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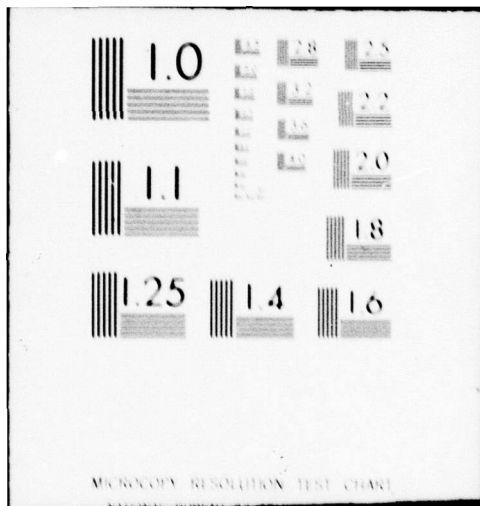
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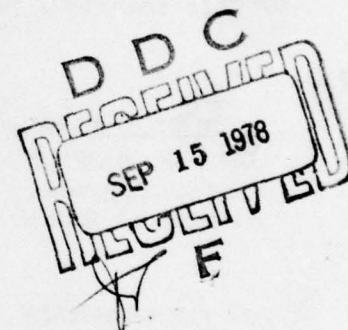
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FEBRUARY 1978

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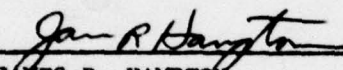
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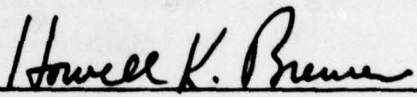
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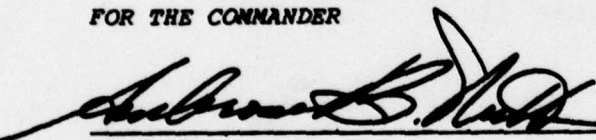


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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report covers the work performed through Phase I under Air Force Contract F33615-76-C-3021, "New Concepts in Composite Material Landing Gear for Military Aircraft." The effort during Phase I included the selection of the landing gear system to be studied, the documentation of the baseline requirements and constraints data, the conceptual design and evaluation of three distinct concepts having different constraints, plans for 1/5 scale models, and methodology to be used during the Phase II section of the program. (Cont'd on Reverse)		

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Phase II of this program will include preliminary designs for complete landing gear system for all three concepts, the construction of the 1/5 scale working models of the Concept 2 and Concept 3 designs, cost and weight comparisons of each concept and preparation of data plots to illustrate the weight, cost, and life-cycle cost advantages of composite material hardware for landing gear.

The B-1 Nose Landing Gear has been used as the baseline and the hardware has been modified to use composite material for structural parts under the three different degrees of constraint. Concept 1 was constrained by "form, fit and function"; Concept 2, by "fit and function"; and Concept 3 by only the "function" constraint.

Concept 1, substitution (form, fit and function) parts have been designed and some have composite material spliced to metal end fittings to meet the high load requirements within the form constraint. These designs were not weight effective.

Concept II, modified (fit and function) parts, using existing structural attachments, but revised kinematics, have been designed to foster increased usage of composites. The piston and lower end of the strut cylinder have been kept metallic since the larger diameter required for composite parts would result in spreading the wheels which would violate the stowage limit constraints. Increased usage of composites and improved weight effectivity was gained by reducing the constraints.

Concept III, redesigned (function) parts utilize a system which requires a slightly larger wheel well bay to accommodate the revised nose gear. This allowed the wheels to be positioned farther apart to allow room for a composite axle, piston and strut. This further reduction in constraints allowed more parts to be made from composites and further increased weight effectivity.

The methodology section of this report shows the approaches, methods and comparisons which will be used during Phase II to determine the pay-offs possible through the maximum usage of composite material in a landing gear system.

FOREWORD

This is Volume II, Appendices, of a two volume Final Report which was prepared by the Los Angeles Division of Rockwell International, Los Angeles, California, under United States Air Force Contract F33615-76-C-3021, Air Force Project No. 2402, Task No. 240201, "New Concepts in Composite Material Landing Gear for Military Aircraft." The program is being administrated by the Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, under the direction of Mr. J. Hampton (AFFDL/FEM).

This volume contains the Appendices to Volume I, the final report, covering work performed from April 1976 through February 1978. Volume I of the report contains the technical discussion. Rockwell International personnel directly participating on the program were:

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The report was submitted in February 1978.

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PHASE I REPORT
NEW CONCEPTS IN COMPOSITE
MATERIAL LANDING GEAR
FOR MILITARY AIRCRAFT

SECTION I

INTRODUCTION

Composite materials have outstanding strength and stiffness characteristics which can be used advantageously in the design of landing gear hardware. The objective of this program was to explore the extent to which composite material could be used in a complete landing gear system, and the cost and weight benefits that could result from this usage.

The Air Force, through AFFDL, has sponsored a number of successful composite landing gear hardware programs. These have established the feasibility of using composite material for certain landing gear components, but all hardware designed was constrained by "form, fit and function." This program has three separate sections so that hardware was designed under three distinct levels of constraint. The first is "Substitution," with "form, fit and function" constraints. The second section is "Modification" with both "fit and function" constraints. The third section is "Redesign" with only the "function" constraint.

This program is phase oriented with this report covering Phase I. Phase II will not be started until this report and a presentation of its contents is approved by the Air Force. A Phase I and Phase II task flow diagram is shown in figure 1.

The approach used for the Phase I section followed the task outline shown in figure 1 and resulted in the choice of the B-1 Nose Landing Gear, see figure 2, as the baseline. Conceptual designs for composite landing gear hardware were then developed for each section and level of constraint as described above. Methodology to be used in the Phase II preliminary design and to be used in generating data plots to illustrate the advantages of composite landing gear hardware has been determined and documented in the Methodology Section.

Evaluations of the design concepts created in this phase were then used as the basis for recommendations of concepts which should be carried into Phase II for preliminary design effort.

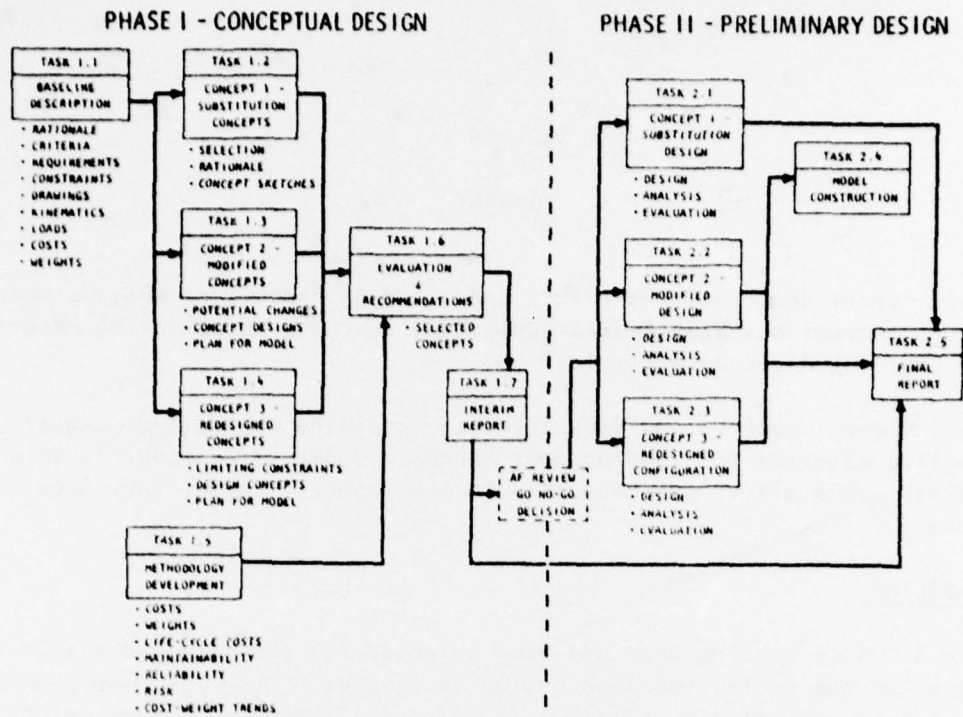


Figure 1. Task Flow Diagram

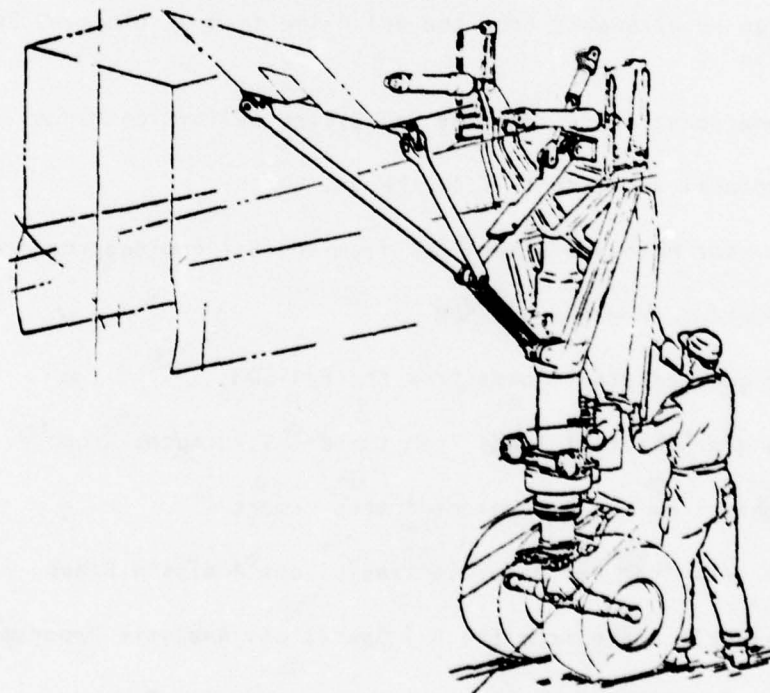


Figure 2. B-1 Nose Landing Gear

SECTION II

SUMMARY

This report describes the effort conducted on Phase I of the two-phase Air Force Contract No. ~~F33615-76-C-3021~~, "New Concepts in Composite Material Landing Gear for Military Aircraft."

This Phase I section was structured to determine the maximum practical use of composite material for landing gear hardware under three specific sets of constraints. The effort was conducted in accordance with the Task Flow Diagram of Figure 1.

2.1 BASELINE

The B-1 Nose Landing Gear has been selected for the baseline system and rationale for the selection made on the basis that it meets contract requirements; it is a current Air Force airplane (over 175,000 lbs. gross weight) and is completely described by the information listed below:

1. Design criteria from MIL-A-8862
2. Design requirements from the B-1 Prime Item Development Specification
3. Volume constraints from the B-1 System Definition Manual (SDM)
4. Structural attachments from the B-1 SDM
5. Nose gear hardware dimensions from the B-1 Engineering drawings
6. Kinematics from the B-1 SDM
7. Nose gear external loads from the B-1 SDM
8. Nose gear internal loads from the B-1 Structures Group
9. Weights from the B-1 Weight Status report
10. Cost data from B-1 Major Contracts Cost Analysis Group
11. Life-cycle costs from the B-1 Operations Analysis Program
12. Maintainability from the Integrated Logistics Program

13. Environmental data from the B-1 SDM

14. Reliability data from the B-1 Reliability Program

2.2 DESIGN CONCEPTS

The Design Concepts section of this program resulted in the selection of intermediate strength graphite/epoxy as the baseline composite material for use in the design studies. The three design sections included:

1. Substitution, constrained by form, fit and function;
2. Modified, constrained by fit and function, and
3. Redesigned, constrained by function only.

These designs were qualitatively evaluated by the experts in materials, structures, fabrication, weights and cost and a summary of these evaluations is presented in section VI, page 92. A summary of conclusions reached appears with the sections below.

2.2.1 Concept 1 - Substitution

Baseline information and drawings of B-1 nose gear metallic hardware was studied and conceptual design drawings were made for composite and composite/metal parts which have identical key dimensions, and can be substituted on a part-for-part basis for the baseline metallic hardware. Some of these concepts were designed to have composite material spliced to metallic end fittings to meet the high load requirements within the form constraint. Table I lists the parts designed in this section. All parts except the torque links (very high technical risk) are recommended for further effort in Phase II.

2.2.2 Concept 2 - Modified

Existing structural attachments were used, but kinematics of the drag braces and down lock links were revised to allow increased usage of composites. It was determined that for this concept the piston and the lower end of the strut cylinder must remain metallic since the larger diameter required for composite parts would result in having to spread the nose wheels and this would violate the stowage limit (fit) constraint. Table II lists the parts designed in this section. All listed parts are recommended for further effort in Phase II.

TABLE 1
SUMMARY
CONCEPT 1 - SUBSTITUTION

PART	PART DESCRIPTION	REMARKS
Drag Brace - Fwd.	Composite tube with metal end fittings.	Recommended for Phase II
Drag Brace - Aft.	Composite "I" Beam with metal end fittings.	Same
Down Lock - Fwd.	Inverted "U" section all composite part.	Same
Down Lock - Aft.	Composite "I" section with one metal end fitting.	Same
Torque Link	All composite solid section	Very high technical risk. Part not recommended.
Strut-A-Trunnion Arms	Composite Trunnion Arms section including actuator arms bonded to metal strut	Very high technical risk. Part not recommended
Strut-B-Trunnion Arms	Two Composite Box section torque arms bolted to metal strut and actuator arms	Recommended for Phase II
Wheels	All composite. Two-piece dish shaped.	Same

TABLE II
SUMMARY
CONCEPT 2 - MODIFIED

PART	PART DESCRIPTION	REMARKS
Drag Brace - Fwd.	All composite box sections with "racetrack" caps.	Recommended for Phase II
Drag Brace - Aft	All composite box sections with "racetrack" caps.	Same
Spreader Bar- (Drag Brace)	Composite tube with metal end fittings.	Same
Down Lock - Fwd.	All composite "I" section with "racetrack" caps.	Same
Down Lock - Aft	All composite "I" section with "racetrack" caps.	Same
Torque Link	All composite-solid section No base lugs	Same
Strut-Trunnion Arms	Trunnion arms-flattened cone shape metal strut and actuator arms.	Same
Wheels	All composite 3-piece with rims and drum	Same

2.2.3 Concept 3 - Redesigned

Studies were made to evaluate the use of landing gear concepts which were allowed to differ from the baseline system in kinematics, attachment location and storage volume, see Table III. A "leaf"spring" concept, shown in figure 35 was evaluated as a very high technical risk and not weight effective. On that basis, effort on this concept was stopped. The size of the B-1 nose gear is an important factor against usage of this concept, but the "leaf spring" nose gear configuration may prove to be a viable weight effective system on a smaller fighter airplane.

TABLE III
SUMMARY

CONCEPT 3 - REDESIGNED

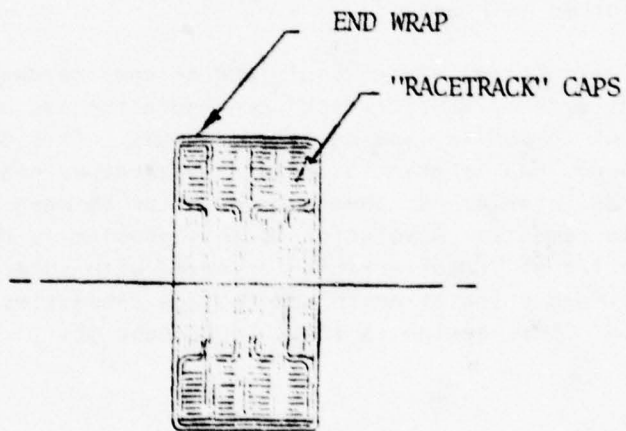
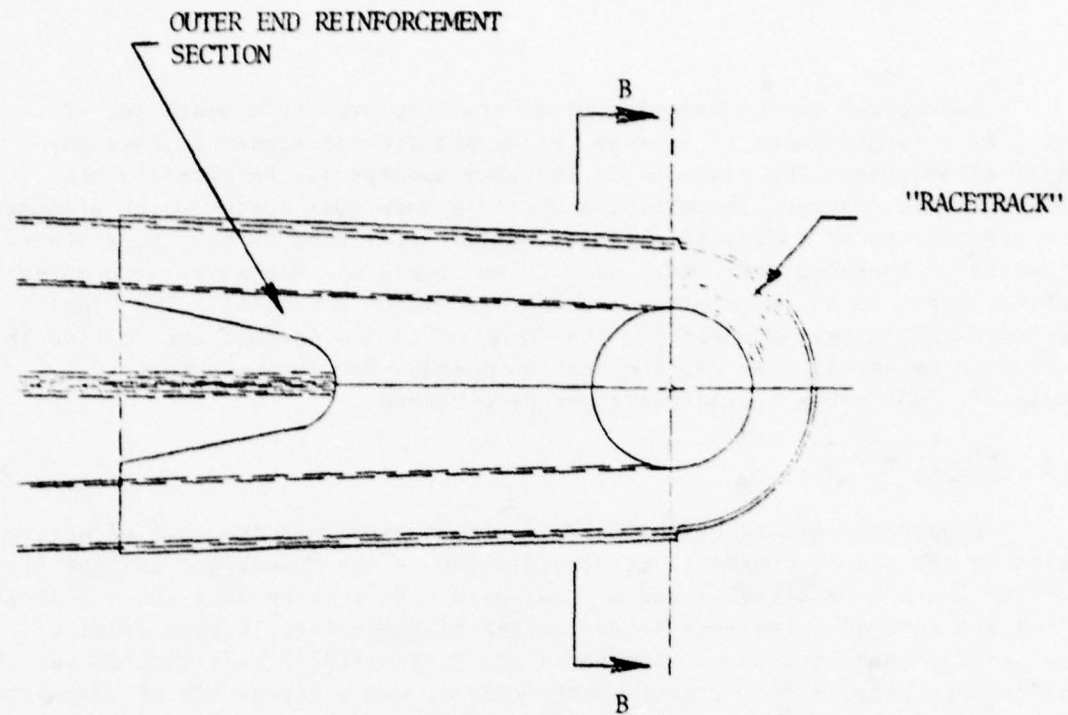
PART	PART DESCRIPTION	REMARKS
"Leaf Spring" Concept	Laminated composite leaves with resilient plastic inter-layers between leaves.	Very high technical risk - no weight advantage - not recommended.
Drag Brace - Fwd. (3-B Concept)	All composite "H" section with "racetrack" caps and stiffener clips.	Recommended for Phase II
Drage Brace - Aft (3-B Concept)	Same	Same
Spreader Bar (Drag Brace)	Composite tube and end fittings.	Same
Down Lock - Fwd.	All composite "I" section with "racetrack" caps.	Same
Down Lock - Aft	Same	Same
Torque Link	All composite with solid section and no lugs on base.	Same
Strut - Complete	Composite inner pressure cylinder, outer flattened cone shaped trunnion arms and lugs.	Same
Piston	Composite pressure cylinder and axle attach lugs.	Very high technical risk. Part not recommended.
Axle	Composite cylinder with metal wheel retainer.	Recommended for Phase II.
Wheel	All composite 2-piece with integral bolt spacers.	Same

A conceptual design was made of a "trailing arm" nose gear, but it requires a large change in storage volume and did not appear to have any major advantages. The study using the same concept as the baseline and only slightly changed kinematics, provided a nose gear system which allowed the maximum use of composite material while restricting changes to a minor widening of the nose gear wheel well. The wheels on this study were moved farther apart to allow room for a composite piston and strut. The "leaf spring" landing gear concept and the "piston" on 3-A concept are considered very high technical risk and are not recommended for further effort in Phase II. All other listed parts are recommended.

2.3 RESULTS

The general results of the Phase I effort show that the most effective gains in the use of composite structure occur in the "Redesign" Concept 3, section where more design freedom is allowed. This is because space limitations are removed which restrained the use of composites in some areas of the landing gear structure. Concept 1 and 2 resulted in more compromises in the design, because of increased restrictions, and a lesser use of composite structure; however, the concepts developed will still generally result in cost effective hardware, but to a lesser extent, based on the limited evaluation performed in Phase I.

Many structural elements of landing gear hardware are axially loaded and the weight effective "racetrack" configuration was used similar to that used in previous composite landing gear programs. This configuration, as previously used, has inherent structural weaknesses near the end of the member where large interlaminar shear forces occur between the "racetrack" and the web reinforcements. A solution to this problem is shown in figure 3, which uses a series of "racetracks" interleaved with shear webs which should significantly improve the strength and fatigue properties of the "racetrack" configuration. This design is shown in Concept 3b.



SECTION B - B
 END SECTION WITH SEGMENTED
 "RACETRACK" CAPS & LAMINATED
 REINFORCEMENT.

Figure 3. Structural Concept For Axially
 Loaded Struts

SECTION III

BASELINE

The B-1 nose landing gear installation consists of a semicantilevered shock strut with twin wheels and tires, a steering damping unit, and strut fairing doors. The shock strut is a dual chambered air-oil piston type. The forward retracting nose gear is attached to fuselage structural beams by a journaled trunnion at the top of the strut, and by a forward mounted folding drag brace. With the gear in the down and locked position, the drag brace is held in the on-center position by a jury strut downlock at the apex of the drag brace. A spring bungee holds the jury strut in its locked position. The nose gear strut incorporates a centering cam to center the nose wheels automatically and hold them centered while the shock strut is extended.

3.1 RATIONALE FOR SELECTION

The B-1 nose landing gear was selected as the baseline system for this program for the following reasons:

- ° The B-1 meets contract requirements for a baseline landing gear system.
- ° It is a current Air Force aircraft. Three aircraft are currently being flight tested, and production is expected to start late in 1976.
- ° The B-1 gross weight is 395,000 pounds which is over twice the contract minimum requirement of 175,000 pounds gross weight.
- ° The design requirements and constraints for the B-1 nose landing gear are available from the B-1 Prime Item Development Specification and the B-1 System Definition Manual.
- ° B-1 Division engineering drawings, layouts and vendor drawings are available to define the Air Vehicle (A/V) No. 4 nose landing gear hardware.
- ° The B-1 nose gear is relatively simple and provides a baseline system which can be readily handled within the scope of this program.
- ° Production of the B-1 nose gear for A/V No. 4 has not yet started, so changes as a result of this or possible follow-on programs could be implemented early in the production run.

- ° The B-1 contract is expected to reach a total of 240 aircraft, thus, cost savings in the nose gear could result in large total savings over the life of the program.
- ° The proximity of the B-1 design section makes the nose gear designers readily available for consultation.
- ° Cost and weight data for the baseline is readily available, and B-1 experts can be contacted for assistance on weight and cost estimates for the new hardware.

3.2 BASELINE DESCRIPTION

The data presented in this section completely describes all the design parameters and constraints which were used in the development of the current B-1 A/V No. 4 nose gear system design.

3.2.1 Design Criteria

The B-1 nose landing gear has been designed to comply with the landing and ground handling loads requirements of MIL-A-8862. This specification is not included with this report since it is readily available.

3.2.2 Design Requirements

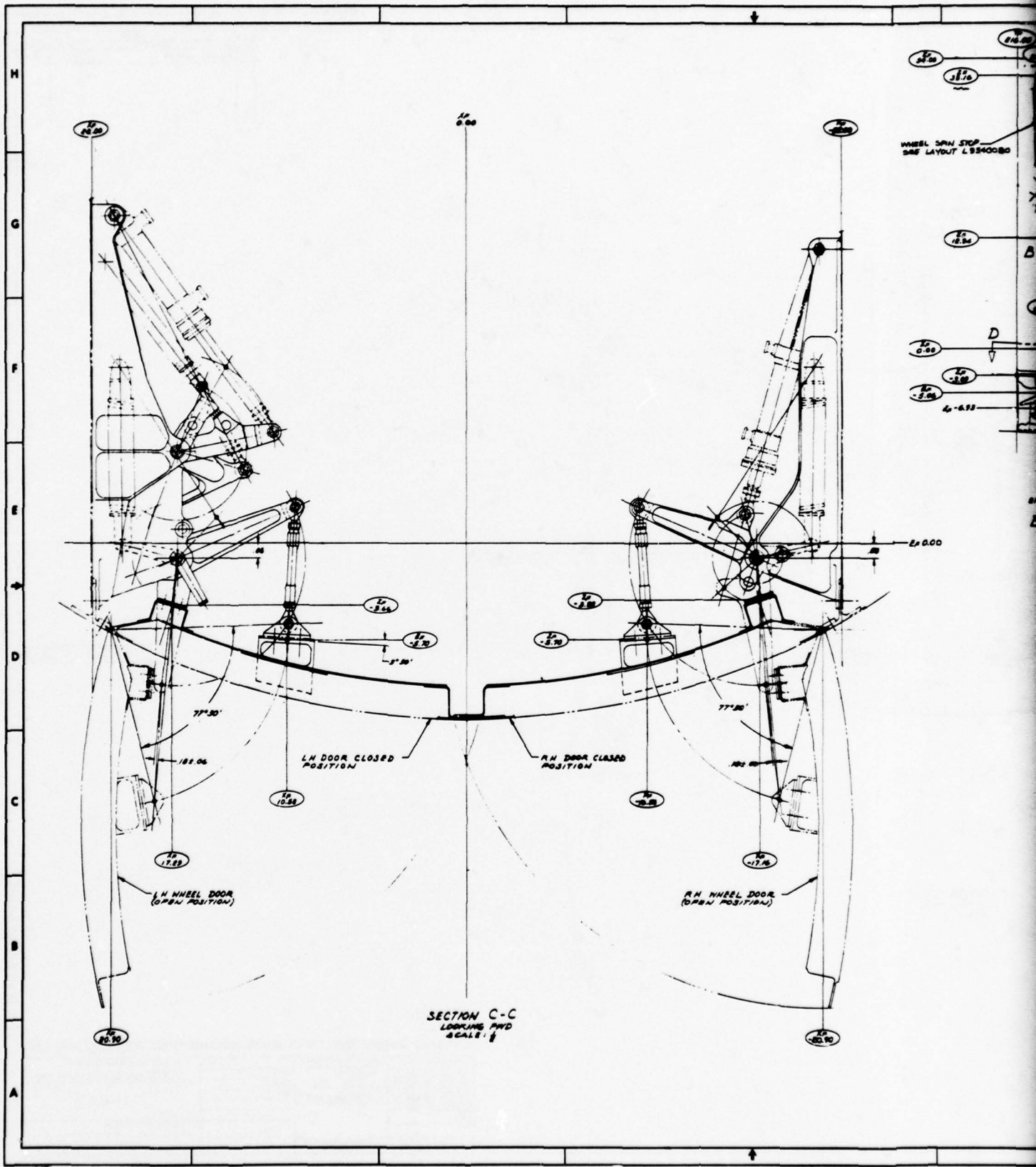
The B-1 design requirements from the Prime Item Development Specification (CP109L20018) are presented in Appendix B.

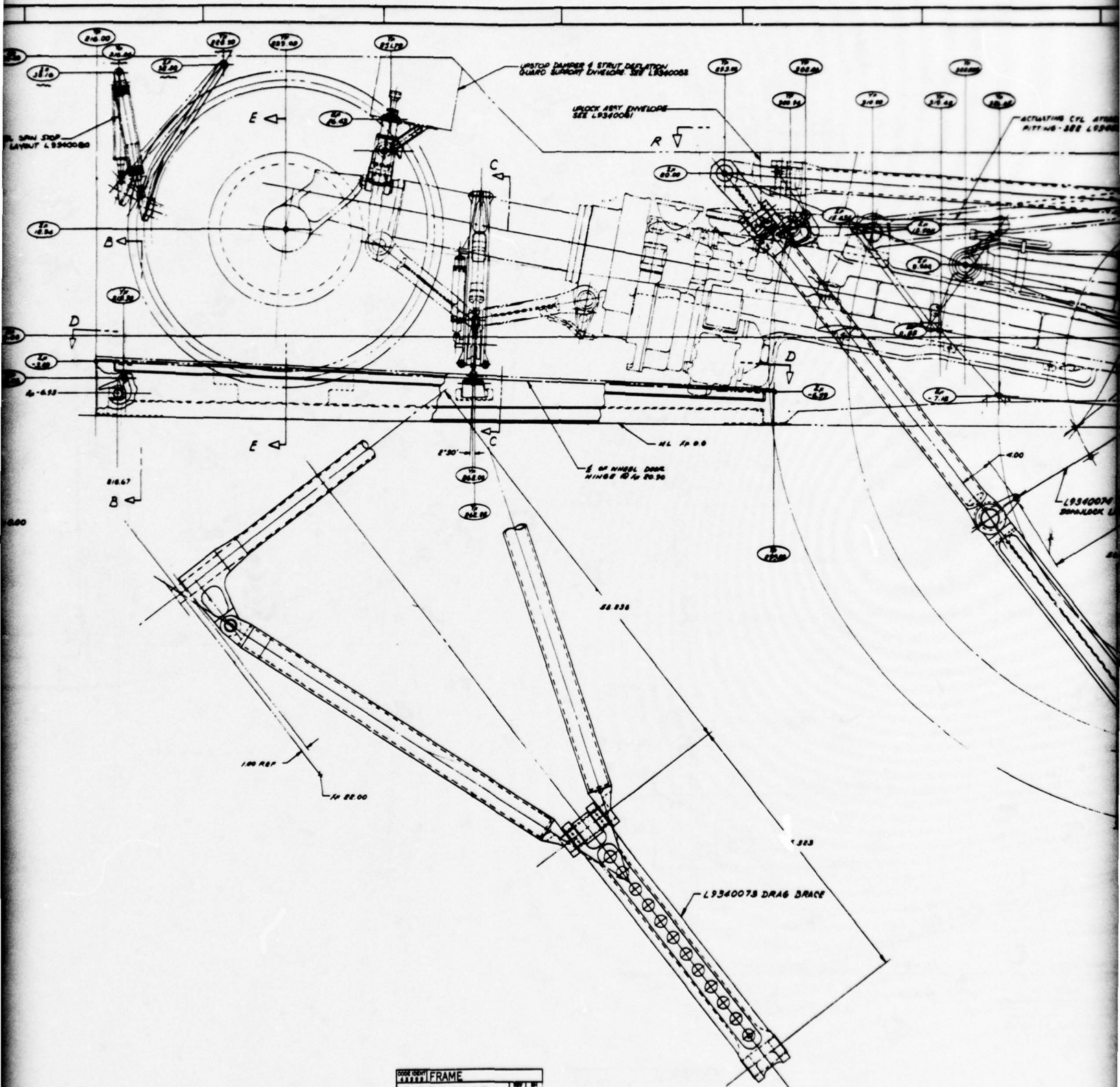
3.2.3 Dimensional Constraints

The B-1 System Definition Manual (NA-69-190-2) describes the dimensional constraints associated with the nose gear system. The volume constraints, structural attachments and kinematics are shown on drawing L9340068, sheets 1, 2 and 3 (figures 4, 5, and 6).

3.2.4 Metallic Hardware Dimensions

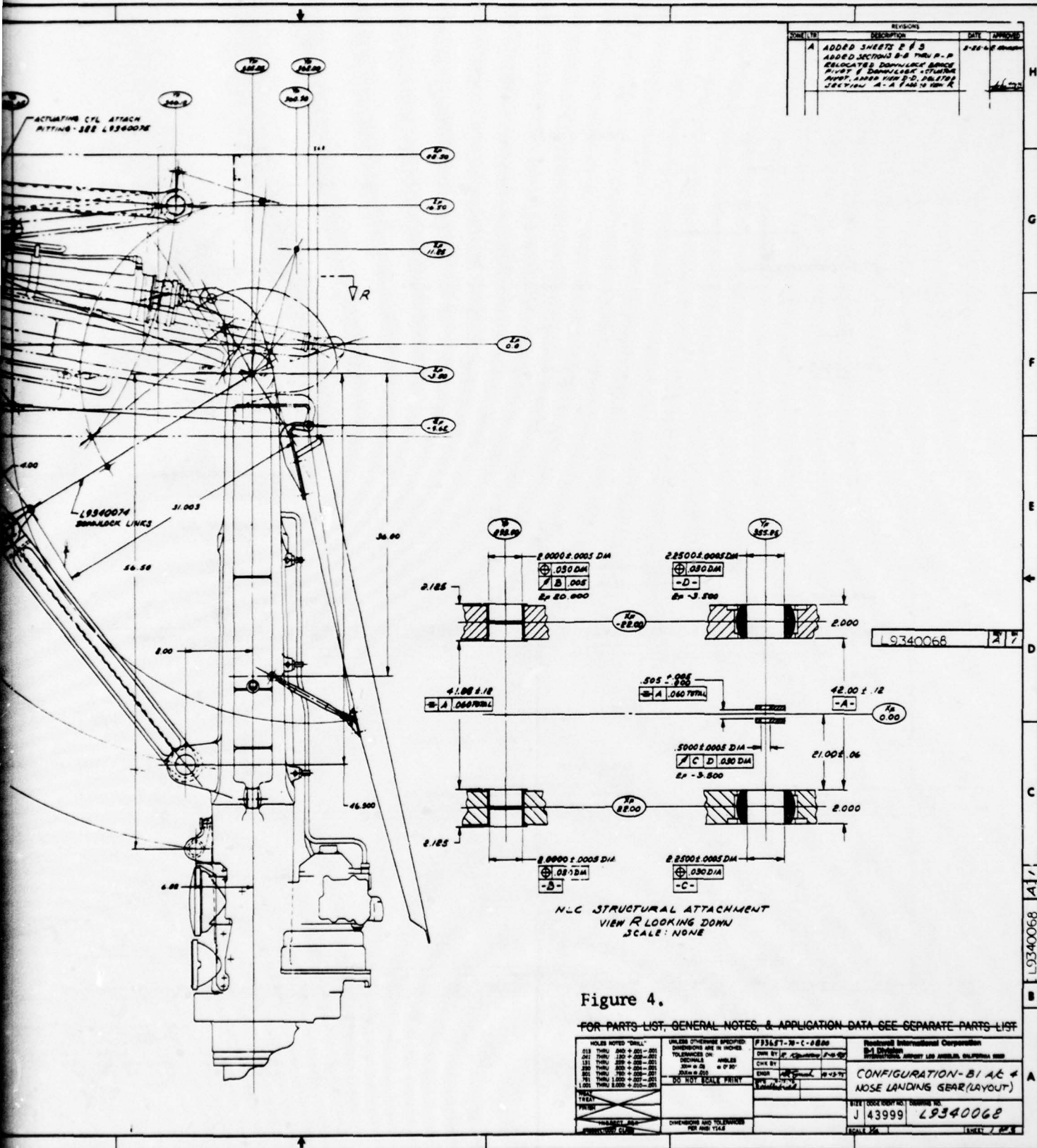
Dimensions of the A/V No. 4 metallic nose gear hardware are given on: B-1 Engineering drawings; L3400308, sheets 1 and 2, L3400311, sheets 1 and 2 (figures 7, 8, 9, and 10); layout L9340074 (figure 11); Menasco drawing 3002600, sheets 1 and 2; and 3002602 (figures 12, 13 and 14), and 3002687, sheets 1 and 2 (figures 15 and 16); and on Goodyear drawing PD 2661, sheets 1 and 2 (figures 17 and 18).



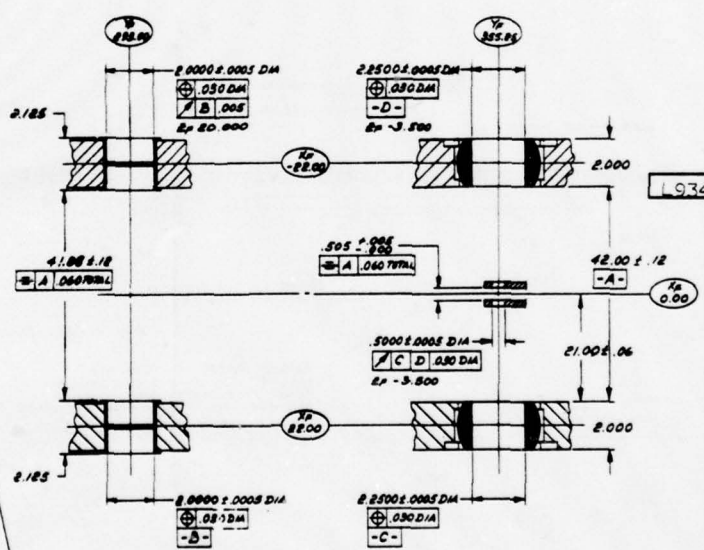


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2



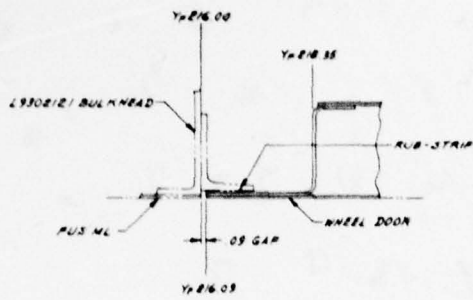
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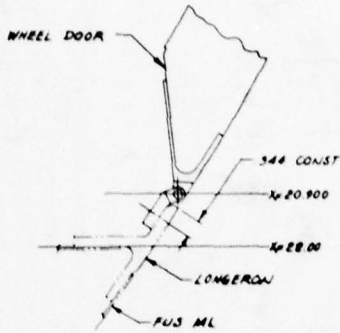
NLC STRUCTURAL ATTACHMENT
VIEW R LOOKING DOWN
SCALE: NONE

Figure 4.
FOR PARTS LIST, GENERAL NOTES & APPLICATION DATA SEE SEPARATE PARTS LIST

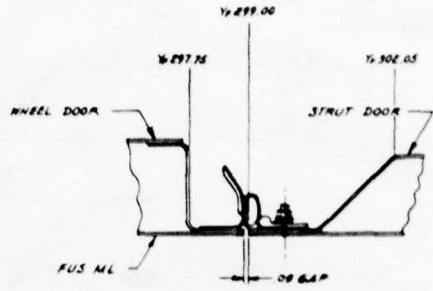
<p>HOLER NOTED "DRILL"</p> <p>UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES</p> <p>TOLERANCES ON DECIMALS UNLESS SHOWN AS FOLLOWS:</p> <p>3RD ± .005</p> <p>2ND ± .002</p> <p>1ST ± .001</p> <p>ANGLES ± 30'</p> <p>DO NOT SCALE PRINT</p> <p>TREAT</p> <p>FINISH</p> <p>PROTECTIVE COAT</p>	<p>UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES</p> <p>TOLERANCES ON DECIMALS UNLESS SHOWN AS FOLLOWS:</p> <p>3RD ± .005</p> <p>2ND ± .002</p> <p>1ST ± .001</p> <p>ANGLES ± 30'</p> <p>DO NOT SCALE PRINT</p> <p>TREAT</p> <p>FINISH</p> <p>PROTECTIVE COAT</p>	<p>F936F7-70-C-0880</p> <p>OWN BY: F. G. GARDNER, INC.</p> <p>DATE: 3-26-67</p> <p>SCALE: AS SHOWN</p> <p>SHEET: 1 OF 2</p>	<p>Republic International Corporation</p> <p>41 Division</p> <p>INTERNATIONAL AIRPORT LEO JEROME CALIFORNIA 9000</p> <p>CONFIGURATION - B1 A6 & NOSE LANDING GEAR (LAYOUT)</p> <p>DATE: 3-26-67</p> <p>WORKING NO: J 43999</p> <p>SCALE: 3/4"</p> <p>SHEET: 1 OF 2</p>
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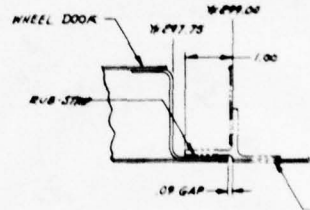
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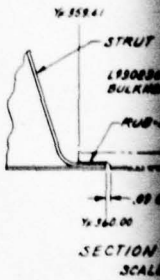
SECTION L-L
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SECTION H-H
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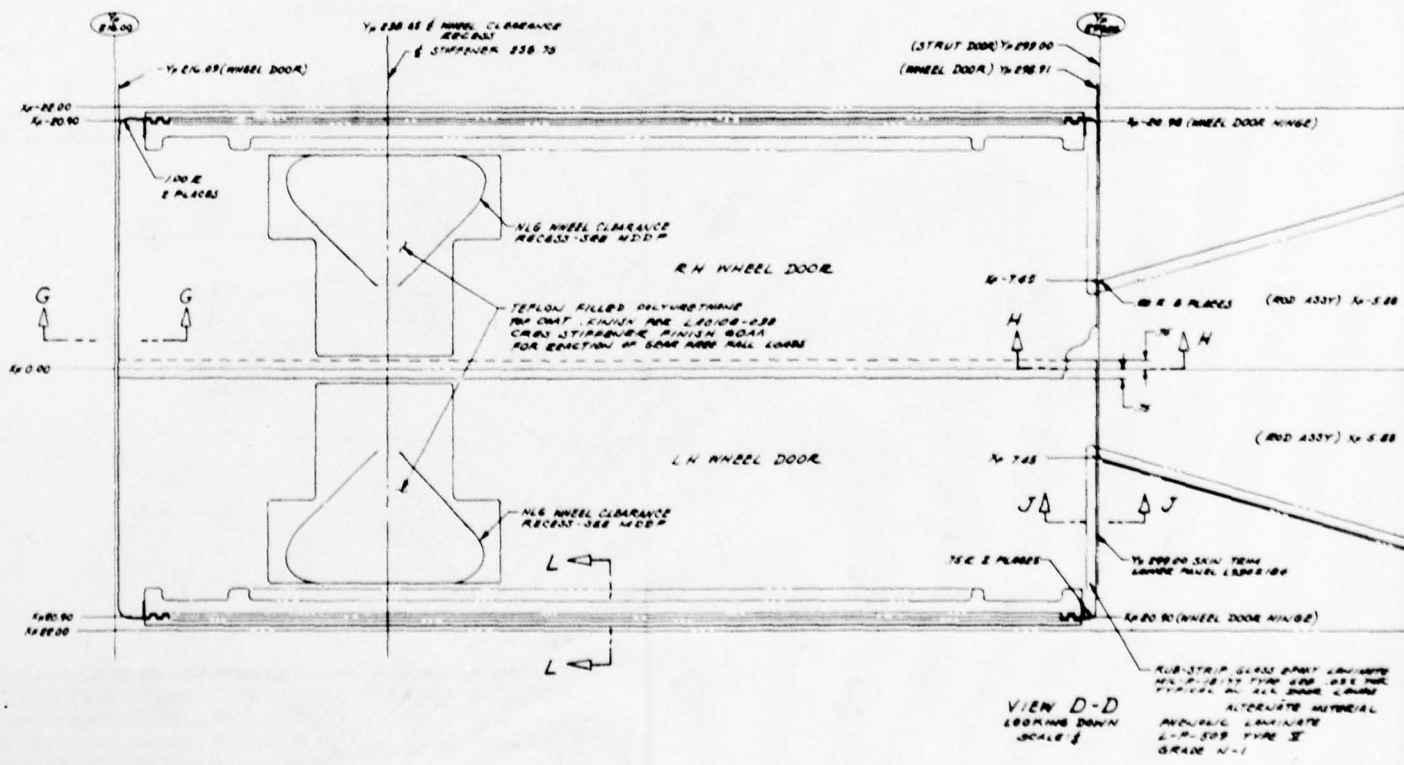


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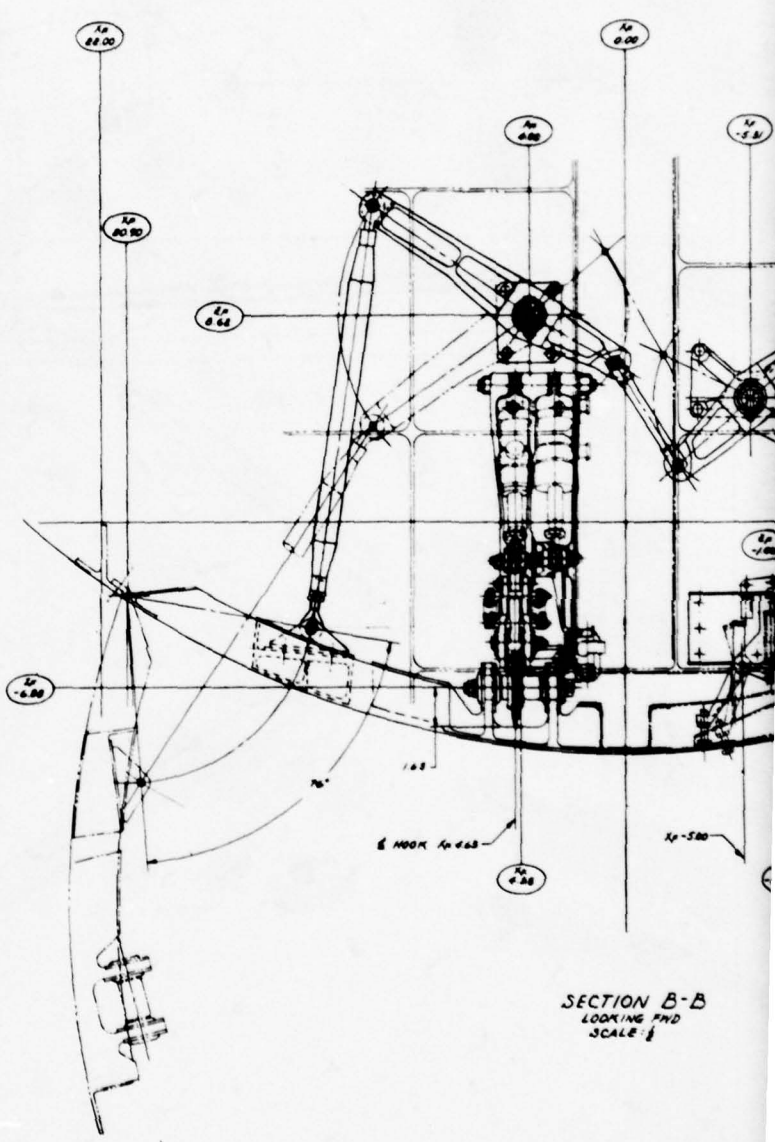
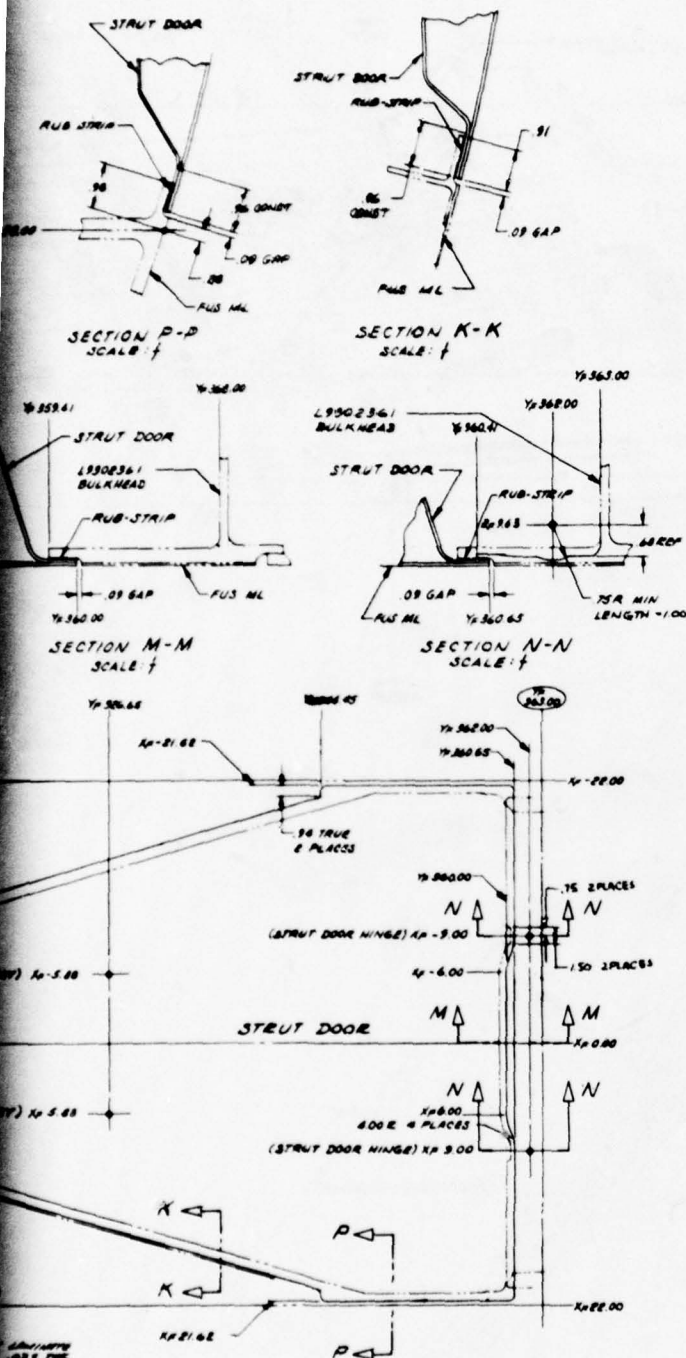
SECTION SCALE

SECTION SCALE



VIEW D-D
LOOKING DOWN
SCALE: f

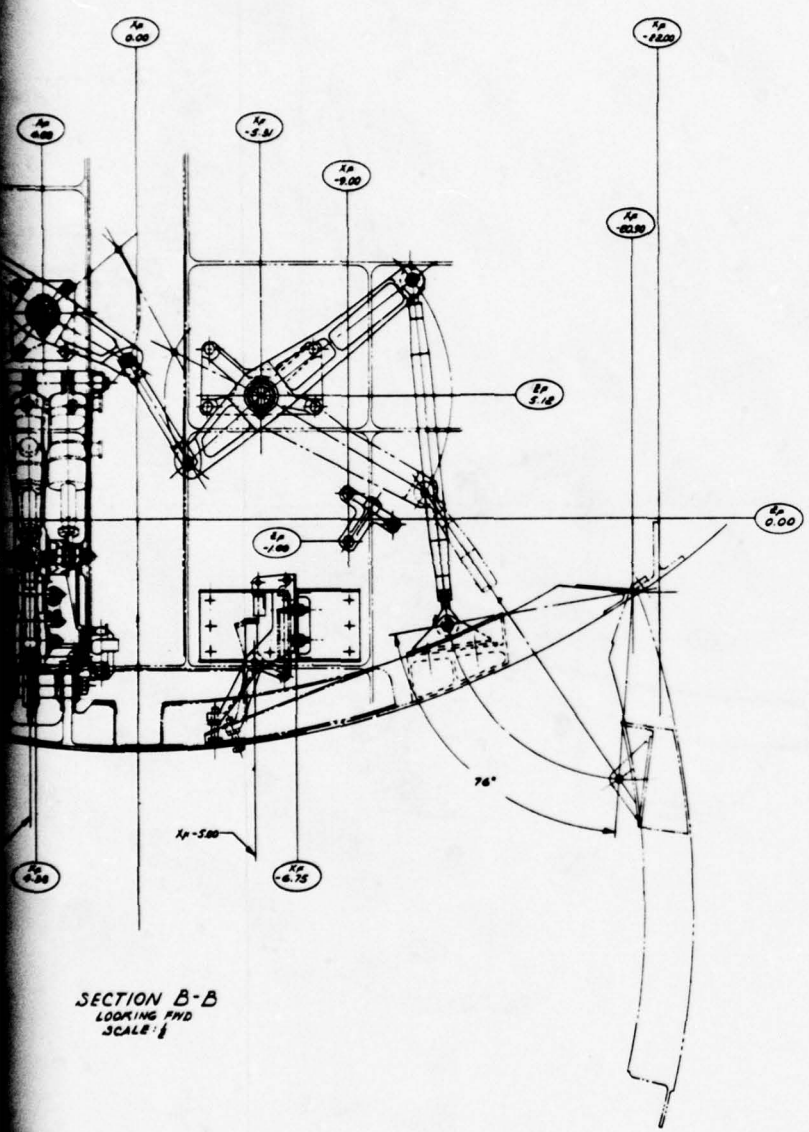
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ALUMINUM LAMINATE L-P-503 TYPE II GRADE N-1



COOK	FRAME	NO.	REV.
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REVISIONS			
NO.	DESCRIPTION	DATE	APPROVED
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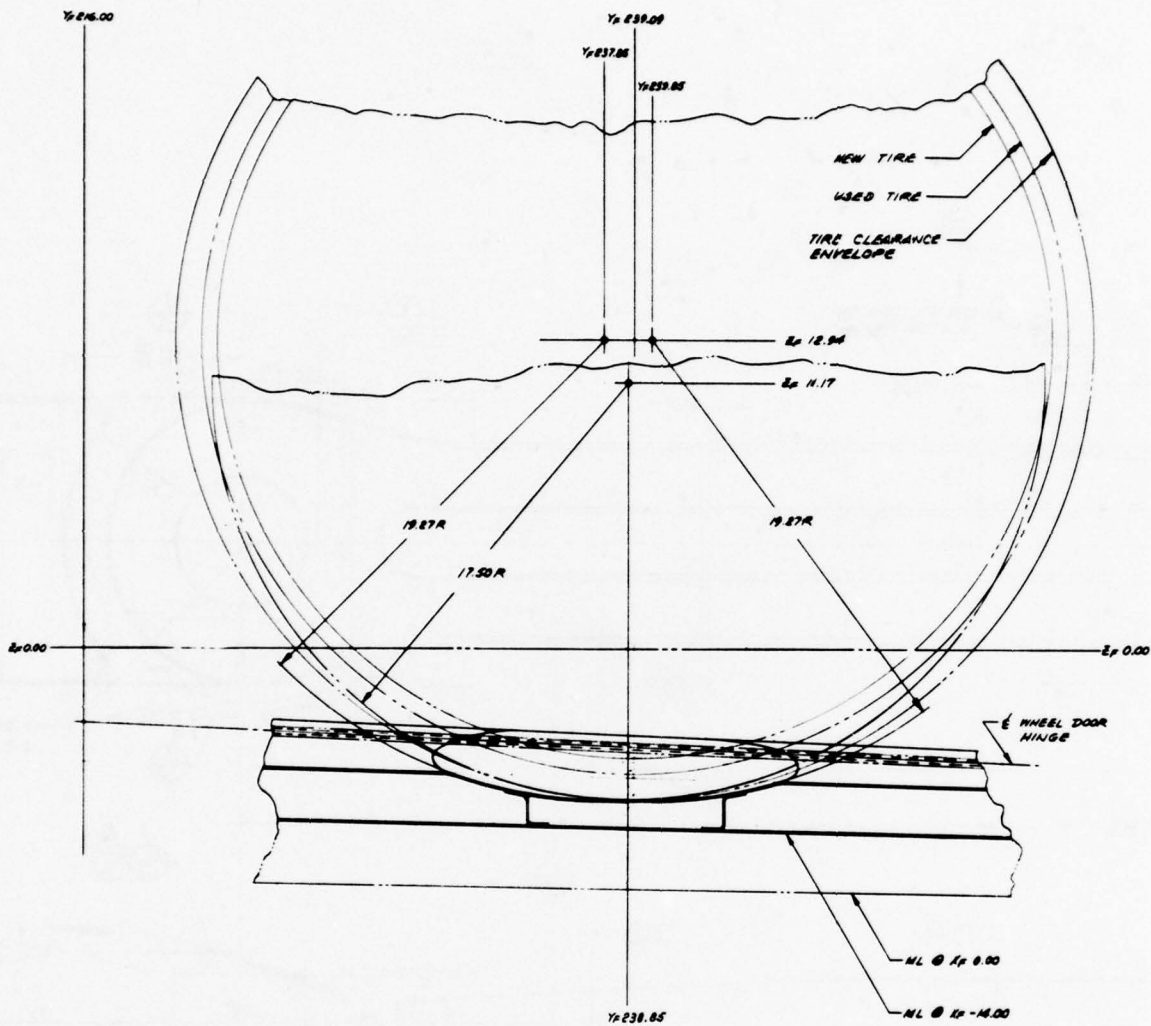


L9340068 A/E

Figure 5.
FOR PARTS LIST, GENERAL NOTES & APPLICATION DATA SEE SEPARATE PARTS LIST

UNLESS NOTED "DRILL"	UNLESS OTHERWISE SPECIFIED:	DRW BY	Boothroyd International Corporation
013 THRU .001 - .001 - .001	DIMENSIONS ARE IN INCHES.		B-I Division
.001 THRU .001 - .001 - .001	TOLERANCES ON:	CHK BY	STANTON, MASSACHUSETTS 01906, CALIFORNIA 92502
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.001 THRU .001 - .001 - .001	ANGLES		
.001 THRU .001 - .001 - .001	DIAMETERS		
.001 THRU .001 - .001 - .001	DRILL		
.001 THRU .001 - .001 - .001	DO NOT SCALE DRAWING		
TEXT			
TREAT			
FINISH			
INSPECT PER	DIMENSIONS AND TOLERANCES	SIZE CODE IDENT NO. DRAWING NO.	SCALE 1/2" SHEET 2
ASSEMBLY CLERK	PER ASSEMBLY	J 43999 L9340068	

3



SECTION F-F
 LOOKING OUTBD
 RH SIDE Xp -14.00
 SCALE 1/2

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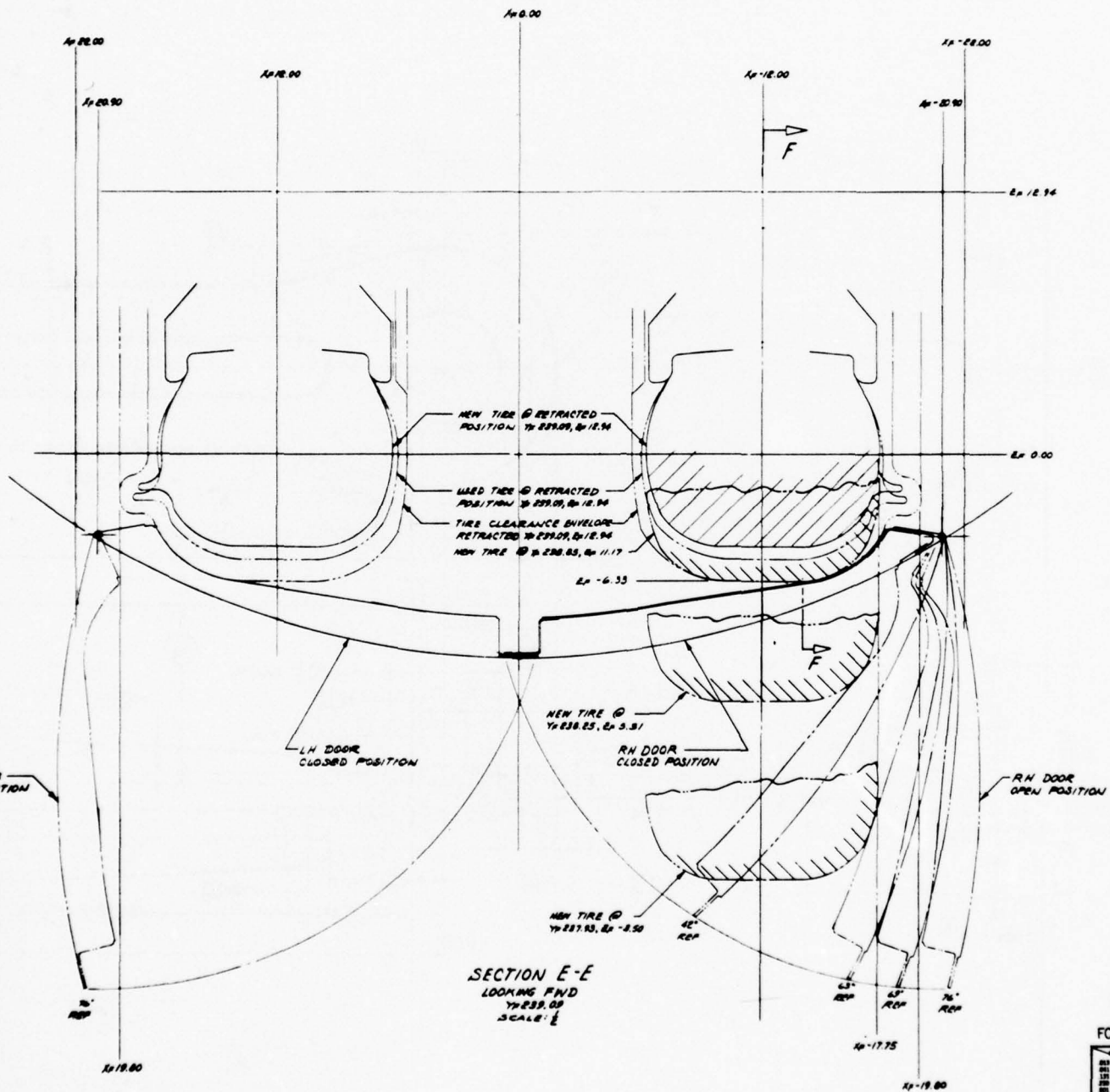
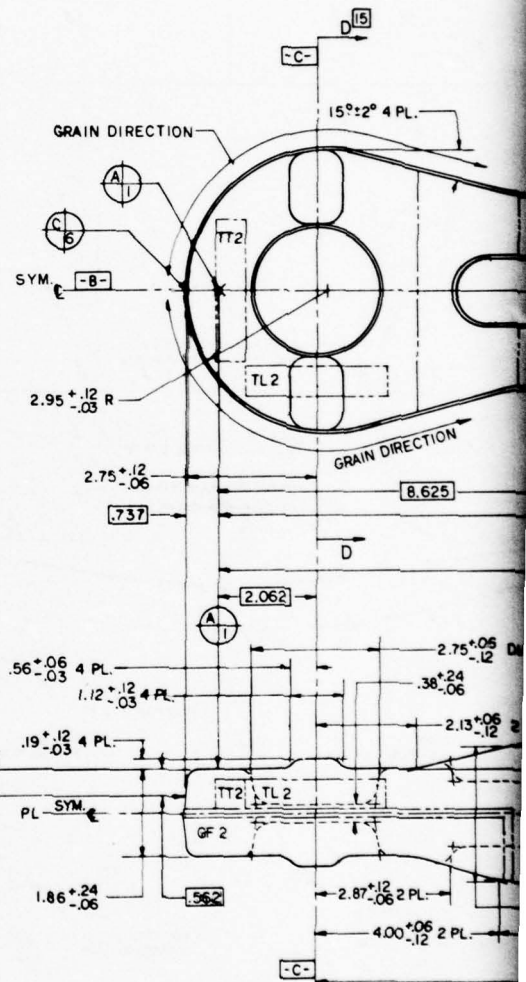
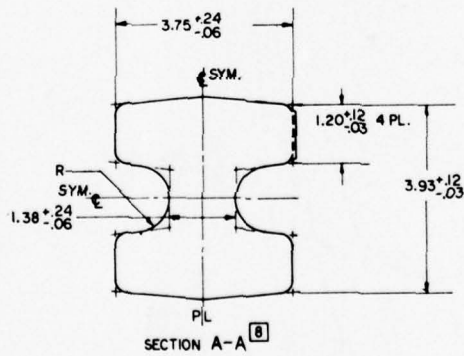
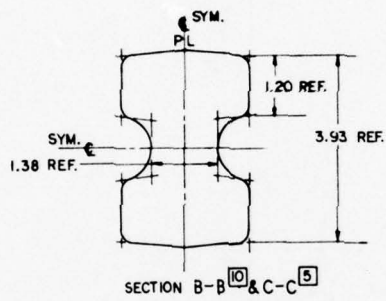
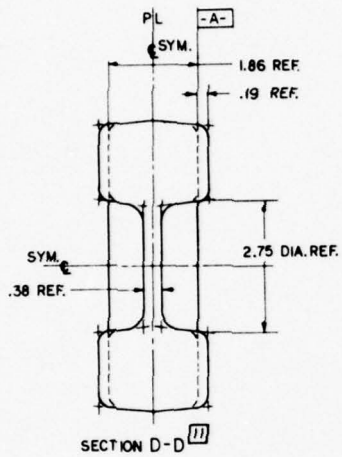


Figure 6.
 FOR PARTS LIST, GENERAL NOTES,

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TREAT TREAT TREAT	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS TOLERANCES ARE: DECIMALS .05 FRACTIONS 1/32" OR 1/64" HOLE DIA. .0015" HOLE DIA. .002"

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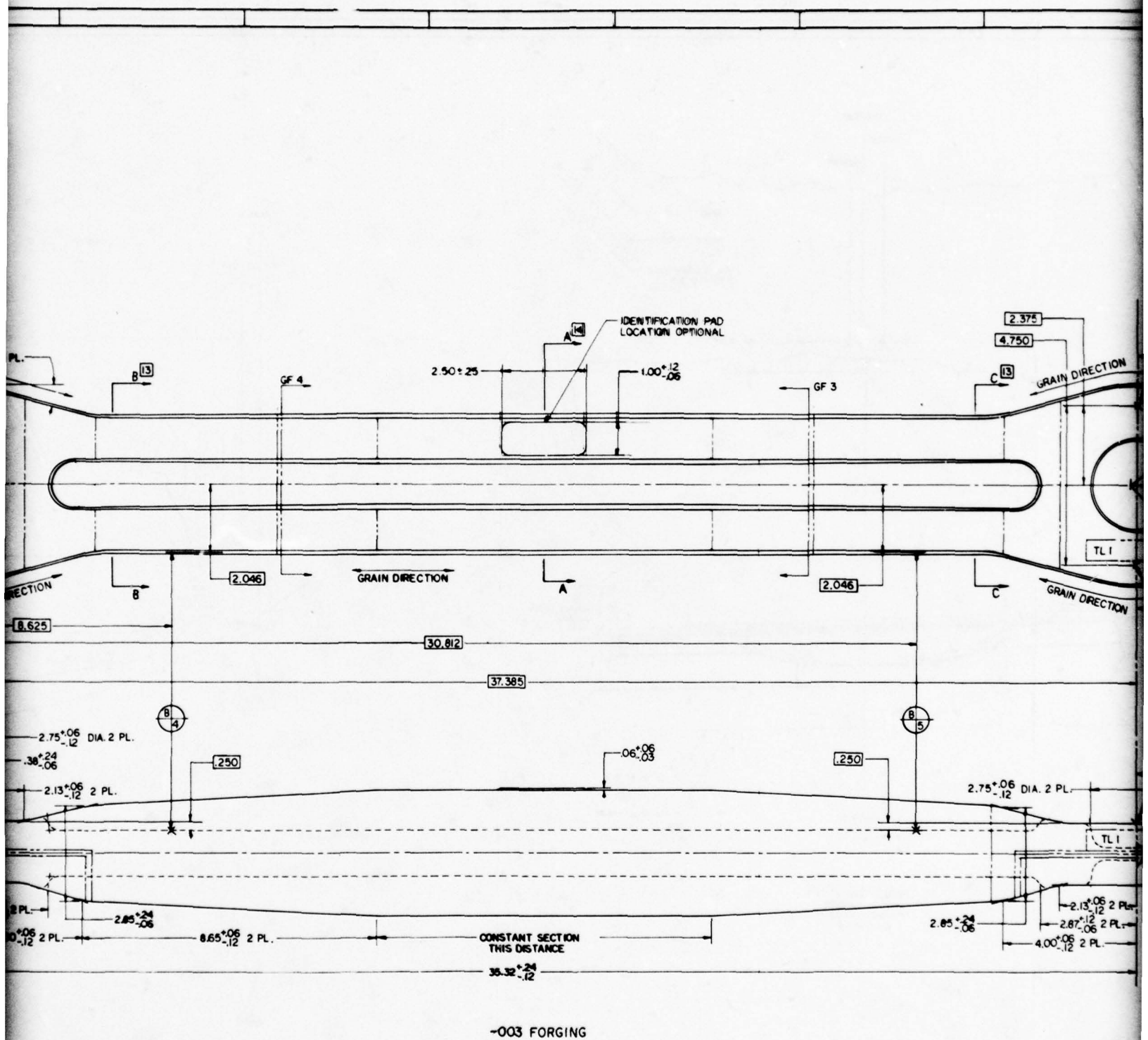
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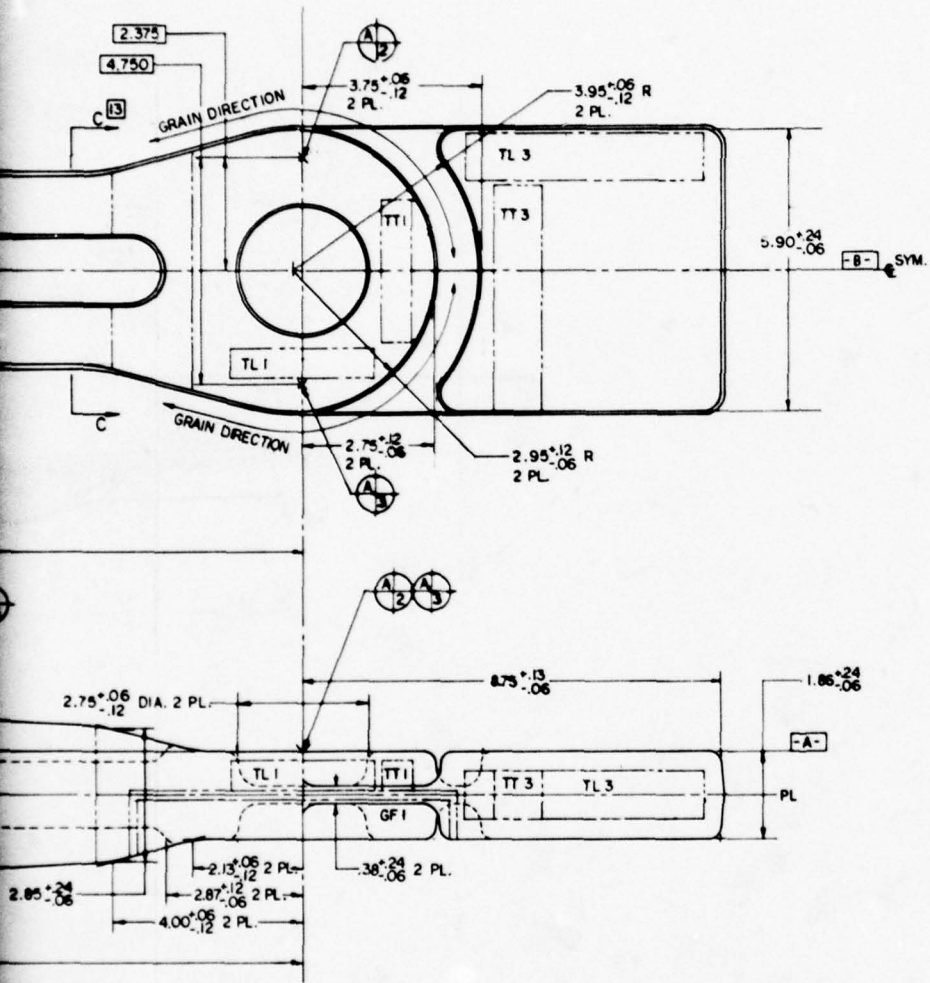
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CODE IDENT	FRAME
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REVISIONS			
NO.	DATE	DESCRIPTION	APPROVED



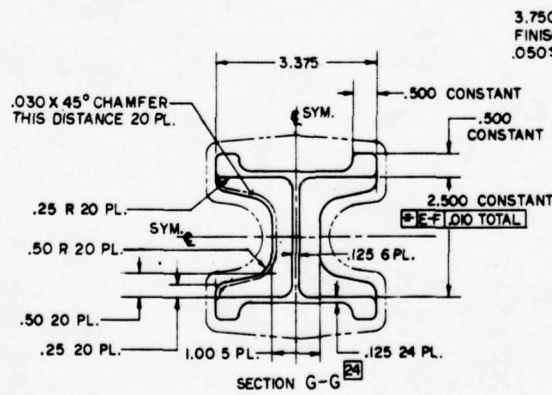
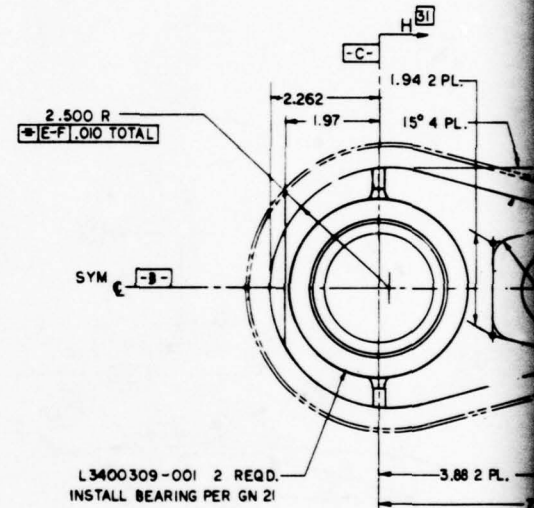
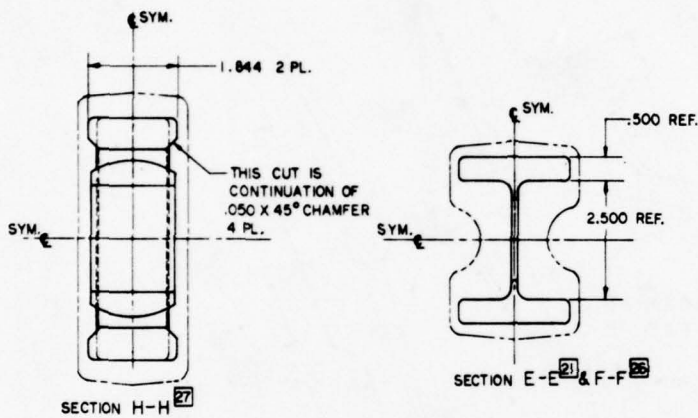
L3400308

Figure 7.

FOR PARTS LIST, GENERAL NOTES, & APPLICATION DATA SEE SEPARATE PARTS LIST

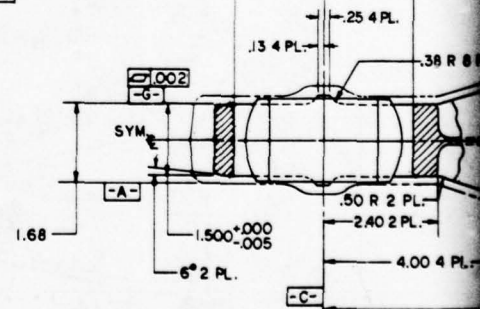
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3



3.7500±.0005 DIA. HOLE THRU
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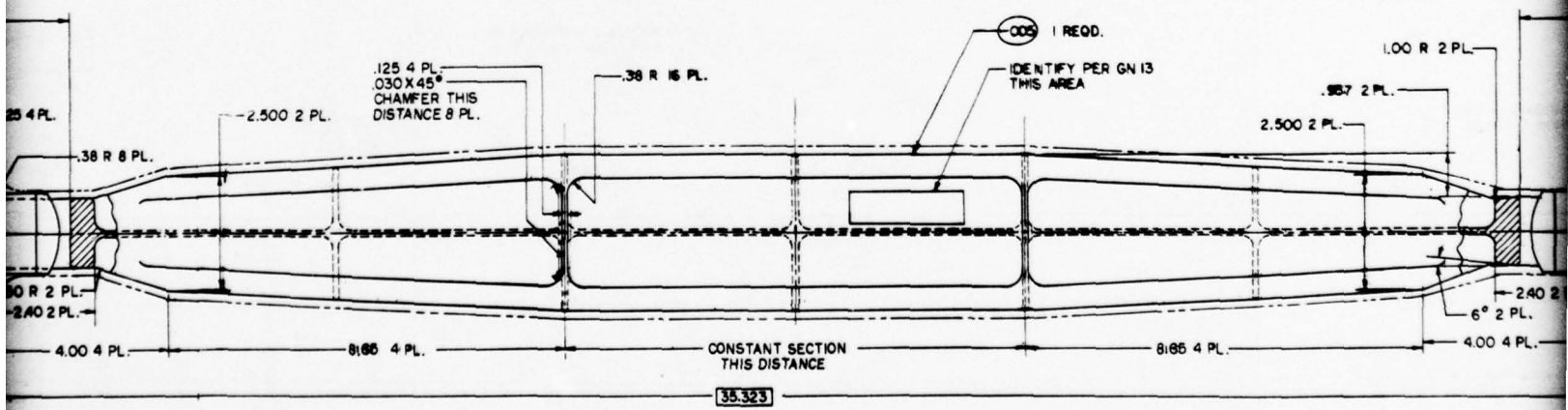
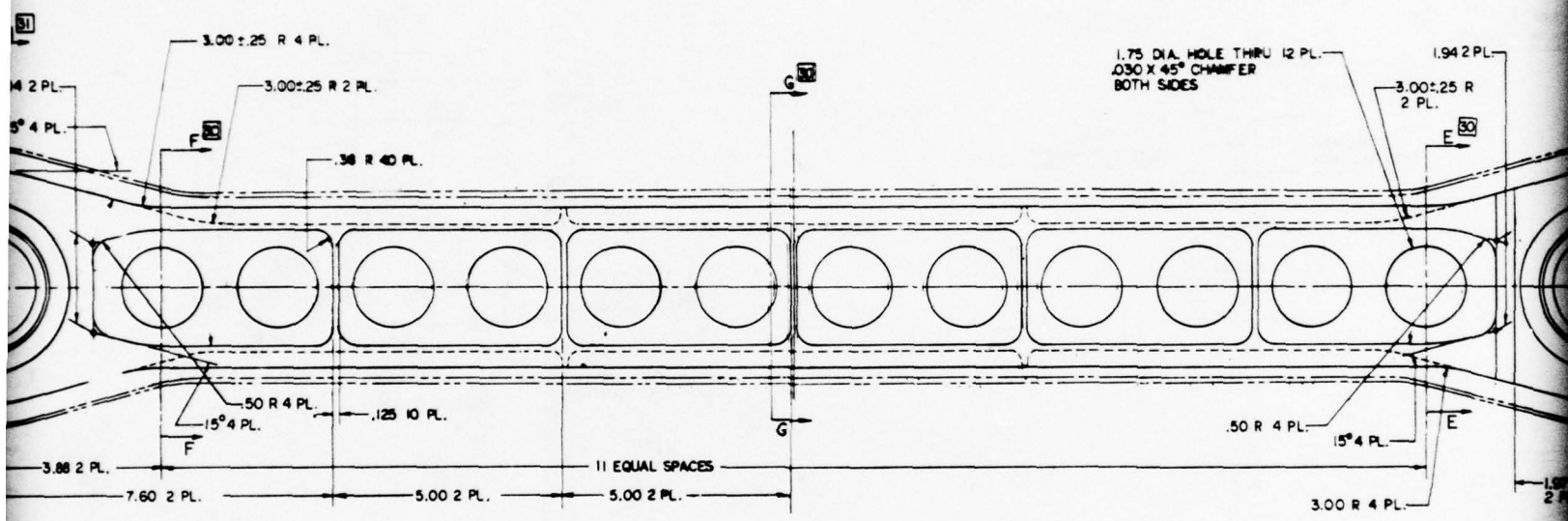
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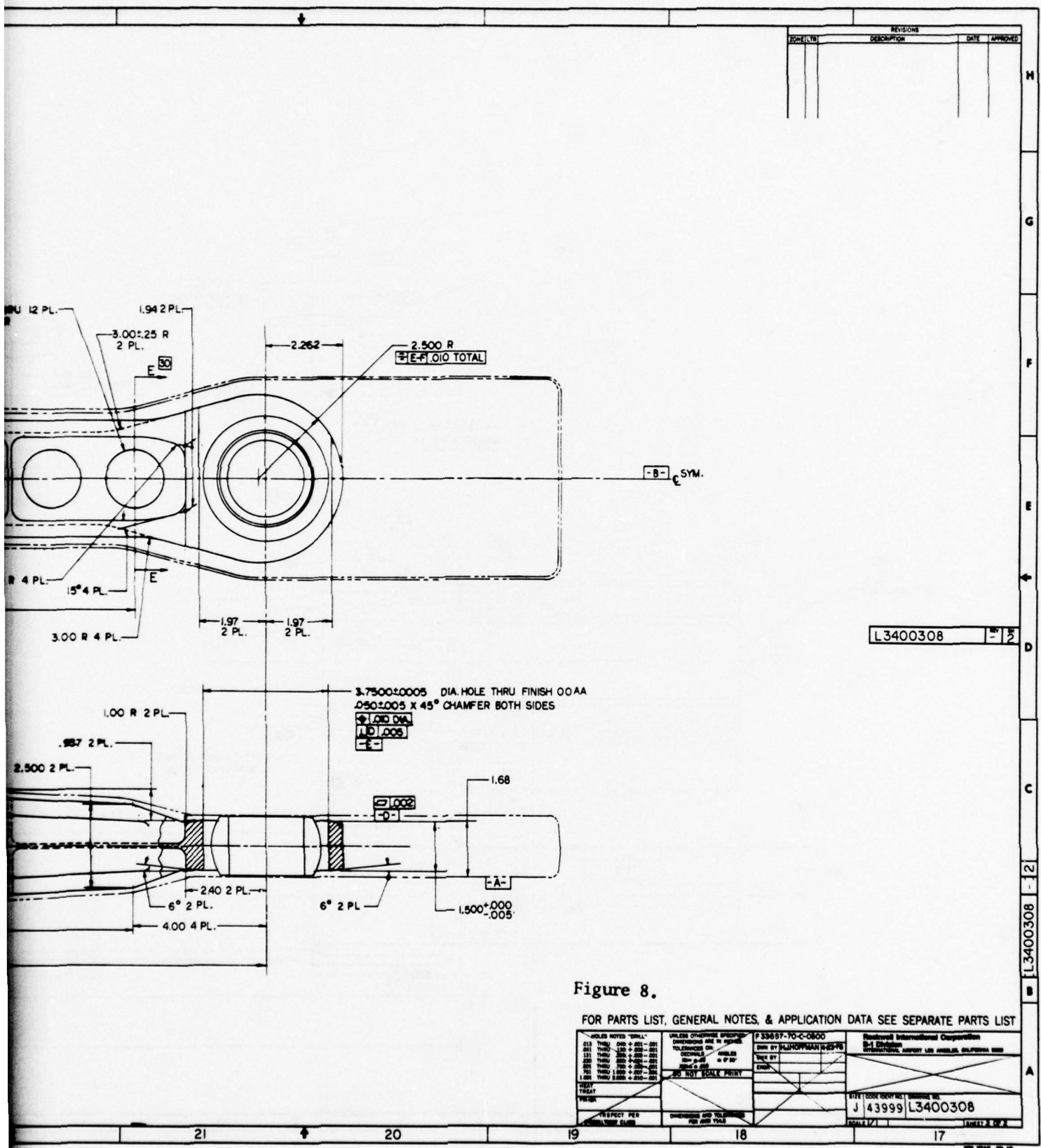


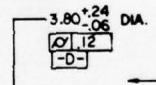
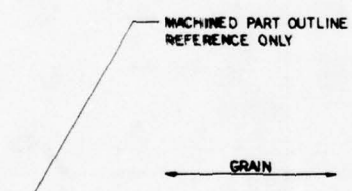
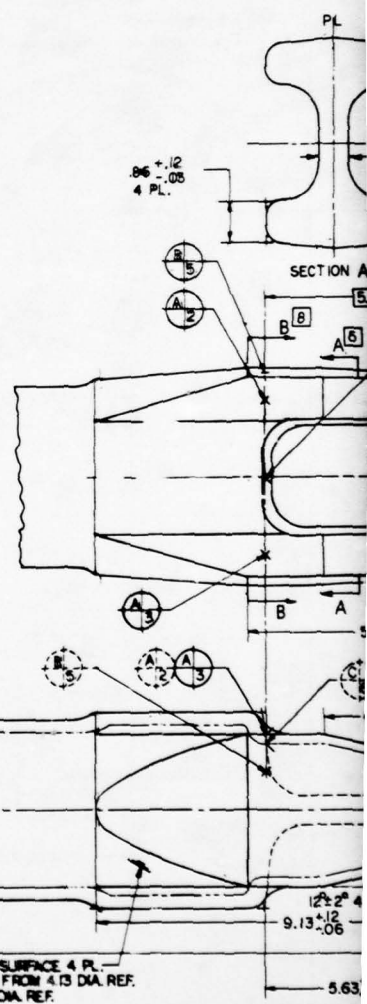
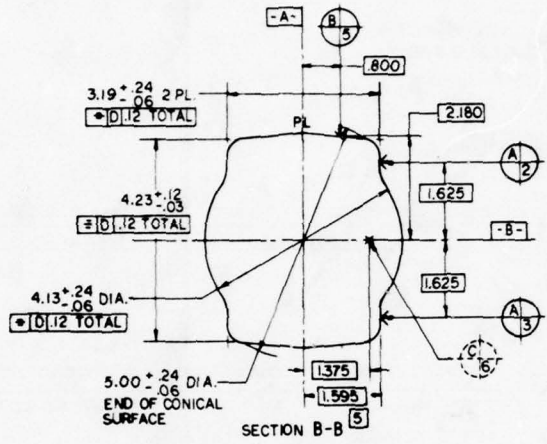
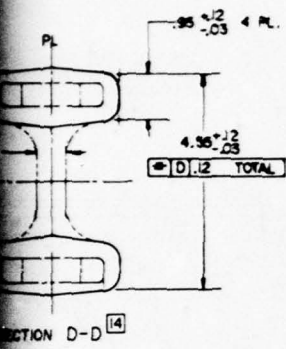
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49.445

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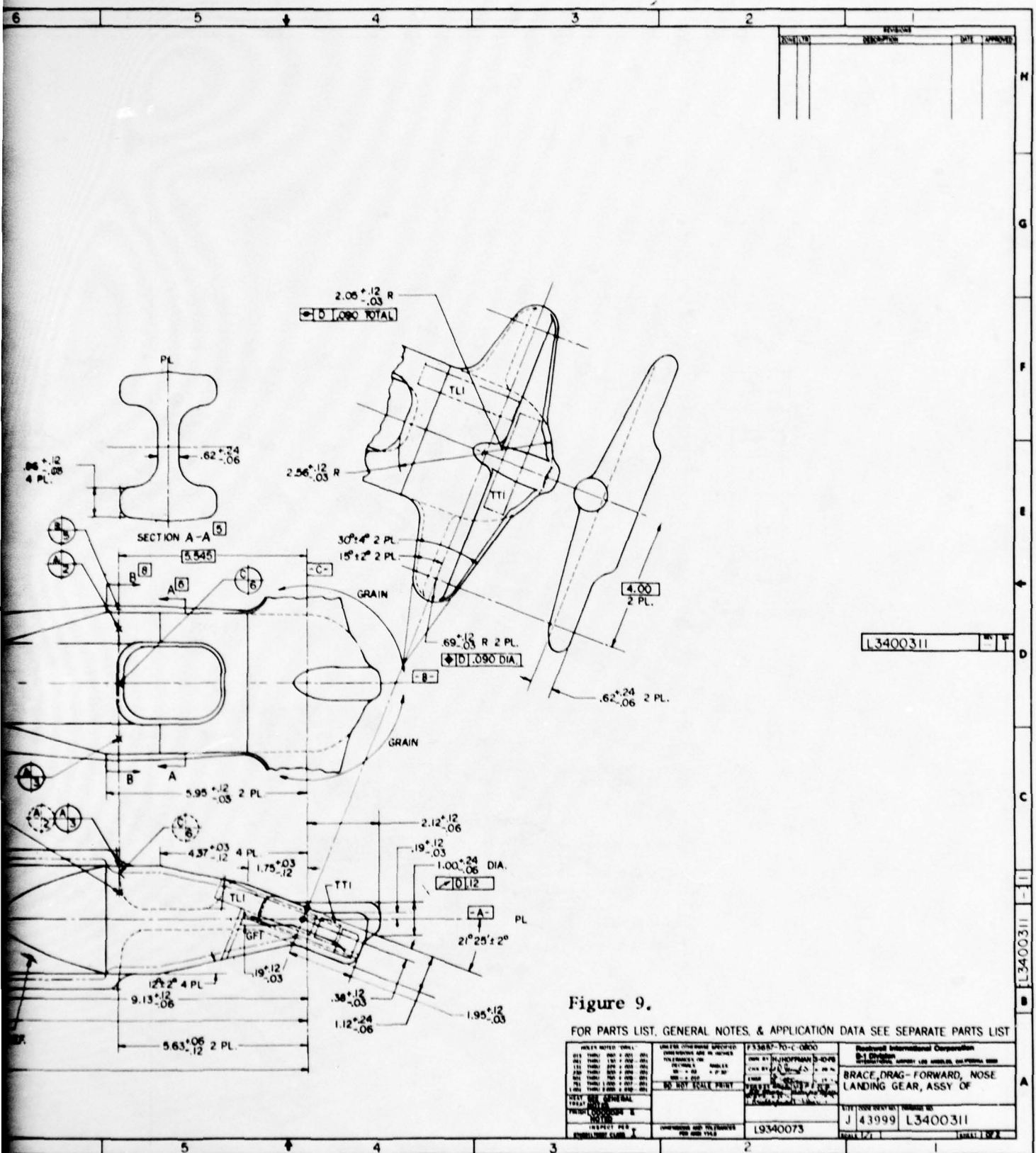
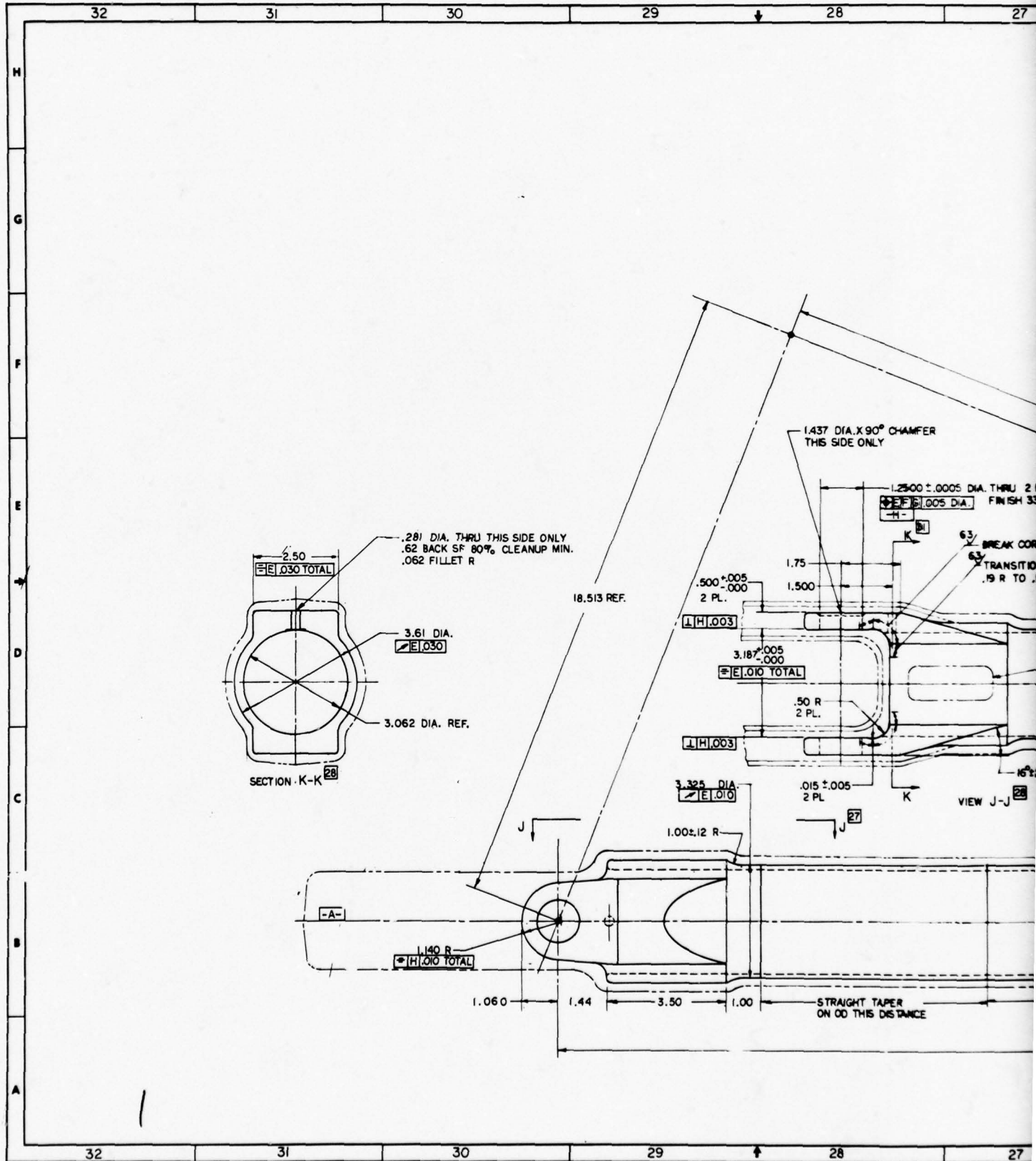


Figure 9.

FOR PARTS LIST, GENERAL NOTES, & APPLICATION DATA SEE SEPARATE PARTS LIST

CHECKED BY: [] DATE: [] DESIGNED BY: [] DATE: [] DRAWN BY: [] DATE: [] PART NO.: [] REV.: [] QUANTITY: []	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: .005" - .015" ± .001 .015" - .030" ± .002 .030" - .060" ± .003 .060" - .120" ± .004 .120" - .250" ± .005 .250" - .500" ± .006 .500" - 1.000" ± .008 1.000" - 2.000" ± .010 2.000" - 5.000" ± .015 OVER 5.000" ± .020 FINISH: [] TREAT: [] MATERIAL: [] QUANTITY: []	F33887-70-C-0800 DRAWN BY: [] CHECKED BY: [] DATE: [] PART NO.: [] REV.: [] QUANTITY: []	Lockheed International Corporation B-1 Division BRACE, DRAG - FORWARD, NOSE LANDING GEAR, ASSY OF PART NO.: [] REV.: [] QUANTITY: []
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27

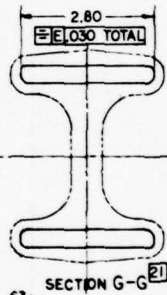
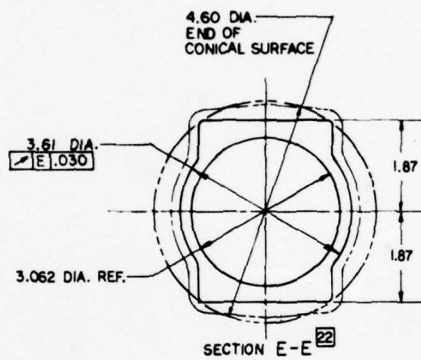
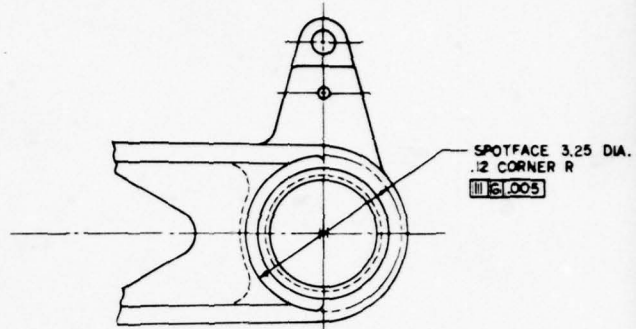
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3 DIA. THRU 2 HOLES IN LIN. FINISH 33AA

63 BREAK CORNER .19 R 4 PL. 63 TRANSITION AREA .19 R TO .12 R 8 PL.

46.738 REF.

IDENTIFY PER NOTE 11 IN THIS APPROX. AREA

63 BREAK CORNER .19 R 6 PL. 63 TRANSITION AREA FROM .19 R TO .12 R 38 LONG 12 PL.

005 SHOWN 1 REQD. 006 OPPOSITE

16±2° 2 PL. VIEW J-J

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3.062 I.D. ±0.010 -E-E

3.306 DIA. ±0.010

1.00±.12 R

18.00±.06

9.87±.06 STRAIGHT TAPER ON OD THIS DISTANCE

1.00

2.87

30.271

-001 SHOWN -002 OPPOSITE

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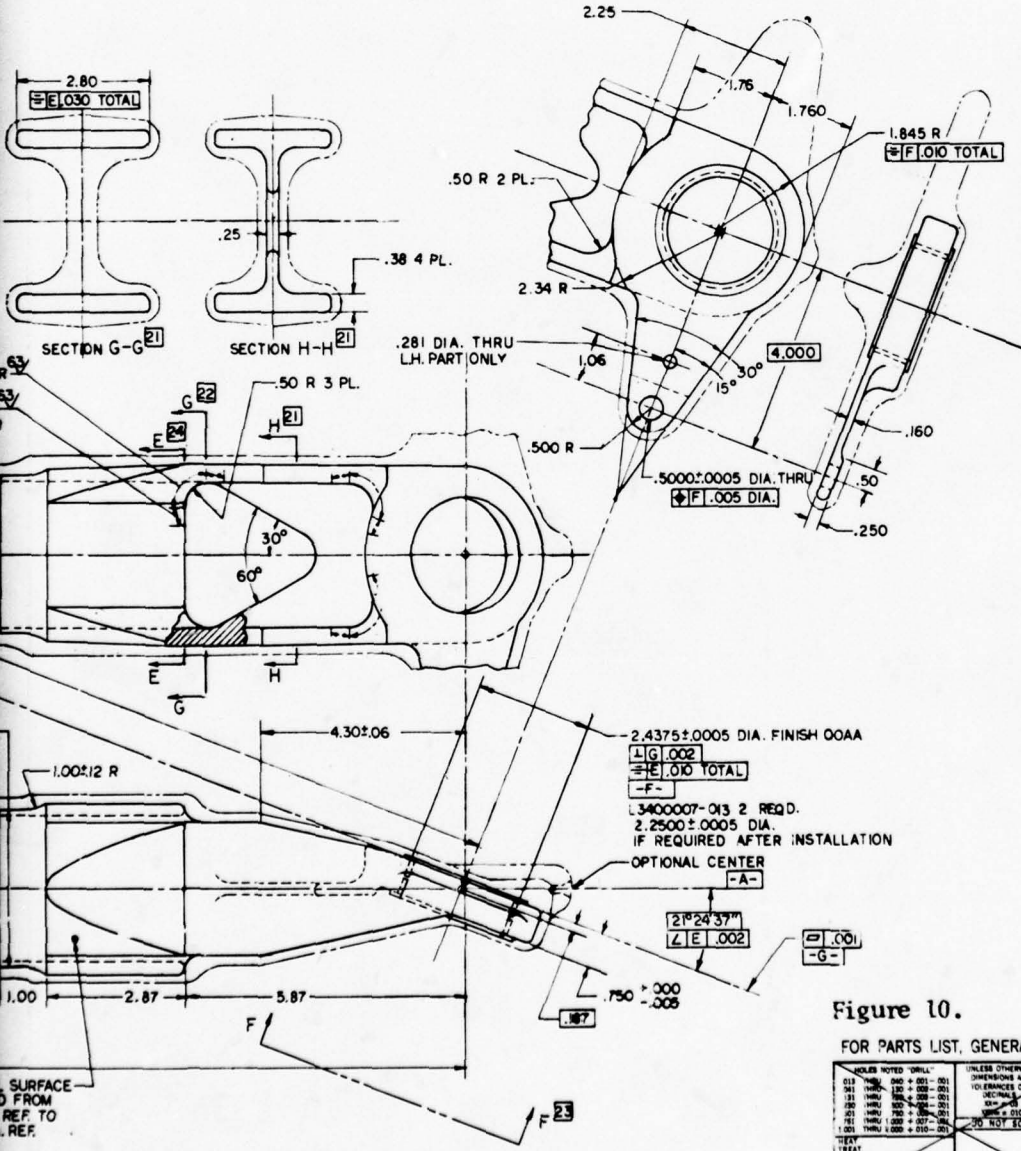
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22 21 2G 19 18 17

REVISIONS			
ZONE	LTN	DESCRIPTION	DATE APPROVED

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1/2 CORNER R
[E] .005



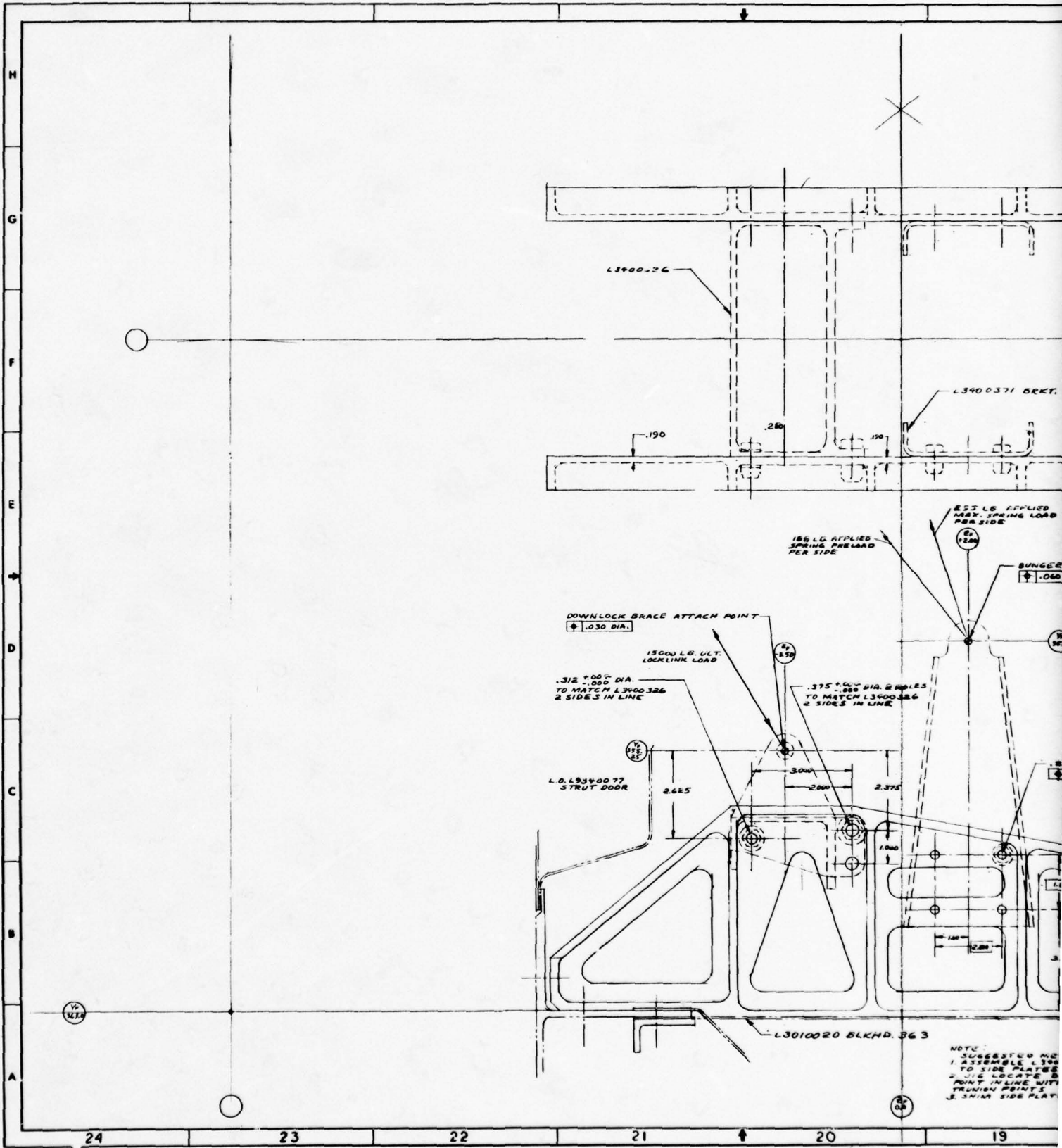
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Figure 10.

FOR PARTS LIST, GENERAL NOTES, & APPLICATION DATA SEE SEPARATE PARTS LIST

<p>UNLESS NOTED OTHERWISE DIMENSIONS ARE IN INCHES DECIMALS ON UNLESS OTHERWISE SPECIFIED</p> <p>FRONT VIEW</p> <p>TOP VIEW</p> <p>RIGHT SIDE VIEW</p> <p>LEFT SIDE VIEW</p> <p>REAR VIEW</p> <p>ISOMETRIC VIEW</p> <p>SECTION A-A</p> <p>SECTION B-B</p> <p>SECTION C-C</p> <p>SECTION D-D</p> <p>SECTION E-E</p> <p>SECTION F-F</p> <p>SECTION G-G</p> <p>SECTION H-H</p> <p>SECTION I-I</p> <p>SECTION J-J</p> <p>SECTION K-K</p> <p>SECTION L-L</p> <p>SECTION M-M</p> <p>SECTION N-N</p> <p>SECTION O-O</p> <p>SECTION P-P</p> <p>SECTION Q-Q</p> <p>SECTION R-R</p> <p>SECTION S-S</p> <p>SECTION T-T</p> <p>SECTION U-U</p> <p>SECTION V-V</p> <p>SECTION W-W</p> <p>SECTION X-X</p> <p>SECTION Y-Y</p> <p>SECTION Z-Z</p>	<p>UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DECIMALS ON UNLESS OTHERWISE SPECIFIED</p> <p>FRONT VIEW</p> <p>TOP VIEW</p> <p>RIGHT SIDE VIEW</p> <p>LEFT SIDE VIEW</p> <p>REAR VIEW</p> <p>ISOMETRIC VIEW</p> <p>SECTION A-A</p> <p>SECTION B-B</p> <p>SECTION C-C</p> <p>SECTION D-D</p> <p>SECTION E-E</p> <p>SECTION F-F</p> <p>SECTION G-G</p> <p>SECTION H-H</p> <p>SECTION I-I</p> <p>SECTION J-J</p> <p>SECTION K-K</p> <p>SECTION L-L</p> <p>SECTION M-M</p> <p>SECTION N-N</p> <p>SECTION O-O</p> <p>SECTION P-P</p> <p>SECTION Q-Q</p> <p>SECTION R-R</p> <p>SECTION S-S</p> <p>SECTION T-T</p> <p>SECTION U-U</p> <p>SECTION V-V</p> <p>SECTION W-W</p> <p>SECTION X-X</p> <p>SECTION Y-Y</p> <p>SECTION Z-Z</p>	<p>F33687-70-C-0800</p> <p>Rev. 21 JANUARY 1964</p> <p>DESIGNED BY: []</p> <p>DRAWN BY: []</p> <p>CHECKED BY: []</p> <p>APPROVED BY: []</p> <p>DATE: []</p> <p>SCALE: []</p> <p>NOT TO SCALE PRINT</p>	<p>Received International Corporation</p> <p>4-1 Division</p> <p>INTERNATIONAL AIRPORT LOS ANGELES, CALIFORNIA 90045</p> <p>ITEM CODE IDENTIFY DRAWING NO.</p> <p>J 43999 L3400311</p> <p>SCALE: []</p> <p>ENTERED R.P.P.</p>
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22 21 20 19 18 17



1

7.000 SPACING TO
MATCH L390032*
AND L390032L

L390032*

L3900371 ORKT.

190

250

1.00

253 LB APPLIED
MAX. SPRING LOAD
PER SIDE

BUNGEE SPRING ATTACH POINT

Ø .060 DIA.

.851 DIA. 4 HOLES

Ø .010 DIA.

CYLINDER ATTACH POINT

Ø .060 DIA.

.250

8300 LB ULT.
CYL. LOAD
(BUSHSTRAPPED)

1.625

Ø .010 DIA.

Ø .010 DIA.

Ø .010 DIA.

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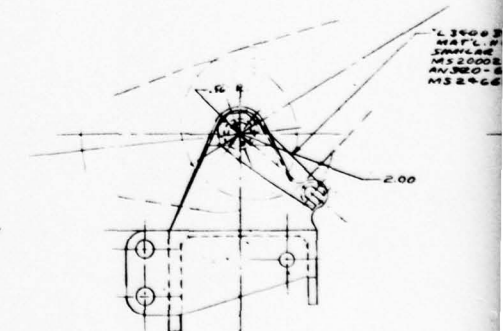
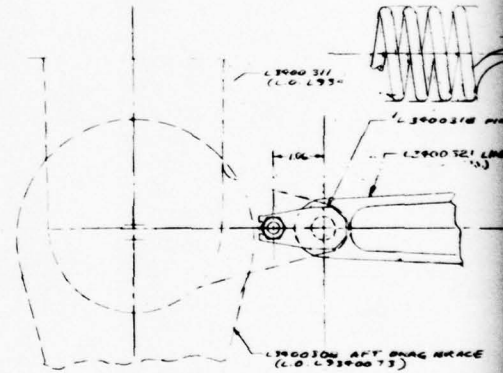
11900 LB ULT.
CYL. LOAD
(BUSHSTRAPPED)

L301002* FITTING
L301004* FITTING ASSY.

.250*Ø DIA. 3 HOLES
TO MATCH L390032*
2 SIDES IN LINE

NOTE:
SUGGESTED METHOD OF INSTALLATION
1. ASSEMBLE L390032* & L390032L ORKTS.
TO SIDE PLATES.
2. LOCATE DOWNLOCK BRACE ATTACH
POINT IN LINE WITH NLG SHOCK STRUT
TENSION POINTS.
3. SHIM SIDE PLATES TO OBTAIN ALIGNMENT

19200	FRAME	REV	BY
	L9340074	B	



19

18

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16

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2

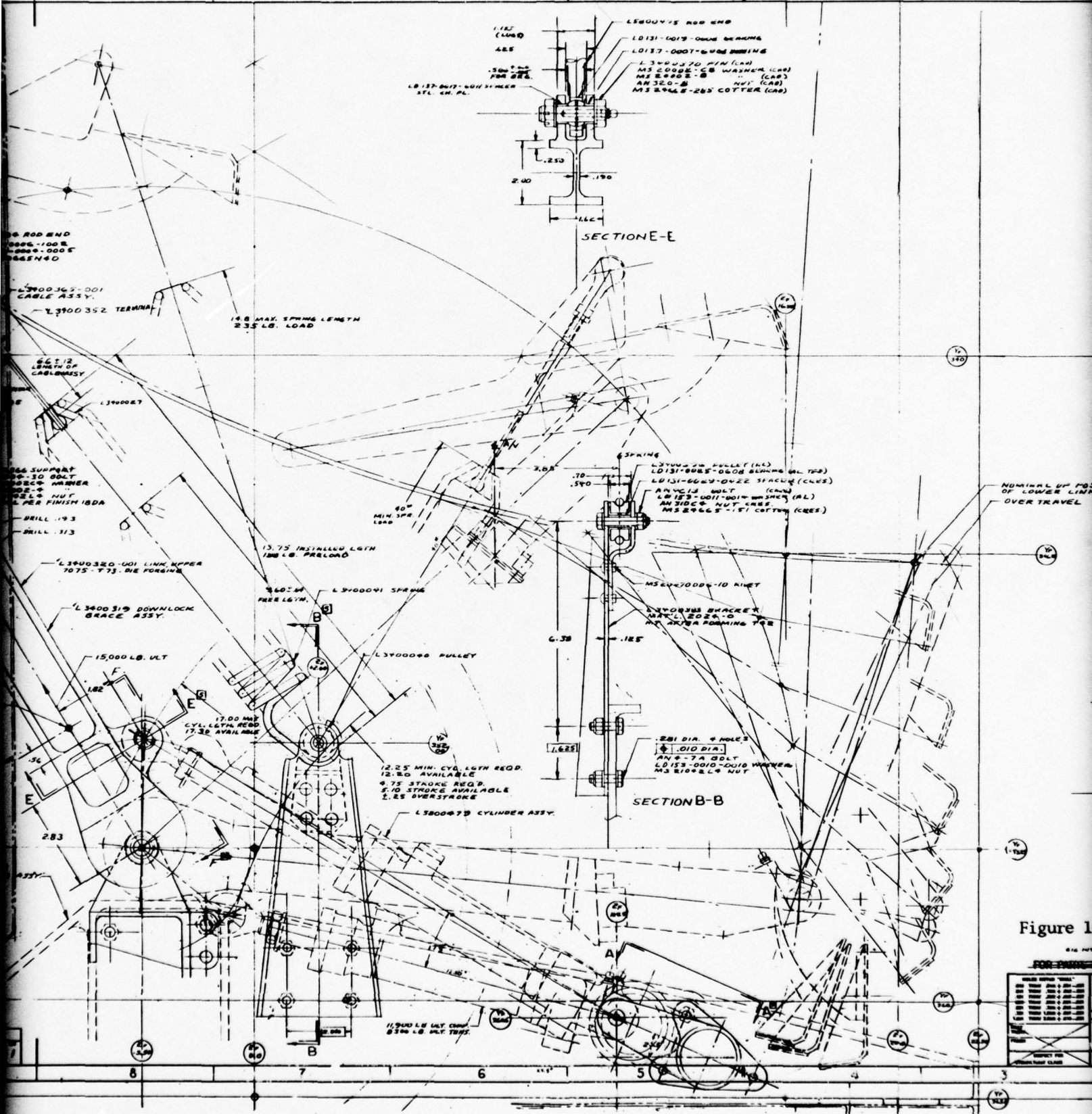


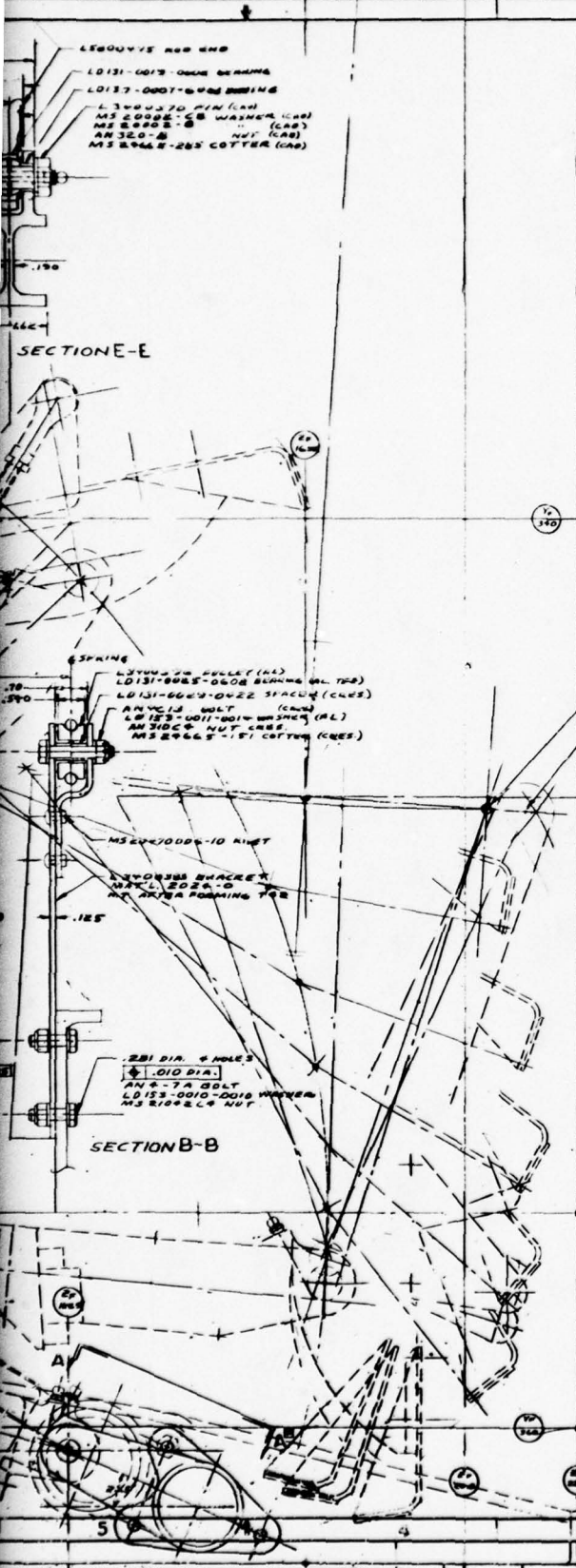
Figure 11

616 PARTS
FOR PROVISIONAL

NO.	DESCRIPTION	QTY.	UNIT
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100

FOR PROVISIONAL

4



REV	DESCRIPTION	DATE	APPROVED
A	COMPLETELY REVISED	1-2-76	[Signature]
B	REVISED INTERFACE BETWEEN L3940 SEL & L3100RT FITTING	2-13-76	[Signature]
C	REVISED SPACING OF BUMPER SPRINGS AND END JOINTS OF ACT. CYL.	5-18-76	[Signature]
D	REVISED FASTENER CALLOUTS FOR MATERIAL COMPATIBILITY	7-27-76	[Signature]

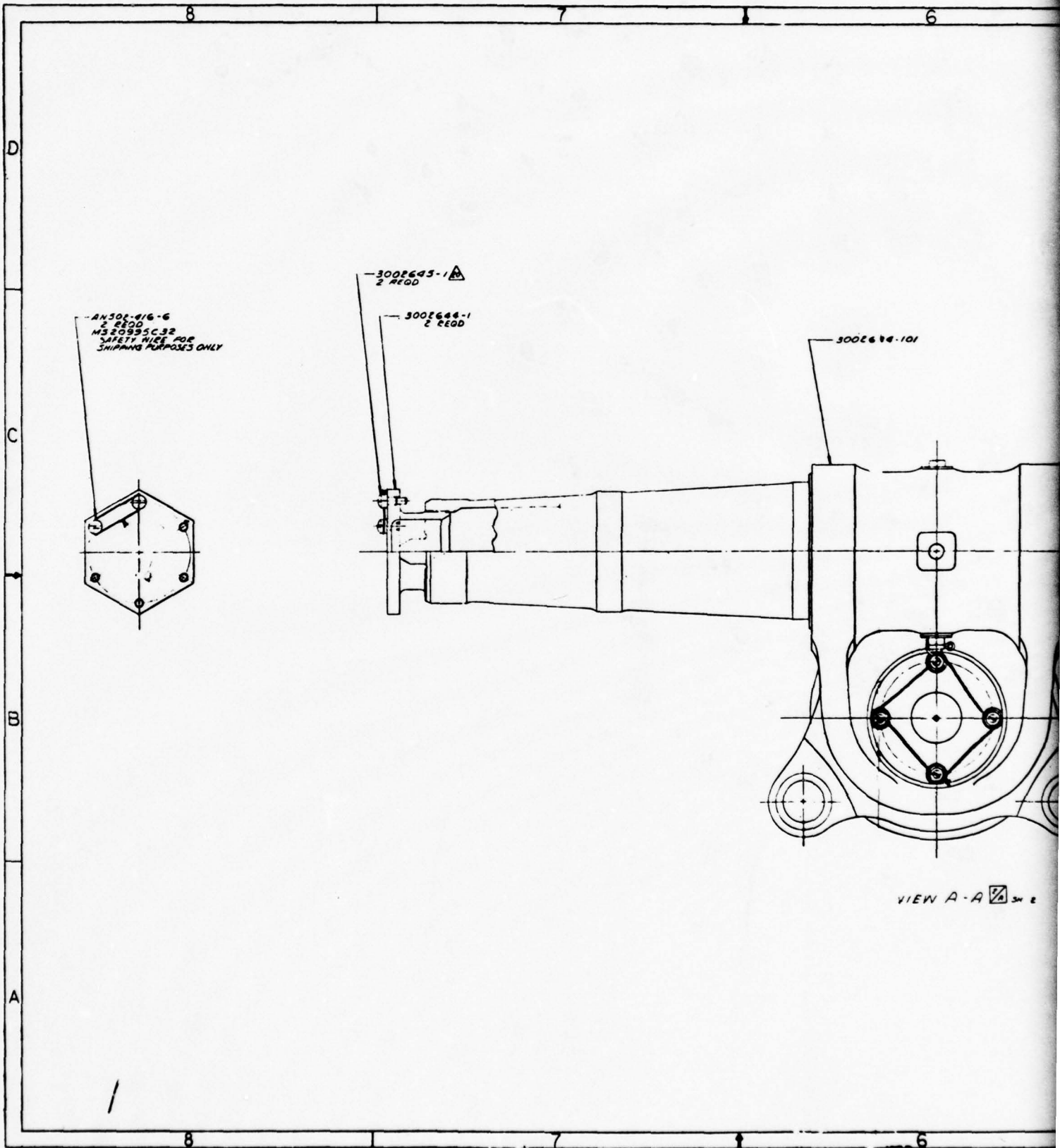
L9340074 511


Figure 11.

FOR PARTS LIST, GENERAL NOTES, & DIMENSIONS SEE SEPARATE PARTS LIST

PARTS LIST QTY PART NO PART NAME UNIT ASSEMBLY DRAWING NO DATE BY CHECKED BY APPROVED BY TITLE	F 33457-70-C-0000 PART NO. (A) APPROVED 1-10-76 DATE BY CHECKED BY APPROVED BY TITLE	B-1 A/C-4 NLG DOWNLOCK LINKS (LAYOUT) J 43999 L9340074
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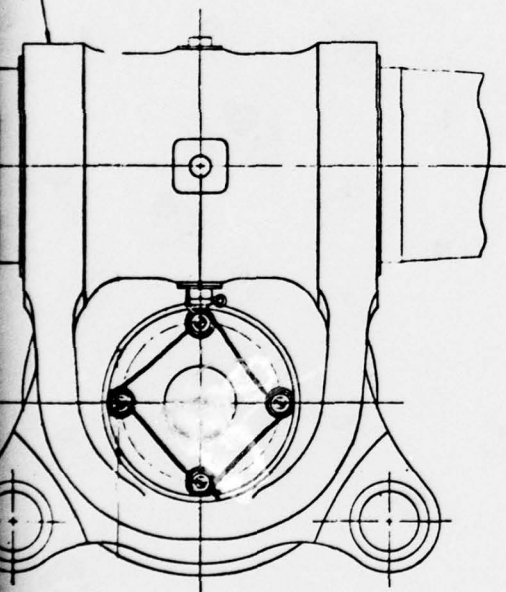
VIEW A-A  SH 2

6

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4

3002600-101



VIEW A-A

- ▲ INSTALL WITH BLACK BACK-UP RINGS ON OUTSIDE OF PACKING ASSY
- ▲ WITH TORQUE ARM AND DISCONNECTED AND UPPER TORQUE ARM PERPENDICULAR TO CENTERLINE OF STRUT, TORQUE 3002600-101 NUT UNTIL A FORCE ALONG CENTERLINE OF TORQUE ARM APPEARS. 50-70 FT/LBS IS REQUIRED TO START STRUT COLLARS ROTATING. BACK-OFF TO NEAREST LOCKING SLOT
- ▲ DO NOT COAT THREADS WITH THREAD COMPOUND PER MIL-T-5548
- ▲ POSITION ZERO MARK 180° ± 1° FROM TORQUE ARM LUG CENTERLINE
- 30 AFTER PLATING, APPLY SEALANT BEAD AROUND ALL BUSHING FLANGE ODS PER M15793
- ▲ TORQUE TO BOTTOM OUT 3002600-1 RETAINER AND BACK-OFF TO THE NEAREST LOCKING HOLE
- ▲ PART 3002600-1 NUT (MINIMUM OF 100 FT/LBS TORQUE) BACK-OFF TO PROVIDE A GAP OF .004-.007. LOCK NUT. PERFORM THIS OPERATION NEXT
- ▲ TORQUE TO BOTTOM OUT 3002600-1 ISLAND NUT AND BACK-OFF TO THE NEAREST LOCKING SLOT
- ▲ INSTALL PER M14955, TYPE 1A AFTER
- ▲ DO NOT PAINT THESE SURFACES
- ▲ TAP TO PROVIDE A MAXIMUM CLEARANCE OF .001 BETWEEN TORQUE ARM INNER BUSHING FACES AND ATTACHING PART BUSHING FACES TO ALLOW TORQUE ARM TO ROTATE FREELY AFTER ASSEMBLY
- ▲ POSITION IN APPROXIMATE CENTER OF ADJUSTMENT RANGE. BEND M15065 372 COLLAR IN ONLY ENOUGH TO RETAIN FOR SHIPPING
- ▲ SEAT 3002600-101 DIAPHRAGM ASSY AND DIMPLE 3002643-1 LOCK INTO SLOT ON 3002600-1 TUBE
- ▲ WITH STRUT FULLY COMPRESSED, ADJUST 3002600-1 INDICATOR PLATE TO ALIGN WITH HOLES IN NOTCH ON UPPER TORQUE ARM
- ▲ DO NOT COAT WITH PRIMER
- ▲ INSTALL ALL BOLTS AND PINS WITH OD AND CONTACTING SURFACES COATED WITH NET 8000 POLYAMIDE PRIMER PER MIL-P-23377, EXCEPT
- ▲ TORQUE TO REMOVE ALL PERCEPTIBLE END PLAY AND BACK-OFF TO THE NEAREST HOLE
- ▲ DELETED
- 16 COAT ALL THREADS WITH THREAD COMPOUND PER MIL-T-5548 EXCEPT AS NOTED
- 13 LUBRICATE WITH MIL-G-81322 GREASE
- 18 LUBRICATE PACKINGS SEALS, BACK-UP RINGS & INNER RINGS IN M1-V AND LUBRICATE WITH 11 P-136 REGULATOR BEFORE INSTALLING
- ▲ BEFORE INSTALLATION, STAMP SERIAL NUMBER, PART IDEN NO AND CHANGE LETTER. FILL STAMPED CHARACTERS WITH BLACK LACQUER. COLOR NO. 17036 PER FED-STD-595
- ▲ SAFETY WIRE PER M33540
- ▲ STENCIL 3 INCH HIGH LETTERS WITH BLACK EPOXY ENAMEL PER MIL-P-22808 COLOR NO. 7228 PER FED-STD-595
- ▲ APPLY ONE COAT EACH POLYAMIDE PRIMER PER MIL-P-23377 AND ONE COAT URETHANE COATING PER MIL-C-83206. GLOSS INSIGNIA WHITE COLOR NO. 17075 PER FED-STD-595 MASK. ALL FUNCTIONAL SURFACES BEFORE PAINTING
- 9 ACCEPTANCE TEST PER M15925
- 8 APPROXIMATE STRUT CAPACITY 2.5 QUARTS. FILL WITH CHEVRON M1-V HYDRAULIC FLUID. CHARGE WITH DRY NITROGEN CONFORMING TO MIL-P-27401
- 7 O-RING SEALS ARE NOT ESSENTIAL FOR GEAR OPERATION
- 6 MENASCO STRESS ANALYSIS REPORT CSR 007
- 5 DESIGNED IN ACCORDANCE WITH NORTH AMERICAN ROCKWELL SPECIFICATION LB87C006
- 4 FULLY EXTENDED AIR PRESSURE: 130 PSIG (PRIMARY CHAMBER) 1,060 PSIG (SECONDARY CHAMBER)
- 3 COMPRESSION RATIO 3.87 TO 1 (ABSOLUTE); STATIC TO FULLY COMPRESSED
- 2 WEIGHT (NET): 667.9 LBS MAXIMUM
- 1 THIS IS AN INTERCHANGEABLE ASSEMBLY PER MIL-E-8300

NOTES:

3002600

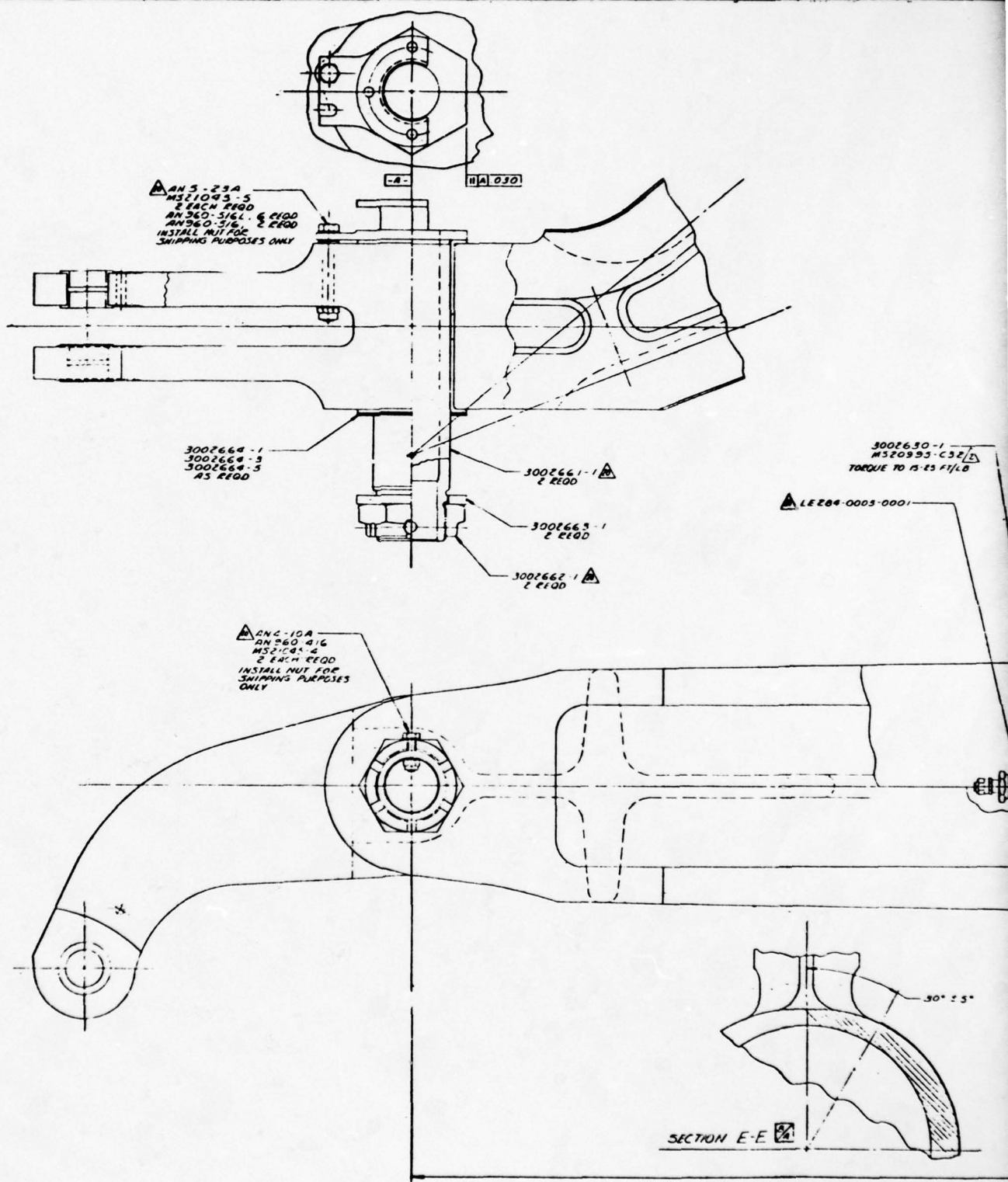
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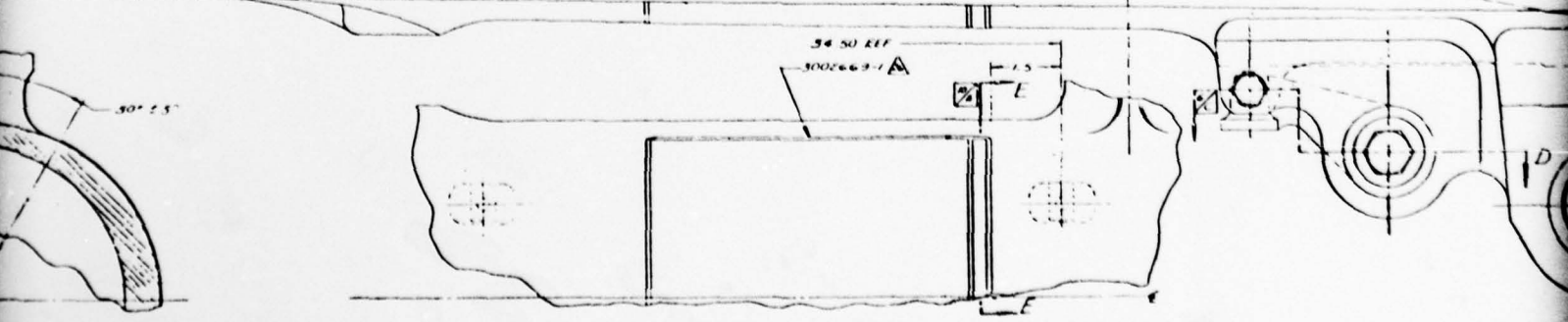
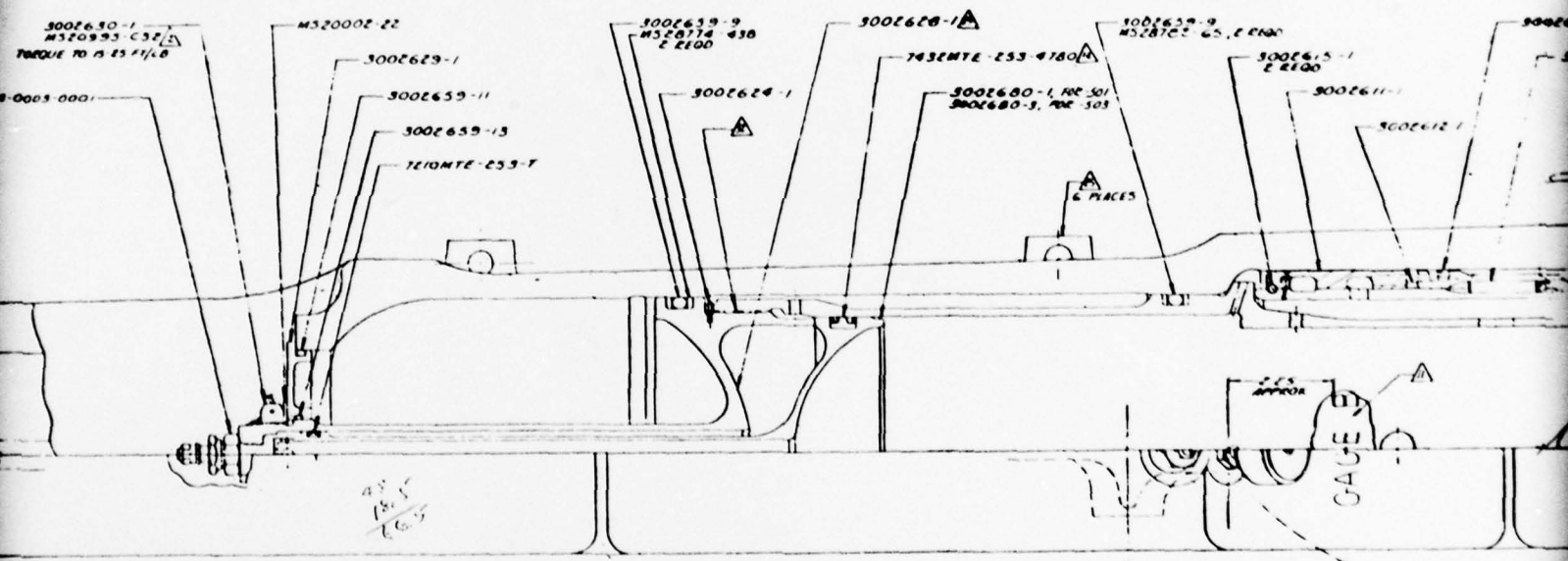
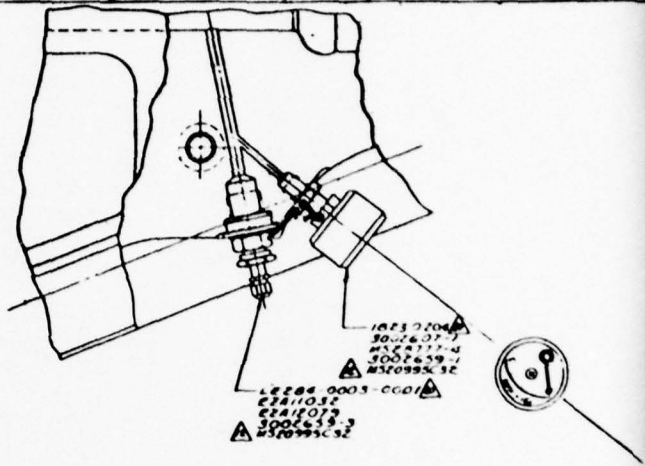
4

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10 9 8 7

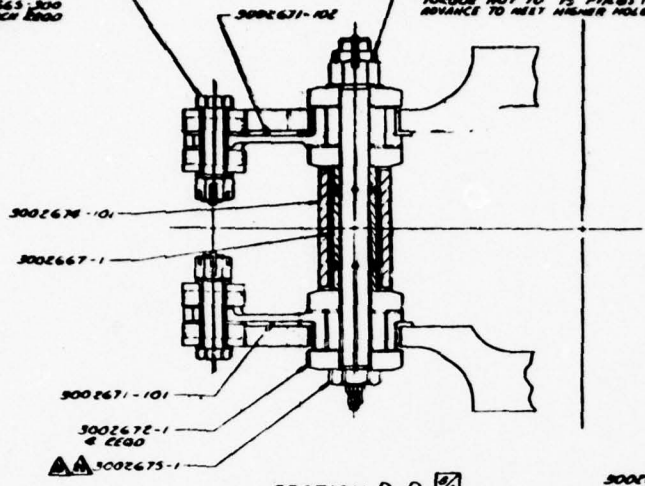


3002600 2

2

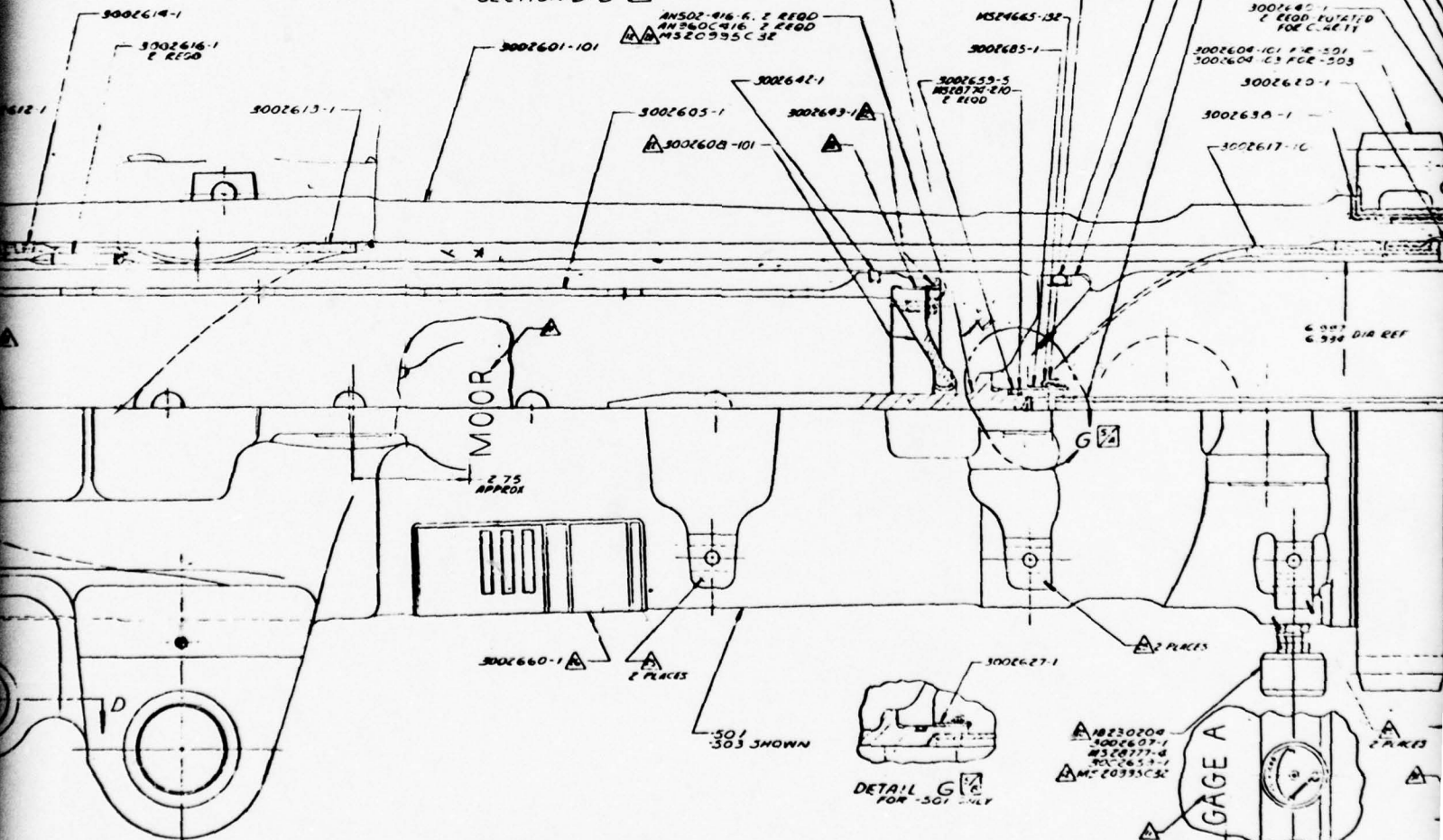
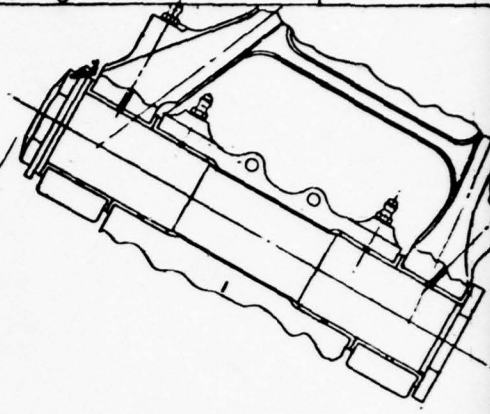
AN 177C 16
AN 560-754
MS 2465-7
MS 2465-300
2 REED

AN 510-10
AN 560-106
MS 2465-372
TOLERANCE MUST BE 75 PERCENT
ADVANCE TO AIT HIGHER HOLE ALIGNMENT



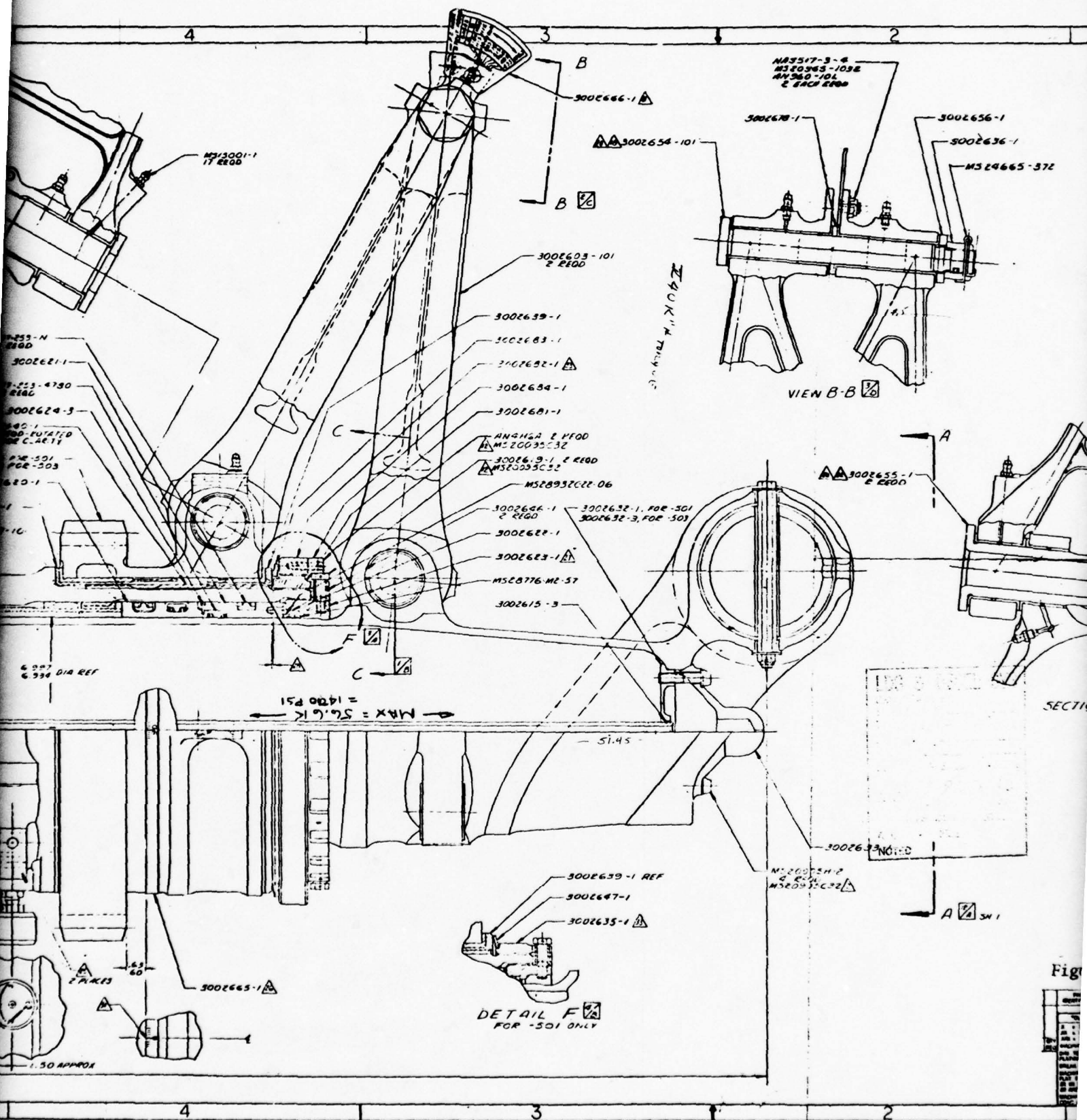
SECTION D-D

ANS 02-816 R. 2 REED
AN 560C 816-2 REED
MS 20335C 3E



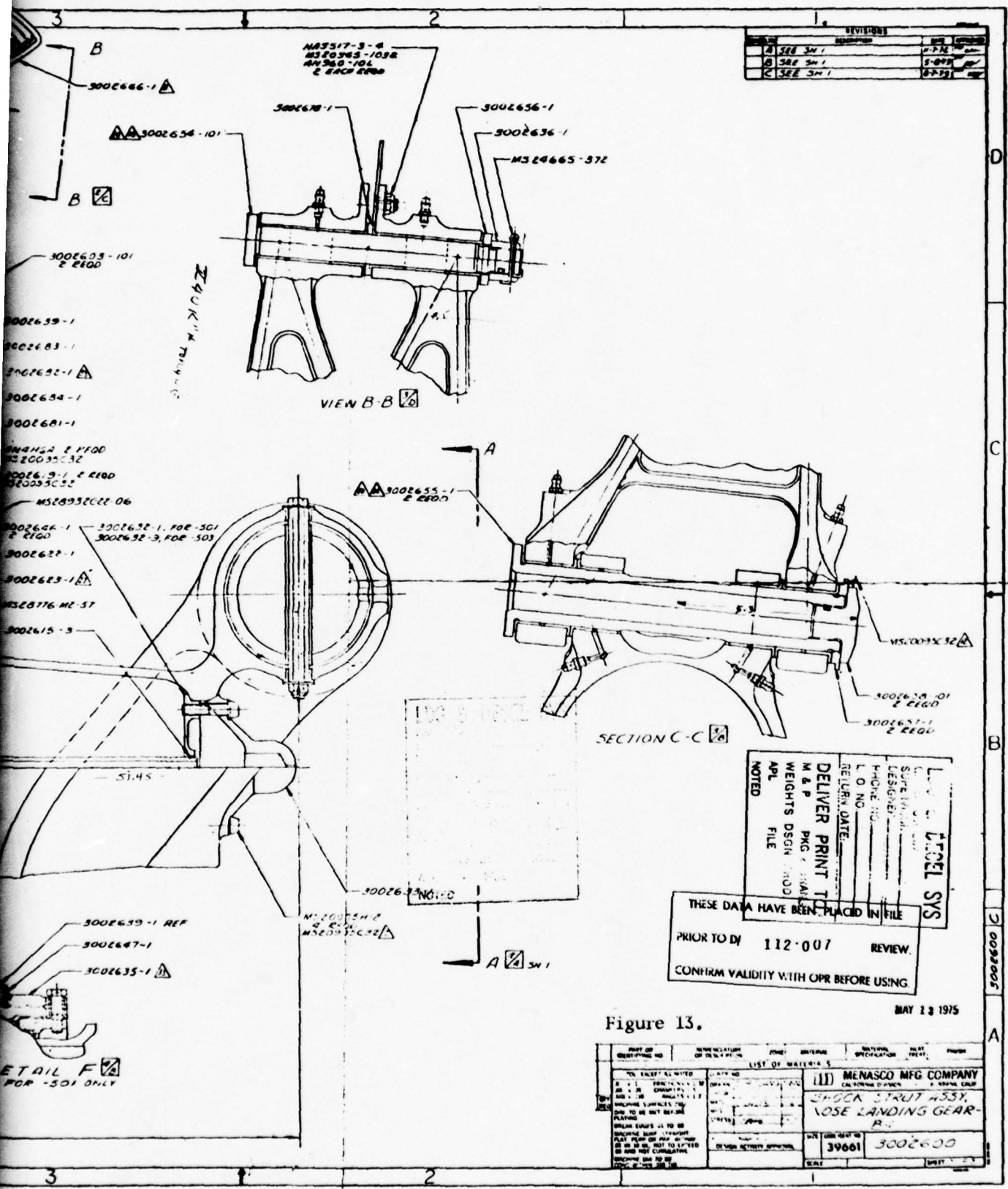
117.21 ± .10 FULLY EXTENDED
103.21 ± .04 STATIC
96.21 ± .04 FULLY COMPRESSED (SHOWN)
21.00 ± .14 STROKE

3002600



Fig

4



REVISIONS			
NO.	DESCRIPTION	BY	DATE
A	SEE SW 1	W-172	
B	SEE SW 1	S-877	
C	SEE SW 1	S-877	

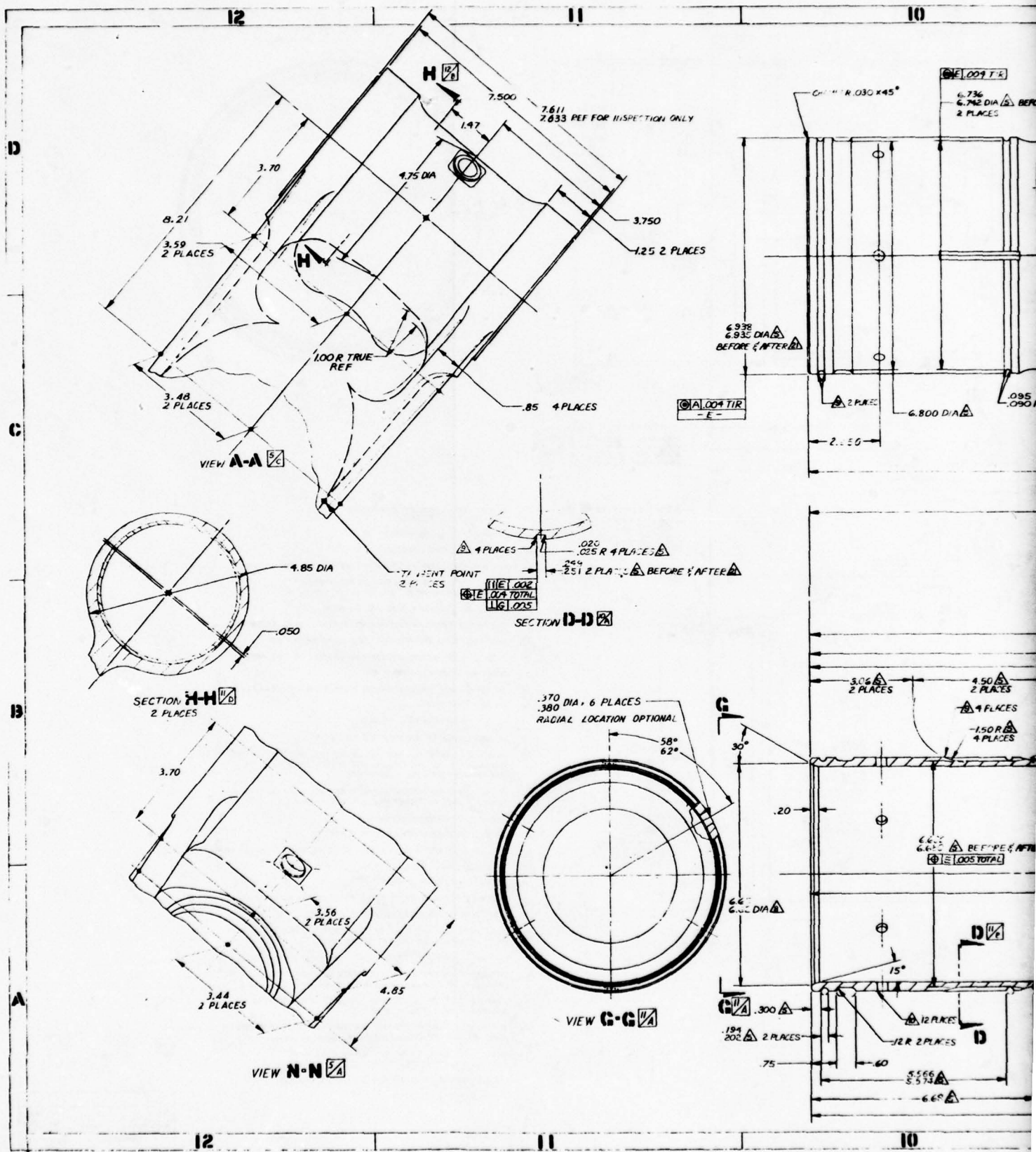
DELIVER PRINT TO	FILE
M & P	PRG & STAN
WEIGHTS	DSGN & MOD
APL	
NOTED	

THESE DATA HAVE BEEN PLACED IN FILE
 PRIOR TO BY 112-007 REVIEW.
 CONFIRM VALIDITY WITH OPR BEFORE USING

Figure 13.

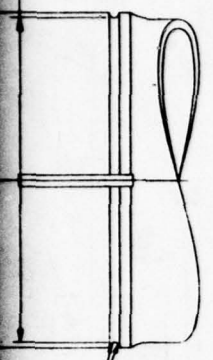
PART OR IDENTIFYING NO.	DESCRIPTION OF IDENTIFYING	QUANTITY	UNIT	REVISION	NATIONAL SPECIFICATION	DATE	FROM
LIST OF MATERIALS							
MENASCO MFG COMPANY CALIFORNIA DIVISION 2700A STRUT ASSY, NOSE LANDING GEAR R.							
DATE						39661	3002600

5

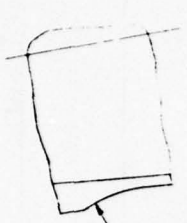


1

① F.009 TIR
 6.736
 6.742 DIA BEFORE & AFTER
 2 PLACES

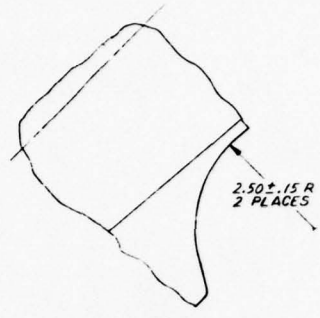


0.095
 .090 R 2 PLACES



SECTION L-L

2.50 ± .15 R
 2 PLACES

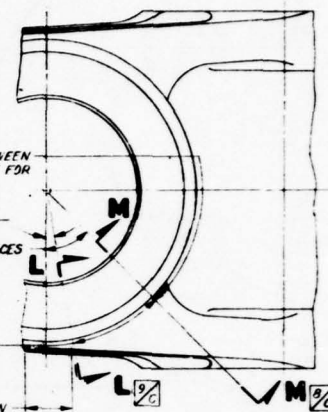


SECTION M-M

2.50 ± .15 R
 2 PLACES

BLEND SMOOTHLY BETWEEN
 2.5R AND 1.0 R FILLET FOR
 THIS DISTANCE
 2 PLACES

10° 2 PLACES
 45° 2 PLACES



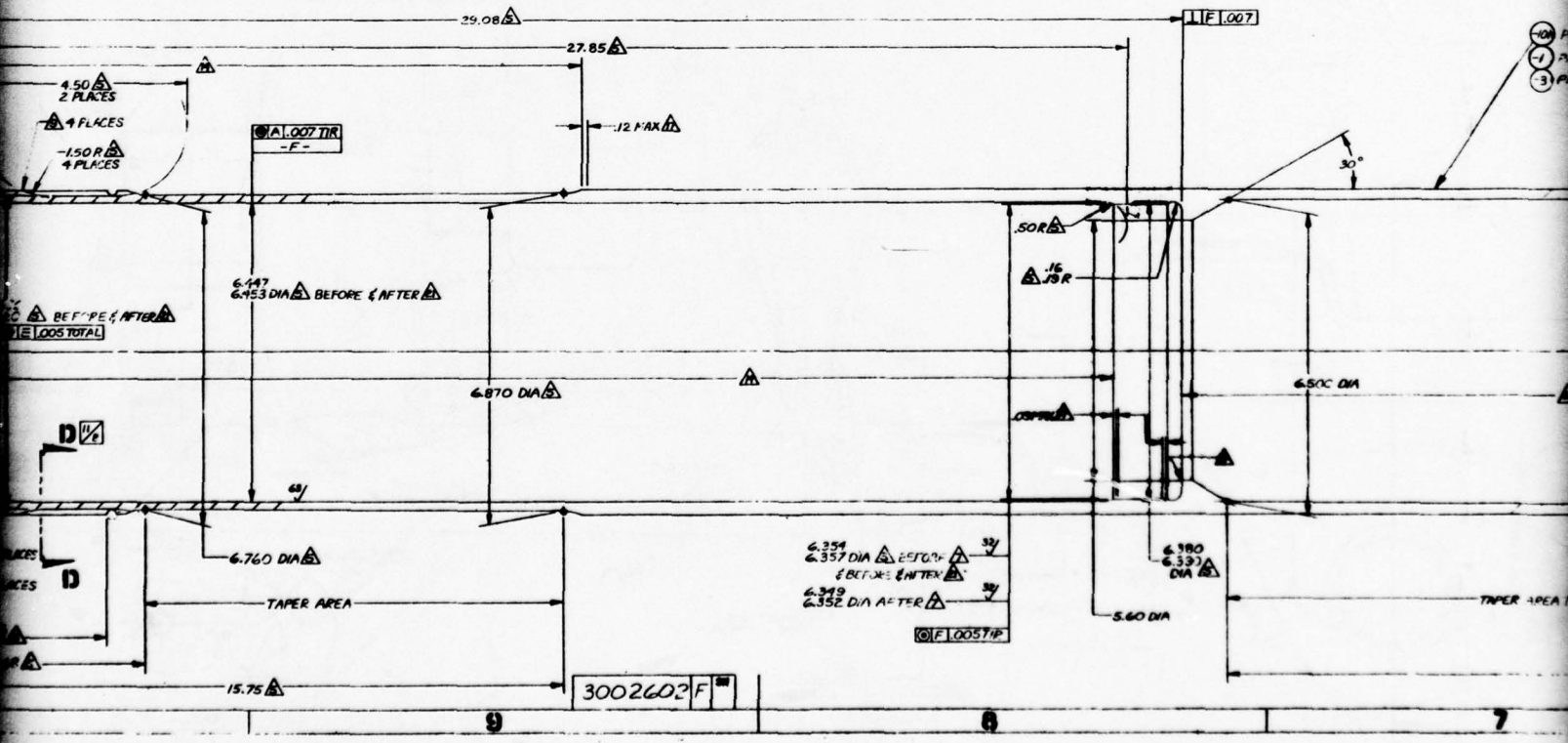
SECTION K-K

CONSTANT 2.50 R FILLET
 FOR THIS DISTANCE
 2 PLACES

BLEND SMOOTHLY BETWEEN
 2.5 R AND 1.0 R FILLET FOR
 1.0 INCH
 2 PLACES

57.44

54.91

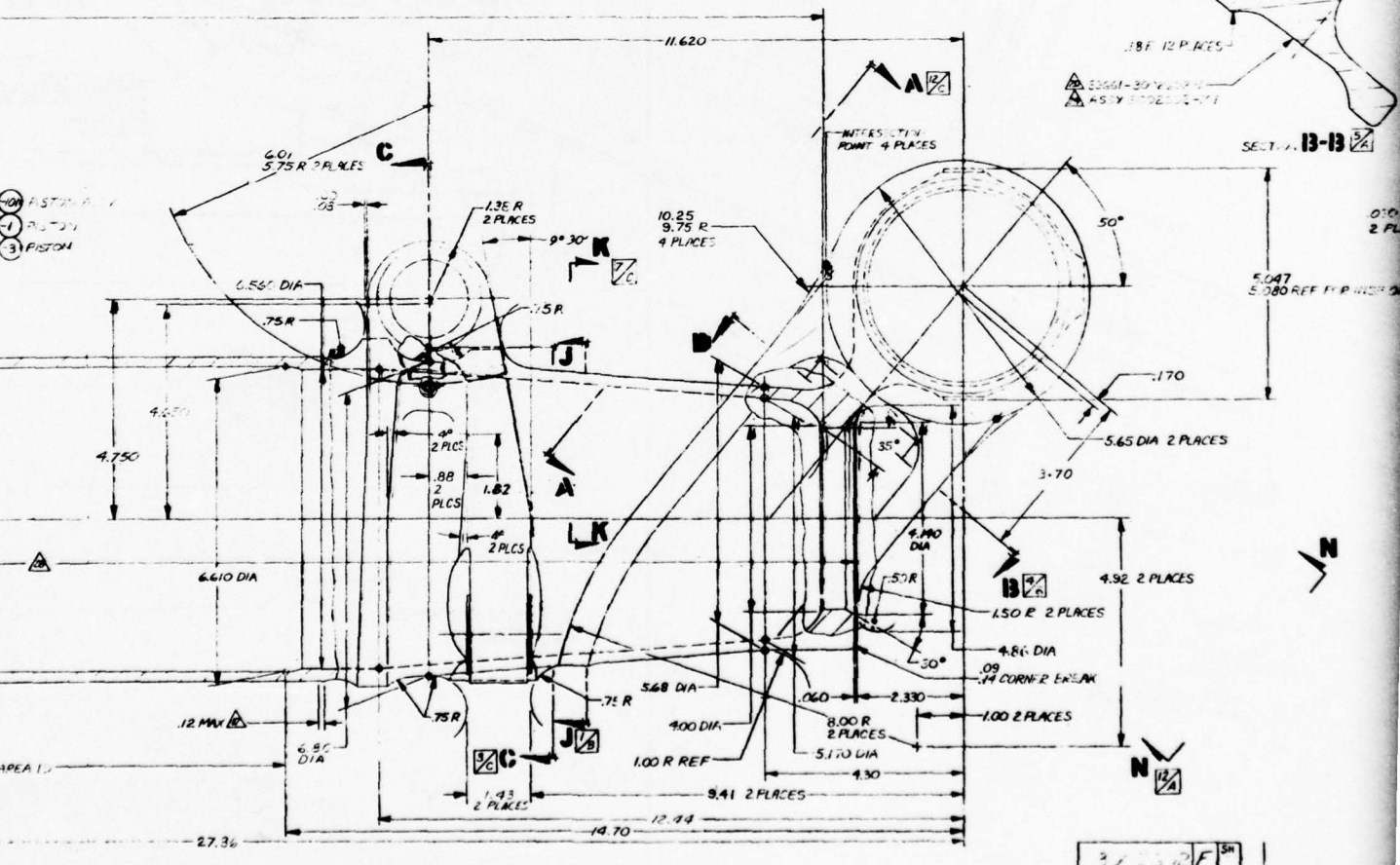
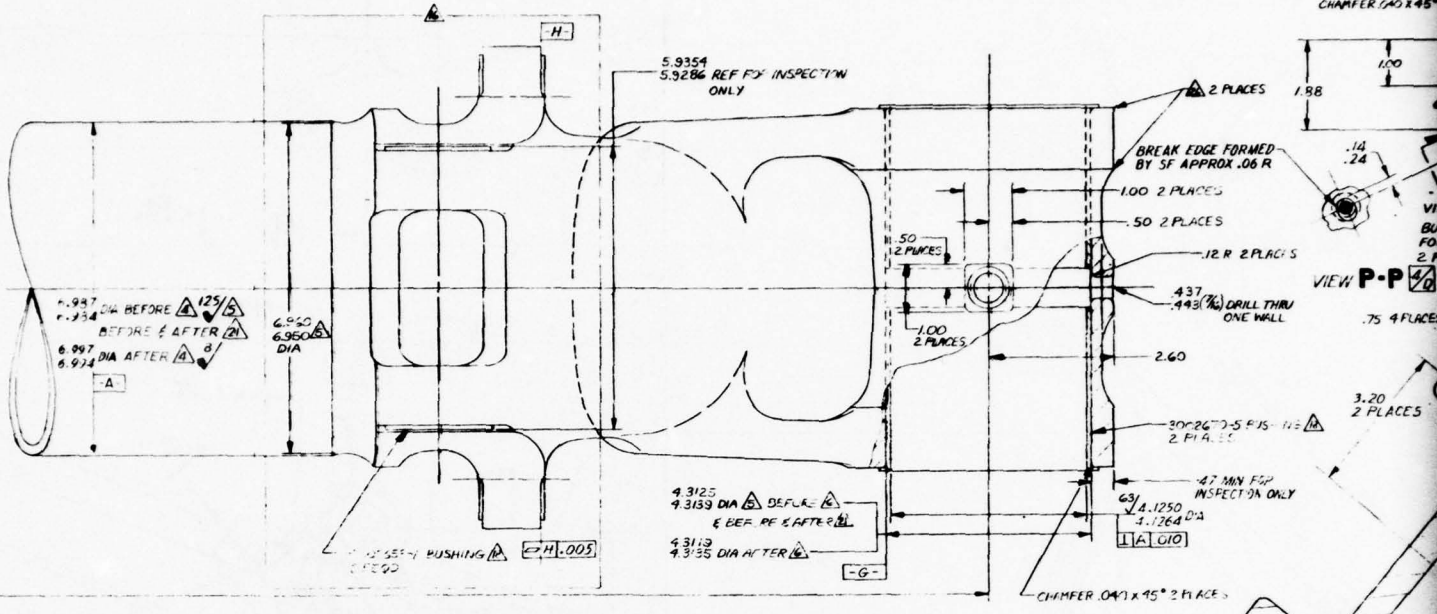


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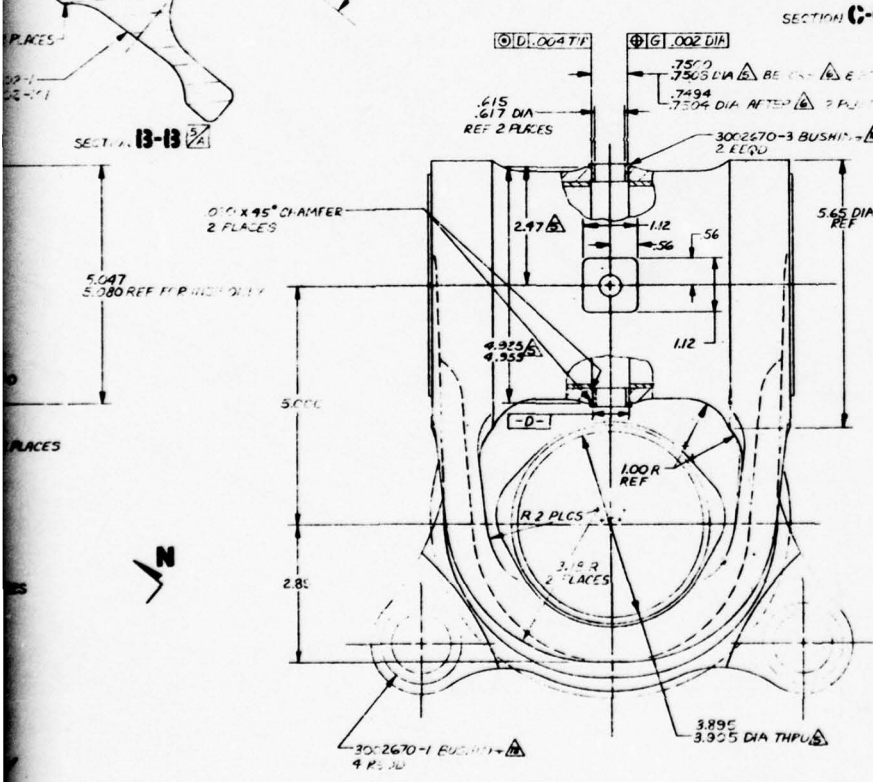
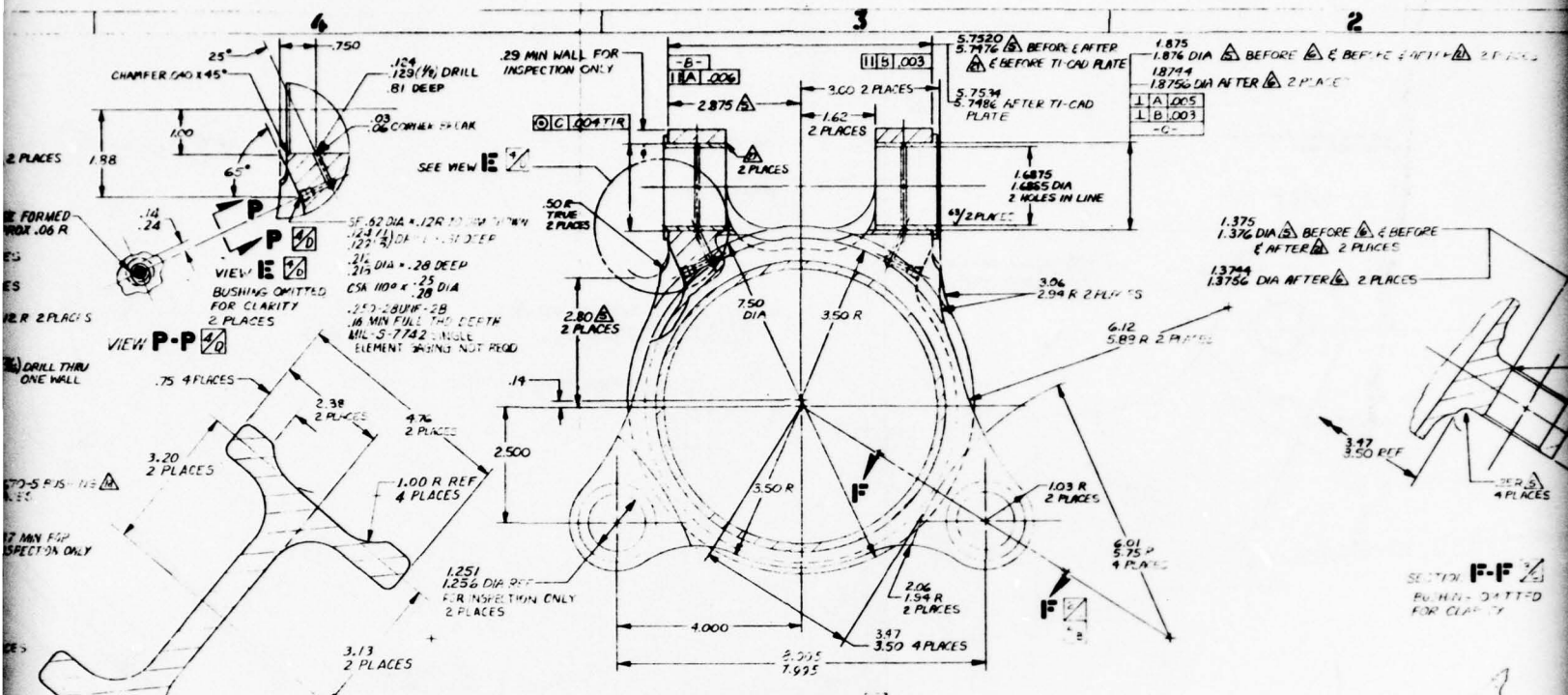


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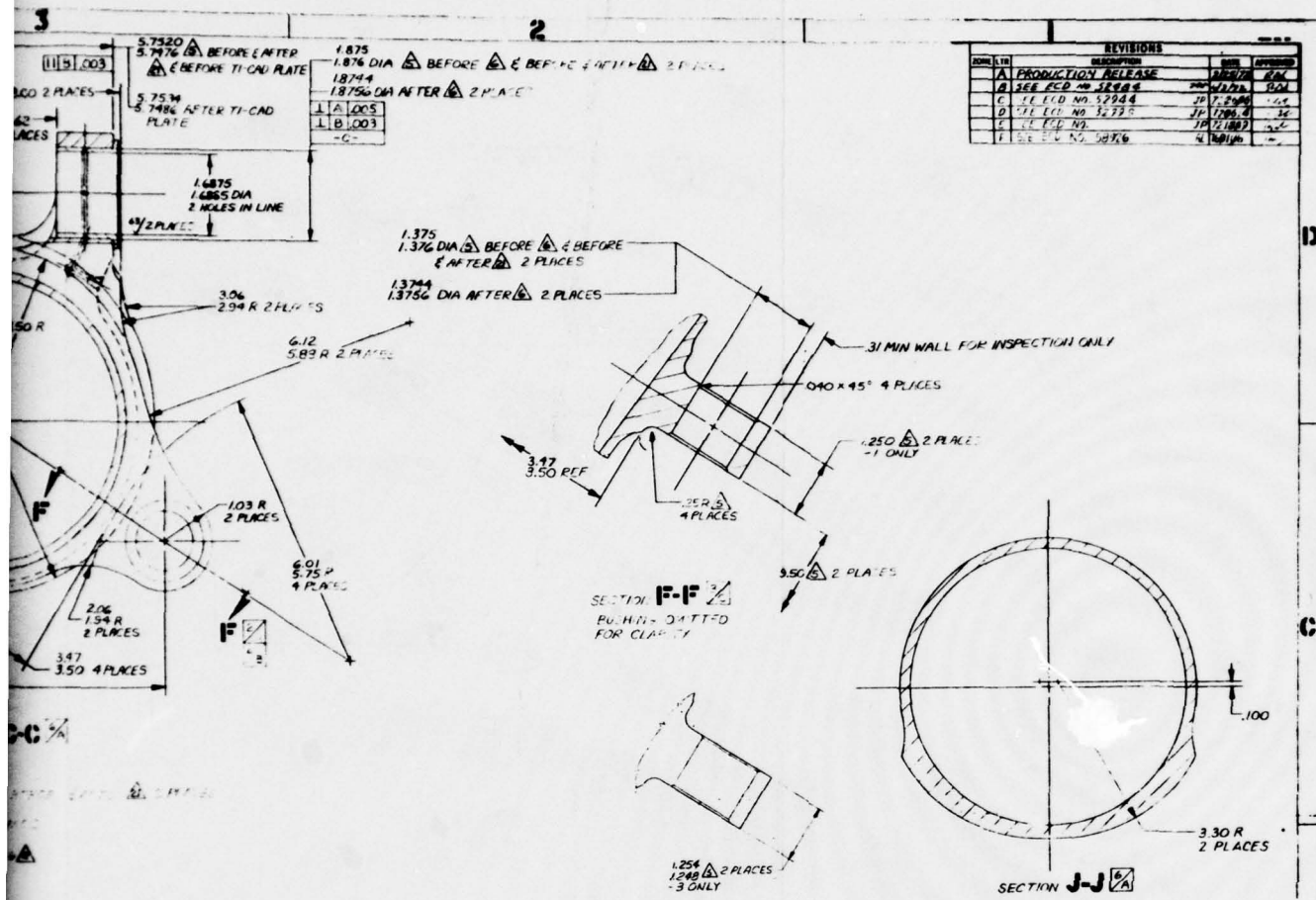
5



- ▲ ONE COAT EPOXY PRIMER PER MIL-P-23377 "IN ID AS SHOWN."
- ▲ BREAK EDGE (A) APPROX PLUNG BREAK EDGE (B) APPROX PLUNG
- ▲ 25 MAXIMUM PERMISSIBLE REMAIN ON MACHINE SURFACES AFTER HEAT TREAT NOT TO EXCEED .12 PER SURFACE
- ▲ INK STAMP ONLY MARKS
- ▲ 23 FILED BOTH ENDS
- ▲ 22 MAXIMUM PARTICLE SIZE PER MIL-STD-200 (MIL-STD-200, CLASS 1)
- ▲ SHIP PER DETAIL PART ALL OVER EXCEPT THE 1/4" DIA MIL-S-13165 SHOT NO. 230, 010-010A INTENSITY
- ▲ APPLY SOLUBLE T, PART NO. IN POSITION SYMBOLS PER SERIAL NO. USE PNEUMATIC INK AT 15 PSI. RUBBER STAMP INSPECTION SYMBOLS, OPTIONAL DO NOT INTERFERE WITH STAMP
- ▲ 19 INSTALL BUSHINGS PER DRAWING
- ▲ CHROME PLATE FINISH
- ▲ BREAK EXTERNAL EDGES (A) APPROX PLUNG ALL (B) WITH IDENTICAL AREA
- ▲ 15 BREAK EDGE (A) EXCEPT (B) AND (C)
- ▲ DO NOT CAD-TI PLATE
- ▲ CADMIUM-TITANIUM PLATE PER MIL-STD-200 CLASS 1 TYPE II (.0005 MIN THICK PER ALL OVER EXCEPT (A) (B) (C) (D) (E) (F) (G) (H) (I) (J) (K) (L) (M) (N) (O) (P) (Q) (R) (S) (T) (U) (V) (W) (X) (Y) (Z) (AA) (AB) (AC) (AD) (AE) (AF) (AG) (AH) (AI) (AJ) (AK) (AL) (AM) (AN) (AO) (AP) (AQ) (AR) (AS) (AT) (AU) (AV) (AW) (AX) (AY) (AZ) (BA) (BB) (BC) (BD) (BE) (BF) (BG) (BH) (BI) (BJ) (BK) (BL) (BM) (BN) (BO) (BP) (BQ) (BR) (BS) (BT) (BU) (BV) (BW) (BX) (BY) (BZ) (CA) (CB) (CC) (CD) (CE) (CF) (CG) (CH) (CI) (CJ) (CK) (CL) (CM) (CN) (CO) (CP) (CQ) (CR) (CS) (CT) (CU) (CV) (CW) (CX) (CY) (CZ) (DA) (DB) (DC) (DD) (DE) (DF) (DG) (DH) (DI) (DJ) (DK) (DL) (DM) (DN) (DO) (DP) (DQ) (DR) (DS) (DT) (DU) (DV) (DW) (DX) (DY) (DZ) (EA) (EB) (EC) (ED) (EE) (EF) (EG) (EH) (EI) (EJ) (EK) (EL) (EM) (EN) (EO) (EP) (EQ) (ER) (ES) (ET) (EU) (EV) (EW) (EX) (EY) (EZ) (FA) (FB) (FC) (FD) (FE) (FF) (FG) (FH) (FI) (FJ) (FK) (FL) (FM) (FN) (FO) (FP) (FQ) (FR) (FS) (FT) (FU) (FV) (FW) (FX) (FY) (FZ) (GA) (GB) (GC) (GD) (GE) (GF) (GG) (GH) (GI) (GJ) (GK) (GL) (GM) (GN) (GO) (GP) (GQ) (GR) (GS) (GT) (GU) (GV) (GW) (GX) (GY) (GZ) (HA) (HB) (HC) (HD) (HE) (HF) (HG) (HH) (HI) (HJ) (HK) (HL) (HM) (HN) (HO) (HP) (HQ) (HR) (HS) (HT) (HU) (HV) (HW) (HX) (HY) (HZ) (IA) (IB) (IC) (ID) (IE) (IF) (IG) (IH) (II) (IJ) (IK) (IL) (IM) (IN) (IO) (IP) (IQ) (IR) (IS) (IT) (IU) (IV) (IW) (IX) (IY) (IZ) (JA) (JB) (JC) (JD) (JE) (JF) (JG) (JH) (JI) (JJ) (JK) (JL) (JM) (JN) (JO) (JP) (JQ) (JR) (JS) (JT) (JU) (JV) (JW) (JX) (JY) (JZ) (KA) (KB) (KC) (KD) (KE) (KF) (KG) (KH) (KI) (KJ) (KK) (KL) (KM) (KN) (KO) (KP) (KQ) (KR) (KS) (KT) (KU) (KV) (KW) (KX) (KY) (KZ) (LA) (LB) (LC) (LD) (LE) (LF) (LG) (LH) (LI) (LJ) (LK) (LL) (LM) (LN) (LO) (LP) (LQ) (LR) (LS) (LT) (LU) (LV) (LW) (LX) (LY) (LZ) (MA) (MB) (MC) (MD) (ME) (MF) (MG) (MH) (MI) (MJ) (MK) (ML) (MN) (MO) (MP) (MQ) (MR) (MS) (MT) (MU) (MV) (MW) (MX) (MY) (MZ) (NA) (NB) (NC) (ND) (NE) (NF) (NG) (NH) (NI) (NJ) (NK) (NL) (NM) (NO) (NP) (NQ) (NR) (NS) (NT) (NU) (NV) (NW) (NX) (NY) (NZ) (OA) (OB) (OC) (OD) (OE) (OF) (OG) (OH) (OI) (OJ) (OK) (OL) (OM) (ON) (OO) (OP) (OQ) (OR) (OS) (OT) (OU) (OV) (OW) (OX) (OY) (OZ) (PA) (PB) (PC) (PD) (PE) (PF) (PG) (PH) (PI) (PJ) (PK) (PL) (PM) (PN) (PO) (PP) (PQ) (PR) (PS) (PT) (PU) (PV) (PW) (PX) (PY) (PZ) (QA) (QB) (QC) (QD) (QE) (QF) (QG) (QH) (QI) (QJ) (QK) (QL) (QM) (QN) (QO) (QP) (QQ) (QR) (QS) (QT) (QU) (QV) (QW) (QX) (QY) (QZ) (RA) (RB) (RC) (RD) (RE) (RF) (RG) (RH) (RI) (RJ) (RK) (RL) (RM) (RN) (RO) (RP) (RQ) (RR) (RS) (RT) (RU) (RV) (RW) (RX) (RY) (RZ) (SA) (SB) (SC) (SD) (SE) (SF) (SG) (SH) (SI) (SJ) (SK) (SL) (SM) (SN) (SO) (SP) (SQ) (SR) (SS) (ST) (SU) (SV) (SW) (SX) (SY) (SZ) (TA) (TB) (TC) (TD) (TE) (TF) (TG) (TH) (TI) (TJ) (TK) (TL) (TM) (TN) (TO) (TP) (TQ) (TR) (TS) (TT) (TU) (TV) (TW) (TX) (TY) (TZ) (UA) (UB) (UC) (UD) (UE) (UF) (UG) (UH) (UI) (UJ) (UK) (UL) (UM) (UN) (UO) (UP) (UQ) (UR) (US) (UT) (UU) (UV) (UW) (UX) (UY) (UZ) (VA) (VB) (VC) (VD) (VE) (VF) (VG) (VH) (VI) (VJ) (VK) (VL) (VM) (VN) (VO) (VP) (VQ) (VR) (VS) (VT) (VU) (VV) (VW) (VX) (VY) (VZ) (WA) (WB) (WC) (WD) (WE) (WF) (WG) (WH) (WI) (WJ) (WK) (WL) (WM) (WN) (WO) (WP) (WQ) (WR) (WS) (WT) (WU) (WV) (WW) (WX) (WY) (WZ) (XA) (XB) (XC) (XD) (XE) (XF) (XG) (XH) (XI) (XJ) (XK) (XL) (XM) (XN) (XO) (XP) (XQ) (XR) (XS) (XT) (XU) (XV) (XW) (XX) (XY) (XZ) (YA) (YB) (YC) (YD) (YE) (YF) (YG) (YH) (YI) (YJ) (YK) (YL) (YM) (YN) (YO) (YP) (YQ) (YR) (YS) (YT) (YU) (YV) (YW) (YX) (YZ) (ZA) (ZB) (ZC) (ZD) (ZE) (ZF) (ZG) (ZH) (ZI) (ZJ) (ZK) (ZL) (ZM) (ZN) (ZO) (ZP) (ZQ) (ZR) (ZS) (ZT) (ZU) (ZV) (ZW) (ZX) (ZY) (ZZ)

50026-01	MR B-1	REV 01
DATE	ISSUED BY	APP'D BY

4



REV	DATE	DESCRIPTION	BY	APP'D
A		PRODUCTION RELEASE		
B		SEE ECD NO 52848		
C		SEE ECD NO 52944		
D		SEE ECD NO 52720		
E		SEE ECD NO		
F		SEE ECD NO 52976		

- ONE COAT EPOXY PRIMER PER MIL-P-23377 IN ID AS SHOWN.
- BREAK EDGE ON APPROX RADIUS
- BREAK EDGE 12 IN RADIUS
- 25 MAXIMUM PERMISSIBLE REMAIN ON MACHINING SURFACES AFTER HEAT TREAT NOT TO EXCEED 12 PER CENT
- 24 FINISH TO FACED SURFACES
- 22 MAXIMUM PERMISSIBLE WELDED PER MIL-STD-2000 MM5537, CLASS 1
- 21 SHOT PEEN DETAIL PART ALL OVER EXCEPT THE 1/4" MIL-S-13165, SHOT NO. 230, 010-00A INTENSITY
- APPLY CODE "P", PART NO., IN POSITION SYMBOLS AND SERIAL NO. USE - PNEUMATIC APPLICATOR NUMBER STAMP INSPECTION SYMBOLS, OPTIONAL
- DO NOT MAKE DIMENSION STAMP
- INSTALL BUSHINGS PER MM743
- CHROME PLATE RUN-OUT
- BREAK EXTER. EDGES 16-23 APPROX WITH ALL 1/8" WITH 1 DENOTED AREA
- 15 BREAK OFF 03-04 EXCEPT AND
- DO NOT CAD-TI PLATE
- 13 CADMIUM-TITANIUM PLATE FOR M44339 CLASS 1 TYPE II (0005 MIN THICK PER ALL OVER EXCEPT)
- 12 THIS PART MAY BE MACHINED BEFORE HEAT TREAT AS LIMITED BY
- 11 DELETED
- BREAK EDGE ON APPROX RADIUS
- BREAK EDGE ON APPROX RADIUS
- GRINDING PERMISSIBLE AFTER HEAT TREATMENT
- CHROME PLATE PER QQ-C-347, CLASS 2, THICKNESS 0.01 MIN
- CADMIUM-TITANIUM PLATE PER M44339, CLASS 1 TYPE II (0002-04 3 TH. REF)
- THIS DIMENSION OR SURFACE MAY BE MACHINED AFTER HEAT TREAT
- CHROME PLATE PER QQ-C-320 CLASS 2, THICKNESS 0.01 MIN
- 3 SURFACE ROUGHNESS EXCEPT AS SHOWN
- PRIMER AND HEAT TREAT TO PER MIL-STD-2000 PER MIL-STD-2000
- 1 MAKE FROM 3002702-1 HANG FORGINGS (300M STEEL REF)

SECTION F-F FOR -3 ONLY

Figure 14.

QTY	PART OR IDENTIFYING NO.	DESCRIPTION OR DESIGNATION	ZONE	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH
2	3002670-5	BUSHING	5C				
4	3002670-1	BUSHING	4A				
2	3002670-3	BUSHING	5B				
2	3002655-	BUSHING	6C				
1	-3	PISTON	7B				
1	-1	PISTON	7B				
1	-10B	PISTON ASSY	7B				
1	-10I	PISTON ASSY	7B				

LIST OF MATERIALS	
3002602	UNCONTROLLED COPY
MENASCO MFG COMPANY	
PISTON ASSY - SHOCK	
ST. T. NLS, B-1	
J 396601	3002602

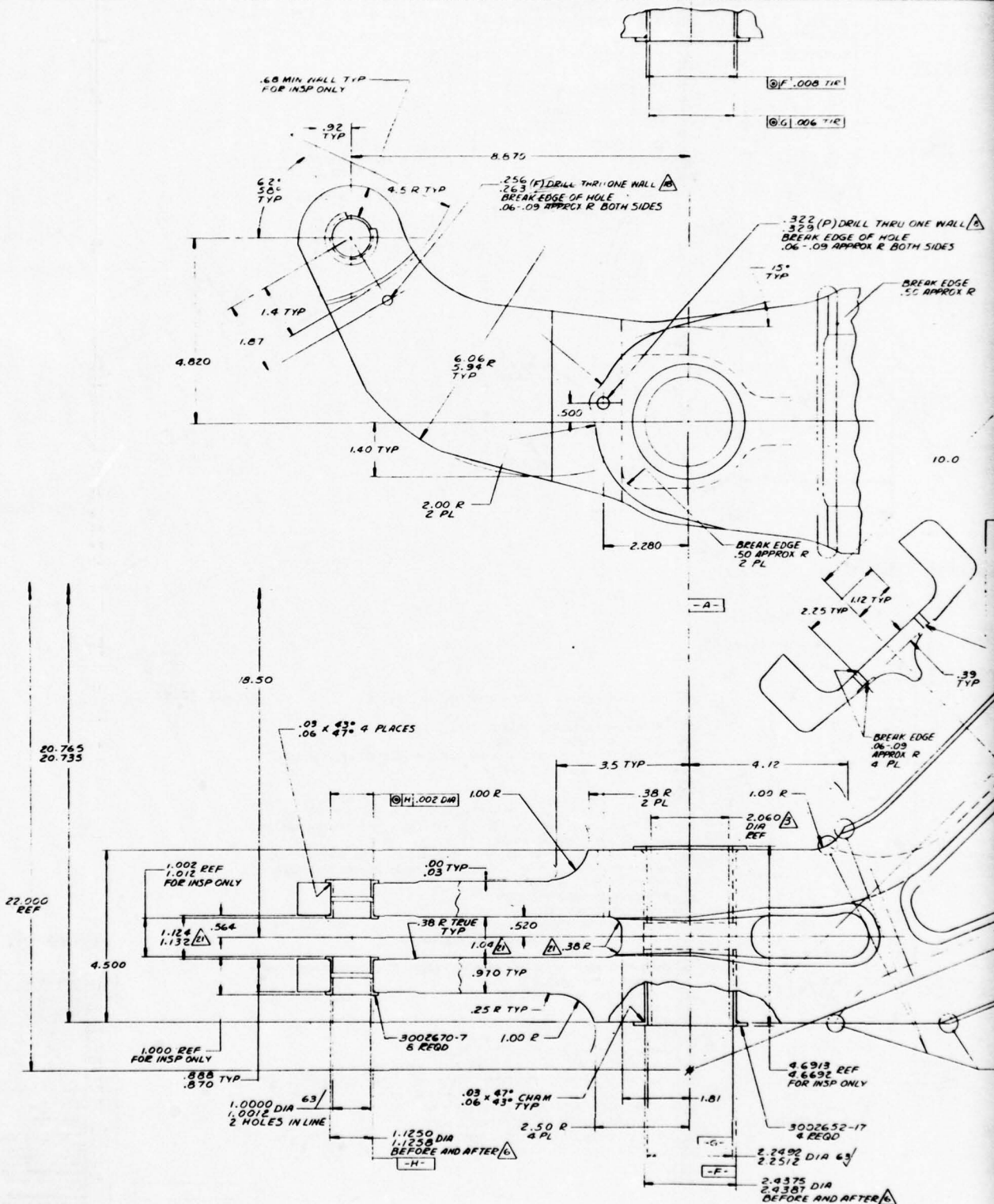
3002602	NR B-1	1/400	1/400
APPLICATOR	USED ON	QTY REQUIRED	QTY USED

5

13

12

11



13

12

11

1

10

9

8

22.00

36.00

36.50

BREAK EDGE
.25 APPROX
TYP

.8

K

2.00

4.00

6.95 DIA
REF

SYN
EXCEPT AS
NOTED BY

NOTED BY

7.3

VIEW L

EN EDGE
.05 APPROX

VIEW L

.925
.985 (NO. 10) DRILL
SF .62 DIA x .06-.09 R
6 PL

.39
TYP

10.320
BOTH ARMS

6.660
BOTH ARMS

3.000
THIS ARM
ONLY

5.880

7.56

.97

22°

5/8 MIN

10°

51°30'

10°

3/2

25.50
REF

P

20°

125

.190 R

VIEW A
SCALE: 4/1

8.280
DIA

8.100
DIA

1.580

SF 1.50 DIA x .12 R
.09

BREAK EDGE .03/.06 R

.03
.06 R

1.000 DIA
1.003 DIA

1.020 DIA
1.030 DIA

VIEW L
SCALE: 4/1

4.62
TYP

4.12
TYP

BREAK EDGE
.50 APPROX
TYP

.256 (F) DRILL x .06 DEEP
.263
6 PL

.531 DIA DEPTH AS SHOWN
B
BREAK EDGE OF NOSE
.06/.09 APPROX R
6 PL

SECTION M-M
SCALE: 4/1

3002687

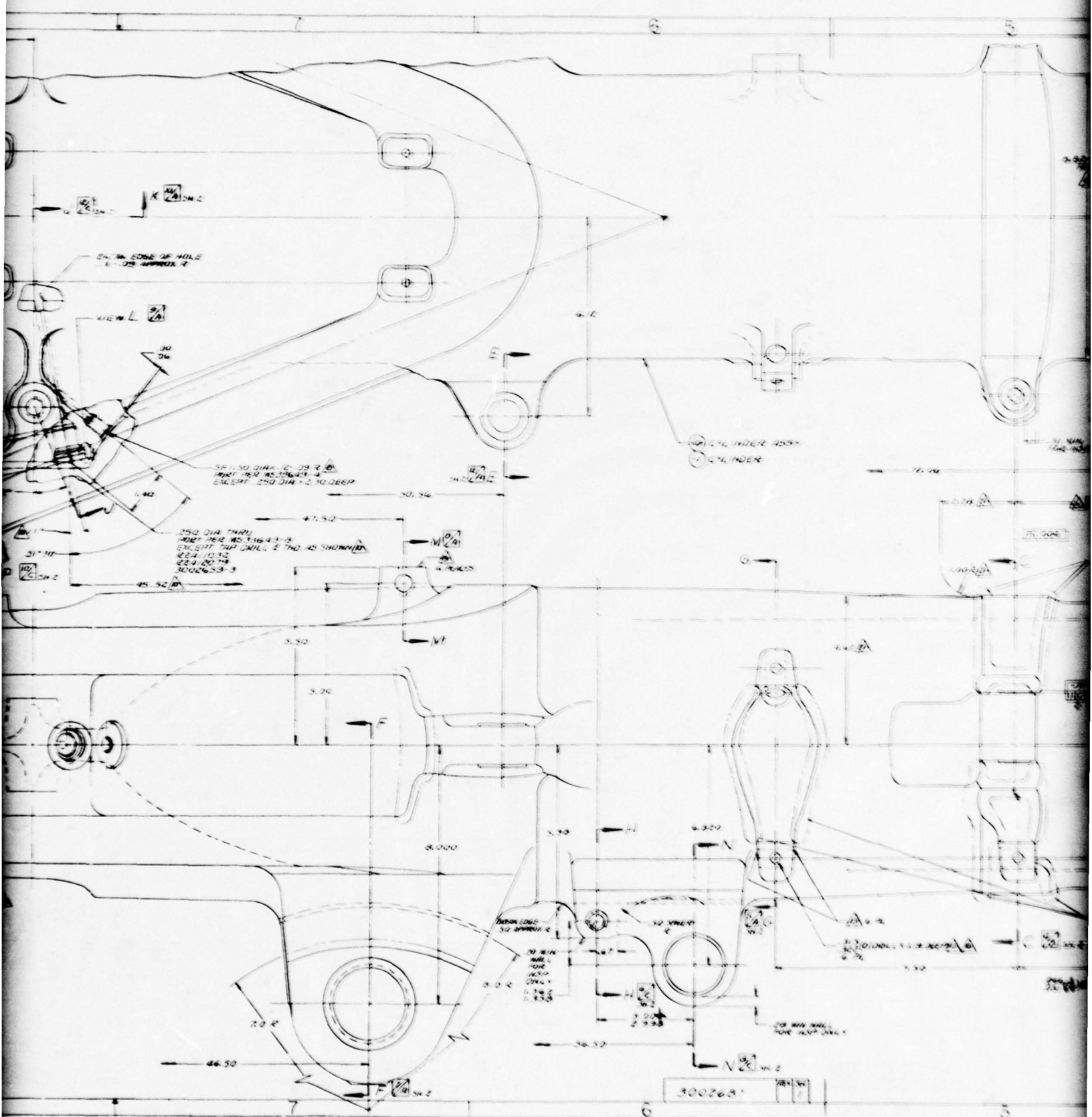
REV 34
1

10

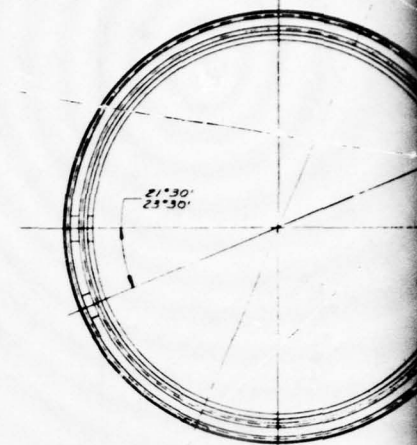
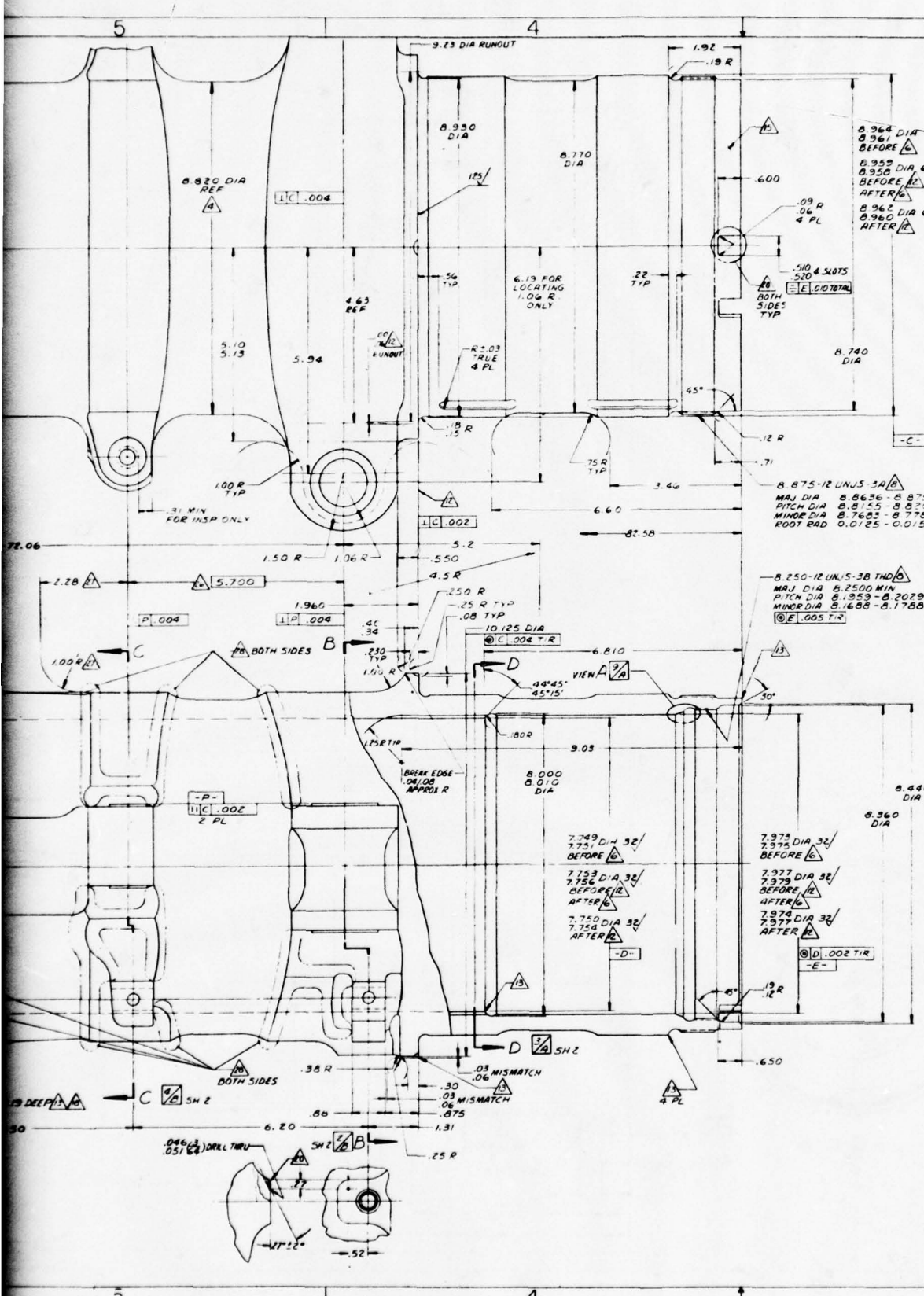
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8

2



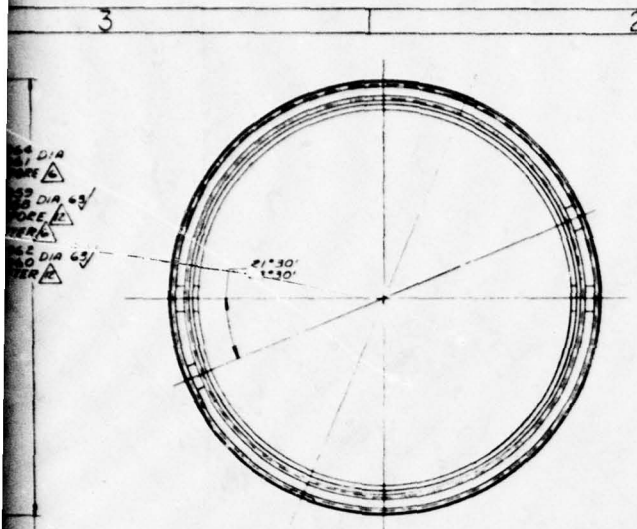
3



- 2050A, INC. NEWPORT BEACH, CA
CODE IDENT NO. 03320
- BREAK EDGE .19/.38 APPROX R
- 100% CLEAN UP NOT REQUIRE
- THIS DIMENSION APPLIES TO MACHINING OF BUSHING ID ONLY
- INSTALL 3002652-15 BUSHINGS PER MM5743 EXCEPT CLATING TO BE MIL-C-16173, GRADE 4
- LOCATE W/ MASTER TGCL NO. G-14876
- ONE COAT OF EPOXY PRIMER PER MIL-P-23977 ON ID AS SHOWN
- BRUSH QAD PLATE PER MIL-STD-865 AFTER MACHINING
- REDUCED SHOT PEENING INTENSITY ACCEPTABLE IN THIS AREA
- BREAK EDGE .01/.03 APPROX R
- DO NOT ANODIZE, BRUSH CHEMICAL FILM PER MIL-C-5541 CLASS DO NOT SHOT PEEN
- 17 CLEAN PER MM5534 AFTER
- 16 INSTALL BUSHINGS PER MM5743 EXCEPT
- ALY CODE IDENT NO., PART NO., SERIAL NO., AND INSP SYMBOL PNEUMATIC VIBRATING PENCIL, INK STAMP ASSY NO., INK STAMP INSP SYMBOL OPTIONAL
- 14 FLUORESCENT PENETRANT INSPECT PER MIL-I-6866 TYPE I METHOD A OR B. NO DETECTABLE DEFECTS PERMITTED
- BREAK EDGE APPROX .08/.06 R
- ANODIZE PER MIL-A-8625, CL I, TYPE III
- THIS SIDE ONLY
- 9 DO NOT IMPRESSION STAMP
- THREADS PER MIL-S-8879, SINGLE ELEMENT GASING NOT REQD
- 7 BEAN EXTEROP SHARP EDGES .13 APPROX R EXCEPT AS SHOWN
- SHOT PEEN ALL OVER EXCEPT THREADS PER MIL-S-13163, SHOT NO 230, .010-GMRA INTENSITY
- 5 DATUM **A** AND **B** TO BE IN THE SAME PLANE WITHIN .080
- DATUM **B** (1/4 OF BASIC CYLINDER) TO BE ESTABLISHED BY CENTERING AT 6.45 DIA REF AND 8.820 DIA REF WITHIN .020
- DATUM **C** TO BE ESTABLISHED BY CENTERING AT 2.06 DIA REF HOLES WITHIN .030
- 2 MACHINED SURFACES 125/ BEFORE SHOT PEEN EXCEPT AND 25/ AFTER SHOT PEEN EXCEPT AS SHOWN
- MAKE FROM 3002 686-1 ROUGH MACHINE (AL ALY 7175-7736 REF)

NOTES: UNLESS OTHERWISE SPECIFIED

4



REVISIONS			
DATE	APPROVED	DESCRIPTION	INITIALS

0.870
 0.820
 0.770
 0.0150

- 17 CLEAN PER MM5534 AFTER
- 16 INSTALL BUSHINGS PER MM5743 EXCEPT
- 15 KEY CODE IDENT NO., PART NO., SERIAL NO., AND INSP SYMBOL WITH PNEUMATIC VIBRATING PENCIL. INK STAMP ASSY NO., INK STAMP INSP SYMBOL OPTIONAL.
- 4 FLUORESCENT PENETRANT INSPECT PER MIL-I-6066 TYPE I METHOD A OR B. NO DETECTABLE DEFECTS PERMITTED.
- 14 BREAK EDGE APPROX .03/06 R
- 12 ANODIZE PER MIL-A-8625, CL I, TYPE III
- 10 ANODIZE PER MIL-A-8625, CL I, TYPE II ALL OVER EXCEPT AND
- 9 THIS SIDE ONLY
- 9 DO NOT IMPRESSION STAMP
- THREADS PER MIL-S-8879, SINGLE ELEMENT GASING NOT REQD
- 7 BREAK EXTERIOR SHARP EDGES IS APPROX R EXCEPT AS SHOWN
- SHOT PEEN ALL OVER EXCEPT THREADS PER MIL-S-15165, SHOT NO. 230, .010-.018A INTENSITY
- 5 DATUM AND TO BE IN THE SAME PLANE WITHIN .080
- DATUM (4 OF BASIC CYLINDER) TO BE ESTABLISHED BY CENTERING AT 6.45 DIA REF AND 8.020 DIA REF WITHIN .020
- DATUM TO BE ESTABLISHED BY CENTERING AT 2.06 DIA REF HOLES WITHIN .030
- 2 MACHINED SURFACES 125% BEFORE SHOT PEEN EXCEPT AS SHOWN AND 25% AFTER SHOT PEEN EXCEPT AS SHOWN
- MAKE FROM 3002686-1 ROUGH MACHINE (AL ALY 7175-7736 REF)
- NOTES: UNLESS OTHERWISE SPECIFIED

Figure 15.

QTY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	UNIT	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH
1	27A12079	INSERT	7C	1			
1	27A11032	LOCK RING	7C	1			
1	3002659-3	PACKING	7C	1			
4	3002670-7	BUSHING	12A	1			
4	3002652-7	BUSHING	11A	1			
2	3002670-8	BUSHING	3C	2			
4	3002670-17	BUSHING	6C	2			
2	3002670-15	BUSHING	8C	2			
4	3002670-8	BUSHING	18D	2			
2	3002670-11	BUSHING	1B	2			
2	3002672-5	BUSHING	5C	2			
2	3002652-3	BUSHING	5C	2			
4	3002652-13	BUSHING	7A	2			
4	3002651-1	BUSHING	12B	2			
	-1	CYLINDER	6C	1			MAY 20 1976
	-101	CYLINDER ASSY	6C	1			

UNCONTROLLED COPY

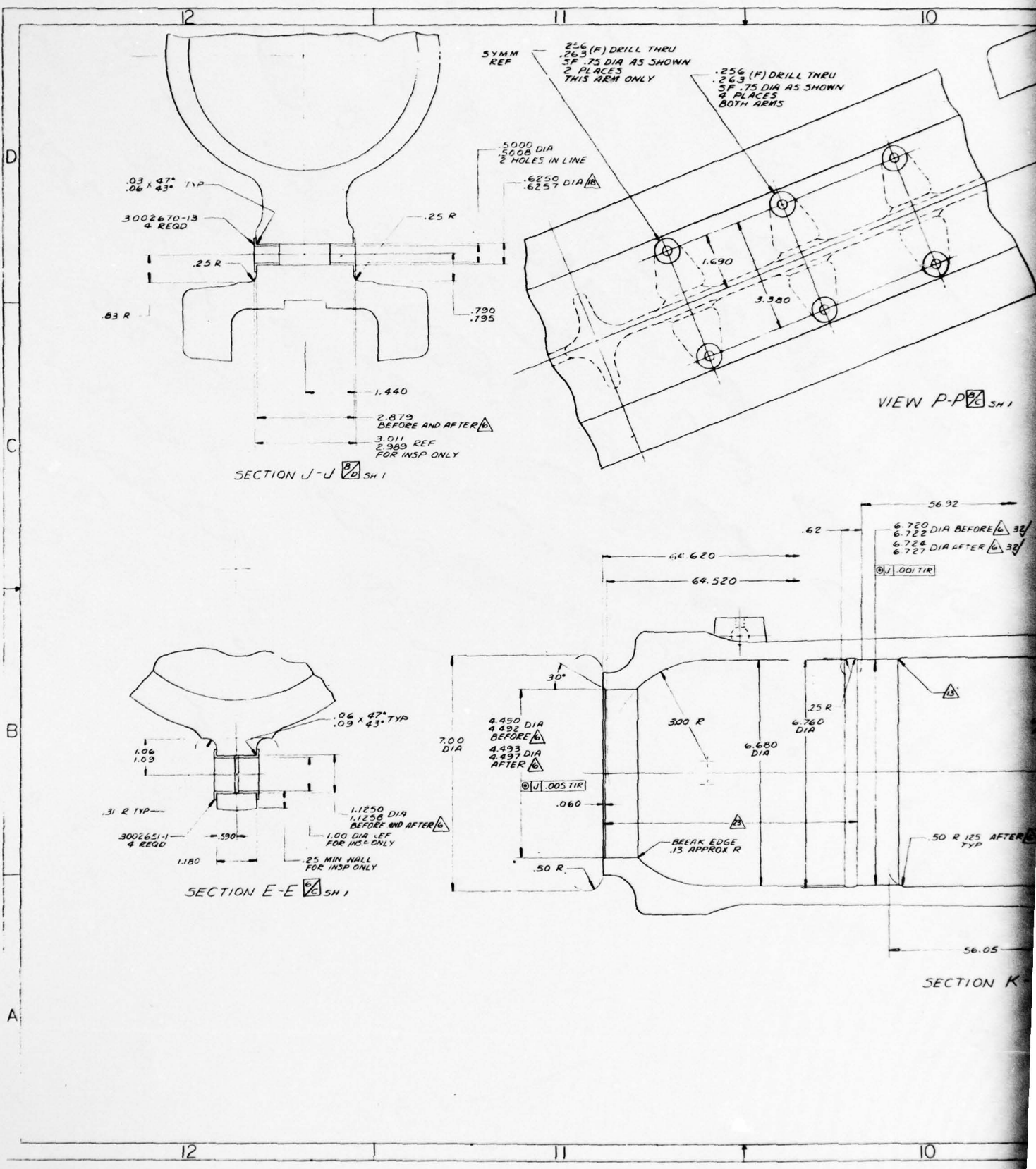
Menasco MFG COMPA. CALIFORNIA DIVISION BIRBAK, CA

CYLINDER ASSY, SHOCK STRUT-NLG

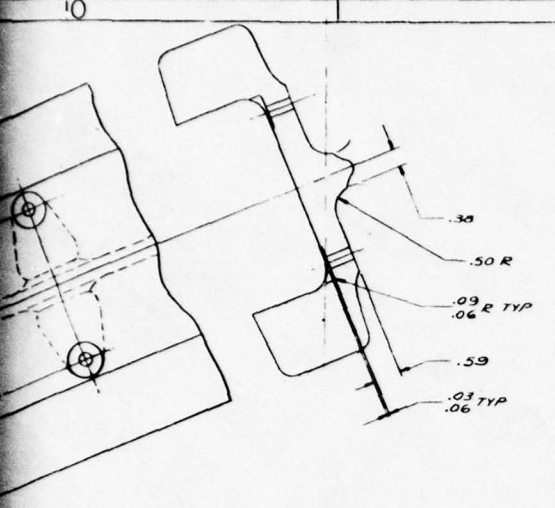
3002651 3002657

3002651	B-1	(40)	(40)
NET WEIGHT	USED ON	TOTAL	REMA
APPLICATION	QTY REQUIRED		

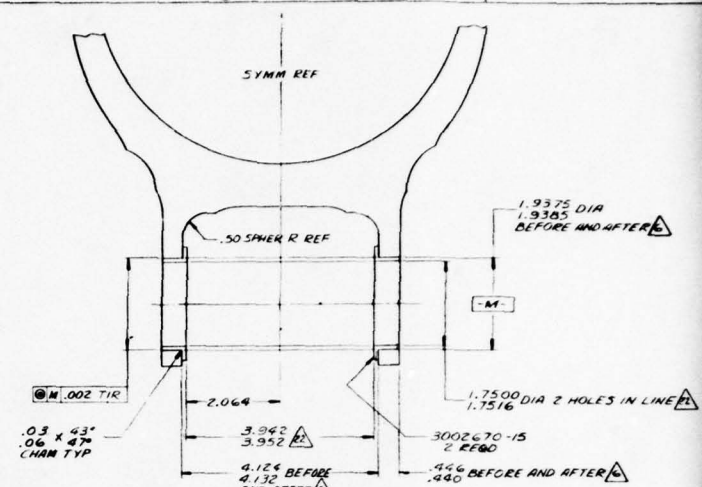
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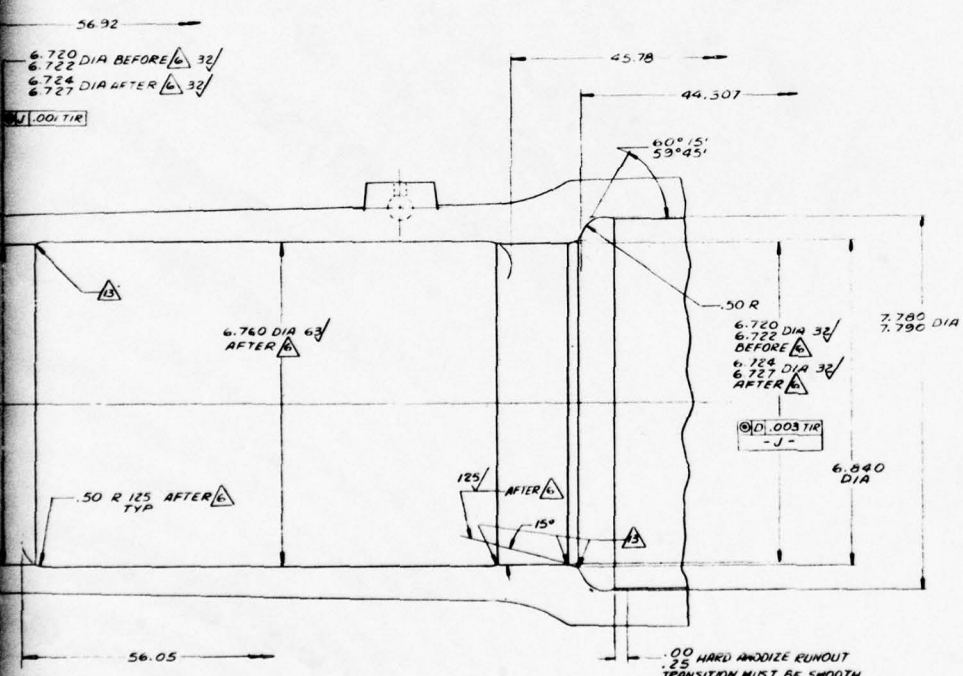
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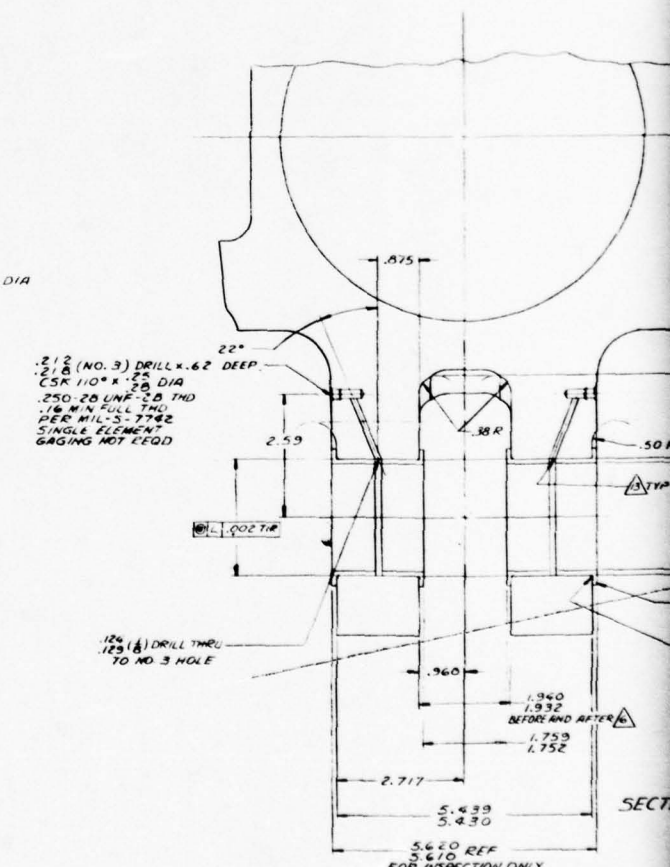
VIEW P-P $\frac{1}{2}$ SH 1



SECTION N-N $\frac{1}{2}$ SH 1



SECTION K-K $\frac{1}{2}$ SH 1



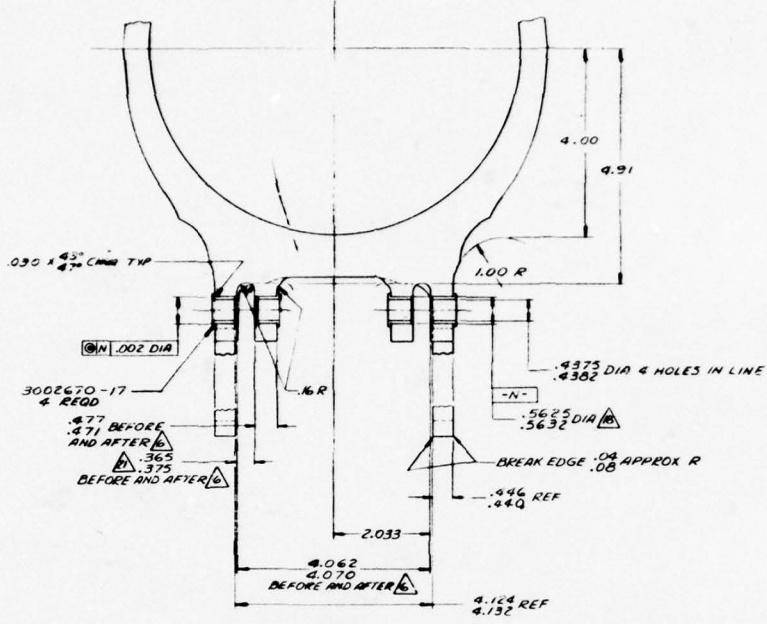
SECTION M-M $\frac{1}{2}$ SH 1

3002687 REV 5/81 2

2

7 6 5

SYMM REF



$\text{H}11 \text{C} .005 \text{ DIA}$
2 PLACES

3002652-13
2 REED

$\text{H}11 \text{A} .006$

1.599
1.592
BEFORE AND AFTER

2.100

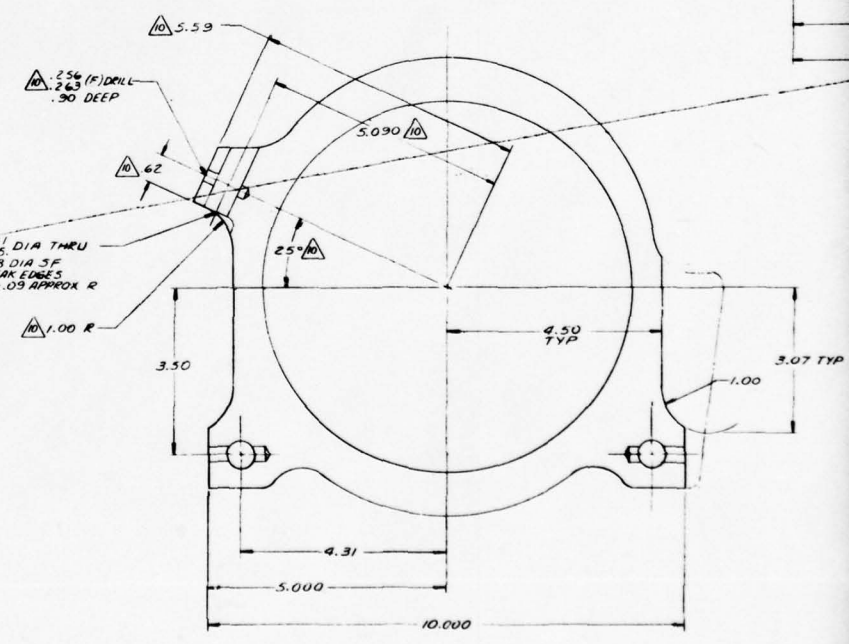
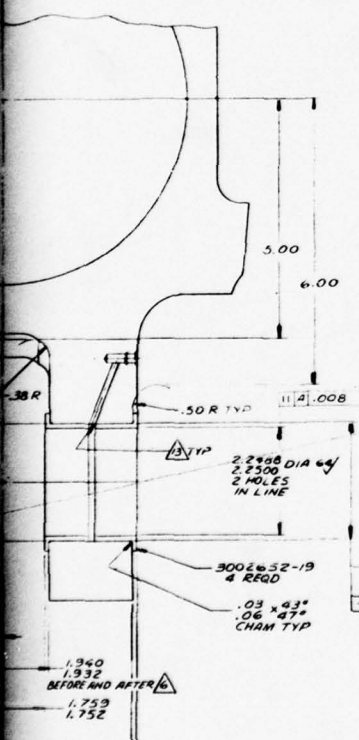
.51 R

6 PLACES

1.9375 DIA
1.9385 DIA
BEFORE AND AFTER

.500 DIA 2 HOLES IN LINE

10-15
BEFORE AND AFTER



39
30
REF
SECTION ONLY

SECTION F-F $\frac{7}{A}$ SH 1

SECTION G-G $\frac{6}{A}$ SH 1

300268 SH 2

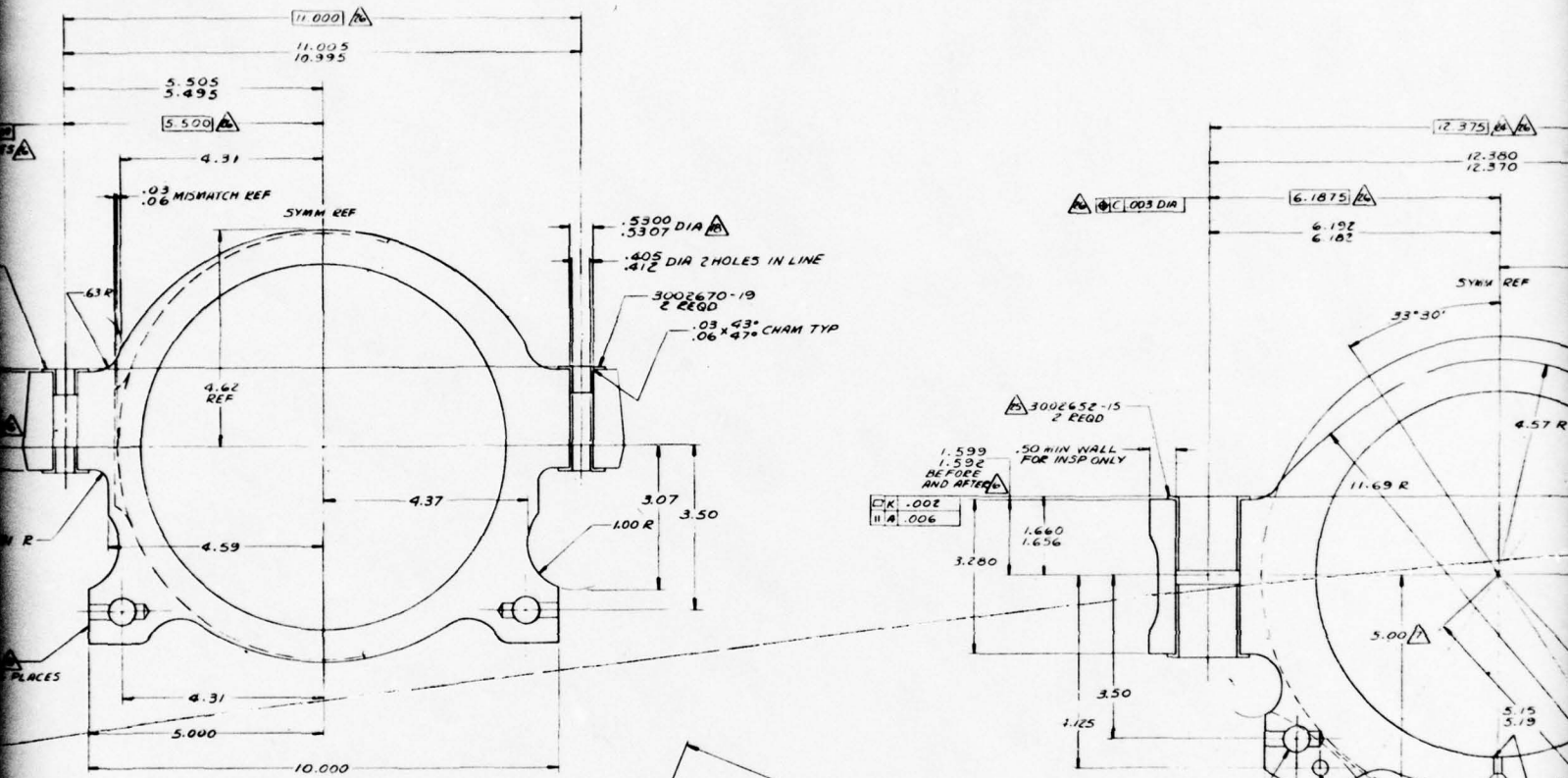
7 6 5

3

4

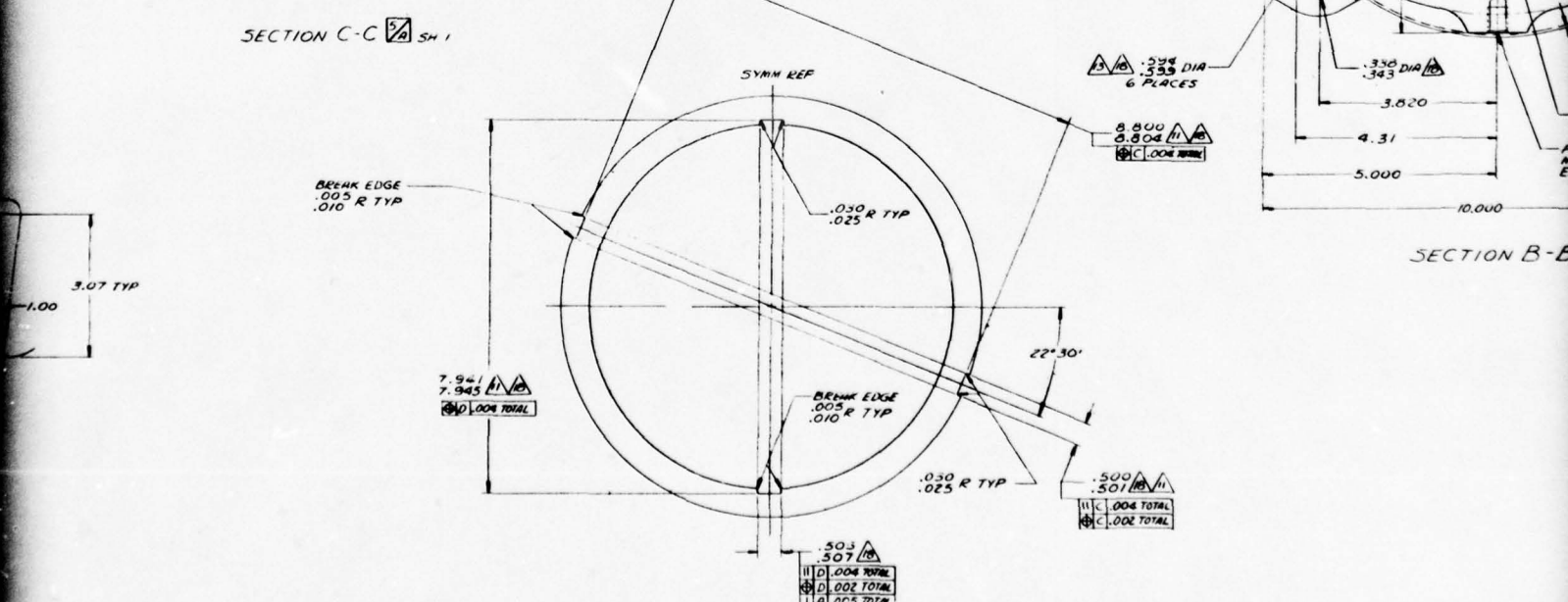
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2



SECTION C-C $\frac{5}{8}$ SH 1

SECTION B-B



SECTION D-D $\frac{5}{8}$ SH 1

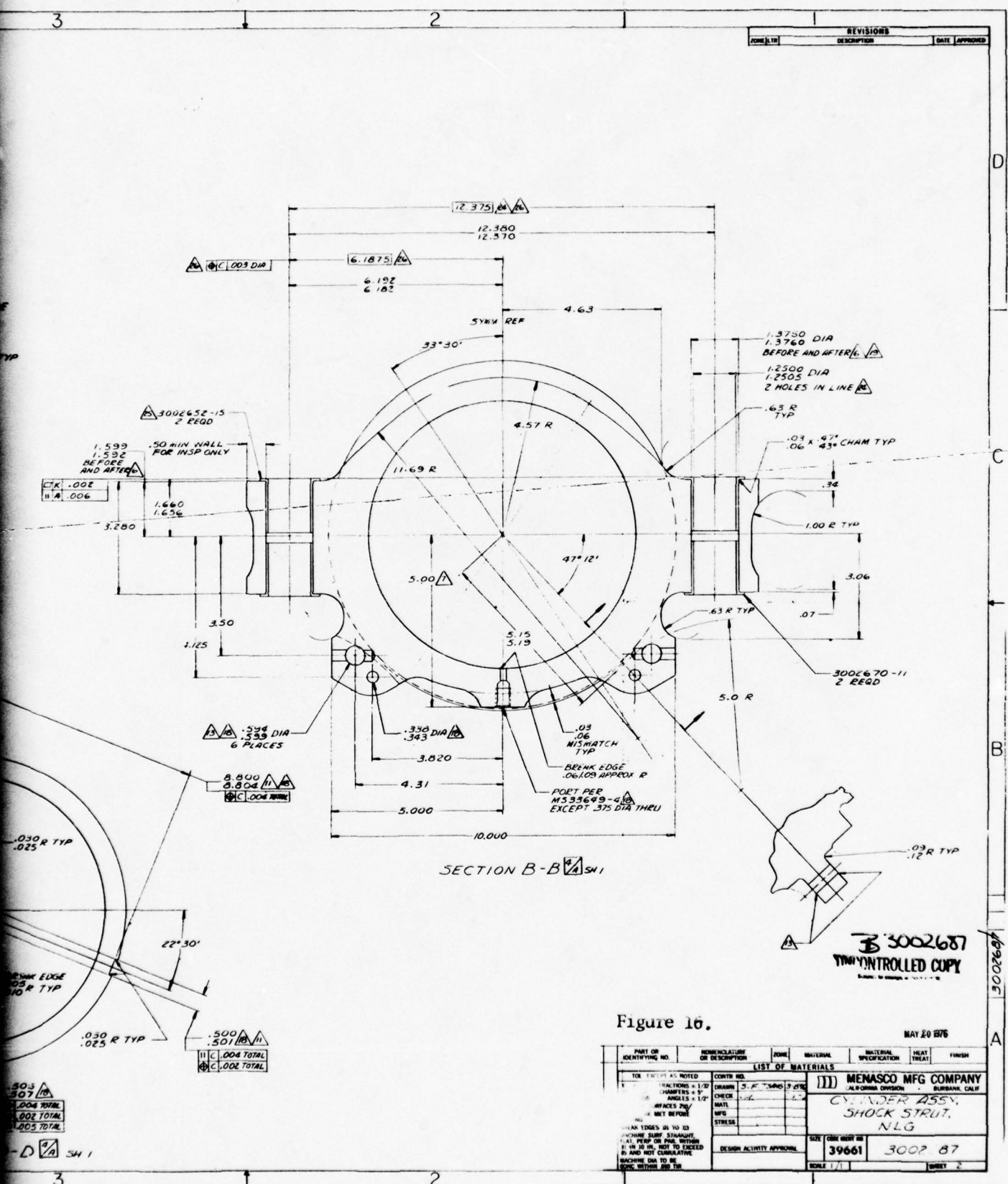
REV SH 2

4

3

2

4



REVISIONS		
FORM 111	DESCRIPTION	DATE APPROVED

Figure 10.

MAY 20 1976

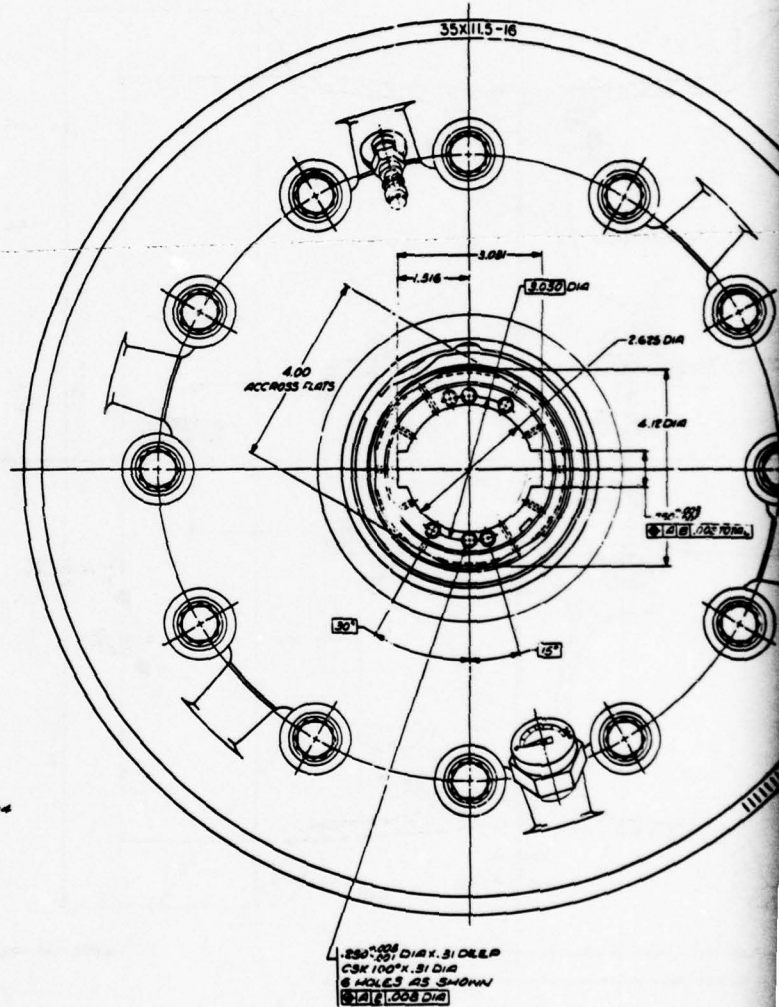
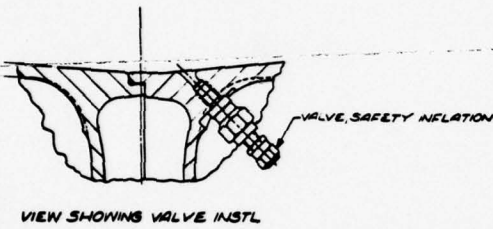
PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	FORM	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH
LIST OF MATERIALS						
FOR INFO AS NOTED	COURT. NO.	MENASCO MFG COMPANY ALBION DIVISION BURBANK, CALIF.				
DRAWING 5-1-76	3-676	CYLINDER ASSY. SHOCK STRUT NLG				
DESIGN ACTIVITY APPROVAL	DATE	39661	3002 87		SHEET 2	

5

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27-925
PFC 5-22-72

H
G
F
E
D
C
B
A



NOTES:

1. WHEEL CONFORMS TO SPEC MIL-N-50188 AND NAR SPEC L184C0004
 2. WHEEL RATED STATIC CAPACITY 23000 LBS
 3. POLAR MOMENT OF INERTIA 18.85 LB FT²
- ▶ TIMKEN ROLLER BEARING CO, OR EQUIV PER SPEC 501-255

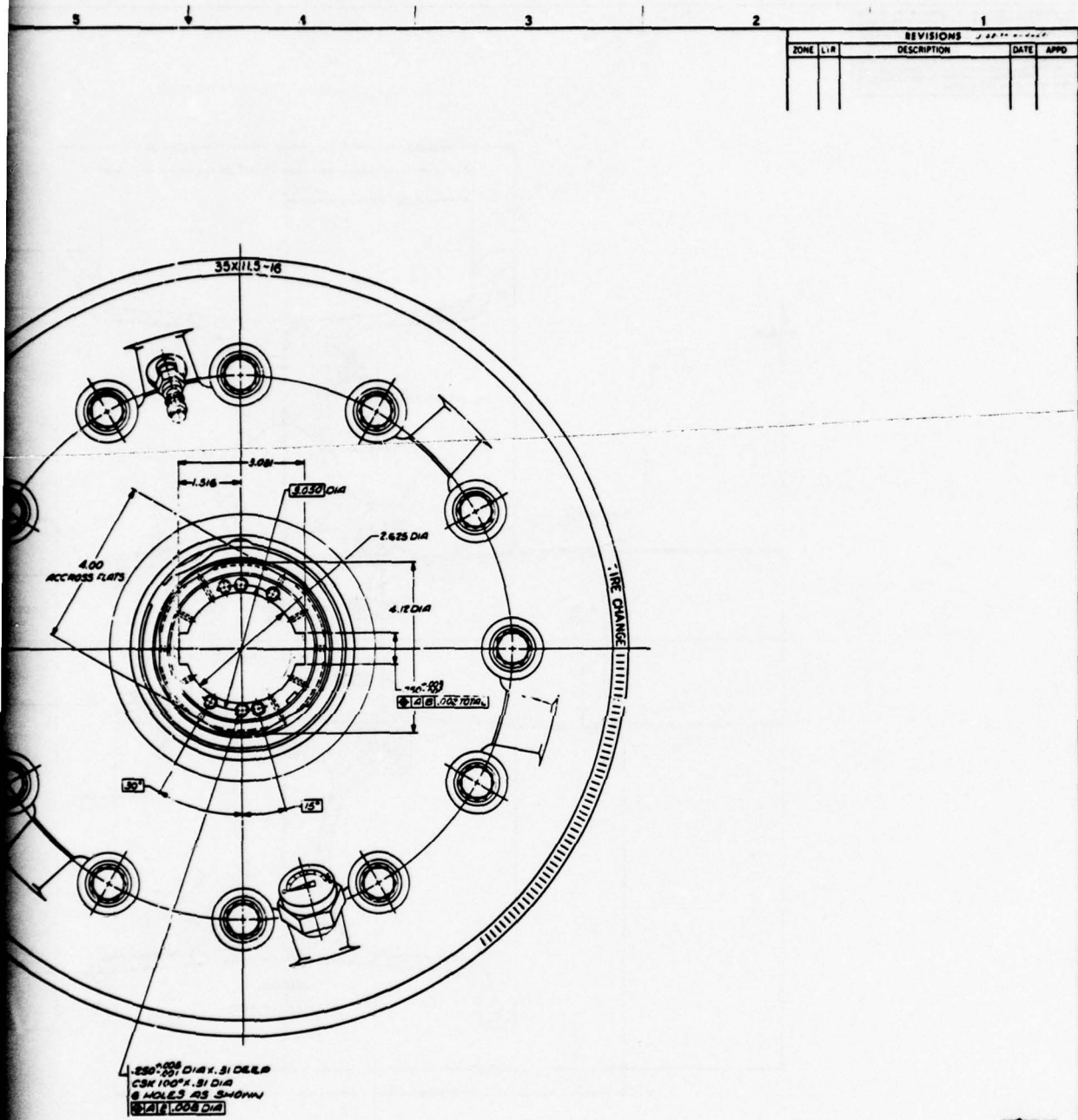
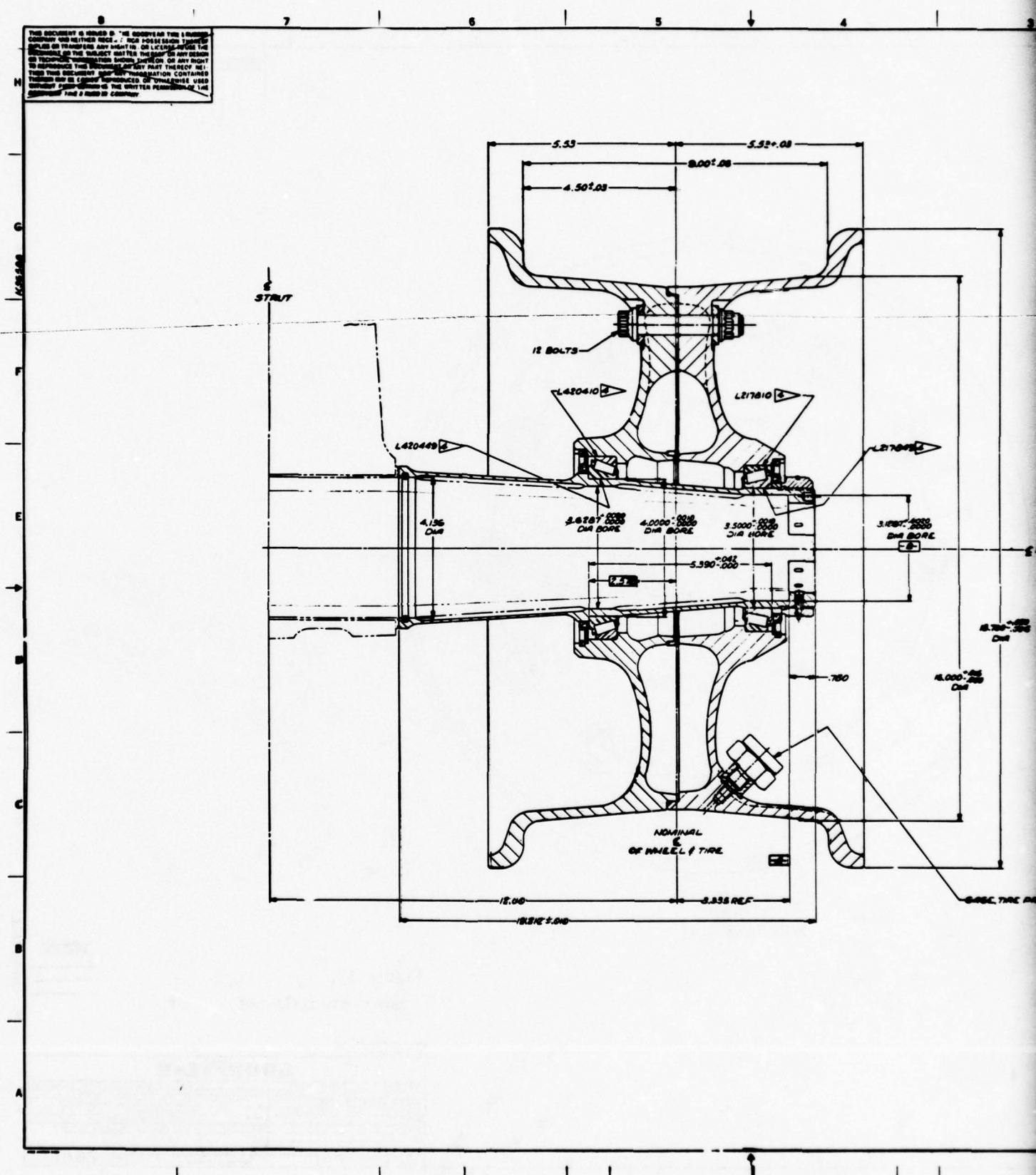


Figure 17.
35X11.5-16 TUBELESS TIRE

REV STATUS	SHEET 112	OF SHEETS	REV -
GOOD YEAR			
WEIGHT OF STEEL	INCLUDED IN NET WT	WEIGHT OF RUBBER	WEIGHT OF OTHERS
ITEM	QTY	WT	WT
WHEEL	1	35.2	3.4
WHEEL LTR	AL 500 378	36.4	
WHEEL LTR			
WHEEL LTR			
WHEEL 35 X 11.5-16 TUBELESS			
TOTAL NET WT	36.4	THE GOOD YEAR TIRE & RUBBER CO., AERON., OHIO 44118	
TOTAL GROSS WT		PD 2661	

2

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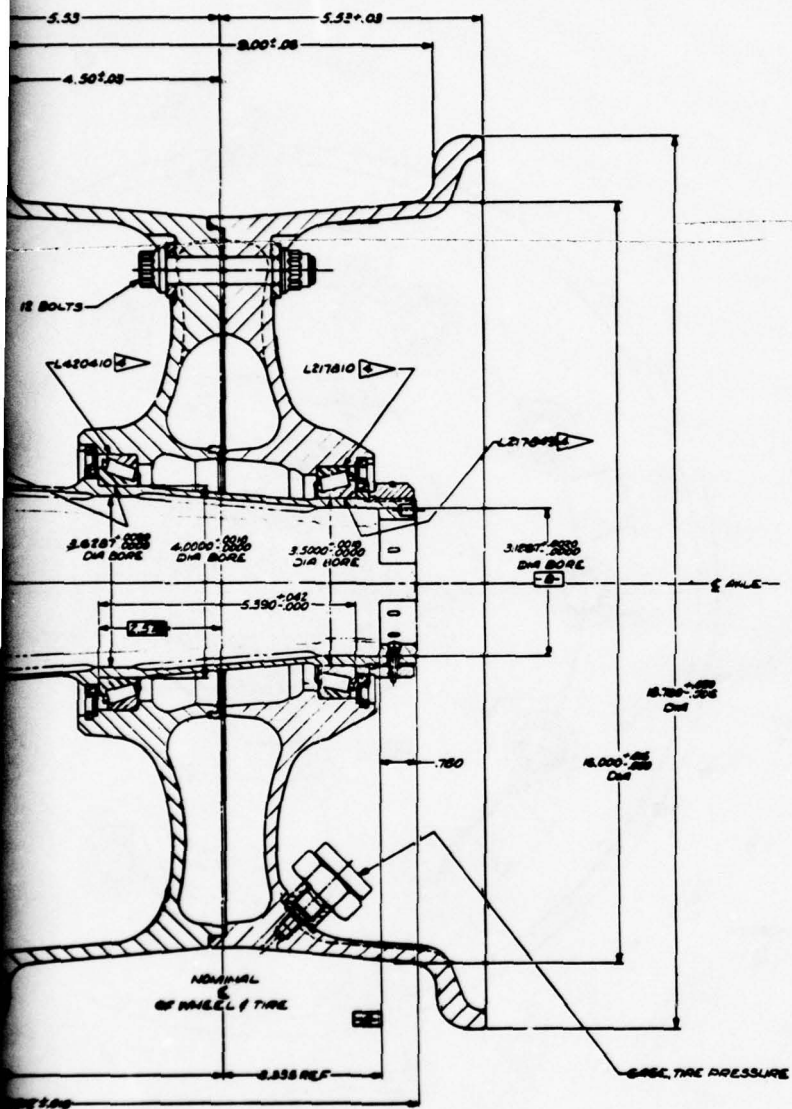


Figure 18.

12-073-0

THE GOODYEAR TIRE & RUBBER COMPANY
 WHEEL & RIM OPERATIONS AKRON, OHIO 44316
 DRAWING NO. PD2661
 SHEET NO. 1 SHEET 2 OF 2

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3.2.5 External Loads

A summary of nose gear loads for B-1 A/V No. 4, from the B-1 Systems Definition Manual is presented in Appendix C. Included are the following:

1. Landing, Taxi, and Handling Loads
2. Dual Wheel Load Distribution
3. Ultimate Load Determination
4. Fuselage Support Structure Deflections
5. Temperature Condition
6. Drop Test Requirements
7. Actuation System Loads
8. Nose Gear Uplock Loads
9. Nose Gear Door Link Loads
10. Nose Gear Steering Torque
11. Repeated Loads Design Requirements
12. Nose Landing Gear Support Reactions

3.2.6 Component Loads

The loads on B-1 nose gear components for A/V No. 4, as used for structural analysis of the metallic hardware, are presented in this section.

- A. Forward Drag Brace
 1. 134500 lb. Tension (ULT)
 2. 136400 lb. Comp. (ULT)
- B. Aft Drag Brace
 1. 250500 lb. Tension (ULT)
 2. 25400 lb. Comp. (ULT)
- C. Spreader Bar - Drag Brace
 1. Axial Compression of 46600 lb. (ULT) in combination with end moments equal and opposite of 20000 inch-pounds (ULT)
 2. Axial Tension of 47300 lb. (ULT) with 17700 inch-pounds (ULT) end moments
- D. Down Lock Links
 1. \pm 11000 lb. (Design) axial load, with a transverse load applied to the forward end acting upward of 559 lb. (Limit)
 2. Axial stiffness requirement of lock link and and back-up structure - K 25000 lb/inch

E. Torque Links

1. Apex load \pm 24500 lb. (Design)

F. Strut and trunnion arm loads are shown in figure 19.

G. Piston loads are shown in figure 20.

H. Axle loads are shown in figure 21.

I. Wheel loads are shown in figure 22.

3.2.7 Nose Landing Gear System Weight

The weight of the B-1 nose gear component parts, as given in the Weight Status Report #45, 3 May 1976, is shown in Table IV. Columns under "Weight Status" indicate the percentage of the weight of the component that is "estimated," "calculated," and "actual." It should be noted that many of the parts for A/V No. 4 have not been built and are therefore 100% estimated or calculated.

3.2.8 Environmental Data

The environmental data is presented in Appendix D.

3.2.9 Reliability

The baseline reliability of the B-1 nose landing gear for A/V No. 4 will be based on the reliability of the mechanical equipment installation components of the nose gear, including the wheels but not tires. Table V presents the predicted hardware reliability expressed in "mean time between corrective maintenance action" (MTBCMA).

The predicted MTBCMA for the baseline B-1 nose landing gear is 715.5 flight hours representing a hardware failure rate of 1397.7×10^{-6} flight hours.

3.2.10 Maintainability

The baseline maintainability costs for the B-1 A/V No. 4 nose landing gear system is based on consideration of the following "line replaceable units" (LRU) and "shop replaceable units" (SRU). See Table VI.

The B-1 baseline nose gear maintenance costs are shown in Table VII.

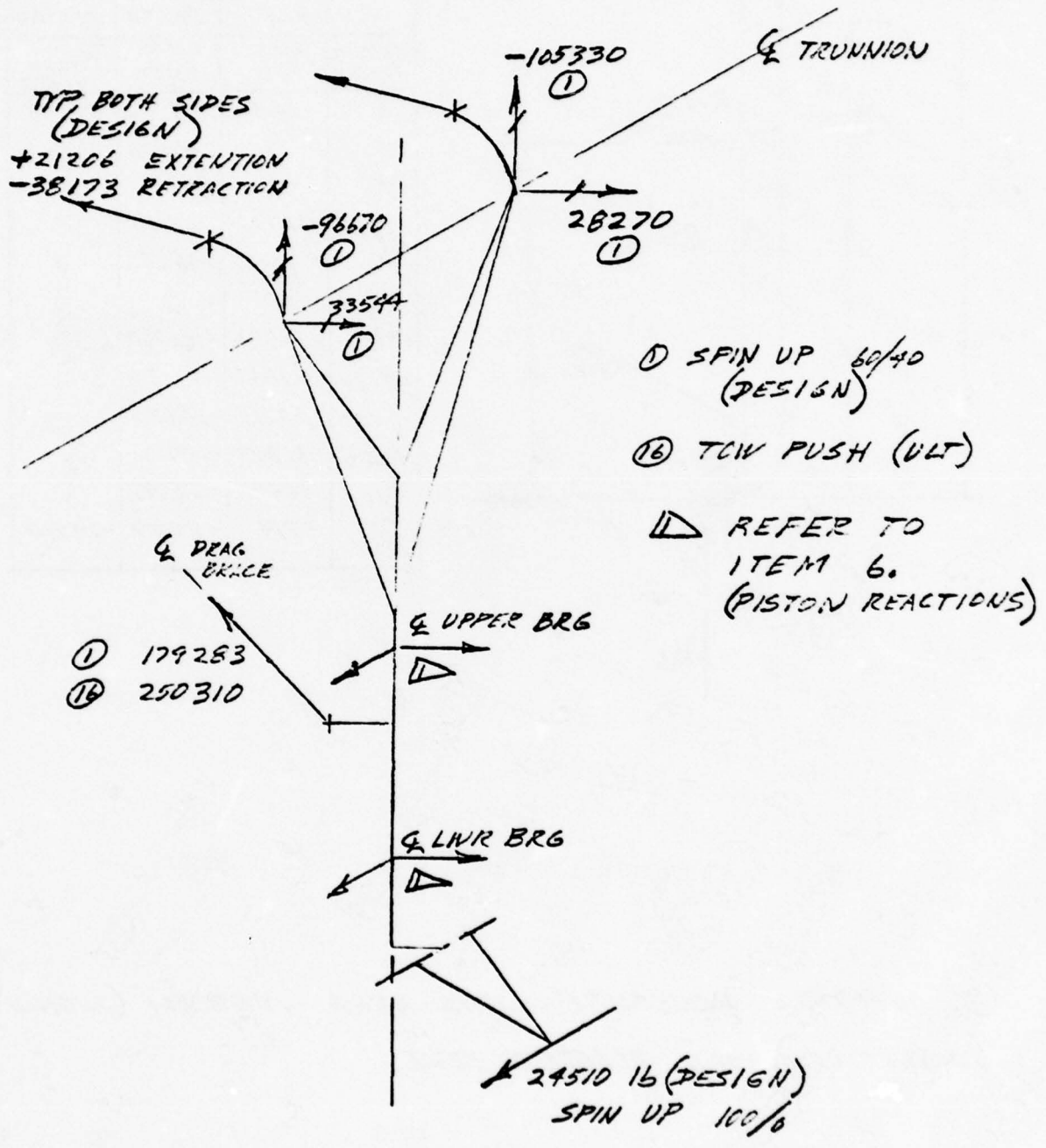
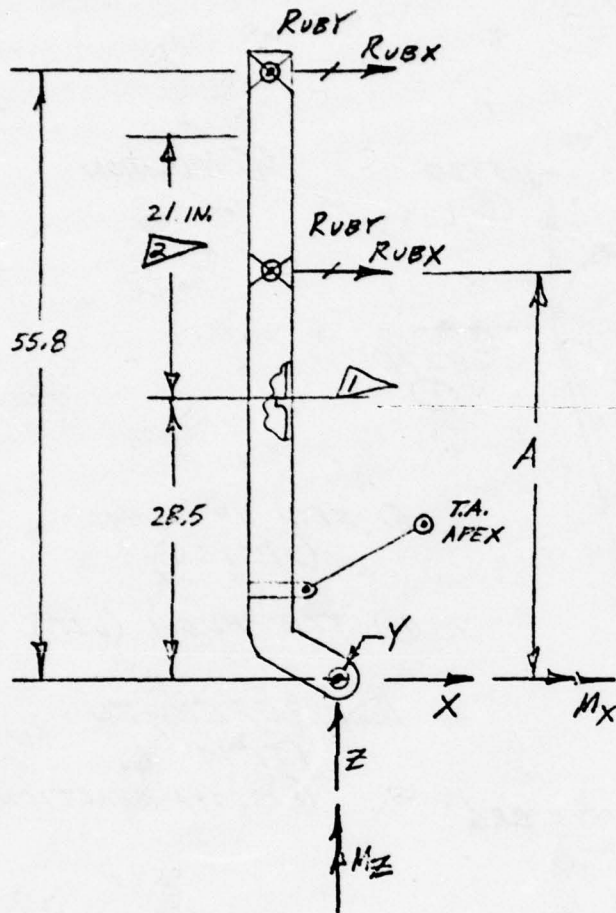


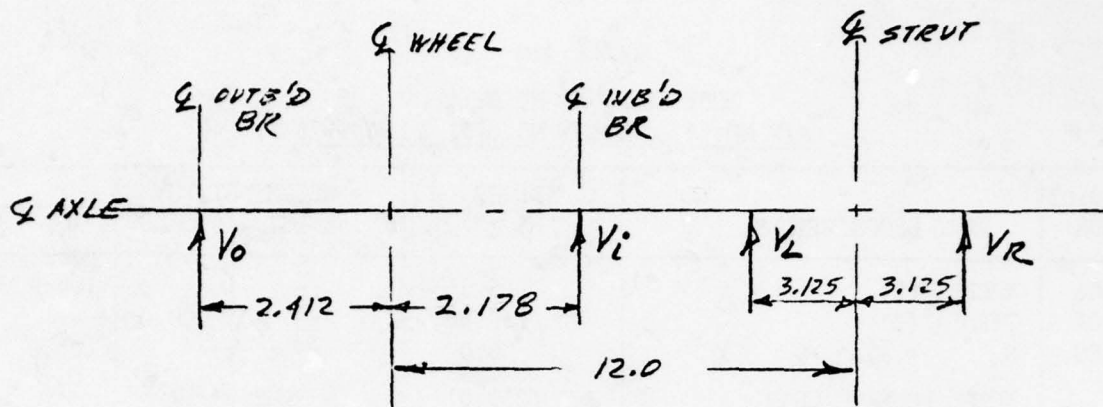
Figure 19. Strut and Trunnion Arm Loads



	DYNAMIC TAXI	SPIN UP 6/40	SPIN UP 100/0
	ULT	DESIGN	DESIGN
CRITICAL AREA	LWR END	UPPER END	T.A. ATTACH POINTS
A	24.5	35.35	35.35
X	0	47000	↑
Y	0	0	↑
Z	101700	61100	↑
M_x	1220400	146640	↑
M_y	0	0	↑
M_z	-508500	-112800	↑
RUBX	21045	121192	NOT CRITICAL
RUBY	50715	14520	↓
RLBY	-21847	-169202	↓
RLBY	-51428	-22797	↓
T.A. APEX	-714	-8277	-24510

▲ INTERNAL PRESSURE THIS AREA 1858 PSI (DESIGN)
 ▽ VERTICAL LOAD REACTED HERE.

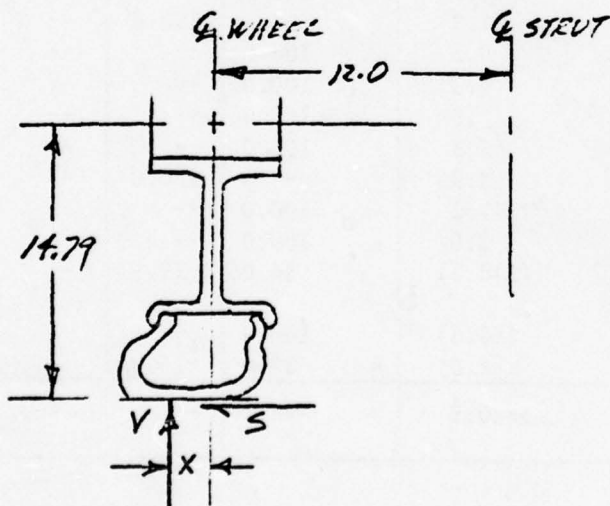
Figure 20. Strut and Piston Loads



	.25 G TURN	DYNAMIC TAXI
V_0	118073	70415
V_i	-57023	31285
V_2	-213180	-262390
V_R	152130	160690

(ULT.) LOADS
ONE TIRE FLAT

Figure 21. Axle Loads



(ULT.) LOADS
ONE TIRE FLAT

	.25 G TURN	DYN. TAXI
V	61050	101700
S	15270	0
X	3.00	1.000

Figure 22. Wheel Loads

TABLE IV
NOSE GEAR WEIGHT DETAILS
A/V NO. 4 - STATUS NO. 45. 3 MAY 1976

AN 9103 CODE	PART DESCRIPTIONS	WEIGHT LBS A/V	WEIGHT STATUS		
			% EST.	% CALC	% ACT
11 B 06	WHEELS (2)	115.0	--	--	100.0
11 B 07	TIRES (2)	138.0	--	100.0	--
11 B 09	N ₂	6.0	--	--	100.0
	TOTAL RUNNING GEAR	(259.0)	--	--	--
11 B 34	DRAG BRACES	100.0	100.0	--	--
11 B 38	SHOCK STRUT	586.4	--	6.82	93.17
11 B 40	BEAM ASSY. (AXLE)	31.5	--	--	100.0
11 B 41	TORQUE ARMS (2)	15.6	--	--	100.0
11 B 43	SHIMY DAMP/STEER. CONTROL	184.3	--	3.63	96.36
11 B 47	FITTINGS - BODY	68.0	100.0	--	--
	TOTAL STRUCTURE	(985.8)	--	--	--
11 B	WTB/STRUCTURE	(1244.8)	13.49	14.83	71.66
12 D 13	CONTROLS	4.3	--	23.25	76.74
12 D 22	PLUMBING	6.3	--	100.0	--
12 D 28	FLUID	2.4	--	100.0	--
12 D	STEERING CONTROLS	(13.0)	--	74.61	25.38
12 E 13	CONTROLS	1.0	100.0	--	--
12 E 14	WIRING, CONDUIT, ETC.	14.8	--	100.0	--
12 E 16	MECHANISM	0.3	100.0	--	--
12 E 21	CONTROLS	9.9	100.0	--	--
12 E 22	PLUMBING	7.8	100.0	--	--
12 E 26	ACTUATORS	62.8	100.0	--	--
12 E 28	FLUID	8.9	--	100.0	--
12 E 41	LOCKING MECHANISM	41.2	100.0	--	--
12 E 45	POSITION IND. MECH.	2.0	100.0	--	--
12 E	RETRACT CONTROLS	(148.7)	84.06	15.93	--
12 F	BRAKE OPER. CONTROLS	(10.0)	100.0	--	--
12 G	EMERG'Y. EXT. CONTROLS	(4.0)	85.0	15.0	--
	TOTAL NOSE GEAR	1420.5	---	---	---

TABLE V - B-1 NLG BASELINE HARDWARE RELIABILITY

WORK UNIT CODE	MECHANICAL EQUIPMENT INSTALLATION COMPONENTS	QTY. PER A/C	HARDWARE RATE (PER 10 ⁶ HOURS)
13BAA	SHOCK STRUT	1	256.4
13BAB	DRAG BRACE ASSY, UPPER	1	20.0
13BAC	UPLOCK ASSY.	1	278.6
13BAD	DOORLOCK ASSY. FWD.	1	278.6
13BAE	DOOR SEQUENCE LINK ASSY.	1	51.1
13BAF	BUMPER-WHEEL STOP	2	8.8
13BAH	JURY BRACE	1	10.0
13BAJ	TENSION SPRING FORWARD DOORLOCK	1	8.9
13BAK	BUNGEE, AFT DOORLOCK	1	8.9
13BAL	TENSION SPRING, DOWNLOCK	2	17.8
13BAM	TENSION SPRING, UPLOCK	2	17.8
13BAN	BUNGEE, WHEEL STOP BUMPER	2	17.8
13BAP	DRAG BRACE ASSY. LOWER	1	20.0
13BAQ	TORQUE ARM ASSY.	2	22.0
13BAR	ACTUATION ASSY, LH W/W DOOR	1	10.0
13BAS	ACTUATION ASSY., RH W/W DOOR	1	10.0
13BDA	WHEEL ASSY., (INCL. FALSE AXLE)	2	361.0

$\Sigma = 1397.7$

TABLE VI

B-1 NOSE LANDING GEAR HARDWARE REPLACEABILITY

NOMENCLATURE	REPLACEABLE CODE	WORK UNIT CODE
Shock Strut - Nose Landing Gear*	LRU	13BAA
Cylinder, Shock Strut - NLG	SRU	13BAA9A
Piston, Shock Strut - NLG	SRU	13BAA9B
Drag Brace, Upper - NLG	LRU	13BAB
Jury Brace - NLG	LRU	13BAH
Drag Brace, Lower - NLG	LRU	13BAP
Torque Arm Assembly-NLG	LRU	13BAQ
Wheel/Tire Assembly-NLG**	LRU	13BDA
Wheel Assembly-NLG	SRU	13DA9A

*Due to the fact that the shock strut assembly must be removed from the aircraft for repair, the complete assembly, consisting of strut (cylinder) and piston, must also be considered, as well as the component parts, for the purposes of this study.

**Only the nose landing gear wheel is to be considered as a composite candidate, however, due to the fact that the wheel/tire assembly is removed from the aircraft for repair, the complete assembly must be considered for the purposes of this study.

TABLE VII

BASELINE - B-1 NOSE LANDING GEAR MAINTENANCE COSTS

NOMENCLATURE	WUC. NO.	SPARES COST	MAINTENANCE				TOTALS
			OFF A/C	ON A/C AGE	ON A/C PERSONNEL	TOTALS	
SHOCK STRUT ASSY.	13BAA (LRU)	204,676	12,476	4,551	56,834	278,537	
CYLINDER	13BAA9A (SRU)	51,463	4,731	-----	-----	56,194	
PISTON	13BAA9B (SRU)	65,021	56	-----	-----	65,077	
DRAG BRACE-UPPER	13BAB (LRU)	43,405	43,380	3,501	9,473	99,759	
JURY BRACE	13BAH (LRU)	6,933	2,870	431	1,164	11,398	
DRAG BRACE-LOWER	13BAP (LRU)	44,536	12,570	674	2,159	59,939	
TORQUE ARM ASSY.	13BAQ (LRU)	24,930	8,356	142	2,192	35,620	
WHEEL TIRE ASSY.	13BDA (LRU)	-----**	17,089 *	356 *	1,636 *	19,131	
WHEEL ASSY.	13BDA9A (SRU)	23,570	4,216	-----	-----	27,786	
TOTAL		464,534	105,744	9,655	73,508	653,441	

*Portion of the LRU Cost Attributable to SRU

**Not Spared at LRU Level

SUMMARY: Spares Cost = \$464,534
 Maint. Cost = 188,907
 Grand TOTAL = 653,441

The following assumptions have been made:

1. The current B-1 support concept was used.
 - A. Depot repair of the listed items.
 - B. Spare LRU's are stocked at the using wing level.
2. The current operational concept for the B-1 was used. Two hundred and ten operational aircraft (7 wings with 30 aircraft each).
 - A. One combat crew training squadron wing with 30 aircraft flying 977 hours per month.
 - B. Six normal wings with 30 aircraft flying 525 hours per month.
3. The baseline costs were projected in 1976 dollars.
4. The time span of the support is 10 years.

3.2.11 Cost

The baseline cost data for the B-1 nose landing gear hardware for A/V No. 4 is, in part, estimated since no parts have been fabricated. All costs are given in 1976 dollars and for a production quantity of 240 aircraft.

A. Strut Assembly

The nose gear shock strut, consisting of the strut (cylinder) the piston and the torque links, is subcontracted to Menasco Manufacturing Company. Nonrecurring costs have been negotiated, and recurring costs have been estimated for production quantities using the ship 4 through 7 costs and projected using an 89% slope.

- | | |
|----------------------|-------------------|
| 1. Nonrecurring Cost | \$ 245,320 |
| 2. Recurring Cost | \$ 78,632/shipset |

B. Downlock Links

Cost estimates for the upper and lower downlock links were based on price quotes from the material division and the machining cost estimating department. The recurring cost for material is projected on a 95% (Wright) cost reduction curve (CRC) and the machining costs on a 78% CRC.

- | | |
|----------------------|-----------------|
| 1. Nonrecurring Cost | \$ 56,587 |
| 2. Recurring Cost | \$ 450/ship set |

C. Wheel

The wheel is subcontracted to Goodyear Aerospace Corporation and the cost has been negotiated. The production cost reduction slope is assumed to be a very shallow 98% slope.

- | | |
|----------------------|---------------------------|
| 1. Nonrecurring Cost | \$ -0- (No design change) |
| 2. Recurring Cost | \$ 9,408/ship set |

D. Drag Braces

The cost estimate for the forward and aft drag braces are based on a supplier quote. The production quantity is projected on a 92% CRC.

- | | |
|----------------------|-------------------|
| 1. Nonrecurring Cost | \$62,660 |
| 2. Recurring Cost | \$10,195/ship set |

3.2.12 Life Cycle Costs

The B-1 nose gear baseline life cycle costs have been estimated using the data from the Reliability, Maintainability and Cost sections. The total Life Cycle Cost is \$24,702,638, for the mechanical equipment components listed, based on 240 aircraft. Table VIII lists life cycle costs by each major component.

TABLE VIII
LIFE CYCLE COST
(1976 Dollars)

Nomenclature	240 Shipset		Support
	Implementation (Nonrecurring)	Acquisition (Recurring)	
Nose Landing Gear			
1. Shock Strut Assy.			278,537
2. Cylinder			56,194
3. Piston			65,077
4. Torque Link			<u>35,620</u>
	<u>245,320</u>	<u>18,872,000</u>	<u>435,428</u>
Drag Braces			
1. Upper			99,759
2. Lower			<u>59,939</u>
	<u>62,660</u>	<u>2,446,700</u>	<u>159,698</u>
Down Lock (Jury Brace)			
1. Upper			
2. Lower			
	<u>56,587</u>	<u>107,917</u>	<u>11,398</u>
Wheel			
(Wheel Assembly)			19,131
1. (shipset) (wheel)	0	<u>2,258,013</u>	<u>27,786</u>
TOTAL	<u>364,567</u>	<u>23,684,630</u>	<u>653,441 =</u>

GRAND TOTAL \$24,702,638, TOTAL LIFE CYCLE COST

SECTION IV

DESIGN CONCEPTS

The five conceptual design studies for Phase I presented in this section have been made to determine the potential of using composite material for the B-1 nose landing gear. Studies have been made for three design concepts each having different constraints. The concepts are:

1. Substitution - Constrained by form, fit and function.
2. Modified - Constrained by fit and function.
3. Redesigned - Constrained by function only.

4.1 MATERIAL SELECTION

The baseline material system selected for this study effort is intermediate strength graphite/epoxy. The intermediate strength graphite fiber offers a good balance between fiber characteristics and fiber cost. The use of a high temperature, 275 to 350 F, service epoxy is indicated for the composite matrix in order to meet the environmental requirements for the B-1.

The selection of composite landing gear materials for this study program was based on design considerations and material property parameters. These design considerations and property parameters are presented in table IX.

Fiber strength and modulus provide a measure of composite material mechanical property potential, and the ultimate tensile elongation indicates the potential overload capacity. Matrix temperature limitations and resistance to environmental degradation are resin selection criteria. Ultimate elongation of the resin also has been considered for maximum composite performance, and high transverse lamina elongation generally result in:

- First-ply failure strains above the static design limit load.
- Reduced composite notch sensitivity.

Matrix processability will influence composite properties, transverse strain capacity, and laminate reproducibility. Prepreg resins exhibiting good tack drape and shelf life characteristics that can be molded into low void composites will improve composite mechanical properties and fabrication economics.

The selection of landing gear component composite materials includes consideration of the various reinforcements. In addition to the various candidate types of graphite fiber, nongraphitic fibers such as Kevlar 49, S-glass, and

TABLE IX . COMPOSITE LANDING
GEAR MATERIAL SELECTION PROPERTY
CONSIDERATIONS

- | | |
|--|--|
| <ul style="list-style-type: none"> - Static loading <ul style="list-style-type: none"> Load direction Stiffness requirement Factor of safety Viscoelastic considerations | <ul style="list-style-type: none"> - Fiber <ul style="list-style-type: none"> Strength Modulus Tensile strain Matrix compatibility |
| <ul style="list-style-type: none"> - Failure criteria <ul style="list-style-type: none"> Strain Strength | <ul style="list-style-type: none"> - Resin <ul style="list-style-type: none"> Temperature limitations Transverse tensile strain Processability Environmental compatibility |
| <ul style="list-style-type: none"> - Dynamic Loading <ul style="list-style-type: none"> Fatigue life Impact Fracture Toughness | <ul style="list-style-type: none"> - Composite <ul style="list-style-type: none"> Laminate orientation |
| <ul style="list-style-type: none"> - Environment <ul style="list-style-type: none"> Temperature Compatibility Corrosion Moisture | <ul style="list-style-type: none"> Configuration mechanical properties Coefficient of expansion Initial failure strain Coefficient of friction |

boron has been considered for this program. Orthotropic laminate mechanical properties for typical 60-percent fiber volume composite materials are presented in table X. The composite properties presented indicate an average unidirection (0°) tensile strength of 230 (+30) KSI for all the reinforcements with the exception of HM graphite fiber. The reinforcements, other than graphite, are high strength structurally efficient materials exhibiting completely different elastic constants, physical characteristics, and thermal properties.

The coefficient of thermal expansion of various composite materials and isotropic materials are presented in table XI. The unidirectional laminate coefficients provide an indication of range of values obtainable by tailoring the laminate to a desired value. The use of high thermal coefficient materials, such as aluminum, will be avoided to minimize thermally induced internal stresses. Titanium and low thermal expansion steels will be favored for mating to "tailored" composites with minimal thermal mismatch.

Material properties for various candidate materials are given in tables X and XII. Typical properties for continuous fiber reinforced laminates in an epoxy matrix are shown in table X. Table XII gives typical properties for chopped fiber reinforced compressed molded thermoset materials.

The third edition of the Advanced Composite Design Guide has served as the basis for unidirectional oriented ply composite mechanical properties. The orientations selected during this study consider such factors as predicted laminate strain to initial failure, coefficient of thermal expansion, environmental knock-down factors, and etc.

The environmental requirements for the nose wheel landing gear are shown in Section III. The thermal exposure temperature of 265° F for the gear require that, as a minimum, a 350° F curing composite matrix resin be utilized. Other environmental conditions are not critical to the selection of a baseline composite material system. The most significant environmental effect to be considered is the combined effect of moisture on the mechanical properties. The "wet" design allowables established for graphite/epoxy in various advanced composite application programs are to be utilized for this study.

4.2 CONCEPT 1 - SUBSTITUTION

The design concepts in this study are limited to composite material substitution for the existing metal hardware on a component by component basis. The composite hardware must have identical key dimensions to satisfy the form, fit and function of the metal baseline components.

TABLE X
TYPICAL COMPOSITE PROPERTIES
UNIDIRECTIONAL - 60-PERCENT FIBER VOLUME

Property	Material				
	AS/ Epoxy	HMS/ Epoxy	Kevlar/ Epoxy	S-Glass/ Epoxy	Boron/ Epoxy
Elastic constants (psi x 10 ⁶)					
0° tensile modulus	19.8	28.0	12.5	8.8	30.0
0° compression modulus	16.0	24.8	10.5	7.4	30.0
90° tensile modulus	1.4	1.4	0.8	1.9	2.7
90° compression modulus	1.4	1.4	0.8	1.9	2.7
Poisson's ratio	0.30	0.30	0.325	0.30	0.21
In-plane shear modulus	0.65	0.65	0.4	0.55	0.70
Thermal expansion coefficients (in./in./°F x 10 ⁻⁶)					
0° coefficient	-0.2	-0.3	-2.2	6.0	2.3
90° coefficient	15.0	13.0	32.0	20.0	10.6
Ultimate strains (%)					
0° tensile	1.15	0.5	1.8	2.8	0.65
0° compression	1.40	0.6	0.3	1.7	—
90° tensile	0.63	0.4	0.57	0.33	0.40
90° compression	1.90	1.0	3.1	2.4	—
Ultimate strenghts (psi x 10 ³)					
0° tensile	220.0	145.0	210.0	250.0	200.0
0° compression	220.0	145.0	38.0	115.0	350.0
90° tensile	8.4	6.0	2.8	5.1	10.4
90° compression	30.0	25.0	20.0	25.0	40.0
In-plane shear	18.6	8.0	6.0	6.0	15.3
Density (lb/in. ³)	0.056	0.057	0.050	0.072	0.072

TABLE XI
COEFFICIENT OF THERMAL EXPANSION
 $(\alpha \text{ IN. } 10^{-6} \text{ IN./IN./}^\circ\text{F})$

Material	Unidirectional Laminate		Isotropic Material
	Parallel	Perpendicular	
S-glass*	3.5	11	—
Kevlar 49*	-2.0	30	—
LHS*	-0.1	14	—
HM*	-0.5	15	—
UHM*	-0.8	17	—
Boron*	2.3	8	—
Aluminum	—	—	12 - 14
Steel	—	—	6 - 10
Titanium	—	—	4 - 7
Epoxy resin	—	—	30 - 50

* 60-percent fiber volume epoxy composite

TABLE XII
TYPICAL PROPERTIES FOR COMPRESSION-MOLDED CHOPPED-FIBER/EPOXY COMPOSITES

Mechanical Property	Material			
	AS/Epoxy	HMS/Epoxy	Boron/Epoxy	Glass/Epoxy
Tensile strength (psi x 10 ³)	30.0	30.0	35.0	27.0
Tensile modulus (psi x 10 ⁶)	6.7	8.0	10.0	3.0
Compressive strength (psi x 10 ³)	40.0	35.0	60.0	38.0
Bearing strength (psi x 10 ³)	50.0	—	65.0	—
Density (lb/in. ³)	0.057	0.059	0.076	0.065

The B-1 nose landing gear hardware has been studied to determine whether individual parts could be made from composite material and still satisfy the above constraints. In several cases, investigation showed that sections of some parts should remain metal to accommodate the high loads within the "form" constraint, but it was felt that these parts could still be viable candidates using spliced metal/composite construction.

Components chosen for study included: drag braces, forward and aft; down locks, forward and aft; the torque link; strut trunnion arms; and the wheels. See figure 23.

4.2.1. Forward Drag Brace

The drag braces attach to the forward side of the strut and stabilize it in a fore and aft direction. The drag brace folds for stowage about a center pivot. The forward section is dual and connects the center pivot to both wheel well side walls, see figure 23. The loads in the forward drag brace are axial and the tension load is 134,500 pounds ultimate and the compression load is 136,400 pounds ultimate.

The baseline B-1 part, figures 9 and 10, is a forging made from HP 9-4-30 steel which is heat treated to 220,000 to 240,000 psi. The part is cylindrical with lug ends which connect the part to the upper structure supports and to the aft drag brace.

The design concept shown in figure 24 is an example of the spliced metal/composite construction previously referred to. Two end fittings are made of 220,000 to 240,000 psi heat treated steel. The lugs on these fittings are identical to the baseline so that they can react the high loads and mate with the adjoining parts without changes. These end fittings are multi-step lap spliced to the cylindrical composite section. This 37.3 inch long composite tube is laminated graphite epoxy (Gr/Ep) using more than 80% 0° (longitudinal) plies and less than 20% $\pm 15^\circ$ (spiral wound) plies. This composite tube is co-cured to the end fittings using a 5-inch long multi-step lap splice.

4.2.2 Aft Drag Brace

The aft drag brace is a single structural component which connects the apex of the dual forward drag braces to the strut, see figure 23. The loads in the aft drag braces are axial and the tension load is 250,500 pounds ultimate and the compression load is 254,000 pounds ultimate.

The baseline B-1 aft drag brace, figures 7 and 8, is an "I" section forging made from MIL-S-8844 Class 3 300M steel which is heat treated to 280,000 to 300,000 psi. The "I" section terminates in end lugs which are

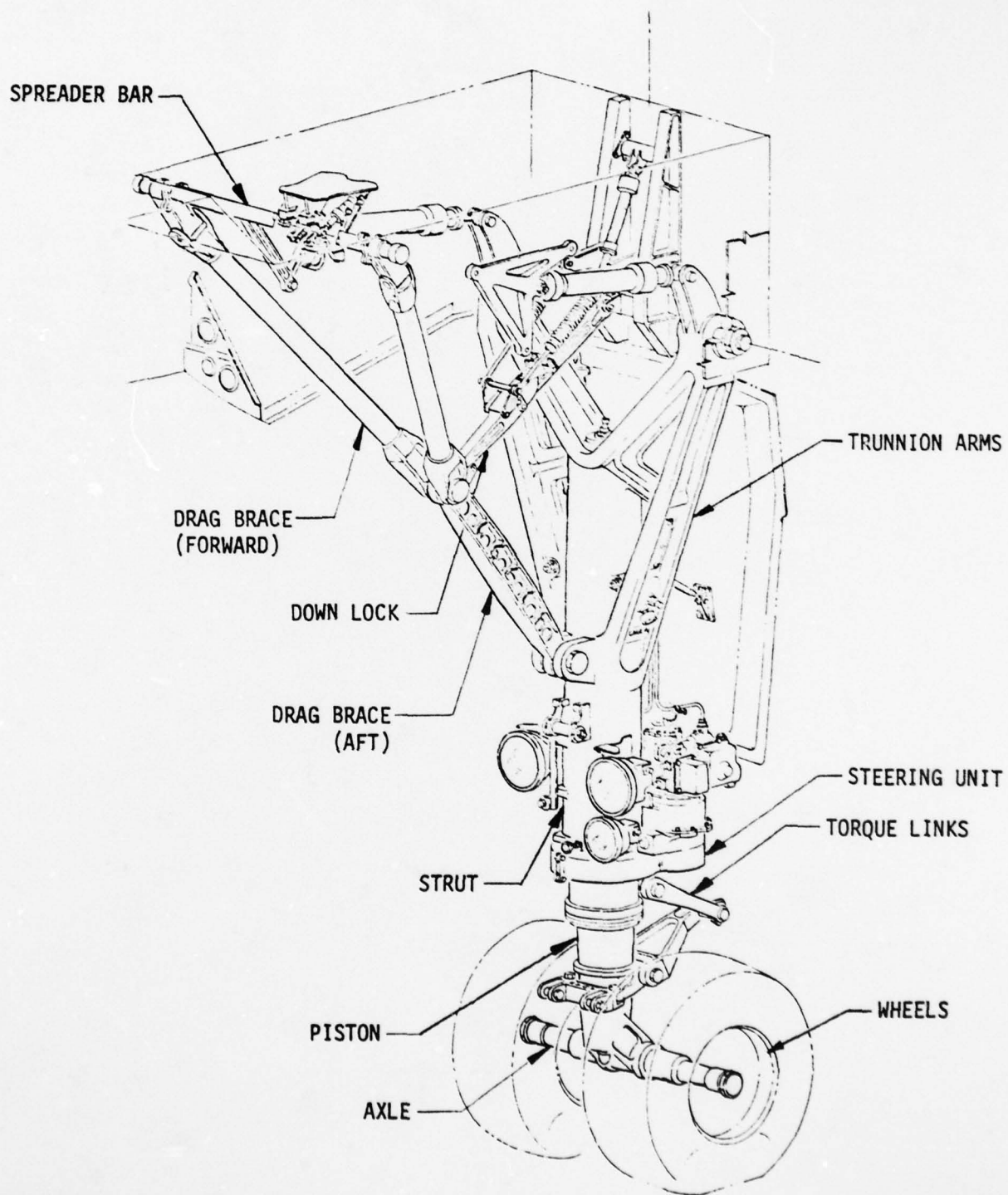


Figure 23. B-1 Nose Landing Gear Components

AD-A058 672

ROCKWELL INTERNATIONAL LOS ANGELES CALIF LOS ANGELES--ETC F/G 11/4
NEW CONCEPTS IN COMPOSITE MATERIAL LANDING GEAR FOR MILITARY AI--ETC(U)
FEB 78 V E WILSON F33615-76-C-3021

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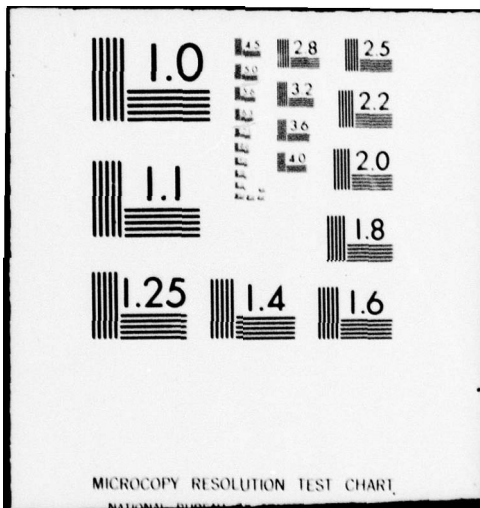
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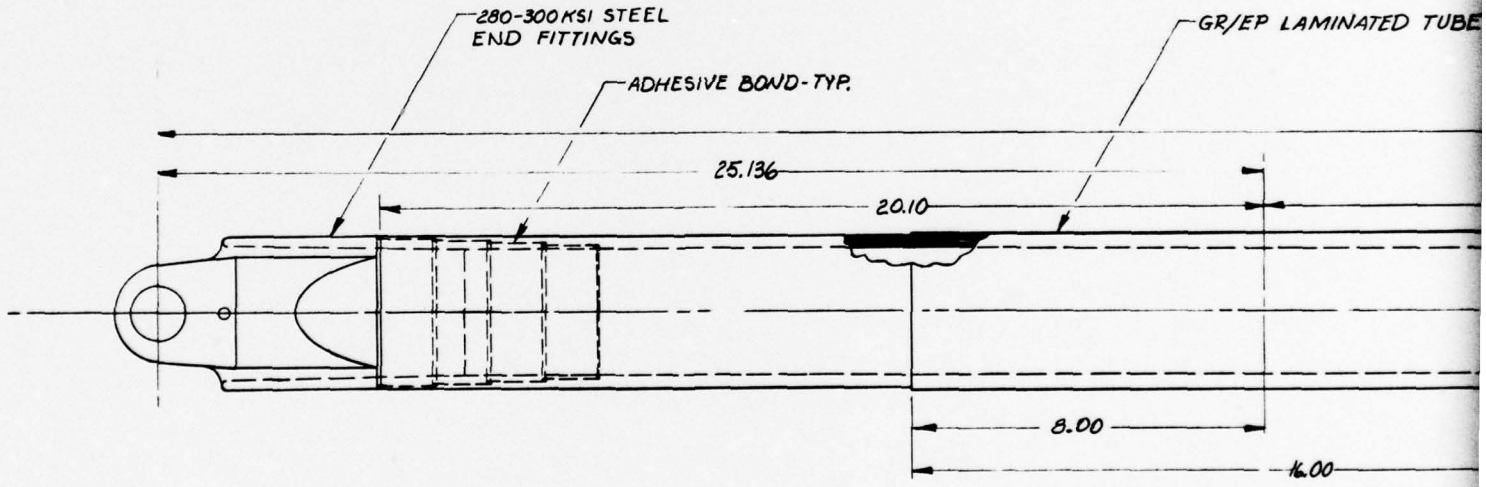
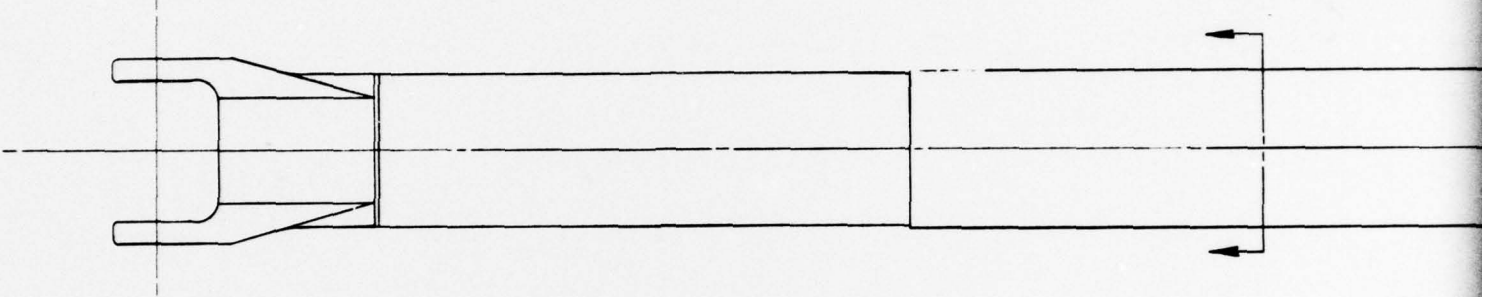
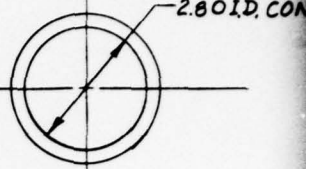
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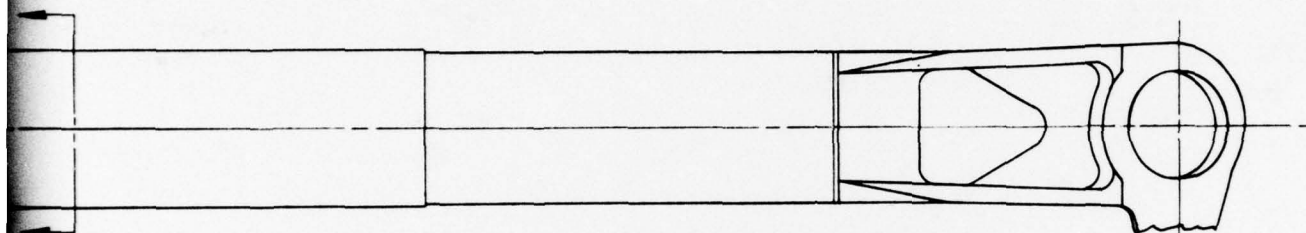
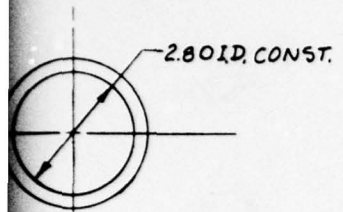


MICROCOPY RESOLUTION TEST CHART

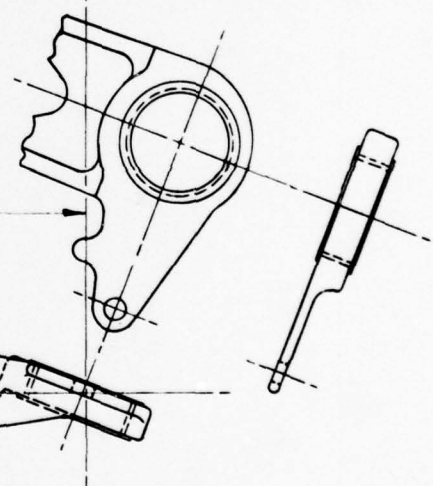
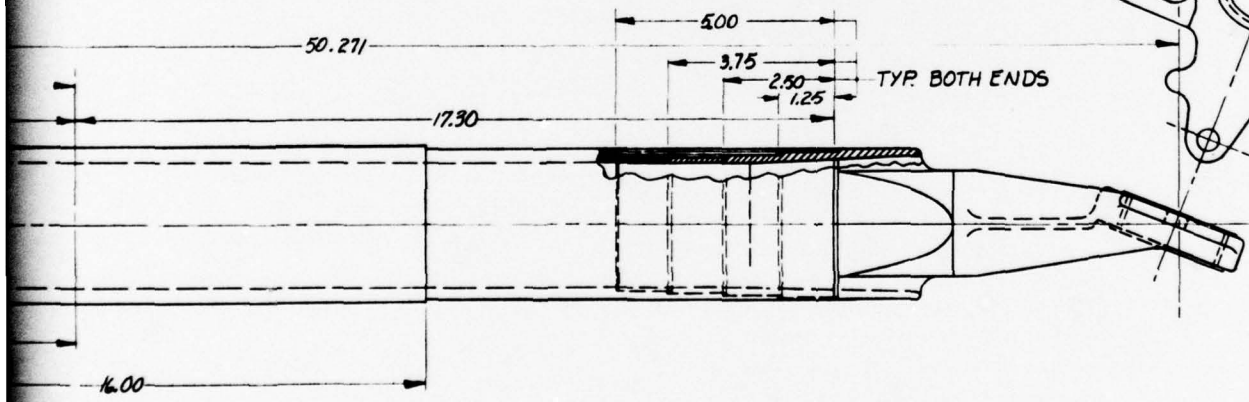
NATIONAL BUREAU OF STANDARDS-1963-A



1



GR/EP LAMINATED TUBE



2

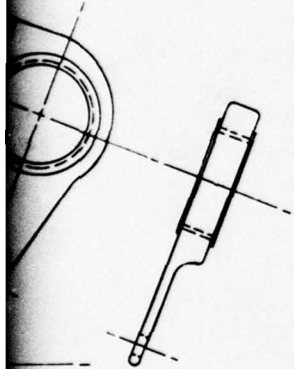


Figure 24.

SCALE $\frac{1}{2}$	DR. <i>V.E. Wilson</i> DATE <i>5-6-76</i>	Los Angeles Aircraft Division Rockwell International INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 90009	ADVANCED DESIGN
STUDY-COMPOSITE DRAG BRACE, FORWARD, B-1 NOSE GEAR - PHASE I, CONCEPT 1			<i>D615-1-400</i>

drilled for bearings. The forward end is pinned to the apex of the forward drag braces and the aft end is fastened to the strut.

The composite aft drag brace shown in figure 25 also uses the spliced metal/composite construction since steel end fittings are required to accommodate the high loads within the form constraint. The bearing end of these fittings is identical to the baseline part, but each fitting is only 10.25 inches long and terminates in a double multi-step lap joint for both caps and webs of the composite "I" section.

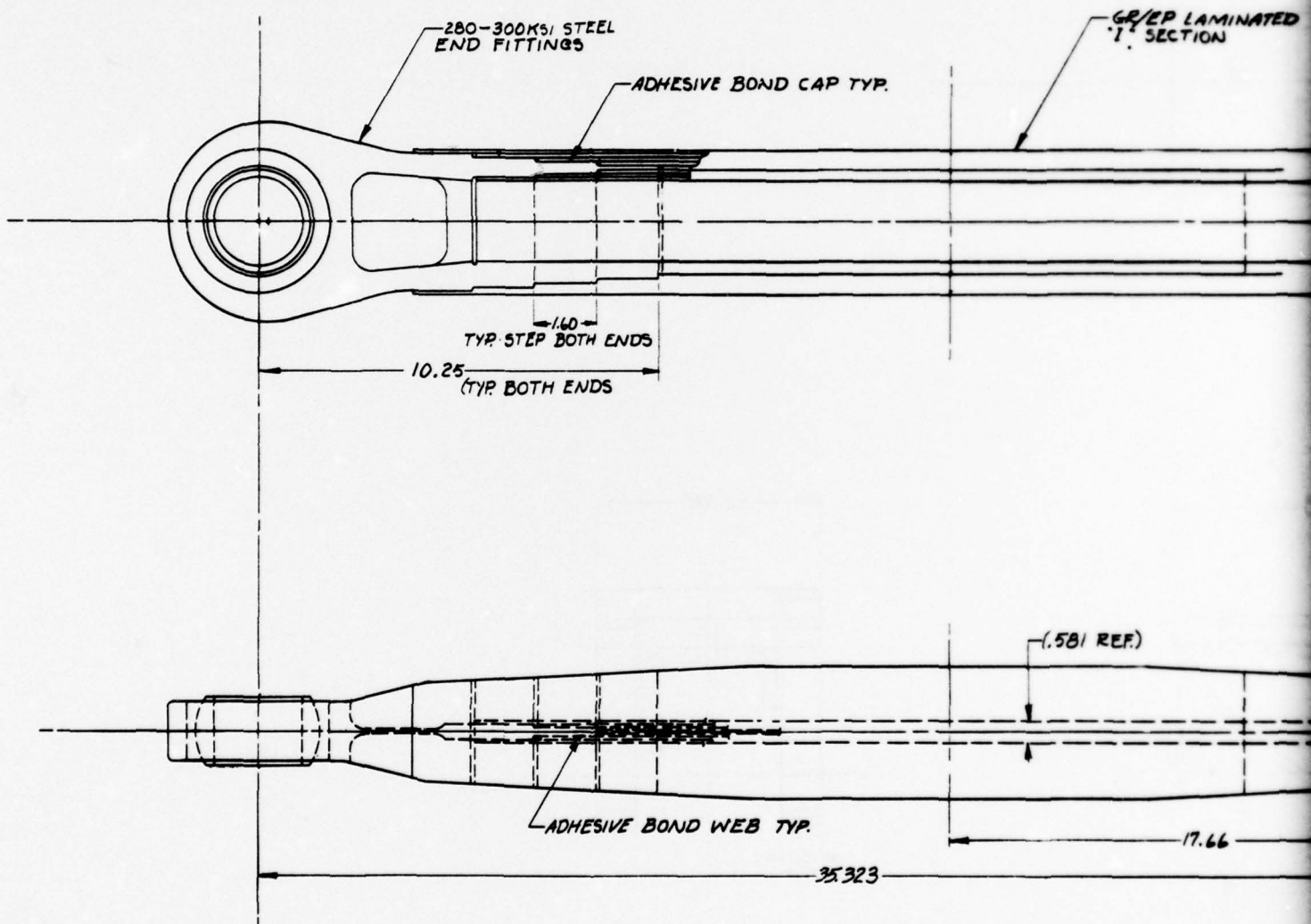
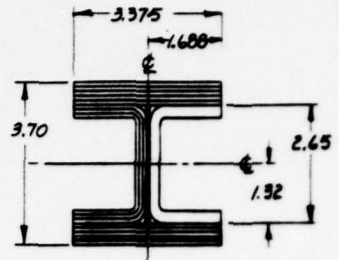
The graphite epoxy laminated "I" section is made up of back-to-back channel shaped laminates, using $50\% \pm 45^\circ$ plies and $50\% 0^\circ$ (longitudinal) plies, with reinforced caps using more than $90\% 0^\circ$ plies and less than $10\% \pm 15^\circ$ plies. This "I" section is 27.6 inches long and overlaps each end fitting 6.4 inches. The composite web is multi-step lap spliced to both sides of the web portion of the end fittings and the composite caps are multi-step lap spliced to both sides of both top and bottom cap sections of the end fittings to provide enough bond area to transfer the high axial loads. The entire assembly is then co-cured.

4.2.3 Forward Down Lock

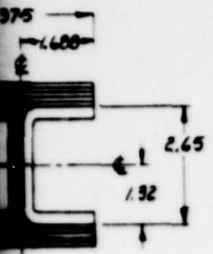
The down lock struts, forward and aft, serve as a jury strut which holds the drag braces in the "on center" position when the gear is in the down position. The down lock struts connect the center joint of the drag braces to the fuselage structure, and are designed with an "over center" locking feature to assure that the drag braces will be supported. The loads in the down lock struts are axial and bending (a $\pm 11,000$ pound design axial load with a transverse load applied to the aft end of the forward link acting upward of 559 pounds limit). The axial stiffness requirement for the lock links and backup structure "K" must be greater than 25,000 pound/inches.

The baseline B-1 forward down lock, figure 11, is a 7075 aluminum alloy forging. The forward portion of the part is an "I" section joined to a channel shaped aft section to straddle the aft down lock strut in the "over center" lock area.

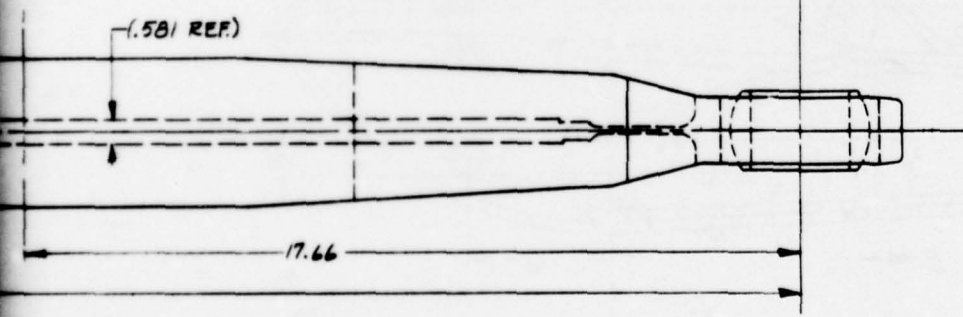
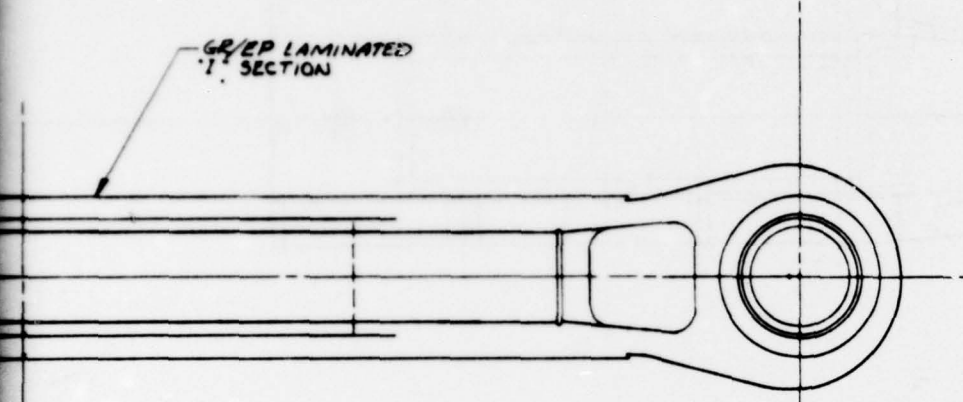
The design concept shown in figure 26 is a graphite epoxy laminated inverted "U" shaped part using "race track" windings over laminated side walls and upper webs. The "race tracks" will be more than $90\% 0^\circ$ plies and the laminated webs will be $50\% 0^\circ$ plies and $50\% \pm 45^\circ$ plies. This entire assembly will be co-cured.



1



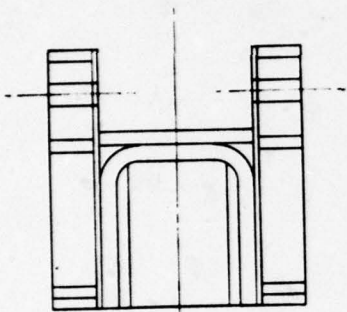
GR/EP LAMINATED
SECTION



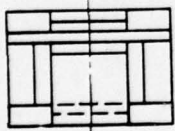
2

Figure 25.

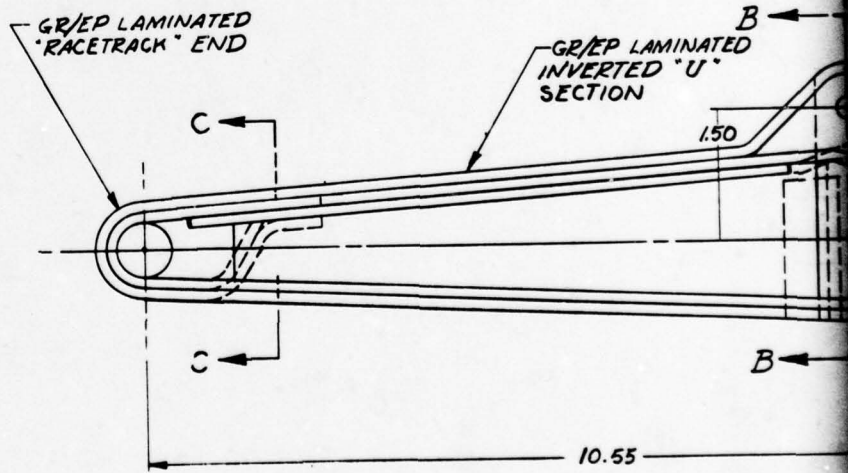
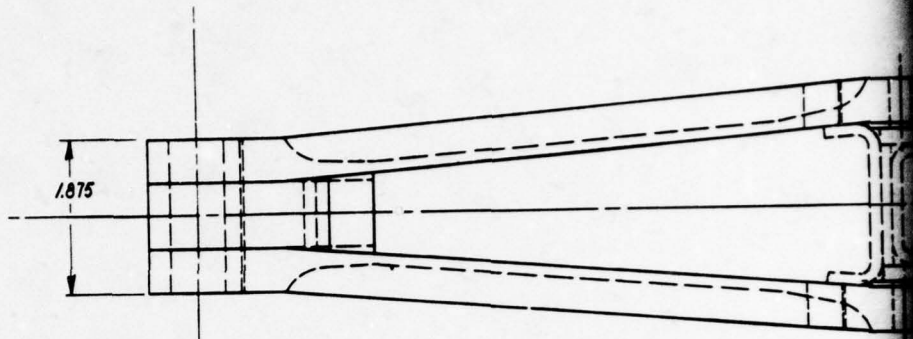
SCALE: $\frac{1}{2}$	DR. <i>KE WILSON</i> DATE <i>5-12-76</i> MODEL	Los Angeles Aircraft Division Rockwell International INTERNATIONAL AIRPORT · LOS ANGELES, CALIFORNIA 90009	ADVANCED DESIGN
STUDY-COMPOSITE DRAG BRACE, AFT B-1 NOSE GEAR-PHASE I, CONCEPT 1			<i>D615-1-401</i>



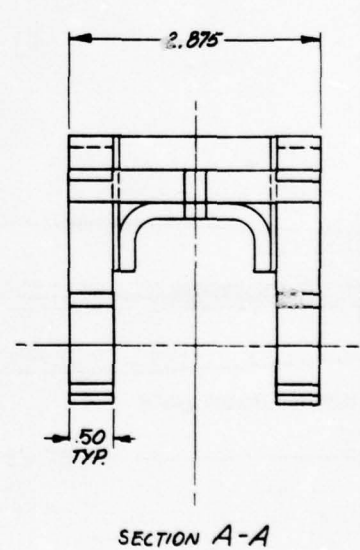
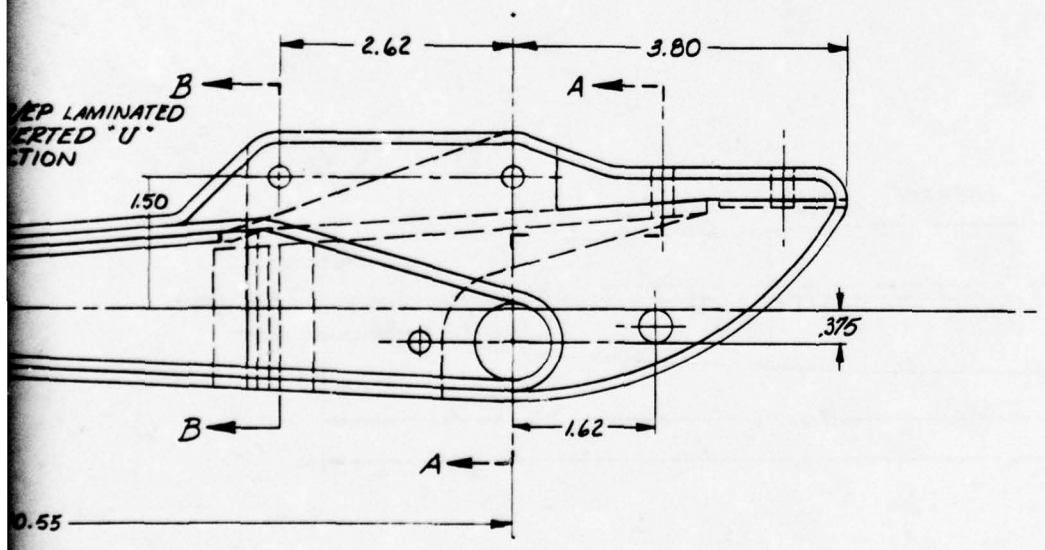
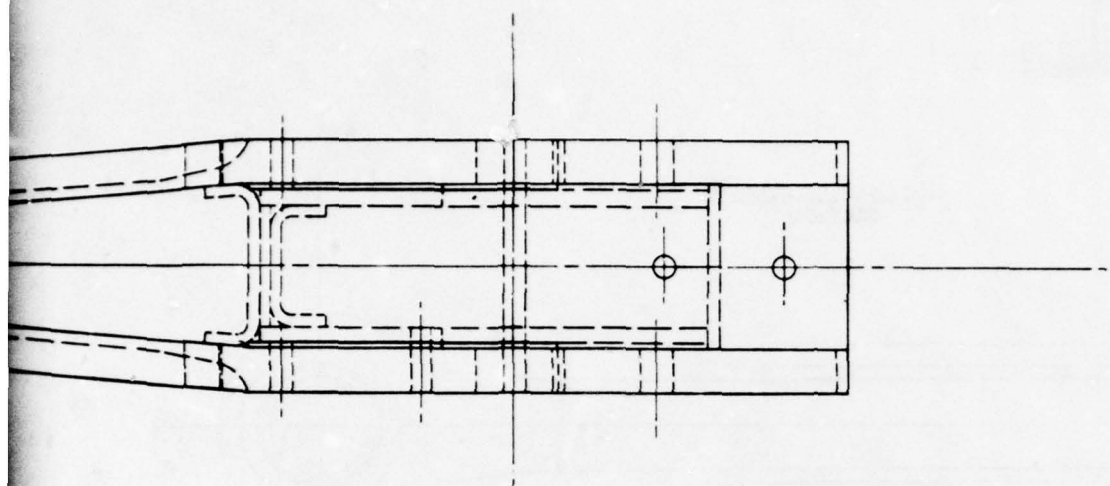
SECTION B-B



SECTION C-C



ADVANCED
DESIGN
D-25-401



2



Figure 26.

SCALE:	DR. <i>VE. WILSON</i>	Los Angeles Aircraft Division	ADVANCED DESIGN
<i>FULL</i>	DATE <i>5-21-76</i>	Rockwell International	
	MODEL	INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 90009	
STUDY-COMPOSITE DOWN LOCK, FORWARD, B-1 NOSE GEAR-PHASE I, CONCEPT 1			<i>D615-1-402</i>

4.2.4 Aft Down Lock

The aft down lock connects the over center locking end of the forward down lock to the fuselage structure. The loads are as given in the Forward Down Lock section.

The baseline B-1 aft down lock, figure 11, is an "I" section 7075 aluminum alloy die forging. The forward section in the over-center lock area is a solid section and the aft end has a single lug for structural attachment, and dual lugs for attachment of the actuating cylinder.

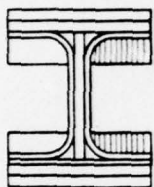
The composite aft down lock uses the spliced metal/composite construction which was employed on the drag braces. The aft end is aluminum and is identical to the end of the baseline aft down lock. This is necessary in order to react the high loads in the thin lug sections required to meet the form constraint and to assure interchangeability with the baseline components.

Figure 27 shows the composite design concept for the aft down lock. The aluminum actuator end is multi-step lap spliced to the graphite epoxy laminated "I" section. The "I" section consists of back-to-back channel shaped laminates using $50\% \pm 45^\circ$ plies and $50\% 0^\circ$ (longitudinal) plies with "race track" wound caps using more than $90\% 0^\circ$ plies and less than $10\% \pm 15^\circ$ plies. The composite section is 23.25 inches long with 2.75 inch splice overlaps. The composite web is multi-step spliced to both sides of the aluminum lug, and the composite caps are multi-step spliced to the inside surface of the aluminum caps from the lug. The caps are continued around (race track) the forward end of the lock link. The ends are reinforced using laminated fillets of $50\% \pm 45^\circ$ and $50\% 0^\circ$ plies. The forward fillet will be 9 inches long to reinforce the over-center lock area. The entire assembly will be co-cured.

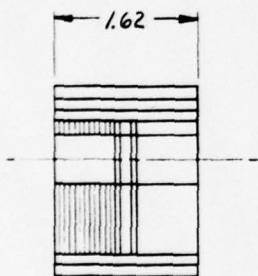
4.2.5 Torque Links

There are two torque links which are located on the aft side of the lower strut, see figure 23. They provide hinged links between the fixed outer strut and the rotating and translating inner piston/axle/wheel assembly. This allows steering and up and down motion of the nose wheel. The links are loaded by steering torque and the apex load on each link is $\pm 24,500$ pounds (design).

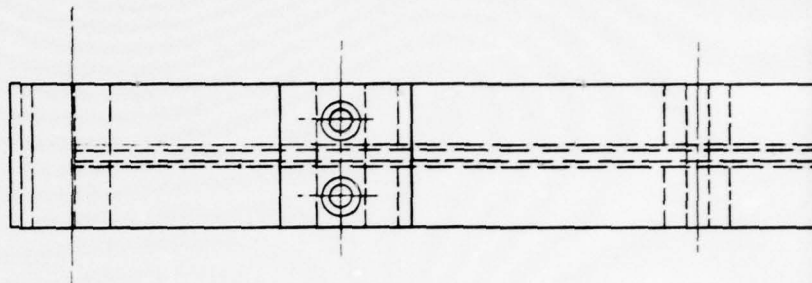
Menasco Manufacturing Company will build the baseline torque links. They will be aluminum forgings, triangular shaped, fastened together at the apex and mounted to the strut and the piston at the base, see figure 13.



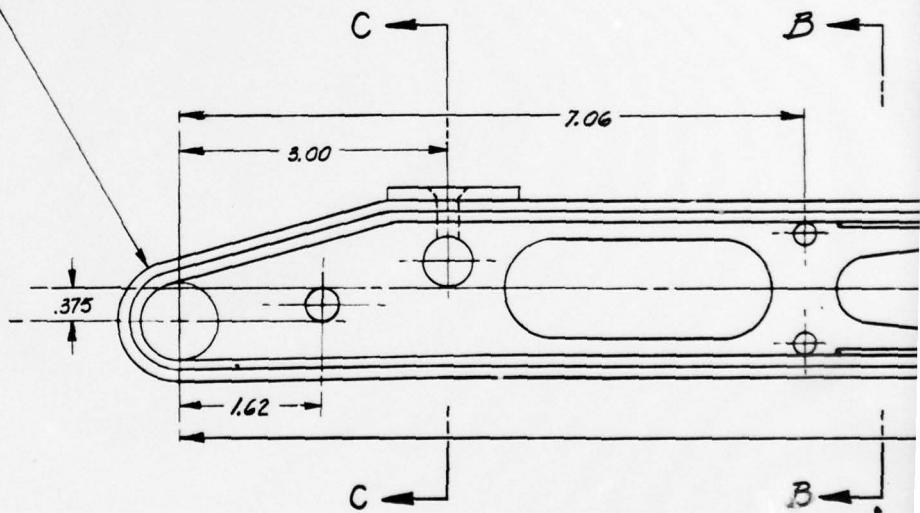
SECTION B-B

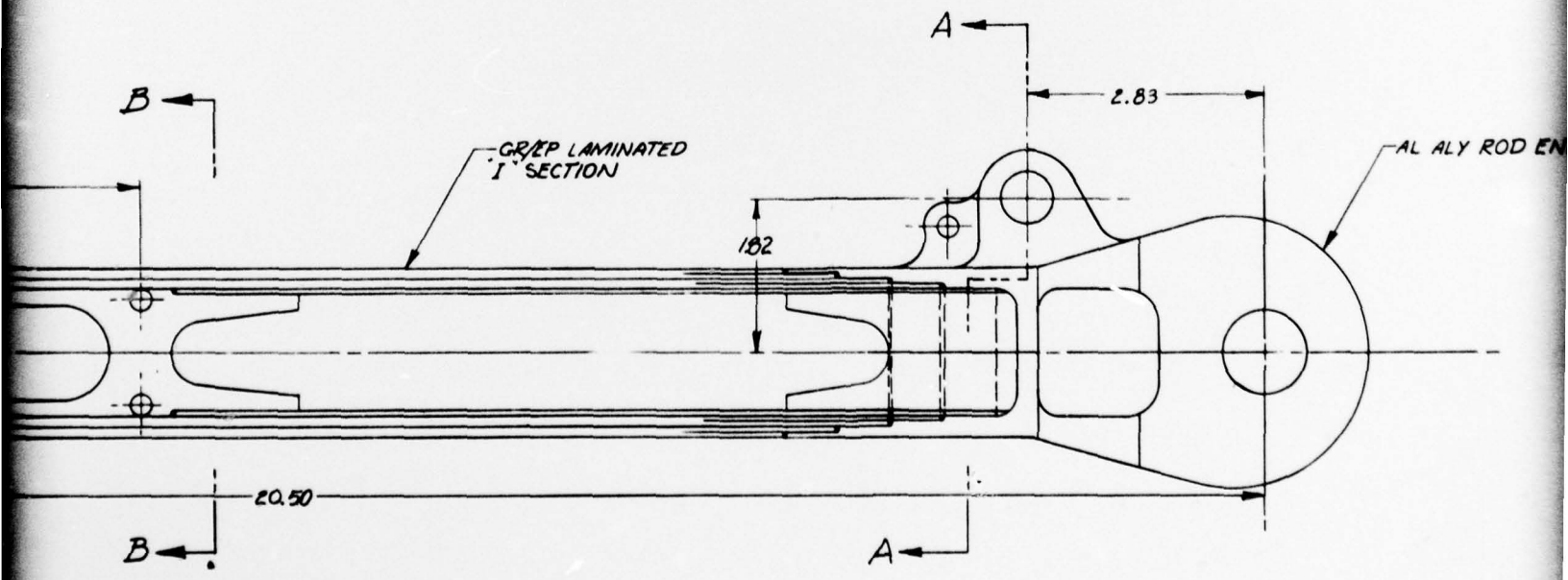
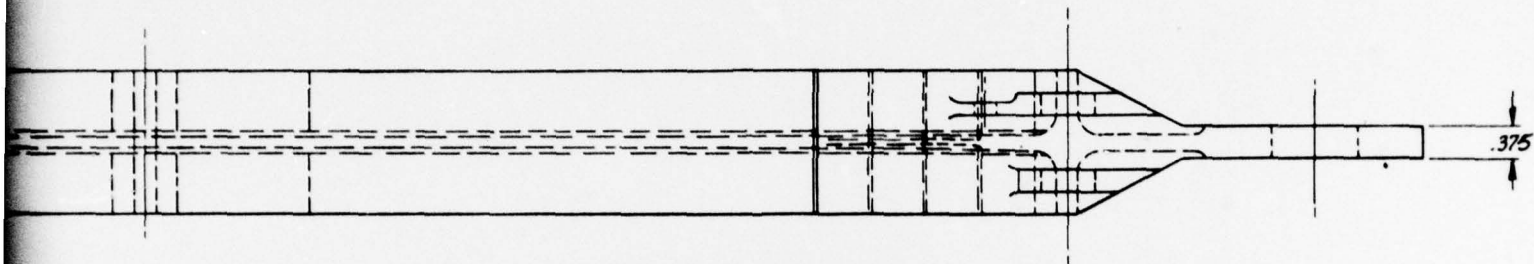


SECTION C-C



GR/EP "RACETRACK"
WOUND ROD END





7

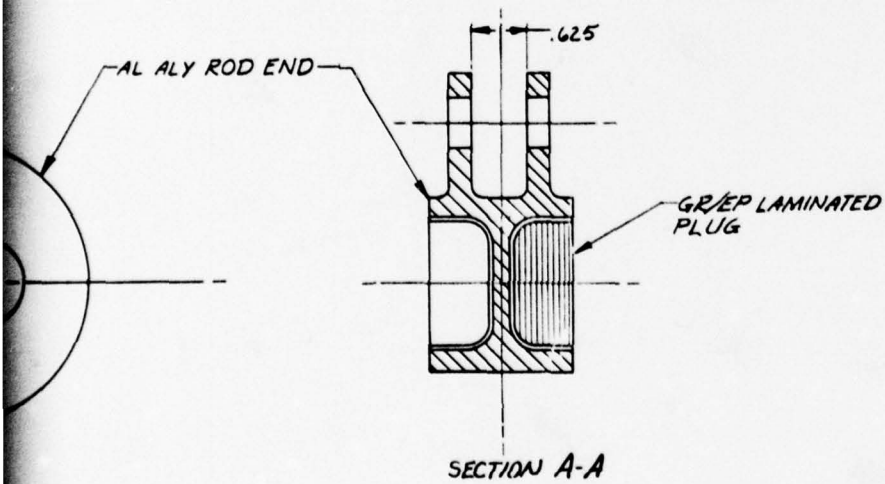
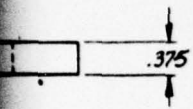


Figure 27.

SCALE:	DR. K.E. Wilson	Los Angeles Aircraft Division	ADVANCED DESIGN
FULL	DATE 5-26-76	Rockwell International	
MODEL		INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 90009	
STUDY-COMPOSITE DOWN LOCK, AFT B-1 NOSE GEAR-PHASE I, CONCEPT 1			D615-1-403

The design concept shown in figure 28 is a graphite epoxy laminated part using "race track" wound laminations. The outer race track laminate will be more than 80% 0° (base to apex) plies with less than 20% \pm 45° plies. The inner race track laminate will be 60% 0° plies and 40% \pm 45° plies. The laminated inner block will be 50% 0° plies and 50% \pm 45° plies. The assembly will be co-cured.

4.2.6 Strut and Trunnion Arms

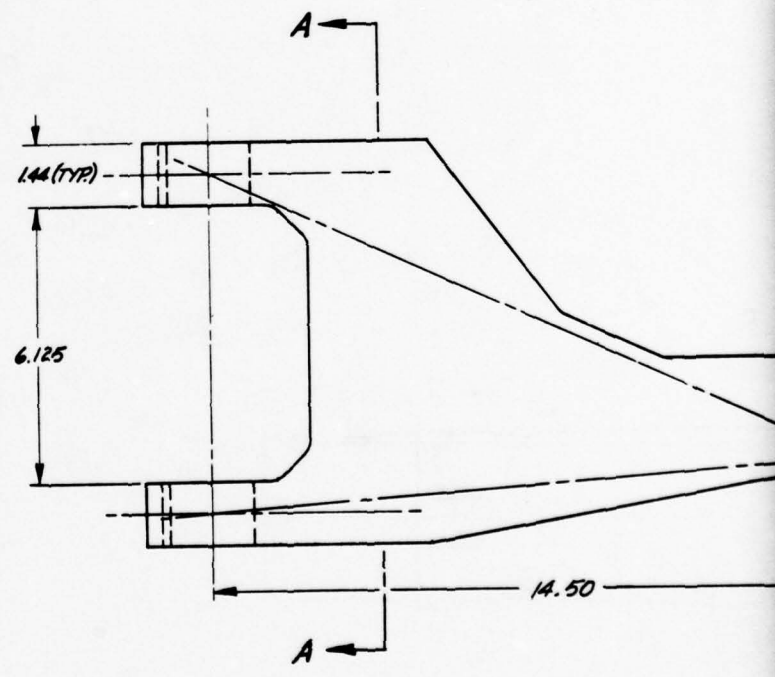
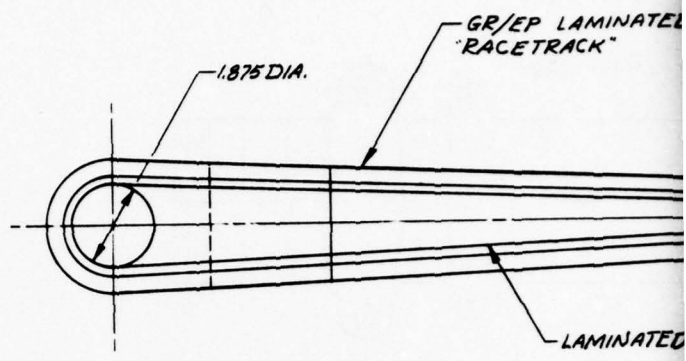
The strut is the structural component which fastens to the trunnion fittings on the fuselage structure, it contains the shock absorbing system and supports the piston/axle/wheel assembly. It provides for attachment of major components such as the actuating cylinders, the drag braces, the up lock, the steering system, the torque links and the piston/axle/wheel assembly. The loads are given in figure 19 and 20.

Menasco will build the baseline strut using a machined aluminum alloy forging. This one piece part will include the cylindrical strut, the trunnion arms and the actuation cylinder attachment horns, see figures 15 and 16.

Two design studies were made of the strut and trunnion arms. Both studies use an aluminum strut section to assure that the attachment for major components, listed in the first paragraph above, will meet the form constraint and fit the metallic mating parts.

Study A, figure 29, features a graphite epoxy composite one piece section which incorporates both actuator horns, trunnion arms and a center cylindrical tube which is mechanically fastened to the aluminum center strut. Both the actuator horns and the trunnion arms use race track wound cap sections using at least 90% 0° and less than 10% \pm 45° plies. The webs will be 50% \pm 45°, 25% 0° and 25% 90° plies. The caps will be multi-step lap spliced to the horn and trunnion race track wound plies, and to the laminations forming the tube around the strut. Additional 0° race track plies will be wound around the top and bottom of the tubular section to tie the trunnion arms to the strut. The entire composite subassembly will be co-cured.

Study B, figure 30, shows an aluminum strut, similar to the baseline except for two additional sets of lugs which pick up the composite trunnion arms. The apex of the trunnion arms are fastened to the actuator horn/trunnion arm end fitting. The strut is then assembled using mechanical fasteners. The composite trunnion arms are a triangular box section with beams to the apex and upper and lower webs connected by channel sections at the base leg and across the center.



1

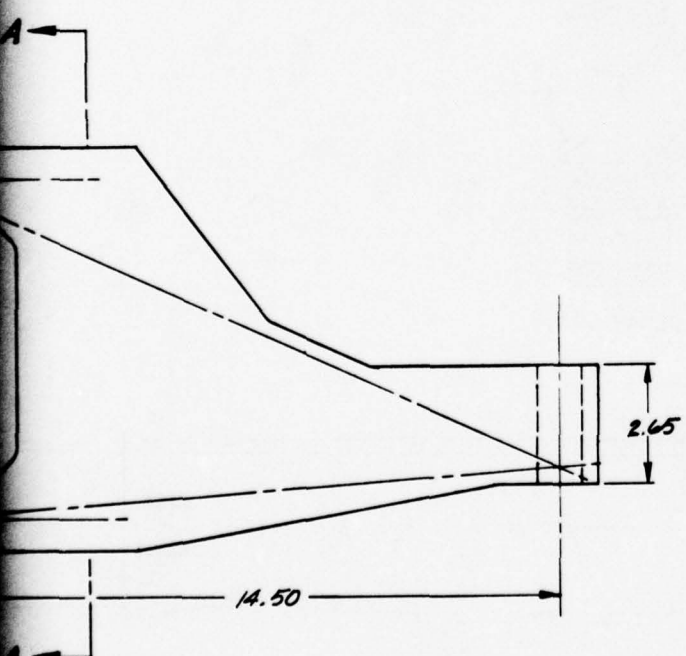
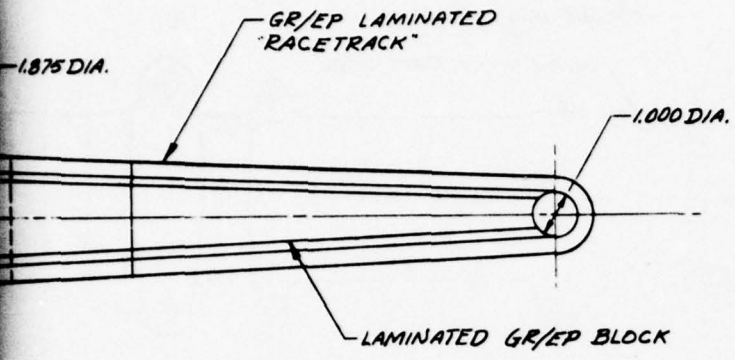


Figure 28.

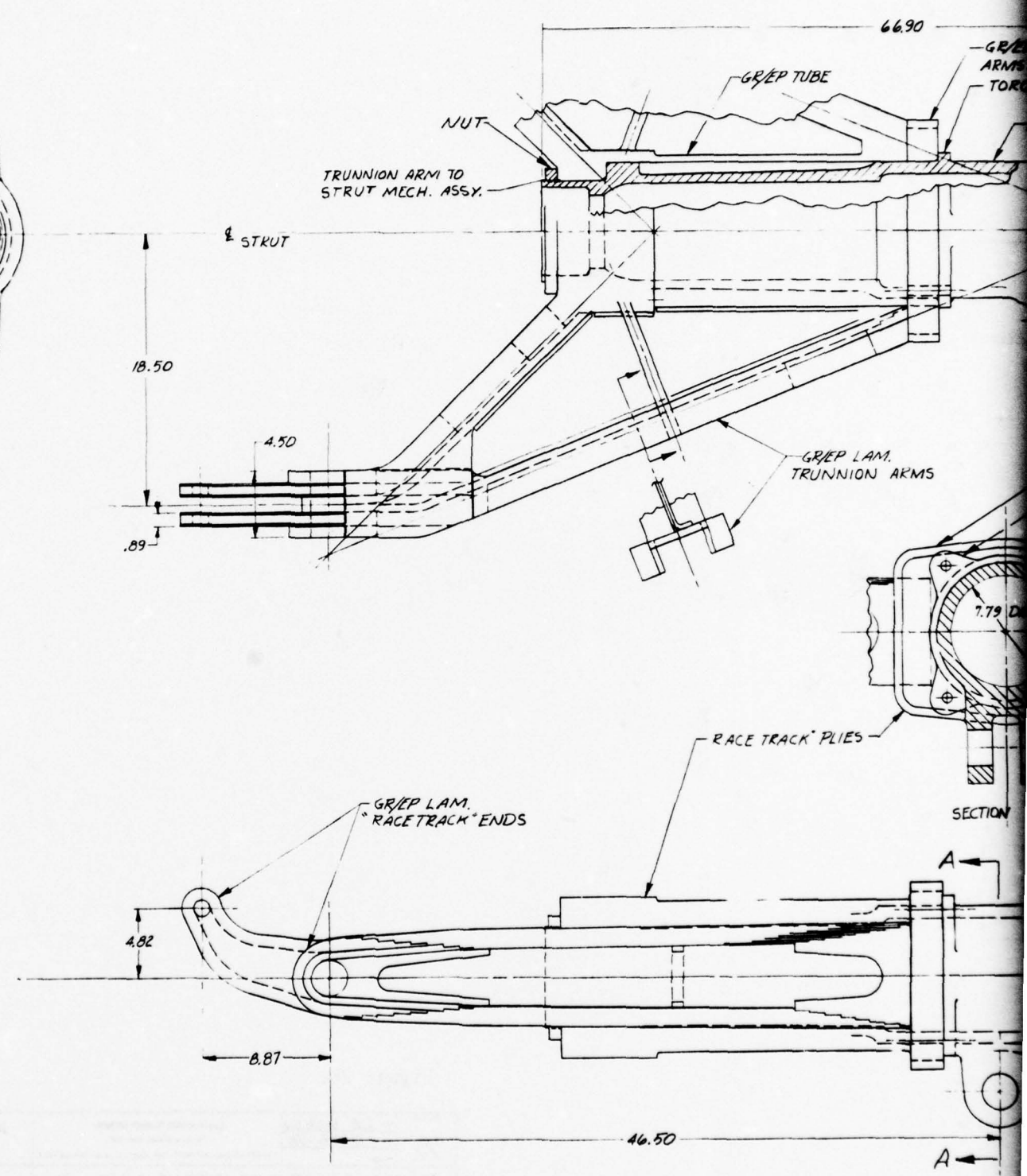
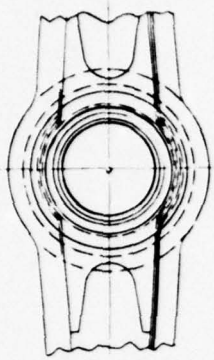
SCALE	DR. <i>V.E. Wilson</i>	INTERNATIONAL
$1/2$	DATE 5-28-76	
MODEL		
STUDY-COMPOSITE 7		
NOSE GEAR-PHASE		

2

Figure 28.

SCALE: <i>1/2</i>	DR. <i>V.E. Wilson</i> DATE <i>5-28-76</i> MODEL	Los Angeles Aircraft Division Rockwell International INTERNATIONAL AIRPORT · LOS ANGELES, CALIFORNIA 90009	ADVANCED DESIGN
STUDY-COMPOSITE TORQUE LINK, B-1 NOSE GEAR - PHASE I, CONCEPT 1			<i>D615-1-40A</i>

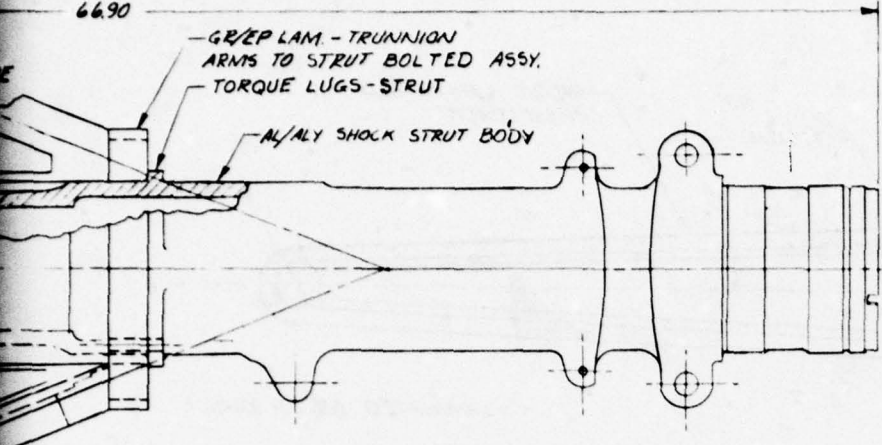
3



1

66.90

- GR/EP LAM. - TRUNNION
ARMS TO STRUT BOLTED ASSY.
- TORQUE LUGS - STRUT
- AL/ALY SHOCK STRUT BODY



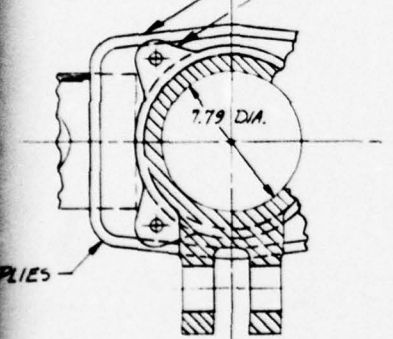
GR/EP LAM.
TRUNNION ARMS

- GR/EP LAM. LUG
- AL/ALY STRUT LUG

7.79 DIA.

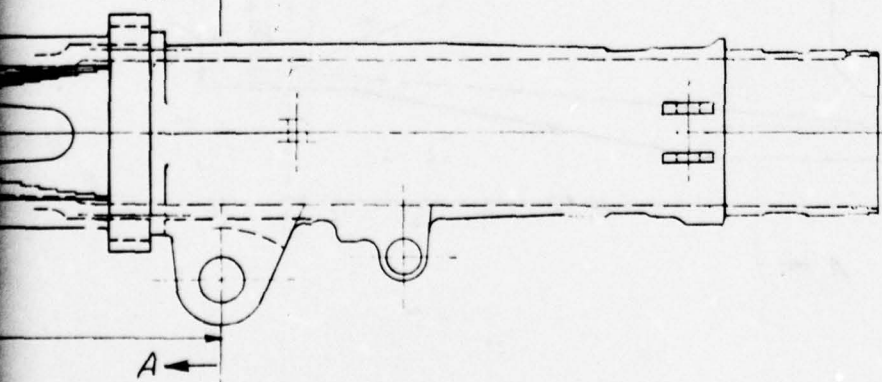
PLIES

SECTION A-A



A

A

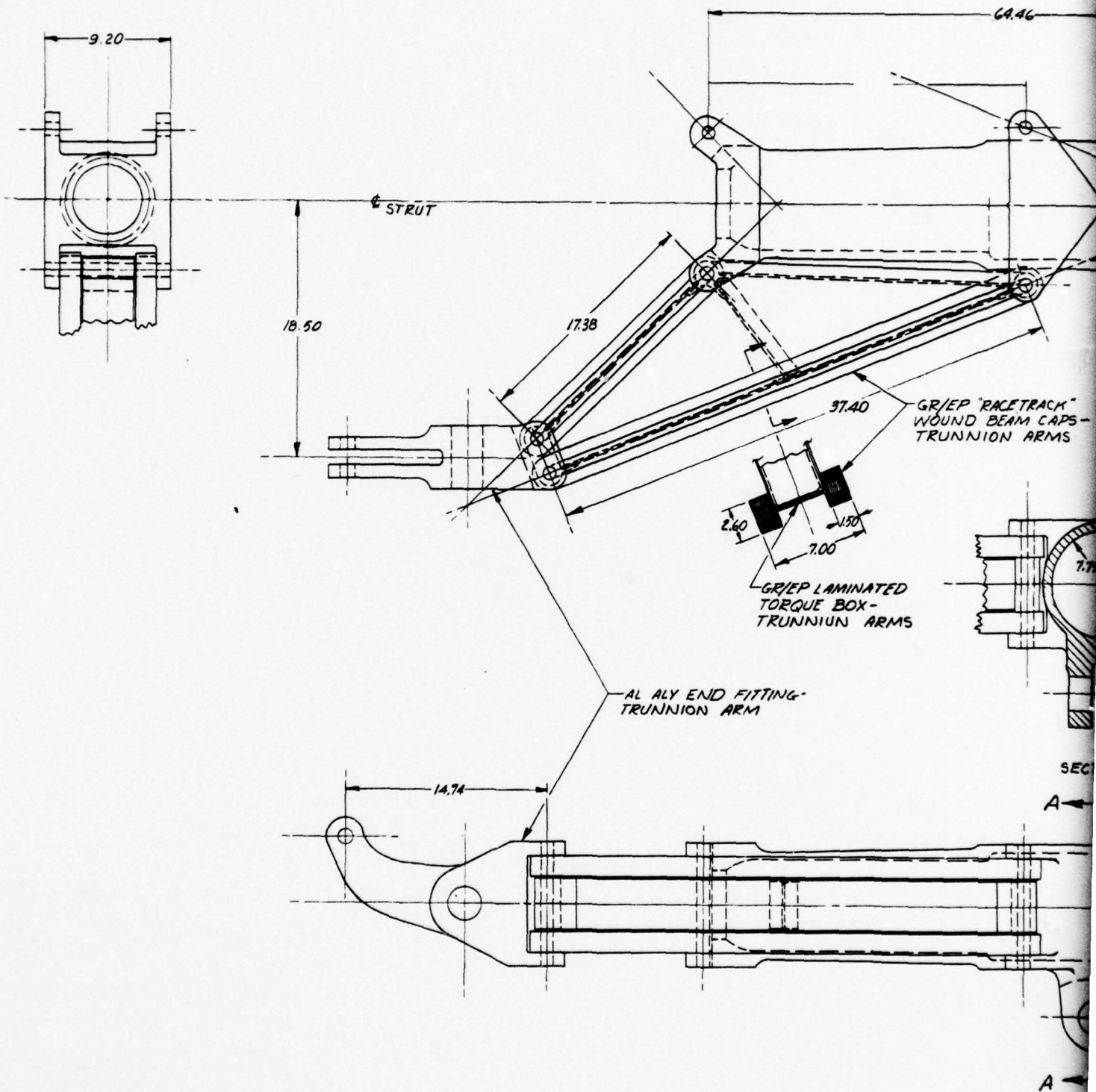


2

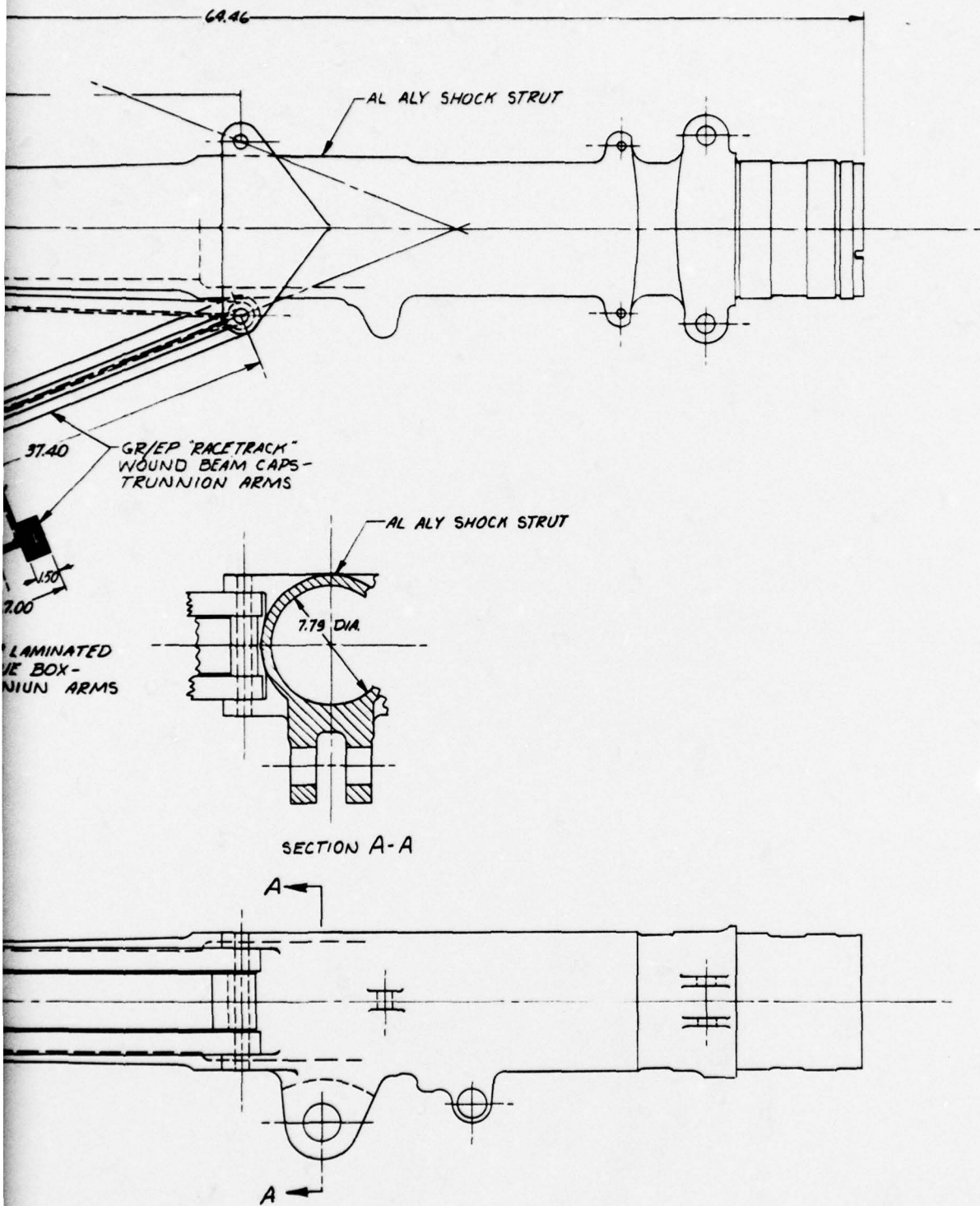
Figure 29

SCALE .23	DR. V.E. WILSON DATE 6-15-76 MODEL	Los Angeles Aircraft Division Rockwell International INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 90009	ADVANCED DESIGN
STUDY A-COMPOSITE TRUNNION ARMS & AL ALY STRUT-BI NOSE GR - PHASE I, CONCEPT 1			D615-1-411

5



1



2

Figure 30.

SCALE:	DR. V.E. WILSON	Los Angeles Aircraft Division	ADVANCED DESIGN
.23	DATE 6-29-76	Rockwell International	
	MODEL	INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 1000	
STUDY-B-COMPOSITE TRUNNION ARMS & AL ALY STRUT-B-1 NOSE GR.-PHASE I, CONCEPT 1			D615-1-405

The two beams are "I" sections with caps which consist of a "race track" wound around a solid laminated center section, and channel section webs. The cap "race track" and center section laminate will be at least 90% 0° plies with less than 10% $\pm 15^\circ$ plies. The channel section beam webs and the top and bottom box webs will be 50% $\pm 45^\circ$, 25% 0° and 25% 90° plies. The beam end corners of the box section are composite spools with flanges to pick up the webs. They will be "race track" wound around the fastener hole using 50% $\pm 45^\circ$, 25% 0° and 25% 90° plies.

"Race track" beam caps together with corner spools, the top and bottom box webs, the long beam channel web and the center stiffener channel web will be co-cured. In a secondary operation, the channel webs on the base and short side will be bonded to close out the trunnion arm box assembly.

4.2.7 Wheels

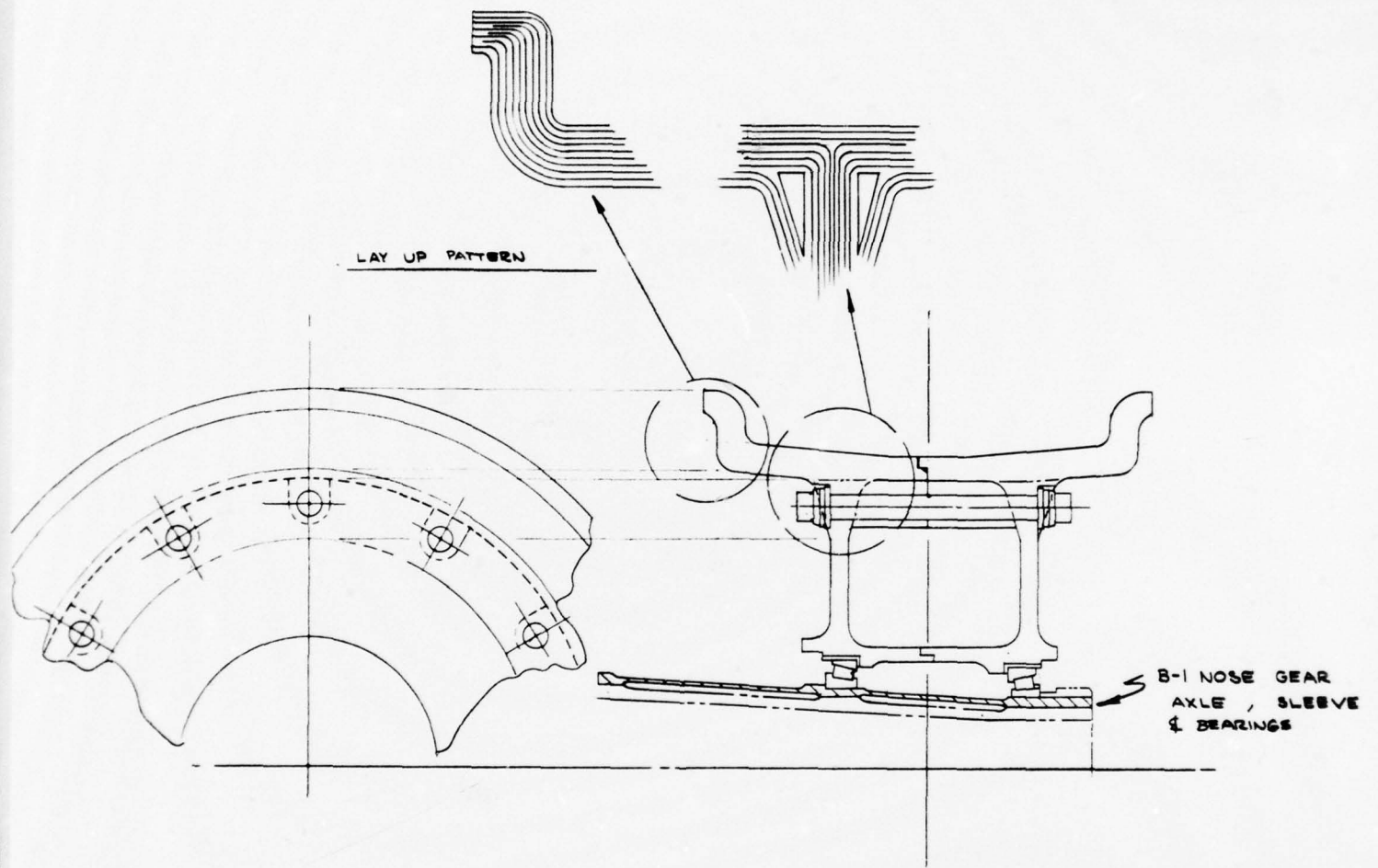
The B-1 baseline nose landing gear has dual wheels, see figure 23. Each wheel consists of an inboard and an outboard wheel half which are bolted together. These half wheels are dish shaped aluminum alloy forgings, see figure 17. Goodyear Aerospace will build the wheels. The loads on the wheels are given in figure 22.

The composite wheel, shown in figure 31, is made up of two laminated graphite epoxy wheel halves which are bolted together to form a complete wheel. The wheel halves will be laid up with plies, as shown in figure 31. Both 0° (radial), and $\pm 45^\circ$ plies will be continuous from hub to rim, and 90° (hoop) plies will be continuous around both hub and rim areas. Machined ring shaped inserts are used in both hub and rim "Tee" areas, as shown in figure 31. The inserts will be precured before machining to size and used in the wheel layup. This assembly will then be co-cured.

4.3 CONCEPT 2 - MODIFIED

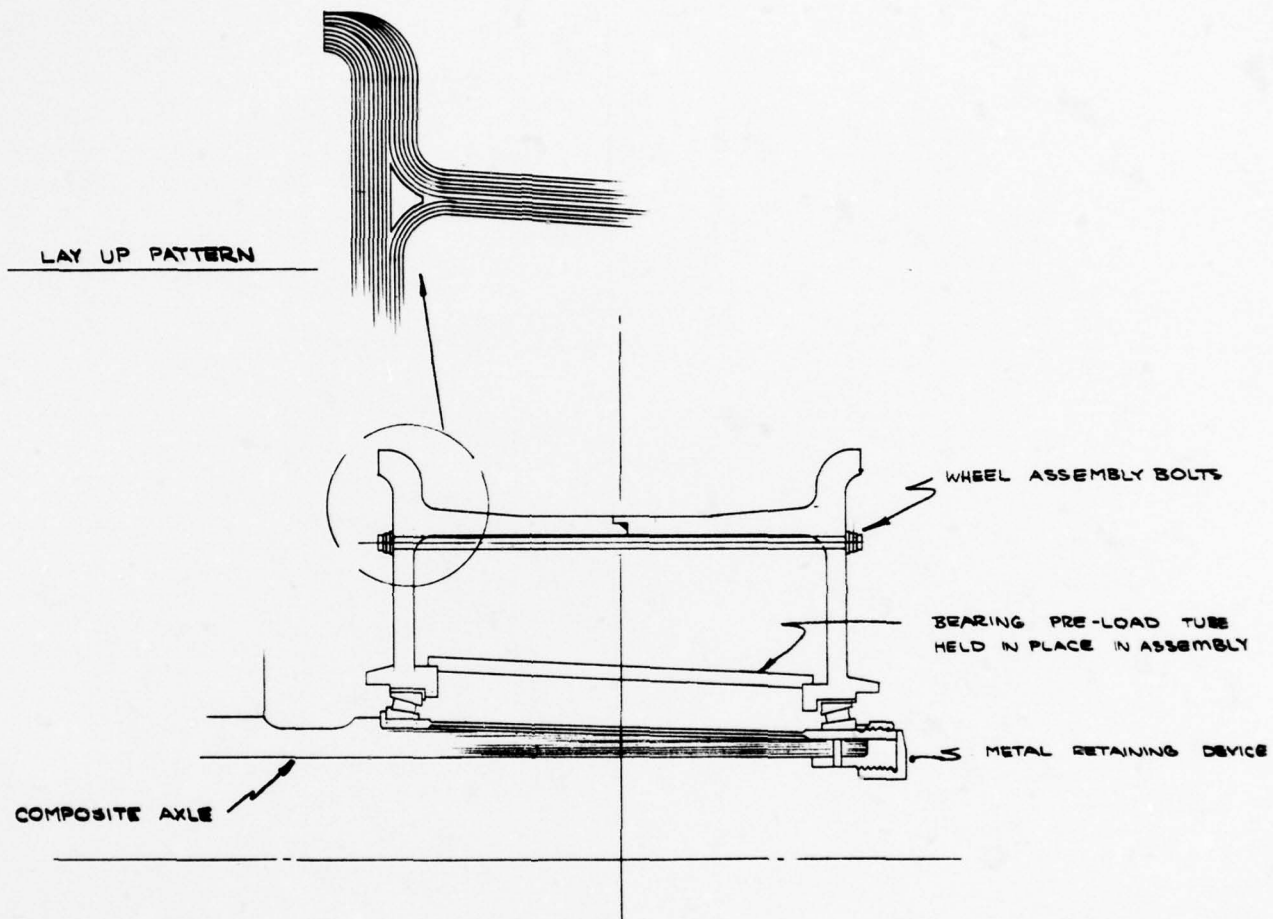
This study was made to determine what additional usage of composites could be gained by removing the "form" constraint which limited Concept 1 designs. The Concept 2 designs are constrained by the existing attachment, stowage and functional requirements ("fit and function") of the baseline B-1 metallic nose gear. The existing location of the strut trunnions, the drag brace structure mounts, the gear retract cylinder mounts and the up lock hook mounts were retained. The size of the baseline nose gear wheel well and stowage clearances were also retained.

Study showed that the wheel well width constraint required that the piston and the lower strut (cylinder) remain metallic to avoid a larger



CONCEPT 1

1

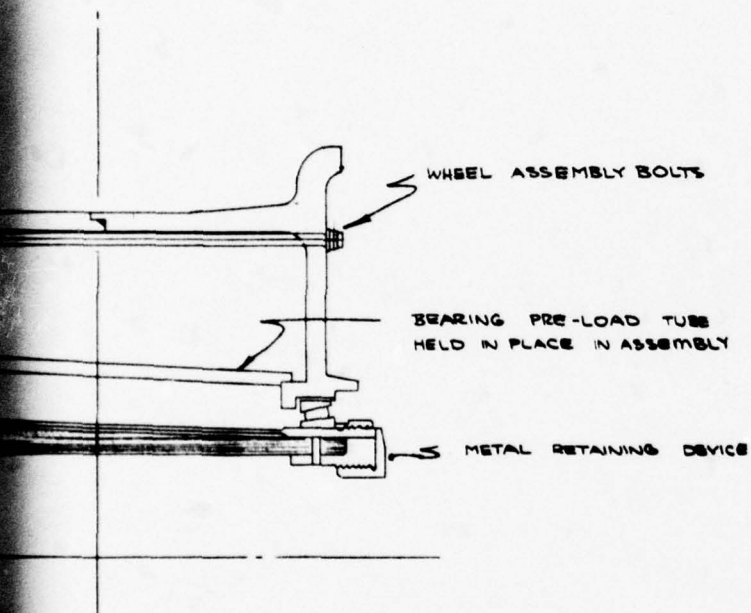


CONCEPT 2

Figure 31.

SCALE:	DR. F. A. T.
1/2	DATE JUNE
	MODEL
STUDY - COM NOSE GEAR	

2



CEPT 2

Figure 31.

SCALE: $\frac{1}{2}$	DR. <i>F. ATKINS</i> DATE <i>JUNE 8, 78</i> MODEL	Los Angeles Aircraft Division Rockwell International INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 90001	ADVANCED DESIGN
STUDY - COMPOSITE WHEELS, B-1 NOSE GEAR, PHASE I, CONCEPT 1 & 2			<i>D615-1-406</i>

diameter composite cylinder which would force the nose wheels apart and create interference with the nose gear well side walls. Two studies have been made of drag braces, down lock links, torque arms, strut and wheels to improve the usage of composites by altering the "form" of the parts.

4.3.1 Concept 2 - Study A

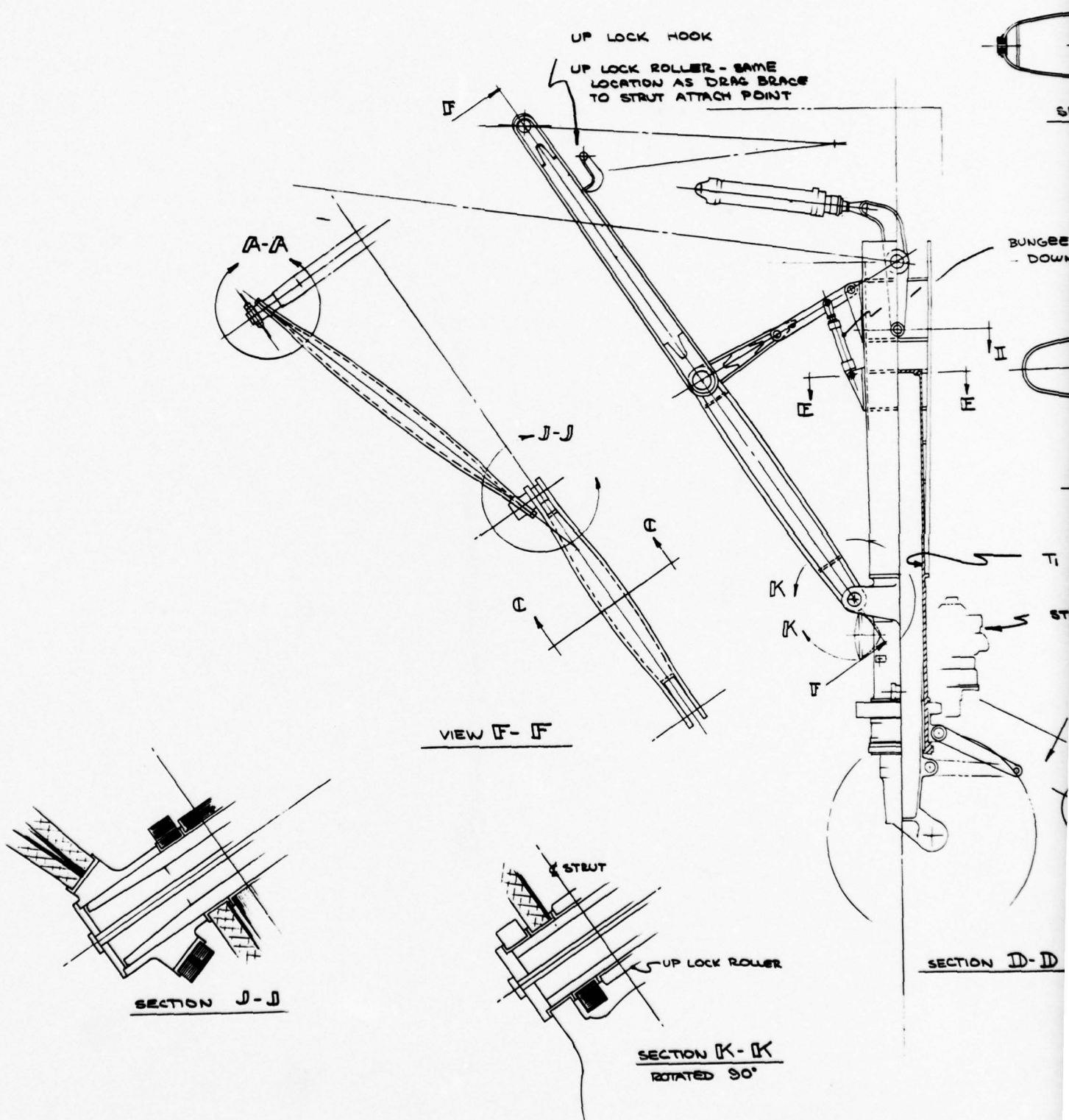
This nose gear concept works as described in the "baseline section, except that the kinematics of the drag braces and the lock links have been revised, see figure 32. The drag brace lower attachment was moved down the strut to the location of the "up lock" pin. This kept all the highly loaded lugs on the lower, metallic section of the strut. The upper mount for the down lock links was moved to allow a change in configuration of the upper strut.

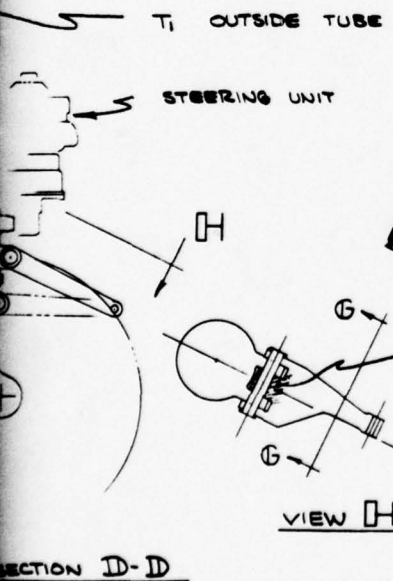
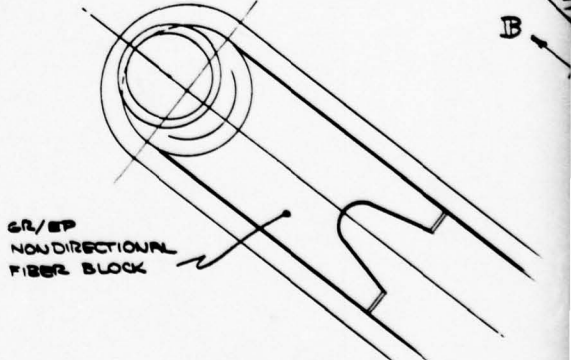
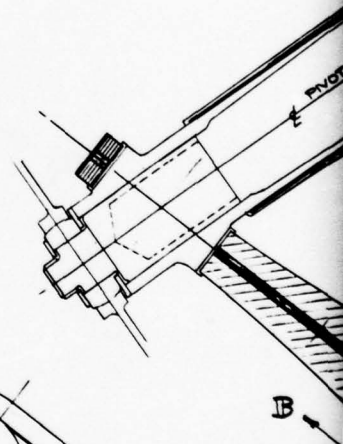
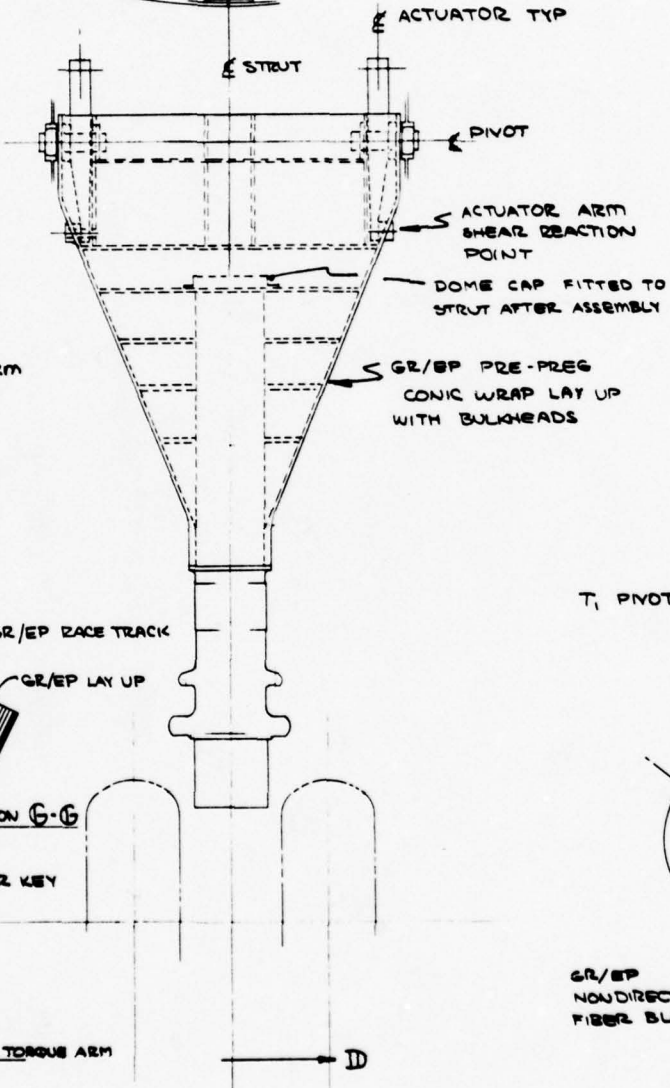
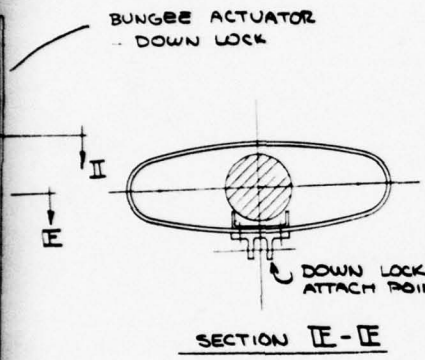
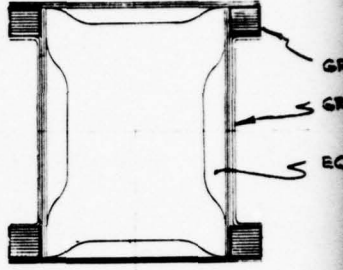
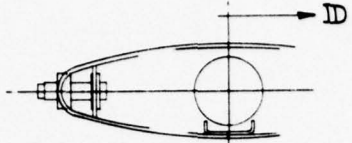
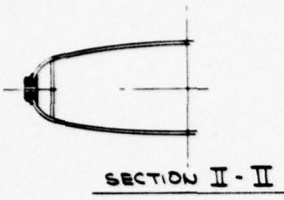
The drag braces are all composite in this concept since the configuration of the ends have been revised. The drag brace mounting pins and fittings have been enlarged to accept the required larger size of the composite drag brace end configurations. Both forward and aft drag braces now feature a dual "race track" configuration in which the race track caps are positioned on each corner of a rectangular box section. This allows the size of the box section, and therefore the cap locations, to vary according to the section property needs of the part. At the midpoint of the long axially loaded member, the box section is square so that the cap locations produce equal section properties in both the X-X and Y-Y directions. The box section sidewalls are stiffened by beading the inner ply of the laminated web and bonding it to the flat webs.

The configuration of the down lock links have been revised to improve the joint design and the usage of composites. The forward (lower) down lock is a one piece link which fastens to the drag brace apex pin between the lugs of the aft drag brace. This avoids the necessity of a separate down lock lug on the drag brace, which is difficult to fabricate using composites. The upper end of the forward down lock is extended beyond the pivot pin to act as an over-center latch.

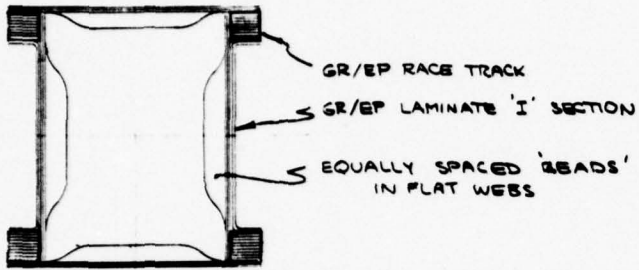
The aft (upper) down lock is a dual link configuration which provides for both the forward down lock link and the actuator/bungee to mount between the links. A pin between the links acts with the extended forward link to provide the over-center latch feature. Both the single forward and the dual aft links will use the "race track" design concept.

Torque link mounting lugs on both the strut (cylinder) and piston have been revised to allow a change in torque link design. A center shear lug

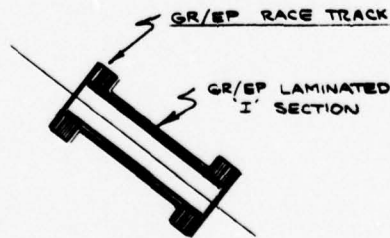
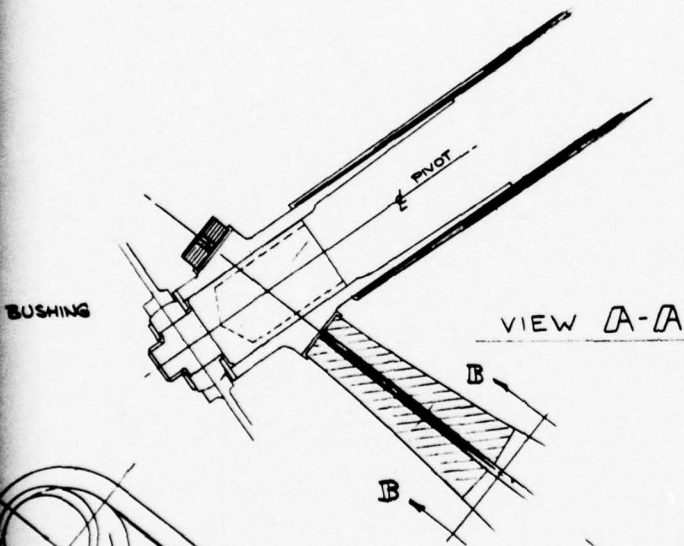




2



SECTION C-C



SECTION B-B

Figure 32.

SCALE 1/64 1/2	DR. F. ATKINS DATE JUNE 28, 75	Los Angeles Aircraft Division Rockwell International INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 9009	ADVANCED DESIGN
STUDY - COMPOSITE NOSE GEAR COMPONENTS, PHASE I, CONCEPT 2A			D615-1-407

has been added to the base of the torque link to relieve the load on the two outside lugs. The link will be "race track" wound over a solid laminated core.

The strut has retained the hydraulic-pneumatic load absorption features of the baseline strut. This concept uses the baseline piston. The cylinder and lower strut section is metallic, but uses titanium for better compatibility with composites. The inside titanium cylinder is bonded to the outside composite strut which is shaped like a flattened cone. This shape offers a good load path to the trunnion and is stiffened with horizontal bulkheads and vertical webs. The gear retract cylinder bell cranks are aluminum and are mounted on the trunnion pins and attached to the strut body by shear pins.

The wheel for Concept 2 is shown in figure 31. The configuration has been changed to spread out the bearings and to provide a direct load path from the tire beads down to the support points on the axle. The metallic axle sleeve, which is assembled with the wheel and bearings, has been retained since it improves maintainability by allowing wheel replacement on the "line" without handling the bearings.

4.3.2 Concept 2 - Study B

Kinematics of the B version of Concept 2 is approximately the same as the A version described in the previous section. The major change is in the configuration of the strut. This study uses axially loaded side braces to react the vertical loads and stabilize the strut for side loads. The drag brace reacts forward and aft loads the same as on Study A.

The strut consists of a titanium cylinder which has all the highly loaded lugs near the lower end. These include provisions for the drag brace, the side braces, the up lock pin and the steering mechanism. The location of the side braces at this position produces a larger side moment restraint arm, thus lowering the axial loads in the side braces. The center strut cylinder is keyed and bonded to the upper composite tube which will react the steering torque at the upper trunnion cross shaft. The nose gear retract cylinder bell cranks are aluminum and are bolted to composite sleeves attached to the trunnion shaft. (See figure 33.)

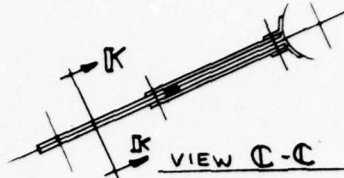
The configuration of the axially loaded struts, including the side struts, are "racetrack" caps on box sections, similar to the struts described in study A, except that the ends are provided with aligning features which reduce secondary bending moments from the truss.

Torque link lugs have been increased in span to provide a full width shear key effect. The axle hub on the piston has been increased in diameter to allow the use of a composite axle as shown in figure 33.

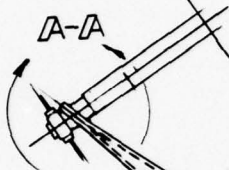
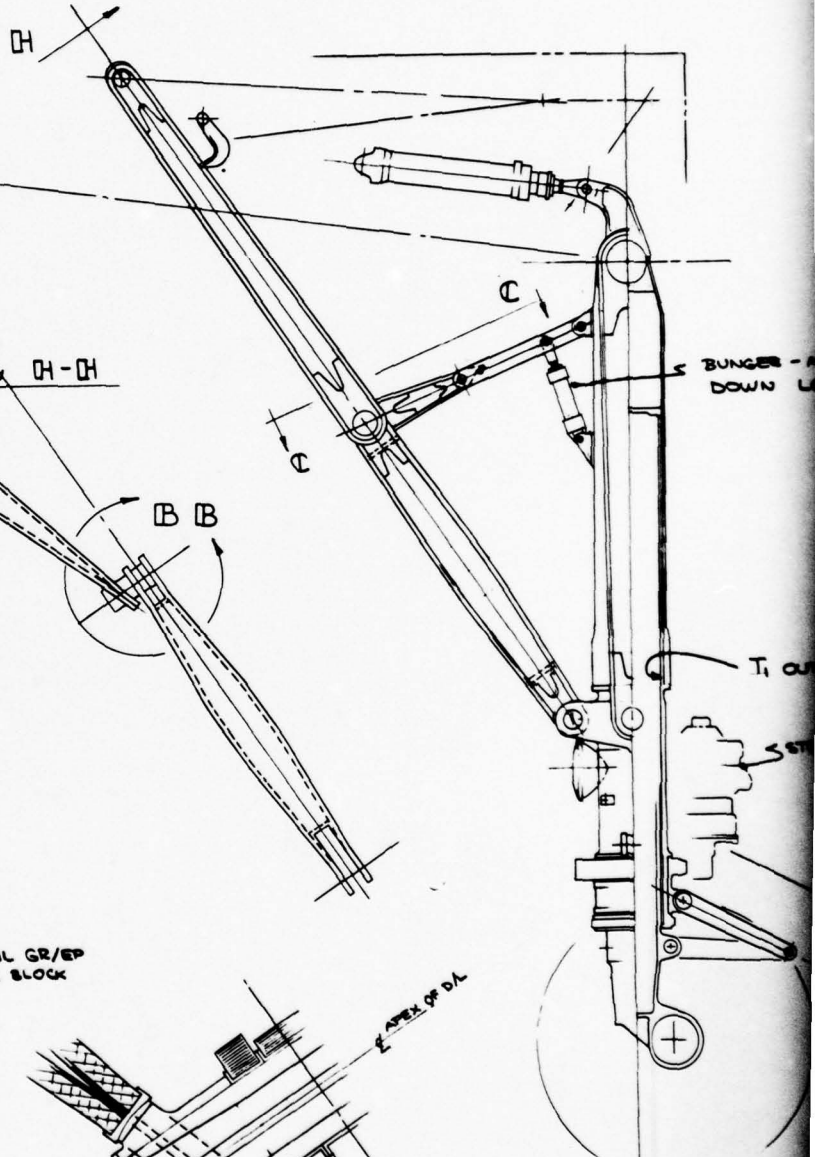
GR/EP RACE TRACK
GR/EP LAMINATE

I

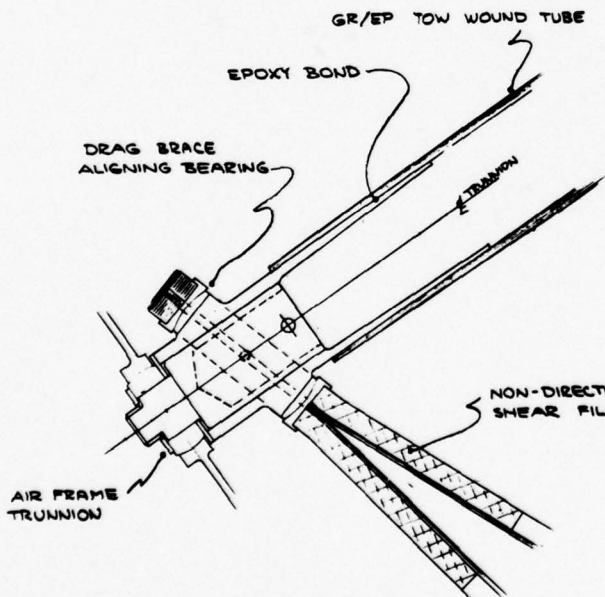
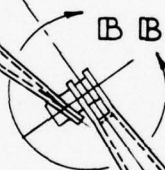
SECTION **K-K**



VIEW **C-C**

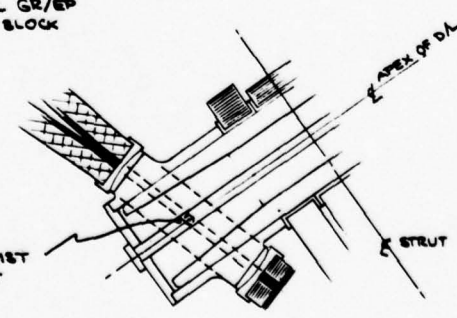


VIEW **H-H**



VIEW **A-A**

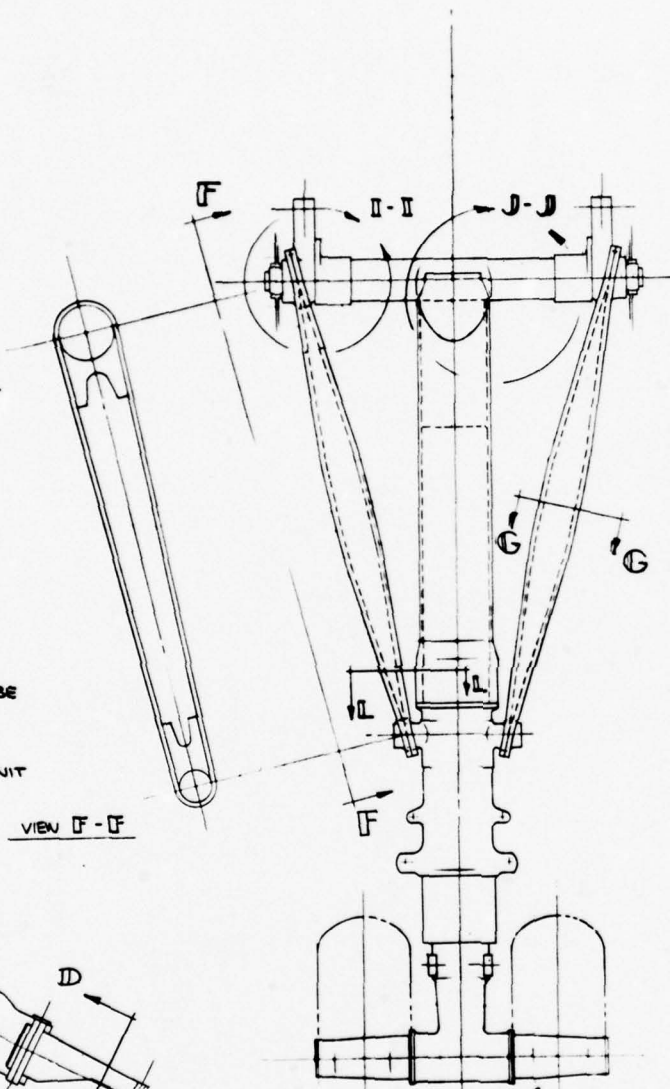
ANTI-TWIST RESTRAINT



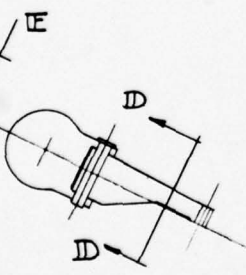
VIEW **B-B**

SIDE VIEW

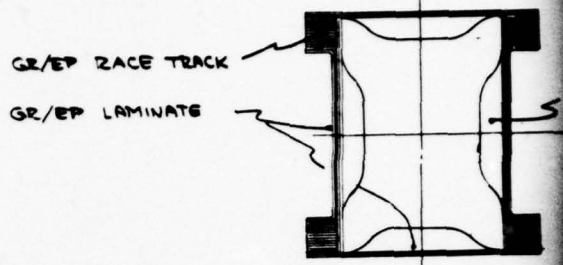
1



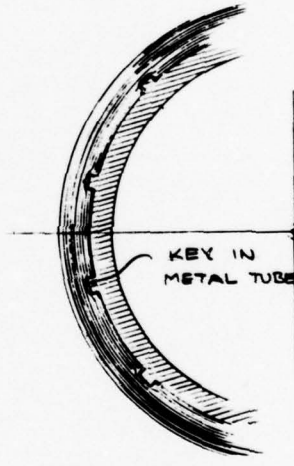
VIEW F-F



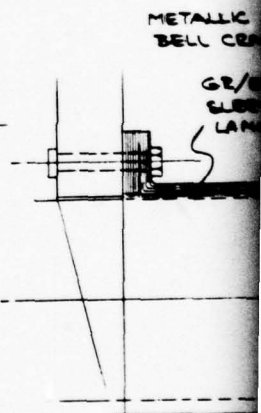
VIEW IE-IE



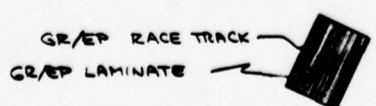
SECTION G-G
TYPICAL BOX SECTION



SECTION I-I



SEE CONCEPT 2 DWG D615-1406
FOR WHEEL-AXLE DETAIL



SECTION D-D

2

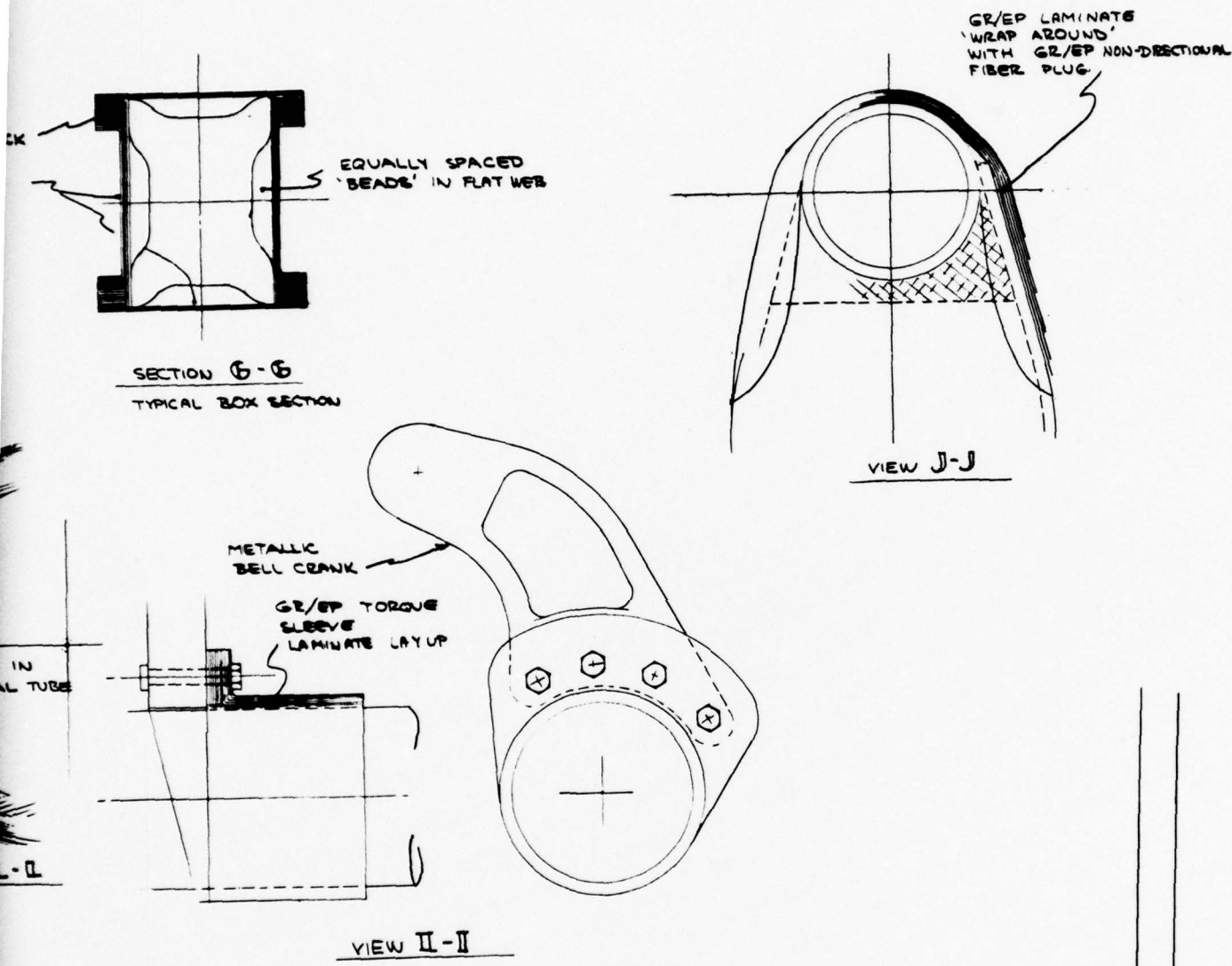


Figure 33.

SCALE:	DR. F. ATKINS	Los Angeles Aircraft Division	ADVANCED DESIGN
	DATE 7-26-76	Rockwell International	
	MODEL	INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 90009	
STUDY-COMPOSITE NOSE GEAR COMPONENTS, PHASE I, CONCEPT 2-B			D615-1-408

4.3.3 Display Model

A one-fifth scale working model of Concept 2-A will be built during the Phase II effort. This model will be mounted in a display case and will be manually extended and retracted, see figure 34. A shipping case will be furnished to protect the model and display case during transportation.

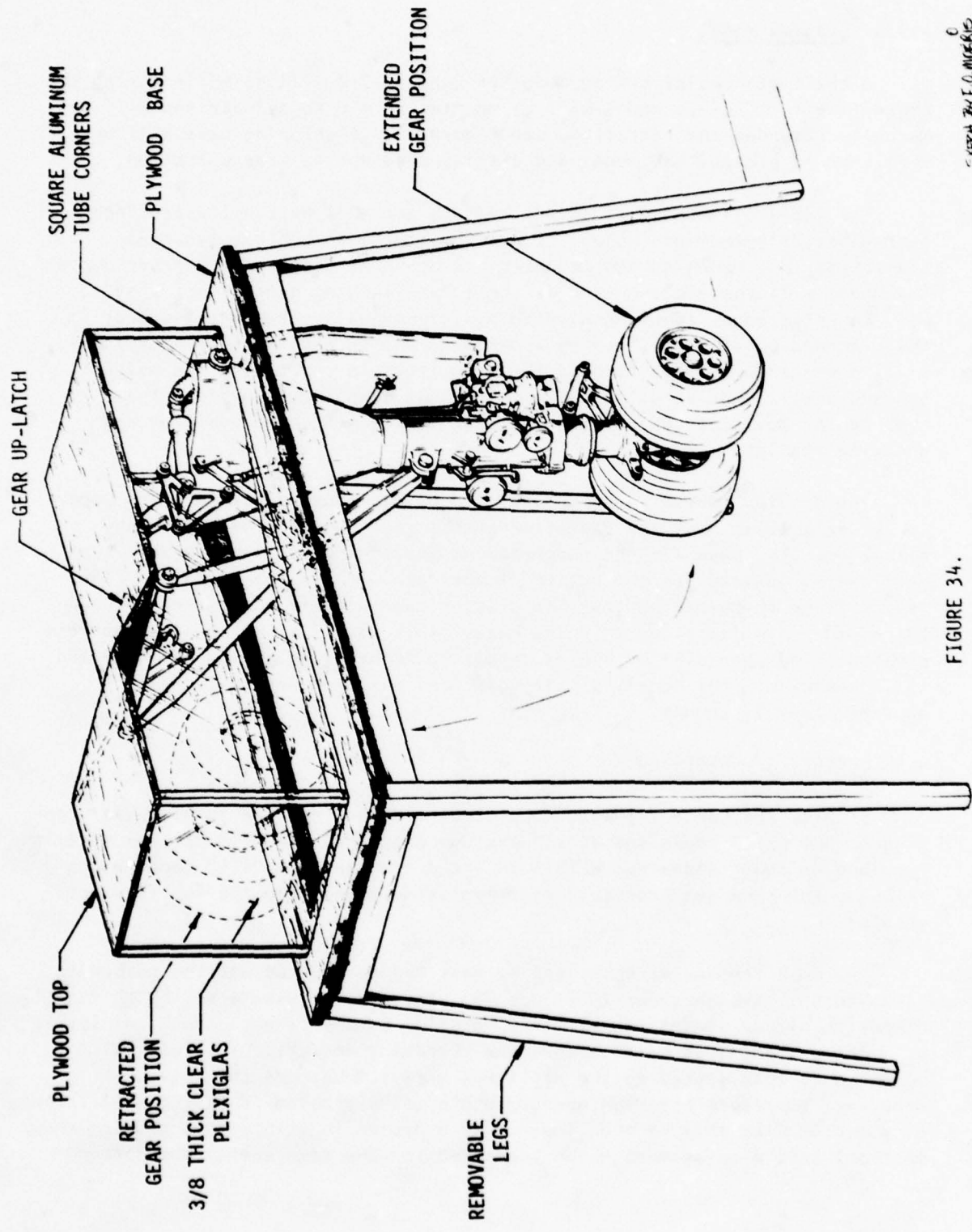
The model will be built to scale (1/5) and will be constructed from fiberglass, aluminum and wood. It will be sturdy enough to withstand transportation, handling and repeated operation of the extend-retract cycle. The model will operate the same as the actual landing gear except that it will be actuated by removing a latch pin and manually lowering the gear to the extended position. The drag links will unfold and the down lock links will "over-center" latch to hold the drag links in position. The retract procedure will consist of manually moving the down lock links off the over-center position and raising the gear to the retracted position and engaging the latch.

The display case will be constructed of aluminum, plexiglass and wood. It is designed so that the operation of the gear can be viewed from any direction. The case will be supported on four removable legs so that the gear can be lowered out the bottom of the case without interference. The legs will be removable so that the display case and stowed legs can be contained in a minimum sized shipping case. This case will be constructed from plywood. The case will be approximately 30 inches long, 14 inches high and 13 inches wide. The model, display case and shipping case will weigh approximately 27 pounds.

4.4 CONCEPT 3 - REDESIGN

Studies for Concept 3 were conducted to determine nose landing gear configurations which could foster the maximum practical use of composite material for landing gear hardware. With both the "form" and the "fit" constraints removed, the nose gear concepts were evaluated using only the "function" constraint.

The most innovative nose landing gear system studied was the composite "leaf spring" design shown in figure 35. This system uses a series of flat composite plates bonded to resilient material between them. The "leaf spring" will deflect and load up to absorb the kinetic energy, but it will also "kick-back" this energy so the resilient material between the leaves is necessary to reduce the high energy return. The problem is that the efficiency of a system like this is much lower than a hydraulic strut, thus causing the vertical axle displacement to be increased for the same energy absorption



0
 CHECK BY E.O. MICKERIS
 1/14/64 IAD B-576

FIGURE 34.
 SCALE MODEL - 1/5 SIZE AND DISPLAY CASE

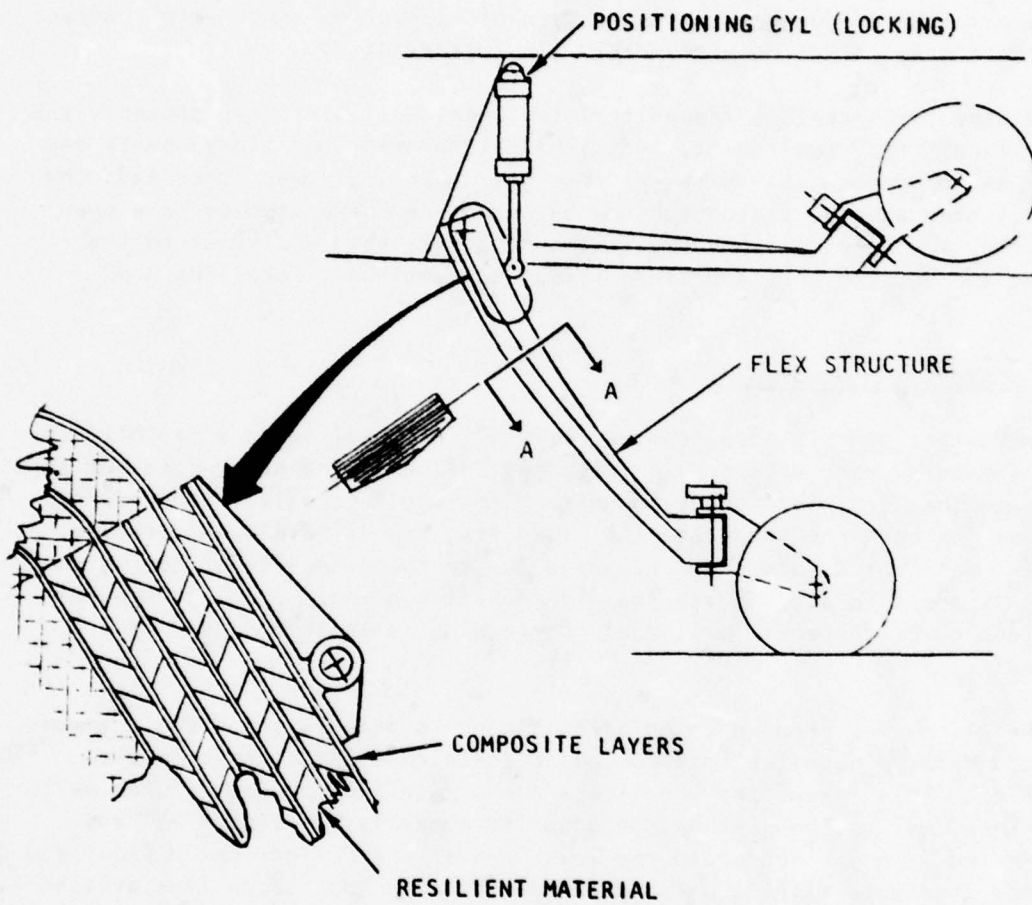


Figure 35. "Leaf Spring" Concept

requirements. Side loads on the wheel would create an undesirable torque load in the "leaf spring" strut. Stabilizing hardware would be required to hold the castoring axis to a near vertical position at all axle displacements. Preliminary studies suggest that this type of mechanism is not weight effective, therefore, it was not considered for further study.

Studies in Concept 11 showed that the wheel well width was probably the most critical "fit" constraint, and with that removed, additional parts can be made using composites. With the nose gear wheels allowed to spread, the lower cylinder and the piston can now be composite. Two studies have been made for this concept. Study A uses a configuration very similar to the baseline and Study B uses a different, but conventional, "trailing arm" concept.

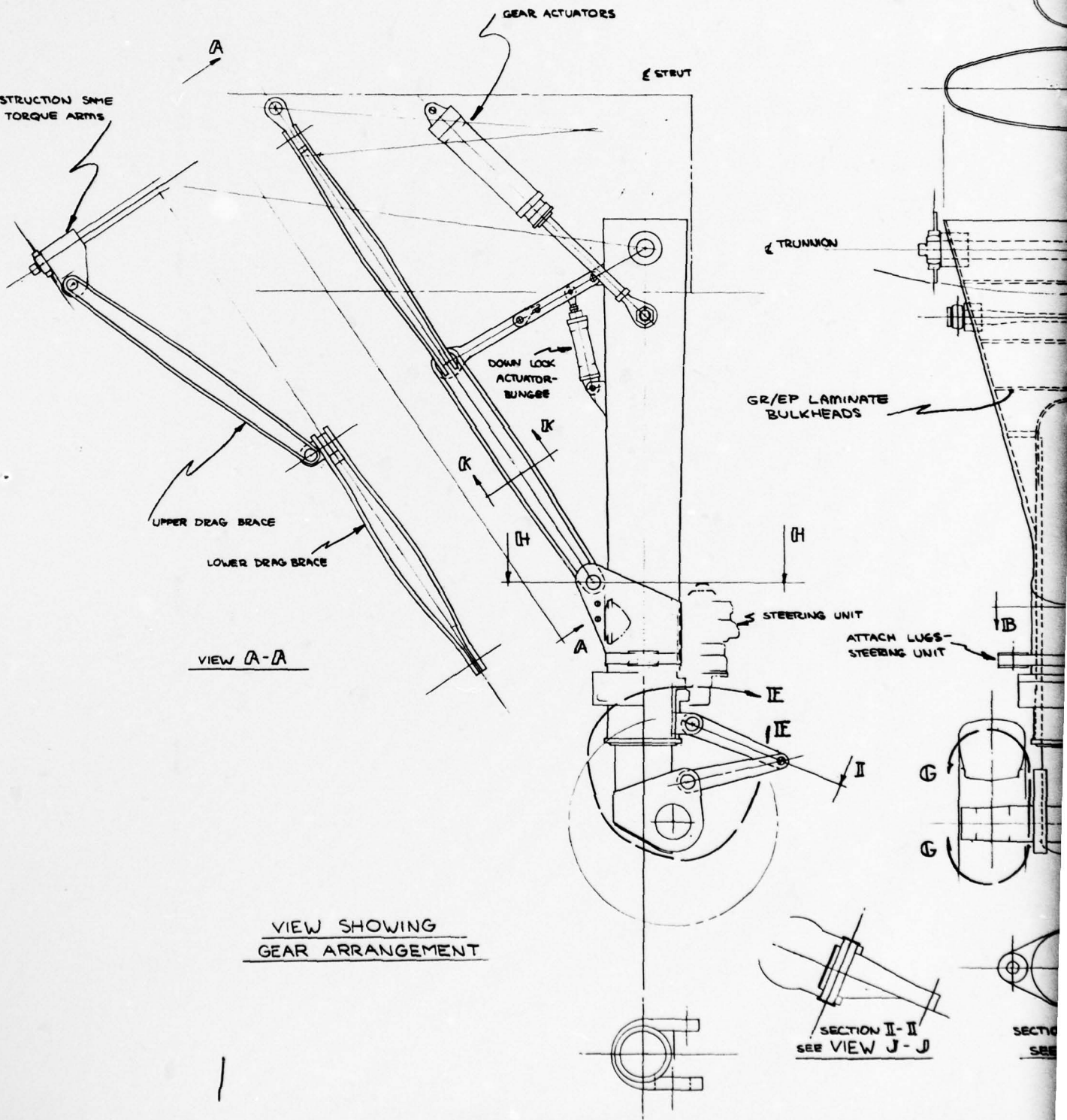
4.4.1 Concept 3 - Study A

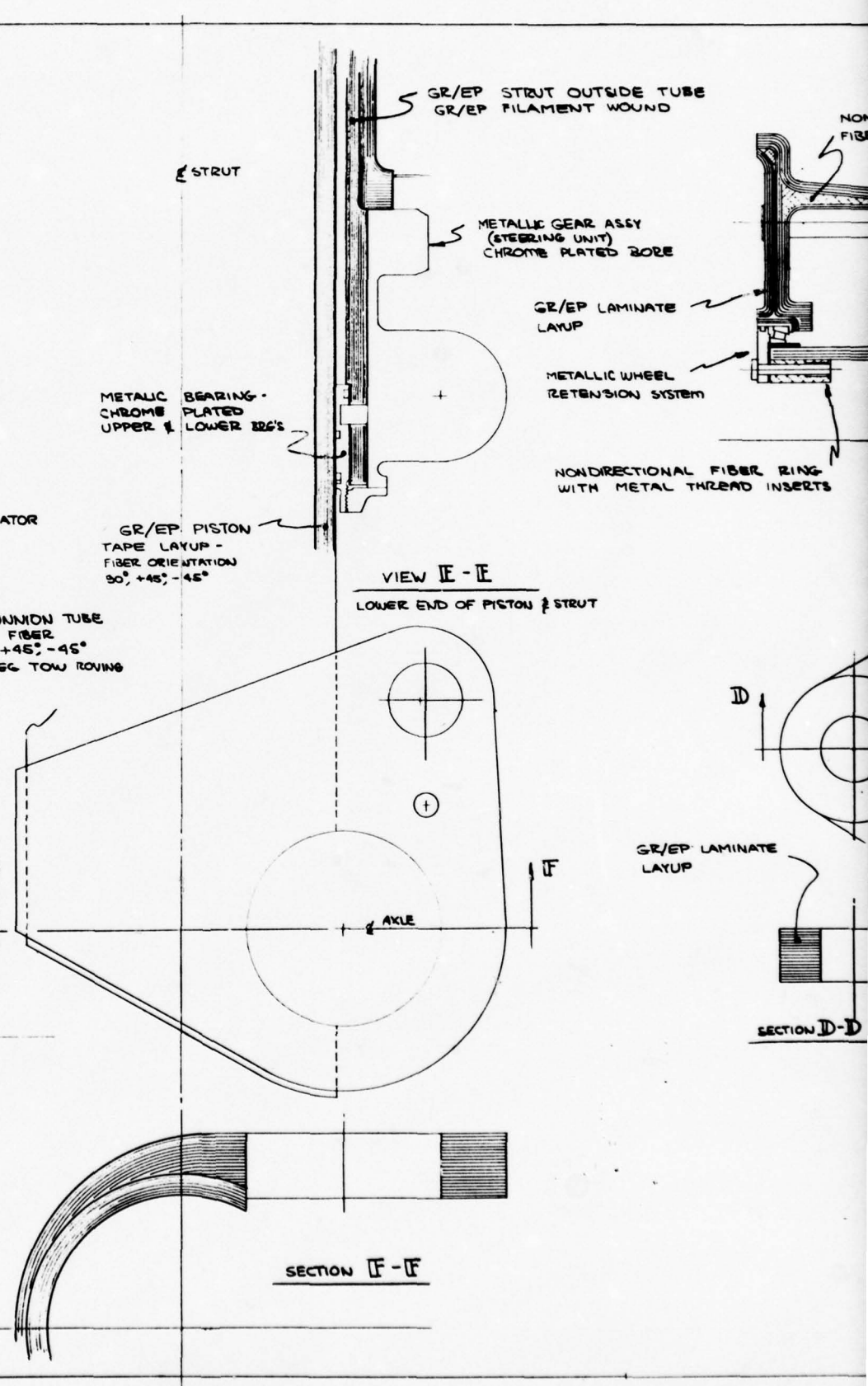
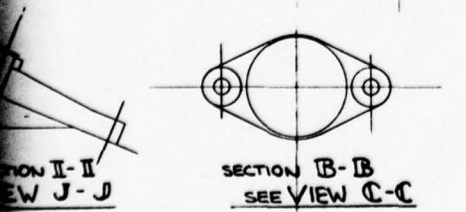
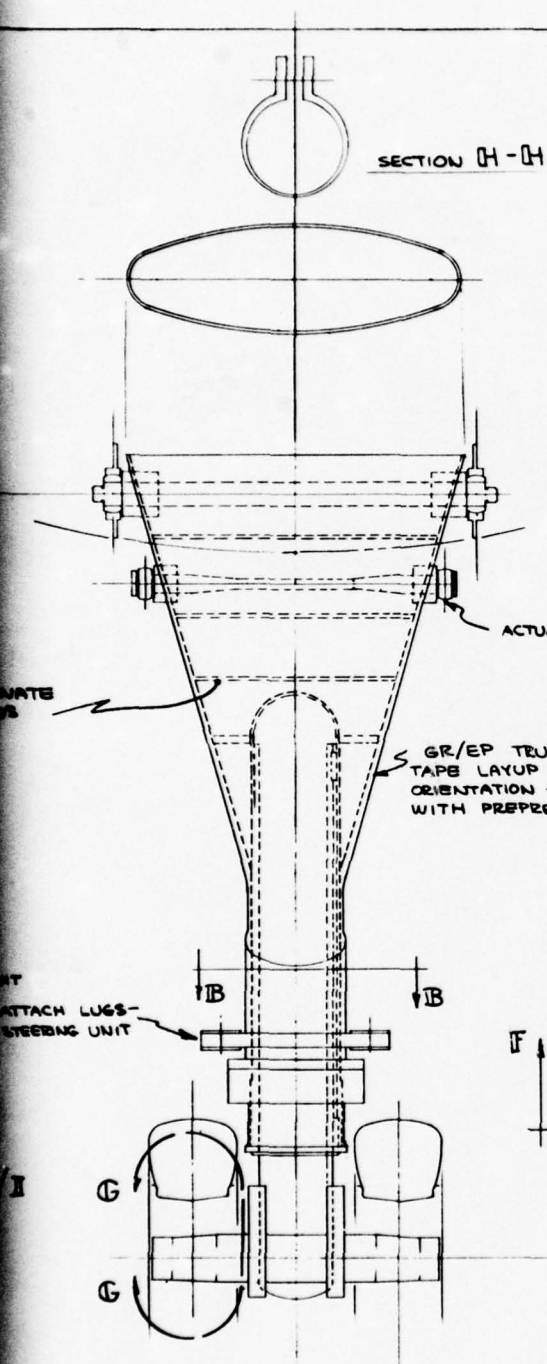
Kinematics of this nose gear varies from the baseline only slightly in that the gear retract cylinder is relocated and pulls the gear up rather than pushing on the strut bell crank to retract it, see figure 36. The trunnion locations for both the strut and the upper drag braces have been retained. The wheel well volume has been increased due to the necessity of moving the side walls apart to accommodate the wider wheel spacing. The less than 2-inch widening of the wheel well does not require relocation of any major equipment.

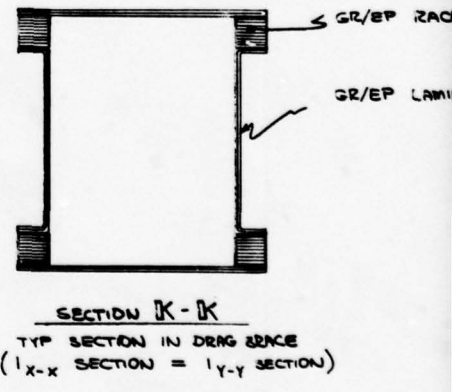
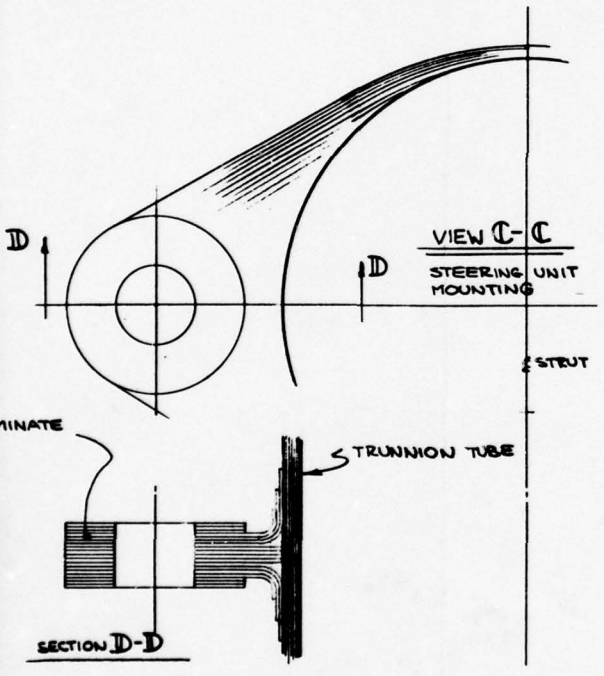
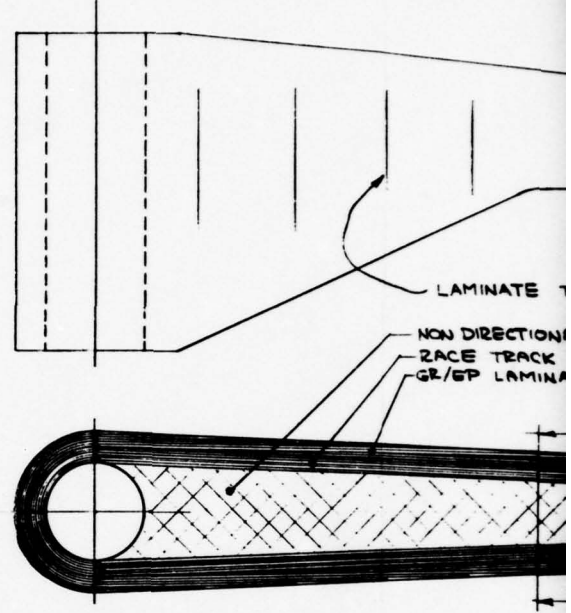
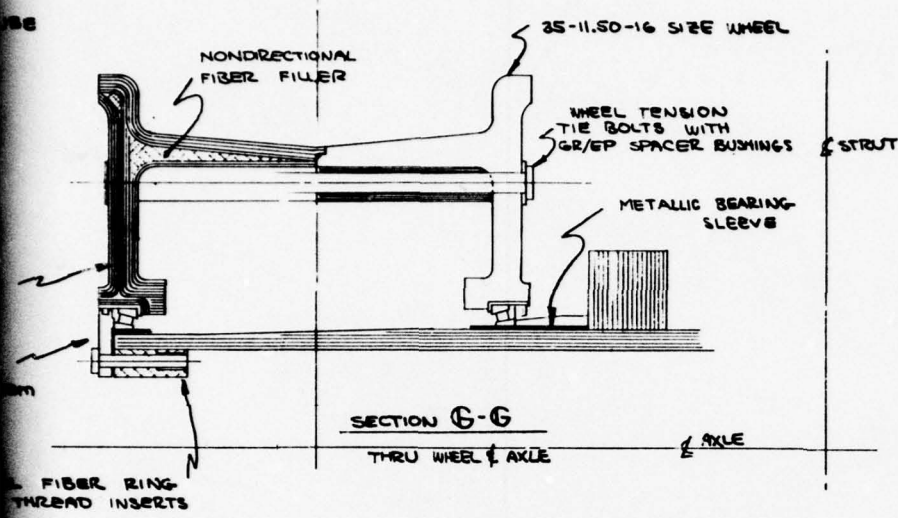
The piston has been designed using composite material, and the diameter enlarged over the baseline to accommodate the high loads using composite allowables. This forced the wheels apart and required moving the side walls of the wheel well. The piston is a graphite/epoxy layup using $\pm 45^\circ$ and 90° oriented fibers. Bonded to the lower end of the cylindrical piston is a laminated composite fitting which provides for axle and torque link attachments. The piston moves up and down on chrome plated steel bearings which are fastened to the composite cylinder. The wear characteristics of this combination of materials has proven satisfactory (see reference 8) for the expected life cycles required for this application.

The inside cylinder of the strut is a graphite epoxy filament wound tube with a hemispherical top. This is the pressurized component of the strut. The internal hydraulic-pneumatic load absorption system is similar to the baseline except for the larger diameter of the cylinder. The chrome plated steel bearings are bonded and pinned to the composite cylinder. The lower bearing ring is threaded to provide for an end ring which retains the metallic gear assembly of the steering unit. This steering system is similar to the baseline, but the diameter is larger to accommodate the composite cylinder.

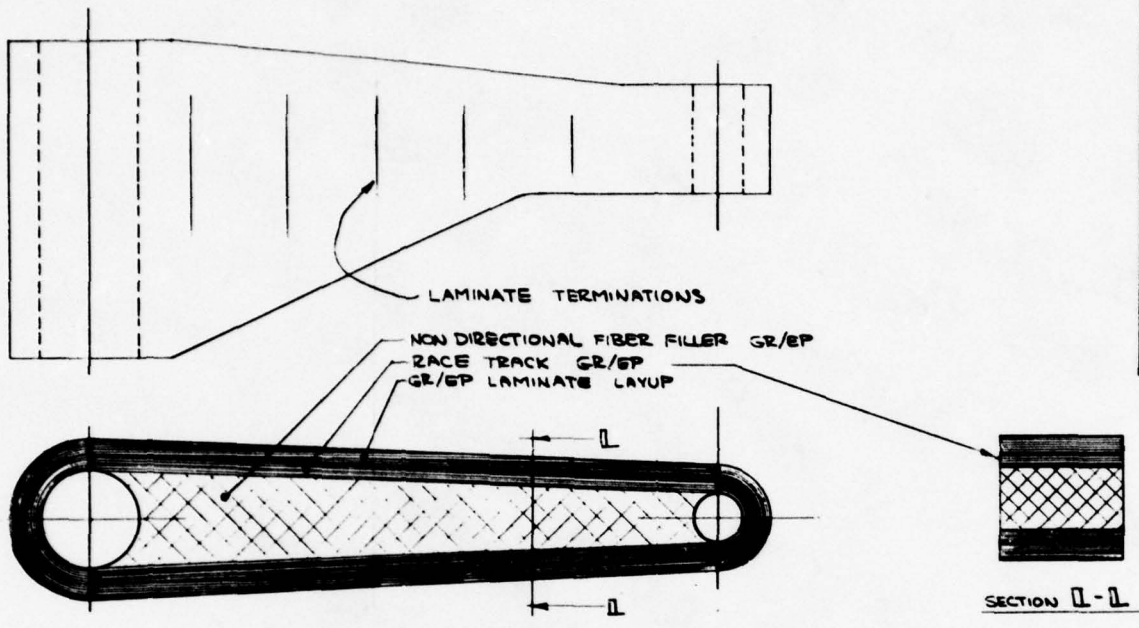
CONSTRUCTION SAME AS TORQUE ARMS



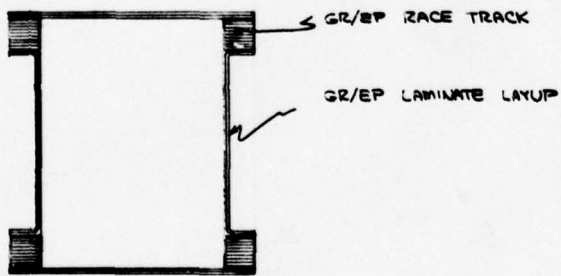




3



VIEW J-J
TORQUE ARM



SECTION K-K
TIP SECTION IN DRAG BRACE
(1x-x SECTION = 1y-y SECTION)

Figure 36.

SCALE: 1/10 ±	DR. ATKINS DATE JULY 3/76 MODEL B-1	Los Angeles Aircraft Division Rockwell International INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 90045	ADVANCED DESIGN
STUDY-COMPOSITE NOSE GEAR COMPONENTS PHASE I, CONCEPT 3-A			D516-1-409

4

The upper strut section is a flattened cone shape and is similar to Concept 2 except that the gear retract bell cranks have been eliminated and the actuator mounts directly to the strut body. Both the actuator and the main strut mounts are composite bushings, bonded to the strut. Through shafts connect the bushings to assure that no moment loads are imposed on the bushings. The drag strut and steering system lugs are laminated composite and are bonded to the strut. The clamp type drag brace lugs are bolted to assure that the bond to the strut is not subjected to peel loads.

The drag braces are "race track" wound caps with laminated webs similar to the Concept 2 braces except that the pins and end fittings are designed so that the axis of rotation is always normal to the drag brace webs so that the loads are always axial.

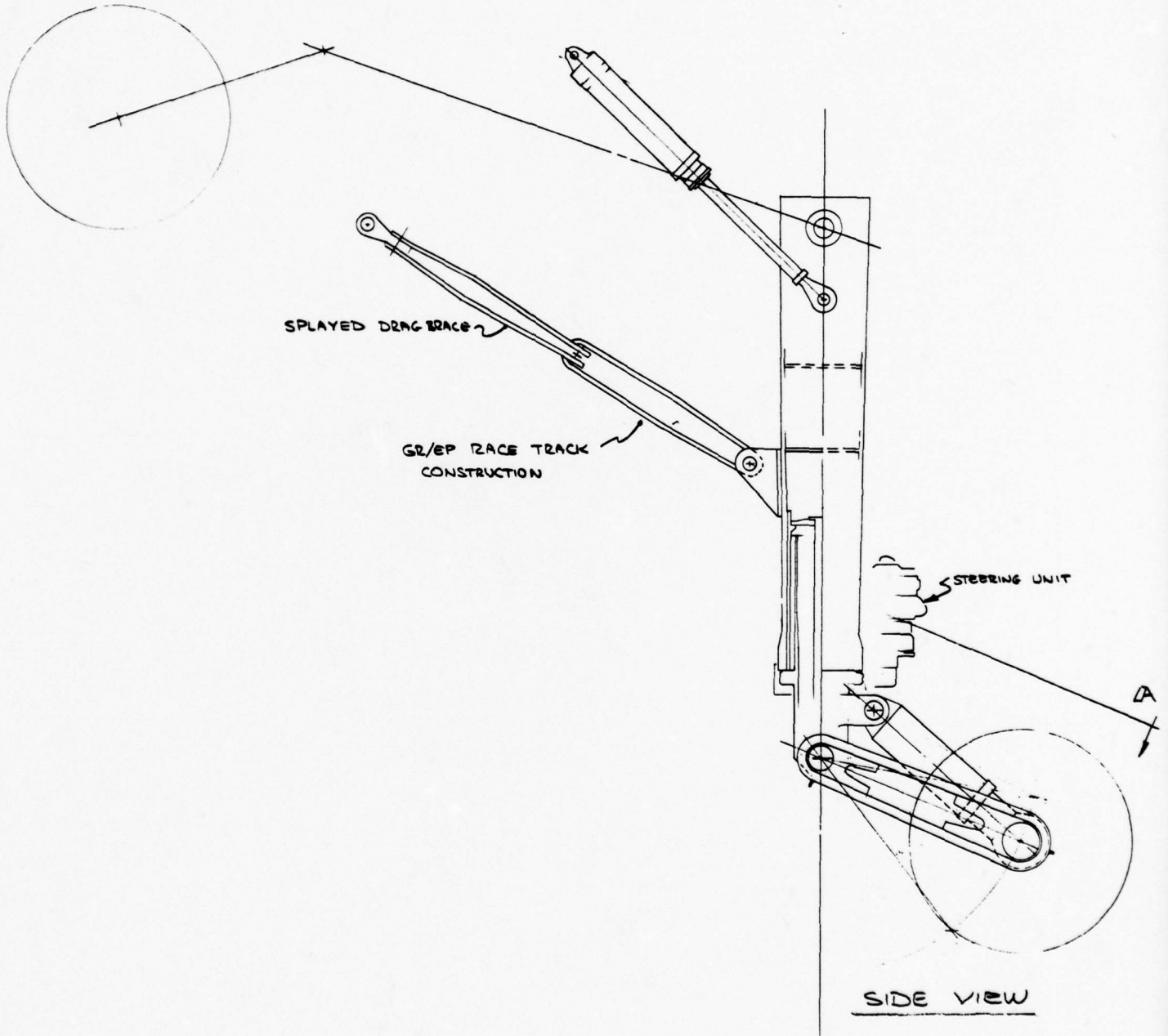
Torque links are similar in construction to the Concept 2 design except that the mounting lugs have been widened so that the base can be solid and act as a shear lug without the need to machine the base.

The wheel concept shown is similar to Concept 2 except that a machined fiber cylinder is used as a base filler in the rim section and composite spacer bushings are provided for the tension bolts joining the wheel halves.

4.4.2 Concept 3 - Study B

The nose gear arrangement for this study is a departure from the baseline but still a conventional gear. It is a trailing arm concept with a vertical pivot for full circle steering capability, see figure 37. The steering unit can be similar to the baseline. The strut trunnion location has been retained, but the drag brace upper trunnions have been moved. The volume of the wheel well has been changed to accommodate this concept. The upper surface was raised and the side walls moved apart to provide clearance for the wheels. This change would require moving equipment as well as structure.

The drag braces and down locks are similar to that shown on Concept 3, Study A. The upper strut area is also similar except that the strut mounting and gear retract cylinder attach bushings are bonded to the outside wall of the strut and to an internal vertical web instead of having a through shaft as on Concept 3, Study A. The strut cylinder is not the shock absorbing system in this concept, but it does have provisions for the rotating stem of the vertical pivot. A composite sleeve is bonded to the inside of the strut and acts as the rubbing surface for the chrome plated steel stem.



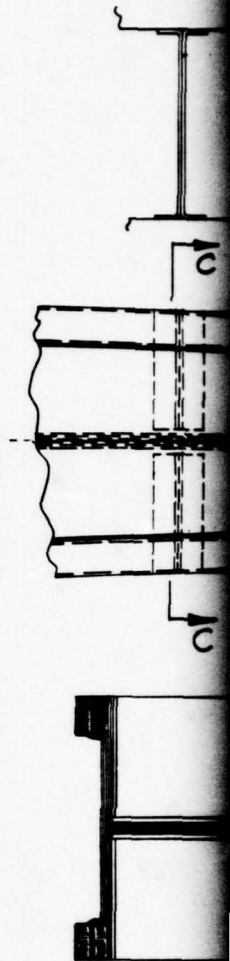
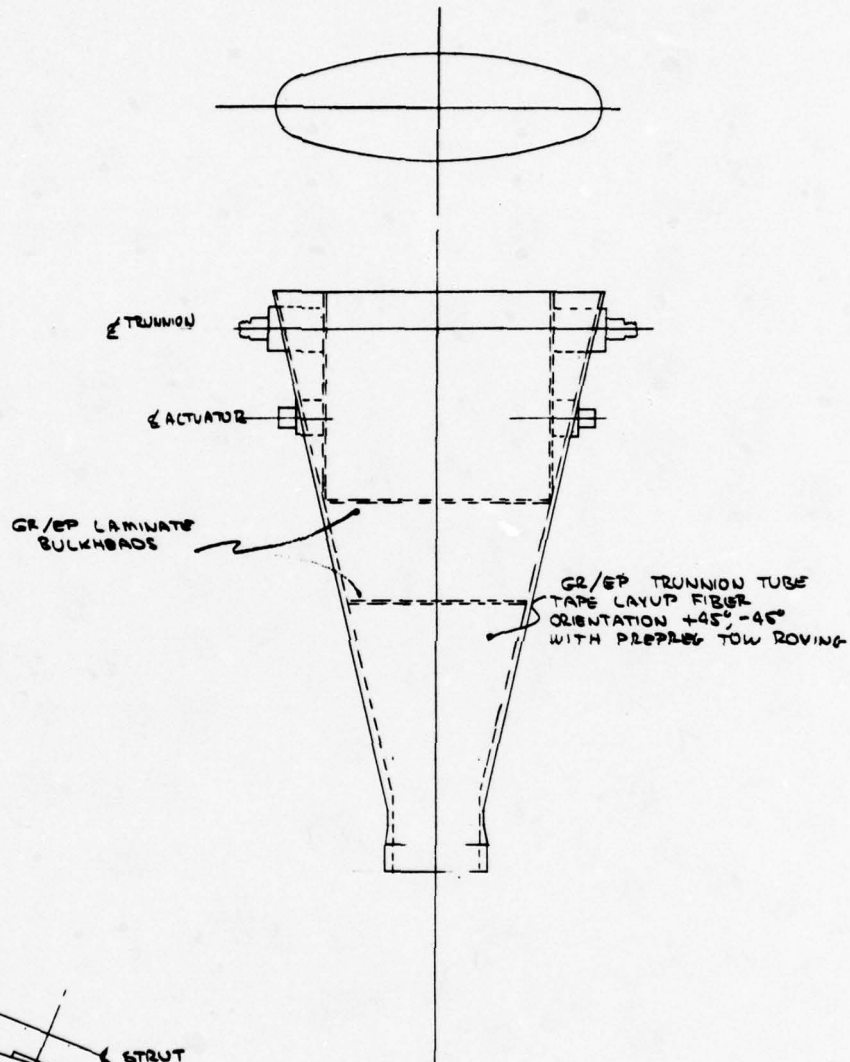
SPLAYED DRAG BRACE

GR/EP RACE TRACK
CONSTRUCTION

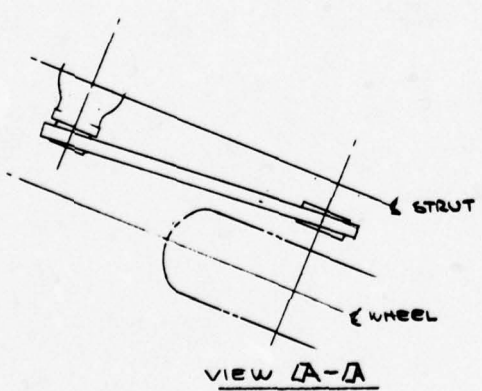
STEERING UNIT

SIDE VIEW

1



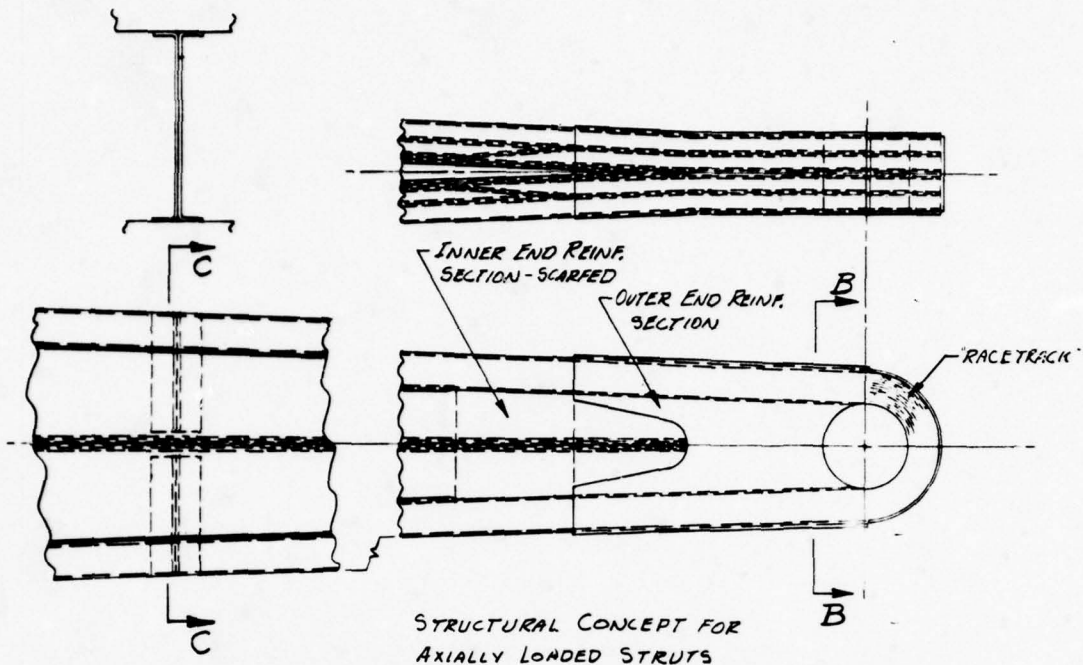
SECTION
MID STRUT &
CAPS SPREAD
& EQUALLY SPACED



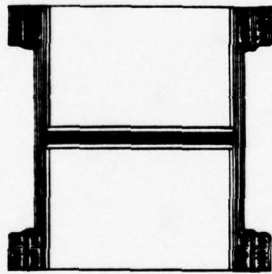
VIEW A-A

CONCEPT III C

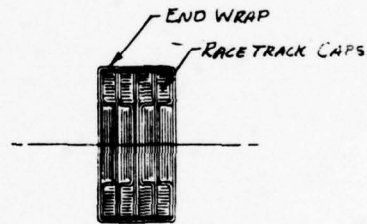
2



TRUNNION TUBE
WUP FIBER
ON +45° -45°
WUP TOW ROVING



SECTION C-C
MID STRUT SECTION WITH
CAPS SPREAD TO GIVE $I_{x-x} = I_{y-y}$
& EQUALLY SPACED STIFFENING CLIPS



SECTION B-B
END SECTION WITH SEGMENTED
"RACETRACK" CAPS & LAMINATED
REINFORCEMENT.

Figure 37.

SCALE: $\frac{1}{10} \& \frac{1}{2}$	DR. F. ATKINS DATE AUG. 1 '76 WOOD	Los Angeles Airport Division Rockwell International INTERNATIONAL AIRPORT - LOS ANGELES, CALIFORNIA 90097	ADVANCED DESIGN
STUDY - COMPOSITE NOSE GEAR COMPONENTS PHASE I CONCEPT 3-B			DG151-410

The steel stem is integral with the gear for the steering system. The upper portion of the stem has two bearing areas which are chrome plated and bear against the composite sleeve. The lower end provides for the shock absorbing cylinder attach lugs and the pins for the trailing arm member.

The trailing arm member is a "U" shaped part with "race track" wound side wall beams and a bonded laminated bottom web. The beams are designed to react the axial loads and the bottom web, the shear load due to steering torque.

The structural concept for axially loaded struts is designed to use multiple narrow "race track" caps which are bonded to the webs by wrapping the webs around the caps. This provides a better tie between them by increasing the bond area and force them to work together and reduce the potential for cracking at the interface.

A one-fifth scale model of Concept 3-A will be built during the Phase II effort. The model and display case will be similar to that described for the Concept 2 model, see figure 34.

SECTION V

METHODOLOGY

This section describes the methodology which will be used to provide the data necessary to assess and illustrate the payoffs from the use of composite material for landing gear hardware. These data will be used to generate plots showing potential initial cost savings, life-cycle cost savings, and total weight reduction versus percent by weight of composite material in the landing gear.

5.1 DESIGN

The design concepts selected in Phase I for further study will be analyzed to see how improvements can be made to optimize the use of composites to produce a more efficient design. Inputs from the materials, structures, producibility and reliability sections will be used to modify the design concept. A preliminary design drawing will then be made. It will show critical dimensions, material identification, layup orientation, gages, and type of construction.

The drawing will then be routed to these same sections for checking to see whether further improvements can be made to the part. After incorporating the changes, if any, the preliminary design drawing will be sent to the reliability, logistics, cost and weight groups for analysis. See figure 38.

5.2 MATERIALS

During Phase II the designs will be evaluated to assure that the resin and fiber system is optimum and that fabrication processes planned for the part will produce a viable composite part. Conferences will be held with design and fabrication personnel to determine if design changes can be made to improve producibility and whether feasible manufacturing techniques can be developed to produce more efficient structural parts.

5.3 STRUCTURAL ANALYSIS

During the Phase II effort a structural analysis of the preliminary designs will be made to assure that sizing of the parts is realistic and that weights can be calculated with the required degree of accuracy. The gear components can be considered generally as elements subjected basically to axial tension compression and/or beam bending loads.

The material strength allowable and elastic properties will be generated using the AC-50/AC-50A programs described on page 77. The local strength

PHASE I

PHASE II

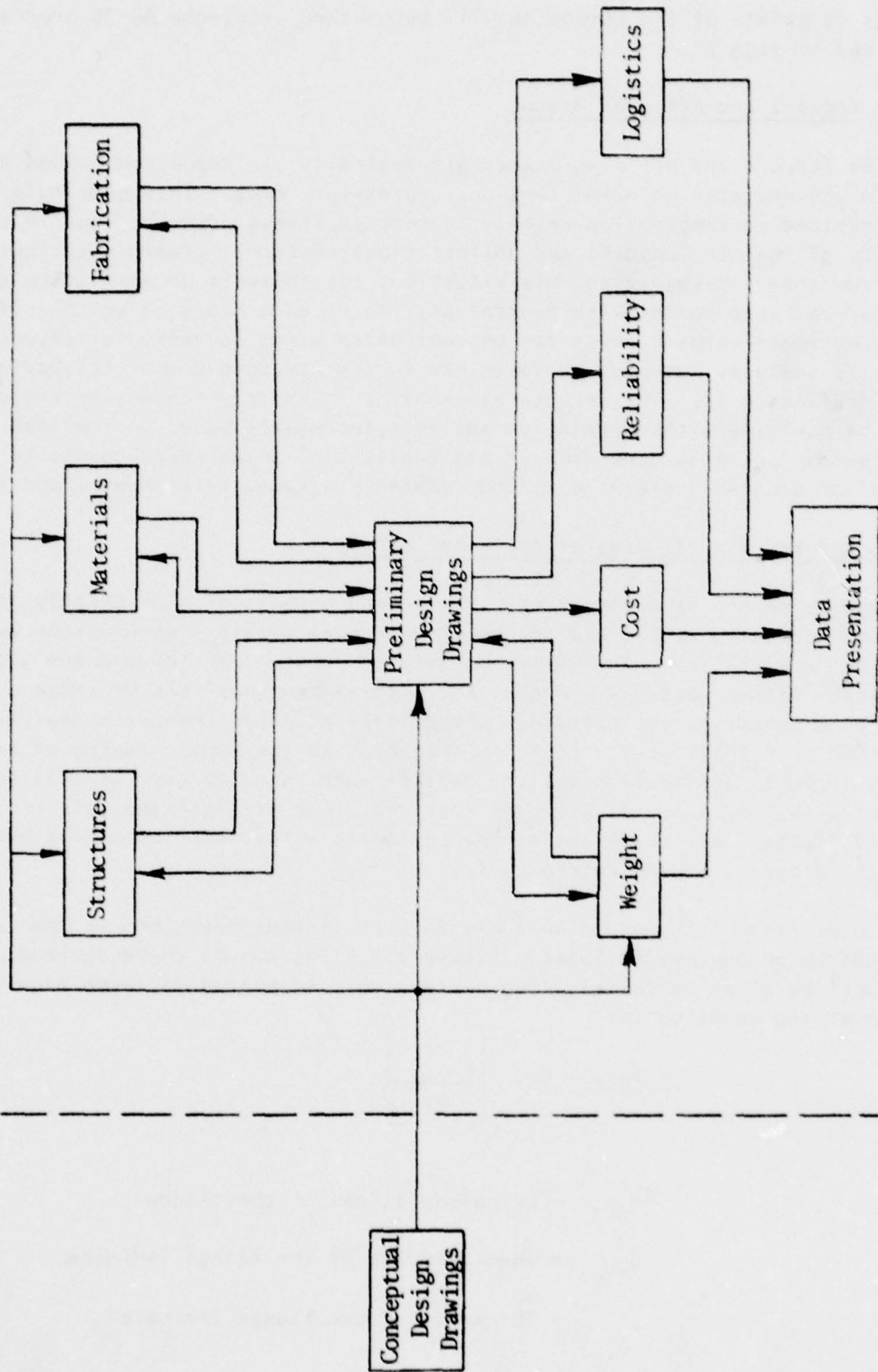


Figure 38 Phase II Flow Chart

margins of safety of the composite will be checked using the AC-3R program described on page 77.

5.3.1 Forward and Aft Drag Braces

The forward and aft drag braces are basically pin supported columns subject to concentrated uniaxial tension compression loads. This particular geometry-loading combination results in complex stress distributions in the vicinity of the pin supports and uniform cross-sectional strain distribution away from them. Recognizing this situation, the analysis of each brace can be separated into parts. The central portion of each brace in which uniform cross-sectional strains exist can be considered using conventional advanced composite analysis methods, as described in the Advanced Composites Design Guide (reference 1). The structural behavior in the pin connection regions would be analyzed with correlative analysis techniques based on the load distribution patterns generated in the analysis of an advanced composite wing pivot program (reference 2) and related programs, references 3 and 4.

5.3.2 Forward and Aft Drag Brace Center Sections

Due to de St. Venant's principle, the end effects of a uniaxially loaded long column are localized and the cross-sectional strain distributions away from them are uniform. The latter behavior exists in the forward and aft drag brace center sections. Hence, a finite-element analysis of these regions is unnecessary. Existing conventional advanced composite analysis tools can be readily used. To fully characterize the center region of each brace, strength and local stability of their webs and flanges, as well as a general stability analysis would be required. The strength analysis of the web and flange laminate layups can be performed with the point stress analysis computer program, AC-3R (reference 1).

Local instability would be analyzed with methods described in the Advanced Composite Design Guide. Flange crippling can be characterized as the buckling of an infinitely long plate simply supported on three edges. Its governing equation is:

$$F_{CCR} = G_{XY} \left[\frac{t_f}{b_f} \right]^2$$

where

F_{CCR} = Crippling stress of the flange

G_{XY} = Shear modulus of the flange laminate

t_f = Thickness of the flange laminate

b_f = Width of the flange

Local buckling of the brace web can be idealized as the buckling of an infinitely long panel simply supported on all four edges whose failure equation is:

$$N_{X,CR} = \frac{2\pi^2}{b_w^2} \left[\sqrt{D_{11}D_{22}} + D_{12} + 2D_{66} \right]$$

where

$N_{X,CR}$ = Buckling load per unit length of web

b_w = Width of web

D_{ij} = Flexural rigidities of the web laminate

General stability of each brace can be considered using the equation

$$P_{CR} = K\pi^2 \frac{\bar{E}_x I}{L^2}$$

where

P_{CR} = Brace buckling load

\bar{E}_x = Equivalent axial modulus

I = Moment of inertia of the brace cross - section

L = Distance between pin supports

K = End restraint coefficient

Buckling behavior in the two planes of symmetry of each brace must be considered.

Redesign of the brace center region cross - section would be performed if any of these analyses indicated unacceptable structural behavior in that member.

5.3.3 Pin Connection Regions

The complex nature of the stress distribution, caused by the concentrated applied loads in the vicinity of the pinned ends of each brace, necessitates a local analysis of typical ends to ensure the adequacy of their design. Provided that the geometry and applied loading of each pin end are similar to the concept considered in the AFFDL technical report, "Preliminary Design and Analysis of an Advanced Composite Wing Pivot Structure" (reference 2), a correlation may be drawn as to the load introduction patterns and resulting stress distributions from the results of this program. However, the accuracy of this analysis/internal loads generation shall only be as efficient as the initial assumptions made in comparing the separate design concepts. To initially size the developed design concepts, an iteration of a point stress analysis computer program, AC-3R, will be required to check the developed margins-of-safety.

5.3.4 Upper and Lower Downlock Arms

The upper (aft) and lower (forward) downlock arms are tension-compression axially loaded members with transverse loads introduced by the downlock actuator on the upper (aft) arm at one end and the off-center reaction loads at the juncture of the upper and lower arms. This results in combined axial and bending loaded members (beam-column) which will be analyzed using procedures previously described for the drag brace components and from references 1 and 5.

5.3.5 Tubular Strut Assembly

The primary loading conditions are those of (tension/compression) fatigue and beam column bending. The fixity of this element allows the use of conventional advanced composite analysis methods (reference 1) for tubular shells. These methods are based primarily on orthotropic shell theory and employ little or no computer analysis. However, once material allowables have been generated and a preliminary sizing developed for known loads, the point stress analysis program, AC-3R (reference 1) will be implemented to develop appropriate margins of safety and thus determine the necessity of design iterations.

5.3.6 A-Frame Truss Assembly (Trunnion)

The A-frame truss structure (trunnion), which supports the tubular strut assembly, may be idealized as pinned at the upper fuselage pivot attachments and statically determined. This simplification lends itself to the use of conventional advanced composites analysis methods (reference 1) for beam

column theory. In this manner, tension, compression and beam bending, as well as local instability and fatigue loads, may be resolved without the use of computer programs. However, the pinned end of the structure may be subject to complex loads distributions due to the induced combined loading conditions and complex part geometry. Therefore, the lug attachments of the truss assembly will be analyzed similar to the pin connection regions of the drag braces previously described.

5.3.7 Torque Arm Link

The torque arm links, transmit the turning loads from the wheel-lower-piston assembly to the tubular strut assembly. The upper and lower arms are linked to allow extension or retraction of the piston assembly into the strut assembly.

The torque arms can be considered a cantilever beam type structure loaded at one end and reacted by shear and couple loads at the opposite end. The reacting couple loads are perpendicular to the applied end load direction.

Tension, compression, and shear loads can be developed based on a strength of materials approach with sufficient accuracy to determine preliminary structural sizing. The point stress analysis program, AC-3R (reference 1) will be used when material orientation, and known internal loads are established. This will develop the combined loads margins of safety and thus determine the necessity for any further design modifications.

5.3.8 Wheel Analysis

The analysis of the wheel will be performed using a strength of materials approach. The geometrical constraint of form fit and function necessitates a wheel geometry very similar to the metal baseline, but with the avoidance of sharp corners and the use of increased wall thicknesses to reduce shear stress levels and tapered thicknesses to provide smooth load transitions. Methods provided in references 1, 5, and 6 will be used.

5.3.9 Axle-Piston

The axle-piston components will be preliminary analyzed using the strength of materials approach. Where composite materials are used, the methods described for the drag brace will be used.

5.3.10 Spreader Bar

The spreader bar transmits the two forward drag brace loads into the drag brace support points in the fuselage through localized bending. Also,

the spreader bar ties both the left and right hand forward drag braces together as a truss unit. A strength of materials approach will be used to determine preliminary structural sizing. Where composite materials are used, the methods described for the drag brace will be used.

5.3.11 AC-50/AC-50A Design Strength and Characterization for Advanced Composites

These two linear analysis computer programs will be used to provide material property input to program AC-3R by calculating initial laminate failure strength, final failure strength and synthetic design allowable strength (for either stress or strain design criteria), elastic properties, and physical constants for cross-ply advanced composite laminates. Program AC-50 produces carpet plots in numerical and graphical form (see figures 40 and 41) for the $[0/\pm\theta/90]_s$ family of laminates. Program AC-50A calculates these numbers for any layup with up to 10 different orientations and materials.

5.3.12 AC-3R Margin-of-Safety Calculations

This program calculates; (1) the laminate flexural and extensional constants when treated as a set of laminae (A_{ij} , B_{ij} , and D_{ij}) or as an orthotropic homogeneous material (E_x , E_y , G_{xy} , ν_{xy} and ν_{yx}); and (2) the stresses, strains, and margins of safety for prescribed layers, given the external loads. The prescribable external loads are the inplane (N_x , N_y , and N_{xy}), rotational (M_x , M_y , and M_{xy}), and transverse (Q_x , Q_y) stress resultants at a point (figure 39) as well as the temperature differential (ΔT) within each layer. The transverse shear stresses, S_{xy} and S_{yz} , are only computed when the laminate is prescribed to be symmetric.

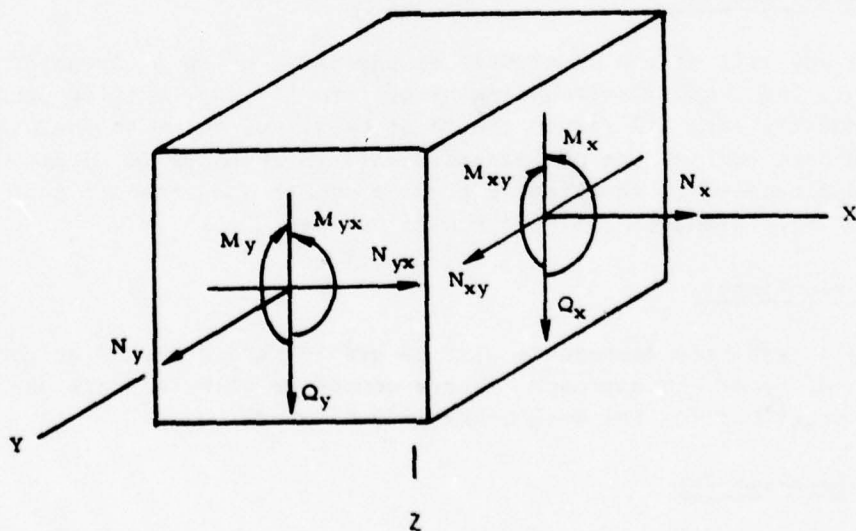


Figure 39. Structural Element Applicable External Loads

AC-50 MATERIAL PROPERTY GENERATION

MATERIAL IS B/EP AT R.T.
EX

	VERTICAL AXIS IS PERCENTAGE OF		HORIZONTAL AXIS IS PERCENTAGE OF		BALANCE IS	
	0.0 DEGREE PLYS		50.0 DEGREE PLYS		90.0 DEGREE PLYS	
100 *	30000.					
90 *	27319.					
80 *	24598.	24449.				
70 *	21867.	21862.	21663.			
60 *	19132.	19200.	19105.	18876.		
50 *	16395.	16477.	16507.	16339.	16088.	
40 *	13657.	13749.	13798.	13723.	13567.	13298.
30 *	10919.	11017.	11080.	11067.	10969.	10791.
20 *	8179.	8283.	8356.	8387.	8329.	8209.
						7719.
10 *	5440.	5549.	5629.	5692.	5663.	5584.
						5444.
						5231.
0 *	2700.	2812.	2899.	2959.	2980.	2931.
						7832.
						2675.
						2448.
						2138.
*	0	10	20	30	40	50
						60
						70
						80
						90
						100

Figure 40. Typical Material Property Data Output

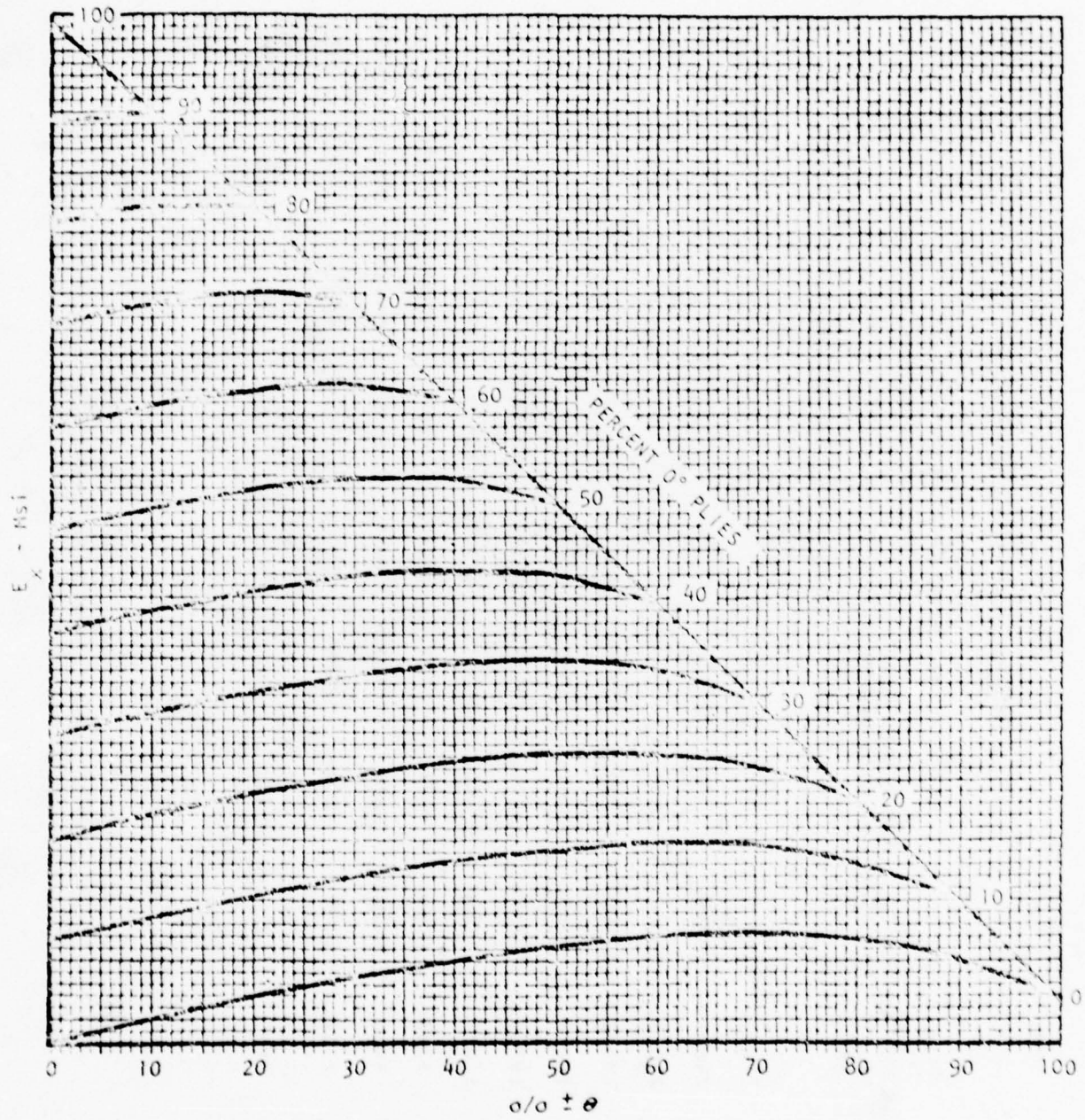


Figure 41. Typical AC-50 Material Property Carpet Plot

Lamination theory is used in the calculations. Two types of margin of safety may be computed:

1. The strength criteria (where R = stress resultant)

$$R_L \leq 1 \quad (\text{fiber})$$

$$R_T^2 + R_{LT}^2 \leq 1 \quad (\text{matrix})$$

$$R_L = \frac{F_L}{F_L}$$

$$R_{LT} = \frac{F_{LT}}{F_{LT}}$$

2. The strain criteria

$$R_{LT} \leq 1$$

$$R_T \leq 1$$

$$R_{LT} \leq 1$$

$$R_i = \frac{\epsilon_i}{\epsilon_i (\text{allowable})}$$

The margin of safety is defined as the amount that all the stress resultants R must be increased in order that the laminate reach the incipient failure condition (i.e., the equality holds).

As can be seen in figure 42, either stress or strain (fiber or matrix) failure conditions may be easily recognized and the need for design/sizing iterations assessed. The problem illustrated is for an AVCO 5505 $[0/+45/90]_S$ cross-plyed boron/epoxy laminate at room temperature, under combined loading conditions ($N_x = 2000$ lb/in., $N_y = 1000$ lb/in., and $N_{xy} = 500$ lb/in.). It can be readily seen that the lowest margin of safety generated is 3 percent and matrix (strain is critical.)

5.4 MASS PROPERTIES

Preliminary design drawings generated during the Phase II effort will be used to develop the required mass properties. Weight and center of

gravity data will be calculated from these drawings. The nose gear component weights will also be broken down by material types to develop a material breakdown for support of the cost model. The weight data will involve the basic weight parameters of volume displacement and material density.

The weight data necessary for the plots will be obtained by using the baseline weights of the B-1 metallic components and calculated composite hardware weights. The difference will give the total weight reduction. The estimated weight reduction will be calculated using the weight of the structural moving hardware components; forward and aft drag braces, forward and aft down lock links, torque links strut, piston axle and wheel. In addition, certain other items will change in Concept 3 and therefore must be included in the total weight. They are; new actuators, steering system and nitrogen and oil charges.

5.5 FABRICATION

During the Phase II effort, manufacturing specialists will make a tooling and fabrication study, in depth, of the concepts selected during Phase I for preliminary design. Studies will include: simplification of parts for lower cost fabrication, alternate tooling concepts for lower cost and conceptual manufacturing technology development for better producibility.

Conferences will be held during the preliminary design stage with all disciplines involved to assure that as the design progresses, producibility will receive necessary consideration. All preliminary design drawings will be checked prior to release.

A complete tooling and fabrication plan will be developed for each design. It will specify what tooling is required for each fabrication step, and what manufacturing processes will be used to make each part. Estimated hours for both tooling and fabrication will be provided for cost estimates of the parts.

5.6 COST

The Phase II preliminary designs of composite parts and the baseline metal parts will be subjected to a detailed cost analysis. Hardware cost data for the concepts selected for Phase II will be "grass roots" estimates by manufacturing experts. These estimates will be compared to standards which are being established for the B-1 program. Variance between estimates and standards will be reconciled. The standards are being developed from the test specimens and production hardware currently under contract (vertical stabilizer, weapons bay doors, stub box, etc.). Information from the composite material suppliers and the manufacturers of composite structures is

being evaluated to supplement our data. Our current composite programs are being continuously scrutinized for the purpose of developing learning curve trends for production quantities. Composite material estimates will be based on projections provided by the suppliers. Those items not selected to utilize composite materials will be evaluated on current cost or estimated based on corporate standards and projected for production quantities. The cost data for each of the composite parts and for the comparison baseline metal parts will be presented on forms similar to figures 43 and 44 and will be compared against quantity using curves similar to figure 45.

5.7 RELIABILITY

The hardware reliability analysis will utilize a serial computer math model. Table XIII presents an example of the format and output data of the hardware reliability analysis.

Explanation of Output Data:

WUC Number - Work Unit Code Number

MEL Number - B-1 Master Equipment List Number

Nomenclature - Description of Component(s) Represented by
WUC/MEL Number

MTBCMA - Mean Time Between Corrective Maintenance Action

$$\text{MTBCMA} = 1.0 / \text{Hardware Rate (Hour Rate)}$$

$$\text{Hdwr. Rate} = \text{Corrective Maintenance Action Rate} \\ (\text{Per } 10^6 \text{ Flight Hours})$$

QPA - Quantity Per Aircraft

UF - Utilization Factor (Multiplying Factor to Account
for Components with Excessive Ground Operating Time)

$$\text{TOTAL MTBCMA} = \frac{1.0}{\text{HDWR RATE} \times \text{QPA} \times \text{UF}}$$

Percent Contrib. - Percent Contribution of the Individual WUC
(Component) to the Total Subsystem MTBCMA

Cum Percent - Cumulative Percent Contribution of the WUC's
(Components)

*011166911
120274 0004

CONTRACT	RELEASE	QUANTITY	ANALYST	REQUESTED	DEPT	DATE	MODEL
QUANTITY	QUANTITY	PER SHIP		BY			
PROD.	12.	1.	TIHACEK	L. ASCANI	421	12-3-74	

PART NAME	QUANTITY	UNIT	UNIT	COST PER	COST PER	PERCENT COST
	PER ASSY	COST	WEIGHT	POUND		OF ASSEM.
TI FGD ASSEM	1.	9513.29	81.100	117.30		100.00

MATERIAL COST	=	3293.08	COST PER POUND =	40.61	PER CENT OF TOTAL =	34.62
FABRICATION COST	=	5765.05	COST PER POUND =	71.09	PER CENT OF TOTAL =	60.60
TOOLING COST	=	455.17	COST PER POUND =	5.61	PER CENT OF TOTAL =	4.78
PURCHASED LABOR COST	=		COST PER POUND =		PER CENT OF TOTAL =	
Q AND R A COST	=		COST PER POUND =		PER CENT OF TOTAL =	

TOTAL COST OF ASSEMBLY = \$ 9513.29
TOTAL COST PER POUND OF ASSEMBLY = 117.30

TOTAL WEIGHT OF ASSEMBLY = 81.10

COSTS SHOWN PROVIDE A RELATIVE COMPARISON OF CONCEPTS FOR DESIGN EVALUATION. THESE COSTS DO NOT INCLUDE ALL ELEMENTS REQUIRED FOR PRICING. ESTIMATES FOR FACILITIES, EQUIPMENT, RESEARCH, DEVELOPMENT, TEST, AND ENGINEERING ARE NOT INCLUDED.

Figure 43. Summary of Dash-Numbered Parts in Concept No.1 - TI FGD Concept L3400008

*011165611
120274 0333

CONTRACT QUANTITY	RELEASE QUANTITY	QUANTITY PER SHIP	ANALYST	REQUESTED BY	DEPT	DATE	MOELL
PROD.	12.	1.	TIMACEK	L. ASCANI	421	12-3-74	

PART NAME	QUANTITY PER ASSEMBLY	UNIT COST	UNIT WEIGHT	COST PER POUND	COST PER	PERCENT COST OF ASSEMBLY
GR/EP COMPOS ASSY L340000B	1.	7500.10	39.400	190.36		100.00

MATERIAL COST	= 3299.27	COST PER POUND =	83.74	PER CENT OF TOTAL =	43.93
FABRICATION COST	= 3301.49	COST PER POUND =	83.79	PER CENT OF TOTAL =	44.02
TOOLING COST	= 859.34	COST PER POUND =	22.83	PER CENT OF TOTAL =	11.99
PURCHASED LABOR COST	=	COST PER POUND =		PER CENT OF TOTAL =	
Q AND R A COST	=	COST PER POUND =		PER CENT OF TOTAL =	

TOTAL COST OF ASSEMBLY = \$ 7500.10
 TOTAL COST PER POUND OF ASSEMBLY = 190.36

TOTAL WEIGHT OF ASSEMBLY = 39.40

COSTS SHOWN PROVIDE A RELATIVE COMPARISON OF CONCEPTS FOR DESIGN EVALUATION. THESE COSTS DO NOT INCLUDE ALL ELEMENTS REQUIRED FOR PRICING. ESTIMATES FOR FACILITIES, EQUIPMENT, RESEARCH, DEVELOPMENT, TEST, AND ENGINEERING ARE NOT INCLUDED.

Figure 44. Summary of Dash-Numbered Parts in Concept No. 2 - Gr/Ep COMPOS Concept L340000B

CONTRACT VALUE (\$)

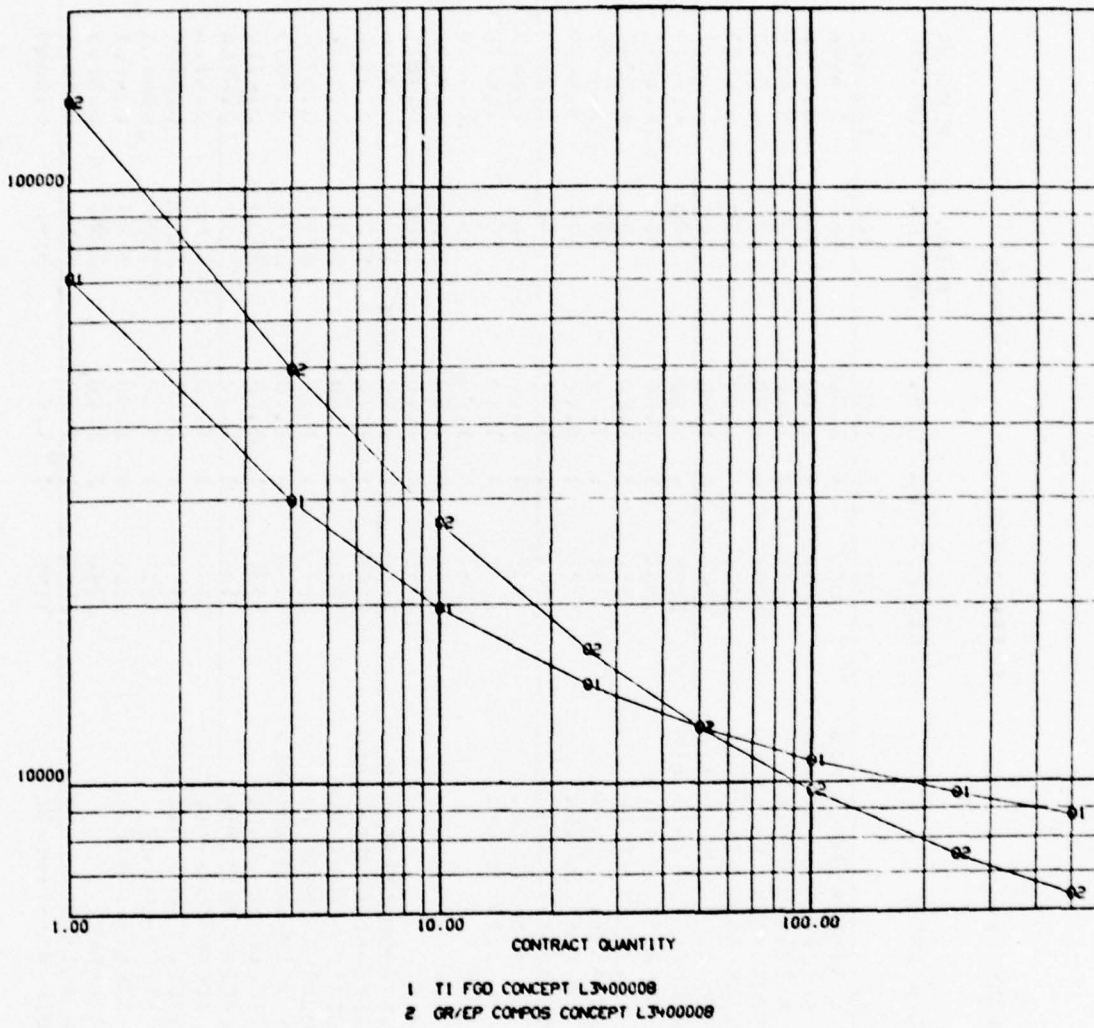


Figure 45. Effect of Quantity on Cost - DC-384
NLG Drag Brace

TABLE XIII

HARDWARE RELIABILITY RANKING

MUC NUMBER	MEL NUMBER	DESCRIPTION	MTRCA	DFA	U.F.	TOTAL MTRCA	PERCENT CONTRIB.	CUM. PERCENT RANK	PAGE
13C1A9B		TIRE, MLG	77C	6	1.00	100	13.0324	13.0324	1
13C1A1		WHEEL & TIRE ASSY-LH MLG	63C	4	1.00	100	8.3346	21.9671	2
13C1A2		WHEEL & TIRE ASSY-RH MLG	63C	4	1.00	100	8.3346	30.3017	3
13C1A		WHEEL ASSY+TIRE-MLG	47C	2	1.00	200	5.6659	35.9676	4
13EAC1		HEAT SINK ASSY+BRK-LH MLG	129C	4	1.00	320	4.0017	39.9693	5
13EAC2		HEAT SINK ASSY+BRK-RH MLG	129C	4	1.00	320	4.0017	44.0311	6
13E1E1		ACTUATOR ASSY+BRK-LH MLG	129C	4	1.00	320	4.0017	48.0328	7
13E1E2		ACTUATOR ASSY+BRK-RH MLG	129C	4	1.00	320	4.0017	52.0345	8
13ACH2	AD1325	PROX. SW ASSY 20 CH.	35C	1	1.00	320	4.0242	56.0187	9
13ACH3	AD1326	PROX. SW ASSY 20 CH.	35C	1	1.00	320	4.0242	60.0429	10
13ACH1	AD1326	PROX. SW ASSY 20 CH.	35C	1	1.00	320	5.7045	65.7474	11
13ACU		PROX. SW ASSY 20 CH.	37C	1	1.00	370	5.2447	67.9921	12
13ACA	AD1325	PROX. SW ASSY 10 CH.	35C	1	1.00	350	2.2663	69.7184	13
13ACC1		PROX. SW ASSY 10 CH.	35C	1	1.00	350	2.2663	71.9847	14
13ACC2		PROX. SW ASSY 10 CH.	35C	1	1.00	350	1.6274	73.6121	15
13C1A4*		WHEEL, MLG	63C	4	1.00	300	1.5226	75.1347	16
13C1A4A		WHEEL, MLG	1375C	3	1.00	1720	0.7613	75.8960	17
13C1A4C		TIRE, MLG	1575C	3	1.00	1720	0.7613	76.6573	18
13E1D1	AD4653	VALVE, HYD=DUAL MTRK-LH MLG	180C	1	1.00	1800	0.2286	77.5169	19
13E1E2	AD4653	VALVE, HYD=DUAL MTRK-RH MLG	180C	1	1.00	1800	0.2286	78.1154	20
13E1U	AD4160	ACCUMULATOR-EMERG MLG	227C	1	1.00	2270	0.2774	78.6928	21
13CEW	AD4139	ACCUMULATOR-EMERG MLG	227C	1	1.00	2270	0.2774	79.2701	22
13C1D		FILTER ASSY-ANTI-SKID, MLG	95C	4	1.00	2330	0.5053	79.7754	23
13E1V	AD4100	GAUGE, ACCUM PRESS, MLG	313C	1	1.00	3130	0.4180	80.2934	24
13CEZ	AD4142	GAUGE, ACCUM PUMP-NLC	313C	1	1.00	3130	0.4180	80.9700	25
13E1N	AD4162	VALVE, ACCUM PUMP-RELIEF	313C	1	1.00	3130	0.4180	81.3880	26
13C1F	AD4141	VALVE, ACCUM PUMP-RELIEF	313C	1	1.00	3130	0.4180	81.8060	27
13CAF	AC4309	SHOCK STRUT-LH MLG	325C	1	1.00	3230	0.4061	82.2121	28
13CAB	AC4309	SHOCK STRUT-RH MLG	325C	1	1.00	3230	0.4061	82.6182	29
13E1H	AD4151	ACTUATOR-NLC	674C	2	1.00	3370	0.3885	82.7067	30
13EAC	AC4105	UPLOCK ASSY-MLG	342C	1	1.00	2520	1.2642	83.9709	31
13EAD	AC4112	UPLOCK ASSY, FWD-NLC	342C	1	1.00	2520	0.3642	84.3351	32

Rank - WUC's (Components) are Ranked by Percent Contribution of the Total Subsystem MTBCMA

The analysis is based on each components hardware failure rate, which is a function of the component's corrective maintenance frequency, the hardware reliability approach was chosen due to the unavailability of historical operational failure data on composite components. On this basis a hardware reliability analysis based on component corrective maintenance frequencies was concluded to be more meaningful at this time.

5.8 MAINTENANCE

The preliminary design drawings will be evaluated in terms of maintenance required during the ten year support time span and the cost of this support will be estimated as an increase or decrease from the baseline costs previously reported.

The change (Δ) in support cost is given by the following equation.

$$\Delta \text{ Support Cost} = \Delta \text{ Spares Cost} = \Delta \text{ AGE Cost} + \Delta \text{ Personnel Cost}$$

- A. Spares = Initial Spares + Recurring Spares + Parts & Kits
- B. AGE = Cost of Special AGE for all Bases
- C. Personnel = Cost of Maintenance Airmen and their Training

A-1. The "Initial Spares" costs equation is given below:

$$\begin{aligned} \text{Initial Spares Costs} &= \text{Maintenance Demand Rate} \\ &\quad \times \text{Quantity/Aircraft} \\ &\quad \times \text{Flight Hours/Month/Wing} \\ &\quad \times \text{Turn-around Time} \\ &\quad \times \text{Number of Wings} \\ &\quad \times \text{Unit Cost of Spare} \end{aligned}$$

The change (Δ) in cost is given below.

$$\Delta \text{ Initial Spares Cost} = \text{Initial Spares Cost (Composite)} \\ - \text{Initial Spares Cost (Baseline Metallic)}$$

A-2. The "Recurring Spares" cost equation is shown below:

$$\begin{aligned} \text{Quantity Recurring Spares} &= \text{Maintenance Demand Rate} \\ &\quad \times \text{Quantity per Aircraft} \\ &\quad \times \text{Total Fleet Flying Hours} \\ &\quad \times \text{Condemnation Factor} \\ \text{Cost Recurring Spares} &= \text{Quantity} \times \text{Unit Cost} \\ \Delta \text{ Recurring Spares Cost} &= \text{Recurring Spares Cost (Composite)} \\ &\quad - \text{Recurring Spares Cost (Baseline)} \end{aligned}$$

A-3. The "Parts/Kits" cost equation is given below:

$$\begin{aligned} \text{Parts/Kits Cost} &= \text{Maintenance Demand Rate} \\ &\quad \times \text{Total Fleet Flying Hours} \\ &\quad \times \text{Repair Factor} \\ &\quad \times \text{Unit Cost} \\ \text{Repair Factor} &= F (\text{Unit Cost \& Historical Repair Data}) \\ \Delta \text{ Parts/Kits Cost} &= \text{Parts/Kits Cost (Composite)} \\ &\quad - \text{Parts/Kits Cost (Baseline)} \end{aligned}$$

B. AGE costs are given by the following equation.

$$\begin{aligned} \Delta \text{ AGE Cost} &= \Delta \text{ Quantity} \\ &\quad \times \text{Number of Wings} \\ &\quad \times \text{Unit Cost} \\ \Delta \text{ Quantity} &= \text{Maintenance Demand Rate} \\ &\quad \times \text{Quantity per Aircraft} \\ &\quad \times \text{Flying Hours/Month/Wing} \\ &\quad \times \Delta \text{ Mean Time to Repair} \\ &\quad \times 1/(\text{Operating Time} \times 0.9) \end{aligned}$$

C. Personnel cost is given by the equation below:

$$\begin{aligned} \Delta \text{ Personnel Cost} &= \Delta \text{ Maintenance Demand Rate} \\ &\quad \times \text{Quantity per Aircraft} \\ &\quad \times \text{Total Fleet Flying Hours} \\ &\quad \times \text{Cost/Productive Manhours} \\ &\quad \times \text{Maintenance Task Time} \end{aligned}$$

Cost per productive manhour includes efficiency, personnel types, and training of maintenance airmen.

5.9 LIFE CYCLE COST

Life cycle cost is the sum of development, production, and support costs. The assumed life cycle cost baseline will be the existing metallic design. This baseline will be compared separately with each of the proposed composite concepts and the cost deltas shown. An attempt will be made to identify all areas of cost impact. Particular attention will be paid to problems that might be encountered in field maintenance: probability of accidental damage, special tool requirements, material and training necessary for composite repair, and repair task time. Special problems that will be addressed include galvanic corrosion and wear of composite bearing surfaces. Such factors will be expressed in terms of a 10-year maintenance cost.

The affect of changes in empty weight on fuel and tanker requirements will also be evaluated. A summary of the life cycle cost evaluation will be made for each of the proposed concepts. This summary will include explanations of the major factors affecting each element of life cycle cost.

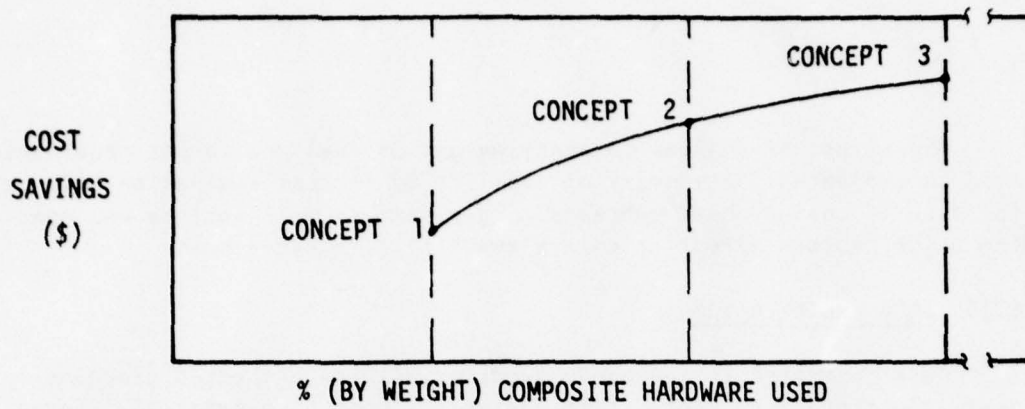
5.10 DATA PRESENTATION

Data generated in the above sections will be presented graphically to best illustrate the payoffs from the use of composite material. Three data plots will be made: initial cost savings; life cycle cost savings; and total weight reduction; all plotted against percent (by weight) of composite hardware used in the nose gear. See example in figure 46.

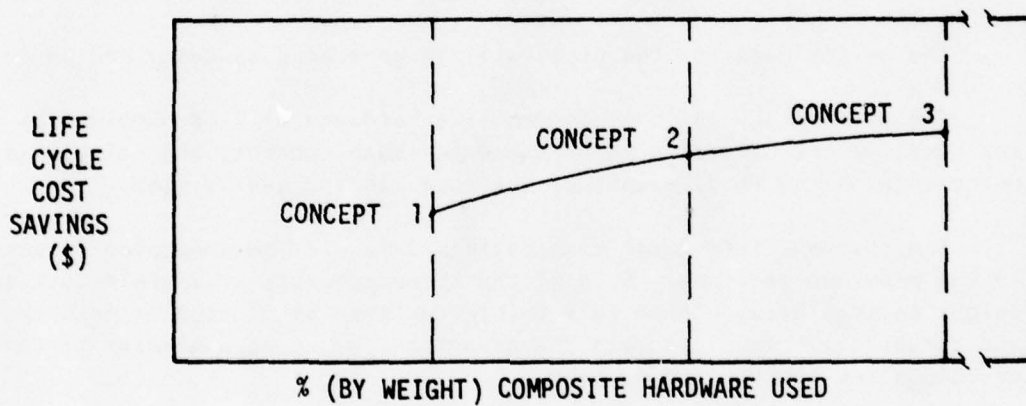
The weight data for the plots will be generated as described on page 80.

The percent (by weight) of composite hardware will be obtained by using the total weight of composite hardware for each concept, and calculating its percentage of the total weight of the nose landing gear system.

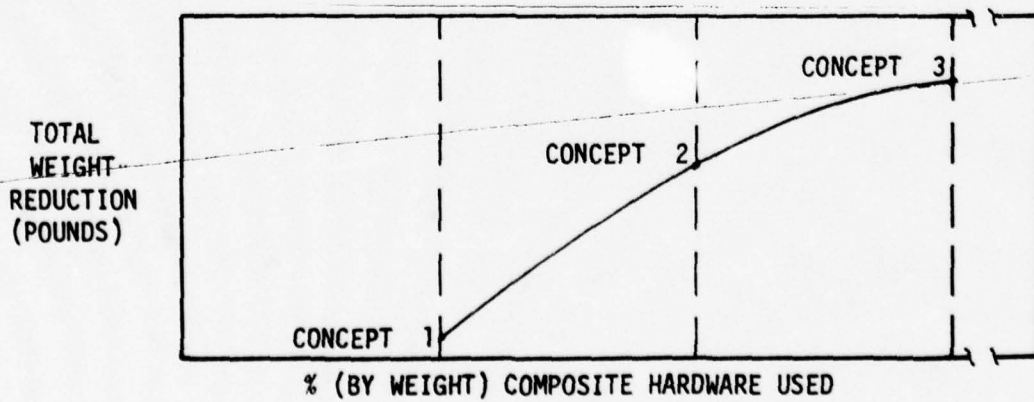
The cost and life cycle cost savings data will be generated as described in the previous sections. Each of the three concepts will yield cost and weight savings data. These data points can then be plotted on each chart and curves drawn to illustrate the advantages of using a greater percentage of composites in the landing gear.



INITIAL COST SAVINGS CHART



LIFE CYCLE COST SAVINGS CHART



TOTAL WEIGHT REDUCTION CHART

FIGURE 46 DATA PLOT EXAMPLES

SECTION VI

EVALUATION

6.1 RATING SYSTEM

Design concepts studied during Phase I have been evaluated and rated to provide a basis for selection of parts to be carried forward into Phase II for Preliminary Design and Analysis. The evaluation of these Phase I studies has been made by all disciplines concerned and the information generated has been organized into rating tables and each design studied has been rated to indicate whether it is a "good," "Moderately effective" or "marginally effective" design. Weighting factors were then assigned to each rating according to their importance in the overall system.

The baseline composite material, Graphite/Epoxy, was used in all designs and therefore was not used for rating the designs. A qualitative cost evaluation indicates that most designs could be cost effective and would result in weight savings over the baseline metallic part. A better cost estimate would require more information on tooling and manufacturing processes than could be generated in this time limited program.

6.1.1 Weighting Factor

Subratings have been given for "Fabrication," "Technical Risk" and "Weight Savings," but since all the subratings are not considered equal in their influence on the final rating of the part, a "weighting" factor has been used. This "weighting" factor has been assigned a value of 1 to 5 which indicates that the subrating has an effect on the total evaluation rating of; 1 = negligible importance, 2 = moderate importance, 3 = important, 4 = great importance, and 5 = very important.

6.1.2 Fabrication Rating

The fabrication rating indicates a consideration of manufacturing methods necessary to produce the part and whether or not they are state-of-the-art. Complexity and number of tools and fabrication time have also been considered. A rating of 1 to 3 points has been used with; 1 = good, 2 = moderate, and 3 = marginal producibility. A weighting factor of 2 has been used indicating "moderate importance."

6.1.3 Technical Risk

Technical risk is a very important consideration and indicates the estimated structural adequacy of a part built to the design concept studied.

It is based on a consideration of:

1. Assmptions necessary for analysis
2. State-of-the-art of the analysis required.
3. Load Paths
4. Stress concentrations, and
5. Stiffness changes

A rating of 1 to 4 points has been used with 1 = low, 2 = moderate, 3 = high, and 4 = very high risk design. A "very high risk" design will not be selected for further design effort in Phase II. A weighting factor of 5 has been used, indicating "very great importance."

6.1.4 Weight Savings

Weight saving ratings are based on the estimated weight saved when compared to the baseline part. A rating of 1 to 3 points has been used with: 1 = high, 2 = moderate, and 3 = low or no weight savings on the part. A weighting factor of 3 has been used indicating "important."

6.1.5 Evaluation Rating

Each of the design in all concepts have been rated and the rating (a) and weighted ratings (b) have been entered as a/b in the columns in Tables XIV, XV, XVI, XVII, and XVIII. The "evaluation" rating is the sum of all the weighted subratings, (b), and could have a range of values from 10 to 35. The values indicate the rating of the design concept as:

- a) 10-20 = good design
- b) 21-30 = moderately effective design
- c) 31-35 = marginal design

Designs rated "marginal" have not been selected for preliminary design effort in Phase II.

6.2 CONCEPT 1 - SUBSTITUTION

Concept 1 - Substitution design, see figure 25-31, was constrained by "form, fit and function." See Table XIV for rating of the designs.

TABLE XIV

PHASE 1 CONCEPT 1 "SUBSTITUTION"

CONCEPT EVALUATION CHART

	I	II	III	IV
DESIGN CONCEPT	FABRICATION RATING *WF = 2	TECHNICAL RISK WF = 5	WEIGHT SAVINGS WF = 3	EVALUATION RATING I+II+III
Drag Brace - Fwd.	**2/4	2/10	3/9	23
Drag Brace - Aft	3/6	2/10	3/9	25
Down Lock - Fwd.	3/6	3/15	3/9	30
Down Lock - Aft	2/4	3/15	3/9	28
Torque Link	2/4	4/20	3/9	33
Strut-Trunnion Arms-A	3/6	4/20	3/9	35
Strut Trunnion Arms-B	2/4	3/15	3/9	28
Wheels	3/6	3/15	2/6	27

*W.F. = Weighting Factor

** 2/4 = 2 (Rating) X 2 (Weighting Factor) = 4 (Weighted Rating)

The "very high technical risk" rating given to the designs for the "Torque Links" and "Strut-Trunnion Arms-A" eliminate these designs from further effort in Phase II of this program. "Weight Savings" ratings indicate that "Substitution" parts will not be weight effective.

"Substitution" designs, all rated "moderately effective design," and recommended for further effort in Phase II include:

1. Drag Brace - Fwd.
2. Drag Brace - Aft
3. Down Lock - Fwd.
4. Down Lock - Aft
5. Strut - Trunnion Arms-B
6. Wheels

6.3 CONCEPT 2 - MODIFICATION

Concept 2 - Modified design was constrained by "fit and function". Two versions, Concept 2-A and Concept 2-B were produced and are rated separately.

Concept 2-A, see figure 32, is rated in Table XV .

TABLE XV
PHASE 1 CONCEPT 2-A "MODIFIED"
CONCEPT EVALUATION CHART

	I	II	III	IV
DESIGN CONCEPT	FABRICATION RATING *WF = 2	TECHNICAL RISK WF - 5	WEIGHT SAVINGS WF - 3	EVALUATION RATING I+II+III
Drag Brace - Fwd.	2/4	3/15	1/3	22
Drag Brace - Aft	2/4	2/10	1/3	17
Spreader Bar- (Drag Brace)	2/4	2/10	3/9	23
Down Lock - Fwd.	2/4	3/15	3/9	28
Down Lock - Aft	2/4	3/15	3/9	28
Torque Link	2/4	4/20	3/9	33
Strut-Trunnion Arms	3/6	3/15	2/6	27
Wheel	3/6	3/15	1/3	24

*W.F. = Weighting Factor

The "Torque Links" were again eliminated from further effort in Phase II by a "very high technical risk" rating.

Concept 2-B, see figure 33, is rated in Table XVI.

TABLE XVI
 PHASE 1 CONCEPT 2-B 'MODIFIED'
 CONCEPT EVALUATION CHART

	I	II	III	IV
DESIGN CONCEPT	FABRICATION RATING *W.F. = 2	TECHNICAL RISK W.F. = 5	WEIGHT SAVINGS W.F. = 3	EVALUATION RATING I+II+III
Drag Brace - Fwd.	3/6	2/10	1/3	19
Drag Brace - Aft	2/4	2/10	1/3	17
Spreader Bar - (Drag Brace)	2/4	2/10	3/9	23
Down Lock - Fwd.	2/4	3/15	3/9	28
Down Lock - Aft	2/4	3/15	3/9	28
Torque Link	2/4	3/15	3/9	28
Strut-Trunnion Arms	3/6	3/15	3/9	30
Wheel (Same as 2-A)	3/6	3/15	1/3	24

*W.F. = Weighting Factor

Kinematics on both Concept 2-A and 2-B is the same, so designs from either study have been recommended for the Concept 2 effort in Phase II, based on their respective evaluations.

"Modified" designs recommended for further effort in Phase II include:

1. Drag Brace - Fwd. - Concept 2-B - rated "good design" and selected on the basis of lower technical risk.

2. Drag Brace - Aft - Concept 2-A - rated "good design" and is the same design as 2-B
3. Spreader Bar - Concept 2-B - rated "moderately effective design" mates with 2-B drag brace and ratings are the same as 2-A
4. Down Lock - Fwd. - Concept 2-A - rated "moderately effective design" and 2-B is same design
5. Down Lock - Aft - Concept 2-A - same as above
6. Torque Link - Concept 2-B - rated "moderately effective design" and Concept 2-A was a very high technical risk design
7. Strut - Trunnion - Concept 2-A - rated "moderately effective design" and selected on the basis of being more weight effective
Arms
8. Wheels - Concept 2 - design on figure 31 is rated as "moderately effective design"

6.4 CONCEPT 3 - REDESIGN

Concept 3 "redesign" studies were constrained by function only. Two studies were made for this concept, concept 3-A and 3-B, and they have been rated separately.

Concept 3-A, see figure 36, is rated in Table XVII.

Concept 3-B, see figure 37, is rated in Table XVIII.

TABLE XVII
 PHASE 1 CONCEPT 3-A "REDESIGNED"
 CONCEPT EVALUATION CHART

	I	II	III	IV
DESIGN CONCEPT	FABRICATION RATING *W.F. = 2	TECHNICAL RISK W.F. = 5	WEIGHT SAVINGS W.F. = 3	EVALUATION RATING I+II+III
Drag Brace - Fwd.	2/4	3/15	1/3	22
Drag Brace - Aft	2/4	3/15	1/3	22
Spreader Bar (Drag Brace)	2/4	3/15	1/3	22
Down Lock - Fwd.	2/4	3/15	3/9	28
Down Lock - Aft	2/4	3/15	3/9	28
Torque Link	2/4	3/15	3/9	28
Strut - Complete (cylinder & trunnion arms)	3/6	3/15	1/3	24
Piston	3/6	4/20	2/6	32
Axle	2/4	3/15	2/6	25
Wheel	3/6	3/15	3/9	30

* W.F. = Weighting Factor

The "Piston" design was rated as a "very high technical risk" and therefore is not recommended for further effort in Phase II.

TABLE XVIII

PHASE 1 CONCEPT 3-B "REDESIGNED"

CONCEPT EVALUATION CHART

	I	II	III	IV
DESIGN CONCEPT	FABRICATION RATING *W.F. = 2	TECHNICAL RISK W.F. = 5	WEIGHT SAVINGS W.F. = 3	EVALUATION RATING I+II+III
Drag Brace - Fwd. (structural concept)	3/6	2/10	1/3	19
Drag Brace - Aft (structural concept)	3/6	2/10	1/3	19
Spreader Bar (drag brace-3-A)	2/4	3/15	1/3	22
Down Lock - Fwd. (same as 3-A)	2/4	3/15	3/9	28
Down Lock - Aft (same as 3-A)	2/4	3/15	3/9	28
Strut - Complete	3/6	3/15	3/9	30
Stem (rotating)	2/4	3/15	3/9	28
Trailing Arm	2/4	4/20	3/9	33
Axle	2/4	3/15	2/6	25
Wheel (same as 3-A)	3/6	3/15	3/9	30

*W.F. - Weighting Factor

The "Trailing Arm" design was eliminated from further effort in Phase II since it was rated as a very high risk design.

Both Concept 3-A and 3-B require a larger nose wheel well, but the change required to accommodate the 3-A concept is slight, while a more extensive revision would be required for the 3-B concept. In addition, concept 3-A is more weight effective; therefore, it has been selected as the "redesigned" study to be carried into Phase II, but since the drag links are similar, the structural concept for axially loaded struts of concept 3-B will be used.

"Redesigned" part concepts recommended for further effort in Phase II include:

1. Drag Brace - Fwd. - Concept 3-B - rated "good design" and selected on the basis of lower technical risk.
2. Drag Brace - Aft - Concept 3-B - rated "good design" and selected on the basis of lower technical risk.

The following are all rated as "moderately effective design."

3. Spreader Bar - Concept 3-A and 3-B are same design
4. Down Lock - Fwd. - Concept 3-A and 3-B are same design
5. Down Lock - Aft - Concept 3-A and 3-B are same design
6. Torque Links - Concept 3-A required for 3-A concept
7. Strut - Complete - Concept 3-A more weight effective
8. Axle - Concept 3-A required for 3-A concept
9. Wheel - Concept 3-A no 3-B wheel concept

SECTION VII

CONCLUSIONS

The following conclusions were reached as a result of work done on Phase I of this two-phase program:

1. The B-1 nose landing gear is well suited to use as a baseline system.
2. Baseline requirements and constraints for the B-1 nose landing gear present no major obstacle to the use of composite material hardware.
3. More design, analysis and evaluation effort must be expended before firm statements can be made as to the expected results of this program.
4. Designs using composite material for landing gear hardware are considered to be practical under all three levels of constraint: form, fit and function; fit and function; and function only.
5. Usage of composite material for landing gear hardware can be increased as design freedom is increased.
6. Methodology to provide and evaluate data necessary to illustrate the pay-offs from the use of composite material hardware either exists or has been developed during this phase.

REFERENCES

1. Advanced Composite Design Guide, Volume II, Third Edition, prepared for AFML by Rockwell International, Los Angeles Aircraft Division, January 1973.
2. Ascani, L., "Preliminary Design and Analysis of an Advanced Composite Wing Pivot Structure," Volume III, Part I, AFFDL-TR-74-2, March 1974.
3. AFML-TR-74-5, "Advanced Composite Wing and Empennage to Fuselage Attachment Fittings," Contract F33615-71-C-1587. Prepared by General Dynamics/Convair Aerospace Division, Schaefer, W. H., et. al., for Air Force Materials Laboratory, January 1974.
4. AFFDL-TR-73-69, "Graphite Composite Landing Gear Components - Side Brace Assembly and Torque Link for A37B Aircraft," Contract F33615-71-C-1508, prepared by Hercules Incorporated for Air Force Flight Dynamics Laboratory, May 1973.
5. NA-72-1, "Structures Manual," prepared by Rockwell International, B-1 Division.
6. "Graphite Composite Aircraft Landing Gear Wheel," Air Force Contract F33615-74-C-3040, prepared by Hercules Incorporated for the Air Force Flight Dynamics Laboratory.
7. Phase II Report, "Graphite Composite Landing Gear Component," Contract F33615-72-C-1725.
8. AFFDL-TM-74-199-FEM, "Wear and Pressure Testing of an Unlined Graphite/Epoxy Cylinder Subjected to Landing Gear Test Conditions," prepared by Mechanical Branch, Vehicle Equipment Division, AFFDL, WPAFB; Shumaker, Gerald C., Capt. USAF.

APPENDIX B
DESIGN REQUIREMENTS

APPENDIX B

DESIGN REQUIREMENTS

The B-1 Prime Item Development Specification (CP109L2001B) lists the following design requirements.

A. CHARACTERISTICS

1. Performance: Performance of the landing gear system (LGS) shall permit accomplishment of the air vehicle performance specified in the paragraphs entitled "Flotation, Landing and Takeoff" of CP621L2002 and "Structural Criteria" of CP621L2003 as modified by Appendix III, hereto, for MLG wheels, tires and brakes. The LGS shall provide the following functions:

- a. Absorb and/or transmit the static and dynamic energy resulting from the air vehicle takeoff, landing, and ground maneuvering operations.
- b. Provide directional control to accomplish steering, turning, pivoting, taxiing, and braking of the air vehicle.
- c. Provide ground flotation for the air vehicle during ground maneuvers.
- d. Provide for retraction, extension and locking of the main and nose gears for the flight and ground mode of operation, and indication and warning to the pilot of gear position.
- e. Provide for towing, tie-down, and wheel jacking.

2. Landing Gear Operation The main and nose landing gear assemblies shall be hydraulically operated and electrically controlled. Gear position shall be selected by means of the landing gear control handle located in the flight station. Sequencing shall be accomplished by use of switches, relays, solenoid and/or mechanically operated valves. Protection against inadvertent retraction of the landing gear with the air vehicle on the ground shall be provided.

3. Retraction and Extension The main and nose landing gears shall be fully retractable and completely enclosed when in the retracted position. The gears shall automatically lock in the extended and retracted position by means of positive mechanical locks. Locking the gears in either the extended or retracted position shall not be dependent upon hydraulic pressure. The locks

shall be designed such that they shall release the gears prior to or at the same instant the gear extension actuator receives hydraulic pressure. The main nose gear doors and gear uplock mechanisms shall be unlocked by hydraulic power. Fairings and closures shall be designed with adequate clearance considering flat tire and flat strut conditions. Interruption of the control sequence or driving power to the landing gear and fairing door actuation system during normal or emergency operation shall not result in system malfunction or structural damage to any part of the air vehicle. The landing gear and fairing doors shall continue to the selected position upon reapplication of hydraulic power.

4. Retraction and Extension Time Retraction and extension time for the main and nose landing gear and door assemblies shall be as shown in Table B-1. The main and nose landing gears shall be retracted and locked before the air vehicle reaches 75 percent of the gear structural design limit speed (V_{LF}) at the maximum rate of acceleration.

TABLE B-1

RETRACTION AND EXTENSION TIME

Item	Temperature	Maximum Allowable Time to Open Doors and Extend and Lock Gears	Maximum Allowable Time to Retract and Lock Gears and Doors
a	Above minus 20 F	15 Seconds	15 Seconds
b	Minus 65 F to minus 20 F	30 Seconds	30 Seconds

5. Structural Design Speeds The main and nose landing gears shall be designed to withstand air loads resulting from speeds up to 340 knots equivalent air speeds (EAS) for all extension positions to full extension, and shall be capable of operating (retraction and extension) at speeds up to 280 knots EAS. Actuators and linkages shall be designed to withstand the loads imposed by these design operating conditions, including the effects of hydraulic surges and pressures.

6. Emergency Gear Operation An emergency extension control shall be provided that is independent of the normal gear operating controls. It shall be possible to extend the landing gear to the down and locked position in the event of any single hydraulic or electrical component failure. The landing gear shall be capable of emergency extension to a down and locked position, independent of the air vehicle hydraulic and electrical power generation subsystems. Primary means of emergency operating power shall not be dependent upon battery power. Emergency extension time shall not be greater than twice the maximum allowable operating limits specified in Table B-1.

7. Free Fall Capability After uplock release, the nose gear shall have the capability of free fall extension and lock. Free fall extension and lock of the main gear shall be a design goal, with the assistance of spring bungees and/or stored hydraulic energy as required to assure safe operation.

8. Jacking Wheel jacking provisions shall be incorporated in accordance with MIL-STD-809.

9. Towing Towing provisions shall be incorporated in accordance with MIL-STD-805.

10. Attachment Provisions Provisions shall be made for attachment, routing, and protection of electrical wire, switches, door operating linkages, valves, nameplates, and hydraulic lines.

11. Mooring Provisions The nose gear shock strut shall incorporate mooring lugs for tie-down of the air vehicle.

12. Protection from Damage The effects of rocks, ice and other foreign object damage shall be considered in the design and installation of hydraulic lines and components.

13. Spare Strut Piston Seals Provisions shall be incorporated in the design of the lower bearing and glad to carry spare seals as replacements for the lower piston seal.

B. RELIABILITY

The LGS shall incorporate those design characteristics essential to the achievement of the quantitative and qualitative reliability requirements specified for the air vehicle.

C. MAINTAINABILITY

1. Quantitative Maintainability The LGS shall incorporate those design characteristics essential to the achievement of the quantitative maintainability requirements specified for the air vehicle.

2. Qualitative Maintainability The standard Air Force policy of three levels of maintenance (organizational, intermediate and depot) shall be employed for the LGS. The following qualitative requirements shall apply.

3. General

- a. The LGS shall be self-sufficient to the extent of permitting preflight inspections to be performed without prepositioned AGE, and permitting postflight inspections to be performed without prepositioned AGE, except for step ladders or workstands, and ground safety locks/devices.
- b. The LGS shall permit all maintenance to be accomplished by Air Force technicians 5 skill level maintenance personnel, with occasional 7 skill level personnel, using existing Air Force facilities and for most tasks, existing AGE. Design for repair by Air Force technician 3 skill level maintenance personnel shall be a goal.
- c. Equipment design shall reflect thorough consideration of the capabilities of human resources available to maintain the equipment and the utilization of automatic test equipment to support maintenance personnel.

D. MAJOR COMPONENT CHARACTERISTICS

1. Shock Struts - General The main and nose landing gear shock strut shall comply with the requirements of MIL-L-8552, MIL-T-6053, AFSC DH 2-1, and the engineering critical item development specifications. The shock struts shall be designed such that the passage of oil through an orifice shall absorb the energy of impact and in which dry nitrogen is used as the elastic medium to restore the unsprung parts to their extended position. The shock struts shall be capable of withstanding the loads derived from MIL-A-8860, MIL-A-8862, MIL-A-8866, MIL-A-8867, and the load conditions specified in CP621L2002 and CP621L2003, including static strength and four lifetime fatigue requirements. The air vehicle design sinking speed shall be 10 feet per second at the target landplane landing design weight and 8 feet per second at the target maximum design landing weight. The shock

struts shall be capable of supporting the air vehicle on a flat strut (loss of nitrogen) through the complete landing cycle, at normal landing conditions, without damage to the shock struts or carry-through structure. A complete landing cycle at normal landing conditions shall consist of landing at a landplane landing design target weight at a sink speed of 8 feet per second. The landing runout and taxi design load for the flat strut condition shall be the static gear load at maximum taxi weight times a dynamic factor of 1.2. Compression ratios shall be compatible with all applicable LGS design and performance requirements.

2. Nose Gear Shock Strut The nose gear shock strut shall be of the conventional air-oil piston type with provisions for mounting twin free rotating wheels on a fixed axle. The shock strut shall withstand the loads induced by the steering and damping unit.

3. Stroke The nose gear shock strut shall have a design vertical stroke of 21 inches measured at the axle centerline and a design 7-inch stroke from the static to compressed position.

4. Torsional Spring Rate The torsional spring rate of the nose gear shock strut, in the static position, shall not exceed 1.4×10^{-4} radians per 1000 inch-pounds.

5. Swivel Angle The nose gear shock strut shall allow the nose wheels to caster through 360 degrees rotation without requiring mechanical disconnect.

6. Nose Wheel Centering The nose gear shock strut shall be capable of centering the nose wheels, prior to retraction, to within plus or minus 0.25 degree of center.

7. Interface Compatibility The nose gear shock strut shall be designed for interface compatibility with the following:

- a. Nose wheel assembly.
- b. Tire (see figure B-1 for tire clearance envelope dimensions).
- c. Steering and damping unit, including all fittings and mountings required to route hydraulic lines.
- d. Air vehicle structure. The air vehicle structure shall provide adequate space to permit retraction and extension of the nose gear assembly without interference or blinding. The doors shall operate properly without interfering with the retract/extend cycle of the nose gear. Attachment provisions shall be provided to reduce the tendencies of gear shimmy.

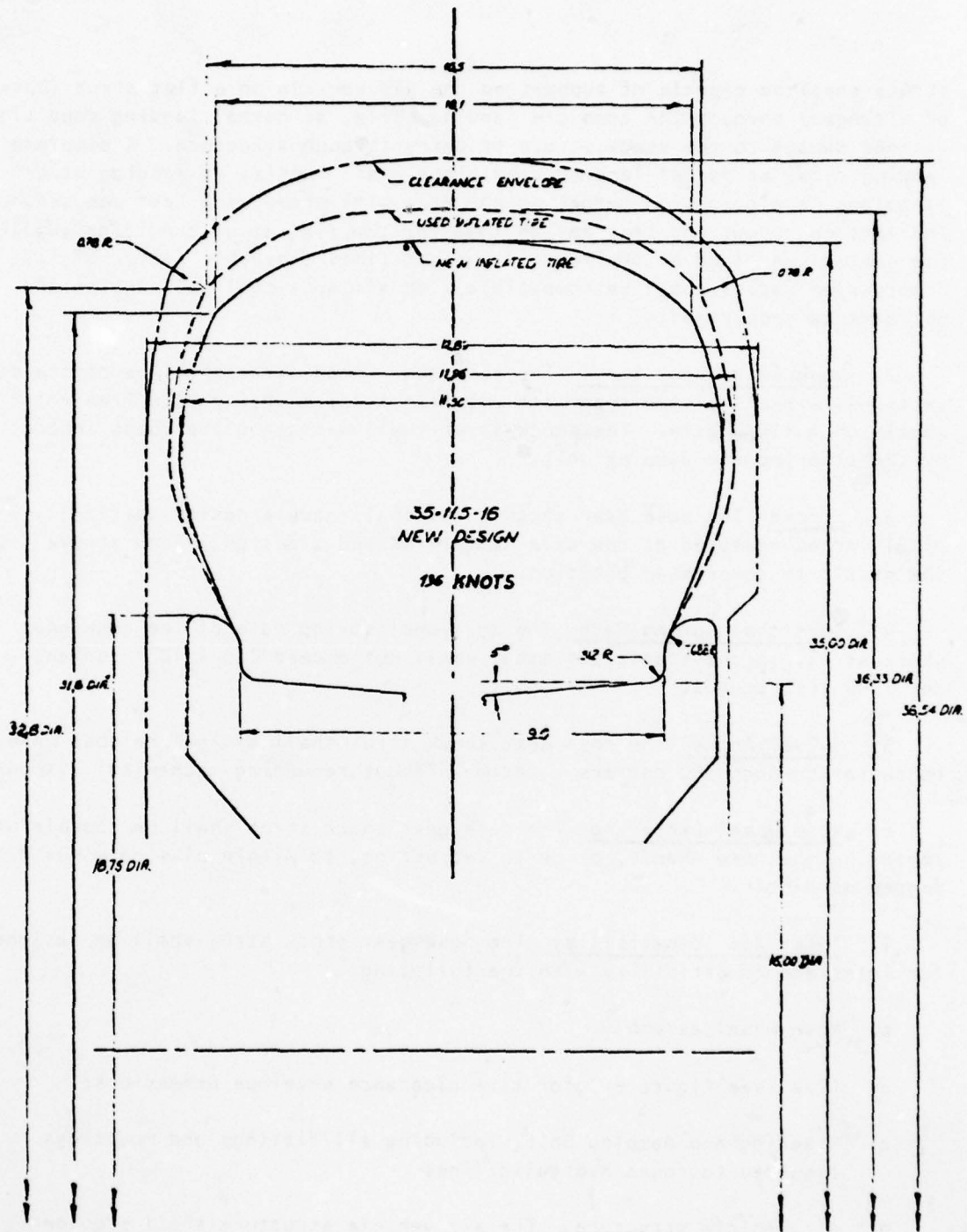


Figure B-1 Nose Gear Tire Clearance Envelope

E. WHEEL ASSEMBLIES - GENERAL

The main and nose landing gear wheel assemblies shall comply with the requirements specified in the engineering critical item development specifications and MIL-W-5013, except the wheels shall be capable of being rolled a distance of 2500 miles, including consideration for combined radial and side loads corresponding to those produced by 0.25g turns.

1. Overpressure Relief Valve A pressure relief valve shall be provided for the wheel to prevent overpressurization of the wheel and tire assembly.

2. Tire Change Counter Provisions shall be incorporated in each wheel for recording a minimum of 50 tire changes.

3. Tire Pressure Gage A tire pressure gage shall be incorporated on the outboard side of the wheel assembly. The gage shall conform to MIL-G-83016, except the gage shall withstand exposure to vibration and to a burst pressure of 625 psi.

F. NOSE GEAR WHEEL ASSEMBLY

1. Structural Loads The nose gear wheel assembly shall be capable of withstanding the structural loads resulting from air vehicle takeoff, landing and ground maneuvering operations.

2. Interface Compatibility The nose gear wheel assembly shall be designed for interface compatibility with the nose landing gear shock strut and for installation of a tubeless tire in accordance with figure B-1. Stops shall be provided in the nose gear wheel well to prevent rotation of the nose wheel after completion of the retraction cycle. The physical interface shall be as defined in the engineering critical item development specification.

G. STEERING AND DAMPING SUBSYSTEM

The steering and damping subsystem shall comply with the requirements of MIL-S-8812, AFSC DH 2-1, and the engineering critical item development specification. The steering and damping subsystem shall provide electrically controlled, hydraulically powered angular displacement of the nose landing gear wheels to permit directional control of the air vehicle during ground maneuvers, including taxi, takeoff, and landing operations. In addition, the subsystem shall provide effective shimmy damping to assure dynamic stability of the nose landing gear under all ground operating conditions.

1. Swivel Range The steering and damping subsystem shall allow the nose wheel to caster through 360-degree rotation without requiring mechanical disconnects or lost motion cam mechanisms. Loss of steering power shall result in the nose wheels being capable of returning to a neutral or safe position. The nose wheels shall caster in a safe trail position, with damping after loss of power and shall be capable of free caster to within the powered steering range, from any parked position, with forward motion of the air vehicle.

APPENDIX C
EXTERNAL LOADS

APPENDIX C
EXTERNAL LOADS

The following pages present a summary of nose gear loads for the B-1 A/V #4 from the B-1 System Definition Manual.

Included are:

1. Landing, Taxi, and Handling Loads
2. Dual Wheel Load Distribution
3. Ultimate Load Determination
4. Fuselage Support Structure Deflections
5. Temperature Condition
6. Drop Test Requirements
7. Actuation System Loads
8. Nose Gear Uplock Loads
9. Nose Gear Door Link Loads
10. Nose Gear Steering Torque
11. Repeated Loads Design Requirements
12. Nose Landing Gear Support Reactions

NOSE GEAR LOADS

(Reference L287C2037, dated 30 January 1976)

1. LANDING, TAXI, AND HANDLING LOADS

Tables C-I, C-II, C-III, and C-IV define the loads attendant to the landing, taxi, and handling conditions.

TABLE C-I
LANDING WEIGHTS AND SINK SPEEDS

Item	Landing Condition	Weight	Sink Speed (V_s) (fps)
a	Landplane landing weight	263,330	10
b	Maximum landing weight	346,500	8
c	Minimum landing weight	161,700	10
d	Flat strut landing weight	263,330	8

TABLE C-II
NOSE GEAR "DESIGN" DYNAMIC LANDING LOADS

Item	Landing Condition	V (Parallel to Strut)	D (Perpendicular to Strut)
a	Spinup (SU)	61,100	47,000
b	Springback (SB)	98,500	-42,000
c	Maximum vertical reaction (MVR)	98,500	+24,600, -42,000

TABLE C-III
NOSE GEAR "LIMIT" TAXING LOADS FOR
W TAXI = 395,000 POUNDS

Item	Taxi Conditions	V (Parallel to Strut)	D (Perpendicular to Strut)	S (Side Load)
a	Three-point braked roll	85,296	---	---
b	Unsymmetrical Braking	61,621	---	±16,814
c	Turning	34,027	---	±13,611
d	Dynamic taxi	93,500	---	---

TABLE C-IV
NOSE GEAR HANDLING LIMIT LOADS
PARALLEL AND PERPENDICULAR TO GROUND
FOR W TAXI - 395,000 POUNDS

Item	Condition	V (Parallel to Strut)	D (Perpendicular to Strut)
a	Static reactions:		
	WL normal = 263,300	36,630	0
	WL maximum = 346,500	39,150	0
	WL minimum = 161,700	18,270	0
	W taxi = 395,000	34,027	0
b	Towing	34,027	Ft maximum - 59,250
c	Jacking (side load = ±15,910)	53,710	±15,910

General Notes.

a. Sign Convention.

- (1) +V is up
- (2) +D is aft
- (3) +S is to right

b. Landing Conditions.

- (1) SU, SB, and MVR loads act perpendicular and parallel to the strut centerline and are applied at the centerline of the axle.
- (2) Strut is extended a maximum of 85 percent at design load; tires are static.

c. Taxi and Handling Conditions.

- (1) All loads are perpendicular and parallel to the ground line and are applied at the ground contact point. (See Figure C-1).
- (2) The strut is in the static position corresponding to the airplane weight being considered.
- (3) Tires are static.

- d. Handling Conditions. Towing and jacking load combinations shall be in accordance with MIL-A-8862.
- e. Secondary Loads. The load analysis shall include the effects of elastic deflections.
- f. Actuation Loads. Effects of actuating cylinder loads shall be considered when critical and applicable.
- g. Side Loads. Side loads should be distributed to the trunnion support fitting using a 60/40 distribution. In addition, induced equal and opposite side loads equal to 15 percent of the total (left-hand and right-hand) vertical trunnion load shall be applied in the inboard direction to the trunnion if such a load combination is critical.
- h. For taxi and ground handling load conditions at $W_{\text{taxi}} = 395,000$ pounds, the definition of ultimate shall be 1.5 times the limit external load applied at limit load deflections.

2. DUAL WHEEL LOAD DISTRIBUTION

The nose landing gear loads specified herein shall be distributed to the respective wheels noted on Figure C-1 as follows:

- a. Symmetrical Load Distribution. Landing gear loads shall be equally distributed to each wheel.
- b. Unsymmetrical Load Distribution. The following conditions need not be considered for unsymmetrical load distribution:

(1) Unsymmetrical Braking.

- (a) Unequal Tire Pressure Conditions. Individual wheel loads shall be as follows: (See Figure C-1)

Case	NL	NR
A	60.0	40.0
B	40.0	60.0

Where the above values are percents of design or limit load. For the turning condition, side load to the right, 60 percent need not be considered on the right wheel. For side load to the left, 60 percent need not be considered on the left wheel.

- (b) Flat Tire Conditions. Individual wheel loads shall be as follows: (See Figure C-1).

Case	NL	NR
A	1.00	0
B	0	1.00

Where the above values are to be used with 60 percent of the specified gear load for landing conditions and 50 percent for taxi conditions, except:

The reaction shall not be less than static.

For three-point braked roll use V load = 64,150 pounds limit.

AD-A058 672

ROCKWELL INTERNATIONAL LOS ANGELES CALIF LOS ANGELES--ETC F/G 11/4
NEW CONCEPTS IN COMPOSITE MATERIAL LANDING GEAR FOR MILITARY AI--ETC(U)
FEB 78 V E WILSON F33615-76-C-3021

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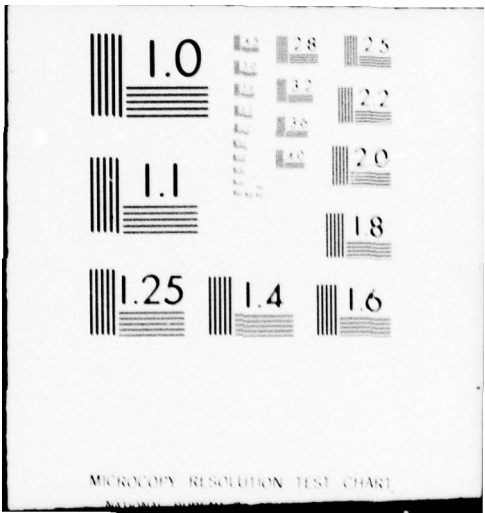
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(b) Flat Tire Conditions. (Cont.)

For the turning condition a vertical load factor of 1.0 shall be acting at the center of gravity (CG). The side load factor at the CG shall be the most critical value (up to 50 percent for one flat tire) of that resulting from the most severe condition specified for no flat tires. For this condition, refer to the following:

For W Taxi = 395,000
145.41 inches
174.00 inches
618.82 inches
677.75 inches

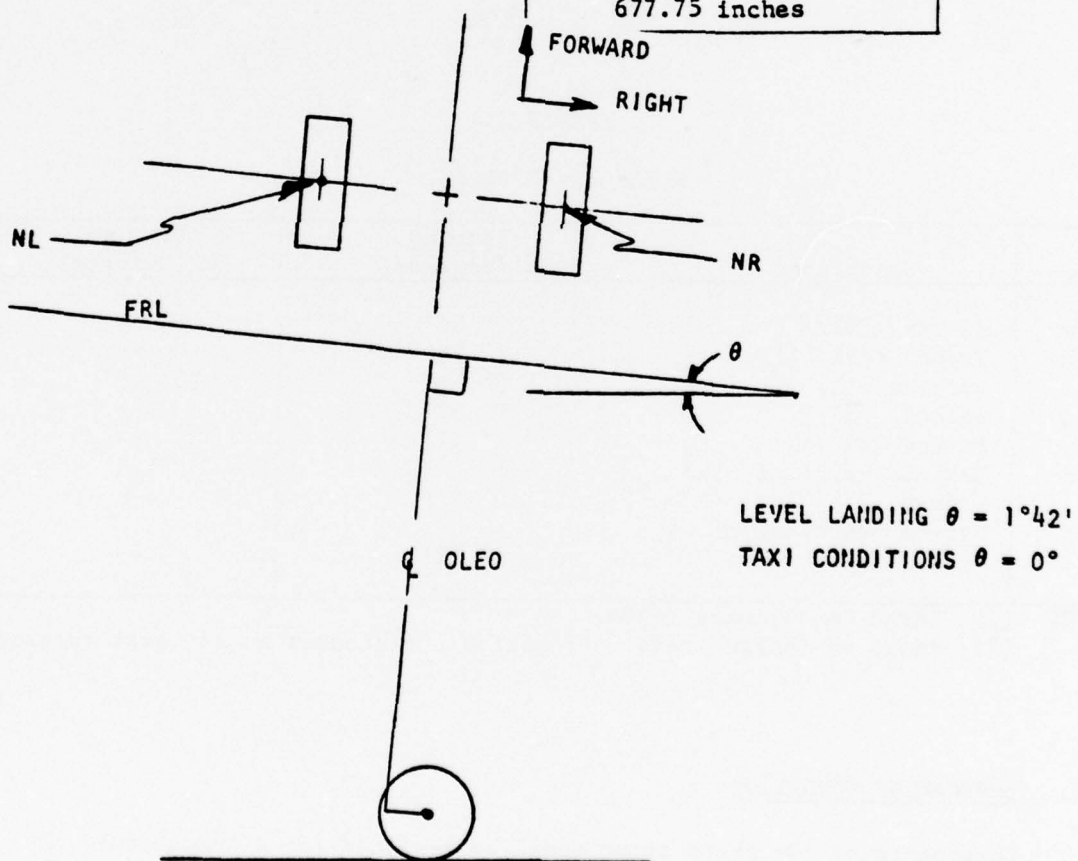


Figure C-1. Nose Gear Geometry

3. ULTIMATE LOAD DETERMINATION

Taxi and handling loads are "limit" loads and must be multiplied by 1.5 to obtain ultimate loads. Landing loads are shown as "design loads" and ultimate strength requirements do not apply; however, the deformation limitation of MIL-A-8860 shall apply. "Design Loads" will be checked versus yield strengths.

4. FUSELAGE SUPPORT STRUCTURE DEFLECTIONS

The angular rotation of the nose landing gear shock strut from its undeflected (zero-G airplane loading) position due to fuselage bending or torsion, in addition to local deflections are shown in Table C-V.

TABLE C-V
NOSE GEAR DEFLECTIONS

Item	Condition	Bending α (degrees)	Torsion θ (degrees)
a	2G taxi (1)	0° 48'	--
b	Braked roll (1)	-1° 55'	--
c	Turning (1)	0° 16'	±2° 30'
d	Spinup (2)	0° 58'	--
e	Springback (2)	-1° 12'	--
f	Maximum vertical plus drag (2)	0° 27'	--
g	Maximum vertical minus drag (2)	-1° 12'	--

NOTES (1) Based on ultimate loads.
(2) Based on design loads. Positive α indicates an aft gear rotation.

5. TEMPERATURE CONDITION

Components of the shock strut shall be designed for a temperature condition of 160 F at time of application of landing and taxi loads. This condition is subsequent to 313 hours of exposure to an ambient temperature of 265 F.

6. DROP TEST REQUIREMENTS

Drop tests shall be conducted in accordance with MIL-T-6053, except the test conditions shall be as shown in Table C-VI.

TABLE C-VI
DROP TEST CONDITIONS

Item	Airplane Weight	Attitude (degrees)	Contact Vertical Velocity (fps)	Contact Horizontal Velocity (fps)	Max Gear Load Factor
a	WL normal	Level	10	242	2.40
b	WL maximum	Level	8	279	2.24
c	WL minimum	Level	10	193	4.80
d	WL normal (flat strut)	Level	8	242	2.40

Additional Drop Test Requirements. During the drop test, loads shall not reach a peak value until at least 15 percent of the total stroke has been used. The shock strut dynamic characteristics should approximate the data shown in Table C-VII

TABLE C-VII
DYNAMIC CHARACTERISTICS

Item	Nomenclature	Characteristics
a	Static position	Inches from extended position: 14
b	Compression ratio	7.41; stroke zero to 14 inches 3.47; stroke 14 to 21 inches
c	Damping coefficient	See Figure C-2

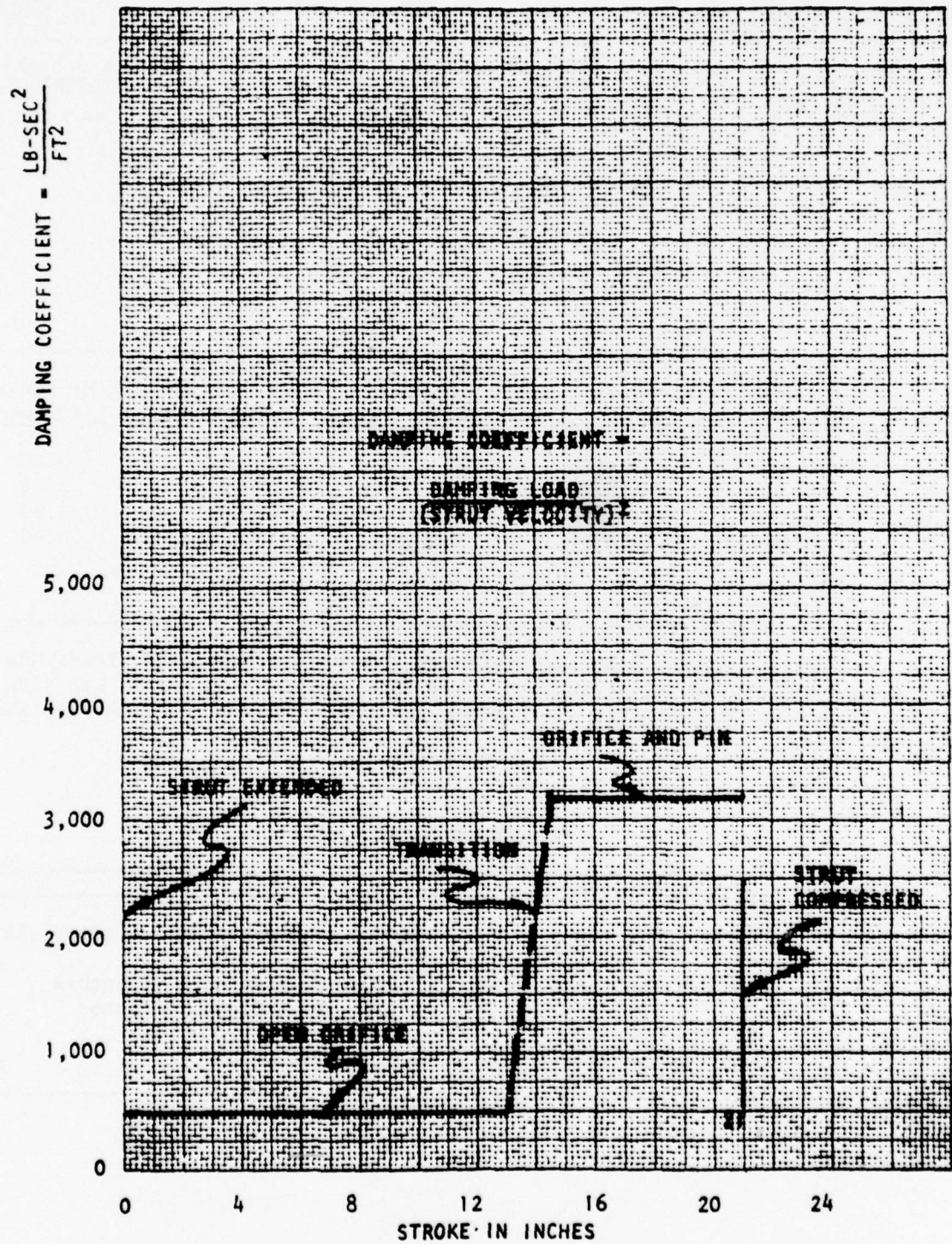


Figure C-2. Damping Requirements for Nose Gear Strut

7. ACTUATION SYSTEM LOADS

- a. The nose landing gear assembly shall be structurally capable of withstanding exposure to 340-knot airloads without sustaining damage.
- b. The nose landing gear assembly shall be capable of operating (retraction and extension) at airspeeds up to 280 knots.
- c. Wheel, tire, and steering and damping equipment weight per nose landing gear assembly shall not exceed 439 pounds (tires and wheels 259 pounds; steering unit 180 pounds).

Actuation Load Conditions. Static and fatigue strength conditions are as follows:

Condition I: Static Strength Conditions (see Figure C-3).

a. Yield Requirements:

IA1C Piston driving, compression
IA1T Piston driving, tension
IA2C Airload plus inertia loads driving, compression

b. Ultimate Requirements:

$$IB1C = [IA1C] \frac{6,000}{5,400}$$

$$IB1T = [IA1T] \frac{6,000}{5,400}$$

$$IB2C = [IA2C] [1.50]$$

Condition II: Fatigue Strength Requirements (see Figure C-4).

Where: R = Retraction phase
E = Extension phase
IIR + IIE = 1 cycle
6,000 cycles = 1 life
@ Scatter factor = 4.0
Total requirement = (6,000)(4.0) = 24,000 cycles

ACTUATION LOAD CONDITIONS - STATIC

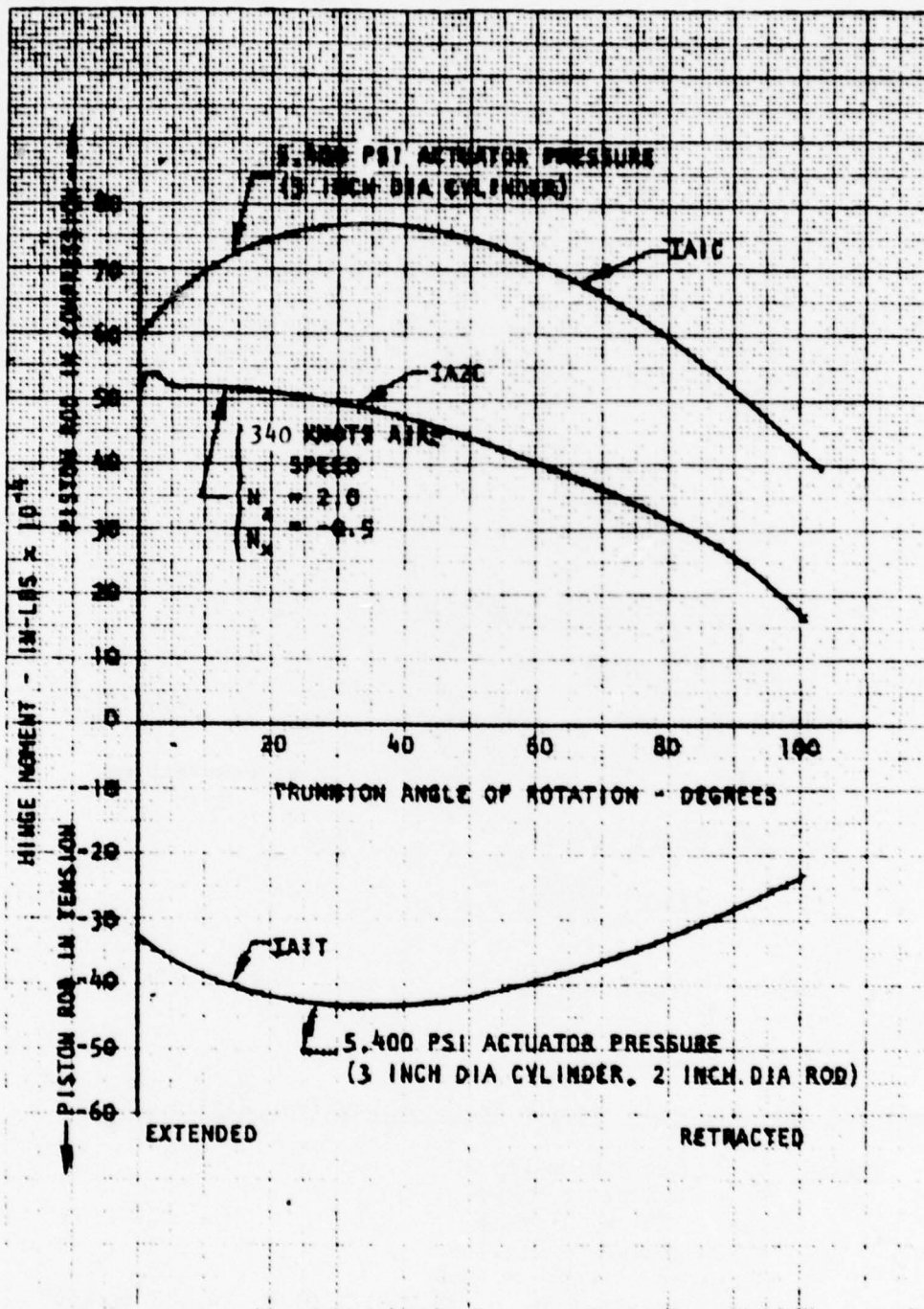


Figure C-3. Nose Gear Hinge Moment vs Retraction Angle (Static Yield Conditions)

ACTUATION LOAD CONDITIONS - FATIGUE

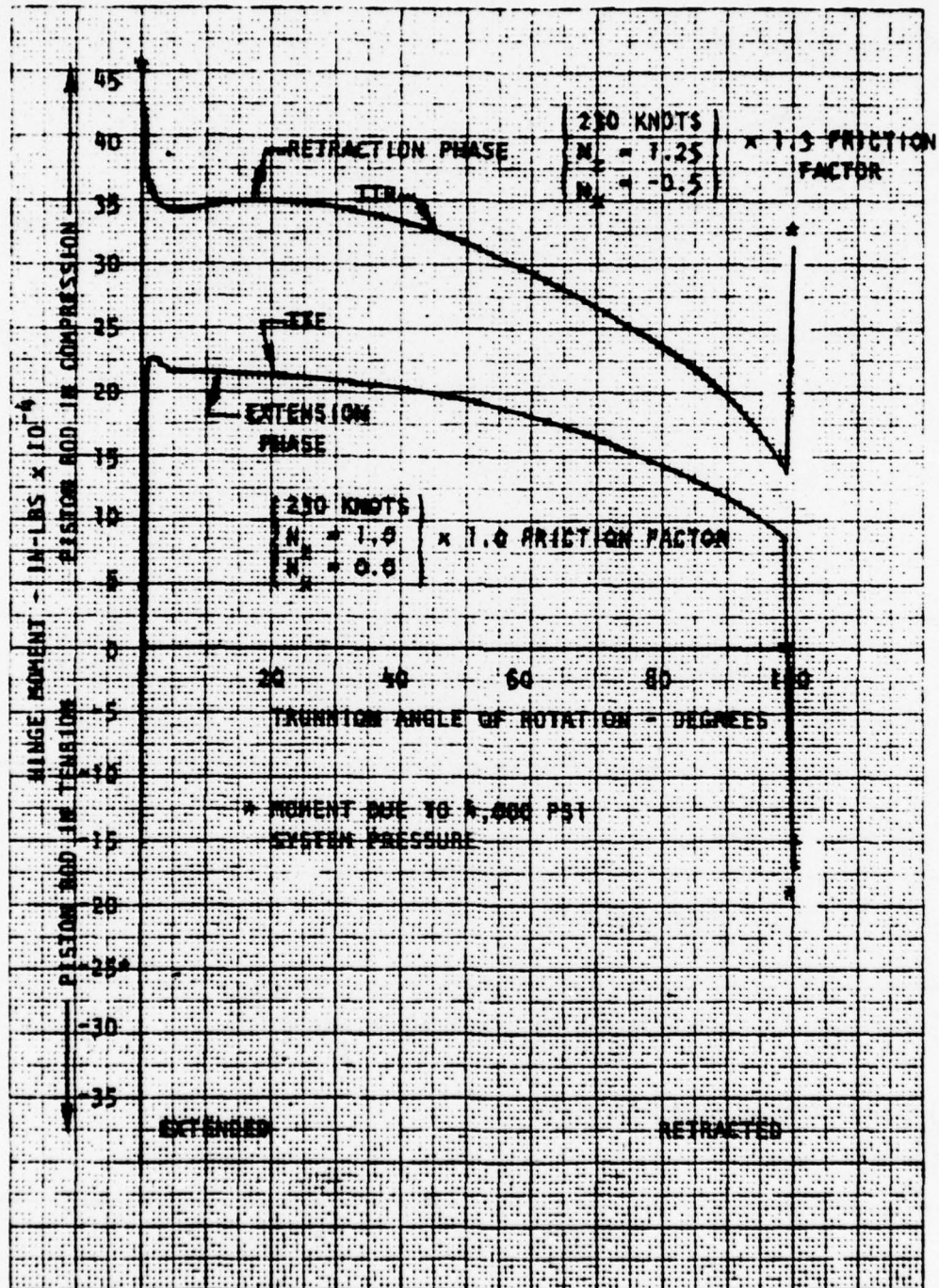
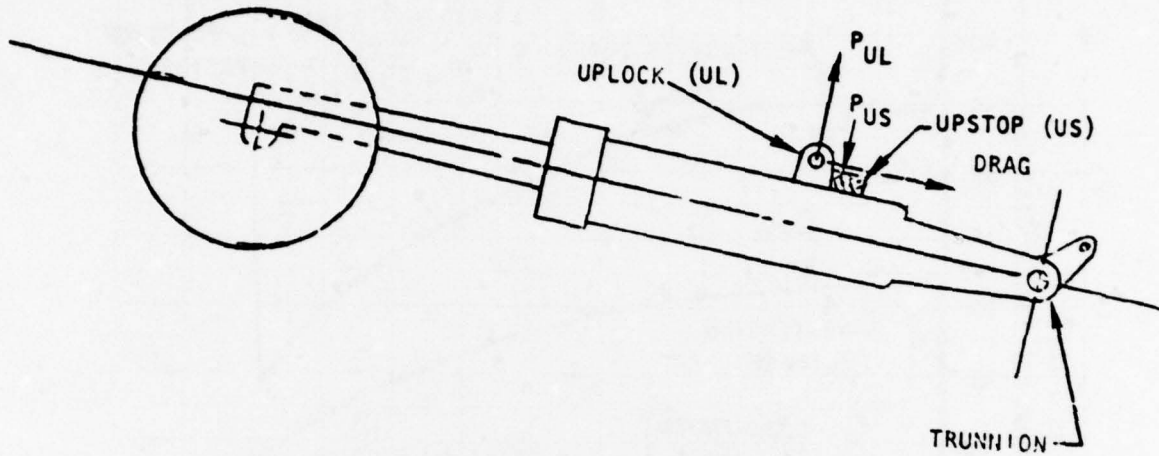


Figure C-4. Nose Gear Hinge Moment vs Retraction Angle (Fatigue Cycles)

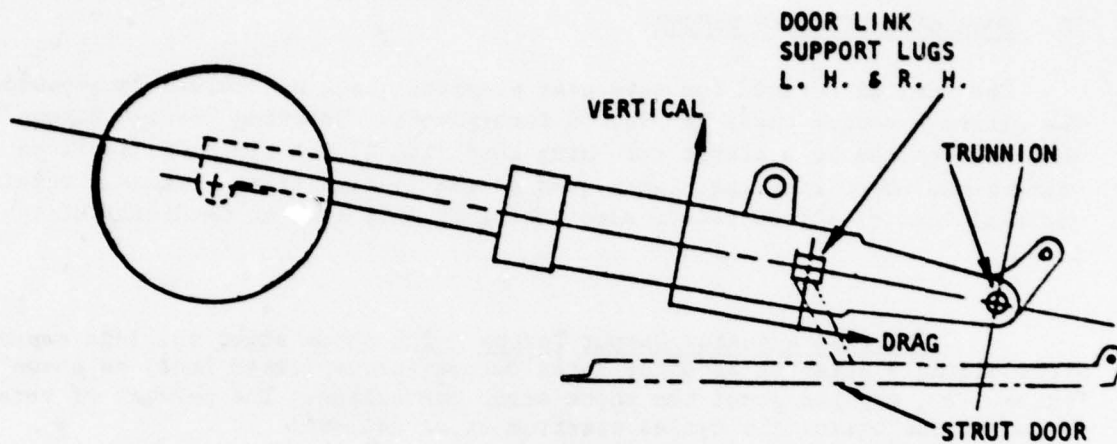
8. NOSE GEAR UPLOCK LOADS



CONDITION		P _{UL} (POUNDS)	P _{US} (POUNDS)
①	VERTICAL GUST (+N _z)	7,126	---
③	ACTUATION SURGE PRESSURE (5,400 LB-INCHES)	---	5,969
②	ACTUATION ULTIMATE PRESSURE (6,000 LB-INCHES)	---	6,777
① VERTICAL GUST CONDITIONS ARE LIMIT LOAD CONDITIONS. ULTIMATE = (1.50) X (LIMIT)			
② EQUIVALENT TO ULTIMATE LOADS			
③ YIELD LOADS			

Figure C-5. Nose Gear Uplock Loads

9. NOSE GEAR DOOR LINK LOADS



GEAR UP POSITION SHOWN

	CONDITION	VERTICAL LOAD (POUNDS)	DRAG LOAD (POUNDS)
DOOR	OPEN GEAR DOWN AIR SPEED 340 KT*	-2,760	-950
DOOR	OPEN GEAR DOWN AIR SPEED 280 KT	-1,865	-640
DOOR	CLOSED 2 PSI NEGATIVE PRESSURE	-1,100	1,230

*AIRSPEED OF 340 KNOTS IS A DESIGN LOAD. REFER TO 10.3.7 "a" FOR REQUIREMENT.

OTHER CONDITIONS SHOWN ARE LIMIT LOAD CONDITIONS.

LOADS SHOWN ARE FOR THE LEFT-HAND SIDE. LOADS OF THE SAME MAGNITUDE ALSO ACT ON THE RIGHT-HAND SIDE.

Figure C-6. Nose Gear Door Link Loads

10. NOSE GEAR STEERING TORQUE

The "design torque" for nose gear steering shall be 350,000 inch-pounds. The ultimate torque shall be 390,000 inch-pounds. Steering "design torque" shall be reacted by a static scrubbing condition of the tires and shall be distributed 60/40 with the higher load at the leading tire. Assume a total vertical load of 40,700 pounds also acting at this time to be distributed 60/40.

Steering Actuator Output Torque. The shock strut shall be capable of withstanding a steering actuator rated output torque (rated load) as shown on Figure C-7, applied about the shock strut centerline. The percent of rated output torque versus the cycles spectrum is as follows:

- a. Full steering angle (75 degrees right and left) at 100 percent rated output torque; 50,000 cycles.
- b. Fifty percent steering angle (37-1/2 degrees right and left) at 50 percent rated output torque; 25,000 cycles.
- c. Ten degrees steering angle each side of the shock strut centerline at 25 percent rated output torque; 25,000 cycles.

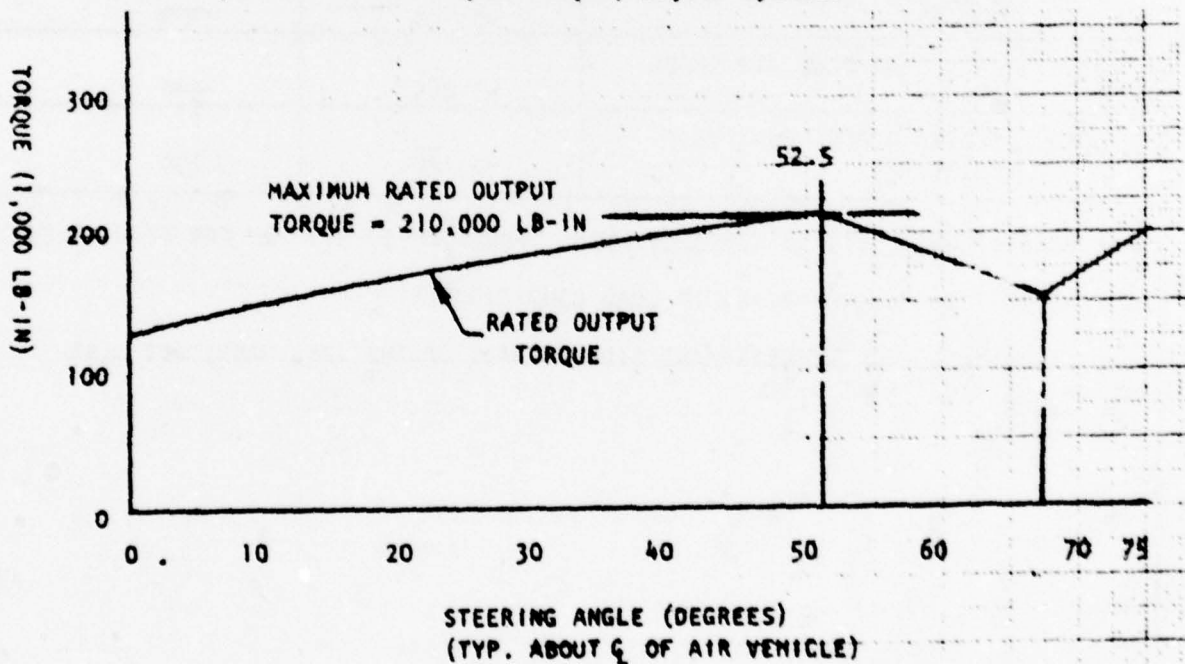


Figure C-7. Steering Actuator Rated Output Torque

11. REPEATED LOAD DESIGN REQUIREMENTS

The requirements are based on 2697 landings.

Loads Spectrum. The following landing, ground handling, and taxi spectrum (Table C-VIII) comprise the repeated load design requirements for one life of the aircraft. However, a scatter factor of 4.0 is required for both the fatigue analysis and test program.

Actuation System Requirements. The nose landing gear shock strut and the appropriate actuating mechanism shall be designed to withstand 6000 retraction/extension cycles.

TABLE C-VIII
 NOSE LANDING GEAR TEST SPECTRUM - BLOCK LOADING
 (Ref. L287C2037 Amed. 2)

Step	Sub Step	Mission Segment	Vertical Load Kips		Drag Load Kips		Side Load Kips		Cycles Per Block
			Max	Min	Max	Min	Max	Min	
1	a	Landing (Spin Up & Spring Back) Take off	20.5	20.5	11.1	-6.4	0.	0.	7
	b		20.5	20.5	5.5	-3.2	0.	0.	
	c		0.	0.	0.	0.	0.	0.	
2	a	Landing (spin Up & Spring Back) Take off	26.1	26.1	9.9	-5.4	0.	0.	64
	b		26.1	26.1	4.9	-2.7	0.	0.	
	c		0.	0.	0.	0.	0.	0.	
3	a	Landing (Spin Up & Spring Back) Take off	26.1	26.1	9.9	-5.4	0.	0.	64
	b		26.1	26.1	4.9	-2.7	0.	0.	
	c		0.	0.	0.	0.	0.	0.	
4	5	Hard Braking	50.6	20.6	0.	0.	0.	0.	64
			41.9	16.3	0.	0.	0.	0.	
6	7	Medium Braking	61.7	33.9	0.	0.	0.	0.	64
			35.7	19.9	0.	0.	0.	0.	
			30.1	16.3	0.	0.	0.	0.	
9	10	Left Turn	31.5	31.5	0.	0.	-12.6	0.	128
			18.5	13.5	0.	0.	-7.4	0.	
11	12	Right Turn	31.5	31.5	0.	0.	12.6	0.	128
			18.5	18.5	0.	0.	7.4	0.	
3	14	Taxi	48.7	25.1	0.	0.	0.	0.	64
			41.7	26.1	0.	0.	0.	0.	
			40.7	19.3	0.	0.	0.	0.	
			38.6	21.4	0.	0.	0.	0.	
			36.3	23.7	0.	0.	0.	0.	
			21.4	11.3	0.	0.	0.	0.	
			20.0	12.7	0.	0.	0.	0.	

TABLE C-VIII - Continued
NOSE LANDING GEAR TEST SPECTRUM - BLOCK LOADING

Step	Sub Step	Mission Segment	Vertical Load Kips		Drag Load Kips		Side Load Kips		Cycles Per Block
			Max	Min	Max	Min	Max	Min	
20		Towing	33.9	33.9	29.6	-29.6	0.	0.	128
21			30.0	30.0	23.2	-23.2	0.	0.	256
22			16.3	16.3	14.6	-14.6	0.	0.	384
23			33.9	33.9	13.9	-13.9	13.9	-13.9	64
24		Ground-Air-Ground	30.0	30.0	10.9	-10.9	10.9	-10.9	192
25			16.3	16.3	6.8	-6.8	6.8	-6.3	320
26			74.9	0.0	0.0	0.0	0.0	0.0	64

The nose landing gear block loading spectrum represents 64 composite missions. One block of loads consists of all load steps 1 through 26. Steps 1 through 3 each contain 3 sub-steps (a through c) which are applied in order each time that particular load step is applied. Thus, steps 1 through 3 contain 9 sub steps or 405 load cycles. The block spectrum has 11,029 cycles per block or 220,580 cycles per lifetime (20 blocks per life).

Notes

1. Sign Convention
 + Vertical Load - Up Load
 + Drag Load - Aft Load
 + Side Load - Load to the right side

2. Synchronization of Loads

For each spectrum step all loads shown as maximum loads, (i.e., vertical load, drag load, side load) applied simultaneously. Similarly for each spectrum step all loads shown as minimum are applied simultaneously.

NOSE LANDING GEAR TEST SPECTRUM - (Continued)

NOTES - Continued

3. Loads application Points and Strut Setting

All nose gear loads except towing loads are applied at the ground line. The towing loads are applied at the towing attachment, 10.13 inches above the axle center line.

An average strut stroke setting of 5.0 inches (measured from fully extended position) may be used for the landing segments, and a strut stroke setting of 14.0 inches may be used for all other segments.

12. NOSE LANDING GEAR SUPPORT REACTIONS

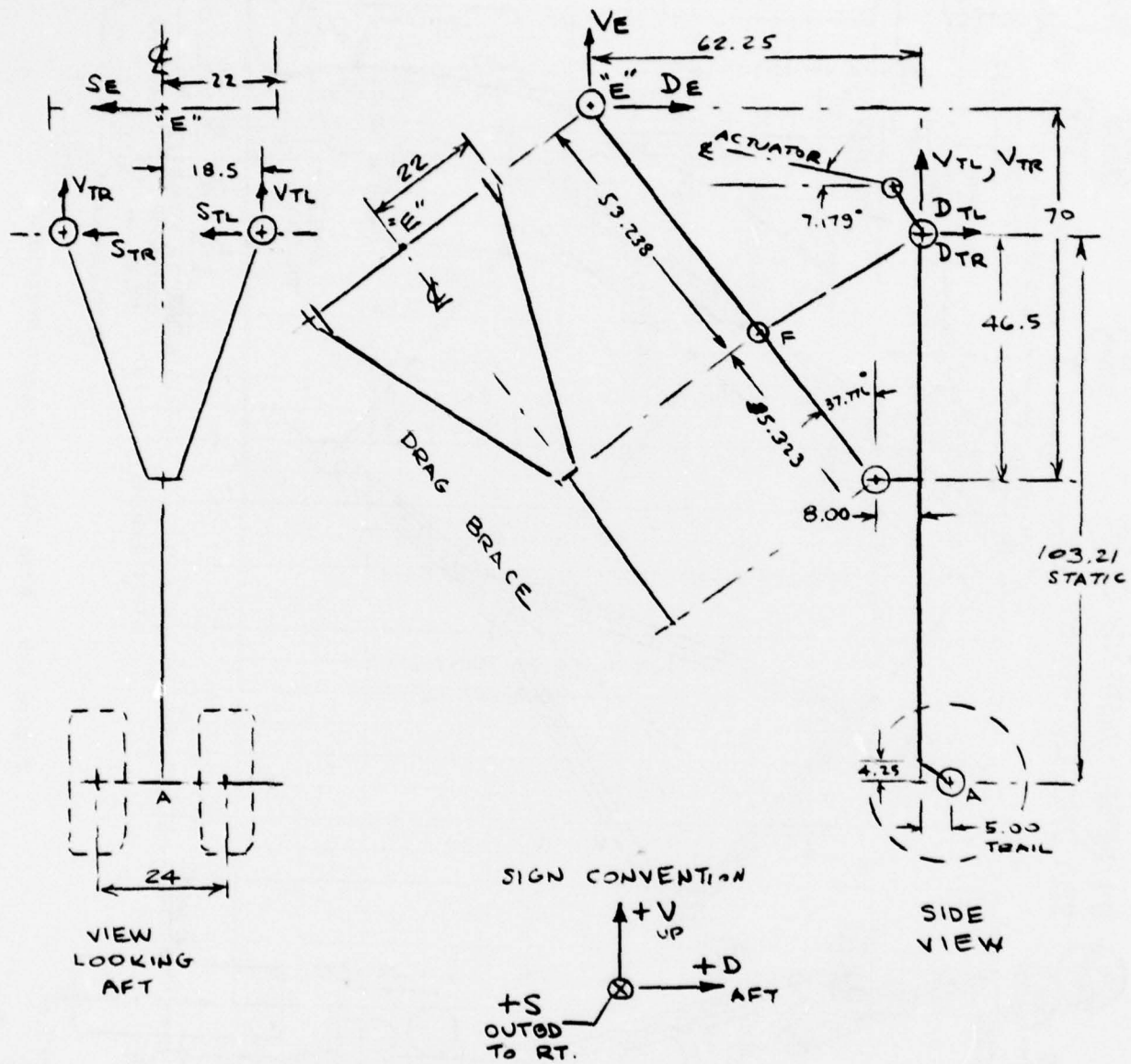


Figure C-8. Schematic - Nose Gear

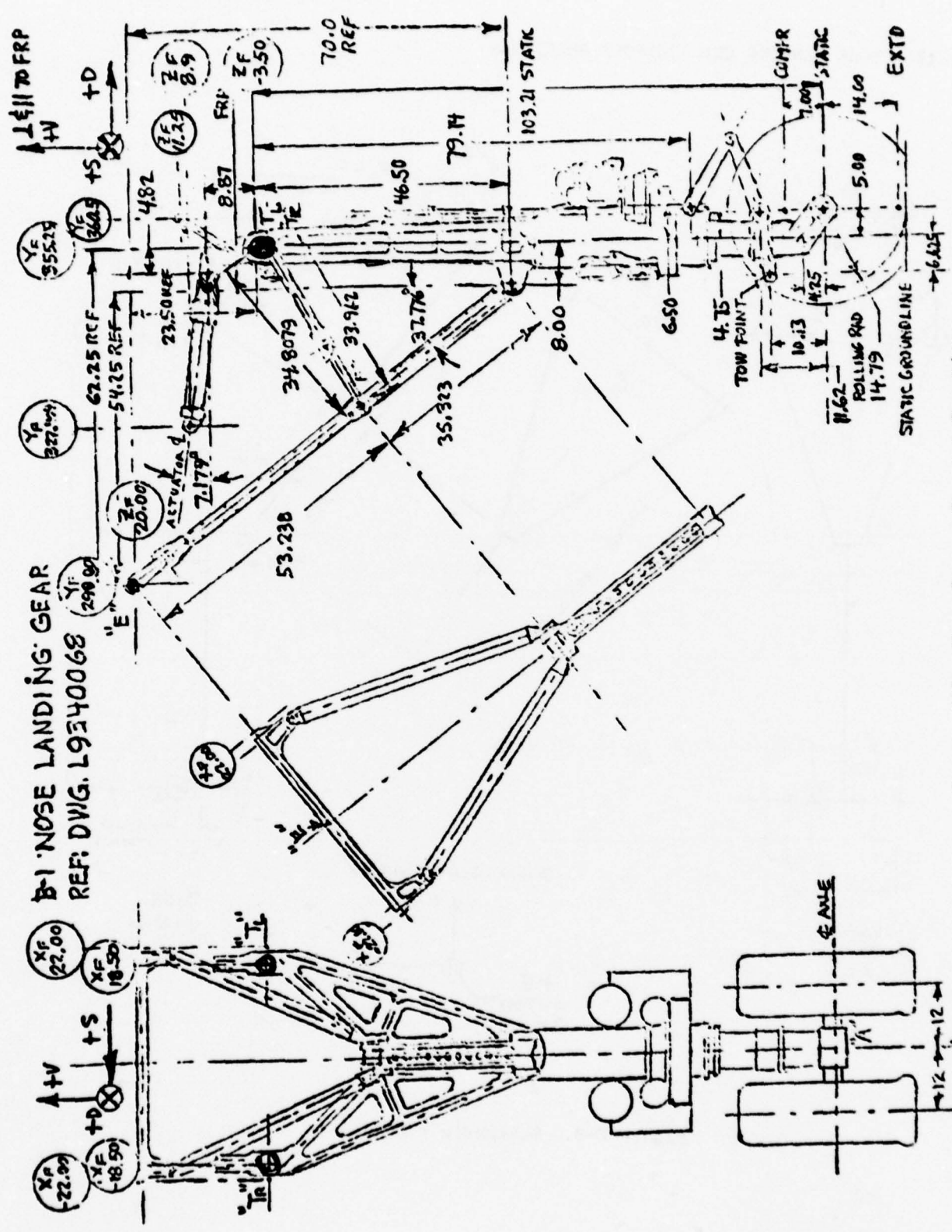


Figure C-9. Nose Gear - Support Reactions

TABLE C-IX

"DESIGN" DYNAMIC LANDING LOAD REACTIONS

- (1) Check "Design" Loads Versus Yield Strengths
 - (2) Ultimate Check Not Required
- Nose Gear Support Reactions (Ref. SDM - II-B-10.2.7.2, Sht. 2.1)

COND.	L,R	DE	SE	VE	DTL	STL	VTL	DTR	STR	VTR
SPIN UP	5,5	-112024.	0.	144528.	47609.	51859.	-104403.	47669.	-51859.	-104403.
SPIN UP	6,4	-112027.	146.	144558.	45435.	51791.	-108006.	49794.	-51937.	-100820.
SFIN UP	4,6	-112027.	-146.	144558.	49794.	51937.	-100820.	45435.	-51791.	-108006.
SPIN UP	1,0	-67038.	434.	86504.	26243.	30286.	-73551.	41315.	-30720.	-52967.
SPIN UP	0,1	-67038.	-434.	86504.	41315.	30720.	-52967.	28343.	-30266.	-73851.
SPR BACK	5,5	79738.	0.	-102894.	-2671.	-1522.	501.	-2671.	1522.	501.
SPR BACK	6,4	79738.	-152.	-102894.	-704.	-1440.	-6276.	-4573.	1599.	7277.
SPR BACK	4,6	79738.	152.	-102894.	-4573.	-1599.	7277.	-769.	1446.	-6276.
SPR BACK	1,0	43752.	-448.	-56458.	12181.	64.	-21624.	878.	385.	15240.
SPR BACK	0,1	43752.	448.	-56458.	178.	-385.	15248.	12151.	-64.	-21624.
MAX V +D	5,5	-72310.	6.	53307.	30642.	48892.	-97752.	30992.	-48892.	-97752.
MAX V +D	6,4	-72310.	68.	53307.	37105.	48358.	-104217.	40178.	-48358.	-91267.
MAX V +D	4,6	-72310.	-68.	53307.	40179.	48426.	-91287.	37805.	-48426.	-104217.
MAX V +D	1,0	-42587.	204.	54953.	25833.	28385.	-76886.	32841.	-28385.	-41019.
MAX V +D	0,1	-42587.	-204.	54953.	32841.	28385.	-76886.	25833.	-28385.	-41019.

DESIGN - REF. DEFORMATION REQTS - MIL-A-8860(ASG)
/UP, AFT, AND RIGHT POSITIVE - RIGHT HAND RULE FOR MOMENTS

ABOVE REACTIONS INCLUDE REACTIONS DUE TO ACTUATORS (Ref. Sht. 5.1)

TABLE C-X
 "LIMIT" TAXI AND HANDLING REACTIONS
 (Ref. SDM II B-10.2.7.2 Sht. 3.1 and Sht. 4.1)

COND.	L.R	DE	SE	VE	DTL	STL	VTL	DTR	STR	VTR
LFT TURN 5,5	5,5	-7795.	-146.	9941.	20619.	17239.	-62291.	18287.	-3030.	14582.
LFT TURN 4,6	4,6	-7705.	-142.	9941.	20637.	17237.	-60333.	18277.	-3032.	12624.
LFT TURN 1,0	1,0	-7716.	-112.	9956.	20134.	14620.	-57738.	18784.	-5718.	9901.
LFT TURN 0,1	0,1	-7716.	-70.	9957.	20242.	14599.	-38151.	18676.	-5739.	-9833.
RGT TURN 5,5	5,5	-7795.	146.	9941.	18287.	3030.	14582.	20619.	-1739.	-62291.
RGT TURN 4,6	4,6	-7705.	142.	9941.	18277.	3032.	12624.	20630.	-17237.	-60333.
RGT TURN 1,0	1,0	-7716.	70.	9957.	18676.	5739.	-9685.	20242.	-14599.	-38151.
RGT TURN 0,1	0,1	-7716.	112.	9956.	18784.	5718.	-9901.	20134.	-1739.	-62291.
UNSM B+S 5,5	5,5	-10505.	187.	13684.	19365.	9505.	10065.	22417.	-27518.	-6971.
UNSM B-S 5,5	5,5	-10675.	-187.	13684.	22417.	27518.	-89010.	19465.	-9505.	10065.
3 PT B R 5,5	5,5	-12537.	0.	16177.	22187.	25609.	-52698.	22184.	-25609.	-52698.
3 PT R R 6,4	6,4	-12537.	-13.	16177.	22187.	25616.	-53753.	22188.	-25602.	-47342.
3 PT R P 4,6	4,6	-12537.	13.	16177.	22188.	25692.	-47342.	22189.	-25616.	-53753.
3 PT H R 1,0	1,0	-9998.	-43.	12901.	20795.	17837.	-56163.	20796.	-17837.	-20324.
3 PT R R 0,1	0,1	-9998.	43.	12901.	20785.	17837.	-20324.	20786.	-17837.	-56163.
TAXI 5,5	5,5	-14354.	0.	13522.	22709.	28423.	-57773.	22709.	-23423.	-57573.
TAXI 6,4	6,4	-14354.	-13.	13522.	22185.	28430.	-63929.	22933.	-28417.	-52017.
TAXI 4,6	4,6	-14354.	13.	13522.	22933.	28417.	-52017.	22933.	-28430.	-53929.
TAXI 1,0	1,0	-10837.	-42.	13983.	20982.	19264.	-60120.	21161.	-19221.	-21557.
TAXI 0,1	0,1	-10837.	42.	13983.	21161.	19221.	-21552.	20982.	-19264.	-21557.
5A TOW 5,5	5,5	97225.	0.	-125449.	-18718.	-23555.	46189.	-18718.	23555.	46189.
5A TOW 6,4	6,4	97225.	-6.	-125449.	-18706.	-23552.	44230.	-18730.	23558.	48137.
5A TOW 4,6	4,6	97225.	6.	-125449.	-18730.	-23558.	46147.	-18706.	23552.	44230.
5A TOW 1,0	1,0	97225.	-29.	-125449.	-13656.	-23560.	36395.	-18780.	23570.	35981.
5A TOW 0,1	0,1	97225.	29.	-125449.	-14780.	-23570.	35982.	-13556.	23560.	36395.
6A TOW 5,5	5,5	-102275.	0.	131965.	21275.	43123.	-82576.	21275.	-43123.	-82576.
6A TOW 6,4	6,4	-102275.	-3.	131965.	21262.	43124.	-84529.	21309.	-43121.	-82576.
6A TOW 4,6	4,6	-102275.	3.	131965.	21309.	43121.	-87623.	21242.	-43126.	-84529.
6A TOW 1,0	1,0	-102275.	-13.	131965.	21106.	43129.	-92341.	21346.	-43116.	-72811.
6A TOW 0,1	0,1	-102275.	13.	131965.	21444.	43116.	-72811.	21106.	-43129.	-92341.

(1) Check ULTIMATE Case as 1.5 x "LIMIT" values.

ACTUATOR REACTIONS NOT INCLUDED

TABLE C-X
"LIMIT" TAXI AND HANDLING REACTIONS (Cont.)

CRND.	L.R	DE	SE	VE	DTL	STL	VTL	DIR	STR	VTR
7A TOW	5.5	103727.	0.	-133839.	-21969.	-25644.	50384.	-21969.	25644.	50384.
7A TOW	6.4	103727.	-6.	-133839.	-21957.	-25641.	48425.	-21982.	25647.	52343.
7A TOW	4.6	103727.	6.	-133839.	-21982.	-25647.	52343.	-21957.	25641.	48425.
7A TOW	1.0	103727.	-29.	-133839.	-21908.	-25630.	40590.	-22031.	25659.	60177.
7A TOW	0.1	103727.	29.	-133839.	-22031.	-25659.	60177.	-21908.	25650.	40590.
8A TOW	5.5	-96081.	0.	123973.	18179.	41132.	-78580.	18179.	-41132.	-78580.
8A TOW	6.4	-96081.	-3.	123973.	18145.	41134.	-80533.	18212.	-41131.	-76627.
1A TOW	4.6	-96081.	3.	123973.	18212.	41131.	-76627.	18145.	-41134.	-80533.
1A TOW	1.0	-96081.	-13.	123973.	18010.	41134.	-88345.	18348.	-41126.	-68015.
8A TOW	0.1	-96081.	13.	123973.	18348.	41126.	-68015.	18010.	-41139.	-88345.
9A TOW	5.5	33109.	54.	-42720.	-5916.	-12873.	48438.	-6028.	-1819.	-39176.
9A TOW	6.4	24195.	49.	-44122.	-6461.	-13220.	47770.	-6592.	-1463.	-37100.
9A TOW	4.6	32123.	59.	-41318.	-5395.	-12927.	49111.	-5465.	-9171.	-41256.
9A TOW	1.0	38540.	29.	-49729.	-6532.	-14606.	45075.	-8846.	-7002.	-28804.
9A TOW	0.1	27177.	79.	-35711.	-3304.	-11140.	51901.	-3211.	-10377.	-49142.
11A TOW	5.5	-37454.	57.	48327.	8385.	10708.	8448.	7973.	-32405.	-90275.
11A TOW	6.4	-38522.	56.	49705.	8883.	11052.	8365.	8542.	-32748.	-89561.
11A TOW	4.6	-36116.	58.	46949.	7887.	10365.	10531.	7403.	-32002.	-90971.
11A TOW	1.0	-42763.	52.	52116.	10876.	12426.	-1967.	10821.	-34118.	-86747.
11A TOW	0.1	-37114.	45.	41436.	5802.	8999.	9433.	5216.	-30083.	-84568.
11A TOW	5.5	37637.	62.	-48563.	-8082.	-14332.	57176.	-8393.	-7368.	-42070.
11A TOW	6.4	38723.	57.	-49965.	-8605.	-14675.	56503.	-8957.	-7017.	-39990.
11A TOW	4.6	36551.	67.	-47161.	-7559.	-13985.	57046.	-7829.	-7720.	-44145.
11A TOW	1.0	43166.	37.	-55572.	-10696.	-16605.	53813.	-11211.	-5011.	-31698.
11A TOW	0.1	32205.	56.	-41554.	-5468.	-12599.	60539.	-5575.	-9120.	-52442.
12A TOW	5.5	-33103.	40.	42584.	6197.	9287.	5661.	5710.	-30966.	-81682.
12A TOW	6.4	-31435.	41.	41200.	5698.	8943.	7684.	5141.	-30624.	-82388.
12A TOW	4.6	-34071.	34.	43962.	6695.	9630.	3518.	6280.	-31309.	-80978.
12A TOW	1.0	-27664.	45.	35694.	3705.	7509.	16010.	2605.	-29253.	-85209.
12A TOW	0.1	-38342.	35.	49473.	8680.	11005.	-4814.	8556.	-32679.	-76158.
JACK +6.		-25028.	0.	45197.	9559.	26141.	-49454.	9559.	-26141.	-49454.
JACK +0,+5		-35028.	47.	45197.	9701.	18162.	-11454.	9417.	-34119.	-87453.
JACK +5		-5390.	47.	6955.	2837.	8300.	7740.	2553.	-24259.	-68411.
JACK -0,+5		24375.	48.	-31451.	-4090.	-1602.	27029.	-4375.	-14345.	-49280.
JACK -6		24375.	0.	-31451.	-4252.	6377.	-11130.	-4252.	-6377.	-11130.

NOSE LANDING GEAR SUPPORT REACTIONS

DUE TO RETRACTION ACTUATORS: (Sheet 5.1)

During normal ground operation (landing and taxi, not towing or jacking) the retraction actuators are pressurized to extend the gear. (400 psi on the net area).

$$\text{Net Area} = 3.927 \text{ in}^2$$

$$\text{Pact} = 3.927 \times 4000 = 15708 \text{ lbs. each (LIMIT)}$$

The resulting support reactions are:

Drag Brace, Pt. E	DE = -4533
	SE = 0
	VE = 5849

Left Trunnion	DTL = 17851
	STL = -50
	VTL = -4887

Right Trunnion	DTR = 17851
	STR = 50
	VTR = -4887

(Ref. SDM IIB-10.2.7.2, Sht. 5.1)

APPENDIX D
ENVIRONMENTAL DATA

APPENDIX D
ENVIRONMENTAL DATA

A. THERMODYNAMIC ENVIRONMENT DATA

The B-1 System Definition Manual lists the following external environment data.

The temperature, pressure, and contaminant conditions to which the air vehicle and subsystem equipment will be exposed are defined in this section. Time of exposure and equipment operational requirements for both ground and flight conditions are defined, including alert, start, takeoff, and in-flight normal and emergency ECS operation.

1. System Surrounding Environment. The weapon system shall be capable of meeting specified worldwide conditions of weather and climate. Values for the extremes of worldwide climate shall be as specified in MIL-STD-210.

2. Storage and Transit. The weapon system (air vehicle and equipment) shall be capable of being started up after warmup to minus 65 F and performing as required after being subjected to the following storage and transit temperature and pressure conditions:
 - a. Temperature Minus 80 to plus 160F
 - b. Pressure 1.68 to 15.4 psia
 - c. Humidity Minus 65 to plus 85 F dewpoint
 - d. Rain 32-inch rainfall in 24-hour period
 at 70F as shown by Table C-1.
 - e. Blowing Sand 10 to 1,000 micron diameter with
 predominant diameters between
 150 and 300 microns; wind, 40 mph

- e. (continued) at 5-foot height; temperature, 100 F; concentration of sand 10 pounds per foot cross section
- f. Blowing Dust 6×10^{-9} grams/cc; 1 to 10 micron diameter; 40 mph at height of 5 feet; temperature, 70 F

TABLE D-1 RAINFALL PROPERTIES

Applicable to packaging for storage and transit and to air vehicle

ITEM	CRITERIA	CONDITION			
		1	2	3	4
a.	Amount (inches)	12	2	11*	7
b.	Duration (hours-minutes)	11:55	0:05	11:00	1:00
c.	Rate (inch/hour)	1	24	1	7
d.	Drop Size (mm), mean	2.25	4.0	2.25	3.2
e.	Standard Deviation (mm)	0.77	1.68	0.77	1.1

* Wind speed of 40 mph (35 knots) during this portion of cycle

3. Temperature and Altitude (Pressure). Installed equipment shall withstand exposure to the surrounding steady-state and transient temperature and pressure conditions specified below:

TABLE D-II

AIR VEHICLE EQUIPMENT SURROUNDING TEMPERATURE AND PRESSURE CONDITIONS

ENVIRONMENTAL PARAMETERS TEMPERATURE °F	UNCOOLED EQUIPMENT UNPRESSURIZED COMPARTMENTS WHEEL WELL BAYS
<u>GROUND</u> Nonoperating Operating	-80 to 203 -65 to 203
<u>INFLIGHT</u> NORMAL Nonoperating Operating EMERGENCY Operating and Nonoperating 5 Minute Duration Extended Duration <u>TRANSIENT</u> °F/sec	-65 to 265 -65 to 265 ----- ----- 3.0
PRESSURE paia <u>GROUND</u> Operating and Nonoperating Compartment Pressure Test	10.1 to 15.4 -----

AIR VEHICLE EQUIPMENT SURROUNDING TEMPERATURE AND PRESSURE CONDITIONS

(continued)

ENVIRONMENTAL PARAMETERS TEMPERATURE °F	UNCOOLED EQUIPMENT UNPRESSURIZED COMPARTMENTS WHEEL WELL BAYS
<u>INFLIGHT</u> Normal Operating and Nonoperating EMERGENCY Operating and Nonoperating 5 Minute Duration Extended Duration <u>TRANSIENT</u> psi/sec	 .65 to 15.4 ---- ---- 0.5

4. Humidity. The humidity of surrounding air will range from zero to 182 grains of water per pound of dry air, including the condition of moisture condensation in the form of liquid or frost.

5. Rain. The ground rain environment for the air vehicle and external equipment will be the operational worldwide ground precipitation extremes, Inflight rain shall be a design consideration for erosion, leakage, and vision through transparent areas.

6. Icing. Air vehicle components and equipment exposed to the external environment will experience icing conditions within the aircraft operating envelope bounded by airspeeds up to mach 0.85 at sea level, mach 1.1 at 8,000 feet, and mach 1.2 at 20,000 feet.

7. Salt Fog and Spray. The air vehicle and installed equipment will be exposed to salt-sea atmosphere having particle sizes as small as 1.0 micron in diameter.

8. Hail. The air vehicle and externally mounted equipment may be exposed to hailstones having a diameter up to 3/4 inch.
9. Sand and Dust. Dust particles will vary from 0.1 to 10 microns in diameter, and sand particles will vary from 10 to 1,000 microns in diameter, with predominant diameters less than 300 microns, at a velocity of 1,750 plus or minus 250 feet per minute. The sand and dust concentration will be up to 0.5 gram per cubic foot of air.
10. Fungus. The air vehicle and equipment will be exposed to fungus growth as encountered in tropical climates.

B. VIBRATION, ACOUSTIC NOISE, SHOCK AND ACCELERATION ENVIRONMENT DATA.

The B-1 Prime Item Development Specification lists the following data:

1. Vibration. The vibration levels to which the equipment shall be exposed is specified in Tables C-3 and C-4 and are composite curves of the predicted maximum vibration level encountered during air vehicle operation throughout the flight envelope.
2. Mass Attenuation. The air vehicle vibration levels in Tables C-3 and C-4 shall be reduced for equipment weight in excess of 80 pounds.
3. Acoustics. The maximum aircraft equipment noise level encountered during operation within the flight envelope shall be as shown by the internal and external operating noise levels in Table C-7. The equipment internal levels shall be based on the external levels and structural noise transmission loss.
4. Shock. Equipment design shall be based on the requirement to withstand and operate without malfunction during or after exposure, for a duration of 11 plus or minus 1 milliseconds, to:
 - a. Sawtooth shock pulses of 20G peak magnitude for rigidly mounted equipment weighing less than 300 pounds, or
 - b. Half-sine wave shock pulses of 15G peak magnitude for shock mounted equipment, or equipment weighing 300 pounds or more.

TABLE D-III

SINUSOIDAL VIBRATION LEVELS - EQUIPMENT OPERATING

Frequency Range Cycles per Second (cps)	Double Amplitude (da) Acceleration (G)
Nose gear wheel well Nose gear (shock strut) 5 to 10 10 to 100	0.2 inch da displacement 1G peak

TABLE D-IV

RANDOM VIBRATION LEVEL - EQUIPMENT OPERATING

Frequency Range Cycles per Second (cps)	Acceleration Power Spectral Density
Nose gear wheel well Nose gear (shock strut) 20 to 300 300 to 1,000 1,000 to 2,000	3 db per octave increase 0.2 G ² per cps 6 db per octave decrease

TABLE D-V

SINUSOIDAL VIBRATION LEVELS - EQUIPMENT NONOPERATING
(ACCELERATED TEST)

Frequency Range Cycles per Second (cps)	Double Amplitude (da)/ Acceleration (G)
Nose gear wheel well Nose gear (shock strut) 5 to 10 10 to 100	0.27 inch da displacement 1.35G peak

TABLE D-VI

RANDOM VIBRATION LEVELS - EQUIPMENT NONOPERATING
(ACCELERATED TEST)

Frequency Range Cycles per Second (cps)	Acceleration Power Spectral Density
Nose gear wheel well Nose gear (shock strut) 20 to 300 300 to 1,000 1,000 to 2,000	3 db per octave increase 0.037G ² per cps 6 db per octave decrease

TABLE D-VII

MAXIMUM OVERALL ACOUSTIC NOISE LEVELS (DB)
 (REFERENCED TO 0.0002 DYNE PER SQUARE CENTIMETER)

ZONE	EXTERNAL EQUIPMENT		INTERNAL EQUIPMENT	
	OPERATING	NONOPERATING	OPERATING	NONOPERATING
Nose Gear	147	151	132	136

TABLE D-VIII

SINUSOIDAL - RANDOM EQUIVALENT - EQUIPMENT OPERATING

Frequency Range Cycles per Second (cps)	Double Amplitude (da)/ Acceleration (G)
Nose gear wheel well Nose gear (shock strut)	
5 to 10	0.2 inch da displacement
10 to 140	1G peak
140 to 200	0.001 inch da displacement
200 to 2,000	2G peak

TABLE D-IX

SINUSOIDAL-RANDOM EQUIVALENT - EQUIPMENT NONOPERATING

Frequency Range Cycles per Second (cps)	Double Amplitude (da)/ Acceleration (G)
Nose gear wheel well Nose gear (shock strut)	
5 to 10	0.27 inch da displacement
10 to 140	1.35G peak
140 to 200	0.0014 inch da displacement
200 to 2,000	2.7G peak

TABLE D-X

SPECIAL ENVIRONMENTS

EXTENDED LANDING GEAR - UNSPRUNG MASS

Frequency Range Cycles per Second (cps)	Double Amplitude (da)/ Acceleration (G)
<u>Nose gear (axle assembly)</u>	
	Sinusoidal Operating
5 to 24	0.5 inch da displacement
24 to 2,000	15G peak
	Sinusoidal Nonoperating
5 to 28	0.5 inch da displacement
28 to 2,000	20G peak

TABLE D-X (Continued)

SPECIAL ENVIRONMENTS

EXTENDED LANDING GEAR - UNSPRUNG MASS (continued)

Frequency Range Cycles per Second (cps)	Double Amplitude (da)/ Acceleration (G)
<u>Wheels</u>	
Sinusoidal Operating	
5 to 34	0.5 inch da displacement
34 to 2,000	30G peak
Sinusoidal Nonoperating	
5 to 39	0.5 inch da displacement
39 to 2,000	40G peak

APPENDIX E
MAINTENANCE ANALYSIS DATA

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

PREPARED BY - R. Sandoval D/312
DATE - 9-7-77

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
PART NO - D619-3A

WUC - 13XXX

LRU NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES			
								OSE (ID)	PERSONNEL AFSC QTY	OTHER (SPECIFY)	
13CDA9C	TBD	Tire (Remove & Replace Defective or Worn Tire)	2	505	10	Fault Verification & Isolation <input checked="" type="checkbox"/> Inspection <input checked="" type="checkbox"/> Prep for R&R <input type="checkbox"/> Secure Access Drain Jack A/C <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	5	None	43151	1	
						Remove & Replace Assy & Dis-Assy	15	1 Jack	43171	1	
						Prep for Checkout Service Safety Hookup Inflate Tire	5	GN2 Bottle	43151	2	
						Checkout	5	None	43151	1	

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRJ MUC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 RH	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES			
								OSE (ID)	PERSONNEL AFSC	OTHER QTY (SPECIFY)	
13EAC	TBD	Brake Stack Assy.	2	3434	78	Fault Verification & Isolation Check Wear <input checked="" type="checkbox"/>	5	None	43151	1	
						Prep for R&R Secure Access Drain Jack A/C <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>	30	Jacks	43151	1	
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/> <input type="checkbox"/>	15	Tools	43151	1	
						Prep for Checkout Service Safety Hookup <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	15		43151	1	Hyd Cart Elect Cart
						Checkout Activate Brakes <input checked="" type="checkbox"/>	10		43151	2	" "
						Closout Adjust Brakes Every 50 Landings <input type="checkbox"/>	5	None	43151	1	
					6.5		40	Jacks		2	

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline PREPARED BY - R. Sandova1 D/312
 MUC - 13.XXX PART NO - D619-3A DATE - 9-7-77

LRJ NUC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 FH	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT PERSONNEL		RESOURCES OTHER (SPECIFY)
								OSE (ID)	AFSC QTY	
13E8E	TBD	Brake Actuator Assembly	2	2290	.78	Fault Verification & Isolation <input type="checkbox"/>				
						Prep for R&R <input type="checkbox"/>				
						Secure <input checked="" type="checkbox"/>	10	43151	1	
						Access <input checked="" type="checkbox"/>	30	43151	1	
						Drain <input checked="" type="checkbox"/>				
						Jack A/C <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/>	15	43151	1	
						Tools <input checked="" type="checkbox"/>	15	43151	1	
						Prep for Checkout Service <input checked="" type="checkbox"/>	10	43151	1	Hyd Cart
						Safety <input type="checkbox"/>				Elect Cart
						Hookup <input checked="" type="checkbox"/>	15			
						Checkout Operate Brakes <input checked="" type="checkbox"/>	10	43151	2	"
						Closeout <input type="checkbox"/>	5	43151	1	"

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline PREPARED BY - R. Sandoval D/312
 WUC - 13000 PART NO - D619-3A DATE - 9-7-77

LIRJ WUC NO.	LIRJ PART NO.	LIRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	NDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT PERSONNEL		RESOURCES OTHER (SPECIFY)
								OSE (ID)	AFSC QTY	
13CBL	TBD	Strut Hyd. Actuator	2	1517	.15	<input checked="" type="checkbox"/> Fault Verification & Isolation <input type="checkbox"/> Inspect Prep for R&R <input type="checkbox"/> Secure <input type="checkbox"/> Access <input checked="" type="checkbox"/> Drain	5	None	43151 1	
						<input type="checkbox"/> Remove & Replace Assy & Dis-Assy Prep for Checkout <input checked="" type="checkbox"/> Service <input type="checkbox"/> Safety <input checked="" type="checkbox"/> Hookup	10	Hyd. Cart	43151 1	Hyd Cart Elect Cart
						<input checked="" type="checkbox"/> Checkout <input type="checkbox"/> Swing Gear <input type="checkbox"/> C/checkout	30	None	43151 3	"
							15	Tools	43151 1	

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRU NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MBR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC	OTHER QTY (SPECIFY)
13BA09A	TBD	MLG Cylinder	2	28,584	.135	Fault Verification & Isolation Verify Leaks <input checked="" type="checkbox"/>	10	None	43151	1
						Prep for R&R Secure Access Drain <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	30	Jacks Hyd Con-tainer	43151	2
						Jack A/C Depressurize GN ₂ Drain Hyd. <input type="checkbox"/> <input checked="" type="checkbox"/>	30		43151	2
						Remove & Replace Assy & Dis-Assy Replace Seals <input type="checkbox"/> <input checked="" type="checkbox"/>	15		43151	2
						Prep for Checkout Service Safety hookup <input checked="" type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	15	Hyd Cart GN ₂ 2000 psi	43151	2
						Checkout <input checked="" type="checkbox"/>	15	"	43151	2
						Closeout <input type="checkbox"/>	5	None	43151	1

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 W/C - 13XXX
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRJ MUC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES			
								OSE (ID)	PERSONNEL A/FSC QTY	OTHER (SPECIFY)	
13CDA9*	TBD	Wheel Assy. (R&R)	2	2888	.125	Fault Verification & Isolation Inspection <input checked="" type="checkbox"/>	5	None	43151	1	
						Prep for R&R Secure Access Drain Jack A/C <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>	30	Jacks	43151	3	
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/> <input type="checkbox"/>		Jacks Tools	43151	2	
						Prep for Checkout Service Safety Hookup <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	5	None	43151	1	
						Checkout <input type="checkbox"/>	10	Pwr.	43151	3	Hyd. Cart Elect. Pwr. Cart
						Closoout <input type="checkbox"/>	5	None	43151	1	

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 MJC - 13000 PRT NO - D619-3A

PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRJ WJC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MOR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		OTHER (SPECIFY)
								OSE (ID)	PERSONNEL AFSC QTY	
13BAC1	TBD	Down Lock Assembly	2	2009	.083	Fault Verification & Isolation <input checked="" type="checkbox"/> Jack A/C, Inspect Rigging	30	Jacks	43151 3	Hyd. Cart Elect. Cart
						Prep for RER Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/>	20	Jacks	43151 1	
						Prep for Checkout Service <input type="checkbox"/> Safety <input type="checkbox"/> Hookup <input checked="" type="checkbox"/>	15		43151 3	Hyd. Cart Elect. Cart
						Checkout <input checked="" type="checkbox"/> Swing Gear	15	Jacks	43151 3	Hyd. Cart Elect. Cart
						Closout <input type="checkbox"/>	10	None	43151 1	

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 WUC - 13XXX
 PART NO - D619-3A
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LIRU MUC NO.	LIRU PART NO.	LIRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT		RESOURCES OTHER (SPECIFY)
								OSE (ID)	PERSONNEL AFSC QTY	
13BAC	TBD	Up-Lock Assy.	2	2009	083	Fault Verification & Isolation Jack A/C, Inspect Rigging <input checked="" type="checkbox"/>	30	Jacks	43151 3	Hyd Cart Elect Cart
						Prep for R&R Secure Access Drain <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/> <input type="checkbox"/>	20	Jacks	43151 1	
						Prep for Checkout Service Safety Hookup <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	15		43151 3	Hyd Cart Elect Cart
						Checkout Swing Gear <input checked="" type="checkbox"/>	15	Jacks	43151 3	Hyd Cart Elect Cart
						Closeout <input type="checkbox"/>	10	None	43151 1	

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 RUC - 13XXX
 PART NO - D619-3A
 PREPARED BY - R. Sandova1 D/312
 DATE - 9-7-77

LRJ RUC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								PERSONNEL	OTHER	
								AFSC	QTY	
13BAQ1	TBD	Torque Link, Upper	2	820	.011	Fault Verification & Isolation <input checked="" type="checkbox"/> Inspect Wear & Alignment <input checked="" type="checkbox"/>	30	Alignment Tools	43151	1
		Prep for R&R Secure Access Drain				<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>				
		Remove & Replace Assy & Dis-Assy				<input checked="" type="checkbox"/> <input type="checkbox"/>	30	Tools	43151	2
		Prep for Checkout Service (Grease) Safety Hookup				<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	15	Grease Gun	43151	1
		Checkout				<input checked="" type="checkbox"/>	15	Tools	43151	2
		Closeout				<input type="checkbox"/>				

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 MUC - 13000 PART NO - D619-3A

PREPARED BY - R. Sandoval D/512
 DATE - 9-7-77

LRU MUC NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HH	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC QTY	OTHER (SPECIFY)
13BAQ2	TBU	Torque Link, Lower		820	.011	Fault Verification & Isolation <input checked="" type="checkbox"/> Inspect Wear & Alignment <input checked="" type="checkbox"/> Prep for R&R <input type="checkbox"/> Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/>	30	Align-ment Tools 43151	1	
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/>	30	Tools 43151	2	
						Prep for Checkout Service (Grease) Safety Hookup <input checked="" type="checkbox"/>	15	Grease Gun 43151	1	
						Checkout Check Alignment <input checked="" type="checkbox"/> Closout <input type="checkbox"/>	15	Tools 43151	2	

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 WUC - 13XXX
 PART NO - D619-3A

PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRU NUC NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC	OTHER (SPECIFY)
13BA49B	TBD	MLG Piston	2	26,412	.007	Fault Verification & Isolation <input checked="" type="checkbox"/> Inspection <input checked="" type="checkbox"/>	10	None	43151	1
						Prep for R&K <input type="checkbox"/> Secure <input checked="" type="checkbox"/> Access <input checked="" type="checkbox"/> Drain <input checked="" type="checkbox"/>	30	Jacks	43151	3
						Jack A/C <input type="checkbox"/> Drain Hyd <input type="checkbox"/> Dump GN ₂ Press. <input type="checkbox"/>	15	Hyd Cont."		2
						Remove & Replace Assy & Dis-Assy <input type="checkbox"/>	10	N/A	43151	2
						Prep for Checkout <input checked="" type="checkbox"/> Service GN ₂ Hyd <input type="checkbox"/> Safety Hookup <input type="checkbox"/>	60	Tools	43151	3
						Checkout <input type="checkbox"/> Closeout <input type="checkbox"/>	30	GN ₂ Hyd Cart	43151	3

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 MJC - 13XXX

LRU PART NO. - TBD

PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRU NUC NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 FH	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES			
								OSE (ID)	PERSONNEL AFSC	OTHER (SPECIFY)	
130CB	TBD	Anti-Skid Detector	2	807	.0068	Fault Verification & Isolation Check Detector <input checked="" type="checkbox"/>	15	Anti-Skid Test Set	42350	2	
						Prep for R&R Secure Access Drain <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>					
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/> <input type="checkbox"/>	15	Tools	42350	1	
						Prep for Checkout Service Safety Hookup <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	15	Anti-Skid Test Set	42350	1	
						Checkout Rotate Sensor <input checked="" type="checkbox"/>	10	"	42350	2	Elect Pwr. Cart
						Closcout <input checked="" type="checkbox"/>	5		42350	1	

TABLE E-1

ON-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 WUC - 13XXX
 PART NO - D619-3A
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRJ WUC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 FH	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC QTY	OTHER (SPECIFY)
13BA9C	TBD	Axle	2	8650	.005	Fault Verification & Isolation Inspection <input checked="" type="checkbox"/> <input type="checkbox"/>	10	None	43151 1	
						Prep for R&R Secure Access Drain <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	Remove Wheel & Brake Assy 13CDAD*, 13EAC, 13EBC	See LRJ Shts for Details		
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/> <input type="checkbox"/>	30	Tools	43151 3	
						Prep for Checkout Service Safety Hookup <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Covered in Maint. of in the way Removal Items (N ₂ & Hyd.)			
						Checkout Inspection <input checked="" type="checkbox"/>	10		43151 1	Hyd. Cart Elect. Cart
						Closetout <input checked="" type="checkbox"/>	10		43151 2	

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 WJC - 13000 PART NO - D619-3A PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRJ NUC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MOR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC QTY	OTHER (SPECIFY)
13CDA9C	TBD	Tire	2	505	10	R&R Tire from Wheel Assy. Fault Verification & Isolation <input type="checkbox"/>				Retread or New Tire
						Prep for R&R Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/> <input type="checkbox"/>	20	Tools	42354	1 Holding Fixture
						Prep for Checkout Service <input checked="" type="checkbox"/> Safety <input type="checkbox"/> Hookup <input type="checkbox"/> Inflate <input type="checkbox"/>	10	GN ₂ Source	42354	1 GN ₂ & Tire Inflation Cage
						Checkout <input type="checkbox"/>				
						Closeout <input type="checkbox"/>				

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 KUC - 1300X PART NO - D619-3A
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRU MUC NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MOR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES			
								OSE (ID)	PERSONNEL AFSC QTY	OTHER (SPECIFY)	
13EAC	TBD	Brake Stack Assy.		3434	.78	RER Disks Fault Verification & Isolation <input type="checkbox"/>					
						Prep for RER Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/>					
						Remove & Replace Assy & Dis-Assy <input type="checkbox"/> <input checked="" type="checkbox"/>	30	Bench Tools	53150	1	Replace w/New Discs Discard Old Discs
						Prep for Checkout Service <input type="checkbox"/> Safety <input type="checkbox"/> Hookup <input type="checkbox"/>					
						Checkout <input checked="" type="checkbox"/>	10	None	53150	1	
						Closeout <input type="checkbox"/>					

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

PREPARED BY - R. Sandoval D/312
DATE - 9-7-77

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
PART NO - D619-3A

WUC - 13XXX

LRU NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC	OTHER QTY (SPECIFY)
13EBE	TBD	Brake Actuator Assy.	2	2290	.78	Repair Cylinder(s) Fault Verification & Isolation <input type="checkbox"/>				
						Prep for R&R Secure Access Drain <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy <input type="checkbox"/> <input checked="" type="checkbox"/>	60	Bench Tools	42354	1
						Prep for Checkout Service Safety Hookup <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>	10	Actuator Test Set	42354	1
						Checkout <input checked="" type="checkbox"/>	15	Actuator Test Set	42354	1
						Closeout <input type="checkbox"/>				

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

13CBL - 13XXX
 PART NO - D619-3A

LRJ NUC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES			
								OSE (ID)	PERSONNEL AFSC QTY	OTHER (SPECIFY)	
13CBL	TBL	Strut Hyd. Actuator	2	1517	.15	Fault Verification & Isolation <input checked="" type="checkbox"/> Verify Failure <input type="checkbox"/> Prep for R&R <input type="checkbox"/> Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/> Remove & Replace <input type="checkbox"/> Assy & Dis-Assy <input checked="" type="checkbox"/> Clean, Replace Seals <input type="checkbox"/> Refinish <input type="checkbox"/> Prep for Checkout <input type="checkbox"/> Service <input type="checkbox"/> Safety <input type="checkbox"/> Hookup <input type="checkbox"/> Checkout <input checked="" type="checkbox"/> Closeout <input type="checkbox"/>	15	Actuator Stand 42354	1		
							60	Depot Equip	53150	1	Depot Actuator Sta.
							15	Actuator Stand	42354	1	

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

PREPARED BY - R. Sandoval D/312
DATE - 9-7-77

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
PART NO - D619-3A

MUC - 13XX

LRU NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES	
								OSE (ID)	PERSONNEL AFSC QTY
13BA09A	TBD	MIG Cylinder	2	28,584	.135	Fault Verification & Isolation <input type="checkbox"/>	60	Depot Equip.	53150 1 Depot Actuator Sta.
						Prep for MGR Secure Access Drain <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>			
						Remove & Replace Assy & Dis-Assy Clean, Replace Upper Seals, Refinish Prep for Checkout Service Safety Hookup <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/>	15	Actuator Test Stand	42354 1 Depot Test Sta.
						Checkout Closeout <input checked="" type="checkbox"/> <input type="checkbox"/>			

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 WUC - 13000 PART NO - D619-3A
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRU NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (1D)	PERSONNEL AFSC	OTHER QTY (SPECIFY)
13CDA9*	TBD	Wheel Assy (Replace Bearings) (2)	2	2888	.125	R&R Bearings				
						Fault Verification & Isolation <input type="checkbox"/>				
						Prep for R&R Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/> <input type="checkbox"/>	15	None	53150	1
						Prep for Checkout Service <input checked="" type="checkbox"/> Safety Hookup <input type="checkbox"/> Grease Bearings <input type="checkbox"/>	10	None	53150	1
						Checkout Inspection <input checked="" type="checkbox"/> Closeout <input type="checkbox"/>	10	None	53150	1

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

PREPARED BY - R. Sandoval D/312
DATE - 9-7-77

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
PART NO - D619-3A

WUC - 13XXX

LRU WUC NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES	
								PERSONNEL (ID)	OTHER (SPECIFY)
13BAC1	TBD	Down Lock Assy.	2	2009	.083	Repair Hyd. Actuator Fault Verification & Isolation <input checked="" type="checkbox"/>	15	Hyd Test Stand 42354	1
		Prep for R&R Secure Access Drain				<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>			
		Remove & Replace Assy & Dis-Assy				<input type="checkbox"/> <input checked="" type="checkbox"/>	30	Bench Tools 42354	1
		Prep for Checkout Service Safety Hookup				<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>			
		Checkout				<input checked="" type="checkbox"/>	15	Hyd Test Stand 42354	1
		Closout				<input type="checkbox"/>			

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OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline PREPARED BY - R. Sandoval D/312
 WUC - 13XX PAKT NO - D619-3A DATE - 9-7-77

LRJ WUC NO.	LRJ PAKT NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES	
								USE (ID)	PERSONNEL AISC QTY OTHER (SPECIFY)
13BAC2	TBD	Uplock Assy	2	2009	.083	Repair Hyd. Actuator	15	Hyd Test Stand	42354 1
						Fault Verification & Isolation	15		
						Prep for M&R Secure Access Drain			
						Remove & Replace Assy & Dis-Assy	30	Bench Tools	42354 1
						Prep for Checkout Service Safety Hookup	15	Hyd Test Stand	42354 1
						Checkout			
						Closure			

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

PREPARED BY - R. Sandoval D/312
DATE - 9-7-77

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
PART NO - D619-3A

WUC - 13XXX

LIRU WUC NO.	LIRU PART NO.	LIRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC	OTHER QTY (SPECIFY)
13BAQ1	TBD	Torque Link, Upper	2	820	.011	Replace Bearings (2) Fault Verification & Isolation Inspect <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	15	None	42354	1
						Prep for R&R Secure Access Drain <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	20	Bearing Tool	53150	1
						Remove & Replace Assy & Dis-Assy <input checked="" type="checkbox"/> <input type="checkbox"/>		None	53150	1
						Prep for Checkout Service Safety Hookup <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>				
						Checkout <input checked="" type="checkbox"/>	15	None	53150	1
						Closout <input type="checkbox"/>				

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 PREPARED BY - R. Sandoval D/312
 WUC - 13XXX PART NO - D619-3A DATE - 9-7-77

LRJ MUC N.O.	LRJ PART N.O.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 Hr	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC	OTHER (SPECIFY) QTY
13BAQ2	TBD	Torque Link Lower	2	820	.011	Replace Bearings (2) Fault Verification & Isolation Inspection Prep for R&R Secure Access Drain	15	None	42354	1
						<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy Prep for Checkout Service Safety Hookup	20	Bearing Tool	53150	1
						<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>				
						Checkout Closeout	15	None	53150	1
						<input checked="" type="checkbox"/> <input type="checkbox"/>				

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

PREPARED BY - R. Sandoval D/312
DATE - 9-7-77

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
PART NO - D619-3A

LRU M/C NO.	LRU PART NO.	LRU NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		OTHER (SPECIFY)
								OSE (ID)	PERSONNEL AFSC QTY	
13BA9B	TBD	MLG Piston	2	26,412	.007	Clean & Resurface Piston	10	None	53150	1 Depot Gages
						Fault Verification & Isolation Inspection <input checked="" type="checkbox"/>				
						Prep for R&R Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy Clean & Resurface <input type="checkbox"/> <input checked="" type="checkbox"/>	30	None	53150	1 Depot Equipment
						Prep for Checkout Service Safety Hookup <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>				
						Checkout Inspection <input checked="" type="checkbox"/>	10	None	53150	Depot Gages
						Closeout <input type="checkbox"/>				

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 WUC - 13000 PART NO - D619-3A
 PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRJ WUC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								PERSONNEL (ID)	A/FSC QTY	OTHER (SPECIFY)
136CB	TBD	Anti-Skid Detector	2	807	.0068	Fault Verification & Isolation <input type="checkbox"/> Prep for RGR Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/>	NOTE:		THIS ITEM IS A DISCARD ITEM FOR REMOVAL FROM AIRCRAFT	
						Remove & Replace Assy & Dis-Assy <input type="checkbox"/> <input type="checkbox"/> Prep for Checkout Service <input type="checkbox"/> Safety Hookup <input type="checkbox"/> <input type="checkbox"/>			NO OFF-AIRCRAFT MAINTENANCE IS REQUIRED.	
						Checkout <input type="checkbox"/> Closeout <input type="checkbox"/>				

TABLE E-II

OFF-AIRCRAFT CORRECTIVE MAINTENANCE ANALYSIS

SYSTEM NOMENCLATURE - Main Gear Assembly - Metallic Baseline
 WUC - 13XXX

PART NO - D619-3A

PREPARED BY - R. Sandoval D/312
 DATE - 9-7-77

LRJ WIC NO.	LRJ PART NO.	LRJ NOMENCLATURE	QTY PER A/C	UNIT COST \$	MDR PER 1000 HI	MAINTENANCE TASK DESCRIPTION	TASK TIME MIN.	MAINTENANCE SUPPORT RESOURCES		
								OSE (ID)	PERSONNEL AFSC	OTHER QTY (SPECIFY)
13BA9C	TBD	Axle	2	8650	.005	Clean and Resurface				
						Fault Verification & Isolation <input checked="" type="checkbox"/>	10	None	53150	1 Depot Gages
						Prep for R&R Secure <input type="checkbox"/> Access <input type="checkbox"/> Drain <input type="checkbox"/>				
						Remove & Replace Assy & Dis-Assy Clean & Resurface <input type="checkbox"/> <input checked="" type="checkbox"/>	30	None	53150	1 Depot Equipment
						Prep for Checkout Service <input type="checkbox"/> Safety <input type="checkbox"/> Hookup <input type="checkbox"/>				
						Checkout Inspection <input checked="" type="checkbox"/>	10	None	53150	Depot Gages
						Closeout <input type="checkbox"/>				