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Stress Analysis of XB-36 Test Nacelle and Installation

53227

(None)

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USAF Project MX-140 Contr. No. W535-AC-22352

FZS-36-106

(None)

pt' 43 Unclass. U.S. English 92 diagrs, graphs

ress analysis is made of the engine stub wing of the XB-36 bomber. The report is subdivided into alyses of the engine mount and of the wing structure. The mount is a welded Chrome-Moly tubular ace frame work which carries the loads from the engine and accessories to the main wing fittings. ıe leads are then carried through welded steel fittings to two wing bulkheads which distribute the load the wing structure. The basic wing structure consists essentially of a front and rear spar, and two ord trusses separated by truss type bulkheads at each station point. The conctruction is of wlded strucral steel. The leading and trailing edge air loads are carried to the interspar bulkheads by means of ywood ribs which support wooden longitudinal stringers. The entire wing is covered with plywood, which turn is covered with galvanized steel sheet to obtain smoothness of airflow.

Copies of this report obtainable from CADO (1)

Structures (7) B-36 - Stress analysis (14884.605); XB-
Stress Analysis of Specific Aircraft (6) 36 (99409); Nacelles, Engine - Stress analysis (66079)

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Model XB-36 Report # FZS-36-106

STRESS ANALYSIS

OF

XB-36 TEST NACELLE AND INSTALLATION

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MODEL XB-36 AIRPLANE

REPORT NO FZS-36-106

STRESS ANALYSIS

OF

XB-36 TEST NACELLE AND INSTALLATION

SEPTEMBER 9, 1943

[redacted]

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STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

NOTATIONS USED IN REPORT

A - Cross sectional area in square inches

P - Load in pounds

P_c - Applied compressive load in pounds

P_t - Applied tensile load in pounds

P_C - Allowable compressive load in pounds

P_T - Allowable tensile load in pounds

f_s - Applied shear unit stress in pounds per square inch

f_c - Applied compressive unit stress in pounds per square inch

f_t - Applied tensile unit stress in pounds per square inch

f_b - Applied bending unit stress in pounds per square inch

F_S - Allowable shear unit stress in pounds per square inch

F_C - Allowable compressive unit stress in pounds per square inch

F_T - Allowable tensile unit stress in pounds per square inch

F_B - Bending modulus of rupture

M - Statical moment

t - Thickness of plate (in weld equations, thickness of thinnest metal joined by weld) in inches

L - Length of weld in shear in inches

P_W - Allowable weld shear load in pounds

P_w - Applied weld shear load in pounds

P_S - Allowable bolt shear load in pounds

S - Total shear in pounds

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

NOTATIONS USED IN REPORT (CONT.)

$S_{allow.}$ - Total allowable shear in pounds

$\bar{x}, \bar{y}$ - Distance from neutral axis to reference line in calculation of section properties

y_1 - Distance from neutral axis of a section to neutral axis of total section

L_c - Column length in inches

ρ - Radius of gyration of section

I_o - Moment of inertia of a component of a section about its own neutral axis

$I_{c.g.}$ - Moment of inertia of the total section about its neutral axis

M.S. - Margin of safety based on ultimate loads and ultimate stresses

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

INTRODUCTION

The stress analysis of the XB-36 Engine Stub wing is made in accordance with A.A.F. Specification 40440, Section E-2. The report consists of the analysis of the engine mount and the wing structure.

The mount is a welded Chrome-Moly tubular space frame work which carries the loads from the engine and accessories to the main wing fittings. The loads are then carried through welded steel fittings to two wing bulkheads which distribute the load to the wing structure.

The basic wing structure consists essentially of a front and rear spar, and two chord trusses separated by truss type bulkheads at each station point. The construction is of welded structural steel.

The leading and trailing edge air loads are carried to the interspar bulkheads by means of plywood ribs which support wooden longitudinal stringers. The entire wing is covered with plywood, which in turn is covered with galvanized steel sheet to obtain smoothness of airflow.

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

CALCULATION OF ALLOWABLE STRESSES

In the design of the engine mount, the allowable loads for Chrome-Molybdenum Steel Tubes are taken directly from the values given in A.N.C.-5. Since good welded clusters are obtained at the ends of the tubes, a fixity coefficient of 1.5 is considered to be satisfactory.

The allowable stresses for structural steel, as given in the A.I.S.C. handbook could not be used directly, since the loads applied to the structure are at ultimate, which is a deviation from standard structural steel practice.

The minimum guaranteed Ultimate Tensile Strength for Structural Steel, from the A.I.S.C. handbook is 60,000 #/□".
This value is used throughout the design.

For design of structural steel columns, the Rankine Equation is used in a form which is somewhat different from the form generally adopted in the handbook due to the use of Ultimate Loads in the design rather than 1g loads.

The general form of the Rankine Equation is $F_c = \frac{S}{1 + q(L/\rho)^2}$

For a factor of safety = 3, S = 12,500

For use with Ult. loads, q = 3 x 12500 = 37,500

The value of 1/1800 for q is the one generally adopted in in steel construction.

$$F_c = \frac{37500}{1 + 1/1800(L/\rho)^2}$$

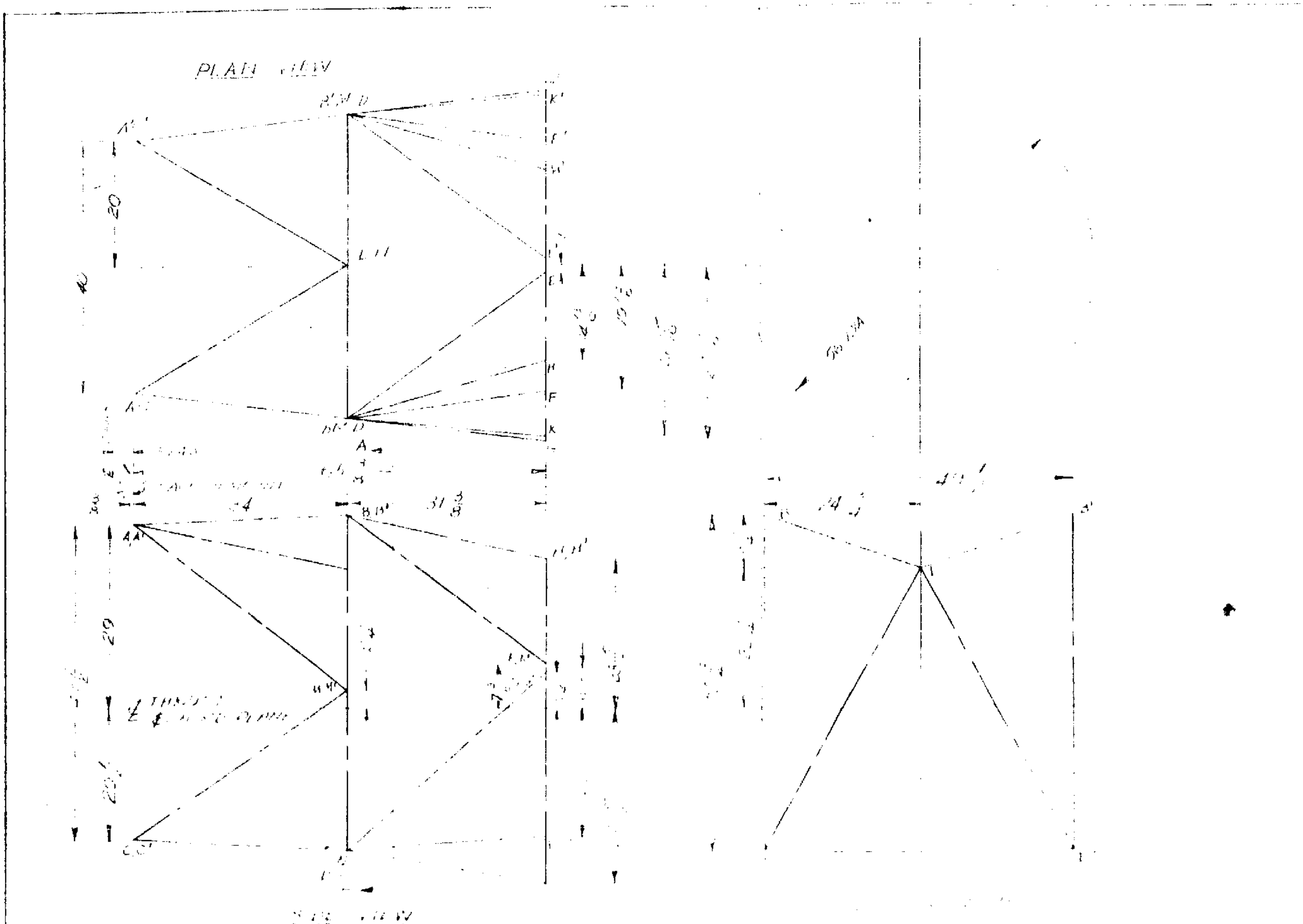


FIG. 1. ... ENGINE TEST STAND

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION (Cont'd.)

ANALYSIS OF ENGINE MOUNT

DESIGN CONDITIONS

The primary design condition for the engine mount is a 5 g vertical load acting down from the engine. The loads from this condition are combined with these resulting from torque and thrust if they are additive. Torque and thrust loads are never subtracted from the downward vertical loads if they are relieving loads. The mount is also satisfactory for approximately 2/3 reversal or up load.

DETAIL ANALYSIS (For referenced members see fig. 1 page 2)

A conservative analysis of the mount as a space framework has been made. The vertical shear has been assumed to be carried in the vertical truss systems (i.e.: AM, AB, BD, CM, CD, BK and DG) while the overhang moment is taken by members BH, B'H', DE and D'E' and thus back to the attachment points. Conservative overlaps have been made with respect to taking the engine torque out, as couples in either the vertical or horizontal plane. The detailed work of going through this analysis is not shown but the resulting member loads and margins of safety are shown on table III page 7. Also shown on table IV page 8 are the various loads on the engine mount fittings which will be used later on in this report while analyzing the spars, etc.

TABLE I [illegible] TEST [illegible] WEIGHT [illegible]

[illegible] SECTION [illegible]

ITEM	WEIGHT	DISTANCE AFT OF WEIGHING POINT	MOMENT IN LB	DISTANCE BELOW THRUST LINE	MOMENT	[illegible] TO A & A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NACELLES			[illegible]	0								
ENGINE MOUNTINGS	127	6[illegible]	[illegible]	44.[illegible]	[illegible]		[illegible]		[illegible]			–
1ST SECTION	67	34.[illegible]	[illegible]	-5.[illegible]	-1[illegible]	[illegible]		[illegible]				–
2ND SECTION	[illegible]	0		0								[illegible]
[illegible]	134	61.[illegible]		[illegible]	34[illegible]		[illegible]		[illegible]			–
COWLING, ETC.	5[illegible]	47.[illegible]	14,[illegible]	6.0	54				[illegible]			–
STR. PARTS	14	4[illegible]	6.0[illegible]									–
ENGINE & FANS				0	[illegible]					[illegible]		[illegible]
ENGINE	[illegible]	47.9[illegible]	[illegible]	0						[illegible]	[illegible]	[illegible]
FAN & FANS	26[illegible]	4[illegible]	11,4[illegible]									–
ENGINE ACCESSORIES		24.8[illegible]	[illegible]	[illegible]	1[illegible]6.0	[illegible]	[illegible]	[illegible]	1[illegible]			–
TURBO SUPERCHARGERS	[illegible]	24.83	.875	[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]			–
SUPERCHARGER SUPPORTS	1[illegible]	[illegible].13	[illegible]	-4.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			–
INTERCOOLERS	142	[illegible]	[illegible]	4.[illegible]	-[illegible]		[illegible]	[illegible]	[illegible]			–
INTERCOOLER SUPPORTS	8	[illegible]	[illegible]	-4	4		[illegible]	[illegible]				–
INTERCOOLER SHUTTERS	12	[illegible]	[illegible]	[illegible]	[illegible]							[illegible]
OIL COOLERS	64	8.13	[illegible]	[illegible]	[illegible]							–
OIL COOLER SUPPORTS	4	-8.13	33	[illegible]	[illegible]		14.6		[illegible]	[illegible]		–
[illegible] SYSTEM	265	[illegible].13	[illegible]	8.0	[illegible]	14.6	[illegible]	[illegible]	[illegible]			–
AIR DUCTS	147	17.[illegible]	[illegible]	0			[illegible]		[illegible]			
FUEL PUMPS	4	[illegible]	101	[illegible]			[illegible]		[illegible]	[illegible]		
MISCELLANEOUS	10	[illegible]	[illegible]									
PROPELLERS										[illegible]		[illegible]
PROPS.	[illegible]	[illegible]	[illegible]							[illegible]	[illegible]	[illegible]
[illegible]	40	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]	
[illegible] SYSTEM	[illegible]	[illegible]	1[illegible]									
[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible] PANEL	[illegible]	[illegible]	[illegible]	.4	[illegible]							
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							
[illegible]	[illegible]	[illegible]										

TABLE II

[illegible]

MEMBER	V	D	S	L	V/L	D/L	S/L	SAME AS
AB	1.75	34.375	4.75	34.754	.0442	.9884	.1367	A'B'
CD	1.75	34.375	4.75	34.754	.0504	.9884	.1367	C'D'
AM	20.25	34.375	4.75	43.516	.6032	.7900	.1091	A'M'
CM	23.25	34.375	4.75	41.766	.5567	.8230	.1137	C'M'
BM	21.75	0	0	21.750	1	0	0	B'M'
MD	25.00	0	0	25.00	1	0	0	M'D'
DN	0	0	24.75	24.75	0	0	1	D'N'
BL	8.25	0	24.75	26.094	.3162	0	.9485	B'L
DL	44.50	0	24.75	50.922	.8739	0	.4860	D'L
AL	6.75	34.375	20.00	40.344	.1673	8520	.4957	A'L
CN	1.75	34.375	20.00	39.812	0440	8634	.5024	C'N
BH	6.875	31.375	9.94	33.625	.2045	.9331	.2955	B'H'
BK	23.312	31.375	2.19	39.156	.5954	.8013	0559	B'K'
DG	27.50	31.375	2.69	41.813	.6577	.7504	.0643	D'-G'
DF	2.25	31.375	4.94	31.844	.0707	.9853	.1551	D'-F'
DE	5.64	31.375	23.75	39.750	.1431	7893	.5975	D'-E'
BX	24.20	32.572	2.53	40.656	.5955	8013	.0623	B'X'
DX	28.55	32.572	2.53	43.406	6511	.7505	0583	D'X'
DY	5.93	32.700	24.75	41.470	.1428	.7891	.5968	D'Y'

TABLE III

ENGINE MOUNT LOADS & MARGINS OF SAFETY

Member	[illegible]	[illegible]	[illegible]	Tension	Length L	L/ρ	Allow. Tension	Allow. Compr.	Margin of Safety
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15
[illegible]	[illegible]	[illegible]	[illegible]	1181	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2240	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	4990?	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.33?
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26.6?	[illegible]	[illegible]	.11
[illegible]	[illegible]	[illegible]	[illegible]	1841	[illegible]	92.45?	[illegible]	[illegible]	.044?
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52.45	[illegible]	[illegible]	.476
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31.9?	14700	[illegible]	.143
[illegible]	[illegible]	[illegible]	18175?	7021	31.150	[illegible]	[illegible]	15?	[illegible]
[illegible]	[illegible]	[illegible]	2000?	11062	41.875	-4.1?	[illegible]	24220	1.210
HG'	[illegible]	[illegible]	[illegible]	18?	41.875	[illegible]	[illegible]	24200	.323
AR	[illegible]	-11180?	7480?	215?	24.184	[illegible]	[illegible]	30100	.400
AR'	[illegible]	-11180?	[illegible]	15170	24.?	[illegible]	[illegible]	30100	.5?
BL	[illegible]	[illegible]	4526	6655	26.?4	[illegible]	[illegible]	16,?	1.615
BL'	[illegible]	[illegible]	5,151?	4660	20.114	21.5?	[illegible]	16,?	1.255
EM	[illegible]	+6510?	1145?	1140	21.?	[illegible]	316?	[illegible]	.350
EM'	[illegible]	[illegible]	[illegible]	13?20	21.7?	22.55	[illegible]	[illegible]	.961
[illegible]	[illegible]	[illegible]	[illegible]	1100	30,152	41?	13,?40	[illegible]	1.118
DE	[illegible]	+1665?	[illegible]	[illegible]	[illegible]	[illegible]	?40	[illegible]	.?7
CD	[illegible]	[illegible]	175?	[illegible]	34.?4	[illegible]	[illegible]	42?	[illegible]
CD'	[illegible]	11840?	[illegible]	[illegible]	34.?4	[illegible]	[illegible]	42?	.4?1
[illegible]	[illegible]	[illegible]	104?	[illegible]	[illegible]	[illegible]	3.?	24?	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE IV
LOADS ON ENGINE MOUNT FITTINGS

MEMBER	UNIT VERTICAL X 5	TORQUE	THRUST	V/L	D/L	S/L	UNIT VERT. X V/L (2)x(5)	TORQUE X V/L (3)x(5)	THRUST X V/L (4)x(5)	UNIT VERT. X D/L (2)x(6)	TORQUE X D/L (3)x(6)	THRUST X D/L (4)x(6)	UNIT VERT. X S/L (2)x(7)	TORQUE X S/L (3)x(7)	THRUST X S/L (4)x(7)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
							UP LOAD - U / DOWN LOAD - D			FWD. LOAD - F / AFT LOAD - A			INBOARD - I / OUTBOARD - O		
I. MOUNT FITTING AT A':															
A'B'	117980	15535	-3990	.0432	.7814	.1367	775-U	[illegible]-U	172-D	17800-A	[illegible]-A	[illegible]-F		7[illegible]-I	[illegible]
A'M'	+16030	+8060	+143	.6032	.7900	.1011	96[illegible]-D	4860-D	86-D	1268[illegible]	[illegible]-A	[illegible]-A		[illegible]-I	16[illegible]
A'L	-2[illegible]5	-2250	0	.1673	.8520	.4157	40-U	377-U	[illegible]	190[illegible]	[illegible]-F	[illegible]	[illegible]	[illegible]	
					Σ FORCES =		[illegible]	4244-D	258-D	30[illegible]A	11[illegible]A	2837 F	4[illegible]	1752-I	[illegible]
II. MOUNT FITTING AT A:															
AB	117980	15535	-3990	.0432	.7814	.1367	775-U	231-D	122-D	17800-A	[illegible]-F	4150 F	[illegible]-O	7[illegible]-I	[illegible]-I
AM	+16030	-8060	+143	.6032	.7900	.1011	96[illegible]-D	48[illegible]-U	8[illegible]-D	[illegible]A	6370-F	[illegible]-A	17[illegible]	5.87-I	16[illegible]
AL	-2[illegible]5	+2250	0	.1673	.8520	.4157	40-U	377-D	0	190-F	1917-A	0	[illegible]-I	1115	
					Σ FORCES =		8835-D	4244-U	258-D	30[illegible]0A	21[illegible]	2837 F	4[illegible]	[illegible]-I	[illegible]-I
III. MOUNT FITTING AT C':															
C'D'	-17790	-5525	-6630	.0504	.9874	.1367	890-U	27[illegible]-U	334-U	17600-F	54[illegible]-F	6560 F	[illegible]	[illegible]-O	905-O
C'M'	-15380	-7740	-137	.5567	.8230	.1137	8560-D	4310-D	76-D	12650-F	[illegible]-A	11[illegible]-F	17[illegible]	[illegible]-O	12[illegible]
C'N	0	+2238	0	.0440	.8634	.5024	0	98-D	0	0	19[illegible]-A	[illegible]		[illegible]	
					Σ FORCES =		7670-D	4129-D	258-U	30250-F	7510 F	6673-F	4[illegible]	1757-O	[illegible]
IV. MOUNT FITTING AT C:															
CD	-17790	+5525	-6630	.0504	.9874	.1367	890-U	27[illegible]-D	334-U	17600-F	54[illegible]-A	[illegible] F	[illegible]	[illegible]	[illegible]-I
CM	-15380	+7740	-137	.5567	.8230	.1137	8560-D	4310-U	76-D	12[illegible]-F	12[illegible]A	[illegible]F	[illegible]	[illegible]	[illegible]-I
CN	0	-2238	0	.0440	.8634	.5024	0	98-U	0	0	1[illegible]-F			[illegible]	
					Σ FORCES =		7670-D	4129-U	258-U	30[illegible]F	9870-A	6673 F	[illegible]	1757-[illegible]	[illegible]-I

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DESIGN CONDITIONS AND GENERAL DATA FOR STUB WING

The wing structure is analyzed for two wind tunnel conditions. The data for C_L, α, and C.P. are estimated on the basis of previous wind tunnel tests on scale models.

For a load distribution, the values of C_N are assumed to be constant over the entire span.

A factor of 5 is used on the air loads, and a similar factor is used for relieving inertia effects.

AERODYNAMIC DATA

Condition I	Condition II
$C_L = 1.0$	$C_L = 1.5$
$\alpha = 10^\circ$	$\alpha = 14^\circ$
$V = 250$ mph.	$V = 150$ mph.
$C_{D_o} = .012$	$C_{D_o} = .012$
C.P. = .3406 C	C.P. = .2967 C
$C_{D_p} = .0347$	$C_{D_p} = .0347$

GENERAL DATA

(For Planform and dimensions of stub wing see Fig. 2, page 10.)

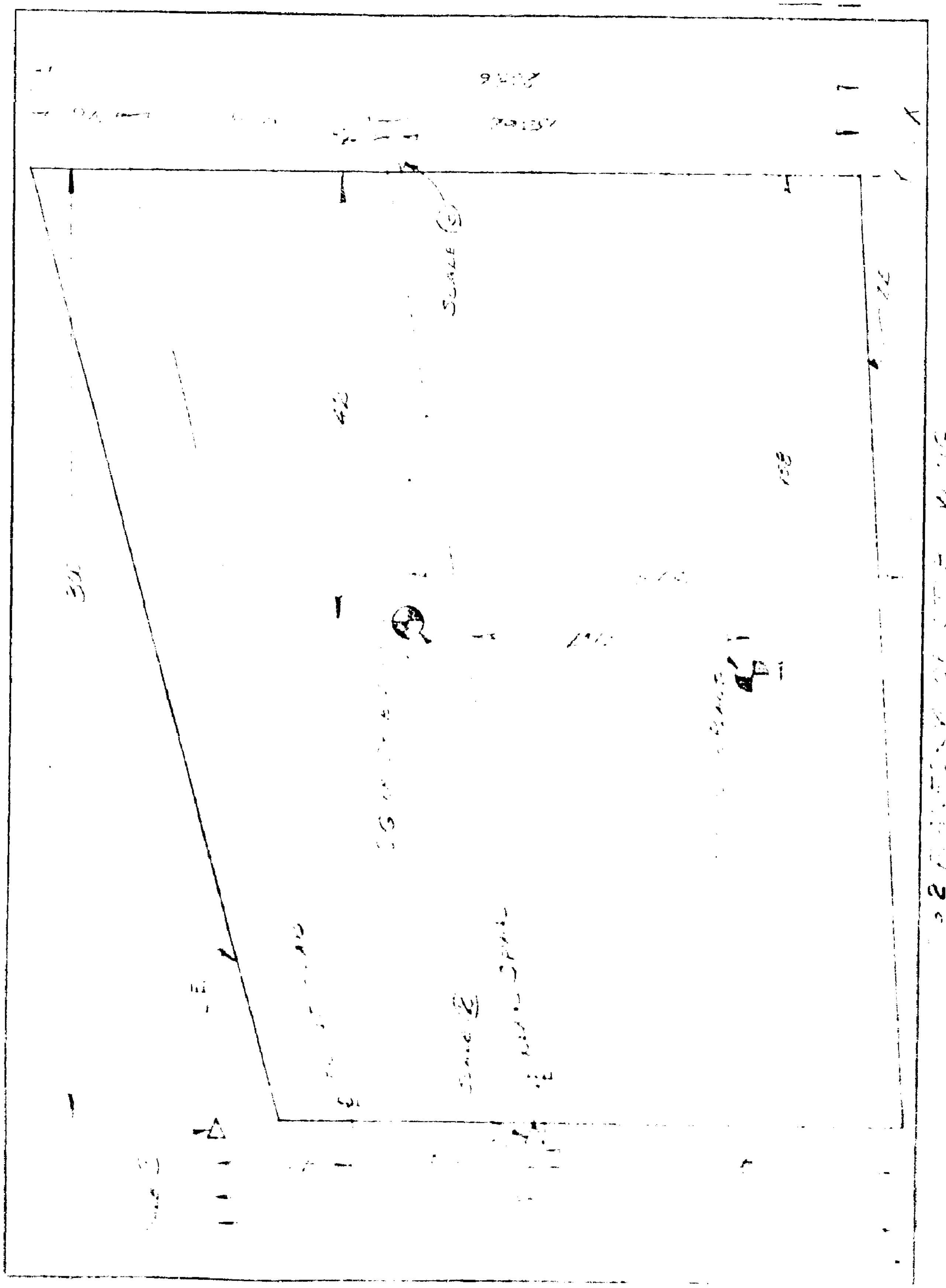
Stub Wing Area $= \left(\frac{263.6 + 198.5}{2}\right)300 = 69{,}315$ sq. in.

$= 481.35$ sq. ft.

Chord Equation $= 263.6 - \frac{263.6 - 198.6}{300}x = 263.6 - .217x$

Where x = distance from largest chord of stub wing

A.R. $= \frac{b^2}{S} = \frac{25^2}{481.35} = 1.297$



STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DESIGN CONDITIONS AND GENERAL DATA FOR STUB WING

Overal Drag Coefficients

Condition I

$$C_{D_i} = \frac{C_L^2}{(A.R.)} = .2455$$

$$C_D = C_{D_O} + C_{D_D} + C_{D_i} = .012 + .0347 + .2455 = .2922$$

Condition II

$$C_{D_i} = .553$$

$$C_D = .012 + .0347 + .553 = .5997$$

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

CONDITION I - AIR LOADS AND DISTRIBUTIONS

DETERMINATION OF NORMAL SPAN LOADING

$q = 1/2 \rho V^2 = .002558(250)^2 = 159.8$ #/□'

$C_N = C_L \cos\alpha + C_D \sin\alpha$

$= 1 (\cos 10^\circ) + .2922 \sin 10^\circ = .985 + .0508$

$= 1.0358$

$N = 1/2 \rho V^2 C_n A = qCnA$

$= 159.8(1.0358)(481.35) = 79{,}900$#

Assuming uniform C_N on total area the loading in pounds per inch of span may be determined.

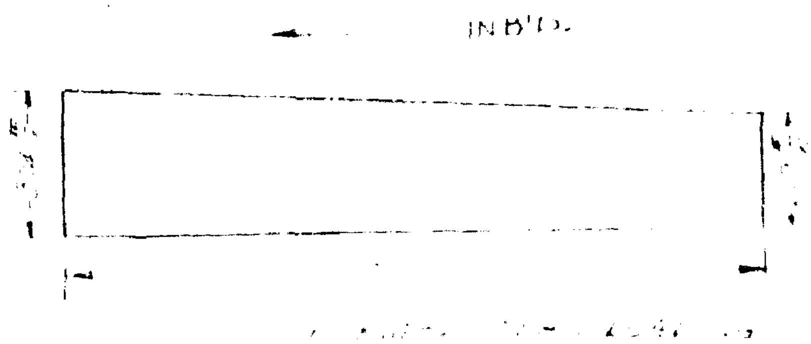
$\frac{N}{A} = \frac{79{,}900}{69315} = 1.1527$ #/sq. in.

Span loading at largest chord of stub wing:

$= \frac{N}{A} \times C = (1.152)(263.5) = 304$ #/in.

Span Loading at smallest chord of stub wing:

$\frac{N}{A} \times C = (1.152)(198.5) = 229$ #/in.



STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINATION OF CHORDWISE SPAN LOADING

$C = 1/2\rho V^2 C_c A = q \times C_c \times A$ $\qquad q = 159.8$ #/□'

C_c $\quad C_c = C_D \cos\alpha - C_L \sin\alpha$

$= .2922 \cos 10^\circ - 1 \sin 10^\circ =$

$= .288 - .1736 = .1144$

$C = 159.8(.1144)(481.35) - 8{,}800$#

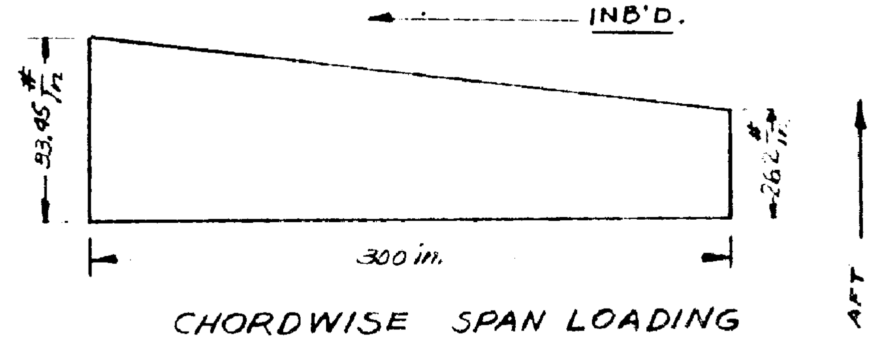
$\frac{C}{A} = \frac{8800}{69315} = .127$ #/sq. in.

Chordwise span loading at largest chord

$= \frac{C}{A} \times C_N = (.127)(263.6) = 33.45$ #/in. of span

Chordwise span loading at smallest chord

$= \frac{C}{A} \times C_N = (.127)(198.5) = 26.2$ #/in. of span



CHORDWISE SPAN LOADING

DETERMINATION OF SPAR LOADS

Assuming the total vertical load acting at the C.P., the load is divided between the spars inversely as their distance from the C.P.

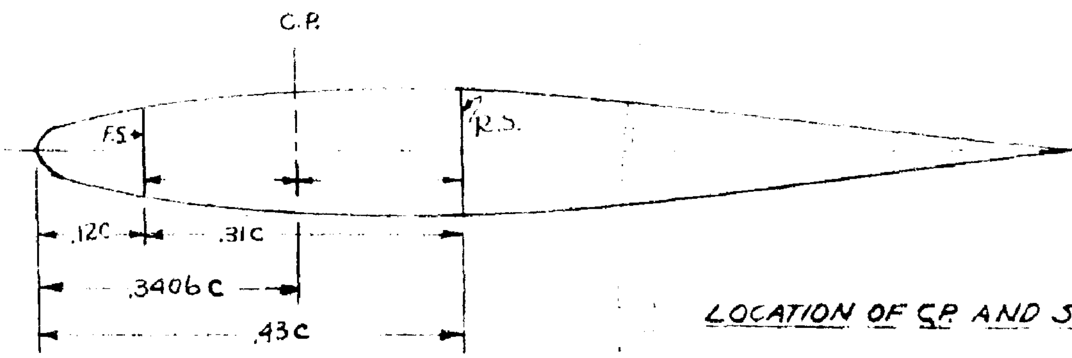
C.P. = .3406 Chord

Front spar = .12 Chord

Rear Spar = .43 Chord

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINATION OF SPAR LOADS (CONT.)



LOCATION OF C.P. AND SPARS

At largest chord W/C = 304 #/in.

W to F.S. = $\frac{.0894C}{.31C}$ (304) = 87.6 #/in.

W to R.S. = $\frac{.2206C}{.31C}$ (304) = 216 #/in.

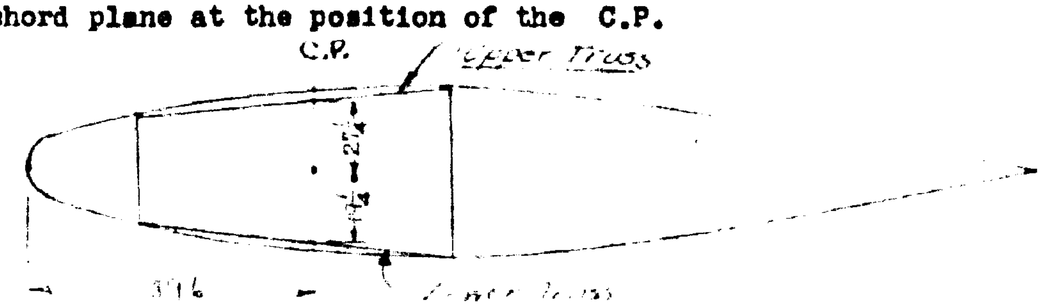
At smallest chord W/C = 229 #/in.

W to F.S. = $\frac{.0894C}{.31C}$ (229) = 66 #/in.

W to R.S. = $\frac{.2206C}{.31C}$ (229) = 163 #/in.

DETERMINATION OF HORIZONTAL TRUSS LOADS

Assuming the total chordwise load distributed between upper and lower trusses inversely as their distance from the chord plane at the position of the C.P.



STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINATION OF HORIZONTAL TRUSS LOADS (Cont.)

C.P. = .3406 (263.6) = 89.6 inches aft of L.E.

Distance from chord line to upper truss = 27 1/4 inches, and distance to lower truss = 19 1/4 inches at largest chord.

W to upper truss (largest chord) = $\frac{19\ 1/4}{46.5}$ (33.45) = 13.85 #/in.

W to lower truss = $\frac{27.25}{46.5}$ (33.45) = 19.6 #/in.

Corresponding distances at smallest chord = 18.75" and 15.5". Smallest chord of stub = 198.5 in.

W to upper truss (tip section) = $\frac{15.5}{34.25}$ (26.2) = 11.85 #/in.

W to lower truss (tip section) = $\frac{18.75}{34.25}$ (26.2) = 14.32 #/in.

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

CONDITION II - AIR LOADS AND DISTRIBUTION

DETERMINATION OF SPAN LOADING

$q = 1/2 \rho V^2 = .002558 \ (130)^2 = 43.15$

$C_N = C_L \cos \alpha + C_D \sin \alpha$

$= 1.5 \cos 14^{\circ} + .5997 \ (\sin 14^{\circ}) = 1.5 \ (.97) + .5997 \times (.242)$

$= 1.455 + .145 = 1.6$

$N = 1/2 \rho V^2 C_N A = q \ CNA = 43.15 \ (1.6) \ (481.35) = 33{,}300$ #

Assuming uniform CN on total area, the loading in #/sq.in. of span may be determined.

$\frac{N}{A} = \frac{33{,}300}{69315} = .4805$

Large Chord: W (Normal loading) $= \frac{N}{A} \times C = .4805 \ (263.5) = 126.7$#/in.

Small Chord: W (Normal Loading) $= \frac{N}{A} \times C = .4805 \ (198.5) = 95.5$#/in.

DETERMINATION OF CHORDWISE SPAN LOADING

$C = 1/2 \rho V^2 C_c A = q \times C_c \times A$ $\qquad q = 43.15$

$C_c = C_D \cos \alpha - C_L \sin \alpha = .5997 \ (\cos 14^{\circ}) - 1.5 \sin 14^{\circ}$

$= .5805 - .363 = .2175$

$C = 43.15 \ (.2175) \ (481.35) = 4525$ #

Chordwise span loading at largest chord $= \frac{C}{A} \times C$

$C/A = \frac{4525}{69315} = .0654$ #/sq.in.

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINATION OF CHORDWISE SPAN LOADING (Cont'd.)

$W = \frac{C}{A} \times C = .0654\ (263.5) = 17.2\#/\text{in.}$ (largest chord)

$W = \frac{C}{A} \times C = .0654\ (198.5) = 12.97\#/\text{in.}$ (smallest chord)

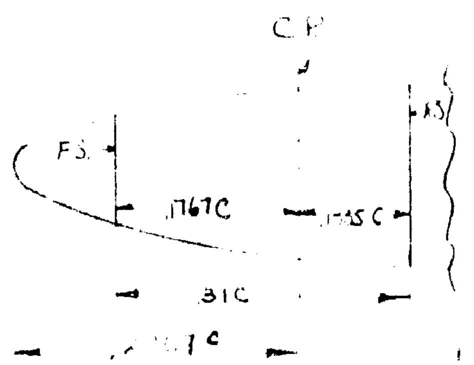
DETERMINATION OF SPAR LOADS

Assuming the total normal load acting at the C.P., the load may be divided between the spars inversely as their distance from the C.P.

C.P. = .2962 x chord

Front Spar = .12 chord

Rear Spar = .43 chord



W to front spar = $\frac{.1335c}{.31c}$ (126.7) = 54.5#/in. (Largest Chord)

W to rear spar = $\frac{.1767c}{.31c}$ (126.7) = 72.2#/in. (Largest Chord)

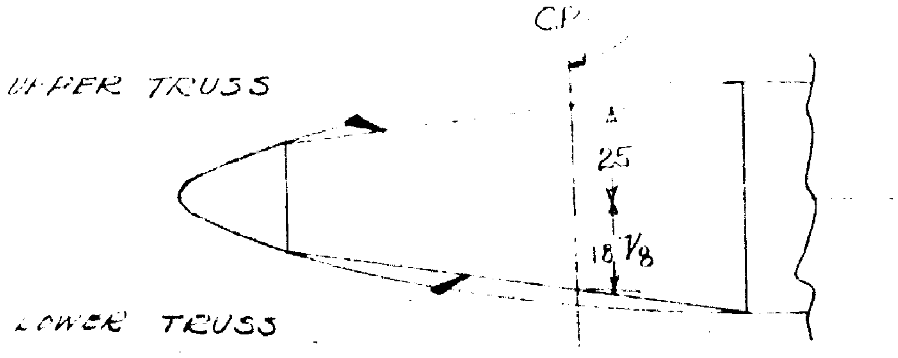
W to front spar = $\frac{.1335c}{.31c}$ (95.5) = 41.1#/in. (Smallest Chord)

W to rear spar = $\frac{.1767c}{.31c}$ (95.5) = 54.4#/in. (Smallest Chord)

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINATION OF HORIZONTAL TRUSS LOADS

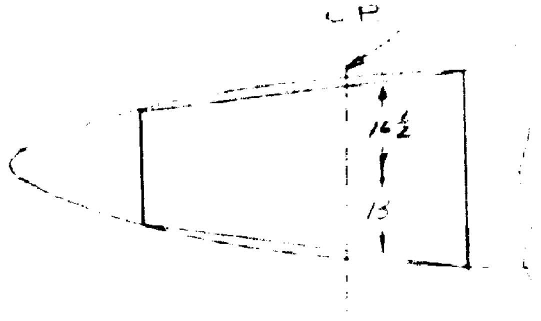
Assuming the total chordwise load distributed between the upper and lower truss inversely as their distance from the chord plane at the position of the C.P.



LARGEST SECTION

W to upper truss $= \frac{18\ 7/8}{43.875}(17.2) = 7.3\#/\text{in.}$ (Largest Chord)

W to lower truss $= \frac{25}{43.875}(17.2) = 9.8\#/\text{in.}$ (Largest Chord)



SMALLEST SECTION

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINATION OF HORIZONTAL TRUSS LOADS (Cont'd.)

W to upper truss $= \frac{13}{29\ 1/2}$ (12.97) = 5.71#/in. (Smallest Chord)

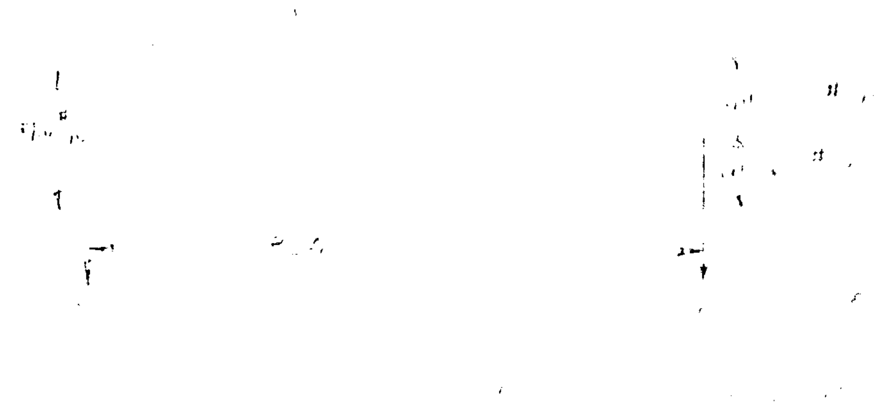
W to lower truss $= \frac{16\ 1/2}{29\ 1/2}$ (12.97) = 7.25#/in. (Smallest Chord)

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

SHEARS & BENDING MOMENTS DUE TO AIR LOADS ALONE

CONDITION I ($C_L = 1.0$)

FRONT SPAR



$$R_1 = -\frac{WL}{2} - \frac{W'L}{3} = -\frac{66(300)}{2} - \frac{21.600(300)}{3} = -9900 - 2160 = -12,060\#$$

R_1 = 12,060 # Down

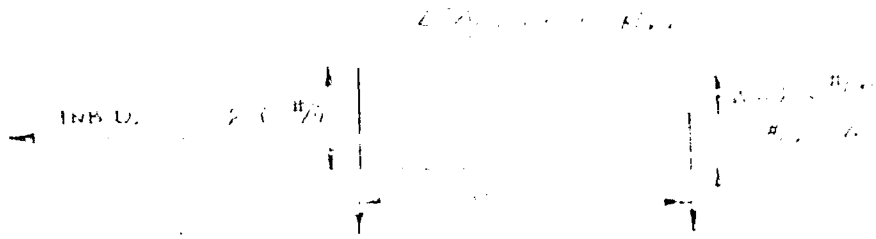
$$R_o = -\frac{WL}{2} - \frac{W'L}{6} = -\frac{66(300)}{2} - \frac{21.6(300)}{6} = -9900 - 1080 = -10,980\#$$

R_o = 10,980# Down

The shear and bending moment curves may be found by the integration of the loading curves and are plotted on Fig. 1, Page [illegible].

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

REAR SPAR REACTIONS



$R_i = \frac{-WL}{2} - \frac{W'L}{3} = -\frac{163(300)}{2} - \frac{53(300)}{3} = -24,450 - 5300 = 29750\#$

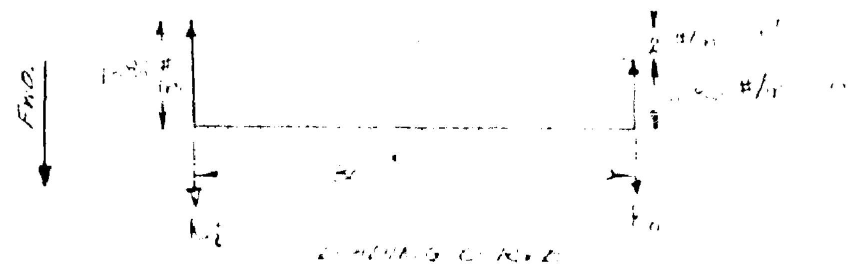
$R_i = 29,750\#$

$R_o = \frac{-WL}{2} - \frac{W'L}{6} = -\frac{163(300)}{2} - \frac{53(300)}{6} = -24450 - 2650 = -27,100\#$

$R_o = 27,100\#$

The shear and bending moment curves are plotted on Fig. 4 Page 28.

UPPER TRUSS



$R_i = \frac{-WL}{2} - \frac{W'L}{3} = -\frac{11.85(300)}{2} - \frac{2(300)}{3} = -1780 - 200 = -1980\#$

$R_i = 1980\#$ Fwd.

$R_o = \frac{-WL}{2} - \frac{W'L}{6} = -\frac{11.85(300)}{2} - \frac{2(300)}{6} = -1780 - 100 = -1880\#$

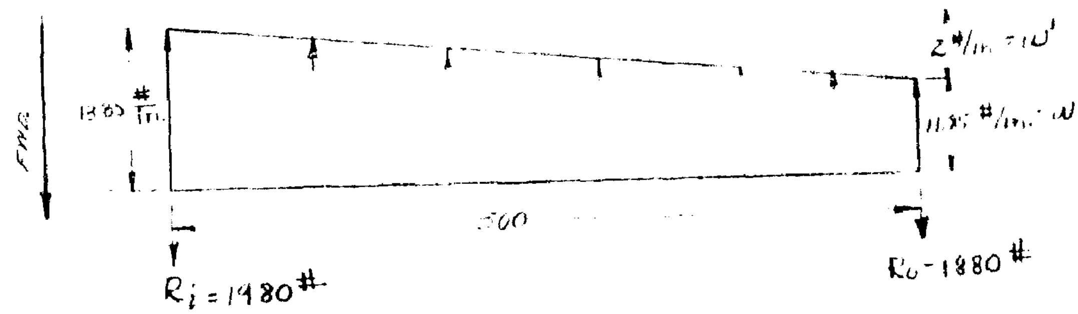
$R_o = 1880\#$ Fwd.

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

UPPER TRUSS (Cont'd.)

The shear and bending moment curves are plotted on Fig. 5, Page 29.

LOWER TRUSS



LOADING CURVE

$$R_i = \frac{-WL}{2} - \frac{W'L}{3} = -\frac{1432(300)}{2} - \frac{5.28(300)}{3} = -2150 - 528 = -2678$$

$$= 2678\# \text{ Fwd.}$$

$$R_o = \frac{-WL}{2} - \frac{W'L}{6} = \frac{14.32(300)}{2} - \frac{5.280(300)}{6} = -2150 - 264 = -2414\#$$

$$= 2414\# \text{ Fwd.}$$

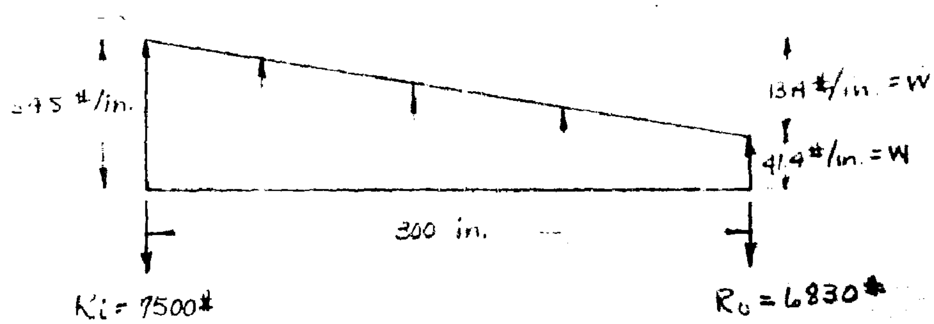
The shear and bending moment curves are plotted on Fig. 6, Page 30.

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

SHEARS & BENDING MOMENTS DUE TO AIR LOADS ALONE

CONDITION II (C_L = 1.5)

FRONT SPAR



LOADING CURVE

REACTIONS

$$R_i = \frac{-WL}{2} - \frac{W'L}{3} = -\frac{41.1(300)}{2} - \frac{13.4(300)}{3}$$

$$R_i = -6160 - 1340 = -7500\# \text{ or } 7500\# \downarrow$$

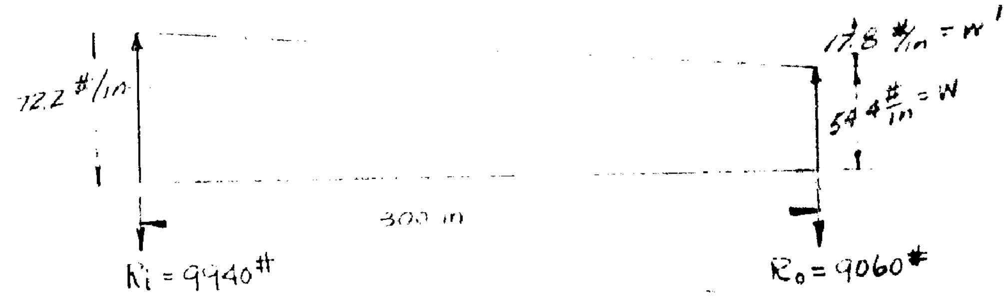
$$Ro = \frac{-WL}{2} - \frac{W'L}{6} = \frac{-41.1(300)}{2} - \frac{13.4(300)}{6} = -6160 - 670$$

$$Ro = 6830\# \downarrow$$

The shear and bending moment curves are plotted on Fig. 3, Page 27.

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTRUCTIONS

REAR SPAR



LOADING CASE

REACTIONS

$$R_i = \frac{-WL}{2} - \frac{W'L}{3} = -\frac{54.4(300)}{2} - \frac{17.8(300)}{3} = -8160 - 1780$$

R_i = -9940# or 9940# ↓

$$R_o = \frac{-WL}{2} - \frac{W'L}{6} = -\frac{544(300)}{2} - \frac{17.8(300)}{6} = -8160 - 890 = -9060$$

R_o = 9060 # ↓

The shear and bending moment curves are plotted on Fig. 4, Page 28.

UPPER TRUSS

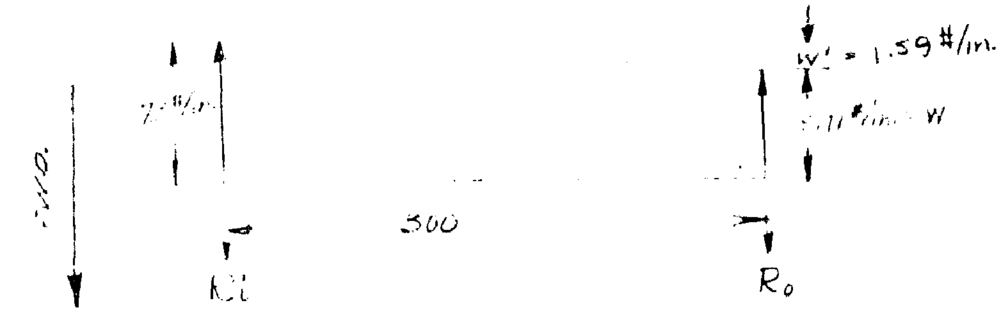
BY

CHECKED

APPROVED

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

UPPER TRUSS



LOADING

$R_1 = \frac{-WL}{2} - \frac{W'L}{3} = \frac{-5.71(300)}{2} \; \frac{-1.59(300)}{3} = -856 - 159 = -1015\#$

$\underline{\underline{R_1}} = \underline{1015\# \text{ Fwd.}}$

$R_o = \frac{-WL}{2} - \frac{W'L}{6} = -\frac{5.71(300)}{2} - \frac{1.59(300)}{6} = -856 - 80$

$\underline{\underline{R_o}} = -936\#$ or $\underline{936\# \text{ FWD}}$.

The shear and bending moment curves are plotted on Fig. 5 Page 29.

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

LOWER TRUSS

$$R_1 = \frac{-WL}{2} - \frac{W'L}{3} = -\frac{7.25(300)}{2} - \frac{2.55(300)}{3}$$

$$\underline{\underline{R_1}} = -1088 - 255 = \underline{\underline{1343\#\ \text{Fwd}}}.$$

$$R_o = \frac{-WL}{2} - \frac{W'L}{6} = -\frac{7.25(300)}{2} - \frac{2.55(300)}{6}$$

$$R_o = -1088 - 128 = 5272$$

$$\underline{\underline{R_o}} = \underline{\underline{1216\#\ \text{Fwd}}}.$$

The shear and bending moment curves are plotted on Fig. [illegible], Page 50.

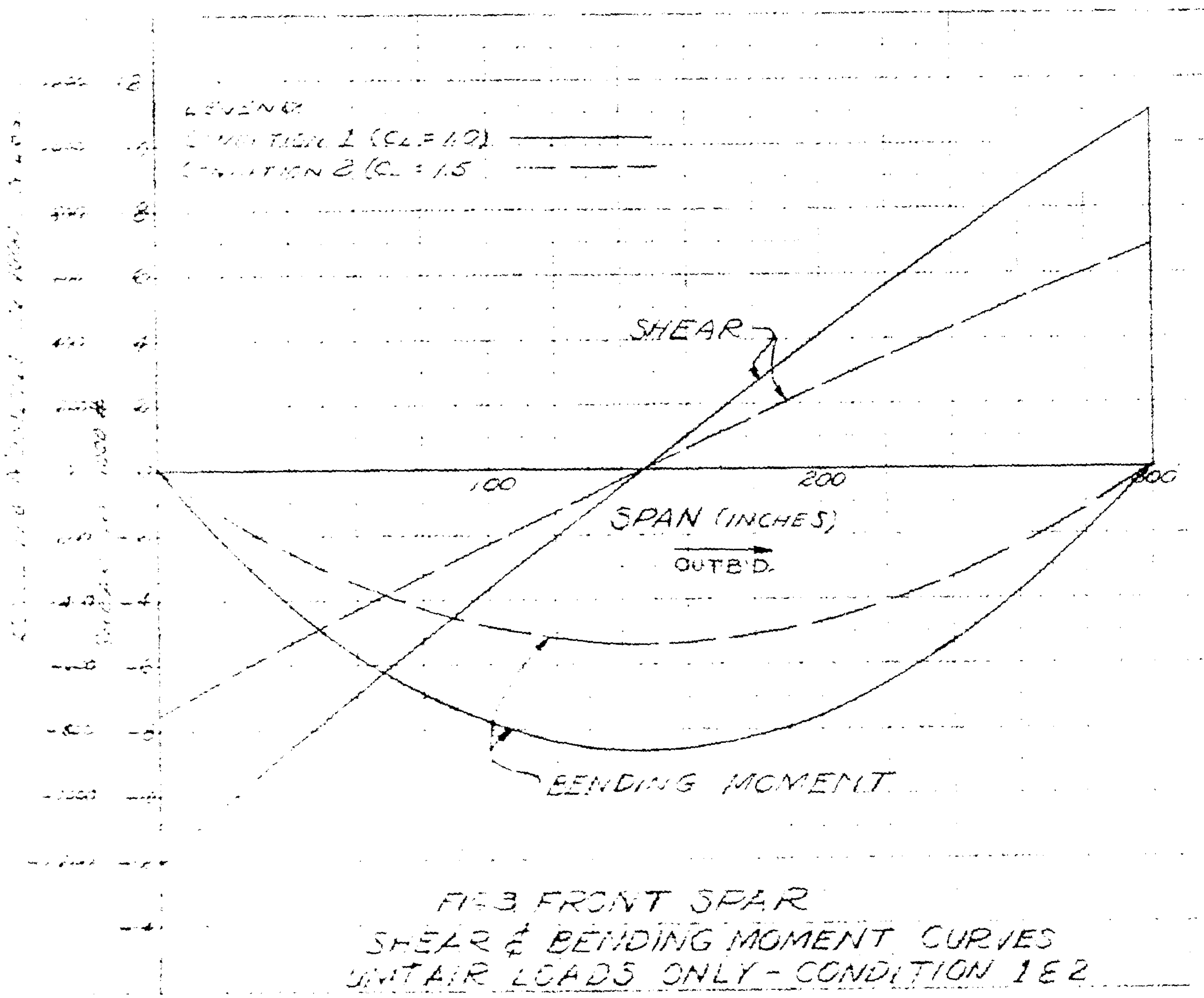


FIG. 3 FRONT SPAR
SHEAR & BENDING MOMENT CURVES
UNIT AIR LOADS ONLY - CONDITION 1 & 2

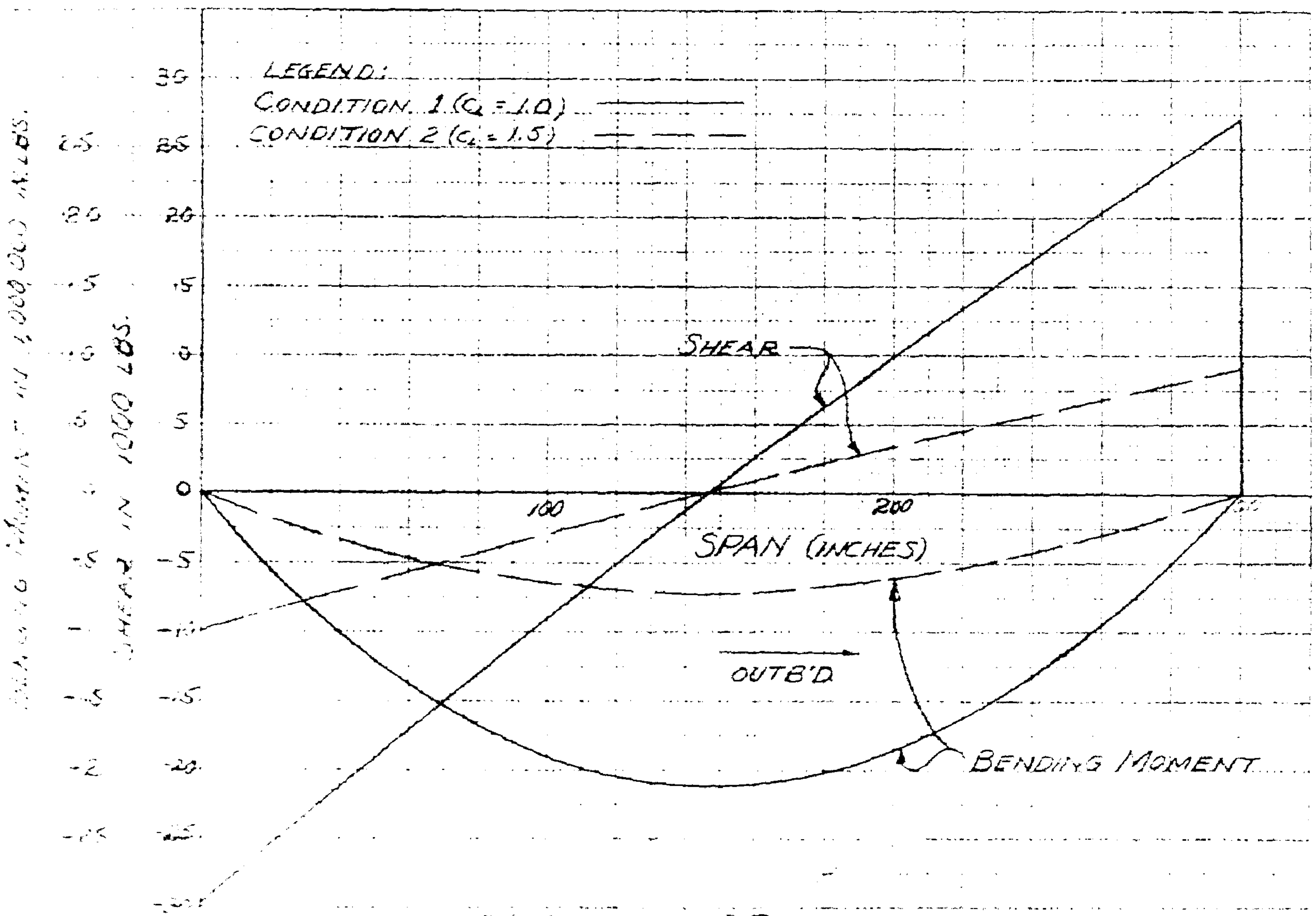
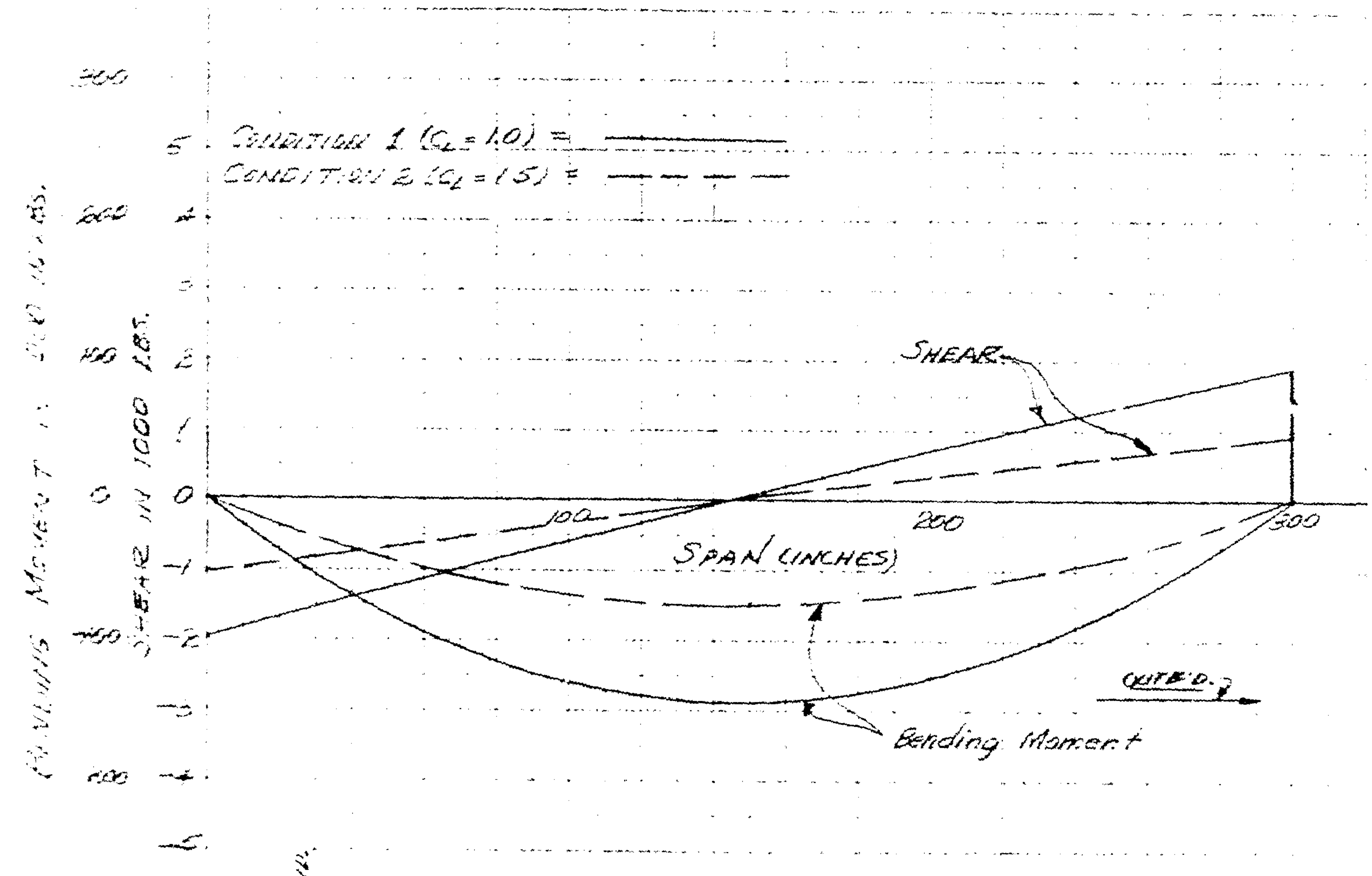


Fig. 4 REAR SPAR
SHEAR & BENDING MOMENT CURVES
UNIT AIR LOADS ONLY - CONDITION 1 & 2



FESUPPER TRUSS
SHEAR & BENDING MOMENT CURVES
AIR LOADS ONLY — CONDITION 1 & 2

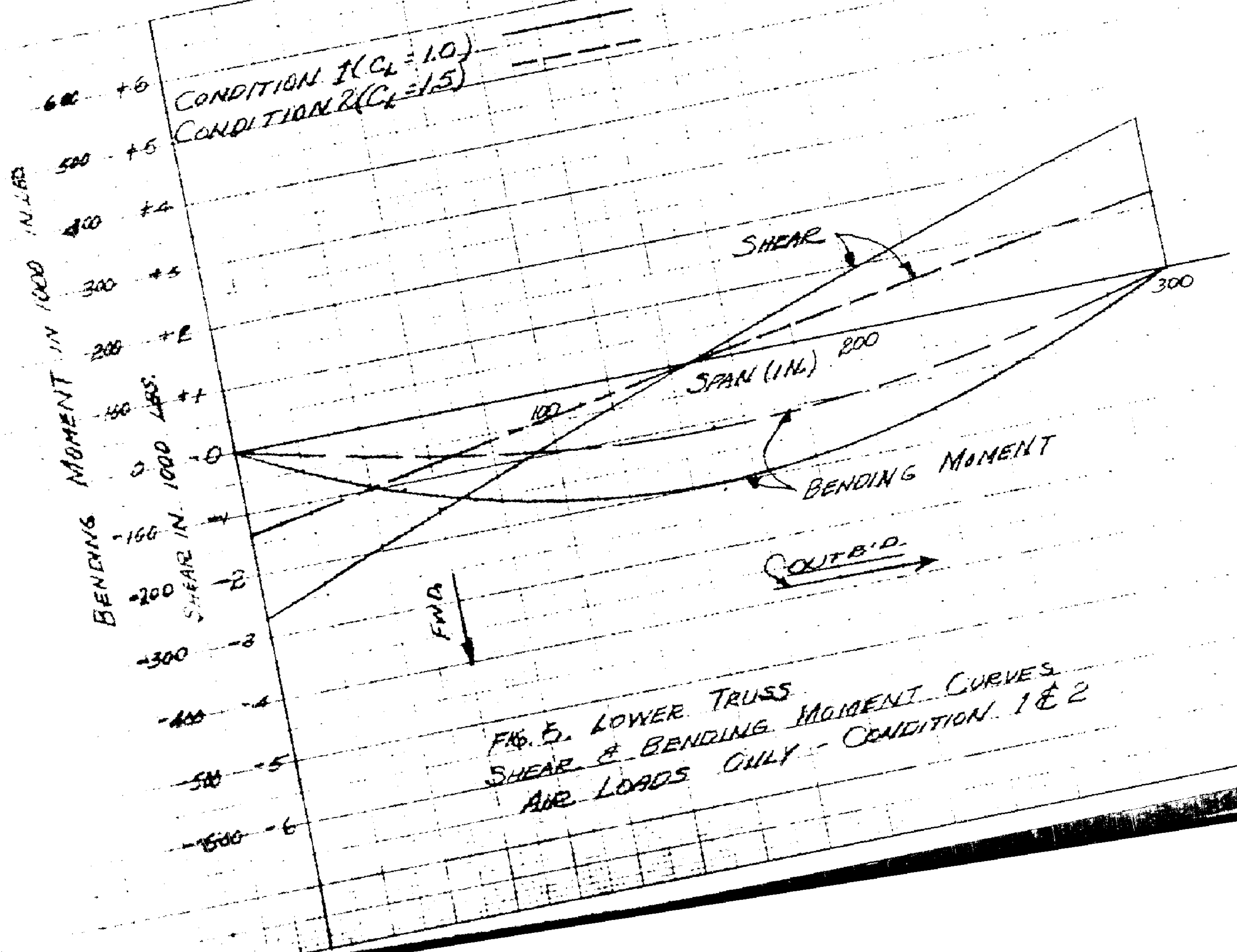


Fig. 5. Lower Truss
Shear & Bending Moment Curves
Air Loads Only - Condition 1 & 2

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DISTRIBUTION OF DEAD WEIGHT

The complete stub wing minus the power plant was found by actual weighing to weigh 12,880 lbs. To arrive at the weight to be distributed the weight of the end plates and end fittings was subtracted from the gross weight. The end plates and fittings were calculated to weigh 3068 lbs. Therefore, the net weight was 12882 - 3068 = 9814 lbs.

Three scales were used in the weighing and were placed as shown in Fig. (2). The net scale reactions are also shown.

Using lines x-x and y-y as reference lines the C.G. may be determined as follows:

Summing moments about line x-x

ΣM_{x-x} = (Reaction Scale 1 x Distance to x-x) + (Reaction Scale 2 x distance 6 x-x) + (Reaction Scale 3 x distance to x-x)

$\Sigma M_{x-x} = 1870 (217.75) + 2775(115.75) + 5169(161.95)$

$= 407,193 + 321,206 + 837,120 = 1,565,518$ in lbs.

$\bar{Y} = \frac{\Sigma M_{x-x}}{Net.Wt.} = \frac{1,565,518}{9814} = 159.52$ in.

Summing moments about y-y

ΣM_{y-y} = (Reaction scale 1 x distance to y-y + (Reaction Scale 2 x distance to y-y = 1870(-300) + 2775(-300) = -1,393,500 in.#

$\bar{x} = \frac{\Sigma M_{y-y}}{Net.Wt.} = \frac{-1,393,500}{9814} = -142"$

Position of the C.G. relative to parts of stub wing are shown on sketch Fig. (2)

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

SPAN LOADING

DEAD WEIGHT LESS ENGINE

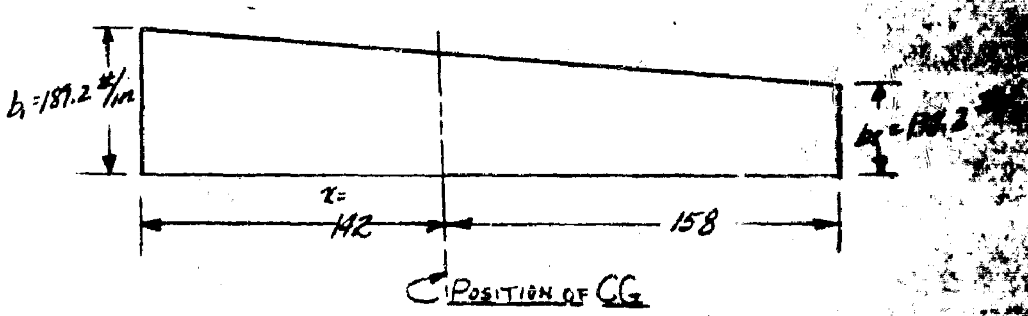
Assuming a uniformly varying distribution of weight along the span, the span distribution may be found as follows: (load factor = 5 g down.)

Ultimate inertia load = 5 x net weight

= 5 (9814) = 49,070 #

Average Span Loading = $\frac{\text{Ultimate load}}{\text{Span}} = \frac{49,070}{300}$

= 163.7 #/in. of span



Position of C.G.

$X = \frac{142}{300} \times 100 = 47.4$ % of span

From table of geometric properties of trapezoids

$\frac{b_1}{b_2} = 1.37$

$b_1 = 1.37\ b_2$

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DEAD WEIGHT LESS ENGINE (Cont.)

but $\frac{(b_1 + b_2)}{2}(\text{span}) = \text{total load}$

$$\frac{(1.37b_2 + b_2)}{2}(300) = 49{,}070\ \#$$

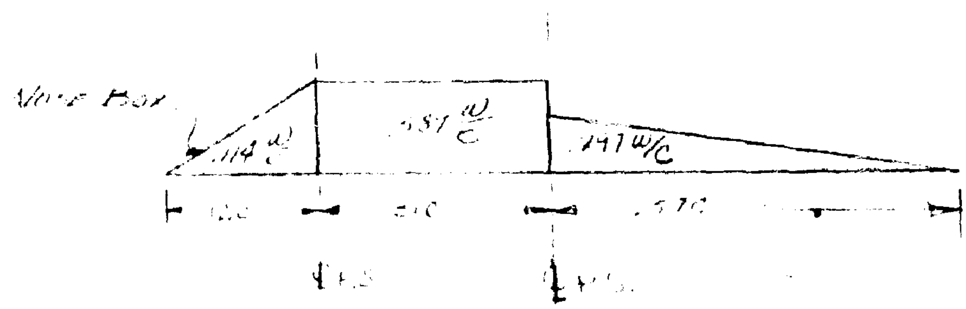
$\underline{b_2} = \underline{138.2}$ #/in.

$\underline{b_1} = 1.37(138.2) = \underline{189.2}$ #/in.

DISTRIBUTION OF WEIGHT TO SPARS

DEAD WEIGHT LESS ENGINE

The chordwise distribution of weight was taken as shown below.



Taking half of the interspar load to the front spar and half to the rear spar and finding spar loadings.

Load to front spar = $.114\ W/C + \frac{.589}{2}\ W/C = .4085\ W/C$

Load to rear spar = $.297\ W/C + \frac{.589}{2}\ W/C = .5915\ W/C$

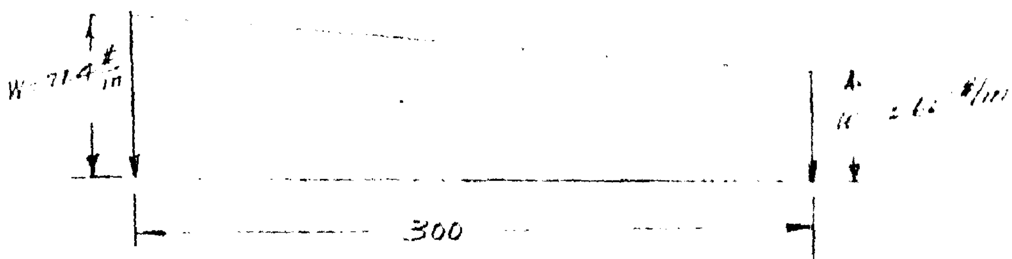
STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DEAD WEIGHT LESS ENGINE (Cont.)

Therefore, loading on spars are:

Loading Front Spar Inb'd. Section = .4085 (189.2) = 77.4 #/in.

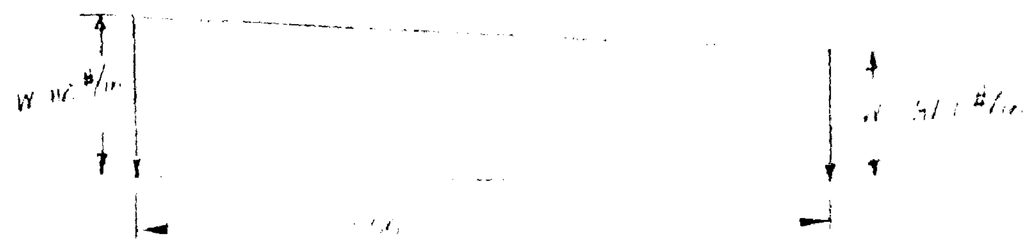
Loading Front Spar Outb'd. Section = .4085 (138.2) = 56.5 #/in.



FRONT SPAR LOADING

Loading Rear Spar Inb'd. Section = .5915 (189.2) = 112 #/in.

Loading Rear Spar Outb'd. Section = .5915 (138.2) = 81.9 #/in.



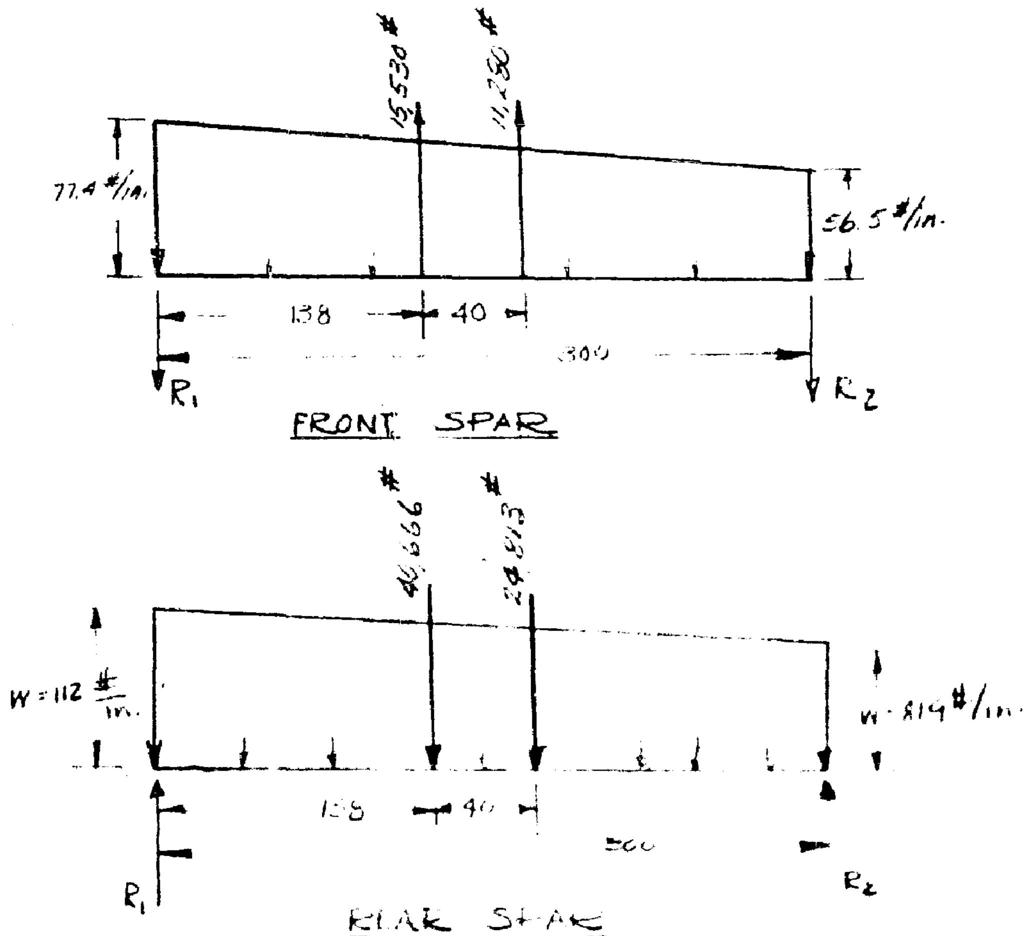
REAR SPAR LOADING

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DEAD WEIGHT PLUS ENGINE

The loads from the power plant are found in table IV Page 8.

Superimposing the loads from the power plant at the dead wt., the spar loading curves are shown below:



STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINATION OF R_1 & R_2 OF FRONT SPAR

$$R_1 = \frac{W_2L}{2} + \frac{(W_1-W_2)L}{3} - \frac{P_1(162)}{300} - \frac{P_2(122)}{300}$$

$$= \frac{56.5(300)}{2} + \frac{(77.4-56.5)(300)}{3} - \frac{15,530(162)}{300} - \frac{11,280(122)}{300}$$

$$= 8475 + 2090 - 8400 - 4585$$

$$= -2420\ \# \text{ or } 2420\ \#\downarrow$$

$$R_2 = \frac{W_2L}{2} + \frac{(W_1-W_2)L}{6} - \frac{P_1(138)}{300} - \frac{P_2(178)}{300}$$

$$R_2 = \frac{56.5(300)}{2} + \frac{(77.4-56.5)(300)}{6} - \frac{15530(138)}{300} - \frac{11,280(178)}{300}$$

$$= 8475 + 1045 - 7150 - 6690 = -4320\ \# \text{ or } 4320\ \#\downarrow$$

DETERMINATION OF R_1 & R_2 OF REAR SPAR

$$R_1 = \frac{W_2L}{2} + \frac{(W_1-W_2)L}{3} + \frac{P_1(162)}{300} + \frac{P_2(122)}{300}$$

$$= \frac{81.9(200)}{2} + \frac{(112-81.9)(300)}{3} + \frac{40666(162)}{300} + \frac{24813(122)}{300}$$

$$= 12,290 + 3010 + 22,000 + 10,100$$

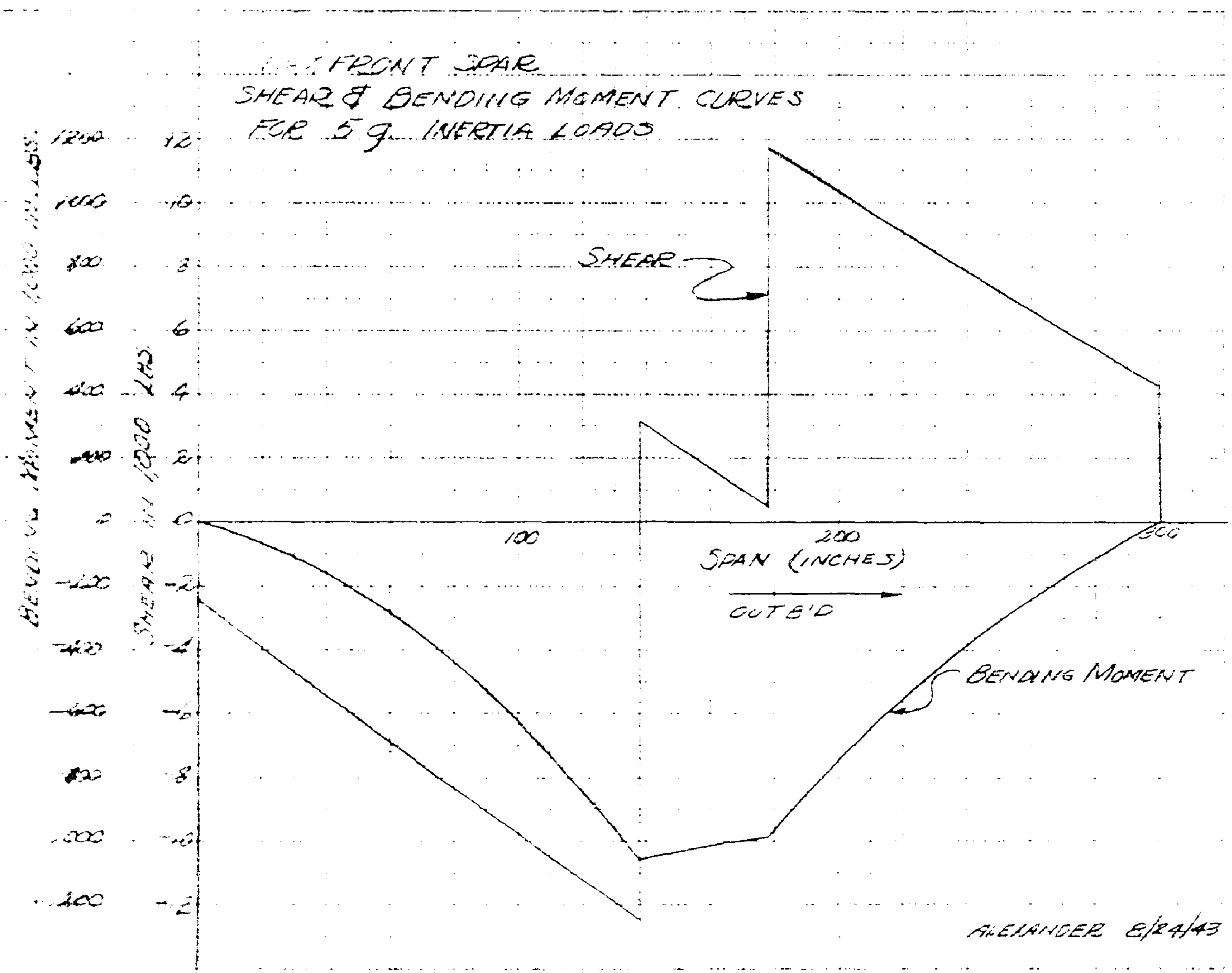
$$= 47,400\ \#\uparrow$$

R_2 = Total Load − 47400 = 94479 − 47400 = 47079 #↑

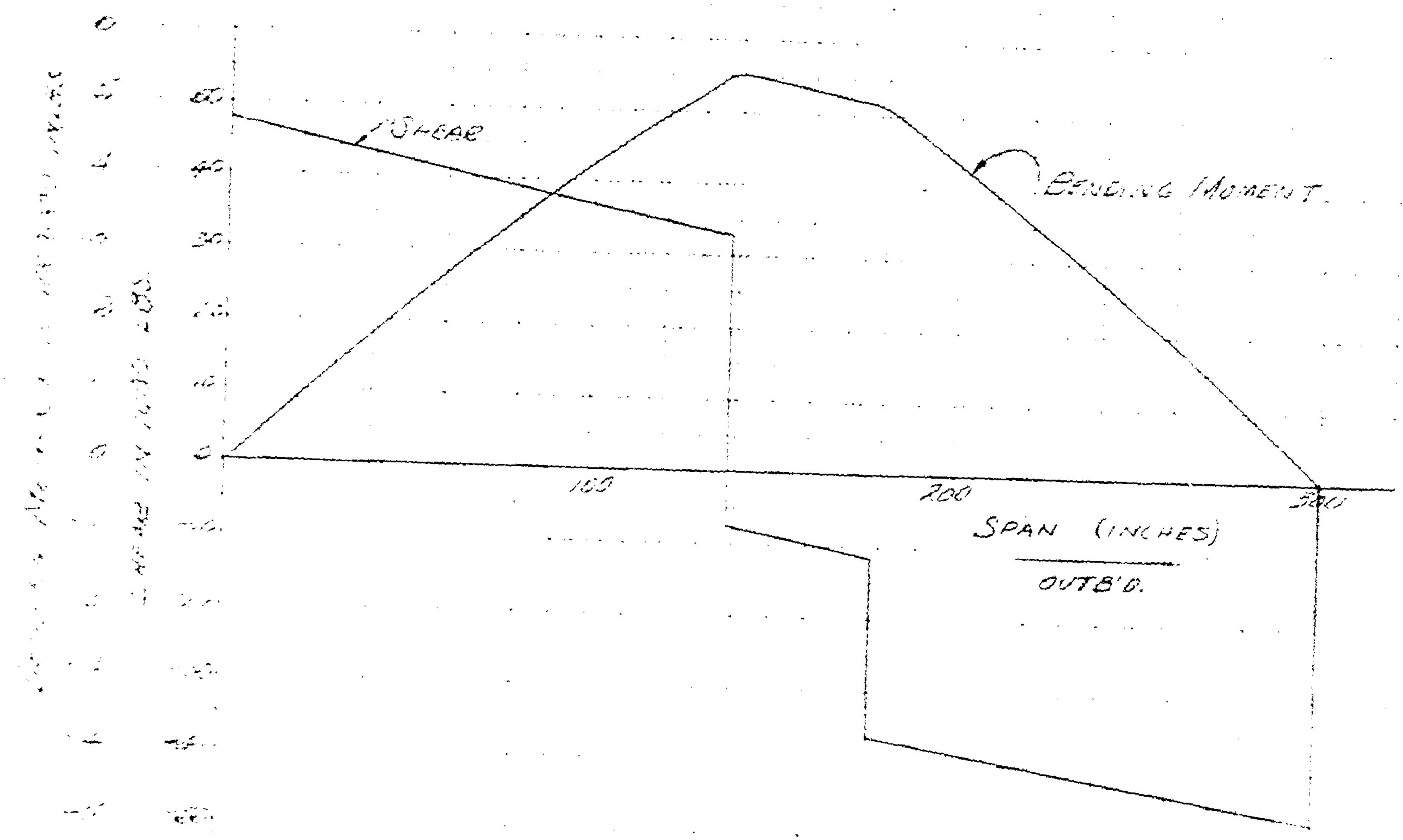
The shear and bending moment curves for the total inertia loads alone are shown on Figs. 7 & 8 Page 37 & 38.

REAR SPAR

Examining the air load shear and bending moment curves and the 5 g inertia loading shear and bending moment curves,



FRONT SPAR
SHEAR & BENDING MOMENT CURVES
FOR 5 g INERTIA LOADS
SHEAR
BENDING MOMENT
SPAN (INCHES)
OUTB'D
100
200
300
SHEAR IN 1000 LBS
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
BENDING MOMENT IN 1000 IN. LBS.
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
ALEXANDER 8/24/43



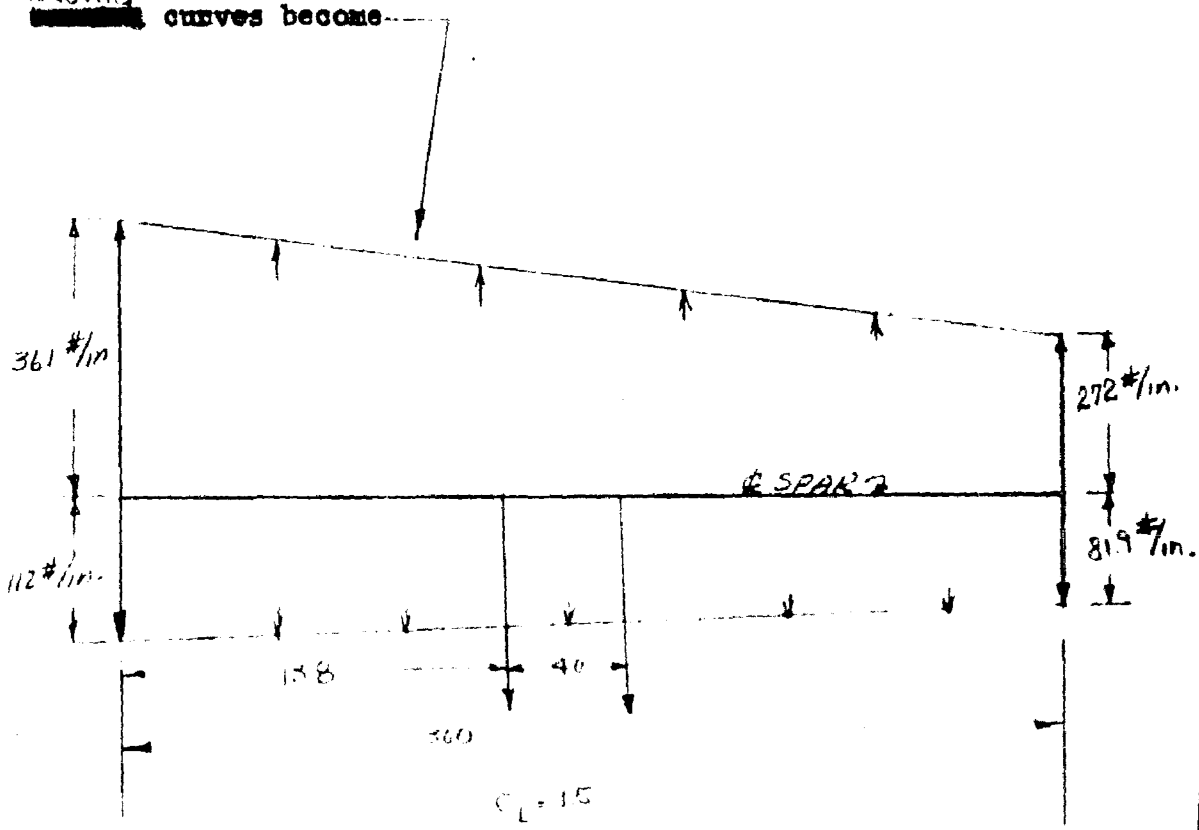
Rear Spar
Shear and Bending Moment Curves
For 5 g Inertia Loads

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

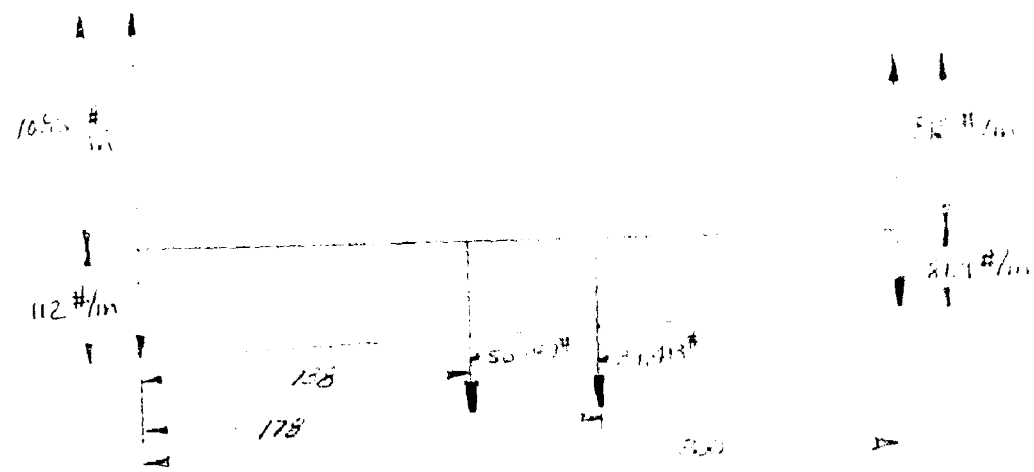
REAR SPAR (Cont.)

it is found that the inertia loads in combination with either of the air load conditions might give a critical condition. Both conditions will be investigated.

Increasing the unit air loads five times and superimposing the loading curve upon the 5 g inertia loading curves the loading [redacted] curves become



STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION



REAR SPAR $C_L = 1.0$

The resulting shear and bending moment curves are shown in Figure 10, Page 43.

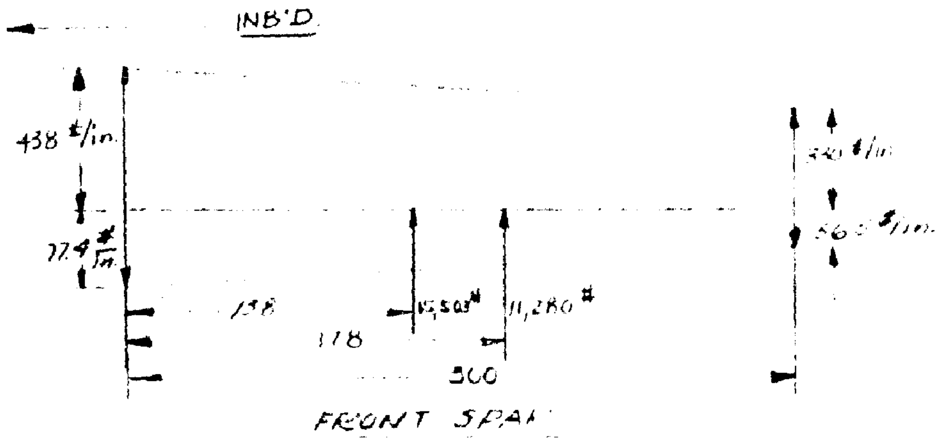
STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

COMBINED AIR AND INERTIA SHEARS AND BENDING MOMENTS ON SPARS

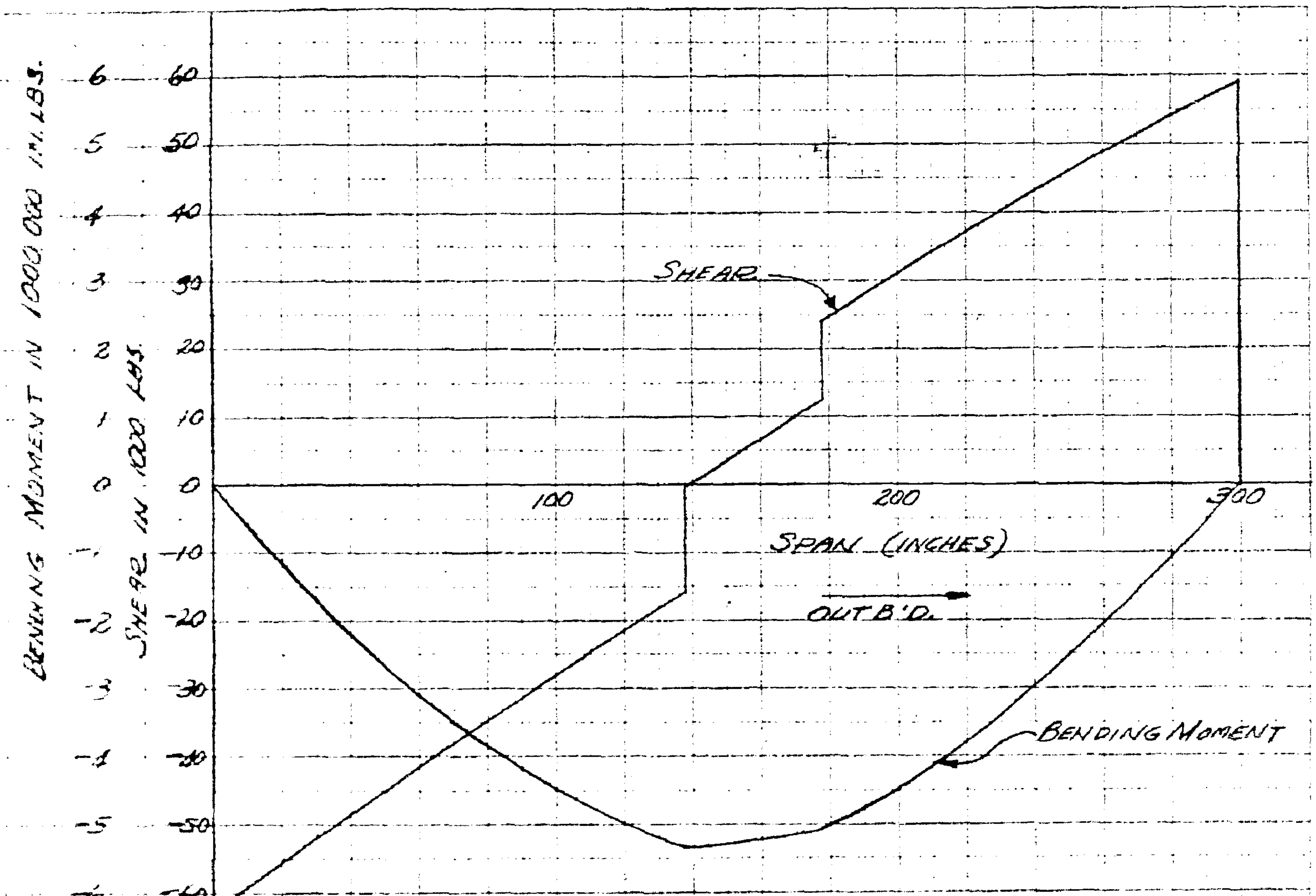
FRONT SPAR

Examining the air load shear and bending moment curves and the 5g. static loading shear and bending moment curves, it is found that the air load condition where $C_L = 1.0$ in combination with the 5g inertia loads will be the critical condition for the front spar structure.

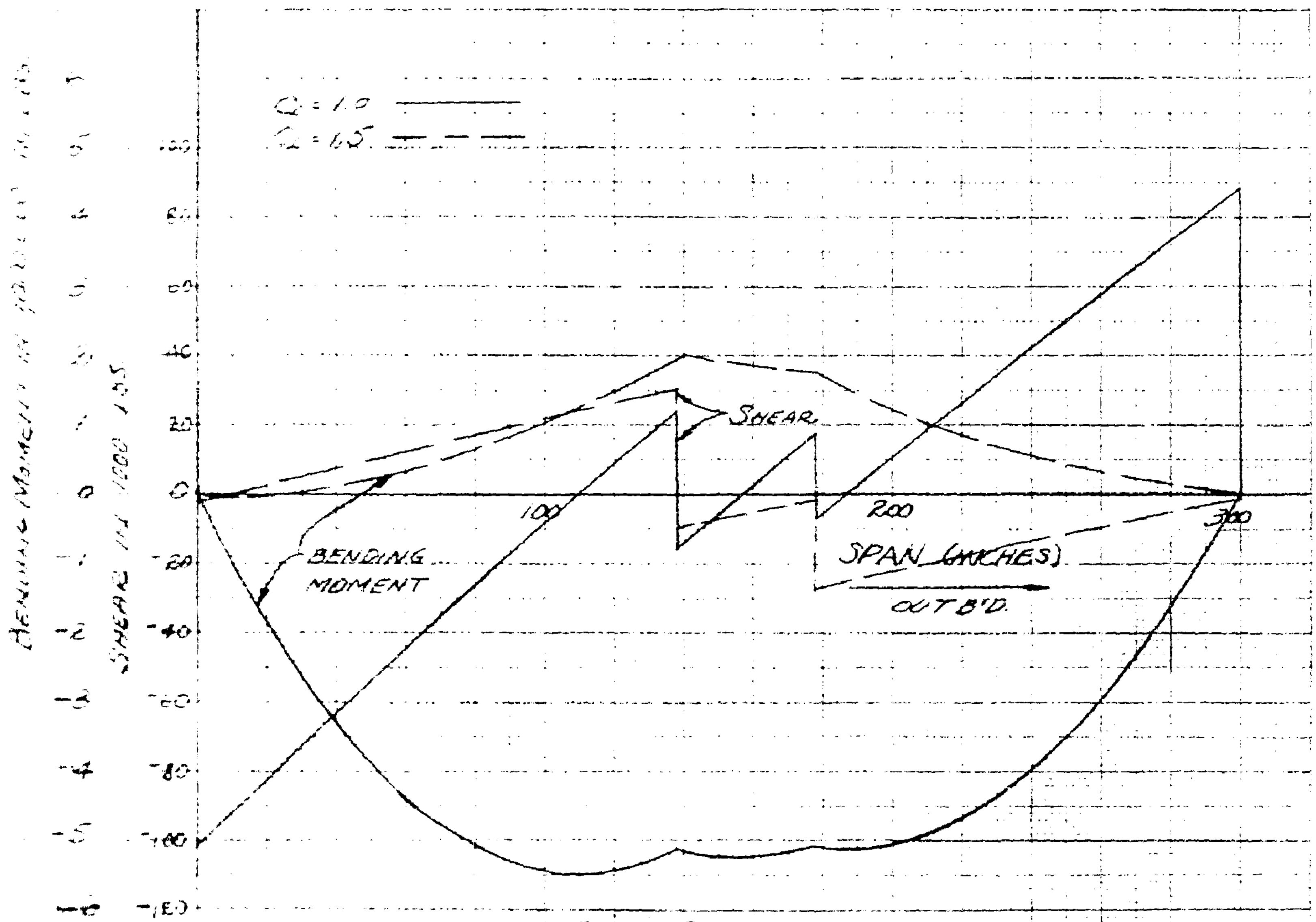
Increasing the unit air load curves five times and superimposing the loading curve upon the 5g. inertia loading curves, the loading curve becomes



The resulting shear and bending moment curves are shown in Figure 9, Page 42.



F.4.2 FRONT SPAR
SHEAR & BENDING MOMENT CURVES
Combined 5g. AIR LOAD + 5g. INERTIA LOADS



FIG(4) REAR SPAR
SHEAR & BENDING MOMENT CURVES
Combined 5g Air Load + 5g Inertia Load

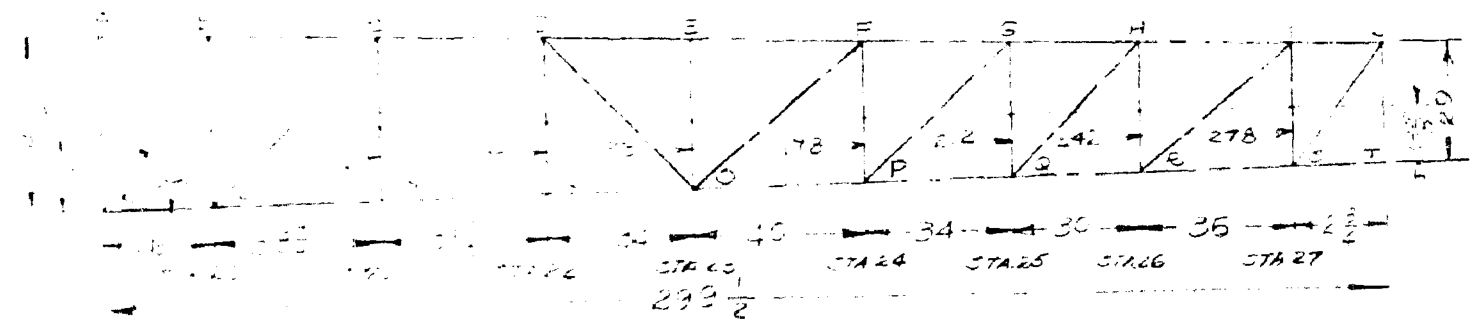


FIG. 11

[illegible] TRUSS

[illegible] 1 IN. = 40 [illegible]

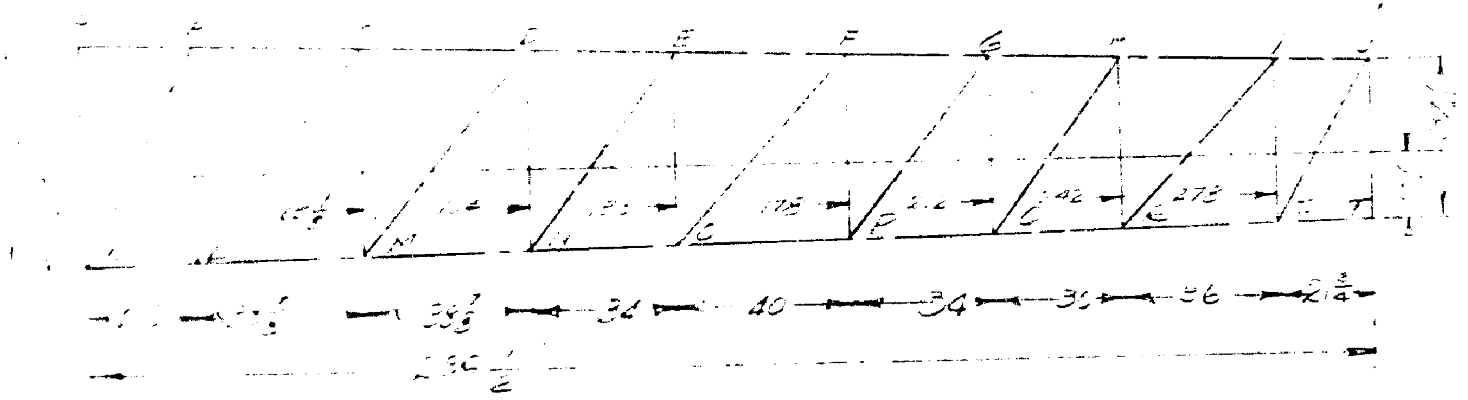


FIG 12. REAR SPAR TRUSS
SCALE APPROX 1 IN = 46 IN

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

ANALYSIS OF SPARS

The applied loads are taken as the maximum loads from the three conditions, (1) 5g. inertia loads only; (2) 5g. inertia loads + air loads, $C_L = 1.5$; (3) 5g. inertia loads + air loads, $C_L = 1.0$.

FRONT SPAR

For point and member notations refer to sketch, Fig. 11.

Applying vertical shear at K to diagonal KB. Shear = 62,250# down.

$P_{KB} = \frac{Shear}{\sin\alpha}$ where α = angle between KB and horizontal

$P_{KB} = \frac{62,250}{\sin 57.7^\circ} = 73,600\#$ Tension

Member is a 3 x 3 x ¼ angle Area = 1.44□"

$f_t = \frac{73600}{1.44} = 51,100\#/sq.in.$

$F_T = 60,000\#/sq.in.$

$M.S. = \frac{F_T}{f_t} - 1 = \frac{60,000}{51,100} - 1 =$ + .17

Applying the vertical shear at L to diagonal LC. Shear = 53,000#

$P_{LC} = \frac{Shear}{\sin\alpha} = \frac{53,000}{\sin 45^\circ} = 75,000\#$ Tension

$f_t = \frac{P_{LC}}{A}$ A = 1.44 sq. in. (3 x 3 x ¼ - angle)

$f_t = \frac{75000}{1.44} = 52,000\#/sq.in.$

$F_T = 60,000\#/sq.in.$

$M.S. = \frac{F_T}{f_t} - 1 = \frac{60000}{52000} - 1 =$ + .15

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

FRONT SPAR (Cont'd.)

Obviously, since the member MD is typical of members KB and LC and since the shear is decreasing toward the center of span, MD will also show a positive M.S.

Applying the vertical shear at N to diagonal DO

Shear = 26,700#

$$P_{DO} = \frac{Shear}{\sin\alpha} = \frac{26,700}{\sin 46.3^{\circ}} = 36,900\#C$$

Length of DO = 50 inches. Column fixity C = 1.0

DO is a 3 x .083 C.M. Steel Tube.

Allowable Compressive Load = 47,000#

$$M.S. = \frac{47,000}{36,900} - 1 = +.27$$

Applying vertical shear at O to diagonal OF. Max. Shear = 16,000#

$$P_{OF} = \frac{Shear}{\sin\alpha} = \frac{16000}{\sin 40.5^{\circ}} = 24,600\# \text{ Tension}$$

Member OF is a 3 x .083 C.M. Steel Tube

Area = .7606 sq.in.

$$f_t = \frac{P_{OF}}{A} = \frac{24600}{.7606} = 32,350\#/sq.in.$$

$$F_T = .841\,(95000) = 80,000\#/sq.in.$$ (Ref. ANC-5)

$$M.S. = \frac{F_T}{f_t} - 1 = \frac{80,000}{32,350} - 1 = +1.47$$

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

FRONT SPAR (Cont'd.)

Applying shear at G to diagonal GP. Max. shear = 35,000#

$P_{GP} = \frac{\text{Max. Shear}}{\sin \alpha} = \frac{35,000}{\sin 44^\circ} = 50,400\#C$

Length of GP = 45 in. - Member: 3 x .083 C.M. Steel Tube

Allowable Compressive load = 51,500# (Ref. ANC-5)

$M.S. = \frac{51500}{50400} - 1 =$ + .020

Applying the vertical shear at J to diagonal JS. Max. Shear = 59,300#

$P_{JS} = \frac{\text{Max. Shear}}{\sin \alpha} = \frac{59,300}{\sin 53.5^\circ} =$ 73,800# Comp.

Length of JS = 30 inches - Member = 3 x 3 x $\frac{1}{4}$ in. angle

$\rho = .93$ $\frac{L}{\rho} = \frac{30}{.93} =$ 32.3 in.

$F_C = 58,200\#/\text{sq.in.}$ (Ref.: A.I.S.C. Handbook)

$f_c = \frac{73,800}{1.44} = 51,200\#/\text{sq.}$

$M.S. = \frac{F_C}{f_c} - 1 = \frac{58,200}{51,200} - 1 =$ + .135

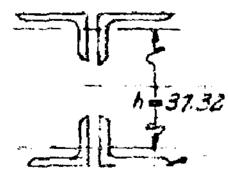
Since the maximum shear curve decreases inboard and since the members are of typical section, obviously members HQ and IR will show positive margins of safety.

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

FRONT SPAR (Cont'd.)

Maximum bending moment occurs at Sta. 23.

Checking axial stress in chord member at that section



3 x 2½ x ¼ - in. angle

CHORDS

Area per angle = 1.31 sq. in.

Max. Moment = 5,500,000 in.#

Axial Chord Load = $\frac{M}{h} = \frac{5,500,000}{37.32}$ = 147,300#

$f_b = \frac{147,300}{2.62}$ = 56,300#/sq.in.

M.S. = $\frac{60,000}{56300} - 1$ = + .065

REAR SPAR

For point and member notations refer to sketch, Fig. 12.

Applying vertical shear at K to diagonal KB. Max. Shear = 101,500#

$P_{KB} = \frac{\text{Max. Shear}}{\sin \alpha} = \frac{101,500}{\sin 63.8°}$ = 113,100# Tension

KB is a 3½ x 3½ x ½ in. angle, Area = 3.25 sq. in.

$f_t = \frac{113,100}{3.25}$ = 34,850#/sq.in.

F_T = 60,000#/sq.in.

M.S. = $\frac{F_T}{f_t} - 1 = \frac{60,000}{34850} - 1$ = + 0.72

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

REAR SPAR (Cont'd.)

Maximum shear causing compression = 47,700#

$P_{KB} = \frac{47,700}{\sin 63.8^\circ} = 53,200\#$ Compression

$\rho = 1.06$ Length of KB = 55

$\frac{L}{\rho} = \frac{55}{1.06} = 52$

$F_C = \frac{37500}{1 + \frac{(52)^2}{18000}} = \frac{37500}{1.15} = 32,600\#/\text{sq.in.}$

$f_c = \frac{P_{KB}}{A} = \frac{53200}{3.25} = 16,380\#/\text{sq.in.}$

$M.S. = \frac{F_C}{f_c} - 1 = \frac{32,600}{16,380} - 1 =$ **+ .98**

Since the curves of shear decrease inboard and since members LC and MD are of typical sections, the members LC and MD will obviously show positive margins of safety.

Applying shear at N (Sta. 104) to diagonal NE

Maximum Shear = 36,400#

$P_{NE} = \frac{\text{Max. Shear}}{\sin \alpha} = \frac{36,400}{\sin 53^\circ} = 45,600\#$ Compression

NE: $3\frac{1}{2}$ x .095 C.M. Steel Tube Length = 55 inches

Allowable Compressive Load = 64,400# (Ref.: ANC-5)

$M.S. = \frac{64,400}{45,600} - 1 =$ **+ 0.41**

Since members QF and PG are subjected to less shear than NE and since QF and PG are typical tubes, obviously they will show positive margins of safety.

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STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

REAR SPAR (Cont'd.)

Applying the vertical shear at T to diagonal JS

Max. Shear = 88,500#

JS is a $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{2}$ in. angle $\rho = 1.06$ $A = 3.25$ sq.in.

$$P_{JS} = \frac{\text{Max. Shear}}{\sin \alpha} = \frac{88500}{\sin 59.5^\circ} = 102{,}100\# \text{ Compression}$$

$$f_c = \frac{P_{JS}}{A_{JS}} = \frac{102{,}100}{3.25} = 31{,}420\#/\text{sq.in.}$$

$$\frac{L}{\rho} = \frac{40}{1.06} = 38$$

$$F_C = \frac{37500}{1 + \frac{(38)^2}{18000}} = \frac{37500}{1.08} = 34{,}700\#/\text{sq.in.}$$

$$M.S. = \frac{34{,}700}{31{,}420} - 1 = \quad \underline{+0.10}$$

Since the shear decreases as the curves progress inboard and since RI and QH are typical sections, obviously they will show positive margins of safety.

Maximum bending moment due to combined loads occurs at Sta. 23,- 138 inches from inboard end. Applying this moment and checking chords in bending at this station, Maximum moment = + 5,500,000 in. #

Chords: 2 - $3 \times 2\frac{1}{2} \times \frac{1}{2}$ inch angles.

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STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

REAR SPAR (Cont'd.)

Chord Axial Load $= \frac{M}{h} = \frac{5,500,000}{46} = 119,400\#$

$f_b = \frac{\text{Chord Axial Load}}{\text{Area}} = \frac{119,400}{2 \times 1.31} = 45,600\#/\text{sq.in.}$

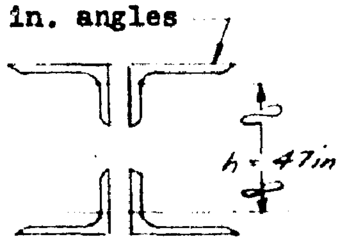
M.S. $= \frac{60,000}{45,600} - 1 =$ $+0.314$

Maximum bending moment due to inertia loads alone occurs at 110 inches from inboard end of stub wing.

Applying this moment and checking chords

Maximum moment = 5,500,000 in. #

Chords 3 x 2½ x ¼ in. angles



Chord Axial Load $= \frac{M}{h} = \frac{5,500,000}{47} = 117,000\#$

$f_b = \frac{\text{Chord Axial Load}}{\text{Area}} = \frac{117,000}{2 \times 1.31} = 44,650\#/\text{sq.in.}$

$F_B = 60,000$

M.S. $= \frac{F_B}{f_b} - 1 = \frac{60,000}{44,650} - 1 =$ $+0.341$

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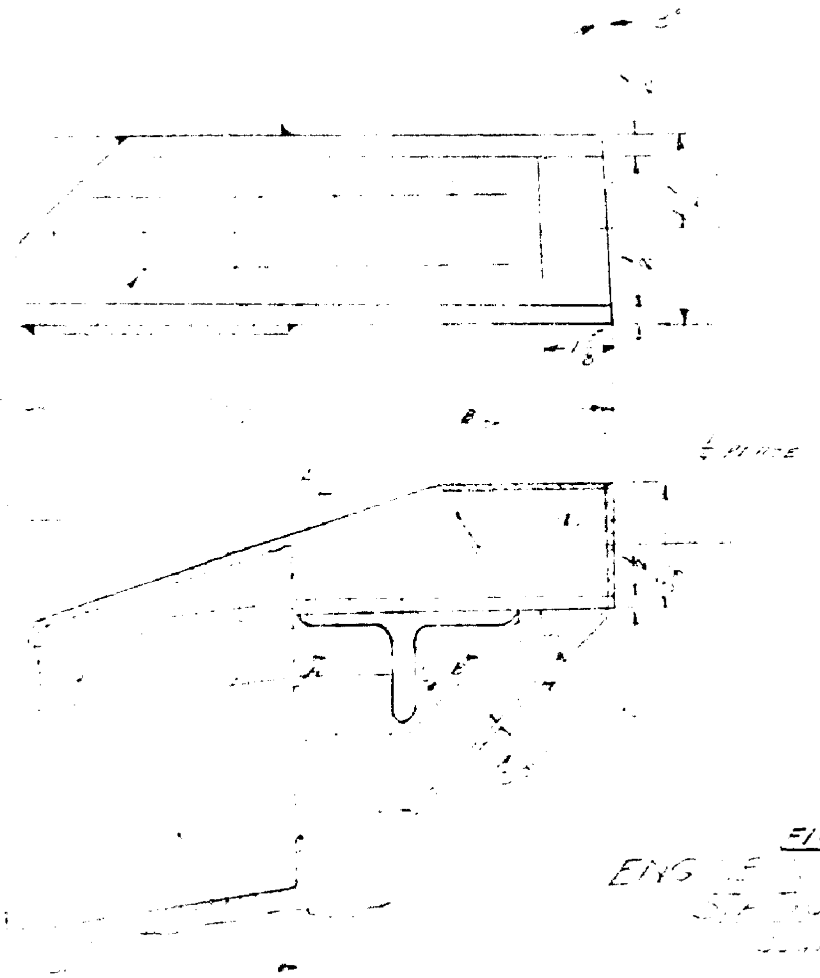

FIG. 13

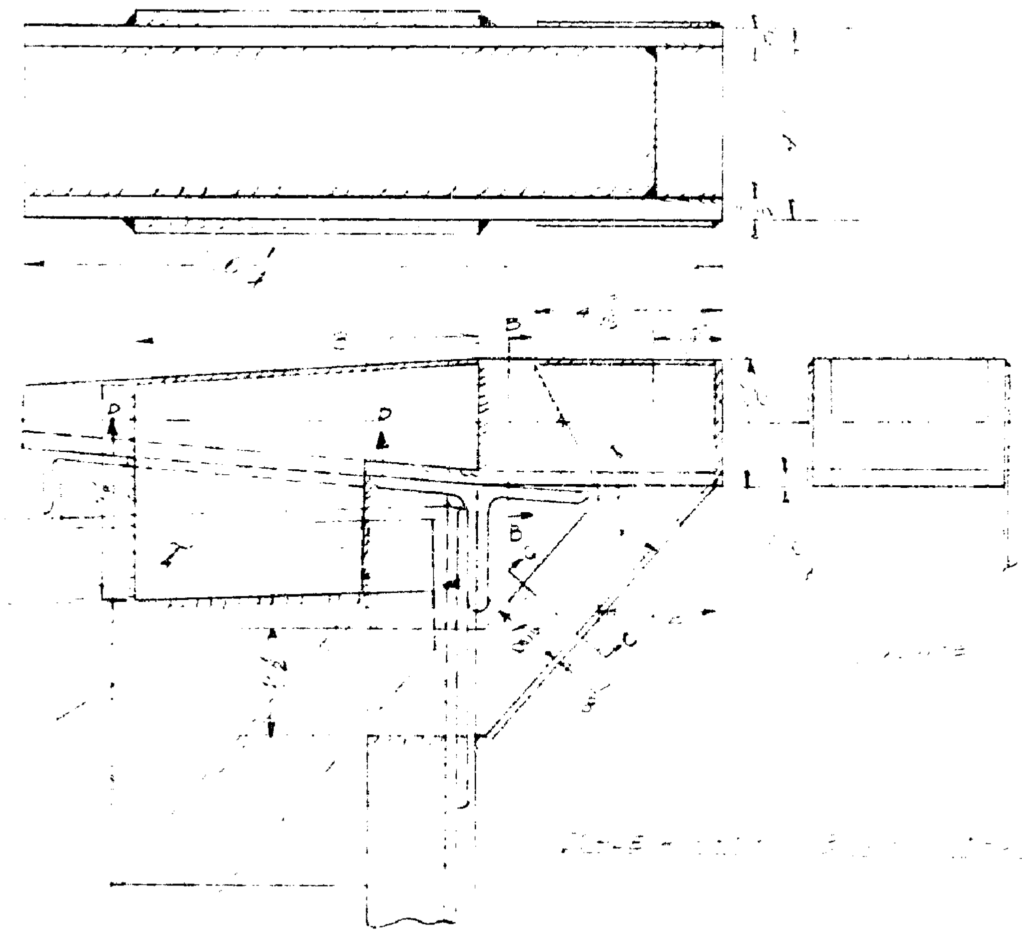

FIG. 14

ENGINE MOUNT LUG FITTINGS
TYPICAL AT STATION 24 AND AT
STATION 23 - LOWER

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ANALYSIS OF ENGINE MOUNT WING FITTINGS

Description: The engine mount wing fittings are constructed of welded structural steel, and are shown in Figs. 13 and 14.

Location: The fittings are attached to the rear spar of the wing. There are four fittings, two at station 23 and two at station 24. At each station there is one above the upper chord of the rear spar and one below the lower chord. Accompanying sketches and drawings give the dimensional locations.

The loads imposed by the engine mount on the fittings are tabulated on page 8 of this report. The loads are resolved into components in three directions - (1) The vertical direction perpendicular to the chord plane; (2) fore and aft (drag) direction parallel to the thrust line; (3) side direction perpendicular to the thrust line.

Method of analysis: The loads are applied at the face of the bushing block and carried through the fitting, weld plates, etc. to the wing structure. Welds are assumed to transfer loads only as shear connections and the equation for allowable loads for welds on low carbon steel from ANC-5 is used.

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

UPPER FITTING AT STATION 23

Ultimate loads applied at the fitting-mount connection are: (Ref. Page 8)

1. Vertical load = 13,337 # Down
2. Drag load = 40,213 # Aft
3. Side load = 6072 # Inboard

Applying the total drag load to the block and checking the weld to the fitting for strength in shear:

P_t = 40,213 # Aft.

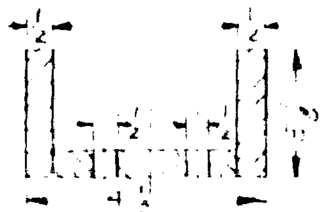
L = 2 (1.625) = 3.25 in.

P_W = 32000 Lt; t = 1/2 inch

= 32000 (3.25) (.5) = 52000 #

$$M.S. = \frac{P_W}{P_t} - 1 = \frac{52000}{40213} - 1 = +.29$$

Applying the total drag load to the fitting and checking at section BB for tensile strength. P_t = 40,213 #



BB OF FIG 13

Area, A = Total Area - area of bolt holes

= 3.5 (.5) + 2 x 3.125 (.5) - 2 (.5) (.5)

= 1.75 + 3.125 - .5 = 4.875 - .5 = 4.375 sq. in.

$$f_t = \frac{P_t}{A} = \frac{40,213}{4.375} = 9190 \text{ \#/Sq. in.}$$

F_T = 60,000 #/sq. in.

$$M.S. = \frac{60000}{9190} - 1 = +5.54$$

STRESS ANNALYSIS OF XB-36 TEST NACELLE & INSTALLATION

UPPER FITTING AT STATION 23 (Cont'd.)

The nine 1/2 inch bolts and the weld along the upper edges of the inboard and outboard weld plates may be considered to resist the drag load. The resistance offered by the components (bolts and welds) may be assumed proportional to their relative strength. The bolts in addition must resist the side load as shear

L_1 of outboard weld plate = 6 in.

L_2 of inboard weld plate = 3 1/2 in.

P_W / inch = 32000 Lt
t = .25

P_W/ inch = 32000 (1) (.25) = 8000 #

P_W Total = 8000 (9.5) = 76,000 #

P_S = 14720 #/bolt on 1/2" bolt

P_S Total = 14,720 (9) = 132,700 #

S_{allow} = Total P_W + Total P_S = 76,000 + 132,700 = 208,700 #

P_t = 40,213 #

$$\text{Total Shear in Welds} = \frac{\text{Strength of welds}}{\text{Strength of welds + strength of bolts}} (P_t)$$

$$= \frac{76,000}{208,700} (40,213) = 14,650 \#$$

$$\text{M.S. (welds)} = \left(\frac{Pw}{\text{Total shear in welds}}\right) -1 = \frac{76000}{14650} -1 = +4.19$$

Shear in bolts due to drag load = Total Shear -Shear in Weld

= 40213 - 14650 = 25,563 #

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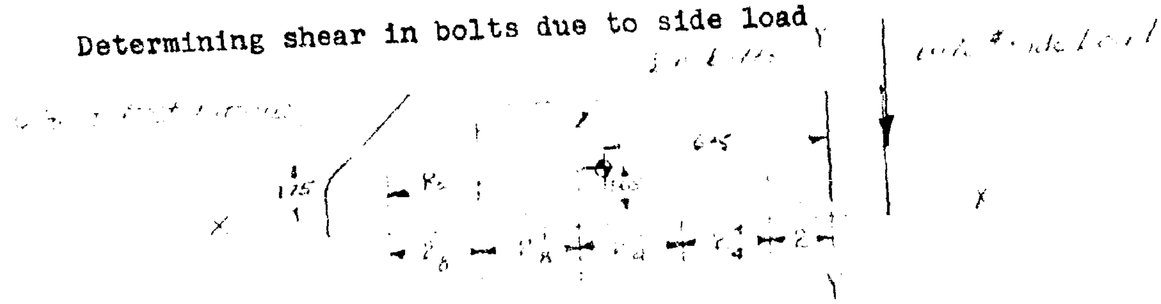
STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

UPPER FITTING AT STATION 23 (Cont'd.)

Shear per bolt due to drag load $= \frac{25,563}{9} = 2840$ #

Determining shear in bolts due to side load



Cross sectional area of one 1/2 in. bolt = .1961 sq. in.

ΣAy about line X-X $= 4(.1961)(2.625) + 5(.1961)(.875)$

$= 2.06 + .859 = 2.919$

$\Sigma A = 9(.1961) = 1.765$ sq. in.

$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{2.919}{1.765} = 1.651$ in.

ΣAx about line y-y $= .1961(11.25) + 2(.1961)(9.125)$

$+ 2(.1961)(7) + 2(.1961)(4.75)$

$+ 2(.1961)(2)$

$= 2.21 + 3.58 + 2.75 + 1.86 + .79$

$= 11.19$

$\bar{x} = \frac{\Sigma Ax}{\Sigma A} = \frac{11.19}{1.765} = 6.35$ in.

$\Sigma R^2 = \Sigma(x^2+y^2)$ since $R = \sqrt{x^2+y^2}$

$= (\overline{4.35}^2 + \overline{.975}^2) + (\overline{4.35}^2 + \overline{.775}^2) + (\overline{1.6}^2 + \overline{.775}^2)$

$+ (\overline{1.6}^2 + \overline{.975}^2) + (\overline{.65}^2 + \overline{.775}^2) + (\overline{.65}^2 + \overline{.975}^2)$

$+ (\overline{2.775}^2 + \overline{.775}^2) + (\overline{2.775}^2 + \overline{.975}^2) + (\overline{4.9}^2 + \overline{.775}^2)$

$= 113.96$

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UPPER FITTING AT STATION 23 (Cont'd.)

Moment of shear about C.G. of pattern = 6072(6.55+1.625)

= 48,450 in.#

Maximum R = $(4.9^2+.775^2)^{\frac{1}{2}}$ = 4.96 in., x = 4.9; y = .775

Shear in drag direction due to side load = $\frac{My}{\Sigma R^2}$

$= \frac{48,450(.775)}{113.96} = \underline{330}$ #

Shear in side direction due to side load = $\frac{6072}{9} + \frac{Mx}{\Sigma R^2}$

$= 675 + \frac{48450(4.9)}{113.96}$

= 675 + 2082 = $\underline{2757}$#

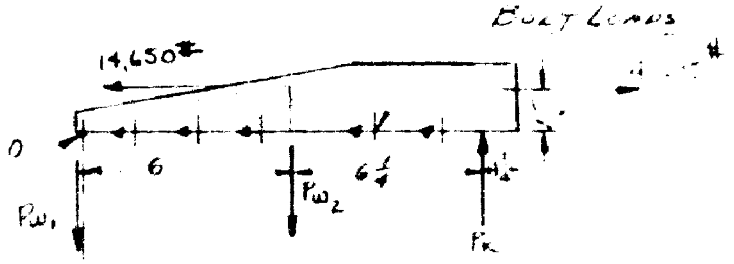
Total Shear in drag direction = 330 + 2840 = 3170#

Total Shear in side direction = 2757#

Total shear on bolt = $\sqrt{317^2 + 2757^2}$ = 4205 #

M.S. = $\frac{14,720}{4205} - 1$ = + $\underline{2.5}$

Since the side load is carried as shear in the bolts and the vertical load is to be taken directly into the spar by the diagonal K, the drag load is applied and the fitting may be put into equilibrium as shown below.



STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

UPPER FITTING AT STATION 23 (Cont.)

First assume $Pw_1 = Pw_2$

Summing moments about point 0

$\Sigma M_o = 0$

(1) $-(Pw_2 \times 6) - (P_k \times 12.25) - (14650)(.65) + 40213(1.625) = 0$

$\Sigma F_V = 0$

(2) $-Pw_2 + P_k + Pw_1 = 0$

Since $Pw_1 = Pw_2$

$2Pw_2 + P_k = 0$

$Pw_2 = -\frac{P_k}{2}$

Substituting in (1) and transposing terms

(1) $-(-\frac{P_k}{2}) \times 6 - 12.25\, P_k = -4021.3(1.625) + 14650(.65)$

$3P_k - 12.25\, P_k = 65{,}400 + 9530$

$-9.25\, P_k = 55{,}870$

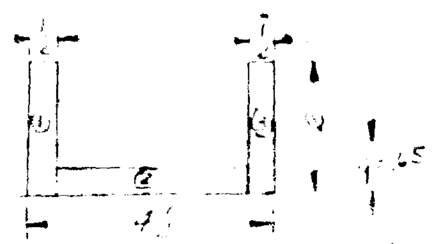
$P_k = 6040\#\uparrow$

$Pw_2 = -\frac{P_k}{2} = -\frac{6040}{2} = -3020\#$ or $3020\#\downarrow$

$Pw_1 = Pw_2$

$Pw_1 = -3020\#$ or $3020\#\downarrow$

To determine the stress at section A-A:



SECTION A-A (FIG 13)

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STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

UPPER FITTING AT STATION 23 (Cont.)

PROPERTIES OF SECTION A-A

Item	Area, A	Y	AY	Y1	$Y1^2$	$AY1^2$	Io
1	1.00	1	1.0000	.35	.1225	.1225	.333
2	1.75	.25	.4375	-.40	.16	.2000	.037
3	1.00	.1	1.0000	.35	.1225	.1225	.333
Σ	3.75		2.4375			.5250	.703

$$\bar{y} = \frac{AY}{A} = \frac{2.4375}{3.75} = .65 \text{ in.}$$

$$I_{c.g.} = Io + AY1^2 = .703 + .525 = 1.228 \text{ In.}^4$$

Summing moments to the right of section A-A about the neutral axis of $A-A_1$ we have

ΣM_A = (Drag load x distance to neutral axis of A-A) + (P_k x Dist. to Section A-A) + (Bolt load x distance to neurtal axis of section A-A)

Bolt Load = load taken by firts 4 bolts
= 4/9 (Total Bolt Load)
= 4/9 (25,563) = 11,360#

$$\Sigma M_A = 40213(1.625-.65) - 6040(6) + 11360(.65)$$
$$= 39250 - 36240 + 7380 = +10,390 \text{ in. \#}$$

$$f_t \text{ (section A-A)} = \frac{P_t}{A} + \frac{M_AC}{I} = \frac{40213}{3.75} + \frac{10390(1.35)}{1.228}$$
$$= 10,720 + 11,410 = 22,130 \text{ \#/sq. in.}$$

F_T = 60,000

$$M.S. = \frac{60,000}{22130} - 1 = +1.71$$

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

UPPER FITTING AT STATION 23 (Cont.)

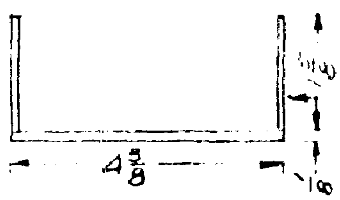
Applying the load P_k to the diagonal and assuming the applied vertical load is taken directly by the diagonal K,

Total Vertical Load = P_k + Applied Vertical

= 6040 + 13,337 = 19, 377#

α (Refer to sketch) = 45°

$$P_c = \frac{19,377}{\sin 45^\circ} = 27,400\#$$



SECTION C-C

PROPERTIES OF SECTION C-C

Item	Area	Y	AY	Y_1	Y_1^2	AY_1^2	Io
1	.203	.875	.1777	.466	.2085	.0423	.0446
2	.546	.0625	.0341	.3465	.1200	.0656	0
3	.203	.875	.1777	.466	.2085	.0423	.0446
Σ	.952		.3895			.1502	.0892

$$\bar{y} = \frac{AY}{A} = \frac{.3895}{.952} = .409 \text{ in.}$$

$$I_{c.g.} = Io + AY_1^2 = .1502 + .0892 = .2394 \text{ in.}^4$$

$$\rho = \sqrt{\frac{I_T}{A}} = \sqrt{\frac{.2394}{.952}} = .502 \text{ in.}$$

L_c = 5.5 in.

$$L_c/\rho = \frac{5.5}{.502} = 10.95$$

By ______

Checked ______

Approved ______

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

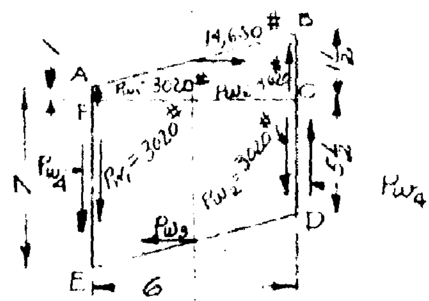
UPPER FITTING AT STATION 23 (Cont.)

$$F_C = \frac{37,500}{1 + \frac{(10.95)^2}{18000}} = 35,200 \text{ \#/sq. in.}$$

$$P_C = A \times F_C = .952(35,200) = 33,500\#$$

$$M.S. = \frac{33,500}{27,400} - 1 = \underline{\underline{+.22}}$$

Applying the loads to the weld plate and checking welds for strength, considering all the loads on one plate,



Summing Forces in a horizontal direction

$$F_H = 0 = 14650 - Pw_3$$

$$Pw_3 = 14,650\#$$

The horizontal couple is resisted by a vertical couple of magnitude 6 Pw_4.

Summing moments about center of plate.

$$7\ Pw_3 - 6\ Pw_4 = 0$$

$$Pw_4 = \frac{7}{6} Pw_3 = \frac{7}{6}(14650) = 17,100\#$$

Since there are two weld plates, one or each side of the fitting, the load obtained above is divided by two to obtain the load per plate.

UPPER FITTING AT STATION 23 (Cont.)

Therefore,

$P_{w_1} = \frac{1}{2} \times 3020 = 1510\#$

$P_{w_2} = \frac{1}{2} \times 3020 = 1510\#$

$P_{w_3} = \frac{1}{2} \times 14650 = 7325\#$

$P_{w_4} = \frac{1}{2} \times 17100 = 8550\#$

$P_W/\text{in.} = 32000\ L_t = 32000\ (1)(.25) = 8000\#/\text{in.}$

Determining the loads in pounds per inch of weld.

Segment AF $\qquad L_{AF} = 1$ inch

$P_{w_{AF}} = \frac{P_{w_1}}{L_{AF}} = \frac{3020}{1} = 3020\#/\text{in.}$

$P_W = 8000\#/\text{in.}$

$M.S. = \frac{8000}{3020} - 1 = \qquad \underline{+1.65}$

Segment FE

$P_{w_{FE}} = \frac{P_{w_1}}{L_{FE}} + \frac{P_{w_4}}{L_{AE}} = \frac{3020}{6} + \frac{17100}{6}$

$= 503 + 2850 = 3353\#/\text{in.}$

$P_W = 8000\#/\text{in.}$

$M.S. = \frac{8000}{3353} - 1 = \qquad \underline{+1.38}$

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

UPPER FITTING AT STATION 23 (Cont.)

Segment CD $L_{CD} = 5\frac{1}{2}$ in.

$$P_{w_{CD}} = -\frac{P_{w_2}}{L_{CD}} + \frac{P_{w_4}}{L_{BD}} = -\frac{3020}{5.5} - \frac{17100}{6} = -550 + 2850$$

$P_{w_{CD}} = 2300\#/\text{in.}$

$P_W = 8000\#/\text{in.}$

$M.S. = \frac{8000}{2300} - 1 =$ **+ 2.48**

Segment BC $L_{BC} = 1\frac{1}{2}$ in.

$$P_{w_{BC}} = -\frac{P_{w_2}}{L_{BC}} = -\frac{3020}{1.5} = -2010$$

$P_{w_{BC}} = 2010\#/\text{in.}$

$P_W = 8000\#/\text{in.}$

$M.S. = \frac{8000}{2010} - 1 =$ **+ 2.98**

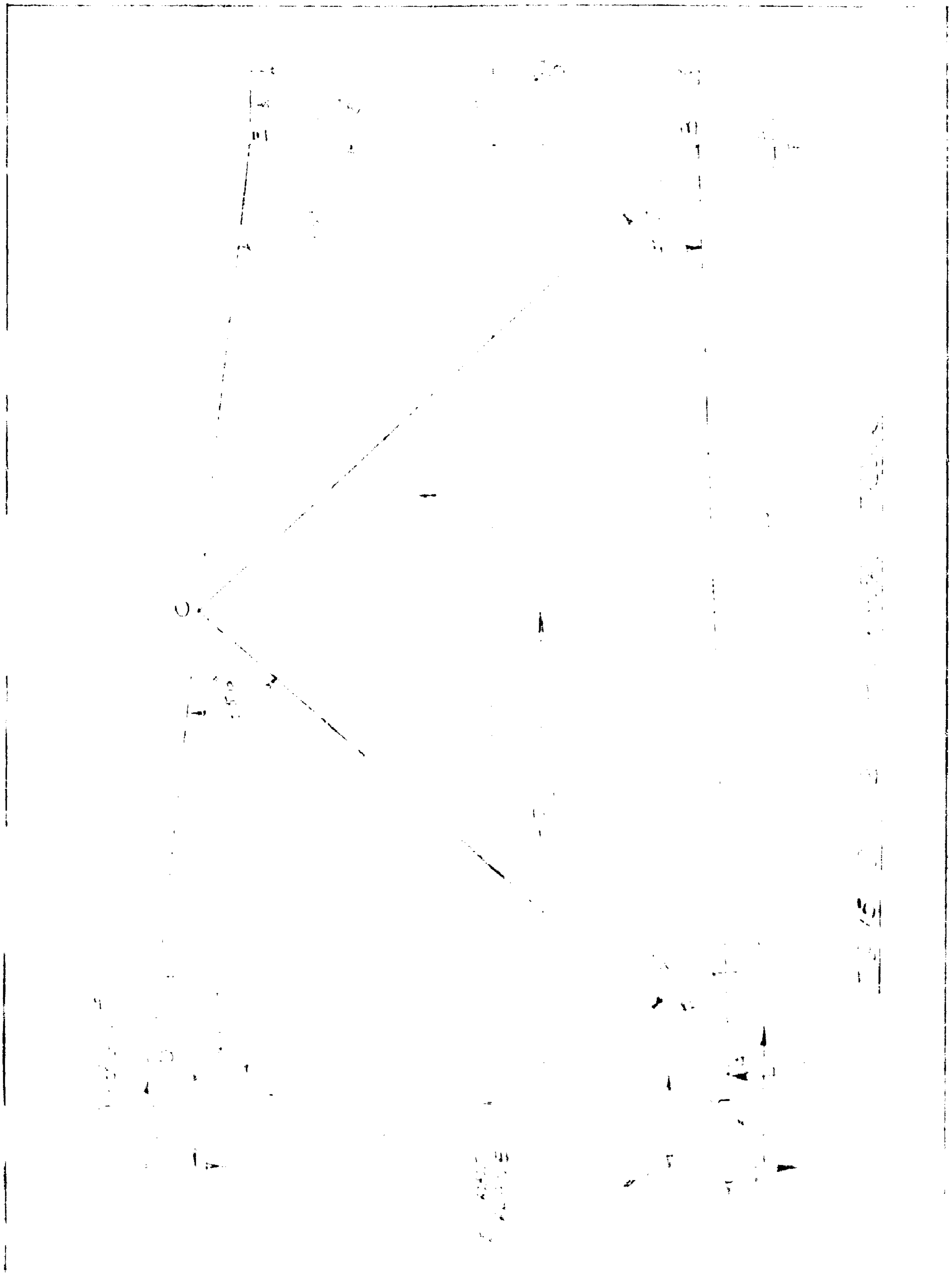
Segment AB and ED $L_{AB} = L_{ED} = 6$ in.

$$P_{w_{AB}} = \frac{146050}{L_{AB}} = \frac{14650}{6} = 2442\#/\text{in.}$$

$P_{w_{ED}} = P_{w_{AB}} = 2442\#/\text{in.}$

$P_W = 8000\#/\text{in.}$

$M.S. = \frac{8000}{2442} - 1 =$ **+ 2.27**



STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

ANALYSIS OF ENGINE MOUNT SUPPORT BULKHEADS

The engine mount support bulkheads are of welded structural steel construction. Pages 66 and 73 show the essential dimensions of the bulkheads.

The loads from the engine mount are distributed to the spars and to the upper and lower chord trusses by means of the bulkheads.

The system has one degree of redundancy, but since their stiffnesses are approximately equal, the overhang moment is assumed reacted half by the chord trusses and half by the spars.

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

DETERMINATION OF REACTIONS FOR BULKHEAD #23

(For engine loads refer to Table II, Page 8.)

$\Sigma M_A = 46813(2.75) + 11{,}799(7) + 13337(7) + 40213(47.24)$

$= 128{,}800 + 82600 + 93400 + 1{,}900{,}000$

$= 2{,}204{,}800$

Moment balanced in upper and lower trusses = 1,102,400 in.#

Moment balanced in spars = 1,102,400 in#

$71B_V = 1{,}102{,}400$

$B_V = 15{,}530\#\downarrow$

Shear at front spar = 15,530#

$\Sigma F_V = 0$ Shear at rear spar = 15,530 + 13,337 + 11,799

= 40,666#

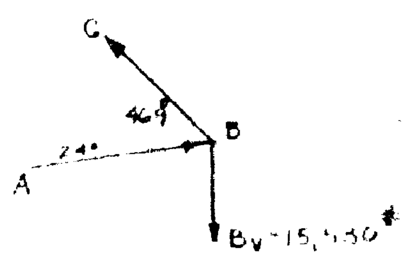
Truss shear to balance moments = $\frac{1{,}102{,}400}{44{,}875}$ = 24,600#

$\Sigma F_H = 0$

Horizontal Force at A = - 40213 + 24600 + 46813 = 31200# ←

Determining internal loads

Taking joint B as a free body



STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

DETERMINATION OF REACTIONS FOR BULKHEAD #23 (Cont'd.)

$\Sigma F_V = 0$

(1) $AB \sin 2.4^\circ + BC \sin 46.9^\circ - 15530 = 0$

$\Sigma F_H = 0$

(2) $AB \cos 2.4^\circ - CB \cos 46.9^\circ = 0$

$$AB = \frac{CB \cos 46.9^\circ}{\cos 2.4^\circ} = .685\ CB$$

Substituting in equation (1)

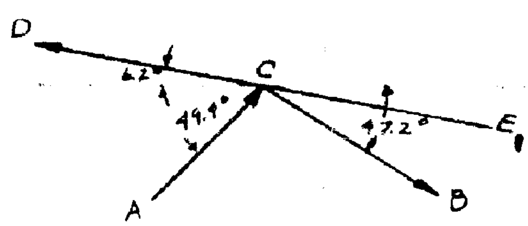
$.685\ CB \sin 2.4^\circ + CB \sin 46.9^\circ = 15530^{\#}$

$(.02865 + .73)\ CB = 15530$

CB = 20,500# Tens.

AB = .685(20,500) = 14,030# Comp.

Taking joint C as a free body and solving for CD and CA



CE = D since ΣF_H at E must = 0

$\Sigma F_V = 0$

(1) $DC \sin 6.2^\circ + AC \sin 49.4^\circ - 20{,}500 \sin 47.2^\circ = 0$

$\Sigma F_H = 0$

(2) $AC \cos 49.4^\circ + 20{,}500 \cos 47.2^\circ - DC \cos 6.2^\circ = 0$

(2) $AC = \frac{.994DC - 13910}{.651} = 1.525\ DC - 21{,}400$

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

DETERMINATION OF REACTIONS FOR BULKHEAD #23 (Cont'd.)

Substituting in (1)

$.108\ DC + .759(1.525DC - 21400) = 15{,}050$

$.108\ DC + 1.158\ DC = 15050 + 16220$

$DC = \frac{31{,}270}{1.266} = 24{,}720\#$ Tension

$AC = 1.525(24720) - 21400 = 16{,}300\#$ Comp.

Shear to upper truss $= \Sigma F_H$ at D

$\Sigma F_H = 24{,}720 \cos 6.2^\circ + 24600 - 40213 = 8887\#$

Shear in upper truss = 8887#

Shear to lower truss $= \Sigma F_H$ at A

F_H at A $= 31{,}200 - 46813 + AC \cos 49.4^\circ + AB \cos 2.4^\circ$

$= 31{,}200 - 46813 + .651(16300) + 14{,}030(.998)$

$= -15{,}613 + 10{,}700 + 14000$

Shear to lower truss = 8887#

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

CHECK OF MEMBERS FOR STRENGTH

Checking member DC for strength

Load DC = 24,720# Tension

Section of DC - 4 x 1 5/8 x 1/4 open channel

A = 1.82

$f_t = \frac{24,720}{1.82} = 13,580$ #/sq. in.

$F_T = 60,000$ #/sq.in.

$M.S. = \frac{60000}{13,580} - 1 =$ **+3.42**

Checking member AC for strength

Load in AC = 16,300# C

Section - 4 x 1 5/8 x 1/4 channel

A + 1.82 I (least) = .38

$\therefore \rho \text{ (least)} = \sqrt{\frac{.38}{1.82}} = .4565$ in.

$\frac{LC}{\rho} = \frac{54.3}{.4565} = 119$

$Fc = \frac{37,500}{1 + \frac{(119)^2}{18000}} = 21,000$ #/sq. in

$fc = \frac{16300}{1.82} = 8,960$

$M.S. = \frac{21000}{8960} - 1 =$ **+1.34**

Checking member CB for strength

Load CB = 20,500 # Tension

Section 4 x 1 5/8 x 1/4 open channel

Area = 1.82 sq. in.

By
Checked
Approved

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

CHECK OF MEMBERS FOR STRENGTH (Cont.)

$f_t = \frac{20,600}{1.82} = 11,280$

$F_T = 60,000$ #/sq. in.

$M.S. = \frac{60,000}{11,280} - 1 =$ **+4.32**

Checking member AB for strength

Load AB = 14,030 # C. Section (typical)

L_C = 35.75 inches

ρ = .4565 in.

$\frac{L_C}{\rho} = \frac{35.75}{.4565} = 78.1$

$F_C = \frac{37,500}{1 + \frac{(78.1)^2}{15000}} = 27,800$

$f_c = \frac{14,030}{2} = 7720$ #/sq. in.

$M.S. = \frac{F_C}{f_c} - 1 = \frac{27,800}{7720} - 1 =$ **+2.6**

DETERMINATION OF REACTIONS FROM BLKHD. #24

M_K = 30290(46.25) + 9093(2) + 7670(2) + 36923(3)

= 1,400,000 + 18,186 + 15,340 + 110,800

= 1,544,326 in. #

Moment reacted by front spar = $\frac{1,544,326}{2}$ = 772,163" #

68.5 V_Y = 772,163 =

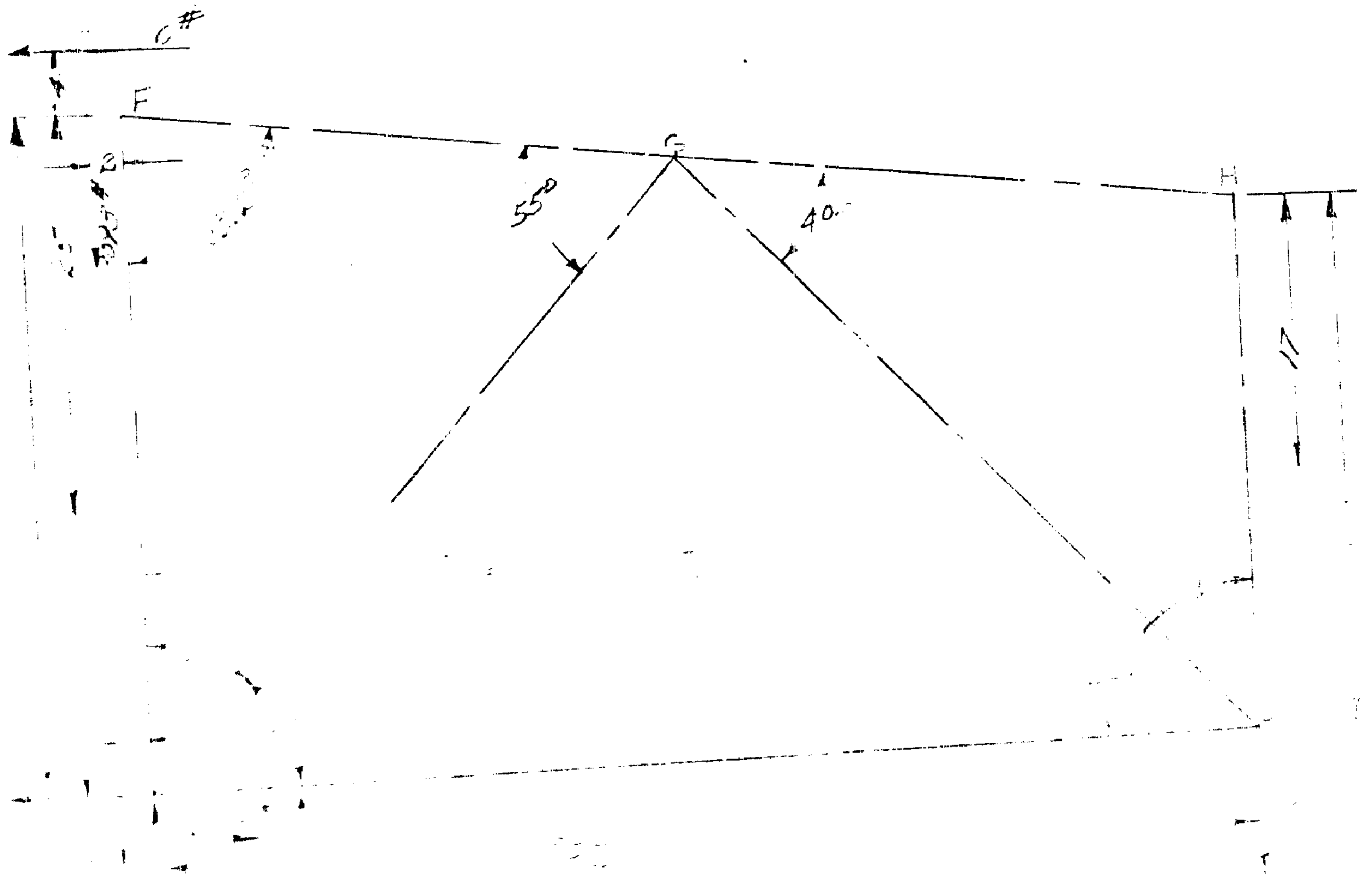
V_Y = 11,280 #

Moment reacted by force at F = 772,163" #

By ___

Checked ___

Approved ___



[illegible] 6 [illegible] BULKHEAD [illegible]

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

DETERMINATION OF REACTIONS FROM BLKHD. #24 (Cont.)

Force at F = $\frac{772,163}{42.25}$ = 18,280 #

Shear at front spar = 11,280 # ↑

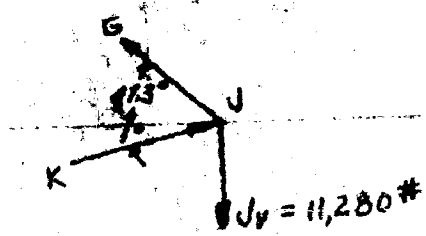
$\Sigma F_V = 0$

Shear at rear spar = 11,280 + 9093 + 7670 = 28,043 # ↓

$\Sigma F_H = 0$

Horiz. force at K = -30390 + 18280 + 36923 = 24,813#

Taking joint J as a free body and solving for GJ & KJ



$\Sigma F_V = 0$

(1) GJ sin 47.5° + KJ sin 1° - 11280 = 0

$\Sigma F_H = 0$

(2) KJ cos 1° - GJ cos 47.5° = 0

KJ = $\frac{\text{GJ cos } 47.5^\circ}{\text{cos } 1^\circ}$

Substituting for KJ in equation (1)

GJ sin 47.5° + GJ cos 47.5° tan 1° = 11280

(.735 + .01182) GJ = 11280

GJ = $\frac{11280}{.747}$ = 15,090 # T

KJ = $\frac{15090 \text{ cos } 47.5^\circ}{\text{cos } 1^\circ}$ = 10,220 # C

BY

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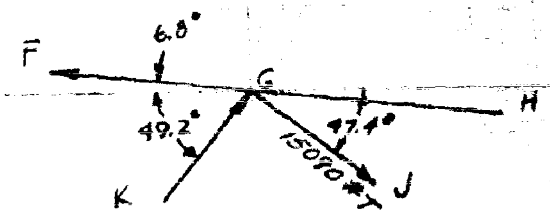
STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

DETERMINATION OF REACTIONS FROM BLKHD. #24 (Cont.)

Taking joint G as a free body and solving for GF & GK



GH = 0 since EF_H at H must equal 0.

$EF_V = 0$

(1) $FG \sin 6.8^\circ + KG \sin 49.2^\circ - GJ \sin 47.4^\circ = 0$

$EF_H = 0$

(2) $KG \cos 49.2^\circ + GJ \cos 47.4^\circ - FG \cos 6.8^\circ = 0$

$$KG = \frac{FG \cos 6.8^\circ - 15090 \cos 47.4^\circ}{\cos 49.2^\circ}$$

Substituting for KG in equation (1)

$$FG \sin 6.8^\circ + \left(\frac{FG \cos 6.8^\circ - 15090 \cos 47.4^\circ}{\cos 49.2^\circ}\right) \sin 49.2^\circ = 15090 \sin 47.4^\circ$$

$.1183FG - 1.149FG = 11{,}080 + 11{,}820 = 22{,}900$

$$\underline{FG} = \frac{22900}{1.2673} = \underline{18{,}070}\ \#\ T$$

$$\underline{KG} = \frac{18{,}070 \cos 6.8^\circ - 15090 \cos 47.4^\circ}{\cos 49.2^\circ} =$$

$= \underline{11780\#\ C}$

Shear to upper Truss = EF_H at F

EF_H at F = $-30290 + 18280 + 18070 \cos 6.8^\circ = 5950$ #

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

DETERMINATION OF REACTIONS FROM BLKHD. #24 (Cont.)

Shear to upper truss = 5950 #

Shear to lower truss = ΣF_H at K

ΣF_H at K = - 24813 + 36923 - 11780 cos 48° - 10220 cos 1°

= -24,813 + 36,923 - 7,870 - 10,210 = 5970 #

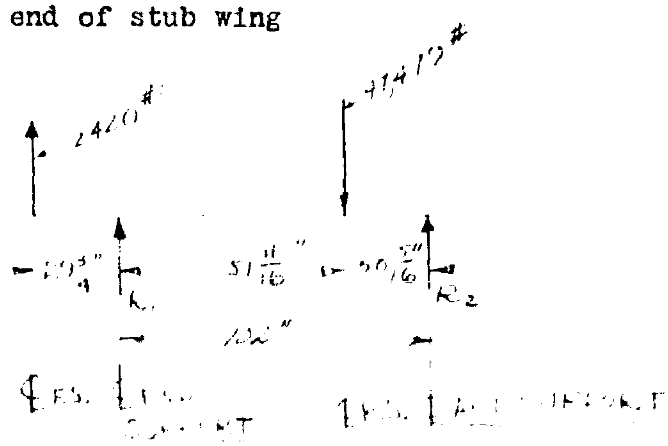
Shear to lower truss = 5970#

END PLATE BOLTS AND FITTINGS

DETERMINING SUPPORT REACTIONS

Due to inertia loads (5 g.)

Inboard end of stub wing



$\Sigma M_{R1} = 0$

2420 (29.75) + 47,479 (51.688) - R_2(102) = 0

$102R_2$ = 72,000 + 2,456,000

$R_2 = \frac{2,528,000}{102} = 24,800$ #

$\Sigma F_V = 0$

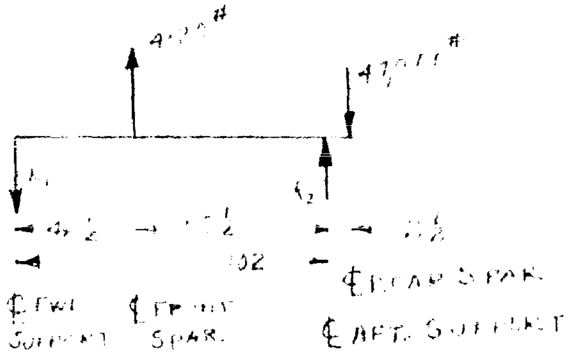
2420 + 24800 - 47479 + R_1 = 0

R_1 = 47479 - 27,220 = 20,259 #

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINING SUPPORT REACTIONS

Outboard End of Stub Wing



$\Sigma M_{R_1} = 0$

$$47{,}079\,(104.5) - R_2\,(102) - 4320\,(42\ 1/2) = 0$$

$$102R_2 = 4{,}930{,}000 - 183{,}800$$

$$R_2 = \frac{4{,}746{,}200}{102} = 46{,}500\ \# \uparrow$$

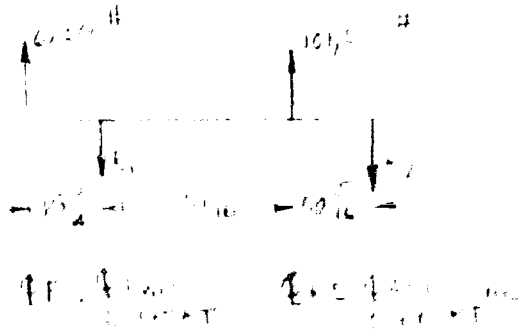
$\Sigma F_V = 0$

$$4320 + 46500 - 47079 - R_1 = 0$$

$$R_1 = 50{,}830 - 47079 = 3751\ \# \downarrow$$

Due to Combined Air + Inertia Loads

Inboard End



STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

DETERMINING SUPPORT REACTIONS

$\Sigma M_{R_1} = 0$

$62500\ (29.75) + 102(R_2) - 101{,}500\ (51.688) = 0$

$102R_2 = 5{,}250{,}000 - 1{,}859{,}000$

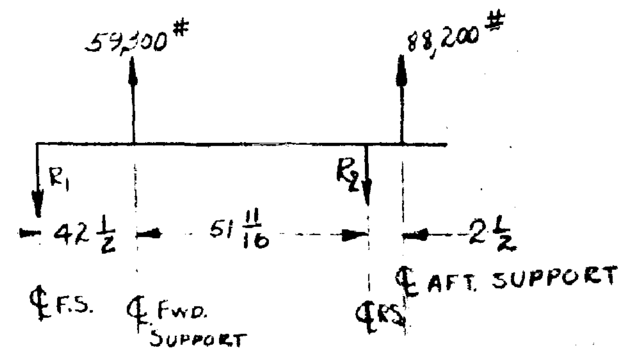
$R_2 = \frac{3{,}391{,}000}{102} = 33{,}210$ #

$\Sigma F_V = 0$

$62500 + 101{,}500 - 33210 - R_1 = 0$

$R_1 = 130{,}790$ #

Outboard End



$\Sigma M_{R_1} = 0$

$-59300\ (42.5) - 88200\ (104.5) + R_2\ (102) = 0$

$R_2 = \frac{11{,}740{,}000}{102} = 115{,}100$ #

$\Sigma F_V = 0$ $\quad R_1 = 88200 + 59300 - 115{,}100 = 32{,}400$ #

CHECKING SHEAR IN BOLTS TRANSFERRING LOAD FROM SPARS TO END PLATE

Inboard End

1. Bolts at rear spar = 48 - AN6-22A bolts

   Maximum shear = 101,500 #

BY

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STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

CHECKING SHEAR IN BOLTS TRANSFERRING LOAD FROM SPARS TO END PLATE

Allow. Shear per bolt = 8280 #

Shear per bolt = $\frac{101,500}{48}$ = 2115 #

M.S. = $\frac{8280}{2115}$ - 1 = +2.91

Bolts at front spar = 38 - AN6 - 22A bolts

Maximum Shear = 62,500 #

Allow shear per bolt = 8280 #

Shear per bolt = $\frac{62500}{38}$ = 1645 #

M.S. = $\frac{8280}{1645}$ -1 = +4.04

Outboard End

Bolts at rear spar: AN6-27A - 29 bolts

Maximum Shear = 98,200 #

Allow Shear per bolt: 8280

Shear per bolt = $\frac{98,200}{29}$ = 3,450#

M.S. = $\frac{8280}{3450}$ -1 = + 1.4

Bolts at front spar : AN6-27A-20 bolts

Maximum Shear: 59,300 #

Allowable Shear per bolt = 8280 #

Shear per bolt = $\frac{59,300}{20}$ = 2965 #

M.S. = $\frac{8280}{2965}$ -1 = + 1.79

BY: ______

CHECKED: ______

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STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

CHECKING SHEAR IN BOLTS TRANSFERRING LOAD FROM END PLATES TO FITTINGS

Inboard End

Bolts at forward support

31-AN8-31A Bolts

Maximum Shear = 130,790 #

Allowable Shear per bolt = 14,720 #

Shear per bolt = $\frac{130,790}{31}$ = 4215 #

M.S. = $\frac{14,720}{4215}$ -1 = +2.5

Bolts at aft support

29-AN8-31A bolts

Maximum Shear = 33,210

Allowable Shear per bolt = 14,720 #

Shear per bolt = $\frac{33,210}{29}$ = 1147 #

M.S. = $\frac{14720}{1147}$ -1 = +11.8

Outboard End

Bolts at forward support

36 - AN8 Bolts

Maximum Shear = 32,400 #

Allowable shear per bolt = 14,720 #

Shear per bolt = $\frac{32400}{36}$ = 900 #

M.S. = $\frac{14,720}{900}$ -1 = + 15.3

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

CHECKING SHEAR IN BOLTS TRANSFERRING LOAD FROM END PLATES TO FITTINGS

Bolts at aft support

27-AN8 bolts

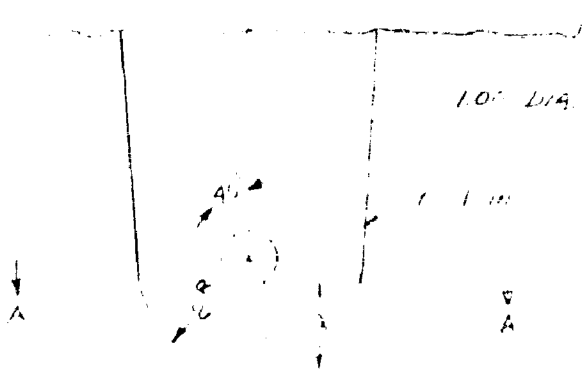
Maximum Shear = 115,100 #

Allowable Shear per bolt = 14,720 #

Shear per bolt = $\frac{115,100}{27}$ = 4265 #

M.S. = $\frac{14,720}{4,265}$ -1 = +2.45

ANALYSIS OF SUPPORT FITTING



Checking shear tearout of lug

Allowable Load = (2)x(t)(F_S) (Ref. ANC-5)

x as shown on sketch

t = thickness of lug

F_S = ultimate shear allowable

STRESS ANALYSIS OF XB-36 TEST NACELLE & INSTALLATION

ANALYSIS OF SUPPORT FITTING

Allowable load = 2 (1.6) (1) (.75 x 60,000) = 144,000 #

$M.S. = \frac{144,000}{130,790} - 1 = \quad = \underline{0.10}$

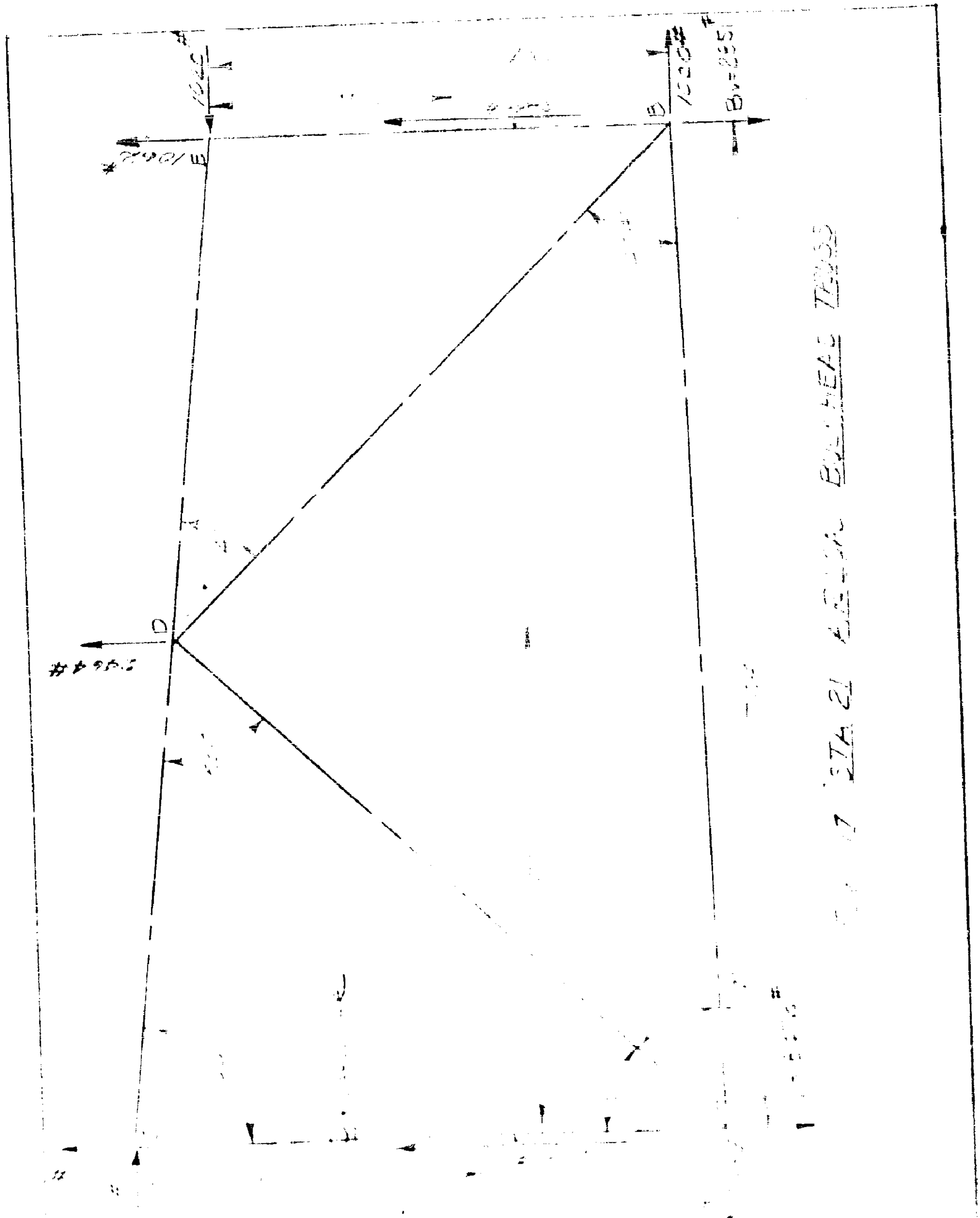
Checking tension at section A-A across bolt hole

Allowable Tensile Load, $P_T = (2R-D)\ t\ F_T$ (Ref. ANC-5)

$P_T = (2 \times 2-1)(1)(60,000) = 180,000\#$

$M.S. = \frac{180,000}{130,790} - 1 = \quad \underline{+0.377}$

BY
CHECKED
APPROVED


E
B
D
STA 21

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

ANALYSIS OF AIR LOAD RIB & BULKHEAD

For purposes of analysis, a section at Sta. 21 is taken as a typical bulkhead.

Chord = 249.5"

Dist. midway between adjacent stations = 38.5"

Loading at L.E. = 2.263#/sq. in.

Loading at T.E. = .0526#/sq. in.

Load per inch at L.E. = 2.26 x 38.5 = 87.2#/in.

Load per inch at T.E. = .0526 x 38.5 = 2.025#/in.

Rate of change = $\frac{87.2 - 2.025}{249.5}$ = .341#/in./in.

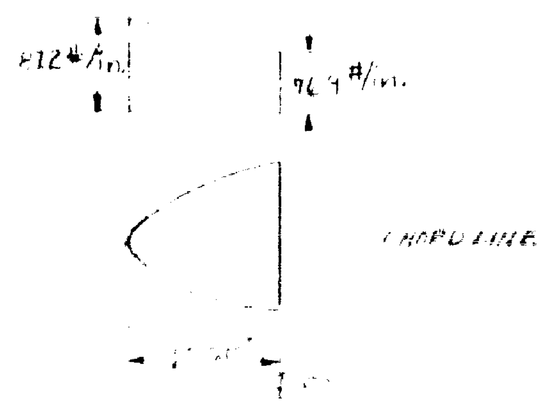
Front spar = .12 x 249.5 = 29.95" aft of L.E.

Rear spar = .43 x 249.5 = 107.3" aft of L.E.

Loading at Front Spar = 87.2 - .341 x 29.95 = 76.9#/in.

Loading at Rear Spar = 87.2 - .341 x 107.3 = 50.5#/in.

Loading over nose section:



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DATE

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

ANALYSIS OF AIR LOAD RIB & BULKHEAD (Cont'd.)

$$\text{Load} = \frac{87.2 + 76.9}{2} \times 29.95 = 2455\#$$

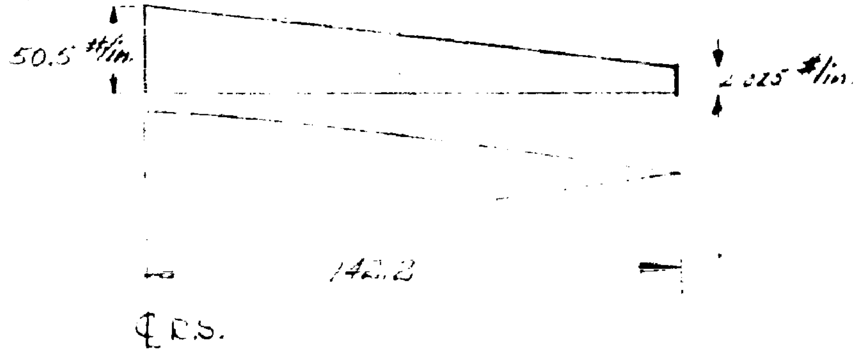
$$\text{Ratio of loadings} = \frac{87.2}{76.9} = 1.034$$

$$\text{C.G.} = .505 \times 29.95 = 14.93''$$

$$M = 2455 \times 14.93 = 36{,}600''\#$$

$$\text{Couple} = \frac{36600}{35.9} = 1020\#$$

Loading over section aft of rear spar:



$$\text{Load} = \frac{50.5 + 2.025}{2} \times 142.2 = 3750\#$$

$$\text{Moment at rear spar} = 2.025 \frac{(142.2)^2}{2} + \frac{48.475}{2}\frac{(142.2)^2}{3}$$

$$= 20{,}450 + 163{,}000 = 183{,}450''\#$$

$$\text{Couple} = \frac{183{,}450}{46.15} = 3980\#$$

$$\text{Interspar load} = \frac{76.9 + 50.5}{2} \times 77.35 = 4930\#$$

The total loading is summed up in Fig. 7, Page [illegible].

The interspar air load bulkheads have the same type of

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

ANALYSIS OF AIR LOAD RIB & BULKHEAD (Cont'd.)

construction as the ones supporting the engine mount. Inspection of the loading shows that the air loads are much less than those imposed by the engine. Therefore no further investigation is necessary.

Check of airload rib aft of bulkhead.

$M_{max} = 183,450"\#$

The rib is made from 1" Douglas Fir Plywood.

Depth = 46.15

$f_b = \frac{6 \times 183,450}{1 \times 46.15^2} = 517\#/\text{sq. in.}$

$F_b = \frac{9460}{517} - 1 =$ + 17.3

[redacted]

STRESS ANALYSIS OF XB-36 TEST NACELLE AND INSTALLATION

ANALYSIS OF CHORD TRUSSES

The chord trusses are of the same construction as the Front and Rear Spars. Inspection of the loadings shows that the shears and moment are less than those imposed on the spars. Therefore the chord members are considered satisfactory with no further check.

TITLE: Stress Analysis of XB-36 Test Nacelle and Installation

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ABSTRACT:

Stress analysis is made of the engine stub wing of the XB-36 bomber. The report is subdivided into analyses of the engine mount and of the wing structure. The mount is a welded Chrome-Moly tubular space frame work which carries the loads from the engine and accessories to the main wing fittings. The loads are then carried through welded steel fittings to two wing bulkheads which distribute the load to the wing structure. The basic wing structure consists essentially of a front and rear spar, and two chord trusses separated by truss type bulkheads at each station point. The construction is of welded structural steel. The leading and trailing edge air loads are carried to the interspar bulkheads by means of plywood ribs which support wooden longitudinal stringers. The entire wing is covered with plywood, which in turn is covered with galvanized steel sheet to obtain smoothness of airflow.

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

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