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MANUFACTURING PLAN FOR SATURN S-II, STAGES 16-25

14 June 1967

Approved by

R. E. Greer
Vice President and S-II Program Manager

NORTH AMERICAN AVIATION, INC.
SPACE DIVISION

TECHNICAL REPORT INDEX/ABSTRACT

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MANUFACTURING PLAN FOR SATURN S-II STAGE (S-II-16 THRU S-II-25)

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ABSTRACT

THE MANUFACTURING PLAN PRESENTED IN THIS REPORT CONTAINS INSTRUCTIONS AND PROCEDURES FOR FABRICATION, ASSEMBLY, AND TESTING OF THE SATURN S-II STAGE (S-II-16 THROUGH S-11-25). THE S-II STAGE WILL CONSIST OF A FORWARD SKIRT, LIQUID HYDROGEN (LH_2) TANK, LIQUID OXYGEN (LOX) TANK, THRUST STRUCTURE, HEAT SHIELD, INTERSTAGE, AND ENGINE AND SYSTEM COMPONENTS. A LIST OF THE S-II STAGES AND ALL DELIVERABLE CONTRACT ITEMS IS PROVIDED IN THE SATURN S-II PROGRAM PLAN.

FOREWORD

This document is submitted to the National Aeronautics and Space Administration (NASA) in accordance with the requirements of line item 75 of SD 67-700. This report includes the latest Saturn S-II manufacturing concepts and plans of the Space Division of North American Aviation, Inc.

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INTRODUCTION

The manufacturing plan presented in this report contains instructions and procedures for the fabrication, assembly, and testing of the Saturn S-II stage. The S-II stage will consist of a forward skirt, liquid hydrogen (LH_2) tank, liquid oxygen (LOX) tank, thrust structure, heat shield, interstage, and engine and system components. A list of the S-II stages and all deliverable contract items is provided in the Saturn S-II Program Plan (S-II-16 through S-II-25).

The manufacturing plan presented herein is divided into four major sections: fabrication and assembly procedures (Section 1.0), factory test plan (Section 2.0), ground support equipment (Section 3.0), and special tooling (Section 4.0). The S-II Manufacturing organization is shown in Figure 1, and the Seal Beach (Calif.) assembly site is shown in Figure 2. Section 1.0 delineates the progressive fabrication of the S-II stage. Section 2.0 contains the procedures and tests required in establishing the reliability of the structural and system components. Section 3.0 covers the fabrication, testing, and calibration of GSE modules and components. Section 4.0 describes the major assembly fixtures and contains lists of tooling and measuring devices.

All articles produced by SD Manufacturing are authorized, controlled, and documented by means of fabrication, assembly, and inspection records (FAIR), the basic forms of the SD production control system.

Manufacturing Planning prepares FAIR tickets that authorize and describe the manufacture of the items required. Manufacturing Planning coordinates all FAIR tickets with Quality Engineering of Manufacturing Quality and Reliability Assurance (Q&RA) before these tickets are released.

North American Aviation, Inc. Space Division
MANUFACTURING
SATURN S-II PROGRAM
May 31, 1967
APPROVED:

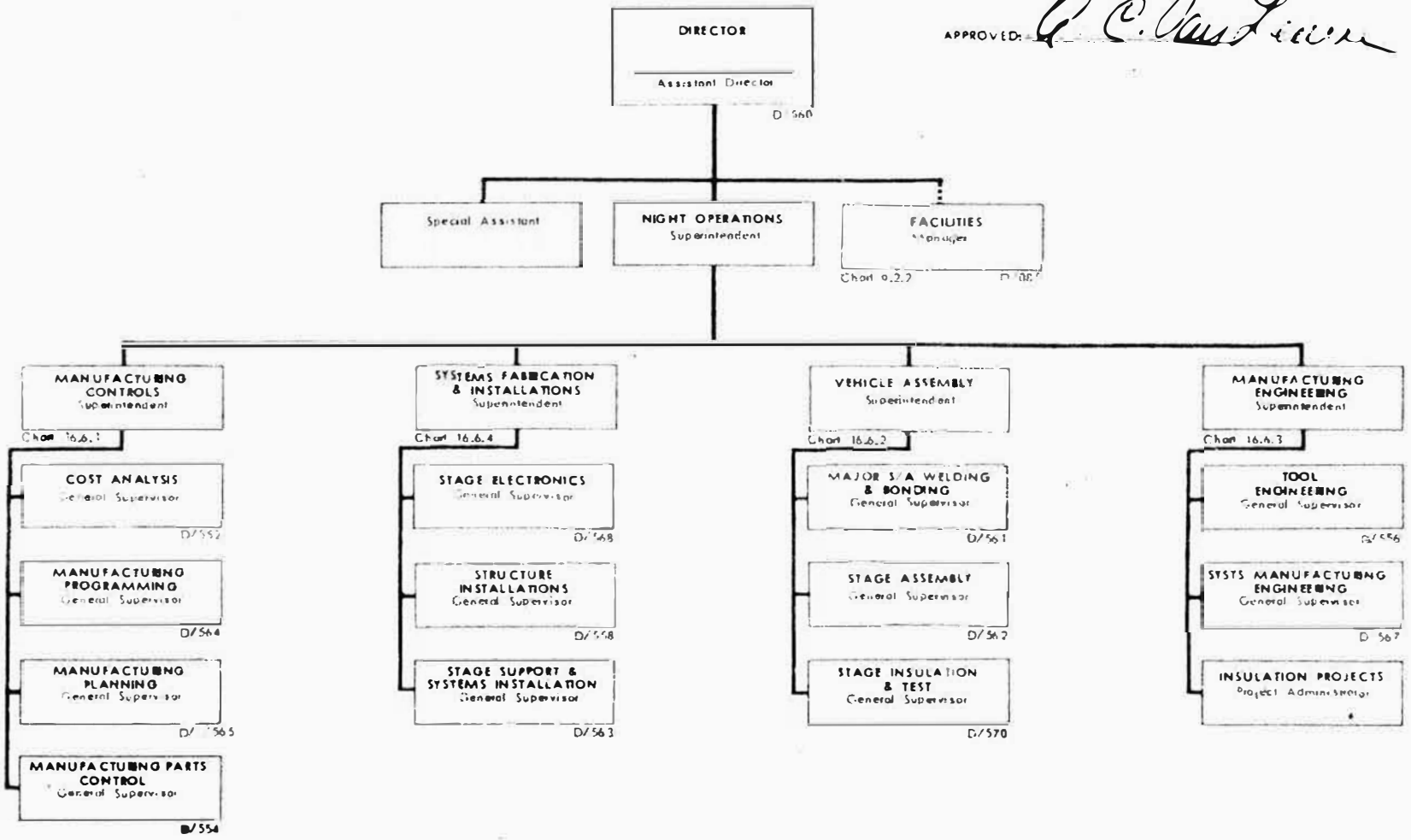


Figure 1. S-II Manufacturing Organization

Figure 2. Seal Beach Assembly Site

1.0 FABRICATION AND ASSEMBLY PROCEDURES

1.1 SUBASSEMBLY FABRICATION

1.1-1 The S-II stage subassemblies and their fabrication steps and tooling requirements are described in this section. A structural breakdown of major subassemblies is shown in Figure 1-1. (A production breakdown is depicted in Figure 1-31.) To control diametrical tolerances of the mating subassemblies, critical assembly operations will be conducted in a temperature-controlled atmosphere. Final assembly and subassembly joining operations will be performed at controlled temperature levels. All procedures used in the fabrication of the S-II stage will conform to approved specifications.

1.1.1 FORWARD SKIRT STRUCTURE

1.1.1-1 The forward skirt assembly of the S-II stage will be of riveted, semimonocoque, skin-stringer construction and will be fabricated in four panels as shown in Figure 1-2. The assembly will consist of subassembled external longerons and sheet metal internal frames. The skirt forward surface will be station-controlled. A bolt pattern for the mating of the forward skirt to the S-IVB stage will be coordinated by a control master gauge. The unit is received from Tulsa with insulation panels bonded in place and then installed. Closeouts are then bonded in place at the four splice-line areas to complete skirt insulation.

Procedure	Tooling
Frame subassemblies	
a. Install web and cap segments in jig. (See Figure 1-3.)	Subassembly jig
b. Drill and tack rivet.	
c. Inspect and identify.	Pick-up jig
Skin segment and stringers	
a. Install skin segments and external hat sections in jig. (See Figure 1-3.)	Subassembly jig

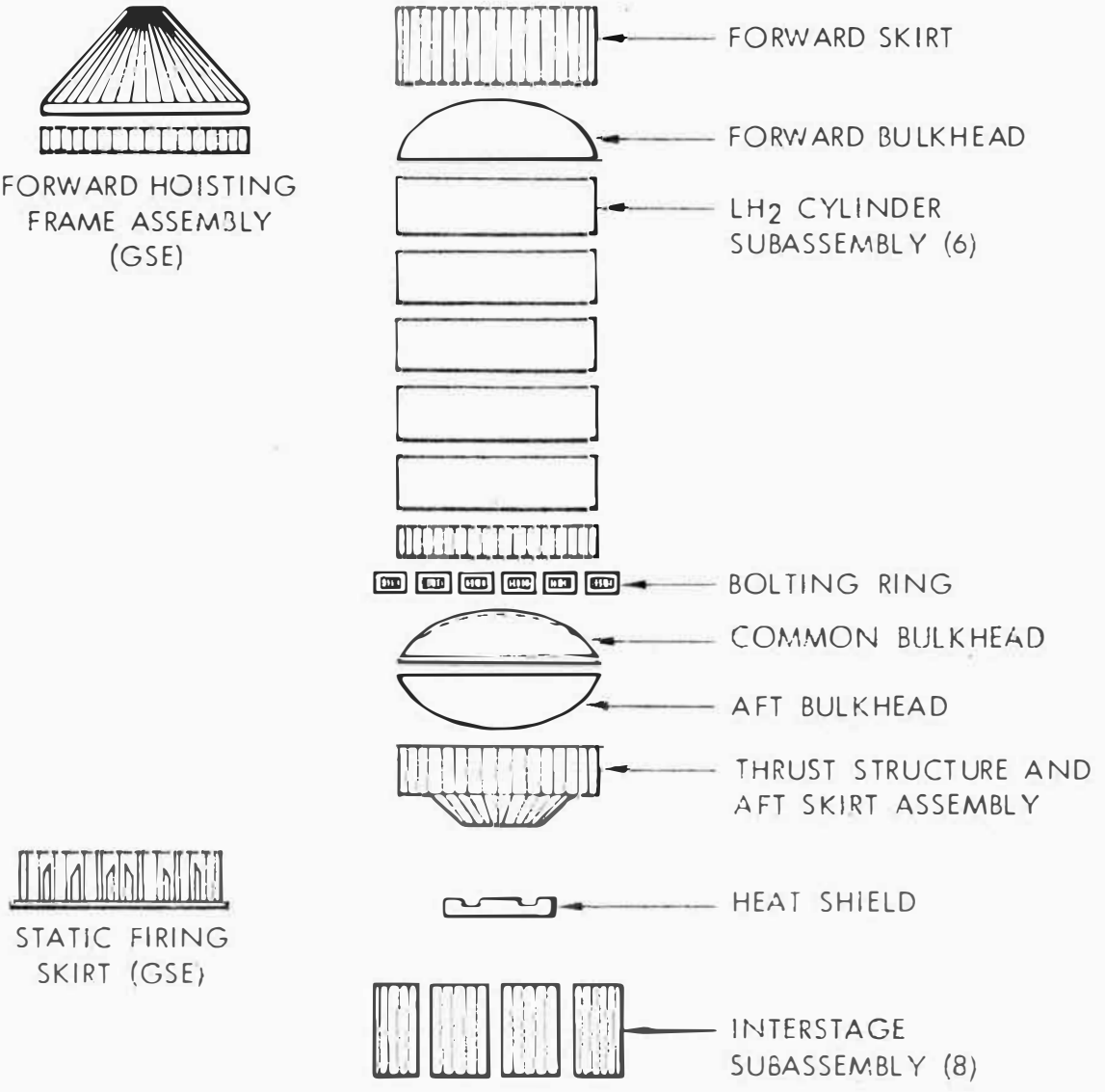


Figure 1-1. S-II Stage Breakdown

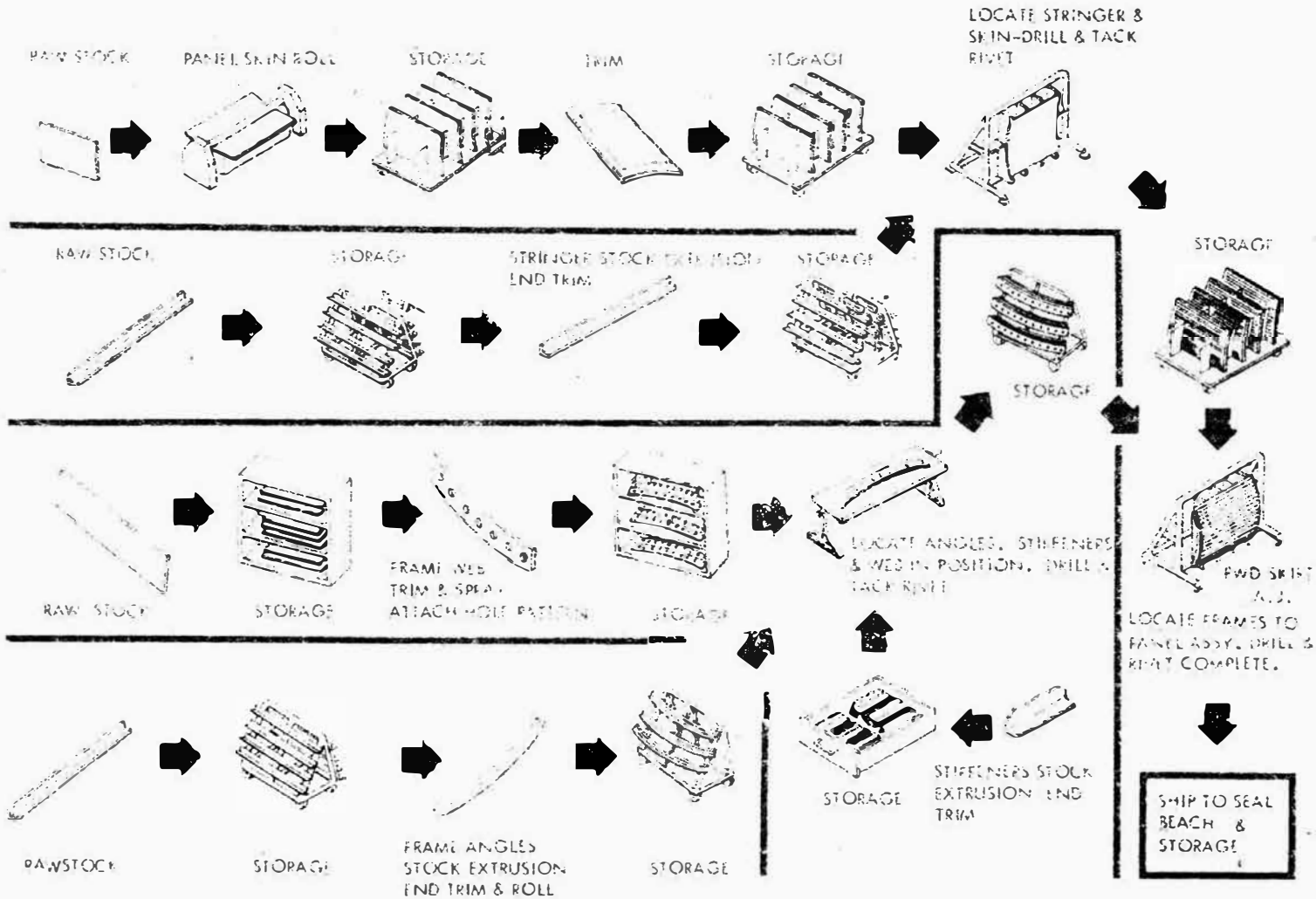
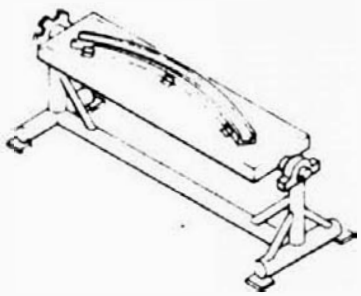
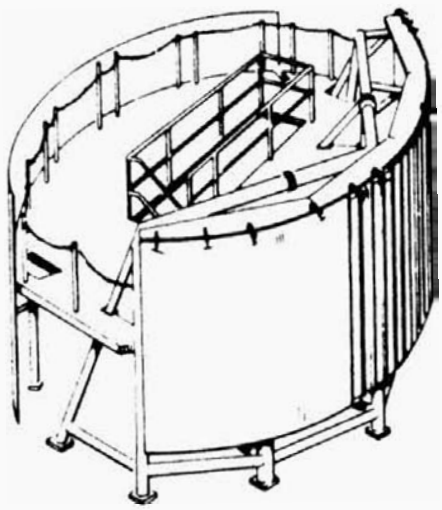


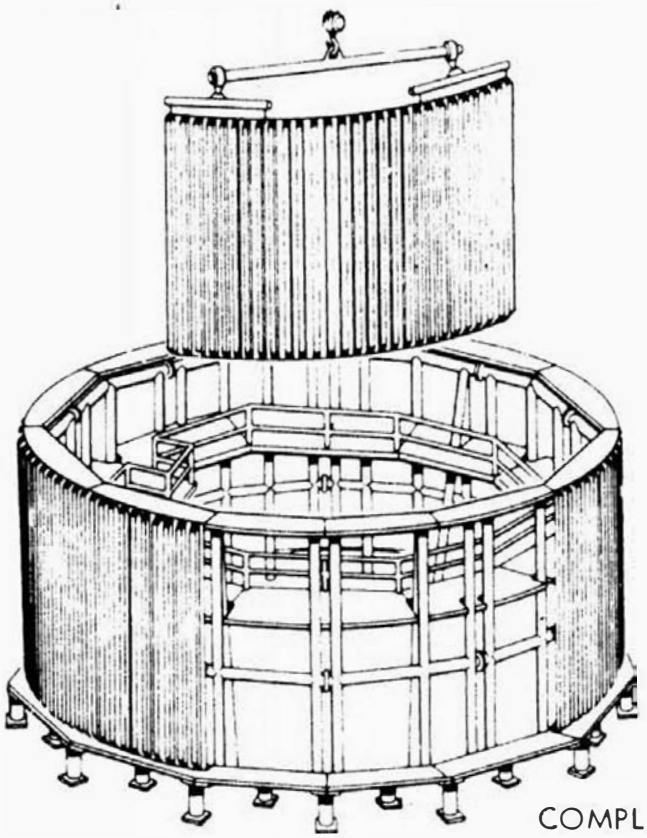
Figure 1-2. Forward Skirt Assembly Sequence



FRAME SUBASSEMBLY



SKIN SUBASSEMBLY AND
FRAME ASSEMBLY



COMPLETE FORWARD SKIRT ASSEMBLY

Figure 1-3. Forward Skirt Fabrication

Procedure	Tooling
b. Drill and tack rivet.	
c. Inspect and identify.	Pick-up jig
Skin panels and frames	
a. Install skin panels and frames in jig. (See Figure 1-3.)	Assembly jig
b. Drill and rivet (NAA specification LA0101-004).	
c. Inspect and identify.	
Forward skirt	
a. Install skin panels in assembly jig. (See Figure 1-3.)	Assembly jig
b. Drill and rivet skin splices (NAA specification LA0101-004).	
c. Drill and bolt frame splices (NAA specification LA0101-004).	
d. Install antenna, windows, antenna mounts, and electrical brackets. Drill and rivet (NAA specification LA0101-004).	Assembly jig
e. Drill mating S-II hole pattern.	
f. Inspect and identify.	Transportation dolly
g. Disassemble and package.	
h. Deliver to next assembly.	

1.1.2 INTERSTAGE STRUCTURE

1.1.2-1 The interstage structure will be fabricated of riveted, semi-monocoque, skin-stringer construction (Figure 1-4) as outlined for the forward skirt. The interstage aft surface will be controlled for station plane. A bolt pattern for the mating of the aft surface to the S-IC stage will be coordinated by a master control gauge. The forward surface will be controlled by a tool master, and a field break will be provided for attachment to the thrust structure. A separation plane will be provided at Station 0 and at Station 196 for in-flight stage separation.

Procedure	Tooling
Frame subassemblies	
a. Install web and cap segments in jig. (See Figure 1-5.)	Subassembly jig
b. Drill and rivet.	
c. Inspect and identify.	Pick-up jig
Skin segments and stringer subassemblies	
a. Install skin segment and external bulb stringers in jig. (See Figure 1-5.)	Subassembly jig
b. Drill and tack rivet.	
c. Rivet complete (NAA specification LA0101-004).	
d. Inspect and identify.	
Panel assemblies	
a. Install frame segments and skin panel segment in jig. (See Figure 1-5.)	Assembly jig
b. Drill and rivet complete (NAA specification LA0101-004).	
c. Inspect and identify.	Pick-up jig

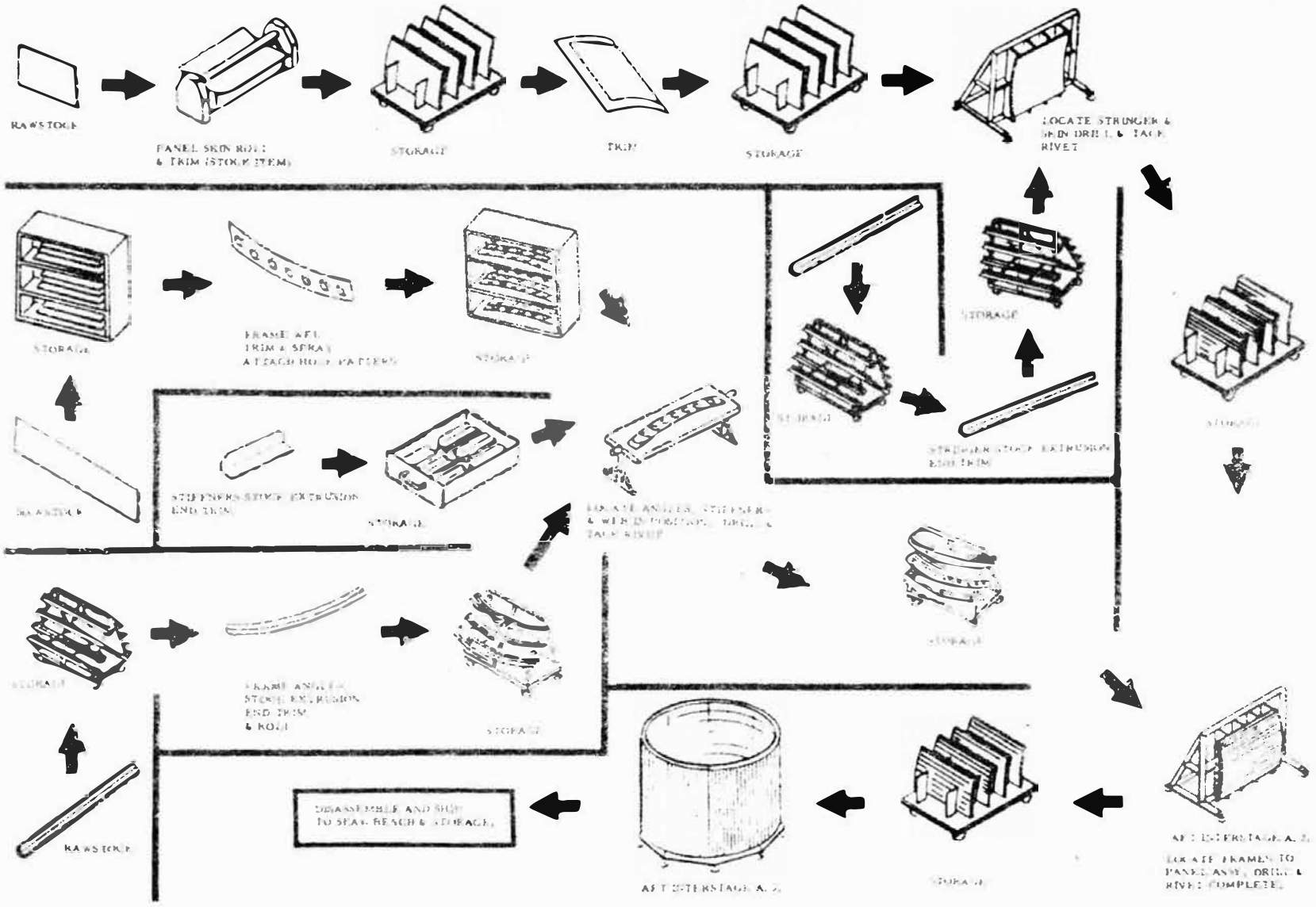
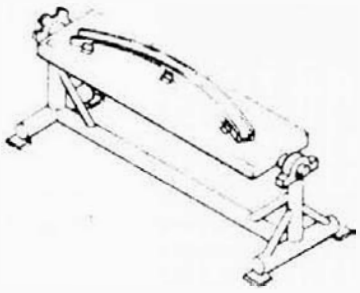
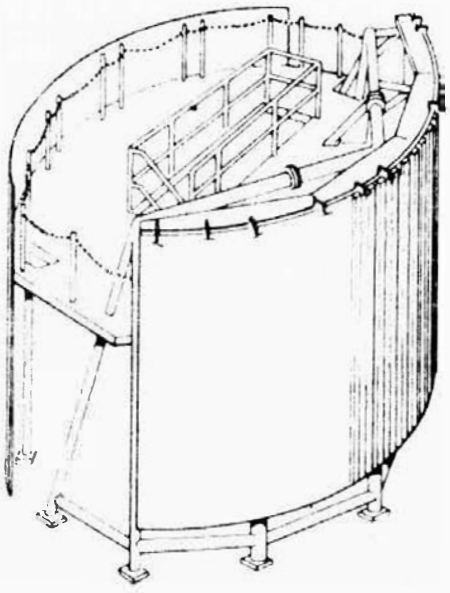


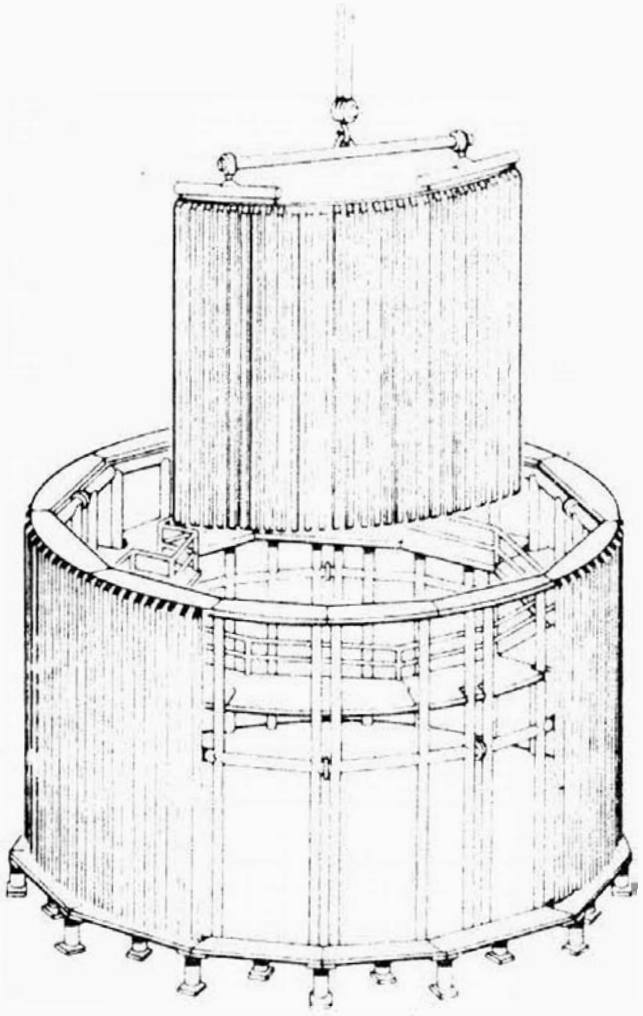
Figure 1-4. Interstage Assembly Sequence



FRAME SUBASSEMBLY



FRAMES TO PANEL ASSEMBLY



INTERSTAGE COMPLETE

Figure 1-5. Interstage Fabrication

Procedure	Tooling
Access door assembly	
a. Position frame, skin, and hinge in assembly jig.	Assembly jig
b. Drill and tack rivet.	
c. Automatic rivet complete.	
d. Inspect and identify.	
Aft interstage (complete)	
a. Install skin panels and fore and aft fittings in assembly jig. (See Figure 1-5.)	Assembly jig
b. Drill and rivet skin splices.	
c. Drill bolt holes; bolt splices temporarily to facilitate assembly separation into four sections. Complete remaining splices.	
d. Drill matched hole pattern for frame splices.	
e. Install access doors.	
f. Drill and rivet access doors (NAA specification LA0101-004).	
g. Drill coordinated interface for S-IC stage and aft skirt.	
h. Inspect and identify.	
i. Disassemble and package for shipment.	

1.1.3 THRUST STRUCTURE

1.1.3-1 The thrust structure will be fabricated of riveted, skin-stringer and internal frame construction as shown in Figure 1-6. This structure will consist of a combination of a riveted cone fabricated of four panel sections and a machined cylindrical skirt fabricated of four panel sections. The external longerons will be spaced approximately 7 inches apart on the skirt; the longerons will be fan-positioned on the thrust cone. Internal frames will maintain circular exactness of both the skirt and the cone to aid in thrust dispersion along the longerons.

1.1.3.1 Thrust Structure Subassembly

1.1.3.1-1 Following is the fabrication procedure and tooling for the thrust structure subassembly:

Procedure	Tooling
Frame assemblies	
a. Install webs and angles in jig. (See Figure 1-7.)	Subassembly jig
b. Drill and rivet (NAA specification LA0101-004).	
c. Inspect and identify.	
Cone skin subassembly	
a. Assembleexternal stringers to skin segment. (See Figure 1-7.)	Subassembly jig
b. Drill and rivet.	
c. Inspect.	
d. Assemble internal frame sections to skin assembly. (See Figure 1-7.)	Subassembly jig
e. Rivet complete (NAA specification LA0101-004).	
f. Inspect and identify.	

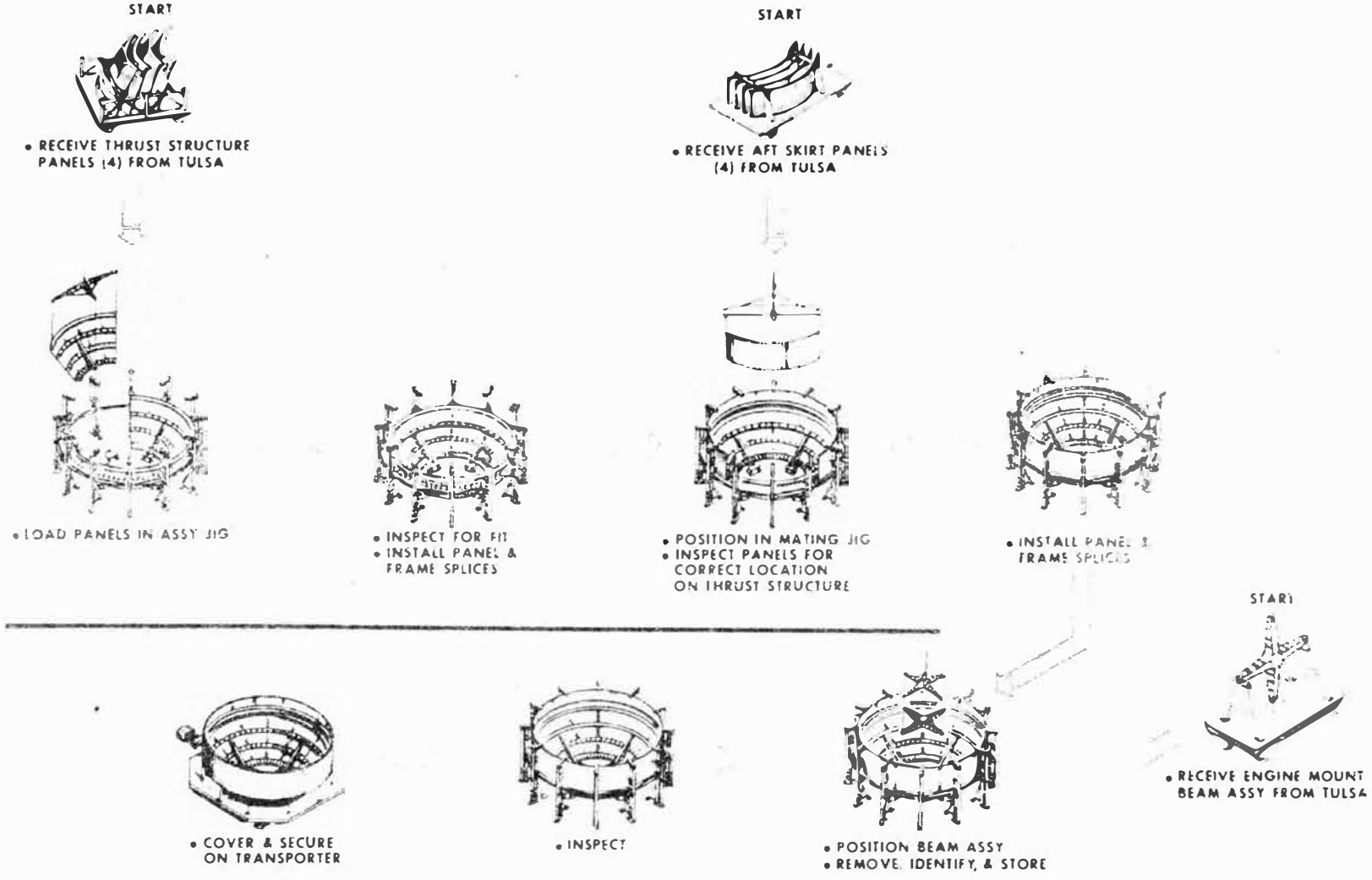
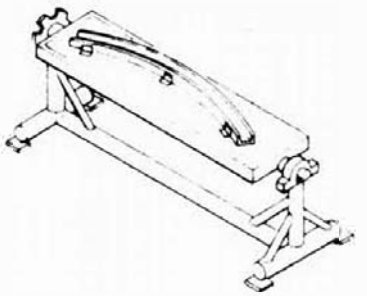
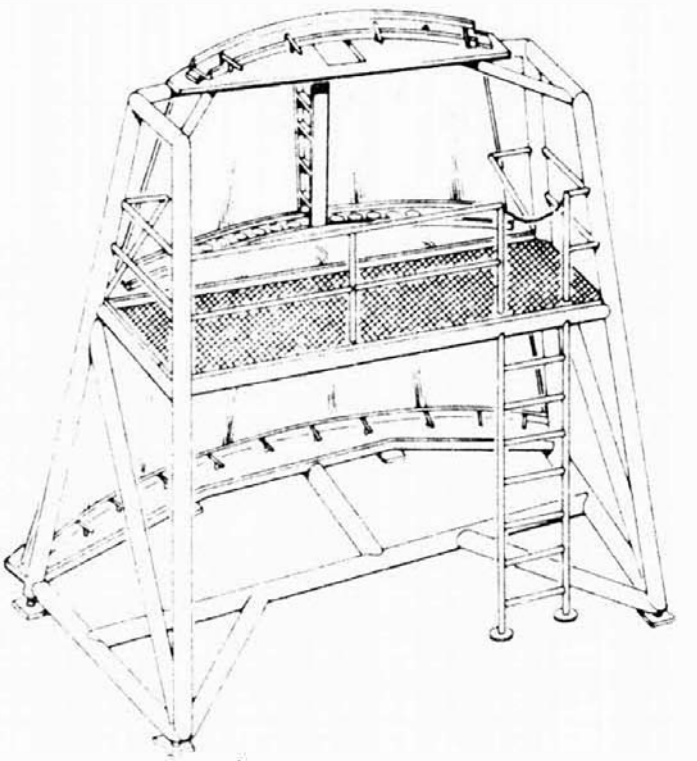


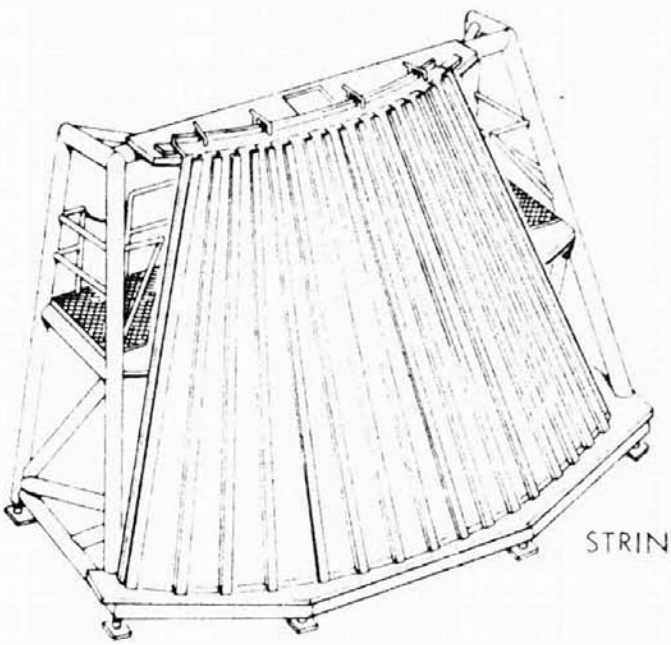
Figure 1-6. Aft Skirt and Thrust Structure Fabrication Sequence



ENGINE MOUNT FRAME ASSEMBLY



FRAME AND SKIN ASSEMBLY



STRINGER AND SKIN FABRICATION

Figure 1-7. Thrust Structure Fabrication

Procedure	Tooling
Aft skirt panels	
a. Install webs and angles in jig.	Subassembly jig
b. Drill and rivet.	
c. Inspect and identify.	Pick-up stand
Cone assembly completion	
a. Install cone panels.	Assembly jig
b. Install splice plates. (See Figure 1-8.)	
c. Drill and rivet (NAA specification LA0101-004).	
d. Inspect and identify.	
Thrust structure completion	
a. Install aft skirt panels in jig. (See Figure 1-8.)	Assembly jig
b. Drill and rivet skirt to forward cone frame.	
c. Splice skirt segments; drill and rivet.	
d. Install center engine beam.	
e. Drill and pin.	
f. Drill attachment holes to mate with interstage structure and intermediate skirt.	
g. Inspect and identify.	

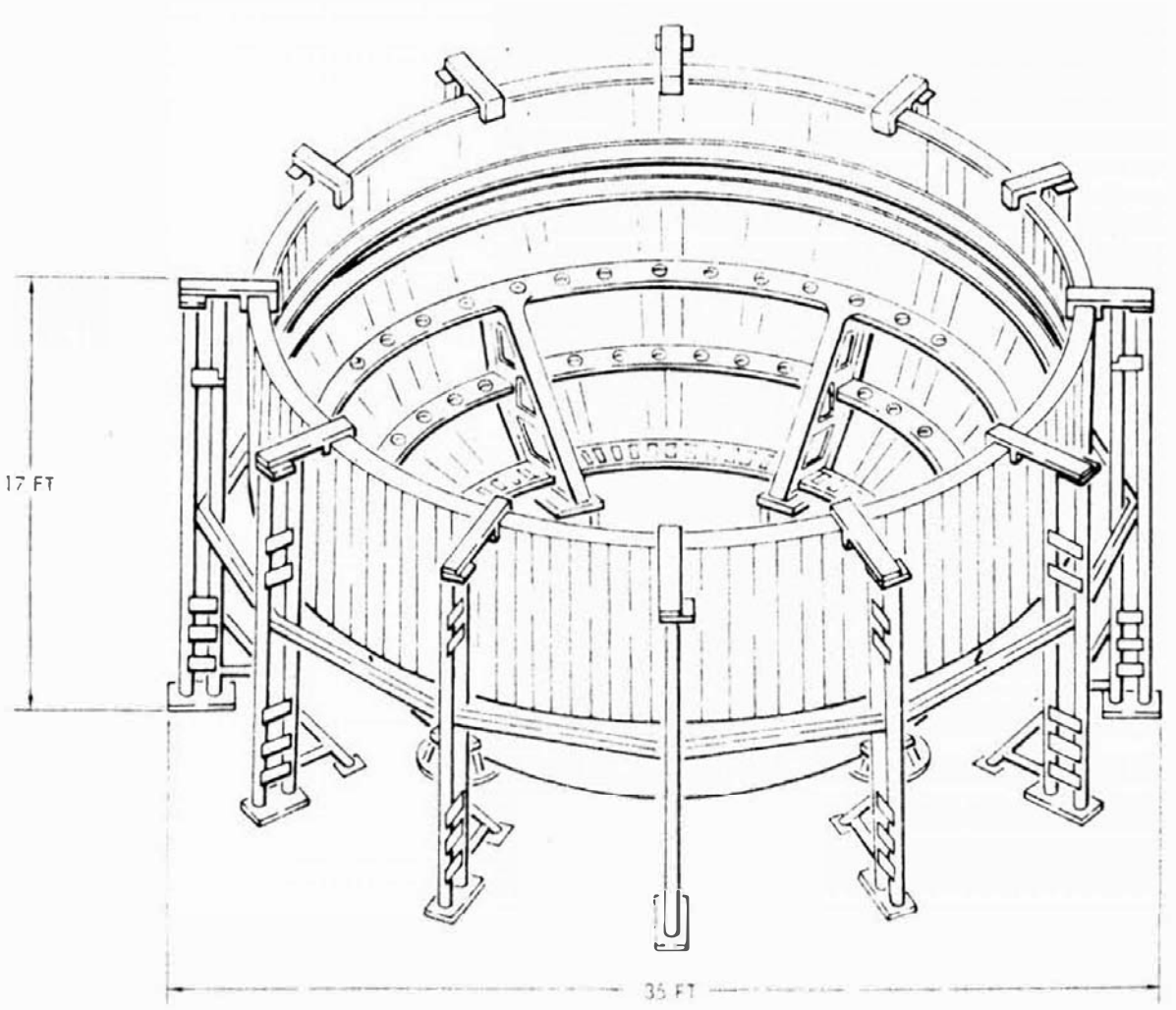


Figure 1-8. Thrust Structure and Aft Skirt in Assembly Fixture

1.1.3.2 Heat Shield

1.1.3.2-1 The thrust structure heat shield assembly will be a conventional structure of honeycomb panels, silicon rubber curtains, mounting webs, and angles that form a station-oriented shield with supporting beams for attachment to the thrust structure and motors.

Procedure	Tooling
Heat shield assembly	
a. Install beams and web assembly in jig.	Assembly jig
b. Drill and rivet attachments (NAA specification LA0101-004).	
c. Inspect.	

1.1.4 BOLTING RING SEGMENTS

1.1.4-1 The bolting ring will consist of 12 externally machined, formed U-frames. These bolting frames will be mechanically fastened to the LOX tank, the LH_2 skin cylinder, the aft skirt, and the adjacent segment.

1.1.5 LH_2 SKIN CYLINDER

1.1.5.1 Panel Assembly

1.1.5.1-1 The skin cylinder assembly will consist of machined-milled panels joined by machine fusion welding (Figure 1-9). Internal frames and splices will be formed of conventional webs and angles riveted together. External insulation will be applied to each panel prior to weld-joining. All weld equipment and operators will be certified in accordance with ABMA-PD-W-45A and ABMA-PD-153. Preproduction tests will be performed in accordance with noted specifications.

Procedure	Tooling
Frame subassembly	
a. Install webs and angles in jig.	Subassembly jig
b. Drill, burr, and rivet.	
c. Inspect and identify.	

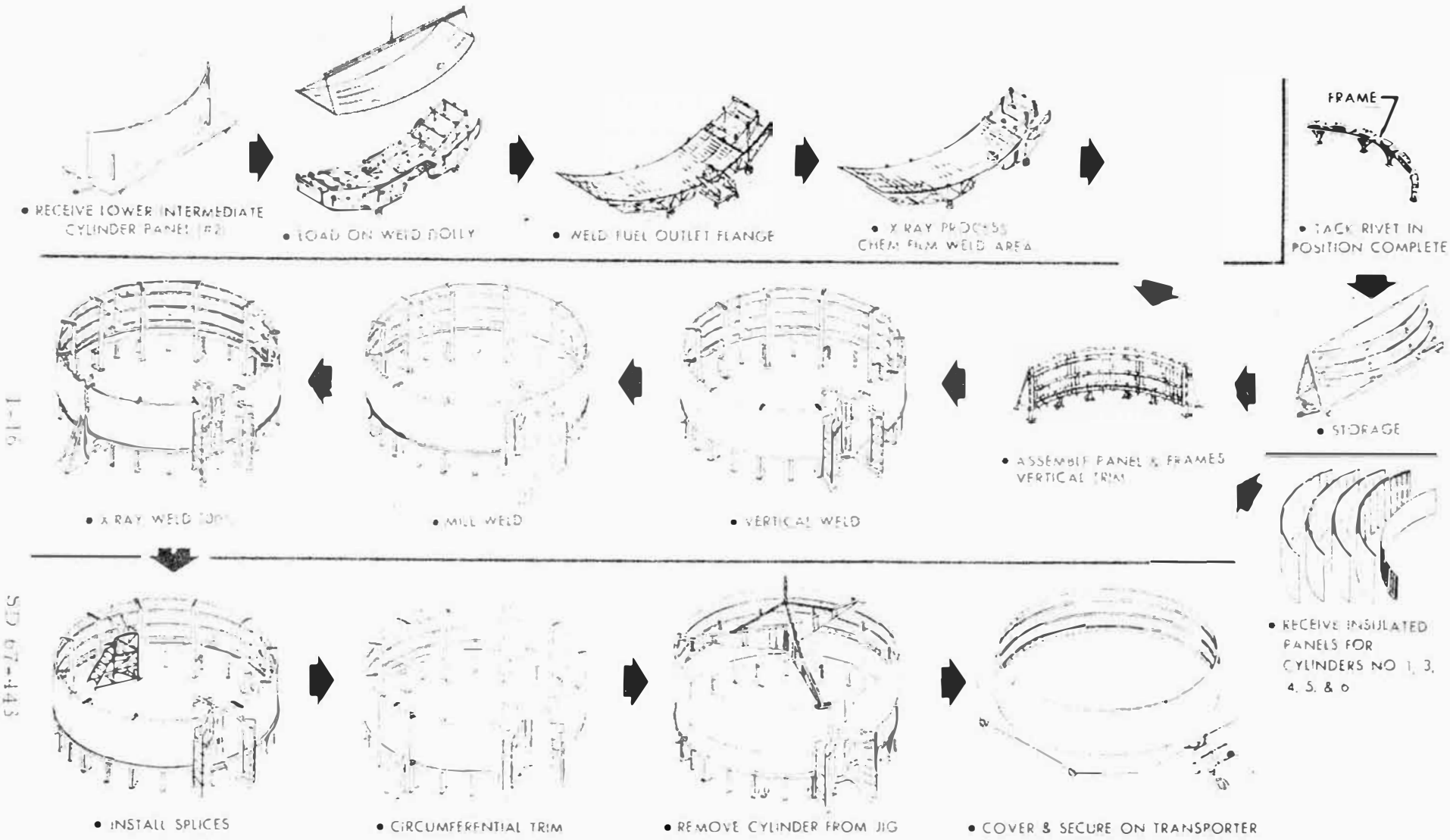


Figure 1-9. LH_2 Cylinder Assembly Sequence

Procedure	Tooling
Panel Assembly	
a. Install premachined skin and frames in jig. (See Figure 1-10.)	Assembly jig
b. Drill and rivet frames to panel-machined ribs (NAA specifications MA0601-001 and MA0601-002).	
c. Inspect per drawing.	
d. Trim skin longitudinally (both edges): allow excess material for weld shrinkage.	Assembly jig (panel and frames)
e. Remove burrs and clean.	
f. Inspect and identify.	

1.1.5.2 Preparation and Insulation of LH_2 Cylinder Panels

1.1.5.2-1 Insulation material will be adhesive-bonded to the external surface of each cylinder panel prior to weld-joining. This insulation will consist of prefabricated panels made of phenolic honeycomb filled with isocyanate foam; the honeycomb will be adhesive-bonded to a laminate Nylon external skin. Insulation test coupons will be tested per MA0605-003 by using special test equipment (STE) model 8FS-5919. Panel insulation will be applied as follows:

Procedure	Tooling
Panel insulation	
a. Receive skin panels from warehouse on transportation dolly.	
b. Position spreader bar 8FH-0033 and sling for hoist pick-up.	
c. Hoist and transport spreader bar and sling into position.	
d. Attach spreader bar and sling to panel for hoist pick-up.	

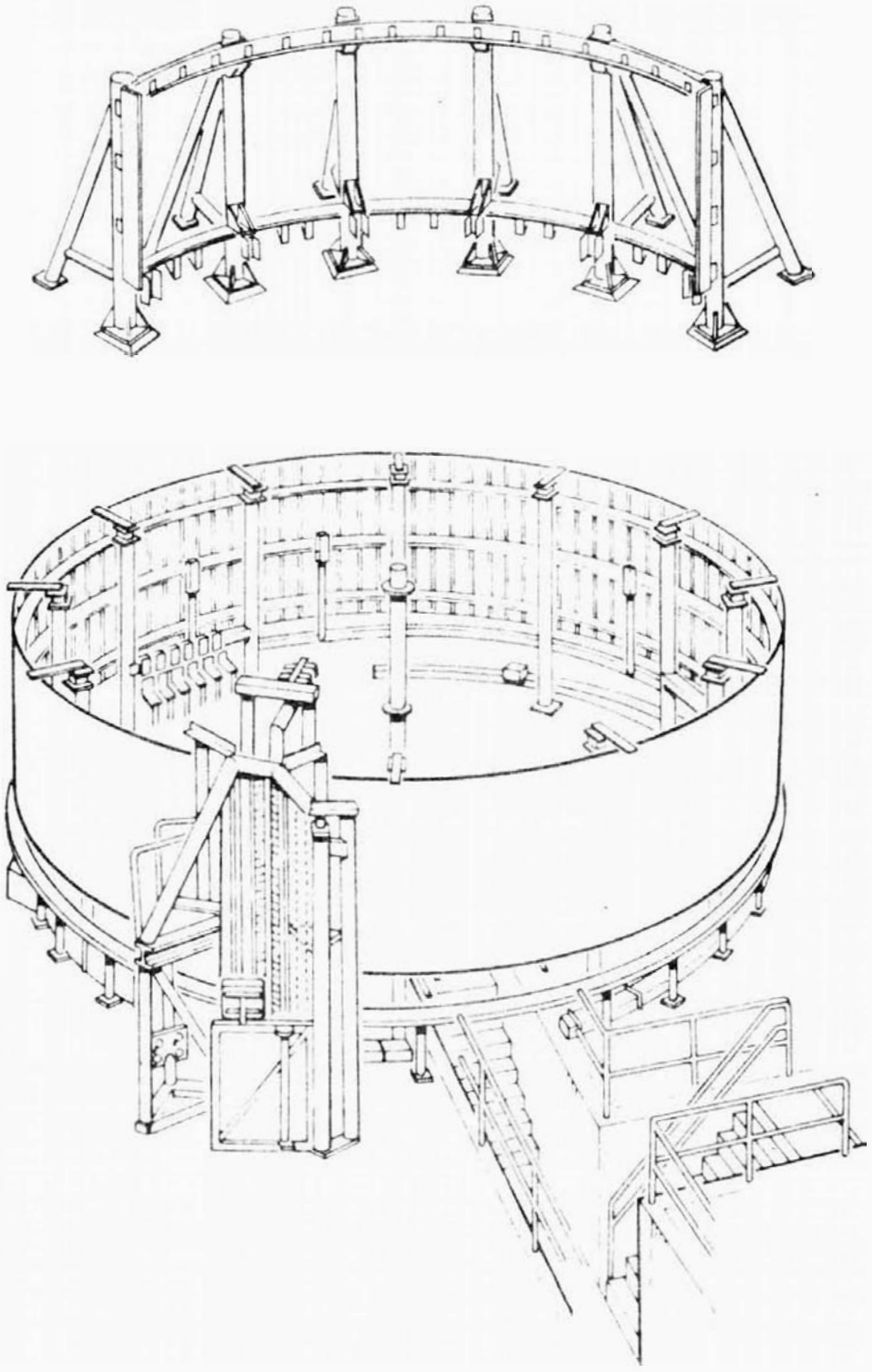


Figure 1-10. Panel Assembly Intermediate Fabrication

Procedure	Tooling
e. Transport and position panel in processing booth on floor. Remove hoist from spreader bar.	
f. Close booth. Alkaline-clean, rinse, etch, and rinse. (Inspect for water breaks.)	
g. Force-dry panel with oil-free air temperature up to 150 F.	
h. Employees are to wear clean white cotton gloves for all handling of cleaned panels.	
i. Hoist and transport panel from cleaning booth; and position panel in paint booth.	Spreader bar 8EH-0033
j. Mask all areas of panel where M-602 or 424 primer is not required.	
k. Spray manually with M-602 or 424 primer.	
l. Air-dry primer 30 minutes between coats to obtain maximum thickness of 0.001 inch, and dry 30 minutes after final coat.	
m. Force-dry M-602 primer with oil-free air at 240±10 F for 30 minutes, at 290±10 F for 120 minutes, and inspect. For 424 primer, force-dry for 60 minutes at 150±10 F.	
n. Secure spreader bar 8EH-0033 to panel.	
o. Hoist panel from primer booth and position on insulation bonding tool T-7200198. Remove 8EH-0033 spreader bar.	

	Procedure	Tooling
p.	Transport dolly and panel to insulation layup room.	
q.	Apply adhesive HT-424 to primer area of LH_2 panel. Inspect.	
r.	Apply vacuum lift 8EH-0049 on insulation, and hoist into position on LH_2 panel. Inspect.	
s.	Apply thermocouple wires, bleeder cloth, and vacuum bag and fairings. Seal bag, and apply vacuum on assembly. Inspect.	
t.	Transport bonding fixture and panel assembly into oven.	
u.	Attach thermocouple wire to recorder, and apply vacuum to assembly. Inspect.	
v.	Cure HT-424 adhesive at 290±10 F for 3 hours. Inspect.	
w.	Remove assembly from oven. and transport to high-bay area.	
x.	Remove vacuum bag and other materials per step s.	
y.	Clean excessive adhesive from assembly, and trim insulation net.	
z.	Hand process and Chem-film outside surface: seal and bag entire outside surface, apply Chem maskant, and dry 5 hours at 150 F.	
aa.	Hoist spreader bar 8EH-0033 and sling into position; attach bar and sling special angle to cylinder panel.	

Procedure	Tooling
bb. Rotate to a vertical position; remove special angle.	
cc. Transport and position panel in the processing booth with 8EH-0033 bar and sling.	
dd. Alkaline-clean and rinse; deoxidize and rinse and dry; conversion coat and rinse and dry; and reidentify. Inspect each operation.	
ee. Remove protective cover and hand-finish covered areas by manual process method, if necessary. Check insulation seal to assure no leaks occur during ultrasonic operation.	
ff. Remove spreader bar 8EH-0033 and sling; remove panel from primer booth; install protective covers, and position on transportation dolly.	
gg. Deliver panel to ultrasonic inspection area.	

1.1.5.3 LH_2 Skin Cylinder Assembly

1.1.5.3-1 LH_2 panels are joined by four vertical welds to fabricate one cylinder. The frames installed previously are then joined by splices across the weld area to give hoop strength to the assembly.

Procedure	Tooling
LH_2 cylinder sections (longitudinal-to-axis weld)	
a. Load and position panels 1 and 2 in weld jig. (See Figure 1-11.)	
b. Vertical-climb weld (NAA specification MA0107-016).	

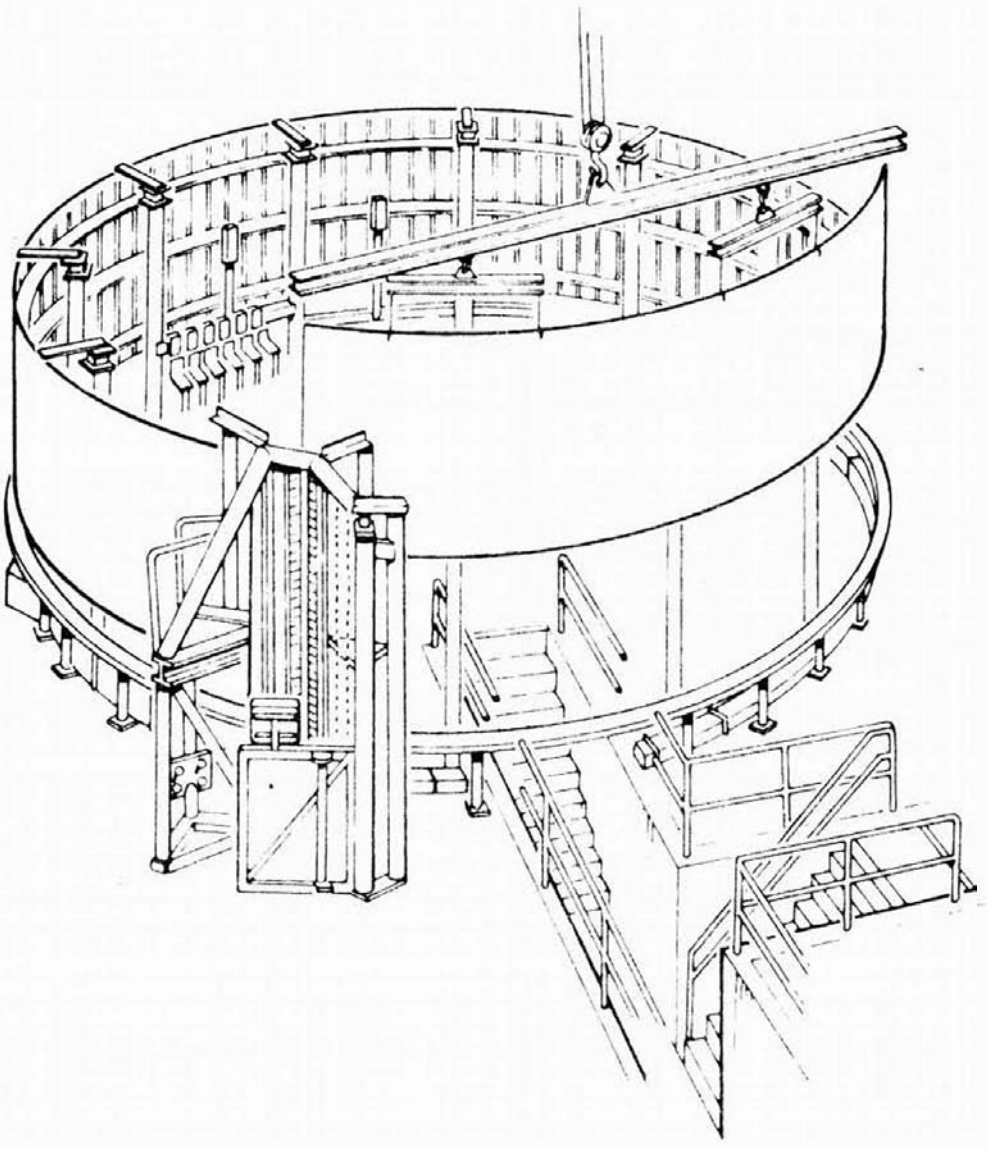


Figure 1-11. Installing LH_2 Quarter Panel in Assembly and Weld Fixture

Procedure	Tooling
c. Visually and radiographically inspect weld while it is in weld tool (MIL-I-6865).	Vertical weld jig
d. Load and position panel 3 in weld jig. (See Figure 1-11.)	Vertical weld jig
e. Vertical-climb weld (NAA specification MA0107-016).	
f. Visually and radiographically inspect weld while it is in weld tool (MIL-I-6865).	
g. Position panel 4 in weld jig; check for trim size.	Vertical weld jig
h. Vertical-climb weld (NAA specification MA0107-016) in two places.	
i. Visually and radiographically inspect.	
j. Install splice segments; drill and rivet (NAA specification LA0101-004).	Vertical weld jig
k. Circumferentially trim cylinder.	
l. Machine the weld ends flush.	
m. Inspect and identify.	
n. Load on transporter. (See Figure 1-12.)	Cylinder transporter 8EH-0146 spreader bar
o. Install protective shroud. (See Figure 1-13.)	

1.1.6 FORWARD BULKHEAD

1.1.6.1 Forward LH_2 Bulkhead Assembly

1.1.6.1-1 This aluminum skin assembly will consist of 12 preformed, Chem-Milled* skins and an access cover. An insulating layer will be applied and adhesive-bonded in place after a hydrostatic test of the welded bulkhead. The access cover will be insulated by the same bonding procedure. All

*Trademark

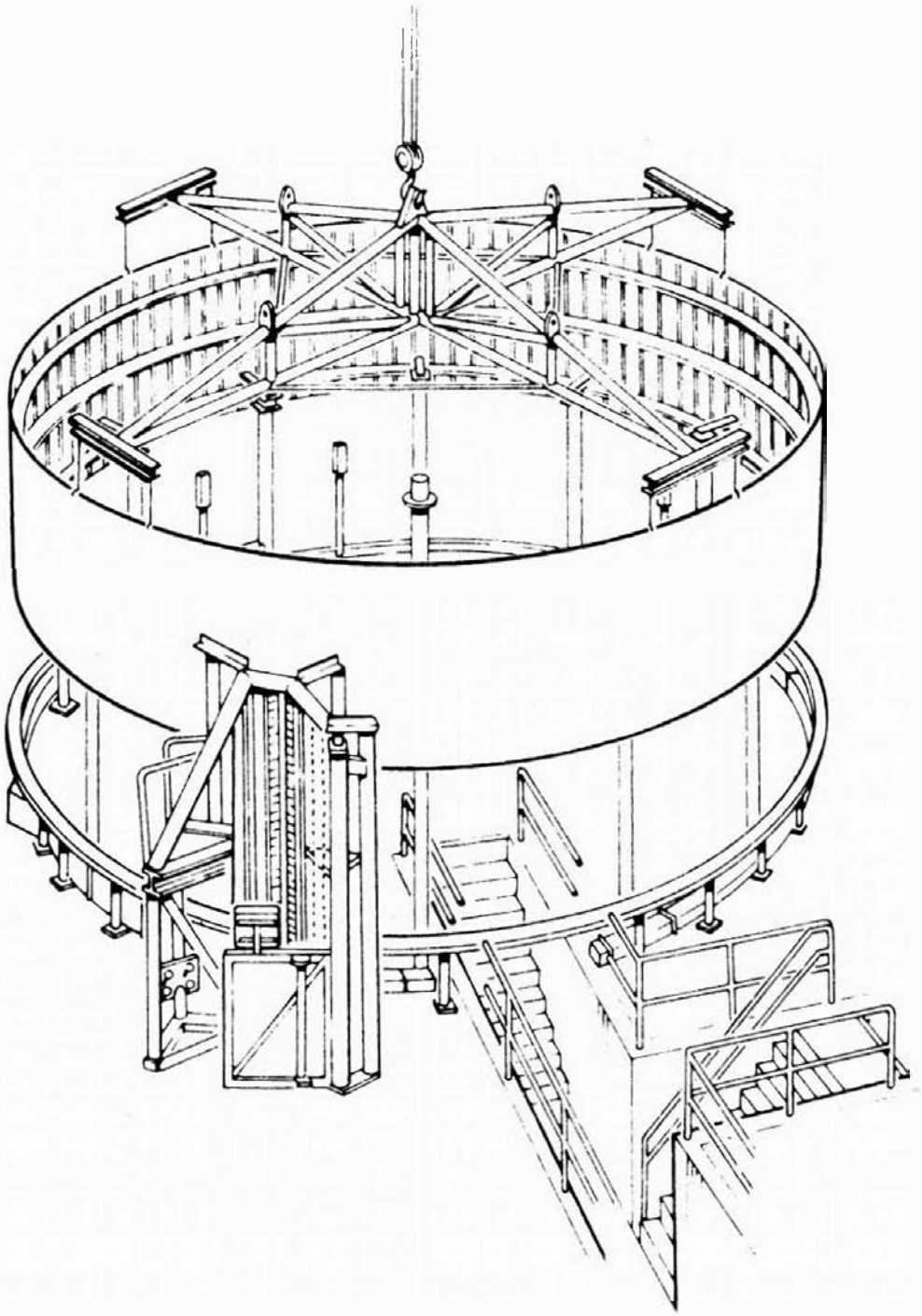


Figure 1-12. Lifting LH2 Cylinder Out of Assembly Fixture

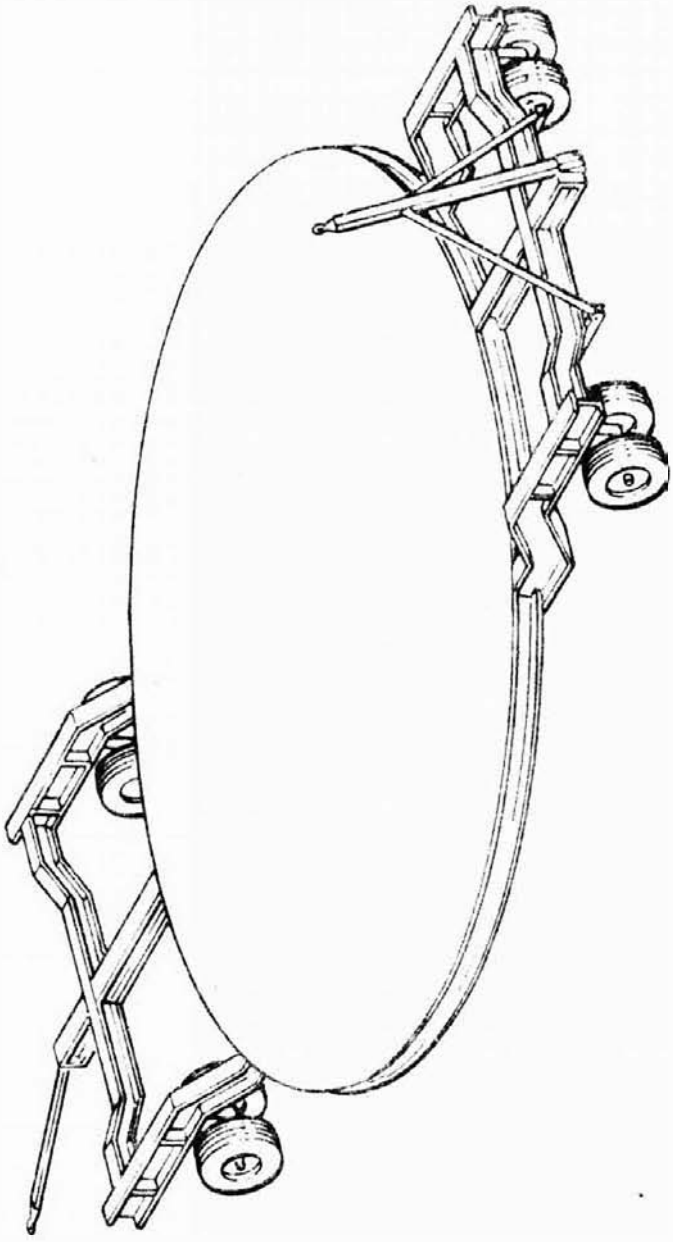


Figure 1-13. Transporter Support Bed

operations and equipment will be certified in accordance with NAA specifications. Preproduction tests will be made in accordance with noted specifications. (See Figure 1-14.) A membrane seal is attached with Narmco 7343 resin. After this application and after the forward skirt is attached, the remainder of the seal is tied to the flange of the forward skirt tee to complete the seal.

	Procedure	Tooling
a.	Position first gore and trim.	Weld jig
b.	Position next gore and trim, clean, and fit to adjacent gore. Inspect. (See Figure 1-15.)	Weld jig
c.	Weld (NAA specification MA0107-016 and 971-D).	Weld jig
d.	Rotate into position, mill, and inspect radiographically (MA0107-016). (See Figure 1-16.)	Weld jig
e.	Repeat steps b, c, and d for gore segments 3 through 9.	Weld jig
f.	Position gore 12 and trim both sides. Set aside. (See Figure 1-17.)	Weld jig
g.	Repeat steps b, c, and d for gores 10 and 11.	Weld jig
h.	Trim opening to fit gore 12, clean and position gore 12.	Weld jig, sling 8EH-0018
i.	Repeat steps c and d for 11th and 12th welds.	Weld jig
j.	Inspect assembly.	
k.	Transfer assembly to dollar weld fixture. (See Figure 1-18.)	Dollar weld fixture T-6200077 Vac-U-lift 8EH-0069

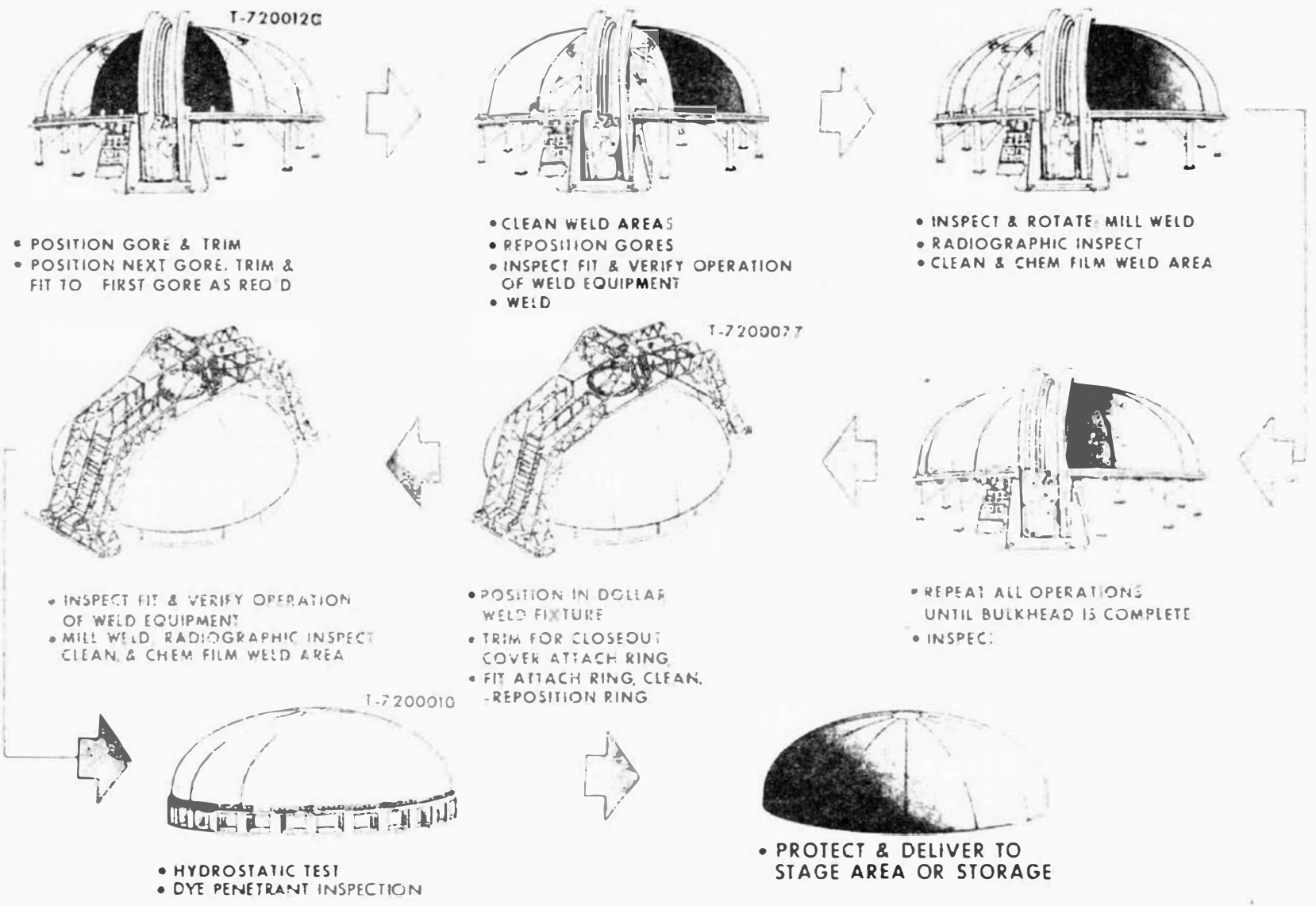


Figure 1-14. Forward LH2 Bulkhead Fabrication Sequence

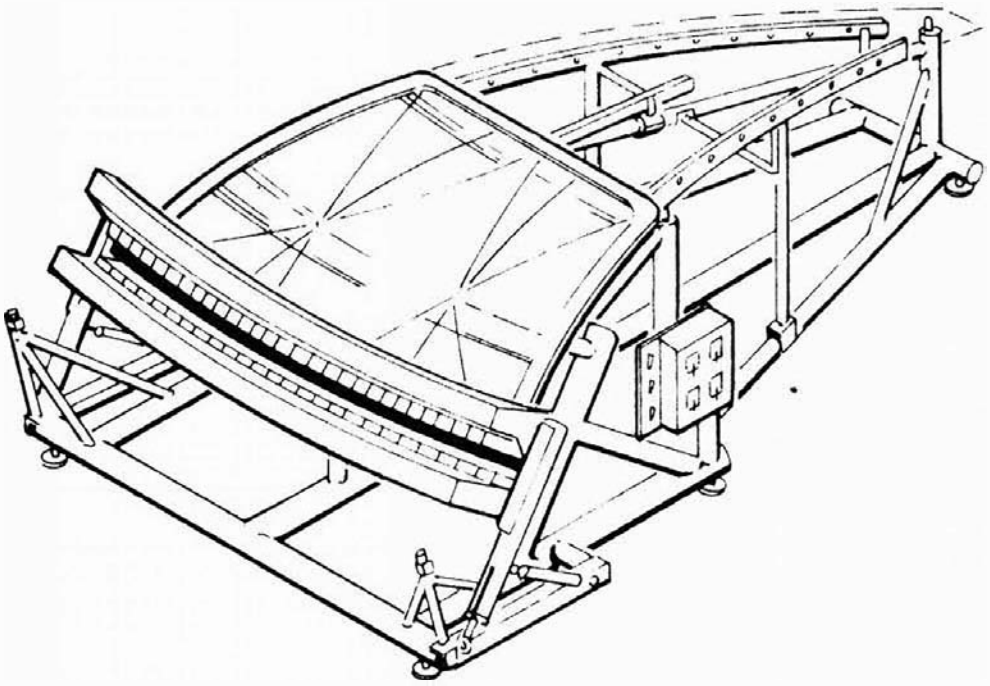


Figure 1-15. Thick-to-Thin Weld Fixture

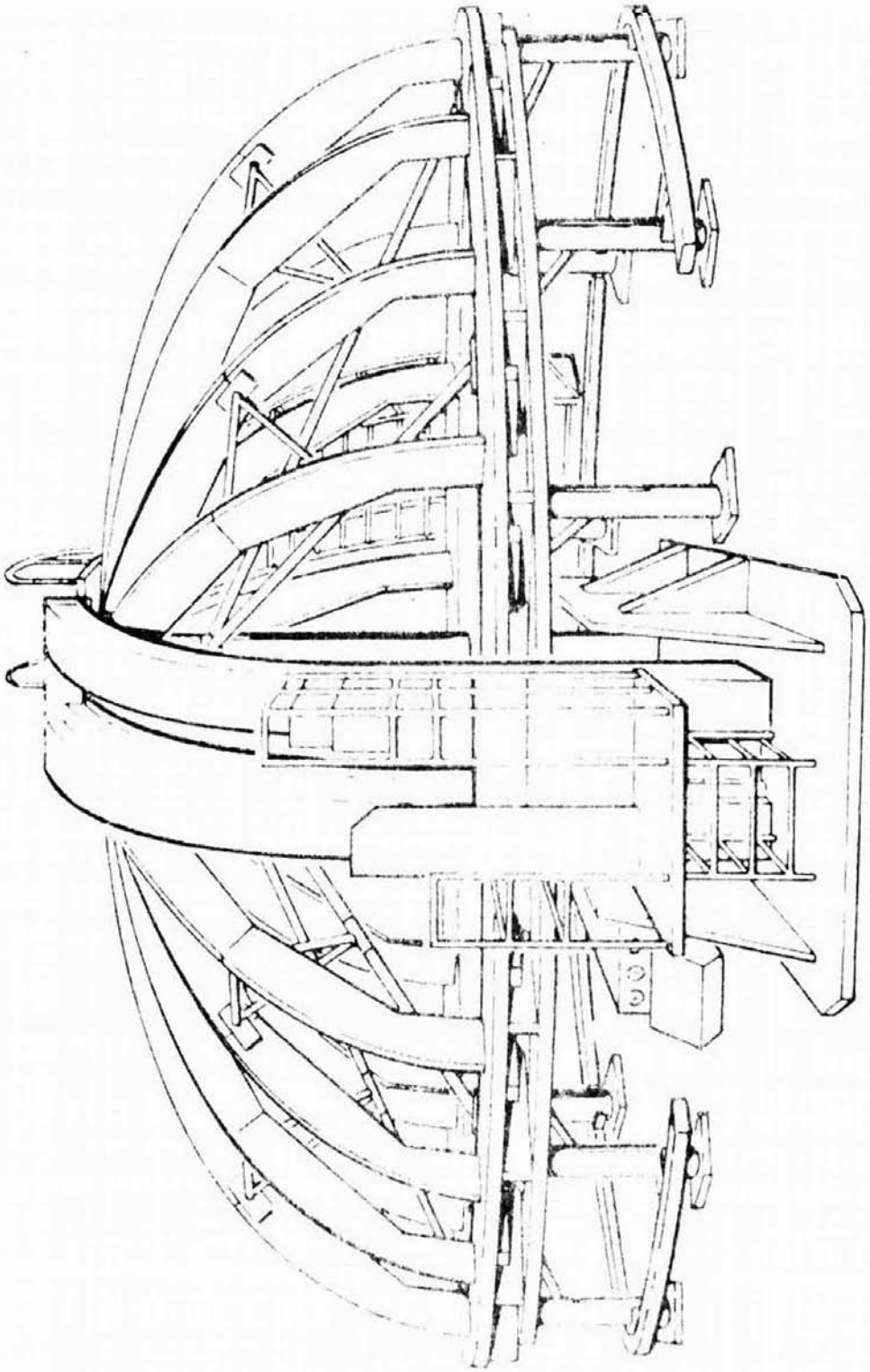


Figure 1-16. Bulkhead Subassembly Fabrication

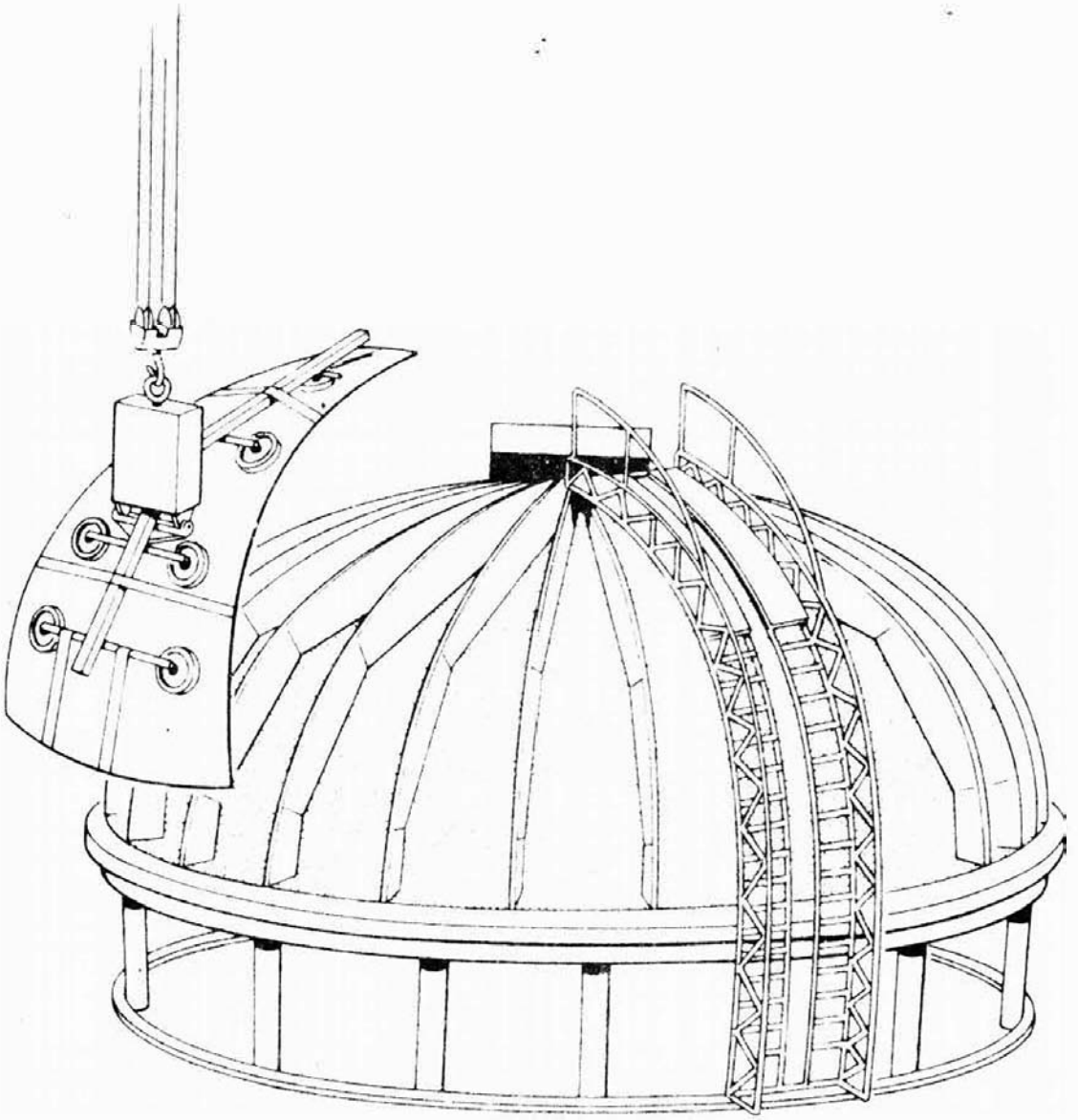


Figure 1-17. Loading Gore Segments Into Welding Fixture

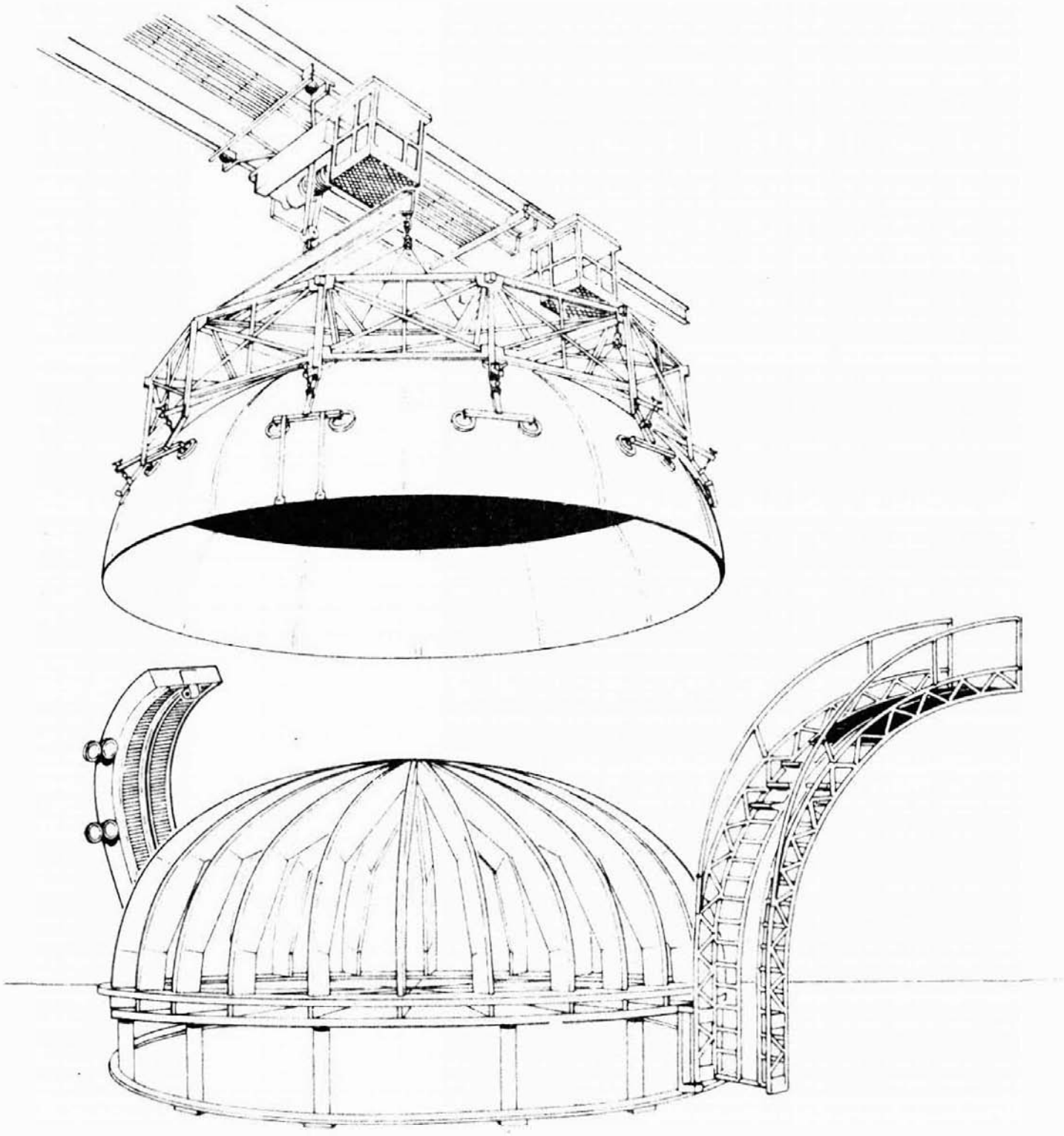


Figure 1-18. Removing Completed Bulkhead Section From Welding Fixture

	Procedure	Tooling
l.	Locate assembly, route opening, and cover attach ring to match; clean fit, and inspect (NAA specification MA0107-016 and 971-D).	Dollar weld fixture
m.	Weld cover attach ring. Mill and inspect radiographically (NAA specification MA0107-016 and 971-D).	Dollar weld fixture
n.	Inspect assembly.	
o.	Deliver to hydrostatic test fixture. (See Figure 1-18.)	Vac-U-lift 8EH-0069
p.	Hydrostatic pressure test bulkhead. (See Process and Test section.)	Hydrostatic test facility
q.	Dye penetrant inspection.	
r.	Clean.	
s.	Apply insulation. (Refer to insulation procedures for LH_2 cylinders.)	
t.	Package and store.	

1.1.6.2 Forward LH_2 Bulkhead Insulation Bonding Sequence

	Procedure	Tooling
a.	Secure LH_2 bulkhead insulation layup and bonding fixture T-7200994 and ring T-7200390 (bonding room No. 2).	
b.	Transport and lower the LH_2 bulkhead onto layup and bond fixture, and inflate to 1-3/8 psi. (See Figure 1-19.)	
c.	Fit insulation on bulkhead assembly, and submit assembly to inspection for fit verification.	
d.	Identify, remove, and store insulation (temporary).	

Figure 1-19. Forward LH2 Bulkhead Installation Sequence

	Procedure	Tooling
e.	Apply mismatch material on bulkhead. Reinstall fitted insulation on bulkhead and cover with bleeder cloth.	
f.	Transport vacuum bag T-7200175 to bulkhead. Secure, seal, and attach vacuum lines. Pull vacuum on assembly to make impression check.	
g.	Disconnect, remove, and store vacuum bag. Store bleeder cloth.	
h.	Submit assembly to inspection for impression check.	
i.	Hoist bulkhead from bond fixture, transport and secure it in turnover fixture, and rotate to dome-down position.	Adapter 8EH-0068, frame 8EH-0146, drops 8EH-0182
j.	Remove ring T-7200390 from processing room to autoclave for temporary storage.	
k.	Remove work platform 8EH-0139 from processing pit, and transport to storage area.	
l.	Obtain bulkhead dome-down adapter from storage, and position in processing room.	Holding fixture 8EH-0052, etching solution retainer
m.	Hoist bulkhead from turnover fixture, and transport to processing room. Secure bulkhead to adapter, and ready it for processing.	Turnover fixture 8EH-0054
n.	Process per specification MA0610-002.	
o.	Remove bulkhead from process booth. Transport and secure bulkhead in turnover fixture.	

	Procedure	Tooling
p.	Rotate bulkhead to a dome-up position, and attach segmented hoisting bars.	Adapter 8EH-0068
q.	Remove bulkhead dome-down adapter 8EH-0052 from processing pit, and transport to storage area.	
r.	Obtain processing pit work platform 8EH-0139 from storage; install over the processing pit.	
s.	Remove ring T-7200390 from temporary storage, and position it on work platform in the processing room.	
t.	Transport LH_2 bulkhead from turnover fixture, and position it on layup jig in processing room No. 2; inflate to 1-3/8 psi.	Adapter 8EH-0068, spreader bar 8EH-0146, Nylon drops 8EH-0182
u.	Position work ladder over bulkhead assembly, and ready the spray equipment.	Work platform 8EH-0064
v.	Prime bulkhead with HT424 prime per specification MA0106-033; layup HT424 adhesive film per specification MA0106-028.	
w.	Install insulation; apply bleeder cloth.	
x.	Install vacuum bag T-7200175; pull vacuum.	
y.	Hoist and transport bulkhead and holding fixture into autoclave.	
z.	Cure adhesive at 350±10 F for 1 hour. Inspect to verify cure.	
aa.	Remove vacuum bag and send to storage.	

Procedure	Tooling
bb. Prepare insulation for bonding Nylon laminate over meridian joints of insulation. Inspect.	
cc. Apply adhesive (Aerobond 430) to faying surface of laminate.	
dd. Install vacuum bag, and apply vacuum.	
ee. Pressurize as required.	
ff. Cure adhesive 45 minutes at 330±10 F.	
gg. Remove and store vacuum bag.	
hh. Inspect Nylon laminate doublers for voids.	
ii. Apply Narmco 7343 adhesive to faying surface of Tediar, and install Tedlar strips.	
jj. Apply bleeder cloth and vacuum bag.	
kk. Apply vacuum, and inspect bag.	
ll. Install autoclave cover, and secure.	
mm. Pressurize as required.	
nn. Cure adhesive 4 hours at 160 F.	
oo. Remove vacuum bag, and store.	
pp. Transport bulkhead and holding fixture to layup area, and leak-check insulation. Inspect.	
qq. Deliver to ultrasonic inspection.	Spreader bar 8EH-0146, adapter 8EH-0068, drops 8EH-0182

Procedure	Tooling
rr. Transport bulkhead to processing booth, seal off insulation, and apply conversion coating. Inspect.	
ss. Identify bulkhead after each operation as required.	
tt. Position bulkhead on transportation dolly, and deliver to vertical tower.	

1.1.7 AFT BULKHEAD

1.1.7-1 The aft bulkhead will be a welded aluminum skin assembly made of 12 performed skins and an access cover attachment fitting. The access cover fitting will be positioned at the center of the diaphragm, then fusion-welded into place. Welding will be accomplished per NAA specification MA0107-016. All weld equipment and operators will be certified in accordance with ABMA-PD-W-45A and ABMA-PD-W-153. Preproduction tests will be performed in accordance with noted specifications. (See Figure 1-20.)

1.1.7-2 Following is the fabrication procedure and tooling for the LOX bulkhead assembly:

Procedure	Tooling
a. Position first gore and trim.	Weld jig
b. Position next gore and trim, clean, and fit to adjacent gore. Inspect.	Weld jig
c. Weld (NAA specification MA0107-016).	
d. Rotate into position, mill, and inspect radiographically (MA0107-016).	Weld jig
e. Repeat steps b, c, and d for gore segments 3 through 9.	Weld jig
f. Position gore 12 and trim both sides. Set aside.	Weld jig
g. Repeat steps b, c, and d for gores 10 and 11.	Weld jig

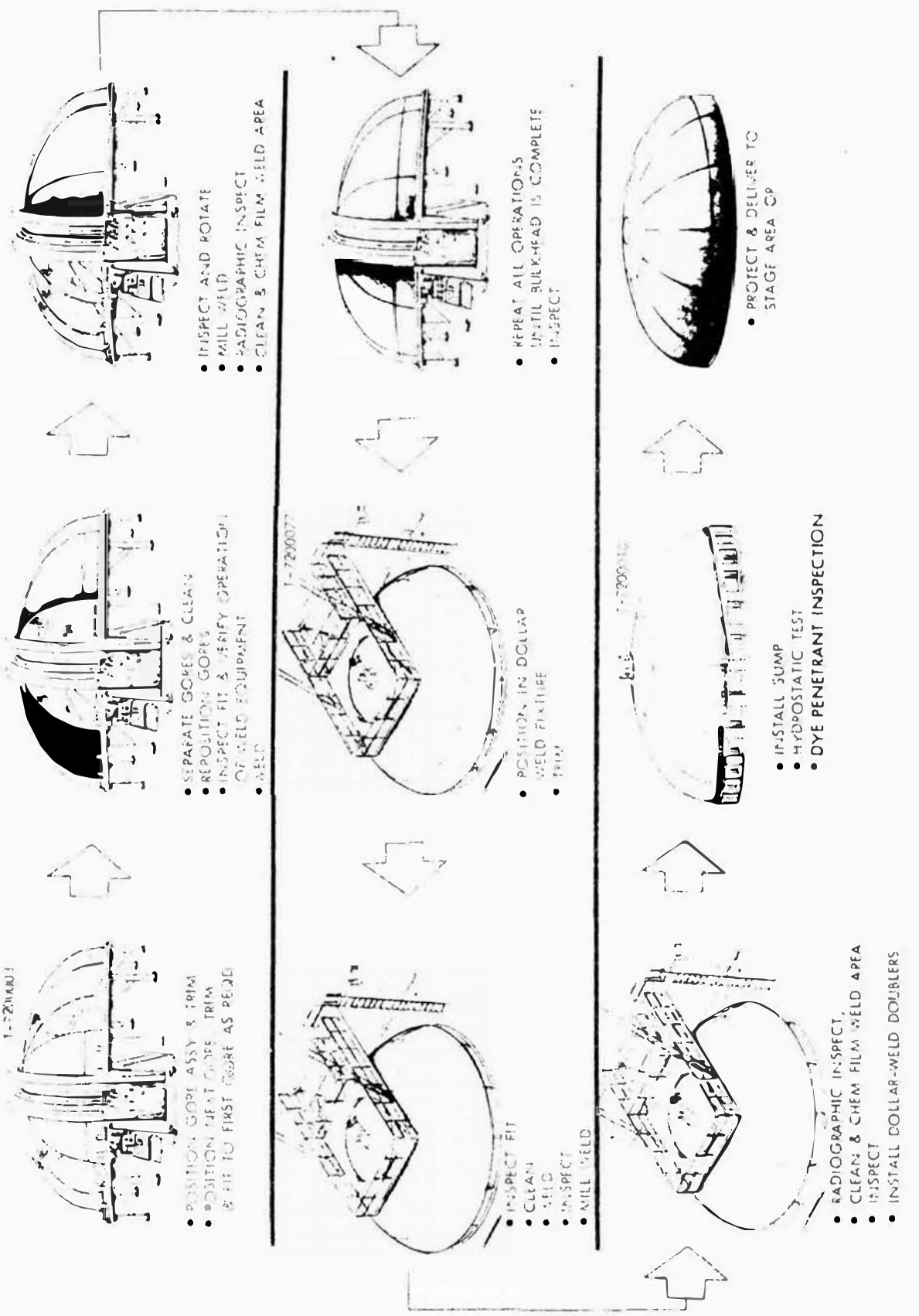


Figure 1-20. Aft LOX Bulkhead Fabrication Sequence

	Procedure	Tooling
h.	Trim opening to fit gore 12; clean and position gore 12.	Weld jig, 8EH-0018 sling
i.	Repeat steps c and d for 11th and 12th welds.	Weld jig
j.	Inspect assembly	
k.	Transfer assembly to dollar weld fixture. (See Figure 1-18.)	Dollar weld fixture T-7200077 Vac-U-lift 8EH-0069
l.	Locate assembly; rout opening and sump attachment ring to match. Clean, fit, and inspect (NAA specification MA0107-016 and 971-D).	Dollar weld fixture
m.	Weld sump attachment ring. Mill and inspect radiographically (NAA specification MA0107-016 and 971-D).	Dollar weld fixture
n.	Inspect assembly.	
o.	Deliver to hydrostatic test fixture. (See Figure 1-18.)	Vac-U-lift 8EH-0069

1.1.8 COMMON BULKHEAD

1.1.8-1 The common bulkhead will consist of upper and lower preformed, welded diaphragms and a preassembled honeycomb core. After the appropriate adhesives have been applied, the bulkhead will be bond-cured (per specification) to complete the assembly. All welding equipment and operators will be certified in accordance with existing NAA specifications. Preproduction tests will be made in accordance with noted specifications. (See Figures 1-21 and 1-22.)

1.1.8.1 Aft Facing Sheet

1.1.8.1-1 Each of the 12 aft skin gore segments that form the aft facing sheet will consist of a high-energy formed and machined panel butt-welded to a preformed gore panel. The following operational sequence is accomplished for the aft common bulkhead and aft LOX bulkhead subassemblies:

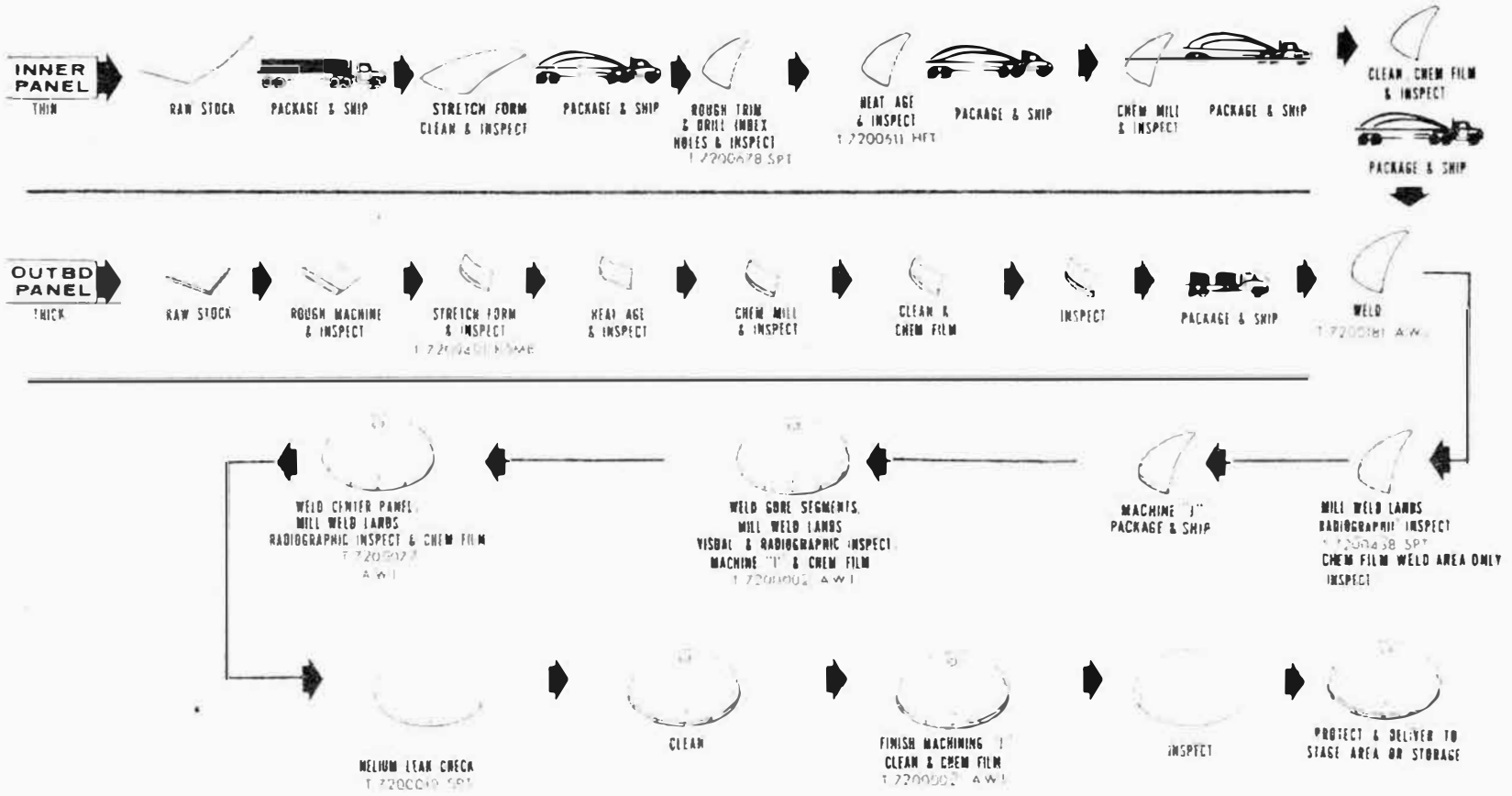


Figure 1-21. Forward Common Bulkhead Fabrication Sequence

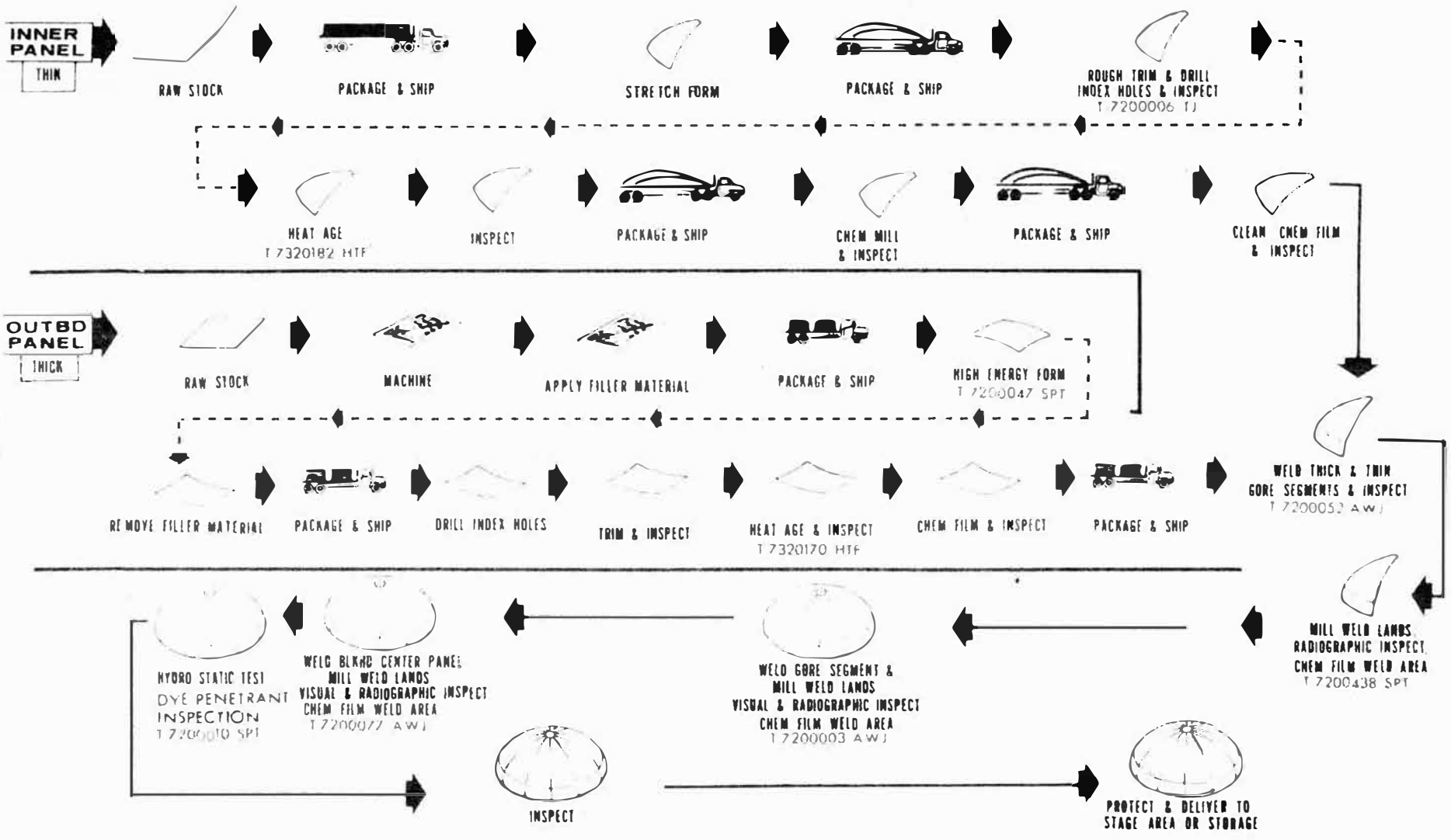


Figure 1-22. Aft Common Bulkhead Fabrication Sequence

Procedure	Tooling
a. Check operational plaque on assembly weld jig (AWJ) T-7200052 for aft facing sheet and aft LOX bulkhead.	
b. Position thin panel for trim; apply vacuum chuck; make trim.	
c. After trim, move thin panel back without removing from jig.	
d. Position thick panel for trim; make trim.	
e. Preweld-clean in accordance with weld schedule 971-D.	
f. Reposition panels; set up for weld.	
g. Verify weld machine operation.	
h. Inspection O.K. to weld; weld in accordance with NAA specification MA0107-016 and 971-D; retain clamping pressure until part has cooled.	
i. Inspection O.K. to remove from AWJ. Transfer to T-7200438 holding fixture.	
j. Mill weld reinforcement per drawing; inspect radiographically.	
k. Chem-film weld land (NAA specification MA0109-003).	
l. Apply part number and serial number; electro-etch.	
m. Submit assembly and FAIR ticket to inspection.	
n. Deliver assembly to bulkhead AWJ.	

1.1.8.2 Forward Facing Sheet

1.1.8.2-1 The common bulkhead forward facing sheet panel assembly will consist of 12 gore skin panels welded to a machined J-section. Each panel is stretch-formed from a single aluminum sheet. The following operational sequence is accomplished for the forward facing sheet gore assemblies:

Procedure	Tooling
a. Position J-section for trim, T-7200181 (Figure 1-15).	
b. Make trim.	
c. Remove J-section for preweld clean.	
d. Locate thin section for trim; apply vacuum chuck; make trim.	
e. Preweld-clean thin section and J-section in AWJ in accordance with cleaning procedure 971-D.	
f. Reposition J-section and thin section AWJ.	
g. Verify weld machine operation.	
h. Inspection O.K. to weld; weld in accordance with NAA specification MA0107-016 and 971-D; retain clamping pressure until part has cooled.	
i. Inspection O.K. to remove from AWJ.	
j. Mill weld as required.	
k. Radiographically inspect (T-7200438).	
l. Chem-film weld land area (manually).	
m. Apply part number and serial number; electro-etch.	
n. Submit assembly and FAIR ticket to inspection.	

Procedure	Tooling
o. Deliver assembly to bulkhead AWJ (T-7200002).	

1.1.8.3 Forward and Aft Facing Sheet Assemblies

1.1.8.3-1 The forward and aft skin panel assemblies will both be fabricated in the same manner. The preformed gore skin panels will be automatically butt-weld-joined to form each diaphragm. The assembly will then be hydrostatically pressure-tested.

Procedure	Tooling
a. Locate segments in fixture.	Bulkhead weld fixture
b. Trim both sides of segments 1 and 2 (Figure 1-16).	
c. Clean for weld (NAA specification MA0107-016).	
d. Inspect.	
e. Locate panels 1 and 2 in bulkhead weld fixture. (See Figure 1-16.)	Weld fixture
f. Machine weld-join panels.	
g. Inspect weld both visually and radiographically while it is in weld fixture.	Weld fixture
h. Rotate tool; index for next weld.	Weld fixture
i. Repeat loading of panels; perform steps e through h for each panel until all but the last panel have been positioned.	Weld fixture
j. Trim excess material to maintain diametrical size.	Weld fixture
k. Position last panel, and repeat steps c, d, f, and g.	Weld fixture

	Procedure	Tooling
l.	Circumferentially trim bulkhead to accommodate center dome.	Dollar fixture
m.	Clean (NAA specification MA0110-011).	
n.	Inspect per drawing.	
o.	Circumferentially trim center dome.	
p.	Clean (NAA specification MA0110-011).	
q.	Inspect per drawing.	
r.	Position center dome for welding.	Weld fixture
s.	Machine-weld center dome to bulkhead (NAA specification MA0107-016).	Weld fixture
t.	Inspect weld visually and radiographically while it is in weld fixture.	Weld fixture
u.	Machine welds per drawing.	
v.	Deliver to hydrostatic test facility.	

1.1.8.4 Honeycomb Core Assembly

1.1.8.4-1 The common bulkhead honeycomb core will consist of preassembled segments and one round, preassembled center segment. Segments will be assembled and prefitted in the core bonding fixture prior to bonding.

	Procedure	Tooling
a.	Prefit honeycomb core detail pieces.	Core assembly jig (three required)
b.	Detail edges, and install details.	
c.	Install thermocouples in glue lines as required.	
d.	Cover entire surface of core with bleeder cloth.	

Procedure	Tooling
e. Lay vacuum bag over entire surface.	
f. Install vacuum line	
g. Seal vacuum bag, and draw a vacuum.	Vacuum pump with automatic control
h. Cure.	
i. Cool to 150 F before releasing vacuum.	
j. Repeat operations to complete ship set.	
k. Assemble and trim complete as a gore.	Trim jig
l. Identify, wrap, and store.	

1.1.8.5 Common Bulkhead Assembly

1.1.8.5-1 After the forward and aft facing sheets have been adhesive-primed and cured, they will be bonded to the honeycomb core. The core will be bonded to the aft facing sheet; the forward sheet will be bonded to the core assembly. (See Figure 1-23.)

Procedure	Tooling
a. Position and rig aft facing sheet on bond fixture. (See Figure 1-24.)	Bond fixture T-7200004 or T-720094
b. Inflate bulkhead from 0.5 to 2 psi of pressure.	Inflation apron
1. Install machine fixture with dial indicators mounted and set to bulkhead mold line.	T-7200415
2. Trace and record aft bulkhead for contour dimensions.	
3. Remove machine fixture.	T-7200415

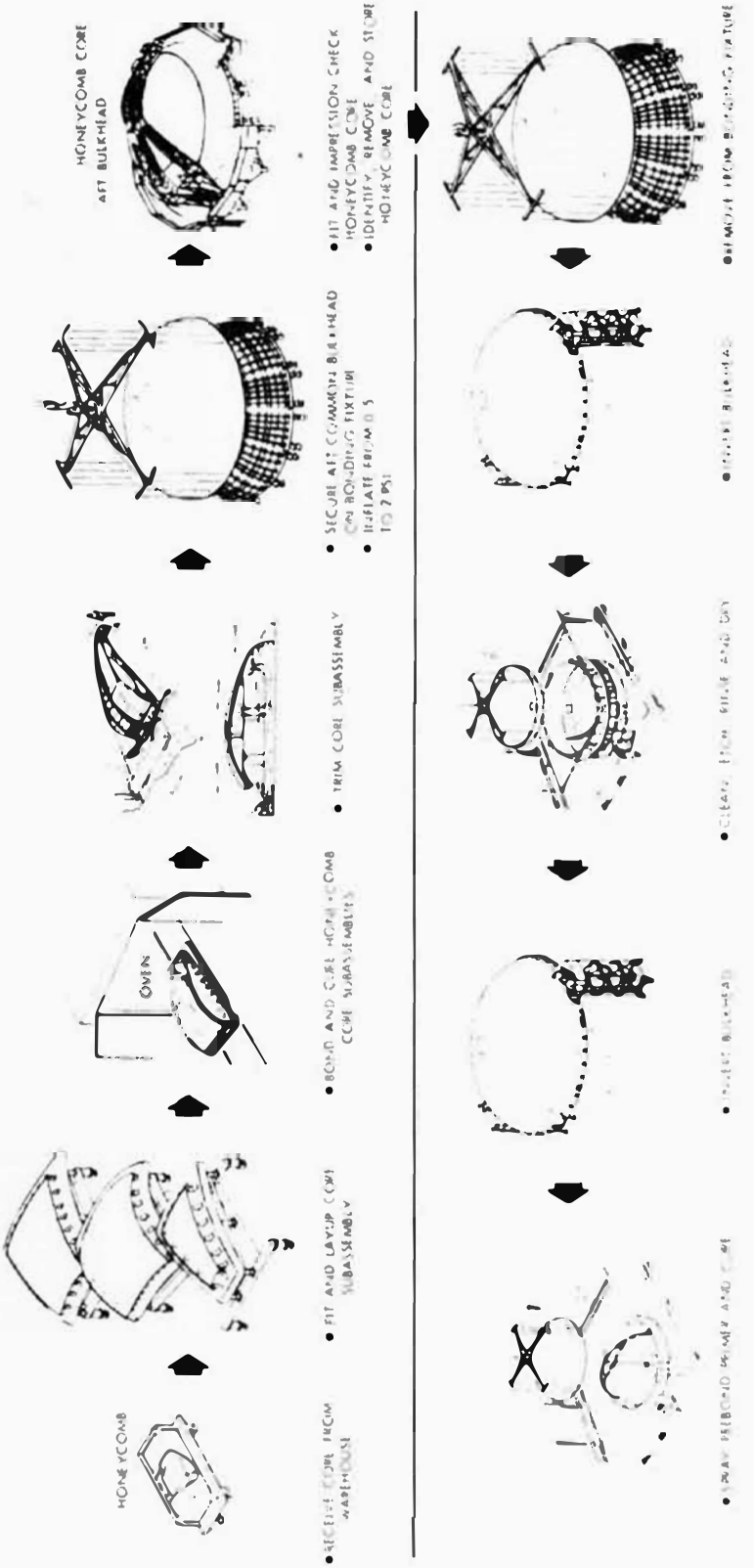


Figure 1-23. Common Bulkhead Bonding Sequence (Sheet 1 of 2)

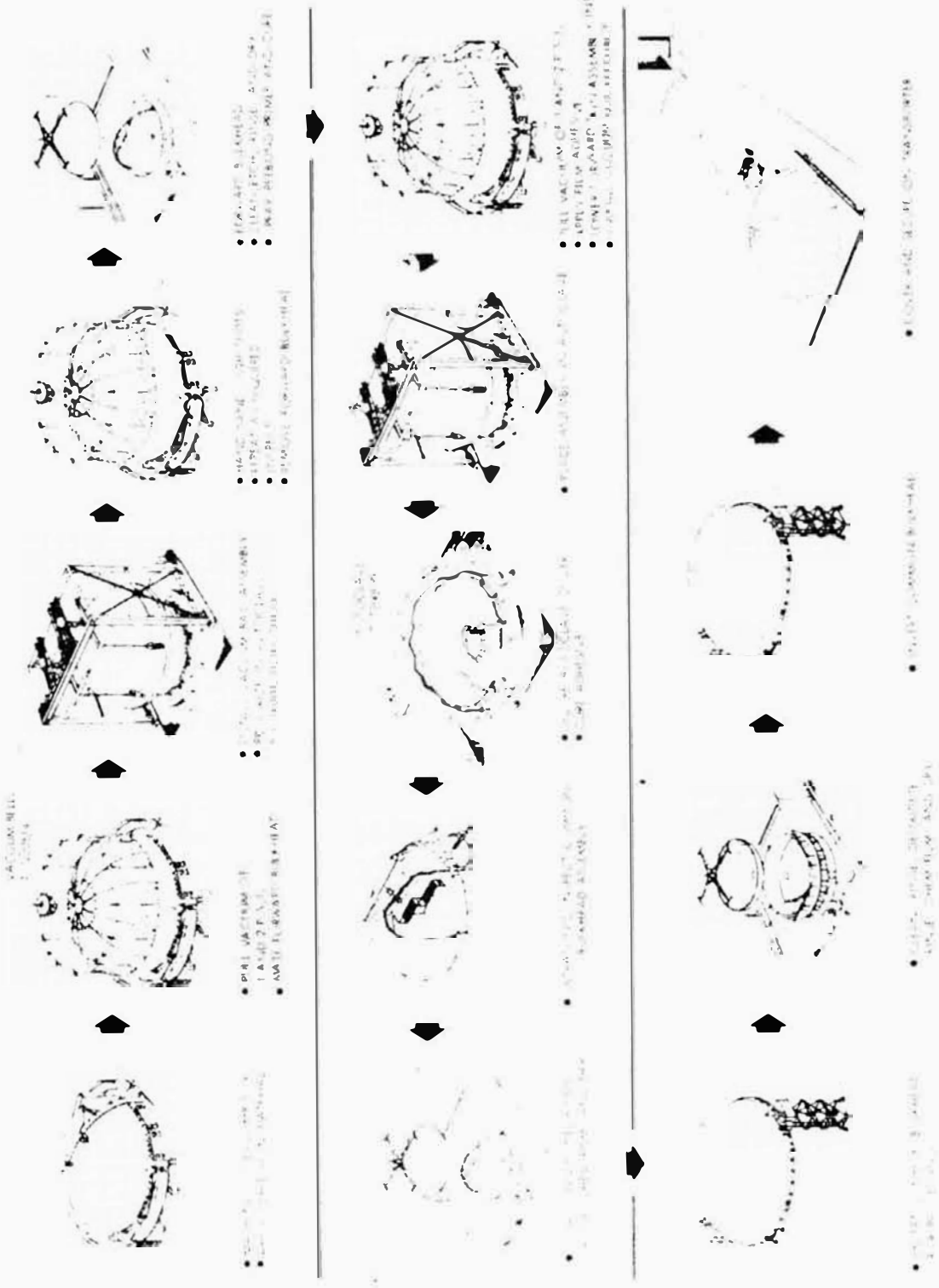


Figure 1-23. Common Bulkhead Bonding Sequence (Sheet 2 of 2)

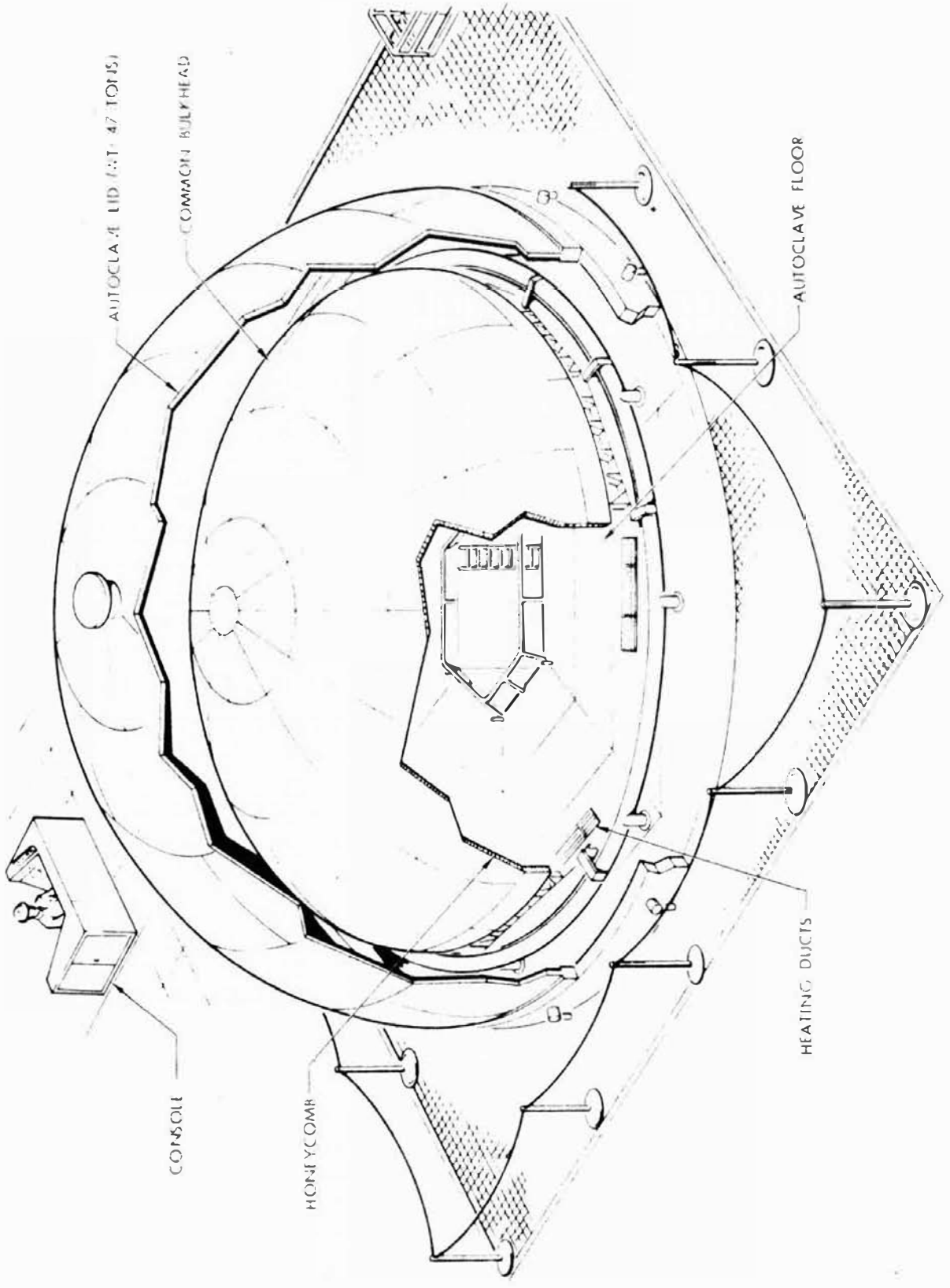


Figure 1-24. Autoclave Bonding Fixture

	Procedure	Tooling
c.	Position honeycomb core sub-assemblies on aft facing sheet for prebond fitup.	
d.	Remove and store honeycomb subassemblies.	
e.	Apply Vinyl impression check material to outer surface of the aft facing sheet.	
f.	Reposition honeycomb core sub-assemblies. Cover surface of core with bleeder material, install vacuum bag, and draw vacuum and transport to autoclave for run of impression cycle.	Gantry 8EH-0126 Spreader bar 8EH-0146 and sling Vacuum bag T-7200175
g.	Install autoclave cover; lock, seal and pressurize, and heat to prescribed temperature; cool down, remove from autoclave, and transfer to bond room.	Autoclave bond fixture T-7200099
h.	Remove vacuum bag and bleeder cloth; remove and store honeycomb subassemblies; remove and check impressions.	
i.	Remove aft facing sheet from tool; clean, prime cure bond surface, and return to bond room.	Spreader bar 8EH-0146, Turnover fixture 8EH-0054
j.	Apply film adhesive to outer surface of aft facing sheet, and position honeycomb subassemblies in their correct relationship.	
k.	Place foam adhesive strip between segment edges.	
l.	Install thermocouples in glue lines as required.	
m.	Cover entire surface of core with bleeder material; install vacuum bag and lines.	Vacuum bag T-7200175
n.	Draw vacuum.	

Procedure	Tooling
o. Transport to autoclave, install cover, and lock and pressurize.	Gantry 8EH-0126 Spreader bar 8EH-0146 and sling
p. Cure at prescribed temperature.	
q. Cool to 150 F; release pressure and remove cover.	
r. Transport to bond room; remove vacuum bag and bleeder cloth; rig bulkhead. Inspect. Position bulkhead in T-7200390 tool; trace and record forward bulkhead for contour dimensions.	
s. Machine sand core facing to contour utilizing bulkhead tracing data.	T-7200415
t. Fit upper facing sheet to surface of core.	Vacuum bell T-7200514
1. Apply Vinyl impression check material; position forward bulkhead on assembly, draw vacuum, and transport to autoclave for impression cycle.	Vacuum bell T-7200514 Gantry 8EH-0126
2. Install autoclave cover; lock, seal, pressurize, and heat to prescribed temperature; cool down; remove from autoclave and transfer to bond room. (See Figure 1-25.)	Autoclave bond fixture T-7200099
u. Inspect (final prefit). NAA specification LQ0401-001.	
v. Remove upper facing sheet, and transport to processing room; clean, prime, and cure bond primer.	

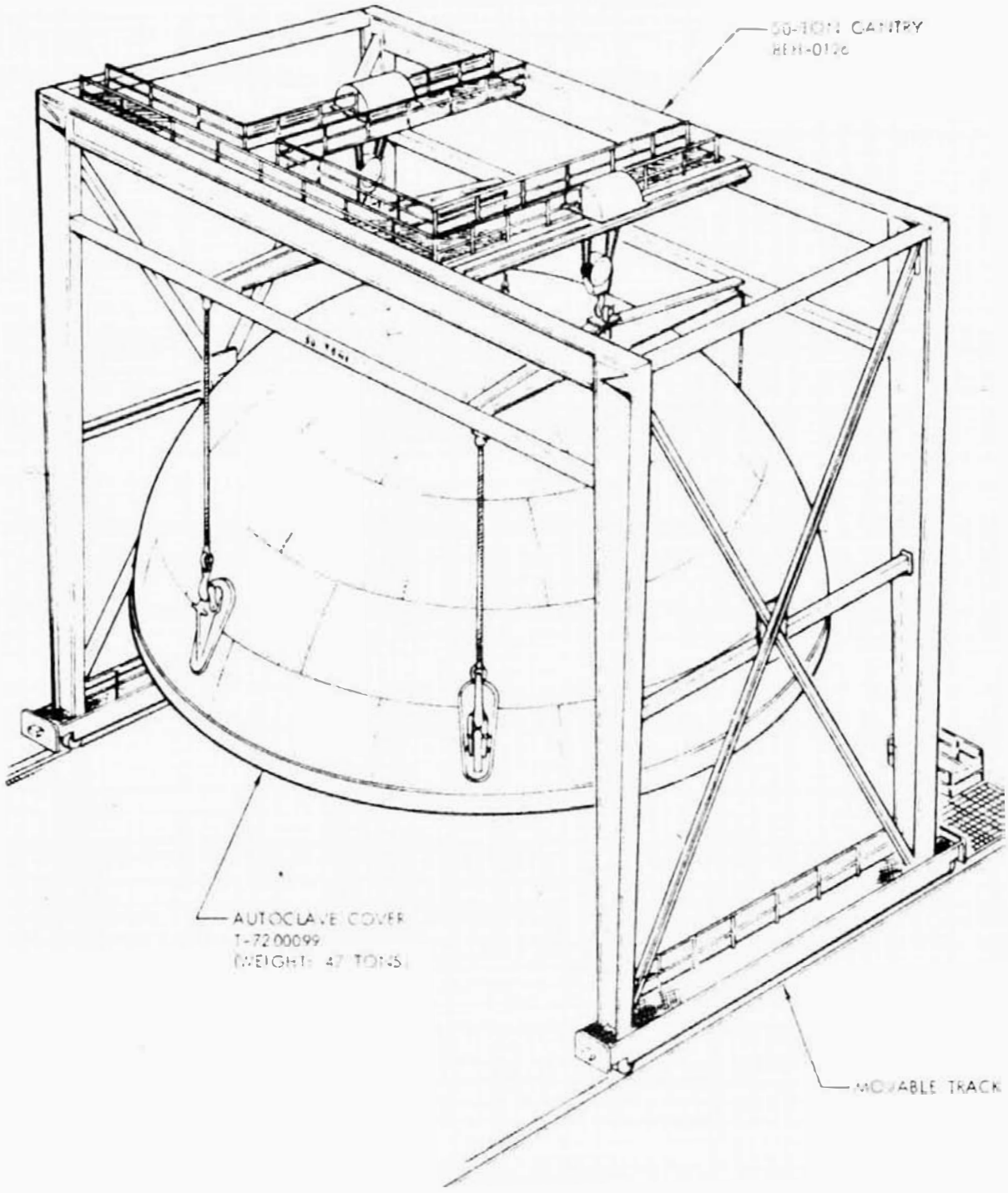


Figure 1-25. Fifty-Ton Autoclave Gantry Crane

Procedure	Tooling
w. Vacuum (as required) core surface to remove dust or other foreign matter.	
x. Apply adhesive film to inner surface of forward facing sheet, and install forward facing sheet (use extreme care not to damage cell walls or permit movement of the adhesive).	
y. Seal bulkhead, and pull full vacuum.	
z. Transport unit to autoclave, install cover, and lock and pressurize.	
aa. Cure at prescribed temperature.	
bb. Cool to 150 F, release pressure, and remove autoclave cover.	
cc. Inspect (NAA specification LQ-0401-001).	
dd. Flow test gore sections using STE console 8FS-5915 per requirements of MA0201-1837.	
ee. Cover and store unit.	

1.2 VEHICLE AIRBORNE ELECTRONIC/ELECTRICAL AND RF EQUIPMENT

1.2-1 The vehicle airborne electronic/electrical and RF (to include telemetry) equipment for the Saturn S-II stage will be composed of electrical, electronic, electromechanical, and RF assemblies of both NAA-procured and NAA-fabricated items at the component module assembly, subassembly, and subsystem level.

1.2.1 PROCURED ITEMS

1.2.1-1 Quality and Reliability Assurance (Q&RA) will assure the mechanical and electronic excellence of procured items prior to the acceptance for use in the Saturn S-II stage as required by NASA contract and Q&RA document. In the case of modules and subassemblies, S&ID Source Inspection will perform a physical and functional test of all packages utilizing a NAA procurement specification prior to shipment from the supplier. Upon receiving assemblies at NAA, Receiving Inspection will check parts for identity, damage,

and proper quantity and subsequently will route them (with receiving inspection documentation) to the warehouse. Upon deletion from the warehouse, the part either will undergo modifications, becoming a S&ID-identified part, or will be routed directly to the functional test area. If reidentified, the part is physically inspected and readied for a functional test at NAA.

1.2.2 NAA-MANUFACTURED ITEMS

1.2.2-1 Saturn S-II stage assemblies, subassemblies, and subsystems will be fabricated and/or assembled in designated assembly areas of NAA in accordance with specific engineering drawing and specification requirements. Emphasis will be placed on quality of workmanship and material handling. Fabrication procedures will be approved and controlled as outlined in NASA contract and related contractual Quality Reliability and Assurance documents for S-II-16 through S-II-25. All components used in NAA-fabricated assemblies and purchased outside NAA will be inspected for quality and quantity (in accordance with Q&RA documents) prior to installation into any assembly.

1.3 ELECTRONIC/ELECTRICAL MODULE ASSEMBLY (IN-HOUSE)

1.3-1 In specified assembly areas, electromechanical, electrical, and electronic components (relays, resistors, capacitors, transistors, and diodes) will be assembled into functional modular assemblies (timer modules, power distributor modules, signal-conditioner modules, amplifier modules, RF power control modules, and converter modules). Systems manufacturing engineering assembly instruction documents, engineering specifications, and engineering drawings will be utilized. (See Figures 1-26 and 1-27.)

1.3-2 Before a module leaves the assembly area, the FAIR ticket will be signed by the assembler and stamped by Q&RA personnel after the latter has verified that the module has been assembled in accordance with applicable engineering drawings and specifications and is free of improperly mounted or damaged components, improperly soldered connections, etc. The completed module is then routed along with the FAIR ticket to the appropriate functional test area.

1.4 SD-PROCURED ELECTRONIC/ELECTRICAL MODULE TESTS

1.4-1 With few exceptions, all modules procured by NAA are subjected to a bench-level type functional test. Functional tests are performed by using special test equipment (STE) GSE, and other test equipment.

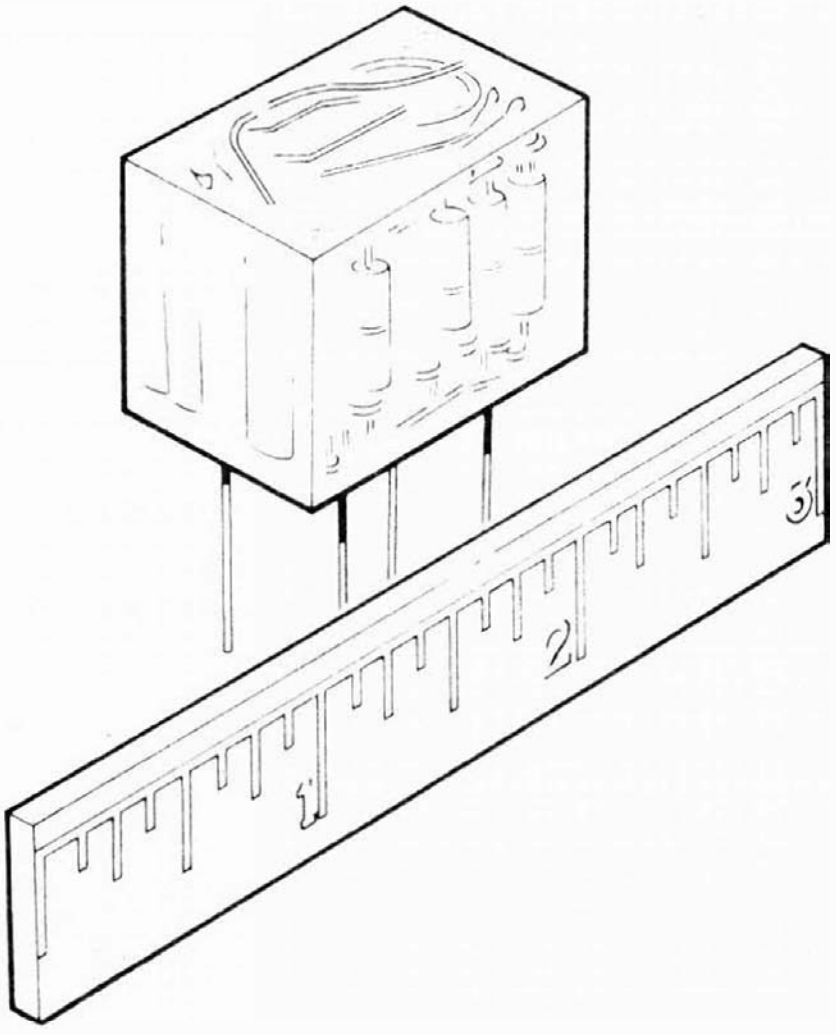


Figure 1-26. Module Designed and Developed by Engineering Development Laboratory

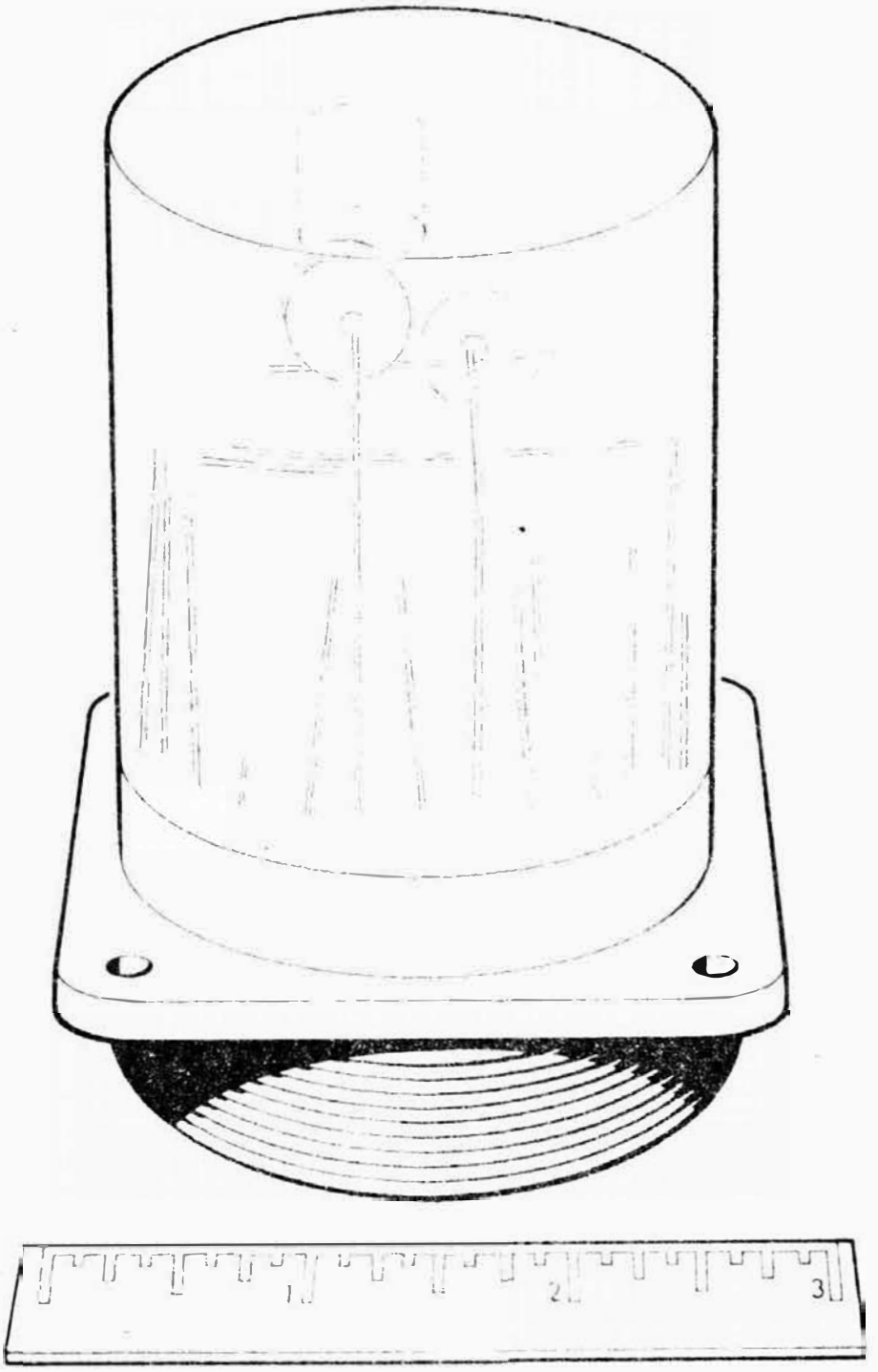


Figure 1-27. Saturn S-II Engine Control Assembly No. 1

1.4-2 The operating manuals have previously been approved for use by the Manual Evaluation and Certification (ME&C) Department in accordance with Quality Assurance procedures, which, in part, specify that the manual must perform the test as required by the Engineering process specification.

1.4-3 The special test equipment (STE) will have been accepted previously by Q&RA, which certifies its conformance to STE acceptance checkout procedures. The modules under test, utilizing subject test equipment and the operating manual, are subjected to NAA certification by Q&RA personnel, who certify that the equipment will perform the functional test in accordance with the process specification. A certification stamp is affixed to the FAIR book by Q&RA.

1.4-4 Once certified, the module is tested and witnessed by Q&RA personnel, who record all test data on appropriate data sheets and stamp the FAIR book in accordance with O&RA procedures. Then the module is ready to be installed into next assembly/subassembly.

1.5 NAA-FABRICATED ELECTRONIC/ELECTRICAL MODULE TESTS

1.5-1 The same type functional tests will be performed on all in-house fabricated modules as are performed on procured modules using the same type operating manuals and test equipment.

1.5-2 Q&RA personnel will subject all modular assemblies requiring encapsulation to a prepotting functional test and certification.

1.5-3 Once certified, the module is tested and witnessed by Q&RA personnel who record all test data on appropriate data sheets and stamp FAIR books in accordance with Q&RA procedures. The prepotted-tested module is subsequently routed to the potting area for encapsulation or coating as required by specification. (See Potting Area, Paragraph 3.12.)

1.5-4 Modules are processed according to instructions in the appropriate potting specifications and Q&RA procedures. Upon completion of the potting and curing process, Q&RA inspects the module for workmanship per Q&RA procedures and stamps the FAIR book to denote acceptance, and the module is rerouted to the Manufacturing test area for a post-potting functional test.

1.5-5 A post-potting functional test is made by using the same operating manual and test equipment as the prepotting tests. Q&RA witnesses the test and certifies that no shorts, open circuits, or physical irregularities

were created as a result of the potting process. Q&RA stamps the FAIR book and processes the data sheets to the data center files. Then the module is ready for installation into the next assembly/subassembly.

1.6 ASSEMBLY OF ELECTRONIC/ELECTRICAL RF AND TELEMETRY SUBASSEMBLIES

1.6-1 Intermediate steps of assembly, such as the installation of modules, boards, plug-in power supplies, amplifiers, and interconnecting wire harnesses, will be carried out in the subassembly area. Apparatus (i.e., telemetry packages, charge amplifier chassis, temperature bridge chassis, RF filter networks, (GFP) switch selector, (GFP) EBW firing units, etc.) are to be construed as subassemblies.

1.6-2 Four typical categories of subassemblies are:

a. GFP subassemblies (furnished by NASA)

b. NAA-purchased subassemblies (MEXXX controlled parts)

c. NAA-purchased subassemblies modified at S&ID from ME parts and reidentified to S&ID part numbers

d. NAA-designed and fabricated subassemblies

1.6-3 Assembly effort is required on items c and d in paragraph 1.6-2 only.

1.6-4 During assembly processes, Q&RA personnel will verify that the assembly is in accordance with the applicable engineering drawing and specification and is free of improperly mounted or damaged components, improper solder connections, etc. Prior to the installation of electrical/electronic or RF modules, the chassis assembly wiring will be given a complete continuity test and verified by Q&RA personnel. After acceptance of continuity tests, the electronic/electrical and RF components will be installed and the subassembly completed.

1.6-5 After acceptance of the completed subassembly by Q&RA personnel, it is routed to the Manufacturing Test department to undergo functional tests.

1.7 ELECTRICAL/ELECTRONIC RF AND TELEMETRY SUBASSEMBLY TESTING

1.7-1 Subassembly testing will be performed on all in-house-fabricated subassemblies and, with few exceptions, GFP-furnished subassemblies. In some cases GFP subassemblies will be tested by using GFP test apparatus and operating manuals. In the remainder of cases, GFP testing will be performed by using special test equipment (STE), SME operating manuals, and test consoles and adapters approved and certified by Q&RA.

1.7-2 All in-house subassemblies will be subjected to a functional test by utilizing approved and certified STE operating manuals and test consoles and adapters.

1.7-3 Testing of subassemblies will be witnessed and verified by a member of Q&RA in accordance with process specification requirements and Q&RA documents.

1.7-4 Q&RA stamp is affixed to the FAIR book, and the subassembly is routed to the container assembly area for installation into containers (subsystems). After successful completion of the functional tests, a Q&RA stamp is affixed to the FAIR book.

1.8 CABLE HARNESSING ASSEMBLIES

1.8-1 There are three basic categories of cable harnesses used in the Saturn S-II stage, as follows:

a. Instrumentation subassembly (black box) harness assemblies

b. Electrical/instrumentation container and J-box harness assemblies

c. Stage interconnecting trunk harness assemblies

1.8-2 Cable harnesses are fabricated by using systems manufacturing engineering assembly instructional documents and approved dimensional tools certified by Q&R.A. All wiring, ties, crimping and soldering connections, and etc., are inspected for conformance to the applicable Engineering documentation. Cable harnesses are given a continuity and insulation resistance test after they are fabricated and before they are installed into their next assembly. This testing is performed per the applicable Engineering process

specification utilizing STE operating manuals, automatic continuity and insulation resistance test equipment, programming test tapes, patchboards, and cable adapters (STE model 8FC-5408), which are reviewed, appraised, and certified by Q&RA.

1.9 CONTAINER ASSEMBLY (SUBSYSTEM)

1.9-1 Components and subassemblies mounted inside an enclosure and interconnected with cable harnesses are designated as containers. Subject containers are mounted on the forward and aft skirts of the Saturn S-II stage.

1.9.2 Before a container leaves the assembly area, the fabrication and inspection record (FAIR) ticket will be affixed with the assembly's serial number and stamped by a Q&RA member after the latter has verified that the container has been assembled per applicable Engineering drawings and specifications.

1.10 CONTAINER AND J-BOX TESTING

1.10.1 BENCH-LEVEL TESTING OF ASSEMBLIES

1.10.1-1 A continuity and insulation resistance test will be performed on all harness assemblies after they are installed into containers and J-boxes per applicable process specification and STE operating manuals by using automatic continuity and insulation resistance test equipment, programming test tapes, patchboards, and adapter cables (STE model 8FC-5408), which are reviewed, appraised, and certified by Q&RA.

1.10.1-2 All containers fabricated at SD and McAlester (Oklahoma) Division of NAA will be subjected to a confidence level or functional test after the installation of all subassemblies, cable harnesses, etc. Confidence level test is performed on those containers (prior to S-II-6) which do not have Engineering process specifications. Functional test will be performed on those containers (prior to S-II-6) which have Engineering process specifications and on all containers effective S-II-6 and subsequent. The confidence level and functional tests are intended to confirm that wiring connections are correct and that major components are operating properly, ensuring that the container will interface and function compatibly with the stage systems. STE will be designed to perform these tests through the use of an STE operating manual. Both the manual and test equipment are approved and certified by Q&RA to meet all requirements of Engineering process specifications.

1.11 MECHANICAL COMPONENTS

1.11-1 Mechanical components, such as control valves, pressure regulators, pumps, and pressure vessels, will be thoroughly tested by the supplier prior to initial acceptance at S&ID receiving inspection. Hydraulic system components are routed to an assembly area, while other stage components are routed to Seal Beach for stage installation.

1.11-2 Each hydraulic component will be cleaned and flushed with hydraulic oil prior to assembly into an engine actuation system (EAS). After the system has been completed, it will be filled with oil, flushed, bled, and checked for contamination. The contamination test is verified before and after the hydraulic system functional test.

1.11-3 Other mechanical components will be routed to Seal Beach for installation without additional testing, unless specifically required by engineering documentation.

1.12 ENGINE

1.12-1 The engine shop will consist of a five-station layout. Station I will contain a receiving inspection for identity and damage inspection and functional tests of engines and log books and will check and log all in-shipment discrepancies. Station II will be used to install components that are shipped separately and to install instrumentation. In Station III, engine components and systems will be pressure-checked. In Station V, the engines will be placed on a G-4035 vertical engine installer and checked to ensure that each engine is ready for installation on the stage. Each engine will then be routed to the Vertical Assembly Building and installed on the stage.

1.13 COMPONENT FAILURES

1.13.2.6-1 Each component failure will be recorded on applicable nonconformance documents and forwarded to the Reliability data center for analysis. The component will be routed to the Material Review Board (MRB) for evaluation. The evaluation will determine if the part can be repaired satisfactorily or if it must be scrapped.

1.14 SUBASSEMBLY DELIVERY TO ASSEMBLY AREA

1.14-1 Modern and economical handling equipment will be used in handling and transporting subassemblies to the assembly area. Transportation of all subassemblies will be accomplished with a minimum of actual item-handling contact. In-route transfer of assemblies will not be necessary. In all highway transport, the assembly will be protected from physical damage by coverings or shipping containers.

1.14.1 TRANSPORTER SUPPORT BED

1.14.1-1 The transporter support bed (Figure 1-13) will be constructed of box framework and will consist of individual modules that are bolted together. This bolting will allow disassembly and packaging for return shipment to the manufacturing area at a reduced shipping charge. To prevent excessive torsional forces from being transmitted to the subassemblies, truss members will be used to join the lateral arms. Use of these trusses will also ensure structural rigidity of the transporter bed. Warning lights, directional signals, floodlights, and safety lights will be placed on all outer edges of the transporter support bed.

1.14.2 LOADING AND PACKAGING PROCEDURES

1.14.2-1 Cylinder loading operations will be conducted as follows:

	Procedure	Tooling
a.	Assemble transporter support bed to truck bed. Place flexible reinforced plastic over truck bed to protect part during transport.	
b.	Position crane; attach spreader bar and slings.	
c.	Following acceptance of subassembly by Q&RA, transfer from work stand to material-handling dolly; deliver to loading area.	
d.	Secure slings to subassembly for use in lifting and positioning item on transporter bed. (See Figure 1-13.)	

Procedure	Tooling
e. Secure subassembly by clamps to the transporter contour support attachment ring.	
f. Attach flexible reinforced cover to spreader bar; drape cover over subassembly with crane.	
g. Secure cover in position by tie-down cords.	
h. Transfer subassembly, utilizing interdivisional packing sheets. Packing sheets will be signed by Q&RA personnel to indicate completion of loading operations accomplished under their surveillance.	

1.14.2-2 Loading interstage panel assembly will be accomplished as follows:

Procedure	Tooling
a. Fabricate cleated plywood container (Figure 1-28); deliver to subassembly area.	
b. After acceptance of subassembly by Q&RA, disassemble subassembly for packaging.	
c. Place each section in contoured cradle of container base.	
d. When all sections have been padded and cradled in container, accomplish blocking, bracing, and tie-down operations.	
e. Position container panels; secure with Klimp fasteners to ensure easy disassembly at assembly site and quick turnaround and reuse capabilities. All material used will conform with MSFC drawing 10509302.	

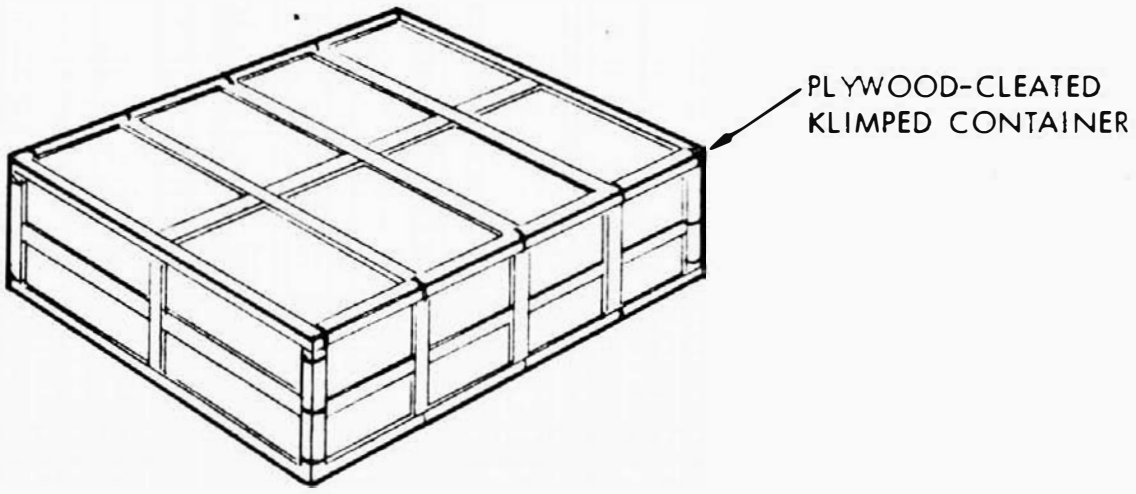


Figure 1-28. Panel Assembly Carrier

1.14.2-3 Loading of the skirt and thrust structure assembly will be performed as follows:

The same procedure and techniques applied in loading the cylinder section will be used. (See Figure 1-13.)

1.14.2-4 Packaging miscellaneous loose hardware will be accomplished as follows:

Wrap, cushion, and properly protect all miscellaneous loose hardware for transfer to assembly site. All material used will conform with MSFC drawing 10509302.

1.15 FINAL ASSEMBLY

1.15-1 Final assembly operations will be performed in the vertical assembly station. (See Figures 1-29.) Each assembly (Figure 1-30), beginning with the lower sections, will be progressively positioned in the tool (Figure 1-32); joining will be accomplished by fusion welding or by bolting (Figures 1-31 through 1-34). Optical alignment, in conjunction with

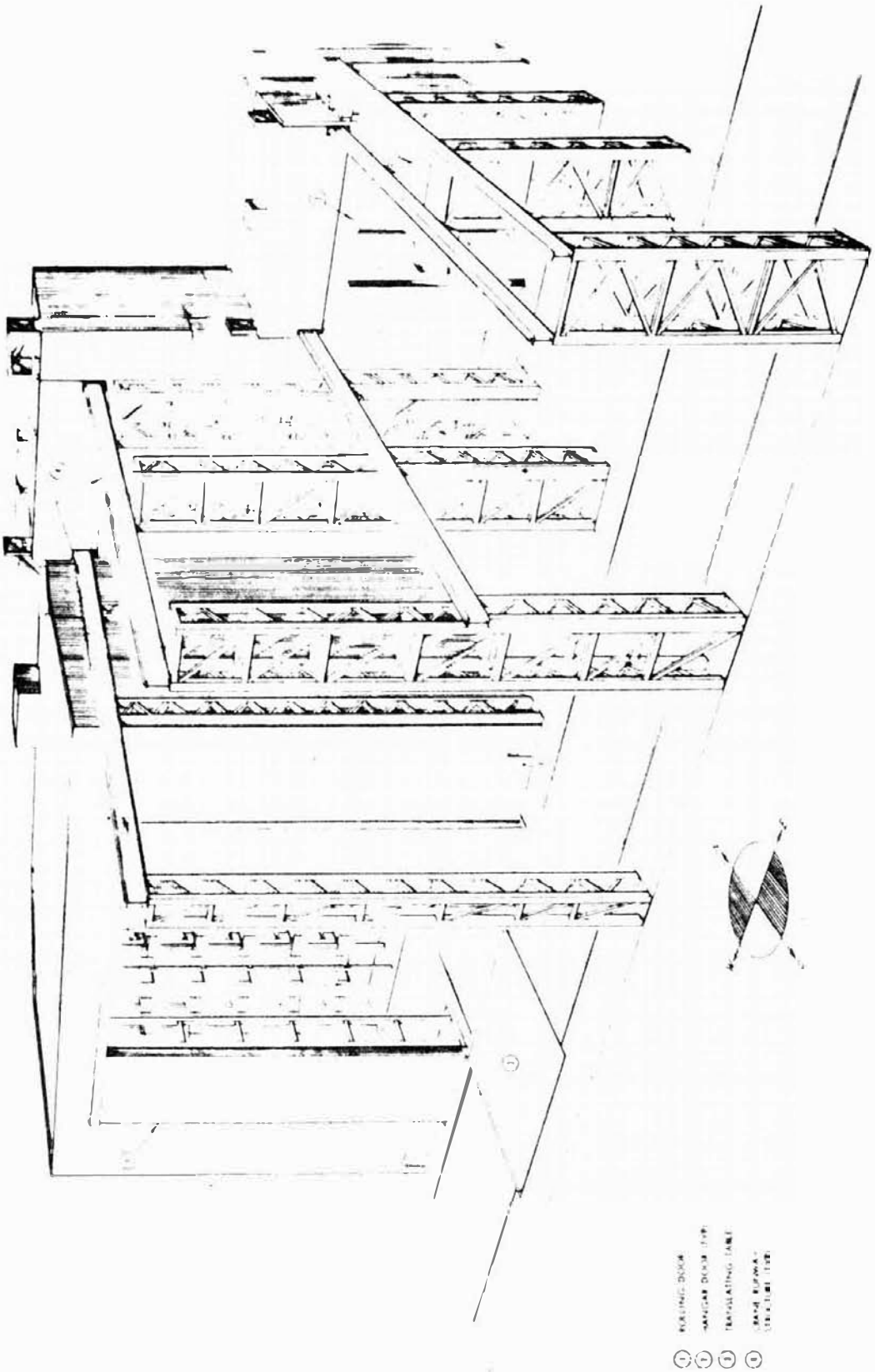


Figure 1-29. Vertical Assembly and Hydrostatic Test Building

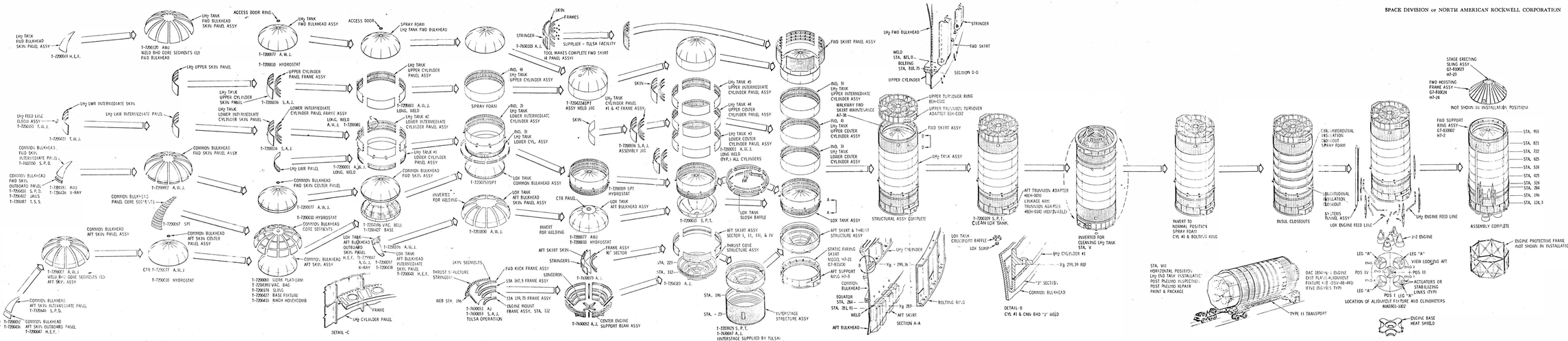


Figure 1-30. Vertical Assembly Sequence

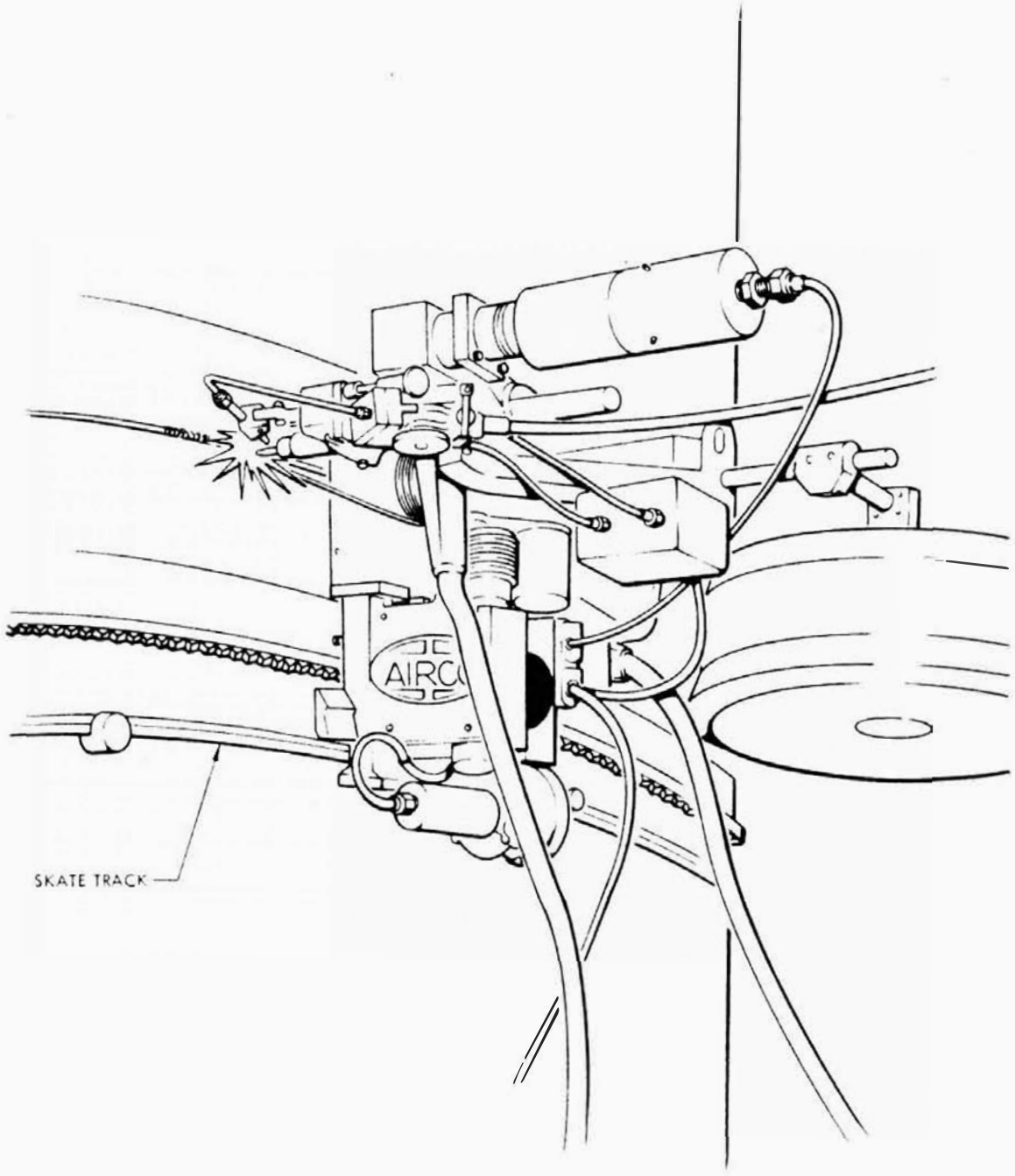


Figure 1-31. Weld Skate

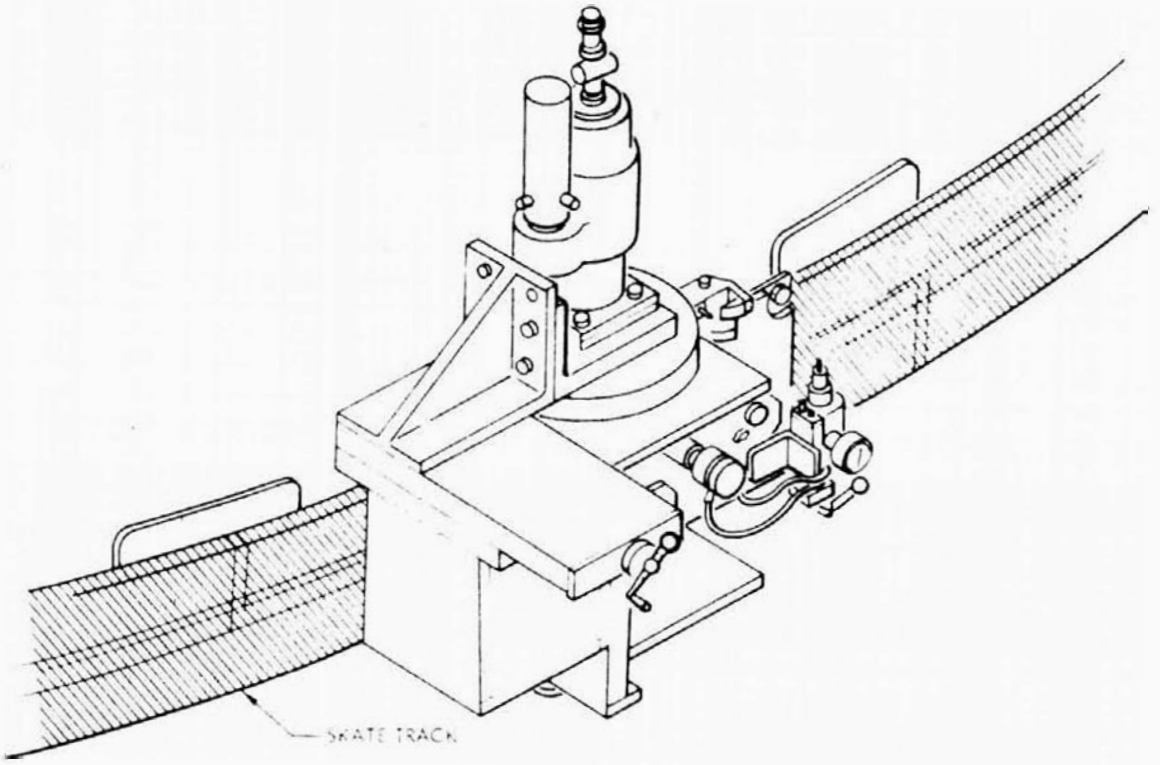


Figure 1-32. Trim Skate

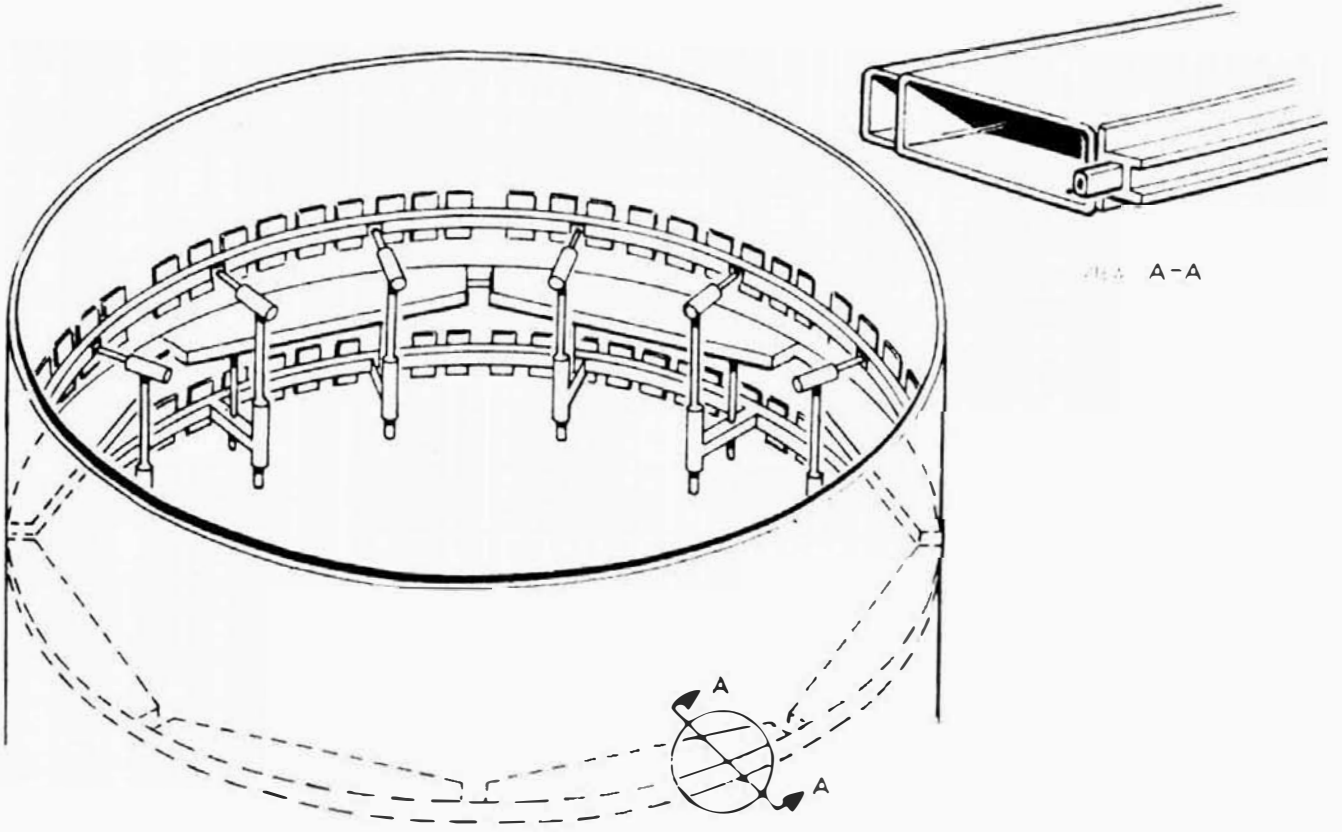


Figure 1-33. Welding Backup Bar

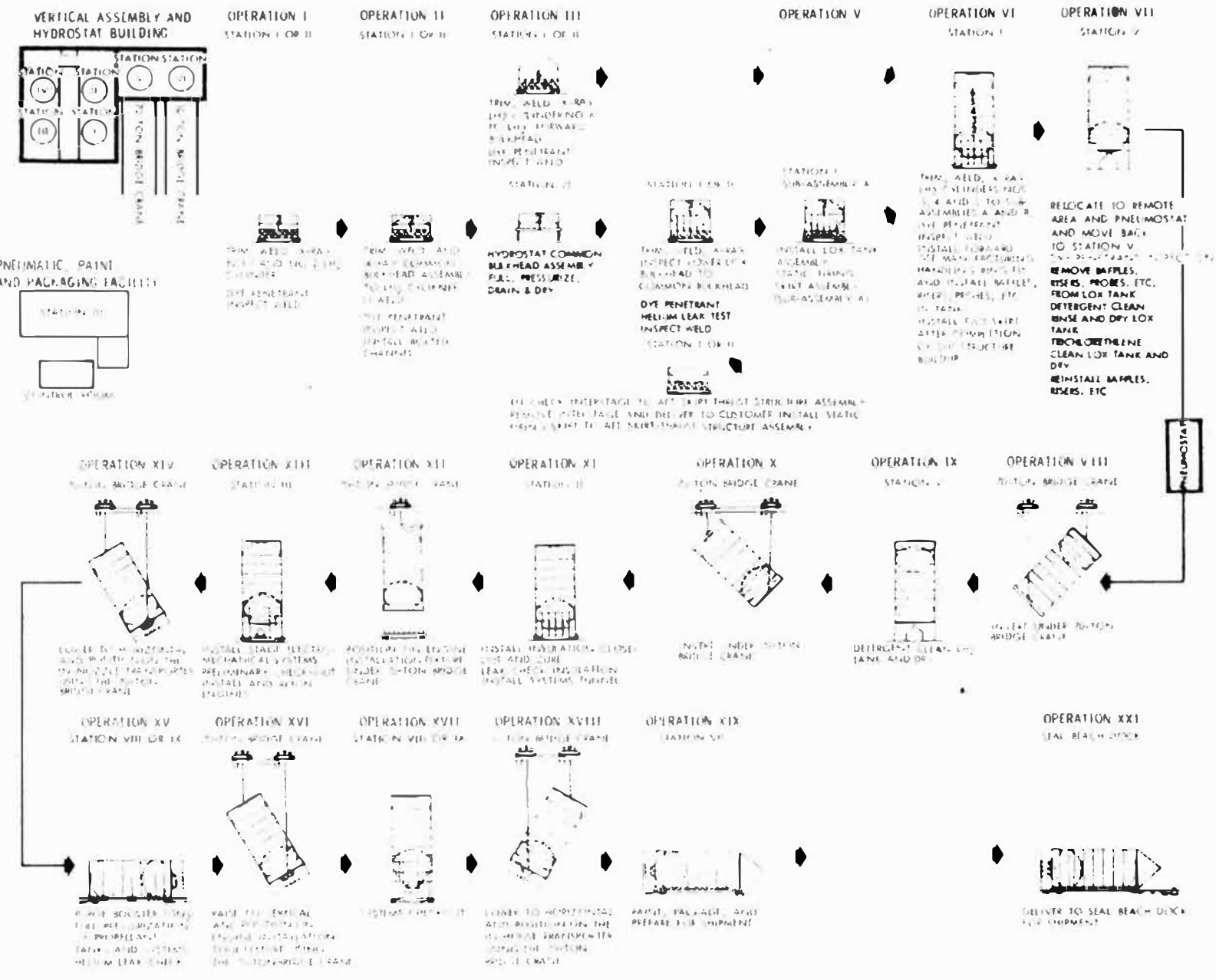


Figure 1-34. Final Assembly Flow Sequence

mechanical mold line positioners, will be used to check each assembly operation during the final structure buildup. Welds will be inspected immediately after each joining operation. A diagram of final assembly stationing is shown in Figure 1-34.

1.15.1 CIRCUMFERENTIAL WELDING OF LOWER LH_2 AND LOWER INTERMEDIATE LH_2 CYLINDER TO COMMON BULKHEAD ASSEMBLY

1.15.1-1 All weld equipment and operators will be certified in accordance with NAA specifications.

	Procedure	Tooling
a.	Transfer stage dolly containing weld fixture to Station III level tooling.	Assembly station
b.	Obtain Cylinder 1 from storage and position in weld fixture.	Tooling support fixture
c.	Locate and install weld backup tooling.	Welding backup
d.	Obtain Cylinder 2 from storage, and position on Cylinder 1 for welding.	
e.	Install weld heads on skate track, and verify operation.	
f.	Make a dry run over weld joint, and check accuracy of weld head tracking.	
g.	Weld Cylinders 1 and 2 (NAA specification MA0107-016).	
h.	Inspect weld (penetrant and radiograph).	
i.	Remove cylinder weld assembly from weld fixture, and transfer to storage area.	
j.	Obtain common bulkhead assembly from storage, and install in weld fixture.	Tooling support fixture

	Procedure	Tooling
k.	Trim J joint	Trim skate
l.	Obtain assembly for Cylinders 1 and 2 from storage, and position over common bulkhead.	
m.	Check weld joint mating, and position J-weld backup bars.	
n.	Qualify weld equipment operation.	
o.	Install weld heads on skate track, and make a tracking run over weld joint.	
p.	Weld J to cylinder joint.	
q.	Radiographically inspect weld joint.	
r.	Locate bolting channel segments around periphery of common bulkhead.	
s.	Position drill fixtures and drill, counterbore, and tap holes for Rosan inserts.	
t.	Install Rosan inserts.	
u.	Install shoulder bolts and all bolts that attach channels to lower LH_2 cylinder.	
v.	Torque-check all bolts.	

1.15.2 CIRCUMFERENTIAL WELDING OF UPPER LH_2 CYLINDER TO FORWARD LH_2 BULKHEAD (See Figure 1-35.)

1.15.2-1 Following is the procedure and tooling to be used for circumferential welding of the upper LH_2 cylinder to the forward LH_2 bulkhead:

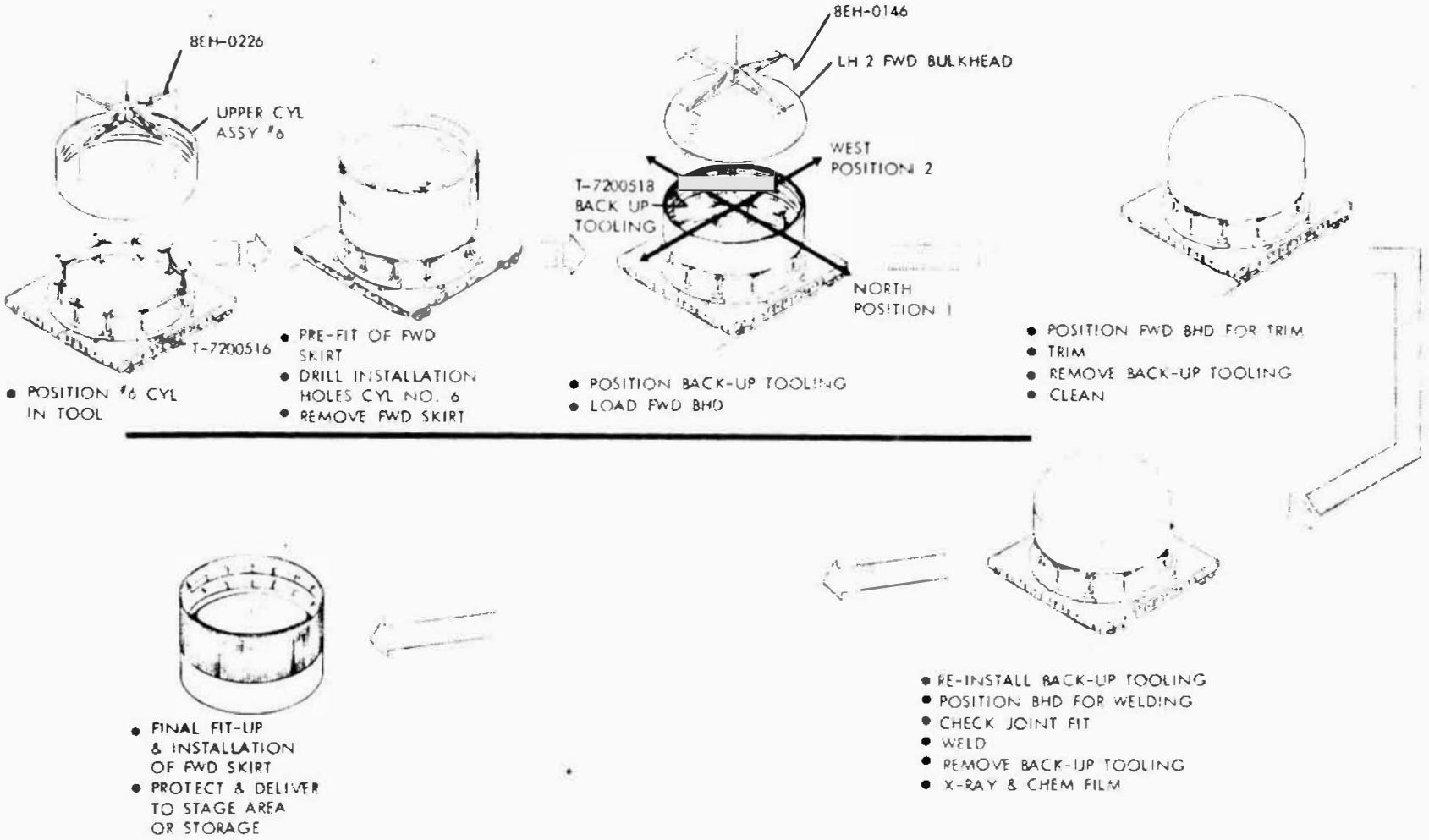


Figure 1-35. Forward Skirt, Forward Bulkhead, Upper Cylinder Final Assembly Sequence

Procedure	Tooling
a. Obtain Cylinder 6 from storage, and position on weld fixture.	Assembly station Tooling support fixture
b. Position weld backup tooling inside Cylinder 6.	Welding backup
c. Obtain forward LH_2 bulkhead from storage, and position over Cylinder 6.	
d. Trim lower edge of bulkhead.	
e. Position LH_2 bulkhead on Cylinder 6, and check weld joint fitup.	
f. Verify weld equipment operation, and install weld heads.	
g. Weld bulkhead to Cylinder 6 (upper LH_2).	
h. Radiographically inspect weld.	
i. Transport assembly to hydrostatic tower.	

1.15.3 INTERSTAGE FIT-CHECK TO AFT SKIRT AND THRUST STRUCTURE

1.15.3-1 The procedure and tooling for interstage fit-check to the aft skirt and thrust structure is as follows:

Procedure	Tooling
a. Obtain from storage and assemble interstage panels on the support fixture T-7200516, picking up aft interface hole pattern.	Assembly station
b. Loosely install splice plate between interstage segments.	

Procedure	Tooling
c. Obtain aft skirt and thrust structure assembly from storage, and position on interstage.	
d. Install and tighten all bolts in attach holes at Station 196 in panel segment splices.	
e. Locate longeron fittings at Station 196, and check for proper fit.	
f. Locate Station 196 separation plates on thrust longerons, drill and ream attach holes, and identify attach holes for location.	
g. Inspect interstage fit-check, and remove bolts from Station 196 attach fittings.	
h. Remove aft skirt and thrust structure from interstage: place on stage dolly.	
i. Install GSE handling ring on upper end of interstage (Performed after paint, but before packaging).	
j. Install wire harnesses. (May be installed prior to fit check.)	
k. Deliver to interstage assembly, Station VII, for painting and shipment.	

1.15.4 CIRCUMFERENTIAL WELDING OF LOX TANK (See Figure 1-36.)

1.15.4-1 Following is the procedure and tooling for accomplishing circumferential welding of the LOX tank:

Procedure	Tooling
a. Position and align aft bulkhead in jig, and trim upper edge.	Assembly station
b. Position common bulkhead and cylinder assembly over lower LOX bulkhead and backup bars.	

Figure 1-36. LOX Tank Final Assembly Sequence

Procedure	Tooling
c. Trim lower edge of common bulkhead.	Trim skate
d. Verify two weld heads on short skate track.	
e. Circumferentially weld LOX tanks.	Weld skate
f. Inspect weld (visually and radiographically).	Radiograph head
g. Raise LOX tank, using sling and overhead bridge.	
h. Move stage dolly with aft skirt and thrust cone into position in Station I, using transfer table.	
i. Lower LOX tank onto aft skirt and align, using reference system.	
j. Drill and ream 432 holes through aft skirt and bolt channel.	
k. Install bolts and torque.	
l. Install internal work platform and backup bars inside of Cylinder 2.	

1.15.5 MATING FINAL TANK ASSEMBLY STRUCTURE

1.15.5-1 Following is the procedure and tooling to be used for mating the final tank assembly structure:

Procedure	Tooling
a. Obtain Cylinder 3 from storage, and locate on tool. Install backup bars to top of Cylinder 3.	Support tooling vacuum-supported
b. Obtain Cylinder 4 from storage, and locate on Cylinder 2 and backup bars. Align radially.	

	Procedure	Tooling
c.	Verify two weld heads, and install on track.	
d.	Circumferentially weld Cylinder 3 to Cylinder 4.	
e.	Inspect weld visually and radiographically. Dye penetrant inspection weld.	
f.	Iridite (Chem-film) weld area, and install splices across weld.	
g.	Repeat steps a through f using Cylinder 5.	
h.	Install skate track at top of Cylinder 5, and install backup bars.	Vacuum-supported track
i.	Obtain LH_2 bulkhead and Cylinder 6 assembly from storage.	
j.	Index assembly to Cylinder 5, and check rotation vertical and horizontal alignment using alignment reference system.	
k.	Trim lower edge of Cylinder 6.	
l.	Verify two weld heads, and install on skate track.	
m.	Circumferentially weld Cylinder 5 to Cylinder 6.	
n.	Remove backup tooling.	
o.	Inspect weld visually and radiographically. Dye penetrant inspection weld.	
p.	Iridite (Chem-film) weld area, and install splices across weld.	
q.	Obtain Cylinders 3 through 6 and forward skirt assembly from storage, and locate on backup support tooling in Cylinder 2.	

Procedure	Tooling
r. Check vertical and rotational alignment.	
s. Circumferentially weld Cylinder 2 to Cylinder 3.	
t. Inspect weld visually and radiographically; dye penetrant check weld.	
u. Iridite (Chem-film) weld area, and install splices across weld.	
v. Install eight EM-0035 catwalks.	
w. Remove backup bars and internal support tooling.	

1.15.6 TANK INSULATION

1.15.6-1 The container will be moved to the vertical insulation station for completion of the final tank insulation. The external surfaces of the forward bulkhead and the LH_2 panels will have been insulated prior to the final welding of the container. Areas approximately 10 inches wide at all weld joints on the LH_2 panels will have been left uninsulated; insulation will be applied at this time.

1.15.6.1 Preparation of Surface for Bonding

1.15.6.1-1 The surface will be prepared for bonding as follows:

Procedure	Tooling
a. Prefit insulation closeout subassembly to fit area to be insulated.	
b. Seal off edges of tank insulation to prevent contamination during surface preparation per MA0110-010 and MA0610-023.	

Procedure	Tooling
c. Bear-tex and solvent-wipe to remove surface contamination received during weld-joining process.	
d. Apply acid-etch solution.	
e. Wash with demineralized water.	
f. Air-dry.	
g. Inspect.	

1.15.6.2 Bond of Insulation Closeout Subassembly

Procedure	Tooling
a. Mix and apply adhesive per MA0606-027 to the tank wall, and inspect.	SEMCO mixer Adhesive hand spreader
b. Inspect.	
c. Place insulation closeout subassembly over weld area; apply positive pressure (5 psi) 4 hours.	Positive pressure tool T-7203326
d. Remove positive pressure tool.	
e. Inspect.	
f. Repeat steps a, b, c, d, and e until all of the external surface is insulated.	

1.15.6.3 Application of Outer Insulation Laminate Strips

1.15.6.3-1 The outer insulation laminates will be bonded over the closeout areas to the dimensions required per drawings and specifications.

Procedure	Tooling
a. Apply film adhesive on laminate strips, and rub out wrinkles or air entrapments per MA0106-033 process specification.	
b. Install thermocouple wires at glue line.	
c. Inspect.	
d. Apply prepared laminate skin; press firmly into place.	
e. Apply PVA film over area of bond, and install vacuum valves.	Polyvinyl alcohol bag
f. Apply zinc chromate tape to outer periphery of layup area.	
g. Draw vacuum to secure bond.	
h. Apply heat (strip) blanket, and cure (MIL-A-9067).	Heat blanket
i. Remove heat blanket and PVA bag. Clean for inspection.	
j. Inspect (NAA specification LQ-0401-001).	

1.15.6.4 Sealing and Leak-Check of Insulation Splices

1.15.6.4-1 The insulation will be sealed by applying Narmco adhesive over faying surfaces of the laminates. The sealed insulation will be subjected to leak-check.

1.15.6.5 Leak. Proof, and Flow Check of Insulation

1.15.6.5-1 Insulation leak, proof, and flow checks will be performed using special test equipment and operating manuals complying with process specifications MA0201-4264, MA0201-4265, MA0201-4266, and MA0201-1837.

1.16 SYSTEM INSTALLATION

1.16-1 The S-II stage structural assembly will be positioned in the Vertical Assembly Building for installation of systems. During installation, control of equipment and hardware will be maintained through the use of appropriate documents to be included in the data package delivered with each S-II stage. Following are the documents to be delivered with each stage:

Equipment serialization
Operation time
Signoff
Calibration
Change verification
Part removal
Process specification

1.16-2 After each installation, Q&RA personnel will verify that the preceding data have been entered and the system has been installed per applicable engineering drawings.

1.16-3 After the vehicle has been pneumostatically tested and cleaned in accordance with applicable engineering documentation, it will be positioned in the Vertical Assembly Building where Stations II and IV will be utilized. In these stations, systems, including electrical power, control RF, instrumentation, pressurization, propellant, relay boxes, and hydraulic systems, will be installed. STE model 8FS-0007 will be used to aid in repairing insulation when required. Tube assemblies and wire harnesses will be installed as a warehouse operation on the aft thrust structure. Wire harnesses are installed using approved Operators General Instruction Document (GID) provided by systems manufacturing engineering.

These documents detail the sequential installation of wire harnesses throughout the aft thrust structure area, the forward skirt area, tunnel, and the interstage.

1.16-4 The following installation and operation sequence has been established for the purpose of accessibility of installations. The installation effort can proceed in each area at the same time (with close coordination maintained at all times) to permit proper sequencing.

1.16-5 The installation sequence at Stations II or IV is as follows:

Procedure	Tooling
a. Provisions redundant instrumentation, forward skirt	
b. Provisions instrumentation system, aft skirt	

Procedure	Tooling
c. Systems, LOX recirculation.	
d. Support mast, gas distributor pressurization system.	
e. Provisions, instrumentation LOX tank.	
f. Equipment and wire, GSE test aft skirt.	
g. Vent system, LOX tank.	
h. System, propellant management and LOX.	
i. Provisions redundant instrumentation, forward skirt.	
j. Electrical instrumentation system, control, installation, forward skirt.	
k. Provisions instrumentation system, forward skirt.	
l. Equipment, electrical systems, aft skirt.	
m. Equipment and wire electrical system, forward skirt.	
n. System, propellant management LH_2.	
o. Equipment, electrical system.	
p. Electrical instrumentation system, control installation, aft skirt.	

1.16-6 The installation sequence at Stations II or IV is as follows:

Procedure	Tooling
a. Instrumentation, LOX tank-vehicle*	
b. Provisions, instrumentation LOX tank*	

*Stations II or IV

Procedure	Tooling
c. Instrumentation, LH_2, tank-vehicle**	
d. Provisions, instrumentation systems LH_2 tank**	
e. Systems, LOX recirculation*	
f. Support mast, gas distributor pressurization systems*	
g. Vent systems, LOX tank*	
h. Line, outboard engine feed—LOX*	
i. Screen assembly, feed line—LH_2*	
j. Deflectors, fill and drain line—LH_2*	
k. Gas distributor assembly, pressurization system—LOX tank*	
l. System, propellant management—LOX*	
m. Line, center engine feed—LOX*	
n. System, propellant management—LH_2**	
o. Pressurization system, internal LOX tank*	
p. Pressurization system, internal LH_2 tank**	
q. Baffle and screen, LOX sump*	
r. Baffle, antivortex upper—LOX*	

1.16-7 The installation sequence on the low tool T-7200515 at Stations II or IV is as follows:

Procedure	Tooling
a. Instrumentation, system tunnel	
b. Instrumentation, instrumentation thrust cone, static-firing	

*Stations II or IV
**Stations VII

Procedure	Tooling
c. Wiring, instrumentation, aft skirt	
d. Instrumentation, aft skirt, stage	
e. Electrical instrumentation systems, control installation, aft skirt	
f. Equipment, electrical system	
g. Wiring, electrical system, aft skirt	
h. Equipment, electrical system, aft skirt	
i. Engine actuation, hydraulic system	
j. Electrical instrumentation system, control, forward skirt	
k. Leak detection and purge systems, lower cylinder and bolting ring	

1.16-8 The installation sequence at Station II or IV is as follows:

Note: Portions of these installations are performed as subassemblies and warehouse operation.

Procedure	Tooling
a. Instrumentation, aft skirt, stage	
b. Electrical instrumentation systems, control installation, aft skirt	
c. Electrical instrumentation systems, control installation, forward skirt	
d. Equipment, electrical systems	
e. Wiring, electrical systems, aft skirt	
f. Equipment, electrical systems, aft skirt	
g. Equipment and wire, electrical systems, forward skirt	

Procedure	Tooling
h. Systems, leak detection and purge, forward bulkhead and skirt	
i. Leak detection and purge system, Station 196	
j. Engine actuation, hydraulic system	
k. Line, outboard engine feed, LH_2	
l. Leak detection and purge systems, LH_2 sidewall	

1.16-9 The Station II installation sequence on the high tool (T-7200100) is as follows: (See Figure 1-37.)

Note: Portions of these installations are performed as a subassembly in the warehouse operation.

Procedure	Tooling
a. Equipment, instrumentation, aft skirt	
b. Instrumentation, aft skirt, stage	
c. Tubing assembly, instrumentation static firing	
d. Electrical instrumentation system, control installation, forward skirt	
e. Instrumentation, hydraulic system	
f. Equipment, electrical system	
g. Wiring, electrical system, aft skirt	
h. Equipment, electrical system, aft skirt	
i. Equipment and wire, electrical system, forward skirt	
j. Engine actuation, hydraulic system	

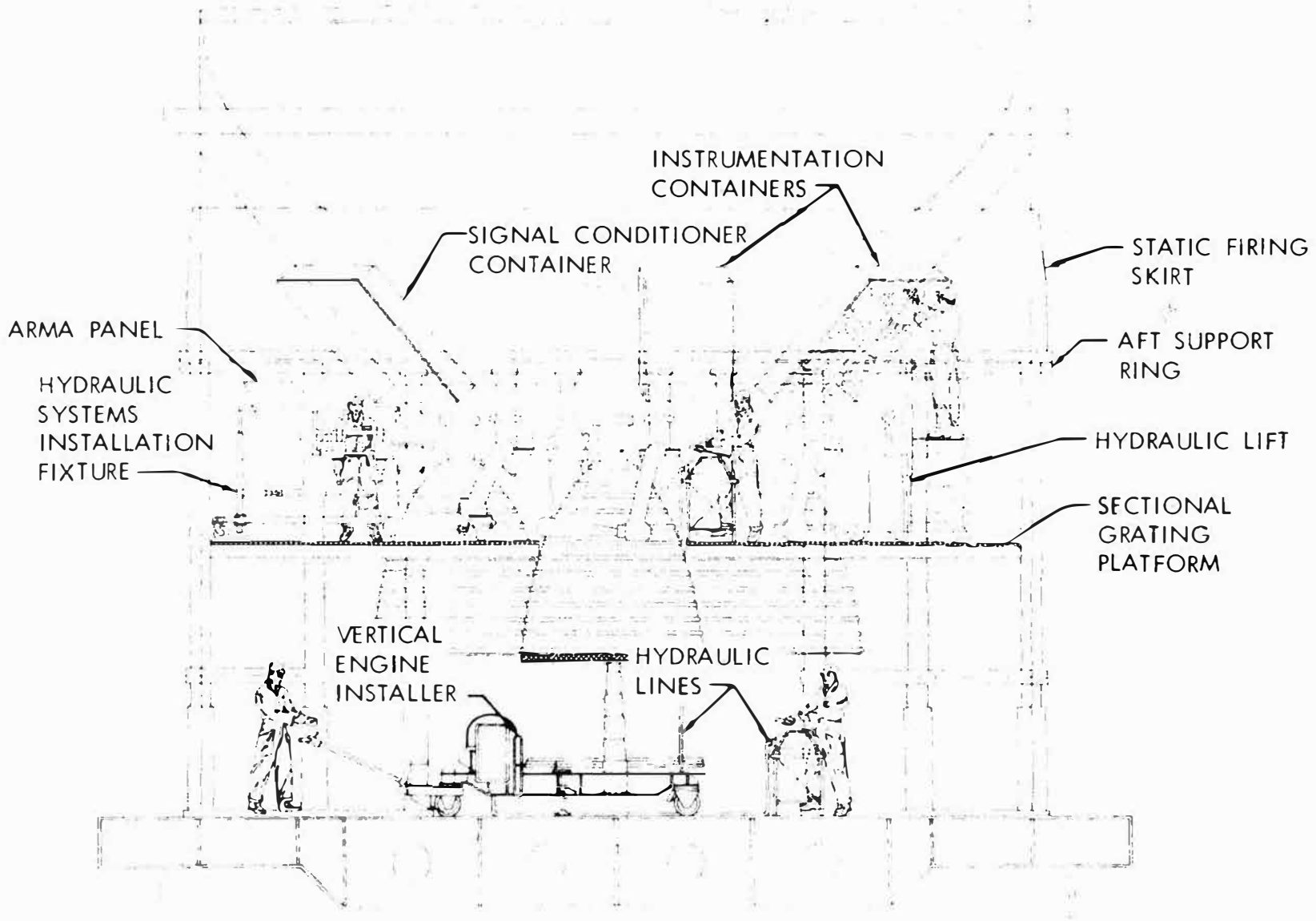


Figure 1-37. Engine Installation and Alignment

Procedure	Tooling
k. Engine, J-2 engine	
l. Pressurization system, LOX tank	
m. Pressurization system, LH_2 tank, external	
n. Actuation and checkout lines, LOX and LH_2 tank pressurization systems	
o. Pneumatic actuation systems, engine propellant valves	
p. Line, outboard engine feed—LH_2	
q. Leak detection and purge, LH_2 sidewall	
r. Vent systems, LOX tank	
s. Thermostatic control systems, instrumentation and electrical, aft skirt	
t. System, LH_2 recirculation	
u. System, engine component	
v. Manifold, LOX and LH_2 tank pressurization	
w. Helium pressurization systems, LH_2 tank ullage	
x. Line, center engine feed—LH_2	
y. Leak detection, common bulkhead	
z. Vent systems, LOX tank	
aa. Line, outboard engine feed—LOX	
bb. Wiring, instrumentation, special test	
cc. Wiring, instrumentation, forward skirt	

Procedure	Tooling
dd. Equipment, instrumentation, forward skirt	
ee. Instrumentation, forward skirt	
ff. Engine servicing	
gg. Vent systems, LH_2 tank	
hh. Purge systems, LH_2 tank pressurization line	
ii. Line, fill and drain, LOX and LH_2	
jj. Wire, special test, forward skirt	
kk. Simulated base heat shield	
ll. Thermostatic control systems, instrumentation and electrical, forward skirt	
mm. System, LOX recirculation	
nn. Helium pressurization systems, LOX tank pressurization	
oo. Leak-check, LH_2 flanged joint	
pp. Line, center engine feed—LOX	
qq. Tubing assembly, instrumentation, static firing	

1.16.1 STAGE-LEVEL TESTING

After containers, J-boxes, and trunk harness assemblies are installed, the following test will be performed in the sequence as listed. These tests will conform to the applicable process specification and STE operating manual, utilizing manual continuity and insulation resistance test equipment and adapters (STE model 8FC-5407). The manuals, test equipment, and adapters are reviewed, appraised, and certified by Q&RA.

1.16.1-1 For S-II-3 and Subs

Insulation resistance testing will be performed on all S-II stage trunk harness assemblies.

Bus isolation test will be performed to ensure that there are no short circuits between buses or from buses to ground.

Continuity test will be performed on all resistive free circuit paths from one extreme end to the other extreme end, as reflected per the applicable stage schematics.

Stage master schematic book will be maintained by systems manufacturing engineering to reflect the "as built" configuration during the manufacturing installation cycle.

1.16.1-2 After completion of continuity testing, final inspection occurs, and the stage is moved to Stations 8 or 9 for stage systems checkout.

1.17 FIBER GLASS FAIRINGS

1.17-1 Aerodynamic heating problems on the hydrogen feed lines, forward elbows of the LOX vent valves, and other stage external protrusions make it necessary for these areas to be faired. This function will be accomplished by a series of fiber glass fairings.

1.17-2 Materials used for the fairings consist of fiber glass cloth preimpregnated with a phenolic resin system. Such preimpregnations permit greater shop flexibility with the following advantages:

Elimination of formulation problems and the annoying mess of wet layup

Consistent quality and constant resin content

Adaptability to assembly-line techniques for increased production at lower unit cost

Fewer rejects

Less variance in mechanical properties

Lower inventory, because no resins or catalysts need be stocked

The cloth is placed in female layup dies, and a vacuum bag is installed and cured in large gas-fired ovens.

1.17-3 .Atypical fairing consists of a fairing skin with a thickness of five laminations. A series of internal stiffeners and stringers (the same material as the fairing skin) is bonded to the fairing skin. The adhesive system employed is the same as the system currently used for bulkhead bonding. The completed units are then shipped to the Vertical Assembly Building to be installed.

1.18 PAINTING AND PACKAGING

1.18-1 Following the integrated systems tests, the outside surfaces will be chemically treated, painted, or coated in the Pneumatic Testing, Painting, and Packaging Building. The paint design and color will be specified by MSFC. The S-II stage will be painted before shipment and after static firings.

1.18-2 Specifications will be developed to define the design criteria and details of methods and procedures for packaging and preservation. In general, the following procedure will be used to prepare the S-II stage for shipment:

Procedure	Tooling
a. Install sensing elements for intransit instrumentation.	
b. Cover all stage access doors and ports (with the exception of the main propellant tank vents) on exterior surfaces with a flexible moisture barrier (MIL-B-121, Grade A); seal with tape (PPP-T-60).	
c. Cover all instrumentation, separation, and control system components (that are not hermetically sealed or otherwise inherently protected) with a flexible, metal-foil moisture barrier (MIL-B-131C, Class 1); seal with tape (PPP-T-60).	

Procedure	Tooling
d. Check to ensure that engine actuator locks are installed.	
e. Coat all exposed critical surfaces, such as bearings and actuating arms, with a corrosion-preventative compound (MIL-C-16173).	
f. Purge the propulsion system (including propellant containers) with nitrogen gas.	
g. Fit desiccator breathers with activated desiccant charges; install breathers on the propellant tank main vent openings.	
h. Fill desiccant baskets on the thrust chamber dust covers with a bulk desiccant (MIL-D-3464B); install covers to seal off the chambers.	
i. Install protective covers on the stage.	
j. Connect in-transit instrumentation.	
k. Place static desiccant charges in forward and aft skirt areas.	
l. Install the transportation light set on the transporter mounting rings for over-the road movement.	

2.0 FACTORY TEST PLAN

2.0-1 This section contains the test and final assembly procedures for the S-II stage. Procedures are outlined under three general headings: process and test, pneumatic pressure test, and systems tests.

2.1 PROCESS AND TEST

2.1-1 All process and test operation data will be recorded in a log that will accompany the stage through all major assembly operations. Pertinent data will include acceptance test results, calibration and cleaning inspection records, and lists of applicable drawings and specifications.

2.1.1 HYDROSTATIC TEST OPERATIONS

2.1.1-1 The hydrostatic test will be performed in a test facility that will provide access to all tank welds. A means of filling, draining, and depressurizing the assembly also will be available. An automatic vent valve will be installed to prevent negative collapsing pressure in the case of assembly failure. Recording cameras will be provided to monitor hazardous areas. The test site will be fully equipped to accomplish all phases of the hydrostatic testing and leak detection. (See Figure 2-1.)

2.1.1.1 Preparation for Bulkhead Tests

2.1.1.1-1 The following procedure and tooling will be used in the preparation:

Procedure	Tooling
a. Lift bulkhead from handling dolly, position, and fasten to hydrostatic test fixture in facility. (See Figure 2-2.)	40,000-pound hoist Hydrostatic test fixture
b. Install appropriate fittings on all bulkhead openings.	Blanking plates 8FS-5908
c. Perform pretest calibration of hydrotest instrumentation	Hydrostatic test fixture

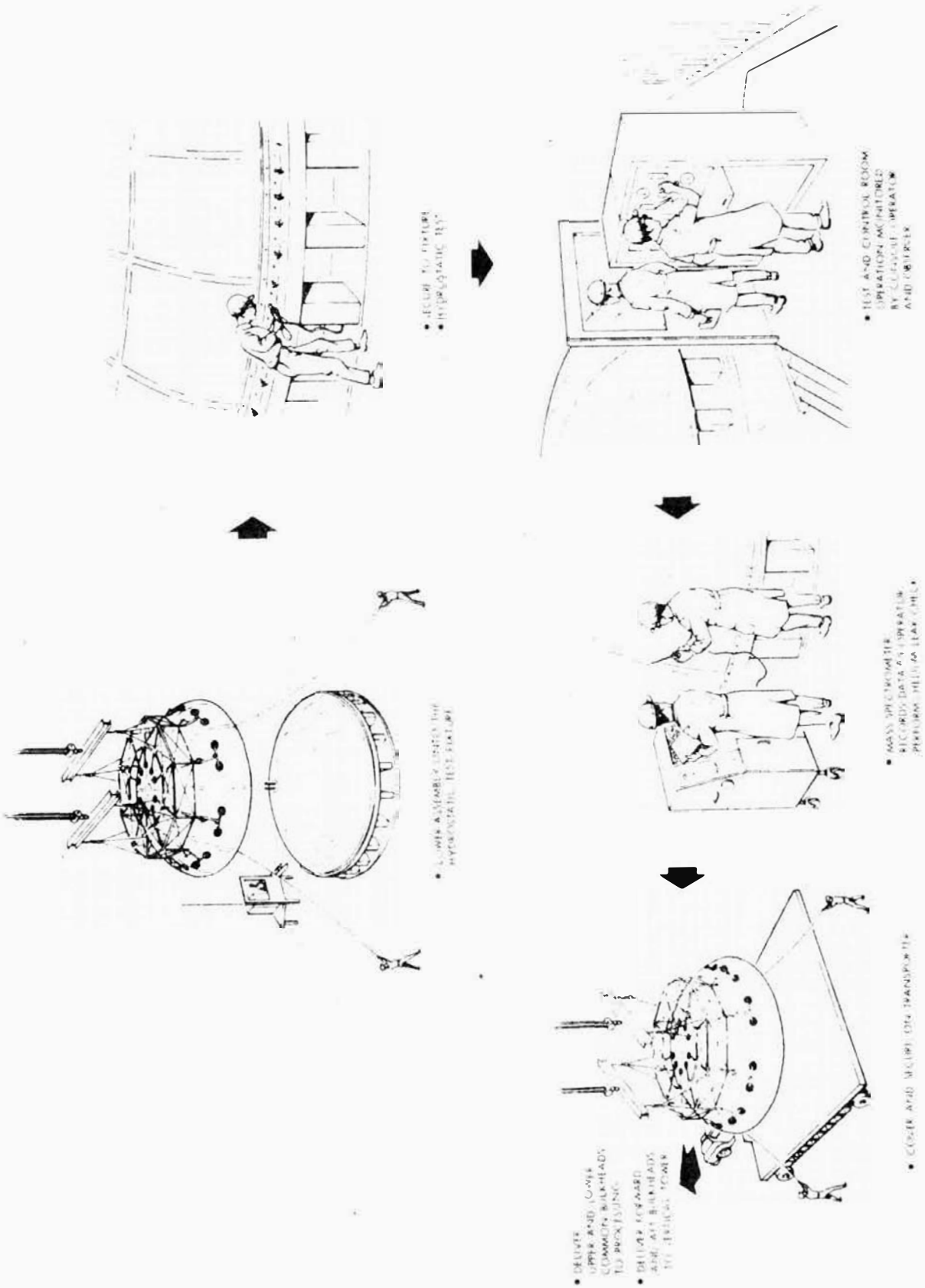


Figure 2-1. Hydrostatic Test Sequence

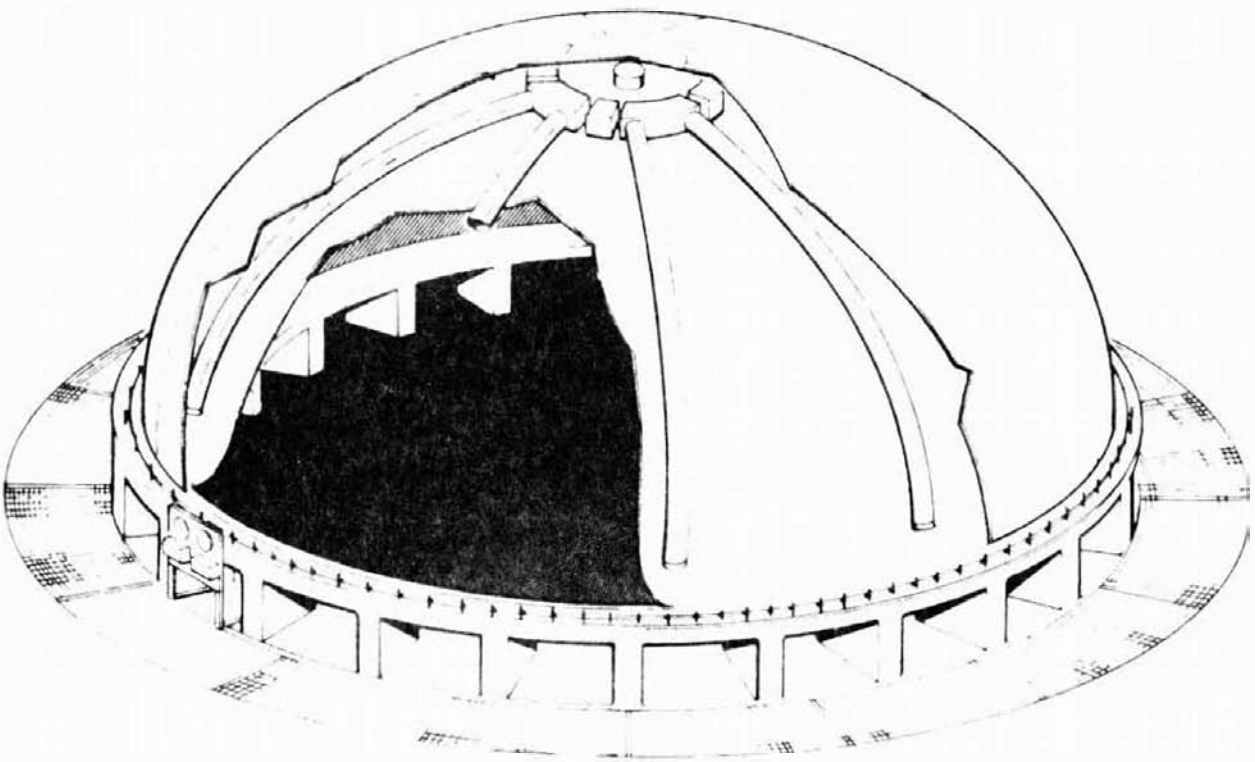


Figure 2-2. Bulkhead Hydrostatic Test Fixture (T-7200010)

2.1.1.2 Bulkhead Hydrostatic Test

2.1.1.2-1 The individual forward, aft, and aft common bulkhead diaphragm will be hydrostatically pressure-tested (Figure 2-2) with the prescribed pressures indicated at the bottom of the bulkhead. Tests will be conducted with clean demineralized water that contains a corrosion inhibitor.

Procedure	Tooling
a. Fill bulkhead, through 2-inch fill line, with clean demineralized water (corrosion inhibitor added).	Hydrostatic test fixture T-7200010; Hydrostatic test unit 8FS-5908
b. Pressurize bulkhead through 1-inch pressurization line to required pressure per MA0208-1001 process specification.	
c. Hold test pressure for 10 minutes minimum.	
d. Visually inspect all welds for leaks.	
e. Drop pressure. Drain and dry bulkhead.	
f. Dye penetrant inspection of welds.	

2.1.1.3 Bulkhead Leak-Check

2.1.1.3-1 The forward common bulkhead diaphram only will be leak-checked with a helium leak detector. Helium will be inserted into the bulkhead and pressurized per process specification MA0615-003. The helium leak detector, incorporating a sample probe, is capable of detecting 1 part of helium in 10 million parts of air.

Procedure	Tooling
a. Introduce small quantity of helium-charged air into bulkhead. (See Figure 2-2.)	Helium detector (type 24-120 or equivalent); Test equipment 8FS-5908;
b. Test exposed welds with leak detector and sampling probe.	Hydrostatic test fixture
c. Inspect and verify weld quality.	

2.1.1.4 Major Subassembly Hydrostatic Test

2.1.1.4-1 The completed common bulkhead with the two lower LH_2 cylinders and LOX girth bolting ring attached will be hydrostatically tested prior to further assembly operations. (See Figure 2-3.)

Procedure	Tooling
a. Load common bulkhead in test fixture.	Hydrostatic test fixture T-7200009
b. Install closeout plates over openings in LH_2 Cylinder 2.	Test covers 8FS-5909
c. Hook up STE fill and drain lines and vent lines.	Hydrostatic test unit 8FS-5909
d. Fill lower compartment with demineralized treated water.	
e. Pressurize lower compartment as prescribed in process specification MA0208-1001.	
f. Install upper dome on test fixture to close off upper end of LH_2 Cylinder 2.	
h. Fill upper compartment with treated demineralized water.	
i. Pressurize upper and lower compartment per process specification. MA0208-1001.	

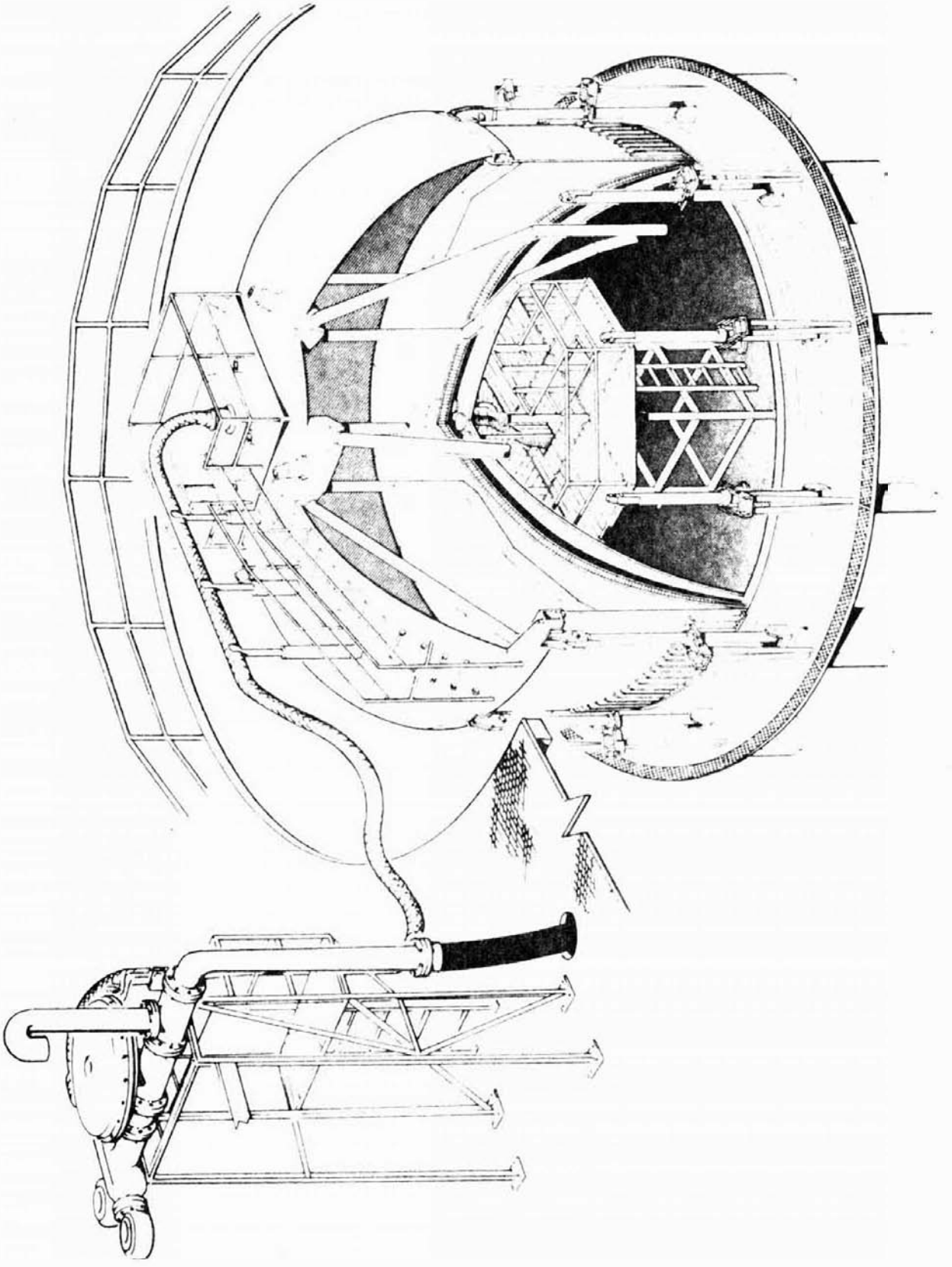


Figure 2-3. LOX Tank in Hydrostatic Holding Fixture (T-72060)

Procedure	Tooling
j. Inspect assembly for leakage.	
k. Drop pressure; drain and dry both compartments.	

NOTE: Tanks will receive dye penetrant inspection of all welds after pneumatic test.

2.1.1.5 The Pneumatic Test

2.1.1.5-1 The pneumatic pressure test (pneumastat) is performed on the S-II stage prior to vehicular system installations. The test is made at a remote area with the stage in a horizontal position. The structural integrity of the stage already has been partially established by hydrostatic testing operation at Station VI; thus a pressurized tank rupture accompanied by violent gaseous expansions, although still possible, is unlikely to occur. For this reason, the pneumastatic test is performed at a remote area using a GN_2 supply, test covers 8FS-5917, and control test equipment 8FS-5917.

2.1.1.6 LH_2 and LOX Tank Preliminary Cleaning

2.1.1.6-1 Preliminary cleaning of the interior of the LH_2 and LOX tanks will be accomplished prior to hydrostatic testing.

Procedure	Tooling
a. Ready the necessary equipment for preliminary cleaning.	Filtered air blower, breathing apparatus, special work stands
b. Install air blower to container opening.	
c. Thoroughly vacuum interior of tank, removing all chips and foreign matter.	Cyclone cleaner with 100-foot flex-hose
d. Starting at bottom of tank and working toward opening, wipe and/or brush interior and remove all visible greases, oils, and stains by using detergent solution and trichloroethylene (ABMA-C-4). Caution is to be taken to ensure that blowers and breathing apparatus work properly while trichoroethylene is in use.	White static-, lint-, and oil-free cloth and Nylon-bristled brushes

Procedure	Tooling
e. Inspect for loose foreign matter.	
f. Remove all preliminary cleaning equipment from tank.	
g. Disconnect air blower.	
h. Reinstall manhole and vent covers.	

2.1.1.7 LOX Tank Cleaning

2.1.1.7-1 Cleaning operations will be accomplished after pneumastatic test operation while the stage is in a vertical position.

Procedure	Tooling
a. Install shutoff valve and drain hose to vent opening.	Fire hose, 6-inch diameter, 100 feet long, with 4-inch valve
b. Insert cleaning boom and spray nozzles, commence impingement detergent spray cycle; spray detergent per process specification MA0610-0001.	Spray nozzle, rotating jet with maximum operating pressure of 200 psi at 120 to 130 F and rotation speed of 2 rpm, 200-foot cleaning radius
c. After detergent cleaning is complete, spray rinse per process specification MA0610-00001.	
d. During rinse cycle, Quality and Reliability Assurance personnel will sample water to assure particle count conformance with MA0610-0001.	
e. Dry tank with hot, oil-free air at 140 to 180 F.	Hot air blower (and insulated ducts that will filter air to 100-micron level (absolute)

Procedure	Tooling
f. Insert cleaning spray probe and nozzle; commence impingement spray cycle (using trichloroethylene) until nonvolatile residue and particulate contamination pickup conform to process specification MA0610-001.	
g. Thoroughly dry container using hot, oil-free air at 170 to 180 F.	
h. Install manhole and LOX sump.	
i. Inspect manhole cover installation and torque.	
j. Inspect and seal LOX tank.	Test covers 8FS-5914
k. Pressure LOX tank with missile clean air to prevent contamination.	Pressurization unit 8FS-5914

2.1.1.8 LH_2 Tank Cleaning

2.1.1.8-1 Following the completion of the LOX tank cleaning the stage will be inverted and the LH_2 tank will be cleaned per MA0610-001.

Procedure	Tooling
a. Lift stage from support fixture T-7200109	70-ton bridge cranes
b. Invert stage and secure on fixture T-7200109	Support fixture T-7200109
c. Insert cleaning boom and spray nozzles in LH_2 tank.	
d. Spray detergent per process specification MA0610-001.	
e. Spray rinse water per process specification MA0610-001.	

Procedure	Tooling
f. During rinse cycle, Quality and Reliability Assurance personnel will sample water to assure particle count conformance with MA0610-001.	
g. Dry LH_2 tank with hot, clean, oil-free air.	
h. Inspect tank for cleanliness.	
i. Seal tank openings.	8FS-5914 test covers
j. Pressurize LH_2 tank to prevent recontamination.	8FS-5914 pressurization unit
k. Rotate stage to normal position and secure on T-7200515 tool.	T-7200515 support fixture

2.2 PNEUMATIC PRESSURE TEST

2.2-1 The pneumatic operations in Station IV consist of proof pressure and leak check of the stage pressurization system and engine systems. Piping and equipment are checked by STE model 8FC-5910 by using operating manuals that comply with the proof-pressure and leak-check portion of the process specifications, MA0206-1028 and MA0210-1060.

2.2-2 Functional tests of the stage system are performed in Stations VIII or IX following the proof pressure and leak-check in Station IV.

3.0 GROUND SUPPORT EQUIPMENT

3.0-1 The ground support equipment (GSE) for the Saturn S-II stage will be composed of electronic, electrical, electromechanical and mechanical assemblies of both procured and S&ID-fabricated items at the component, module assembly, and rack (end item) assembly level.

3.1 PROCURED ITEMS

3.1-1 Quality and Reliability Assurance (Q&RA) will assure the mechanical and electronic excellence of procured items prior to the acceptance for use in S-II GSE as outlined in the Q&RA document.

3.2 SD-MANUFACTURED ITEMS

3.2-1 S-II GSE will be fabricated in the GSE assembly area in accordance with the specified drawing and specification requirements. Emphasis will be placed on the quality of workmanship and material handling. Fabrication procedures will be approved and controlled as outlined in the Q&RA document.

3.3 MODULE ASSEMBLY

3.3-1 In the module assembly area, electrical and electronic components, such as relays, resistors, capacitors, diodes, and transistors will be assembled into functional modular assemblies, such as logic cards, relay driver cards, and amplifiers per assembly instruction documents and applicable engineering drawings.

3.3-2 Before a module leaves the assembly area, the FAIR ticket will be signed by the assembler and stamped by a member of Q&RA, who has verified that the module has been assembled in accordance with applicable engineering drawings and specifications and is free of improperly mounted or damaged components, improperly soldered connections, etc.

3.4 MODULE TESTING

3.4.1 ELECTRONIC MODULES

3.4.1-1 Module testing will be performed on all in-house fabricated GSE modules. These tests will be performed using special test equipment (STE) test consoles, adapters, and operating manuals approved and certified by Q&RA. Module testing will be in accordance with the applicable engineering process specification and will accurately simulate the operational condition to which the module will be subjected in the operational drawer assembly or system for which it was designed. The testing of each module assembly will be witnessed and verified by a member of Q&RA in accordance with the Q&RA document.

3.4.2 MECHANICAL MODULES

3.4.2-1 Mechanical modules, such as control valves, pressure regulators, and gauges, will be thoroughly tested by the supplier prior to an initial acceptance and functional test in the SD receiving inspection area.

3.5 DRAWER ASSEMBLY

3.5.1 ELECTRICAL/ELECTRONIC DRAWERS

3.5.1-1 Intermediate steps of assembly (Figure 3-1), such as the installation of panels, chassis carrier cards, and wire harnesses, will be carried out in the drawer assembly area. During these steps, Q&RA personnel will verify that the assembly is in accordance with the applicable engineering drawing and specification, and is free of improperly mounted or damaged components, improper solder connections, etc. Prior to the installation of damageable electrical or electronic modules, the drawer will be given a complete continuity test and verified by Q&RA personnel. When the continuity test has been accepted by Q&RA, the electrical/electronic modules will be installed and the drawer assembly completed.

3.5.1-2 Before a drawer assembly leaves the assembly area, the FAIR ticket will be signed by the assembler and stamped by a member of Q&RA, who has verified that the assembly is complete and in accordance with the applicable engineering drawings, specifications, and Q&RA procedures.

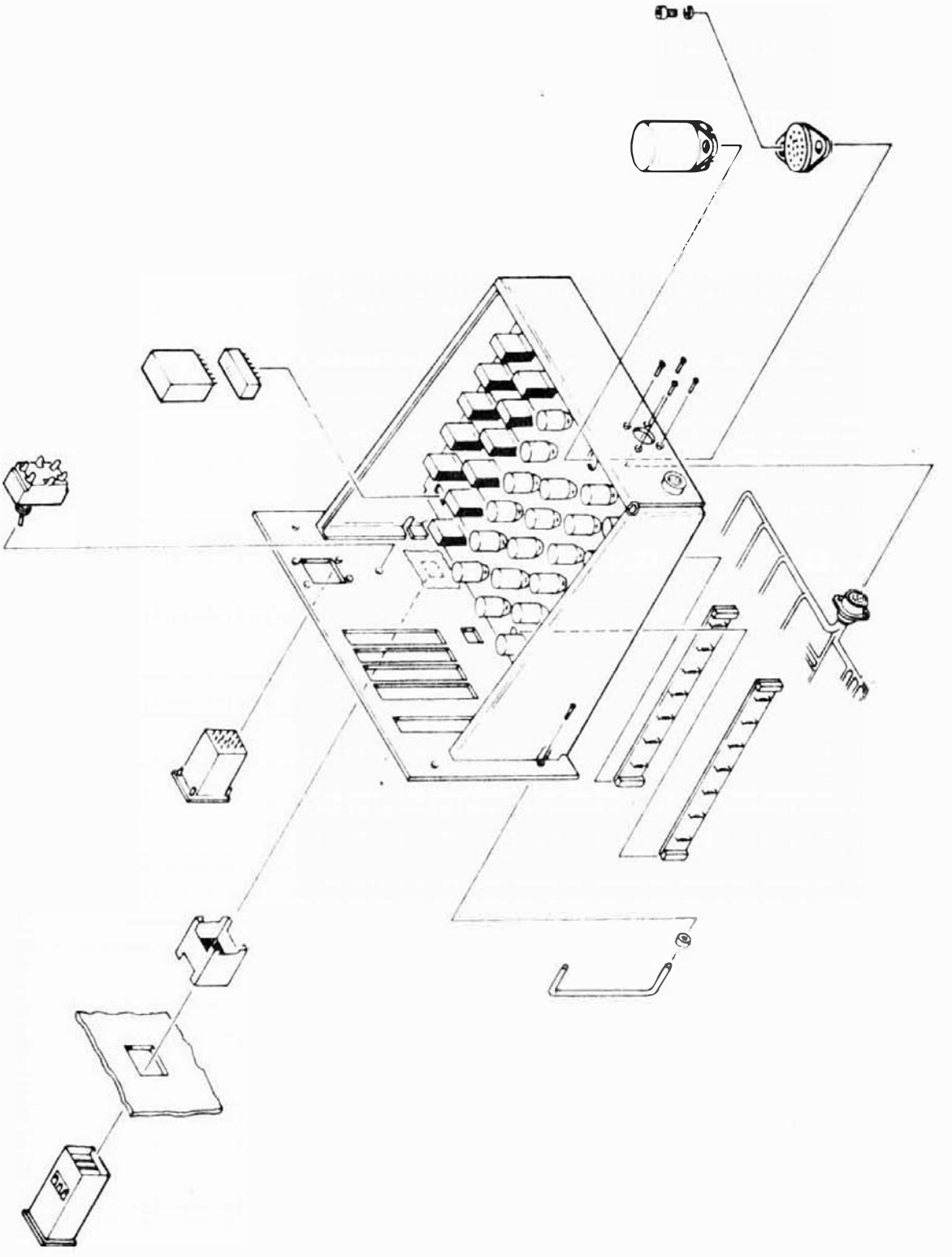


Figure 3-1. Typical GSE Drawer Assembly

3.5.2 MECHANICAL DRAWERS

3.5.2-1 Mechanical drawer assembly will be conducted in the same fashion as electrical/electronic drawer assemblies, with the exception of the installation of tubing, valves, regulators, gauges, etc.

3.6 DRAWER TESTING

3.6.1 Drawer testing will be performed on all in-house fabricated GSE electrical, electronic, or mechanical drawer assemblies. These tests will be performed using STE test console, adapters, and operating manuals approved and certified by Q&RA. Drawer testing will be in accordance with the applicable engineering process specification and will accurately simulate the operational conditions to which the drawer assembly will be subjected in the rack (end item) assembly or system for which it was designed. The testing of each drawer assembly will be witnessed and verified by a member of Q&RA in accordance with the Q&RA document.

3.7 RACK (END ITEM) ASSEMBLY

3.7.1 ELECTRICAL/ELECTRONIC RACKS

3.7.1-1 In the rack (end item) assembly area as intermediate steps of assembly, such as panels, hardware, and cable harness assemblies, are finished, Q&RA personnel will verify that the assembly is per applicable engineering drawings and specifications. Prior to the installation of any damageable drawer assemblies, the rack will be given a complete continuity test and verified by Q&RA personnel. If the continuity test has been accepted by Q&RA, then the drawer assemblies will be installed and the rack assembly completed.

3.7.1-2 Before a rack leaves the assembly area, the FAIR ticket will be signed by the assembler and stamped by a Q&RA member who has verified that the assembly is complete and in accordance with the applicable engineering drawings, specifications, and quality control procedures.

3.7.2 MECHANICAL RACKS

3.7.2-1 Mechanical rack assembly will be conducted in the same fashion as electrical/electronic drawer assemblies with the exception of the installation of tubing and leakage test thereof.

3.8 RACK (END ITEM) TESTING

3.8-1 Rack testing will be performed on all in-house fabricated GSE rack (end item) assemblies. These tests will be performed using STE test consoles, adapters, and operating manuals approved and certified by Q&RA. Rack testing will be in accordance with the applicable engineering process specification and will accurately simulate the operational condition to which the rack assembly will be subjected in the operational system for which it was designed. The testing of each rack assembly will be witnessed and verified by a member of Q&RA in accordance with the engineering process specification and the Q&RA document.

3.9 CABLE HARNESSING ASSEMBLIES

3.9-1 Cable harnesses are fabricated by using dimensional tools certified by Q&RA and systems manufacturing engineering assembly instruction documents. All wiring, spot ties, crimping and soldering connections, etc., are inspected for conformance to the applicable Engineering documentation. A continuity and insulation resistance test is performed on the cable harnesses after they are installed into the GSE drawer and rack assemblies. This testing is performed in accordance with the applicable Engineering process specification while utilizing STE operating manuals, automatic and/or fixed programmed continuity and insulation resistance test equipment, programmed test tapes and/or matrix charts, patchboards, and cable adapters (STE model 8FC-5437), which are reviewed, appraised, and certified by Q&RA.

3.10 TUBING ASSEMBLIES

3.10-1 Tubing assemblies will be fabricated using dimensional tools to ensure subsequent unit configuration. All tubing details and assemblies will be inspected by a Q&RA member who will verify that all tubing is in accordance with the applicable drawings, specifications, and Q&RA procedures.

3.11 CALIBRATION

3.11-1 Electrical, electronic, pneumatic and hydraulic measuring devices will be calibrated and serviced prior to installation into drawer and rack assemblies. All devices will be individually calibrated or serviced, with Q&RA verification, in a complete laboratory which merits secondary and laboratory calibration standards in accordance with requirements of the U.S. Bureau of Standards. The standard parameters established by Q&RA and Engineering specifications will be met. Figures 3-2 through 3-5 show typical checkout equipment.

3.11-2 All GSE and STE will be completely inspected, serviced, and calibrated at regular intervals.

3.12 POTTING AREA

3.12-1 The potting area has facilities with high-quality systems and equipment to provide a high capability in the area of potting, encapsulation, and coating operations.

3.12-2 Some of the latest equipment used in this area include an ultrasonic cleaner for cleaning soldered assemblies, a vapor degreasing system for vapor cleaning electronic assemblies and printed circuit boards, and a chemtronic vapor spray system for applying high solid coating to electronic assemblies. Additionally, the area is equipped with high-quality conventional equipment, including vacuum deaeriation units, curing ovens, spray booth, nitrogen pressure system, triple beam balances, potting guns, and all other tools and equipment needed for the potting, encapsulation, and coating operations.

3.13 MODIFICATION AND REPAIR AREA

3.13-1 The modification and repair area serves as the manufacturing control center for all S&ID-built items requiring modification or repair. The control center routes reparables to the cognizant SD manufacturing group for modification and repair and monitors the progress of the work on these items.

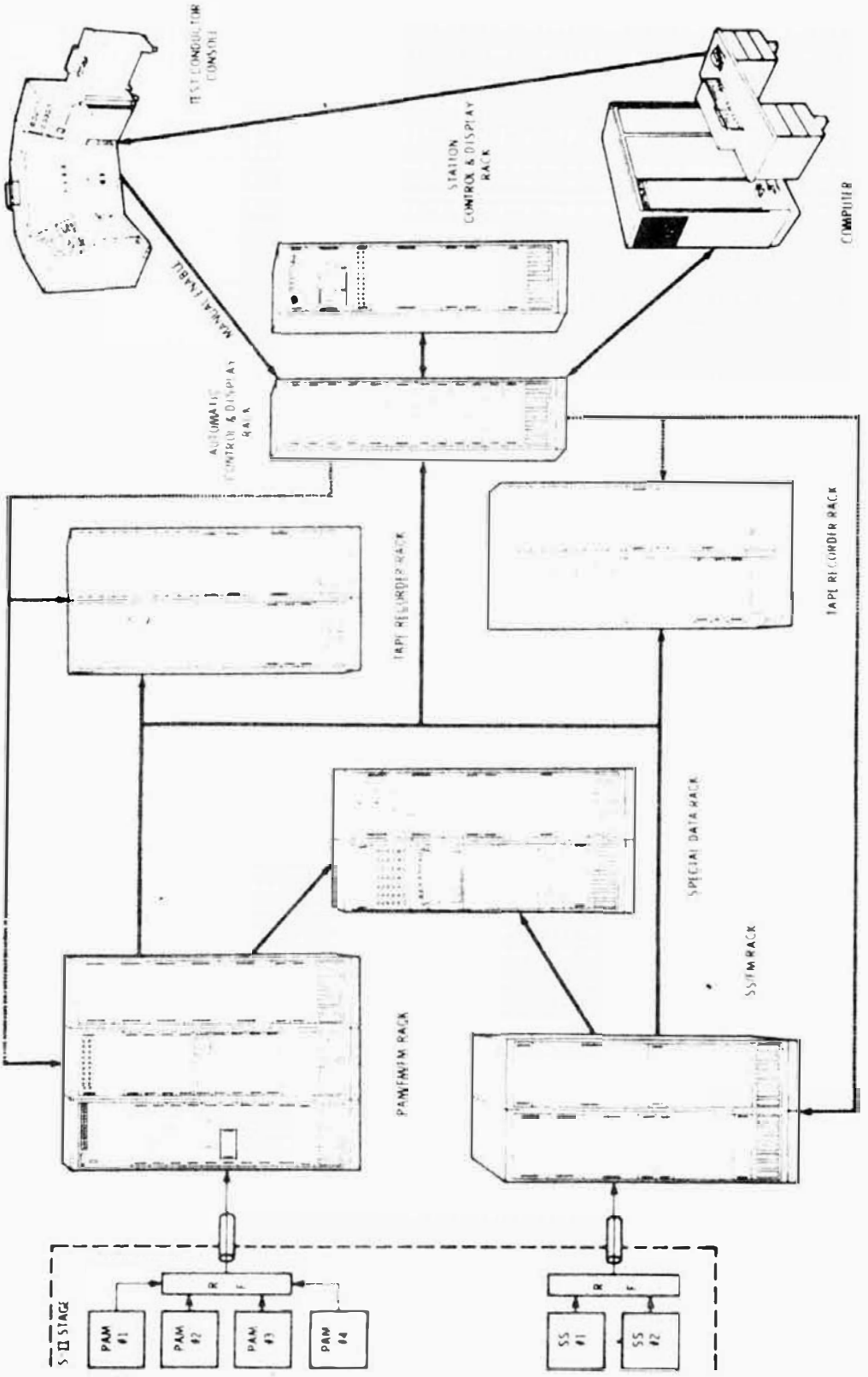


Figure 3-2. Telemeter Checkout Station

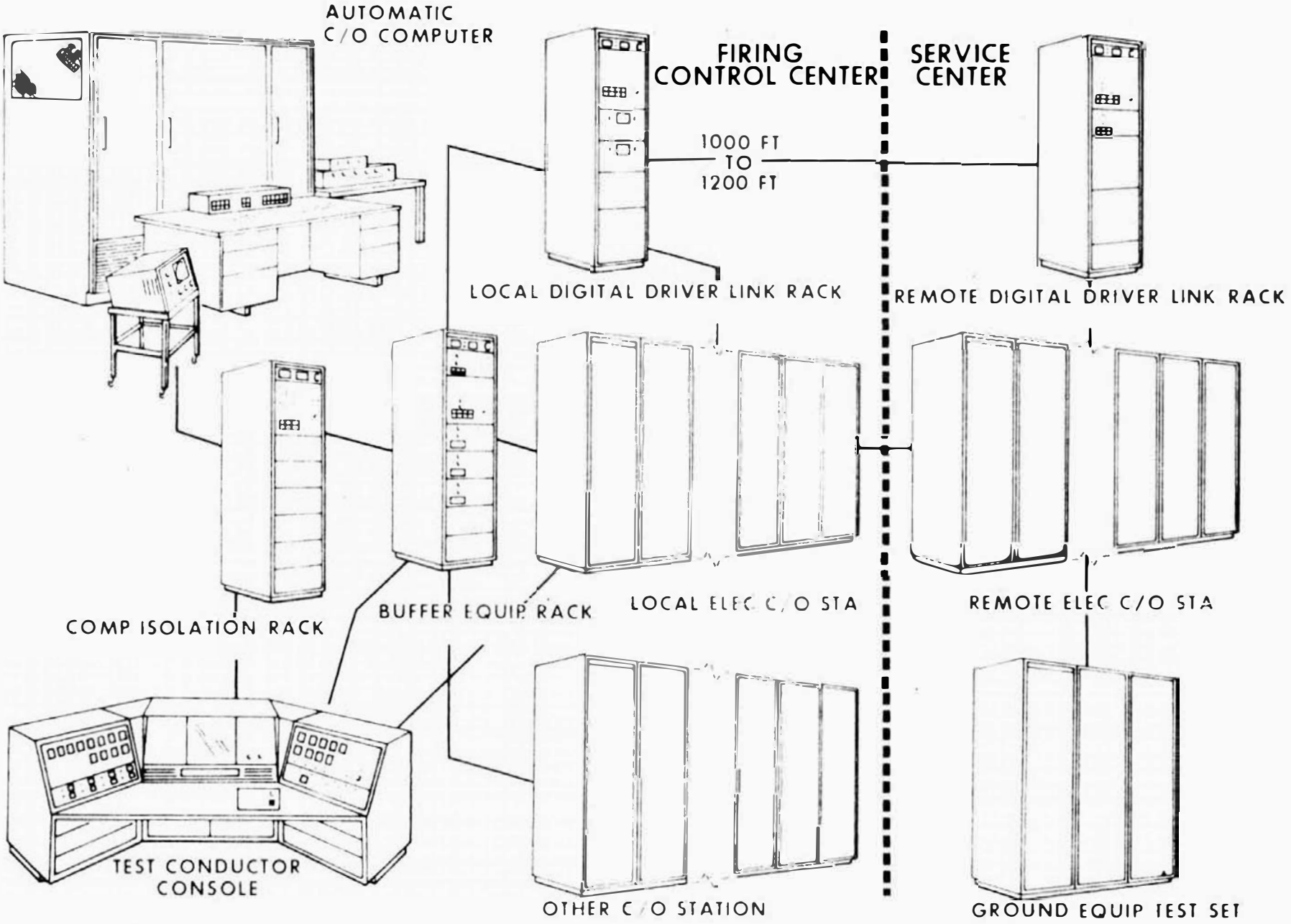


Figure 3-3. S-II Automatic Checkout Equipment

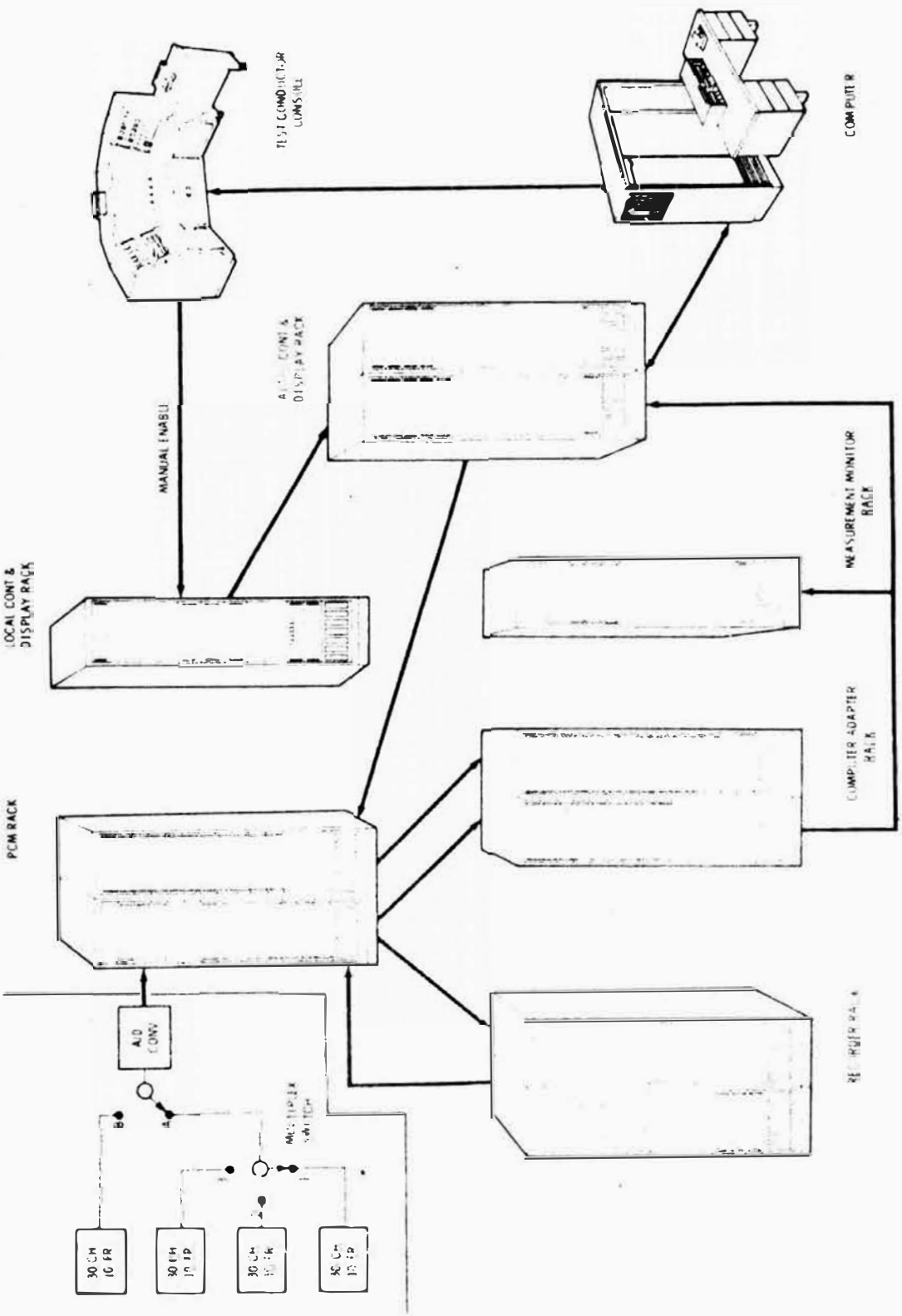


Figure 3-4. Digital Data Acquisition Station

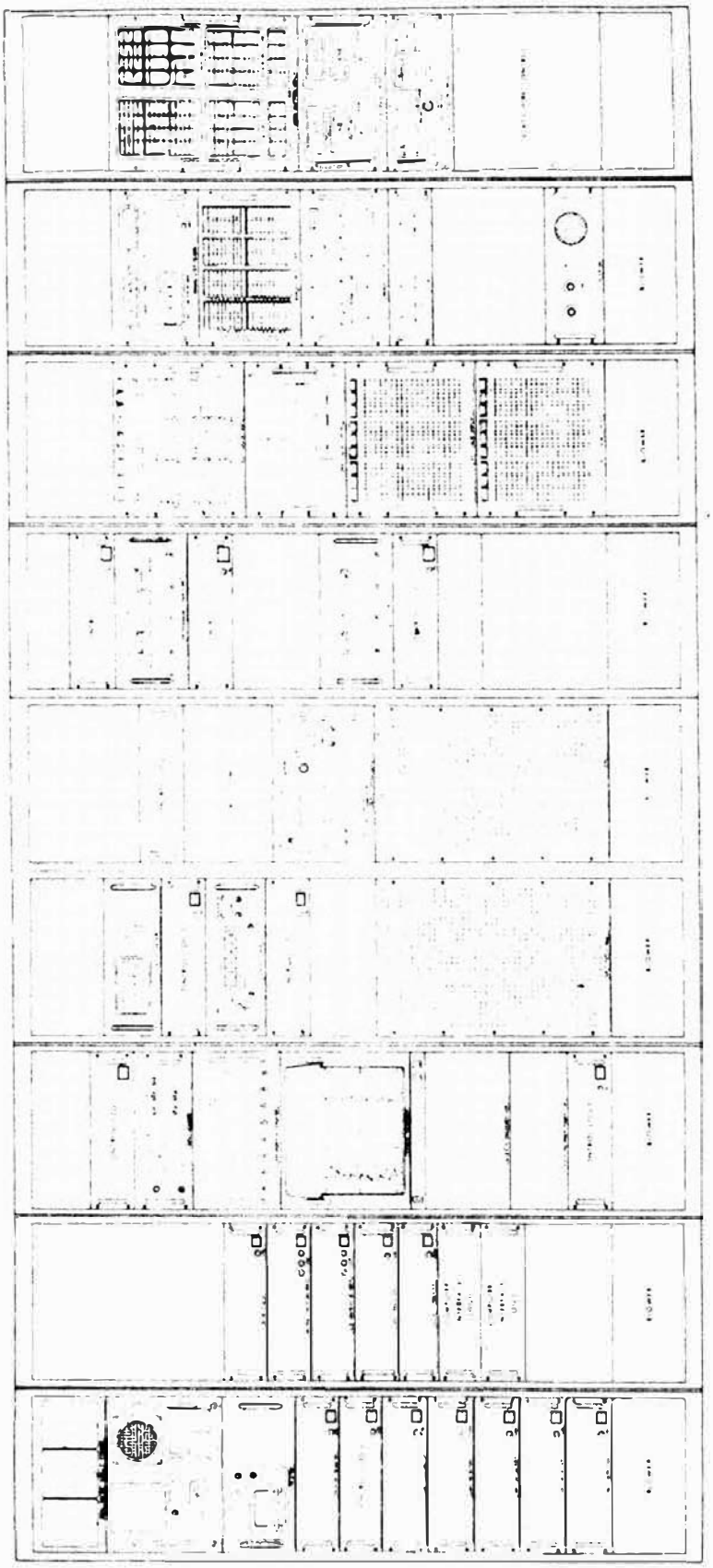


Figure 3-5. Electrical Checkout Station

4.0 SPECIAL TOOLING

4.0-1 Bulkhead welding, cylindrical-section longitudinal welding, and final assembly operations require major tool complexities. In these operations, multiple functions are required of each tool. A description of the fabrication and capabilities of these tools is outlined in this section. Complete lists of tools and systems measuring devices are also included.

4.1 TOOLING ASPECTS

4.1.1 FINAL ASSEMBLY WELD FIXTURE

4.1.1-1 Final assembly in a vertical position is based on a building block concept. In this position, subassembly loading, circumferential exactness, and station locating is benefited by the even gravitational force exerted during each assembly routine. Constant checks and verification of station planes and stage alignment are maintained during each joining procedure by the use of Taylor-Hobson scopes, Wild levels, theodolites, and the traditional plumbing devices.

4.1.1-2 Circumferential welding of tank components is accomplished with the use of vacuum cup-supported skate track. Two welding heads operate in unison, 180 degrees apart, to minimize weld growth and stress riser problems. Preweld trimming operations and postweld radiographic inspection also use the skate and skate-track tools for their procedures. No attachment to, or support from, the tower structure is allowed for either the stage or tooling during assembly procedures. Tower-supported section positioners are used only during initial loading procedures (to assist in correct placement of stage substructures).

4.1.1-3 Internal round-out tooling and weld backup bars are supported by vacuum cup attachment to the stage interior. All interior tooling is disassembled then removed through the tank manhole.

4.1.2 BULKHEAD WELD FIXTURES

4.1.2-1 The bulkhead welding fixtures are dome-like tools that weld bulkhead segments together. An elliptically contoured, hydraulically

operated weld boom extends from the outer periphery to the dome center. Four bulkhead welding fixtures are required: one for the forward bulkhead; a second for the lower common bulkhead diaphragm; a third for the upper common bulkhead diaphragm; and a fourth for the LOX aft bulkhead. All tools are similar both structurally and operationally.

4.1.2-2 A hydraulically clamped center shaft positions and supports the weld boom at the center during segment welding operations. Incorporated in the boom are clamping and supporting mechanisms with a dual-track system for welding equipment and for operator travel during the welding operation. The welding equipment carriage and platform roller is powered with variable-speed motors to accommodate all welding speed requirements. The boom base remains stationary while the part is rotated into position.

4.1.2-3 The dome framework is equipped with vacuum chuck facilities that hold each segment in its proper position after loading. At each welding position, the required pressure is applied to the weld area by the boom during the elliptical travel of the weld head.

4.1.2-4 After each segment is weld-joined and radiographically inspected within the tool, the diaphragm is rotated to the next weld location by electromechanical drive-and-lock mechanisms. After all welding and inspection operations have been successfully completed, the boom is hydraulically pivoted to permit removal of the welded bulkhead.

4.1.3 SKIN CYLINDER LONGITUDINAL WELD FIXTURE

4.1.3-1 The skin cylinder longitudinal welding fixture performs the vertical weld-joining of the four-panel cylindrical sections. Each panel assembly will be circumferentially placed in the longitudinal welding fixture and held by vacuum chucks. The panels remain stationary during this assembly procedure. The vacuum cups are mounted on each side of each mold line contour bar. The contour bars have a 3-inch travel limit in both directions from the index location to facilitate loading of the large panels. Four grooved backup bars with side-mounted vacuum cups are located so that the longitudinal weld edges are precisionally aligned and held for welding at those locations.

4.1.3-2 The welding equipment is mounted on an electrically powered dolly. Included on the dolly is a weld-operator carriage that uses a dual chain drive and a variable-speed motor control to permit vertical operator travel. The dolly is positioned to locate and vertically align the weld skate and track; it will then be moved into the operator control and observation position. The vertical-climb welding procedure is controlled from a console that is mounted on the carriage within easy reach of the operator.

After each weld has been completed and radiographically inspected, the dolly is repositioned to load the weld skate and track. The dolly is then moved to the next weld station. When the four longitudinal welds have been satisfactorily completed, the frame splices are installed and riveted to complete the assembly.

4.2 TOOLING LIST

4.2-1 A list of S-II stage tooling requirements is presented in Table 4-1.

Table 4-1. Tooling Requirements

Tooling	Application	No. Required
LH_2 CYLINDER ASSEMBLY		
Subassembly jig T-7200017	Subassembly of panel frame, webs, and caps	2
Assembly jig T-7200036	Installing frames to skin panel segments	2
Longitudinal welder T-7200001	External fusion welding of panels to complete LH_2 cylinder	2
Weld pack	400-amp, dc, tungsten inert gas (dc-TIG)	1
Fuel outlet welder T-7200423	Welding fuel outlet assembly to cylinder panels	1
Weld pack	400-amp, dc, tungsten inert gas (also used on T-7200536)	1
Bonding fixture T-7200198	Bonding insulation to cylinder panels	1
Bonding fixture T-7201320	Bonding insulation to cylinder panels	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
Manufacturing requirement sheets T-7200437 T-7200439 T-7200446	Detail machining	1 each
Numerical control machine data T-7320235 T-7320236 T-7320230 T-7320231 T-7320215 T-7320238 T-7320239 T-7320240 T-7320241 T-7320242 T-7320243 T-7320244	Detail machining	1 each
Apply jig T-7320411 T-7320237	Detail machining	1 each
Check jig T-7320232 T-7320233	Detail machining	1 each
Tracer pattern T-7320449 T-7320450	Detail machining	1 each
Master T-7320234	Detail machining	1
T-7320412	Detail machining	1
T-7320191	Detail machining	1
T-7320433	Detail machining	1
T-7320426	Detail machining	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
FORWARD BULKHEAD ASSEMBLY		
High-energy forming die T-7200049	High-energy forming bulkhead segments	1
Trim and drill fixture T-7320437	Rough trim and tool hole drilling of segment panels prior to weld joining	1
Weld fixture T-7200120	Weld-joining bulkhead segments and X-raying	1
Weld pack	400-amp, dc, tungsten inert gas (dc-TIG)	1
Weld fixture T-7200077	Welding manhole ring, trimming, and X-raying	1
Weld pack	600-amp, dc, tungsten inert gas (dc-TIG)	1
Hydrostatic test fixture T-7200010	Pressure-testing bulkhead	1
Drill plate T-7200718	Drilling manhole cover attach	1
Weld fixture T-7200536	Welding systems plate in segment	1
Weld pack	400-amp, dc, tungsten inert gas (dc-TIG) (also used on T-7200423)	1
Drill plates T-7200708 T-7200710	Drilling systems plate	1 each
Bond fixture T-7200519	Curing insulation on forward bulkhead	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
Autoclave T-7200099	Bonding	1
Trim fixture T-7320211	Rough trim and drill segment edges prior to weld joining	1
Trim fixture T-7320438		1
Trim fixture T-7320443		1
Trim fixture T-7320185	Locate tool holes	1
Manufacturing requirement sheet T-7200347	Special instructions	1
Manufacturing requirement sheet T-7320589	Special instructions	1
Manufacturing requirement sheet T-7200861	Special instructions	1
Manufacturing requirement sheet T-7320596	Special instructions	1
Manufacturing requirement sheet T-7320589	Special instructions	1
Manufacturing requirement sheet T-7200349	Special instructions	1
Inspection check fixture T-7320161	Check gores	1
Inspection check fixture T-7320167	Check contour	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
Inspection check fixture T-7320163	Check machining	1
Inspection check fixture T-7320184	Check machining	1
Heat treat fixture T-7320170	Gore panels	1
Heat treat fixture T-7320176	Gore panels	1
Heat treat fixture T-7320179	Gore panels	1
Heat treat fixture T-7320181	Gore panels	1
Pick-up jig T-7200117	Bulkhead pick-up jig	1
Bond fixtures T-7200427	Base fixture	1
Bond fixtures T-7200390	Holding fixture	1
Bond fixtures T-7201003	Support fixture	1
Bond fixtures T-7201013	Core cutter and drive unit	1
Cutting beam T-7200415	Honeycomb machine fixture	1
Vacuum bell T-7200514	LOX common bulkhead	1
Tracing beam T-7200982	For Sanborn recorder	

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
BULKHEAD INSULATION		
Bench operations	Trimming insulation segments	
Bond fixture T-7200519	Applying adhesive to insulation inside surface	1
COMMON BULKHEAD		
High-energy forming die T-7200047	Forming lower thick segment	1
High-energy forming die T-7200048	Forming upper thin segment	1
Trim fixtures T-7200438 T-7320168 T-7320247 T-7320197 T-7320198	Rough trim and drill thick/thin segment edges prior to weld joining	1 each
Weld fixture T-7200052	Weld-joining thick/thin segments	1
Weld pack	400-amp, dc, tungsten inert gas (dc-TIG)	1
Weld fixture T-7200002	Weld-joining upper diaphragm segments	1
Weld pack	400-amp, dc, tungsten inert gas (dc-TIG)	1
Weld fixture T-7200181	Welding J to thin	1
Weld pack	400-amp, dc, tungsten inert gas (dc-TIG)	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
Weld fixture T-7200003	Weld-joining common bulkhead lower diaphragm and aft bulkhead segments	1
Weld pack	400-amp, dc, tungsten inert gas (dc-TIG)	1
Power hammer	Forming bulkhead center domes	1
High-energy forming die T-7200050	Forming bulkhead thin skin	1
Stretch form die T-7200401	Forming J skin panel	1
Weld fixture T-7200077	Welding dome in bulkheads	1
Weld pack	600-amp, dc, tungsten inert gas (dc-TIG)	1
Bond fixtures BJ-7200067 BJ-7200377 BJ-7200378 BJ-7200379	Assembling, trimming, and bonding honeycomb core segments	1 each
Bond fixtures T-7200004 T-7200174 T-7200175	Bond-curing bulkhead	1 each
Autoclave T-7200099	Bond-curing honeycomb bulkhead	1
Handling fixture T-7200514	Handling bulkhead	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
Hydrostatic test fixture T-7200009	(Bulkhead inversion operations) Hydrostatic test fixture	1
Inspection fixture	Ultrasonically inspecting honeycomb bulkhead	1
AFT BULKHEAD ASSEMBLY		
Tooling requirements for this bulkhead are similar to those for the common bulkhead. However, no insulation or bonding tools are required.		
FORWARD SKIRT ASSEMBLY		
Subassembly jig	Assembling frames	1
Subassembly jig T-7630102	Assembling skin and stringers	1
Assembly jig T-7630105	Mating skirt panels and drill pilot holes	1
Master - coordinate hole pattern to match S-IVB T-7200019	Master forward interface	1
Master - mating gauge T-7200005	Mating gauge forward (See Figure 4-1.)	1
AFT SKIRT ASSEMBLY		
Subassembly jig T-7630073	Assembling skin frames and stringers	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
Assembly jig T-7200013	Assembling complete panel and mating	1
AFT INTERSTAGE ASSEMBLY		
Subassembly jigs T-7630061 T-7630062 T-7630063	Assembling frames	1 each
Master T-7201486		1
Subassembly jigs T-7630064 T-7630065	Assembling skin, frames, and stringers	1 each
Assembly jig T-7630067	Assembling skin assembly and frames to complete panel assembly	1
Subassembly jig T-7630065	Assembling door assembly	1
Master - coordinate interface attach pattern S-II to S-IC, T-7200084	See Figure 4-1	
Master - control separation interface, T-7200085	See Figure 4-1	
Assembly jig	Mating interstage panels and drilling attach bolt pattern	1
Subassembly jig	Assembling antenna door	1
Subassembly jig	Assembling access door	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
THRUST STRUCTURE CONE ASSEMBLY		
Subassembly jig	Assembling frame segments	1
Subassembly jig	Assembling frame and skin	1
Subassembly jig		
Monorail and hoist	Automatic welder	1
Access platform	Propellant lines and rocket engine installation	1
THRUST STRUCTURE ASSEMBLY		
Subassembly jig	Mating cone assembly and aft skirt	1
HEAT SHIELD ASSEMBLY		
Subassembly jig	Assembling frames	1
Subassembly jig	Assembling web assemblies	1
Subassembly jig	Assembling support beam	1
Assembly jig	Assembling beams, frames, and web assemblies	1
Master - coordinate attach bolt pattern		
HANDLING FIXTURES		
Collapsible work platform	LOX tank operations	1
Mobile work platform	Welding and installation operations	1

Table 4-1. Tooling Requirements (Cont)

Tooling	Application	No. Required
Collapsible work platform	LH_2 tank operations	1
Electrical motorized bench with 250-pound capacity	General usage	1
FINAL ASSEMBLY WELD PACKS		
Weld pack	600-amp, dc, tungsten inert gas (dc-TIG) (use with T-7200040)	3
Weld pack	600-amp, dc, tungsten inert gas (dc-TIG) (use with T-7200761)	1

4.3 SPECIAL TEST EQUIPMENT

4.3.1 Special test equipment (STE), previously identified as systems measuring devices (SMD), are implements of in-plant equipment required to manufacture or check out S&ID products to the specifications ultimately set forth by the customer. These devices are motivated by Systems Manufacturing Engineering (SME) and may be of a special design (STE) or of ground support equipment (GSE) design, depending upon specific factory requirements. These devices may range from a simple mechanical device, such as a gauge, to a 13-bay, 31-rack electrical checkout station that is used in the systems checkout of the vehicle. Special test equipment is provided by the (SME) group to the Manufacturing departments when unique implements are required to measure the input or output of a system or its components (as dictated by the specifications set forth by Engineering or by the customer) to ensure the reliability and accuracy of the deliverable product. The SME group orders GSE items for Manufacturing to be used as test equipment within the factory. Factory GSE is, therefore, identical to deliverable GSE; and, where identical systems or component testing is required, the GSE is utilized to its fullest extent to provide the customer with a financial advantage Those items previously identified as SMD shall retain the identity of SMD throughout the Saturn S-II program, and shall be recognized as STE.

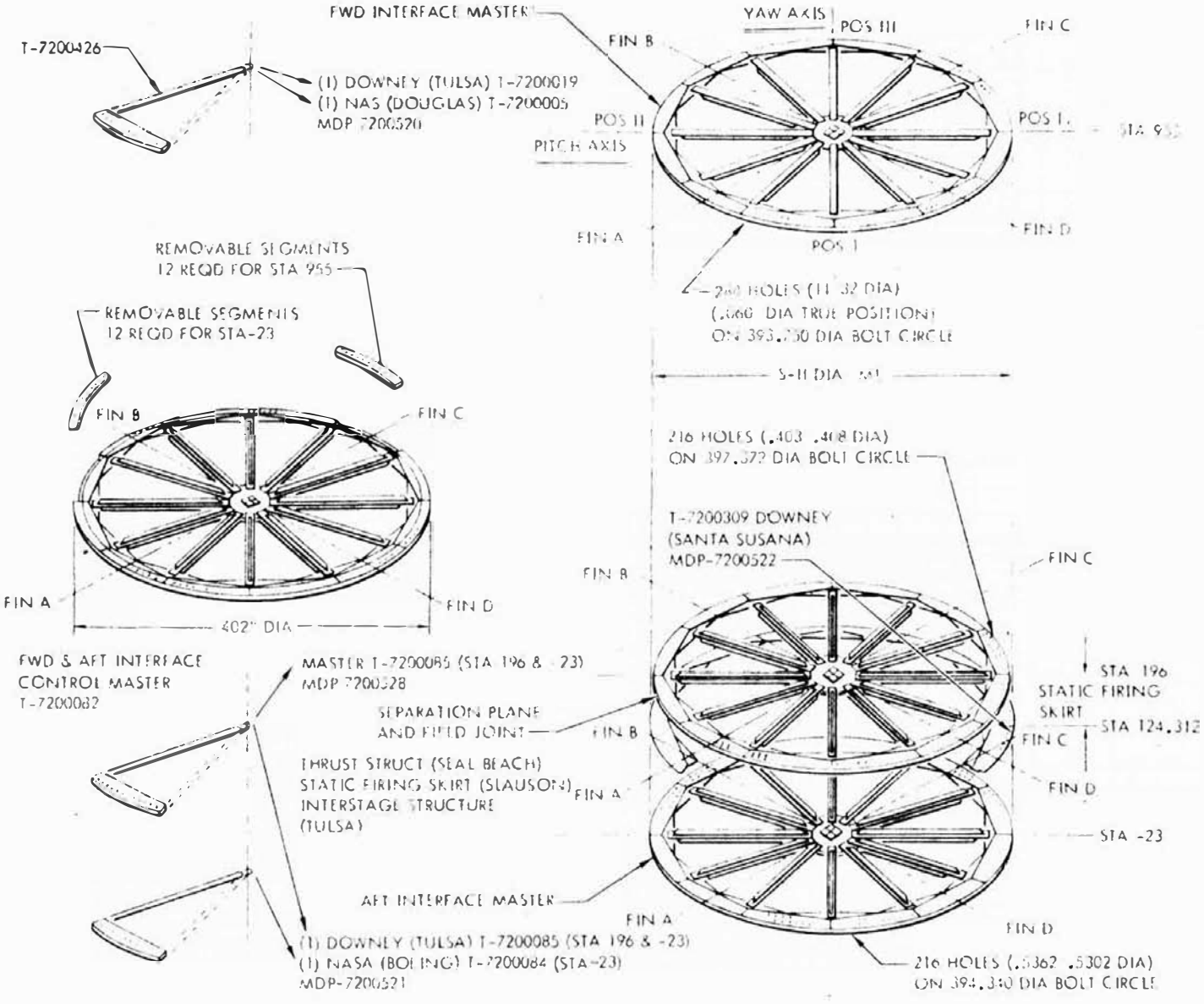


Figure 4-1. Master Mating Gauges

4.3.2 The components, subassemblies, and assemblies of STE and factory GSE will be manufactured or purchased and will be inspected visually to verify acceptable levels of workmanship and reliability. Each STE and end item of factory GSE will be inspected to verify complete physical and functional conformance to applicable documentation. This equipment will be periodically serviced and calibrated in accordance with established Quality and Reliability Assurance procedures. Factory GSE will receive the same inspection and Quality and Reliability Assurance as will deliverable GSE and STE in process physical inspection at all levels of fabrication (detail, subassembly, and assembly); however, the functional inspection will be performed only at the end-item level in accordance with the applicable acceptance checkout procedure.

4.3.3 The acceptance checkout procedure is the document used by Quality and Reliability Assurance for accomplishing functional checkout of STE at the initial acceptance and for inspecting verification of operations at subsequent major change points. The document is applicable only to the unit or units that are listed in the procedure, and it establishes methods and procedures essential to the checkout (testing) and maintenance of the units. The acceptance checkout procedure is maintained by Systems Manufacturing Engineering.

4.3.4 The operation of STE is established by an operating manual that is an instruction guide for operating a specific STE model. These instructions are complete, step-by-step directions that will leave no assumptions to the discretion of the operator. Each operating manual is applicable only to the unit or units listed in the manual. An operating manual is compiled as a directive for the operator to follow when using STE to check out an airborne or GSE part (functional part, subassembly, assembly, or end item) in accordance with the applicable process specification requirements.

4.3.5 STE requirements are shown in Tables 4-2, 4-3, 4-4, and 4-5.

Table 4-2. Vehicle Systems Functional Test Equipment

Model Number	Description	Quantity
8FC-0025	Operating Manuals for Stage Testing During Manufacturing (Sets)	10 sets
8FC-0027	Operating Manuals - Bench Test of S-II Cont	1 set
8FC-5408	Automatic continuity analyzer support, Vehicle-bench test	1 set
8FC-5435	Console, vehicle component functional test	3
8FC-5436	Adapter, vehicle component functional test	1 set

Table 4-2. Vehicle Systems Functional Test Equipment (Cont)

Model Number	Description	Quantity
8FC-5452	Console, high-current resistance test	1
8FC-5454	Cryogenic harness test set	1
8FC-7101	Console, command destruct, functional	1
8FC-7501	Console, instrument component	1
8FC-7502	Adapter, instrument component console	1
8FC-7601	Console, antenna checkout	2
8FC-7603	Console, telemeter functional	2
8FS-0002	Vibration equipment, hydraulic component	1
8FS-5801	Console, hydraulic service	1
8FS-5804	Console, ARMA and servoactuator flushing	1
8FS-5919	Proof test unit, insulation test coupons	1

Table 4-3. Functional Test Support GSE

Model Number	Description	Quantity
8FC-5420	Console, GSE module checkout	1
8FC-5421	Adapter set, GSE module checkout	1 set
8FC-5422	Console, GSE logic drawer checkout	5
8FC-5423	Adapter, GSE logic drawer checkout	1 set

Table 4-3. Functional Test Support GSE (Cont)

Model Number	Description	Quantity
8FC-5424	Console, GSE RF drawer and rack checkout	1
8FC-5425	Adapter, GSE RF drawer and rack checkout	1 set
8FC-5428	Console, GSE special requirements drawer checkout	3
8FC-5429	Adapter, GSE special requirements drawer checkout	1 set
8FC-5430	Console, GSE logic rack checkout	4
8FC-5431	Adapter, GSE logic rack checkout	1 set
8FC-5432	Console, GSE special requirements rack checkout	1
8FC-5433	Adapter, GSE special requirements rack checkout	1 set
8FC-5437	Automatic continuity analyzer support, GSE bench	1 set
8FC-5440	RAC's checkout console	1
8FC-5441	0- to 22-vdc battery box assembly	2
8FC-5442	Calibration switching device box assembly	2
8FC-5443	Calibration load bank, box assembly	1
8FC-5444	Banner test station	1 set
8FC-5453	Intercom test set	2
8FC-5910	Console, GSE checkout high pressure pneumatic	5

Table 4-4. Seal Beach STE Functional Test Equipment

Model Number	Description	Quantity
8FC-0026	Spare parts for SMD models (vehicle)	1 set
8FC-5407	Continuity and insulation resistance test, S-II stages	1 set
8FC-5901	Instrumentation, hydrotest	1
8FC-7601	Console, antenna checkout	1
8FS-0003	Console, heat element control	6
8FS-0006	LOX tank, access equipment	2
8FS-0007	Console, temperature monitoring	1
8FS-5805	Control unit, hydrostatic test	1
8FS-5901	Control unit, hydrostatic test	1
8FS-5908	Control equipment, bulkhead hydrostatic test	1
8FS-5909	Hydrostatic test equipment, bulkhead assembly	1
8FS-5911	Console, leak test, insulation closeout	1
8FS-5912	Console, leak test, LH_2 tank insulation	1
8FS-5913	Leak test unit, LOX tank	1
8FS-5914	Pressurization unit, propellant tanks	3
8FS-5915	Console, purge test common bulkhead	1
8FS-5916	Console, pressure test quarter panel	1
8FS-5917	Pneumatic test system	1
8FS-5918	Console, leak detection and purge system	1

*Cancel

Table 4-5. Seal Beach Factory GSE

Model Number	Description	Quantity
A7-40*	LH_2 tank servicing air conditioner	1
A7-85	Ladder, thrust cone internal access	4
A7-88	Protective ring, LOX tank access	2
A7-89	Protective ring, LH_2 tank access	2
A7-119	Portable helium leak detector set	1
C7-53	Plate set, blanking, pneumatic c/o	1
C7-59	Power cable set, engine checkout equipment	1
C7-85	Propellant utilization test set	1
H7-20	Simulator, actuator, engine	4
H7-27	Sling, interstage and static firing segments	2
H7-28	Sling, ring segment support	1
H7-29	Lines, adapter, tag	1
H7-30	Interstage and static firing skirt	1
H7-83	Transporter, component sling	1
H7-94	Adapter center engine vertical installation	1
H7-95	Adapter outboard engine vertical installation	1
S7-34*	Air servicing unit, electrical container	2
S7-37*	Pump unit, portable, vacuum	1
*Cancel		

Table 4-5. Seal Beach Factory GSE (Cont)

Model Number	Description	Quantity
S7-38*	Servicing unit, precharge	1
SDD-151*	Head sets, intercommunications	90
SDD-152*	Head sets, intercommunications	10
SDD-154*	Facility interface J-box	2
SDD-159	Electrical power control and monitor	1
SDD-163	Cable installation, Station VII	1
SDD-165	Fluid distribution system, Station VII	1
SDD-191	Retract mechanism, forward, Station VII	1
SDD-192	Retract mechanism, aft, Station VII	1
SDD-193*	Console, hydraulic power	2
SDD-196*	Cable installation	1
SDD-197*	Cable installation	1
SDD-198*	Distribution system	1
SDD-199*	Distribution system	1
SDD-238	Adapter, stage forward erecting	1
SDD-239*	Adapter, aft hoisting frame	1
SDD-243*	Servicing unit, hydraulic fluid	1
SDD-244*	Jumper unit, hydraulic systems	2
SDD-262*	Simulator, camera capsule	2

*Cancel

Table 4-5. Seal Beach Factory GSE (Cont)

Model Number	Description	Quantity
SDD-263*	Arrestor, camera capsule	2
SDD-264*	Tool set, camera capsule	1
SDD-273*	Recorder, engine sequence	3
SDD-337*	Rack, power supply, 56 volts dc, 200 amperes	2
930	Installation fixture, hydraulic system	2
931	Buildup fixture, hydraulic system assembly	12

*Cancel

4.4 COORDINATION TOOLS

4.4.1 MASTER MATING GAUGES

4.4.1-1 The forward and aft master mating gauges will be of minimum-weight material; theses gauges will generally consist of an aluminum outer ring connected by approximately 12 inner supports to a center hub. The gauge will be fabricated in a manner that will allow it to be disassembled into 12 segments for shipping (Figure 4-1).

4.4.1-2 The aft S-II interface bolt attachment points will be located on the outer ring of the aft master mating gauge, which will also provide the location of the plugs and fittings for the mating of aft system interfaces. The S-IC associate contractor will provide a similar master mating gauge for the S-IC forward face. These two tools will be exchanged to check mating surfaces and to assure structure and system interface fitups.

4.4.1-3 The forward S-II interface bolt attachment points will be located on the outer ring of the forward master mating gauge, which will also provide the locations of the systems tunnel, plugs, and fittings for the

mating of forward system interfaces. The S-IVB associate contractor will provide a similar master mating gauge for the S-IVB aft face. These tools will be exchanged to check mating surfaces and to assure structure and system interface fitups.

4.4.1-4 The master mating gauges will be delivered as requested by MSFC.