MANUFACTURING PLAN

SATURN V
BOOSTER STAGE S-IC

MANUFACTURING
ENGINEERING DIVISION

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUNTSVILLE ALABAMA

MSFC Form 1227 (August 1961)

XI.9
XIV.2

1/15/63

SECTION I

GENERAL INFORMATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Memorandum

TO : Recipients of C-5 Manufacturing Plan

DATE 15 January 1963

FROM : Chief, Engineering Planning Section, M-ME-SE

SUBJECT : C-5 Manufacturing Plan

The attached C-5 Manufacturing Plan, dated 15 January 1963, has been updated to include the latest manufacturing concepts and plans and supersedes C-5 Manufacturing Plan, dated 11 June 1962, and C-5 Manufacturing Plan, dated 15 July 1962.

Changes or modifications to the C-5 Manufacturing Plan will be submitted in memorandum form to the Manufacturing Engineering Division, Structures Engineering Branch, Tool Engineering Section M-ME-ST, Attention Mr. W. K. Vardaman, phone 536-7415. (Reference page v of Manufacturing Plan.)

Input changes from The Boeing Company will be submitted to the above section, prepared in a rough draft format by the above section, and then copies returned to The Boeing Company, Attention Mr. W. B. Edmiston, Manufacturing Manager, Saturn Booster Branch, The Boeing Company. Copies in turn will be sent to the responsible parties in the Manufacturing Engineering Division of MSFC for review. See attached letter dated December 18, 1962. As attached letter indicates, a period of seven days will be allowed for comments and changes. After this time if no comments are returned to the originating office (The Boeing Company), the changes will be considered acceptable and will be incorporated into the Manufacturing Plan.

In a like manner, changes will be submitted by parties within the MSFC organization to the above section, prepared in rough draft format by the above section, and then copies sent to the parties within MSFC organization and The Boeing Company, Attention Mr. W. B. Edmiston, Manufacturing Manager, Saturn Booster Branch for review. If no comments are received from The Boeing Company or other parties concerned within the seven-day limit, the changes will be considered acceptable and will be incorporated into this Manufacturing Plan.

J. H. Chesteen

MSFC - Form 488 (August 1960)

December 18, 1962

To: W. B. Edmiston
W. R. Kuers

Subject: Integrated Boeing-MSFC Manufacturing Plan

Subsequent to publication of the subject document, maintainence will be performed as follows:

1. Coordination of all revisions will be made between the offices of the Boeing Manufacturing Engineering Manager and the MSFC Manufacturing Engineering Structures Manager's office.

2. As changes become apparent, they will be submitted immediately. A period of seven (7) calendar days, from the date of submittal, will be allowed for comments or changes to be returned to the originator. In the event no answer is received within this period of time, the change will be considered acceptable and incorporated in the document.

3. MSFC will publish and distribute all revisions to the document.

J. H. Chesteen

N. E. Johansen

11 June 1962
Changed 15 January 1963
Changed 15 July 1965

MANUFACTURING PLAN

SATURN V
BOOSTER STAGE S-IC

MANUFACTURING ENGINEERING LABORATORY
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

LIST OF EFFECTIVE PAGES

Insert latest changed pages; destroy superseded pages.

NOTE: The portion of the text affected by the changes is indicated by a vertical line in the outer margins of the page.

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 801 CONSISTING OF THE FOLLOWING:

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*A, B, C	15 July 1965
i thru b	Original
1	1 October 1964
*2 thru 4b	15 July 1965
5	Original
1-1, 1-2	Original
1-3, 1-4	15 March 1963
1-5	Original
1-6	15 March 1963
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10-19 thru 10-22	15 April 1964

*The asterisk indicates pages changed, added, or deleted by the current change.

15 January 1963

SATURN C-5 BOOSTER STAGE S-IC

MANUFACTURING PLAN

APPROVAL

WERNER R. KUERS
Director
Manufacturing Engineering Division
MSFC

W. B. EDMISTON
Manufacturing Manager
Saturn Booster Branch
The Boeing Company

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ACKNOWLEDGEMENT

Information for this Manufacturing Plan was drawn from the research effort contributed jointly by the Manufacturing Engineering Division and The Boeing Company with an additional input of information furnished by other elements of the Marshall Space Flight Center.

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N O T I C E

Changes or modifications to this Manufacturing Plan will be accomplished by the Manufacturing Engineering Division, Structures Engineering Branch M-ME-S. When changes or modifications are required, the information will be furnished to M-ME-S so such changes or modifications can be included in the Manufacturing Plan and distributed.

This Manufacturing Plan in itself does not authorize any design or fabrication efforts. Such efforts shall be in accordance with Contract NAS8-5608.

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Changed 15 July 1965

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INTRODUCTION

This procedure provides the necessary information for the fabrication and assembly of the Saturn C-5 booster stage S-IC. The manufacturing methods outlined herein represent techniques that will be utilized both at Michoud and MSFC wherever possible. The concepts and methods outlined are of a preliminary nature consistent with the stage of design at this time. These concepts and methods are subject to change. This Manufacturing Plan will be periodically updated to reflect such changes.

The processes and techniques proposed in this Manufacturing Plan are generally within the present state of the art, consistent with reliability requirements for manned space flight and advocated for use with the limited manufacturing facilities of the Marshall Space Flight Center and the Michoud Production Facility.

SECTION I
GENERAL INFORMATION

1. GENERAL DESCRIPTION.

The Saturn C-5 booster stage S-IC is of a cylindrical tandem tank configuration and is capable of producing 7.5 million pounds of thrust at sea level. The Saturn C-5 booster stage S-IC is shown in figure 1-1. The booster stage S-IC is based on Propulsion and Vehicle Engineering Division, MSFC, drawing number SK10-3486E, "Assembly Layout, Saturn C-5 S-IC Stage", dated 24 October 1962. The booster stage S-IC is equipped with individual propellant tanks, the oxidizer tank assembly being located above the fuel tank assembly, and is powered by a cluster of five F-1 engines.

The booster stage S-IC will be approximately 138 feet long, 33 feet in diameter (excluding fins), and will weigh approximately five million pounds at liftoff. The booster stage S-IC is composed of the following major components:

Nomenclature	Weight
FORWARD SKIRT ASSEMBLY	5,961
Skin Segments	
Channel Rings	
INTERTANK STRUCTURE ASSEMBLY	9,908
Skin Segments	
Ring Assemblies	
THRUST STRUCTURE ASSEMBLY	44,910
Engine Support and Holddown Post Base Fittings	
Lower Thrust Ring Assembly	
Thrust and Holddown Posts	
Center Engine Support Assembly	
Upper Thrust Ring Assembly	
Auxiliary Shear Panels	
Intermediate Rings	
Skin Assemblies	
Suction Line Bracketry	
Actuator Support Structure	
BASE HEAT SHIELD	6,063
ENGINE FAIRINGS	6,617
FIN ASSEMBLIES	2,020
FUEL TANK ASSEMBLY	30,566
Upper Head Assembly	
Lower Head Assembly	
Cylindrical Skin Sections	
Anti-Slosh Baffles	
Oxidizer Line Tunnels	
Head Fittings	
OXIDIZER TANK ASSEMBLY	38,334
Upper Head Assembly	
Lower Head Assembly	
Cylindrical Skin Sections	

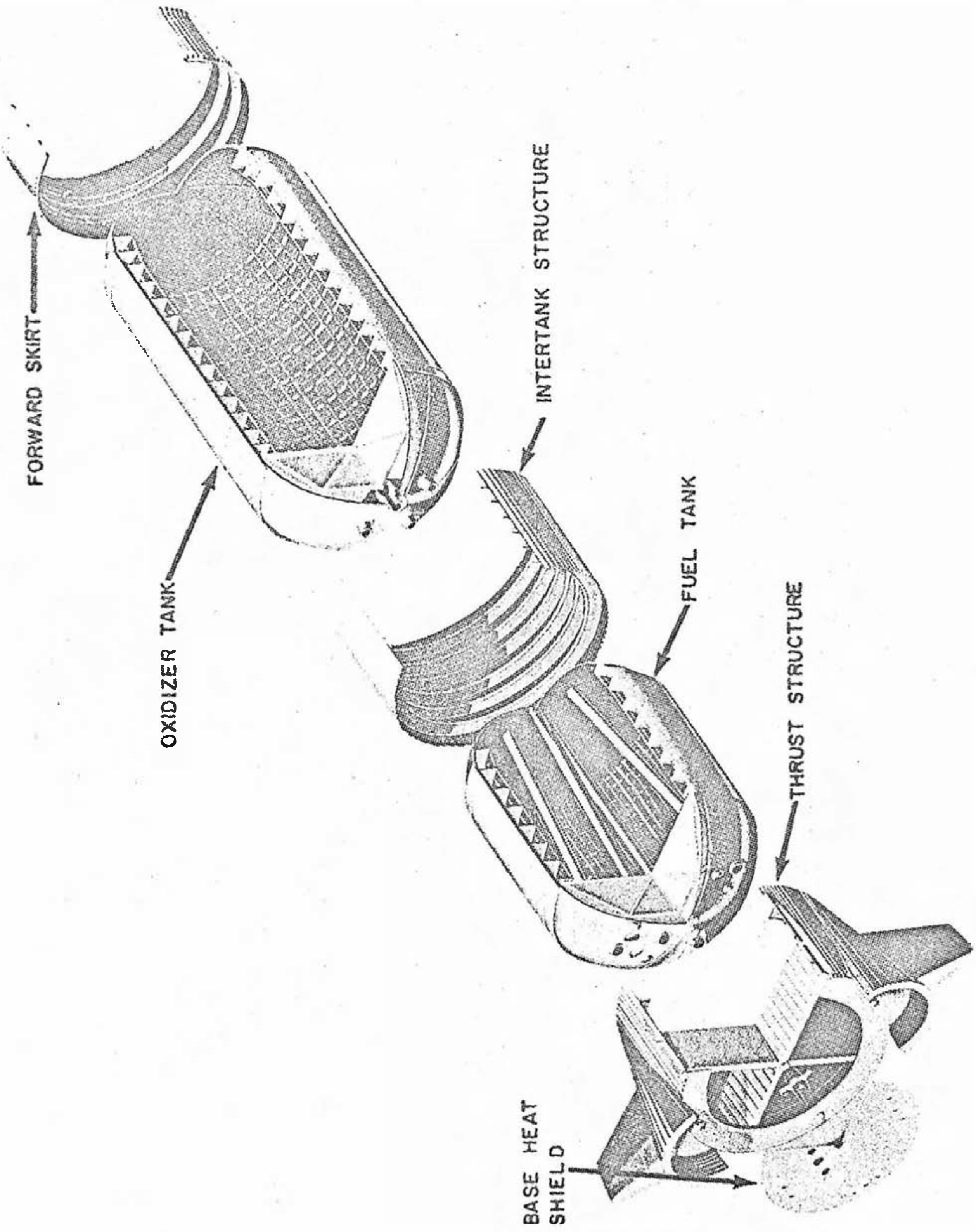

Figure 1-1. Saturn C-5 Booster Stage S-IC

1. (Con.)

Nomenclature	Weight
Anti-Slosh Baffles	
Head Fittings	
Fuel Pressurization System	
PROPULSION SYSTEM AND ACCESSORIES	119,436
INSTRUMENTATION AND ELECTRICAL NETWORK	11,660
RETRO-ROCKETS	6,800
CONTINGENCIES	3,212
	285,487

The booster stage S-IC structure is of semi-monocoque structure design and generally utilizes aluminum alloy 2219-T87 and 7075-T6. The propellant containers are of cylindrical fusion welded construction with the oxidizer tank assembly located above the fuel tank assembly. Material for the tank assemblies is 2219-T87 aluminum alloy plate. The cylindrical sections of the tank are numerically milled into a semimonocoque structure to reduce weight and provide structural integrity. Circumferential internal rings, manufactured from aluminum alloy 7178-T6, are added to provide rigidity where required. The tank assemblies use elliptical cross section bulkheads at both ends. Anti-slosh baffles will be installed in both tank assemblies. The forward skirt assembly cylindrical skin sections are of 7075-T6 aluminum alloy stiffened externally with hat-shaped stringers and internally with channel rings. The thrust structure assembly consists of 7075-T6 aluminum alloy cylindrical skin assemblies with internal ring assemblies and support structure. The intertank structure assembly is composed of corrugated aluminum alloy 7075-T6 skin panels with five ring assemblies added internally for stiffness. Mechanical attachments are used in securing the thrust structure assembly, intertank structure assembly, and forward skirt assembly to the oxidizer and fuel tank assemblies.

The four outer F-1 engines will be mounted circumferentially on a diameter of 365 inches. Each of the five engines is fed by a separate LOX duct, which runs through a tunnel in the fuel tank assembly. Each engine also requires two fuel inlets, which are fed by two fuel suction lines connected to the bottom of the fuel tank assembly. The fuel tank assembly will be pressurized with helium. The oxidizer tank assembly will be pressurized with GOX.

The booster stage S-IC will be controlled by gimballing the four outboard engines a maximum of plus or minus five degrees in both the pitch and yaw planes. Aerodynamic fins will also be installed to provide stability and assure positive control of the vehicle.

Eight rotro-rocket motors will be utilized to assure prompt and adequate separation between the booster stage S-IC and the upper stages when the separation command is given.

2. MANUFACTURING PLAN CONCEPT.

This Manufacturing Plan is based on procurement of detailed parts, such as structural, electrical, mechanical and hydraulic components, from industry.

2. (Con.)

Fabricated parts will be completely finished except for welding, trim stock, and mechanical fastening holes.

Manufacturing operations for the booster stage S-IC will begin at MSFC with the fabrication of ground test stages and the first flight vehicle. Included in the effort will be fabrication and assembly of the fuel tank assembly bulkhead structural test, static firing stage S-IC-T, structural test component, dynamic test stage S-IC-D, and flight vehicle S-IC-1. Manufacturing operations at Michoud will include the systems checkout stage S-IC-F and flight vehicles S-IC-2 and subsequent. Manufacturing operations will start at MSFC with the fabrication and assembly of the fuel tank assembly bulkhead structural test unit and static firing stage S-IC-T. The S-IC-F vehicle is the first scheduled to be fabricated at Michoud.

2.1 Reliability. The approach taken herein is that reliability is derived from proper design, manufacture, and inspection operations. Reliability in manufacturing is a prime consideration of this Manufacturing Plan. By use of automated tooling and facilities and a thorough preplanning of each step of the manufacturing operation, human error is reduced while efficiency and economy are imporved. Some of the automated fabrication concepts being considered are:

2.1.1 Numerical Control Machining. Major structural components, such as skins, forgings, etc., are machined by numerically controlled milling machines. A punched paper or plastic tape controls the position of the cutter automatically, virtually eliminating human error. Costly machining fixtures and the lead times necessary to build them are eliminated.

2.1.2 Automatic Welding. Fusion welding of the structural components that comprise the propellant containers is accomplished automatically by both mechanical and electronic controls. Either the weld head or the structural components may be held stationary during the assembly operation. The gores are held stationary during the head assembly operation and the welding head travels along a track. The track follows the contour of the head assembly, but the proximity of the head to the work surface does not depend on the accuracy of the track. This is accomplished by an electronic sensing device which compensates for variations in curvature of the work surface. Rate of travel of the welding head, angle of attack, rate of shielding gas flow, rate of filler wire feed, and voltage and current are programmed and monitored electronically. This provides a system that effectively reduces human error and provides a high degree of reliability.

2.2 Tooling Concepts. It has been decided to use the "soft tooling" concept both at MSFC and at Michoud wherever practical. The definitions regarding tools for welded structures generally agreed to by most of industry for soft and hard tooling are as follows:

SOFT TOOLING does not have holddown fingers or restraining bars. The material is free to expand during welding.

HARD TOOLING is massive and has holddown fingers or restraining bars. The material is restrained during welding.

It has also been agreed to use wherever possible existing tooling and facilities located in industry for the manufacture of components. Part manufacturing will be kept to an absolute minimum both at MSFC and at Michoud. Companies set up to manufacture parts will supply both MSFC and Michoud.

The tooling used at Michoud will be identical to the tooling used at MSFC wherever practical and conducive to economical production. When MSFC phases out of the S-IC program, the tooling will be transferred to Michoud and will enable increased production at the Michoud facility.

2.3 Tool Policy. Tools shall be of such durability and quality as to support the Saturn S-IC Program and not be limited to the quantities ordered by MSFC on work directives except as noted on the work directives.

2.4 Vertical and Horizontal Assembly. The proposed manufacturing assembly plan has been developed on the basis of utilizing existing facilities wherever possible and providing a minimum of new facilities to ensure an efficient orderly assembly sequence. Where modification to existing facilities or the requirement for new equipment was found necessary, the selection was influenced by versatility, contribution to vehicle reliability, and economic factors.

2.4.1 At MSFC. Certain assembly operations are most efficiently performed with the major structural assembly in the vertical position while others are best performed in the horizontal position.

2.4.2 At Michoud. The new high bay area, justified by vehicle production rates, will be effectively used to perform the maximum structural assembly operations in the vertical position.

3. STAGE CONFIGURATION.

This paragraph presents information pertaining to the Plan V S-IC ground test stages. The overall mission of the S-IC ground test stages

3. (Con.)

is to ensure the maximum degree of reliability and confidence for the first stage of the C-5 booster system. Because of the compressed development phase of the C-5 program, fewer research and development launches are scheduled than for previous booster programs. This places an increased importance upon each ground test stage. Past experience has proven that a comprehensive ground test program can reduce the time required to reach operational status and, therefore, reduce the total cost of a space vehicle program. The various ground test stages for the S-IC program will, in general, be built to flight documentation, except as noted. Descriptions of each ground test stage are given below and are followed by an index of information in tabular form, and a copy of the latest program schedule. (See figures 1-2 and 1-3 and table 1-1.)

3.1 Static Firing Stage S-IC-T.

3.1.1 Description. This will be a complete stage built to flight documentation except for those components which must be modified to permit a full duration, full thrust captive firing. Both oxidizer and fuel tank upper head assemblies will be strengthened to withstand the internal tank pressure required to provide the minimum net position suction head for the pump inlets for a full duration captive firing. Tank skins will also be heavier. Certain access doors, special instrumentation, drain valves, special heat shields, and safety features will be added to maximize reliability, safety, maintainability, and data gathering during repetitive captive firings. Fins will be omitted because space does not permit installation on the stage while supported in the test tower.

3.1.2 Test Mission. This stage is the principle research and development ground test stage for the S-IC program. Although the initial purpose is to prove the propulsion system, the series of captive firings of this stage will serve to prove the overall functional reliability, design, and fabrication adequacy of the various S-IC stage systems. Many stage components will receive final pre-flight qualification tests from environmental conditions experienced during captive firing. F-1 engines will be qualified for cluster capability as well as other conditions, only possible during a captive stage firing. Conversion to automated GSE operation will occur prior to receipt of the first flight stage in order that proof of final compatibility of system operation can be accomplished.

3.1.3 Schedules.

3.1.3.1 Manufacturing. Stage hardware will be fabricated and assembled between May 1963 and April 1964. The F-1 engine delivery will commence in October

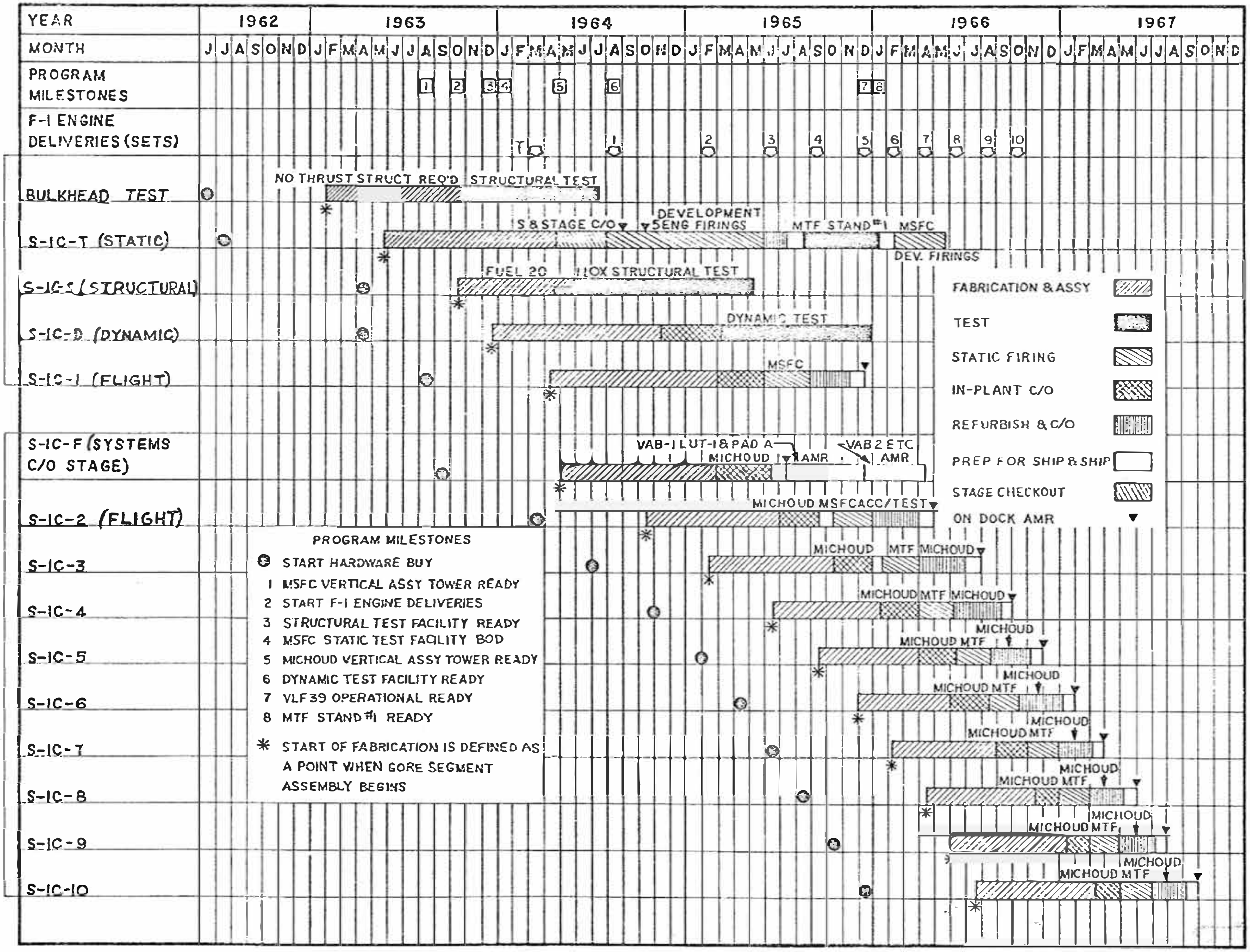

Figure 1-2. Saturn C-5 Booster Stage S-IC Schedule (Plan V)

Changed 1 March 1963

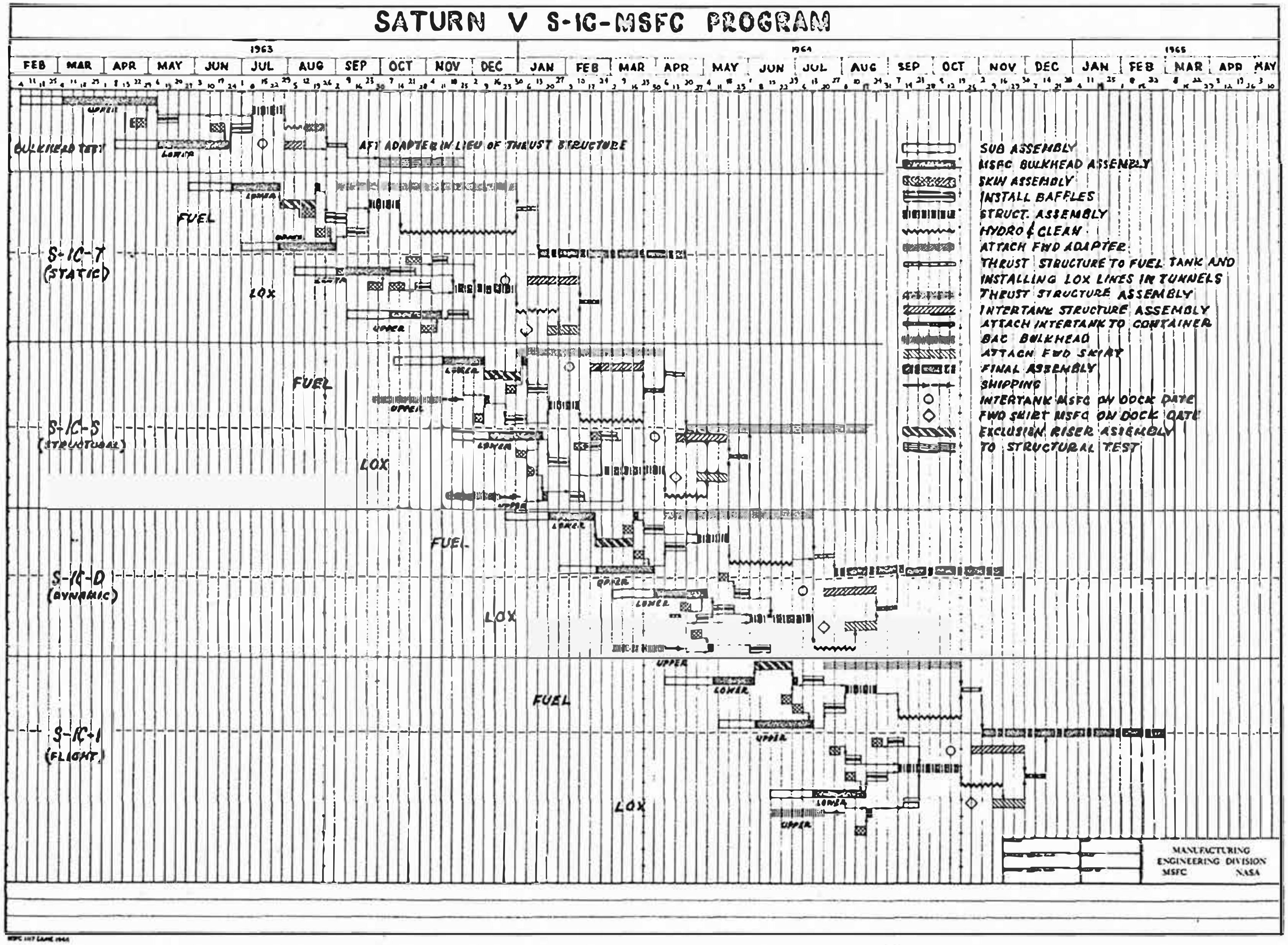

Figure 1-3. Saturn V Booster Stage S-IC - MSFC Program (Sheet 1 of 2)

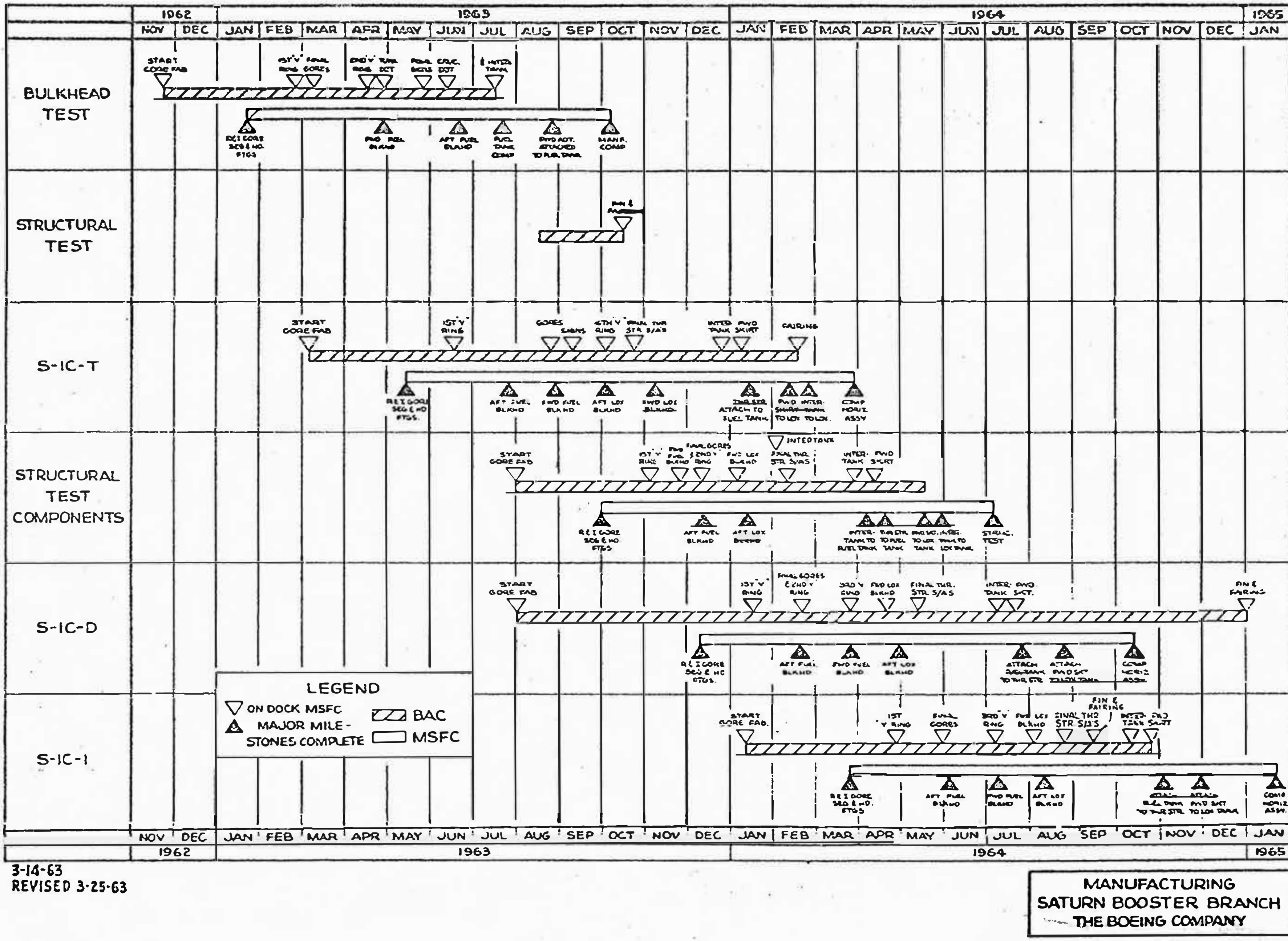

Figure 1-3. Saturn V Booster Stage S-IC - MSFC Program (Sheet 2 of 2) (Boeing Assist)

Table 1-1. S-IC Index - Ground Test Stages

ITEMS	S-IC -S	S-IC -T	S-IC -F	S-IC -D
A. GENERAL INFORMATION				
1. Configuration	V	V	V	V
2. Part of Vehicle	NO	NO	YES	YES
3. Assemblies	NO	YES	YES	YES
B. HARDWARE				
1. Structures				
a. Oxidizer Tank	*V	*V	V	V
b. Engine Fairing	(3)	V	V	V
c. Thrust Structure	*V	V	V	V
d. Base Heat Shield	V	V	V	V
e. Forward Skirt	V	V	V	V
f. Intertank	(2)V	V	V	V
g. Fins	(3)	X	V	V
h. Fuel Tank	*V	*V	V	V
2. Propulsion Systems				
a. Engines	X	V	**D	**D
b. Environment Control	X	V	V	D
c. LOX Fill, Feed, Drain	P	V	V	V
d. Fuel Fill, Feed, Drain	X	V	V	V
e. Water Quench	X	V	V	X
f. Retro-Rockets	****(2)	X	D	D
g. Fuel Pressurization	X	V	V	P
h. LOX Pressurization	X	V	V	V
i. Control Pressure	X	V	V	V

ITEMS	S-IC -S	S-IC -T	S-IC -F	S-IC -D
3. Electrical System				
a. Stage Sequencing	X	V	V	V
b. Emer Detector	X	V	V	V
c. Power Gen & Csl	X	***V	***V	***
d. E. B. W. System	X	X	V	D
e. Cabling & Distr	X	V	V	V
4. Instrumentation				
a. Transd & Sig Cnd	X	V	V	V
b. RF Systems	X	V	V	V
c. Telemetry	X	V	V	V
d. Special Inst	V	V	V	V
5. Flight Control				
a. Hydraulic Power	X	V	V	V
b. Thrust Vectoring	X	V	V	V
c. Control Inst	X	V	V	V
d. Actuators	X	V	V	V
6. GSE				
a. Checkout, Man/Auto	S	M/A	A	A/S
b. Electrical	X	V	V	V/S
c. Mechanical	S	V	V	V/S
d. Transport, Hand.	S	V	V	V

* Modified Flight Configuration
** Mechanical - Dummy Simulators
*** Power from Ground Source
**** Inert Rocket Motors

LEGEND

V Denotes item is needed, or applies
X Not used or applicable
D Indicates dummy will be used
(2) Indicates exact No. of units to be used
P Indicates partial system requirements

M Manual checkout equipment
A Automatic checkout equipment
S Special test equipment supplied by MSFC
NOTE: See narrative descriptions for more detail.

3.1.3.1 (Con.)

of 1963 and continue with a frequency of one per month until six are received. Engines will be delivered to the Quality Division for receiving inspection. They will then be sent to Test Division for disposition. All of the engines should be prefitted to the S-IC-T stage, and then removed, prior to delivery of stage to Test Division; however, the final determination will be made by Test Division.

3.1.3.2 Test. The S-IC-T stage will be delivered and installed in the static test facility without engines or retro-rockets in April 1964. Engines and retro-rockets will be installed on the test stand as required by Test Division. Checkout of S-IC-T will be made in the static test stand. The first captive firing test will be made in August 1964 and continue as outlined on the attached schedule. As shown, the S-IC-T stage will be removed from the test stand approximately June 1, 1965, and sent to Quality for refurbishment and checkout. If refurbishment cannot be accomplished by ME Division while stage is in Quality Division, the stage will be sent to the ME Division first for refurbishment and then to Quality Division for checkout. Around July 20, 1965, the S-IC-T stage will be sent to MTF to checkout MTF test stand #1.

3.1.4 MSFC Responsible Divisions. Manufacturing Engineering Division will be responsible for manufacturing or procurement of all stage hardware, except engines. Propulsion and Vehicle Engineering Division will be responsible for supplying all test requirements to the Test Division. Astrionics Division will have responsibility for all electrical checkout and flight instrumentation equipment requirements. Test Division will be responsible for all static tests and checkouts in static test tower. Quality Division will be represented at Test Division during checkout periods. Similarly, Manufacturing Engineering Division will assist Test Division during any modification or refurbishments. Test Division will be responsible for all special stage and ground instrumentation necessary to monitor captive firings.

Propulsion and Vehicle Engineering Division will have responsibility to monitor contractor generated documentation of S-IC-T and to see that it is kept up to date. All modifications, including hardware, location changes, back-up hardware, material changes, thicknesses, etc., will be made known to Propulsion and Vehicle Engineering Division, who has the responsibility to transmit these changes on the S-IC-T stage to the contractor.

3.1.4 (Con.)

The test and operating procedures will be generated by Test Division on the basis of design information furnished by Astrionics and Propulsion and Vehicle Engineering Divisions. These procedures will be coordinated with Astrionics, Launch Operations Control, Quality, and Propulsion and Vehicle Engineering Divisions. These procedures would then serve as a basis for operation at MTF.

3.1.5 Hardware Requirements. All structural and propulsion components necessary for a complete stage must be provided. Instrumentation, other than flight documented, will be installed primarily by the Test Division with assistance from other divisions as required. The initial electrical systems will be only those components to support the propulsion system coupled to a complete manual set of electrical ground support equipment. Later, on a schedule parallel with the S-IC-D, hardware for the electrical, instrumentation, and control systems will be produced in order to convert the S-IC-T to essentially flight configuration such that "All Systems" type testing can be run utilizing EASE test and checkout equipment. The S-IC-T stage will be equipped with flight instrument mounting hardware and dummy instrumentation (if live instrumentation is not installed) in the forward skirt area, and in other areas to determine the following:

a. The effect of vibration transmitted through the structure to the mounting hardware and instrumentation.

b. The effect on noise induced vibration created by the engines and transmitted to the mounting hardware and instrumentation.

c. The efficiency of the environmental protective covers that are required to package the instrumentation. Temperature in the forward area is estimated to be -100°F when the oxidizer tank is filled.

The electrical power, however, will be supplied from a ground source. Telemeter data transmission will be strived for, even though "hard wire" transmission may be used the majority of the time during initial test tower operations. A tabular summary of hardware requirements is shown in table 1-1.

3.1.6 Checkout and Ground Support Equipment Requirements. Manual type checkout equipment will be used initially. An automated set of GSE will be provided for later test stand operation conversion such that at least one automatic checkout firing of S-IC-T will be accomplished before the first acceptance firing of the S-IC-1 is scheduled.

3.1.6 (Con.)

Astrionics Division will furnish ESE and EASE as it becomes available. Test Division will furnish all GSE mechanical, handling, and transportation equipment. A hydraulic power source capable of meeting checkout and operating requirements for the test stand will be furnished by Test Division.

3.2 Structural Test Components S-IC-S.

3.2.1 Description. These components will be assembled at MSFC, and individually subjected to structural load tests by Propulsion and Vehicle Engineering Division. Components will be built to flight documentation, except as noted. These structural test components will include a test fuel tank with a forward and aft load adapter attached, an equivalent structural stage built in two subassemblies, and detail components. The flight instrumentation, propulsion (including engines), electrical, and control systems will not be active. The propellant tanks, however, must be capable of being pressurized. Slosh baffles will be required since they are a part of primary structure. Special instrumentation required for structural tests, such as strain gages, load cells, etc., will be installed at the test site by Propulsion and Vehicle Engineering Division. More detailed hardware descriptions are included in the hardware requirements paragraph.

3.2.2 Test Mission. Tests performed on these components will provide verification of design approaches prior to static firing of S-IC-T, and in time to permit required modifications to structural design prior to the first launch. Components will be tested to optimize and prove the design load carrying capability, and to establish a margin of safety beyond maximum expected service operational environments, simulating captive firing, launch, and flight loading conditions. The test program will be organized such that needed reliability oriented tests are integrated into the test program.

3.2.3 Schedules. Manufacturing of these components is scheduled to start in February 1963 for the test fuel tank, and in the fourth quarter of CY 63 for the other components. All components will be completed prior to June 1964. Testing of the fuel tank will start in October 1963. The other components will be tested as they are completed. (See figure 1-2.)

3.2.4 MSFC Responsible Divisions. Propulsion and Vehicle Engineering Division will have prime responsibility with Test Division support. All special instrumentation used in structural testing, such as strain gages, accelerometers, temperature transducers, etc., will be furnished and installed by Propulsion and Vehicle Engineering Division. Manufacturing Engineering Division will have responsibility for all

3.2.4 (Con.)

manufacturing and/or component procurement. Test Division will have responsibility for transportation and handling equipment.

3.2.5 Hardware Requirements. The following major assemblies will be built:

3.2.5.1 Test Fuel Tank. A full length test fuel tank, complete with milled skin sections and cruciform and anti-slosh baffles, will be built. The tank will be equipped with an intertank section and an aft skirt section. The test fuel tank will be built to flight documentation except as presented in the following paragraphs:

a. Upper Head Assembly. The upper head assembly will be unmilled except as required for fabrication of the head assembly. All fittings except a manhole fitting on position IV, an upper head outboard LOX tunnel fitting on Fin Line C, and a tank vent in the manhole fitting will be omitted.

b. Lower Head Assembly. All gores will be built to flight documentation. All fittings except the inboard and outboard LOX tunnel fittings on Fin Line C, the two outboard fuel suction fittings on Fin Line C, two inboard fuel suction fittings located in adjoining apex gores, a fuel fill and drain fitting near position I, and a fuel emergency drain fitting near position I will be omitted. A total of eight fittings will be installed in the lower head assembly. Also, the exclusion riser will be omitted. The polystyrene filler plate will be installed at the site.

c. Oxidizer Line Tunnels. The outboard tunnel on Fin Line C will be built and installed to flight documentation. The remaining oxidizer line tunnels, electrical tunnels, and the GOX line will be omitted. One tunnel fitting, bellow and a short section of a tunnel built up as an assembly, and one bellow will be required for separate test.

d. Intertank Section. The corrugated skin will be fabricated such that it will extend approximately ten inches above the top of the upper head assembly. A closure ring will be attached to the corrugations. This is necessary to transfer loads during the structural tests.

e. Aft Skirt Section. The cylindrical section of the thrust structure will extend approximately 66 inches below the Y-ring and will be built with a closure ring on bottom to transfer loads during the structural tests.

3.2.5.2 Oxidizer Tank Assembly. The oxidizer tank assembly will include a full size oxidizer tank, an intertank section, and a forward skirt assembly. The oxidizer tank assembly will be built to flight documentation except as presented in the following paragraphs:

a. Intertank Section. The intertank section will be a full length corrugated skin section. Two closure rings will be attached to the corrugations to transfer loads during the structural tests.

b. Forward Skirt. A full length skirt will be furnished with the master hole pattern in the S-II interface.

c. Interstage. Approximately 72 inches of the S-II interface, with a closure ring, will be attached to the forward skirt to transfer loads during the structural tests. This structural part will be procured by MSFC from the S-II stage contractor.

3.2.5.3 Fuel Tank and Thrust Structure Assembly. This assembly will include a complete intertank section, a full size fuel tank, and a thrust structure assembly. Deviations from flight documentation are included below:

a. Intertank Section. The intertank section is a full length corrugated skin section with a closure ring in place of the oxidizer tank Y-ring.

b. Two fin and engine fairing assemblies will be installed.

c. Two sets of engine actuator supports will be installed.

d. One set each of outboard and center propellant line supports on Fin Line C will be installed.

NOTE 1: See Table 1-1.

NOTE 2: The test fuel tank will be tested to failure.

3.2.5.4 Sub-Components. The following items will be furnished as loose hardware.

a. One fin and engine fairing assembly.

b. A test panel simulating the connection of the intertank section to the fuel tank Y-ring will be furnished so that the load distribution and load carrying capacity can be determined. This panel will be a straight section measuring approximately two feet by six feet.

c. Base heat shield samples will be furnished for testing under elevated temperatures and vibration environments. Approximately 15 samples of the base metal coated with insulation, measuring one foot by two feet, will be provided.

3.2.6 Checkout and Ground Support Equipment Requirements. Checkout equipment will be special and will be furnished by Propulsion and Vehicle Engineering Division. Other ground support and/or test equipment will be special and will be supplied by Propulsion and Vehicle Engineering Division. Handling and transportation equipment will be supplied by Test Division as required.

3.3 Dynamic Stage S-IC-D.

3.3.1 Description. This stage will be built to flight documentation and will be assembled with other dynamic stages to form a complete C-5 dynamic vehicle. All structural and other systems or components will be supplied to flight documentation to simulate both local and overall dynamic properties of the S-IC flight stages. Although it is not practical to supply operational engines, mechanical dynamic simulators will be supplied; all such outboard simulators will have gimbal capability.

3.3.2 Test Mission. The first mission for the S-IC-D stage at MSFC will be to prove the automatic checkout equipment and procedures prior to checkout of the first flight stage. This stage, as assembled in the complete C-5 dynamic vehicle, will be subjected to a series of dynamic tests at MSFC to monitor the dynamic response of the S-IC stage and the C-5 vehicle under such conditions as launch, maximum aerodynamic loading, etc. The following types of test information will be gathered:

a. Vehicle bending modes

b. Frequencies

c. Interaction between engine gimbal maneuvers and the vehicle and/or stage structures.

d. Damping

e. Local modes and frequencies.

As well as proving the overall structural design adequacy of the S-IC stage under dynamic loads, these tests will serve to provide information needed to finalize the vehicle guidance and control systems. Also, these tests will provide information on the dynamic responses of various stage mounted components during the vehicle dynamic tests. These tests will also serve to prove the structural quality of the stage as related to the manufacturing techniques used to build the stage.

This stage will also serve as a backup for the systems checkout stage (S-IC-F).

3.3.3 Schedules. Fabrication of this stage will begin in December 1963 and assembly completed by November 1964. Checkout by Quality Division will begin around November 15, 1964, and will continue until March 1965. Stage will then be delivered to dynamic test tower. Dynamic testing will begin in April 1965 and continue for an indefinite period.

3.3.4 MSFC Responsible Divisions. Manufacturing will be the responsibility of the Manufacturing Engineering Division. Quality Division will perform checkout of S-IC-D stage. Propulsion and Vehicle Engineering Division and Test Division will conduct the dynamic tests. Propulsion and Vehicle Engineering Division and Astrionics Division will provide special instrumentation for dynamic tests. Astrionics Division will provide all flight type instrumentation and Electrical Support Equipment (ESE). Aeroballistics Division will provide inputs for required data to Propulsion and Vehicle Engineering Division. Data evaluation will be conducted by Propulsion and Vehicle Engineering, Test, Astrionics, and Aeroballistics Divisions in close cooperation with each other.

3.3.5 Hardware Requirements. A complete flight configuration structure will be required including slosh baffles, fins, and engine fairings. All propellant ducting and valves should be provided. This hardware may not be qualified for flight worthiness, but tanks, ducting, valves, etc., must be supplied cleaned to flight specifications. All stage peculiar flight instrumentation and electrical equipment should be supplied to permit proving of checkout equipment. The stage will be equipped with flight type instrument mounting hardware and instrumentation in the forward skirt area to determine the effect of vibration transmitted through the structure to the mounting hardware and instrumentation.

One hard mock-up engine will be provided by Rocketdyne.

3.3.5 (Con.)

(See Memo dated July 3, 1962, from M-P&VE-OF, Subject: Minutes of Meeting on F-1 Engine Full Scale Mock-Up.) Four engine mechanical dynamic simulators (weight, c.g., and moment of inertia within 5%) will be designed by Propulsion and Vehicle Engineering Division and built by Manufacturing Engineering Division. All simulators must be provided with flanges for service connections. Four sets of actuators must be supplied with operational servo systems. The electrical system will be as nearly complete as possible although special instruments and dynamic sensors will be supplied power from a ground source. Pressurizing systems should be complete, but helium bottles may be simulated as to weight, stiffness, and c.g.

3.3.6 Checkout and Ground Support Equipment Requirements. Checkout equipment in the form of one test station will be supplied to the Quality Division by The Boeing Company. The S-IC-D stage will serve to prove and finalize the automatic checkout concept prior to delivery of this stage to the dynamic test stand. Checkout equipment requirements for the dynamic test program will be special and not related to launch operations. Test, Propulsion and Vehicle Engineering, and Astrionics Divisions will supply needed ground support equipment for the dynamic test. Test Division will supply the transportation equipment.

3.4 Systems Checkout Stage S-IC-F.

3.4.1 Description. This stage will be built to flight documentation (structural and electrical) and will be complete except for the engines. All stage mating interfaces and support and holddown attach points will be to flight configuration to facilitate erection of stage and C-5 vehicle on the launch pad. All fin assembly attachments will be included. Stage will contain flighr type access doors arranged in both forward and aft skirt structures to be reached along a radial line same as the umbilicals, preferably directly underneath the umbilical connectors. While the vehicle is on the launch pad, access is possible only through the access doors which accommodate ramps (tunnels) in the swing arms that connect the umbilical tower to each of the interstage areas. There will be no external platforms or other access after the arming structure leaves the vehicle.

The S-IC-F stage should be equipped with all physical components and hardware which will protrude external to the stage. These components may be the actual items or dummy units of the proper size and shape. Dummy ordnance items such as retrograde rockets, ullage rockets, and linear shape charges will be provided. These items should provide ease of installation and removal from the configuration. Complete

3.4.1 (Con.)

operating disconnects will be provided to test the disconnects and swing arm functions. This will include all umbilical connections, electrical, pneumatic, and those associated with on-pad venting of combustibles.

3.4.2 Test Mission. This stage will be the first ground test stage built to flight documentation at Michoud. At Michoud this stage will be used to prove manufacturing techniques and to develop checkout procedures and equipment, since it will be the first S-IC stage to be checked out by Boeing. At AMR the stage will be erected with other C-5 facilities checkout stages into a complete vehicle. This vehicle will be used to prove all of the propellant facilities associated with the storage and transfer of vehicle propellants. For S-IC, all stage-peculiar ground support equipment necessary to erect and launch will be checked out. Also, personnel will be trained in all the various launch operations and procedures from the time the stage arrives until it is launched. Further, this stage will be used to prove the automatic checkout concept for S-IC as related to launch operations. Since all of the systems will not be active, simulators will be provided where needed. The following detail objectives should be met within the framework of the above descriptions:

a. All propellant facility valves, liquid sensors, time delay relays, pressure switches, circuit breakers, pumps, motors, fans, vaporizors, sub-coolers, and vents will be checked for proper operation.

b. All propellant transfer and interconnect lines will be checked for leakage.

c. All stage peculiar GSE associated with propellants transfer, such as valve complexes, pneumatic valves, control valves, chillers, and pressure switches will be checked for proper operation.

d. A component operational check for the various components test panels will be conducted.

e. A propellant system simulated (dry) transfer of propellants to verify the proper time sequences, fault circuits, interconnects and electrical circuits will be conducted.

f. An actual transfer of propellants from the facility to the S-IC stage and back to the stage facility will be carried out. Main propellant utilization system during tanking will verify probe functions, verify time sequences, and loading computers. Pumping or transfer

f. (Con.)

time will be recorded, influent and effluent pressures across valves, strainers, and transfer lines will be recorded. Tank (stage) overpressures will be recorded to verify design and operation of stage vents.

3.4.3 Schedules. Manufacturing of this stage will start in the second quarter of CY 64. Fabrication and assembly will be completed in March 1965. Checkout equipment verification and stage checkout will be completed in June 1965. Preparation for shipment will be completed around June 20, 1965. Shipment and test operations of stage at AMR will begin around 15 July 1965 for VAB 1, LUT-1 and Pad C. Checkout of the next position will follow. Details of AMR test schedules and operations will be supplied by Launch Operations Control.

3.4.4 MSFC Responsible Divisions. Launch Operation Control will have the prime responsibility for this stage. Propulsion and Vehicle Engineering will be responsible to establish requirements for mechanical checkout of the propulsion system and associated GSE. The Boeing Company will have responsibility to provide the EASE (electrical automatic checkout equipment) which will be used for this stage at Michoud. Astrionics and Quality Assurance Divisions will assist Boeing in proving the functional operability of this equipment. Boeing will provide functional simulators to replace those systems (or parts of system) which are missing for the automatic checkout.

3.4.5 Hardware Requirements. A complete S-IC structure is required, built to flight documentation. All systems will be active except as noted. The following types of stage systems will be operational:

a. Fuel pressurizing system.

b. Oxidizer pressurizing system (pressurant will be supplied from ground source).

c. Oxidizer and fuel venting systems.

d. Fuel fill and drain systems.

e. Oxidizer fill and drain system.

f. Electrical system.

g. Instrumentation system.

h. Control system.

i. Engine purge and servicing systems.

3.4.5 (Con.)

Four mechanical dynamic engine simulators will be installed on the S-IC-F stage complete with actuators and operational servo systems such that gimbal maneuvers may be performed during the launch operations checkout.

Engine fairings and fins will be supplied as part of the structure. In addition, certain special measuring instrumentation will be supplied as specified by Launch Operation Control. All standard safety systems will be supplied with this stage.

3.4.6 <u>Checkout and Ground Support Equipment Requirements.</u> A complete set of EASE is required by both Boeing at Michoud and by LOC/LVOD at AMR. In addition, a complete set of stage peculiar mechanical, handling, and transporter equipment is required by LVOD. All launch oriented facilities at AMR, which are required to perform missions previously described must be in operational readiness. At Michoud a stage trans porter must be available prior to completion of assembly. Provisions will be made to load/unload stage on/off the barge at Michoud and AMR. Barge transportation and all barge supporting hardware to transport stage to AMR must be ready prior to shipment.

4. MSFC - BOEING RELATIONSHIP.

To support Plan V, the MSFC inhouse efforts will be supplemented by the Boeing Company both at Michoud and Wichita.

The fabrication of detail parts which require large but existing machinery will be accomplished at Wichita. Subassemblies required from The Boeing Company will be built up at Michoud and shipped to MSFC. Four complete bulkheads (head assemblies) will be required from The Boeing Company, Michoud. (See figure 1-3.) The intertank structure assemblies will be assembled complete at Michoud, disassembled in six segments, and shipped to MSFC for reassembly. A one-half intertank structure assembly will be required for the fuel tank assembly bulkhead structural test. The one-half intertank structure assembly will be manufactured at Michoud and shipped to MSFC as a complete assembly. The forward skirt assemblies will be manufactured at Michoud and shipped to MSFC as a complete assembly.

One set of tools which are to support the assembly of the head assemblies will be manufactured from the current designs. After these tools have produced an acceptable part at MSFC, each head assembly tool design will be released to The Boeing Company for duplicate head assembly tool manufacture which will support the assembly of the head assemblies at Michoud. All major inhouse tools will be shipped to Michoud after completion of the MSFC inhouse program and will serve as a second set of tools which will support the high production rate required in the latter part of the program.

SECTION II

PROCESS DEVELOPMENT

February 28, 1963

TO: Mr. W. B. Edmiston
Mr. W. R. Kuers

SUBJECT: Process Development and Special Equipment, Boeing-MSFC Manufacturing Plan

1. Subsequent to inclusion of the subject documents into the integrated Boeing-MSFC Manufacturing Plan for S-IC, maintenance will be performed as follows: Coordination of all revisions and additions will be made between the Offices of The Boeing Fabrication Development Manager and Chief, MR&D Branch, MSFC.

2. As changes become apparent, they will be submitted immediately for coordination and will subsequently be provided the MSFC Manufacturing Engineering Structures Engineering Branch Office for inclusion in the plan. A period of seven (7) calendar days, from the date of submittal, will be allowed for comments or changes to be returned to the originator. In the event no answer is received within this period of time, the change will be considered acceptable and incorporated in the document.

3. MSFC will publish and distribute all revisions to the document.

William A. Wilson
William A. Wilson

Etric L. Stone
Etric L. Stone

SECTION II
PROCESS DEVELOPMENT

1. INTRODUCTION.

Process development requirements for the booster stage S-IC are divided into four general categories depending upon the location at which the development is performed. The preliminary process development work is being performed at the Marshall Space Flight Center. Other developments are being conducted at the Wichita facility and at the Michoud Plant of The Boeing Company. Development at the Michoud Plant consists primarily of refinement of MSFC processes as related to the manufacturing of the booster stage S-IC. A fourth category will cover subcontractor effort.

Wherever possible, the same processing techniques will be used at both MSFC and Michoud facilities. At this time, the only firm methods are those applicable to the fuel tank assembly bulkhead structural test unit. Others are of a preliminary nature. These processes will be verified during the fabrication of the test components. Paragraphs 6. and 8. of this section contain copies of typical manufacturing process documents. These documents will be kept current and others added upon completion. The process development as outlined below may not necessarily meet the full development requirements to fabricate the booster stage S-IC. As work is accomplished to improve the state-of-the art and as the design parameters are established, this section will be modified.

2. PROCESS DEVELOPMENT - MSFC.

To meet schedule demands, engineering requirements, and quality standards to obtain uniform and consistent performance in utilizing high strength aluminum alloys, it was necessary to rapidly expand the state-of-the-art in manufacturing processes. Accelerated programs, both basic and applied, are being conducted at MSFC in the areas of welding, primary fabrication of material to make the general shapes available, heat treating, and machining of components of the booster stage S-IC.

2.1 Welding. Programs are being conducted at MSFC in welding in the areas of weld equipment, process development for welding out-of-position, and process development for the welding of heavy gage aluminum in position.

2.1.1 Development of weld technique for joining 2219 aluminum alloy plate in thicknesses up to 1/2 inch in flat, horizontal, and vertical positions in a single pass.

2.1.2 Development of weld technique for joining 2219 aluminum alloy wrought plate to forging.

2.1.3 Development of technique and process control for two-pass welding of 2219 aluminum alloy in thicknesses up to one inch in the flat, horizontal, and vertical positions.

2.1.4 Development of weld repair techniques for type 2219 aluminum alloy plate up to one inch thickness.

2.1.5 Development of techniques for preparations of the edges prior to performing the weld operation.

2.1.6 Development of techniques for step welding the transition from the normal skin thickness to the Y-ring leg.

2.1.7 Development of remote viewing techniques.

2.1.8 Development of equipment and related technology for control of the position of the welding arc on the joint being fabricated.

2.1.9 Establish requirements for high quality type 2319 filler wire and a method for evaluation.

2.1.10 Establish criteria for weld standards for aluminum alloy plate.

2.1.11 Establish the shrinkage tolerances for various thicknesses of materials and establish mill pattern in areas adjacent to the weld joint to reduce localized heat sink effect. Determine the permissable misfit and misalinement of the weld joint.

2.1.12 Development of a system for programming of travel speed, voltage, and amperage for welding gore assemblies on the meridian weld fixture.

2.1.13 Development of local clamping for alinement capability.

2.1.14 Development of technique for mechanized weld joining of the ribs internally.

2.2 Forming. Physical size of the parts, the number of outlets required for the head assembly, and the strength of material desired in the final product dictated that new processes be developed and the present state-of-the-art for forming of the skins and head assembly components for the booster stage S-IC be extended. Head assembly components are being fabricated by the hydraulic bulge method and by explosive forming. These components will be further formed during aging as required to attain and maintain a very close tolerance between mating parts.

2.2.1 Development of forming techniques for head assembly segments using explosives. Determine methods of providing positive edge clamping required for explosive stretch forming. Establish percent of stretch required for optimum contour.

2.2.2 Development of techniques for bulge forming the polar cap.

2.2.3 Forming of tunnel elbows of LOX and fuel drain line components and bellows.

2.2.4 Forming of gore segments using incremental method.

2.2.5 Development of forging technology for 2219 and 7079 aluminum alloys.

2.2.6 Development of tube forming and flaring methods.

 Changed 15 February 1964

2.3 Surface Treatment.

2.3.1 Development of technique for application of conversion coat to all surfaces. Conversion coat parts as fabricated and hand application after welding.

2.3.2 Development of procedure for painting the booster stage S-IC structure.

2.3.3 Establish procedure for application of dye penetrant to fabricated surfaces.

2.3.4 Development of procedure to attain the cleanliness levels of engineering requirements as given in MSFC-SPEC-164.

2.3.5 Determination of effect that weld heat has on conversion coat.

2.3.6 Development program to determine the cause of pitting during chemical processing of 2219 alloy.

2.3.7 Determination of the effect of weld heat on sulfuric acid anodized 2219 alloy.

2.3.8 Development program to determine the effect of post working on conversion coated 2219 alloy.

2.3.9 Development of cleaning procedure for S-IC propellant tanks.

2.3.10 Development of cleaning procedure for external surface of suction lines.

2.3.11 Development of procedure for anodizing AL-Mg castings.

2.4 Heat Treating.

2.4.1 Development of procedures for artificial aging of head assembly components and composites.

2.4.2 Development of interrupted aging technique for reducing distortion due to welding.

2.4.3 Development of age sizing techniques for optimizing part contour.

2.5 Metal Removal.

2.5.1 Development of chemical milling technique for application to 2219 aluminum alloy in various tempers.

2.5.2 Development of chemical milling technique for stainless steel to permit the use of welding and/or brazing for hydraulic fittings.

2.6 Special Fasteners.

2.6.1 Development of technique for utilizing Rosan fasteners.

2.6.2 Development of procedure for drilling a composite containing various tempers of aluminum and steel.

2.6.3 Development of technique for utilizing titanium fasteners.

2.7 Foaming. Development of foaming techniques for fabrication of the S-IC fuel tank exclusion riser.

3. PROCESS DEVELOPMENT - BOEING/MICHOUD PLANT.

3.1 Welding. Refinement of techniques established at MSFC will be carried out to reflect Michoud requirements. Weldor training and process and equipment certification will be conducted concurrently. Programs will be conducted in the areas listed.

3.1.1 Weld development programs will be conducted initially using a universal flat-plate holding fixture (universal development weld fixture DWF-300-00001) to establish basic welding parameters. This universal fixture may be used for welding test plates in the flat, vertical, and horizontal positions. (See figure 2-1.)

3.1.2 Process development for fusion welding fittings to apex and base gore segments. The simulated fitting development weld fixture DWF-300-00002, capable of holding up to one-inch thick material, will be used to develop the welding techniques required to attach the fittings and polar cap to the gores. (See figure 2-2.)

3.1.3 Process development for fusion welding apex gore to base gore. using the basic welding parameters established on universal fixture DWF-300-00001, full-scale test panel welding of the apex-to-base joint will be conducted using apex-to-base development weld fixture DWF-300-00003. (See figure 2-3.)

3.1.4 Process development for gore-to-gore assemblies. Production welding carriages and facilities will be installed on gore-to-gore development weld fixture DWF-300-00004 where they will be debugged and used to develop setting and train operators. (See figure 2-4.)

3.1.5 Process development for fusion welding head assembly to Y-ring assemblies. Production weld facilities will be utilized in conjunction with development weld fixture DWF-300-00005. (See figure 2-7.)

3.1.6 Process development for fusion welding polar cap to head assemblies. (See figure 2-2.)

3.1.7 Process development for fusion welding LOX and fuel fitting assemblies. To support the production welding of the fuel suction elbows, manufacturing development will be required to determine the weld settings, shrink tolerances, and techniques before production assemblies can be fabricated. Manufacturing development will utilize aft fuel fitting test weld fixture TWF2-304-24216 & 60 to fabricate the aft fuel fitting assemblies for the first mockup head assembly. (See figure 2-5.)

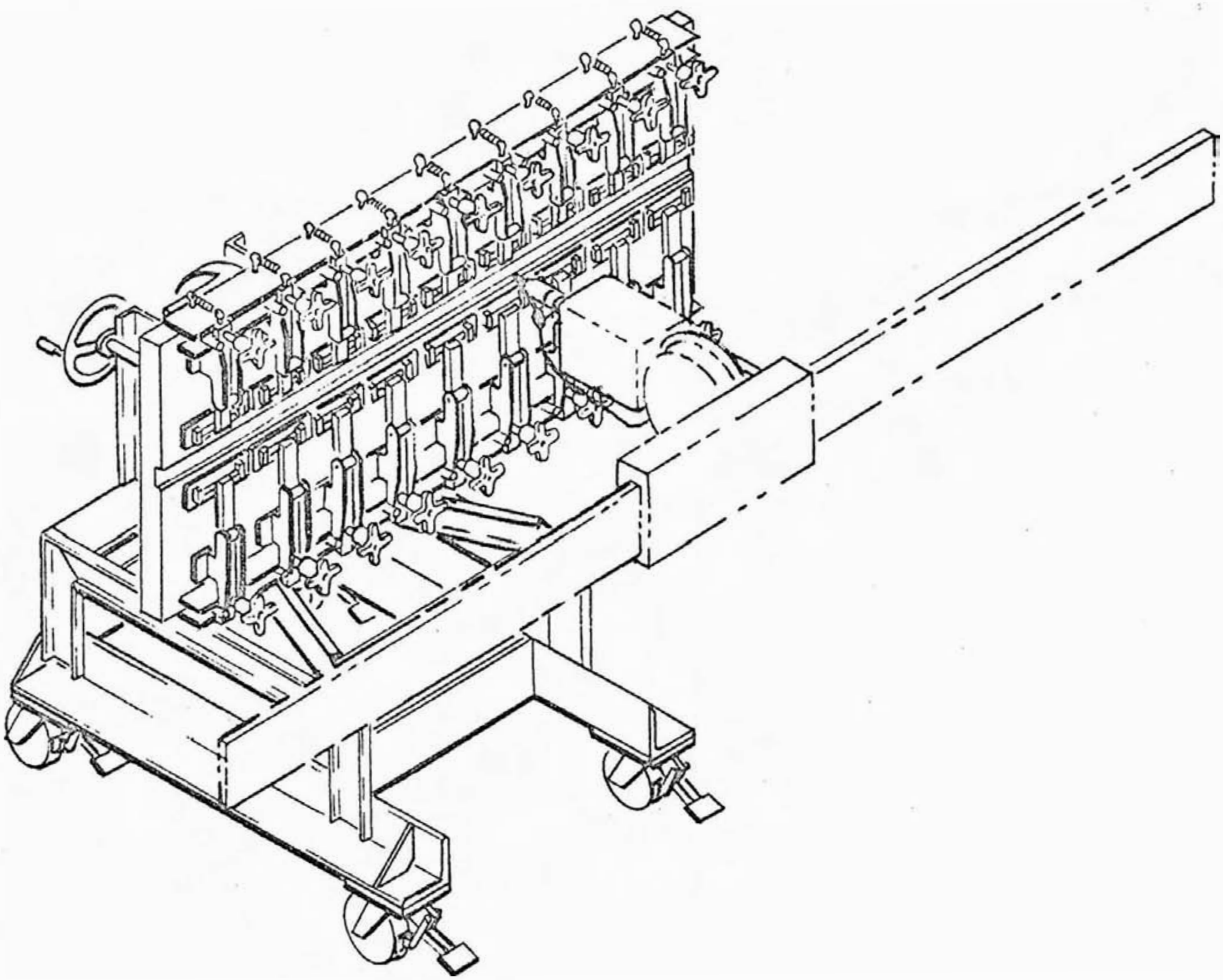

Figure 2-1. Universal Development Weld Fixture
DWF-300-00001 (Sheet 1 of 3)

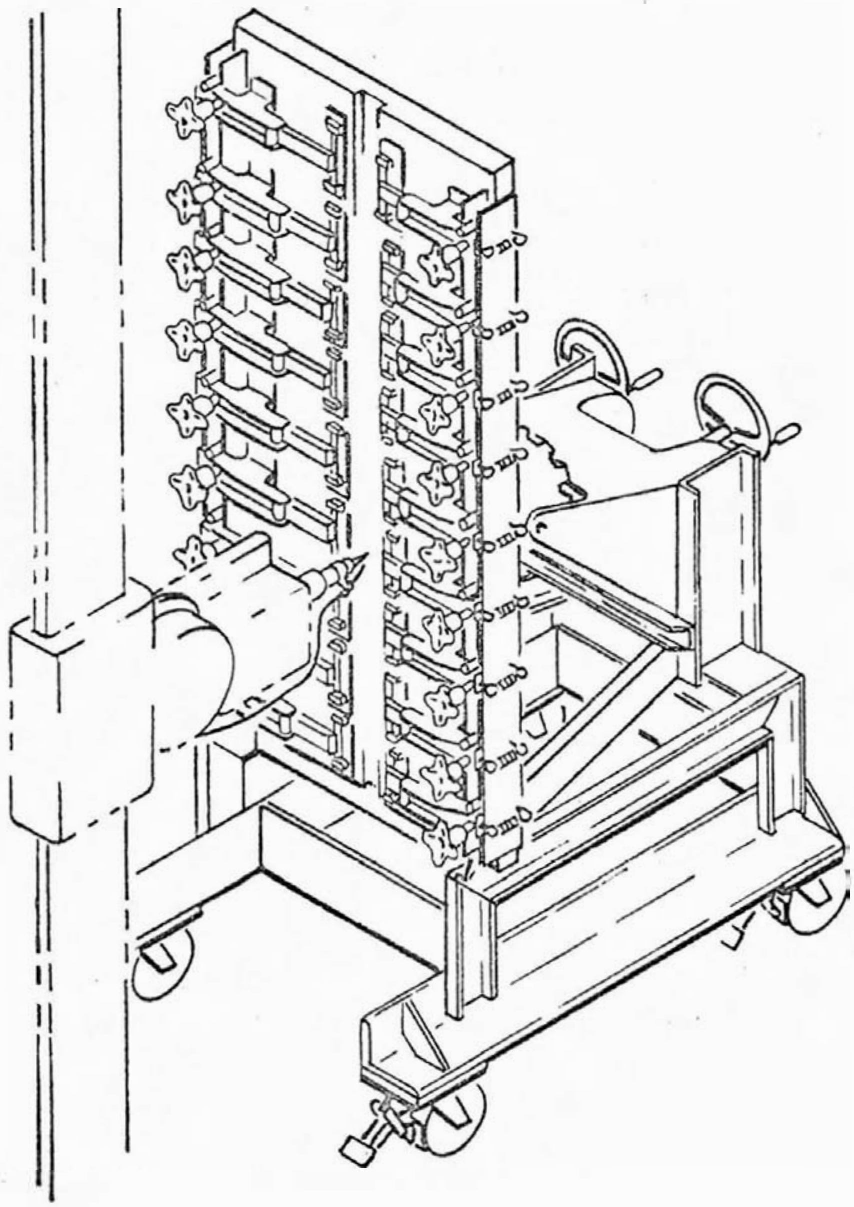

Figure 2-1. Universal Development Weld Fixture
DWF-300-00001 (Sheet 2 of 3)

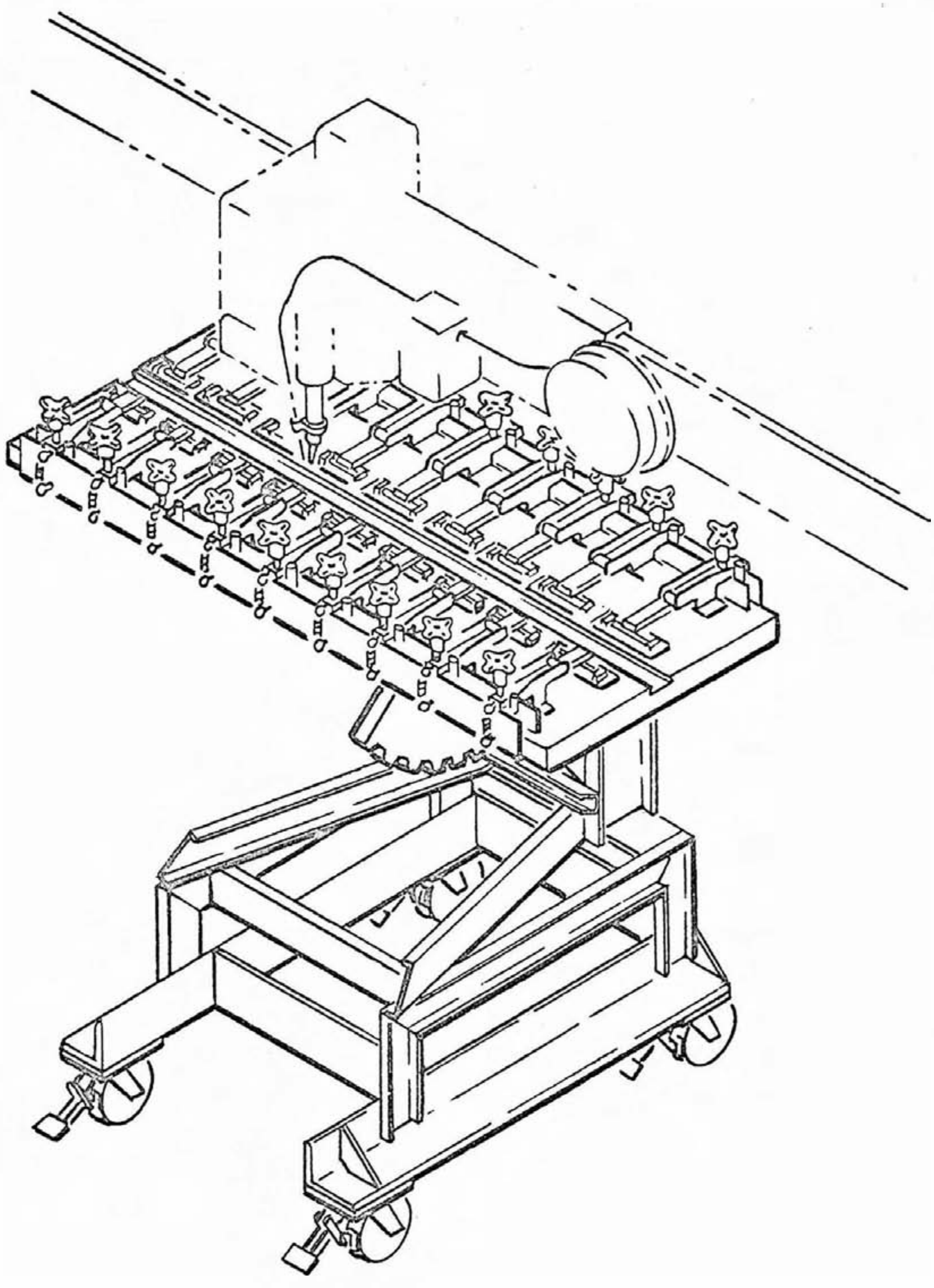

Figure 2-1. Universal Development Weld Fixture
DWF-300-00001 (Sheet 3 of 3)

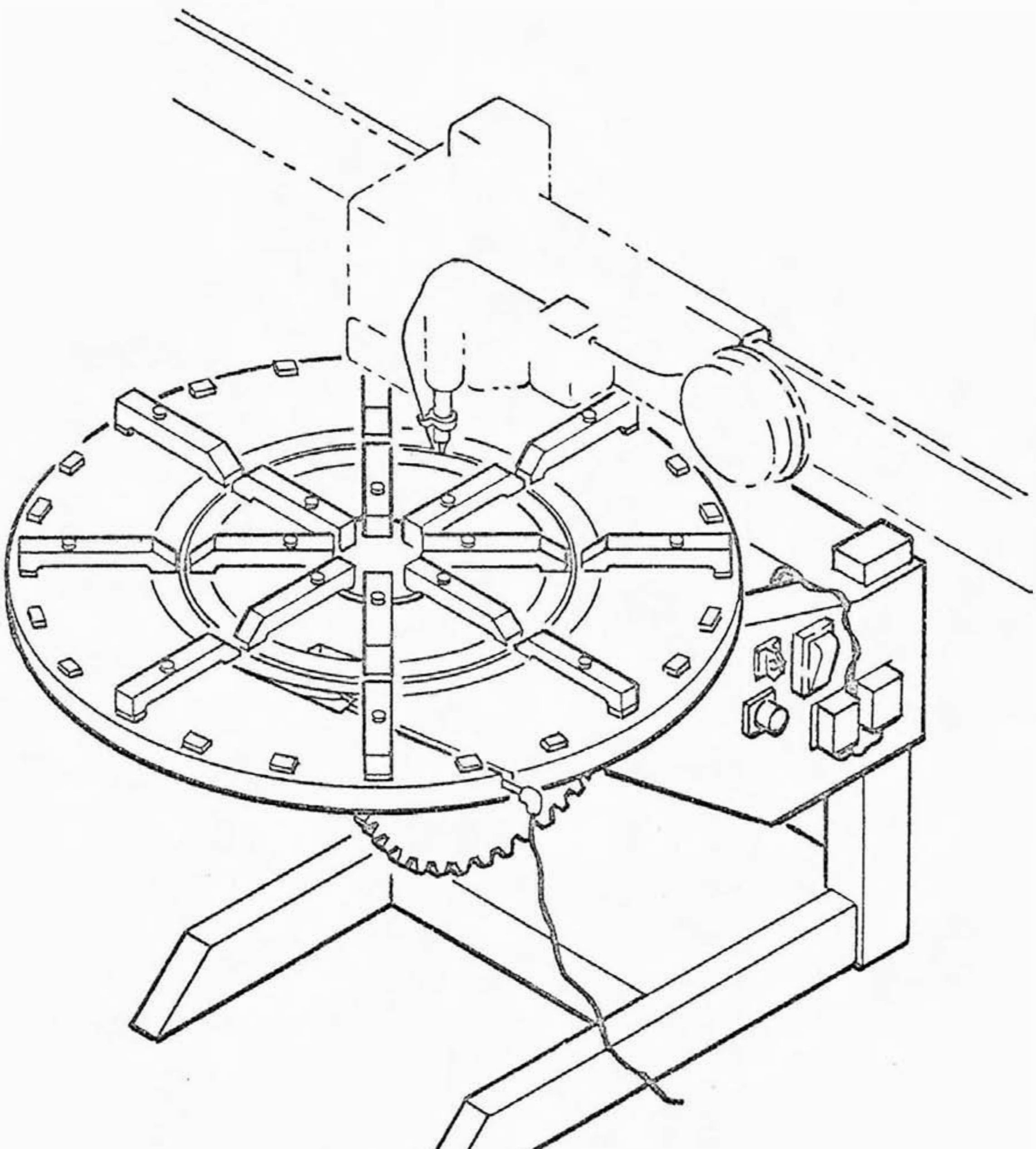

Figure 2-2. Simulated Fitting Development Weld Fixture
DWF-300-00002

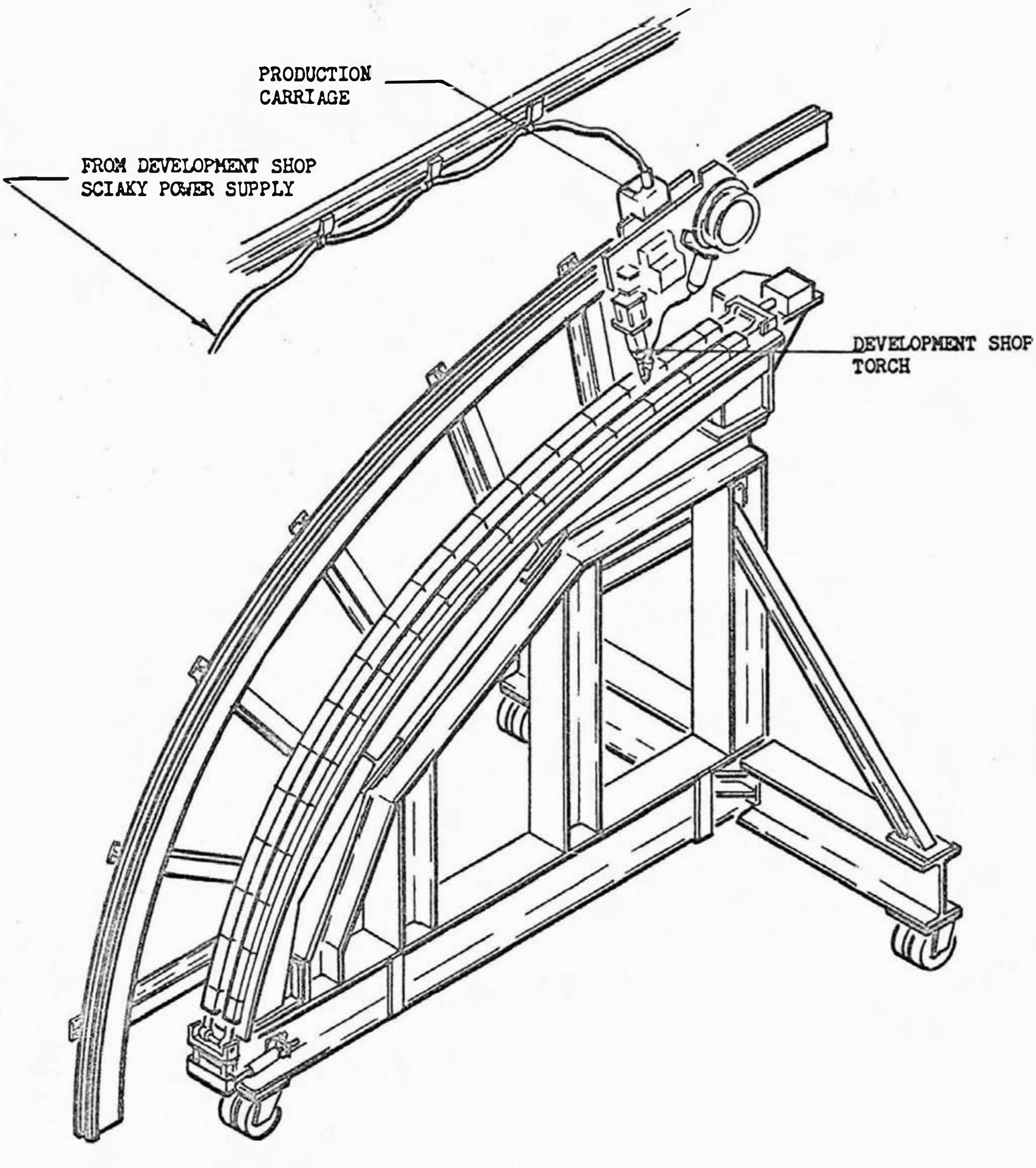

Figure 2-3. Apex-to-Base Development Weld Fixture
DWF-300-00003

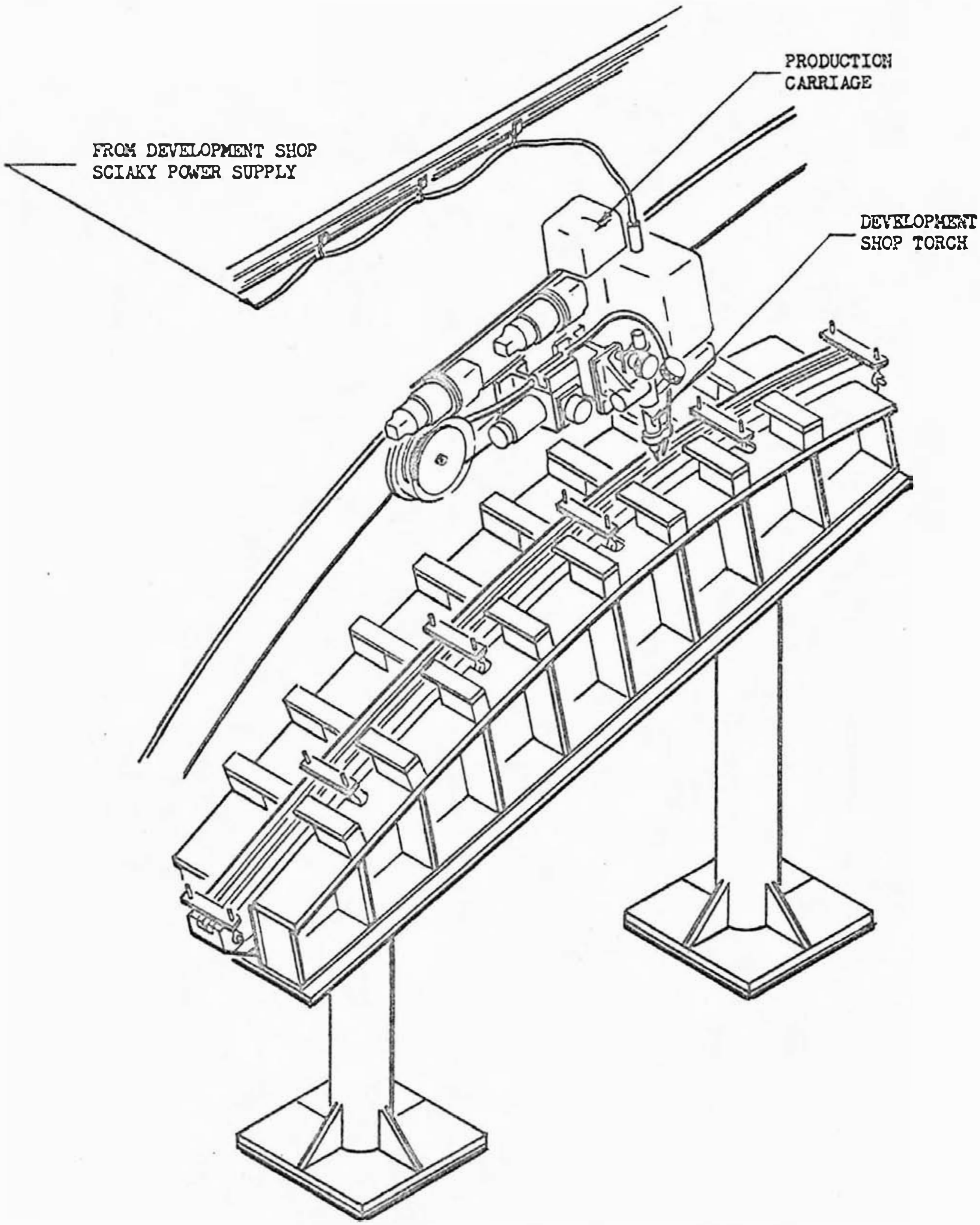

Figure 2-4. Gore-to-Gore Development Weld Fixture
DWF-300-00004

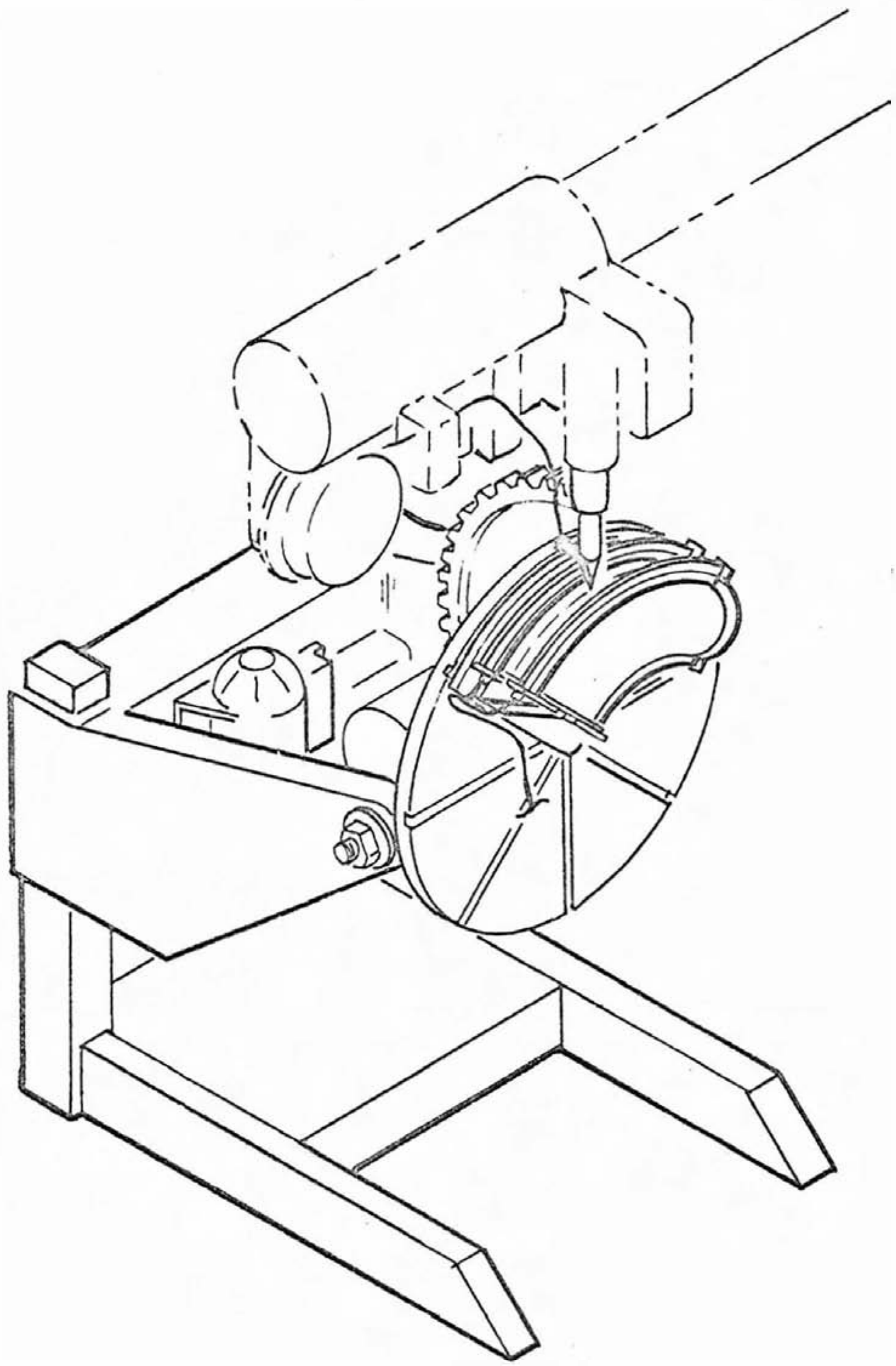

Figure 2-5. Aft Fuel Fitting Test Weld Fixture
TWF2-304-24216 & 60

3.1.8 Determination of manual weld properties in terms of reliability and repeatability.

3.1.9 Acceptance-test weld equipment to verify performance and endurance capability. Welding equipment acceptance test weld fixture DWF-300-00007 will be constructed to utilize a standard side beam and carriage with motor and speed controls which will be mounted on a fabricated pedestal. The pedestal will be designed to allow the beam to be rotated for vertical acceptance weld testing. After acceptance tests are completed, the welding system would be released to production and the fixture made ready for the next acceptance test. (See figure 2-6.)

3.1.10 Refinement and improvement of fusion welding techniques for Y-rings.

3.1.11 Process development for fusion welding of LOX tunnel components and assemblies.

3.1.12 Establishment of weldor training criteria.

3.1.13 Establishment of process control documentation of all production welding operations.

3.1.14 Process development for fusion welding of circumferential joints.

3.1.15 Process development for TIG welding of stainless steel rigimesh.

3.1.16 Process development for fusion welding Y-ring to skin.

3.1.17 Development of welding techniques for Hastelloy-C tubular assemblies used in the fairings.

3.1.18 Development of processes for shrinking fittings into place prior to welding.

3.1.19 Development of weld planishing process.

3.1.20 Establishment of process control documentation for processes used in production.

3.2 <u>Chemical Processes.</u>

3.2.1 <u>Cleaning.</u>

3.2.1.1 Development of cleanliness requirements for Saturn S-IC propulson system and subsystem hardware.

3.2.1.2 Development of processes for cleaning and etching of aluminun alloys in tank cleaning line.

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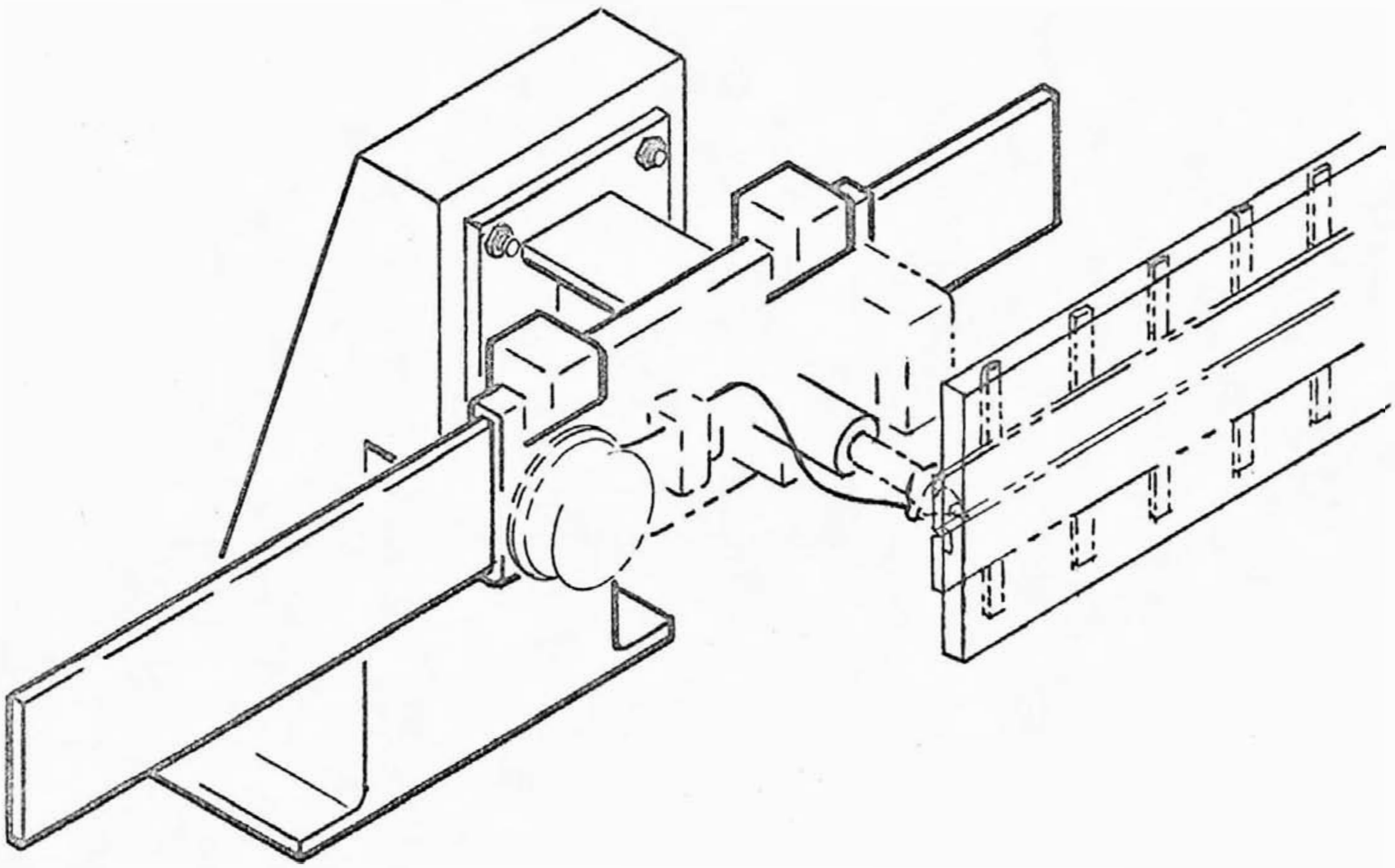

Figure 2-6. Welding Equipment Acceptance Test Weld Fixture DWF-300-00007 (Sheet 1 of 3)

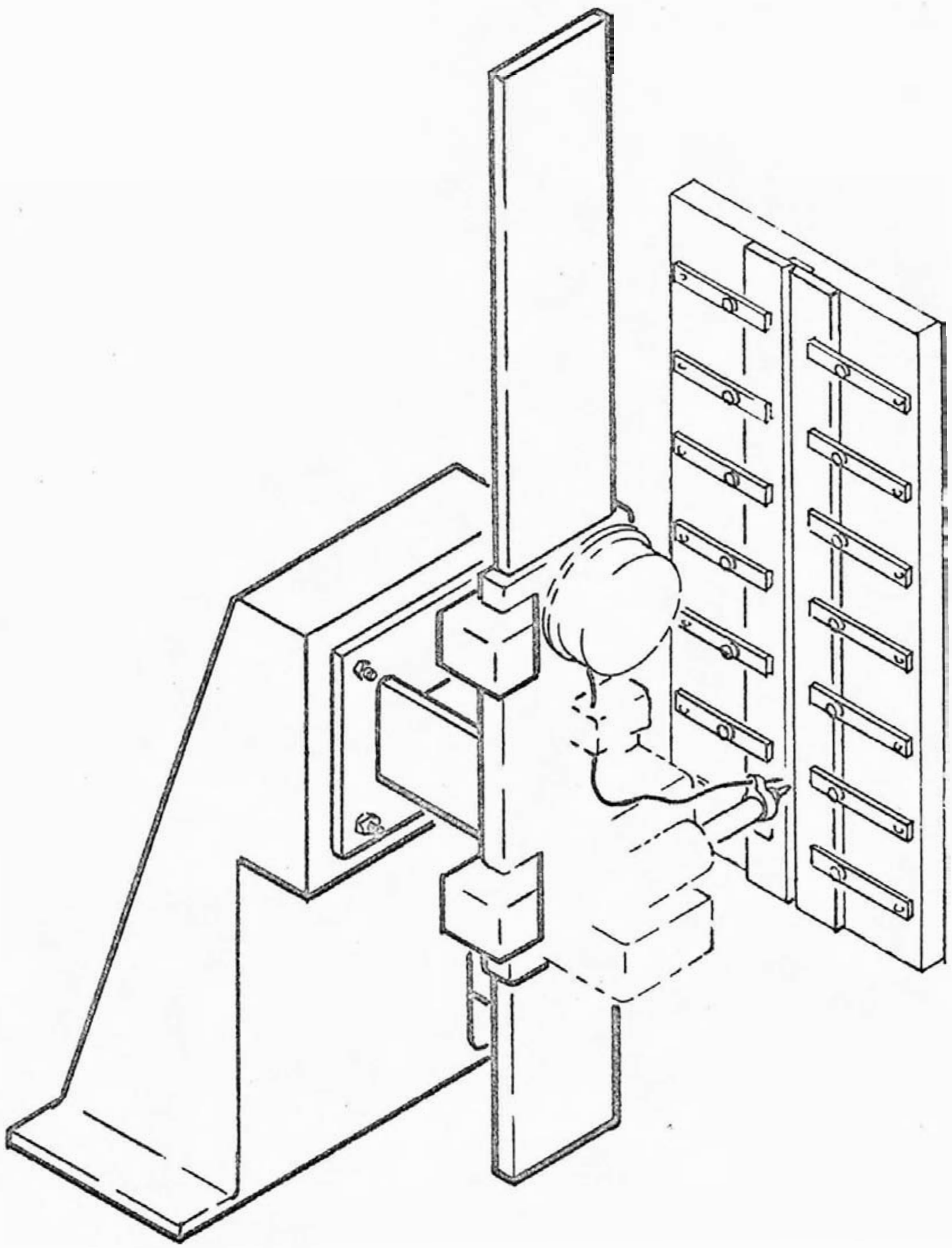

Figure 2-6. Welding Equipment Acceptance Test Weld Fixture DWF-300-00007 (Sheet 2 of 3)

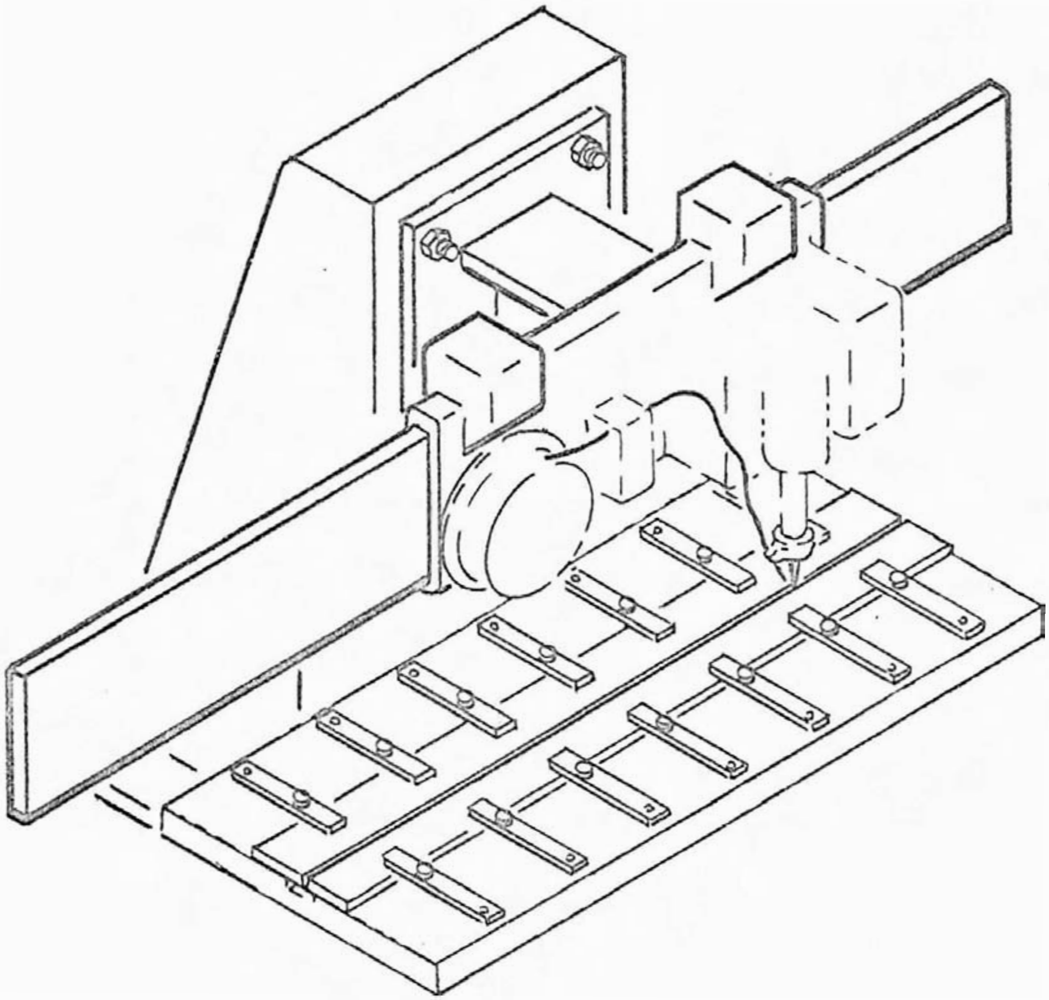

Figure 2-6. Welding Equipment Acceptance Test Weld Fixture DWF-300-00007 (Sheet 3 of 3)

3.2.1.3 Development of process for use in the major component cleaning facility.

3.2.1.4 Development of processes for cleaning other than aluminum parts.

3.2.1.5 Development of chemical or mechanical methods for cleaning weld surfaces prior to and after welding.

3.2.1.6 Establishment of process control documentation for all production cleaning requirements.

3.2.2 Chemical Milling.

3.2.2.1 Development of procedures for chemical milling 2219 aluminum.

3.2.2.2 Establishment of process control documentation for all production chemical milling requirements.

3.2.3 Conversion Coating.

3.2.3.1 Development of methods for conversion coating in-process materials.

3.2.3.2 Development of process for hand conversion coating of stripped areas.

3.2.3.3 Establishment of process control documentation for all production conversion coating requirements.

3.3 Foaming.

3.3.1 Development of foaming techniques for fabrication of the S-IC fuel tank exclusion riser.

3.3.2 Establishment of process control documentation for all production foaming requirements.

3.4 Bonding and Insulation.

3.4.1 Insulation.

3.4.1.1 Development of installation and repair procedures for all S-IC insulation requirements.

3.4.1.2 Establishment of process control documentation for application and repair of all insulating materials used in production.

3.4.2 Bonding.

3.4.2.1 Development of techniques to satisfy established bonding requirements.

3.4.2.2 Establishment of process control documentation for all production bonding requirements.

3.5 Machining.

3.5.1 Development of techniques for trimming of components prior to welding.

3.5.2 Development of Y-ring machining techniques.

3.5.3 Evaluation of cutting fluids for use in machining processes.

3.5.4 Evaluation of abrasive belt grinding to produce various finishes on 2219 aluminum.

3.5.5 Establishment of process control documentation for all production machining requirements.

3.6 Portable Tools.

3.6.1 Evaluation and selection of portable tools to assure capability for intended application and compatability with factory cleanliness requirements.

3.6.2 Establishment of process control documentation for all production portable tool requirements.

3.7 Fasteners.

3.7.1 Establishment of fastener installation and repair requirements.

3.7.2 Establishment of process control documentation for all production fastener installation requirements.

3.8 Heat Treating and Heat Sources.

3.8.1 Development of heat-treat processing for Y-ring weldments.

3.8.2 Development of heat-treat processing for Y-ring segments after rolling to reduce residual stresses.

3.8.3 Development of methods and processes for aging gore apexes and bases to contour.

3.8.4 Establishment of process control documentation for all production heat-treat requirements.

3.9 Electrical/Electronics.

3.9.1 Establishment of process criteria for printed cables and connectors.

3.9.2 Establishment of process criteria for potting of components.

3.9.3 Establishment of insulation and cable-sheathing process criteria.

3.9.4 Definition of wire bundle processing requirements.

3.9.5 Definition of printed circuit board processing requirements.

3.9.6 Development of procedures for packaging electronic components.

3.9.7 Establishment of process control documentation for production electrical/electronic assemblies.

3.10 <u>Forming.</u>

3.10.1 Development of tube forming and flaring methods.

3.10.2 Development of tube gathering techniques for engine purge system.

3.10.3 Establishment of process control documentation for all production forming requirements.

3.11 <u>Metallurgy and Nondestructive Testing.</u>

3.11.1 Development of X-ray interpretation techniques for heavy aluminum weldments.

3.11.2 Development of weld defect locating techniques.

3.11.3 Development of producible weld allowables.

3.11.4 Development of stress corrosion allowables.

3.11.5 Establishment of process control documentation in the areas of metallurgy and nondestructive testing as required.

4. PROCESS DEVELOPMENT - BOEING/WICHITA FACILITY.

4.1 <u>Welding.</u> Establishment of process control documentation for welded assemblies produced in Wichita. (Flight hardware.)

4.2 <u>Chemical Processes.</u>

4.2.1 Development of cleaning, etching, and conversion coating criteria for Wichita-produced hardware.

4.2.2 Establishment of process control documentation for all production chemical requirements.

4.3 <u>Machining.</u>

4.3.1 Development of machining criteria for presulptured skin and gore panels.

4.3.2 Establishment of process control documentation for criteria production machining operations.

4.4 <u>Heat Treat and Heat Sources.</u>

4.4.1 Development of heat-treat and heat-source criteria for age-formed components.

4.4.2 Development of heat-treat criteria for welded steel tublar assemblies.

4.4.3 Establishment of process control documentation for critical production heat-treat operations.

4.5 Forming.

4.5.1 Development of bulge-forming techniques for gore segments and polar caps.

4.5.2 Development of age-forming techniques for skin segments.

4.5.3 Development of hammer-forming process criteria for fuel fitting elbows.

4.5.4 Development of forming methods for titanium and aluminum engine-fairing parts.

4.5.5 Development of tube "T" forming techniques for S-IC components.

4.5.6 Establishment of process control documentation for all production forming operations.

5. PROCESS DEVELOPMENT - SUBCONTRACTOR.

MSFC and Boeing will use established subcontractors to minimize outplant development requirements. MSFC and Boeing will provide development support for their respective subcontractors where necessary. Each will work independently to assist the subcontractor; however, problems affecting both MSFC and Boeing concerning one subcontractor will be jointly coordinated.

5.1 Chemical Milling. Development of chemical milling of bulge-formed gores by Ryan, Martin, Anadite, and Chem-Contour.

5.2 Shear Forming. Development of shear forming technique for one-piece LOX tunnels by Parsons.

6. MANUFACTURING PROCESSES - MSFC.

6.1 Cleaning and Testing of Gas Supply Slosh Measuring MSFC Drawing Number 10419906. This paragraph presents the interim procedure of the Manufacturing Engineering Laboratory for the cleaning (purging) and monitoring cleanliness levels of gas bearing gas supply and slosh measuring subsystems. Due to the system complexity and difficulties encountered in testing the completely assembled slosh measuring system, testing procedures within the scope of this manufacturing process will be limited to slosh measuring system assemblies and subsystems as required by documentation. The final verification of the procedures will be established during the production of the first test vehicles. R-QUAL will perform the final cleaning inspections.

6.1.1 Applicable Documents. The following specifications, of the issue in effect on the date of this Manufacturing Plan, form a part of this manufacturing process.

6.1.1.1 George C. Marshall Space Flight Center.

MSFC-SPEC-237	Solvent, Freon, Precision Cleaning Agent, Specification for
MSFC-SPEC-245	Carbon Tetrachloride Scrubber Method for Analysis of Oil Contamination in Compressed Gases, Procedure for

6.1.1.1 (Con.)

MSFC-PROC-195	Cleanliness Level Requirements and Inspection Methods for Determining Cleanliness Level of Gas Bearing Supply and Slosh Measuring Systems, Procedure for
MSFC-10419906	Cleaning and Testing Gas Supply Slosh Measuring

6.1.1.2 Military.

MIL-A-148	Aluminum Foil
MIL-D-16791	Nonionic Detergent
O-C-141	Carbon Tetrachloride, Technical

6.1.1.3 Federal.

O-A-51	Acetone
BB-N-411	Nitrogen
O-T-634	Trichloroethylene

6.1.2 Definitions. For the purpose of this manufacturing process, the following definitions apply:

6.1.2.1 Assembly. An assembly is defined as a unit consisting of two or more replaceable parts (e.g. filter element, filter housing, and fittings are parts of a filter assembly) having a common mounting and which is within its physical makeup, capable of performing a definite function.

6.1.2.2 Subsystem. A subsystem is defined as a unit consisting of two or more assemblies joined together to perform a definite function and is capable of independent operation and checkout when interconnected with simulated complete systems.

6.1.2.3 Gas Bearing Gas Supply System. The gas bearing gas supply system is defined as a series of assemblies or subsystems joined together to perform a definite supply function within a space vehicle.

6.1.2.4 Slosh Measuring System. The slosh measuring system is defined as a series of assemblies or subsystems joined together to perform a definite measuring function within a space vehicle.

6.1.2.5 Critical Surfaces. Critical surfaces are defined as those surfaces of assemblies, subsystems, systems and ground support equipment that normally contact service media (gases) during use.

6.1.3 Materials.

6.1.3.1 Nitrogen. Nitrogen gas used for cleaning (purging) processes shall conform to type I, Class 1, grade A of specification BB-N-411. Nitrogen used for cleaning and testing shall be prefiltered to the 20 micron particle level and 0.3 ppm hydrocarbon level prior to use.

6.1.3.2 Carbon Tetrachloride. Spectro-grade, redistilled.

6.1.3.3 Acetone. Spectro-grade.

6.1.3.4 Oil. Oil obtained from compressed nitrogen gas lines as a standard for comparing a sample under test for condensable hydrocarbons.

6.1.4 Acceptability Provisions. The cleaning and testing of gas bearing gas supply and slosh measuring systems and assemblies shall meet the cleanliness level requirements of specification MSFC-PROC-195.

Reclean. When additional cleaning (purging) fails to meet cleanliness requirements of specification MSFC-PROC-195, reclean the assembly in accordance with MSFC drawing number 10419906.

6.1.5 Safety Requirements.

6.1.5.1 The maximum allowable concentration of carbon tetrachloride in the air of the room shall be 10 ppm by volume.

6.1.5.2 During the sampling of carbon tetrachloride, proper venting of the sampling bottles is required to eliminate toxic fumes and meet the 10 ppm maximum by volume allowable concentration.

6.1.5.3 Distillation or heating of carbon tetrachloride must be done under a hood with adequate exhaust to meet the 10 ppm maximum allowable concentration.

6.1.6 Cleaning Procedure #1. This procedure covers the gas bearing gas supply cleaning procedure for assemblies and subsystems. These assemblies and subsystems will be cleaned (purged), tested, and packaged if applicable within the Matthews Research, Inc. clean room bench.

6.1.6.1 Attach the compressed gas (nitrogen) line to the inlet port of the assembly or subsystem (test unit). (See figure 2-7.)

6.1.6.2 Flow the compressed gas through the test unit with the flow rate and inlet pressure as required by design criteria until the test unit is cleaned to the required level of cleanliness as determined by the requirements in specification MSFC-PROC-195.

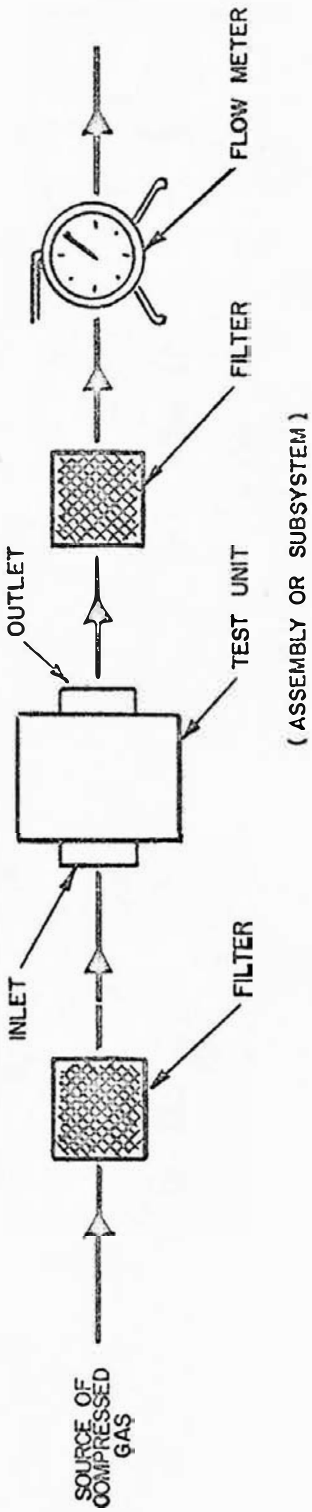

Figure 2-7. Schematic Drawing Showing Connections for Test

6.1.6.3 Test the compressed gas flowing from the effluent side of the test unit for particle contamination and condensable hydrocarbons to meet the requirements of specification MSFC-PROC-195. The flow rates and pressures are governed by the capability of the assembly and the test setup for the condensable hydrocarbon determination.

CAUTION: Do not test an assembly where no exit port is present.

a. Particle Testing.

(1) Thoroughly wash the millipore filter holder and the millipore filter membrane with (20 micron absolute) solvent (Trichloroethylene conforming to specification O-T-634, Freon Precision Cleaning Agent, or equivalent).

(2) Using precleaned forceps with unserrated tips, insert the millipore membrane into the millipore filter holder.

(3) Attach the millipore filter to the outlet port of the test unit.

(4) Attach the calibrated wet test meter to the downstream side of the millipore filter holder.

(5) Unless otherwise specified on applicable documentation, flow the compressed gas sample (30 standard cubic feed minimum) through the test unit at a flow rate of seven standard cubic feet per minute.

(6) Remove millipore filter holder from sampling point; using forceps, carefully remove the filter membrane from the millipore filter holder.

(7) Using a microscope with ocular micrometer movable stage and an illuminating lamp, analyze the filter membrane to determine the particle number count and size ranges on the entire surface of the filter membrane.

(8) When the gas bearing gas supply test unit is found to exceed the levels specified in paragraph 6.1.6.2, repeat the preceding cleaning (purge) procedure.

(9) When additional cleaning (purges) fail to render acceptable test results, reclean the test unit in accordance with MSFC drawing 10419906.

b. Condensable Hydrocarbon Testing.

(1) Preparation of carbon tetrachloride shall be as follows: (See figure 2-8.)

(a) The carbon tetrachloride shall be distilled at approximately 300 mls per hour until three liters have been collected. The first 50 mls of distillate shall be discarded. The collecting bottle shall be rinsed carefully with portions of the distilled carbon tetrachloride.

(b) Thoroughly clean and degrease the 800 ml beaker with distilled carbon tetrachloride. Evaporate 600 mls of distilled carbon tetrachloride to approximately two mls in the 800 ml beaker in an exhaust hood. Quantitatively transfer the distilled carbon tetrachloride to a cleaned and degreased five ml volumetric flask. Wash the 800 ml beaker with small quantities of the distilled carbon tetrachloride. Allow the carbon tetrachloride to come to room temperature and refill to volume if necessary.

(c) Use a degreased hypodermic syringe to transfer the sample to a two mm sodium chloride sealed cell. Place the filled cell in the infrared spectrophotometer and record the absorbance at 2920-CM^{-1} (wavenumber) or 3.42 microns. There should be no absorbance at the above wavenumber. If absorbance is observed, the carbon tetrachloride shall be redistilled.

(2) Preparation of standards.

(a) Transfer 0.1000 gram (gm) of oil to a thoroughly cleaned liter volumetric flask and dilute to volume with blanked carbon tetrachloride (1 ml to 0.1 milligram of oil).

CAUTION: Extreme care shall be taken not to contaminate the standard.

NOTE: The oil used in the standard is collected from the compressed gas that is to be analyzed. This is done by scrubbing the gas with blanked carbon tetrachloride. The carbon tetrachloride is then evaporated and the oil retained as a control for testing future samples.

(b) From this standard solution, prepare several samples containing varying amounts of oil in five ml volumetric flasks. If the volume of these standards is in excess of five mls, evaporate the carbon tetrachloride to approximately two mls. Transfer the sample quantitatively to a five ml volumetric flask and fill to volume.

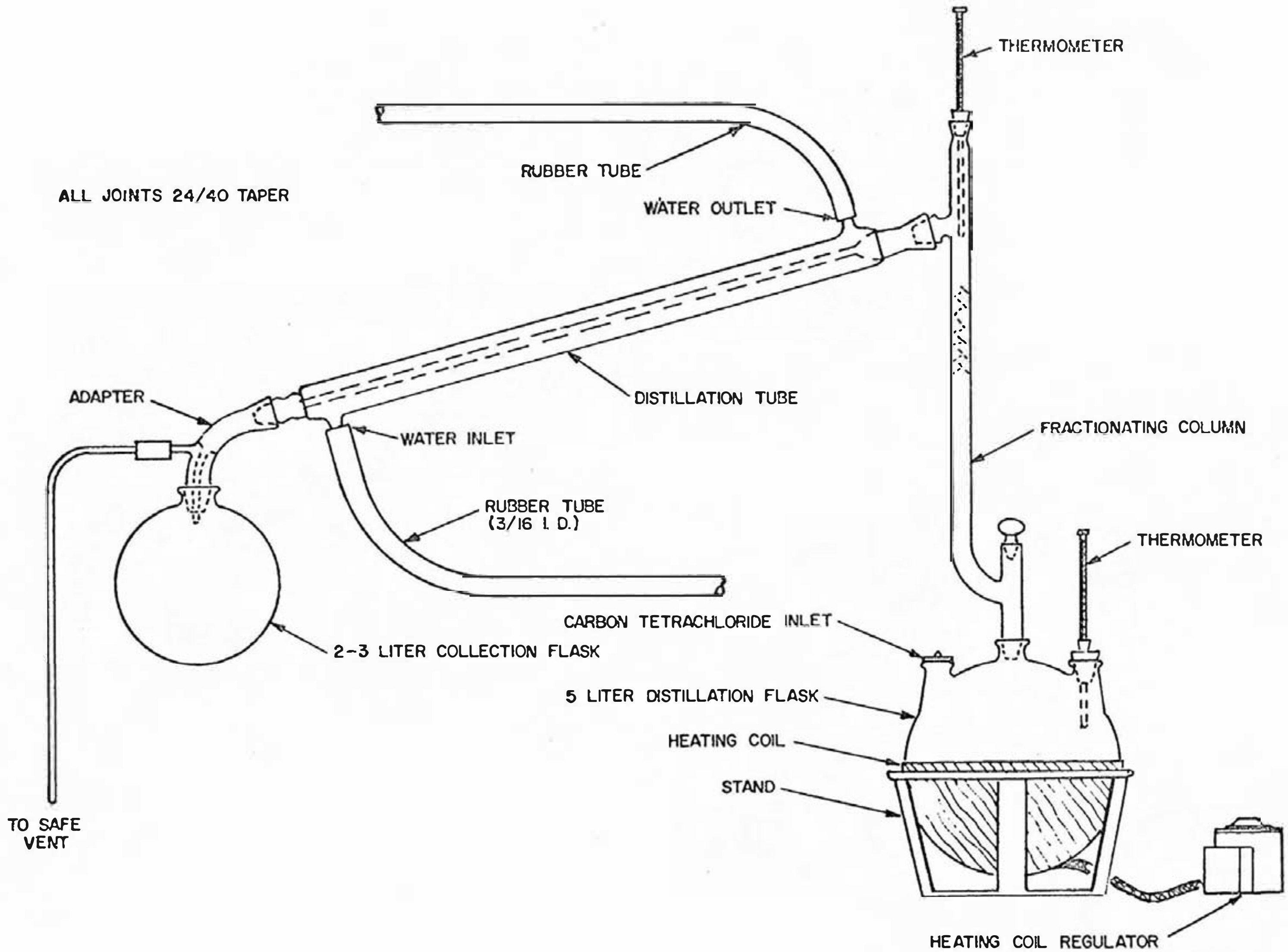

Figure 2-8. Carbon Tetrachloride Redistillation Equipment Setup

(c) Determine the net absorbance on each of the standard samples using the 2920-CM-^{1} (3.42 microns) band and prepare a working curve on absorbance versus mgs of oil. The two mm sealed cells shall be blanked before each determination. Use a degreased hypodermic syringe to transfer the blanked CCl_4 2mm sodium chloride sealed cell. Place the filled cell in the infrared spectrophotometer and record the absorbance at 2920-CM-^{1} (wavemeter) or 3.42 microns. There should be no absorbance at the above wavemeter. If absorbance is observed, the sodium chloride cell shall be cleaned and polished. At least two determinations shall be made on each standard and the average value taken as the absorbance.

NOTE: If using an automatic infrared spectrophotometer, the same slit opening, speed, and conditions must be used for all determinations.

(d) Check the preceding calibration curve periodically to ensure accuracy of the analysis.

NOTE: Use extreme care in handling all samples. Contamination from fingerprints can cause errors in the analysis.

(3) Sampling Procedures.

(a) Clean the three gas washing bottles with liquid detergent solution and rinse thoroughly with demineralized water. Rinse again with acetone, dry, and rinse at least three times with previously blanked carbon tetrachloride. Do not dry with compressed air.

(b) Fill the gas washing bottles with 100 mls of blanked distilled carbon tetrachloride and seal the tops with rubber bands. Connect the bottles in series with rubber tubing. The tubing shall be approximately 1-1/2 inches long to prevent having excess tubing exposed to the carbon tetrachloride vapor.

(c) The gas supply that is to be sampled shall have a flow rate of approximately .15 cubic feet per minute when the test is first started. After a few minutes, increase the gas flow rate to .18 to .20 feet per minute. Exercise care to prevent the carbon tetrachloride from blowing from one scrubber to the other. If this occurs, repeat operations outlined in paragraph 6.1.7.3, (3), (a) using new rubber tubing for the connections.

(d) Connect the calibrated wet test meter to the exit side of the scrubbers before the test is started. The exhaust from the wet test meter shall be properly vented because of the toxicity of carbon tetrachloride. (Refer to paragraph 6.1.5.) (See figure 2-9.)

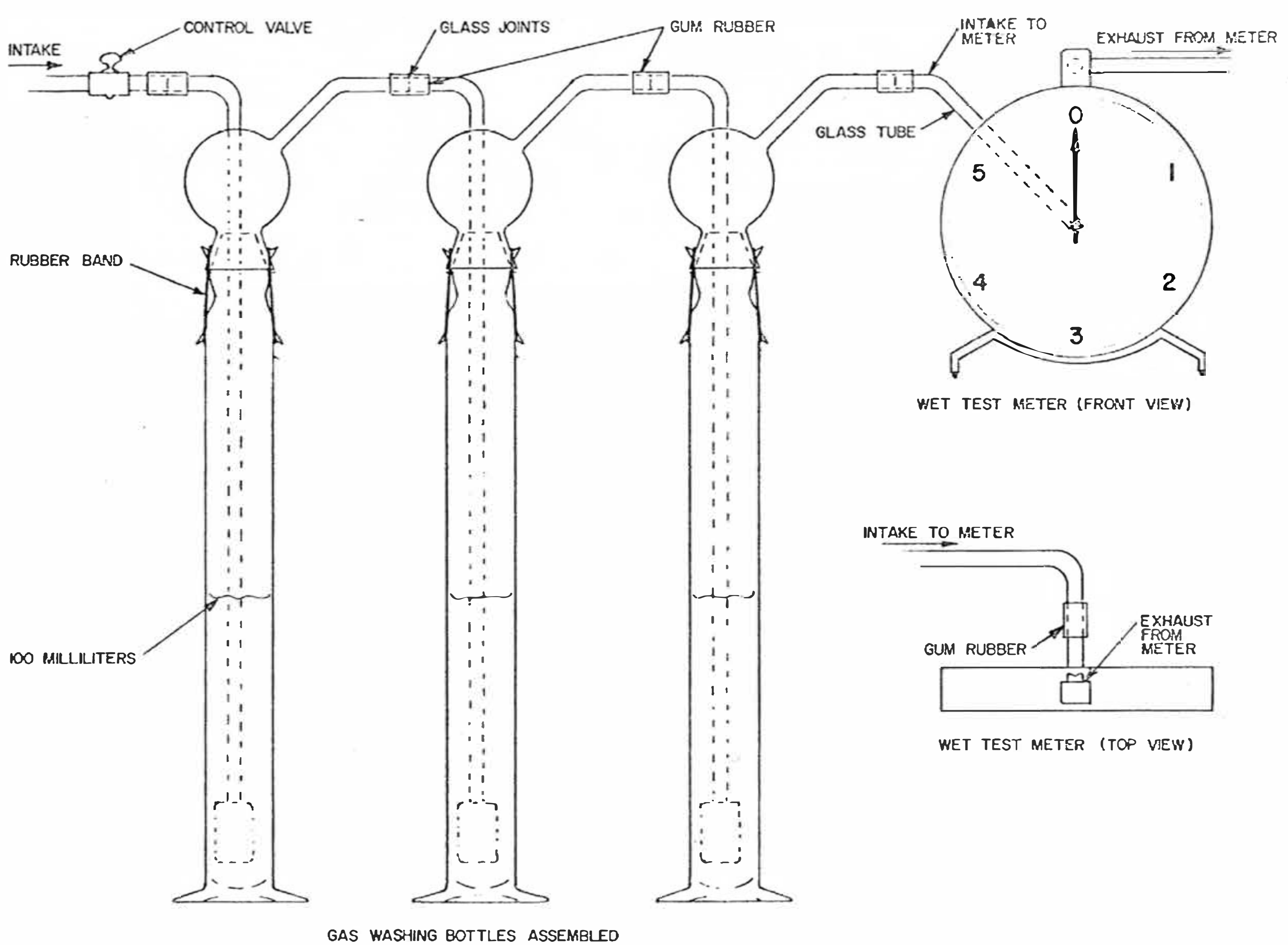

Figure 2-9. Carbon Tetrachloride Scrubber Apparatus Diagram with Wet Test Gas Meter

(e) Do not permit the carbon tetrachloride to evaporate to less than 50 mls. When adding carbon tetrachloride to the scrubbers, release the rubber band on scrubber number one, detach the inlet line, and immediately separate the top and bottom sections of the scrubbers. This prevents the carbon tetrachloride in the scrubbers from blowing over due to internal pressure. Carbon tetrachloride can be added without completely removing the fritted tube from the scrubber. Reseal scrubber number one and proceed to scrubber number two and then scrubber number three in the same manner. (See figure 2-10.)

(f) Record the temperature shown on the wet test meter at the beginning and end of the test and use the average value in the calculations. Record the barometric pressure at the calibrated wet test meter.

(g) After approximately 600 liters of gas have been scrubbed, release the pressure as described in paragraph 6.1.6.3, b., (3), (e) and remove all rubber connections from the 800 ml bottles. Cover bottles with aluminum foil conforming to specification MIL-A-148 until the solution is transferred to the beaker.

(h) Clean an 800 ml beaker as outlined in paragraph 6.1.6.3, b., (1), (b). Transfer the distilled carbon tetrachloride quantitatively by washing each section of each bottle at least three times with the blanked carbon tetrachloride.

(i) Evaporate the sample under an exhaust hood to approximately two mls using a low heat near the end and transfer the sample quantitatively (very carefully) to a five ml volumetric flask.

(4) Calculations. Correct the volume of gas to standard conditions and calculate the weight from its density. Calculate the quantity of oil in the gas in parts per million (ppm) by weight. Use the following calculations to find the volume of gas at stp weight of gas and ppm of oil in gas:

a) $$\frac{V \times P(mm)}{760\ mm} \times \frac{273.1}{273.1 + avg\ T^{o}C} = V \text{ of gas at stp}$$

Definitions

V = Volume of sample gas in liters.
P = Barometric pressure at calibrated wet test gas meter.
mm = Millimeters of mercury, pressure.
T = Average temperature in degrees centigrade of gas sample.
stp = Standard conditions of temperature and pressure.

Density of nitrogen = 1.2507 G/l at zero degree centigrade and one atmosphere of pressure.

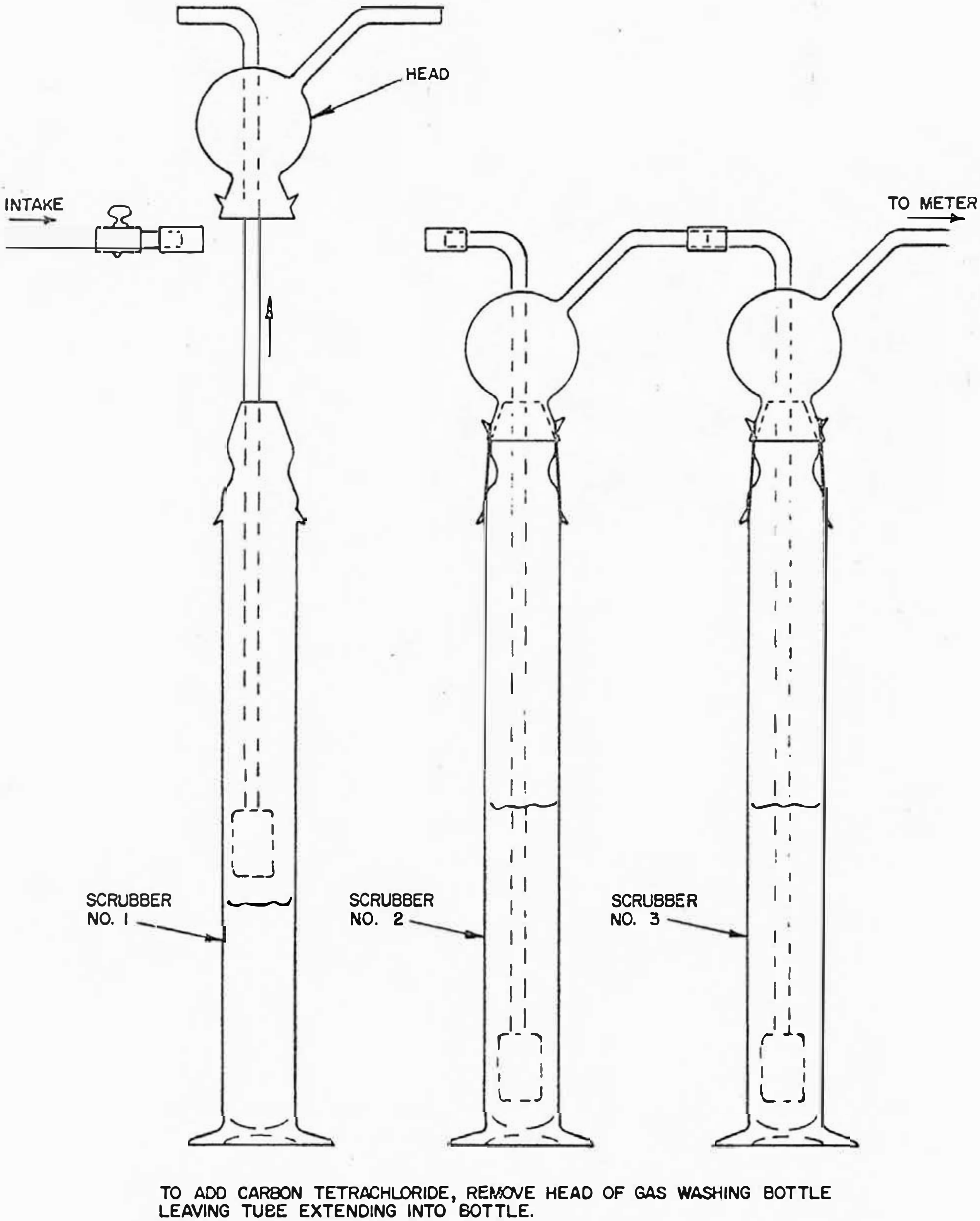

Figure 2-10. Method of Adding Carbon Tetrachloride to Gas Washing Bottles

b) Volume of gas at stp x density of gas = weight of gas

c) $\frac{\text{Mgms of oil x 1000}}{\text{Weight of gas (gms)}}$ = ppm of oil in gas

(5) Acceptance Test. The acceptance test shall be conducted as specified herein. Dilute the sample to volume, then determine the net sample absorbance on the infrared spectrophotometer as described in paragraph 6.1.6.3, b., (2), (c). From the absorbance, the concentration of oil is found on the working curve.

6.1.7 Cleaning Procedure #2. The slosh measuring system cleaning procedure for assemblies and subsystems (test unit) is as follows:

6.1.7.1 Flow the nitrogen through the test unit with the flow rate and inlet pressure as required by design criteria until the test unit is cleaned to the required level of cleanliness as determined by the requirements in specification MSFC-PROC-195.

6.1.7.2 Monitor the compressed gas flowing from the effluent side of the test unit for particle contamination and condensable hydrocarbons in accordance with the requirements of specification MSFC-PROC-195.

6.1.7.3 When the gas bearing gas supply test unit is found to be excessively contaminated, repeat the cleaning (purge) procedure.

6.1.7.4 When additional cleaning (purge) does not provide the cleanliness level requirements of specification MSFC-PROC-195, reclean the test unit in accordance with MSFC drawing number 10419906. Retest the test unit for particle contamination and condensable hydrocarbon to meet cleanliness levels in accordance with the requirements of specification MSFC-PROC-195.

CAUTION: Do not test an assembly where no exit port is present.

6.1.8 Packaging Requirements. Whenever any test unit has been cleaned (purged) or tested for particles and/or condensable contaminants, the openings in the test unit must be sealed immediately. Refer to the Manufacturing Plan for Saturn Packaging Specification for details.

6.1.9 Acceptability Provisions. The cleaning and testing of gas bearing gas supply and slosh measuring systems and assemblies shall meet the cleanliness level requirements of specification MSFC-PROC-195.

6.2 Surface Treatment of Skin and Fully Assembled Container Bulkhead Material for the S-IC Launch Vehicle. This paragraph presents the interim procedure of the Manufacturing Engineering Laboratory for the cleaning and surface treatment of the skin, head assembly material, and fully assembled container for the S-IC launch vehicle fuel and LOX containers prior to welding. The cleaning and surface treatment procedures presented are applicable to type 2219 aluminum alloy in the T-31, T-37, T-81, T-87, T-352, and T-852 heat-treat conditions. The procedures herein have been coordinated within the Manufacturing Engineering Laboratory. Any deviation from the basic procedure will require written concurrence from the Manufacturing Research and Technology Division R-ME-M. An emergency concurrence may be made by telephone, but it must be confirmed in writing.

CAUTION: String, wood, paint, or other organic material shall not be placed in the conversion coating solution because of the strongly oxidizing nature of the solution.

6.2.1 Applicable Documents - Other Publications. The following publications form a part of this process. Unless otherwise indicated, the issue in effect on the date of this Manufacturing Plan shall apply.

a. Bulletin #14-2 AL Coat	Operating Data for Iridite #14-2 AL Coat for Aluminum and Aluminum Alloys.

NOTE: Copies of this publication may be obtained from Allied Research Products, Inc., 4404 E. Monument St., Baltimore 5, Maryland.

b. Bulletin #78	Turco 4215 (Non-Silicated Alkaline Spray Washing and Hot Tank Compound for Use on Aluminum)
c. Bulletin #84	Turco Smut-Go (2897 Redstone)

NOTE: Copies of bulletins #78 and #84 may be obtained from Turco Products, Inc., P.O. Box 1055, Wilmington, California.

6.2.2 Equipment.

6.2.2.1 Vapor Degreasing Equipment. Aerojet General Corporation trichloroethylene vapor degreasing equipment, with working clearance of 24-foot long, 6-foot wide, and vapor depth of 10 feet, shall be used.

6.2.2.2 Sand Blasting Equipment. Vacu-Blast equipment, capable of blasting with 200 mesh or finer glass beads at 35 to 55 psi air pressure, shall be used.

6.2.2.3 Alkaline Cleaning Tanks. Tanks 24-feet long, 6-feet wide, and 10-1/2 feet deep constructed of mild steel may be used for cleaning parts. The welded construction shall include joints welded from inside and outside the tank.

6.2.2.4 <u>Deoxidizer or Conversion Coating Solution Tanks.</u> Tanks 24 feet long, 6 feet wide, and 10-1/2 feet deep constructed of stainless steel or of hot-rolled, SAE 1020, plate steel covered inside with koroseal, rubber, or other acid resistant coating and with joints welded inside and outside may be used.

6.2.2.5 <u>Final Rinse Tanks.</u> The rinsing tank immediately following the conversion coating tank may be constructed of hot-rolled, SAE 1020, plate steel with joints welded inside and outside. The inside surface shall be protected with Plastisol. Dimensions of the tank are 24 feet long, 6 feet wide, and 10-1/2 feet deep.

6.2.2.6 <u>Crane.</u> An overhead rail-type crane system of approximately 2000-pound capacity shall service the tank area.

6.2.2.7 <u>Racks.</u> Racks for supporting parts during cleaning and conversion coating shall permit thorough draining and may be constructed of stainless steel.

6.2.3 <u>Material.</u>

6.2.3.1 <u>Vapor-Degreasing Solvent.</u> Trichloroethylene conforming to specification O-T-634, Type II, shall be used for vapor or liquid degreasing.

6.2.3.2 <u>Alkaline Cleaner.</u> The alkaline cleaner shall be Turco 4215 at a concentration of 6 to 12 ounces per gallon of water at a temperature of 140 to 180 degrees Fahrenheit and at a pH of 8 to 10.

6.2.3.3 <u>Deoxidizer.</u> The deoxidizer employed shall be Turco Smut-Go (2897 Redstone) at a concentration of 8 to 16 ounces per gallon of water at ambient temperature and at a pH of 2 to 4.

6.2.3.4 <u>Final Rinse.</u> Demineralized filtered water possessing a minimum electrical resistivity of 50,000 ohms shall be used for all rinsing and conversion coating solutions.

6.2.3.5 <u>Conversion Coating Solution.</u> Iridite 14-2 Al coat at a concentration of .75 to 1.75 ounces per gallon of aqueous solution with a pH between 1.2 and 1.9 at ambient temperatures shall be used. Adjust pH with nitric acid when conversion coating solution pH rises above 1.9.

6.2.3.6 <u>Blasting Abrasive.</u> Contamination-free glass beads, 200 mesh or finer, shall be used.

6.2.4 Procedures. Parts not requiring artificial aging shall be conversion coated following the forming and/or milling operation. Parts to be artificially aged after welding (2219-T37 gore segments) shall be conversion coated after artificial aging.

6.2.4.1 Cleaning.

a. Solvent Cleaning. Vapor degrease with Type II trichloroethylene at a temperature of 188 ± 3 degrees Fahrenheit by lowering the part into the vapors at approximately 11 feet per minute. Allow the vapors to condense and flow from the part until the part reaches the temperature of the vapor. Remove the part at a rate not greater than 11 feet per minute.

b. Alkaline Cleaning. Alkaline clean the part with Turco 4215 at a temperature of 140 to 180 degrees Fahrenheit by dip immersion of the part for 20 minutes. The concentration of alkaline cleaner shall be 6 to 12 ounces of cleaner per gallon of water and at a pH of 8 to 10.

c. Rinse. Rinse the part with hot, filtered, tap water at a temperature of 160 to 180 degrees Fahrenheit until the pH of the aluminum surface is between 6 and 8. If the surface is not water-break free, the procedures outlined in paragraphs 6.2.4.1, a. and 6.2.4.1, b. shall be repeated.

d. Deoxidization. Deoxidize the part with Turco Smut-Go (2897 Redstone), at a concentration of 8 to 16 ounces per gallon of water, at ambient temperature and at a pH of 2 to 4, for 30 minutes.

e. Rinse. Rinse the part with demineralized water at ambient temperature until the pH of the aluminum surface is between 6 and 8.

6.2.4.2 Conversion Coating. Conversion coat the part by dip immersion for 1-1/2 to 3 minutes in Iridite 14-2 at ambient temperature. The solution shall contain .75 to 1.75 ounces of Iridite 14-2 per gallon of water. The pH of the solution shall be between 1.2 to 1.9.

a. Rinse. Rinse the part with ambient temperature demineralized water until the pH of the aluminum surface is between 6 and 8.

b. Drying. Allow the part to dry for a minimum of 24 hours at ambient temperature.

6.2.4.3 <u>Stripping of Parts Requiring Artificial Aging.</u> Conversion coated parts, such as 2219-T37, which require subsequent artificial aging shall have the coating entirely removed as follows:

a. Immerse part in Turco Form Etchant #13 at ambient temperature until the conversion coating is entirely removed.

CAUTION: Metal removal shall not exceed .0006 inch.

b. Rinse part thoroughly by immersion at ambient temperature in water agitated by air.

c. Deoxidize part with Turco Smut-Go (2897 Redstone) for 30 minutes at ambient temperature. The solution shall be at a concentration of 8 to 16 ounces per gallon of water. The pH of the solution shall be 2 to 4.

6.2.4.4 <u>Stripping Weld Areas.</u> Parts, such as 2219-T87, that do not require subsequent artificial aging shall have the conversion coating removed at least nine inches from the trim line. The coating shall be removed from the weld area as follows:

a. If there is a delay between the conversion coating operation and stripping of the weld area, pre-clean the area to be stripped by wiping with a clean, dry, lint-free cloth followed by an ethyl alcohol or acetone solvent wiping.

b. Remove conversion coating from weld area by either of the following methods:

(1) Blast the conversion coating from the surface using 200 mesh or finer, contamination-free, glass beads.

NOTE: The cleaning speed should be approximately two square feet-per-minute at an air pressure of 35 to 55 psi.

(2) Brush or wipe the conversion coating from the surface using a stainless steel wire brush or stainless steel wool.

6.2.5 <u>Manufacturing Control Provisions.</u>

6.2.5.1 <u>Visual Examination.</u> Coatings usually exhibit an iridescent color ranging from light golden to brown. The coating shall be continuous, smooth, adherent, and uniform in appearance.

6.2.5.2 Test Panels. At the same time skin and head assembly materials are conversion coated, 2219 aluminum alloy test panels shall be forwarded to R-QUAL for testing in accordance with specification FED-STD-151.

6.2.5.3 pH Requirements. pH control checks shall be performed electrometrically on the applicable material listed in paragraph 6.2.3.

6.2.5.4 Final Surface Cleanliness. Final surface cleanliness requirements shall be determined by R-QUAL.

6.2.6 Preparation for Delivery. The protection given parts coated with conversion coatings during handling or shipment must be adequate to ensure acceptable parts. Parts shall be treated as required by purchasing agreements, drawings, or related specifications. Packaging of finished parts shall be accomplished by the instructions in applicable engineering drawings. Finished parts prior to packaging must be in a dry condition. The part shall be retained in a dry condition while packaged.

6.3 Surface Treatment of Weld Areas of the S-IC Tanks M-ME-MPROC 150.9. This paragraph presents the interim procedure of the Manufacturing Engineering Laboratory for the surface treatment of head assembly, longitudinal, and girth weld areas of the S-IC vehicle fuel and oxidizer tanks prior to and following welding. The surface treatment procedures presented are applicable to 2219 aluminum alloy in the T-31, T-37, T-81, T-87, and T-352 heat-treat conditions. The procedures herein have been coordinated within the Manufacturing Engineering Laboratory. The final verification of the procedure will be established during the production of the first test vehicles. Any deviation from the basic procedure will require concurrence from Manufacturing Research and Technology Division R-ME-M. An emergency concurrence may be made by telephone, but must be confirmed in writing.

CAUTION: String, wood, paint, or other organic material shall not be placed in the conversion coating solution.

6.3.1 Applicable Document - Other Publication. The following publication, of the issue in effect on the date of this Manufacturing Plan, forms a part of this manufacturing process.

#14-2 AL Coat	Operating Data for Iridite #14-2 AL Coat for Aluminum and Aluminum Alloys

NOTE: Copies of this publication may be obtained from Allied Research Products, Inc., 4404 E. Monument St., Baltimore 5, Maryland.

6.3.2 Equipment.

6.3.2.1 Mechanical Deoxidation Equipment. A file shall be used for deoxidizing edges to be welded. A tool steel scraper shall be used on the metal adjacent to the weld.

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6.3.2.2 Spray Equipment. A stainless steel spray gun with a cup capacity of approximately one quart shall be used when spray applying the conversion coating solution. The pressure pot shall be constructed of stainless steel and have an approximate capacity of two gallons.

6.3.2.3 Paint Brush. Two inch disposable brushes shall be used when brush applying the conversion coating solution.

6.3.3 Material.

6.3.3.1 Cleaning Solvent. Ethyl alcohol conforming to specification O-E-760 or trichloroethylene conforming to specification O-T-634 shall be used.

6.3.3.2 Conversion Coating Solution. Iridite 14-2 aluminum coat at a concentration of four ounces per gallon of aqueous solution with a pH between .9 and 1.1 at ambient temperature shall be used. Adjust pH with nitric acid when conversion coating solution pH rises above 1.1.

6.3.3.3 Thickener for Conversion Coating Solution. Cab-O-Sil, a silica based thickener, shall be added to the conversion coating solution. The concentration shall be one to two ounces of Cab-O-Sil per gallon of conversion coating solution. Cab-O-Sil is available from Cabot Corporation; Minerals and Chemicals Division; 125 High Street; Boston 10, Massachusetts.

6.3.3.4 Demineralized Water. Filtered water, possessing a minimum electrical resistivity of 50,000 ohms, shall be used for rinsing and for makeup of the conversion coating solution.

6.3.4 Procedures.

6.3.4.1 Deoxidation Prior to Welding.

a. Solvent clean metal surface to be deoxidized with ethyl alcohol conforming to specification O-E-760.

b. Allow metal surface to dry.

c. Mechanically deoxidize by draw filing edges to be welded and by scraping adjacent parent metal on all sides of weld with a tool steel scraper for a distance of 1/2 to 1 inch.

6.3.4.2 Welding. Weld according to the appropriate manufacturing process within 24 hours of the deoxidation process.

6.3.4.3 <u>Surface Treatment Following Welding.</u> All parts to be heat treated, such as 2219-T37, will be conversion coated as follows:

a. Vapor degrease with Type II trichloroethylene at 185 to 191 degrees Fahrenheit. Allow to dry.

b. Alkaline clean with Turco 4215 by dip immersion for 20 minutes at 140 to 180 degrees Fahrenheit. The concentration of cleaner is 6 to 12 ounces per gallon of water; pH is 8 to 10.

c. Rinse with 160 to 180 degree Fahrenheit filtered tap water until pH of aluminum surface is from 6 to 8; if surface is not water-break free, repeat paragraph a. and b.

d. Deoxidize with Turco Smut-Go (2897 Redstone) for 30 minutes at a concentration of 8 to 16 ounces per gallon of water at ambient temperature at a pH of from 2 to 4.

e. Rinse with ambient temperature demineralized water until pH of aluminum surface is from 6 to 8.

f. Conversion coat with Iridite 14-2 by dip immersion for 1-1/2 to 3 minutes at ambient temperature. The bath shall contain 0.75 to 1.75 ounces of Iridite 14-2 per gallon of water at a pH of 1.2 to 1.9.

g. Rinse with ambient temperature demineralized water until pH of aluminum surface is from 6 to 8.

h. Allow to dry for a minimum time of 24 hours at ambient temperature.

Parts not requiring heat treatment after welding will be conversion coated as follows:

a. Mechanically clean weld areas and areas adjacent to welds not covered by a conversion coating by hand or grinding operation using nonelectrolytic material (aluminum wool or aluminum oxice abrasive).

b. Solvent clean with ethyl alcohol conforming to specification O-E-760 or trichloroethylene conforming to specification O-T-634 (Type I or II). Allow surface to dry.

c. Brush or spray the conversion coating solution (4 ounces Iridite 14-2 plus one to two ounces Cab-O-Sil per gallon of solution) over the entire uncoated weld area.

d. Rinse off excess conversion coating solution from the weld area with demineralized water; allow surface to air dry. Allow to dry for a minimum of 24 hours or until the conversion coat has sufficiently aged.

e. Visual Examination. Conversion coatings usually exhibit an iridescent color ranging from light golden to brown. The coating shall be continuous, smooth, adherent, powder-free, and uniform in appearance.

f. pH Determination. The pH of the conversion coating solution shall be maintained between 0.9 and 1.1. pH determinations shall be made electrometrically using a potentiometer with a glass electrode.

6.3.5 Manufacturing Control Provisions.

6.3.5.1 Visual Examination. Conversion coatings usually exhibit an iridescent color ranging from light golden to brown. The coating shall be continuous, smooth, adherent, powder-free, and uniform in appearance.

6.3.5.2 pH Determination. The pH of the conversion coating solution shall be maintained between .9 and 1.1. pH determinations shall be made electrometrically using a potentiometer with a glass electrode.

6.4 Welding of Bulkhead Gores for the S-IC Vehicle. The procedures for welding of fittings into the gore segments, welding of gore segments to form the head assembly, welding of the centerpiece to the head assembly, welding Y-ring to head assembly, welding of skin segments to form cylinders, and welding of skin segments to the Y-ring, are presently being verified in the development of the S-IC fuel test tank. This includes repair welding procedures. This will be fully documented when completed.

6.4.1 Applicable Documents. The following specifications, of the issue in effect on the date of this Manufacturing Plan, form a part of this manufacturing process.

6.4.1.1 George C. Marshall Space Flight Center.

ABMA-PD-R-27	Radiographic Inspection: Soundness Requirements for Fusion Welds in Aluminum and Magnesium Missile Components
ABMA-PD-W-45	Welding, Fusion, Shielded Arc, Missile Components, Aluminum and Magnesium, Manual or Automatic

6.4.1.1 (Con.)

MSFC-SPEC-120	Welding, Fusion Shielded Arc, Aluminum and Magnesium Alloys, Launch Vehicle Components, Specification for
MSFC-SPEC-130	Certification of Welding Operators for Fusion Welding Airframes, Specification for
MSFC-10M01646	Aluminum Alloy Plate, 2219, Specification for
MSFC-SPEC-135	
MSFC-SPEC-363	
MSFC-SPEC-364	

6.4.1.2 Military.

MIL-A-8920	Aluminum Alloy, Plate and Sheet, 2219
MIL-T-5021(ASG)	Tests, Aircraft Welding Operators Certification
MIL-I-6865(ASG)	Inspection, Radiographic
MIL-W-8604	Welding of Aluminum Alloys, Process for
MIL-W-22248	Weldments, Aluminum and Aluminum Alloys

6.4.2 Welding Operator. Welding operators shall meet the requirements of specifications MSFC-SPEC-120, MSFC-SPEC-130, and MIL-T-5021 as governed by the 2219 aluminum alloy (for both manual and mechanized).

6.4.3 Equipment.

6.4.3.1 Apex Gore to Base Gore Weld.

a. WF-302-7002 Welding Carriage, Bulkhead

b. T&WF-302-7003 Welder Subbase, Bulkhead Gore Trim and Weld Fixture

c. WF-302-7004 Backup Bar, Apex

d. HF-302-7009 Holding Fixture, Apex Gore

e. WF-302-7010 Weld Fixture, Apex Gore-to-Base Gore

f. EWF-302-7010 Electrical Drawing, Weld Fixture, Apex Gore-to-Base Gore

g. WFA-302-7020 Weld Head Manipulator

h. WFA-302-7040 Weld Head Manipulator Adapter

i. TWF-302-7042 Test Weld Fixture, Gore Section

j. PP-302-7046 Personnel Platform, Apex-to-Base Gore Weld

k. WFA-302-7058 Weld Fixture Accessory, Tilting Platform

l. HF-302-7082 Holding Fixture, Bulkhead Base Gore

6.4.3.2 Meridian Weld.

a. WF-302-7002 Welding Carriage, Bulkhead

b. T&WF-302-7003 Welder Subbase, Bulkhead Gore Trim and Weld Fixture

c. AF-302-7011 Turntable, Bulkhead Fabrication

d. WF-302-7012 Welding Station, Bulkhead Fabrication

e. EWF-302-7012 Electrical Drawing, Welding Station, Bulkhead Fabrication

f. HF-302-7017 Holding Fixture, Bulkhead Gore

g. TWF-302-7019 Test Weld Fixture, Gore

h. WFA-302-7020 Weld Head Manipulator

i. HF-302-7028 Holding Fixture, Bulkhead-to-Turntable

j. WFA-302-7040 Weld Head Manipulator Adapter

k. PP-302-7045 Personnel Platform Bulkhead Fabrication Welding Station

6.4.3.3 Centerpiece to Head Assembly Weld.

a. T&WF-302-7014 Trim and Weld Fixture, Centerpiece to Bulkhead

b. ET&WF-302-7014 Electrical Drawing, Trim and Weld Fixture, Centerpiece to Bulkhead

c. PP-302-7047 — Personnel Platform, Trim and Weld Centerpiece to Bulkhead

6.4.3.4 <u>Y-Ring to Head Assembly.</u>

a. Head Assembly, Upper and Lower Bulkhead

b. Apex Gore

c. Base Gore

d. Centerpiece, Head

e. Y-Ring, Forward Fuel Tank

f. Y-Ring, Rear Fuel Tank

6.4.3.5 <u>Welding Equipment and Controls.</u> The welding equipment and fixtures shall be in a condition capable of producing satisfactory welds. This equipment must be such that it will be reproducible within one percent of present value for 10 percent line voltage fluctuation. Arc guidance and proximity may be used for these welds. The arc guidance is to be operated to ± 1/32 inch and the proximity to ± .015 inch.

6.4.3.6 <u>Gas Regulators and Flow Meters.</u> Gas regulators and flow meters shall accurately meter inert gas flow from 0.5 to 200 cubic feet per hour. The gas regulators and flow meters shall be calibrated or adjusted every six months or when deemed necessary by the operator due to erratic performance of the gas shield.

6.4.4 <u>Material.</u>

6.4.4.1 <u>Filler Wire.</u> The filler wire shall be type 2319 and conform to the requirements of specification M-ME-MPROC 700.1 - Manufacturing Process for the Acceptance of Spooled (Type 2319) Aluminum Weld Filler Wire for the S-IC Vehicle.

6.4.4.2 <u>Inert Gas.</u> Argon or helium gas, or a combination of these gases, may be used. Argon gas shall meet the requirements of specifications MSFC-SPEC-363 and MSFC-SPEC-364. The argon gas shall be 99.99 percent pure. Helium gas shall be of the highest purity obtainable from the Bureau of Mines. The dew point of each bottle of gas shall be checked by a Manufacturing Engineering Laboratory approved dew point indicator. The dew point of each bottle of gas used shall be -65 degrees Fahrenheit or below.

6.4.5 Procedures.

6.4.5.1 Welding Process. Mechanized TIG (tungsten inert gas) (DCSP) welding process shall be used. Test weld panels shall be made in the presence of Quality Assurance Division personnel.

6.4.5.2 Procedure Certification. The welding machine settings and procedures shall be established by preparing a minimum of three acceptable welded samples using a square-butt joint. Welding is to be done in the same position as the finished component. The weld torch alinement to the weld joint and the torch lead angle are to be established when making the three test panels. Test weld samples shall be 4 x 24 inches and of the same thickness and temper of type 2219 as the final components. Prior proof of capability shall be established by performing test to meet Class II requirements of specification ABMA-PD-R-27.

a. Typical Machine Settings. The following are typical machine settings that can be used in establishing the optimum settings for making the required welded samples:

Material Thickness	0.224"	0.359"
Current	180 amps	285 amps
Voltage	11-1/2 volts	11-1/2 volts
Arc Travel Speed	12 in/min	7 in/min
Wire Feed Speed	20 in/min	24 in/min
Inert Gas Shielding	85 CFM helium	100 CFM helium

b. Allowable Variations. Once the optimum machine settings are established, the allowable variation that shall be permitted is as follows:

Current	± 5 percent of established setting
Voltage	± 1/2 volt
Arc Travel Speed	± 1/4 in/min
Wire Feed Speed	± 2 in/min

The operator can vary the machine settings using hand-box controls as required to overcome known defective conditions. If any condition is not overcome with the above noted variations, the operator should stop the weld and investigate.

6.4.5.3 Weld Joint Preparation. The joint geometry shall be the same as called for on the production drawing.

6.4.5.4 Weld Joint Fitup. The weld joint shall be made to fit within the following tolerances:

a. Allowable misfit - .030 inch with zero misalinement.

b. Allowable misalinement - .030 inch with zero misfit.

c. Allowable misfit plus misalinement - total allowable .030 inch.

6.4.5.5 Surface Preparation. The edge shall be stripped of any protective finish, the edges shall be draw filed. The adjacent parent metal on all sides of the weld joint shall be scraped with a tool steel scraper for a distance of 1/2 to 1 inch for the removal of surface oxides. Clean paper can be placed over the area to be welded for protection until welding is started, if deemed advantageous. The welding is to be started within 24 hours after the weld area has been cleaned and processed without interruption.

6.4.5.6 Marking of Welds. An approved method permitting identification of each weld with test panels, recording charts, X-ray films, etc., will be used. Weld identification to be submitted to Quality Assurance Division for use in final inspection and acceptance.

6.4.5.7 Repairing Welds. The X-ray film, clearly marked with grease pencil showing the defect, shall be placed in the original position on the weld which it occupied during the initial X-ray shot. The defective area shall be measured and marked for identification. An additional area at each end of the defect shall be included in the defective area. Layers of metal shall be removed from the defective weld by means of an appropriate cutting method other than abrasive grinding. As each layer of weld metal is removed, visual examination for defects is to be made by the operator. X-ray examination may be used as final assurance that the defect has been completely removed. The weld metal necessary to be removed shall not exceed 60 percent of the parent metal thickness. The manual TIG welding process with aluminum alloy type 2319 filler metal shall be used to completely fill the area removed and to bring the bead contour back to its original size. Where excessive weld metal has been deposited, this excess shall be removed and the weld bead repuddled if necessary by means of a fusion TIG pass so that the resulting weld contour is smooth. The repaired weld area shall be X-rayed to determine its acceptance according to the requirements of specification ABMA-PD-R-27. If weld defects are greater than 25 percent for any individual weld, removal of the weld buildup and rewelding of the entire weld using mechanical equipment is permissible.

6.4.6 Physical Features of Acceptability. The weld shall have a uniform smooth appearance with full penetration not to exceed 3/32 inch and with the weld reinforcement not to exceed 3/32 inch. Visual cracks and abrupt changes in weld bead contour that could cause a notch effect are not acceptable. Other provisions as presented in paragraphs 3.4.3 and 4.1.3 of specification ABMA-PD-W-45 apply.

6.5 Welding of Fittings into the Bulkhead for the S-IC Vehicle M-ME-MPROC 200.2. This paragraph presents the interim procedure of the Manufacturing Engineering Laboratory for fusion welding of type 2219 aluminum alloy in areas of welding fittings into the gore assemblies and centerpieces into the head assemblies of the S-IC vehicle. The fusion weld procedures presented are applicable to 2219 aluminum alloy plate in T-31, T-37, T-81, and T-87 heat-treat condition, and 2219 aluminum alloy fittings in T-352 and T-852 heat-treat conditions. The procedures contained herein have been coordinated within the Manufacturing Engineering Laboratory. The final verification of the procedure will be established during the production of the first test vehicles. Any deviation from the basic procedure will require written concurrence from Manufacturing Research and Technology Division R-ME-M. An emergency concurrence may be made by telephone, but must be confirmed in writing.

6.5.1 Applicable Documents. The following specifications, of the issue in effect on the date of this Manufacturing Plan, form a part of this manufacturing process.

6.5.1.1 George C. Marshall Space Flight Center.

ABMA-PD-R-27	Radiographic Inspection: Soundness Requirements for Fusion Welds in Aluminum and Magnesium Missile Components
ABMA-PD-W-45	Welding, Fusion, Shielded Arc, Missile Components, Aluminum and Magnesium, Manual or Automatic
MSFC-SPEC-120	Welding, Fusion Shielded Arc, Aluminum and Magnesium Alloys, Launch Vehicle Components, Specification for
MSFC-SPEC-130	Certification of Welding Operators for Fusion Welding Airframes, Specification for
MSFC-10M01646	Aluminum Alloy Plate, 2219, Specification for

6.5.1.1 (Con.)

MS 100.2	Manufacturing Specification for the Deoxidation of Aluminum Alloys
M-ME-MPROC 700.1	Manufacturing Process for the Acceptance of Spooled (type 2319) Aluminum Weld Filler Wire for the S-IC Vehicle

6.5.1.2 Military.

MIL-A-4144(USAF)(1)	Argon, Gas, Welding
MIL-A-8920	Aluminum Alloy, Plate and Sheet, 2219
MIL-T-5021(ASG)	Tests, Aircraft Welding Operators Certification
MIL-I-6865(ASG)	Inspection, Radiographic
MIL-W-8604	Welding of Aluminum Alloys, Process for
MIL-W-22248	Weldments, Aluminum and Aluminum Alloys

6.5.2 Welding Operator. Welding operators shall meet the requirements of specifications MSFC-SPEC-120, MSFC-SPEC-130, and MIL-T-5021 as governed by the 2219 aluminum alloy (for both manual and mechanized).

6.5.3 Equipment.

6.5.3.1 Fittings to Apex Gores.

a.	W&TF-302-7018	Weld and Trim Fixtures, LOX Tunnel Fitting to Apex Gore
b.	W&TF-304-7033	Weld and Trim Fixture, Outboard Fuel Outlet in Lower Fuel Tank
c.	W&TF-304-7034	Weld and Trim Fixture, Inboard Fuel Outlet in Lower Fuel Tank
d.	W&TF-304-7035	Weld and Trim Fixture, Outboard LOX Tunnel to Lower Fuel Tank
e.	W&TF-304-7036	Weld and Trim Fixture, Inboard LOX Tunnel to Lower Fuel Tank
f.	RF-302-7037	Routing Spindle, Apex Gore
g.	WF-302-7038	Welding Spindle, Fitting-to-Apex Gore

h.	TWF-302-7039	Test Weld Fixture, Fitting-to-Apex Gore
i.	W&TF-302-7054	Weld and Trim Fixture, Upper Fuel and Oxidizer Tanks Manhole
j.	W&TF-304-7055	Weld and Trim Fixture, Fuel Fill and Drain, Lower Fuel Tank
k.	W&TF-304-7056	Weld and Trim Fixture, Fuel Emergency Drain, Lower Fuel Tank
l.	WFA-304-7057	Trim and Weld Gantry, Fitting-to-Gore
m.	PP-302-7068	Personnel Platform, Weld Gantry
n.	W&TF-312-7084	Weld and Trim Fixture, LOX Vent Fitting, Upper Head, Oxidizer Tank
o.	W&TF-312-7085	Weld and Trim Fixture, GOX Line Fitting, Upper Head, Oxidizer Tank

6.5.3.2 Assembly Drawings.

a. Head Assembly, Upper and Lower Bulkhead

b. Apex Gore

c. Centerpiece, Head

6.5.3.3 Welding Equipment and Controls. The welding equipment and fixtures shall be in a condition capable of producing satisfactory welds. This must be such that it will be reproducible within one percent of a preset value for 10 percent line voltage fluctuation. Proximity may be used for these welds and is to operate at $\pm$ .015 inch.

a. Weld Equipment for Fittings. The welding equipment for these operations shall be the mechanized Linde Missile Maker welding equipment, which includes an SVI-750 ampere power source, a Linde HW-13 welding torch, and Linde precision welding controls.

b. Weld Equipment for Centerpiece. The welding equipment for this operation shall consist of an Airco 600 ampere functional control power source with Linde HW-13 welding torch.

6.5.3.4 Gas Regulators and Flow Meters. Gas regulators and flow meters shall accurately meter inert gas flow from 0.5 to 200 cubic feet per hour. The gas regulators and flow meters shall be calibrated or adjusted every six months or when deemed necessary by the operator due to erratic performance of the gas shield.

6.5.4 Material.

6.5.4.1 Filler Wire. The filler wire shall be type 2319 and conform to the requirements of specification M-ME-PROC 700.1 - Manufacturing Process for the Acceptance of Spooled (Type 2319) Aluminum Weld Filler Wire for the S-IC Vehicle.

6.5.4.2 Inert Gas. Argon or Helium gas, or a combination of these gases, may be used. Argon gas shall meet the requirements of specification MIL-A-4144(USAF) (1). The argon gas shall be 99.99 percent pure. Helium gas shall be of the highest purity obtainable from the Bureau of Mines. The dew point of each bottle of gas shall be checked by a Manufacturing Engineering Laboratory approved dew point indicator. The dew point of each bottle of gas used shall be -65 degrees Fahrenheit or below.

6.5.5 Procedures.

6.5.5.1 Welding Process. Mechanized TIG (tungsten inert gas) welding process shall be used. Test weld panels shall be made in the presence of Quality Assurance Division personnel.

6.5.5.2 Procedure Certification. The welding machine settings and procedures shall be established by preparing a minimum of three acceptable welded samples using a square-butt joint and welding in the flat position. The weld torch alinement to the weld joint and the torch lead angle are to be established when making the three test samples. Test weld samples shall be 4 x 24 inches, type 2219-T37 and 2219-T352 material, and the same material thickness as the finished component. Welding is to be accomplished in a single-pass weld. Prior proof of capability shall be established by performing tests to meet Class II requirements of specification ABMA-PD-R-27.

a. Typical Machine Settings. The following are typical machine settings that can be used in establishing the optimum settings for making the required welded samples:

Material Thickness	0.244"	0.359"
Current	180 amps	285 amps
Voltage	11-1/2 volts	11-1/2 volts
Arc Travel Speed	12 in/min	7 in/min
Wire Feed Speed	20 in/min	24 in/min
Inert Gas Shielding	85 CFH helium	100 CFH helium

b. Allowable Variations. Once the optimum machine settings are established, the allowable variations that shall be permitted are as follows:

Current	± 5 percent of established settings
Voltage	± 1/2 volt
Arc Travel Speed	± 1/4 in/min
Torch Angle	± 1/2 degree

The operator can vary the machine settings using hand-box controls as required to overcome known defective conditions. If any condition is not overcome with the above noted variations, the operator should stop the weld and investigate.

6.5.5.3 Weld Joint Preparation. A square-butt joint shall be machined on all edges to be welded.

6.5.5.4 Joint Fitup. The weld joint shall be made to fit within the following tolerances:

a. Allowable misfit - .030 inch with zero misalinement.

b. Allowable misalinement - .030 inch with zero misfit.

c. Allowable misfit plus misalinement - total allowable .030 inch.

6.5.5.5 Surface Preparation. The edge shall be stripped of any protective finish that might be presented and the edges shall be draw filed. The adjacent parent metal on all sides of the weld joint shall be scraped with a tool steel scraper for a distance of 1/2 to 1 inch for the removal of surface oxides. Clean paper can be placed over the area to be welded for protection until welding is started, if deemed advantageous. The welding is to be started within 24 hours after the weld area has been cleaned and processed without interruption.

6.5.5.6 Marking of Welds. An approved method permitting identification of each weld joint with test panels, recording charts, X-ray films, etc., will be used. Weld identification to be submitted to Quality Assurance Division for use in final inspection and acceptance.

6.5.5.7 Repairing Welds. The X-ray film, clearly marked with grease pencil showing the defect, shall be placed in the original position on the weld which it occupied during the initial X-ray shot. The defective area shall be measured and marked for identification. An additional area at each end of the defect shall be included in the defective area. Layers of metal shall be removed from the defective weld by means of an appropriate cutting method other than abrasive grinding. As each layer of weld is removed, visual examination for defects is to be

6.5.5.7 (Con.)

made by the operator. X-ray examination may be used as final assurance that the defect has been completely removed. The weld metal necessary to be removed shall not exceed 60 percent of the parent metal thickness. The manual TIG welding process with aluminum alloy type 2319 filler metal shall be used to completely fill the area removed and to bring the bead contour back to its original size. Where excessive weld metal has been deposited, this excess shall be removed and the weld head repuddled if necessary by means of a fusion TIG pass so that the resulting weld contour is smooth. The repaired weld area shall be X-rayed to determine its acceptance according to the requirements of specification ABMA-PD-R-27. If weld defects are greater than 25 percent for any individual weld, removal of the weld buildup and rewelding of the entire weld using mechanical equipment is permissible.

6.5.6 Physical Features of Acceptability. The weld shall have a uniform smooth appearance with full penetration not to exceed 3/32 inch, and with the weld reinforcement not to exceed 3/32 inch. Visual cracks and abrupt changes in weld beam contour that could cause a notch effect are not acceptable. Other provisions as presented in paragraphs 3.4.3 and 4.1.3 of specification ABMA-PD-W-45 apply.

6.6 Welding of Skins for The S-IC Vehicle M-ME-MPROC 200.3. This paragraph presents the interim procedure of the Manufacturing Engineering Laboratory for the vertical and horizontal fusion welding of type 2219 aluminum alloy in the fabrication of the skins of the S-IC vehicle. The procedures presented are applicable to 2219 aluminum alloy in the T-87 heat-treat condition. The procedures contained herein have been coordinated within the Manufacturing Engineering Laboratory. The final verification of this procedure will be established during the production of the first test vehicles. Any deviation from this basic procedure will require written concurrence from Manufacturing Research and Technology R-ME-M. An emergency concurrence may be made by telephone, but must be confirmed in writing.

6.6.1 Applicable Documents. The following specifications, of the issue in effect on the date of this Manufacturing Plan, form a part of this manufacturing process.

6.6.1.1 George C. Marshall Space Flight Center.

ABMA-PD-R-27	Radiographic Inspection: Soundness Requirements for Fusion Welds in Aluminum and Magnesium Missile Components

6.1.1.1 (Con.)

ABMA-PD-W-45	Welding, Fusion, Shielded Arc, Missile Components, Aluminum and Magnesium, Manual or Automatic
MSFC-SPEC-120	Welding, Fusion Shielded Arc, Aluminum and Magnesium Alloys, Launch Vehicle Components, Specification for
MSFC-SPEC 130	Certification of Welding Operators for Fusion Welding Airframes, Specification for
MSFC-10M01646	Aluminum Alloy Plate, 2219, Specification for
MS 100.2	Manufacturing Specification for the Deoxidation of Aluminum Alloys
M-ME-MPROC 700.1	Manufacturing Process for the Acceptance of Spooled Aluminum (Type 2319) Weld Filler Wire for the S-IC Vehicle

6.1.1.2 <u>Military.</u>

MIL-A-4144(USAF)(1)	Argon, Gas, Welding
MIL-A-8920	Aluminum Alloy, Plate and Sheet, 2219
MIL-T-5021(ASG)	Tests, Aircraft Welding Operators Certification
MIL-I-6865(ASG)	Inspection, Radiographic
MIL-W-8604	Welding of Aluminum Alloys, Process for
MIL-W-22248	Weldments, Aluminum and Aluminum Alloys

6.6.2 <u>Welding Operator.</u> Welding operators shall meet the requirements of specifications MSFC-SPEC-120, MSFC-SPEC-130, and MIL-T-5021 as governed by the 2219 aluminum alloy (for both manual and mechanized).

6.6.3 Equipment.

6.6.3.1	AF-300-7016	Turntable, Assembly Tower, Main Weld Station
6.6.3.2	WFA-302-7020	Weld Head Manipulator
6.6.3.3	WFA-302-7063	Weld Head Manipulator Short Adapter
6.6.3.4	WF-306-7067	Weld Fixture, Cylindrical Skins, Tank Section
6.6.3.5	TWF-306-7496	Test Weld Fixture, Longitudinal Welds, Cylindrical Skin
6.6.3.6	TWF-300-7509	Test Weld Fixture, Circumferential Weld, Cylindrical Skin, Assembly Tower

6.6.3.7 Welding Equipment and Controls. The welding equipment and fixtures shall be in a condition capable of producing satisfactory welds.

a. Mechanized Welding. The welding equipment shall be the Sciaky full automatic welding equipment. This shall include a 600 ampere constant current or constant potential power source, a Linde HW-13 TIG welding torch, a Sciaky PH-8 welding head, and Sciaky precision welding controls. This equipment must be such that it will be reproducible within one percent of preset value for 10 percent line voltage fluctuation. Arc guidance and proximity may be used for these welds. The arc guidance is to be operated to ± 1/32 inch and the proximity to ± .015 inch.

b. Manual Welding. The welding equipment shall be Linde HW-9 welding torch with 400 ampere Vickers constant current power supply.

6.6.3.8 Gas Regulators and Flow Meters. Gas regulators and flow meters shall accurately meter inert gas flow from 0.5 to 200 cubic feet per hour. The gas regulators and flow meters shall be calibrated or adjusted every six months or when deemed necessary by the operator due to erratic performance of the gas shield.

6.6.4 Material.

6.6.4.1 Filler Wire. The filler wire shall be type 2319 and conform to the requirements of specification M-ME-MPROC 700.1 - Manufacturing Process for the Acceptance of Spooled (Type 2319) Aluminum Weld Filler Wire for the S-IC Vehicle.

6.6.4.2 Inert Gas. Argon or Helium gas, or a combination of these gases, may be used. Argon gas shall meet the requirements of specification MIL-A-4144(USAF)(1). The Argon gas shall be 99.99 percent pure. Helium gas shall be of the highest purity obtainable from the Bureau of Mines. The dew point of each bottle of gas shall be checked by a Manufacturing Engineering Laboratory approved dew point indicator. The dew point of each bottle of gas used shall be -65 degrees Fahrenheit or below.

6.6.5 Procedures.

6.6.5.1 Welding Process. Mechanized TIG (tungsten inert gas) (DCSP) welding process shall be used. Test weld panels shall be made in the presence of Quality Assurance Division personnel.

6.6.5.2 Procedure Certification. The welding machine settings and procedures shall be established by preparing a minimum of three acceptable welded samples using a square-butt joint and welding in the same position as the production weld will be made. The weld torch alinement to the weld joint and the torch lead angle are to be established when making the three test samples. Test weld samples shall be 4 x 24 inches, type 2219-T87 material, and the same material thicknesses as the finished component. The test samples for the horizontal welds shall be radiused to the same curvature as the finished component. The test samples for the vertical welds shall be flat panels and welding done in the vertical position. When more than one weld pass is required, a macrosection shall be taken of test weld samples to ensure adequate penetration and weld bead overlap (1/8-inch minimum overlap). Prior proof of capability shall be established by performing test to meet Class II requirements of specification ABMA-PD-R-27.

a. Typical Machine Settings. The following are typical machine settings that can be used in establishing the optimum settings for making the required welded samples:

Material Thickness	0.400"	0.810"	1.000"
Current	300 amps	400 amps	500 amps
Voltage	12 volts	12 volts	12 volts
Arc Travel Speed	6 in/min	6 in/min	5 in/min
Wire Feed Speed	28 in/min	No wire	No wire
Inert Gas Shielding	100 CFH helium	100 CFH helium	100 CFH helium

Torch Position - 3-1/2-degree lead angle with 90-degree side angle

b. Allowable Variations. Once the optimum machine settings and torch position are established, the allowable variations that shall be permitted are as follows:

Current	±	5 percent of established setting
Voltage	±	1/2 volt
Arc Travel Speed	±	1/4 in/min
Wire Feed Speed	±	2 in/min
Torch Angle	±	1/2 degree

The operator can vary the machine settings using hand-box controls as required to overcome known defective conditions. If any condition is not overcome with the above noted variations, the operator should stop the weld and investigate.

6.6.5.3 Weld Joint Preparation.

a. Mechanized Welds. A square-butt joint shall be machined on all edges to be welded.

b. Manual Weld (Step Weld). A single-V weld joint having a 45-degree included angle and a .400-inch root lands is to be made.

6.6.5.4 Joint Fitup. The weld joint shall be made to fit within the following tolerances:

a. Allowable misfit - .030 inch with zero misalinement.

b. Allowable misalinement - .030 inch with zero misfit.

c. Allowable misfit plus misalinement - total allowable .030 inch.

6.6.5.5 Surface Preparation. The edge shall be stripped of any protective finish that might have dripped on it and the edges shall be draw filed. The adjacent parent metal on all sides of the weld joint shall be scraped with a tool steel scraper for a distance of 1/2 to 1 inch for the removal of surface oxides. Clean paper can be placed over the area to be welded for protection until welding is started, if deemed advantageous. The welding is to be started within 24 hours after the weld area has been cleaned and processed without interruption.

6.6.5.6 Marking of Welds. An approved method permitting identification of each weld joint with test panels, recording charts, X-ray films, etc., will be used. Weld identification to be submitted to Quality Assurance Division for use in final inspection and acceptance.

6.6.5.7 Repair Welding. The X-ray film, clearly marked with grease pencil showing the defect, shall be placed in the original position on the weld which is occupied during the initial X-ray shot. The defective area shall be measured and marked for indentification. An additional area 1/2-inch long at each end of the defect shall be included in the defective area. Layers of metal shall be removed from the defective welds by means of an appropriate cutting method other than abrasive grinding. As each layer of weld metal is removed, visual examination for defects is to be made by the operator. X-ray examination may be used as final assurance that the defect has been completely removed. The weld metal necessary to be removed shall not exceed 60 percent of the parent metal thickness. The manual TIG welding process with aluminum alloy type 2319 filler metal shall be used to completely fill the area removed and to bring the bead contour back to its original size. Where excessive weld metal has been deposited, this excess shall be removed and the weld bead repuddled if necessary by means of fusion TIG pass so that the resulting weld contour is smooth. The repaired weld area shall be X-rayed to determine its acceptance according to the requirements of specification ABMA-PD-R-27. If weld defects are greater than 25 percent for any individual weld, removal of the weld buildup and rewelding of the entire weld using mechanical equipment is permissable.

6.6.6 Physical Features of Acceptability. The weld shall have a uniform smooth appearance with full penetration not to exceed 3/32 inch, and with the weld reinforcement not to exceed 3/32 inch. Visual cracks and abrupt changes in weld bead contour that could cause a notch effect are not acceptable. Other provisions as presented in paragraphs 3.4.2 and 4.1.3 of specification ABMA-PD-W-45 apply.

6.7 Age Hardening of the Apex Gore to Fitting Assemblies. The age hardening procedures are presently being verified for the static test and flight configurations, material, and conditions.

6.8 Hydraulic Bulge Forming of 54-Inch Centerpieces for the S-IC (Saturn V) Vehicle. This process is primarily the responsibility of the Boeing Company.

6.9 Machining of Tank Skin Sections for the S-IC (Saturn) Space Launch Vehicle. This process is primarily the responsibility of the Boeing Company.

6.10 Acceptance of Spooled Type 2319 Aluminum Weld Filler Wire for the S-IC Vehicle. This process is presently being reworked since the material being furnished has been found to be defective.

7. TECHNICAL REPORTS - MSFC.

Technical reports covering some of the manufacturing processes in paragraph 6 are available upon request. Example reports are:

a. Investigation of Misfit and Misalinement Tolerances for S-IC Fabrication MDM-7-62.

b. Consistency and Reliability of Welding 3/4 Inch and One Inch Type 2219-T87 Plate M-ME-MW-25.

c. Report on Welding 2219-T87 to 2219-T81 Aluminum Plate M-ME-MW-44.

d. Cleaning and Surface Preparation for S-IC Vehicle M-ME-IN-62-16.

e. Metal Forming Development for S-IC - Saturn V M-ME-IN-62-17.

f. Bulge Forming of S-IC - Saturn V Centerpieces MDM-4-62.

8. MANUFACTURING PROCESS CONTROL DOCUMENTS - BOEING.

The following is a list of manufacturing process control documents prepared by The Boeing Company. Copies of these documents may be obtained upon request.

a. Y-Ring Weldment Stress Relief Operations D5-11578.

b. Chemical Processing of Aluminum Alloys in Interim Facilities or Remote Locations D5-11580.

c. Welding of the Fuel and LOX Tank Y-Ring D5-11636.

d. Machining Welded Y-Rings Using an Internal Mandrel D5-12736.

e. Welding S-IC LOX Tunnel Assemblies D5-12698.

f. Cleaning Contamination-Sensitive Parts in the Interim Clean Trailers D5-12706.

g. Shot-Peening Saturn S-IC Engine Actuator Support Assembly D5-12748.

SECTION III

CONTAINER COMPONENT CONCEPT

SECTION III
CONTAINER COMPONENT CONCEPT

1. AT MSFC.

1.1 Fuel Tank Assembly Components. (See figure 3-1.)

1.1.1 Gore Segments. The gore segments will be delivered to MSFC as semi-finished items. The gores will consist of two parts, the apex gore and the base gore. The apex gores will be received in T-37 condition and the fittings in T-352 or T-31 condition. Surface treatment, alodine 1200 or iridite 14-2, will be omitted on all gores. The gores will be received formed to contour, inner surface milled to predetermined pattern, excess stock for final trimming, and with tooling holes in the excess stock.

NOTE: The gores will be fabricated by either the explosive forming method or the bulge forming method. An extensive development program is required for either of these methods.

The apex gore will be located, by tooling holes, in trim and weld fixtures. Apex gore routing spindle RF-302-7037 will be used for routing the head assembly fitting holes and welding spindle WF-302-7038 for welding the fittings in place. (See figure 3-2.) The apex gore will then be transported to X-ray and the welds X-rayed, then to heat treat for heat treatment. The apex gore is then cleaned and a coating of iridite 14-2 or alodine 1200 applied. The mating edges of the apex and base gores will be trimmed and prepared for welding in apex and base gore trim fixture TmF-302-7023. (See figure 3-3.) The apex and base gores will then be located in apex gore-to-base gore weld fixture WF-302-7010 and welded into a gore assembly. (See figure 3-4.) All welds will be X-rayed and repaired as required prior to leaving weld fixture WF-302-7010. The gore assembly will then be loaded into bulkhead gore trim fixture TmF-302-7006 and trimmed to predetermined meridian trim lines. (See figure 3-5.)

1.1.2 Head Assembly. (See figures 3-6 and 3-7.) Two gore assemblies will be located on bulkhead fabrication turntable AF-302-7011 and the mating edges checked and fitted. The mating edges of the two gore assemblies are then welded utilizing bulkhead fabrication welding station WF-302-7012. The weld is then X-rayed and repaired as required. The two welded gore assemblies will then be measured to determine weld shrinkage; the third gore assembly will be trimmed in trim fixture TmF-302-7006 to compensate for weld shrinkage. The third gore assembly will then be placed on turntable AF-302-7011 and the mating edges checked, welded, and X-rayed. (See figure 3-8.) The above process will be repeated for the remaining gore assemblies. The base of the

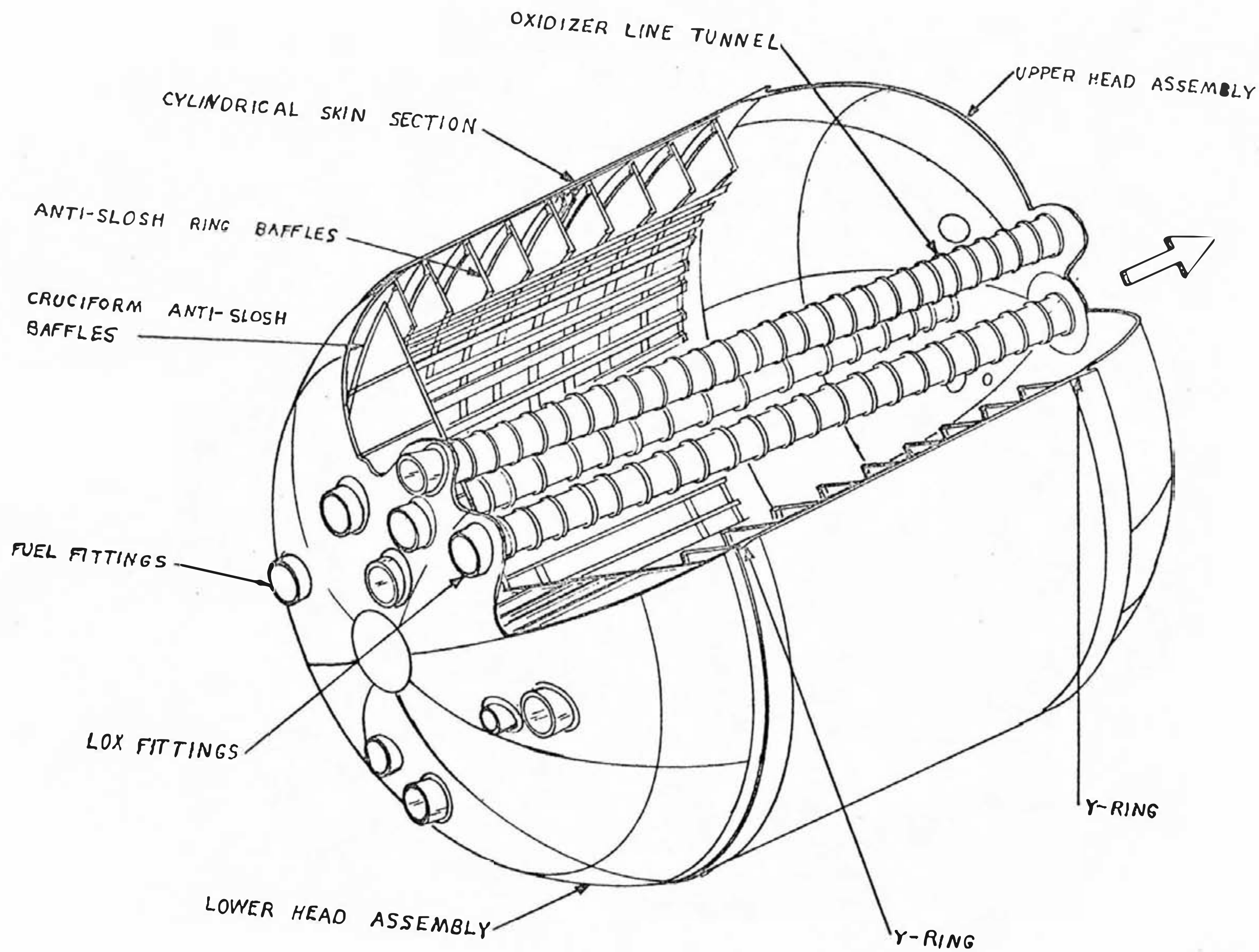


Figure 3-1. Fuel Tank Assembly

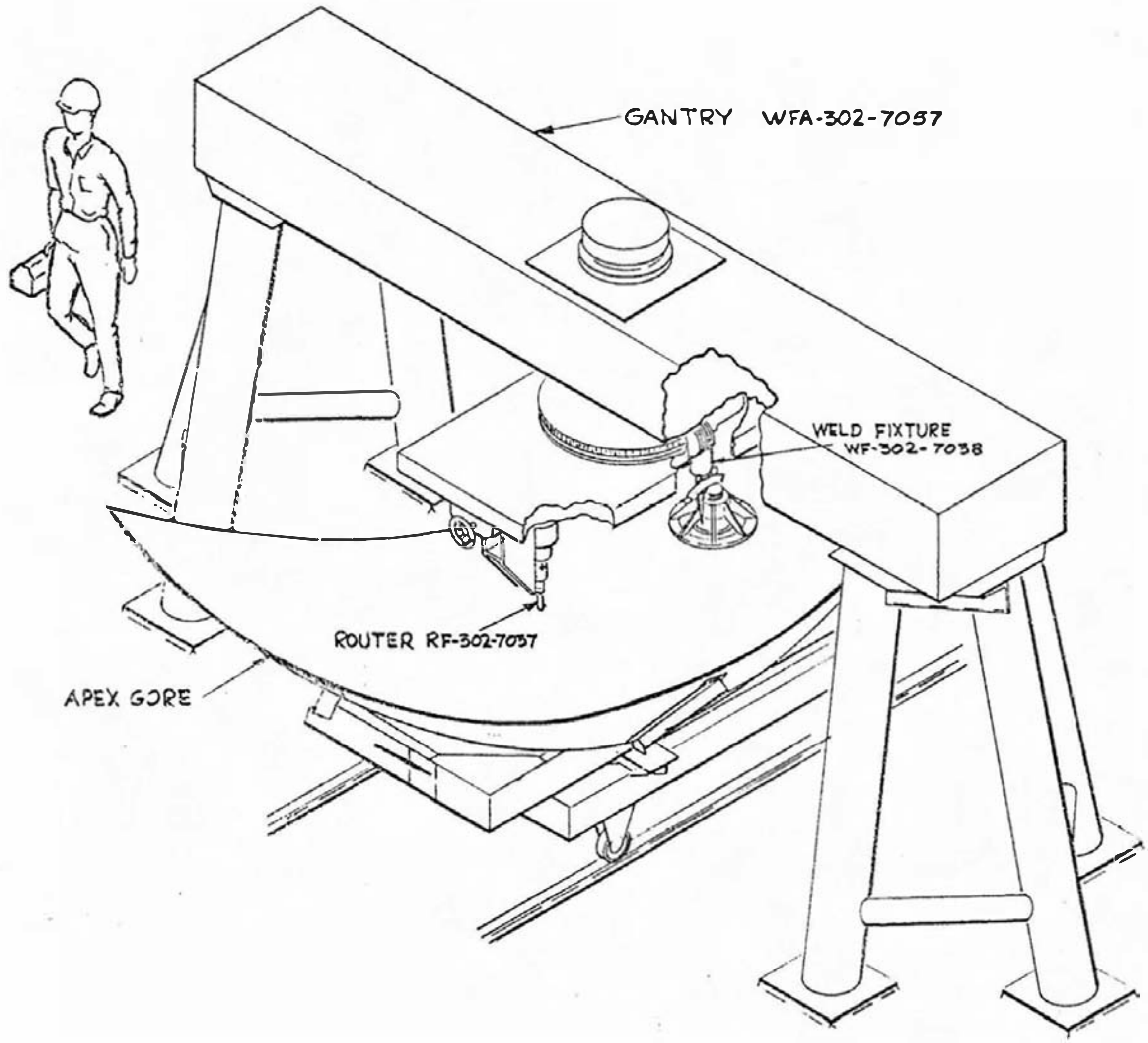
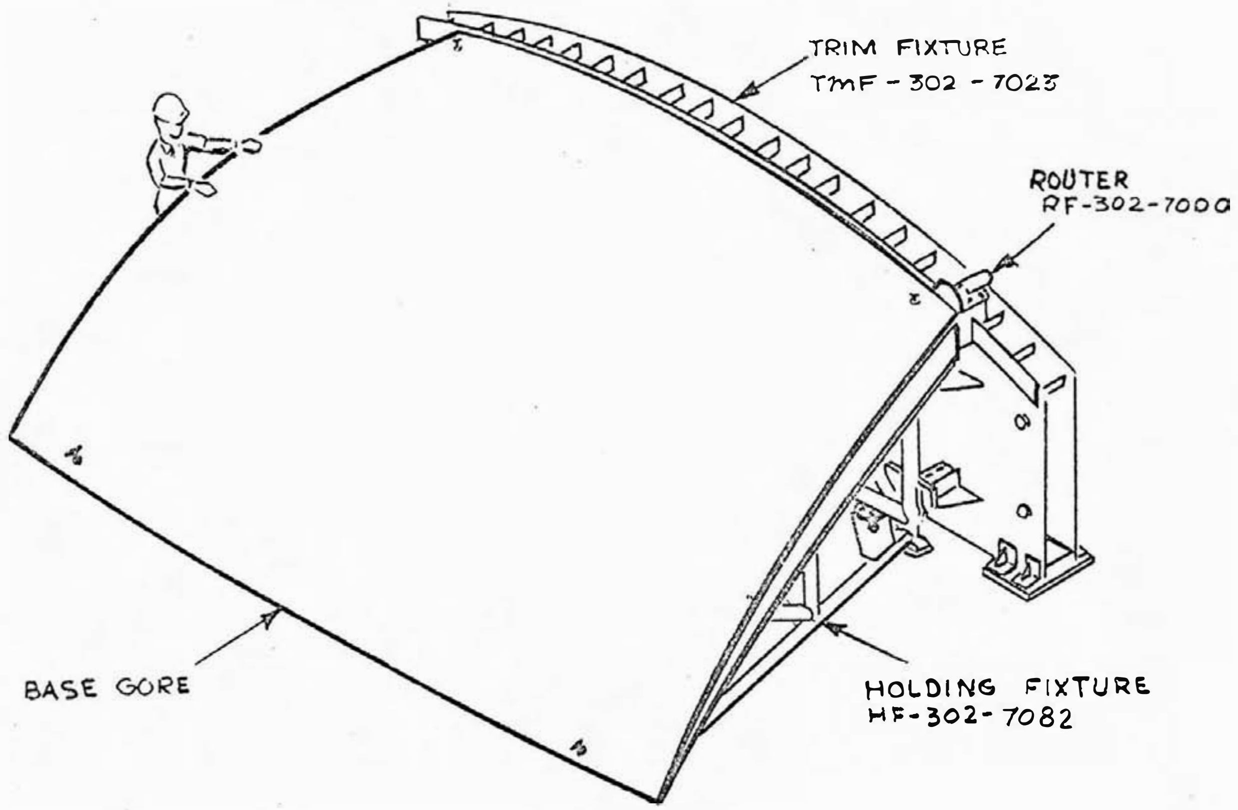


Figure 3-2. Routing and Welding Fittings to Apex Gore



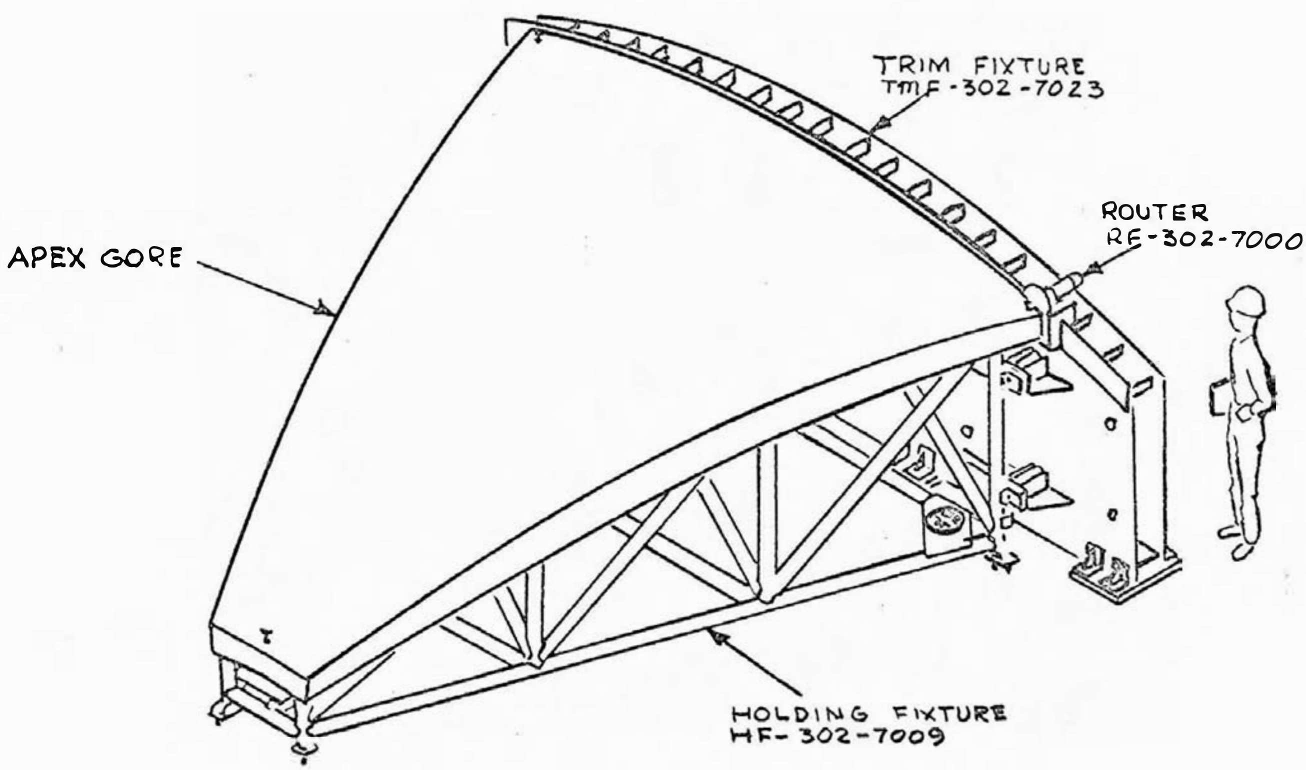


Figure 3-3. Routing Apex and Base Gores

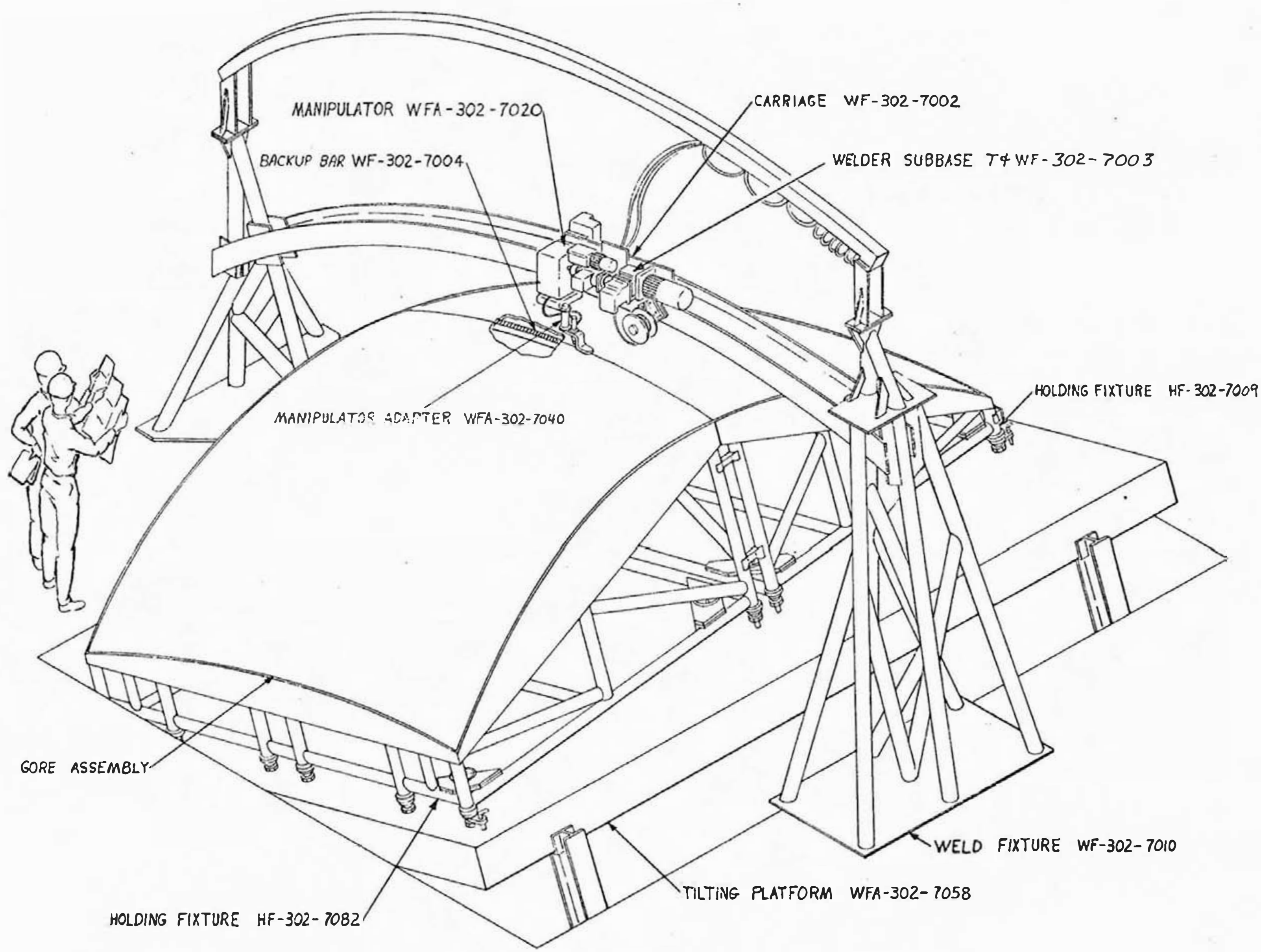


Figure 3-4. Apex to Base Welding Operation

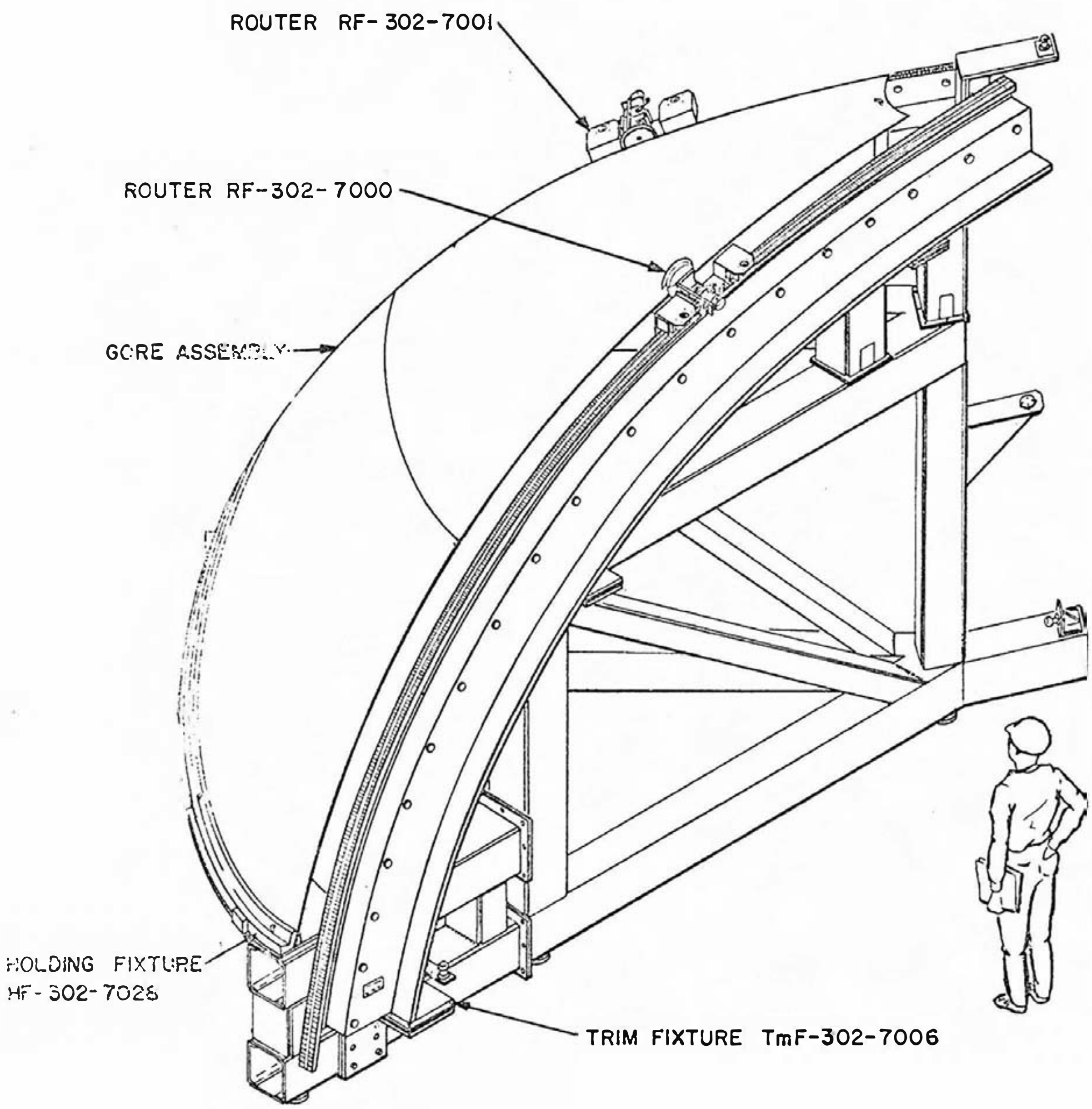


Figure 3-5. Routing Gore Assembly

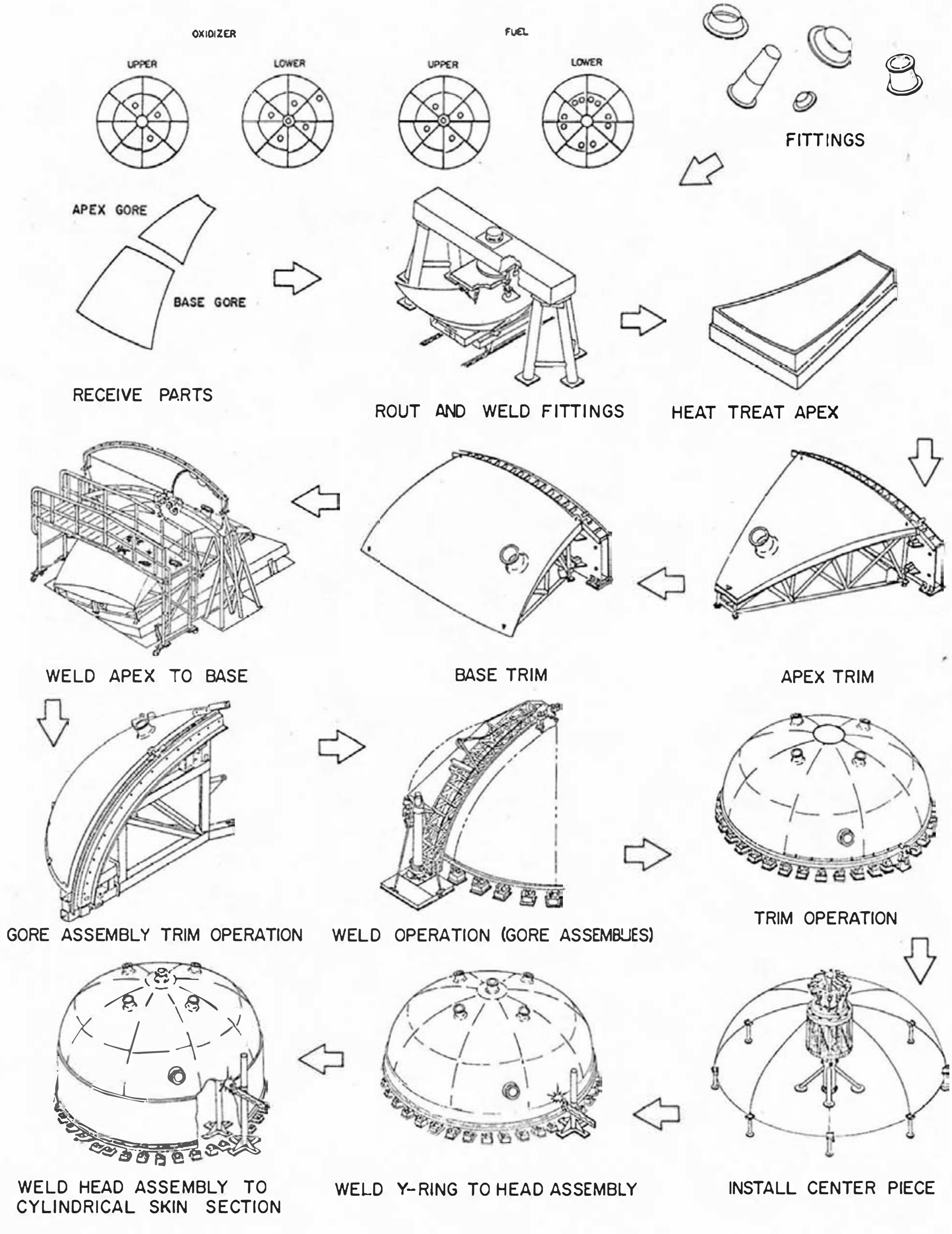


Figure 3-6. Head Assembly Buildup Sequence

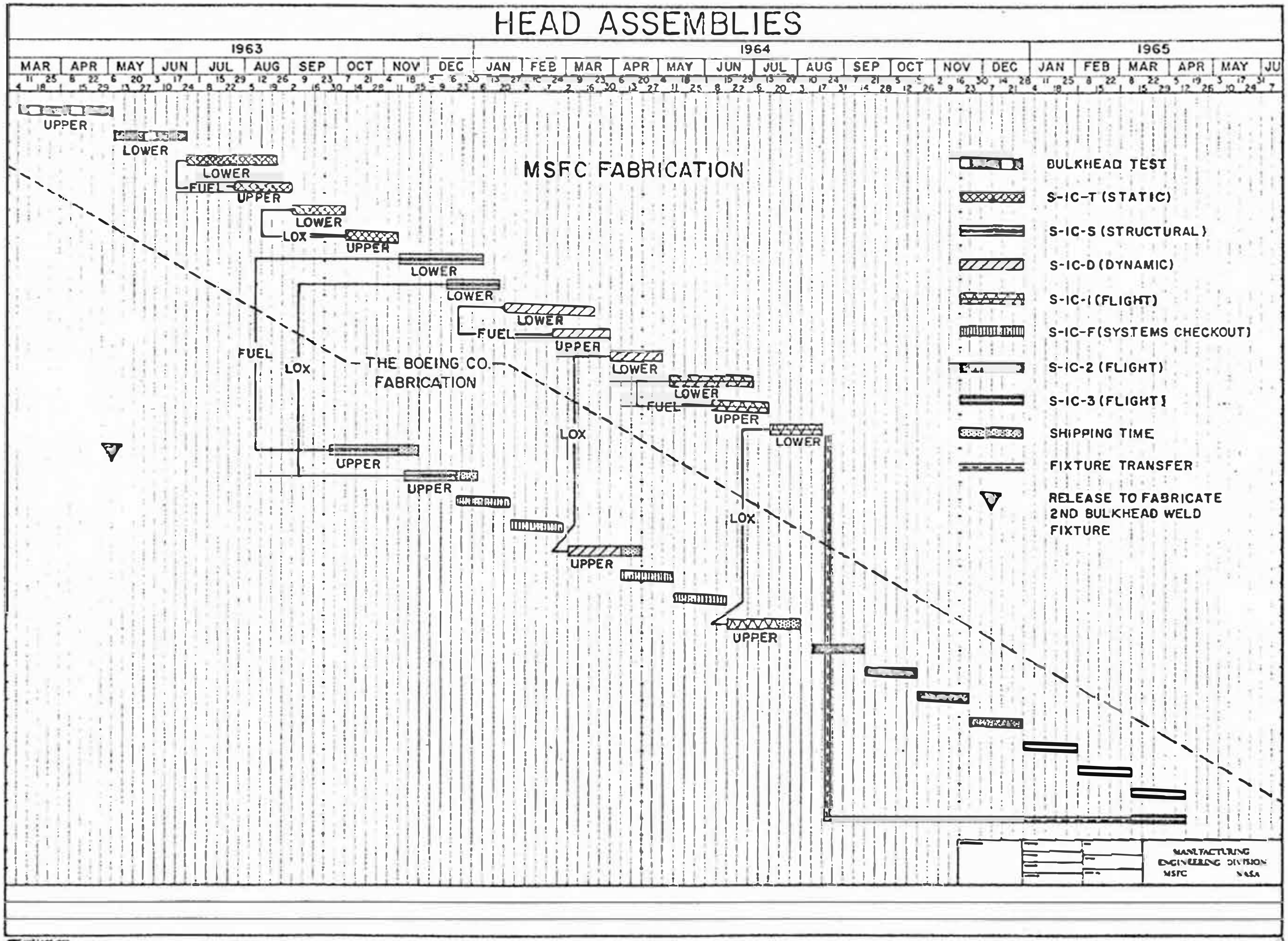


Figure 3-7. Head Assembly Schedule Chart (Sheet 1 of 3)

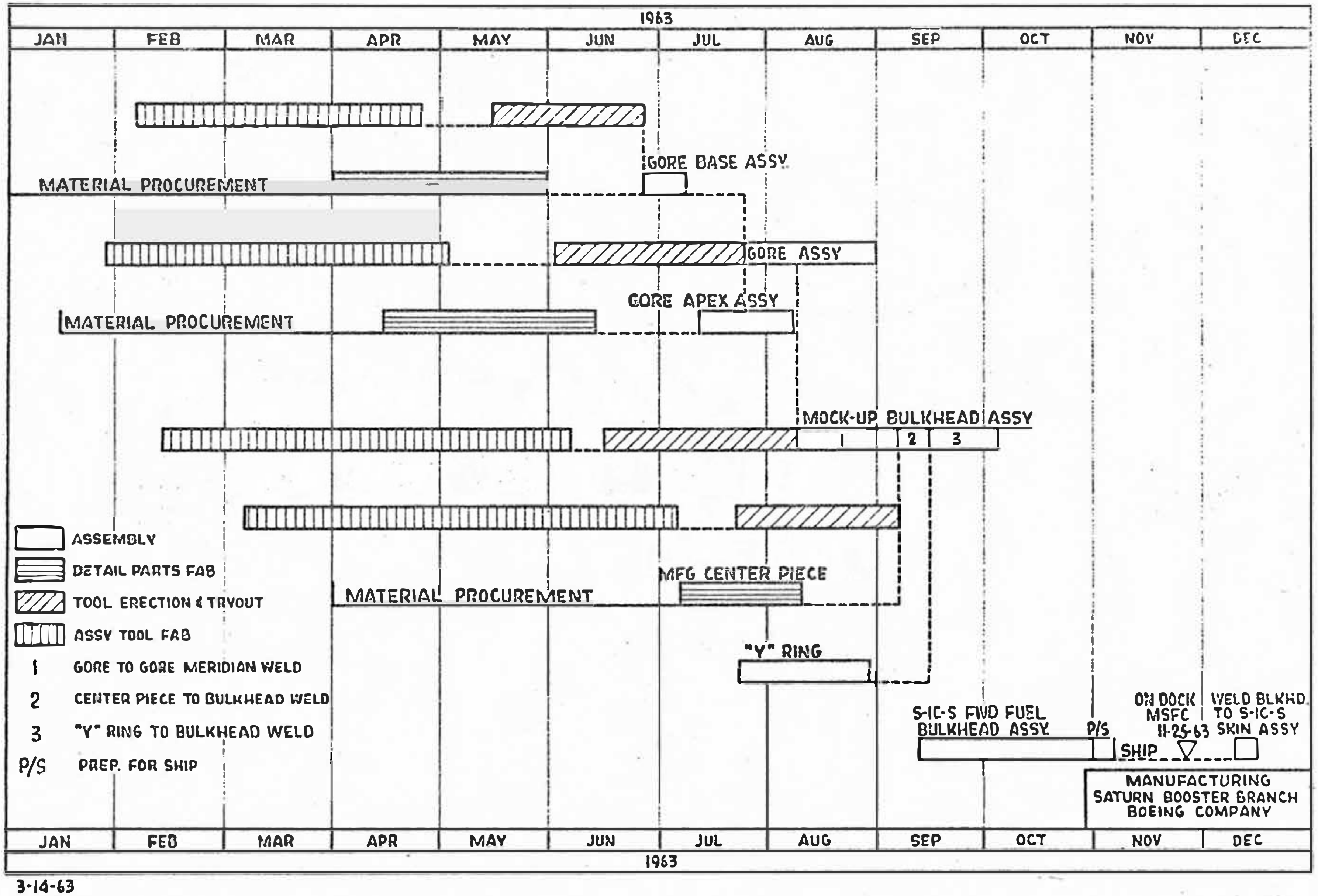


Figure 3-7. Head Assembly Schedule Chart (Sheet 2 of 3) (Boeing)

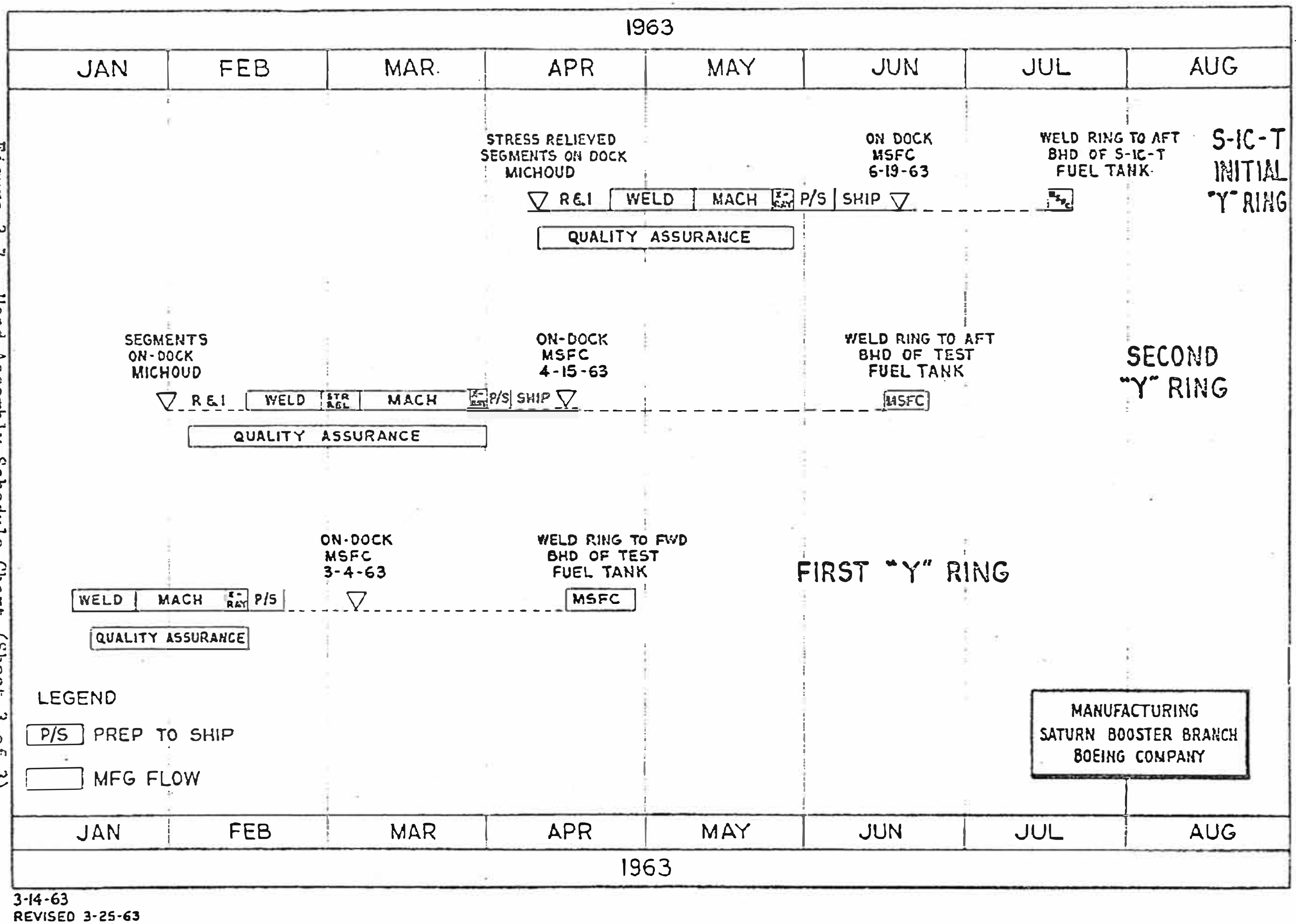


Figure 3-7. Head Assembly Schedule Chart (Sheet 3 of 3)
(Y-Ring - Boeing)

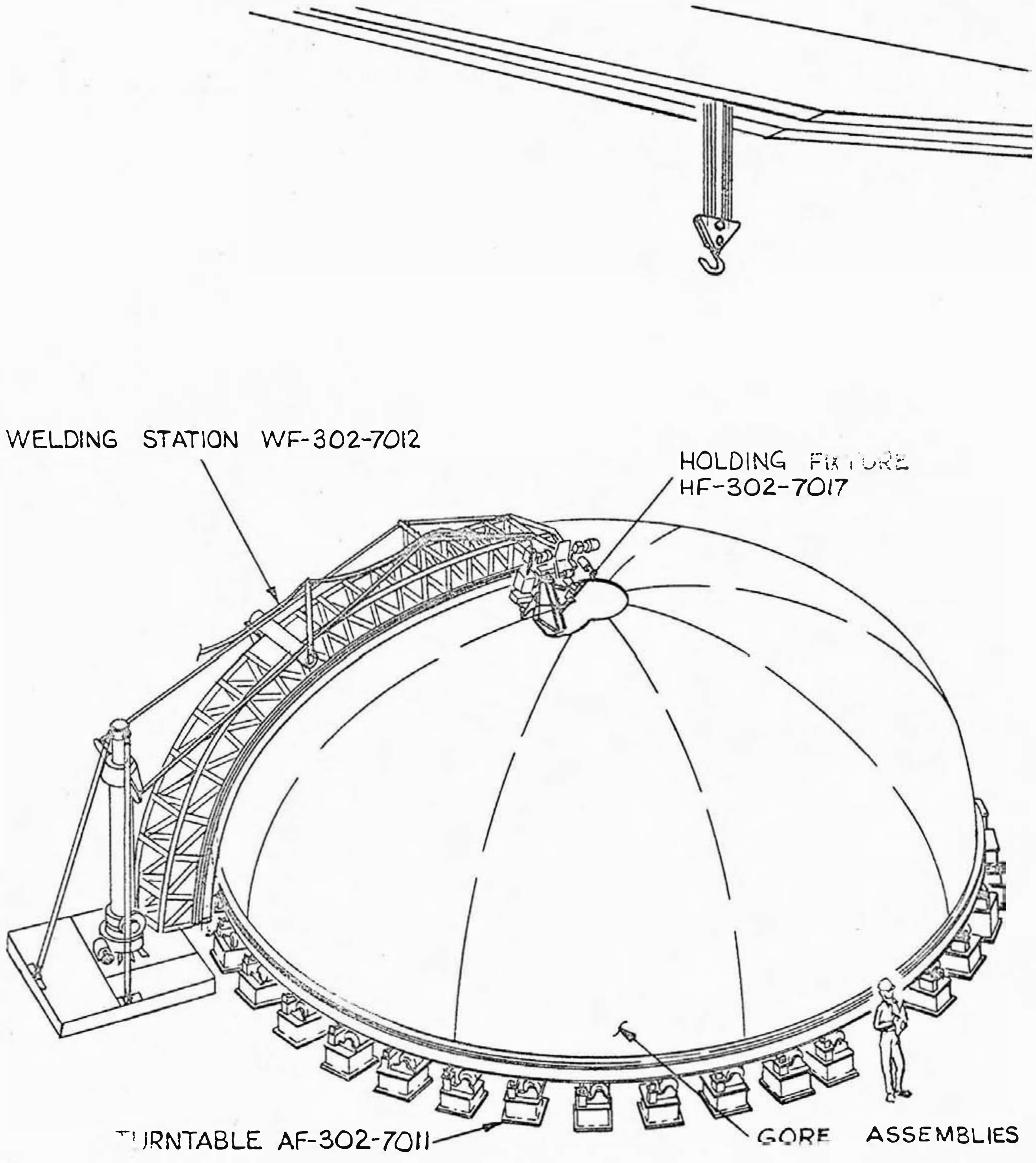


Figure 3-8. Welding Gore Assemblies to Form Head Assembly

1.1.2 (Con.)

welded head assembly is then trimmed utilizing bulkhead skirt trim station RF-302-7013. (See figure 3-9.) The head assembly is then transferred to center piece-to-bulkhead trim and weld fixture T&WF-302-7014 and the 54-inch diameter center piece is welded in place. (See figure 3-10.) The Y-ring, which will be delivered as a completed item, is set on turntable AF-302-7011; the head assembly is then lowered onto the Y-ring and fitted. The head assembly is then welded to the Y-ring utilizing welder boom weld fixture WF-302-7026. (See figure 3-11.) The weld is then X-rayed and repaired as required.

1.1.3 Skin Section. (See figure 3-12.) The 90-degree skin segments will be delivered to MSFC completely machined with internal T-stiffeners. Four skin segments will be welded together to form one cylindrical skin section utilizing tank section cylindrical skins weld fixture WF-306-7067.

1.1.4 Installation of Exclusion Riser. (See figure 3-13.) In the lower head assemblies, the exclusion riser is installed as follows:

1.1.5.1 Using overhead crane, remove lower head assembly, with handling ring AFA-370-7031 attached, from turntable AF-302-7011 and position on transportation dolly.

1.1.5.2 Using C-frame SA-370-7098, remove lower head assembly from transportation dolly.

1.1.5.3 Using C-frame SA-370-7098 and bulkhead inverting fixture MiT-370-7508, invert lower head assembly.

1.1.5.4 Position lower head assembly on lower head assembly holding fixture; secure in place.

1.1.5.5 Install inboard LOX tunnel extension on inboard LOX tunnel fitting in lower head assembly.

1.1.5.6 Install exclusion riser in lower head assembly.

1.1.5 Attaching Skin Section to Head Assembly. (See figure 3-14.) With tank assembly handling ring AFA-370-7031 attached to the Y-ring, the head assembly will be raised above turntable AF-302-7011. A cylindrical skin section is placed on turntable AF-302-7011. The head assembly is then lowered to the cylindrical skin section and fitted. The head assembly is then welded to the cylindrical skin section utilizing weld fixture WF-302-7026 and Y-ring-to-cylindrical skin weld fixture WF-300-7044. The weld is then X-rayed and repaired as required.

NOTE: On the upper head assembly only of the fuel tank assembly, a specially designed handling ring is used for hoisting. Handling ring AFA-370-7031 is used in all other cases.

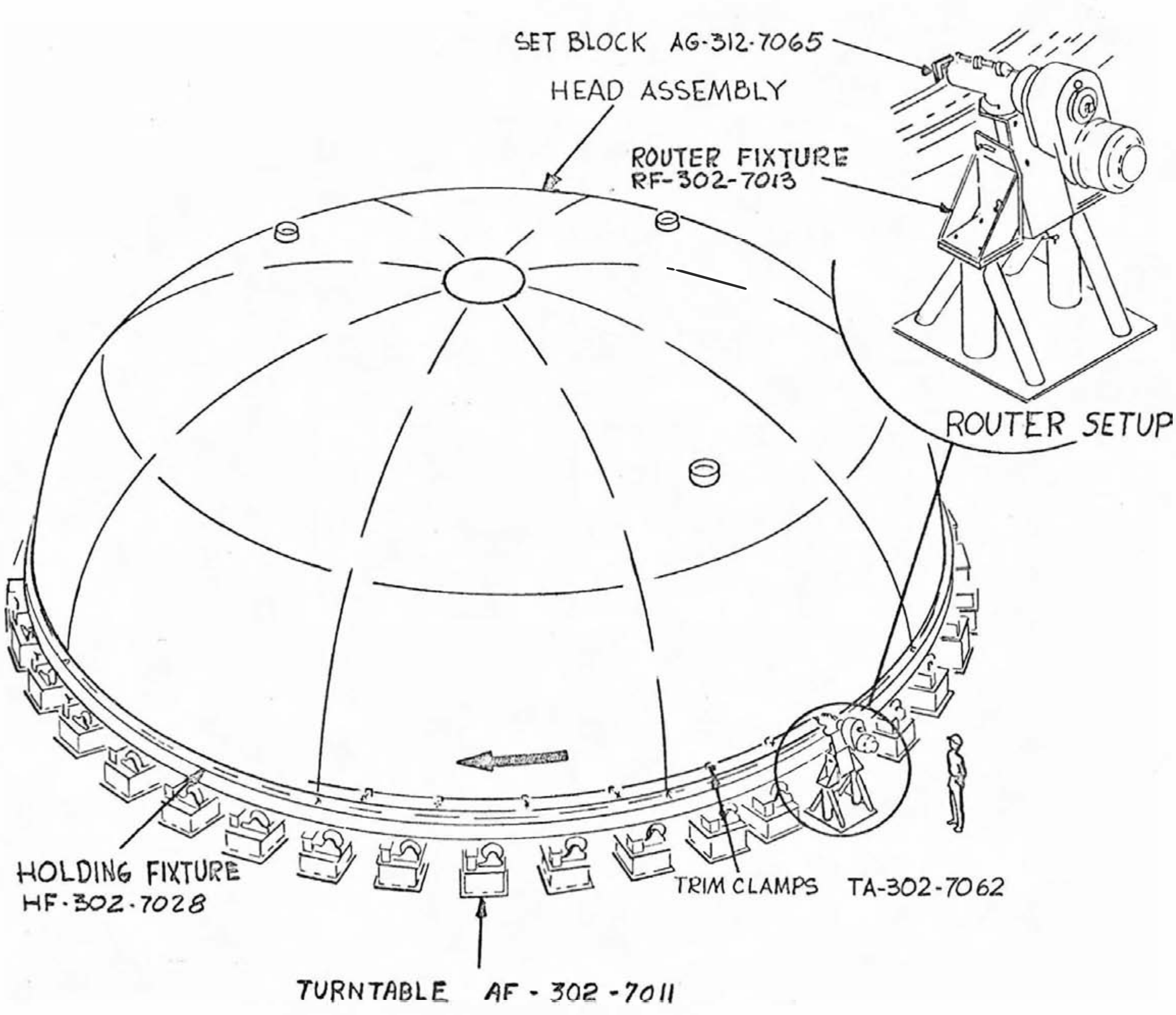


Figure 3-9. Routing Base of Head Assembly

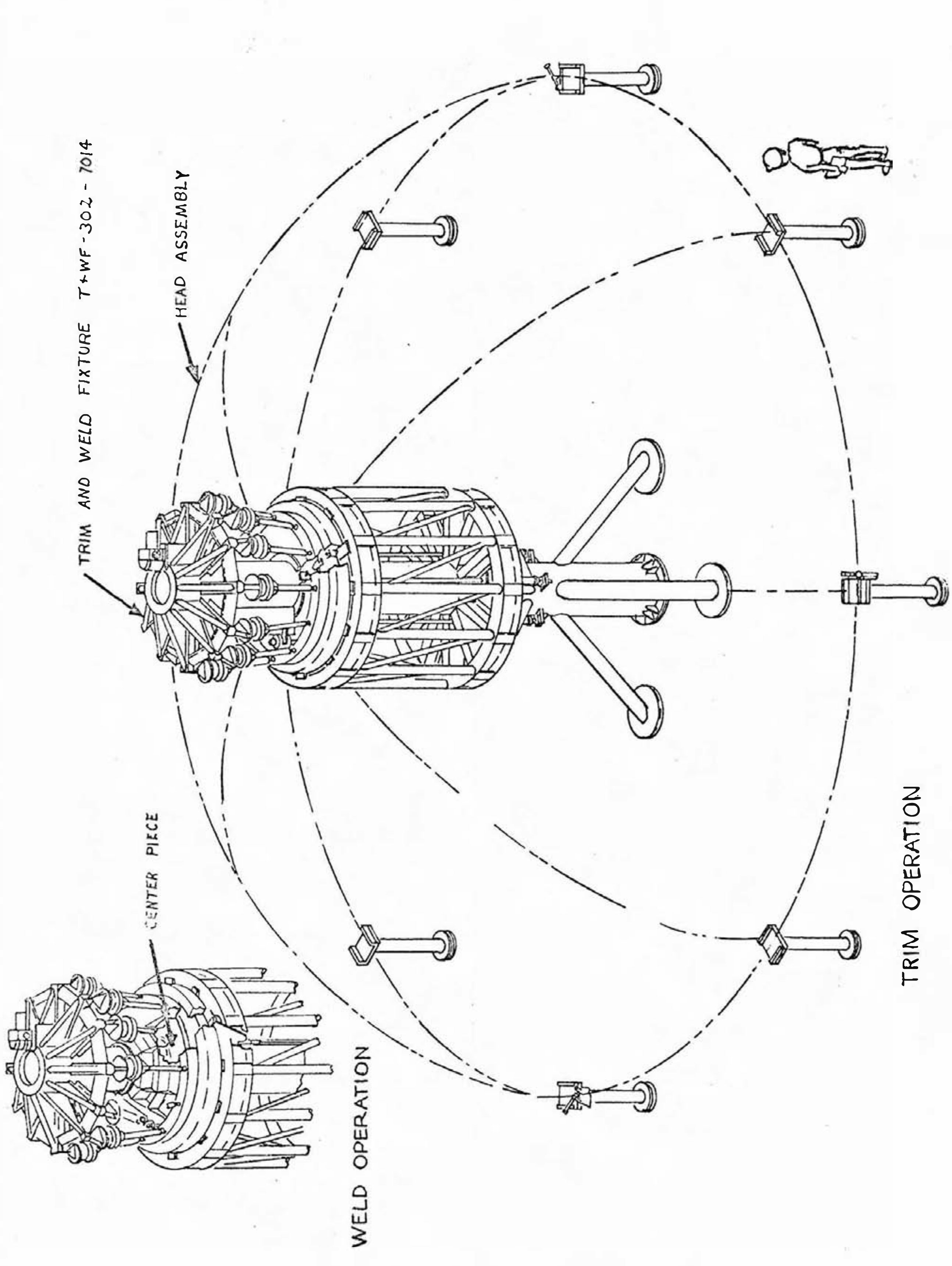


Figure 3-10. Installing Center Piece

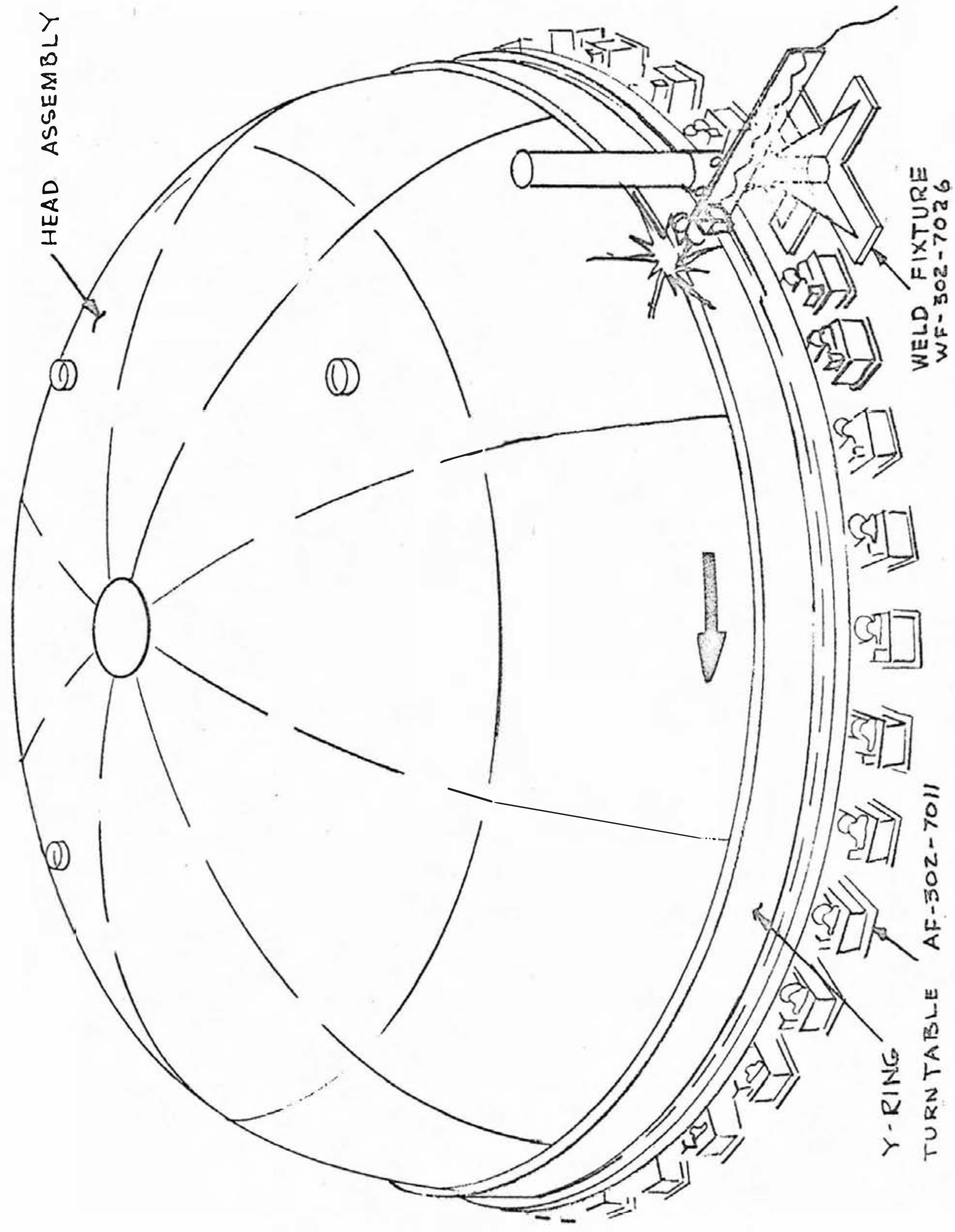


Figure 3-11. Welding Y-Ring to Head Assembly

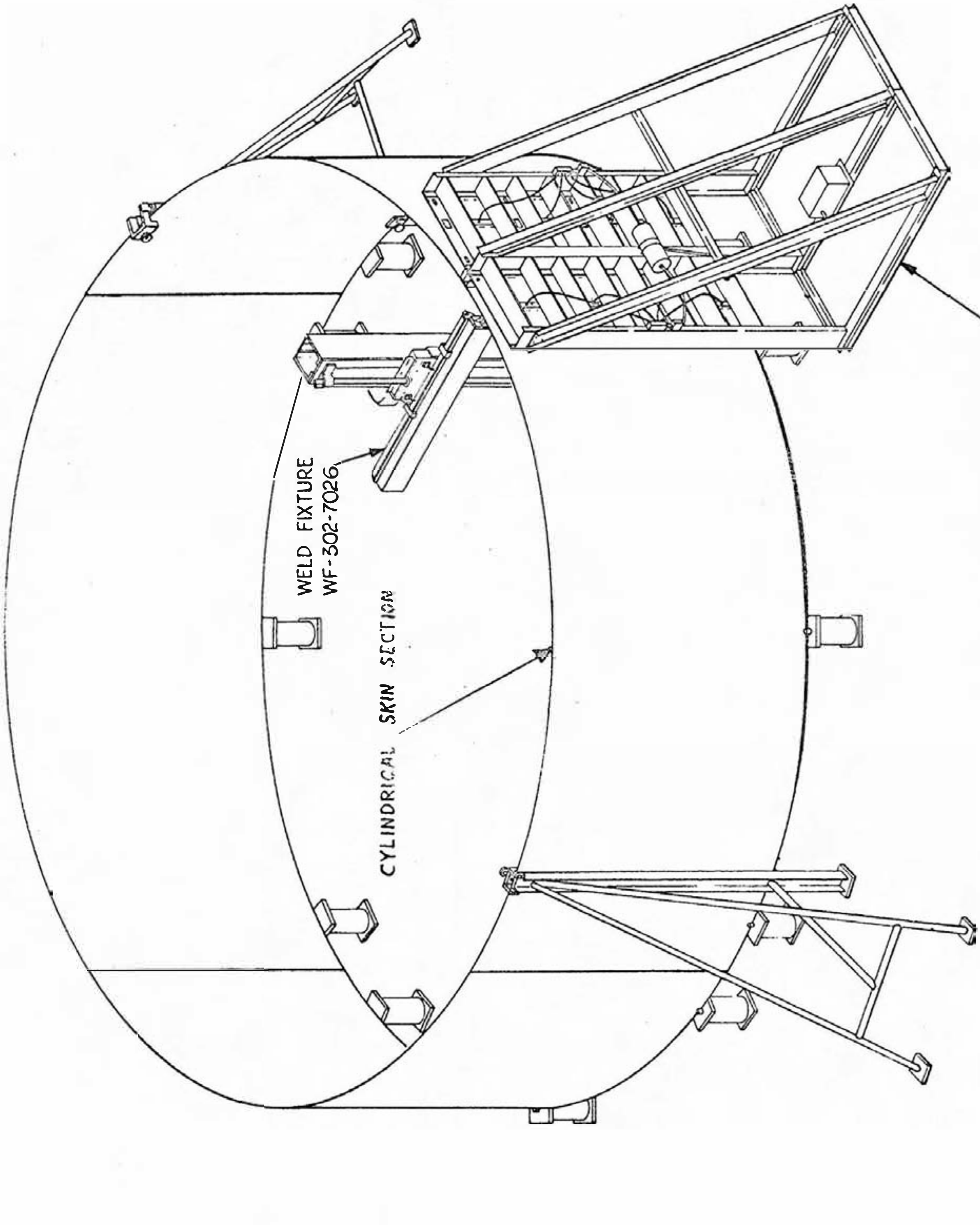


Figure 3-12. Cylindrical Skin Section Buildup

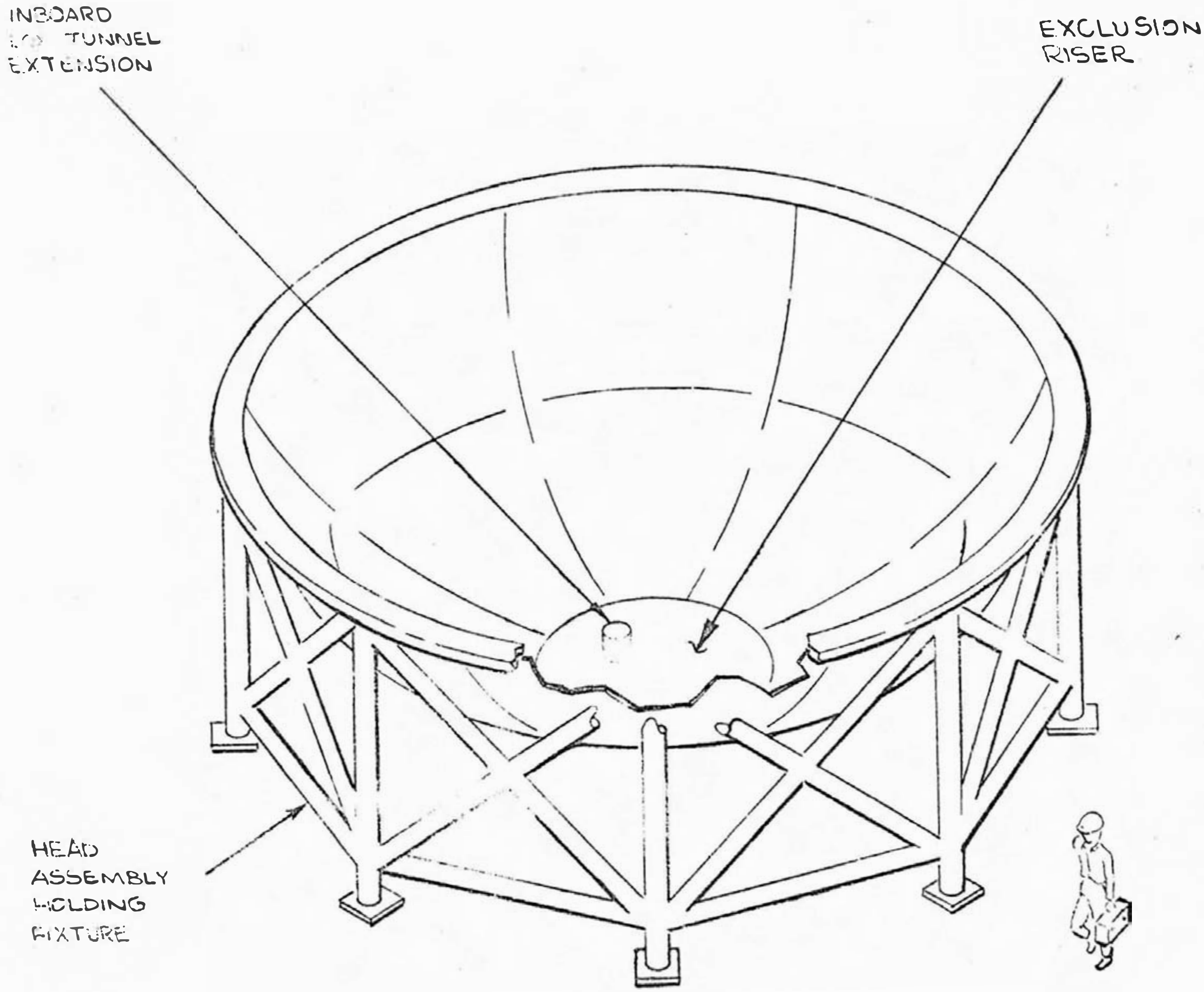


Figure 3-13. Installing Exclusion Riser

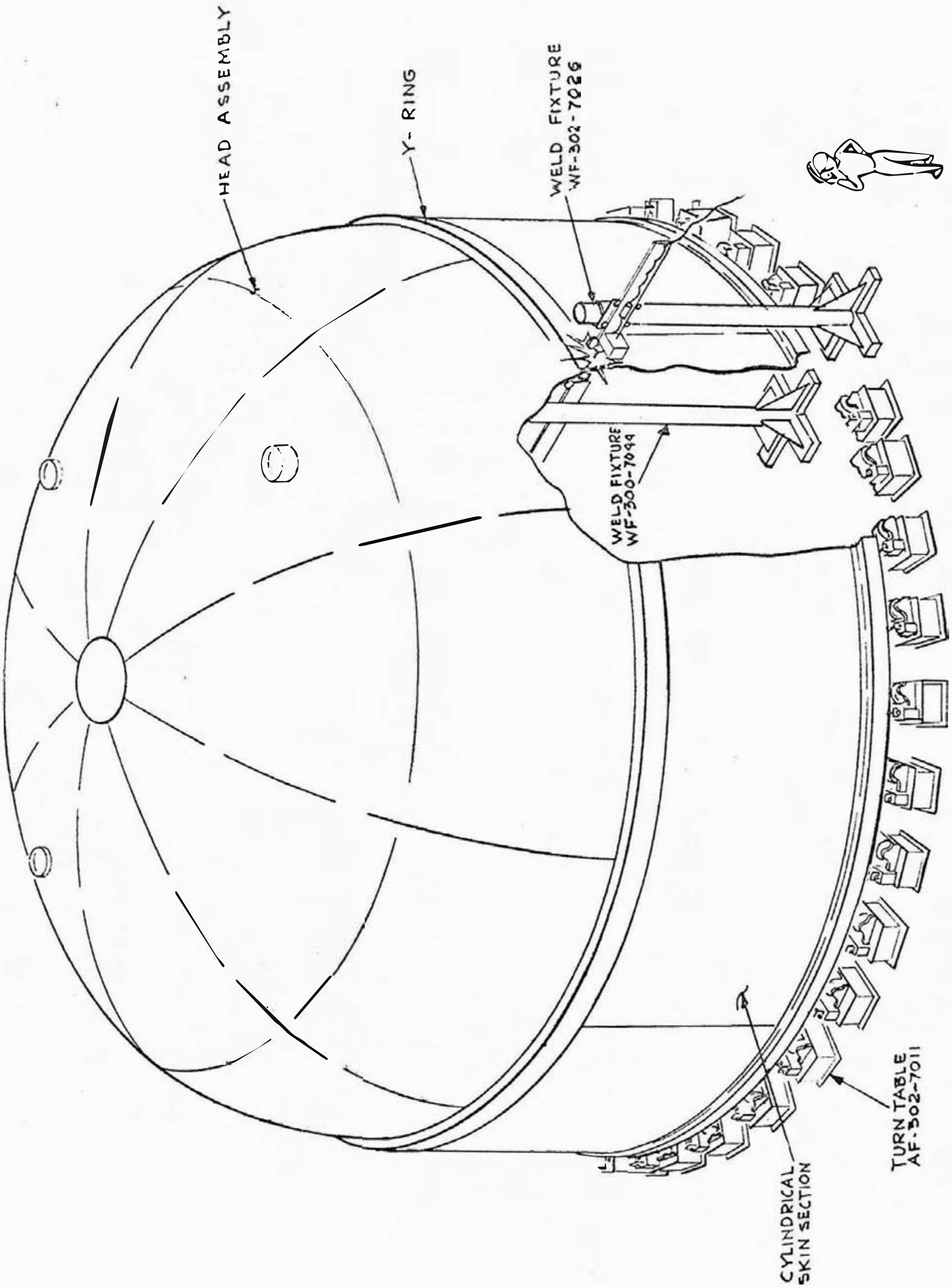


Figure 3-14. Welding Cylindrical Skin Section to Head Assembly

1.1.6 Baffle Installation. (See figure 3-15.) A cylindrical skin section, with the upper or lower head assembly attached, is placed in ring baffle assembly fixture AF-300-7076. The anti-slosh ring baffle subassemblies are then placed in assembly fixture AF-300-7076 and attached to the T-stiffeners inside the cylindrical skin section. In the lower head assemblies, the cruciform anti-slosh baffling is installed.

NOTE: Use elevator SA-395-5030 for personnel access during baffle installation.

1.1.7 Instrument Bracketry. The instrument bracketry is prefitted in the cylindrical skin section while on the ring baffle assembly fixture AF-300-7076. This bracketry is prefitted after baffle installation. Personnel will perform the following perfit operations in the lower fuel head assembly using elevator SA-395-5030 for personnel access:

1.1.7.1 Prefit anti-vortex assembly 60B43007 in accordance with fuel delivery system installation drawing 60B43011.

1.1.7.2 Prefit electrical installation (operational) in accordance with drawing 60B70073-1.

1.1.7.3 Prefit electrical installation (research and development) in accordance with drawing 60B70073-3.

1.1.7.4 Prefit electrical installation (free ride) in accordance with drawing 60B70073-9.

1.2 Oxidizer Tank Assembly Components. (See figure 3-16.)

NOTE: The buildup of the head assemblies, skin sections, and attaching skin sections to the head assemblies for the oxidizer tank assembly is the same as for the fuel tank assembly. Install baffles in oxidizer tank assembly as follows: (See figure 3-17.)

1.2.1 Position No. 1 cylindrical skin section, with upper head assembly attached, on assembly fixture AF-300-7076. Position anti-slosh ring baffle subassemblies in assembly fixture AF-300-7076 and attach to the T-stiffeners inside No. 1 cylindrical skin section. Prefit bracketry for instruments. Remove No. 1 cylindrical skin section, with upper head assembly attached, from assembly fixture AF-300-7076.

NOTE: Use elevator SA-395-5030 for personnel access during baffle installation.

1.2.2 Position No.4 cylindrical skin section, with lower head assembly attached, on assembly fixture AF-300-7076. Position anti-slosh ring baffle subassemblies in assembly fixture AF-300-7076 and attach to the T-stiffeners inside No. 4 cylindrical skin section. Install cruciform anti-slosh baffling in lower head assembly. Install support bracketry for the helium bottles in No. 4 cylindrical skin section. Prefit bracketry for instruments. Remove No. 4 cylindrical skin section, with lower head assembly attached, from assembly

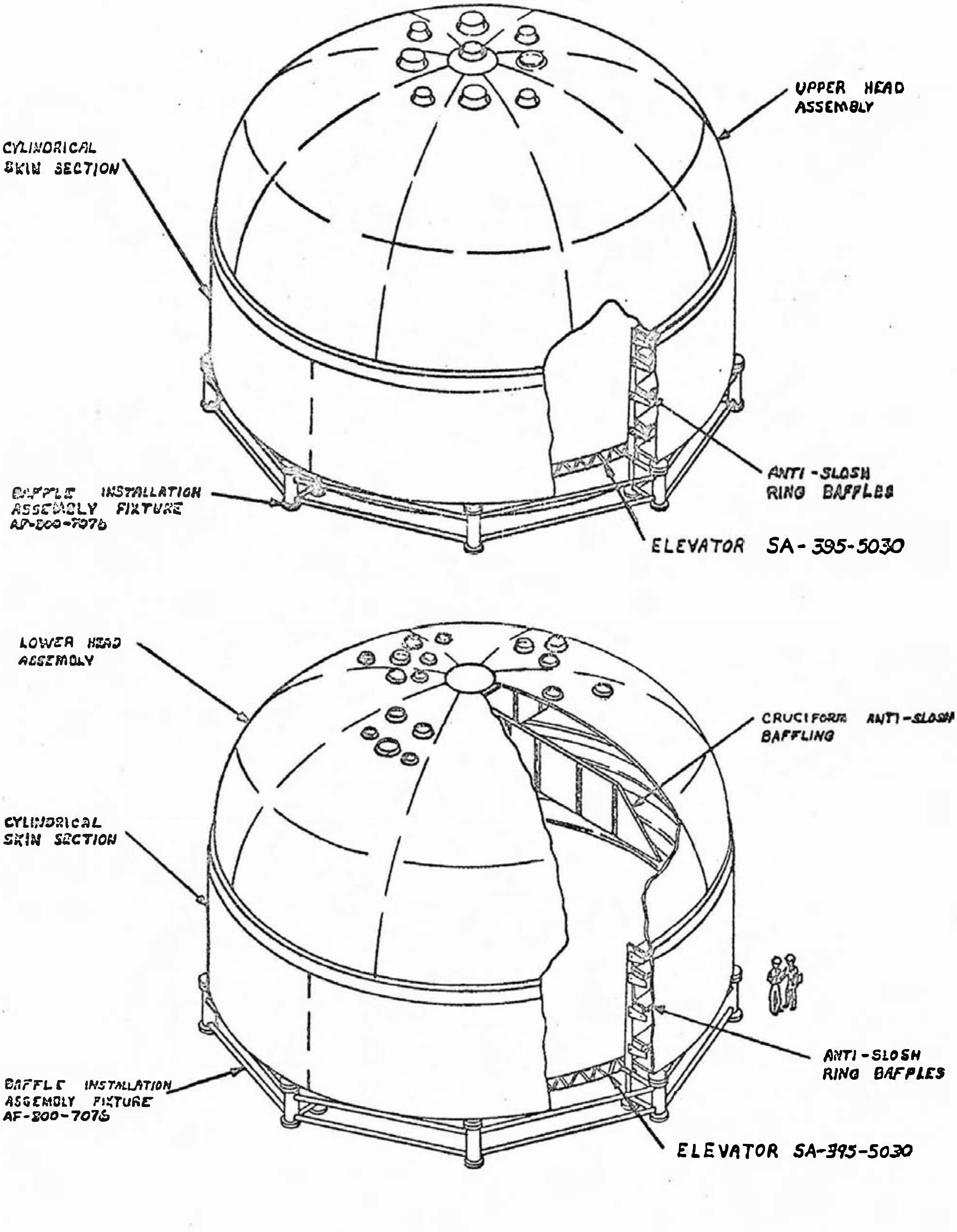


Figure 3-15. Baffle Installation (Fuel Tank Assembly)

1.2.2 (Con.)

fixture AF-300-7076.

1.2.3 Position No. 3 cylindrical skin section on assembly fixture AF-300-7076. Position anti-slosh ring baffle subassemblies in assembly fixture AF-300-7076 and attach to the T-stiffeners inside No. 3 cylindrical skin section. Install support bracketry for instruments. Remove No. 3 cylindrical skin section from assembly fixture AF-300-7076.

1.2.4 Position No. 2 cylindrical skin section on assembly fixture AF-300-7076. Position anti-slosh ring baffle subassemblies in assembly fixture AF-300-7076 and attach to the T-stiffeners inside No. 2 cylindrical skin section. Prefit bracketry for instruments. Remove No. 2 cylindrical skin section from assembly fixture AF-300-7076.

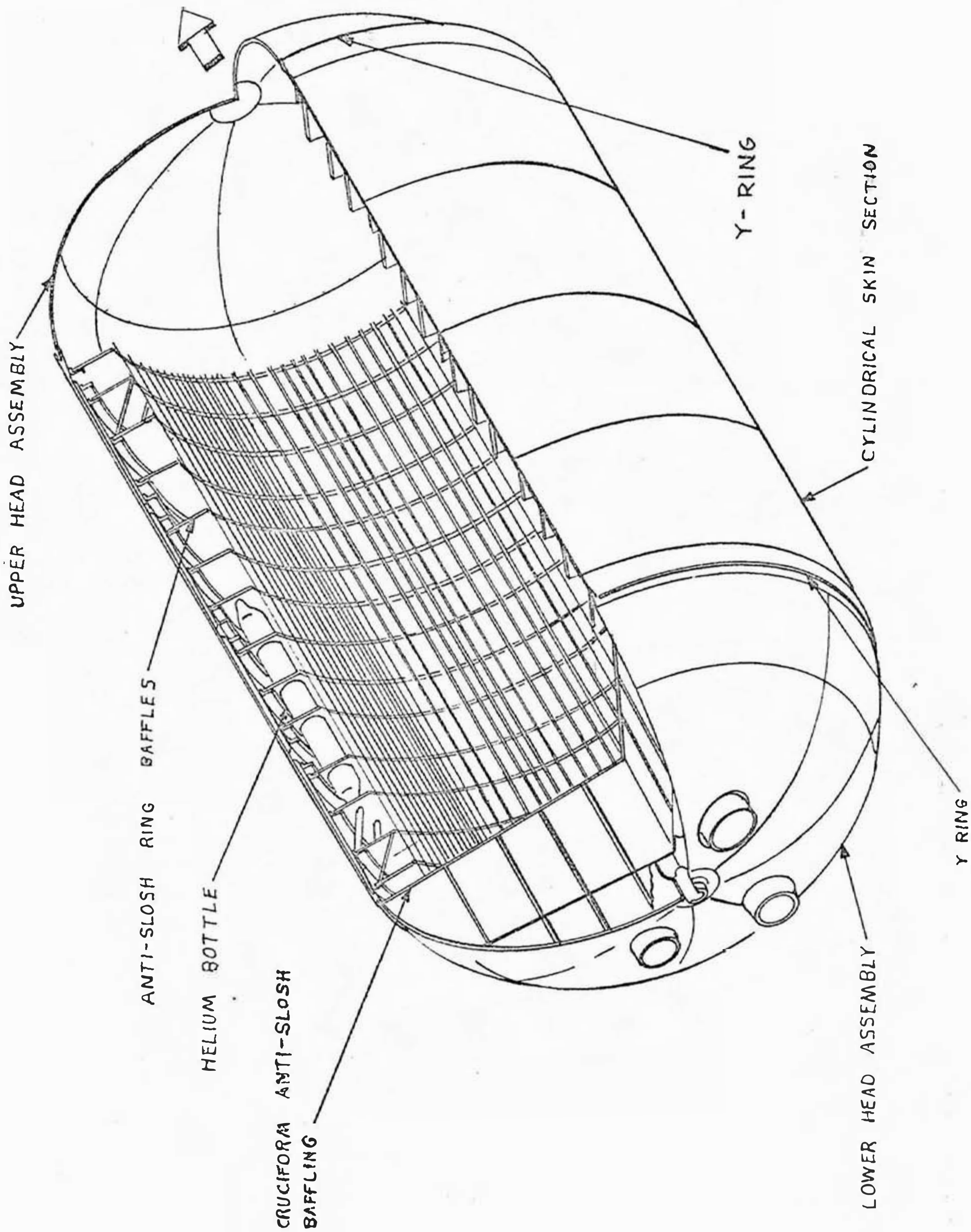


Figure 3-16. Oxidizer Tank Assembly

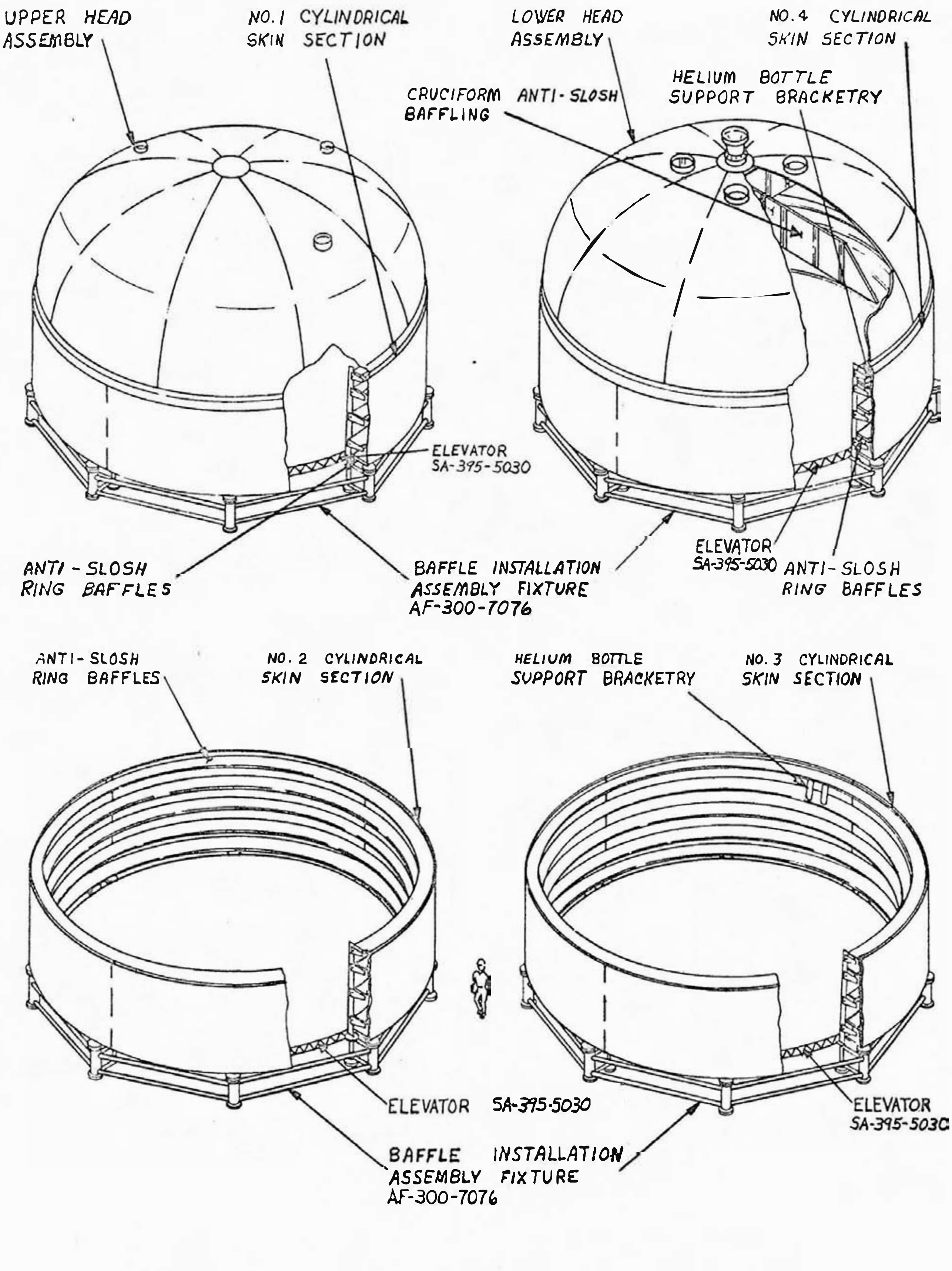


Figure 3-17. Baffle Installation (Oxidizer Tank Assembly)

2. AT MICHOUD.

The procedures outlined below are for the fuel tank assembly and oxidizer tank assembly components unless otherwise indicated.

2.1 <u>Gore Segments.</u> The Michoud processes for the assembly of the gore assemblies are identical to the processes outlined in paragraph 1.1.1 for MSFC with the following exceptions:

2.1.1 Deleted.

2.1.2 The apex gores and base gores will be transported to X-ray, supported during X-ray operation, and stored using the fixtures shown in figure 3-18.

2.2 <u>Head Assembly.</u> The Michoud processes for the assembly of the head assemblies are identical to the processes outlined in paragraph 1.1.2 for MSFC with the following exceptions:

2.2.1 The head assembly is removed from turntable AF-302-7011 and positioned on centerpiece trim and weld fixture without the head base (open end) being trimmed to match the Y-ring.

2.2.2 After the centerpiece is fitted and welded, the head assembly is moved to trim and weld fixture and match trimmed to fit the Y-ring. The head assembly is then welded to the Y-ring and X-rayed.

2.3 <u>Exclusion Riser Installation.</u> (See figure 3-19.) The exclusion riser installation consists of bonding polyurethane foam blocks to the lower fuel tank bulkhead assembly with a polyurethane adhesive. The foam is topped with nylon fabric that has been impregnated with polyurethane elastomeric resin. The upper contour of the exclusion riser has a spherical radius of 525 inches, while the lower contour conforms to the ellipsoidal and sculptured surfaces of the bulkhead. Maximum depth is approximately 20 inches; maximum diameter is approximately 167 inches. The exclusion riser thus provides a seep-and-leakproof, chemically resistant, lighter-than-fuel bulk, in the bottom of the fuel tank, to eliminate fuel holdup and effect complete fuel discharge.

NOTE: Handling ring HT-370-7031 optional to HT5-370-24000 below.

2.3.1 Transport lower fuel bulkhead assembly to vertical assembly building on transportation trailer TnTr-370-18050. Using hoisting tool HT2-370-24000 on 180 ton overhead crane, install handling ring HT5-370-24000 on bulkhead. Lift bulkhead into turning dolly ME-370-24000. Disconnect hoisting tool from handling ring and invert bulkhead. Transport bulkhead to low bay area in turning dolly. Using two 15 ton cranes, lift bulkhead into support fixture SF-304-24000 and level bulkhead.

2.3.2 Install protective padding around one outboard LOX tunnel hole for access into bulkhead. Install protective walk-on rubber matting all around and just above area which is to support exclusion riser. Cover, fill and drain, fuel suction and fuel

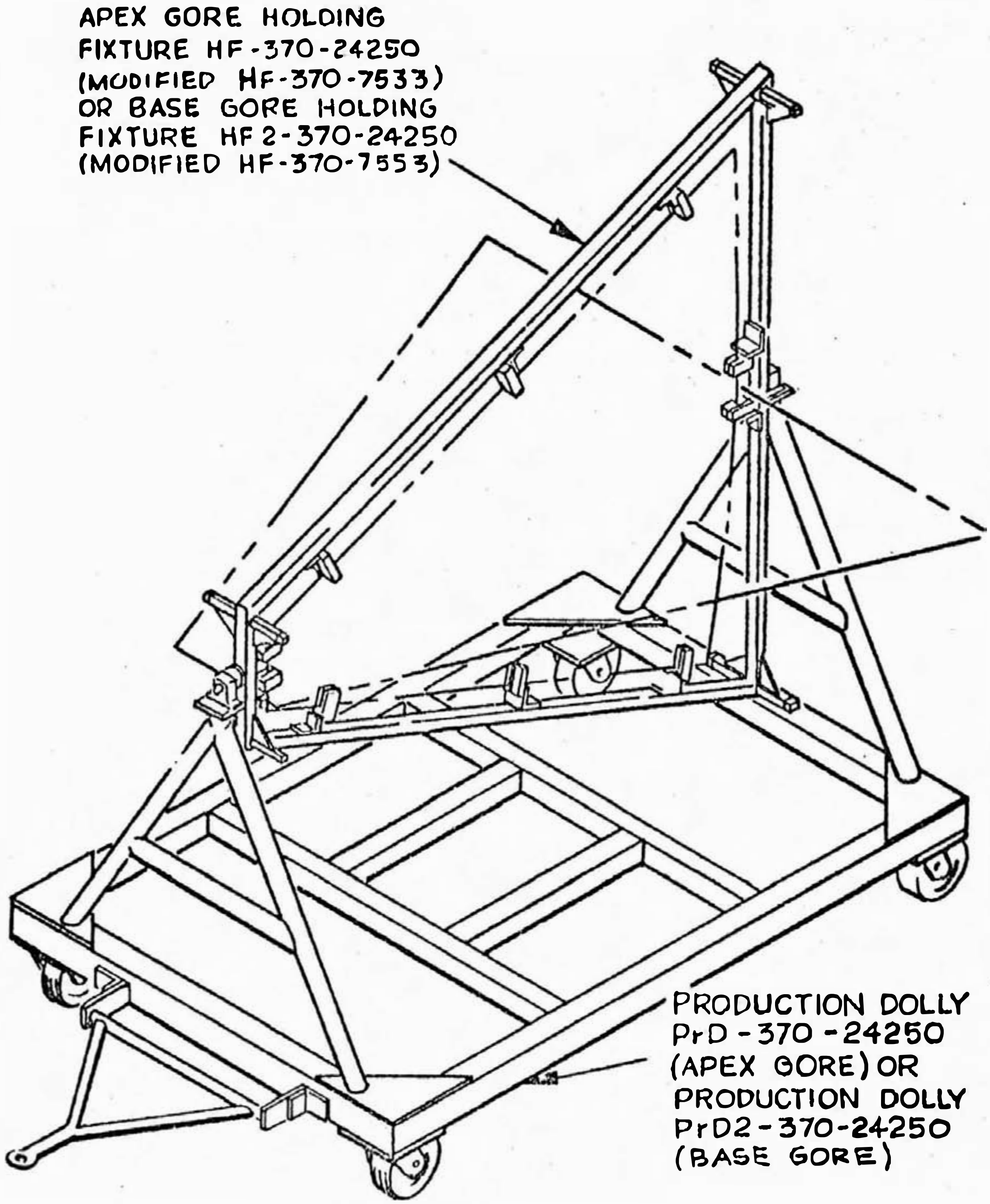


Figure 3-18. Transporting Apex Gore or Base Gore to X-Ray

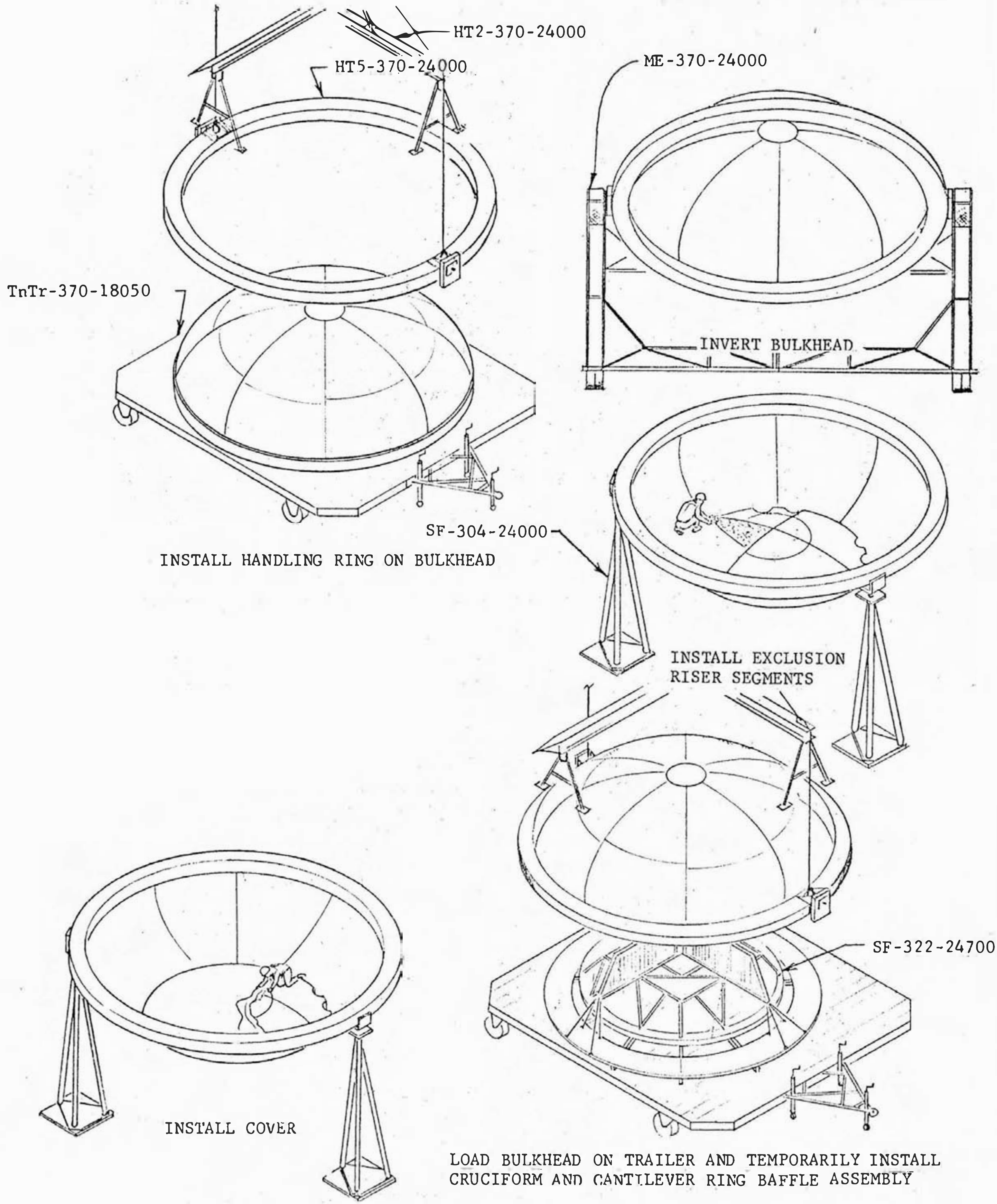


Figure 3-19. Exclusion Riser Installation

2.3.2 (Con.)

sensor, fitting holes with wooden protective covers.

2.3.3 Using hoisting tool HT-370-24600, lift foam segments into bulkhead. Install facility vent hood and connect hood to venting system. Fit dry foam segments and hand lap parts, as necessary, for snug net fit (less glue lines). Check glue line clearance of plastic clay balls that have been flattened between parts. Rework segments as necessary. Clean faying surfaces. Using polyurethane adhesive, bond segments in place in prefitted locations.

2.3.4 Apply coat of polyurethane elastomer to LOX tunnel transition segment and exlusion riser area. Smoothly install prefitted nylon fabric cover, without wrinkles or air pockets, over wet polyurethane. Apply final coats of polyurethane elastomer and allow to cure. This completes installation of exclusion riser assembly.

2.3.5 Using two overhead cranes, lift bulkhead out of support fixture SF-304-24000 and place in turning dolly ME-370-24000. Transport bulkhead to vertical assembly building and invert bulkhead. Using hoisting tool HT2-370-24000, lift bulkhead out of turning dolly. Lower bulkhead onto transportation trailer TnTr-370-18050, on which cruciform and cantilever ring baffle assembly is nested in support fixture SF-322-24703. Disengage handling ring HT5-370-24000 from bulkhead and remove ring. Transport bulkhead to storage.

2.4 Ring Baffle Segment Assembly (See figure 3-20.) The ring baffle segment assembly is a shear-web type aluminum structure in the shape of a 90 degree circular segment. It has an inside radius of approximately 14 feet and an outside radius of approximately 16 feet. These segments are mounted around the inside of the LOX and fuel tanks to form rings. Fifteen such rings are located along the LOX tank wall and nine in the fuel tank, perpendicular to the tank centerlines. These rings provide structural rigidity to the tanks and prevent sloshing of the LOX and fuel during flight. The segment assemblies are fabricated by Boeing-Michoud in six assembly fixtures:

LOX Tank	Fuel Tank
AF-318-12414	AF-322-24705
AF-318-12420	AF-322-24733
AF-318-12428 (2 units)	

2.4.1 Load inboard and outboard chords, webs, stiffeners, and fittings into fixture and clamp in place. Drill all rivet holes common to stiffeners and webs from pilots in stiffeners. Drill all remaining holes from assembly fixture drill templates.

2.4.2 Remove details from assembly fixture and place on cleaning table MiT-310-12428. Deburr all holes and swab with Chlorothene and clean mating surfaces.

2.4.3 Reassemble details using cleco clamps as required. Place assembly on riveting table MiT-310-12428 and install all rivets and lockbolts. Clean and package assembly for storage and/or shipping.

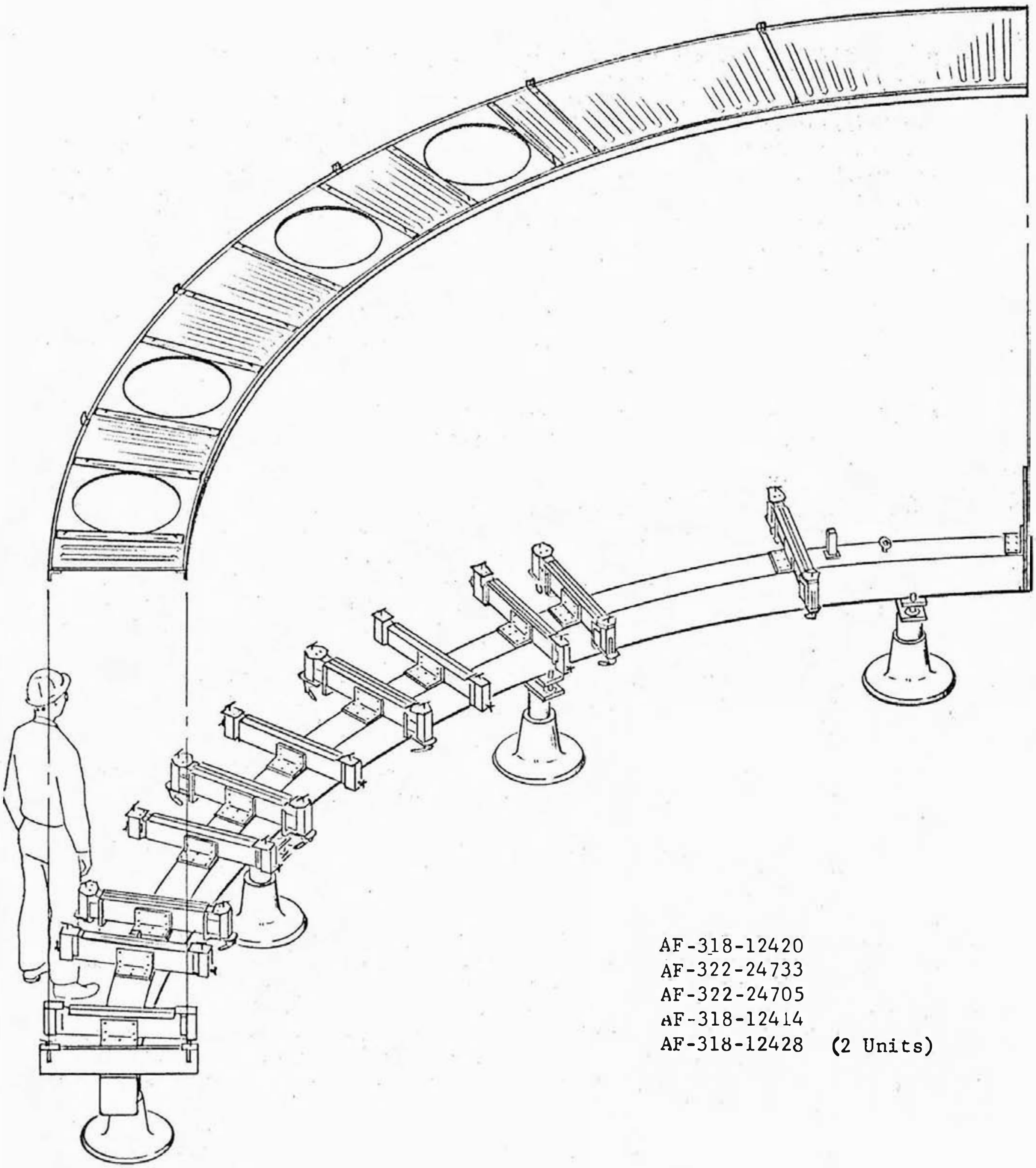


Figure 3-20. Ring Baffle Segment Assemblies

2.5 Helium Bottle and Liquid Level Probe Support Panel Assemblies. (See figure 3-21.) The helium bottle and liquid level probe support panel assemblies are rectangular aluminum shear web structures located between ring baffles 1B and 1C in the LOX tank. They are attached to the ring baffles and skin tees. Two helium bottle support panel assemblies support the weight of four helium bottles in the LOX tank. One liquid level probe support panel assembly supports each LOX level sensing probe. The helium bottle support panel assemblies are made up in assembly fixture AF-318-12417; assembly fixture AF-318-12413 is used to build the liquid level probe support panel assemblies.

2.5.1 Load web, chords, and angles into applicable fixture and drill all fastener holes. Disassemble, deburr, and swab holes with Chlorothene. Clean mating surfaces.

2.5.2 Reassemble with cleco clamps as required. Install fasteners. Package for storage and/or shipping.

2.6 Cruciform Baffle Panel Assembly. (See figure 3-22.) The cruciform baffle panel assembly is a triangular aluminum structure approximately four feet high and 13 feet long. Four of these panel assemblies are arranged in the form of a cross, at the bottom of LOX and fuel tanks, to prevent vortexing of propellants as they are drawn from the tanks. The LOX tank panel assemblies are fabricated by Boeing-Michoud in assembly fixture AF-318-12411, and the fuel tank panels are made in assembly fixture AF-322-24708.

2.6.1 Load all details into applicable assembly fixture and clmap. Drill all rivet and lockbolt holes from bushings. Ream all lockbolt holes.

2.6.2 Remove details from assembly fixture, deburr all holes, and swab with Chlorothene; clean mating surfaces.

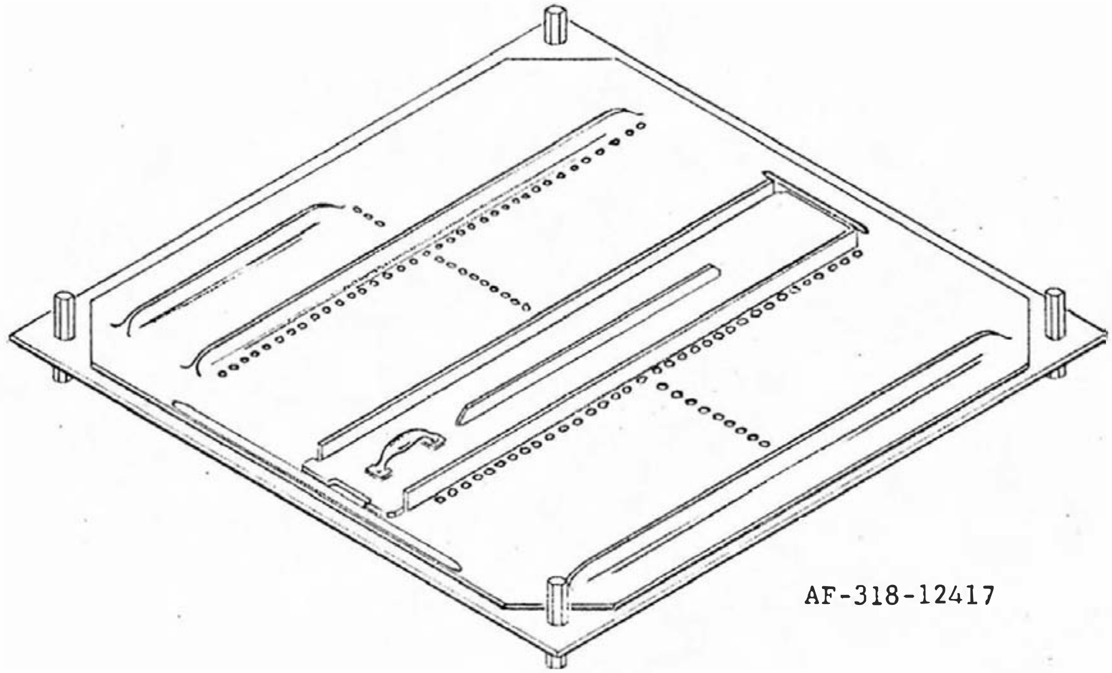
2.6.3 Reassembly details using cleco clamps as required. Install all rivets and lockbolts. Clean and package assembly for storage and/or shipping.

2.7 Cruciform and Cantilever Ring Baffle Assembly - Cantilever Ring Baffle Assembly. (See figure 3-23.) The cruciform and cantilever ring baffle assembly includes four cruciform baffle panel assemblies (See Para. 2.6) and four ring baffle segment assemblies (See Para. 2.4) held approximately three feet apart by a series of struts. The cantilever ring baffle assembly consists only of four ring baffle segment assemblies. Both assemblies for the LOX and fuel tank are made up in assembly fixture AF-322-24703.

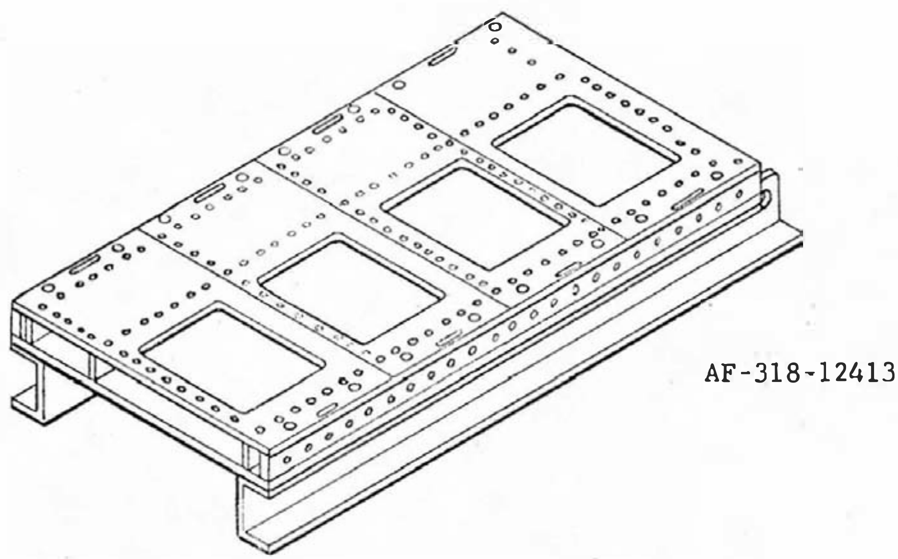
2.7.1 Locate cruciform baffle panel assemblies and/or cantilever ring baffle assemblies into assembly fixture AF-322-24703. Load struts and/or splice fittings. Drill and ream fastener holes. Deburr, clean faying surfaces, and install fasteners.

2.7.2 Position support fixture SF-322-24700 under assembly. Using overhead crane, lift assembly out of assembly fixture AF-322-24703 and place on transportation trailer TnTr-370-18050.

2.8 Cylindrical Skin Assembly. (See figure 3-24.) The cylindrical skin

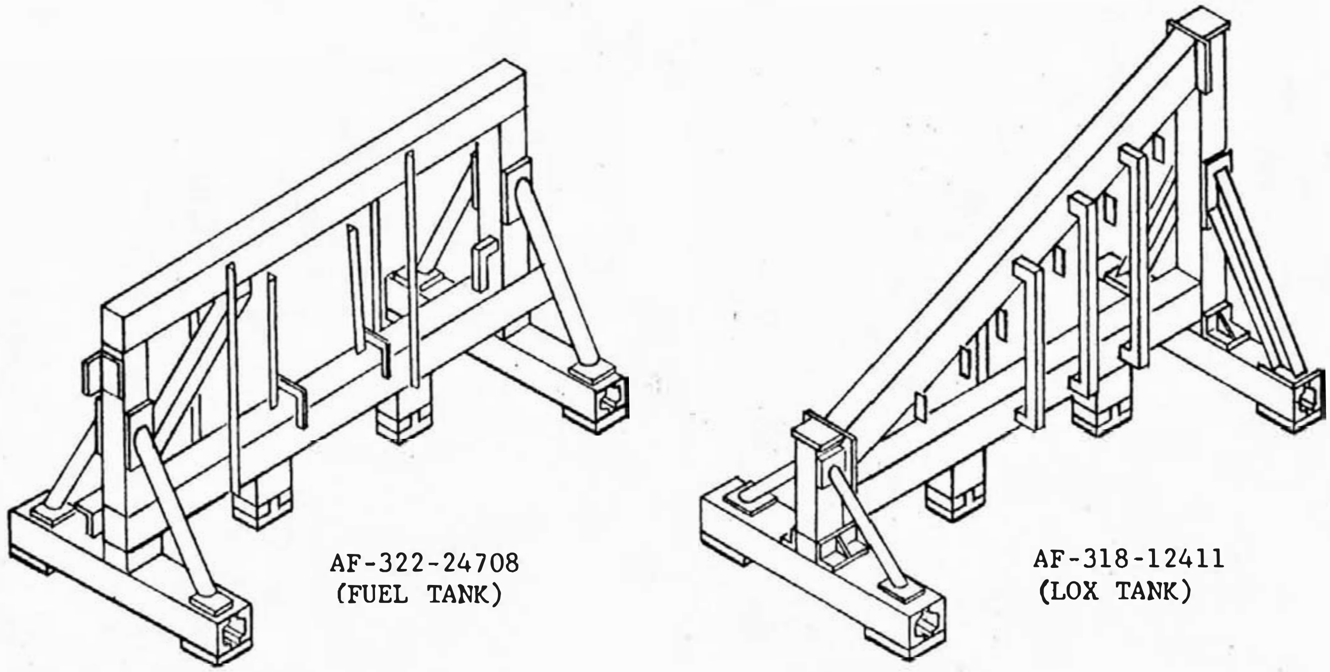


HELIUM BOTTLE SUPPORT PANEL ASSEMBLY

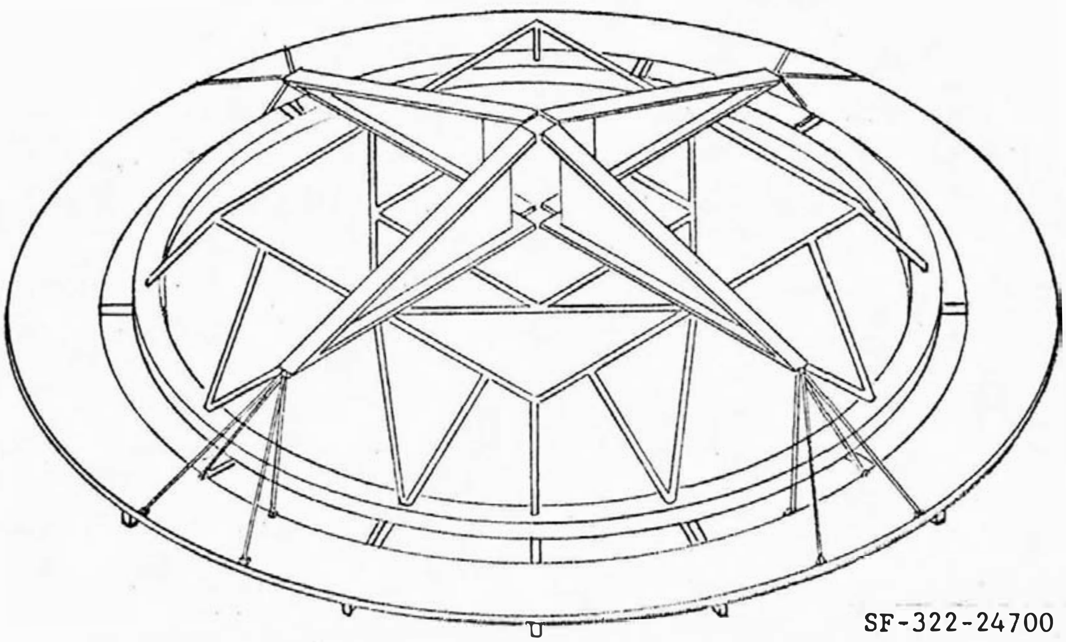


LIQUID LEVEL PROBE SUPPORT PANEL ASSEMBLY

Figure 3-21. Helium Bottle and Liquid Level Probe Support Assemblies



CRUCIFORM BAFFLE PANEL ASSEMBLIES



CRUCIFORM AND CANTILEVER RING BAFFLE ASSEMBLY

Figure 3-22. Cruciform Baffle Panel Assemblies; Cruciform and Cantilever Ring Baffle Assembly

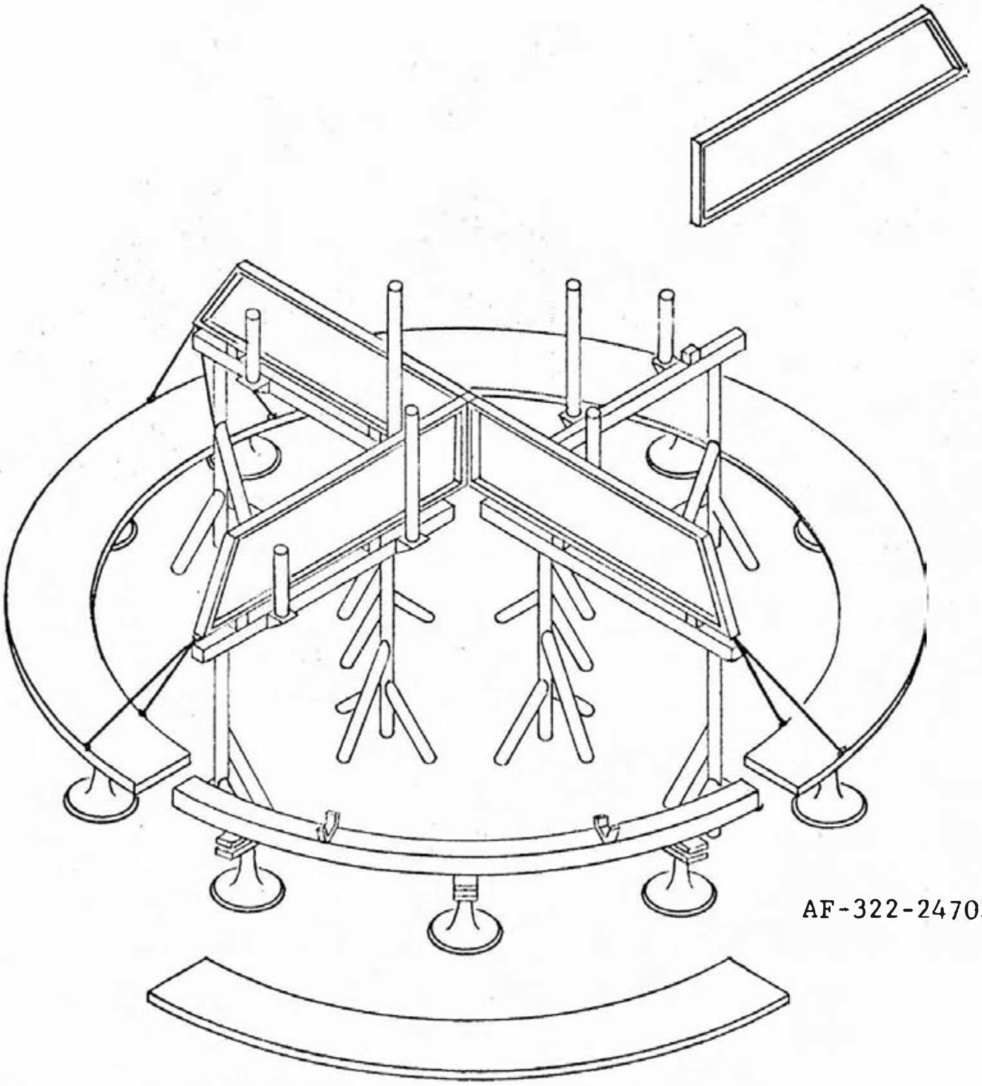


Figure 3-23. Cruciform and Cantilever Ring Baffle Assembly (Fuel Tank Assembly)

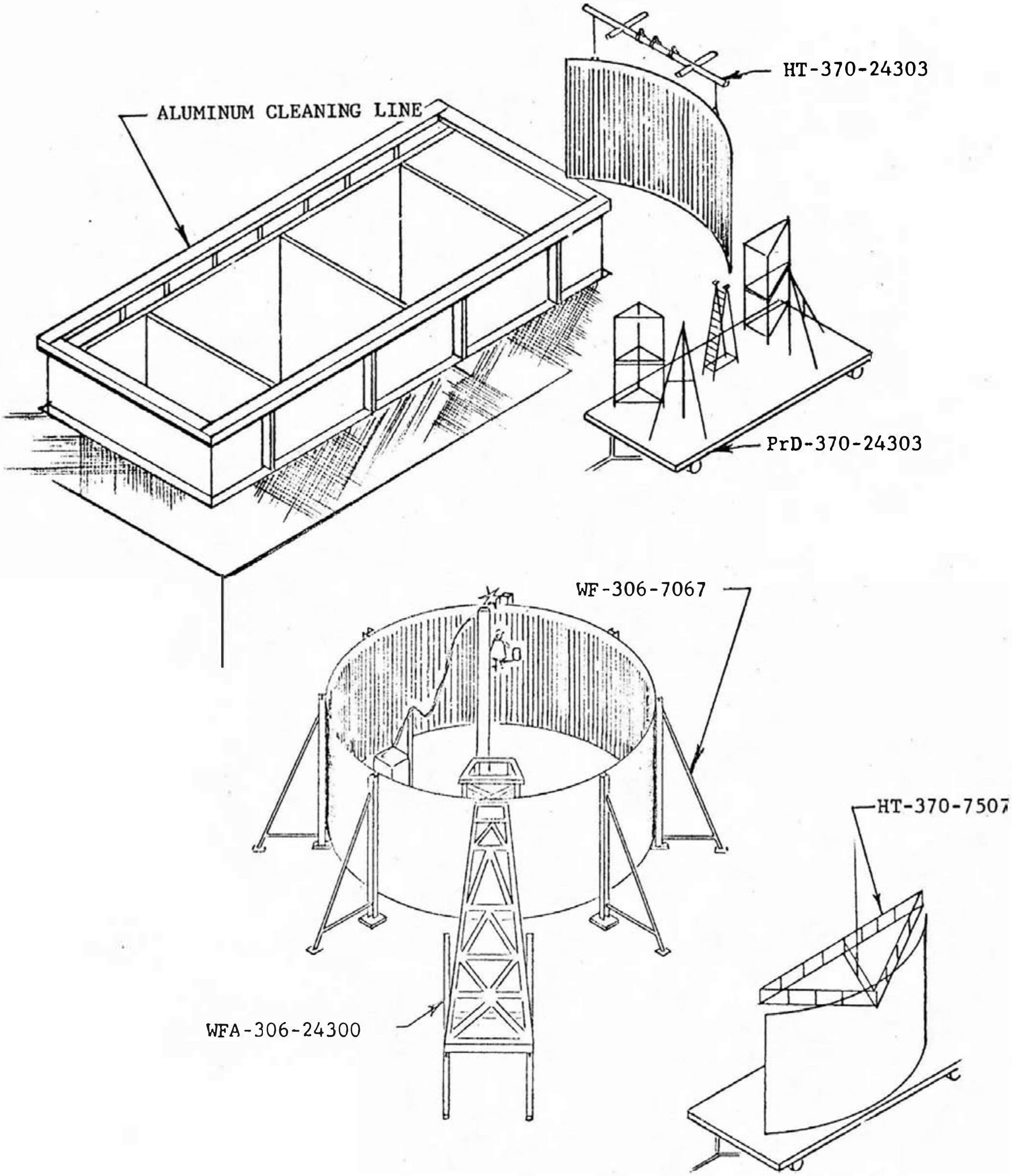


Figure 3-24. Cylindrical Skin Assembly

2.8 (Con.)

assembly consists of four skin sections, each approximately 10 feet high and 26 feet long, welded together to form a 33 foot diameter ring. The sections are machined with integral "T" stiffeners and lifting tabs and formed to contour by Boeing-Wichita. The sections, with tabs up, are then packaged in a contamination and moistureproof container for shipment to Michoud. Upon arrival at Michoud, perform the following:

2.8.1 Using hoisting tool HT-370-7507, remove sections from shipping container, place on production dolly PrD-370-24303, and transport to aluminum cleaning line. Using overhead crane, hoisting tool HT-370-24303, and skin tabs, process sections through cleaning line for precleaning.

2.8.2 Using hoisting tool HT-370-24303, place skin sections on production dolly PrD-370-24303 and route to dye penetrant inspection line. Using overhead crane, hoisting tool HT-370-24303, and skin tabs, process skin through dye penetrant inspection line.

2.8.3 Position sections on production dolly PrD-370-24303 and transport back to aluminum cleaning line for final cleaning and conversion coating.

2.8.4 Place skins on production dolly PrD-370-24303 and transport to weld fixture WF-306-7067. Using hoisting tool HT-270-7507, position sections on weld fixture. Weld two sections at a time as follows:

a. Strip back conversion coating twelve inches on both sides of weld line.

b. Clean and dry.

c. Aline adjacent sections.

d. Check dimension from section edge to "T" web using MiT-300-12300.

e. Trim.

f. Recheck edge to web dimension.

g. Retrim if necessary.

h. Perform test weld.

i. Perform production weld.

j. Rotate 90 degrees.

k. Check weld contour using MiT3300-12300.

l. Shave weld bead flush.

m. Rotate 90 degrees.

2.8.4 (Con.)

n. X-ray using X-ray fixture WFA-306-24300.

o. Rotate 90 degrees.

p. Surface inspect weld bead using PP2-370-12300 and MiT8-370-12300.

q. Clean and conversion coat.

NOTE: The above procedure is repeated until a complete 360 degree skin ring is assembled. A decal determining ring orientation is then alined on the outer side of the skin using positioning and holding fixture P&HF2-312-12000.

2.8.5 Using over head crane and hoisting tool HT-370-7539, remove cylindrical skin assembly from weld fixture WF-306-7067 and lower onto cylindrical skin and baffle assembly fixture AF-318-12402.

2.9 Cylindrical Skin and Baffle Assembly. (See figure 3-25.) The cylindrical skin and baffle assembly includes the cylindrical skin assembly (See Para. 2.8), the ring baffle segment assemblies (See Para. 2.4) and other components as noted below. Two assemblies make up the fuel tank wall, and four assemblies make up the LOX tank wall. The assemblies, for one S-IC booster, are built in the following order and designated as shown:

a. Lower Fuel Tank Cylindrical Skin and Baffle Assembly

b. Upper Fuel Tank Cylindrical Skin and Baffle Assembly

c. No. 4 LOX Tank Cylindrical Skin and Baffle Assembly

d. No. 1 LOX Tank Cylindrical Skin and Baffle Assembly

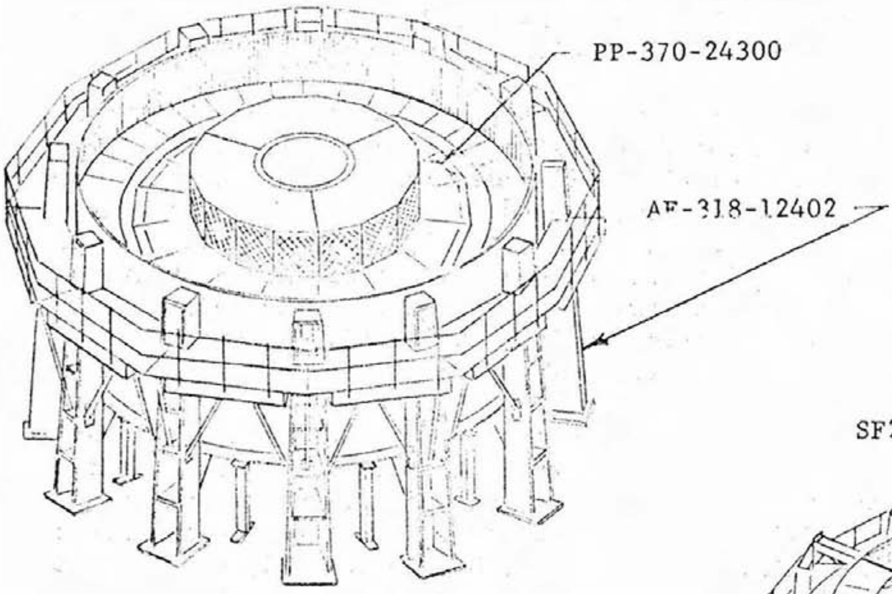
e. No. 2 LOX Tank Cylindrical Skin and Baffle Assembly

f. No. 3 LOX Tank Cylindrical Skin and Baffle Assembly

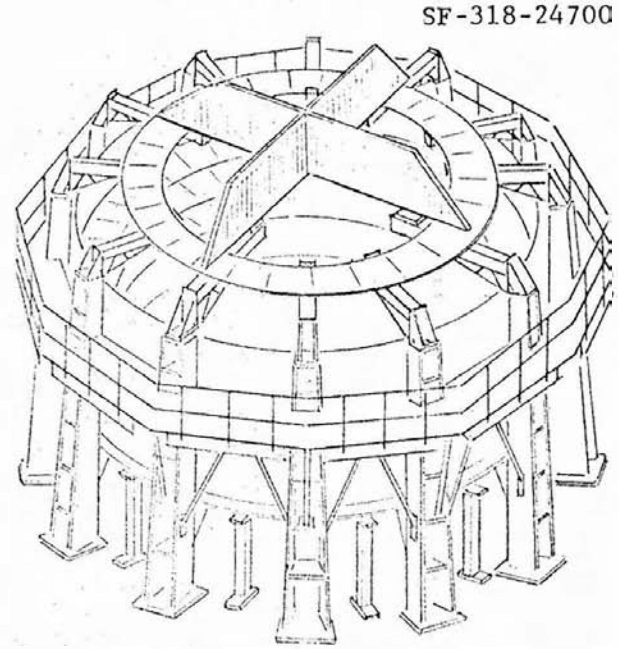
The assemblies are built up in two units in assembly fixture AF-318-12402.

2.9.1 Using hoisting tool HT-370-7539, load cylindrical skin assembly into assembly fixture AF-318-12402. Position tooling posts MiT2-318-12402 (LOX) or MiT2318-24701 (fuel) from elevator platform PP-370-24300. Locate baffle locating frames to tooling posts, fasten frames to skin tees, and remove tooling posts. Locate ring baffle segment assemblies on frames. Locate splice fittings, vertical stringers, and diagonal struts. Drill and ream fastener holes using the following drill jigs:

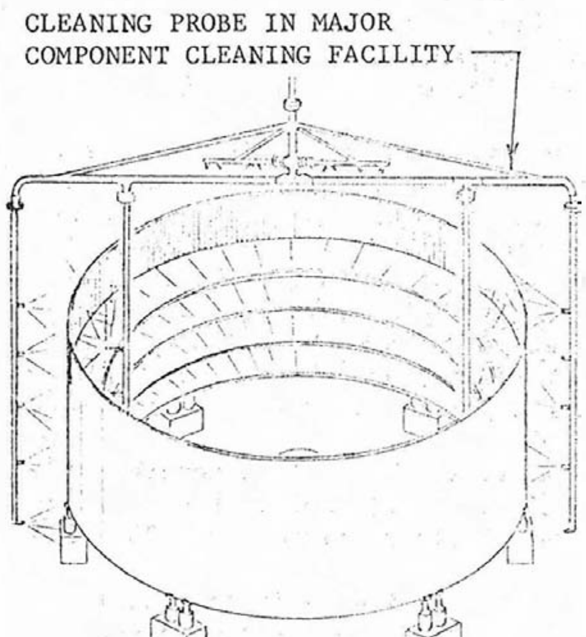
Lower Fuel - DJ-318-24702
Upper Fuel - DJ-318-24071
No. 4 LOX - DJ-318-12404
No. 1 LOX - DJ-318-12401
No. 2 LOX - DJ-318-12402
No. 3 LOX - DJ-318-12403



INSTALLING RING BAFFLES



TEMPORARILY INSTALLING CRUCIFORM
AND CANTILEVER RING BAFFLE ASSEMBLY



CLEANING CYLINDRICAL
SKIN AND BAFFLE ASSEMBLY

Figure 3-25. Cylindrical Skin and Baffle Assembly

2.9.1 (Con.)

NOTE: All fastener holes, with location or alinement affected by tank assembly circumferential weld distortion, are omitted at this time and installed after welding.

2.9.1.1 Lower Fuel Only. Position support fixtures SF-318-24700 and SF2-318-24700 on assembly fixture AF-318-12402. Load cruciform and cantilever ring baffle assembly, supported in support fixture SF-322-24700, onto support fixtures. Load diagonal struts. Using drill jig DJ-318-24700, drill all fastener holes not to be affected by circumferential weld. Remove baffle assembly and place on transportation trailer TnTr-370-18050 for temporary suspension in lower bulkhead. Remove support fixtures SF-318-24700 and SF2-318-24700.

2.9.1.2 Upper Fuel Only. Position support fixtures SF-318-24700 and SF2-318-24700 on assembly fixture AF-318-12402. Load cantilever ring baffle assembly and related struts. Using drill jig DJ2-318-24700, drill all fastener holes not to be affected by circumferential weld. Remove baffle assembly and place on transportation trailer TnTr-370-18050 for temporary suspension in upper bulkhead. Remove support fixtures SF-318-24700 and SF2-318-24700.

2.9.1.3 No. 4 LOX Only. Position support fixtures SF-318-24700 and SF2-318-12401 on assembly fixture AF-318-12402. Load cantilever ring baffle assembly onto support fixtures. Load diagonal struts. Using drill jig DJ-318-12404, drill all fastener holes not to be affected by circumferential weld. Remove baffle assembly and place on transportation trailer TnTr-370-18050 for temporary suspension in upper bulkhead. Remove support fixtures SF-318-24700 and SF-318-12401.

2.9.1.4 No. 1 LOX Only. Position support fixtures SF-318-24700 and SF-318-12401 onto assembly fixture AF-318-12402. Load cruciform and cantilever ring baffle assembly, supported on support fixture SF-322-24700, onto support fixtures. Load diagonal struts. Using drill jig DJ-318-12401, drill all fastener holes not to be affected by circumferential weld. Remove baffle assembly and place on transportation trailer TnTr-370-18050 for temporary suspension inside lower bulkhead. Remove support fixtures SF-318-24700 and SF-318-12401.

2.9.2 Deburr all holes and clean mating surfaces. Install fasteners. Support baffle adjacent to weld joint edges on adjacent baffles and tie down with straps MiT-370-7710. Lower elevator platform PP-370-24300.

2.9.3 Using hoisting tool HT-370-7539, lift cylindrical skin and baffle assembly out of assembly fixture AF-318-12402 and place on production dolly PrD-370-10005. Transport to major component cleaning facility. Aline dolly on facility tracks, and remove dolly strongback. Move dolly into cleaning facility until cylindrical skin and baffle assembly is positioned over twelve air jacks MiT2-300-24000. Use six jacks to lift assembly off dolly and remove dolly. Install nozzle piping and close cleaning facility door.

2.9.4 Clean, conversion coat, rinse, and dry cylindrical skin and baffle assembly. Alternately support assembly, during each operation with two sets of air jacks MiT2300-24000 (six jacks per set) to ensure all areas of assembly are exposed to cleaning agents. Control cleaning process and jacks from external facility control panels.

2.9.5 Open cleaning facility door and remove nozzle piping. Lift cylindrical skin and baffle assembly with six air jacks MiT2-300-24000. Position production dolly PrD-370-10005 under assembly and lower assembly onto dolly. Remove loaded dolly from facility and reinstall dolly strongback. Transport assembly to bulkhead weld station (See Para. 2.10) or transfer to transportation trailer TnTr-370-18050 using hoisting tool HT-370-7539 on overhead crane, and cover with polyethylene for transportation to vertical assembly building (See Section VII, Para. 2.2.1).

2.10 Bulkhead and Skin Assembly. (See figure 3-26.) The bulkhead and skin assembly consists of the upper or lower LOX or fuel tank bulkhead assembly (See Para. 2.2) and the adjacent cylindrical skin and baffle assembly (See Para. 2.9). The assembly is 22 feet long and varies in weight from approximately 11,000 pounds to 15,000 pounds.

2.10.1 Transport cylindrical skin and baffle assembly to bulkhead weld station on transportation trailer TnTr-370-18050. Loosen shoes AF2-300-7016-2. Using hoisting tool HT-370-7539, lift skin off trailer; shoes to remain on trailer. Install 32 leveling jacks MiT-302-24002 on bottom edge of skin and position on turntable AF-302-7011. Use jacks to adjust skin to correct orientation. Saw lifting tabs off skins. Trim top edge of skin with router mounted on external boom welder WF-302-7026.

2.10.2 Transport bulkhead assembly to bulkhead weld station on transportation trailer TnTr-370-18050. Install safety standoffs MiT-370-7660 on skin ring. Using hoisting tool HT-370-7080, lift bulkhead onto standoffs with bulkhead weight remaining on crane. Using scraper MiT2-300,12300, prepare weld joint edges for welding. Install lengths of .030 inch welding wire, for spacers, across weld joint at skin tee locations. Install alinement clamps MiT-370-7546. Lift bulkhead and remove standoffs. Position bulkhead on skin ring and tighten alinement clamp.

2.10.3 Manually tack weld joint between alinement clamps MiT-370-7546 and remove clamps. Install test weld fixture TWF-300-7509 opposite external boom welder. Weld and check samples. Remove test weld fixture. Begin rotation of turntable AF-302-7011. Using boom welder WF-302-7026 weld outside. Manually weld tees inside. Shave external weld flush. Using X-ray fixtures WFA10-300-24100 and WFA4-24100, X-ray inspect. Dye penetrant inspect weld. Repair and reinspect as required. Begin rotation of turntable AF-302-7011. Using router mounted on boom welder, trim bottom edge of skin. Remove leveling jacks MiT-302-24002 ahead of router. Replace jacks with a second set of jacks behind router adjusted for router cut. Clean and reconversion coat entire weld area.

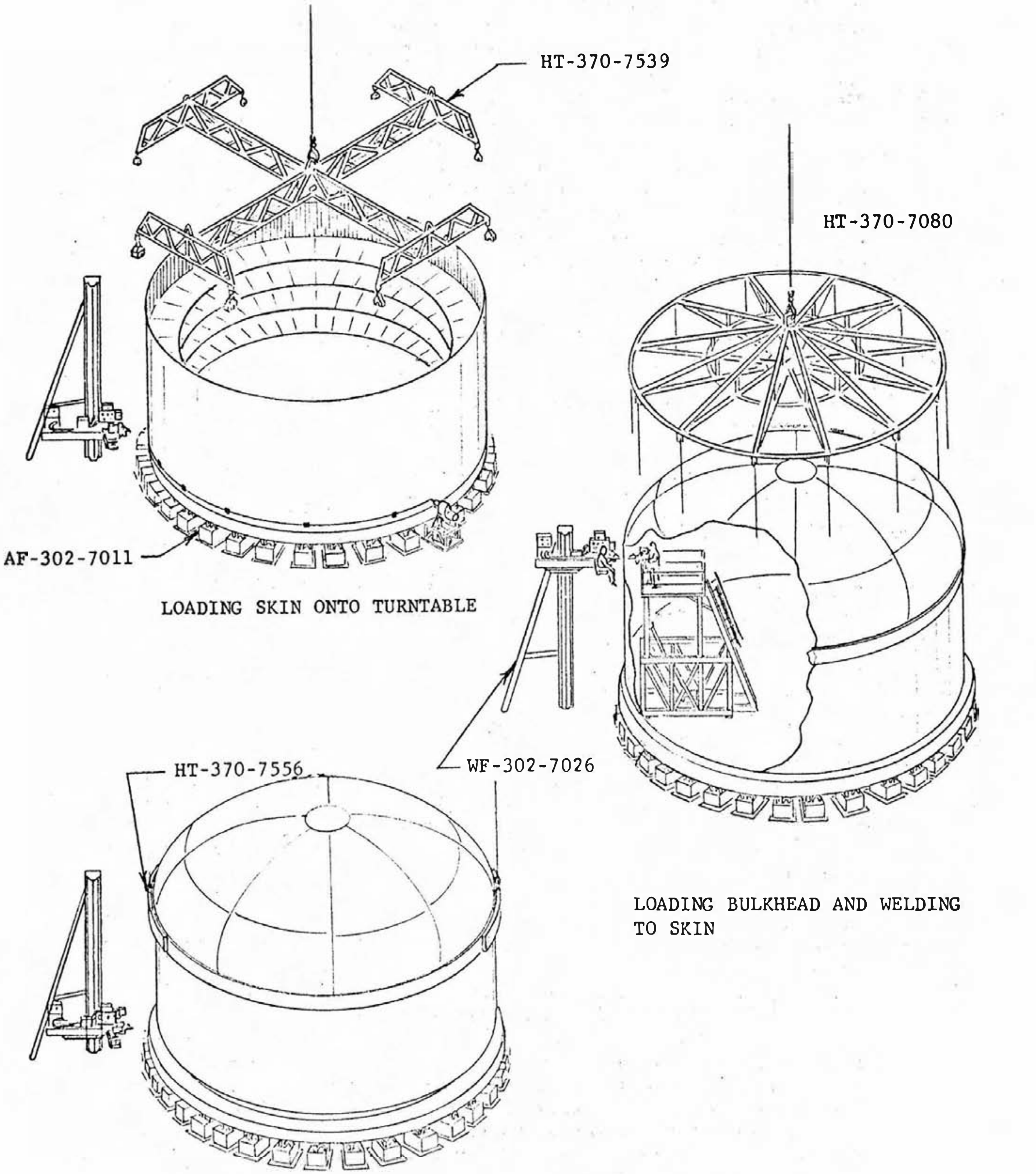


Figure 3-26. Bulkhead and Skin Assembly

2.10.4 Install ring baffle adjacent to weld joint. Install vertical stringers and diagonal struts. Complete installation of cruciform and cantilever ring baffle assembly or cantilever ring baffle assembly and remove support fixture SF-322-24700. Install personnel platform PP-370-7510 in upper LOX and lower fuel assemblies only.

2.10.5 Attach hoisting tool HT-370-7556 to tank subassembly. Using two overhead cranes, lift subassembly off turntable AF-302-7011. Remove leveling jacks MiT-302-24002. Replace skin shoes AF2-300-7016-2 and place tank subassembly on transportation trailer TnTr-370-18050.

2.11 LOX Tunnel Assembly (Inboard and Outboard.) The LOX tunnel assemblies are 2219 aluminum alloy cylinders having a diameter of 25 inches and varying in length from approximately 40 feet to 42 feet. The LOX tunnel consists of two main sections, an upper tunnel and a tube tunnel. The upper tunnel, approximately three feet long, is fabricated, cleaned, dye penetrant inspected, and anodized by vendors and packaged and shipped to Michoud. The tube tunnel has a series of "T" rings bonded to its exterior, at about nine inch intervals, along the length of the tunnel. These rings are installed by bonding two 180 degree "T" segments to the tunnel surface and connecting segment ends by riveting to splice plates. The tube tunnel is also fabricated, cleaned, penetrant inspected, and anodized by outside suppliers. The tube tunnel is then packaged in package and storage cart StR-370-24404 and shipped to Michoud.

2.11.1 Upon arrival of upper tunnel at Michoud, route to weld fixture WF-300-24404 on plant service dolly. Upon arrival of tube tunnel at Michoud, transport to weld fixture WF-300-24404 on storage cart StR-370-24404. Locate upper tunnel in weld fixture. Attach hoisting tool HT-370-7614 to the tube tunnel and place tube in weld fixture. Remove hoisting tool. Aline tunnel sections and perform weld. Clean and dry.

2.11.2 Using hoisting tool HT-370-7614, remove tunnel from weld fixture WF-200-24404 and place on production dolly PrD-370-7537. Remove hoisting tool and X-ray, clean,and conversion coat weld area while tunnel is still in humidity controlled area. Transport tunnel to trim fixture TmF-300-7616.

2.12 GOX Distributor Assembly. The GOX distributor is a cylindrical stainless steel structure approximately 30 inches in diameter by 48 inches long. The lower two-thirds of its length is perforated with 1/4 inch holes on 1/2 inch centers. The lower end is closed by a welded-on stainless steel sheet dome. The upper end is provided with a flange by which the assembly is bolted inside the top of the upper LOX tank bulkhead. A perforated dome is located inside the upper end. Below this dome, in the side of the assembly, is an opening into which the GOX line is inserted. During statis test of the S-IC, the LOX tank is pressurized by ground supply nitrogen and the flow is diffused through the upper dome and the distributor wall. Tank pressurization, during flight, is provided by gaseous oxygen and is diffused through the GOX line and the wall of the distributor. The GOX distributor assembly is fabricated complete by Boeing-Seattle and shipped to Michoud for installation.

2.13 Helium Distributor and Cover Assembly. The helium distributor assembly is a cylindrical structure of stainless steel sheet approximately 17 inches in diameter and 18 inches long. The lower 2/3 of its length is perforated with 1/4 inch holes on 1/2 inch centers. A stainless steel sheet dome is welded

2.13 (Con.)

over the lower end; the upper end has a flange to which a cover is bolted. The cover attaches the distributor to the upper fuel tank bulkhead and is connected to the helium pressurant supply line. During stage operation, the helium flow is dispersed by a splash plate inside the cover and is then diffused through holes in the distributor. The helium distributor assembly is built by Boeing-Seattle and the cover and splash plate are fabricated by Boeing-Wichita. The parts are then assembled and installed at Michoud.

2.14 LOX Emergency Drain Pipe Assembly. The LOX emergency drain pipe assembly consists of a rolled and welded aluminum pipe approximately 18 inches in diameter, 30 inches long, with flanges welded on either end. During static test firing of the S-IC Stage, one end of the pipe assembly is bolted to the lower LOX tank bulkhead. The other end protrudes through the innertank and is connected to the LOX emergency drain system of the test stand. The pipe assembly is removed after test firing and covers are replaced on the bulkhead and intertank openings.

2.14.1 Roll form plate for pipe. Trim longitudinal seam and prepare edges for welding. Clamp in longitudinal weld positioner and weld. X-ray inspect.

2.14.2 Trim ends of pipe to length. Rough machine flanges from roll-forged rings. Prepare circumferential weld joint edges for welding. Load details into weld lathe and weld flanges to pipe. X-ray inspect.

2.14.3 Finish machine pipe assembly on boring mill. Using drill jigs DJ-310-12217 and DJ2-310-12217, drill leak detector and bolt holes. Tap leak detector holes.

2.14.4 Clean and anodize pipe assembly. Install heli-coils in leak detector holes.

2.14.5 Hydrostatic test, LOX clean, and package for storage and/or shipping.

SECTION I V a

FIN AND FAIRING

SECTION IVa
FIN AND FAIRING

1. GENERAL DESCRIPTION.

1.1 Fin Assembly. A fin assembly is an airfoil structure that attaches to each lower fairing. (See figure 4a-1.) The fin assembly, extending from stage station 81.0 to 216.4, is 11-1/4 feet high, 11-1/2 feet long, 15 inches wide at the inboard end, 4 inches wide at the outboard end and weighs 511 pounds. All external components are titanium alloy and the internal components are aluminum alloy. The spar assembly protrudes from the fin and attaches to the fairing frame at station 115.5. Closure angles, attached to the fin assembly skin, bolt to the fairing skin. The fin assembly is a replaceable assembly. A fin assembly is made up primarily of forward rib assemblies, aft rib assemblies, fin tip beam assembly, trailing edge beam assembly, and a spar assembly. (See figure 4a-2 for schedule chart.)

1.1.1 Forward Rib Assembly. (See figure 4a-3.) Forward rib assemblies extend from the spar to the leading edge connecting with the spar at fin stations 37.191, 47.400, 57.609, and 67.819. Each rib consists of the following aluminum alloy details: a web, two chords, and four tee stiffeners. Detail parts are loaded and clamped in an assembly fixture. A drill plate and a hand drill are used to drill all holes. Selected fasteners are installed prior to removing the assembly from the assembly fixture. The following assembly fixtures are used to assemble the forward rib assemblies:

AF-345-30301 Forward Rib Fin Station 37.191 Assembly Fixture
AF-345-30302 Forward Rib Fin Station 47.400 Assembly Fixture
AF-345-30303 Forward Rib Fin Station 57.609 Assembly Fixture
AF-345-30304 Forward Rib Fin Station 67.819 Assembly Fixture

1.1.2 Aft Rib Assemblies. (See figure 4a-4.) Aft rib assemblies extend from the spar to the trailing edge beam and are located at fin stations 37.191, 47.400, 57.609, and 67.819. Each rib consists of the following aluminum alloy details: a web, two chords, and four tee stiffeners. Detail parts are loaded and clamped in an assembly fixture. A drill plate and a hand drill are used to drill all holes. Selected fasteners are installed prior to removing the assembly from the assembly fixture. The following assembly fixtures are used to assemble the aft rib assemblies:

AF-345-30202 Aft Rib Fin Station 37.191 Assembly Fixture
AF-345-30203 Aft Rib Fin Station 47.400 Assembly Fixture
AF-345-30204 Aft Rib Fin Station 57.609 Assembly Fixture
AF-345-30205 Aft Rib Fin Station 67.819 Assembly Fixture

1.1.3 Fin Tip Beam Assembly. The fin tip beam assembly consists of the following titanium alloy detail parts: two chords, a web, and a tip channel. The detail parts are located and clamped in place with the drill plate in assembly fixture AF-345-30400. Drilling of the assembly is accomplished using a drill plate and a positive-feed drill. Selective fasteners are installed prior to removing the assembly from the assembly fixture.

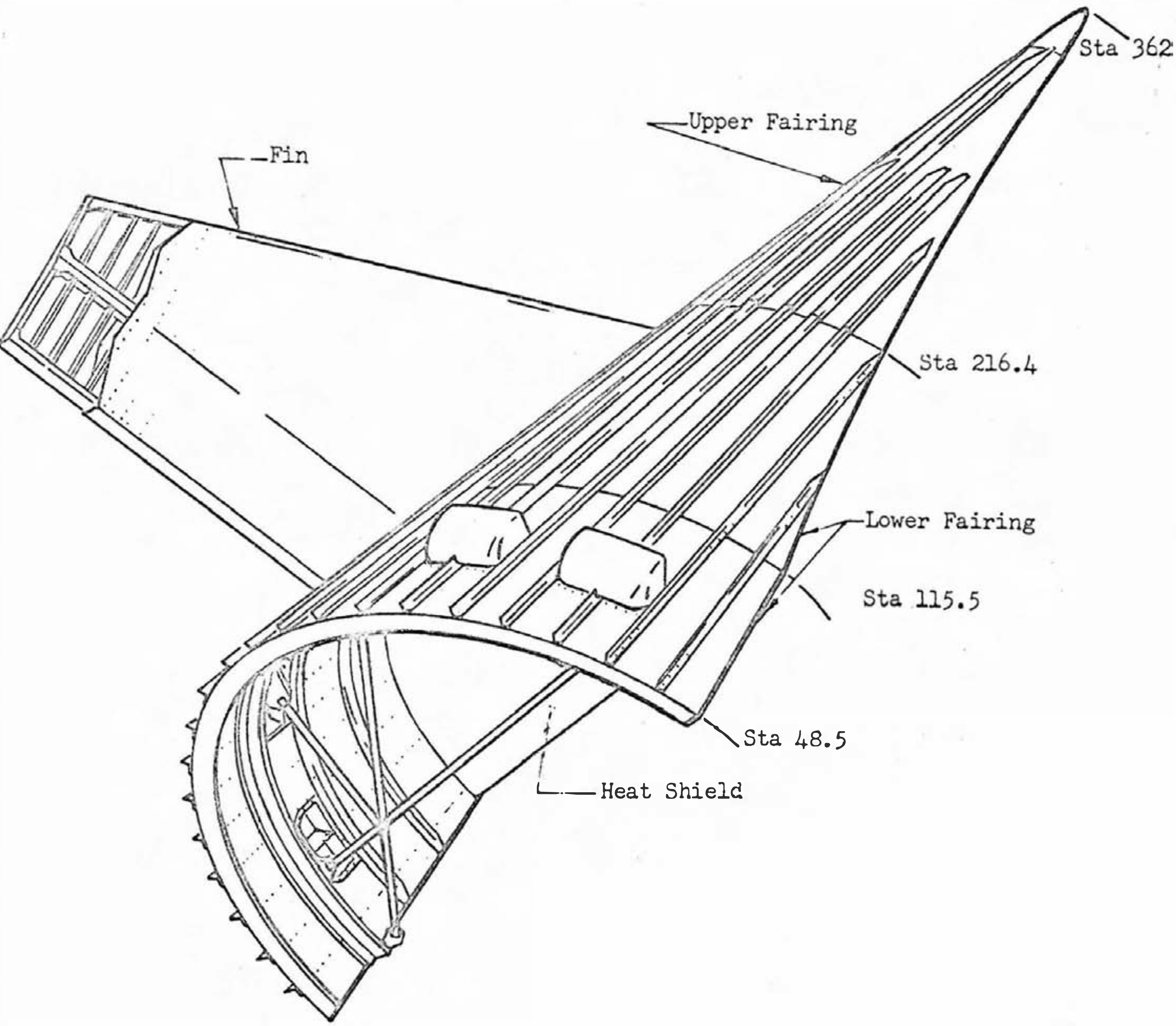


Figure 4a-1. Engine Fairing and Fin Assembly

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Figure 4a-2. Engine Fairing and Fin Assembly Detail Schedule and Program Chart

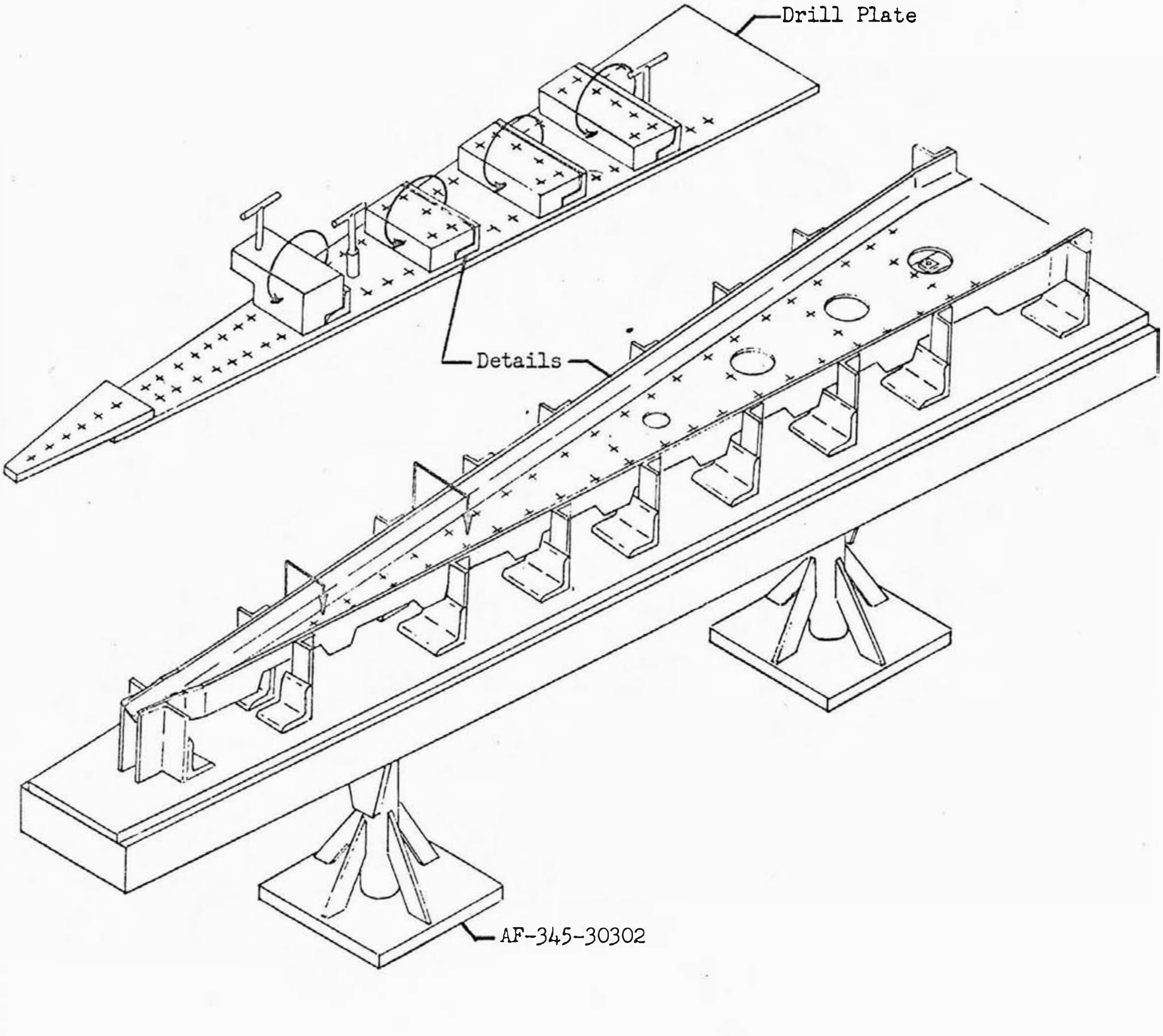

Figure 4a-3. Forward Rib Assembly

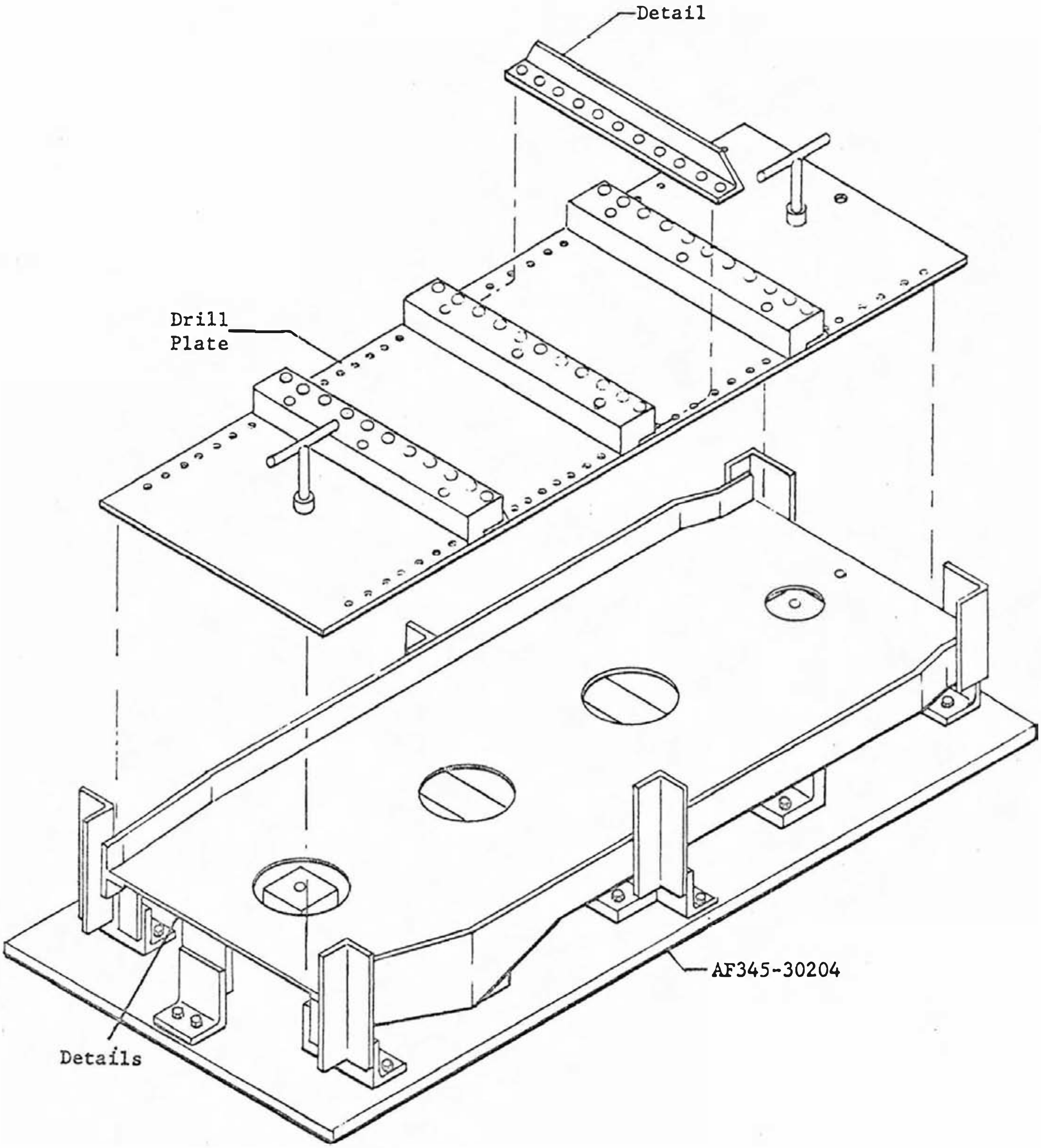

Figure 4a-4. Aft Rib Assembly

1.1.4 Trailing Edge Beam Assembly. (See figure 4a-5.) The trailing edge beam assembly consists of the following titanium alloy detail parts: two chords, a web, stiffener angles, a filler angle, and a close-out angle. Detail parts are located and clamped in place with a drill plate in assembly fixture AF-345-30200. Drilling of the assembly is accomplished using a drill plate and a positive-feed drill. Selected fasteners are installed prior to removing the assembly from the assembly fixture.

1.1.5 Spar Assembly. (See figure 4a-6.) The spar assembly consists of the following aluminum alloy detail parts: two chords, a web, stiffener angles, fillers, and laminated shim stock. Assembly fixture AF-345-30100 is used to assemble the spar assembly. The forward stiffeners, web, and chords are located and clamped in assembly fixture AF-345-30100. Holes common to the web and chords are drilled from a drill plate with positive-feed drills. The drill plate is removed and the drill frame is loaded. Aft stiffeners, laminated shims, and fillers are loaded and clamped; then holes in the stiffeners are drilled from the drill frame with positive-feed drills. The drill frame is removed and the aft stiffeners are dimensionally adjusted by removing strips of the shim as required. The holes common to the fairing frame at stage station 115.5 are drilled with positive-feed drills from a drill plate which is coordinated to TT-345-16150. Selected fasteners are installed prior to removing the assembly from the assembly fixture.

1.2 Fairing Assembly. (See figure 4a-1.) The fairing assembly is a conically-shaped structure that attaches to the thrust structure assembly at each outboard engine location. The fairing assembly, which extends from stage station 48.5 to station 362.0, partially covers the outboard engine and houses the retro-rocket and the actuator support structure. The fairing assembly is approximately 16-1/2 feet wide and eight feet deep; weight of the fairing assembly is approximately 1500 pounds. Construction is similar to conventional riveted and bolted aircraft structure. Below station 115.5, the components are primarily titanium alloy. Above station 115.5, the components are primarily aluminum alloy. Four fairing assemblies are required and are interchangeable. The fairing assembly is divided at station 216.4 into an upper and lower fairing. The lower fairing attachment fittings consist of two fixed fittings at station 115.5, six link fittings for attachment to the thrust structure, and two pins for alinement of upper fairing. The upper fairing attachments consist of six fittings, a hook for attachment to the thrust structure, and two holes for alinement with the lower fairing.

1.2.1 Lower Fairing Assembly (Station 48.5 to 115.5).

1.2.1.1 Station 115.5 Frame Assembly. (See figure 4a-7.) The station 115.5 frame assembly forms the basic structural tie between the thrust structure and the fairing and between the fairing and fin. Assembly components consist of two segments machined from aluminum plate, a steel center segment to which the fin attaches, two steel terminal fittings which attach to the support assembly on the thrust structure, chords, and shims. Terminal fittings

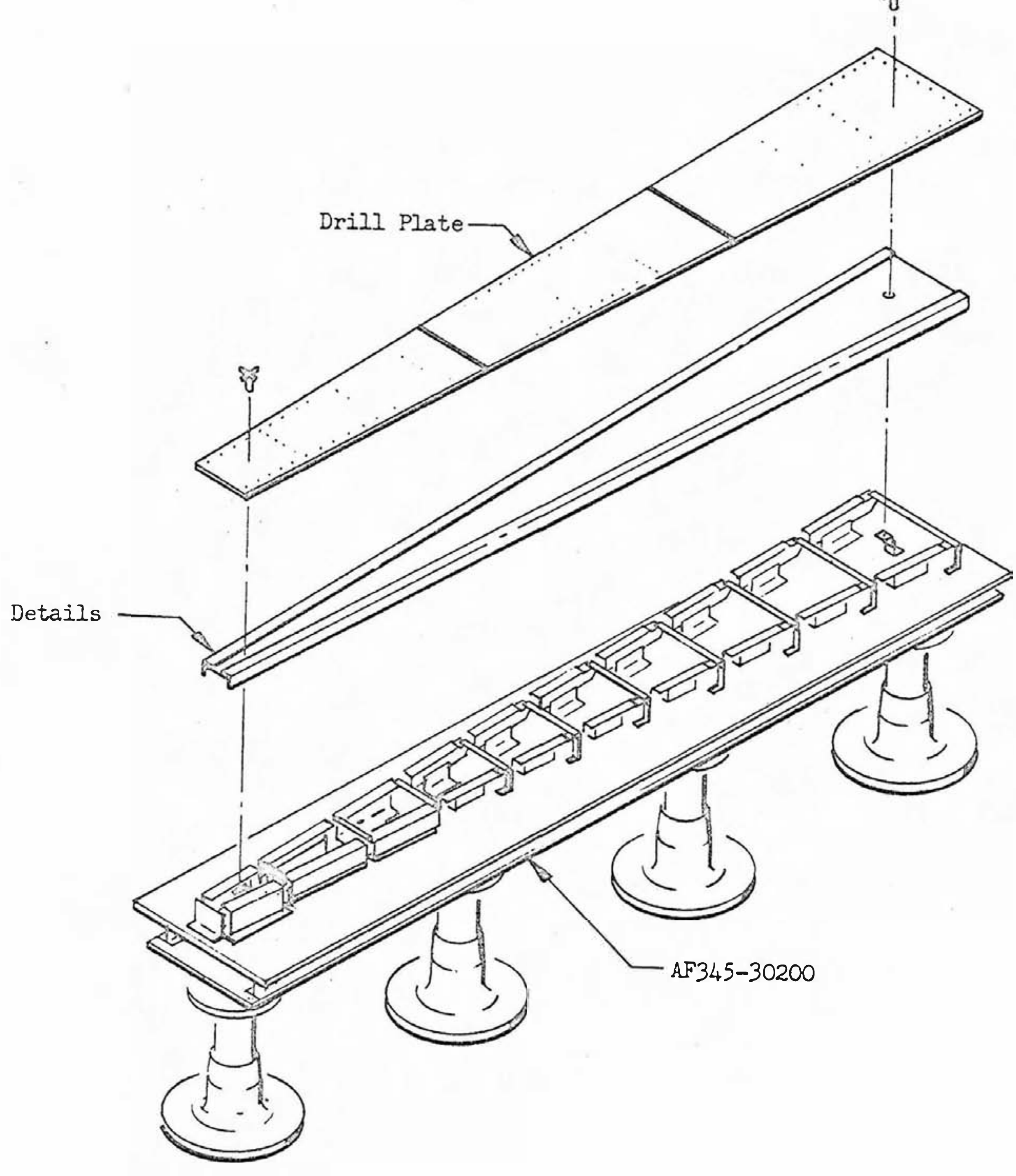

Figure 4a-5. Trailing Edge Beam Assembly Fixture

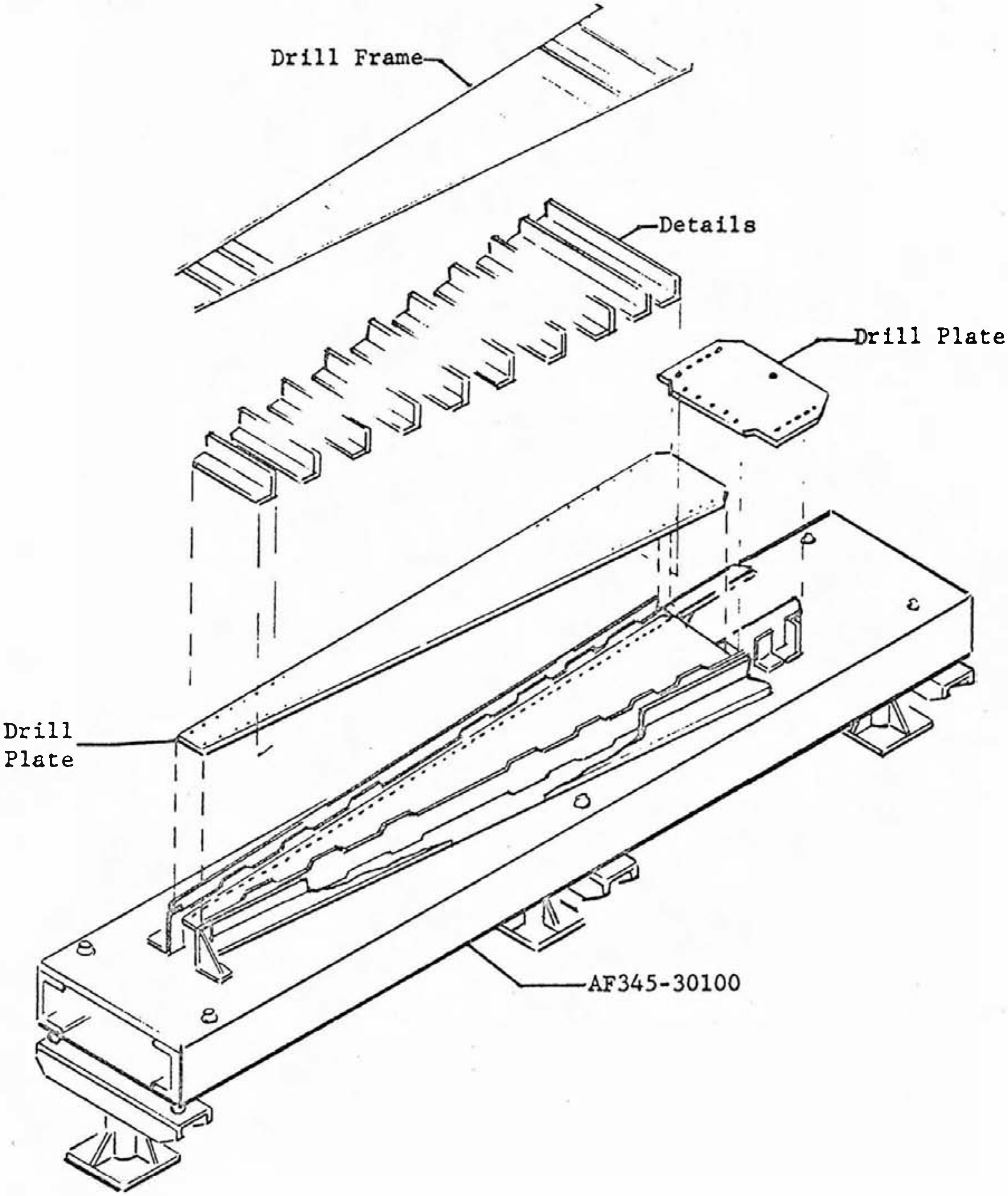

Figure 4a-6. Spar Assembly

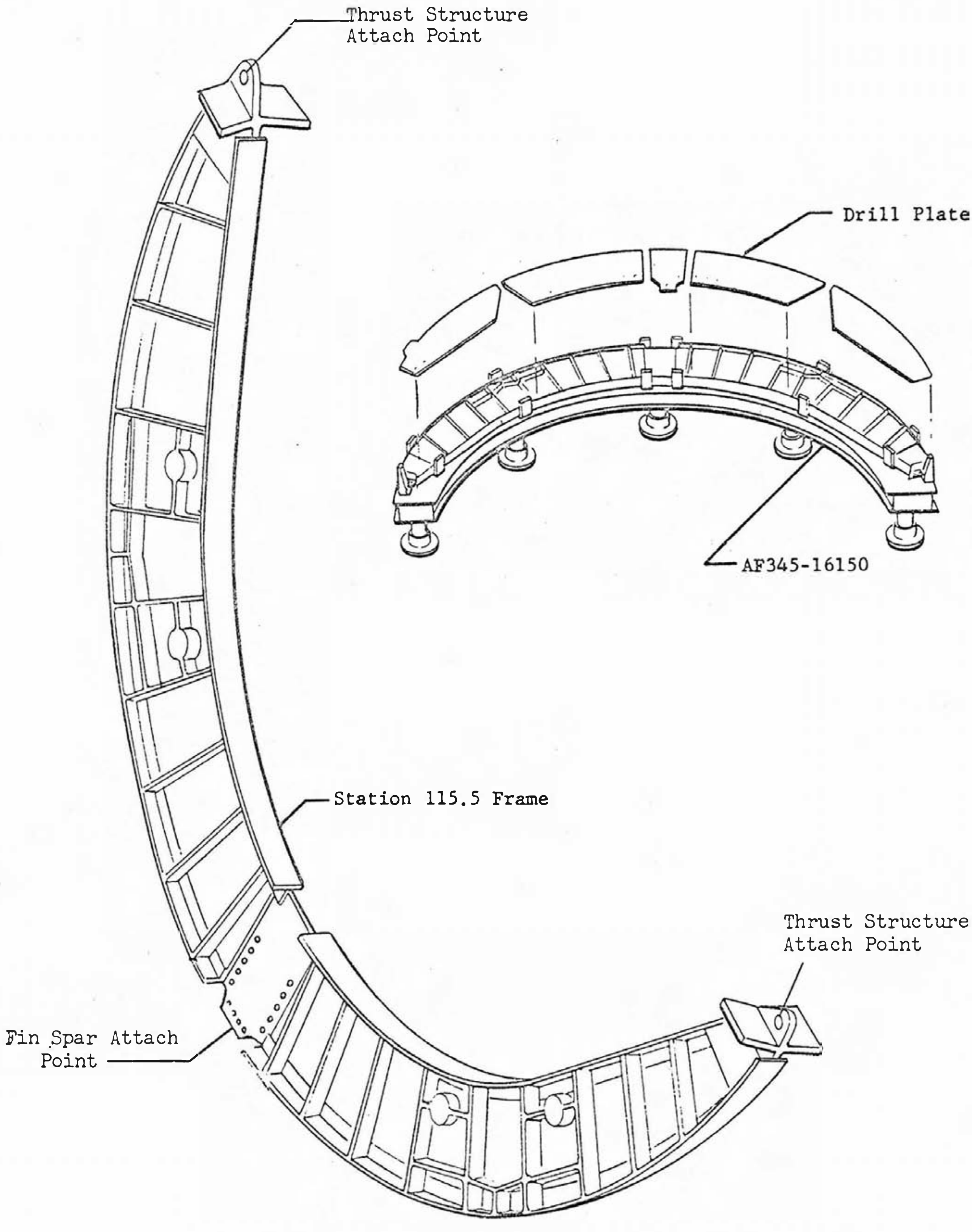

Figure 4a-7. Station 115.5 Frame Assembly

1.2.1.1 (Con.)

include undersize holes common to the support assembly. Details are indexed and clamped in assembly fixture AF-345-16150 which is coordinated to TT-345-16150. The terminal fittings are indexed to the undersize hole locations and the remainder of the details are indexed to contour and edges. All fasteners are installed while the details are clamped in assembly fixture AF-345-16150. Holes through the center segment common to the fin spar are drilled undersize from a drill plate. The frame assembly is lifted from assembly fixture AF-345-16150 with hoisting tool HT-370-16000. (See figure 4a-8.) The holes common to the fin spar are not shown on the engineering documentation for the frame assembly; therefore, the frame assembly is assigned a -900 number, 60B16150-1-900.

1.2.1.2 Station 66.75 Frame Assembly. (See figure 4a-9.) The station 66.75 frame assembly is the major structural frame in that portion of the fairing with cantilevers below the thrust structure and consists of a titanium alloy chord and a welded truss assembly. The truss consists of a series of tubes and plates. The truss details are indexed in assembly fixture AF-345-16110 and welded complete. Assembly fixture AF-345-16110 is a trunnion-mounted picture frame tool which allows optimum access for welding. After welding, the truss assembly is reindexed in assembly fixture AF-345-16110, the chord is located, and the fastener holes are drilled from drill plates with a positive-feed drill. Selected fasteners are installed while the truss and chord are clamped in assembly fixture AF-345-16110. The frame assembly is lifted from assembly fixture AF-345-16110 with hoisting tool HT-370-16000. (See figure 4a-8.)

1.2.1.3 Titanium Frame Assemblies. (See figure 4a-10.) Titanium frame assemblies are located in the lower portion of the lower fairing at stations 48.5, 83.5, and 100.25. Each frame is composed of titanium alloy chords and webs. The intercostal attach angles shown on the station 83.5 engineering documentation are not included in the production assembly. Omission of the angles on the subassembly allow the intercostals to be located later to aline with the external stringers on the fairing. This frame is therefore assigned a -900 number, 60B16130-1-900. Assembly fixture AF-345-16101-903 is used for assembling all three of these frames. The details are located, clamped, and drilled from drill plates with a positive-feed drill. Selected fasteners are installed while the details are clamped in assembly fixture AF-345-16101-903.

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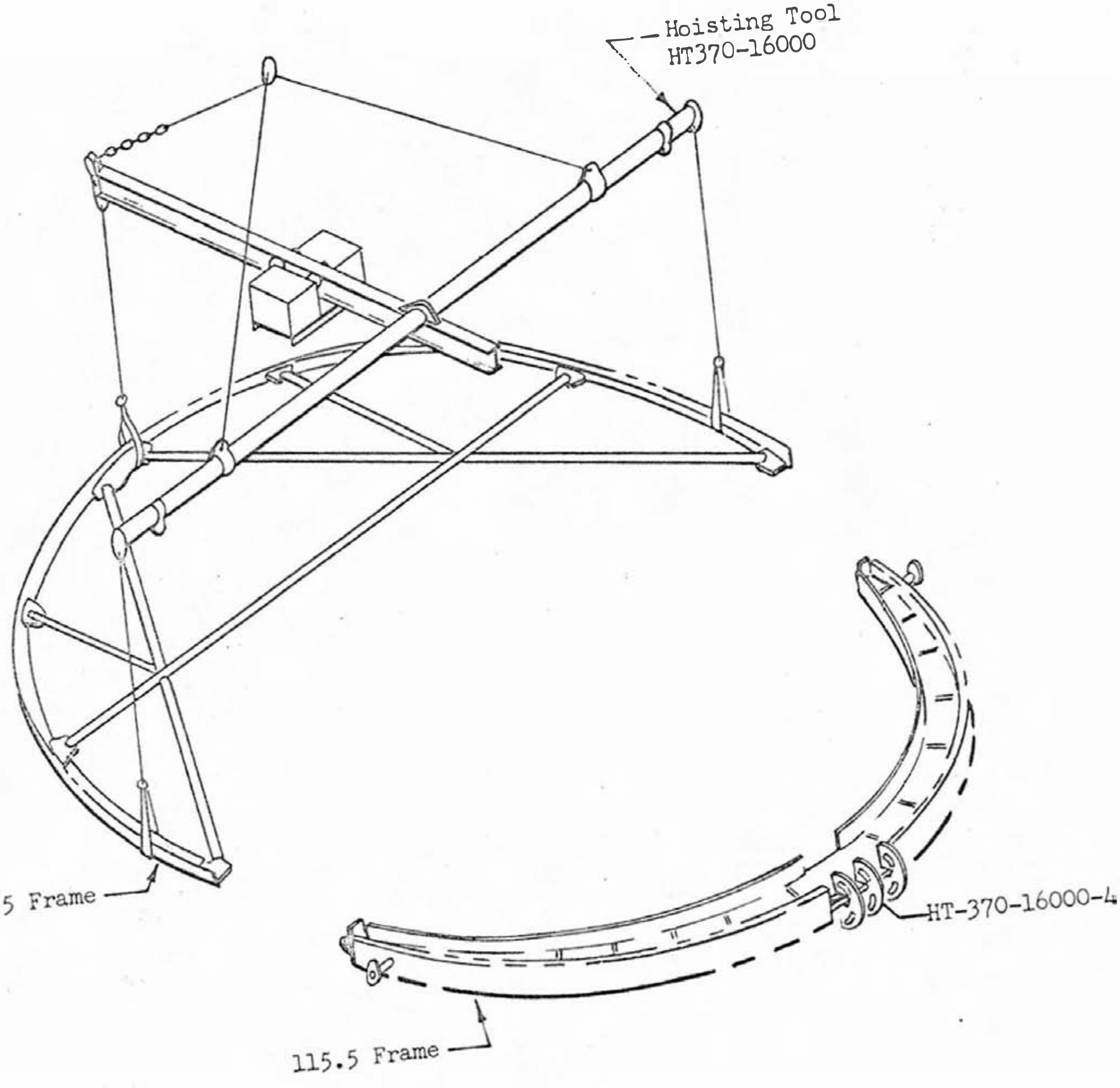

Figure 4a-8. Hoisting Tool for Stations 66.75 and 115.5 Frame Assemblies

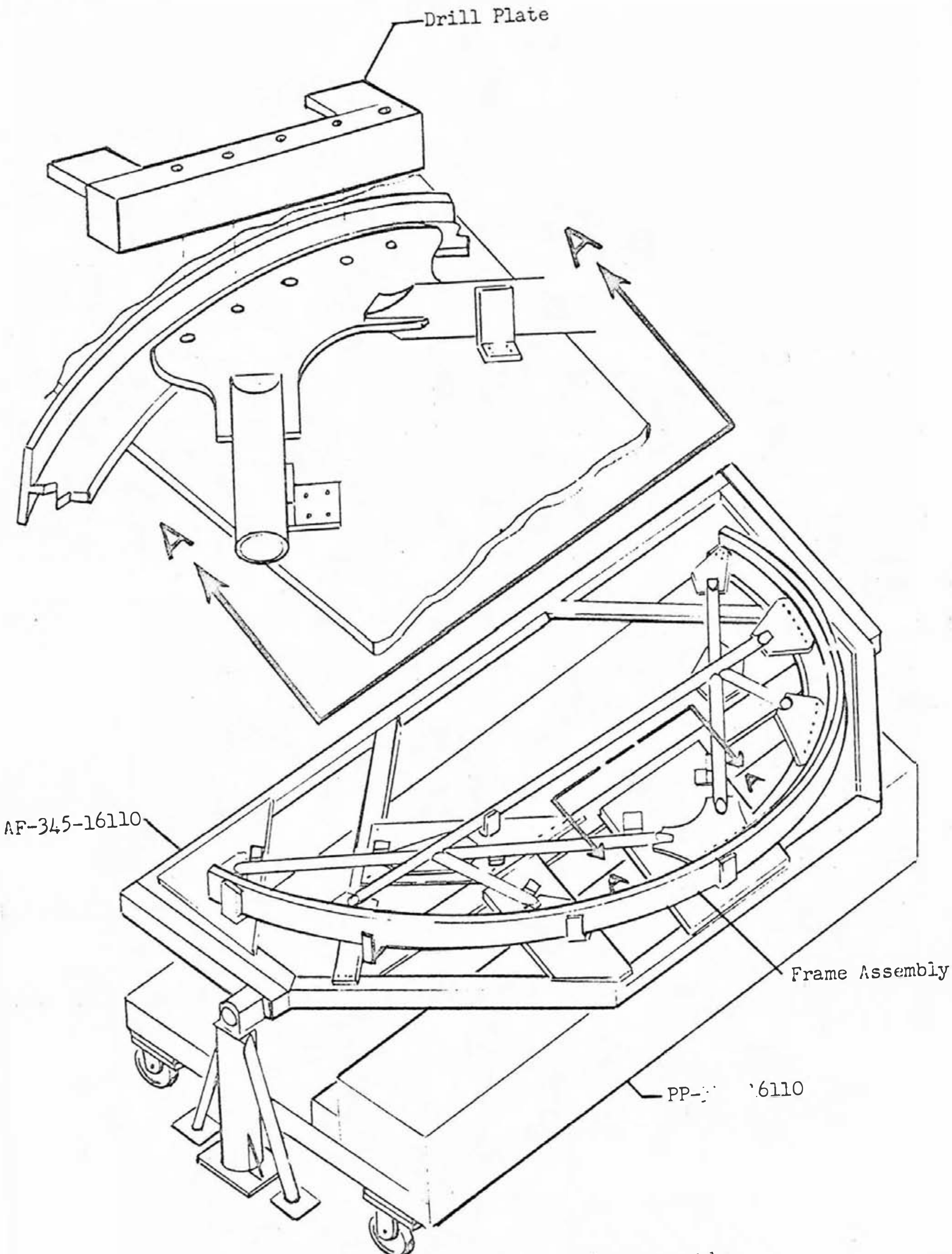

Figure 4a-9. Station 66.75 Frame Assembly

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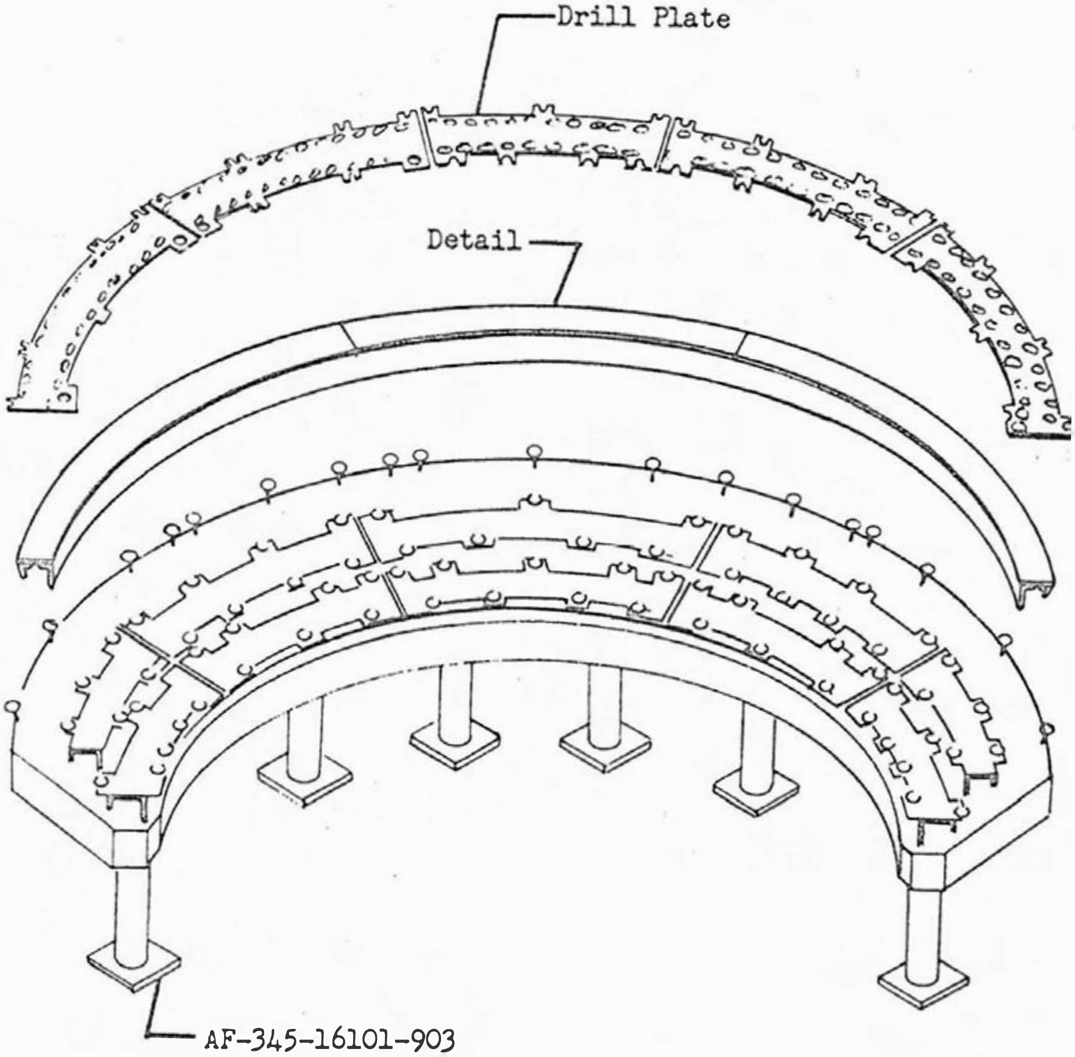

Figure 4a-10. Titanium Frame Assembly

1.2.1.4 Air Scoop Assembly. (See figure 4a-11.) These are four air scoop assemblies on each lower fairing assembly. Each air scoop assembly consists of a skin, a doubler, an attach angle, a center frame called a splitter, and two end frames. The splitter and the two end frames each consist of a web, a chord, doublers, and fillers. All detail parts are titanium alloy. The end frames and the splitter details are located and clamped in their respective assembly fixtures AF2-345-16500, AF3-345-16500, and AF4-345-16500. Fastener holes are drilled from drill plates with a positive-feed drill, and fasteners are installed. The end frame and splitter subassemblies are then indexed and clamped in assembly fixture AF-345-16500. The skin, doubler, attach angle, and a drill plate are indexed and clamped. The fastener holes are drilled with a positive-feed drill. Selected fasteners are installed while the components are clamped in assembly fixture AF-345-16500. The air scoop assembly is removed from assembly fixture AF-345-16500, and the remaining fasteners are installed.

1.2.2 Lower Fairing Assembly (Station 115.5 to 216.4).

1.2.2.1 Aluminum Frame Assembly. (See figure 4a-10.) Three aluminum frame assemblies are located in the upper portion of the center fairing at stations 152.45, 183.89, and 216.4. Each of these assemblies consist of chords and webs. The intercostal attach angles shown on the engineering documentation are not included in the production assembly. The angles are omitted to allow location of intercostals to match the external stringers during a later assembly operation. Each one of the frames noted is therefore assigned a -900 number, 60B16190-1-900, 60B16160-1-900, and 60B16198-1-900. The detail parts of each frame assembly are indexed and clamped in the applicable assembly fixture. The fastener holes are drilled from a drill plate. Selected fasteners are installed while the details are clamped in the assembly fixture. Assembly fixture AF-345-16180 is used to assemble the frame assemblies at station 152.45 and 183.89. Assembly fixture AF-345-16188 is used to assemble the center fairing frame at station 216.4. Assembly fixture AF-345-16188 at station 216.4 is coordinated to TI-345-16135 for contour.

1.2.2.2 Intercostal Tube Assemblies. Four intercostal tube assemblies are located in the upper portion of the lower fairing. The intercostal tube assemblies attach to the station 115.5 frame assembly and to a fitting near station 152. Each intercostal tube assembly consists of an aluminum tube with a gusset welded into a slot at each end. Assembly fixture AF-345-16628 is used to position the components of each intercostal tube assembly for welding.

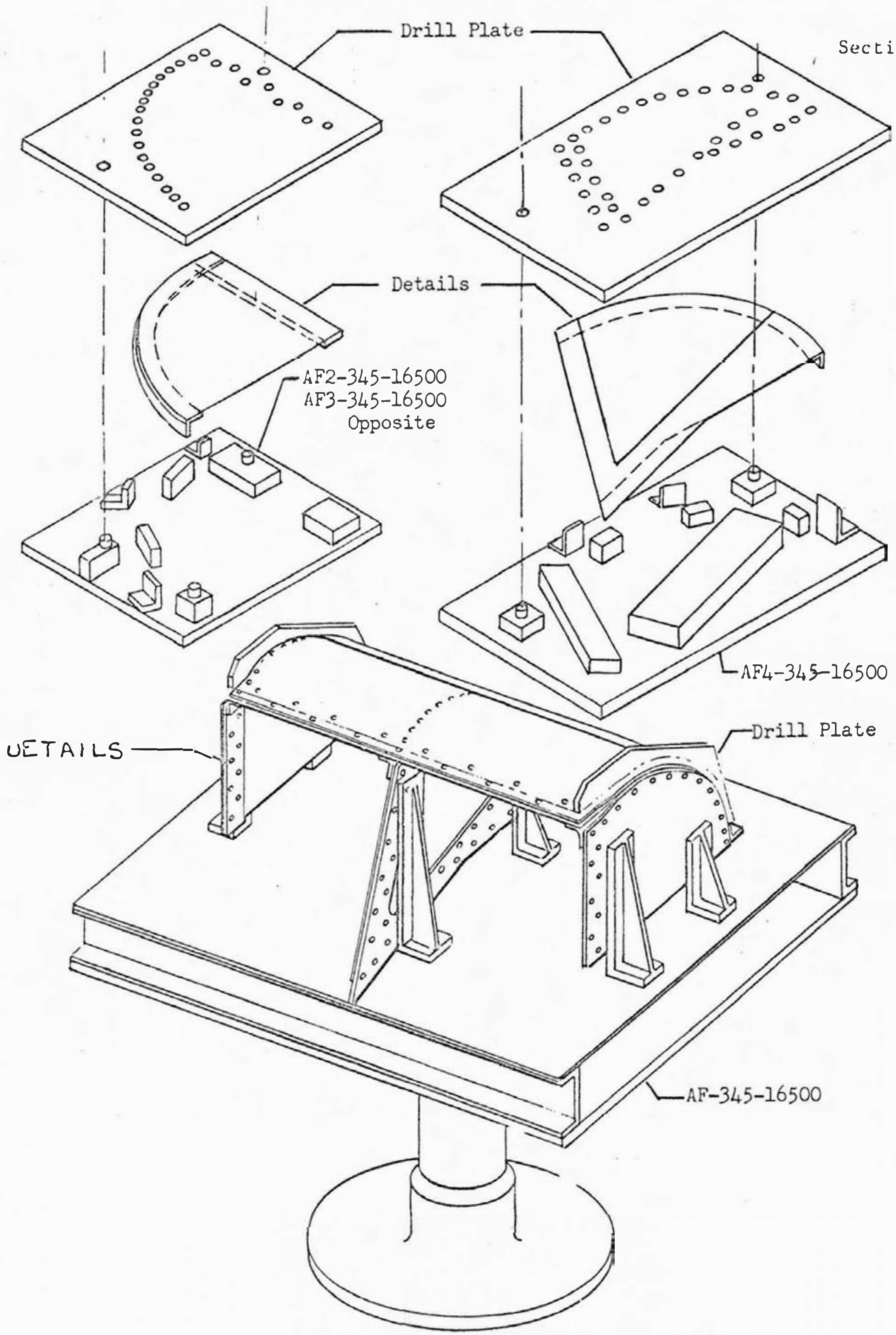

Figure 4a-11. Air Scoop Assembly and Assembly Fixture

1.2.3 Upper Fairing Assembly. (See figure 4a-10.) Three aluminum frame assemblies are located in the upper fairing at stations 216.4, 247.8, and 279.8. Each of these frame assemblies consist of chords and webs. The intercostal attach angles shown on the engineering documentation are not included in the production assembly. The angles are omitted to allow location of intercostals to match the external stringers during a later assembly operation. Each one of the frame assemblies noted is therefore assigned a -900 number, 60B16135-1-900, 60B16201-1-900, and 60B16204-1-900. The details of each frame assembly are indexed and clamped in the applicable assembly fixture. The fastener holes are drilled from a drill plate. Selected fasteners are installed while the details are clamped in the assembly fixture. Assembly fixture AF-345-16135 assembles the upper fairing frame assembly at station 216.4. Assembly fixture AF-345-16201 assembles the frame assemblies at stations 247.8 and 279.8. Assembly fixture AF-345-16135 at station 216.4 is coordinated to TT-345-16135 for contour.

2. ASSEMBLY.

2.1 Fin Assembly. (See figure 4a-1.) The fin assembly is composed of a spar, a trailing edge beam, a tip beam, built-up and formed internal ribs, skins, a leading edge insert and channel, closeout angles common to the fairing intercostals, and miscellaneous angles and fillers.

2.1.1 Assembly of the fin assembly is performed on assembly fixture AF-345-30000. Personnel platform PP4-370-16000 is used with assembly fixture AF-345-30000. Assembly fixture AF-345-30000 is coordinated to MrSG-345-30000 for contour and holes common to the fairing. Attach holes common to the fairing are in the closeout angles and the spar. The spar is located and clamped in assembly fixture AF-345-30000. Primary index is from the undersize holes in the spar common to the fairing. The trailing edge beam is located. The aft ribs are located and clamped to the stiffeners on the spar and trailing edge beam. Fastener holes common to the ribs are drilled by hand from pilot holes in the stiffeners.

2.1.2 The leading edge channel is located and clamped on the leading edge drill plate. The forward ribs are located to stiffeners on the spar and pins on the leading edge drill plate and clamped in position. The holes common to the ribs are drilled by hand from pilot holes in the spar stiffeners. Holes common to the ribs and leading edge channel are drilled undersize from the leading edge drill plate. A tack rivet is installed in one hole common to each rib and the leading edge channel.

2.1.3 The intercostals are located and clamped in position. The intercostals are held in position by the installation of one tack rivet at each intercostal and rib intersection. The splice plate is located and bonded in position. All fasteners not common to the skin are installed. One aft skin is located and clamped. All holes, except holes common to the closure angle and skin, are drilled from drill plates with positive-feed drills. The skin is removed and the opposite side skin is located clamped and drilled. One set of three forward skins, the leading edge insert, and filler are

2.1.3 (Con.)

located and clamped. All holes except the holes common to the closure angle and fin assembly and the holes common to the skin and leading edge insert are drilled from drill plates with positive-feed drills. The opposite side skins are located and clamped. The holes common to the near and opposite side skins and the leading edge insert are drilled from a drill plate with positive-feed drills. The near side skins are removed and the drilling is completed on the opposite side skins.

2.1.4 All skins are installed and permanently fastened in place.

2.1.5 The closure angles are located and clamped. The holes common to the closure angle and fin assembly are drilled from drill plates with positive-feed drills. The fasteners common to the fin assembly and closure angles are installed.

2.1.6 The holes in the closure angles common to the fairing assembly are drilled undersize from a drill plate with positive-feed drills.

2.1.7 Four lifting lugs MiT2-370-16000 are installed on the fin assembly. The fin assembly is removed from assembly fixture AF-345-30000 with hoisting tool HT-370-7115. (See figure 4a-12.)

2.2 Fairing Assembly. (See figure 4a-13.)

2.2.1 Lower Fairing Assembly (Station 48.5 to 216.4) 60B16090. This assembly is the installation of the center fairing to the lower fairing in the final assembly position. (Reference paragraph 2.3)

2.2.2 Lower Fairing Subassembly (Station 48.5 to 216.4) 60B16090-1-901. (See figure 4a-14.) A production break is made in the lower fairing at station 115.5 in order to provide a workable assembly sequence. The portion of lower fairing below station 115.5 is designated 60B16090-1-901. The following assemblies and details are included: Frame assemblies at stations 48.5, 66.75, 83.5, 100.25, and 115.5; two close-out channels; intercostals which lie between frames and consist of channels or webs, chords, and attach angles; skins; external stringers; and four air scoop assemblies. All detail parts not previously subassembled are titanium alloy. The station 115.5 frame assembly is indexed in assembly fixture AF-345-16101-901 to the undersize holes in the terminal fittings. Assembly fixture AF-345-16101-901 is coordinated to TT-345-16150 for these hole locations. The close-out channels are indexed and clamped to assembly fixture AF-345-16101-901 and to station 115.5 frame assembly. The remainder of the frame assembly are indexed to assembly fixture AF-345-16101-901 and clamped. The attach angles common to the frame assembly and the close-out channels are located, drilled, and fasteners are installed. Each intercostal is fixture-located, drilled, and fastened with permanent fasteners (positive-feed drilling is provided where allowed by accessibility). The air scoop assemblies are located and clamped when the adjacent intercostals are being installed. Fastener holes common to the air scoop assemblies and the intercostals

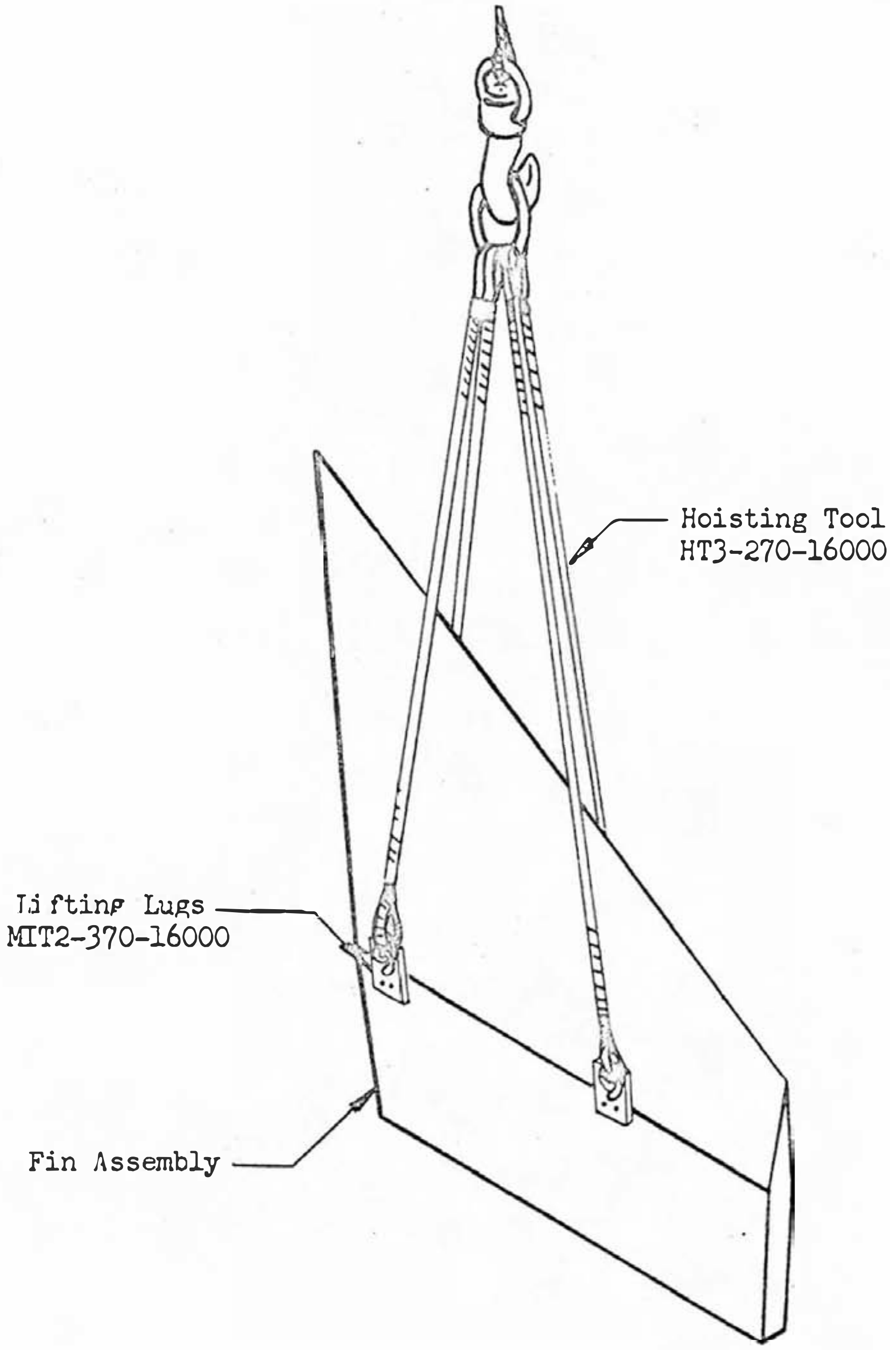

Figure 4a-12. Hoisting Tool for Fin Assembly

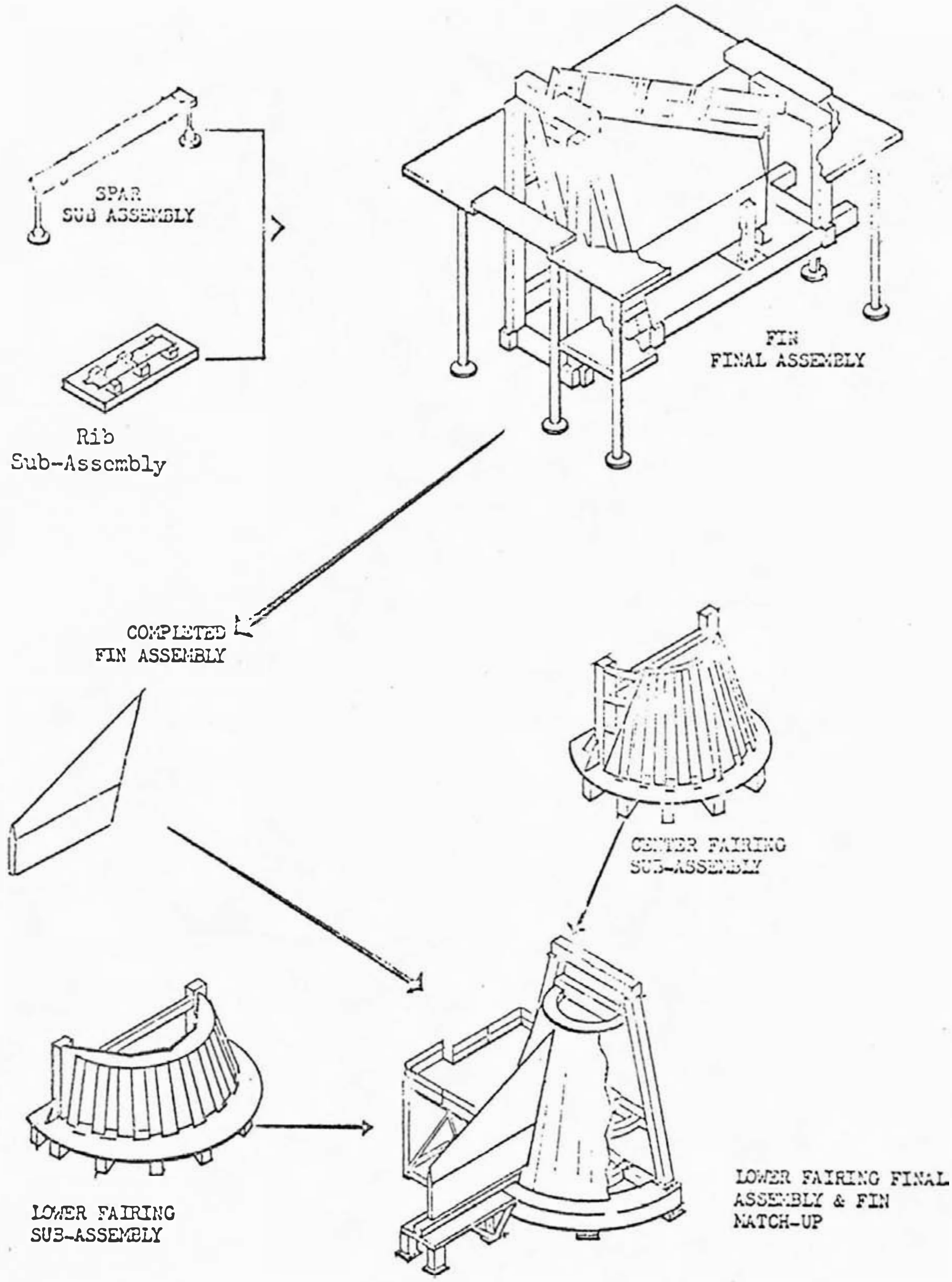

Figure 4a-13. Fin and Fairing Flow Diagram

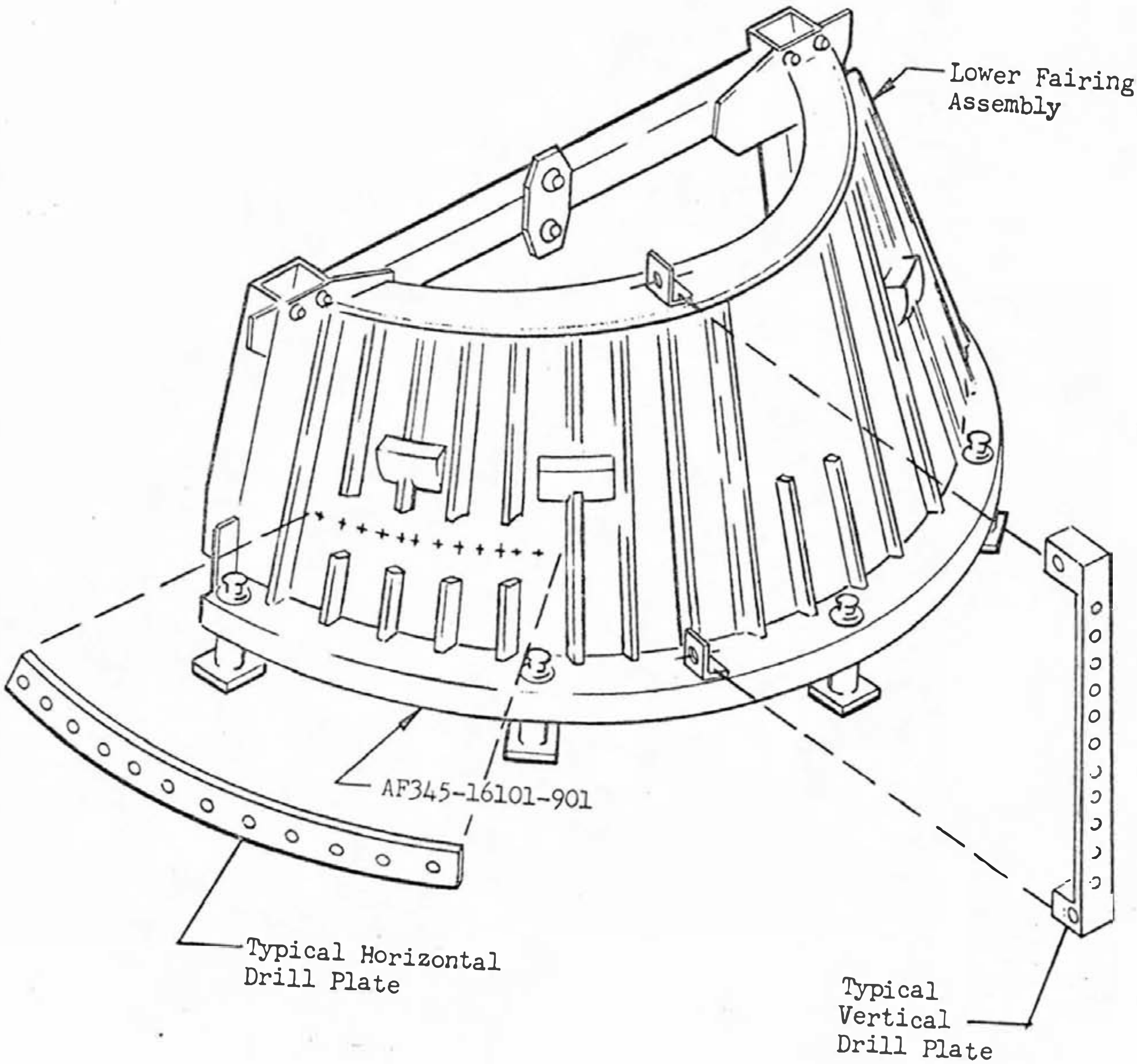

Figure 4a-14. Assembly Fixture for Lower Fairing Assembly

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are drilled then the air scoop assemblies are removed from the lower fairing subassembly to complete the basic skeleton of the subassembly. One of the fairing skins is located and clamped. One external stringer is located and clamped to an external drill bar and the fastener holes are drilled with a positive-feed drill. Additional stiffeners and skins are applied and drilled with the fixture-located external drill bars until all holes common to the external stringers have been drilled. The stringers are removed from the lower fairing subassembly and deburred after drilling. Holes common only to the frames and skins are then drilled from external drill plates which index to holes common to the stringers, frames, and skins. The skins are then removed for deburring. The skins and stringers and air scoop assemblies are reapplied, located, and clamped through the previously drilled holes. The remainder of the holes common to the air scoop assemblies are drilled. All remaining fasteners are installed completing the subassembly. Handling fittings MiT-370-16000 are bolted to the lower fairing subassembly. Hoisting tool HT-370-7116 is used to lift the lower fairing subassembly. (See figure 4a-15.)

2.2.3 Center Fairing Subassembly (Station 115.5 to 216.4) 60B16090-1-902. (See figure 4a-16.) The center fairing subassembly 60B16090-1-902 is the portion of the lower fairing forward of station 115.5. The center fairing subassembly consists of three frame assemblies; six formed frames; two close-out channels; angles for attaching close-out channels to the frames; intercostals that lie between frames and consist of webs, chords, and attach angles; skins; and external stringers. All detail parts are aluminum alloy. The fittings along the close-out channels to which the link fittings attach are not included in the subassembly. Close-out channels are located and clamped in assembly fixture AF-345-16101-902. All the frame assemblies are located and clamped in assembly fixture AF-345-16101-902. The attach angles common to the frame assemblies and close-out channels are located, drilled, and permanent fasteners are installed. Each intercostal is fixture-located, drilled, and fastened with permanent fasteners. Drilling is accomplished using apply-type drill templates and from pilots with hand motors to complete the basic subassembly. The external stringers are temporarily located on the subassembly to match the intercostals and frame assemblies. Fastener locations common to the frame assembly and stringers are drilled pilot size using a small drill plate which indexes to the frame assembly and the stringer. The stringers are then removed. Each skin is located, clamped, and drilled pilot size from the pilot holes in the frame assemblies. A stringer and an external drill bar are indexed and clamped to these pilot holes. The remaining fastener holes in the stringer are drilled full size from the drill bar. The stringer is then removed from assembly fixture AF-345-16101-902. The operation is repeated for each stringer. The holes common only to the frame assemblies and skins are then drilled from horizontal external drill plates which index to the holes drilled through the frame assemblies at the stringer locations. The skins and stringers are deburred, reindexed, and the remainder of the

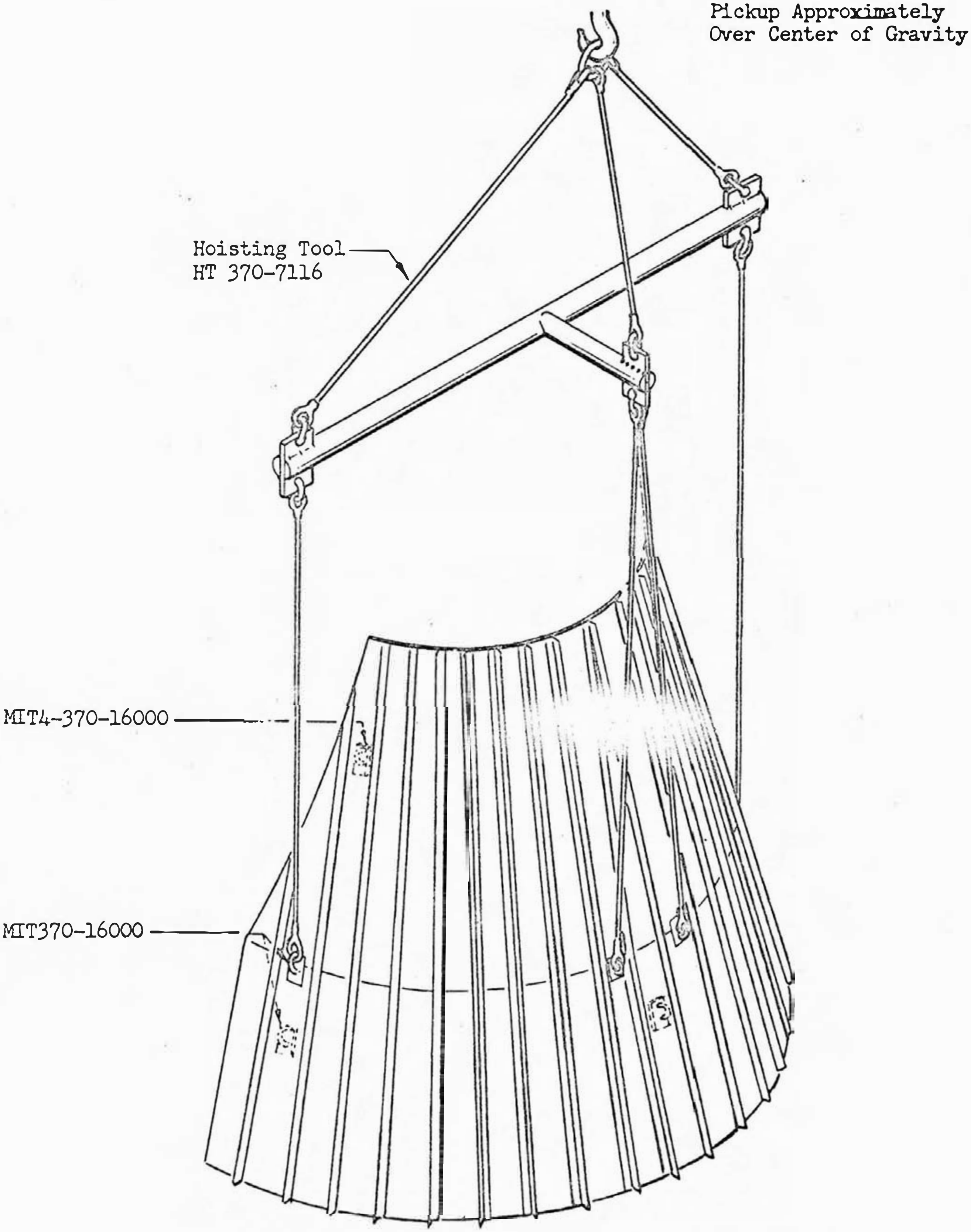


Figure 4a-15. Hoisting Tool for Lower Fairing Subassembly

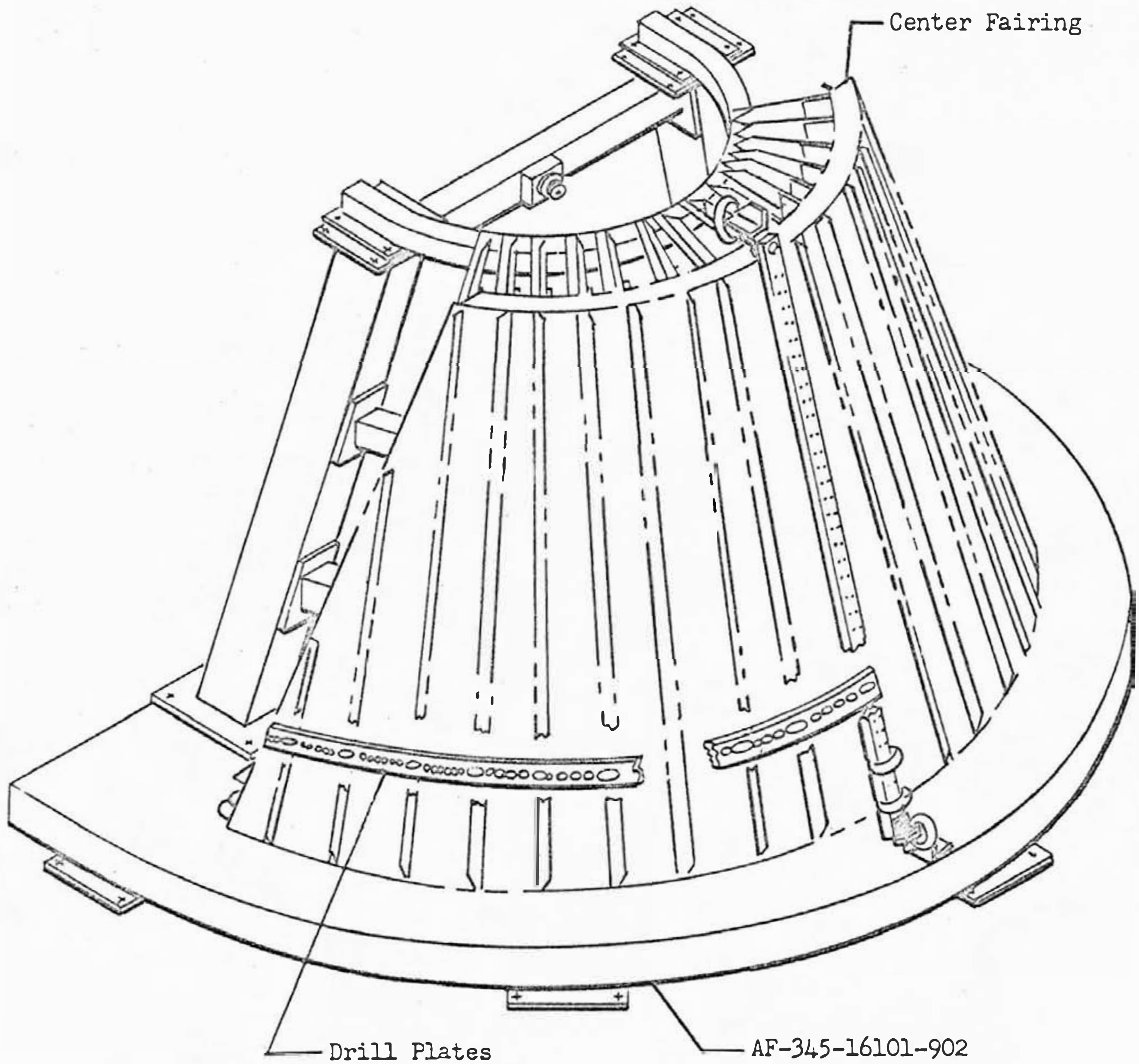


Figure 4a-16. Assembly Fixture for Center Fairing Subassembly

2.2.3 (Con.)

fasteners are installed completing the center fairing subassembly. Handling fittings MiT-370-16000 are bolted to the center fairing subassembly. Hoisting tool HT-370-7116 is used to lift the center fairing subassembly. (See figure 4a-15.)

2.2.4 Upper Fairing Assembly 60B16102. (See figure 4a-17.) The upper fairing assembly consists of a skeleton, skins, and external stringers, six link fittings for attachment to the thrust structure, link support fittings, and a hook common to the receiver installation on the thrust structure. The skeleton consists of three frame assemblies, ten formed frames, close-out channels, angles which attach the close-out channels to the frames, intercostals which consist of tee sections or webs, chords and attach angles, and two closure pans and attach angles. The upper fairing assembly is assembled complete in assembly fixture AF-345-16102. (See figure 4a-17.) MrG-345-16102 coordinates the locators on assembly fixture AF-345-16102 for link support fittings, the hook fitting, and for drilling the holes common to the alinement pins on the lower fairing assembly. TT-345-16135 coordinates the contour at station 216.4. The close-out channels are located and clamped in assembly fixture AF-345-16102. All the frame assemblies are located and clamped. The angles common to the frame assemblies and the close-out channels are located and clamped. Attach angles common to the closure pans are located, drilled, and permanent fasteners are installed. Each intercostal is located, drilled, and fastened with permanent fasteners. Drilling is done from apply-type drill plates and from pilots with hand motors. This completes the basic skeleton. The external stringers are temporarily located on the skeleton to match the intercostals and frame assemblies. Fastener locations common to the frame assemblies and stringers are drilled pilot size from a small drill plate which indexes to the frame assembly and the stringer. The stringers are then removed. Each skin is located, clamped, and drilled pilot size from the pilot holes in the frame assemblies. A stringer and an external drill bar are indexed and clamped to these pilot holes. The remaining fastener holes in the stringer are drilled full size from the drill bar. The stringer is then removed from assembly fixture AF-345-16102. This is repeated for each stringer. The holes common only to the frame assemblies and skins are then drilled from horizontal external drill plates which index to the stringer locations. The skins and stringers are deburred, re-indexed, and the fasteners are installed completing the basic structure. The six link support fittings include an undersize hole common to the link. These fittings are located from this hole, and shimmed common to the fairing structure. Fastener holes common to fairing structure are drilled, and fasteners are installed. The hook fitting is fixture-located, drilled, and permanently fastened. The undersize holes in the link support fitting are reamed full size from assembly fixture AF-345-16102 completing the assembly. MiT3-370-16000 handling fitting is bolted to the upper fairing assembly. Hoisting tool HT-370-7117 is used to lift the upper fairing assembly from assembly fixture AF-345-16102. (See figure 4a-18.)

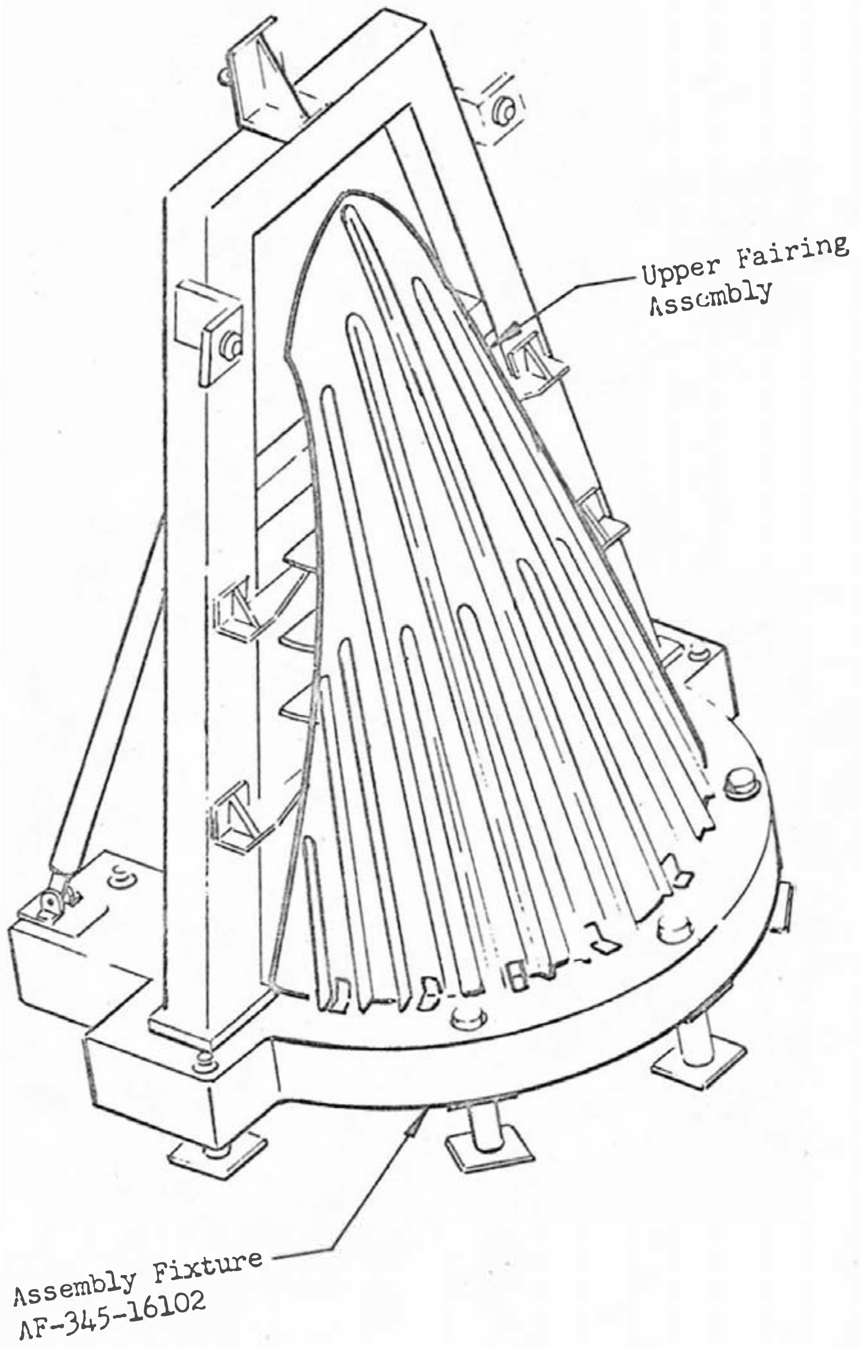


Figure 4a-17. Assembly Fixture for Upper Fairing Assembly

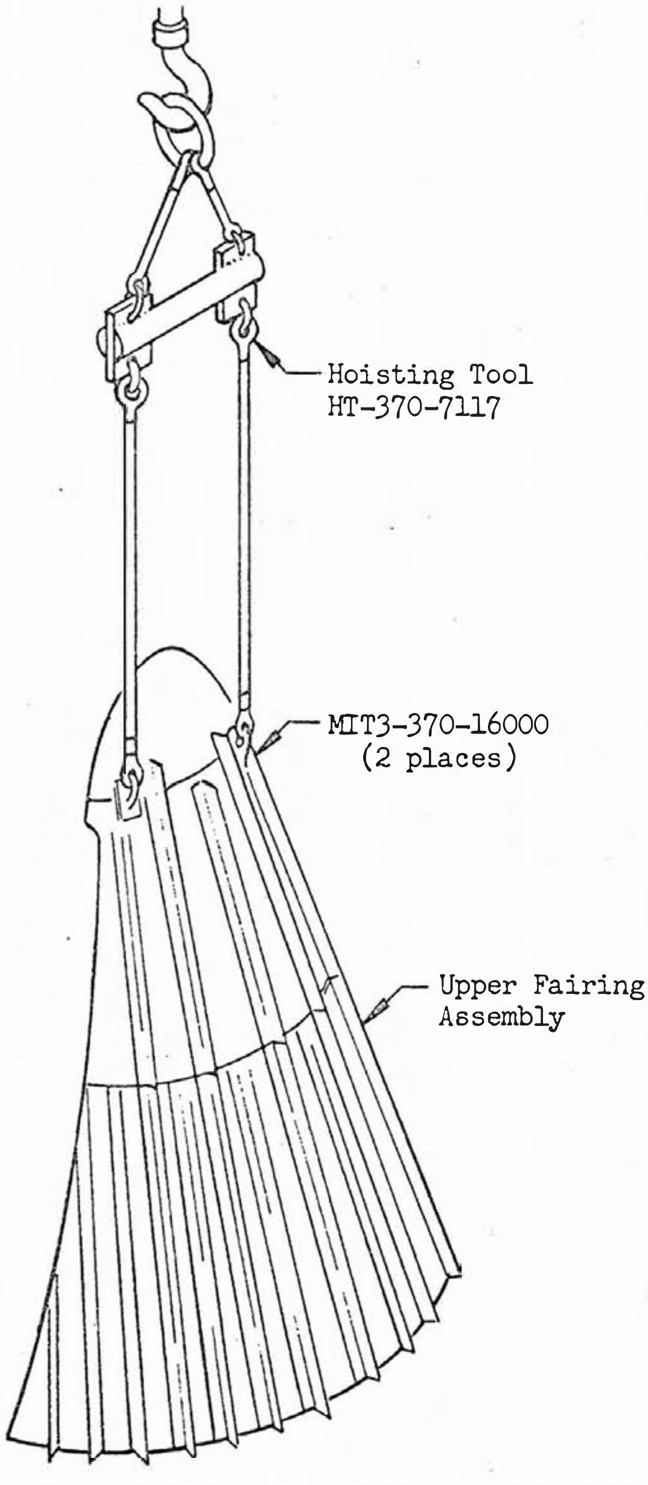


Figure 4a-18. Hoisting Tool for Upper Fairing Assembly

2.2.5 Alinement Check. The upper and lower fairingsare positioned and indexed on MrSG-345-7114. Alinement and fitup between the fairings will be checked at this time to ensure match-up at installation. Upon completion of this check the fairings will be transferred to fairing shipping cradle 65B63001, a ground support design tool. (See figure 4a-19.) Fairing shipping cradle 65B63001 is also used as an inplant transportation dolly.

2.3 Assembly of Lower Fairing and Fin Assembly 60B16001. (See figure 4a-20.) The lower fairing assembly consists of the lower fairing subassembly, the center fairing subassembly, the intercostal tube assemblies, six fittings which attach the link fittings to the fairings, fillers, and shims. Link fittings are not attached to the fairing assembly during the assembly operation. The fin assembly is assembled with the fairing assembly during this operation; then the fin assembly is removed and shipped separately.

2.3.1 Assembly fixture AF-345-16000 is used for the lower fairing and fin assembly operation. Master gage MrG-345-16090 coordinates all the locators on assembly fixture AF-345-16000 related to thrust structure attachment and the locators for the alinement pins common to the upper fairing. Master gage MrG-345-30000 is used to coordinate the large external drill plate which drills undersize holes through the fairing skin common to the fin closure angles. For initial setting, this drill plate is oriented in assembly fixture AF-345-16000 using TT-345-16150 and TT-345-16135; then the drill plate index points are set to the drill plate.

2.3.2 The lower fairing subassembly is loaded and indexed by pinning to the undersize holes in the terminal fittings in the station 115.5 frame assembly and supporting the station 115.5 frame assembly in the area common to the fin spar. The center fairing subassembly is loaded and rough indexed. The large external drill plate is then positioned on assembly fixture AF-345-16000. The center fairing subassembly is indexed to the drill plate and to fixture locators at station 216.4. Holes common to the center fairing skin and the lower fairing assembly are drilled from drill plates, and fasteners are installed. Intercostal tube assemblies are located, fastener holes are drilled, and fasteners are installed.

2.3.3 The six fittings which attach the link fitting to the fairing assembly include an undersize hole common to the link. These fittings are located from this hole and shimmed common to the closure beam. Fastener holes common to the closure beam are drilled, and fasteners are installed. This completes the basic structure of the lower fairing assembly. The undersize holes in the fittings just installed and the undersize holes in the terminal fitting on the station 115.5 frame assembly are now reamed full size from assembly fixture AF-345-16000. The alinement pin holes common to the upper fairing are drilled from assembly fixture AF-345-16000, and the alinement pins are installed. The holes common to the fin closure angle are drilled undersize from the external drill plate, and the drill plate is removed.

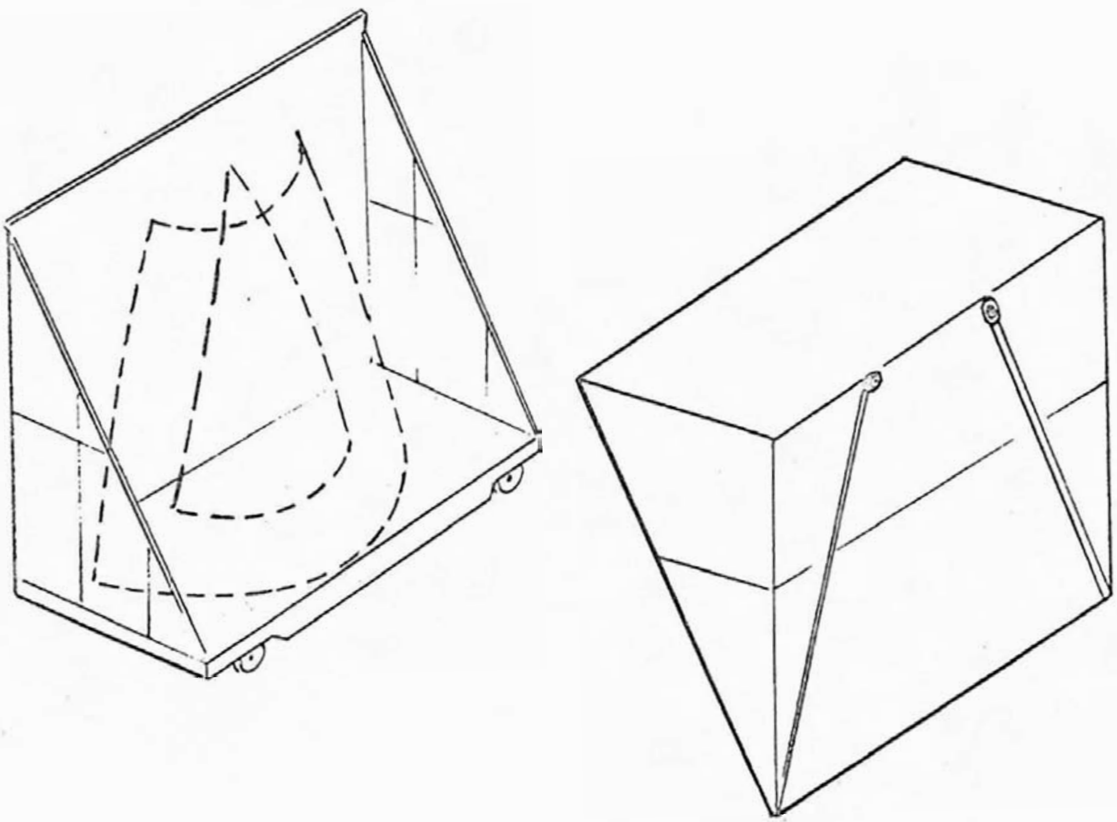


Figure 4a-19. Shipping Fixture 65B63001 for Fairing Assembly

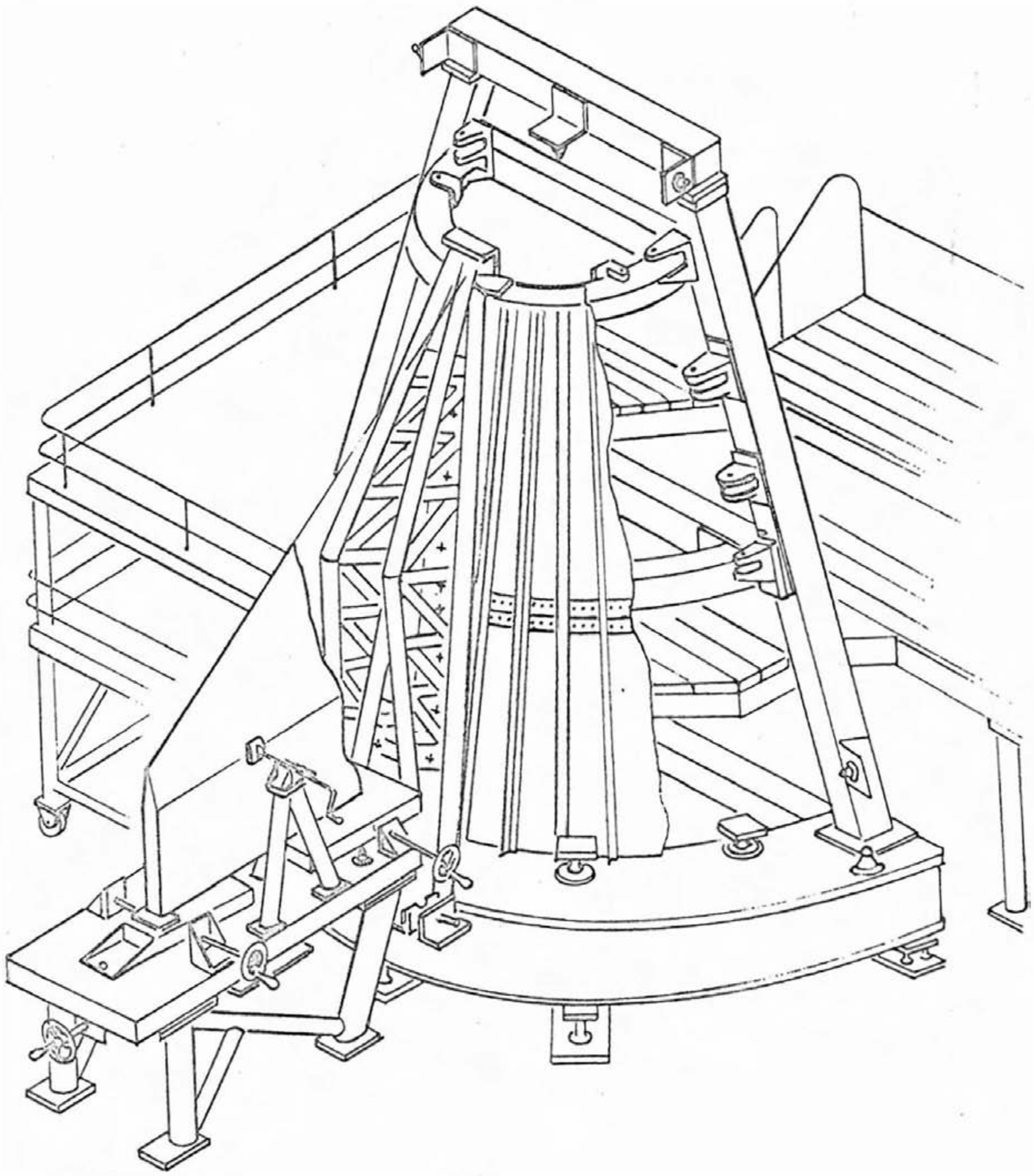


Figure 4a-20. Lower Fairing Assembly and Fin Assembly Final Assembly

2.3.4 The fin assembly is secured to the adjustable support table and moved into rough position on the fairing assembly. The position of the fin assembly is adjusted to achieve the best possible alinement with all undersize attach holes. The fin assembly is then checked optically for alinement per engineering requirements. Additional adjustments are made as required. The hole pattern common to the fin spar and the station 115.5 frame assembly is then reamed full size from a drill plate which is applied to the joint, and bolts are installed. The holes common to the fin closure angle are reamed full size, and bolts are installed. The fin assembly is then rechecked for conformance to the alinement requirements.

2.3.5 The fin assembly 65B63017 is unbolted and transferred to the fin shipping cradle, a ground systems design tool. (See figure 4a-21.) This cradle is also used as an inplant transportation dolly.

2.3.6 The fairing assembly is removed from assembly fixture AF-345-16000 with hoisting tool HT-370-7116 and held for a subsequent check with the upper fairing assembly. (See figure 4a-15.)

3. FIN AND FAIRING MASTER TOOLING.

A series of master tools are used to control the interchangeable and replaceable features of the fairing and fin. A general description of these tools follows.

3.1 <u>MrSG-345-7114.</u> (See figure 4a-22.) This gage represents the support and receiver assemblies on the thrust structure, including the link fittings at the link joints. This is the basic gage for the fairing to thrust structure interface.

3.2 <u>MrG-345-16090.</u> (See figure 4a-23.) This gage represents the attach fittings on the lower fairing assembly less the link fittings at the link joints. This gage is coordinated to MrSG-345-7114.

3.3 <u>MrG-345-16102.</u> (See figure 4a-23.) This gage represents the attach fitting on the upper fairing assembly less the link fittings at the link joints. This gage is coordinated to MrSG-345-7114.

3.4 <u>MrSG-345-30000.</u> (See figure 4a-24.) This gage represents the fin assembly side of the fin to fairing interface. This is the basic gage for this interface.

3.5 <u>MrG-345-30000.</u> (See figure 4a-24.) This gage represents the fairing assembly side of the fin to fairing interface. This gage is coordinated to MrSG-345-30000.

3.6 <u>TT-345-16150.</u> (See figure 4a-25.) This tool represents the station 115.5 frame assembly plane of the fairing assembly. The fin to fairing attach points are included in the tool and are coordinated to MrSG-345-7114. The fin spar to fairing attach points are included in the tool and are coordinated to MrSG-345-30000. Contour in the area of the fin closure angles is also coordinated to MrSG-345-30000.

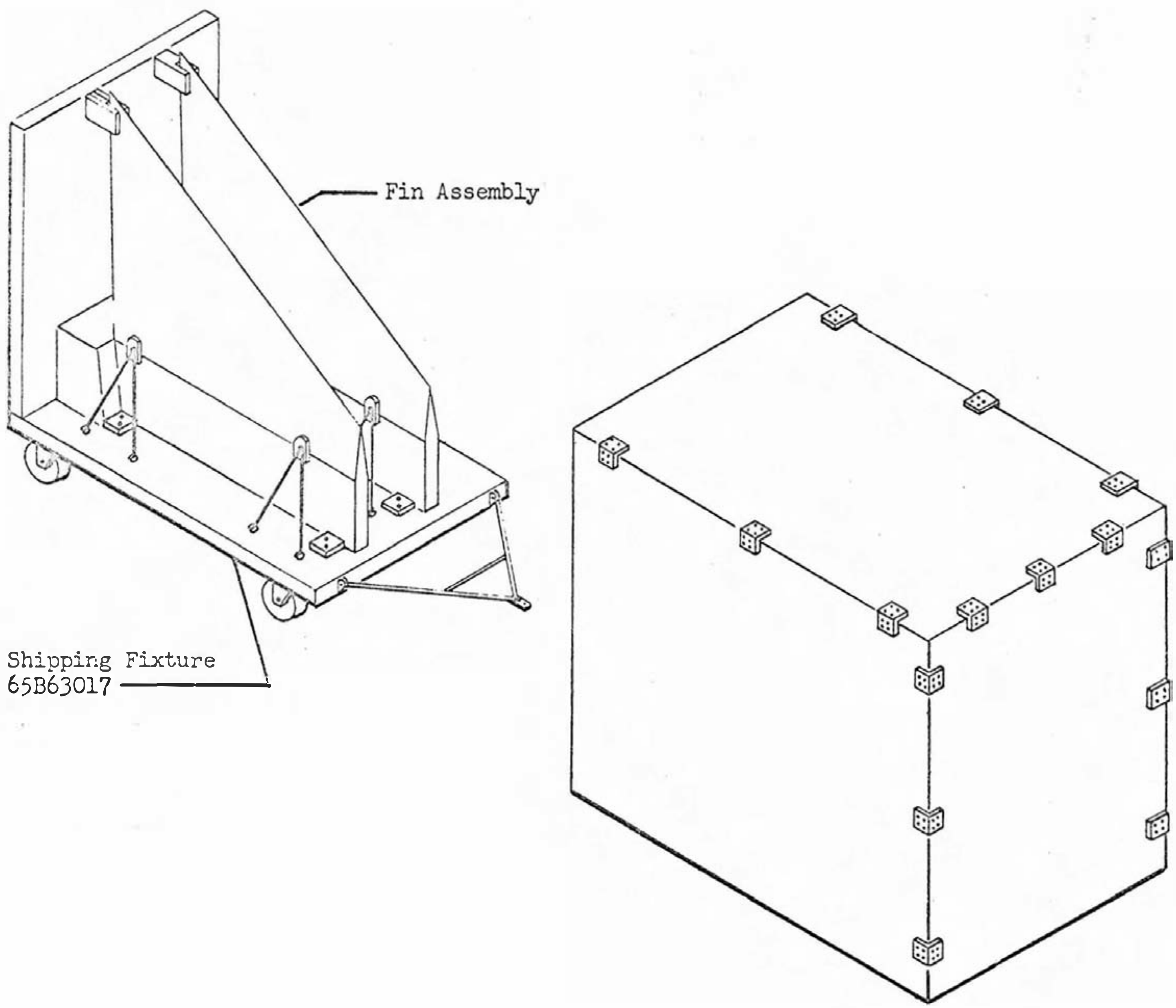


Figure 4a-21. Shipping Fixture 65B63017 for Fin Assembly

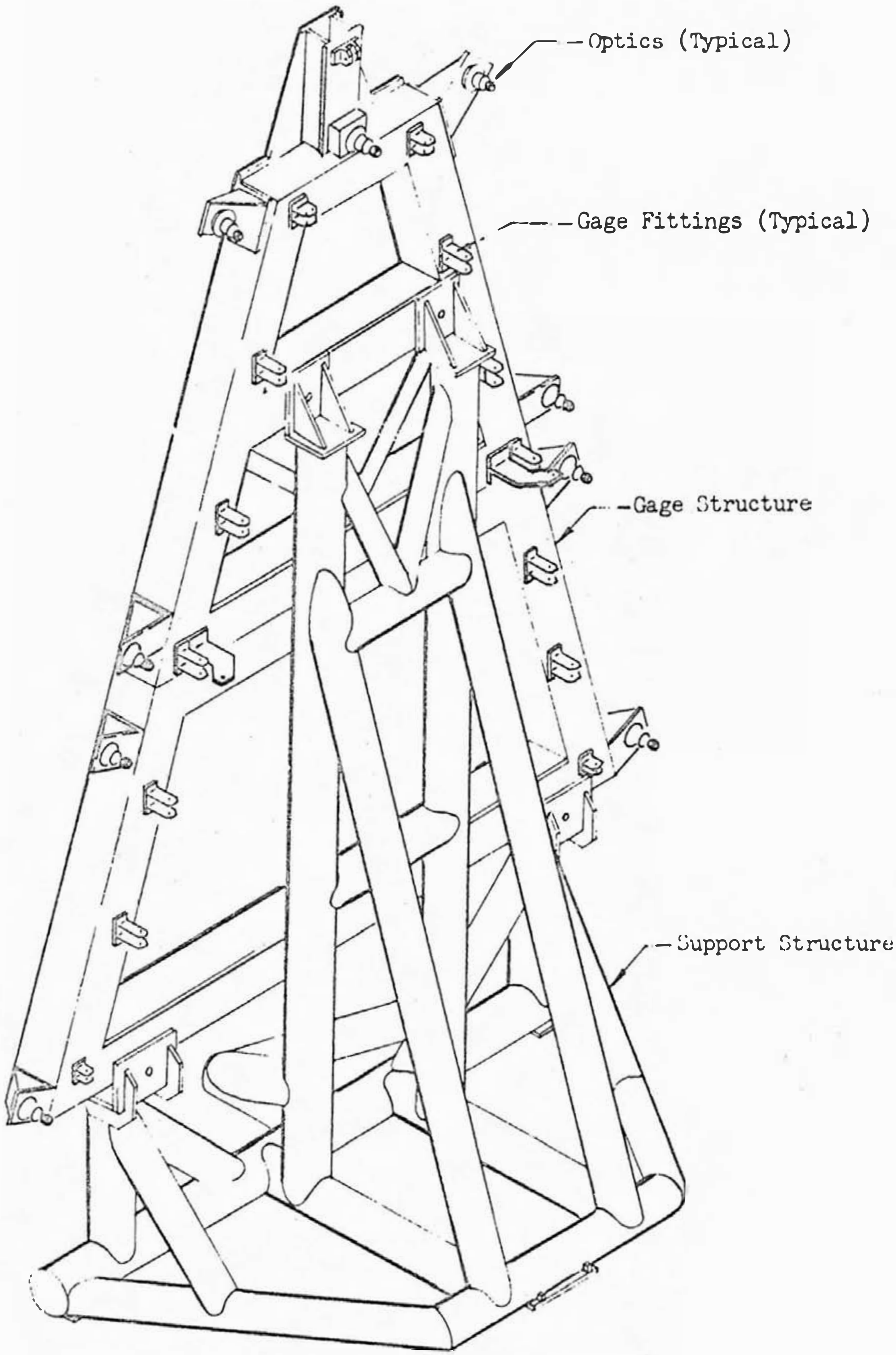


Figure 4a-22. Master Setting Gage MrSG-345-7114

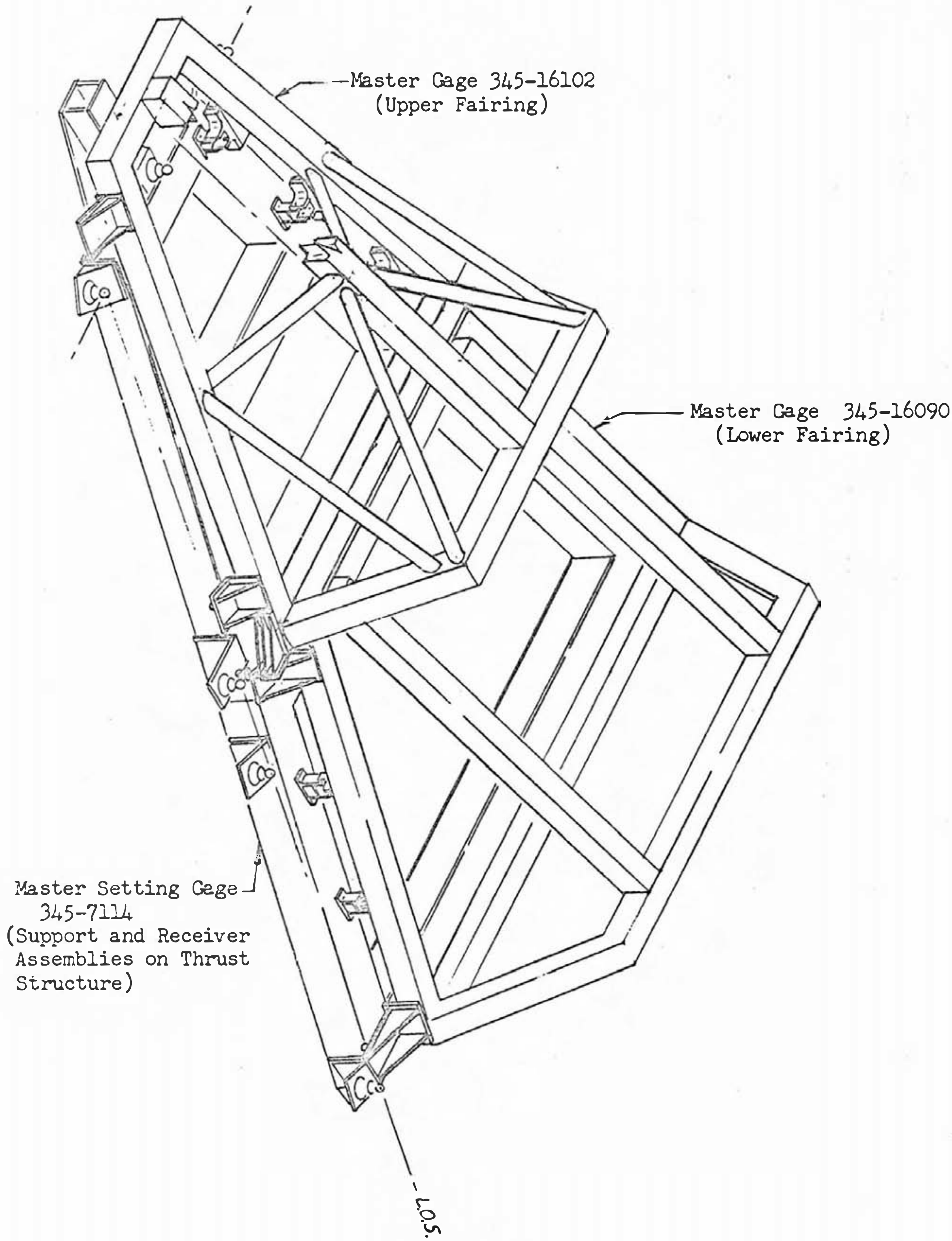


Figure 4a-23. Master Gages MrG-345-16090 and MrG-345-16102

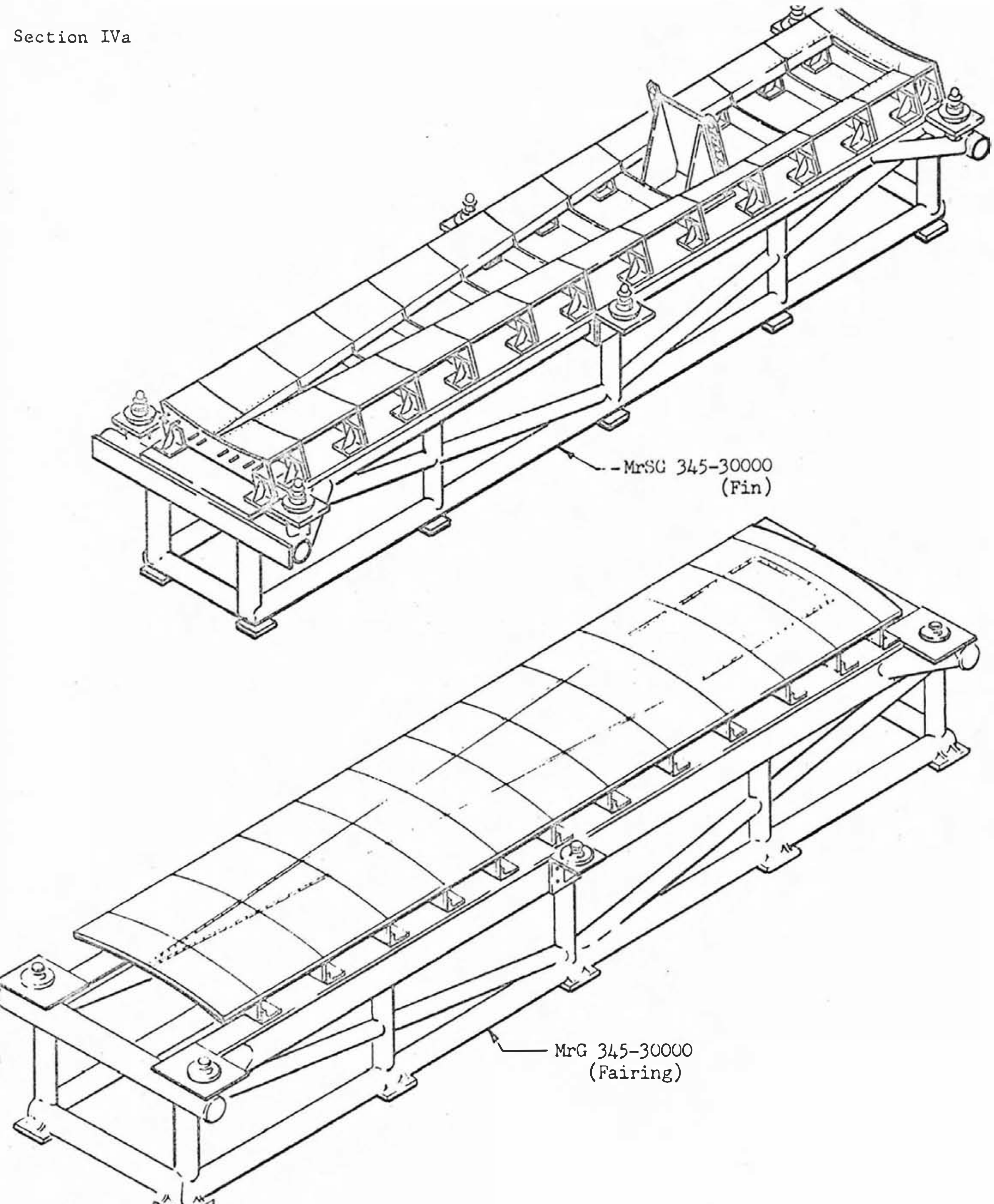


Figure 4a-24. Master Setting Gage MrSG-345-30000 and Master Gage MrG-345-30000

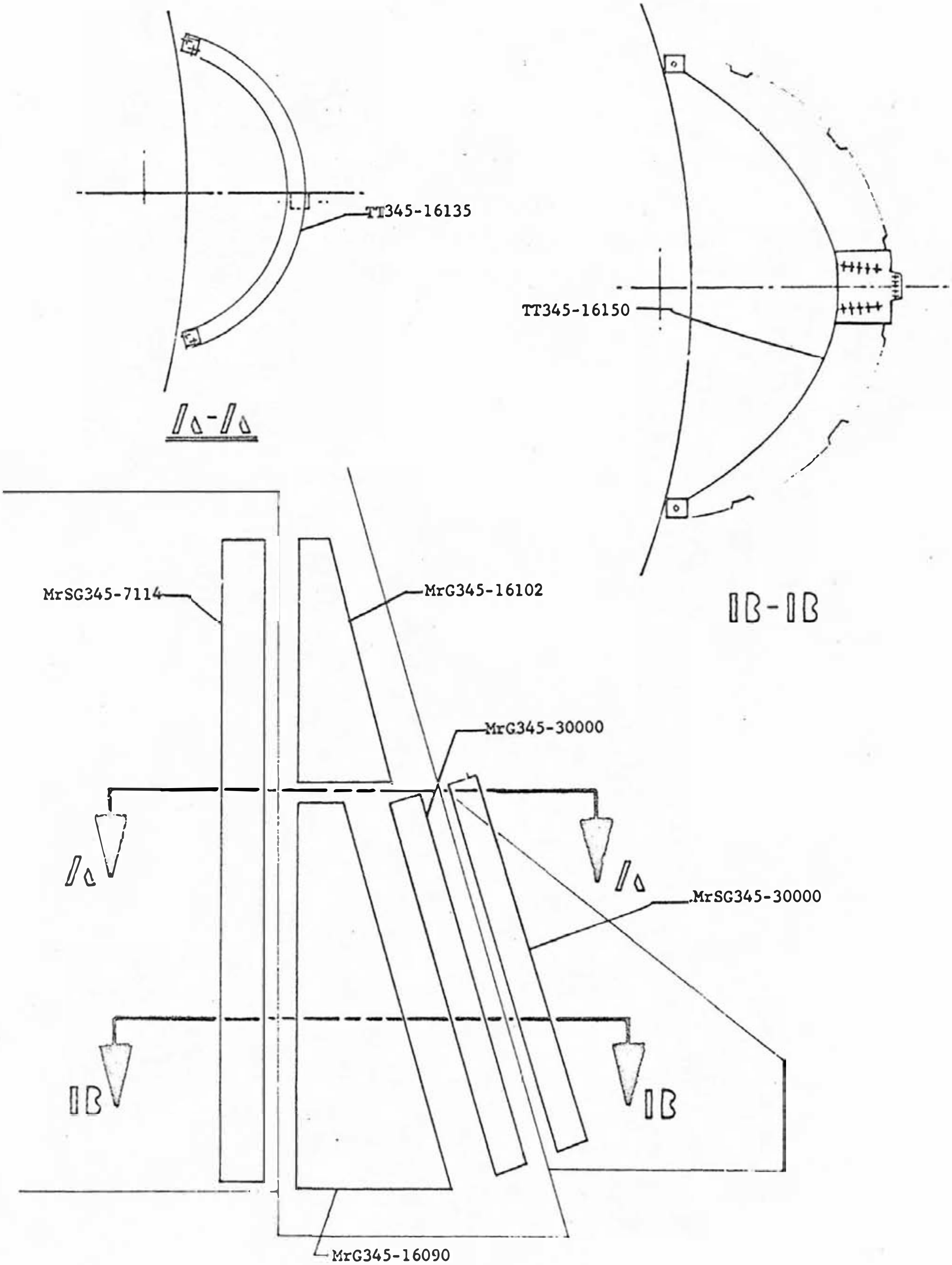


Figure 4a-25. Fin and Fairing Gages

3.7 TT-345-16135. (See figure 4a-25.) This tool represents the station 216.4 plane of the fairing assembly. The location of the pins which aline the upper fairing assembly to the lower fairing assembly are included and are coordinated to MrSG-345-7114. Contour is dimensionally controlled.

3.8 MrG-345-7109. (See figure 4a-26.) This tool is used to install the support assembly on the thrust structure assembly and is coordinated to MrSG-345-7114.

4. STAGE INSTALLATION.

4.1 Fin and Fairing Assembly.

4.1.1 Support Assembly. (See figures 4a-27, 4a-28, and 4a-29.) The support assembly consists of a series of machined fittings bolted to the thrust structure. Undersize holes are drilled in the fittings at locations common to the fairing assembly attach points. Master gage MrG-345-7109 is used to install the fittings on the thrust structure at the thrust structure assembly position. (See figure 4a-26.) Fittings are located and clamped in master gage MrG-345-7109 and indexed to the undersized holes common to the thrust structure. Master gage MrG-345-7109 is indexed to thrust structure assembly fixture AF-335-7027 for up and down movement and for rotational location and to the thrust structure for inboard-outboard location. A spirit level is used to establish a vertical axis for master gage MrG-345-7109. When master gage MrG-345-7109 has been properly indexed, the fitting is shimmed and fastener holes common to the thrust structure are drilled. Permanent fasteners are installed and torqued. Undersize holes common to the fairing assembly are reamed to final size from the fixture.

4.1.2 Receiver Assembly. (See figure 4a-30.) The receiver assembly is attached to the thrust structure at the junction of the thrust structure and Y-ring. The receiver assembly includes a pin which engages the hook on the upper fairing assembly. Installation of the receiver assembly is accomplished after the thrust structure has been joined to the fuel tank assembly. Locating drill jig LDF-322-7467 is used to install the receiver assembly. Locating drill jig LDF-322-7467, which indexes to three of the support assembly fittings previously installed on the thrust structure, is coordinated to master set gage MrSG-345-7114. After the receiver assembly is located and clamped in position, locating drill jig LDG-322-7467 is indexed and pinned to the support assembly. Shims are installed between the receiver assembly and the thrust structure. Fastener holes are drilled from locating drill jig LDF-322-7467, and fasteners are installed to complete the receiver assembly installation.

4.1.3 Fairing Assembly. The fairing assembly is supplied ready to bolt onto the vehicle. No metal cutting operations are required. Adequate scaffolding and hoisting tools HT-370-7116 and HT-370-7117 will be required for installation operations.

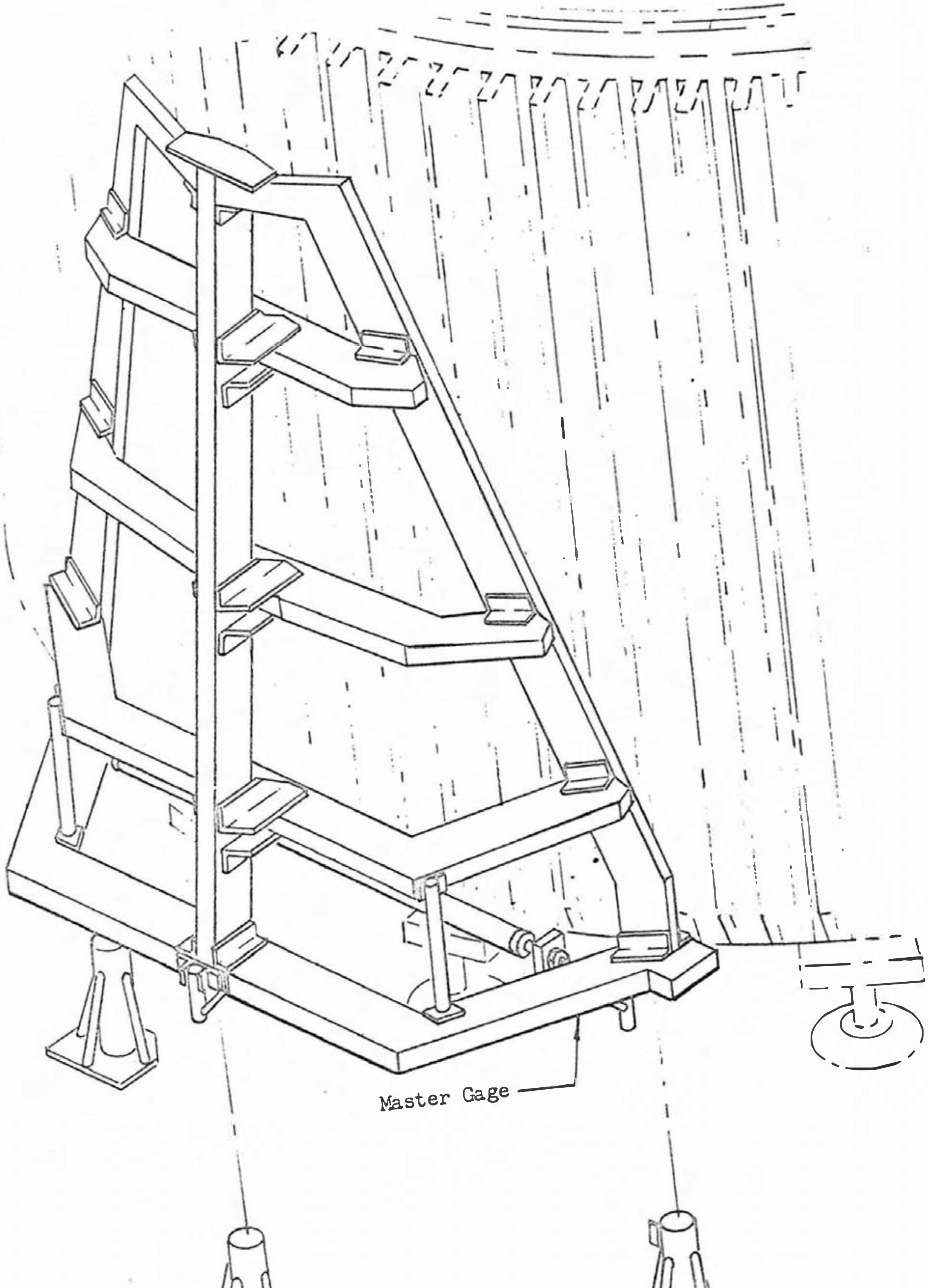


Figure 4a-26. Master Gage MrG-345-7109

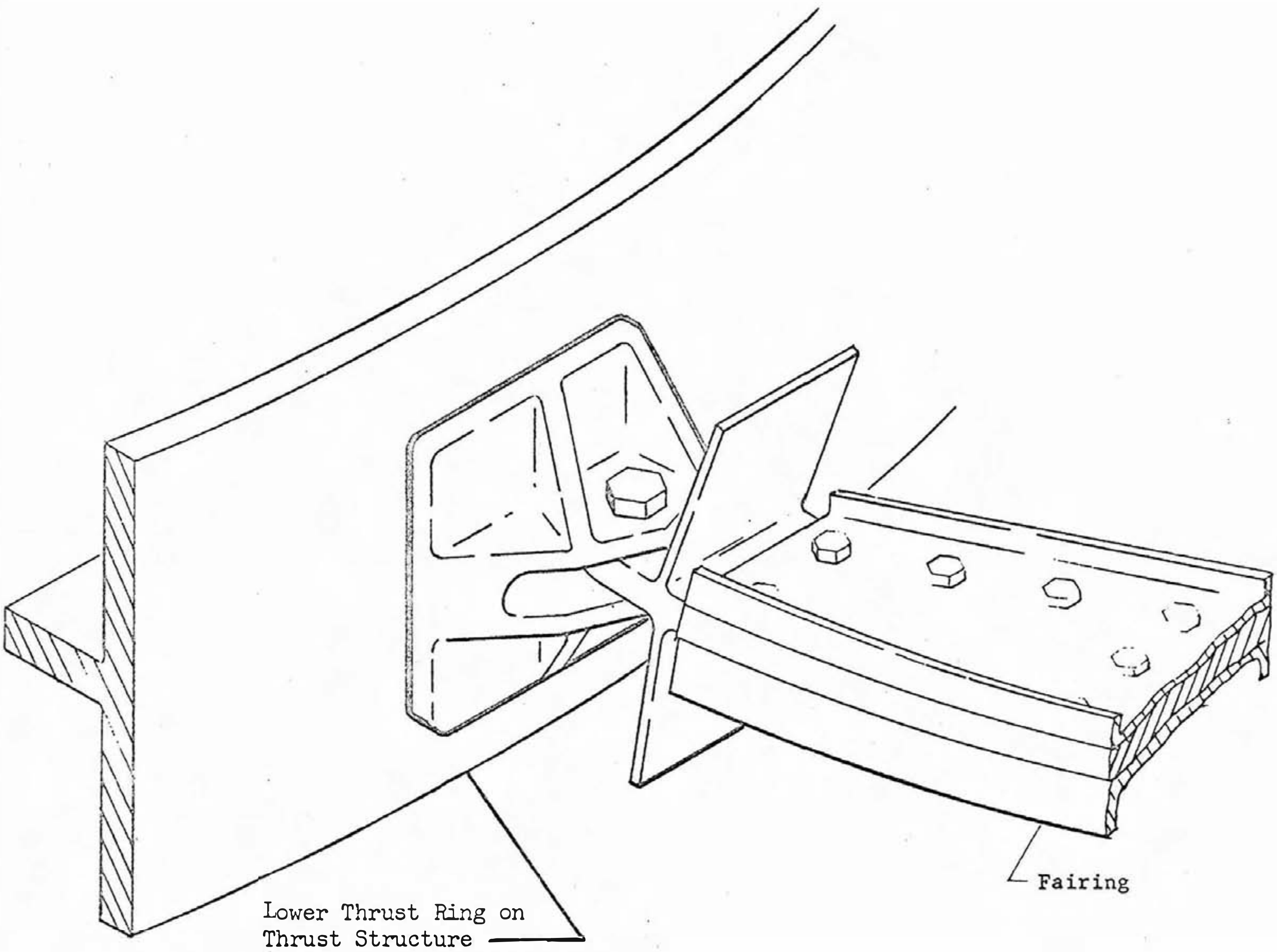


Figure 4a-27. Support Assembly at Station 115.5

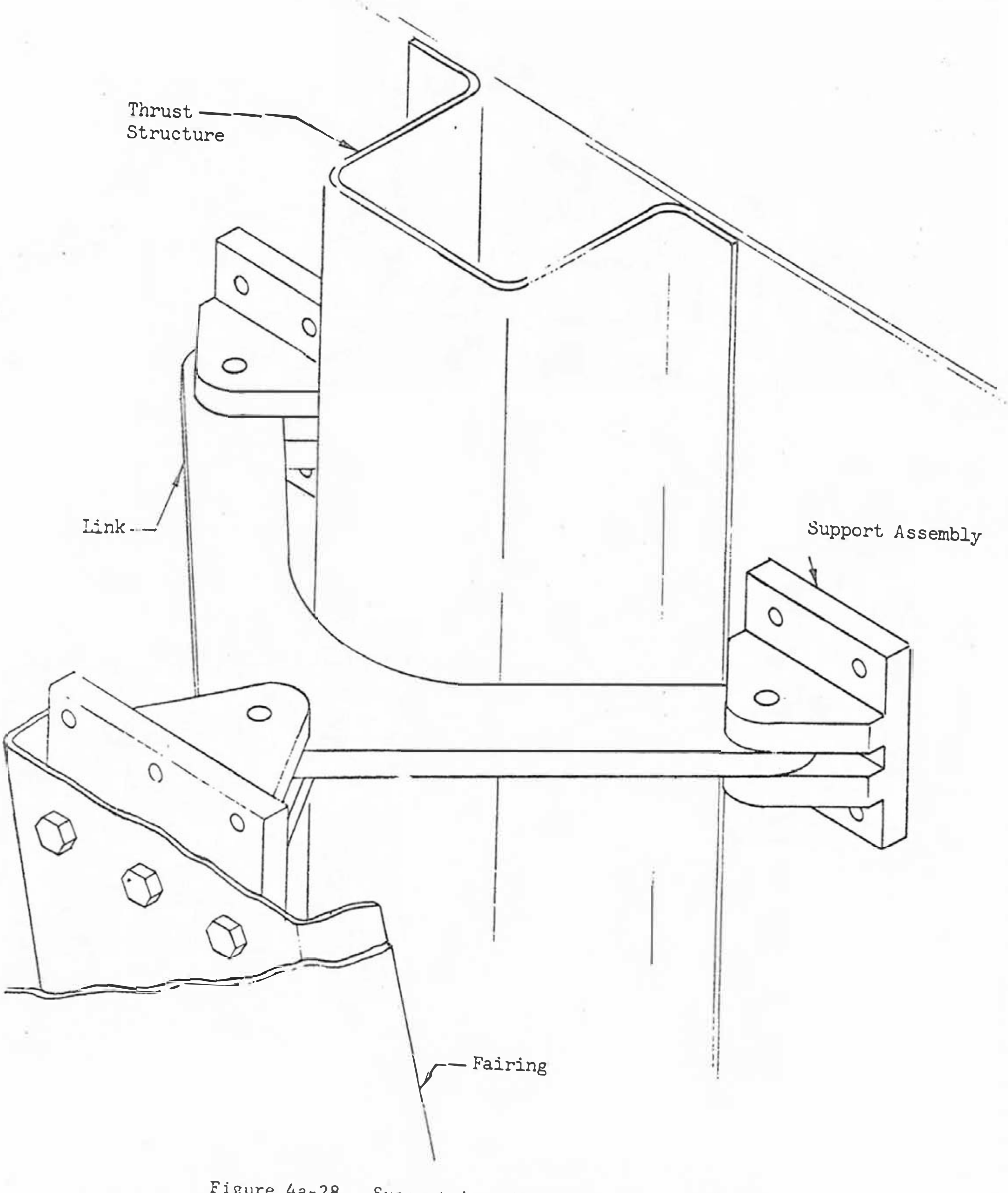


Figure 4a-28. Support Assembly and Link Attachment

Changed 16 December 1963

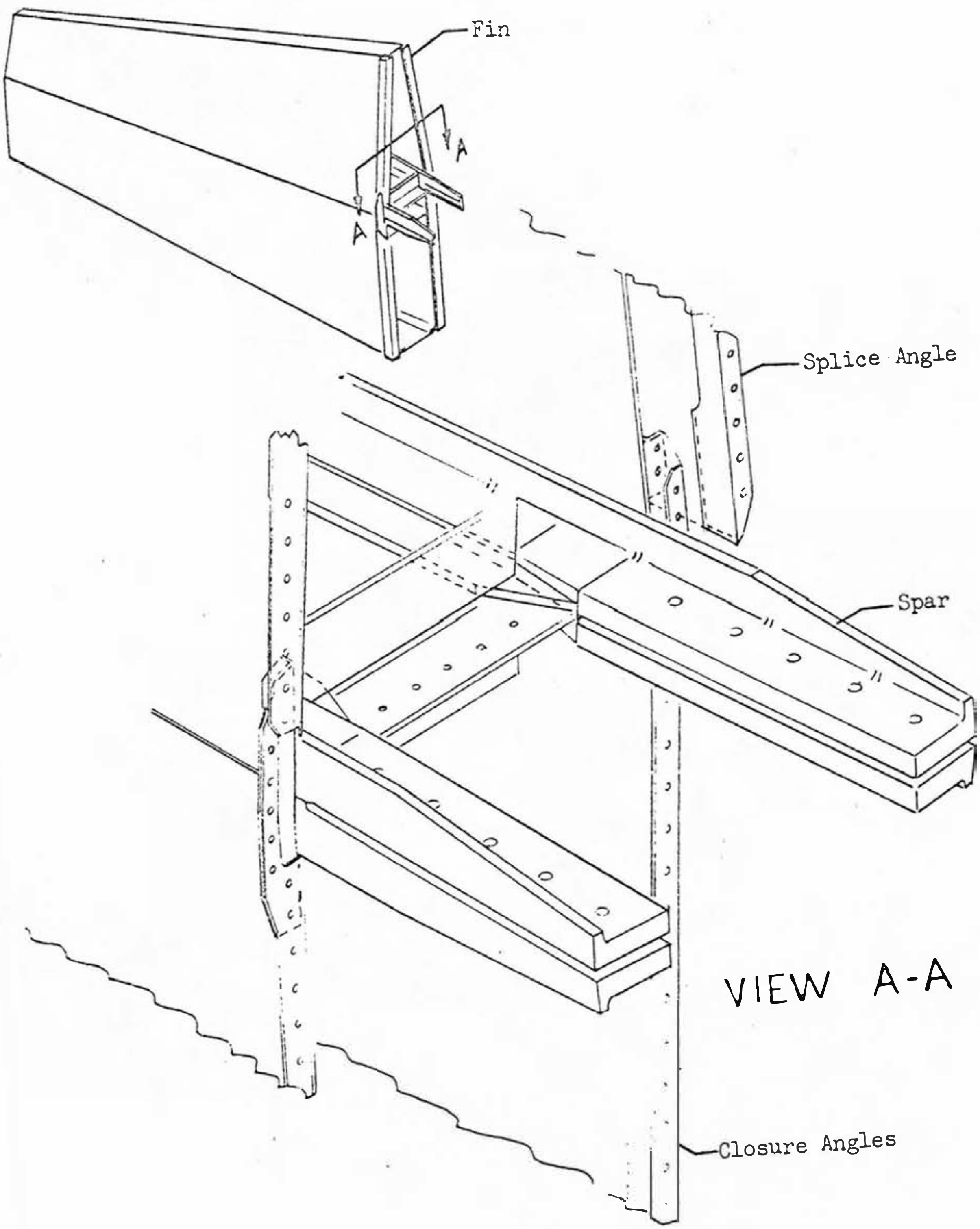


Figure 4a-29. Fin Spar and Closure Angles

Changed 16 December 1963

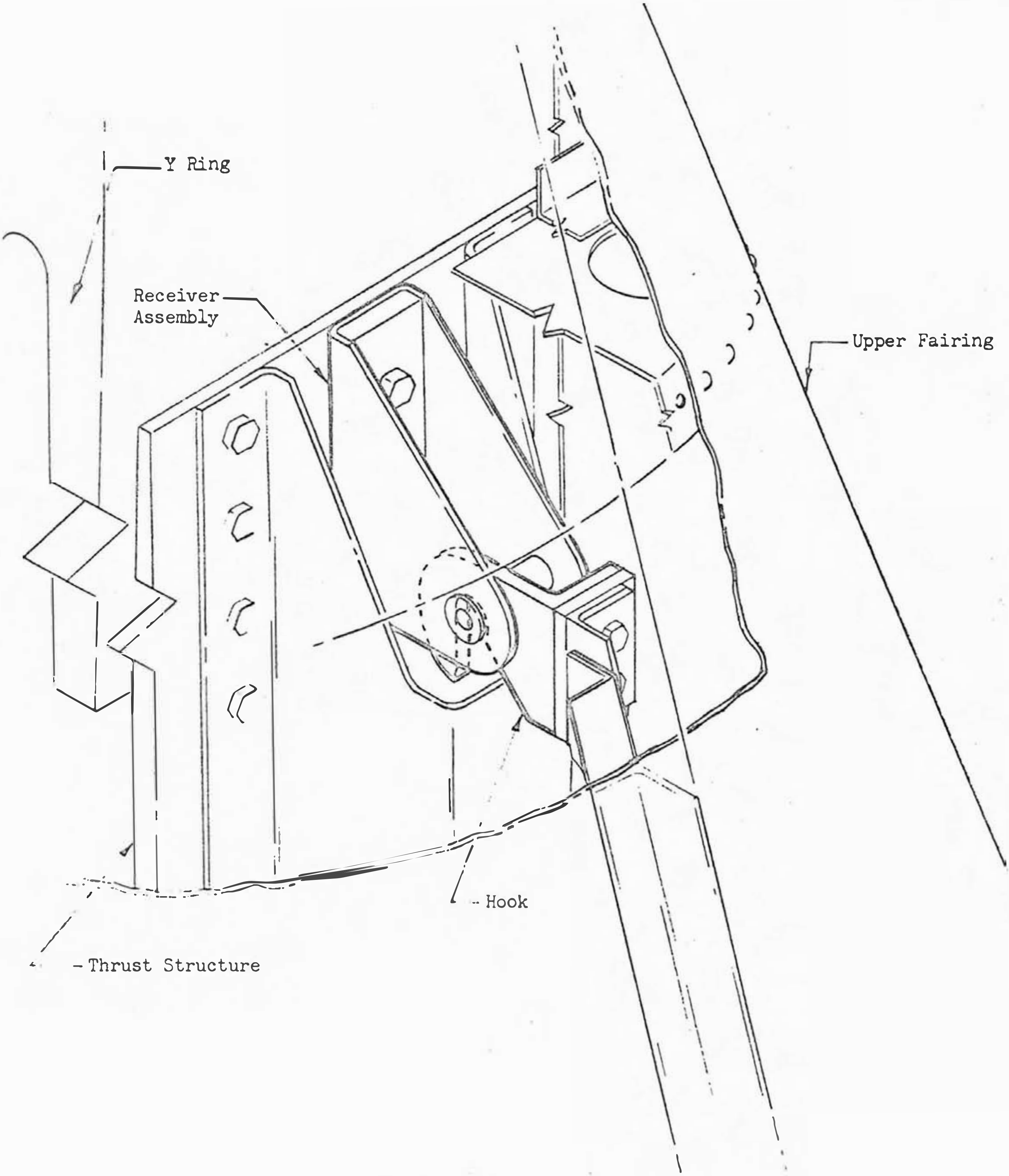


Figure 4a-30. Receiver Assembly

4.1.4 Fin Assembly. (See figure 4a-31.) The fin assembly is supplied ready for installation. No special tools, other than hoisting tool HT-370-7115 and adequate scaffolding, are required.

4.1.5 Seal Assembly. (See figure 4a-32.) The seal assembly consists of a series of sheet metal plates and rubber seals which bolt to the fairing assembly and close the gap between the fairing assembly and the thrust structure. Oversize and slotted bolt holes provide the means for adjustment.

4.2 Static Test Heatshield.

4.2.1 Support Structure.

4.2.1.1 Actuator Attachment Beam Assembly. The actuator attachment beam assembly attaches to the lower diagonal actuator at two locations. The beam assembly is located in approximate position from the underside of the actuator arm. Inboard end of the beam is clamped to the arm loosely. A detail slotted fitting is positioned in the cut-out in the outboard end of the beam assembly. The beam assembly and slotted fitting are then moved inboard along the arm until the hole in the slotted fitting alines with the previously drilled hole in the actuator apex fitting. A bolt is installed from the underside; the slotted fitting is rotated until the dowel drops into the alinement hole in the apex fitting. A 0.66-inch dimension is maintained on outboard fitting to beam and the inboard bottom face of the beam is faired with station 112 of the lower thrust ring. A 0.40-inch dimension is maintained at apex fitting; the bolt is tightened to secure the outer end of the beam assembly. The inboard beam assembly is equal shimmed to the channel fittings that are part of the retro-rocket actuator fittings. The beam-to-channel fittings attach holes are drilled from proper pilots. The detail beam cap plate is positioned and secured. Attach holes are then drilled from pilot holes. The preceding operations are repeated for the opposite installation.

4.2.1.2 Inboard Main Beam Assembly. (See figure 4a-33.) Each end of the inboard main beam assembly is attached to the actuator attachment beam assembly. Position the inboard main beam assembly and two pilot-drilled detail clips. Center the inboard main beam assembly between actuator beams, and clamp the clips on actuator attach beam. Drill attachment holes from pilot-drilled detail clips.

4.2.1.3 Inboard Center Beam Assembly. (See figure 4a-34.) The inboard center beam assembly is installed between the inboard main beam assembly and the thrust structure. Locate the inboard center beam assembly using an angle clip on the thrust structure and the pilot-drilled tee clip on the main beam assembly. The inboard center beam assembly is positioned to the clips on each end and faired with station 112 on the inboard end prior to clamping. One additional clip is installed at the main

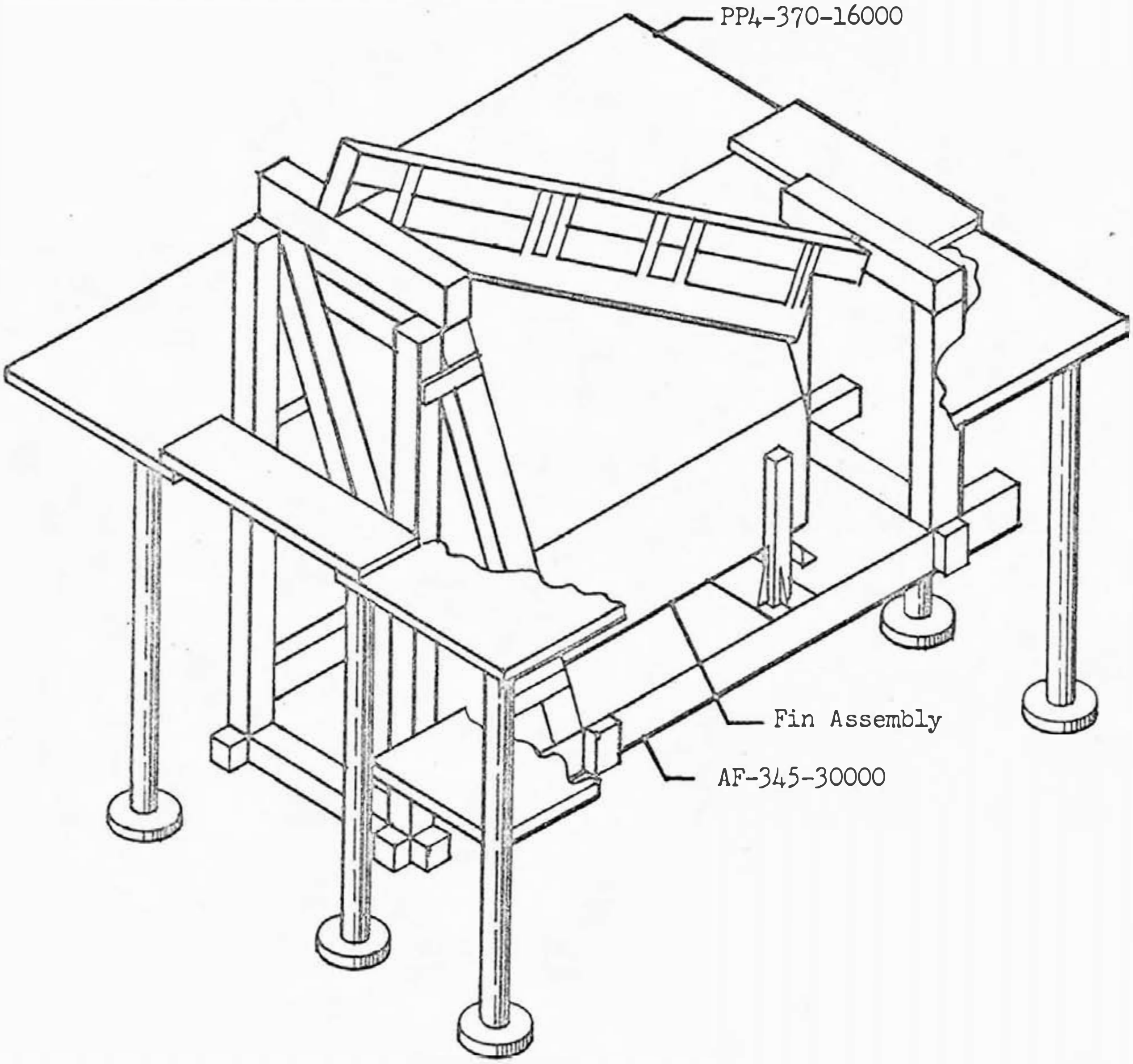


Figure 4a-31. Assembly Fixture for Fin Assembly

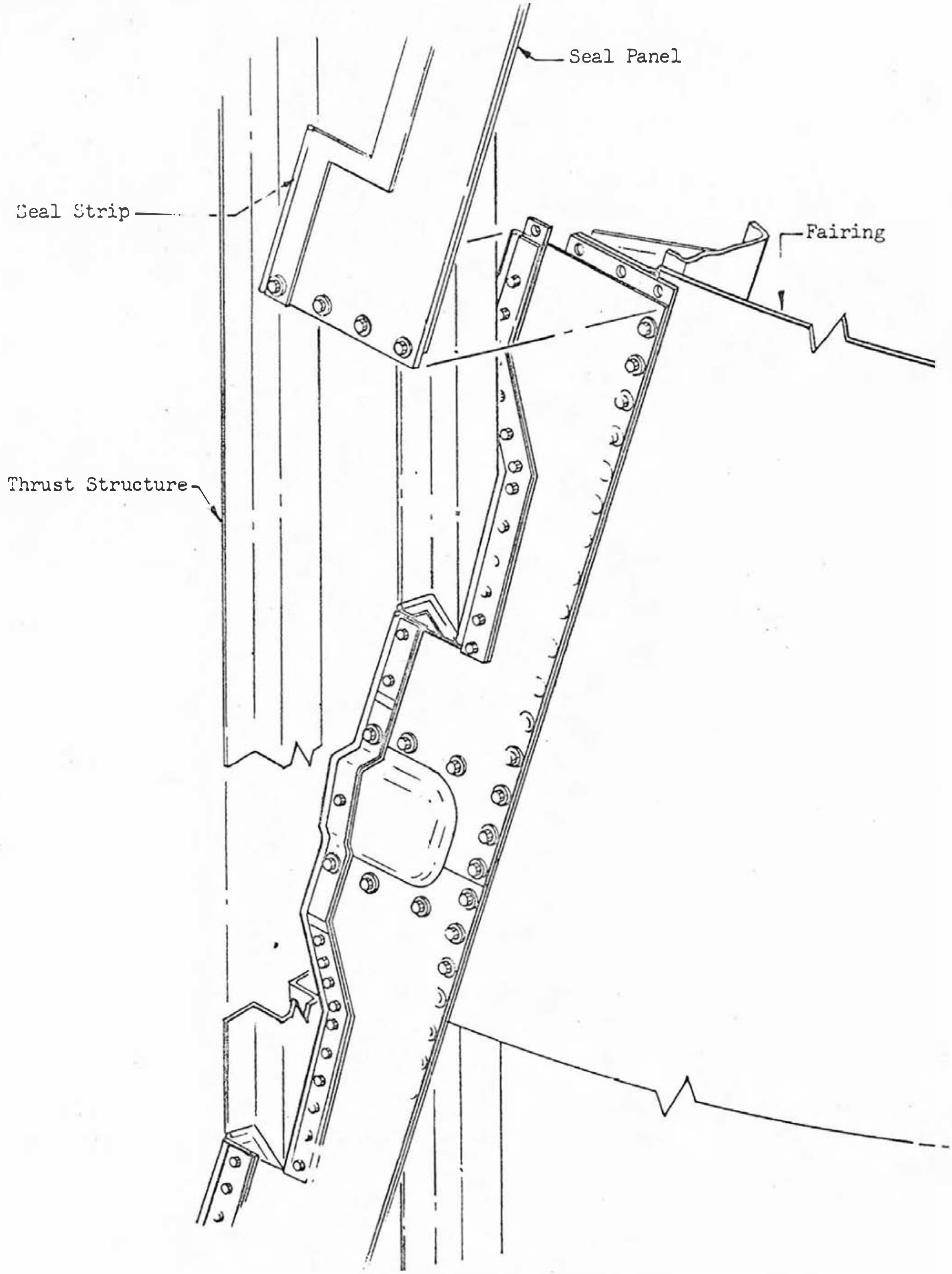


Figure 4a-32. Seal Assembly

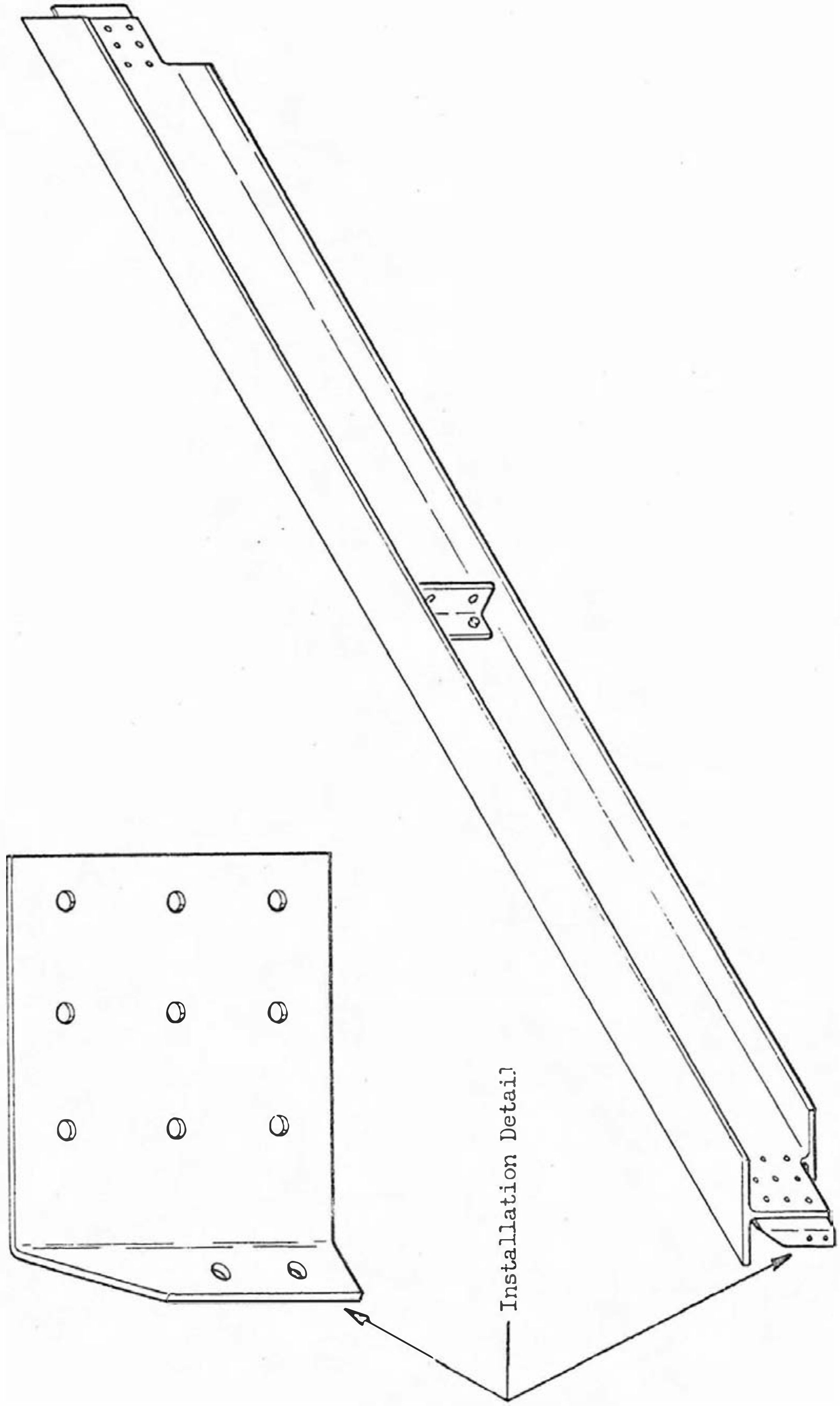


Figure 4a-33. Inboard Main Beam Assembly

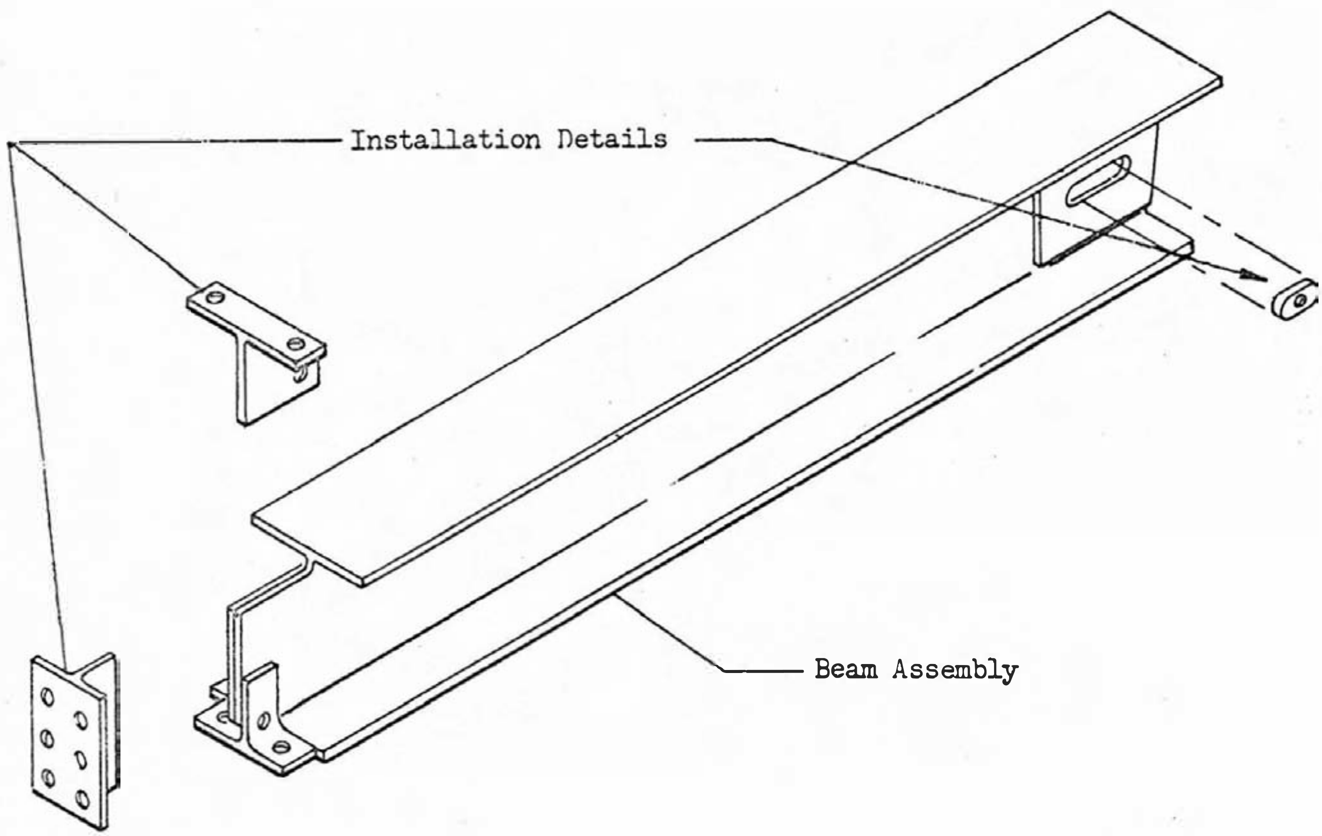


Figure 4a-34. Inboard Center Beam Assembly

4.2.1.3 (Con.)

beam assembly to complete the installation. Pilot holes are used when drilling all fastener holes. Install spacer in slot in beam assembly at inboard attachment point and maintain a 0.500-inch dimension. Drill through spacer to clips and install fastener.

4.2.1.4 Inboard Side Beam Assembly. (See figure 4a-35.) The inboard beam is installed between the actuator beam (at actuator apex location) and the thrust structure. Clips at each end of the inboard side beam assembly are used for locating the beam assembly. Pilot holes are provided to locate fastener holes. Installation of the inboard side beam assembly is similar to that of the inboard center beam assembly.

4.2.2 Static Test Panels. (See figure 4a-36.) The attach hole pattern is drilled using the same locating drill template that is used for the inner flight panels. Outboard clips on the thrust structure are drilled from punch-marked transfers off the two outboard panels. The clips are replaced at AMR prior to installing the flight panel at this location. The panels are placed in position, and the fasteners are installed.

5. ENGINE FAIRING HEATSHIELD ASSEMBLY.

5.1 Flight Heatshield. (See figure 4a-37.) The fairing heatshield is a protective barrier composed of eight heat-resistant panels constructed of stainless steel honeycomb covered with M-31 insulation fastened to an aluminum support structure. The lower surface of the support structure is attached to the stage at station 112.0 and slopes downward 7 degrees and 14 minutes from plane E of the stage. (See figure 4a-38.) The four inner panels and support beams are independent of the four outer panels and support structure. Inner support beams are fastened to the actuator support structure and the thrust structure; the outer support beams fasten to the engine fairing and thrust structure. The controlled gap between the sets of panels is filled with a seal at installation of panels. Two of the inner panels are removable for access into the fairing assembly.

5.1.1 Flight Panel Support Structure. (See figures 4a-39 and 4a-40.)

5.1.1.1 Inner Beam Structure. Assembly of the inner beam structure is the same as for the static test configuration. Refer to paragraph 5.2.1.

5.1.1.2 Outer Beam Structure. The outer beam structure consists of built-up beams, three angular chords, clips, fittings, and fasteners. No assembly tools are required to fabricate the beam assemblies. Hand layout and drilling are employed during fabrication.

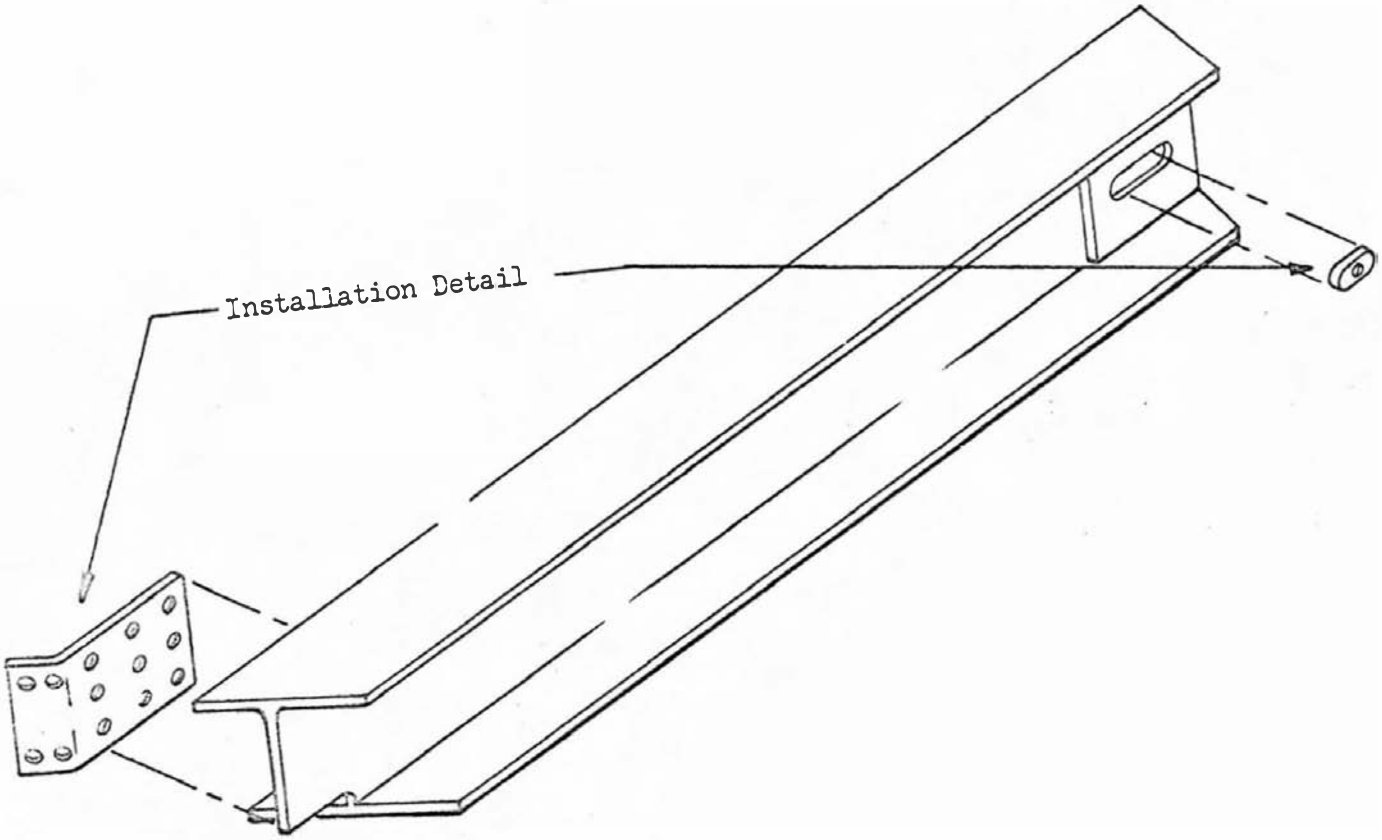


Figure 4a-35. Inboard Side Beam Assembly

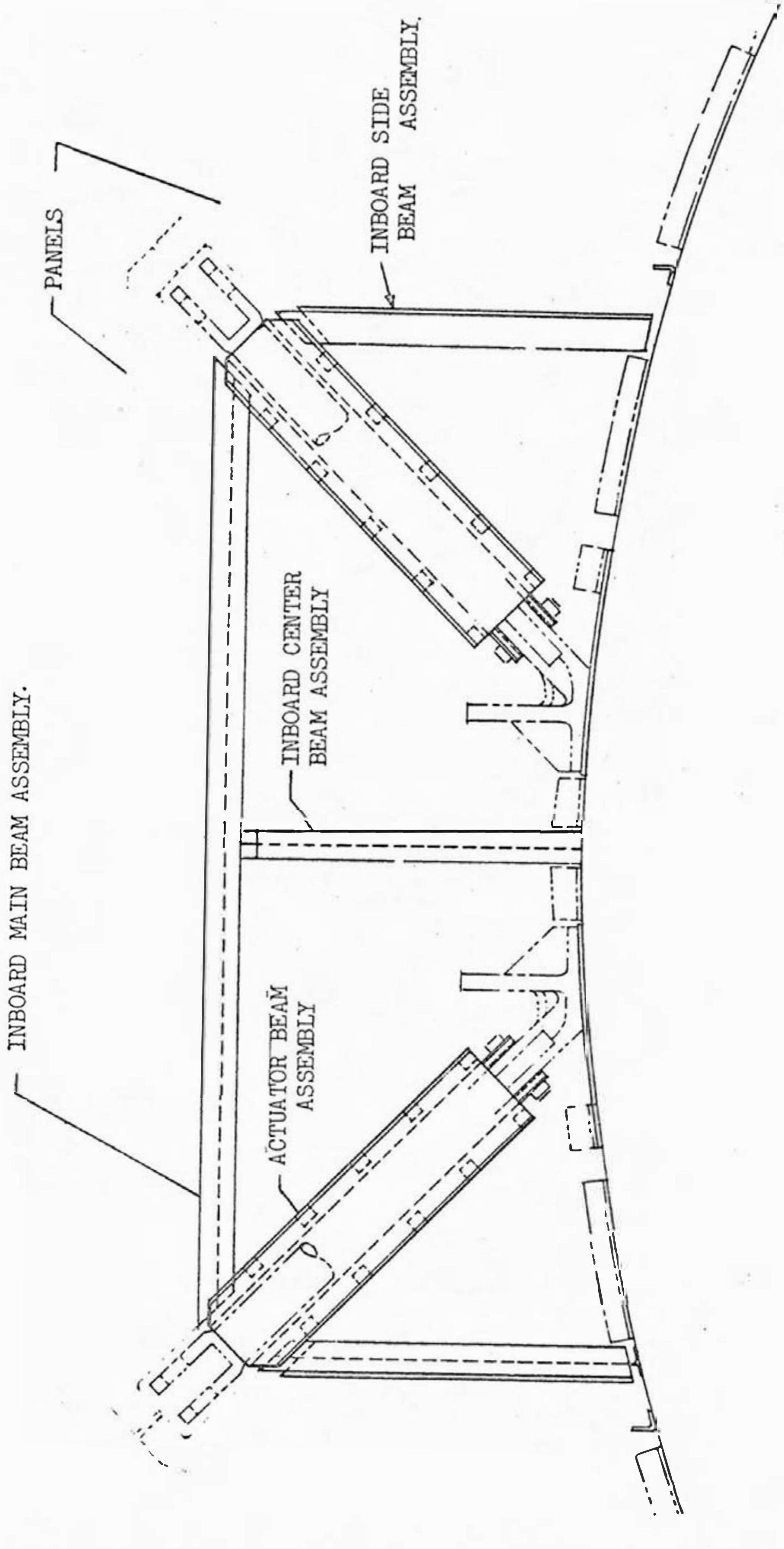


Figure 4a-36. Static Test Support Structure and Panel Installation

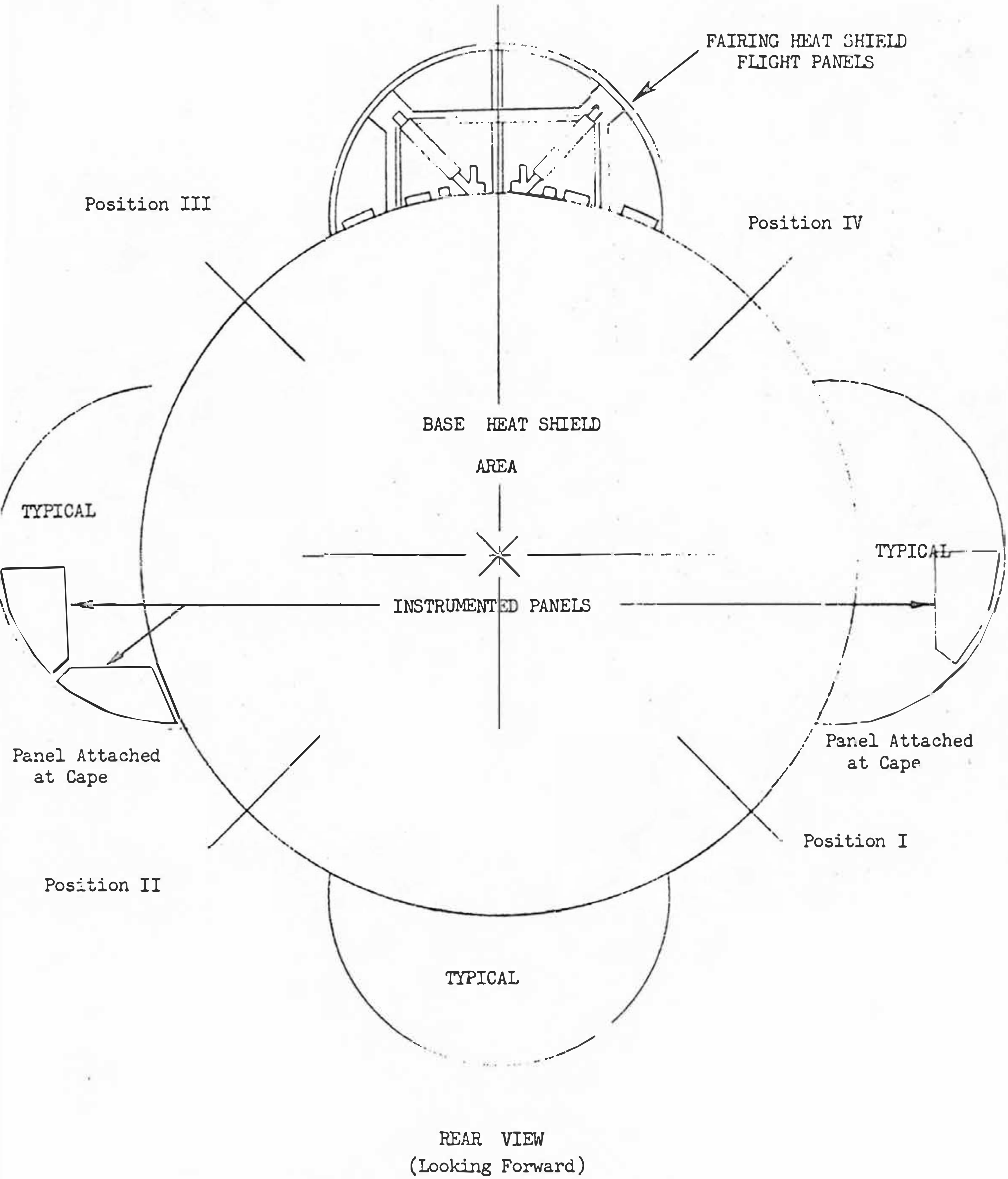


Figure 4a-37. Engine Fairing Heatshield Assembly

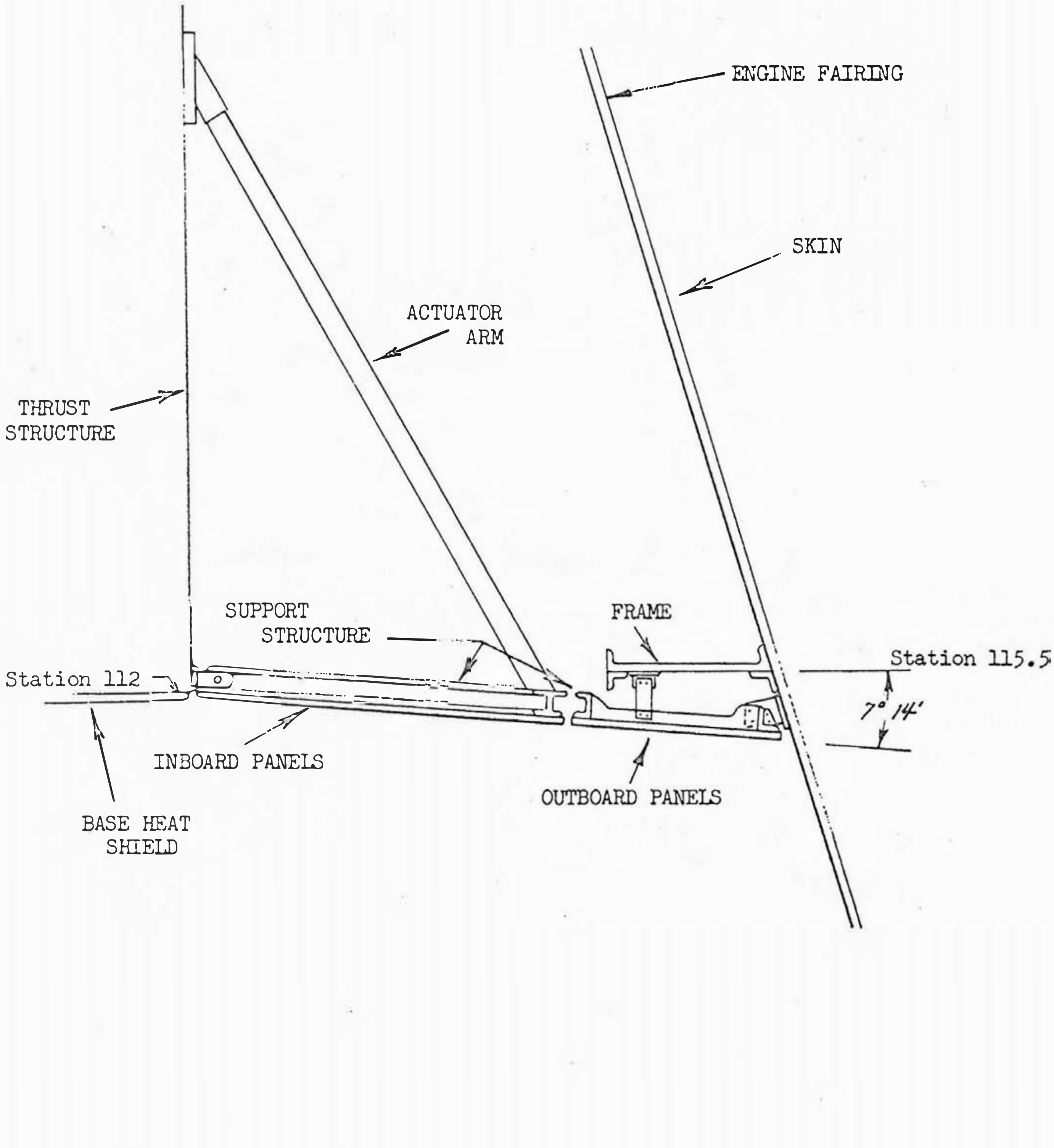


Figure 4a-38. Engine Fairing Heatshield Assembly - Cross-Section View

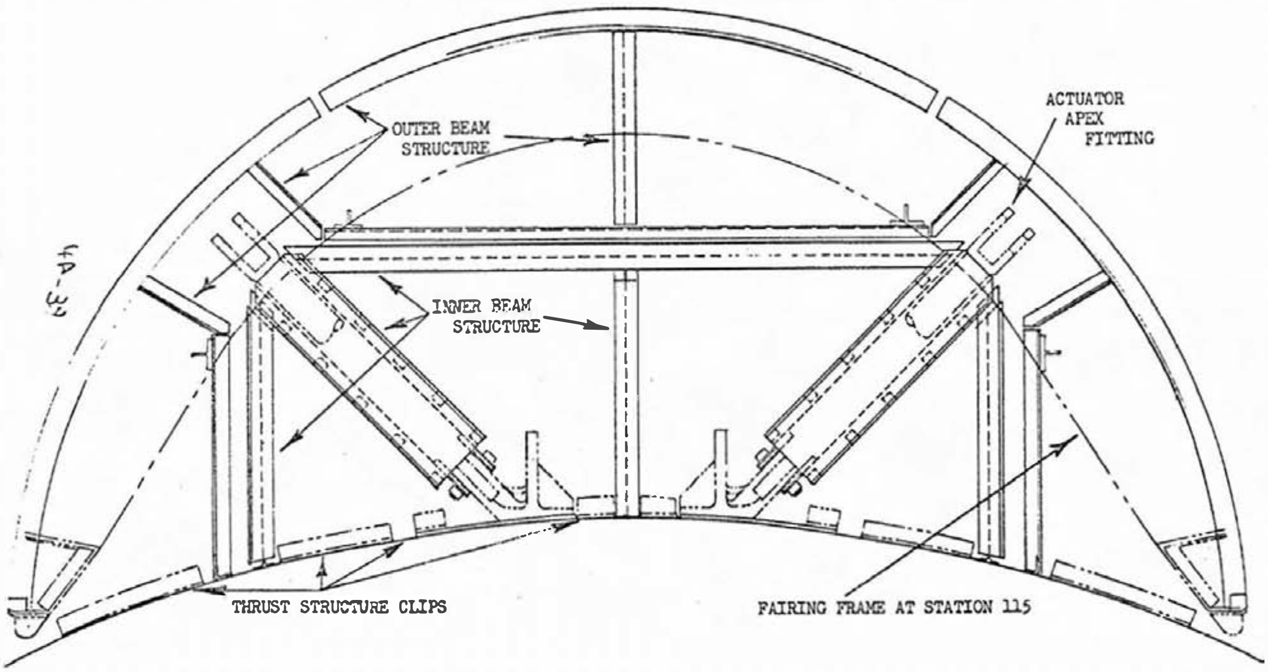


Figure 4a-39. Engine Fairing Heatshield Flight Panel Support Structure

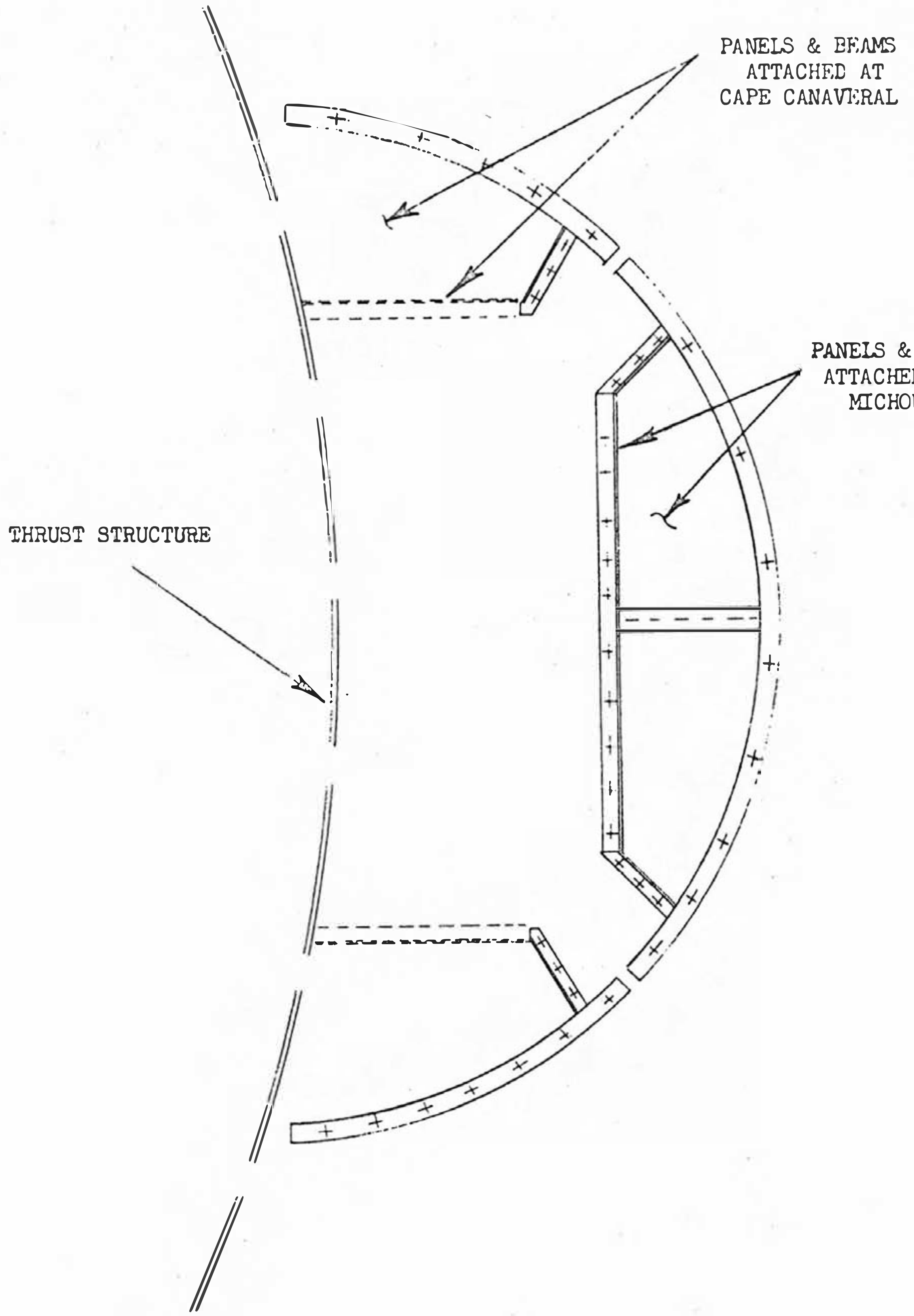


Figure 4a-40. Engine Fairing Heatshield Flight Panel Outer Support Structure

5.1.2 Flight Panels. (See figure 4a-41.) Each flight panel consists of a stainless steel honeycomb core covered on the inside with a thin sheet of stainless steel. The outer surface is a layer of bonded M-31 insulation. Steel cups are bonded in the panels at the attachment locations. Flight panels are procured items ready for installation. To ensure interchangeability, attachment hole patterns are coordinated to the master plates provided by the customer.

5.2 Static Test Heatshield. (See figure 4a-42.) The static test heatshield is a protective barrier consisting of four panels and a support structure. Support structure beams attach to the actuator arms and clips on the thrust structure. The support structure for the static test heatshield is identical to the support structure for the flight heatshield; static test heatshield panels are larger than the flight heatshield panels. (See figure 4a-37.) When static test heatshield panels are used, the fairing assemblies are not installed.

5.2.1 Static Test Support Structure.

5.2.1.1 Actuator Attachment Beam. (See figure 4a-43.) The actuator attachment beam assembly consists of two formed channels, a lower cap, gussets, shims, terminal fittings, and clips of aluminum alloy. The assembly weighs 19 pounds. Detail parts are located and clamped into assembly fixture AF-342-21067 for drilling holes and installing fasteners. Drill plates are provided for areas where pilot holes cannot be utilized. Left-hand and right-hand assemblies are fabricated in the same tool.

5.2.1.2 Inboard Center Beam Assembly. (See figure 4a-34.) The inboard center beam assembly consists of an aluminum I-beam, three doublers, and an aluminum tee clip. No special tools are required for assembly. Hand layout for dimensions and hole locations is employed in fabricating the inboard center beam assembly.

5.2.1.3 Inboard Side Beam Assembly. (See figure 4a-35.) The inboard side beam assembly consists of a modified aluminum I-beam and two doublers. No special tool is required for assembly. Hand layout and drilling is employed to locate and install the two doublers on the inboard side beam assembly. A left-hand and a right-hand assembly is required.

5.2.1.4 Inboard Main Beam Assembly. (See figure 4a-33.) The inboard main beam assembly consists of an aluminum I-beam and an aluminum tee clip. No special tooling is required for assembly. Hand layout and drilling is employed during fabrication.

5.2.2 Static Test Panels. (See figure 4a-44.) Static test panels consist of 1/4-inch thick steel plate with expanded wire mesh and M-31 insulation attached to the lower surface. The four static test panels are coordinated to the master plates that control the hole pattern of the flight panels.

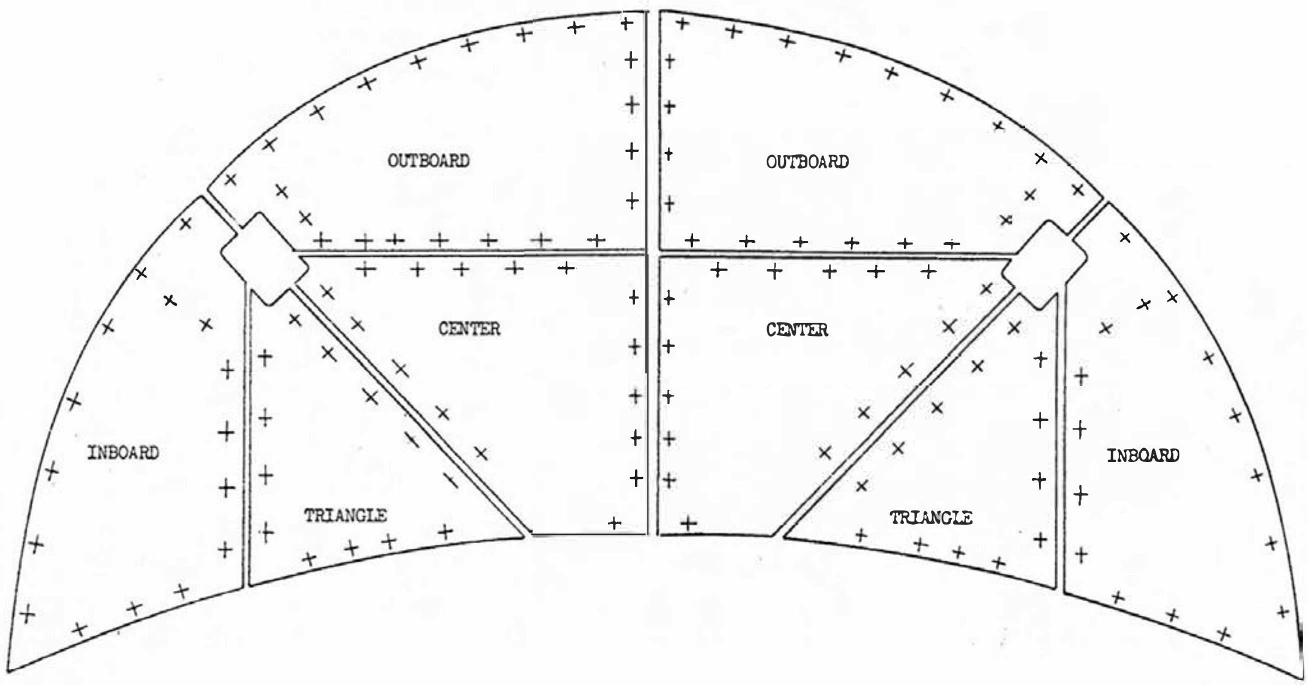
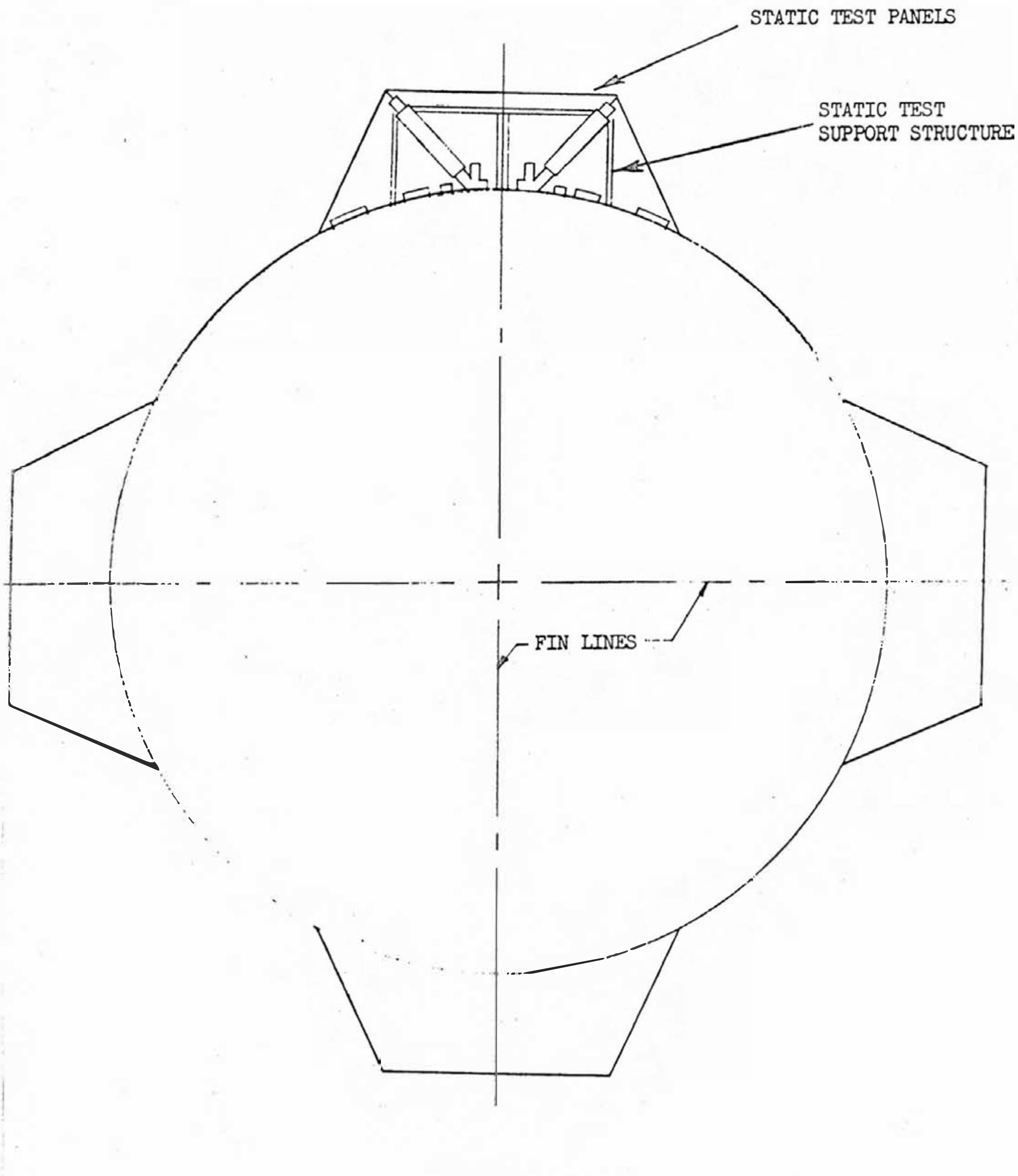


Figure 4a-41. Engine Fairing Heatshield Flight Panels



REAR VIEW
Looking Forward

Figure 4a-42. Static Test Engine Fairing Heatshield

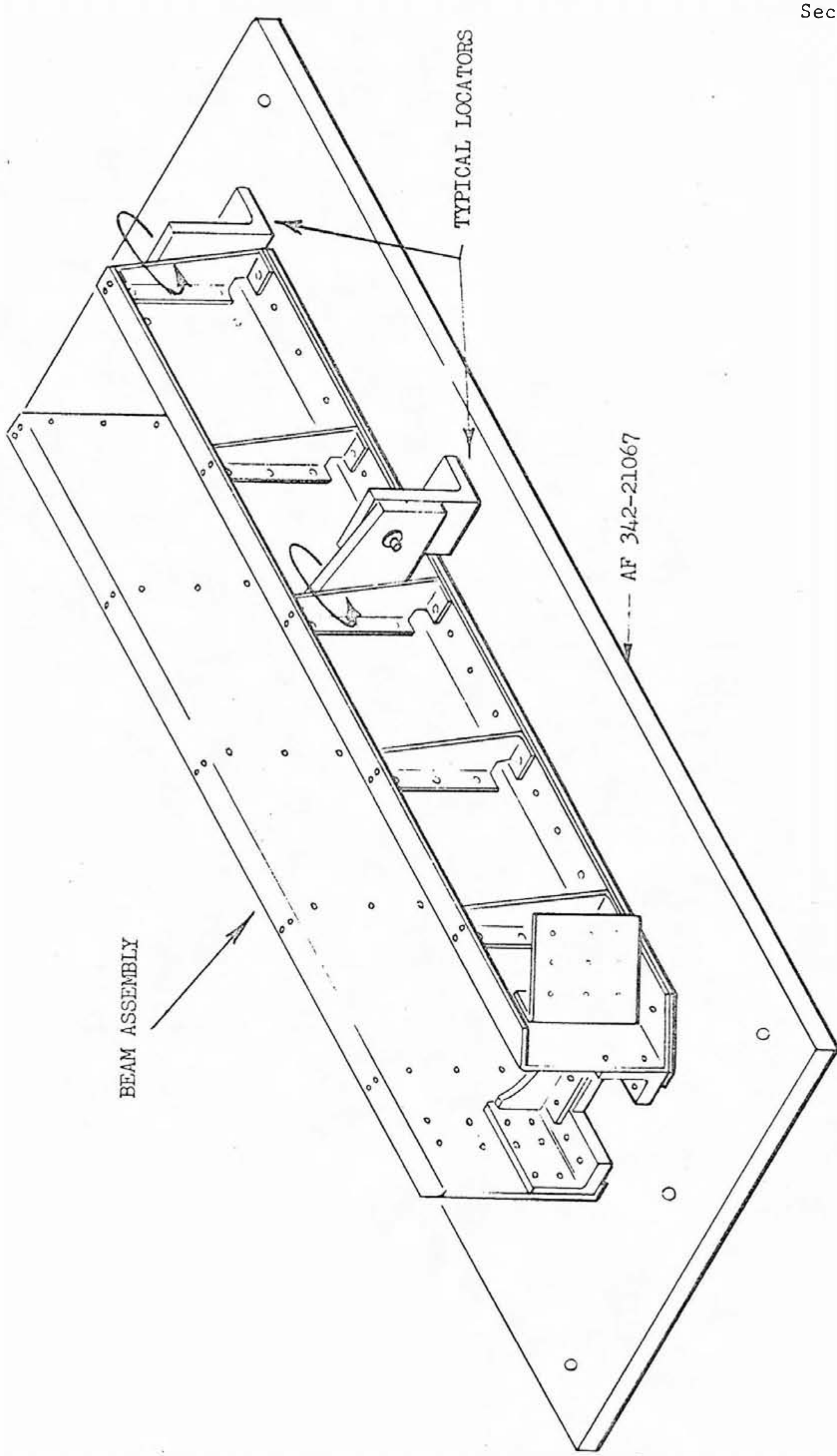


Figure 4a-43. Actuator Attachment Beam Assembly

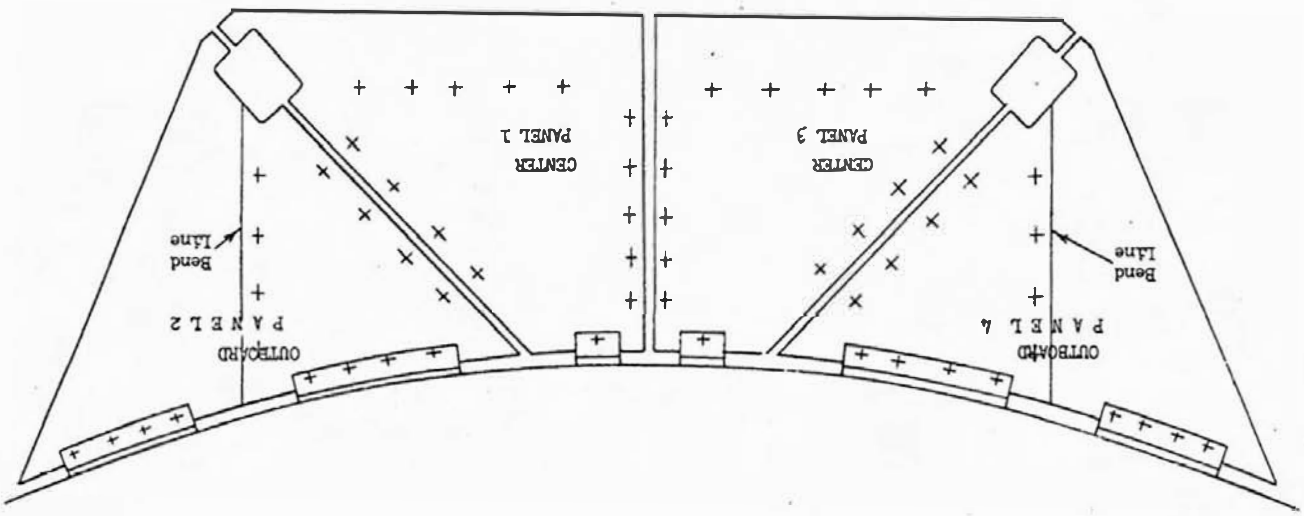


Figure 4a-44. Static Test Heatshield Panels

5.3 Fairing Assembly Heatshield Master Tooling.

5.3.1 Master Checking Gages. (See figure 4a-45.) The following master check gages are required to ensure interchangeability of heatshield panels. Peripheral contour and hole pattern of the flight panels are checked by the master check gages. Each master check gage checks both the left-hand and right-hand panel assembly.

MrCkG-342-21006
MrCkG-342-21007
MrCkG-342-21008
MrCkG-342-21009

5.3.2 Master Plates. (See figure 4a-45.) Four master plates are used to control the peripheral contour and hole pattern of the flight panels. The master plates are used by the vendor and the customer to coordinate drilling tools. Master plates are coordinated to the master check gages of the same number.

MrP-342-21006
MrP-342-21007
MrP-342-21008
MrP-342-21009

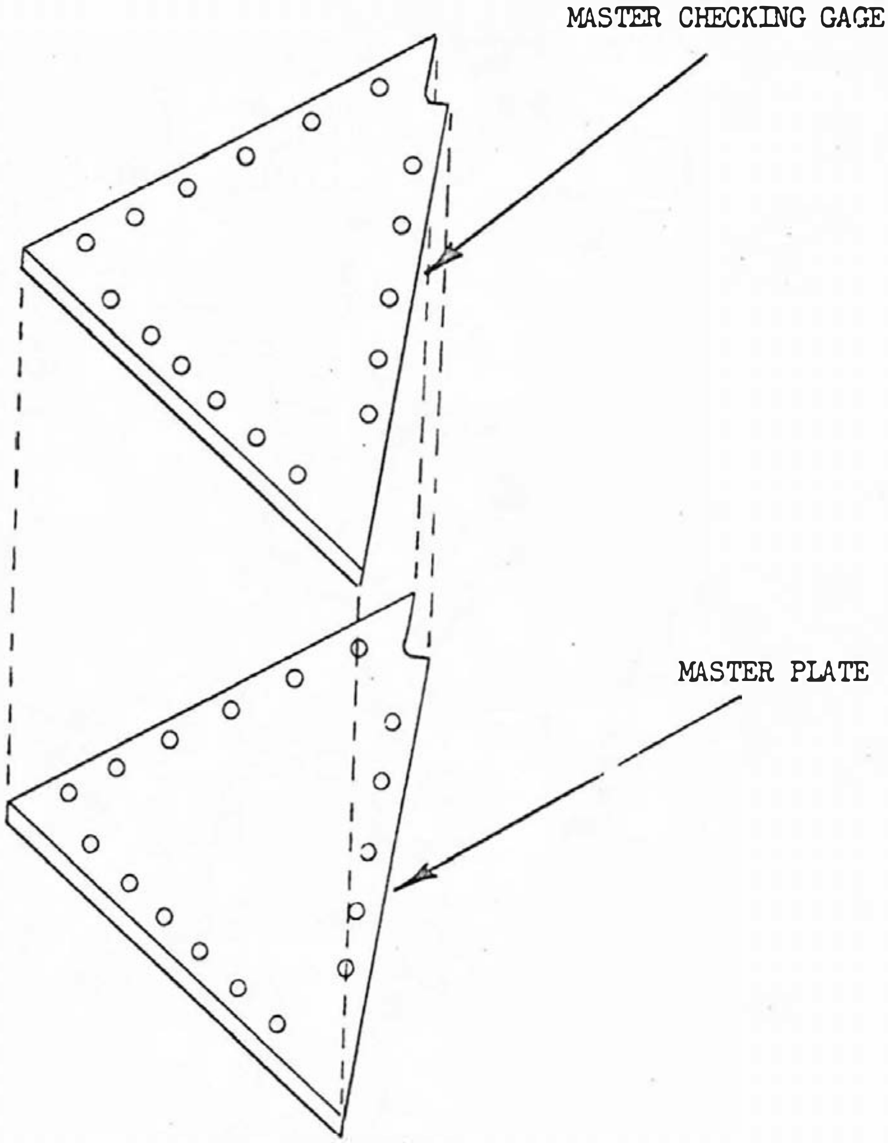


Figure 4a-45. Typical Heatshield Master Checking Gage and Master Plate

SECTION IV b

BASE HEATSHIELD

SECTION IVb
BASE HEATSHIELD

1. GENERAL DESCRIPTION.

The base heatshield consists of 50 one-inch thick stainless steel honeycomb core panels mounted on a grid support structure. (See figures 4b-1 and 4b-2.) In conjunction with the engine curtain, the base heatshield completely seals off the diameter of the vehicle at station 112.0 to protect the vehicle structure above station 112.0 from the intense heat generated by the five F-1 engines. Each panel has approximately 28 cup-type attachments bonded to the honeycomb core for attachment points. A 0.125-inch thick open face stainless steel face sheet is brazed to the aft side of the one-inch stainless steel panels to provide a holding base for the M-31 asbestos plaster coating. The M-31 plaster is troweled over the open face honeycomb to form a uniform 0.175-inch coating, allowed to dry, and then a sealant is applied. Prime function of the M-31 plaster is disipation of the initial heat from the firing of the engines. (See figure 4b-3.) The substructure for supporting the panels inside of the lower thrust ring is a grid structure consisting of 7075-T6 aluminum alloy extruded channels, I-beams, and clip angles (attached to the inboard face of the inner caps of lower thrust ring assembly 60B18700). The main portion of the grid structure consists of nine I-beams which are attached at eight places to the inner cap of the lower thrust ring by two clip angles at each location. I-beams are slotted at clip angle attachments to allow for thermal expansion and deflection at ignition and while in flight. The grid structure is also attached to the lower caps of the center engine support assembly 60B18900. In the areas of engine cutouts, the heatshield support structure also serves as attach areas for the engine curtain. The forward surfaces of the base heatshield panels are located on station 112.0. Heatshield panels directly below the thrust ring proper are supported by angles attached to the thrust ring caps. Several panels have openings through which service lines are run. One panel in each quadrant is removable for access.

2. ASSEMBLY.

2.1 <u>Assembly of Base Heatshield Structure 60B20100-1-900 at Michoud.</u> (See figures 4b-4 and 4b-5.)

2.1.1 Locate lower thrust ring assembly 60B18700 in assembly fixture AF-342-20100.

2.1.2 Position radial tee beams under lower thrust ring assembly 60B18700.

2.1.3 Locate angles and U-shaped channels common to inner thrust ring cap; drill all holes through drill plate segments of assembly fixture AF-342-20100 full size.

2.1.4 Locate angles common to outer thrust ring cap; drill all holes full size (excluding holes common to skin panels) through drill plate segments of assembly fixture AF-342-20100.

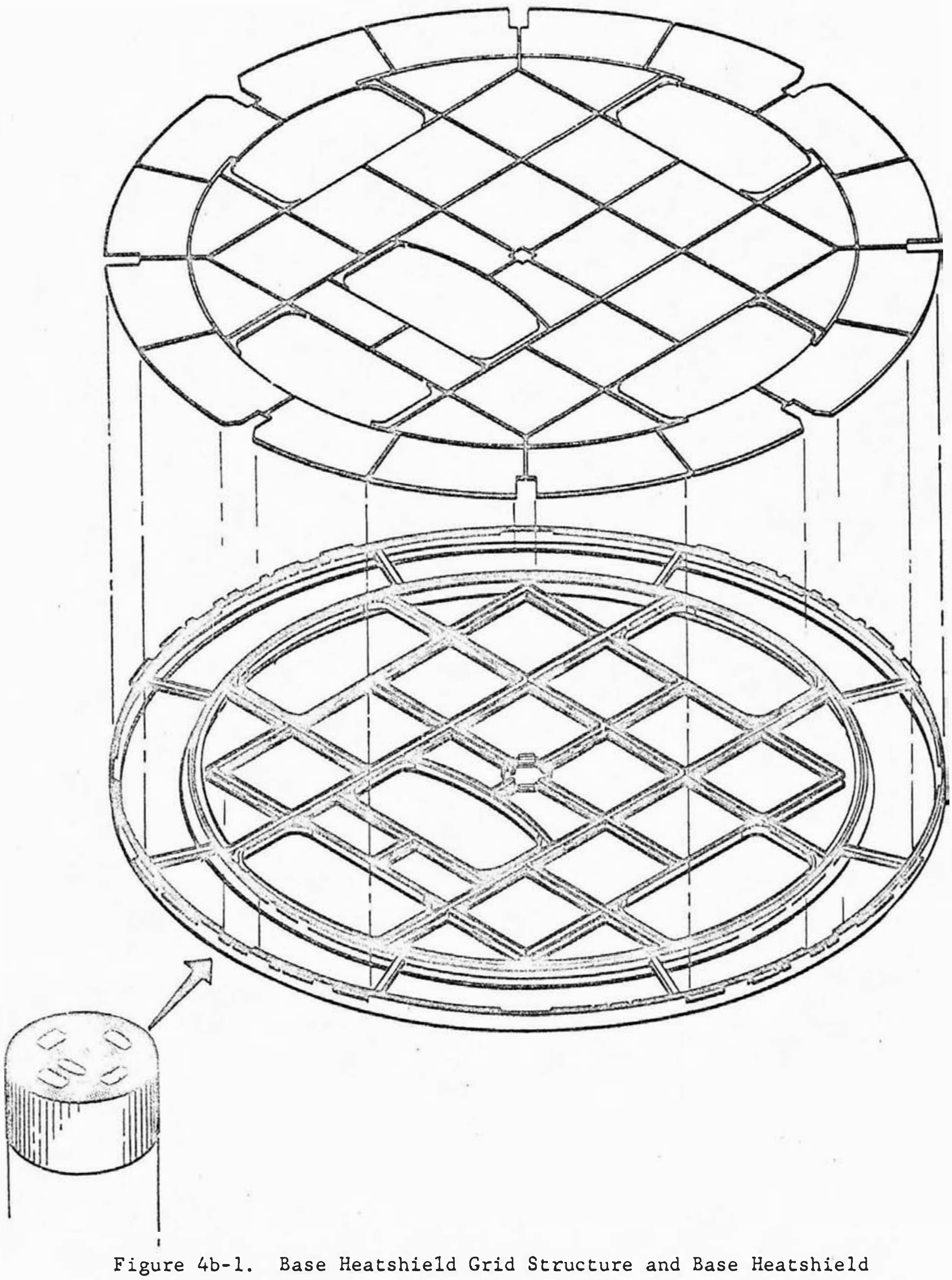


Figure 4b-1. Base Heatshield Grid Structure and Base Heatshield Panels

INFORMATION NOT AVAILABLE.

Figure 4b-2. Base Heatshield Detail Program and Schedule Chart

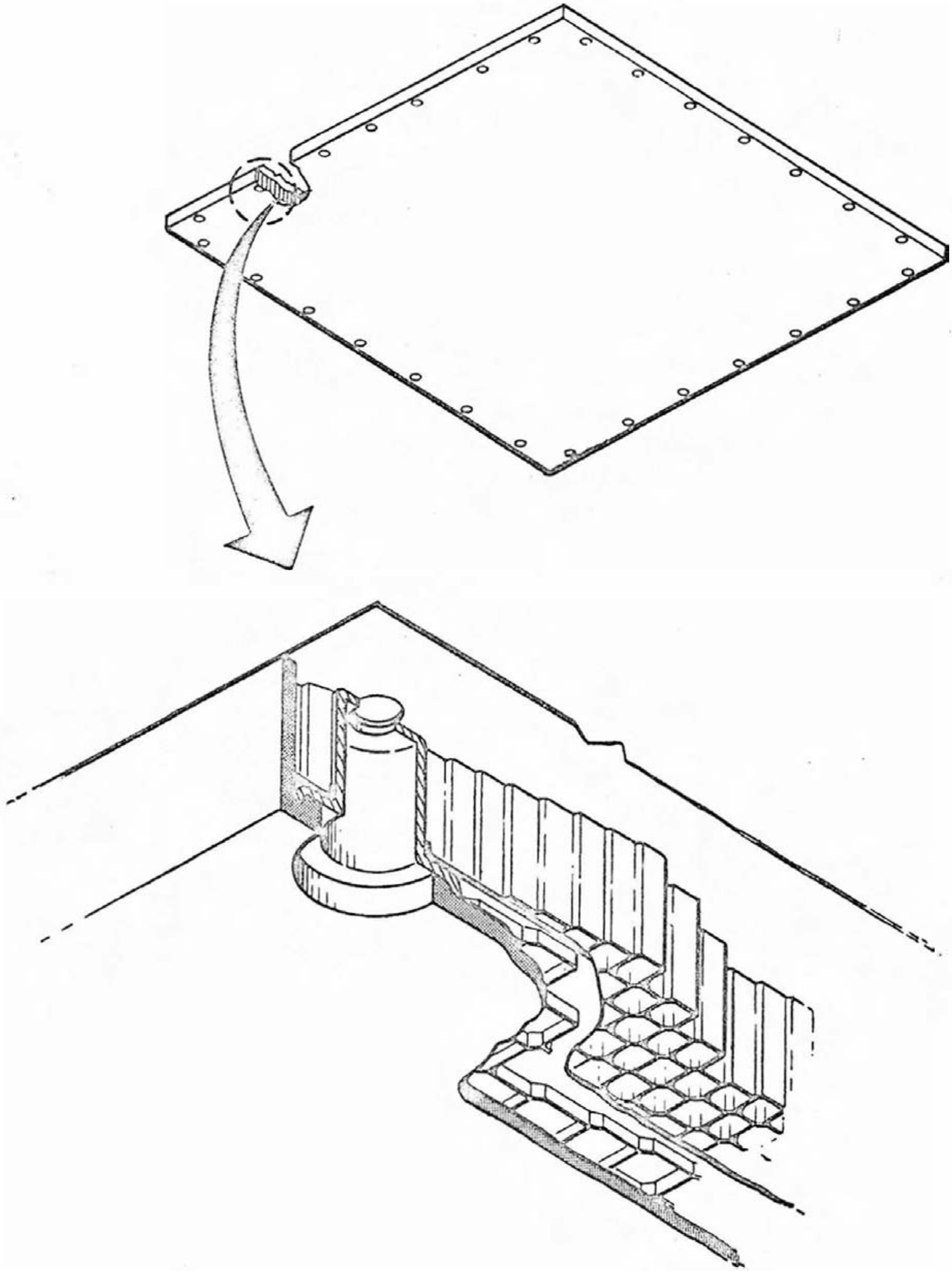


Figure 4b-3. Detail of Base Heatshield Panel

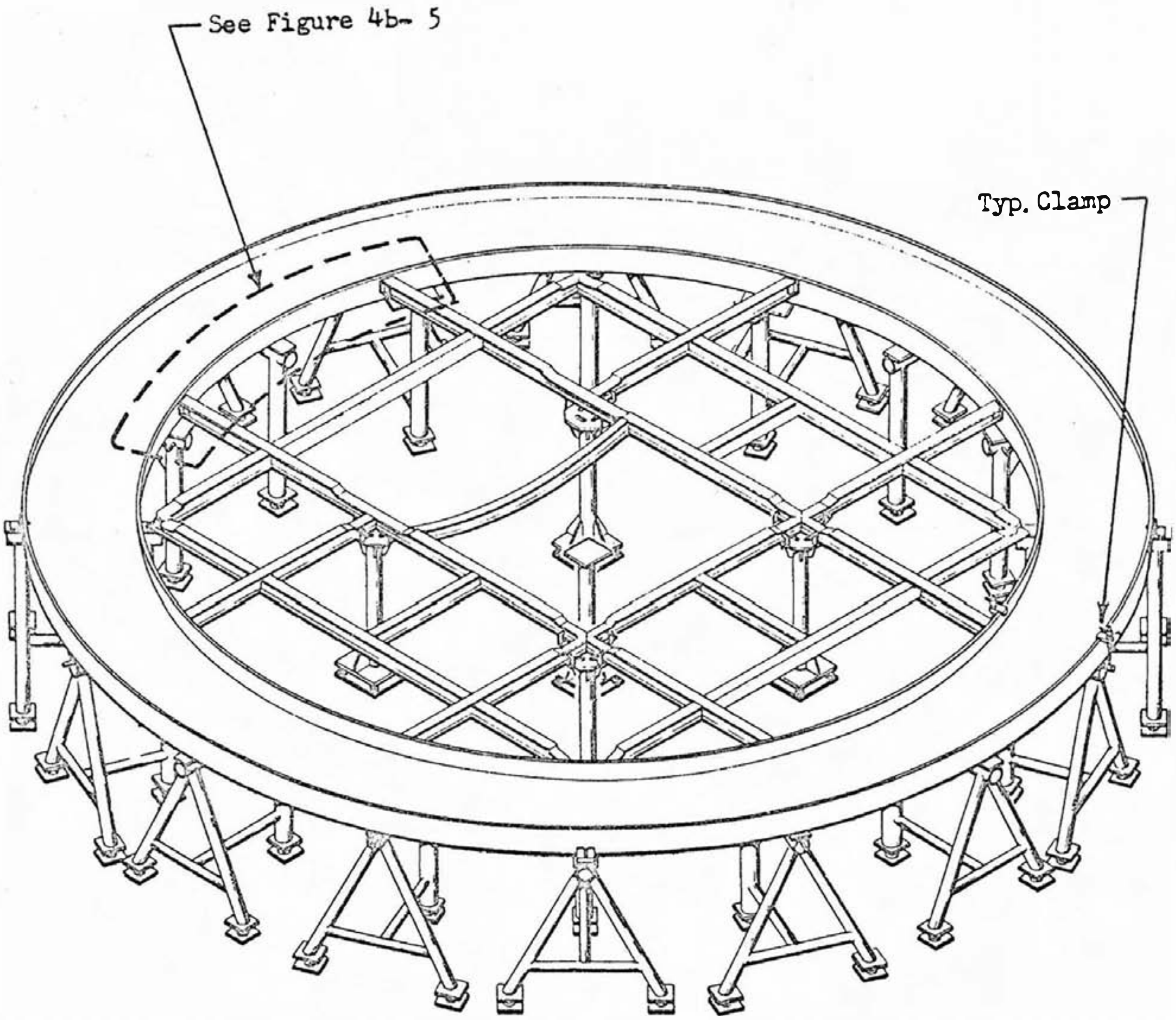
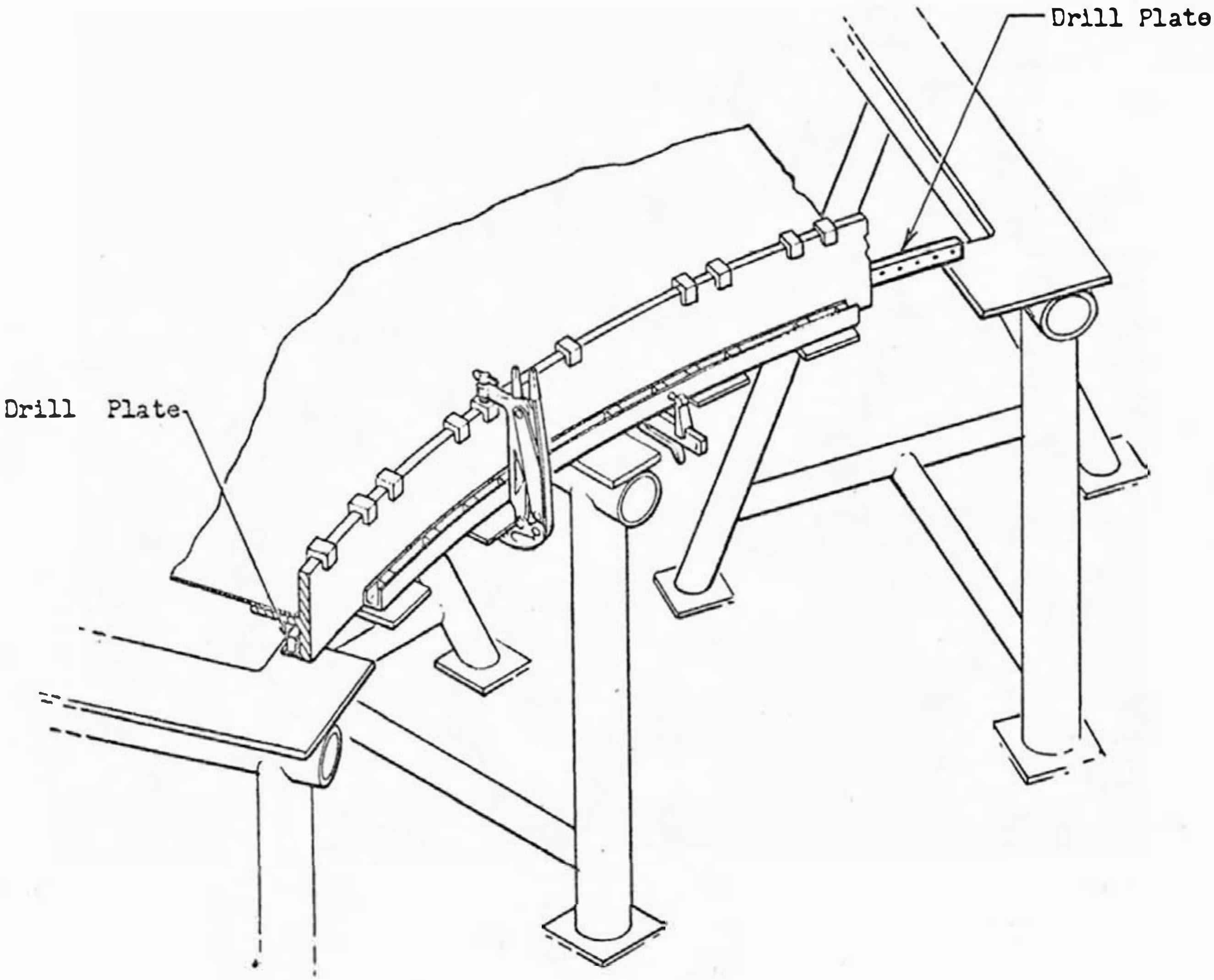


Figure 4b-4. Base Heatshield Structure Assembly Fixture
AF-342-20100



NOTE: DRILL PLATES USED ON OUTER CAPS ARE SIMILAR.

Figure 4b-5. Typical Inner Cap Drill Plate

2.1.5 After match-marking hole locations in paragraphs 2.1.3 and 2.1.4, remove angles, channels, and tees. Ship to MSFC.

2.1.6 Attach main beam to ring clips on inner cap of lower thrust ring assembly 60B18700 at eight locations. Using locating drill jig LDJ-342-20100, drill holes in clips common to main beams.

2.1.7 Locate nine main beam assemblies and the clips which secure the beam assemblies in assembly fixture AF-342-20100. Drill full-size holes in beam assemblies from pilot holes in clips. Install shop fasteners.

2.1.8 Locate and hold remaining I-beam and channel assemblies using locating drill jigs LDJ-342-20210, LDJ-342-20401, LDJ-342-20402, LDJ-342-20403, and LDJ-342-20409. Position clips and intercostals, drill holes full size, and install shop fasteners.

2.1.9 Locate curtain support channel assemblies; position intercostals at each outboard engine location and the center engine location. After shimming channel assemblies, drill holes full size; install shop fasteners.

2.1.10 Drill holes full size in substructure common to panels using locating drill jigs LDJ-342-20210, LDJ-342-20401, LDJ-342-20402, LDJ-342-20403, LDJ-342-20409, LDJ-342-20410-1, LDJ-342-20410-2, LDJ-342-20411-1, and LDJ-342-20411-2. Install nut plates.

2.1.11 Disassemble substructure and ship to MSFC. Each intersection and part will be match-marked to facilitate reassembly. A schematic illustrating the assembly procedure will accompany the heatshield structure to MSFC.

2.2 Assembly Fixture AF-342-20100 Support Tools at Michoud.

2.2.1 Assembly fixture AF-342-20200 is used for assembly of beam assemblies 60B20200-1-900, 60B20124-1-900, and 60B20124-2-900. (See figure 4b-6.)

2.2.2 Assembly fixtures AF-342-20101 and AF2-342-20101 are used for assembly of beam assemblies 60B20101-1-900 and 60B20101-2-900. (See figures 4b-7, 4b-8, and 4b-9.)

2.2.3 Assembly fixture AF-342-20120 is used to assemble beam assemblies 60B20120-1-900 and 60B20120-2-900. (See figure 4b-10.)

2.2.4 Assembly fixture AF-342-20130 is used to assemble beam assembly 60B20130-2-900. (See figure 4b-11.)

2.2.5 Assembly fixture AF2-342-20130 is used to assemble beam assembly 60B20130-1-900. (See figure 4b-12.)

2.2.6 Assembly fixture AF-342-20140 is used to assemble beam assembly 60B20140-1-900. (See figure 4b-13.)

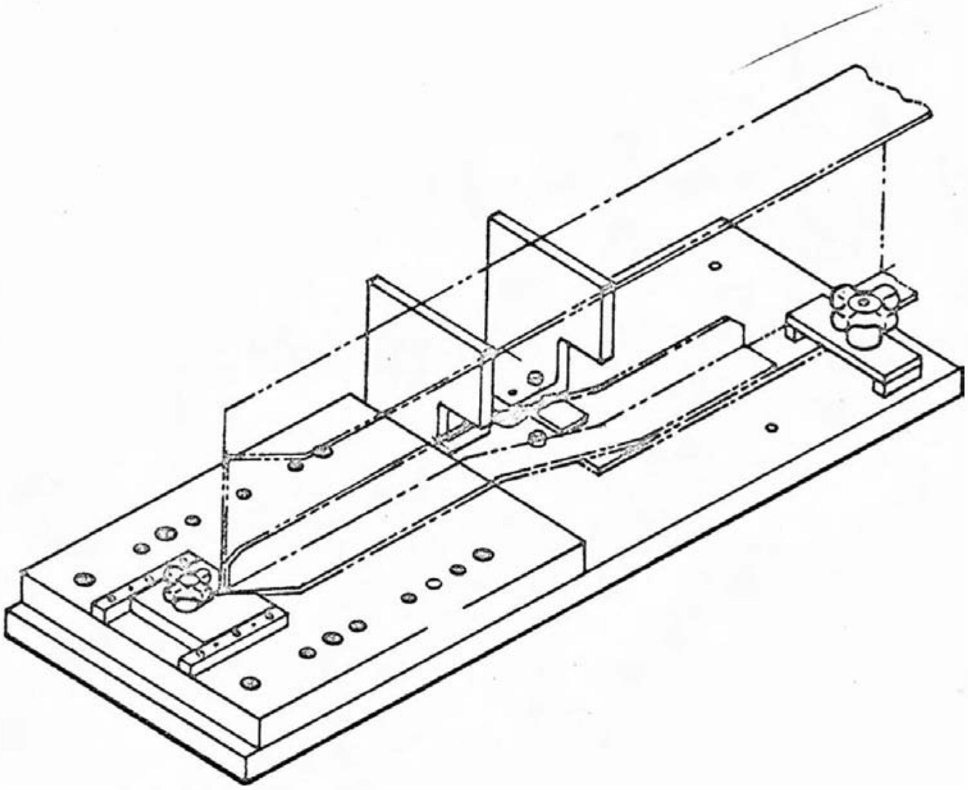


Figure 4b-6. Base Heatshield Beam Assembly, Assembly Fixture
AF-342-20200

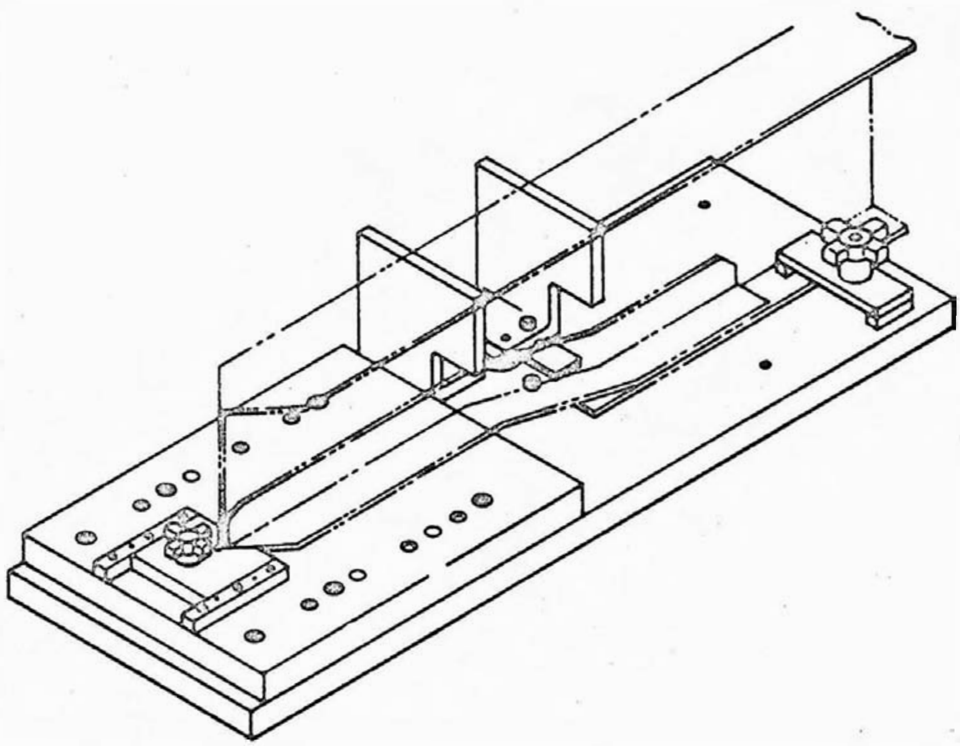


Figure 4b-7. Base Heatshield Beam Assembly, Assembly Fixture
AF-342-20101-1-0

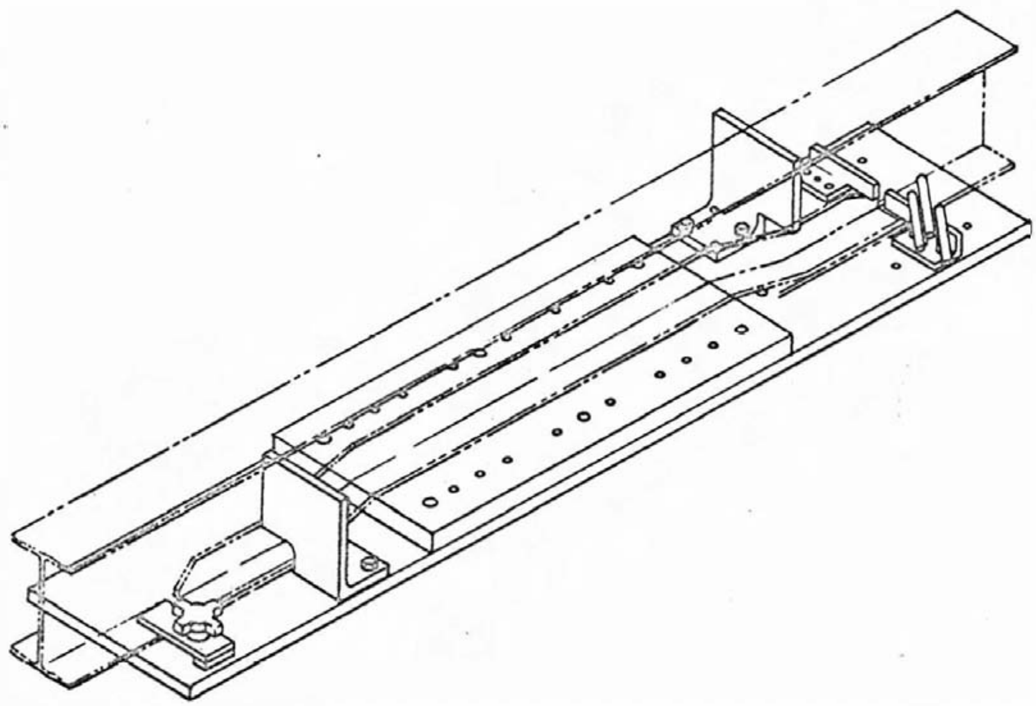


Figure 4b-8. Base Heatshield Beam Assembly, Assembly Fixture AF-342-20101-2-0

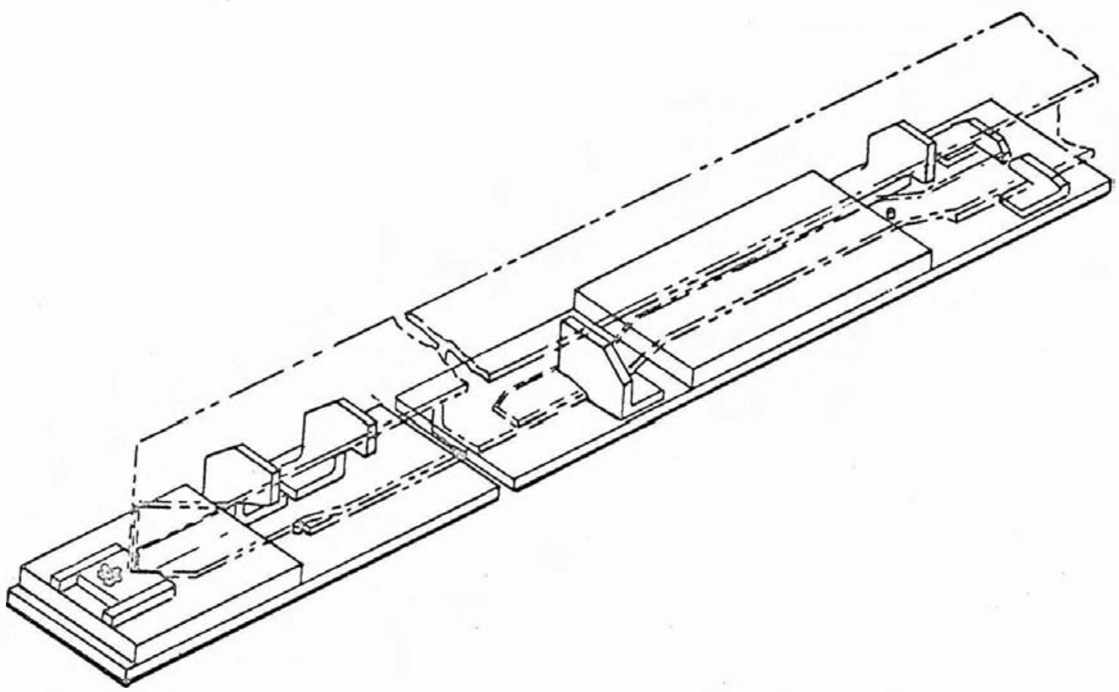


Figure 4b-9. Base Heatshield Beam Assembly, Assembly Fixture AF2-342-20101

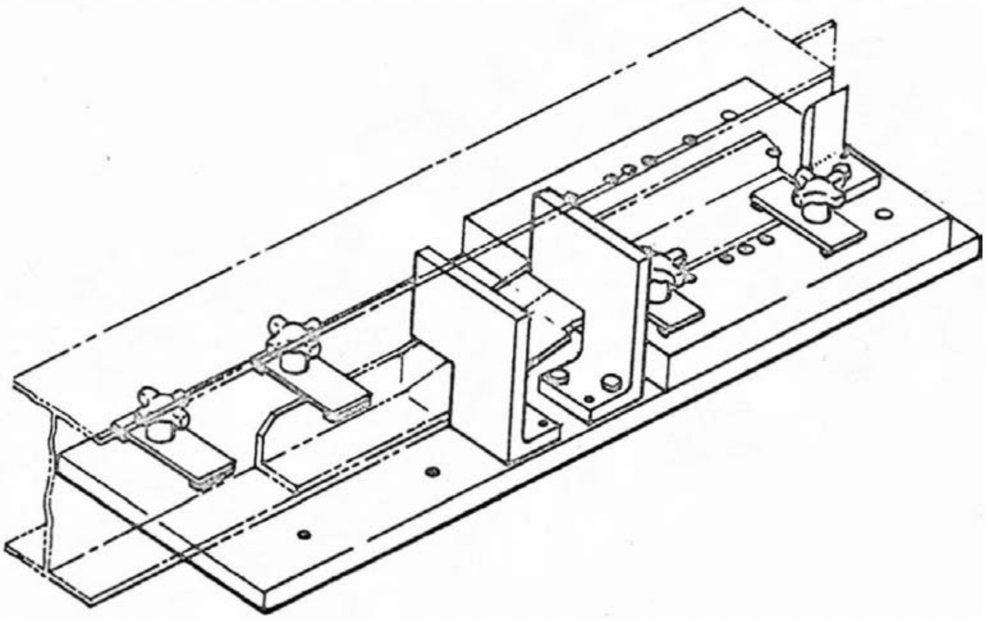


Figure 4b-10. Base Heatshield Beam Assembly, Assembly Fixture
AF-342-20120

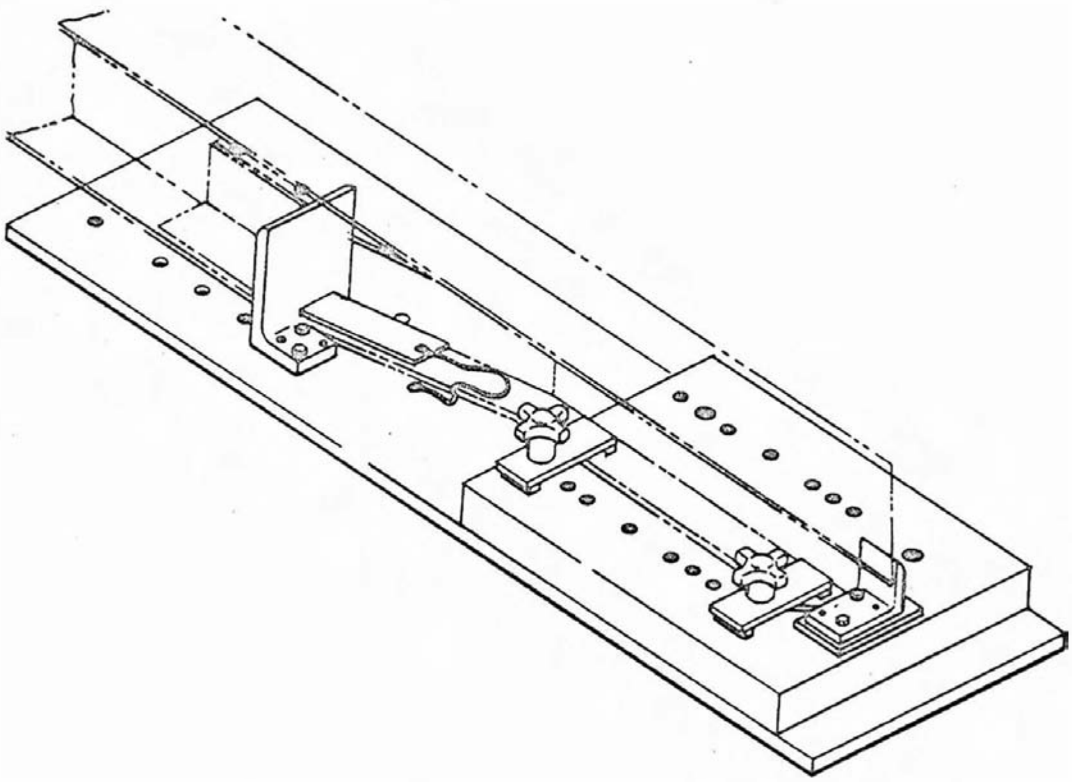


Figure 4b-11. Base Heatshield Beam Assembly, Assembly Fixture AF-342-20130

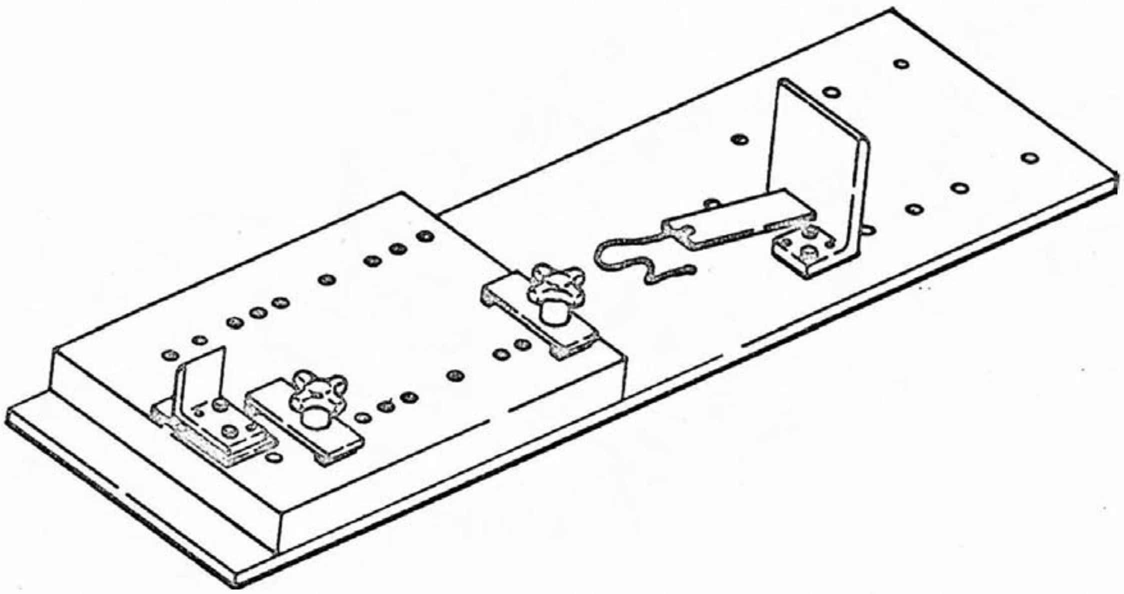


Figure 4b-12. Base Heatshield Beam Assembly, Assembly Fixture
AF2-342-20130

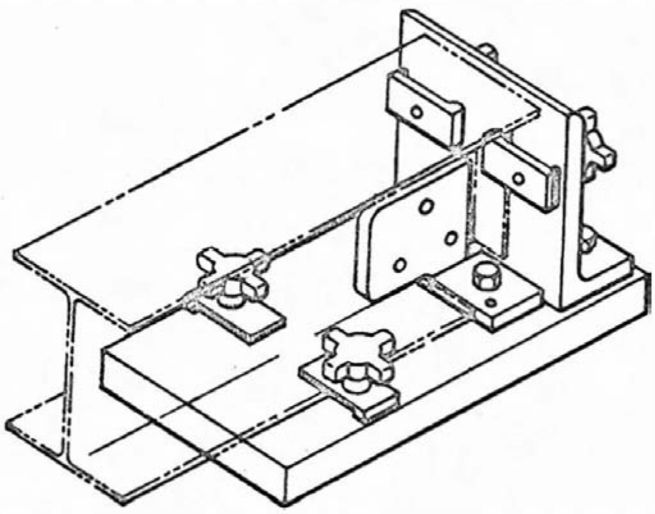


Figure 4b-13. Base Heatshield Beam Assembly, Assembly Fixture AF-342-20140

2.2.7 Assembly fixture AF-342-20170 is used to assemble beam assembly 60B20170-1-900. (See figure 4b-14.)

2.2.8 Assembly fixture AF-342-20542 is used to assemble channel assemblies 60B20542-1-900 and 60B20542-2-900. (See figure 4b-15.)

2.2.9 Assembly fixture AF2-342-20542 is used to assemble channel assemblies 60B20542-3-900 and 60B20542-4-900. (See figure 4b-15.)

2.3 <u>Hole Pattern Control Tools.</u> Heatshield panels are purchased complete per engineering drawings from vendor. The following tools are used to control hole pattern and periphery of heatshield panels at the vendor's installation. Tools listed are coordinated to the master check gages of the same numbers.

MrP-342-20210
MrP-342-20401
MrP-342-20402
MrP-342-20404
MrP-342-20406
MrP-342-20410
MrP-342-20411
MrP-342-20680
MrP-342-20690

2.4 <u>Assembly of Base Heatshield Structure 60B20100 at MSFC.</u> (See figure 4b-16.)

2.4.1 Reassemble base heatshield support structure in reassembly fixture AF-342-7181. Install fasteners.

2.4.2 Elevate the support structure to proper position on thrust structure assembly 60B18050.

2.4.3 Install ring clips on lower thrust ring assembly 60B18700 and support structure.

2.4.4 Install all pre-drilled angles on inner cap of lower thrust ring assembly 60B18700.

2.4.5 Install angles on outer cap of lower thrust ring assembly 60B18700.

2.4.6 Locate and install beam assemblies and clips in the area of center engine support structure 60B18900.

2.4.7 Locate detail parts and make splices between engine curtain channels and U-channels on lower thrust ring assembly 60B18700.

2.4.8 Using drill jigs DJ-342-7173 and DJ-342-7172, drill full-size attach holes for panel assemblies 60B20404, 60B20408, 60B20407, and 60B20405.

2.4.9 Using drill jig DJ-342-7174, drill full-size attach holes and router starter holes in panel assembly 60B20406.

2.4.10 Using router fixtures RF-342-7249 and RF-342-7250, rout radial slots for panel assembly 60B20406.

2.4.11 Using drill jigs DJ-342-7175, DJ-342-7176, and DJ-342-7177, drill full-size attach holes for panel assemblies 60B20680, 60B20681, 60B20690, and 60B20691.

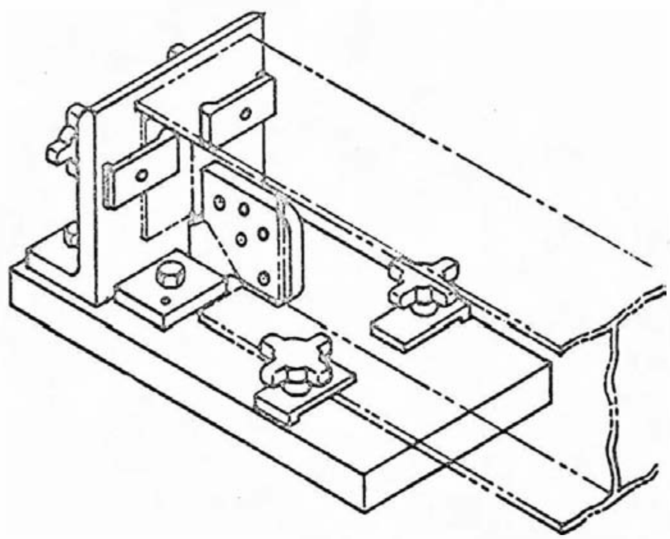


Figure 4b-14. Base Heatshield Beam Assembly, Assembly Fixture
AF-342-20170

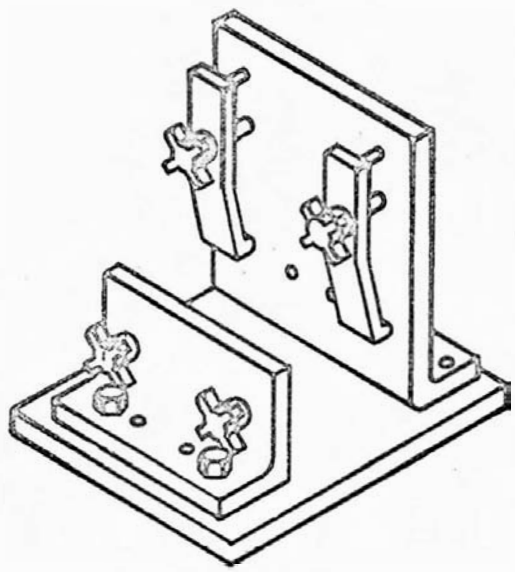


Figure 4b-15. Base Heatshield Channel Assembly, Assembly Fixtures AF-342-20542 and AF2-342-20542

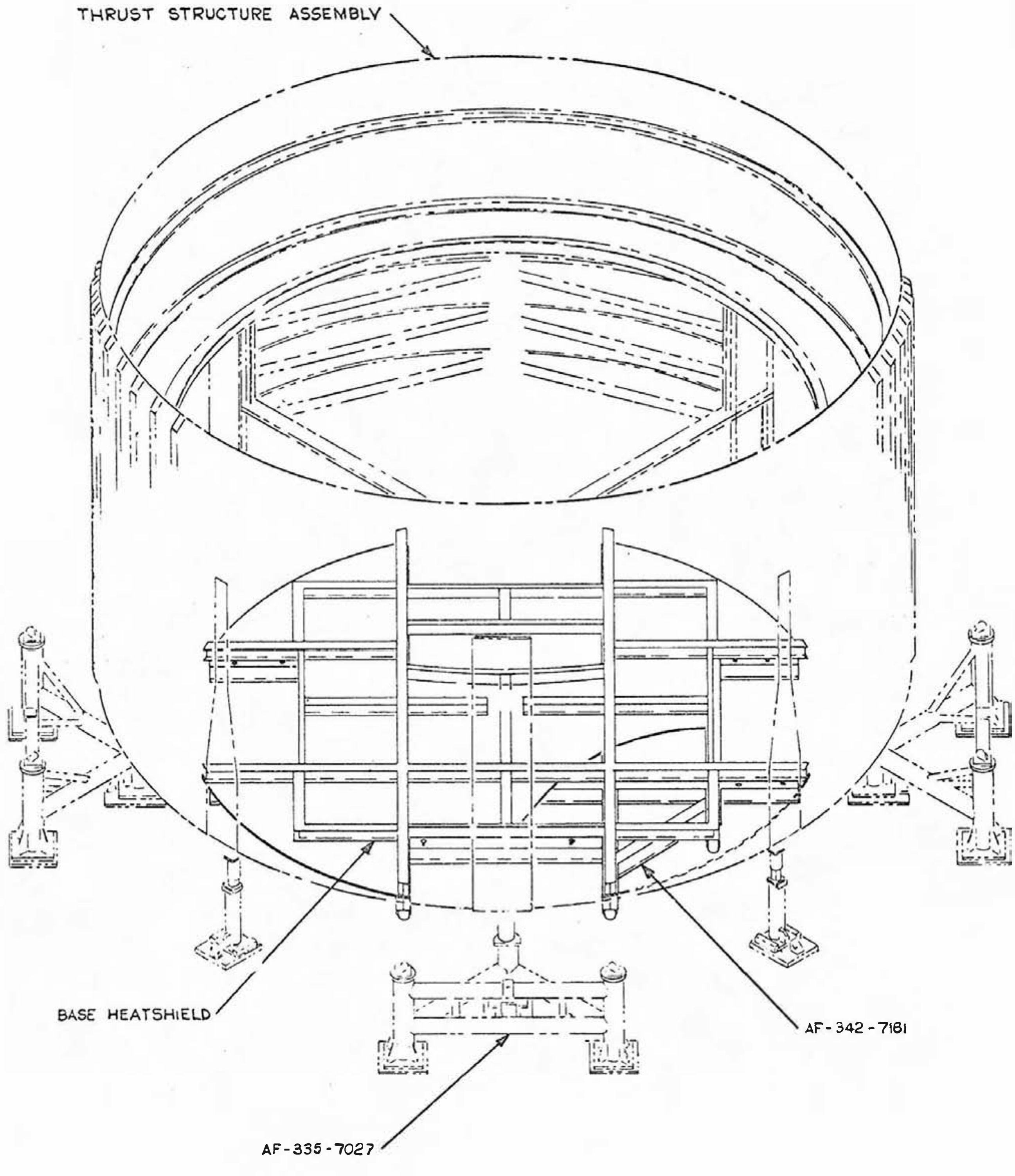


Figure 4b-16. Reassembly of Base Heatshield Structure 60B20100

2.4.12 Install nut plates on support angles attached to lower thrust ring caps.

2.4.13 Install BMS-5-33 Type B filler in engine cutout areas.

2.4.14 Apply aluminum tape and asbestos tape on the heatshield beams and angles under lower thrust ring assembly 60B18700.

2.4.15 Install heatshield panels under the thrust ring proper.

2.4.16 Prefit the heatshield panels in the center of lower thrust ring assembly 60B18700. Final installation of the heatshield panels and application of the aluminum and asbestos tapes will be accomplished after all other assembly operations requiring access through the area have been completed.

3. BASE HEATSHIELD SEAL INSTALLATION 60B21600-1. (See figure 4b-17.)

3.1 General Description. This installation is used in the heatshield area of the thrust structure assembly 60B18050 for heat protection of the thrust structure interior during engine firing. Several different configurations of seal assemblies are welded, bolted, and riveted structures fabricated from inconel, aluminum, and firewall sheet; glass fabric reinforced plastic; and tadpole seals. These seal assemblies attach to the center engine support area of the thrust structure or to heatshield panels in all areas where clearance holes are required for mechanical systems interface connections between the vehicle structure and the engine area. This includes seal assemblies around the calorimeter purge lines, hydraulic supply and return lines, center engine alinement struts, and the adapter fitting. Also included are seal assemblies around the center engine pan to replace the flight curtain, seal assemblies around flak curtain clearance holes, and water deluge seal assemblies, which are used only during static testing.

3.2 Hardware Fabrication and Assembly. The attach holes in all seal assemblies and the corresponding mounting holes in thrust structure assembly 60B18050 shall be drilled full size prior to installation of the seal assemblies. Coordinated drill jigs or master checking fixtures are used to assure proper alinement and interchangeability of attach hole patterns. Seal assembly attach holes and structure mounting holes will be established as follows:

3.2.1 Center Engine Colorimeter Purge Seal Assembly 60B21605-1. Seal assembly 60B21605-1 will be fabricated complete in accordance with engineering documentation including full size attach holes as dimensioned on canister drawing 60B21606-1. Drill jig DJ-B335-18970 is used at Michoud for drilling fitting 60B18970-1 to match seal assembly 60B21605-1 for booster stages S-IC-D. S-IC-F, and S-IC-1 through S-IC-10.

3.2.2 Center Engine Hydraulic Supply Seal Assembly 60B21615-1. Hole patterns for seal assembly 60B21615-1 and fitting assembly 60B18971 are drilled using drill jig DJ-335-9369 at MSFC and Michoud. Dimensions are shown on canister drawing 60B21616-1 for booster stages S-IC-T, S-IC-D, S-IC-F, and S-IC-1 through S-IC-10.

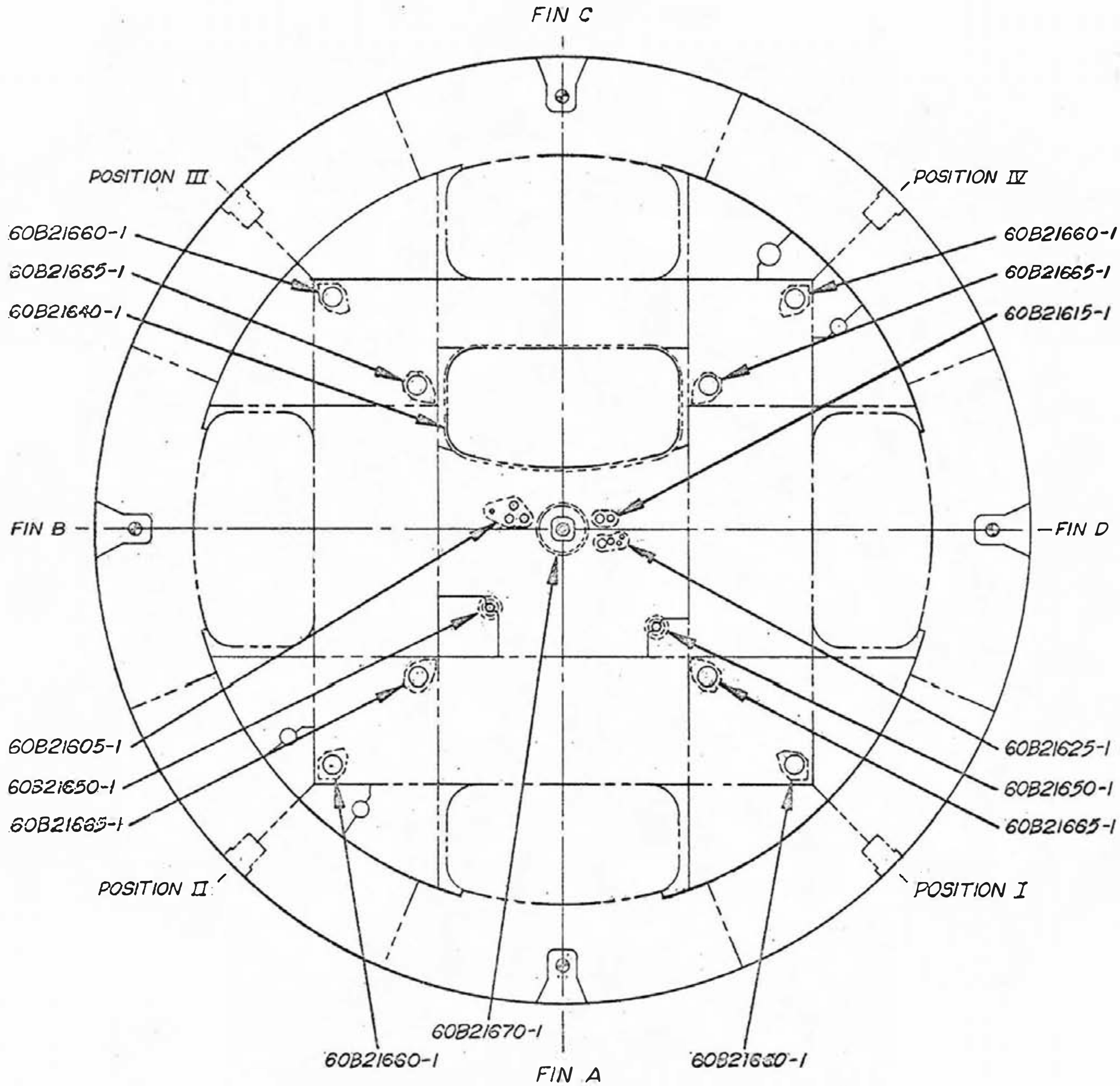


Figure 4b-17. Base Heatshield Seal Installation 60B21600-1

3.2.3 Center Engine Hydraulic Return Seal Assembly 60B21625-1. Seal assembly 60B21625-1 will be fabricated complete in accordance with engineering documentation including full size attach holes as dimensioned on canister drawing 60B21626-1. Drill jig DJ-B335-18971 is used at Michoud for drilling fitting assembly 60B18971-1 to match seal assembly 60B21625-1 for booster stages S-IC-D, S-IC-F, and S-IC-1 through S-IC-10.

3.2.4 Center Engine Pan Seal Assembly 60B21640-1. Hole patterns for seal assembly 60B21640-1 are drilled using drill jig DJ-335-9375 at both MSFC (for booster stage S-IC-T) and Michoud (for booster stages S-IC-1 through S-IC-10). Coordinated mounting holes are drilled in heatshield panel assemblies 60B20456-1, 60B20456-3, 60B20457-1, and 60B20457-3 using drill jig DJ-335-9376.

3.2.5 Center Engine Alinement Structure Seal Assembly 60B21650-1. Seal assembly 60B21650-1 will be fabricated without attach holes. These holes will be drilled in accordance with canister drawing 60B21651-1 prior to installation of seal assembly 60B21650-1 using drill jig DJ-335-9370 for booster stages S-IC-T, S-IC-D, S-IC-F, and S-IC-1 through S-IC-10. Coordinated mounting holes are drilled in lower cap beams 60B18912-1 and 60B18934-1 using drill jig DJ-335-9371 during assembly of thrust structure assembly 60B18050.

3.2.6 Inboard Flak Curtain Seal Assembly 60B21660-1. Coordinated full size attach holes are drilled in seal assembly 60B21660-1 in accordance with plate detail drawing 60B21667-1 during initial fabrication and assembly using master check gage MrCkG-B342-20210. Mounting holes in heatshield panel assemblies 60B20475-1, 60B20476-1, 60B20477-1, and 60B20478-1 are also drilled using master check gage MrCkG-B342-20210. Coordinated hole patterns are fabricated in ring assembly 60B21668-1 (part of seal assembly 60B21660-1), flak curtain plate 60B21524-3, and flak curtain fitting assembly 60B21553-1 in accordance with the respective documentation. Seal assembly 60B21660-1 is used on booster stages S-IC-T and S-IC-1 through S-IC-10.

3.2.7 Outboard Flak Curtain Seal Assembly 60B21665-1. Coordinated full size attach holes are drilled in seal assembly 60B21665-1 in accordance with plate detail drawing 60B21667-1 during initial fabrication and assembly using master check gage MrCkG-B342-20210. Mounting holes in heatshield panel assemblies 60B20475-1, 60B20476-1, 60B20477-1, and 60B20478-1 are also drilled using master check gage MrCkG-B342-20210. Coordinated hole patterns are fabricated in ring assembly 60B21668-1 (part of seal assembly 60B21665-1), flak curtain plate 60B21524-3, and flak curtain fitting assembly 60B21553-1 in accordance with the respective documentation. Seal assembly 60B21665-1 is used on booster stages S-IC-T and S-IC-1 through S-IC-10.

3.2.8 Center Adapter Fitting Seal Assembly 60B21670-1. Attach hole patterns for seal assembly 60B21670-1 are drilled in accordance with canister documentation 60B21671-1 using drill jig DJ-335-9367. Coordinated mounting holes are drilled in adapter 60B18910-1 using drill jig DJ-335-9368. Seal Assembly 60B21670-1 is used on booster stages S-IC-T, S-IC-D, S-IC-F, and S-IC-1 through S-IC-10.

3.2.9 Water Deluge Duct Installation Seal Details 60B203XX. These seal details are fabricated in accordance with engineering documentation. Seal details 60B203XX are used on booster stages S-IC-T and S-IC-1 through S-IC-10. Attach holes are not required for mounting seal details 60B203XX to the duct installation.

3.3 Installation. All seal assemblies will be installed while the thrust structure assembly 60B18050 is located at the thrust structure pickup position for booster stages S-IC-D, S-IC-F, S-IC-1, and S-IC-2 at Michoud. Seal assemblies 60B21640-1, 60B21660-1, and 60B21665-1 that attach to the heatshield for booster stages S-IC-3 through S-IC-10 will not be installed until horizontal final assembly. The remaining seal assemblies will be installed at the thrust structure pickup position. All attach holes will be predrilled and no special installation tools are required. MSFC will install all seal assemblies used on booster stage S-IC-T at Huntsville. Seal assemblies 60B21605-1 and 60B21625-1 will require hand layout and drilling of attach hole locations. All other seal assemblies are predrilled. Seal assemblies used only during static firing (non-flight) will be removed during refurbishment of booster stages S-IC-3 through S-IC-10 at Michoud. Seal details 60B203XX used in conjunction with the water deluge duct installation will be installed prior to static firing along with the water deluge installation at MTO. After static testing, seal details 60B203XX will be removed at MTO.

SECTION IV

THRUST STRUCTURE ASSEMBLY

SECTION IV
THRUST STRUCTURE ASSEMBLY

1. GENERAL DESCRIPTION.

The thrust structure assembly is 33 feet in diameter, exclusive of fins and engine fairings, and approximately 20 feet tall (from station 100, engine gimbal point, to station 345.7, forward end of the cylindrical panels). The thrust structure is a mechanically fastened assembly designed to react the thrust of the five F-1 rocket engines and to distribute the loads throughout the entire structure. Scantlings of the thrust structure assembly consist basically of 7000-series aluminum alloy plating, forgings, extrusions, and rolled shapes. The thrust structure assembly will be mechanically attached to the fuel tank assembly. The weight of the thrust structure assembly is approximately 52,000 pounds excluding fin assemblies, engine fairings, and base heat shield and is of the configuration shown in figures 4-1 and 4-2. (See figure 4-3 for schedule chart.) Major components of the thrust structure assembly are as follows:

1.1 Outboard Engine Adapter Fitting 60B18806. The outboard engine adapter fitting is fabricated from 4340 steel. (See figures 4-4 and 4-5.)

1.2 Holddown Post Fittings 60B19601. The base fitting is the rest pad for the entire vehicle. Configuration of the fittings is shown in figures 4-4 and 4-5. The holddown post, holddown post fitting, and the lower thrust ring assembly are connected with common fasteners.

1.3 Lower Thrust Ring Assembly 60B18700. (See figure 4-6.) The lower thrust ring assembly is 33 feet in diameter with an inside diameter 80 inches smaller. It is, in essence, a circular beam consisting of eight tee caps (four inner and four outer). Each of the eight web assemblies (one centered at each holddown position and one centered at each fin position) consists of a web plate, a doubler, radial zee stiffeners, tee cap angles, tee cap splice plates, hat-shaped stiffeners at tee cap splice locations, and web splice tees. The tee caps are 10 inches high and 1/18 inch thick with a leg 7 inches long and 5/8 inch thick. The tee caps are extrusions which are stretch-formed and machined to contour. The web plate and the doublers are each 3/8 inch thick. The zee stiffeners are 3-1/2 inches high with 1-3/4 inch long flanges. Approximate weight of the lower thrust ring assembly is 6000 pounds.

1.4 Center Engine Support Assembly 60B18900. (See figures 4-7 and 4-8.) The center engine support assembly consists of two intersecting plate girders fabricated from two stiffened panels. Plate girders bisect each other at the intersection of Fin Lines A-C and B-D and are in a vertical plane to the position lines. Each panel is attached to the center engine thrust post at the point of intersection. The structure is then capped with the upper and lower chords (tees). The completed center engine support assembly attaches to the holddown post, the lower thrust ring assembly, and the auxiliary web assembly at final assembly of the thrust structure. Approximate weight of the center engine support assembly is 7000 pounds.

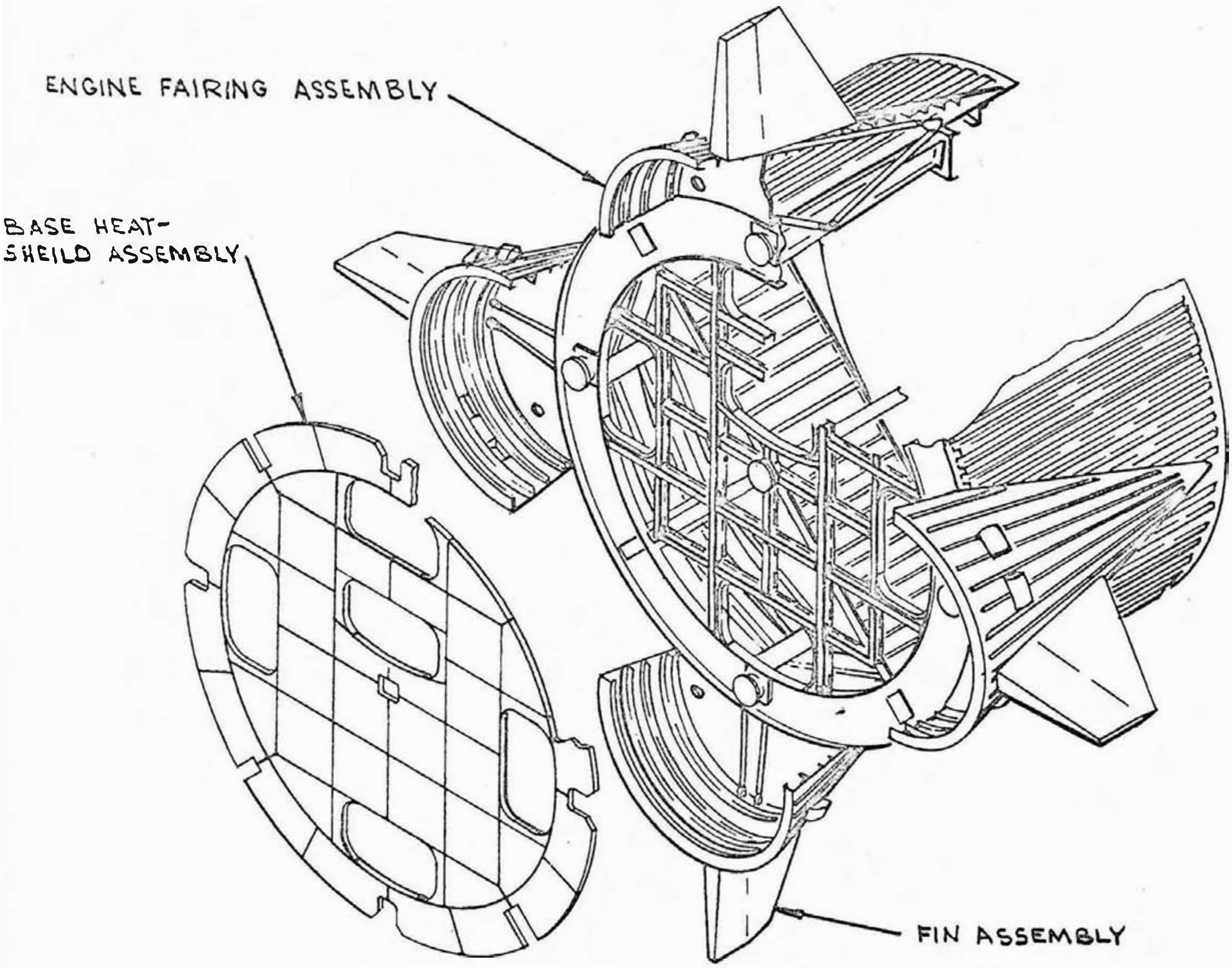


Figure 4-1. Completed Thrust Structure Assembly

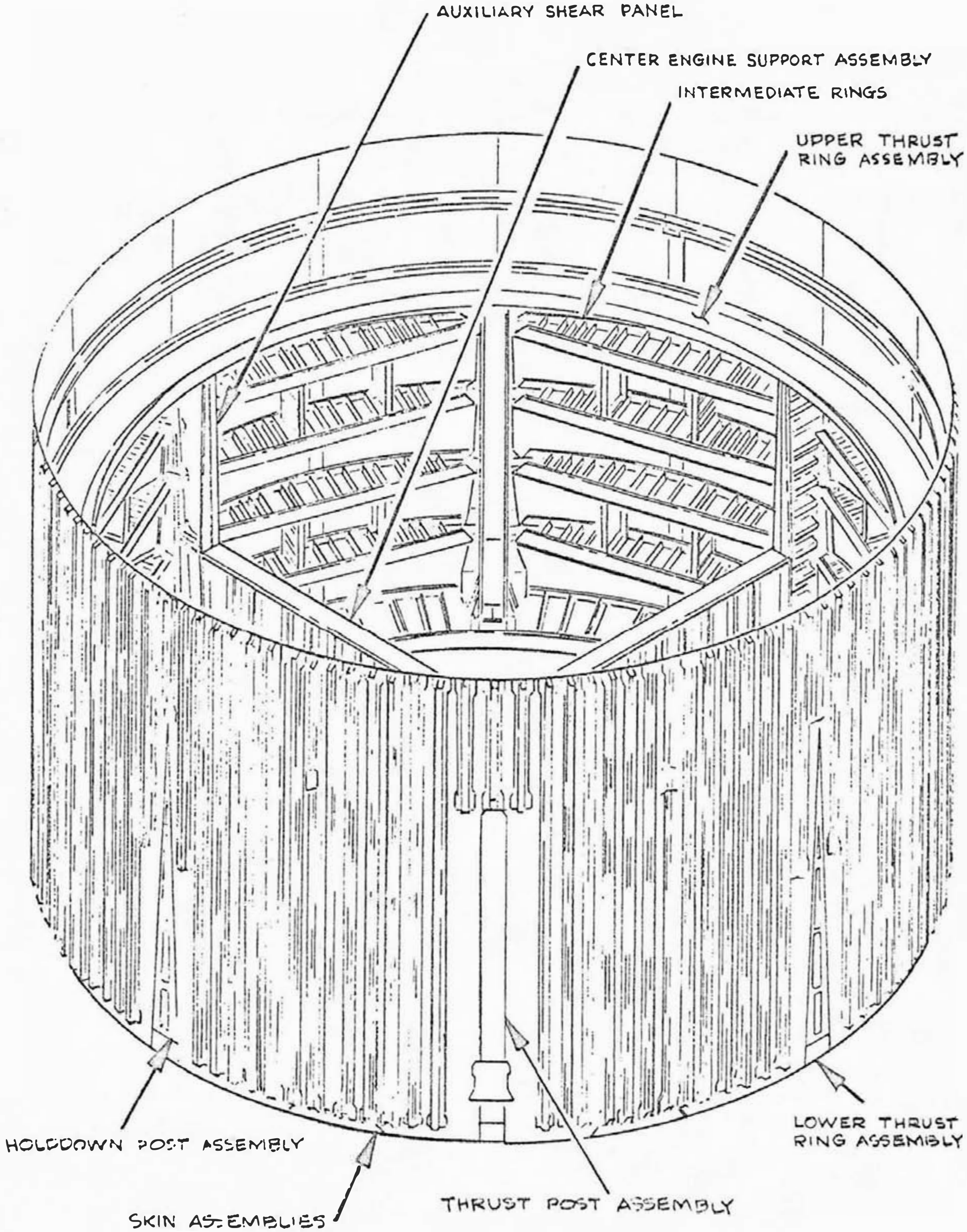


Figure 4-2. Partial Thrust Structure Assembly

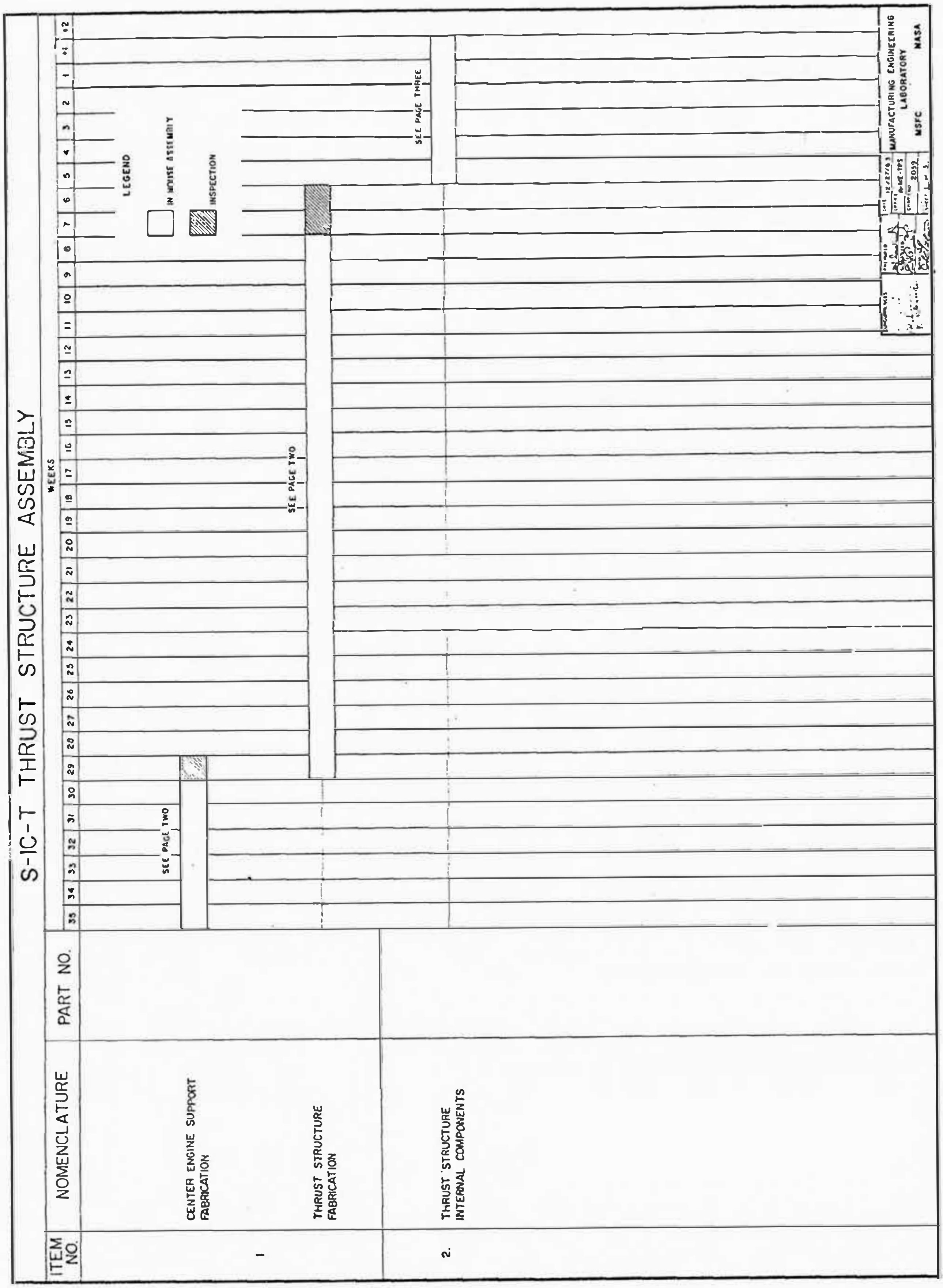


Figure 4-3. Thrust Structure Assembly Detail Schedule and Program Chart (Sheet 1 of 6)

S-IC-T THRUST STRUCTURE ASSEMBLY

ITEM NO.	NOMENCLATURE	PART NO.
1	CENTER ENGINE SUPPORT LOWER CAPS	60818912-1-900 60818934-1-900 60818935-1-900 60818936-1-900
2	CENTER ENGINE SUPPORT THRUST POST	6081895-1-900
3	CENTER ENGINE SUPPORT WEB ASSEMBLIES	60818901-1-900 60818902-1-900 60818919-1-900 60818920-1-900
4	CENTER ENGINE SUPPORT UPPER CAPS	60818911-1-900 [illegible]-1-900
5	CENTER ENGINE SUPPORT INSTALLATION	60818940
6	OUTBOARD ENGINE ADAPTER FITTING	60818806-1-900
7	HOLDDOWN POST FITTING	60819601-1-900
8	LOWER THRUST RING ASSEMBLY	60818700-1-900
9	HOLDDOWN POSTS	60819600-1-900 60819604-1-900 60819605-1-900
10	THRUST POST ASSEMBLY, OUTBOARD ENGINE	60818800-1-900
11	AUXILIARY WEB ASSEMBLIES	60818940-1-900 60818940-1-901 60818940-1-902 60818940-1-903
12	UPPER THRUST RING ASSEMBLY	60818600-1-900
13	INTERMEDIATE RING ASSEMBLIES	60819110-1-900 60819120-1-900 60819130-1-900 60819140-1-900 60819159-1-900 60819160-1-900
14	INTERCOSTAL ASSEMBLIES	60819300-1-900 60819301-1-900 60819310-1-900 60819316-1-900
15	HEAT SHIELD SUPPORT STRUCTURE	60820001
16	SKIN PANEL ASSEMBLIES	60818100-1-900 60818200-1-900 60818300-1-900 60818327-1-900
17	ACTUATOR SUPPORT, RETRO ROCKET	60832200
18	INTERMEDIATE RING, STA 315	60818501
19	PROPELLANT DUCT SUPPORT	60819700
20	HEAT SHIELD PANELS	60820420
21	ENGINE FAIRING SUPPORTS	NOT REQD S-IC-T
22	RETRO ROCKET BRACKETS	60832200
23	PROPULSION AND ELECTRICAL SYSTEMS SUPPORT	60818060 60818061
24	THRUST STRUCTURAL ASSEMBLY	60818050-1-900

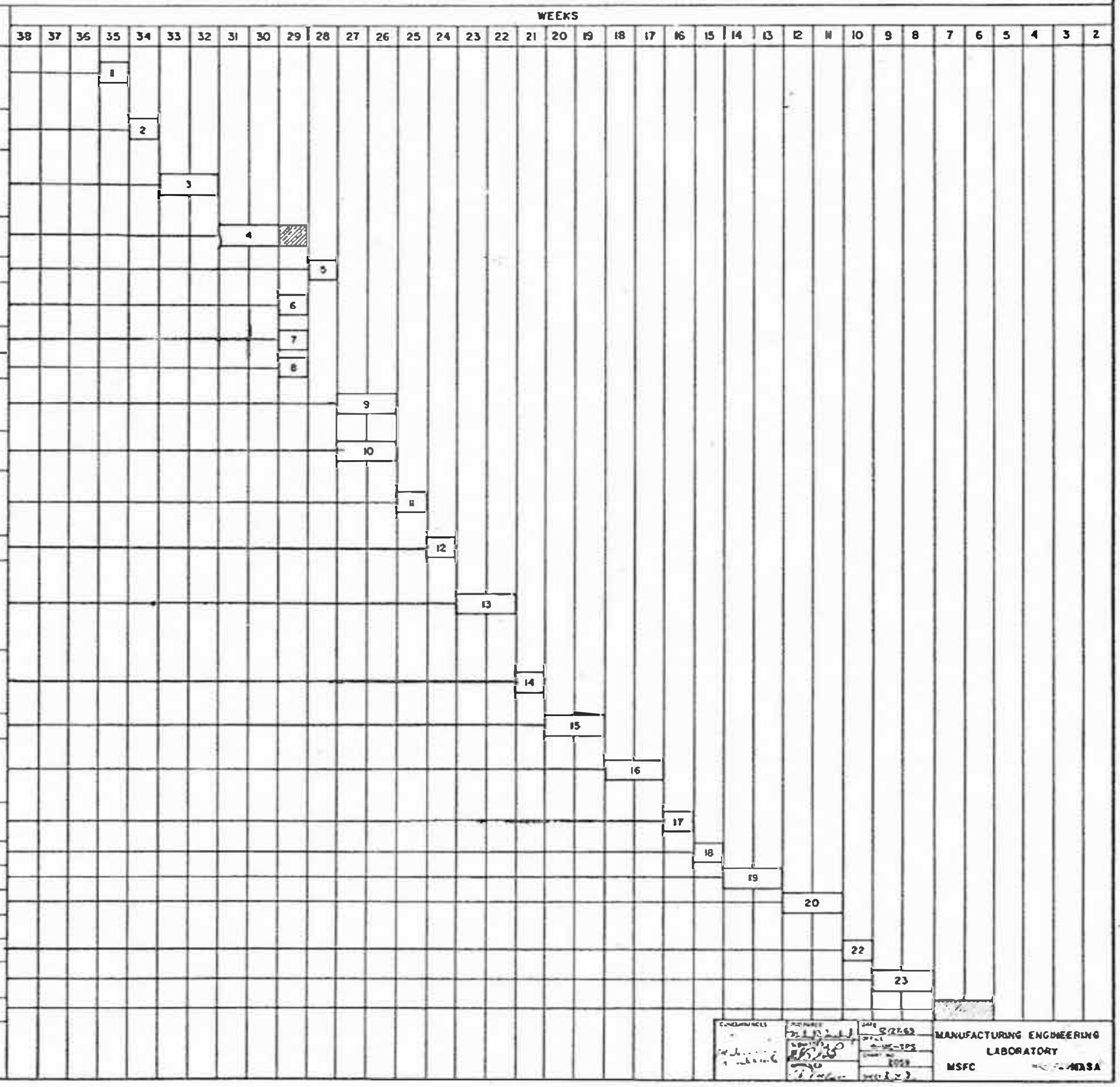
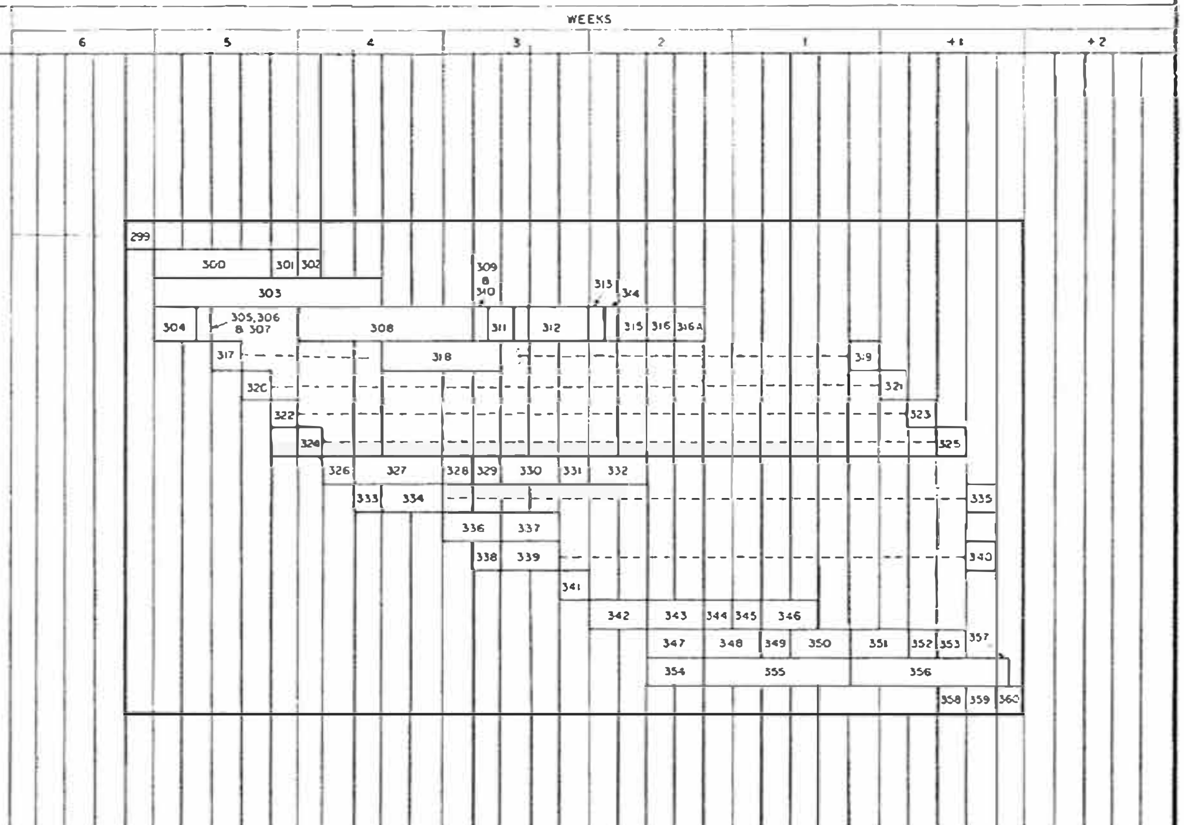


Figure 4-3. Thrust Structure Assembly Detail Schedule and Program Chart (Sheet 2 of 6)

S-IC-T THRUST STRUCTURE ASSEMBLY

ITEM NO.	NOMENCLATURE	PART NO.
299	THRUST STRUCTURE ASSEMBLY	60B03552-901
300	LOX DELIVERY SYSTEM	60B41014 - 901
301	LOX DELIVERY SYSTEM	60B41014 - 902
302	LOX DELIVERY SYSTEM	60B41014 - 903
303	CURTAIN INSTALLATION, HEAT SHIELD	60B20500 - 901
304	CONTROL PRESSURE SYSTEM	60B52200 - 901
305	AFT UMBILICAL PLATE NO 1	65B80013
306	AFT UMBILICAL PLATE NO 2	65B80014
307	AFT UMBILICAL PLATE NO 3	65B80015
308	FUEL DELIVERY SYSTEM	60B43014 - 901
309	LOX DELIVERY SYSTEM	60B41014 - 904
310	LOX DELIVERY SYSTEM	60B41014 - 905
311	LOX DELIVERY SYSTEM	60B41014 - 906
312	FUEL DELIVERY SYSTEM	60B43014 - 902
313	FUEL DELIVERY SYSTEM	60B43014 - 903
314	FUEL DELIVERY SYSTEM	60B43020 - 904
315	FUEL DELIVERY SYSTEM	60B43014 - 905
316	PNEU TUBING LOX DELIVERY SYSTEM	60B41223 - 901
316A	LOX CONDITIONING SYSTEM	60B41222 - 901
317	LOX DOME & GG LOX INJECTION PURGE SYSTEM	60B37600 - 901
318	PROPELLANT CONTAINER ASSEMBLY	60B03052-7-901
319	LOX DOME & GG LOX INJECTION PURGE SYSTEM	60B37600 - 902
320	TURBO PUMP LOX SEAL & GG HOUSING PURGE SYS	60B37601 - 901
321	TURBO PUMP LOX SEAL & GG HOUSING PURGE SYS	60B37601 - 902
322	GG & FUEL INJECTOR PURGE SYSTEM	60B37602 - 901
323	GG & FUEL INJECTOR PURGE SYSTEM	60B37602 - 902
324	CALORIMETER PURGE SYSTEM	60B37770 - 901
325	CALORIMETER PURGE SYSTEM	60B37770 - 902
326	CONTROL PRESSURE SYSTEM	60B52200 - 902
327	RING FRAME NO. 1 (OPERATIONAL)	60B71142 - 901
328	RING FRAME NO 1 (R&D)	60B70036 - 901
329	RING FRAME NO. 2 (OPERATIONAL)	60B71085 - 901
330	RING FRAME NO 2 (R&D)	60B70037 - 901
331	RING FRAME NO. 3 (OPERATIONAL)	60B71082 - 901
332	RING FRAME NO 3 (R&D)	60B70038 - 901
333	CONTROL PRESSURE SYSTEM	60B52200 - 903
334	CONTROL PRESSURE SYSTEM	60B52200 - 904
335	CONTROL PRESSURE SYSTEM	60B52200 - 905
336	ENVIRONMENTAL CONTROL SYSTEM	60B40000 - 901
337	ENVIRONMENTAL CONTROL SYSTEM	60B40000 - 902
338	THRUST CHAMBER PREFILL SYSTEM	60B37550 - 901
339	THRUST CHAMBER PREFILL SYSTEM	60B37550 - 902
340	THRUST CHAMBER PREFILL SYSTEM	60B37550 - 903
341	LOX PRESSURIZATION SYSTEM	60B51400 - 901
342	FUEL PRESSURIZATION SYSTEM	60B49600 - 901
343	FUEL PRESSURIZATION SYSTEM	60B49600 - 902
344	LOX PRESSURIZATION SYSTEM	60B51400 - 902
345	LOX PRESSURIZATION SYSTEM	60B51400 - 903
346	LOX PRESSURIZATION SYSTEM	60B51400 - 904
347	RING FRAME NO 4 (OPERATIONAL)	60B71083 - 901
348	RING FRAME NO 4 (R&D)	60B70039 - 901
349	RING FRAME NO 5 (OPERATIONAL)	60B70040 - 901
350	RING FRAME NO 5 (R&D)	60B71084 - 901
351	RING FRAME NO 6 (OPERATIONAL)	60B71030 - 901
352	RING FRAME NO 6 (R&D)	60B70033 - 901
353	RING FRAME NO 7 (OPERATIONAL)	60B70035 - 901
354	FLUID POWER SYSTEM - STAGE MOUNTED	60B82000 - 901
355	FLUID POWER SYSTEM - STAGE MOUNTED	60B82000 - 902
356	MEASUREMENT (THRUST STRUCTURE)	60B70149 - 901
357	LOX DELIVERY SYSTEM	60B41014 - 907
358	PROPELLANT CONTAINER ASSEMBLY	60B03052-7-902
359	PROPELLANT CONTAINER ASSEMBLY	60B03052-7-903
360	REWORK & MODIFICATION	



NOTES:

1. OPERATIONS 300, 302 & 308 MAY REQUIRE OPTICAL ALIGNMENT WHICH WILL HAVE TO BE PERFORMED ON 2nd SHIFT. ALL OTHER OPERATIONS ARE PERFORMED UNDER NORMAL EFFORT.
2. DOTTED LINES SHOW A CONTINUATION OF TUBE FABRICATION BOTH ON THE THRUST STRUCTURE & IN THE FABRICATION SHOP

MANUFACTURING ENGINEERING LABORATORY
MSFC NASA

Figure 4-3. Thrust Structure Assembly Detail Schedule and Program Chart (Sheet 3 of 6)

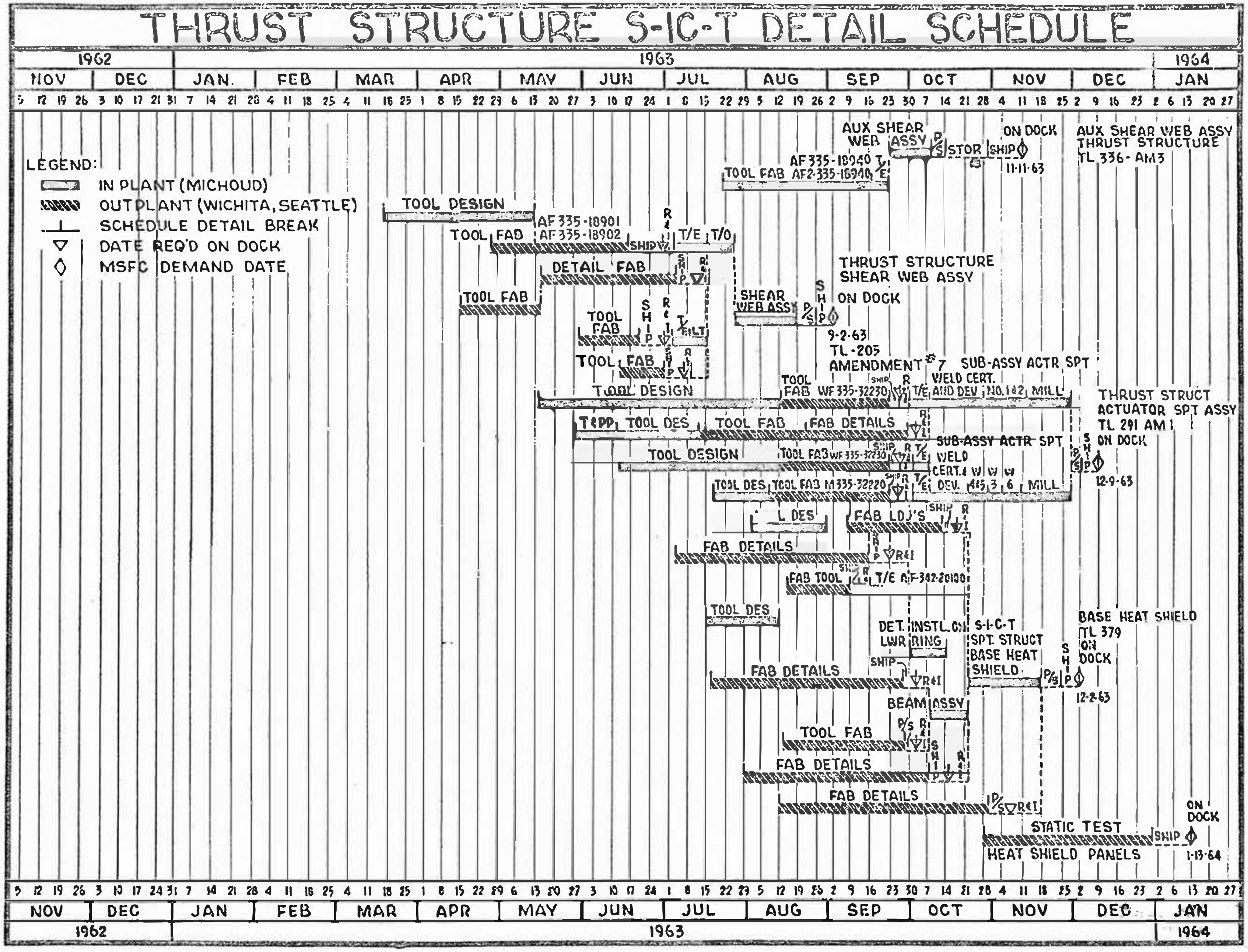


Figure 4-3. Thrust Structure Assembly Detail Schedule and Program Chart
(Sheet 4 of 6)

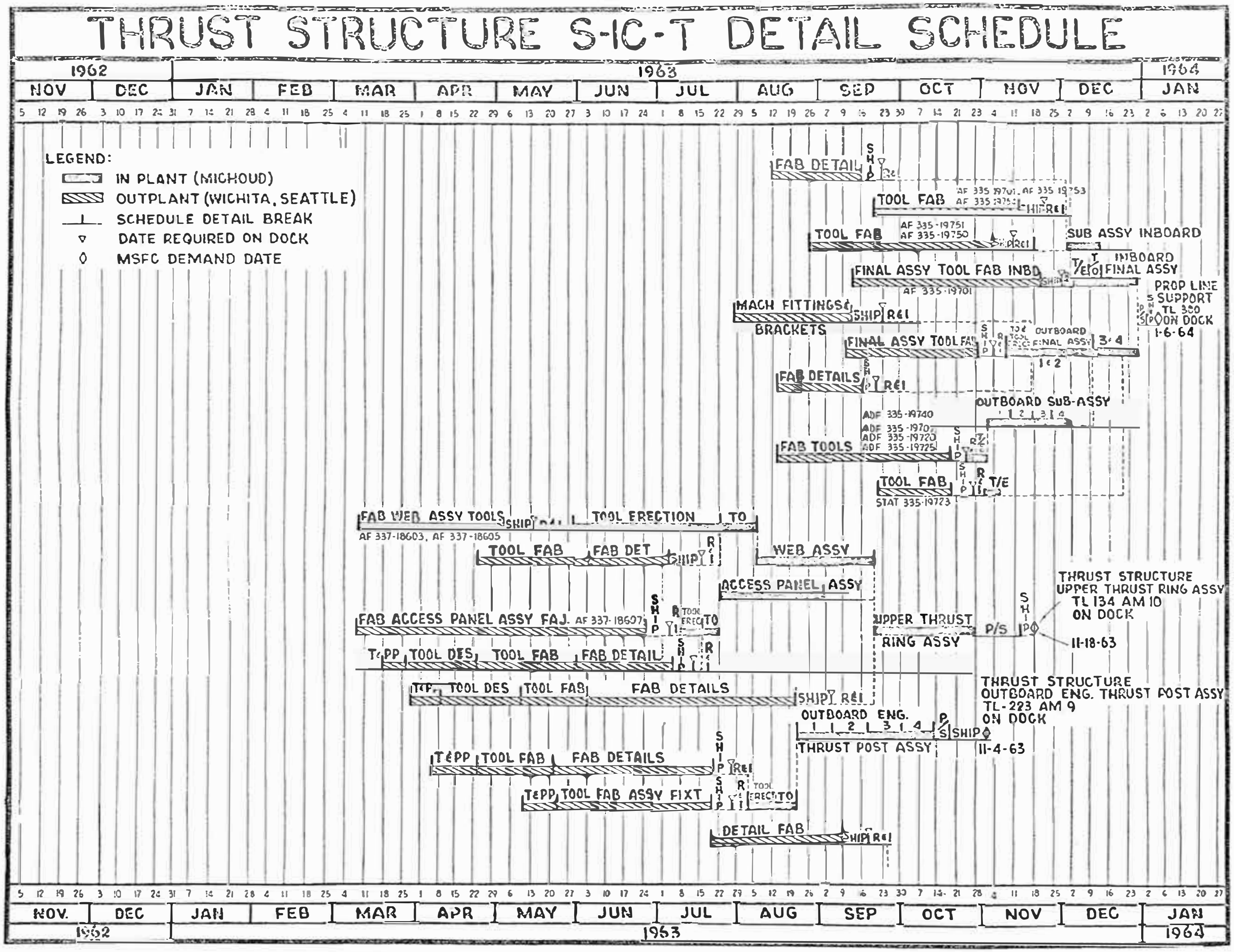


Figure 4-3. Thrust Structure Assembly Detail Schedule and Program Chart (Sheet 5 of 6)

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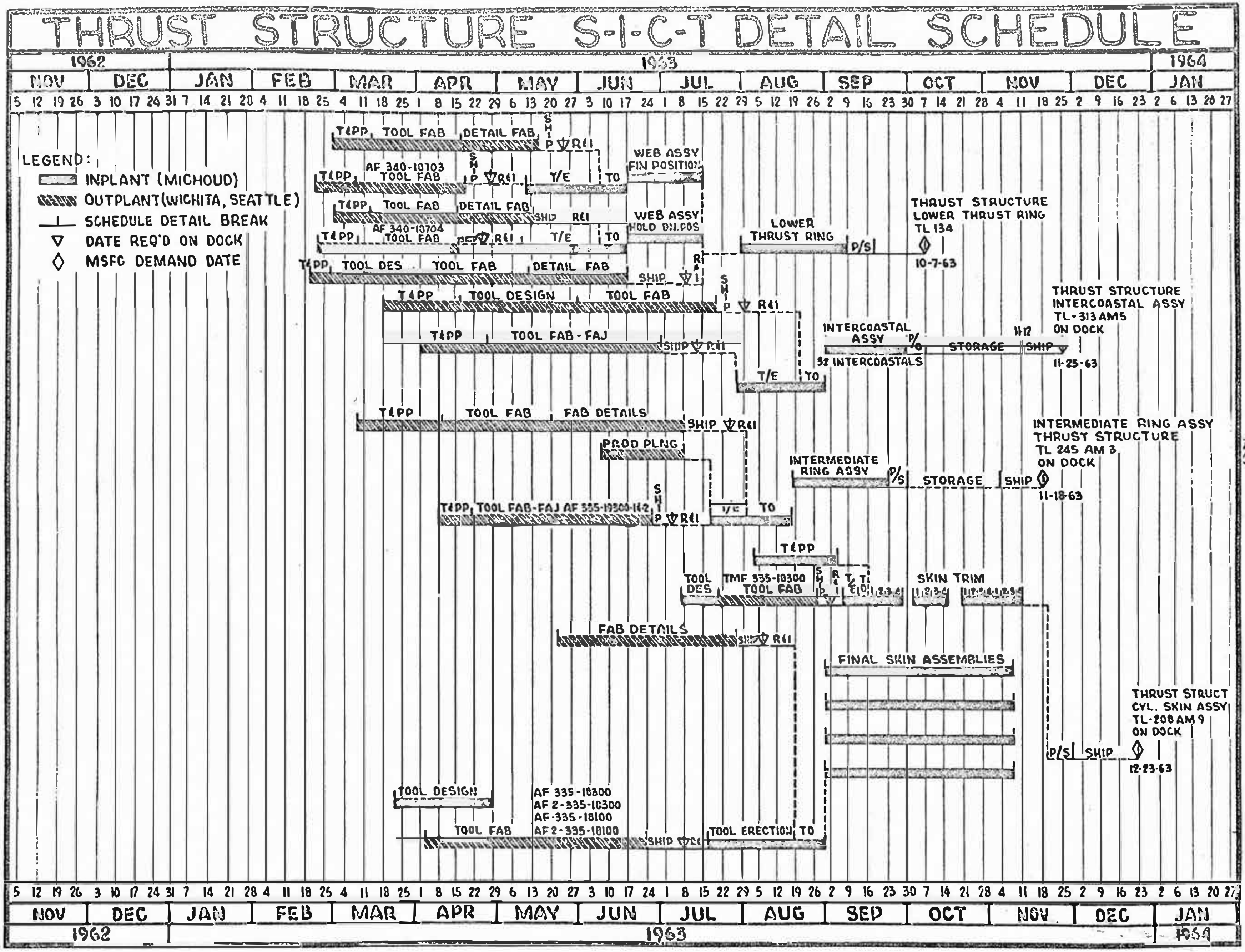


Figure 4-3. Thrust Structure Assembly Detail Schedule and Program Chart (Sheet 6 of 6)

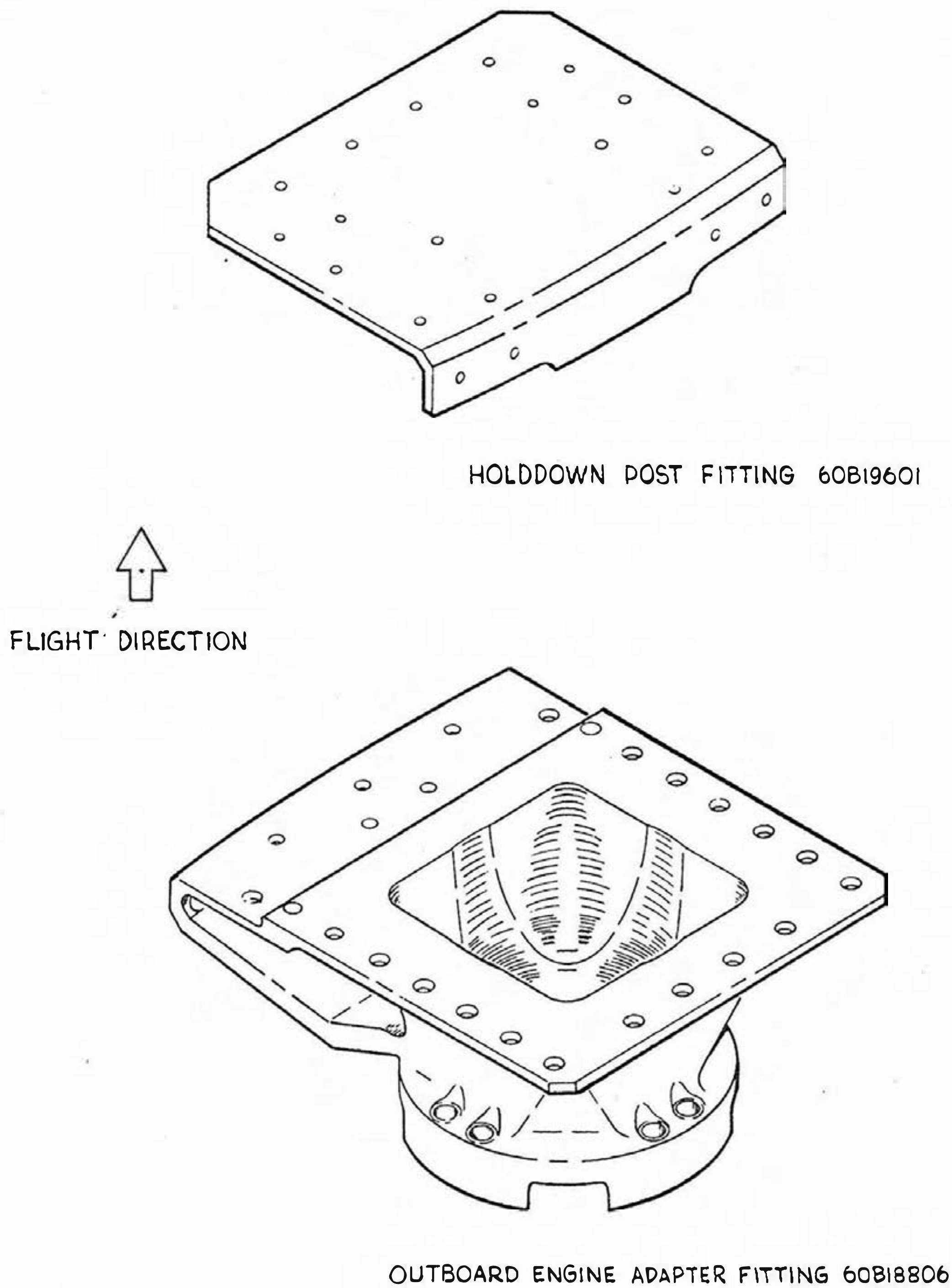
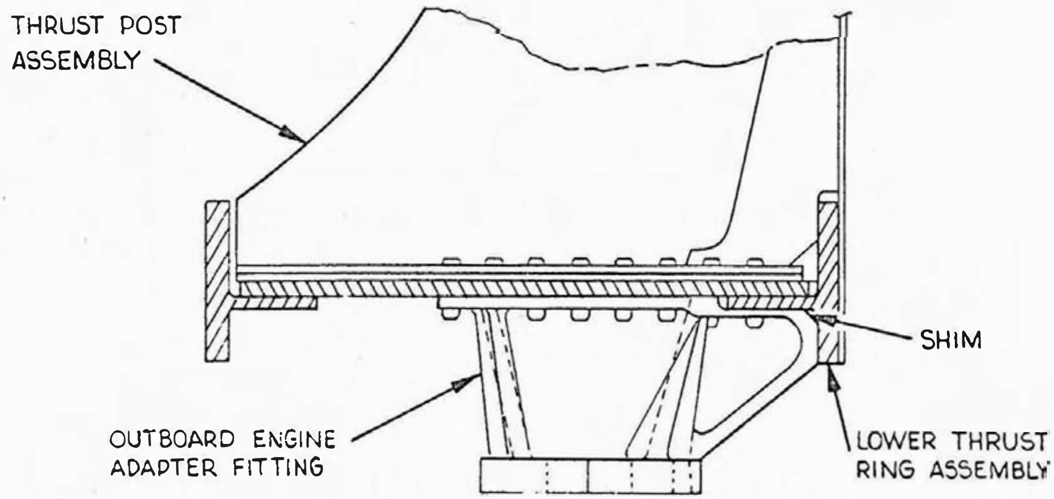
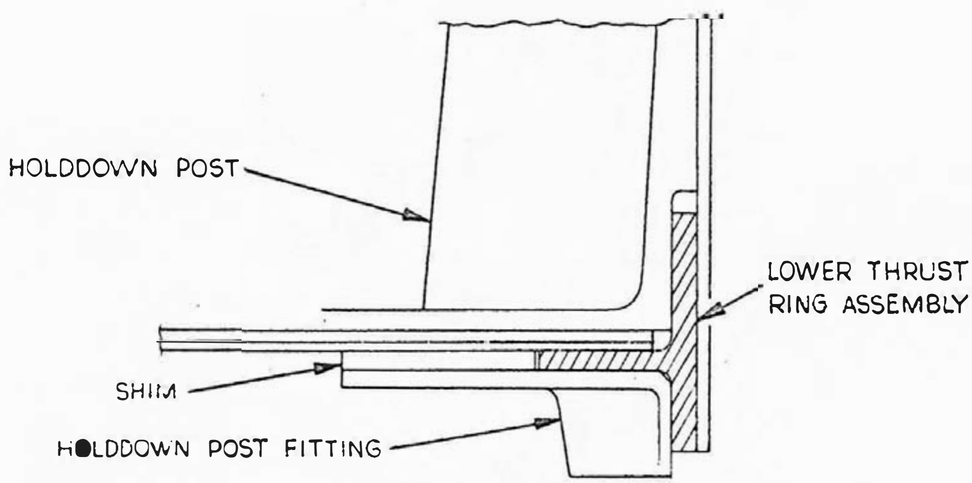


Figure 4-4. Outboard Engine Adapter and Holddown Post Fittings



OUTBOARD ENGINE ADAPTER FITTING INSTALLED



HOLDDOWN POST FITTING INSTALLED

Figure 4-5. Outboard Engine Adapter and Holddown Post Fittings Installed

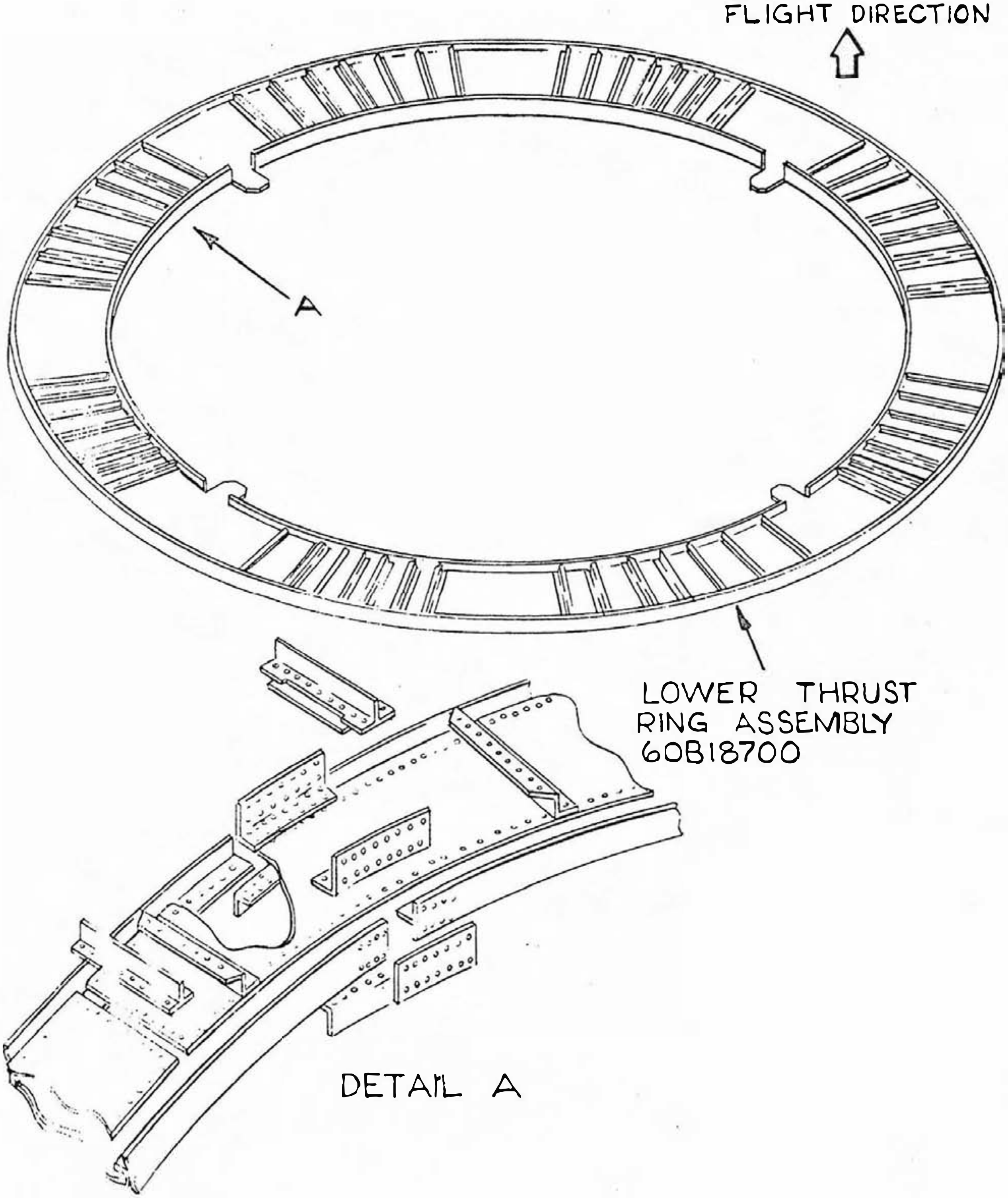


Figure 4-6. Lower Thrust Ring Assembly 60B18700

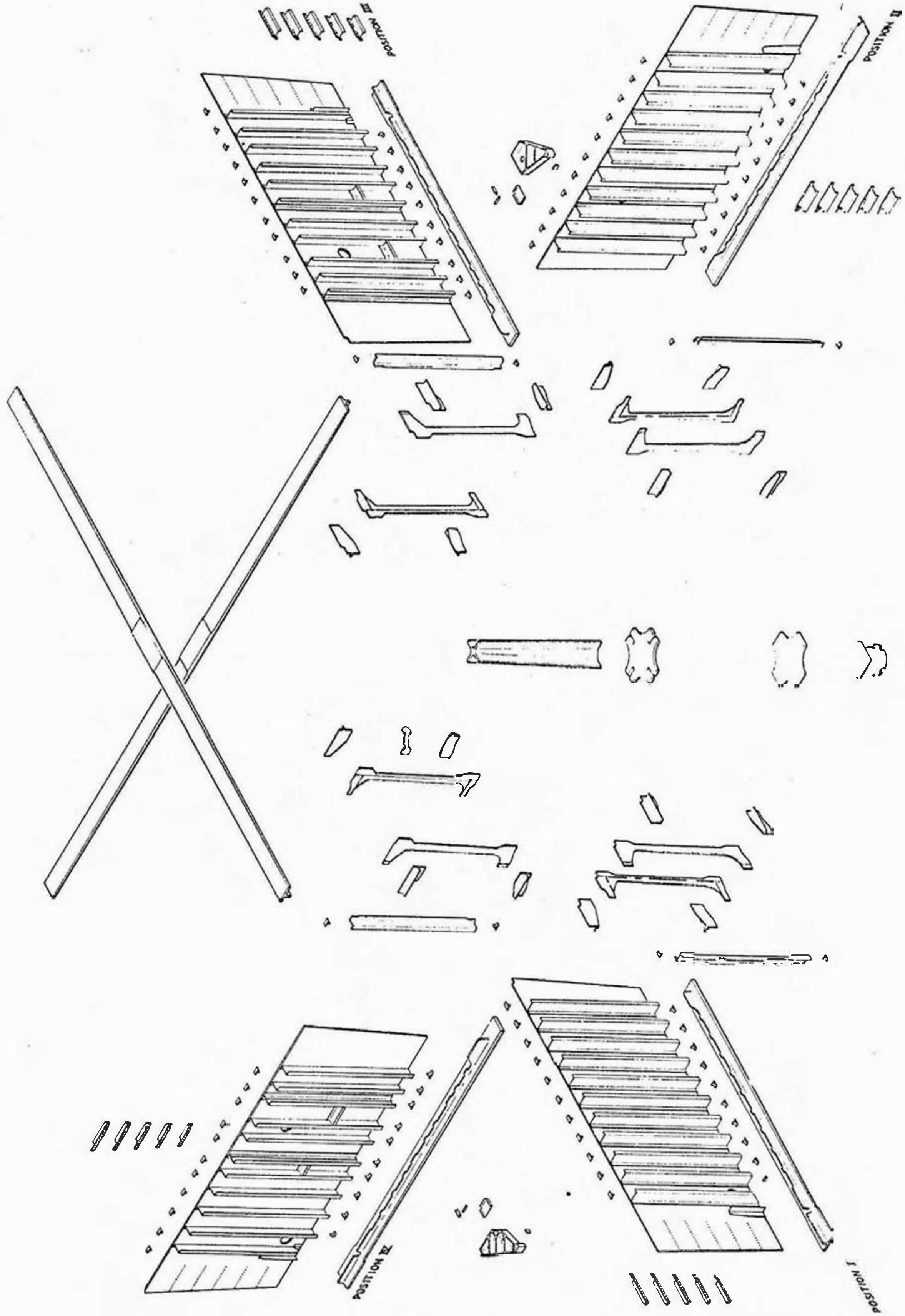


Figure 4-7. Center Engine Support Assembly - Exploded View

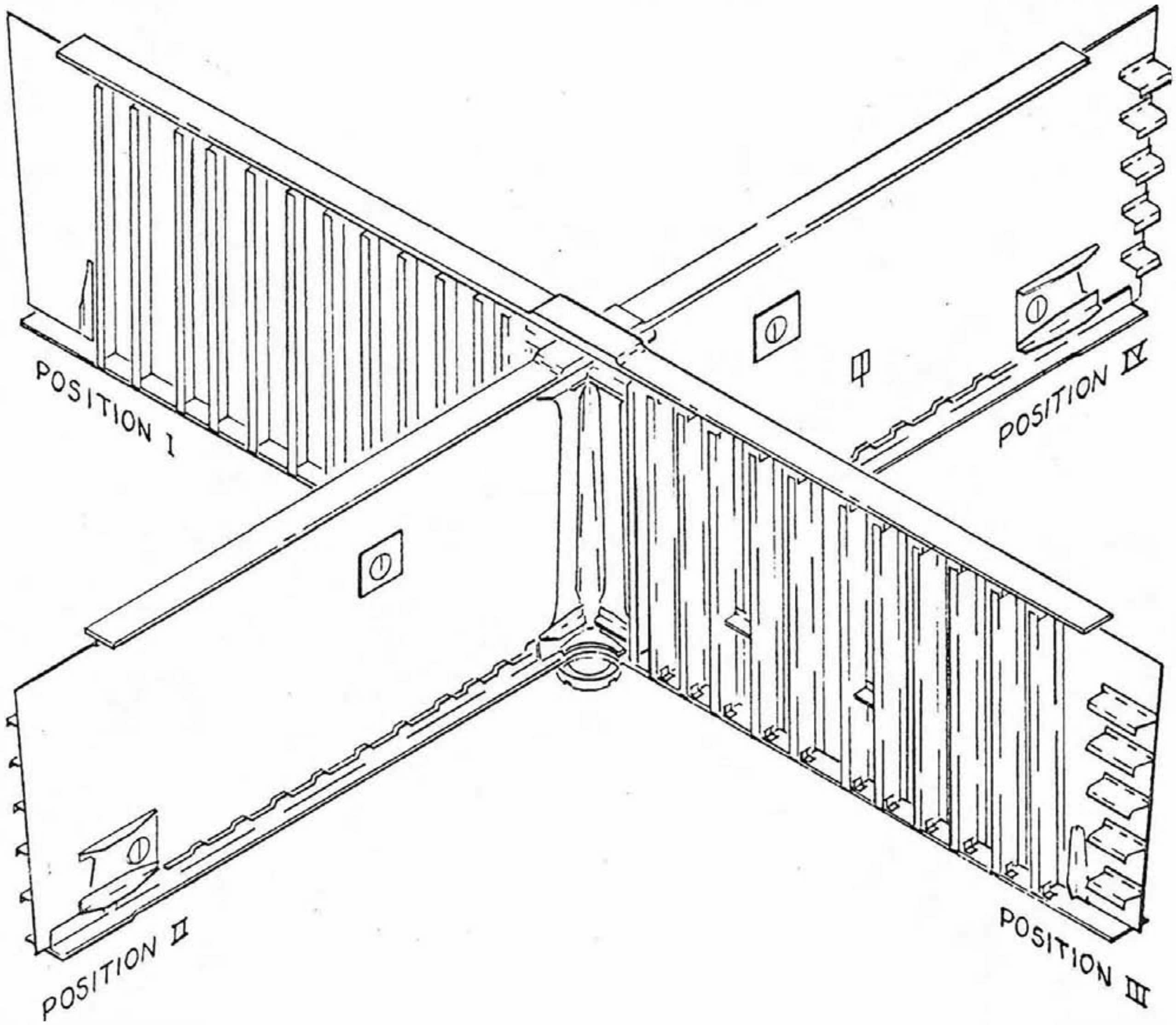


Figure 4-8. Center Engine Support Assembly 60B18900

1.5 <u>Outboard Thrust Post Assembly 60B18800.</u> The outboard thrust post assembly is a built-up, tapered, box-type structure, 14 feet tall and approximately 14 inches by 22 inches at the forward end and 36 inches by 39 inches at the aft end common with the lower thrust ring attach surface. Each outboard thrust post consists of two channels, four bulkheads, two side plates, two shear ties, one lower ring attach fitting and eight intermediate ring attach tees, all joined with common fasteners. There are four outboard thrust posts per thrust structure assembly, one located on each fin line. (See figure 4-9 for detail view of the thrust post assembly.)

1.6 <u>Holddown Post 60B19600.</u> The holddown post is a one-piece forging 14 feet tall and approximately 11 inches square at the base, not including the flange at the faying surface, and tapering to a much smaller section at the upper thrust ring assembly. (See figure 4-9.) There are four holddown posts, one located on each position line between the upper and lower thrust rings.

1.7 <u>Auxiliary Shear Panels.</u> Four auxiliary shear panels are required, one attached to each holddown post bridging the span between the center engine support assembly and the upper thrust ring assembly. (See figure 4-10.) An auxiliary shear panel consists of a web, approximately two feet by seven feet; two angle caps, approximately 13 feet long; and zee stiffeners.

1.8 <u>Upper Thrust Ring Assembly 60B18600.</u> (See figure 4-11.) The upper thrust ring assembly has an outside diameter of 33 feet and an inside diameter of 28 feet. In essence, the upper thrust ring assembly is a circular beam consisting of eight tee caps (four inner and four outer), eight web assemblies, four access panel assemblies, tee cap splice angles, tee cap splice plates, zee stiffeners (at tee cap splice locations) and web splice channels. The web assembly at the fin position is centered on the fin position centerline and the web assembly-access panel combination at the holddown position centerline. Each web assembly consists of a web plate and radial zee stiffeners. An access panel consists of a web plate, a zee stiffener and two splice plates. The tee caps are seven inches high and 3/4 inch thick with a leg 4-1/4 inches long and 1/2 inch thick. The tee caps are extrusions which are stretch-formed and machined to contour. Web plates are 3/16 inch thick and zee stiffeners are 2-1/4 inches high with flanges 1-1/4 inches long. Web splice channels are 7-1/4 inches wide and 2-1/2 inches deep. Approximate weight of the complete upper thrust ring assembly is 2700 pounds.

1.9 <u>Intermediate Rings.</u> An intermediate ring consisting of eight subassemblies is located at each of the following stations: 152.5, 184.0, 216.0, and 248.0. Each assembly is located between a holddown post and thrust post and is fastened to the posts and skins. A subassembly consists of an outer tee chord (curved), inner tee chord (straight), doublers, stiffener angles, and web. A jay-cross section ring, located at station 315, is from eight stretch-formed extrusions spliced together. (See figures 4-2 and 4-12.)

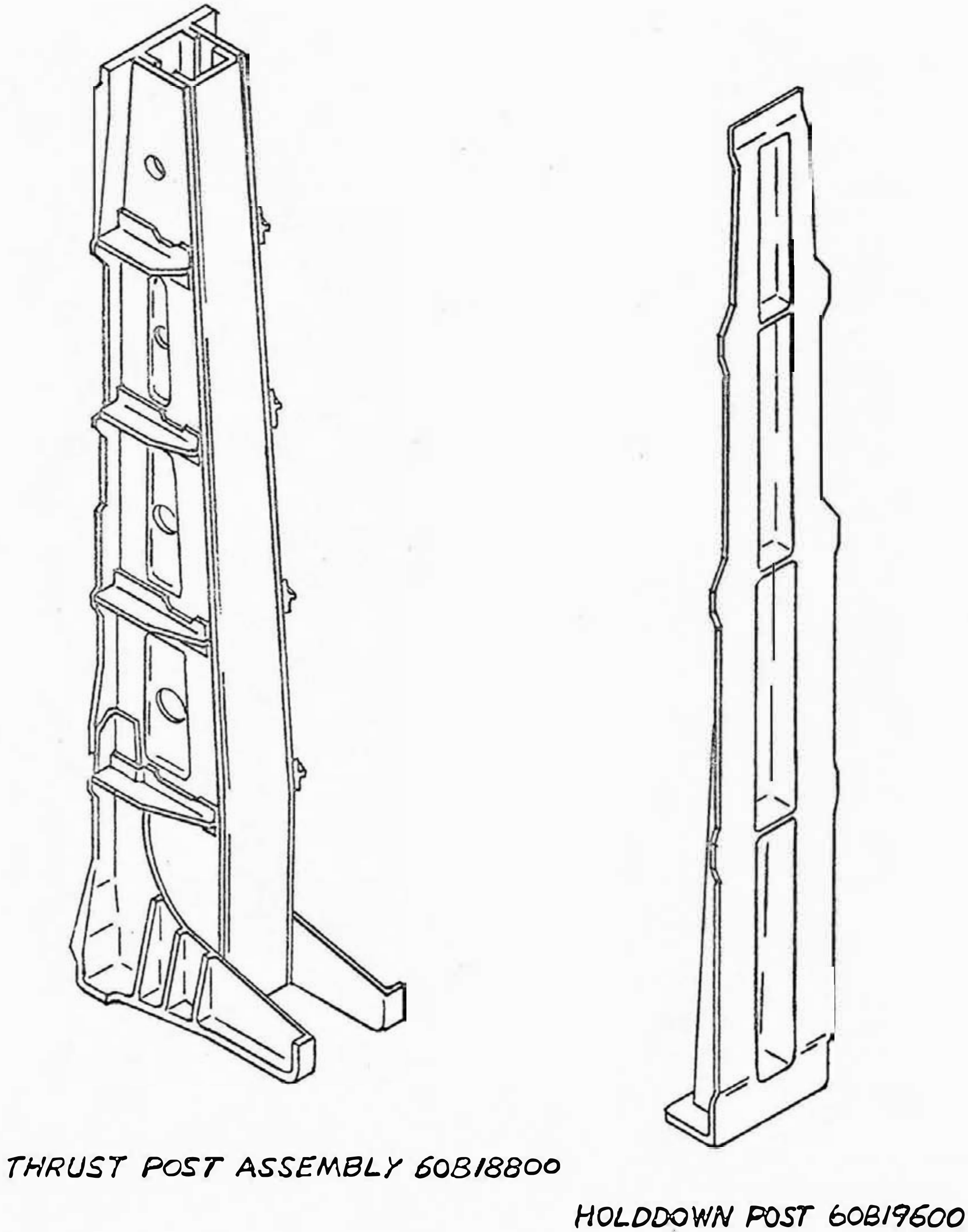


Figure 4-9. Assembled Thrust and Holddown Posts

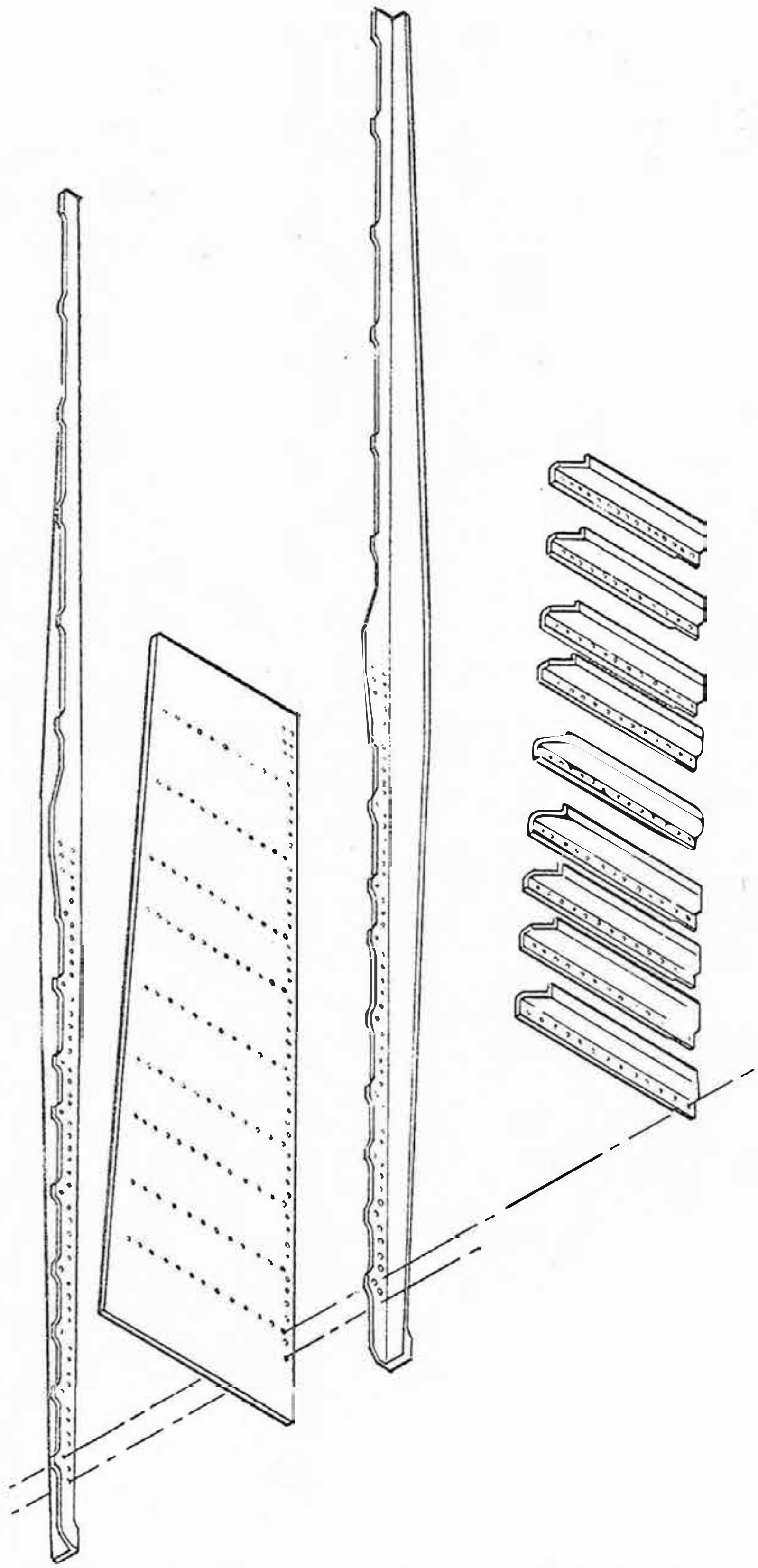


Figure 4-10. Auxiliary Shear Panel - Exploded View

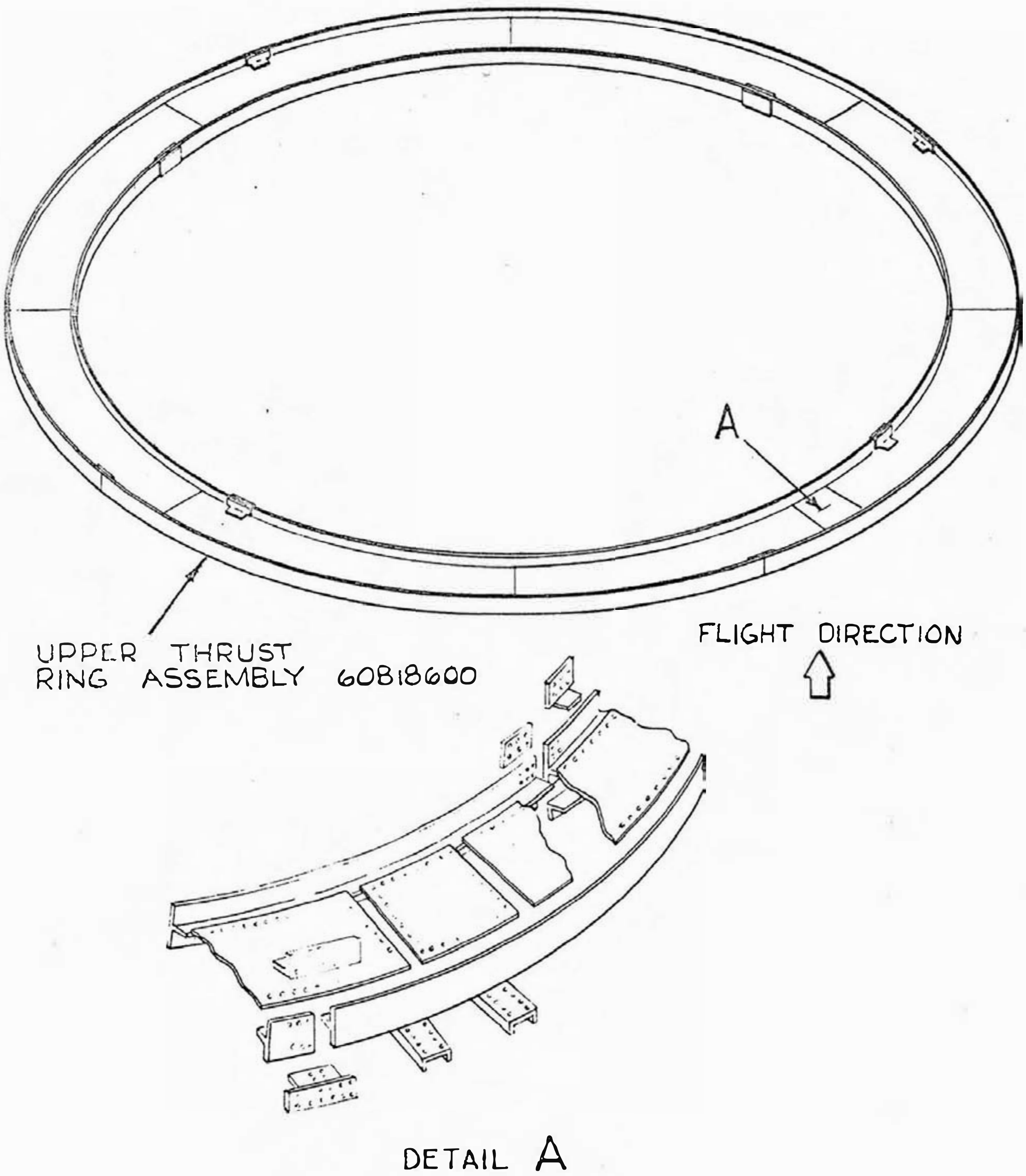
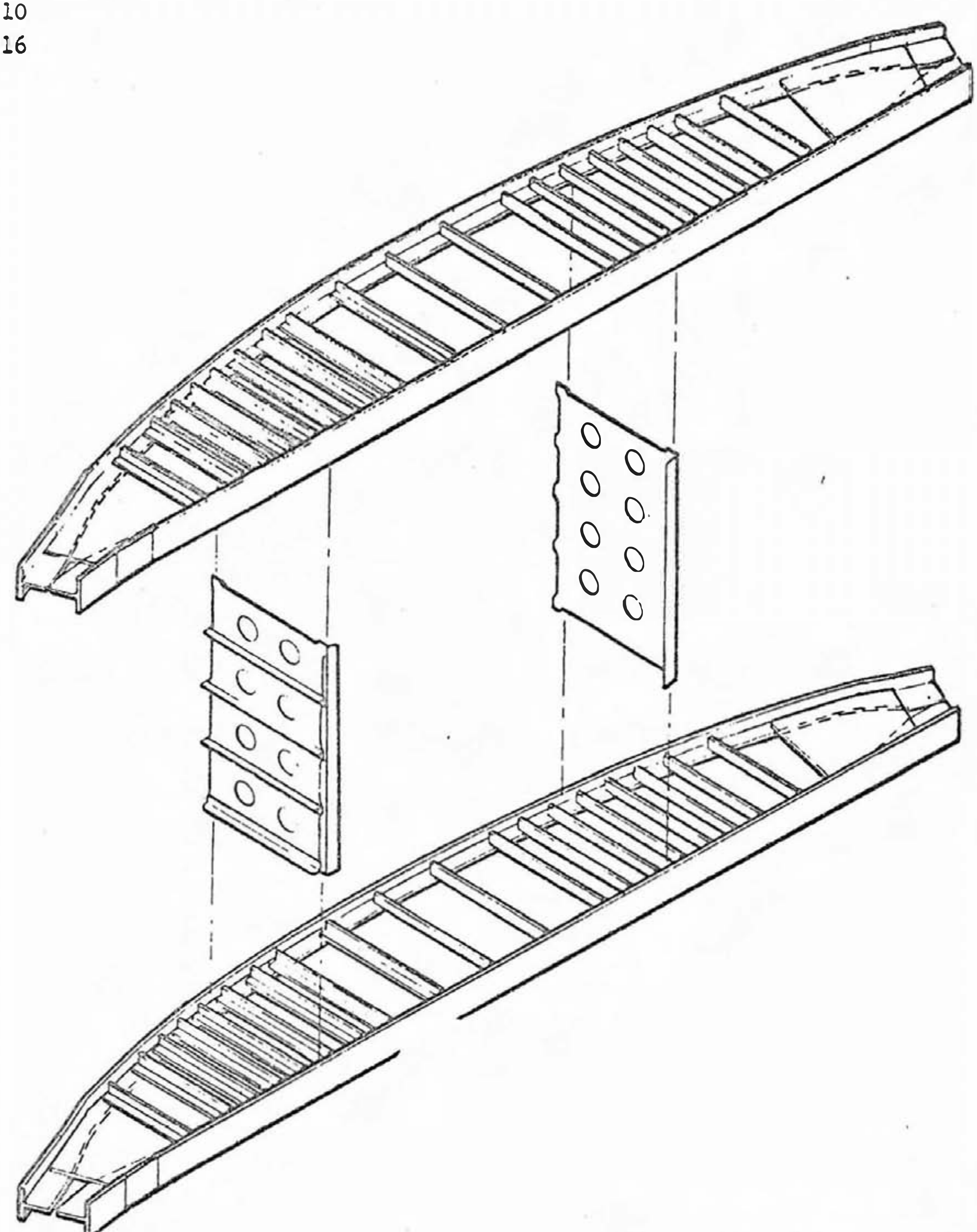


Figure 4-11. Upper Thrust Ring Assembly 60B18600

Intercostal Assemblies

60B19300
60B19301
60B19310
60B19316



Intermediate Ring Assemblies

60B19110	60B19140
60B19120	60B19159
60B19130	60B19160

Figure 4-12. Intermediate Rings and Intercostal Assemblies

1.10 Intercostal Assembly. (See figure 4-12.) The intercostal assemblies are web-type assemblies approximately 19 inches by 32 inches, consisting of web, cap, chord, and three stiffeners. A total of 32 intercostals is used in the thrust structure. Sixteen assemblies are installed between the intermediate rings at stations 152.5 and 184 and sixteen are positioned between the intermediate rings at stations 216 and 248. Two intercostal assemblies at each of the stations 152.5, 184, 216, and 248 are spaced between each holddown post and each thrust post.

1.11 Skin Assemblies. The skin assemblies are fabricated from cylindrical panels reinforced by hat-shaped stiffeners. Cylindrical panels are machined plate varying in thickness from 3/16 inch to 5/8 inch. The complete thrust structure skin is fabricated from 16 skin assemblies vertically spliced together. Each skin assembly weighs approximately 1000 pounds; the complete thrust structure skin weighs approximately 16,000 pounds. (See figures 4-2 and 4-13.)

1.12 Propellant Line Supports 60B19701 and 60B19702. The propellant line supports include four outboard supports 60B19702 and one inboard support 60B19701. Outboard supports are a sheet-girder-type, rectangular box-like structure secured to the outboard thrust posts 60B18800 by four struts and the intermediate ring 60B19120 by two struts per each support. The inboard support is a sheet-girder-type, trapezoidal box-like structure supported by the center engine support shear webs 60B18902 and 60B18920 and secured to the center engine thrust post 60B18915 by two struts. (See figures 4-14 and 4-15.)

1.13 Base Heatshield. For information pertaining to the base heatshield, refer to Section IVb of this Manufacturing Plan.

1.14 Actuator Support Structure. The actuator support structure consists of tubing and machined forgings welded together to form the structure as shown in figure 4-16.

1.15 Retro-Rocket Support Structure. The retro-rocket support structure is, in essence, three separate fittings, one aft and two forward, and is required at eight places to support the right retro-rockets. The aft fitting is a combination fitting which attaches to the outer structure and the actuator support tube and consists of a ball-in-socket bearing for the retro-rockets and a clevis-type attachment for the actuator support tube. The forward fittings attach to the outer structure and are equipped with ball-in-socket bearings for attachment to the retro-rocket pivot supports. The attach fitting assemblies and the retro-rockets must fit with controlled interchangeability.

1.16 Engine Fairing Assemblies. For information pertaining to the engine fairing assemblies, refer to Section IVa of this Manufacturing Plan.

1.17 Fin Assemblies. For information pertaining to the fin assemblies, refer to Section IVa of this Manufacturing Plan.

1.18 Details and Subassemblies - MSFC. To expedite the Saturn V booster stage S-IC Program, it is anticipated that the following details and subassemblies are to be procured for the thrust structure assembly. The Boeing Company Saturn Booster Branch will procure all handware as details.

1.18.1 Details.

a. Center Engine Thrust Post (See figure 4-7.)

b. Outboard Engine Adapter Fittings (See figure 4-4.)

c. Holddown Post Fittings (See figure 4-4.)

d. Intermediate Rings, Station 315 (See figure 4-2.)

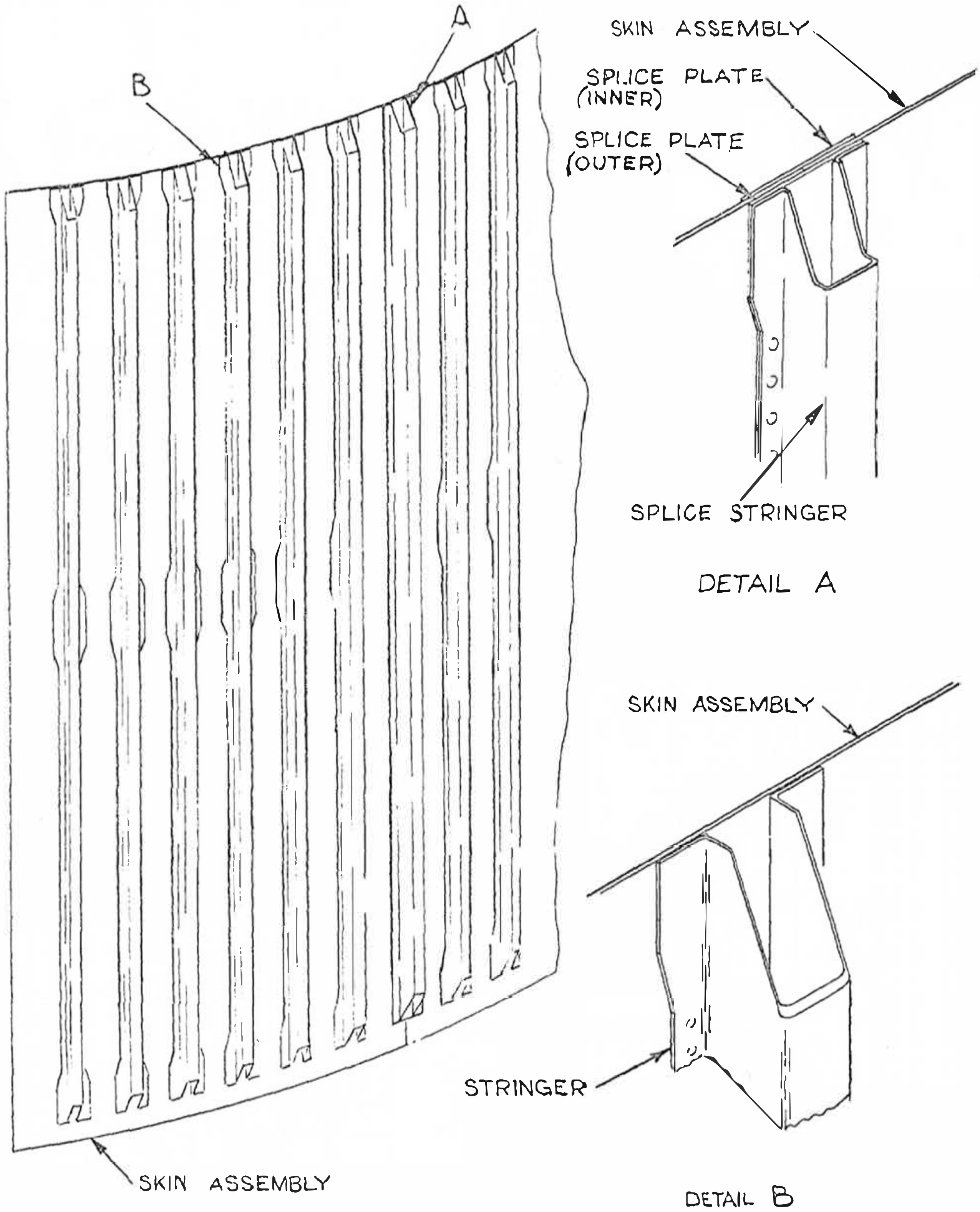


Figure 4-13. Skin Assemblies

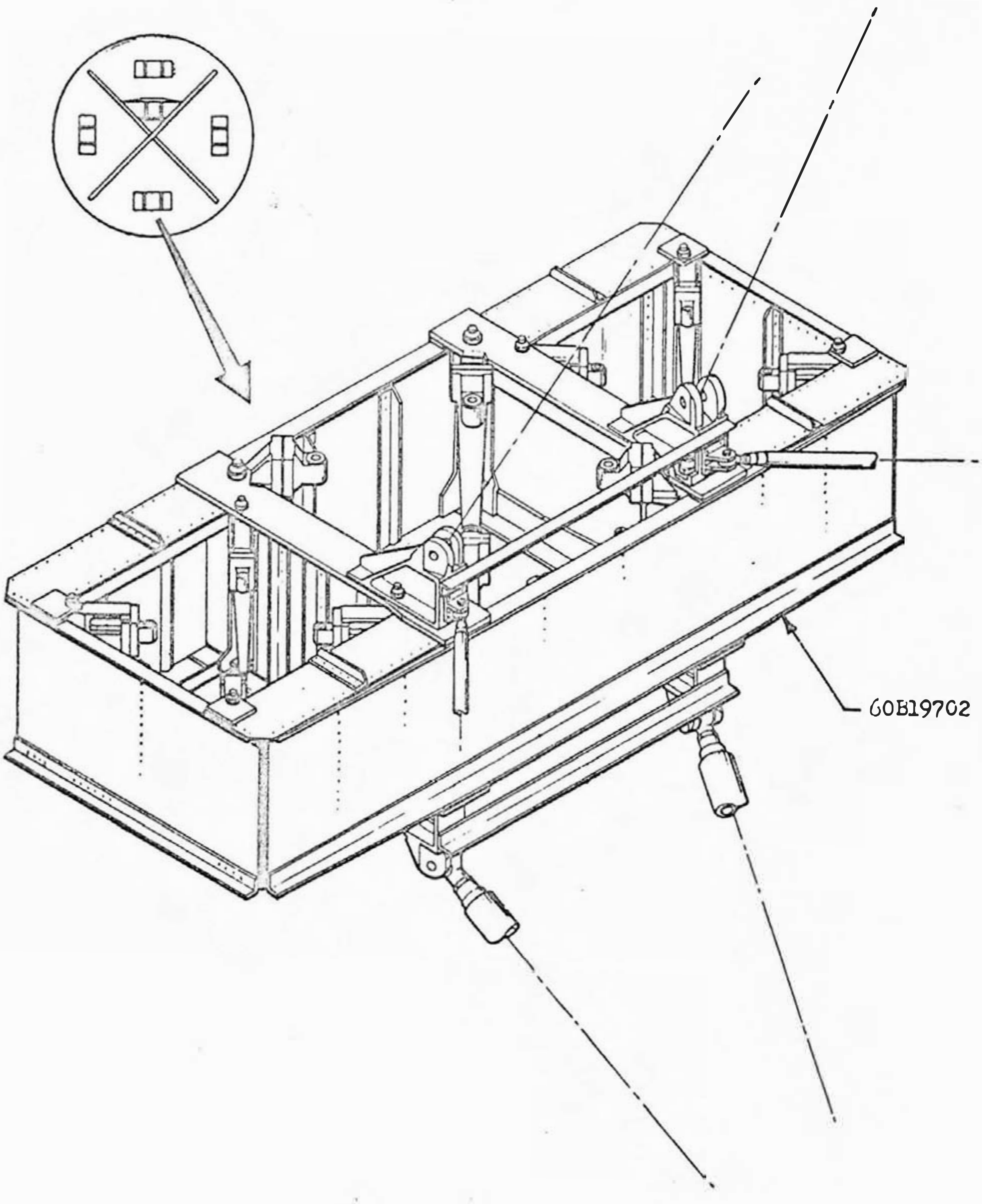


Figure 4-14. Outboard Propellant Line Supports 60B19702

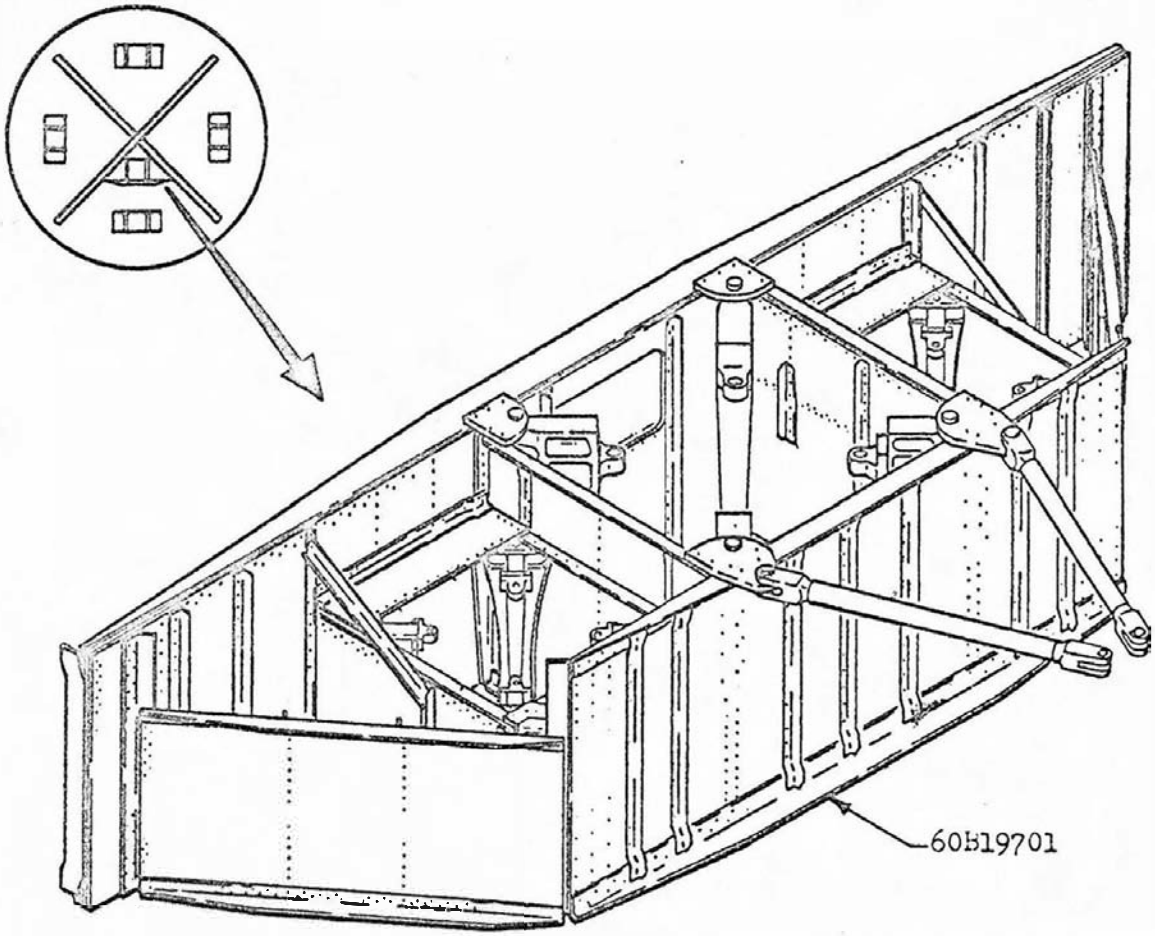


Figure 4-15. Inboard Propellant Line Supports 60B19701

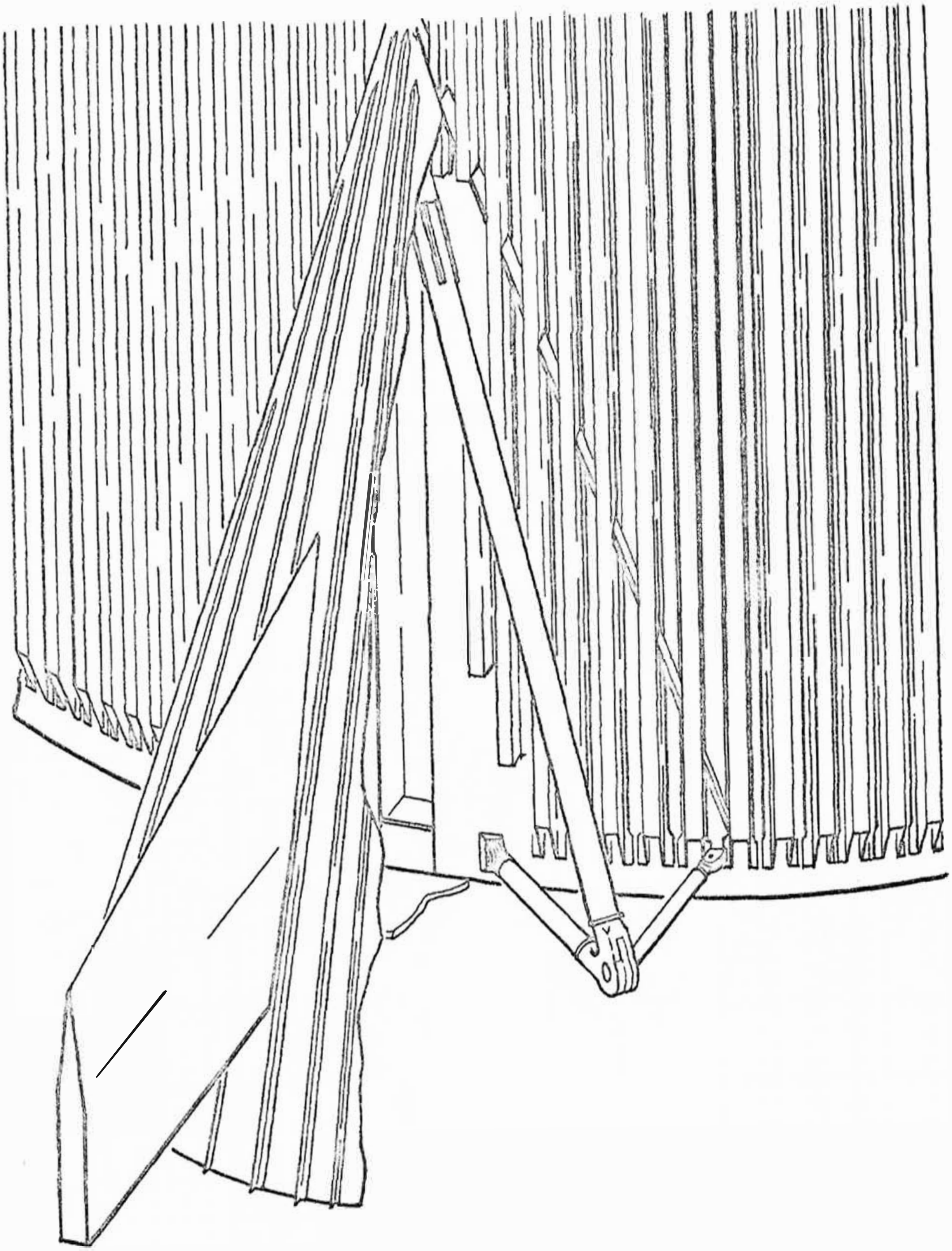


Figure 4-16. Actuator Support Structure

1.18.1 (Con.)

e. Center Engine Adapter Fitting (See figure 4-7.)
f. Holddown Posts (See figure 4-9.)
g. Miscellaneous Clips, Splice Plates, Fittings, etc.

1.18.2 Subassemblies.

a. Outboard Thrust Post Assemblies (See figure 4-9.)

b. Skin Assemblies (See figure 4-13.)

c. Center Engine Support Web Assemblies (See figure 4-7.)

d. Upper Thrust Ring Assembly (See figure 4-11.)

e. Lower Thrust Ring Assembly (See figure 4-6.)

f. Propellant Line Support Structure (See figure 4-15.)

g. Retro-Rocket Support Structure (See figure 4-17.)

h. Fin Assemblies (Refer to Section IVa.)

j. Engine Fairings (Refer to Section IVa.)

k. Actuator Support Structure (See figure 4-16.)

l. Auxiliary Shear Panels (See figure 4-10.)

m. Intermediate Rings (See figure 4-12.)

n. Heatshield Support Structure (Refer to Section IVb.)

o. Intercostal Assemblies (See figure 4-12.)

2. ASSEMBLY.

2.1 Lower Thrust Ring Web Assemblies.

2.1.1 The lower ring holddown position web assemblies 60B18704-1A-900 and 60B18704-1A-901 are assembled in lower ring holddown position web assembly assembly fixture AF-340-18704. (See figure 4-18.)

2.1.1.1 Web assembly 60B18704-1A-900 is identical to the web assembly 60B18704-1A except for the omission of four stiffeners and holes and fasteners common to the tee caps.

2.1.1.2 Web assembly 60B18704-1A-901 is identical to web assembly 60B18704-1A except for the omission of two stiffeners and holes and fasteners common to the tee caps.

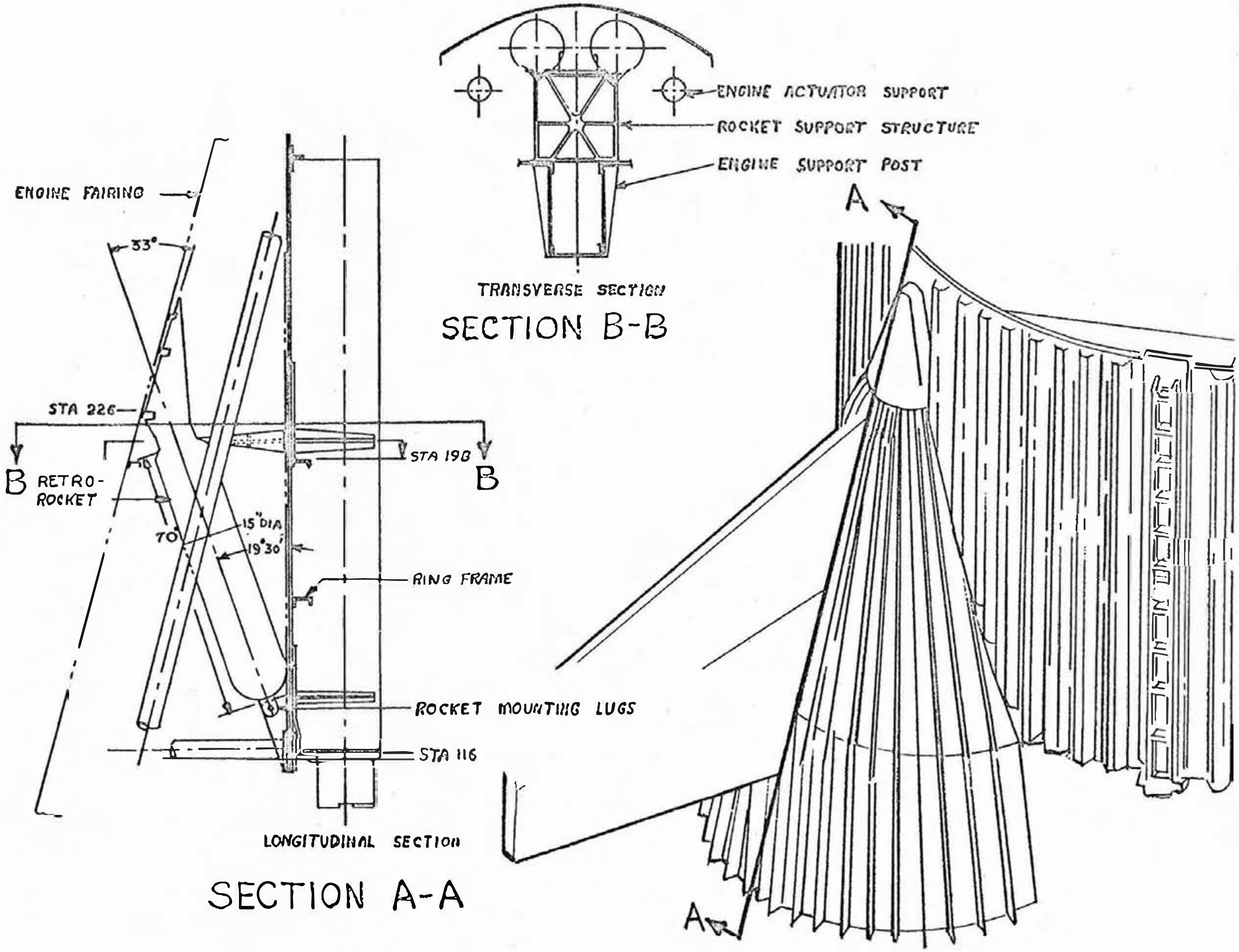


Figure 4-17. Retro-Rocket Support Structure

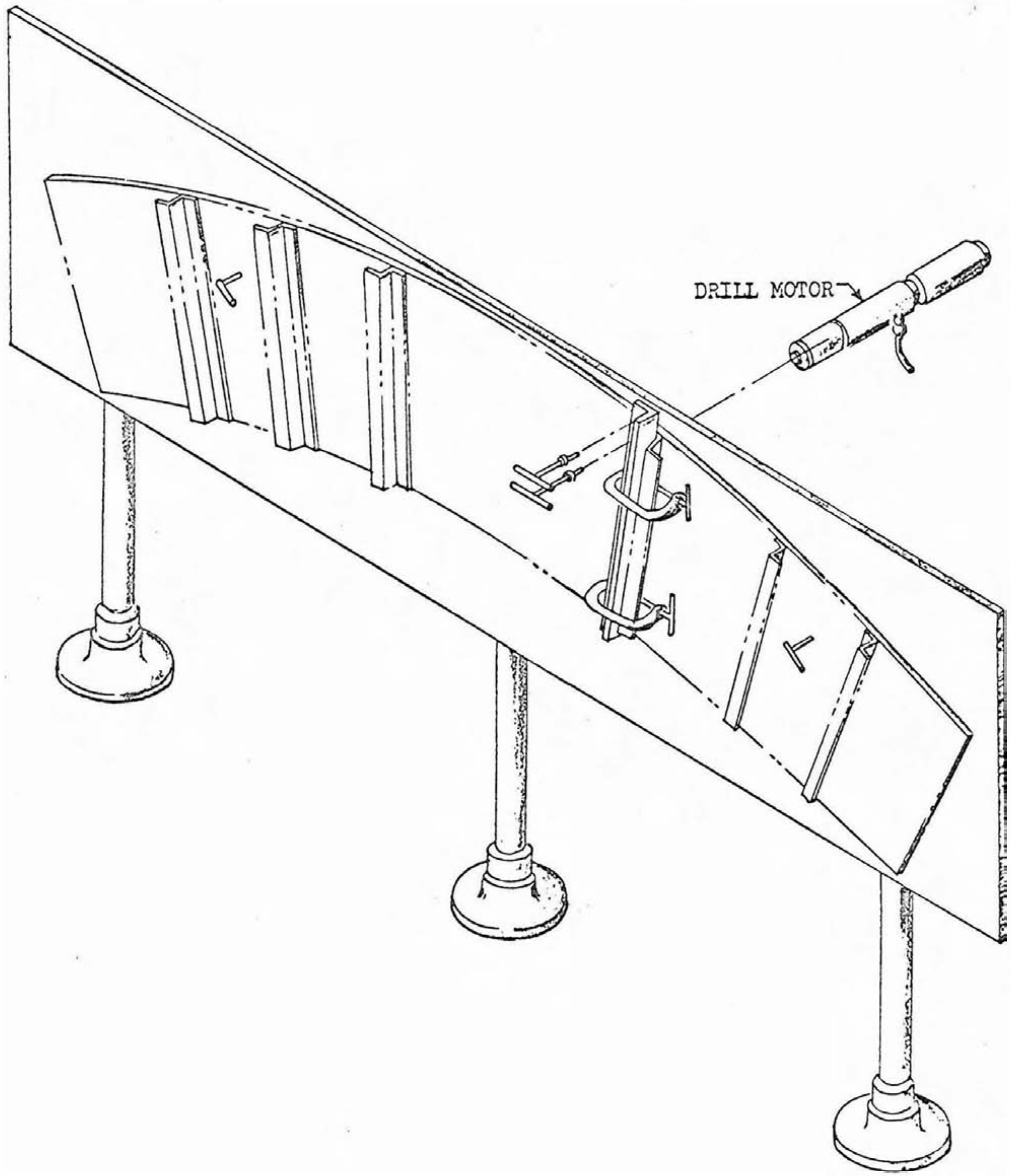


Figure 4-18. Typical Thrust Ring Web Assembly, Assembly Fixture

2.1.1.3 Assemble web assemblies 60B18704-1A-900 and 60B18704-1A-901 as outlined in paragraphs 2.1.1.4 through 2.1.1.9.

2.1.1.4 Use web assembly hoisting tool HT-370-18100 to load web into assembly fixture AF-340-18704. (See figure 4-19.)

2.1.1.5 Drill two 1/4-inch diameter tooling holes.

2.1.1.6 Load the doubler and the stiffeners.

2.1.1.7 Drill all fastener holes common to web, stiffeners, and doublers. Omit all fastener locations common to the inboard and outboard thrust ring tee caps.

2.1.1.8 Install fasteners.

2.1.1.9 Remove web assembly from assembly fixture AF-340-18704 using hoisting tool HT-370-18100.

2.1.2 The lower ring fin position web assembly 60B18703-1A-900 is assembled in the lower ring fin position web assembly fixture AF-340-18703. (See figure 4-18.)

2.1.2.1 Web assembly 60B18703-1A-900 is identical to web assembly 60B18703-1A except for the omission of holes and fasteners in the area common to the stiffeners and lower thrust ring tee caps.

2.1.2.2 Use hoisting tool HT-370-18100 to load web into assembly fixture AF-340-18703. (See figure 4-19.)

2.1.2.3 Drill two 1/4-inch diameter tooling holes.

2.1.2.4 Load and locate the doubler and stiffeners.

2.1.2.5 Drill all fastener holes common to web, stiffeners, and doubler. Omit all fastener locations common to inboard and outboard thrust ring tee caps.

2.1.2.6 Install fasteners.

2.1.2.7 Remove web assembly from assembly fixture AF-340-18703 using hoisting tool HT-370-18100.

2.2 Lower Thrust Ring Assembly 60B18700-1-900. The lower thrust ring assembly 60B18700-1-900 is assembled in the upper and lower thrust rings assembly fixture AF-340-7071. (See figure 4-20.) The ring assembly 60B18700-1-900 is identical to the ring assembly 60B18700-1 except for the addition of twenty base heatshield attach clips, omission of twelve stiffeners near the holddown position, omission of four holes common to tee cap splice, and undersize fasteners and bolts in the splice cap area. The lower thrust ring is assembled as outlined in paragraphs 2.2.1 through 2.2.8.

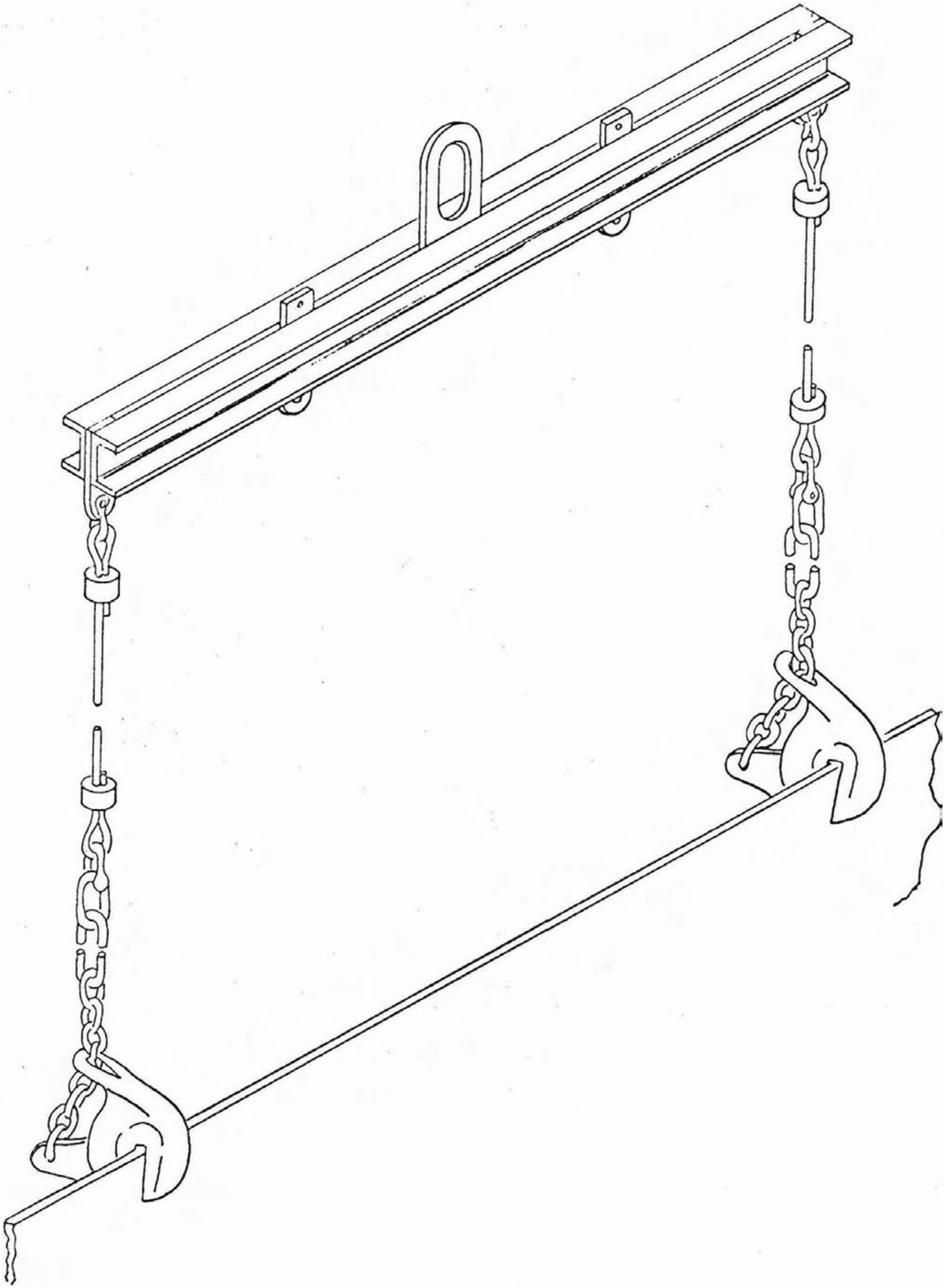


Figure 4-19. Skin Panel Assemblies and Thrust Ring Web Assemblies Hoisting Tool HT-370-18100

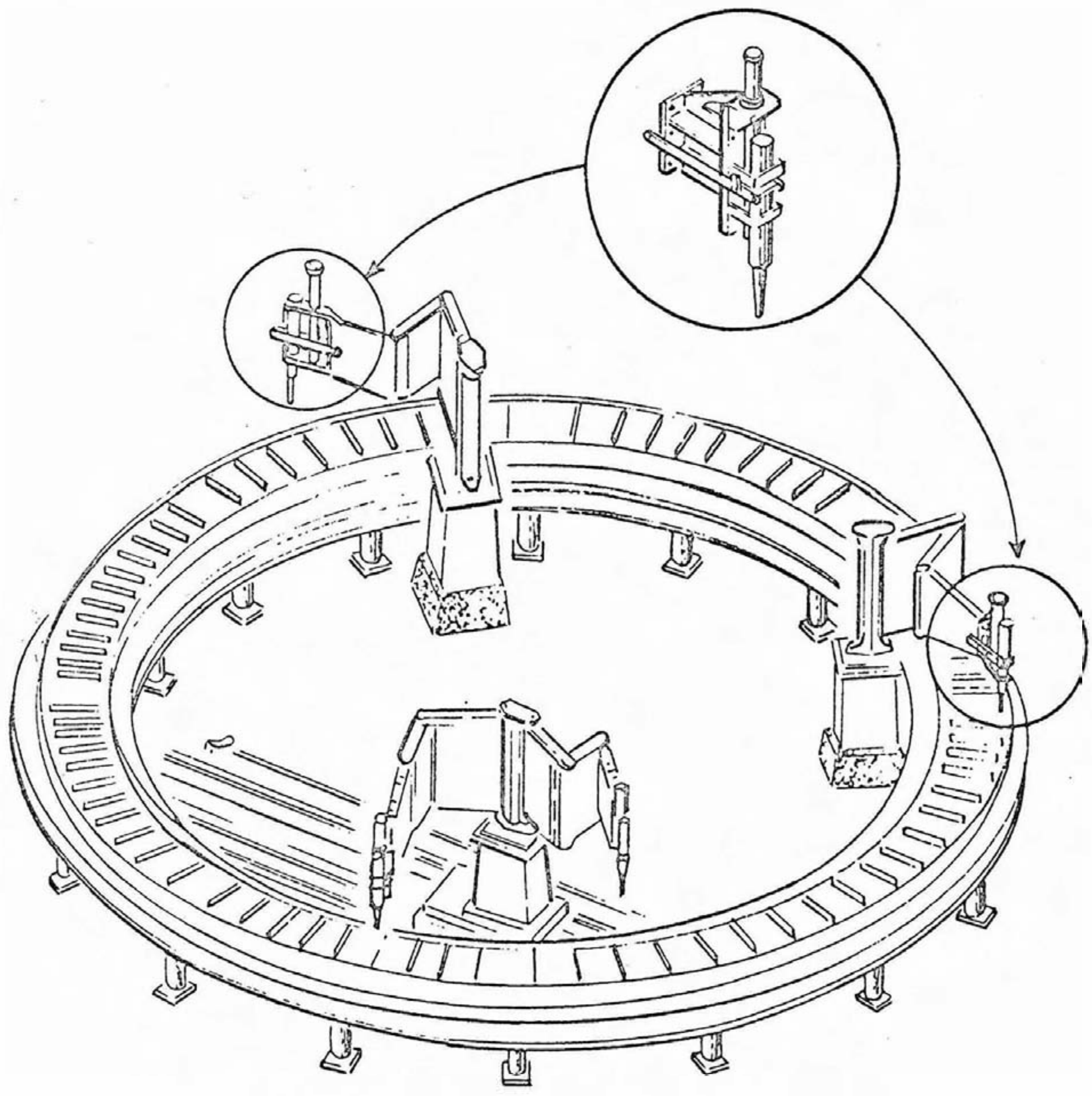


Figure 4-20. Upper and Lower Thrust Rings Assembly Fixture AF-340-7071

2.2.1 Load lower tee cap splice angles and outboard heatshield clip angles.

2.2.2 Load inboard and outboard thrust ring tee caps using tee cap hoisting tool HT-370-18709. (See figure 4-21.)

2.2.3 Load lower thrust ring web assemblies using hoisting tool HT-370-18703. (See figure 4-22.)

2.2.4 Load web splice plate, upper tee cap splice angles, tee cap splice plates, and inboard heatshield clip angle.

2.2.5 Drill all fastener holes full size except holes common to outer tee cap splice. Drill holes common to splice 3/8-inch diameter.

2.2.6 Install fasteners.

2.2.7 Drill four 0.500 diameter tooling holes.

2.2.8 Remove lower thrust ring assembly 60B18700-1-900 from assembly fixture AF-340-7071 using thrust ring assembly hoisting tool HT-370-7101. (See figure 4-23.)

2.3 Center Engine Support Web Assemblies 60B18901, 60B18902, 60B18919, and 60B18920 - At Michoud. (See figures 4-7 and 4-8.) Assemble center engine support web assemblies 60B18901 and 60B18919 in assembly fixture AF-335-18901. (See figure 4-24.) Assemble center engine support web assemblies 60B18902 and 60B18920 in assembly fixture AF-335-18902. All web assemblies have been fabricated to meet the drawing requirements except as follows:

All holes in web assemblies for fasteners common to the center engine support caps are omitted. The horizontal stiffeners on the center engine support web assemblies are located and drilled; however, the fasteners are omitted. The horizontal stiffeners are shown on the center engine support installation drawing 60B18940. Web assemblies are designated as follows:

Web Assembly Part No.	Position
60B18901-1-900	I
60B18919-1-900	II
60B18902-1-900	III
60B18920-1-900	IV

2.3.1 For web assembly 60B18901, load stiffeners in assembly fixture AF-335-18901 and clamp in place. Load web into assembly fixture AF-335-18901 with hoisting tool HT-370-7092. (See figure 4-25.) Load doublers and miscellaneous parts. Personnel platforms PP-370-18901 are provided to gain access to upper part of assembly fixture AF-335-18901. (See figure 4-26.)

2.3.2 Using drill plates of assembly fixture AF-335-18901 and locating drill jigs LDJ-335-18901, drill and ream all fastener holes common to web, doublers, and stiffeners. (See figure 4-27.)

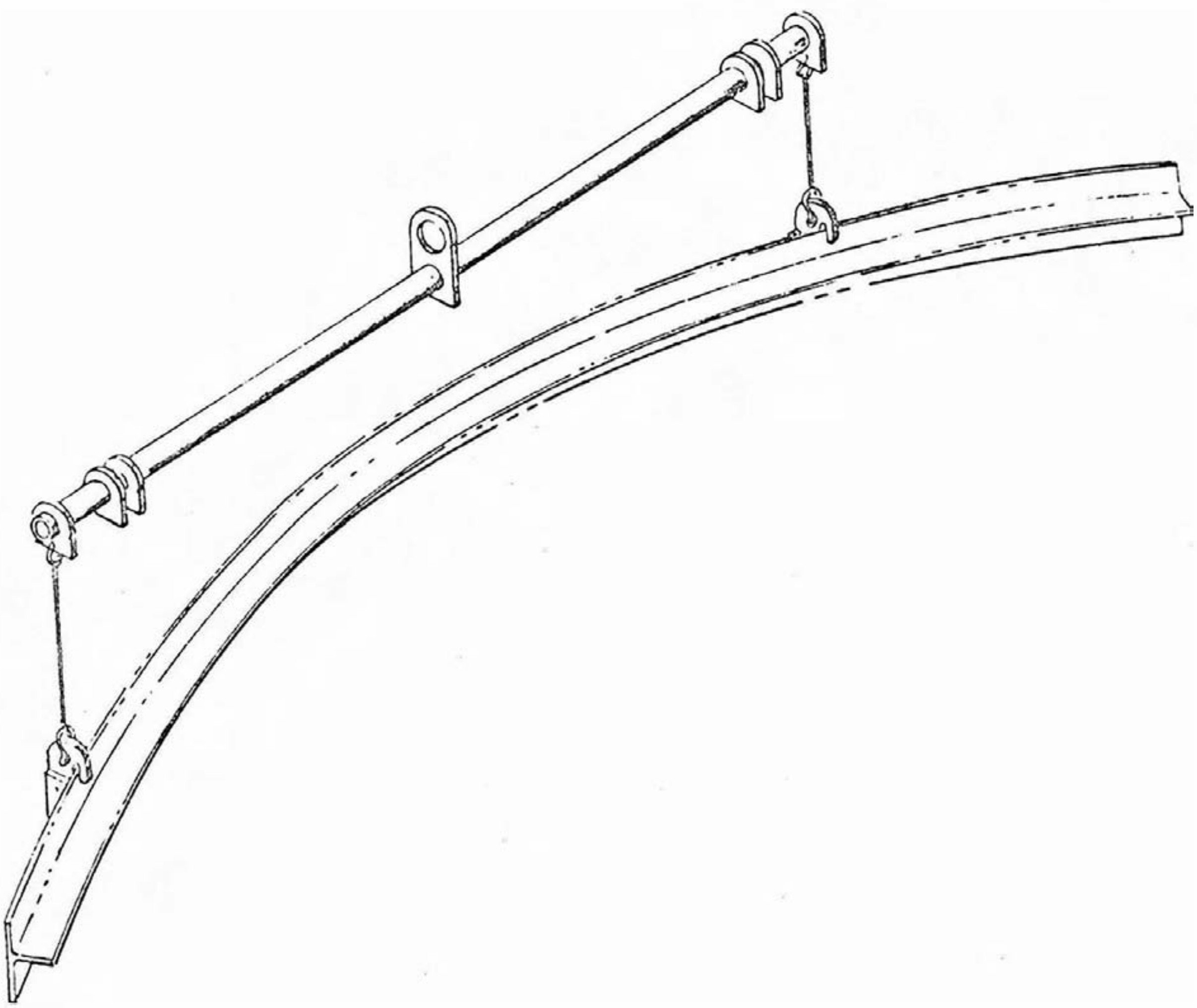


Figure 4-21. Upper and Lower Thrust Ring Tee Caps Hoisting Tool HT-370-18709

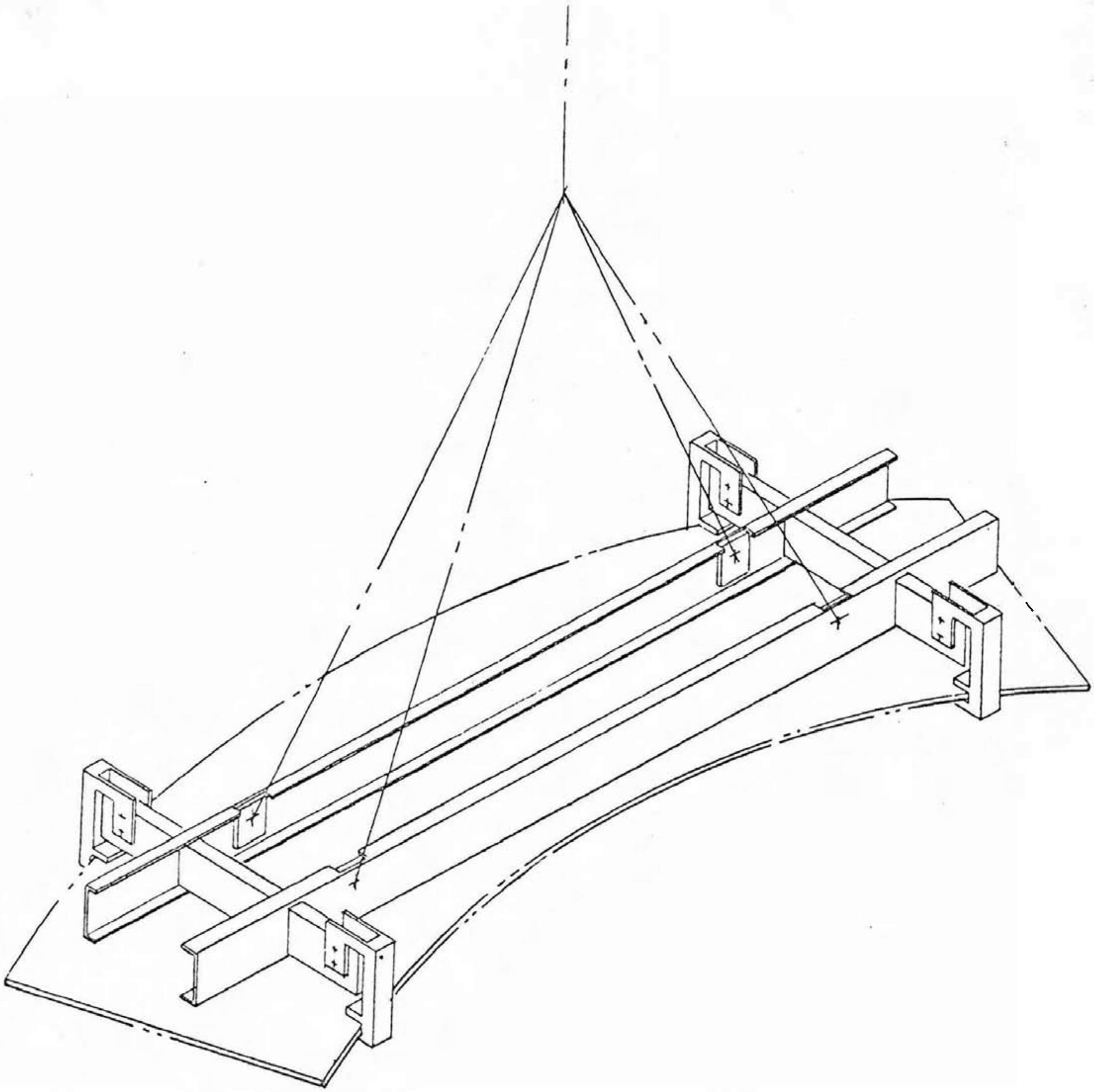


Figure 4-22. Upper and Lower Thrust Ring Web Assemblies Hoisting Tool HT-370-18703

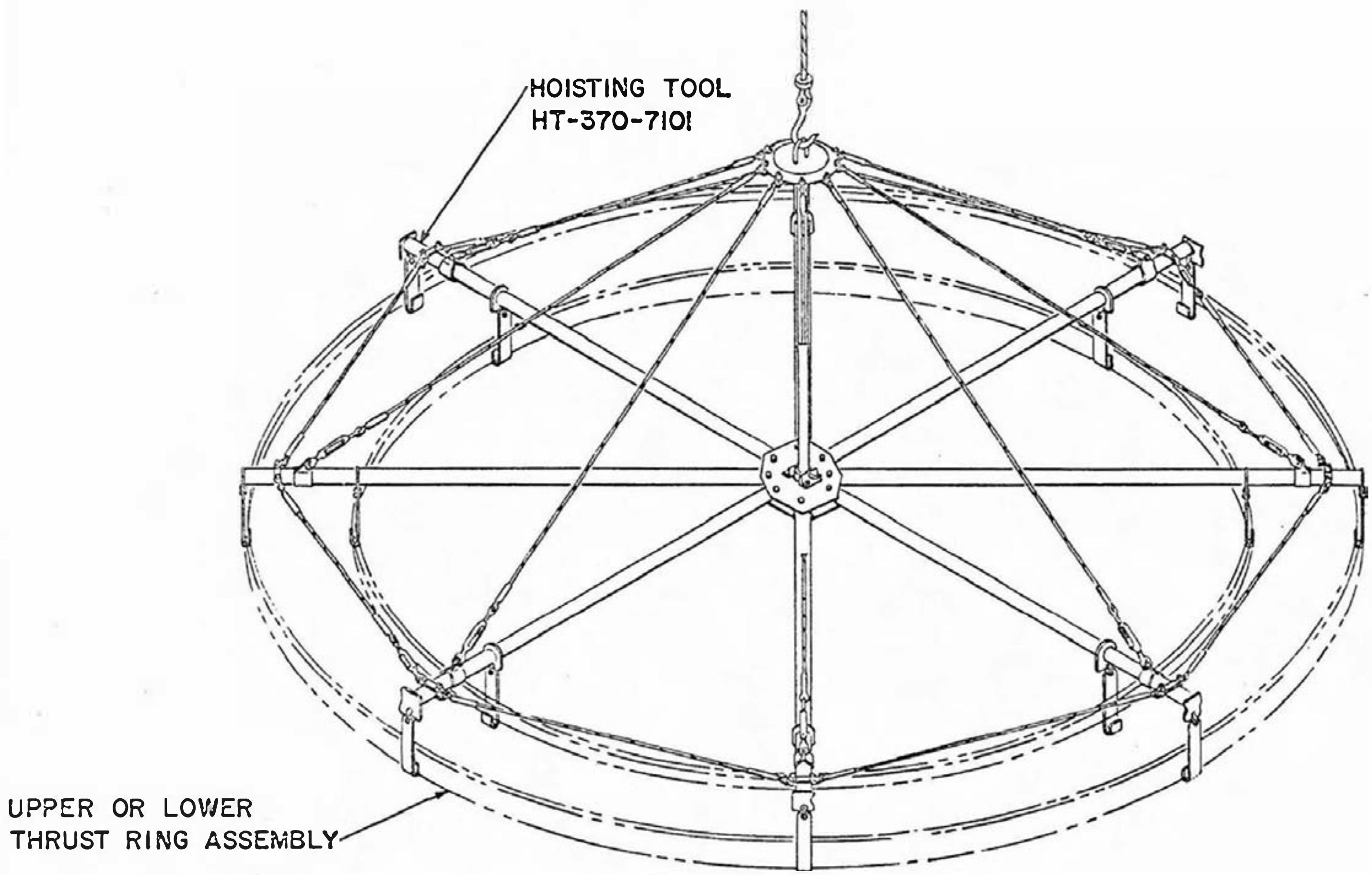


Figure 4-23. Upper and Lower Thrust Ring Assembly Hoisting Tool HT-370-7101

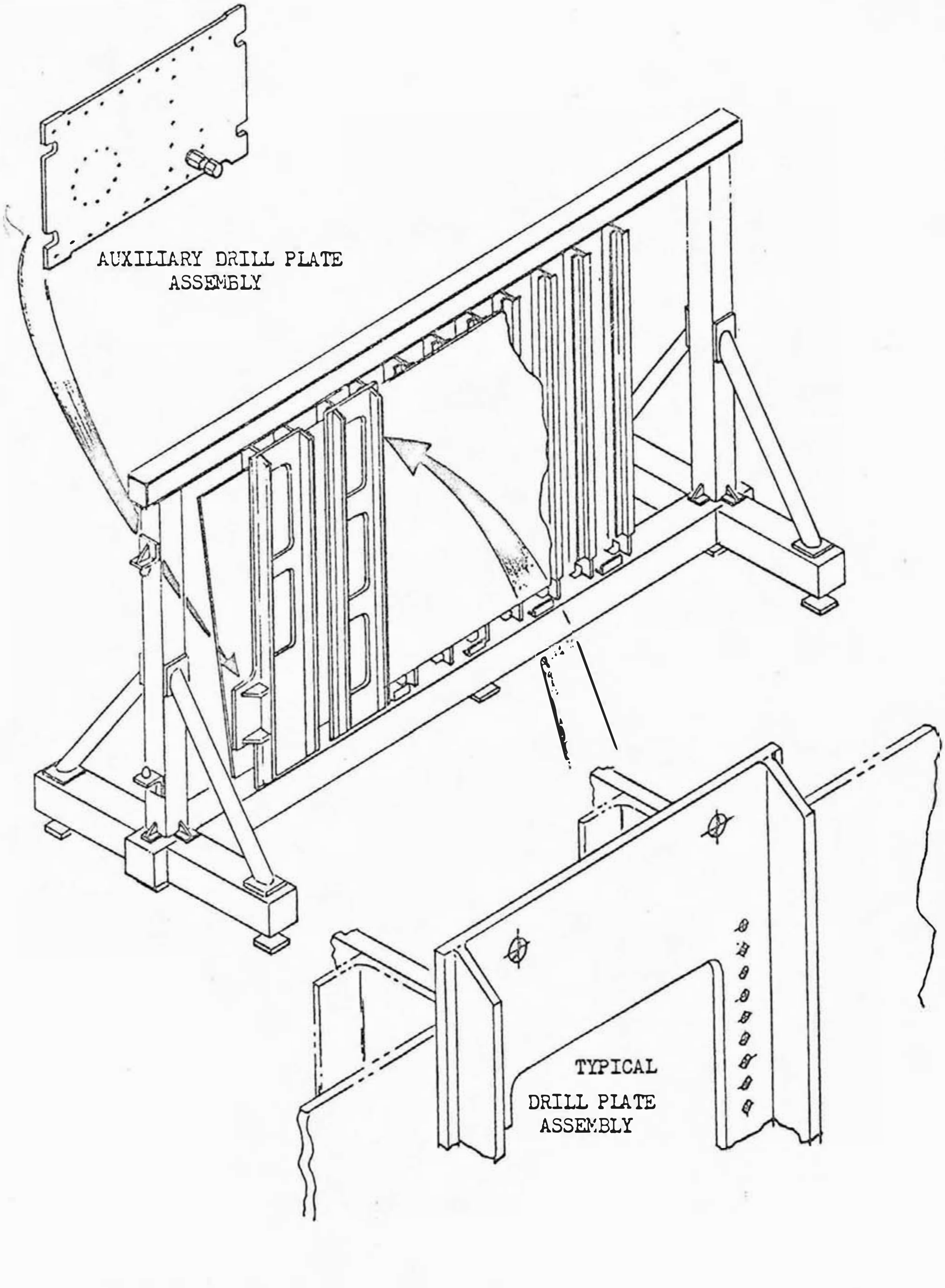


Figure 4-24. Center Engine Support Web Assemblies Assembly Fixture AF-335-18901

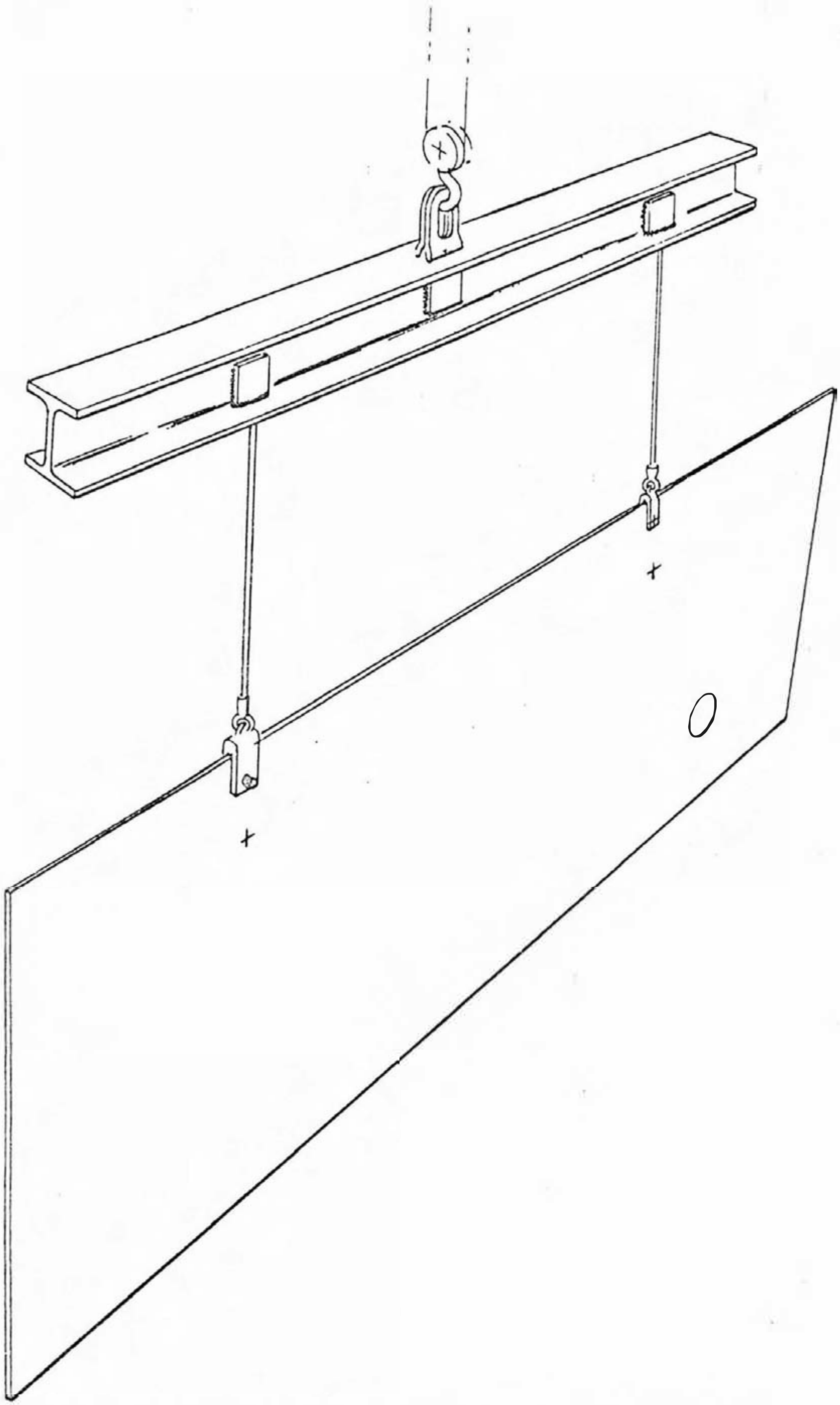


Figure 4-25. Center Engine Support Web Assembly Hoisting Tool
HT-370-7092

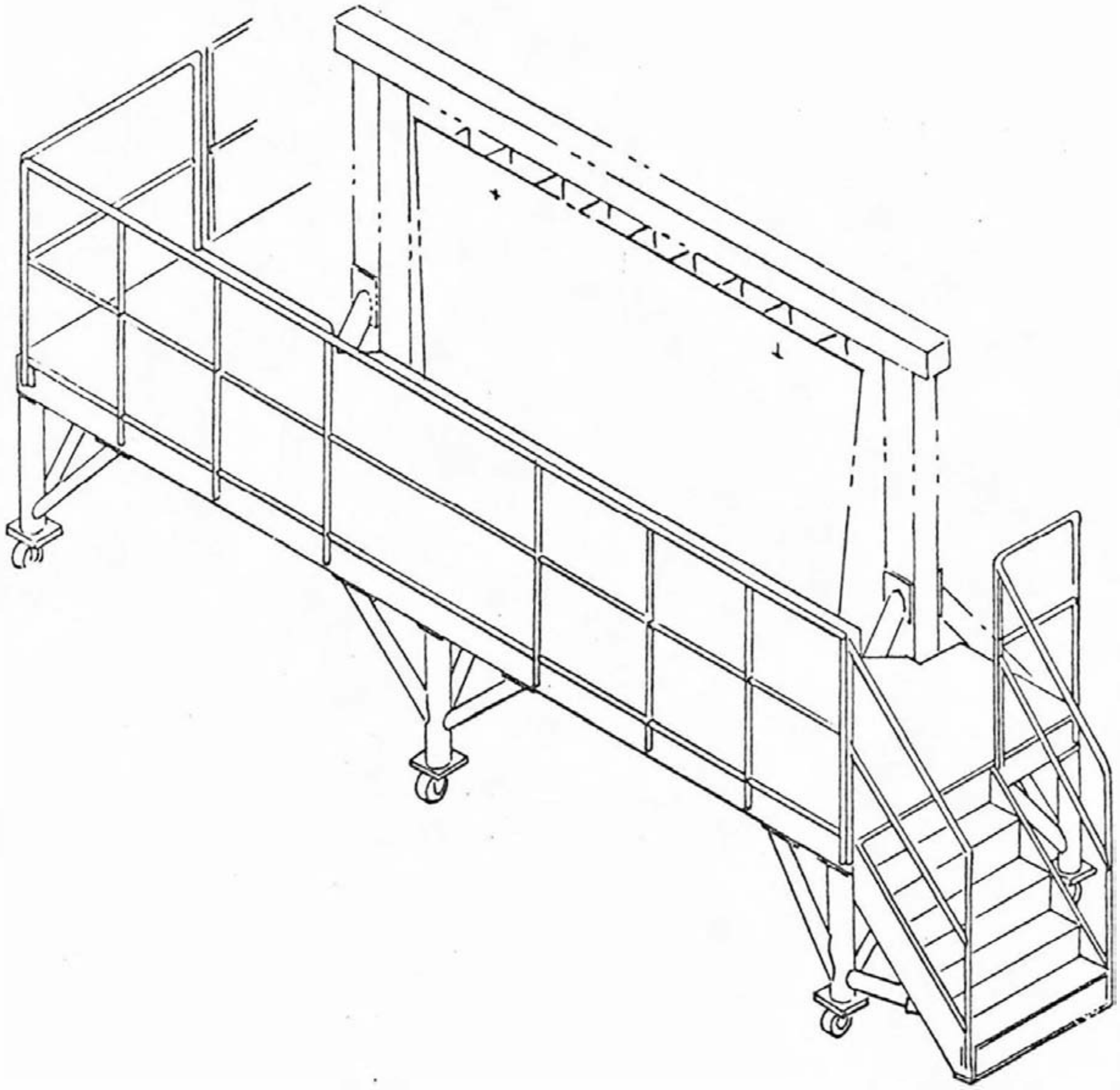


Figure 4-26. Center Engine Support Web Assemblies Personnel Platform PP-370-18901

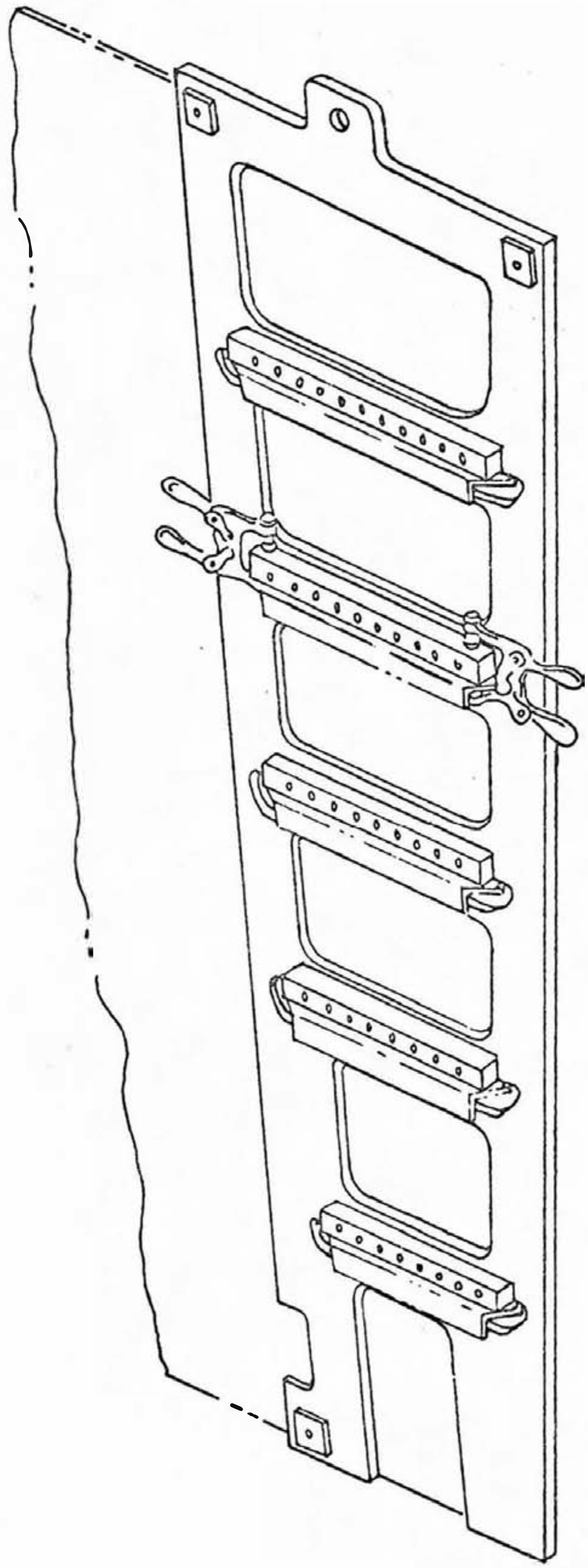


Figure 4-27. Center Engine Support Web Assemblies Locating Drill Jig LDJ-335-18901

2.3.3 Inspect.

2.3.4 Remove center engine support web components from assembly fixture AF-335-18901 with hoisting tool HT-370-7092. Deburr fastener holes. Reassemble and fasten web assembly 60B18901 on support fixture SF-335-18901. (See figure 4-28.)

2.3.5 Repeat operations outlined in paragraphs 2.3.1 through 2.3.4 for center engine support web assembly 60B18919 using LDJ-335-18919. Repeat operations outlined in paragraph 2.3.1 through 2.3.4 for center engine support web assemblies 60B18902 and 60B18920 using assembly fixture AF-335-18902.

2.3.6 Inspect.

2.3.7 Crate and ship center engine support web assemblies to MSFC.

2.4 Center Engine Support Assembly 60B18900 - At MSFC. (See figures 4-7, 4-8, 4-25, 4-29, 4-30, 4-31, and 4-32.) Center engine support assembly is a -900 assembly and shall be assembled per drawing except as follows:

1. Omit four fasteners, located seven spaces from outboard end, at each position common to lower caps and web assemblies.

2. Omit two inboard tee clips 60B18959-1-900 at lower position because of interference with drill fixture (AF-335-7070-1-0). This operation will be completed at next assembly.

3. Omit two outboard tee clips 60B18959-1-900 at lower position to facilitate tooling.

4. Holes not drilled in splice plates at all positions are to be drilled at next assembly to facilitate tooling.

5. Drilled parts not fastened, but sent to store room, are to be fastened at next assembly to facilitate tooling.

Assemble center engine support assembly 60B18900-1-900 in center engine support structure assembly fixture AF-335-7070 as outlined in paragraphs 2.4.1 through 2.4.14.

2.4.1 Position and clamp center engine support fitting 60B18910-1-900 in center engine support structure assembly fixture AF-335-7070.

2.4.2 Position and clamp bottom lower cap splice plate 60B18913-1-900 in assembly fixture AF-335-7070.

2.4.3 Position and clamp lower caps 60B18912-1-900, 60B18934-1-900, 60B18935-1-900, and 60B18936-1 in assembly fixture AF-335-7070.

2.4.4 Position and clamp top lower splice plate 60B18944-1 in assembly fixture AF-335-7070.

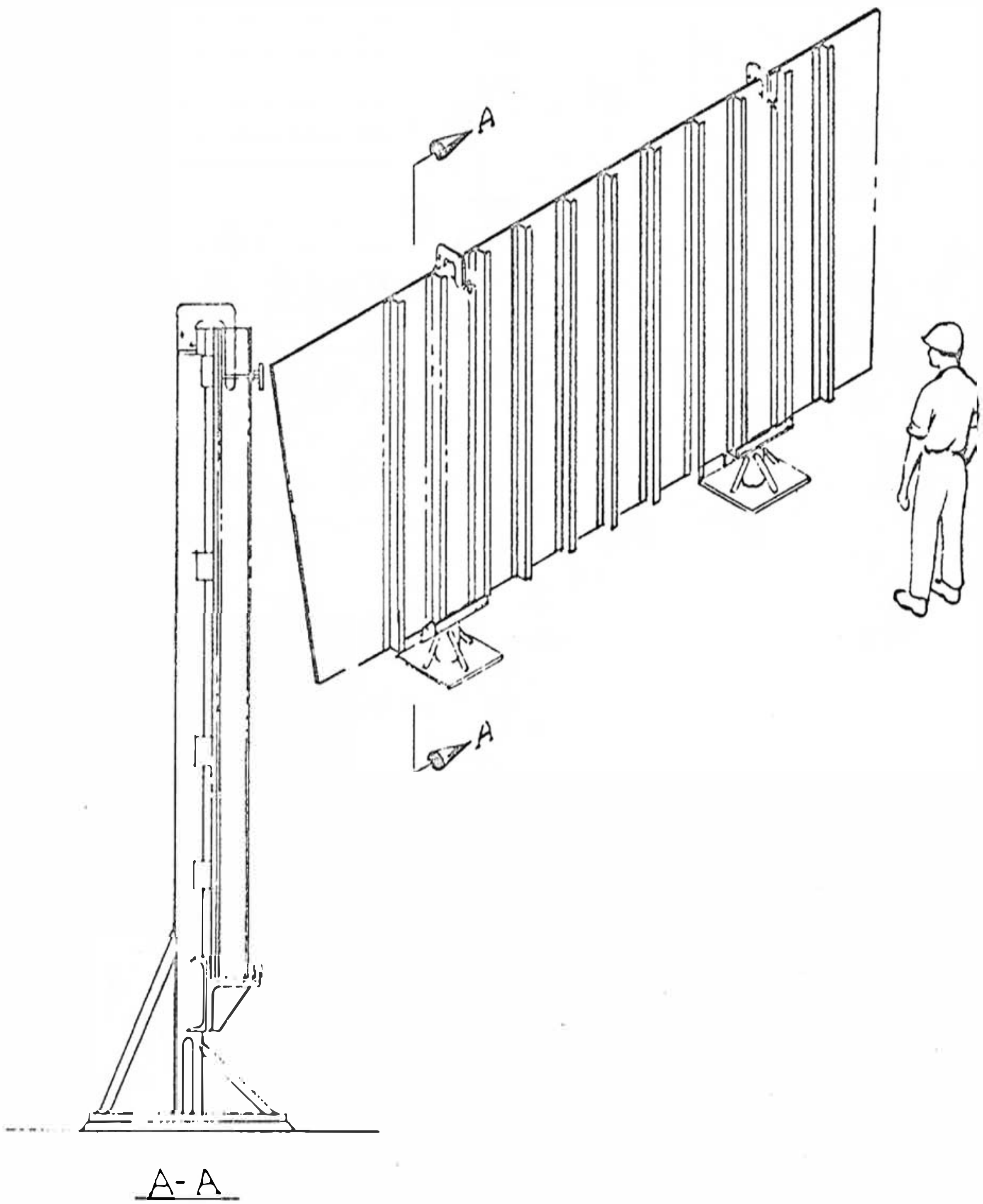


Figure 4-28. Center Engine Support Web Assemblies Support Fixture SF-335-18901

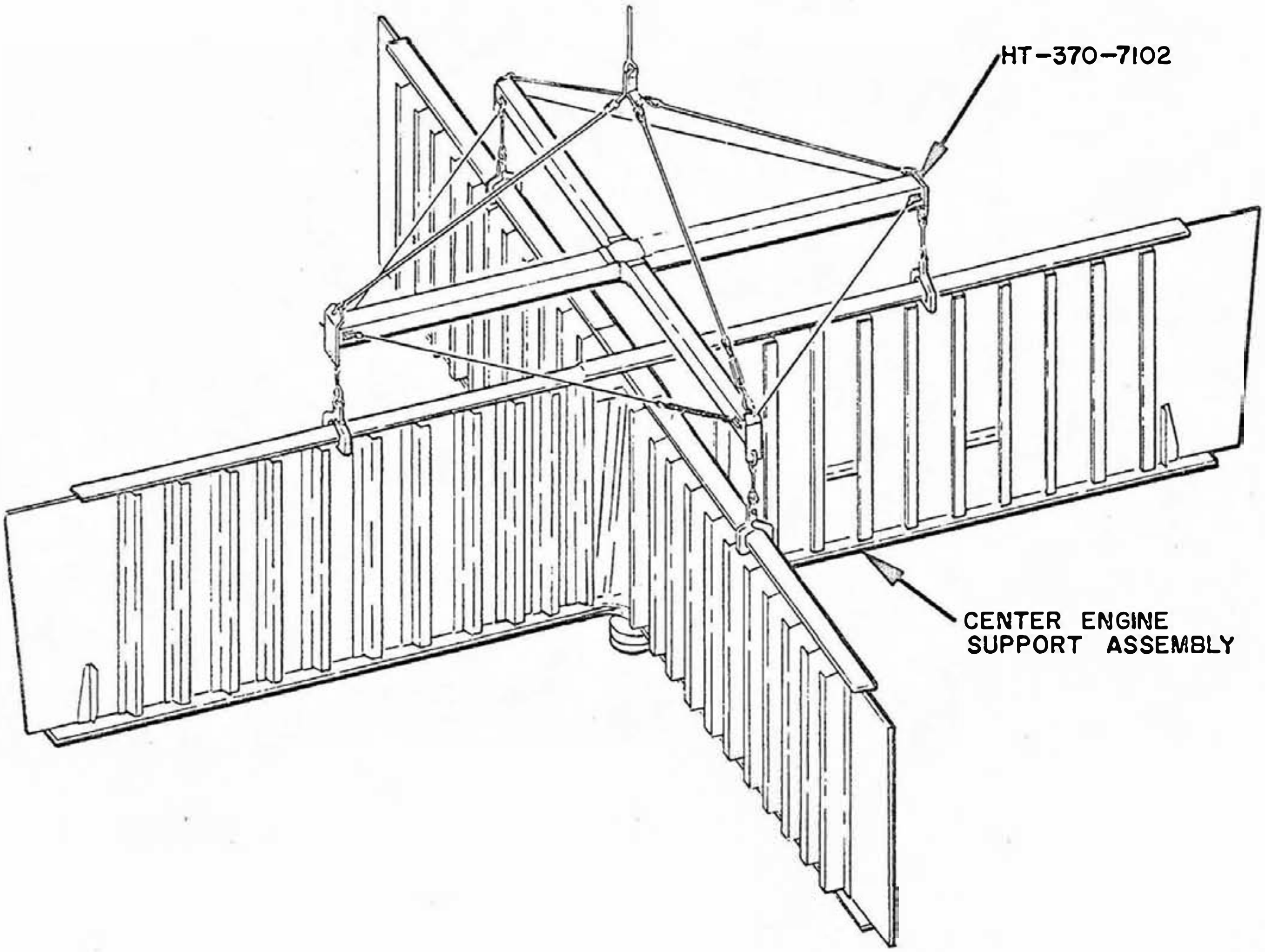


Figure 4-29. Center Engine Support Assembly Hoisting Tool HT-370-7102

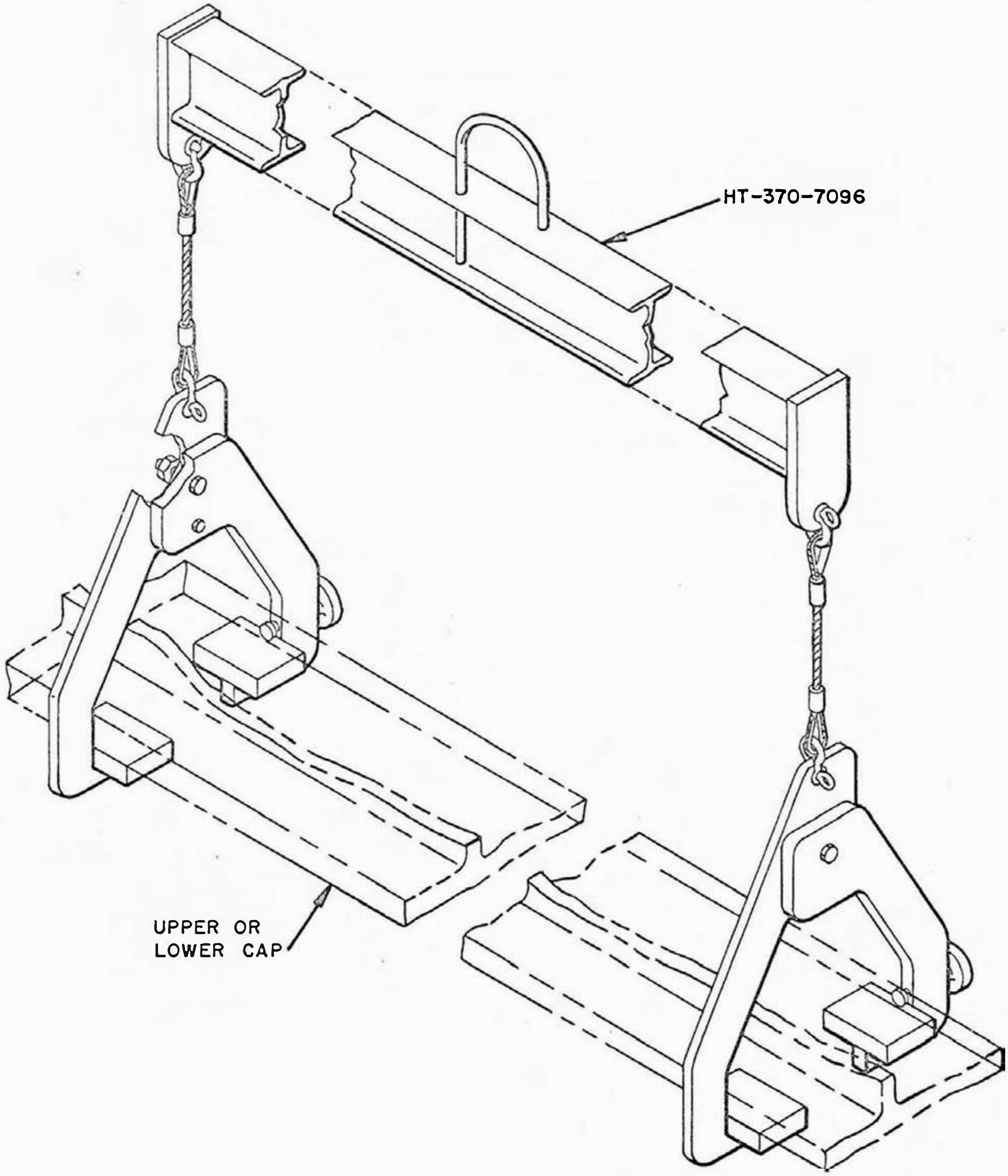


Figure 4-30. Center Engine Support Upper and Lower Caps Hoisting Tool HT-370-7096

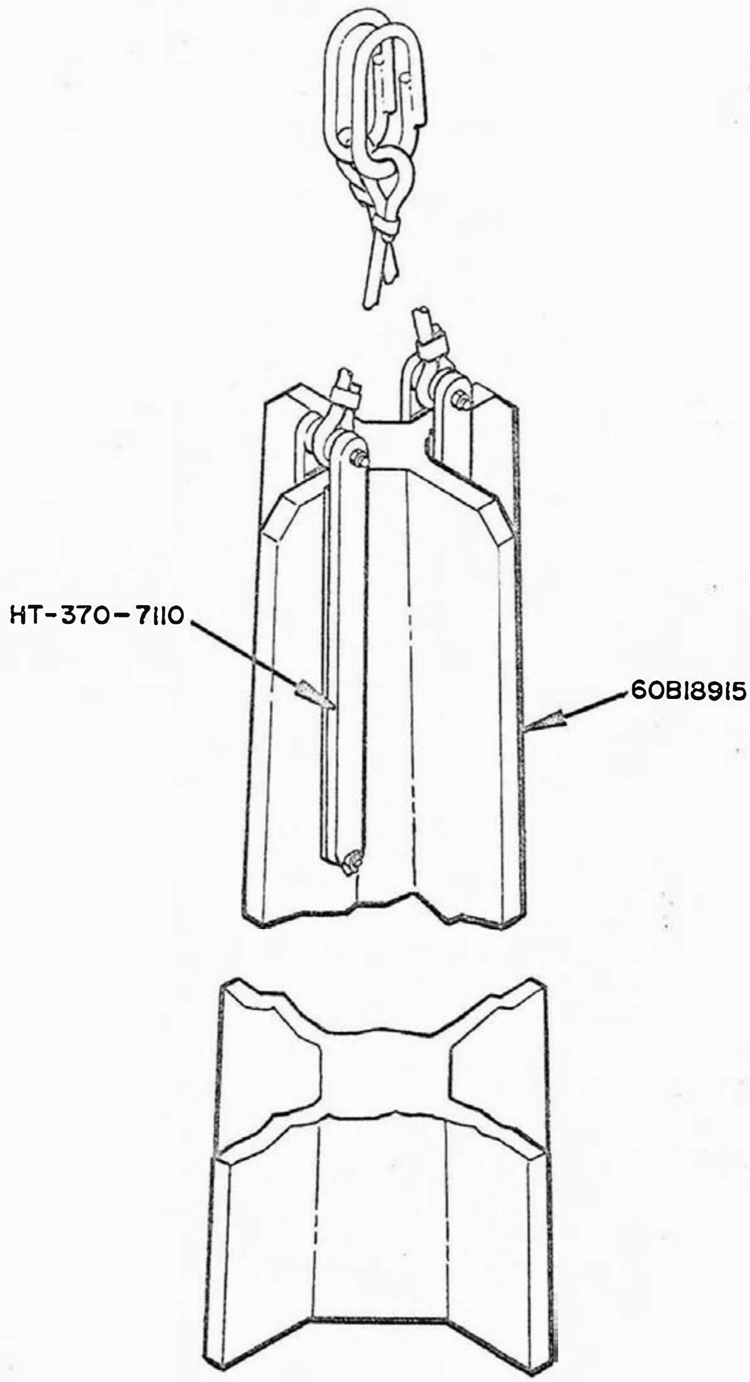


Figure 4-31. Center Engine Post Hoisting Tool HT-370-7110

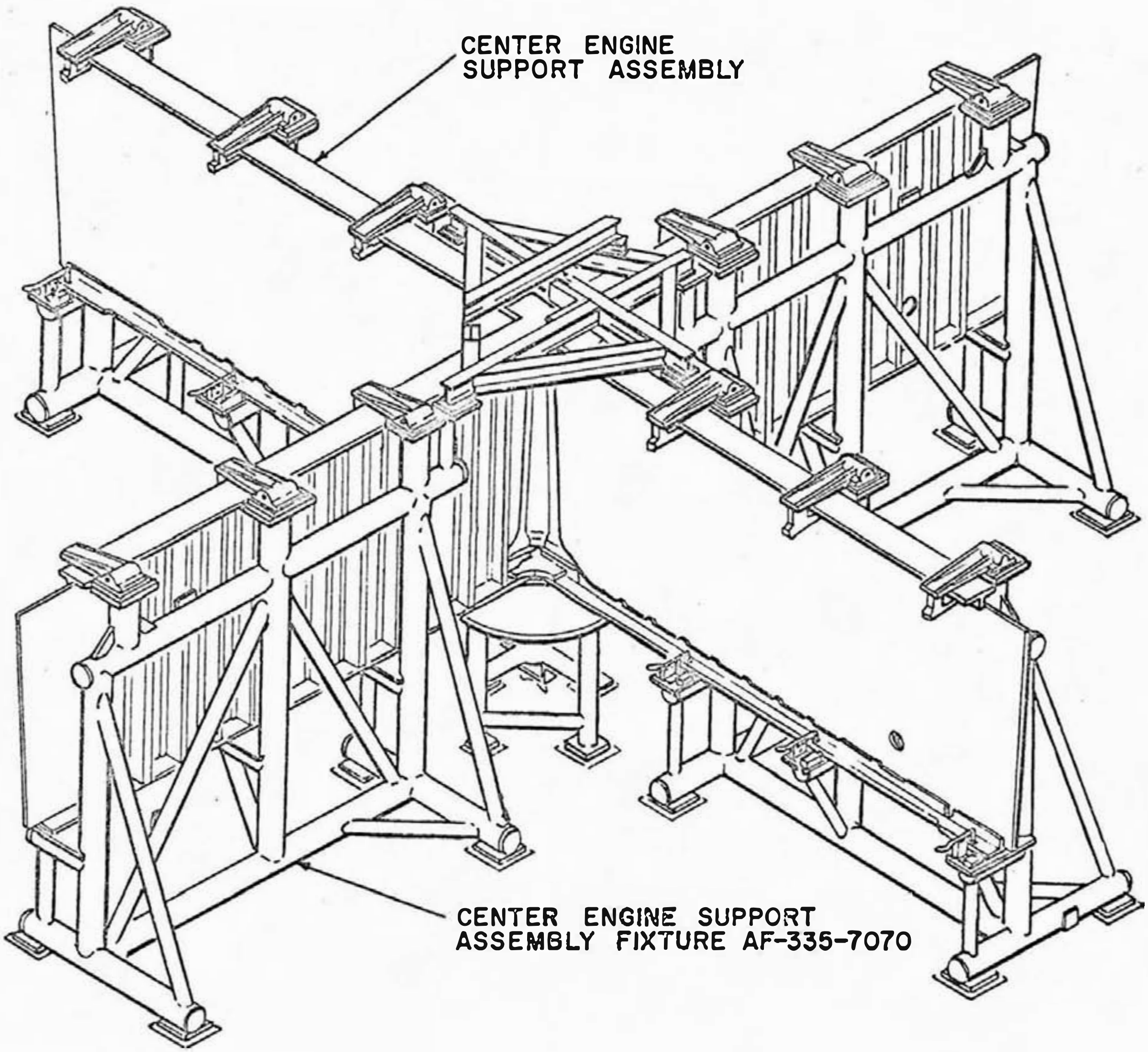


Figure 4-32. Center Engine Support Assembly, Assembly Fixture AF-335-7070

2.4.5 Using subassembly -1-3, drill and ream through center engine support fitting, bottom lower cap splice plate, lower caps, and top lower splice plate. Install temporary fasteners.

2.4.6 Position and clamp center engine thrust post 60B18915-1-900, using details -5, -11, and -12 of assembly fixture AF-335-7070.

2.4.7 Clamp web assembly at Position III using assembly fixture AF-335-7070-1-0. Load splice plates 60B18903-2-901 and 60B18923-2 into DJ-335-7130 and then locate, along with stiffener 60B18945-1-900, onto web assembly. Drill and ream holes. Install fasteners. Locate lower cap web assembly drill jig DJ-335-7155 onto lower cap; drill and ream holes. Install fasteners.

2.4.8 Clamp web assembly 60B18901-1-900 at Position I using assembly fixture AF-335-7070-1-0. Load splice plates 60B18903-1-900 and 60B18923-1 into DJ-335-7128 and then locate, along with stiffener 60B18945-2-901, onto web assembly. Drill and ream holes. Install fasteners. Locate lower cap web assembly drill jig DJ-335-7153 onto lower cap; drill and ream holes. Install fasteners.

2.4.9 Clamp web assembly 60B18920-1-900 at Position IV using assembly fixture AF-335-7070-1-0. Load splice plates 60B18924-1 and 60B18904-1-900 into DJ-335-7129 and then locate, along with stiffener 60B18945-3-902, onto web assembly. Drill and ream holes. Install fasteners. Locate lower cap web assembly drill jig DJ-335-7156 onto lower cap; drill and ream holes. Install fasteners.

2.4.10 Clamp web assembly 60B18919-1-900 at Position II using assembly fixture AF-335-7070-1-0. Load splice plates 60B18924-2 and 60B18904-2-900 into DJ-335-7131 and then locate, along with stiffener 60B18945-4-903, onto web assembly. Drill and ream holes. Install fasteners. Locate lower cap web assembly drill jig DJ-335-7154 onto lower cap; drill and ream holes. Install fasteners.

2.4.11 At all four positions, load lower splice doublers into drill jigs DJ-335-7218 at Position III, DJ-335-7214 at Position I, DJ-335-7220 at Position IV, and DJ-335-7216 at Position II and load into assembly; drill and ream holes. Install fasteners.

2.4.12 Load upper caps 60B18911-1 and 60B18933-1. Load upper splice doubler at all four positions into drill jigs DJ-335-7219 at Position III, DJ-335-7215 at Position I, DJ-335-7221 at Position IV, and DJ-335-7217 at Position II and load into assembly; drill and ream holes. Install fasteners.

2.4.13 Locate upper cap web assembly drill jigs DJ-335-7151 at Position III, DJ-335-7149 at Position I, DJ-335-7152 at Position IV, and DJ-335-7150 at Position II; drill and ream holes. Install fasteners.

2.4.14 Install clips 60B18959-1 at upper Position I, upper Position III, lower Position II, and lower Position IV using drill jig DJ-335-7222. Install clips 60B18959-1 at lower Position I, lower Position III, upper Position II, and upper Position IV using drill jig DJ-335-7132; drill and ream holes. Install fasteners.

2.5 Outboard Thrust Post Assembly 60B18800. The outboard thrust post assembly 60B18800 is assembled in outboard thrust post assembly fixture AF-335-18800. (See figures 4-33, 4-34, and 4-35.) The assembled thrust post assembly is located in milling fixture MF-335-18800 to mill the aft end of the completed thrust post to ensure a smooth mating surface with the lower ring and also to establish proper overall height. (See figure 4-36.) Use hoisting tool HT-370-7108 for lifting outboard thrust post assembly 60B18800. (See figure 4-37.)

2.5.1 Load outboard channel, four bulkheads, and inboard channel into assembly fixture AF-335-18800. Using drill plates of assembly fixture AF-335-18800, drill full-size holes common to outboard channel, bulkheads, and inboard channel; install fasteners.

2.5.2 Load two side plates and drill plates into assembly fixture AF-335-18800. Drill full-size holes common to both side plates and channels; install fasteners.

2.5.3 Load two shear ties and drill plates into assembly fixture AF-335-18800. Drill full-size holes common to both shear ties and channels; install fasteners.

2.5.4 Load eight intermediate ring attach tees and drill plates into assembly fixture AF-335-18800. Drill full-size holes common to tees and channels; install fasteners.

2.5.5 Remove outboard thrust post assembly 60B18800 from assembly fixture AF-335-18800.

2.5.6 Load outboard thrust post assembly 60B18800 into milling fixture MF-335-18800; mill aft surface common to the lower thrust ring.

2.5.7 Remove outboard thrust post assembly 60B18800 from milling fixture MF-335-18800.

2.5.8 Repeat operations outlined in paragraphs 2.5.1 through 2.5.7 for the three remaining outboard thrust post assemblies 60B18800.

2.5.9 Use hoisting tool HT-370-7108 to load outboard thrust post assemblies 60B18800 into thrust structure final assembly fixture AF-335-7027.

2.6 Auxiliary Shear Web Assemblies 60B18940. Auxiliary shear webs (Positions I and III) are assembled in a bench-type assembly fixture AF-335-18940. (See figure 4-38.)

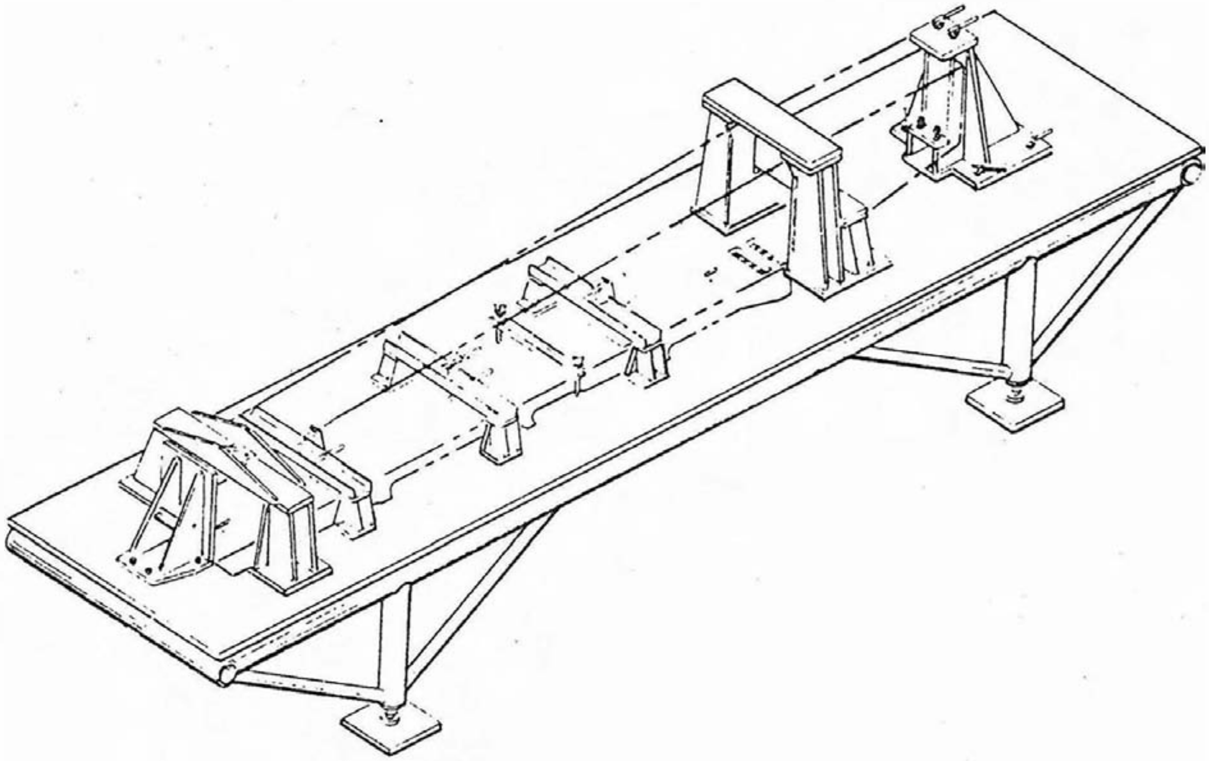


Figure 4-33. Outboard Thrust Post Assembly, Assembly Fixture AF-335-1880 (Phase 1)

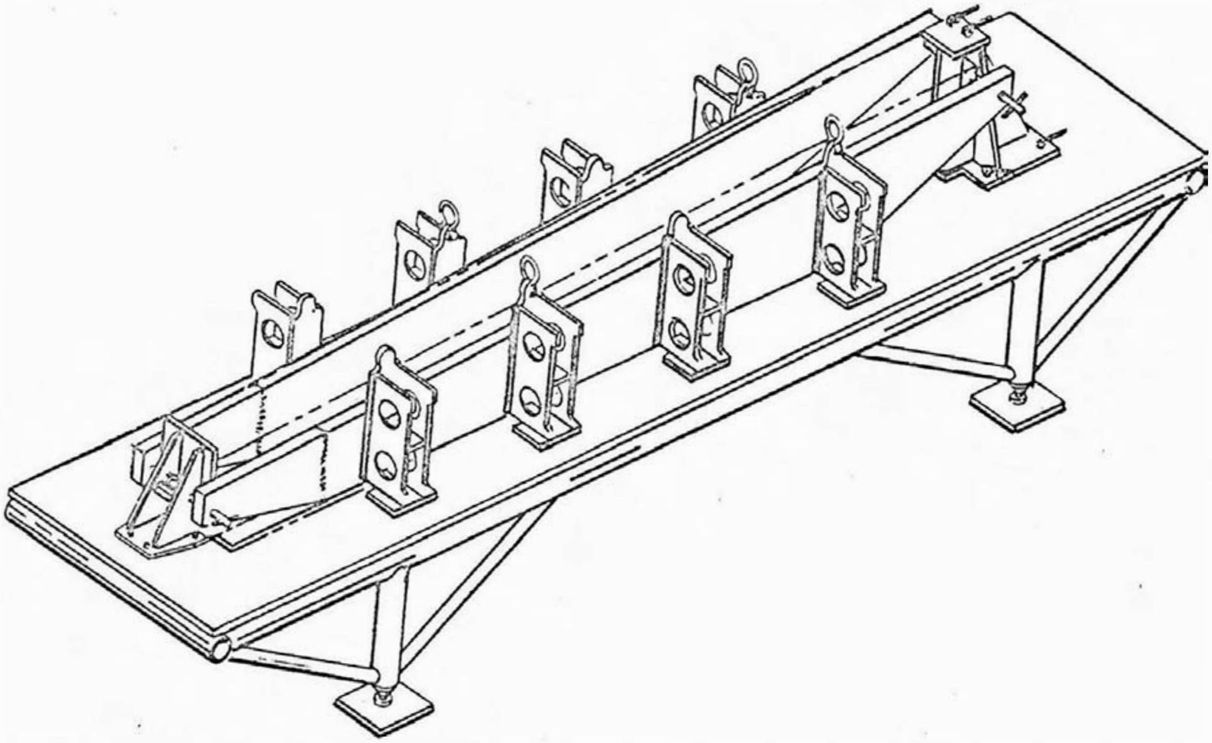


Figure 4-34. Outboard Thrust Post Assembly, Assembly Fixture AF-335-18800 (Phase 2)

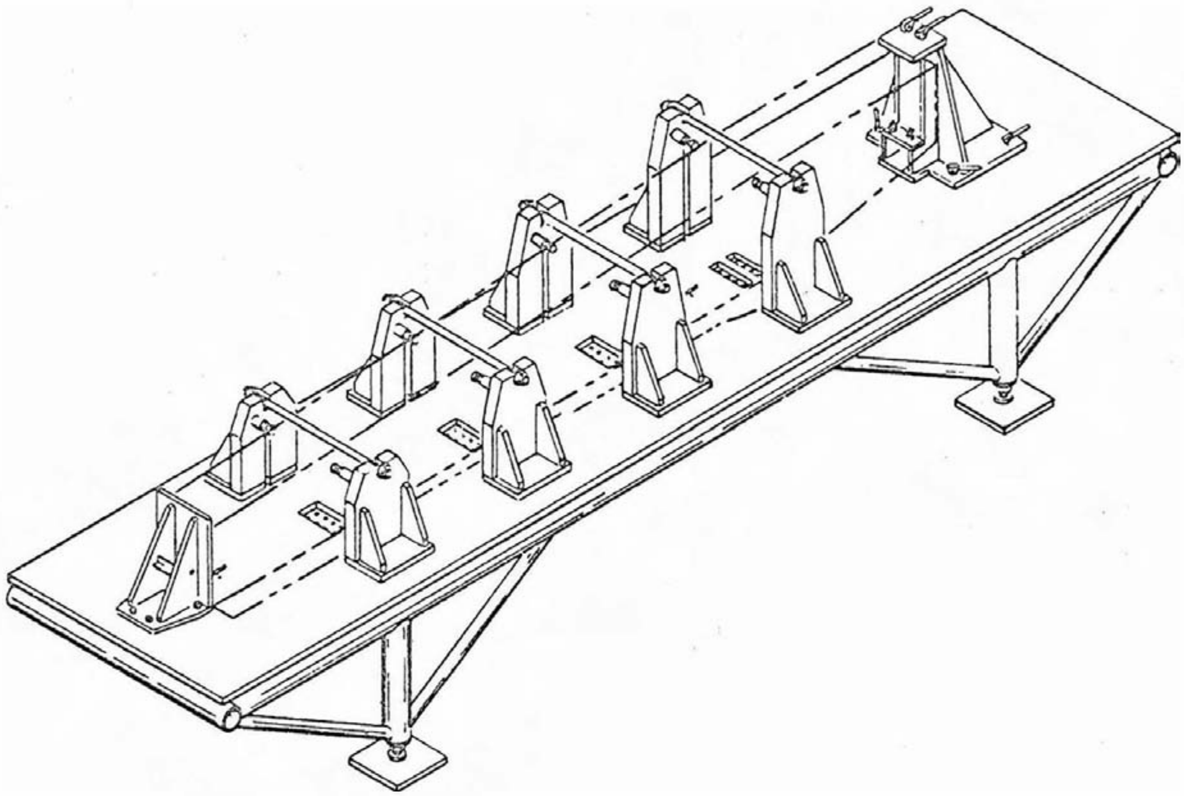


Figure 4-35. Outboard Thrust Post Assembly, Assembly Fixture AF-335-18800 (Phase 3)

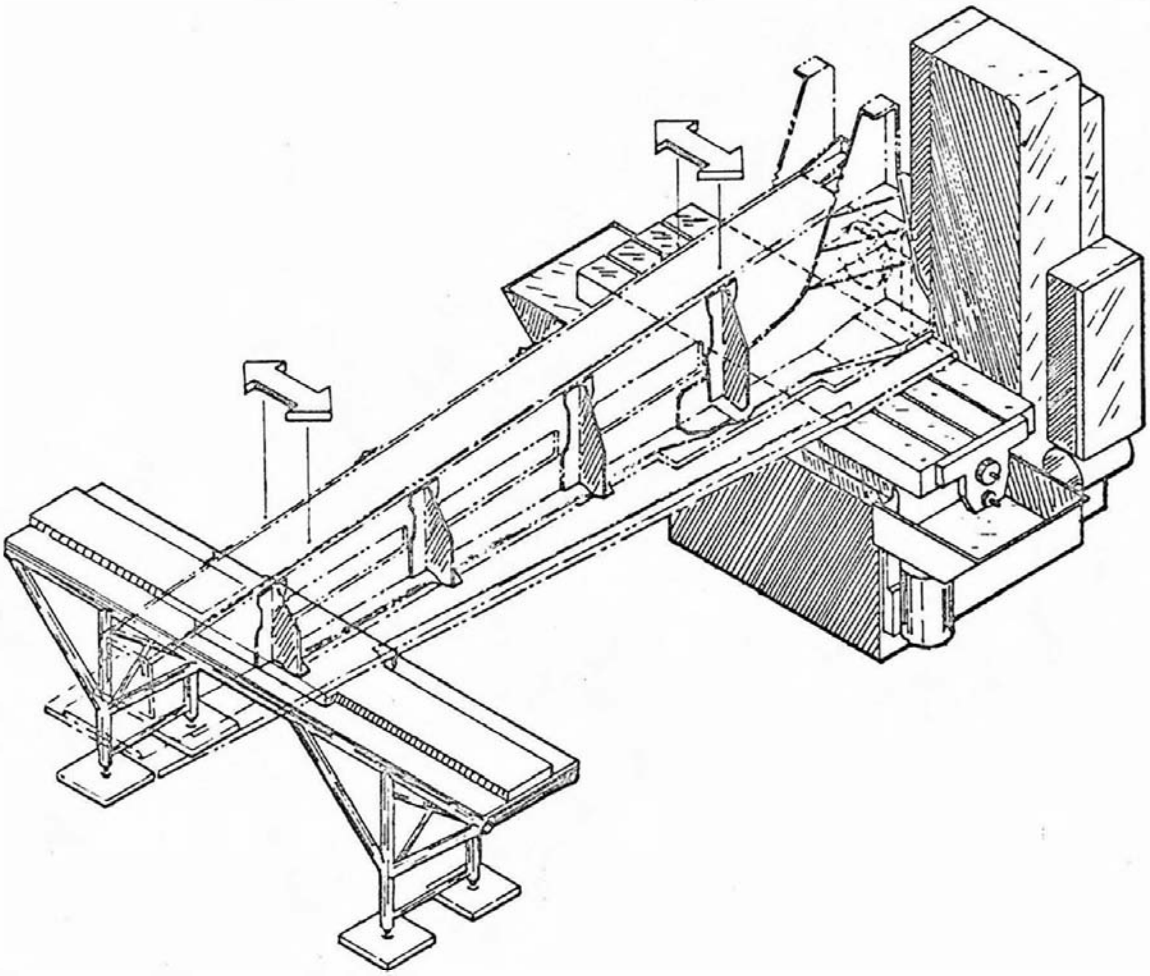


Figure 4-36. Outboard Thrust Post Assembly Mill Fixture MF-335-18800

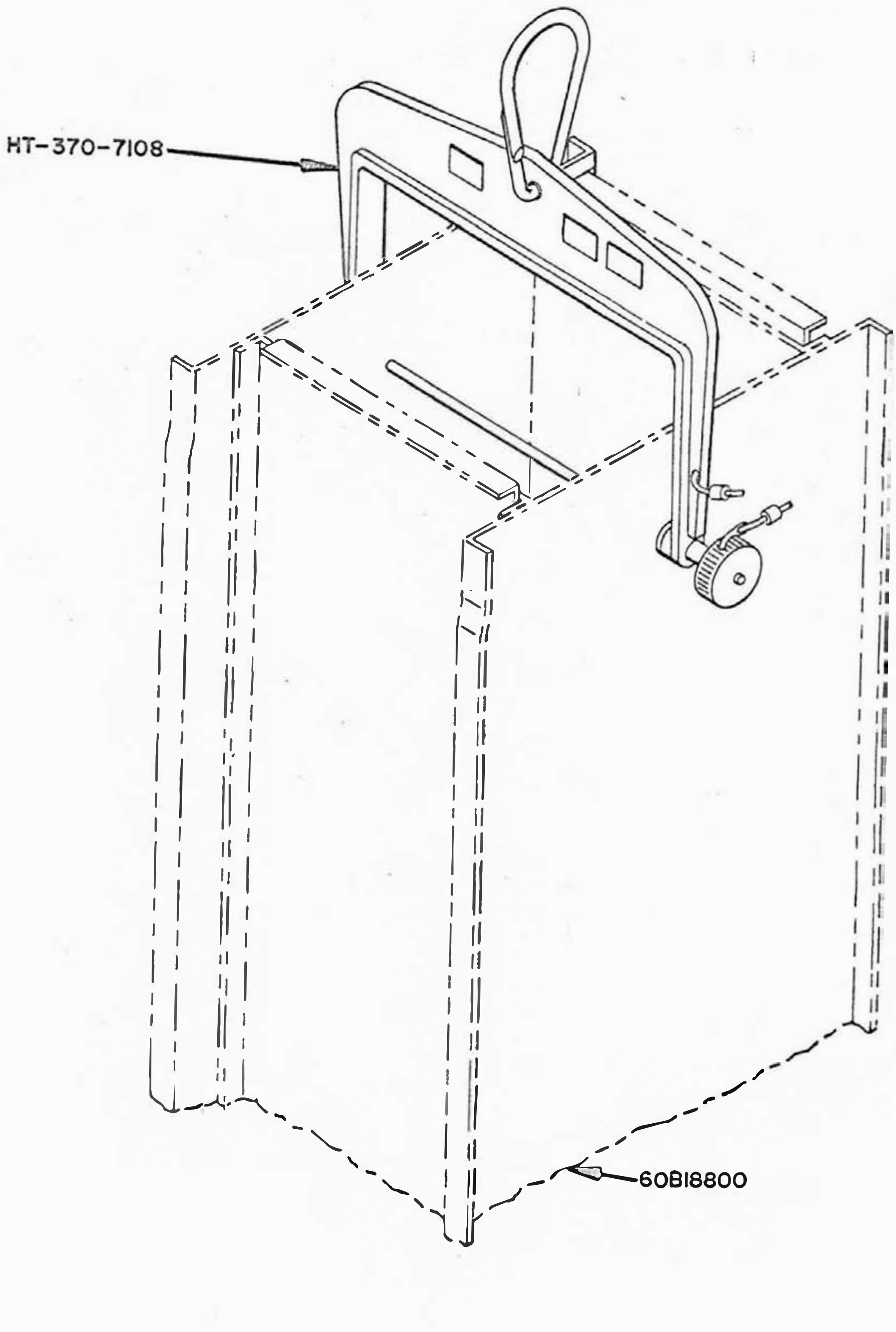


Figure 4-37. Outboard Thrust Post Assembly Hoisting Tool HT-370-7108

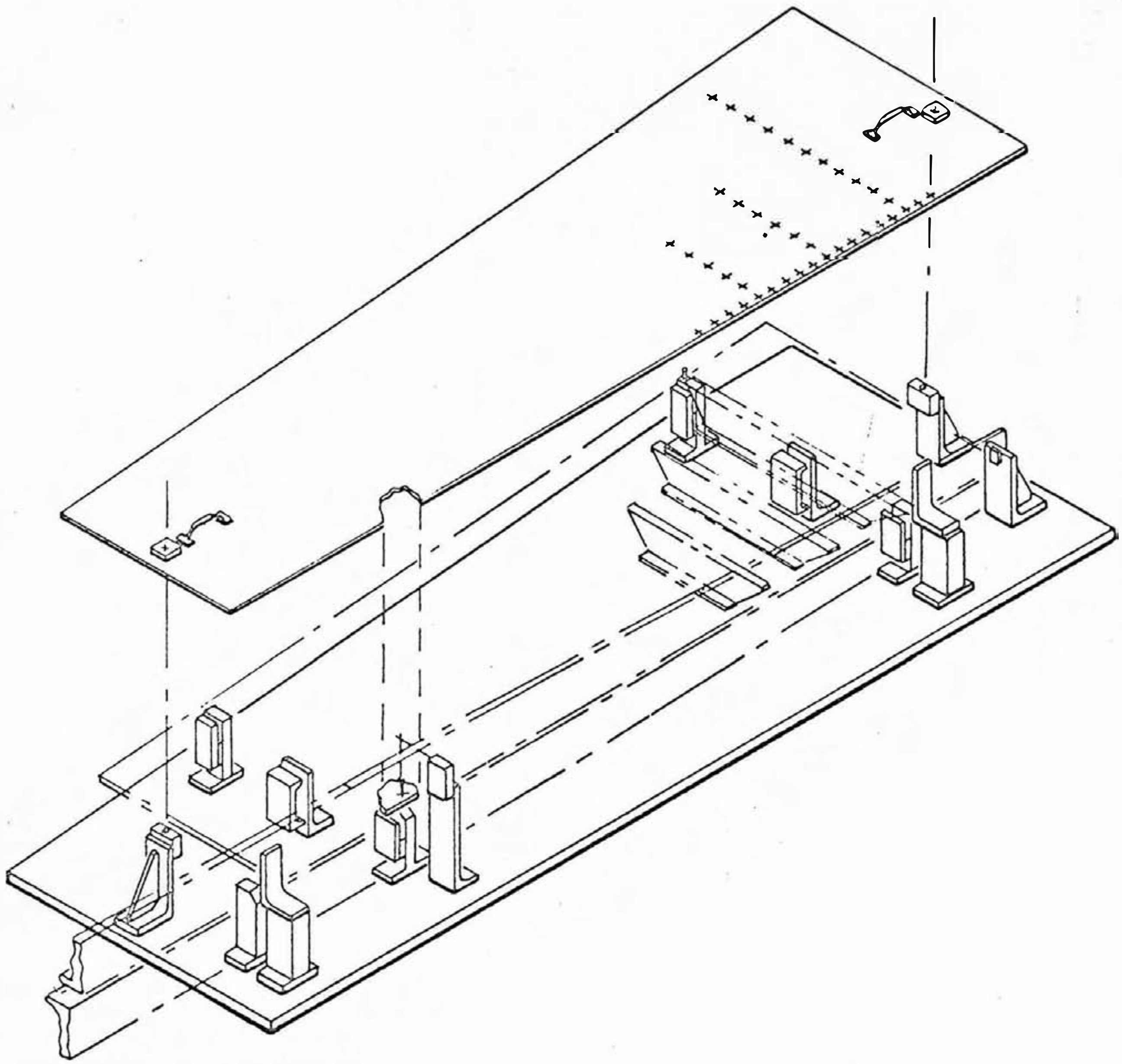


Figure 4-38. Auxiliary Shear Web Assemblies Assembly Fixture AF-335-18940

2.6.1 These assemblies, as well as those at Positions II and IV, are -900 assemblies and differ from the engineering installation drawing as follows: All holes and fasteners common to the holddown post and in the area of the upper thrust ring and shear web attach fittings and gussets are omitted. The second hole from the outboard end of each stiffener is drilled pilot size and fasteners are omitted from these holes. All holes in the caps common to the center engine support are also omitted.

2.6.2 The assembly sequence for auxiliary shear web (Position I) is outlined in paragraphs 2.6.3 through 2.6.9.

2.6.3 Position and clamp stiffeners 60B18949.

2.6.4 Position and clamp auxiliary web cap.

2.6.5 Position auxiliary shear web in assembly fixture AF-335-18940.

2.6.6 Position auxiliary web cap and clamp in place.

2.6.7 Load drill plate and drill all holes.

2.6.8 Remove drill plate, disassemble, and deburr.

2.6.9 Install all required fasteners.

2.6.10 Repeat operations outlined in paragraphs 2.6.3 through 2.6.9 for auxiliary shear web (Position III).

2.6.11 Auxiliary shear webs (Positions II and IV) are assembled in a bench-type assembly fixture AF2-335-18940. (See figure 4-38.) The sequence of assembly operations for auxiliary shear webs (Positions II and IV) is the same as outlined in paragraphs 2.6.3 through 2.6.9.

2.7 <u>Upper Thrust Ring Web Assemblies.</u>

2.7.1 The four fin position web assemblies 60B18602-1-900 are fabricated in assembly fixture AF-337-18602. (See figure 4-18.)

2.7.1.1 Upper thrust ring web assemblies are -900 assemblies and differ from the actual engineering assemblies in that two stiffeners are omitted and holes common to tee caps are omitted.

2.7.1.2 The assembly sequence for fin position web assemblies 60B18602-1-900 is outlined in paragraphs 2.7.1.3 through 2.7.1.9.

2.7.1.3 Use web assembly hoisting tool HT-370-18100 to load web into assembly fixture AF-337-18602. (See figure 4-19.)

2.7.1.4 Drill two 1/4-inch diameter tooling holes.

2.7.1.5 Install stiffeners and locate.

2.7.1.6 Drill all fastener holes common to web and stiffeners.

2.7.1.7 Omit all fastener locations common to inboard and outboard thrust ring tee caps.

2.7.1.8 Remove web assembly 60B18602-1-900 from assembly fixture AF-337-18602 using hoisting tool HT-370-18100; install fasteners.

2.7.1.9 Repeat operations outlined in paragraphs 2.7.1.3 through 2.7.1.8 for three remaining web assemblies 60B18602-1-900.

2.7.2 The four holddown post position web assemblies 60B18605-1-900 are fabricated in assembly fixture AF-337-18605. (See figure 4-18.)

2.7.2.1 Holddown post position web assemblies are -900 assemblies and differ from the actual engineering assemblies in that holes common to tee caps are omitted.

2.7.2.2 The assembly sequence for holddown post position web assemblies 60B18605-1-900 is outlined in paragraphs 2.7.2.3 through 2.7.2.7.

2.7.2.3 Use web assembly hoisting tool HT-370-18100 to load web into assembly fixture AF-337-18605. (See figure 4-19.)

2.7.2.4 Drill two 1/4-inch diameter tooling holes.

2.7.2.5 Install stiffeners. Omit all fastener locations common to inboard and outboard thrust ring tee caps.

2.7.2.6 Remove web assembly 60B18605-1-900 from assembly fixture AF-337-18605 using hoisting tool HT-370-18100; install fasteners.

2.7.2.7 Repeat operations outlined in paragraphs 2.7.2.3 through 2.7.2.6 for three remaining web assemblies 60B18605-1-900.

2.7.3 The four access panel assemblies 60B18607-1-900 are fabricated in assembly fixture AF-337-18607. (See figure 4-39.)

2.7.3.1 The access panel assemblies are -900 assemblies and differ from the actual engineering assemblies in that holes common to tee caps are omitted.

2.7.3.2 The assembly sequence for access panel assemblies 60B18607-1-900 is outlined in paragraphs 2.7.3.3 through 2.7.3.8.

2.7.3.3 Load panel into assembly fixture AF-337-18607.

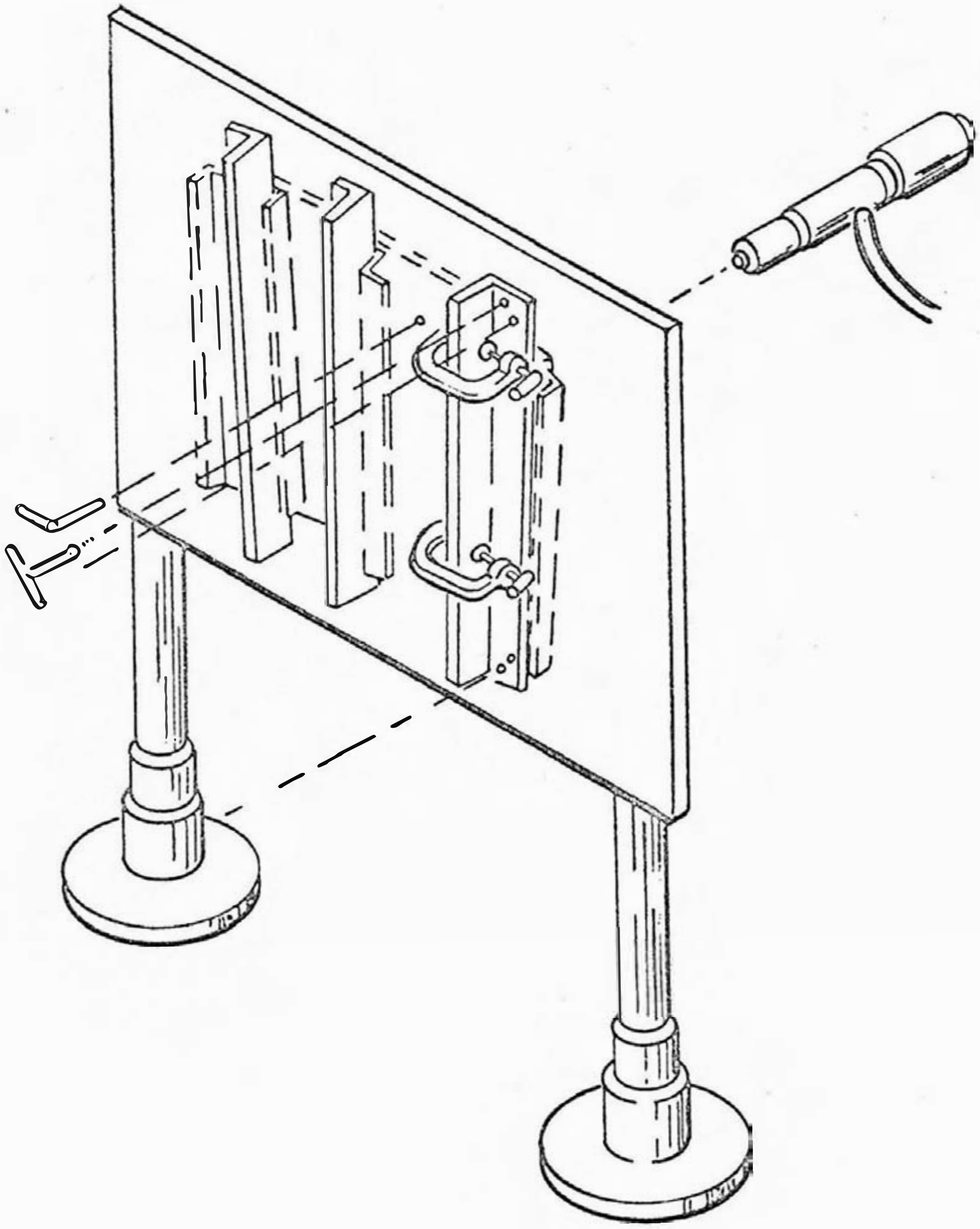


Figure 4-39. Upper Thrust Ring Access Panel Assemblies Assembly Fixture AF-337-18607

2.7.3.4 Drill two 1/4-inch diameter tool holes.

2.7.3.5 Install stiffener and splice webs.

2.7.3.6 Drill all fastener holes common to panel, stiffener, and splice webs. Omit all fastener locations common to inboard and outboard thrust ring tee caps.

2.7.3.7 Remove access panel assembly 60B18607-1-900 from assembly fixture AF-337-18607.

2.7.3.8 Install fasteners.

2.8 Upper Thrust Ring Assembly 60B18600-1-900. The upper thrust ring assembly 60B18600-1-900 is fabricated in the upper and lower thrust rings assembly fixture AF-340-7071. (See figure 4-20.)

2.8.1 The upper thrust ring assembly is a -900 assembly and differs from the actual engineering assembly in that holes common to fittings which tie the upper thrust ring assembly to the auxiliary shear webs are omitted.

2.8.2 The assembly sequence for upper thrust ring assembly 60B18600-1-900 is outlined in paragraphs 2.8.3 through 2.8.10.

2.8.3 Load lower tee cap splice angles, web splice plates, and stiffeners in assembly fixture AF-340-7071.

2.8.4 Load upper thrust ring web assemblies and access panel assemblies in assembly fixture AF-340-7071. (See figure 4-19.)

2.8.5 Load inboard and outboard thrust ring tee caps in assembly fixture AF-340-7071 using tee cap hoisting tool HT-370-18709. (See figure 4-21.)

2.8.6 Load upper tee cap splice angles and tee cap splice plate in assembly fixture AF-340-7071.

2.8.7 Apply drill plates, and drill all fastener holes full size except holes common to outer tee cap splice. Drill holes common to splice 1/4-inch diameter.

2.8.8 Install fasteners.

2.8.9 Drill four 0.500 diameter tooling holes using locator bushings provided.

2.8.10 Remove upper thrust ring assembly 60B18600-1-900 from assembly fixture AF-340-7071 using thrust ring assemblies hoisting tool HT-370-7101. (See figure 4-23.)

2.9 Intermediate Ring Assemblies. (See figure 4-12.) The four intermediate ring assemblies segments are manufactured individually. (See figures 4-40 and 4-41.)

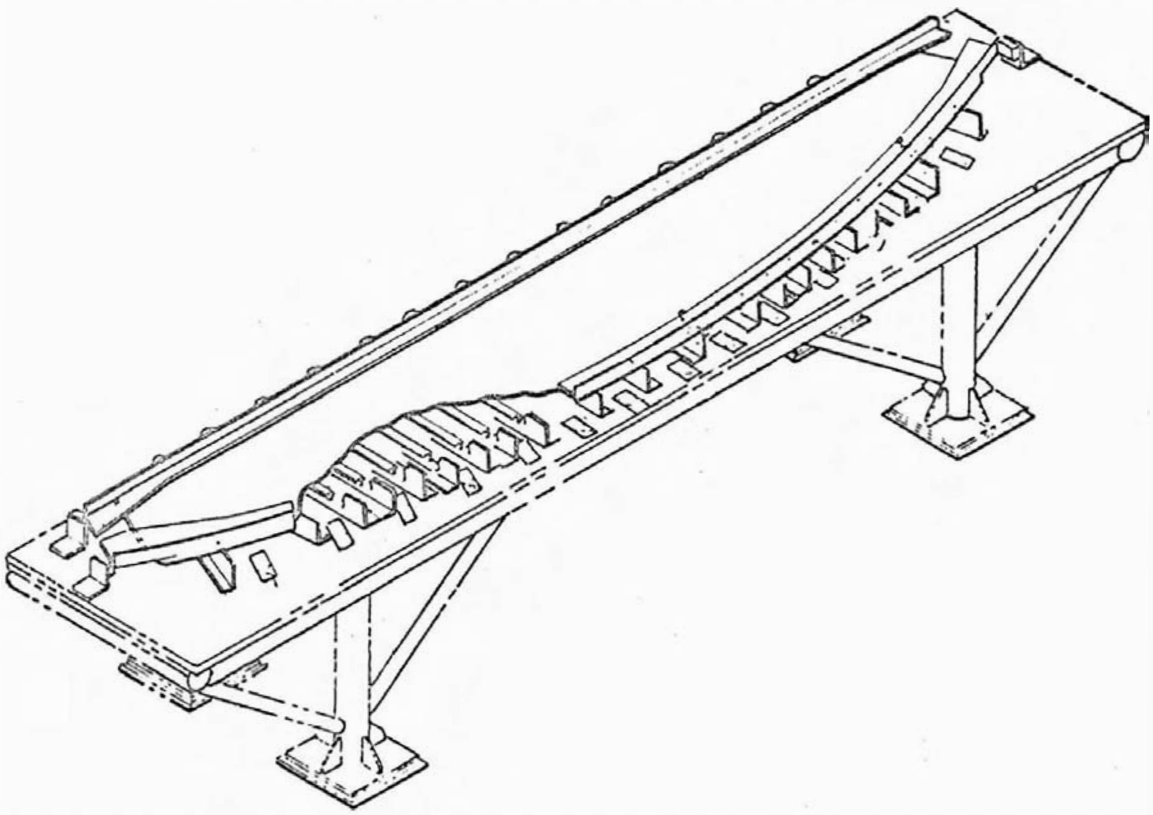


Figure 4-40. Intermediate Ring Assembly, Assembly Fixture AF-335-19110 (Sheet 1 of 2)

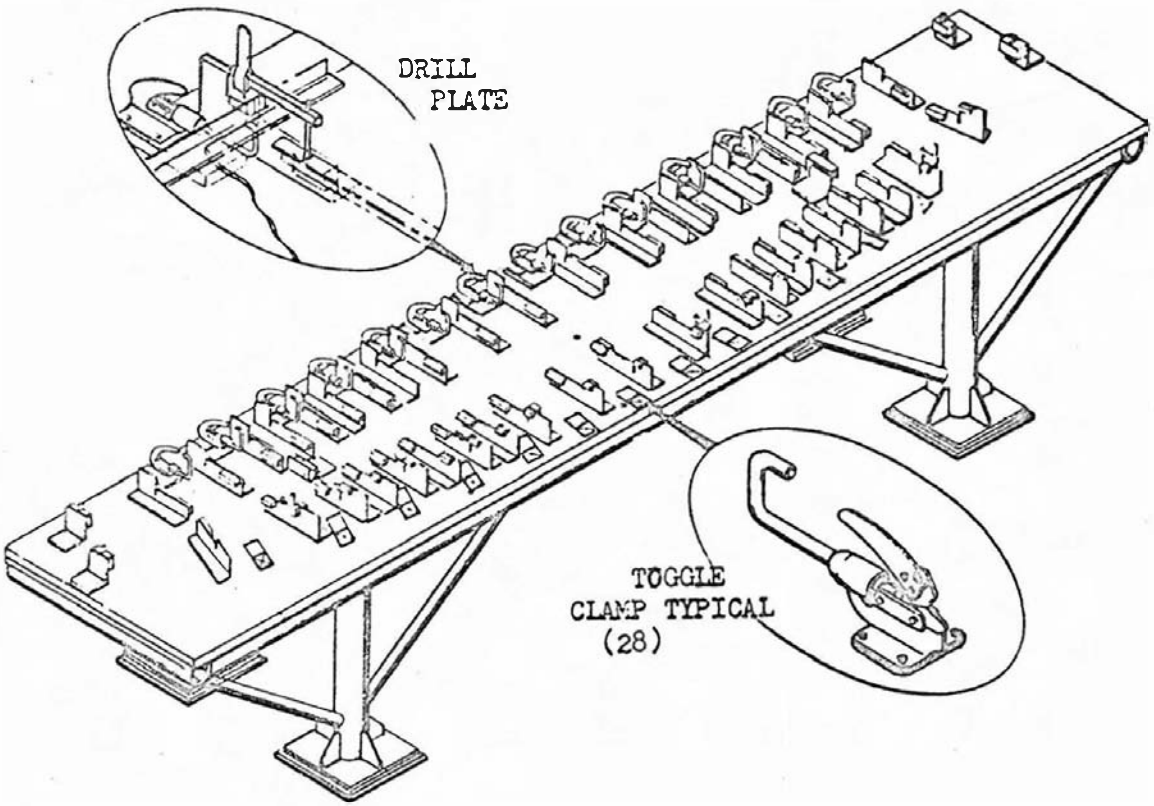


Figure 4-40. Intermediate Ring Assembly, Assembly Fixture AF-335-19110
(Sheet 2 of 2)

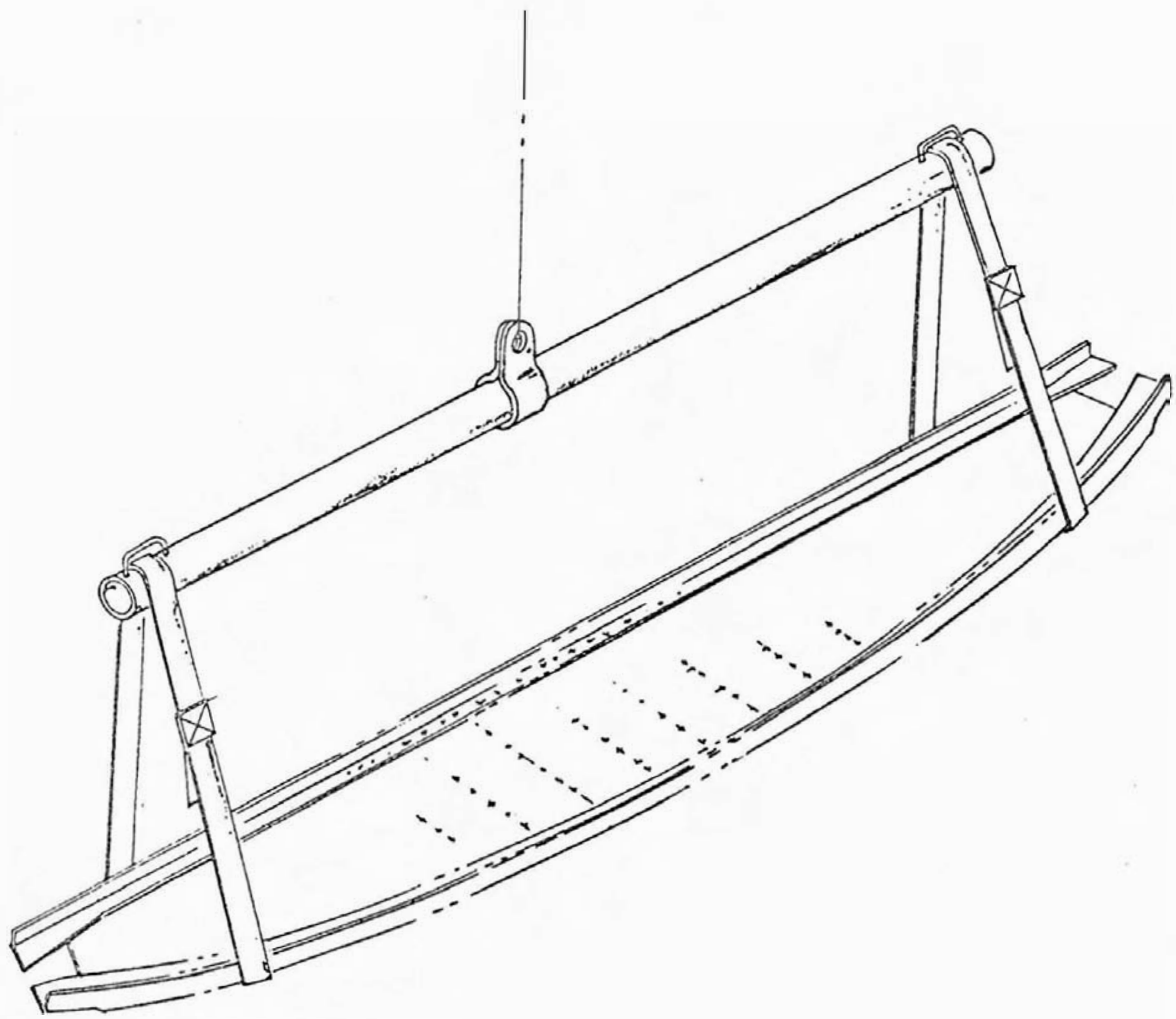


Figure 4-41. Intermediate Ring Assembly Hoisting Tool HT-370-19110

2.9 (Con.)

All eight segments for Station 152.5 are built on AF-335-19110.

All eight segments for Station 184.0 are built on AF-335-19120.

All eight segments for Station 216.0 are built on AF-335-19130.

All eight segments for Station 248.0 are built on AF-335-19140.

2.9.1 Intermediate ring segment assemblies are assigned -900 series numbers and differ from the actual engineering assembly in that all holes common to the holddown and thrust posts are omitted.

2.9.2 Check location of stiffener locating angles at centerline of assembly fixture AF-335-19110.

2.9.3 Load, position, and clamp all stiffeners in assembly fixture AF-335-19110.

2.9.4 Load and position doublers in assembly fixture AF-335-19110.

2.9.5 Load and aline web in proper position.

2.9.6 Load, position, and clamp inner cap (straight) in assembly fixture AF-335-19110.

2.9.7 Load, position, and clamp outer cap (contoured) in assembly fixture AF-335-19110.

2.9.8 Locate and clamp drill plate assembly.

2.9.9 Drill all holes full size using Winslow Spacematic.

2.9.10 Remove drill plate assembly.

2.9.11 Realine and clamp web.

2.9.12 Install all bolts in proper locations.

2.9.13 Remove intermediate ring assembly segment from assembly fixture AF-335-19110 and install in support fixture SF-335-19110 using hoisting tool HT-370-19110. (See figures 4-42 and 4-41.)

2.9.14 Install all rivets at proper locations per engineering drawing.

2.9.15 Repeat operations outlined in paragraphs 2.9.2 through 2.9.14 for the remaining intermediate ring assembly segments using the required assembly fixtures.

2.10 <u>Intercostal Assemblies 60B19300-1-900, 60B19301-1-900, 60B19310-1-900, and 60B19316-1-900.</u> The intercostal assemblies 60B19300-1-900, 60B19301-1-900, 60B19310-1-900, and 60B19316-1-900 are assembled in bench-type assembly fixtures AF-335-19310 and AF-335-19316. (See figure 4-43.)

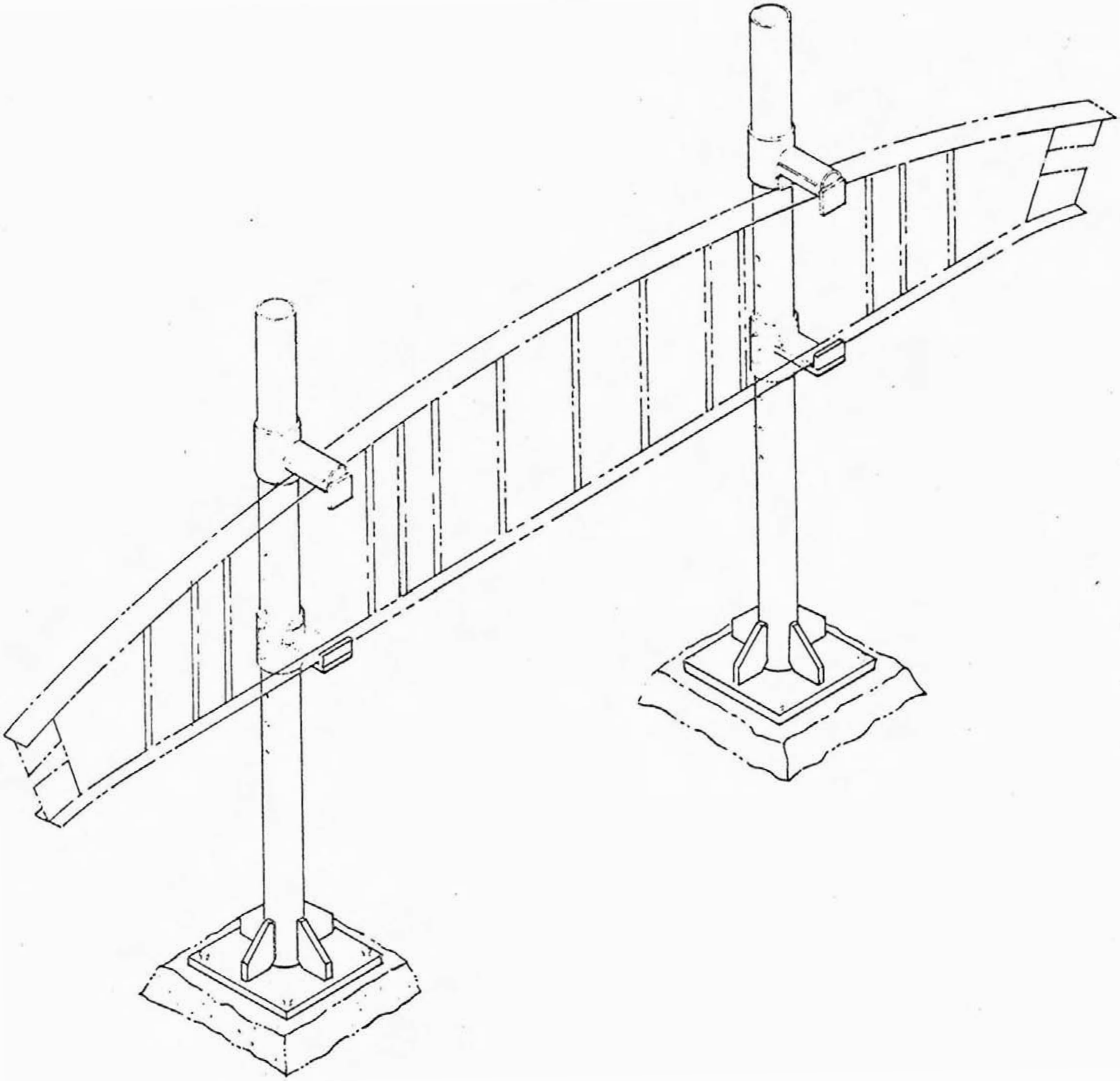
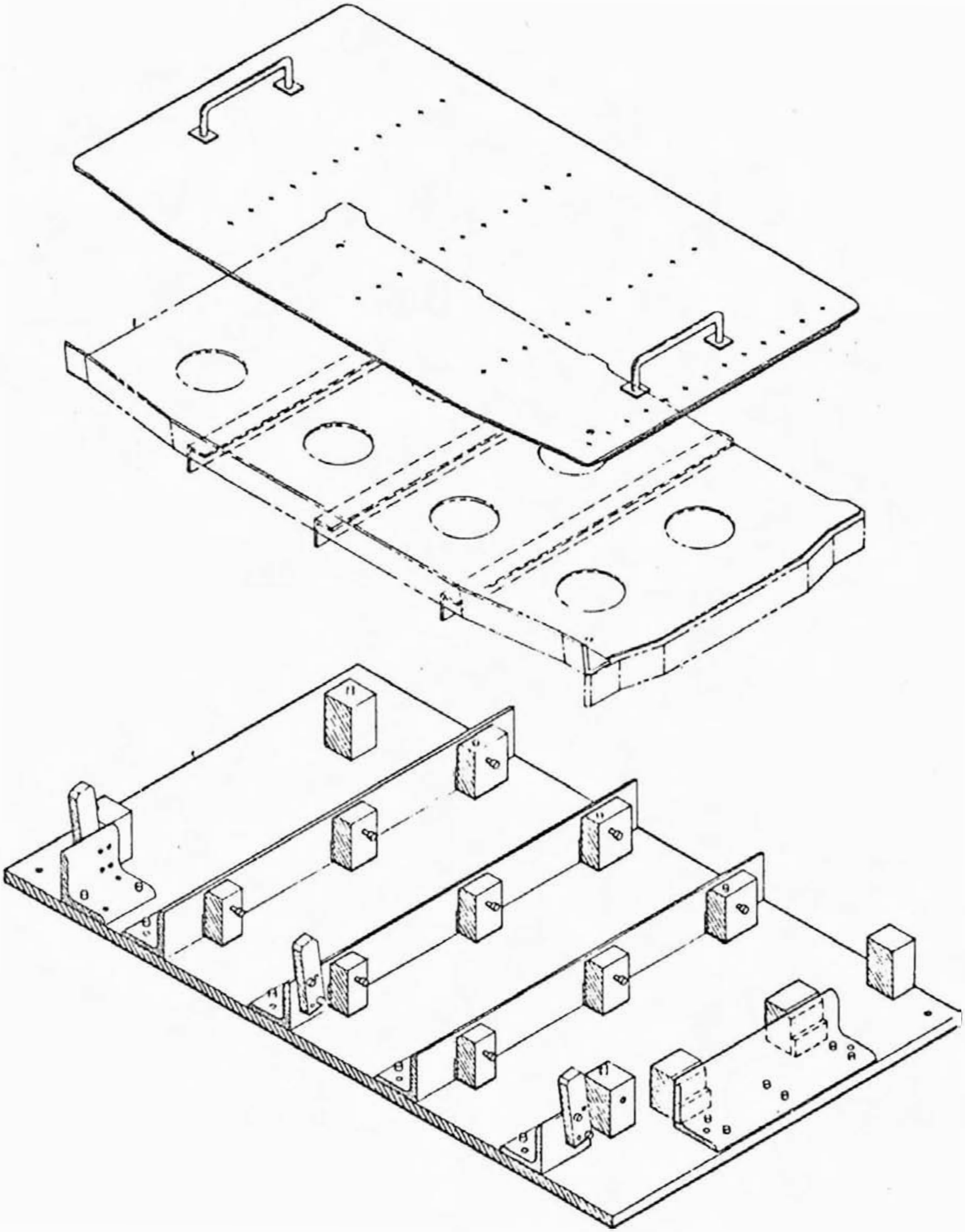


Figure 4-42. Intermediate Ring Assembly Support Fixture SF-335-19110



Fixture 4-43. Intercostal Assembly, Assembly Fixture AF-335-19310

2.10.1 The intercostal assemblies are -900 assemblies and differ from the actual engineering assemblies in that stiffeners are omitted to facilitate tooling.

2.10.2 The assembly sequence for intercostal assemblies 60B19300-1-900, 60B19301-1-900, 60B19310-1-900, and 60B19316-1-900 is outlined in paragraphs 2.10.3 through 2.10.7.

2.10.3 Load stiffeners and cap in assembly fixture AF-335-19310.

2.10.4 Load web and chord in assembly fixture AF-335-19310; apply drill plate and drill all holes.

2.10.5 Install fasteners.

2.10.6 Remove intercostal assembly 60B19300-1-900 from assembly fixture AF-335-19310.

2.10.7 Repeat operations outlined in paragraphs 2.10.3 through 2.10.6 for the remaining intercostal assemblies 60B19300-1-900, 60B19301-1-900, 60B19310-1-900, and 60B19316-1-900 using the required assembly fixtures.

2.11 Holddown Position Skin Panel Assemblies 60B18100-1-900, 60B18200-1-900, and 60B18320-1-900. The holddown position skin panel assemblies 60B18100-1-900, 60B18200-1-900, and 60B18320-1-900 are assembled in the holddown position skin panel assembly, assembly fixture AF-335-18100. (See figure 4-44.) The skin panel assemblies trim fixture TmF-335-18300 is also used to produce a complete assembly. (See figure 4-45.) The holddown position skin panel assemblies are fabricated as -900 assemblies and differ from engineering drawings in the omission of some holes to facilitate tooling.

2.11.1 The assembly sequence for skin panel assembly 60B18100-1-900 is outlined in paragraphs 2.11.1.1 through 2.11.1.21.

2.11.1.1 Load the hat-section stringers in assembly fixture AF-335-18100. (See figure 4-44.)

2.11.1.2 Using hoisting tool HT-370-18100, load the skin panel (with doubler temporarily attached where applicable) into assembly fixture AF-335-18100. (See figure 4-46.)

2.11.1.3 Install the removable contour headers of assembly fixture AF-335-18100; locate and clamp parts in place.

2.11.1.4 Load tapered fillers in joggled areas, where applicable.

2.11.1.5 Drill fastener holes; install fasteners.

2.11.1.6 Drill holes for indexing the Y-ring plates.

2.11.1.7 Install alinement fixtures and seal. (See figure 4-44.)

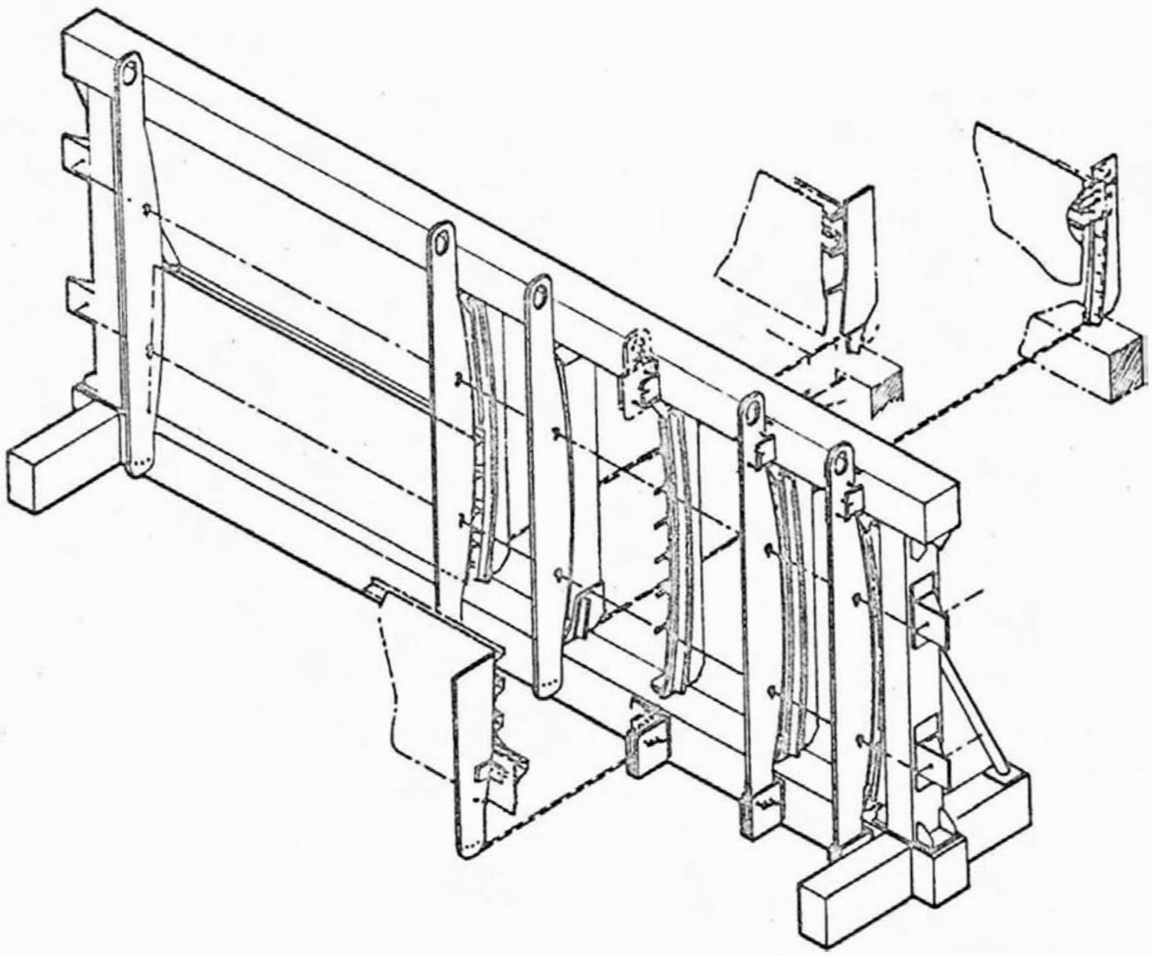


Figure 4-44. Skin Panel Assemblies Assembly Fixture AF-335-18100
(Sheet 1 of 2)

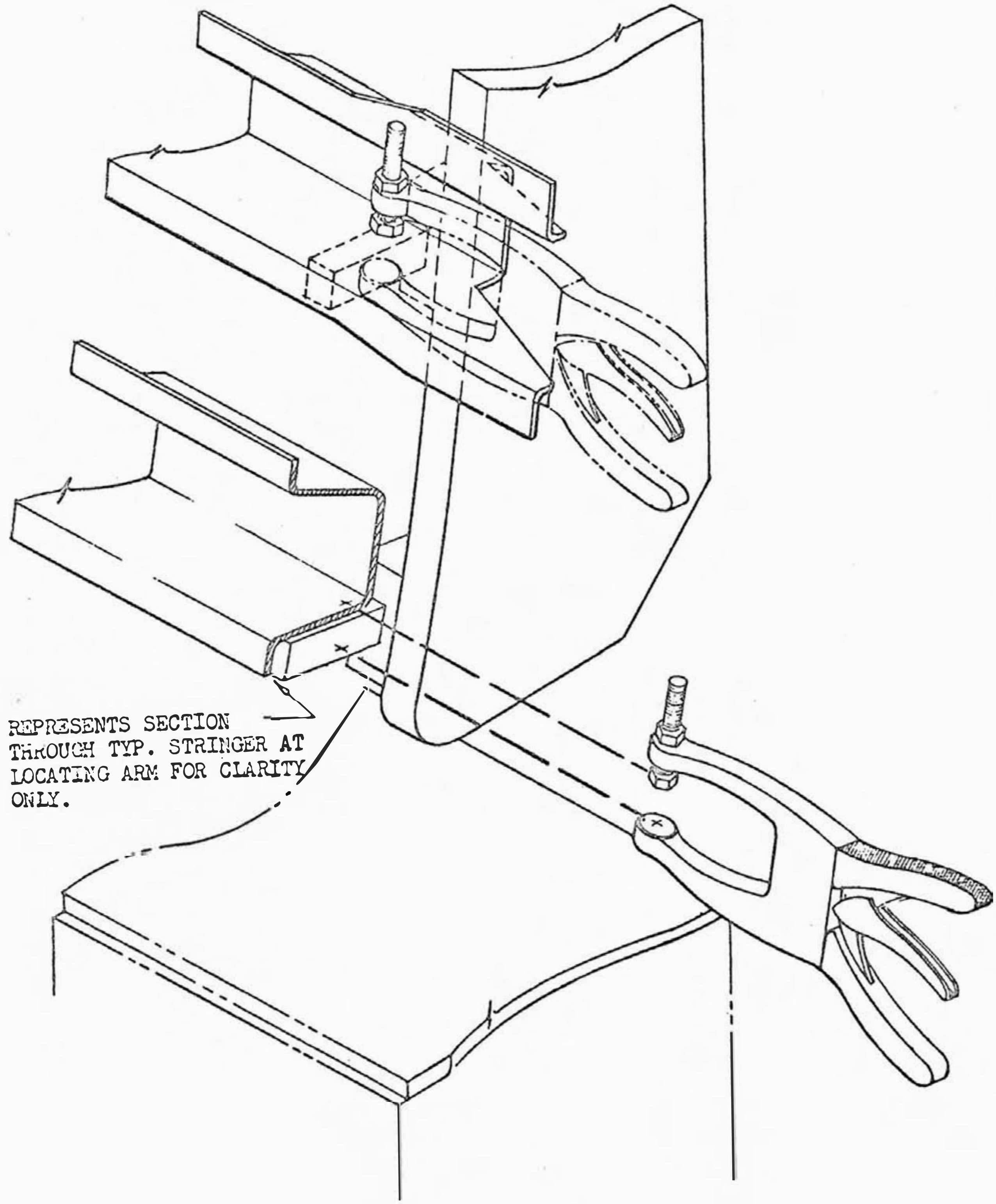


Figure 4-44. Skin Panel Assemblies Assembly Fixture AF-335-18100
(Sheet 2 of 2.)

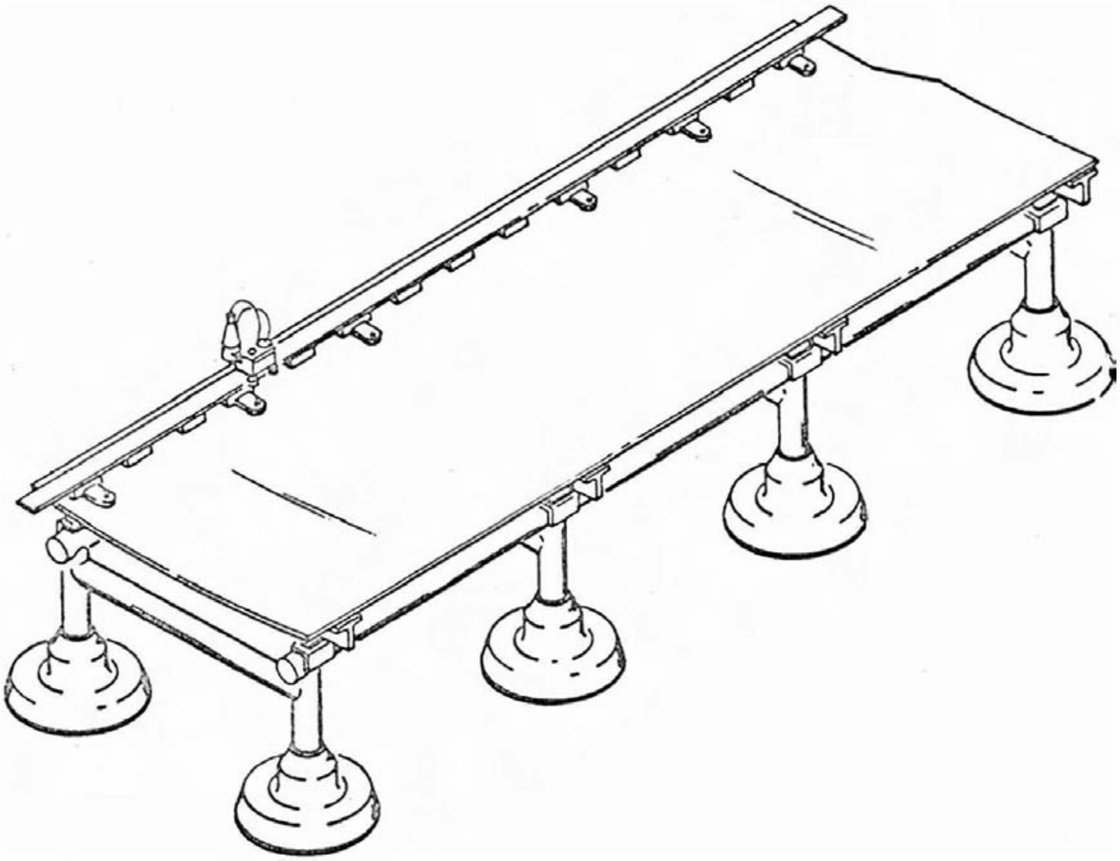


Figure 4-45. Skin Panel Assemblies Trim Fixture TmF-335-18300

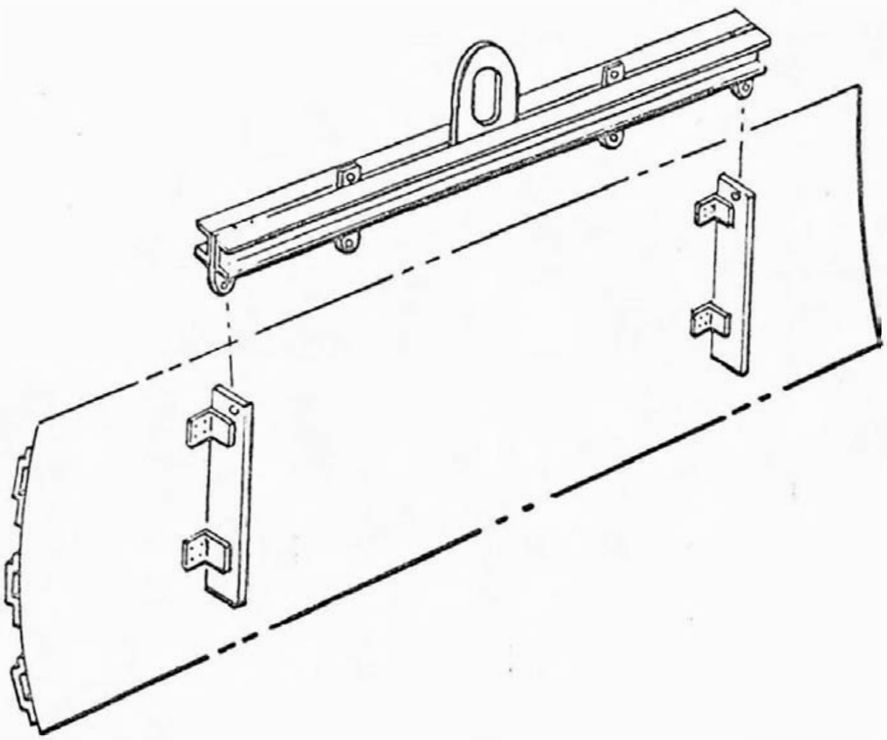


Figure 4-46. Skin Panel Assemblies Hoisting Tool HT-370-18100

2.11.1.8 Drill "K" holes for router guides of trim fixture TmF-335-18300.

2.11.1.9 Attach hoisting tool HT-370-18100 and strongbacks. (See figure 4-46.)

2.11.1.10 Remove skin panel assembly 60B18100-1-900 from assembly fixture AF-335-18100 using hoisting tool HT-370-18100.

2.11.1.11 Load skin panel assembly 60B18100-1-900 onto table of trim fixture TmF-335-18300. (See figure 4-45.)

2.11.1.12 Apply router guides and bolt to skin panel assembly 60B18100-1-900.

2.11.1.13 Net trim aft end and sides of skin panel assembly 60B18100-1-900.

2.11.1.14 Remove router guides.

2.11.1.15 Install special bolts of holding fixture HF-335-18100 in tool holes in skin panel assembly 60B18100-1-900. (See figures 4-47 and 4-48.)

2.11.1.16 Remove skin panel assembly 60B18100-1-900 from trim fixture TmF-335-18300 using hoisting tool HT-370-18100.

2.11.1.17 Load skin panel assembly 60B18100-1-900 into holding fixture HF-335-18100. (See figure 4-47.)

2.11.1.18 Drill full-size "K" holes for router guides of trim fixture TmF-335-18300; install fasteners.

2.11.1.19 Remove strongbacks. Drill full-size attach holes; install fasteners.

2.11.1.20 Using hoisting tool HT-370-18100, transfer skin panel assembly 60B18100-1-900 from holding fixture HF-335-18100 to storage and shipping rack StR-370-18100. (See figure 4-49.)

2.11.1.21 Remove special bolts from tool holes in skin panel assembly 60B18100-1-900.

2.11.2 The assembly sequence for holddown position skin panel assemblies 60B18200-1-900 and 60B18320-1-900 is outlined in paragraphs 2.11.2.1 through 2.11.2.24.

2.11.2.1 Load the hat section and double tee stringers in assembly fixture AF-335-18100. (See figure 4-44.)

2.11.2.2 Using hoisting tool HT-370-18100, load the skin panel, with the doubler temporarily attached, in assembly fixture AF-335-18100. (See figures 4-44 and 4-46.)

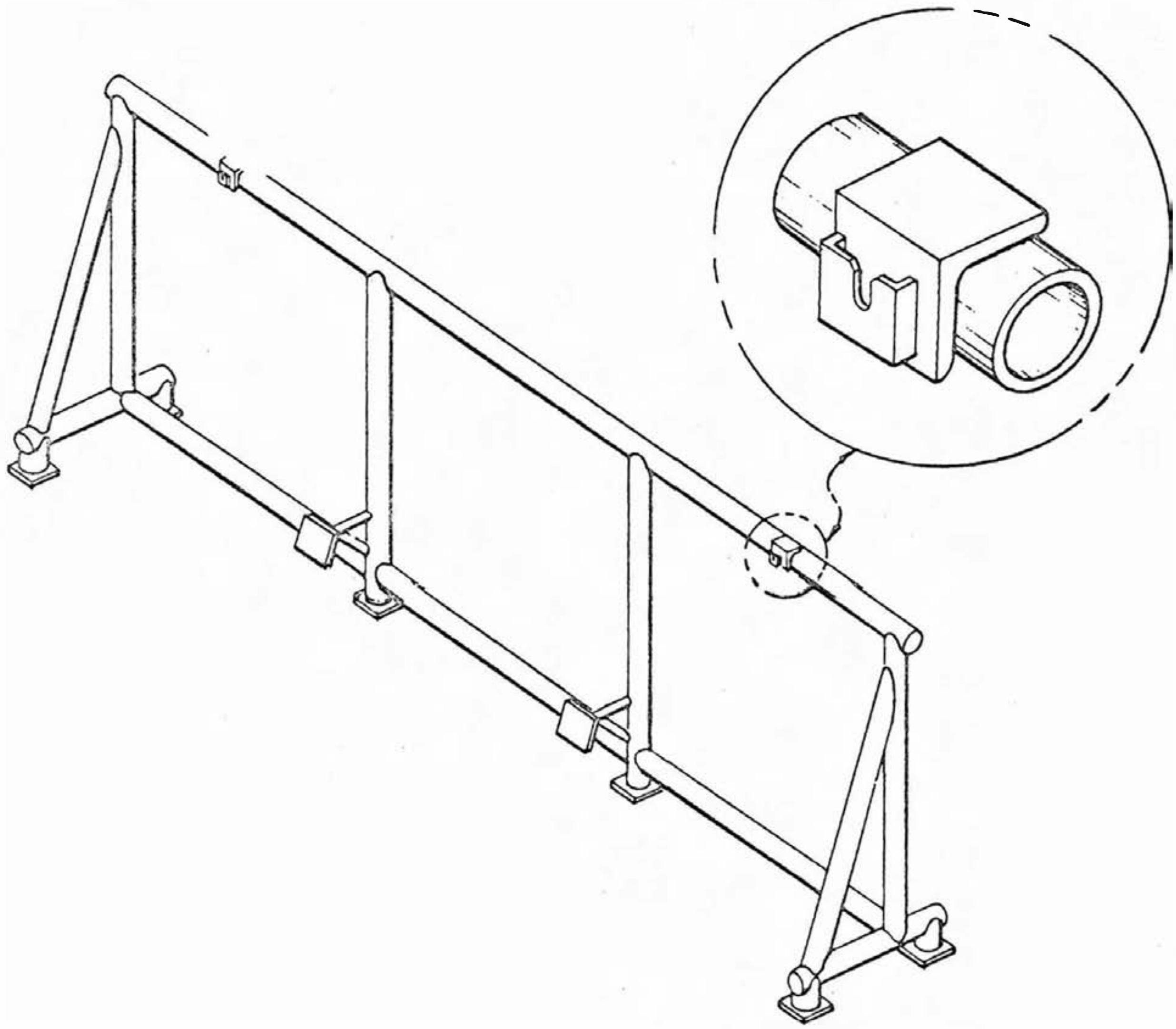


Figure 4-47. Skin Panel Assemblies Holding Fixture HF-335-18100

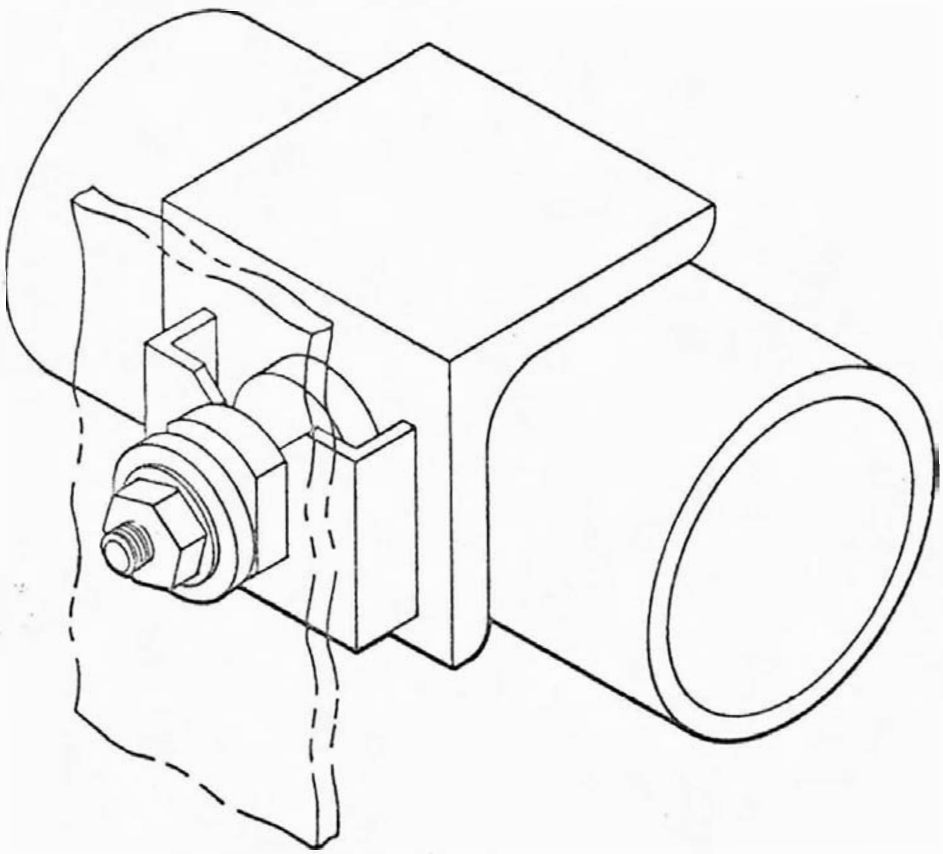


Figure 4-48. Special Bolts of Holding Fixture HF-335-18100

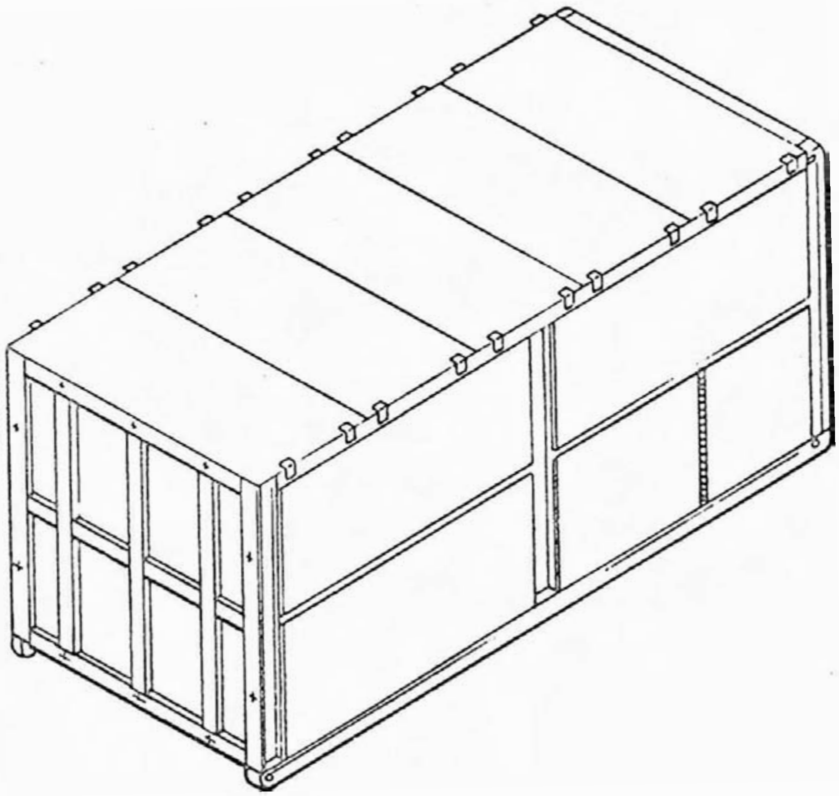


Figure 4-49. Skin Panel Assemblies Shipping and Storage Rack StR-370-18100

2.11.2.3 Install the removable contour headers of assembly fixture AF-335-18100; locate and clamp parts in place.

2.11.2.4 Load tapered fillers in joggled areas.

2.11.2.5 Drill fastener holes; install fasteners.

2.11.2.6 Drill holes for indexing the Y-ring drill plate.

2.11.2.7 Install alinement fixtures and seal.

2.11.2.8 Drill "K" holes for router guides of trim fixture TmF-335-18300.

2.11.2.9 Hand locate fillers at upper and lower edge of umbilical opening. Drill and tack rivet in place.

2.11.2.10 Attach hoisting tool HT-370-18100 and strongbacks. (See figure 4-46.)

2.11.2.11 Remove skin panel assembly 60B18200-1-900 from assembly fixture AF-335-18100.

2.11.2.12 Load skin panel assembly 60B18200-1-900 onto table of trim fixture TmF-335-18300.

2.11.2.13 Apply router guides and bolt to skin panel assembly 60B18200-1-900.

2.11.2.14 Net trim aft end and sides of skin panel assembly 60B18200-1-900.

2.11.2.15 Remove router guides.

2.11.2.16 Install special bolts of holding fixture HF-335-18100 in tool holes in skin panel assembly 60B18200-1-900. (See figure 4-48.)

2.11.2.17 Remove skin panel assembly 60B18200-1-900 from trim fixture TmF-335-18300 using hoisting tool HT-370-18100.

2.11.2.18 Load skin panel assembly 60B18200-1-900 into holding fixture HF-335-18100. (See figure 4-47.)

2.11.2.19 Drill full-size "K" holes for router guides of trim fixture TmF-335-18300; install fasteners.

2.11.2.20 Apply drill plate and drill attach hole pattern for umbilical plate.

2.11.2.21 Install fasteners around umbilical opening.

2.11.2.22 Remove strongbacks. Drill full-size attach holes; install fasteners.

2.11.2.23 Using hoisting tool HT-370-18100, transfer skin panel assembly 60B18200-1-900 from holding fixture HF-335-18100 to storage and shipping rack StR-370-18100. (See figure 4-49.)

2.11.2.24 Remove special bolts from tool holes in skin panel assembly 60B18200-1-900.

2.12 Holddown Position Skin Panel Assemblies 60B18100-2-900, 60B18327-1-900, and 60B18327-3-900. The holddown position skin panel assemblies 60B18100-2-900, 60B18327-1-900, and 60B18327-3-900 are assembled in the holddown position skin panel assembly, assembly fixture AF2-335-18100. (See figure 4-44.) The skin panel assemblies trim fixture TmF-335-18300 is also used to produce a complete assembly. (See figure 4-45.)

2.12.1 The holddown position skin panel assemblies are fabricated as -900 assemblies and differ from engineering drawings in the omission of some holes to facilitate tooling.

2.12.2 The assembly sequence for skin panel assembly 60B18100-2-900 is identical to that for skin panel assembly 60B18100-1-900 as outlined in paragraphs 2.11.1.1 through 2.11.1.21.

2.13.3 The assembly sequence for skin panel assemblies 60B18327-1-900 and 60B18327-3-900 is identical to that for skin panel assemblies 60B18200-1-900 and 60B18320-1-900 as outlined in paragraphs 2.11.2.1 through 2.11.2.24.

2.13 Fin Position Skin Panel Assembly 60B18300-1-900. The fin position skin panel assembly 60B18300-1-900 is assembled in the fin position skin panel assembly fixture AF-335-18300. (See figure 4-44.) The skin panel assemblies trim fixture TmF-335-18300 is also used to create a complete assembly. (See figure 4-45.)

2.13.1 The fin position skin panel assembly 60B18300-1-900 is fabricated as a -900 assembly and differs from engineering drawings in the omission of some holes to facilitate tooling.

2.13.2 The assembly sequence for fin position skin panel assembly 60B18300-1-900 is outlined in paragraphs 2.13.3 through 2.13.23.

2.13.3 Load the hat-section stringers into assembly fixture AF-335-18300. (See figure 4-44.)

2.13.4 Using hoisting tool HT-370-18100, load the skin panel, with the doubler temporarily attached, into assembly fixture AF-335-18300.

2.13.5 Install the removable contour headers of the tool, locate parts, and clamp in place.

2.13.6 Load tapered fillers in joggled areas.

2.13.7 Drill fastener holes; install fasteners.

2.13.8 Drill holes for indexing the Y-ring plates.

2.13.9 Install alinement fixtures and seal.

2.13.10 Drill "K" holes for router guides of trim fixture TmF-335-18300.

2.13.11 Attach hoisting tool HT-370-18100 and strongbacks. (See figure 4-46.)

2.13.12 Remove skin panel assembly 60B18300-1-900 from assembly fixture AF-335-18300.

2.13.13 Load skin panel assembly 60B18300-1-900 onto table of trim fixture TmF-335-18300. (See figure 4-45.)

2.13.14 Apply router guides and bolt to skin panel assembly 60B18300-1-900.

2.13.15 Net trim aft end and sides of skin panel assembly 60B18300-1-900.

2.13.16 Remove router guides.

2.13.17 Install special bolts of holding fixture HF-335-18100 in tool holes in the skin panel assembly 60B18300-1-900. (See figure 4-48.)

2.13.18 Remove skin panel assembly 60B18300-1-900 from trim fixture TmF-335-18300 using hoisting tool HT-370-18100.

2.13.19 Load skin panel assembly 60B18300-1-900 into holding fixture HF-335-18100. (See figure 4-47.)

2.13.20 Drill full-size "K" holes for router guides of trim fixture TmF-335-18300; install fasteners.

2.13.21 Remove strongbacks. Drill full-size attach holes; install fasteners.

2.13.22 Using hoisting tool HT-370-18100, transfer skin panel assembly 60B18300-1-900 from holding fixture HF-335-18100 to storage and shipping rack StR-370-18100. (See figure 4-49.)

2.13.23 Remove special bolts from tool holes in skin panel assembly 60B18300-1-900.

2.14 Fin Position Skin Panel Assembly 60B18300-2-900. The fin position skin panel assembly 60B18300-2-900 is assembled in the fin position skin panel assembly fixture AF2-335-18300. (See figure 4-44.) The skin panel assemblies trim fixture TmF-335-18300 is also used to create a complete assembly. (See figure 4-45.)

2.14.1 The fin position skin panel assembly 60B18300-2-900 is fabricated as a -900 assembly and differs from engineering drawings in the omission of some holes to facilitate tooling.

2.14.2 The assembly sequence for the fin position skin panel assembly 60B18300-2-900 is identical to that for the fin position skin panel assembly 60B18300-1-900 as outlined in paragraph 2.13.3 through 2.13.23.

2.15 <u>F-1 Engine Actuator Support Assemblies 60B32220-1 and 60B32220-2.</u> The F-1 engine actuator support assemblies 60B32220-1 and 60B32220-2 are assembled in weld fixture WF-335-32220 and mill fixture MF-335-32220. (See figures 4-50 and 4-51.)

2.15.1 The -900 details differ from the actual engineering parts in that excess material is planned into the detail. Excess material is removed by finish machining operations during the assembly process.

2.15.2 The assembly sequence for F-1 engine actuator support assemblies 60B32220-1 and 60B32220-2 is outlined in paragraphs 2.15.3 through 2.15.15.

2.15.3 Place seven-inch diameter terminal fitting 60B32222-1-900 or 60B32222-2-900 opposite the machined-finish end of seven-inch diameter tube 60B32221-1-900 and load into weld fixture WF-335-32220. Position expandable welding bladder MiT-335-32220 and circumferential back-up inside the tube. Machine weld.

2.15.4 Load the seven-inch diameter tube weldment into mill fixture MF3-335-32220; trim to net length, and cut weld chamfer.

2.15.5 Load apex fitting 60B32224-1-900 or 60B32224-2-900 and five-inch diameter tube 60B32223-1-900 into weld fixture WF-335-32220.

2.15.6 Load the five-inch diameter tube weldment into mill fixture MF4-335-32220; trim the five-inch diameter tube weldment to net length, and cut weld chamfer.

2.15.7 Reload five-inch diameter tube weldment into weld fixture WF-335-32220 and weld end fitting 60B32226-1 to the trimmed end of the five-inch diameter tube weldment. Position expandable welding bladder MiT-335-32220 and circumferential back-up inside the tube. Machine weld.

2.15.8 Load the seven-inch diameter tube weldment into weld fixture WF-335-32220.

2.15.9 Use optical alinement bar and alinement scope MiT2-335-32220 to establish the five-inch diameter tube weldment and the seven-inch diameter tube weldment in their correct radial alinement.

2.15.10 Use alinement gage MiT3-335-32220 to establish the correct angular relationship between the centerline of five-inch diameter tube 60B32223-1-900 and the centerline of seven-inch diameter tube 60B32221-1-900.

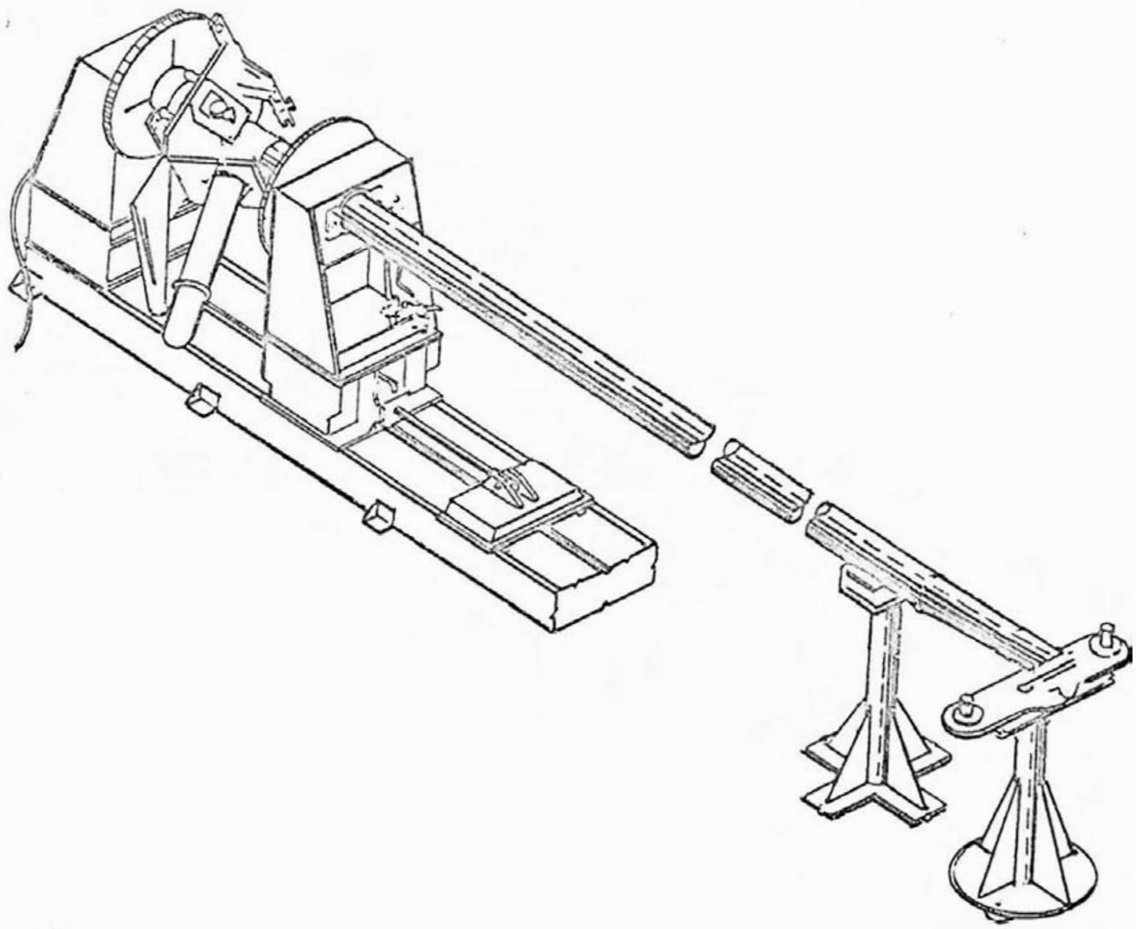


Figure 4-50. F-1 Engine Actuator Support Assembly Weld Fixture WF-335-32220

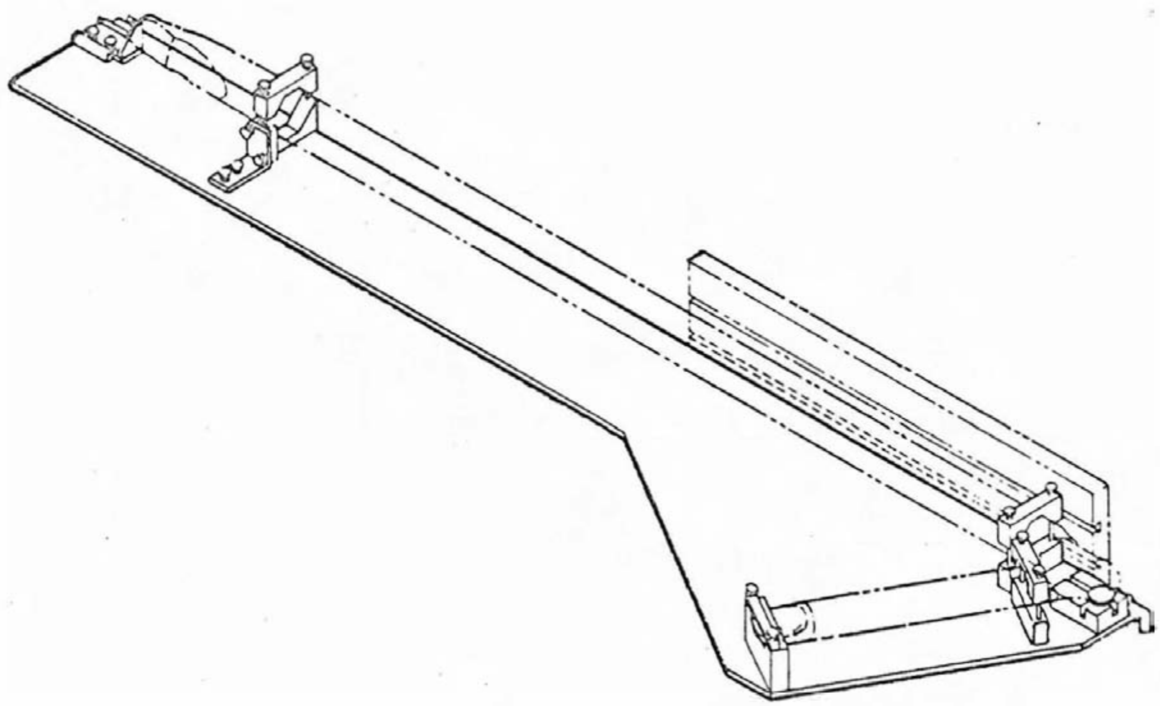


Figure 4-51. F-1 Engine Actuator Support Assembly Mill Fixture MF-335-32220

2.15.11 Weld the five-inch diameter tube weldment to the seven-inch diameter tube weldment. Use expandable weld bladder MiT-335-32220 to provide backup.

2.15.12 Attach mill fixture MF-335-32220 to milling machine; load F-1 engine actuator support assembly 60B32220-1-900 or 60B32220-2-900. (See figure 4-51.) Mill excess material from apex fitting 60B32224-1-900 or 60B32224-2-900.

2.15.13 Line bore and chamfer the hole in apex fitting 60B32224-1-900 or 60B32224-2-900.

2.15.14 Ream the bushings of apex fitting 60B32224-1-900 or 60B32224-2-900 to correct inside diameter, and place in Dewar container of liquid nitrogen.

NOTE: Cryogenic method to -310 degrees Fahrenheit.

2.15.15 Press fit bushings into apex fitting 60B32224-1-900 or 60B32224-2-900 with driving tool MiT-335-32220.

2.16 <u>Lower Ring Actuator Support Strut Assemblies 60B32230-1 and 60B32230-2.</u> Lower ring actuator support strut assemblies 60B32230-1 and 60B32230-2 are assembled in weld fixture WF-335-32230 and mill fixture MF-335-32230. (See figures 4-52 and 4-53.)

2.16.1 The -900 details differ from the actual engineering parts in that excess material is planned into the details. Excess material is removed by finish machining operations during the assembly process.

2.16.2 The welding-milling sequence for strut assemblies 60B32230-1 and 60B32230-2 is outlined in paragraphs 2.16.3 through 2.16.8.

2.16.3 Load the actuator support strut apex fitting 60B32233-1-900 into weld fixture WF-335-32230; aline per drawing, and circumferential weld.

2.16.4 Drill two fixture holes in actuator support strut apex fitting 60B32233-1-900.

2.16.5 Remove weldment from weld fixture WF-335-32230 and load into mill fixture MF2-335-32230; trim 2.50-inch diameter tube to net length.

2.16.6 Remove weldment from mill fixture MF2-335-32230 and load weldment and support actuator strut end fitting 60B32232-1A into weld fixture WF-335-32230; aline and weld.

2.16.7 Remove weldment from weld fixture WF-335-32230 and load into mill fixture MF-335-32230; mill strut assemblies 60B32230-1 or 60B32230-2 to drawing tolerances.

2.16.8 Remove strut assembly 60B32230-1 or 60B32230-2 from mill fixture MF-335-32230.

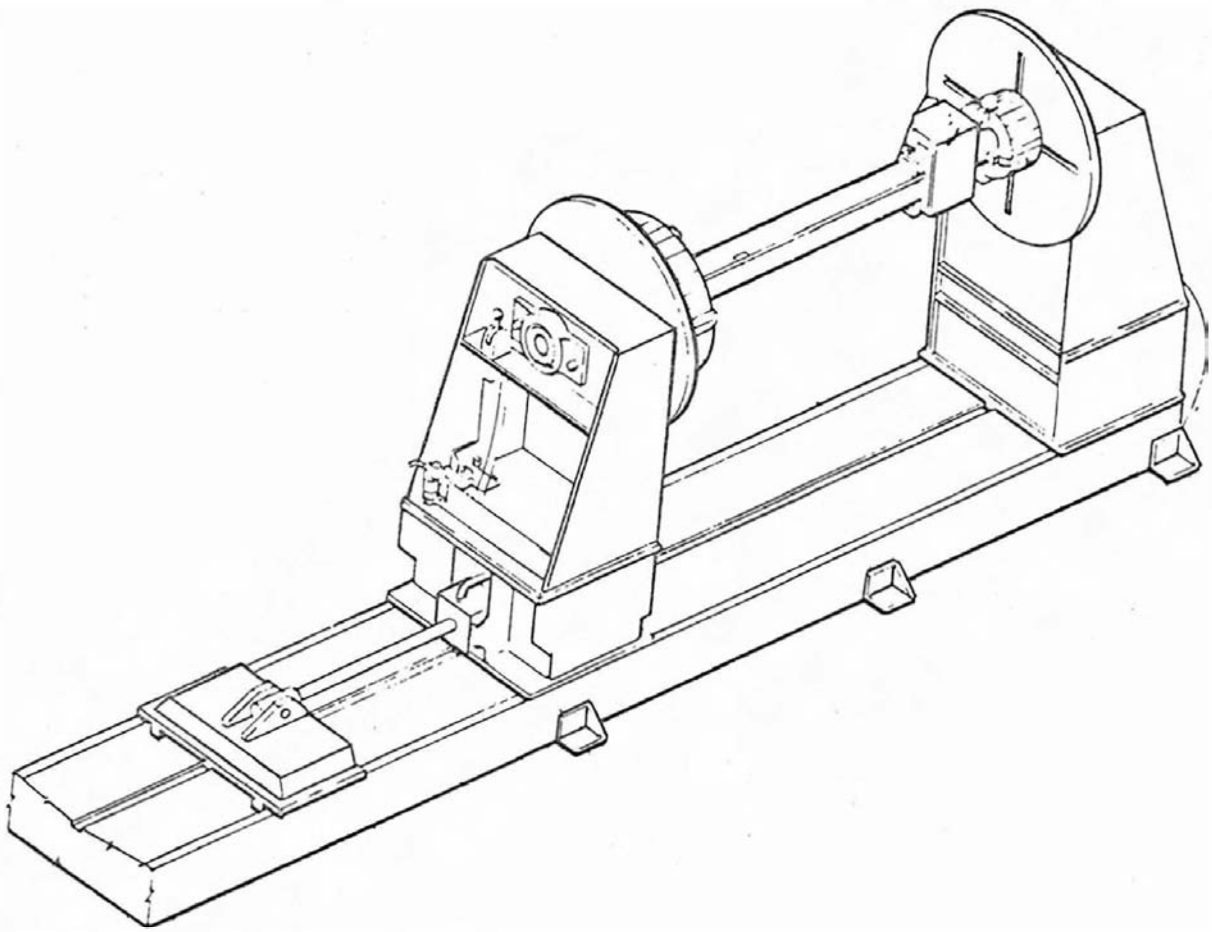


Figure 4-52. Lower Ring Actuator Support Strut Assemblies Weld Fixture WF-335-32230

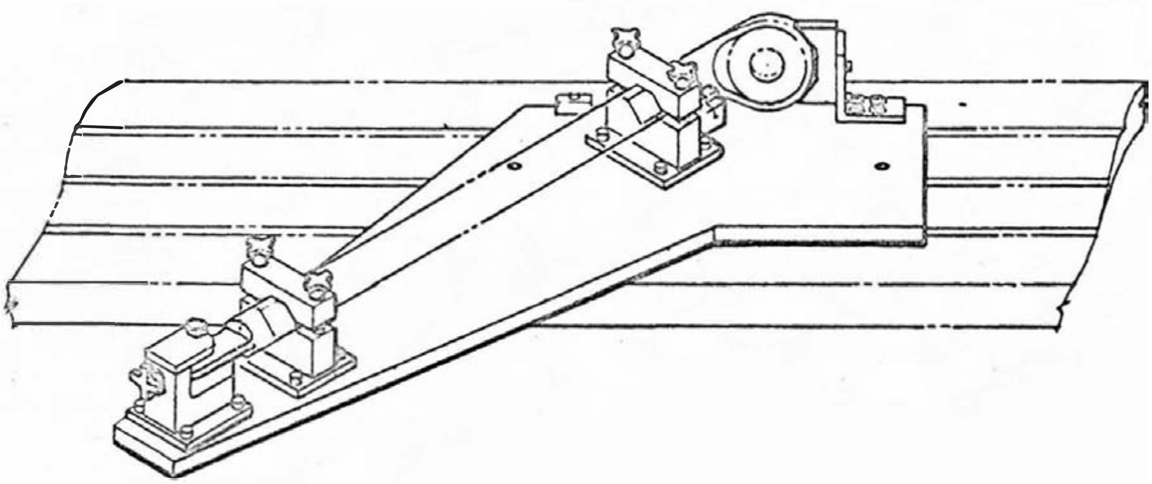


Figure 4-53. Lower Ring Actuator Support Strut Assemblies Mill Fixture MF-335-32230

2.17 <u>Outboard Propellant Duct Support Assembly 60B19702 - At Michoud.</u> (See figure 4-54.) The outboard propellant duct support assembly 60B19702-1 is fabricated in assembly fixture AF-335-19702. The assembly sequence is outlined in paragraphs 2.17.1 through 2.17.5.

2.17.1 Position two bulkhead assemblies 60B19740 in assembly fixture AF-335-19702.

2.17.2 Position four fuel duct terminal fittings and two end beam assemblies 60B19707 in assembly fixture AF-335-19702.

2.17.3 Position two side beam assemblies 60B19703 in assembly fixture AF-335-19702.

2.17.4 Position four attach angles (common to end beam and side beam assemblies), eight shear panel assemblies 60B19709 and 60B19711, two beam cap angles, and eight attach plates in assembly fixture AF-335-19702. Drill all holes full-size, and install fasteners.

2.17.5 Remove outboard propellant duct support assembly 60B19702 from assembly fixture AF-335-19702; install LOX and fuel link assemblies 60B19730 and 60B19734.

2.18 <u>Subassembly Tools for Production Assemblies Which Go Into AF-335-19702.</u>

2.18.1 Assembly fixture AF-335-19703 is used to assemble beam assembly 60B19703. (See figure 4-54.)

2.18.2 Assembly fixture AF-335-19707 is used to assemble end beam assembly 60B19707. (See figure 4-54.)

2.18.3 Assembly fixture AF-335-19711 is used to assemble shear panel assemblies 60B19709 and 60B19711. (See figure 4-55.)

2.19 <u>Outboard Propellant Duct Support Bulkhead Assembly 60B19740-1 - At Michoud.</u> (See figure 4-56.) Assemble bulkhead assembly 60B19740-1 in assembly fixture AF-335-19740.

2.19.1 Position and locate three angle stiffeners and two fuel duct terminal fittings in assembly fixture AF-335-19740.

2.19.2 Position and locate web in assembly fixture AF-335-19740.

2.19.3 Position and locate two tee caps, two LOX terminal fittings, and two bulkhead fittings in assembly fixture AF-335-19740.

2.19.4 Position drill plate and drill full-size holes common to LOX and fuel fittings, stiffeners, tee caps, and web.

2.19.5 Line drill holes common to LOX fitting, fuel fitting, tee caps, and bulkhead fittings.

2.19.6 Line drill holes common to LOX fitting, fuel fitting, and tee cap.

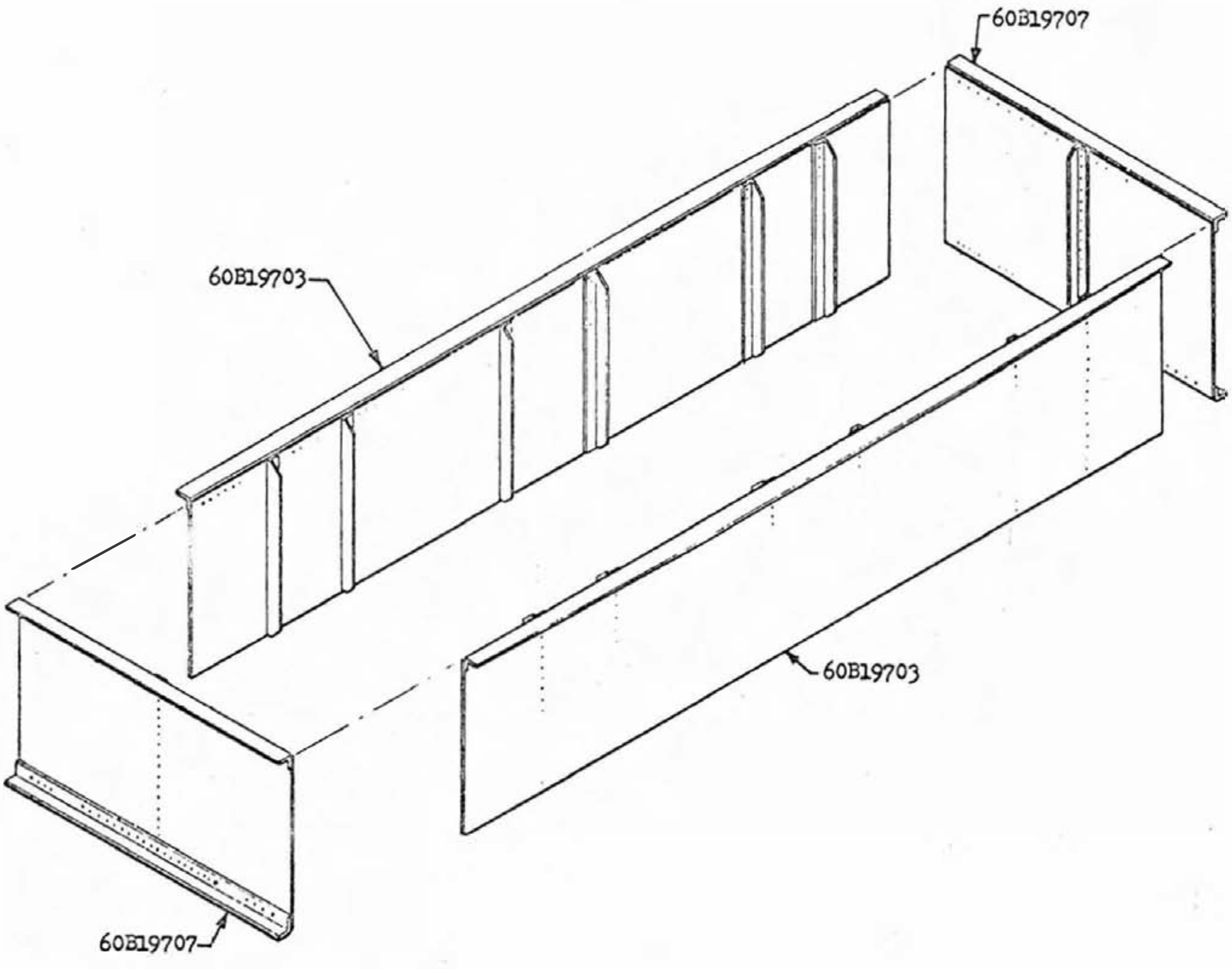


Figure 4-54. Outboard Propellant Duct Support Assembly 60B19702

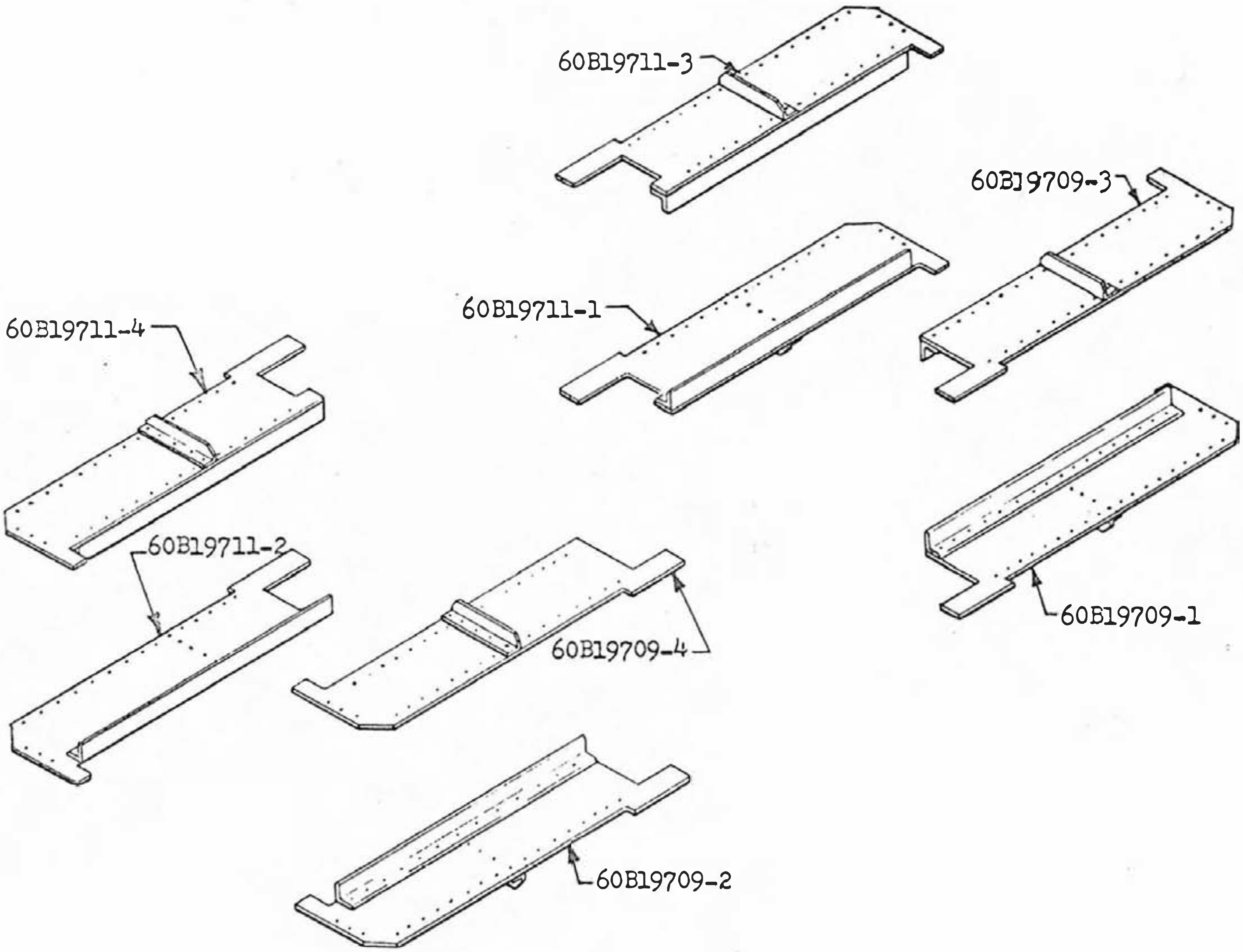


Figure 4-55. Outboard Propellant Duct Support Shear Panel Assemblies 60B19709 and 60B19711

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Figure 4-56. Outboard Propellant Duct Support Bulkhead Assembly
60B19740-1

2.19.7 Drill holes common to bulkhead fittings and tee caps.

2.19.8 Install fasteners for components listed in paragraph 2.19.4.

2.19.9 Remove outboard propellant duct support bulkhead assembly 60B19740-1 from assembly fixture AF-335-19740.

2.20 Outboard Propellant Duct Support Bulkhead Assembly 60B19740-2 - At Michoud. (See figure 4-56.) Assemble bulkhead assembly 60B19740-2 in assembly fixture AF2-335-19740. Refer to paragraphs 2.19.1 through 2.19.8 for assembly sequence.

2.21 (Outboard) Propellant Line Support Lower Strut Assembly 60B19720-1 - At Michoud. (See figure 4-57.)

2.21.1 Locate and position lower strut 60B19724 and adapter 60B19722 into assembly drill fixture ADF-335-19720. Line drill holes for attach bolts; install bolts.

2.21.2 Repeat procedure outlined in paragraphs 2.21.1 for other end of lower strut 60B19724.

2.21.3 Components assembled in paragraphs 2.21.1 and 2.21.2 make up a partial strut assembly 60B19720-1.

2.21.4 Press bearing into rod with MiT-335-19723 and roller swage with STAT-335-19723.

2.21.5 Assemble two rod end assemblies 60B19723 with lock nuts and one partial strut assembly 60B19720-1 to complete lower strut assembly 60B19720-1.

2.22 (Outboard) Propellant Line Support Upper Strut Assembly 60B19719 - At Michoud. (See figure 4-57.) Repeat operations outlined in paragraphs 2.21.1 through 2.21.5 for upper strut 60B19721 and partial strut assembly 60B19719-1.

2.23 (Outboard) Propellant Line Support Strut Assembly 60B19725 - At Michoud. (See figure 4-57.)

2.23.1 Locate and position strut 60B19726 and adapter 60B19727 into assembly drill fixture ADF-335-19725. Line drill holes for attach bolts and install bolts.

2.23.2 Repeat procedure outlined in paragraph 2.32.2 for other end of strut 60B19726.

2.23.3 Components assembled in paragraphs 2.23.1 and 2.23.2 make up a partial strut assembly 60B19725-1.

2.23.4 Press bearing in rod end and roller swage to complete rod end assembly 60B19728.

2.23.5 Assemble two rod end assemblies 60B19728 with lock nuts and one partial strut assembly 60B19725-1 to complete strut assembly 60B19725-1.

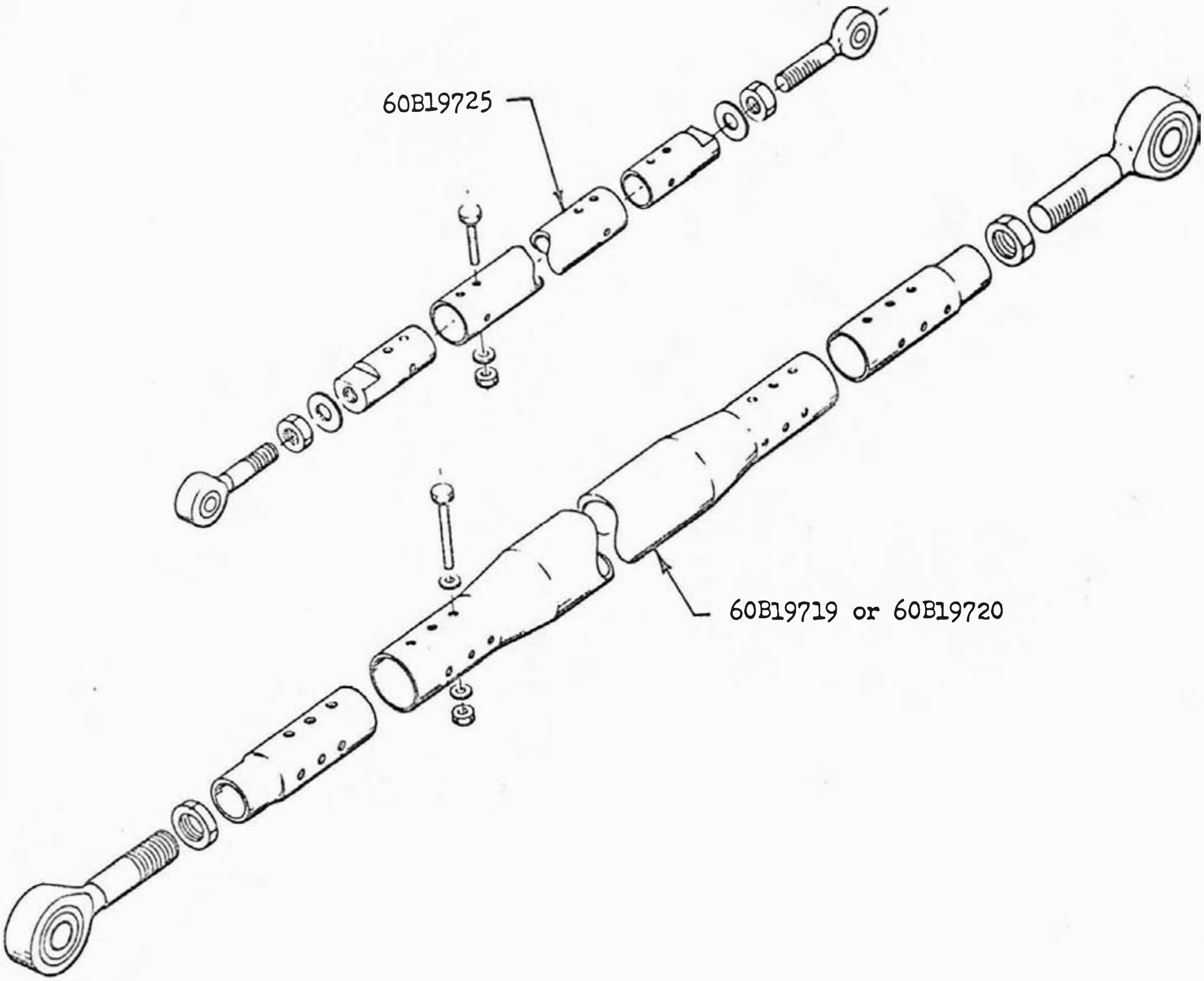

Figure 4-57. Outboard Propellant Line Support Strut Assemblies

2.24 Outboard Propellant Duct Support LOX Link Assembly 60B19730 and Fuel Link Assembly 60B19734 - At Michoud. (See figure 4-58.)

2.24.1 Locate LOX link 60B19731 and LOX lug 60B19733 in assembly drill fixture ADF-335-19730; drill holes.

2.24.2 Install shim, fasten with attach bolts, and press fit bearings which make up LOX link assembly 60B19730.

2.24.3 Locate fuel link 60B19735 and fuel lug 60B19736 in assembly drill fixture ADF-335-19734; drill holes.

2.24.4 Install shim, fasten with attach bolts, and press fit bearings to complete fuel link assembly 60B19734.

2.25 Inboard Propellant Duct Support Assembly 60B19701-1 - At Michoud. (See figure 4-59.) The outboard propellant duct support assembly 60B19701-1 is fabricated in assembly fixture AF-335-19701.

2.25.1 Position one short beam assembly 60B19750-1-900, one long beam assembly 60B19751-1-900, two inner bulkhead assemblies 60B19752-1-900 and 60B19752-2-900, two outer bulkhead assemblies 60B19753-1-900 and 60B19754-2-900, six web assemblies (two 60B19760-1-900, two 60B19760-2-900, one 60B19761-1-900, one 60B19761-2-900, and two webs 60B19788) in assembly fixture AF-335-19701.

2.25.2 Position four upper LOX fittings, four lower LOX fittings, eight fuel fittings, and two support angles in assembly fixture AF-335-19701.

2.25.3 Locate and position all clip angles, shims, doubler, and fillers.

2.25.4 Drill all holes; install fasteners.

2.25.5 Line drill holes in LOX and fuel fittings.

2.25.6 Remove partial assembly 60B19701-1 from assembly fixture AF-335-19701; install LOX and fuel link assemblies 60B19776, 60B19766, and 60B19769 which make up the complete inboard propellant duct assembly 60B19701.

2.26 Subassembly Tools for AF-335-19701 Production Assemblies.

2.26.1 Assembly fixture AF-335-19750 is used to assemble short beam assembly 60B19750-1-900. Some hole locations will be drilled and some fasteners installed while the short beam assembly 60B19750-1-900 is in assembly fixture AF-335-19701. (See figure 4-60.)

2.26.2 Assembly fixture AF-335-19751 is used to assemble long beam assembly 60B19751-1-900. Some hole locations will be drilled and some rivets will be installed while the long beam assembly is in assembly fixture AF-335-19701. (See figure 4-60.)

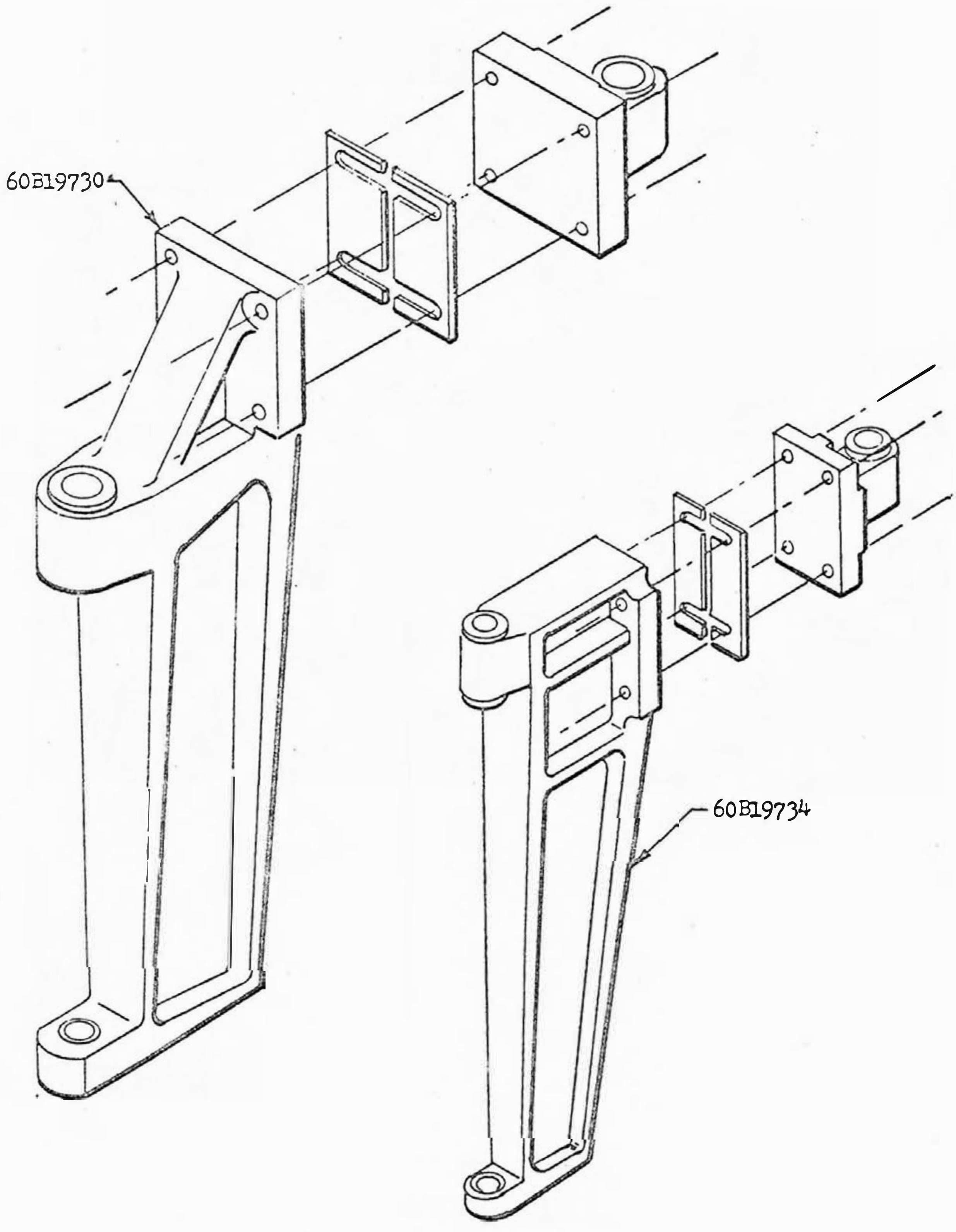

Figure 4-58. Outboard Propellant Duct Support Link Assemblies

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Figure 4-59. Inboard Propellant Duct Support Assembly 60B19701

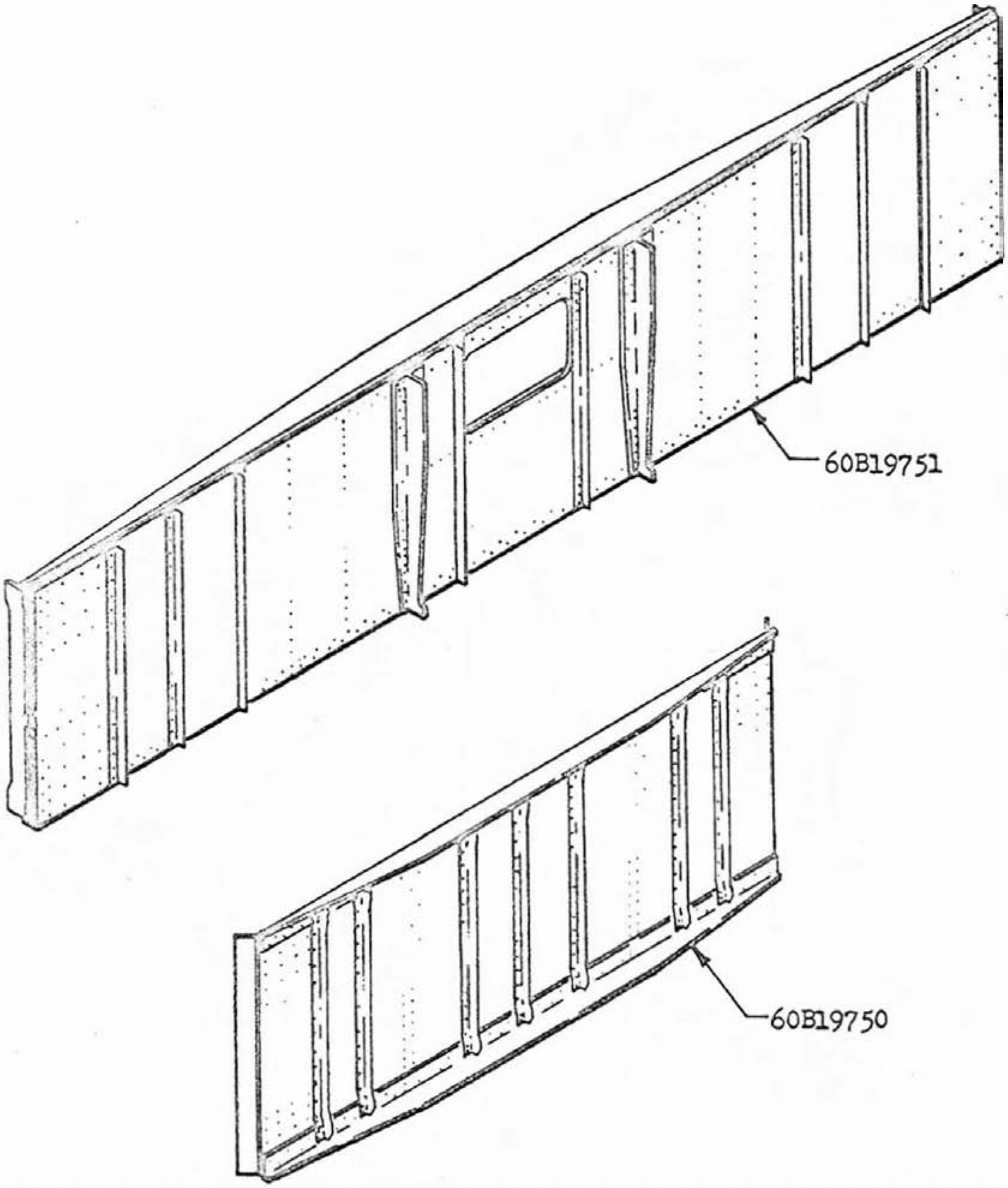
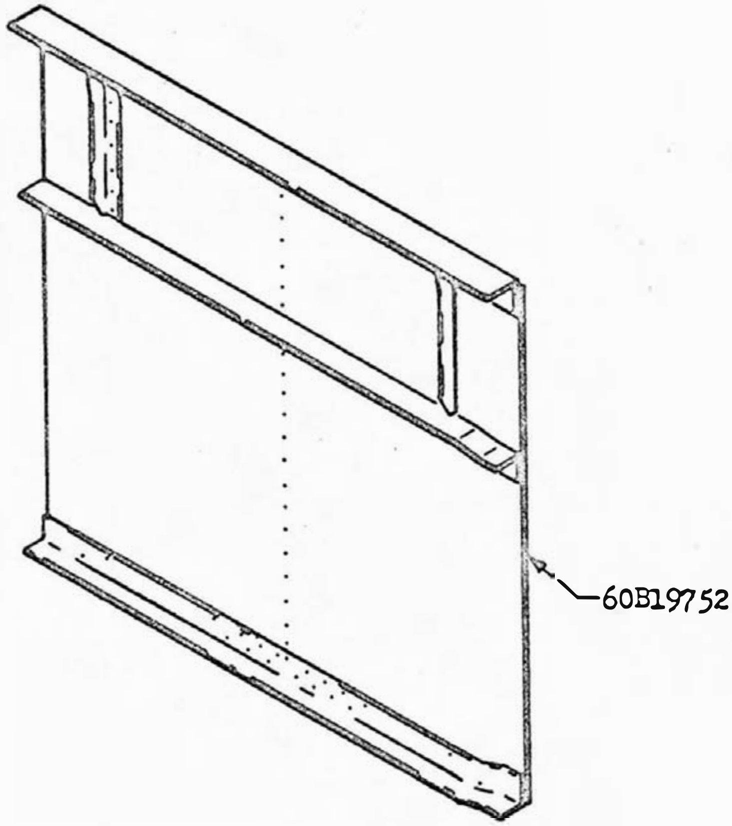


Figure 4-60. Short Beam Assembly 60B19750 and Long Beam Assembly 60B19751



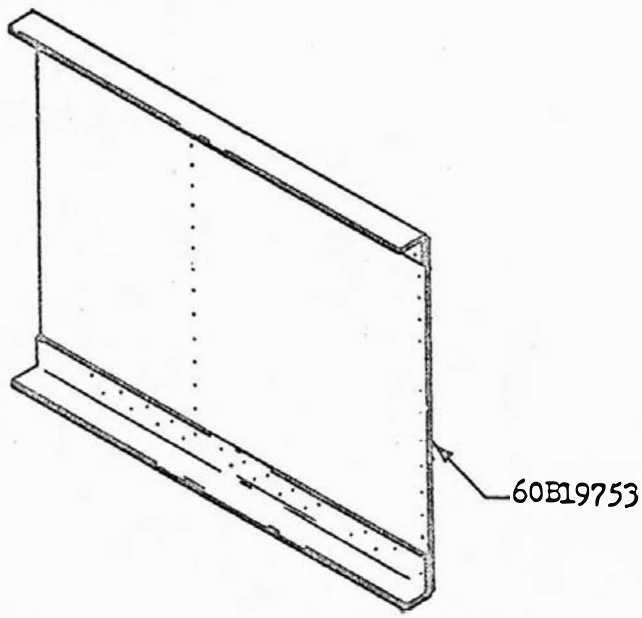


Figure 4-61. Inner Bulkhead Assembly 60B19752 and
Outer Bulkhead Assembly 60B19753

2.26.3 Assembly fixture AF-335-19752 is used to assemble inner bulkhead assembly 60B19752-1-900. The upper angle cap will be installed while inner bulkhead assembly 60B19752-1-900 is in assembly fixture AF-335-19701. (See figure 4-61.)

2.26.4 Assembly fixture AF2-335-19752 is used to assemble inner bulkhead assembly 60B19752-2-900. The upper angle cap will be installed while inner bulkhead assembly 60B19752-2-900 is in assembly fixture AF-335-19701. (See figure 4-61.)

2.26.5 Assembly fixture AF-335-19753 is used to assemble outer bulkhead assembly 60B19753-1-900. The upper angle cap will be installed while outer bulkhead assembly 60B19753-1-900 is in assembly fixture AF-335-19701. (See figure 4-61.)

2.26.6 Assembly fixture AF2-335-19753 is used to assemble outer bulkhead assembly 60B19753-2-900. The upper angle cap will be installed while outer bulkhead assembly 60B19753-2-900 is in assembly fixture AF-335-19701. (See figure 4-61.)

2.26.7 Assembly fixture AF-335-19754 is used to assemble canted bulkhead assembly 60B19754-1-900. Some hole locations will be drilled and some fasteners installed while canted bulkhead assembly 60B19754-1-900 is in assembly fixture AF-335-19701. (See figure 4-62.)

2.26.8 Assembly fixture AF2-335-19754 is used to assemble canted bulkhead assembly 60B19754-2-900. Some hole locations will be drilled and some fasteners installed while canted bulkhead assembly 60B19754-2-900 is in assembly fixture AF-335-19701. (See figure 4-62.)

2.26.9 Assembly fixture AF-335-19760 is used to assemble web assembly 60B19760-1-900. Some hole locations will be drilled and some fasteners will be installed while web assembly 60B19760-1-900 is in assembly fixture AF-335-19701. (See figure 4-62.)

2.26.10 Assembly fixture AF2-335-19760 is used to assemble web assembly 60B19760-2-900. Some hole locations will be drilled and some fasteners installed while web assembly 60B19760-2-900 is in assembly fixture AF-335-19701. (See figure 4-62.)

2.26.11 Assembly fixture AF-335-19761 is used to assemble web assembly 60B19761-1-900. Some hole locations will be drilled and some fasteners will be installed while web assembly 60B19761-1-900 is in assembly fixture AF-335-19701. (See figure 4-62.)

2.26.12 Assembly fixture AF2-335-19761 is used to assemble web assembly 60B19761-2-900. Some hole locations will be drilled and some fasteners installed while web assembly 60B19761-2-900 is in assembly fixture AF-335-19701. (See figure 4-62.)

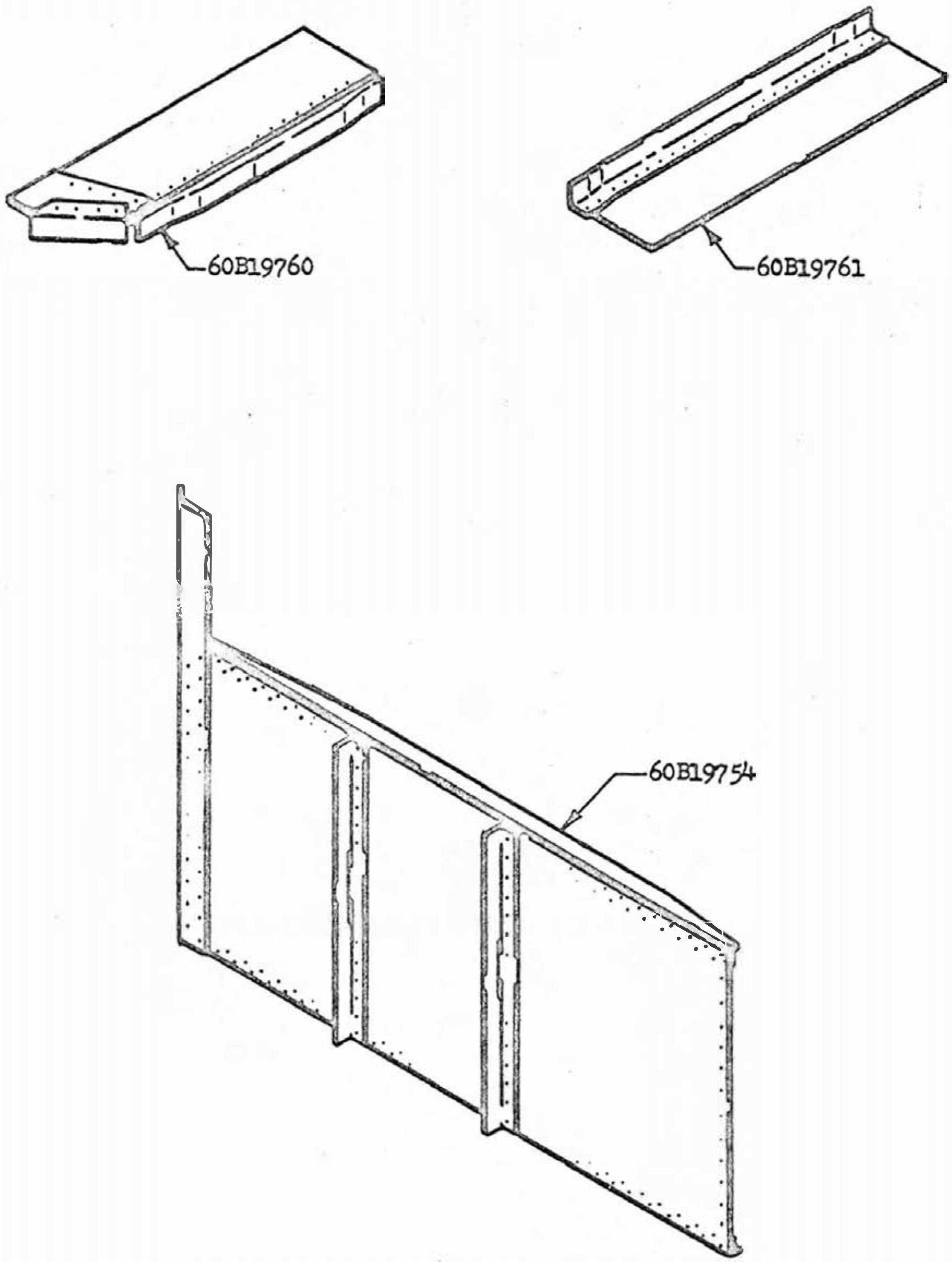


Figure 4-62. Canted Bulkhead Assembly 60B19754, Web Assembly 60B19760, and Web Assembly 60B19761

2.27 Inboard Propellant Duct Support LOX Link Assembly 60B19766 and Fuel Link Assembly 60B19769 - At Michoud. (See figure 4-62a.)

2.27.1 Locate LOX link 60B19767 and LOX lug 60B19768 in assembly drill fixture ADF-335-19766; drill holes.

2.27.2 Install shim, fasten with attach bolts, and press fit bearings which complete LOX link assembly 60B19766.

2.27.3 Locate fuel link 60B19770 and fuel lug 60B19771 in assembly drill fixture ADF-335-19769; drill holes.

2.27.4 Install shim, fasten with attach bolts, and press fit bearings which complete fuel link assembly 60B19769.

2.28 Inboard Propellant Duct Support Strut Assembly 60B19765 - At Michoud. (See figure 4-63.)

2.28.1 Locate fitting 60B19774-3 and strut 60B19772-1 in assembly drill fixture ADF-335-19765; drill holes.

2.28.2 Fasten with attach bolts which complete strut assembly 60B19765.

2.29 Thrust Structure Assembly Final Structural Assembly. (See figures 4-3, 4-64, and 4-65.) Assemble thrust structure assembly on thrust structure assembly fixture AF-335-7027 as follows:

2.29.1 Loading Sequence - Thrust Structure Assembly Fixture AF-335-7027.

2.29.1.1 The thrust structure assembly fixture AF-335-7027 is designed to hold the detail parts and subassemblies in position for drilling, reaming, and fastening. The loading sequence for assembly fixture AF-335-7027 is as follows:

* Not applicable at Michoud.

a. Engine Support Fitting

b. Holddown Post Base Fitting

c. Lower Thrust Ring Assembly

d. Center Engine Support Assembly

e. Holddown Posts

f. Auxiliary Shear Webs

g. Outboard Thrust Post Assemblies

h. Upper Thrust Ring Assembly

j. Intermediate Rings. (stations 152.5, 184, 216, and 248)

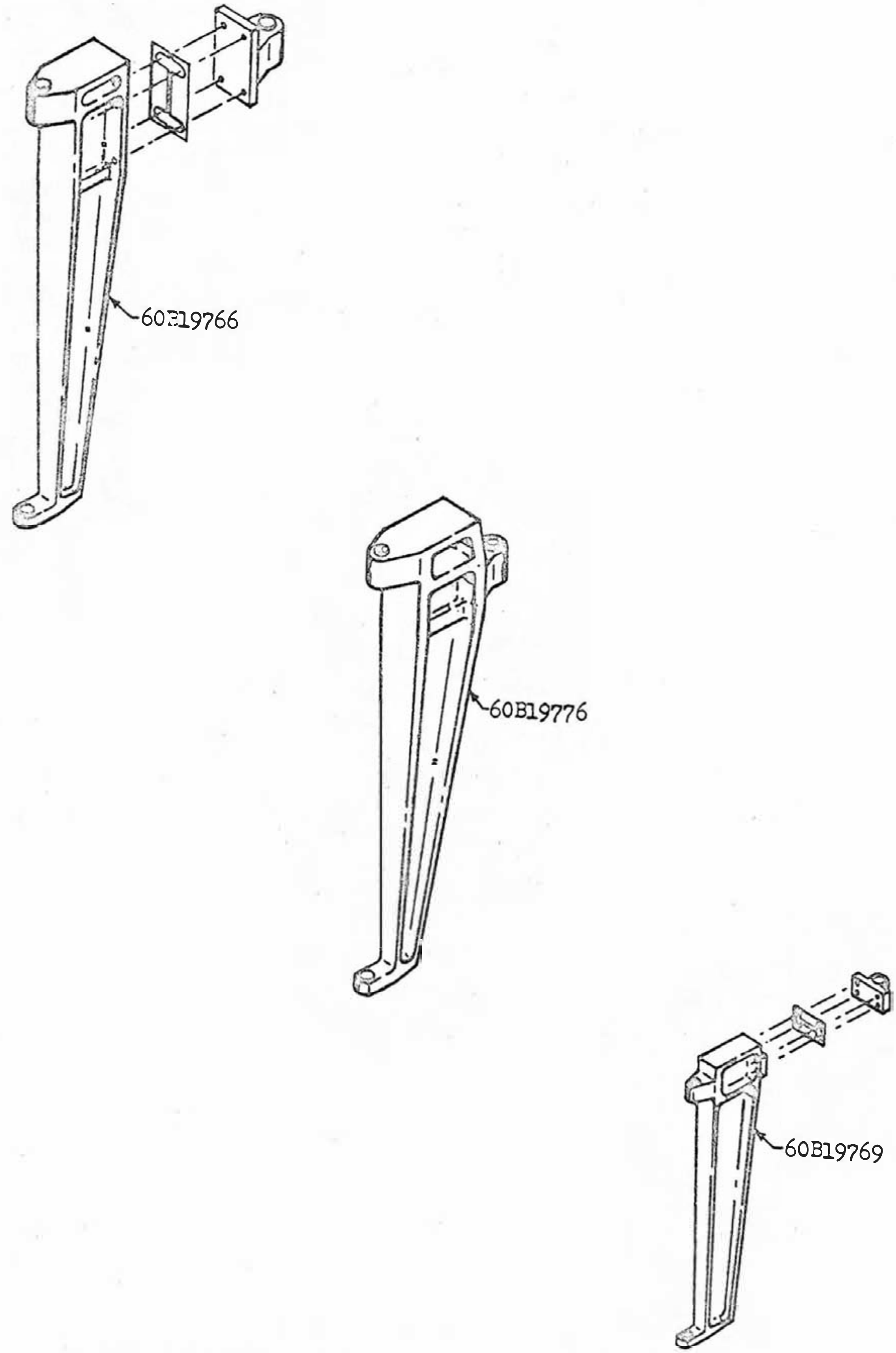


Figure 4-62a. Inboard Propellant Duct Support Link Assemblies

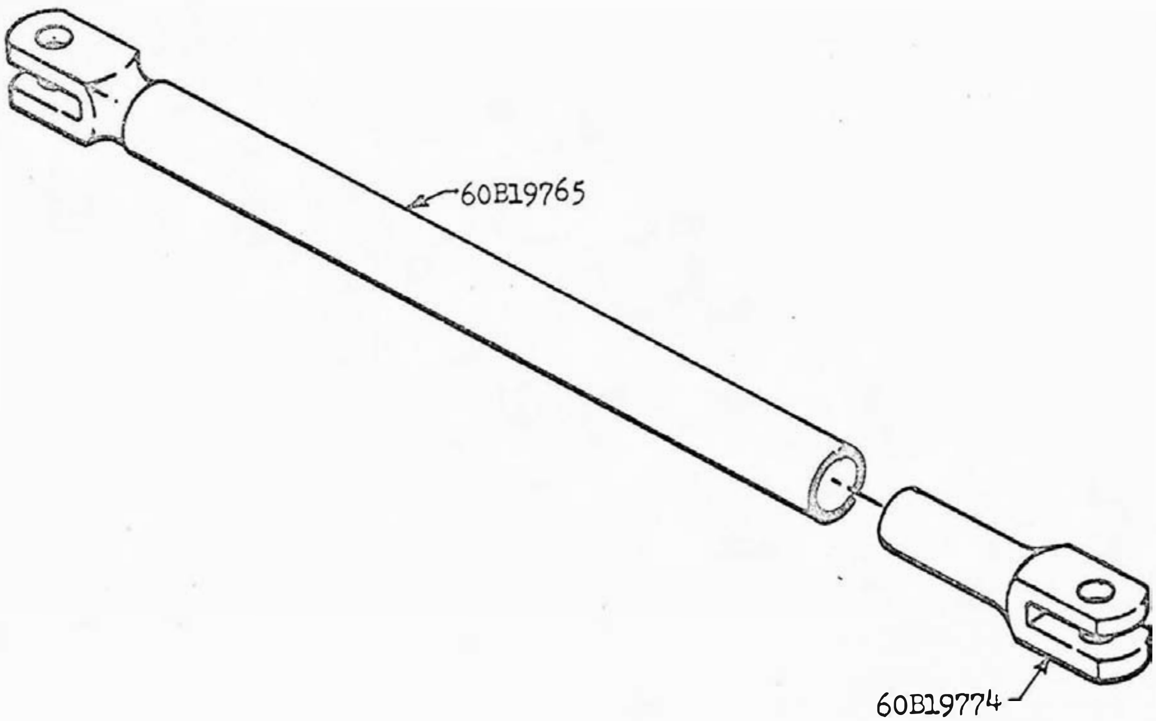
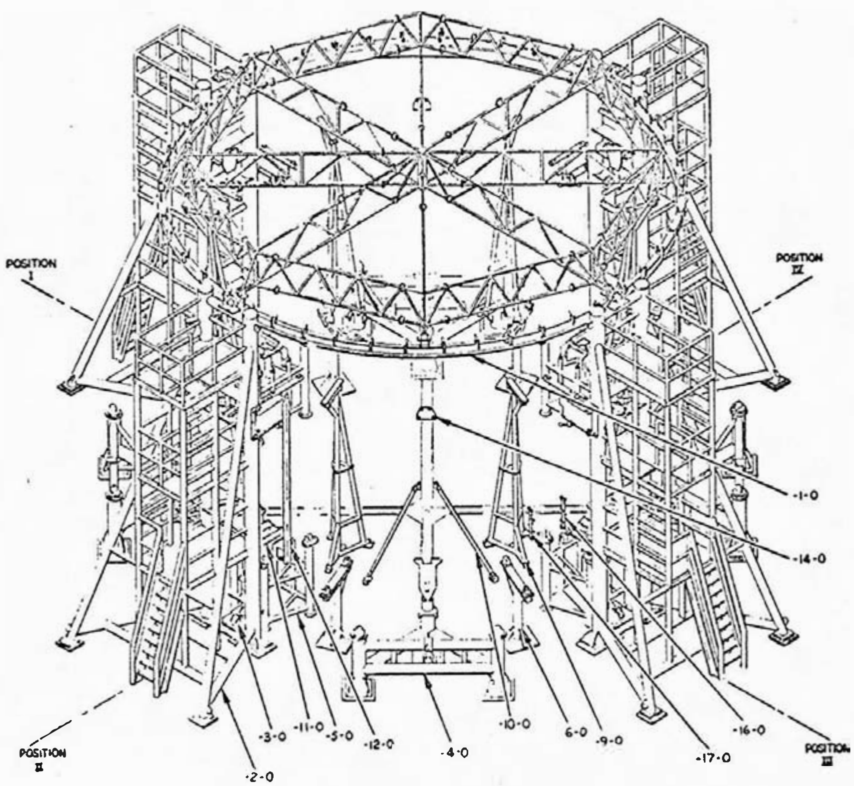


Figure 4-63. Inboard Propellant Duct Support Assembly 60B19765



ASSEMBLY FIXTURE (AF-335-7027) SUBASSEMBLIES

Subassembly No.	Quantity	Nomenclature
-1-0	1	Sizing Ring
-2-0	4	Locator Assembly Tower
-3-0	4	Holddown Fitting Locator
-4-0	4	Engine Fitting Actuator Support Locator
-5-0	4	Holddown Fitting Drill Plate Locator
-6-0	8	Lower Ring Auxiliary Support
* -7-0	24	Ring Station 315.000 Lower Bracket
* -8-0	24	Ring Station 315.000 Upper Bracket
-9-0	8	Auxiliary Support
-10-0	8	Thrust Post Support
-11-0	4	Holddown Post Backup
-12-0	2	Intermediate Ring Locator
*-13-0	4	Holddown Post Bottom Alinement Fixture
-14-0	4	Thrust Post Top Alinement Fixture
*-15-0	4	Lower Ring Trunnion
-16-0	1	Intercostal Locator
-17-0	1	Intercostal Locator

* Not shown in illustration.

Figure 4-64. Thrust Structure Assembly Fixture AF-335-7027

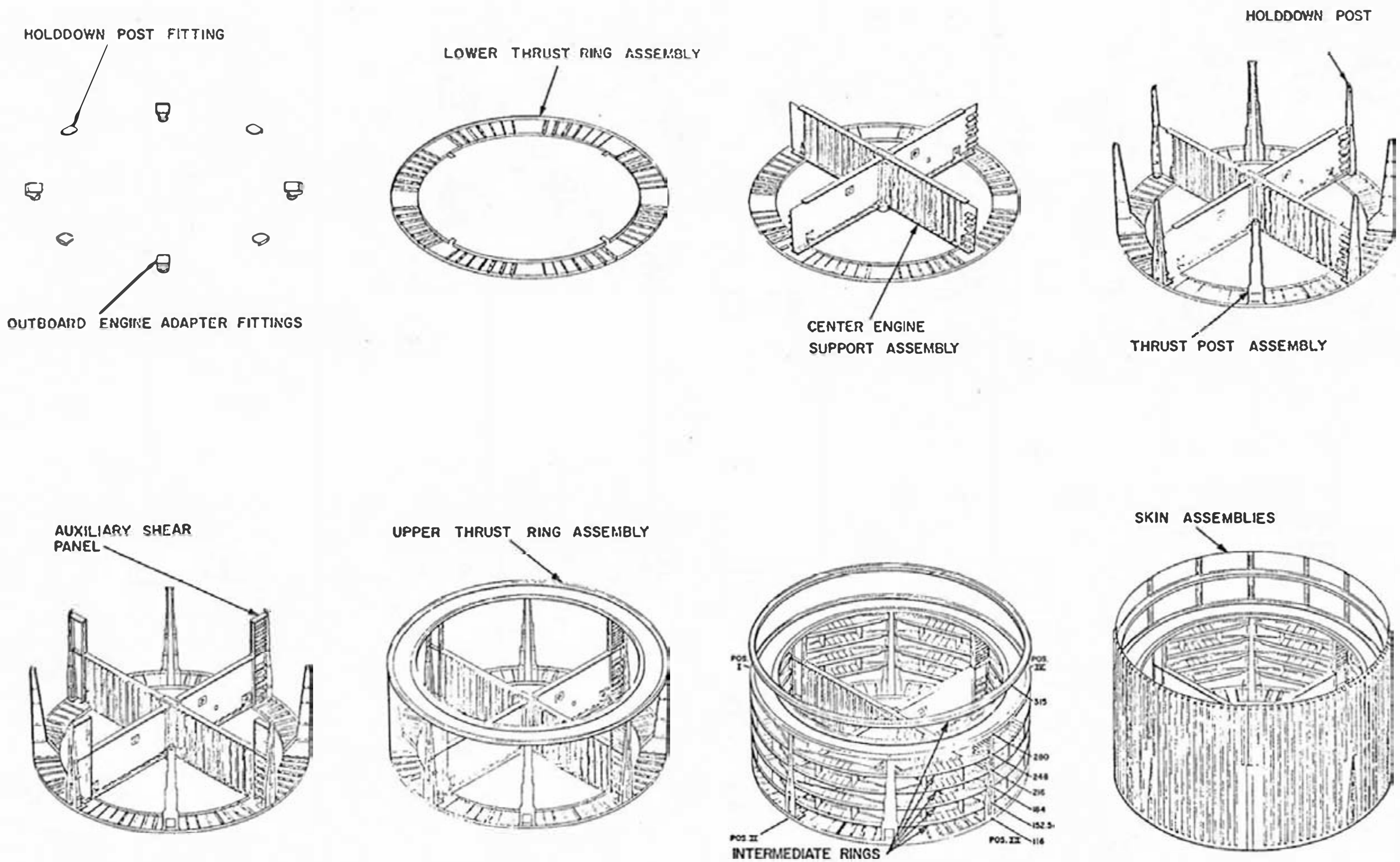


Figure 4-65. Thrust Structure Assembly Buildup Sequence

2.29.1.1 (Con.)

k. Intercostals

m. Skin Assemblies

n. Intermediate Ring (station 315)

*o. Propellant Line Supports (inboard and outboard)

p. Retro-Rocket Support Structure

*r. Heatshield Support Structure

s. Actuator Support Structure

*t. Miscellaneous Plumbing, Electrical Wiring, and Electronic Equipment

2.29.1.2 Michoud only - The details and subassemblies to be loaded into the thrust structure assembly at the pickup position are as follows:

a. Portions of Heatshield Support Structure

b. Propellant Line Support (inboard and outboard)

c. Miscellaneous Plumbing, Electrical Wiring, and Electronic Equipment

2.29.1.3 The thrust structure components listed in paragraphs 2.29.1.1 and 2.29.1.2 are to be complete except for minor items, i.e., omitted holes, etc., as planned. All subassemblies must be properly sized to meet the drawing requirements. All procured items shall be delivered to MSFC ready for installation. For example, the skin assemblies shall be trimmed for length and machined to guarantee perpendicularity of adjacent edges; therefore, ensuring that the opposite sides of the skin assemblies are parallel. The drilling and locating tools used in conjunction with AF-335-7027 are as follows:

NOTE: NASA will furnish a list of all the drill jigs, locating drill jigs, etc., that are used to produce the final assembly.

2.29.2 Using proper drill jig, drill and ream undersized hole pattern in four outboard engine adapter fittings 60B18806 and load along with four holddown post fittings 60B19601 on assembly fixture AF-335-7027.

2.29.3 Using hoisting tool HT-370-7101, position and clamp lower thrust ring assembly 60B18700 in assembly fixture AF-335-7027. (See figure 4-23.)

2.29.4 Adjust all fittings outboard until fittings locate to inside mold line of the lower thrust ring outer cap.

2.29.5 Using hoisting tool HT-370-7102, position center engine support assembly 60B18900. The actual location will be accomplished in the next operation. (See figure 4-29.)

2.29.6 Locate tower assembly AF-335-7027-2-0 at each position.

2.29.7 Using hoisting tool HT-370-7107, position and clamp four holddown posts 60B19600. Final locate center engine support assembly 60B19600. (See figure 4-66.)

2.29.8 Load the auxiliary shear web assemblies and clamp with provided positioning and holding fixture.

2.29.9 Using provided drill jig, drill and ream two holes in four angle fittings 60B18962-2.

2.29.10 Locate and clamp angle fittings 60B18962-1 and 60B18962-2 in AF-335-7027-11-0. Locate fittings, along with shims and fillers, at each position.

2.29.11 Using hoisting tool HT-370-7108, position and clamp four outboard thrust post assemblies 60B18800. (See figure 4-37.)

2.29.12 Using upper thrust ring assembly hoisting tool HT-370-7101, position and clamp upper thrust ring assembly 60B18600.

2.29.13 Position auxiliary support assembly AF-335-7027-9-0 between each holddown and thrust post. Secure to upper and lower thrust ring.

2.29.14 Aline, fair, and clamp structure and begin drilling and reaming operation, starting with four holddown post base fittings 60B19601 through lower thrust ring assembly 60B18700 and holddown posts 60B19600; install hardware.

2.29.15 Using proper drill jigs, attach angle fittings to center engine support assembly 60B18900 and lower thrust ring 60B18700, and attach center engine support assembly 60B18900 to holddown posts 60B19600.

2.29.16 Using positioning and holding fixture, final locate the auxiliary shear web assemblies, and apply the drill jigs to drill hole patterns common to fittings and details which tie the auxiliary shear web assemblies to the center engine support assembly 60B18900, upper thrust ring assembly 60B18600, and holddown posts 60B19600.

2.29.17 Locate zee stiffeners 60B18953 on outboard end of center engine support web assemblies per match-marked locations; using drill jigs, drill holes through the outboard end of the stiffeners common to holddown posts 60B19600 and through the inboard end of the stiffeners common to the auxiliary shear web assemblies cap angles.

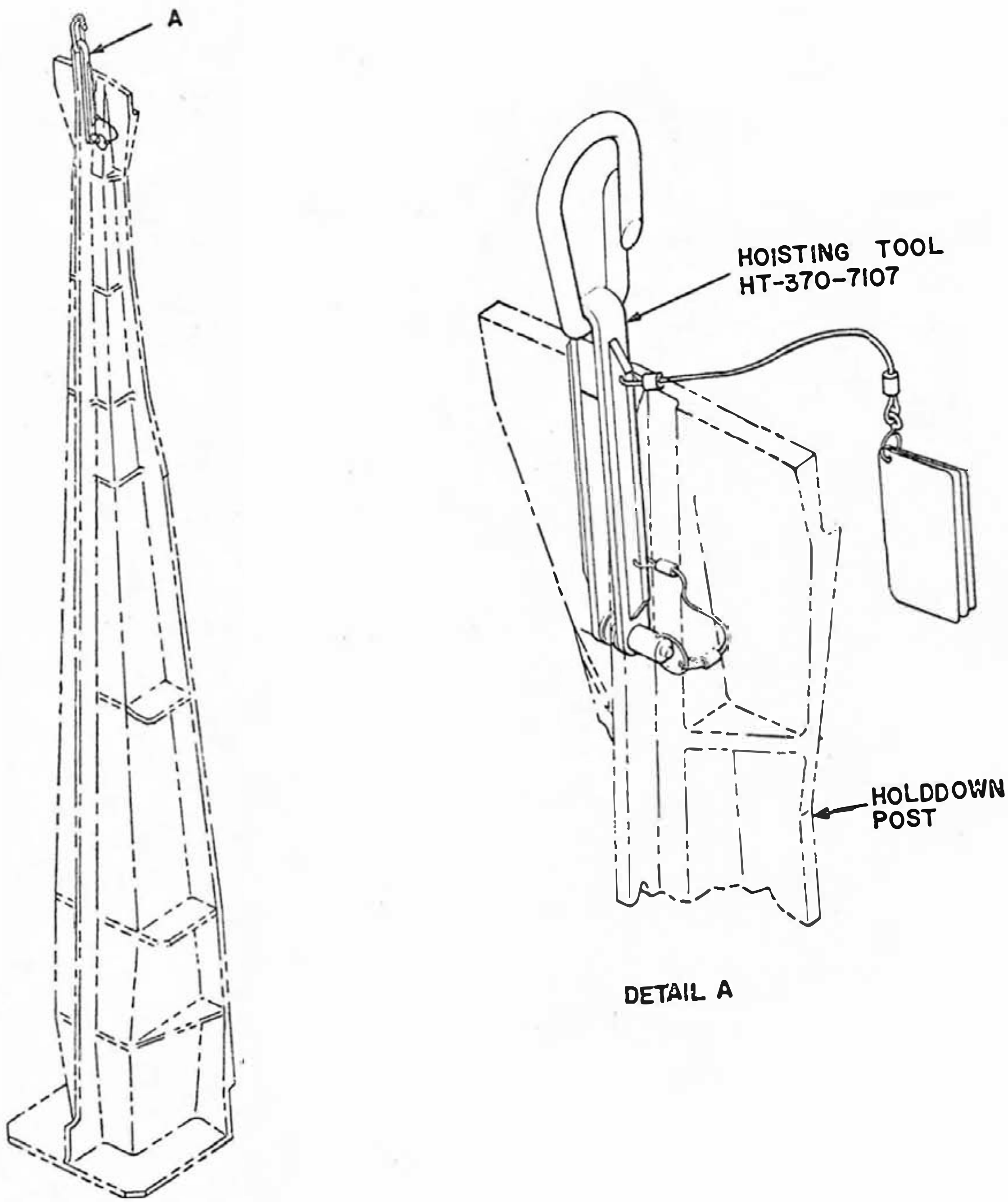


Figure 4-66. Holddown Post Hoisting Tool HT-370-7107

2.29.18 Using drill jigs, locate and drill holes through clip angles common to auxiliary shear web cap angles and center engine support webs.

2.29.19 Using drill jigs, drill holes through center engine support lower caps common to lower thrust ring assembly 60B18700. Install fasteners.

2.29.20 Aline, fair, and clamp the outboard thrust post assemblies 60B18800; using provided drill jigs, drill and ream holes through outboard engine adapter fittings 60B18806, lower thrust ring assembly 60B18700, and outboard thrust posts assemblies 60B18800. Install fasteners.

2.29.21 Using drill jigs, drill and ream holes through outboard thrust post assemblies 60B18800, outboard engine adapter fittings 60B18806, and upper thrust ring assembly 60B18600 at all four fin lines. Install fasteners.

2.29.22 Install personnel platforms PP-370-7072 and PP-370-7179. (See figure 4-67.)

2.29.23 Using hoisting tool HT-370-7118, position eight intermediate ring segments at each of the following stations: 152.5, 184.0, 216.0, and 248.0; temporarily clamp intermediate ring segments in position; radially locate intermediate ring segments; install intermediate ring locators AF-335-7027-12-0 in place and fair the intermediate ring segments with the upper and lower thrust ring assemblies. Position and clamp attach fitting; using provided drill jigs, drill and ream holes; install hardware.

2.29.24 Install intercostal assemblies, fairing with outside mold line of intermediate ring outer caps. Using drill jigs, drill and ream all attach holes; install fasteners.

2.29.25 Locate sizing ring on tower assemblies AF-335-7027-2-0. (See figure 4-64.)

2.29.26 Remove auxiliary support assembly AF-335-7027-9-0 from all places. Position support fixtures SF-335-7180. (See figure 4-68.)

2.29.27 Using hoisting tool HT-370-7090, install one skin panel assembly on either side of each fin position with the alinement fixtures AlF-335-7106 on each panel assembly located to the sizing ring. (See figure 4-69.) Using drill jigs, drill and ream all attach holes; install fasteners. Holes in area of skin panel splice and common to station 315 intermediate ring will be drilled in a later operation.

2.29.28 Remove tower assembly AF-335-7027-2-0 at Position I and install one skin panel assembly on either side of the position line. Drill and ream as noted in paragraph 2.29.27.

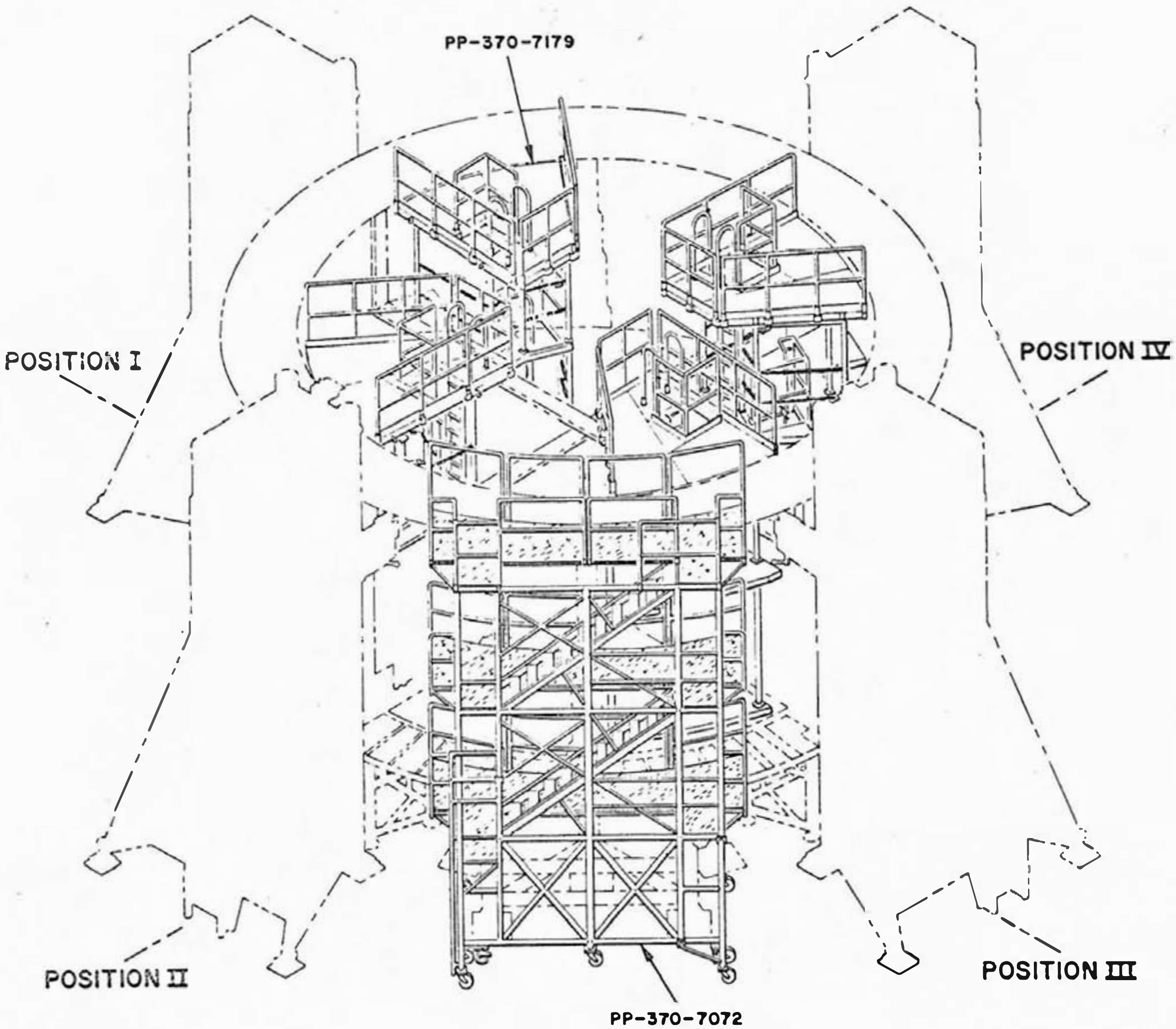


Figure 4-67. Personnel Platforms PP-370-7072 and PP-370-7179

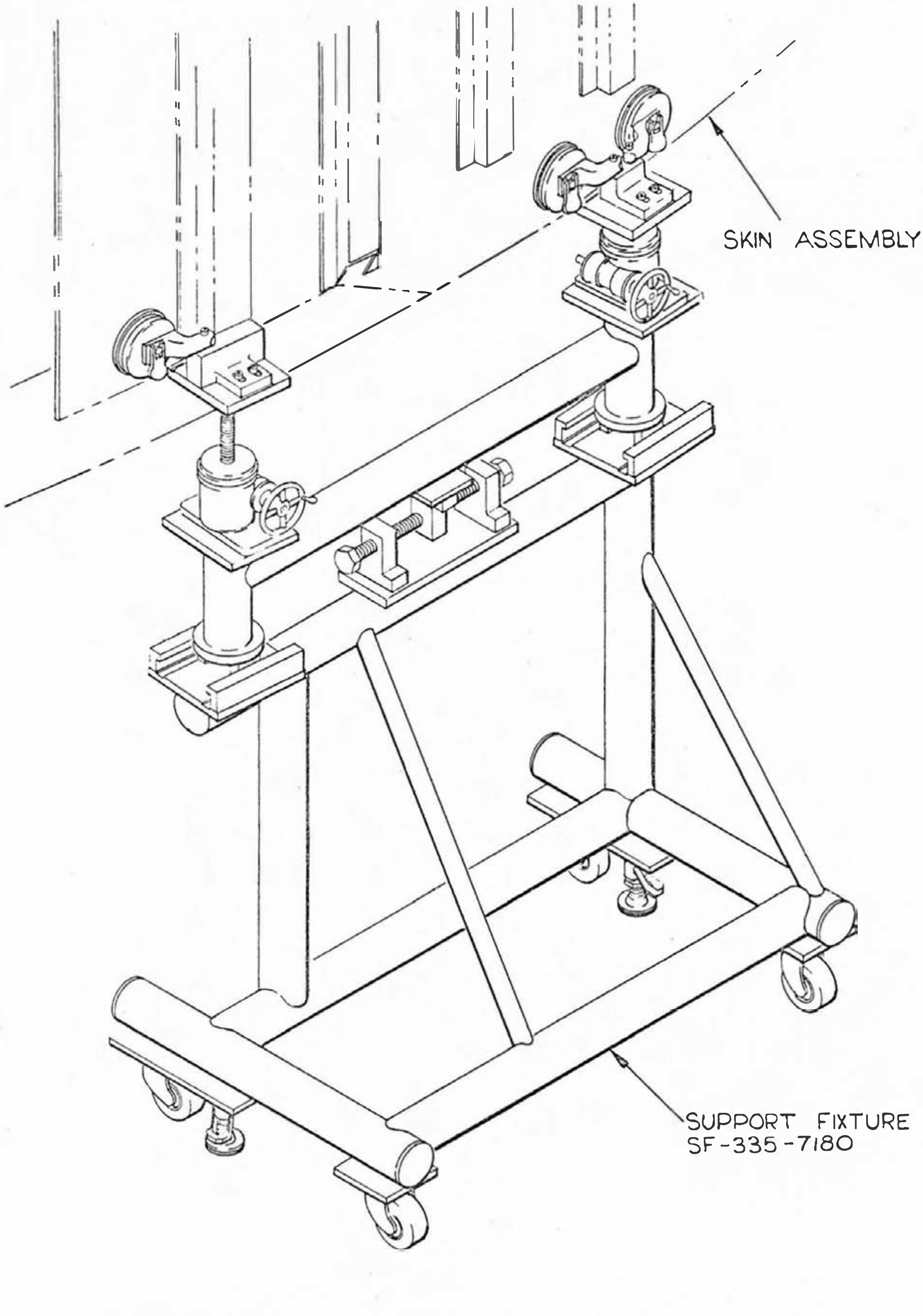


Figure 4-68. Skin Panel Assembly Support Fixture SF-335-7180

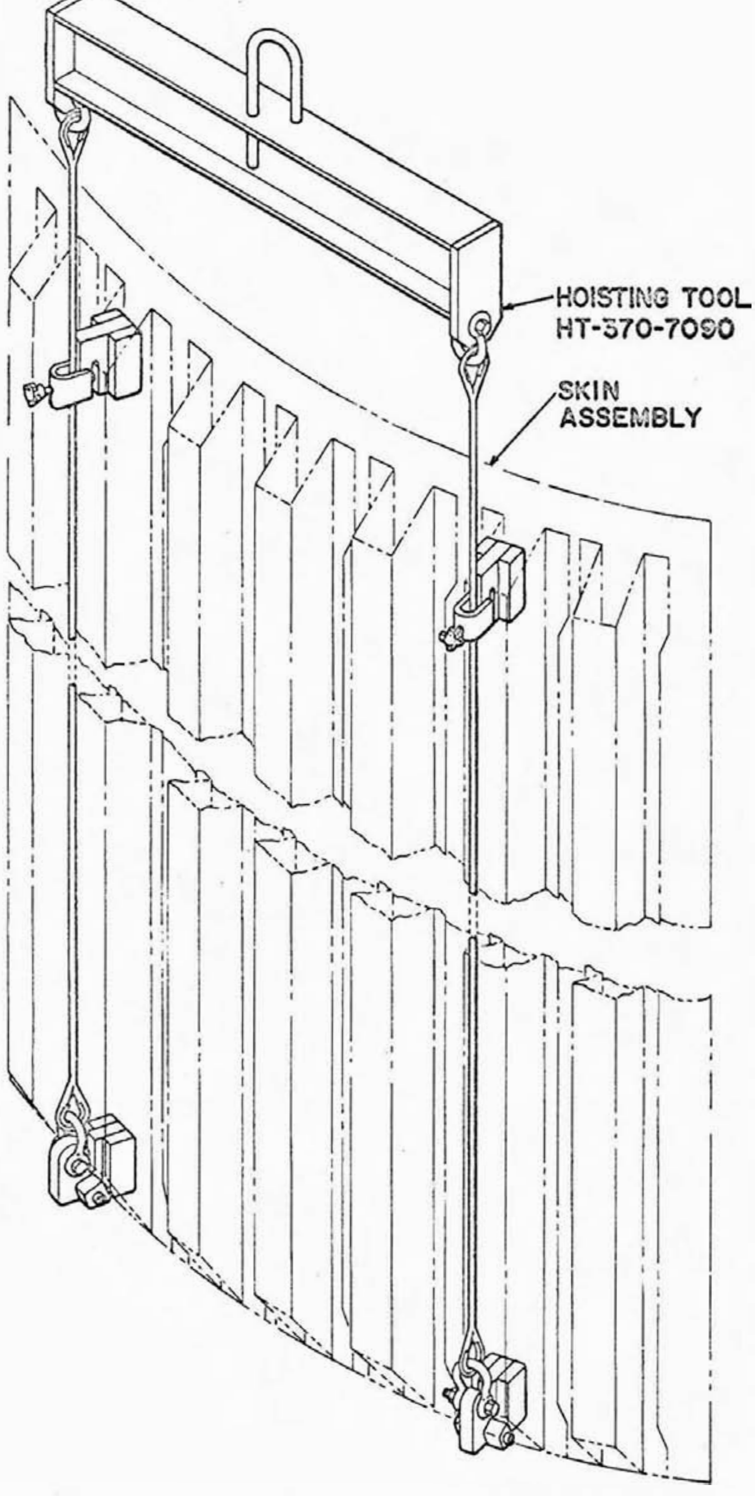


Figure 4-69. Thrust Structure Cylindrical Panels Hoisting Tool HT-370-7090

2.29.29 Repeat procedure outlined in paragraph 2.29.28 at Positions II, III, and IV.

2.29.30 After all tower assemblies AF-335-7027-2-0 have been removed, the sizing ring is entirely supported by the skin panel assembly alinement fixtures.

2.29.31 Using suitable hoisting arrangement, maneuver eight station 315 intermediate ring segments 60B18501 around sizing ring and clamp into position with locating brackets; using drill jigs, drill and ream all attach holes undersize; install fasteners. Holes in the area common to the skin panel splice area are omitted.

NOTE: Proper hardware and ring splice plates will be installed in the next assembly after the thrust structure has been attached to the fuel tank assembly.

2.29.32 Install inside and outside skin splice doublers and skin splice stringers at all skin joints; using drill jigs, drill and ream holes; install fasteners. Holes common to station 315 intermediate ring splice plates are drilled in the next assembly.

2.29.33 Remove sizing ring and personnel platforms PP-370-7072 and PP-370-7179. Erect personnel platform PP-370-7113 and set up optical equipment as required to check alinement of alinement fixtures AlF-335-7106. (See figures 4-70 and 4-71.)

2.29.34 Check alinement of alinement fixtures AlF-335-7106 and adjust as necessary.

2.29.35 Remove optical equipment and personnel platform PP-335-7179.

2.29.36 Locate actuator support assemblies 60B32220 in assembly fixture AF-335-7027. (See figure 4-16.) Using drill jigs, drill and ream four attach holes at approximate station 257 through skin panels and back-up fittings; install fasteners.

2.29.37 Using drill jigs, bench drill fittings 60B32275.

2.29.38 Using drill jigs, drill fitting 60B32225 attach hole pattern through thrust structure and one hole common to actuator support assembly 60B32220. Install fasteners.

2.29.39 Using drill jigs, locate and drill attach holes for fittings 60B32240 and one hole common to strut assemblies 60B32230.

2.29.40 Using drill jigs, install upper retro-rocket fittings.

2.29.41 Using drill jigs, install lower retro-rocket fittings.

2.29.42 Locate and drill aft retro-rocket fitting to actuator support arm. (See figure 4-17.)

2.29.43 Locate provided locating drill jig, along with the two forward fittings, and drill attach holes in forward fittings.

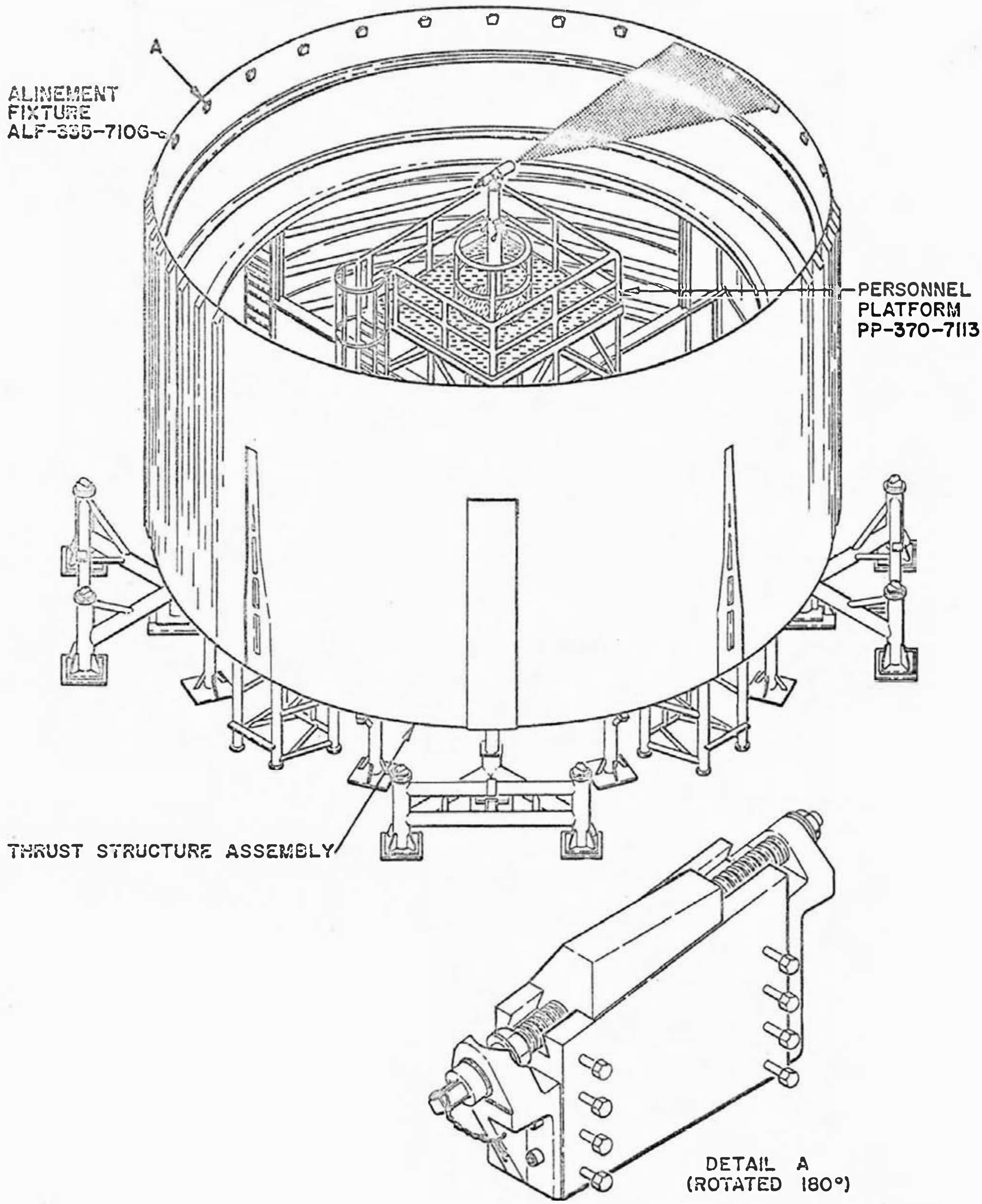


Figure 4-70. Checking Alinement of Alinement Fixtures AlF-335-7106

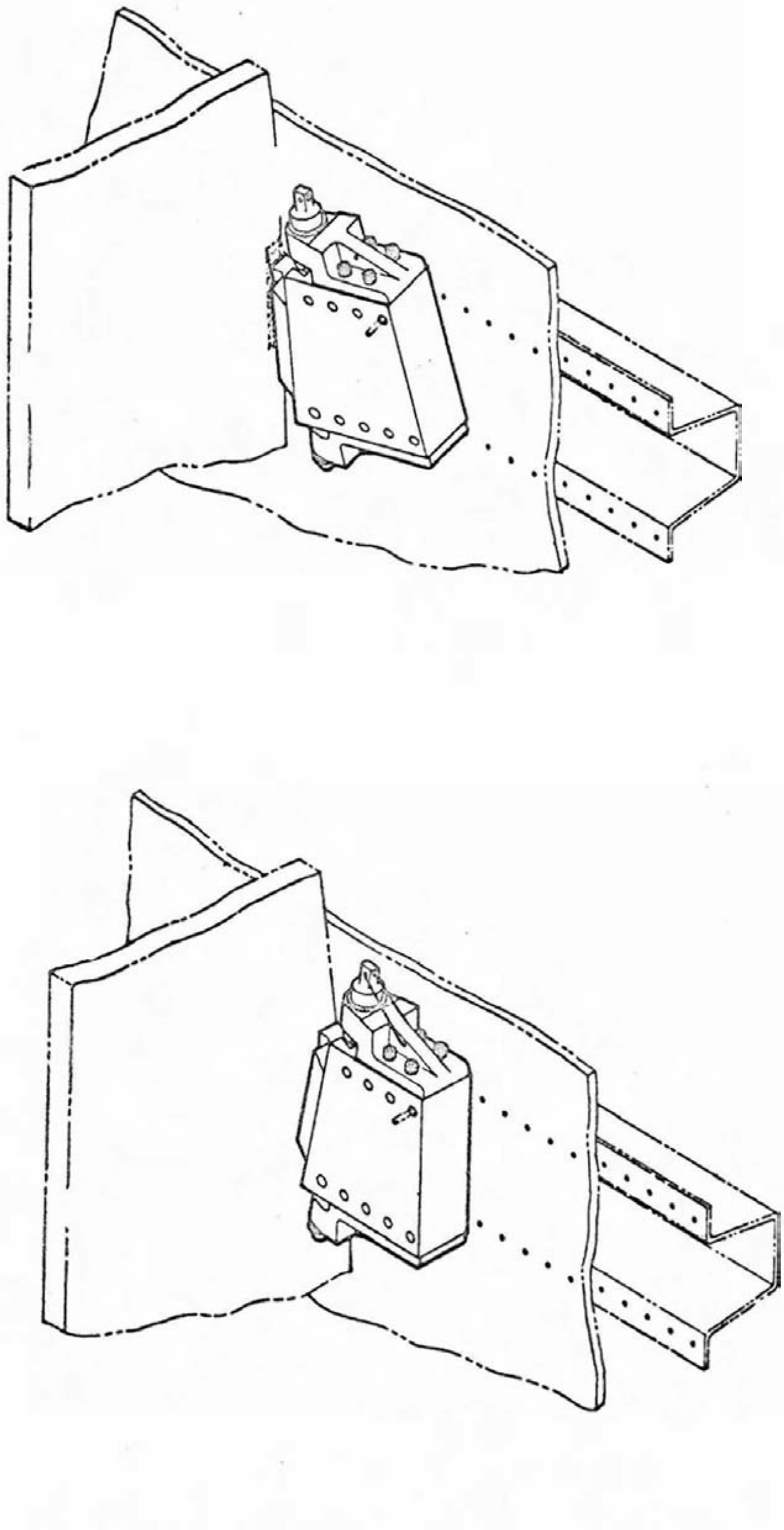


Figure 4-71. Alinement Fixtures AlF-335-7106

2.29.44 Remove locating drill jig, and install fasteners.

2.29.45 Replace locating drill jig and check forward fittings for movement. If movement has occurred, remove fasteners and install shims until forward fitting locations will meet the interchangeability requirements as checked by locating drill jig.

2.29.46 Refer to Section IVa for installation of fairing attach fittings.

2.29.47 Position inboard propellant duct support assembly 60B19701.

*2.29.48 Shim as required between fittings common to center engine support assembly 60B18900 and inboard propellant duct support assembly 60B19701. Drill holes and install fasteners.

*2.29.49 Position two strut assemblies 60B19765 common to fittings on center engine support assembly 60B18900 and inboard propellant duct support assembly 60B19701. Install attach bolts.

*2.29.50 Position four outboard propellant duct support assemblies 60B19702.

*2.29.51 Position, for each outboard propellant duct support assembly 60B19702, four strut assemblies 60B19719 and 60B19720 common to fittings on outboard thrust post assemblies 60B18800 and outboard propellant duct support assemblies 60B19702.

*2.29.52 Position, for each outboard propellant duct support assembly 60B19702, two strut assemblies 60B19725 common to fitting on intermediate ring assembly and outboard propellant duct support assemblies 60B19702.

*2.29.53 Install attach bolts.

*2.29.54 Install base heatshield structure. (Refer to Section IVb.)

2.29.55 MSFC only - Using A-frame SA-370-7420 and thrust structure assembly hoisting tool HT-370-7111, remove thrust structure assembly 60B18050 from assembly fixture AF-335-7027 and position on thrust structure assembly vertical position support assembly tool AT-435-8056 with flight direction up. (See figure 4-72.)

2.30 Propulsion Systems Assembly.

2.30.1 Thrust Structure LOX Delivery System 60B41014 and Fuel Delivery System 60B43014. The LOX and fuel delivery systems 60B41014 and 60B43014 consist of the flight propellant delivery hardware which is located in the thrust structure area and originates at the lower end of the LOX suction lines at the lower fuel tank head assembly and extends to the engine interfaces. Installation of LOX and fuel delivery systems 60B41014 and 60B43014 will be accomplished in the following sequence.

*The operations described in these paragraphs are accomplished in the second position assembly fixture at Michoud. (See figure 4-73.)

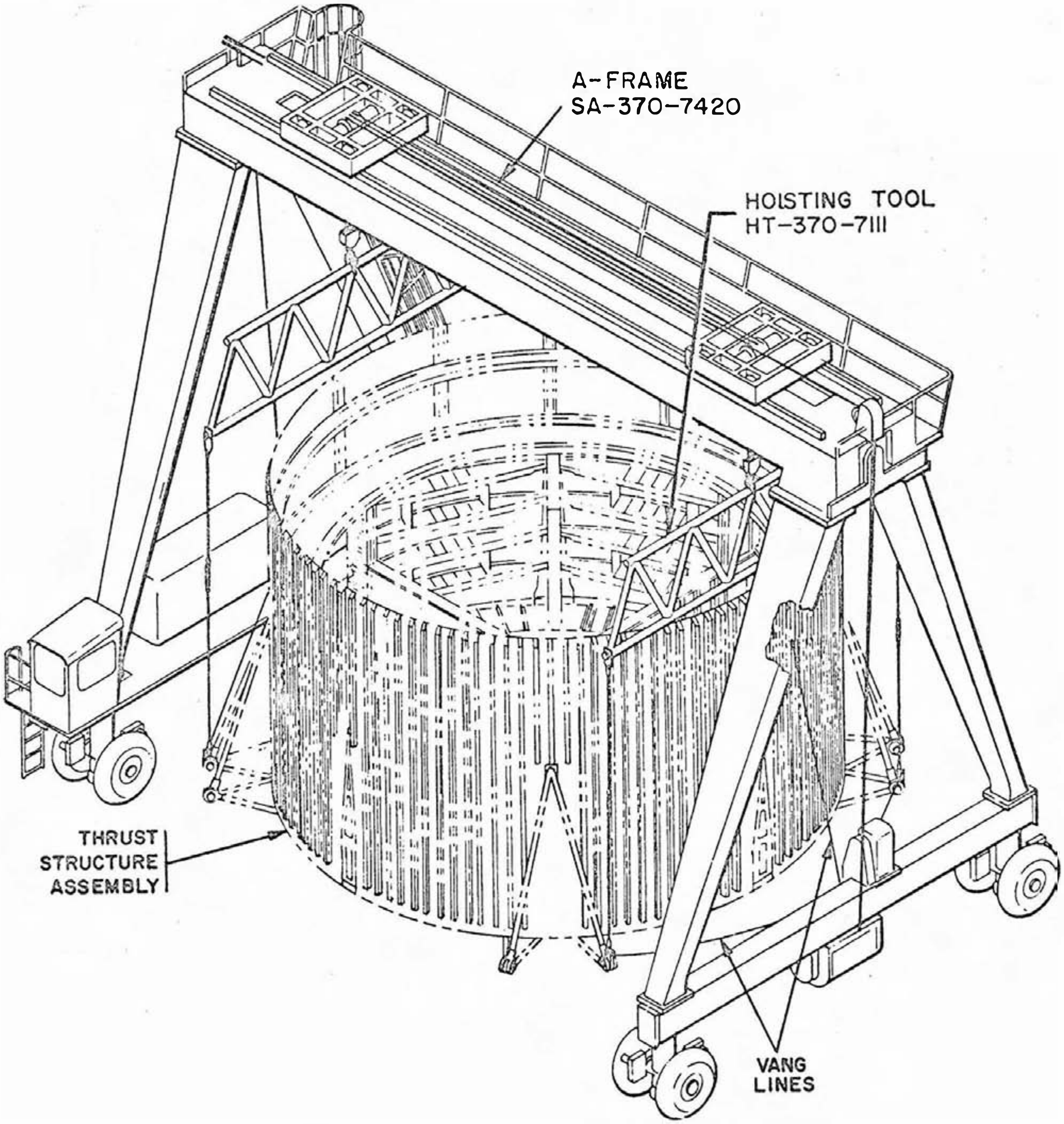


Figure 4-72. Transporting Thrust Structure Assembly

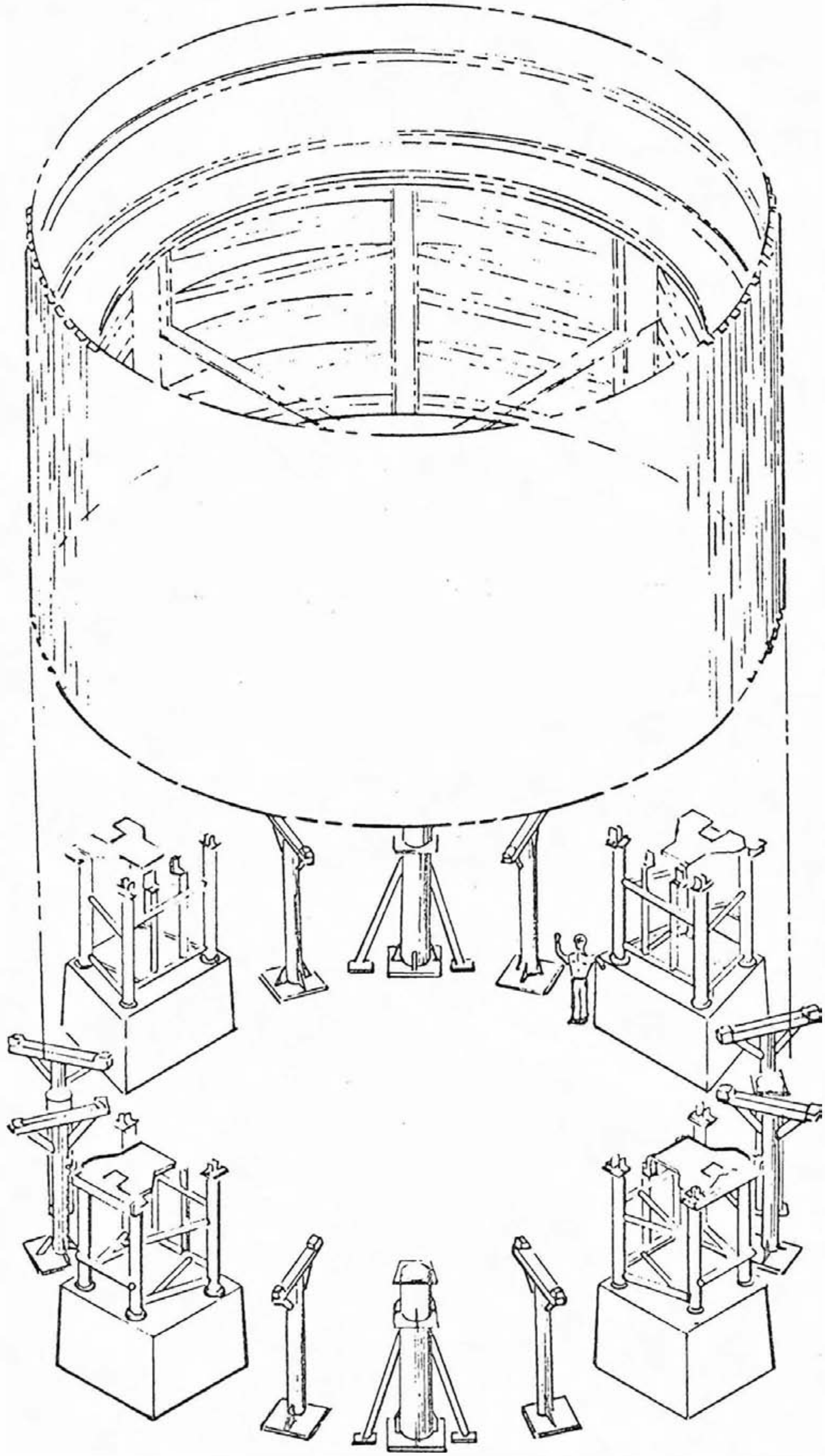


Figure 4-73. Thrust Structure Second Position Final Assembly Fixture (Boeing)

2.30.1.1 Outboard LOX Adapter Spools 60B41023. Using hoisting tool and overhead crane, lift and position adapter spools 60B41023 on outboard propellant duct support assembly 60B19702. Using alinement fixture , position and make necessary adjustments to aline adapter spools 60B41023 and outboard propellant duct support assembly 60B19702.

2.30.1.2 Outboard LOX Pressure Volume Compensators (PVC) 20M02000. Remove vendor restrainer from PVC 20M02000. Attach PVC sliding joint compression tool AT-435-8501 to the duct on PVC 20M02000; attach hoisting tool HT-435-8500 to the handling points provided on compression tool AT-435-8501. Using overhead crane, hoisting tool HT-435-8500, and compression tool AT-435-8501, lift and position PVC 20M02000 over thrust structure assembly 60B18050; lower and maneuver PVC 20M02000 into position on the under side of outboard propellant duct support assembly 60B19702; make the flange connection, attaching PVC 20M02000 to outboard propellant duct support assembly 60B19702. Remove compression tool AT-435-8501 and hoisting tool HT-435-8500.

2.30.1.3 Inboard LOX Pressure Volume Compensator (PVC) 20M02002. Remove vendor restrainer from PVC 20M02002. Attach compression tool AT-435-8501 to the duct on PVC 20M02002; attach hoisting tool HT-435-8500 to the handling points provided on compression tool AT-435-8501. Using overhead crane, hoisting tool HT-435-8500, and compression tool AT-435-8501, lift and position PVC 20M02002 over thrust structure assembly 60B18050; lower and maneuver PVC 20M02002 into position on the under side of inboard propellant duct support assembly 60B19701; attach top flange of PVC 20M02002 to inboard propellant duct support assembly 60B19701. Perform the necessary alinement using alinement fixture . Remove compression tool AT-435-8501 and hoisting tool HT-435-8500.

2.30.1.4 Outboard Fuel Pressure Volume Compensators (PVC) 20M02001. Remove vendor restrainer from PVC 20M02001. Attach fuel PVC sliding joint compression tool AT-435-8502 to the duct on PVC 20M02001; attach hoisting tool HT-435-8500 to the handling points provided on compression tool AT-435-8502. Using overhead crane, hoisting tool HT-435-8500, and compression tool AT-435-8502, lift and position PVC 20M02001 over thrust structure assembly 60B18050; lower and maneuver PVC 20M02001 into position on the under side of outboard propellant duct support assembly 60B19702; attach top flange of PVC 20M02001 to outboard propellant duct support assembly 60B19702. Perform the necessary alinement using alinement fixture . Remove compression tool AT-435-8500.

2.30.1.5 Inboard Fuel Pressure Volume Compensator (PVC) 20M02003. Inboard fuel pressure volume compensators 20M02003 are installed into inboard propellant duct support assembly 60B19701 in the same manner as described for PVC 20M02001 in paragraph 2.30.1.4.

2.30.1.6 Outboard LOX Prevalves 20M32000. Attach hoisting tool to the upper flange of outboard LOX prevalve 20M32000. Using overhead crane and hoisting tool , lift and position outboard LOX prevalves 20M32000 in place on outboard LOX adapter spools 60B41023; make the necessary bolt connections. Remove hoisting tool from outboard LOX prevalves 20M32000.

2.30.1.7 Inboard LOX Prevalve 20M32000. Installation of inboard LOX prevalve 20M32000 is identical to outboard LOX prevalve 20M32000 as outlined in paragraph 2.30.1.6 except inboard LOX prevalve 20M32000 is bolted to the upper flange of inboard LOX pressure volume compensator 20M02002.

2.30.1.8 Inboard LOX Adapter Spool 60B41021. Attach hoisting tool to the upper flange of inboard LOX adapter spool 60B41021. Using overhead crane and hoisting tool , lift and position inboard LOX adapter spool 60B41021 in place on inboard LOX prevalve 20M32000; make necessary bolt connections. Remove hoisting tool from inboard LOX adapter spool 60B41021.

2.30.1.9 Inboard Fuel Prevalves 20M32001. Attach hoisting tool inboard fuel prevalves 20M32001. Using overhead crane and hoisting tool , lift and position inboard fuel prevalves 20M32001 in place. Attach prevalve and suction duct positioning and holding fixture P&HF-435-8511 to inboard fuel prevalves 20M32001; locate inboard fuel prevalves 20M32001 into position.

2.30.1.10 Inboard Fuel Suction Ducts 60B43001. The vendor restrainer provided with each inboard fuel suction duct 60B43001 has provisions for compressing and handling; therefore, the vendor restrainer will be utilized as an installation tool. Compress inboard fuel suction ducts 60B43001 to minimum length; attach handling sling to the vendor restrainer. Using overhead crane, lift and position inboard fuel suction ducts 60B43001 in place between inboard fuel prevalves 20M32001 and inboard fuel pressure volume compensators 20M02003. Loosely attach the lower flange of inboard fuel suction ducts 60B43001 to inboard fuel pressure volume compensators 20M02003; loosely attach the upper flange of inboard fuel suction ducts 60B43001 to inboard fuel prevalves 20M32001.

2.30.1.11 Outboard Fuel Prevalves 20M32001. Installation of the outboard fuel prevalves 20M32001 is similar to inboard fuel prevalves 20M32001 as outlined in paragraph 2.30.1.9 except using positioning and holding fixture P&HF-435-8509.

2.30.1.12 Outboard Fuel Suction Ducts 20M02006. Installation of outboard fuel suction ducts 20M02006 is similar to inboard fuel suction ducts 60B43001.

2.30.1.13 LOX Drain Duct 60B41003 and Valve 60B41002. Using nylon slings and overhead crane, lift, position, and attach LOX drain duct 60B41003 and valve 60B41002 between inboard LOX adapter spool 60B41021 and umbilical plate No. 1.

2.30.1.14 LOX Interconnect Lines (Prefitting Only). Make LOX interconnect duct bracket, prefit, and drill only the necessary holes. (Refer to Section VIII of this Manufacturing Plan for installation.)

2.30.2 Thrust Structure Fuel and LOX Pressurization System 60B49600 and 60B51400. Information will be added at a later date.

2.30.3 Thrust Structure Pressure Control System 60B52200. Information will be added at a later date.

2.30.4 Engine and Calorimeter Purge System 60B37650. Information will be added at a later date.

2.30.5 LOX Pneumatic System 60B41223. Information will be added at a later date.

2.30.6 LOX Conditioning and Fuel Bubbling System 60B41222 and 60B43014. Information will be added at a later date.

2.30.7 Environmental Control Duct Assembly 60B40000. The environmental control system is a gaseous nitrogen purge system, which under normal conditions floods the thrust structure assembly with heated nitrogen at approximately 0.5 psi. If fire is sensed, the pressure is automatically increased to 20 psi which causes two sections of the seven-inch outside diameter inlet tubing to break away and flood the thrust structure assembly with nitrogen.

2.30.7.1 The environmental control system, basically a pair of graduated aluminum tubes secured to the thrust structure assembly with brackets, originates at the No. 3 umbilical plate. The two independent tubes, mounted parallel to each other and perpendicular to the skin diameter, extend to station 272.0 (approximately) where they make opposing bends and run circumferentially around the inside of upper thrust ring assembly (60B18600).

2.30.7.2 The environmental control duct assembly 60B40000 is installed in two sections; each section is installed in two phases. The first, or vertical, section included the installation of all components of both lines from the No. 3 umbilical plate (station 142.0 (approximately), 15 degrees clockwise from Position III toward Position II) to station 272.0 (approximately). Phase one installs the right-hand tube assembly (The tube assembly nearest to Position III.) and phase two installs the left-hand tube assembly. Both of these phases include the vertical to horizontal transition ducts at station 272.0 (approximately).

2.30.7.3 The second, or horizontal, section of the environmental control duct assembly 60B40000 is installed in two phases. Phase one installs the right-hand tube assembly which begins at the end of the vertical to horizontal transition duct (station 272.0 approximately) and continues in a counterclockwise direction from Position III through Position IV towards Position I. Phase two installs the left-hand tube assembly which runs in a clockwise direction through Position II towards Position I.

2.30.8 Michoud Only. Install miscellaneous propulsion, electrical and electronic components, electrical wiring, wire tunnels, and tube assemblies.

2.31 MSFC Only. Using A-frame SA-370-7420 and hoisting tool HT-370-7111, remove thrust structure assembly 60B18050 from assembly tool AT-435-8056 and transport to the structural assembly tower. (See figure 4-72.)

SECTION V

FORWARD SKIRT ASSEMBLY

SECTION V
FORWARD SKIRT ASSEMBLY

1. GENERAL DESCRIPTION.

The forward skirt assembly comprises that section of the vehicle which extends from the upper head assembly of the oxidizer tank assembly to the second stage. (See figures 5-1 and 5-2.) The basic structure of the forward skirt assembly consists of 12 skin panels attached to three circumferential support rings. The skin panels are reinforced by hat-shaped vertical stringers. The upper circumferential ring is the interface between the first and second stages and contains the gage-controlled attach hole pattern for the 216 fasteners. This gage-controlled hole pattern is obtained from a gage made by North American for Boeing to use in setting up the forward skirt final assembly fixture. (See figure 5-3.) Mechanical fasteners are used to attach the forward skirt assembly to the upper Y-ring of the oxidizer tank assembly.

A small access door permits entry for servicing of the several electrical-electronic installations. The umbilical disconnect door is located above the access door. Fittings are provided for the LOX, GOX, and electrical openings. The telemetry and command antennas are attached to the reinforcing hat stringers. Approximate size of the completed forward skirt assembly is 33 feet in diameter by 10 feet high with a flight weight of 5250 pounds.

2. FORWARD SKIRT ASSEMBLY SUBASSEMBLIES.

2.1 Hat Stiffener Subassembly 60B14430-1-900. (See figure 5-4.) Hat stiffener subassembly 60B14430-1-900 consists of a hat-shaped stiffener approximately 120 inches long, six wedge-shaped tapered fillers, and four radius fillers. The fillers are located in relative position on the hat stiffener with fixtures MiT-B425-14430 and MiT2-B425-14430 and bonded in place.

2.2 Hat Stiffener Subassemblies. Hat stiffener subassemblies 60B14230-1-900, 60B14650-1-900, 60B14820-1-900, 60B15050-1-900, and 60B15050-2-900 are similar to hat stiffener subassembly 60B14430-1-900.

2.3 Channel Frame Subassembly 60B14290-1-900. (See figure 5-5.) Channel frame subassembly 60B14290-1-900 consists of a channel-shaped stiffener approximately 120 inches long, one wedge-shaped tapered filler, and four radius fillers. The fillers are located in relative position on the channel stiffener with fixture MiT-B425-14290 and bonded in place.

2.4 Umbilical Door Assembly 60B14260-1. (See figure 5-6.) Umbilical door assembly 60B14260-1 is approximately 20 inches wide by 28 inches long consisting of one compound-contoured skin, six hat stiffeners, two outer angle stiffeners, two inner angle stiffeners, a support bracket, and a camlock latch. Umbilical door assembly 60B14260-1 is loaded and assembled in a picture-frame type fixture AF-B425-14260 which is trunnion supported and floor mounted. (See figure 5-7.) The detail parts are loaded and assembled starting with the inner angles, the outer angles, skin, and hat stiffeners. Holes are then drilled, and fasteners are installed. The camlock latch and door support bracket are then loaded, holes drilled, and fasteners are installed to complete umbilical door assembly 60B14260-1.

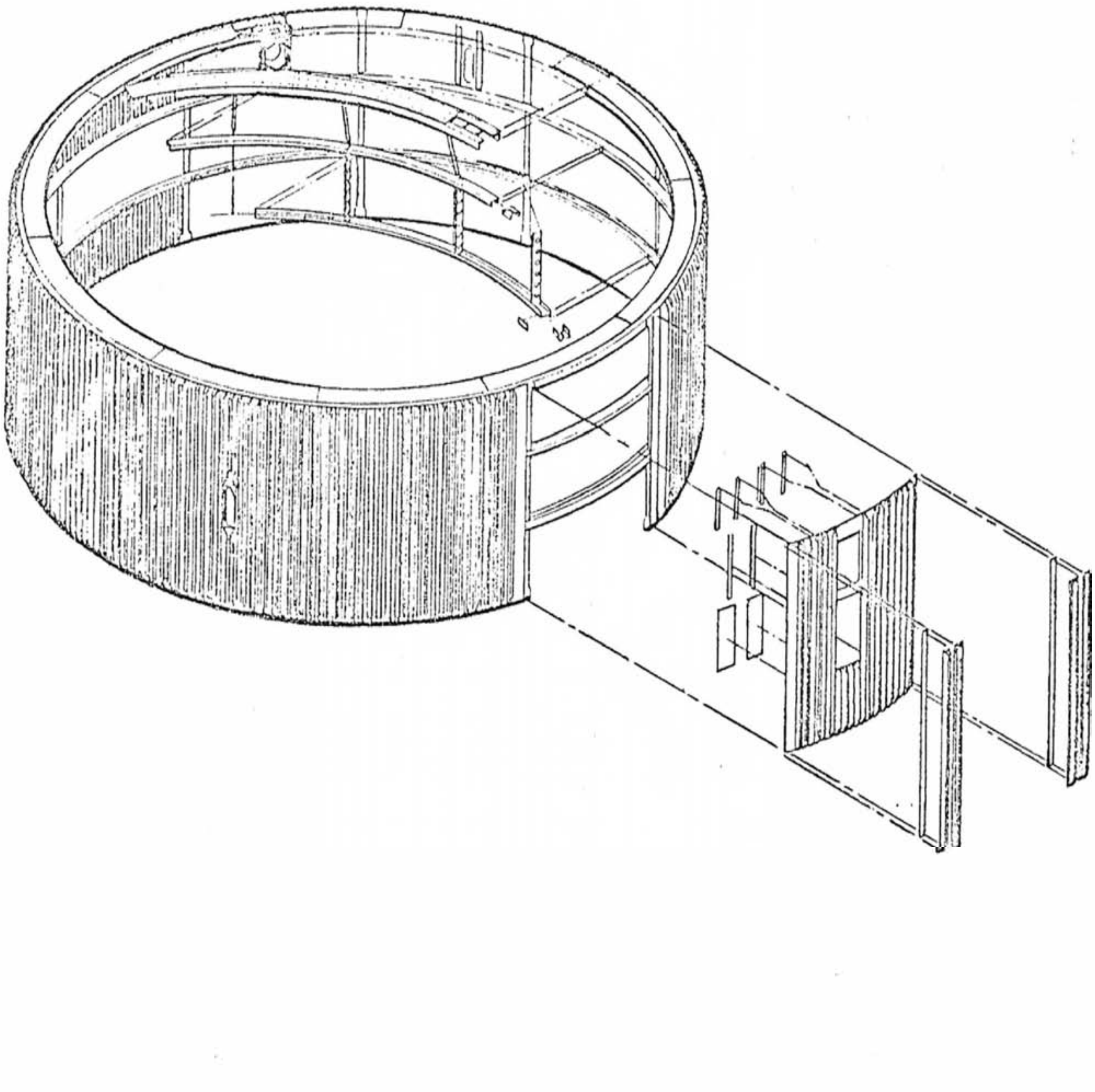


Figure 5-1. Forward Skirt Assembly

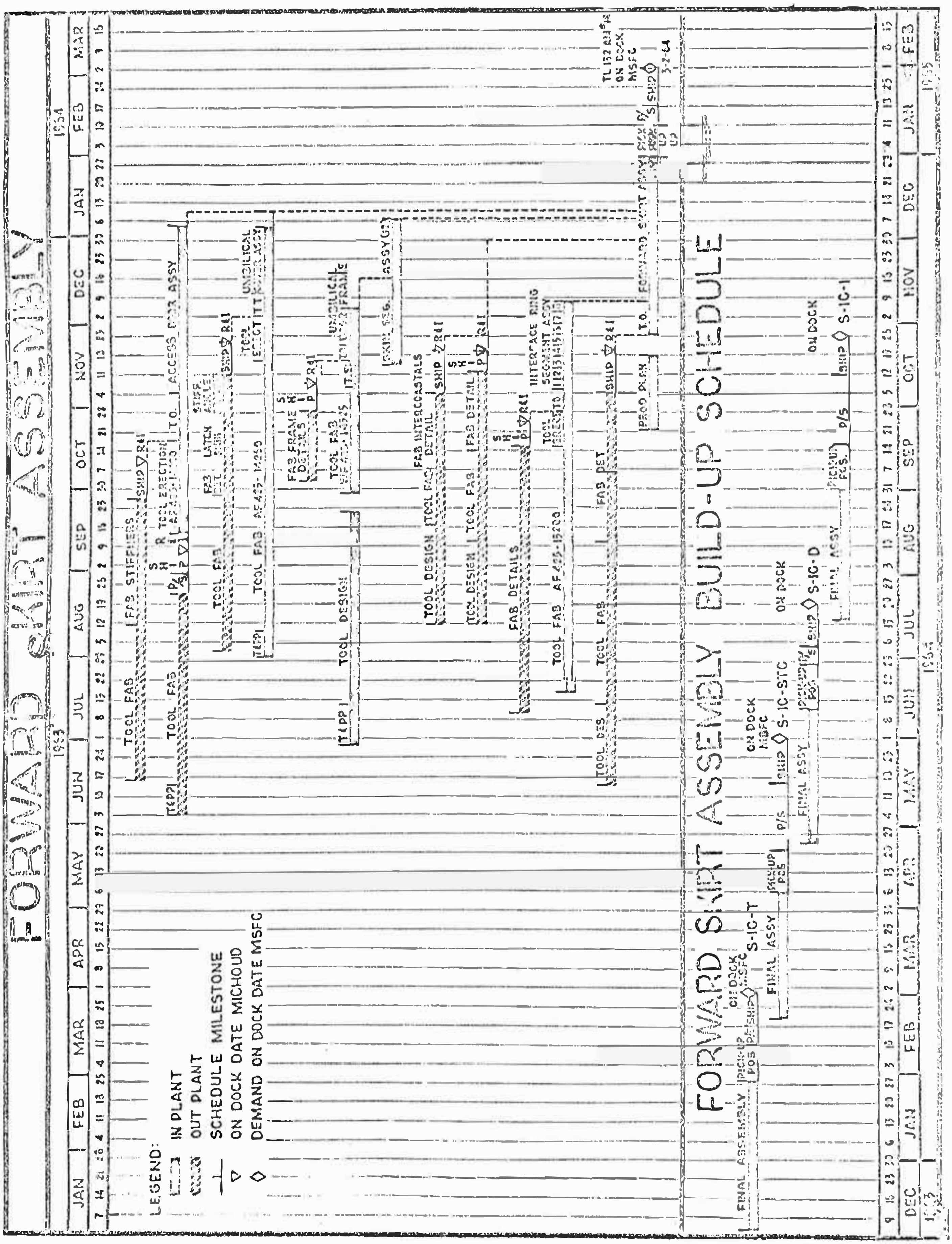


Figure 5-2. Forward Skirt Assembly Schedule - Plan V

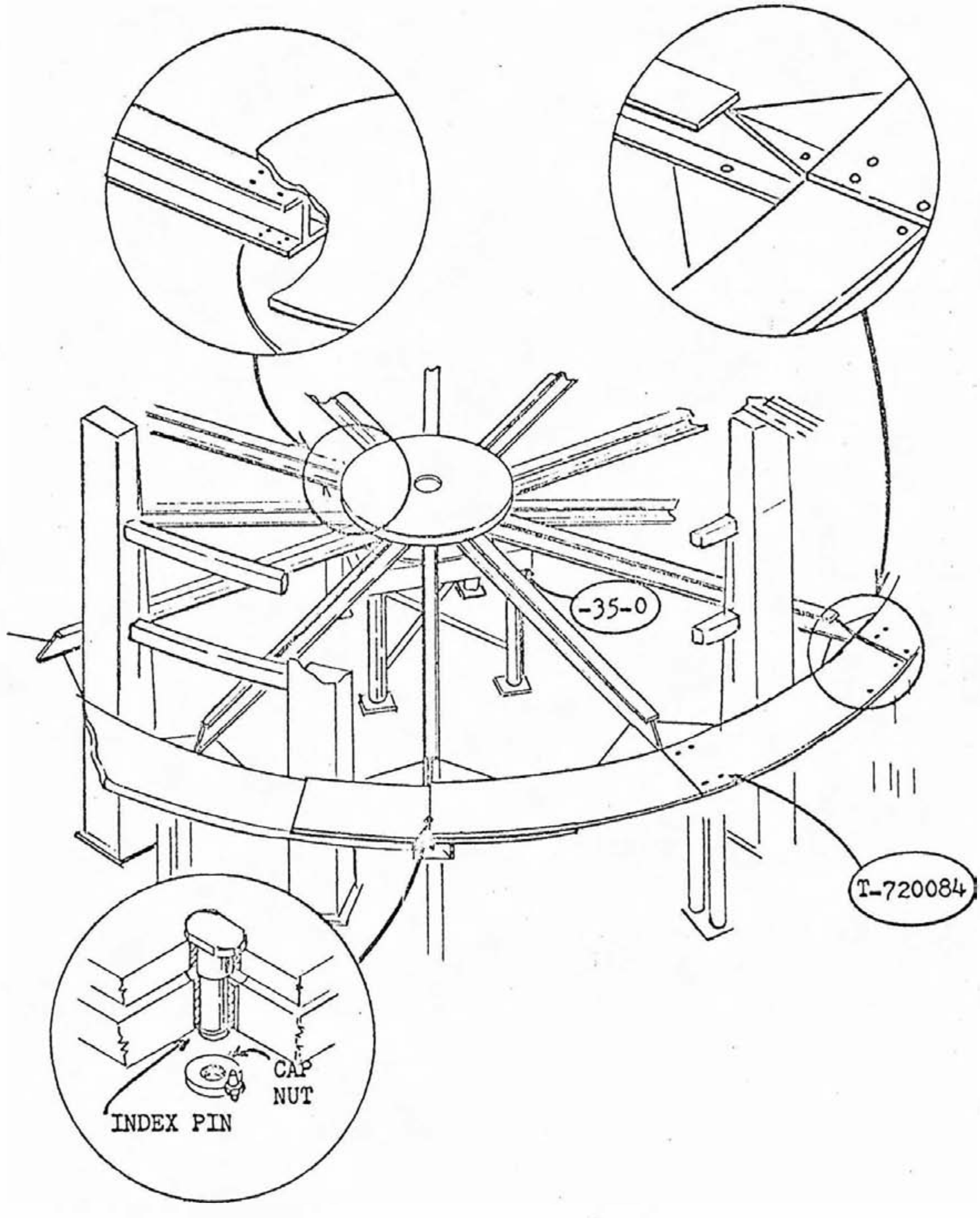


Figure 5-3. Interface Gage Installation

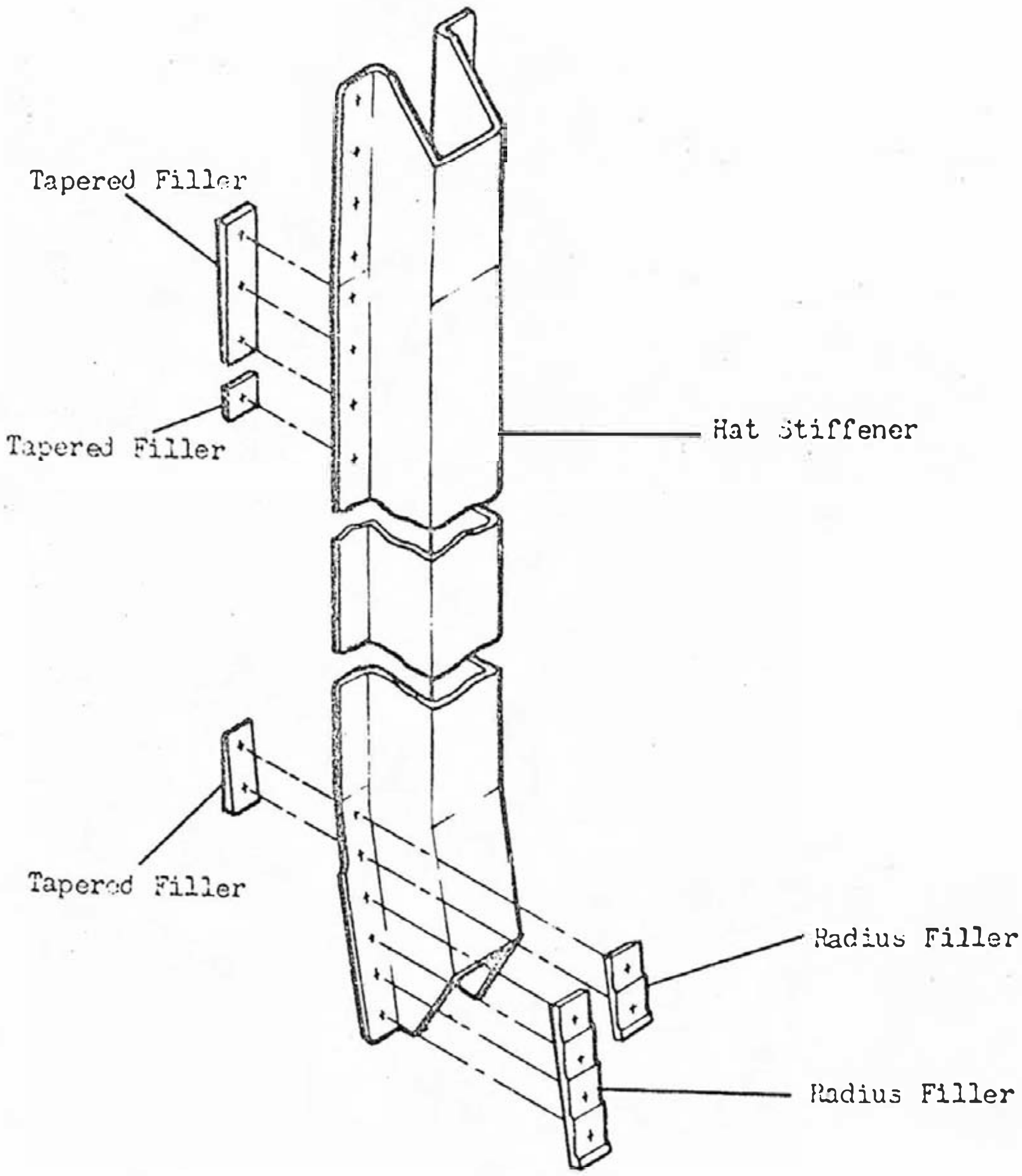


Figure 5-4. Typical Hat Stiffener Subassembly

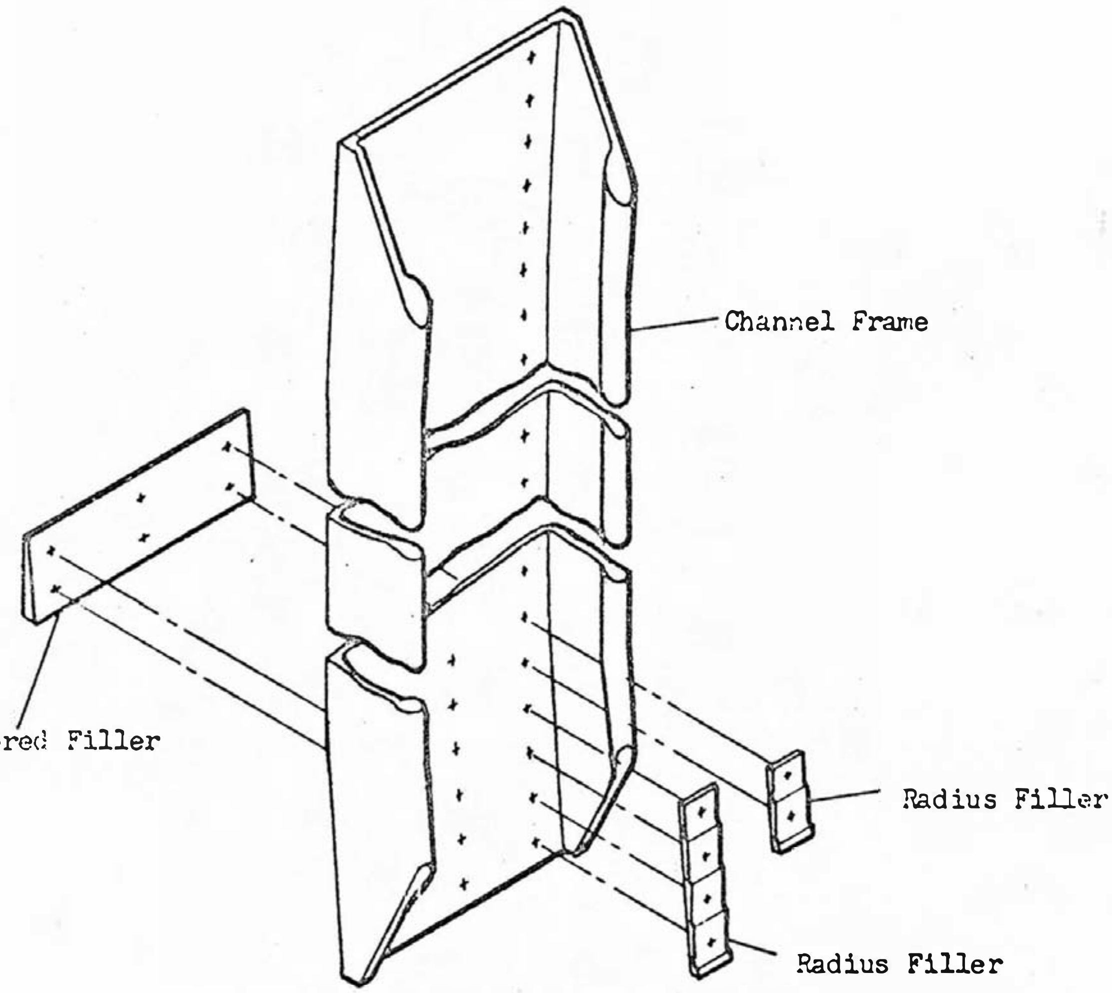


Figure 5-5. Channel Frame Subassembly

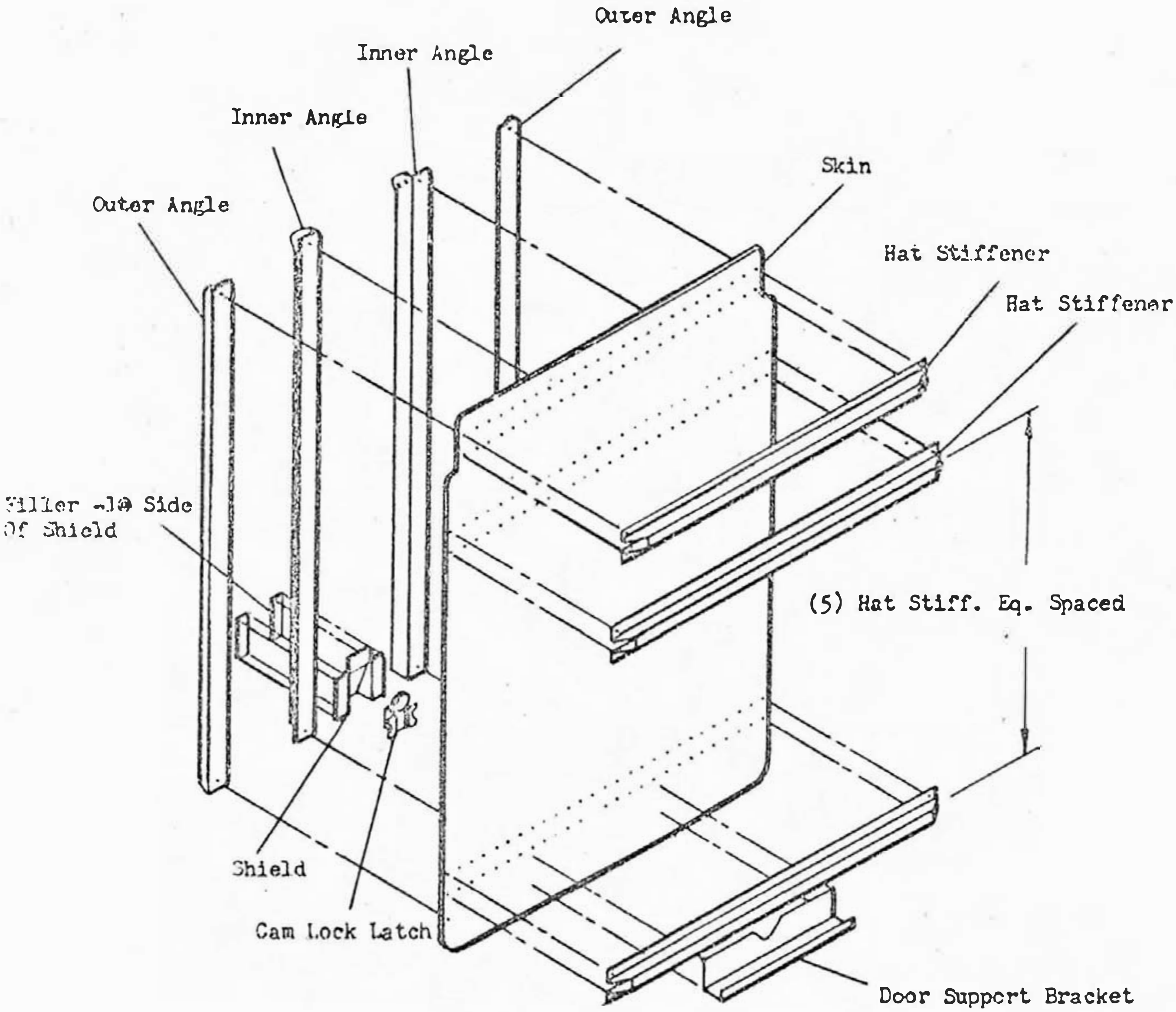


Figure 5-6. Umbilical Door Assembly

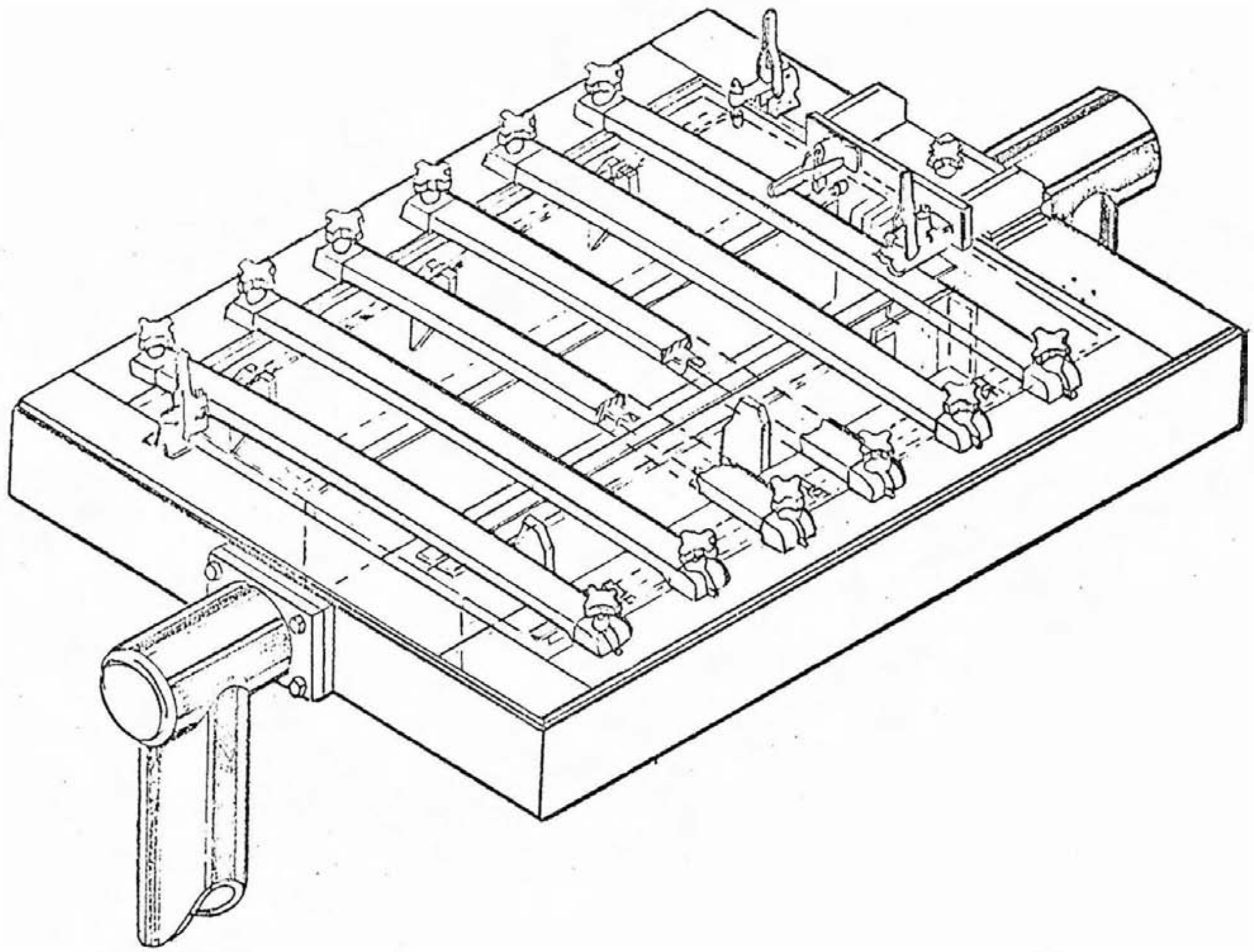


Figure 5-7. Umbilical Door Assembly Fixture AF-B425-14260

2.5 Umbilical Frame Weldment 60B14325-1. (See figure 5-8.) Umbilical frame weldment 60B14325-1 is approximately 33 inches wide by 29 inches long consisting of two side angles, a lower angle, an upper angle, and a plate. Umbilical frame weldment 60B14325-1 is loaded and assembled in a picture-frame type weld fixture WF-B425-14325 which is trunnion supported and floor mounted. (See figure 5-9.) The detailed parts are located and assembled starting with the lower angle, the side angles, the upper angle, and plate. The assembly is welded complete, removed from weld fixture WF-B425-14325, inverted 180 degrees, and reclamped in weld fixture WF-B425-14325 for a routing operation. The latch slot is then routed. The assembly is now removed from the fixture and the 34 attach holes for the umbilical plate are drilled using WF-B425-14325-2-0 drill plate which is coordinated with the umbilical plate furnished by GSE. The assembly is now complete.

2.6 Access Door Assembly. (See figure 5-10.) The access door assembly is approximately two feet wide by three feet long weighing 12-1/2 pounds. The access door assembly consists of a skin, hat stiffeners, stiffener angles, shims, hinges, and various fasteners. Assembly of the access door assembly is accomplished in assembly fixture AF-B425-14220. (See figure 5-11.) Assembly fixture AF-B425-14220 is floor mounted and equipped with Bettys trunnions allowing rotation of access door assembly to obtain the optimum position for drilling holes and installing fasteners. The loading sequence of assembly fixture AF-B425-14220 is as follows:

2.6.1 The hat stiffeners are end stopped and spaced by locating stops in assembly fixture AF-B425-14220. The hinge sections are then pinned through their hinge point and set to position. The door skin is set against a locator assembly and locating stops. The side angle is end stopped to a locating dowel and C-clamped to the angle supports. The two stiffener angles are also end stopped and C-clamped in position.

2.6.2 The fastener locations are drilled in the access door assembly from drill bushings and pilot holes in the detail parts. Fasteners are then installed to complete the access door assembly.

2.6.3 The access door assembly is now complete in accordance with the engineering drawing less five 3/16-inch diameter holes in each hinge plate common to the forward skirt assembly structure.

2.7 Interface Ring Segment Assembly 60B15200-1-900. (See figure 5-12.) Interface ring segment assembly 60B15200-1-900 is approximately 21 inches wide by 197 inches long consisting of an inner chord angle, an outer chord angle, two shear webs, a tee splice, 14 stiffener angles, and 14 gussets. Interface ring segment assembly 60B15200-1-900 is loaded and assembled in picture-frame type assembly fixture AF-B425-15200 which is floor mounted in a vertical position. (See figure 5-13.) The detail parts are loaded and assembled starting with the inner chord angle, the outer chord angle, the shear webs, the stiffener angles, the tee splice, and the gussets. The holes are then drilled with a Spacematic drill, and the fasteners are installed to complete interface ring segment assembly 60B15200-1-900.

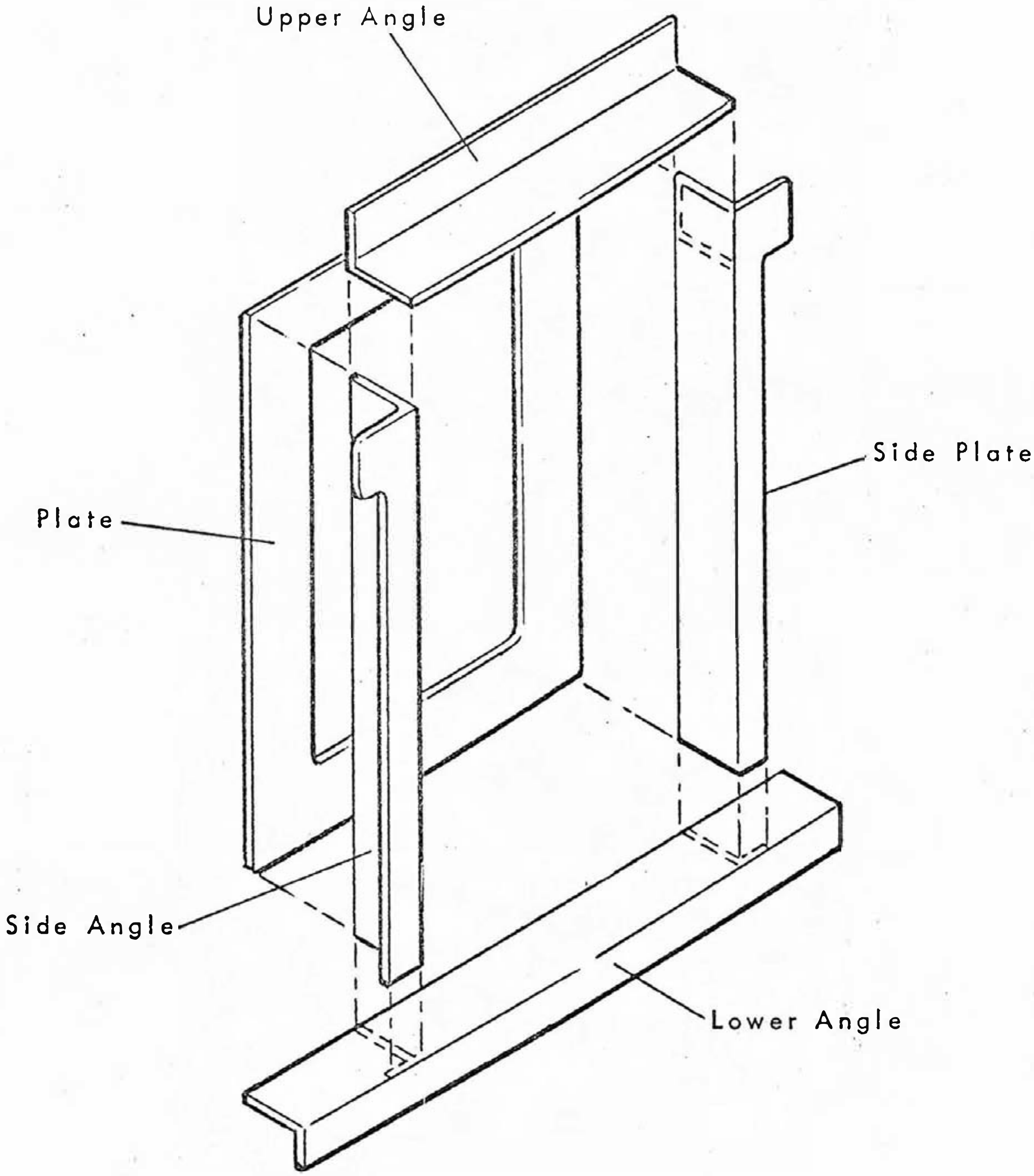


Figure 5-8. Umbilical Frame Weldment

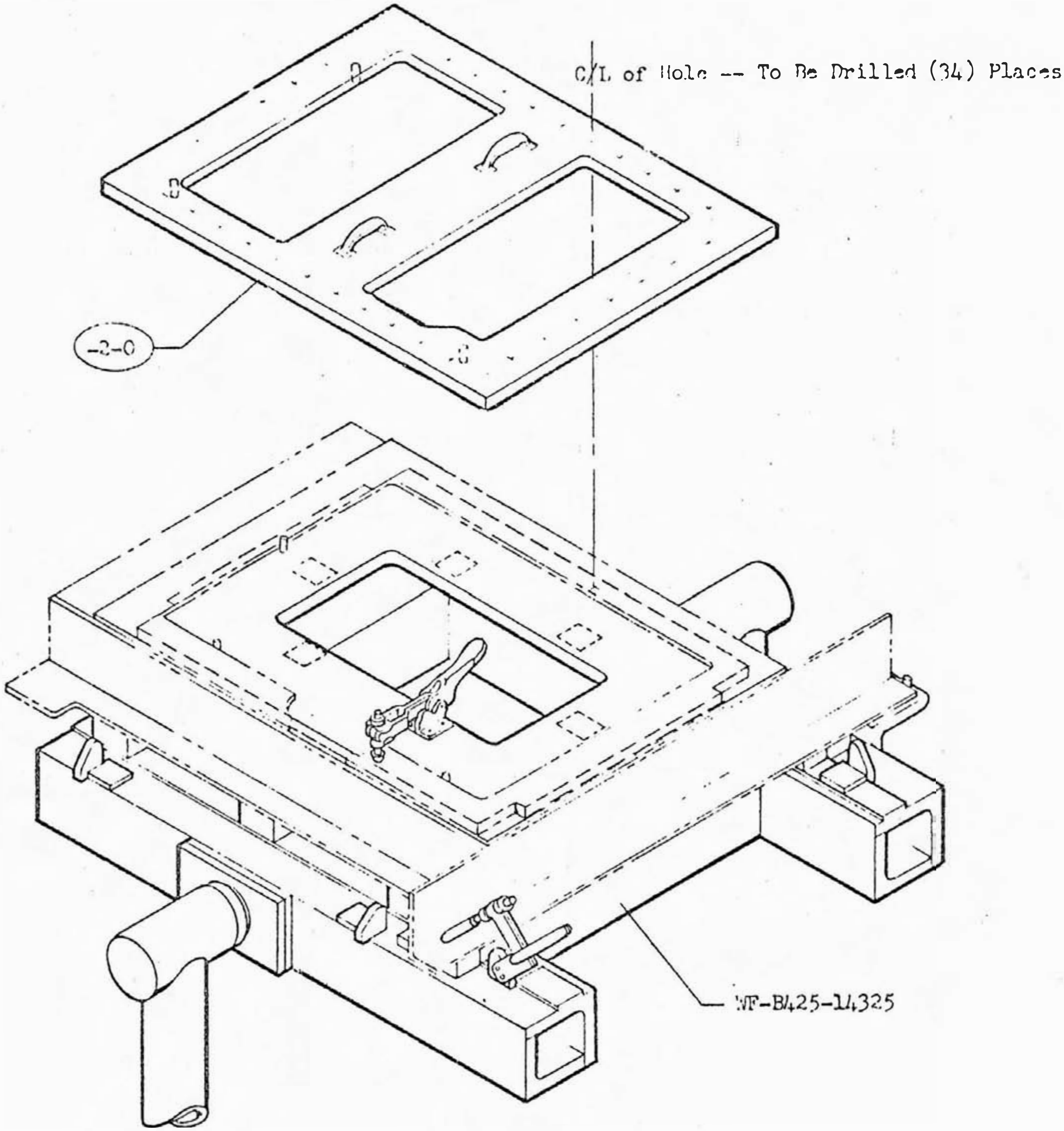


Figure 5-9. Umbilical Frame Weldment Weld Fixture
WF-B425-14325

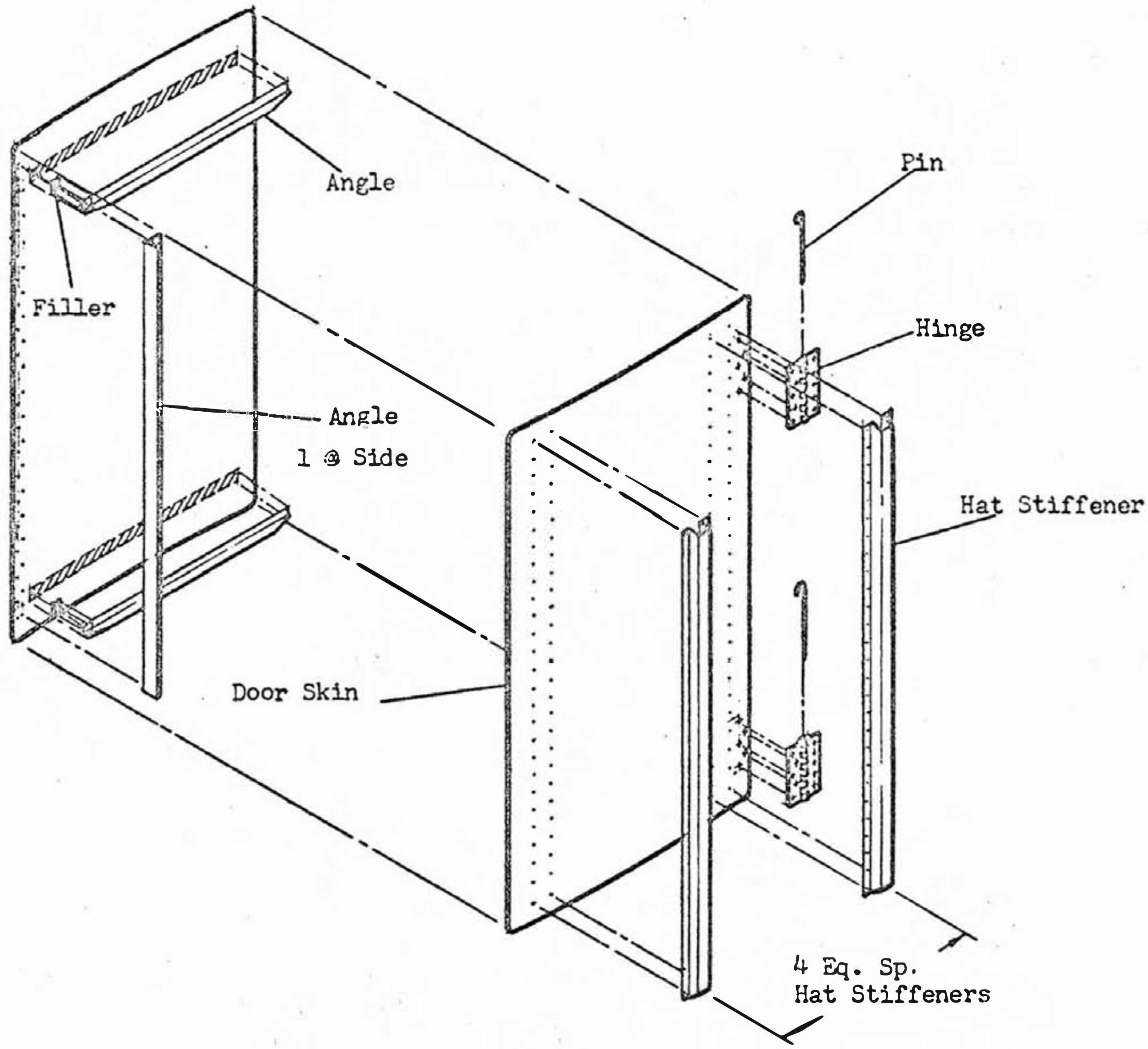


Figure 5-10. Access Door Assembly

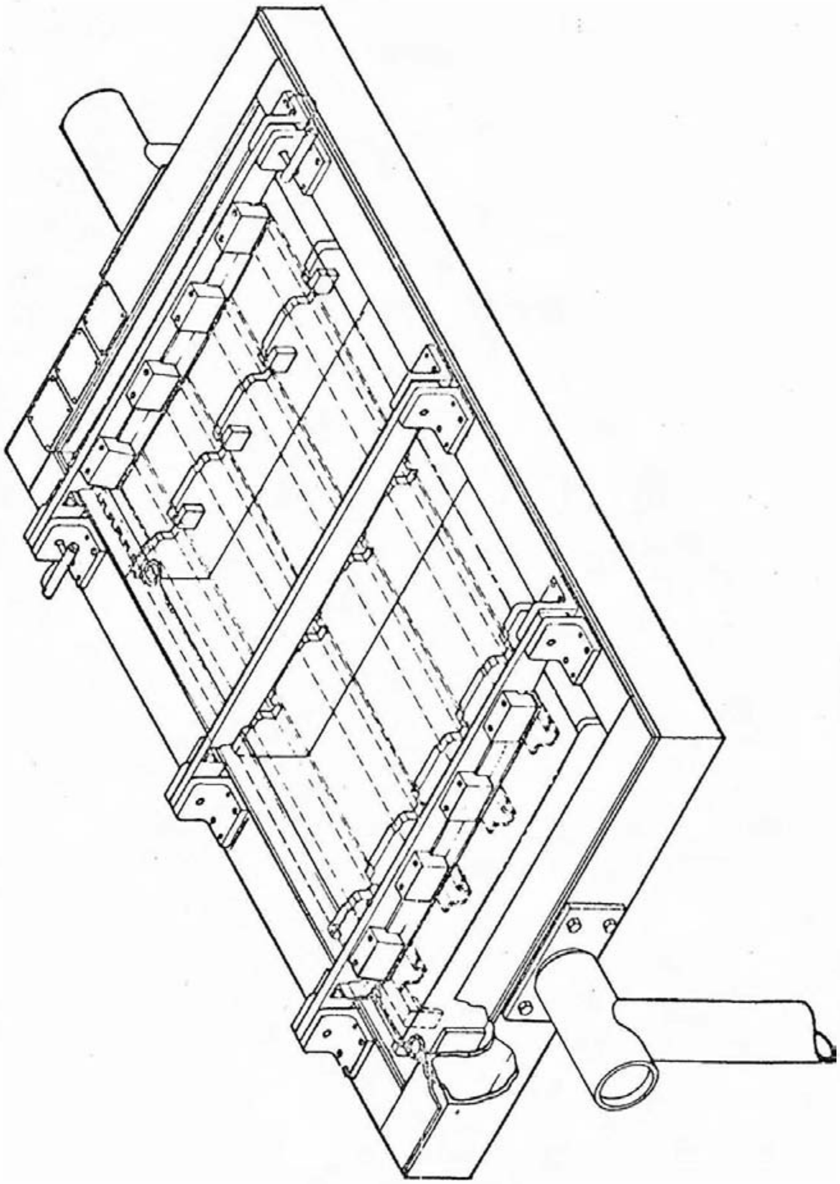


Figure 5-11. Access Door Assembly Fixture
AF-B425-14220

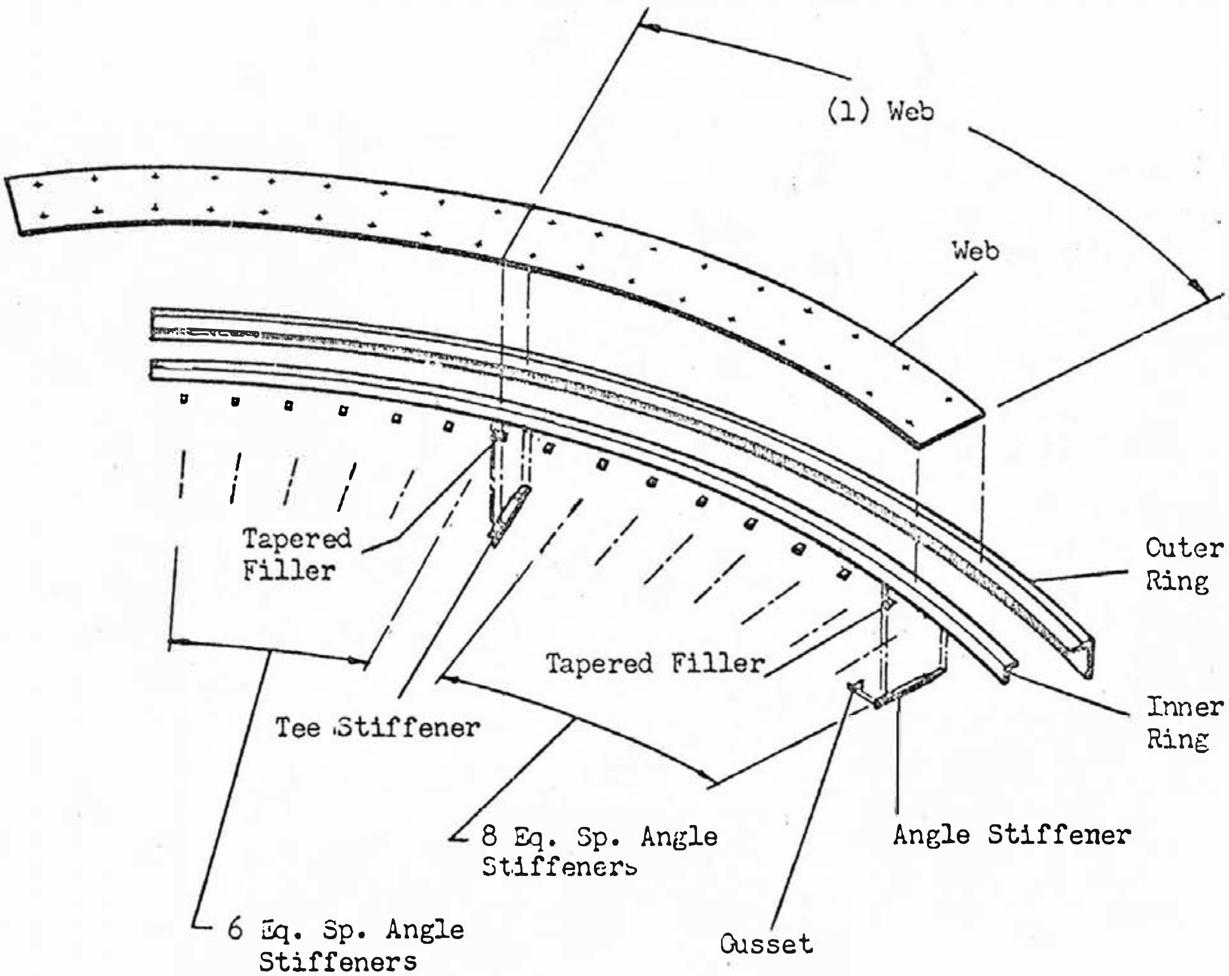


Figure 5-12. Interface Ring Segment Assembly

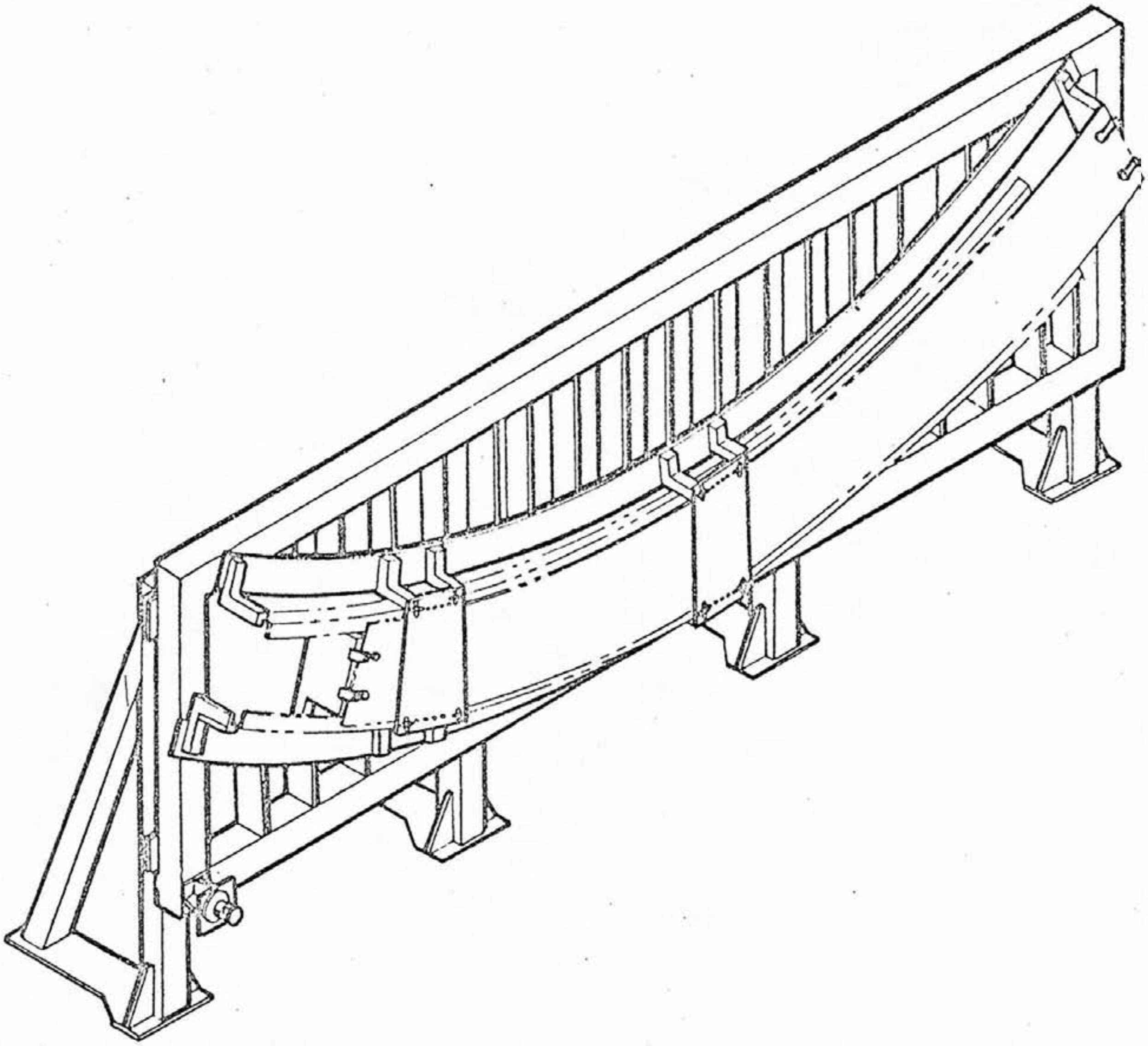


Figure 5-13. Interface Ring Segment Assembly Fixture
AF-B425-15200

2.7 (Con.)

NOTE: Two stiffener angles, two gussets, one tee splice, one splice angle, and four splice plates have been omitted from interface ring segment assembly 60B15200-1-900 to facilitate assembly in the forward skirt assembly final assembly fixture.

2.8 Skin Segment Assembly 60B14200-1-900. (See figure 5-14.) Skin segment assembly 60B14200-1-900 is approximately 103 inches wide by 120 inches long consisting of a conical skin, cylindrical skin, 14 hat stiffener assemblies, 10 upper skin doublers, 9 lower skin doublers, access door doubler, two channel frame assemblies, four zee stiffeners, two umbilical brackets, two channel doublers, and one vent slot doubler. Skin segment assembly 60B14200-1-900 is loaded and partially assembled in picture-frame type assembly fixture AF-B425-14400 which is trunnion supported and floor mounted. (See figure 5-15.) The partial assembly is then moved to a second picture-frame type assembly fixture AF2-B425-14400, which is floor mounted (See figure 5-16) to complete assembly and drilling. The assembly is moved with handling tools MiT-B370-14400 and HT-370-14400 (See figure 5-17) from AF2-B425-14400 to MiT-B425-14400 where the remaining fasteners are installed to complete the skin segment assembly.

2.8.1 The detail parts are loaded and assembled in assembly fixture AF-B425-14400 starting with the upper skin doublers, the lower skin doublers, the conical skin, and the cylindrical skin. The hat stiffener assemblies are then loaded and partially drilled with a Zephyr drill adapter, and temporarily fastened.

2.8.2 The partial assembly is removed from assembly fixture AF-B425-14400 and loaded into assembly fixture AF2-B425-14400 to complete assembly and drilling. The umbilical router template AF-B425-14400-23-0 is located on the partial assembly and camlocked in position through full-size fastener holes. The access router template is then located on the partial assembly and camlocked in position through full-size fastener holes. The access door doubler is located in assembly fixture AF2-B425-14400 and holes are drilled common to the doubler. The channel frame assemblies and channel frame doublers are located and clamped in position on the partial assembly. Drill plates AF2-B425-14400-8-0, -15-0, -16-0, -17-0, -26-0, and -28-0 are then located on the partial assembly and camlocked in position through full-size fastener holes. The remaining holes are drilled with a Spacematic drill.

2.8.3 The zee stiffeners and umbilical brackets are hand located on the partial assembly and clecoed in position through No. 30 pilot holes. The holes are then drilled by hand through No. 30 pilot holes. Router bars AF2-B425-14400-30-0, -31-0, and -32-0 are then placed in position; the sides of the partial assembly are then routed.

2.8.4 The skin segment assembly is removed from AF2-B425-14400 for deburring, followed by reassembly in AF2-B425-14400 for partial fastener installation, and installation of four MiT-B370-14400 attach fittings. Handling tool HT-B370-14400 is then used to place the assembly in skin panel support fixture MiT-B425-14400, to complete fastener installation and touch up painting.

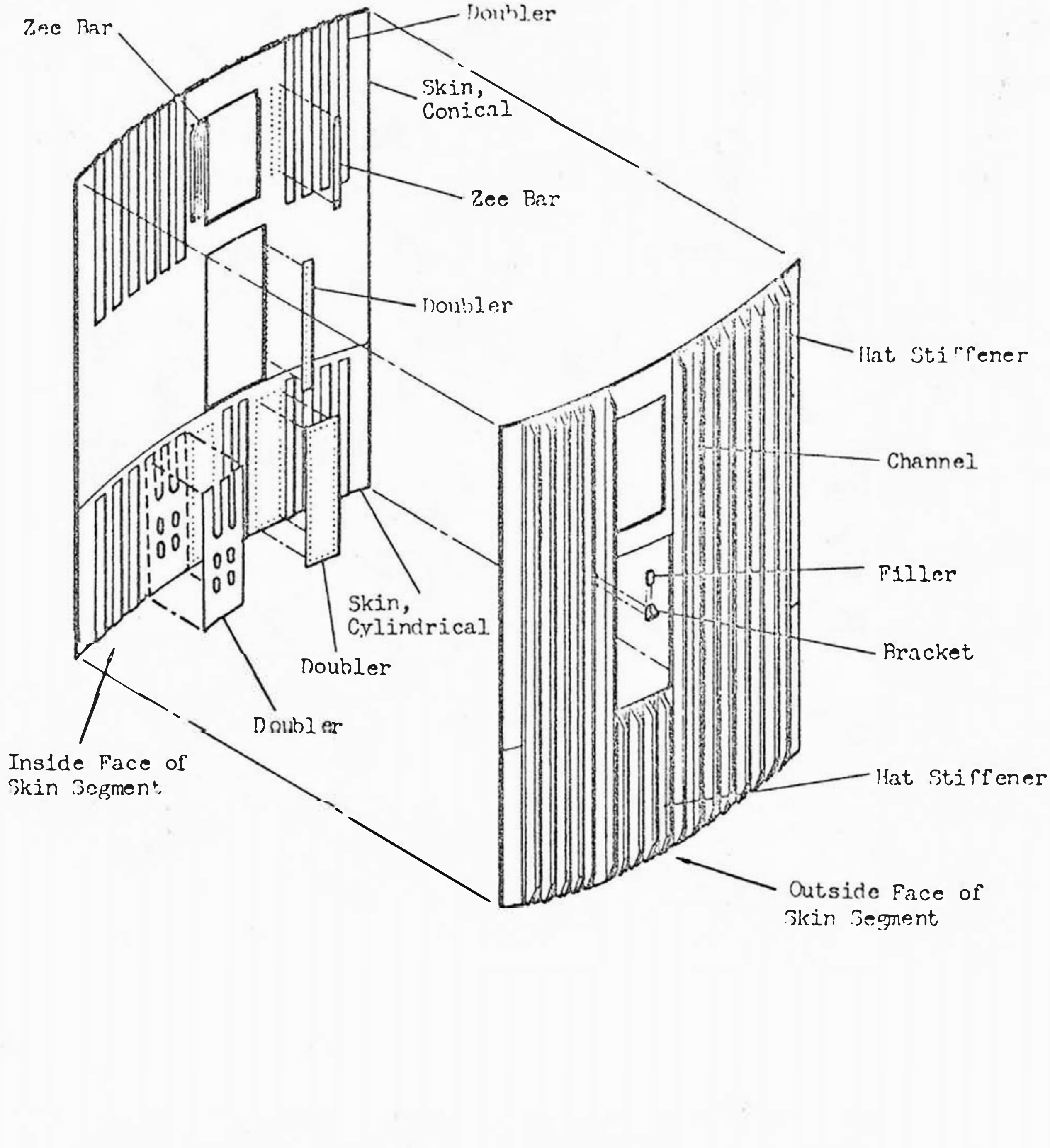


Figure 5-14. Skin Segment Assembly (Umbilical and Access Door)
60B14200-1-900

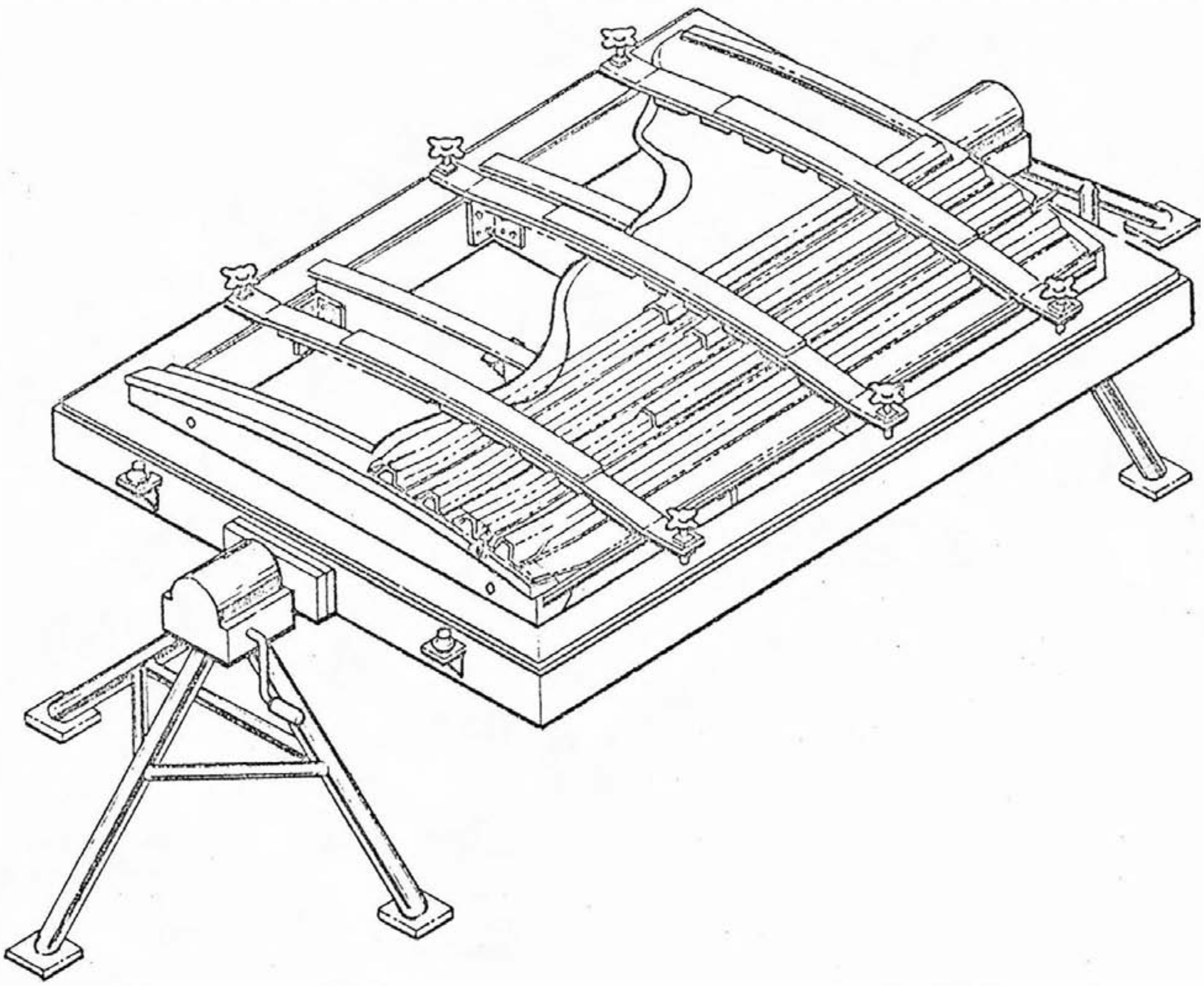


Figure 5-15. Skin Segment Assembly Fixture
AF-B425-14400

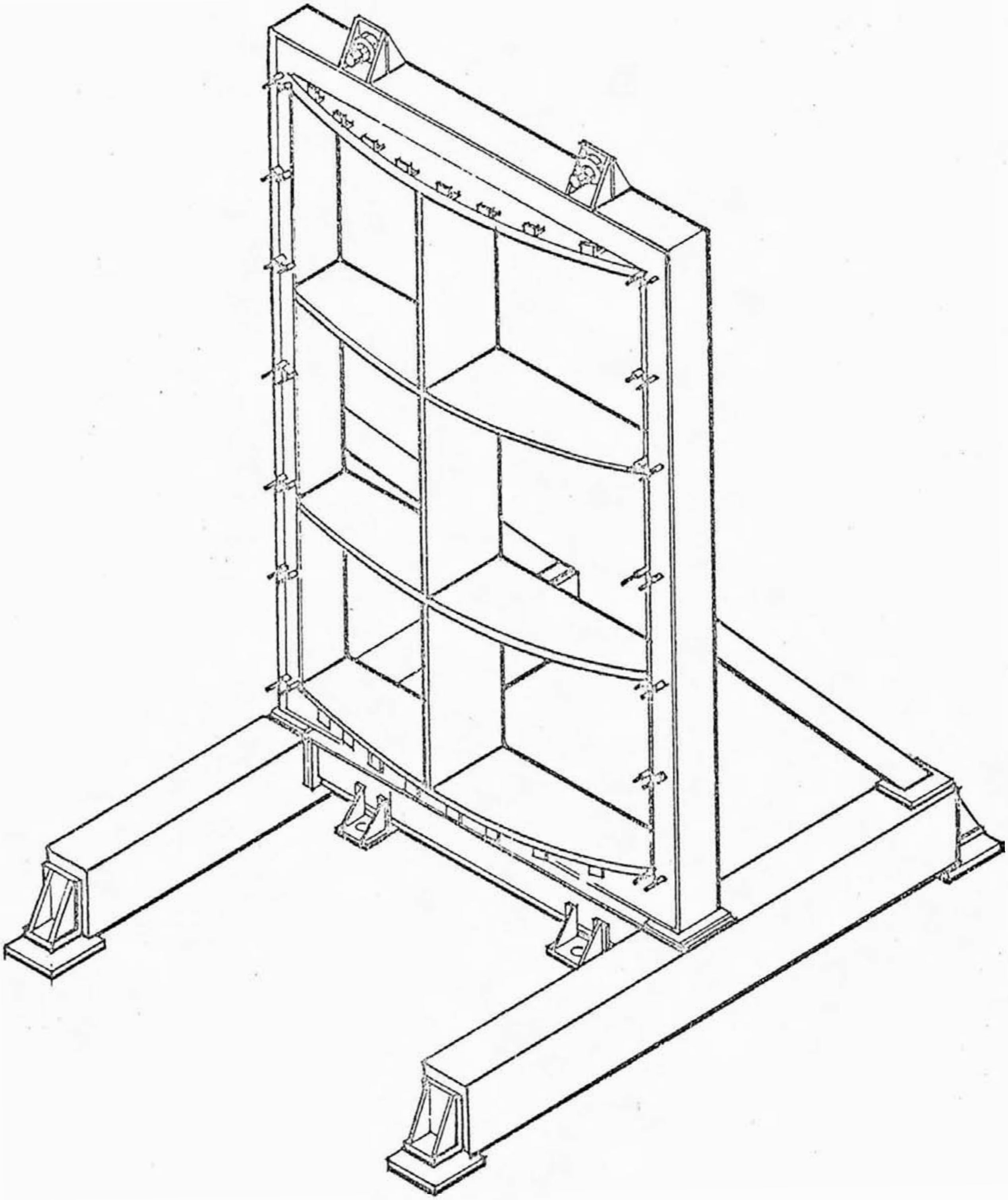


Figure 5-16. Skin Segment Assembly Fixture AF2-B425-14400

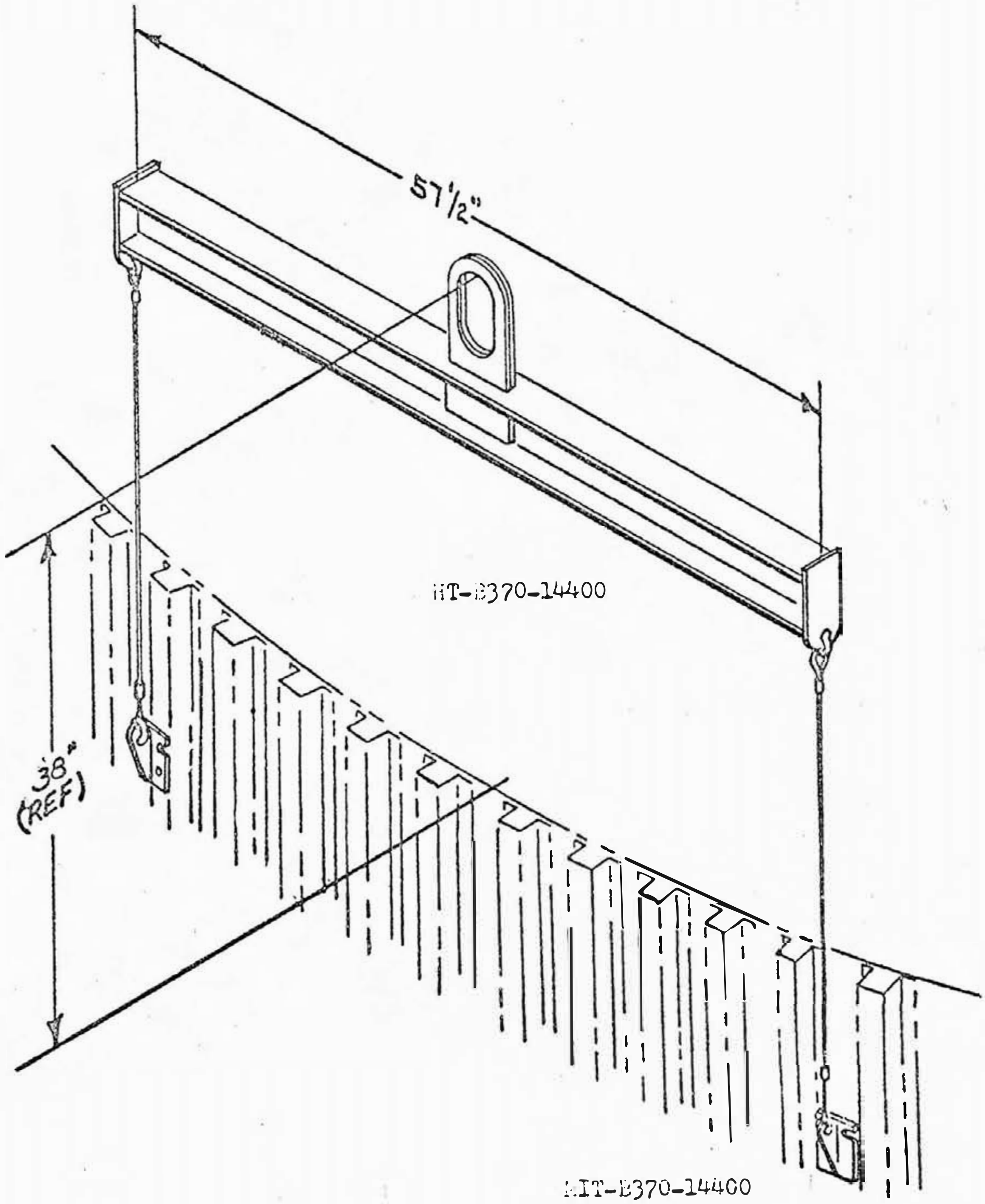


Figure 5-17. Skin Segment Assembly - Forward Skirt Hoisting Tool

2.8.4 (Con.)

NOTE: Two hat stiffener assemblies, three skin splice doublers, one umbilical frame weldment, and one umbilical door assembly have been omitted from skin segment assembly 60B14200-1-900 to facilitate assembly in the final assembly fixture.

2.9 Skin Segment Assembly 60B14400-1-900. (See figure 5-18.) Skin segment assembly 60B14400-1-900 is approximately 103 inches wide by 120 inches long consisting of one conical skin, one cylindrical skin, 16 hat stiffner assemblies, 16 upper skin doublers, 13 lower skin doublers, and one vent slot doubler. Skin segment assembly 60B14400-1-900 is loaded and partially assembled in picture-frame type assembly fixture AF-B425-14400 which is trunnion supported and floor mounted. (See figure 5-15.) The partial assembly is then moved to a second picture-frame type assembly fixture AF2-B425-14400, which is floor mounted (See figure 5-16), to complete assembly and drilling. The assembly is moved with handling tools MiT-B370-14400 and HT-370-14400 (See figure 5-17) from AF2-B425-14400 to MiT-B425-14400 where the remaining fasteners are installed to complete the skin segment assembly.

2.9.1 The detail parts are loaded and assembled in assembly fixture AF-B425-14400 starting with the upper skin doublers, the lower skin doublers,one vent doubler, the conical skin, and the cylindrical skin. The hat stiffener assemblies are then loaded, drilled and temporary fasteners are installed.

2.9.2 The partial assembly is then removed from assembly fixture AF-B425-14400 and loaded in assembly fixture AF2-B425-14400 for completion. Drill plates AF2-B425-14400-1-0, -2-0, -5-0, -6-0, -10-0, and -28-0 are then located on the partial assembly and camlocked in position through full-size fastener holes. The remaining holes are drilled with a Spacematic drill. Router bars AF2-B425-14400-30-0, -31-0, -32-0, are then placed in position on the partial assembly; the sides of the partial assembly are then routed.

2.9.3 The skin segment assembly is removed from AF2-B425-14400 for deburring, followed by reassembly in AF2-B425-14400 for partial fastener installation, and installation of four MiT-B370-14400 attach fittings. Handling tool HT-B370-14400 is then used to place the assembly in skin panel support fixture MiT-B425-14400, to complete fastener installation and touch up painting.

NOTE: Two hat stiffener assemblies and three skin doublers have been omitted from skin segment assembly 60B14400-1-900 to facilitate assembly in the final assembly fixture.

2.10 Skin Segment Assembly 60B14400-3-900. (See figure 5-19.) Skin segment assembly 60B14400-3-900 is similar to skin segment assembly 60B14400-1-900 except upper skin doubler 60B14481-1 is installed in lieu of two upper skin doublers in assembly fixture AF-B425-14400. Drill plates AF2-B425-14400-1-0, -2-0, -3-0, -5-0, -6-0, and -11-0 are then located on the partial assembly and camlocked in position through full-size fastener holes. The remaining holes are drilled with a Spacematic drill.

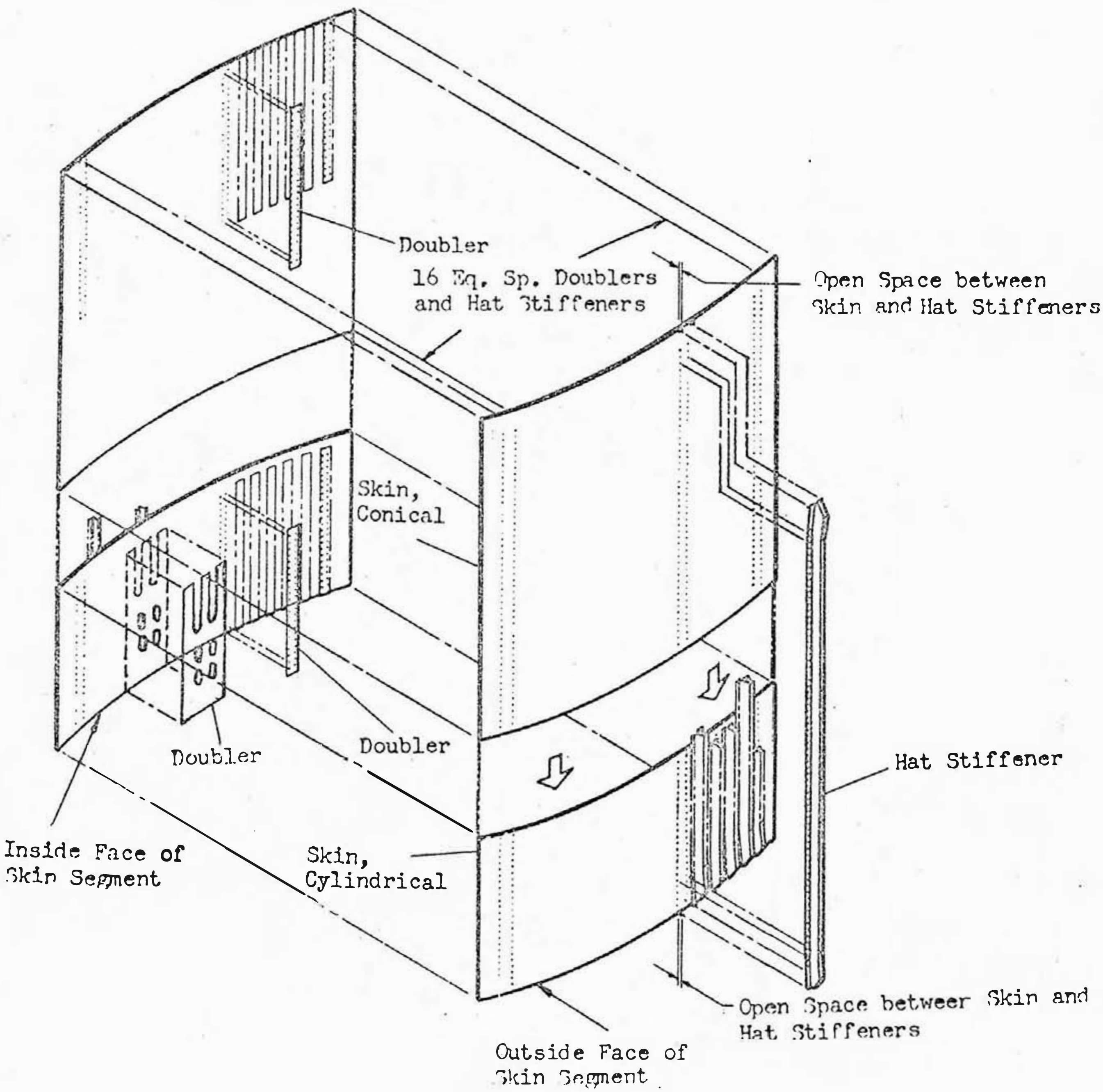


Figure 5-18. Skin Segment Assembly 60B14400-1-900

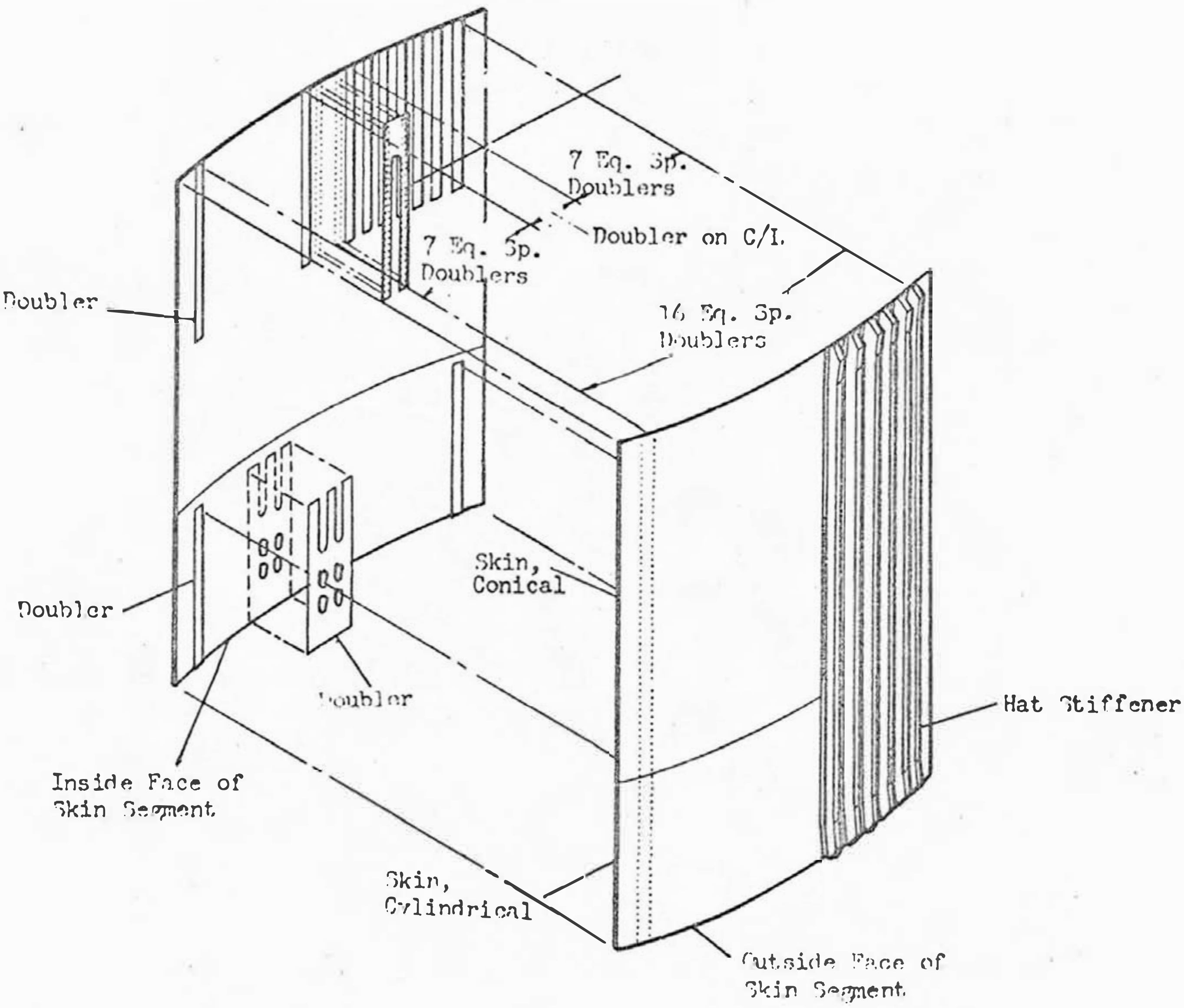


Figure 5-19. Skin Segment Assembly 60B14400-3-900

2.11 Skin Segment Assembly 60B14600-1-900. (See figure 5-20.) Skin segment assembly 60B14600-1-900 is similar to skin segment assembly 60B14400-1-900 except as follows:

2.11.1 Two short hat stiffener assemblies are located in assembly fixture AF-B425-14400 in lieu of one long hat stiffener assembly, plus the addition of one detonator fuse doubler.

2.11.2 The electrical opening is routed, after the partial assembly is placed in assembly fixture AF2-B425-14400, from router plate AF2-B425-14400-19-0 which is located on the partial assembly to four No. 30 pilot holes and camlocked in position.

2.11.3 The electrical fitting which is fabricated from a 7079-T6 forging and machined on a single spindle Keller mill with two electrical doublers are then located and clamped in position on the partial assembly. The partial assembly is then drilled using drill plates AF2-B425-14400-30-0 and -31-0 in lieu of drill plates AF2-B425-14400-2-0, -6-0, -43-0, -44-0, -46-0, and -47-0.

2.12 Skin Segment Assembly 60B14800-1-900. (See figure 5-21.) Skin segment assembly 60B14800-1-900 is similar to skin segment assembly 60B14400-1-900 except as follows:

2.12.1 A short hat stiffener assembly is located in assembly fixture AF-B425-14400 in lieu of one long hat stiffener assembly, plus the addition of one detonator fuse doubler.

2.12.2 The GOX opening is routed, after the partial assembly is placed in assembly fixture AF2-B425-14400, from router plate AF2-B425-14400-20-0 which is located on the partial assembly to four No. 30 pilot holes and camlocked in position.

2.12.3 The GOX line fitting which is fabricated from a 7079-T6 forging and machined on a single spindle Keller mill, with two GOX line doublers and two GOX line brackets, are then located on the partial assembly and clamped in position. The partial assembly is then drilled using drill plates AF2-B425-14400-1-0, -2-0, -6-0, -35-0, -45-0, and -47-0.

2.13 Skin Segment Assembly 60B15000-1-900. (See figure 5-22.) Skin segment assembly 60B15000-1-900 is similar to skin segment assembly 60B14400-1-900 except as follows:

2.13.1 Two short hat stiffener assemblies are located in assembly fixture AF-B425-14400 in lieu of one long hat stiffener assembly.

2.13.2 The LOX vent opening is routed undersize, after the partial assembly is placed in assembly fixture AF2-B425-14400, from router plate AF2-B425-14400-21-0 which is located on the partial assembly to four No. 30 pilot holes and camlocked in position. Router arm AF2-B425-14400-29-0 is then located on assembly fixture AF2-B425-14400, and the LOX vent opening is routed to full size.

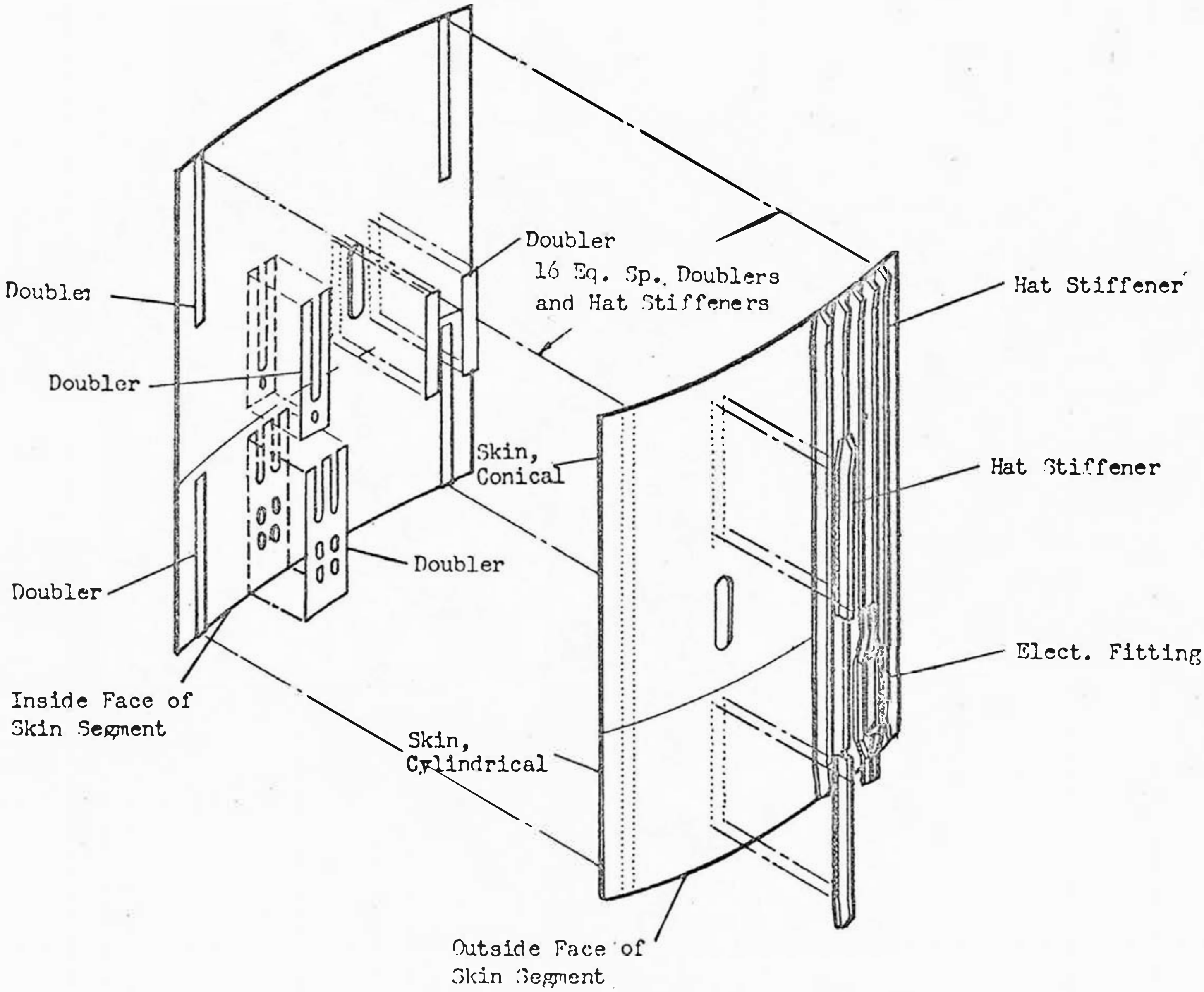


Figure 5-20. Skin Segment Assembly (Electrical Cable Inlet Fitting) 60B14600-1-900

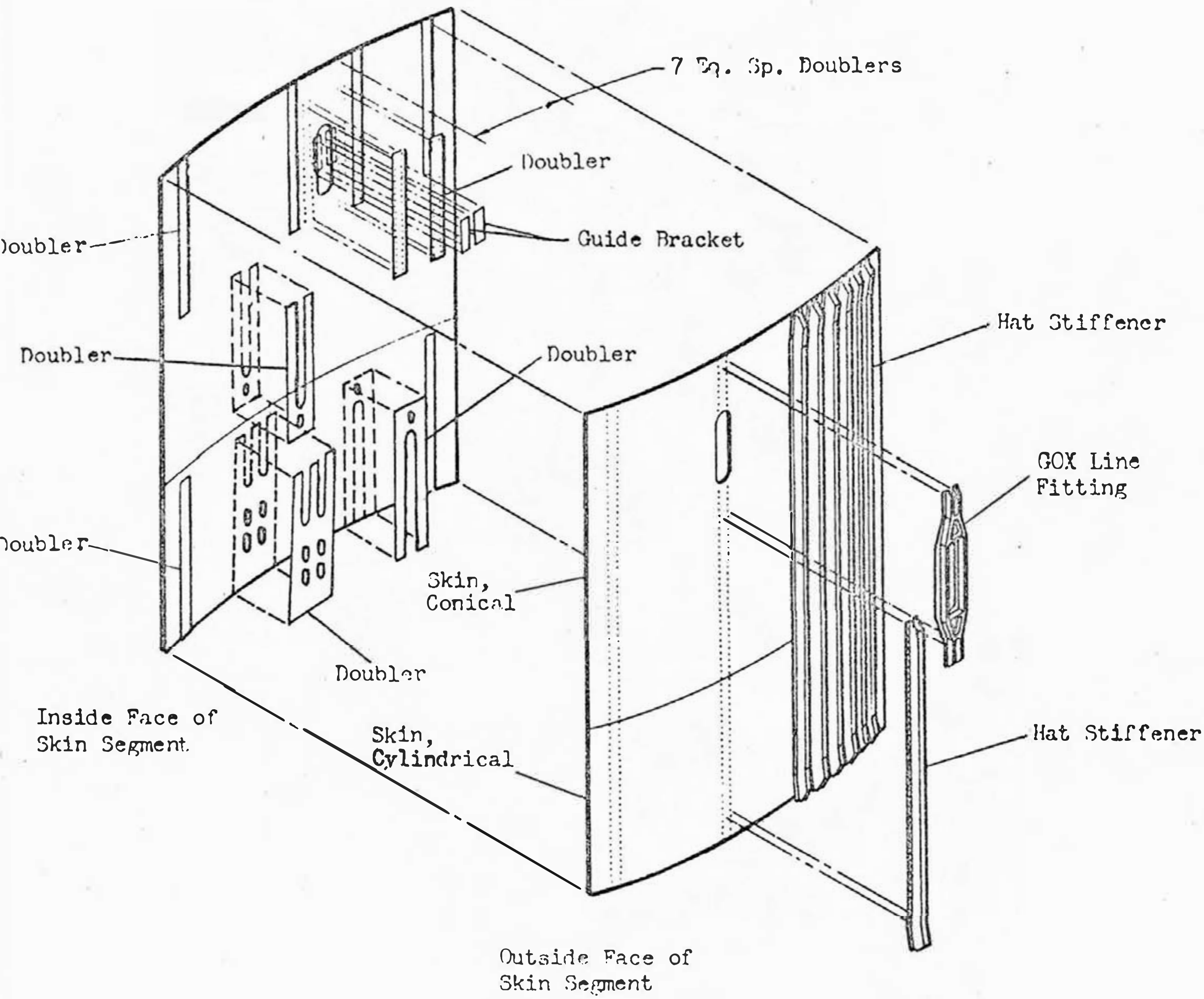


Figure 5-21. Skin Segment Assembly (GOX Line Fitting)
60B14800-1-900

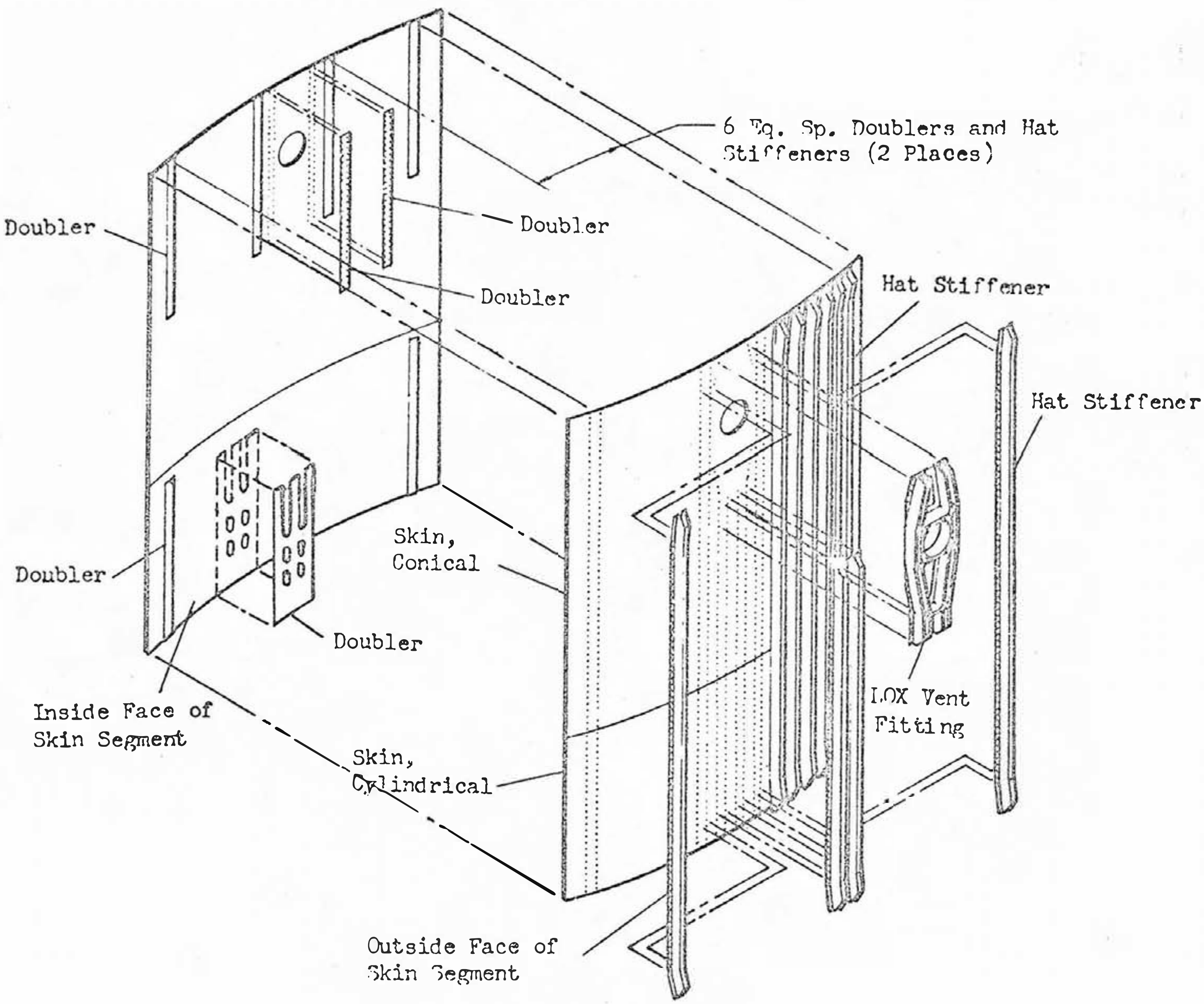


Figure 5-22. Skin Segment Assembly (LOX Vent Opening Fitting) 60B15000-1-900

2.13.3 The LOX vent fitting, which is fabricated from a 7079-T6 forging and machined on a single spindle Keller mill, with two LOX vent doublers, are then located on the partial assembly and clamped in position. The partial assembly is then drilled using drill plates AF2-B425-14400-2-0, -11-0, -12-0, -13-0, -14-0, -33-0, and -34-0.

2.14 Skin Segment Assembly 60B15000-3-900. (See figure 5-22.) Skin segment assembly 60B15000-3-900 is the same as skin segment assembly 60B15000-1-900 except the partial assembly is drilled using plates AF2-B425-14400-1-0 2-0, -12-0, -13-0, -14-0, -36-0 and -37-0.

3. FORWARD SKIRT FINAL ASSEMBLY.

The forward skirt assembly will be assembled at Michoud in an inverted position using major assembly fixture AF-B425-14000. (See figure 5-23.) The following assembly sequence will be followed:

3.1 The interface ring segments are set in position by placing the ring segment on the interface drill plate, setting the end reinforcing angle of the ring segment on an end stop, and setting the outer chord to location stops establishing the outside diameter of the interface ring. (See figure 5-12.) The interface ring segments are then clamped in position. Interface drill plates, drill angles, two angle stiffeners, two gussets, two splice plates common to the inner chord, and a tee splice are located at the interface ring splice. (See figures 5-24, 5-25, and 5-26.) Holes are then drilled from bushings in the drill plates and drill angles. Fasteners are then installed partially completing the interface splice. The outer chord splice common to skin panel will be completed after the skin segment assemblies are in position.

3.2 The six extruded channel ring segments, each approximately 207 inches long, stretch-formed and final machined to establish the final shape, are placed in support arms setting the end of the channel ring segments to tool holes in the channel ring splice plate. (See figure 5-27). Two splice angles are located against stops in the channel ring splice and clamped in position at each of the six splice locations. The channel ring splices are partially drilled and fastened. The hole pattern common to the splice and skin panel is completed as part of the skin segment assembly installation.

3.3 The six extruded J-ring segments, each approximately 207 inches long, pre-machined, stretch-formed and final machined to establish the required conical shape, are set in support arm assemblies and stopping at a tool hole in the J-ring splice drill assembly. (See figure 5-28). Two splice plates and a splice angle are then located at each of the six J-ring splices. Partial drilling and fastening is done at the six J-ring splices ensuring against any possible movement in the established diameter.

3.4 The skin segment assemblies are set in assembly fixture AF-B425-14000 by placing the forward flight end of the skin panel on adjustable supports, attaching the dummy Y-ring segment in position, and adjusting the skin segment assembly to line up two tool holes in the skin segment assembly, one common to a tooling hole in the locator assembly; the skin segment assemblies are then clamped in position. (See figure 5-29.) The skin segment assembly hole pattern common to the J-ring, channel ring, and

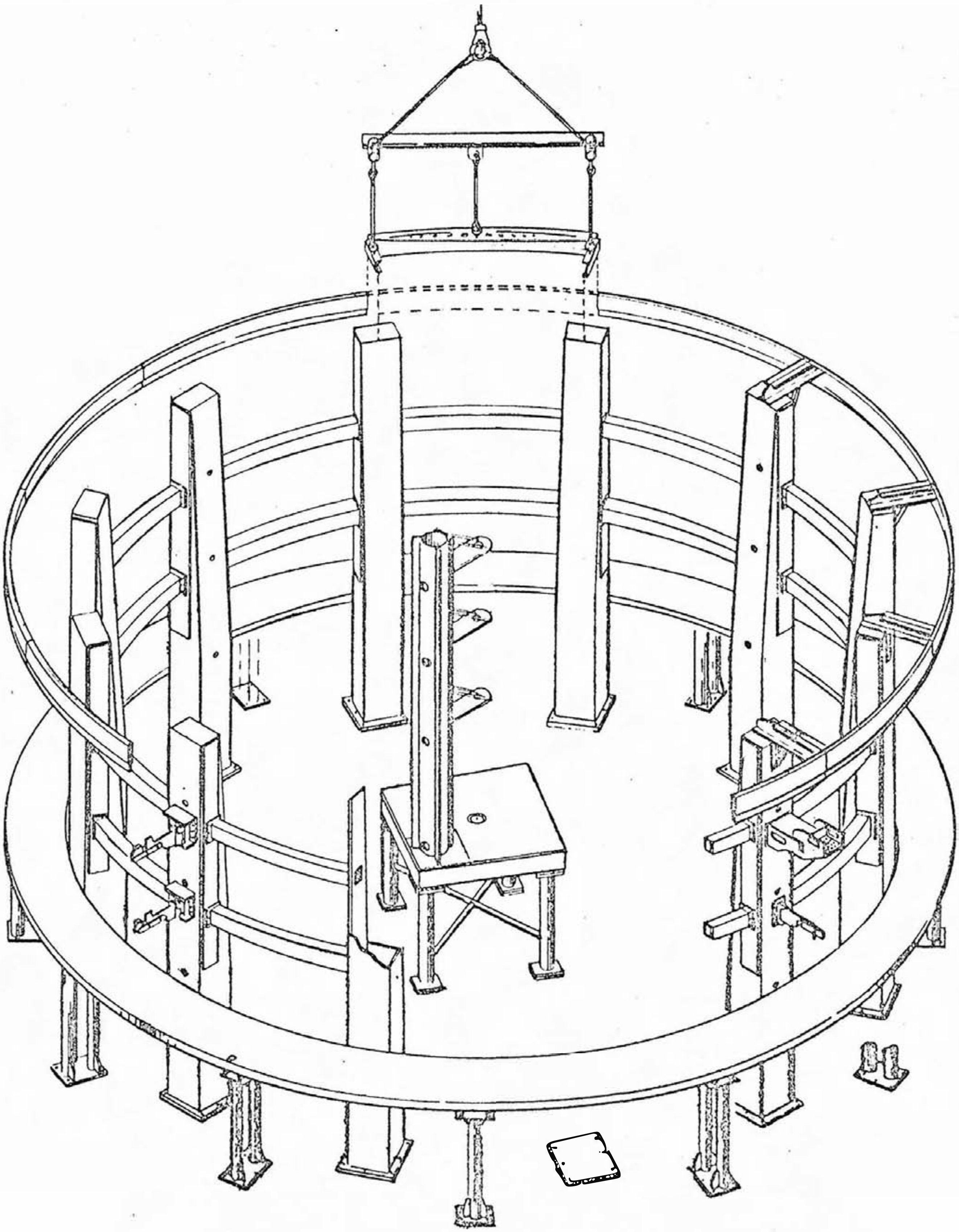


Figure 5-23. Forward Skirt Assembly Final Assembly Fixture AF-B425-14000

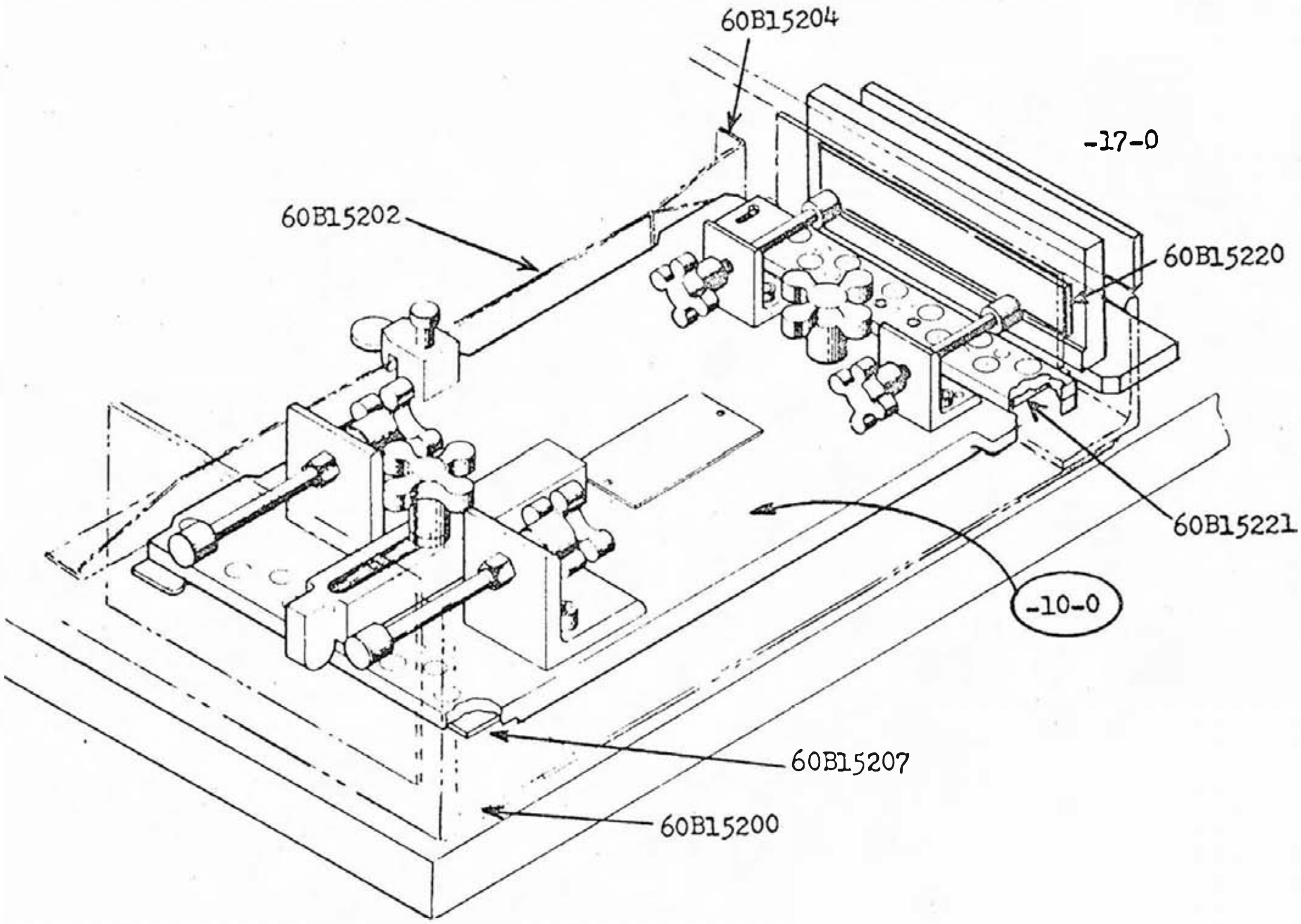


Figure 5-24. Interface Drill Plate (1)

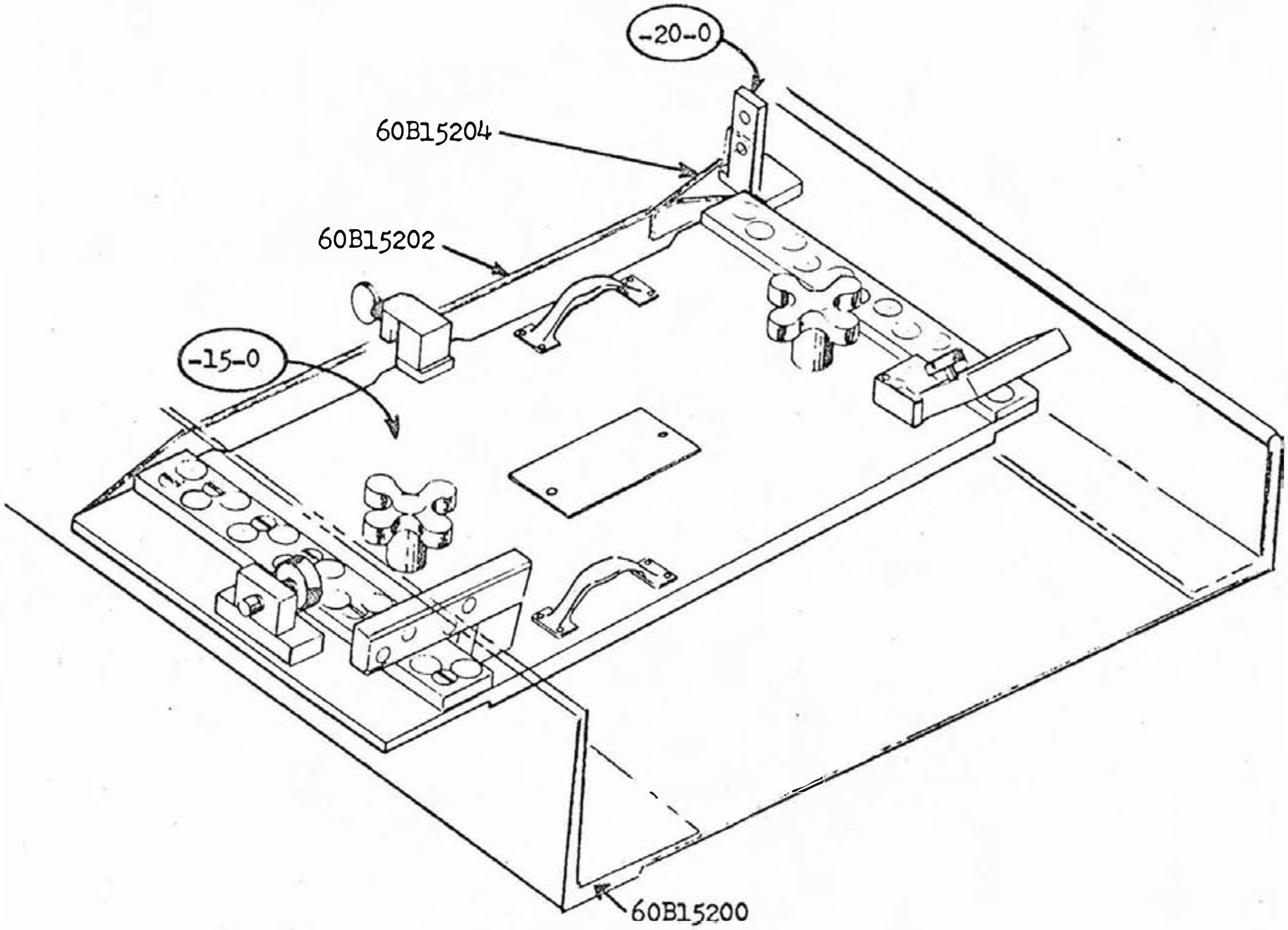


Figure 5-25. Interface Drill Plate (2)

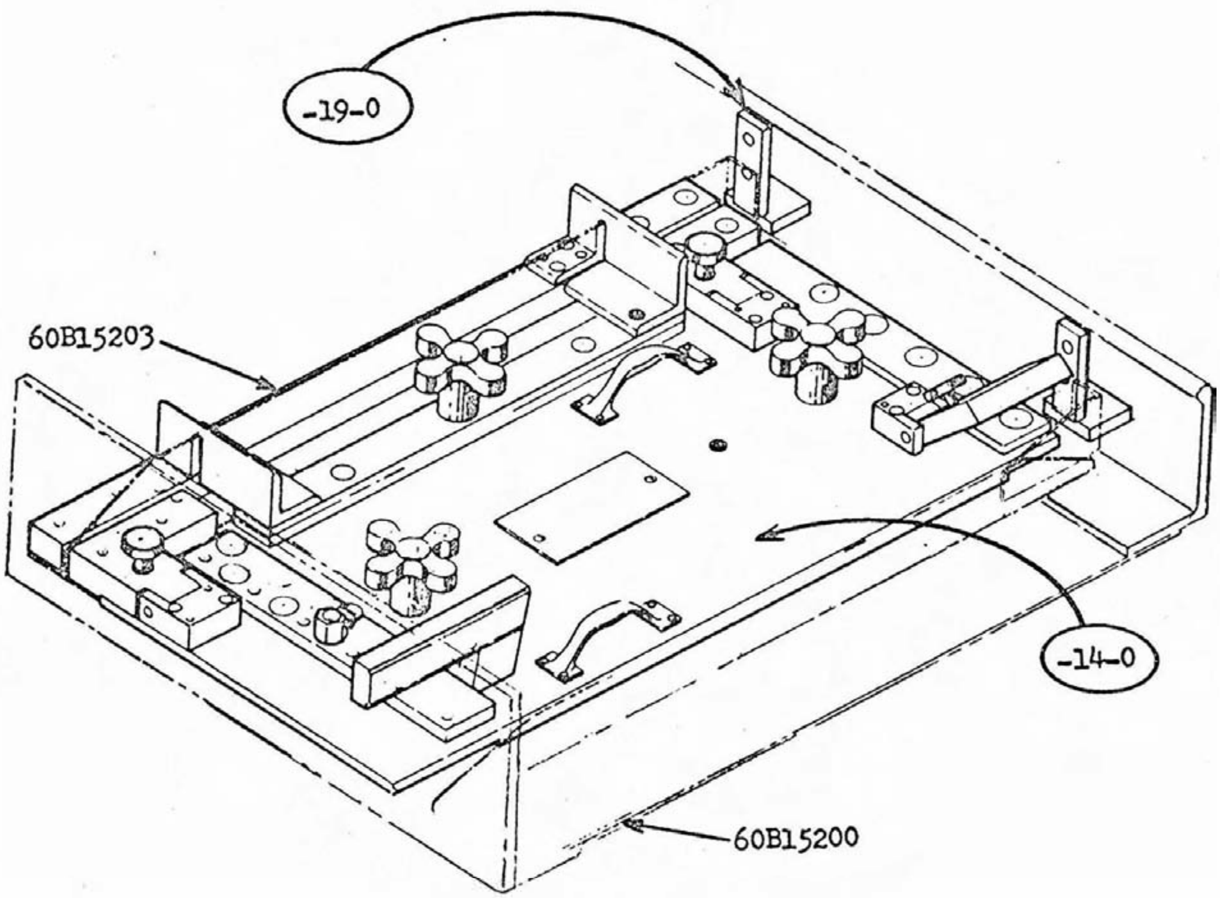


Figure 5-26. Interface Drill Plate (3)

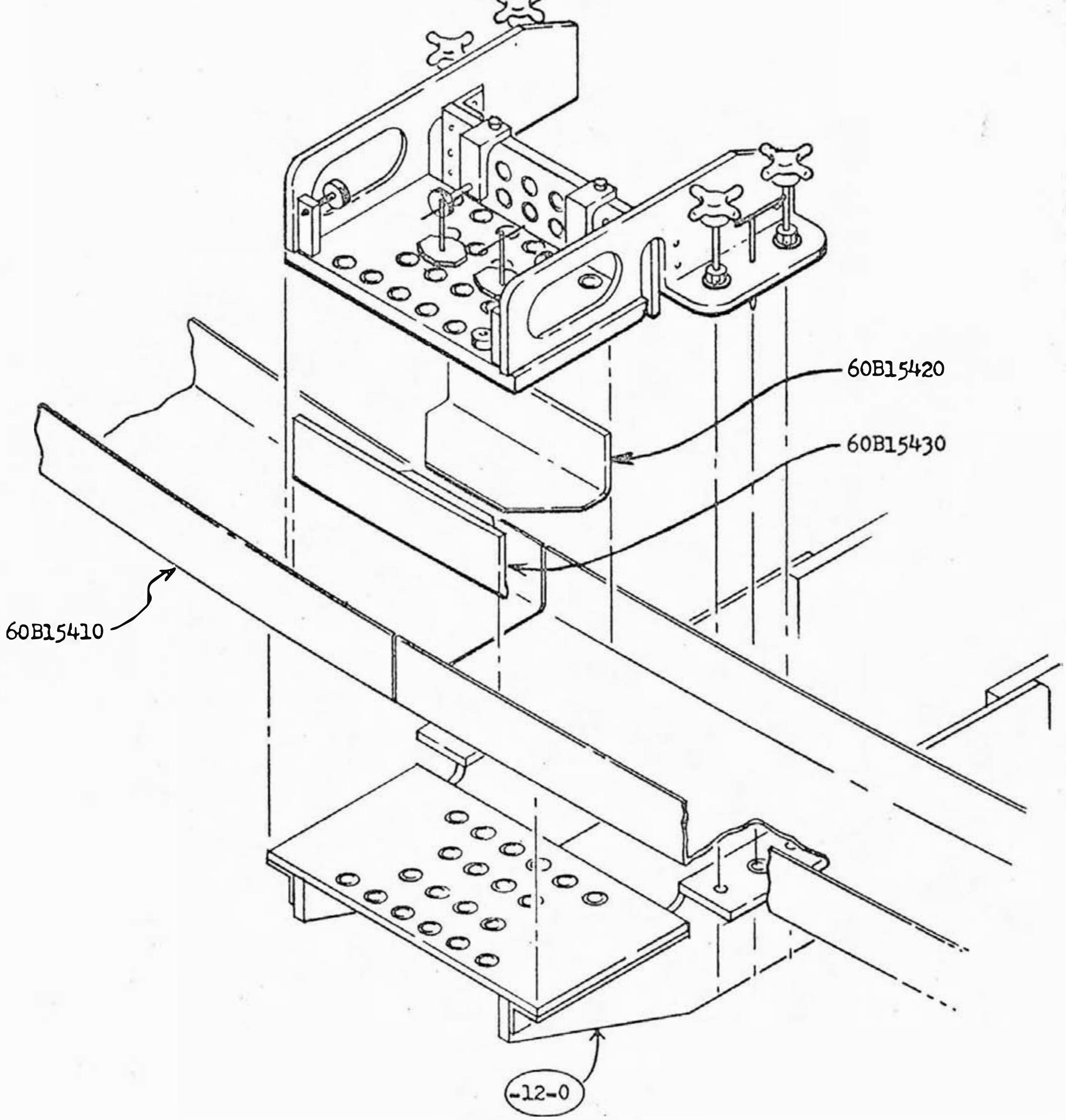


Figure 5-27. Channel Ring Splice

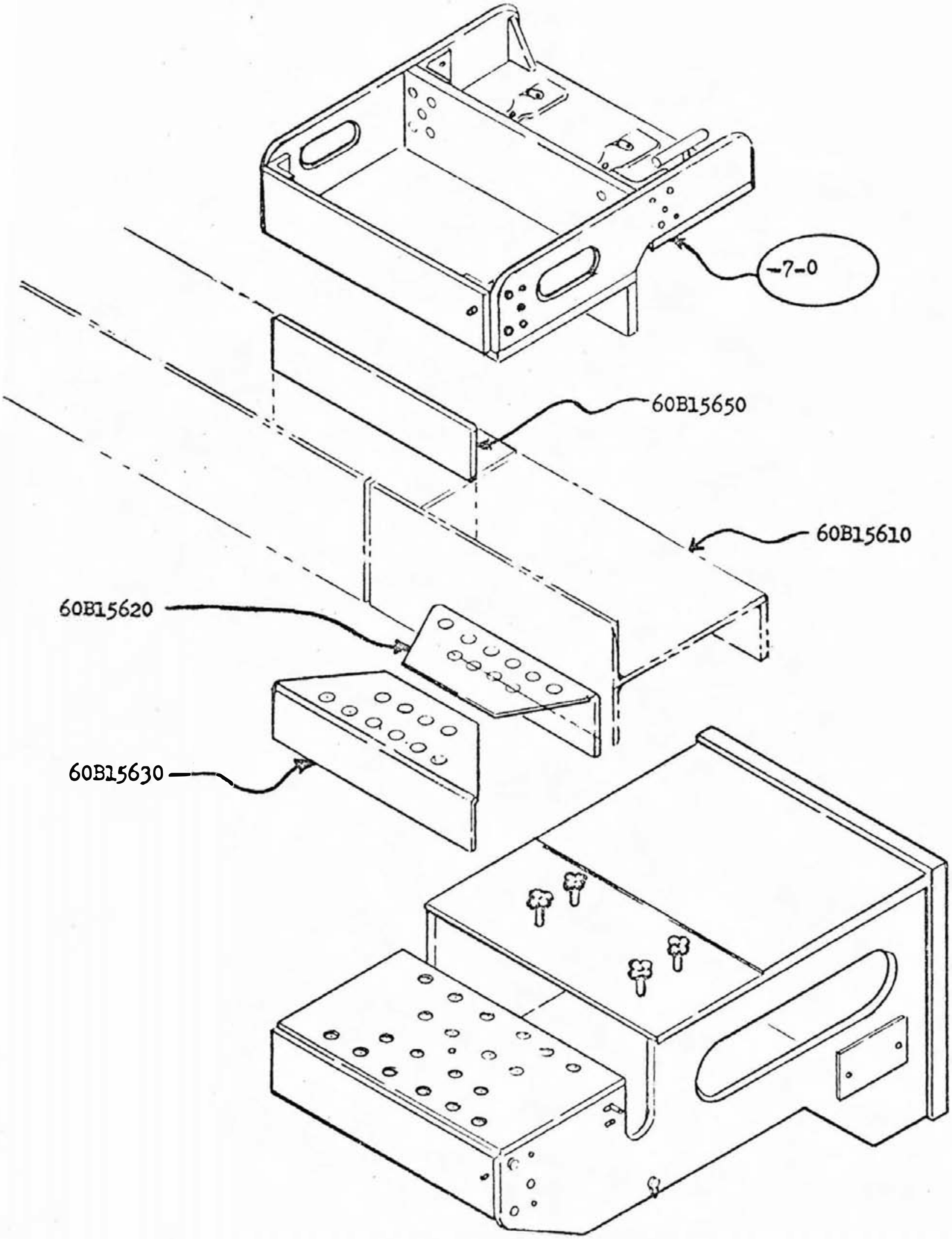


Figure 5-28. J-Ring Splice

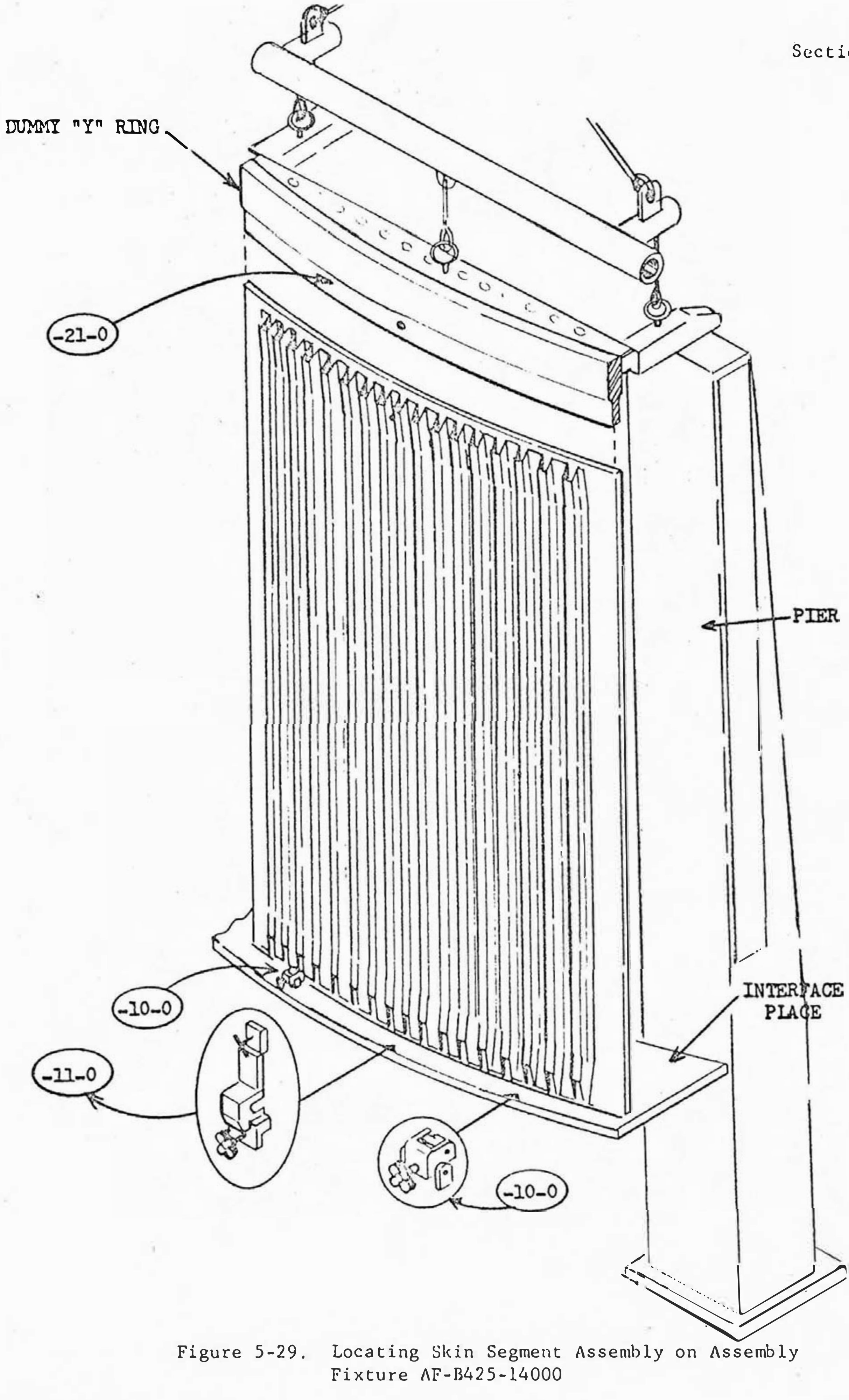


Figure 5-29. Locating Skin Segment Assembly on Assembly Fixture AF-B425-14000

3.4 (Con.)

interface ring is drilled by drill bar assemblies. The hole pattern is drilled, and fasteners are installed starting at the centerline of the skin segment assembly and working toward the skin panel splice.

3.5 The skin panel splices are completed one at a time in the following sequence: (See figure 5-30.)

3.5.1 Locate the three skin splice doublers on the inside with back-up assemblies.

3.5.2 Locate the two hat stiffeners and one outside skin splice doubler in the splice panel fixture.

3.5.3 Attach the splice panel fixture by setting the lower end to locating blocks and centering the upper end between the skin panel splice.

3.5.4 The splice panel fixture is held in position by removable fasteners installed in holes common to the skin panel.

3.5.5 The skin panel splice is drilled, and fasteners are installed completing the skin panel splice.

3.6 Various drill plates are attached to the interface drill plate, one at each LOX fitting location, one at the GOX fitting, and one common to the skin segment assembly and interface ring in the area under the electrical fitting. Holes common to the interface ring are then drilled; the drill plates are then removed.

3.7 The 18 intercostal installation follows, with intercostal locator locating the intercostal along with the upper attach angle. The angle common to the skin segment assembly is located by the intercostal locator and pilot holes, predrilled in the angle, common to the skin panel hole pattern. Holes are then drilled from bushings in the intercostal locator and pilots in the attach angles. Installation of fasteners complete the intercostal installation.

3.8 The gussets common to the strut installation and channel ring are located with a clip locator in 19 places; attach holes are drilled from pilots in the gussets. The attach hole common to the gusset in the interface ring is drilled full size with a drill plate. The strut assembly is then fastened to the gusset in the interface ring, which also facilitates drilling the strut attach hole full size. Upon removal of the locating tool, the fastener is installed completing the strut installation. The preceding sequence is used to install the 19 struts.

3.9 The umbilical door frame, a rectangular weldment approximately two feet by three feet, is set in position with an umbilical frame locator. The attach hole pattern is drilled from bushings in the umbilical frame locator, and the fasteners are installed completing the installation.

3.10 The two LOX vent beam installations, each consisting of two LOX beams, two attach angles, and four reinforcing straps, are installed with two LOX

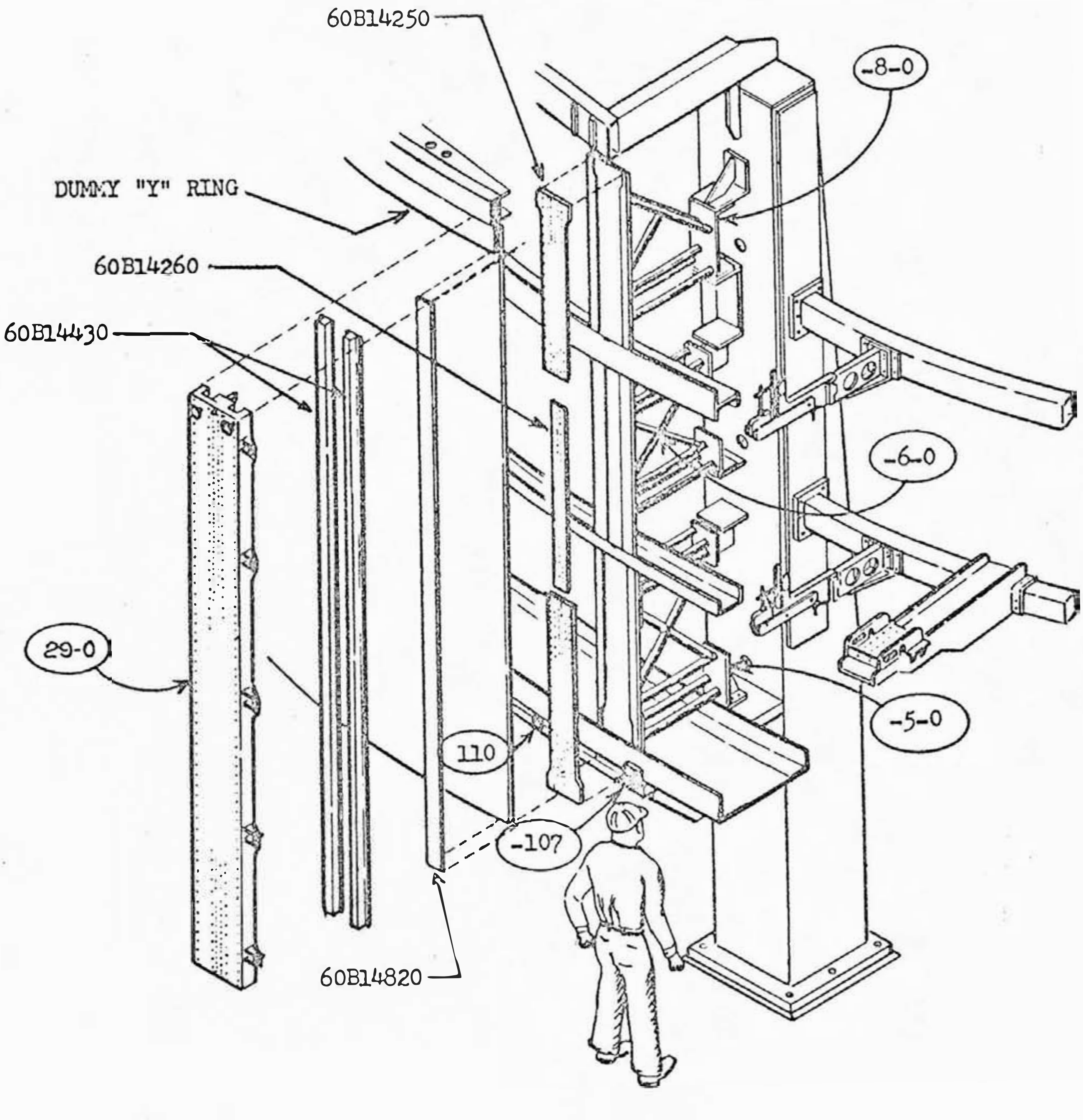


Figure 30. Skin Splice

3.10 (Con.)

beam locators. One locator positions the attach angles common to the channel ring while the other locator sets the LOX vent beam in position. Holes are drilled from bushings in the LOX beam locator, pilot holes in the LOX beams, and pilot holes in the attach angles. Installation of the four support straps complete the LOX beam installation.

3.11 The hole pattern common to the access door is then drilled with drill plates, and the access door is installed. Holes common to the access door hinges and the forward skirt assembly structure are drilled from pilots in the hinge after the access door is set in position. To complete the work accomplished in assembly fixture AF-B425-14000, the 216-hole interface hole pattern is drilled along with the three guide receptacle holes from gage-controlled bushings in the interface drill plate.

3.12 The 216-hole interface hole pattern is drilled, along with the three guide pin receptacle holes, from gage-controlled bushings in the interface drill plate of the AF-B425-14000. The facility holes in the aft end of the forward skirt are jig located and drilled. The 18 vertical positioners are now located and planized in relation to Station 1541 to a tolerance of $\pm$ .010.

3.13 The Forward Skirt is now removed from AF-B425-14000 with HT-B370-14400 and HT2-B370-28000 (See figure 5-31) and placed on ME-370-7353 in the removal position. The radial alignment tool is now installed along with all fasteners which were inaccessable due to tool interference. This completes the assembly of the forward skirt and it is delivered to shipping for transportation to MSFC, Huntsville, Alabama.

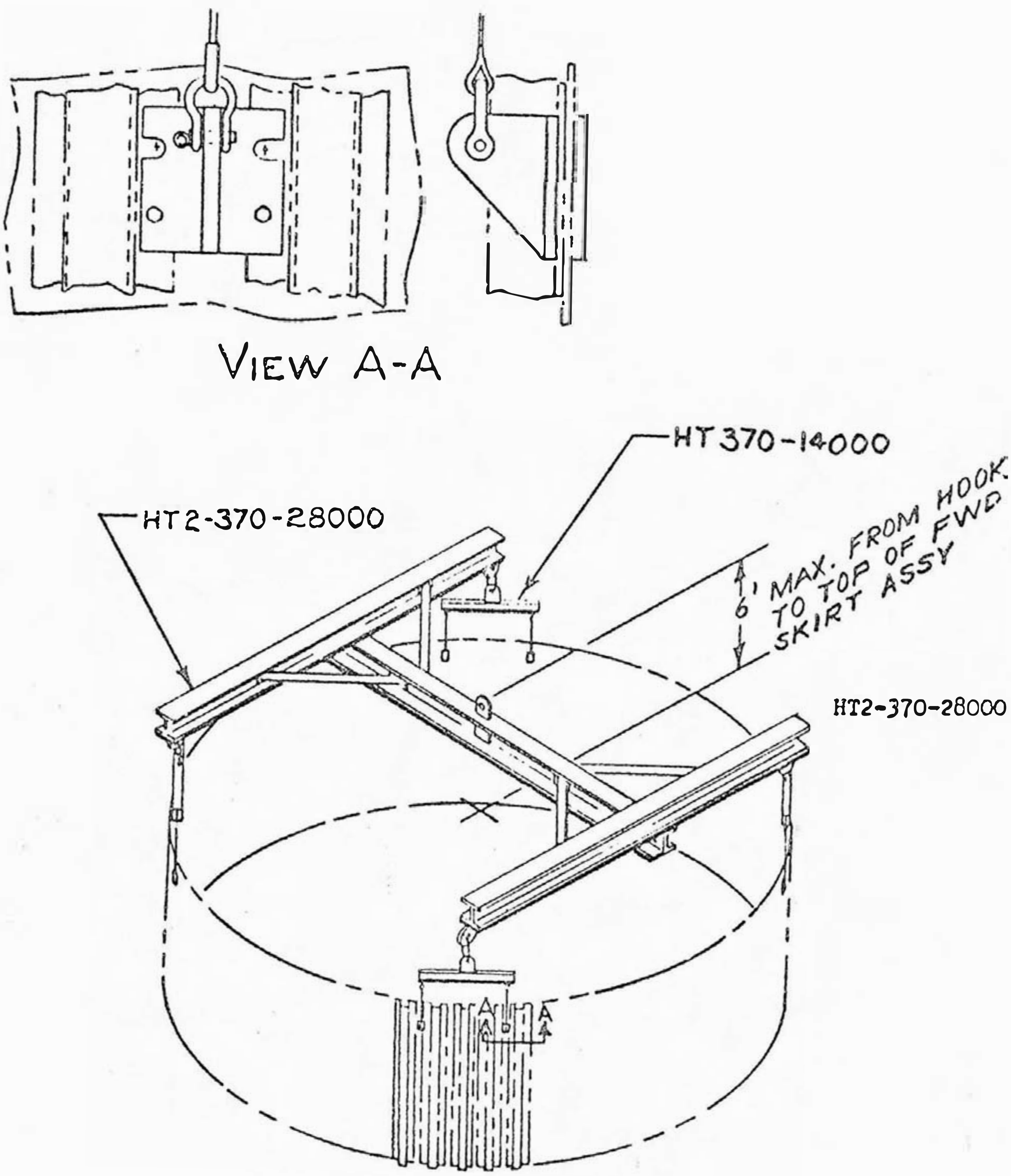


Figure 5-31. Forward Skirt Hoisting Tool

SECTION VI

INTERTANK STRUCTURE ASSEMBLY

SECTION VI
INTERTANK STRUCTURE ASSEMBLY

1. GENERAL. (See figures 6-1, 6-1a, and 6-2.)

The intertank structure assembly, which transmits all the thrust loads, mechanically connects the oxidizer tank assembly to the fuel tank assembly. The intertank structure assembly, which is a cylindrical structure approximately 33 feet in diameter by 22 feet long, will be made up of five H-ring assemblies covered with 18 corrugated skin panels which include the forged fittings that attach the intertank structure assembly to the Y-rings of the fuel tank assembly and the oxidizer tank assembly. A personnel access door for servicing will be located in one of the skin panels. A LOX dump door, a fuel vent line, and a fuel pressurization line will each be located in different skin panels. A pressurization vent will be located in five of the six 60-degree skin panel subassemblies.

2. AT MICHOUD.

2.1 <u>H-Ring Segment Subassemblies.</u> The H-ring segment subassemblies will be made up of an inner chord, an outer chord, shear webs, a splice plate, stiffeners, attach angles, and T-clips, which are positioned in H-ring segment assembly fixtures AF-320-28800 or AF-320-28820 for drilling and installation of permanent fasteners. (See figure 6-3.)

2.2 <u>Intertank Skin Panel Subassembly.</u> (See figures 6-1, 6-4, 6-5, and 6-6.)

2.2.1 Using skin panel subassembly assembly fixture AF-320-28050, six skin panel subassemblies will be assembled for each complete intertank structure assembly. The following is a list of the dash numbers assigned to the skin panel subassemblies and the quantity of each required for a complete intertank structure assembly.

Dash Number	Quantity Required
-900	1
-901	2
-902	1
-903	1
-904	1

2.2.2 The -900 skin panel subassembly will be made up of a skin panel containing the LOX door opening with the inner frame attached, a skin panel containing the skin vent opening with the outer doubler attached, and a skin panel without openings. There will be two outer splice plates and six inner splice plates at each skin splice line. These splices will be drilled; then permanent fasteners will be installed, joining the three skin panels into an integral subassembly. Three inner Y-ring fittings will be positioned at each end of the skin panel subassembly on the location shown on drawing MCD-330-10000 to receive vertical

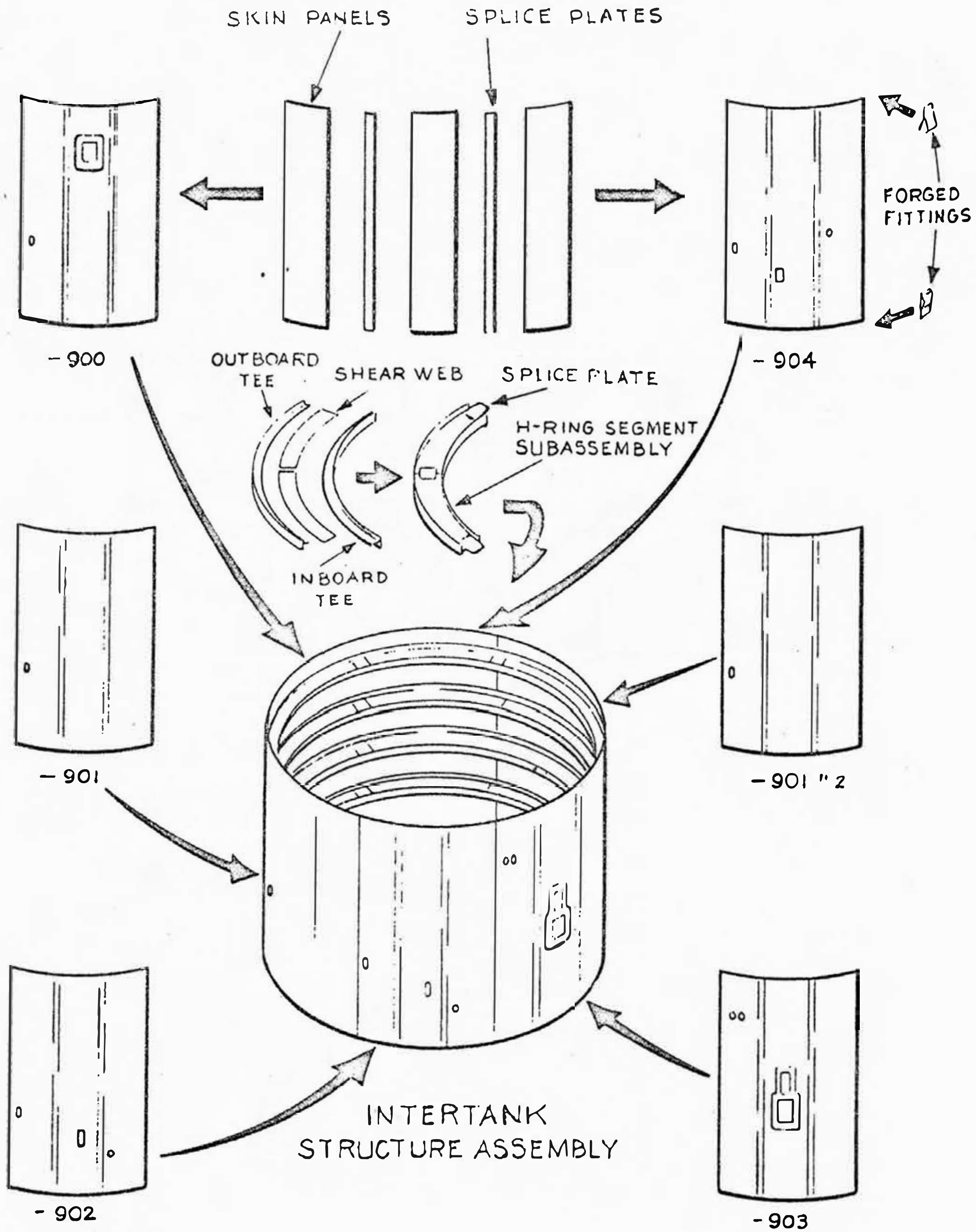


Figure 6-1. Intertank Structure Assembly - Flow of Parts

Changed 15 February 1964

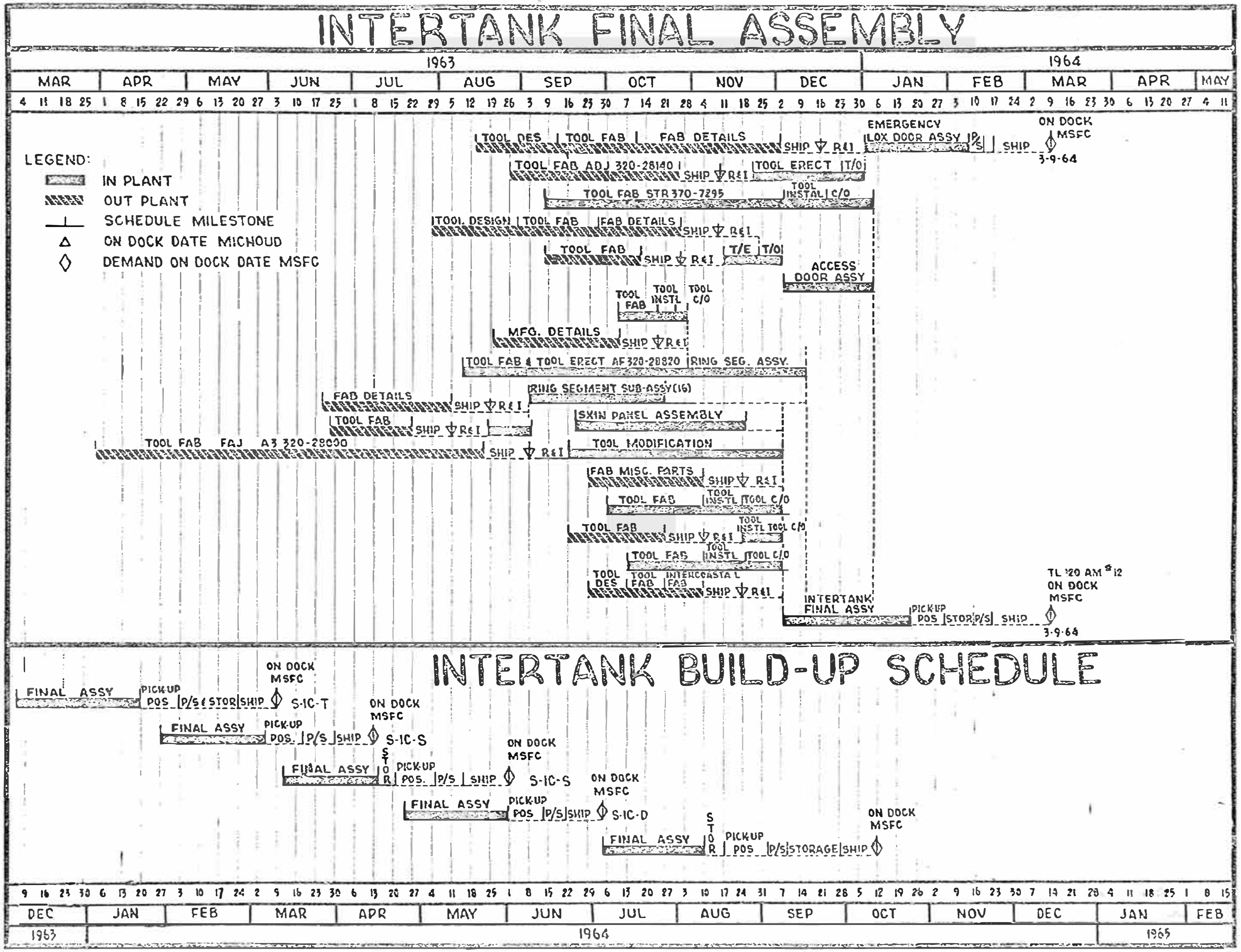


Figure 6-1a. Intertank Structure Assembly Schedule - Plan V

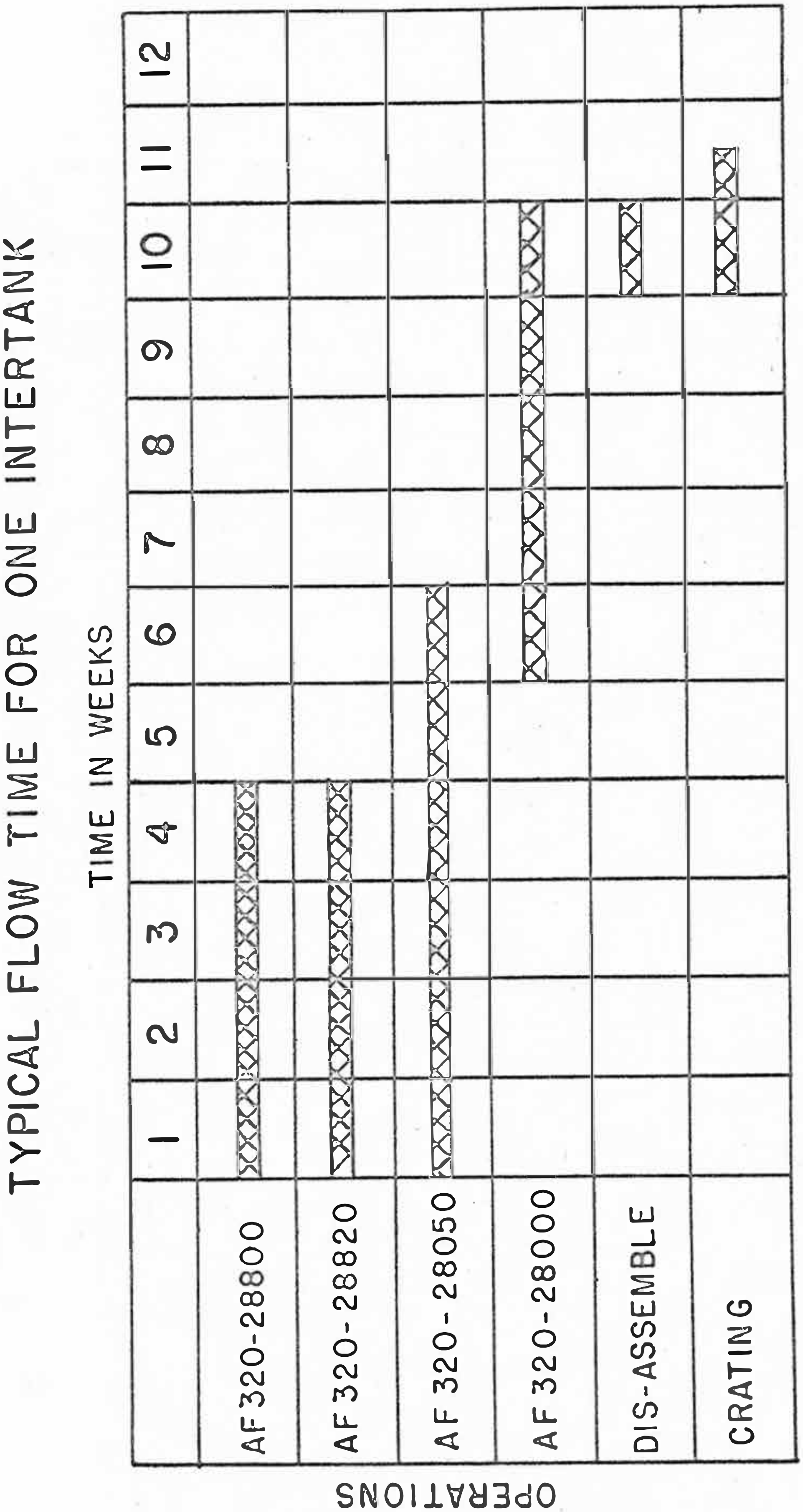
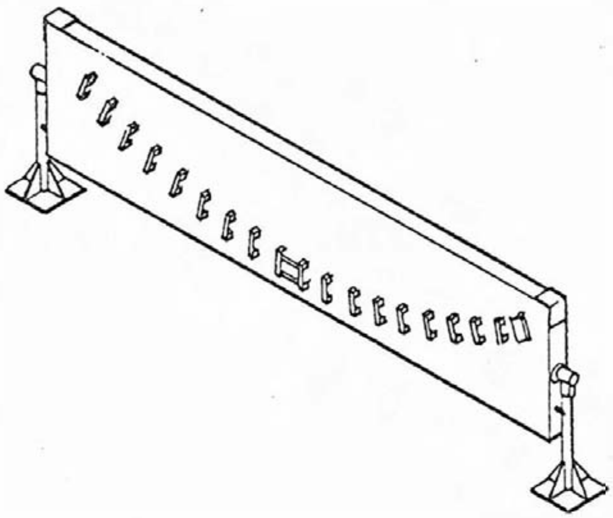
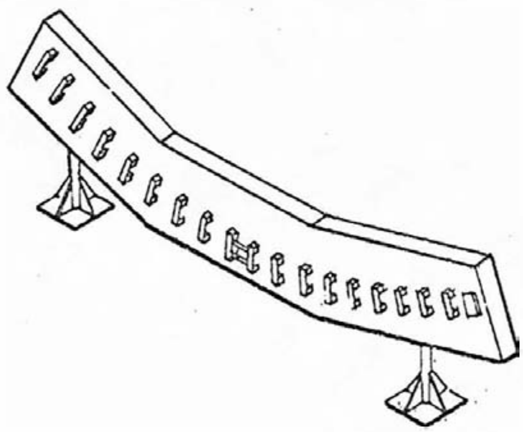


Figure 6-2. Typical Flow Time for One Intertank Structure Assembly



AF-320-28800



AF-320-28820

Figure 6-3. H-Ring Segment Assembly Fixtures

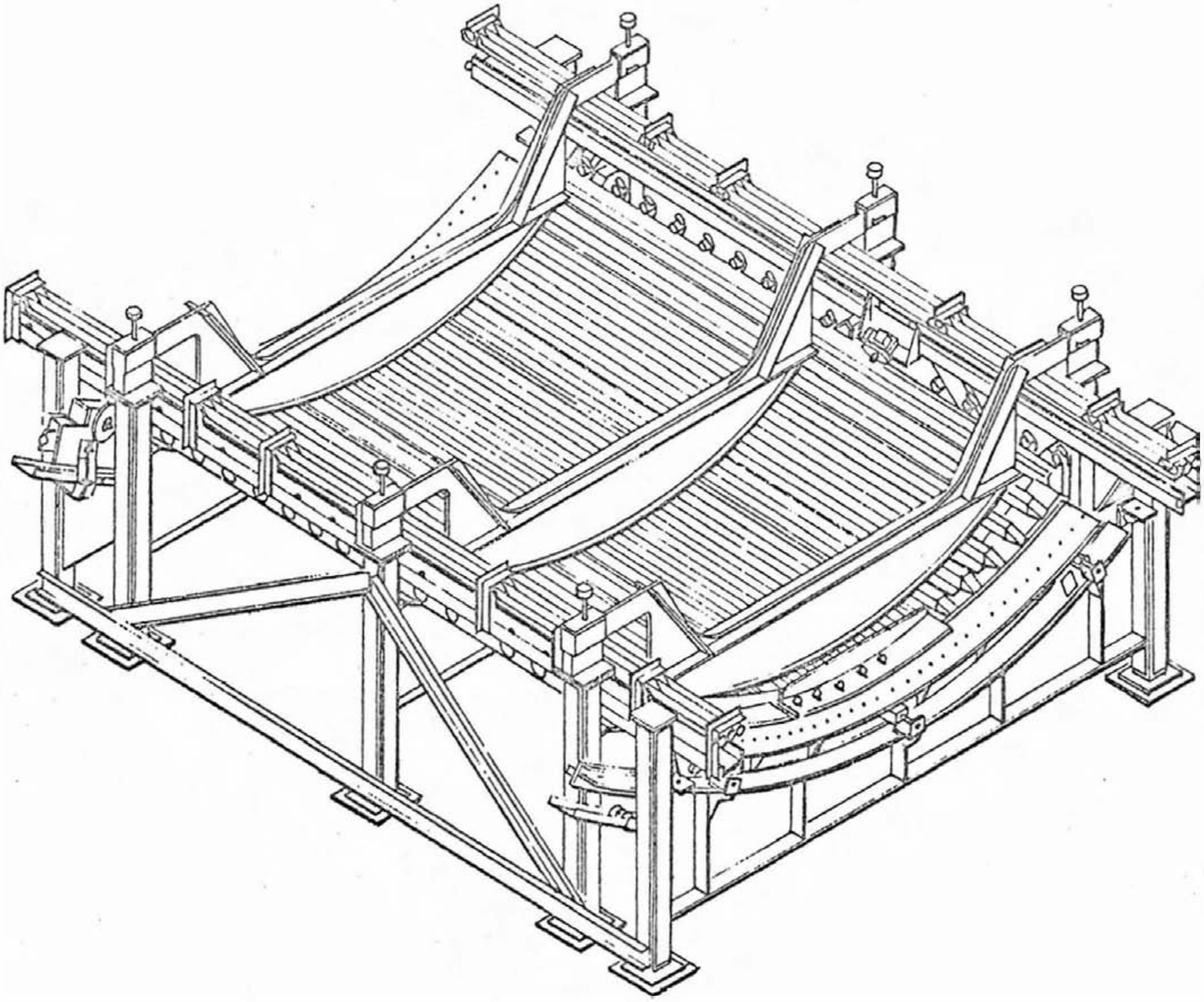


Figure 6-4. Skin Panel Subassembly Assembly Fixture AF-320-28050

Changed 16 December 1963

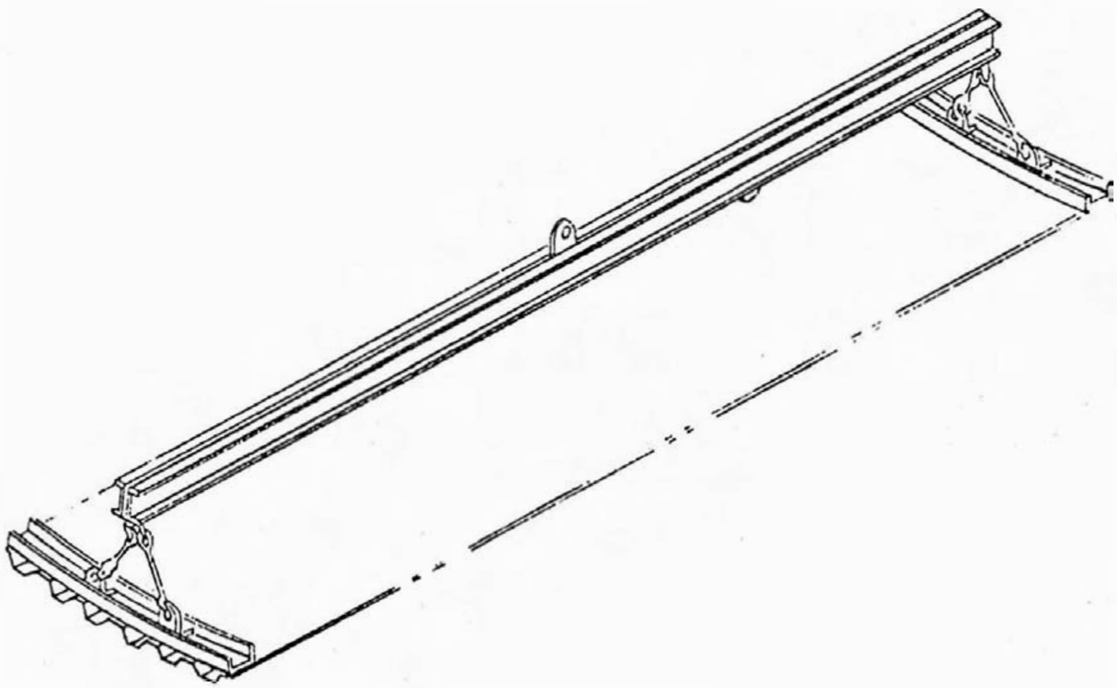


Figure 6-5. Single Skin Panel Handling Tool HT-370-28205

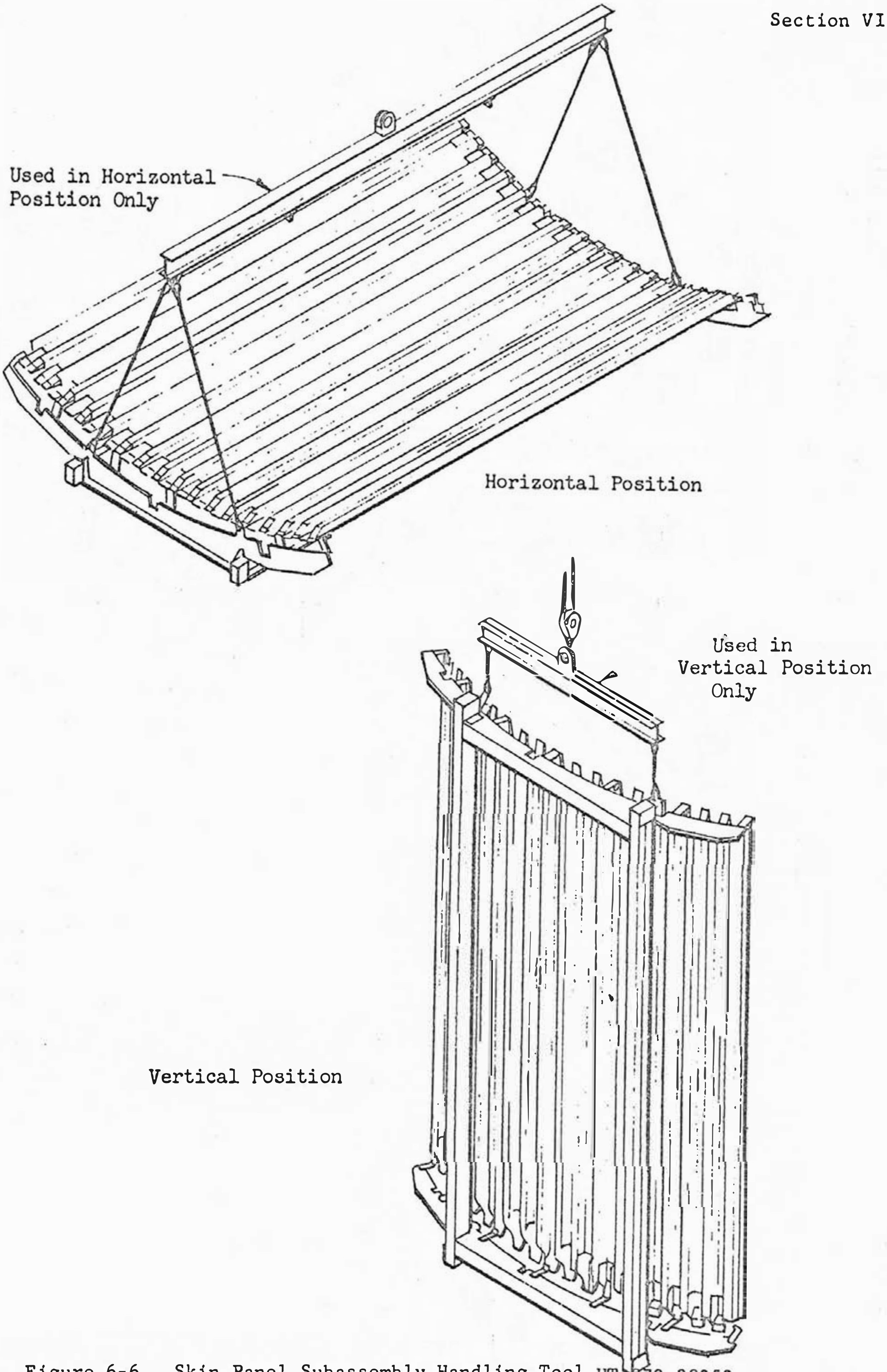


Figure 6-6. Skin Panel Subassembly Handling Tool HT-570-28050

2.2.2 (Con.)

positioners MiT-330-7445. Using drill jigs DJ-320-28201 and DJ-320-28203, the attach holes will be drilled undersize (.218 diameter). The fittings will be identified for relocation at MSFC, removed, and packaged for shipment. A vertical positioner (figure 6-12) will be installed at each of the above locations, adjusted to reference plane perpendicular to the centerline of the skin panel subassembly, and sealed. The remaining fifteen inner Y-ring fittings at each end will be positioned, attach holes drilled full size, identified for relocation, removed, and packaged for shipment in a separate container. Seventeen outer Y-ring fittings will be positioned at the fuel tank end of the skin panel subassembly and the attach holes drilled full size except the two fittings located at the skin splices which will be drilled .218 diameter in the flat and full size on the sides. These undersize holes will be used to attach handling tool HT-370-28050; these holes will be reamed to full size during reassembly at MSFC. The three fittings at the locations shown on drawing MCD-330-10000 which receive the positioning hangers of handling tool HT-370-7292 and the two fittings at the skin splices will be identified for relocation, removed, and packaged for shipment. The remaining twelve fittings will be permanently fastened. The seventeen outer Y-ring fittings at the oxidizer tank end of the skin panel subassembly will be positioned and the attach holes, except the two holes located at the skin splices, drilled full size. These two holes will be drilled .218 diameter in the flat and full size on the sides. These two locations will be used to attach handling tools HT-370-28050 at Michoud and HT-370-7296 at Michoud and MSFC. The two fittings will be identified for relocation, removed, and packaged for shipment. The remaining fifteen fittings will be permanently attached.

2.2.3 Each -901 skin panel subassembly will be made up of a skin panel containing a skin vent opening with the outer doubler attached and two skin panels without openings. Assembly of the -901 skin panel subassemblies is the same as described in paragraph 2.2.2, except two positioning hangers of handling tool HT-370-7292 are installed instead of three.

2.2.4 The -902 skin panel subassembly will be made up of a skin panel containing a skin vent opening with the outer doubler attached, a skin panel containing the electrical opening with the outer doubler attached, and a skin panel without openings. Assembly of the -902 skin panel subassembly is the same as described in paragraph 2.2.2, except the outer fitting at Position I on each end will be identified for relocation, removed, and packaged for shipment. Rotational fixture MiT-330-7452 will later occupy these areas. (See figure 6-11.)

2.2.5 The -903 skin panel subassembly will be made up of a skin panel containing the fuel vent opening with two outer doublers installed, a skin panel containing the access door opening with the inner doubler installed, and a skin panel without openings. Assembly of the -903 skin panel subassembly is the same as described in

2.2.5 (Con.)

paragraph 2.2.2 except five inner skin splice plates and two outer skin splice plates will be positioned at each skin splice, the attach holes drilled, and permanent fasteners installed. The access door inner doubler is also the inner skin splice plate at each edge of the access door panel.

2.2.6 The -904 skin panel subassembly will be made up of a skin panel containing the skin vent opening with the outer doubler installed, a skin panel containing the pressurization (flight) opening with the outer doubler installed, and a skin panel containing the pressurization (test) opening with the outer doubler installed. Assembly of the -904 skin panel subassembly will be the same as described in paragraph 2.2.2.

2.2.7 The skin panels used in all of the skin panel subassemblies will have excess material on one edge and one end when received from the vendor. As the first two skin panels are phased through AF-320-28050, the excess will be trimmed from the remaining edge, one at a time, while in a temporary position. These skin panels will be relocated to this final position and the third skin panel will be loaded. After splicing is complete and prior to the installation of the fittings at the oxidizer tank end, the excess material will be removed from the remaining edge and the end of the skin panel subassembly. The cut-outs that are required in the various skin panels will then be routed to size. The outer doublers will be positioned, the attach holes drilled, and permanent fasteners installed. The five skin vent openings in the -900, -901, -902, and -904 skin panel subassemblies are trimmed by ATDT-320-28241. The fuel vent opening in the -902 skin panel subassembly and the two fuel vent openings in the -903 skin panel subassembly are trimmed; the outer doublers are positioned and drilled by MiT-320-28162. The access door opening and umbilical plate opening in the -903 skin panel subassembly are trimmed to size by ATDT-302-28103. The access door inner doubler is positioned and drilled with ADJ-320-28100-902. The pressurization (flight) opening in the -904 skin panel subassembly is trimmed; the outer doubler is positioned and drilled by MiT-320-28221. The pressurization (test) opening in the -904 skin panel subassembly is trimmed; the outer doubler is positioned and drilled by MiT-320-28261. The LOX door opening in the -900 skin panel subassembly is trimmed by TmF-320-28143, which also trims the LOX door to size; this material is salvaged for fabrication of the LOX door assembly. The inner LOX door frame is positioned and drilled by ADJ-320-28150.

2.3 <u>Intertank Structure Assembly (MSFC Units).</u> (See figures 6-1, 6-7, 6-8, 6-9, 6-10, 6-11, and 6-12.) The intertank structure assembly will be made up of six skin panel subassemblies, thirty H-ring segment subassemblies, six outer Y-ring fittings at each end of the intertank structure assembly at the splices joining the six skin panel subassemblies, and the inner and outer splice plates for the skin splices. The intertank structure assembly will be assembled in assembly fixture AF-320-28000. (See figure 6-7.)

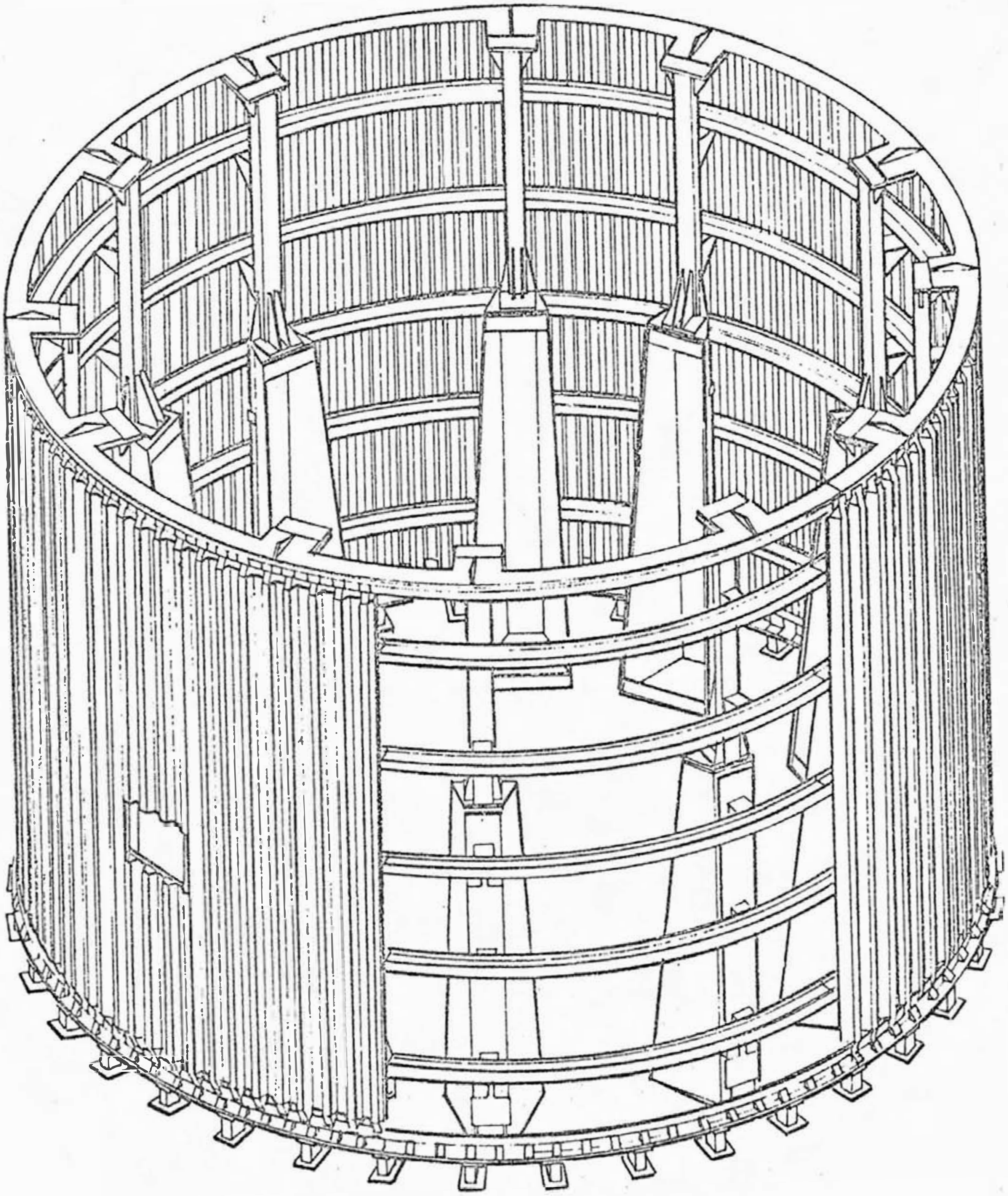


Figure 6-7. Intertank Structure Assembly Final Assembly Fixture AF-320-28000

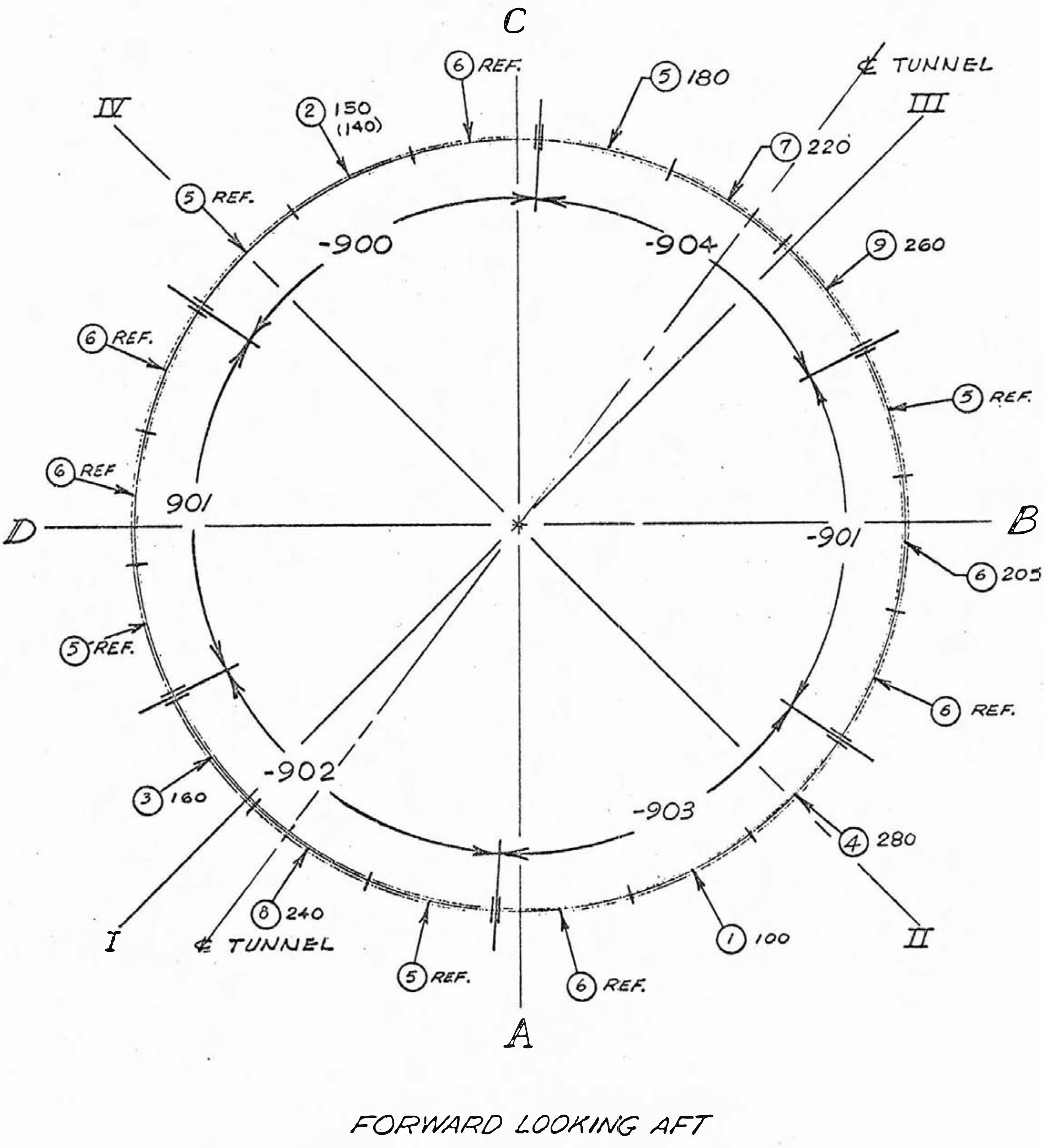


Figure 6-8. Layout of Skin Panel Subassemblies

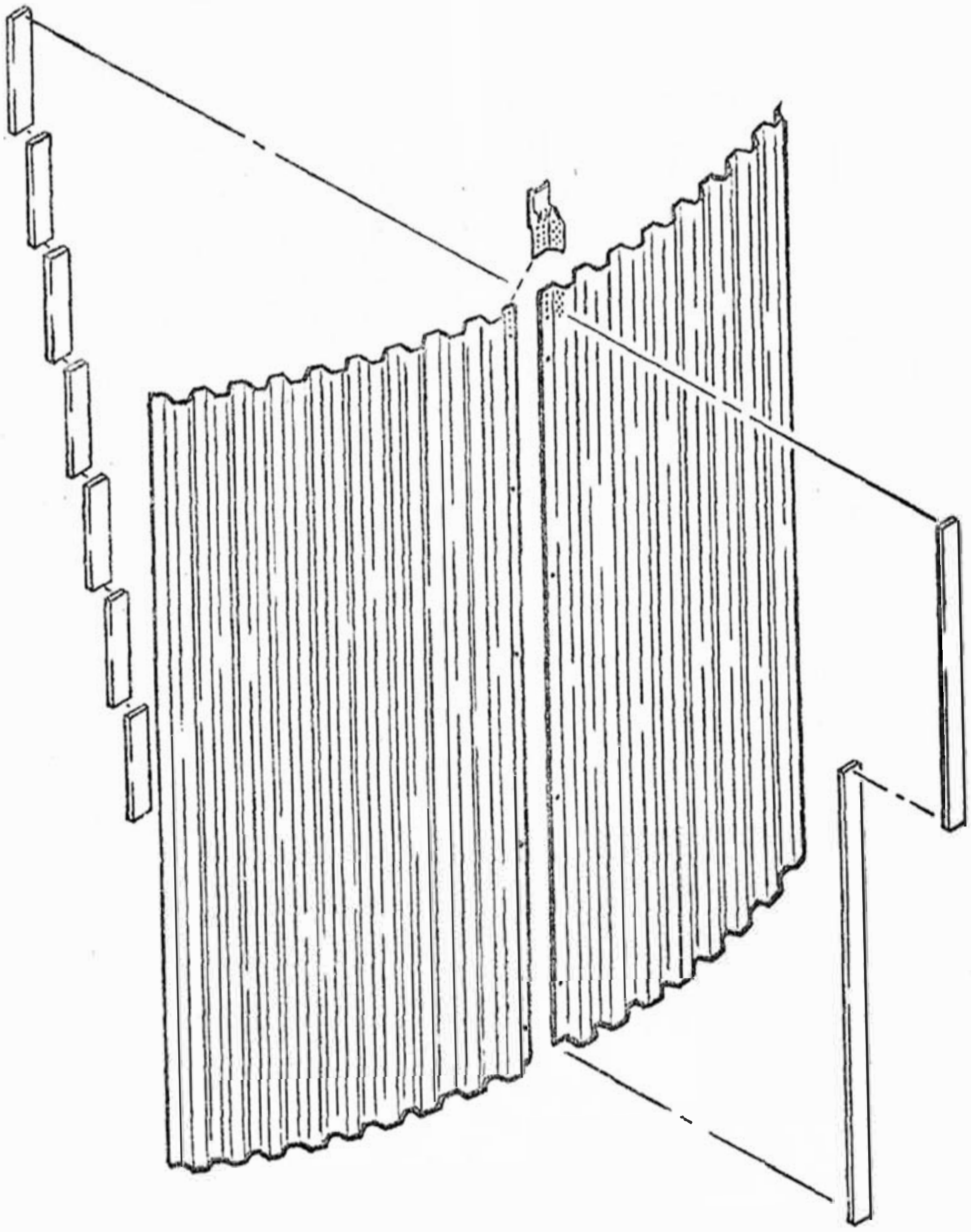


Figure 6-9. Intertank Skin Splice Assembly Detail

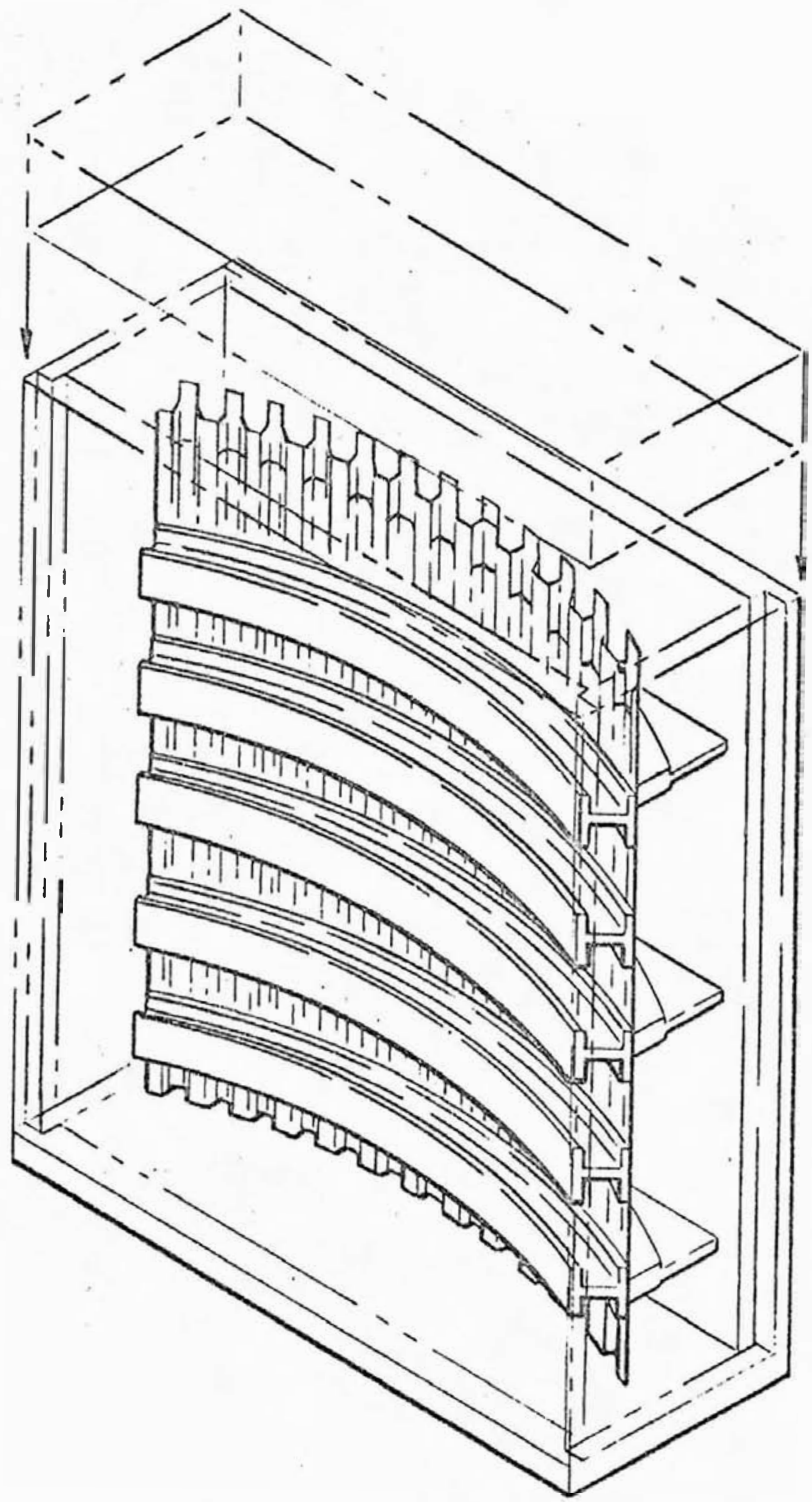


Figure 6-10. Intertank Skin Panel Subassembly Shipping Fixture StR-370-7295

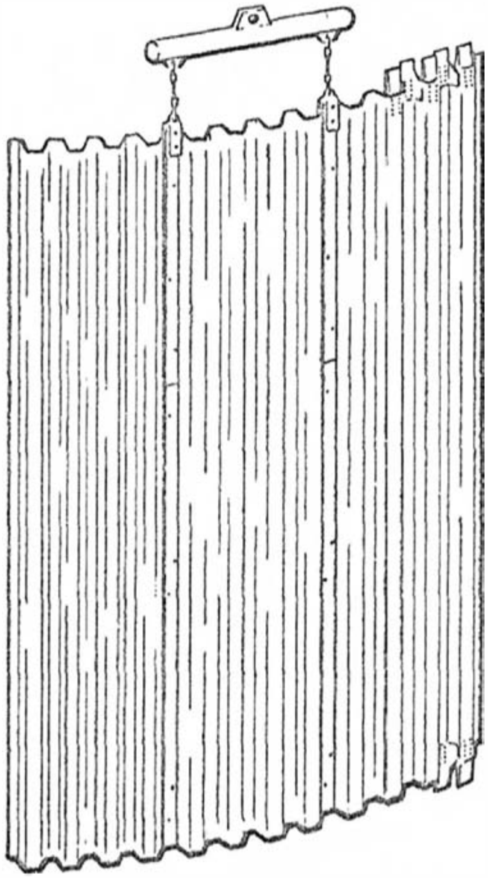


Figure 6-11. Intertank Skin Section Assembly Hoisting Tool HT-370-7296

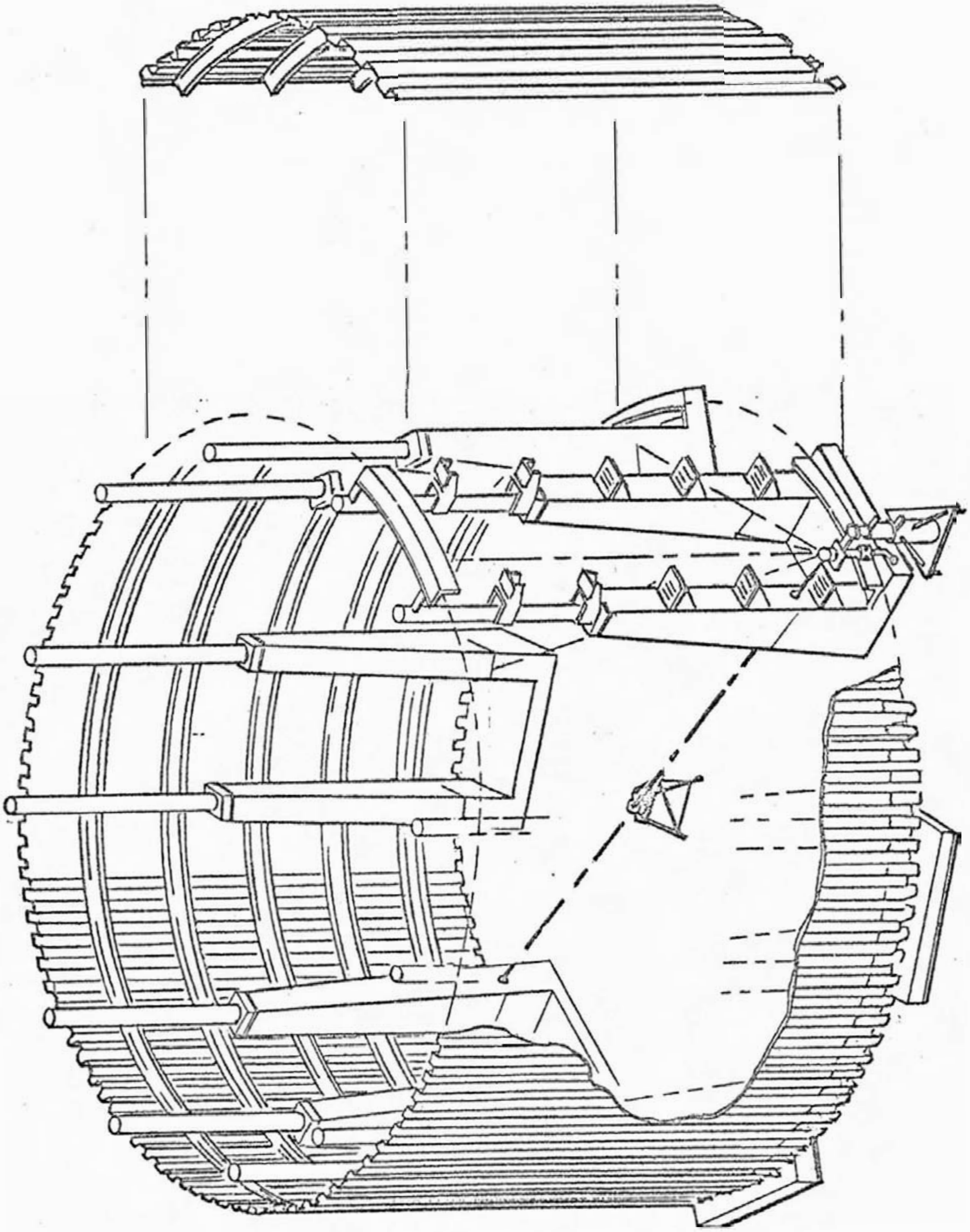


Figure 6-12. Intertank Structure Assembly Final Assembly Alinement

2.3.1 The H-ring segment subassemblies will be loaded and clamped out of position in assembly fixture AF-320-28000. The -902 skin panel subassembly, with provisions for the electrical tunnel, and the -904 skin panel subassembly, with provisions for the pressurization tunnel, will be positioned and secured in assembly fixture AF-320-28000. The -900 skin panel subassembly containing the LOX opening and the -903 skin panel subassembly containing the access door opening will be positioned next. The two -901 skin panel subassemblies will be positioned and secured.

2.3.2 With the diameter of the intertank structure assembly being controlled by dummy Y-rings at each end of the assembly, the H-ring segment subassemblies will be positioned against the skin panel subassemblies and secured; the attach holes common to the skin will be drilled; and permanent fasteners are installed, omitting holes common to the H-ring segment subassemblies and skin panels at all skin splice and gusset locations. The H-ring subassembly splices will not be drilled and attached at this time.

2.3.3 The inner and outer skin splice plates will be positioned; using assembly fixture drill plates AF-320-28000-34-0 through 39-0, the splices will be intermittently drilled full size and temporary fasteners installed. The above holes will be used at reassembly to index drill jig DJ-320-7294 and complete drilling operations.

2.3.4 Using drill jig DJ-320-28000 and indexing to full size fastener holes common to the outer Y-ring fittings, at the locations for handling tool HT-370-7292 on the fuel tank end of the intertank structure assembly per drawing MCD-330-10000, pilot holes will be drilled through the skin panels and H-ring segment subassemblies at the first location from the aft end.

2.3.5 Using MiT-320-28000 and MiT2-320-28000, the H-ring stiffeners and the T-clips will be positioned at the skin splices, drilled, and permanently attached to the H-ring segment subassemblies. Also, the H-ring stiffeners, T-clips, and gusset attach angles, common to the positioning hangers of handling tool HT-370-7292, will be positioned, drilled, and permanently attached to the H-ring segment subassemblies.

2.3.6 Drill jig DJ-320-28000 will again be used at the sixteen positions common to handling tool HT-370-7292 locations and the holes common to the skin panels and H-ring segment subassemblies will be drilled full size. These holes will be used at MSFC for attachment of positioning hangers of handling tool HT-370-7292; fasteners will be omitted in these holes. The H-ring chord splice angles and plates at the six separation points will be positioned. Using drill jigs DJ-320-28800, DJ2-320-28800, DJ-320-28820, and DJ2-320-28820, all H-ring splice attach holes will be drilled full size and temporary fasteners installed.

2.3.7 The gussets and T-clips that tie the H-ring segment subassemblies to the skin panels will be positioned and secured, all attach holes drilled, and permanent fasteners installed. The remaining H-ring-to-skin panel attach holes will be drilled and permanent

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fasteners installed, except at the six splice locations where the intertank structure assembly will be disassembled for shipment to MSFC.

2.3.8 Using ADJ-320-28100-901, the access door outer doubler will be positioned, the attach holes drilled, and permanent fasteners installed. Using MF-320-28100, the umbilical plate attach frame will be positioned, attached, and the umbilical plate attach holes will be drilled.

2.3.9 Using ADJ2-320-28220, the pressurization (flight) inner frame subassembly will be positioned, the attach holes drilled, and permanent fasteners installed. Using ADJ2-320-28260, the pressurization (test) inner frame subassembly will be positioned, the attach holes drilled, and permanent fasteners installed. Using ADJ2-320-28160, the fuel vent inner frame subassembly will be positioned, the attach holes drilled, and permanent fasteners installed. Using ADJ2-320-28160, the fuel vent inner frame subassembly will be positioned, the attach holes drilled, and permanent fasteners installed. Using ADJ2-320-28150, the LOX outer frame will be positioned, the attach holes drilled, and permanent fasteners installed. Six outer Y-ring fittings will be positioned on the temporary splices at each end. Using drill jigs panels DJ-320-28202-900 at the fuel tank end, the attach holes common to the fittings and skin panels only will be drilled full size, and the attach holes common to the fittings and the splices will be drilled undersized. The fittings at the forward end will be drilled using the same format, but drill jig DJ-320-28204-900 will be used. These fittings will then be identified for location, removed, and packaged for shipment.

2.3.10 The access door will be installed. Mounting holes for the rotational fixture MiT-330-7452 will be drilled at each end at Position I. The rotational fixture MiT-330-7452 will not be installed but will be identified for relocation, packaged, and shipped separately.

2.3.11 Using drill jig DJ3-320-28000, the pressurization and electrical tunnel bracket attach holes will be drilled undersize in the intertank structure assembly. One bracket will have to be omitted at each tunnel location. These omitted brackets will later attach to the intertank structure assembly using holes through the skin panels and H-ring subassemblies that are used for attaching the positioning hangers of handling tool HT-370-7292. Positioning and holding fixtures P&HF-358-27220 and P&HF-358-27230 will be used to position the tunnel brackets while the brackets are back-drilled from the undersize holes in the intertank structure assembly. The two tunnel attach fittings omitted at the hanger location will be packaged and shipped in a separate container. Using drill jig DJ4-320-28000, the attach holes for the vent valve pressure control solenoid will be drilled in the aft H-ring assembly at Position I. Using drill jigs DJ5-320-28000 and DJ6-320-28000, equipment attach holes will be drilled through the

2.3.11 (Con.)

intertank structure assembly outer skin.

2.3.12 The vertical positioners will be checked to the dummy Y-ring at each end of assembly fixture AF-320-28000, readjusted, and resealed if necessary.

2.4 Disassembly and Shipment of Intertank Structure Assembly (MSFC Units).

2.4.1 Upon completion of the intertank structure assembly at Michoud and approval of quality control, the H-ring chord splices will have the temporary fasteners removed from one side of the splice, leaving the chord splices attached with temporary fasteners to the end of the H-ring segment subassembly that will be protected by the over hang of the outer skin after disassembly.

2.4.2 The inner and outer splice plates at the temporary splices will be identified for location, the temporary fasteners removed, and the splice plates removed.

2.4.3 The intertank structure assembly is then disassembled into six 60 degree subassemblies using hoisting tool HT-370-7296 and prepared for shipment in storage rack StR-370-7295, one 60 degree segment to each container. (See figures 6-10 and 6-11.)

2.4.4 All drilled fittings, removed and packaged from AF-320-28050 and the inner and outer splice plates and fittings from assembly fixture AF-320-28000, are packaged and shipped in a separate container. All permanent fasteners that are required to complete the intertank structure assembly at MSFC will be shipped in a separate container. The LOX door, with the attaching doublers temporarily attached, will be shipped separately.

2.5 Intertank Structure Assembly (Michoud Units). The Michoud intertank structure assembly units will be assembled in assembly fixture AF-320-28000 in the same manner as described in paragraph 2.3, except all H-ring splices, skin splices and outer Y-ring fittings at the splices will be drilled complete and permanent fasteners installed, resulting in a completed unit in lieu of a break-down unit. After all assembly operations are completed, assembly fixture AF-320-28000 will be partially dismantled by removing the forward dummy Y-ring, all H-ring locators, and the upper sections of the assembly fixture pylons. Handling tool HT-370-28000 will be secured to the sixteen fittings MiT-370-28000 which are positioned at the aft end and similar in use to handling tool HT-370-7292 for the MSFC units. (See figure 6-13.) The intertank structure assembly will then be moved vertically approximately 15 feet to clear the assembly fixture lower pylon sections and moved laterally to clear the assembly fixture AF-320-28000. The intertank structure assembly will then be placed in storage.

3. REASSEMBLY OF INTERTANK STRUCTURE ASSEMBLY AT MSFC.

The six intertank skin panel subassemblies will be received from Michoud in shipping fixtures StR-370-7295. Each shipping fixture StR-370-7295 will

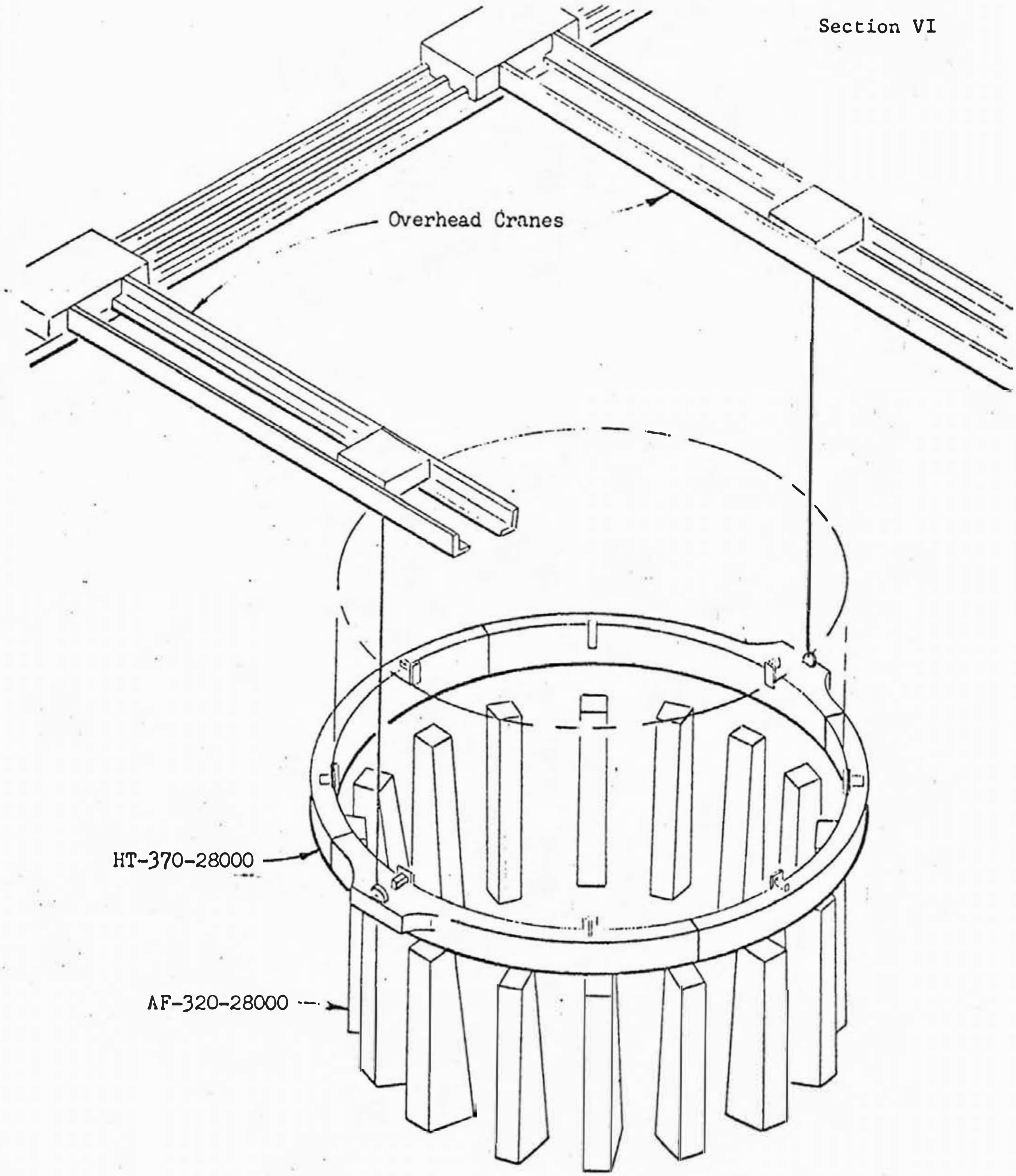

Figure 6-13. Intertank Structure Assembly Handling Tool HT-370-28000

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contain only one skin panel subassembly. The skin panel subassemblies will be identified as indicated in paragraph 2.2.1.

3.1 Attach hoisting tool HT-370-7296 to skin panel subassembly; using overhead hoist and hoisting tool HT-370-7296, remove skin panel subassembly from shipping fixture StR-370-7295. Position skin panel subassembly on intertank reassembly assembly fixture AF-320-7290, starting at fin A; secure in place on assembly fixture AF-320-7290. (See figures 6-11 and 6-14.)

3.2 Position next skin panel subassembly in position beside (counterclockwise) the first skin panel subassembly. (See figure 6-8.) The chord splices are attached on one side of the H-ring segment subassemblies with temporary fasteners. These temporary fasteners are not to be removed until after all skin panel subassemblies have been positioned in place on assembly fixture AF-320-7290. Install temporary fasteners in H-ring chord splices as the skin panel subassemblies are positioned on assembly fixture AF-320-7290 to secure H-ring segment subassemblies together.

CAUTION: Intertank-to-tanks vertical positioner miscellaneous tools MiT-330-7445 were alined and installed on the skin panel subassemblies during buildup of the skin panel subassemblies. When positioning the skin panel subassemblies on assembly fixture AF-320-7290, ensure that miscellaneous tools MiT-330-7445 are held in a horizontal plane.

3.3 Remove the temporary fasteners from the H-ring chord splices and replace with permanent fasteners. Position the web splices at the six locations and install permanent fasteners.

CAUTION: As each temporary fastener is removed, replace with a permanent fastener to prevent loss of alinement. The fastener holes are drilled full size at Michoud in the chord splices and web splices.

3.4 The gusset supports and T-clips are to be positioned on the H-ring segment subassemblies at six locations. Drill holes and install permanent fasteners.

NOTE: The gusset supports and T-clips will be identified at Michoud for their proper locations.

3.5 The inner and outer splice plates for connecting the skin sections together will be received from Michoud identified for their proper locations. Position inner and outer skin splice plates on the skin panel subassemblies at their proper locations. Position and secure the intertank reassembly drill jig DJ-370-7294 on the splice joint between the skin panel subassemblies. Drill holes and install permanent fasteners. (See figure 6-15.)

3.6 The six outer Y-ring fittings will be identified at Michoud for their proper locations. Position the six Y-ring fittings on the intertank structure assembly at the skin splices at each end. Install the nine permanent fasteners through the fitting and skin. These holes are

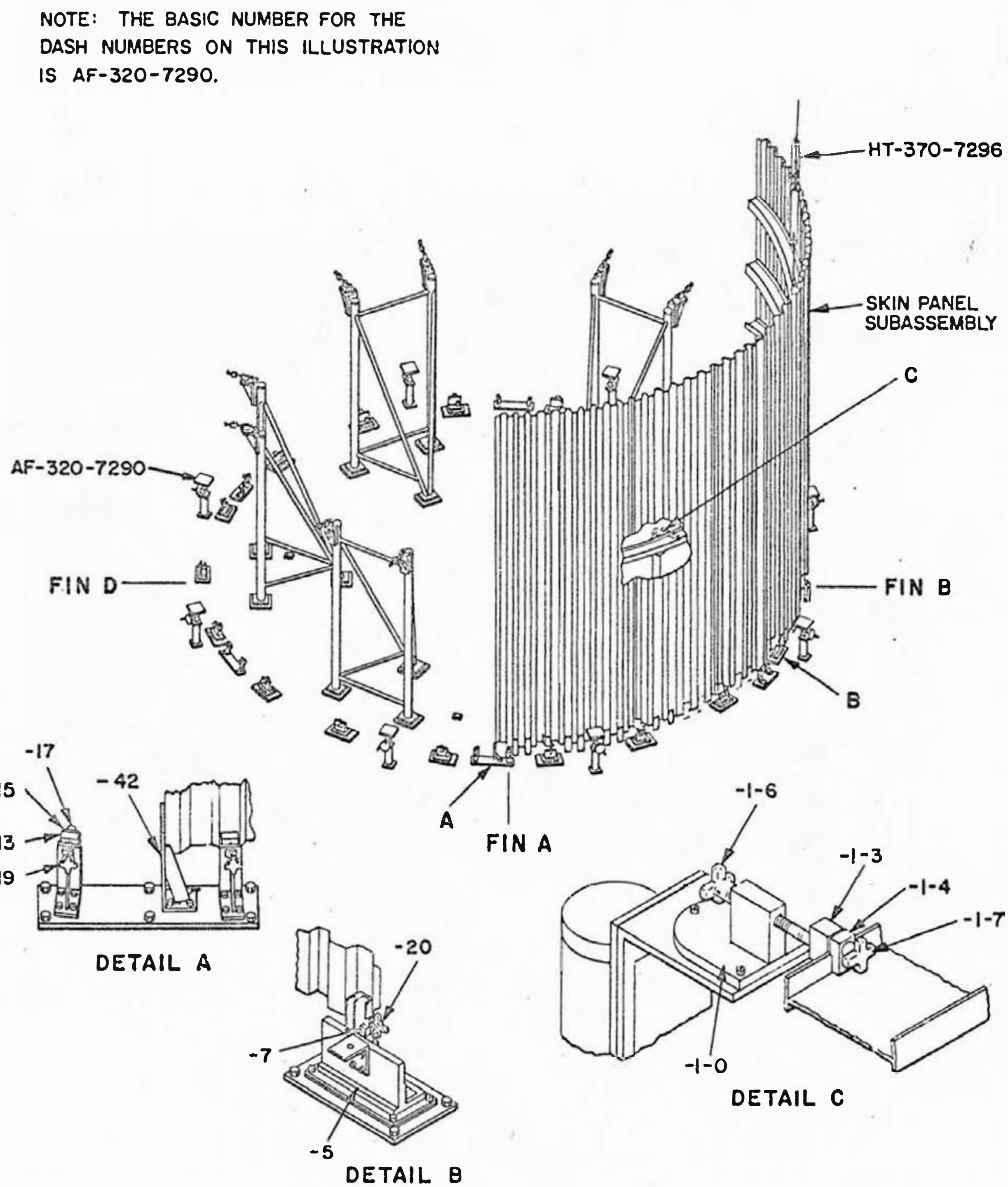

Figure 6-14. Installing Skin Panel Subassemblies on Assembly Fixture AF-320-7290

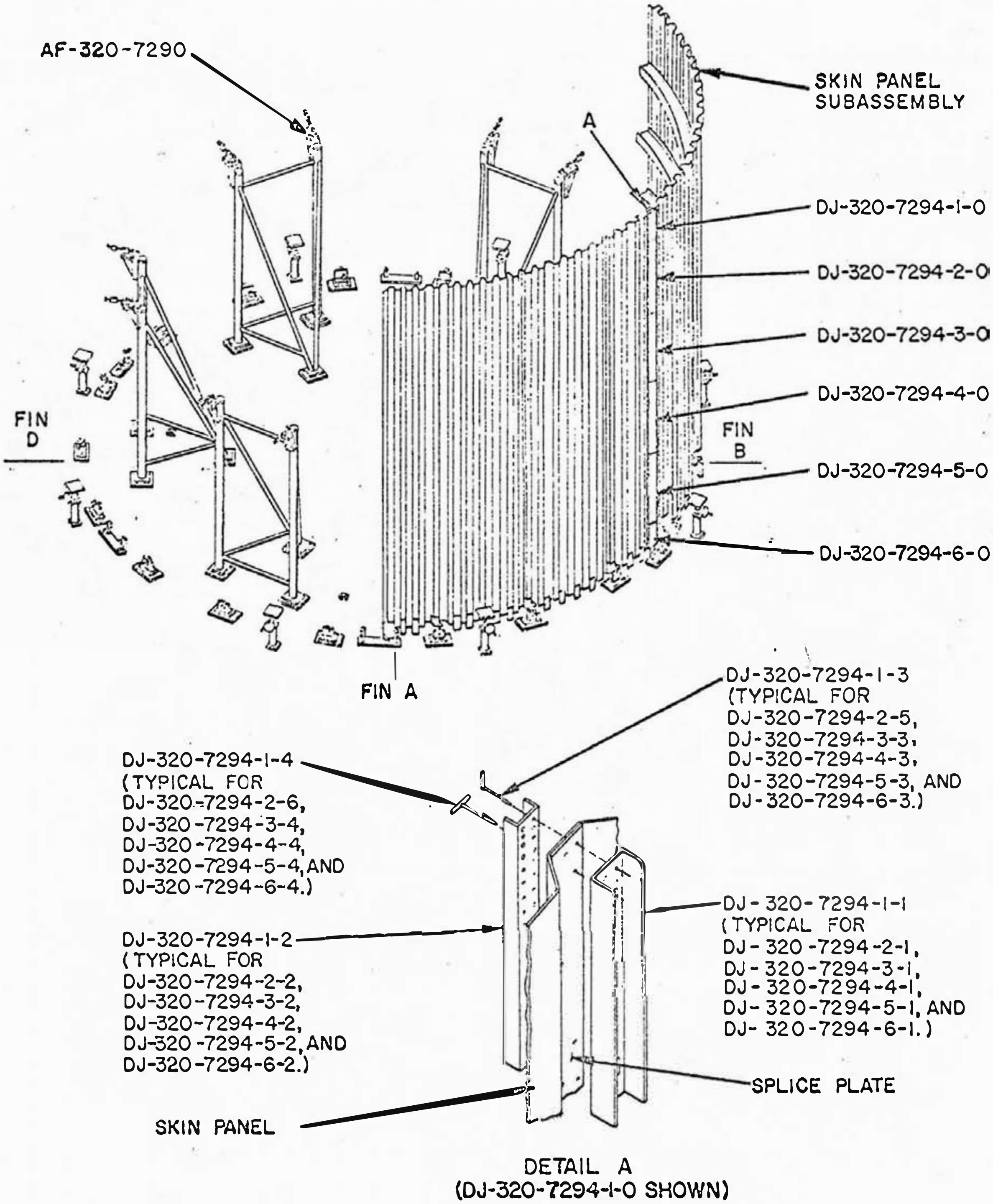

Figure 6-15. Drilling Skin Splices Using Drill Jig DJ-320-7294

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drilled full size at Michoud. Drill, ream, and deburr the eight holes that attach the fittings to the skin splices. These holes were drilled undersize at Michoud. Install permanent fasteners through the eight holes.

3.7 Position sixteen hangers HT-370-7292-14 on aft end of intertank structure assembly at their proper locations per drawing MCD-330-10000. Using overhead cranes, position intertank assembly handling tool HT-370-7292 on plates AF-320-7290-21 and jack weldments AF-320-7290-22; level handling tool HT-370-7292 by turning handwheels AF-320-7290-24; secure handling tool HT-370-7292 to sixteen hangers HT-370-7292-14 on the intertank structure assembly. (See figure 6-16.)

3.8 Position intertank structure assembly attach clip miscellaneous tools MiT-370-7456 to intertank structure assembly; secure miscellaneous tools MiT-370-7456 to intertank structure assembly with required hardware; secure miscellaneous tools MiT-370-7456 to angles AF-320-7290-30 with bolts AF-320-7290-38 and nuts AF-320-7290-17. Remove clamps, blocks, clamping blocks, strap clamps, pull pins, and screws of assembly fixture AF-320-7290 to release intertank structure assembly from assembly fixture AF-320-7290.

NOTE: Locators (-5 and -6) of the fixture (AF-320-7290) will remain on the intertank structure assembly until the intertank structure assembly is removed from assembly tower main weld station turntable AF-300-7016. Locators (-5 and -6) will serve as supports for the intertank structure assembly while on turntable AF-300-7016.

3.9 Using overhead cranes, position and attach half LOX tank assembly handling sling HT-370-7545 to handling tool HT-370-7292. Using overhead cranes, handling sling HT-370-7545, and handling tool HT-370-7292, remove intertank structure assembly from assembly fixture AF-320-7290. Move intertank structure assembly to pick-up area on the floor.

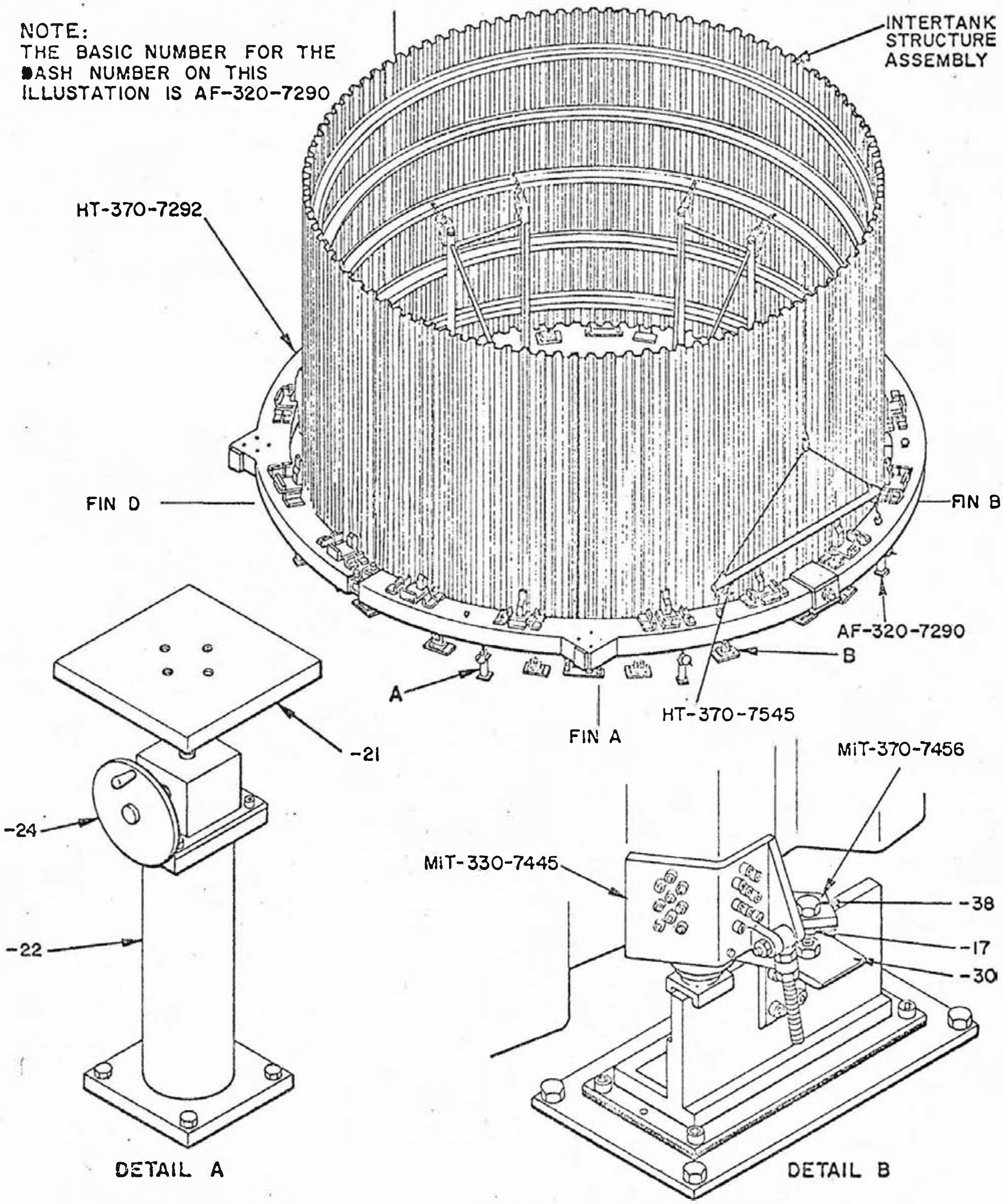

Figure 6-16. Removing Intertank Structure Assembly from Assembly Fixture AF-320-7290