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AUTHORITY

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AFFDL-TR-75-40

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AD B007465

ADVANCED METALLIC AIR VEHICLE STRUCTURE PROGRAM

GENERAL DYNAMICS
FORT WORTH DIVISION

JUNE 1975

FOURTH INTERIM REPORT
TECHNICAL REPORT AFFDL-TR-75-40

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AIR FORCE FLIGHT DYNAMICS LABORATORY
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Wright-Patterson Air Force Base, Ohio 45433

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ADVANCED METALLIC AIR VEHICLE STRUCTURE PROGRAM

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FOREWORD

This report covers the period 16 June 1974 through 15 December 1974. The efforts reported herein were sponsored by the Air Force Flight Dynamics Laboratory (AFFDL) under joint management and technical direction of AFFDL and the Air Force Materials Laboratory (AFML), Wright-Patterson Air Force Base, Ohio.

This work was performed under Contract F33615-73-C-3001 "Advanced Metallic Air Vehicle Structure" (AMAVS) as a part of the Advanced Metallic Structures, Advanced Development Programs (AMS ADP), Program Element Number 63211F, Project Number 486U0104. John C. Frishett, Lt. Col., USAF (AFFDL/FBA), is the ADP Manager, with Mr. N. G. Tupper (AFML) serving as Assistant ADP Manager. Mr. C. R. Waitz (AFFDL/FBA) is the Project Engineer for the AMAVS Program.

Earlier documentation of this program is contained in the following AFFDL-TR-XX-Y reports: 73-1 is the First Interim Report, 73-40 (Vols. 1 and 2) is the Phase 1b Report, 73-77 is the Second Interim Report, 74-17 is the Phase II Report, and 74-98 is the Third Interim Report.

Principal General Dynamics contributors to this report were:

C. E. Hart	- Program Manager
R. C. Bissell	- Deputy Program Manager
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E. F. Cox	- Test Fixture Design
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J. W. Jennings	- Information Transfer
V. Juarez	- Fracture and Fatigue Analysis
J. L. McDaniel	- Manufacturing Engineering
R. E. Miller	- Stress Analysis
K. D. Mabry	- Structural Design
W. O. Sunafrank	- Manufacturing Engineering
J. L. Shults	- Materials Engineering
A. F. Stern	- Structural Design
W. M. Walker	- Test Fixture Design

This work was performed during the period 16 June 1974 through 15 December 1974. It was submitted by the authors in January 1975.

This technical report has been reviewed and is approved for publication.

John C. Frishett

John C. Frishett, Lt. Col., USAF
Program Manager
AMS Program Office
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ABSTRACT

This report covers the manufacture of the wing carrythrough structure and the test fixture structure during the latter portion of Phase III, Fabrication. Included are design and analysis in support of manufacture and additional material testing, component testing and manufacturing research, and development work funded as a part of the "Credible Option" added task.

All detail parts and subassemblies for the wing carrythrough structure (WCTS) are complete. Final assembly of the WCTS is progressing on schedule toward a 31 January 1975 completion date. After final assembly of the WCTS the remaining strain gages will be installed and the dummy wing will be prefit prior to shipment to AFFDL/FBT at WPAFB.

Manufacture of all elements of the test fixture is substantially complete. The test fixture base is reassembled at WPAFB. The forward upper test fixture structure is at AFFDL/FBT at WPAFB being reassembled. The aft upper test fixture structure is being disassembled at Fort Worth in preparation for an early January 1975 delivery to WPAFB.

The Advanced Metallic Air Vehicle Structure (AMAVS) Program is progressing on schedule toward a May 1975 start of testing in the Structural Test Facility at WPAFB. Fifteen months of static, fatigue and damage tolerance testing are planned.

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SECTION 1

INTRODUCTION

This interim report summarizes the accomplishments of the Advanced Metallic Air Vehicle Structure (AMAVS) Program from 16 June 1974 to 15 December 1974. This work is part of the Air Force's Advanced Metallic Structures, Advanced Development Program. It was performed under contract to the Air Force Flight Dynamics Laboratory (AFFDL) by the Fort Worth Division of General Dynamics at Fort Worth, Texas.

The six months covered by this report primarily include the last portion of Phase III, Fabrication. The additional materials testing, component testing and manufacturing development work funded as a part of "Credible Option" program is also included as well as some test planning task which is a part of Phase IV, Testing.

Manufacturing Research and Development has continued work in Electron Beam Welding and Gas Tungston Arc welding of 10 Nickel steel, machining and drilling and reaming of 10 Nickel steel, and large taper-lok fastener hole preparation. Installation of 1-1/4" taper-lok fasteners has been highly successful.

Component Testing funded as part of the "Credible Option" task is substantially complete. These tests are primarily to evaluate specific bonded panel designs, joints and fasteners used in the final selected design. Material testing to more completely characterize the 10 Nickel Steel and the 6Al-4V Beta Annealed Titanium are continuing. Testing of these materials will be complete in mid 1975.

The manufacture of all detail parts and subassemblies of the Wing Carrythrough Structure (WCTS) is complete. Inspection and corrosive protective coatings are required on a few detail parts, i.e.: the upper left hand lug and the X_F 39-84 upper bonded panels. Assembly of the WCTS is on schedule. The lower plate assembly is complete, all internal structure, closure ribs and the Y_F 932 and Y_F 992 bulkheads are installed. The right hand upper lug and the upper X_F 39-39 bonded panel are installed. Completion of the entire WCTS is planned for 31 January 1975.

Manufacture of the test fixture structure including the simulated fuselage is substantially complete. The test fixture base has been reassembled at WPAFB. The dummy wings, dummy landing gears, wing sweep actuator assemblies and the counterbalance system are complete. The forward upper test fixture structure including the forward simulated fuselage is currently being reassembled at the Structural Test Facility at WPAFB. The aft upper test fixture structure and aft simulated fuselage is substantially complete and is being disassembled for shipment to WPAFB in early January 1975.

Installation of the WCTS in the upper test fixture structure by General Dynamics personnel will start in mid February 1975 and be completed in mid April 1975. The strain survey will be started in May 1975 with fatigue testing to start in July 1975. All fatigue, static and damage tolerance testing is scheduled to be completed by 31 July 1976.

SECTION 2

TECHNICAL DISCIPLINES PROGRESS

The progress made by the technical groups during Phase III, Manufacturing, is reported in this section.

2.1 ENGINEERING

The engineering functions progress for the period 16 June to 15 December 1974 is detailed below

2.1.1 Structural Design

The basic production design of the wing carrythrough structure was completed previously and has been documented in earlier reports. The adjacent simulated fuselage design has also been documented. Various design changes, however, have been accomplished to improve structural integrity and to provide proper fit and functional characteristics. The design changes implemented for both the production wing carrythrough structure and the simulated fuselage are described in the following paragraphs. Figure 2.1.1-1 depicts the structural arrangement of the Wing Carrythrough Structure.

2.1.1.1 Wing Carrythrough Structure Design Changes

Additional support was provided to the Y_F932 and Y_F992 bulkhead upper flanges at X_F39 and X_F84, where they change directions, to resist the resulting kick loads. The change consisted of adding external titanium fittings and increasing the strength of the internal ribs at X_F39 and X_F84. The addition of the external fittings resulted in the creation of two new production drawings, X7224078 and X7224098.

Additional support was also provided to the Y_F932 bulkhead upper flange at X_F0 to resist the kick loads introduced by the upper centerline longeron of the simulated fuselage. Additional titanium support fittings were incorporated both internally and externally resulting in one new production drawing, X7224119.

An aluminum splice plate was added across the lower portion of the Y_F932 bulkhead center panels at X_F0. The splice was added and installed with Taper-lok bolts to improve the fatigue characteristics of the joint where tensile stresses are the greatest. No new production drawing was required since the splice detail was added to an existing drawing.

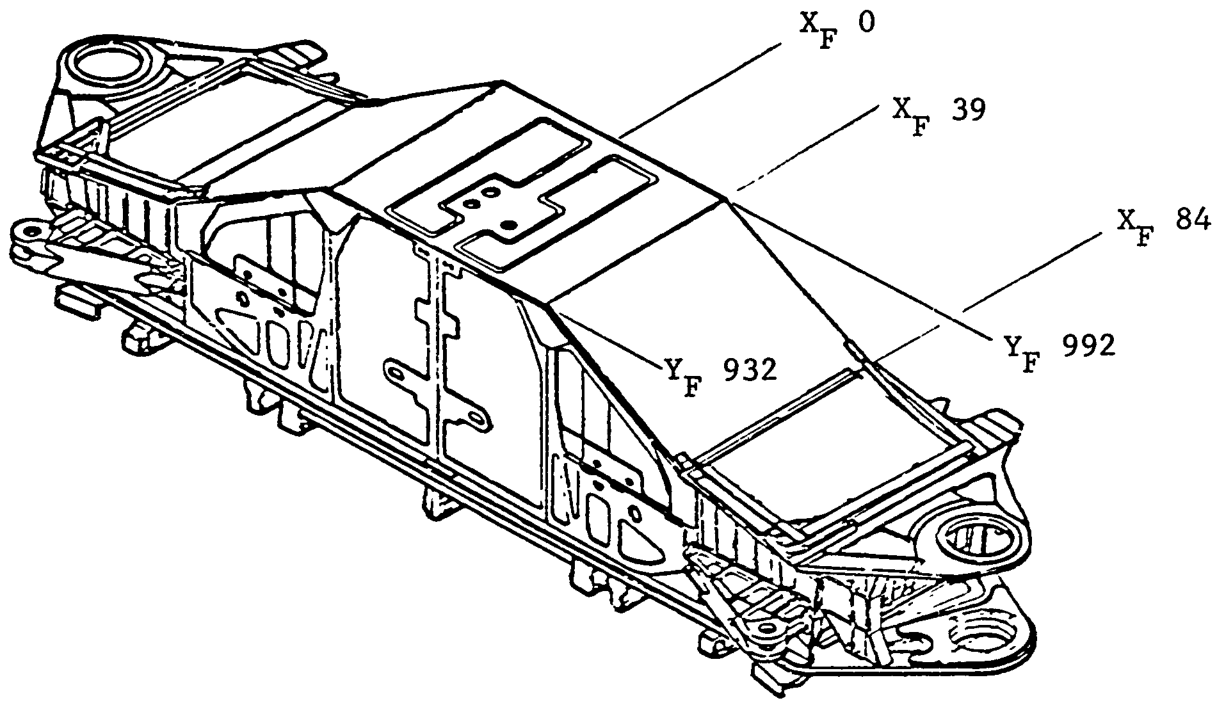


Figure 2.1.1-1 WING CARRYTHROUGH STRUCTURE ARRANGEMENT

The size of Taper-lok bolts was increased in the forward outboard corner where the Y_F932 bulkhead and the closure rib attaches to the lower plate. This change was necessary due to increased loads discovered by additional math model analysis.

Higher strength nuts were added to the tension type Taper-loks attaching the MLG drag fitting to the lower surface. These nuts were necessary to obtain strength compatible with the fastener strength and load requirements.

Mechanical fasteners were added to attach the two elements of the lower centerline longeron together. These attachments were required to obtain an increase in longeron section properties for sufficient stability characteristics.

Miscellaneous changes were accomplished to correct discrepancies discovered during fabrication. These changes include items such as dimensional errors, fastener grip length corrections, spotface and chamfer additions.

2.1.1.2 Simulated Fuselage Design Changes

Fittings were added to the upper centerline longeron at Y_F932 and Y_F992 to simulate the baseline configuration. These fittings transfer the longeron kick loads into the wing carry-through structure.

The aft centerline web was beefed up with doubler plates and additional fasteners in the area of the fitting which introduces the simulated fuselage balancing load.

A new design concept for retaining the pivot pin was incorporated. The original method of bolting a retaining collar through the wall of the pin was replaced with an adjustable clamp-up arrangement. The new concept employs a steel plate bolted to the lower end of the pin utilizing tapped holes. Additional bolts are installed through tapped holes in the steel plate outside of the pin diameter and adjusted to bear on the original collar detail. The torque of these bolts provides the required pre-load to the pin. The original design was judged undesirable as related to hole drilling and fastener installation of the collar with pin pre-load applied. The new design eliminates the need for supplementary tooling to accomplish pin pre-load and simplifies pin installation. This change was accomplished as a revision to drawing 603FTB020 and is shown in Figure 2.1.1-2.

2.1.2 Structural Analysis

2.1.2.1 General

During the reporting period, the principal structural task was to provide structural liaison support during the manufacture of the wing carrythrough structure and the simulated fuselage. In addition, the following tasks were completed or were in work:

1. Completed the overall WCTS finite element analysis.

2. Updated a substantial portion of the preliminary stress analysis to reflect the overall WCTS Math Model results.

3. Performed analysis of design changes found to be necessary during the reporting period for the WCTS and the simulated fuselage.

4. Provided additional stress data for fatigue and fracture analysis.

5. Performed additional fine grid finite element analysis for local areas to determine more detailed stress and load distributions and/or critical buckling loads.

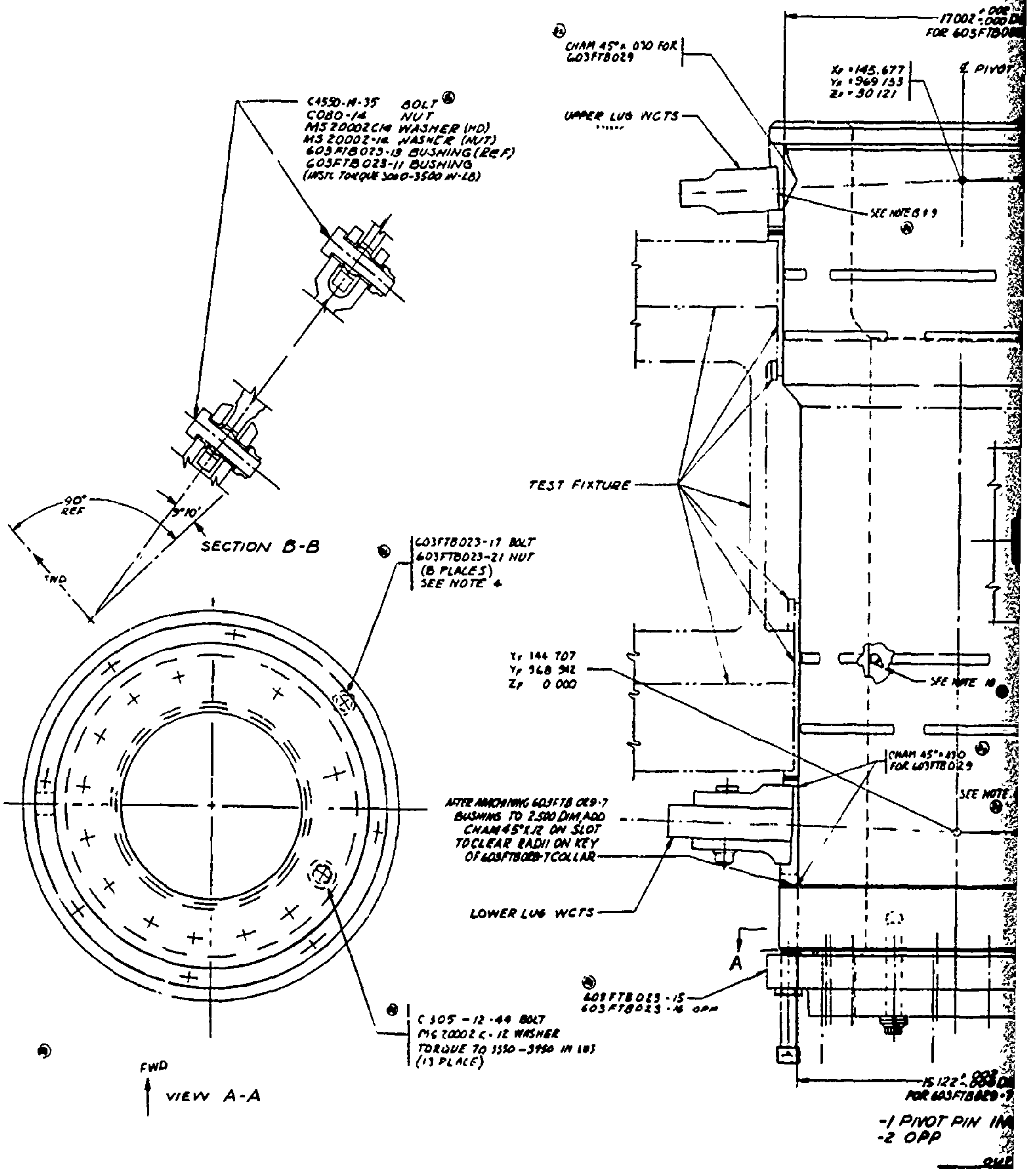
6. Participated in planning for the full scale test program and assisted in finalizing strain gage locations for the WCTS and the simulated fuselage. Prediction of expected stresses and estimation of allowable stresses for use in monitoring the gages during test was substantially completed. Similar data for the simulated fuselage was partially completed.

7. Made an additional run of the upper test fixture - simulated fuselage TN1 model to obtain deflection and load data for the test conditions not previously run on the current model.

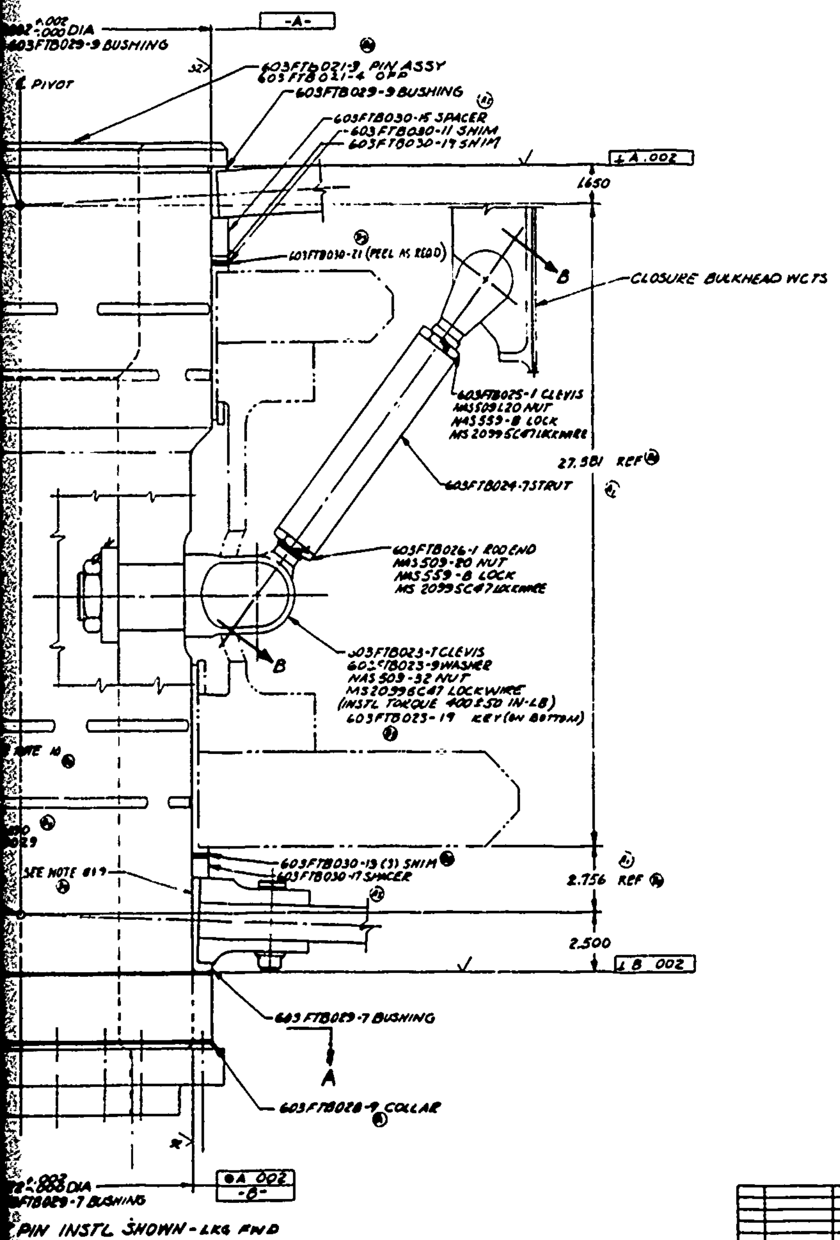
8. Prepared test requests and provided test coordination for the credible option fastener evaluation tests. Reviewed test results.

9. Performed miscellaneous structural studies.

10. Prepared inputs for the November design review and the December B-1 S.A.B. review.



C4550-M-35 BOLT
C080-14 NUT
MS 20002C14 WASHER (HD)
MS 20002-14 WASHER (NUT)
603FTB023-13 BUSHING (REF)
603FTB023-11 BUSHING
SECTION B-B
90° REF
FWD
603FTB023-17 BOLT
603FTB023-21 NUT
(8 PLACES)
SEE NOTE 4
C305 - 12 - 44 BOLT
MS 20002 C- 12 WASHER
(13 PLACE)
VIEW A-A
UPPER LUG WCTS
TEST FIXTURE
LOWER LUG WCTS
AFTER MACHINING 603FTB 029-7 BUSHING TO 2.500 DIM ADD CHAM 45° X.12 ON SLOT TO CLEAR RADII ON KEY OF 603FTB029-7 COLLAR
603FTB023-15
603FTB023-16 OPP
A
-1 PIVOT PIN
-2 OPP



10 AFTER PIN INST IS COMPLETE APPLY -7 LUBRICATION AT ALL FITTINGS
9. SURFACE FINISH RATINGS APPLY PRIOR TO APPLICATION OF DRY FILM LUB
8. FINISH I.D OF 603FTB029 BUSHINGS AS FOLLOWS
   A. PREPARE SURFACE BY CLEANING WITH MIL-C-38736 CLEANER USING CLEAN CHEESE CLOTH
   B. APPLY A LIGHT COAT OF MIL-L-23398 DRY FILM LUBRICANT
   C. AIR DRY FOR 30 MINUTES MINIMUM
7. INSTALL LOCKWIRE PER MS 33540.
6. TIGHTEN 603FTB024-7 STRUT (150±25 IN LB) AFTER 603FTB021-9 PIN IS COMPLETELY INSTALLED.
5. INSTALL 603 FTB021-9 PIN WITH -7 LUBRICANT ON ALL EXTERIOR SURFACES.
4. AFTER PIN IS INSTALLED & GAPS HAVE BEEN FILLED WITH NOTED SHIMS INSTALL 603FTB023-15 RING, C0305 12-44 BOLTS, MS20002C-12 WASHERS & TORQUE AS NOTED. INSTALL 603FTB023-17 BOLTS & 603FTB023-21 NUTS & TORQUE BOLT TO 400-500 IN LBS ON EACH BOLT. RUN UP JAM NUT & TORQUE TO 300-350 IN LBS.
3. ADD OR REMOVE 603FTB030-11 & 603FTB030-21 PEEL SHIM AS REQD TO FILL GAP WITHIN 0.000-.010 BETWEEN 603FTB030-19 SHIM & TEST FIXTURE
1. BREAK SHARP EDGES .015R OR CHAM 45° x .015
NOTES: (EXCEPT AS SHOWN)

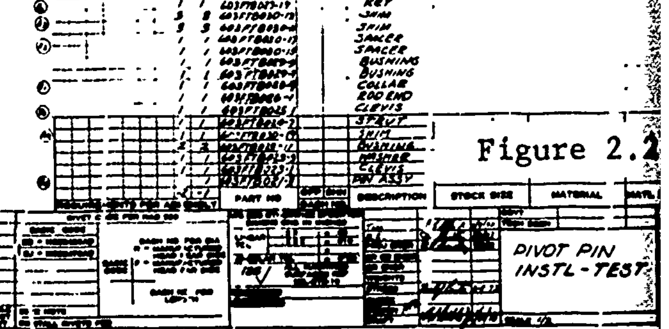


Figure 2.2

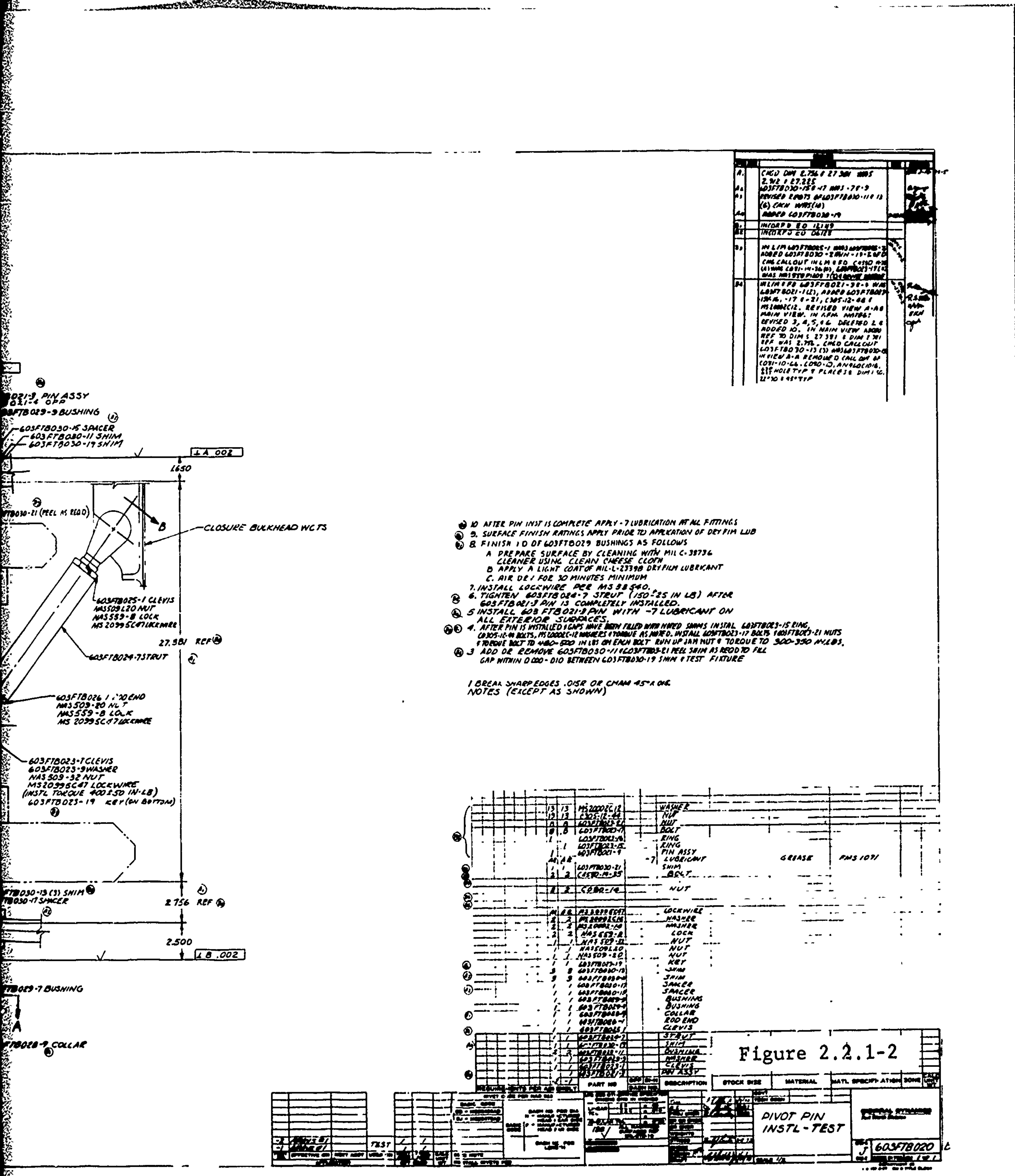


Figure 2.2.1-2

3

2.1.2.2 Design Loads

The design loads remained as previously reported. A cross index relating General Dynamics' condition numbers to NARSAP condition numbers is shown in Table 2.1.2.I.

2.1.2.3 WCTS Overall TN1 Model

The TN1 constant strain element model of the WCTS representative of the current design was run for all of the design conditions. General Dynamics preprocessing procedure UE4 was used to obtain the minimum node separation for optimum computer time usage. Procedure UD6 was used to obtain plots of model geometry for checking purposes. Another program was used to check the input panel point loads for static balance. After the actual solution run, Procedure UD5 was used to obtain final stress and geometry plots.

The model has 932 nodes and 2107 elements consisting of bars and membranes. A view of the model is shown in Figure 2.1.2-1.

Table 2.1.2-II summarizes the runs made.

2.1.2.4 Stress Analysis Updating

An updated preliminary stress analysis was partially prepared during this period. This analysis is based primarily on results obtained from the overall TN1 model and from various fine grid models.

2.1.2.5 Fine Grid Models

Fine grid models were used where appropriate to determine more accurate internal loads and stress distributions or to check buckling allowables.

Upper Lug/Longeron Tab Intersection Model

Since previous TN1 and NARSAP upper lug models were relatively coarse in the intersection area, a fine grid TN1 model was set up and run for condition AS 10001. Boundary forces were obtained from the overall TN1 WCTS model. This condition produces maximum tension stresses in this region of the upper lug.

Table 2.1.2-I LOAD CONDITION SUMMARY

GEN DYNAM [1,2,5] COND. NO.	NARSAP COND. NO.	CONDITION DESCRIPTION	WING POSITION
AS 1000, 1001	660331	Abrupt Roll, 3G Limit	67.5^0
AS 1000A, 1001A	660332		
AS 2000, 2001	110021	Steady Pitch, 2G, Flaps Down	15
AS 3000, 3001	161432	Steady Pitch, 3G	67.5
AS 4000, 4001	110301	Steady Pitch, 0G, Spoilers	15
AS 5000, 5001	112120	Steady Pitch, 2G, Slats	15
AS 6000	810012	2 Pt. Braked Roll, 1G	15
AS 7000	880025	Taxi, 2G	15
AS 8000[3]	880012	Ground Turning, 1G	15
AS 8000A			
AS 9000[4]	122222	Steady Pitch, 2G	25
AS 10000, 10001	160337	Steady Pitch, 3G, Low Level	67.5
AS 11000, 11001	160316	Steady Pitch, 1G	67.5

NOTES:
1. Pivot Loads Taken from NARSAP 39 Sta Data Dtd. 4/23/73
2. Armament and Landing Gear Loads Assumed to Remain as in TFD-72-838 & TFD-72-838 App. A
3. ASKA 8C Used Because ASKA Data for AS 8000 Not Available
4. NARSAP 122222 Used Because Pivot Loads Exceeded 122221
5. When 1 Appears as Last Digit, Wing Pivot Friction Effects were Superposed on Basic NARSAP Condition

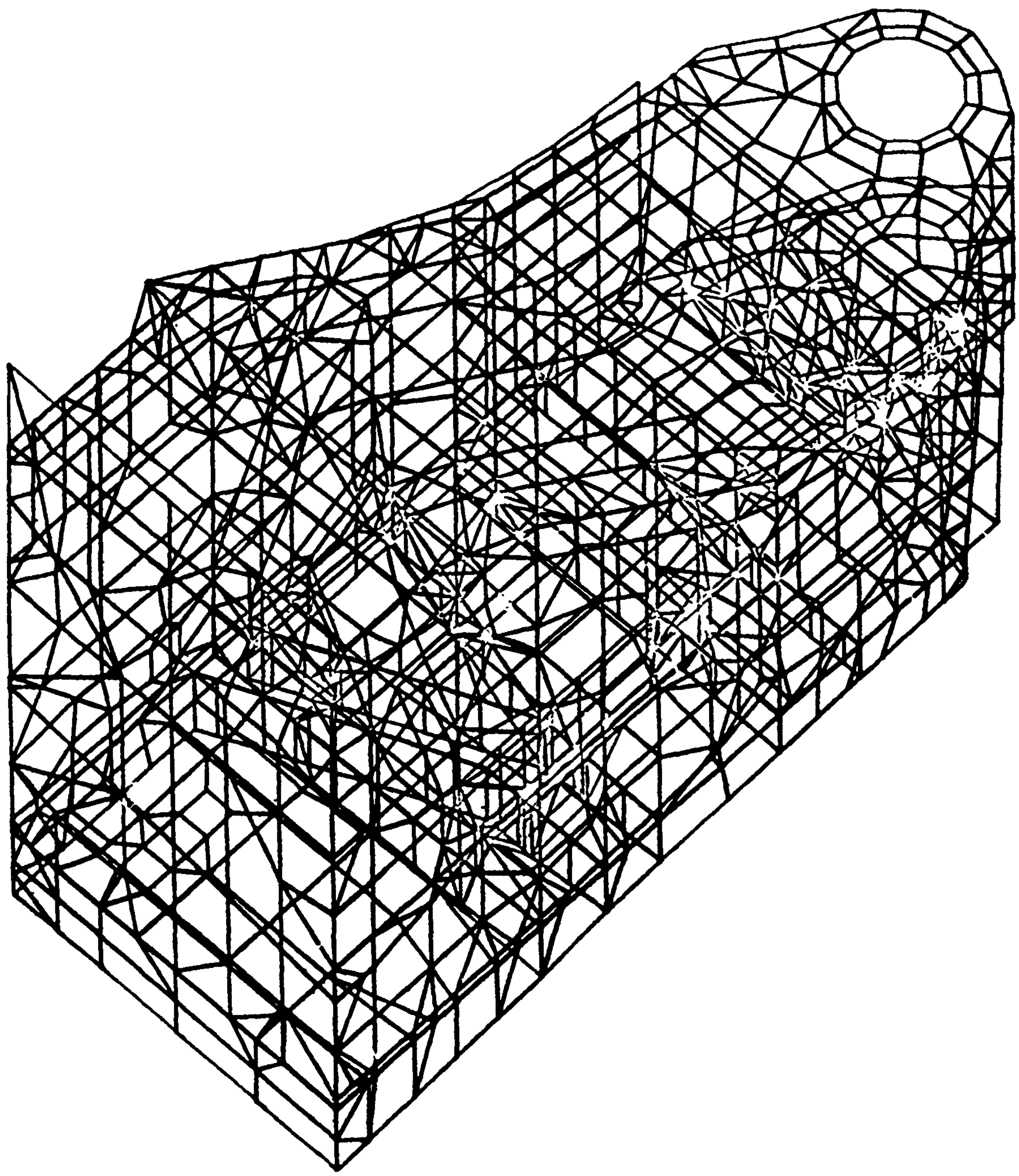


Figure 2.1.2-1 OVERALL MODEL (TN1)-NBB-5 SERIES

Table 2.1.2-II TN1 WCTS MODEL SUMMARY

MODEL DESIGNATION	RUN DATE	PROBLEM NUMBER	USABLE* CONDITIONS	REMARKS
NBB5-1	7/18/74	192015E	AS7000	Remainder of conditions repeated in NBB5-4 for better static balance.
NBB5-2	8/1/74	193135C	AS4001 5001 6001 11001	No significant errors known.
NBB5-3	8/22/74	P193136G	AS1001 L/H 1001 R/H 8000 L/H 8000 R/H	All known errors corrected.
NBB5-4	8/13/74	P193137E	AS2001 3001 9000 10001	All known errors corrected.

*Use of "1" as the final digit indicates inclusion of wing sweeping friction effects.

Figure 2.1.2-2 shows the grid layout used. As indicated in the figure ultimate principal stresses reached 158 ksi at the element centroids. This stress data was provided to the Fatigue and Fracture Mechanics Group for further evaluation.

Lower ℄ Longeron NASTRAN Model

A relatively fine grid buckling model of the lower centerline longeron was run. The node and element arrangement is shown in Figure 2.1.2-3. Loads from the overall model (NBB 5-1) for condition AS 7000 (2G Taxi) were used to load the isolated section. Simple supports in the spanwise direction were assumed around the periphery of the model.

The eigenvalues obtained were as follows:

Mode 1 - E.V. = 1.21

Mode 2 - E.V. = 1.64

The lower values represented the lowering of a stiffener in the web plane which would be prevented by the web in the actual structure. Consequently, only the 1.64 value is meaningful and it is conservative since a moment-of-inertia input error in the buckled region resulted in a model that was more flexible than the actual longeron. By ratio, the conservative eigenvalue for the design condition, AS 6000, was found to be 1.19.

Lower Plate Fine Grid Model

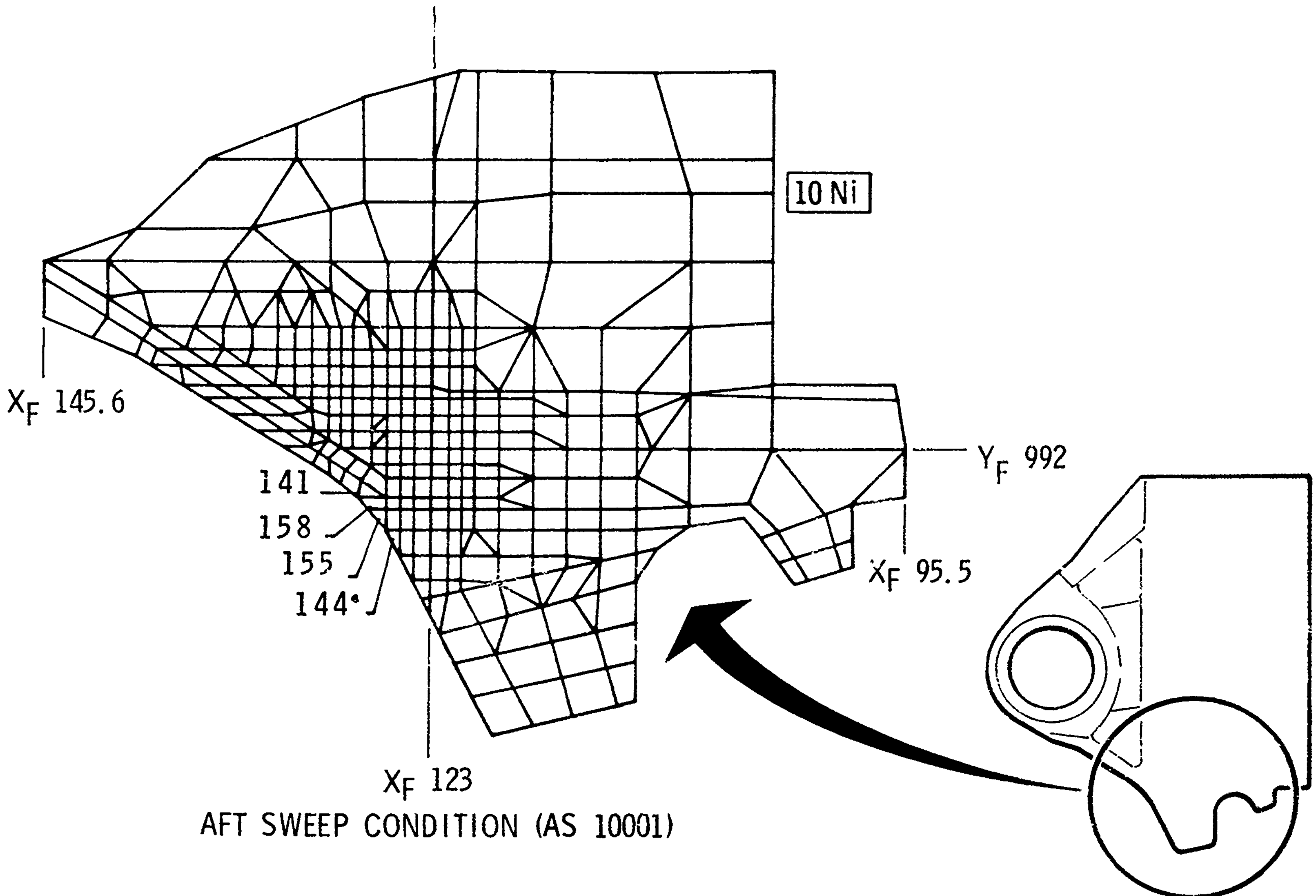
' fine grid TN1 Model of the aft portion of the lower plate between X_F 39 and X_F 0 was developed to allow study of the effects of the drag load from the main landing gear side brace fitting. It was found that the aft steel rail was stiff enough to spread the load over a large enough area to prevent local fastener and/or material overloading.

Lower Lug Linear Strain Model

Review of the results was completed. The grid used along with corrected station locations is shown in Figure 2.1.2-4.

2.1.2.6 Stress Level Data

In the course of preparing data for the B-1 S.A.B. review, summaries of representative stress levels were prepared for the major WCTS components. These summaries are presented for



AFT SWEEP CONDITION (AS 10001)

Figure 2.1.2-2 UPPER LUG FINE GRID ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION-TN 1 MODEL

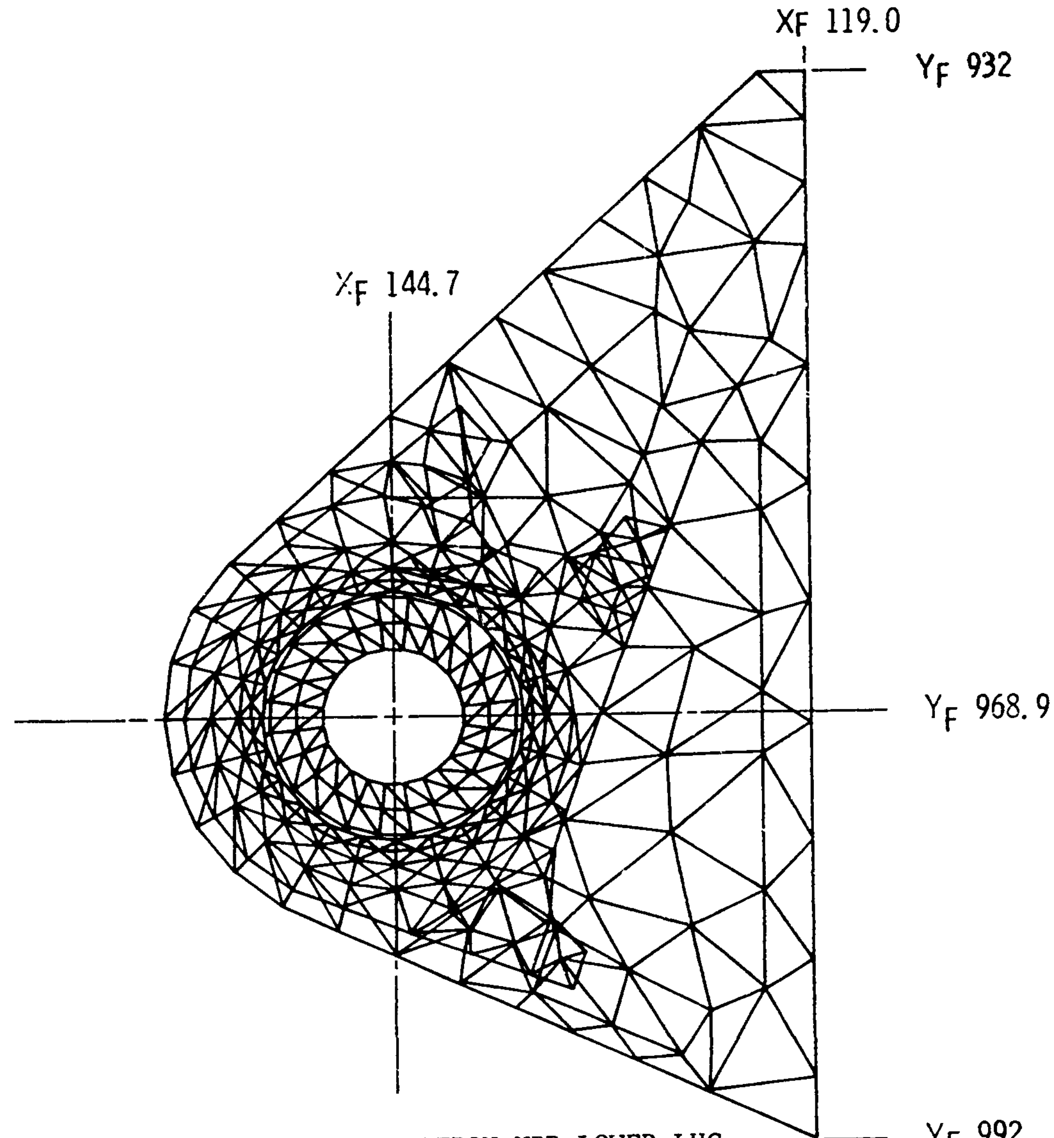


Figure 2.1.2-3 TLO SIMULATION NBB LOWER LUG

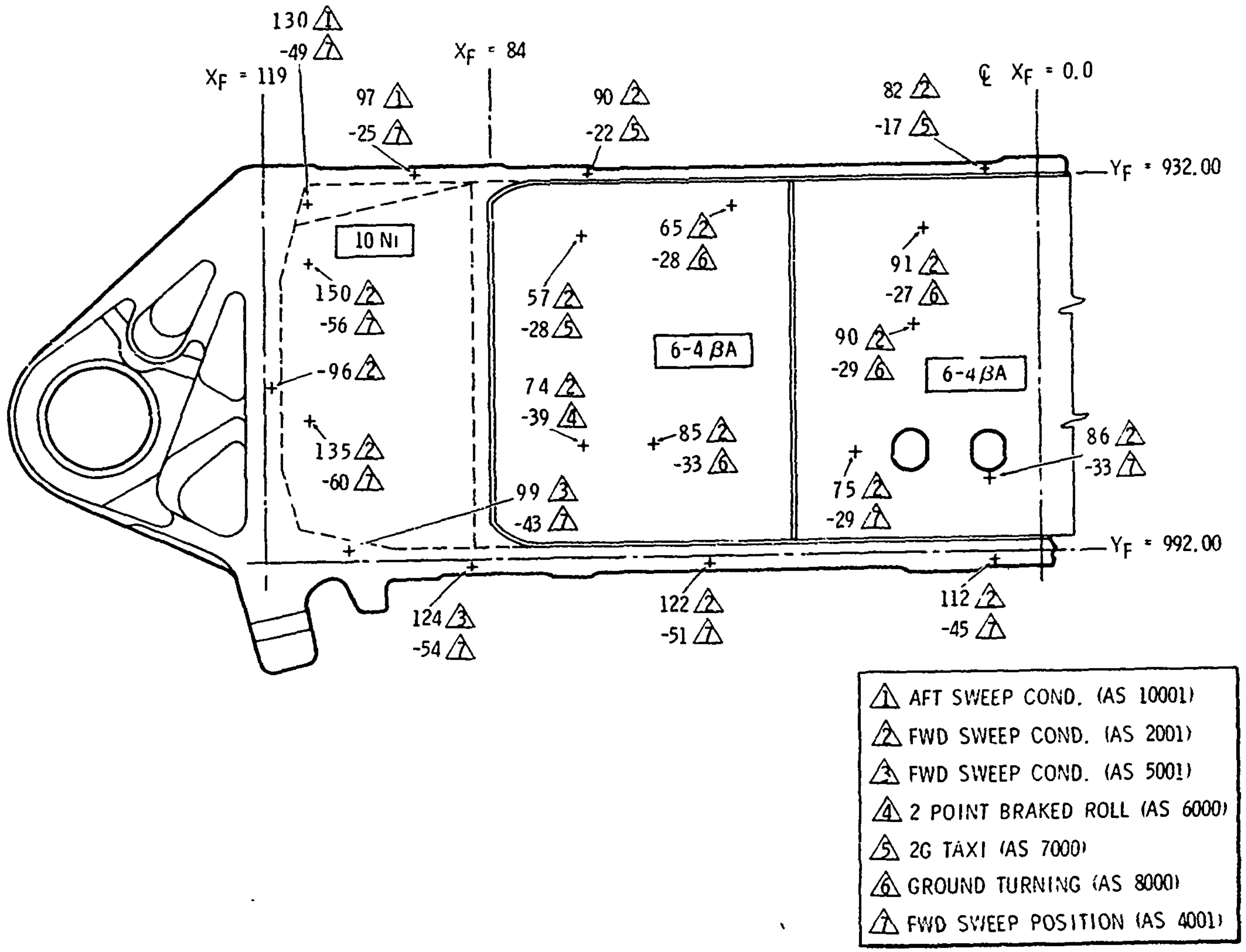


Figure 2.1.2-4 REPRESENTATIVE LOWER PLATE ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION-TN 1 MODEL

information in Figure 2.1.2-5 through 2.1.2-14. The stress data shown is for elastic material and does not reflect redistributions that will take place after yielding occurs. In general, the stress levels are taken directly from the models indicated on the figures.

2.1.2.7 Simulated Fuselage

The most recent upper test fixture - simulated fuselage math model was run for Conditions AS 4000, 5000, and 11000 since these conditions had not been run previously. The results at the WCTS interface are shown in Tables 2.1.2-III and 2.1.2-IV.

As for Conditions AS 2000, 7000, 9000, and 10000, longeron loads showed better agreement with the NARSAP data provided by Rockwell than the shear flows did.

2.1.2.8 Full Scale Test Support

Assistance was provided in selecting final strain gage locations on the WCTS and the simulated fuselage. Predicted and allowable stresses for the former were substantially completed while work continues on the latter.

2.1.2.9 Weights

All of the detail part weighings were completed during this period. The calculated weight for the "no-box" box is 12,660 pounds. The projected actual weight of the box, exclusive of test hardware, is 12,886 pounds. The actual part weights exceeded the calculated weights by 226 pounds.

Table 2.1.2-V presents a comparison between the calculated, actual and estimated production weights.

It is estimated about 150 pounds of this overweight would be applicable to a production article of the box. There are some areas as noted in Table 2.1.2-VI where weight changes/cost reduction could be accomplished. These changes could be incorporated without negating the static or fatigue testing of the box done in the AMAVS program

A materials break down based upon the calculated weight is shown in Table 2.1.2-VII.

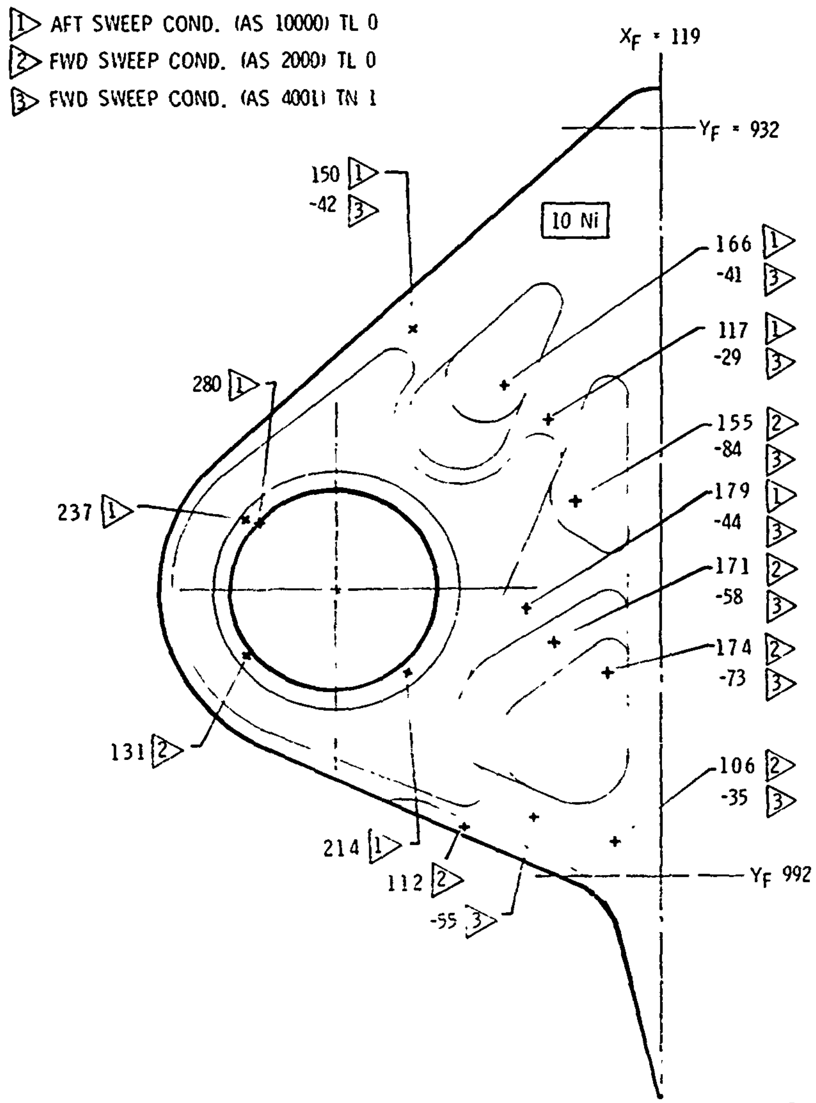


Figure 2.1.2-5 REPRESENTATIVE LOWER LUG ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION

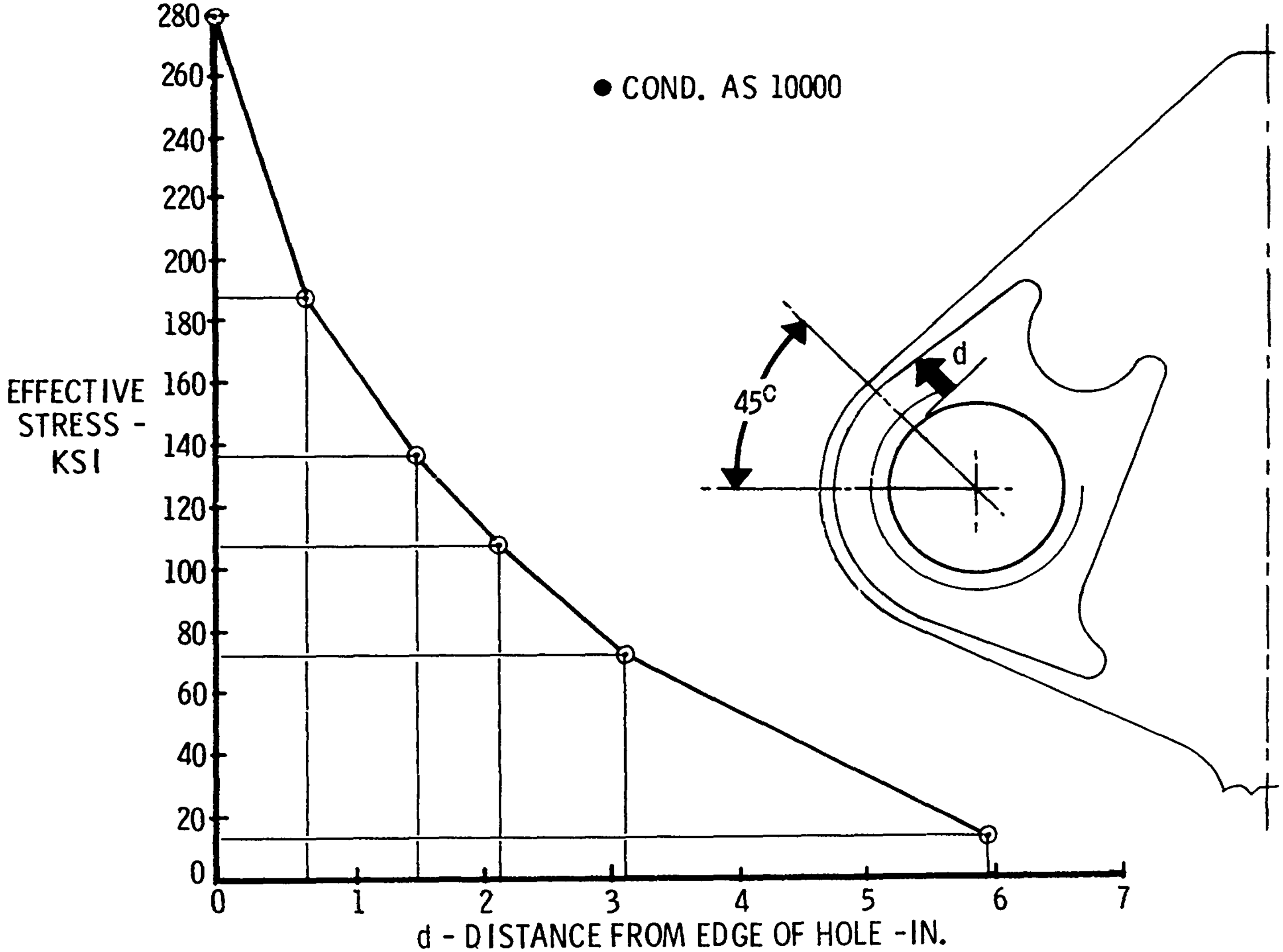


Figure 2.1.2-6 NBB LOWER LUG - TLO MODEL TYPICAL ULTIMATE EFFECTIVE STRESS DISTRIBUTION

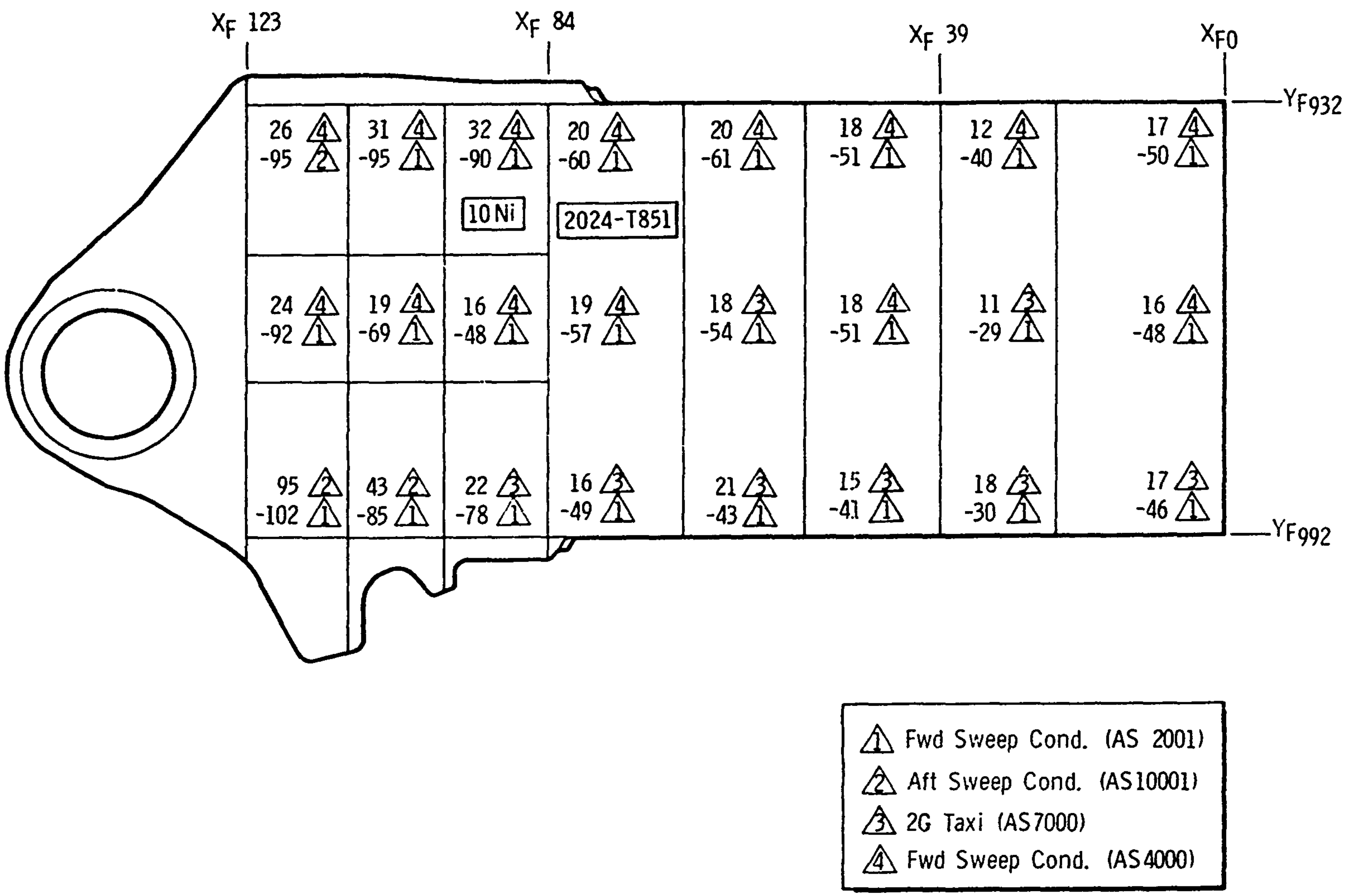


Figure 2.1.2-7 REPRESENTATIVE UPPER COVER ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION-TN 1 MODEL

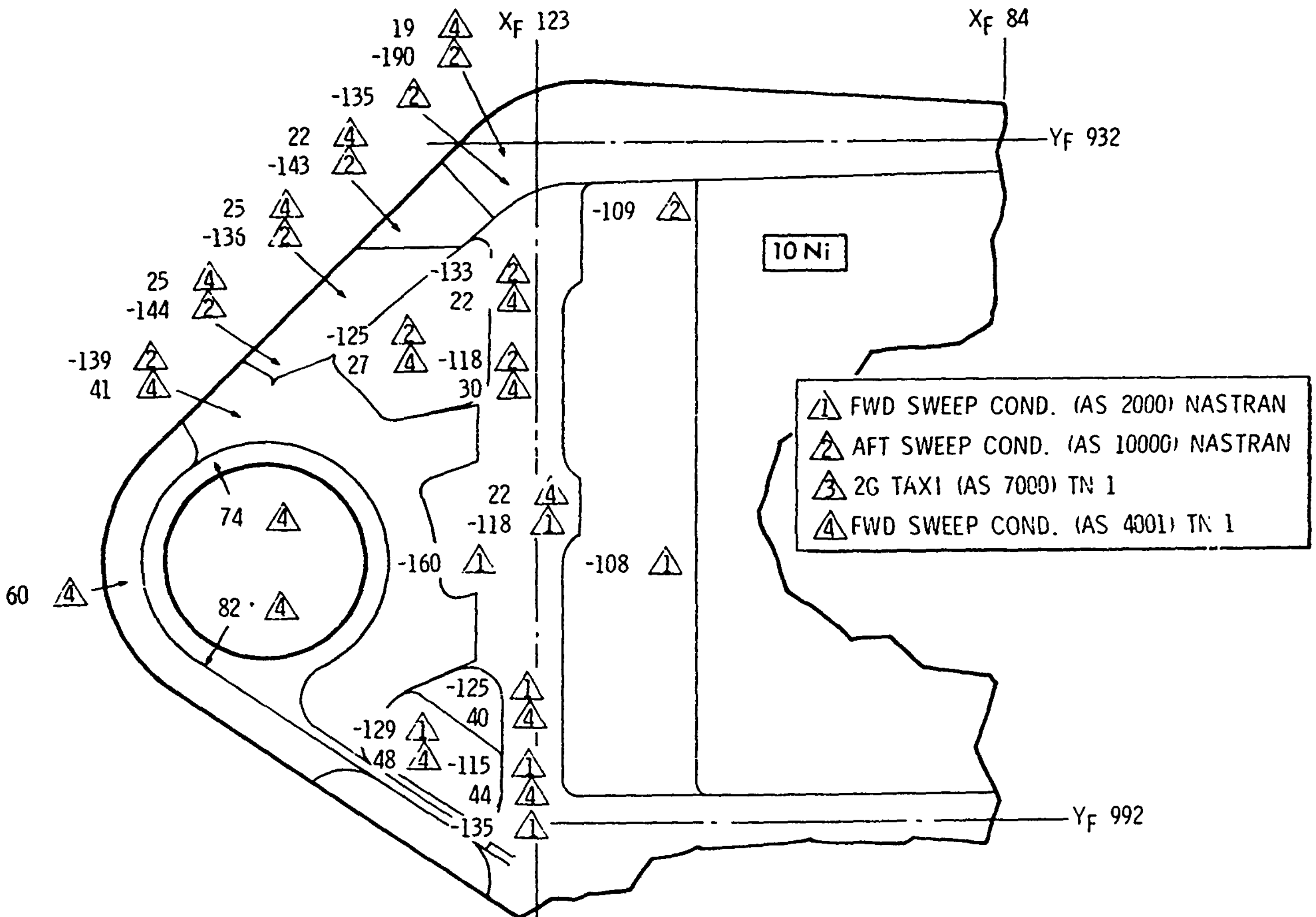


Figure 2.1.2-8 REPRESENTATIVE UPPER LUG ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION

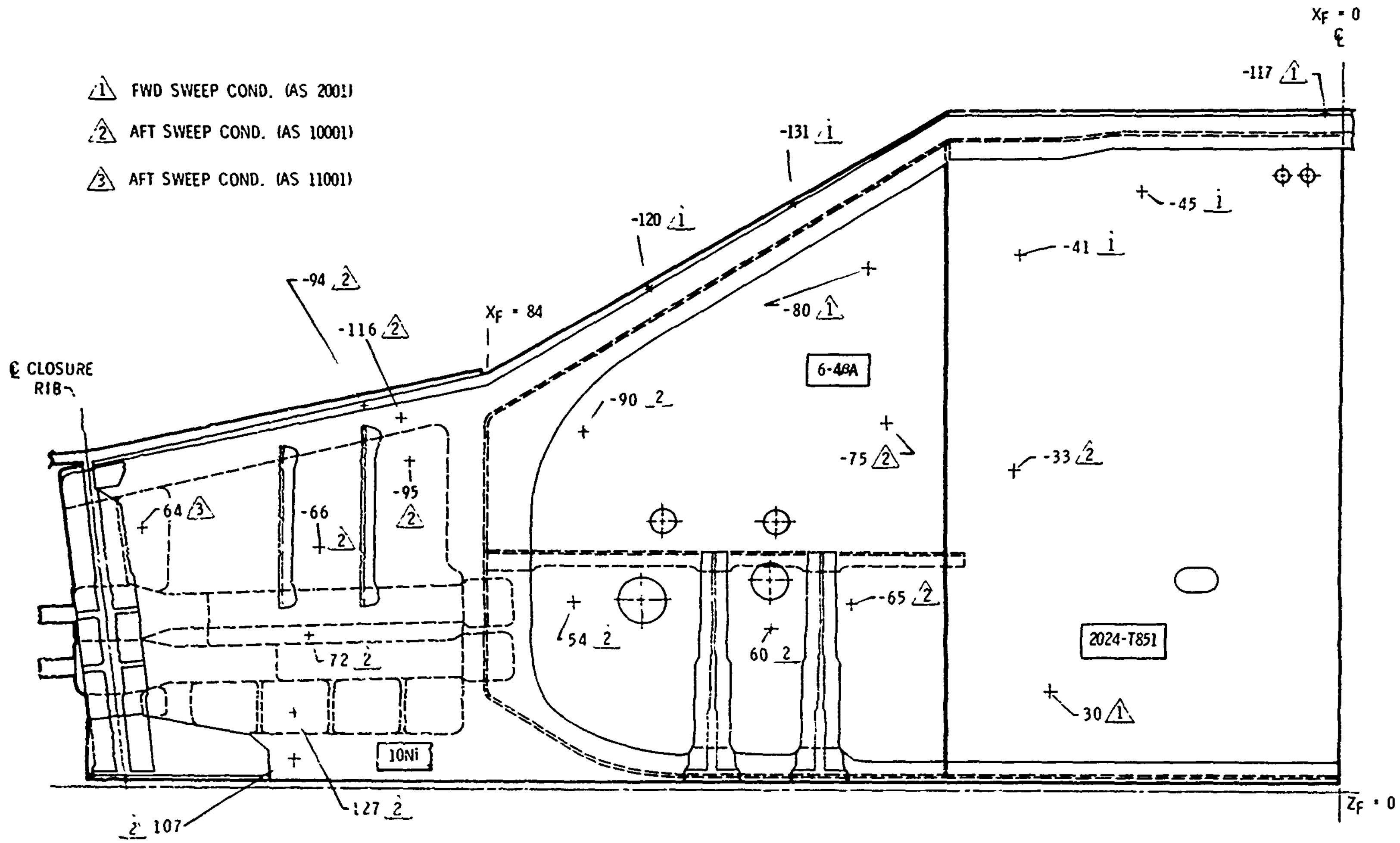


Figure 2.1.2-9 REPRESENTATIVE Y_F 932 BULKHEAD ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION - TN1 MODEL

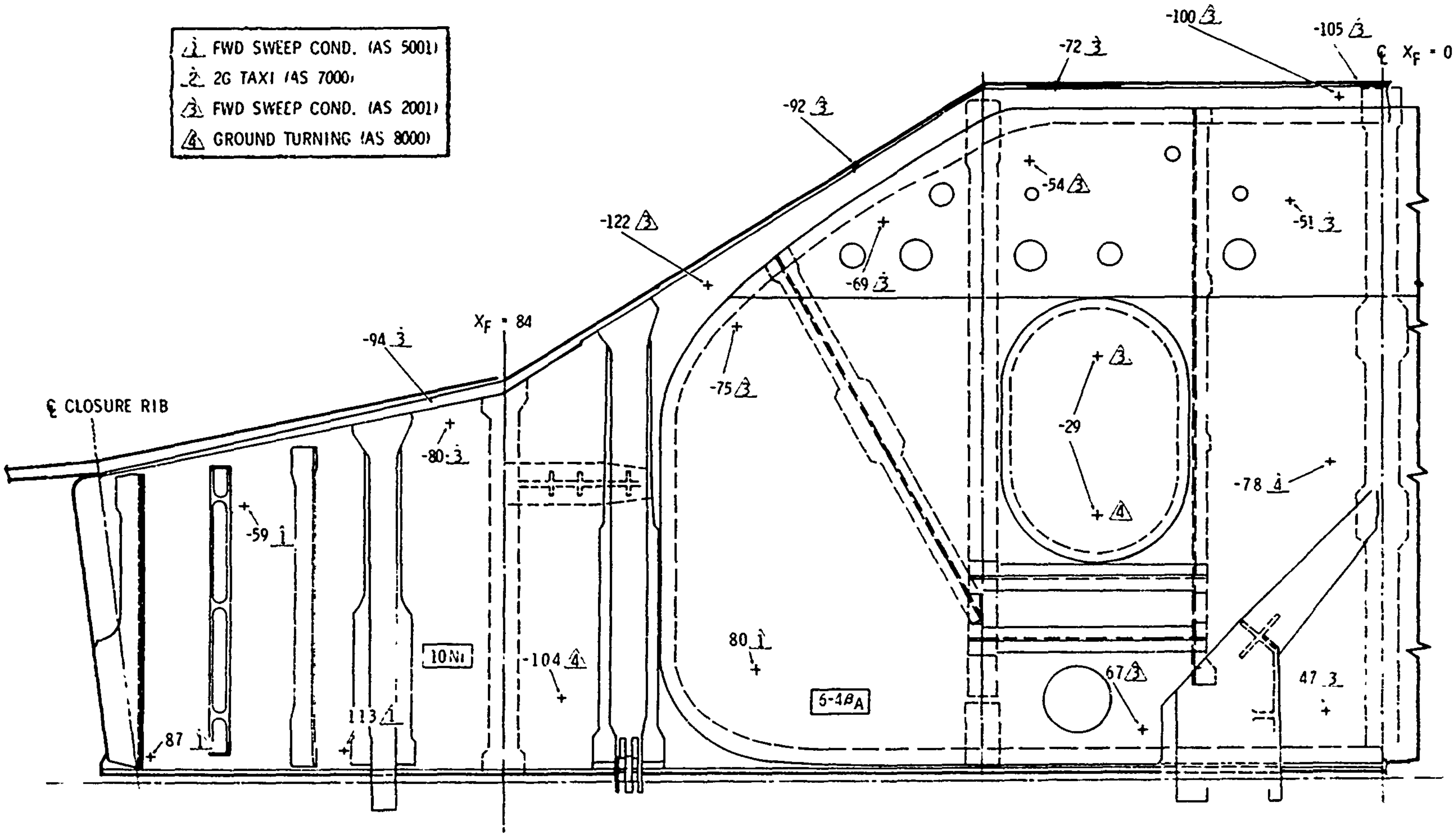
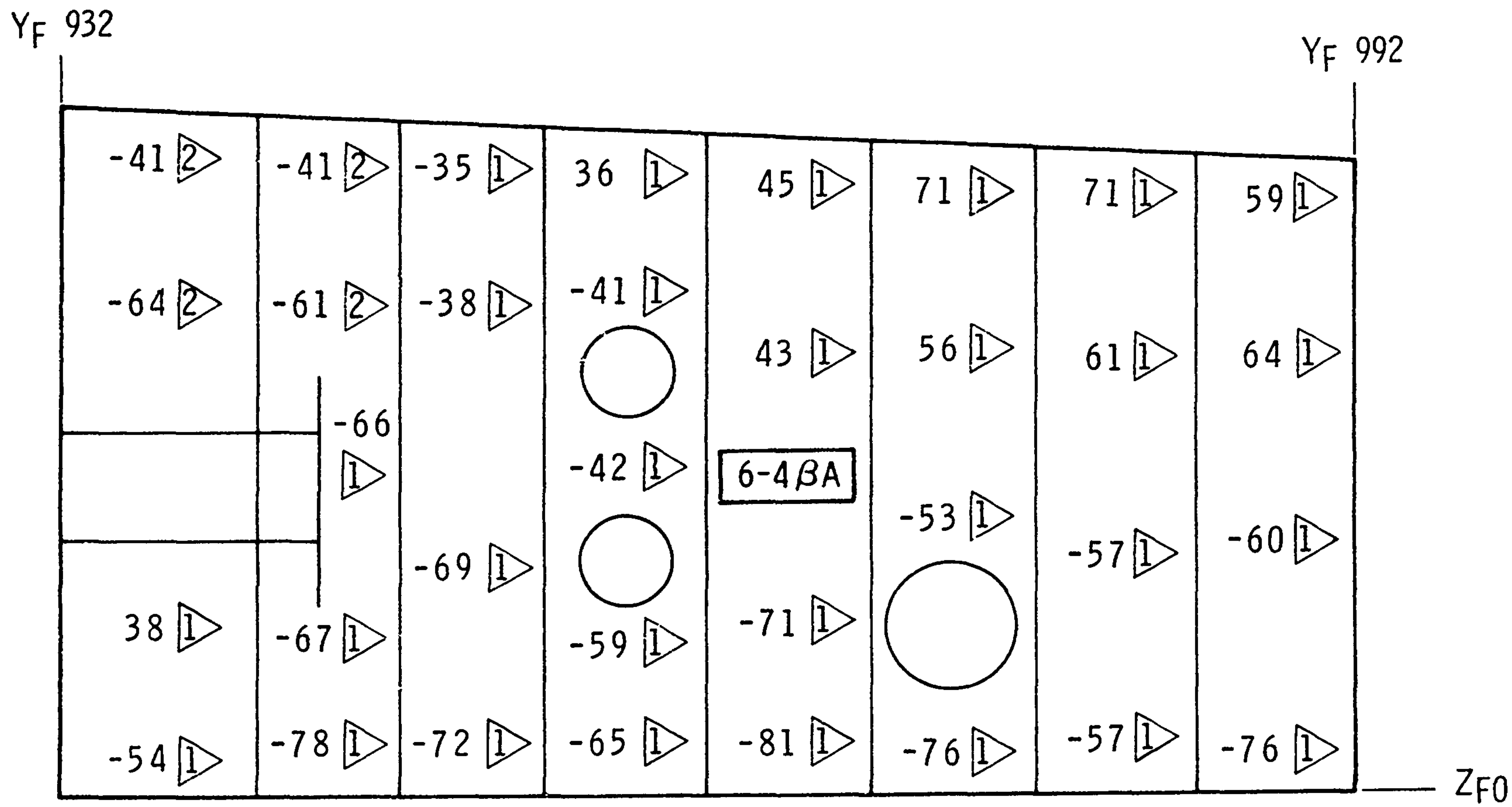


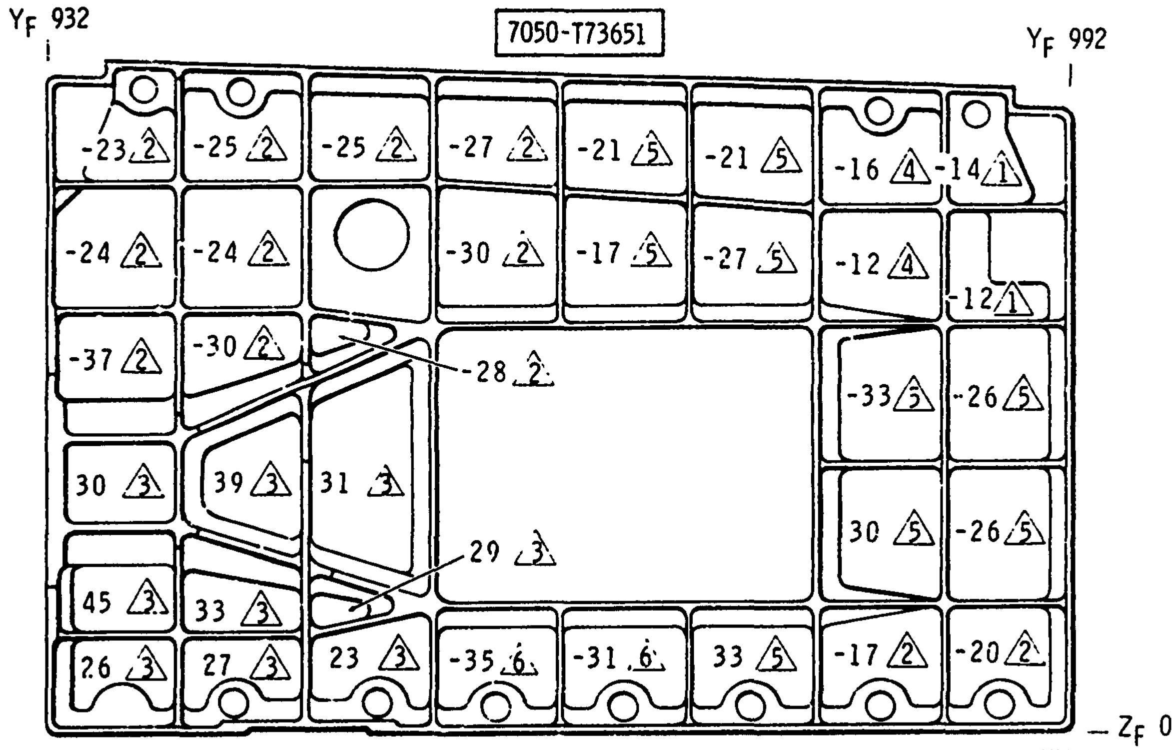
Figure 2.1.2-10 REPRESENTATIVE Y_F 992 BULKHEAD ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION - TN1 MODEL



1 AFT SWEEP CONDITION (AS 10001). MAX SWEEP ACTUATOR COMPRESSION LOAD

2 AFT SWEEP CONDITION (AS 11001). MAX SWEEP ACTUATOR TENSION LOAD

Figure 2.1.2-11 REPRESENTATIVE CLOSURE RIB ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION-TN 1 MODEL



1 FWD SWEEP COND. (AS 2001)

2 FWD SWEEP COND. (AS 5001) MAX COMPRESSION LOAD FROM SWEEP ACTUATOR

3 AFT SWEEP COND. (AS 11001) MAX TENSION LOAD FROM SWEEP ACTUATOR

4 25° SWEEP COND. (AS 9000)

5 TWO POINT BRAKED ROLL COND. (AS 6000)

6 AFT SWEEP COND. (AS10001)

Figure 2.1.2-12 REPRESENTATIVE X_F 84 RIB ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION-TN1 MODEL

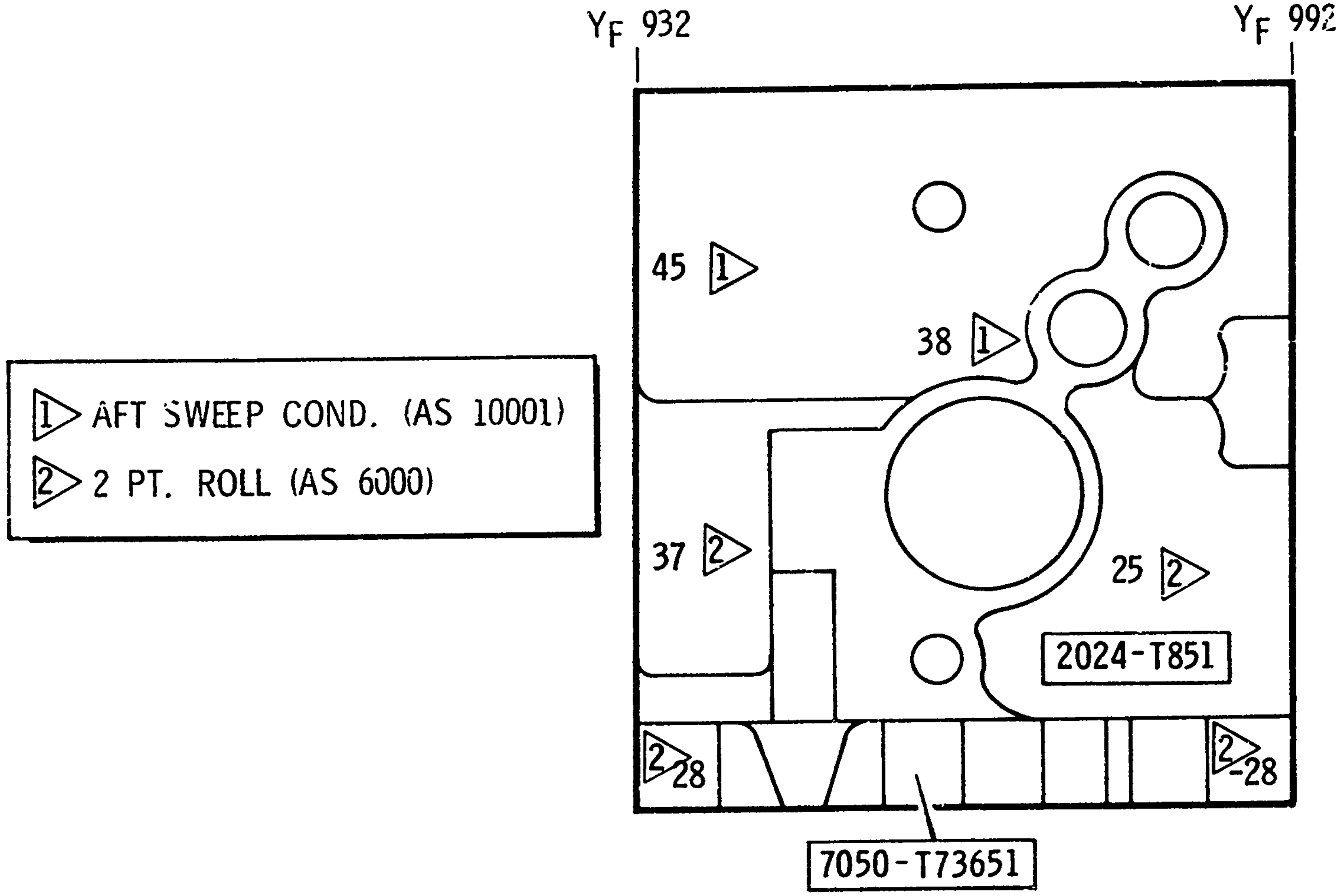


Figure 2.1.2-13 REPRESENTATIVE X_F 39 RIB ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION-TN 1 MODEL

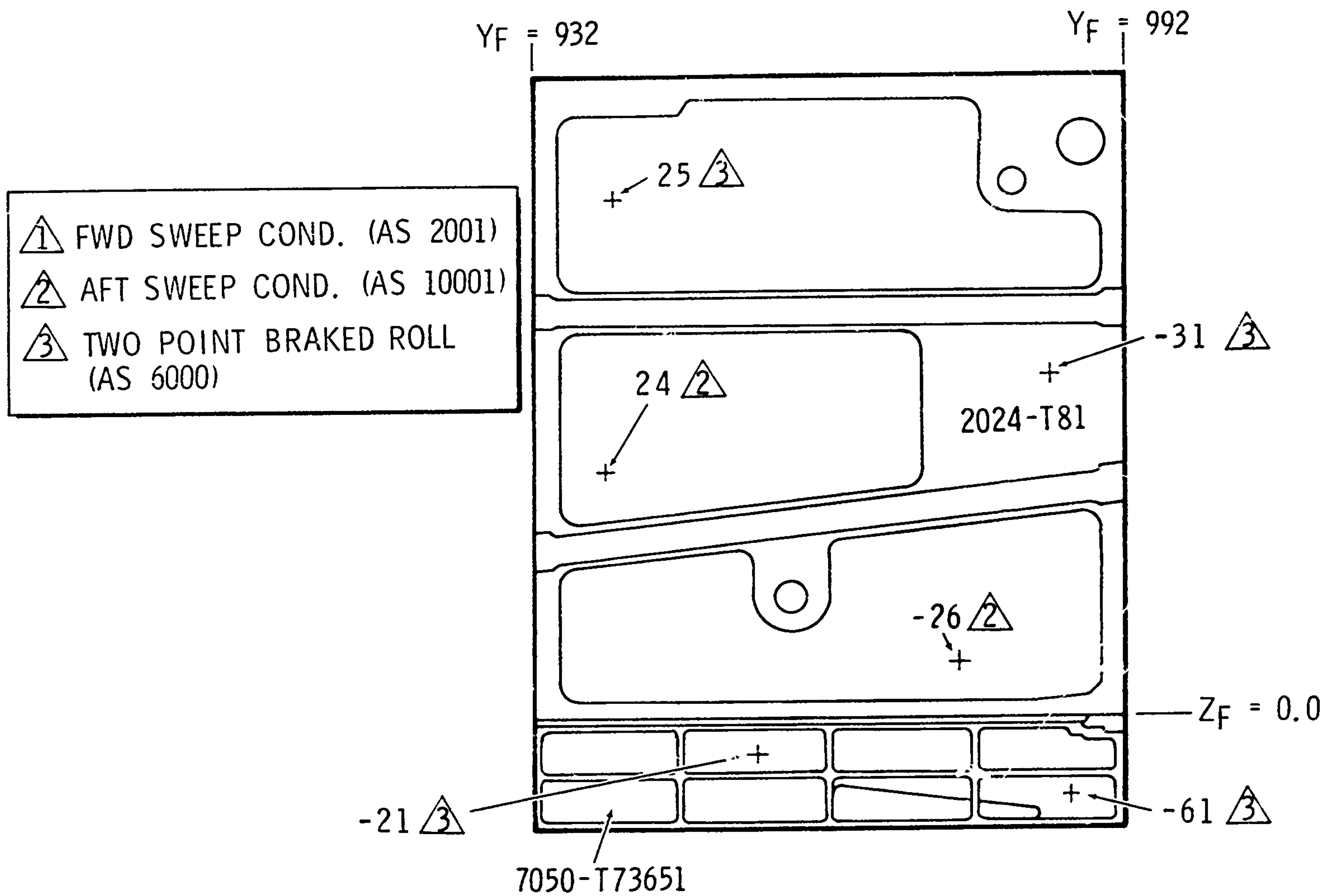


Figure 2.1.2-14 REPRESENTATIVE X_FO RIB ULTIMATE PRINCIPAL STRESS LEVELS - KSI - GROSS SECTION -TN 1 MODEL

Table 2.1.2-III CONVAIR AND NARSAP SHEAR FLOW - LBS/IN.

SHEAR FLOW NO.	AS 4000		AS 5000		AS 11000	
	NBB	NARSAP	NBB	NARSAP	NBB	NARSAP
1	- 63	- 140	224	279	148	-26
2	40	169	-206	6	-84	99
3	-181	- 306	839	690	-10	-49
4	-649	- 936	1545	1817	-75	-373
5	-721	- 936	1731	1817	-96	-373
6	52	206	-179	-66	-73	105
7	-300	- 531	816	1075	64	-90
8	-218	125	436	461	-119	143
9	-166	- 33	515	147	-7	7
10	-174	3	82	-40	-114	-6
11	-579	636	1606	-1424	152	290
12	-127	131	501	-168	145	143
13	-620	34	1074	-444	-212	-142
14	-474	- 329	812	559	-162	-217
15	367	- 636	-360	2833	208	519
16	192	-1203	323	2499	69	-499
17	1973	1446	-5656	-3622	-636	-453
18	-255	- 231	549	394	-120	-115
19	863	63	-3657	-1620	-812	-878
20	72	- 151	-1308	-755	-730	-710
21	281	- 151	-1576	-755	-583	-710
22	-93	84	343	-162	98	100
23	164	- 42	-755	-666	-212	-454
24	-100	- 183	385	381	48	-126
25	29	183	-165	-381	21	126
26	596	348	-1502	-450	142	352

NOTES: 1. Full value on ℄

2. See Figures 2.1.2-15 and 2.1.2-16

Table 2.1.2-IV CONVAIR AND NARSAP LONGERON LOADS - KIPS

LONGERON NO.	AS 4000		AS 5000		AS 11000	
	NBB	NARSAP	NBB	NARSAP	NBB	NARSAP
141	- 6	- 4	- 94	-162	-45	-56
146	- 33	- 32	165	149	17	9
148	- 59	- 50	245	232	13	14
150	- 23	- 28	72	86	- 7	- 8
157	77	65	-144	-86	21	47
162	44	49	-243	-219	1	- 5
256	- 50	- 57	205	209	19	2
257	- 2	- 5	24	28	5	4
258	6	2	- 7	- .2	4	3
259	- 50	- 38	208	161	24	15
260	- 12	- 14	56	55	7	6
262	- 2	- 7	49	56	19	19
266	- 10	- 3	47	7	8	-.5
267	-114	-136	161	214	-49	-32
275	148	166	-567	-510	-63	-46
282	37	65	- 79	-145	4	23
286	49	27	- 99	- 75	20	5

NOTES: 1. One half value on ℄

2. See Figures 2.1.2-15 and 2.1.2-16

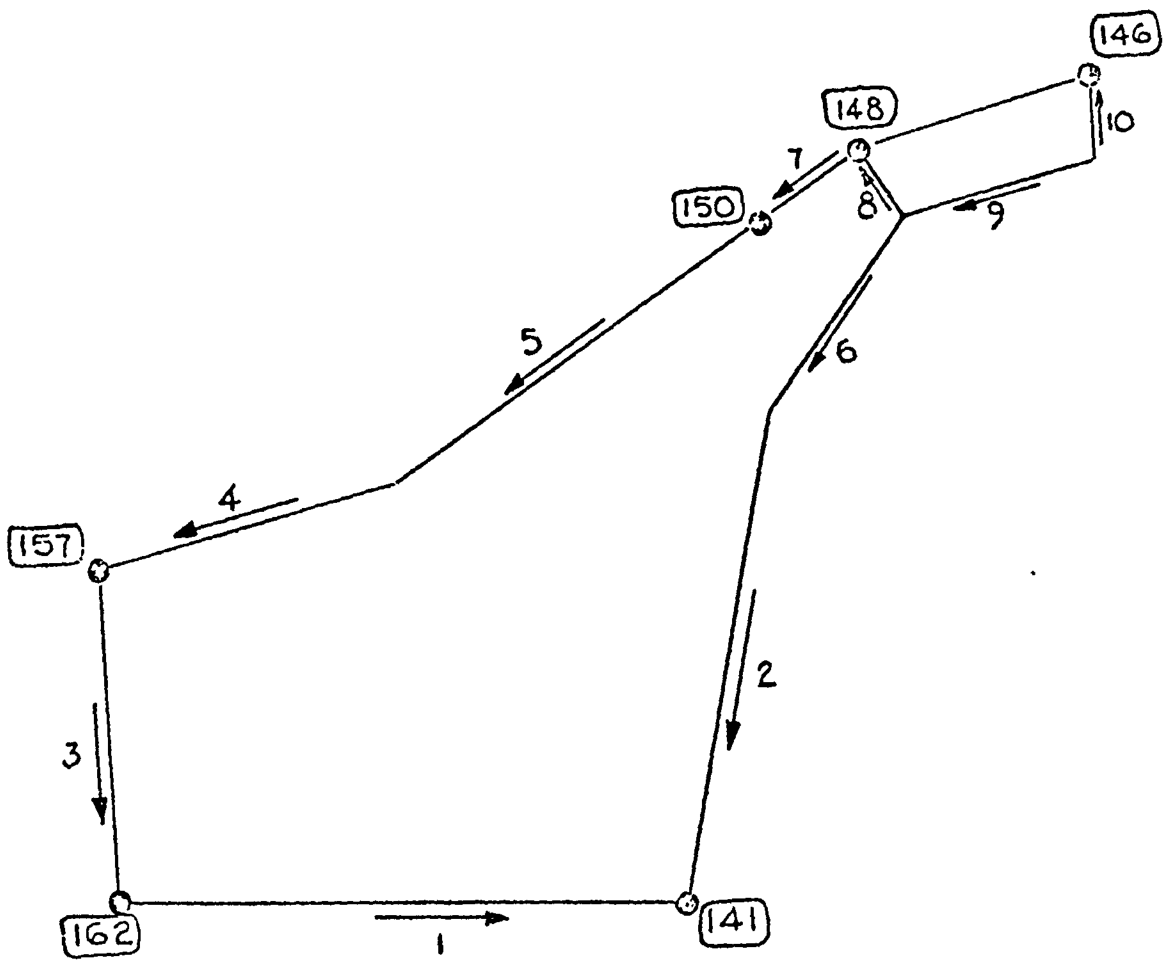


Figure 2.1.2-15 FORWARD SIMULATED FUSELAGE SHEAR FLOW AND LONGERON LOCATION DIAGRAM - Y_F891-932

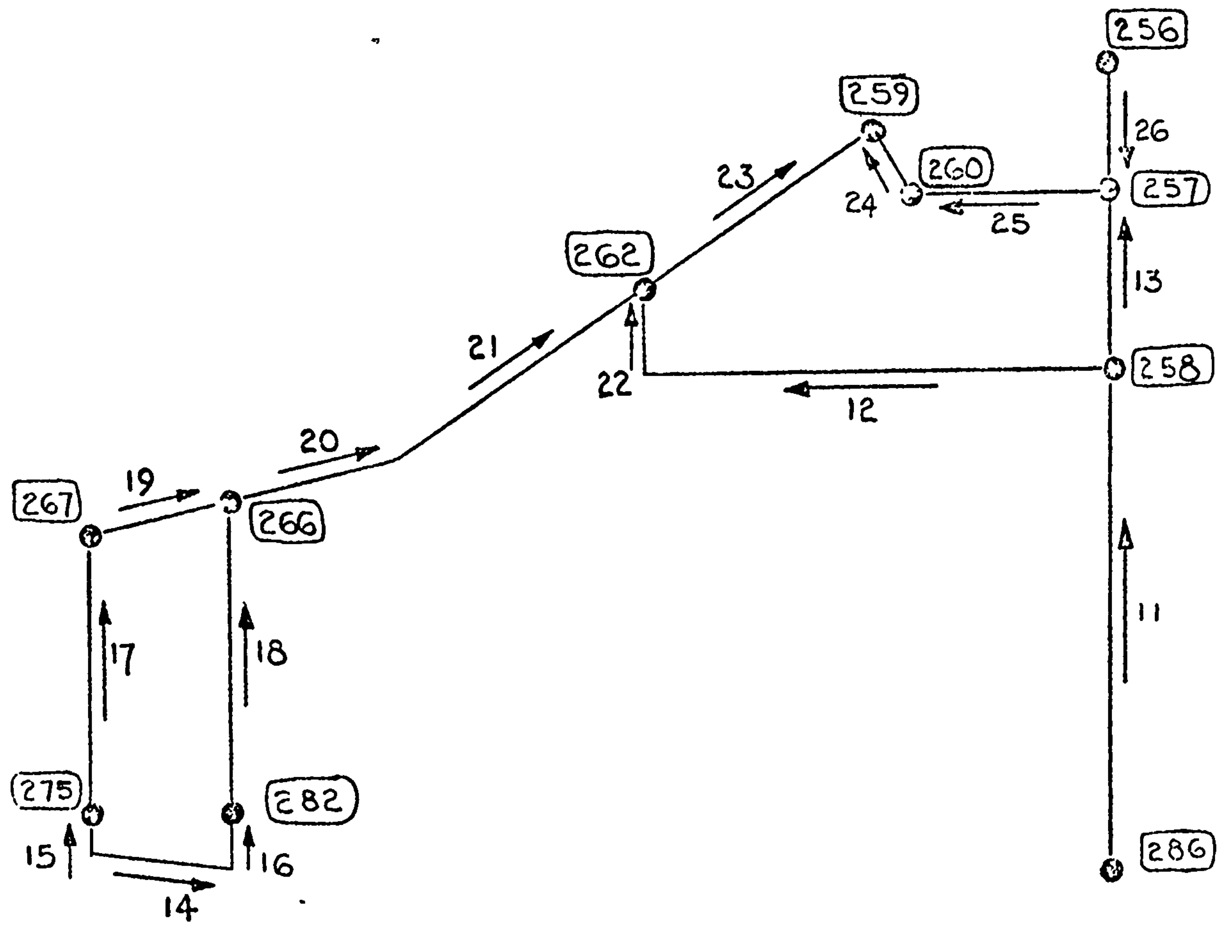


Figure 2.1.2-16 AFT SIMULATED FUSELAGE SHEAR FLOW AND LONGERON LOCATION DIAGRAM Y_F992-1021

Table 2.1.2-V "NO-BOX" BOX COMPARATIVE WEIGHT

	POUNDS CALCULATED		POUNDS ACTUAL	POUNDS EST. PROD.
GENERAL DYNAMICS REDESIGNED	(10867.3)	(226)[1]	(11093.3)	(10858)
LOWER PLATE	2970.9	12.3	2983.2	2950
UPPER PLATE	2132.8	38.5	2171.3	2150
BULKHEADS	2351.7	79.8	2431.5	2280
RIBS	1259.5	59.6	1319.1	1284
FITTINGS	1185.0	32.8	1217.8	1222
MISCELLANEOUS & FAIRINGS	967.4	3.0	970.4	972
ROCKWELL INTERNATIONAL DESIGN	(1792.7)		(1792.7)	(1793)
PIVOT PIN/SHEAR LINK/NAC TIE	1426.7	0	1426.7	
MISCELLANEOUS	41.0	0	41.0	
FITTINGS	325.0	0	325.0	
TOTAL	(12660.0)		(12886.0)	(12651)

1 This column shows the variation between actual and calculated weights.

Table 2.1.2-VI PROJECTED NBB PRODUCTION WEIGHT

		POUNDS
PROJECTED ACTUAL WEIGHT OF AMAVS TEST ARTICLE		12,886
MANUFACTURING VARIATION FOR FIRST ARTICLE		226
CALCULATED WEIGHT FOR FIRST ARTICLE		12,660
ESTIMATED PRODUCTION MANUFACTURING VARIATION		150
REVISED ESTIMATED PRODUCTION WITHOUT CHANGES		12,810
ONE-PIECE 10 NI STEEL BULKHEADS	-29	
MAKE GUSSETS AT YF 120 PART OF BULKHEAD		
INTEGRATE FLANGE SUPPORT FTGS INTO BULKHEADS	-20	
RELOCATE FUEL PUMPS FROM LOWER PLATE	-15	
ONE-PIECE BONDED FORWARD BULKHEAD WEB (SIMILAR TO AFT) WITH SAME STIFFNESS	-20	
INTEGRATE WING SWEEP ACTUATOR BACKUP FITTINGS AND CLOSURE RIB WEB	-30	
ONE-PIECE LOWER BONDED PANEL	-25	
SUBTOTAL POTENTIAL WEIGHT/COST CHANGES	(-159)	
PROJECTED PRODUCTION BOX WEIGHT		12,651

Table 2.1.2-VII "NO-BOX" BOX MATERIALS BREAKDOWN

	PERCENT GD DESIGNED	POUNDS	PERCENT TOTAL	
2024 ALUMINUM	6.34	742.8	5.87	
7050 ALUMINUM	7.76	843.1	6.66	
OTHER ALUMINUM	1.97	214.3	1.69	
	(16.57)	(1800.2)	(14.22)	ALUMINUM
6-4 TITANIUM	24.25	2635.2	20.81	
COMM PURE TITANIUM	.29	31.8	.25	
	(24.54)	(2667.0)	(21.06)	TITANIUM
10 NICKEL STEEL	51.13	5556.3	43.89	
OTHER STEEL	5.94	645.5	5.10	
	(57.07)	(2501.8)	(48.99)	STEEL
MISCELLANEOUS	1.82	198.3	1.57	
GD REDESIGNED	(100.00)	(10867.3)	(85.84)	
ROCKWELL DESIGNED		1792.7	14.16	
TOTAL		(12660.0)	(100.00)	

2.1.3 Fatigue and Fracture Analysis

The fatigue and fracture analysis tasks during this reporting period were directed toward the up-dating of preliminary fatigue and fracture analyses to reflect NBB-5-4 math model stresses, review and revision of the preliminary version of the test plan (FZS-219) for the full-scale test program to reflect the updated analyses, initiation of the credible option test program as applicable to the fatigue and fracture section, and disposition of QAR's (Quality Assurance Reports) during manufacturing of fracture critical parts.

2.1.3.1 Fatigue Analysis

Fatigue analyses are currently in progress using updated math model stresses at control points in the WCTS. Control points were selected on the basis of the stress/load state of individual sections of the wing carrythrough structure. Control point locations are shown in Figure 2.1.3-1. These areas are primarily tensile-loaded elements of the WCTS established on evaluations of the finite-element math model stresses, stress analysis results, and details of specific local section geometry. Stress distributions considered for fatigue analysis include the five basic fatigue mission segments (Conditions AS 2000, AS 10000, AS 5000, AS 9000, and AS 7000) representing post-take-off, TFR, prelanding, climb-cruise-refuel, and ground/taxi. Final fatigue analysis results are not complete and therefore will not be covered herein.

2.1.3.2 Fracture Analysis.

Crack growth analyses based on linear elastic fracture mechanics were conducted at the six control points (Reference Figure 2.1.3-1) to determine the crack growth characteristics of the WCTS. Analyses were conducted in accordance with the AMAVS fracture control plan (FZM-6068) requirements using the NBB-5-4 math model gross section principal stresses. An initial crack length of 0.15 inches was assumed to exist in the most unfavorable orientation with respect to the applied stresses and material properties.

Gross section stresses, critical crack length, and type of crack used at each control point are summarized in Table 2.1.3-I. Crack growth rates as a function of the baseline aircraft flights are summarized for the six control points in Figures 2.1.3-2 thru 2.1.3-7.

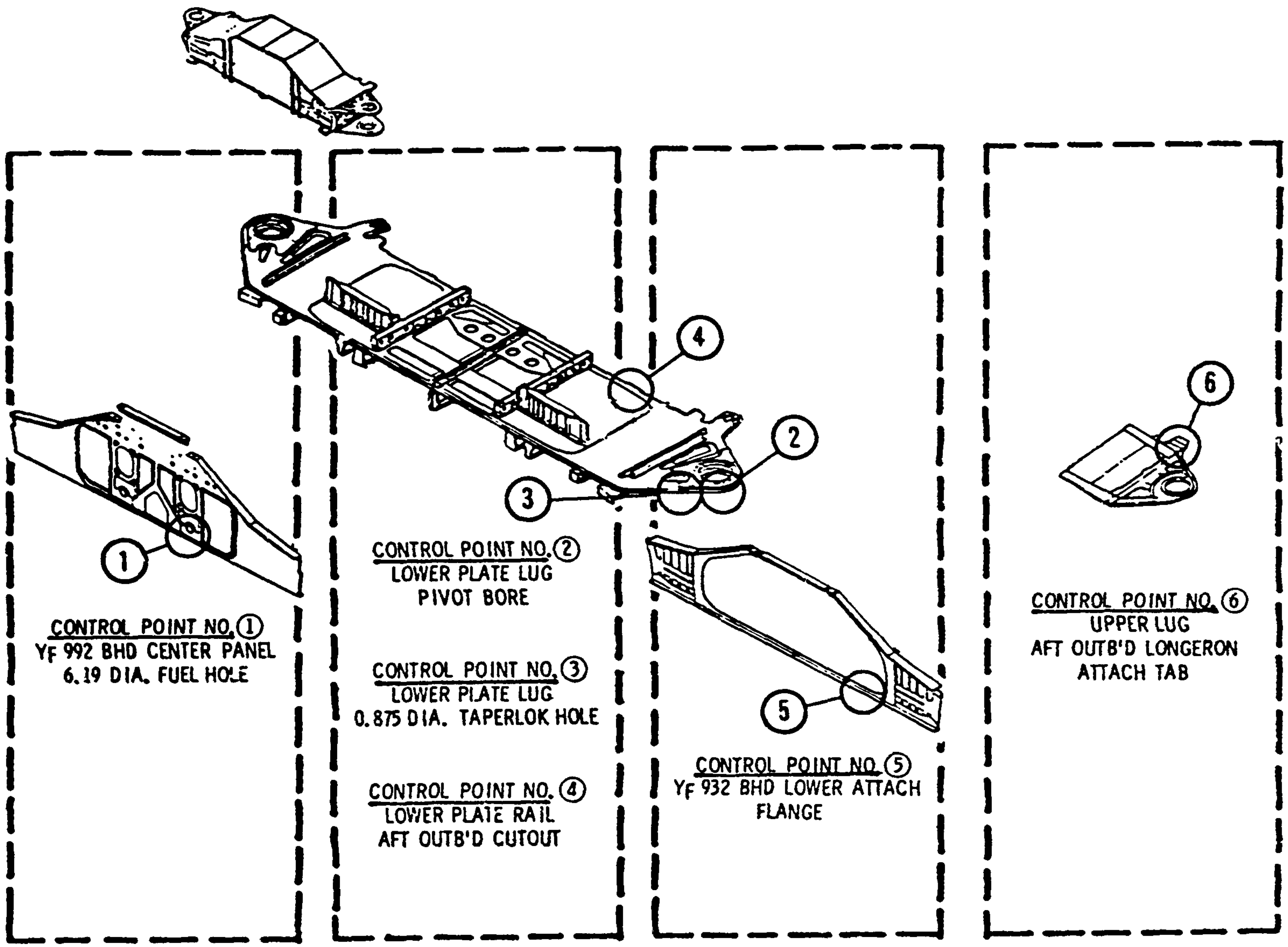


Figure 2.1.3-1 AMAVS WCTS FATIGUE AND FRACTURE ANALYSIS CONTROL POINT LOCATIONS

Table 2.1.3-I AMAVS WCTS CONTROL POINTS GROSS SECTION RESSES

CONTROL POINT	NO. 1 Y_F 992 BHD - INBD. FUEL TRANSFER HOLE, X_F 29					NO. 2 LOWER PLATE LUG - PIVOT BORE					NO. 3 LOWER PLATE LUG - 0.875 DIA. TAPER-LOK HOLE				
Condition	AS2000	AS10000	AS5000	AS9000	AS7000	AS2000	AS10000	AS5000	AS9000	AS7000	AS2000	AS10000	AS5000	AS9000	AS7000
Gross Section Ult. Stress, Ksi	64.00	36.56	61.69	58.88	11.94	60.46	108.85	68.92	65.02	0	93.59	130.10	82.10	87.02	-13.14
Spectrum, Max Gross Stress, Ksi	36.32	15.65	37.90	28.00	4.84	34.31	46.61	42.34	20.92	0	53.12	55.71	50.43	43.39	- 5.33
Gross Section Limit Stress, Ksi	42.69	24.39	41.15	39.27	7.69	40.33	72.60	45.97	43.37	0	62.42	86.78	54.76	58.04	- 8.76
Allow. Stress, Ksi	80					131					150				
Initial Crack Size, Inches	0.15					0.15					0.15				
Critical Crack Size, Inches	0.81					1.63					1.82				
Crack Type	Corner Crack					Corner Crack					Cracked Hole				

CONTROL POINT	NO. 4 LOWER PLATE - AFT OUTB'D CUTOUT					NO. 5 Y_F 932 BHD. - LOWER ATTACH FLANGE					NO. 6 UPPER LUG - AFT OUTB'D LONGERON ATTACH.				
Condition	AS2000	AS10000	AS5000	AS9000	AS7000	AS2000	AS10000	AS5000	AS9000	AS7000	AS2000	AS10000	AS5000	AS9000	AS7000
Gross Section Ult Stress, Ksi	126	61	122	116	-21	90	77	69	86	-22	23.91	93.13	13.64	28.53	19.99
Spectrum, Max Gross Stress, Ksi	71.52	26.12	74.94	55.17	-8.52	51.08	32.97	42.39	40.90	-8.92	13.57	39.88	8.38	13.57	8.11
Gross Section Limit Stress, Ksi	84.04	40.69	81.37	77.37	-14.01	60.03	51.36	46.02	57.36	-14.67	15.95	62.12	9.10	19.03	13.33
Allow. Stress, Ksi	150					150					150				
Initial Crack Size, Inches	0.15					0.15					0.15				
Critical Crack Size, Inches	1.16					0,93					1.67				
Crack Type	Cracked Hole					Cracked Hole					Cracked Hole				

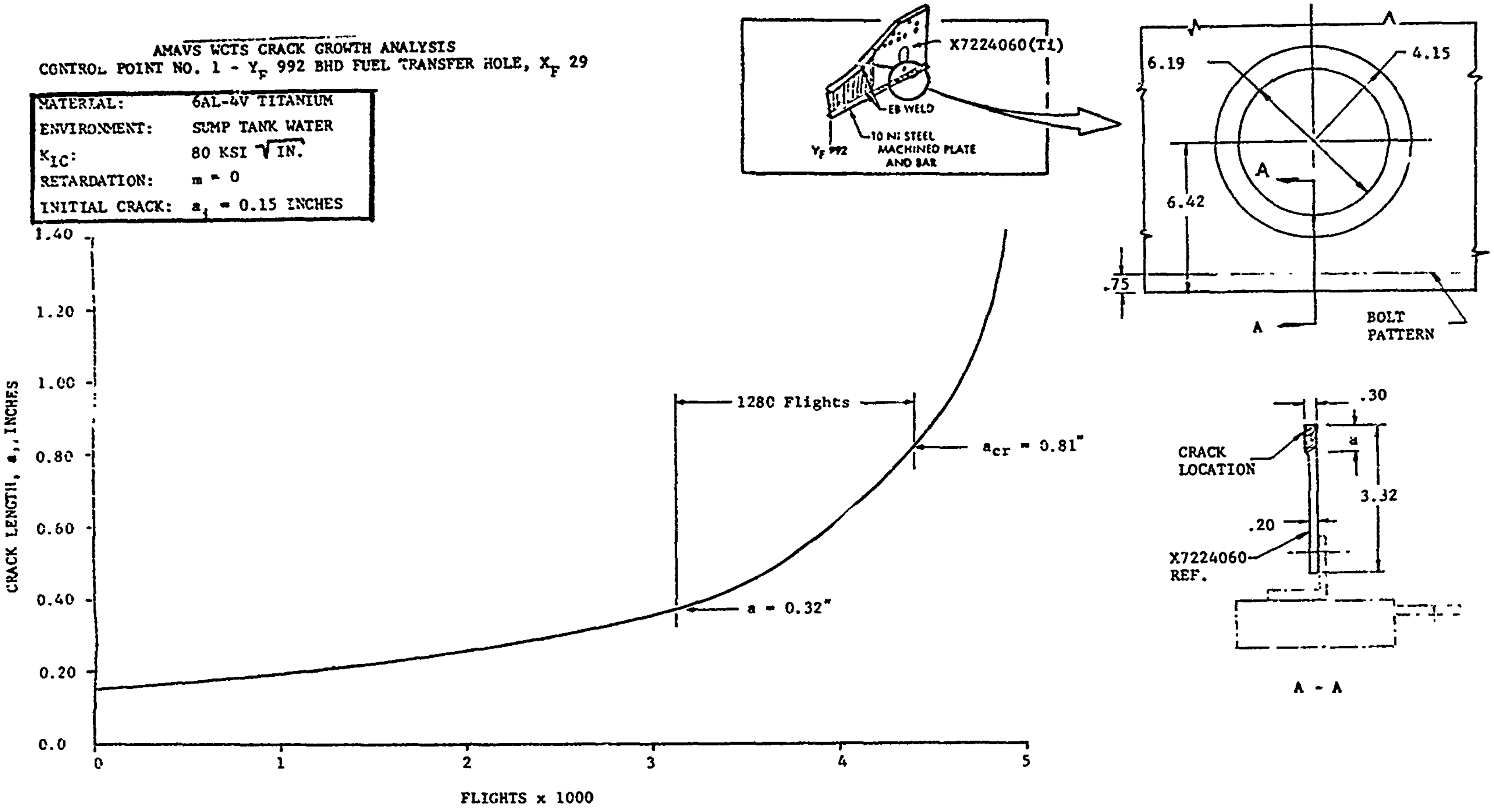


Figure 2.1.3-2 AMAVS WCTS CRACK GROWTH ANALYSIS CONTROL POINT NO. 1 - Y_F 992 BHD FUEL TRANSFER HOLE, X_F 29

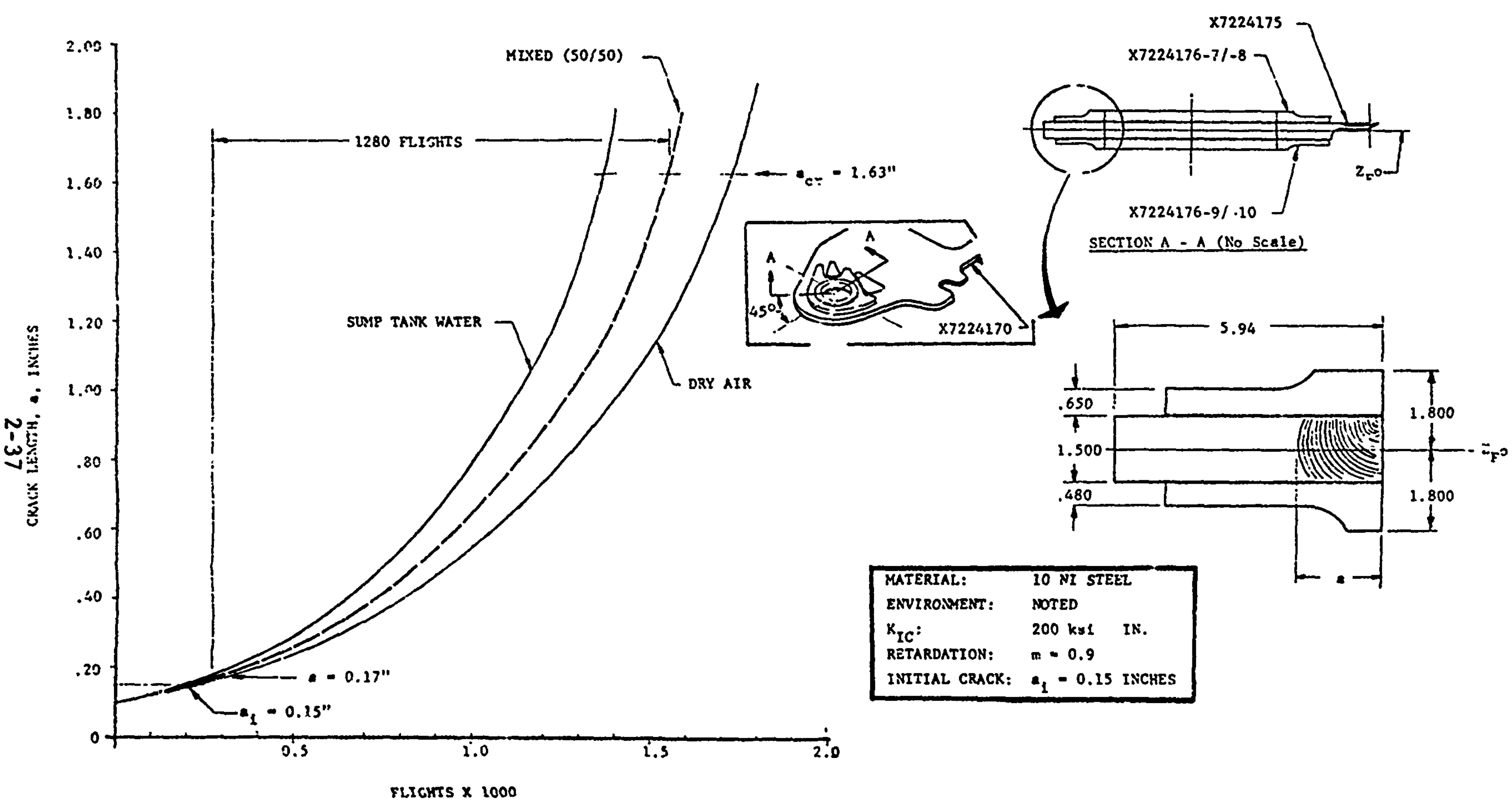


Figure 2.1.3-3 AMAVS WCTS CRACK GROWTH ANALYSIS CONTROL POINT NO. 2 - LOWER PLATE LUG, PIVOT BORE

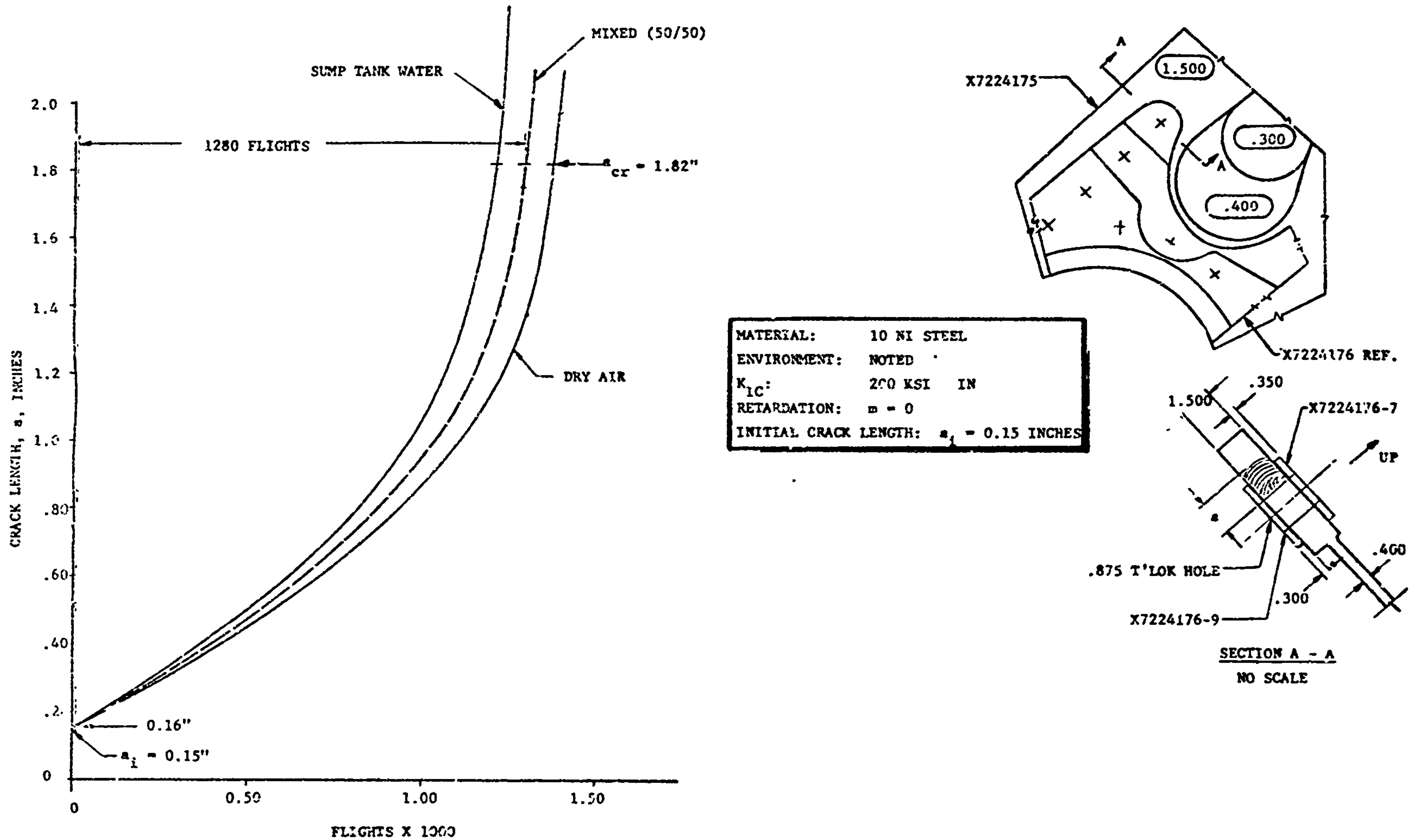


Figure 2.1.3-4 AMAVS WCTS CRACK GROWTH ANALYSIS CONTROL POINT NO. 3 - LOWER PLATE LUG, 0.875 DIA. TAPERLOK HOLE

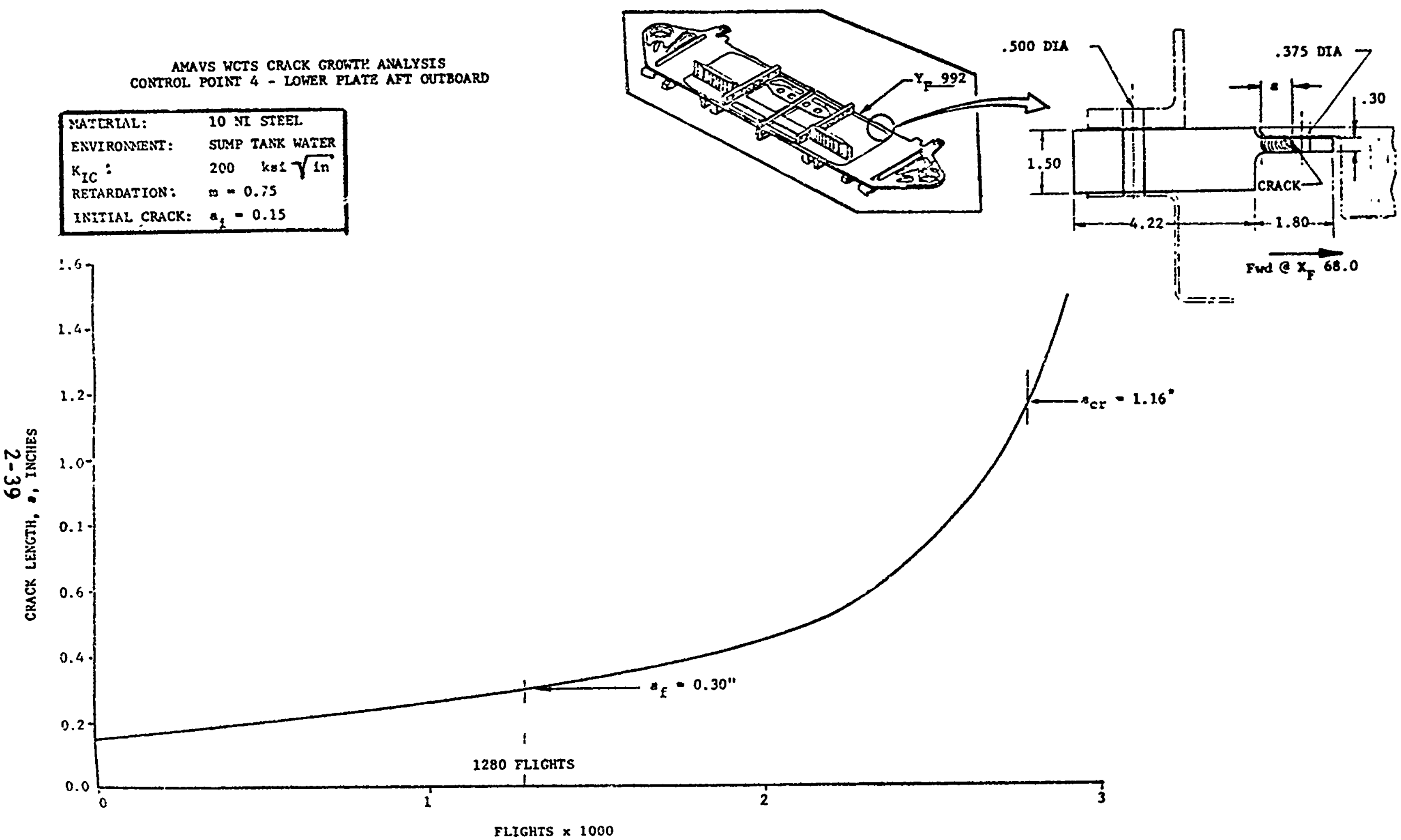
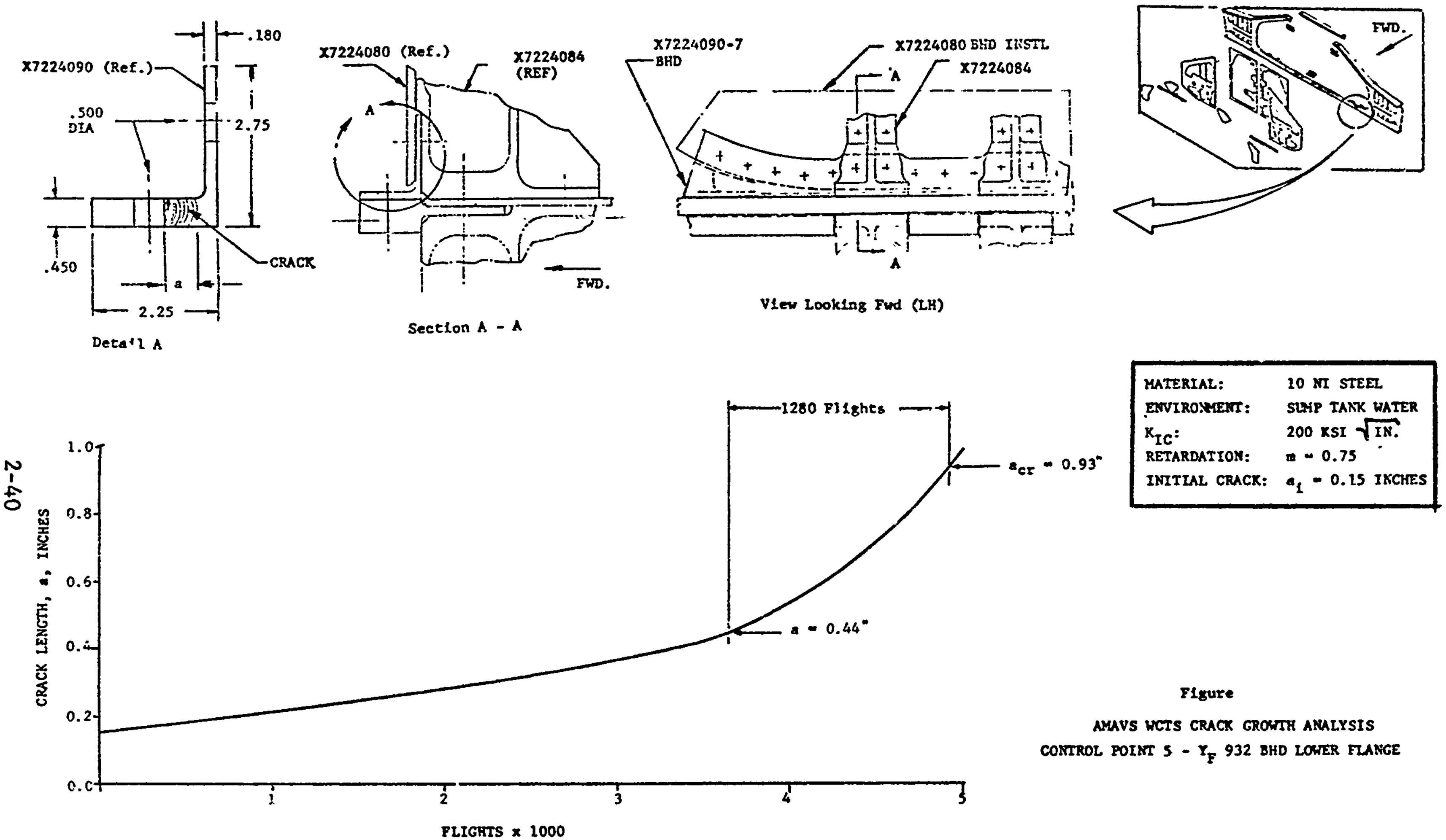


Figure 2.1.3-5 AMAVS WCTS CRACK GROWTH ANALYSIS CONTROL POINT NO. 4 - LOWER PLATE AFT OUTBOARD



Figure

AMAVS WCTS CRACK GROWTH ANALYSIS

CONTROL POINT 5 - Y_F 932 BHD LOWER FLANGE

Figure 2.1.3-6 AMAVS WCTS CRACK GROWTH ANALYSIS CONTROL POINT NO. 5 - Y_F 932 BHD LOWER FLANGE

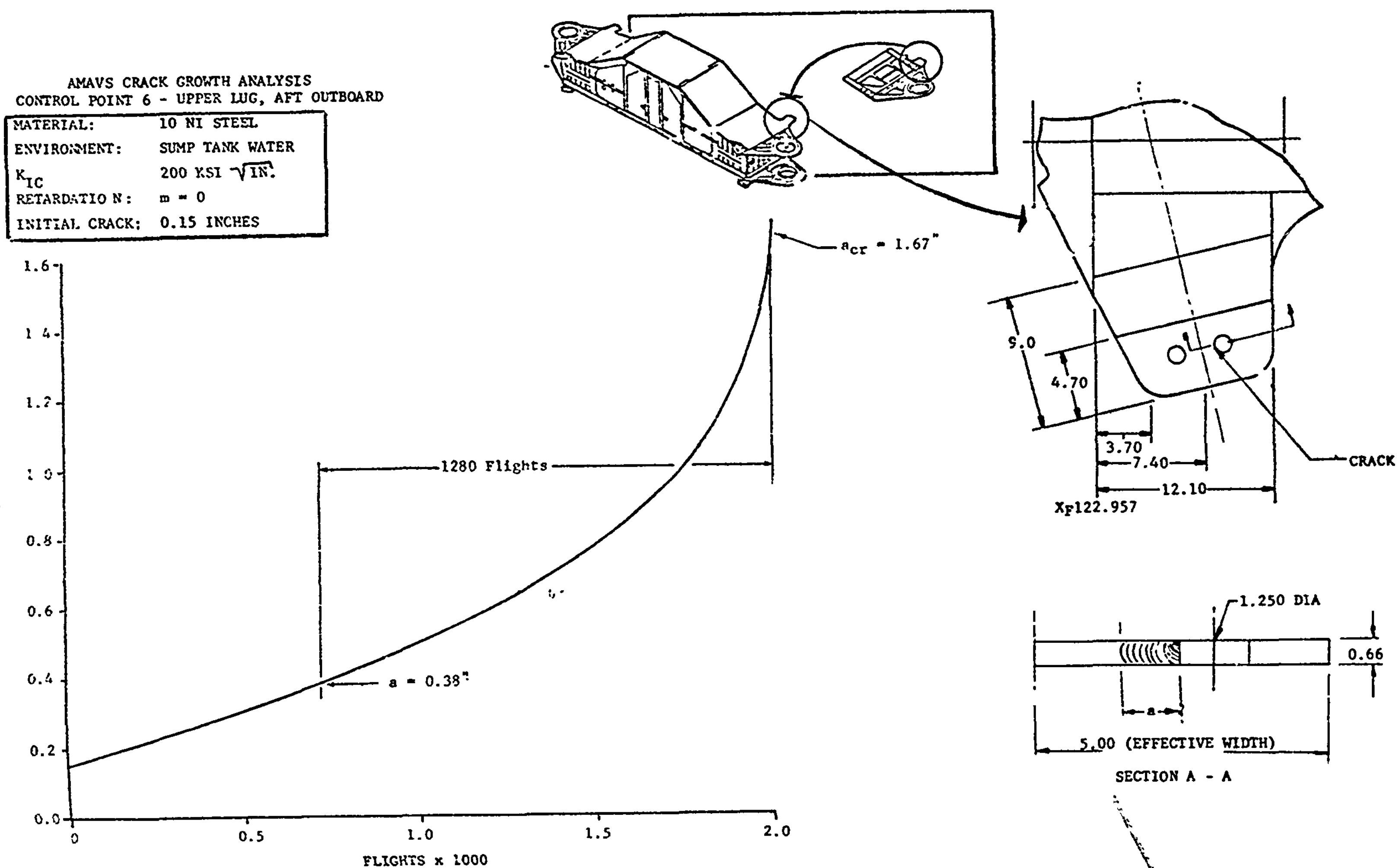


Figure 2.1.3-7 AMAVS WCTS CRACK GROWTH ANALYSIS CONTROL POINT NO. 6 - UPPER LUG, AFT OUTBOARD

2.1.3.3 Credible Option Testing/Fracture Mechanics Specimens

Preparation of (15) test specimens for a series of tests to verify the crack growth analysis procedures used during the design of the WCTS continues. These tests are primarily to verify the mechanical and geometric properties affecting crack growth from loaded and unloaded fastener holes and are supplementary to the crack growth tests in the materials evaluation program.

Fourteen of fifteen specimens are 10 Ni steel. The variables under study are fastener size, Taper-lok vs. straight shank, protrusion level, material thickness, bearing/tension ratio, stress level effect and compression load effects.

The other test is on beta annealed 6Al-4V titanium using the most representative thickness and fastener size, 0.300 and 0.375-inches, respectively. Two of six loaded hole specimens (603FTB064) have been flawed, assembled, and sent to the Engineering Test Lab for testing. Eight of nine unloaded hole specimens (603FTB063) have been precracked and are ready for fastener installation. Initial flawing of holes in these specimens was accomplished by the diamond abrasive/0.003" stainless wire system.

2.1.4 Materials Engineering

2.1.4.1 Material Procurement Activities

The 10 Nickel steel 3" plates for the upper lug were received on dock at General Dynamics 31 July 1974 which completed the receipt of all 10 Nickel steel required for the AMAVS program. United States Steel's test report showed that the parent plate test properties at both ends did not meet specification requirements for yield and Charpy impact strengths. The three pieces ordered were cut from a single parent plate which was solution treated and aged as a single plate with test specimens removed from each end of the plate labeled as A and B ends.

In order to obtain additional data on the upper lug material, tests were conducted at General Dynamics. Two specimens in the longitudinal (L) direction, two in the long transverse (LT) direction, and two Charpy specimens were removed from each of the three pieces identified as C-1-9, C-1-10, and C-1-11. These results, along with the U.S. Steel test results are compared with Specification FMS-1111 requirements in Table 2.1.4-I. General Dynamics test results show that the yield strength is very nearly equal to specification requirements but impact strength is low. A decision was made that the material was acceptable

Table 2.1.4-I SPECIFICATION FMS-1111 VS U.S. STEEL & GENERAL DYNAMICS TEST DATA

10 Nickel Steel for AMAVS Upper Lug

	UTS (KSI)	YTS (KSI)	Elong (% in 2")	Red. Area (%)	Charpy Impact @ $0^{o}F$ (ft-lbs) Avg.	Charpy Impact @ $0^{o}F$ (ft-lbs) Min.
General Dynamics Spec. FMS-1111 (Min.)	190	175	12	60	-	50
U.S. Steel Test Report[1]						
"A" End	204.5	172.5	16.25	64.25	45.3	41
"B" End	208.5	171.5	15.75	63.50	45.7	43
General Dynamics Test Data						
Avg.[2]	209.3	179.9	14.8	62.6	47.2[3]	42
Min.	206.5	174.4	14.0	59.0		

NOTES:
1. U.S. Steel Test Report shows tensile properties as average.
2. Avg. of 12 specimens - 6L Direction and 6LT Direction
3. Avg. of 6 specimens

for use as the "Upper Wing Carrythrough Structure Pivot Lug,", drawing X7224011-7/-8.

2.1.4.2 Warpage of 10 Nickel Steel During Machining

Both the left and right hand "Upper Wing Carrythrough Structure Pivot Lugs" experienced considerable warpage during machining. As noted in paragraph 2.1.4.1, the material for these parts were two of three pieces rolled by U.S. Steel as a single 3" thick plate, solution treated, aged, and then cut into three pieces. After cutting, it was bent approximately 8-1/2° at a temperature of 600°F to 700°F followed by slow cooling. The reason for the forming operation was to minimize metal removal during machining. Unfortunately, during machining the angle relieved itself by approximately 2° and some warpage occurred in the tapered skirt area.

Both parts were cold formed back to the proper plane and angle and thoroughly magnetic particle inspected with supplemental ultrasonic inspection. After forming and inspecting the parts were shot peened on the tension side (upper surface) to an almen intensity of 12 to 14 to relieve the tensile stresses by applying a small amount of compression stresses to the extreme fiber.

The procedure for minimizing this problem on production parts would be to forge the part to shape allowing only for machine clean-up then solution treat and age the forging. Only the quench stresses not relieved by a 6 to 8 hour age at 950°F would remain.

2.1.4.3 GTA Weld Repairs

A preliminary study of the weld repairability of fully heat-treated (Condition STA) 10 Nickel steel has been conducted. Two plates in the STA condition were welded together using the standard weld schedule used for the X_F932 and X_F992 bulkhead GTA welds. The results of tests compared with vendor and General Dynamics test data on the parent plate and with specification minimums for plate material are shown in Table 2.1.4-II. As a result of these tests, an as-welded weld repair was made on a part of the AMAVS CTB as described in paragraph 2.1.4.4.

2.1.4.4 10 Nickel Steel Machining Defect

During the inspection, after machining of X7224090-7 Y_F 932 bulkhead, an unusual defect was noted. It appeared that a small inclusion had been opened to the surface during machining. NDI records of the 0.80 inch thick plate where the defect was found did not indicate any type of ultrasonic indications.

Table 2.1.4-II 10 NICKEL STEEL GTA WELD REPAIR CAPABILITY

HEAT TREATMENT AND CONDITION	SPECIMEN NUMBER	TYPE TEST	YTS (KSI)	UTS (KSI)	% ELONG. IN 1.0"	RED. AREA (%)	FAILURE
STA and Welded - No Subsequent Treatment	W1	Tensile	175.8	194.7	14	62.2	HAZ
	W2		174.3	194.6	14	61.1	HAZ
	W3		168.2	191.6	14	59.3	HAZ
	C1	Charpy @ 0^oF	66 Ft-Lbs				WELD
	C2		68 Ft-Lbs				WELD
	C3		70 Ft-Lbs				WELD
STA - Specimens from Parent Welded Plate	L1	Tensile	182.7	195.2	17	69.2	PM
	L2		179.8	194.7	16	70.4	
	T1		178.8	191.9	18	69.5	
	T2		179.8	194.7	16	69.3	
Design Allowable and Minimum Specification Requirements	--	Tensile	175.0	190.0	15	65.0	
		Charpy @ 0^oF	60 Ft-Lbs				

During efforts to polish the defect back to solid base metal it was noted that the center of the defect was much harder than the surrounding material. To determine, if possible, the cause and nature of the defect it was trephined out, mounted and examined metallurgically. Figure 2.1.4-1 is a photomicrograph of the inclusion. Microhardness readings were taken in the base metal which convert to a Rockwell R_C = 45 and in the inclusion which was in excess of R_C = 70. These readings, plus an examination of the flow lines about the inclusion proves that this is the point of a carbide machining tool that broke during machining and penetrated into the plate.

A weld repair was made to repair the hole left by the trephining operation. Based on the location of the repair with regard to structural criticality the weld repair was left in the "as-welded" condition with no additional heat treatment. A thorough inspection including magnetic particle, X-ray and ultrasonic was made after welding with complete acceptability.

2.1.4.5 Evaluation of Murdock Electron Beam Weldments

As reported in the Third Interim Report AFFDL-TR-74-98 Murdock Machine and Engineering Company of Texas, a Division of Lockheed Corporation, welded the AMAVS X7223941 MLG Drag Brace Fitting. The weldments were performed per their specification LCP74-2022B and were certified and met all specification requirements. Certifications and test results are on file at General Dynamics.

The weldments were also evaluated by General Dynamics to determine tensile, fatigue, and stress corrosion properties. The weld schedules, the number of specimens, and their location in the weldment are reported in AFFDL-TR-74-98. In addition, the tensile data is also reported in that report.

The fatigue data compared with other fatigue data on both EB and diffusion bonded 6Al-4V titanium are shown in Table 2.1.4-III. It can be noted that the small ultrasonically detected defects had no apparent effect. Specimen MR 2-5 was intended to be a sound specimen but apparently something slipped during layout, machining or the inspection report since weld porosity originated the failure. MR 1-3, 2-4 and 2-7 had no porosity in the fracture with all failure started from parent metal. Note also the comparison with other data on flat EB welded specimens and round diffusion bonded specimens. Apparently the flat specimens originally reported in FZM-6148 had a higher K_t than the indicated $K_t = 1$.

(Mag = 200X)

Figure 2.1.4-1 PHOTOMICROGRAPH OF INCLUSION FROM X7224090-7 BULKHEAD

Note flow lines and shape of carbide tool tip

Table 2.1.4-III

AXIAL FATIGUE PROPERTIES OF ELECTRON BEAM WELDED
TI-6AL-4V BETA ANNEALED TITANIUM 1.4" THICK PLATE
TRANSVERSE WELD - AS WELDED CONDITION - $K_T = 1$, $R = 0.1$

Ultrasonic Indication*	Spec. No.	Max. Fatigue Stress, KSI	Cycles to Fail X1000	Location of Origin
None	MR2-2	110	164.6	S-PM
None	MR2-6		74.8	S-PM
75%	MR2-5		169.8	IP-W
	AVG.		136.4	
None	MR1-1	80	784	S-PM
None	MR1-2		229	S-PM
None	MR2-1		2661	I-PM
100%	MR1-3		1171	I-PM
50%	MR2-4		342	S-PM
100%	MR2-7		1305	S-PM
	AVG.		1082	
Reference 1 - EB welded - flat		110	14.6	
" " "		80	256.6+	
Reference 2 - Diffusion Bonded Round		110	249	
" "		80	1095	

Notes:

a. *Ultrasonic indications relative to 2/64" flat bottom hole.
b. EB welded by Murdock Machine & Engr. Co.
c. Longitudinal grain direction in parent metal
d. 0.357" minimum test dia.
e. RMI Heat 3004600
f. S-surface, IP-international porosity, I-internal, PM-parent metal, W-weld zone.

References:

1. Porter, A. C., "Advanced Metallic Air Vehicle Structure Program - Material Property Data Test Report - Phase II," FZM-6148A, 13 July 1972, p. 221.

2. Regalbuto, John A., "Nondestructive Testing of Diffusion Bonded Titanium Alloys For Engine and Airframe Components," FZM-6232, January 1974, p. 77.

Two WOL $K_{I_{scc}}$ specimens which were to be loaded at a K_i of approximately 60 KSI $\sqrt{\text{inch}}$ and 55 KSI $\sqrt{\text{inch}}$ and exposed to STW for 1000 hours were tested by loading to failure after exposure and load-deflection curves obtained. Examination and measurements of the prior fatigue cracks show they were loaded to a K_i of 5.14 and 43.8 KSI $\sqrt{\text{inch}}$ respectively and therefore the $K_{I_{scc}}$ threshold level is in excess of 51.4 KSI $\sqrt{\text{inch}}$ because no crack growth occurred during the 1000 hour exposure to STW. Data for these two specimens and the third stand-by specimen tested for fracture toughness is as follows:

Specimen No.	K_i in STW KSI $\sqrt{\text{inch}}$	Test Time Hours	K_Q KSI $\sqrt{\text{inch}}$	Remarks
MR1-5	51.4	1000	96.9	No Crack Growth Failed in PM
MR2-3	43.8	1000	103.0	No Crack Growth Failed in PM
MR1-4	--	None	87.3	Failed in EB Weld

The 1.0 inch thick specimens used in these tests are valid for a K_{I_c} of about 65 KSI $\sqrt{\text{inch}}$, therefore the values obtained are reported as K_Q.

2.1.4.6 Evaluation of Electron Beam Weldments in 10 Nickel Steel

The evaluation of the 10 Nickel (HY 180) steel electron beam weldments reported in AFFDL-TR-74-98 has been completed. That report showed the weld schedules, NDI results, specimen layout, the results of tensile tests (transverse and longitudinal), and the results of Charpy tests at 0°F.

The results of the da/dN tests in dry air and STW are shown in Figure 2.1.4-2. The tabular data will be reported in next issue of the Materials Data Report.

The results of the fracture toughness testing are shown in Table 2.1.4-IV. Photos of the fracture faces of the various specimens are shown in Figure 2.1.4-3. Figure 2.1.4-4 shows a side view of the fracture of specimens H93-1 and H93-2 and shows that the toughness of the weld joint is fairly uniform in all areas of the weld. This photo was taken perpendicular to the crack path and etched to show the weld and HAZ areas.

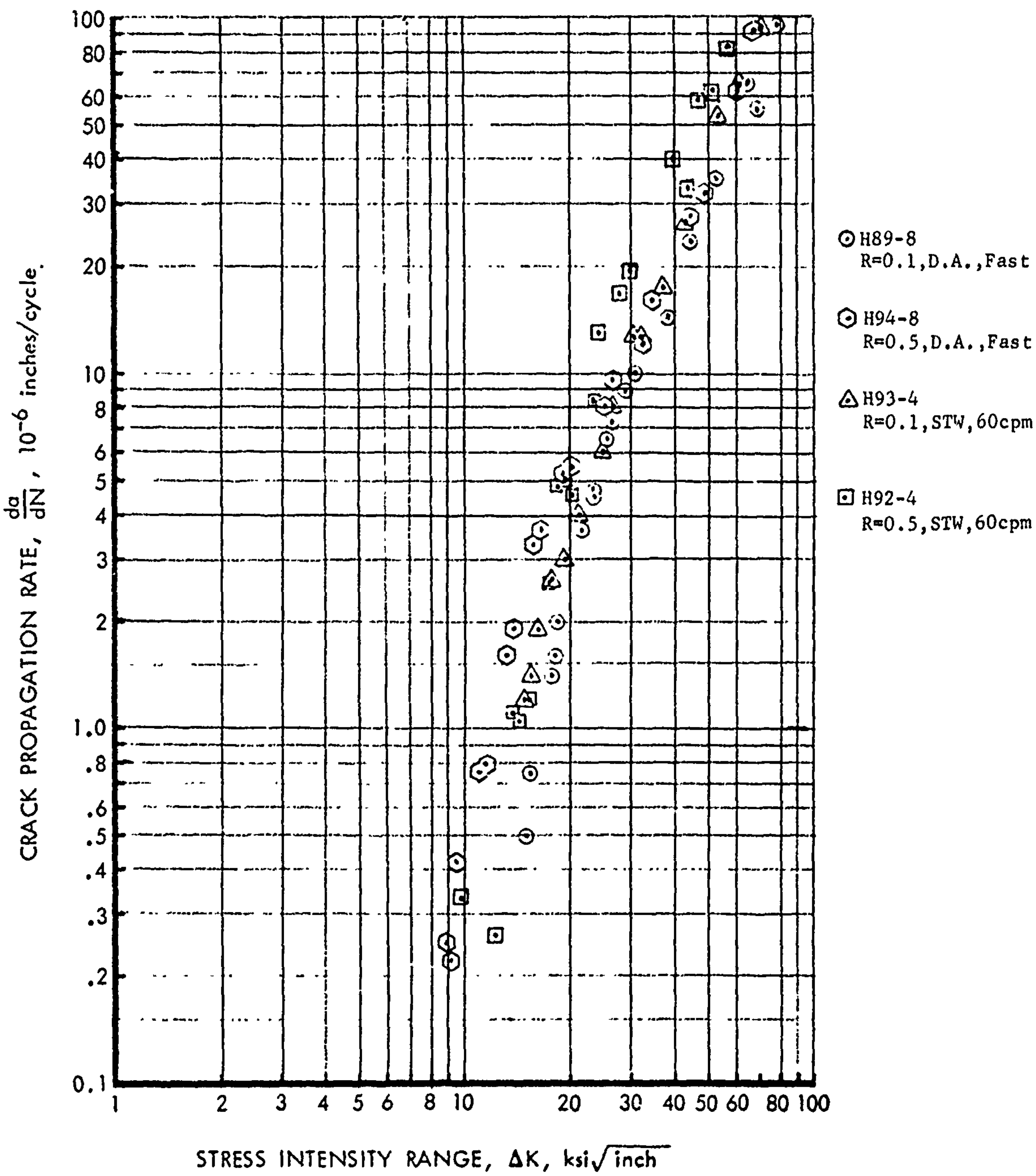


Figure 2.1.4-2 EB-WELDED, 10 NI STEEL ALLOY, CRACKLINE AT ℄ OF WELD

Table 2.1.4-IV 10 NICKEL STEEL ELECTRON BEAM WELDED FRACTURE TOUGHNESS TEST DATA

SPECIMEN NO.	P_{MAX} (LBS)	P_Q (LBS)	B (INS)	W (INS)	a (INS)	K_Q KSI $\sqrt{IN}$	P_{MAX}/P_Q	R_{SC}*
H90-1	74,600	60,000	1.481	3.988	1.913	184	1.24	1.32
H90-2	70,400	58,000	1.485	4.0045	1.930	178	1.21	1.23
H92-1	69,800	63,000	1.450	4.020	2.014	202	1.11	1.40
H92-2	72,900	60,000	1.442	3,990	2.014	200	1.21	1.52
H93-1	80,000	66,550	1.491	3.992	1.974	190	1.20	1.50
H93-2	82,100	60,500	1.481	4.002	1.972	186	1.35	1.67

*R_{SC} (Ref. E399-72) - Specimen strength ratio when $P_{MAX} \div P_Q > 1.10$

$R_{SC} = 2\ P_{MAX}\ (2\ W + a) \div B\ (W - a)^2\ \sigma_{ys}$

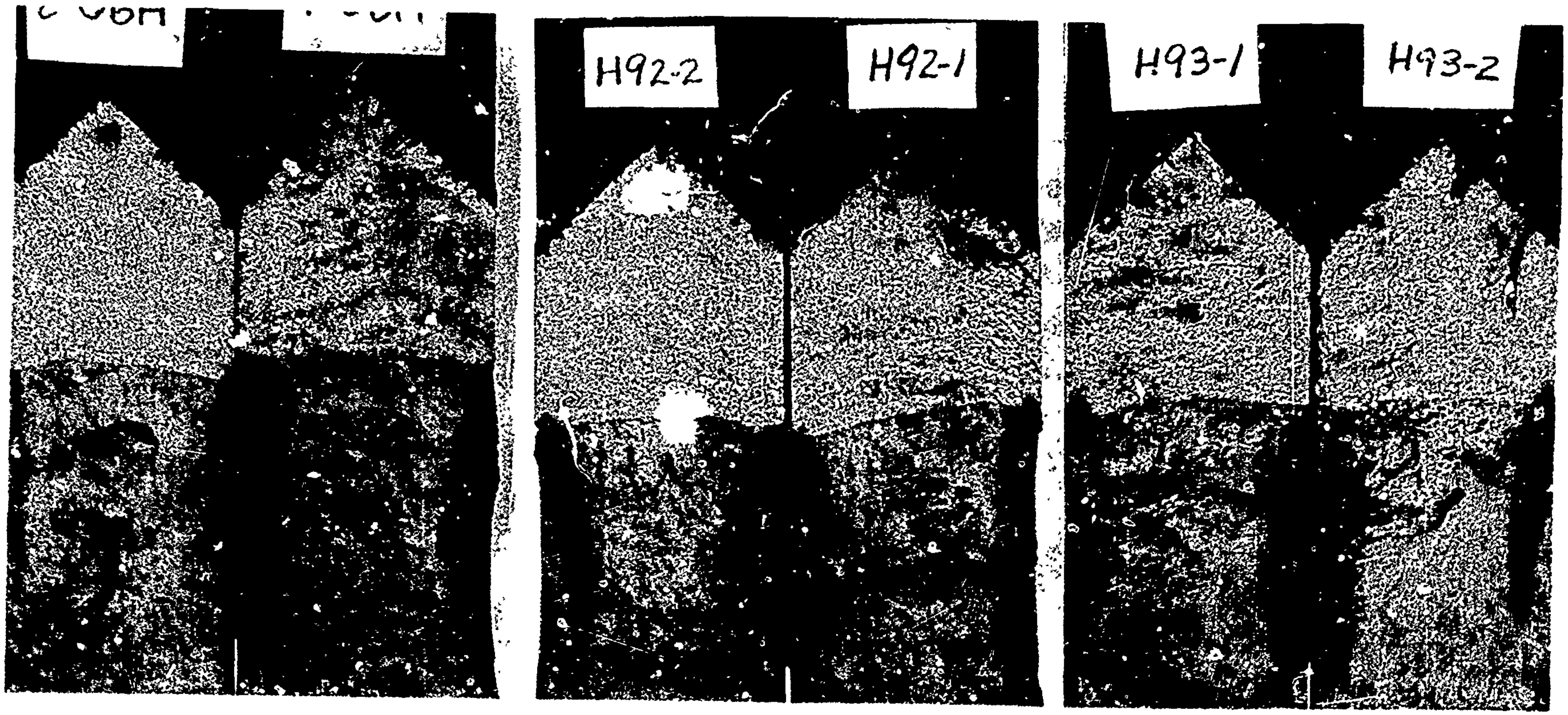


Figure 2.1.4-3 FRACTURE FACE OF FRACTURE TOUGHNESS SPECIMENS

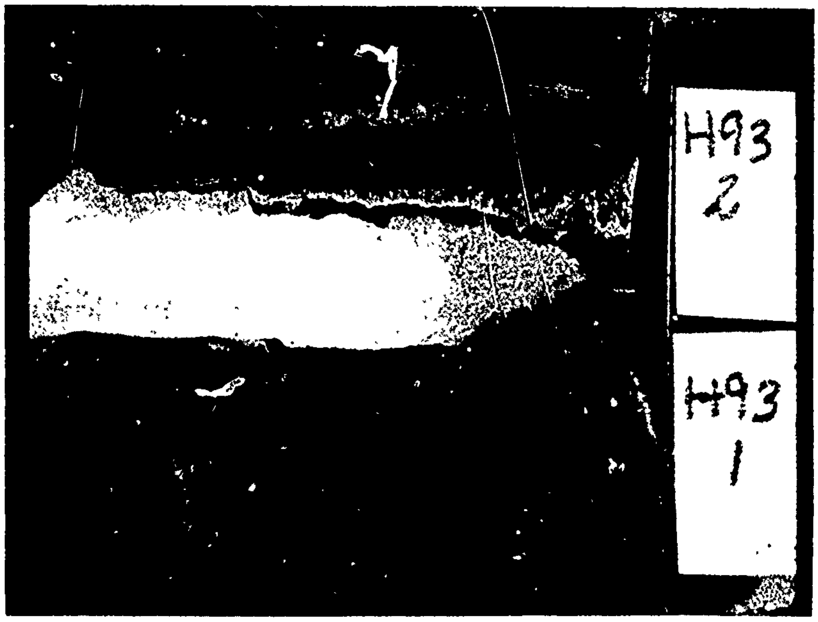


Figure 2.1.4-4 WELD FRACTURE LINE OF FRACTURE TOUGHNESS SPECIMENS ELECTRON BEAM WELDED (2.5 MAG)

The results of the fatigue test are included in Table 2.1.4-V. A comparison of this test data with base metal and GTA welds is shown in Figure 2.1.4-5. The EB welds appear to be at least equal to GTA welds in fatigue. Note that H94-1 and H94-2 were retested at a higher stress level and did have slightly longer fatigue life than H94-6 which had no prior testing.

The KI_{scc} testing has also been completed. Two specimens, H91-16 and H89-7, were exposed for 1584 hours, and specimen H90-3 was exposed for 1032 hours. Figure 2.1.4-6 is a photograph of the fractures of the three specimens. Only specimen H91-16 shows any signs of stress corrosion crack extension. The fact that the crack front for H91-16 was not straight, as can be noted in the photograph, invalidates this specimen. The actual K_i for each of these specimens was as follows:

Specimen No.	K_i (KSI $\sqrt{\text{inch}}$)
H91-16	110 (invalid)
H89-7	105.1
H90-3	108.7

The crack extension for H91-16 averaged 0.238 inch, from an average length of 2.086 inches to an average length of 2.248 inches. Calculations based on the extended crack length shows the specimen K_i, at the time the test was stopped, to be 103 KSI $\sqrt{\text{inch}}$. It appears then that the KI_{scc} threshold level in the EB welded 10 Nickel exceeds 100 KSI $\sqrt{\text{inch}}$ but is probably lower than that for the base metal of GTA welds.

2.1.4.7 Credible Option Test Planning and Test Results

Addendum No. 1 to FZM-5999, "Material Test Plan Design and Development Update AMAVS Program," dated 5 August 1974 with Errata No. 1 dated 25 November 1974 has been issued depicting the additional test data to be generated during Phases III and IV of the AMAVS program. This data includes the Murdock electron beam weldments and the 10 Nickel steel electron beam weldment tests previously included in this report. In addition, evaluations of both 6Al-4V beta annealed titanium and 10 Nickel steel procured to AMAVS specifications are being conducted. The scope of this program is shown in Section 2.2.1 of this report.

Table 2.1.4-V

AXIAL FATIGUE PROPERTIES OF
ELECTRON BEAM WELDED 10 NICKEL STEEL

$K_T = 1, R = 0.1$

SPECIMEN NO.	MAX STRESS (KSI)	CYCLES (KC)
H94-1	100	10,920 NF
-2	100	10,734 NF
-3	100	12,081 NF
-4	100	1,976
-5	100	15,480 NF
-6	130	78
-1 (Retest)	130	216
H94-2 (Retest)	130	132

NF = No Failure

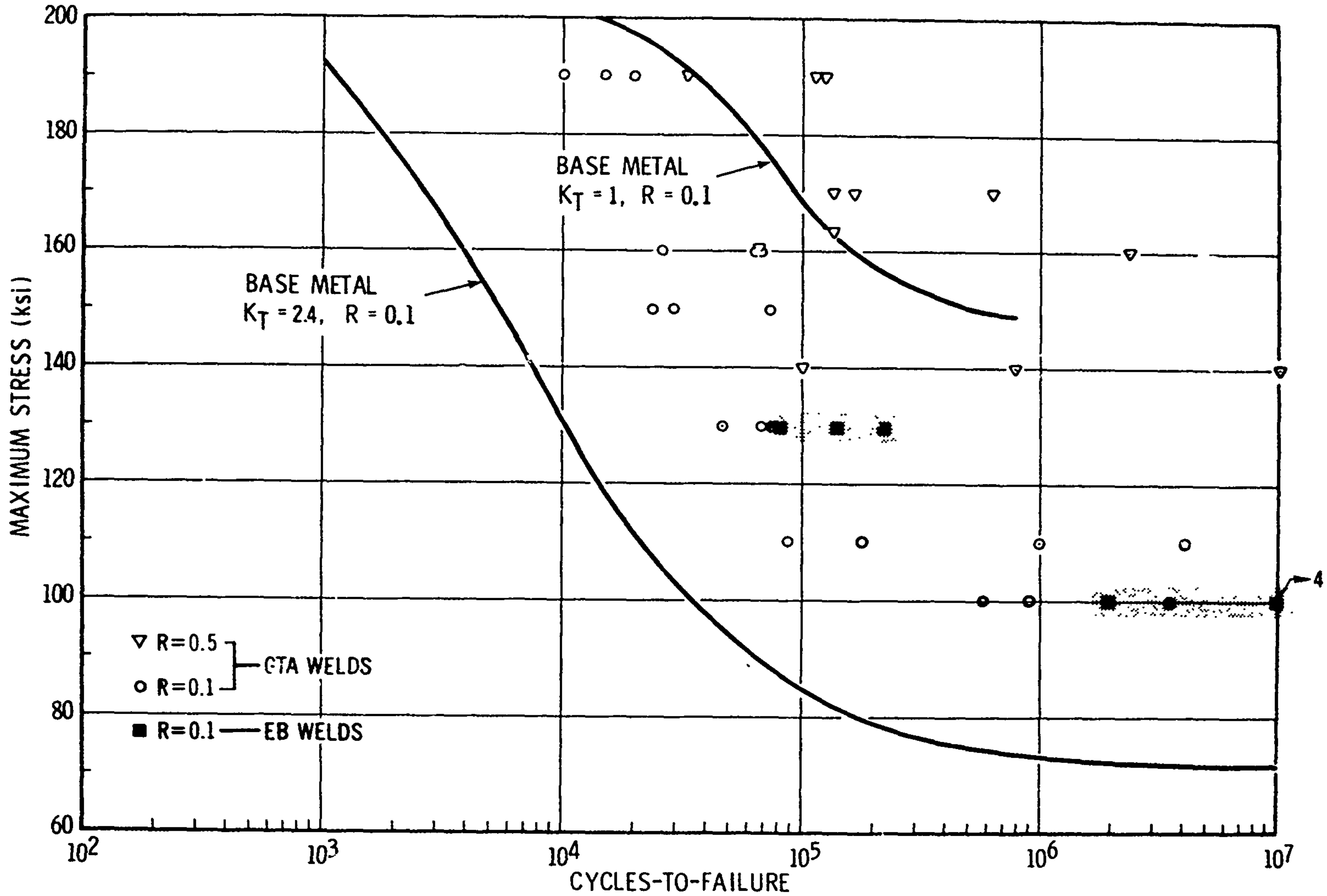


Figure 2.1.4-5 FATIGUE DATA SUMMARY - 10 NICKEL STEEL WELDMENTS

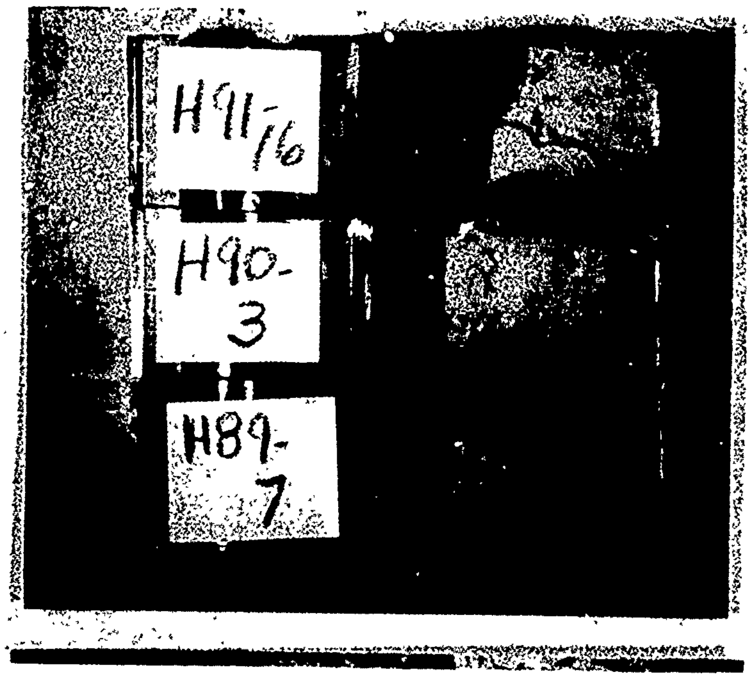


Figure 2.1.4-6 FRACTURE FACE OF EB WELD $K_{I_{scc}}$ SPECIMENS

The material test program is being accomplished on 6Al-4V beta annealed titanium 0.5-inch plate taken from the same piece used for the Y_F 932 bulkhead panels and 3.0-inch plate used to make the closure rib, both of which were considered fracture critical. Both plates were from RMI Company heat number 800724.

The 10 Nickel steel for the material test program will come from the 1.9 inch thick plate used for the lower plate of the WCTS, U.S. Steel heat number C52299, the 3.5 inch thick plate used for the lower rail of the Y_F 932 and Y_F 992 (fore and aft) bulkheads, U.S. Steel heat number C52300; and 0.8 inch thick plate used for the web of the fore and aft bulkheads, U.S. Steel heat number C52301. All three parts have been established as fracture critical. In addition the 3-1/2 inch plate is the thickest rolled plate received and the 0.8 inch plate was the thinnest plate stock received. The only portions of this part of the program completed to date are the tension, compression, and fatigue tests of the 6Al-4V titanium; and the tension, compression and shear tests of the 10 Nickel steel (Ref. 603R100-13 and -14 in section 2.2.1).

2.1.5 Information Transfer

A Design Review was held on July 9-10, 1974, for ADPO, AFFDL, B-1 SPO and Rockwell International personnel. The review consisted of formal presentations, informal reviews of drawings and data, and a factory tour. Activities observed on the tour included detail part fabrication, WCTS assembly operations, dummy wing manufacture, and test fixture assembly.

An Open Design Review was conducted in Fort Worth on Nov. 12-13, 1974. Approximately seventy-five representatives of industry and government attended the two day session. Formal technical presentations were kept to a minimum and five demonstration/display areas were used to show the results of manufacturing, inspection and testing. The WCTS assembly operation was included as one of the five demonstrations.

The B-1 Scientific Advisory Board reviewed the program on December 16-17, 1974. Representatives of AFML, AFFDL, ASD, the B-1 SPO, Headquarters USAF and Rockwell International were also in attendance. Formal presentations were made to show program scope and status, loads and criteria, configuration details, cost and weight status, material data, analysis methods and results, and testing. Preliminary verbal reports indicate that the board members were pleased with the presentations and the status of the program and that they feel this program is very beneficial from a technology viewpoint. They expressed the belief that such programs should continue in the future. Professor James Mar is chairman of this board.

During this reporting period, the preliminary Static, Fatigue and Damage Tolerance Full Scale Test Plan, FZS-219, was completed and submitted to the ADPO for approval. The final version of the test plan is now in work.

2.2 TESTING

2.2.1 Materials Testing

The materials test program requirements for the Credible Option Program were finalized during this reporting period and submitted as an addendum to the original AMAVS Materials Test Plan. The additional 10 Nickel steel materials testing to be accomplished is shown in Figure 2.2.1-1 (Dwg. 603R100-13) and on Ti 6Al-4V beta annealed titanium in Figure 2.2.1-2 (Dwg. 603R100-14).

Material Allocation Plans (MAP's) have been prepared and released to ensure traceability of the specimens. Test specimen preparation is approximately 80% complete and testing has been started.

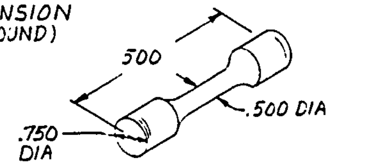
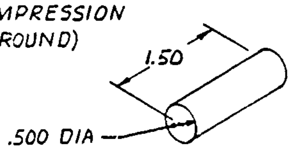
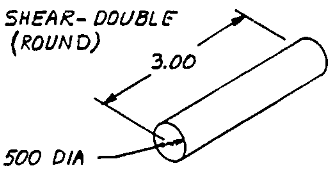
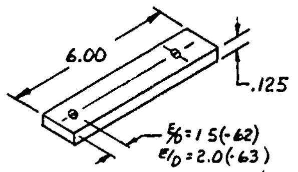
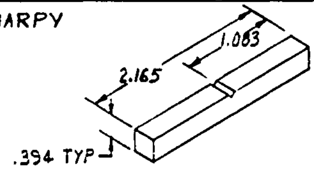
2.2.1.1 Weldment Testing

The tests requirements for additional data on weldments are shown in Figure 2.2.1-3, Figure 2.2.1-4 and Table 2.2.1-I. Figure 2.2.1-3 (Dwg. 603R100-11"B") covers tests to be conducted on 10 Nickel steel electron beam welds and GTA weld repaired electrom beam welds. Figure 2.2.1-4 (Dwg. 603R100-12) covers tests to be conducted on GTA welds of 10 Nickel steel. Table 2.2.1-I covers the tests to be conducted on Ti-6Al-4V beta annealed titanium electron beam welded by Murdock Machine and Engineering Company of Texas.

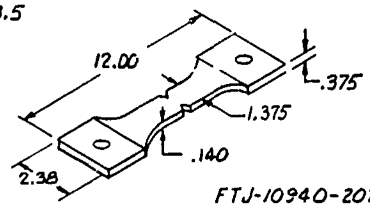
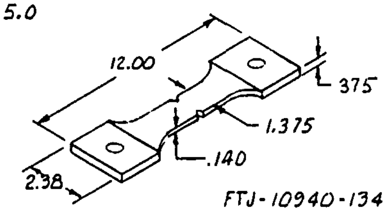
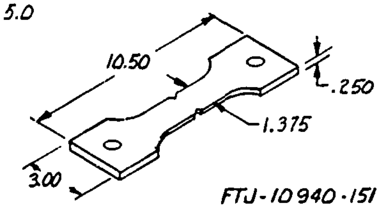
Table 2.2.1-I BETA ANNEALED 6AL-4V TITANIUM ELECTRON BEAM WELDMENTS BY MURDOCK

TEST TYPE	SPEC. DRAWING	NO. OF TESTS
TENSION	FTJ10940-1	4
FATIGUE	FTJ10940-92	9
STRESS CORROSION	FTJ10940-142	3

DESIGN ALLOWABLES

SPECIMEN		STOCK THICK-NESS	NO OF SPEC	GRAIN DIR	SPECIMEN IDENTIFICATION
TENSION (ROUND)  FTJ-10940-1		3.50	3	L	C-1-6-5A,-5B,-5C
			3	LT	C-1-6-4A,-4B,-4C
		1.90	3	L	C-1-3-26A,-26B C-1-3-91
			3	LT	C-1-3-27A,-27B C-1-3-28
		0.80	3	L	C-1-1-40 ,-41 ,-42
			3	LT	C-1-1-43 ,-44 ,-45
COMPRESSION (ROUND)  FTJ-10940-38		3.50	3	L	C-1-5-63A,-63B,-63C
		1.90	3	L	C-1-3-89A,-89B C-1-3-90
		0.80	3	L	C-1-1-46 C-1-1-47 C-1-1-48
SHEAR-DOUBLE (ROUND)  FTJ-10940-161		3.50	3	L	C-1-5-64A,-64B,-64C
		1.90	3	L	C-1-3-47A,-47B C-1-3-48
BEARING  FTJ-10940-62 & -63	-62	3.50	3	L	C-1-5-53A,-53B,-53C
	-63	3.50	3	L	C-1-5-62A,-62B,-62C
	-62	1.90	3	L	C-1-3-31A,-31B,-31C
	-63	1.90	3	L	C-1-3-32A,-32B,-32C
CHARPY  FTJ-10940-100		3.50	4@RT	RW	C-1-5-65A,-65B,-65C
			4@0°	RW	C-1-5-66A,-66B,-66C △
			4@-65°	RW	C-1-5-67A,-67B,-67C C-1-5-68A,-68B,-68C
		1.90	4@RT	RW	C-1-3-81A,-81B,-82A,-82B
			4@0°	RW	C-1-3-83A,-83B C-1-3-84A,-84B △
			4@-65°	RW	C-1-3-85,-86,-87,-88
		0.80	4@RT	RW	C-1-1-49 THRU -60 △
			4@0°	RW	
			4@-65°	RW	

FATIGUE

SPECIMEN	STOCK THICK-NESS
$K_T = 3.5$  FTJ-10940-202	3.50
	3.50
	3.50
	1.90
	1.90
	1.90
$K_T = 5.0$  FTJ-10940-134	1.90
	1.90
	1.90
$K_T = 5.0$  FTJ-10940-151	SPEC STOCK NO O GRAIN SPEC IDENT

EL MATERIAL PROPERTIES

TIGUE

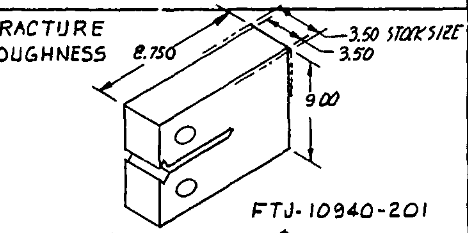
	STOCK THICK-NESS	NO OF SPEC	TEST CONDITION: R RATIO	TEST CONDITION: GRAIN DIR	SPECIMEN IDENTIFICATION
	3.50	9	0.1	L	C-1-5-35A, -35B, -35C; C-1-5-36A, -36B, 36C; C-1-5-37A, -37B, -37C
	3.50	9	0.5	L	C-1-5-38A, -38B, -38C; C-1-5-39A, -39B, -39C; C-1-5-40A, -40B, -40C
.375	3.50	9	-0.5	L	C-1-5-41A, 41B, -41C; C-1-5-42A, -42B, -42C; C-1-5-43A, -43B, -43C △
	1.90	9	0.1	L	C-1-3-58A, 58B, -58C; C-1-3-59A, 59B, 59C; C-1-3-60A, -60B, -60C
	1.90	9	0.5	L	C-1-3-61A, -61B, -61C; C-1-3-62A, -62B, -62C; C-1-3-63A, -63B, -63C
0-202	1.90	9	-0.5	L	C-1-3-64A, -64B, -64C; C-1-3-65A, 65B, -65C; C-1-3-66A, -66B, -66C △
	1.90	6	0.1	L	C-1-3-67A, -67B, -67C; C-1-3-68A, -68B, -68C
.375	1.90	6	0.5	L	C-1-3-69A, -69B, -69C; C-1-3-70A, -70B, -70C △
	1.90	6	-0.5	L	C-1-3-71A, -71B, -71C; C-1-3-72A, -72B, -72C
-134					

	SPECTRUM	A	A*	B	B*
	STOCK THICK	1.90	1.90	1.90	1.90
.250	NO OF SPEC	4	4	4	4
	GRAIN DIR	L	L	L	L
-151	SPECIMEN IDENTIFICATION	C-1-3-43A, -43B, -43C, -43D; C-1-3-44A, -44B, -44C, -44D; C-1-3-45A, -45B, -45C, -45D; C-1-3-45A, -45B, -45C, -45D △			

FRACTURE MECHANICS

SPECIMEN / TEST CONDITIONS

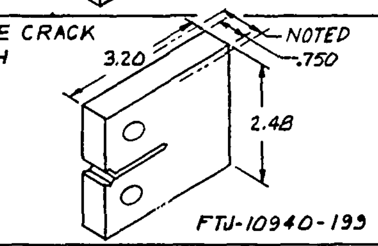
FRACTURE TOUGHNESS



FTJ-10940-201

STOCK THICK	NO OF SPEC	ORIENTATION	TEMP	SPECIMEN IDENT
3.50	2	RW	RT	C-1-5-44, C-1-5-45, △
3.50	2	RW	-65°	C-1-5-46, C-1-5-47

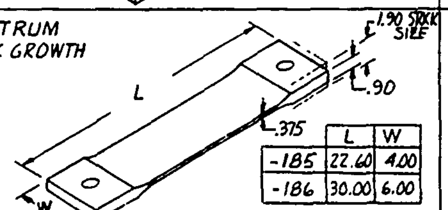
FATIGUE CRACK GROWTH



FTJ-10940-199

R RATIO	0.1	0.1	0.1	0.1	0.1
FREQUENCY, CPM	360	360	60	60	6[illegible]
ENVIRONMENT	DRY AIR	DRY AIR	SUMP TANK W	SUMP TANK W	SUMP TANK [illegible]
ORIENTATION	RW	RW	RW	RW	RW
NO OF SPECIMENS	1	1	1	1	1
STOCK THICKNESS	3.50	1.90	3.50	1.90	3.50
SPECIMEN IDENT	C-1-5-50, -51, -52, -55, -56, -57 △				

SPECTRUM CRACK GROWTH

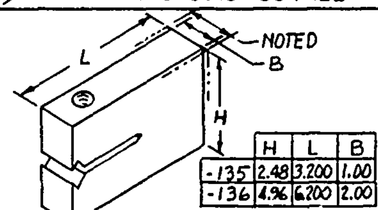


	L	W
-185	22.60	4.00
-186	30.00	6.00

FTJ-10940-185 & -186

SPECTRUM	A*	A*	B*	A	A
ENVIRONMENT	DRY AIR / SUMP WATER	DRY AIR / SUMP WATER	DRY AIR / SUMP WATER	DRY AIR	DRY AIR
NO. OF SPECIMENS	1	1	1	1	1
ORIENTATION	RW	RW	RW	RW	RW
FTJ-10940 -	-185	-186	-186	-185 MOD	-186 MOD
SPECIMEN IDENT	C-1-3-49, -50, -51, -52, -53, -54 △				

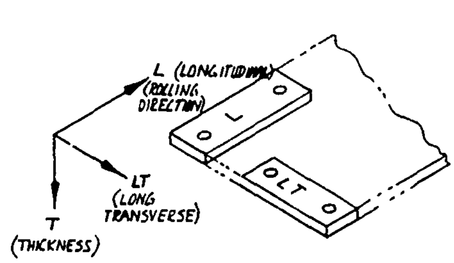
STRESS CORROSION

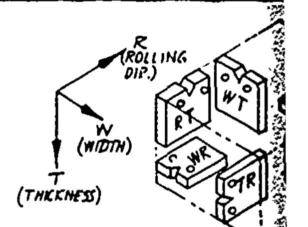


	H	L	B
-135	2.48	3.200	1.00
-136	4.96	6.200	2.00

FTJ-10940-135 & -136

ENVIRONMENT	SUMP TANK WATER FOR 1000 HR			
NO. OF SPECIMENS	2	2	2	2
ORIENTATION	RW	WR	TR	RW
STOCK THICKNESS	3.50	3.50	3.50	1.90
FTJ-10940 -	-136	-136	-135	-136
SPECIMEN IDENT	C-1-5-60, -61	C-1-6-6, -7	C-1-5-48, -49	C-1-3-41, -42





SPECIMEN ORIENTATION SYSTEM

2

URE MECHANICS

TEST CONDITIONS

TOCK THICK.	NO OF SPEC	ORIENTATION	TEMP	SPECIMEN IDENT
3.50	2	RW	RT	C-1-5-44, C-1-5-45, △
3.50	2	RW	-65°	C-1-5-46, C-1-5-47

R RATIO	0.1	0.1	0.1	0.1	0.1	0.1
FREQUENCY, CPM	360	360	60	60	6	6
ENVIRONMENT	DRY AIR	DRY AIR	SUMP TANK W	SUMP TANK W	SUMP TANK W	SUMP TANK W
ORIENTATION	RW	RW	RW	RW	RW	RW
NO. OF SPECIMENS	1	1	1	1	1	1
STOCK THICKNESS	3.50	1.90	3.50	1.90	3.50	1.90
SPECIMEN IDENT	C-1-5-50, -51, -52, -55, -56, -57 △					

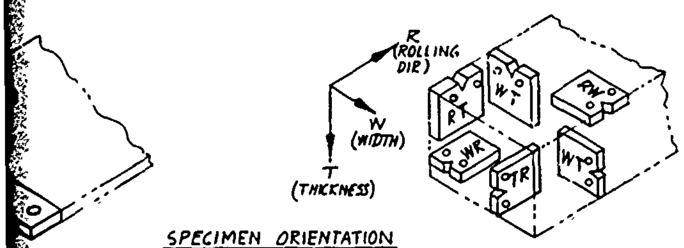
SPECTRUM	A *	A *	B *	A	A	B
ENVIRONMENT	DRY AIR / SUMP WATER	DRY AIR / SUMP WATER	DRY AIR / SUMP WATER	DRY AIR	DRY AIR	DRY AIR
NO. OF SPECIMENS	1	1	1	1	1	1
ORIENTATION	RW	RW	RW	RW	RW	RW
ETJ-10940 -	-185	-186	-186	-185 MOD	-186 MOD	-186 MOD
SPECIMEN IDENT	C-1-3-49, -50, -51, -52, -53, -54 △					

ENVIRONMENT	SUMP TANK WATER FOR 1000 HR			
NO. OF SPECIMENS	2	2	2	2
ORIENTATION	RW	WR	TR	RW
STOCK THICKNESS	3.50	3.50	3.50	1.90
ETJ-10940 -	-136	-136	-135	-136
SPECIMEN IDENT.	C-1-5-60, -61	C-1-6-6, -7	C-1-5-48, -49	C-1-3-41, -42

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED

NOTES:

5. △ SPECIFIC SPECIMEN IDENT. FOR EACH TEST CONDITION TO BE SUPPLIED WITH TEST RESULTS
4. * DENOTES UNTRUNCATED SPECIMENS
3. MFG. OF ALL SPECIMEN TO BE ACCOMPLISHED BY ETL
2. ALL TESTING TO BE ACCOMPLISHED BY E.T.L
1. ALL TESTS TO BE CONDUCTED AT ROOM TEMPERATURE EXCEPT AS NOTED



SPECIMEN ORIENTATION SYSTEM

Figure 2.2.1-1

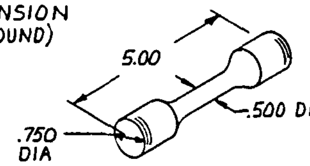
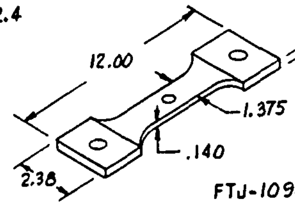
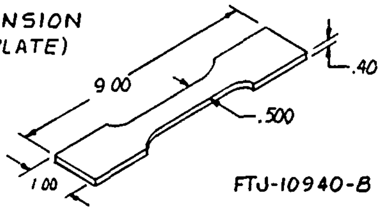
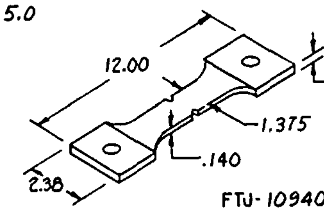
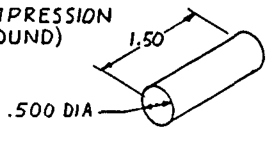
PRELIMINARY DESIGN DRAWING

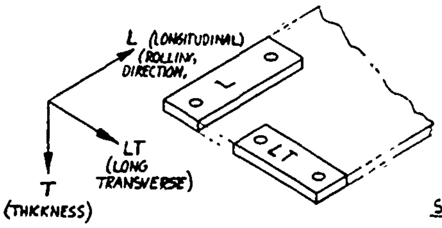
10 NI STEEL - MATERIAL PROPERTIES CREDIBLE OPTION TEST PROGRAM

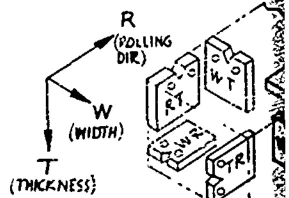
BY	APPROVED	SCALE —	DATE 11/4/74
GENERAL DYNAMICS Convair Aerospace Division Fort Worth Operation		603R100-13	
		SHEET 1 OF 1	

3

BETA ANNEALED 6AL-4…

DESIGN ALLOWABLES					FATIGUE	
SPECIMEN	STOCK THICK-NESS	NO. OF SPEC	GRAIN DIR.	SPECIMEN IDENTIFICATION	SPECIMEN	STO… THI… NE…
TENSION (ROUND)  FTJ-10940-1	3.00	2	L	A-3-7-10 A A-3-7-10 B	K_T = 2.4  FTJ-10940-133	0.…
		2	LT	A-3-7-11 A A-3-7-11 B		
TENSION (PLATE)  FTJ-10940-8	0.50	2	L	A-3-2-3 A-3-2-4	K_T = 5.0  FTJ-10940-134	0.…
		2	LT	A-3-2-5 A-3-2-6		
COMPRESSION (ROUND)  FTJ-10940-38	3.00	4	L	A-3-7-12A A-3-7-12B A-3-7-13A A-3-7-13B		





SPECIMEN ORIENTATION SYSTEM

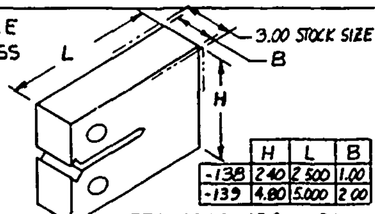
...AL-4V TITANIUM MATERIAL PROPERTIES

STOCK THICKNESS	NO. OF SPEC	TEST CONDITION R RATIO	TEST CONDITION GRAIN DIR	SPECIMEN IDENTIFICATION
0.50	12	0.1	L	A-3-2-7 THRU A-3-2-18
0.50	12	0.1	L	A-3-2-19 THRU A-3-2-30

FRACTURE MECHANICS

SPECIMEN / TEST CONDITIONS

FRACTURE TOUGHNESS

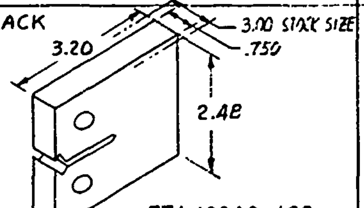


	H	L	B
-138	2.40	2.500	1.00
-139	4.80	5.000	2.00

FTJ-10940-138 & -139

FTJ-10940	NO OF SPEC	ORIENTATION	TEMP	SPECIMEN IDENTIFICATION
-138	3	RW	-65°	A-3-7-24A,-24B,-25
-138	3	TR	RT	A-3-7-21,-22,-23
-139	3	RW	RT	A-3-7-26,-27,-28
-139	3	WR	RT	A-3-7-29,-30,-31

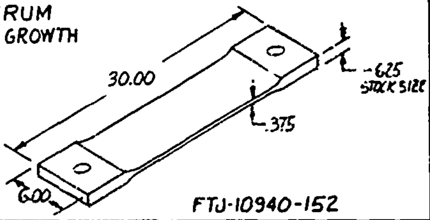
FATIGUE CRACK GROWTH



FTJ-10940-139

FREQUENCY, CPM	360	60
ENVIRONMENT	DRY AIR	SUMP TANK W
ORIENTATION	RW	RW
NO OF SPECIMENS	1	1
SPECIMEN IDENT	A-3-7-32,-33 Δ	

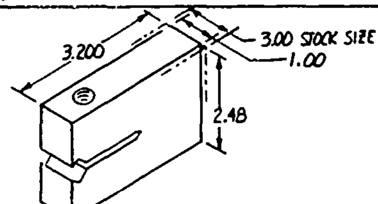
SPECTRUM CRACK GROWTH



FTJ-10940-152

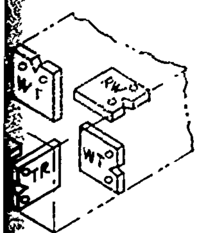
SPECTRUM	A*	A
ENVIRONMENT	DRY AIR SUMP WATER	DRY AIR
NO OF SPECIMENS	1	1
ORIENTATION	RW	RW
FTJ-10940 -	-152	-152 MOD
SPECIMEN IDENT	A-3-3-1,-2 Δ	

STRESS CORROSION



FTJ-10940-135

ENVIRONMENT	SUMP TANK WATER FOR 1000 HR			
NO OF SPECIMENS	3	3	3	
ORIENTATION	RW	WR	TR	
SPECIMEN IDENTIFICATION	A-3-7-14,-15,-16,-17, A-3-7-18,-19,-20 Δ			



2

RE MECHANICS

TEST CONDITIONS

-10940	NO OF SPEC	ORIENTATION	TEMP	SPECIMEN IDENTIFICATION
138	3	RW	-65°	A-3-7-24A,-24B,-25
138	3	R	RT	A-3-7-21,-22,-23
139	3	[illegible]W	RT	A-3-7-26,-27,-28
139	3	WR	RT	A-3-7-29,-30,-31

REQUENCY, CPM	360	60
NVIRONMENT	DRY AIR	SUMP TANK W
IENTATION	RW	RW
O OF SPECIMENS	1	1
ECIMEN IDENT	A-3-7-32,-33 △	

PECTRUM	A *	A
NVIRONMENT	DRY AIR SUMP WATER	DRY AIR
NO. OF SPECIMENS	1	1
RIENTATION	RW	RW
FTJ-10940 -	-152	-152 MOD
SPECIMEN IDENT	A-3-3-1,-2 △	

NVIRONMENT	SUMP TANK WATER FOR 1000 HR			
NO OF SPECIMENS	3	3	3	
RIENTATION	RW	WR	TR	
SPECIMEN IDENTIFICATION	A-3-7-14,-15,-16,-17, A-3-7-18,-19,-20 △			

SYM	ZONE	DESCRIPTION	DATE	APPROVED

NOTES:

1. ALL TESTS TO BE CONDUCTED AT ROOM TEMPERATURE EXCEPT AS NOTED
2. ALL TESTING TO BE ACCOMPLISHED BY E.T.L
3. MFG OF ALL SPECIMENS TO BE ACCOMPLISHED BY E.T.L
4. * DENOTES UNTRUNCATED SPECIMENS
5. △ SPECIFIC SPECIMEN IDENT. FOR EACH TEST CONDITION TO BE SUPPLIED WITH TEST RESULTS

Figure 2.2.1-2

PRELIMINARY DESIGN DRAWING

6AL-4V TITANUM-MATERIAL PROPERTIES CREDIBLE OPTION TEST PROGRAM

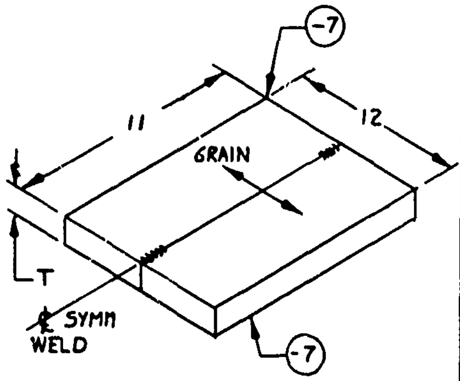
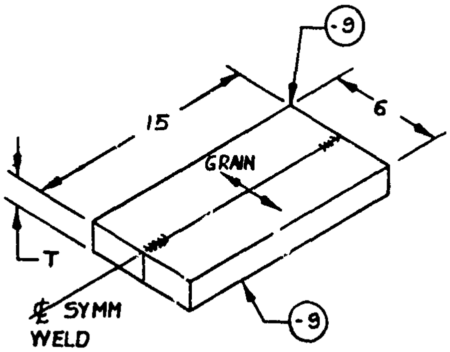
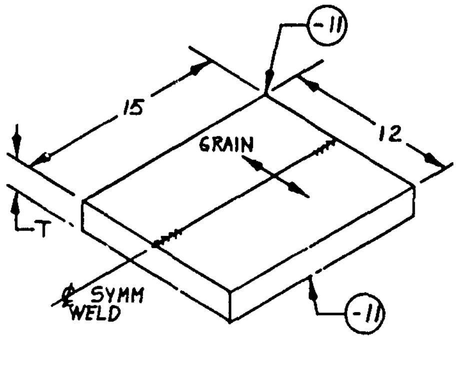
BY [signature] APPROVED [signature] SCALE — DATE 11/8/74

GENERAL DYNAMICS Convair Aerospace Division Fort Worth Operation

603R100-14

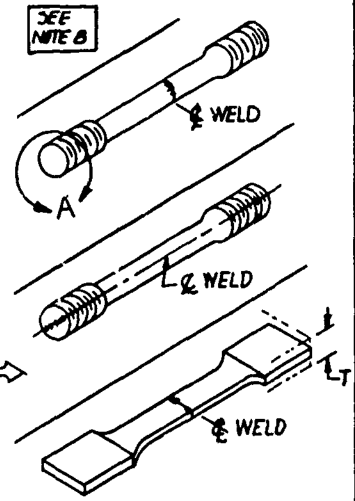
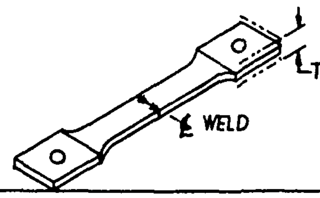
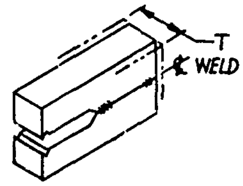
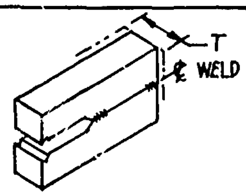
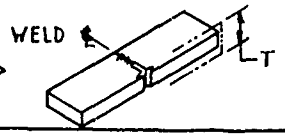
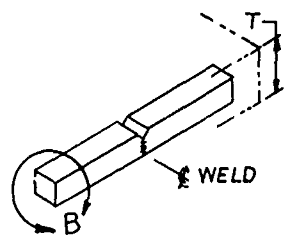
SHEET 1 OF 1

10 NICKEL STEEL E.B. WELD

MANUFACTURING RESEARCH			
SPECIMEN	STOCK THK	"T" THK	ASSY QTY
 -1 ASSY	2.50	1.60	2
 -3 ASSY	2.50	1.60	5
 -5 ASSY (SEE NOTE 5)	1.90	1.60	3

NON DESTRUCTIVE INSPECTION

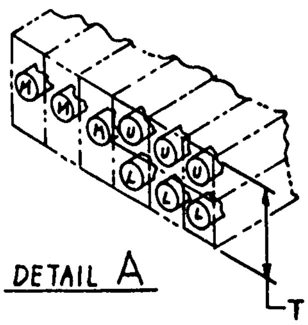
RADIOGRAPHIC X-RAY
MAGNETIC PARTICLE

ENGINEERING TES		
SPECIMEN	TYPE OF TEST	TEST PAR
	TENSION	TRAN WELD FTJ109 LONGIT WELD FTJ109 FTJ109
	FATIGUE	FTJ109
	FATIGUE CRACK GROWTH	FTJ109
	STRESS CORROSION	FTJ109
 	FRACTURE TOUGHNESS	FTJ109 FTJ10
	CVN 0°F	FTJ10
	-65°	FTJ1

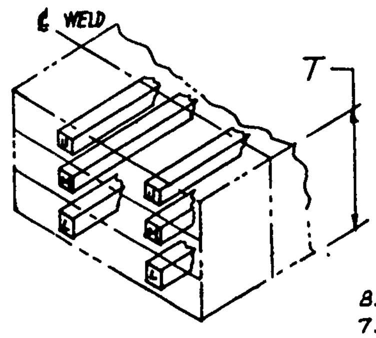
REVISIONS		
SYM	ZONE	DESCRIPTION
A		FTJ10940-195 WAS -146 T THK 1.60 WAS 2.100
B		REVISED & REDRAWN

...ST

...SPEC ...RT NO	QUANTITY	MAKE FROM	SPECIMEN IDENTIFICATION
...NVERSE ...D SPEC ...940-1	1	-1 ASSY	H-95-2
	15	-3	H-89-5 UPPER H-89-4,-9,&-10 MIDDLE H-89-6 LOWER H-91-1,-4,&-7 UPPER H-91-3,-6,&-9 MIDDLE H-91-2,-5,8,&-17 LOWER
...ITUDINAL ...D SPEC. ...0940-3	1	-1 ASSY	H-94-7
	3	-3 ASSY	H-89-13 UPPER H-92-3 H-93-3
...0940-149	2	-5 ASSY	SEE NOTE 7
...0940-124	6	-1 ASSY	H-94-1,-3,&-5 H-94-2,-4,&-6
	6	-5 ASSY	SEE NOTE 7
...10940-147	1	-1 ASSY	H-94-8
	3	-3 ASSY	H-89-8 LOWER H-92-4 H-93-4
	1	-5 ASSY	SEE NOTE 7
...10940-142	3	-3 ASSY	H-89-7 MIDDLE H-90-3 MIDDLE H-91-16 MIDDLE
...10940-195	6	-3 ASSY	H-90-1 & -2 MIDDLE H-92-1 & -2 MIDDLE H-93-1 & -2 MIDDLE
...10940-200	2	-5 ASSY	SEE NOTE 7
...10940-100	1	-1 ASSY	H-95-1
	15	-3 ASSY	H-89-1 & -11 H-91-11 & -14 UPPER H-89-3, H-90-4,-2 & -5,-2 ; H-91-10 & -13, H-92-5,-6,-3 MIDDLE H-89-2 & -12, H-91-12 & -15 LOWER
...10940-100	3 (NOTE 4)	-5 ASSY	SEE NOTE 7



DETAIL A



DETAIL B

8. WELD SPECIMEN H95-3 SHIPPED TO NRL FOR DWTT
7. SPECIMEN IDENT. TO BE ADDED AFTER PANELS HAVE BEEN WELDED & INSPECTED
6. AGE ALL WELDED ASSY'S TO COND STA. PER FPS-...
5. GTA WELD REPAIR TWO (2) PLATES COMPLETE LENGTH... ONE (1) PLATE 7.50 INCHES
4. FTJ10940-100 MADE FROM -5 ASSY TO BE UNREPAIRED WELDED...
3. ALL TESTING TO BE ACCOMPLISHED BY E.T.L.
2. ALL WELDING TO BE ACCOMPLISHED BY MFG. ENGR.
1. MACHINING OF ENGR SPECIMENS TO BE ACCOMPLISHED BY...

NOTES:

Figure 2.2.1-3...

PRELIMINARY DESIGN

10 NICKEL STEEL-ELECTRON B...
WELDING PROPERTIES
DEVELOPMENT TEST PROG...

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

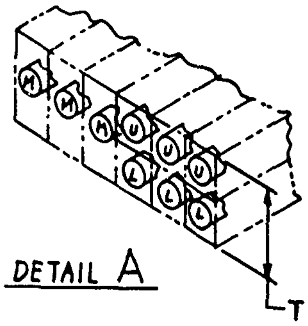
60...

, 2

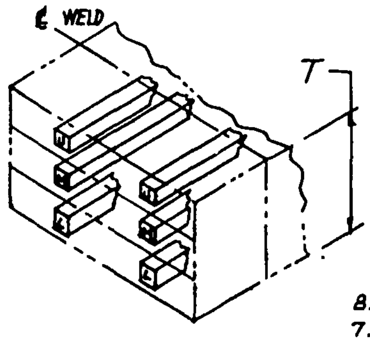
SPECIMEN IDENTIFICATION
H-95-2
H-89-5 UPPER H-89-4, -9, & -10 MIDDLE H-89-6 LOWER H-91-1, -4, & -7 UPPER H-91-3, -6, & -9 MIDDLE H-91-2, -5, -8, & -17 LOWER
H-94-7
H-89-13 UPPER H-92-3 H-93-3
SEE NOTE 7
H-94-1, -3, & -5 H-94-2, -4, & -6
SEE NOTE 7
H-94-8
H-89-8 LOWER H-92-4 H-93-4
SEE NOTE 7
H-89-7 MIDDLE H-90-3 MIDDLE H-91-16 MIDDLE
H-90-1 & -2 MIDDLE H-92-1 & -2 MIDDLE H-93-1 & -2 MIDDLE
SEE NOTE 7
H-95-1
H-89-1 & -11 H-91-11 & -14 UPPER H-89-3, H-90-4, -2 & -5, -2, H-91-10 & -13, H-92-5, -6, -3 MIDDLE H-89-2 & -12, H-91-12 & -15 LOWER
SEE NOTE 7

REVISIONS

SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		FTJ10940-195 WAS -146 T THK 1.60 WAS 2.100		
B		REVISED & REDRAWN		



DETAIL A



DETAIL B

8. WELD SPECIMEN H95-3 SHIPPED TO NRL FOR DWTT
7. SPECIMEN IDENT. TO BE ADDED AFTER PANELS HAVE BEEN WELDED & INSPECTED
6. AGE ALL WELDED ASSY'S TO COND STA. PER FPS-1096
5. GTA WELD REPAIR TWO (2) PLATES COMPLETE LENGTH & ONE (1) PLATE 7.50 INCHES
4. FTJ10940-100 MADE FROM -5 ASSY TO BE UNREPAIRED WELDED PLATE
3. ALL TESTING TO BE ACCOMPLISHED BY E.T.L.
2. ALL WELDING TO BE ACCOMPLISHED BY MFG. ENGR.
1. MACHINING OF ENGR SPECIMENS TO BE ACCOMPLISHED BY E.T.L.

NOTES:

Figure 2.2.1-3

PRELIMINARY DESIGN DRAWING

10 NICKEL STEEL - ELECTRON BEAM WELDING PROPERTIES - DEVELOPMENT TEST PROGRAM

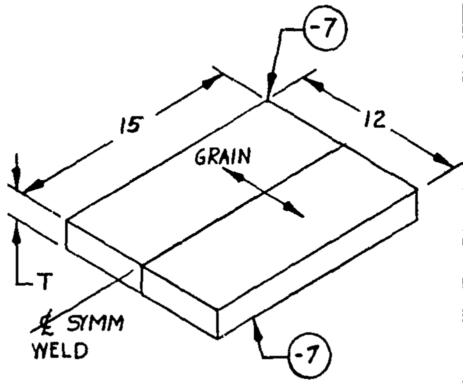
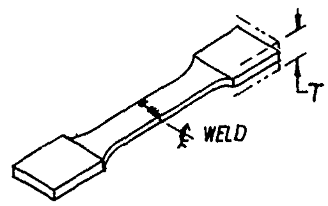
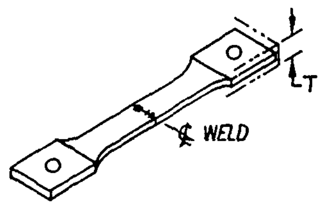
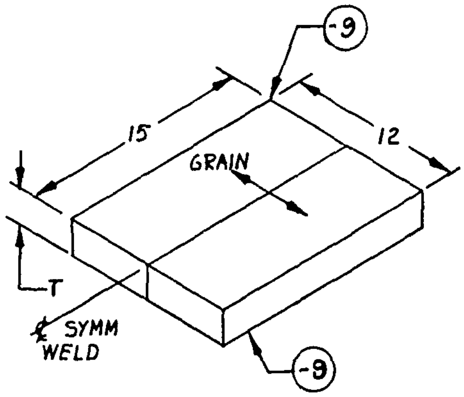
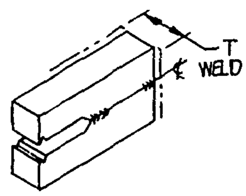
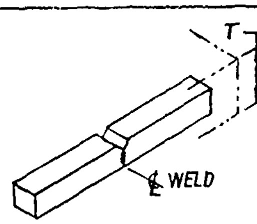
SCALE — DATE 4-12-73

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

603R100-11 "B"

SHEET 1 OF 1

10 NICKEL STEEL GTA WELD

MANUFACTURING RESEARCH				NON DESTRUCTIVE INSPECTION	ENGINEERING TE		
SPECIMEN	STOCK THK	"T" THK	ASSY QTY		SPECIMEN	TYPE OF TEST	TEST PA
 -1 ASSY	.80	.50	5	RADIOGRAPHIC (X-RAY) MAGNETIC PARTICLE		TENSION	FTJ
						FATIGUE	FTJ
 -3 ASSY	1.62	1.30	3			FATIGUE CRACK GROWTH	FTJ
						STRESS CORROSION	FTJ
						CVN	FTJ

TEST			
TEST SPEC PART №	QUANTITY	MAKE FROM	SPECIMEN IDENTIFICATION
FTJ10940-149	4	-1 ASSY	
	4	-3 ASSY	
FTJ10940-124	12	-1 ASSY	
	6	-3 ASSY	
FTJ10940-147	5	-1 ASSY	
FTJ10940-142	3	-3 ASSY	
FTJ10940-100	4 @-65°	-1 ASSY	
	4 @0°		
	4 @0°	-3 ASSY	

REVISIONS		
SYM	ZONE	DESCRIPTION

NOTES:

1. MACHINING OF ALL SPECIMENS TO BE ACCOMPLISHED BY
2. ALL WELDING TO BE ACCOMPLISHED BY MFG. ENGR
3. ALL TESTING TO BE ACCOMPLISHED BY E.T.L
4. AGE ALL WELDED ASSYS TO COND STA PER FPS-1096
5. SPECIMEN IDENT. TO BE ADDED AFTER PANELS HAVE BEEN WELDED & INSPECTED

Figure 2.2.1-

PRELIMINARY DESIG

10 NICKEL STEEL
WELDING PROPERTIE
DEVELOPMENT TEST

BY | APPROVED

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

2

SPECIMEN
IDENTIFICATION

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED

5. SPECIMEN IDENT. TO BE ADDED AFTER PANELS HAVE BEEN WELDED & INSPECTED
4. AGE ALL WELDED ASSYS TO COND STA PER FPS-1096
3. ALL TESTING TO BE ACCOMPLISHED BY E.T.L
2. ALL WELDING TO BE ACCOMPLISHED BY MFG. ENGR
1. MACHINING OF ALL SPECIMENS TO BE ACCOMPLISHED BY E.T.L.

NOTES:

Figure 2.2.1-4

PRELIMINARY DESIGN DRAWING

10 NICKEL STEEL – GTA WELDING PROPERTIES – DEVELOPMENT TEST PROGRAM

BY [signature] APPROVED [signature] SCALE — DATE 9-6-78

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

603R100-12

SHEET 1 OF 1

Test results of all the electron beam welded 10 Nickel steel completed to date are reported in paragraph 2.1.4.6 of this report and in Technical Report AFFDL-TR-74-98. Only the GTA weld repaired electron beam welds and 3 CVW specimens to be tested at -65°F remain to be tested (Ref. Fig. 2.2.1-3). The plates for these tests are in work.

Test results for the Murdock weldments (Ref. Table 2.2.1-I) are reported in paragraph 2.1.4.5 of this report. These are all complete.

Welding of the assemblies for the GTA weldment tests (Ref. Fig. 2.2.1-4) have been completed. These assemblies are now being aged to condition STA or are being inspected (Magnetic Particle, X-ray and Ultrasonic). Specimen layouts for each plate are being made for specimen traceability. No test results are available at this date.

2.2.2 Component Testing

All of the credible option fastener evaluation tests to be conducted by General Dynamics were completed. A summary of the tests is shown in Table 2.2.2-I. For economy reasons, all of the fatigue tests were constant amplitude and aimed toward obtaining K_t values for comparison with those used in design. Consequently the fatigue test results are reported in terms of test versus design K_t values along with cycles to failure.

Figure 2.2.2-1 shows the specimen designed to obtain fatigue data for the bolted-on lug reinforcements. These tests are to be conducted at AFFDL and the specimens are being prepared for shipment.

Figure 2.2.2-2 shows the specimen which represents a typical splice at the X_F 39 rib. The lower aluminum flange of the X_F 39 rib acts as the upper splice plate while a titanium splice plate is used on the lower surface. Test results are shown in the figure. Since test K_t's are well below the design values, the joint is satisfactory.

Figure 2.2.2-3 shows the specimen representing a typical splice of the 10 Ni plate splice to the titanium sandwich panel at X_F 84. The lower flange of the X_F rib partially splices the members while the steel plate - titanium overlap completes the splice. The fairing member tee below the steel was not included in the test because of its secondary nature. It may be noted from the results that test K_t's were close to original design values and higher than for the other splice tests. The explanation

Table 2.2.2-I CREDIBLE OPTION COMPONENT TESTS

COMPONENT	TYPE OF TEST	NUMBER OF SPECIMENS	STATUS
Lower Lug Reinforcement	Constant Amplitude Fatigue*	3	Manufactured
X_F 39 Lower Surface Splice	Constant Amplitude Fatigue	3	Complete
X_F 84 Lower Surface Splice	Constant Amplitude Fatigue	3	Complete
Forward Bulkhead Web Splice	Constant Amplitude Fatigue	3	Complete
Upper Cover Compression Panel	Static Compression	3	Complete
Lower Surface Sandwich Panel	Constant Amplitude Fatigue	2	Complete
	Static Tension	2	Complete
	Static Lateral Pressure	2	Complete
	Static Pressure + Tension	2	Complete

* To be tested at AFFDL

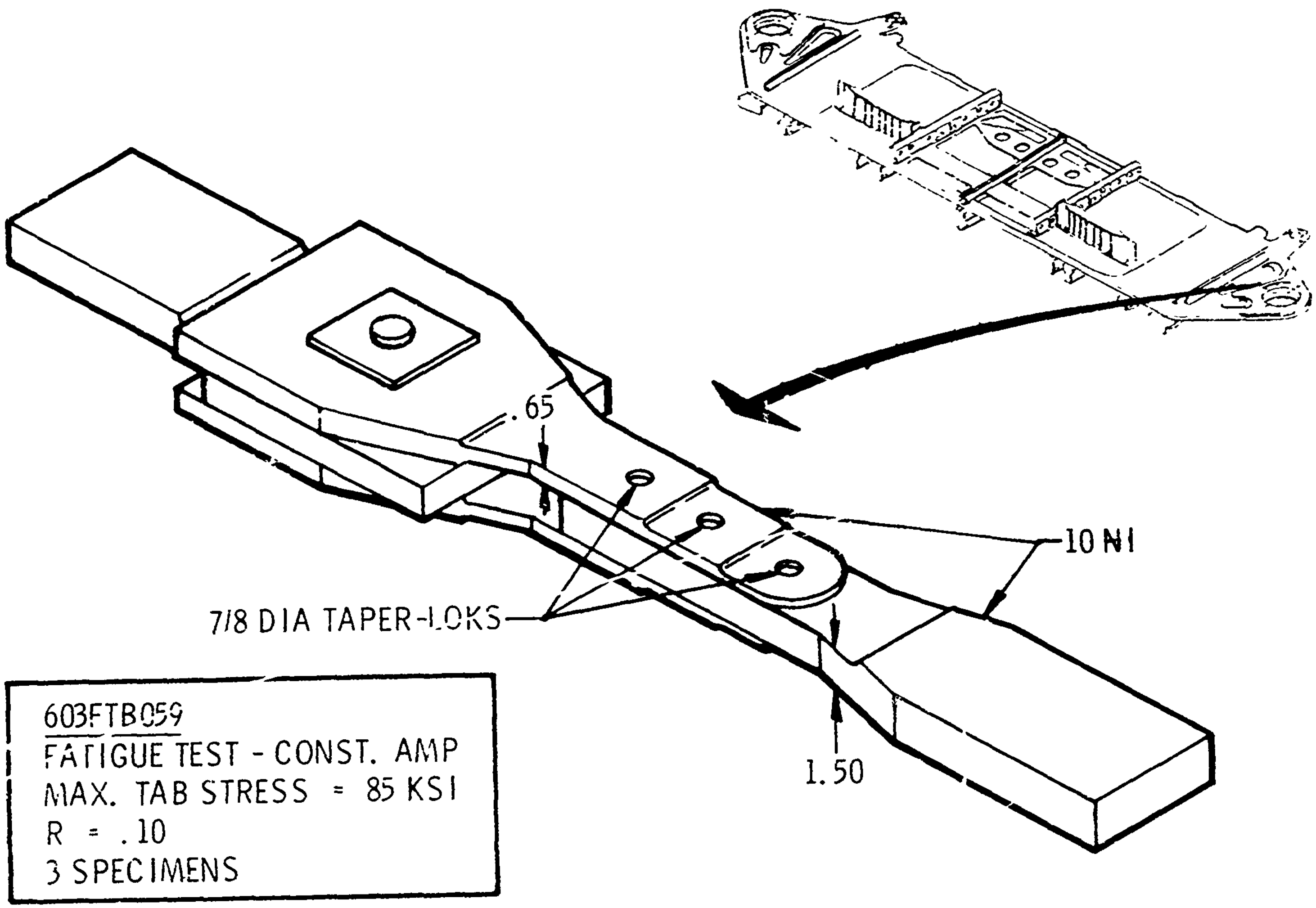
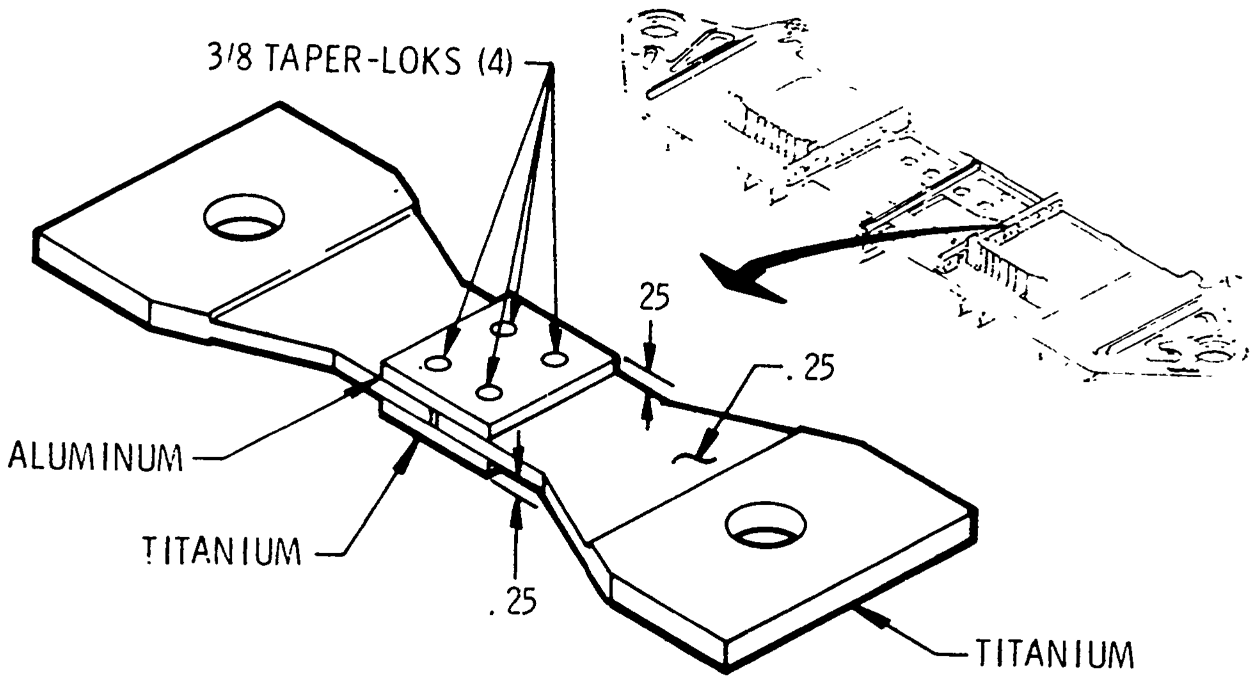


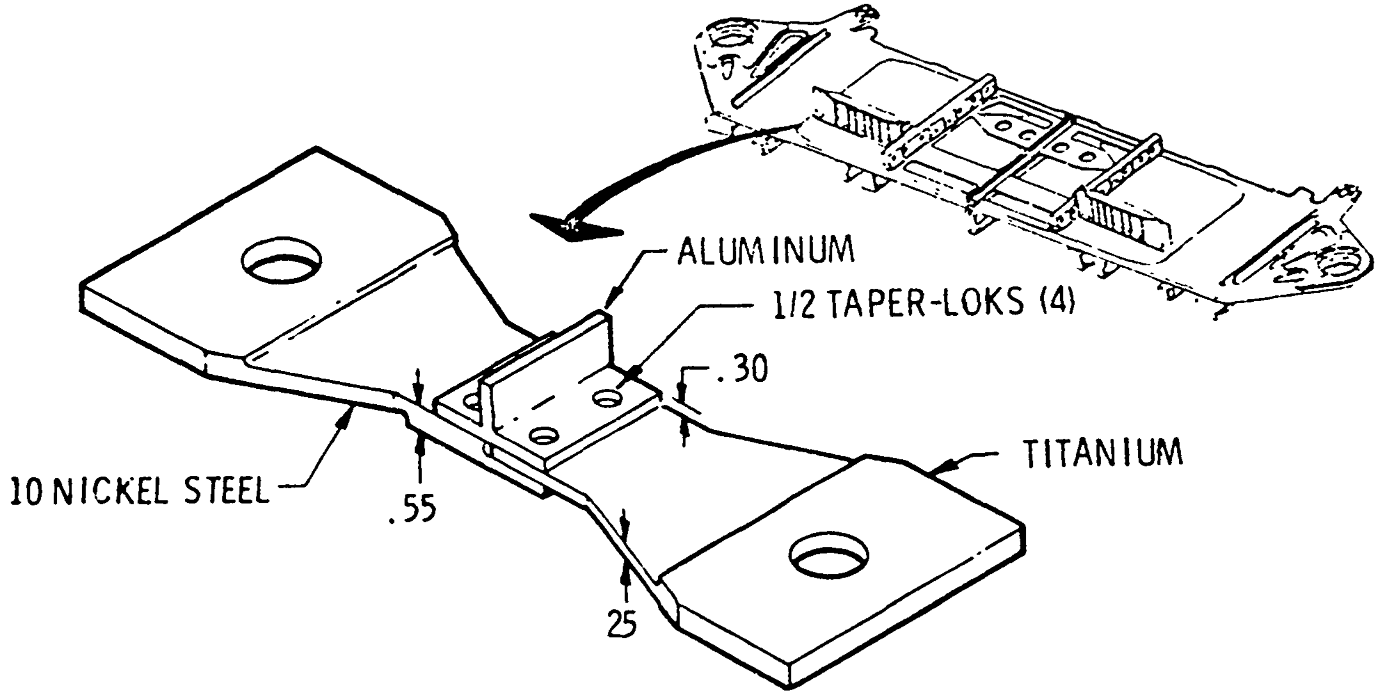
Figure 2.2.2-1 CREDIBLE OPTION FASTENER EVALUATION PROGRAM LUG REINFORCEMENT SPECIMEN



● 60? TB 061

	SPEC. NO.	KC TO FAILURE	TEST K_t	DESIGN K_t	FAILED ELEMENT
▶ FATIGUE TEST - CONST. AMP	1	118	2.23	5.0	SPL
▶ MAX Ti STRESS = 51 KSI	2	74.7	2.40	5.0	SPL/PL
▶ MAX AL STRESS = 25.5 KSI	3	149.2	2.20	5.0	SPL
● R=.10					

Figure 2.2.2-2 CREDIBLE OPTION FASTENER EVALUATION PROGRAM - X_F 39 LOWER SURFACE SPLICE



● 603FTB062

	SPEC. NO.	KC TO FAILURE	TEST K_t	DESIGN K_t	FAILED ELEMENT
FATIGUE TEST - CONST. AMP.	1	15.48	3.97	4.0	TITANIUM
MAX. Ti STRESS = 57 KSI	2	17.82	3.82	4.0	TITANIUM
MAX AL STRESS = 23.6	3	17.31	3.85	4.0	TITANIUM
R = .10					

Figure 2.2.2-3 CREDIBLE OPTION FASTENER EVALUATION PROGRAM - X_F 84 LOWER SURFACE SPLICE

for the relatively high test K_t value appears to be that some bending occurred in the titanium which resulted in higher applied stresses than the average values used to estimate test K_t's. The joint is considered satisfactory.

The Y_F 932 aluminum bulkhead panels splice across the X_F 0 rib forward tee. Although a double shear joint is used adjacent to the lower bulkhead attach angle where tension loads are high, a single shear joint is used above this region. Figure 2.2.2-4 shows the specimen tested to verify design K_t values. As may be seen from the results, the joint design is adequate.

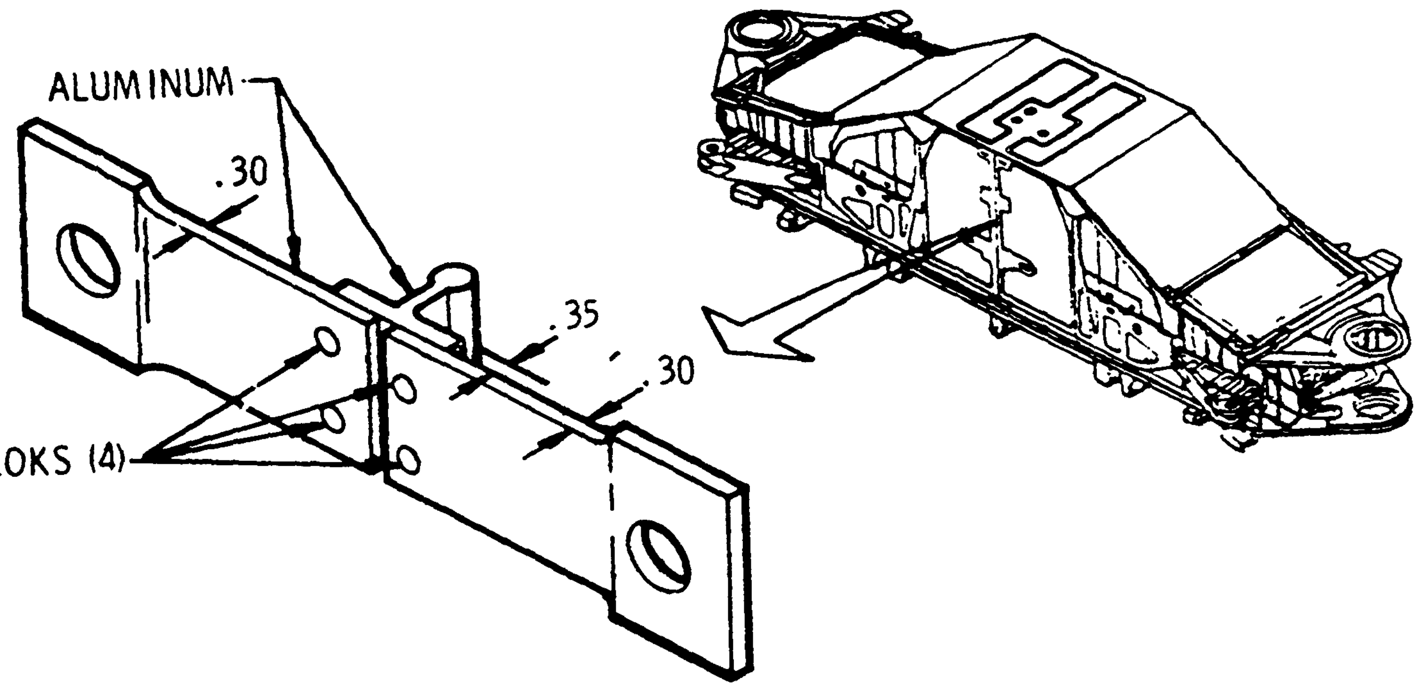
Figure 2.2.2-5 shows the column compression specimens designed to represent the 2024-T851 aluminum sandwich panels. The column length was adjusted to account for the fact that the cover panel is supported on four sides. Test failure occurred in all cases near the non-rotating test machine head where the core separated from the heavy face and the edge member failed in tension and bending. The results are summarized in Table 2.2.2-II. The stresses at failure were consistent among the specimens and demonstrated that the design was adequate.

Figure 2.2.2-6 shows the specimens designed for verifying a typical portion of the lower surface titanium sandwich construction, including the joint. Strain gages were used on all but the lateral pressure specimens. Table 2.2.2-III summarizes the results.

The design K_t was shown to be satisfactory since it was 5.0 compared to the test value of 3.65.

For static tension, very little strain was indicated in the lower face until stresses in the .080 face became inelastic At that time the .032 skin began to show significant strain, which indicated stresses in it of 60 to 70 ksi at the time the .080 face failed in tension at F_{TU}. Just prior to final failure, there was an indication of core separation from the thick face near the edge. The failing test load was much higher than the design load and although the "two dimensional" specimens do not completely simulate the plate action, ample strength was demonstrated.

The lateral pressure tests indicated that the core shear due to pressure could be adequately transferred to the thick face and then to the support members since test loads at failure were nearly double the required value. A failure in the air bag loading system caused the first test to be terminated at 41.9 psi.



● 603FTB069

	SPEC. NO.	KC TO FAILURE	TEST K_t	DESIGN K_t	FAILED ELEMENT
FATIGUE TEST - CONST. AMP MAX. STRESS = 30 KSI R = .10	1	199.3	2.25	5.0	TEE
	2	756.2	2.20	5.0	STRAP
	3	225.2	2.20	5.0	TEE

Figure 2.2.2-4 CREDIBLE OPTION FASTENER EVALUATION PROGRAM - 932 WEB SPLICE

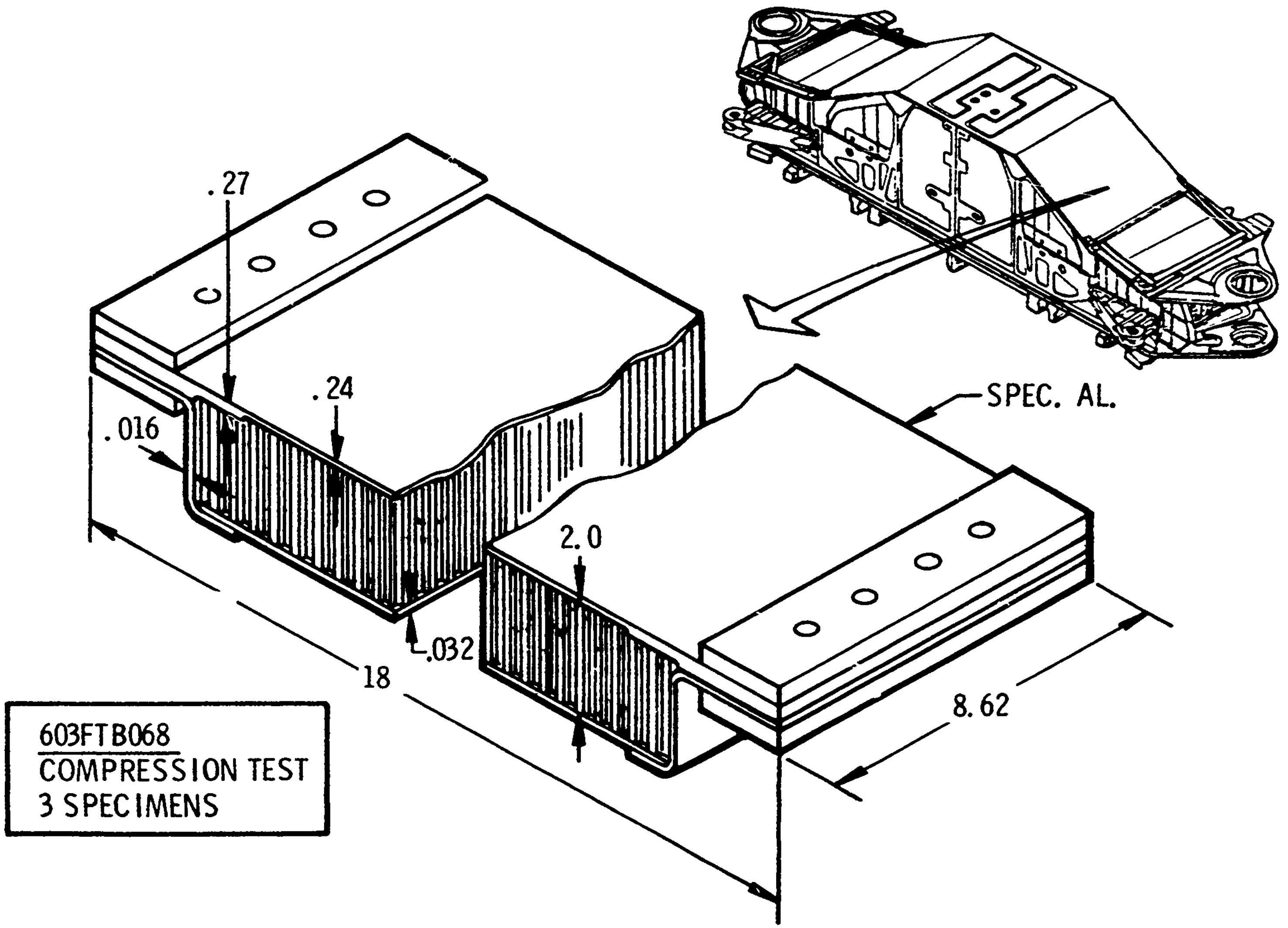


Figure 2.2.2-5 CREDIBLE OPTION FASTENER EVALUATION PROGRAM - UPPER SURFACE SANDWICH PANEL COMPRESSION TEST

Table 2.2.2-II SELECTED TEST RESULTS, 603FTB068 COMPRESSION SPECIMENS

Specimen	Load Pounds	Strain μin/in Thick Face	Thin Face	Central Deflection Inches	Nominal Calc. Stress (1)	Ult. Allowable Used for Design (2)	Remarks
					ksi	ksi	
1	120,000	5535	40	>.086	58.0		Defl. gage bottomed out
	152,000	--	--	--	73.5	60.6	Failure
2	120,000	5600	10	.1035	58.0		
	154,000	--	--	--	74.4	60.6	Failure
3	120,000	5530	245	.063	58.0		
	153,800	--	--	--	74.3	60.6	Failure

NOTES:

(1) Load/Nominal area of thick face

(2) Outer face material is 2024-T851 with F_{cy} from MIL-HDBK-5 of 59 KSI, E_c of 10.7×10^6 psi

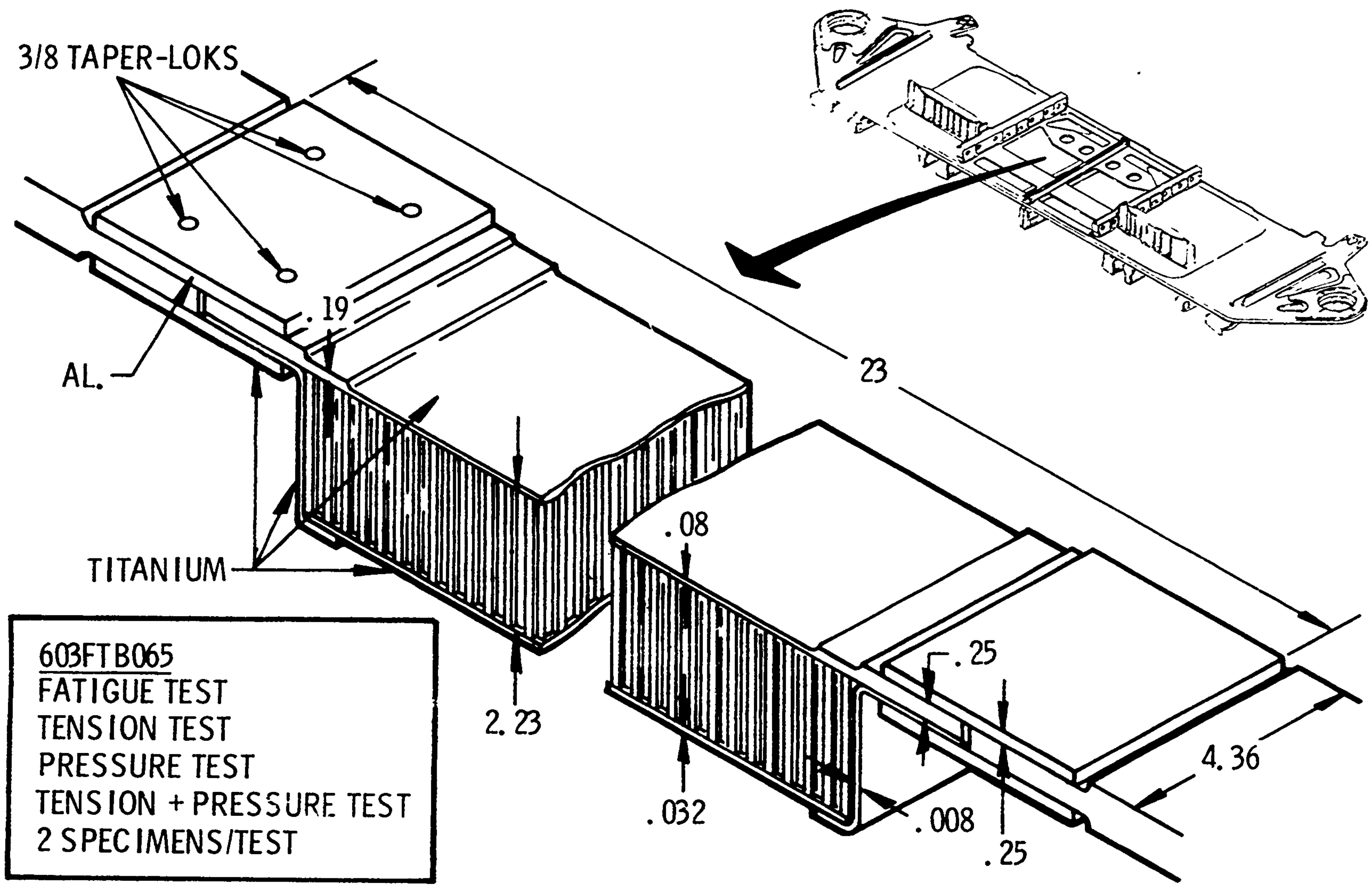
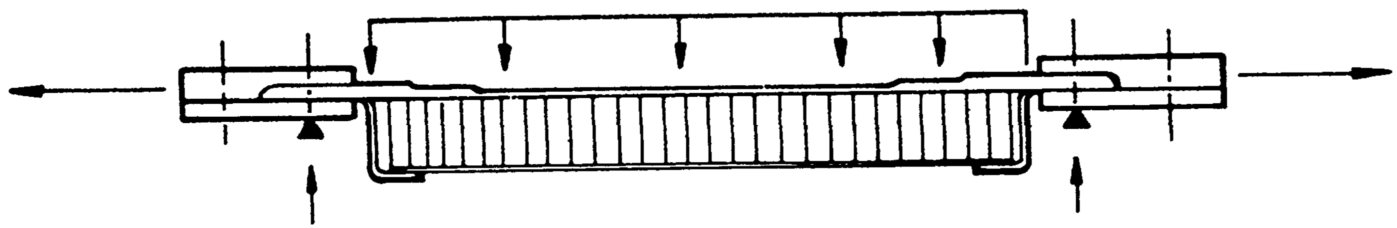


Figure 2.2.2-6 CREDIBLE OPTION FASTENER EVALUATION PROGRAM-LOWER SURFACE SANDWICH PANEL

Table 2.2.2-III SELECTED TEST RESULTS 603FTB065-1 TESTS

TEST TYPE	SPEC. NO.	MAX. TEST STRESS OR PRESSURE	MAX. TEST LOAD / ULT. DESIGN LOAD	REMARKS
Constant Amplitude Fatigue R = .1	1	15.3 ksi on al. spl.	.79	Grip Failure - 450 KC
	2	15.3 ksi on al. spl.	.79	2270 KC - K_t = 3.65
Static Tension Test	1	>130 ksi	1.95	Tension Failure in .08 Face
	2	>130 ksi	1.91	" "
Static Lateral Pressure Test	1	41.9 psi	1.80	No Failure
	2	48.0	2.06	Core Separated From .08 Face
Static Tension Plus Lateral Pressure	1	>130 ksi	1.91	Tension Failure in .08 Face
	2	"	"	" "



The ultimate design pressure for the WCTS panel is 15 psi. The test value was set at 23.23 psi in order to approximate the correct shear reactions at the supports for the "two dimensional" specimen which has a shorter span than the actual panel.

The behavior of the specimens with combined axial tension and lateral pressure was similar to the specimens without pressure except that thin face strains were higher at lower load levels because of pressure induced bending. Lateral pressure reached 40 psi at the time of failure. As in the other tests, ample strength was indicated.

2.2.3 Full Scale Testing (At AFFDL/FBT)

Testing is to be accomplished on a full-scale WCTS of the "No-Box" Box configuration in accordance with the test plan defined in Section 2.2.4 of this report. Testing will be performed at AFFDL in the test set up described in AFFDL-TR-74-98. General Dynamics will provide test planning, test fixture, and the test article; AFFDL will provide test equipment and perform the testing. Manufacturing of test hardware is nearing completion and the status at the end of the reporting period is as follows:

The test fixture base frame and related loading systems hardware have been delivered to AFFDL and re-assembly has been completed as shown in Figure 2.2.3-1.

The forward upper structure and related hardware required for mating was shipped to AFFDL in early December 1974. This hardware is shown in Figure 2.2.3-2, 2.2.3-3 and 2.2.3-4. The aft upper structure and related hardware required for mating is almost complete as shown in Figure 2.2.3-5 and is due for shipment early in January 1975. These items will be re-assembled at AFFDL in preparation for subsequent mating with the test WCTS.

The dummy wings, dummy main landing gears and dummy wing sweep actuators are shown in Figure 2.2.3-6 and are complete except for pre-fitting of some hardware. The aft sections of the dummy wings were shipped in early December 1974. The dummy pivot pins are also complete except for final pre-fit. The test WCTS is still in manufacture as further described in Section 5.0 of this report. The remainder of this hardware is scheduled for shipment in mid-February 1975.

Strain gage installation on the dummy wings (31 gages) simulated fuselage (65 gages) and fuselage extensions (26 gages) was completed. Cables for these gages plus the 296 gages on the WCTS and 16 gages on the shear links are being made up.

Figure 2.2.3-1 TEST FIXTURE BASE - AFTER REASSEMBLY AT AFFDL/FBT

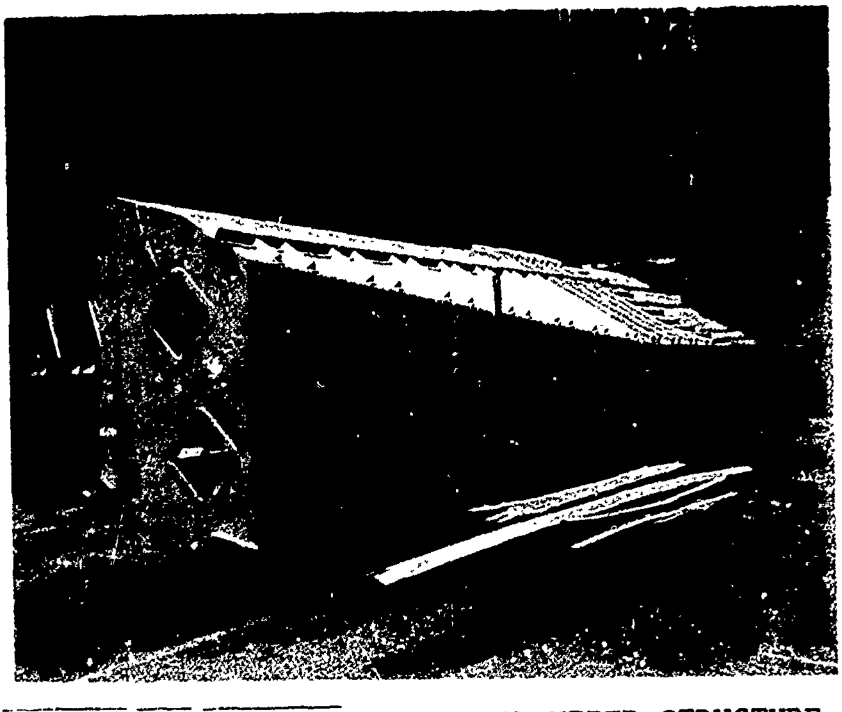


Figure 2.2.3-2 LEFTHAND FORWARD UPPER STRUCTURE - READY FOR SHIPMENT

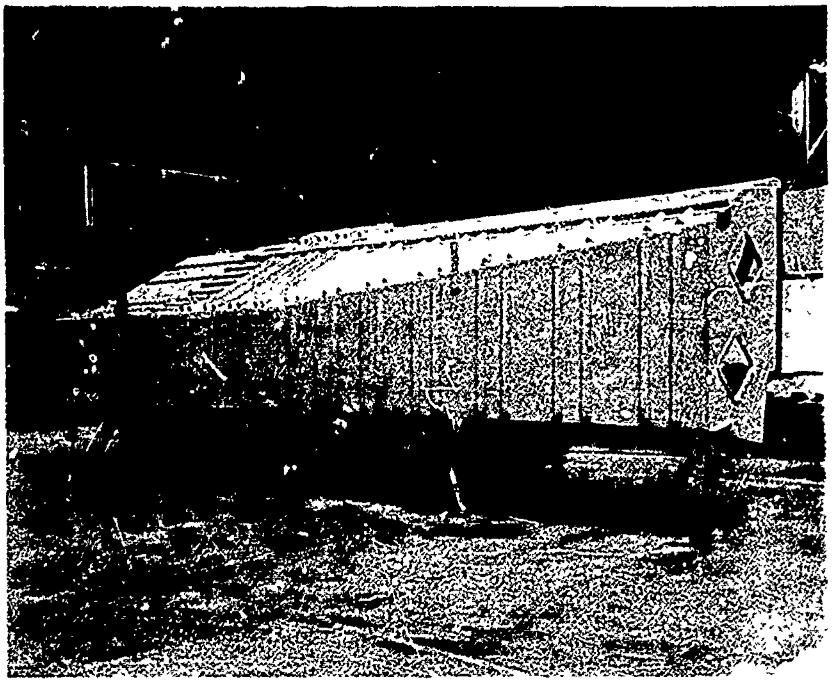


Figure 2.2.3-3 RIGHTHAND FORWARD UPPER STRUCTURE - READY FOR SHIPMENT

Figure 2.2.3-4 REASSEMBLY AND MATING HARDWARE FOR FORWARD UPPER STRUCTURE - READY FOR SHIPMENT

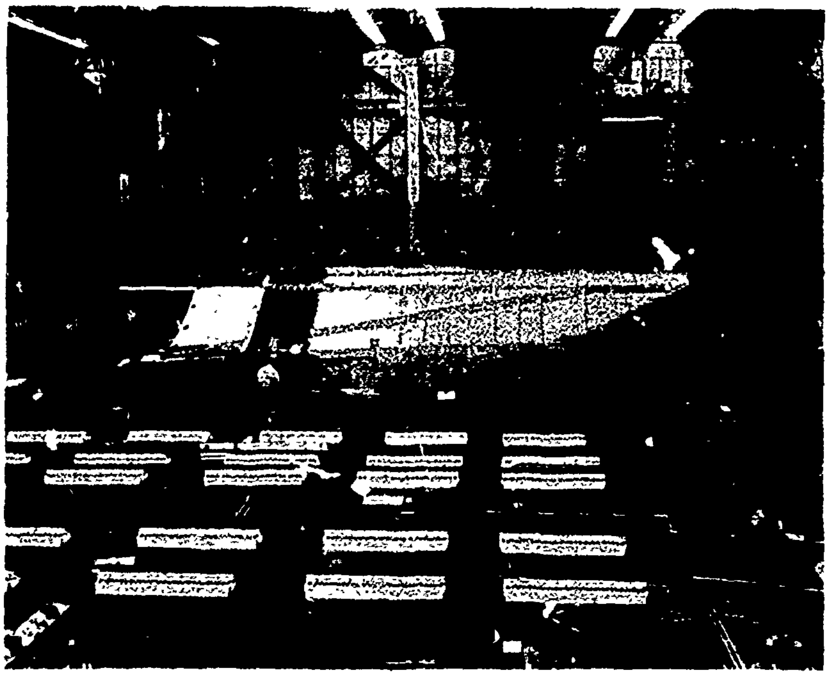


Figure 2.2.3-5 AFT UPPER STRUCTURE - IN FINAL ASSEMBLY

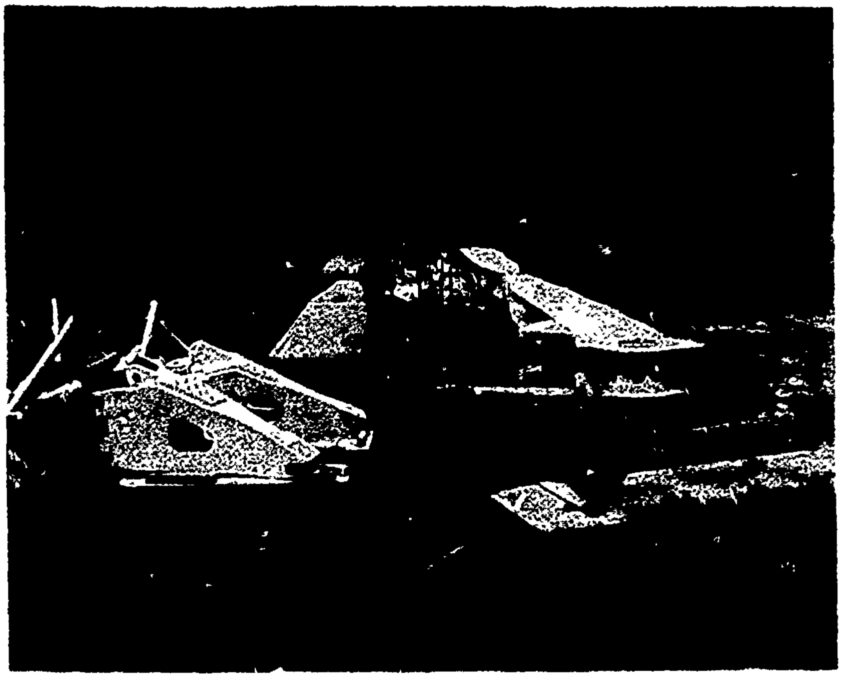


Figure 2.2.3-6 DUMMY WING, DUMMY MAIN LANDING GEARS AND DUMMY WING SWEEP ACTUATORS

2.2.4 Full Scale Test Program Test Planning

The preliminary test plan for the full scale test program has been revised to reflect the latest fracture analysis results outlined in paragraph 2.1.3.2. Minor typographical changes and additions to the material properties section to FZS-219 were accomplished during this period. Fatigue analysis results will be incorporated as those become available.

Strain gage installation of the WCTS continues as areas of the test article are made available. To date 272 of 426 strain gages (or 64%) have been installed.

Cable assemblies (total of 556) for the total instrumentation package are approximately 71% complete.

SECTION 3

QUALITY ASSURANCE AND NDI PROGRESS

Quality Assurance and NDI activities are covered in this section.

3.1 QUALITY ASSURANCE ACTIVITY

During this reporting period the Quality Assurance effort was primarily concerned with the inspection of wing carrythrough structure detail and subassembly items. Data documenting the manufacturing inspections and tests and their results are being recorded, collected and maintained. Product discrepancies are recorded on Quality Assurance Rejection Reports and dispositioned for corrective action as determined by the authorized program engineering personnel.

3.2 PROCEDURES

The required Nondestructive Testing Standards (NDTS) and Process Standards (PS) for the AMAVS program have been finalized, approved and published. The following list itemizes these procedures.

AMAVS NDTS	TYPE INSPECTION	DRAWING
10.06	Penetrant	General
15.04	Hardness Testing	General
15.04-1	Conductivity Testing	General
20.06	Magnetic Particle	General
20.06-1	Magnetic Particle	X7224070/ X7224090
20.06-4	Magnetic Particle	X7224011
20.06-5	Magnetic Particle	X7224065
20.06-8	Magnetic Particle	X7224076
20.06-9	Magnetic Particle	X7224085
20.06-12	Magnetic Particle	X7224175
20.06-13	Magnetic Particle	X7224176
30.01	Radiographic	General
30.01-1	Radiographic	X7224071/ X7224091
30.01-2	Radiographic	X7223920
30.01-3	Radiographic	X7223941
50.40	Ultrasonic 10 Ni Steel Welds	General
50.41	Ultrasonic Titanium Welds	General
60.06	Nondestructive Inspection of Bonded Structures	General

AMAVS PS	TYPE PROCESS
24.01-12	Electron Beam Welding
24.01-13	General Fusion Welding
24.01-14	Inspection Processes and Acceptance Standards for Fusion Welded Assemblies

3.3 BONDING NDI ACTIVITY

A total of thirty-four (34) nondestructive bonding test standards were manufactured for use in the preparation of Nondestructive Testing Standards (NDTS) and inspection of production bonded assemblies. These test standards were designed and manufactured to simulate the various skin gage thicknesses, materials, core densities, and core heights. Figure 3.3-1 shows a typical bonded test standard reference panel. Each test standard had a combination of induced flaw sizes to represent the minimum and maximum flaw detection requirements as stated in FPS-1092 - Processing and Quality Control of Adhesive Bonded Assemblies. Each test standard was evaluated after being manufactured to determine its condition and to verify that it contained induced flaws. This evaluation was accomplished by using through transmission ultrasonics and recording the results on data paper through a "C" scan system. Once the evaluations were complete the specific NDI technique was verified against the test standard and inspection procedures (NDTS) were prepared.

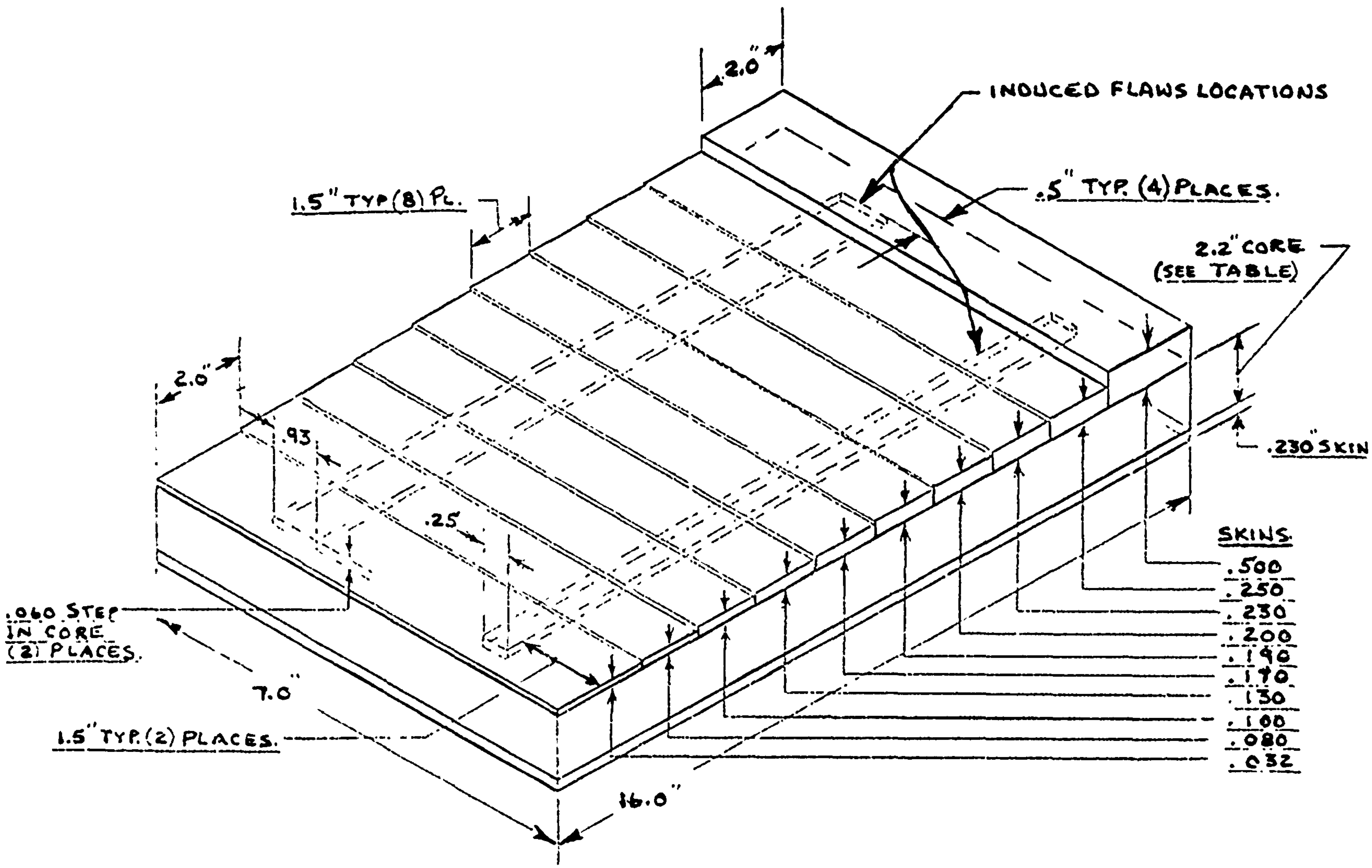


Figure 3.3-1 TYPICAL BONDED REFERENCE PANEL

SECTION 4

MANUFACTURING ENGINEERING PROGRESS

Activity in manufacturing engineering was primarily in two areas. The R&D efforts in Phase II Credible Option were extended during this reporting period to establish improvements in fabrication methods. The second effort concerns the project group co-located with design engineering for the purpose of coordinating the tooling and fabrication of the WCTS.

4.1 RESEARCH AND DEVELOPMENT

Developments during Phase II have been progressively discussed in previous reports. Those areas which had potential for use in fabrication of production components were designated for continued developments. The areas for continued investigation are; installation of 1-1/4 dia. taper-lok bolts, machining and welding.

4.1.1 Taper-Lok Bolt Installation, 1.250 Inch Diameter

A purchase order was issued for the procurement of the Dresser Industries QDA-16 Quackenbush power feed drill unit with depth control. Dresser agreed to loan GD/FW the prototype equipment for research use while the new unit was being assembled.

Using the loaned quipment shown in Figure 4.1.1-1 and purchased and in-house fabricated cutting tools, development of process and equipment continued.

Cutting fluids were evaluated to determine the most effective type for the 1-1/4" taper reaming operation. Water soluable oils, water soluable chemicals (synthetic), solvents such as TB-1 Freon and Isopar-M, and straight mineral oils were evaluated. Only the straight mineral oil was suitable for producing an acceptable hole. All cutting fluids were applied in a high pressure mist to assist in evaluating the cuttings. The oil/air mist created a housekeeping problem and possibly a safety hazard. A vacuum pick-up was used to arrest some of the exhausted spray but still did not completely solve the problem. In the course of development, the vacuum pick-up hose was attached directly to the bottom of the work-piece using a rubber seal to direct the suction through the hole being reamed. The vacuum source and hose are shown in Figure 4.1.1-1. This arrangement not only completely controlled the exhausted spray but also provided a significant aid in chip removal.

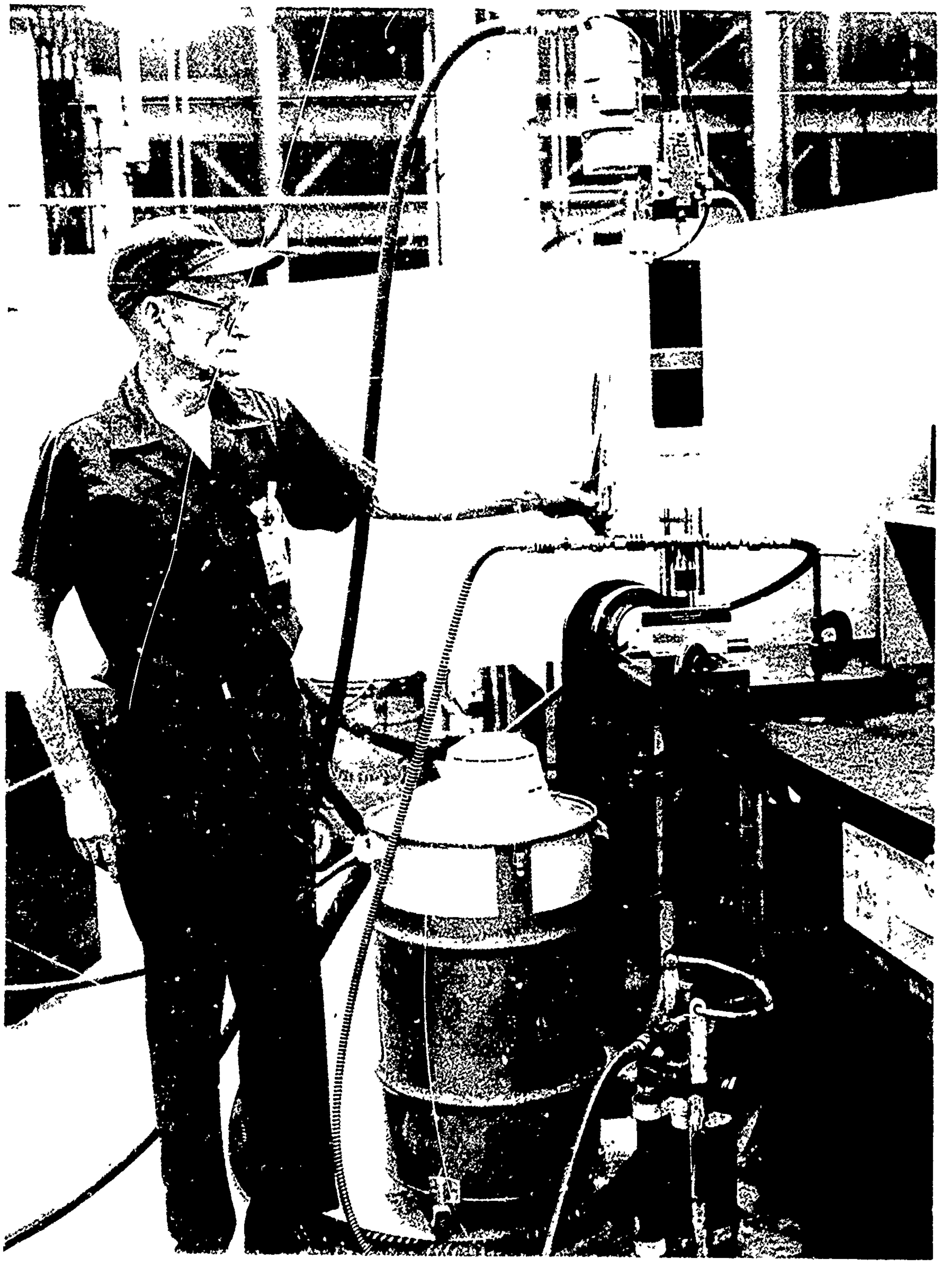


Figure 4.1.1-1 1.250 INCH TAPER-LOK BOLT INSTALLATION

Roughing reamer development has been reduced to two designs, similar in geometry except that one has three flutes and the other four. The three flute design is superior in chip ejection capability but is very sensitive to sharpening accuracy. Unless all three flutes are cut equally, chatter will occur and a "rifled" hole will result. The four flute cutter seldom chatters but causes a chip ejection problem due to reduced flute gullet area. The four flute cutter is also useful in removing the "rifled" condition from a hole as produced by an improper three flute cutter. The present plan is to ream the holes using the three flute cutter and use the four flute cutter for clean-up as required. This approach has consistently produced acceptable rough reamed holes in workpieces that simulate the AMAVS structure.

The multi-flute carbide finish reamers were received in Nov. and finished holes have been produced using these reamers. These reamers are normally used by hand to remove .001"-.002" from the rough reamed hole to provide dimensions and finish as required by Engineering standards. The 1-1/4" diameter reamer requires more power to use than most men can apply, therefore power assist is necessary. Several methods were evaluated and the one selected as satisfactory employs a very large right angle impact wrench altered to provide slow continuous rotation. Several holes have been satisfactorily finished reamed by this process.

Fasteners and nuts have been obtained and coated with cetyl alcohol in preparation for installation tests. Two four-to-one torque multipliers in tandem were used to achieve the necessary pull-in torque. An Engineering representative observed these tests and collected torque requirement data relative to degree of interference (protrusion) which will be reported in the Engineering section of this report.

The new QDA-16 depth control attachment has been received and the power unit is expected soon. Operational tests will be made with this equipment which will also provide an opportunity to proof test other roughing reamers.

It should be noted that no problems have been encountered relative to the function of the QDA-16 power equipment.

4.1.2 Development of 1-1/4" Taper-Lok Airgage Probe

A tapered airgage probe has been fabricated "in-house" for accurate inspection of 1-1/4" tapered fasteners drilling task at WPAFB. See Figure 4.1.2-1. The airgage has been tested and certified to provide visual read out of toleranced throughout the full length of the fastener holes to accuracies of (.00005) fifty

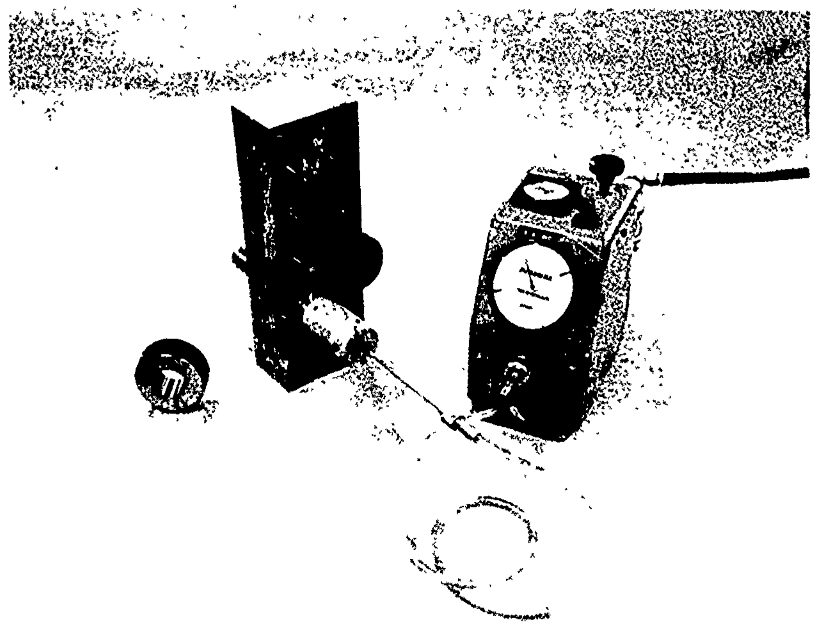


Figure 4.1.2-1 1.250 INCH AIR GAGE

millionth increments. The airgage probe system will analyze accuracy of taper and roundness on the full range of 1-1/4 bolt sizes. The unit is portable and will analyze tapered fastener hole to GD/FW Engineering Specification M-173.

4.1.3 Milling of 10 Nickel Steel HY-180

A major milling problem on 10 Nickel steel is to finish profile mill deep pockets and thin stiffeners up to 3-1/2 inches in height.

The convention High Speed Steel 6 and 8 flute end mill cutters which are effective in rough pocket milling do not have adequate tool life for finish cuts on long length stiffener parts. The high speed steel (HSS) end milled cutters dulled rapidly and produced inconsistant final finishes. The average tool life using HSS end mills is 10 to 20 minutes. Cutter changes during finish cuts also present a cutter mismatch condition on the flange or stiffener surfaces that requires additional hand work to blend in the surfaces.

Based on the initial inefficiencies of numerical control finish milling operations on HY-180 steel, in the 250 KSI strength level, a milling test program was conducted for finish milling operations.

The need for extended cutter life eliminated the testing of premium HS steel milling cutters, since carbide materials offer increased tool life if the correct cutter geometry can be attained to prevent chipping.

The initial side milling tests, simulating finish cuts on stiffener surfaces was conducted on an 8 ft. x 15 ft., 4 axis N.C. milling machine with infinitely variable spindle speeds from 9.0 through 3600 RPM.

Carbide brazed-in cutter inserts for a 2" dia. cutter having conventional D'Rake-15^{o} helix provided slight improved tool life, however, finishes indicated some chipping of the cutter edges. It was also realized that regrinding of the cutters reduced the diameter of the cutter beyond the range of the N.C. programmed path.

Additional cutter tests were conducted using mechanically attached helical carbide cutter blades at varying speeds and feeds.

As a result of the cutter test and evaluation it was determined that the mechanical clamped, replaceable C-6 grade carbide cutters offered improved tool life and finishes for finish milling the prototype detail parts (10 Nickel steel) for this program.

Two slices of carbide blade end mills (Spira-Lok) were procured from Cleveland Twist Drill Co. that were employed on all side mill finishing operations (see figure 4.1.3-1), A & B).

The cutters provided diameter control by adding a shim under the blades prior to resharpening to a specific diameter. The end mills have 5^{o} positive rake angles with 15^{o} helix angle. The 2.0 inch diameter cutter has 6 flutes X 2-1/4" flute length. The 3.0 inch diameter cutter has 6 flutes X 3-3/4" flute length.

The spira-loc cutters provide extended tool life for N.C. finish milling 10 Nickel steel up to 20 times that of High Speed steel when using 90 SFM spindle speed and .002 inch per tooth (IPT) feed with maximum depth of cut not to exceed .1 inches. Average surface finishes of 40 to 80 RMS were obtained on the finishing cuts. Face milling operations on 10 Nickel steel detail have been improved for final finish cuts on parts with large web areas by use of a round insert type cutter (See figure 4.1.3-1, item "C"). The 6" dia. face mill, Lovejoy Ti-dex 6NZR8 uses positive axial and radial rake geometry and 1.0 inches diameter round carbide inserts Lovejoy DA-84P with 10^{o} positive rake angles. Finish skin mill cuts on 10 Ni steel of 1/8" or less offer 40 to 60 minute tool life between insert indexes. Surface speeds of 120 SFM and .004 IPT feed has produced finishes of 63 RMS using Stewart HD950 (20:1) chemical coolant.

4.1.4 GTA - Cold Wire Welding

The Gas Tungsten Arc cold wire welding process was evaluated on 1.8 inch thick specimens. Both single J grooves and double U grooves were used. The single J groove specimens shown in Figure 4.1.4-1 with the 20^{o} included angle (10^{o} each side) required 72 passes for completion. Approximately 30 passes were completed in a normal 8 hour shift. This includes set-up time and cool down time required between passes to maintain the 200^{o}F interpass temperature. The 40^{o} double U groove (20^{o} each side) specimens, Figure 4.1.4-2, were welded using the same weld parameters. A total of 62 weld passes were required for completion. The 20^{o} double U groove (10^{o} each side) specimens were welded in the same manner. A total of 45 weld passes were required for completion. This weld is shown in Figure 4.1.4-3.

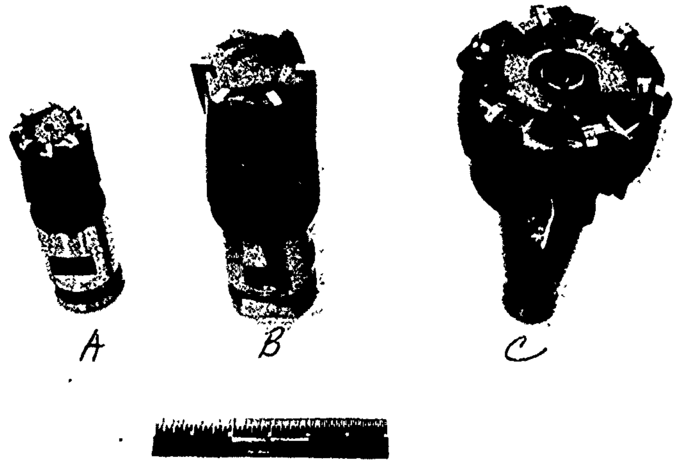


Figure 4.1.3-1 CUTTERS USED FOR 10 NICKEL STEEL

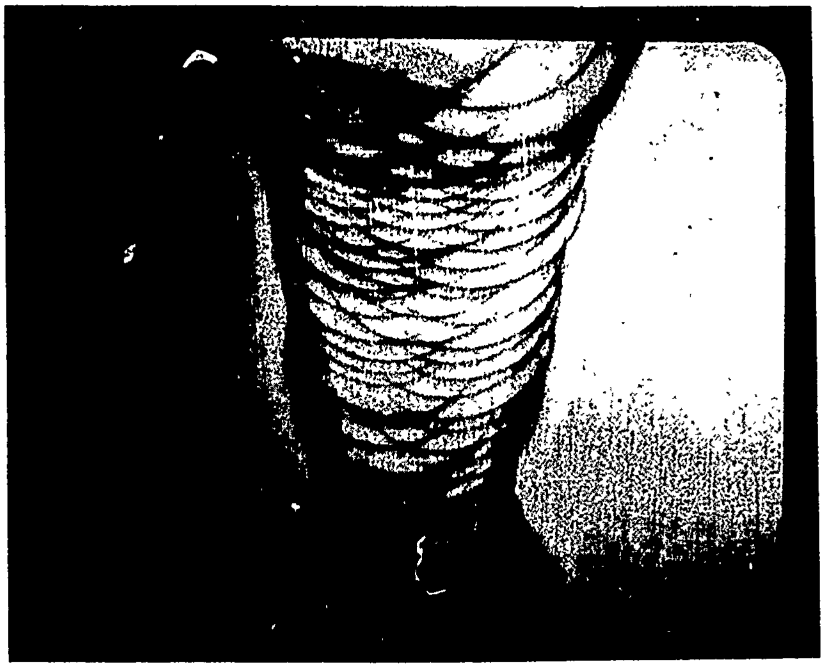


Figure 4.1.4-1 SINGLE J-GROOVE 20^{o} INCLUDED ANGLE - 72 PASS WELD

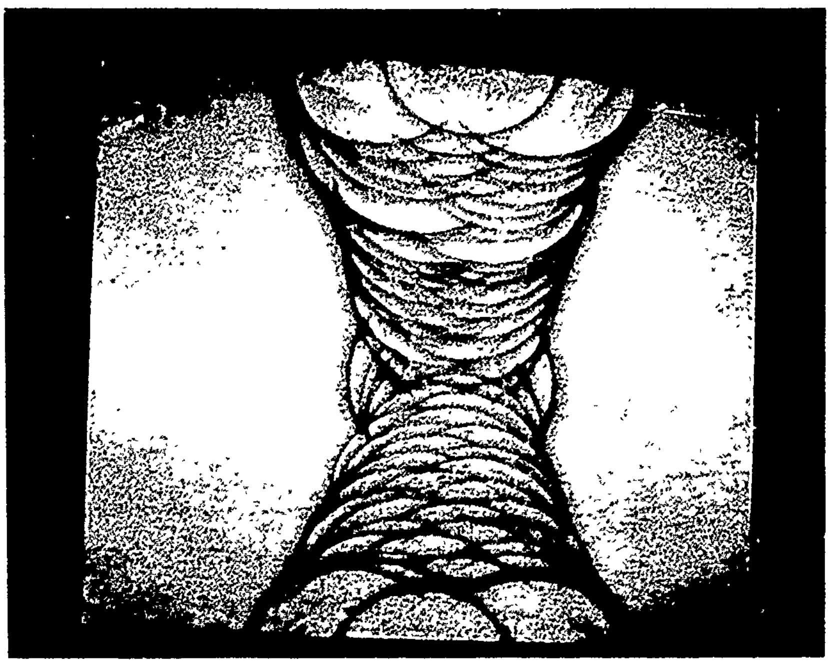


Figure 4.1.4-2 DOUBLE U-GROOVE 40^{o} INCLUDED ANGLE - 62 PASS WELD

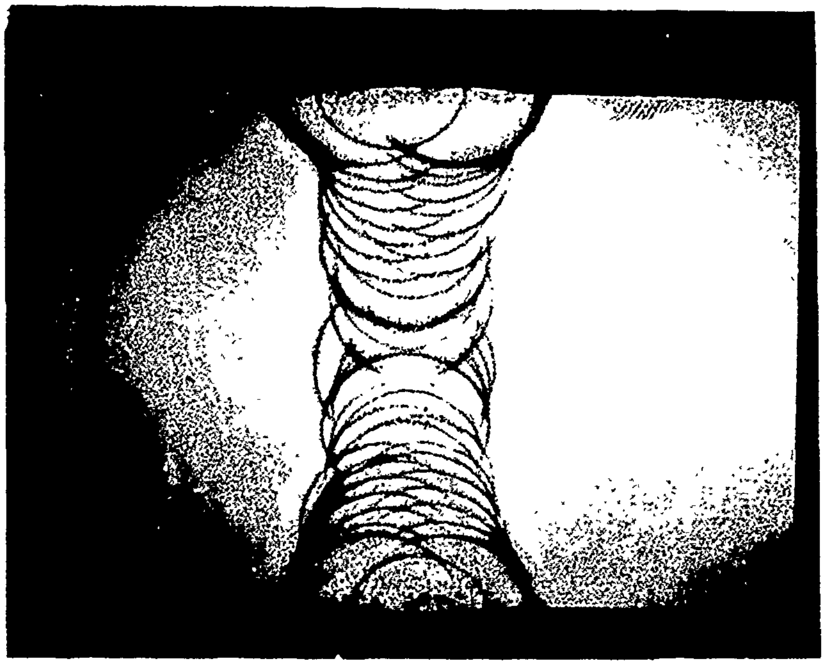


Figure 4.1.4-3 DOUBLE U-GROOVE 20° INCLUDED ANGLE - 45 PASS WELD

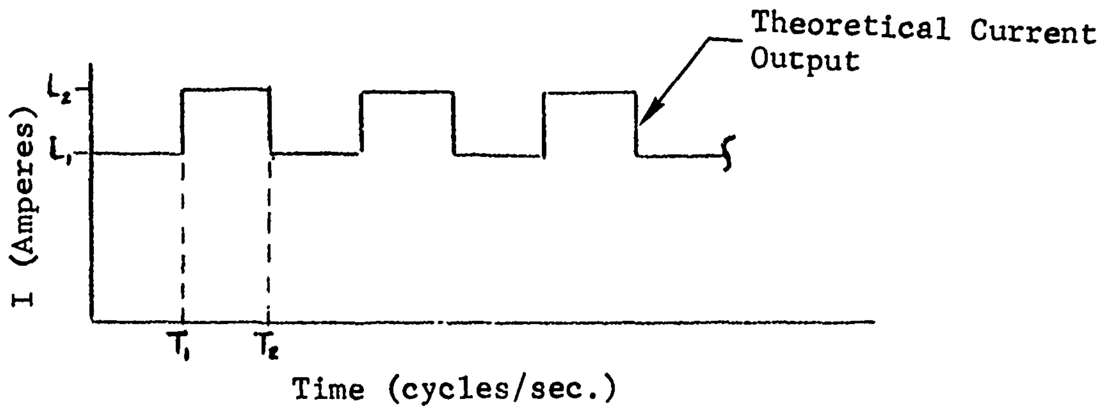
The double U-groove specimens were welded using a copper tube to supply backup gas to the root side of the weld. Five passes were applied to the first side being welded. The plate was then turned over and background to remove any possible contaminated material. The second side was then welded 50% complete. The part was turned over and the first side was then welded complete. The part was again turned over and the remainder of the second side completed. This sequence was used to eliminate the plate warpage.

Additional parameter development work was accomplished in an effort to reduce the heat input levels. Each of the following parameters were considered for change to effect a lower heat input:

A. Arc current (Level 1 and Level 2)
B. Pulsation Control (Level 1 and Level 2)
C. Arc voltage control
D. Travel speed
E. Wire feed volume

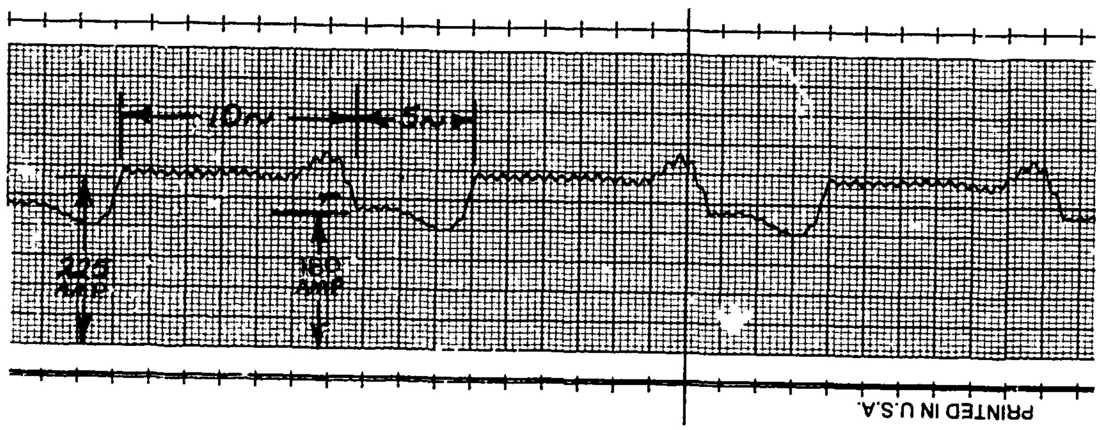
It was found that the use of the pulsed arc welding control provides a very wide range of acceptable operating parameters. The heat input can be tailored very closely to the exact heat input level desired. Once suitable travel and wire speeds are established for a given current level, the pulsation system can be used to effect a very wide set of operating parameters and a wide range of resultant heat input levels.

The theoretical arc pulsation welding mode is depicted in the following graph.



L_1 = Amperage setting at Level 1
L_2 = Amperage setting at Level 2
T_1 = Time duration at L_1 current level
T_2 = Time duration at L_2 current level

The magnitude of the pulse level is determined by the difference between L_1 and L_2. The time base setting T_1 and T_2 determines how long the power supply provides output at each level. The theoretical output is essentially a saw toothed plot. The virtual or actual output is shown in the following oscillographic trace of the pulsed arc welding current.



The above current level was pulsed between 180 and 225 amps. The 180 amp time duration was 5 Hz and the 225 amp time duration was 10 Hz. The trace was made with 200 mm/sec. chart speed. Full scale deflection represents 400 amps. The peaks at the beginning of each pulse cycle indicate a slight current overshoot and the corrective reaction time. Approximately 2 to 3 Hz are required for correction. Clean uniform weld beads were made as low as 11 to 12 kilo-joules. However, in a deep welded section the low heat arc would not properly wet the side walls of the weld groove. Further work indicated that very clean welds can be made at the 18-21 kilo-joule level. These empirically developed parameters are expressed as follows:

Arc Voltage	-	12 V.
Arc Current	-	Pulse Mode
		Level 1 = 125 Amps at 30 cycles
		Level 2 = 200 Amps at 15 cycles
Travel Speed	-	6.0 inches/min.
Wire Feed Speed	-	28.0 inches/min.

The above settings represent a heat input level of 18 kilo-joules. However, if the weld were applied to a narrow deep groove the voltage would have to be increased to approximately 14 volts to provide adequate wetting of the sidewalls. The heat input level would then approach 21 kilojoules. These parameters are based on the use of helium torch gas which adds to the puddle fluidity.

A balance between the travel speed and wire feed volume must be achieved to maintain good puddle fluidity. An excessive amount of wire volume will chill the leading edge of the puddle and result in cold laps and excessive porosity. The same problems can be a result of excessively high travel speeds. As higher travel speeds are used, a trailer shield will be required to protect the hot weld metal from atmospheric contamination.

Good shop proceedures are essential to the consistent production of X-ray quality welds. The interpass cleaning technique is of prime importance. In the case of the deep sections and narrow 20° grooves, the best proceedure is to lightly grind the surface of the preceeding weld using a small high speed carbide burr.

Improved welding techniques and proceedures produced welds of higher quality as a result of work accomplished on this program. However, further work needs to be done to fully optimize the welding parameters to achieve better mechanical properties. It is recommended that further work be accomplished particularly in the area of pulsed arc welding. This is the most promising and undeveloped areas for improvement of gas tungsten arc welding. It is also recommended that both plasma arc and GTA-Hot wire processes be fully investigated for use on the 10 Nickel steel.

4.1.5 Electron Beam Welding

Previous investigations and limited production experience have shown four major problem areas when EB welding thick 10Ni steel are:

1. Porosity - usually caused by trapped gas, metallic vapors.

2. Excessive loss of material, resulting in gross internal voids.

3. Micro-Fissures - caused by uneven solification rate and delayed cooling.

4. Beam deflection by residual magnetic fields.

In order to make the four EB welds on the outboard bulkheads at Station Y_F932 and Y_F992 the above problems had to be solved.

When developing procedures for EB welds on thick material, the weld cross sectional shape or geometry becomes the visual means for determining weld improvement. Any minor variation in focal distance causes this shape to change. This in turn alters the solidification pattern and the cooling progression. By analyzing the shape and micro-sections, the cooling rate can be determined and weld parameter adjustment can be made.

The effects of heat input and the cooling mode are shown in Figure 4.1.5-1.

Weld "A" is a two pass weld made with the beam crossover or focal point at the exact center of the 1.6" thick 10 Ni steel. One of the characteristics of EB welds on 10 Ni is very narrow heat affected zone. This can be attributed to slow heat transfer of the material. It also contributes to the problem of molten metal control.

In early work on thick steel it was found that any noticable bulge in the weld cross section profile usually indicated an over heated area and delayed cooling, resulting in severe cracking.

While the exact mechanics of the penetration of the electron beam are not fully known, it is quite obvious from very careful examination of weld cross sections that progression through the thick material is incremental. When the cross section bulge occurs it is obvious that the beam energy has spread and cracking occurs in that area because of delayed cooling.

Weld "B" shows a two pass weld with mid point focus into a solid back up. Since 10 Ni contains several vapor formers such as cobalt and manganese, care must be taken not to trap gas in the molten weld puddle that will cause porosity. For that reason EB welds on thick 10 Ni cannot be made into a solid back up.

Weld "C" shows a three pass weld with mid point focus. Here the cracks occured near the root of the third pass. Filler wire (.062 dia.) was used on all three welds.

Figure 4.1.5-2 shows the types of hot tears that are typical of welds made when the center of the welds cooled last. Weld "A" and "B" were made with the same parameters for the first pass, on the second or face pass of weld "B" the beam power level was reduced. It should be noted that no root cracks occurred as long as the face pass was made at a low power level. Weld "C" clearly shows the effects of a face pass made with too much beam power.

Figure 4.1.5-1 EFFECT OF HEAT INPUT AND COOLING MODE

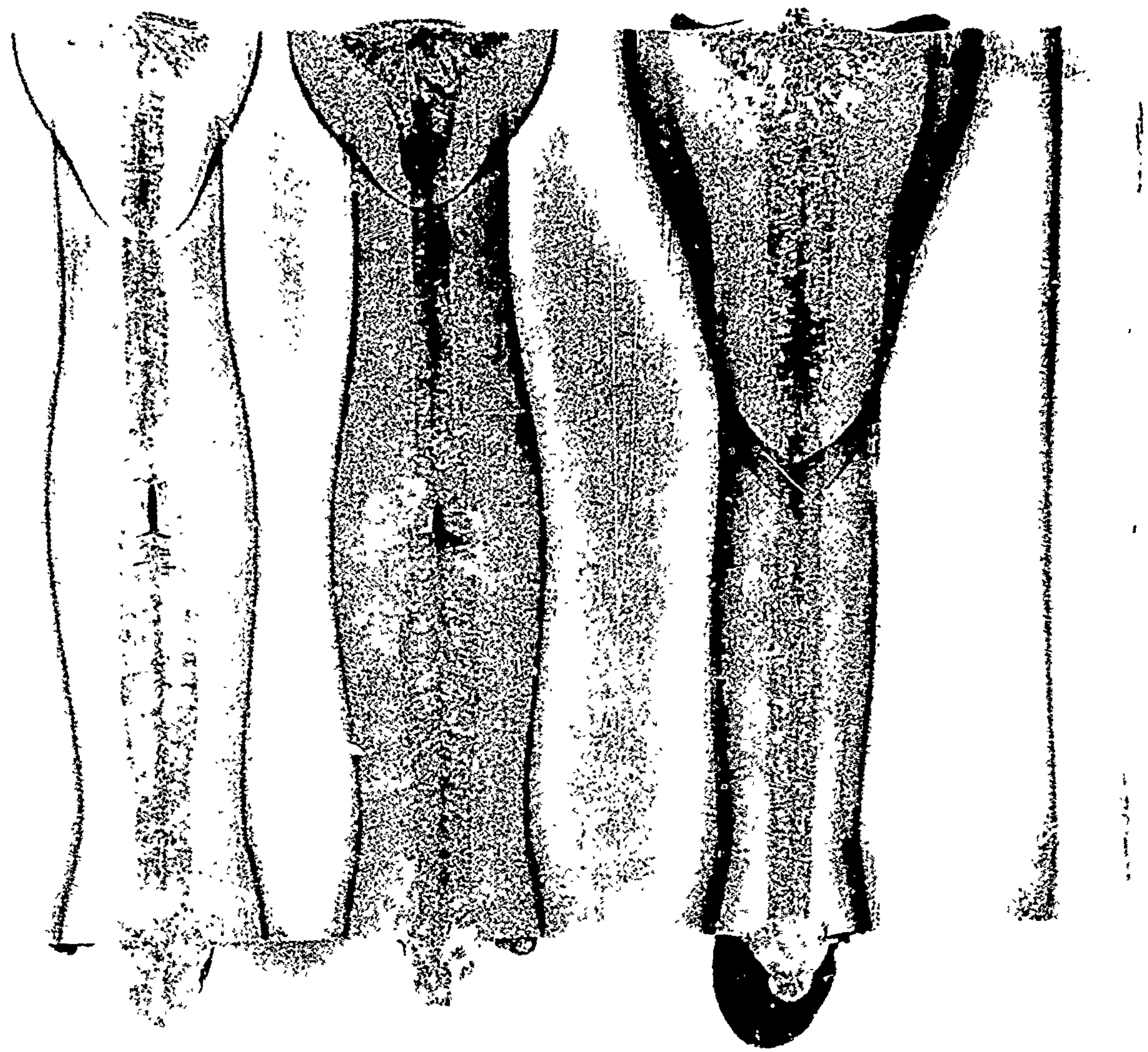


Figure 4.1.5-2 TYPICAL WELD HOT TEARS

While macro-sections are very useful in EB weld parameter development it must be pointed out that they only show the bend shape and weld quality at the point where they are cut out of the weld. To supplement the macro-examination, longitudinal x-rays were used. Longitudinal sections were cut out of the weldment parallel to the weld direction and reduced in thickness so that even the smallest defect could be examined. Figure 4.1.5-3 is an example of such a x-ray of specimen H-17. The mid point micro-fissures shown by the macros were found to be almost continuous. In addition, voids caused by loss of material were also shown. Figure 4.1.5-4 shows the weld root configuration of H-17 specimen. The four globules indicate severe loss of metal and internal voids. The remainder part of the root reinforcement was satisfactory.

Numerous joints and various combination of beam power, focal distance and other parameters were tried to eliminate the cross section bulge and subsequent microfissures. (See appendix A). The Sciaky EB welder used on this program is equipped with a beam current control or bias, however, experience with this feature has shown it to be unstable and not reproducible.

From an analysis of the various development joints run, it was concluded that the beam current was too high and that a stiffer (higher electron velocity) beam was needed to penetrate the thick material but not melt the surrounding metal. Changing the anode to cathode distance of the EB gun by use of mechanical spacers was used to secure various volt-ampers combinations as follows:

No Spacer	30 Kv	-	360 ma
.050"	30 Kv	-	260 ma
.075"	30 Kv	-	200 ma
.100"	30 Kv	-	180 ma
.150"	30 Kv	-	140 ma

It should be noted that while the Kv remain constant the beam current can be reduced.

Bead on plate welds were made to examine the weld cross section and to find the exact volt-amper combination that would produce a parallel sided weld geometry. The .100" spacer was found to produce the output curve shown in Figure 4.1.5-5. This proved to be the best EB gun mode and was used on all test and production parts. The high voltage low current beam was adequate to penetrate the 1.8" steel and produce a uniform cross section bead profile. The EB gun was stable and very few "arc outs" occurred.

Figure 4.1.5-3 LONGITUDINAL X-RAYS OF H-17 SHOWING VOIDS CAUSED BY GLOBULAR ROOT AND EXCESSIVE LOSS OF MATERIAL

Figure 4.1.5-4 H-17, EB WELD ROOT ON 1.8" THICK, 10 NI SHOWING GLOBULES CAUSED BY HEAVY LOSS OF MATERIAL

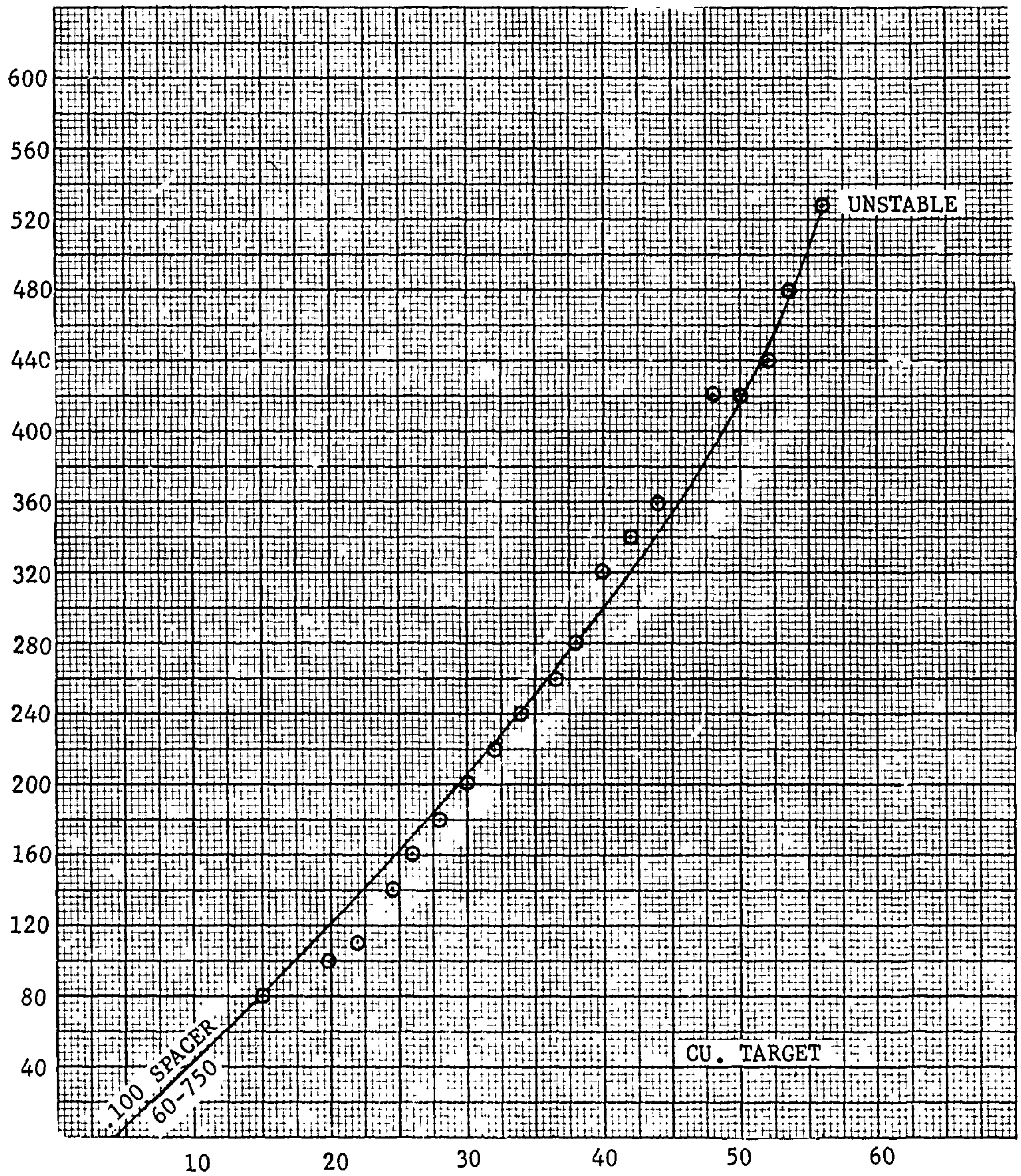


Figure 4.1.5-5 VOLT AMP CURVE WITH .100" SPACER

A typical beam current oscillographic trace is shown in Figure 4.1.5-6. This recording was made of a weld on 1.8" 10 Ni. This is in direct contrast to some of the earlier welds, since the setting for this particular weld was 45 Kv, 380 ma, 22 Ku, 140 ma (20.1 Kw) as compared to 41 Kv 560 ma and 18 Ku, 180 ma.

Another spurious problem inherent to thick section steel welding is the difficulty of controlling the long column of molten metal. This is particularly true of 10 Ni. since it is a very poor thermal conductor and the metal adjacent to the weld will not absorb the weld bent fast enough to prevent severe loss of metal and the resultant internal voids. Efforts to eliminate this metal loss included various frequencies and amplitudes of beam oscillation. While oscillation can be used successfully on D6ac and titanium it cannot be used on 10 Ni., since it seems to contribute to the puddle instability. The steady state or nonoscillated bead was used on all stringer passes and defused beam was used for the face pass. A typical weld schedule is shown in Figure 4.1.5-7.

Earlier experience with solid backups to control the molten column had resulted in porous welds because of trapped gas within the weld cavity. Several different thickness flat spacers between the backup and the weld joint were tested to eliminate this porosity problem. This approach did eliminate the porosity but did not control the molten metal. This led to a grooved backup which provided the necessary venting action as well as mechanical support of the molten weld metal.

A groove .125" deep and .250" wide was machined into the .500" x 1.00" backup strip. This design was used on all mechanical property tests reported earlier. The test plates used a straight grooved backup which presented no problems, but the production joint involved a tee section as shown in Figure 4.1.5-8.

The original bulkhead cap assembly had a .5" relief hole located at the intersection of cap and lower flange as shown in Figure 4.1.5-8. Test welds on this configuration proved to be satisfactory (see H-99, H-100 in appendix) for both the 1.6" and 1.8" thickness with the exception of minor backwelding required after the back up was removed. However, when the first full scale part was welded, the round grooved back up shown in Figure 4.1.5-9 did not absorb the penetrating beam energy and the resultant weld had void areas. (See Appendix H-101.) This was caused by several factors; namely the interface fit of a 140" part reflects the accumulation of several machine tolerances, the copper chill blocks apparently slipped when the parts were mated. To eliminate this occurring again, design engineering was requested to change the .5" diameter hole to a .625" x 1.00" rectangular relief. (See Figure 4.1.5-9.) This relief area was closed at the same time that the manual GTA weld on the T-leg

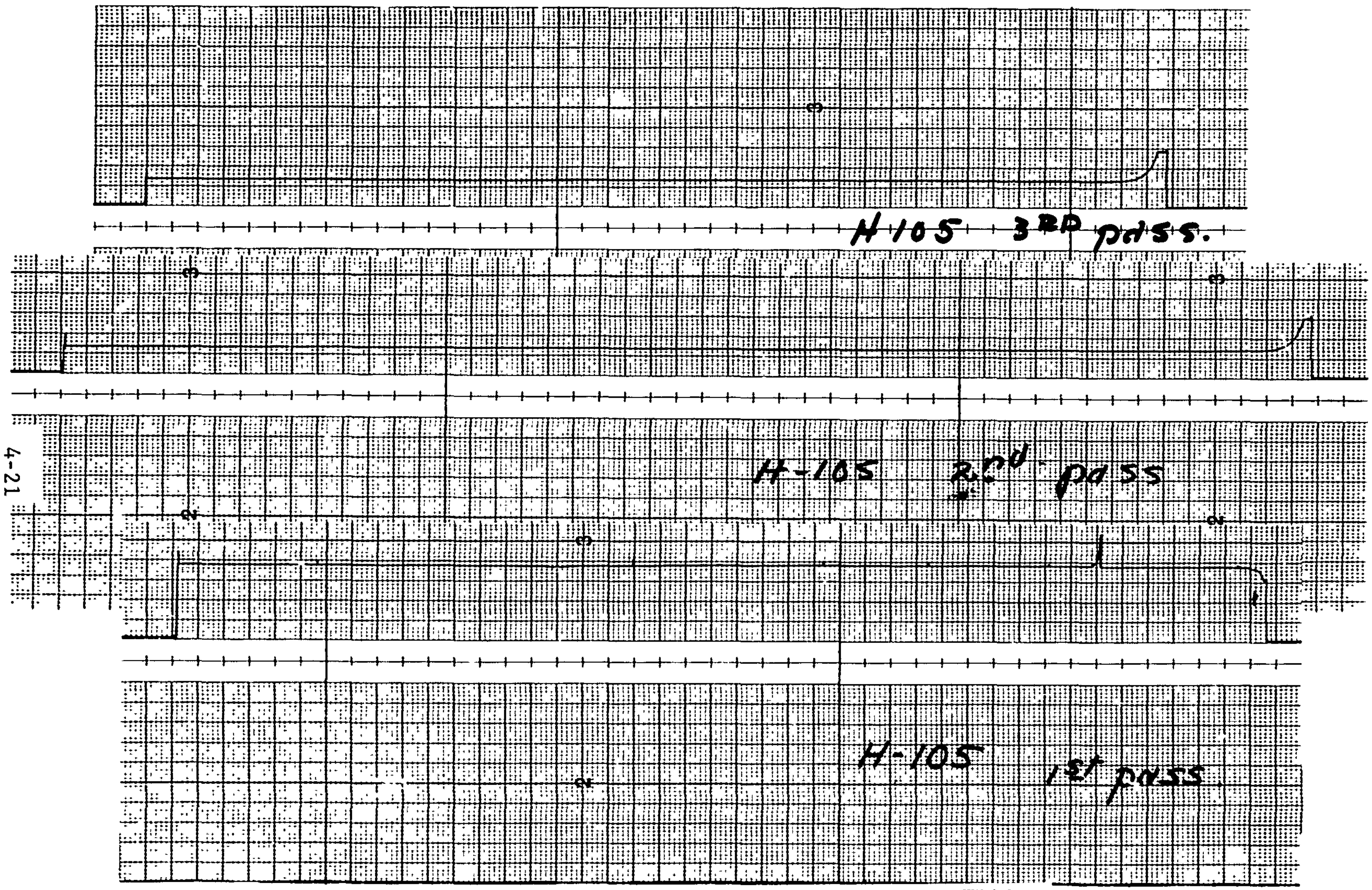


Figure 4.1.5-6 TYPICAL BEAM CURRENT OSCILLOGRAPHIC TRACE

ELECTRON BEAM WELDING SCHEDULE

Schedule Number ______ Date 5-2-74
Part Number H-100 Part Name Producibility Test Material Type 10 Ni (Hy-180)
Serial Number ______ Tool Number T17315 Mat'l. Thick 1.6
Tee Section Filler Wire Type Low Alloy (Hy-180) Diameter .062
10 Ni CR-MO-CO
Ht. No. 51361

UPPER CONTROL PANEL

HV START Delay	MOTOR START Delay	HIGH VOLTAGE Initial KV	HIGH VOLTAGE Final	SPEED ADJUSTMENT Initial and Final
0 0 1	0 0 0	4 5 .2	2 6 0	NA
Seconds	Seconds	Slope	Slope	Run
0 15 30 60 120	0 15 30 60 120	2 0 2	0 1 7	

OSCILLATOR

AXIS X ☐ Y ☐ | FREQUENCY, KC ☐ | RANGE ☐
ATTENUATION, Db ☐ | METER RANGE ☐ | METER READING ☐

CENTER CONTROL PANEL

	BEAM CURRENT, MA	HIGH VOLTAGE, KV	TRAVEL, IPM
Pass 1	3 6 0	4 6 .0	1 2 .0
Pass 2	1 3 0	2 2 .0	1 2 .0
Pass 3			

FOCUS CURRENT METER 1- 5 .2 2 DC Amps.
GUN FILAMENT METER 0 6 8 AC Amps.
FILAMENT ADJUST POT. 0 7 6

SKETCH OF JOINT

TYPE OF JOINT
Tee butt with backup

2- 5 .9 5

GUN ELEMENTS

GUN TYPE,	KV	6 0
FILAMENT,	MA	5 0 0
CATHODE,	MA	7 5 0
ANODE,	KV/MA	7 5 0
SPACER,	Inches	.1 0 0

BIAS On ☐ Off X
METER, AC VOLTS ☐
VOLTAGE ADJUST. ☐
Face Focus
GUN-TO-WORK DISTANCE, Inches 3 .5

OPERATOR'S STATION CONTROL

X-AXIS On ☐ Off ☐ | Y-AXIS On X Off ☐
DIRECTION Fwd. ☐ Rev ☐ | DIRECTION Fwd. ☐ Rev. X
TRAVEL SPEED, IPM ☐ | TRAVEL SPEED, IPM 1 2 .0
WIRE FEED On ☐ Off X | INCH PER MINUTE ☐
BEAM ALIGNMENT ☐ | FOCUS ADJUST. 5 .2 2
HIGH VOLTAGE ADJUST. NOTED | AVR Lock ☐ Unlock X

X-Ray Serial Number ______
Mag Inspection ______ Operator ______
Acceptance Standard ______ MR&D Engineer J. C. Collins
Metallurg

Figure 4.1.5-7 TYPICAL ELECTRON BEAM WELDING SCHEDULE

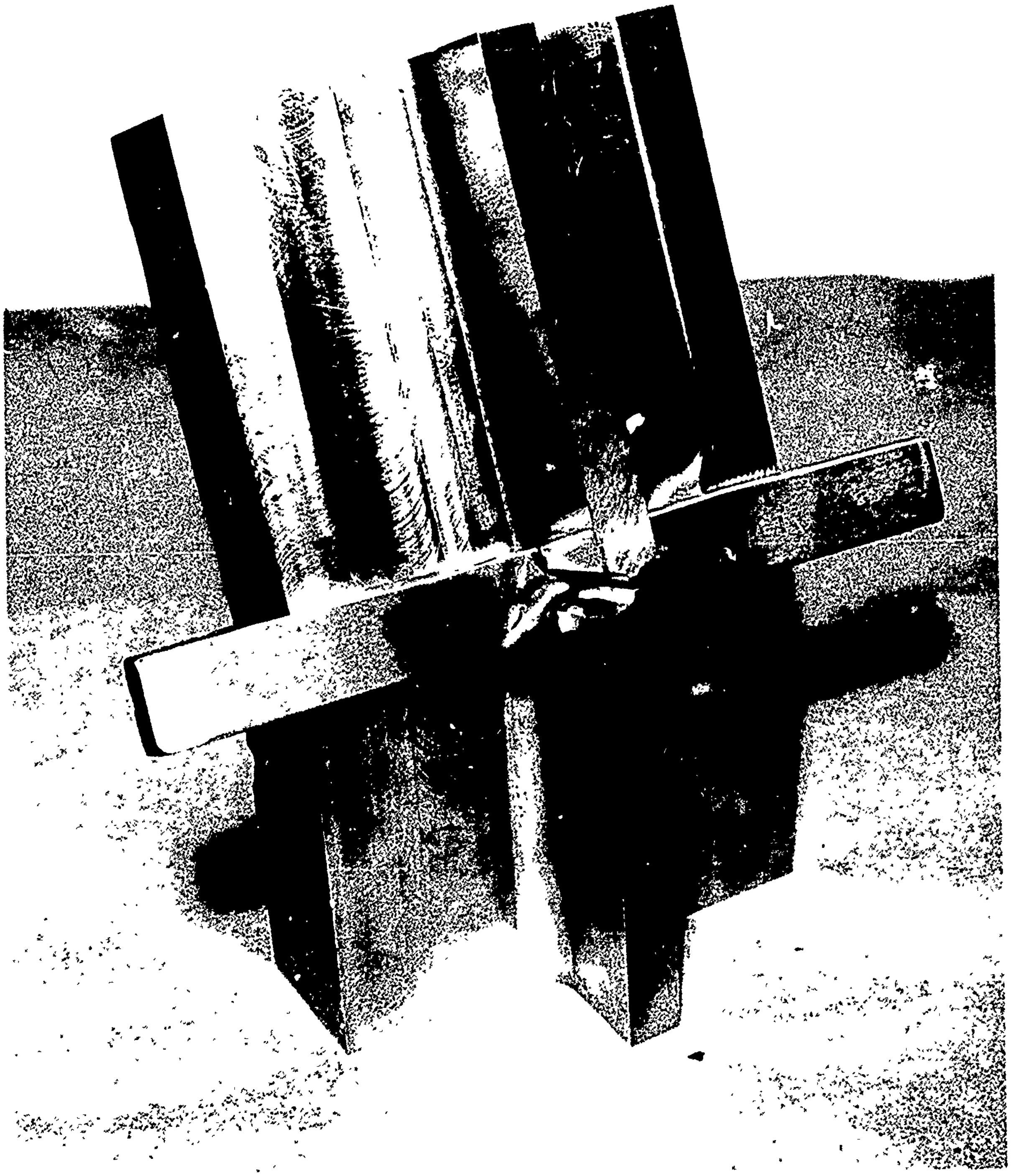


Figure 4.1.5-8 TEE SECTION (SIMULATED CAP WELD) WITH .5" DIA. AND GROOVED BACK UP IN PLACE

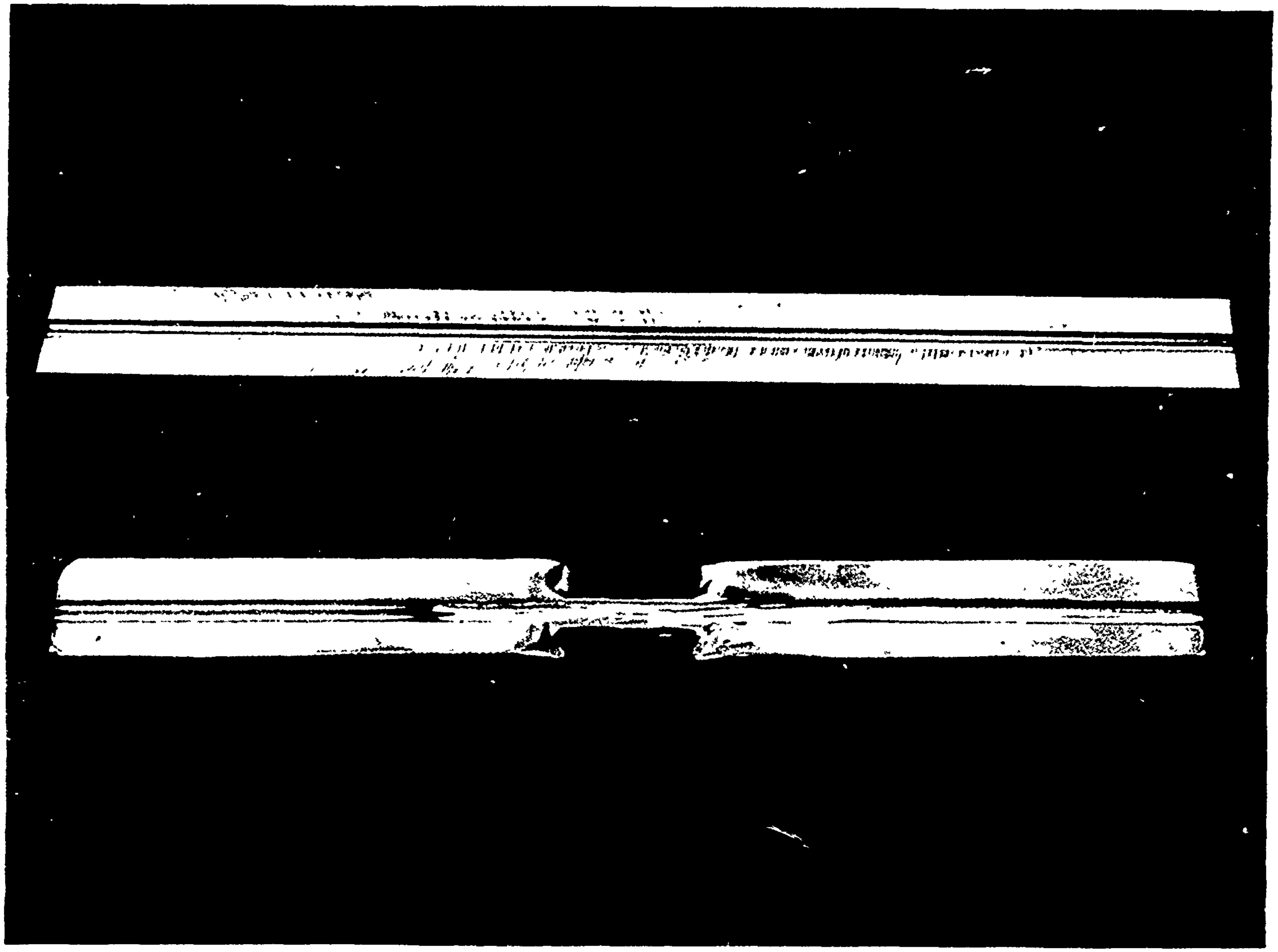


Figure 4.1.5-9 GROOVED BACK-UP BARS
Upper: .625" x 1.00" Rectangular Relief
Lower: .5" Diameter Relief

was made. This redesign proved to be adequate to absorb the penetrating beam and very little back welding or repair was required on the other three parts. Experience with subsequent test parts did show that the relief hole at a tee intersection on a 10 Ni. part is not necessary so future designs will be solid.

Figure 4.1.5-10 shows the macros of three welds made in 1.8" thick 10 Ni with the thicker grooved backup. Weld A has only minor cracks at the root interface. This will be removed with the .030" machine cleanup. Weld B shows the effect beam deflection by a 2.5 gauss magnetic field. Weld C had no defects and was found acceptable by X-ray, ultrasonic and magnaflux inspection.

Magnetic Deflection

One of the major problems found in welding 10 Ni. steel is that of retained residual magnetism. This interferes with efficient operation of both GTA and EB welding systems. While the action of a magnetic field on the GTA weld is an unstable arc, the resultant weld is still acceptable. The effects of a magnetic field in close proximity to the electron stream of the EB system is a deflected beam and a missed joint. This condition is amplified by increased gun to work distance or increased thickness of material.

The EB welding task consisted of four welds on the upper cap assemblys which were 1.6" and 1.8" thick. Initial work on test joints of the two thicknesses showed that 10 Ni retained an abnormally high percentage of residual magnetism after exposure to a magnetizing force. The strengths and location of these fields were found to be dependent on:

1. Strength of the magnetizing force

2. Direction of magnetization (longitudinal or circular fields)

3. Geometry of the part.

Experience with test plates and simulated tee section has shown that demagnitization of thick details must be limited to reducing the degree of magnetic field strength to an acceptable level since attempts to completely demagnetize is impractical.

The only positive method for completely demagnetizing 10 Ni. steel is by raising the temperature above the Curio Point (1050°F

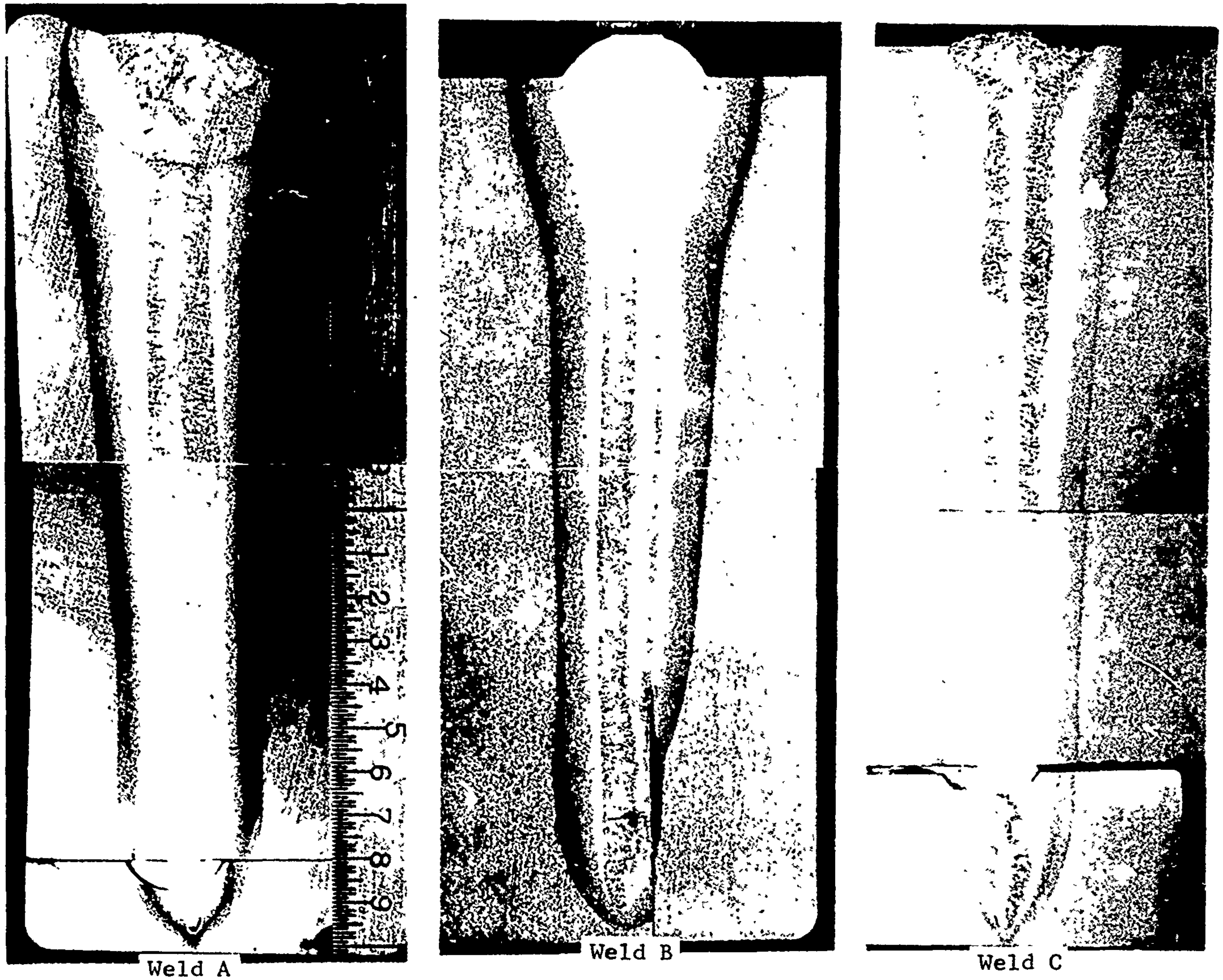


Figure 4.1.5-10 1.8" THICK WELD MACROGRAPHS

to 1450°F). This is impractical for most production work. However, in some cases where the details cannot be demagnetized, stress releiving above the curie point and then finish machining can be used.

Demagnetization

Some of the methods tested for demagnetizing the thick sections were:

Alternating current coil - A production unit rated 1000 ampers through a five turn coil or 5000 ampere turns was evaluated. This unit was found to be ineffective on large parts since the AC field is confined fairly well to the surface of the parts by the cuttent induced within the part itself. Various frequencies were tested but the results indicated that the higher the frequency the more pronounced the skin effect became, thus the penetration became less as the frequency was increased.

Reversing direct current - The direct current flow in a coil is reversed in direction and amplitude. Maximum rated output 6000 amps. This unit is usually very effective on hard to demagnetize parts. Usually ten reversals and reductions will provide satisfactory results. However, more reliability can be obtained by increasing the number of cycles up to 30.

Other methods tested were:

1. AC circular field
2. AC and DC yokes
3. Balanced wave AC
4. Localized demagnetizing by use of permanent magnets.

Methods of Measurement

Magnetic field intensities can be measured by quantitative or comparative methods. Quantitative measurements usually involve D'Arsonval-type meters in conjunction with search coils or probes. Such instruments are classed as laboratory equipment and require considerable time and skill to use. Thus they would not be easily adapted to production application. For the purpose of this investigation and for adaptability to production use the comparative method was used. Figure 4.1.5-11 shows the field strength indicators or magnetometers used to measure the fields in the 10 Ni. parts. They are accurate enough for this task and easy to use. All measurements reported in this report were made with this type of instrument. To determine the actual deflection

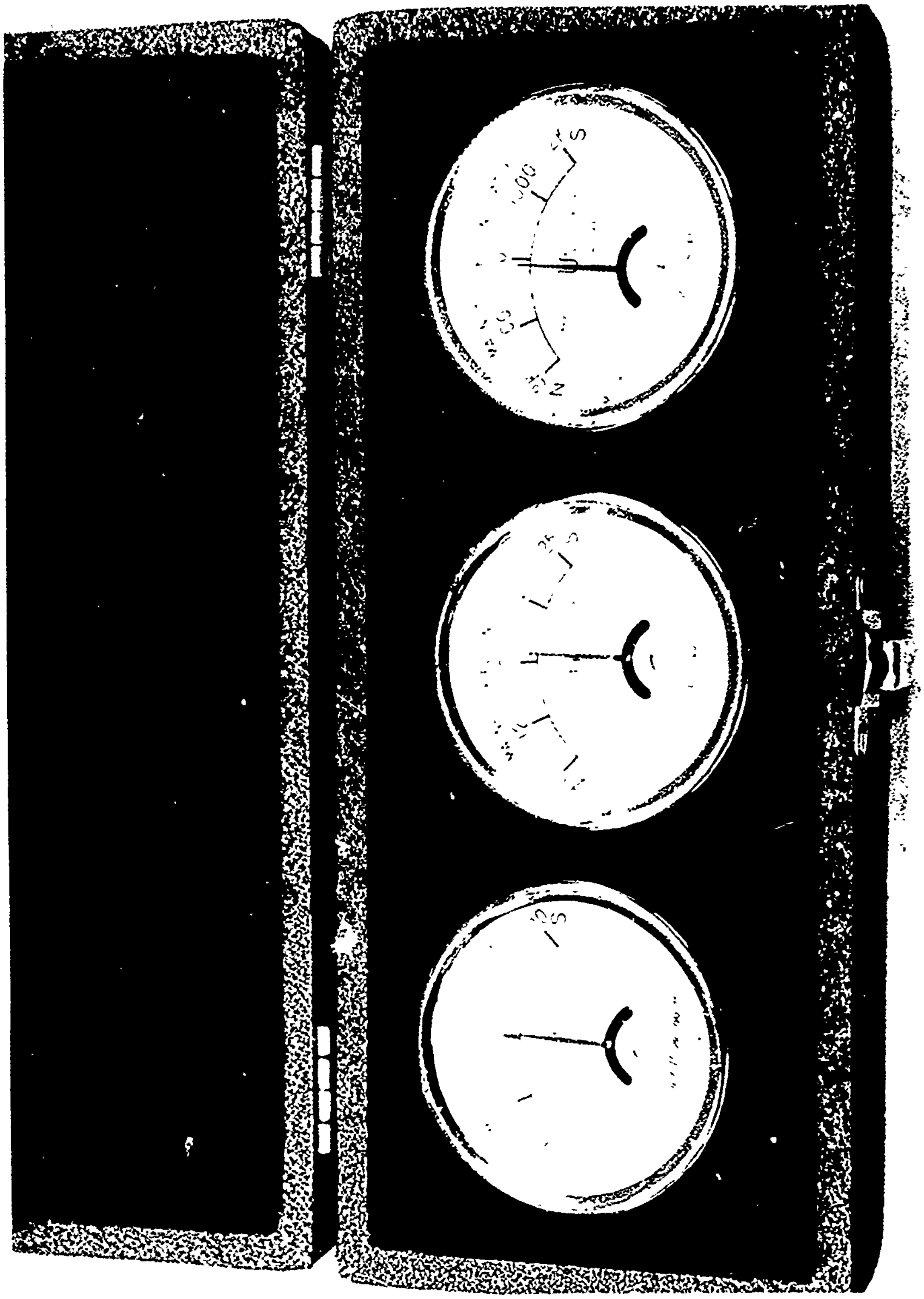


Figure 4.1.5-11 MAGNETIC FIELD STRENGTH METERS

of the beam by residual fields, either in tools or parts above the weld surface, a series of bead on plate type welds were made. A permanent magnet of known field strength was positioned at both 1" and 2" levels above the titanium target plates. Titanium was used as the target material since it is non-magnetic and eleminates the possibility of beam deflection by the base plates.

A low power beam (9 Kv, 80 ma.) was used on all plates in this series. Weld travel speed was held constant at 20 l.p.m. Gun to work distance was set at 3.[illegible]" and 6". A grid of 1" squares were scribed on the target plates as shown in Figure 4.1.5-12. It should be noted that the deflection on this plate was uniform since the positive and negative poles are parallel and equal distance from the beam centerline. From this plate we found that a + 2.5 to -2.5 gauss field located 2" above the work will deflect the beam .435" from a straight line, when the magnet is positioned 1" from the beam centerline. At the 2" position from beam centerline, deflection was .125", while at the 3" position, deflection was .080". Zero deflection was found 5" from the magnet. Several other plates, run under the same weld parameters, verified this deflection. As would be expected, increasing the gun to work distance, resulted in a decrease of beam deflection as shown in Figure 4.1.5-13. Here the deflection is .375" at the 1" line and 0 when magnet is 4" from the beam.

In addition to these tests, a magnetized bar of 10 Ni. steel was used to check the effects of several fields and polarities along the line of weld travel as shown in Figure 4.1.5-14. Here a field strength meter is attached to a centering pointer that is positioned on the geometric centerline of the EB gun. The X and Y drive system of the welder was used to move the meter along the weld joint. Several fields up to +5 and -5 gauss were found in 10 Ni. bar. From this setup, we were able to determine that a circular field parallel to the line of travel with equal fields will cause a uniform deflection, but the beam will return to the original path. If the field is located so that a negative pole will act to deflect the beam away from the source and a positive pole will attract the beam. This was expected but it was found that when the beam is deflected by a single pole of 1.5 gauss or more, that it retains this deflection for considerable distance from the field. No logical reason was found for this action although considerable effort was expended to determine the cause.

A method for counteracting the effects of a strong (1 gauss or more) magnetic field on or above the surface of the work is shown in Figure 4.1.5-15. It consists of a soft iron pipe

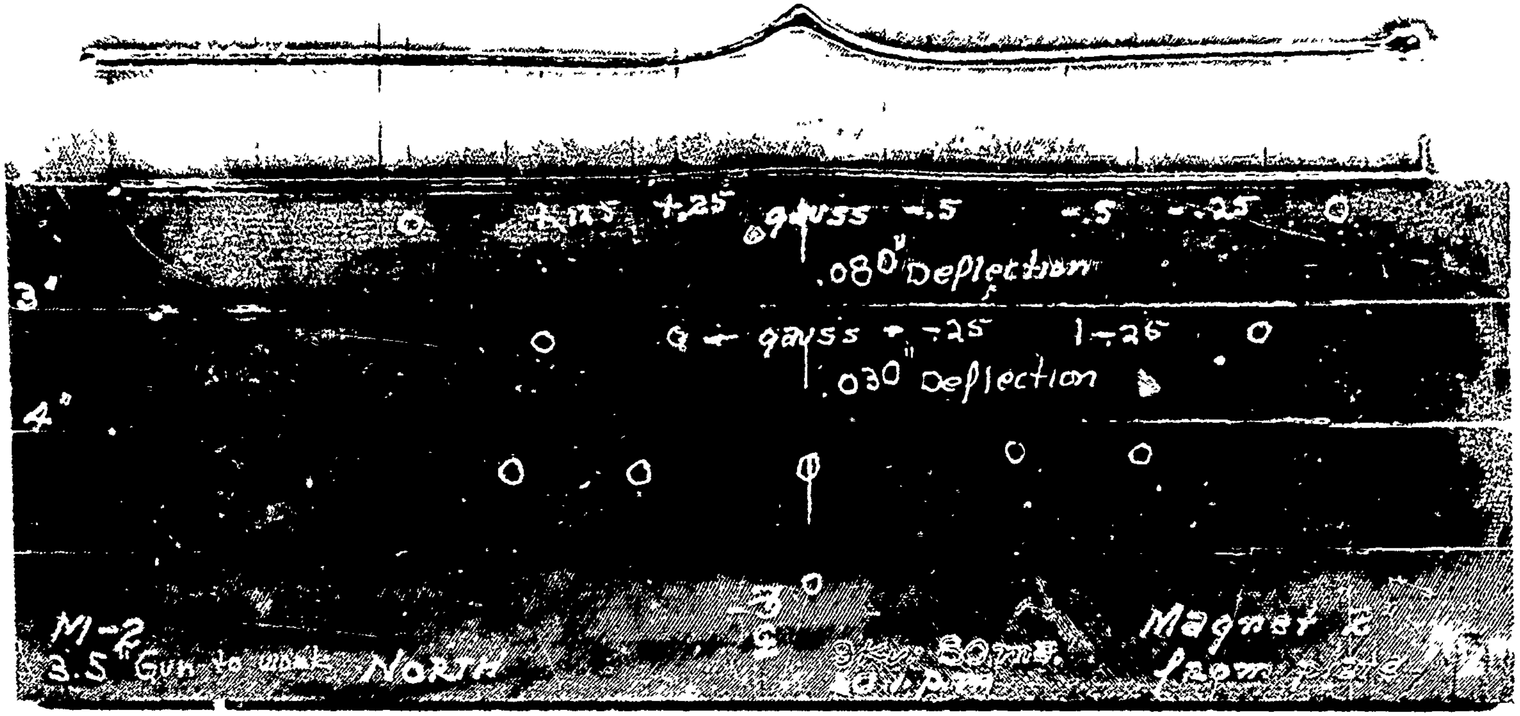


Figure 4.1.5-12 BEAM DEFLECTION TEST PLATE 3.5" GUN TO WORK

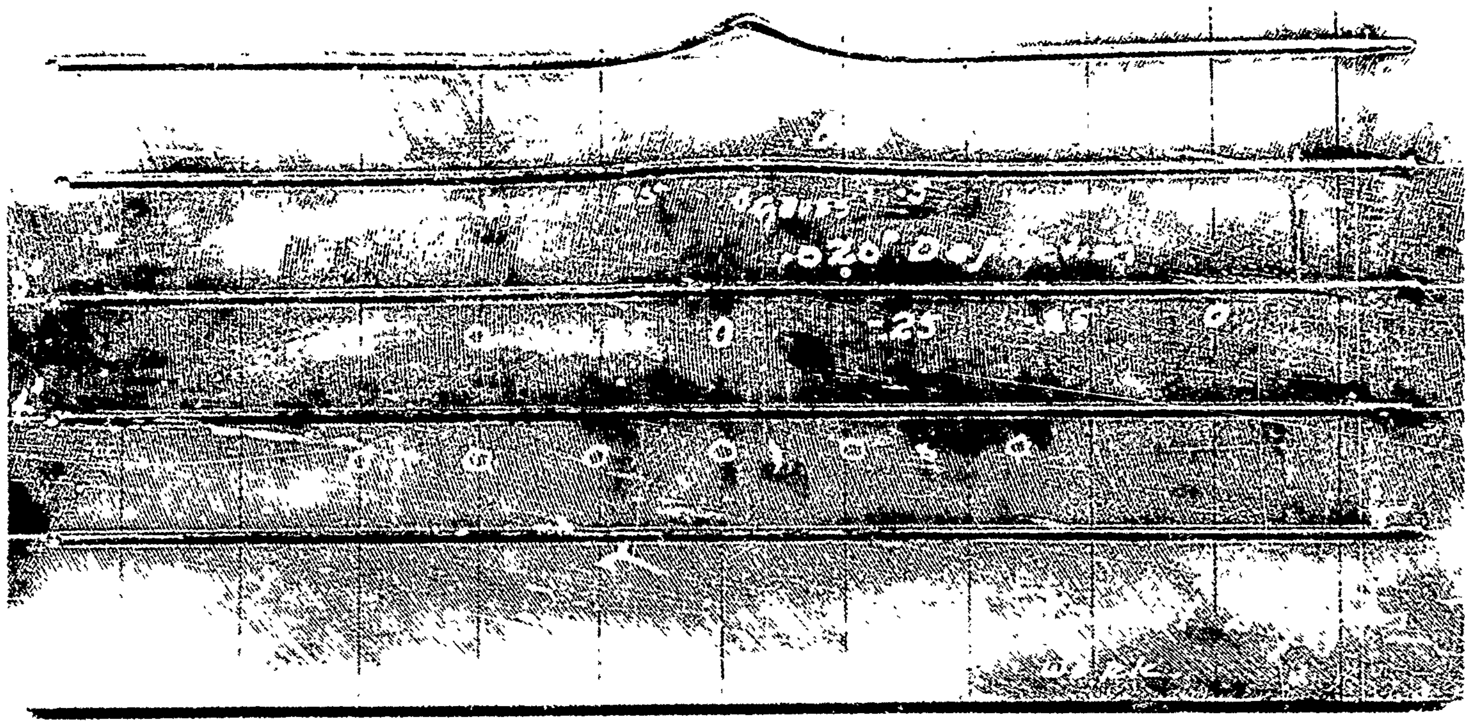


Figure 4.1.5-13 BEAM DEFLECTION TEST PLATE (6" GUN TO WORK)

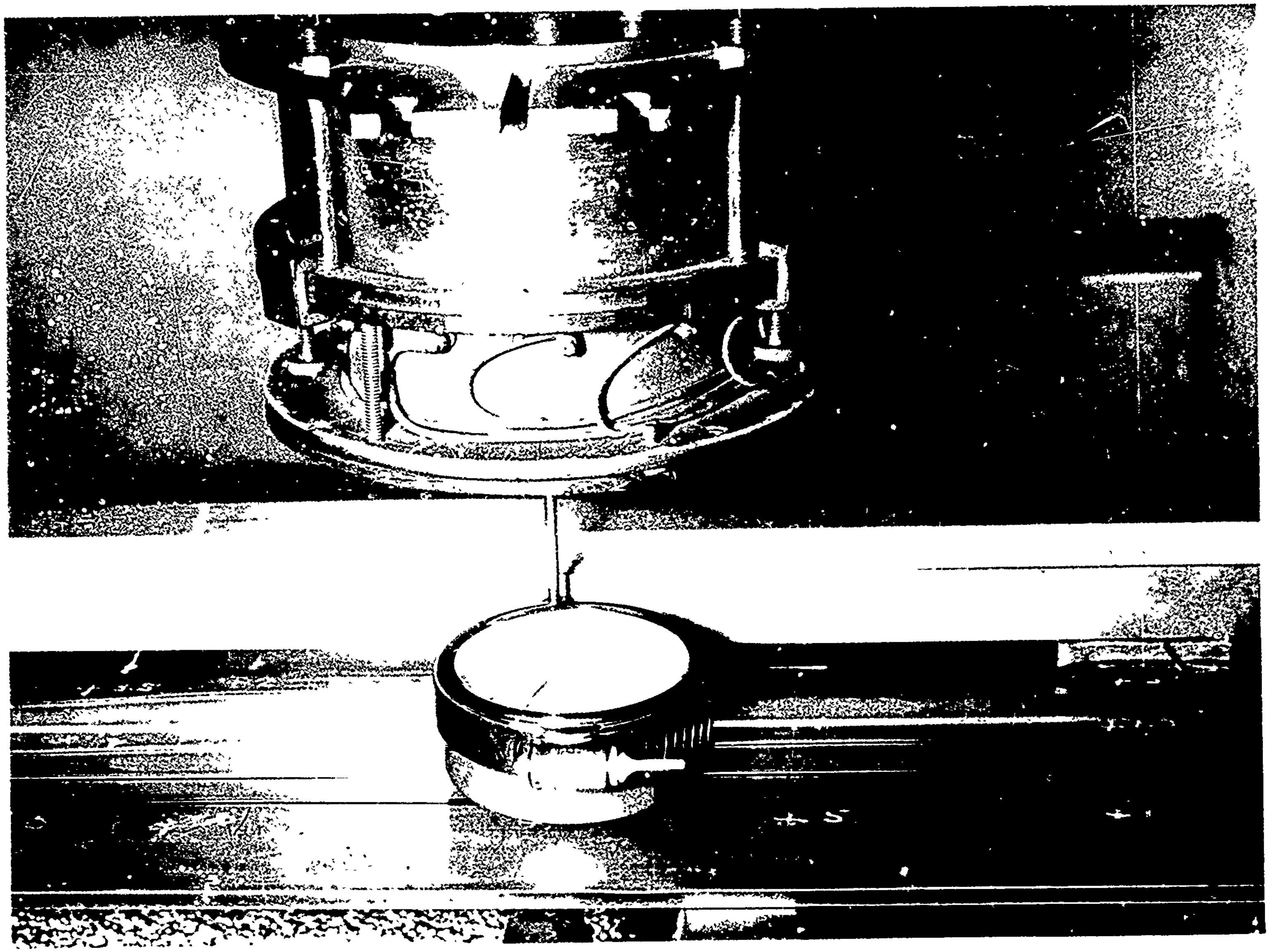


Figure 4.1.5-14 SETUP FOR MEASURING FIELD STRENGTHS

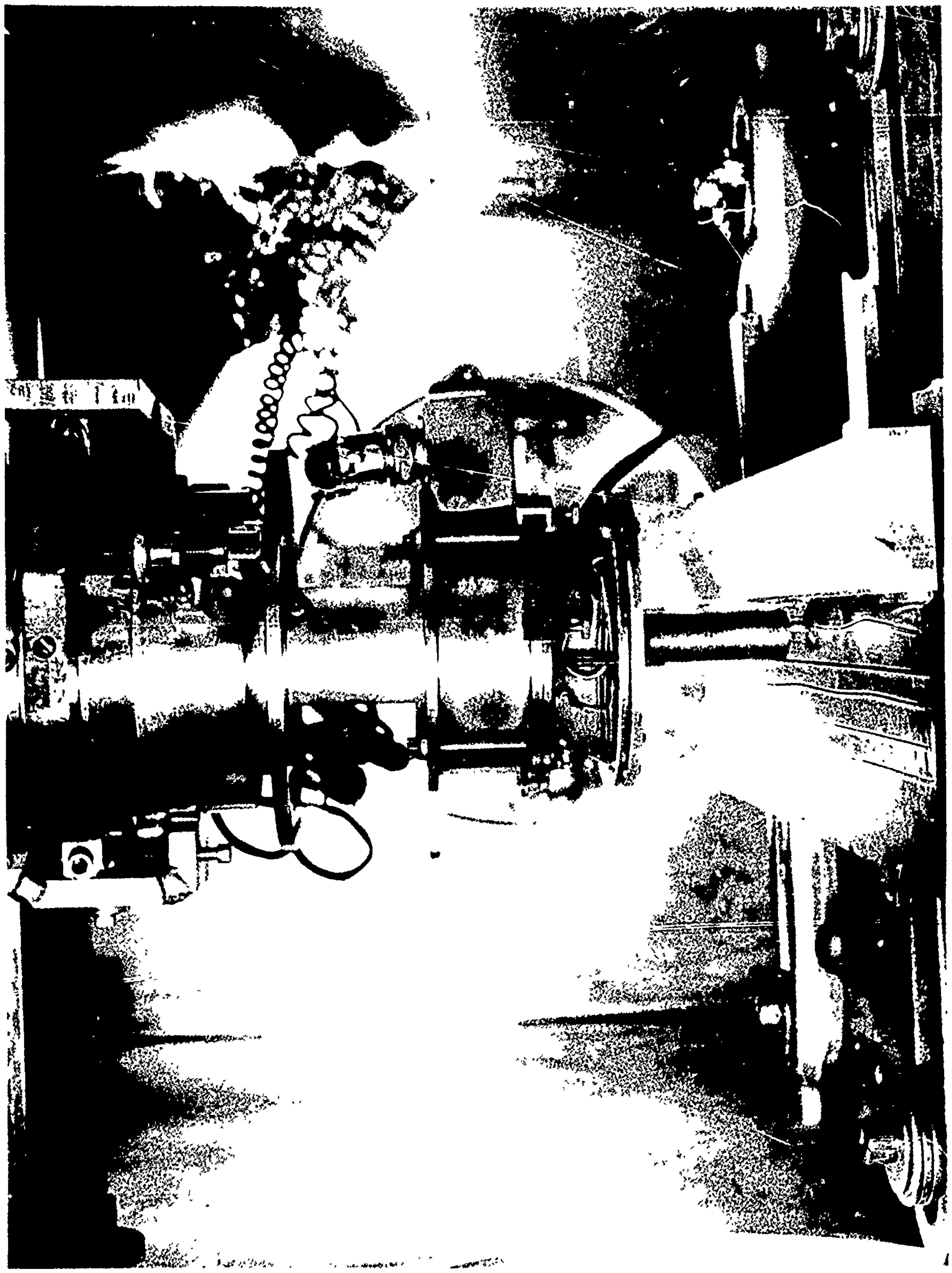


Figure 4.1.5-15 MAGNETIC SHIELD

welded to a mounting flange for attaching to the bottom of the EB gun. Adjusting screws are placed in the flange for centering the beam within the pipe. This unit has proved to be very effective in shielding the beam from magnetic fields up to 15 gauss. For fields within the workpiece the only sure method for checking the intended weld joint is to space the two detail parts .080" apart. This gap is then traced with a low power beam. If the beam is deflected, then additional demagnetizing must be accomplished, this is particularly true on thick sections because the field strength meters used only indicate fields to depth of .125". In most cases a strong permanent magnet can be used manually to move the disturbing field around so that the beam will not be deflected.

From the foregoing and other additional work performed during this report period, the following conclusions and recommendations can be made:

1. The electron beam does not set up or cause magnetic fields to be formed in any material.

2. The presence of magnetic fields below the weld joint has very little effect on the electron beam.

3. Weld fixtures and other tools above the surface of the work must be made from non-magnetic material. Aluminum (6061) has proved to satisfactory for EB tooling.

4. Increasing the accelerating voltage of the beam did not overcome the deflective effects of a magnetic field in excess of one gauss.

5. That the use of any magnetic fields on 10 Ni. steel for any purpose should be avoided at all cost unless subsequent thermal processing in excess of 1050°F is used.

6. That 10 Ni. steel can be welded by the EB process in thickness more than the reported 1.8" but further development work would be required.

7. To insure consistent gun to work location a linear micrometer (Travo-O-Dial) was installed on the EB gun as shown in Figure 4.1.5-16. With this arrangement gun location can be made to ± 0.005".

8. That beam spiking is detrimental to thick section welding only on partially penetrated high power weld passes. Further work on this phenomena is recommended.

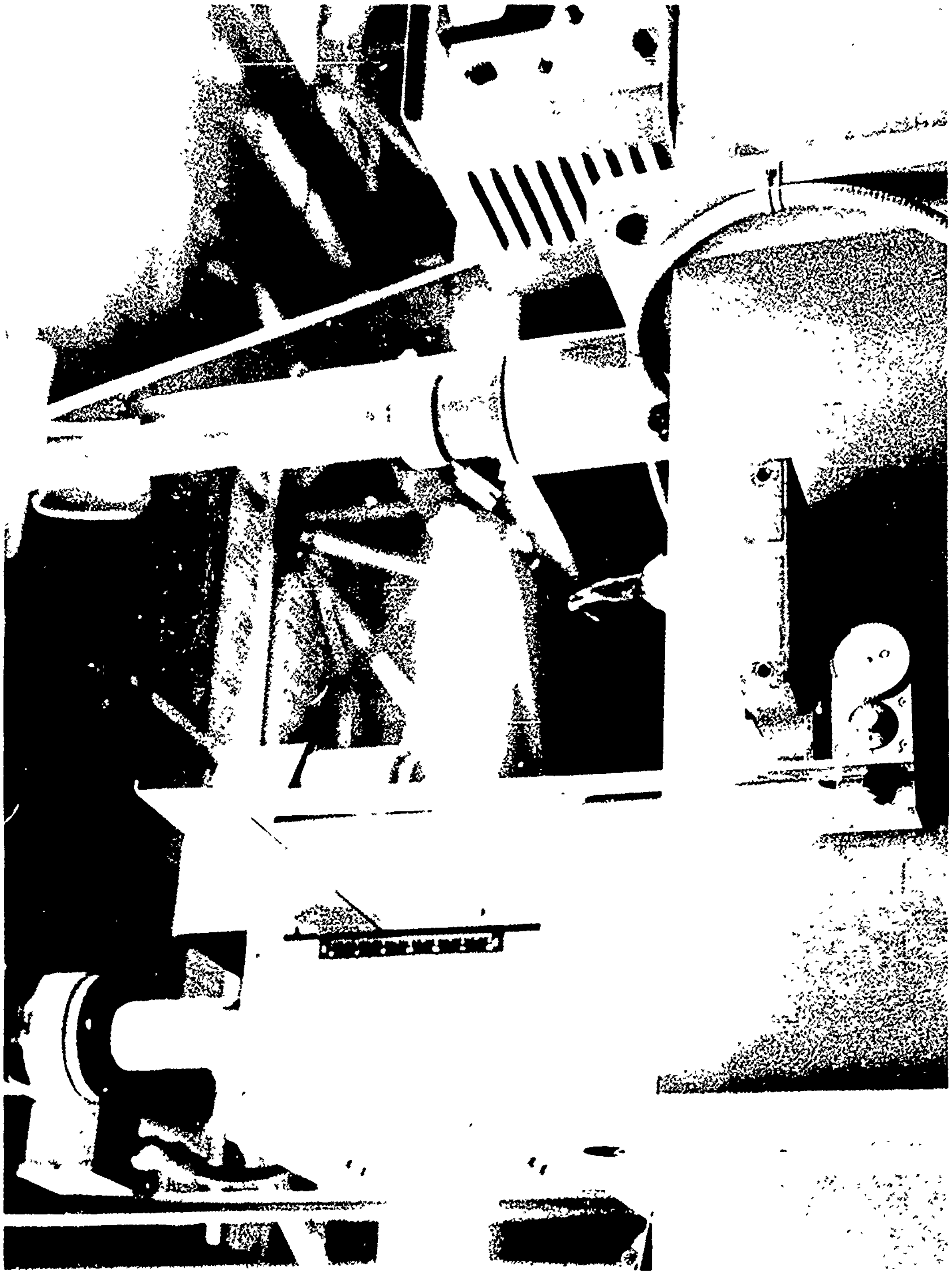


Figure 4.1.5-16 TRAV-O-DIAL - PRECISION VERNIER FOR SETTING EB GUN TO WORK DISTANCE TO $\pm$ 0.005"

9. Vacuum chamber extensions can be used to extend the range of parts that can be EB welded with a small chamber.

10. The technique developed for the thick 10 Ni. steel can ne used on other metals.

11. EB welds can be easily repaired by GTA welding but further work on EB repairs should be accomplished.

4.2 MANUFACTURING ENGINEERING - TOOL PLANNING, DESIGN AND FABRICATION

All activity has been completed related to the planning, design, and fabrication of tools for the manufacture of the simulated fuselage sections and the WCTS. All production planning for the assembly of these units is complete and planning for the mating of the WCTS to the test structure at Wright-Patterson Air Force Base is in final stages.

4.2.1 Make-or-Buy Decisions for Electron Beam Welding

Bids were solicited on sub-contract fabrication of the X7223920 MLG side brace fitting by electron beam welding. These bids and schedules were compared to in-house estimates which indicated a lower cost and earlier delivery date. The decision was then made to proceed with all fabrication in-house.

4.2.2 Manufacturing Engineering Coordination

Manufacturing Engineering specialists were assigned coordination tasks covering tool planning, design, and fabrication of tools required for part and assembly fabrication. These same specialists maintained factory coordination in their respective areas throughout detail parts and assembly fabrication. One basic responsibility of the individual engineer was to monitor costs of tools, parts, and assemblies as the compared with original estimates of cost. Final manufacturing costs of parts and assemblies are currently being accumulated.

SECTION 5

FACTORY PROGRESS

Fabrication and assembly of the WCTS was continued through this reporting period. Basic fabrication of detail parts was completed. At the end of the reporting period some machined fittings were in the process of being inspected, painted, and bored for bushings. Assembly of the WCTS followed the schedule and manufacturing sequence presented in the previous report for period ending 15 June 1974.

5.1 FABRICATION OF WCTS

The exploded illustration, Figure 5.1-1, shows the basic details and components of the WCTS. For numbering simplicity the first 4 digets of the component part number has been dropped from the number shown. (Example: X7224150 is shown as 4150) The structure is symmetrical and all right hand details are opposites of left hand parts.

5.1.1 X7224170 Lower Plate Assembly, Manufacturing Station 1

The lower plate assembly, Figure 5.1.1-1, began as a machined 10 Nickel steel plate with bolted-on reinforcing lugs added. Three adhesive bonded panels, two electron beam welded and machined landing gear fittings, and other fittings and stiffeners were assembled to the plate in this Manufacturing Station 1.

Preparation of the one piece 10 Nickel plate for machining was reported in the previous report. It was flame cut around the outer and inner perimeters allowing approximately 1.00 inch excess material to be removed in the heat affected zone. The starting thickness was 1.90 inch. It was machined on both sides to remove approximately .200 inch material from each surface prior to pocket milling and machining steps. All machining was done on a 40 H.P. spinde, 4 axis N.C. tape machine.

The N.C. tapes were "proofed" by making actual runs in aluminum and were then checked by a team consisting of the N/C programmer, the design engineer, a manufacturing engineer, and a quality control engineer. Tapes that were corrected were rerun for verification.

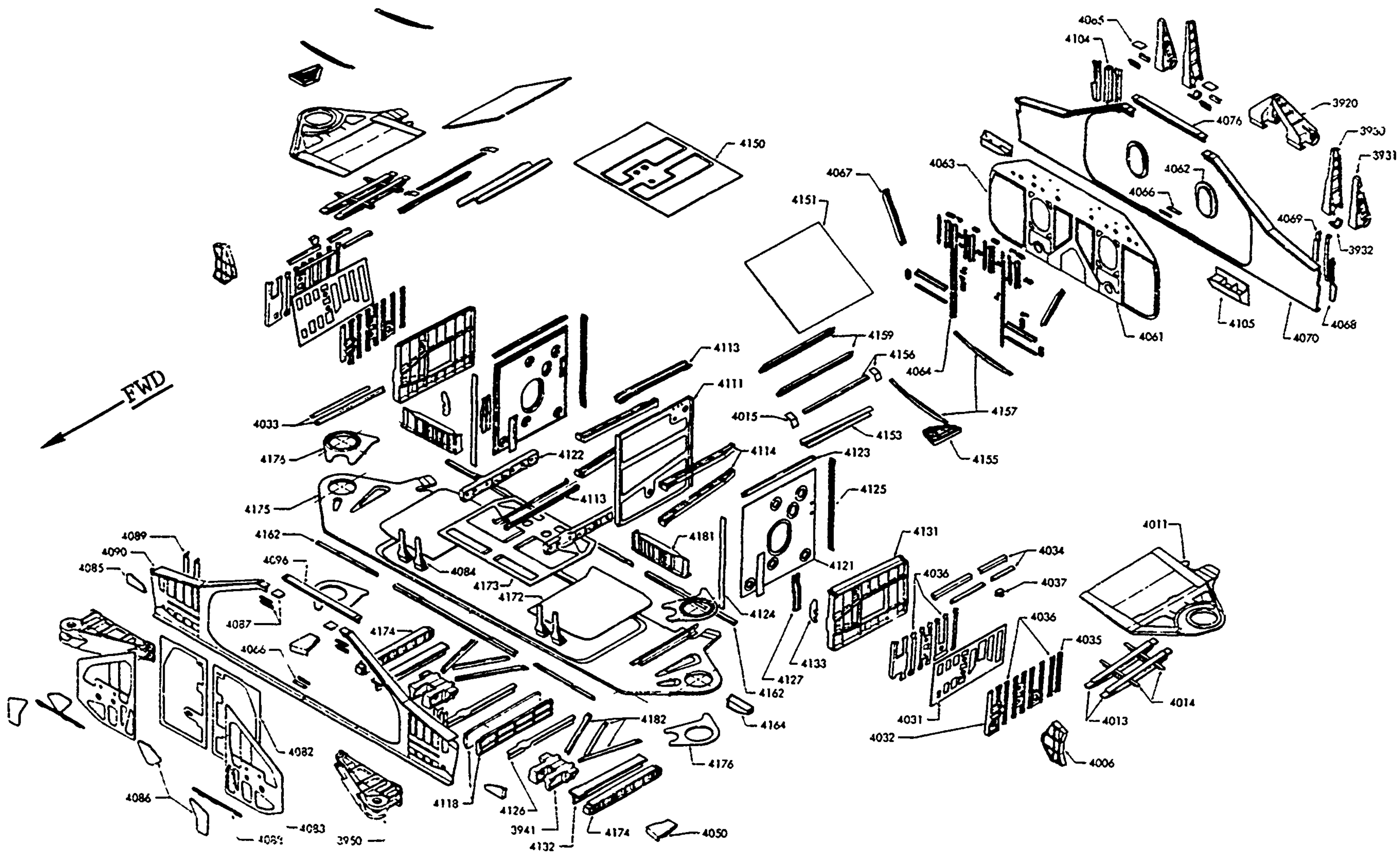
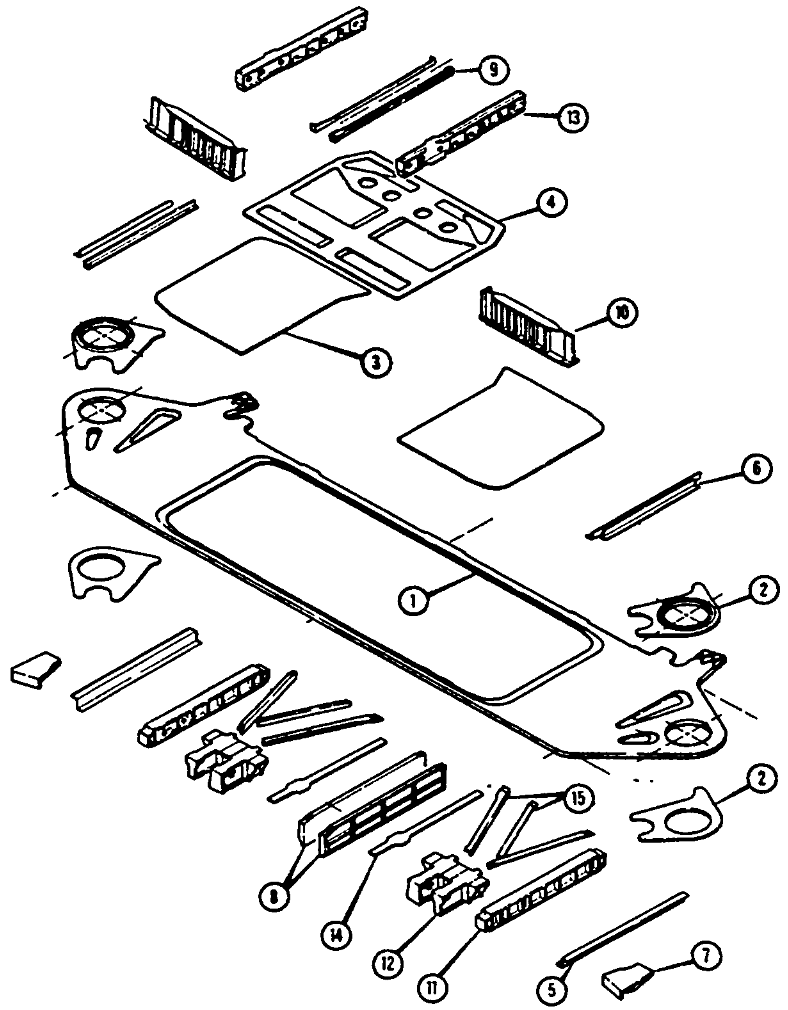
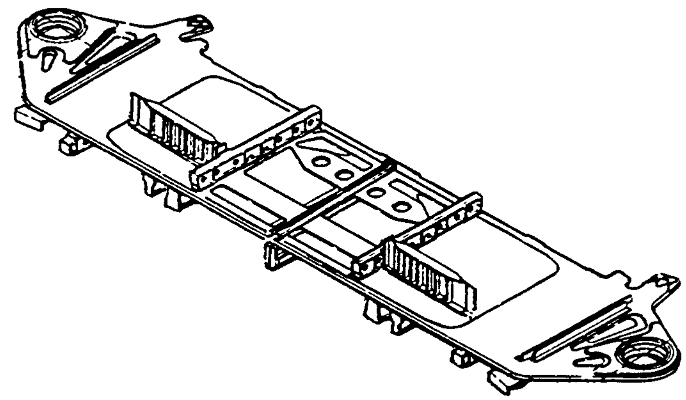


Figure 5.1-1 X7224001 WCTS MANUFACTURING BREAKDOWN





ITEM	PART NUMBER	DESCRIPTION
1	X7224175-7	LOWER LUG
2	X7224176	REINFORCING PLATE
3	X7224172	PANEL, X_F38-84
4	X7224173	CENTER PANEL
5	X7224163	LWR FAIRING SUPT X_F119
6	X7224033	LWR FLANGE X_F119
7	X7224050	LWR FWD LONGERON FTG
8	X7224118	LWR ℄ LONGERON
9	X7224113	LWR FLANGE, ℄ RIB
10	X7224181	SUPT, DRAG BRACE FTG
11	X7224174	LWR FAIRING SUPPORT X_F95.5
12	X7223941	DRAG BRACE FTG
13	X7224122	LWR ATTACH MEMBER, X_F39 RIB
14	X7224126	LWR STRAP, XF39
15	X7224182	STIFFENERS, LWR PLATE

Figure 5.1.1-1 X7224070 LOWER PLATE ASSEMBLY

Holes for attaching the reinforcing lugs to the plate at the pivot bushing locations were drilled by N.C. tapes. These were straight side holes which were drilled prior to the first tapered reaming operation for Taper-lok bolts. Corresponding holes in the reinforcing lugs were likewise drilled by N.C. tapes and set-up bolts were used to assemble and clamp the three pieces at each pivot bushing for taper reaming holes for the Taper-lok fasteners. Figure 5.1.1-2 shows the machined plate with reinforcing lugs attached by set-up bolts.

Rough reaming the tapered holes was accomplished with Quackenbush portable power drilling machine unit. An adapter drill plate was used for indexing and supporting the portable unit. Final reaming of the tapered holes was done by hand employing an 18-flute carbide reamer. The completed holes were inspected by a portable profolimeter for finish. Roundness and taper was checked with an air gage. Figure 5.1.1-3 shows the lower plate as the Taper-lok holes were being inspected. Following installation of the Taper-lok bolts in the reinforcing lugs and plate the assembly was mounted in the large picture frame jig shown in the background of Figure 5.1.1-3.

Drilling of holes attaching components to the lower plate was accomplished with the Quackenbush and Spacematic portable power drilling equipment. The larger diameter holes were made with Quackenbush equipment. This equipment, as shown in Figure 5.1.1-4 required heavy aluminum drill plates for locating and holding the nose piece of the unit in relation to hole patterns.

Holes 3/8-inch in diameter and smaller were drilled through aluminum, titanium, and steel and combinations of each with the Spacematic equipment. Advantages of this unit are low cost tooling and fast set-up for each hole. Basic tooling required is a template type indexing plate for hole location. Holes in the template may be punched or cut with a spotface tool.

The three adhesive bonded titanium honeycomb panels which fill the cutout in the lower plate were made with 6Al-4V beta annealed titanium outer skins and aluminum core as reported in the previous six-month report. The panels were bonded and installed to the lower plate without incident. Tooling for the L.H. panel was designed to be used for bonding of the R.H. panel by making details of the tool in a manner that they were reversable. After bonding the L.H. part details were relocated on the base to bond the R.H. part. This savings in tooling material and labor did not affect the quality of the bonded panels.

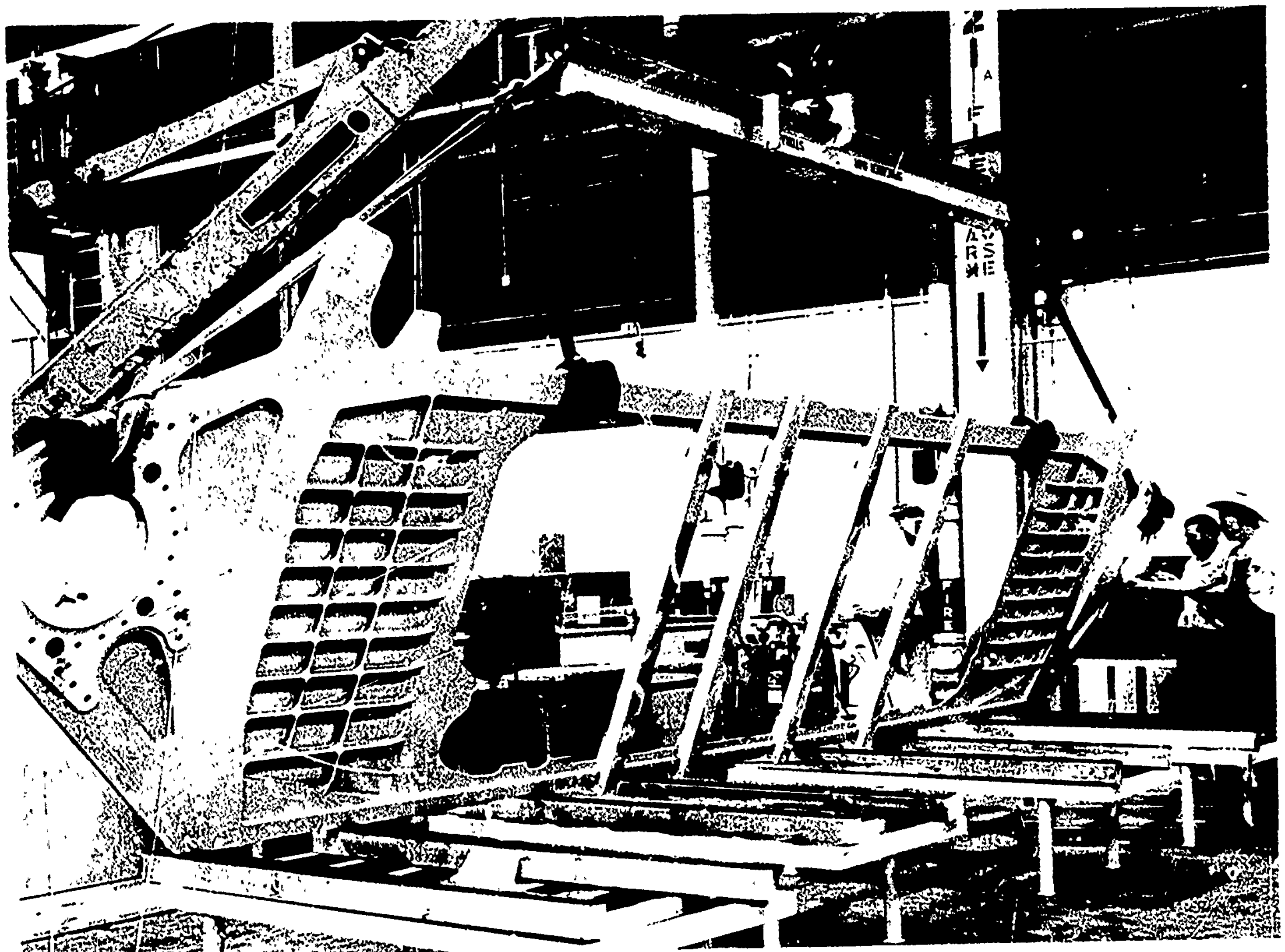


Figure 5.1.1-2 REINFORCING LUGS ATTACHED TO LOWER PLATE WITH SET-UP BOLTS

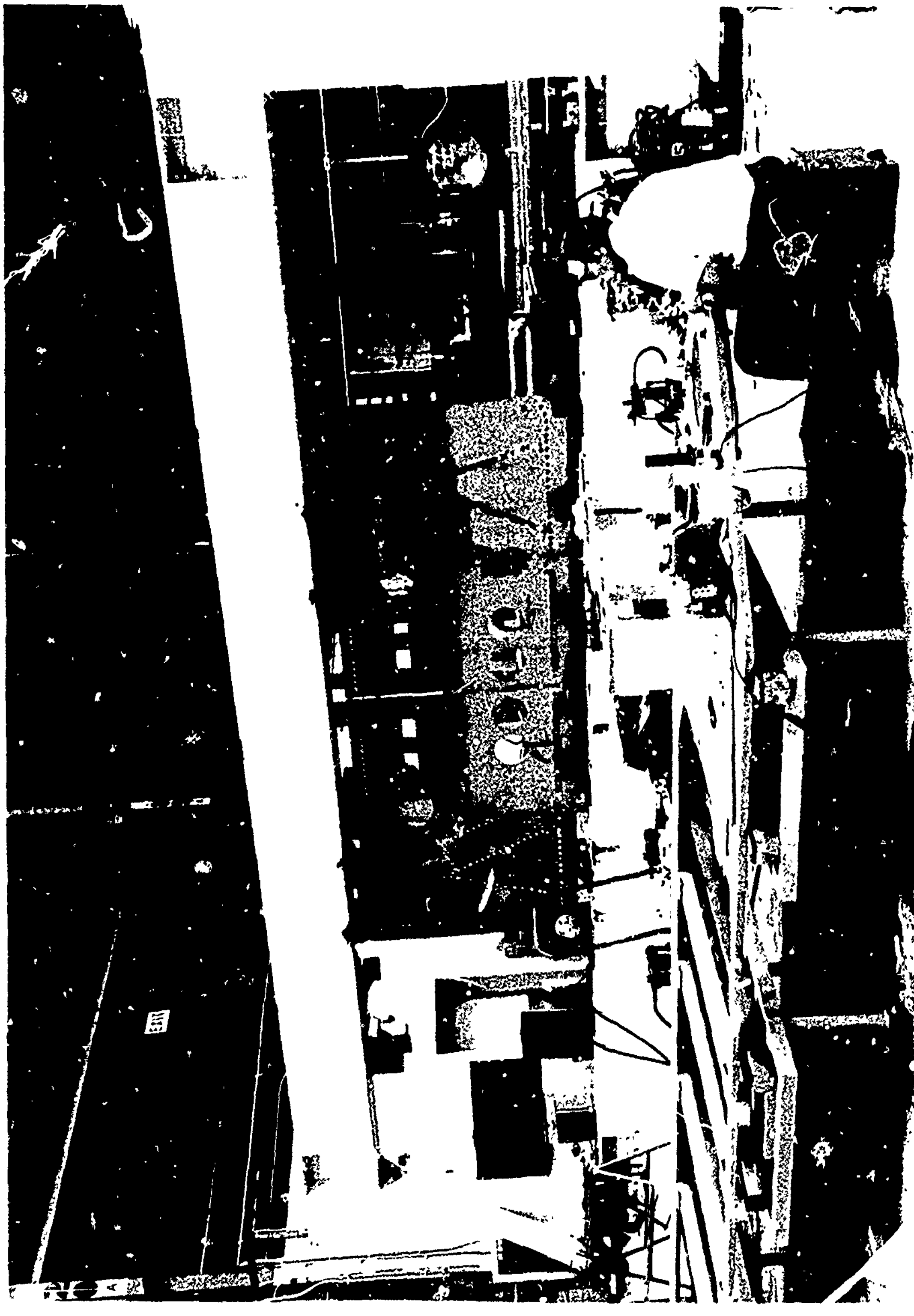


Figure 5.1.1-3 INSPECTION OF TAPER-LOK HOLES BY AIR GAGE

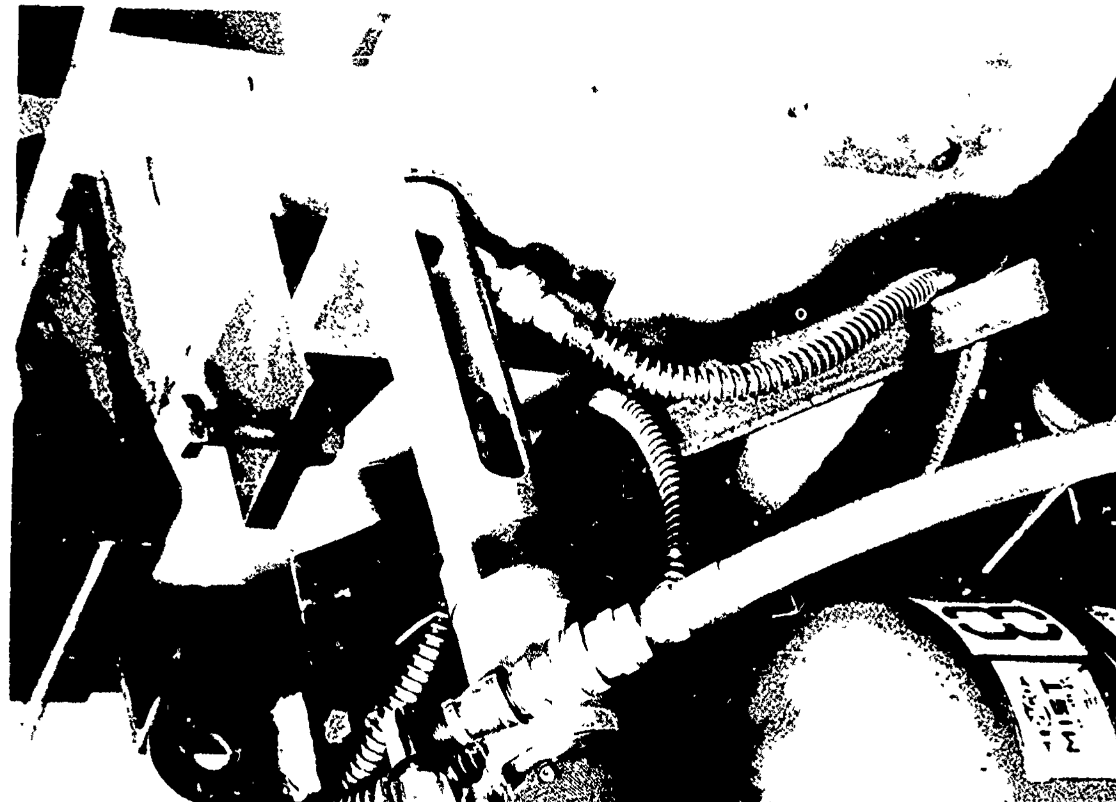


Figure 5.1.1-4 QUACKENBUSH DRILL UNIT FOR LOWER PLATE DRILLING

The completed lower plate bolted assembly was removed from the Station 1 fixture and carried to the horizontal boring mill where each end of the assembly was bored to receive a bushing. Holes for the bushings had been rough machined through the one piece plate and the reinforcing plates at each end. These line boring operations were through the three thicknesses of 10 nickel steel and establish the close tolerance fits necessary for installing the pivot bushings. The position of the plate assembly as it was located on the Gray boring mill is shown in Figure 5.1.1-5.

Wing pivot pin bushings for the lower plate assembly were soaked in dry ice and alcohol at $-100^{o}F$ and pressed into the assembly. The inside diameter of the bushing was not bored to net size since that operation was scheduled after completion of the WCTS final assembly.

5.1.2 Assembly of the X7224001 WCTS, Manufacturing Stations 2 through Station 5

A Station 2 through Station 5 assembly tool was built for assembly of components into the final wing carrythrough structure. The tool shown in Figure 5.1.2-1 was made to position the lower plate assembly and locate ribs and bulkhead segments in relation to the lower plate. Locators for positioning the upper pivot pin lugs and drill plates for drilling coordinated attach holes to match the forward and aft fuselage sections were provided in this tool. These locators and plates were coordinated through use of a tooling accessory (TOAC) in the form of a tooling gage which coordinating the test article and the fuselage sections.

The first component to be located in the assembly tool was the X7224170 lower plate assembly. It was followed by details of the end ribs and the forward bulkhead segments at bulkhead station Y_F932. These items were clamped together for the purpose of checking fits and bolt edge distances. Figure 5.1.2-2 shows the components and their relationship.

Initial prefit of the X7224030 closure rib assembly included only the machined titanium web, vertical stiffeners and lower angles. Following the prefit of these details the rib assemblies were carried to a N.C. drilling machine where all fastener holes common to the webs were drilled and reamed by use of a point-to-point tape. The details were then disassembled for deburring and reassembled with sealant and returned to the assembly tool for

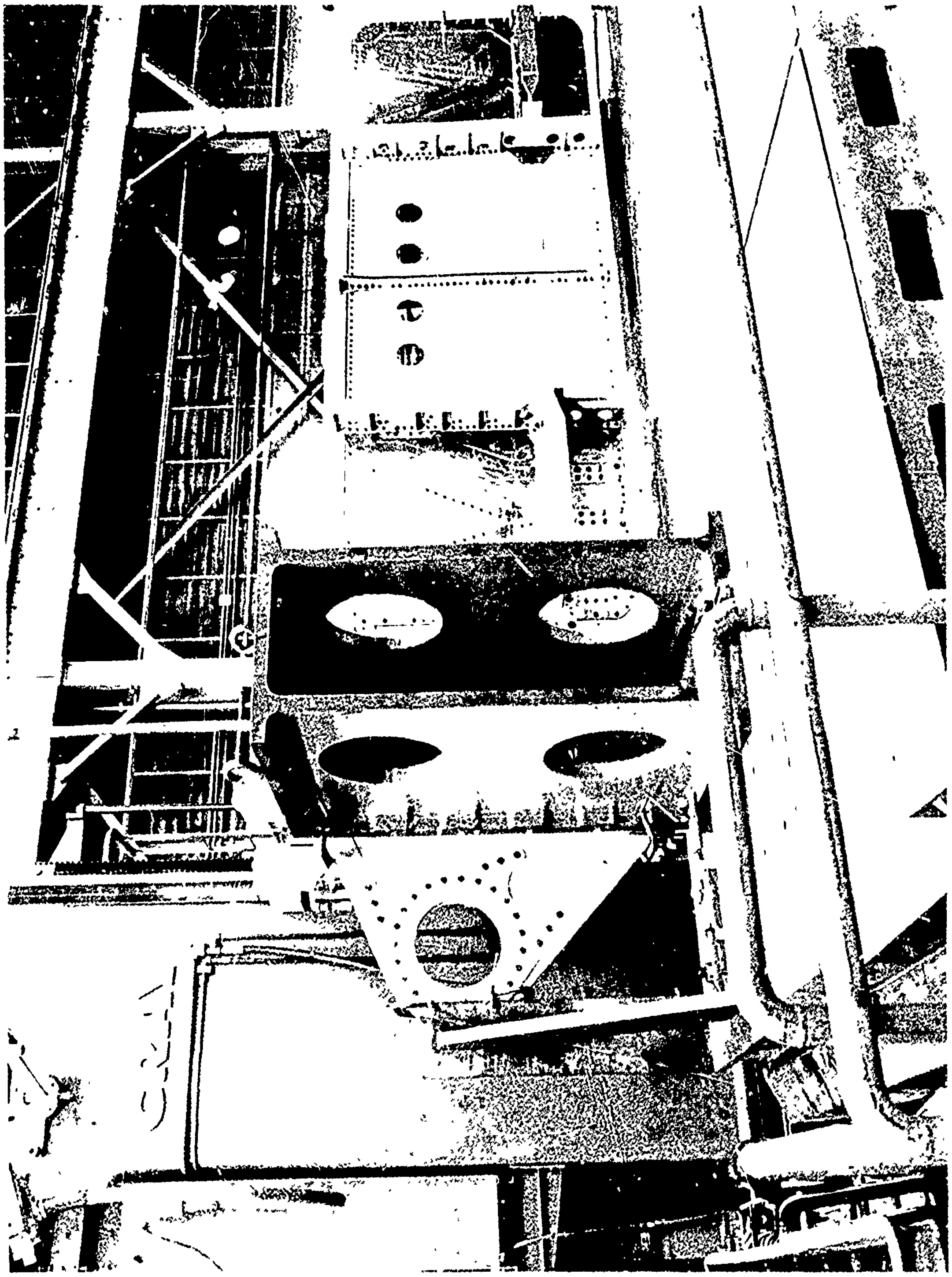


Figure 5.1.1-5 LOWER PLATE ASSEMBLY ON GRAY BORING MILL

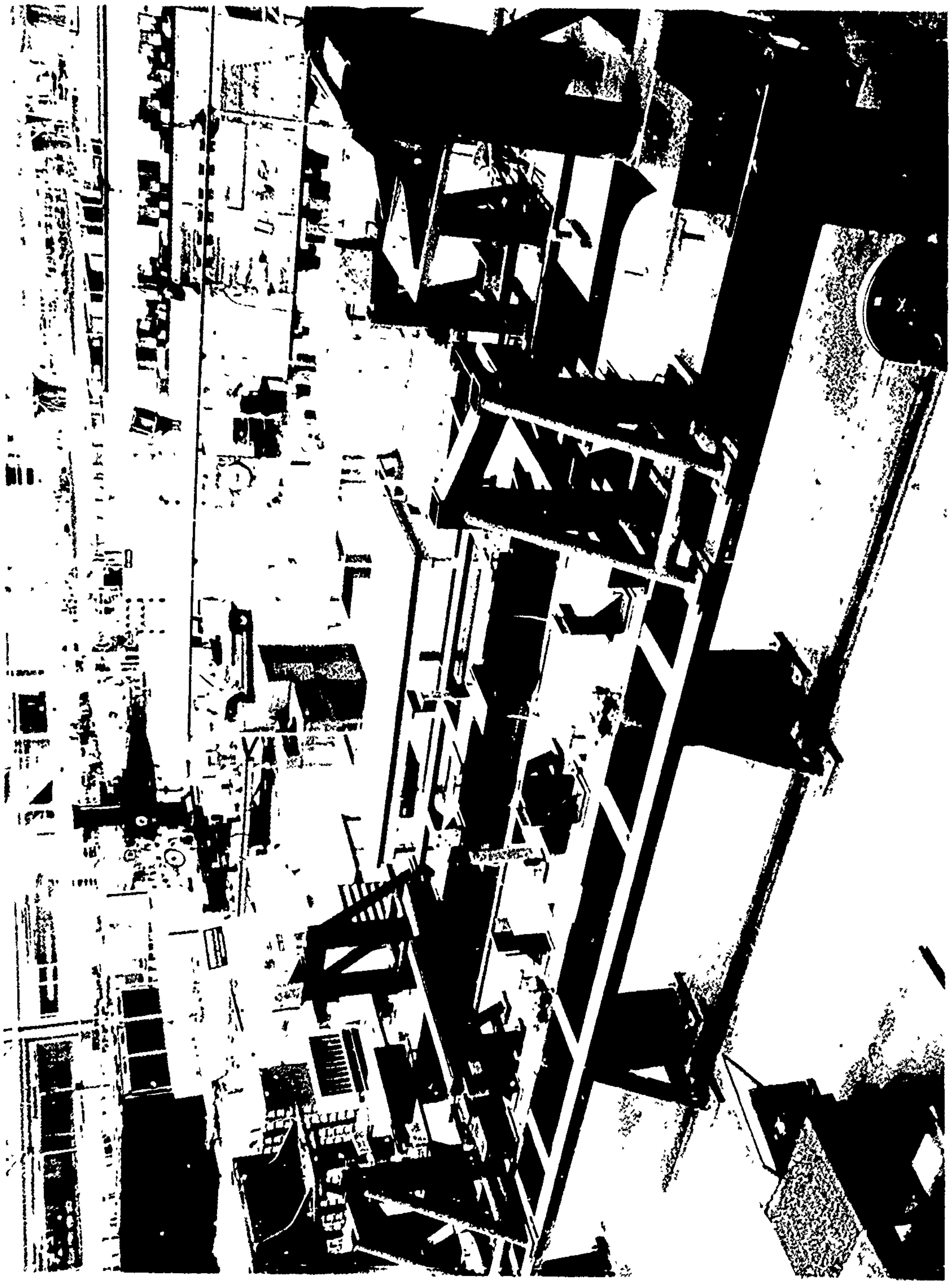


Figure 5.1.2-1 MAJOR ASSEMBLY FIXTURE - FINAL ASSEMBLY

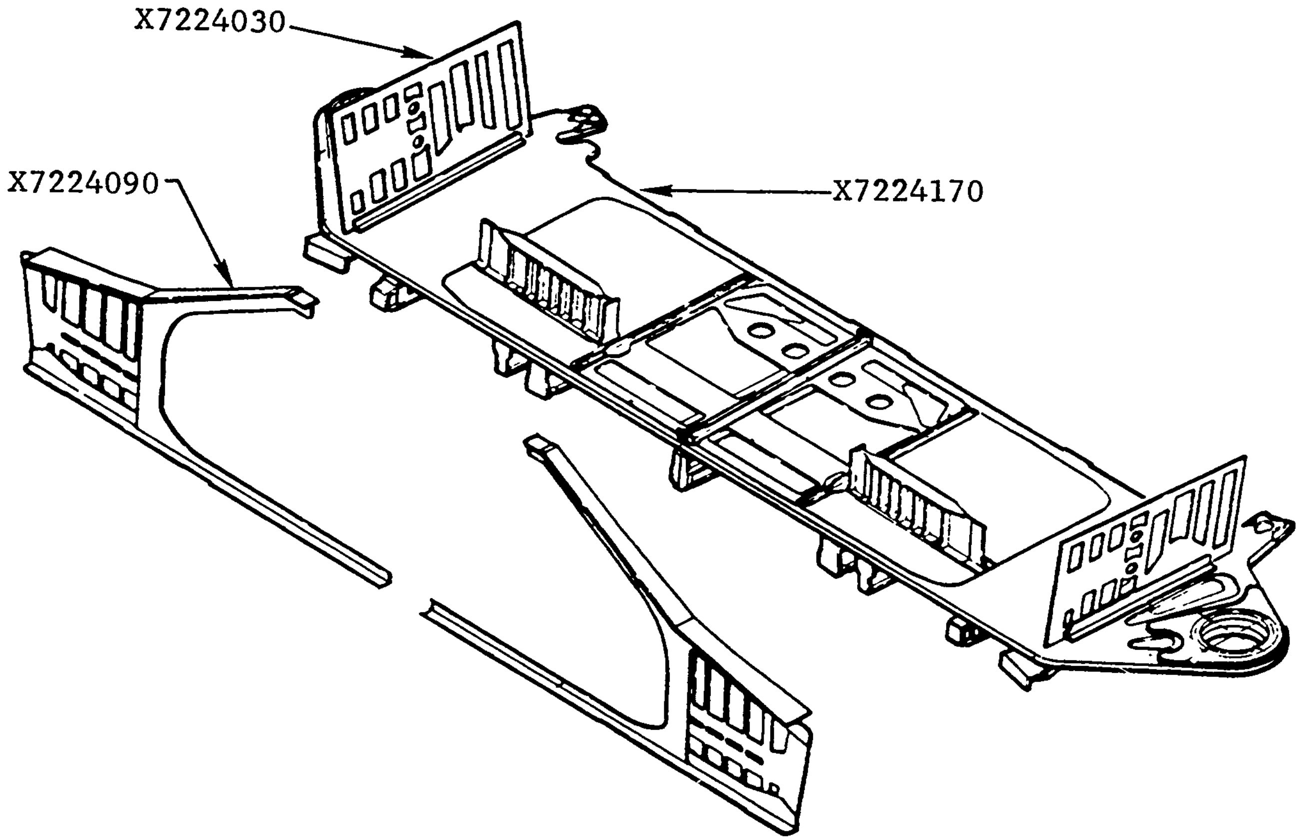


Figure 5.1.2-2 PREFIT INSTALLATION OF LOWER PLATE ASSEMBLY END RIBS AND FORWARD BULKHEAD SEGMENTS

drilling with the corresponding components. Figure 5.1.2-3 shows all details making up the closure rib. Location of the upper angles and fittings was deferred until the upper plate and lug assembly was positioned on the assembly.

Fabrication of the X7224070 bulkhead 10 Nickel steel segment was covered in the previous report. These bulkhead details were rough machined from flame cut plate stock and welded into a rough bulkhead configuration. Approximately .200 inch excess material was left on the upper and lower surfaces of the rails for removal in finish machining. The web areas had only .100 inch per side remaining before pocket milling operations. Figure 5.1.2-4 shows the finish welded bulkhead after a 950°F age cycle and prior to machining.

Prefitting of major components continued with the positioning of the X7224120 rib at Station X_F39, X7224131 rib at Station 84, and X7224070 bulkhead at Station Y_F992. Figure 5.1.2-5 shows relationship of these items and those previously positioned.

The X7224120 rib was a conventional adhesive bonded panel of aluminum. It presented no problems in fabrication or installation.

The X7224131 rib was a conventional aluminum machined rib which was machined by N.C. tape on a four-axis machine. It presented no new technology or problems.

The X7224070 bulkhead was a near carbon copy of the X7224090 bulkhead. The 10 Nickel welded and machined bulkhead was produced with less effort than the X7224090 bulkhead because of a normal learning curve effect.

Following the prefit of these components to the existing ones the entire assembly was dimensionally checked by assembly tool fabrication personnel to verify accuracy of locations for each component. Drilling and reaming of full size holes for fasteners began after the dimensional check was completed. Figure 5.1.2-6 is a photograph of the assembly as it appeared at this point in fabrication.

A schedule problem developed with the X7224011 upper lugs. The 10 Nickel material ordered for the parts was delayed by several weeks. It was decided to use the aluminum tape proofing machined part as a tool to simulate the actual 10 Nickel part, left hand side, in order to coordinate fits with the closure rib assembly. An additional aluminum part simulating the right hand lug was N.C. machined in sufficient detail to coordinate

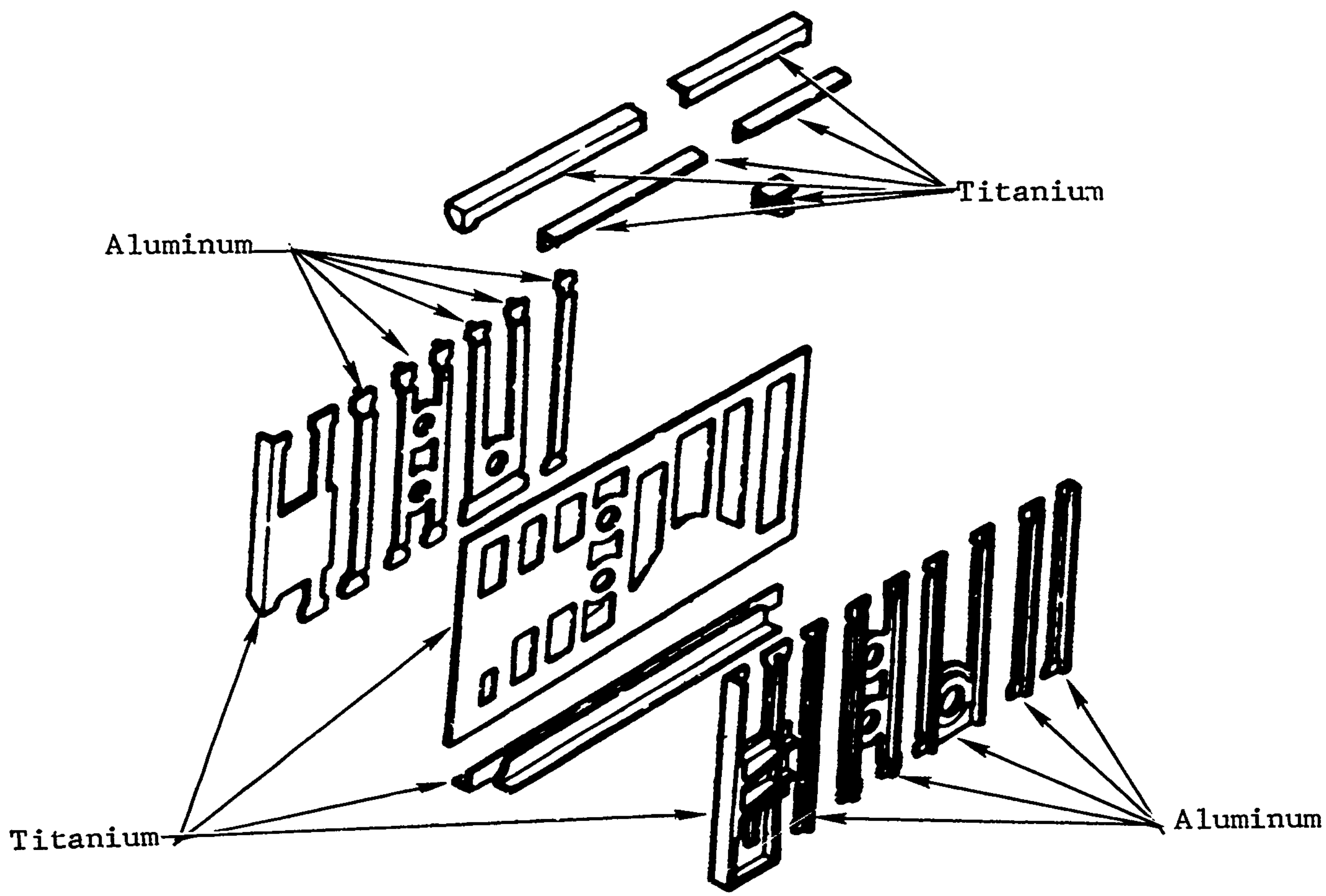


Figure 5.1.2-3 X7224C30 CLOSURE RIB SUBASSEMBLY

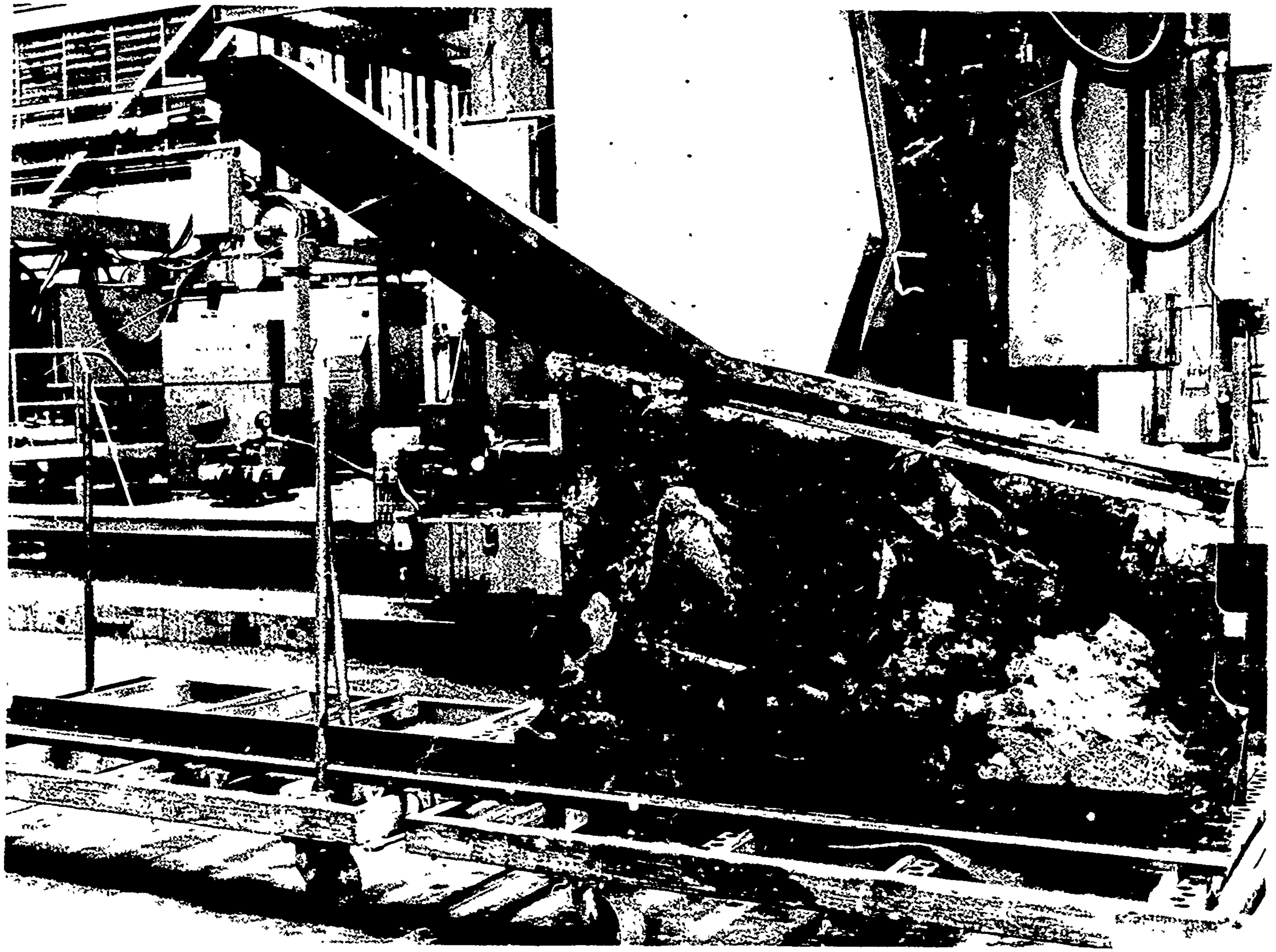


Figure 5.1.2-4 X7224070 BULKHEAD AS WELDED & AGED

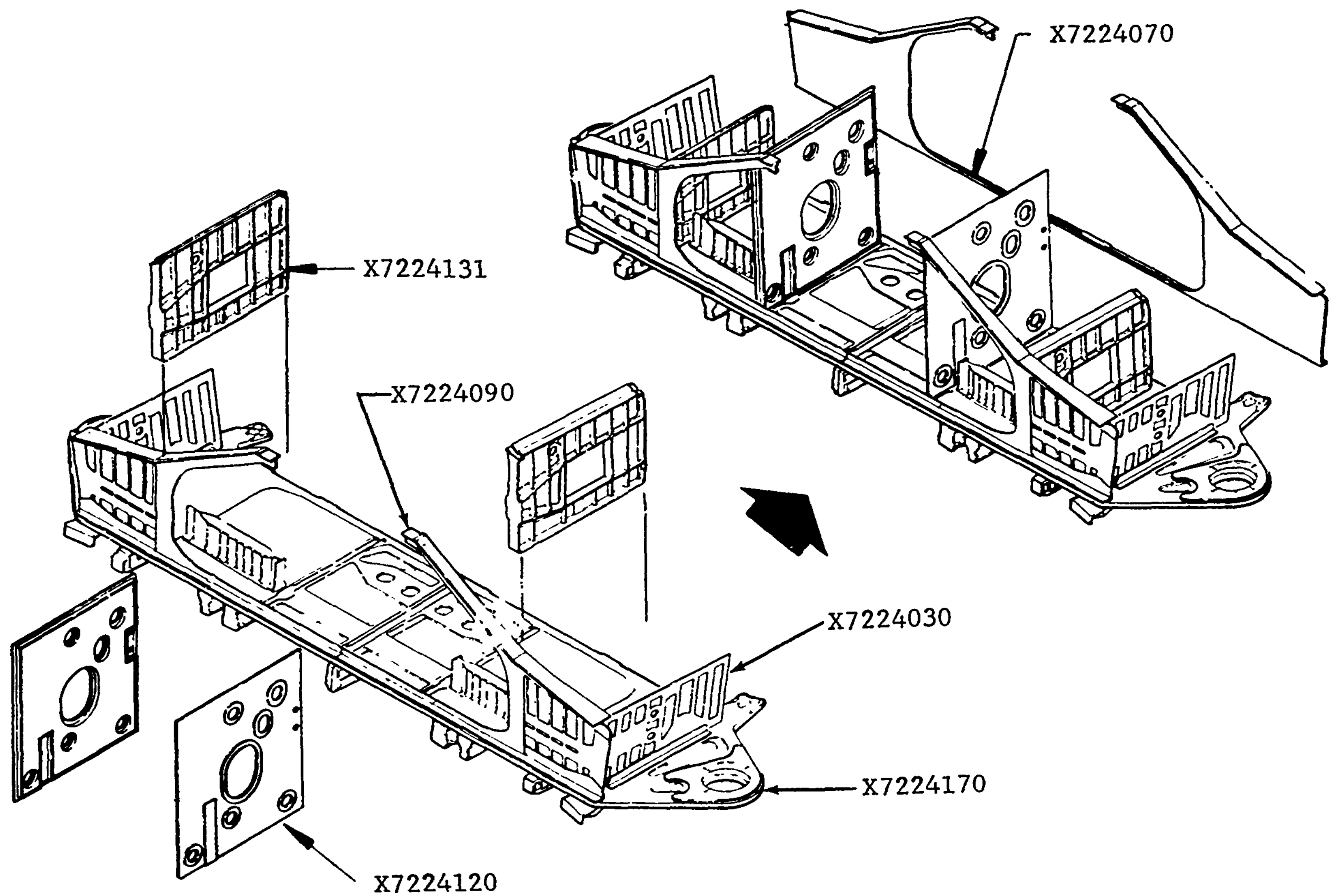


Figure 5.1.2-5 PREFIT AND SET-UP - X_F39 AND X_F84 RIBS AND AFT BULKHEAD SEGMENTS

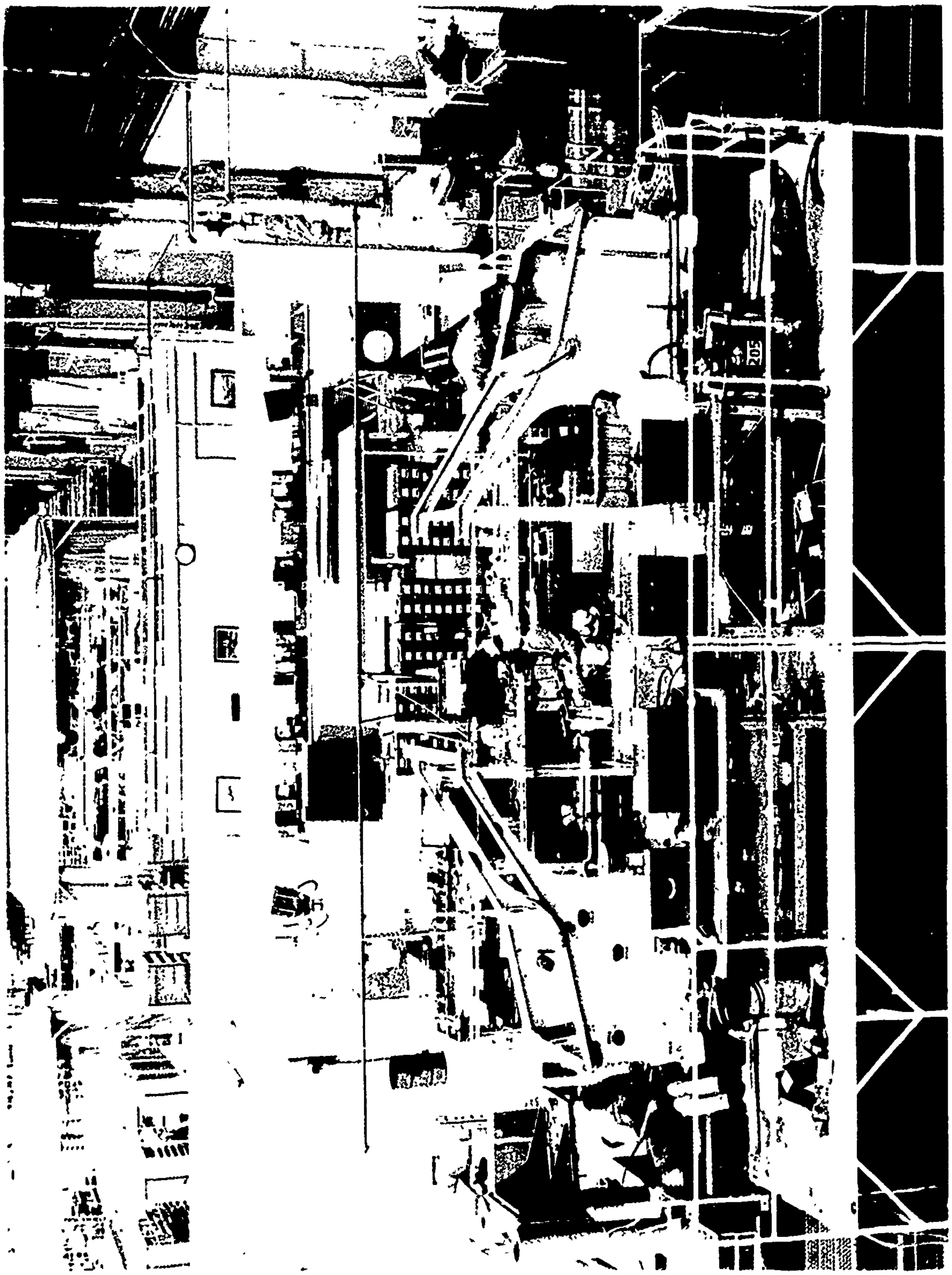


Figure 5.1.2-6 INSTALLATION OF PREFIT COMPONENTS

necessary fits with the closure rib and bulkheads. These two aluminum simulated parts were used to establish location of the upper titanium attach angles with the under surface of the upper lug and pilot size holes were hand drilled at this point through the closure rib web to establish location of the angles to the web. The closure rib was again taken to the N.C. drilling machine for drilling and reaming the upper angles attaching holes to full size. The closure rib was then returned to the assembly where it was installed permanently. Figure 5.1.2-7 shows the relation of the upper lug to the assembly.

The X7224111 centerline rib and the splice angles for the upper rails of the forward and aft bulkheads were left out of the prefit assembly at this time to permit ease of access to the fasteners which installed the X_F39 and X_F84 ribs. After installation of these fasteners the centerline rib and related details were permanently installed. Figure 5.1.2-8 shows those details which completed the interior installations of the WCTS.

The 10 Nickel material for the X7224011 upper lugs arrived 31 July, 1974. The 3 inch thick plate had been formed by bending approximately 8-1/2 degrees as shown in Figure 5.1.2-9. Flame cutting of the formed plates started 3 August, 1974. Two plates were rough cut as shown in Figure 5.1.2-10 for left and right hand parts.

Machining of the upper lug details was done on a 4-axis N.C. tape machine.

Special holding tools were made for positioning the plates on the N.C. machine as shown in Figure 5.1.2-11.

The X7224011 upper lug is reinforced by bolted on structure as shown in Figure 5.1.2-12. The assembly details were held in relation to the lug by assembly and drilling fixtures as shown in Figure 5.1.2-13. Each fixture with reinforcing details and upper plate lug was located on the N.C. drilling machine where all holes common to the plate and details were drilled and reamed to full size. Details were then disassembled for deburring and carried to the WCTS assembly area for relocation with the existing assembly.

Completion of the forward and aft bulkheads required installation of the adhesive bonded honeycomb panels shown in Figure 5.1.2-14. The center panels of the YF932 bulkhead, X7224082, were of conventional aluminum design which presented no advanced technology. The Y_F932 outboard panels, X7224083, were of 6A1-4V titanium which presented no major fabrication problems.

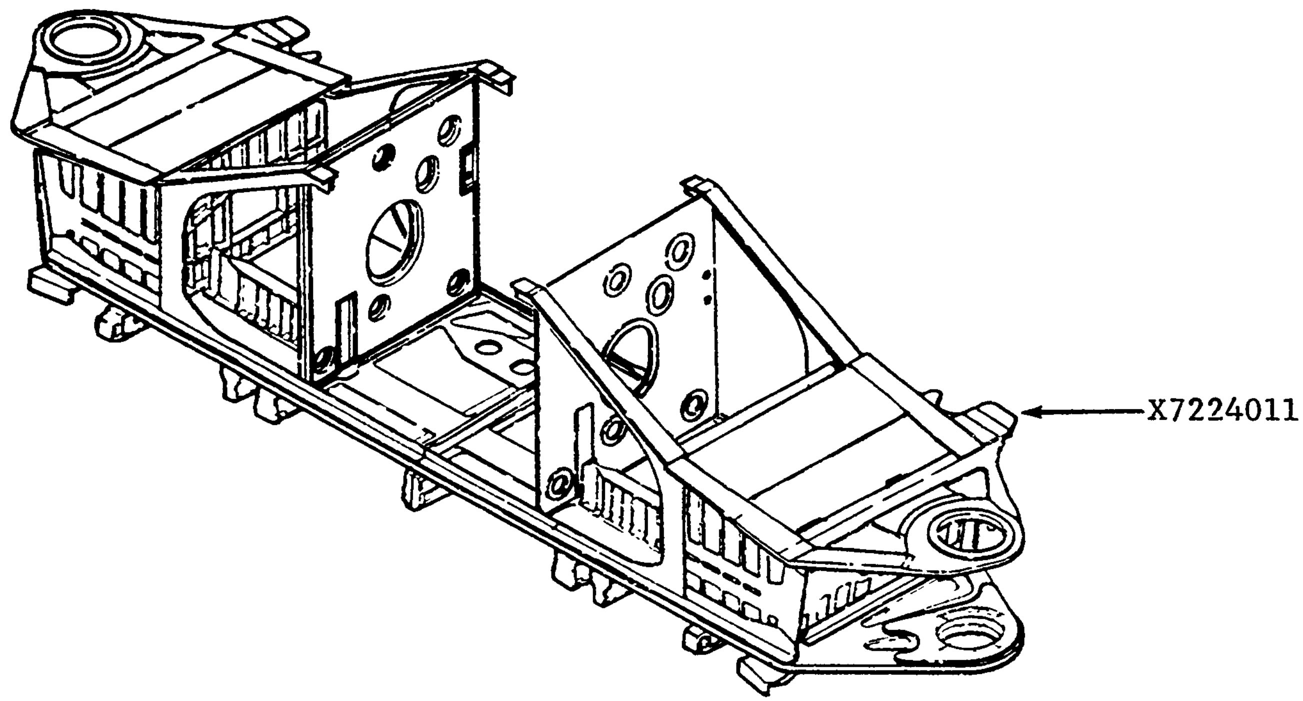


Figure 5.1.2-7 PREFIT OF UPPER LUG DUMMY AND BULKHEAD/RIB ASSEMBLY FOR COORDINATION CHECK - SKETCH

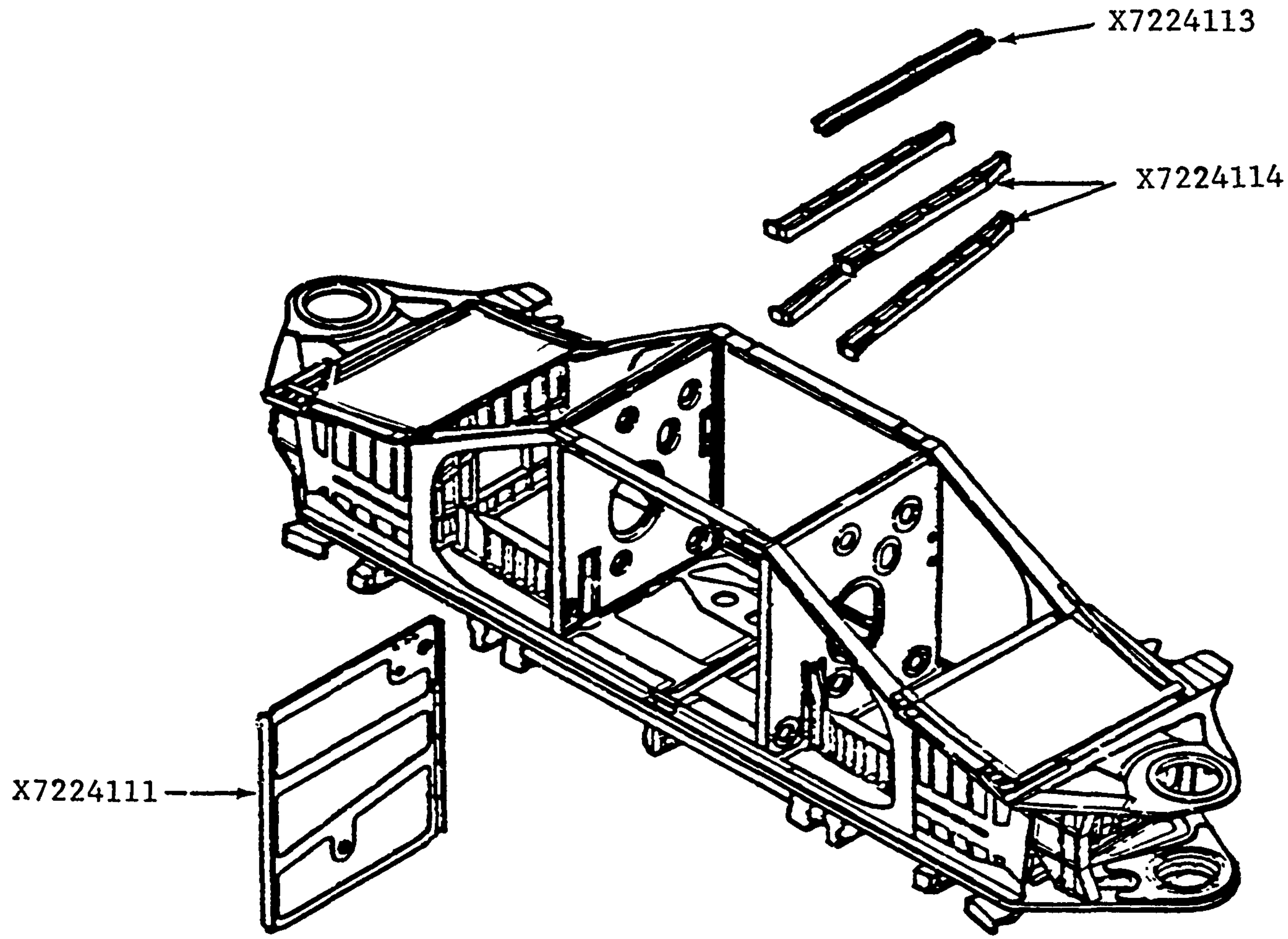


Figure 5.1.2-8 FINAL INSTALLATION SEQUENCE OF INTERNAL COMPONENTS - SKETCH

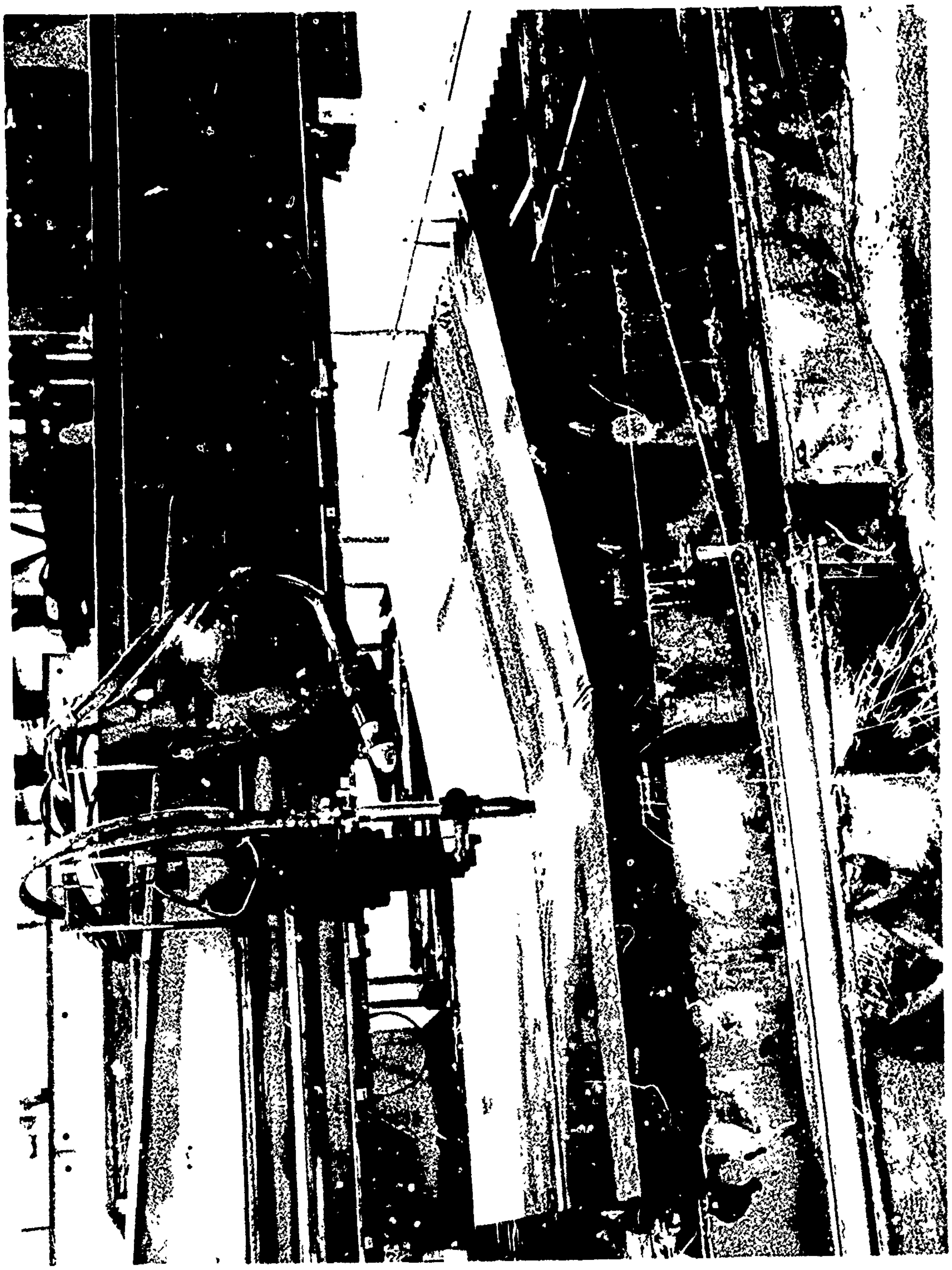


Figure 5.1.2-9 UPPER LUG PLATE MATERIAL ROUGH FLAME CUT

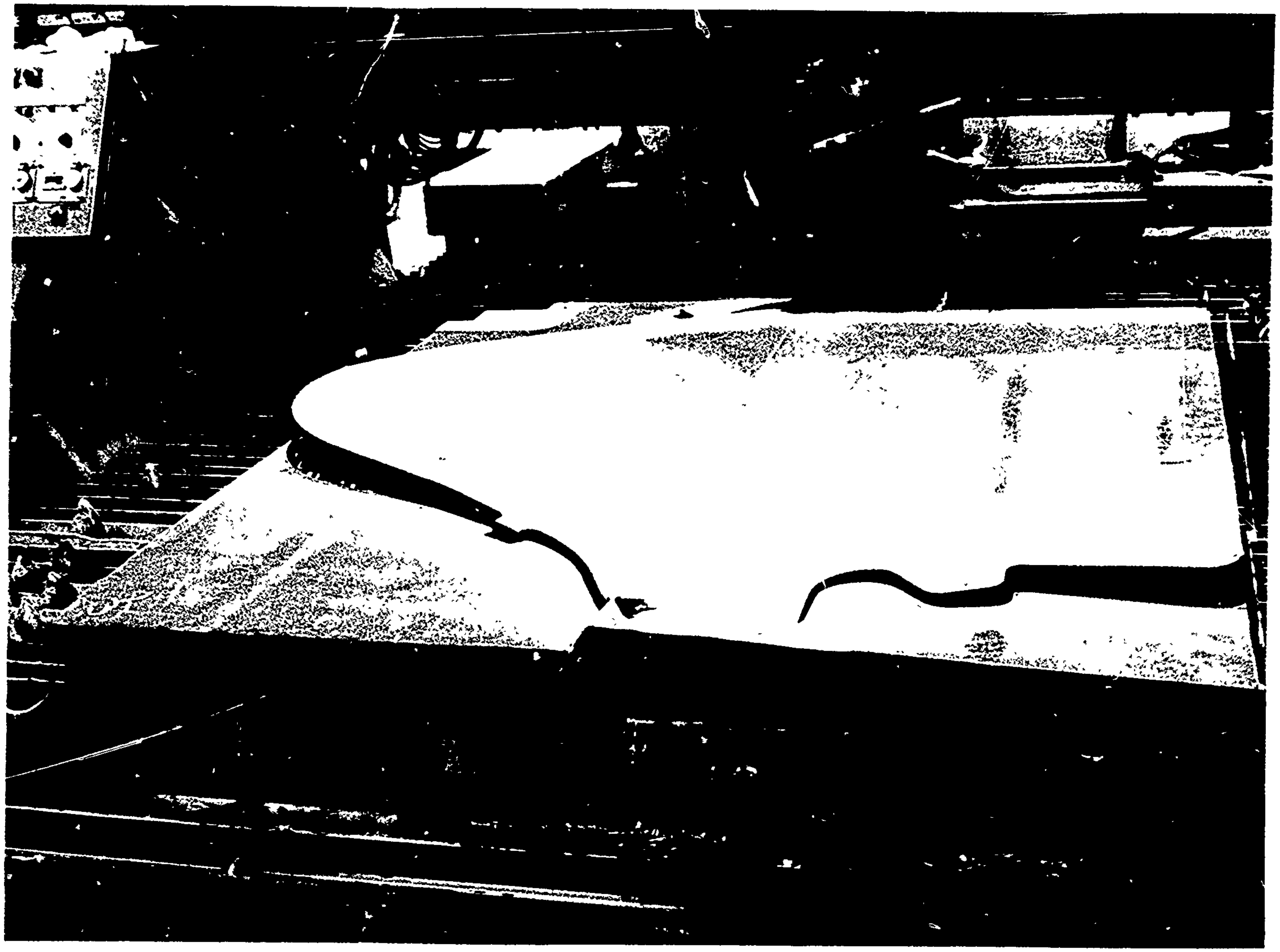


Figure 5.1.2-10 ROUGH CUT OF UPPER LUG MATERIAL

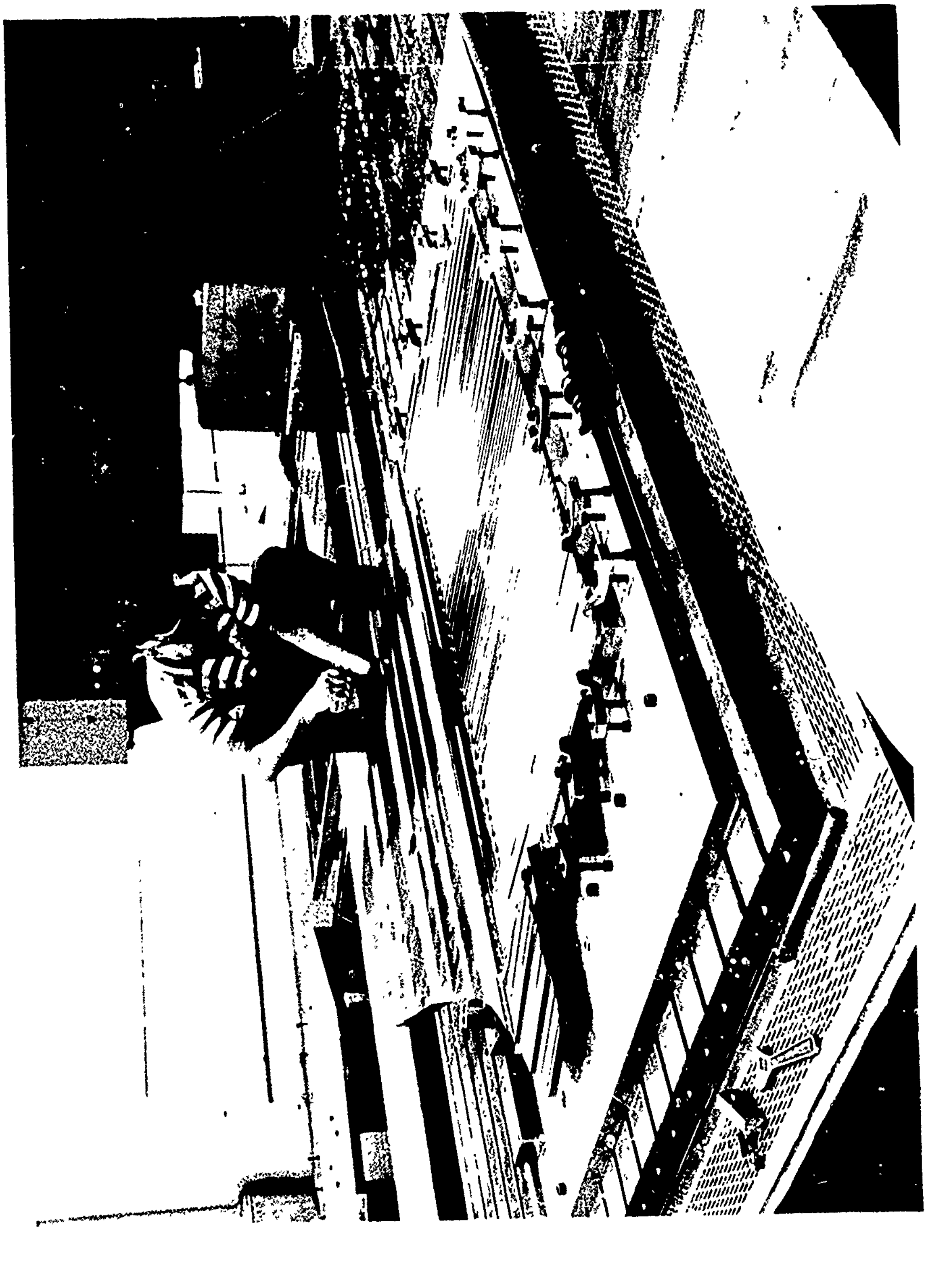


Figure 5.1.2-11 SET-UP FOR N. C. MACHINING OF UPPER LUG

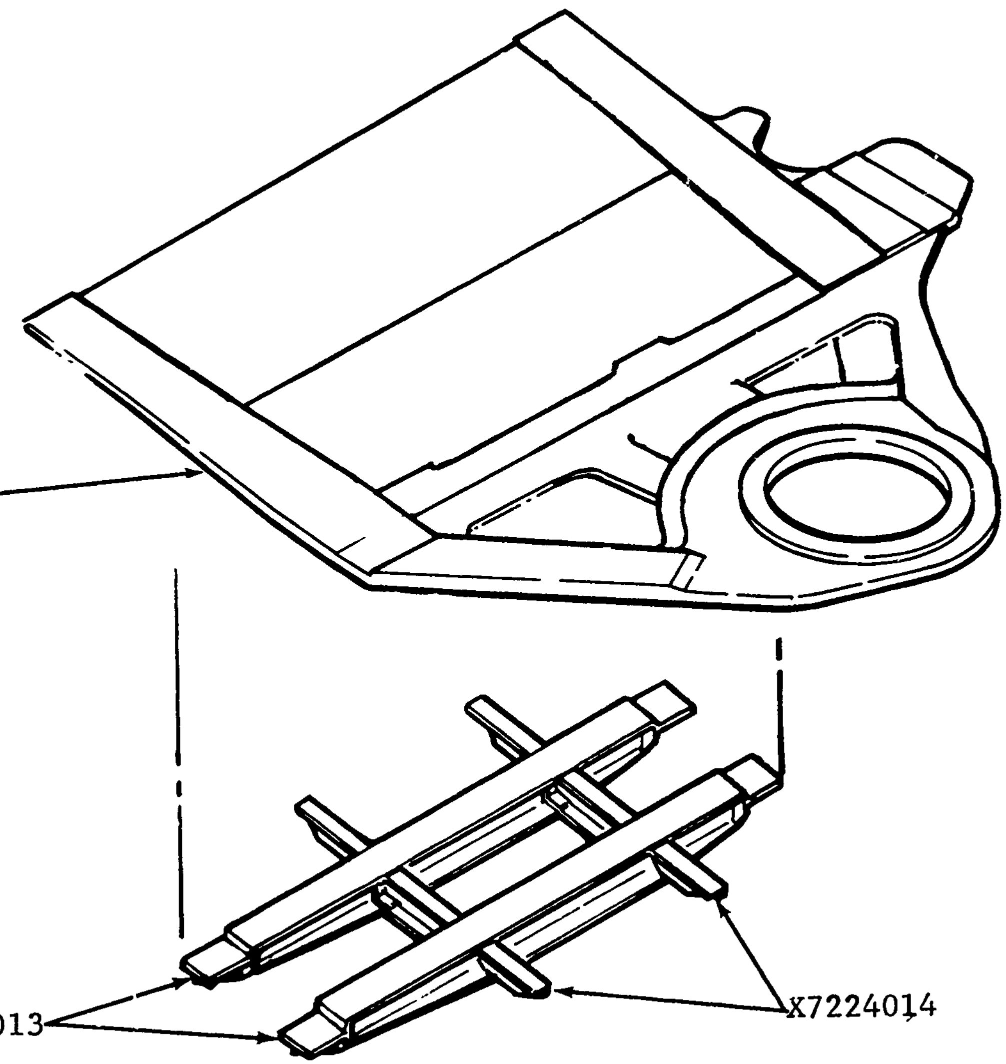


Figure 5.1.2-12 UPPER LUG ASSEMBLY

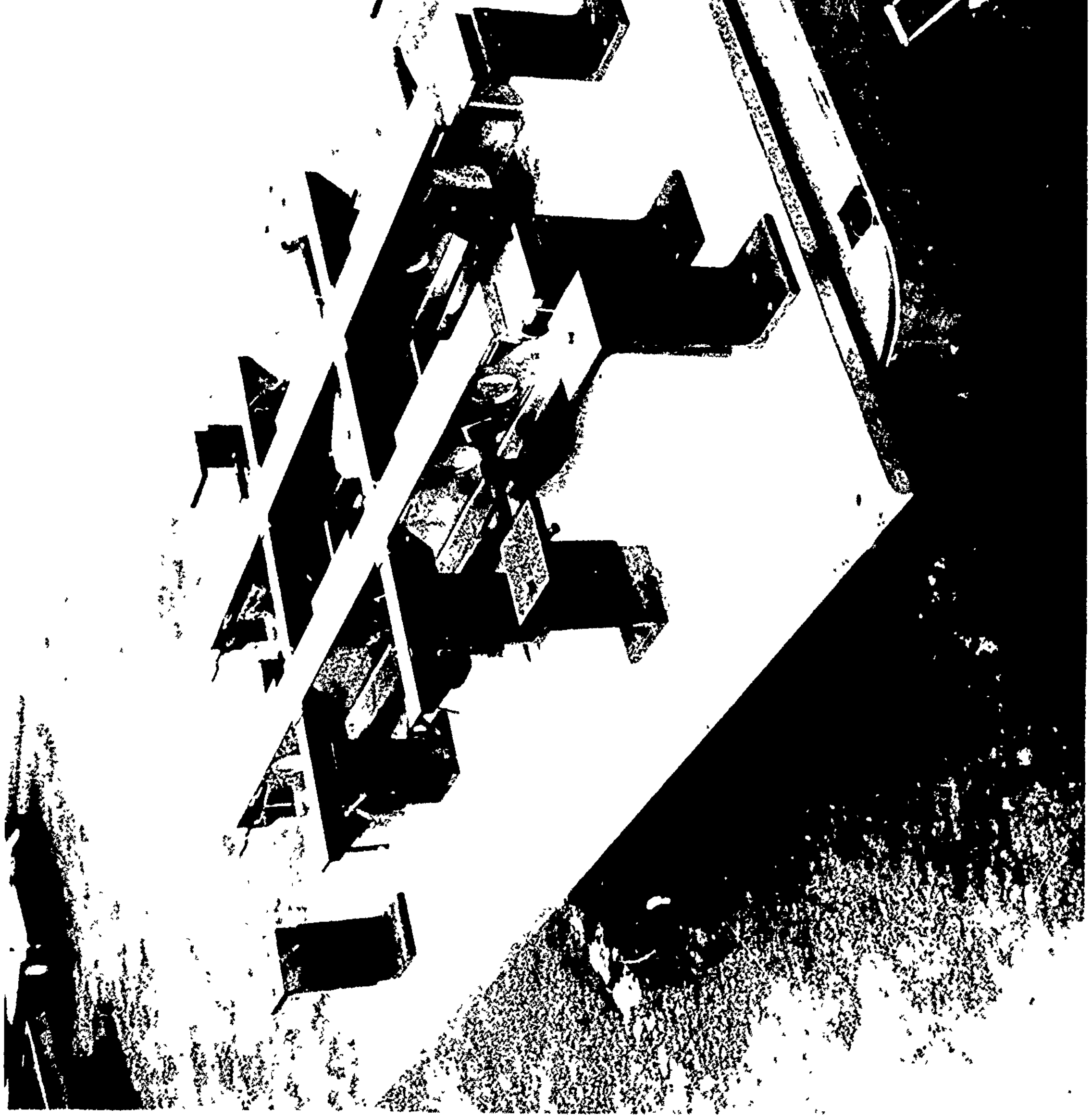


Figure 5.1.2-13 N.C. DRILLING FIXTURE FOR UPPER LUG ASSEMBLY

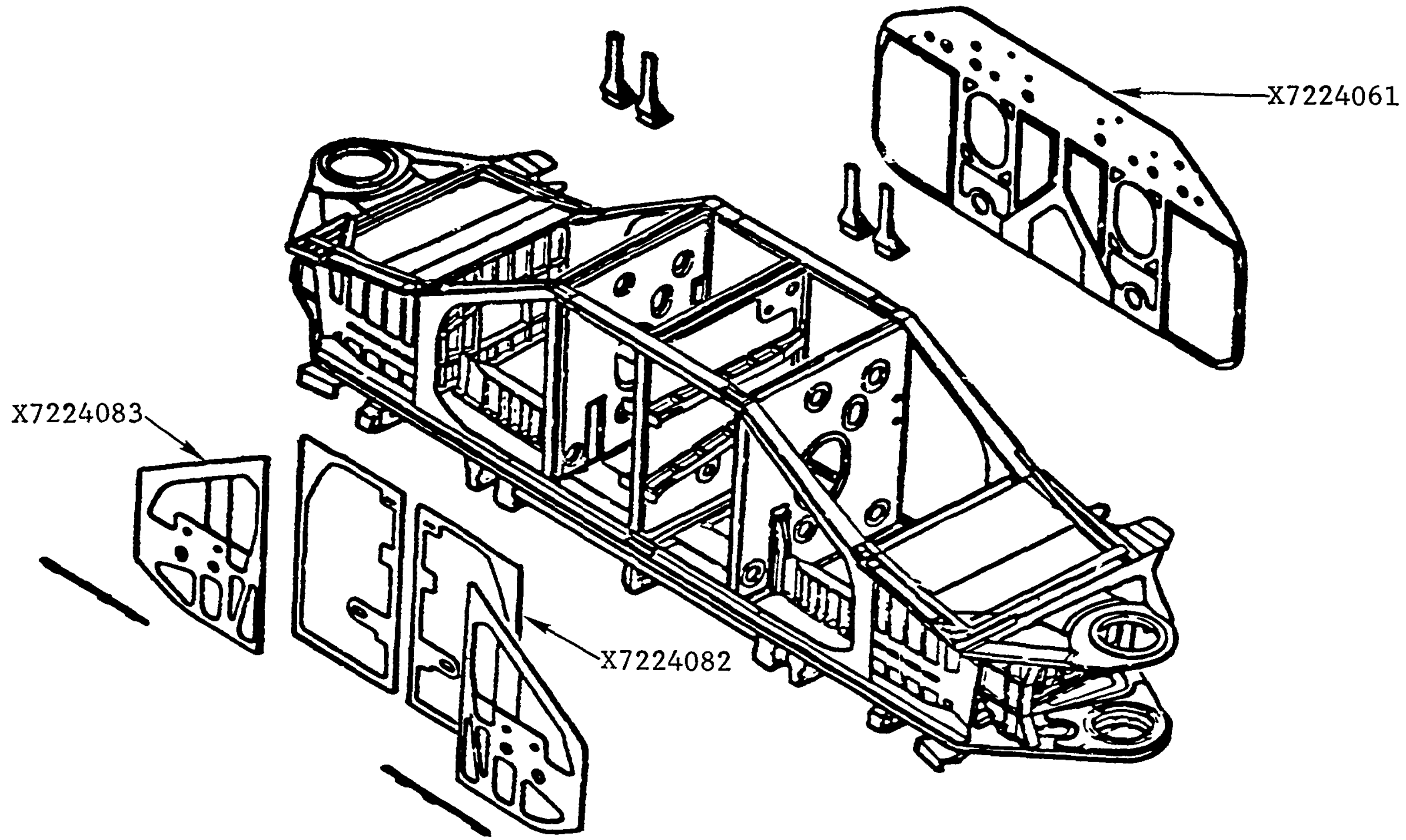


Figure 5.1.2-14 EXPLODED VIEW SHOWING FORWARD AND AFT BULKHEAD BONDED PANELS

The X7224061 aft bulkhead panel was the largest of the 6Al-4V titanium panels installed on the WCTS. The size made it necessary to bond the panel in the autoclave. No significant problems developed in the fabrication of this panel which is shown in Figure 5.1.2-15.

While in the position shown in Figure 5.1.2-15, aluminum stiffeners were bolted to the panel and nut plates for attaching the two access doors were installed.

Installation of the upper covers shown in Figure 5.1.2-16 completed the close-out of the WCTS box assembly except for the X7224062 access door covers. The upper panels, X7224150 and X7224051, were of conventional aluminum bonded panel design. They were bolted to the outer bulkheads and inner rib flanges to seal the box.

At the close of this reporting period the installations which have been described previously were in progress or completed. Only three major events in the fabrication of the WCTS remain uncompleted. Description of these operations will be included in the interest of continuity.

Installation of the titanium landing gear fittings and wing sweep actuator fittings shown in Figure 5.1.2-17 are scheduled as the next assembly operations. All main landing gear trunnion fittings and wing sweep actuator fittings were N.C. machined except for special cuts and boring operations. Wing sweep actuator fittings were assembled in pairs and drilled to match the X7224090 bulkhead which was also drilled full size from a coordinated drilling plate.

The X7223920 main landing gear side brace fittings were of 6Al-4V beta annealed titanium. Their design involved complex fabrication steps of flame cutting rough shapes from plates, machining of detail for weld assemblies, electron beam welding, and finish machining of the weldments.

The lower section of each MLG side brace fitting was an E.B. weldment fabricated from two machined details shown in Figure 5.1.2-18. These details were flame cut from a 7.5 inch thick plate to rough part size, machined complete, and E.B. welded as shown in Figure 5.1.2-19. This figure shows the weldment in the as welded condition prior to removal of back up bars and excess weld beads. This weldment was then welded to a third machined part as shown in Figure 5.1.2-20 to make a complete part. Excess material was allowed for machining and boring the critical dimensions after final welding.

Figure 5.1.2-15 X7224061 BONDED TITANIUM PANEL ASSEMBLY

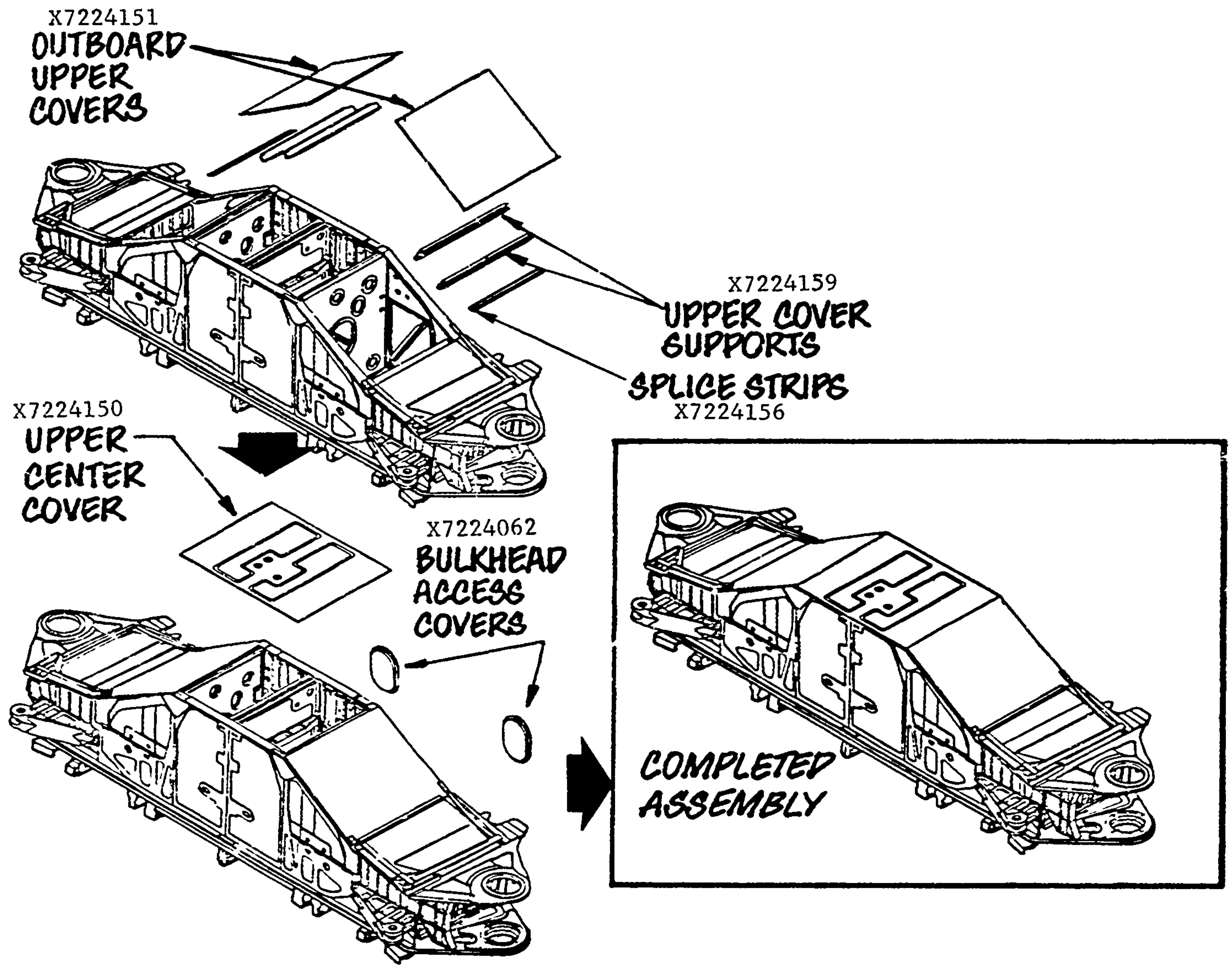


Figure 5.1.2-16 INSTALLATION SEQUENCE OF UPPER COVERS AND AFT ACCESS DOOR

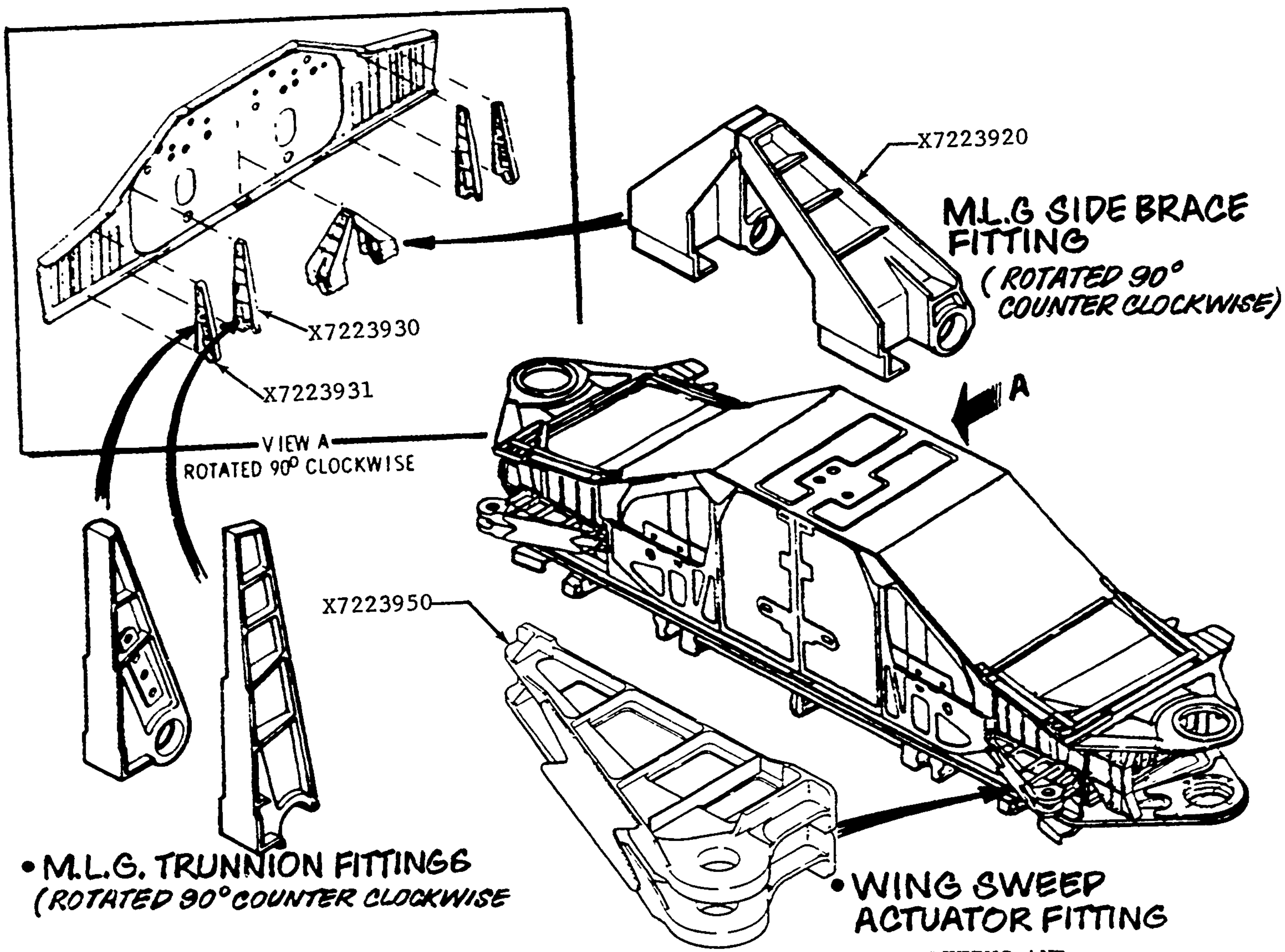


Figure 5.1.2-17 INSTALLATION OF LANDING GEAR FITTING AND WING SWEEP ACTUATOR FITTINGS

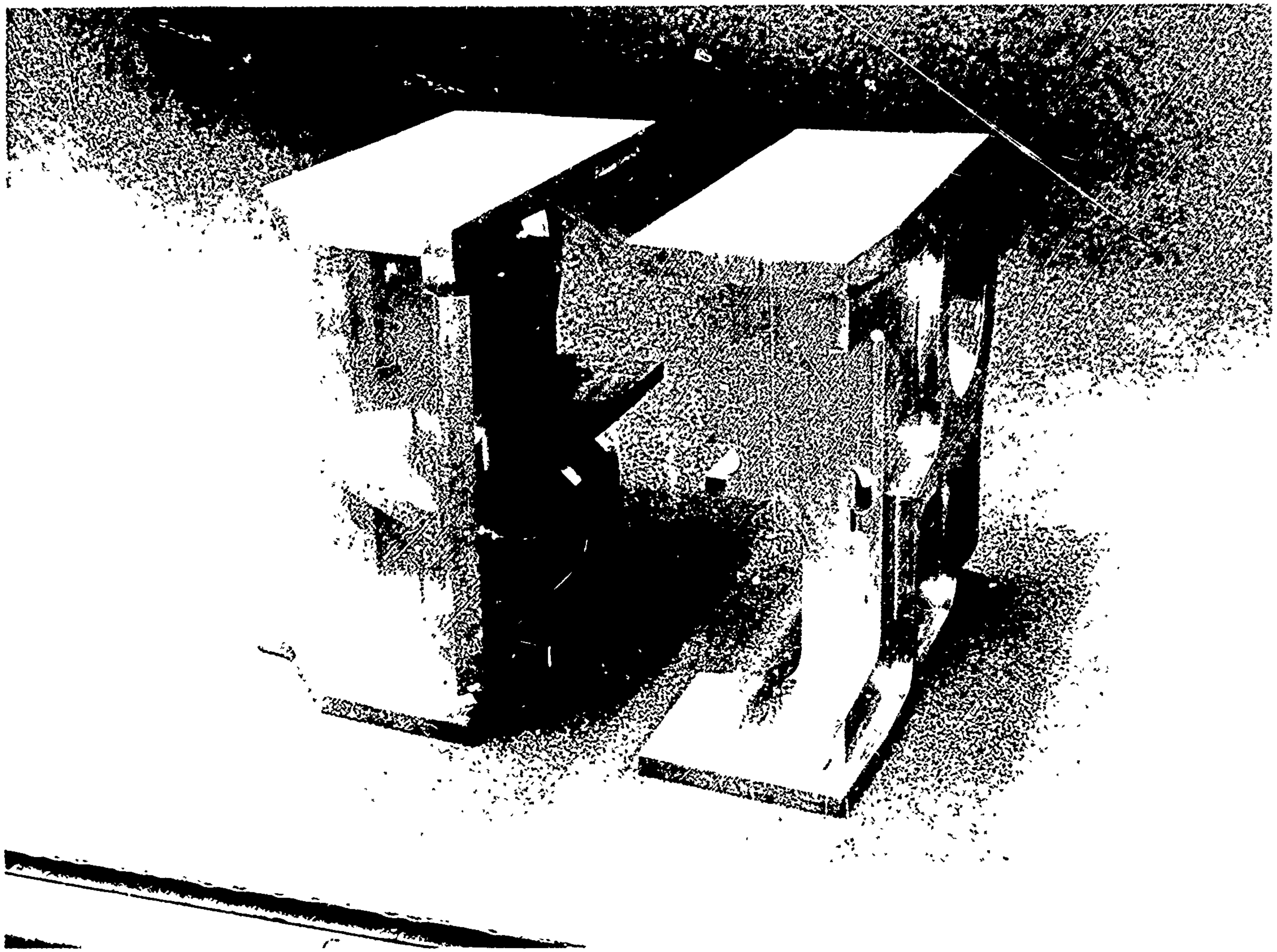


Figure 5.1.2-18 MAIN LANDING GEAR SIDE BRACE FITTING WELDMENT DETAILS

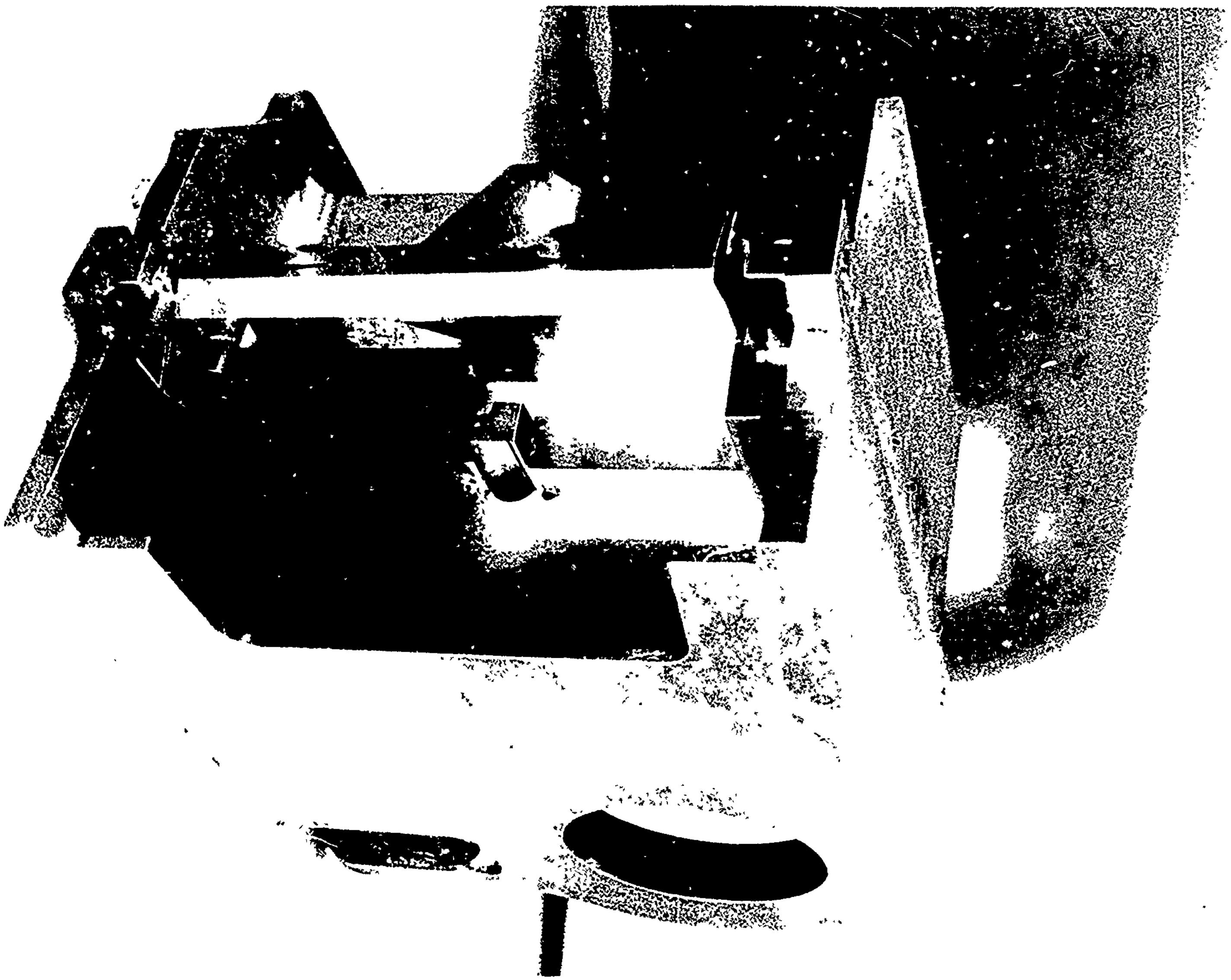


Figure 5.1.2-19 LOWER WELDMENT - MLG SIDE BRACE FITTING

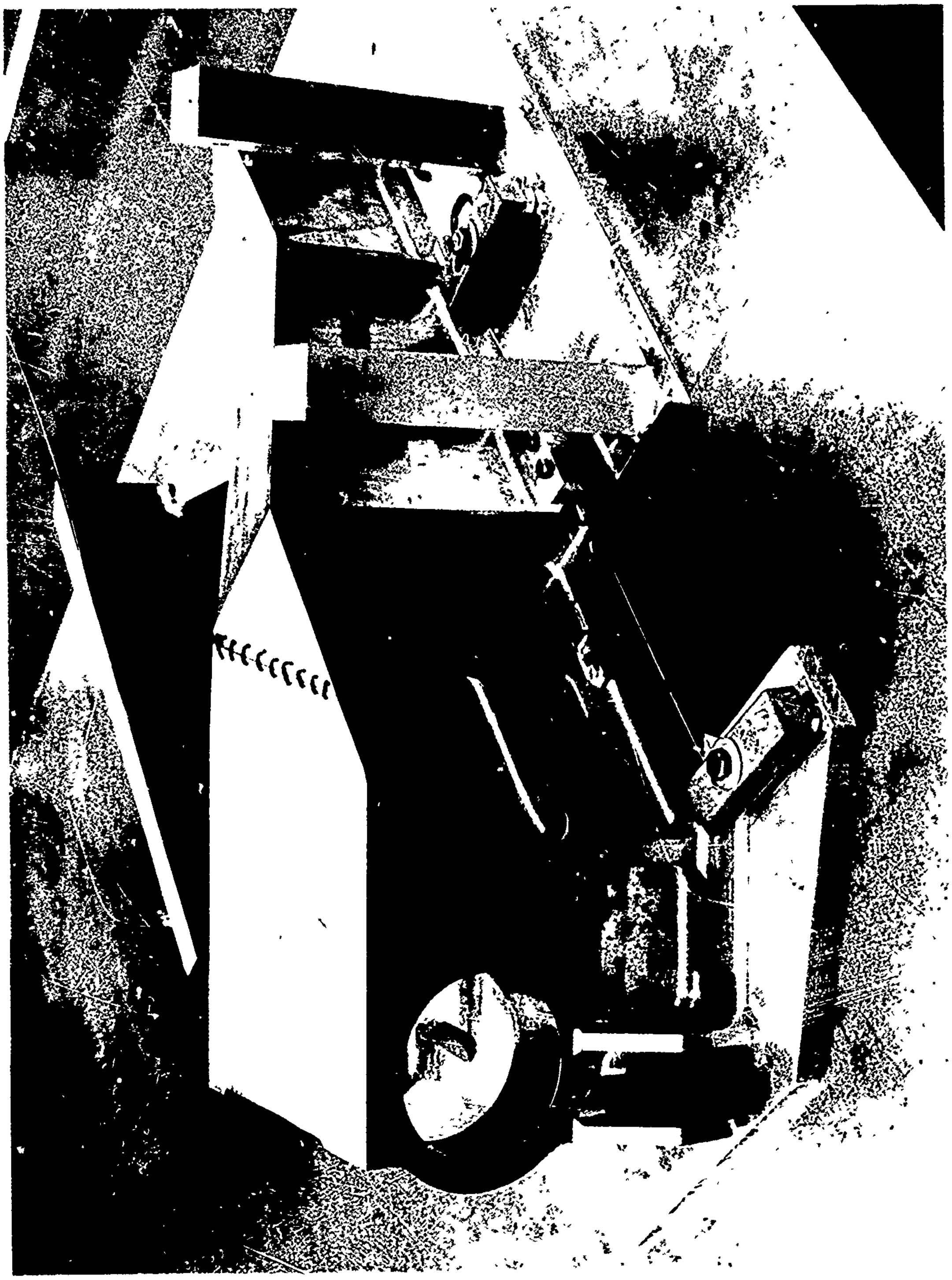


Figure 5.1.2-20 MAIN LANDING GEAR SIDE BRACE FITTING FINAL WELD

The final operations to be done in the Station 2 through 5 assembly fixture are those which drill longeron attachment holes on the WCTS. Full size attaching holes will be drilled in the forward longeron attaching fittings as indicated by Figure 5.1.2-21. These full size holes will be drilled from drill plates on the assembly fixture which have been coordinated to the forward simulated fuselage section by hand tooling.

Aft longeron tabs of the WCTS will not be drilled full size in the assembly fixture. Only two pilot size holes will be drilled. These pilot size holes in each aft tab will serve to coordinate and locate the aft simulated fuselage with the WCTS. Final drilling of these longeron tabs will involve drilling and reaming for 1.250 inch diameter Taper-lok fasteners at installation with the aft simulated fuselage section. Preparations for the installation of the 1.250 inch diameter Taper-lok fasteners is covered in Section 4.1.1 of this report.

Following completion of all assembly and drilling operations in the main assembly fixture the WCTS will be carried to the Gray boring mill for in-line boring and facing of the upper and lower pivot lug bushings to match the pivot pin.

Current plans are to mate the dummy wings, pivot pins, and WCTS as a final assembly operation prior to the shipment of these major items to Wright-Patterson Air Force Base for testing.

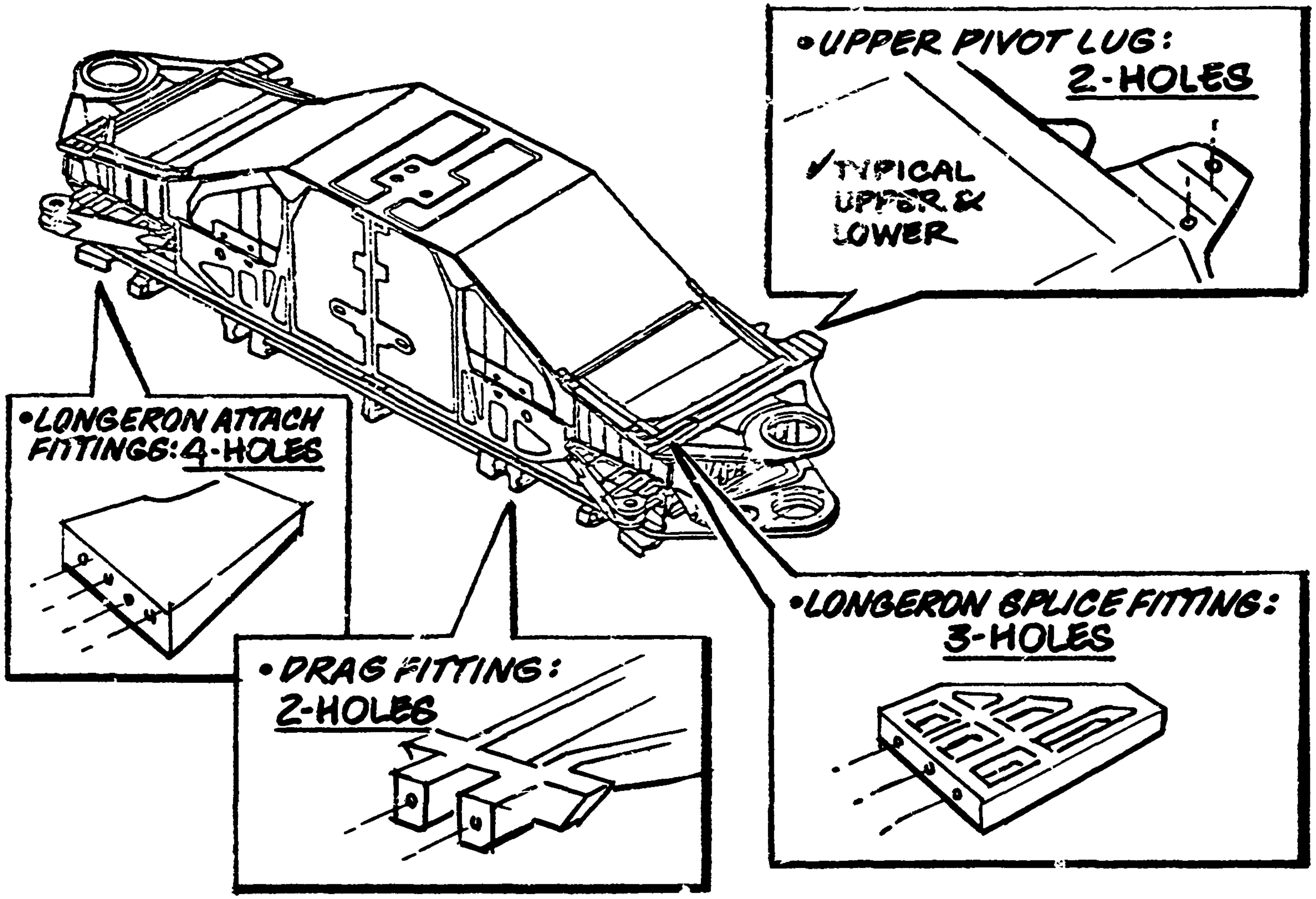


Figure 5.1.2-21 DRILL FORWARD LONGERON ATTACH FITTINGS

APPENDIX A

WELD SCHEDULES AND JOINT ANALYSES

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 2.75 Inches Focal point 3.5" Date 1-2-74

Weld No.	Mat'l	Thickness	Weld Type	Wire Feed	Weld Speed	Weld Axis	Current	Voltage	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current, Trace	Filament	Remarks
		inch		ipm	ipm		ma	kv						
H-42	10 Ni	1.6	Butt	0	16	X	440	34.5	5.22	OFF		X	68	Good root
				44	12	X	260	25.0	"	"		X	"	Wire bridged
				0	12	X	260	25.0	"	5K	9	X	"	
				40	12	X	180	18.0	"	5K	9	X	"	
	Grooved butt - .080" wide x .900" deep.													
	Wire could not be fed into first three passes													
	because of interference.													
	Macrosection shows gross voids & porosity.													
H-43	10 Ni	1.6	BOP	60	12	X	480	38.5	5.22	5K	9	X	65	Arc out
		"	"	60	12	X	180	18.0	"	5K	8	X	"	
	Macrosection shows midpoint fissures.													
H-44	10 Ni	1.6	BOP	60	12	X	460	38.0	5.22	5K	9	X	65	Face focus
		"	"	60	12	X	180	18.0	5.22	5K	8	X	65	3.5" Gun to work
	Root globular - extensive internal voids													
	above each globule, showing loss of material.													

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 2.625 Inches   Focal point 3.5"   Date 1-7-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-45	10 Ni	1.8	Butt	60	12	X	460	38.0	5.22	5K	9	X	68	Arc Out
			"	60	12	X	160	18.0	5.22	5K	8	X	68	2" from start.
		Face good. Root globular												
		Macrosection shows internal voids.												
H-46	10 Ni	1.8	Butt	60	12	X	480	38.5	5.38	5K	9	X	68	
"	"	"	"	60	12	X	160	18.0	5.38	5K	8	X	"	
	2nd Pass run immediately after the 1st pass													
	Face good. Root globular for 1/2 and uniform													
	for 1/2 the weld length.													
	Ultrasonics shows extensive voids.													
H-46-A	10 Ni	1.8	BOP	60	12	X	500	40.0	5.22	5K	9	X	68	
		"	"	60	12	X	580	44.0	5.22	5K	10	X	"	Too narrow
	Face good, Root good -													
	Macrosection shows irregular cross section													
	with bulge @ .75" from the face.													
	Microfissures in the bulge area.													

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 2.75 Inches   Focal point 3.5"   Date 1-18-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-47	10 Ni	1.8	BOP	60	12	X	500	40.0	5.22	5K	8	X	68	
	"	"	"	60	10	X	380	32.0	5.22	5K	9	X	"	
		Root globular until speed was reduced												
		to 10 i.p.m. 32K was not enough												
		for 60 i.p.m. wire												
H-49	10 Ni	1.8	BOP	50	10	X	480	40	5.22	5K	8	X	65	
		Face irregular, root porous and globular.												
		Note: The above was run with a root focal point. Gun to work 1 11/16".												
H-50	10 Ni	1.6	BOP	50	10	X	460	40.0	5.22	OFF		X	68	Face focus
		Face porous, root globular												
H-51	10 Ni	1.6	BOP	60	10	X	460	40.0	5.22	2.5K	9	X	68	
		Face good + Root globular.												

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Gun mode 60Kv, 750 ma. + .050" Date 1-22-74

Weld No.	Mat'l	Thickness	Weld Type	Wire Feed	Weld Speed	Weld Axis	Current	Voltage	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
		inch		ipm	ipm		ma	kv						
H-52	10 Ni	1.6	BOP	60	12	X	400	40.0	5.22	Off		X	68	0.050" Spacer
		Face porous, root globular												in EB gun
		.050" spacer between the cathode and												
		anode of EB gun reduces beam current by 100 ma.												
H-53	10 Ni	1.8	Butt	60	12	X	400	40.0	5.22	Off		X	68	Arc out
	"	"	"	60	12	X	260	30.0	5.68	Defocused		X	68	
		Macrosection shows proosity												
		transverse hot tear .75" from root.												
			Gun mode changed to 60 Kv, 750 ma. + .075" spacer											
H-54	10 Ni	1.8	Butt	50	12	X	380	44.7	5.22	Off		X	68	
		"	"	50	10	X	360	44.0	5.42	Defocused		X	68	
		"	"	50	10	X	140	21.6	5.60	"		X	68	
		Root globular Macros shows hot tears .375" from the root.												

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Gun configuration 60/750 + .100 Date 1-30-74

Weld No.	Mat'l	Thickness (inch)	Weld Type	Wire Feed (ipm)	Weld Speed (ipm)	Weld Axis	Current (ma)	Voltage (kv)	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-55	10 Ni	2.25	BOP	0	12.0	X	340	44	5.22	Off		X	68	
	Good geometry 1.75" deep													
	Macro shows solid weld													
H-55A	"	"	BOP	0	12	X	330	45.0	5.22	Off		X	68	
	Penetration 1.8" deep.													
	Macro shows parallel geometry													
	Face .250" wide good weld.													
H-55B	10 Ni	2.25	BOP	0	10	X	340	46.0	5.22	Off		X	68	
	Face .375", too wide.													
	Penetration 1.9" deep													
	Weld speed too slow.													
	Macro show solid weld.													
H-56	10 Ni	1.8	BOP	0	12	X	340	47.0	5.22	Off		X	68	
	+ .5" back up plate.													
	Face .375" weld good Ultrasonics shows 3 indications - remainder clear.													

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Face focus. Gun 60/752 + .100 Date 2-4-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-57	10 Ni	1.8	BOP	0	11	X	380	48.0	5.22	OFF		X	68	
		+ .5"												
	No good - penetrated through both part and backup.													
	Too much voltage.													
H-58	10 Ni	1.8	Butt	0	16	X	260	36.0	5.22	Off		X	68	ot uniform.
with .080				30	16	X	260	36.0	5.32	"		X	"	
groove in				30	12	X	340	44.0	5.60	"		X	"	
mating plates.						Face porous. Face .437" wide.								
						WELD N G.								
H-58A	10 Ni	1.8	[illegible]	0	12	X	360	47.0	5.22	Off		X	68	
	Plus	.375"	Full penetration				Macro shows							
		very good geometry.												
H-58B	"	"	"	0	12	X	360	48.0	5.22	5K	-10		68	1/2 length
	"	"	"	"	"	"	"	"	5.22	Off			68	Last 1/2 length.
	2nd 1/2 with static beam very good.													
	Macro shows hot tears and bulging													
	geometry on oscillated length . Remainder clear.													

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Face focus. Gun - 60/750/+ .100 Date 2-13-74

We No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-59	10 Ni	1.8	Butt	C	12	X	380	48.0	5.22	Off		X	68	
	Plus .5 Gross porosity caused by													
	Fe oxide on backup strip. Oxides formed													
	gas during welding.													
H-60	10 Ni	2.00	Butt	0	12	X	380	47.5	5.22	Off		X	68	
	Missed joint - macro shows													
	hot tears 1 1/16 from face.													
	Bead geometry poor.													
H-61	10 Ni	2.00	Butt	0	12	X	360	47.5	5.22	Off		X	70	
	Weldment steel grit blasted													
	to determine surface condition													
	(No appreciable difference could be noted)													
	Narrow face .187" wide.													
	Macro shows hot tears and porosity.													

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Face focus - Gun 60/750/.100 Date 2-18-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-62	10 Ni	1.8	Butt	0	12	X	360	47.5	5.22		0	X	70	
	+ 3/8	backup		penetration			very good							
			geometry good											
H-63	10 Ni	1.8	Butt	0	12	X	400	47.5	5.22		0	X	68	
	+ 3/8	backup		full	penetration through backup									
					Gun Mode changed to 60 Kv/750 ma.									
H-64	10 Ni	1.8												
	+ .5"		0	12	X	X	500	38.5	5.22		0	X	67	
	Bead geometry good, fine porosity													
	hot tear .250" from root penetration into backup .125"													
H-65	10 Ni	2"	BOP	0	12	X	520	38.5	5.22	0		X	65	Gun 5°
	+3/8	backup	"	"	12	X	460	35.0	5.22	0		X		lag angle
				full	penetration through back up.									

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches GWFX 60K - 750 ma. + .100" Date 3-5-74

Weld No.	Mat'l	Thickness (inch)	Weld Type	Wire Feed (ipm)	Weld Speed (ipm)	Weld Axis	Current (ma)	Voltage (kv)	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-67	10 Ni	1.8	Butt	0	12	X	400	47.5	5.22	Off		X	65	
	+ 5" backup.													
	Mat'l. condition solution treated.													
	Run in and run out tabs welded to test plates.													
	Face good. Cross section geometry good.													
	(X-Ray shows missed joint for 3/4".													
	Remainder clear.													
	Penetration into backup 3/16".													
H-68	10 Ni	1.8	Butt	0	12	X	400	47.5	5.22	0		X	65	
	+ 5" + .045 space.													
	(Mat'l. condition solution treated and aged)													
	Penetration into back up -3/16"													
	Macrosection shows hot tears .100" from root.													
	Remainder of weld clear.													

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches FX - 60K - 750 - .+.100 Date 3-7-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-70	10 Ni	1.8	BOP	0	12	X	400	47.5	5.22	Off		X	65	Face undercut
	+.5" backup + .045" space.													
			Face undercut, porous.											
		Bead geometry too narrow .090" wide.												
		Penetration into backup .250"												
H-71	10 Ni	1.8	BOP	50	12	X	360	44,9	5.22		0	X	65	
		"	"	50	12	X	260	36.0	5.22		0	X	65	
		"	"	50	12	X	180	20.0	5.6		0	X	65	
		Appearance good + geometry good.												
		No microfissures. Too much wire.												
		Should be 30 i.p.m.												
H-72	10 Ni	1.8	Butt	40	12	X	360	44.0	5.22		0	X	65	
		"	"	50	12	X	280	38.0	5.22		0	X	65	
		Filament failed at mid-point												
		Geometry fair.												

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches FX 60 K - 750 ma. + .100 Date 3-13-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-73	10 Ni	1.8	BOP	50	12	X	400	44.0	5.22		0	X	65	
		"	"	50	12	X	360	39.0	5.22		0	X	65	re-penetrated
		"	"	50	12	X	240	28.0	5.22		0	X	65	
		Geometry irregular, no apparent flaws.												
H-74	10 Ni	1.8	BOP	50	12	X	360	44.5	5.22		0	X	68	
		"	"	50	12	X	300	38.0	5.22		0	X	68	
		Good geometry, face 3/8" wide.												
		No apparent flaws.												
H-75	10 Ni	1.8	Butt	0	12	X	400	47.5	5.22	0		X	68	
	+ .5"		"	50	12	X	180	25.0	5.61	0		X	68	
		Root cracks, .100" from root.												
		Penetration into backup .250".												
		Geometry good.												
H-76	10 Ni	1.8	Butt	0	12	X	380	45.0	5.22		0	X	65	
	+ .5"	+ .045	grp.	30	12	X	220	30.0	5.61		0	X	65	
		Geometry good - root cracks												

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.25 Inches 60K - 750 ma. + .100

Date 3-19-74

Weld No.	Mat'l	Thickness	Weld Type	Wire Feed	Weld Speed	Weld Axis	Current	Voltage	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
		inch		ipm	ipm		ma	kv						
H-77	10 Ni	1.8	Butt	0	12	X	200	30.0	5.22		0	X	65	
	+ 3/8"	+.062	"	0	12	X	300	40.0	5.22		0	X	65	
			"	30	12	X	360	45.0	5.22		0	X	65	
		Geometry fair - root cracks												
H-79	10 Ni	1.8	Butt	0	12	X	400	47.5	5.22		0	X	65	
		"	"	0	12	X	360	45.0	5.22		0	X	65	
		Geometry good - Hot tears .150" from root.												
		Penetration into backup .250"												
H-80	10 Ni	1.8	Butt	0	12	X	360	45.0	5.22		0	X	65	
	+.5"	+.062	"	40	12	X	100	20.0	5.61		0	X	65	
			"	40	12	X	140	22.0	5.61		0	X	65	
		No good - voids - Mid-point cracks												
H-82	10 Ni	1.8	Butt	0	12	X	360	46.0	5.22		0	X	67	
	+.5" = .040"													
	groove.			Face good - incomplete penetration.										

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Face focus. 60-750 + .100 Date 4-4-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-84	10 Ni	1.8	Butt	0	12	X	360	47.5	5.22		0	X	68	
+	.5" backup		"	30	12	X	100	20.0	5.61		0	X	68	
with .045 x 375" groove				0	12	X	120	22.0	5.80		0	X	68	
		Geometry good - penetration into backup												
		.125 Hot tears on start.												
H-85	10 Ni	1.8	Butt	0	12	X	380	47.5	5.22		0	X	68	
+	.5 +.045 x 375"				12	X	120	22.0	5.80		0	X	68	
		Geometry good - penetration into												
		backup 3/16". Hot tears - transverse, .125" from root.												
NDI-1	10 Ni	2.00	Butt		11.5	X	400	48.0	5.22		0	X	68	
+	.5 +.250 groove				11.5	X	140	22.0	5.80		0	X	68	
H-86	10 Ni	1.8	Butt	0	12	X	380	47.5	5.22		0	X	68	
+	.5 +.050 groove				Geometry good - penetration									
					into back .187"									

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Face Focus, 60K -750 ma. + .100" Date 4-10-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
						ENGINEERING TEST PLATES								
H-87	10 Ni	1.8	Butt	0	12	X	400	47.5	5.22		0	X	68	
	+ .5"	x 062"x187"		25	12	X	140	22.0	5.80		0	X	68	
			Appearance good - geometry good											
			X-ray shows 2 small cracks											
			(Ultrasonics picked up 8 indications)											
H-89	10 Ni	1.5	Butt	0	12	X	400/340	47.0/42.0	5.22		0	X	68	
	+ .5" with													
.06" x .187" groove					Full penetration for first 4"									
					Kv reduced for the remainder									
					of the weld with 1 incomplete penetration									
			The 4" section was cut out and rewelded by GTA											
			manual 100%. The remainder of the weld root was grooved											
			with a rotary burr .250" deep to solid weld metal and											
			back welded with GTA manual. This plate was identified											
			in all areas and was used as test for repairs.											
			QC S/N 402751											

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Fx - 60K - 750 ma. + .100 Date 4-16-74

Weld No.	Mat'l	Thickness (inch)	Weld Type	Wire Feed (ipm)	Weld Speed (ipm)	Weld Axis	Current (ma)	Voltage (kv)	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-90	10 Ni	1.5	Butt	0	12	X	380	45.0	5.22		0	X	68	
+	.5" +	.06"x.187"	"	25	12	X	140	22.0	5.80		0	X		
	Backup over solid copper.					Appearance good.								
			603	R 100	-	11	- 3							
			CSC	2500	-	5 -	1 -	41 thru	50					
			QC		S/N	402755								
H-91	10 Ni	1.5	Butt	0	12	X	380	45.0	5.22		0	X	68	
+	.5" +	.06"x.187"	"	0	12	X	140	22.0	5.80		0	X	68	Wire fouled.
			603	R 100	-	11	- 3							
			CSC	2500	-	5 -	1 -	41 thru	50					
			QC		S/N	402754		(Best Plate)						
H-92	10 Ni	1.5	Butt	0	12	X	380	45.0	5.22			X	68	.025" mismatch
+	.5" +	.06"x.187"	"	25	12	X	140	22.0	5.90			X	68	
		Expulsion	6" from start.											
			603	R 100	-	11	- 3							
			SCS	2500	- 5	- 1 -	41 thru 50							

QC S/N 402751

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Fx - 60K - 750 ma. + .100 Date 4-17-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-93	10 Ni	1.503	Butt	0	12	X	380	45.0	5.22	0		X	68	Arc out
	+.5 +.06"x.187"		"	25	12	X	140	22.0	5.90	0		X	68	1" from start.
				603 R - 100 - 11 - 3										
				CSC 2500 - 5 - 1 - 41 thru 50										
				QC S/N 402752										
H-94	10 Ni	1.6	Butt	0	12	X	380	45.0	5.22		0	X	68	
	+.5"+.06"x.187"		"	25	12	X	140	22.0	5.90	0		X	68	
				603 R - 100 - 11 - 3										
				CSC 2500 - 5 - 1 - 41 thru 50										
				QC 402496										
H-95	10 Ni	1.6	Butt	0	12	X	380	45.0	5.22		0	X	68	
	+.5 +.06"x.187"			25	12	X	140	22.0	5.95		0	X	68	
				603 R - 100 - 11 - 3										
				CSC 2500 - 5 - 1 - 41 thru 50										
				QC S/N 402495										

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches FX 60K - 750 ma. + .100" Date 4-23-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-96	10 Ni	1.83	Butt	0	12	Y	400	47.0	5.22		0	X	68	
+.5"	x125"	x.187" "	"	0	12	Y	140	22.0	5.95		0	X	68	
			Test plates for 20° angle welds.											
			Tool tryout - WLFX - T17315											
H-97	10 Ni	1.83	Butt	0	12	Y	400	46.0	5.22		0	X	68	
+.5"	x125"	x.187"	25	"	12	Y	140	22.0	5.95		0	X	68	
		20° Butt weld - Chamber extensions												
		installed - pump down time 12 minutes.												
H-98	10 Ni	1.83	Butt	0	12	Y	400	46.5	5.22		0	X	68	
	"	"	25	0	12	Y	140	22.0	5.95		0	X	68	
+.5"	x.125"	x.187												
H-99	10 Ni	1.8	Butt	0	12	Y	360	46.0	5.22		0	X	68	
+.5"	x.062"	x.187"	"	0	12	Y	130	22.0	5.95		0	X	68	
		Tee section - simulated part for												
		YF 992 cap weld. Root had several												
		shallow cracks that were ground out and repaired with GTA - X ray - OK												

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Fx 60K - 750 ma. + .100 Date 4-30-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-100	10 Ni	1.6	Butt	0	12	Y	360	46.0	5.22		0	X	68	
+.5"	x .062"	x.187"	"	0	12	Y	120	22.0	5.95		0	X	68	
		Tee section simulated cap weld												
		YF 932 bulkhead.												
		Weld OK, Root had 3 surface indications												
		repaired by manual GTA, X-ray OK.												
H-101	10 Ni	1.6	Butt	0	12	Y	360	46.0	5.22		0	X	68	.008" gap
+ .5	x .06"	x.187"	"	0	12	Y	140	22.0	5.95		0	X	68	
		Cap weld assembly												
		X-722 - 4091 - 9												
		QC S/N 402 625 Weld penetrated												
		thru part, back up and into copper.												
		Two holes, located over the relief												
		hole in the flange were repaired												
		using manual GTA. Blowout caused by												
		backup slipping out of position.												

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Fx 60K - 750 ma. + .100 Date 5-29-74

Weld No.	Mat'l	Thickness (inch)	Weld Type	Wire Feed (ipm)	Weld Speed (ipm)	Weld Axis	Current (ma)	Voltage (kv)	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-102	10 Ni	1.6	Butt	0	12	Y	360	45.0	5.22		0	X	68	
.5"	.06" x .137"		"	"	12	Y	140	22.0	5.95		0	X	68	
			Cap weld assembly											
				X - 7224091 -9										
				QC S/N 402624										
		Face good - root back welding												
		required. Run out repair made by												
		manual GTA. Copper backup bars												
		rebuilt												
H-103	10 Ni	1.8	Butt	0	12	Y	380	46.0	5.22		0	X	65	
Backup bar			"	0	12	Y	140	22.0	5.95		0	X	65	undercut face
redesign			"	"	12	Y	140	22.0	5.95		0	X	65	
5/8" x 1" with														
.06" x .187"					Tee section - test part									
groove.				Required because of major										
				electrical component replacement										
				(Filament transformer and silicon rectifiers replaced)										

X-Ray good. VS. OK

ELECTRON BEAM SCHEDULES

Gun-to-Work Distance 3.5 Inches Fx 60K - 750 ma. + .100 Date 5-31-74

Weld No.	Mat'l	Thickness inch	Weld Type	Wire Feed ipm	Weld Speed ipm	Weld Axis	Current ma	Voltage kv	Focus Pot.	Oscillator Freq.	Oscillator Atten.	Current Trace	Filament	Remarks
H-104	10 Ni	1.83	Butt	0	12	Y	340	45.5	5.22	0		X	66	
Backup				0	12	Y	140	22.0	5.95	0		X	65	
5/8" x 1" rectangular				0	12	Y	140	22.0	5.95	0		X	65	
bar with														
.06" x .187" groove.														
					CAP WELD ASSEMBLY									
					X 7224071-9									
					QC S/N 402629									
			Face good - Weld root required											
			only minor back welding. X-Ray OK											
H-105	10 Ni	1.83	Butt	0	12	Y	380	45.0	5.22	0		X	65	
Backup			"	0	12	Y	140	22.0	5.95	0		X	65	
5/8" x 1" rectangular				0	12	Y	140	22.0	5.95	0		X	65	
bar with					CAP WELD ASSEMBLY									
.06" x.187 groove.					X 7224071-9									
					QC S/N 402628									
Detail parts remachined, prefit with Prussian blue. No back welding required. X-Ray OK														

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Structural Design	Materials
Stress Analysis	Manufacturing Technology
Fracture Mechanics	Damage Tolerance

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covers the manufacture of the wing carrythrough structure and the test fixture structure during the latter portion of Phase III, Fabrication. Included are design and analysis in support of manufacture and additional material testing, component testing and manufacturing research and development work funded as a part of the "Credible Option" added task. (over)

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All detail parts and subassemblies for the wing carrythrough structure (WCTS) are complete. Final assembly of the WCTS is progressing on schedule toward a 31 January 1975 completion date. After final assembly of the WCTS the remaining strain gages will be installed and the dummy wing will be prefit prior to shipment to AFFDL/FBT at WPAFB.

Manufacture of all elements of the test fixture is substantially complete. The test fixture base is reassembled at WPAFB. The forward upper test fixture structure is at AFFDL/FBT at WPAFB being reassembled. The aft upper test fixture structure is being disassembled at Fort Worth in preparation for an early January 1975 delivery to WPAFB.

The Advanced Metallic Air Vehicle Structure (AMAVS) Program is progressing on schedule toward a May 1975 start of testing in the Structural Test Facility at WPAFB. Fifteen months of static, fatigue and damage tolerance testing are planned.

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