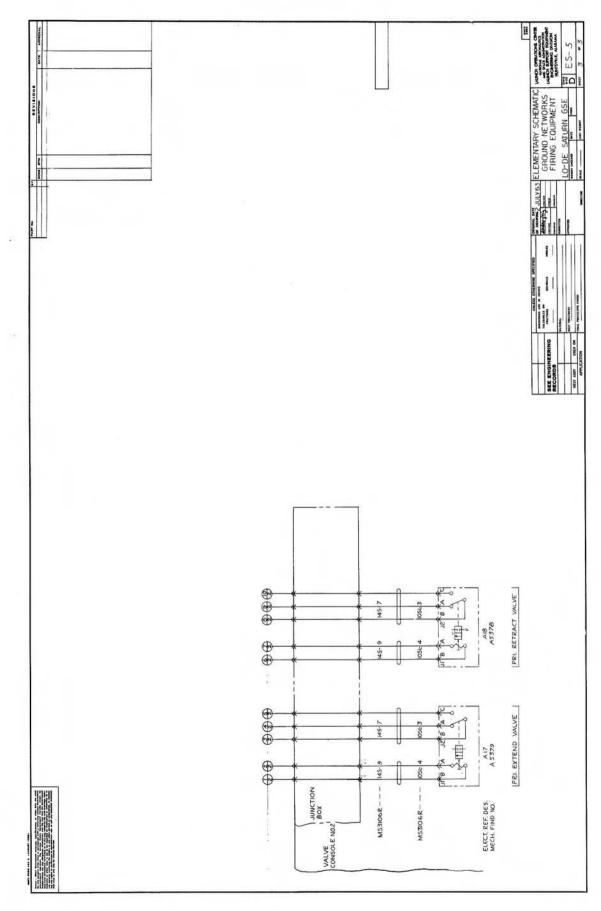


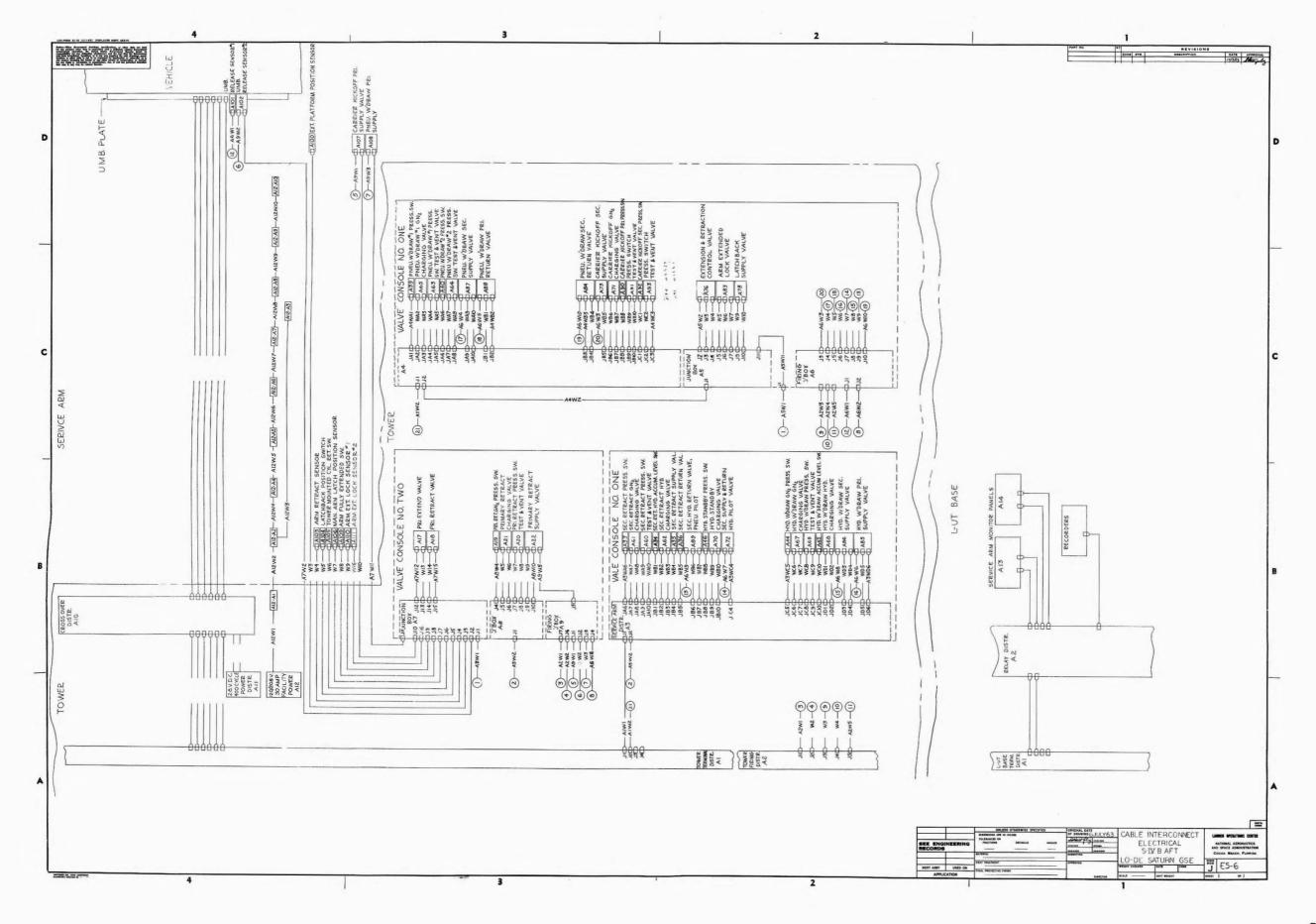


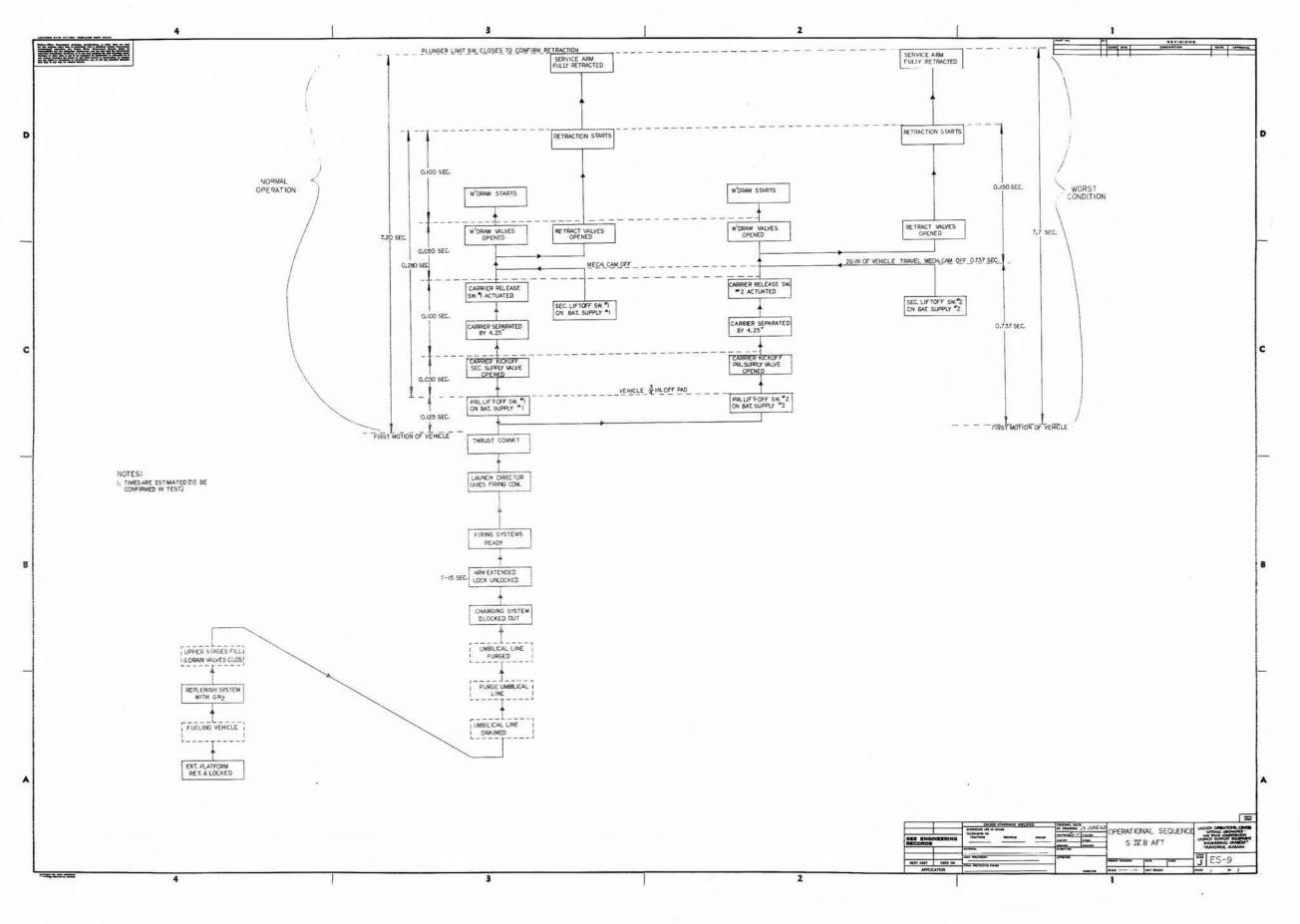


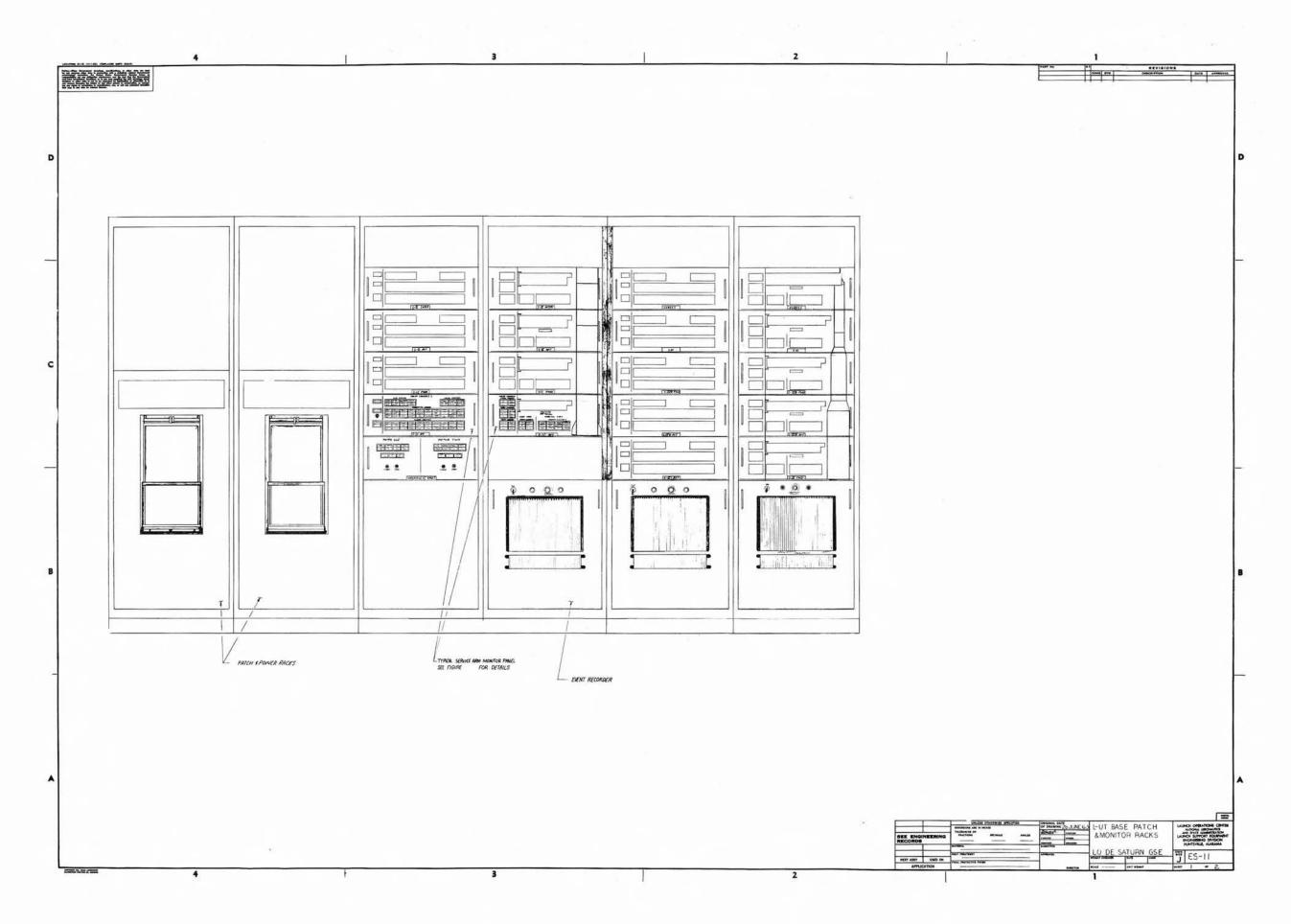


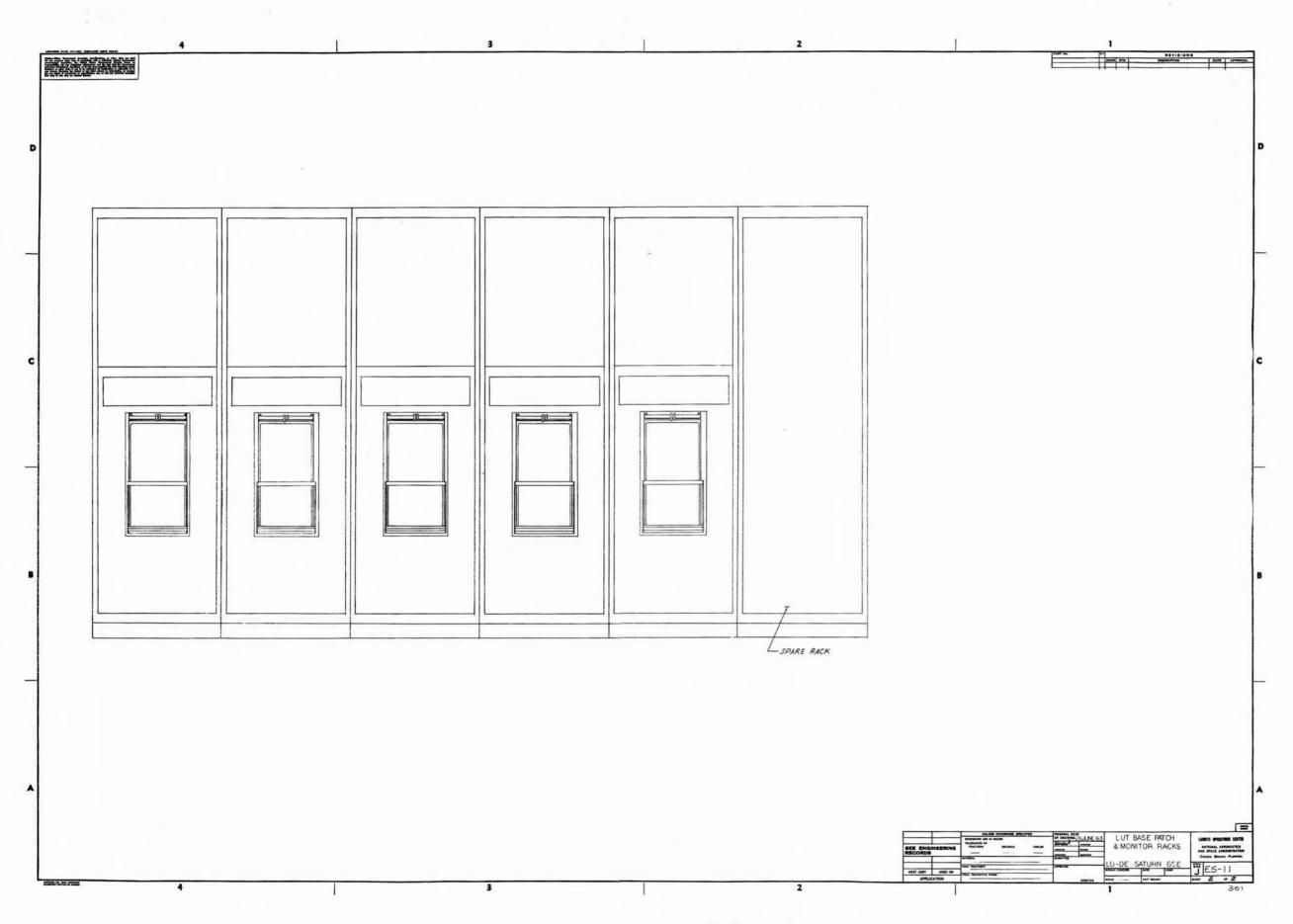


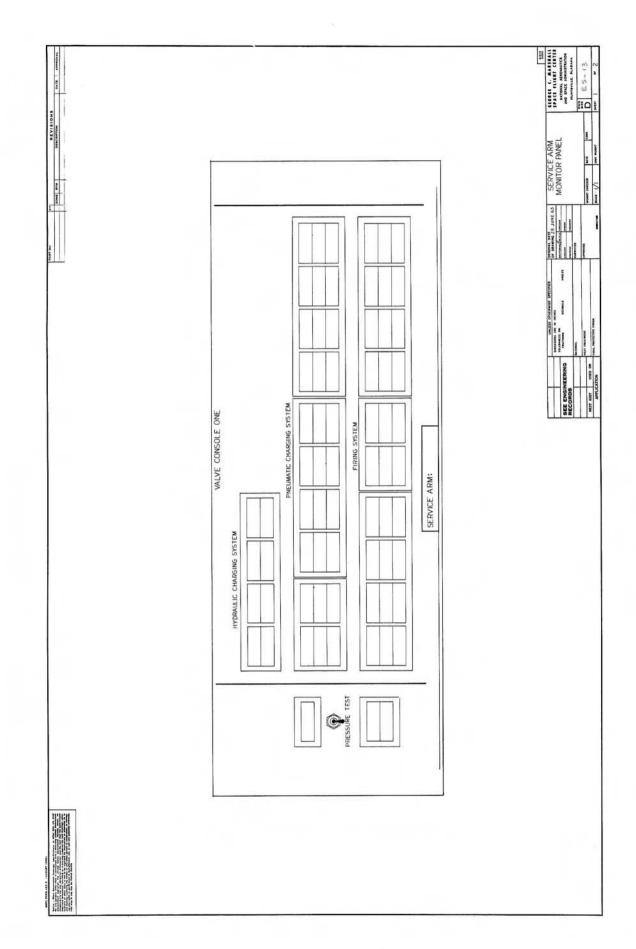




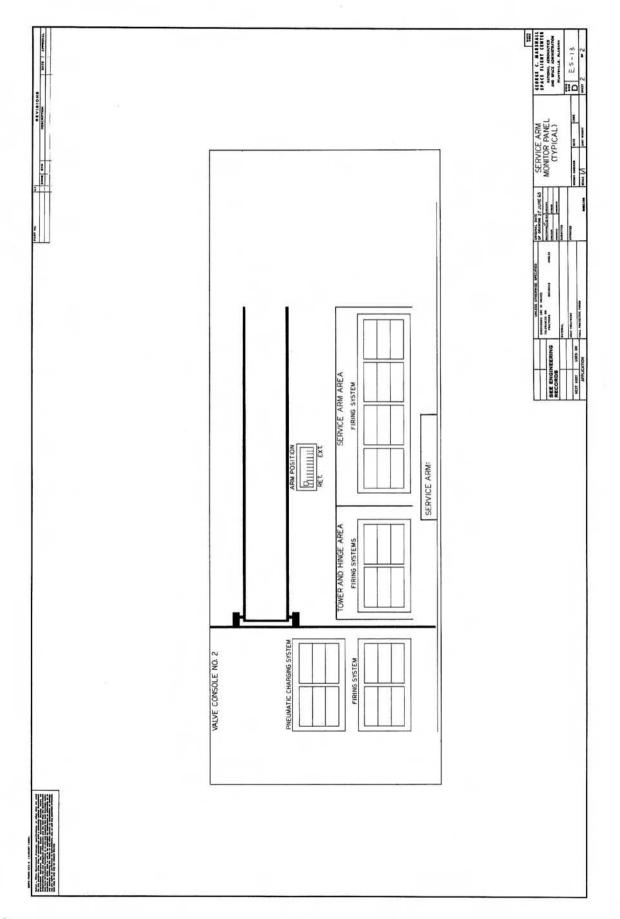


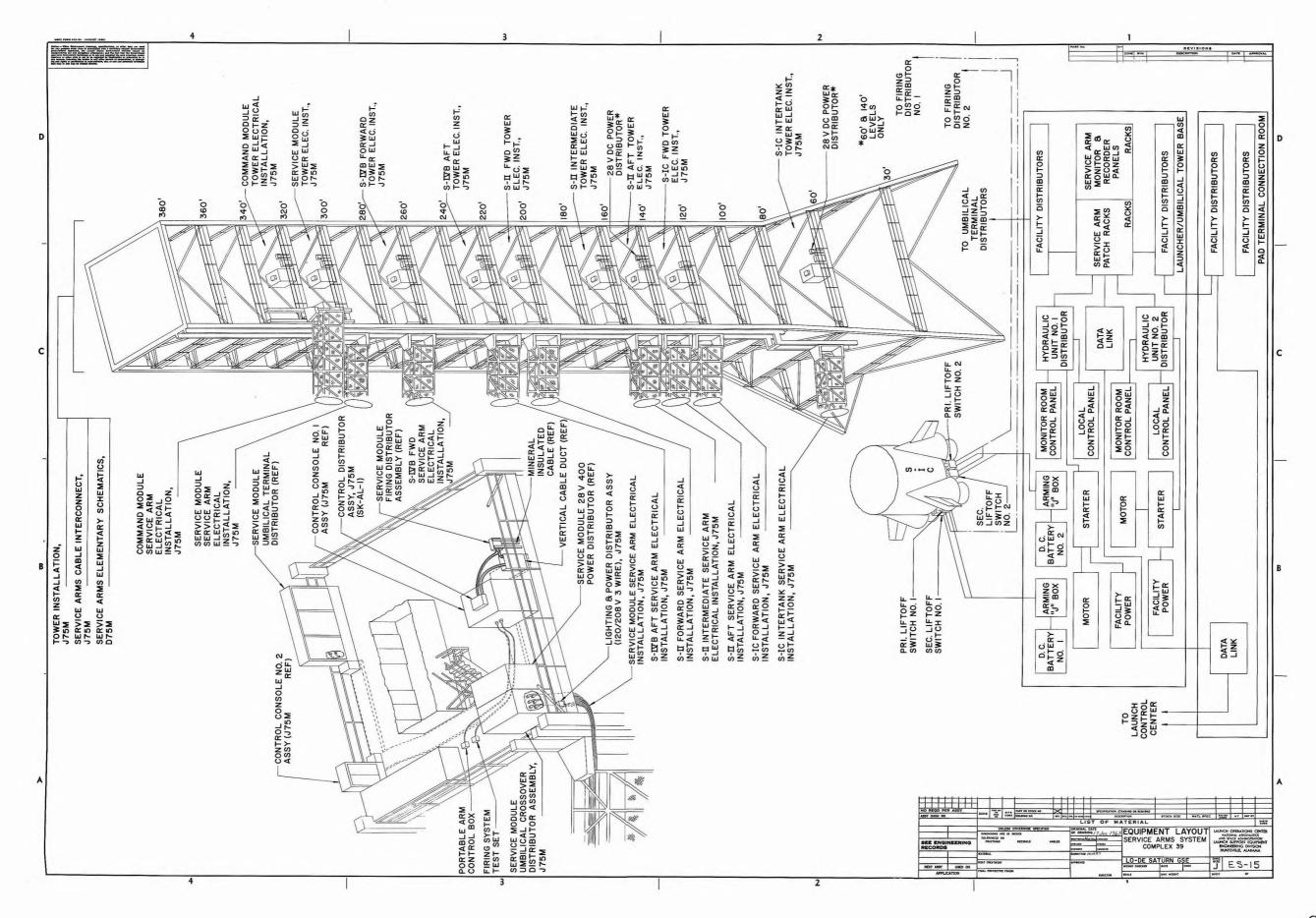


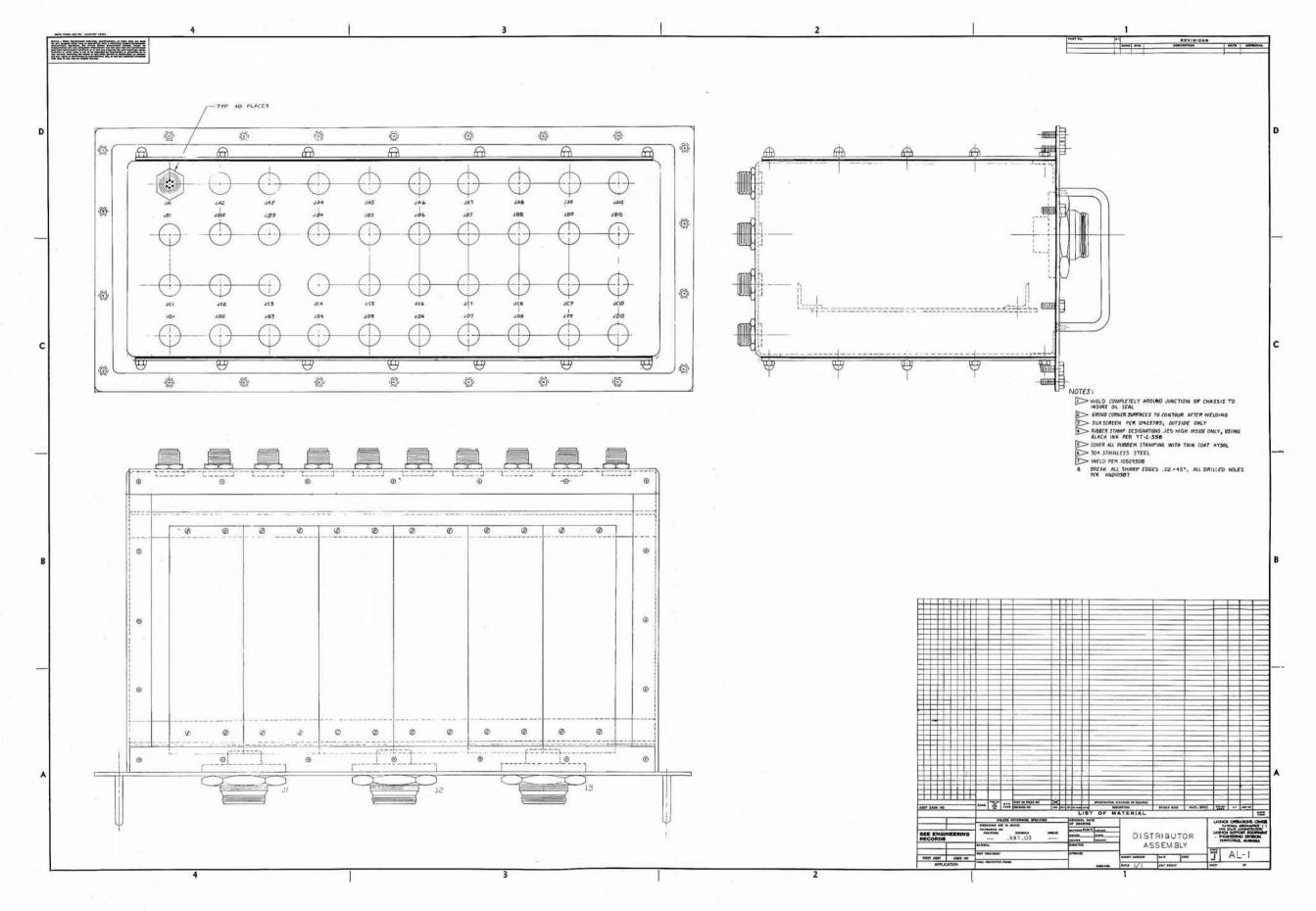


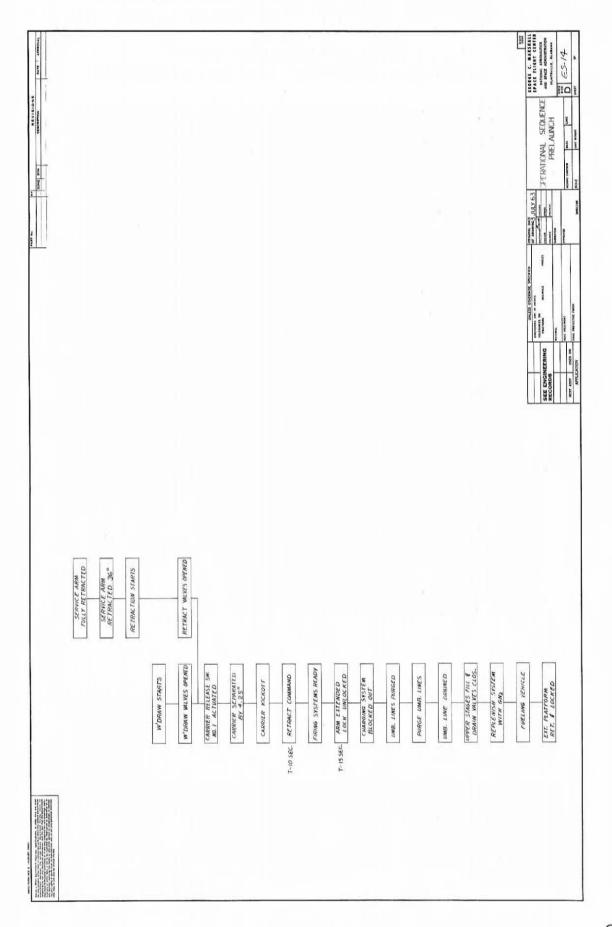


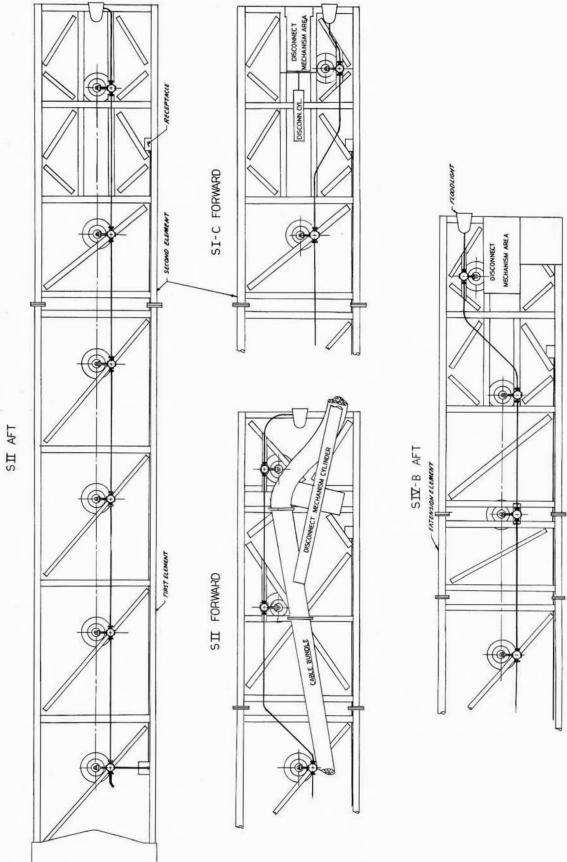
C-27

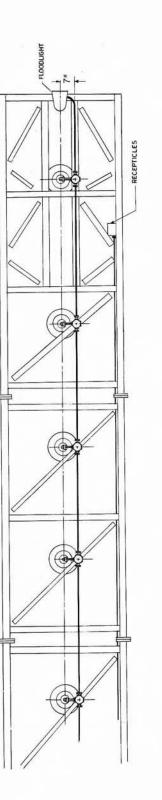




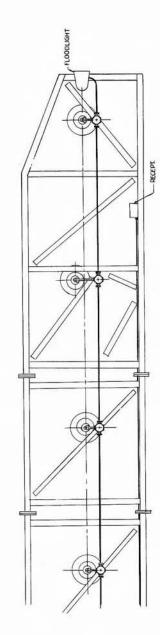




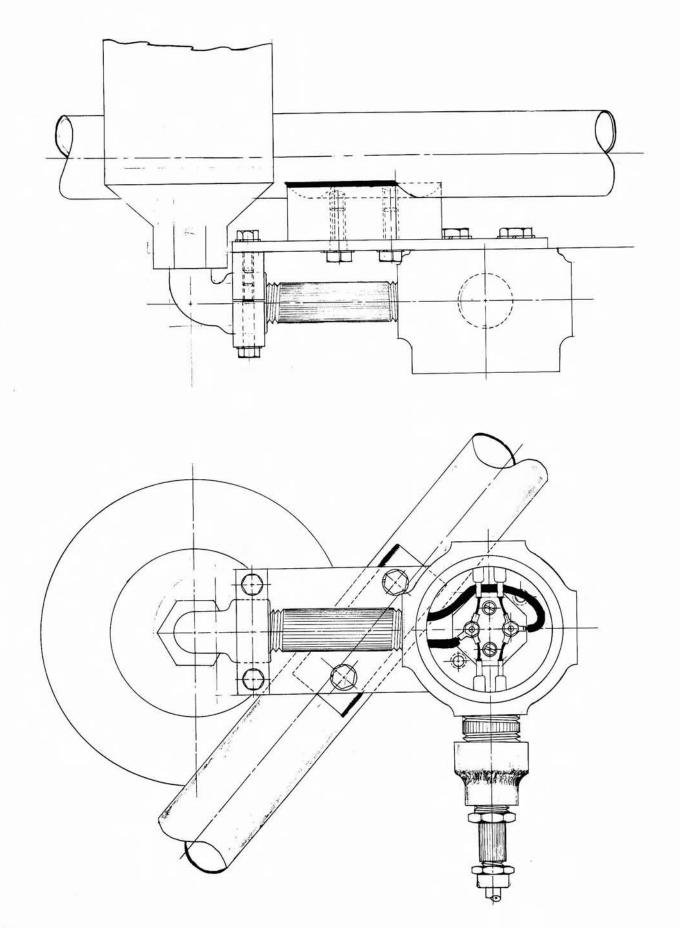


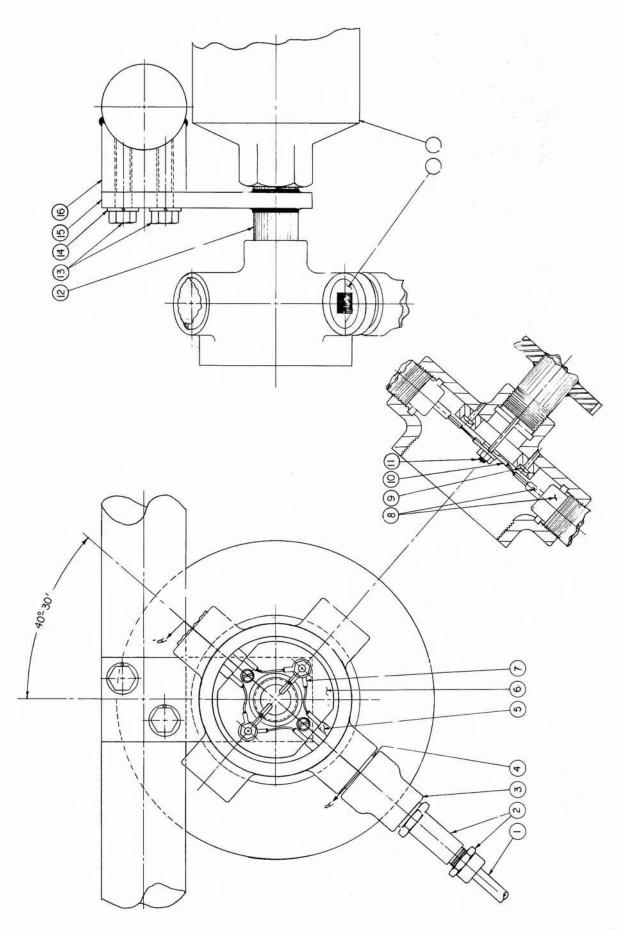


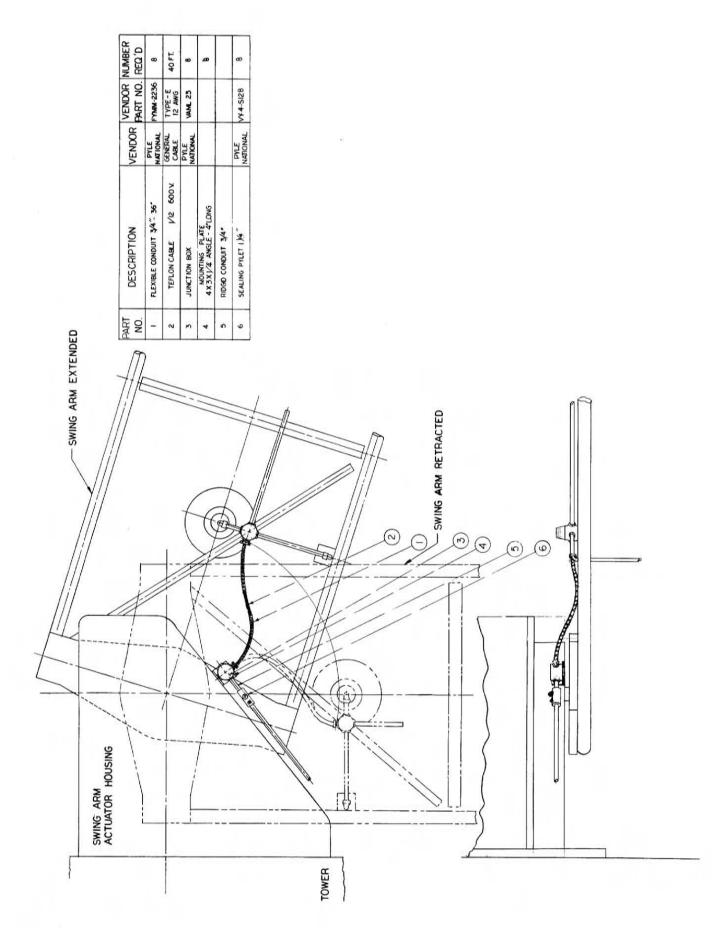




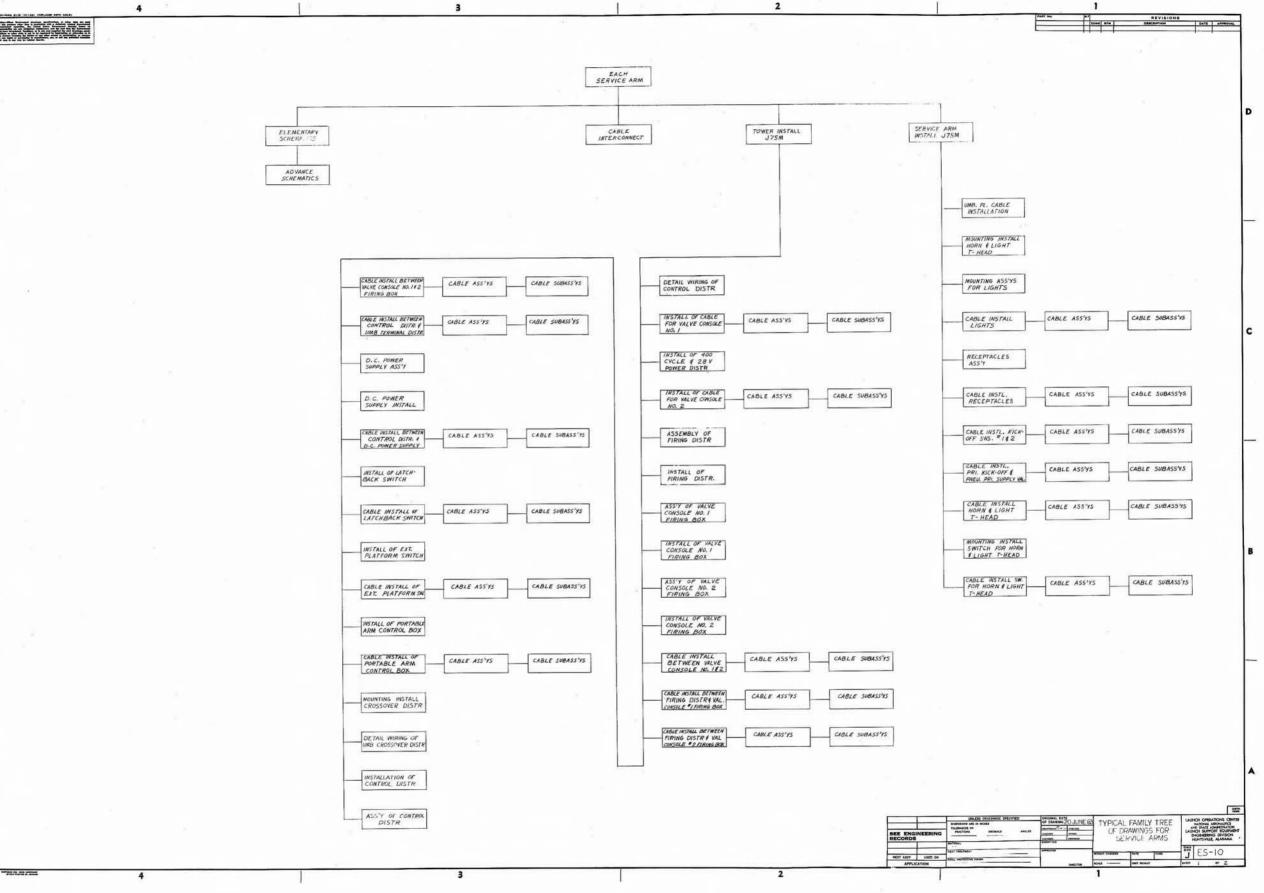
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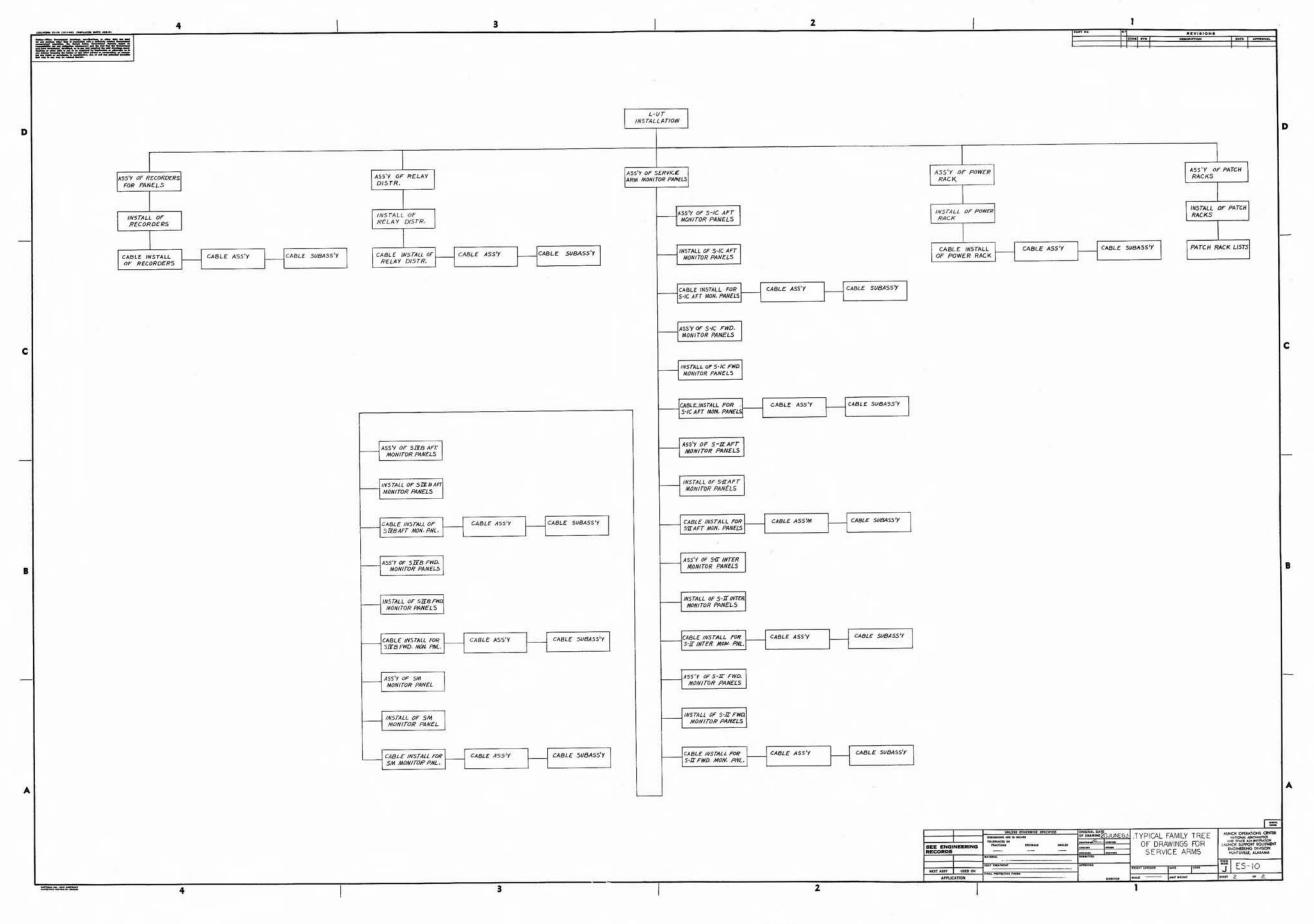




D



C-37

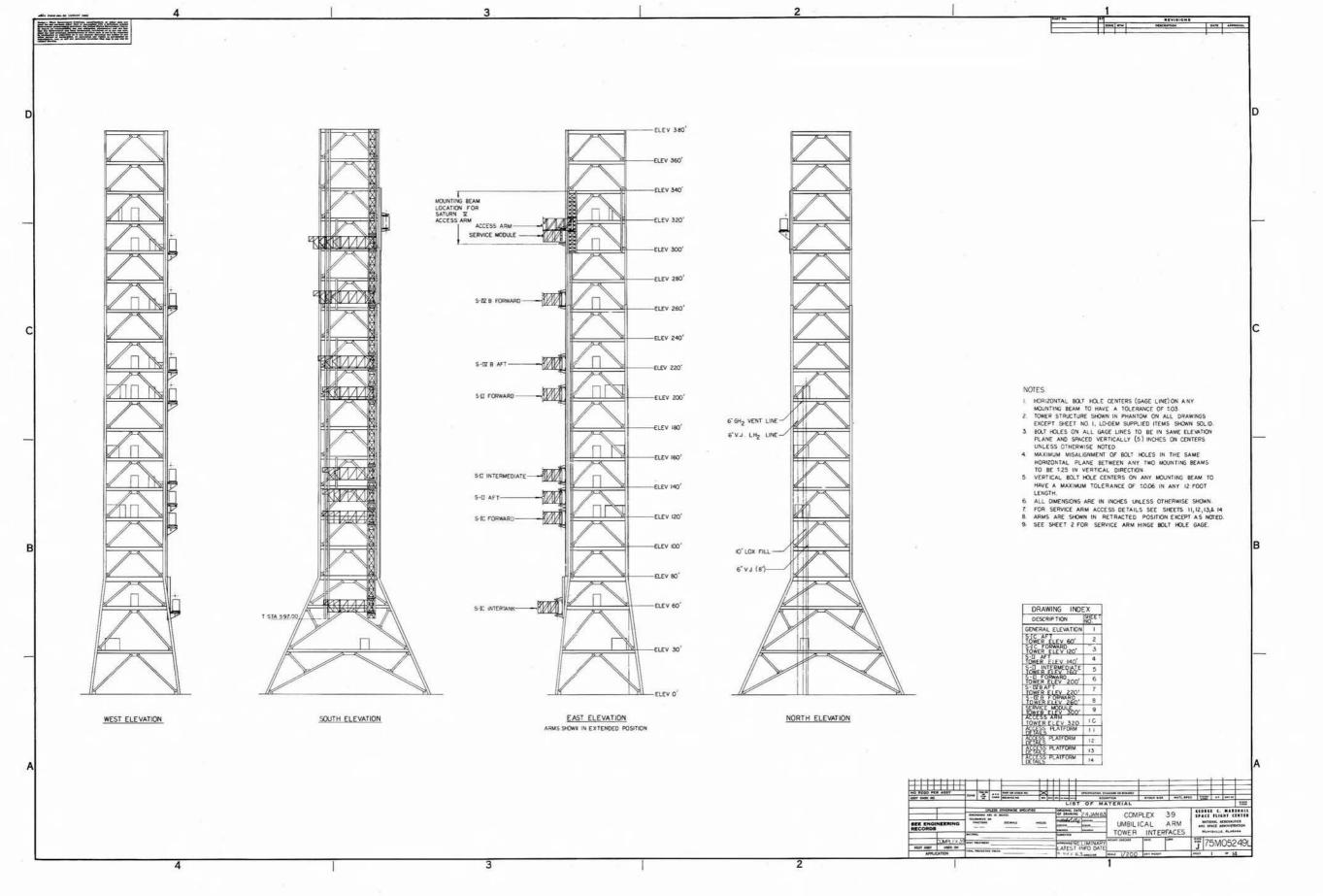


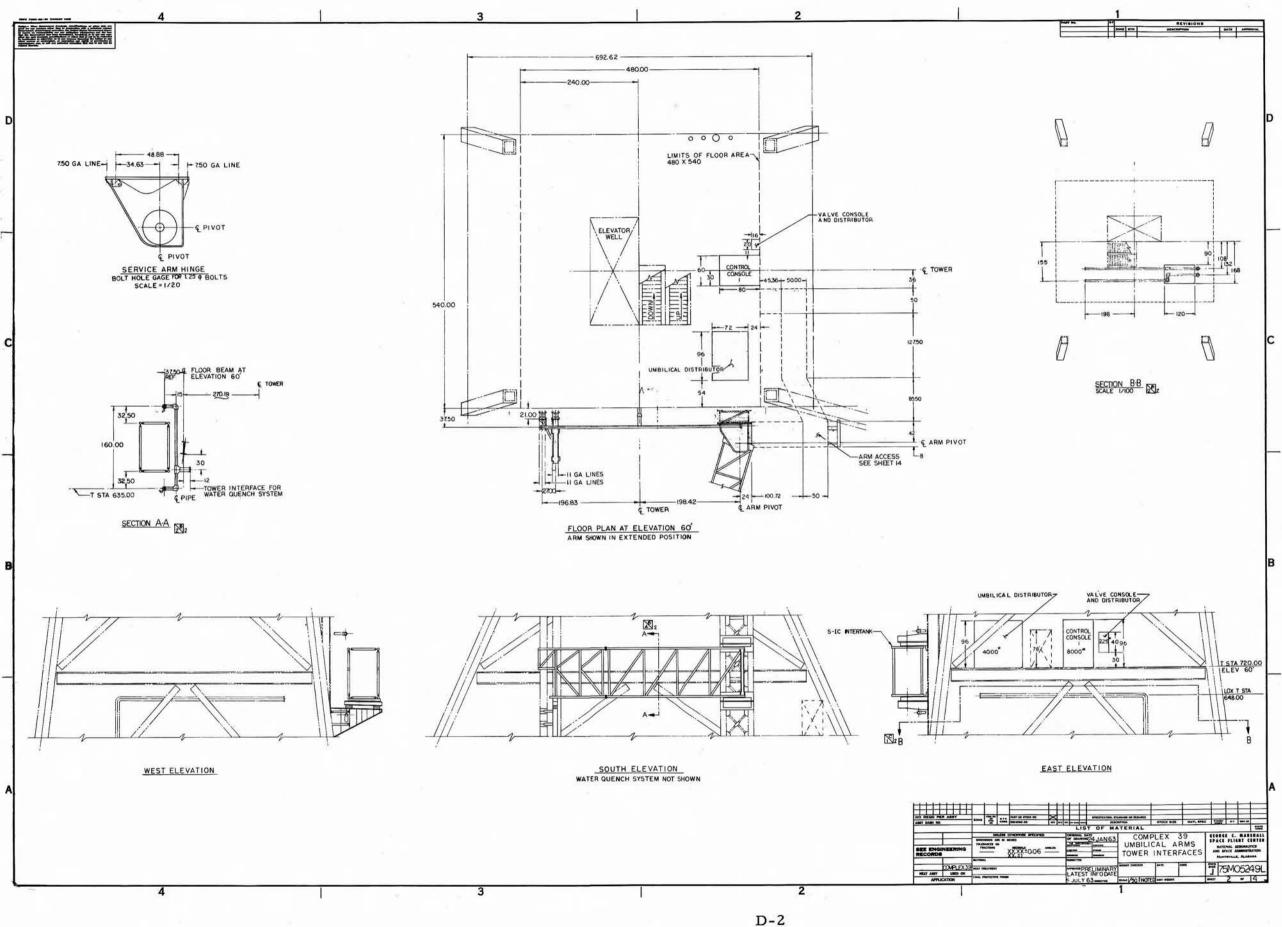
APPENDIX D

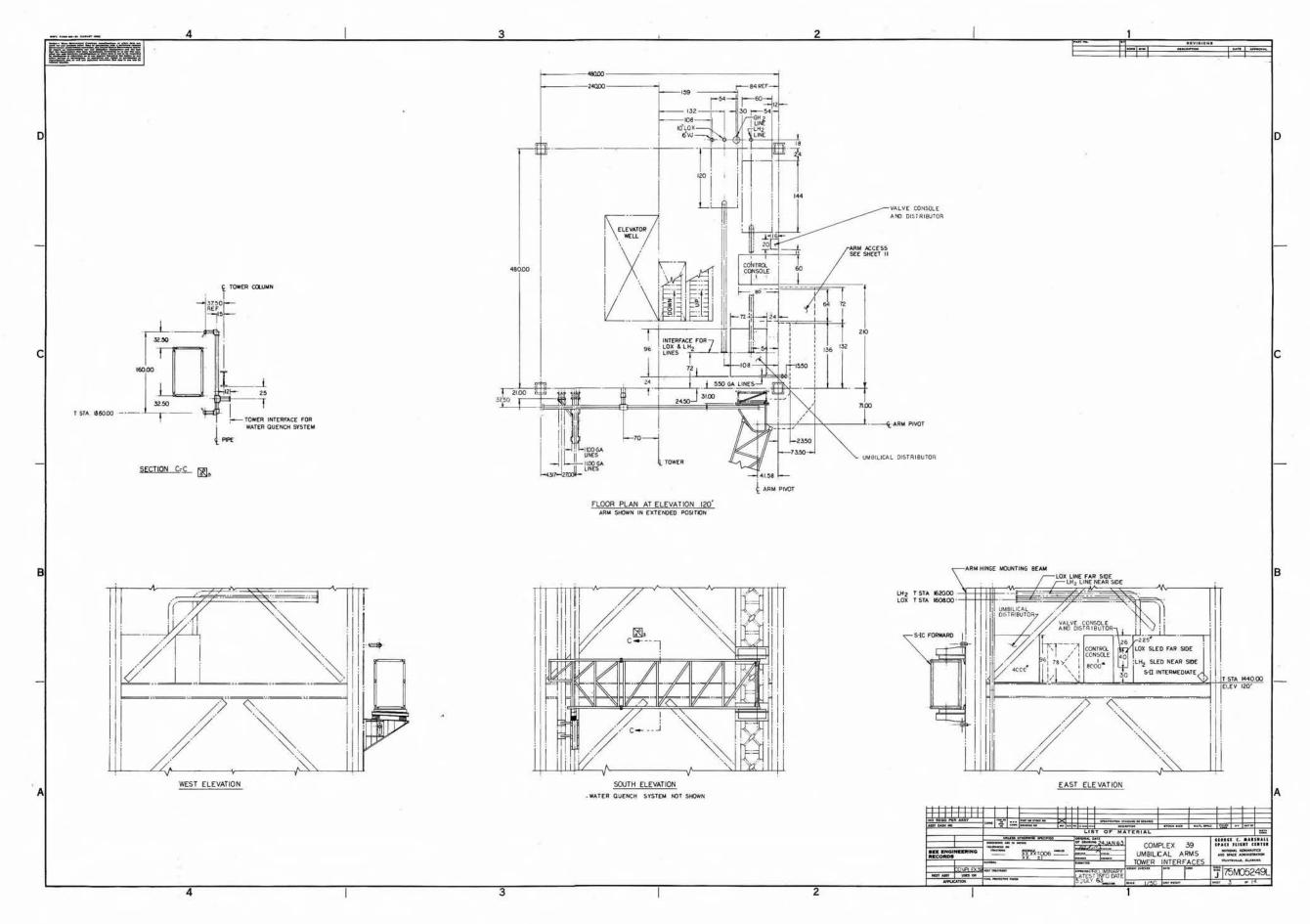
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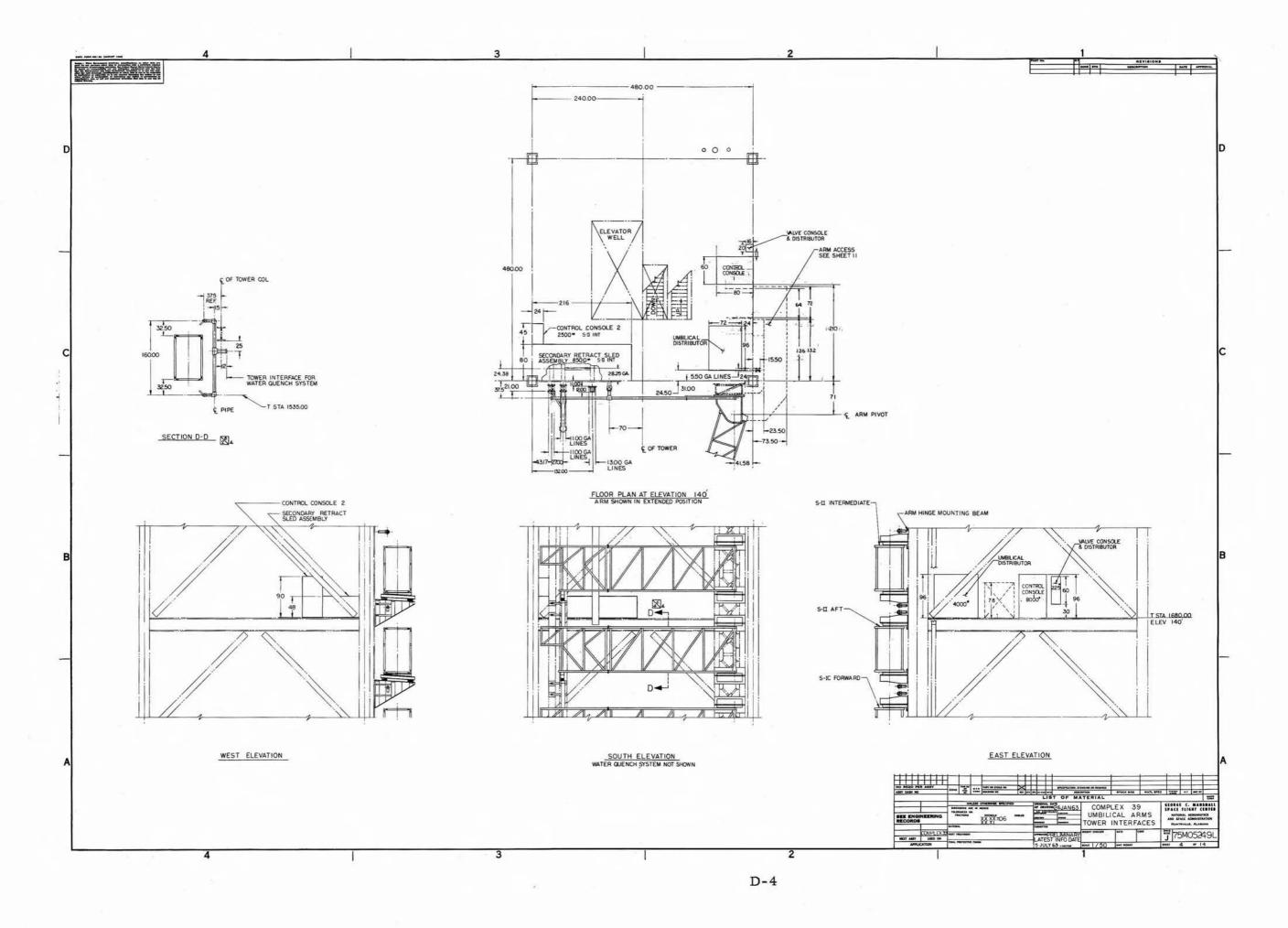
Appendix D contains drawings which show the Umbilical Arm-Tower Interfaces. The following changes, which affect the drawings, are in progress:

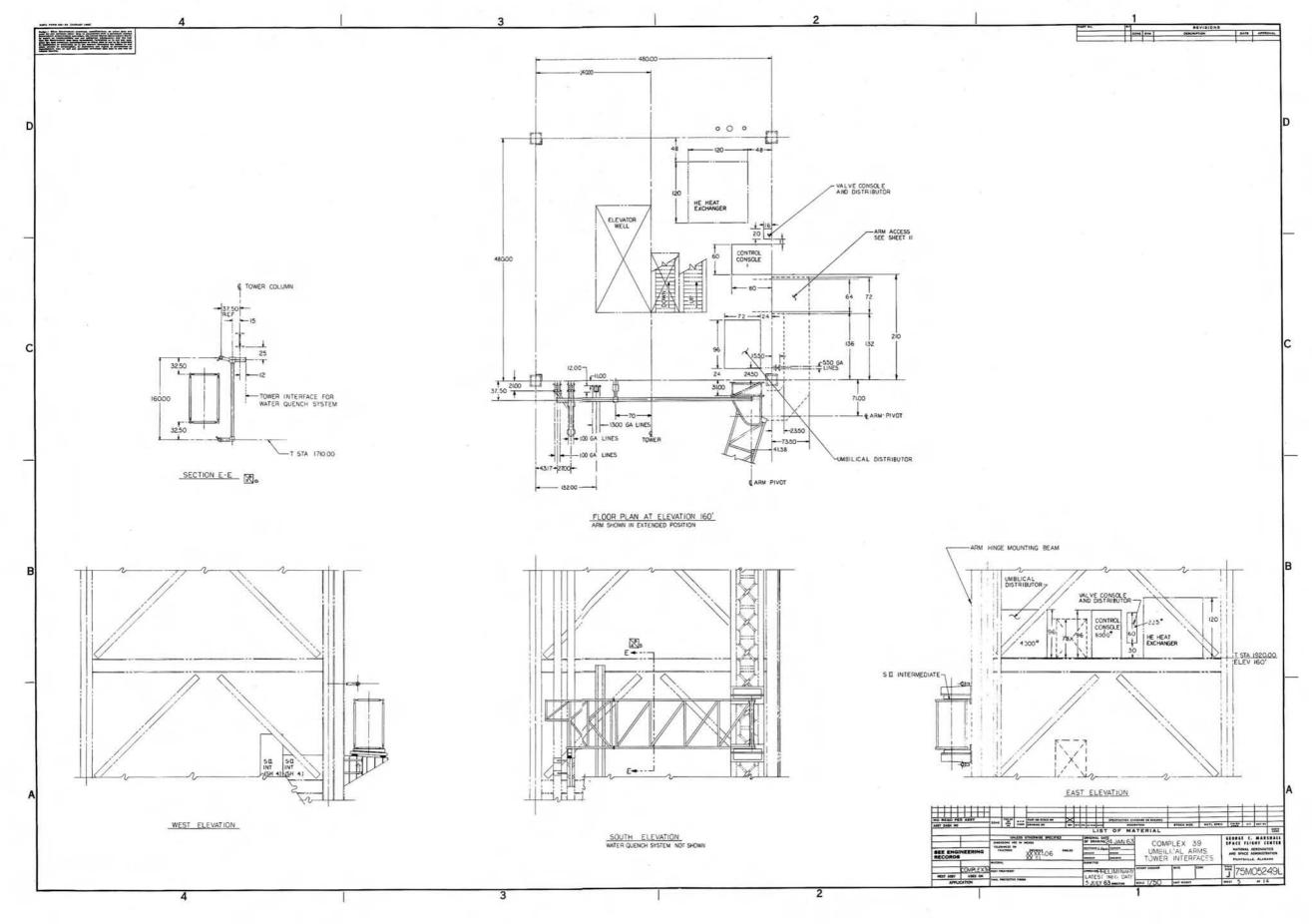
- LOX line elevation shown as station 648.000 on sheet 2 will be lowered.
- (2) Umbilical distributor will be relocated to provide a 48-inch clearance between distributor and column centerlines. Clearance is required for installation and maintenance of umbilical and service lines. This change will affect sheets where distributor is shown.
- (3) Umbilical distributor at the 140-foot level, shown on sheet 4, will be removed.
- (4) All umbilical distributors will be limited to maximum height of 72 inches.
- (5) S-II INTERMEDIATE arm accessway, shown on sheet 11, may be changed from vertical ladder to stairs entering into the 140-foot level deck space.

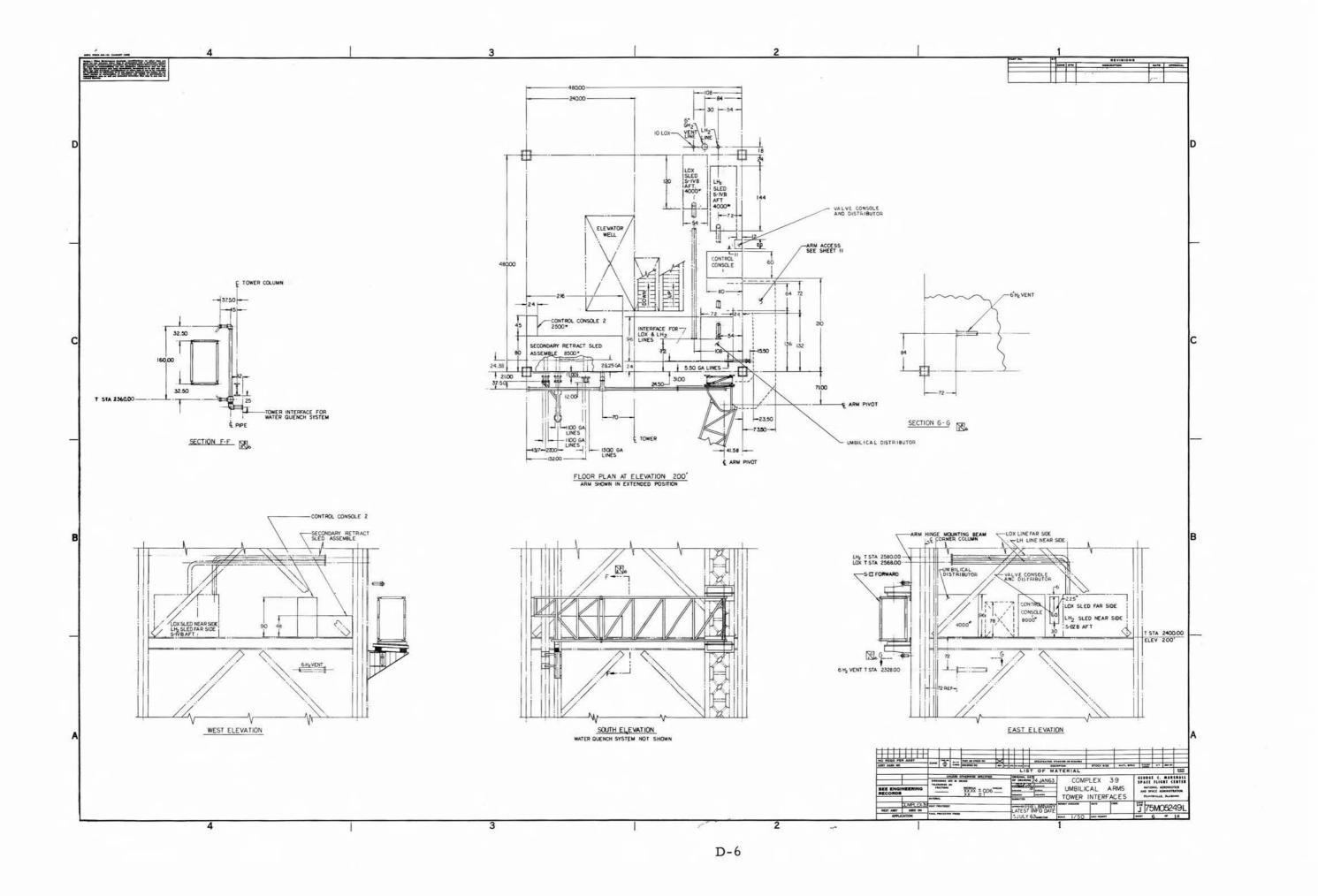


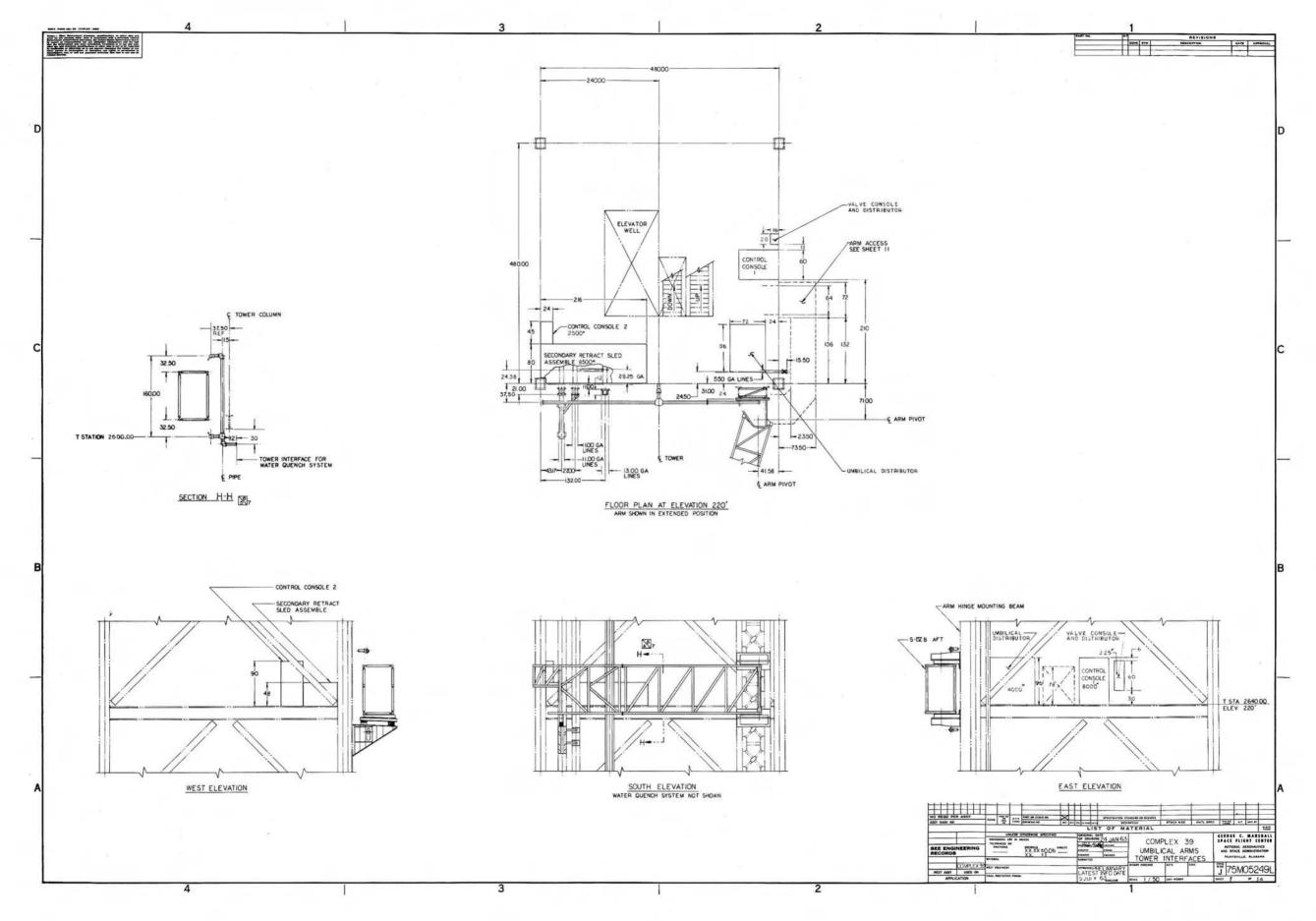


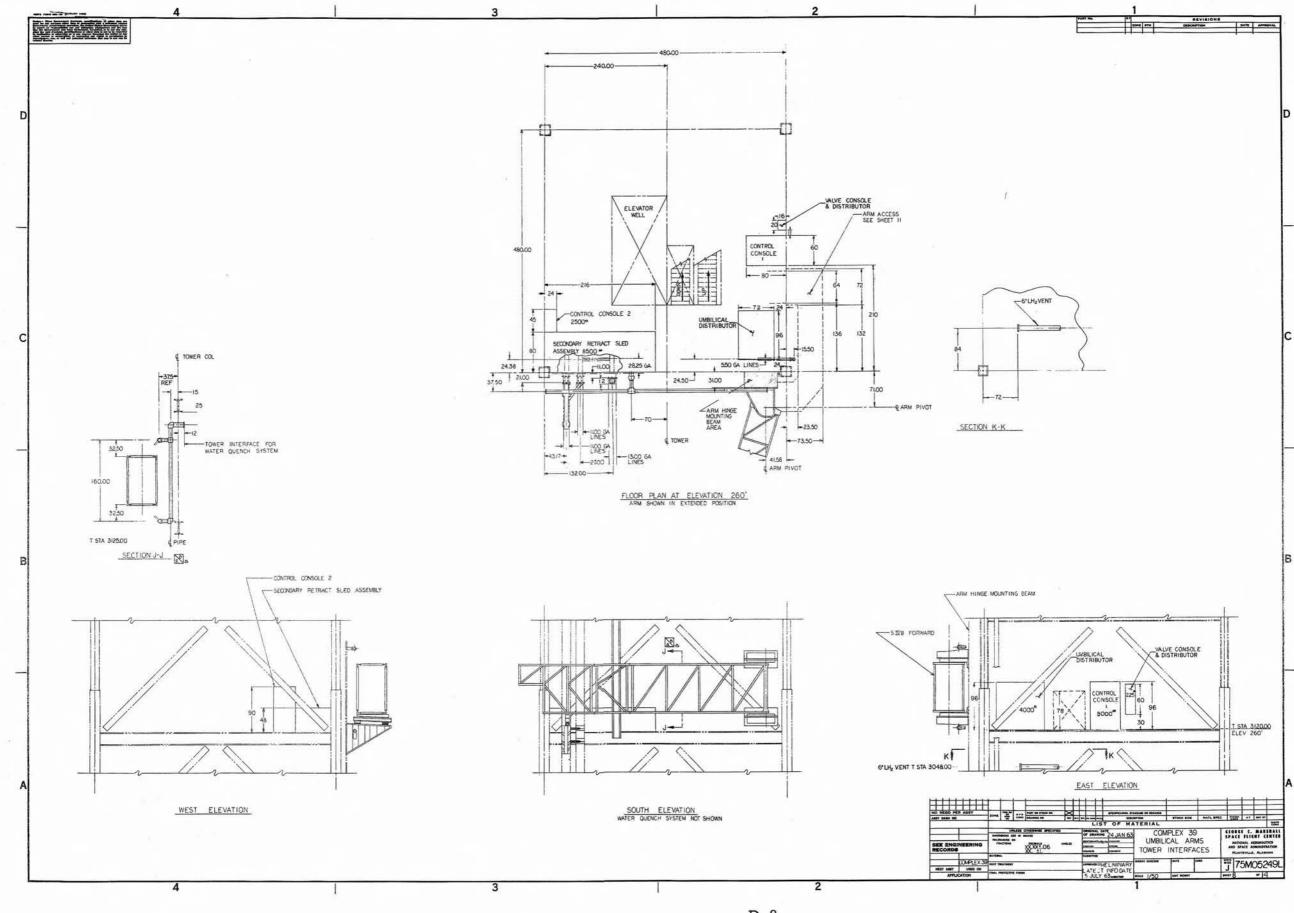


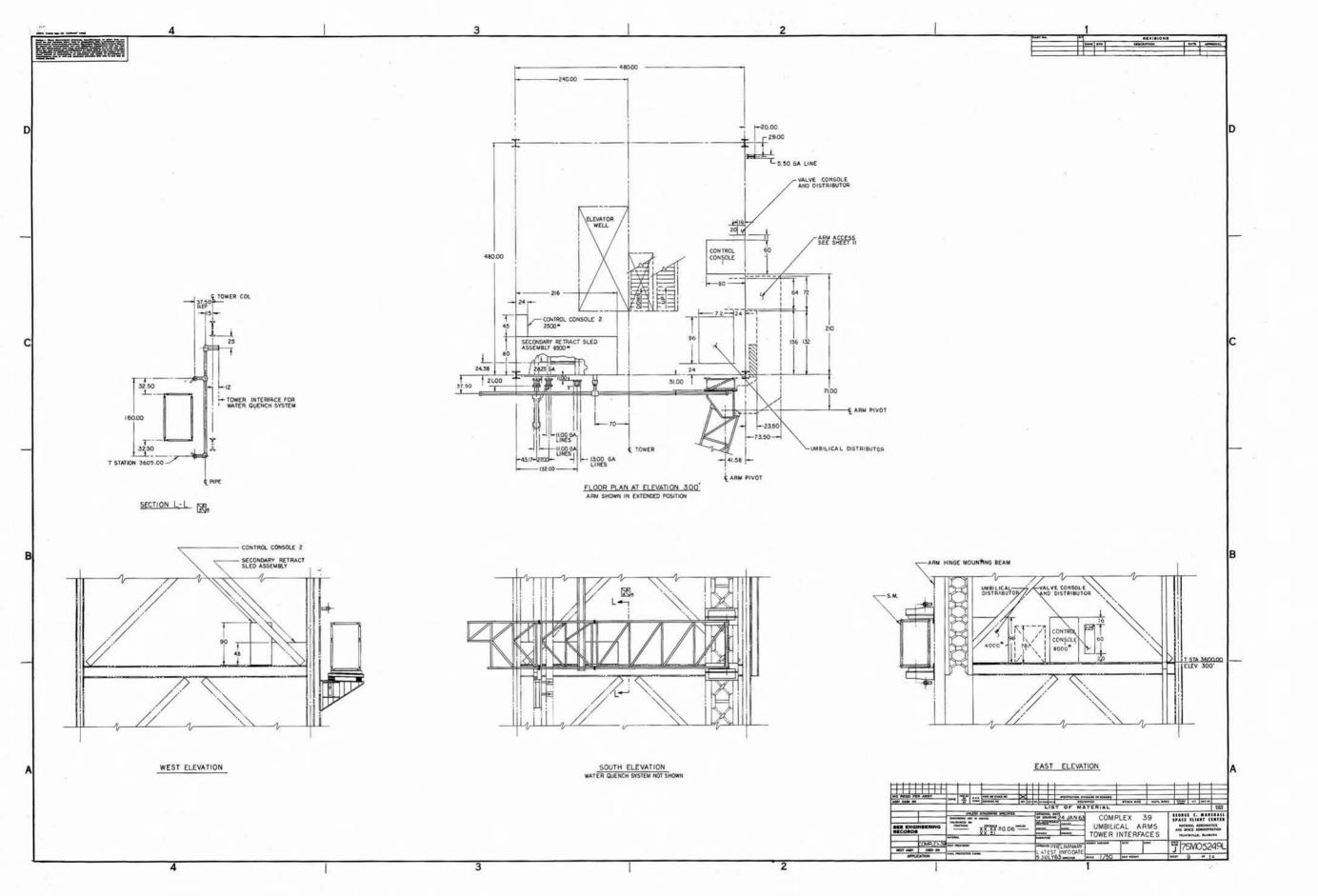


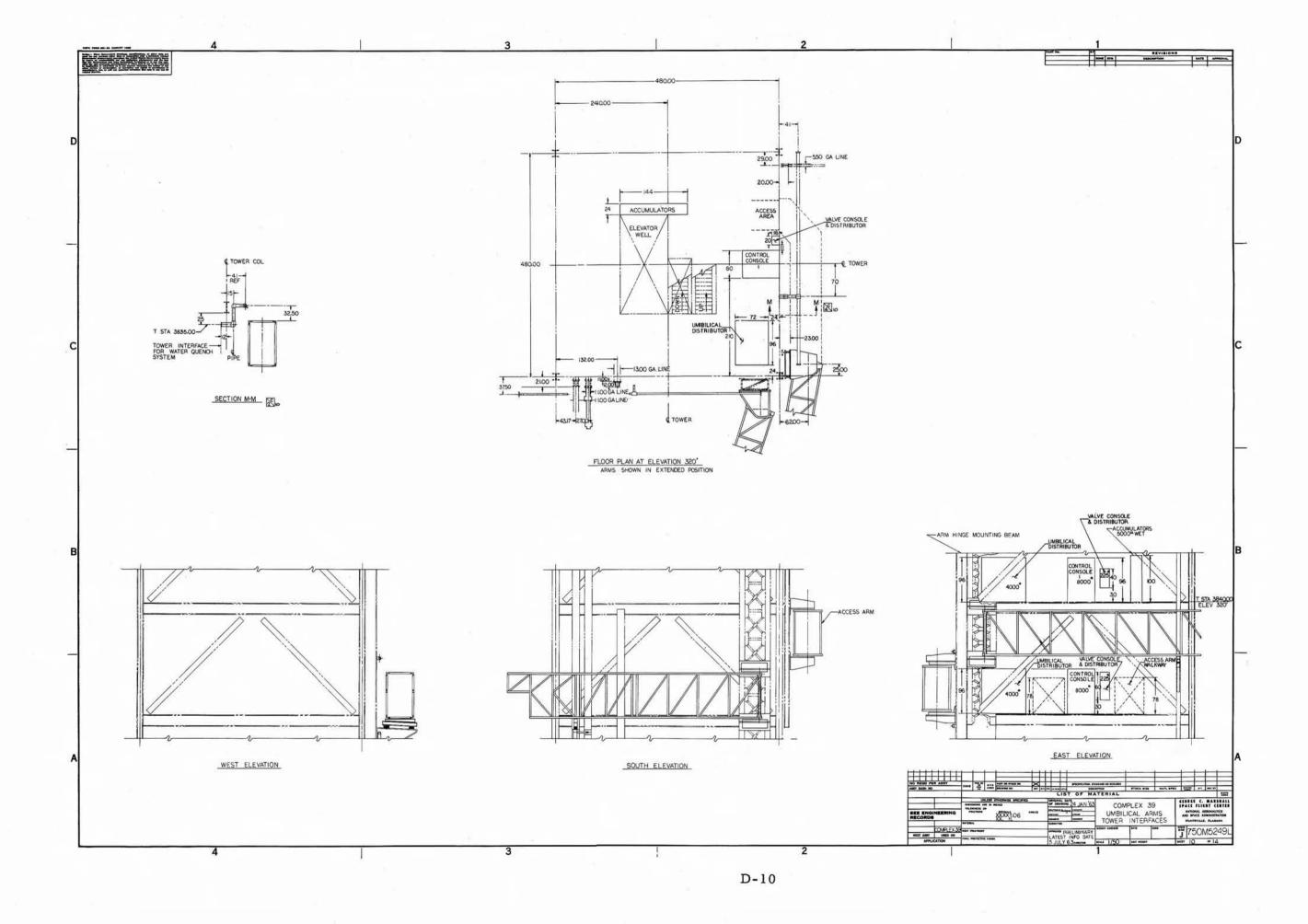


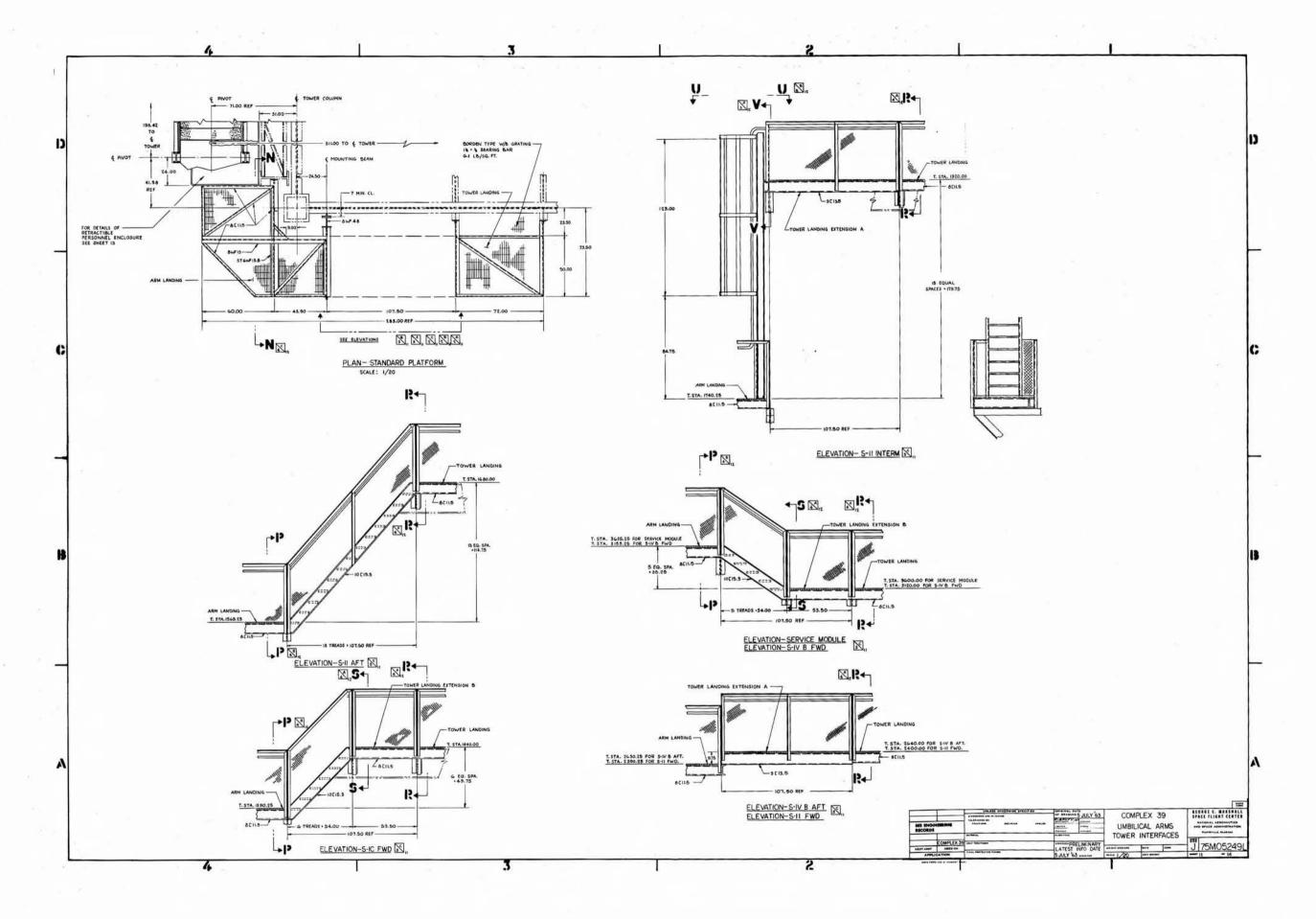


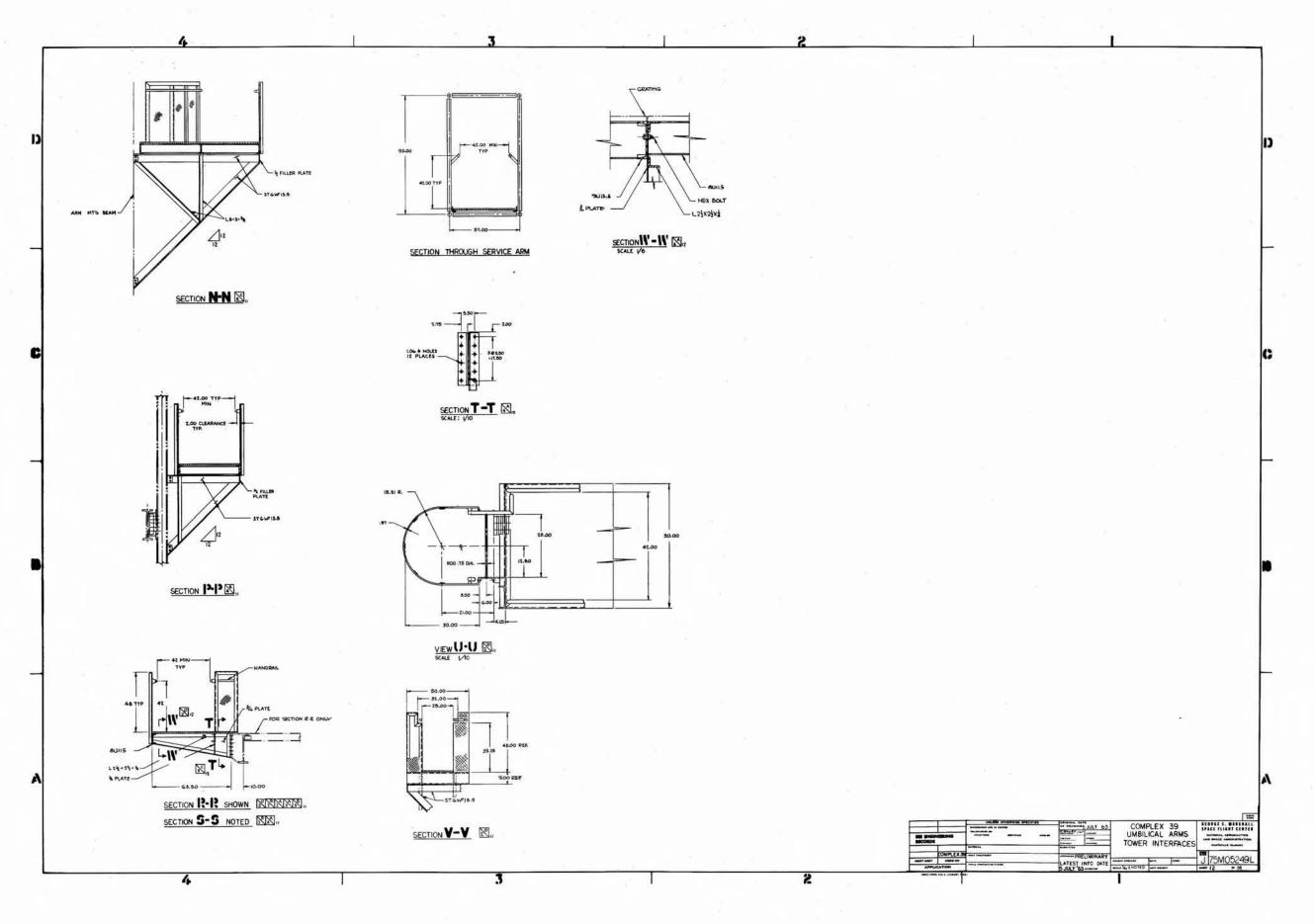




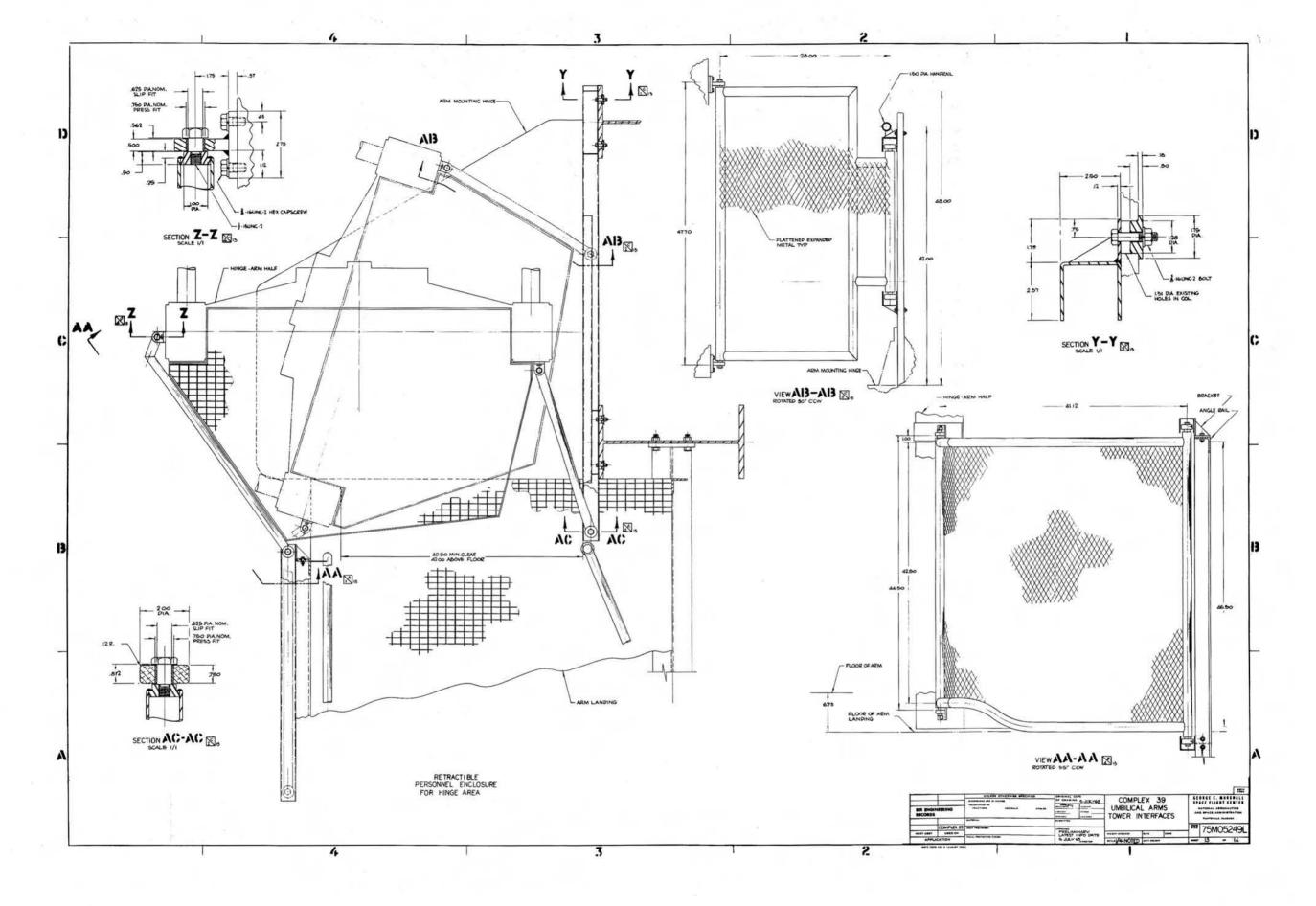






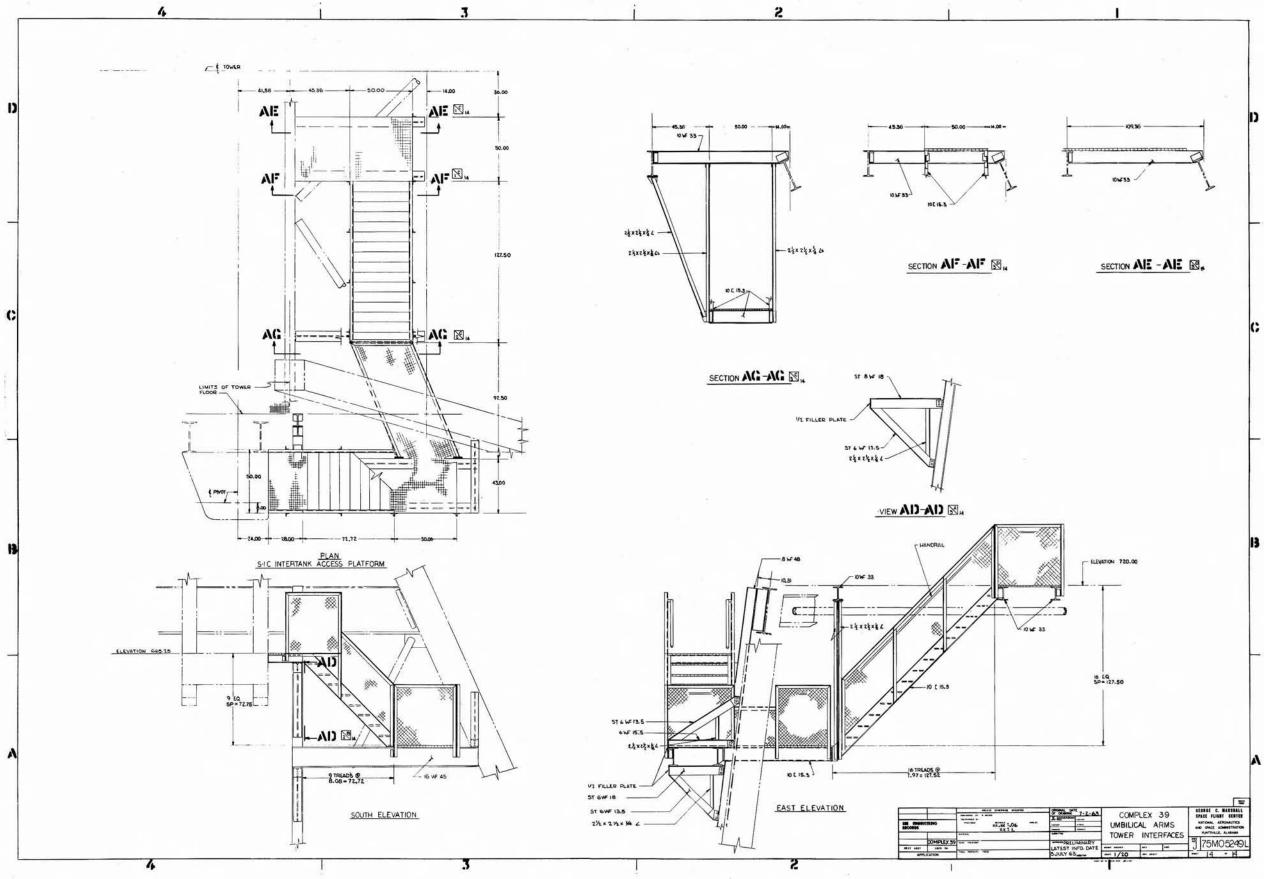


D-12



D-13





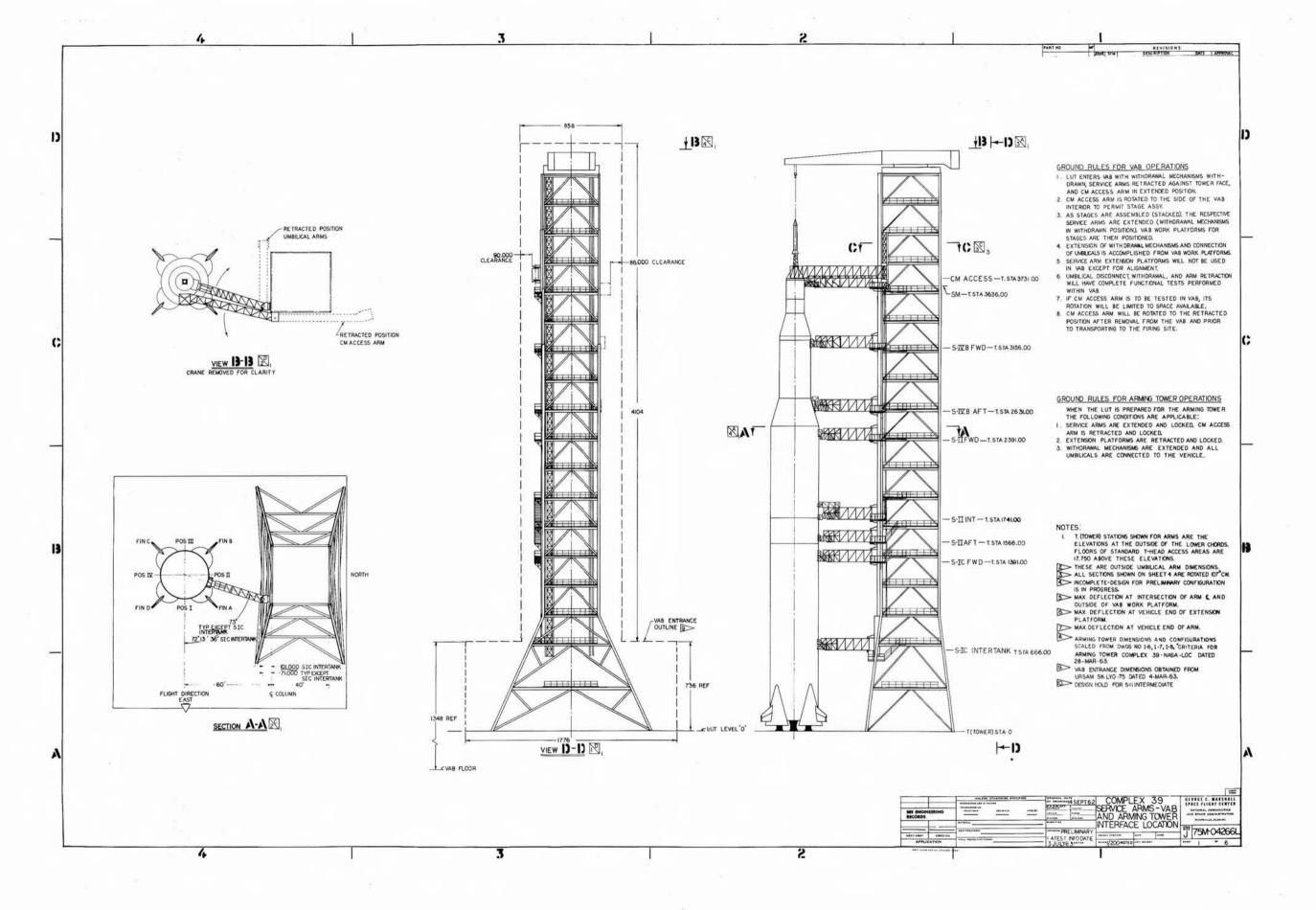
D-14

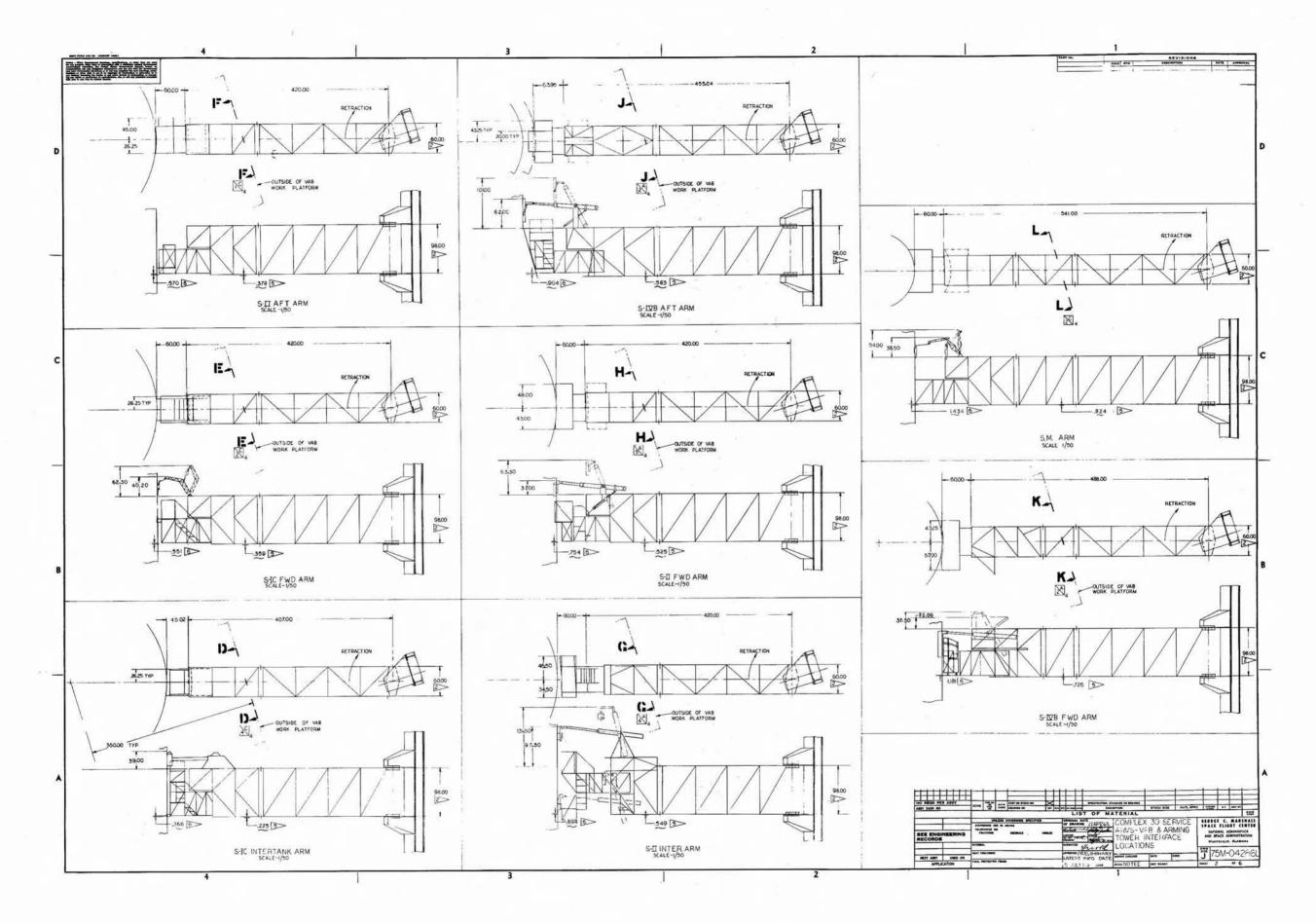
APPENDIX E

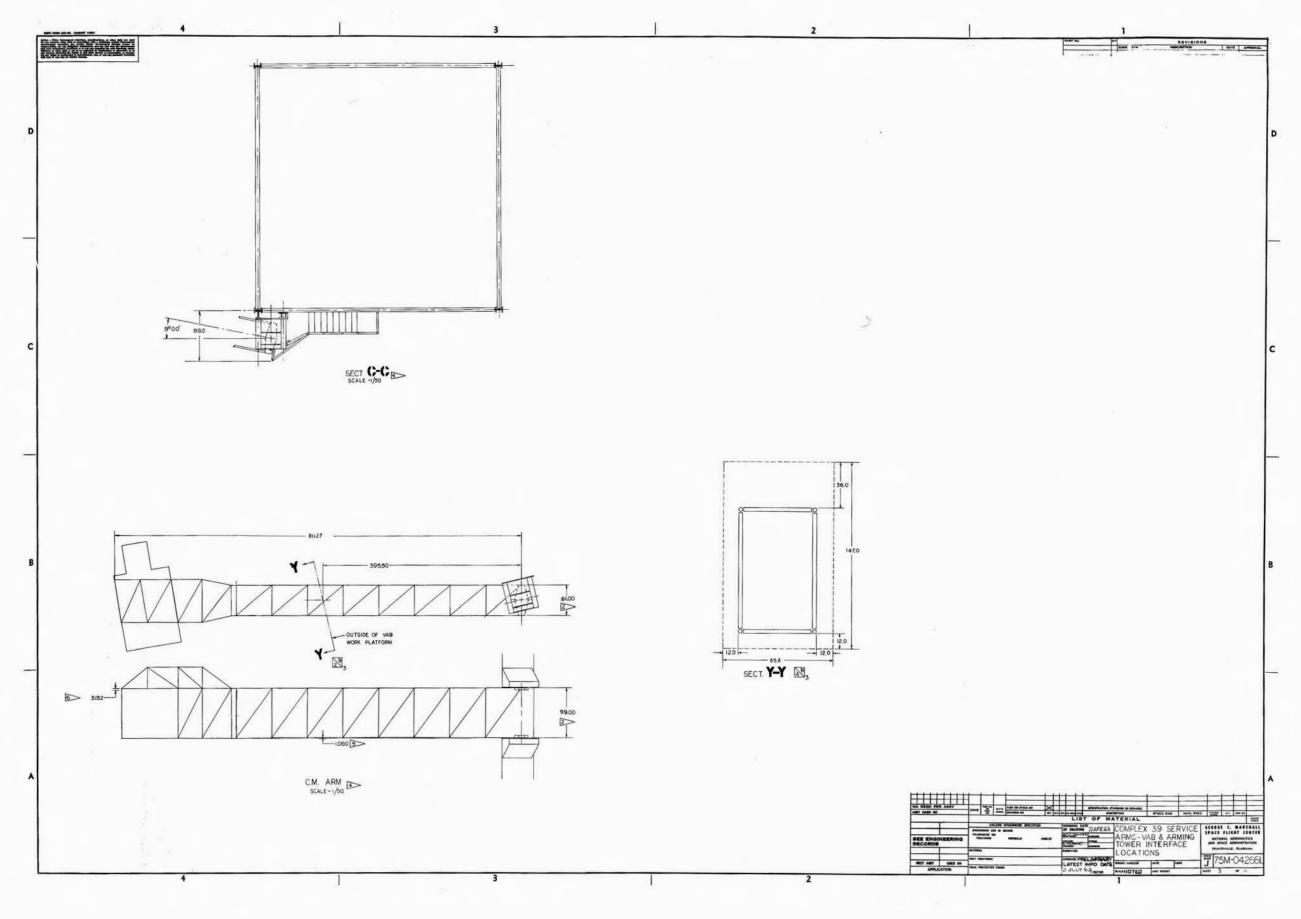
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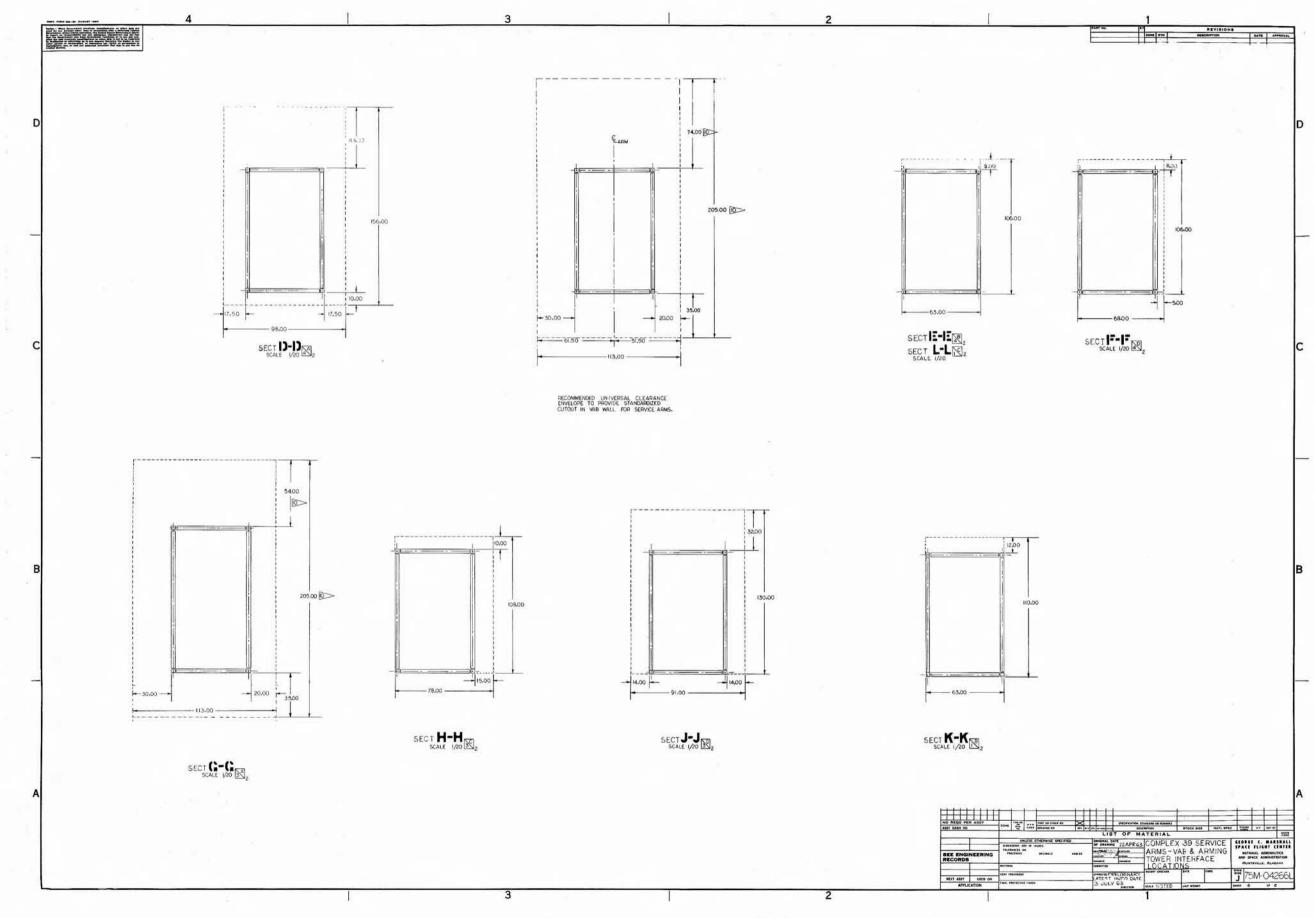
Appendix E contains drawings which show the VAB and Arming Tower Interface locations of the Service and Access Arms. The following changes, which will affect the drawings, are in progress:

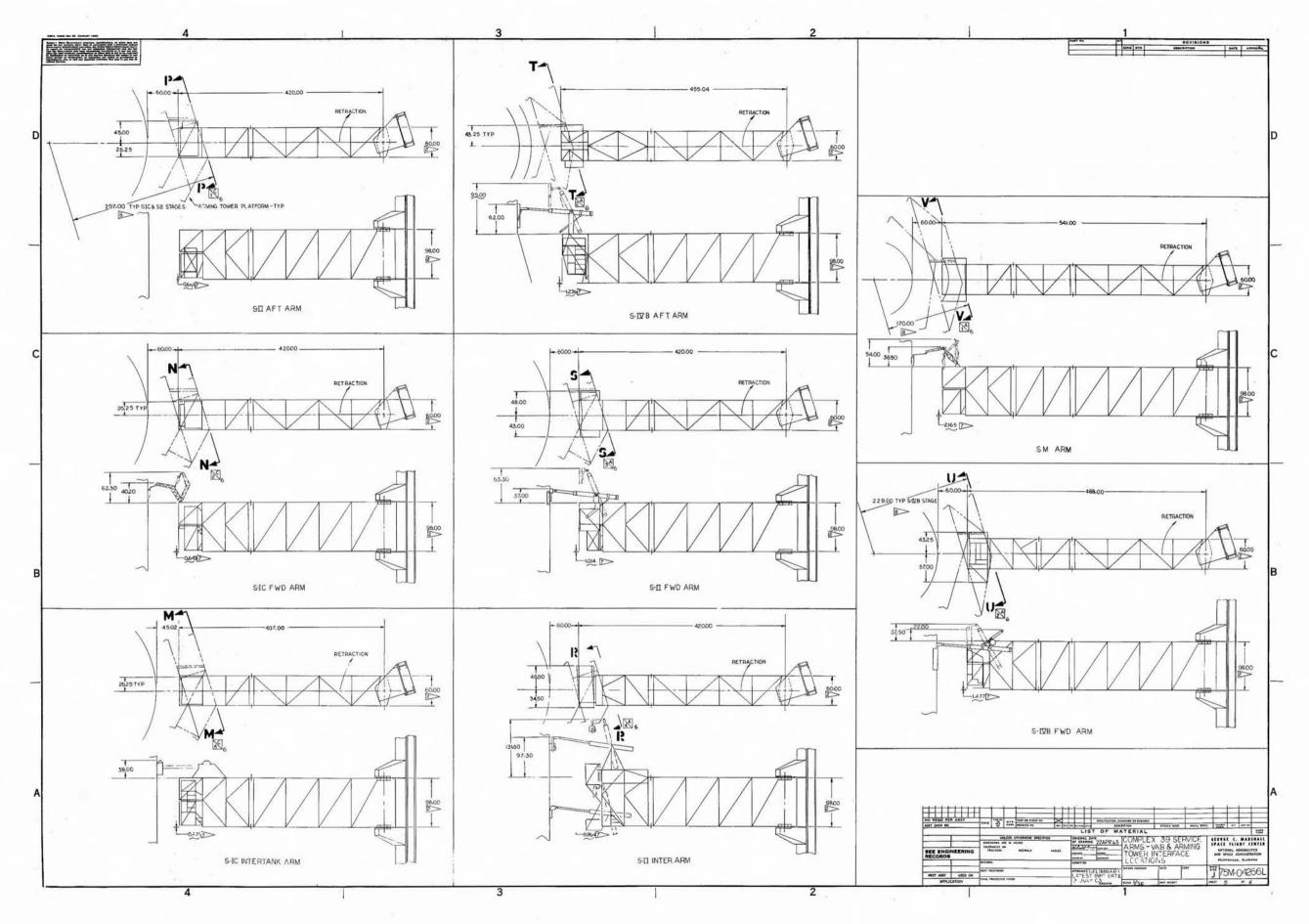
- Extendable service platform being added to the S-II AFT arm. Platform will provide access to S-II INTERMEDIATE umbilical carrier. This change affects sheets 2, 4, 5 and 6.
- (2) Extension platform configuration on S-II INTER-MEDIATE arm will be changed. This change will affect sheets 2, 4, 5 and 6.
- (3) General revisions to all withdrawal mechanisms for configuration changes which affect the clearance envelopes.

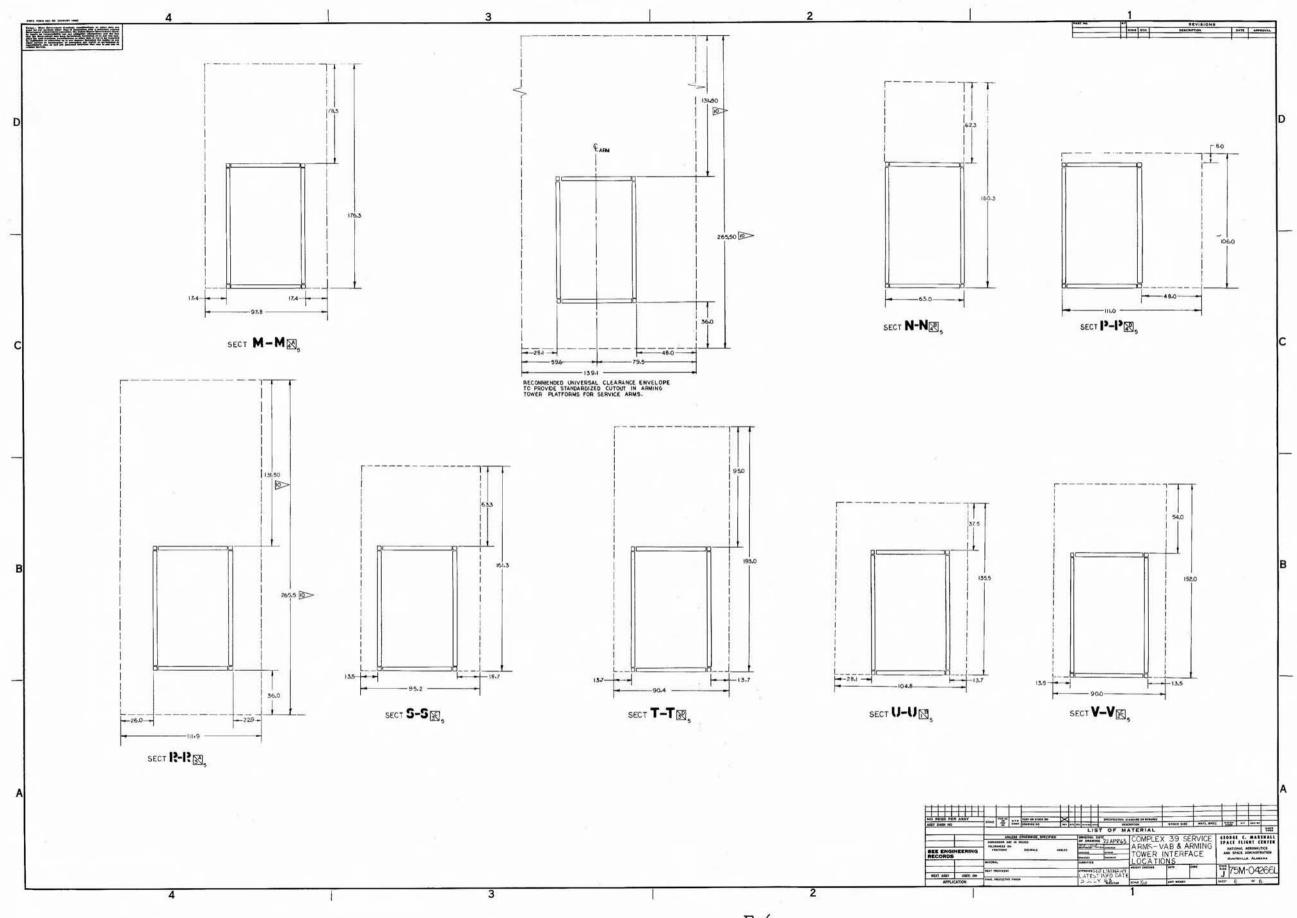








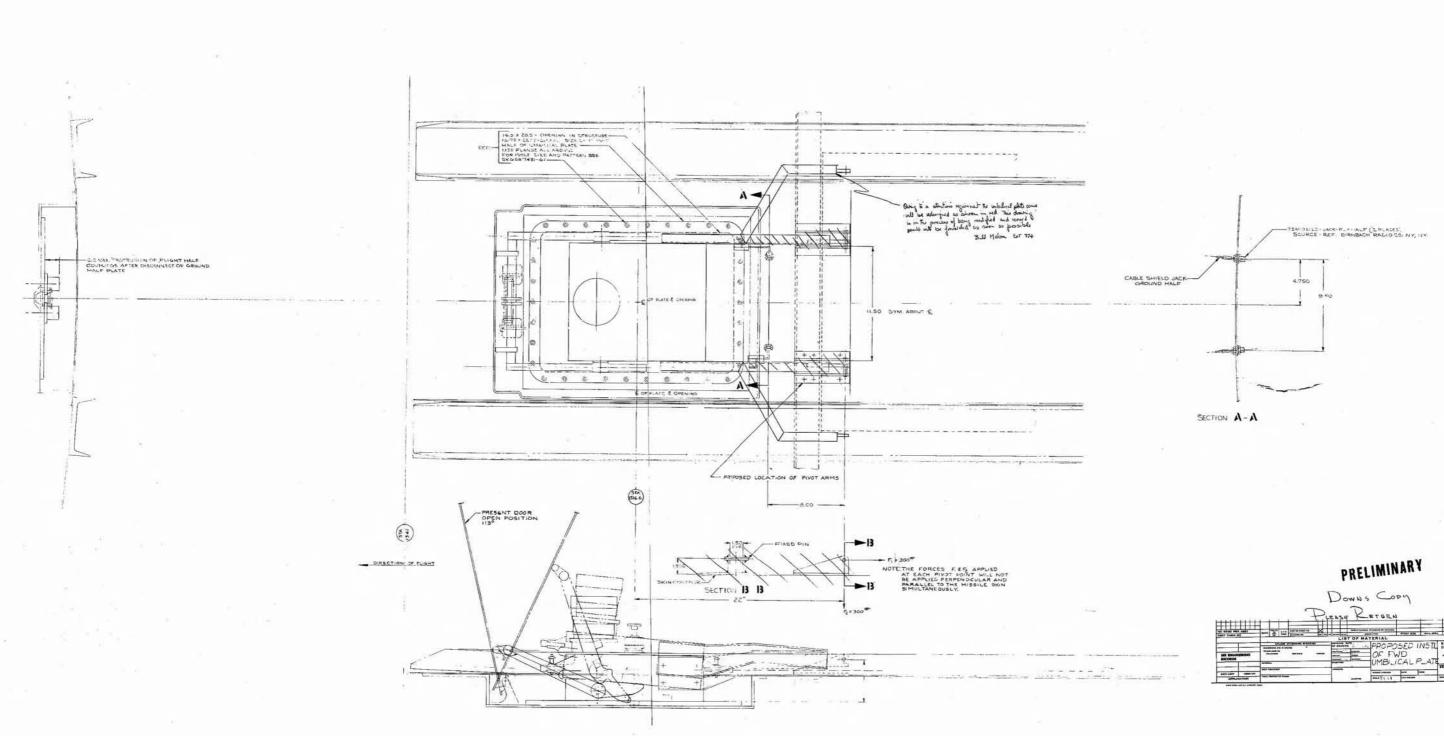




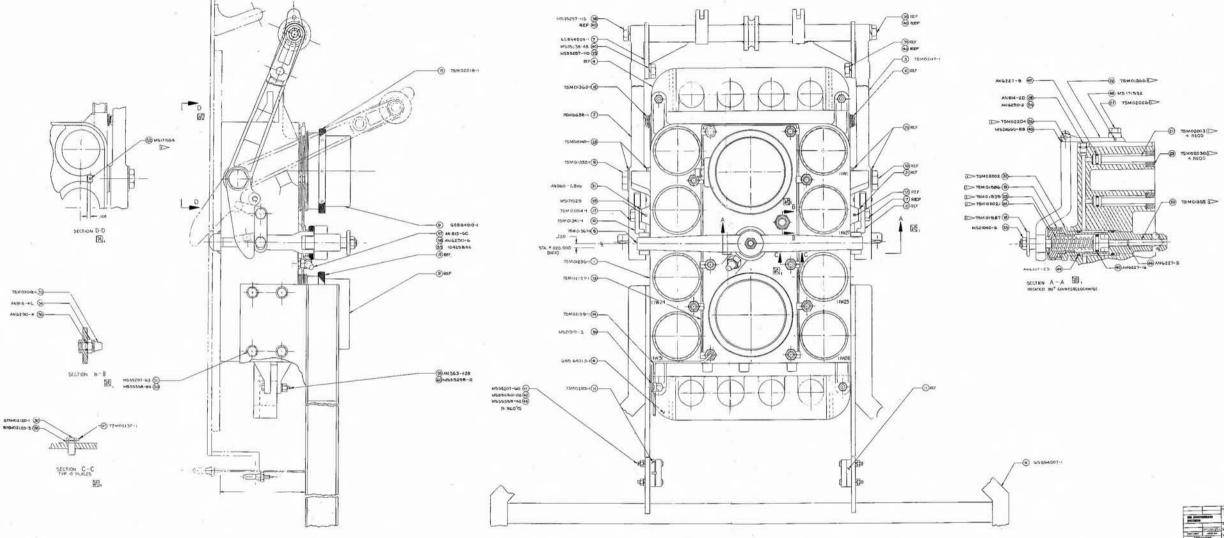
APPENDIX F

Preface

Appendix F contains information which has been received from the various stage contractors. The design of all service arms up until July 10, 1963, has been based upon the information provided on drawings presented on pages F-1 through F-63. Future design will be based upon drawings received after that date. Pages F-64 through F-69 indicate such drawings that have been received after July 10, 1963, and up until publication closing time July 22, 1963. The recently received drawings are recognized to contain information that dictates changes that must be made to designs displayed in this preliminary engineering report.



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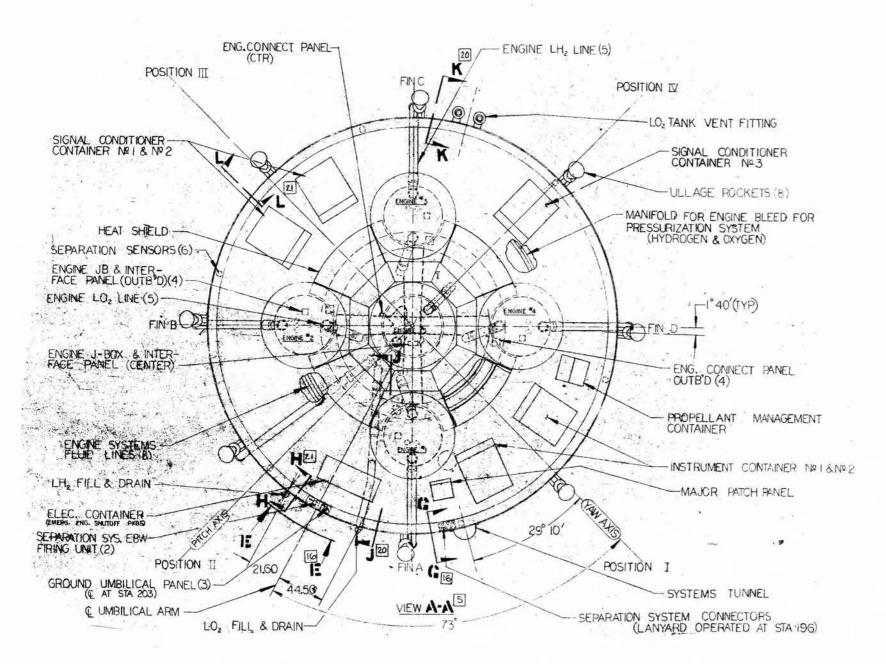


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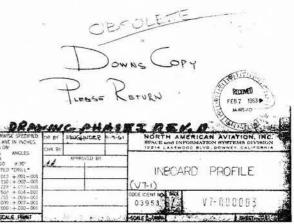
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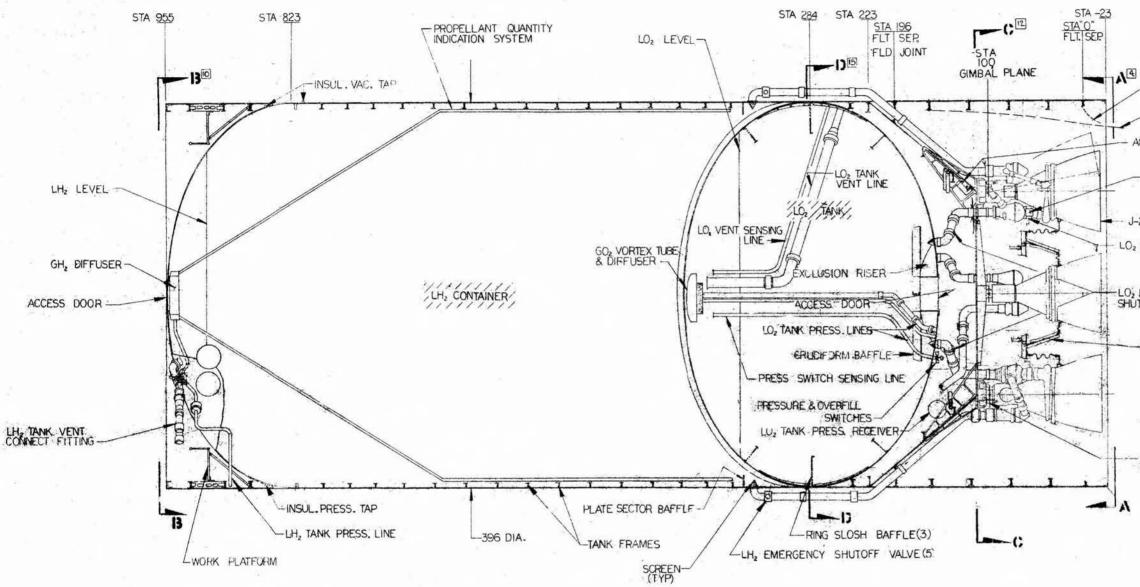
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Sheet 1 of 5



123 PLANE SEP. TRAJECTORY

ACCUMULATOR RESERVOIR (TYP 4 ENGINES)

HYDRAULIC PUMP, ENGINE DRIVEN (4)

-J-2 ENGINE(5)

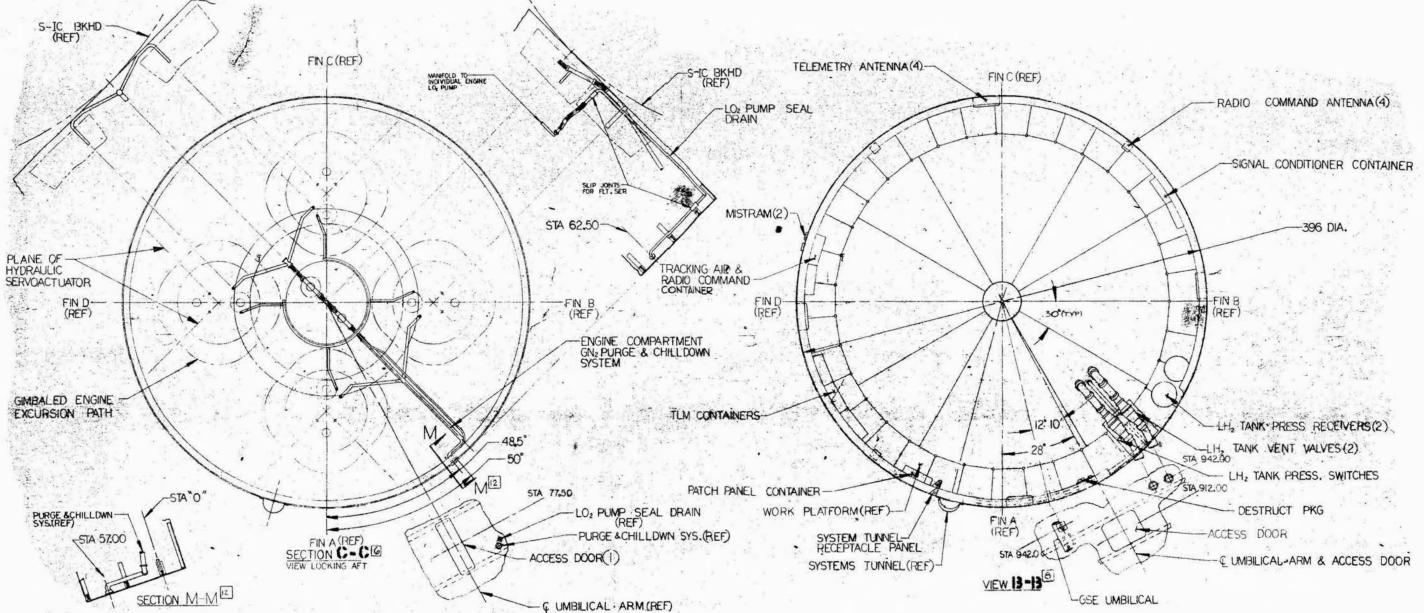
LO2 HEAT EXCHANGER(5)

-LO2 EMERGENCY SHUTOFF VALVE(5)

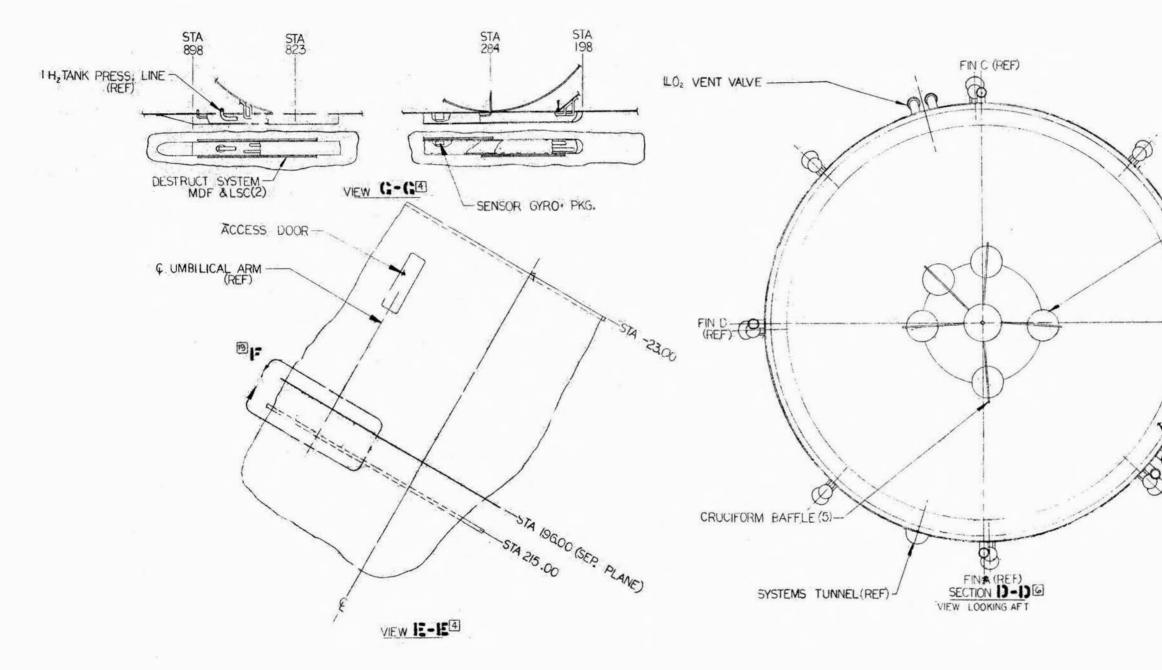
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HYDRAULIC SERVOACTUATOR(8)

Sheet 2 of 5



Sheet 3 of 5



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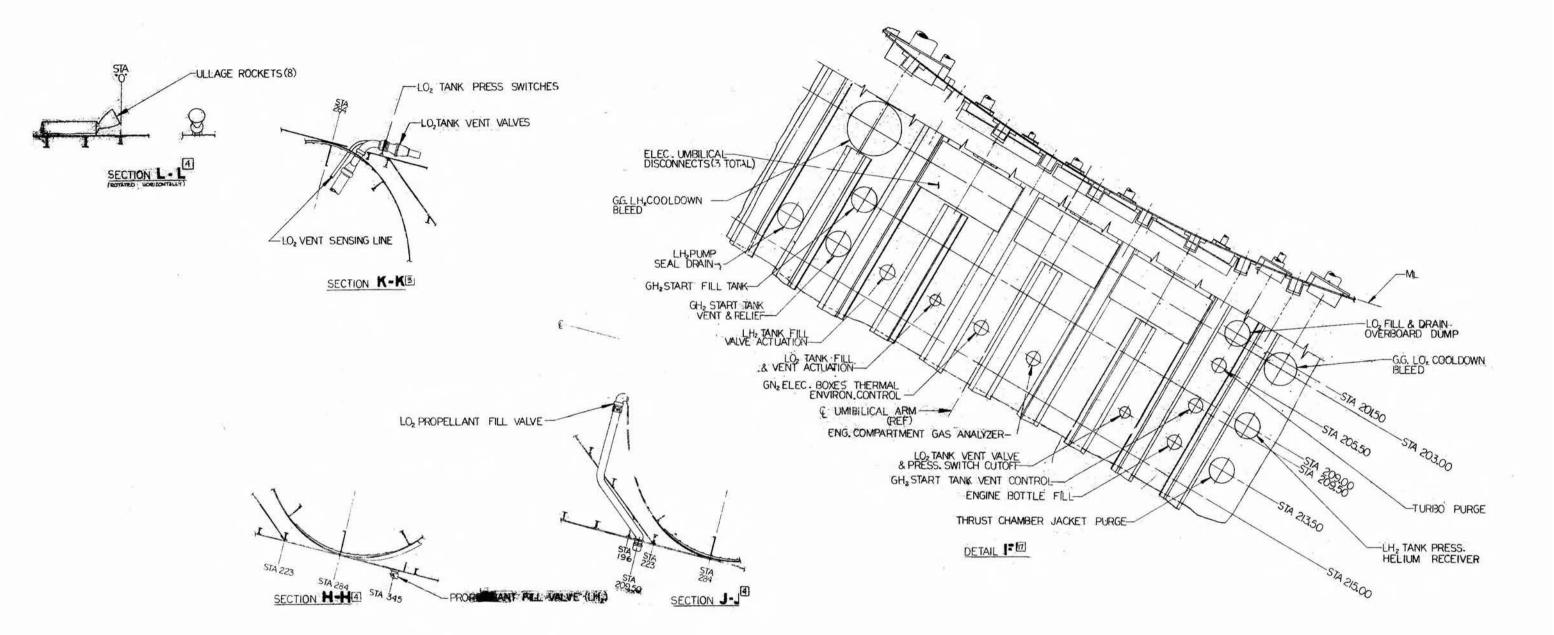
-PLATE ANTI-VORTEX BAFFLE(5)

FIN B (REF)

O - LO2 RING SLOSH BAFFLE



Sheet 4 of 5



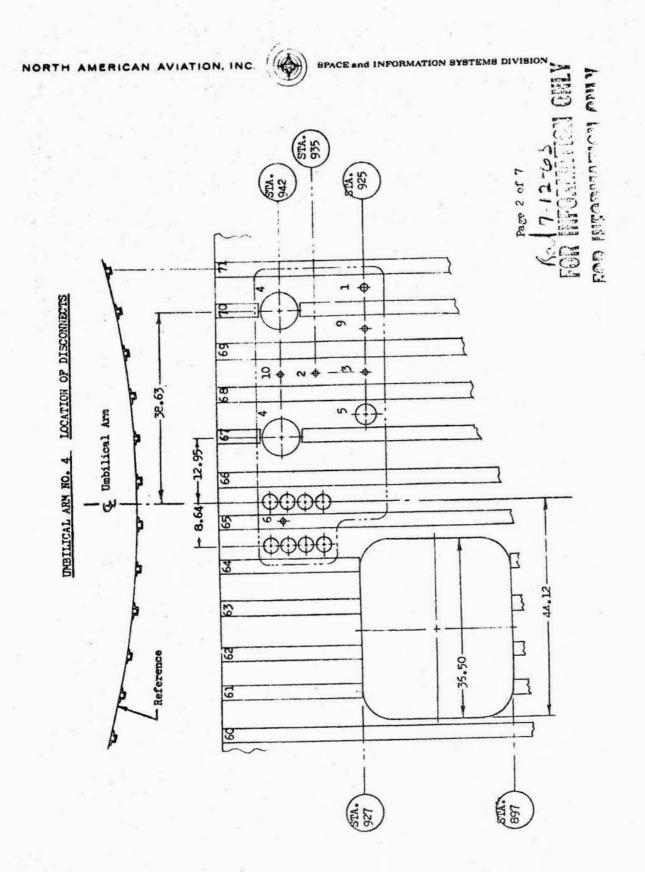
Sheet 5 of 5

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	Red 7-12-63 x13	Revised	15 January 1963	h 1963	1 1963	e 1963	SPEC. NO.	MG273-0013	MC144-0010	NC144-0010	MC273-0017	MC273-0016				NC144-0010			Page 1 of 7	FOR INFORMATIC: J GWLY
	Red	Rev	15 Jan	1 March 1963	l April 1963	15 June 1963	MEDIUM	Не	Не	Не	GH ₂	GN2	He			GN2	GN2		. Pa	or info
		II CSE	EQUITEMENTS	962	. 4		MAX. FRESS. PSIG	3250	22	750	22	2	5		191	1000	750			
		SATURN C-5 STAGE II GSE	UMBILICAL SERVICE REQUIREMENTS	15 November 1962	UMBILICAL ARM NO.	5. 7	DISCONNECT	ľ,	1/2	1/2	7	4	1/2 (1)			1/2	1/2 ①	Ŧ		
1-15 63	Tue al		UTIBITIC .	н	UMB		1	1. IH2 Tank He Fre-Press & Receiver Press.	2. IH2 Tank Press. Switch & Vent Valve C/O	3. IH2 Tank Vent Valve Actuation	4. IH ₂ Tank Vent Valve Disconnect (2)	5. Electrical Equipment Purge	6. Electrical Disconnect Purge	7.	8.	9. Press. System Press. Reg. Checkout	10. GSE Actuation		(1) To Umbilical Plate Only	

NORTH AMERICAN AVIATION, INC.

SPACE and INFORMATION SYSTEMS DIVISION



TT TALIN	W-C .ON LINE TRATTITONO	H.		
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2 DO2 Fill and Drain	8	132	, 8 ,	N0144-0005
10, Tank Fill & Vent Valve Actuation	1/2	750	Re	MC144-0010
102 Tank Vent Valve & Press. Switch C/0 1/2	1/2	37	Не	MC144-0010
Turbo Purge	1/2	100	Не	MC144-0010
GH2 Start Tank Vent Control	1/2	500	He	MC144-0010
	2/1	3200	He	MC144-0010
10, Tank He PrePress & Receiver Press	1"	3250	He	HC273-0013
CL Start Tank Fill	1"	1300	GH2	MC144-0011
LL, Pump Seal Drain	1"	130	LH2/GH2	MC144-0011
GH2 Start Tank Vent and Relief	1ª	1300	CH,	MC144-0011
Thrust Chamber Jacket Purge	1"	750	He	MC144-0011
10, Recirculation He Bubbling	1	400	Яе	MC144-0011
10, Fill & Drain Overboard Dump	1	132	1.02/He	MC144-0011
GG LO2 Cool Down Bleed	2	35	102/602	MC144-0014
Recirculation Pneum. Control System	1	3250	He	MC273-0013
Electrical Equipment Purge 2.2	2.25 x 5.81	5	GN ₂	
Electrical Disconnect Purge	1/2 ①	2	He	
GH, Pressurization Systems Purge	1/2	750	He	MC144-0010
×				÷
Press. Syst. Press. Reg. Checkout	1/2	1000	GN ₂	MC144-0010
Recirculation Press. Reg. Checkout	1/2	0001	GN2	MC144-0010
	*		Pa	Page 3 of 7 7.

UTBILICAL ARM NO. 3-A

Spec. No.			MC144-0011
Medium	GN2	CN2	GH2/GN2
Max. Press. Psig.	750	2.5	50
Disconnect Size	1/2 ©	8 X 17	T
	25. GSE Actuation	26. Engine Compartment Purge	27. Recirc. IA ₂ Ret. Line Purgs Bleed
	25°	26.	27.

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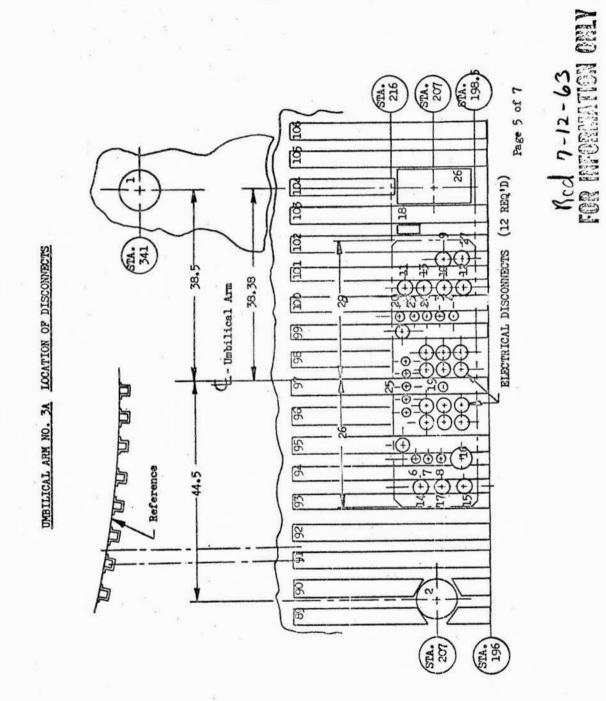
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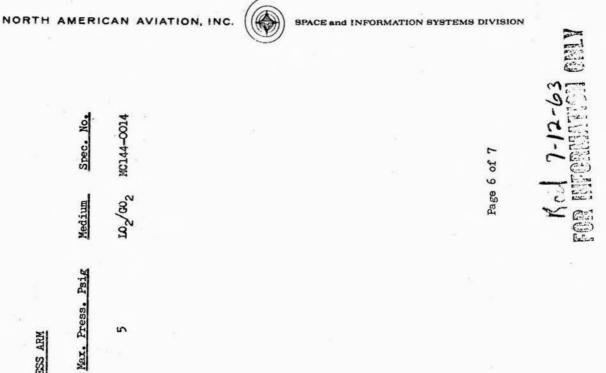


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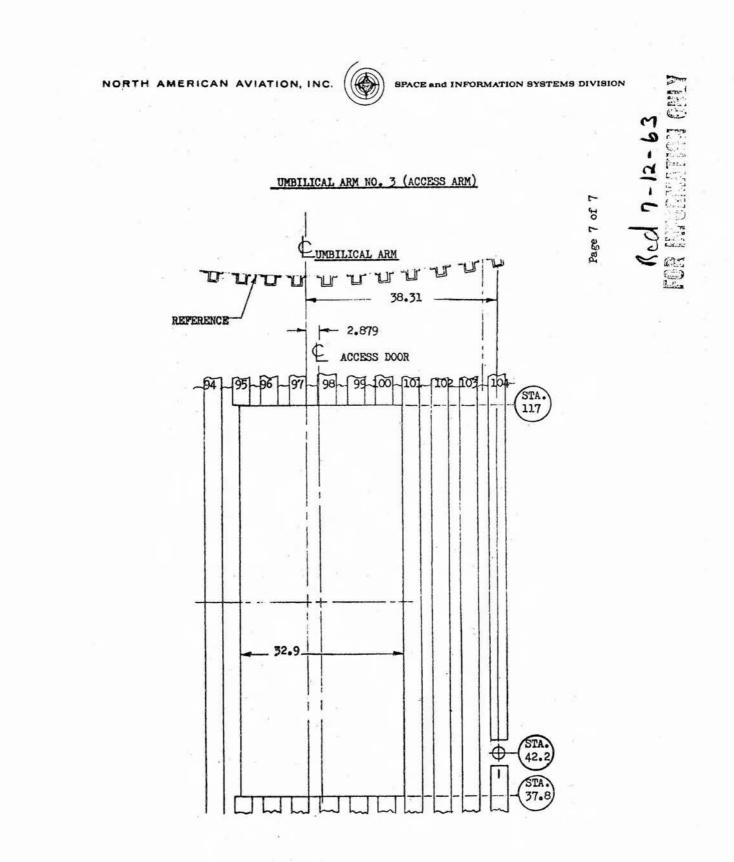


UMBILICAL ARM NO. 3 ACCESS ARM

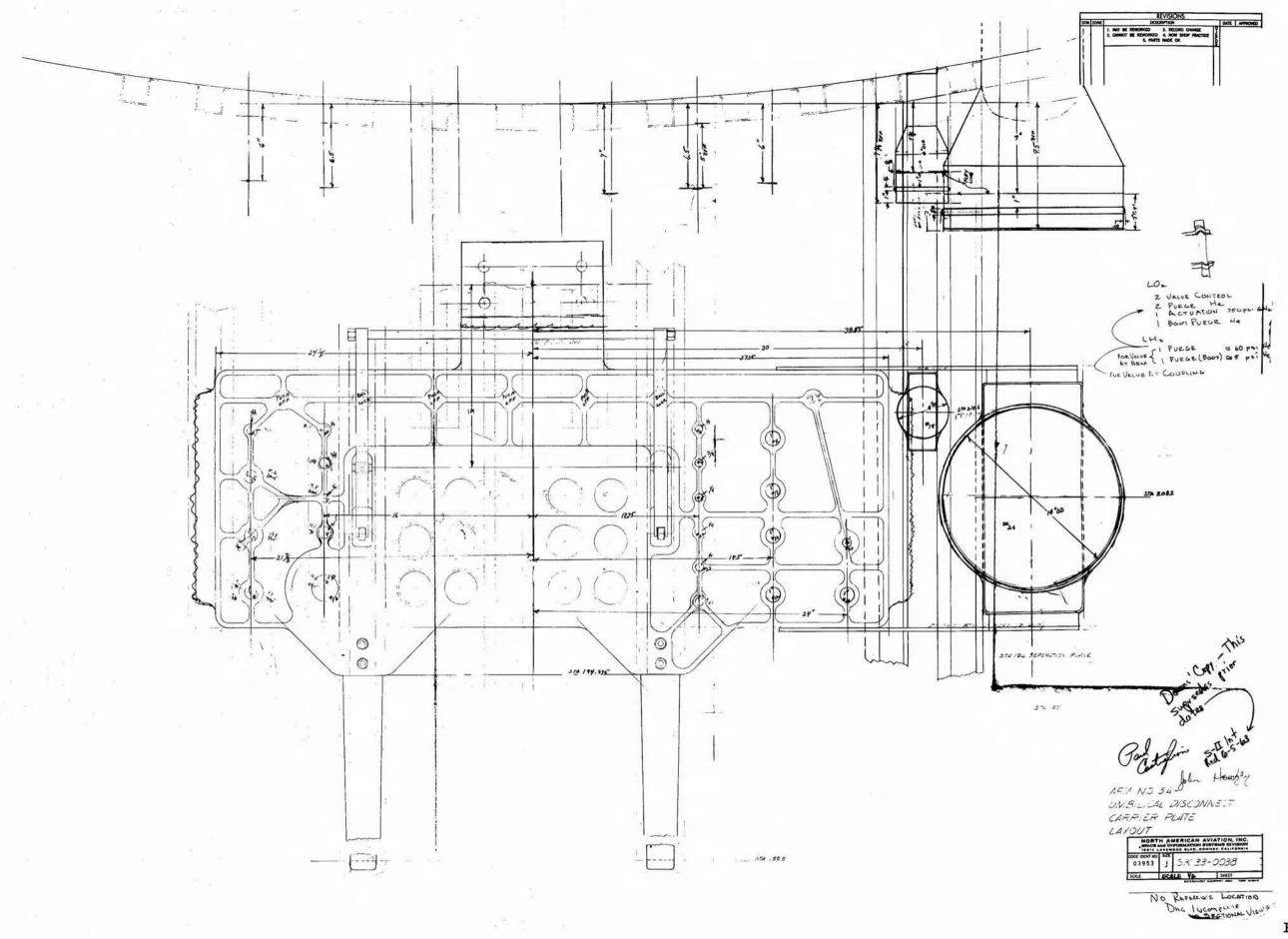
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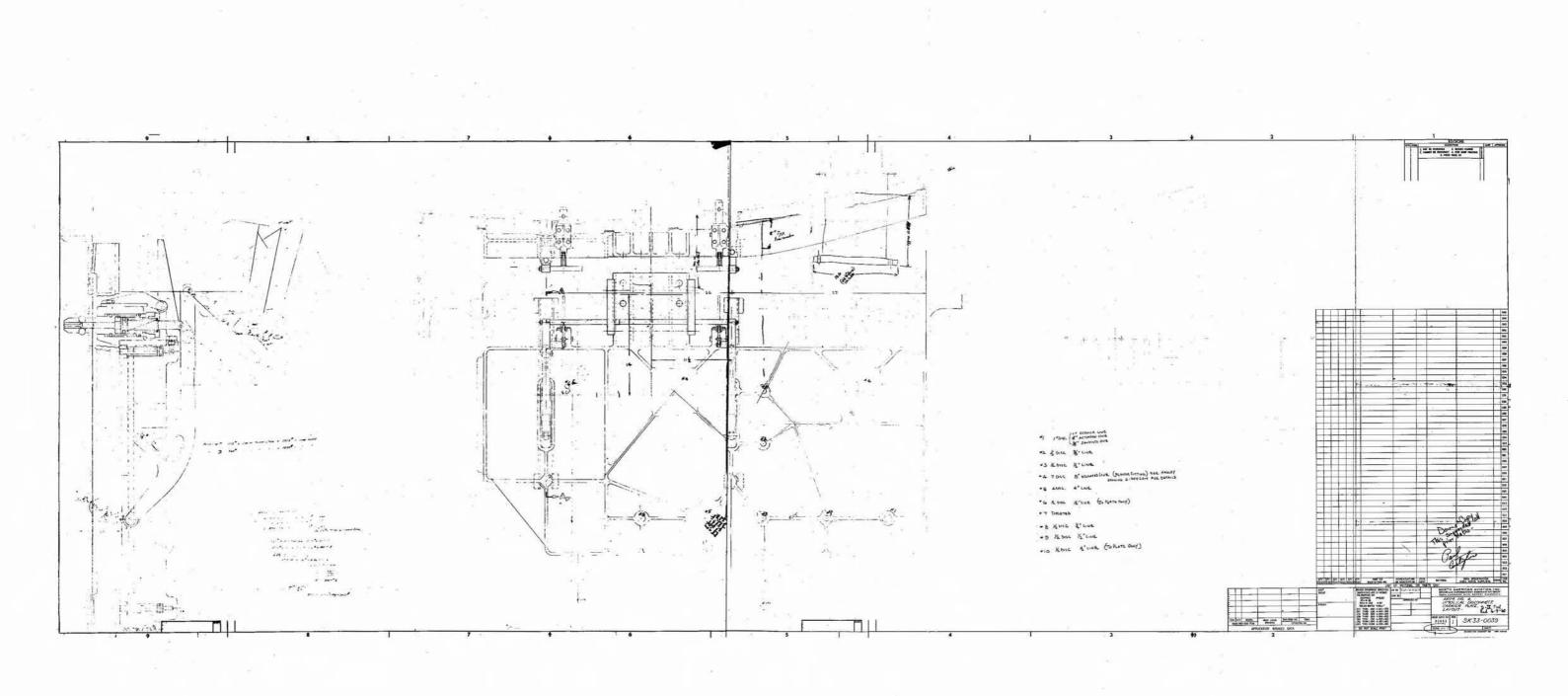
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1. 102 Pump Seal Drain

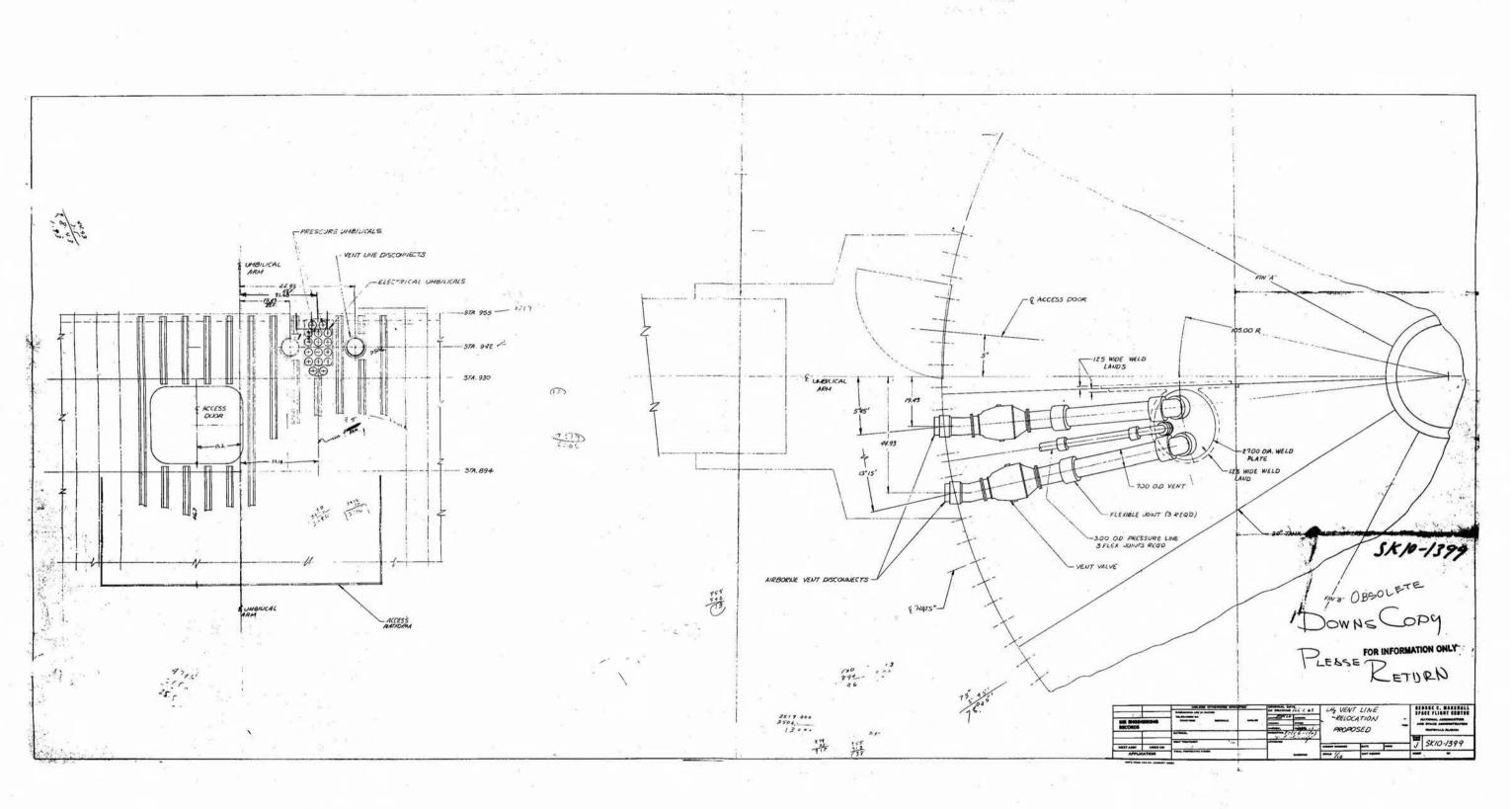


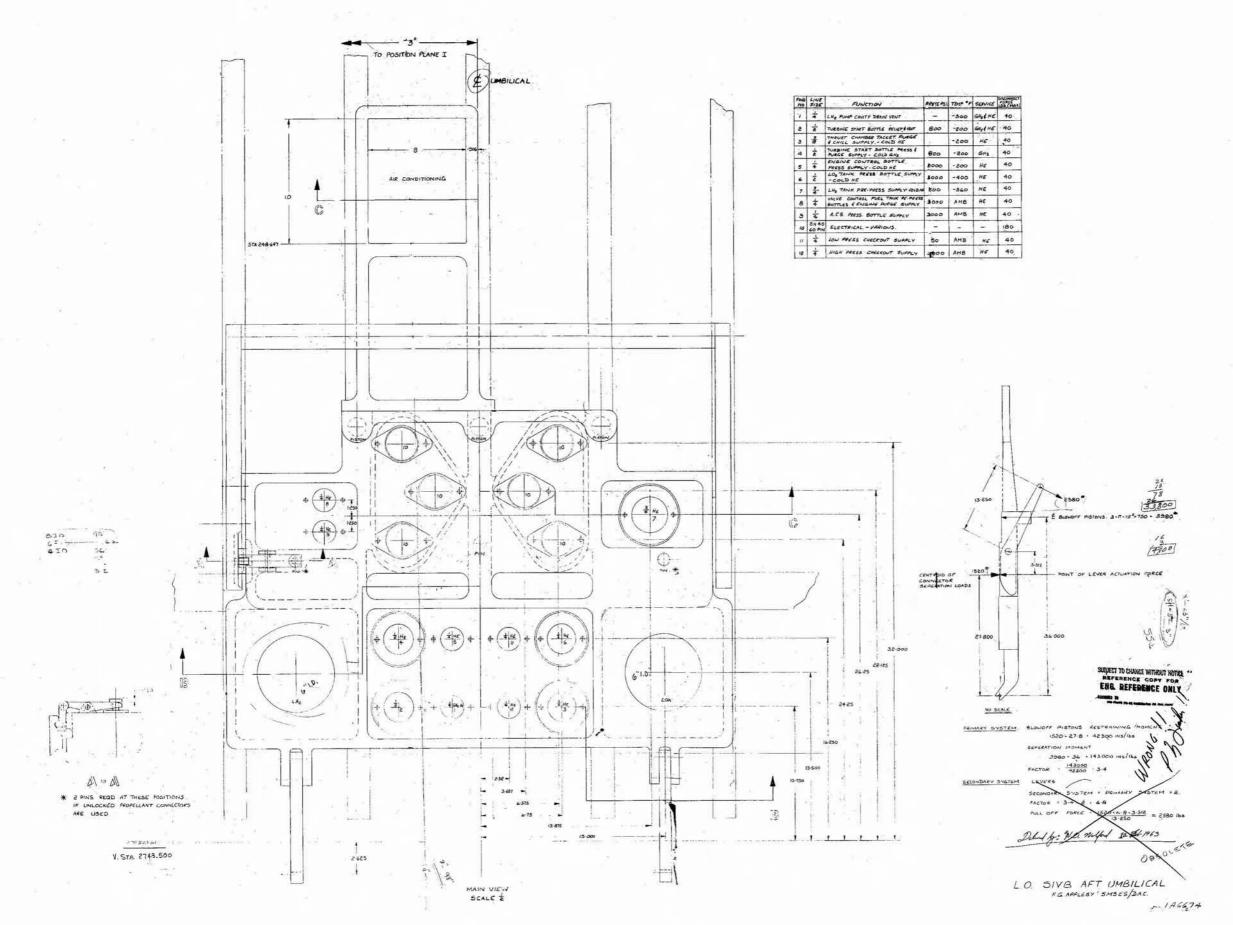
36 DISCONIVIECTS {IE ELECTRICAL DISCONVECTS S-日 1-4-6 ARM NO.3A UMBILICAL DISCOMI CARRIER PLATE 1950 2380 (POS ITIOI 1) INITIAL FORCE AT "" = 109 FORCE NT "0" = 1020 TOTAL FORT REQU 1970 ELLETT & 60° EA: 720 PNEU & 50° EA: 1200' EVE OF TEAVEL FORCE AT "B" = FORCE READ TO DISCOUNTECT (POSITION Z) 9150 LB IN AT A & FORCE TO DISCONNECT 1920# Đ Pro t.s



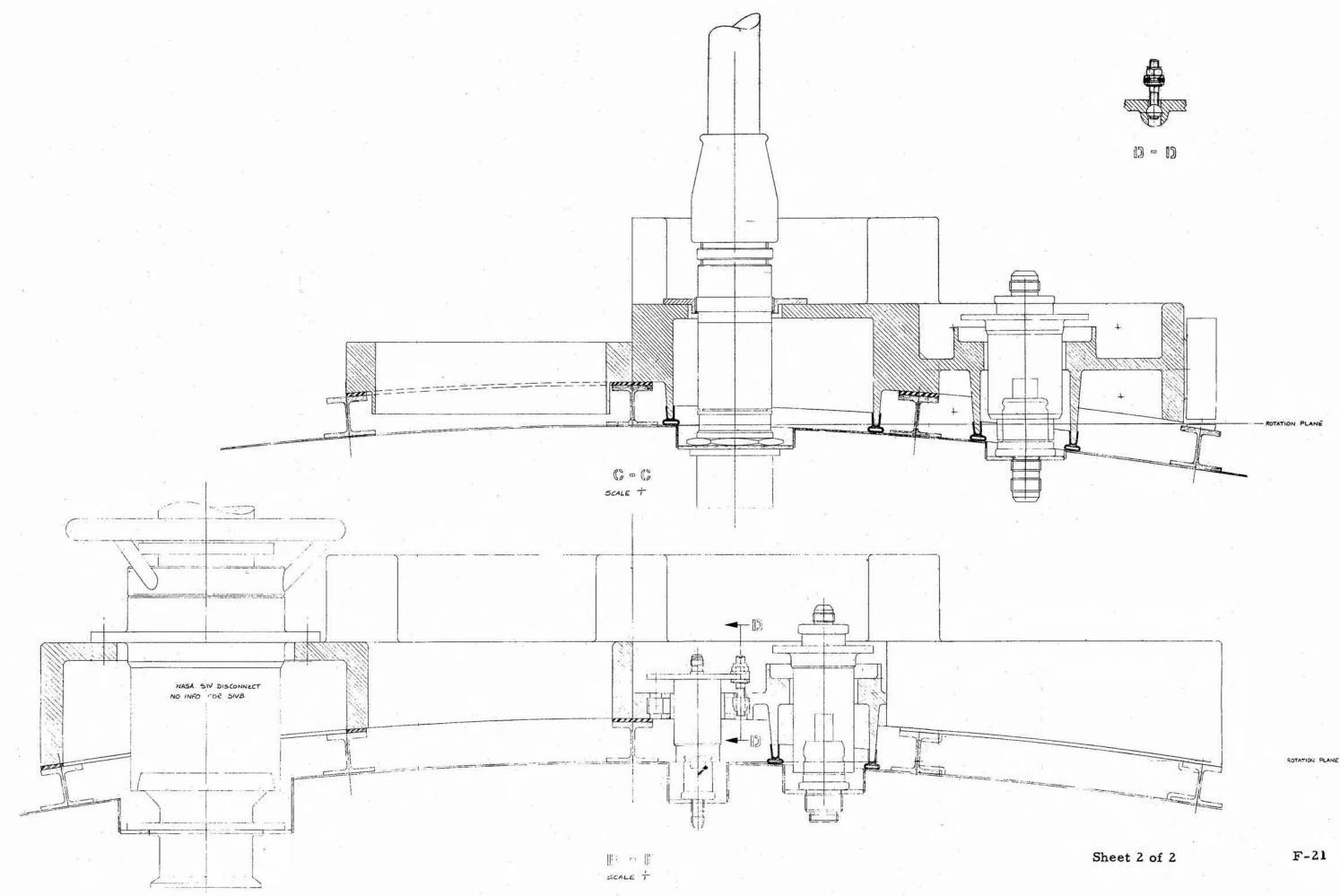


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1. SCOPE

This Specification Control drawing defines the design, test, and data requirements for the design and procurement of a disconnect, which will be used in a liquid oxygen fill line in a space vehicle.

2. APPLICABLE DOCUMENTS

The following specifications and standards (including subsidiaries thereof), drawings, and publications of the issue in effect on 7 September 1961, except as otherwise noted or controlled on an individual basis, form a part of this drawing to the extent specified herein.

2.1 Douglas Prepared Documents

Drawings and Other Publications

7696938

Materials, Compatible, Liquid Oxygen Service

General Procurement Specification

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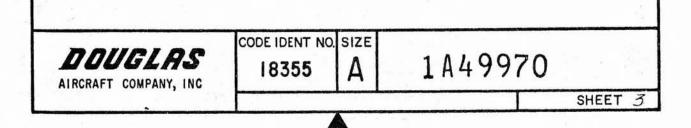
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7869555

Standards

1P00041

Cleanliness, Components, Oxidizer-Fuel-Preumatic System



Missile Components

Government Controlled Documents

Specifications

2.2

ABMA-PD-R-27A

ABMA-PD-R-527 (5-22-59)

ABMA-PD-W-40 (5-1-58)

ABMA-PD-W-45A

Anodic Coatings, for Aluminum and Aluminum Alloys

Radiographic Inspection; Soundness Requirements for Fusion Welds on Aluminum and Magnesium

Radiographic Inspection Procedures and Acceptance Standards for Fusion Welded Joints in Stainless

Steel and Heat Resistant Steels, Procedure for

Manual or Automatic, for Guided Missile Use

Aluminum and Magnesium Manual or Automatic

Welding, Carbon, Low Alloy, and Stainless Steel,

Welding, Fusion Shielded Arc, Missile Components,

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MIL-C-5541 (3-28-50) Amend. 1

MIL-A-8625A

MIL-I-6865B Amend. 1

MIL-N-6011 (3-14-50)

MIL-P-25508C

MIL-R-11468 (9-24-51)

MIL-S-5002 (10-23-56) Amend. 2

MIL-T-152B

Chemical Films for Aluminum and Aluminum Alloys

Inspection, Radiographic

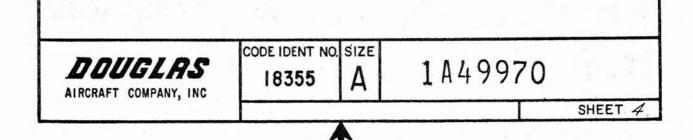
Nitrogen, Liquid and Gas

Propellant, Oxygen

Radiographic Inspection, Soundness Requirements for Arc and Gas Welds in Steel

Surface Treatments (Except Priming and Painting) for Metal and Metal Parts in Aircraft

Treatment, Moisture and Fungus Resistant, of Communications, Electronic, and Associated Electrical Equipment



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	COMPANY, INC	CODE IDEN	T NO. SIZE	144997	70 SHEET 2	
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	MSFC-STD-100 (5-16-61)	(Castings, Aluminu graphic Inspectio	m and Magnesium Al	loy, Radio- tandard for	
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3. REQUIREMENTS

3.1 General

Unless otherwise specified, the contents of 7869555 are applicable.

3.2 Design

3.2.1 Configuration

3.2.1.1 Dimensions

The overall dimensions of the disconnect shall be within the limits specified in figures 1, 2, and 3.

3.2.1.2 Components

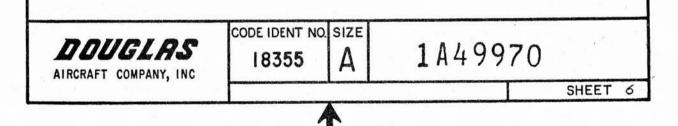
The assembly shall consist of two mating units (ground (-501) and airborne (-1)), which connect together with application of an axial mechanical force. The design shall also incorporate a self-aligning feature, effective 'during engagement of the mating halves, to assure proper mating. The disconnect shall allow angulation and axial motion of the ground half with respect to the airborne half when the two halves are connected together. One half shall be generally conical in shape, the other half spherical. A visual indicator shall indicate when the assembly is connected and sealed. The mating seal between the two halves shall be located on the airborne half. The mating seal shall be preloaded to provide a leakproof seal when one half is offset laterally 1/8 inch from the assembly centerline, and/or one half is angulated 2° from the other half.

3.2.1.3 Disassembly and Assembly for Cleaning

The design and construction of the disconnect shall allow for complete disassembly, cleaning for oxygen service, and assembly without impairing the operational performance parameters as specified herein, or causing replacement of non-standard parts. No special tools shall be required for assembly or disassembly.

3.2.1.4 Securing Devices

The disconnect shall be designed and constructed so that no parts shall work loose during installation or operation. All adjustments which may be provided shall be capable of being securely locked for all operation and test conditions specified herein.



3.2.2 Flow Medium

The flow medium shall be liquid oxygen in accordance with MIL-P-25508.

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3.2.3. Operating Temperatures

3.2.3.1 External

The disconnect shall operate in an external environment of -65 to +160F.

3.2.3.2 Internal

The disconnect shall operate at an internal temperature of -320 to +160F.

· 3.2.4 Actuating Forces

3.2.4.1 Connection

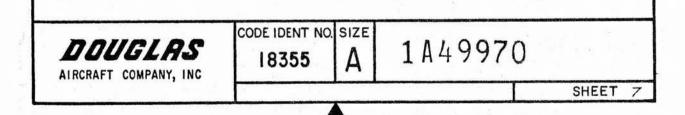
The total applied force required to connect the two halves and to preload the mating seal shall not exceed 35 lbs.

3.2.4.2 Disconnection

The axial force required to disconnect the two halves shall not exceed 50 lbs.

3.2.5 Proof Pressure

The disconnect assembly shall withstand 175 ± 2 psig internal proof pressure without leakage, distortion or failure with the two halves externally held in a fixed position.



3.2.6 Leakage

Leakage past the mating seal shall not exceed 100 sccm of oxygen gas, with the disconnect connected together, 0 to 110 psig internal oxygen pressure, the ground half rotated 2° in any direction and moved axially 1/4 inch in either direction from the airborne half, and the temperature at +100 to -300 ±20F.

3.2.7 Performance

3.2.7.1 Connection

The disconnect shall connect when one half is offset laterally 1/8 inch from the assembly centerline, one half is angulated 2° in any direction from the other half, one half is moved axially 1/4 inch from the other half and 35 lbs maximum force is applied.

3.2.7.2 Disconnection

The disconnect shall uncouple when a force of 50 lbs maximum is applied along the axis.

3.2.7.3 Flow Rate

Flow through the disconnect assembly shall be a minimum of 1000 gpm of liquid oxygen with an inlet pressure of 36 psig.

3.2.7.4 Pressure Drop

Pressure drop across the disconnect assembly shall not exceed 1.5 psi with 36 psig inlet pressure and 1000 gpm liquid oxygen flow.

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3.2.8 Structural

3.2.8.1 Outlet Flange

The outlet flange on the airborne half shall withstand an axial compressive force of 1000 lbs and a tensile force of 500 lbs, applied in any direction around the centerline at a 5° angle.

3.2.5.2 Inlet Flange

The inlet flange on the ground half shall withstand 150 lbs shear force applied along the flange face, and 1000 in-lbs moment applied any plane perpendicular to the flange face.

3.2.9 Service Life

The disconnect shall have a minimum service life of 200 cycles. One cycle .shall consist of a complete connection and a disconnection.

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3.3 Material

3.3.1 Castings

Castings shall be in accordance with MSFC-STD-100, Grade IIF and be of high quality, clean, sound, and free from blowholes, porosity, cracks, or any other defects.

3.3.2 Metals

All metals shall be of the corrosion resistant type unless suitably protected to prevent corrosion during the specified service life and storage life.

3.3.2.1 Non-Ferrous

Non-ferrous materials shall be used for all metallic parts of the disconnect except where ferrous materials are essential.

3.3.2.2 Non-Magnetic

Non-magnetic metals shall be used for all metallic parts of the disconnect except where magnetic metals are essential.

3.3.3 Non-Metallic Parts

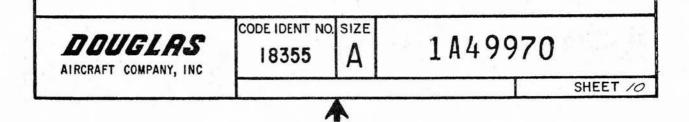
Non-metallic parts shall not have a corrosive effect on other materials when exposed to conditions normally encountered in service. Fungus nutrient materials when used, shall be treated in accordance with MIL-T-152.

3.3.4 Lubricants

Lubricants shall be oxygen-safe, dry film type in accordance with 7696938.

3.4 Weight Control

The weight of the disconnect shall be the minimum weight attainable without degradation of performance or reliability, and shall not exceed 3 pounds, for the airborne half (-1) and 10 pounds for the ground half (-501).



3.5 Environmental

The disconnect shall function in accordance with all the requirements of this specification when subjected to the environmental conditions in the following paragraphs.

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3.5.1 Sl.ock

3.5.1.1 Thermal

The disconnect shall withstand a temperature drop from +160 to -320F at a rate of 15F per second, without failure or degradation of performance.

3.5.1.2 Operational

The disconnect shall withstand shocks of sawtooth pulse shape, 35 g's magnitude for 10 +1 milliseconds without failure or degradation of performance. The shocks shall be applied three times in both directions, along each of the three mutually perpendicular axes.

3.5.1.3 Transportation

The disconnect in the shipping container, shall withstand 65 g's shocks of sawtooth form for 15 +2 milliseconds, applied three times in each direction on each of the six sides of the shipping container.

3.5.2 Vibration

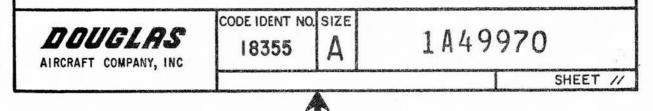
3.5.2.1 Operational

The disconnect shall withstand a sinusoidal vibration, with a logarithmic octave sweep rate of 3.5 minutes per octave over a frequency range of 5 to 2000 to 5 cps, at the following levels:

The vibration shall be applied for 1 hour in each of the three orthogonal axes.

3.5.2.2 Transportation

The disconnect and shipping container shall withstand a sinusoidal logarithmic octave sweep rate vibration from 5 to 600 to 5 cps, at 2 minutes per octave for a period of 3 hours in each of the three principal axes in the "ready for shipment" condition, at the following levels:



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3.5.3 Acoustics

The disconnect shall withstand a random noise environment with an overall sound pressure level (spl) of 158 decibels (db) (re. 0.0002 microbar) for 8 minutes. The random noise shall have an approximate Gaussian amplitude distribution and a peak-to-rms ratio of three or more. This overall spl shall have a spectrum shape, as measured with octave band filters, over the frequency range from 37.5 to 9600 cps as follows:

Octave Band	1	2	3	4	5	6	7	8
Center Frequency (cps)	53		212	424	848	1596	3392	6784
Sound Pressure Level (db)	144	149	1.50	151	150	149	148	147

3.5.4 Fungus

The disconnect shall be capable of withstanding an application of an equal mixture of separate spore suspension (active sporulating cultures between 7-21 days old) with a relative humidity of 96 per cent and temperature of 86F. The mixture of spore suspension shall contain equal parts of the following fungi:

1.	Chaetomium Globosum or Myrothecium Verrucaria	s/n 6205 9095
2.	Memononiella Echinata or Aspergillus Niger	9597 6275
3.	Aspergillus Flavus or Aspergillus Terreus	10836 10690
4 .	Penicillium Citrinum or Penicillium Ochrochloron	9849 9112

3.5.5 Humidity

The disconnect shall withstand a relative humidity of 95 per cent for a period of 10 temperature cycles. A temperature cycle begins at +84F +16F, gradually increases to +155F during a 2-hour period, is held at +155F for 6 hours and is gradually decreased to +84F +16F during a 16-hour period.

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3.5.6 Salt Spray

The disconnect shall function within the mandatory performance requirements following exposure for 48 hours to a finely divided, wet, dense fog containing a 5 per cent salt solution, by weight, having a Ph value of 6.5 to 7.2 at 92F to 97F.

3.5.7 Sand and Dust

The disconnect shall be capable of withstanding a sand and dust density of 0.1 to 0.5 grams per cubic foot, at a velocity of 2500 + 500 feet per minute. for 6 hours at +77F and 6 hours at +155F, with a relative humidity not to exceed 30 per cent.

Sand and dust shall be of angular structure, and have characteristics as follows:

- a. 100 per cent of the sand and dust shall pass through a 100-mesh screen, U.S. Standard Sieve Series.
- b. 98 +2 per cent of the cand and dust shall pass through a 140-mesh screen, U.S Standard Sleve Series.
- 90 +2 per cent of the sand and dust shall pass throug a 200-mesh screen, U.S. Standard Sieve Series.
- d. 75 +2 per cent of the sand and dust shall pass through a 325-mesh screen, U.S. Standard Sieve Series.

3.5.8 Storage Environment

All specified performance requirements for the disconnect shall be met after a minimum storage life of 730 days at temperatures between -65Fand +155F with a relative humidity up to 100 per cent, including conditions wherein condensation takes place in forms of either water and/or frost. All openings on the units shall be sealed. This requirement shall be met in the "as received" condition.

DOUGLAS AIRCRAFT COMPANY, INC	CODE IDENT NO.	size A	14499	70
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Construction

The disconnect shall be so constructed that no parts shall work loose during installation or service. All adjustments which may be provided shall be capable of being securely locked under all service and test conditions.

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3.6.1 Welding

3.6

3.6.1.1 Oorrosion Resistant Steels

Corrosicn resistant steels shall be inert gas shield are welded in accordance with ABMA-PD-W-40, Class I, and radiographically inspected 100 per cent according to MIL-I-6865, ABMA-PD-R-527, and/or MIL-R-11468.

3.6.1.2 Aluminum Alloys

Aluminum alloys shall be inert gas shield arc welded in accordance with ABMA-PD-W-45, and radiographically inspected 100 per cent according to MIL-I-6865 and ABMA-PD-R-27.

3.6.2 Finish

3.6.2.1 Corrosion Resistant Steel

Corrosion resistant steels shall be passivated in accordance with MIL-S-5002.

3.6.2.2 Aluminum Alloy

Aluminum alloy parts shall be anodically treated in accordance with MIL-A-8625. The aluminum oxide film formed by this treatment shall be removed from local areas under screws, nuts, etc., used for assembly or mounting purposes, to provide adequate bonding connections. Marman seal areas shall be masked to limit anodic treatment to specific areas as specified in figures 1, 2, and 3. Unanodized seal areas shall be chemically treated in accordance with MIL C-5541.

3.6.3 Plating

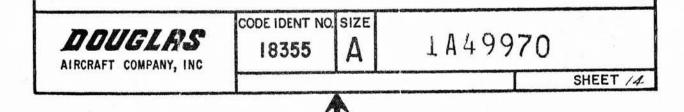
Cadmium or zinc plating shall not be used on any components.

3.6.4 Protective Treatment

Materials subject to deterioration when exposed to the climatic and environmental conditions occuring in service shall be protected in a manner that will not prevent compliance with the performance requirements of this specification. Protective coatings that ship, crack, or scale with age, or under the extreme climatic and environmental conditions specified herein, shall be avoided.

3.6.5 Processing

Process all surfaces in contact with the working media at a certified source and package in accordance with 1F00041.



3.7 Approval of Vendor Part

Final approval of the vendor part (to be accomplished prior to first shipment) shall be contingent upon submission, by the vendor to Douglas, of detailed outline and assembly drawings (including cross sectional views) and a list of materials, for review by, and approval of, the Douglas Missile & Space Systems Engineering Department. This requirement also applies to vendor changes.

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3.8 Identification

The disconnect shall be permanently identified in accordance with MIL-STD-130, with the following minimum information:

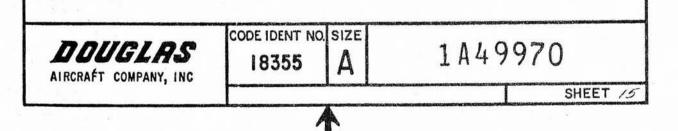
Vendor name or trademark: Vendor part number: Specification control number: 1A49970-1 and 1A49970-501 Manufacturer's serial number:

3.9 Preparation of Vendor Drawing

Vendor drawings shall be prepared in accordance with 7869555, paragraph 3.8 with disassembly, adjustment, and assembly instructions for the article included in the top assembly drawing.

3.10 Reliability

The design, construction, and quality control of the disconnect assembly covered by this specification shall exhibit a probable reliability which will insure that the highest confidence level of field reliability is inherent in the disconnect assembly during its use in a space vehicle. Statistical demonstration of reliability by test shall not be required of the vendor. The probable reliability of the first article of the production configuration will be estimated by Douglas Aircraft Company Engineering.



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4. QUALITY ASSURANCE PROVISIONS

4.1 Design Evaluation Tests

4.1.1 Definition

Design evaluation tests shall determine if the disconnect assembly is in compliance with design requirements.

4.1.2 Requirements

The following design evaluation tests shall be conducted by Douglas Aircraft Company. Tests shall be performed in sequence to attain the maximum utilization as well as the maximum evaluation of the disconnect. The least destructive test shall be performed first. The combining of tests is recommended where justifiable and practical.

4.1.2.1 Cleanliness

Disassembly, cleaning, and assembly of the disconnect shall take place before testing, unless the disconnect has been previously cleaned and packaged in accordance with 1P00041, at a certified source.

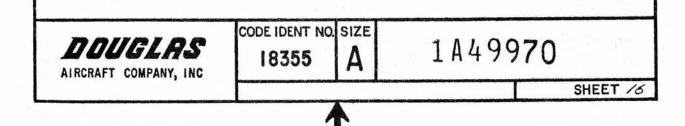
4.1.2.2 Test Medium

Nitrogen, liquid and gas, in accordance with MIL-N-6011.

4.1.2.3 Atmospheric Conditions

Tests shall be made at an atmospheric pressure of 29 +2 inches of mercury, a temperature of 70 +10F and a relative humidity of 40 +10 per cent, except for those environmental tests which specify extreme conditions to demonstrate compliance with design requirements. Tolerances on environmental conditions shall be as follows, unless otherwise specified:

a.	Temperatur									+ 4F
Ъ.	Vibration	a	npl	Lit	tuc	le				710%
c.	Vibration									
d.	Humidity.									7 5%



4.1.3 Test Description

4.1.3.1 Proof Pressure

Couple the disconnect together and cap one end. Apply 175 +2 psig nitrogen gas pressure at the open end for 2 minutes. There shall be no evidence of structural failure or distortion.

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4.1.3.2 Leakage

Couple the disconnect together and cap the outlet. Chill the assembly to -300 +20F Apply nitrogen gas pressure at the inlet varying the pressure from $\bar{0}$ to 110 psig. While varying the pressure, angulate the ground half 2 in any direction from the airborne half, and also move the ground half back and forth axially 1/4 inch from the airborne half. Leakage past the mating seal at any pressure shall not exceed 100 sccm during and after temperature reduction. Reduce the internal pressure to 5 psig. The leakage at 5 psig shall not exceed 100 sccm.

4.1.3.3 Functional

4.1.3.3.1 Connection

Place the two halves close to engagement, but with one half offset laterally 1/8 inch from the assembly centerline, and with one half axially displaced 1/4 inch and angulated 2 from the other half. Apply 35 lbs axial mechanical force. The two halves shall connect together and the visual indicator shall indicate a connection.

4.1.3.3.2 Disconnection

Apply 50 lbs axial mechanical force to the coupled disconnect. The disconnect shall uncouple.

4.1.3.3.3 Flow Rate and Pressure Drop

Couple the disconnect halves together. Apply 36 psig liquid nitrogen pressure at the inlet. The flow rate shall be 1000 gpm minimum. The pressure drop shall not exceed 1.5 psi.

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4.1.3.4 Shock

4.1.3.4.1 Thermal

Stabilize the disconnect assembly at +160F then reduce the disconnect temperature to -320F at a rate of 15F per second. Test according to 4.1.3.2 through 4.1.3.3, after applying the thermal shock.

4.1.3.4.2 Operational

Subject the disconnect assembly to shocks of sawtooth pulse shape, 35 g's magnitude for 10 +1 milliseconds. Apply the shock three times in both directions along each of the three mutually perpendicular axes. Test according to 4.1.3.2 through 4.1.3.3.3, after applying shock in all directions.

4.1.3.5 Vibration

4.1.3.5.1 Operational

Subject the disconnect assembly to a sinusoidal vibration, with a logarithmic octave rate of 3.5 minutes per octave over a frequency range from 5 to 2000 to 5 cps for 1 hour in each of the three orthogonal axes. The frequency range and levels shall be as follows:

5	to	20	cps	at		٠			0.35	inch DA
20	to	96	cps	at					7.0	g's (0 to peak or vector)
96	to	180	срв	at					0.015	inch DA
180	to	2000	CDS	at					25.0	g's (vector)

Test according to 4.1.3.2 through 4.1.3.3.3, before and after the vibration in all directions.

4.1.3.5.2 Transportation

Subject the shipping container and disconnect assembly to a sinusoidal logarithmic octave sweep rate of 5 to 600 to 5 cps at 2 minutes per octave for a period of 3 hours along each of the three principal axes in the "ready for shipment" condition, at the following levels.

There shall be no structural failure of the shipping container. Test the disconnect assembly in accordance with paragraph 4.1.3.2 through 4.1.3.3.3 after applying the vibratic 1 in all directions.

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4.1.3.6 Service Life

Cycle the disconnect asnembly 200 times at a temperature of -300 +20F. One cycle shall consist of a complete connection and a disconnection. After the last cycle, test according to 4.1.3.2 through 4.1.3.3.3.

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4.1.3.7 Humidity

Subject the disconnect assembly to exposure in a relative humidity of 95 per cent for 10 temperature cycles. A temperature cycle shall begin at +84 +16F, be gradually increased to +155F over a 2 hour period, be held at +155F for 6 hours then be gradually reduced to +84 +16F over a 16 hour period. Test according to 4.1.3.2 through 4.1.3.3.3 at the end of the 10 cycles.

DOUGLAS AIRCRAFT COMPANY, INC	CODE IDENT NO.	Α	1A49970	
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4.2 Production Tests

4.2.1 Definition

Production tests shall be those tests which determine if production techniques adversely affect design.

4.2.2 Requirements

Every item submitted to Doulas for acceptance shall be proven by satisfactory demonstration of its capability to meet performance rating requirements by the following tests. In addition to the production test requirements listed herein, parts may be tested at the discretion of the Douglas Aircraft Company, Inc., to verify any or all performance requirements listed in this drawing.

4.2.2.1 Test Medium

Nitrogen gas in accordance with MIL-N-6011.

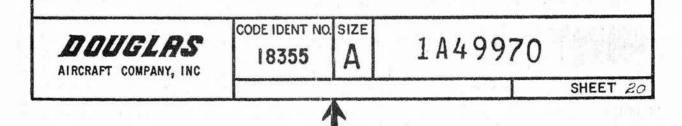
4.2.3 Test Description

4.2.3.1 Proof

Couple the disconnect assembly and cap one end. Apply 175 +2 psig nitrogen gas pressure at the open end for 2 minutes. There shall be no evidence of structural failure or distortion.

4.2.3.2 Leakage

Couple the disconnect together and cap the outlet. Chill the assembly to -300 +20F. Apply nitrogen gas pressure at the inlet varying the pressure from 0 to 110 psig. While varying the pressure, angulate the ground balf 2 in any direction from the airborne half, and also move the ground balf back and forth axially 1/4 inch from the airborne half. Leakage past the mating seal at any pressure shall not exceed 100 sccm during and after temperature reduction. Reduce the internal pressure to 5 psig. The leakage at 5 psig shall not exceed 100 sccm.



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4.2.3.3 Functional

4.2.3.3.1 Connection

Place the two halves close to engagement, but with one half offset laterally 1/8 inch from the assembly centerline, and with one half axially displaced 1/4 inch and angulated 2° from the other half. Apply 35 lbs force. The two halves shall connect together and the visual indicator shall indicate a connection.

4.2.3.3.2 Disconnection

Apply 50 lbs axial mechanical force to the coupled disconnect. The disconnect shall uncouple.

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5. PREPARATION FOR DELIVERY

The disconnect shall be prepared for delivery in accordance with 7869555, paragraph 5.

5.1 Cleaning, Processing, and Packaging

Cleaning, processing, and packaging procedures shall be in accordance with 1P00041. Articles shall be individually packaged, and marked for identification in accordance with MIL-STD-129. Plastic bags, when required, shall be clearly marked with identifying part number, in accordance with MIL-STD-130.

6. NOTES

g

- 6.1 Definitions
- .cps Cycles per second
- DA Double amplitude
- db Decibels
- F. Degrees Fahrenheit
 - The acceleration due to gravity
- gpm Gellons per minute
- mm Hg Millimeters of mercury
- psia Pounds per square inch absolute
- psig Pounds per square inch gauge
- sccm Standard cubic centimeters per minute
- scfm Standard cubic feet per minute
- spl Sound pressure level, measured in decibels

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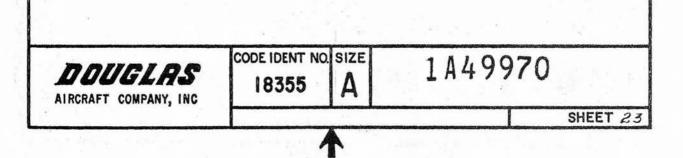
6.2 Approved Sources

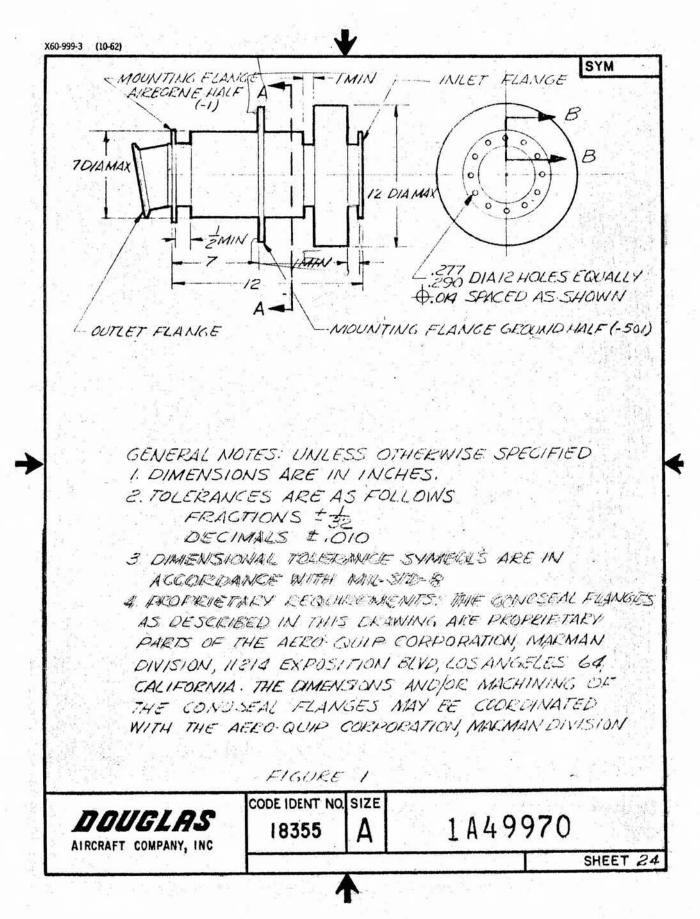
Spec Control Number Vendor Part Number Vendor Name and Address

Vendor Code SYM

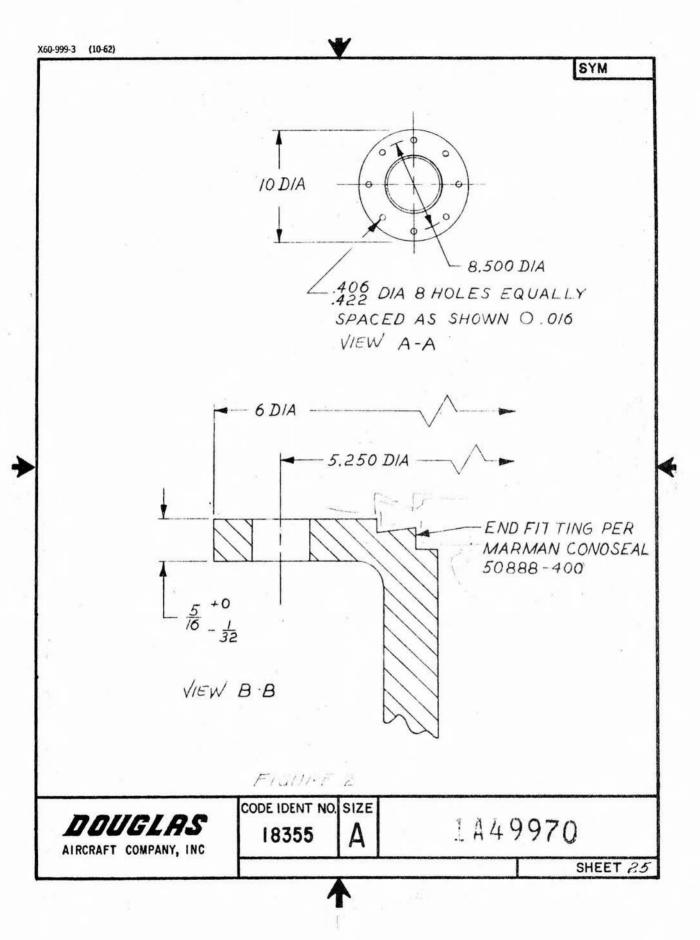
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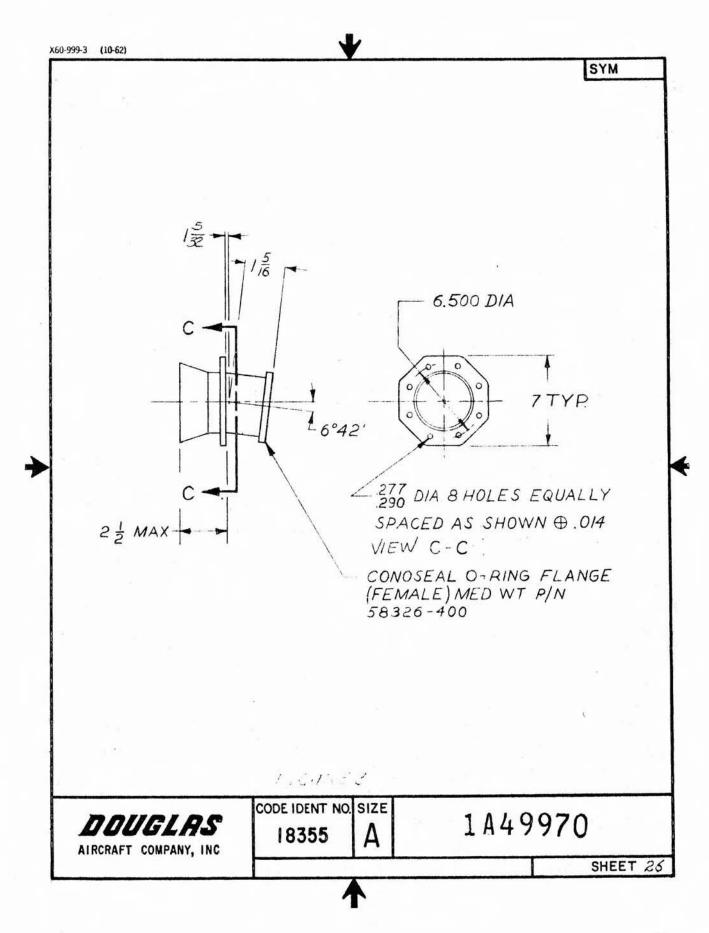
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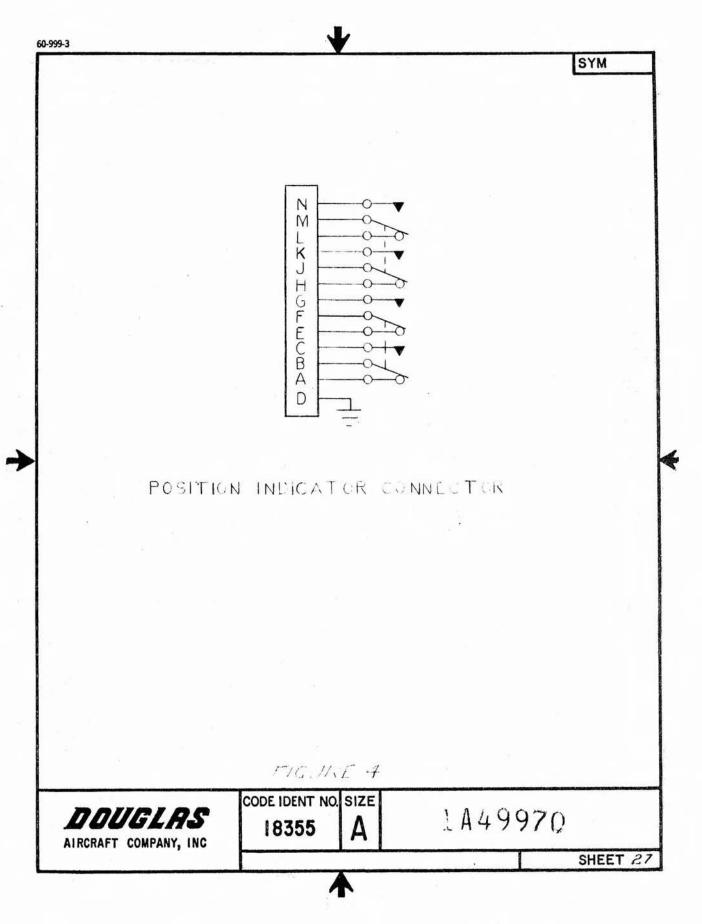


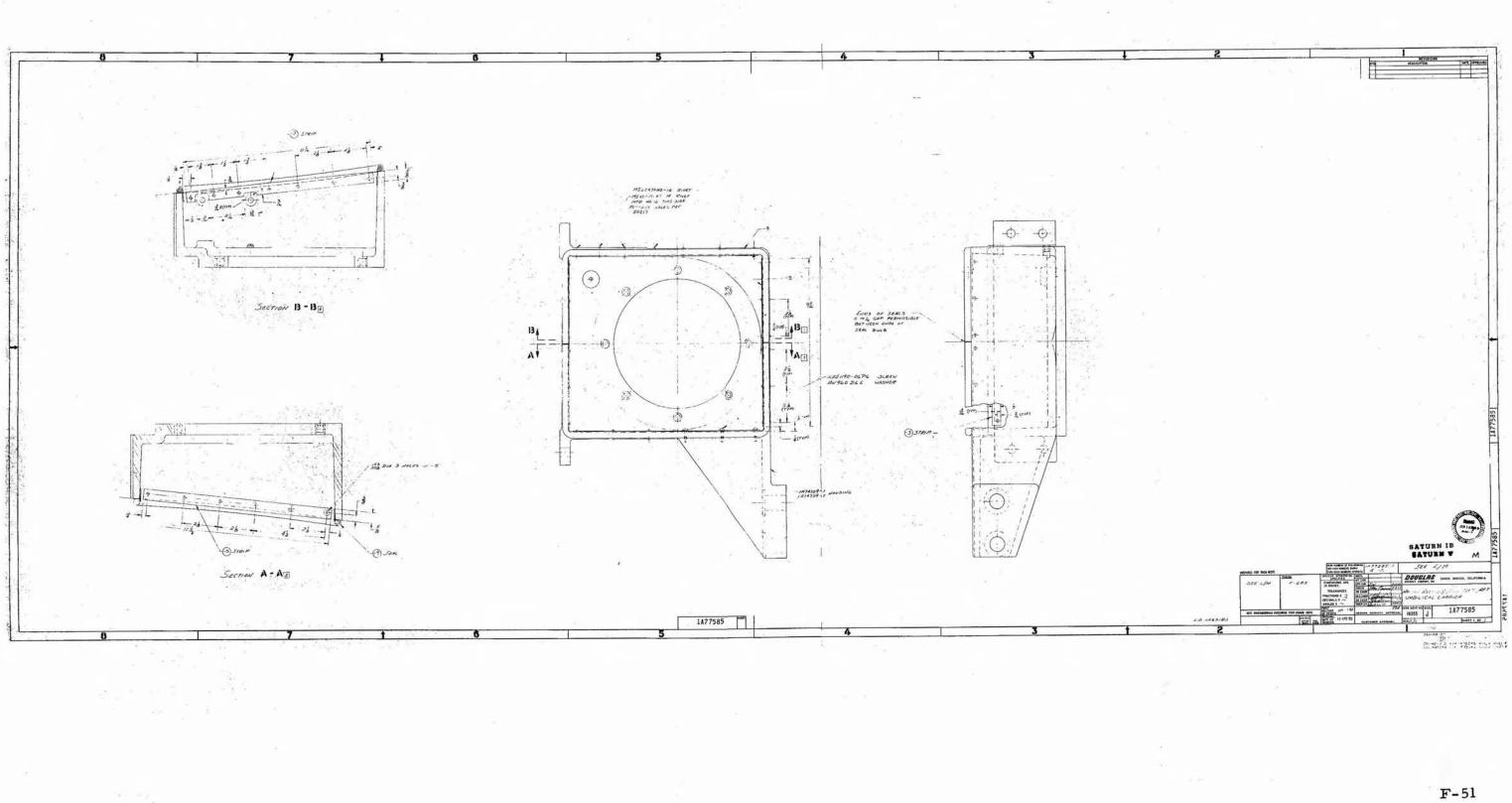


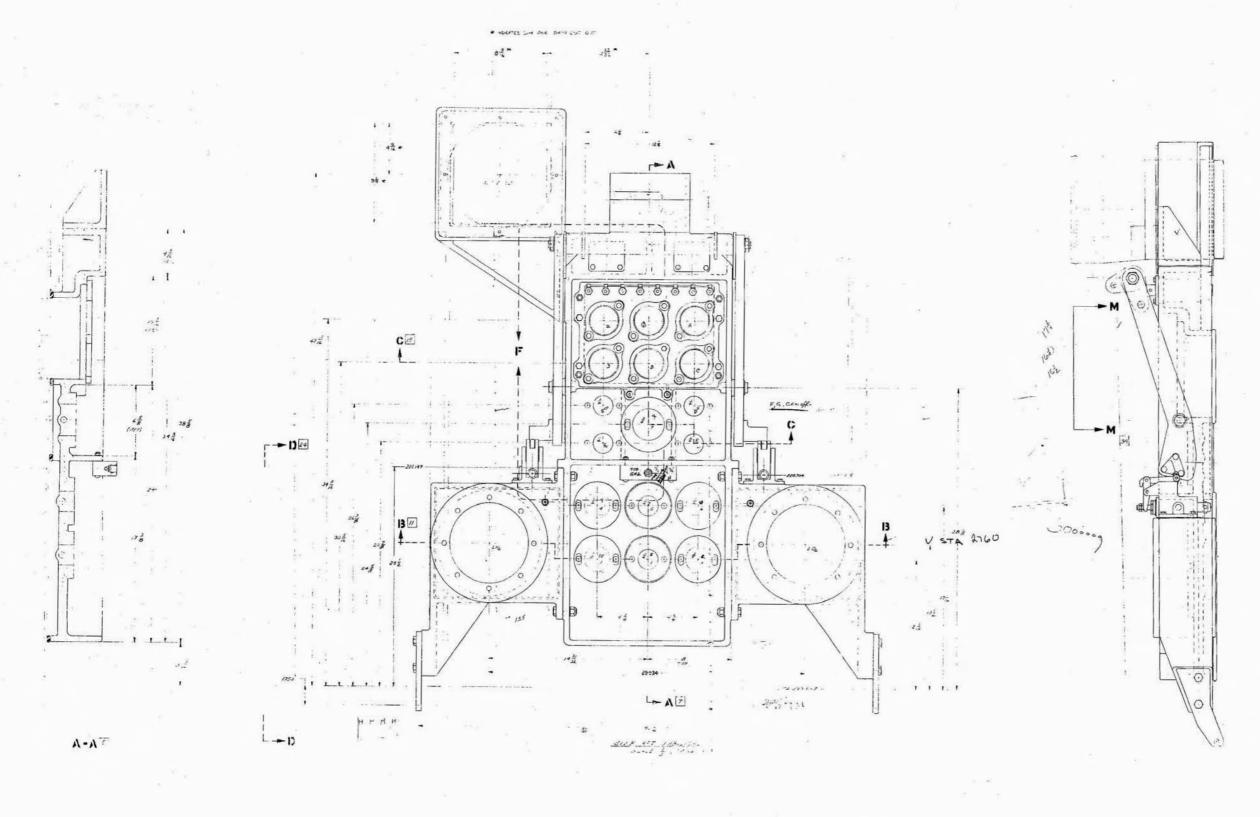
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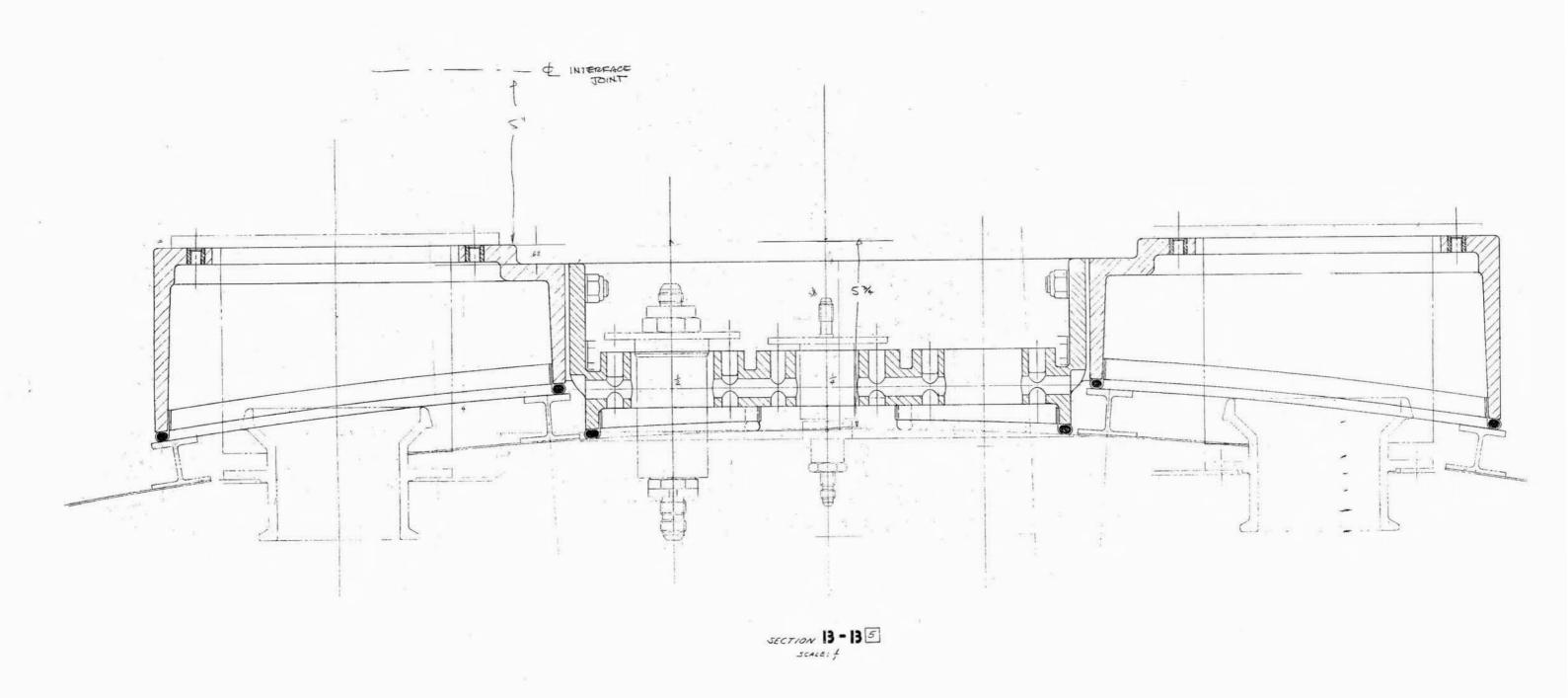


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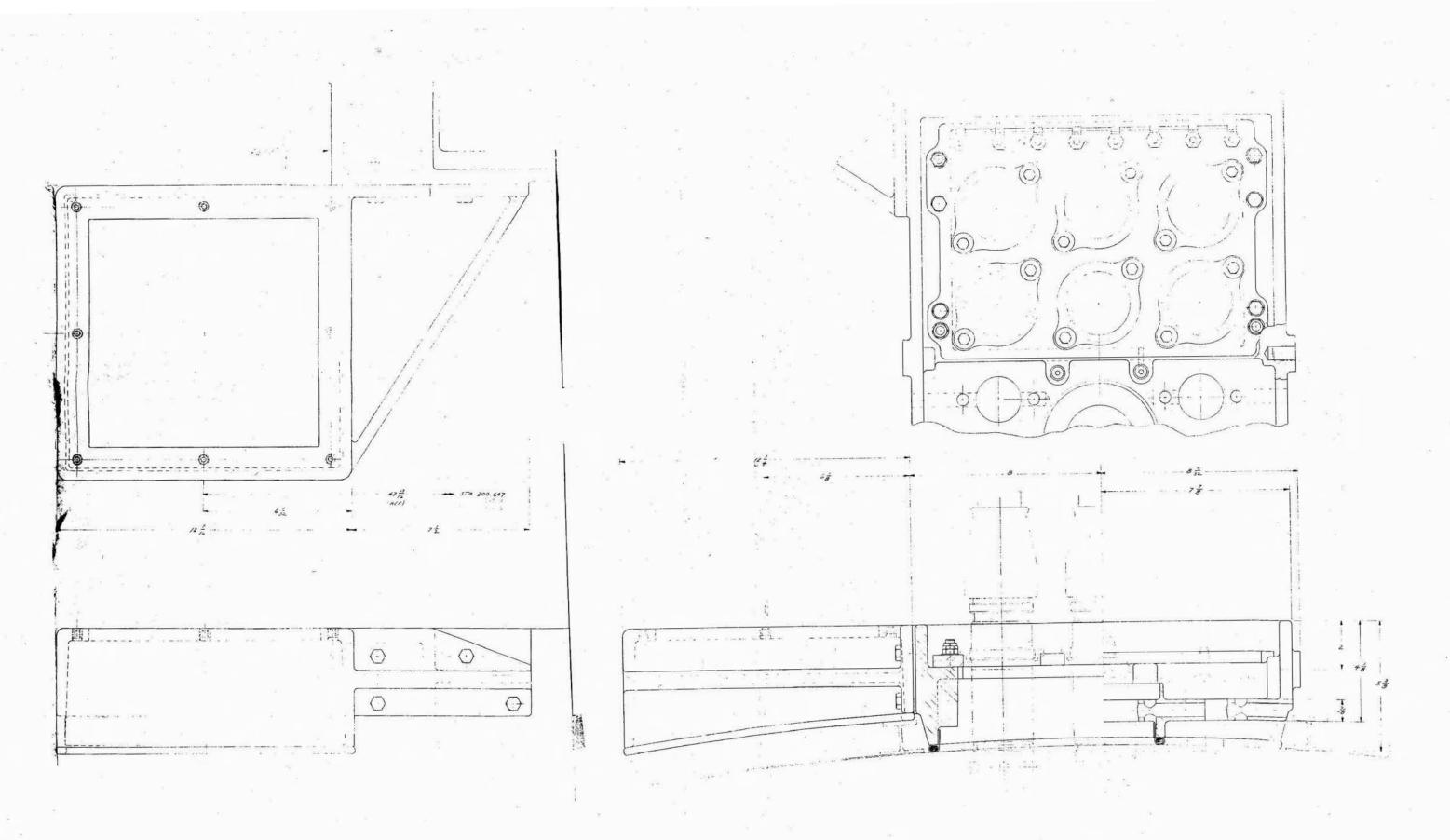


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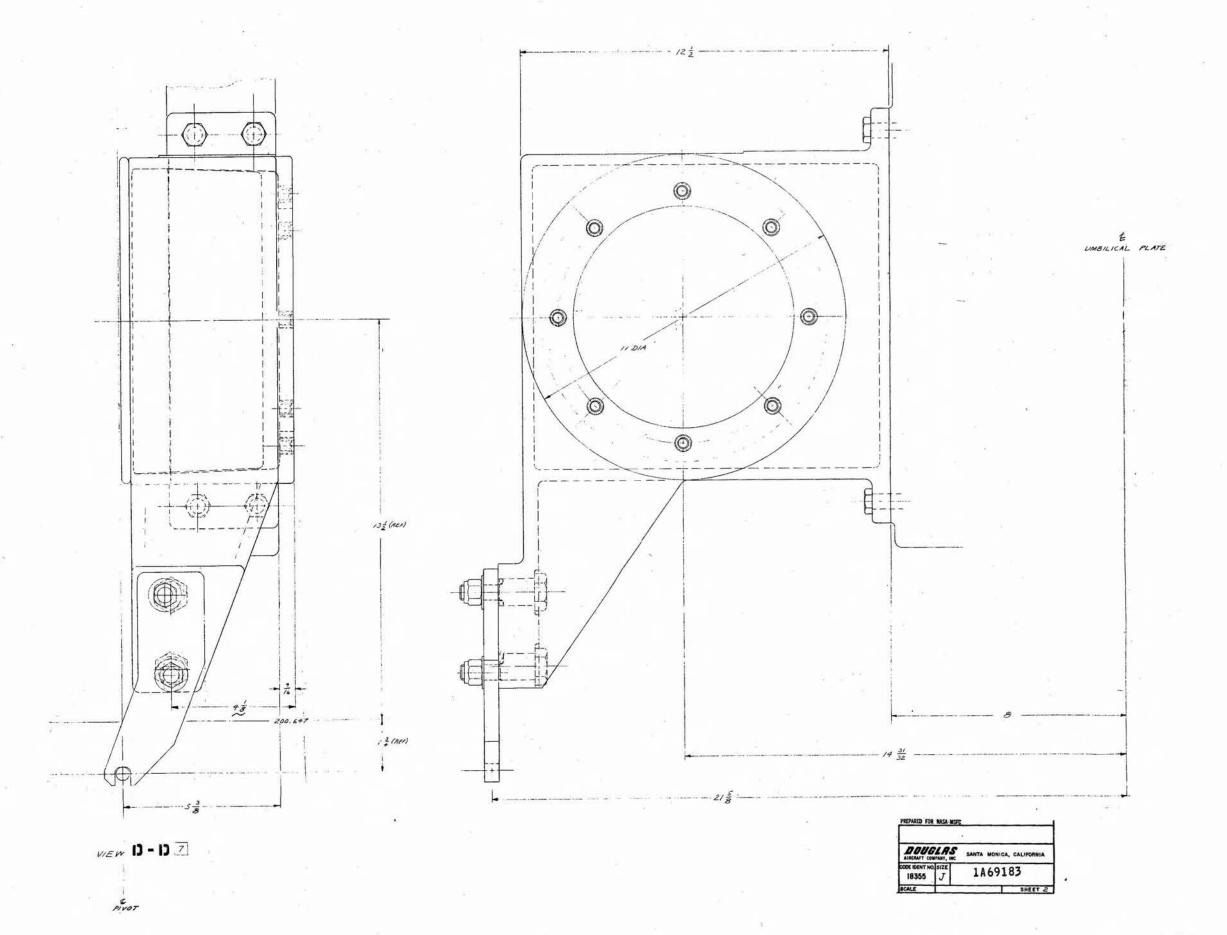
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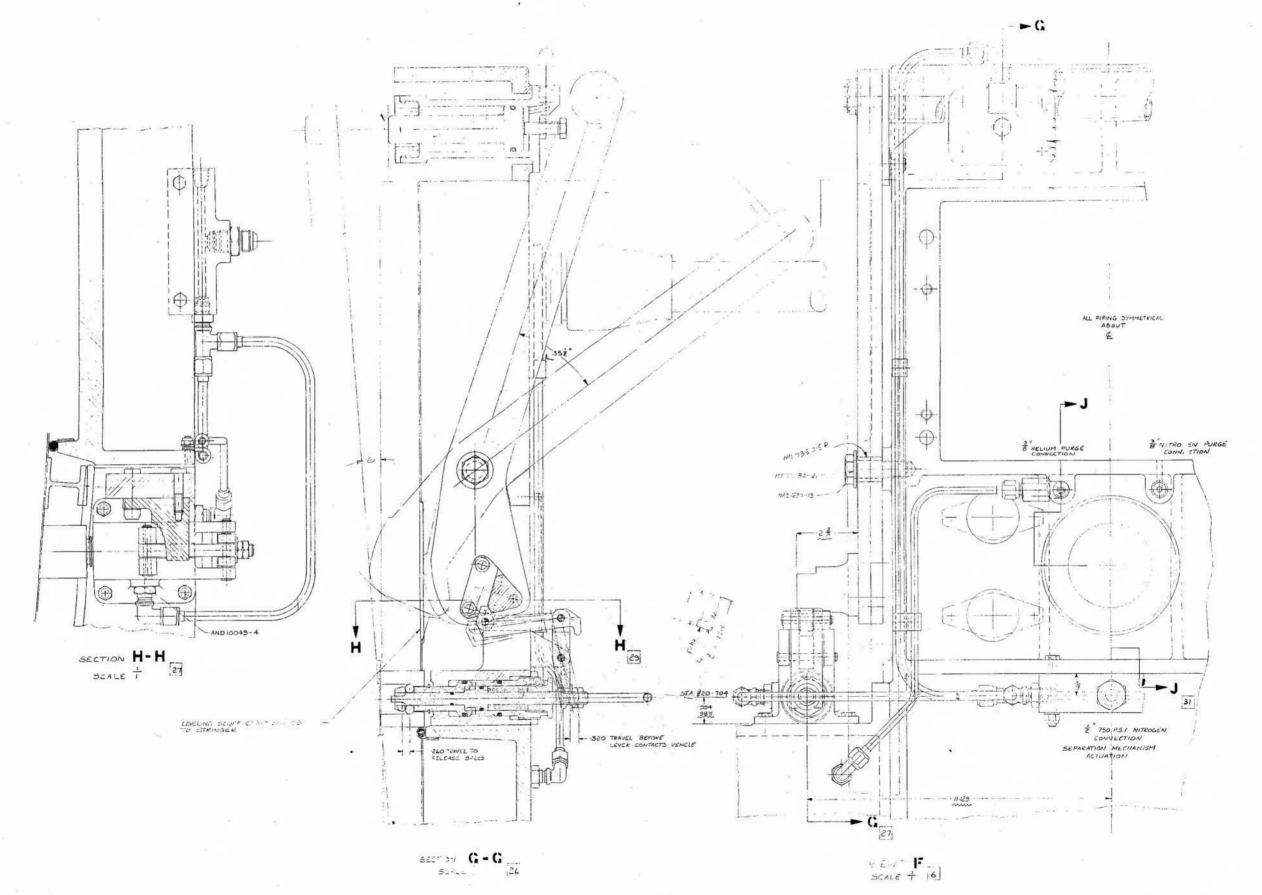
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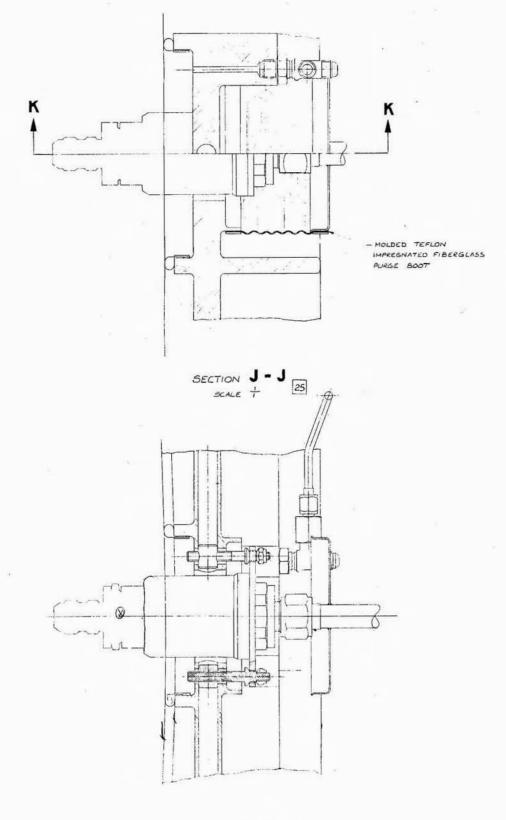
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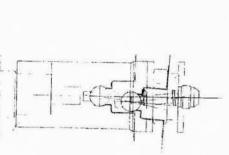


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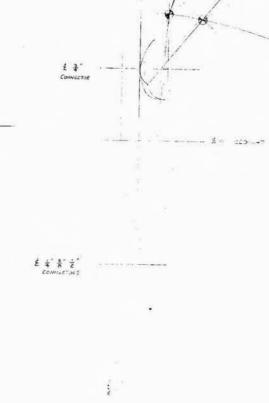
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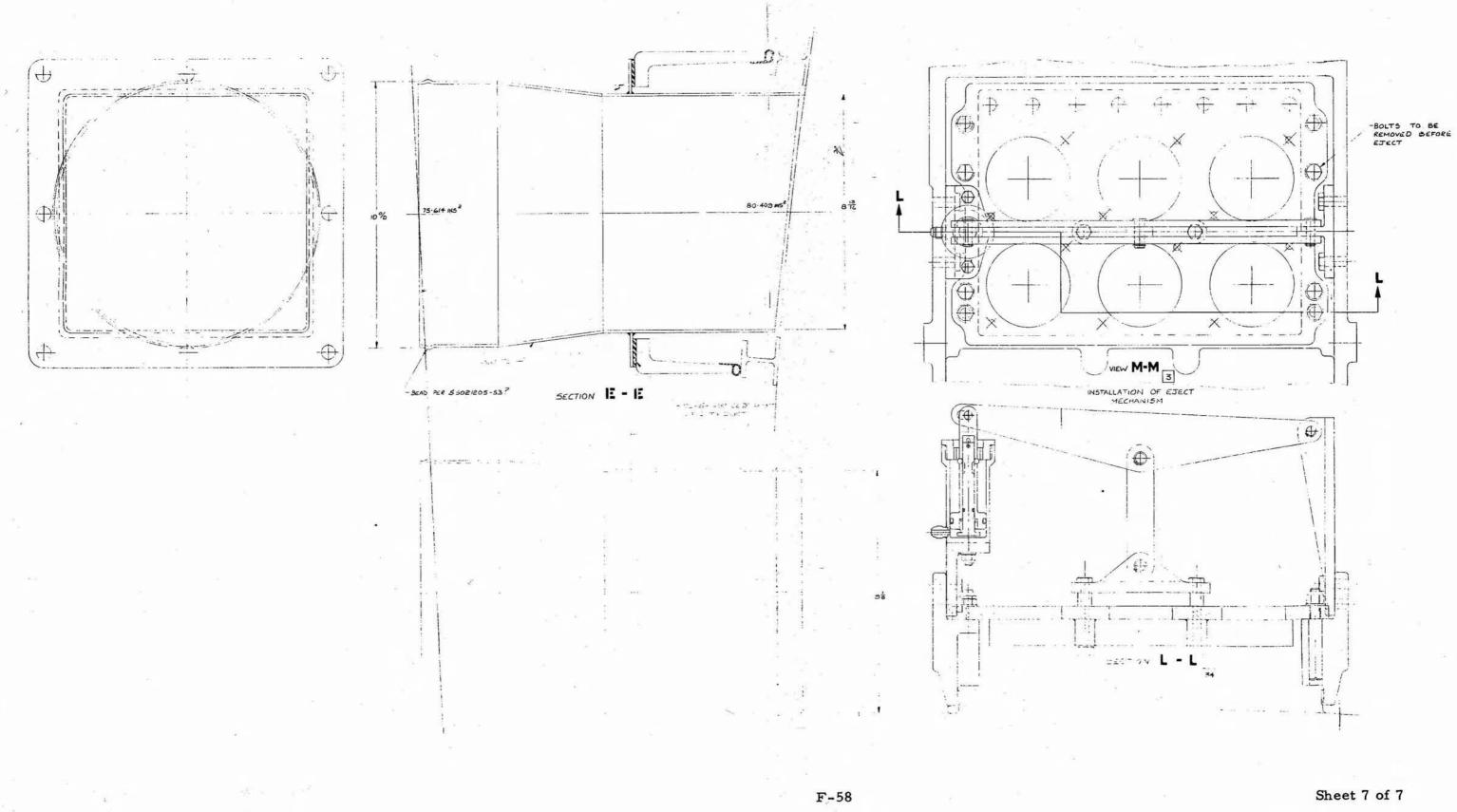
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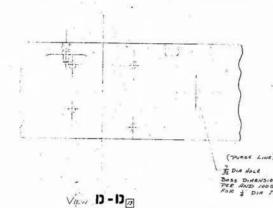
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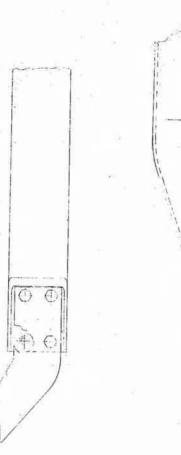
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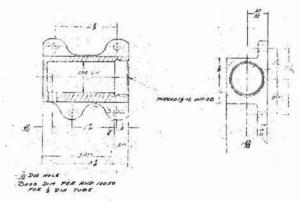
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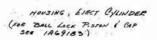


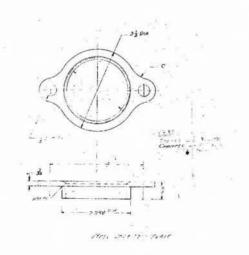
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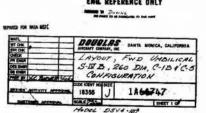




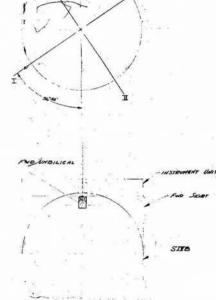






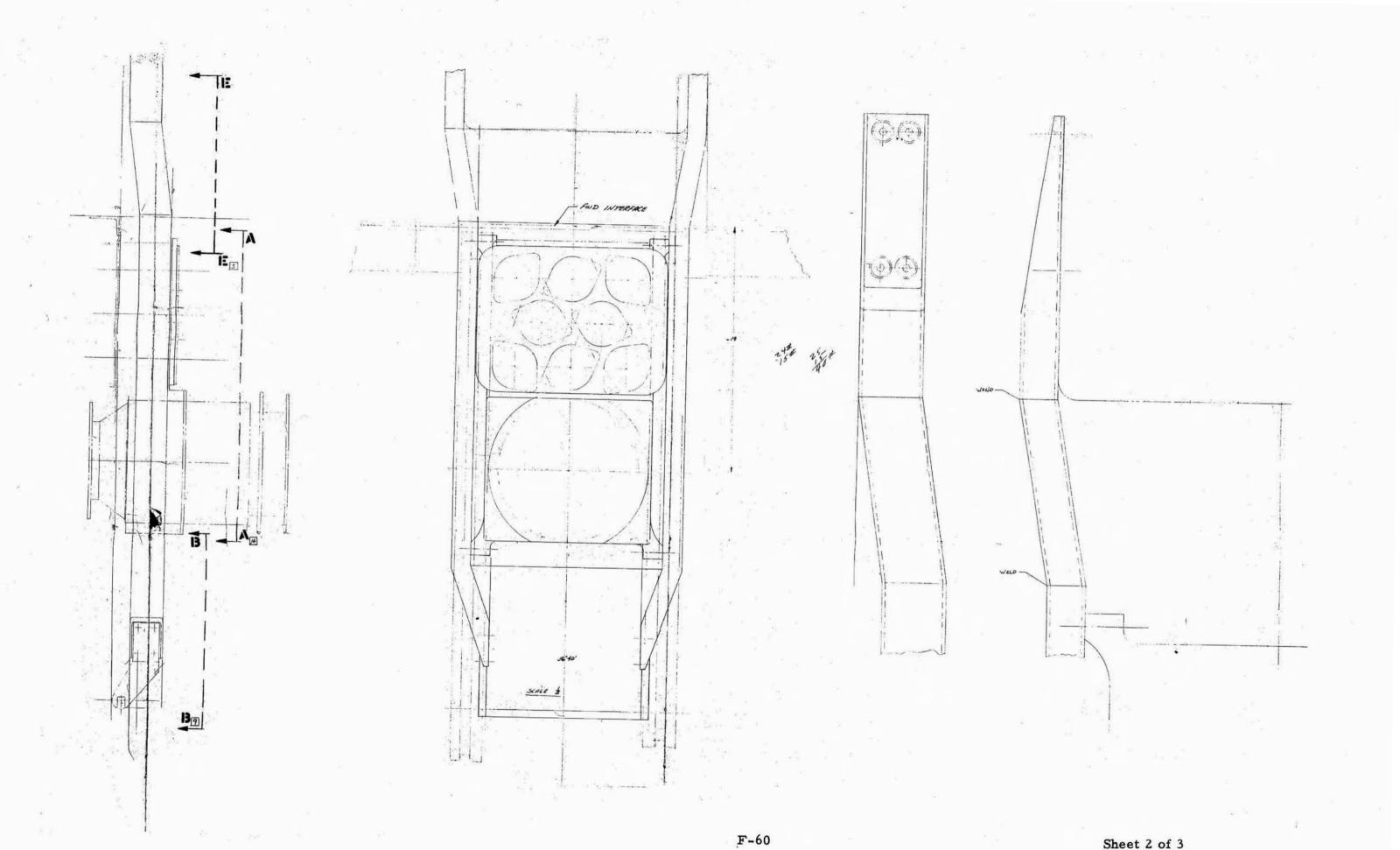




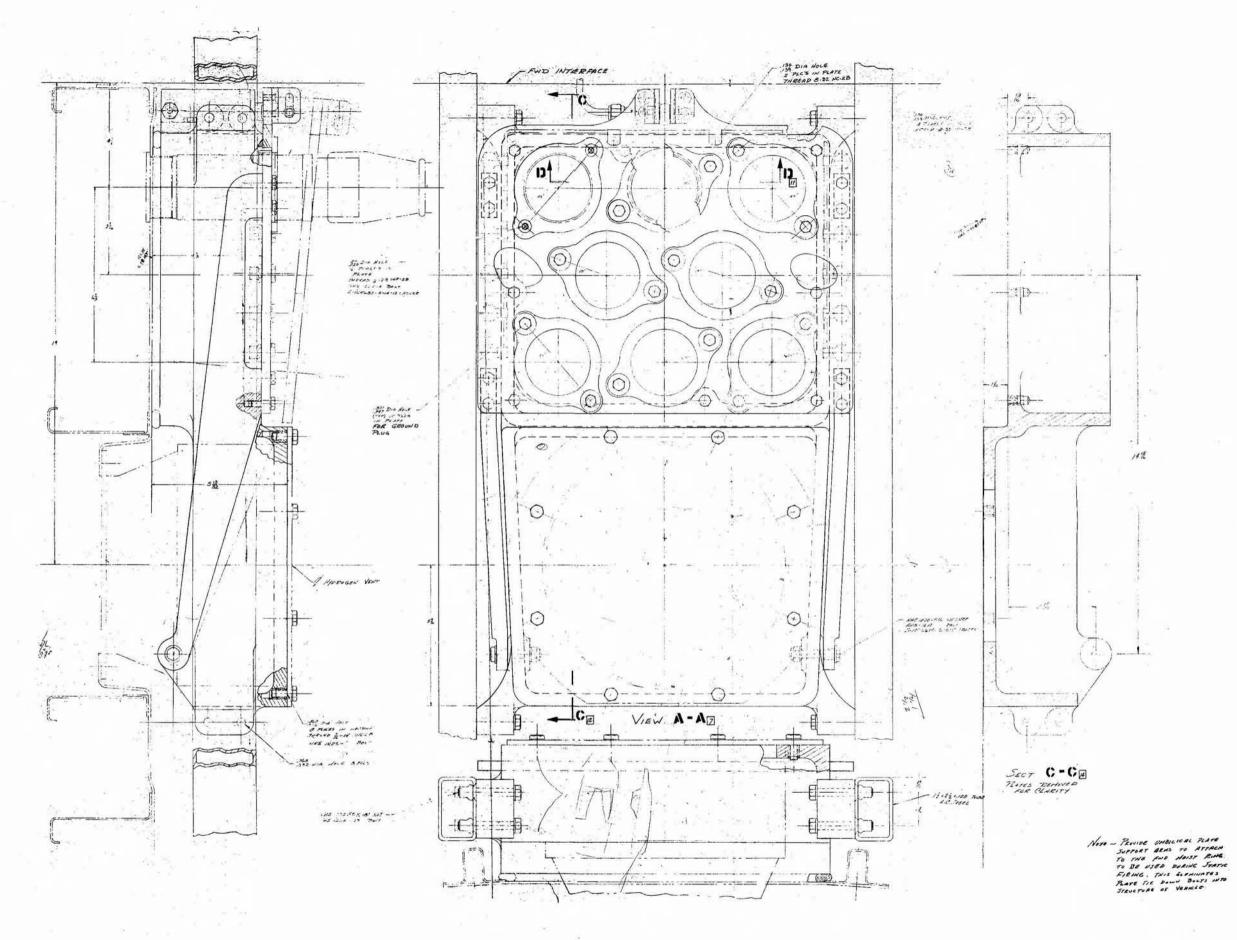


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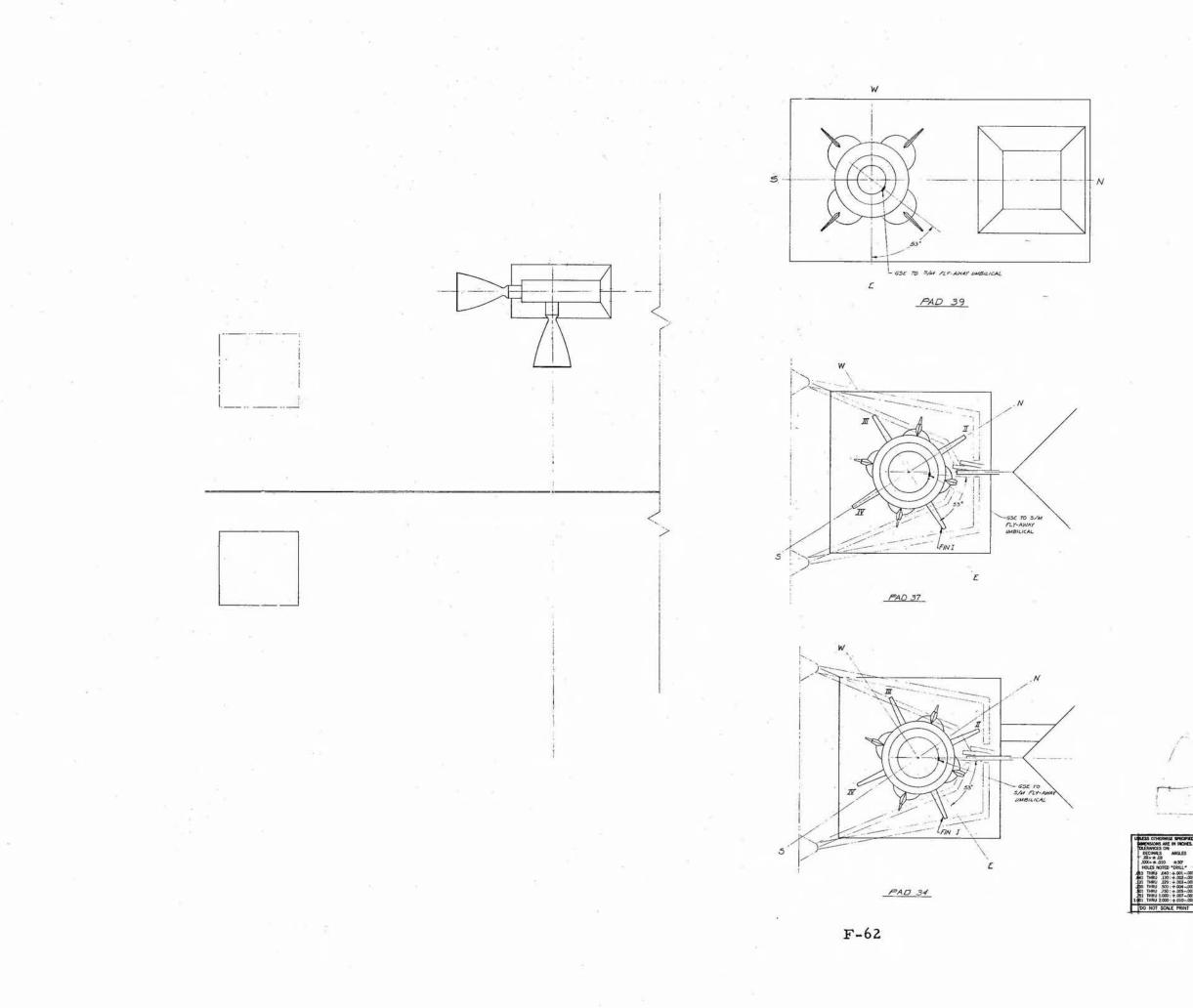


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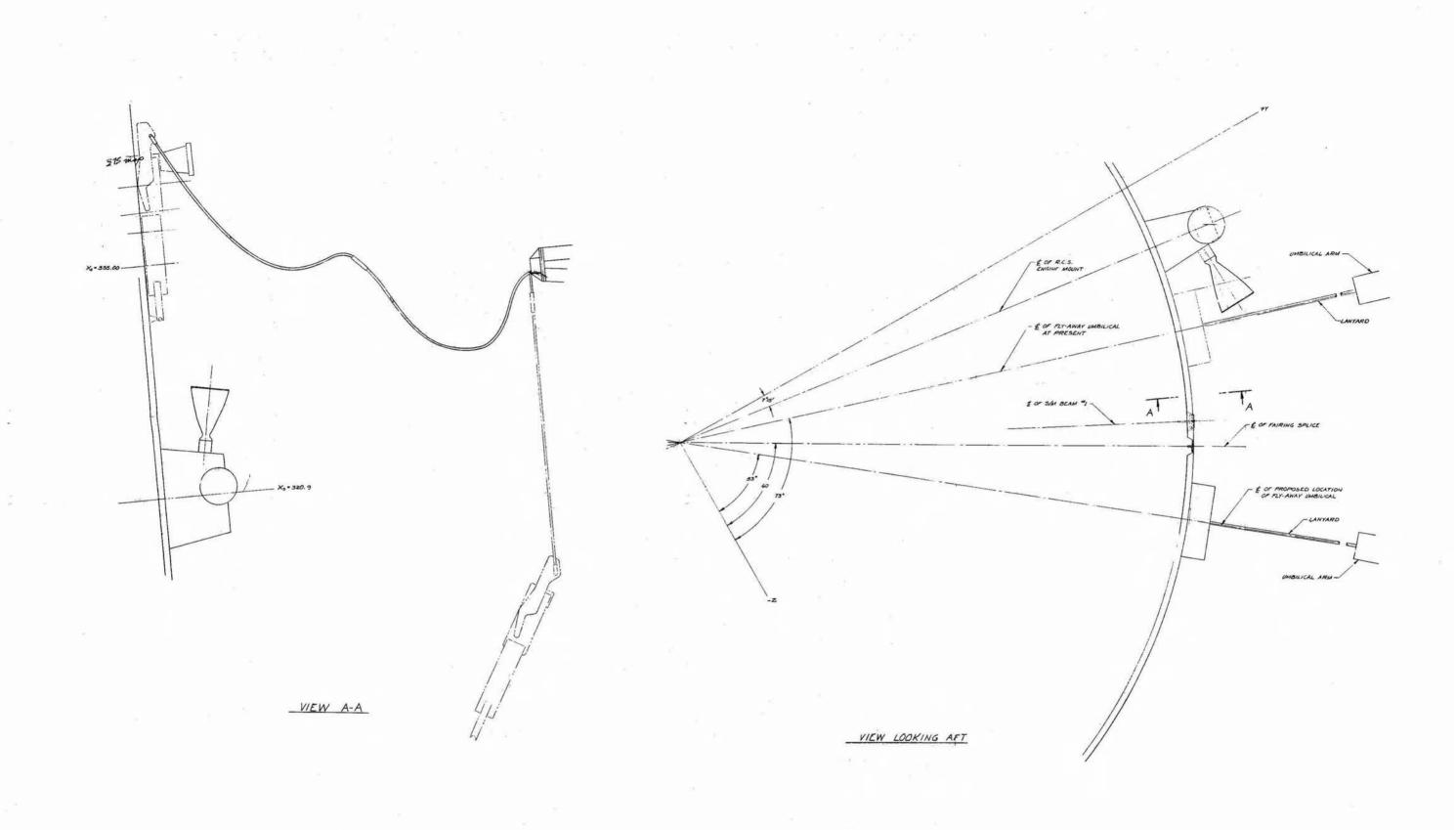
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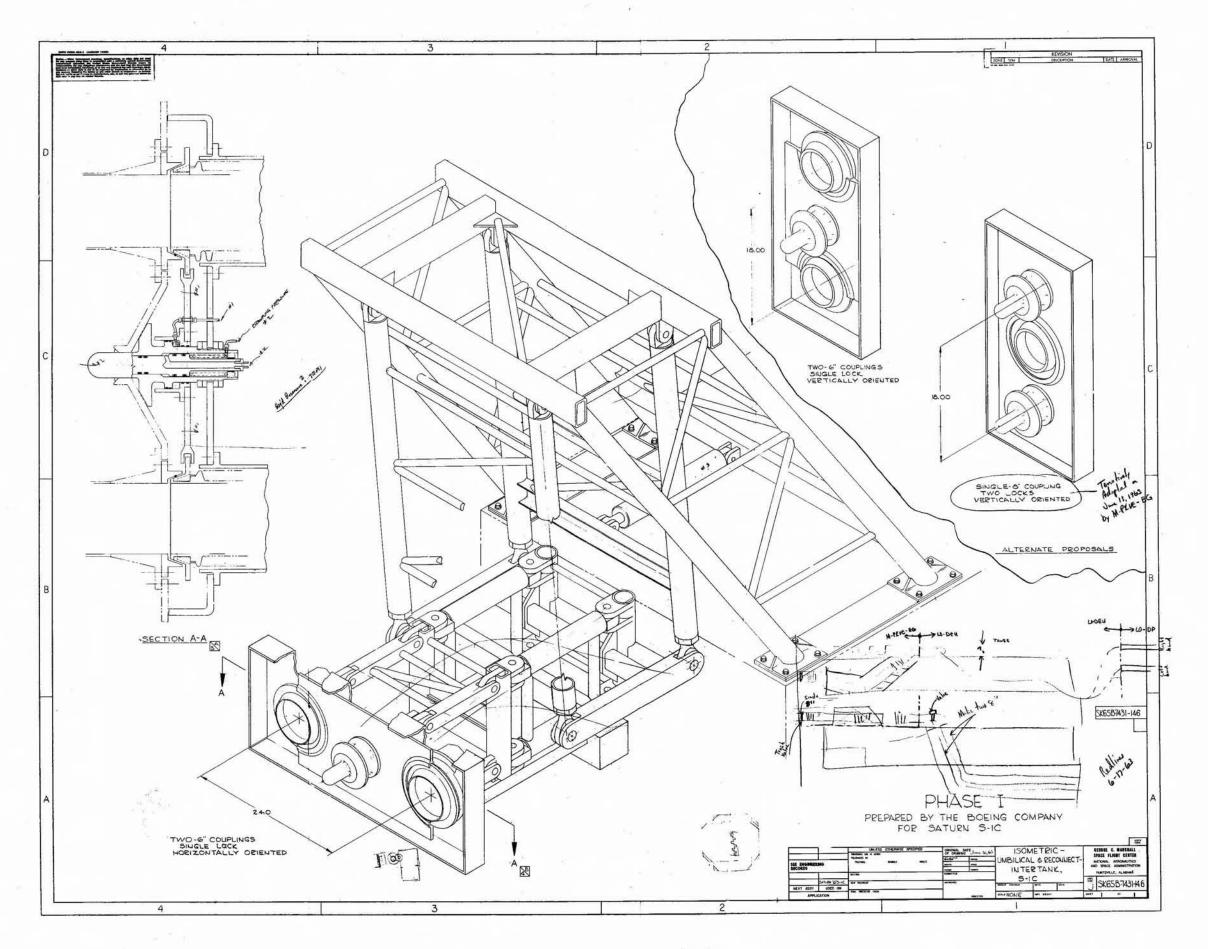
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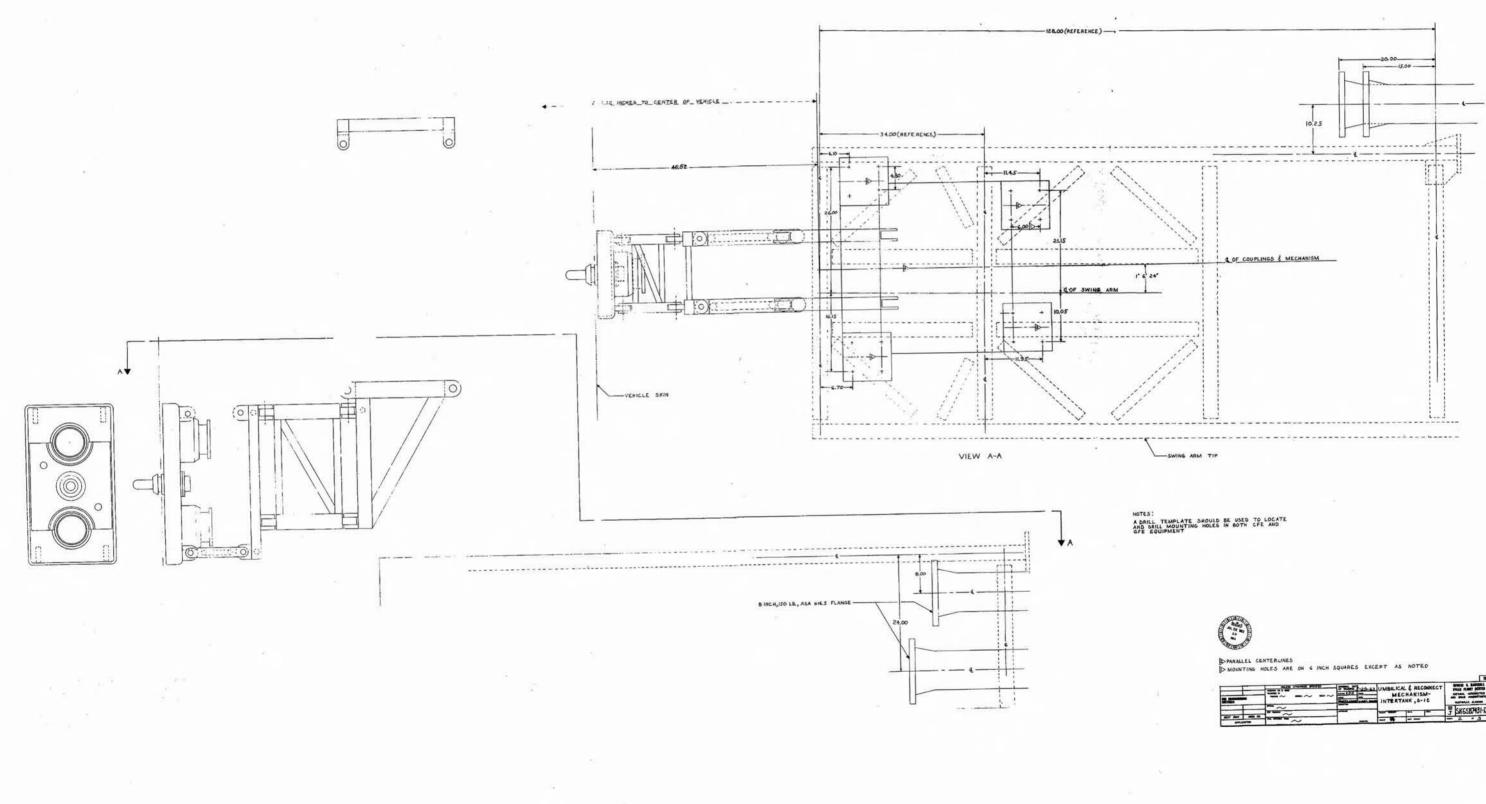
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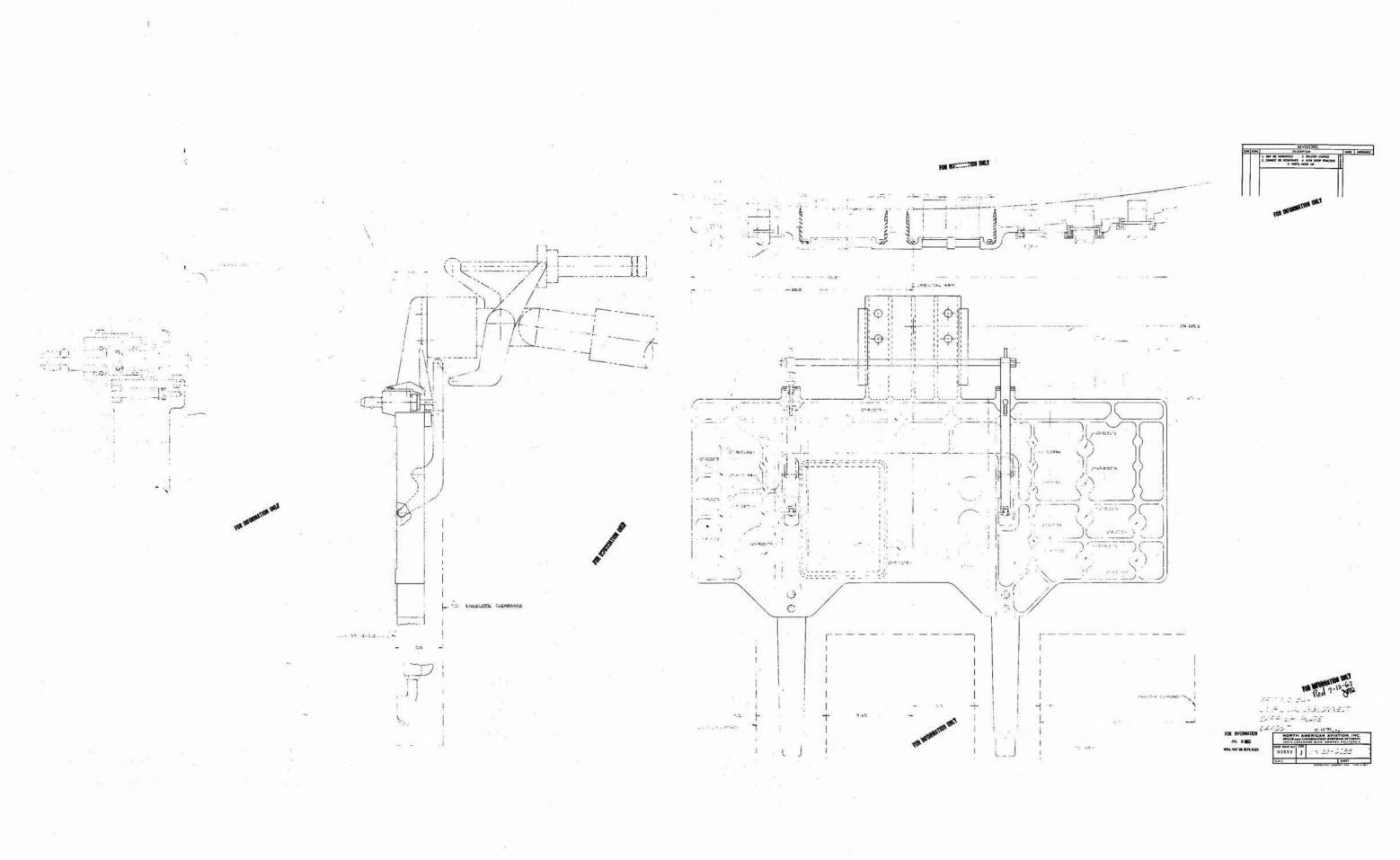


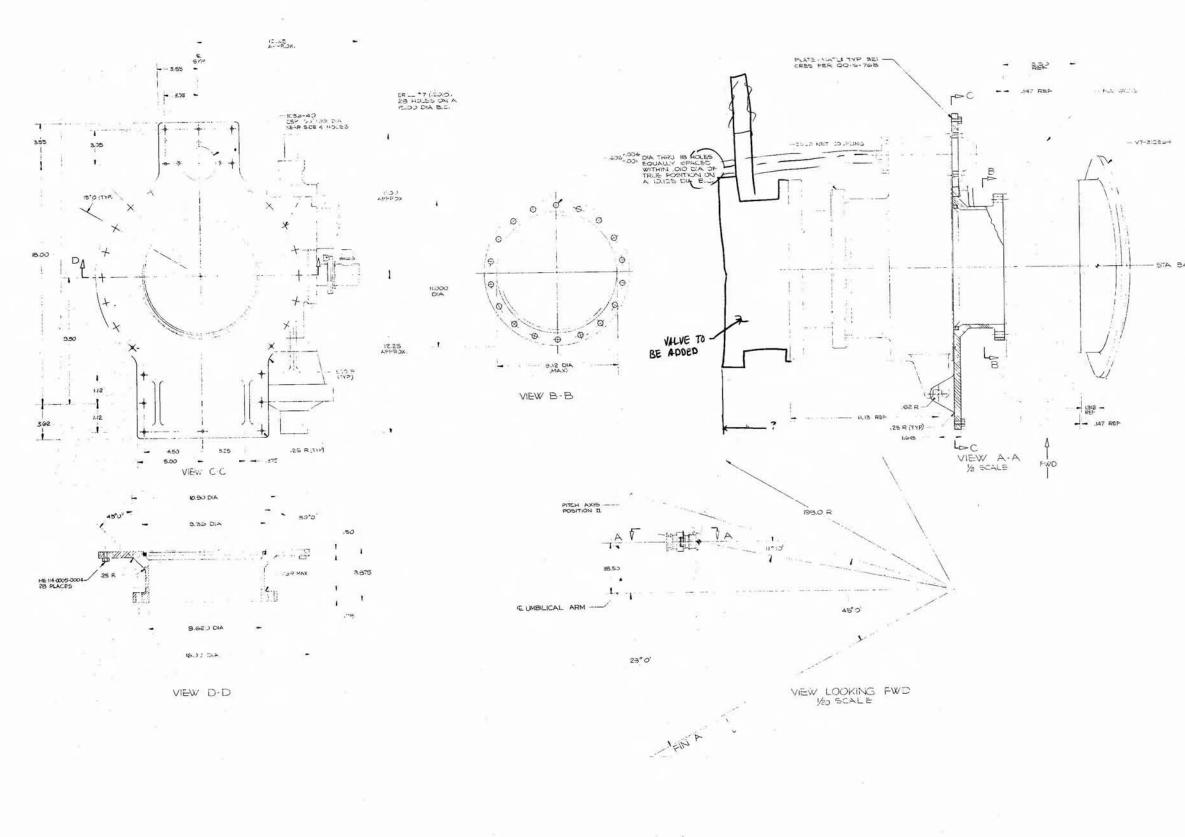


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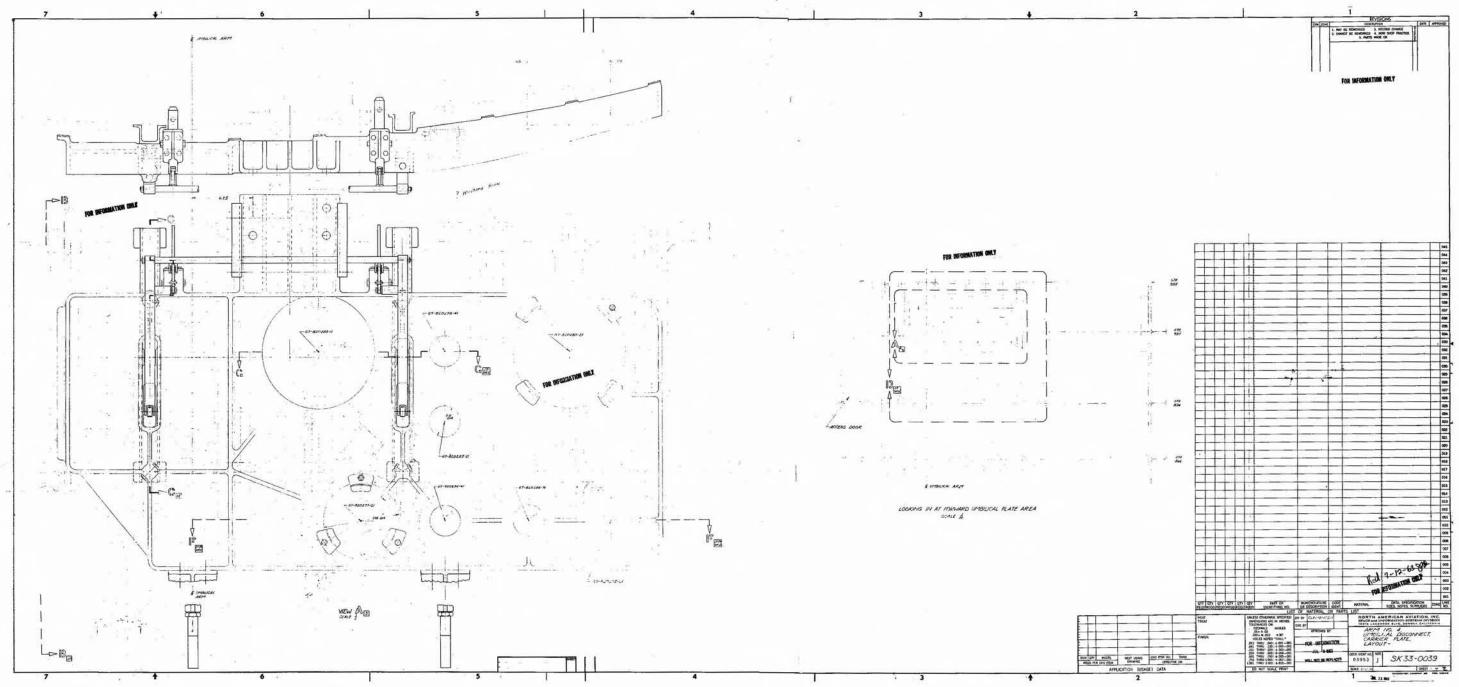
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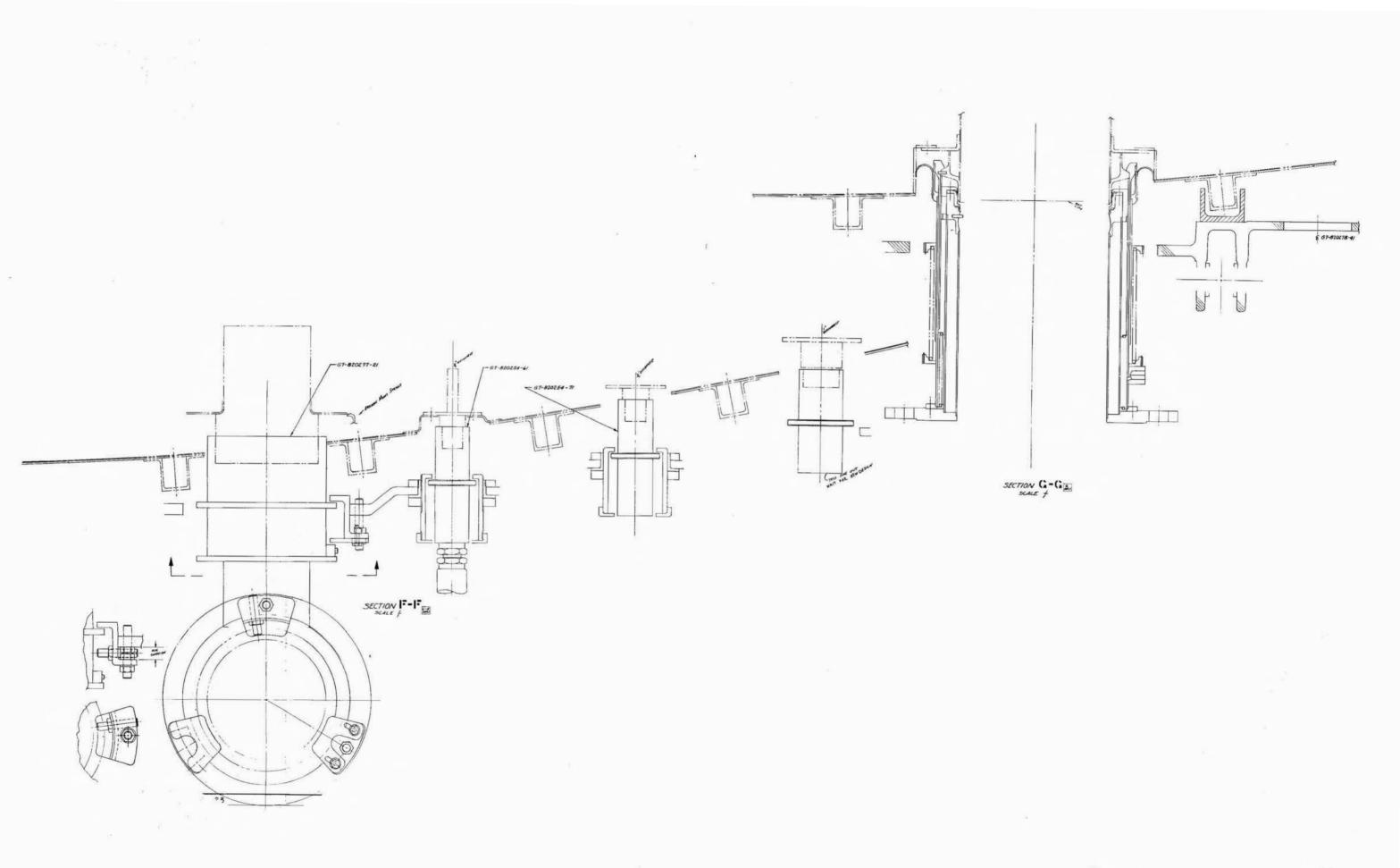
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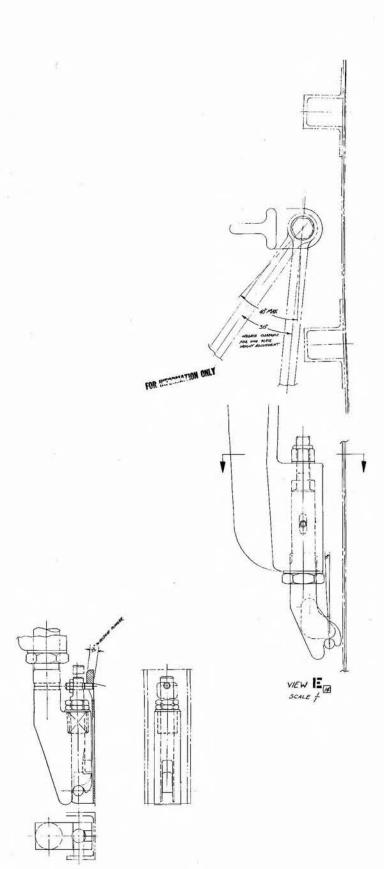
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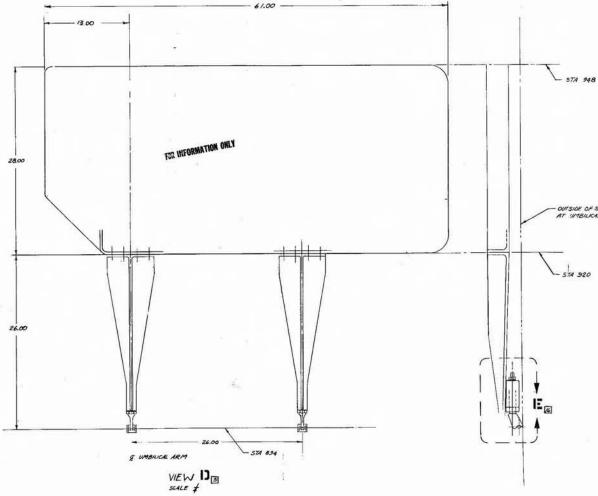


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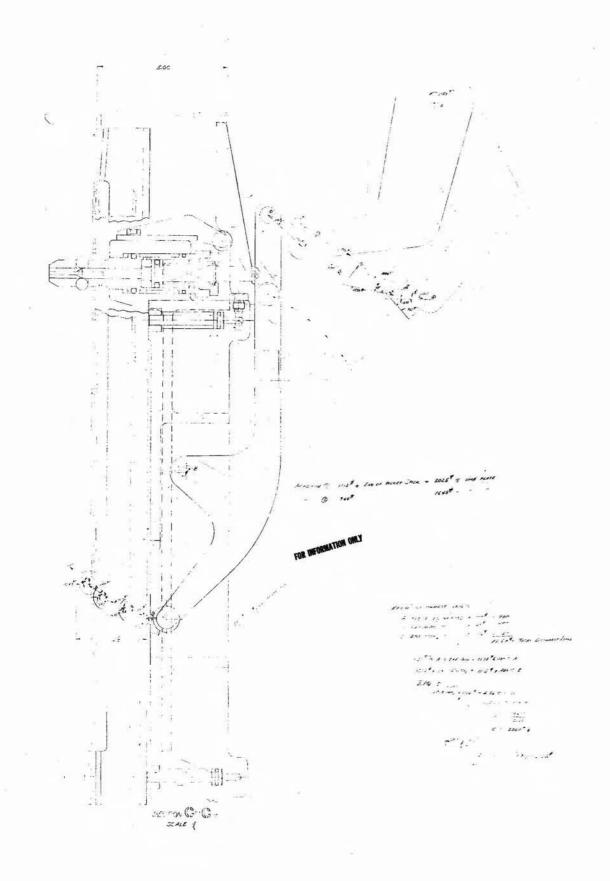
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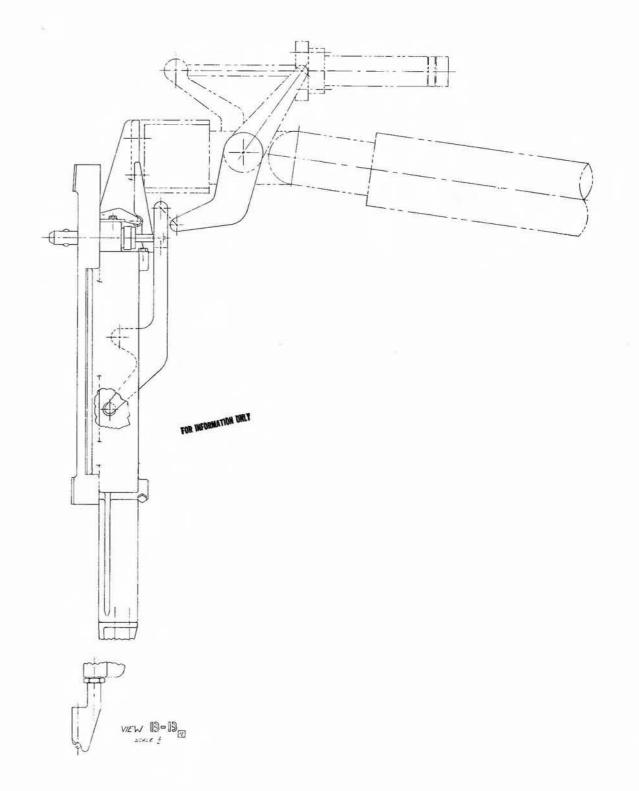
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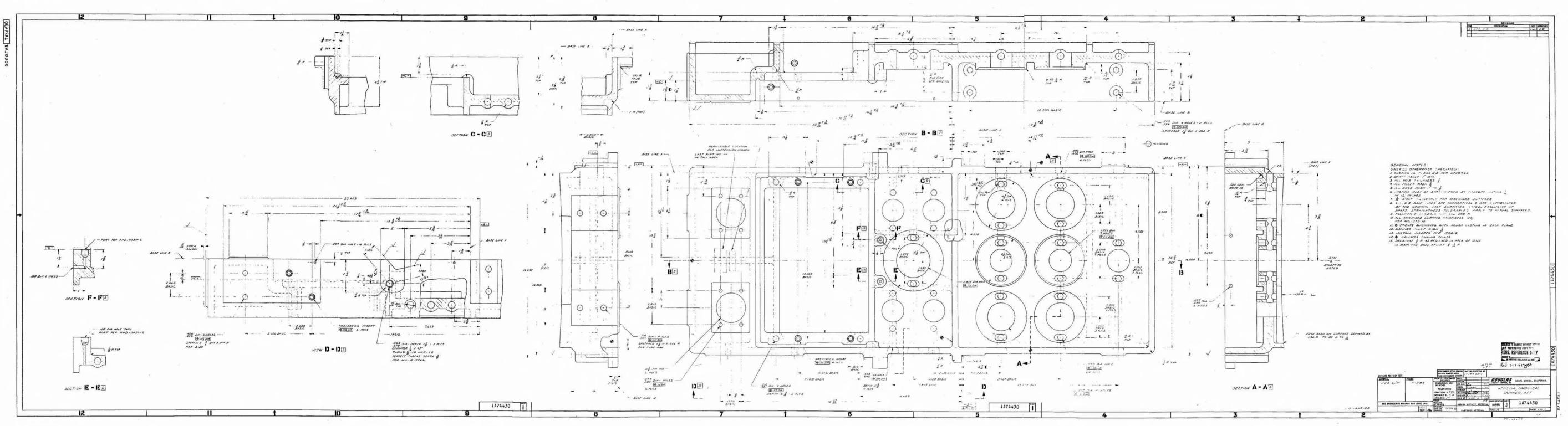
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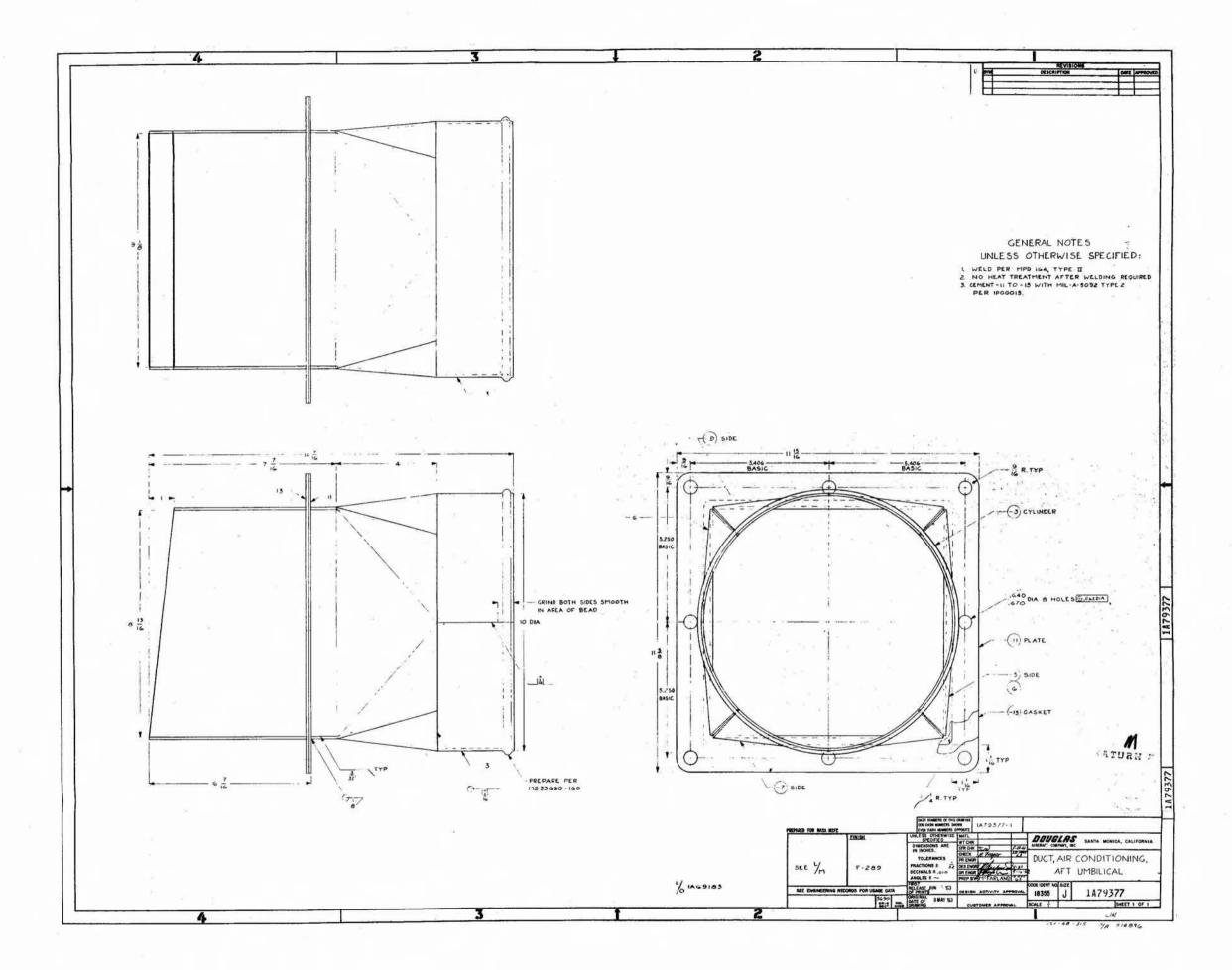
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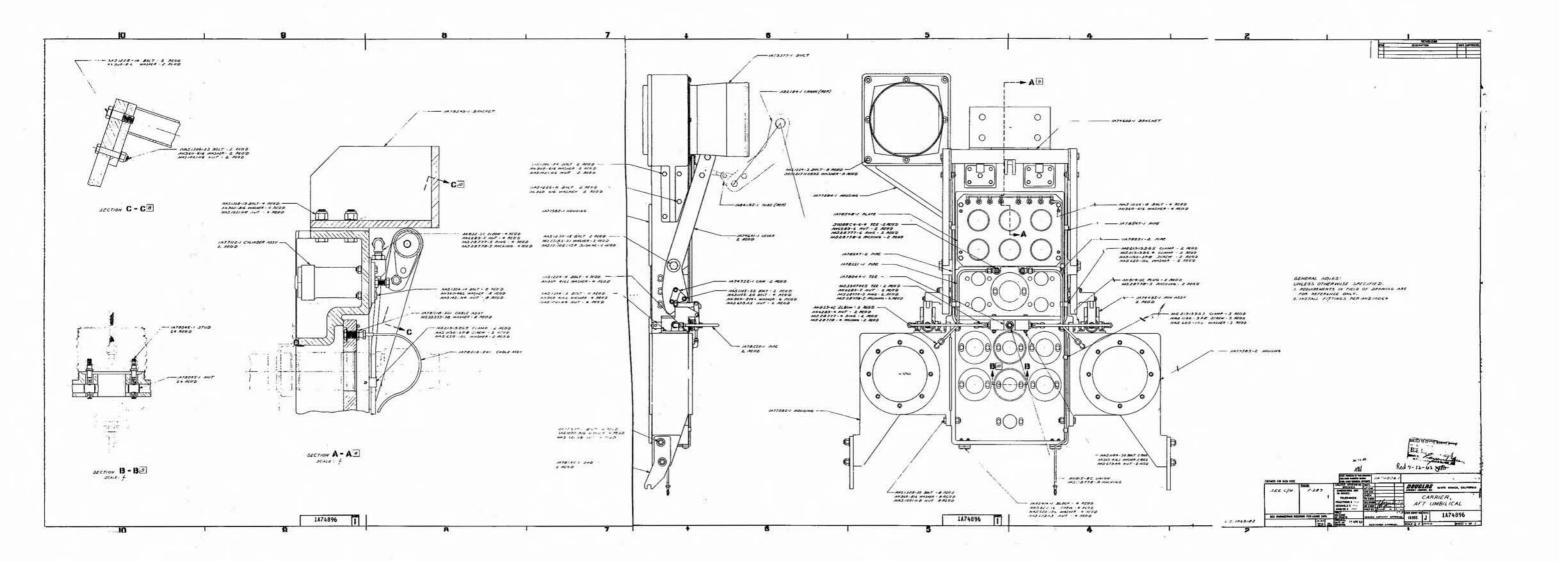


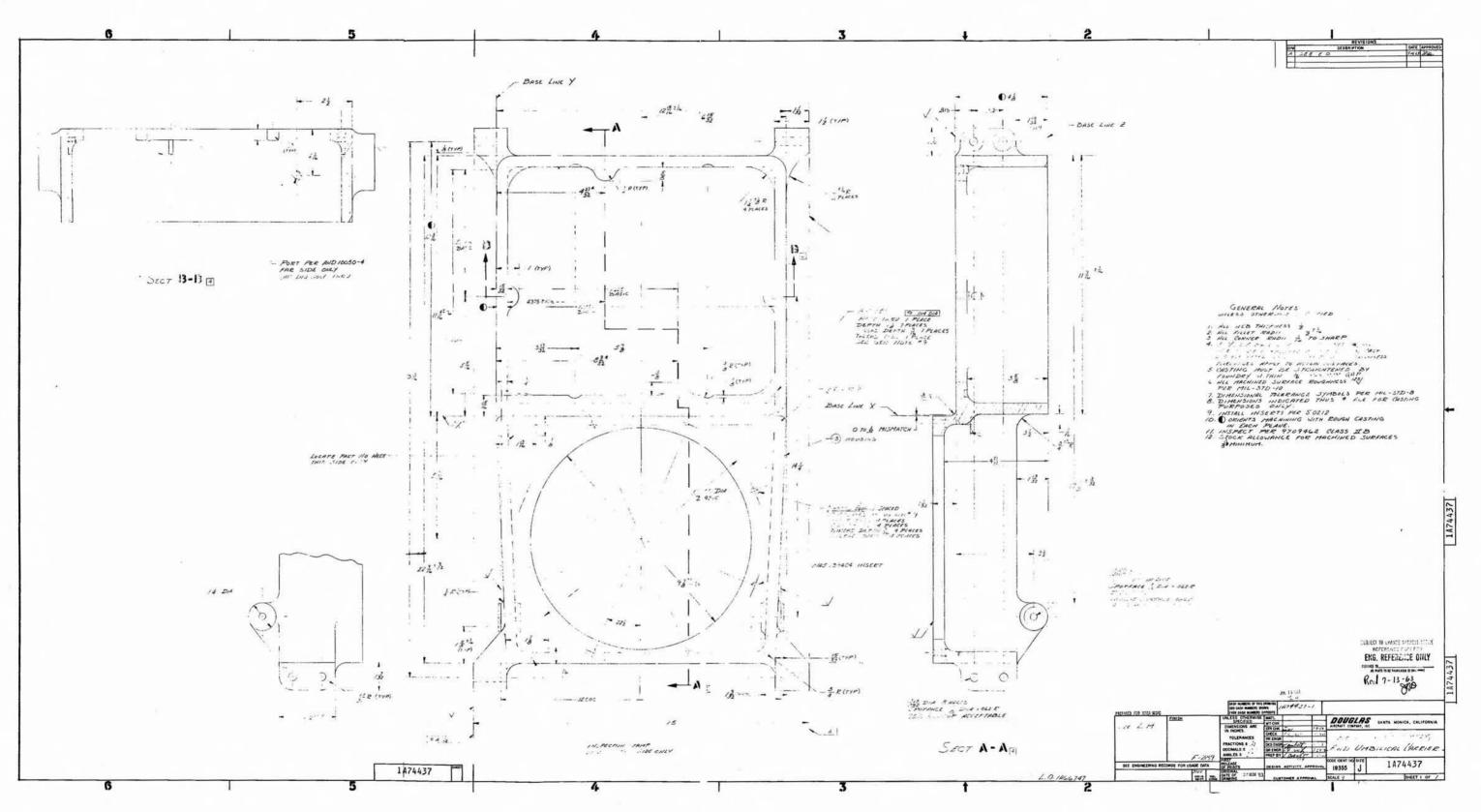


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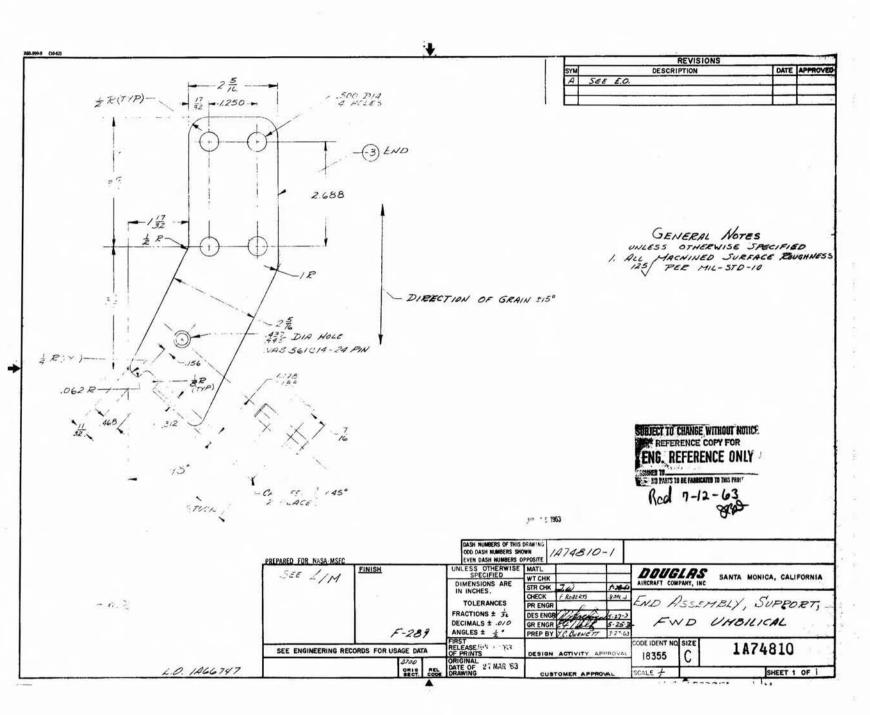
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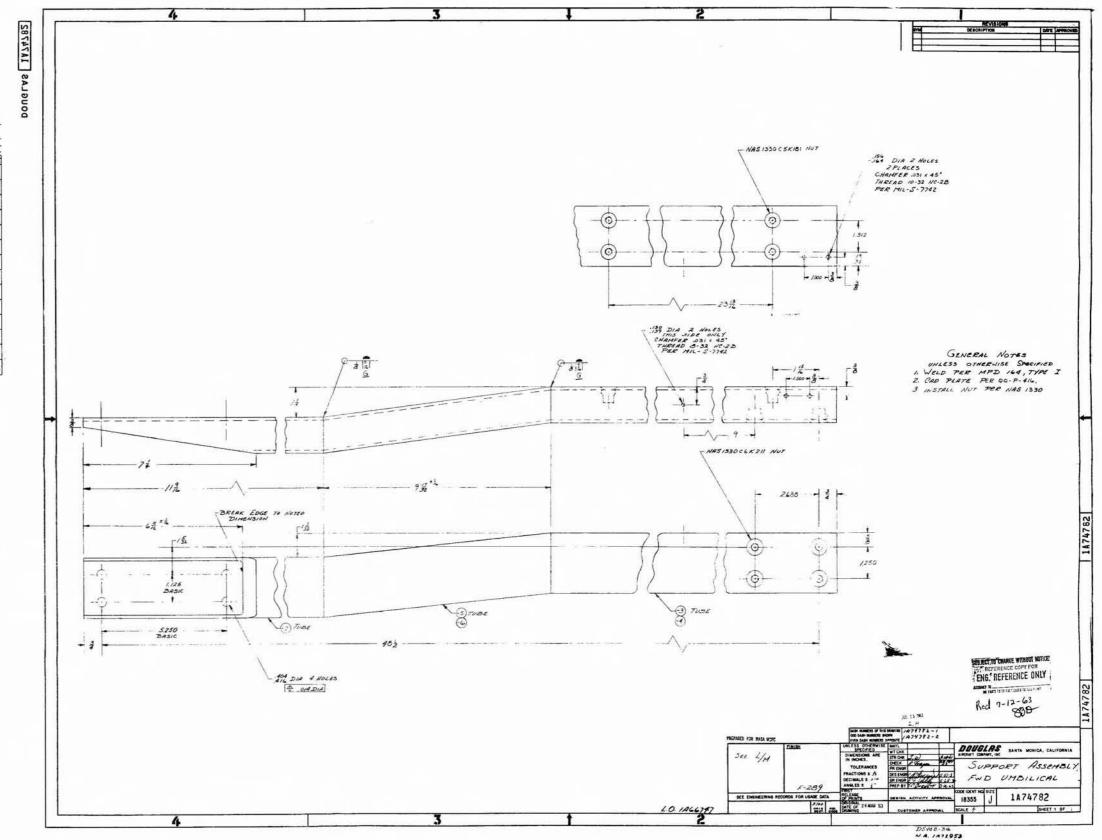
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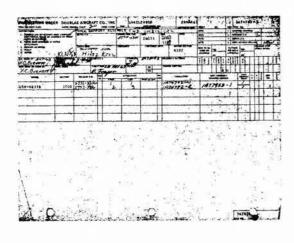
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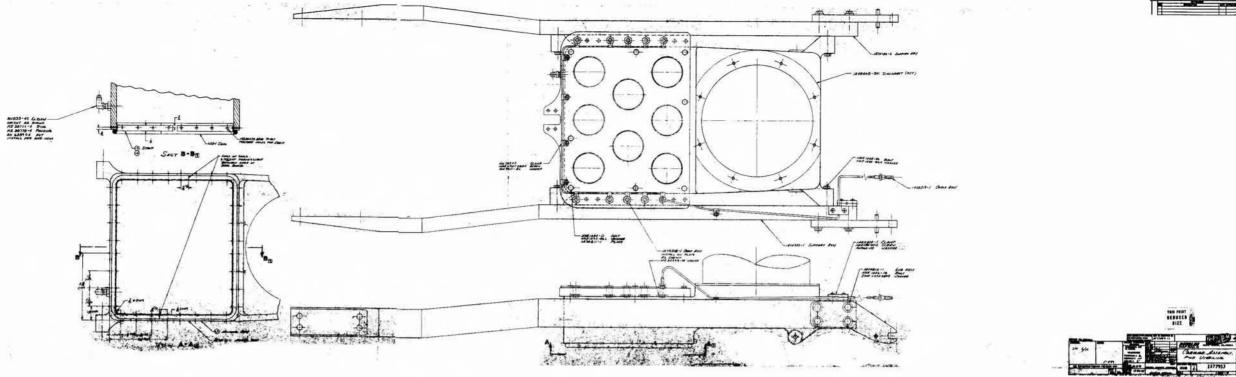
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REFERENCES

Reference 1: Memo # M-P&VE-VA-120, dated August 28, 1963, entitled C-5 GROUND RULES.

Reference 2: Memo # M-P&VE-SL-24-63, dated February 5, 1963, entitled C-5 VEHICLE DEFLECTION ON THE LAUNCHER/ UMBILICAL TOWER.

- Reference 3: Memo # M-P&VE-SL-29-63, dated February 14, 1963, entitled WIND-INDUCED OSCILLATIONS OF THE SATURN V (C-5) VEHICLE ON THE LAUNCHER /UMBILICAL TOWER.
- Reference 4: Memo # M-P&VE-SS-225, dated December 19, 1962, entitled LATERAL AND VERTICAL DEFLECTIONS OF THE C-5 VEHICLE.
- Reference 5: Memo # M-P&VE-ST-34-63, dated January 30, 1963, entitled THE PRELIMINARY SHOCK AND VIBRATION SPECI-FICATIONS FOR THE PROPELLANT COUPLINGS AND ELECTRICAL UMBILICAL CONNECTORS OF THE UPPER STAGES, S-II, S-IVB, and INSTRUMENT UNIT, C-5 CON-FIGURATION.
- Reference 6: LAUNCHER-UMBILICAL TOWER, LAUNCH COMPLEX 39, DESIGN CRITERIA, sheets A-4 through A-7 by Reynolds, Smith and Hills.

Reference 7: DWG. NO. D75M02959L, SHT 53, dated August 14, 1962, entitled INFORMATION DRIFT CURVE C-5 LOR.

- Reference 8: LAUNCHER-UMBILICAL TOWER, LAUNCH COMPLEX 39, DESIGN CRITERIA, sheets A-19 and A-20, Reynolds, Smith and Hills.
- Reference 9: Memo # M-P&VE-PH-36-62, dated July 19, 1963, entitled PREDICTED TEMPERATURES AND PRESSURES FOR C-5 UMBILICAL TOWER.

TR-4-4-2-D July 10, 1963

APPROVAL

SATURN V SERVICE ARMS PRELIMINARY ENGINEERING REPORT COMPLEX 39

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Sitin

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