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DEVELOPMENT OF A GRAPHITE HORIZONTAL STABLIZER

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Douglas Aircraft Company

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13. ABSTRACT

The results of analyses and development component tests of the redesigned graphite horizontal stabilizer are presented. The upper and lower skin panels were redesigned with bonded internal stepped-lap titanium doublers at the main pivot and actuator fitting interfaces. The minimum predicted margin-of-safety for the redesigned pivot joint structure is 29 percent at the first fastener outboard of the titanium doubler. Three development components were fabricated and tested to verify the static and fatigue load capacities of the pivot joint and the static load capacity of the actuator joint. The pivot joint development component attained a static ultimate load of 170 percent DLL and a residual static ultimate load of 195 percent DLL after 12,000 hours of simulated fatigue spectrum loading. The actuator joint development component attained a static ultimate load of 195 percent DLL. The theoretically predicted strains were in good agreement with strain-gage data. The calculated weight of the graphite structure is 183 pounds, an increase of approximately six pounds for the structural redesign, and a reduction of 26 percent in comparison with the conventional metal structure. Fabrication techniques for the upper and lower skin panels are discussed. Engineering drawings, quality control test results, and the test plan for the second stabilizer unit are included in appendices.

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DEVELOPMENT COMPONENTS						
STATIC TEST						
FATIGUE TEST						

FOREWORD

This report was prepared by the Douglas Aircraft Company, McDonnell Douglas Corporation, Long Beach, California under the terms of contract N00156-70-C-1321. It is the seventh interim technical report covering work completed between 1 January and 30 June 1973. The program is sponsored by the Air Vehicle Technology Department, Naval Air Development Center (NADC), Warminster, Pennsylvania, 18974. Mr. Anthony Manno, Code 30331, is the Project Engineer for NADC.

The following Douglas personnel were the principal contributors to the program during the reporting period: G. M. Lehman, Program Manager; Dr. D. M. Purdy, A. Cominski, C. G. Dietz, and Dr. R. Teodosiadis, Structural Analysis; R. J. Palmer, Material and Process Engineering; W. B. Romey, Manufacturing Development; and E. G. Willoughby, Instrumentation and Testing.

Static and fatigue tests of structural development components were conducted by the Ogden Technology Laboratories, Incorporated, in Fullerton, California.

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SUMMARY

The results of analyses and development component tests of the redesigned graphite horizontal stabilizer are presented. The upper and lower skin panels were redesigned with bonded internal stepped-lap titanium doublers at the main pivot and actuator fitting interfaces. The minimum predicted margin-of-safety for the redesigned pivot joint structure is 29 percent at the first fastener outboard of the titanium doubler. Three development components were fabricated and tested to verify the static and fatigue load capacities of the pivot joint and the static load capacity of the actuator joint. The pivot joint development component attained a static ultimate load of 170 percent Design Limit Load (DLL) and a residual static ultimate load of 195 percent DLL after 12,000 hours of simulated fatigue spectrum loading. The actuator joint development component attained a static ultimate load of 195 percent DLL. The theoretically predicted strains were in good agreement with strain-gage data. The calculated weight of the graphite structure is 183 pounds, an increase of approximately six pounds for the structural redesign, and a reduction of 26 percent in comparison with the conventional metal structure. Fabrication techniques for the upper and lower skin panels are discussed. Engineering drawings, quality control test results, and the test plan for the second stabilizer unit are included in appendices.

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TABLE OF CONTENTS

Section		Page
I	INTRODUCTION	1
II	ENGINEERING DESIGN AND ANALYSIS	3
	ANALYSIS OF STABILIZER REDESIGN	3
	Finite Element Analysis	3
	Stepped-Lap Joint Analysis	8
	DEVELOPMENT COMPONENTS	14
	STRUCTURAL WEIGHT SUMMARY	20
III	MANUFACTURING DEVELOPMENT	23
APPENDIX A - ENGINEERING DRAWINGS		29
APPENDIX B - INCOMING MATERIAL AND IN-PROCESS TEST RESULTS		39
APPENDIX C - TEST PLAN FOR STABILIZER UNIT TWO		51
REFERENCES		57

LIST OF FIGURES

Figure		Page
1.	Finite Element Analysis Model of Pivot Joint Redesign	4
2.	Idealization Details Near Pivot Fitting	6
3.	Design Modification for Attach Angle Continuity	7
4.	Spanwise Bending Moments in Upper Skin Panel Near Pivot Fitting	9
5.	Shear Stress-Strain Curves for Hysol EA951 Adhesive	10
6.	Elastic and Elastic-Plastic Adhesive Shear Stress Distributions in Stepped-Lap Joint	12
7.	Internal Adherend Load Levels in Stepped-Lap Joint	13
8.	Pivot Joint Development Component Failure	15
9.	Point of Failure Initiation for Pivot Joint Development Component	16
10.	Strain-Gage Locations on Pivot Joint Development Component	17
11.	Test-Theory Correlation for Pivot Joint Development Component-Station 5.22	18
12.	Test-Theory Correlation for Pivot Joint Development Component-Station 0.265	19
13.	Stepped-Lap Titanium Doublers in Partially Complete Skin Layup	24
14.	Vacuum Bagging Techniques for Study Panels	27
A1	Z3579227 Doubler-Graphite Composite Stabilizer Upper Skin Hinge	31
A2	Z3579228 Doubler-Graphite Composite Stabilizer Lower Skin Hinge	32
A3	Z3579230 Doubler-Graphite Composite Stabilizer Skin Actuator	33
A4	Z5569966 Horizontal Stabilizer Assembly-Graphite Composite	34
A5	Z5569973 Panel Assembly-Graphite Composite Stabilizer Upper Skin	36
A6	Z5569974 Panel Assembly-Graphite Composite Stabilizer Lower Skin	37
B1	In-Process Quality Control Test Specimen Locations for Upper Skin Panel Number Two-Stabilizer Unit Two	50
C1	Internal Strain-Gage Locations	52
C2	External Strain-Gage Locations	53
C3	Displacement Measurement Locations	56

Preceding page blank

LIST OF TABLES

Table		Page
I	Theoretical Strengths of Stepped-Lap Joints	10
II	Weight and Material Utilization Summary- Stabilizer Unit Two	21
III	Average Quality Control Test Results for Various Laminates	26
BI	Prepreg Quality Control Receiving Inspection Report - Lot Number 392	40
BII	Prepreg Quality Control Receiving Inspection Report - Lot Number 395	41
BIII	Prepreg Quality Control Receiving Inspection Report - Lot Number 397	42
BIV	Prepreg Quality Control Receiving Inspection Report-Lot Number 407	43
BV	In-Process Quality Control-Pivot and Actuator Test Specimens	44
BVI	In-Process Quality Control-Stabilizer Unit Two Upper Skin Number One	45
BVII	Test Results for Bagging Technique Study	46
BVIII	Test Results for Envelope Bag Panels on PLM	47
BIX	In-Process Quality Control-Stabilizer Unit Two Lower Skin	48
BX	In-Process Quality Control-Stabilizer Unit Two Upper Skin Number Two	49
CI	Strain-Gage Locations for Stabilizer Unit Two	54
CII	Static Test Load Schedule for Stabilizer Unit Two	55

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SECTION I
INTRODUCTION

The overall objective of the graphite composite structural development program is to obtain significant improvements in aircraft weapon system performance through structural applications of advanced composite materials. A primary requirement of the program is to demonstrate the structural performance and weight characteristics of graphite-epoxy composites in aircraft wing-type applications. This requirement is being met through the design, fabrication, and ground testing of a graphite-epoxy horizontal stabilizer structure for the A-4 attack aircraft, and through analytical comparison of its structural performance with the functionally equivalent metal component.

The stabilizer was designed to take maximum advantage of the engineering properties of graphite reinforced composites in the primary structure. Other materials were used selectively in the design where their properties were advantageous (e.g., fiberglass leading edge assembly, metal fittings and joint reinforcements). The design concept involved the use of solid laminate skins stabilized against buckling by a multi-shear web substructure made primarily of bonded honeycomb panels. Machined metal fittings were utilized at the seven elevator hinge stations and at the stabilizer attach points to the fixed structure. Bonded metal reinforcing was also used to transmit concentrated fitting loads into the composite skin panels. However, reinforced composites comprised approximately 70 percent of the finished stabilizer weight.

A primary multiple bolt joint at the interface between the graphite-epoxy laminate and the main aluminum alloy attach fitting was initially designed without metal reinforcing. This joint failed prematurely during static test at 74 percent design limit load (DLL). Diagnostic investigations indicated that the failure was caused by adverse stress concentration effects in the laminate brought about by unequal load sharing among the attach bolts and by stress gradients through the thickness of the laminate due to joint eccentricity and the inherent stiffness of the skin panel.

The primary bolted joints between the graphite stabilizer and the aluminum attach fittings were redesigned during the reporting period and selected development components were fabricated and successfully tested to verify strength and fatigue life of the structure. The pivot and actuator joint development components attained ultimate strengths of 170 and 195 percent DLL, respectively. A second pivot joint development component attained a residual static strength of 195 percent DLL after sustaining 12,000 hours of simulated fatigue spectrum loading.

The calculated weight of the redesigned stabilizer is 183 pounds, an increase of approximately six pounds over the original graphite-epoxy design configuration. A structural weight reduction of 26 percent is projected in comparison with the baseline metal design.

Significant tasks accomplished during the seventh reporting period included:

- Completion of finite element analysis of the stabilizer redesign,
- Completion of fabrication and testing of the pivot and actuator joint development components,
- Correlation of analytical and experimental results,
- Modification and release of engineering drawings incorporating the redesign,
- Completion of process investigations of various vacuum bagging techniques,
- Modification of the skin laminating mold for envelope bagging during cure cycles,
- Fabrication and quality testing of the skin panels for stabilizer unit two,
- Revision of the test plan for stabilizer unit two to include static testing in addition to fatigue testing.

The analysis, testing, correlation, and fabrication activities are discussed in the following sections. Design details, quality control test results, and the revised test plan are included in the appendices.

SECTION II

ENGINEERING DESIGN AND ANALYSIS

The main pivot and actuator attach joints were redesigned to attain the required strength through the addition of internal stepped-lap titanium doublers. The redesigned joints reduced the local adverse stress concentrations through the use of a yielding metal and minimized reliance on laminate interlaminar shear strength at the points of major load transfer.

Finite element analyses (FEA) were conducted on both the redesigned pivot joint and on the development components which were fabricated and tested for strength verification of the structure. Analysis and test results are summarized in this section, and correlations between theoretical and experimental strain data are shown.

ANALYSIS OF STABILIZER REDESIGN

A bending-element analysis of the pivot joint region of the stabilizer structure and a planar membrane analysis of the Z5569988 pivot joint development component were completed. The latter analysis was supplemented with a local joint analysis from which it was concluded that the stepped-lap bonded joint was considerably stronger than the surrounding structure. The minimum margin-of-safety was predicted to be 29 percent at the fastener hole along the front spar and just outboard of the stepped-lap doubler. Results of the planar analysis gave good general agreement with the strain gage data from the Z5569988 development component static test.

Finite Element Analysis

The bending element analysis was performed using equilibrium elements in a model similar to the one reported in Reference 1. Loads, reactions, and boundary dimensions were identical to the previous analysis. The model (Figure 1) had two planes of symmetry, one about the center plane of the aircraft and another about the chordplane of the stabilizer. The vertical plane of symmetry ($y = 0$) for the structure was used as a reaction plane. For each analysis case, symmetric or anti-symmetric solutions were run which were subsequently superimposed to yield the total solution. The reaction system specified along the center plane forced symmetric or anti-symmetric modes of deformation for each solution.

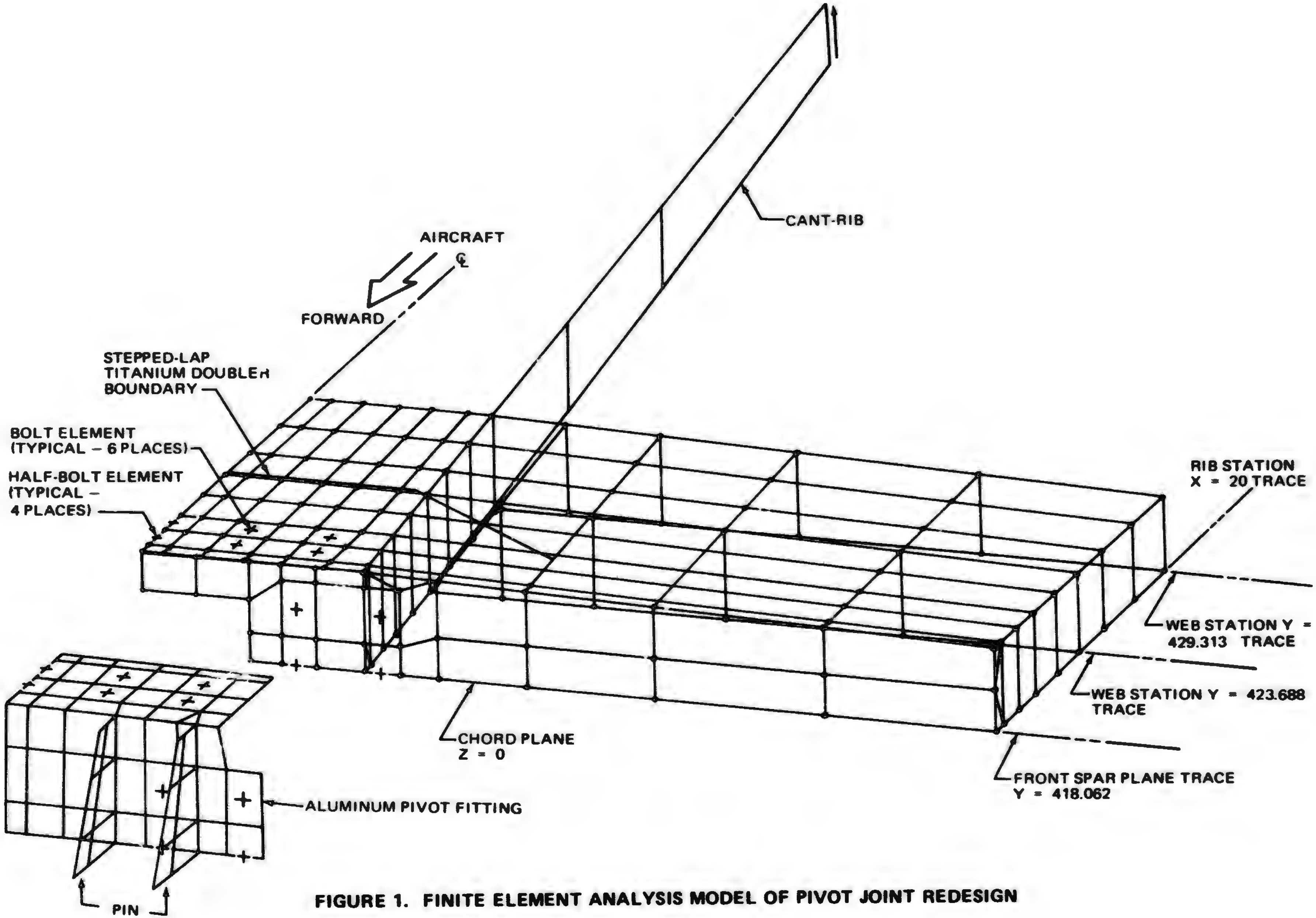

FIGURE 1. FINITE ELEMENT ANALYSIS MODEL OF PIVOT JOINT REDESIGN

A set of anti-symmetric reactions was prescribed along the chordplane (z = 0) to maintain equilibrium during anti-symmetric deformation.

Three improvements were incorporated into the previous analytical model for analysis of the pivot joint redesign. The improvements included (1) representation of the eccentricity between the aluminum alloy fitting flange and the upper skin panel, (2) discrete representation of all attach bolts in the fitting, and (3) separate modelling of the aluminum fitting flanges and the laminated panels in regions where they had previously been "fused" into panels of combined tnickness and equivalent elastic properties. Elastic properties of the skin panel also reflected the inclusion of the titanium alloy stepped-lap doubler in the pivot joint region.

A bolt element was added to transfer loads between the aluminum alloy pivot fitting, the skin panel, and the front-spar shear web. A half-bolt element was also developed for use at the two planes of symmetry of the model. These bolt elements were programmed into the element library of the FORMAT system (Reference 2) and used during analysis of the redesign. The bolt elements are capable of transferring shears and bending moments in two directions in addition to bolt tensile loads.

Initial analysis runs on the redesigned structure indicated a significant stress concentration in the front spar near the cant-rib plane trace where the skin panel attach angles were abruptly terminated at the edge of the pivot fitting. The shear attachment between skin panel and front spar was provided only by the aluminum pivot fitting in this region. The analysis model reflected this design detail as shown in Figure 2.

A design modification, shown schematically in Figure 3, was incorporated to provide continuity of the graphite attach angles across the aircraft centerline. Additional details of the design modification are shown on drawing number Z5569966 in Appendix A. The FEA model, Figure 2, was similarly modified to eliminate the gap between the skin panel and front spar near the aircraft centerline. A subsequent analysis indicated that the design modification eliminated the stress concentration, reducing the peak limit tensile stress from 47 KSI to about 20 KSI.

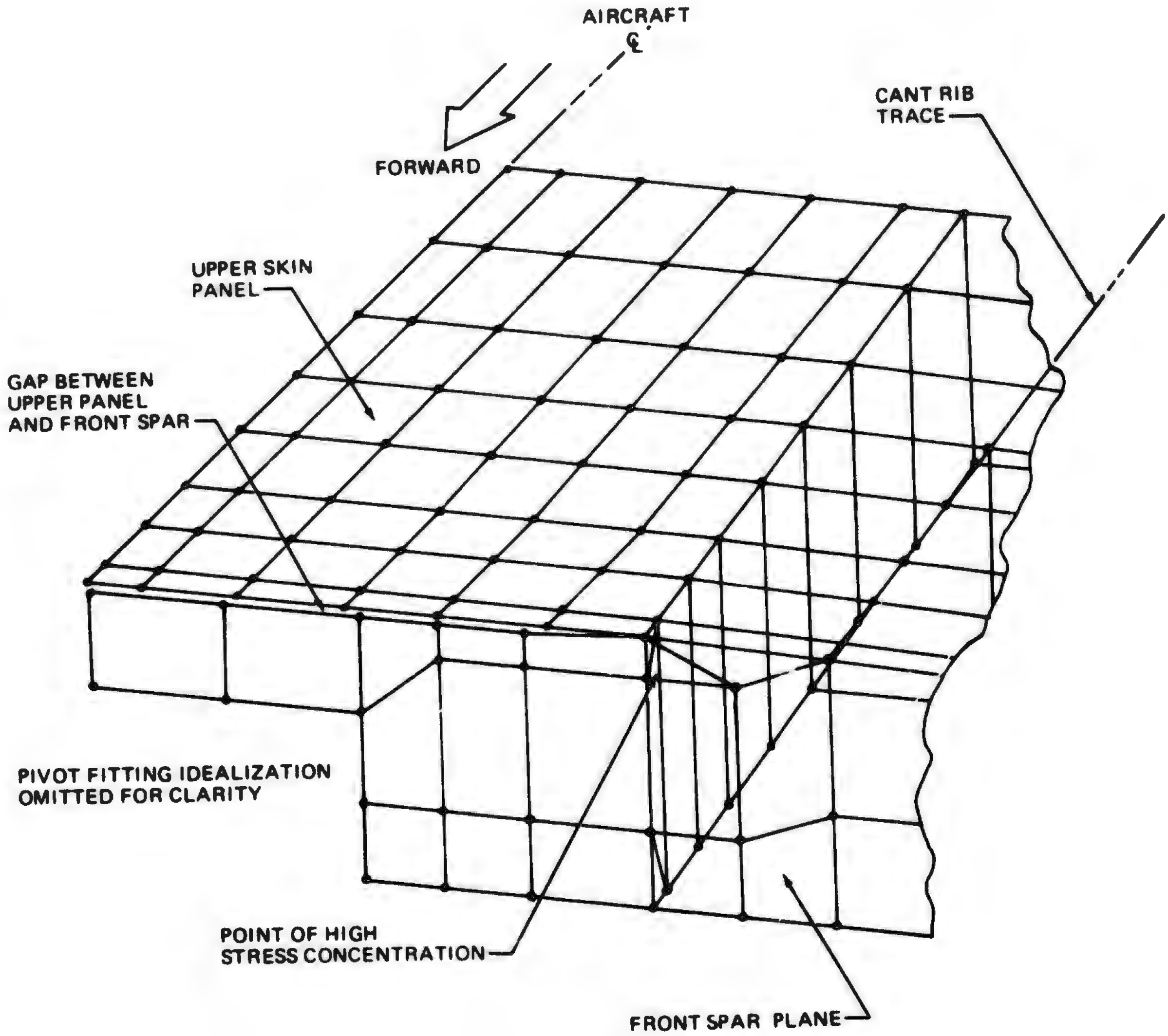

FIGURE 2. IDEALIZATION DETAILS NEAR PIVOT FITTING

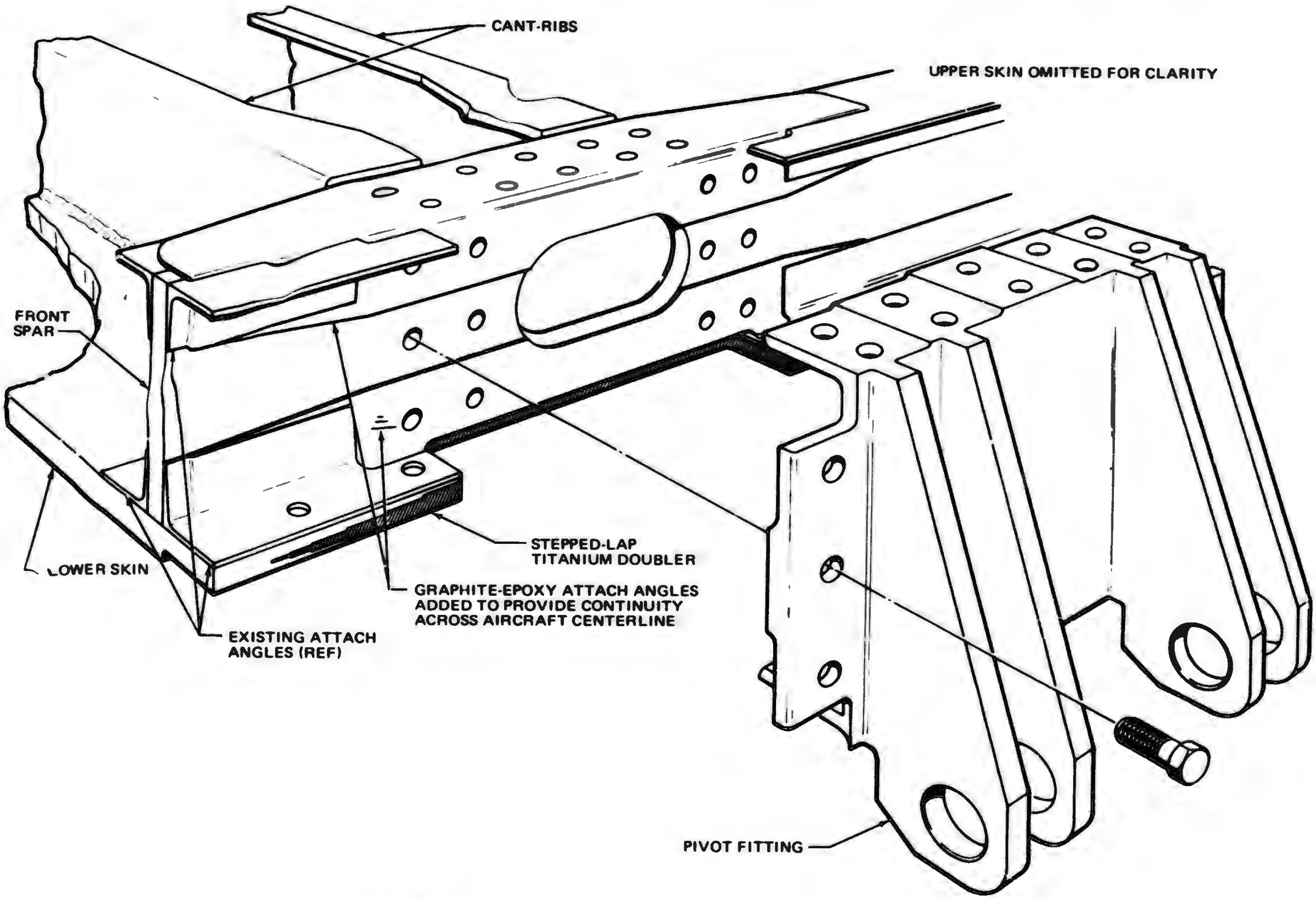

FIGURE 3. DESIGN MODIFICATION FOR ATTACH ANGLE CONTINUITY

Some additional results of the FEA are summarized in Figure 4. Significant bending moments in the skin panel were reacted entirely in the titanium doubler. The peak spanwise bending moment of 1102 in-lb/inch (Figure 4) caused a limit bending stress of 37.2 KSI in the titanium doubler. Bending moments in the composite regions of the skin panel were very small (less than 100 in-lb/inch).

A survey of the analytically predicted stresses indicated that the minimum margin-of-safety in the pivot joint region occurred in the upper skin panel along the front spar at the first fastener hole outboard of the stepped-lap titanium doubler edge. The limit stresses at this point were:

$$\sigma y = 13{,}000 \text{ psi}$$

$$\sigma x = -600 \text{ psi}$$

$$\tau xy = 1000 \text{ psi}$$

The minimum margin-of-safety was therefore calculated as follows:

$$\text{M.S.} = \frac{(\text{allowable stress}/K_T)}{(\text{applied stress})\text{x}(1.5)} - 1$$

$$\text{M.S.} = \frac{(38{,}600/1.54)}{(13{,}000)\text{x}(1.5)} - 1 = 0.29$$

Analytically predicted strains will also be correlated with experimental (strain-gage) data during static test of the second stabilizer (see Appendix C).

Stepped-Lap Joint Analysis

Elastic-plastic analyses of the stepped-lap joint were conducted using a closed-form solution developed in Reference 3. The solution was predicated on elastic-perfectly plastic stress-strain behavior of the adhesive in shear and properly accounted for thermal expansion and stiffness imbalances between the dissimilar adherends. The actual shear stress-strain curve and the elastic-perfectly plastic representation of the curve are shown in Figure 5 for Hysol EA951 adhesive. The elastic-perfectly plastic curve was formulated on the basis of equivalent strain-energy at failure.

Table I summarizes strength computations for the joint in room temperature and in -50°F environments and under tension and compression loadings typical of the upper and lower skin panels, respectively. Thermal stress calculations were based on the temperature difference between cure initiation temperature

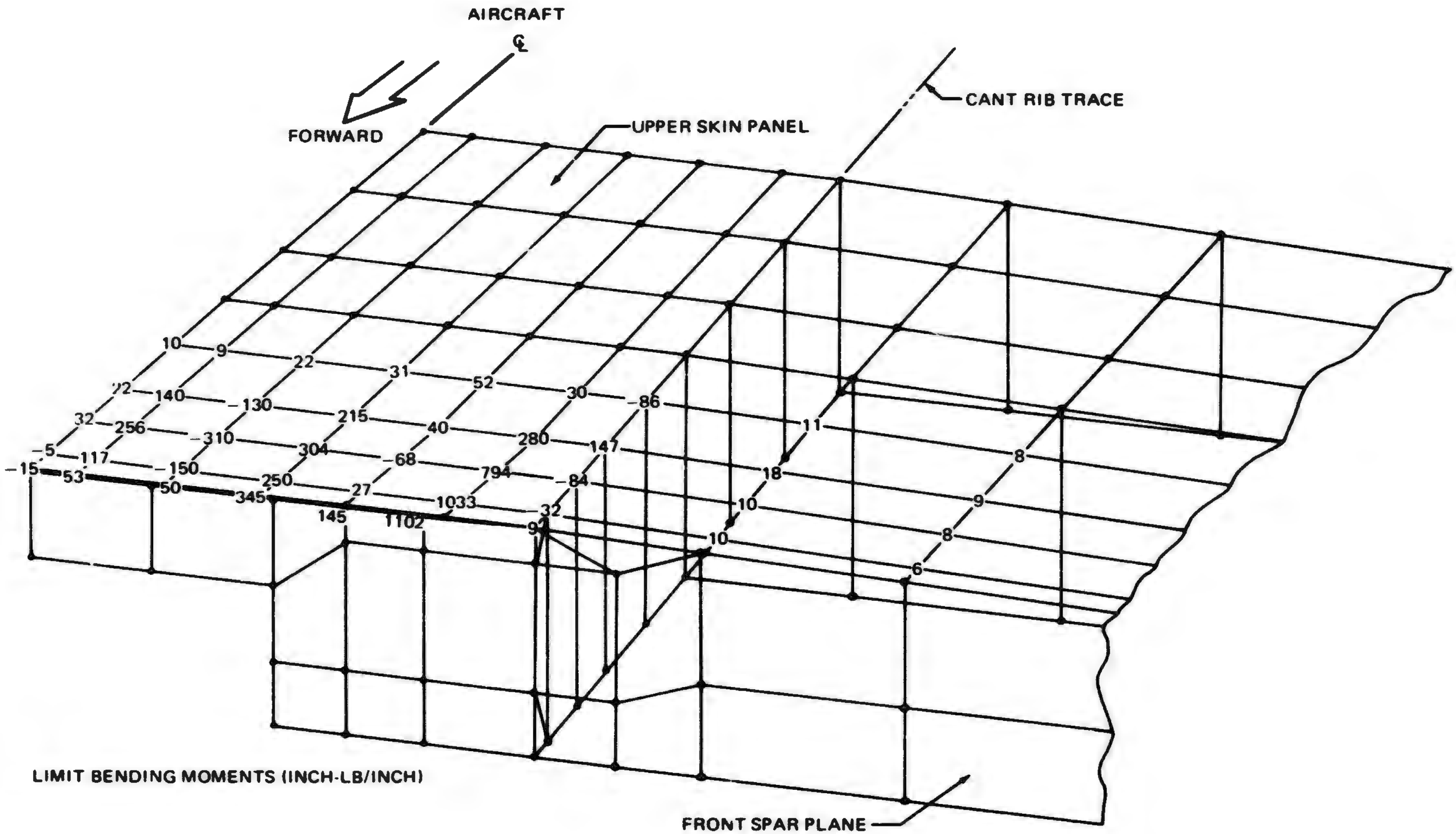

FIGURE 4. SPANWISE BENDING MOMENTS IN UPPER SKIN PANEL NEAR PIVOT FITTING

TABLE I

THEORETICAL STRENGTHS OF STEPPED-LAP JOINT

LOAD LEVEL	CRITICAL LOAD INTENSITIES (POUNDS PER INCH)			
	ROOM TEMPERATURE		$-50^{\circ}F$	
	TENSION	COMPRESSION	TENSION	COMPRESSION
STABILIZER LIMIT LOAD	4550		4550	
THEORETICAL LIMIT OF ELASTICITY	4927	10730	3683	9203
STABILIZER ULTIMATE LOAD	6820		6820	
YIELDING OF THIN TITANIUM STEP	11,866	16997	10769	17821
STRENGTH OF COMPOSITE ADHEREND	18,216		>18,216	
THEORETICAL ULTIMATE BOND STRENGTH	26099	30569	25123	45000

ADHESIVE: HYSOL AE 951
ADHERENDS: QUASI-ISOTROPIC GRAPHITE-EPOXY (NARMCO 5206), 0.264 INCH THICK
TITANIUM-6 Al-4V, 0.250 INCH THICK.

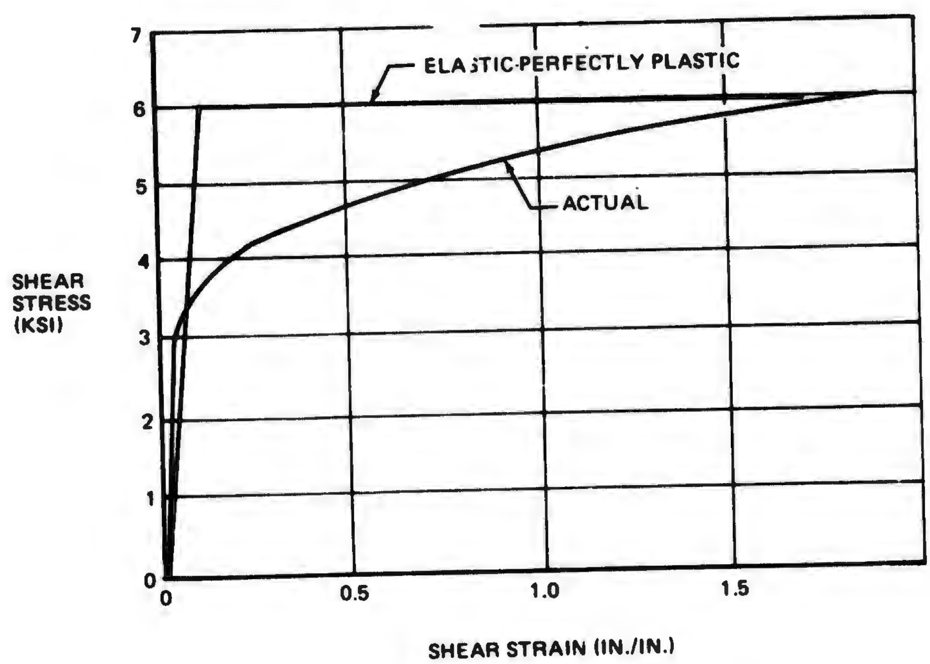

FIGURE 5. SHEAR STRESS-STRAIN CURVES FOR HYSOL EA951 ADHESIVE

of the EA951 adhesive (350°F) and the environmental temperature. The adhesive tensile shear load was always more critical than the compressive, and in each case investigated the bond was predicted to be much stronger than the adjacent adherends. This theoretical conclusion was consistent with the joint specimen test result reported in Reference 1. The joint specimen failed in the predicted mode (tension in the laminate) at a test load of 19,000 pounds, in good agreement with the predicted failing load of 18,216 pounds.

Stress distributions within the adhesive and adherends for various theoretical load levels are shown in Figures 6 and 7. These figures account for the differences in extensional stiffness (elastic modulus times cross-sectional area) between the titanium and graphite-epoxy adherends, but thermal stresses are not included. The theoretical elastic shear stress distributions in the various steps of the joint are shown in Figure 6a. The adhesive shear stresses were higher at the outboard (composite) end of the joint because of the stiffness imbalance between the composite (E = 7.2 MSI) and the titanium (E = 16 MSI) adherends. This effect would have been intensified if steel (E = 29 MSI) had been used rather than titanium.

The theoretical limit of the elastic solution was reached at an applied load intensity of 7828 pounds per inch. As applied loads were increased above this level, the adhesive went into plasticity starting at the outboard step and proceeding inboard. At a load intensity of 14,430 pounds per inch, adhesive plasticity extended through the first step of the joint (Figure 6b) and the thin titanium section reached yield stress. At a theoretical load intensity of 28,262 pounds per inch, adhesive plasticity extended almost through the first three joint steps (Figure 6c) and the adhesive at the outboard end reached the ultimate strain level in shear (γ max = 1.7 in/in), thus defining the maximum theoretical bond strength. However, the latter strength exceeded the load level required to produce ultimate tensile stress in the graphite adherend (P = 18,216 pounds per inch).

The adherend internal load distributions for an applied load intensity of 14,430 pounds per inch are shown in Figure 7, together with the adherend strengths at the various steps. This figure indicates that the yielding of the titanium could be delayed slightly by detail changes to the step lengths.

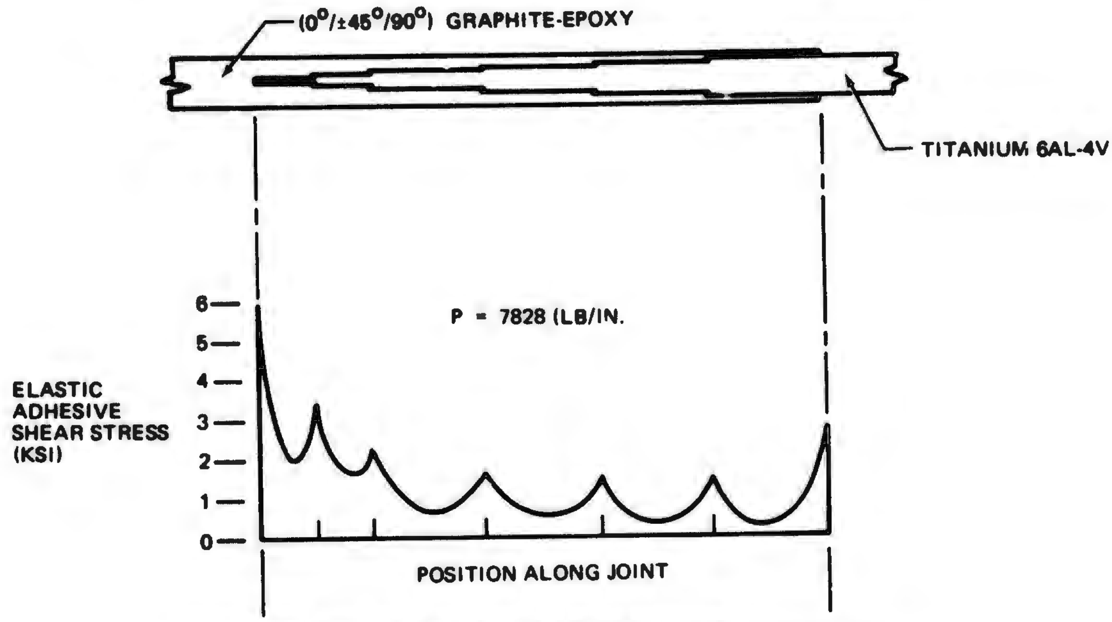

FIGURE 6a. THEORETICAL ELASTIC SHEAR STRESS DISTRIBUTION

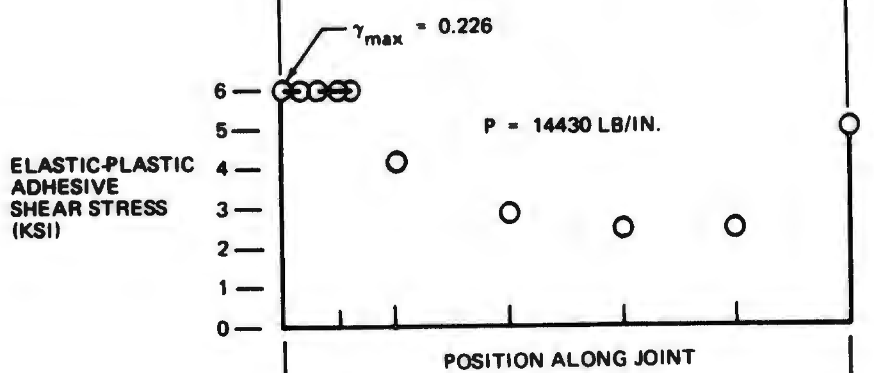

FIGURE 6b. ELASTIC-PLASTIC SHEAR STRESS DISTRIBUTION AT YIELDING OF TITANIUM

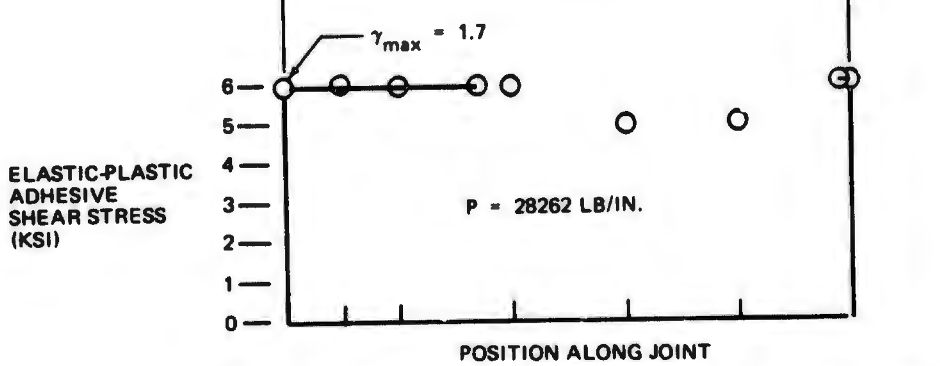

FIGURE 6c. THEORETICAL ELASTIC-PLASTIC SHEAR STRESS DISTRIBUTION AT ADHESIVE ULTIMATE SHEAR CAPACITY

FIGURE 6. ELASTIC AND ELASTIC-PLASTIC ADHESIVE SHEAR STRESS DISTRIBUTIONS IN STEPPED-LAP JOINT

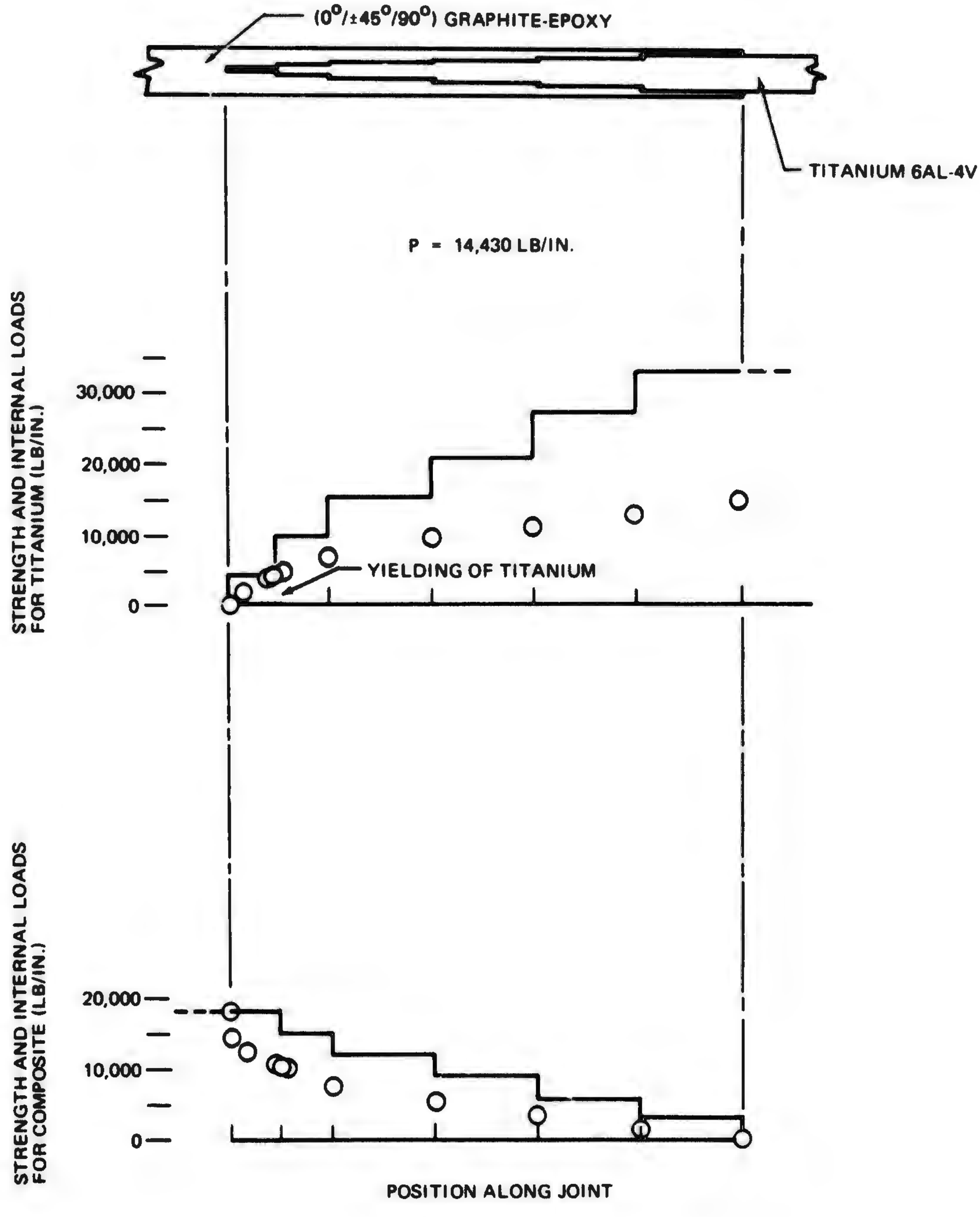

FIGURE 7. INTERNAL ADHEREND LOAD LEVELS IN STEPPED-LAP JOINT

DEVELOPMENT COMPONENTS

Static tests were completed on both the pivot and actuator joint development components and fatigue testing was completed on the pivot joint development component in accordance with the test plan (Reference 1).

The pivot joint static article failed in combined tension, bending, and shear in the test section at a static load of 170% DLL. The failed specimen is shown in Figure 8. The failure initiated at a fastener hole just outboard of the stepped-lap titanium doubler as shown in Figure 9. The failure propagated through the laminate and did not involve the stepped-lap titanium doubler or the bond interface between the graphite laminate and the doubler.

The specimen was instrumented with strain-gages as shown in Figure 10. The results of the lumped parameter stress analysis (Reference 1) are compared with the strain-gage readings in Figures 11 and 12. Two types of analytical results are shown. The results indicated as mechanical stresses only were obtained by ignoring the thermal stresses induced during the cure cycle. These results were generated to enable direct comparisons with the strain-gage data. The analytical results which include thermal effects were obtained to enable a strength prediction. The test results generally confirmed the validity of the analysis although some out-of-plane effects caused by test load eccentricities were present in the test and not included in the analysis model. These effects were most prevalent in the area where a bonded graphite strap represented the spar attachment angles.
In this area the average results of back-to-back strain-gages gave good correlation with the analysis as shown in Figure 12.

The actuator joint static test article failed initially near a test load reaction (grip) point when the primary compression load from the actuator fitting was 150% DLL and the balancing loads in the skin panel were approximately 140% DLL of the limit loads specified in the test plan (Reference 1). The laminate failed in combined tension, bending, and shear within the edge of the grip reinforcement and did not involve the actuator joint test section. The grip was subsequently repaired and the specimen was tested to an ultimate static load of 195% DLL. The point of failure origin was not obvious from the appearance of the failed specimen, since minimal external damage was visible. It was concluded that the failure originated in the

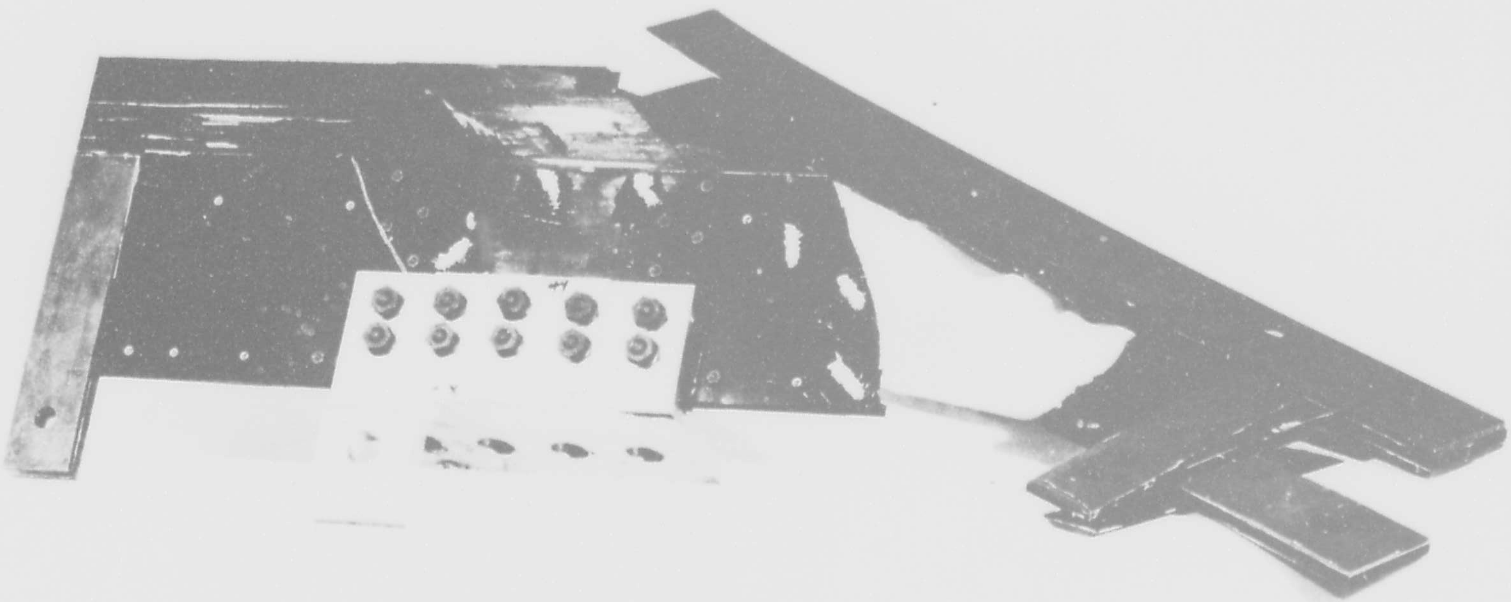

FIGURE 8. PIVOT JOINT DEVELOPMENT COMPONENT FAILURE

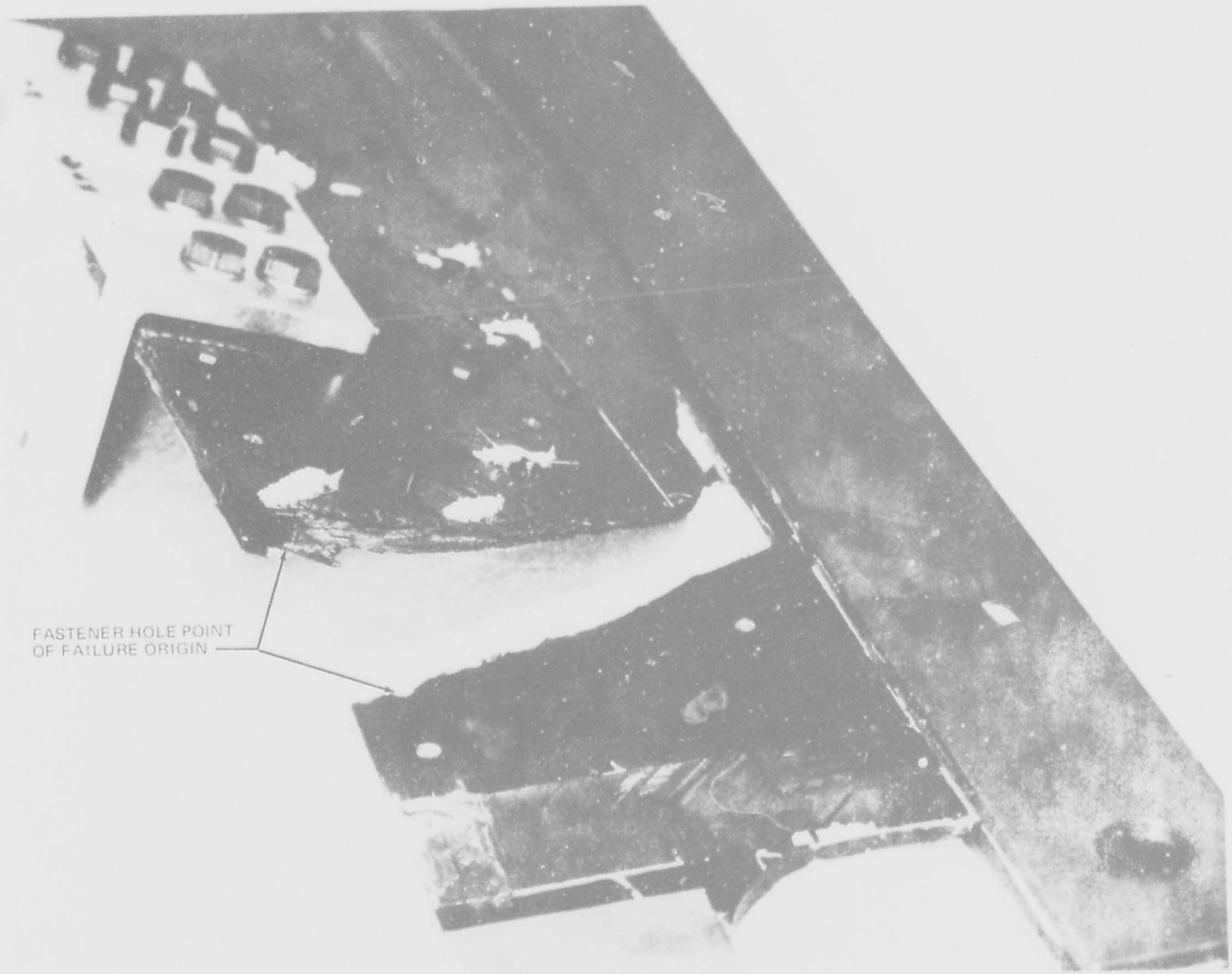

FIGURE 9. POINT OF FAILURE INITIATION FOR PIVOT JOINT DEVELOPMENT COMPONENT

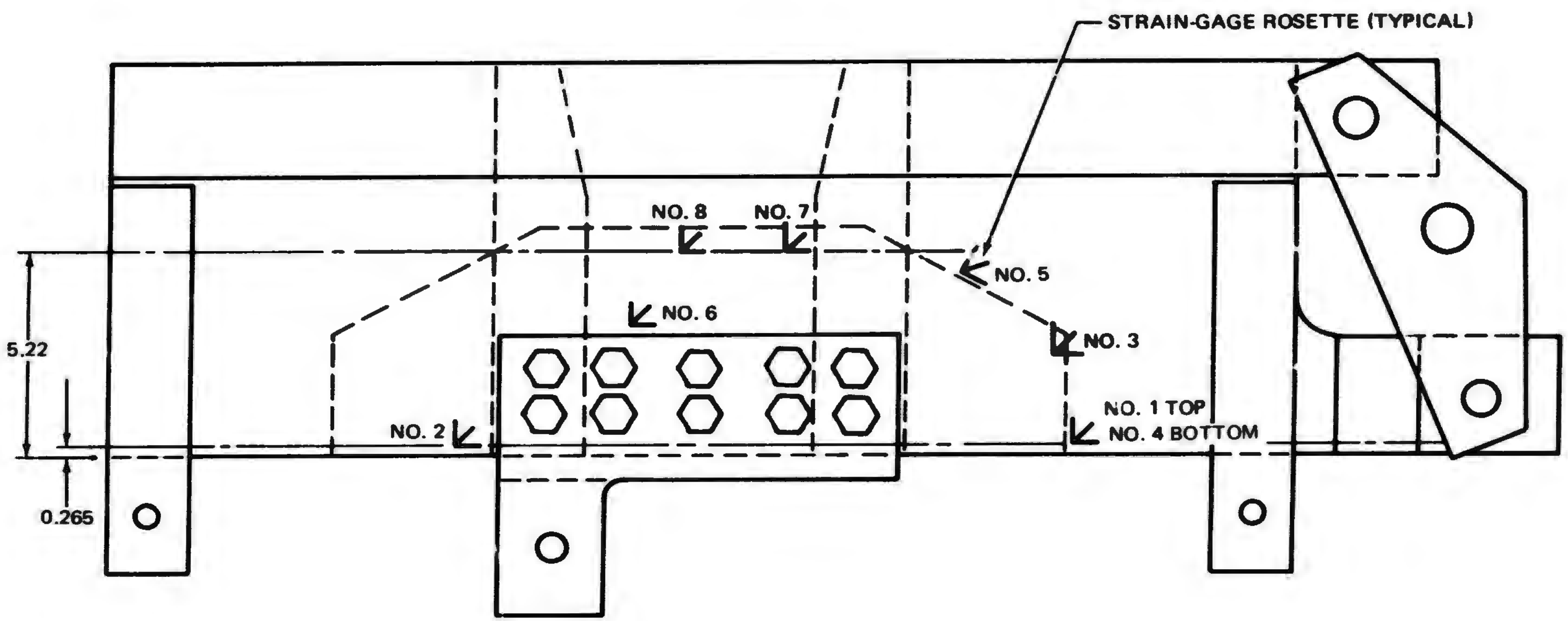

FIGURE 10. STRAIN-GAGE LOCATIONS ON PIVOT JOINT DEVELOPMENT COMPONENT

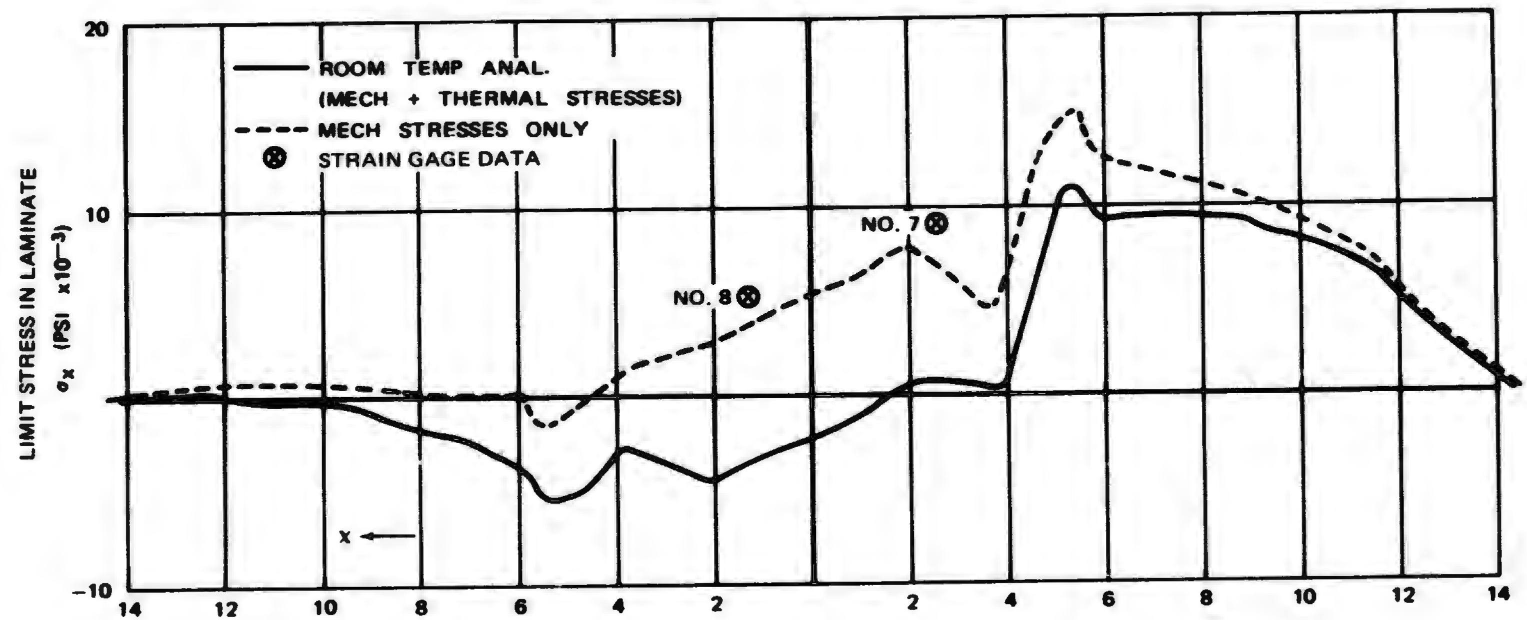

FIGURE 11. TEST-THEORY CORRELATION FOR PIVOT JOINT DEVELOPMENT COMPONENT- STATION 5.22

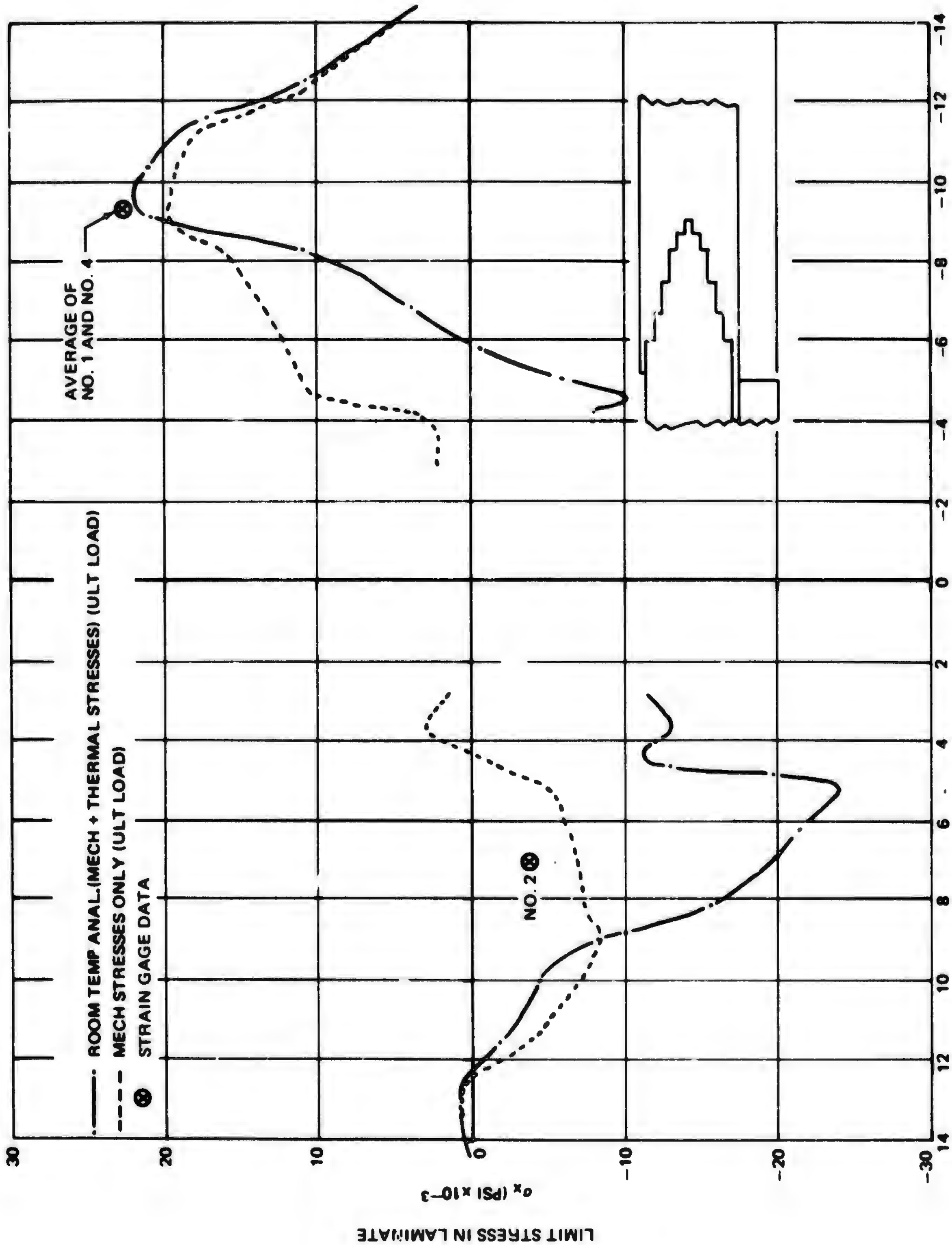

FIGURE 12. TEST-THEORY CORRELATION FOR PIVOT JOINT DEVELOPMENT COMPONENT- STATION 0.265

laminate near the titanium doubler interface in a combined tension and in-plane shear mode.

The pivot joint fatigue specimen also experienced a grip failure during application of the first limit-load cycle (at the conclusion of the first thousand hours of simulated service). The failure was caused by spurious vertical and side loads at the whiffletree lower attach point. A repair drawing was prepared and the specimen was reworked and returned for test resumption with slotted holes in the whiffletree to eliminate spurious vertical reactions. The last 11,000 hours of simulated flight loads were applied to the repair specimen without further difficulty.

After conclusion of the twelfth 1000-hour load block, the specimen was loaded statically to determine residual strength. A failing load level of 195% DLL was attained, compared to 170% DLL on the original static test specimen. The mode of failure was identical in each case (see Figure 9).

STRUCTURAL WEIGHT SUMMARY

A detailed weight and material utilization summary for the second stabilizer assembly is presented in Table II. The calculated weight is currently 183 pounds, including the weight added in the pivot and actuator joint regions during the redesign. The stabilizer weight prior to the redesign was 177.90 pounds (see Reference 4). Inclusion of the stepped-lap titanium doublers added approximately seven pounds to the upper and lower skin panels. This weight increment was partially offset by detailed machining changes to the aluminum alloy pivot fitting (0.60 pound weight reduction) and by revisions in the type and number of fasteners in the upper skin panel.

TABLE II
WEIGHT AND MATERIAL UTILIZATION SUMMARY – STABILIZER UNIT TWO

ITEM	ELEMENT	GRAPHITE	FIBER GLASS	ALUMI-NUM	STEEL	TITA-NIUM	ADHE-SIVE AND FAS-TEN-ERS	TOTAL WEIGHT (LB)
SUBSTRUCTURE	FRONT SPAR	2.68						2.68
	HONEYCOMB PANEL							
	FACINGS	4.76						4.76
	CORE		1.00					1.00
	ADHESIVE						1.30	1.30
	CORNER ATTACH ANGLES	1.53						1.53
	ADHESIVE						0.50	0.50
	REAR SPAR	9.20						9.20
	CANT RIB BLANKS	4.68						4.68
	ATTACH TEES			0.20		1.12		1.32
	STA 58 HINGE BRACKETS				3.84		0.27	4.11
	ATTACH ANGLES	10.91						10.91
	ADHESIVE						3.90	3.90
	EPOXY FILLETS						2.00	2.00
	SUB-TOTAL							(47.89)
SKIN PANELS	UPPER PANEL	33.94				6.80	2.76	43.50
	LOWER PANEL	39.41				6.03	3.20	48.64
	SUB-TOTAL							(92.14)
MISC FTGS	PIVOT			12.40			2.90	15.30
	ACTUATOR			4.00			1.00	5.00
	STA 20 HINGES				2.40		0.35	2.75
	STA 40 HINGES				2.10		0.35	2.45
	SUB-TOTAL							(25.50)
LEADING EDGE	INBD & OUTBD ASSYS		17.47					(17.47)
	TOTAL (LB)	107.10	18.47	16.60	8.34	13.95	18.53	183.00

SECTION III
MANUFACTURING DEVELOPMENT

After successful conclusion of the development component testing, fabrication and assembly of the second stabilizer unit was authorized. Detail part fabrication was completed on the hinge and actuator stepped-lap doublers for the upper and lower skin panels. Detailed engineering drawings are included in Appendix A. The skin panels were laid-up and cured, and the substructure assembly was precision machined to skin contours in preparation for assembly bonding.

The stepped-lap doubler details and the skin panels were processed in essentially the same way as the joint development components (see Reference 1). The stepped-lap titanium doublers were first rougn machined and the steps were subsequently formed by chemical etching. Two tooling holes were provided in each doubler to secure it to the plastic laminating mold (PLM) during the skin panel cure cycle. These holes will subsequently be enlarged for bolting the skin panels to either the pivot or actuator fittings during final assembly.

The skin panels were laid-up on the PLM using aluminum alloy templates to define the layer trims in the vicinity of the stepped-lap doublers. The skin layup, 50 percent complete, with the stepped-lap doublers in position is shown in Figure 13. The titanium doublers were located in position and the lay-up was densified in the autoclave for 30 minutes at 150°F and 100 psi pressure. This procedure insured attaining an intimate fit between the doubler steps and the appropriate layers of the laminate. A four layer pattern (0/45/90/-45) terminated on each step.

The titanium doublers were cleaned using liquid hone, alkaline clean, and chemical etch. The doublers were then rinsed in deionized water and dried, and a coating of Hysol EA951 primer was immediately applied to the clean surface. Hysol EA951 adhesive film was located on the steps and the titanium doublers were relocated. After tne second 28 plies of the laminate were applied, the lay-up was vacuum bagged and cured using the standard autoclave cycle.

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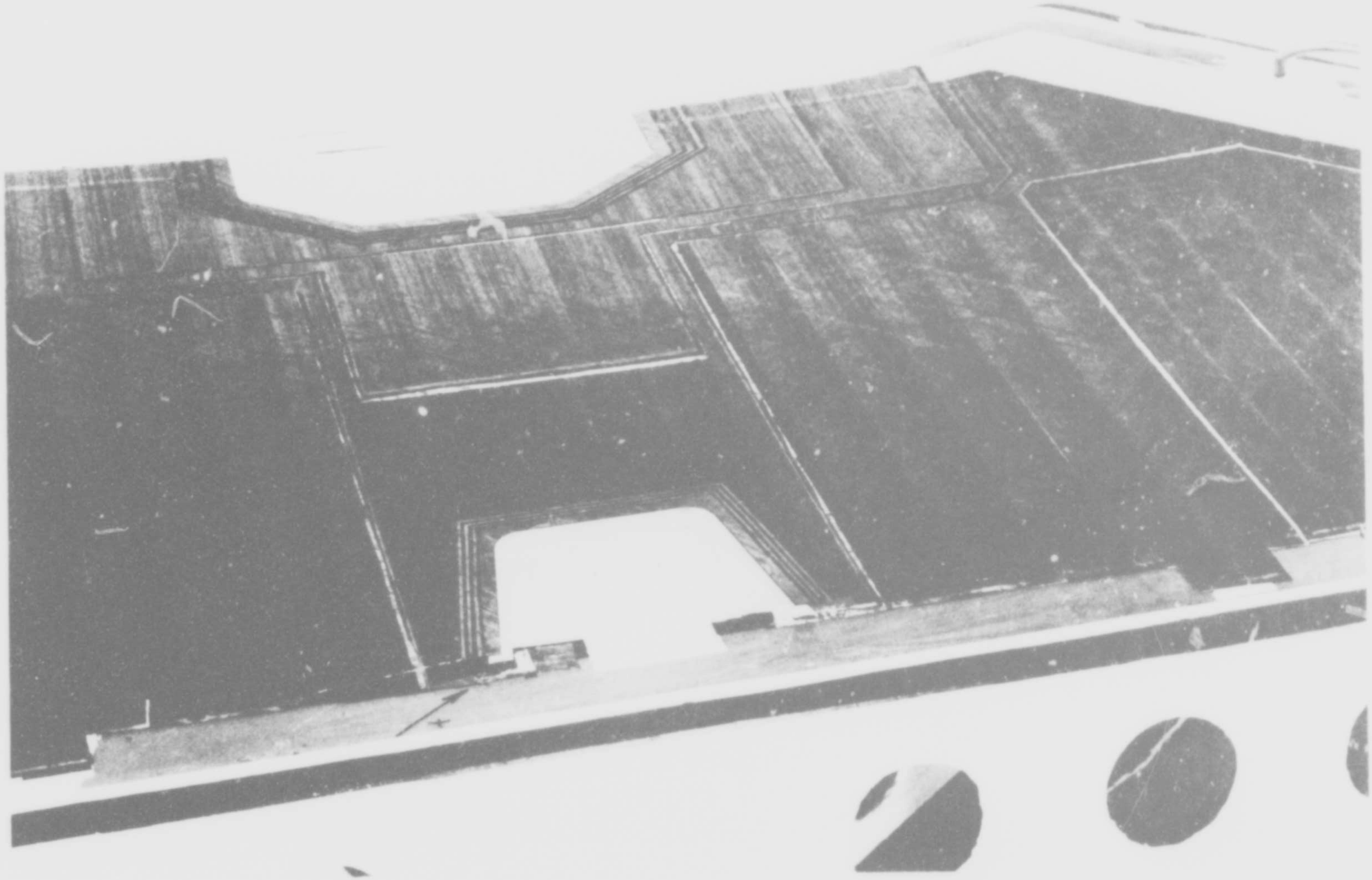


FIGURE 13. STEPPED-LAP TITANIUM DOUBLERS IN PARTIALLY COMPLETE SKIN LAYUP

Prior to fabrication of the upper skin panel, a vacuum check was conducted on the PLM. The mold surface was prepared with a 6-mil PVA sealing film over a layer of dry 120 style fiberglass cloth. A vacuum was drawn between the mold surface and the PVA film to bleed-off autoclave air drawn through the porous mold during the cure cycle. The mold surface seal was covered with a nylon vacuum bag which was sealed to the mold surface outside the edge of the surface seal. An initial vacuum of 28.6 inches of mercury was drawn between the surface film and the nylon overbag. When the vacuum source was removed, the manometer indicated good vacuum retention, indicating 26.1 inches after five minutes, 22.0 inches after 15 minutes, 19.1 inches after 45 minutes, and stabilizing at 16 inches after two hours. However, when the upper skin panel was subsequently laid-up and cured using this bagging technique, the bleed pattern was irregular (indicating inadequate pressure during cure) and the tag-end QC results indicated that high void regions had been produced in the laminate (see Table III).

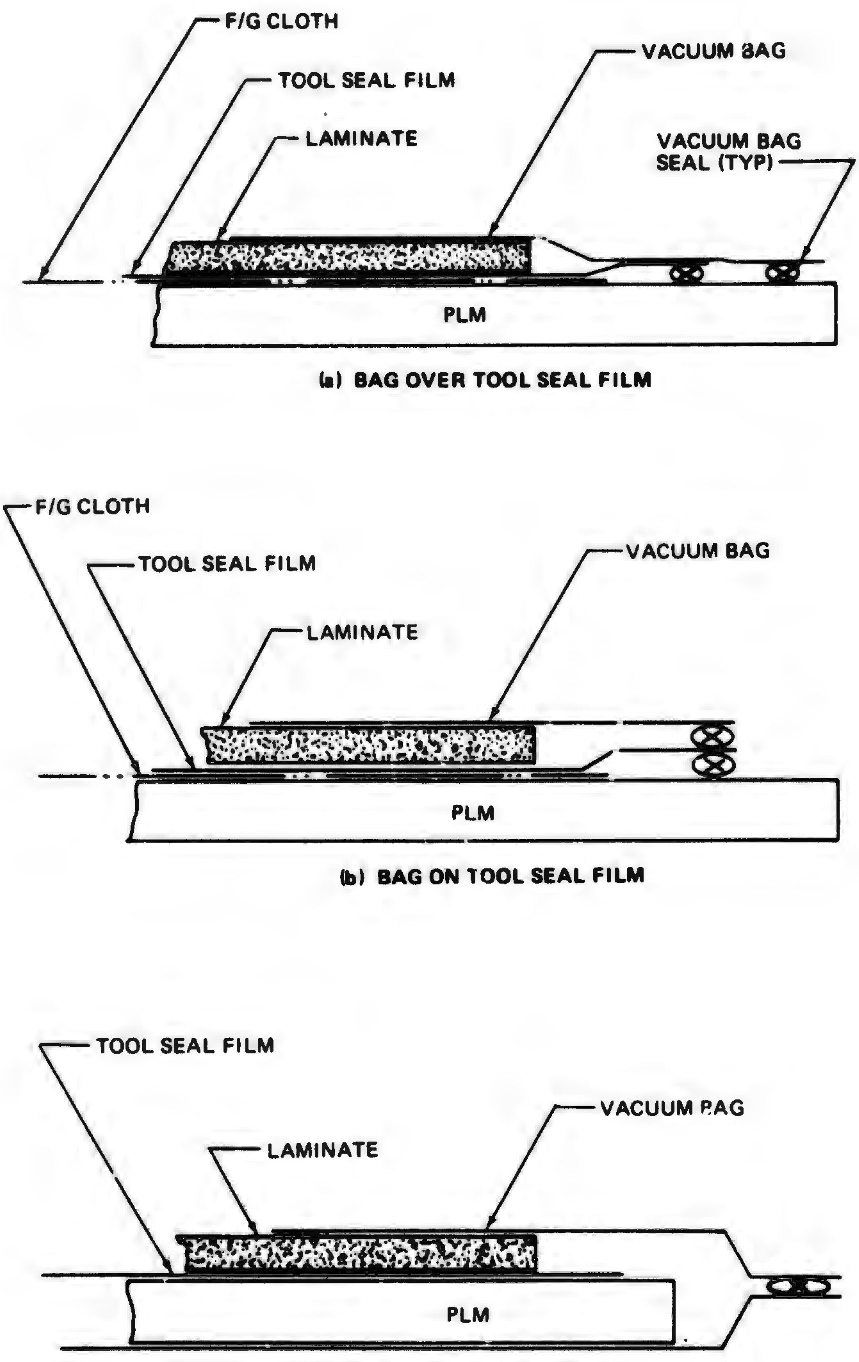
Since the standard cure cycle had been followed without incident and the vacuum bag had not ruptured, a supplementary study of bagging techniques was conducted to determine the cause of the marginal laminate properties. Three test panels were laid-up and cured using the bagging techniques illustrated in Figure 14. The appearance of the cured panels, the relative amounts of resin bleed, and the comparisons of QC test results (Table III) led to the conclusion that envelope bagging was necessary to assure consistent and adequate pressure on the laminate during the cure cycle. Hence, the PLM was modified to permit envelope bagging during subsequent skin panel cures.

After the PLM was modified, a trial autoclave cycle was run to cure three QC panels on the PLM surface using an envelope bag. The flexural and interlaminar shear tests, Table III indicated satisfactory results. The lower skin panel was therefore laid-up and cured using the envelope bagging technique. The subsequent test from the QC tabs also indicated satisfactory laminate properties as shown in Table III.

Inspection of the cured lower skin panel indicated that two localized areas near stations X = 30 and Y = 437, both right and left sides were out of contour because the mold surface distorted slightly during the cure cycle (probably due to residual stress relaxation in the PLM). The distortions

TABLE III
AVERAGE QUALITY CONTROL TEST RESULTS FOR VARIOUS LAMINATES

ITEM		FLEXURAL STRENGTH (PSI)	FLEXURAL MODULUS (MSI)	INTER-LAMINAR SHEAR (PSI)	RESIN CONTENT (WT %)	VOID CONTENT (VOL %)	COMMENTS
UPPER SKIN PANEL (BAG OVER TOOL SEAL)	RH TAB	73,900	7.50	4000	35.7	4.20	IRREGULAR PARTIAL BLEED 50–70% BLEEDER CLOTH SATURATION
	LH TAB	96,900	7.90	7300	37.7	1.00	
BAG TECHNIQUE STUDY PANELS	BAG OVER TOOL SEAL	77,100	8.01	6310	43.2	0.60	POOR RESIN BLEED. 5–10% BLEEDER CLOTH SATURATION
	BAG ON TOOL SEAL	96,300	9.93	7210	37.0	0.60	PARTIAL BLEED 80–90% BLEEDER CLOTH SATURATION
	ENVELOPE BAG	73,900	7.06	7712	36.2	0.50	100% BLEEDER CLOTH SATURATION
TRIAL AUTOCLAVE RUN ON PLM (ENVELOPE BAG)	RH TAB	87,100	8.66	8320	37.9	0.90	70% BLEEDER CLOTH SATURATION
	CTR TAB	78,200	7.96	7710	39.0	1.10	40% BLEEDER CLOTH SATURATION
	LH TAB	87,800	8.19	7690	35.6	1.00	80% BLEEDER CLOTH SATURATION
LOWER SKIN PANEL (ENVELOPE BAG)	RH TAB	85,300	8.23	7130	34.3	1.40	GOOD RESIN BLEED
	LH TAB	85,500	7.62	7110	36.1	1.10	95% BLEEDER CLOTH SATURATION



(a) BAG OVER TOOL SEAL FILM

(b) BAG ON TOOL SEAL FILM

(c) ENVELOPE BAG

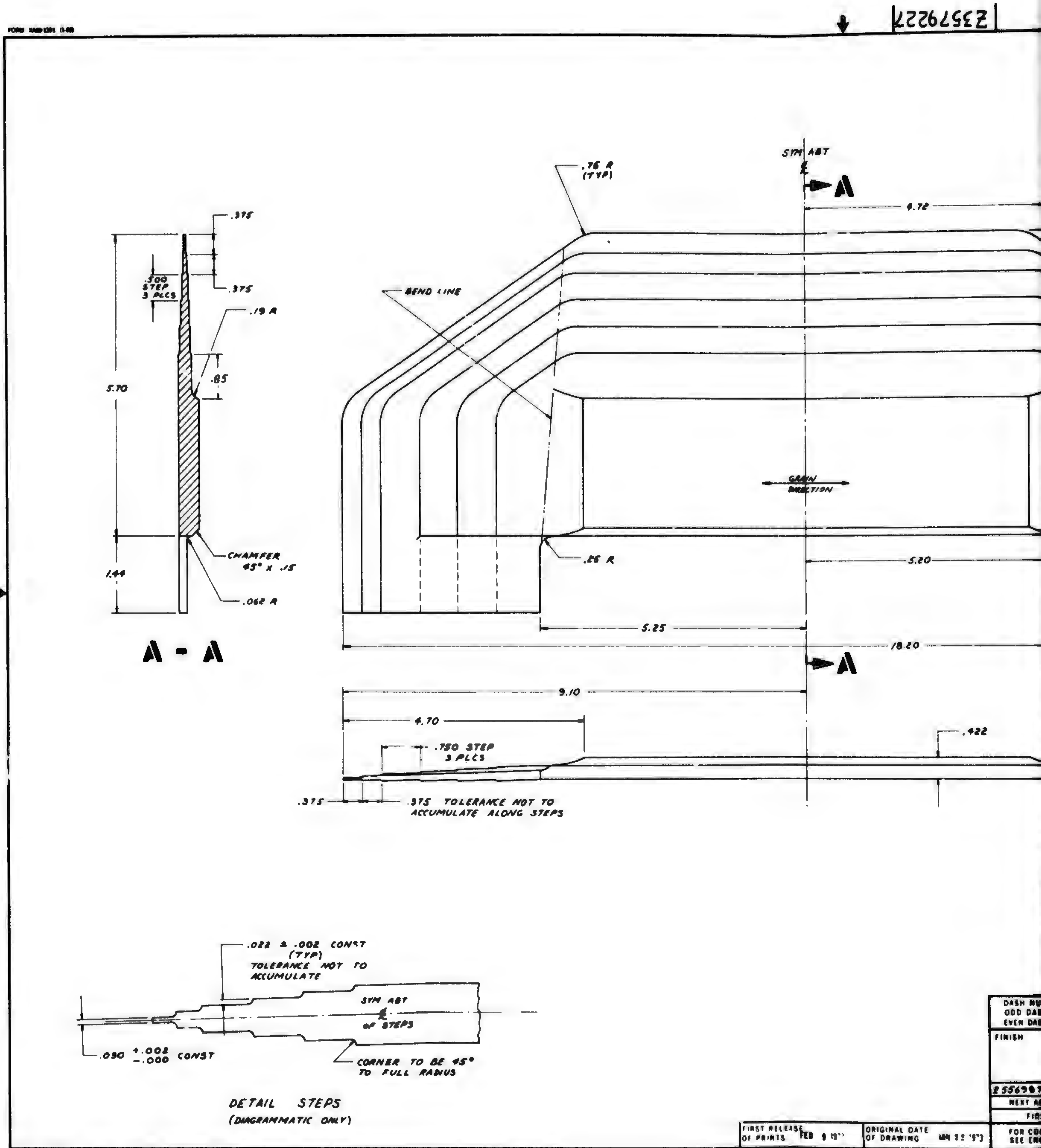
FIGURE 14. VACUUM BAGGING TECHNIQUES FOR STUDY PANELS

occurred in the mold surface at points which had been attached to the mold support structure prior to the tool modification for envelope bagging. The left side of the skin panel had a gentle depression deviating from contour by a maximum of about 0.120 inch and fairing back into contour within a radius of about six inches. The right side depression was less pronounced, deviating from contour a maximum of 0.060 inch over a similar area. The skin panel was accepted for test since the out-of-contour depressions occurred in well stabilized, low stress regions of the structure which will not impair test results in any way. The PLM will be carefully observed for dimensional stability during subsequent cure cycles and modified if required to assure successful assembly bonding.

The upper skin panel was subsequently remade using the envelope bagging technique. Good resin flow during the cure cycle was indicated by 95% bleeder cloth saturation. However, the tag-end QC test results again indicated that some regions of relatively high void were present (see Appendix B). Additional resin, void, and interlaminar shear specimens were cut from the trim of the skin panel around the periphery of the part. These additional specimens indicated that the voided regions were restricted to the QC tabs and the panel was thus accepted for test.

APPENDIX A

ENGINEERING DRAWINGS



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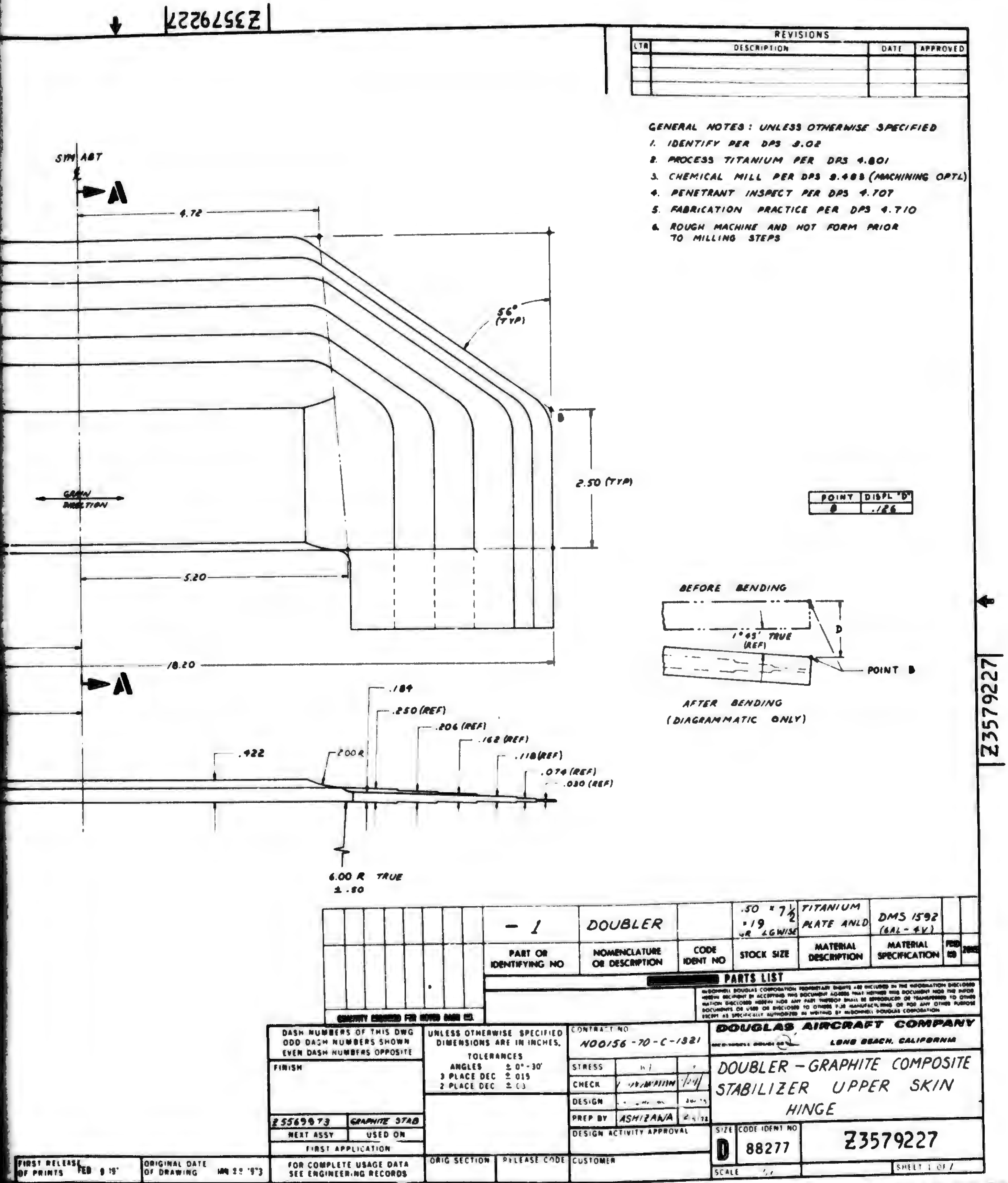
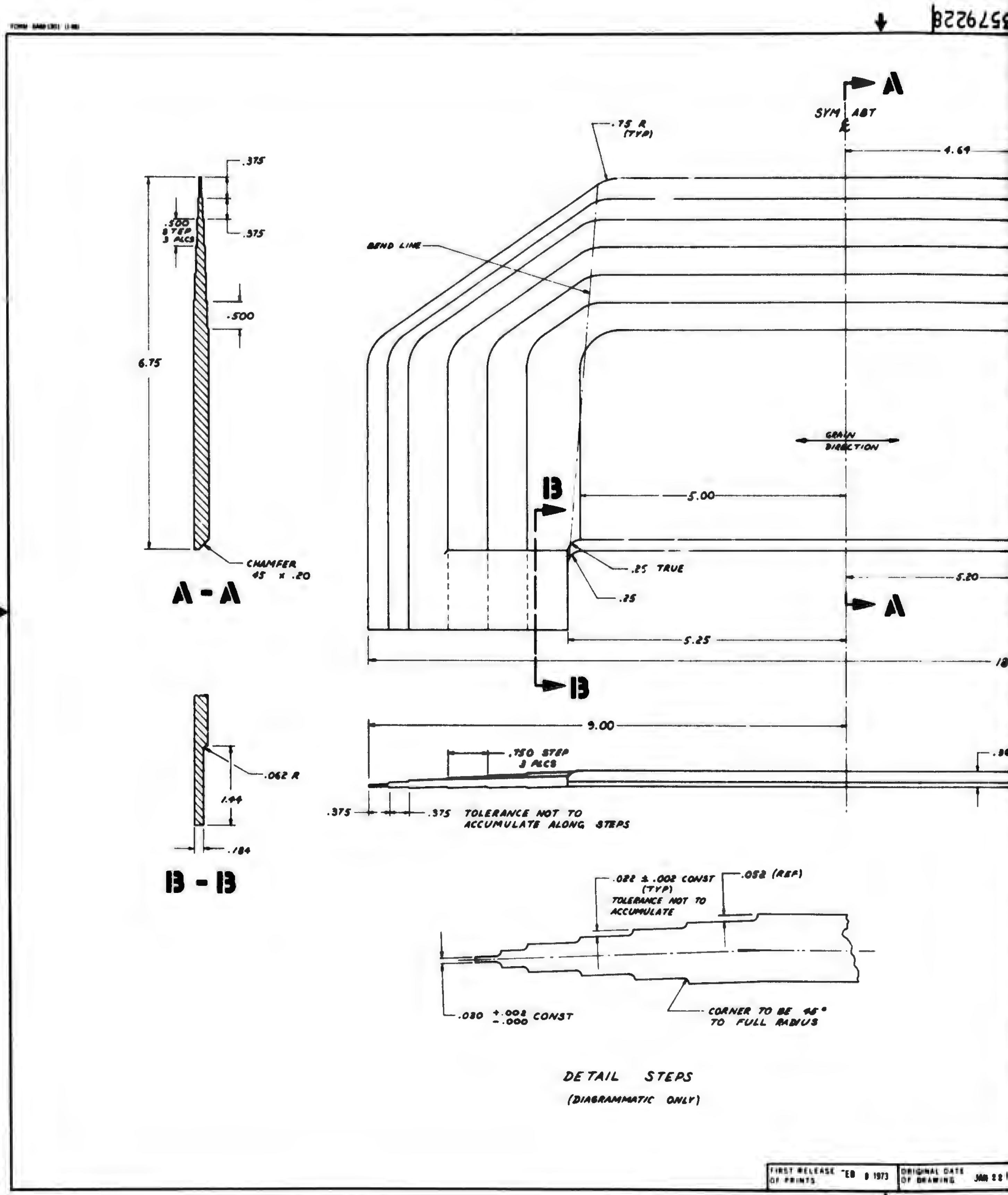


FIGURE A1. Z3579227 DOUBLER-GRAPHITE COMPOSITE STABILIZER UPPER SKIN HINGE



A - A
.375
.500 STEP 3 PLCS
.375
.500
6.75
CHAMFER 45 x .20
B - B
.062 R
1.44
.184
.75 R (TYP)
BEND LINE
SYM ABT ℄
4.69
GRAIN DIRECTION
5.00
.25 TRUE
.25
5.20
5.25
9.00
.750 STEP 3 PLCS
.375
.375 TOLERANCE NOT TO ACCUMULATE ALONG STEPS
.022 ± .002 CONST (TYP) TOLERANCE NOT TO ACCUMULATE
.052 (REF)
.030 +.002 −.000 CONST
CORNER TO BE 45° TO FULL RADIUS
DETAIL STEPS
(DIAGRAMMATIC ONLY)
FIRST RELEASE OF PRINTS FEB 8 1973
ORIGINAL DATE OF DRAWING JAN 22

FI

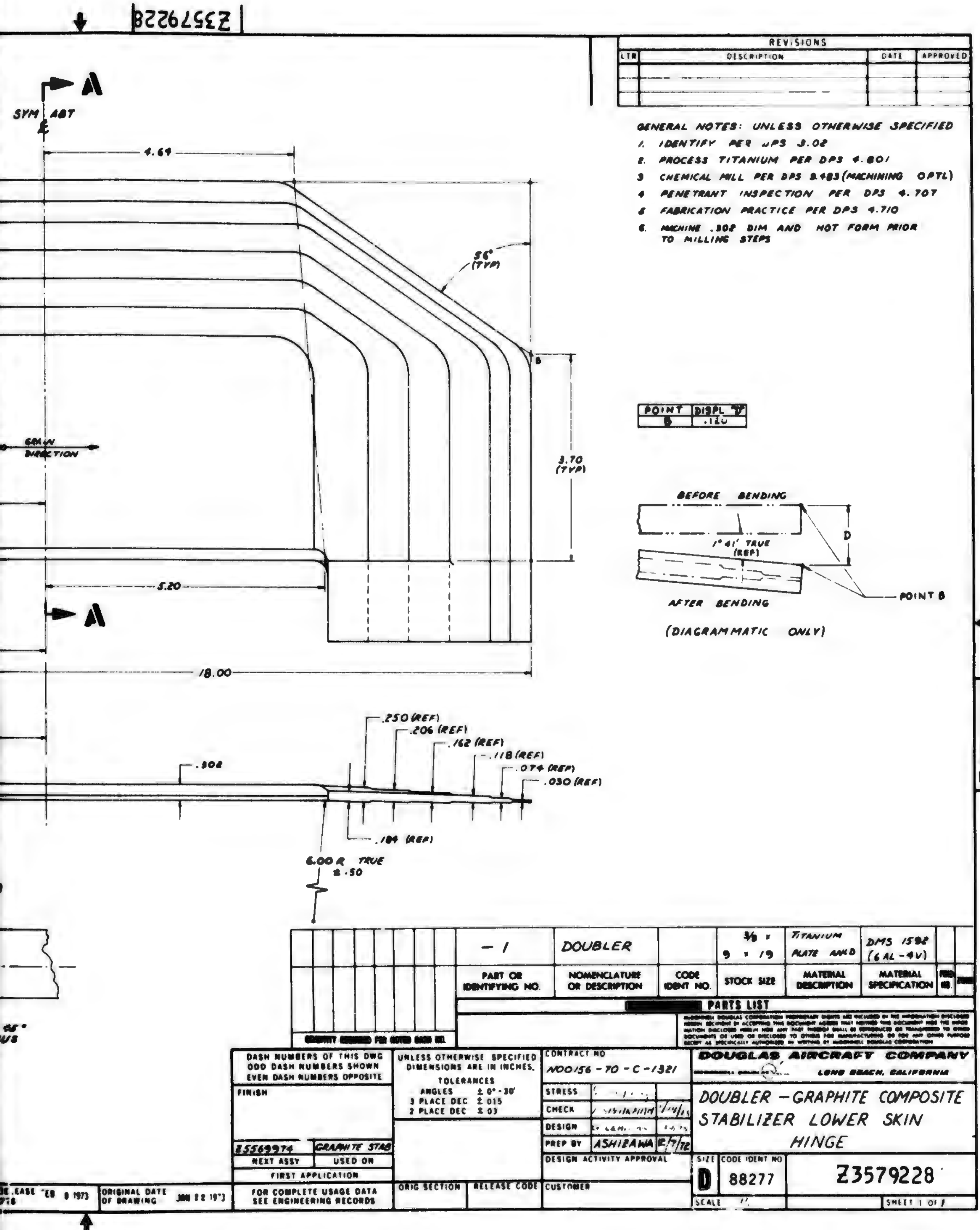
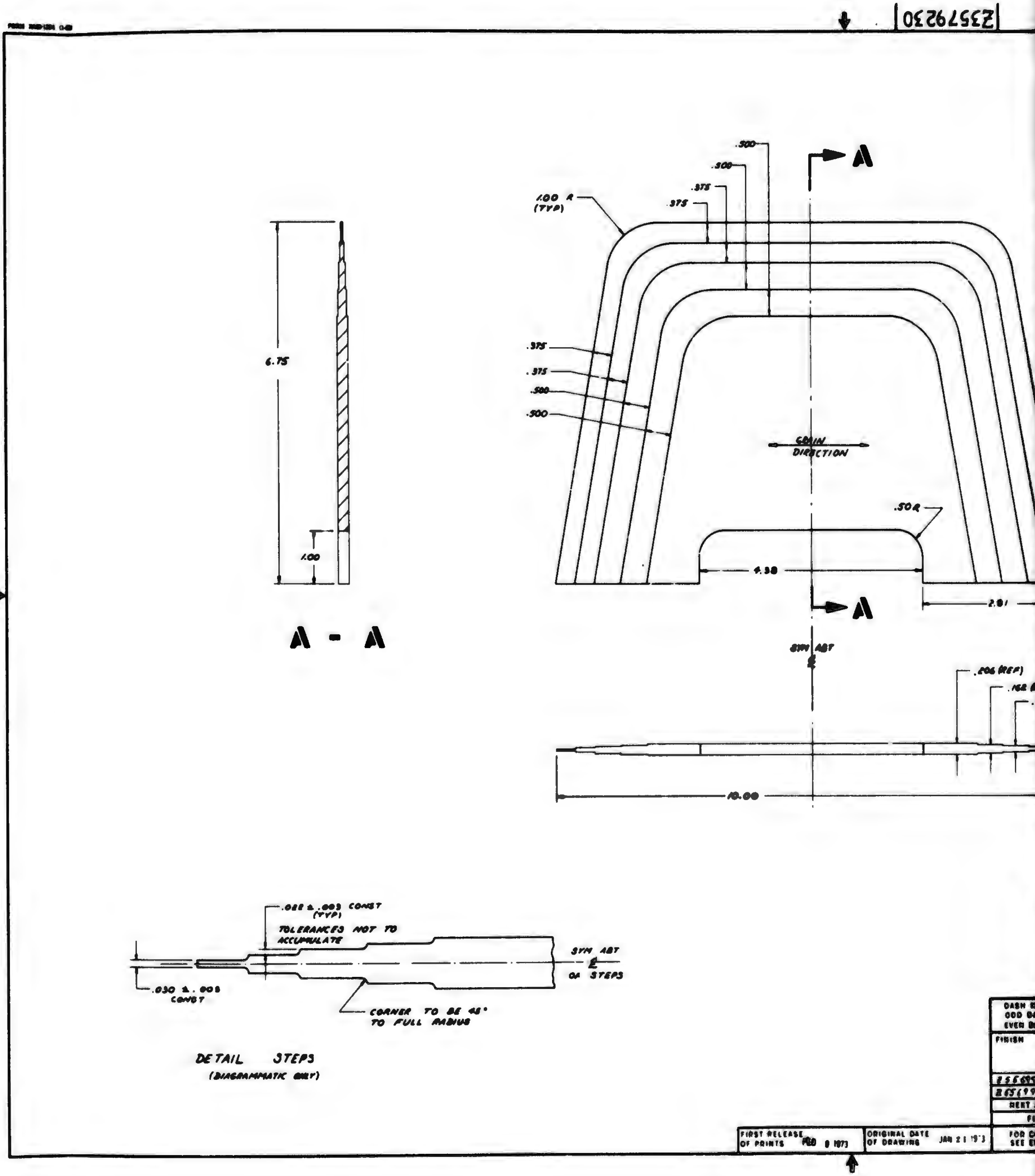


FIGURE A2. Z3579228 DOUBLER-GRAPHITE COMPOSITE STABILIZER LOWER SKIN HINGE


A - A
6.75
1.00
1.00 R (TYP)
.375
.375
.500
.500
GRAIN DIRECTION
.50 R
4.38
2.81
SYM ABT ℄
.206 (REF)
10.00
.022 ± .003 CONST (TYP)
TOLERANCES NOT TO ACCUMULATE
SYM ABT ℄ OF STEPS
.030 ± .005 CONST
CORNER TO BE 45° TO FULL RADIUS
DETAIL STEPS
(DIAGRAMMATIC ONLY)
FIRST RELEASE OF PRINTS
ORIGINAL DATE OF DRAWING
FINISH

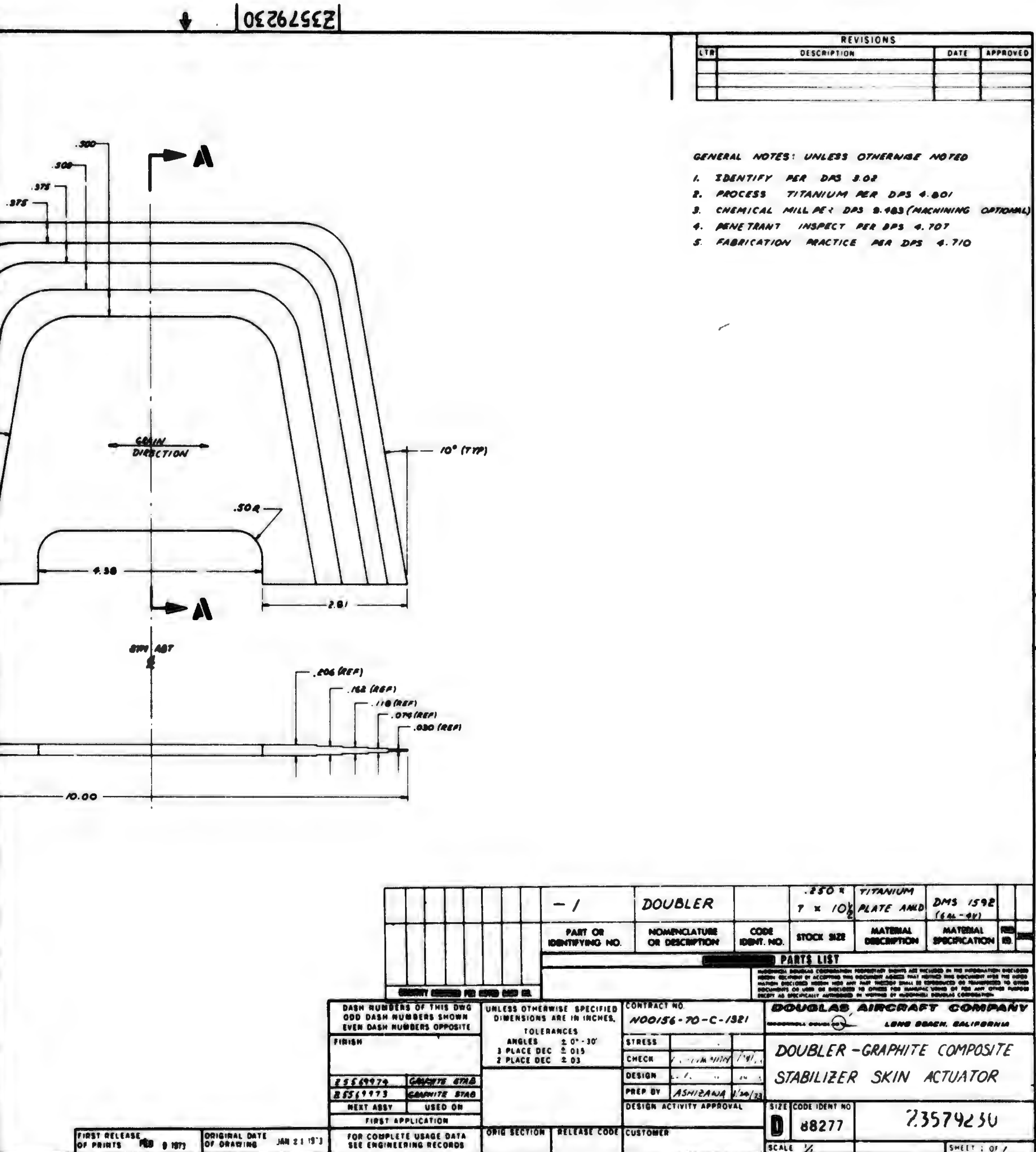
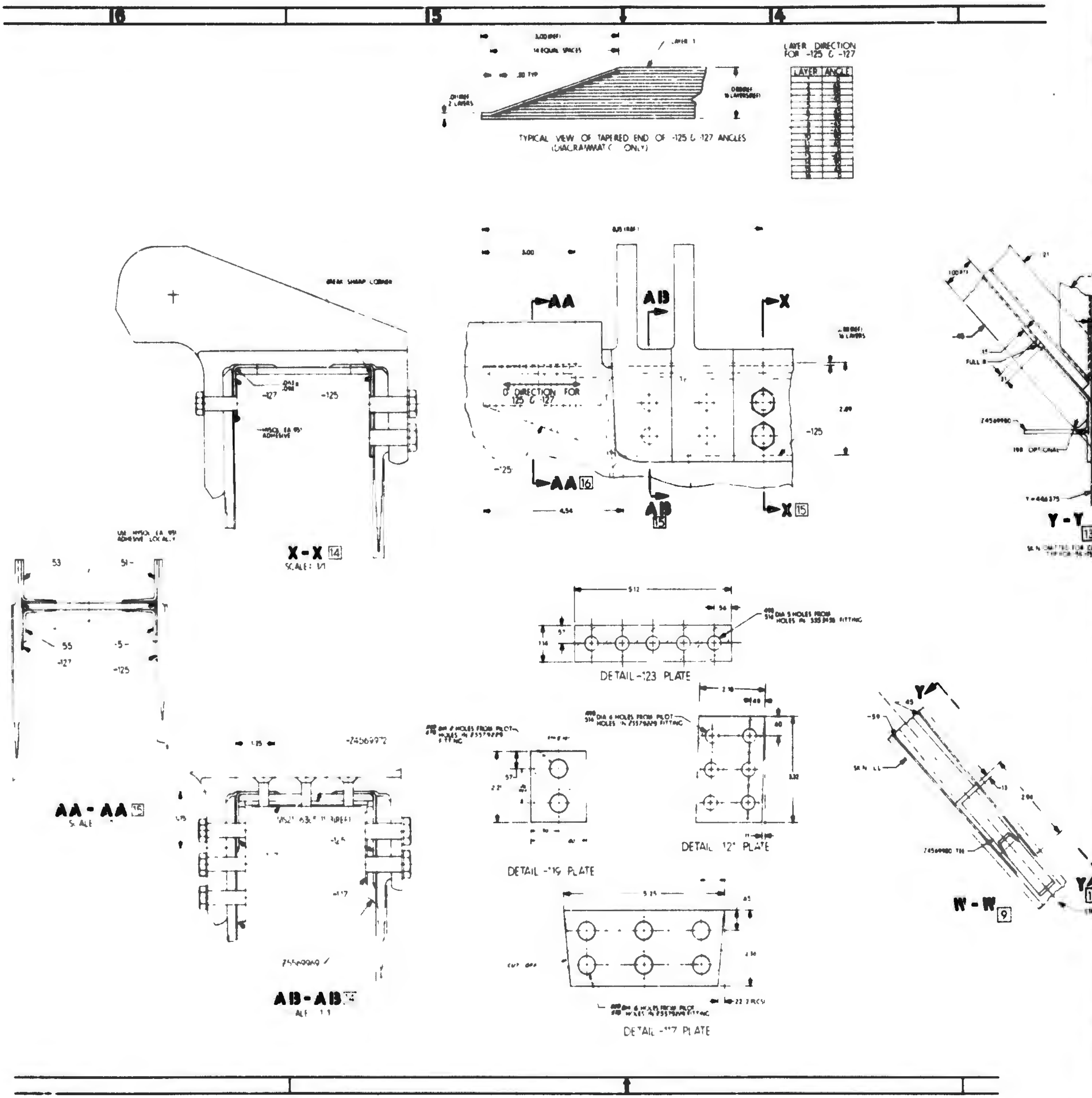


FIGURE A3. Z3579230 DOUBLER-GRAPHITE COMPOSITE STABILIZER SKIN ACTUATOR



TYPICAL VIEW OF TAPERED END OF -125 & -127 ANGLES
(DIAGRAMMATIC ONLY)
LAYER DIRECTION
FOR -125 & -127
LAYER
ANGLE
BREAK SHARP CORNER
AA
AB
X
0° DIRECTION FOR
-125 & -127
-127
-125
AA 16
AB 15
X 15
X - X 14
SCALE: 1/1
Y - Y
AA - AA 15
DETAIL -123 PLATE
DETAIL -119 PLATE
DETAIL -121 PLATE
DETAIL -117 PLATE
AB - AB
W - W 9

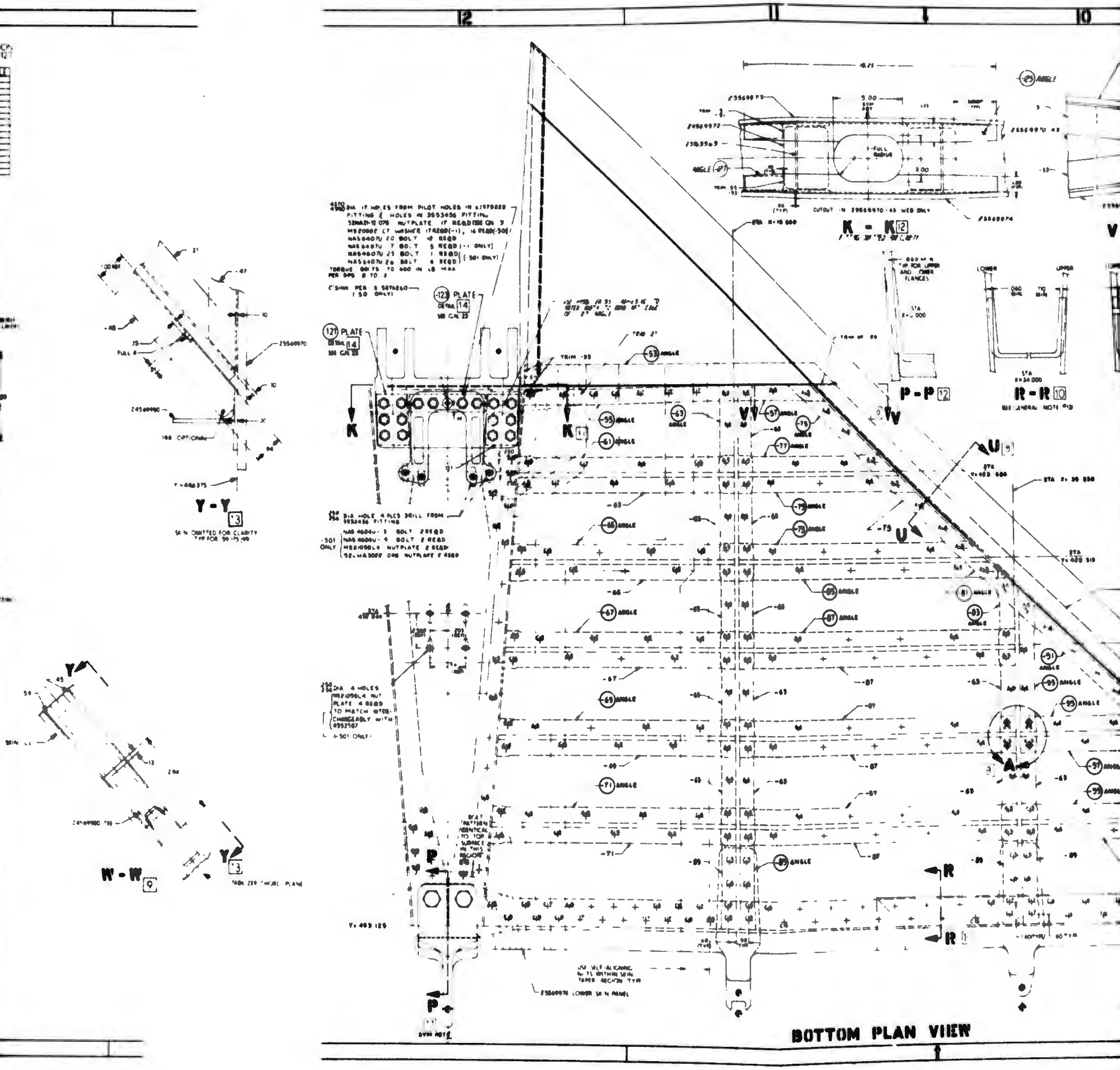


FIGURE A4. Z556996

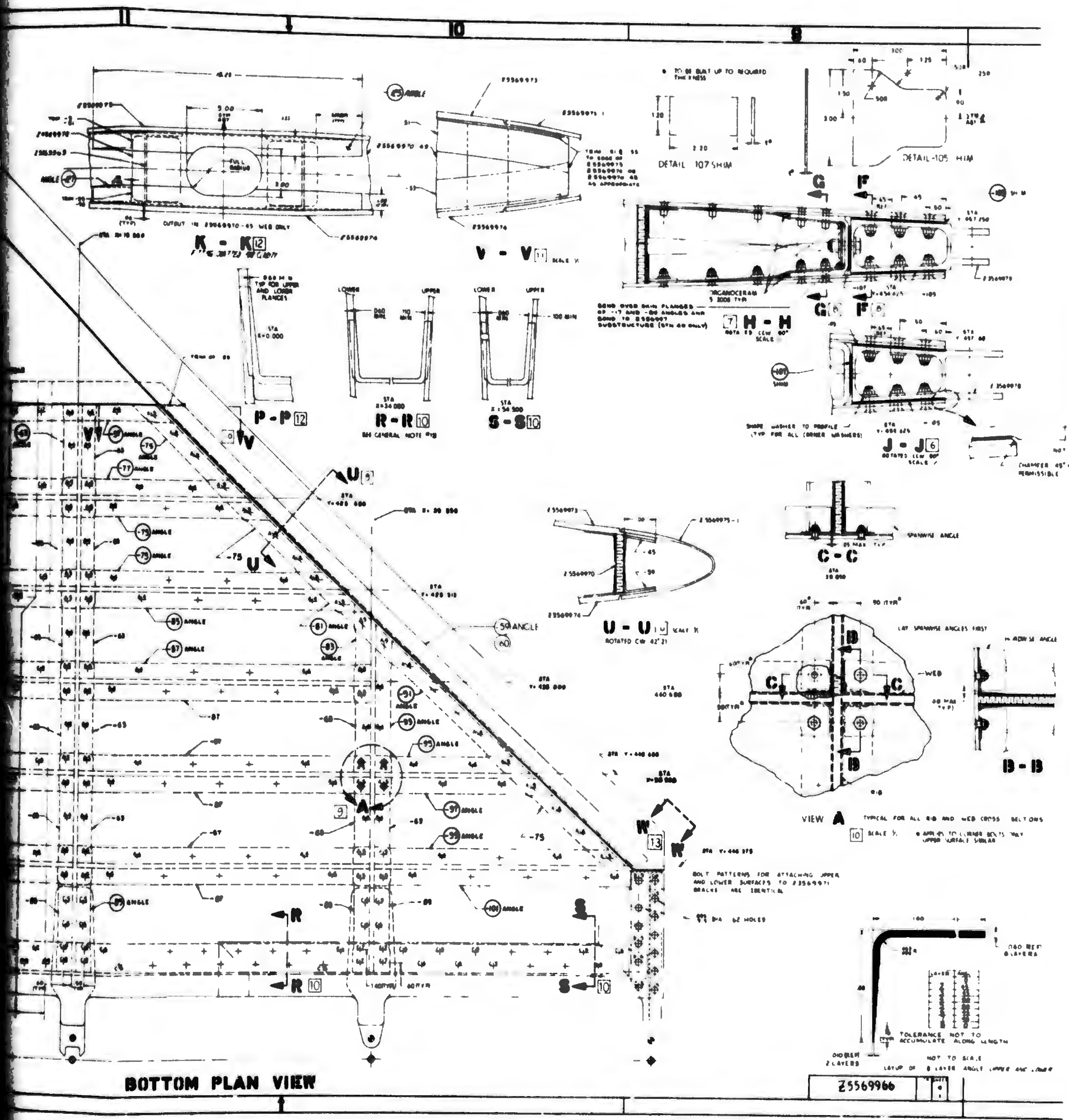
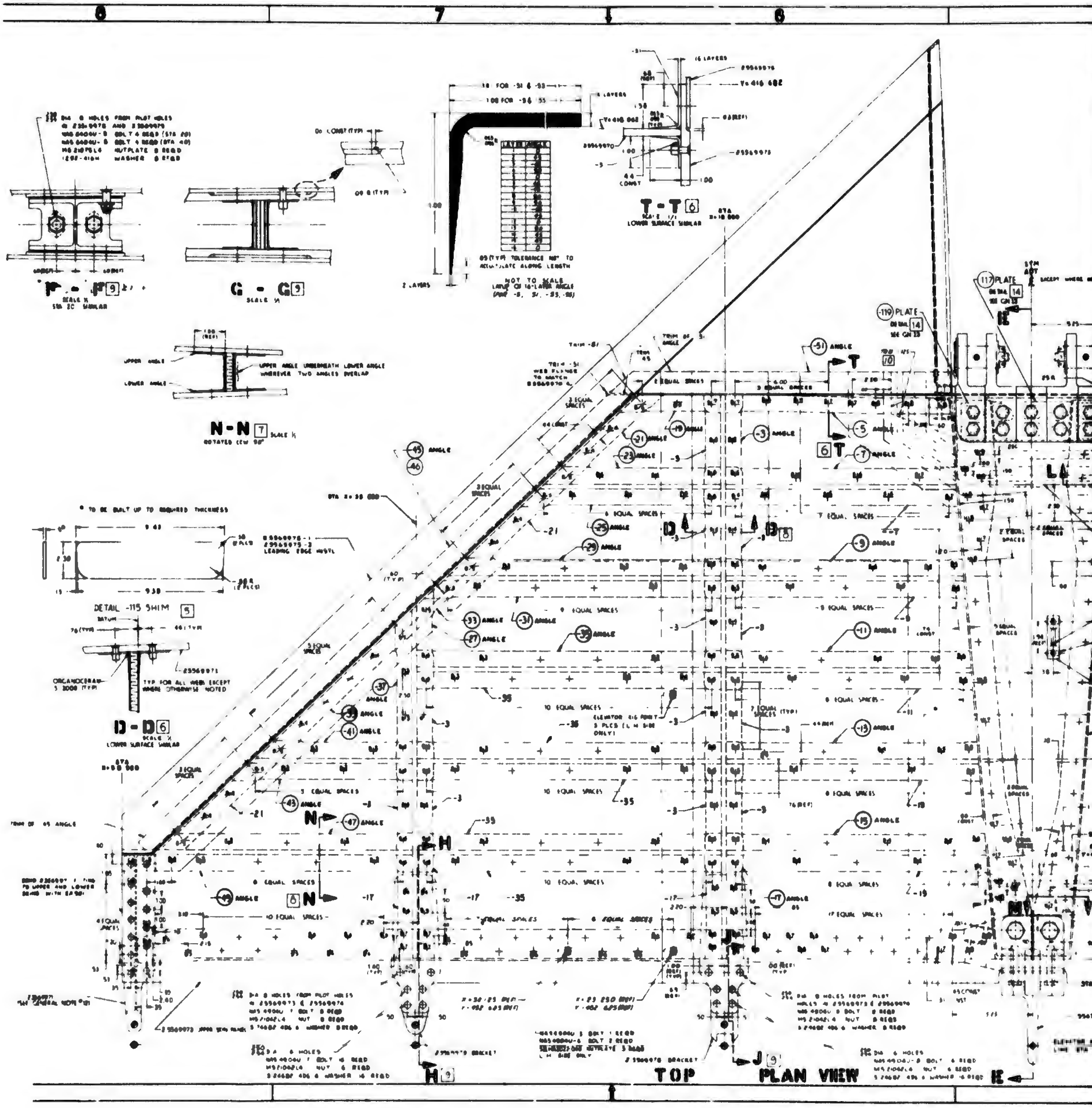
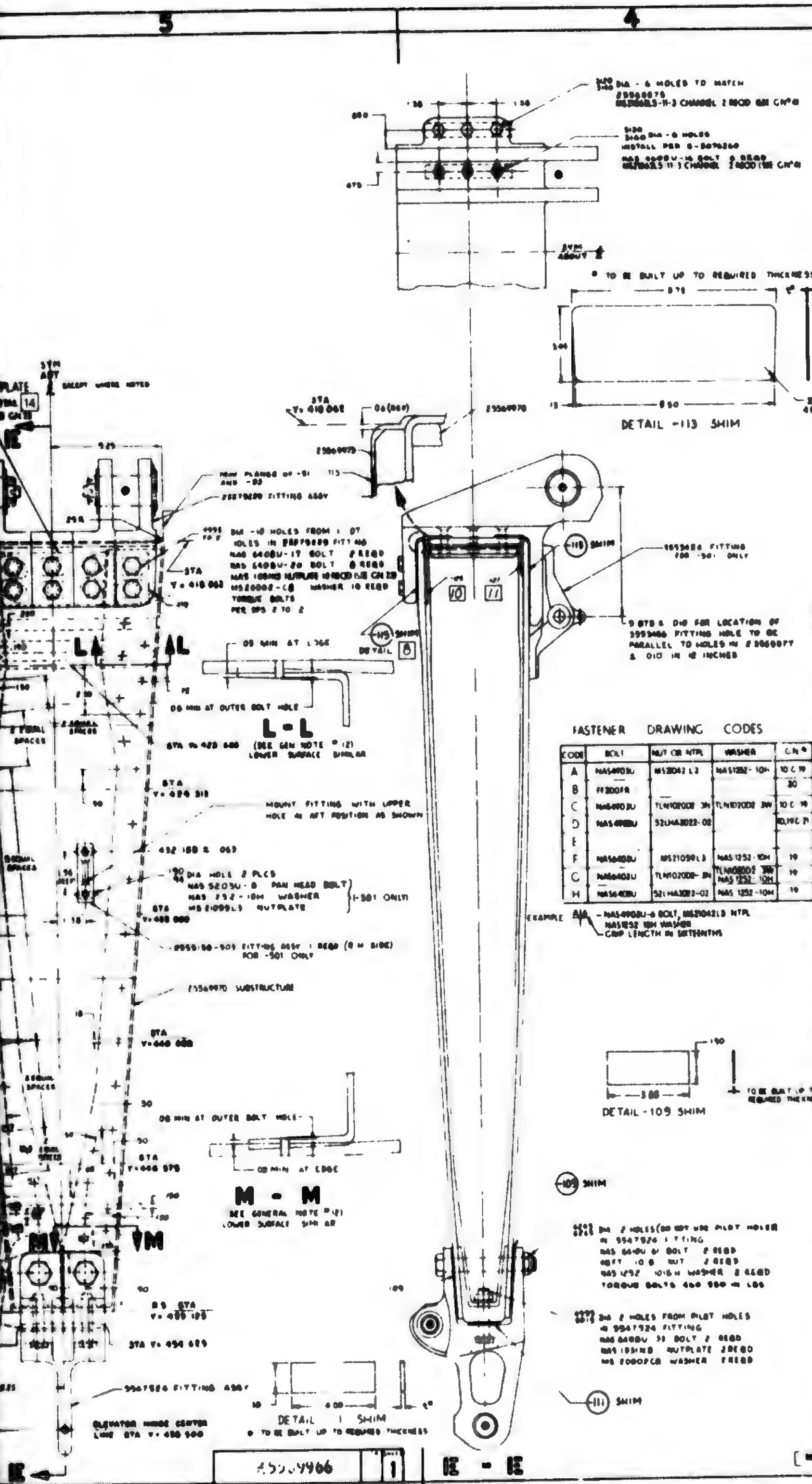


FIGURE A4. Z5569966 HORIZONTAL STABILIZER ASSEMBLY-GRAPHITE COMPOSITE


F - F
G - G
T - T
N - N
DETAIL -115 SHIM
D - D
TOP PLAN VIEW



GENERAL NOTES: UNLESS OTHERWISE SPECIFIED

1. LOCATE ALL POINTS MARKED THUS ◆ PER MASTER DIAGRAM
2. ALL DIMENSIONS IN PLANE OF LAMINATE
3. FOR LOFTED CONTOURS SEE LINES LAYOUT 9442106 AND 23569950
4. ATTACH NUTPLATES WITH HYSOL AD-9150/HE 5600 ADHESIVE
5. ASSEMBLY SHOP PRACTICE PER SRD 2 TO
6. GRAPHITE MATERIAL MARKED THUS ⊙ IS THE L/M IS INITIALLY AT "B" STAGE AND TO BE CURED DURING ASSEMBLY
7. FABRICATION AND PROCESSING METHOD PER TAD DWG EA00548
8. ALL INSIDE RADII TO BE [illegible] FOR ANGLES WHICH ARE TO BE CURED DURING ASSEMBLY - USE ORGANICERAM S-5008 TO ENSURE CORRECT RADII
9. REQUIREMENTS SHOWN ON BODY OF DRAWING ARE FOR REFERENCE ONLY
10. C'SINK 23569973 UPPER AND 23569974 LOWER PANELS 100° X .005 & .009 DIA FOR NAS 4503 BOLTS AND 100° X .007 & [illegible] DIA FOR NAS 4004 BOLTS
11. ADHESIVE BOND, WITH METLBOND 329, "B" STAGE ANGLES TO THE 23569970 SUBSTRUCTURE AND TO THE 23569974 LOWER SKIN PANEL
12. MACHINE 23569970 SUBSTRUCTURE TO MATCH INNER PROFILES OF 23569973 AND 23569974 SKIN PANELS. THE LIMITS IMPOSED BY VIEWS L-L AND M-M (ZONE 5) AND F-F, D-D, AND J-J (ZONE 10 AND 11) MUST BE MET WHERE THESE APPLY. IT IS ACCEPTABLE FOR THE OUTER PROFILES OF THE SKIN PANELS TO PROJECT OUTSIDE THE LOFT CONTOUR. MAKE SMOOTH BLEND BETWEEN 2356997 BRACKET AND THE ADJACENT GRAPHITE PARTS OF THE SUBSTRUCTURE (ZONE 8)
13. LOWER SURFACE BOLT PATTERN IDENTICAL TO UPPER SURFACE
14. BOLTS ON LOWER SURFACE SHALL BE INSTALLED HEAD DOWN
15. BOLT LENGTHS ARE BASED ON NOMINAL DIMENSIONS. ACTUAL LENGTH MAY SHOW SLIGHT VARIATIONS
16. SET SHIMS IN PLACE WITH HYSOL AD 9150/HE 5600 ADHESIVE. FILL GAP COMPLETELY WITH ADHESIVE. MAKE FITTINGS REMOVABLE BY NOT BONDING TO COMPOSITE SURFACES. FOR 115 SHIMS ONLY, BOND TO COMPOSITE BUT NOT TO 23579629 FITTING ASSY
17. THE 0° DIRECTION OF SHEAR ANGLE IS ALONG ITS LENGTH
18. ADHESIVE BOND, WITH EA 951, THE SUBSTRUCTURE AND UPPER ATTACH ANGLES TO THE 23569973 UPPER SKIN PANEL
19. FOR NAS4004U & NAS4003 BOLTS - USE [illegible] DIA HOLE
20. INSTALL FF200FR PER DPS 3.07.11
21. FOR ATTACHMENTS INDICATED THUS [illegible] ATTACH NUTPLATES WITH MS20426AD3 RIVETS
22. INSTALL RIVETS PER S3076260
23. ATTACH NUTPLATES WITH MS20426AD3 RIVETS TO -117, -119, -121, -123 PLATES AND BOND -117, -119, -121-123 TO STRUCTURE WITH HYSOL AD 9150/HE 5600 ADHESIVE

FASTENER DRAWING CODES

CODE	BOLT	NUT OR NTPL	WASHER	C.N.*
A	NAS4903U	MS21042 L3	NAS1252-10H	10 C 19
B	FF200FR			30
C	NAS4903U	TLN1020DE 3N	TLN1020DE 3W	10 C 19
D	NAS4904U	52LMA3022-02		10,19 C 21
E				
F	NAS4903U	MS21059L3	NAS 1252-10H	19
G	NAS4903U	TLN1020DE-3N	TLN1020DE 3W / NAS 1252-10H	19
H	NAS4903U	52LMA3022-02	NAS 1252-10H	19

EXAMPLE A/4 — NAS4903U-4 BOLT, MS21042L3 NTPL, NAS1252 10H WASHER — GRIP LENGTH IN SIXTEENTHS

AR	AR	ORGANICERAM S-5008	FILLER
AR	AR	HYSOL AD 9150/HE-5600	ADHESIVE
AR	AR	METLBOND 329	ADHESIVE
1	1	NAS4904U-5	BOLT
2	2	NAS4904U-6	BOLT
4	4	NAS4904U-5	BOLT
4	4	NAS4904U-6	BOLT
6	6	NAS4903U-6	BOLT
24	24	NAS4903U-[illegible]	BOLT
52	52	NAS4903U-7	BOLT
[illegible]	[illegible]	NAS4903U-6	BOLT
206	206	NAS4903U-5	BOLT
166	166	NAS4903U-4	BOLT
6	6	NAS6403U-10	BOLT
6	6	NAS1252-416H	WASHER
16	17	MS20002-C7	WASHER
46	46	[illegible]	WASHER
2	2	NAS1252-10H	WASHER
12	12	MS20002C6	WASHER
[illegible]	[illegible]	TLN1020DE-3W	WASHER
[illegible]	[illegible]	NAS1252-10H	WASHER
182	182	FF200FR 4	JO BOLT
100	100	FF200FR-5	
92	92	FF200FR 6	
42	42	FF200FR 7	
12	12	FF200FR 8	
4	4	FF200FR 9	
[illegible]	[illegible]	TLN1020DE-3N	NUT
316	[illegible]	MS21042L3	NUT
48	48	MS21042L4	NUT
2	2	46FT-1018	NUT
44	44	FF200FR 3	JO BOLT
AR	AR	MS20426AD3	RIVET
4	4	MS21061L3 11 3	NUT CHANNEL
66	66	52LMA3022-02	NUTPLATE
5		52LMA3022-04	NUTPLATE
10	4	MS21059L3	NUTPLATE
6		MS21059L4	NUTPLATE
6	6	MS21075L4	NUTPLATE
17	17	52MA3 12 070	NUTPLATE
12	12	NAS 1031N 8	NUTPLATE
-501	-1	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION

PARTS LIST

8	8	NAS 6405U-6	BOLT	
22	22	NAS 6405U-9	BOLT	
36	36	NAS 6405U-8	BOLT	
30	30	NAS 6405U-7	BOLT	
8		NAS 6404U-14	BOLT	
		NAS 6404U-15	BOLT	
		NAS 6407U-15	BOLT	
2		NAS 6405U-6	BOLT	
6	6	NAS 6405U-16	BOLT	
2	2	NAS 6406U-17	BOLT	
8	8	NAS 6406U-20	BOLT	
	3	NAS 6407U-17	BOLT	
12	12	NAS 6407U-20	BOLT	
4		NAS 6407U-15	BOLT	
2	2	NAS 6408U-20	BOLT	
2	2	NAS 6410U-61	BOLT	
24	24	NAS4004U-7	BOLT	
24	24	NAS4004U-6	BOLT	
1	1	23569975-2	LEAD EDGE INSTL	
1	1	23569975-1	LEAD EDGE INSTL	
1	1	23569974	LOWER SKIN PANEL	
1	1	23569973	UPPER SKIN PANEL	
1	1	23569970	SUBSTRUCTURE	
1	1	23579629	FITTING ASSY	
2	2	23569979	BRACKET - STN 40	
2	2	23569978	BRACKET - STN 20	
1	1	9947524	FITTING ASSY	
1	1	23569[illegible]-500	FITTING ASSY	
1		9953484	FITTING	
		23569977	FITTING	
1	1	-127	ANGLE	4 x 9
1	1	-125	ANGLE	5 x 9
1	1	-123	PLATE	.090 x 2 x 6
2	2	-121		.090 x 3 x 4
2	2	-119		.090 x 2 x 3
1	1	-117		.090 x 3 x 6
1	1	-115	SHIM	.020 x 3 x 10
1	1	-113		.020 x 4 x 10
1	1	-111		.060 x 2 x 4
2	2	-109		.050 x 2 x 4
4	4	-107		.060 x 2 x 3
8	8	-105	SHIM	.050 x 3 x 8
DELETED		-103	GRID	120 x 35
2	2	-101	ANGLE	2 x 6¾
2	2	-99		2 x 16½
2	2	-97		2 x 11½
2	2	-95		2 x 10½
2	2	-93		2 x 9½
2	2	-91		2 x 13½
8	8	-89		2 x 6½
12	12	-87		2 x 19½
2	2	-85		2 x 19½
2	2	-83		2 x 4½
2	2	-81		2 x 4½
2	2	-79		2 x 13
2	2	-77		2 x 11½
6	6	-75		2 x 9½
2	2	-73		2 x 17½
4	4	-71	ANGLE	2 x 17
-501	-1	PART OR IDENTIFYING NO	NOMENCLATURE OR SPECIFICATION	STOCK SIZE

PARTS LIST

4559966 | 1

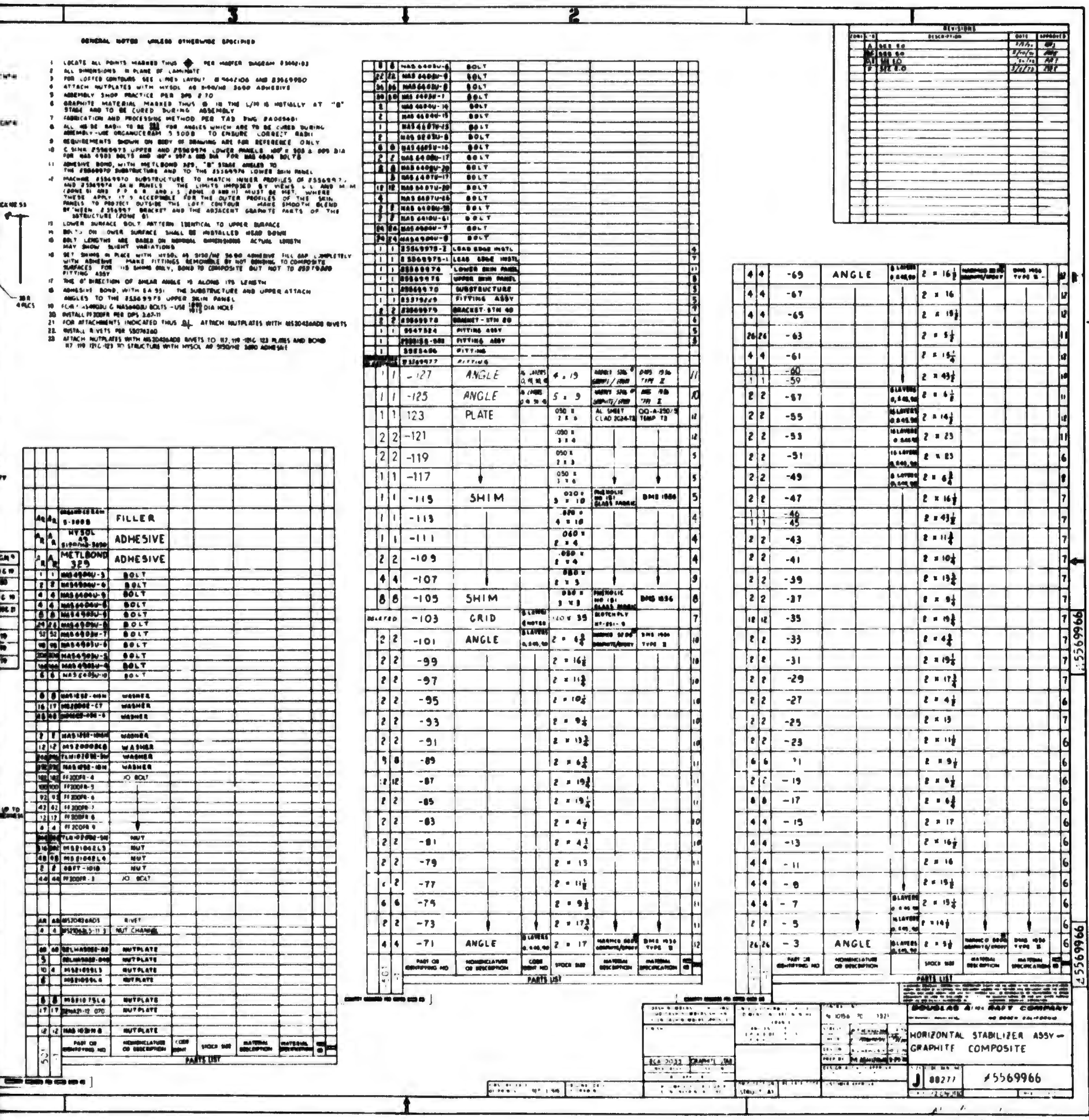
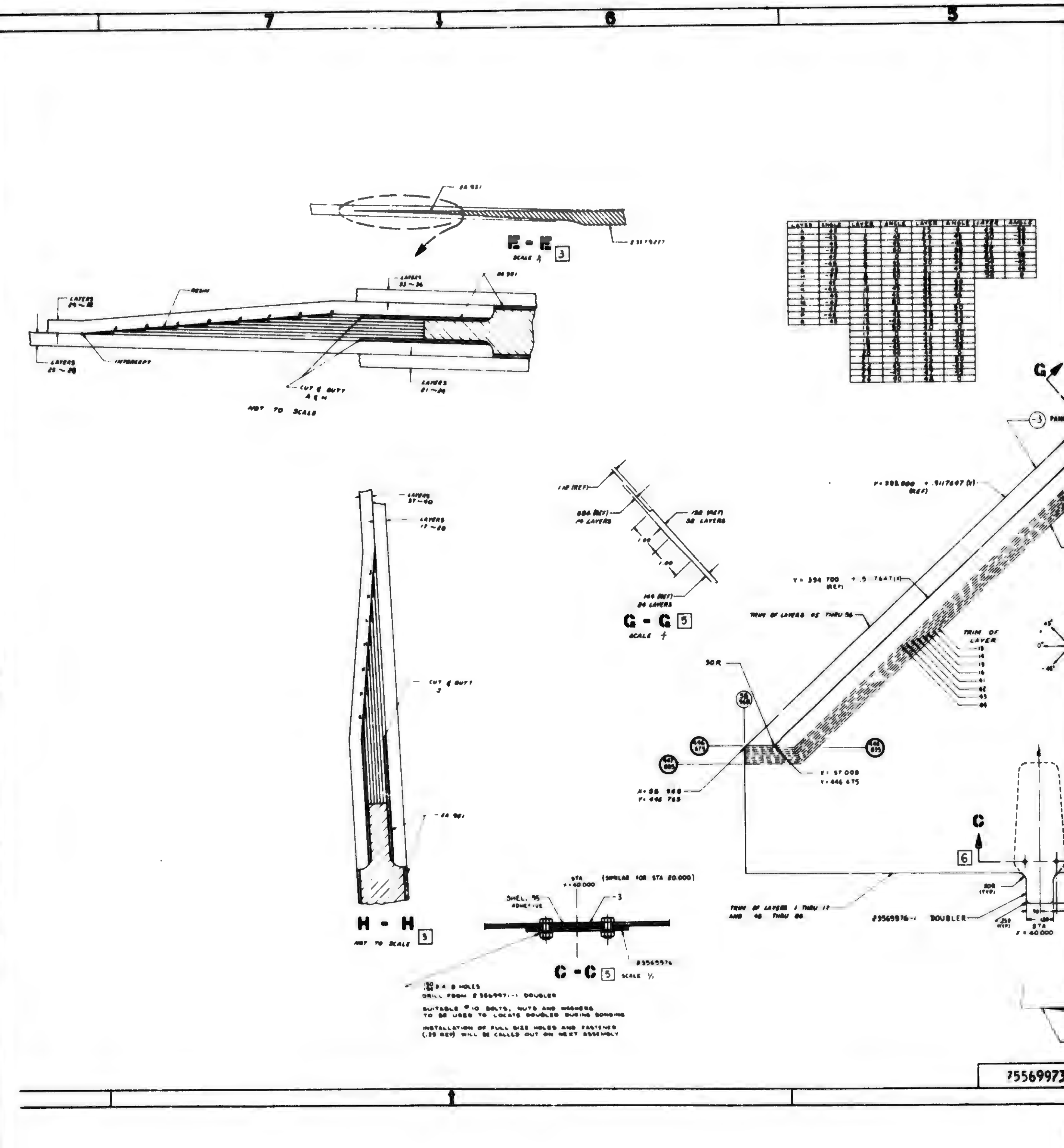


FIGURE A4. Z5569966 HORIZONTAL STABILIZER ASSEMBLY-GRAPHITE COMPOSITE (CONTINUED)



LAYER	ANGLE	LAYER	ANGLE	LAYER	ANGLE	LAYER	ANGLE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	[illegible]	[illegible]	[illegible]		

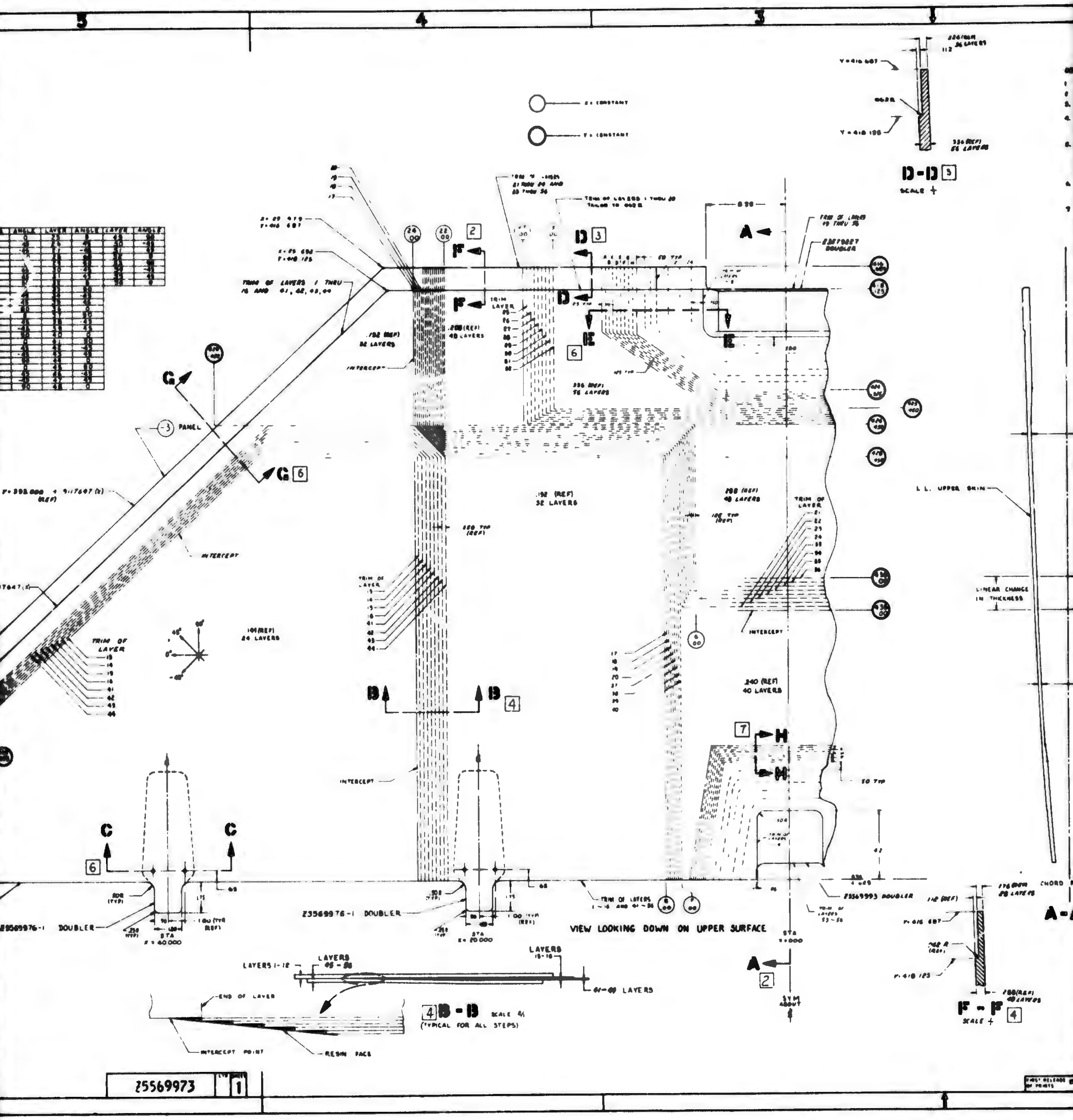


FIGURE A5. Z5569973 FANE

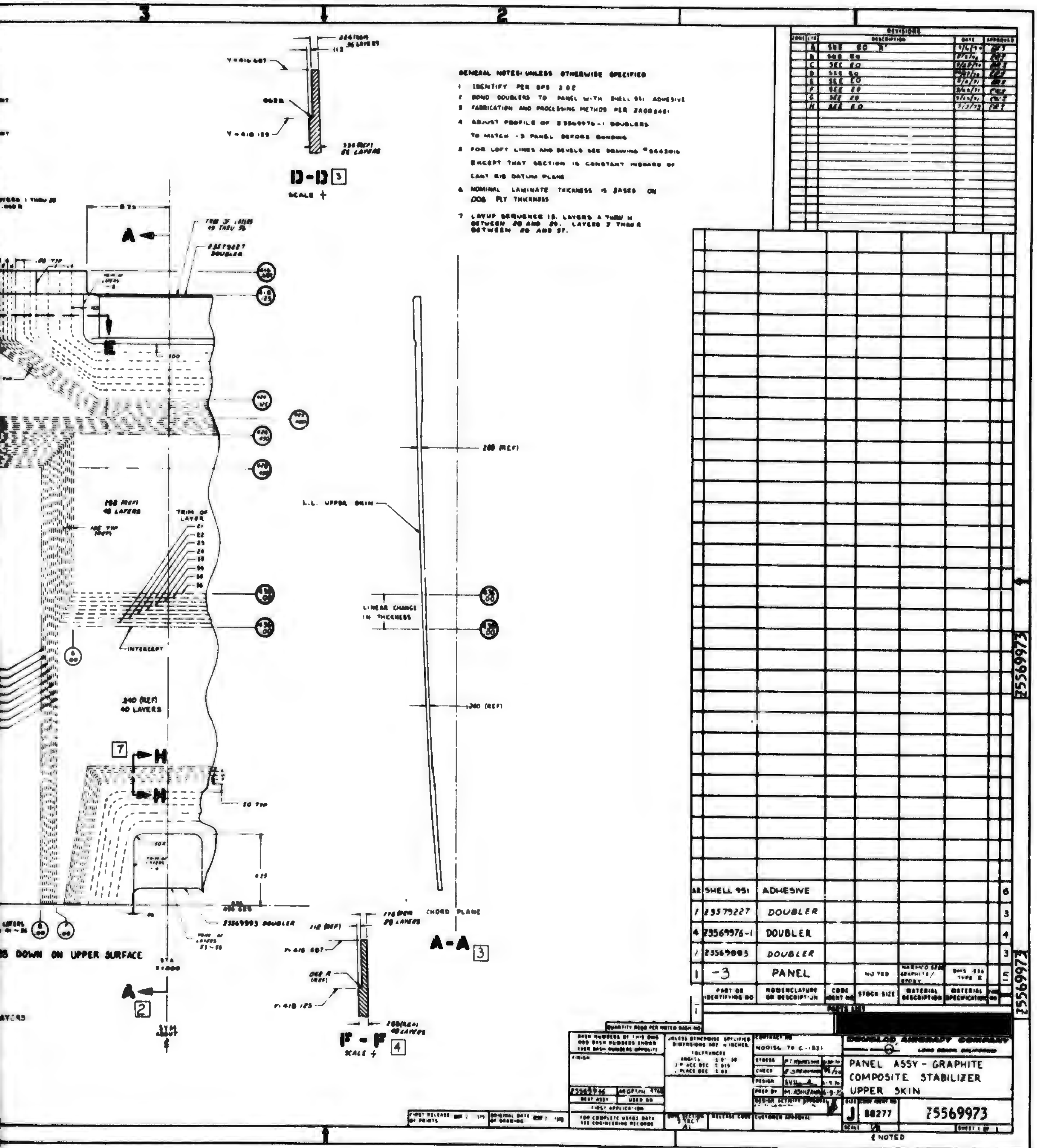
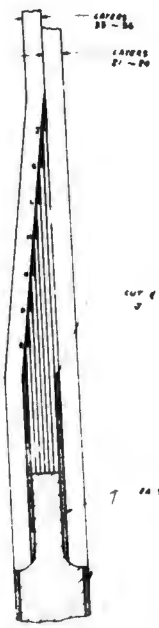
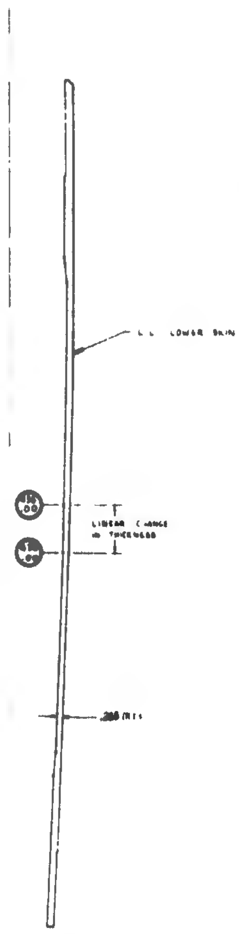


FIGURE A5. Z5569973 PANEL ASSEMBLY-GRAPHITE COMPOSITE STABILIZER UPPER SKIN

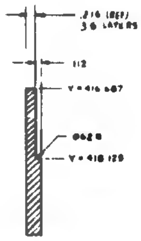
7 6 5



G - G [6]
NOT TO SCALE

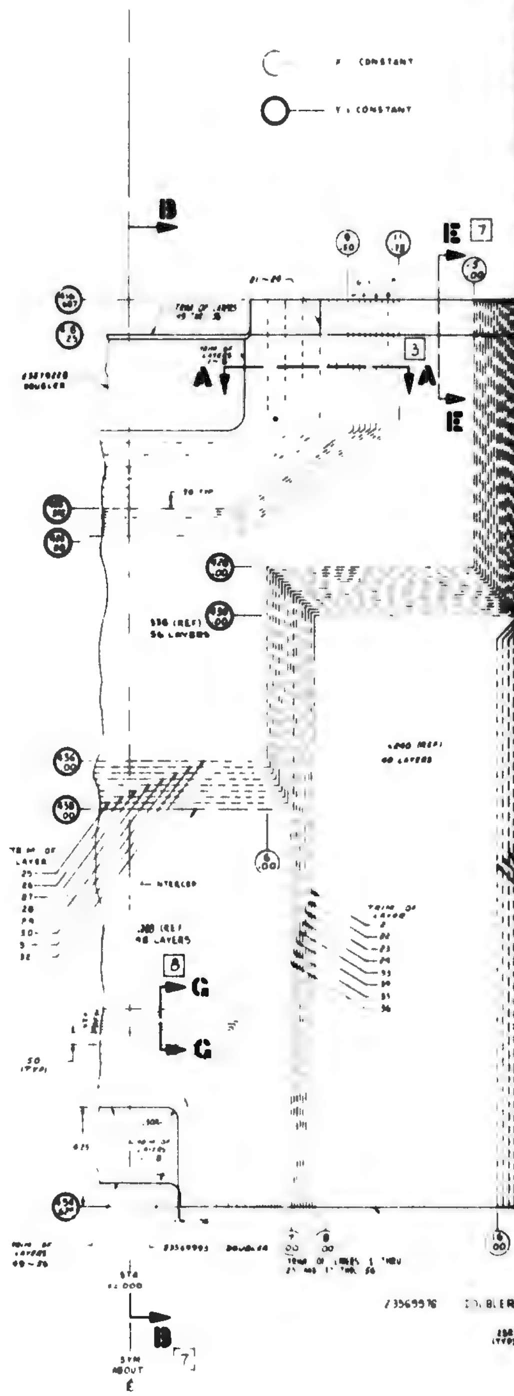


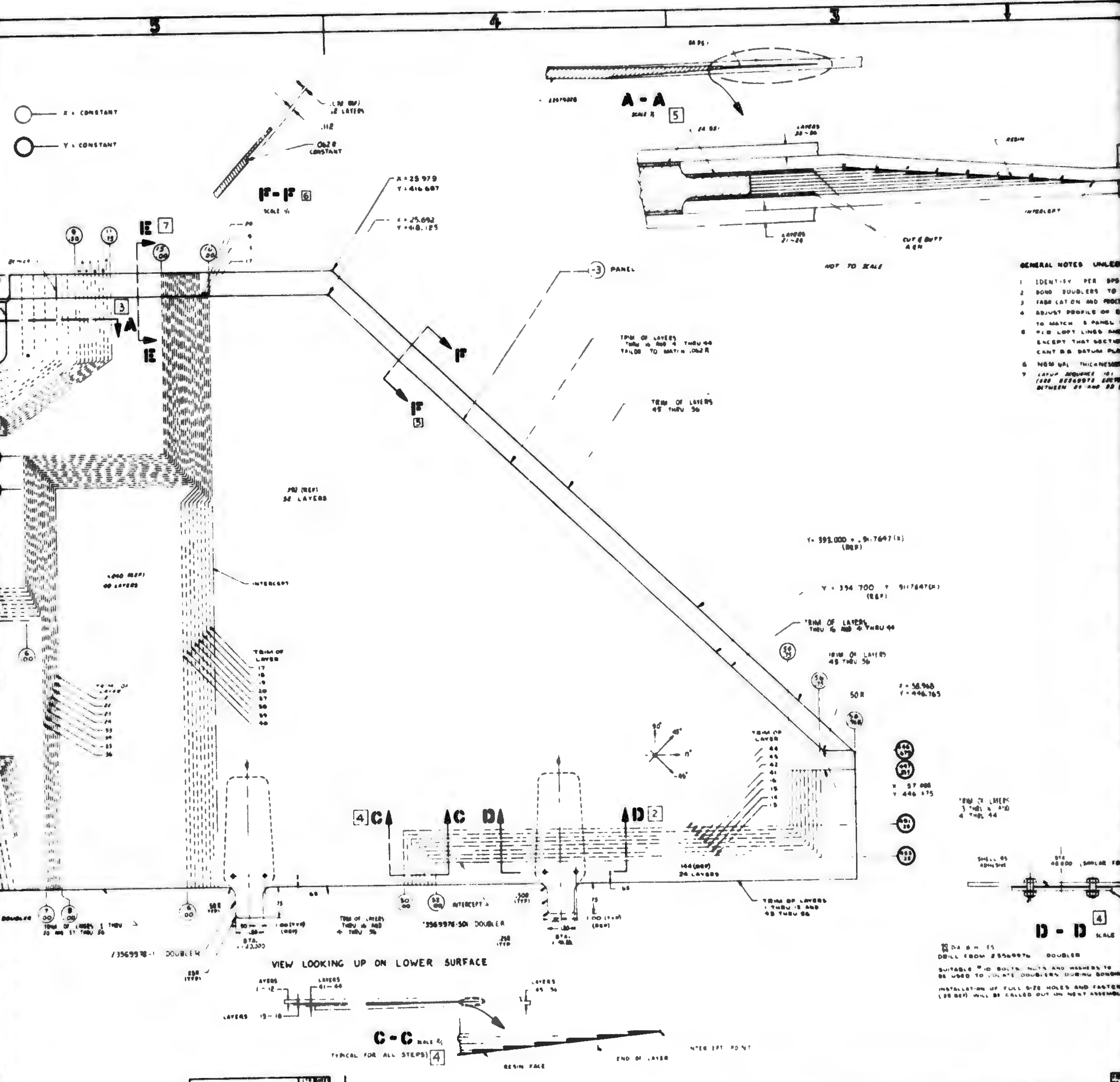
B - B [6]



E - E SCALE
[5]

LAYER	ANGLE	LAYER	ANGLE	LAYER	ANGLE
[illegible]	0	[illegible]	90	[illegible]	[illegible]
[illegible]	45	[illegible]	45	[illegible]	[illegible]
[illegible]	45	[illegible]	45	[illegible]	[illegible]
[illegible]	90	[illegible]	0	[illegible]	[illegible]
[illegible]	0	[illegible]	90	[illegible]	[illegible]
[illegible]	45	[illegible]	45	[illegible]	[illegible]
[illegible]	45	[illegible]	45	[illegible]	[illegible]
[illegible]	90	[illegible]	0	[illegible]	[illegible]
[illegible]	0	[illegible]	90	[illegible]	[illegible]
[illegible]	45	[illegible]	45	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	45	[illegible]	[illegible]
[illegible]	90	[illegible]	0	[illegible]	[illegible]
[illegible]	0	[illegible]	90	[illegible]	[illegible]
[illegible]	45	[illegible]	45	[illegible]	[illegible]
[illegible]	45	[illegible]	45		
[illegible]	90	[illegible]	0		
[illegible]	0	[illegible]	90		
[illegible]	45	[illegible]	45		
[illegible]	45	[illegible]	45		
[illegible]	90	[illegible]	0		
[illegible]	0	[illegible]	90		
[illegible]	45	[illegible]	45		
[illegible]	45	[illegible]	45		
[illegible]	90	[illegible]	0		
[illegible]	0	[illegible]	90		
[illegible]	45	[illegible]	45		
[illegible]	45	[illegible]	45		
[illegible]	90	[illegible]	0		





X = CONSTANT
Y = CONSTANT
F - F
SCALE 4/1
X = 25.979
Y = 416.687
X = 25.692
Y = 418.125
.0628
CONSTANT
A - A
NOT TO SCALE
CUT & BUTT
GENERAL NOTES
-3 PANEL
TRIM OF LAYERS 45 THRU 56
52 LAYERS
INTERCEPT
TRIM OF LAYER
50 R
X = 58.968
Y = 446.765
X 57.000
Y 446.175
VIEW LOOKING UP ON LOWER SURFACE
3569976-501 DOUBLER
Z3569978-1 DOUBLER
144 (REF)
24 LAYERS
D - D
DRILL FROM Z3569976 DOUBLER
C - C
TYPICAL FOR ALL STEPS
RESIN FACE
END OF LAYER

Z5569974 | 1

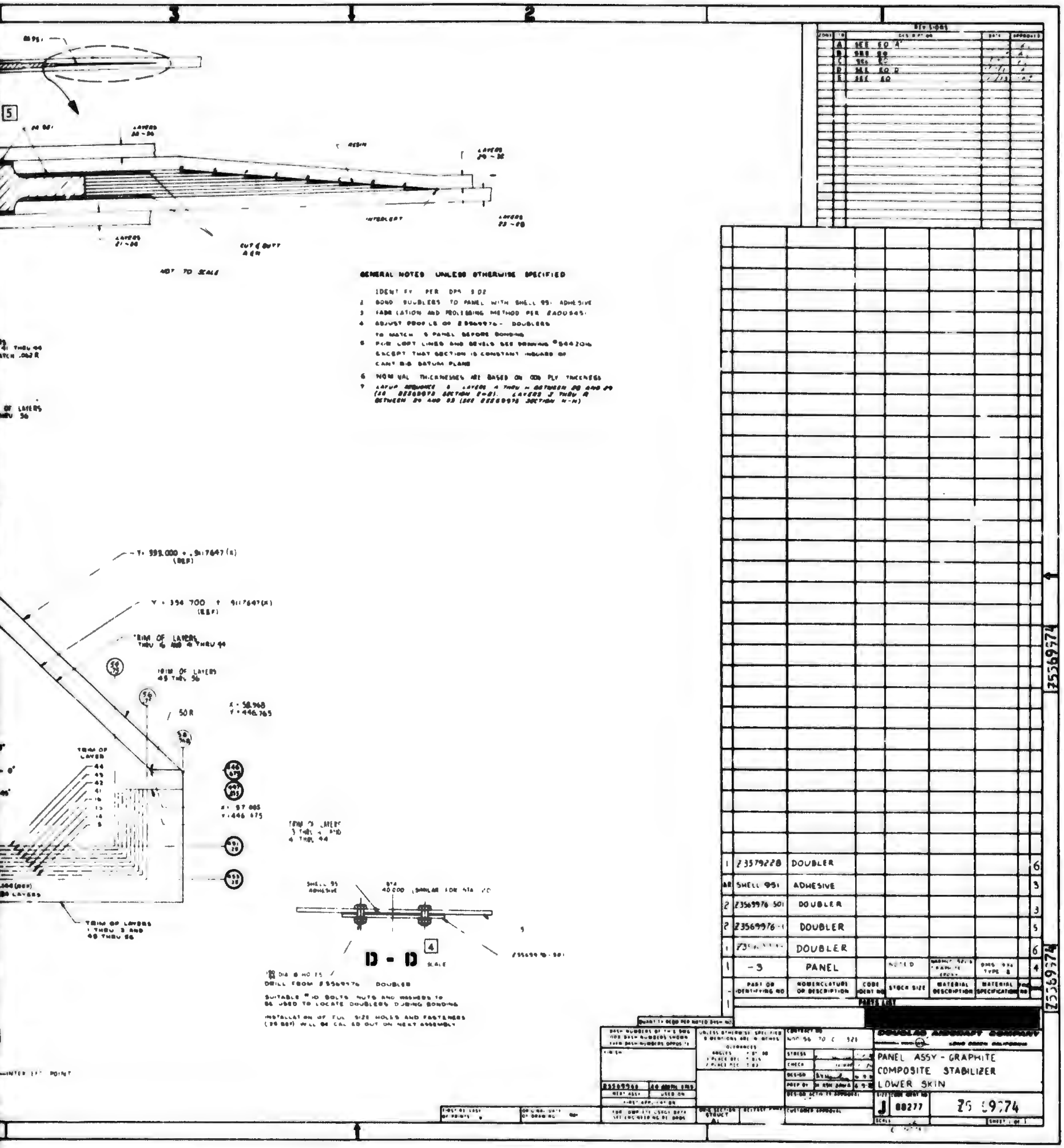


FIGURE A6. Z5569974 PANEL ASSEMBLY-GRAPHITE COMPOSITE STABILIZER LOWER SKIN

TABLE BI
PREPREG QUALITY CONTROL RECEIVING INSPECTIO

MATERIAL MODULITE 5206/II GRAPHITE/EPOXY — LOT NUM
VENDOR NARMCO — DATE OF
QUANTITY RECEIVED 20.05 LB — NUMBER OF UNITS 8 ROLLS — UNIT SIZE

TEST / UNIT IDENTITY	PREPREG PROPERTIES									
	RESIN CONTENT WT. %	VOLATILE CONTENT WT. %	GEL TIME MINUTES	VISUAL	HANDLING		TENSILE STRENGTH 10^3 PSI	TENSILE MODULUS 10^6 PSI	RESIN CONTENT WT. %	VOID CONTENT Vol. %
DMS REQ'TS	39 To 45.0	3.0 Max.	18 To 26	—	—		145.0 Min.	19.0 Min.	28 To 34	1 Max.
VENDOR AVERAGE RESULTS	42.5	1.0	–	–	–		–	–	–	–
SHEET 4 -1 -2 -3 -4 -5 AVE.										
SHEET 6 -1 -2 -3 -4 -5 AVE.	43.1 43.3 39.3 41.9	 1.9	 21.6							
SHEET__ -1 -2 -3 -4 -5 AVE.										
SHEET__ -1 -2 -3 -4 -5 AVE.										
SHEET__ -1 -2 -3 -4 -5 AVE.										

REMARKS:

TABLE BI
ECEIVING INSPECTION REPORT – LOT NUMBER 392

LOT NUMBER 392	DMS 1936B	PAGE 1 OF 1	
DATE OF MANUFACTURER 11-29-72	DATE RECEIVED 12-8-72		
UNIT SIZE –	S/O 16105414	P/O 2CY610245-9	

LAMINATE PROPERTIES									
RESIN CONTENT WT. %	VOID CONTENT Vol. %	FLEXURAL STRENGTH 10^3 PSI	FLEXURAL MODULUS 10^6 PSI	SHEAR STRENGTH 10^3 PSI	RESIN CONTENT WT. %	VOID CONTENT VOL. %	THICKNESS PER PLY INCHES		COMMENTS
28 To 34	1 Max.	195.0 Min.	17.5 Min.	14.0 Min.	28 to 34	1 Max.			
–	–	219.9	–	16.6	–	–	–		
		207.9 243.8 225.8	– –	16.3 16.3 16.4 16.3			0.00536 0.00568 0.00552		
		216.5 241.7 215.1 224.4	23.0 22.8 20.9 22.3	18.6 18.4 18.3 18.4			0.00572 0.00538 0.00566 0.00559		

MEETS SPEC. ☒ DOES NOT MEET SPEC ☐
MEETS P.O. ☒ DOES NOT MEET P.O. ☐
Q.C. REPRESENTATIVE H. M. TOELLNER
DATE: 1-4-73

APPENDIX B

INCOMING MATERIAL AND IN-PROCESS TEST RESULTS

Incoming material tests were conducted on four lots of Modulite 5206/II graphite-epoxy prepreg during the reporting period. All material was in the form of 3-inch wide tape. Acceptance test results are summarized in Tables BI through BIV.

In-process tests results were obtained from tag-end tests for the joint development components, the stabilizer skin panels, and six test panels fabricated to investigate various vacuum bagging techniques (see Section III, Manufacturing Development). Test results for the development components are given in Table BV, and for the first of two upper skin panels in Table BVI. This skin panel was rejected because of the high void content and low interlaminar shear values obtained from the right hand QC tab. Three test panels were then made on a porous laminating mold to determine the effects of various bagging techniques on laminate properties, see Table BVII. Three additional panels were subsequently made on the skin panel PLM using the selected (envelope) bagging technique with the results shown in Table BVIII. Tag-end test results for the lower skin panel and the second upper skin panel are given in Tables BIX and BX, respectively. Specimen locations in the upper skin panel are shown in Figure B1.

TABLE BIII
PREPREG QUALITY CONTROL RECEIVING INSPECTION R

MATERIAL MODULITE 5206/II GRAPHITE-EPOXY LOT NUMBER

VENDOR NARMCO DATE OF MA

QUANTITY RECEIVED 91.22 LB NUMBER OF UNITS 19 ROLLS UNIT SIZE 3

TEST / UNIT IDENTITY	PREPREG PROPERTIES										
	RESIN CONTENT WT. %	VOLATILE CONTENT WT. %	GEL TIME MINUTES	VISUAL	BEAM COMPRES-SION STRENGTH	BEAM COMPRES-SION MODULUS	BEAM TENSILE STRENGTH 10^3 PSI	BEAM TENSILE MODULUS 10^6 PSI	RESIN CONTENT WT. %	VOID CONTENT Vol. %	FLE STR 10
DMS REQ'TS	39 To 45.0	3.0 Max.	18 To 26	—	—		145.0 Min.	19.0 Min.	28 To 34	1 Max.	19 M
VENDOR AVERAGE RESULTS	42.6	1.9	–	–	–	–	–	–	–	–	21
SHEET -1 ROLL 4					166.7	21.8	132.2	21.7			19
-2					133.5	21.8	194.0	25.2			21
-3					171.2	22.8	202.9	25.3			22
-4											
-5											
AVE.					157.1	22.1	176.4	24.1			20
SHEET -1 ROLL 8					156.7	17.0	160.3	22.4			23
-2					184.6	18.3	175.2	21.9			16
-3					183.5	20.3	183.7	22.4			21
-4											
-5											
AVE.					174.9	18.5	173.1	22.2			20
SHEET -1 ROLL 13					186.4	18.3	191.5	23.4			23
-2					183.9	19.2	167.0	24.5			20
-3					218.1	19.5	178.5	20.7			19
-4											
-5											
AVE.					196.1	19.0	179.0	22.8			21
SHEET -1 ROLL 18					167.0	21.6	197.2	23.6			19
-2					172.3	21.8	183.1	23.5			18
-3					168.9	20.9	182.6	23.0			20
-4											
-5											
AVE.					169.4	21.4	187.6	23.4			19
SHEET -1											
-2											
-3											
-4											
-5											
AVE.											

REMARKS:

ABLE BIII
NG INSPECTION REPORT – LOT NUMBER 397

LOT NUMBER 397 DMS 1936B | PAGE 1 OF 1

DATE OF MANUFACTURER 1-23-73 DATE RECEIVED 1-26-73

SIZE 3 S/O 16105414 P/O 3CY357601-9

	LAMINATE PROPERTIES								
T	VOID CONTENT Vol. %	FLEXURAL STRENGTH 10^3PSI	FLEXURAL MODULUS 10^6 PSI	SHEAR STRENGTH 10^3 PSI	RESIN CONTENT WT. %	VOID CONTENT VOL. %	THICKNESS PER PLY INCHES		COMMENTS
	1 Max.	195.0 Min.	17.5 Min.	14.0 Min.	28 to 34	1 Max.			
	–	213.5	–	16.2	–	–			
		191.0 211.5 224.7	22.4 21.9 23.8	14.4 14.5 14.4 15.0			0.00557 0.00544 0.00463		
		209.1	22.7	14.6	37.54	0.75	0.00521		
		230.6 167.9 213.6	21.9 19.3 22.6	16.0 15.3 16.1 15.6			0.00528 0.00564 0.00481		
		204.0	21.3	15.7			0.00524		
		239.4 203.6 198.9	21.9 19.8 21.5	15.1 15.3 15.3 15.8			0.00525 0.00561 0.00491		
		213.9	21.1	15.4			0.00526		
		191.4 182.6 207.4	22.4 19.2 22.2	15.5 15.8 16.0 16.0			0.00531 0.00564 0.00509		
		194.0	21.3	15.8			0.00535		

MEETS SPEC. ☒ DOES NOT MEET SPEC ☐
MEETS P.O. ☒ DOES NOT MEET P.O. ☐
Q.C. REPRESENTATIVE H. M. TOELLNER
DATE: 3-8-73

TABLE BII

PREPREG QUALITY CONTROL RECEIVING INSPECT

MATERIAL MODULITE 5208/II GRAPHITE/EPOXY LOT NU

VENDOR NARMCO DATE O

QUANTITY RECEIVED 44.44 LB NUMBER OF UNITS 12 ROLLS UNIT SIZE 3-IN.

TEST / UNIT IDENTITY	PREPREG PROPERTIES									
	RESIN CONTENT WT. %	VOLATILE CONTENT WT. %	GEL TIME MINUTES	VISUAL	BEAM COMPRESSION STRENGTH	BEAM COMPRESSION MODULUS	BEAM TENSILE STRENGTH 10^3 PSI	BEAM TENSILE MODULUS 10^6 PSI	RESIN CONTENT WT. %	VOID CONTENT Vol. %
DMS REQ'TS	39 To 45.0	3.0 Max.	18 To 26	—	—		145.0 Min.	19.0 Min.	28 To 34	1 Max.
VENDOR AVERAGE RESULTS										
SHEET -1 ROLL 3										
-2										
-3										
-4										
-5										
AVE.										
SHEET -1 ROLL 5										
-2										
-3										
-4										
-5										
AVE.										
SHEET -1 ROLL 7			21:37		180,000	18.04	173,900	22.84		
-2			20:10		181,600	22.83	197,000	23.32		
-3					191,700	21.24	188,800	22.18		
-4										
-5										
AVE.					184,400	20.70	186,600	22.78		
SHEET -1 ROLL 10			19:47		185,900	18.14	177,400	24.33		
-2			20:57		174,400	19.22	187,900	24.51		
-3					183,500	18.82	179,600	22.26		
-4										
-5										
AVE.					181,300	18.73	181,600	23.70		
SHEET -1										
-2										
-3										
-4										
-5										
AVE.										

REMARKS: BATCH ACCEPTABLE. MARGINALLY LOW FLEXURAL STRENGTH OFFSET BY GOOD TENSILE AND COMPRESSIVE RESUL

TABLE BII
EIVING INSPECTION REPORT – LOT NUMBER 395

LOT NUMBER 395 DMS 1936B | PAGE 1 OF 1

DATE OF MANUFACTURER 1-18-73 DATE RECEIVED 1-26-73

IT SIZE 3-IN. TAPE S/O 16105414 P/O 3CY357601-9

	LAMINATE PROPERTIES								
IN ENT %	VOID CONTENT Vol. %	FLEXURAL STRENGTH 10^3 PSI	FLEXURAL MODULUS 10^6 PSI	SHEAR STRENGTH 10^3 PSI	RESIN CONTENT WT. %	VOID CONTENT VOL. %	THICKNESS PER PLY INCHES		COMMENTS
	1 Max.	195.0 Min.	17.5 Min.	14.0 Min.	28 to 34	1 Max.			
		207.9 195.3 170.2	19.7 19.2 17.7	15.0 15.9 15.9 16.4			0.00588 0.00613 0.00565		
		191.1	18.8	15.8			0.00589		
		201.2 229.9 199.1	18.8 22.2 19.3	16.3 16.0 15.9 16.3			0.00545 0.00550 0.00525		
		210.1	20.1	16.1			0.00540		
		205.5 196.2 188.1	20.2 19.1 22.9	16.3 14.9 16.5 14.7			0.00538 0.00568 0.00469		
		196.6	21.1	15.6			0.00525		
		184.2 194.1 191.9	18.4 18.3 19.4	16.5 15.3 16.2 15.5			0.00563 0.00575 0.00494		
		190.1	18.7	15.9			0.00543		

RESSIVE RESULTS.

MEETS SPFC. ☐ DOES NOT MEET SPEC ☐
MEETS P.O. ☒ DOES NOT MEET P.O. ☐
Q.C. REPRESENTATIVE H. M. TOELLNER
DATE: 2-9-73

TABLE BIV

PREPREG QUALITY CONTROL RECEIVING INSPECTIO

MATERIAL MODULITE 5208/II GRAPHITE/EPOXY LOT NUM

VENDOR NARMCO DATE OF

QUANTITY RECEIVED 52.28 LB NUMBER OF UNITS 14 UNIT SIZE

TEST / UNIT IDENTITY	PREPREG PROPERTIES									
	RESIN CONTENT WT. %	VOLATILE CONTENT WT. %	GEL TIME MINUTES	VISUAL	HANDLING		TENSILE STRENGTH 10^3 PSI	TENSILE MODULUS 10^6 PSI	RESIN CONTENT WT. %	VOID CONTENT Vol. %
DMS REQ'TS	39 To 45.0	3.0 Max.	18 To 26	—	—		145.0 Min.	19.0 Min.	28 To 34	1 Max.
VENDOR AVERAGE RESULTS	46.8	0.7	-	-	-		-	-	-	-
ROLL 1 -1	39.0						143.7	23.5		
-2	40.3						148.0	23.2		
-3	39.8						139.2	25.0		
-4										
-5										
AVE.	39.7	0.84	19.6				143.6	23.9		
ROLL 5 -1	41.2						156.6	21.0		
-2	40.7						146.5	21.9		
-3	40.9						149.1	20.5		
-4										
-5										
AVE.	40.9	1.31	20.4				150.7	21.1		
ROLL 10 -1	42.1						145.5	18.9		
-2	41.4						157.7	21.7		
-3							146.9	21.4		
-4										
-5										
AVE.	41.7	0.72	19.8				150.0	20.7		
ROLL 14 -1	40.6						136.0	21.6		
-2	39.7						152.7	19.1		
-3							137.0	19.8		
-4										
-5										
AVE.	40.1	0.98	21.3				141.9	20.2		
SHEET__ -1	40.6	0.96	20.3	OVERALL	AVE.		146.6	21.5		
-2										
-3										
-4										
-5										
AVE.										

REMARKS:

TABLE BIV

...EIVING INSPECTION REPORT – LOT NUMBER 407

LOT NUMBER 407	DMS 1936B	PAGE 1 OF 1	
DATE OF MANUFACTURER 5-15-73	DATE RECEIVED RI – 5/16, BALANCE – 5/18		
...IT SIZE –	S/O 16105414	P/O 3CY357583-9	

LAMINATE PROPERTIES									COMMENTS
...SIN ...TENT %	VOID CONTENT Vol. %	FLEXURAL STRENGTH 10^3PSI	FLEXURAL MODULUS 10^6 PSI	SHEAR STRENGTH 10^3 PSI	RESIN CONTENT WT. %	VOID CONTENT VOL. %	THICKNESS PER PLY INCHES		
28 to 34	1 Max.	195.0 Min.	17.5 Min.	14.0 Min.	28 to 34	1 Max.			
–	–	208.7	23.8	18.9	–	–			
		208.0 212.1 235.9	23.6 21.7 22.3	16.0 16.3 15.1			0.00506 0.00525 0.00518		
		218.7	22.6	15.8			0.00516		
		202.6 199.6 197.8	20.7 22.7 21.6	15.9 16.4 15.8			0.00534 0.00534 0.00528		
		200.0	21.7	16.0			0.00532		
		196.4 201.4 203.0	25.2 23.3 24.0	15.8 16.5 16.9			0.00491 0.00494 0.00494		
		200.3	24.2	16.4			0.00493		
		221.1 187.5 167.5	24.5 21.8 19.3	17.9 17.9 18.2			0.00513 0.00494 0.00521		NARMCO PANEL FLEXURAL ON THIS ROLL WAS 213.6 KSI
		192.0	21.8	18.0			0.00504		
		202.8	22.6	16.6					

MEETS SPEC. ☒ DOES NOT MEET SPEC ☐

MEETS P.O. ☒ DOES NOT MEET P.O. ☐

Q.C. REPRESENTATIVE H. M. TOELLNER

DATE: 5-23-73

TABLE B V

IN-PROCESS QUALITY CONTROL – PIVOT AND ACTUATOR TEST SPECIMENS

SPECIMEN IDENTITY	FLEXURAL STRENGTH KSI	FLEXURAL MODULUS MSI	SHORT BEAM SHEAR STRENGTH PSI	RESIN CONTENT WT %	VOID CONTENT VOL %
PIVOT FITTING NO. 1 – 1	71.1	7.84	8,120		
2	75.3	8.17	8,710		
3			7,740		
4			8,260		
5			8,280		
6			7,870		
AVERAGE	73.2	8.01	8,160		
PIVOT FITTING NO. 2 – 1	62.1	7.15	7,720		
– 2	70.1	7.37	8,170		
– 3	69.6	7.54	8,430		
– 4	58.1	7.47	6,880		
AVERAGE	65.0	7.38	7,800		
ACTUATOR FITTING – LE1	79.7	8.32	6,720	32.5	+1.6
LE2	77.5	8.37	6,460	28.1	+3.0
TE1	78.5	8.69	7,130	34.3	+1.5
TE2			7,260	33.0	+1.6
AVERAGE	78.6	8.46	6,890	32.0	+1.9

TABLE BVI
IN-PROCESS QUALITY CONTROL-STABILIZER UNIT TWO UPPER SKIN NUMBER ONE

SPECIMEN IDENTITY	FLEXURAL STRENGTH KSI	FLEXURAL MODULUS MSI	SHORT BEAM SHEAR STRENGTH PSI	RESIN CONTENT WT %	VOID CONTENT VOL %
LEFT SIDE – 1L	85.0	8.39	6,440	37.4	+0.9
2L	89.6	7.68	7,720	37.6	+0.9
3L	85.3	8.38	7,550	37.8	+1.1
4L	87.8	7.35	7,070	38.2	+1.0
5L			7,270		
6L			8,050		
7L			7,710		
AVERAGE	86.9	7.95	7,400	37.7	+1.0
RIGHT SIDE – 1R	81.6	7.59	3,490	35.8	+4.6
2R	75.3	7.71	3,880	36.0	+3.9
3R	62.1	7.73	4,090	35.7	+4.2
4R	76.6	7.31	3,670	35.5	+4.4
5R			3,910		
6R			4,330		
7R			4,590		
AVERAGE	73.9	7.59	3,990	35.7	+4.3

TABLE BVII
TEST RESULTS FOR BAGGING TECHNIQUE STUDY

SPECIMEN IDENTITY	FLEXURAL STRENGTH KSI	FLEXURAL MODULUS MSI	SHORT BEAM SHEAR STRENGTH PSI	RESIN CONTENT WT %	VOID CONTENT VOL %	COMMENTS
1. BAG OVER TOOL SEAL	83.5	7.47	6,140	46.1	-0.2	5–10%
	81.0	7.96	6,640	44.3	+0.5	BLEEDER
	77.6	8.33	6,340	41.6	+1.0	CLOTH
	66.4	8.27	6,130	41.1	+0.7	SATURATION
AVERAGE	77.2	8.01	6,310	43.3	+0.6	
2. BAG ON TOOL SEAL	87.7	9.23	6,620	39.2	-0.2	80–90%
	100.4	10.03	7,050	39.1	-0.0	BLEEDER
	100.6	10.85	8,330	34.6	+1.3	CLOTH
	96.6	9.64	6,850	34.8	+1.2	SATURATION
AVERAGE	96.3	9.94	7,210	36.9	+0.6	
3. ENVELOPE BAG	67.1	7.26	7,910	37.6	+0.3	100%
	71.8	6.97	6,910	38.2	+0.1	BLEEDER
	73.8	7.13	8,330	34.7	+0.5	CLOTH
	82.7	7.38	7,710	34.5	+0.8	SATURATION
AVERAGE	73.9	7.06	7,710	36.3	+0.3	

TABLE BVIII
TEST RESULTS FOR ENVELOPE BAG PANELS ON PLM

SPECIMEN IDENTITY	FLEXURAL STRENGTH KSI	FLEXURAL MODULUS MSI	SHORT BEAM SHEAR STRENGTH PSI	RESIN CONTENT WT %	VOID CONTENT VOL %	COMMENTS
1. RIGHT SIDE OF TOOL	93.6	8.96	7,810	37.7	+0.8	70% BLEEDER
	88.5	8.30	9,320	38.2	+0.9	CLOTH
	88.0	8.25	8,150			SATURATION
	78.7	9.15	8,010			
AVERAGE	87.2	8.67	8,320	37.9	+0.9	
2. CENTER OF TOOL	81.6	7.64	7,600	38.8	+1.1	40% BLEEDER
	81.4	8.04	7,470	39.4	+1.1	CLOTH
	76.5	8.03	8,100			SATURATION
	73.2	8.14	7,670			
AVERAGE	78.2	7.96	7,710	39.1	+1.1	
3. LEFT SIDE OF TOOL	89.1	7.59	7,680	35.6	+1.0	80% BLEEDER
	83.5	7.79	7,470	35.6	+0.9	CLOTH
	93.7	8.75	7,790			SATURATION
	85.2	8.66	7,860			
AVERAGE	87.9	8.20	7,700	35.6	+1.0	

TABLE BIX
IN-PROCESS QUALITY CONTROL-STABILIZER UNIT TWO LOWER SKIN

SPECIMEN IDENTITY	FLEXURAL STRENGTH KSI	FLEXURAL MODULUS MSI	SHORT BEAM SHEAR STRENGTH PSI	RESIN CONTENT WT %	VOID CONTENT VOL %
LEFT SIDE – 1L	82.8	7.37	6,830	36.7	+1.2
2L	90.5	7.75	7,110	36.1	+1.1
3L	86.0	7.99	7,060	35.5	+1.2
4L			7,320		
AVERAGE	86.4	7.70	7,080	36.1	+1.2
RIGHT SIDE – 1R	88.3	7.86	7,310	33.7	+1.8
2R	88.3	9.32	7,390	34.9	+0.8
3R	82.0	7.78	6,760	34.3	+1.6
4R			7,930		
AVERAGE	86.2	8.32	7,350	34.3	+1.4

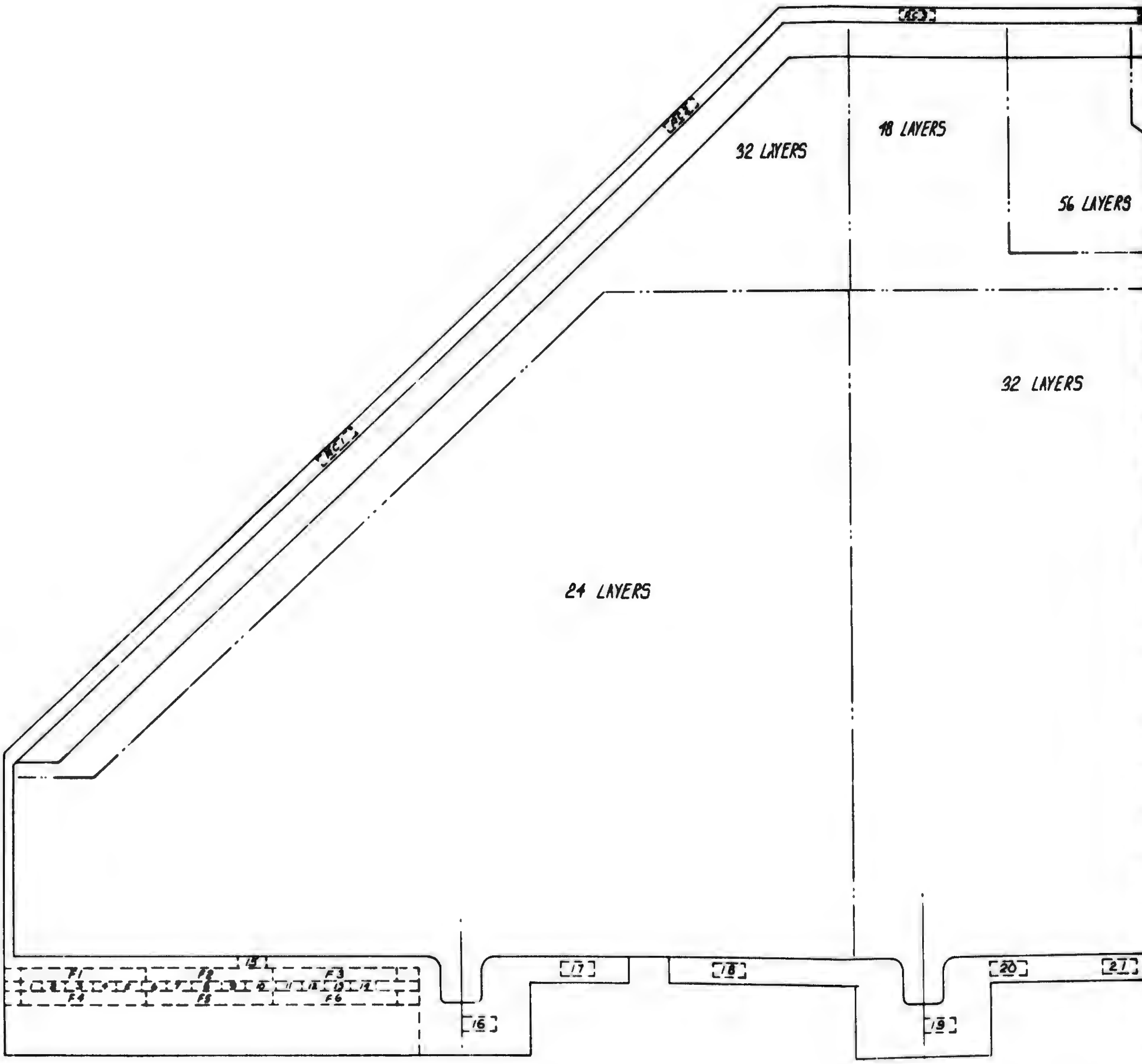
TABLE BX
IN-PROCESS QUALITY CONTROL-STABILIZER UNIT TWO UPPER SKIN NUMBER TWO

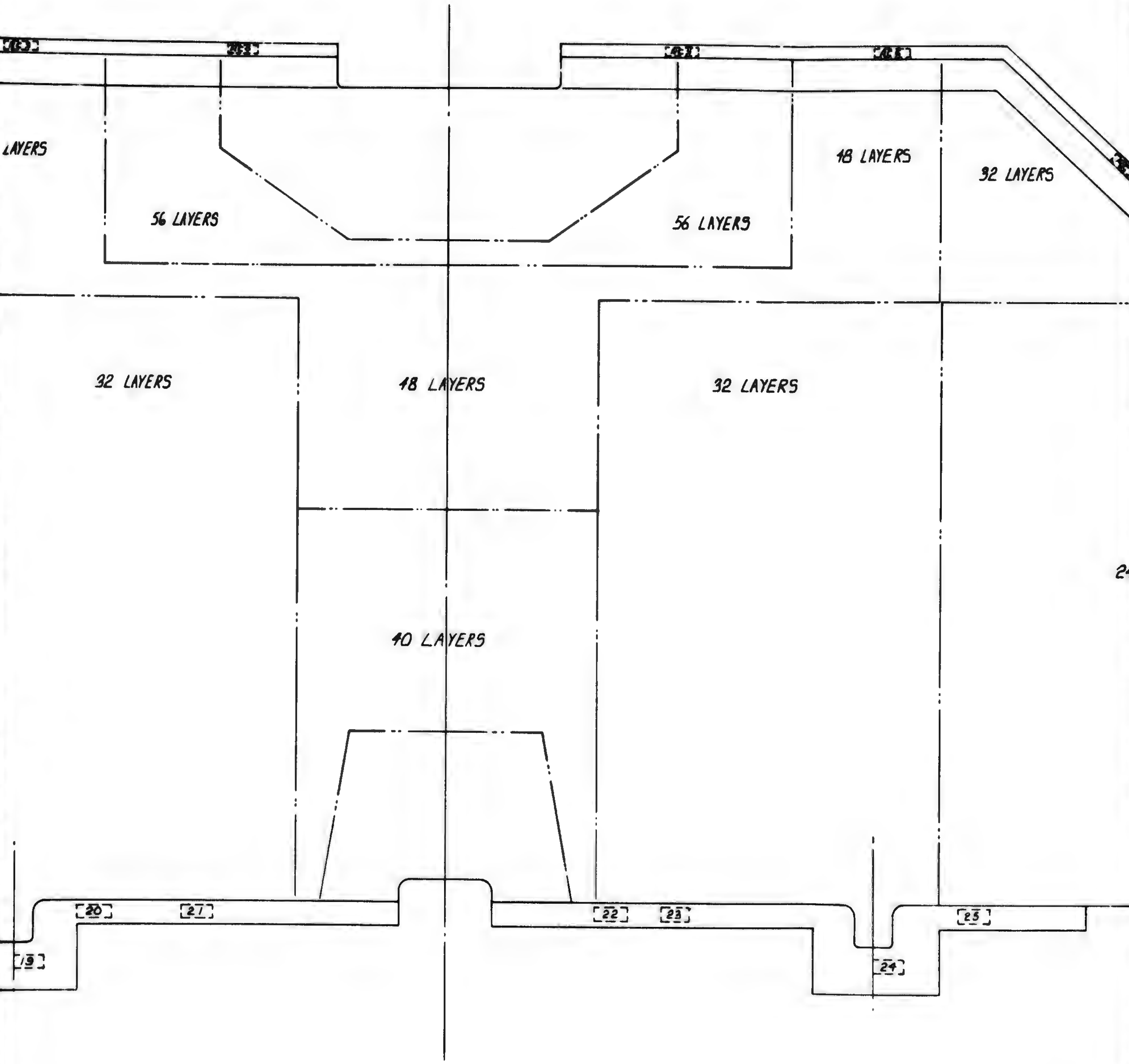
INTERLAMINAR SHEAR TESTS				
SPECIMEN IDENTIFICATION		TEST RESULT		
DWG NO. †	TEST NO.	STRENGTH KSI	RESIN WT %	VOIDS VOL %
1	---	---	---	---
2	L6D	3.6	37.8	+2.9
3	L3D	6.4	36.5	+1.0
4*	L6N	4.8	---	---
5	---	---	---	---
6	---	---	---	---
7	L5D	6.8	37.8	+0.8
8	L2D	4.0	36.5	+2.9
9	L5N	7.4	---	---
10	---	---	---	---
11	L4D	6.9	38.7	+0.2
12	L1D	3.1	41.4	+2.0
13*	L2N	9.2	---	---
14	---	---	---	---
15	L1-1	4.2	36.9	+3.6
16	L1-2	8.1	37.3	+0.7
17	L1-3	7.9	37.3	+0.7
18	L2-4	7.0	41.3	-0.5
19	L3-5	8.5	37.8	+0.6
20	L3-6	8.6	36.8	+0.8
21	L3-7	7.9	41.6	-0.9
22	R1-8	8.0	41.9	-0.9
23	R1-9	8.6	36.6	+0.6
24	R1-10	8.0	37.3	+0.6
25	R1-11	8.5	36.2	+0.7
26	R2-12	8.9	36.5	+0.5
27	R2-13	9.0	34.3	+1.6
28	R2-14	7.8	37.5	+0.6
29	---	---	---	---
30*	R4N	8.5	---	---
31	R1D	7.6	34.3	+1.0
32	R4D	7.1	39.0	+0.1
33*	R5N	8.9	---	---
34	---	---	---	---
35	R2D	7.8	36.9	+0.2
36	R5D	3.4	38.8	+2.6
37	---	---	---	---
38	---	---	---	---
39*	R6N	3.4	---	---
40	R3D	7.9	36.2	+0.1
41	R6D	6.5	37.5	+0.2

FLEXURAL TESTS					
SPECIMEN IDENTIFICATION		TEST RESULT			
DWG NO. †	TEST NO.	STRENGTH KSI	MODULUS MSI	RESIN WT %	VOIDS VOL %
F1	L1D	70.7	7.3	---	---
F2	L2D	78.1	7.7	---	---
F3	L3D	78.2	7.4	---	---
F4*	L1N	97.0	9.2	---	---
F5*	L2N	84.6	8.7	---	---
F6*	L3N	70.2	8.9	---	---
F7	R1D	78.9	7.5	---	---
F8	R2D	69.9	7.4	---	---
F9	R3D	84.5	8.1	---	---
F10*	R1N	86.7	9.0	---	---
F11*	R2N	93.6	9.9	---	---
F12*	R3N	87.7	10.0	---	---
RESIN AND VOID CONTENT TESTS					
RC1	1	---	---	38.4	+0.0
RC2	2	---	---	38.1	+0.1
RC3	3	---	---	36.5	+0.1
RC4	4	---	---	36.7	-0.0
RC5	5	---	---	36.2	+0.2
RC6	6	---	---	36.8	+0.0
RC7	7	---	---	40.5	-0.1
RC8	8	---	---	38.2	-0.3

†SEE FIGURE B1

*THESE SPECIMENS TESTED BY NARMCO MATERIALS DIVISION, THE WHITTAKER CORPORATION, COSTA MESA, CALIFORNIA


32 LAYERS
18 LAYERS
56 LAYERS
32 LAYERS
24 LAYERS
F1
F2
F3
F4
F5
F6
16
17
18
19
20
21


LAYERS
56 LAYERS
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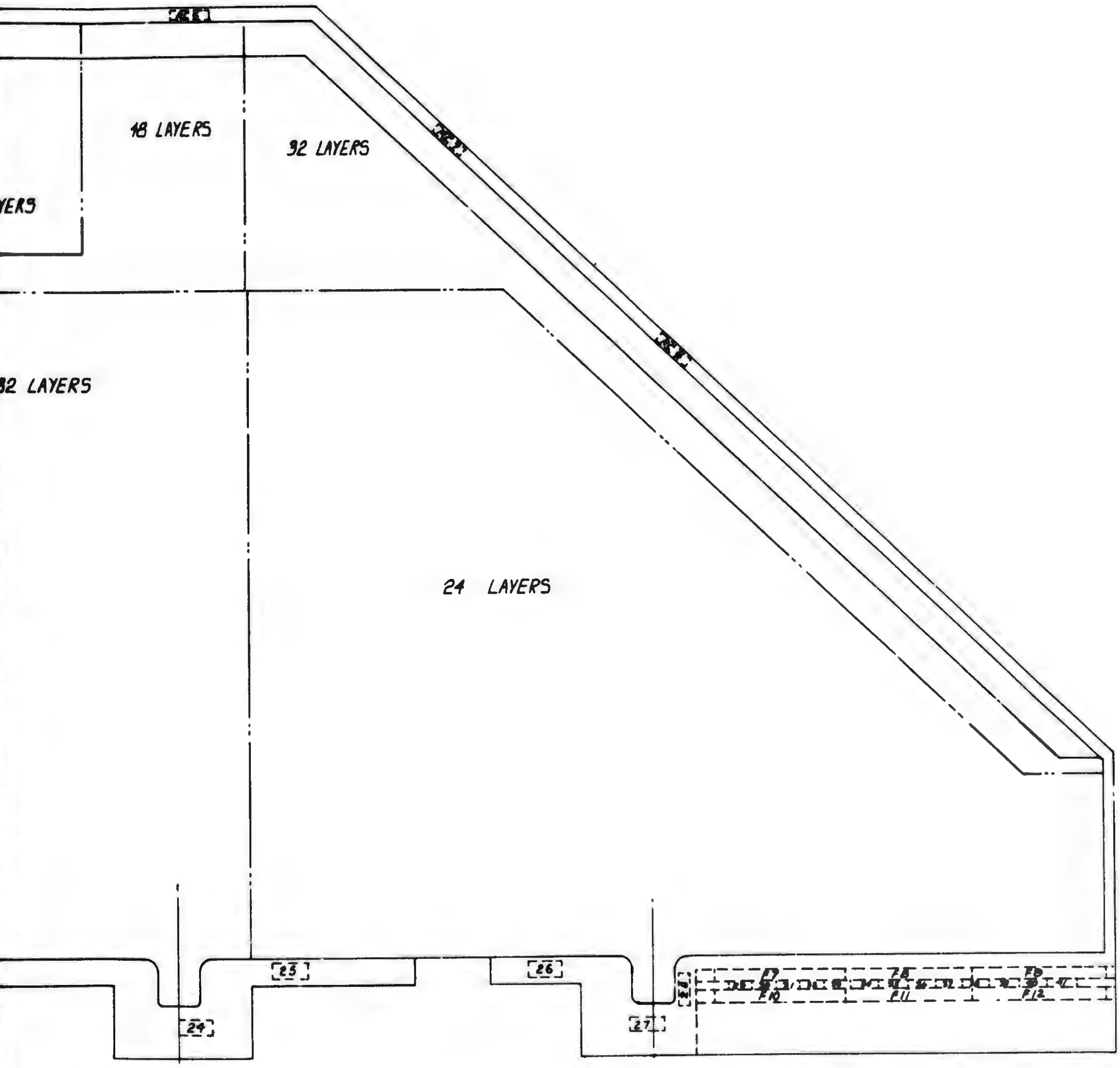


FIGURE B1. IN-PROCESS QUALITY CONTROL TEST SPECIMEN LOCATIONS FOR UPPER SKIN PANEL 'IUMBER TWO – STABILIZER UNIT TWO

APPENDIX C

TEST PLAN FOR STABILIZER UNIT TWO

The second graphite stabilizer structure will be tested statically in two critical conditions of combined torque and bending (Conditions C and D). The test setup and test procedures will be identical to the original test plan, Reference 5. Strain gages will be installed at locations shown in Figures C1 and C2, and Table CI. The internal strain-gages, Figure C1, will be installed by Douglas during construction of the stabilizer. The external strain-gages, Figure C2, will be installed by NADC prior to installation of the tension pads and whiffletree system. Displacement measurements will be determined at the points indicated in Figure C3.

The two critical conditions will be tested using the load schedule shown in Table CII. The test plan includes the following basic steps:

(1) Setup load condition "C".

(2) Apply limit load (100 percent DLL) incrementally and record data after each load increment.

(3) Relieve load and check test-theory correlation for anomalies.

(4) Change test setup to load condition "D".

(5) Apply limit load (100 percent DLL) incrementally and record data after each load increment.

(6) Relieve load and check test-theory correlation for anomalies.

(7) Increase loads uniformly and proportionally from zero to design load (150 percent DLL) at a rate of approximately one percent per second. Maintain 150 percent DLL for two seconds before relieving loads.

(8) Change test setup to load condition "C".

(9) Increase loads uniformly and proportionally from zero to design load (150 percent DLL) at a rate of approximately one percent per second. Maintain 150 percent DLL for two seconds before relieving loads.

After successful application of design load (150 percent DLL) in conditions "C" and "D", the structure will be tested in fatigue in accordance with the original test plan (Reference 5). On completion of 12,000 hours of simulated fatigue spectrum loading, the residual static strength will be determined by increasing loads uniformly and proportionally from zero to ultimate (failing) load at a rate of approximately one percent per second.

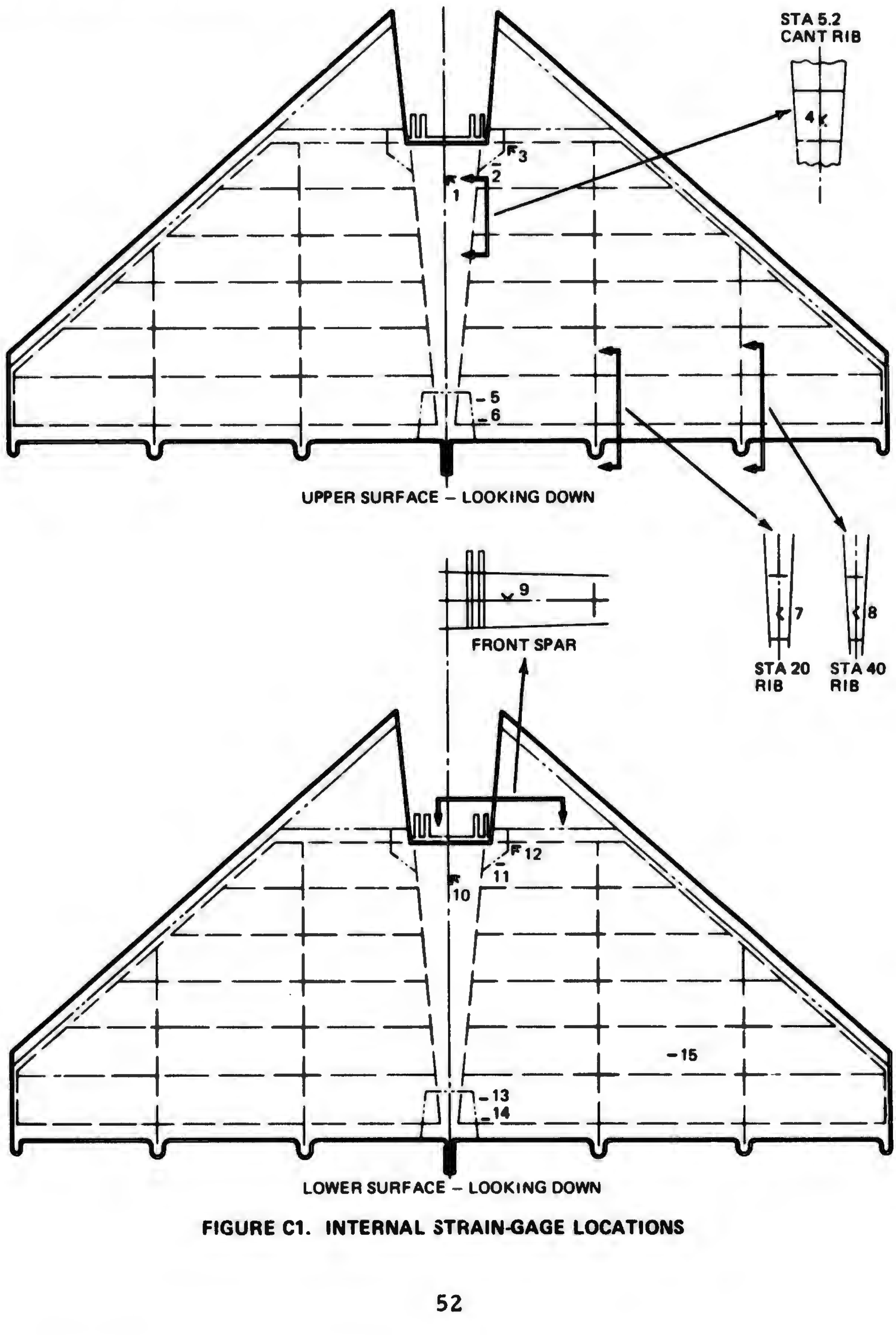


FIGURE C1. INTERNAL STRAIN-GAGE LOCATIONS

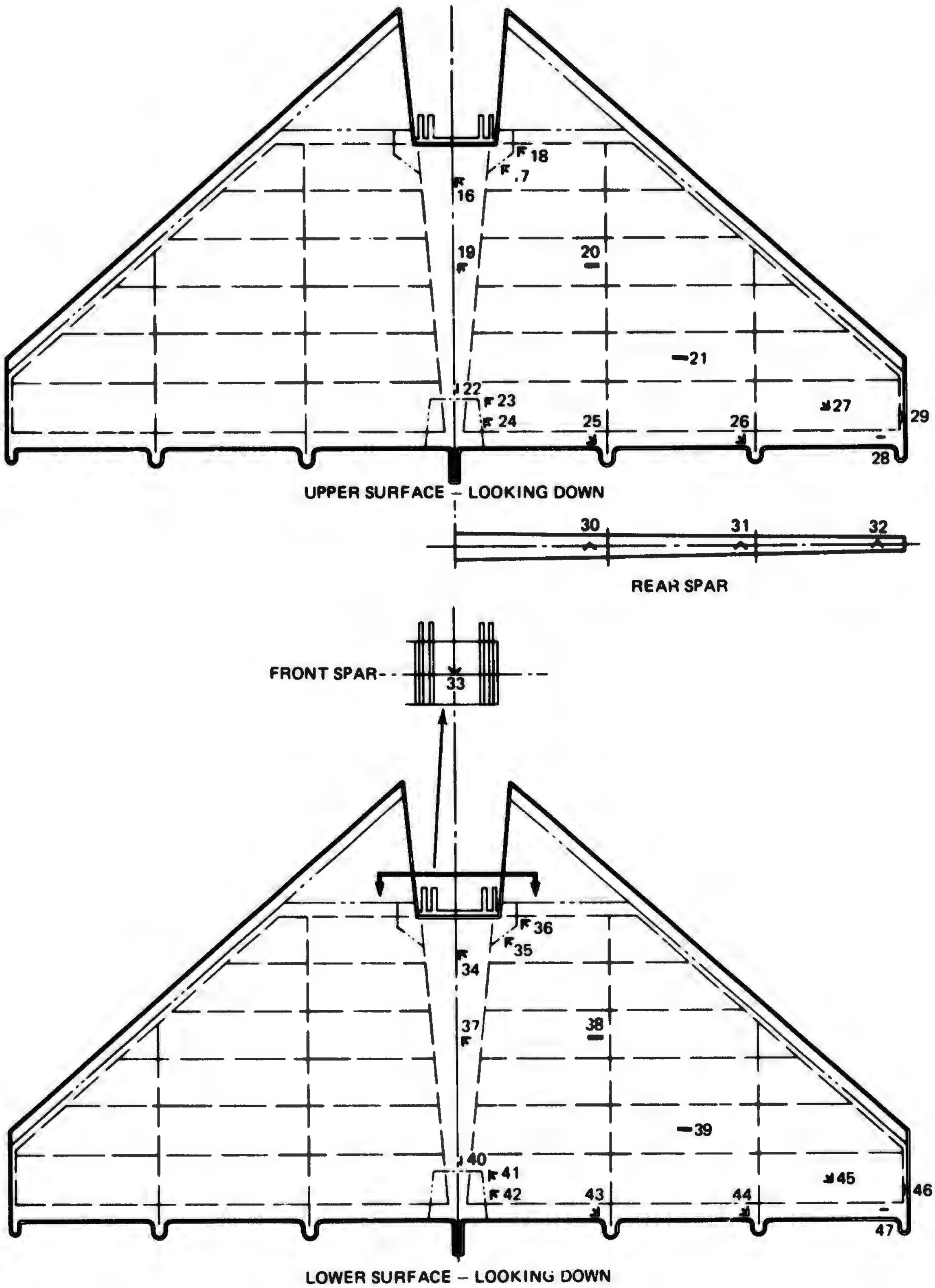
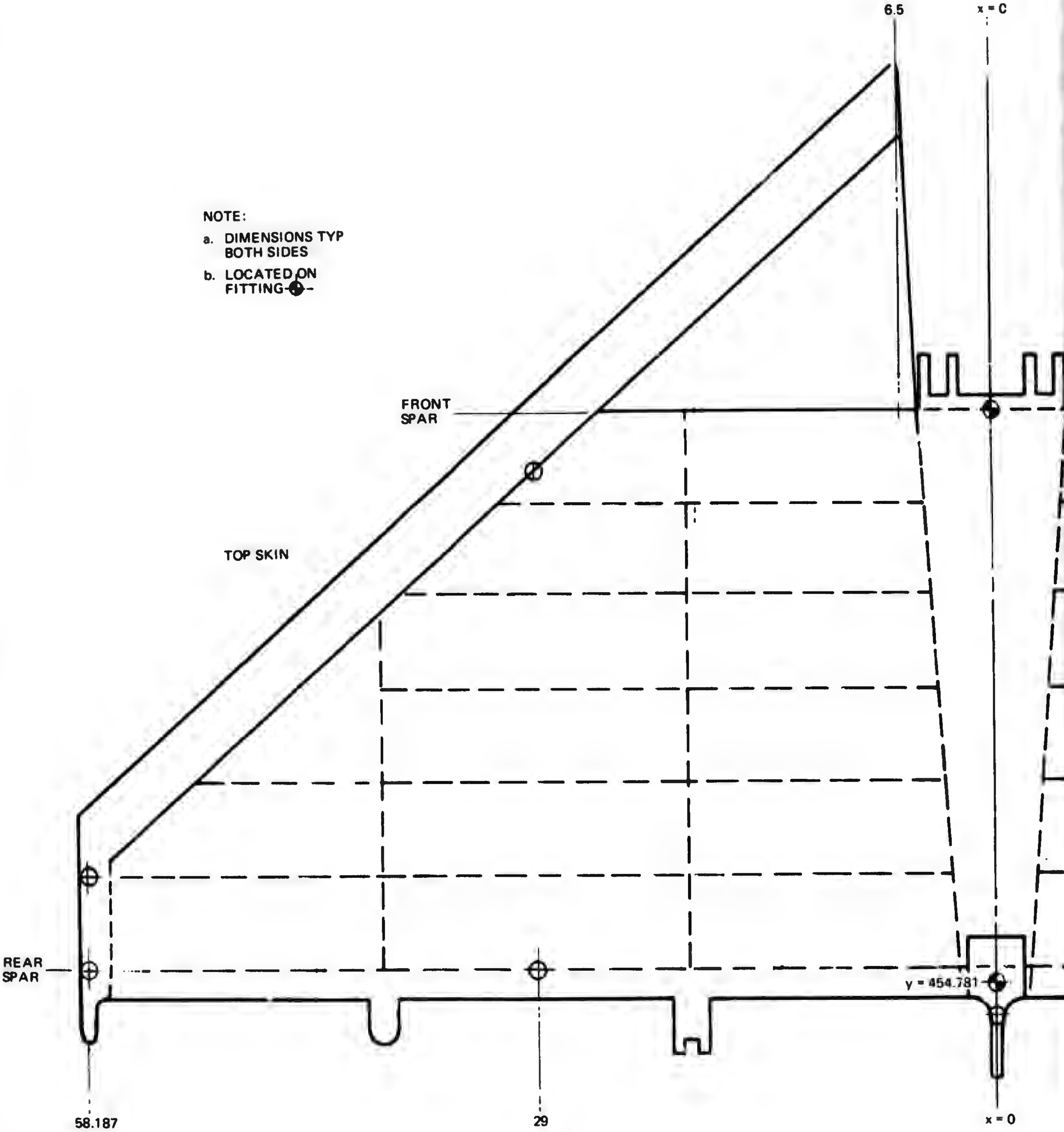


FIGURE C2. EXTERNAL STRAIN-GAGE LOCATIONS

TABLE CI
STRAIN-GAGE LOCATIONS FOR STABILIZER UNIT TWO

	GAGE	LOCATION	COORDINATES			CHANNELS
			X	Y	Z	
INTERNAL GAGES (27 CHANNELS)	1	UPPER SKIN-PIVOT DOUBLER REGION	0	423 70	–	3
	2	UPPER SKIN-PIVOT DOUBLER REGION	7.25	422.10	–	1
	3	UPPER SKIN-PIVOT DOUBLER REGION	10.12	419.50	–	3
	4	STA 5.2 CANT RIB WEB	–	426.00	0	2
	5	UPPER SKIN-ACTUATOR DOUBLER REGION	4.00	448.00	–	1
	6	UPPER SKIN-ACTUATOR DOUBLER REGION	5.25	451.00	–	1
	7	STA 20 RIB WEB	–	449.70	0	2
	8	STA 40 RIB WEB	–	449.70	0	2
	9	FRONT SPAR WEB	7.50	–	0	2
	10	LOWER SKIN-PIVOT DOUBLER REGION	0	424.81	–	3
	11	LOWER SKIN-PIVOT DOUBLER REGION	9.00	422.40	–	1
	12	LOWER SKIN-PIVOT DOUBLER REGION	10.00	419.50	–	3
	13	LOWER SKIN-ACTUATOR DOUBLER REGION	4.00	448.00	–	1
	14	LOWER SKIN-ACTUATOR DOUBLER REGION	5.25	451.00	–	1
	15	LOWER SKIN PANEL	27.00	443.68	–	1
EXTERNAL GAGES (72 CHANNELS)	16	UPPER SKIN-PIVOT DOUBLER REGION	0	423.70	–	3
	17	UPPER SKIN-PIVOT DOUBLER REGION	7.25	422.10	–	3
	18	UPPER SKIN-PIVOT DOUBLER REGION	10.12	419.50	–	3
	19	UPPER SKIN-CENTRAL	0	435.00	–	3
	20	UPPER SKIN PANEL	18.00	432.50	–	1
	21	UPPER SKIN PANEL	27.00	443.68	–	1
	22	UPPER SKIN-ACTUATOR DOUBLER REGION	0	447.37	–	1
	23	UPPER SKIN-ACTUATOR DOUBLER REGION	4.00	448.00	–	3
	24	UPPER SKIN-ACTUATOR DOUBLER REGION	5.25	451.00	–	3
	25	UPPER SKIN-STA 20 HINGE	19.00	454.37	–	3
	26	UPPER SKIN-STA 40 HINGE	39.00	454.37	–	3
	27	UPPER SKIN PANEL	50.00	449.37	–	3
	28	UPPER SKIN-STA 58 HINGE	57.34	454.37	–	1
	29	UPPER SKIN-STA 58 HINGE	57.97	452.87	–	1
	30	REAR SPAR STA 18	18.00	–	0	2
	31	REAR SPAR STA 38	38.00	–	0	2
	32	REAR SPAR STA 55	55.00	–	0	2
	33	PIVOT FITTING	0	–	0	2
	34	LOWER SKIN PIVOT DOUBLER REGION	0	424.81	–	3
	35	LOWER SKIN PIVOT DOUBLER REGION	9.00	422.40	–	3
	36	LOWER SKIN PIVOT DOUBLER REGION	10.00	419.50	–	3
	37	LOWER SKIN CENTRAL	0	435.00	–	3
	38	LOWER SKIN PANEL	18.00	432.50	–	1
	39	LOWER SKIN PANEL	27.00	443.68	–	1
	40	LOWER SKIN-ACTUATOR DOUBLER REGION	0	447.37	–	1
	41	LOWER SKIN-ACTUATOR DOUBLER REGION	4.00	448.00	–	3
	42	LOWER SKIN-ACTUATOR DOUBLER REGION	5.25	451.00	–	3
	43	LOWER SKIN-STA 20 HINGE	19.00	454.37	–	3
	44	LOWER SKIN-STA 40 HINGE	39.00	454.37	–	3
	45	LOWER SKIN PANEL	50.00	449.37	–	3
	46	LOWER SKIN-STA 58 HINGE	57.97	452.87	–	1
	47	LOWER SKIN-STA 58 HINGE	57.34	454.37	–	1


6.5
x = C
NOTE:
a. DIMENSIONS TYP BOTH SIDES
b. LOCATED ON FITTING
FRONT SPAR
TOP SKIN
REAR SPAR
y = 454.781
58.187
29
x = 0

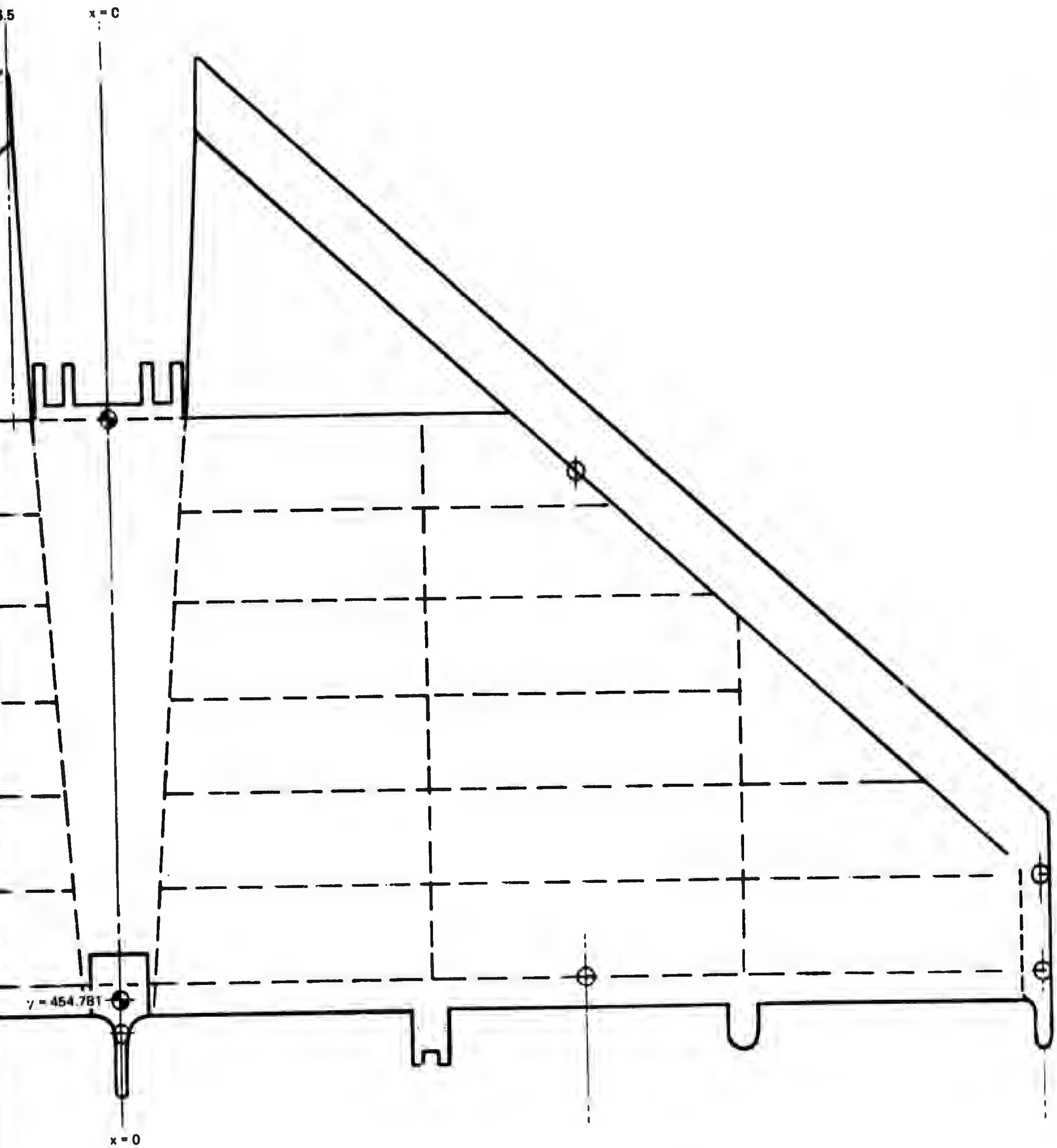


FIGURE C3. DISPLACEMENT MEASUREMENT LOCATIONS

STATIC

LOAD INCREMENT	CONDITION	LOAD (% DLL)	STABILIZER LOADS, F_S			
			HIGH LOAD SIDE (RH)		LOW LOAD SIDE (LH	
			MAGNITUDE (LB)	β (DEG)	MAGNITUDE (LB)	β (DEG
1	C	20	1,016	98.60	364	67.15
2		40	2,032		728	
3	MAXIMUM	0	0		0	
4	ELEVATOR	20	1,016		364	
5	LOADS	40	2,032		728	
6		60	3,047		1,093	
7		80	4,063		1,457	
8		100	5,079		1,821	
9	D	20	3,858	79.84	1,315	74.34
10		40	7,716		2,629	
11	MAXIMUM	0	0		0	
12	STABILIZER	20	3,858		1,315	
13	LOAD	40	7,716		2,629	
14		60	11,575		3,944	
15		80	15,433		5,258	
16		100	19,291		6,573	
17		0	0		0	
18		0 TO 150%	0 TO 28,936		0 TO 9,860	
19		150% TO 0	0		0	
20	C	0 TO 150%	0 TO 150%	98.60	0 TO 150%	67.15

*ASSUMING RIGID SUPPORTS

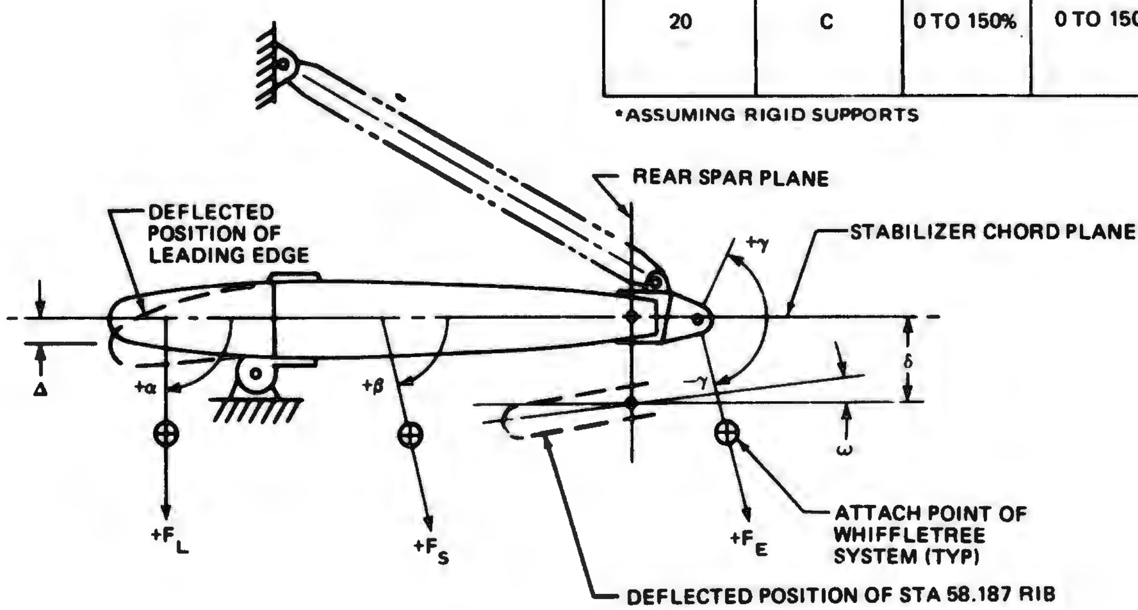


TABLE CII
STATIC TEST LOAD SCHEDULE FOR STABILIZER UNIT TWO

R LOADS, F_S		ELEVATOR HINGE LINE LOAD, F_E		DEFLECTIONS* STA 58.187 RIB				REMARKS
LOW LOAD SIDE (LH)				HIGH LOAD SIDE		LOW LOAD SIDE		
MAGNITUDE (LB)	β (DEG)	MAGNITUDE (LB)	γ (DEG)	δ (IN.)	ω (DEG)	δ (IN.)	ω (DEG)	
364	67.15	3,117	70.10	0.58	−0.58	0.018	−0.19	
728		6,234		1.17	−1.52	0.035	−0.38	
0		0		0	0	0	0	
364		3,117		0.58	−0.77	0.018	−0.19	
728		6,234		1.17	−1.52	0.035	−0.38	
1,093		9,350		1.75	−2.30	0.053	−0.57	
1,457		12,467		2.34	−3.05	0.071	−0.77	
1,821		15,584		2.92	−3.83	0.089	−0.97	CHANGE TEST SETUP
1,315	74.34	341	−79.75	0.31	−0.07	−0.015	0	
2,629		682		0.62	−0.14	−0.030		
0		0	(UP AND	0	0	0		
1,315		341	AFT)	0.31	−0.07	−0.015		
2,629		682		0.62	−0.14	−0.030		
3,944		1,022		0.93	−0.21	−0.045		
5,258		1,363		1.23	−0.28	−0.060		
6,573		1,704		1.54	−0.34	−0.075		
0		0		0	0	0		
0 TO 9,860		0 TO 2,556		0 TO 2.30	0 TO −0.51	0 TO −0.112		INCREASE APPLIED LOADS UNIFORMLY AND PROPORTIONALLY AT 1PERCENT PER SECOND.
0		0		0	0	0		RELIEVE LOADS AND CHANGE TEST SETUP.
0 TO 150%	67.15	0 TO 150%	70.10	–	–	–	–	INCREASE APPLIED LOADS UNIFORMLY AND PROPORTIONALLY AT 1 PERCENT PER SECOND

REFERENCES

1. "Development of a Graphite Horizontal Stabilizer", Sixth Interim Technical Report for Contract N00156-70-C-1321, McDonnell Douglas Corporation, Report MDC J5841, January 1973.
2. Pickard, J., "FORMAT-FORTRAN Matrix Abstraction Technique", AFFDL TR-66-203, October 1968.
3. Hart-Smith, L. J., "Analysis and Design of Advanced Composite Bonded Joints", NASA CR-2218, Final Report for Contract NAS1-11234, January 1973.
4. "Development of a Graphite Horizontal Stabilizer", Fourth Interim Technical Report for Contract N00156-70-C-1321, McDonnell Douglas Corporation, Report MDC J5317, February 1972.
5. "Development of a Graphite Horizontal Stabilizer", Third Interim Technical Report for Contract N00156-70-C-1321, McDonnell Douglas Corporation, Report MDC J5169, July 1971.