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FZS-38-249

Stress Analysis of Landing Gear XB-36

Brown, W. W.; Redwine, D. A.
Consolidated Vultee Aircraft Corp., Fort Worth Div., Texas
USAF Contr. No. W535-ac-22352

June '48 UnClass. U.S. English 39 tables, diagrs

A stress analysis has been made of the landing gear of the XB-36 bomber to determine whether or not the gear meets the requirements of existing criteria. The report is divided into two parts, one of which deals with the main landing gear and the other dealing with the nose gear. Descriptive matter for each gear appears under its respective analysis. Results of the analysis are shown in tables, diagrams, and formulas.

Copies of this report obtainable from CADO

Structures (7)
Stress Analysis of Specific Aircraft (6) XB-36 (99409)

(1)
Landing gears - Stress analysis (54537);

USAF C.N. W535-ac-22352

CONSOLIDATED VULTEE

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MODEL [illegible]

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12. Drawing #[illegible]
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16. Bendix Report #[illegible]
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[illegible]
[illegible], Str[illegible]
[illegible] - (BENDIX)
23. FZW - 36 - 002 ESTIMATED WEIGHT & BALANCE FOR XB-36 AIRPLANE

ANALYSIS Main Landing Gear
PREPARED BY W.W. BROWN
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REVISED BY

Consolidated Vultee Aircraft Corporation
FORT WORTH DIVISION
FORT WORTH, TEXAS

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MODEL XB-36
DATE 5-17-45

INTRODUCTION

The purpose of this report is to show that the XB-36 landing gear meets all of the requirements of existing criteria for such a gear. It is felt that this purpose can be achieved best by utilizing as far as possible the work which has been done on other gears.

This report is divided into two parts, one of which deals with the Main Landing Gear and the other of which deals with the Nose Gear. Descriptive matter for each gear appears under its respective analysis.

Page 1-A gives a list of definitions for all technical terms and symbols used in this report.

SYMBOLS & DEFINITIONS

* 1. GROUND REACTION = LOADS WHICH GROUND APPLIES TO THE GEAR AT GROUND CONTACT POINTS.

* 2. GROUND LOADS = LOADS WHICH ARE APPLIED TO THE GEAR STRUCTURE (I.E.; GROUND REACTIONS LESS THE INERTIA OF ITEMS DIRECTLY RESISTING GROUND REACTION)

3. V_R' = VERTICAL GROUND REACTION

4. D_R' = DRAG GROUND REACTION

5. S_R' = SIDE GROUND REACTION

6. wg = INERTIA OF ITEMS WHICH DIRECTLY RESIST GROUND REACTION.

7. $V_R = V_R' - wg$

8. $D_R = D_R' - wg$

9. $S_R = S_R' - wg$

10. NOTE: IF SUBSCRIPT "f" BE USED INSTEAD OF "R" THE LOAD IS FOR THE NOSE GEAR.

11. V_p = LOAD VECTOR PARALLEL TO ℄ STRUT AT PT. "P"

12. d_p = LOAD VECTOR, FORE OR AFT & NORMAL TO STRUT AT POINT "P"

13. M_{V_p} = MOMENT ABOUT V_p VECTOR AT PT. "P"

* NORMAL & PARALLEL TO GROUND

14. M_{d_p} = MOMENT ABOUT VECTOR d_p AT PT. "P"

15. M_{s_p} = MOMENT ABOUT VECTOR S_p AT PT "P"

16. "EQUIVALENT WHEEL CENTER" IS THE POINT OF INTERSECTION OF A HORIZONTAL LINE PASSING THROUGH THE TWO WHEEL CENTERS & A VERTICAL LINE WHICH REPRESENTS THE LOCATION OF THE VERTICAL LOAD.

17. I_W = POLAR MOMENT OF INERTIA OF ONE WHEEL
= SLUG-FT^2

18. V_L = LANDING VELOCITY FT/SEC

19. V_P = PRE-ROTATION VELOCITY FT/SEC

20. μ = COEFFICIENT OF FRICTION

21. r_e = EFFECTIVE ROLLING RADIUS FT.

22. W = GROSS WEIGHT OF AIRPLANE

23. t_1 = TIME IN SECONDS BETWEEN GROUND CONTACT & BUILD-UP OF MAXIMUM VERTICAL LOAD.

NOTE: OTHER SYMBOLS USED HAVE COMMONLY ACCEPTED MEANING OR ARE DEFINED BY SKETCHES THROUGH-OUT THE REPORT

PART I

MAIN LANDING GEAR

The main landing gear on the XB-36, per Dwg. #2615002, is of the four-wheel type used on the B-36A, and is in most respects identical to the B-36A gear. Table I has been included on page 6 to indicate the make-up of the gear.

Although the original XB-36 main gear was of the single-wheel type similar to the one used on the YB-36, (Ref. 2), the four-wheel gear is considered as being the final arrangement and no analysis of the single-wheel gear will be shown.

Due to similarities between the XB-36 Airplane and the B-36A Airplane, the same conditions will be investigated for the XB-36 main gear as were investigated for the B-36A main gear. These conditions, which are listed below, are based on ANC-2 Ground Loads Handbook (with errata sheet #2) and Air Technical Service Command Memorandum Report #TSEAL2-42[illegible]-1 of September 12, 1945.

Landing Conditions

(1) Side-Drift Landing
(2) Two-Wheel Landing with Vertical Reactions
(3) One-Wheel Landing with Vertical Reaction
(4) Two-Wheel Landing with Brakes (Nose Down)
(5) Two-Wheel Landing with Inclined Reactions Has been replaced by (5_a), (5_b), and (5_c)*

(5_a) Max. Vertical Load
(5_b) Spin-up - NOT CRITICAL
(5_c) Spring Back

(6) Rebound - Not Critical

* [illegible] Ref.

Discussion of Loads

Because of identical geometry for XB-36 main gear and B-36A main gear (page 6), it follows that any change in member loads is a function of ground-loads only. For Condition (1) through (5_a), Ref. pg. 2 , the ratio $\frac{D}{V}$ is not affected by a change in landing gross weight or center-of-gravity location (Ref. 3 & 4), and, therefore, any reduction in landing gross weight results in lesser member loads. The critical landing gross weight for the B-36A main gear is DGW (Less Bombs) 26[illegible],[illegible]00 lbs. (Ref. 3), and for the XB-36 is DGW (Less Bombs) 255,271 lbs. (Ref. 5). Hence all XB-36 main gear member loads are smaller than corresponding B-36A main gear member loads for Conditions (1) through (5a), and for members which are common to both airplanes, no further analysis for these conditions is necessary (see page 6&7).

CONDITION OF DYNAMIC SPRING BACK — DGW (LESS BOMBS)

$$V_R = V_{R_{MAX}} = \frac{1.5nW}{2} - \frac{1.5(wg)}{2} = \frac{1.5 \times 2.67}{2}(255{,}271 - 12040) = 486{,}462^{\#}$$

$$D_R = 1.5 F_{H\,MAX}$$

$$F_{H\,MAX} = \left[\frac{2 I_W (V_L - V_P)\,\mu_{MAX} F_{V\,MAX}}{r_e^2 \times t_1}\right]^{1/2}$$

$$F_{V\,MAX} = \frac{nW}{2} = \frac{2.67 \times 255{,}271}{2} = 340{,}000^{\#} \quad \text{LIMIT}$$

$$I_W = 40.7 \;;\; r_e = 2.21 \;;\; \mu_{MAX} = .55 \;;\; V_L = 176\left(\frac{255271}{268000}\right)^{1/2} = 172\ \text{FT/SEC}$$

$$V_P = 0 \;;\; t_1 \propto \sqrt[3]{W} = .3\left(\frac{255271}{268000}\right)^{1/3} = .295 \quad \text{REF. ----(3)\&(7)}$$

$$D_R = 1.5\left[\frac{2 \times 4 \times 40.7 \times 172 \times .55 \times 340{,}000}{(2.21)^2 \times .295}\right]^{1/2} = -128{,}000^{\#}$$

BELOW IS A COMPARISON OF XB-36 GROUND LOADS TO B-36A GROUND LOADS FOR CONDITION 5 PG —

XB-36 DGW (LESS BOMBS) (255,271 #)	B-36A DGW (LESS BOMBS) (268000)
$V_R = 486{,}462^{\#}$	$V_R = 511{,}920^{\#}$
$D_R = -129000^{\#}$	$D_R = -131{,}500^{\#}$

THIS CONDITION YEILDS HIGHEST COMPRESSIVE LOAD IN DRAG STRUT & SINCE $\frac{D}{V}$ IS NOT CONSTANT FOR THIS CONDITION, MEMBER LOADS MUST BE COMPUTED.

NOTE: SEE PG 16 FOR DEFINITION OF SYMBOLS

MAIN DRAG BRACE - DYNAMIC SPRING BACK

60-40 DISTRIBUTION WITH 60% ON OUT-BD WHEELS

$V_R = V_p = 486,462^{\#}$; $D_R = d_p = -128000^{\#}$; $S_p = 0$

$M_{V_p} = 3.125 \times d_p = -400,000''^{\#}$; $M_{d_p} = -3.125 \times V_p = -1,525,000''^{\#}$

$M_{S_p} = V_R \times 4.40 + D_R \times 70.50 = 486,462 \times 4.40 - 128000 \times 70.50$

REF. — — — — — — — — —(3), PG 31 & 35

$= -6,860,000''^{\#}$

LOAD IN MEMBER $= +.040677 \times 486,462 +$
$2.086158 \times (-128,000) + .04458303 (-400,000) +$
$.02503198 \times (-6,860,000) + .00004028 \times (-1,525,000) =$

$+19,850 - 267,500 - 17,900 - 171,300 - 61 = \underline{\underline{-436,911^{\#}}}$

MEMBER "C" MAIN DRAG BRACE
CLEV. PART # 8535-78 (SEE PG. 6)

XB-36	B-36A
LOAD = $-436,911^{\#}$	LOAD* = $447,240^{\#}$

* REF — — — — —(3); PG 35
COND. 4a

TABLE I ~ MAKE-UP OF GEAR

XB-36 WITH FOUR-WHEEL GEAR		IDENTICAL TO CORRESPONDING PART OF AIRPLANE LISTED
MEMBER OR DATA	PART NO.	B-36A
MAIN DRAG STRUT	CLEV. #8535-78	YES
AUX. DRAG STRUT	CLEV. #8535-75	YES
SIDE BRACE	CLEV. #8499	YES
PIVOT SHAFT	CLEV. #8535-93	YES
OUT-BD TRUSS TUBE *	36L044-7	NO
IN-BD TRUSS TUBE *	36L044-6	YES
GEOMETRY	~	YES

* SEE TABLE II AND FOLLOWING PAGES

TABLE II ~ MAKE-UP OF TRUSS ASSEMBLY PLUS UPPER ATTACHING PARTS

ITEM	DESCRIPTIVE TITLE	XB-36 {FOUR-WHEEL GEAR	B-36A
		DRAWING NUMBER	DRAWING NUMBER
ASSEMBLY	TRUSS ASSEMBLY MAIN LANDING GEAR	36L007	36L4007
DETAIL PARTS	INBOARD TRUSS TUBE	36L004-6	36L044-6
	OUTBOARD TRUSS TUBE	36L004-7	36L4020
	NUT (IN BD TRUSS TUBE)	36L043	36L043
	NUT (OUT BD TRUSS TUBE)	36L043	36L022
	GATHER FITTING	36L013	36L013
PART [illegible] ON ANOTHER ASSEMBLY	SLEEVE (IN BD TRUSS TUBE)	36L040	36L021
	SLEEVE (OUT BD TRUSS TUBE)	36L040	36L4023

Truss Assembly

The same truss assembly as was used on the XB-36 single-wheel gear is used with the four-wheel gear in order to avoid replacing fittings on the air frame wing structure. The truss tubes on the XB-36 and the B-36A are similar in that, for corresponding tubes, the O.D. and I.D. are identical and their theoretical lengths are the same. The only difference between the XB-36 truss tube assemblies and the B-36A truss tube assemblies is the method of upper-end attachment and the upper end of the out-board truss tube is slightly different (See page 6). The XB-36 utilizes a split sleeve and a nut to form a clamp-collar arrangement (p. 6), whereas the B-36A truss tube is attached at the upper end by means of a sleeve which is threaded on both O.D. and I.D. and is, in effect, a threaded joint.

Tests (Ref. 6) have shown that the XB-36 clamping arrangement is inferior to the threaded joint on the B-36A and for this reason an analysis of the truss tube upper-end attachments is necessary. By inspection, the side-drift landing condition is critical for these members, and loads for this condition will be the only ones calculated.

Side-Drift Landing . . . . Ref. (1)

$$S'_{R_{in}} = 1/2 \times 1.5\,W = .75 \times 255,2[illegible] = 191,45[illegible]$$

$$S_{R_{in}} = S'_{R_{in}} - .75\,(wg) = -(191,45[illegible] - .75 \times [illegible]) = -1[illegible]\#$$

$$S'_{R_{out}} = .33 \times 1.5\,W = .495 \times 255,2[illegible] = 126,[illegible]\#$$

$$S_{R_{out}} = S'_{R_{out}} - .495\,(wg) = 126,[illegible] - .495 \times [illegible]$$

$$= 1[illegible]\#.$$

THE TABLE BELOW IS A SUMMARY OF CRITICAL TRUSS ~ TUBE LOADS FOR THE XB-36 MAIN GEAR. THESE LOADS ARE RATIOED DIRECTLY FROM B-36A LOADS.

TABLE III

ITEM	GROUND LOADS B-36A		GROUND LOADS XB-36		MEMBER LOADS B-36A		MEMBER LOADS XB-36	
	$S_{R_{OUT}}$	$S_{R_{IN}}$	$S_{T_{OUT}}$	$S_{T_{IN}}$	MAX. COMP.	MAX. TENS.	MAX. COMP.	MAX. TENS.
OUT-BD TRUSS TUBE	129,680	-196,485	129,300	-186,938	1,046,840	690,910	995,965	657,000
INB-D TRUSS TUBE					749,040	1,114,900	712,500	1,079,756

NOTE:

SIDE LOAD ACTING OUT GIVES MAXIMUM COMPRESSION LOAD IN INBOARD TUBE AND MAXIMUM TENSION IN OUTBOARD TUBE. SIDE LOAD ACTING IN GIVES MAXIMUM TENSION IN INBOARD TUBE AND MAXIMUM COMPRESSION IN OUTBOARD TUBE.

ONLY MARGINS FOR CLAMP COLLAR ARRANGEMENT WILL BE SHOWN AS OTHER ITEMS ARE IDENTICAL IN STRENGTH TO B-36A TRUSS TUBES AND, BECAUSE MEMBER LOADS ARE LOWER, NO ANALYSIS IS NECESSARY.

OUTBOARD TRUSS TUBE ~

MAX TENSION LOAD = 657,000#

P_t = 956,000# - - - (REF: REPORT FSG-242 ; Pg. 2)

$$M.S. = \frac{956,000}{657,000} - 1 = \boxed{+.45}$$

OTHER PORTIONS OF TUBE ASSEMBLY ARE MORE CRITICAL. (SEE FZS-36-149 & -149A)

INBOARD TRUSS TUBE ~

MAX TENSION LOAD = 1,079,756#

P_t = 956,000# (SEE REF. ABOVE)

$$M.S. = \frac{956,000}{1,079,756} - 1 = \boxed{-.11}^{*}$$

* IN VIEW OF EXISTING LIMITATIONS ON THIS AIRPLANE, THE ABOVE MARGIN DOES NOT IMPOSE ADDITIONAL LIMITATIONS.

ANALYSIS Nose Gear
PREPARED BY W. BROWN
CHECKED BY

REVISED BY

Consolidated Vultee Aircraft Corporation
FORT WORTH DIVISION
FORT WORTH, TEXAS

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NOSE GEAR

The XB-36 nose gear is basically the Cleveland Pneumatic Tool Company #6278 Gear reworked by Bendix to accommodate provisions for co-rotating wheels. Rework consisted of removing the entire wheel assembly just above the axle housing by cutting the main piston tube, cleaning out the inside of the main piston tube, and bolting in place Bendix part #69[illegible] per Bendix Dwg. #69[illegible] by means of a special shear-lug arrangement.

Although an analysis has been written by Cleveland Pneumatic Tool Company, (Ref. 15), which covers the original Cleveland part #6278 for the XB-36 with a single-wheel main gear, a supplementary analysis must be made, because examination of material in Reference (2), and in Reference (3), shows that the change from a single-wheel gear to a four-wheel gear causes, for some conditions, an increase in ground loads on the nose gear. For the above reasons, new ground loads must be computed for the XB-36 nose gear and margins shown corresponding to those in Cleveland Pneumatic Tool Company Report #6278.

ANALYSIS NOSE GEAR
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TABLE IV DESIGN GROSS WEIGHT CENTER OF GRAVITY LOCATION — NOSE DOWN

DESCRIPTION OF ITEM	WEIGHT	HORIZONTAL		VERTICAL	
		ARM	MOMENT	ARM	MOMENT
DGW	265,191.2	74.36	19,721,559	3.96	1,050,157
M.LG. OLEO	- 833.6	78.30	- 65 271	3.10	- 2584
WHEELS, BRAKES TIRES & ETC.	- 1724.0	77.40	- 133,438	4.70	- 8103
LESS GAS IN-BD TANK	- 36926.0	69.24	-2,556,756	4.12	- 152135
LESS OIL	- 5658.0	71.70	- 405,248	3.08	- 17389
PLUS GAS IN-BD TANK	+ 39362.6	69.21	+2,724,285	4.12	+ 162,173
PLUS OIL	5779.0	71.70	+ 414,354	3.08	+ 17,799
DGW (INCL. LG CHANGE — FLIGHT	(265191.2)	74.34	(19,699,405)		(1,049,918)
EXTEND FLAPS & GEAR			+ 27,306		+ 122,527
AIRPLANE C.G.		74.27		4.42	
LESS BOMBS	- 9920.0		- 536,970		- 70,432
DGW (LESS BOMBS - FLAPS & GEAR DOWN	(255271.2)	75.17	(19189,821)	4.71	(1,202,013)

NOTE: WEIGHT DATA ABOVE IS BASED ON REF. (5) & (3)
FUEL & OIL C.G. LOCATIONS FROM REF. (17)

ANALYSIS NOSE GEAR
PREPARED BY W W BROWN
CHECKED BY [illegible]
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TABLE V AGW (112-500# BOMBS) CENTER OF GRAVITY LOCATION {NOSE DOWN}

DESCRIPTION OF ITEM	WEIGHT	HORIZONTAL		VERTICAL	
		ARM	MOMENT	ARM	MOMENT
AGW (132-500# BOMBS)	265000.0	74.24	19672 566	4.60	1,218,345
M.L.G OLEO (WEIGHT SAVED)	- 833.6	78.30	- 65271	3.10	- 2584
WHEELS, BRAKES & TIRES	- 1724.0	77.40	- 133438	4.70	- 8103
LESS GAS CENTER TANK	- 29526.0	72.95	- 2153922	3.46	- 102492
LESS OIL	- 3943.0	71.70	- 282713	3.30	- 13013
PLUS GAS CENTER TANK	+ 31916.0	72.94	+ 2327953	3.34	+ 106599
PLUS OIL	+ 4112.6	71.70	+ 294873	3.30	+ 13571
AGW (INCL. LG. CHANGE — FLIGHT	(265,000)	[illegible]	(19660050)		(1,212,323)
EXTEND LANDING GEAR & FLAPS		[illegible]	+ 27306	[illegible]	+ 122527
LESS BOMBS (6) FWD END BAY ①	- 2976.0	36.42	- 108386	9.50	- 28272
(4) AFT END BAY ①	- 1984.0	42.87	- 85,054	10.20	- 20237
(4) FWD END BAY ④	- 1984.0	96.46	- 191377	10.20	- 20237
(6) AFT END BAY ④	- 2976.0	102.91	- 306260	9.50	- 28272
AGW (112-500# BOMBS) —LANDING	(255080)	74.47	(18996279)	4.85	(1237832)

NOTE: WEIGHT DATA ABOVE IS BASED ON REF. (5) & (3)

FUEL & OIL C.G. LOCATIONS FROM REF. (17)

ANALYSIS NOSE GEAR
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TABLE VI AGW (23 - 2000# BOMBS) CENTER OF GRAVITY LOCATION {NOSE DOWN}

DESCRIPTION OF ITEM	WEIGHT	HORIZONTAL		VERTICAL	
		ARM	MOMENT	ARM	MOMENT
AGW (23 - 2000 # BOMBS)	265000	74.29	19687380	4.73	1,253,183
MLG OLEO WEIGHT SAVING	- 833.6	78.30	- 65271	3.10	- 2584
WHEELS, BRAKES, TIRES, & ETC	- 1724.0	77.40	- 133438	4.70	- 8103
LESS GAS CENTER TANK	- 38406.0	72.91	-2800181	3.05	- 117138
LESS OIL	- 4556.0	71.70	- 326665	3.22	- 14670
PLUS GAS CENTER TANK	+ 40,7[illegible].0	72.90	+ 2973683	2.96	+ 120750
PLUS OIL	+ 4725.6	71.70	+ 338825	3.22	+ 15216
AGW (INCL. L.G. CHANGE — FLIGHT)	(265000)		(19,674,532)		(1246654)
EXTEND FLAPS & GEAR			+ 27306		+ 122527
LESS 2-2000# BOMBS BAY ①	- 4100.0	38.73	- 158,793	10.00	- 41,000
LESS 3-2000# BOMBS BAY ④	- 6150.0	98.78	- 607,497	9.50	- 58,425
AGW (23-2000# BOMBS) LANDING	(254,750)	74.33	(18,935,548)	4.98	(1,269,756)

WEIGHT DATA ABOVE IS BASED ON REF (5) & (3)

FUEL & OIL C.G. LOCATIONS FROM REF (17)

ANALYSIS NOSE GEAR
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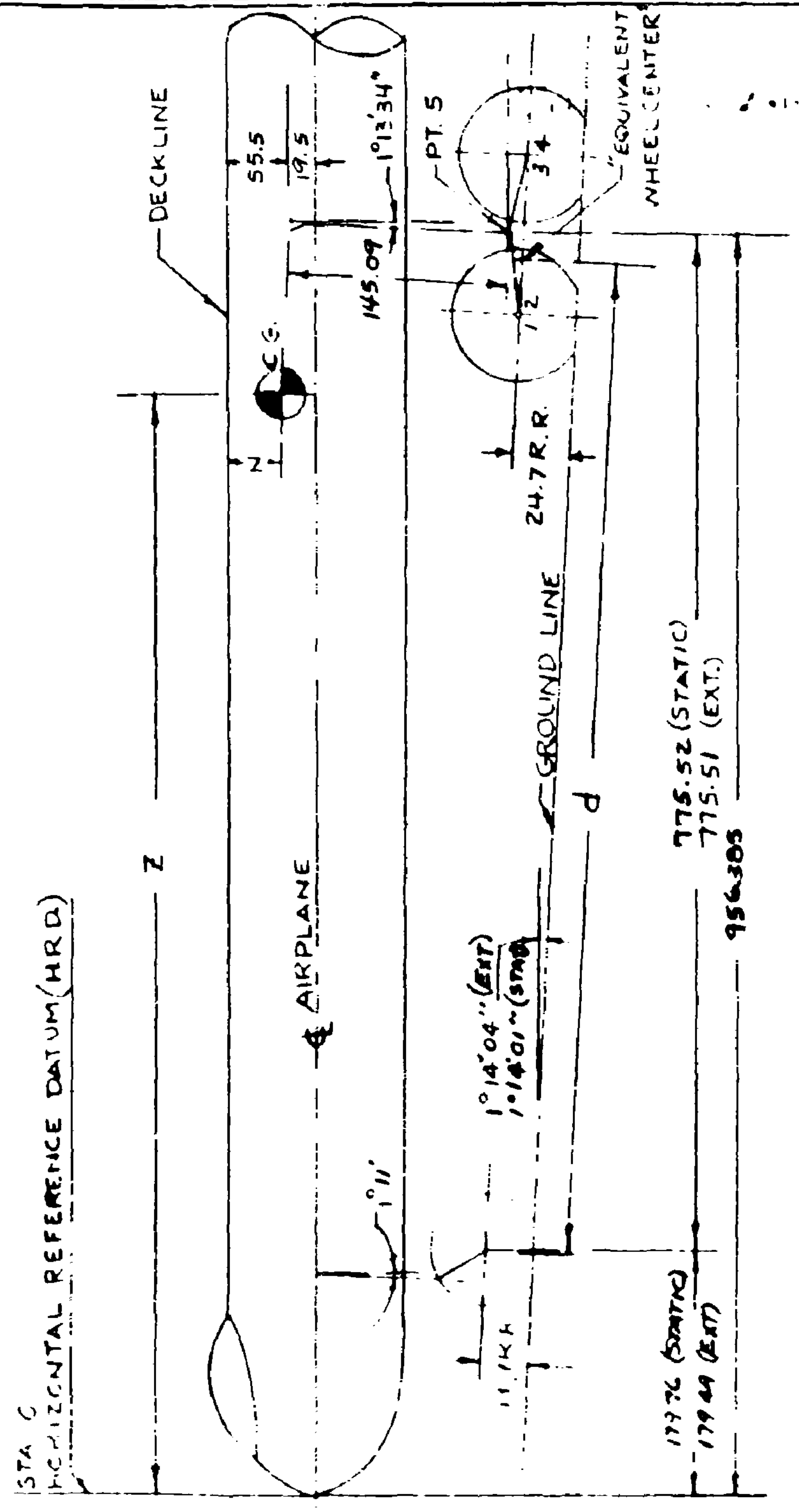


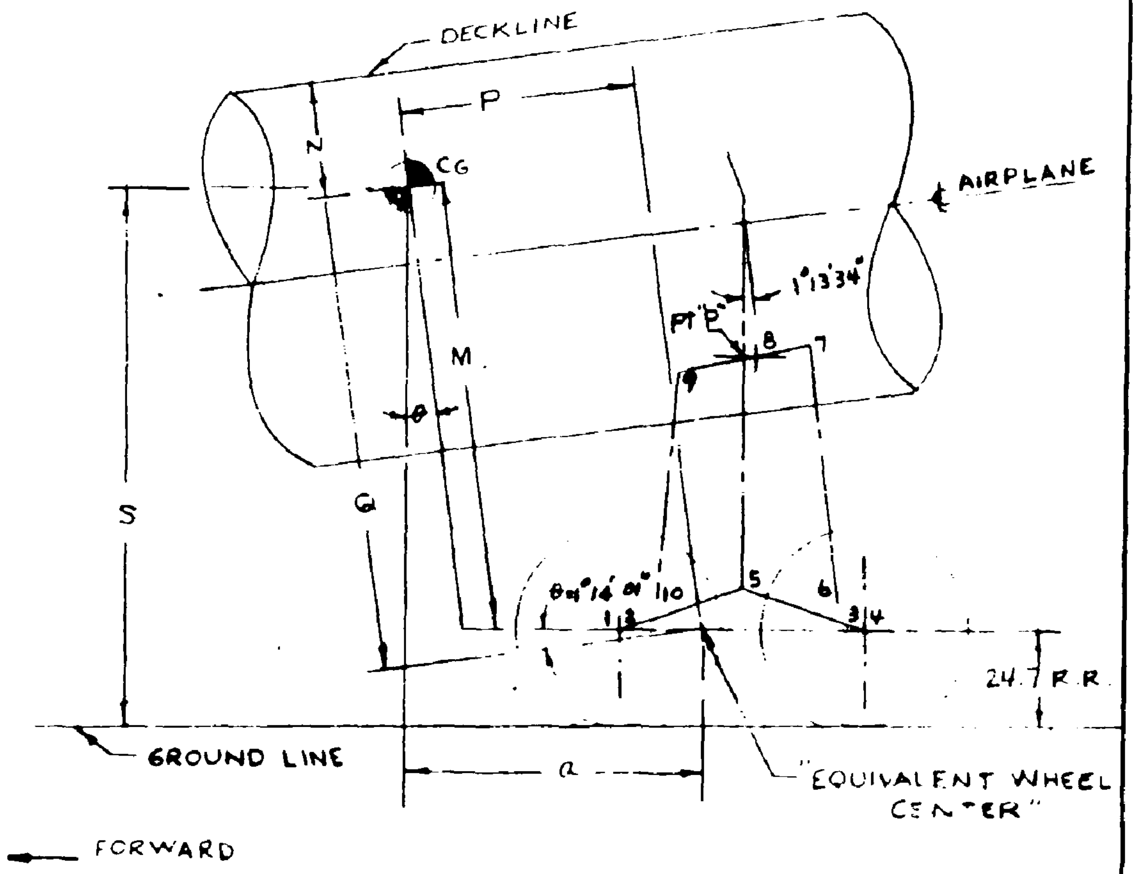
FIG. 1 - BASIC DIMENSIONS

SIN 1°-14'-04" = .02156
COS 1°-14'-04" = .999766
TAN 1°-14'-04" = .021620

SIN 1°-13'-14" = .0215
COS 1°-13'-14" = .9997
TAN 1°-13'-14" =

REFERENCE DRAWINGS 36L001, 36L5002

FIG. 2 SYMBOLS AND DIMENSIONS (NOSE - DOWN)



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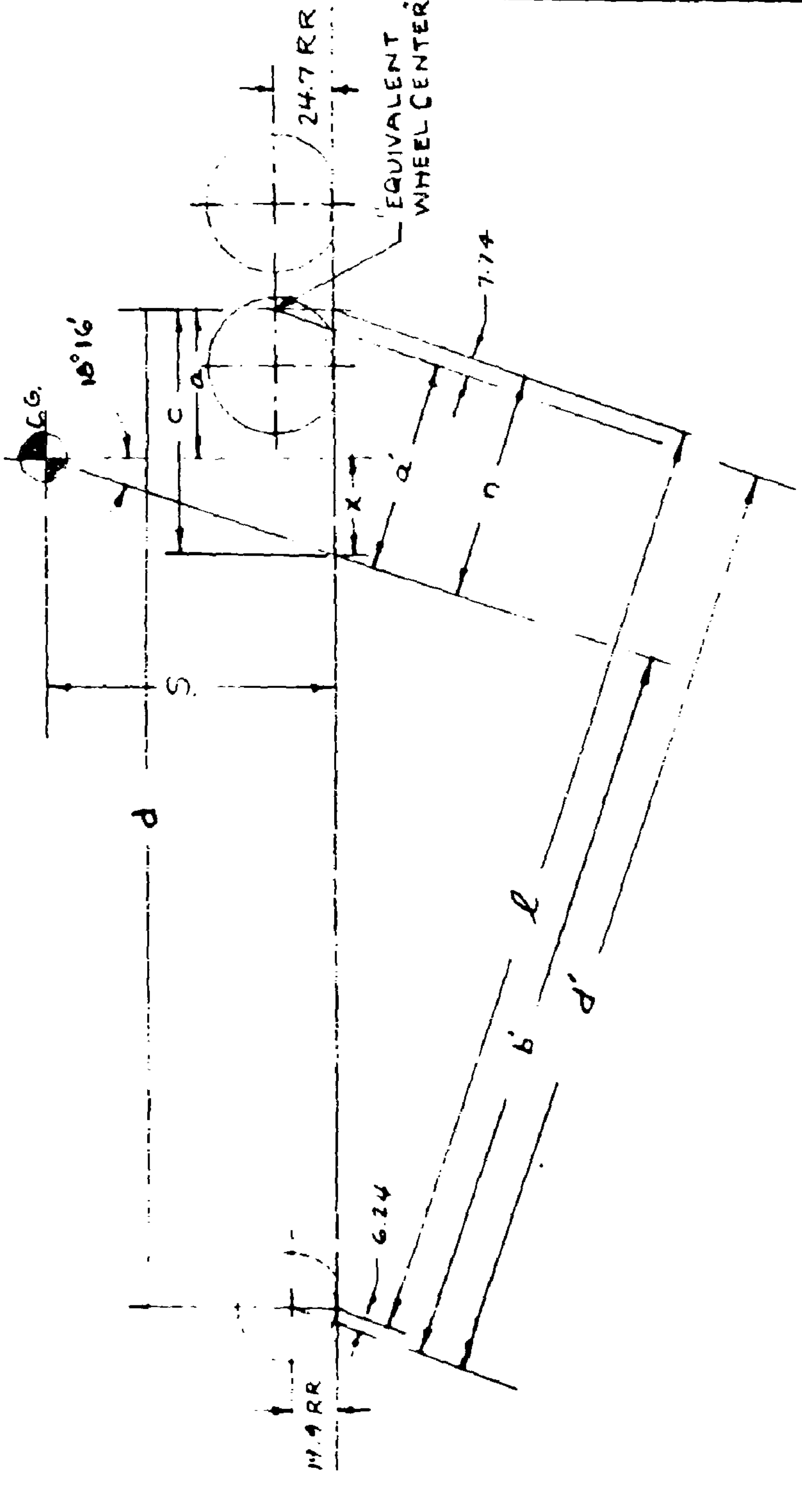

FIG. 3 SKETCH SHOWING DIMENSIONS USED FOR 3 WHEEL LANDING WITH INCLINED REACTIONS

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3W.L − I.R. AGW (23×2000# FORCES) (OLEO FULLY EXTENDED)

COORDINATES OF "EQUIVALENT WHEEL CENTER OF MAIN GEAR"
REF. (3) PG. 18 & 19

FUSELAGE STA. = 956.385 − 8.75 SIN 1° × 13' 14" − .705 COS 1°14'04"
= 955.49

DIST. BELOW DECK LINE = (145.07 + 8.75) COS 13' 34"
− .705 SIN 1°14'04" + 55.5
= 209.28

W = 254,750# Z = 891.96 N = 59.76 P = 955.49 − 891.96 = 63.53

Q = 209.28 − 59.76 = 149.52 θ = 1°14' 04"

P TAN θ = 63.53 × TAN θ = 63.53 × .021620 = 1.37
M = Q − P TAN θ = 149.52 − 1.37 = 148.15
M COS θ = 148.15 × .999766 = 148.12
M SIN θ = 148.15 × .02156 = 3.19
$P/\cos\theta = \frac{63.53}{.999766} = 63.54$

$a = M\sin\theta + P/\cos\theta = 3.19 + 63.54 = 66.73$

$d = \frac{955.49 - 179.49}{\cos\theta} - (19.9 - 24.7)\sin\theta = 776.28$

S = 24.7 + M COS θ = 24.7 + 148.12 = 172.82
x = .33 [illegible] .33 × 172.82 = 57.03
C = x + a = 57.03 + 66.73 = 123.76
n' = C COS 8°16' = 123.76 × .14961
J = 24.7 SIN 8°16' = 7.14
a' = n' − J = 109.78
K = 19.9 SIN 8°10' = 6.24
l = d COS 18°16' = 776.28 × .94961 = 737.16
d' = l + K − J = 737.16 + 6.24 − 7.14 = 735.56
b' = d − a' = 735.56 − 109.78 = 625.78

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ANALYSIS NOSE GEAR
PREPARED BY W. BROWN
CHECKED BY C.A. Kidwell
REVISED BY

Consolidated Vultee Aircraft Corporation
FORT WORTH DIVISION
FORT WORTH, TEXAS

REPORT NO FZS-36-249
MODEL B-36
DATE 5-18-48

3 W.L. - I.R. AGW (23 - 2000# BOMBS) (OLEO FULLY EXTENDED)

GROUND LOADS - NOSE GEAR -

$$V_f' = \frac{4Wa'}{d'} = \frac{4 \times 254,750 \times 109.78}{735.56} = 152,083^{\#}$$

$$V_f = V_f' - 4(Wg) = 152,083 - 4 \times 1319 = 146,807^{\#}$$

$$D_f = .33 \times V_f = .33 \times 146,807 = 48,446^{\#}$$

SIDE DRIFT LANDING AGW (23 - 2000# BOMBS)

$$K_z = \frac{Wa}{d} = \frac{254,750 \times 66.73}{776.28} = 21,899^{\#}$$

$$S_f' = .5 \times 1.5 \frac{nWa}{d} = 2 \times 21899 = 43,798^{\#}$$

$$S_f'/W \times Wg = \frac{43798 \times 1314}{254,750} = 227$$

$$S_f = S_f' - 227 = 43,511^{\#}$$

3 W.L. - I.R. DGW (NO BOMBS) 255,271# (OLEO FULLY EXTENDED)

$W = 255,271^{\#}$ $Z = 902.04$ $N = 56.52$ $P = 955.50 - 902.04 = 53.46$

$$Q = 209.28 - N = 209.28 - 56.52 = 152.76$$

$$P \tan \theta = 53\ 46 \times .021620 = 1.16$$

$$M = Q - P \tan \theta = 152.76 - 1.16 = 151.60$$

$$M \cos \theta = 151.60 \times .999766 = 151.56$$

$$M \sin \theta = 151\ 60 \times .02156 = 3.27$$

$$P/\cos \theta = \frac{53.46}{.999766} = 53.47$$

$$d = \frac{955.50 - 177.41}{\cos 1^\circ 14' 04''} - (19.9 - 24.7) \sin 1^\circ 14' 04'' = 776.29$$

$$\ell = M \sin \theta + P/\cos \theta = 3.27 + 53.47 = 56.74$$

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3W.L.~1.R. DGW (NO BOMBS) 255,271# (OLEO FULLY EXTENDED)

$S = 24.7 + M\cos\theta = 24.7 + 151.56 = 176.26$

$x = .33S = .33 \times 176.26 = 58.17$

$C = x + a = 58.17 + 56.74 = 114.91$

$n' = C\cos 18^\circ 16' = 114.91 \times .94961 = 109.12$

$J = 24.7 \times \sin 18^\circ 16' = 7.74$

$a' = n' - J = 109.12 - 7.74 = 101.38$

$K = 19.9 \sin 18^\circ 16' = 6.24$

$l = d\cos 18^\circ 16' = 776.29 \times .94961 = 737.17$

$d' = l + K - J = 737.17 + 7.74 - 6.24 = 735.67$

$b' = d - a = 735.67 - 101.38 = 634.29$

BENDING IN NOSE STRUT ~ DGW (LESS BOMBS)

$W = 255{,}271^{\#}$

$V_f = 1.5 \times .75 \dfrac{nWa}{d} = \dfrac{3 \times 255{,}271 \times 56.74}{776.29} = 55{,}974^{\#}$

$D_{f_{AFT}} = 1.5 \times (.2W) = .3 \times 255{,}271 = 76{,}581^{\#}$

$D_{f_{FWD}} = .4 V_f = .4 \times 55{,}974 = 22{,}389^{\#}$

BENDING IN NOSE STRUT ~ AGW (23 ~ 2000# BOMBS)

$W = 254{,}750^{\#}$

$V_f = 1.5 \times .75 \dfrac{nWa}{d} = \dfrac{3 \times 254{,}750 \times 66.73}{776.28} = 65{,}620^{\#}$

$D_{f_{AFT}} = 1.5 \times (.2W) = .3 \times 254{,}750 = 76{,}425^{\#}$

$D_{f_{FWD}} = .4 V_f = .4 \times 65{,}620 = 26{,}248^{\#}$

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SYMMETRICAL STATIC THRUST DGW (10,000 # BOMBS) (OLEO STATIC)

$M_{S_B} = 0 \quad \frac{D}{V} = 0$ (REF (3), PGS. 4, 5, & 22)

$V_{1,2} = 31.086 \times \frac{17.018}{20.977} = V_{3,4} \times 31.086 \times \frac{13.908}{20.409}$

$V_{1,2} = .78927\ V_{3,4}$

$V_{3,4} = 1.26618\ V_{1,2}$

$V_{1,2} + V_{3,4} = V_R$

$V_{1,2} = .4411\ V_R$

$V_{3,4} = .55889\ V_R$

$(.55889 - .4411)\ 31.086 = 3.661$ c.g. OF VERTICAL LOAD AFT OF ℄ STRUT.

COORDINATES OF "EQUIVALENT WHEEL CENTER" –

FUS. STA. = 956.385 + 4.25 SIN 1°13'14" + 3.661 COS 1°14'01"
= 960.14

DIST. BELOW DECKLINE = (145.09 − 4.25) COS 1°13'14"
+ 3.661 SIN 1°14'01"
= 196.38

DGW = 265,191# Z = 891.24 N = 53.04 (SEE PG 10)

P = 960.14 − 891.24 68.90 θ = 1°14'01"

P TAN θ = 68.96 × .0216 = 1.49
Q = 196.38 − 53.04 = 143.34
M = Q − P TAN θ 143.34 − 1.49 = 141.85
M COS θ = 141.85 × .9997 141.81
M SIN θ = 141.85 × .0215 = 3.05

SYMMETRICAL STATIC THRUST DGW (10,000 # BOMBS) (OL .O STATIC)

$P/\cos\theta = \frac{68.90}{.9997} = 68.92$

$a = M \sin\theta + \frac{P}{\cos\theta} = 68.92 + 3.05 = 71.97$

$d = \frac{960.14 - 179.76}{\cos\theta} + (19.9 - 24.7)\sin\theta = 783.78$

$b = d - a = 783.78 - 71.97 = 711.81$

783.78 − 775.17 = 8.61 ~ "EQUIVALENT WHEEL CENTER" AFT OF SINGLE WHEEL GEAR AXLE.

11.17 − 8.61 = 2.56 ~ DISTANCE OF "EQUIVALENT WHEEL CENTER" AFT OF VERTICAL COMPONENT OF THRUST OF INBOARD ENGINES.

18.67 − 8.61 = 10.06 ~ DISTANCE OF "EQUIVALENT WHEEL CENTER" AFT OF VERTICAL COMPONENT OF THRUST OF CENTER ENGINES.

26.20 − 8.61 = 17.59 ~ DISTANCE OF "EQUIVALENT WHEEL CENTER" AFT OF VERTICAL COMPONENT OF THRUST FOR OUTBOARD ENGINES.

THE ABOVE DIMENSIONS ARE IN PART FROM REF. (20) PAGE 152 AND THE THRUST COMPONENTS BELOW ARE FROM REF. (20) PAGE 151

$T_S = 441$ #/ENGINE (LIMIT)

$T_V = 275$ #/ENGINE (LIMIT)

$T_H = 8418$ #/ENGINE (LIMIT)

SYMETRICAL STATIC THRUST

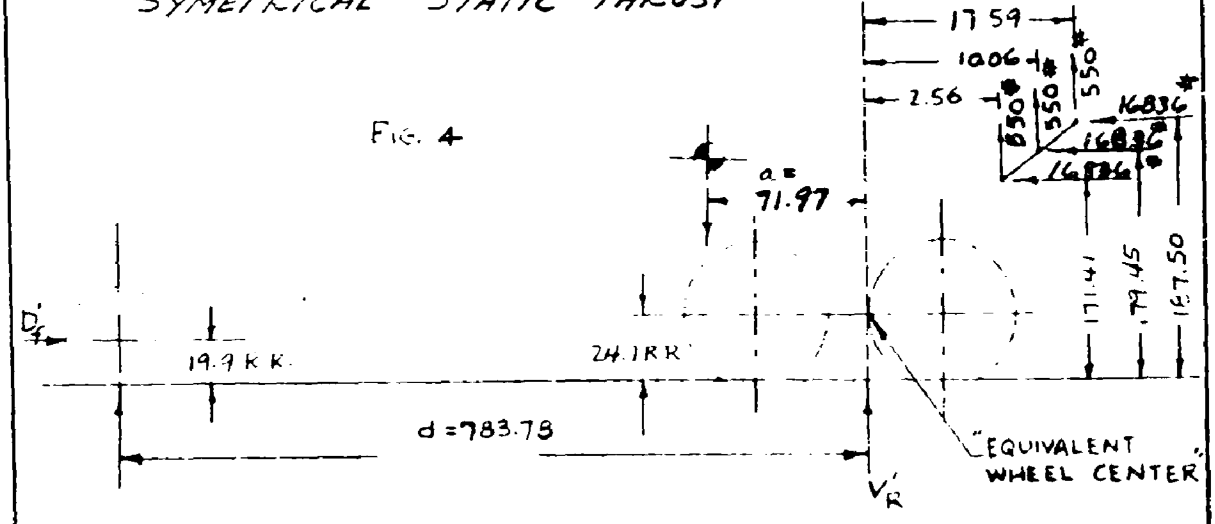

FIG. 4

NOSE GEAR GROUND LOADS DGW (10,000# BOMBS) 265,191#

$$D'_f = 6 \times 1.5 \times 8418 = 75{,}762^{\#} \text{ ULT.}$$

$$V'_f = 1.5\left[\frac{71.97 \times 265{,}191}{783.78} + \frac{2 \times 275(2.56+10.06+17.59)}{783.78} + 2 \times 8418\left(\frac{171.41+179.45+187.50}{783.78}\right)\right] = 53{,}918^{\#}$$

$$V_f = 51{,}296 - 1.5(w\,q) = 53{,}918 - 1.5 \times 1319 = 51{,}940^{\#}$$

$$D_f = 75762 - 1.5\,(1319) = 73{,}784^{\#}$$

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GROUND TURNING CONDITION

DGW = 265,191#

112 - 500# BOMBS

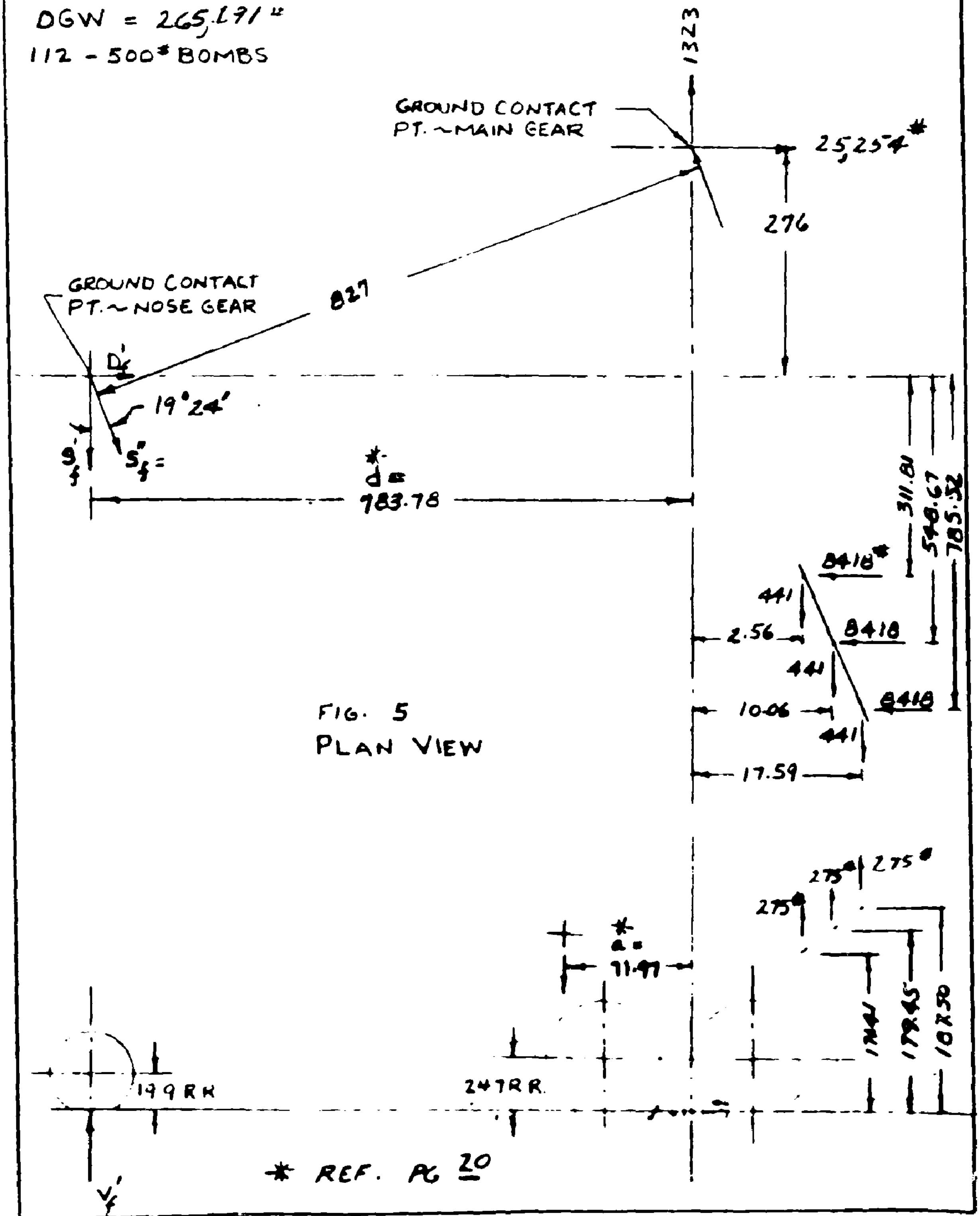

FIG. 5
PLAN VIEW

* REF. PG 20

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GROUND TURNING CONDITION - D.G.W = 265191# (10,000# BOMBS)

$$S_f'' = 1.5\left[\frac{8418(311.81+548.67+785.52+3\times 276)+441(2.56+10.06+17.59)}{827}\right]$$

$$= 37,798$$

$$S_f' = 37,798(\cos 19°24') = 37,798(.9432) = 35,651\# \text{ (ULT)}$$

$$D_f' = 37,798(\sin 19°24') = 37798(.3322) = 12,556\# \text{ (ULT)}$$

$$V_f' = \left[\frac{265191 \times 71.97 + 8418(171.41+179.45+187.50)+275(2.56+10.06+17.59}{783.78}\right]1.5$$

$$= 45,082\#$$

$$V_f = 45082 - 1.5(1319) = 43,104\# \text{ (ULT)}$$

$$S_f = 35,651 - 1.5(1319) = 33,673\# \text{ (ULT)}$$

$$D_f = 12,556 - 1.5(1319) = 10,578\# \text{ (ULT)}$$

$$(S_f^2 + D_f^2)^{1/2} = 35,250\#$$ RESULTANT SIDE-LOAD (ULT)

TABLE VII SUMMARY XB-36 NOSE GEAR GROUND LOADS

CONDITION	DESCRIPTION	OLEO POSITION	LOADS APPLIED AT	V_f	D_f	S_f
1	3WL-IR AGW (25-2000# BOMBS) 254,750#	FULLY EXTENDED	℄ OF WHEEL	146,807	48,446	0
5	SIDE DRIFT LANDING AGW (25-2000# BOMBS) 254,750#	FULLY EXTENDED	GROUND	0	0	± 43,511
7-1	BENDING NOSE STRUT - FORE AGW (25-2000# BOMBS) 254,750#	FULLY EXTENDED	℄ OF WHEEL	65,620	-26,248	0
7-1-A	BENDING NOSE STRUT - AFT AGW (25-2000# BOMBS) 254,750#	FULLY EXTENDED	℄ OF WHEEL	65,620	76,425	0
7-2	BENDING IN NOSE - AFT DGW ([illegible] BOMBS) 255,271#	FULLY EXTENDED	℄ OF WHEEL	55,474	76,581	0
8	REBOUND	FULLY EXTENDED	℄ OF WHEEL	-33,120	0	0
9	SYMMETRICAL STATIC THRUST [illegible] 265,191#	STATIC	℄ OF WHEEL	51,940	73,784	0
10	SECOND TURNING DGW (10,000# BOMBS) 265,191#	STATIC	GROUND	43,104	0	± 35,250 #

NOSE WHEEL IS CASTERED FOR THIS CONDITION REF. Pg. 22
THIS LOAD IS PARALLEL TO AXLE.

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THE TABLE BELOW IS REPRODUCED FROM THE CLEVELAND PNEUMATIC TOOL CO. REPORT # 8278 TABLE I Pg. 3

ULTIMATE DESIGN GROUND LOAD REACTIONS

TABLE VIII

CONDITION	ITEM	OLEO POSITION	LOADS APPLIED AT	V_f	D_f	S_f
1	3W.L.-I.R. 254,750# G.W.	FULLY EXTENDED	℄ OF WHEEL	142,800	47,100	0
5	SIDE DRIFT 254,750# G.W.	FULLY EXTENDED	GROUND	0	0	±46,000
7-1	BENDING IN NOSE-FORE 254,750# G.W.	FULLY EXTENDED	℄ OF WHEEL	69,000	-27,600	0
7-1-A	BENDING IN NOSE-AFT 254,750# G.W.	FULLY EXTENDED	℄ OF WHEEL	69,000	75,900	0
7-2	BENDING IN NOSE-AFT 268,330# G.W.	FULLY EXTENDED	℄ OF WHEEL	58,700	79,900	0
8	REBOUND	FULLY EXTENDED	℄ OF WHEEL	-33,120	0	0
9	SYMMETRICAL STATIC THRUST 255,080# G.W.	STATIC	℄ OF WHEEL	49,505	67,410	0
10	GROUND TURNING 255,080# G.W.	STATIC	GROUND	43,400	0	±35,888 *

APPLIED AT INTERSECTION OF OLEO AND GROUND (SEE ANC-2 P. 16)
OLEO IS NORMAL TO GROUND IN STATIC & FULLY EXTENDED POSITIONS.

a = 50-50
b = 60-40
c = 60-0
} DISTRIBUTION FOR CONDITIONS 1, 5 & 10

a = 50-50 DISTRIBUTION FOR CONDITIONS 7-1, 7-1-A, 7-2, & 9

MARGINS WHICH ARE SMALLER THAN THOSE SHOWN IN REF.(15) PGS. 116 & 117 ARE REDUCED BELOW. MARGINS WHICH ARE LARGER THAN THOSE IN REF. (15) ARE NOT REDUCED.

PART # 8278-26-2 PLUNGER TUBE COLUMNAR LOADING
CONDITION 1-a-b

$$M.S. = 1.10 \times \left(\frac{142{,}800}{146807}\right) - 1 = \text{— — — —} \quad +.07$$

PART # 8278-27 TREADED FLANGE ON ORIFICE PLATE
AT PLUNGER TUBE CONNECTION – COND 1-a-b

$$M.S. = 1.14 \times \left(\frac{142{,}800}{146807}\right) - 1 = \text{— — — — — —} \quad +.11$$

ALL PARTS OF WHICH ATTACH TO THE STRUT BELOW THE JOINT, JUST ABOVE THE AXLE HOUSING, ARE COVERED BY BENDIX REPORT NUMBER 813, AS THE PARTS ARE SAME AND GROUND LOADS ARE LOWER. (SEE TABLE IX PG.__)

ALTHOUGH CONDITION 9* YEILDS HIGHER GROUND LOADS THAN THOSE USED IN REF (14), EXAMINATION SHOWS THAT THIS CONDITION IS NOT CRITICAL.

* REF. PGS 24 & 25

PART #8278-4 PISTON TUBE 21" ABOVE ℄ AXLE COND. 1-b

$$*\text{M.S.} = 1.001\left(\frac{142{,}800}{146{,}807}\right) - 1 = \text{------} \quad -.027$$

PART #8278-24 PISTON TUBE PLUG BEARING COND. 1-a-b

CONTACT AT EDGE OF FLANGE.

$$\text{M.S.} = 1.050\left(\frac{142{,}800}{146{,}807}\right) - 1 = \text{-----} \quad +.02$$

* IN VIEW OF EXISTING LIMITATIONS ON THIS AIRPLANE, THE ABOVE MARGIN DOES NOT IMPOSE ADDITIONAL LIMITATIONS.

ANALYSIS
PREPARED BY
CHECKED BY
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JUNCTION OF N.L.G. AXLE HOUSING (BENDIX # 69738) & INNER CYLINDER (C.P.T. # 8278-4)

THE N.L.G. AXLE HOUSING (BENDIX # 69738) JOINS THE AXLE (BENDIX # 697[illegible]) & THE INNER CYLINDER (C.P.T. # 8278-4). AN ANALYSIS OF THE AXLE APPEARS IN BENDIX REPORT # 813. AN ANALYSIS OF THE INNER CYLINDER APPEARS IN C.P.T. REPORT # 8278. THE AXLE HOUSING WILL BE ANALYZED HEREIN.

THE OUTSIDE DIAMETER OF THE HOUSING AND THE INSIDE DIAMETER OF THE INNER CYLINDER ARE MACHINED TO PROVIDE AN INTERFERENCE OF .002 TO .004 INCHES ON THE DIAMETER. THE PARTS ARE BOLTED TOGETHER BY MEANS OF TWELVE (12) SHEAR (TAPER) PLUGS IN COMBINATION WITH BOLTS AND SPECIAL WASHERS (SEE NEXT PAGE).

THIS JOINT IS MADE NECESSARY BY THE RE-WORK OF THE ORIGINAL C.P.T. 8278 GEAR BY BENDIX IN ORDER TO ACCOMMODATE CO-ROTATING WHEELS. FOR CONVENIENCE A TABLE OF NOSE GEAR PARTS IS INCLUDED.

TABLE OF NOSE GEAR PARTS - TABLE IX

PART USED ON XB-36 NOSE GEAR	DRAWING NUMBER	USED ON MODELS	ANALYZED IN
AXLE - N.L.G. CO-ROTATING WHEELS	BENDIX # 697[illegible]	ALL	BENDIX RPT # 813
BEARING RACES INNER OUTER	103-S-13 67390 TIMKEN [illegible]-S-[illegible]2 67[illegible] TIMKEN	ALL	BENDIX RPT # 813
THRUST NUT	BENDIX # 697[illegible]	ALL	BENDIX RPT # 813
AXLE HOUSING - CO-ROTATING WHEELS	BENDIX # [illegible]	[illegible]	THIS REPORT
INNER CYLINDER N.L.G.	[illegible] # 8278-4	[illegible]	[illegible] # 8278

FW 444 6-46 UTILITY REPORT SHEET

ANALYSIS N.L.G. AXLE [illegible]

PREPARED BY [illegible]

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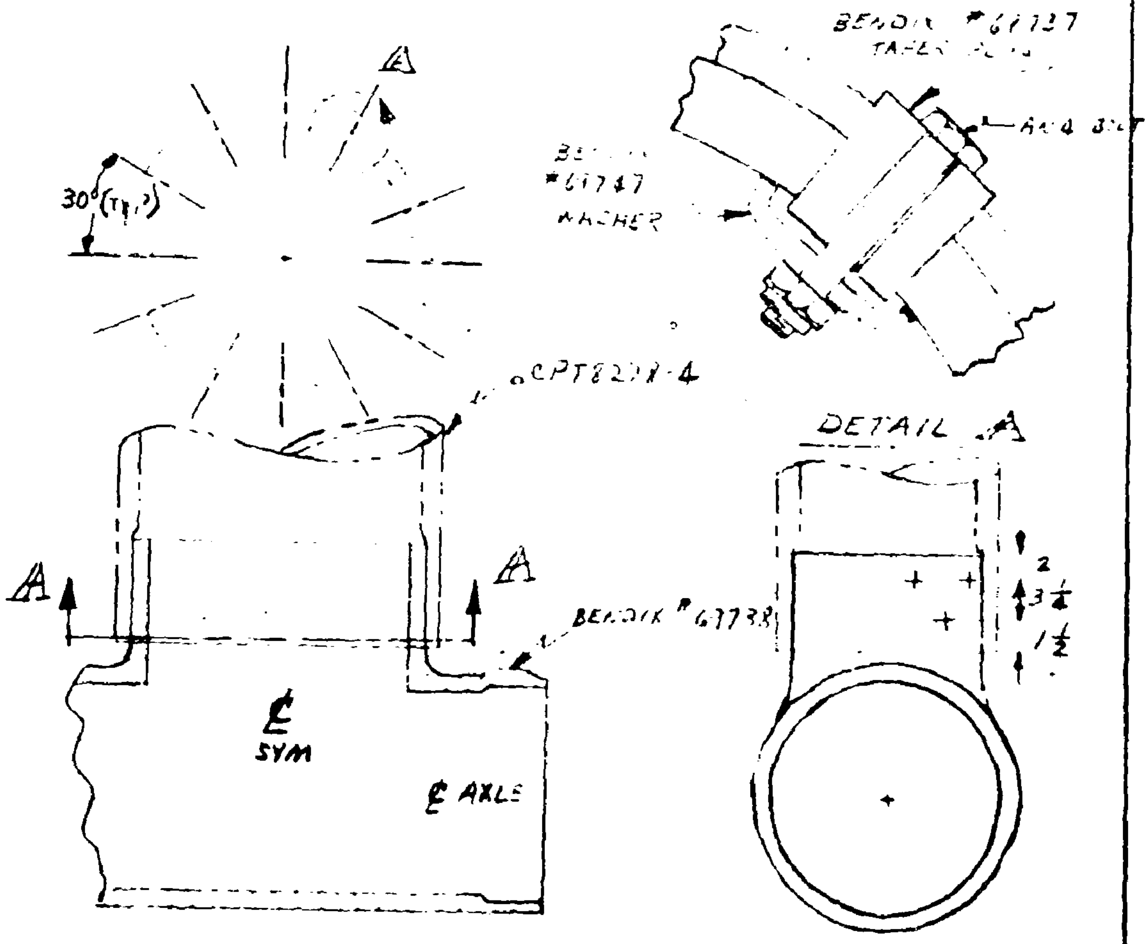
MODEL XB-36

DATE 5/2[illegible]



NOSE LANDING GEAR AXLE [illegible]

A-A

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CHECK OF INNER CYLINDER SECTION THRU ℄ OF UPPER PLUGS

CRITICAL CONDITION – 1-C (3WL-IR, 61-0 V + D)

$V_f = 0.6 \times 146,807$
$= 88,284$ #
$D_f = 0.6 \times 48,446$
$= 29,067$ #

AT SECTION

$S = 88,284 \cos 57.41° +$
$21,067 \sin 57.41°$

$= 71,56$ #

$V = 88,284 \sin 57.41°$
$- 29,067 \cos 57.41°$

$= 58,500$ #

$M'_{bending} = 88,284 \cdot 9.75 \cdot \cos 57.31° +$
$29,067 \cdot 9.75 \sin 57.41°$
$= 487,650$ "#

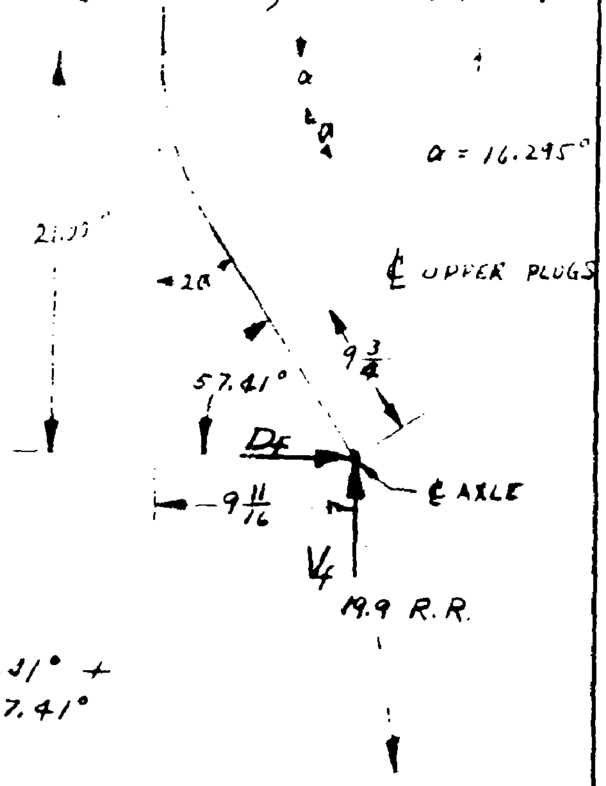
$M_{fore\ and\ aft} = 88,284 \cdot 14.25 = 1,26$ "#

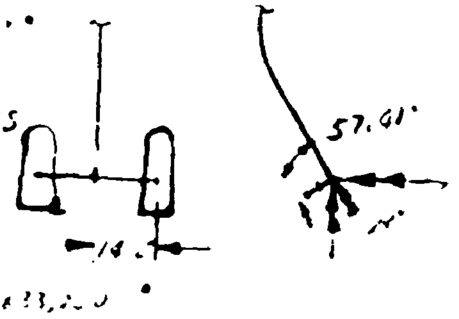
$M_{vert} = 29,067 \cdot 14.25 = 414,$ "#

RESOLVING THE TWO LATTER MOMENTS INTO BENDING & TORSION COMPONENTS IN THE TUBE:

$M''_{bend.} = 1,26 \sin 57.41° -$
$414, \sin 57.41° = 33,$ "#

$T = 1,26 \cos 57.41° + 414, \cos 57.41° = 1,23,9$ "#





ANALYSIS N.L.G. AXLE HOUSING
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THE RESULTANT MOMENT IS

$$M_R = \sqrt{487,650^2 + 833,200^2} = 979,000 \ \#$$

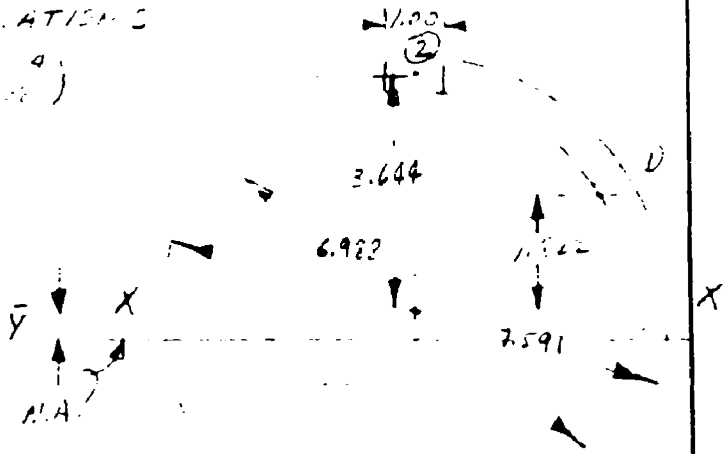
SECTION PROPERTY CALCULATIONS

$$I_{X-X} \text{ SOLID TUBE} = \frac{\pi}{64}\left(7.591^4 - 6.982^4\right)$$

$$= 40.55 \text{ in}^4$$

$$A = \frac{\pi}{4}\left(7.591^2 - 6.982^2\right)$$

$$= 6.87 \text{ in}^2$$



REMOVING EFFECT OF HOLES ON TENSION SIDE

ITEM	A	Y	AY	AY²	I₀
FULL SECTION	6.87	0	0	0	40.55
− 1 + 2	−.604	1.822	−1.10	− 2.006	[illegible]
− 2	−.302	3.644	−1.10	− 4.012	—
	5.964		−2.18	−6.018	40.52

$$\bar{Y} = \frac{-2.18}{5.964} = -.365$$

$$I_{NA} = 40.52 - 6.02 - [illegible] = 33.7 \text{ in}^4$$

ALLOWABLE STRESSES H.T = 2[illegible], [illegible]

$D = 7.5[illegible]1$; $t = .30[illegible]7$; $\frac{D}{t} = \frac{7.[illegible]11}{.3[illegible]7} = 2[illegible].12$

$F_B = 242,[illegible]$; $F_{ST} = 0.625\,(20[illegible]) = [illegible]2[illegible]0[illegible]$
([illegible])

$F_C = 1[illegible],[illegible]$; $F_S = 118,[illegible]$ (REF [illegible] [illegible]
[illegible] p 41)

$f_b = \frac{97[illegible] \cdot (3.[illegible]4 - .[illegible])}{33.70} = 94,3[illegible]$ psi

$f_{[illegible]} = \frac{58,5[illegible]}{6.[illegible]7} = [illegible]8[illegible]$ psi

$f_{[illegible]} = \frac{71,[illegible]}{5.96} = 12,[illegible]$ psi

$f_{st} = \frac{[illegible]23,[illegible] \times 3.644}{2 \times [illegible].55} = 46,[illegible]$ psi

$R_c = \frac{8[illegible]2[illegible]}{1[illegible]0,[illegible]} = .047$

$R_b = \frac{94,30[illegible]}{242,[illegible]} = .389$

$.436$

$R_s = \frac{12,[illegible]}{118,[illegible]} = .102$

$R_{ST} = \frac{46,[illegible]}{12[illegible]} \quad .3[illegible]9$

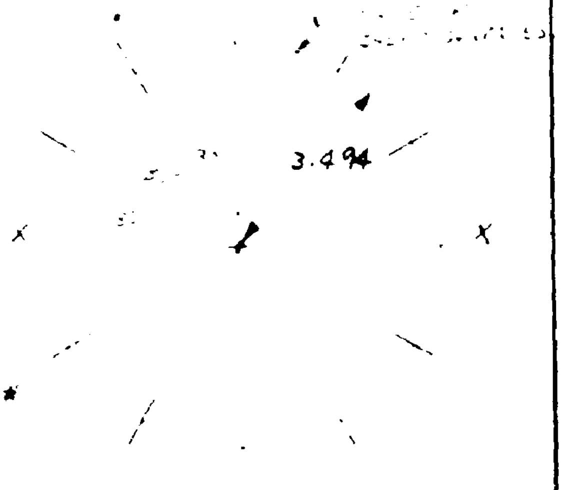
$.[illegible]61$

$$M.S = \frac{1}{\sqrt{(.[illegible]3[illegible])^2 + (.[illegible]61)^2}} - 1 = \frac{1}{.[illegible]} \quad 1 = +1.[illegible]2$$

CHECK OF PLUGS (BELL DWG. # 69737)

THE MOMENT OF INERTIA OF THE PLUGS ABOUT ANY DIAMETER IS A CONSTANT VALUE WITHIN NARROW LIMITS; THEREFORE:

$$I = (3.494 \sin 30^\circ)^2 \cdot 4 + (3.494 \sin 60^\circ)^2 \cdot 4 + 3.494^2 \cdot 2$$
$$= 12.22 + 36.60 + 24.4[illegible]$$
$$= 73.28$$



BENDING LOAD/PLUG =
$$\frac{971[illegible] \cdot 3.494}{73.28} = 4[illegible]\ ^*$$

TORSIONAL LOAD/PLUG =
$$\frac{4,623,900 \cdot 3.494}{2 \cdot 73.28} = [illegible]$$

AXIAL LOAD/PLUG = $\frac{51,5.0}{12}$ = [illegible] *

*RESULTANT LOAD/PLUG = $\sqrt{(4[illegible] + 4[illegible])^2 + (24,1[illegible])^2}$ = 56,7[illegible]

ALLOWABLE LOAD/PLUG

BEARING IN TUBE = [illegible] = 66,[illegible]
SHEAR OF PLUG = [illegible] = 11[illegible]

M.S. = $\frac{66,3[illegible]}{56,750} - 1$ = - - - - $\boxed{+.17}$

* [illegible] ASSUMED TAKEN IN SHEAR.

REEL – C

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ABSTRACT:

A stress analysis has been made of the landing gear of the XB-36 bomber to determine whether or not the gear meets the requirements of existing criteria. The report is divided into two parts, one of which deals with the main landing gear and the other dealing with the nose gear. Descriptive matter for each gear appears under its respective analysis. Results of the analysis are shown in tables, diagrams, and formulas.

DISTRIBUTION: Copies of this report obtainable from CADO (1)

DIVISION: Structures (7)
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