REPORT NUMBER 138

DECEMBER 1963

STRUCTURAL ANALYSIS OF WING SECONDARY COMPONENTS

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REPORT NUMBER 138

STRUCTURAL ANALYSIS OF WING SECONDARY COMPONENTS

XV-5A LIFT FAN
FLIGHT RESEARCH AIRCRAFT PROGRAM
December, 1965

A 13

ADVANCED ENGINE AND TECHNOLOGY DEPARTMENT
GENERAL ELECTRIC COMPANY
Cincinnati, Ohio 45215

CONTENTS

I. INTRODUCTION

Structural Analysis of the flap, aileron, wing fan closure doors, wing trailing edge, and wing fittings for the U.S. Army XV-5A lift fan research aircraft are presented in this report.

For each component, a summary type analysis is presented primarily with the intent of giving structural configuration, final critical loading, and assumptions made. Structural proof tests were conducted satisfactorily on the basic wing, the fan doors, fan fittings, flap and aileron.

Structural analysis of the wing basic components, which include the apars, leading edge, and primary ribs, may be found in Report No. 134.

II. FLAP

SUMMARY

The flap is a conventional single spar, two cell structure supported by two hinges. Bending is reacted by the channel section spar plus a slug and effective skin. Shear and torque are reacted by the two cells formed by the skins and spar web, except in the central region where the nose cell is cut to provide clearance for the fan louver actuator. Stiffening ribs are located approximately 8 inches apart, and heavier end ribs distribute hinge loads and the actuator load into the box structure. The flap pivots about a hinge line located below the lower surface and forward of the spar. The flaps are actuated by individual screw jacks located just inboard of the fuselage side skins. The jack is attached to the flap by a fitting which extends through a slot in the fuselage side skin. Power from a single electrical motor is transmitted to the screw jacks by flexible shafting.

Originally the flap was constructed from aluminum alloy components. Subsequent test data showed that the inboard portion of the flap is subjected to higher temperatures than those originally anticipated. Therefore, the inboard portion was redesigned using components made from titanium alloys.

Critical flap loads occur during conventional flight at 180 knots with flaps and ailerons fully deflected. The high temperatures applied to the inboard portion occur during fan operation in hovering and transition. However, it is conservatively assumed for analysis that the maximum temperatures exist during the critical load condition.

The flap is analyzed as a simply supported beam with the airload uniformly distributed along the span. The torque is reacted at the inboard end by the actuator load. Ordinary engineering theory is used for the shear and bending analyses.

The flap was satisfactorily tested to limit load which simulated the critical loading condition. The structure was at room temperature during this test.

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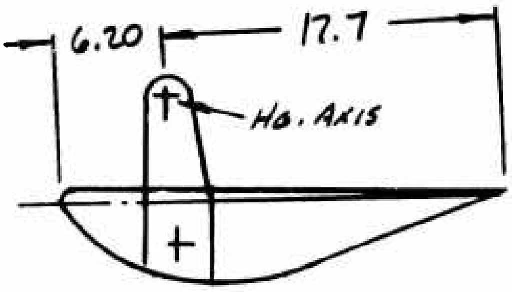
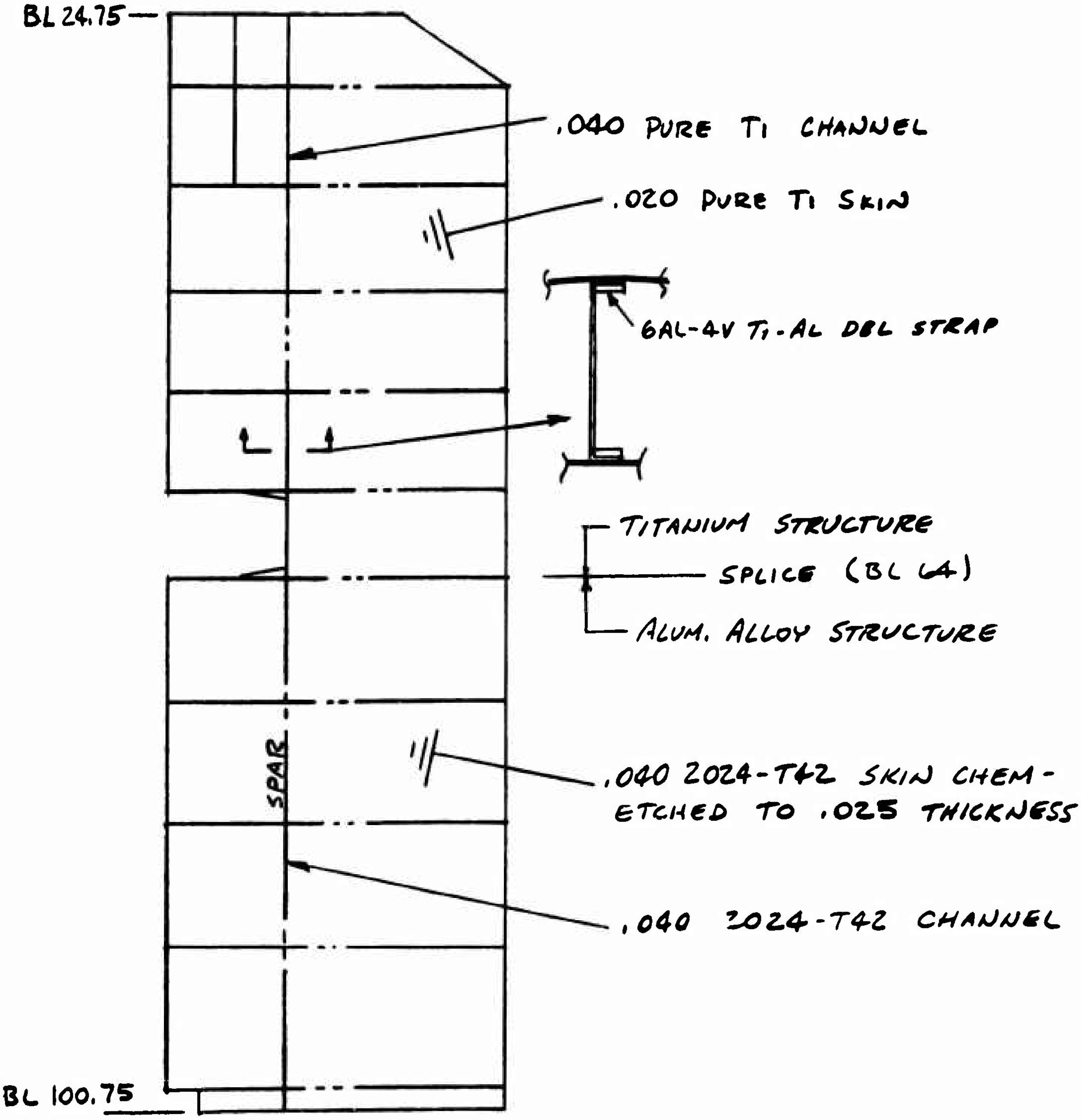
FLAP
(REF DWG 143 W010)



NOTE: INBD PORTION OF FLAP IS CONSTRUCTED OF TITANIUM BECAUSE OF HIGH TEMPERTURES — USE 700° F FOR DESIGN.



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FLAP

ULTIMATE LOADS

HINGE MOMENT = 12470 "#

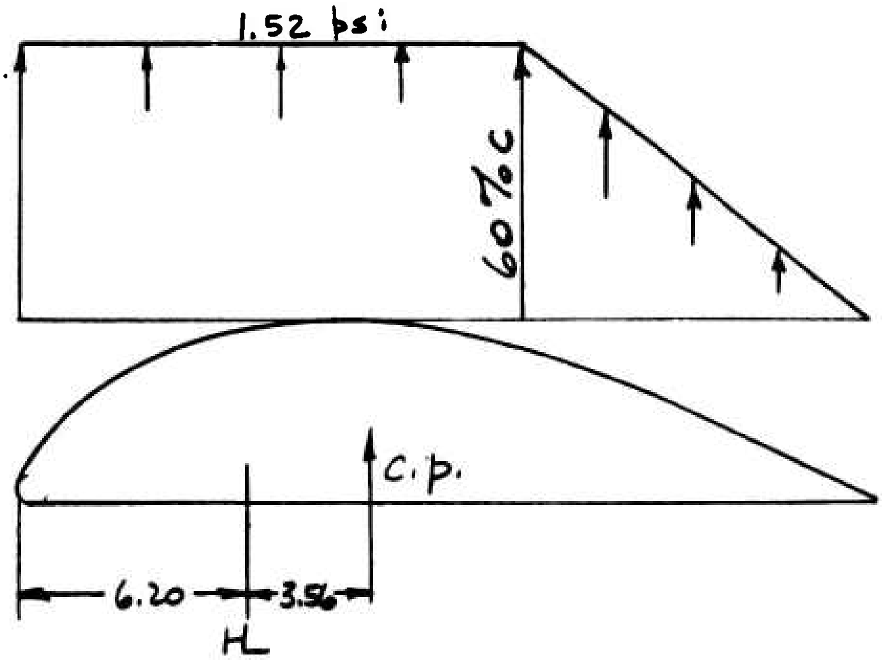
AIRLOAD NORMAL COMPONENT = 2207 #

AIRLOAD CHORDWISE COMPONENT = 659 #

RESULTANT AIRLOAD = 2304 #

ACTUATOR LOAD = 2128 #

CHORDWISE PRESSURE DISTRIBUTION:



COND. — V = 180 KNOTS, FLAPS & AILERONS FULLY DEFLECTED, $\alpha = 16°$, $\psi = 12°$

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FLAP

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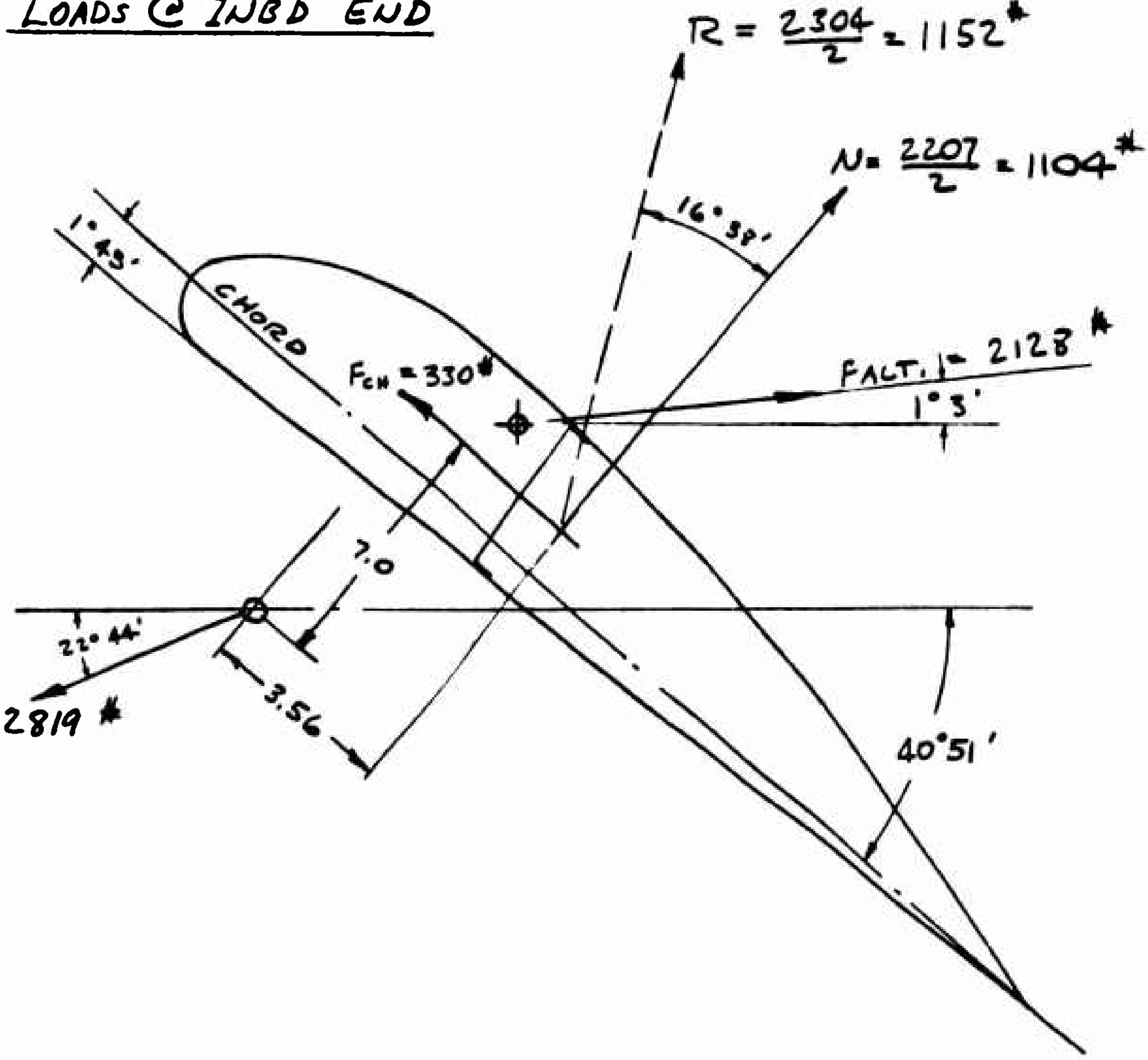
LOADS @ INB'D END



OUTB'D HINGE LOAD

EQUALS HALF AIRLOAD = 1152#

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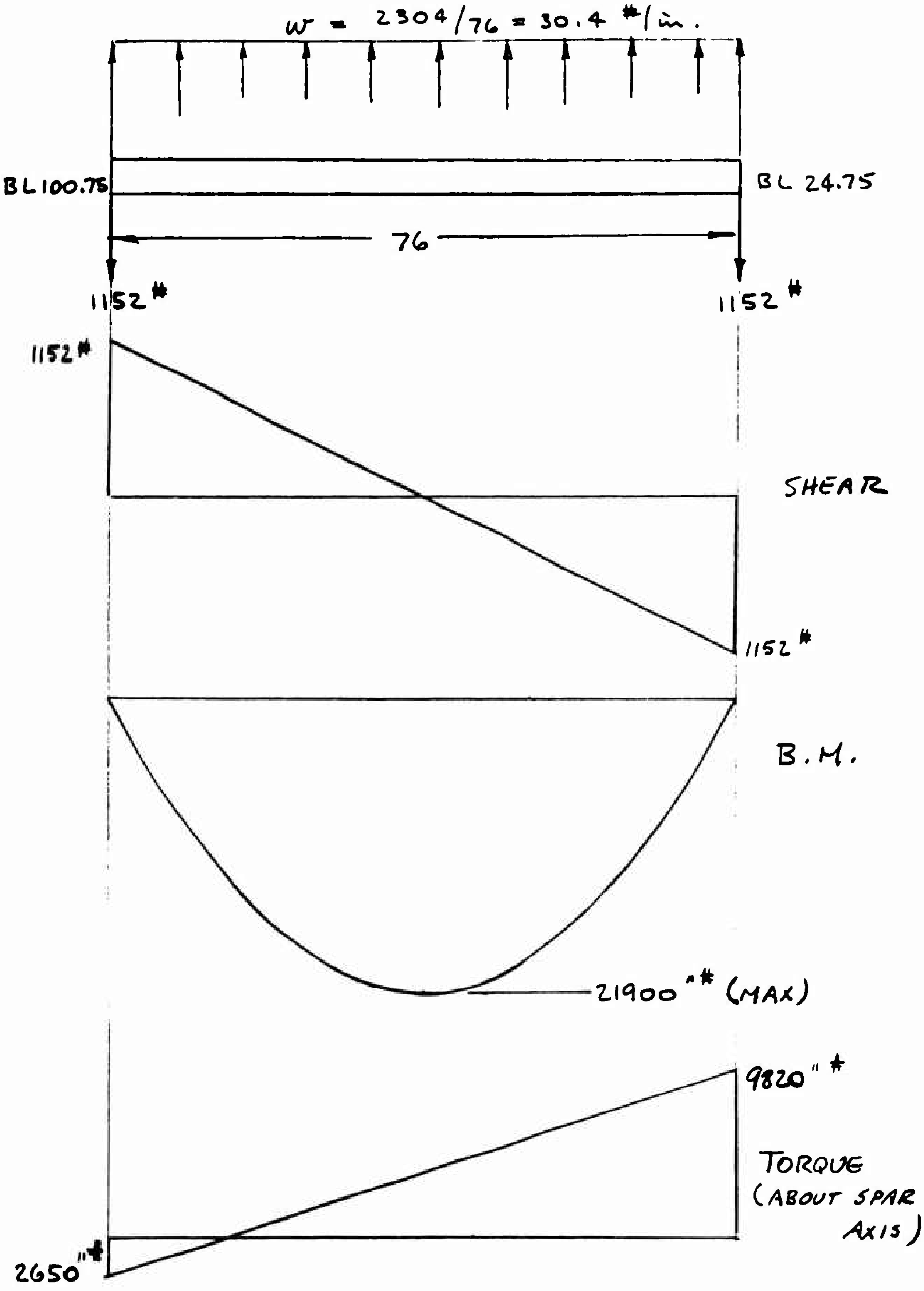
FLAP

ULT. LOAD CURVES



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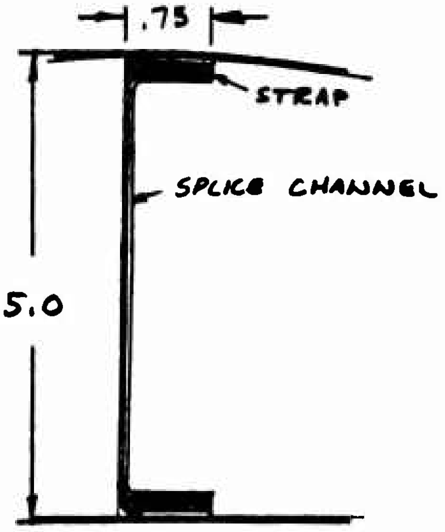
FLAP

BENDING ANALYSIS

SECTION @ SPLICE (BL 64)

DBL STRAP IS CONTINUOUS ACROSS SPLICE OF SPAR AND SKIN. SPAR IS SPLICED BY .040 CHANNEL



$$B.M. = 21800 \text{ ''}\#$$

$$\text{CAP LOAD} = \frac{BM}{h} = \frac{21800}{4.71} = 4630\#$$

$$\text{AREA} = .71 \times .125 + 2 \times .67 \times .04 = .142$$

$$f_c = 4630/.142 = 32600 \text{ psi}$$

ALLOWABLE STRAP COMPRESSIVE STRESS IS ASSUMED EQUAL TO CRIPPLING STRESS OF .040 ANGLE REINFORCED WITH STRAP PER CONVAIR METHOD

PROPERTIES OF 99 Ti @ 700° F

$F_{cy} = 70000 \times .40 = 28000$ psi $\quad E = 12.5 \times 10^6$ psi

USE STRESS MEMOS (CONVAIR) #20 & 30 FOR CRIPPLING ALLOWABLE

$b/t = .73/.040 = 18.2 \qquad \frac{1}{\sqrt{K}} = 1.25$ STRESS MEMO 20 CASE 5

$$\frac{b}{t\sqrt{K}} = 18.2 \times 1.25 = 22.8$$

$F_{cr} = 41000$ psi (ROOM TEMP. REF MEMO 30, P. 6)

$$F_{cr} (@ 700°) \cong 41000 \times \frac{E_{T=700}}{E_{RT}} = 41000 \times \frac{12.5}{16} = 32000 \text{ psi}$$

$$M.S. = \frac{32000}{32600} - 1 = \underline{\underline{-.02}} \; *$$

* O.K. SINCE 700° F TEMP. @ SPLICE IS VERY CONSERVATIVE

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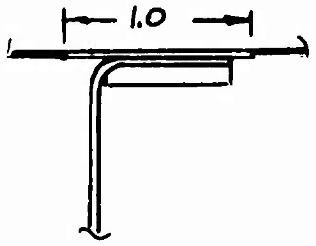
BENDING ANALYSIS

SECTION @ B.L. 50

STRAP TAPERS TO .108 THICKNESS

B.M. = 19200 "#   CAP LOAD = $\frac{19200}{4.5}$ = 4260#



AREA = .71 × .108 + 2 × .67 × .04 + 1 × .04
= .170 in²

$f_c = 4260/.17 = 25000$ psi

$F_c = 32000$ psi (PG. 5)

M.S. = $\frac{32000}{25000} - 1 = +.28$

SECTION @ B.L. 72.5

STRAP TAPERS TO .102 THICKNESS

B.M. = 20200 "#   CAP LOAD = $\frac{20200}{4.5}$ = 4500#

CAP IS SAME AS SHOWN ABOVE EXCEPT
CHANNEL AND EFFECTIVE SKIN ARE 2024 - T42

EFFECTIVE $A = (.71 \times .102)\frac{16}{10.7} + 2 \times .67 \times .04 + 1 \times .04 = .2015$

f_c (AL.AL. CHANNEL) = 4500/.2015 = 22400 psi

CHECK ALLOWABLE @ 300° F

$F_{cy} = 40000 \times .91 = 36400$ psi $E = 10.7 \times 10^6 \times .95 = 10.2 \times 10^6$ psi

$b'/t = .73/.040 = 18.2$ $\frac{F_{cc}}{\sqrt{F_{cy} E}} = .038$ RYAN STRUCT MANUAL, P. 5.9

$F_{cc} = .038\sqrt{36400 \times 10.2 \times 10^6} = 23200$ psi

M.S. = $\frac{23200}{22400} - 1 = +.03$

STRAP STRESS = $22400 \times \frac{16}{10.7} = 33400$ psi   O.K.

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FLAP

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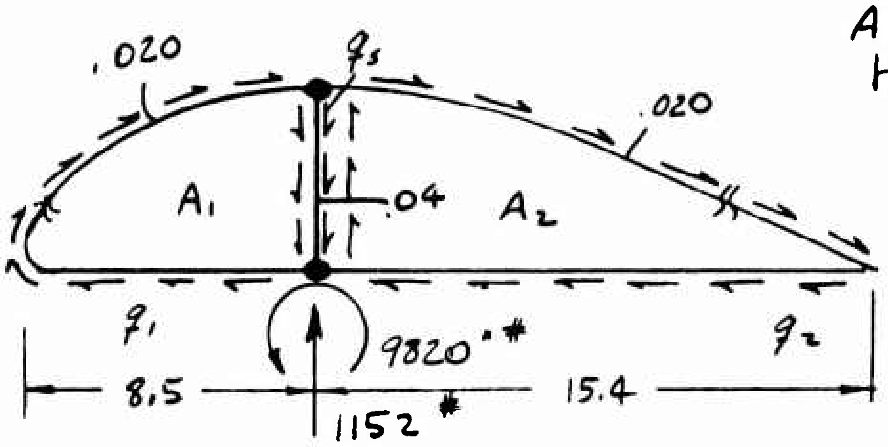
SHEAR ANALYSIS
SECTION @ BL 24.75

$A_1 = 33$
$A_2 = 43$
$h = 5$



ASSUMING NOSE & AFT SKINS CUT :

$q_s = 1152/5 = 230$ #/in.

$T = 2A_1 q_1 + 2A_2 q_2$

$9820 = 66\,q_1 + 86\,q_2$ ------ ①

$\theta_1 = \theta_2$

$$\frac{1}{2A_1G}\oint q\frac{ds}{t} = \frac{1}{2A_2G}\oint q\frac{ds}{t}$$

$$\frac{1}{33}\left[\frac{19}{.020}q_1 + \frac{5}{.04}(q_1 - q_2 + 230)\right] = \frac{1}{43}\left[\frac{32}{.020}q_2 + \frac{5}{.04}(q_2 - q_1 - 230)\right]$$

$35.5\,q_1 - 43.9\,q_2 = -1539$ ------ ②

SOLVING EQS ① & ② :

$q_1 = 50$ #/in. $\qquad q_2 = 76$ #/in.

NET SPAR $q = 230 + 50 - 76 = 204$ #/in.

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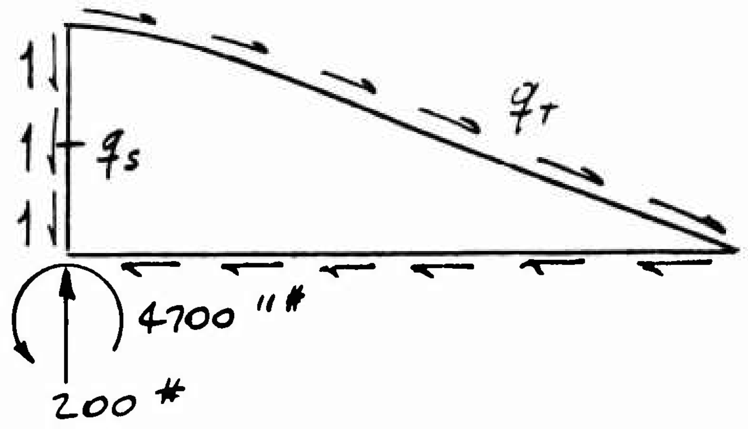
FLAP

SHEAR ANALYSIS

SECTION @ BL 58

NOSE SECTION IS CUT OUT @ THIS STATION



q_s = 200/5 = 40 #/in.

q_T = 4700/2×43 = 55 #/in.

NET SPAR q = 55 - 40 = 15 #/in.

SPAR WEB ANALYSIS - B.L. 24.75 CRITICAL

.040 99Ti

F_{tu} = 80000 × .37 = 29600 psi
F_{su} = 42000 × .45 = 18900 psi
} @ 700 °F

RIB SPACING = 7 2.5 IN. LIGHTENING HOLE / PANEL

$$f_s = \frac{204}{.04} = 5100 \text{ psi}$$

FIND ALLOWABLE F_s BY METHOD IN CONVAIR STRUCTURES MANUAL P. 7.52

$$\frac{1000t}{b} = \frac{1000 \times .04}{7} = 5.7$$

K_1 = .347 K_2 = .338

$$F_s = \left(K_1 - K_2 \frac{D}{b}\right) F_{tu}$$

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SPAR WEB ANALYSIS

$$F_s = (.347 - .338 \times \frac{2.5}{7})\,29600 = 6660\ psi$$

$$M.S. = \frac{6660}{5100} - 1 = \underline{+.30}$$

SKIN ANALYSIS

AFT SKIN IS CRITICAL

$q = 76$ #/in. $\qquad f_s = 76/.020 = 3800$ psi

ALLOWABLE F_s DETERMINED FROM CHARTS ON P. 7.432 OF CONVAIR STRESS MANUAL.

$$\frac{1000t}{h} = \frac{1000 \times .02}{7} = 2.86 \qquad \frac{b}{h} = \frac{7}{7} = 1$$

$$\frac{A_s}{bt} = \frac{.04}{7 \times .02} = .28$$

$$K_1 = .335 \qquad K_2 = .93$$

$$F_s = K_1 K_2 F_{tu}$$

$$F_s = .335 \times .93 \times 29600 = 9200\ psi$$

$$M.S. = \frac{9200}{3800} - 1 = \underline{+1.42}$$

BUCKLING STRESS:

$$a/b = 1 \qquad K_s = 8.5$$

$$F_{s_{cr}} = K E \left(\frac{t}{b}\right)^2 = 8.5 \times 12.5 \times 10^6 \left(\frac{.020}{7}\right)^2 = 870\ psi$$

III. AILERON AND SUPPORTS

SUMMARY

The aileron is a conventional type control surface structure supported by three hinges. The typical section is a two cell box with a single spar, except at the center hinge where the nose cell is cut. Concentrated loads at the hinge fittings are distributed to the box structure by ribs. Stiffening ribs are spaced between the hinge ribs at approximately 6.5 inches. The aileron is controlled by a combined tab and boost servo actuator system. Pilot input at the stick causes tab deflection through mechanical linkage and movement of the servo valve which controls the boost actuator.

Maximum aileron chordwise pressure distribution is based on a condition producing a dynamic pressure of 850 psf and maximum aileron deflection (- 19°, trailing edge up and + 15 , trailing edge down). The loads shown in the following analysis are those for -19° aileron deflection. Loads for +15° deflection are 75% of the values shown. The spanwise distribution is assumed to be proportional to the aileron chord. The total hinge moment resulting from the airload used in the analysis is greater than the maximum input hinge moment based on actuator capacity (4500 #ult) because the reduction in torque due to the tab airload has been conservatively neglected.

The aileron is analyzed as a continuous beam on three supports. Hinge loads normal to the aileron resulting from wing deflection are calculated and superimposed on the airload reactions when critical. A link is incorporated in the inboard hinge fitting to provide freedom of motion in the chordwise direction. Therefore, aileron chordwise hinge loads induced by wing deflection are eliminated. Ordinary engineering theory is used for the shear and bending analyses.

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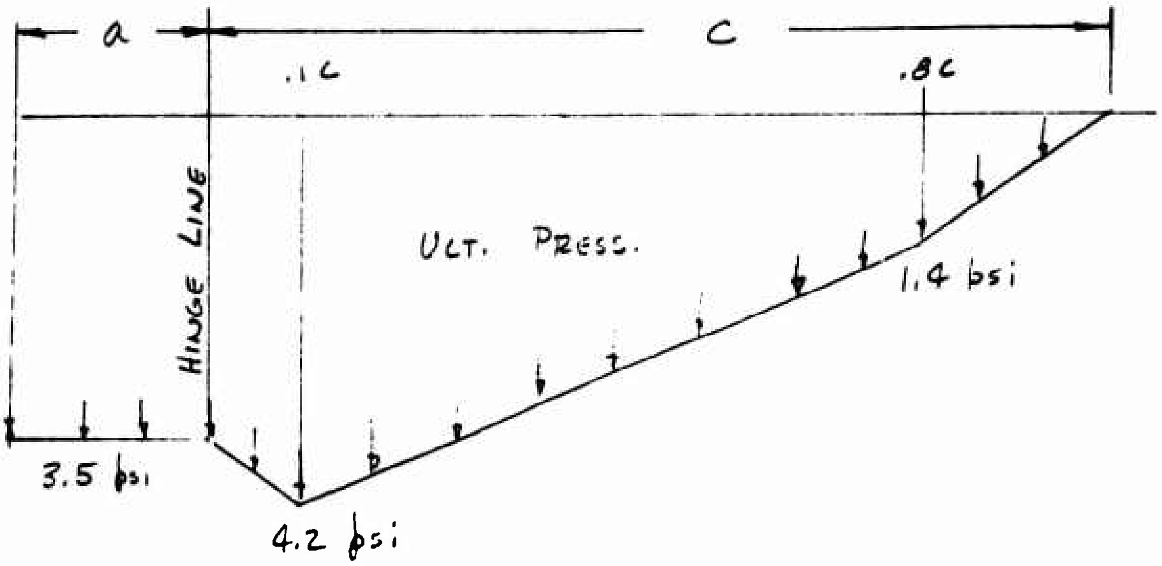
1/9/63 AILERON 15
XV-5A

LOADING – 19° DEFLECTION

USE VALUES FROM GUSKY AVO MULTIPLIED BY .70



$$w = 3.5a + \frac{4.2+3.5}{2} \times .1c + \frac{4.2+1.4}{2} \times .7c + \frac{1.4}{2} \times .2c$$

$$w = 3.5a + 2.48c$$

CENTER OF PRESSURE:

$$c.p.\ (\text{OF LOAD AFT H.L.}) = \frac{1}{2.48c}\Big[\frac{4.2+3.5}{2} \times .1c \times .515 \times .1c$$

$$+ \frac{4.2+1.4}{2} \times .7c\,(.417 \times .7 + .1)c + \frac{1.4}{2} \times .2c\,(\frac{.2}{3} + .8)c$$

$$c.p. = .367c$$

$$t = -3.5a \times \frac{a}{2} + 2.48c \times .367c$$

$$= -1.75a^2 + .909c^2$$

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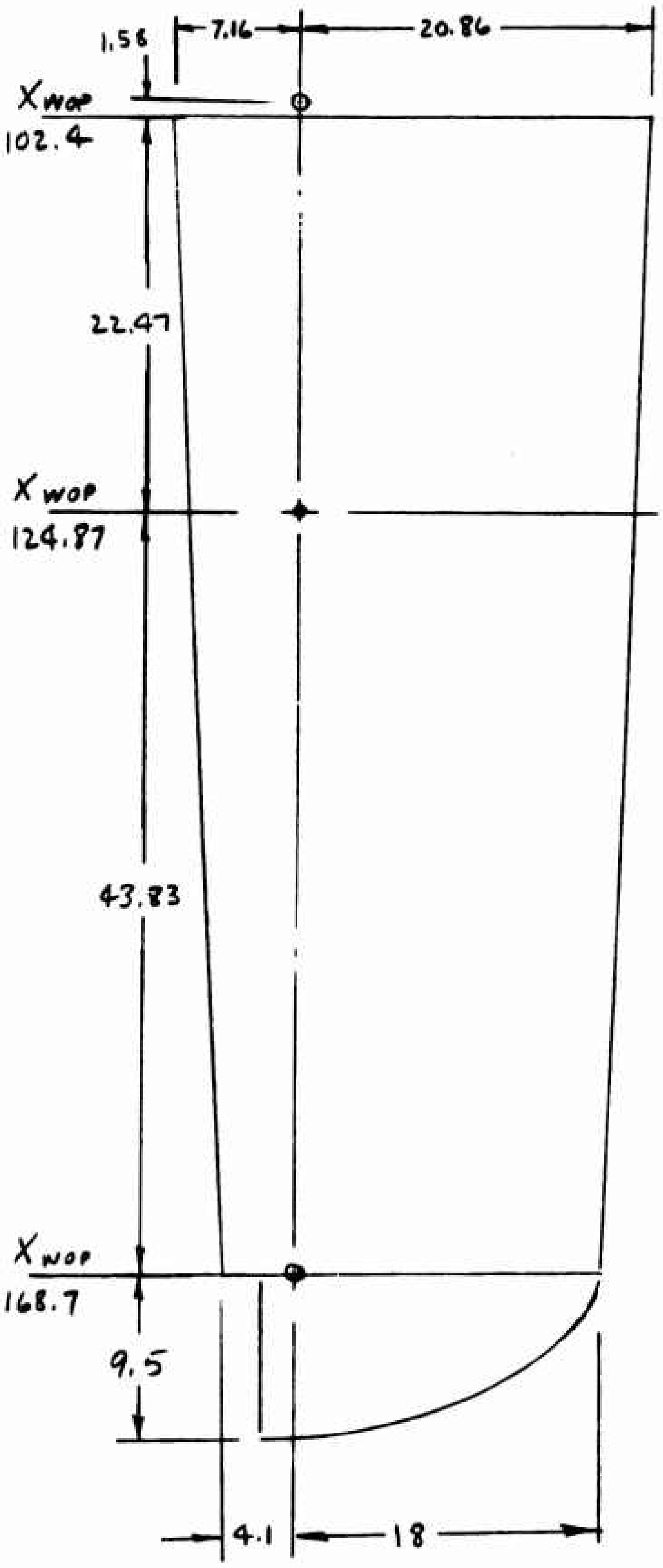


$$w = 3.5 \times 7.16 + 2.49 \times 20.86$$
$$= 76.85 \ \#/in.$$

$$w = 58.95 + \frac{76.85 - 58.95}{66.30} \times 43.83$$
$$= 70.77 \ \#/in.$$

$$w = 3.5 \times 4.1 + 2.48 \times 18$$
$$= 58.95 \ \#/in.$$

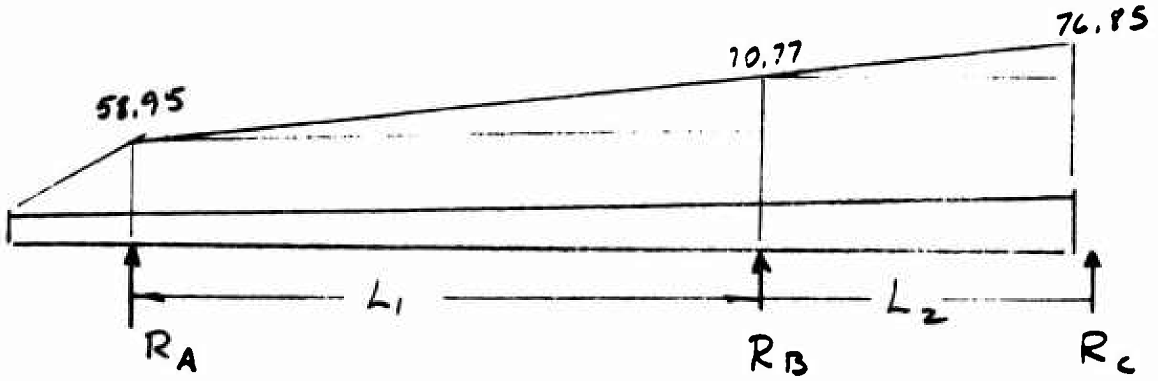
AILERON

SUPPORT LOADS - DUE TO AIRLOADING

MOMENTS OF INERTIA ESTIMATED FROM STIFFNESSES COMPUTED BY CHILDERS

INB'D BAY $I_2 = 4.25$

OUTB'D BAY $I_1 = 2.76$



ASSUME $L_2 = 22.47$ FOR SIMPLICITY

$$M_A = 58.95 \times \frac{9.5}{2} \times \frac{9.5}{3} = 887 \text{ "\#}$$

THREE MOMENT EQ. — ASSUME RIGID SPTS.

$$\frac{M_A L_1}{I_1} + \frac{2 M_B L_1}{I_1} + \frac{2 M_B L_2}{I_2} = K_1 + K_2$$

$$(887 + 2M_B)\frac{43.83}{2.76} + 2M_B \times \frac{22.47}{4.25} = \frac{58.95 \times 43.83^3}{4 \times 2.76} + \frac{2 \times 11.82 \times 43.83^3}{15 \times 2.76}$$

$$+ \frac{70.77 \times 22.47^3}{4 \times 4.25} + \frac{7 \times 6.08 \times 22.47^3}{60 \times 4.25}$$

$$14100 + 31.75 M_B + 10.58 M_B = 449000 + 48000 + 47300 + 1890$$

$$M_B = \frac{532000}{42.33} = 12600 \text{ "\#}$$

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ΣM_B (SPAN I) $= 0$

$$43.83\, R_A + 12600 = \left(58.95 \times \frac{9.5}{2}\right)\left(\frac{9.5}{3} + 43.83\right) + \frac{58.95 \times 43.83^2}{2} + \frac{11.82 \times 43.83^2}{6}$$

$$R_A = 1678^{\#}$$

ΣM_B (SPAN II) $= 0$

$$22.47\, R_C = \frac{70.77 \times 22.47^2}{2} + \frac{6.08 \times 22.47^2}{3} - 12600$$

$$R_C = 282^{\#}$$

$$\text{TOTAL LOAD} = \frac{58.95 \times 9.5}{2} + \frac{58.95 + 70.77}{2} \times 43.83 + \frac{70.77 + 76.85}{2} \times 22.47$$

$$= 4780^{\#}$$

$$R_B = 4780 - 1678 - 282$$

$$= 2820^{\#}$$

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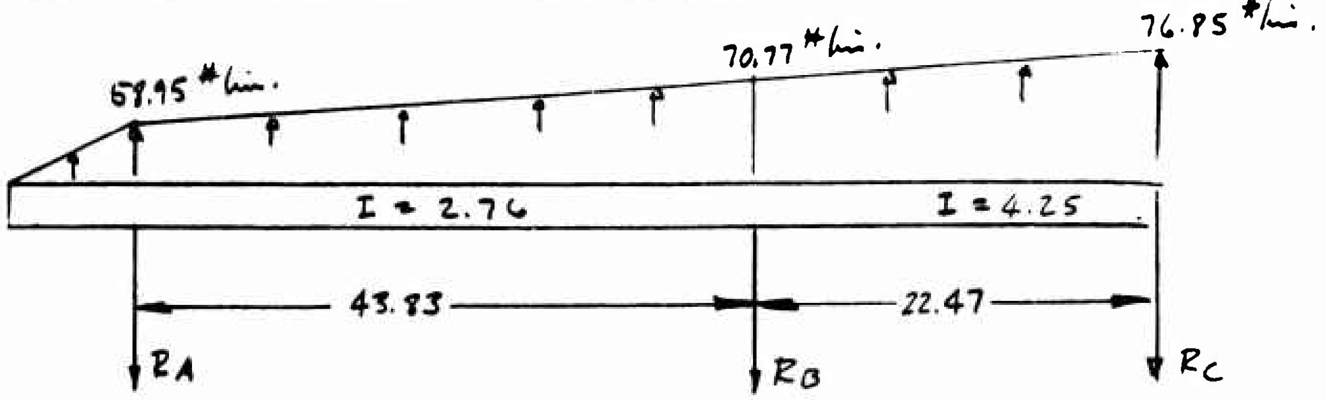
CHECK BY MOMENT DISTRIBUTION



S.F.	0	.063	.063	.189	.189	0
D F.	0	1	.25	.75	1	0
C.O.F.	0	.5	0	0	.5	0
F.E.M	-887	10177	-10553	3082	-3133	0
		-9290			3133	
			-4645	1567		
			2638	7911		
	-887	887	-12560	12560	0	0

CHECKS 12600 "# ON Pg. 3

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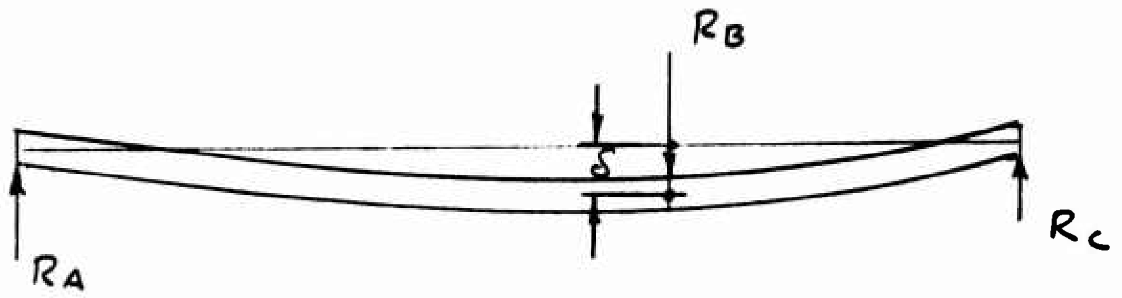
INDUCED SPT. LOADS DUE TO WING DEFLECTION



FROM 3-MOMENT EQ:

$$\frac{2M_BL_1}{I_1} + \frac{2M_BL_2}{I_2} = \frac{6E}{L_1}(\delta_A - \delta_B) + \frac{6E}{L_2}(\delta_c - \delta_B)$$

$$\delta_A = 0 = \delta_c$$

$$M_B\left(\frac{L_1}{I_1} + \frac{L_2}{I_2}\right) = -3E\,\delta_B\left(\frac{1}{L_1} + \frac{1}{L_2}\right)$$

$$M_B\left(\frac{L_1^2L_2}{I_1} + \frac{L_1L_2^2}{I_2}\right) = -3E\delta_B\left(L_2 + L_1\right)$$

$$M_B = \frac{-3E\delta_B L}{\left(\frac{L_1^2L_2}{I_1} + \frac{L_1L_2^2}{I_2}\right)}$$

CHECK: LET $L_1 = L_2$ & $I_1 = I_2$

$$M_B = -\frac{12EI\delta_B}{L^2}$$

$$\delta = \frac{WL^3}{48EI} \qquad W = \frac{48EI\delta}{L^3}$$

$$M = \frac{W}{2} \times \frac{L}{2} = \frac{WL}{4}$$

$$M = \frac{48EI\delta}{L^3} \times \frac{L}{4} = \frac{12EI\delta}{L^2}$$ O.K.

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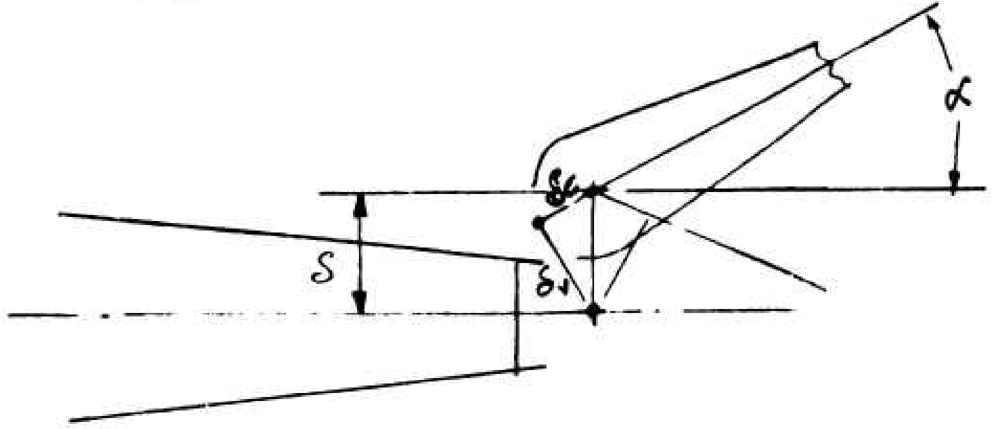
ULT $\delta_B = -.16 \times 1.5 = -.24$



VERT. WING DEFLEC. IS RESOLVED INTO VERTICAL & CHORDWISE COMPONENTS WITH RESPECT TO AILERON

UP AILERON $\alpha = 15°$

$\delta_v = -.24 \cos 15° = -.232$

$\delta_c = +.24 \sin 15° = .062$

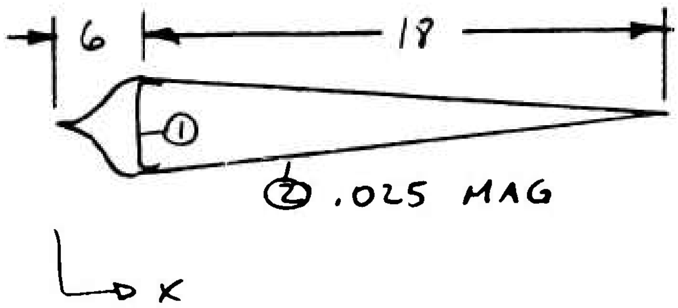
DOWN AILERON $\alpha = -19°$

$\delta_v = -.24 \cos 19° = -.227$

$\delta_c = -.24 \sin 19° = -.078$

CHORDWISE MOMENT OF INERTIA

OUTB'D BAY



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AILERON

XV-5A

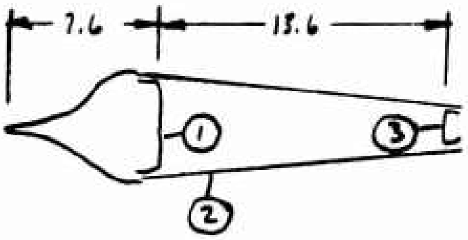
EQUIV. t OF MAG SKIN $= \frac{6.5}{10.5} \times .025 = .0155$

ELE	A	x	Ax	Ax^2	I_o
1	.27	6	1.62	9.72	-
2	.745	12	8.94	107.2	35.8
Σ	1.015		10.56	116.9	35.8

$\bar{x} = 10.56/1.015 = 10.4$

$I_1 = 116.9 + 35.8 - 1.015 \times 10.4^2 = 41.7$

INB'D BAY



ELE	A	x	Ax	Ax^2	I_o
1	.36	7.6	2.74	20.8	
2	.656	10.6	6.95	73.6	24.6
3	.114	21.2	2.42	51.3	
Σ	1.130		12.11	145.7	

$\bar{x} = 12.11/1.13 = 10.7$

$I_2 = 145.7 + 24.6 - 1.13 \times 10.7^2 = 40.5$

Lambert
1/9/63

AILERON

INDUCED SPT. LOADS

VERTICAL:

$$\frac{3EL}{\left(\frac{L_1^2 L_2}{I_1}+\frac{L_1 L_2^2}{I_2}\right)} = \frac{3\times 10.5\times 10^6\times 66.3}{\left(\frac{43.83^2\times 22.47}{2.76}+\frac{43.83\times 22.47^2}{4.25}\right)}$$

$$= 100000$$

UP AILERON: $M_B = -100000(-.232) = 23200''^{\#}$

$R_A = 23200/43.83 = 530^{\#}$

$R_C = 23200/22.47 = 1032^{\#}$

$R_B = -530 - 1032 = -1562^{\#}$

DN. AILERON: $\delta_V = .227$

$R_A = \frac{.227}{.232}\times 530 = 519^{\#}$

$R_C =$ " $1032 = 1010^{\#}$

$R_B =$ " $-1562 = -1530^{\#}$

Lambert
1/10/63

AILERON

INDUCED SPT. LOADS

~~DN. AILERON!; $\delta_c = -.078$~~

~~$R_A = -\frac{.078}{.062} \times 1975 = -2360$ #~~

~~$R_C =$ " $3650 = -4590$ #~~

~~$R_B =$ " $-5525 = +6950$ #~~

SPT. LOADS DUE TO AIRLOAD

FOR CONSERVATIVE LOADS @ OUTB'D & INB'D HINGES ASSUME PINNED JOINT @ CENTER SPT.

SEE P. ④ FOR MOMENT EQS.

$$43.83\ R_A = \left(58.95 \times \frac{9.5}{2}\right)\left(\frac{9.5}{3} + 43.83\right) + \frac{58.95 \times 43.83^2}{2} + \frac{11.82 \times 43.83^2}{6}$$

$$R_A = 1966\ \#$$

$$R_B' = \frac{58.95 \times 9.5}{2} + \frac{58.95 + 70.77}{2} \times 43.83 - 1966 = 1154\ \#$$

$$22.47\ R_C = \frac{70.77 \times 22.47^2}{2} + \frac{6.08 \times 22.47^2}{3}$$

$$R_C = 843\ \#$$

$$R_B'' = \frac{70.77 + 76.85}{2} \times 22.47 - 843 = 815\ \#$$

TOTAL $R_B = 1154 + 815 = 1969\ \#$

Lambert
1/10/63

AILERON

SPT. LOADS SUMMARY

ULT. LOADS APPLIED TO AILERON
PLUS UP & AFT.

		SPT. A OUT B'D		SPT. B CENTER		SPT. C INBD	
		V	D**	V	D**	V	D**
		UP AILERON *					
DUE * TO AIRLOAD	CONTINUOUS BEAM	1273	~~0~~	2115	~~0~~	212	~~0~~
	PINNED @ CENTER SPT.	-1473	~~0~~	1475	~~0~~	632	~~0~~
LOADS INDUCED BY WING DEFLECTION		530	~~1875~~	-1562	~~-5525~~	1032	~~3450~~
NET LOADS		2003	~~1875~~	653	~~-5525~~	1664	~~3650~~
		DOWN AILERON					
DUE TO AIRLOAD	CONTINUOUS BEAM	-1678	~~0~~	-2820	~~0~~	-282	~~0~~
	PINNED @ CENTER SPT.	-1966	~~0~~	-1969	~~0~~	-843	~~0~~
LOADS INDUCED BY WING DEFLECTION		519	~~-2360~~	-1530	~~6950~~	1010	~~-4590~~
NET LOADS		-1447	~~-2360~~	-4350	~~6950~~	729	~~-4590~~

*UP AILERON LOADS DUE TO AIRLOAD ARE 75% OF DOWN AILERON COND. LOADS

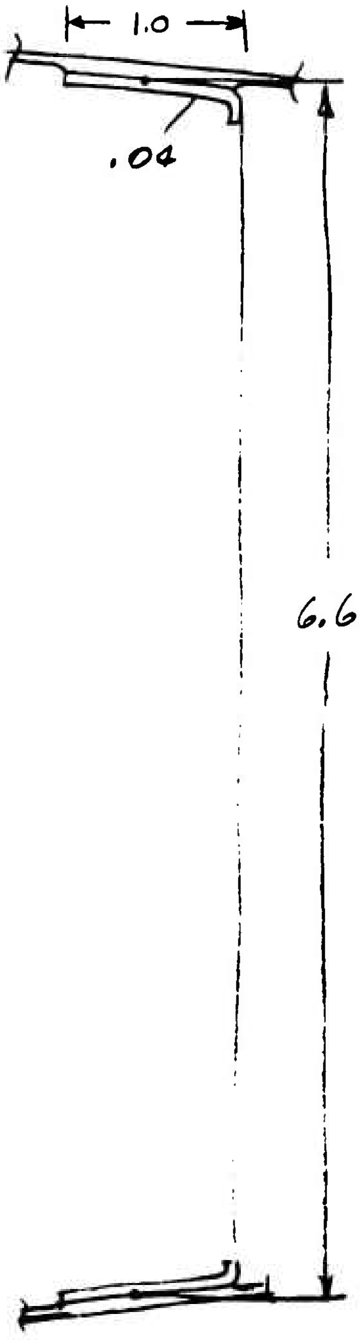
** NO LONGER APPLICABLE. INBOARD HINGE HAS A LINK THAT ALLOWS CHORDWISE FREEDOM

Lambat
1/19/63

AILERON ANALYSIS

BENDING CHECK

MAX. B.M. = 12600 "# @ CENTER HG.



$P = 12600/6.6 = 1910\,\#$

.040 MAG SKIN

$\text{EQUIV. } A = \frac{6.5}{10.5} \times 1 \times .04 = .025$

$\text{TOTAL } A = .025 + 1 \times .04 = .065$

$f = 1910/.065 = 29400 \text{ psi}$

$b/t = .98/.04 = 24.5$

$F_{cc} = .028\sqrt{68000 \times 10.5 \times 10^6} = 23700 \text{ psi}$

ADD .040 × .9 STRAP

$A = .065 + .04 \times .9 = .101$

$f_c = 1910/.101 = 18900 \text{ psi}$

$M.S. = \frac{23700}{18900} - 1 = \underline{+.25}$

TORSION CHECK

SECTION OUTB'D CENTER HINGE

$\Delta T = -1.75\, a^2 + .909\, c^2$

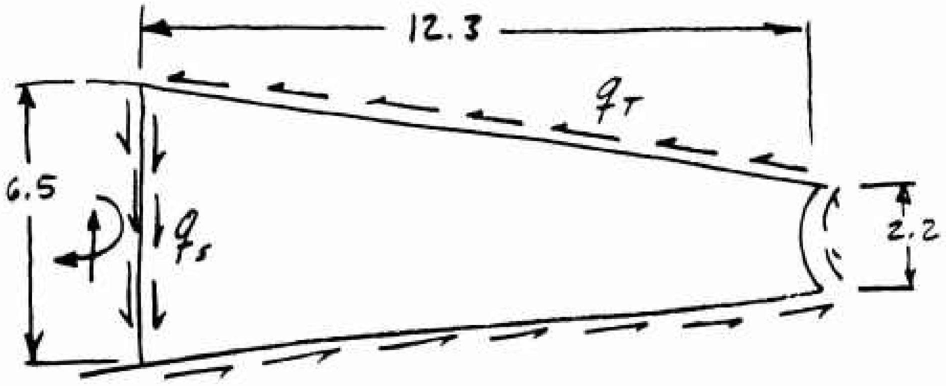
Av. $a = (6+4.1).5 = 5.05$

Av. $c = (18+19.6).5 = 18.8$

$L = 9.5 + 43.83 = 53.3$

$T = 53.3\,(-1.75 \times 5.05^2 + .909 \times 18.8^2)$

$= 14730\ '\#$



SHEAR INB'D $= 70.77 \times 22.47 + 6.08 \times \frac{22.47}{2} - 282 = 1376\#$

$2A = 12.3\,(6.5 + 2.2) = 107$

$q_T = 14730/107 = 138\ \#/in.$

$q_s = 1376/6.5 = 212\ \#/in.$

SPAR SHEAR $= 138 + 212 = 350\ \#/in.$

AILERON ANALYSIS

.040 SKIN IS USED BETWEEN CENTER HINGE BACKUP RIBS

f_s = 138/.04 = 3450 psi ULT   2300 psi LIMIT

a/b = 10.5/5 = 2 K_s = 5.8

$F_{s_{cr}} = 5.8 \times 6.5 \times 10^6 \left(\frac{.04}{5}\right)^2 = 2410$ psi

O.K.

SECTION OUTB'D NOSE CUTOUT

NOSE D $A = 6 \times 6.5 \times \frac{2}{3} = 26$

$q_T = \frac{14730}{\underset{52}{\cancel{26}} + 107} = \overset{93}{\cancel{111}}$ #/in.

.032 SKIN   6.4 RIB SPACING

$f_s = \overset{93}{\cancel{111}}/.032 = \overset{2900}{\cancel{3470}}$ psi   2310 psi LIMIT

$F_{s_{cr}} = 5.8 \times 6.5 \times 10^6 \left(\frac{.032}{6.4}\right)^2 = 940$ psi

O.K.

CHECK BENDING OF T.E. MEMBER DUE TO BUCKLES

$T/T_{cr} = 3470/940 = 3.7$ $K = .28$

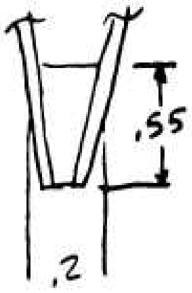
$M = \frac{1}{12} K \tau t d^2 C_3$

FOR BOTH SIDES $M = \frac{2}{12} \times .28 \times 3470 \times .032 \times 6.4^2 = 212''^{\#}$

Lambert
1/21/63

AILERON ANALYSIS

29
XV-5A



$$f_b = \frac{6\times 212}{.2\times .55^2} = 21000 \text{ psi}$$

O.K.

SPAR WEBS

$f_s = 212/04 = 5300$ psi   3530 psi (LIMIT)

$F_{s_{cr}} = 5.8 \times 10.5\times10^6 \left(\frac{.04}{6.4}\right)^2 = 2380$ psi

USE BEADS BETWEEN RIBS

ALLOW. FROM CHANCE-VOUGHT = 360 #/in.

NOSE RIB @ CENTER HG. CUTOUT

MOMENT = 93 × 52 = 4840 "#

COUPLE @ SPAR SPLICE = 4840/6.5 = 745 #

ASSUME 1 × .040 SKIN EFF.

$$f = \frac{745}{.04} = 18600 \text{ psi}$$

O.K.

Lambert
1/15/63

30
XV-5A

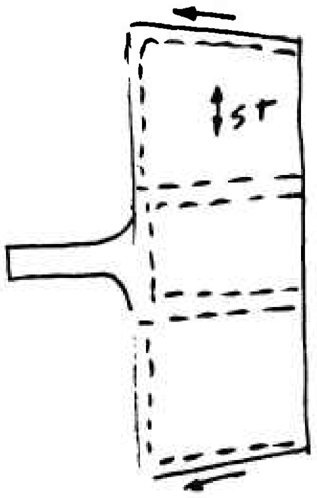
AILERON CENTER HINGE

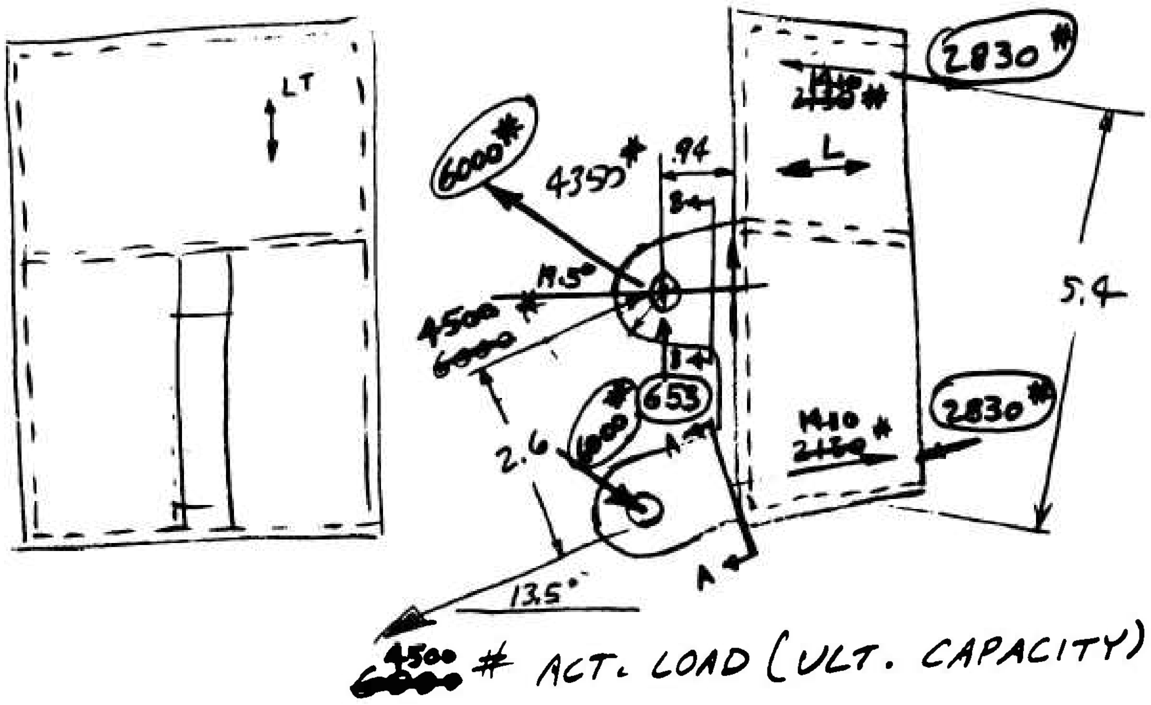
7079-T6 HAND FORGED BILLET

Ftu 71 L
69 LT
67 ST

Fsu 43

Fbru 121





MAX. HG. LOAD = 4350 #

MOMENT = ~~6000~~ 4500 × 2.6 − 4350 × .94 = ~~11500~~ 7610 "#

REACTING COUPLE = ~~11500~~ 7610 /5.4 = ~~2130~~ 1410 #

} DOWN AILERON

UP AILERON LOADS (CIRCLED)

MOMENT = 6000 × 2.65 − 653 × .94 = 15300 "#

REACTING COUPLE = $\frac{15300}{5.4}$ = 2830 #

Lambert
1/16/63

AILERON CENTER HINGE

LUG

$a = .88 \quad D = 1.0 \quad t = .43$

RES. $\cong (6000^2 + 653^2)^{1/2} = 6030^{\#}$

$$f_{br} = \frac{6030}{1 \times .43} = 14000 \text{ psi}$$

$$f_s = \frac{6030}{2 \times .43 \times .38} = 18400 \text{ psi}$$

BENDING SECT A-A —

NORMAL COMP. OF $6000^{\#} = 3800^{\#}$ (FROM LAYOUT)

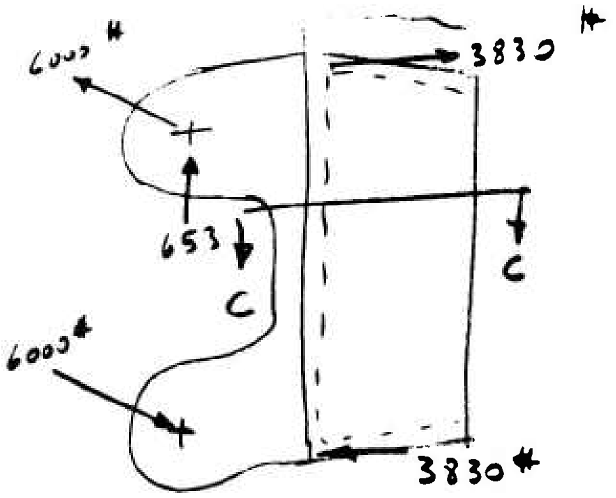
B.M. $= 3800 \times 1.03 = 3920''^{\#}$

$$f_b = \frac{6 \times 3920}{.25 \times 1.1^2} = 77700 \text{ psi}$$

$$F_b = 1.5 \times 71000 = 106500 \text{ psi}$$

M.S. = +.37

SECT. B-B IS DEEPER
MS AMPLE BY COMPARISON



MOMENT = $15300''^{\#}$

COUPLE = $15300/4 = 3830^{\#}$

$$M_{cc} = 2.45 \times 6000 - 3830 \times 2.3 = 5900''^{\#}$$

$$f_b = \frac{6 \times 5900}{.43 \times 1.8^2} = 25400 \text{ psi}$$

M.S. AMPLE

Lambert
1/16/63

AILERON CENTER HINGE

BENDING OF CENTRAL FLANGE

FLG BEAMS 3830# TO VERTICAL WEBS

$$BM = \frac{3830}{2} \times \frac{5.1}{2} = 4880 \text{ "\#}$$

$$f_b = \frac{6 \times 4880}{.125 \times 1.7^2} = 81000 \text{ psi}$$

$$F_b = 1.5 \times 67000 = 100000 \text{ psi}$$

MS: +.23

ATTACHMENT TO RIB

$$\text{MAX. LOAD / SIDE} = \frac{2830}{2} = 1415 \text{ \#}$$

USE 2 3/16 RIVS IN DBL SHEAR, BRG. ON .040 RIB & DBL.

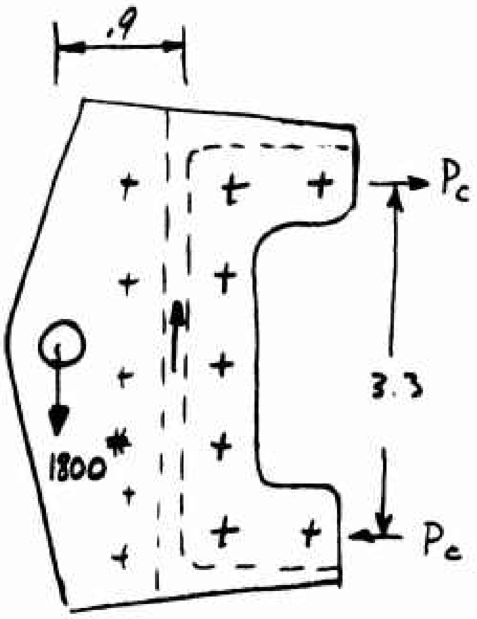
$$\text{ALLOW BRG.} = .040 \times .188 \times 146000 = 1100 \text{ \#}$$

$$\text{ALLOW} = 2 \times 2 \times 1100 = 4400 \text{ \#}$$

MS AMPLE

Lambert
1/11/63

AILERON OUTB'D HINGE
AILERON FITTING



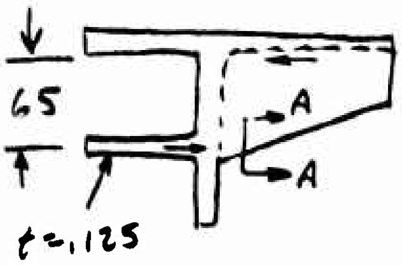
LUG !

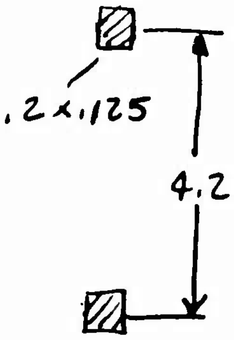
AMPLE BY INSPECTION

$$P_c = \frac{1800 \times .9}{3.3} = 490^{\#}$$

ATTACHMENTS AMPLE BY INSPECTION

SECT A-A





$$P = \frac{1800}{2} \times \frac{.8}{4.2}$$

$$= 171^{\#}$$

$$f = \frac{171}{.2 \times .125} = 6850 \text{ psi}$$

AMPLE

171# CAUSES TORQUE = 171 × .65 = 111 "#

$$f_s = \frac{3T}{\Sigma \ell t^2} = \frac{3 \times 111}{2.75 \times .125^2 + 1.4 \times .125^2 + 1.2 \times .125^2}$$

$$= 4000 \text{ psi}$$

AMPLE

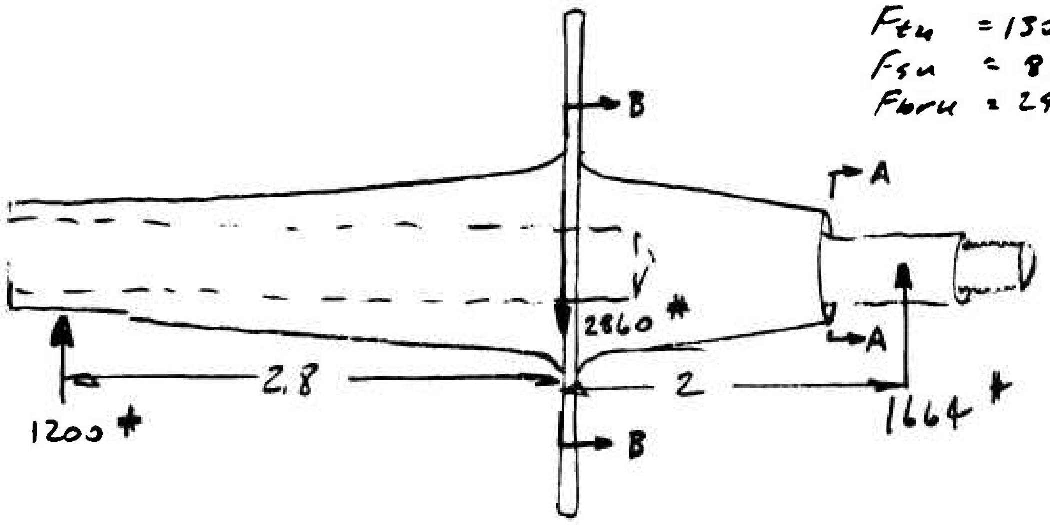
Lambert
1/21/63

AILERON INBD HG. FTG.

MAX. LOAD = 1664#

6AL-4V Ti. AL.

$F_{tu} = 130$
$F_{su} = 80$
$F_{bru} = 248$



$$1664 \times \frac{4.8}{2.8} = 2860^{\#}$$

SECT. A-A

$B.M. = 1664 \times .5 = 832''^{\#}$

.374 DIA. $I = \frac{\pi}{4} \times .187^4 = .00122$

$$f_b = \frac{832 \times .187}{.00122} = 127500 \text{ psi}$$

$F_b = 1.7 \times 130000 = 221000$ $M.S. = \frac{221}{127.5} - 1 = +.73$

SECT. B-B

1.0" OD .375" ID $M = 1664 \times 2 = 3330''^{\#}$

$$I = \frac{\pi}{4}(.5^4 - .1875^4) = .0481$$

$$f_b = \frac{3330 \times .5}{.0481} = 34600 \text{ psi}$$

M.S. HIGH

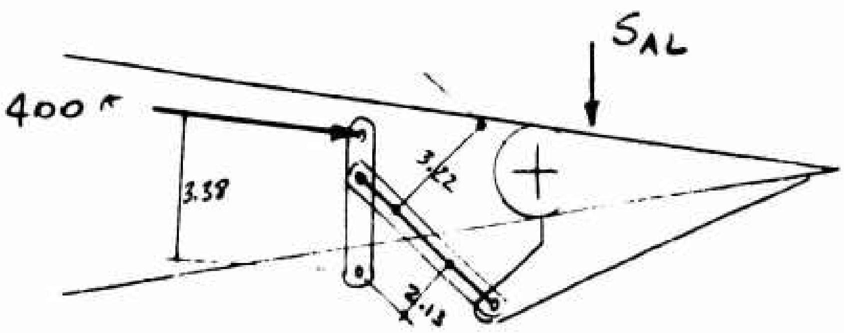
ATTACHMENT

4 - 3/16 SCREWS

M.S. ADEQUATE

Lambert
1/25/63

AILERON TAB



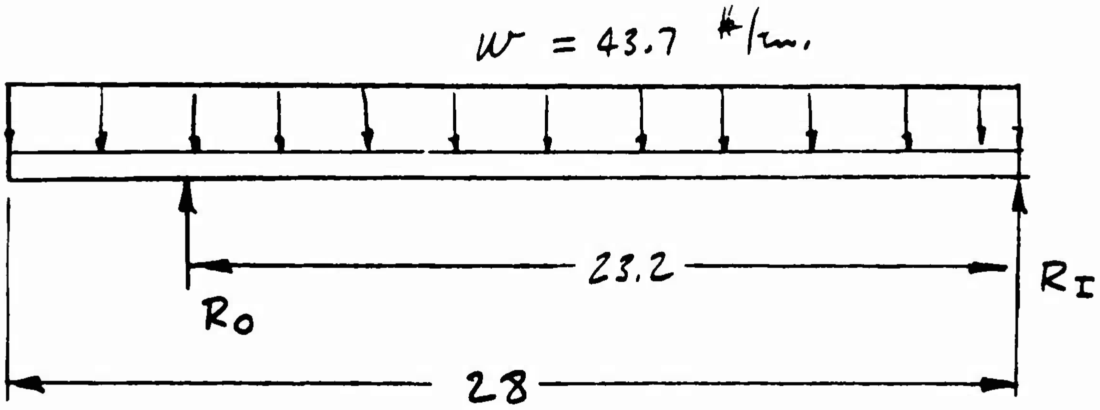
400 # ULT. ACTUATOR STATIC LOAD

LINK LOAD = $\frac{400 \times 3.38}{2.13}$ = 635 #

TAB HINGE MOMENT = 635 × 3.22 = 2040 "#

TAB CHORD = 5.0 "

$S_{AL} = \frac{2040}{5/3} = 1225$ #



$23.2\, R_O = 1225 \times 28 \times \frac{1}{2}$

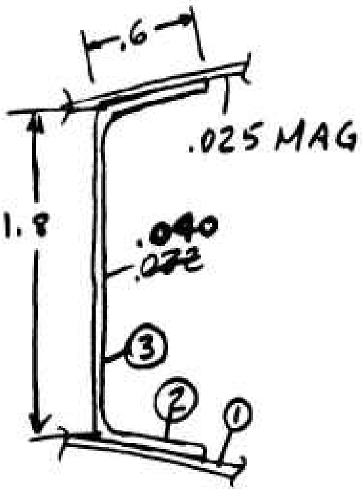
$R_O = 740$ #

$R_I = 1225 - 740 = 485$ #

AILERON TAB

SHEAR = 0 @ $x = {}^{485}/_{43.7} = 11.1$

$M = 485 \times 11.1 - 43.7 \times \frac{11.1^2}{2} = 2680$ "#



$A_{SK} = 1 \times .025 \times \frac{6.5}{10.5} = .0155$

	A	y	Ay^2	I_o
1	.031	.94	.0274	
2	.0364	.93	.0315	
3	.0556	0		0141
Σ			.0589	.0141

$I = .0589 + .0141 = .073$

$f_b = \frac{2680 \times .93}{.073} = 34200$ psi

$b/t = {}^{.585}/_{.032} = 18.3$

$F_{cc} = .036 \sqrt{68000 \times 10.5 \times 10^6} = 30400$ psi

USE .040

$I = .0274 + \frac{.040}{.032}(.0315 + .0141) = .0845$

$f_b = \frac{2680 \times .93}{.0845} = 29500$ psi

$b/t = {}^{.56}/_{.04} = 14$

$F_{cc} = .042 \sqrt{68000 \times 10.5 \times 10^6} = 35500$ psi

$MS = \frac{35500}{29500} - 1 = +.20$

Lambert
1/25/63

AILERON TAB

SHEAR

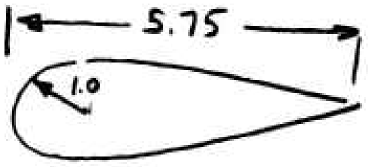
SHEAR @ OUTB'D END = 740 - 4.8×43.7 = 530 #

$$f_s = \frac{530}{1.6 \times .04} = 8300 \text{ psi}$$

O.K.

TORQUE

$$\text{TORQUE} = \frac{23.2}{28} \times 2040 = 1690 \; ''\#$$



$$A = 4.75 \times 2 \times .5 + \frac{\pi}{2} \times 1^2 = 6.32$$

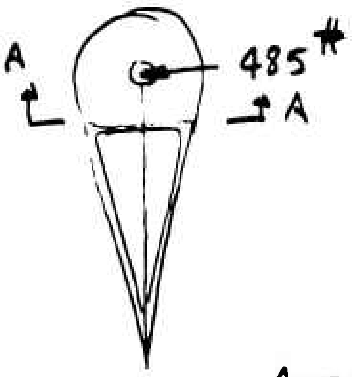
$$q_T = \frac{T}{2A}$$

$$= \frac{1690}{2 \times 6.32} = 133 \; \#/\text{in.}$$

$$f_s = 133/.025 = 5300 \text{ psi}$$

O.K.

INBD HG. FTG



SECTION A-A

$$\text{TORQUE} = .5 \times 485 = 243 \; ''\#$$

$$f_s = \frac{3T}{at^2} = \frac{3 \times 243}{1.6 \times .4^2} = 2850 \text{ psi}$$

M.S. HIGH

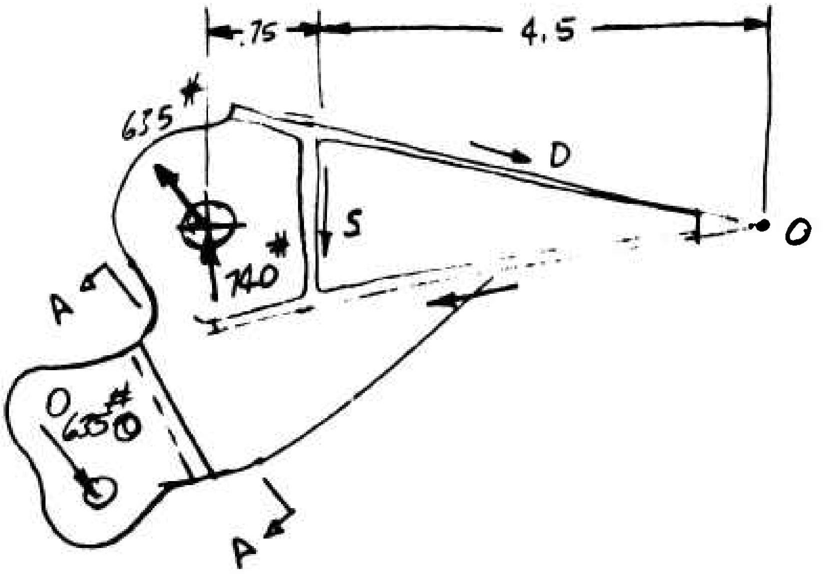
ATTACHED TO SPAR BY 3 1/8 BLIND RIVETS

ALLOW = 3 × 321 = 963 #

Lambert
1/25/63

AILERON TAB

OUTB'D FTG.



HG. MOMENT = 2040 "#

$\Sigma M_o = 0$

$2040 = 740 \times 5.25 - S \times 4.5$

$S = 410^{\#}$

$D = \frac{740-410}{2} \times \frac{4.5}{.78} = 952^{\#}$

LUG

ASSUME RES. = 635 + 740 = 1375

$f_{br} = \frac{1375}{.219 \times .75} = 8380$ psi

$f_{su} = \frac{1375}{2 \times .44 \times .325} = 4800$ psi

M.S. HIGH

Lambert
1/25/63

AILERON TAB

OUTB'D FTG.

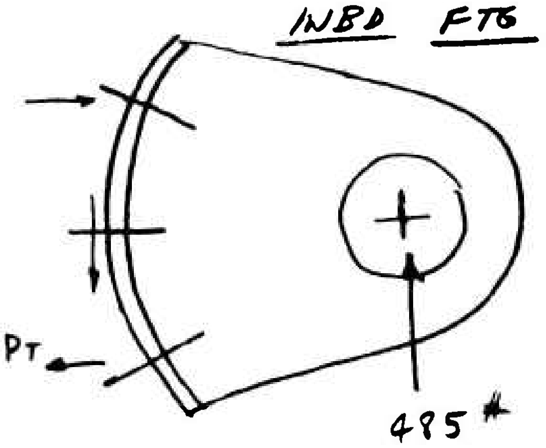
$$B.M. = 1.85 \times 635 = 1176 \ ''\#$$

$$f_b = \frac{6 \times 1176}{.3 \times 1.15^2} = 17800 \text{ psi}$$

M.S. HIGH

AILERON FTGS

INBD FTG



$$P_T = 1.50 \times 485/1.65 = 441 \ \#$$

2 .032 BENDS
CLEARANCE = .3 - .16 = .14

$$\text{ALLOW. LOAD} = 2 \times 100 \times 1.5 = 300 \ \#$$

CVAC #1 P. 8.23 FOR 2024 ANGLE

$$\text{FOR 7075-T6 ALLOW} = \frac{76000}{62000} \times 300$$
$$= 370 \ \#$$

INCREASE t TO .040

$$\text{ALLOW. LOAD} = 2 \times 160 \times 1.5 \times \frac{76}{62} = 588 \ \#$$

O.K.

LUG O.K. BY INSPECTION

BENDING ; $M = 1.2 \times 485 = 581 \ ''\#$

$$f_b = \frac{6 \times 581}{.08 \times 2^2} = 10900 \text{ psi}$$

O.K.

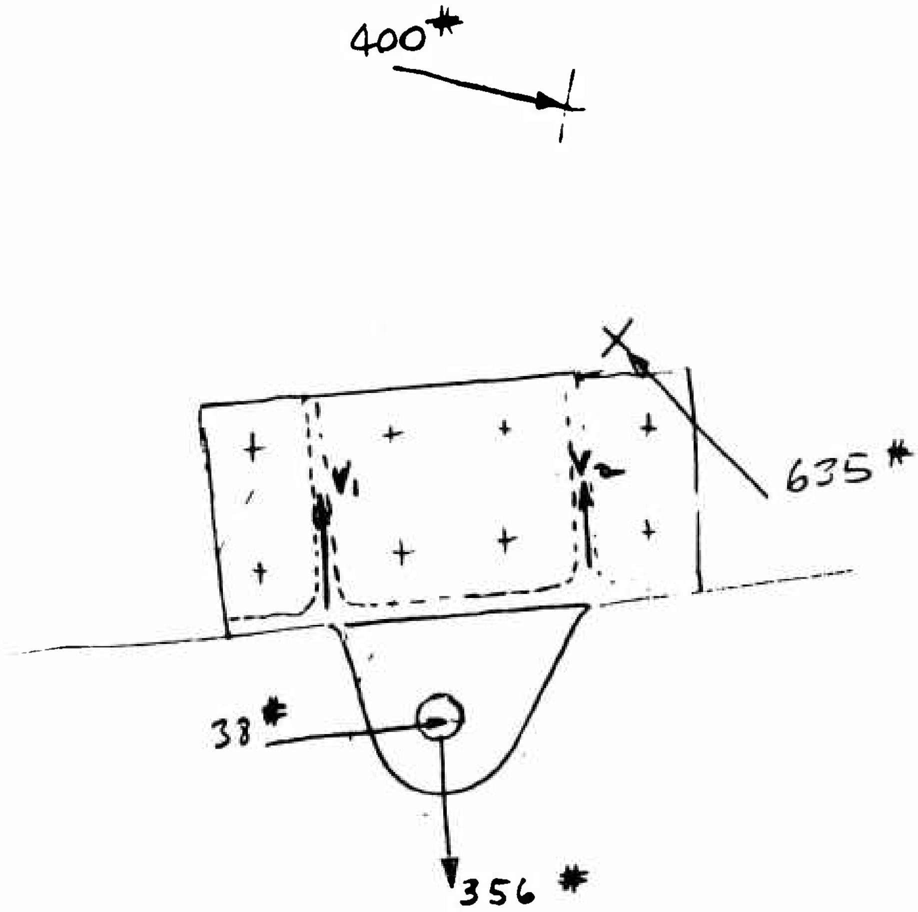
OUTBD FTG

BACKED-UP BY 2 .050 CLIPS & MACHINED CHANNEL

O.K. BY COMPARISON

Lambert
1/29/63

LINK PIVOT FTG.



$$V_1 = 38 \times \frac{.56}{1.38} + 356 \times \frac{.83}{1.38} = 230^{\#}$$

$$V_2 = 356 \times \frac{.55}{1.38} = 142^{\#}$$ (NEGLECT COUPLE)

LUG

.25 BOLT .40 E.D. .20 THICKNESS

M.S. AMPLE BY INSPECTION

FWD FLG.

$$B.M. = \frac{230}{2} \times 1.4 = 161 \ ''^{\#}$$

Lambert
1/30/63

LINK PIVOT FTG.

$$f_b = \frac{6 \times 161}{.08 \times 1.25^2} = 7700 \text{ psi}$$

M.S. HIGH

AFT FLG.

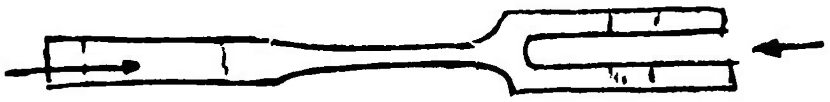
FLG. IS CUT @ ℄, SO BENDING IS TAKEN BY HORIZONTAL LEG.

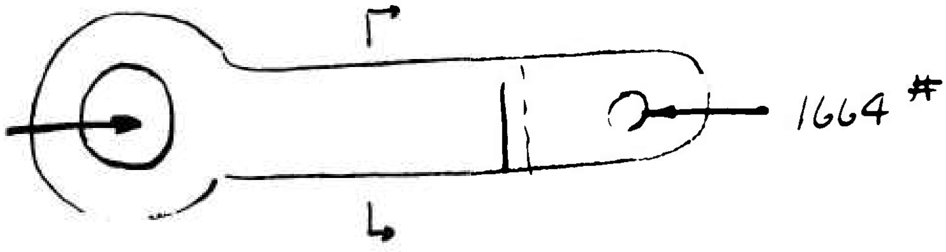
$$B.M. = \frac{142}{2} \times 1.15 = 82 \text{ ''\#}$$

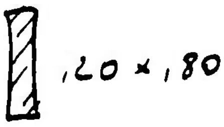
$$f_b = \frac{6 \times 82}{.5 \times .2^2} = 24600 \text{ psi}$$

M.S. ADEQUATE

INB'D HINGE LINK







$$\rho = \frac{.2}{\sqrt{12}} = .0576$$

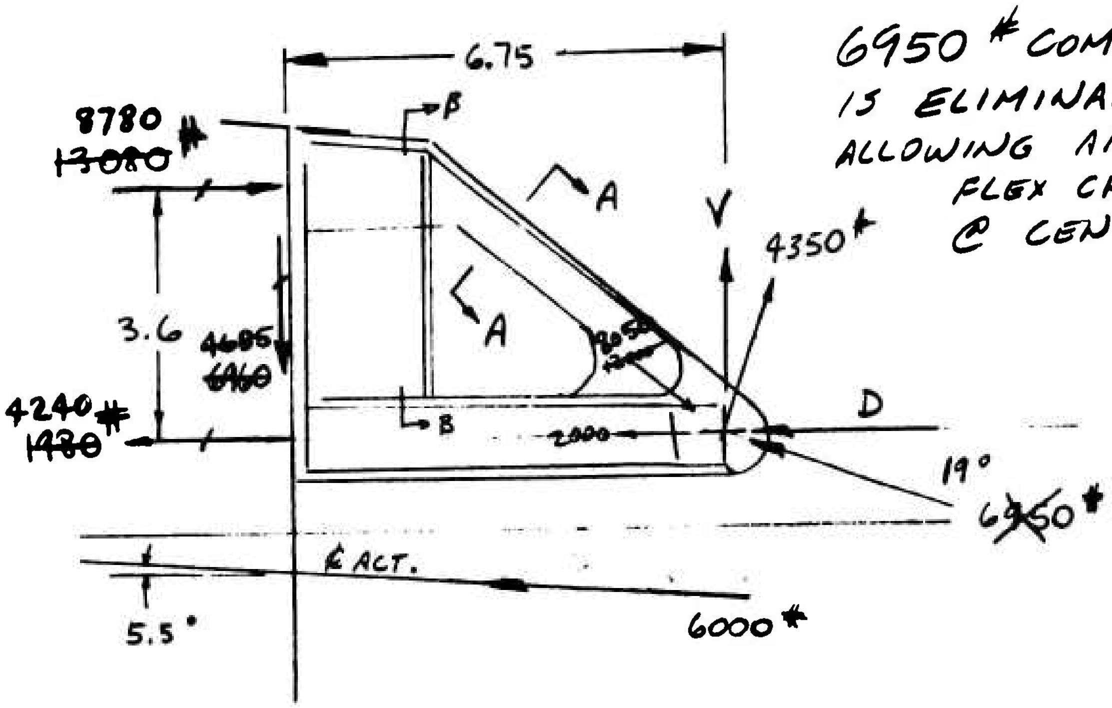
$$f_c = \frac{1664}{.2 \times .8} = 10400 \text{ psi}$$

$$L/\rho = 3/.0576 = 52$$

$F_c = 38000$ psi (EULER CURVE)

Lambert
1/11/63

AILERON CENTER HINGE WING FITTING



6950 # COMPONENT IS ELIMINATED BY ALLOWING AILERON TO FLEX CHORDWISE @ CENTER HG.

$$V = 4350 \overset{.945}{\cos} 19° + 695\cancel{0} \overset{.326}{\sin} 19° + 6000 \overset{.0958}{\sin} 5.5°$$

$$V = \overset{4685}{\cancel{6960}} \#$$

$$D = 695\cancel{0} \cos 19° - 4350 \sin 19° + 6000 \cos 5.5°$$

$$D = \overset{4540}{\cancel{11100}} \#$$

$$\overset{4685}{\cancel{6960}} \times \frac{6.75}{3.6} = \overset{8780}{\cancel{13080}} \#$$

$$\overset{8780}{\cancel{13080}} - \overset{4540}{\cancel{11100}} = \overset{4240}{\cancel{1980}} \#$$

LUG

$$\text{RES.} = \left(\overset{4685}{\cancel{6960}}{}^2 + \overset{4540}{\cancel{11100}}{}^2\right)^{1/2} = \overset{6530}{\cancel{13100}} \#$$

$$f_{br} = \frac{\overset{6530}{\cancel{13100}}}{2 \times .25 \times .5} = \overset{26100}{\cancel{52400}} \text{ psi}$$

$$R = .56 \qquad A = 2 \times 2 (.56 - .25) .25 = .31$$

$$f_s = \frac{\overset{6530}{\cancel{13100}}}{.31} = \overset{21100}{\cancel{42200}} \text{ psi}$$

M.S. AMPLE

Lambert
1/11/63

AILERON CENTER HINGE

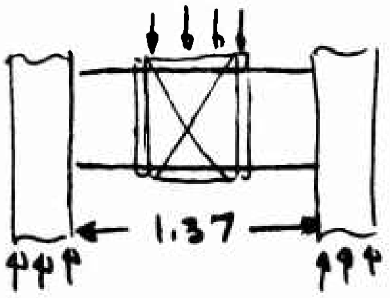
LUG

~~INCREASE t TO .31~~

~~$f_s = 42290 \times \frac{.25}{.31} = 34100$ psi~~

O.K.

BOLT BENDING :



.5 WIDE SPHERICAL BUSHING
.06 SPACERS
TAB BELLCRANK BEARINGS RESULT IN GAP

$$GAP = (1.37 - .5 - 2 \times .06).5 = .375$$

$$b = \frac{\overset{.25}{\cancel{.31}}}{2} + .375 + \frac{.5}{4} = .\overset{.625}{\cancel{655}}$$

$$B.M. = \frac{\overset{6530}{\cancel{13100}}}{2} \times .\overset{.625}{\cancel{655}} = \overset{2040}{\cancel{4300}}\text{"\#}$$

$\frac{1}{2}$ BOLT $I = .003069$

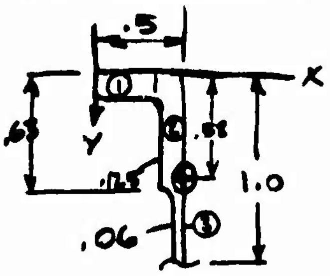
$$f_b = \frac{\overset{2040}{\cancel{4300}} \times .25}{.003069} = \overset{166000}{\cancel{350000}} \text{ psi}$$

USE $\overset{NAS}{\cancel{SPS}}$ $\overset{160000}{\cancel{220000}}$ psi H.T. BOLT

$$F_b = \overset{265000}{\cancel{360000}} \text{ psi}$$

$$M.S. = \frac{\overset{265000}{\cancel{360000}}}{\underset{166000}{\cancel{35000}}} - 1 = +\overset{.60}{\cancel{.03}}$$

SECT. A-A



	A	y	Ay	Ay²	I_{ox}	x	Ax	Ax²	I_{oy}
1	.0468	.0625	.00292	.00018	-	.1875	.00878	.00165	.00055
2	.0787	.315	.0248	.00781	.0026	.437	.0344	.01505	.0001
3	.0222	.815	.0181	.0147	.00025	.47	.0104	.0049	
Σ	.1477		.04582	.02269	.00285		.05358	.02160	.0065

Lambert
1/11/63

AILERON CENTER HINGE
WING FITTING

$\bar{y} = .04582/.1477 = .31$

$I_x = .02269 + .00285 - .1477 \times .31^2 = .01136$

$\bar{x} = .05358/.1477 = .364$

$I_y = .0216 + .00065 - .1477 \times .364^2 = .00273$

$P = 8050/2 = 4025\,\#$

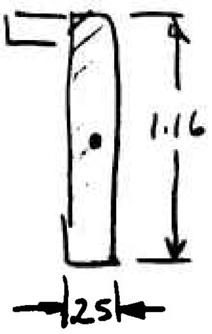
$M_x = 4025(.58 - .31) = 1088\ ''\#$

$M_y = 4025(.5 - .364) = 546\ ''\#$

$$f_c = -\frac{4025}{.1477} - \frac{1088 \times .69}{.01136} - \frac{546 \times .136}{.00273}$$

$$= -27300 - 66000 - 27200$$

REVISED SECTION



LOAD APPLIED @ CENTROID OF RECTANGULAR SECTION

$$f_c = \frac{4025}{1.16 \times .25} = -13900 \text{ psi}$$

M.S. AMPLE

Lambert
1/11/63

AILERON CENTER HINGE WING FITTING

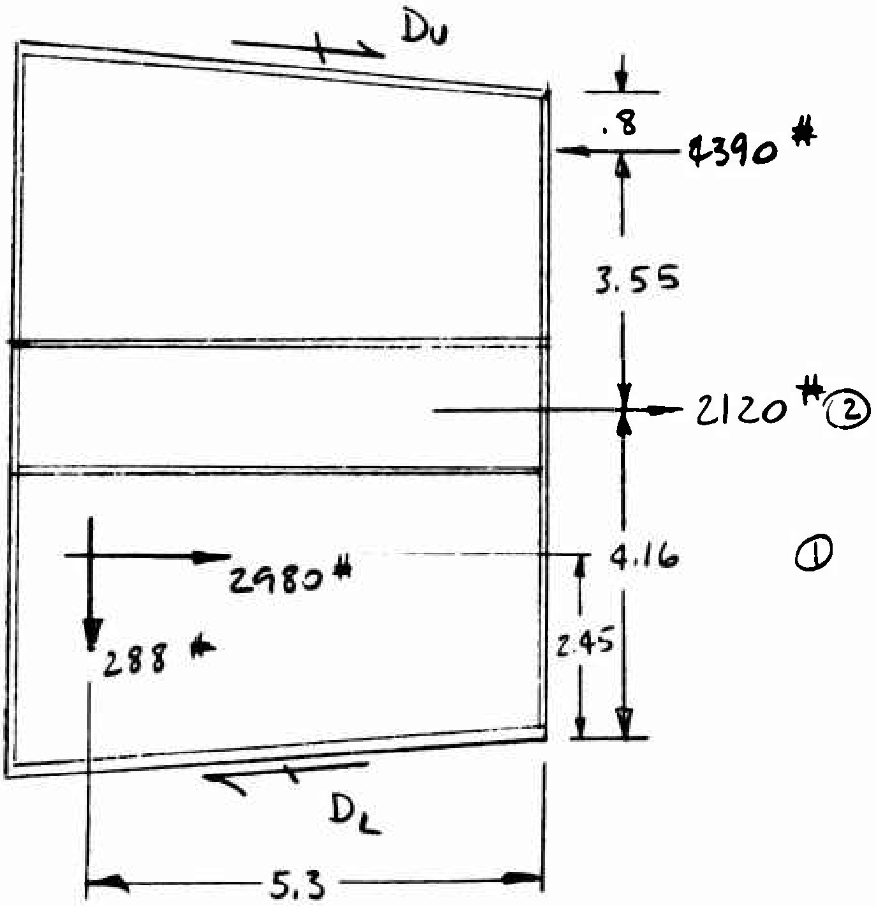
SECTION B-B

SHEAR = 4685#

$$f_s = \frac{4685}{3.3 \times .125} = 11350 \text{ psi}$$

M.S. AMPLE

FWD FITTING



$$8.45\, D_L = -4390 \times .8 + 2120 \times 4.35 + 2980 \times 6.06 + 288 \times 5.3$$

$$D_L = 3000\#$$

$$8.45\, D_U = 4390 \times 7.71 - 2120 \times 4.16 - 2980 \times 2.45 + 288 \times 5.3$$

$$D_U = 2270\#$$

Lambert
1/11/63

AILERON CENTER HINGE
WING FITTING

FWD. FITTING

MAX. SHEAR STRESS = $\frac{3000}{6.3 \times .06}$ = 7940 psi

M.S. AMPLE

B.M. @① = 3000 × 2.45 = 7350"#

B.M. @② = 3000 × 4.16 − 2980 × 1.71 = 7400"#

FLANGE LOAD = 7400/6.2 = 1200 #

FLG. STRESS = $\frac{1200}{1.1 \times .09}$ = 12100 psi

M.S. AMPLE

END PADS

MAX. TENS. ON LOWER BOLT REACTED BY FULL BATHTUB TYPE TENSION TIE.

.20 PAD O.K. BY INSPECTION

ACTUATOR ATTACH. BOSS

ECC = 1.5

M = 1.5 × $\frac{6000}{2}$ = 4500"#

REACTED BY 2 LONGITUDNAL RIBS

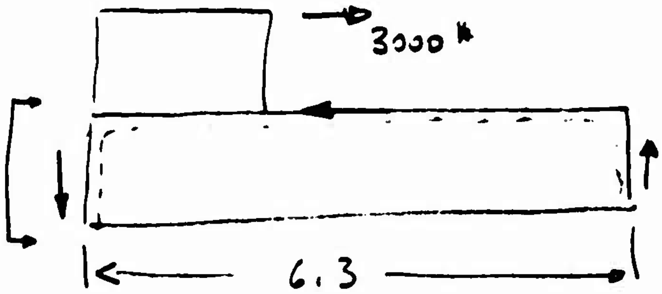
$f_b = \frac{6 \times 4500}{2 \times .09 \times 1.1^2}$ = 124000

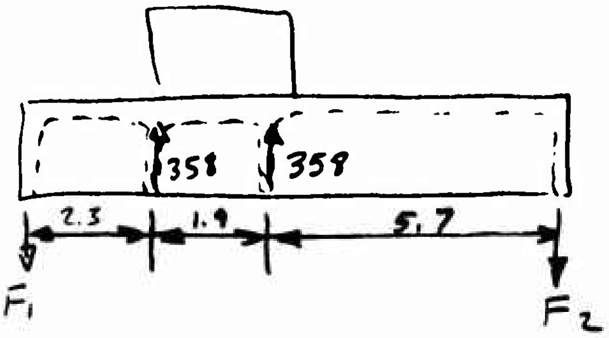
Use .15 t

$f_b = \frac{6 \times 4500}{2 \times .15 \times 1.1^2}$ = 74000 psi

1/11/63

AILERON CENTER HINGE
WING FITTING





$$\text{COUPLE} = \frac{4500}{6.3} = 715^{\#}$$

$$9.9 F_2 = 358 (2.3 + 4.2) =$$

$F_2 = 234\ \#$ $\qquad$ $M = 5.7 \times 234 = 1330\ ''\#$

$F_1 = 715 - 234 = 481\ \#$ $\qquad$ $M = 2.3 \times 481 = 1110$

$$f_b = \frac{6 \times 1330}{.09 \times 1.1^2} = 73000 \text{ psi}$$

O.K.

-7 Boss

ECC. = 1.0

USE .10 THICK LONGITUDNAL STIFF.

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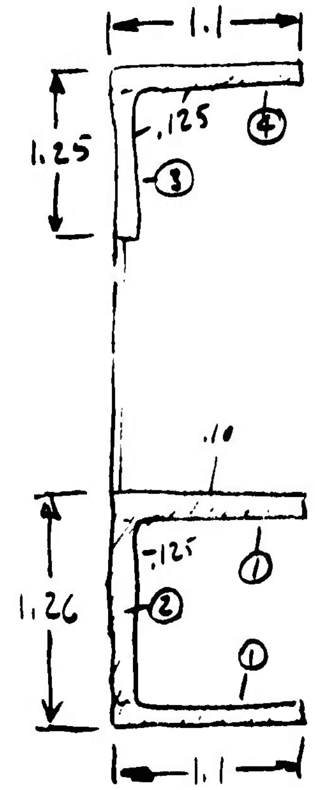
1/12/63

AILERON CENTER HINGE WING FITTING

CHECK FOR SIDE LOAD

600# DUE TO 25 g ACCELERATION

$M = 6.7 \times \frac{600}{2} = 2010$ "#



ELE	A	x	Ax	Ax^2	I_o
1	.22	.55	.121	.0666	.0222
2	.1325	.0625	.0083	-	-
3	.1408	.0625	.0088	-	-
4	.1373	.55	.0756	.0416	.0138
Σ	.6306		.2137	.1082	.0360

$\bar{x} = .2137/.6306 = .338$

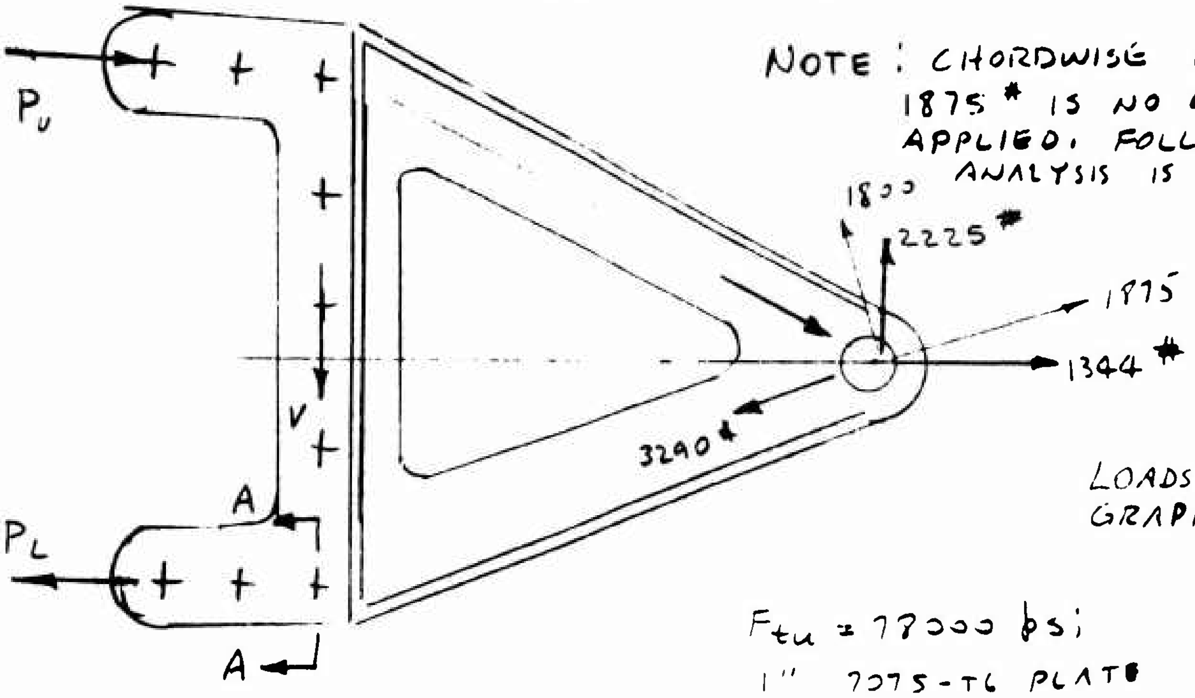
$I = .1082 + .036 - .6306 \times .338^2 = .0719$

$$f_b = \frac{2010 \times .762}{.0719} = 21300 \text{ psi}$$

O.K.

Lambert
1/11/63

AILERON OUTB'D HINGE WING FITTING



NOTE: CHORDWISE LOAD OF 1875# IS NO LONGER APPLIED. FOLLOWING ANALYSIS IS CONSERVATIVE

LOADS BY GRAPHICS

$F_{tu} = 78000$ psi
1" 7075-T6 PLATE

$$P_U = \frac{1}{4.2}(-1344 \times 1.9 + 2225 \times 5) = 2040\#$$

$$P_L = \frac{1}{4.22}(1344 \times 2.35 + 2225 \times 5) = 3390\#$$

LUG $R = .50$ $D = .656$ $t = .31$

$$RES = (2225^2 + 1344^2)^{1/2} = 2600\#$$

$$f_{br} = \frac{2600}{.656 \times .31} = 12800 \text{ psi}$$

$$f_s = \frac{2600}{2 \times .31 \times .172} = 24400 \text{ psi}$$

O.K.

BOLT BENDING

$$b = \frac{.31}{4} + .2 + \frac{.125}{2} = .34$$

$$B.M. = \frac{2600}{2} \times .34 = 442 \text{ "}\#$$

$$I = .0001918$$

$$f_b = \frac{442 \times .125}{.0001918} = 288000 \text{ psi}$$

Lambert
1/11/63

AILERON OUTB'D HINGE WING FITTING

USE 180000 psi H.T. BOLT

$F_b = 303000$ psi

$M.S. = \frac{303000}{288000} - 1 = +.05$

SECT A-A

.18 × 1 (.812 NET)

$f_t = \frac{3390}{.18 \times .812} = 23200$ psi $R_t = \frac{23200}{78000} = .298$

$M = 3390 \times \frac{.18}{2} = 305$ "#

$f_b = \frac{6 \times 305}{.812 \times .18^2} = 69500$

$F_b = 1.5 \times 78000 = 117000$ $R_b = \frac{69500}{117000} = .594$

$\underline{}$
.892

$M.S. = \frac{1}{.892} - 1 = \underline{+.12}$

ATTACHM'T RIVETS

3 C×6

ALLOW. = 3 × 1180 = 3540#

$M.S. = \frac{3540}{3390} - 1 = \underline{+.04}$

IV. WING FAN DOORS

SUMMARY

The wing fan closure doors consist of two pairs of semi-circular honeycomb-fiberglas panels, each hinged to a chordwise wing fan strut at B. L. ±61. In the closed position these doors are latched to a spanwise wing fan strut and act as a part of the upper surface of the wing in sustaining aerodynamic pressure. There are two hydraulic actuators per door (eight per A/C), which open and close the doors for transition flight. These actuators operate under two separate hydraulic systems; One powering the inboard forward and outboard aft actuators while the other; the inboard aft and outboard forward actuators.

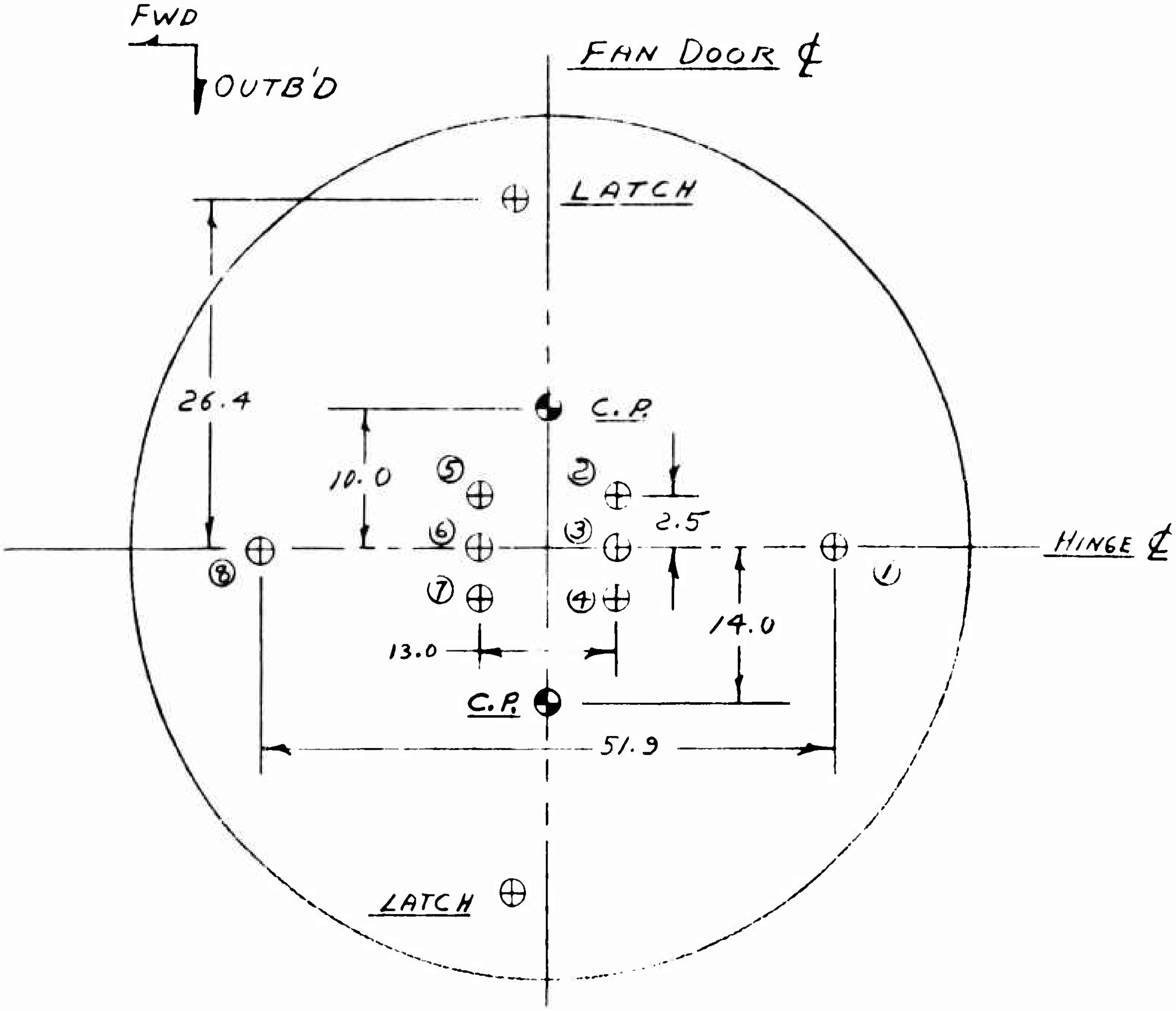
The analysis which follows is primarily a summary of the final critical flight loads on the doors, with calculated distributions and reaction values. In the design phase,the doors were analyzed for preliminary (actually higher) loads, and a series of structural development tests were conducted with these values to prove the concept and sizes. The door and hinge fittings sustained these loads; however for the condition simulating 4 g door-closed flight,the deflection at the leading edge was considered excessive and the door was subsequently structurally stiffened to provide the required stiffness. The production design has a stiffness equal to or greater than that of the development door.

The primary problem that remained was the distribution of door loads (reactions) to the G. E. "Record Player" (Dwg. 4012001-2) and the distribution to the fore-and-aft outrigger locations on the fan strut, since the record player was limited by G. E. to small normal loads and the fan strut to small side load.

Both door-open and door-closed structural proof tests were conducted on the production doors for the critical conditions shown, which involved the three possibilities of hydraulic power in function. The pressure distributions are shown in Report Number 126, Structural Proof Test Program. In addition to the tests called for in the report, one other was conducted to simulate door-open fan mode flight with maximum twist moments on the doors, producing maximum outrigger lateral reactions. Pressure distributions for this condition are shown on pages 70-74.

No permanent set or objectionable deformation was encountered in the proof tests. Reactions normal to the "Record Player" and lateral reactions at the outrigger locations were also found to be within the limits specified by General Electric.

DOOR CLOSED & LATCHED
HIGH SPEED
GENERAL LOAD CONFIGURATION



① = AFT OUTRIGGER ARMS
② = AFT INBOARD ACTUATOR
③ = AFT ACTUATOR ARMS
④ = AFT OUTBOARD ACTUATOR
⑤ = FWD INBOARD ACTUATOR
⑥ = FWD ACTUATOR ARMS
⑦ = FWD OUTBOARD ACTUATOR
⑧ = FWD OUTRIGGER ARMS

LATCH AND ARM REACTIONS

DOOR CLOSED HIGH SPEED

COND. = REACTIONS DUE TO AIR LOAD

LOAD @ C.P. ACTING UP — OUTB'D DOOR = 2930# LIMIT

INB'D DOOR = 2070# LIMIT

OUTB'D DOOR

$P = 4400^{\#}$ ULT. ↑

$$LATCH = \frac{(4400)(14.0)}{26.4} = \underline{2330}^{\#} \downarrow$$

LOAD TO BE REACTED AT HINGE ℄

$R = 4400 - 2330 = 2070^{\#}$

ASSUME 70% OF 2070# LOAD REACTED BY ACTUATOR ARMS 30% BY OUTRIGGERS.

$R_3 = (.7)(2070)/2 = 725^{\#}$

$R_6 = R_3 = \underline{725}^{\#} \downarrow$

$R_1 = R_8 = \underline{310}^{\#} \downarrow$

INB'D DOOR

$P = 3105^{\#}$ ULT ↑

$$LATCH = \frac{(3105)(14.0)}{26.4} = 1650^{\#} \downarrow$$

HINGE ℄ REACTIONS = 3105 - 1650 = 1455#

$R_3 = R_6 = (.7)(1455)/2 = 510^{\#} \downarrow$

$R_1 = R_8 = 218^{\#} \downarrow$

TOTAL HINGE REACTIONS (INB'D + OUTB'D DOOR)

$R_3 = R_6 = 510 + 725 = \underline{1235}^{\#}$ ULT ↓ ←

$R_1 = R_8 = 218 + 310 = \underline{528}^{\#}$ ULT ↓ ←

COND. = REACTIONS DUE TO LOAD FROM
4 ACTUATORS AT FULL POWER
0 AIR LOAD

$P_{ACTUATOR} = 6000^{\#}$ LIMIT

$P_A = 9000^{\#}$ ULT ACTING DOWN

ALL THE LOAD WILL BE REACTED BY LATCH, FORE AND AFT ACTUATOR ARMS

LATCH REACTION

$$R = 2\left[\frac{(9000)(2.5)}{26.4}\right] = 1700^{\#}/\text{LATCH} \updownarrow \quad \text{ULT.}$$

TOTAL ACTUATOR ARM REACTION

$$R_3 = R_6 = \underset{\text{ULT.}}{16300^{\#}} \updownarrow \quad \text{(BOTH DOORS)}$$

COND. = REACTIONS DUE TO LOAD FROM
2 ACTUATORS AT FULL POWER
0 AIR LOAD (ALTERNATE ACTUATORS ACTING)

$P_A = 9000^{\#}$ ULT ACTING DOWN

LATCH REACTION

$$R = \frac{(9000)(2.5)}{26.4} = \underset{\text{ULT.}}{850^{\#}}/\text{LATCH} \updownarrow$$

TOTAL ACTUATOR ARM REACTION

$$R_3 = R_6 = 9000 - 850 = 8150^{\#} \updownarrow \quad \text{ULT} \quad \text{(BOTH DOORS)}$$

LATCH AND HINGE REACTIONS
DOOR CLOSED

COND 3 = COND. 1 + COND 2
COND 5 = COND. 1 + COND 4

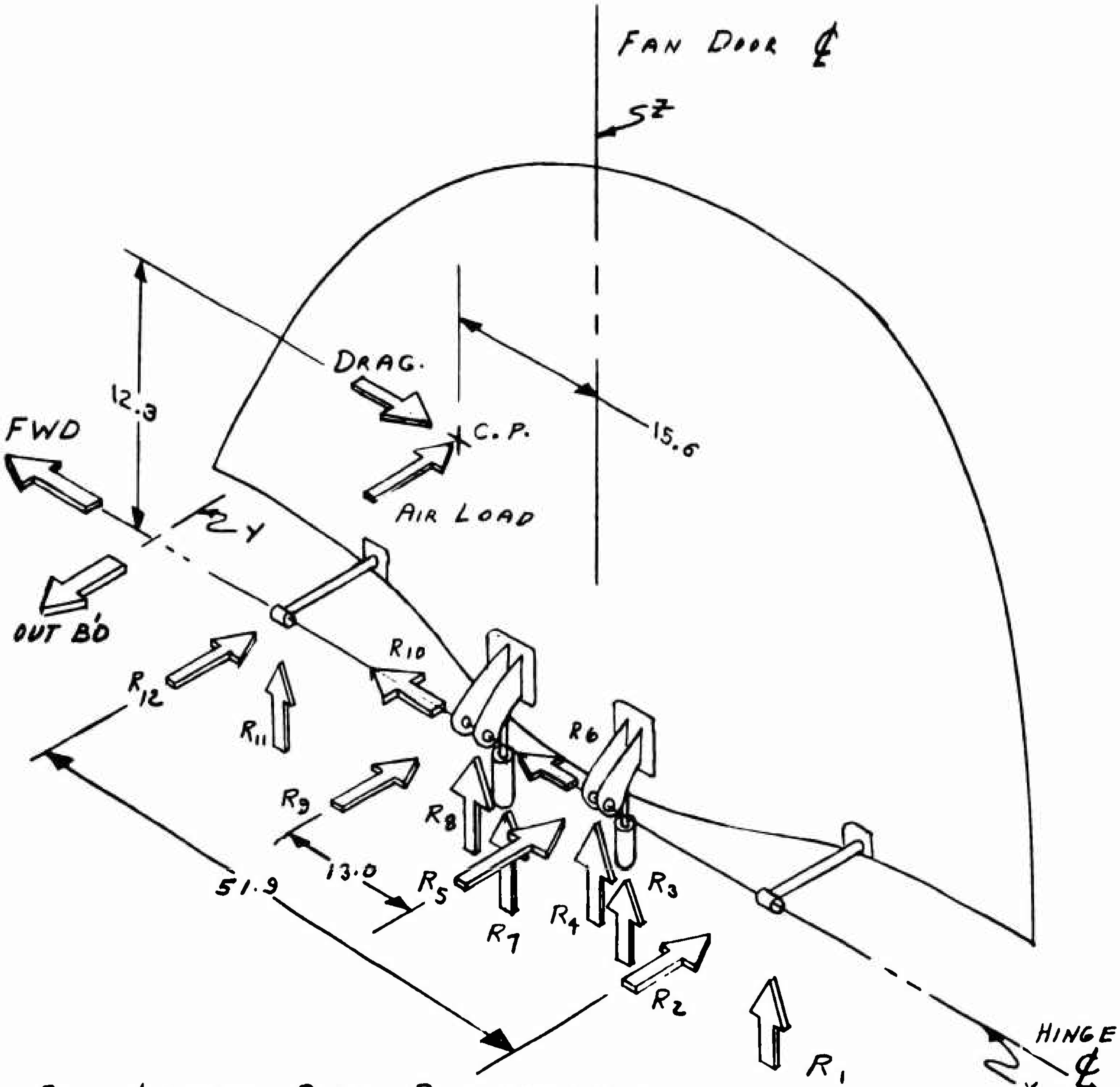
ALL LOADS ULT

	LOADING		REACTIONS					
COND	AIR LOAD	ACT. LOAD	LATCH	R_1	R_3	R_C	R_B	
1	4400	0	-2330	-528	-1235	-1235	-528	OUTB'D
	3105	0	-1650					INB'D
2	0	-9000/ACT	1700	0	16300	16300	0	4 ACTUATORS
3	4400	-9000/ACT	-630	-528	15065	15065	-528	OUTB'D
	3150		50					INB'D
4	0	-9000/ACT	850	0	8150	8150	0	ALTERNATE ACTUATORS
5	4400	-9000/ACT	-1480	-524	6915	6915	-528	OUTB'D
	3150		-800					INB'D

R_1 R_3 R_6 & R_8 ARE NET REACTIONS FROM BOTH DOORS

DOORS OPEN   INB'D DOOR

TRANSITION SPEED



ALL LOADS AND REACTIONS + AS SHOWN

LOADS ON OUTB'D DOOR EQUAL IN MAGNITUDE AND DIRECTION AS INB'D DOOR
C.P. 2.5 IN. INB'D OF HINGE ℄

DOOR OPEN LOADS AND REACTIONS

P_A = AIR LOAD = 800# / DOOR
P_D = DRAG LOAD = 150# / DOOR } LIMIT

P_A = 1200# / DOOR ULT

P_D = 225# / DOOR ULT

M_X = 1200 × 12.3 = 15000 IN# / DOOR ULT

M_Y = 225 × 12.3 = 2770 IN# / DOOR ULT

M_Z = 1200 × 15.6 + 225 × 2.5 = 19300 IN# / DOOR ULT

ASSUME OUTRIGGERS REACT M_Y & M_Z MOMENT.

OUTRIGGER REACTIONS / DOOR

$$R_Z = \frac{M_Y}{51.9} = \frac{2770}{51.9} = \pm 53^{\#} / ARM$$

$$R_Y = \frac{M_Z}{51.9} = \frac{19300}{51.9} = \pm 372^{\#} / ARM$$

ACTUATOR REACTIONS / DOOR

$$R_Z = \frac{M_X}{2.5} = \frac{15000}{2.5} = \pm 6000^{\#} / ACT.^{*}$$

* FOR 2 ACTUATORS OUT

$$R_Z = \frac{15000}{2(2.5)} = \pm 3000^{\#} / ACT. \quad 4\ ACTUATORS$$

HINGE PIN REACTIONS / DOOR

LET HINGE PINS REACT ALL P_A

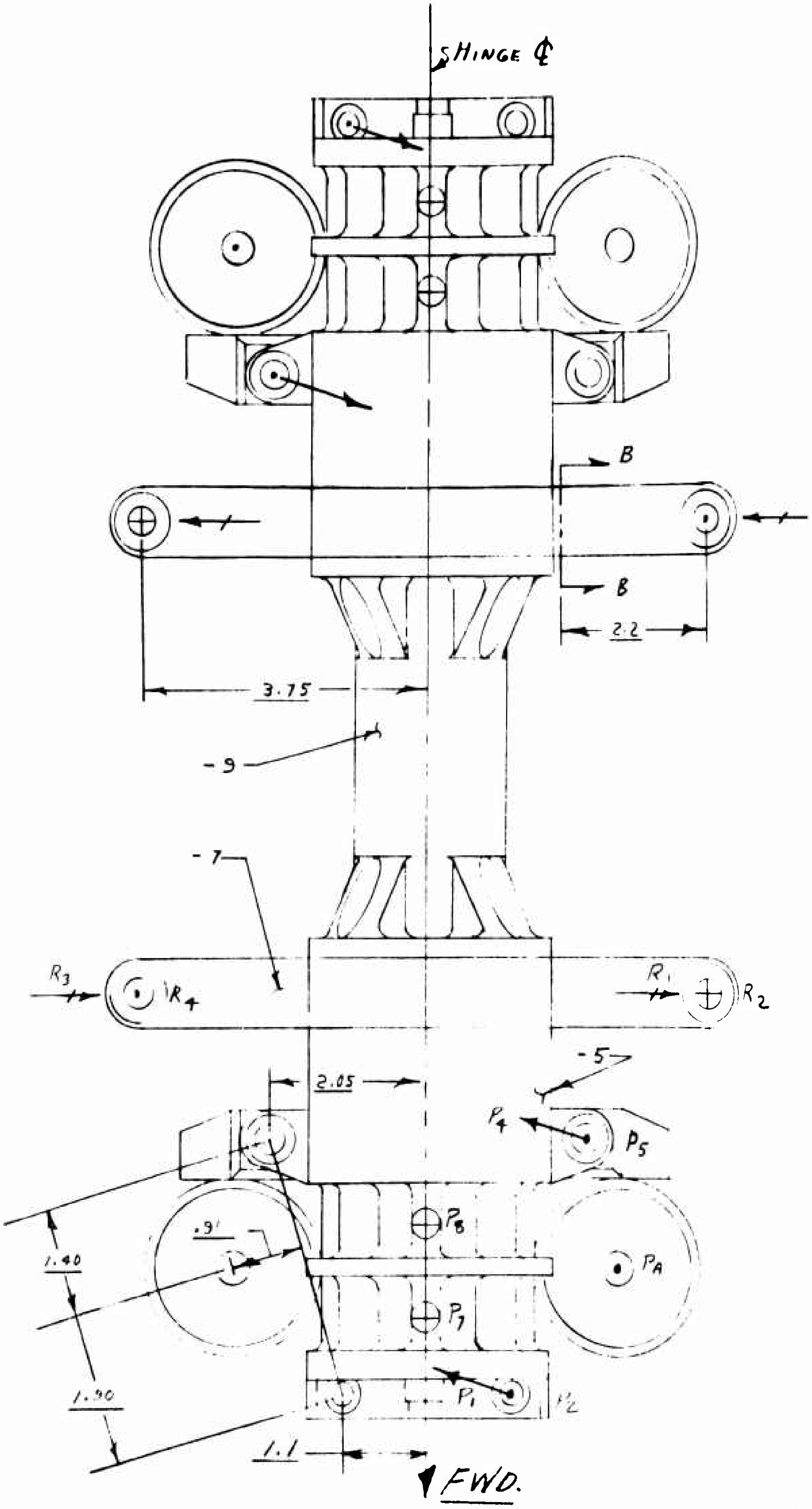
$$R_Y = -\frac{1200}{2} = -600^{\#} / PIN$$

DOOR OPEN LOADS & REACTIONS

NET FAN DOOR REACTIONS

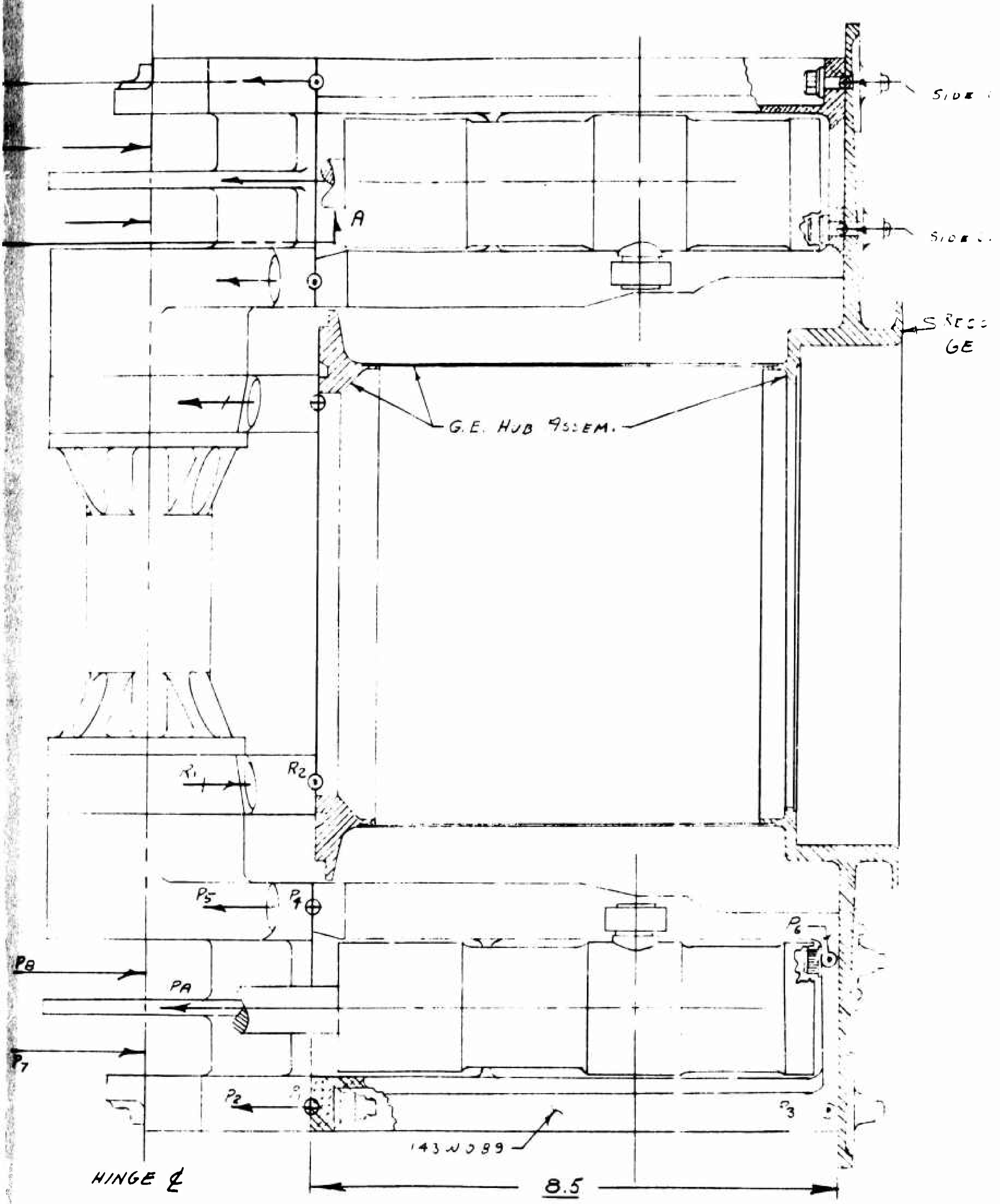
ALL LOADS & REACTIONS ULT

		COND 6	COND 7	
AIR LOAD	P_A	2400	2400	
	P_D	450	450	
ACTUATOR & HINGE REACTIONS	R_1	106	106	
	R_2	744	744	
	R_3	0	3000	INB'D ACTUATOR
	R_3	-6000	-3000	OUTB'D ACTUATOR
	R_4	6000	0	
	R_5	-1200	-1200	
	R_6	225	225	
	R_7	6000	3000	INB'D ACTUATOR
	R_7	0	-3000	OUTB'D ACTUATOR
	R_8	-6000	0	
	R_9	-1200	-1200	
	R_{10}	225	225	
	R_{11}	-106	-106	
	R_{12}	-744	-744	


HINGE ℄
B
B
2.2
3.75
-9
-7
R3
R4
R1
R2
-5
2.05
P4
P5
P8
.91
1.40
PA
P7
1.90
P1
P2
1.1
FWD.

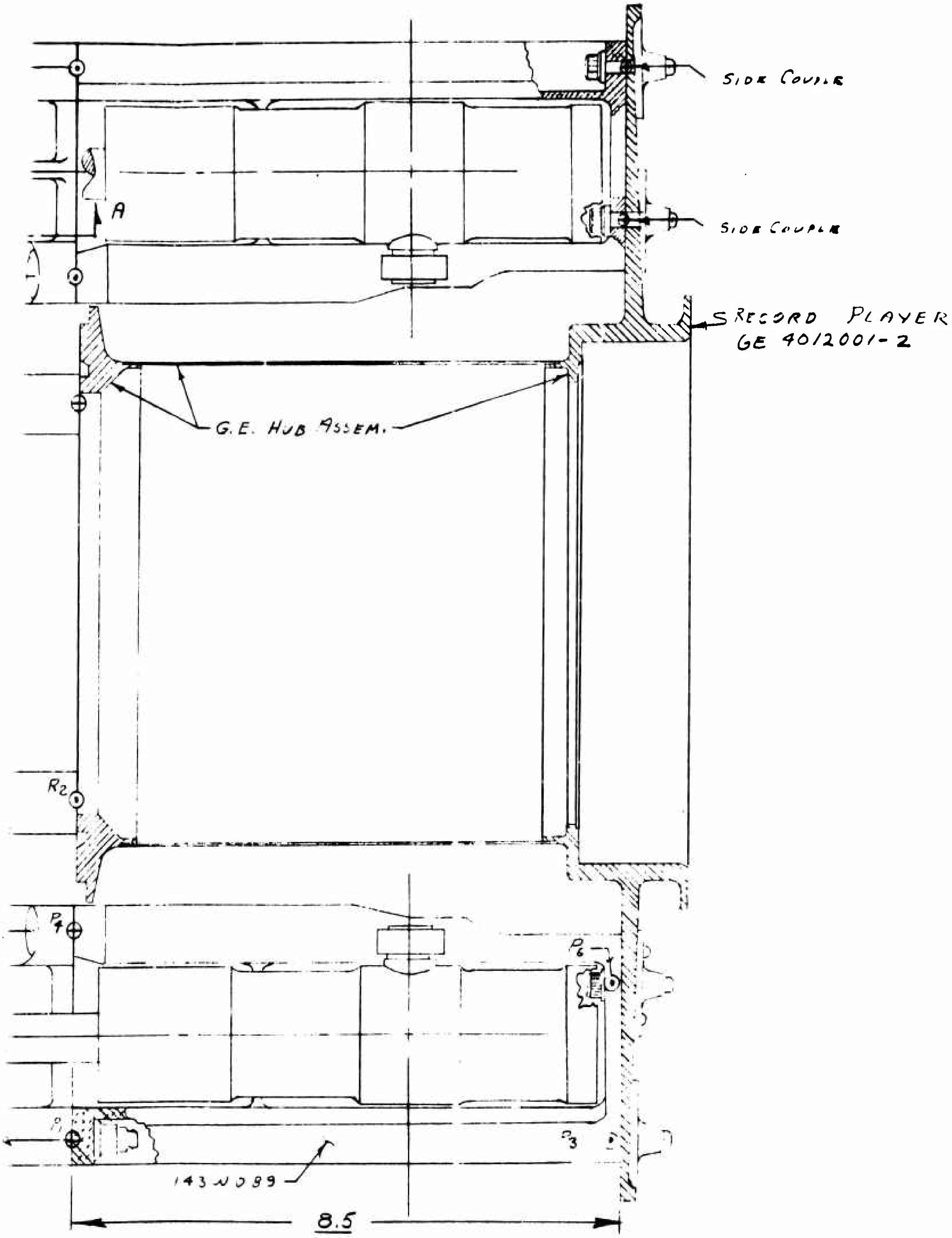

2.6
1.67
A
P8
P7

A



143W042 FAN SUPPORT STRUCT. & 143W089 ACTUAT

B



143W042 FAN SUPPORT STRUCT. & 143W089 ACTUATOR FTG.

C

LOADS & REACTIONS FAN SUPPORT STRUCTURE

COND. 5 CRITICAL

$P_A = 6000^{\#}$ LIMIT $= 9000^{\#}$ ULT

$P_1 = P_3 = P_4 = P_6 = \frac{(9000)(.91)}{2.(8.5)} = 480^{\#}$ COUPLED OUT BETWEEN RECORD PLAYER & HINGE FTG.

$P_2 = \frac{(9000)(1.4)}{3.3} = 3820^{\#}$

$P_5 = \frac{(9000)(1.9)}{3.3} = 5180^{\#}$

P_7 & P_8 = AIR LOAD DISTRIBUTED 50% ON EACH HINGE + ACTUATOR LOAD DISTRIBUTED 2/3 P_7, 1/3 P_8

$P_7 = (8150)(2)/3 - (1235)(.5) = 4820^{\#}$

$P_8 = (2717) - (620) = 2100^{\#}$

$R_1 = R_3 \doteq 480^{\#}$

$R_2 = \frac{(3820)(1.1) + (5180)(2.05)}{7.5} + (.5)(9000 - 6920)$

$R_2 = 1976 + 1040 = 3016^{\#}$

$R_4 = 1976 - 1040 = 936^{\#}$

AFT LOADS & REACTIONS ARE EQUAL TO THESE ABOVE.

ALL LOADS & REACTIONS + AS SHOWN ON PAGE 53.

SECTION A-A

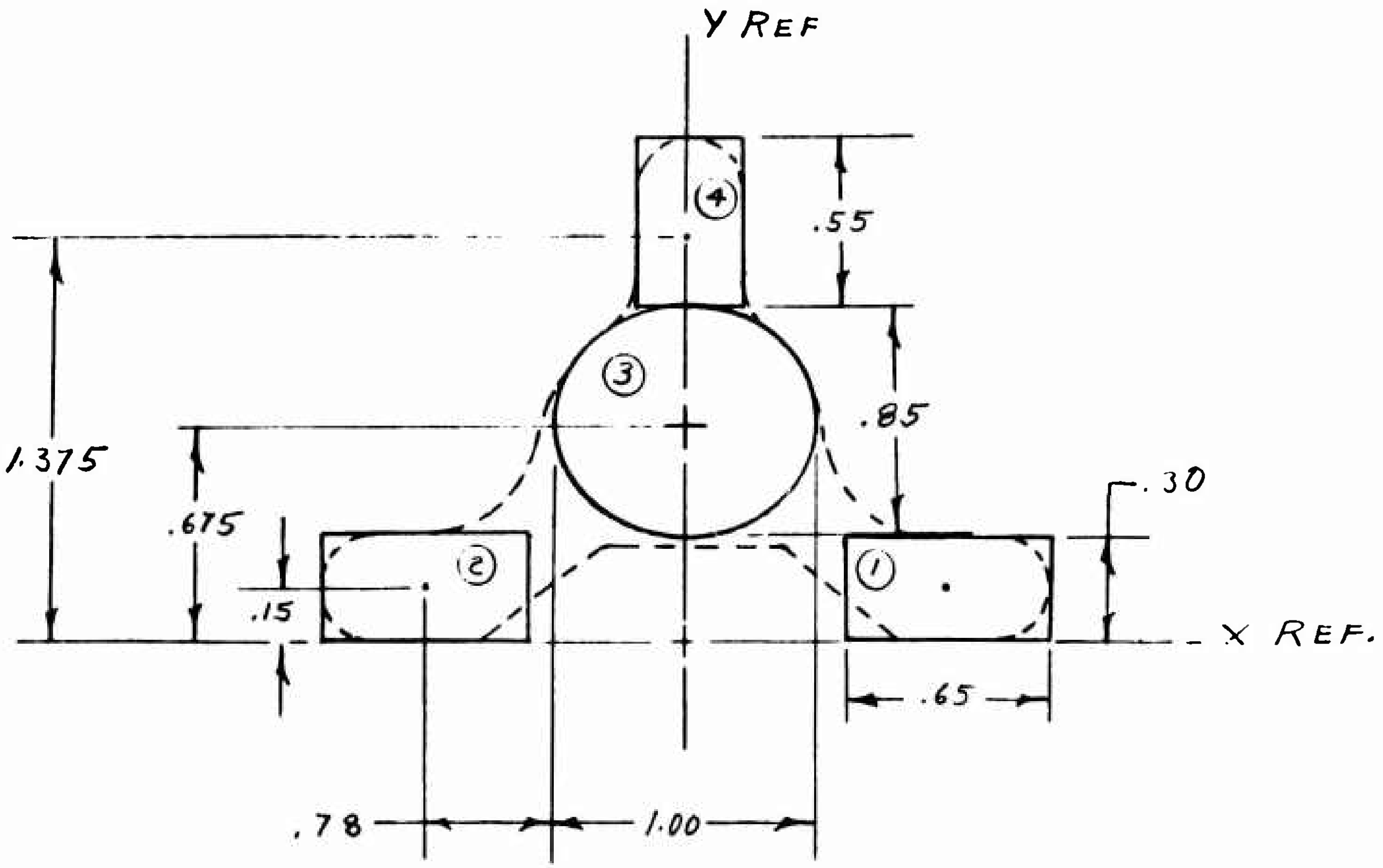
COND 5 CRITICAL

SECTION A-A OF 143W042-5

MATL. STEEL 4340 H.T. 150000 P.S.I. MIN.

TEMP 250°F   Ftu @ TEMP 90%

SECTION PROP. A-A



—— ASSUMED EFFEC. AREA

- - - SECTION A-A OUTLINE

SECTION AA

COND. 5 CRITICAL SECTION PROP.

X - X

ITEM	A	Y	AY	AY^2	I_o
1 & 2	.39	.15	.0585	.0088	.0029
3	.67	.675	.4522	.3053	.0301
4	.21	1.375	.2888	.3970	.0052
Σ	1.27		.7995	.7111	.0382

$$\bar{Y} = \frac{.7995}{1.27} = .63 \text{ IN}$$

$$\bar{I}_{xx} = .7111 + .0382 - (.63)(.7995) = \underline{.246 \text{ IN}^4}$$

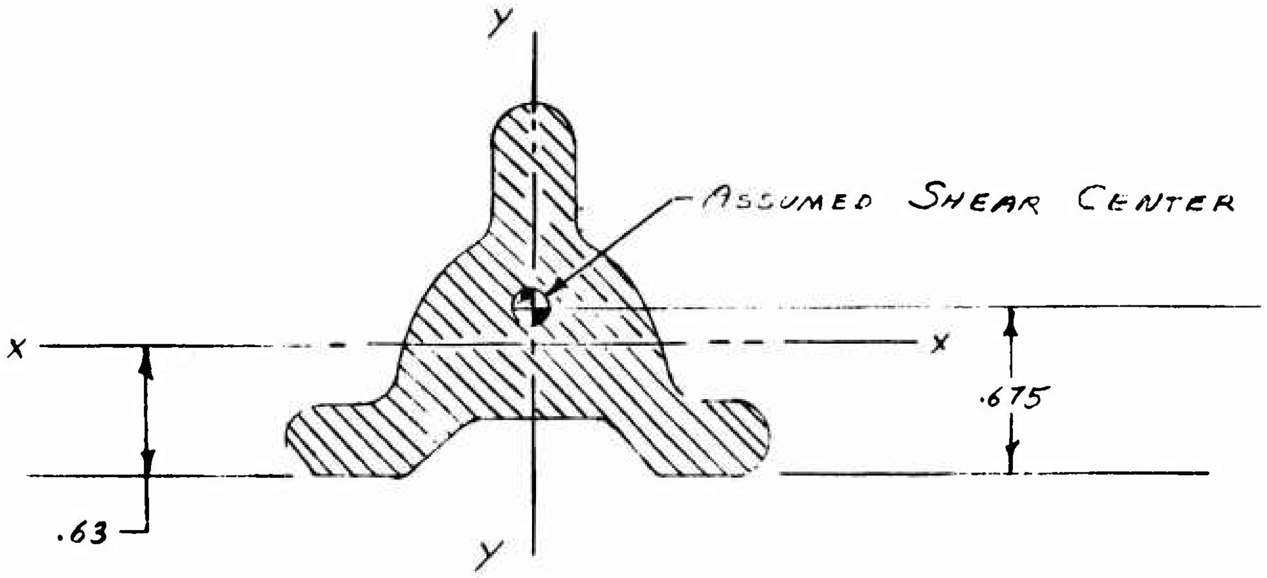
Y - Y

ITEM	A	Y	AY	AY^2	I_o
1	.195	.775	-	.117	.0069
2	.195	-.775	-	.117	.0069
3	.67	-	-	-	.0420
4	.21		-		.0024
Σ				.234	.0582

$$\bar{I}_{YY} = .234 + .0582 = \underline{.292 \text{ IN}^4}$$

SECTION AA

COND. 5 CRITICAL



LOADS REACTED BY SECTION A-A

$P_1 = 480^{\#}$

$P_2 = 3820^{\#}$

$P_7 = 4820^{\#}$

TORQUE $= (3820)(1.1) - (480)(.675) = 3878$ IN$^{\#}$

$M_{xx} = (3820)(2.6) - (4820)(1.67) = 1880$ IN$^{\#}$

$M_{yy} = (480)(2.6) = 1250$ IN$^{\#}$

VERT. SHEAR $= 1000^{\#}$

SIDE SHEAR $= 480^{\#}$

NET SHEAR $= 1000 \;+\!\!\!\rightarrow\; 480 = 1110^{\#}$

TORSIONAL SHEAR

$f_{s_t} = \frac{(2)T}{\pi a b^2}$ & FOR INSCRIBED ELLIPSE $= \frac{(2)(3878)}{3.14(.5)(.425)^2}$

$f_{s_t} = \frac{7756}{.284} = 27300$ PSI

SHEAR

$f_s = \frac{1110}{1.27} = 870$ PSI

SECTION AA

COND. 5 CRITICAL

$F_{SU} = 85500$ PSI $\qquad f_s = 27300 + 870 = 28170$ PSI

$$R_{St} = \frac{28.2}{85.5} = .33$$

BENDING

$$f_{b_{X\text{-}X}} = \frac{(1880)(1.07)}{.246} = 8200 \text{ PSI}$$

$$f_{b_{Y\cdot Y}} = \frac{(1250)(1.1)}{.292} = 4700 \text{ PSI}$$

$$f_b = 8200 \; +\!\!\!\rightarrow \; 4700 = 9500 \text{ PSI}$$

$$F_B = 135000 \text{ PSI}$$

$$R_b = \frac{9.5}{135} = .07$$

$$^{*}M.S. = \frac{1}{\sqrt{.33^2 + .07^2}} - 1 = \underline{1.96} \longleftarrow$$

THIS MARGIN HIGH TO INSURE THAT NO VERTICAL LOAD WILL BE REACTED BY THE "RECORD PLAYER" G.E. 4012001-2.

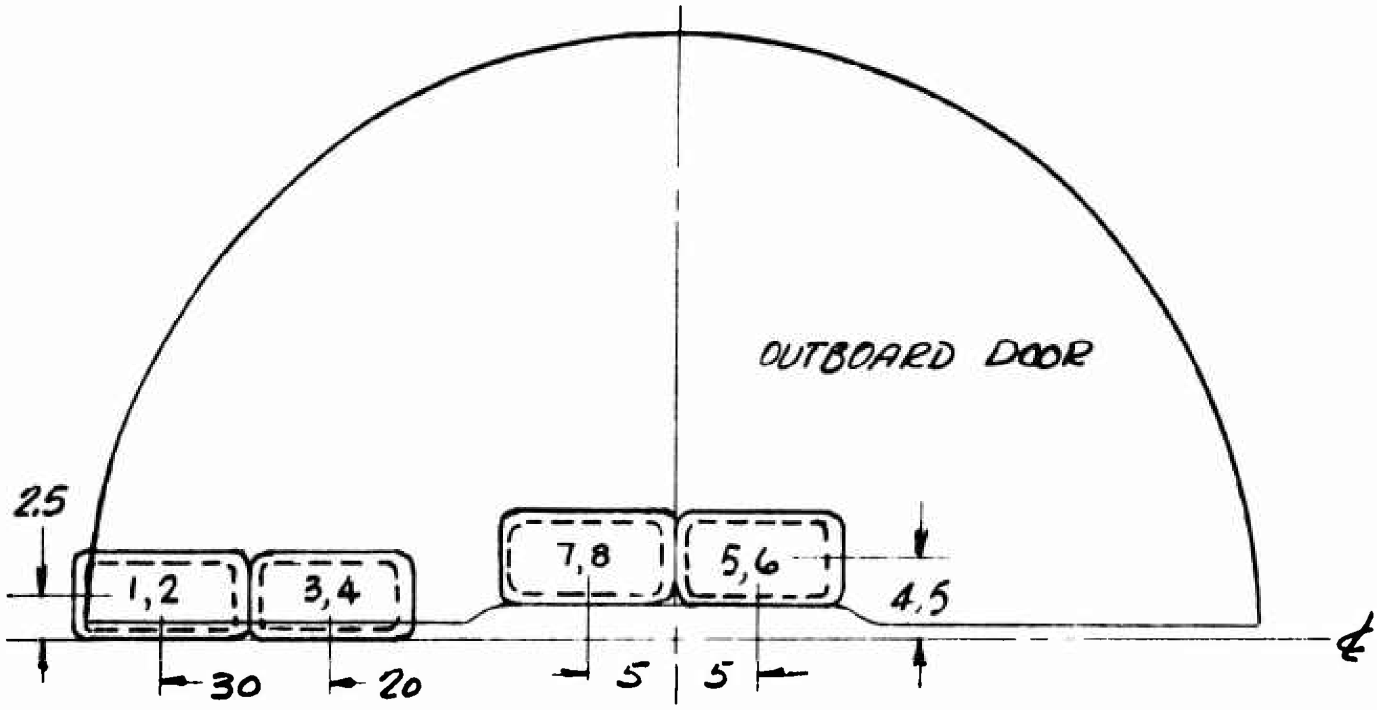
LOADS FOR DOOR-OPEN FLIGHT FOR MAXIMUM TWISTING MOMENT

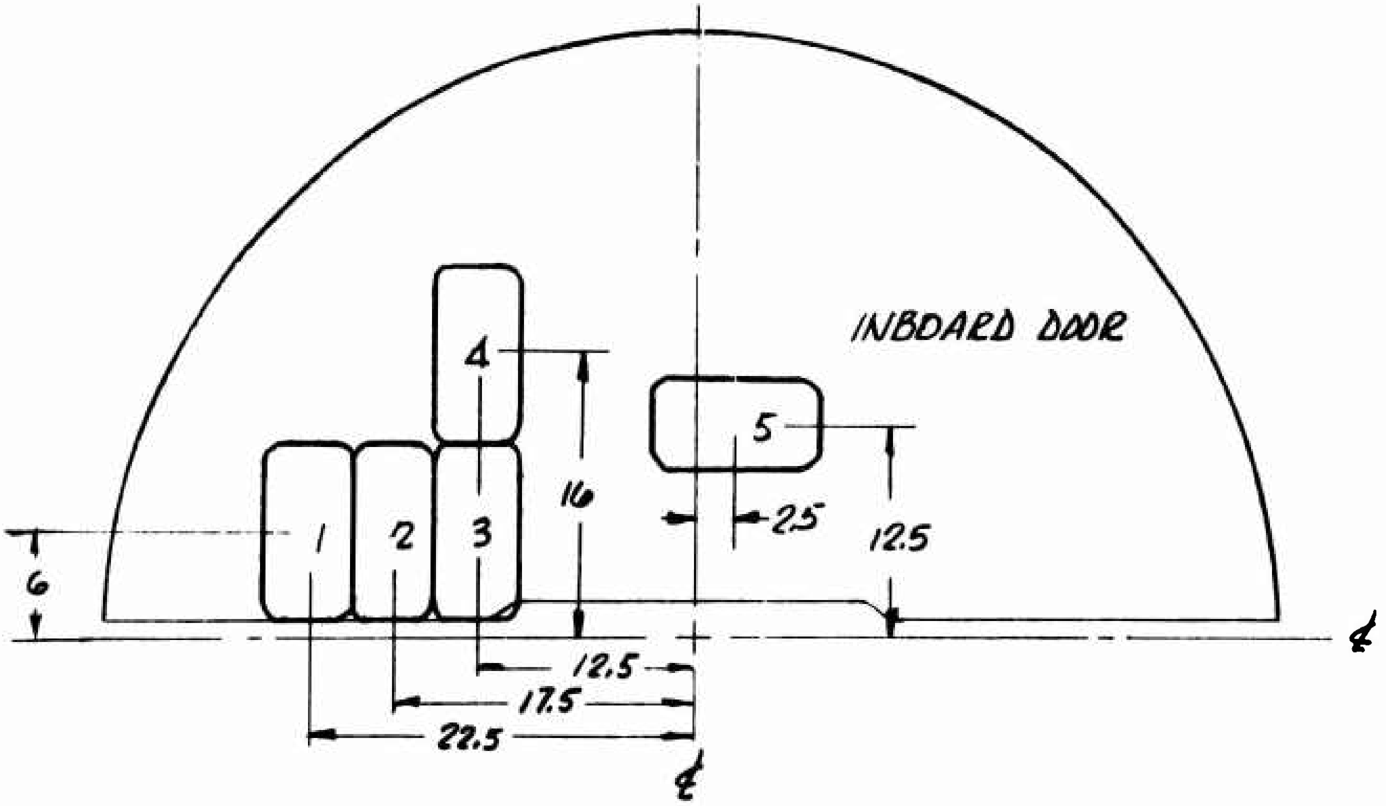
IN THE FINAL DETERMINATION OF FAN DOOR LOADS IT WAS FOUND THAT THE DOOR-OPEN YAW LEFT CONDITION WAS CRITICAL INSOFAR AS DOOR TWISTING MOMENTS ARE CONCERNED. THIS CONDITION WAS THEN ADDED TO THOSE FOR THE PROOF TEST PROGRAM (REPT. 63B048), AND A TEST LOADING SCHEDULE UTILIZING $25^{\#}$ SHOT BAGS IS SHOWN ON THE FOLLOWING PAGES.

THE LIMIT LOADS AND MOMENTS FOR THIS CONDITION ARE AS FOLLOWS:

	OUTBOARD DOOR	INBOARD DOOR
HINGE MOMENT, "#	-5500 (CLOSING)	+7000 (OPENING)
TWISTING MOMENT, "#	12,500 L.E. OUTB'D.	10,000 L.E. OUTB'D.
SIDE FORCE, #	-800 TOWARD OUTB'D. TIP	+500 TOWARD OUTB'D. TIP

TEST #25

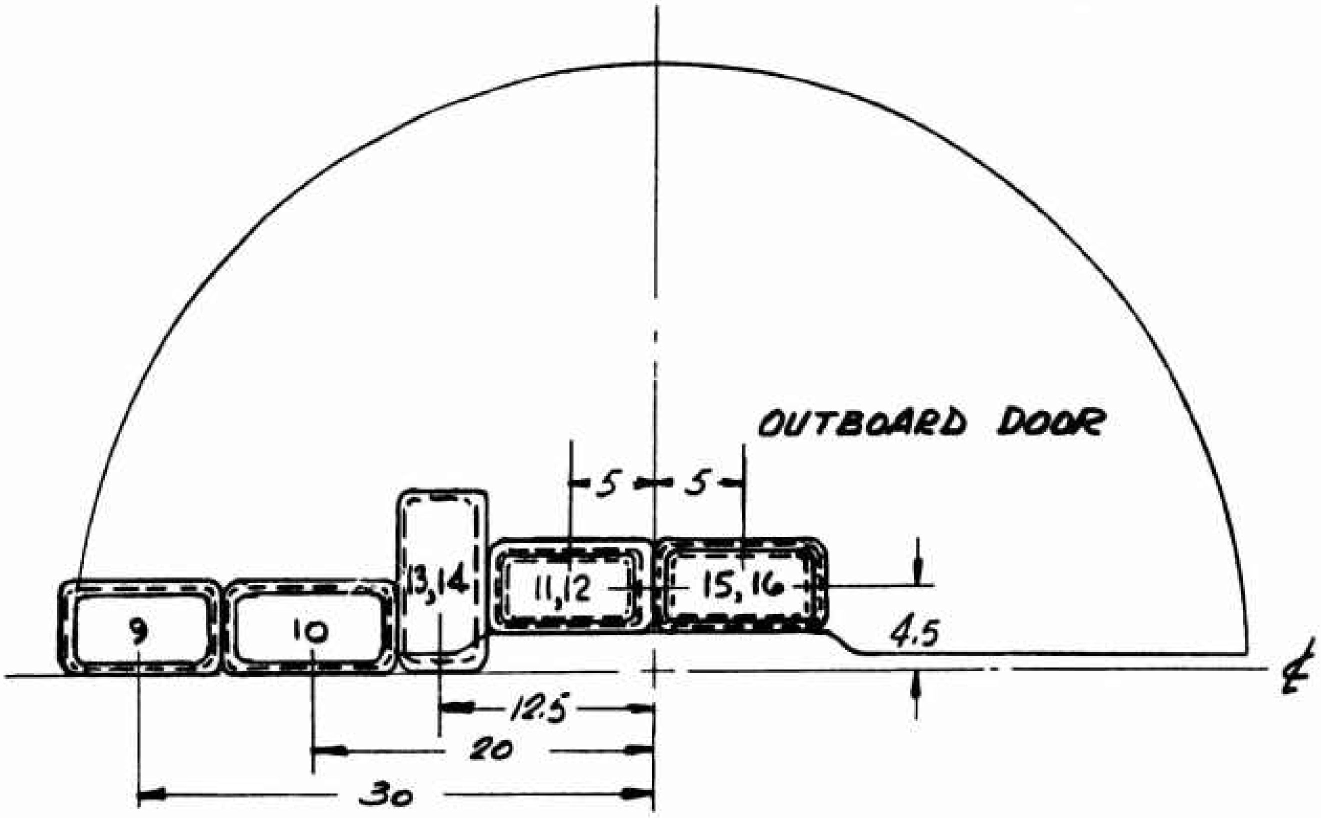




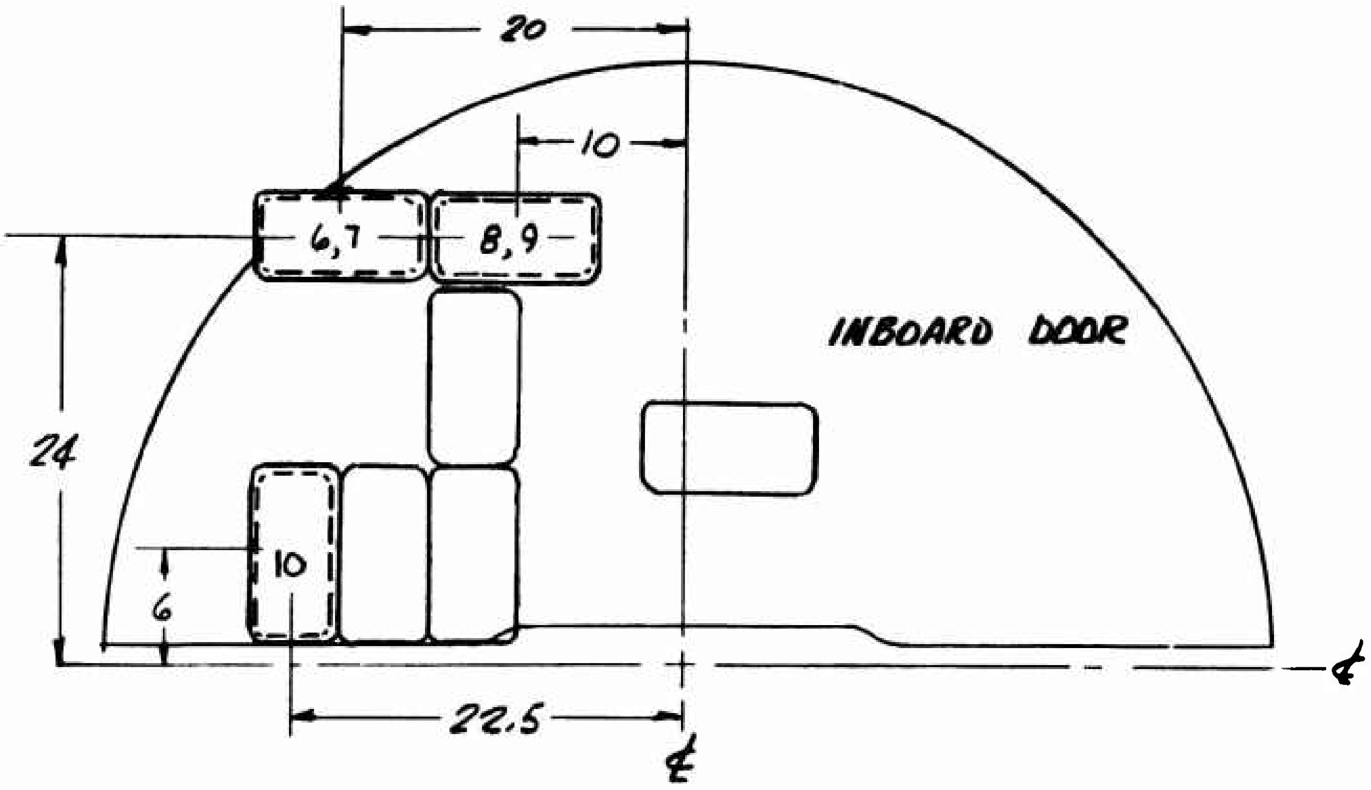
Prepared by J.D. Corbett, Jr.

TEST # 25

50 %

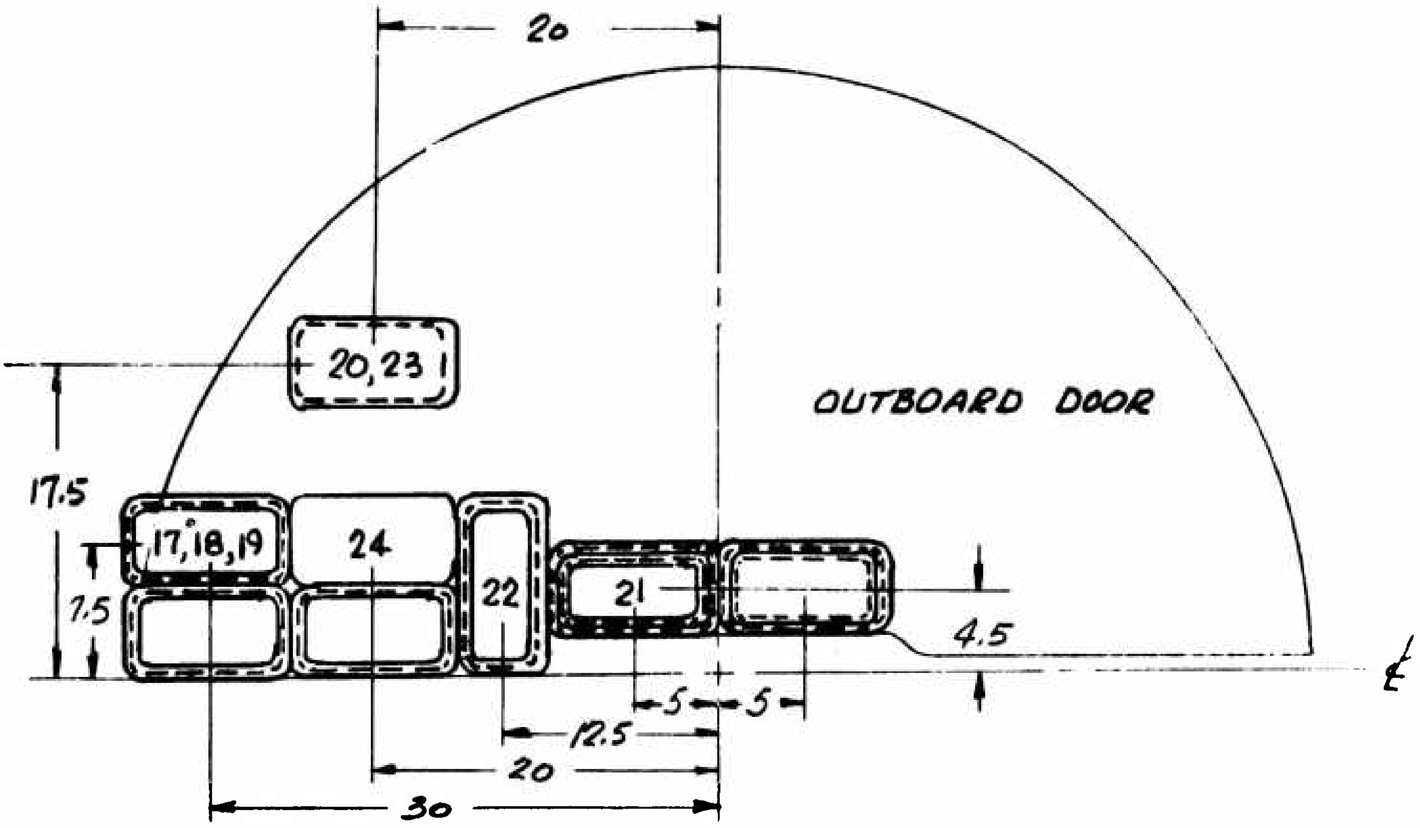


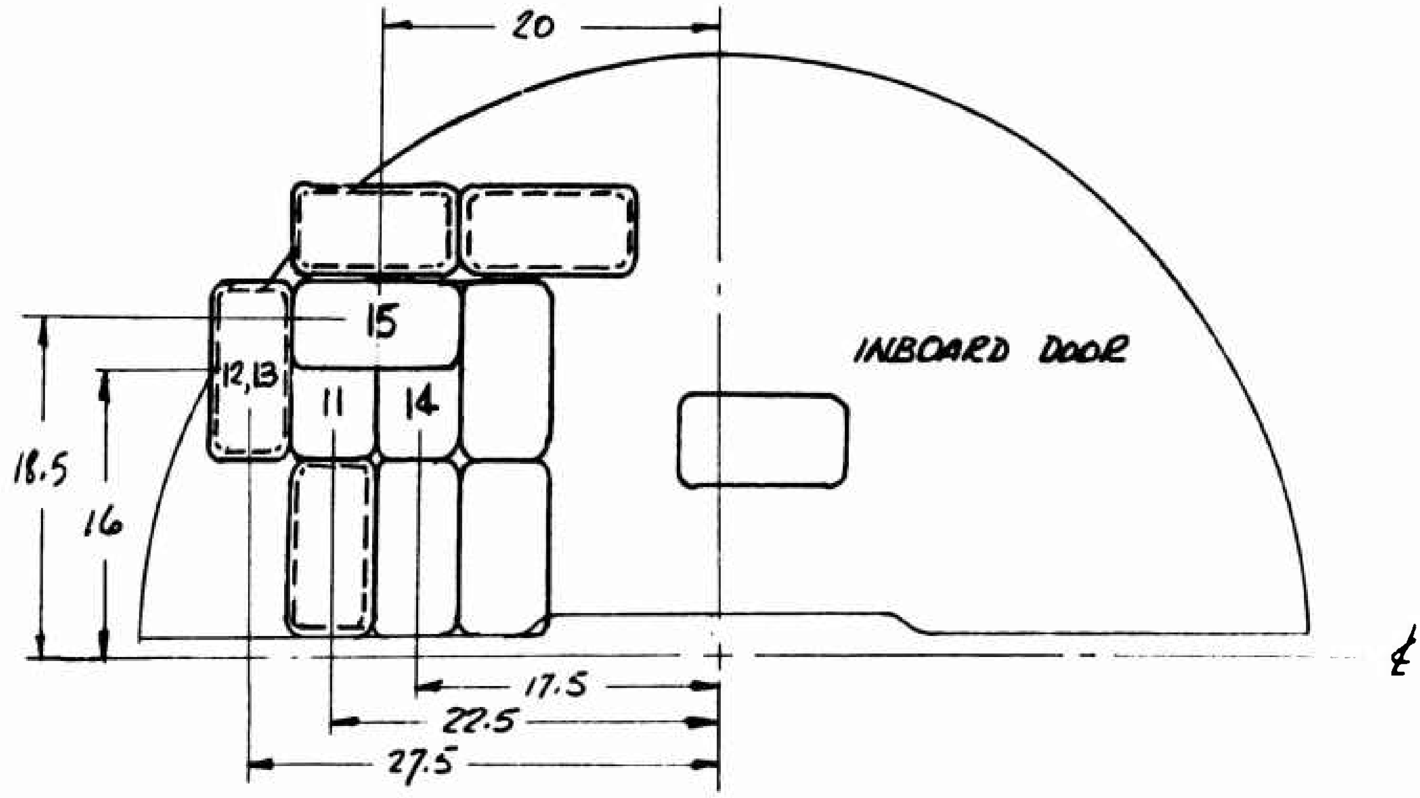
OUTBOARD DOOR
5
5
9
10
13,14
11,12
15,16
4.5
12.5
20
30
℄



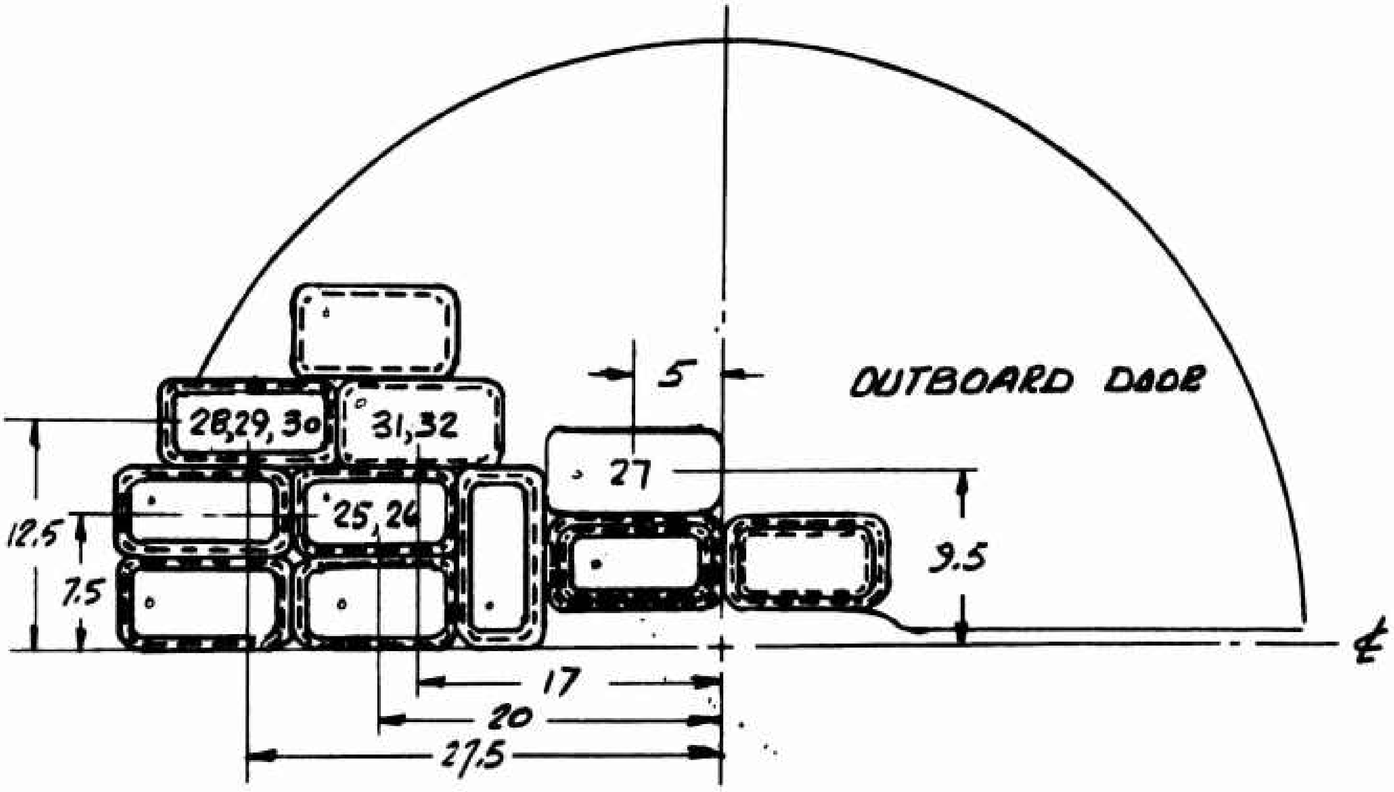
20
10
6,7
8,9
INBOARD DOOR
24
10
6
22.5
℄
℄

TEST # 25

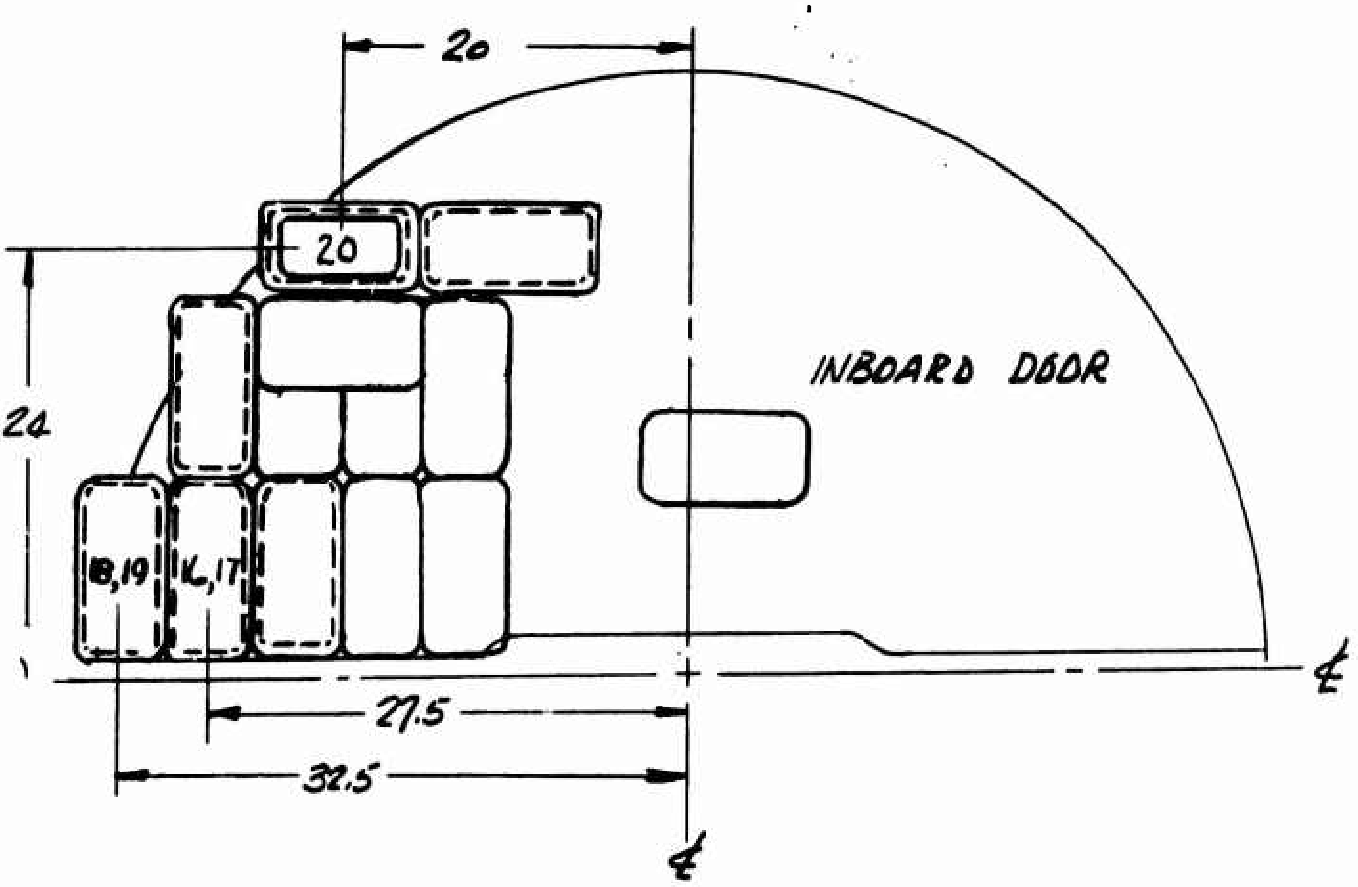

20
20,23
OUTBOARD DOOR
17.5
17,18,19
24
22
21
7.5
4.5
5
5
12.5
20
30
℄


20
15
INBOARD DOOR
12,13
11
14
18.5
16
17.5
22.5
27.5
℄

TEST #25-



5
OUTBOARD DOOR
28,29,30
31,32
27
25,26
12.5
7.5
9.5
17
20
27.5
℄



20
20
INBOARD DOOR
24
18,19
16,17
27.5
32.5
℄
℄

V. TRAILING EDGE

SUMMARY

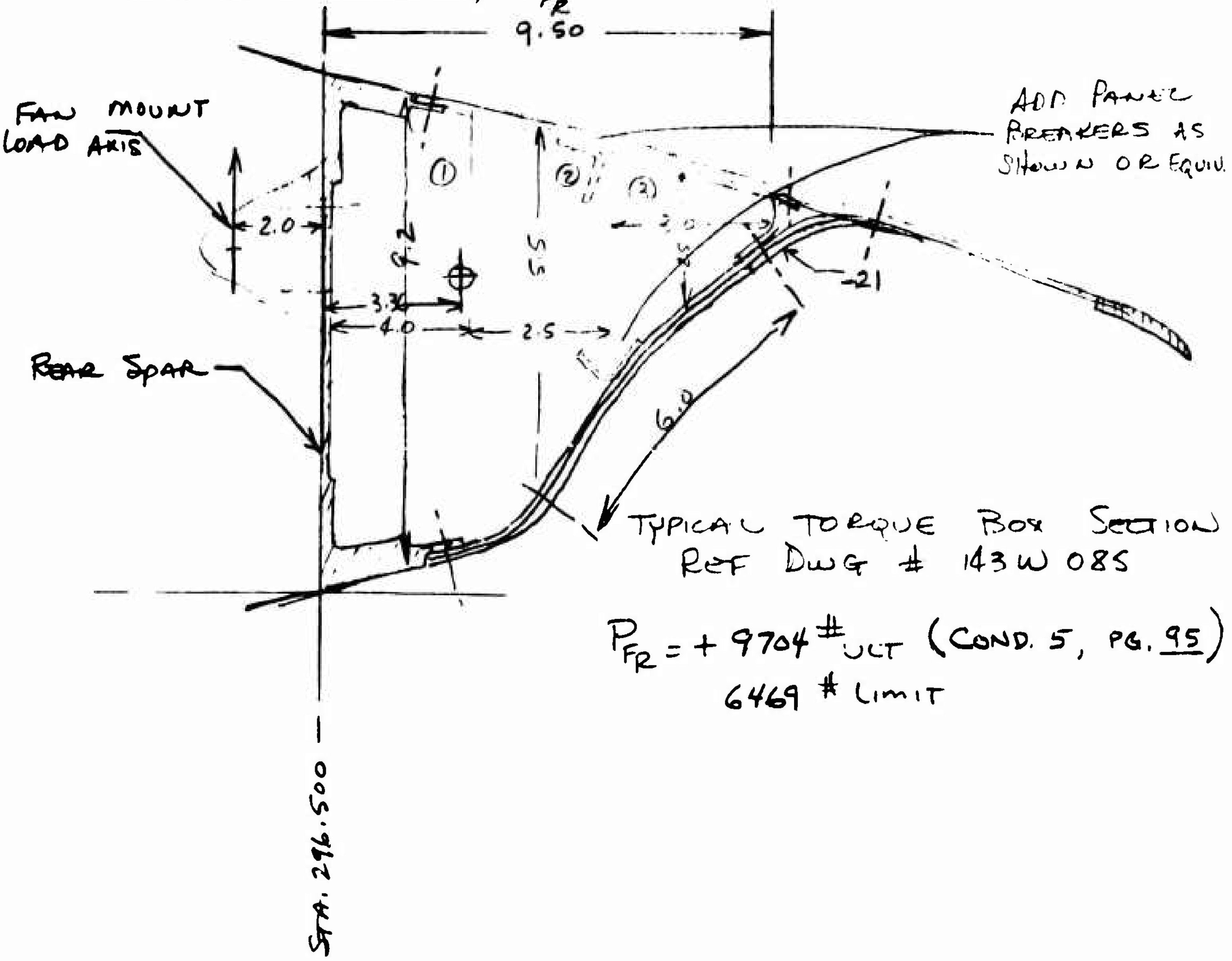
The trailing edge section aft of the rear spar was considered non-structural insofar as primary aerodynamic and inertia loads were concerned. Inboard of B. L. 61, however, the trailing edge structure was considered a torque box resisting the eccentric vertical load on the aft wing fan fitting. Shear from this closed cell is transferred to fuselage structure at B. L. 24.

Originally the aft skin was 2024-T4 clad aluminum chem-milled to a thickness of .025, but the gage was increased to .040 to provide greater shear stability and to preclude permanent buckles. No buckles were observed during structural proof test of the wing fan fittings. In the analysis,a temperature of 300° F was assumed, and an insulating blanket was added to insure that the structural temperature does not substantially exceed this value in fan mode flight.

WING TRAILING EDGE TORQUE BOX

RDF 5/3/63

- DESIGN FOR 300°F FOR A TOTAL OF 10 HOURS
- ASSUME LOADING IS TORQUE ONLY FROM LOAD APPLIED ECCENTRIC TO REAR SPAR WEB ON REAR WING FAN MOUNT, P_{FR}



TYPICAL TORQUE BOX SECTION REF DWG # 143W085

$P_{FR} = + 9704^{\#}_{ULT}$ (COND. 5, PG. 95)
6469 # LIMIT

SEGMENT	A	$\bar{x}$	$\bar{y}$	$A\bar{x}$	$A\bar{y}$
1	36.8	1.9	5.0	69.92	184.00
2	13.8	5.0	6.2	69.00	85.56
3	7.5	7.5	7.1	56.25	53.25
	58.1			195.17	322.81

$\bar{X} = 3.36$
$\bar{Y} = 5.56$

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WING TRAILING EDGE TORQUE BOX   APJ   5/6/63   73

$$T = (3.36 + 2.00)(9704) = 52{,}013 \text{ ''\# (ULT.)}$$
$$= 34{,}693 \text{ ''\# (LIMIT)}$$

$$q_T = \frac{T}{2A} = \frac{34{,}693}{2(58.1)} = 300 \text{ \#/IN LIMIT}$$

$t_{(-21,-22)} = .040$ CHEM MILLED TO <u>.025</u> 2024-T4 CLAD
$t_{(-105)} = .040$ 2024-T4 BARE

$$f_{S_T} = \frac{300}{.025} = 12{,}000 \text{ psi (LIMIT)}$$

FOR BUCKLING ASSUME FLAT PLATE PANEL APPROX. 6.0 LONG
STIFFENER SPACING ≈ 7.5

$a = 7.5$
$b = 6.0$
$a/b = 1.25$
$K_S = 7.0$

$$F_{S_{CR}} = KE\left(\frac{t}{b}\right)^2 = 7.0(10)(10)^6\left(\frac{.025}{6.0}\right)^2 = 7.0(10)(10)^6(17)(10)^{-6}$$

$$= 1190 \text{ psi}$$

THIS IS NON-BUCKLING FOR A LOAD P_{FR} OF:

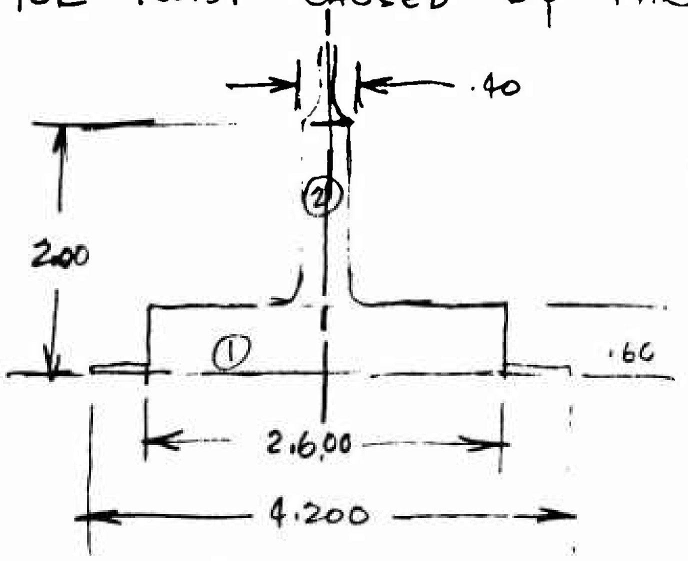
$T = 5.36\, P_{FR}$

$$f_{S_T} = \frac{T}{2At} = \frac{5.36\, P_{FR}}{2At}$$

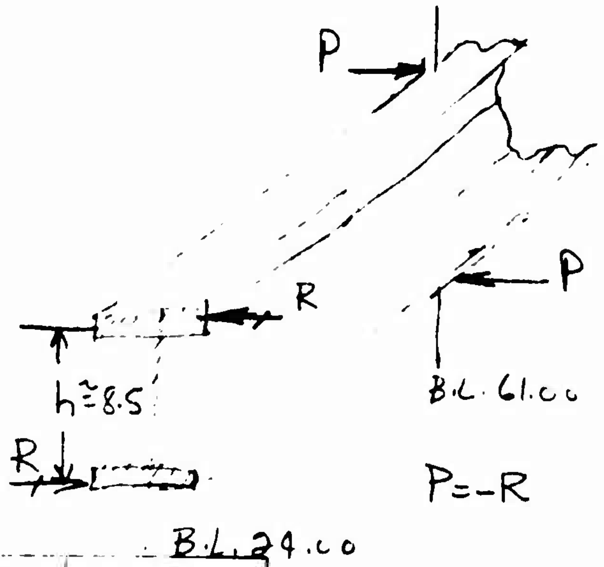
$$P_{FR} = \frac{2At\, F_{S_{CR}}}{5.36} = \frac{2(58.1)(.025)(1190)}{5.36} = 645\ \#$$

CHECK REAR SPAR FROM B.L. 61.00 – TO B.L. 24.00 FOR TWIST CAUSED BY FAN SUPPORT LOAD. CAPS FOR DIFFERENTIAL BENDING.

CAP REF: DWG # 143F022



UPPER & LOWER CAPS ARE TYP.



ITEM	A	y	Ay	Ay²	I_{oy}
1	1.56	-	-	-	.8788
2	.56	-	-	-	.0075
	2.12				.8863

$$f_b = \frac{Mc}{I} = \frac{Pdc}{I} \quad \& \quad d = 61.0 - 24.0 = 37.0$$

$$F_b = 35{,}000 = \frac{37.0 P c}{I}$$

$$P_a = \frac{35{,}000\, I}{37.0\, c} = \frac{35{,}000\,(.8863)}{\underset{481}{37.0\,(1.3)}} = 645\ \#$$

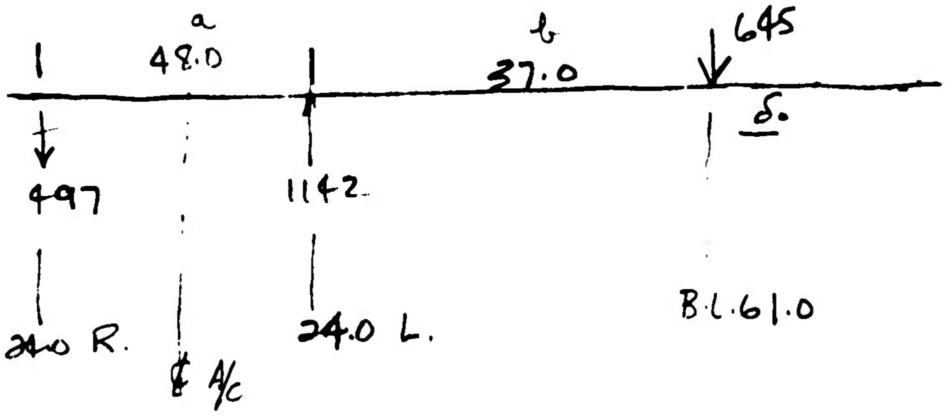
$$T_{S_b} = 8.5(645) = 5483\ ''\#$$

$$P_{FR_{S_b}} = \frac{5483}{2} = 2742\ \#$$ (LIMIT) TAKEN IN DIFF. BENDING IL SPAR

$$P_{FR_T} = 6469 - 2742 = 3727\ \#$$

WING T.E. TORQUE BOX

SPAR CAP DEFL.



$$M_{MAX} = 37(645) = 23{,}865$$

$$f_b = \frac{23{,}865\,(1.3)}{.8863} = 35{,}000 \text{ psi.}$$

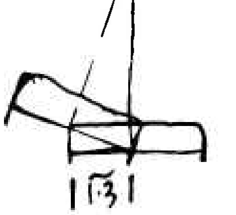
$$\delta_o = \frac{wL^3}{3EI} = \frac{.645\,\overset{50653}{(37)^3}\,\cancel{(10)^3}}{\underset{2.658\cancel{(10)^7}}{3\cancel{(10)^7}(.886)}} = \underline{1.229 \text{ IN.}}$$

[FIXED @ BL.24.0 L]

$$\delta_o = \frac{wbx^3}{3EIL} \qquad X = \left(\frac{\overset{7225}{L^2} - \overset{1369}{b^2}}{3}\right)^{1/2} = (1952)^{1/2} = 44.2$$

$$= \frac{1.142(3.7)(86{,}350)\cancel{(10)^7}}{\underset{2254}{3\cancel{(10)^7}(.886)(85)}} = \underline{1.615 \text{ IN.}}$$

[SIMPLE BEAM BTWN 24.0 R & 61.0 L]



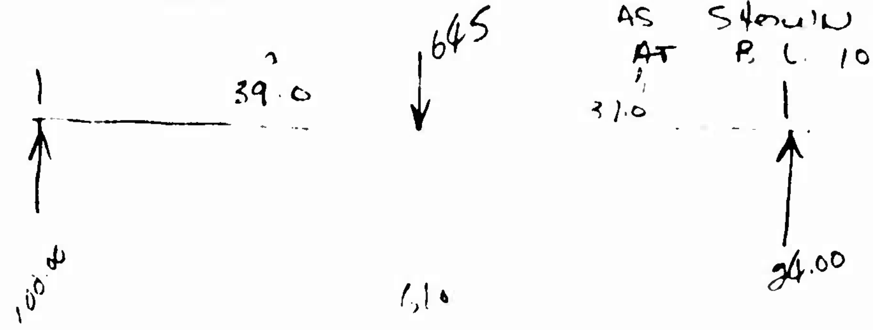
$$\phi = \tan^{-1}\frac{1.3}{4.5} \simeq \underline{16°}$$

WING T.E TORQUE BOX

5/7/63

SPAR. CAP DEFL:

ASSUME SIMPLE BEAM AS SHOWN WITH FIXITY AT B.L. 100.75 RIB



$M_{max} = 37(645) = 23,865$ "#

$f_b \approx 35,000$ psi

$$\delta_0 = \frac{W b X^3}{3EIL} \qquad X = \left(\frac{L^2-b^2}{3}\right)^{1/2} = \left(\frac{\overset{5776}{76^2} - \overset{1369}{37^2}}{3}\right)^{1/2} = (1469)^{1/2} = 38.3$$

$$\delta_0 = \frac{645(3.7)(5.6182)\cancel{(10)^{7}}}{3\cancel{(10)^{7}}(.886)(76)} = .664$$ or approx 1/2 of δ_0 MAX

202

$\delta_{0\,MIN} = .664$ LEAST DEFL. POSSIBLE

$\delta_{0\,MAX} = 1.229$ GREATEST " "

$\delta_0 \approx \underline{\underline{.946}}$ AVG. DEFL./CAP. would twist spar approx. $\underline{12°}$

This is too much — Recheck and beef-up inboard torque box to resist entire torque.

BEEF-UP.

ADD PANEL BREAKER ANGLES AS SHOWN p. ①
USE $t_{21,22,105}$ = .040 NOT REDUCED

$a = 7.5$ $\qquad a/b = 2.000$
$b = 3.75$ $\qquad K_s = 5.75$
$t = .040$

$$q_T = \frac{34,693}{2(58.1)} = 300\text{\#/IN (LIMIT)}$$

$$f_s = \frac{q_T}{t} = \frac{300}{.040} = 7500 \text{ psi}$$

$$F_{s_{cr}} = K_s E \left(\frac{t}{b}\right)^2 = 5.75\,(.94)\cancel{(10)^7}\overset{1136\,\cancel{(10)^7}}{\left(\frac{.040}{3.75}\right)^2} = \underline{\underline{6140 \text{ psi}}}$$

BUCKLING AT $\frac{6140}{7500}$ = 82 % LIMIT

CK

VI. SPAR-FUSELAGE JOINTS

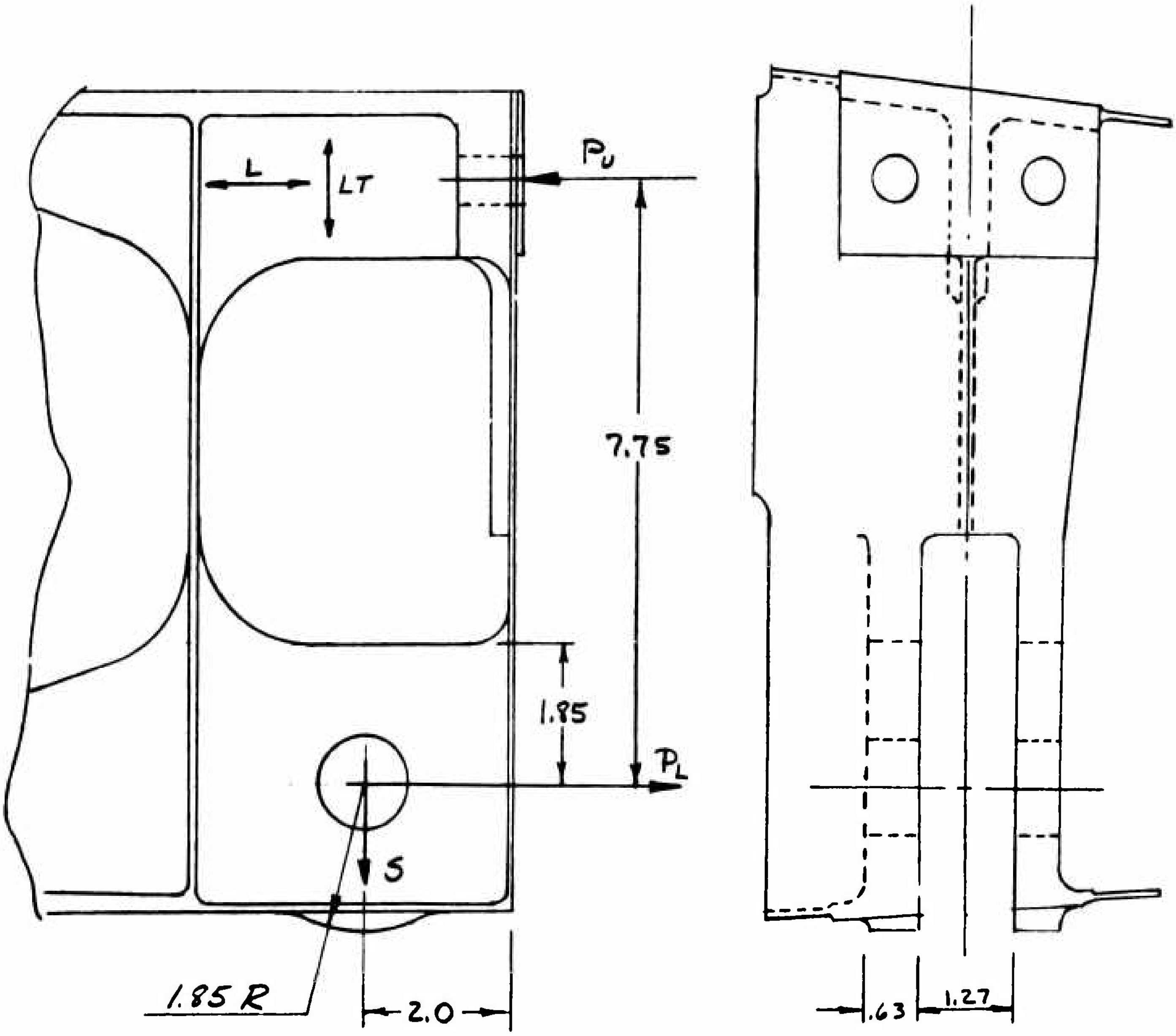
SUMMARY

Each of the spars is connected to fuselage carry-through structure by two pre-loaded tension bolts in the upper cap and a shear bolt in the lower cap. Both front and rear joints were analyzed for the same critical condition, which was also simulated satisfactorily in the structural proof test. Since this loading occurs in conventional flight, the material was considered to be at room temperature. Insulation on the lower wing was provided in order to keep spars and joints at or below 250° F during fan-powered flight. After 10 hours exposure at this temperature, full properties in the 7079 forged spars are obtainable upon return to room temperature.

XV-5A

WING FRONT SPAR ATTACHMENT FITTING

(DWGS. 143W002, 143W022)



MADE FROM 7079-T6-52 BILLET

F_{tu} = 68000 psi (L)
67000 (LT)
65000 (ST)

ROOM TEMPERATURE PROPERTIES AFTER 10 HR. EXPOSURE TO 250 °F

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WING FRONT SPAR ATTACHMENT FITTING

LOWER LUG

SYM. COND. "PLAFO" IS CRITICAL
(REF. REPT. 63B096 PG. 134)

B.M. $= 9.7\, p_{59} = 9.7 \times 49875 \times 1.5 = 725700$ "#

$S = 9.7\, q_{17} = 9.7 \times 904 \times 1.5 = 13150$ #

$P_U = P_L = 725700/7.75 = 93600$ #

RES. SHEAR $= (93600^2 + 13150^2)^{1/2} = 94600$ #

NET AREA $= (3.7 - 1.124) 2 \times .63 = 3.24$ IN^2

ALLOW. $P_T = 3.24 \times 68000 = 220000$ #

SHEAR-OUT AREA $= (2 - .562) 2 \times 2 \times .63 = 3.62$ IN^2

$F_{su} = .6 F_{tu} = .6 \times 67000 = 40200$ psi

ALLOW. $P_s = 3.62 \times 40200 = 145000$ #

ALLOWABLE BEARING STRESS IS DETERMINED BY RATIOING 7079-T6 HAND FORGING PROPERTIES GIVEN IN MIL HDBK 5, PG. 3.2.8.0 (b)

$e/D = 2/1.124 = 1.78$

$$F_{bru} = \frac{68000}{71000}\left[92000 + (121000 - 92000)\left(\frac{1.78 - 1.5}{2 - 1.5}\right)\right]$$

$= 108000$ psi

ALLOW $P_{bru} = 108000 \times 1.124 \times 2 \times .63 = 153000$ #

CRITICAL M.S. $= \dfrac{145000}{94600} - 1 = \underline{\underline{+.53}}$

WING FRONT SPAR ATTACHMENT FITTING

LOWER LUG – BOLT BENDING

INNER LUG WIDTH = 1.25

$$B.M. = \frac{P_{RES}}{2}\left(\frac{t_1}{2} + \frac{t_2}{4} + g\right)$$

$$= \frac{94600}{2}\left(\frac{.63}{2} + \frac{1.25}{4} + .02\right) = 30600 \text{ "\#}$$

1.125 BOLT 180000 psi H.T

$$f_b = \frac{4M}{\pi r^3} = \frac{4 \times 30600}{\pi \times .5625^3} = 219000 \text{ psi}$$

F_b = 300000 psi (REF. MIL HDBK 5, PG. 2.4.1.1.1)

$$M.S. = \frac{300000}{219000} - 1 = \underline{\underline{+.37}}$$

UPPER ATTACHMENT

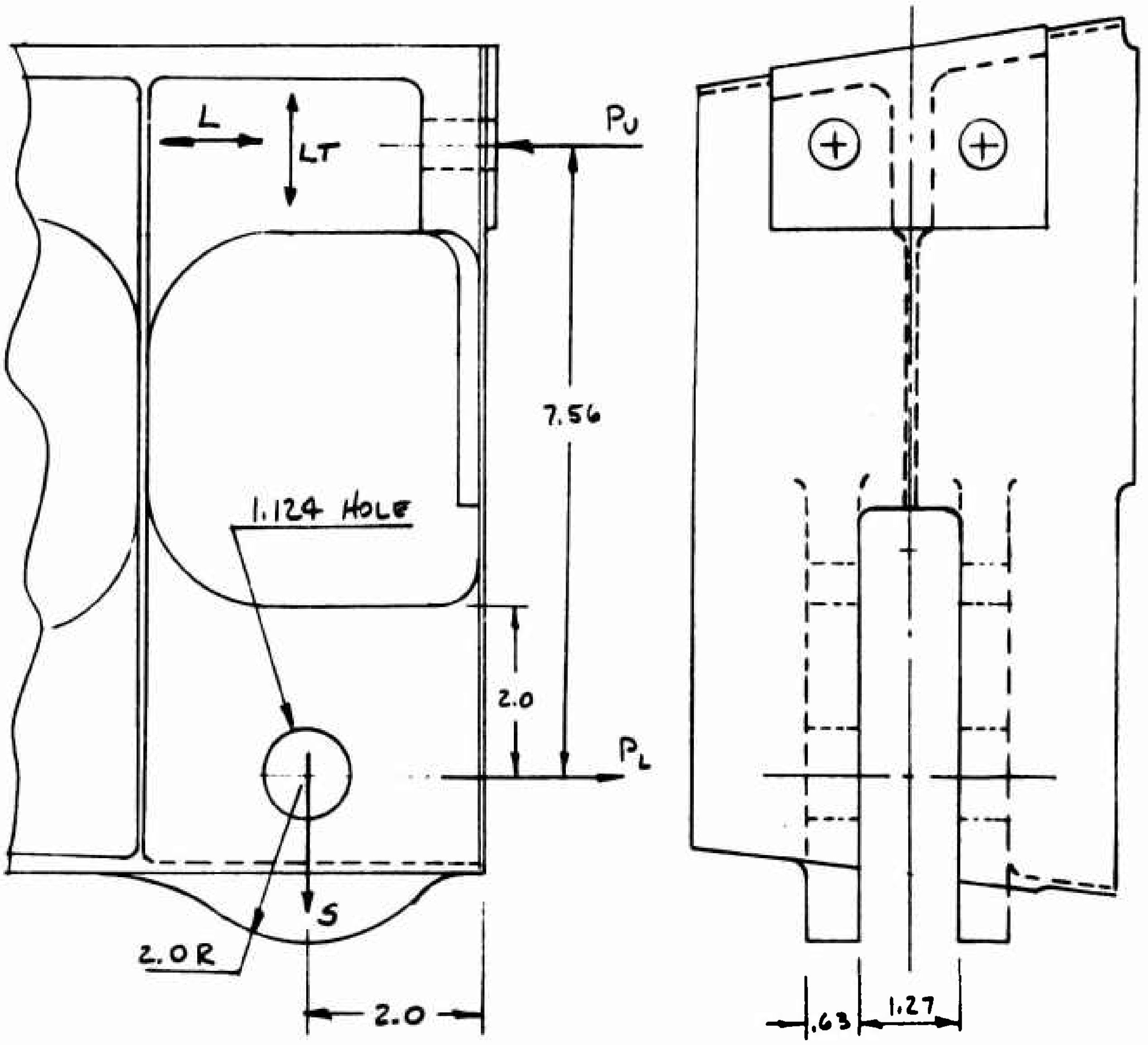
MAX. TENSILE LOAD ON BOLTS OCCURS IN COND. "NHAFO" (REF. REPT. 63B096 PG. 140)

$$\text{ULT. TENSILE LOAD} = 1.5\, p_{59} \times \frac{9.9}{7.75}$$

$$= 1.5 \times 19781 \times \frac{9.9}{7.75}$$

$$= 37900 \#$$

WING REAR SPAR ATTACHMENT FITTING
(DWGS. 143W003, 143W023)



MADE FROM 7079-T6-52 BILLET

F_{tu} = 68000 psi (L)
67000 (LT)
65000 (ST)
} ROOM TEMPERATURE PROPERTIES AFTER 10 HR. EXPOSURE TO 250° F

WING REAR SPAR ATTACHMENT FITTING

LOWER LUG

COND. 5-C (SYM. "PLAFO") IS CRITICAL
(REF. REPT. 63B096, PG. 134)

$B.M. = 9.9\,p_{48} = 9.9 \times 54957 \times 1.5 = 816111\ ''\#$

$S = 9.9\,q_8 = 9.9 \times 563 \times 1.5 = 8361\ \#$

$P_U = P_L = 816111/7.56 = 108000\ \#$

RES. SHEAR $= (108000^2 + 8361^2)^{1/2} = 108300\ \#$

NET AREA $= (4 - 1.124)2 \times .63 = 3.62$

ALLOW $P_T = 3.62 \times 68000 = 246000\ \#$

SHEAR-OUT AREA $= (2 - .562)2 \times 2 \times .63 = 3.62$

$F_{su} = .6\,F_{tu} = .6 \times 67000 = 40200$ psi

ALLOW $P_s = 3.62 \times 40200 = 145000\ \#$

ALLOWABLE BEARING STRESS IS FOUND FROM MIL HDBK 5 PROPERTIES FOR 7079-T6 HAND FORGING
(REF. PG. 3.2.8.0 b)

$e/D = 2/1.124 = 1.78$

$$F_{bru} = \frac{68000}{71000}\left[92000 + (121000-92000)\left(\frac{1.78-1.5}{2-1.5}\right)\right]$$

$= 108000$ psi

$P_{bru} = 108000 \times 1.124 \times 2 \times .63 = 153000\ \#$

CRITICAL M.S. $= \dfrac{145000}{108300} - 1 = \underline{\underline{+.34}}$

WING REAR SPAR ATTACHMENT FITTING

LOWER LUG – BOLT BENDING

INNER LUG WIDTH = 1.25

$$B.M. = \frac{P_{RES}}{2}\left(\frac{t_1}{2} + \frac{t_2}{4} + g\right)$$

$$= \frac{108300}{2}\left(\frac{.63}{2} + \frac{1.25}{4} + .02\right) = 35000 \text{ "\#}$$

1.125 BOLT 180000 psi H.T.

$$f_b = \frac{4M}{\pi r^3} = \frac{4 \times 35000}{\pi \times .5625^3} = 250000 \text{ psi}$$

F_b = 300 000 psi (REF. MIL HDBK 5, PG. 2.4.1.1.1)

$$M.S. = \frac{300000}{250000} - 1 = \underline{+.20}$$

UPPER ATTACHMENT

MAX. TENSILE LOAD ON BOLTS OCCURS IN COND. "NHAFO" (REF. REPT. 63B096, PG. 140)

$$\text{ULT. TENSILE LOAD} = 16360 \times \frac{9.9}{7.56} \times 1.5$$

$$= 32100 \text{ \#}$$

VII. HOIST FITTING

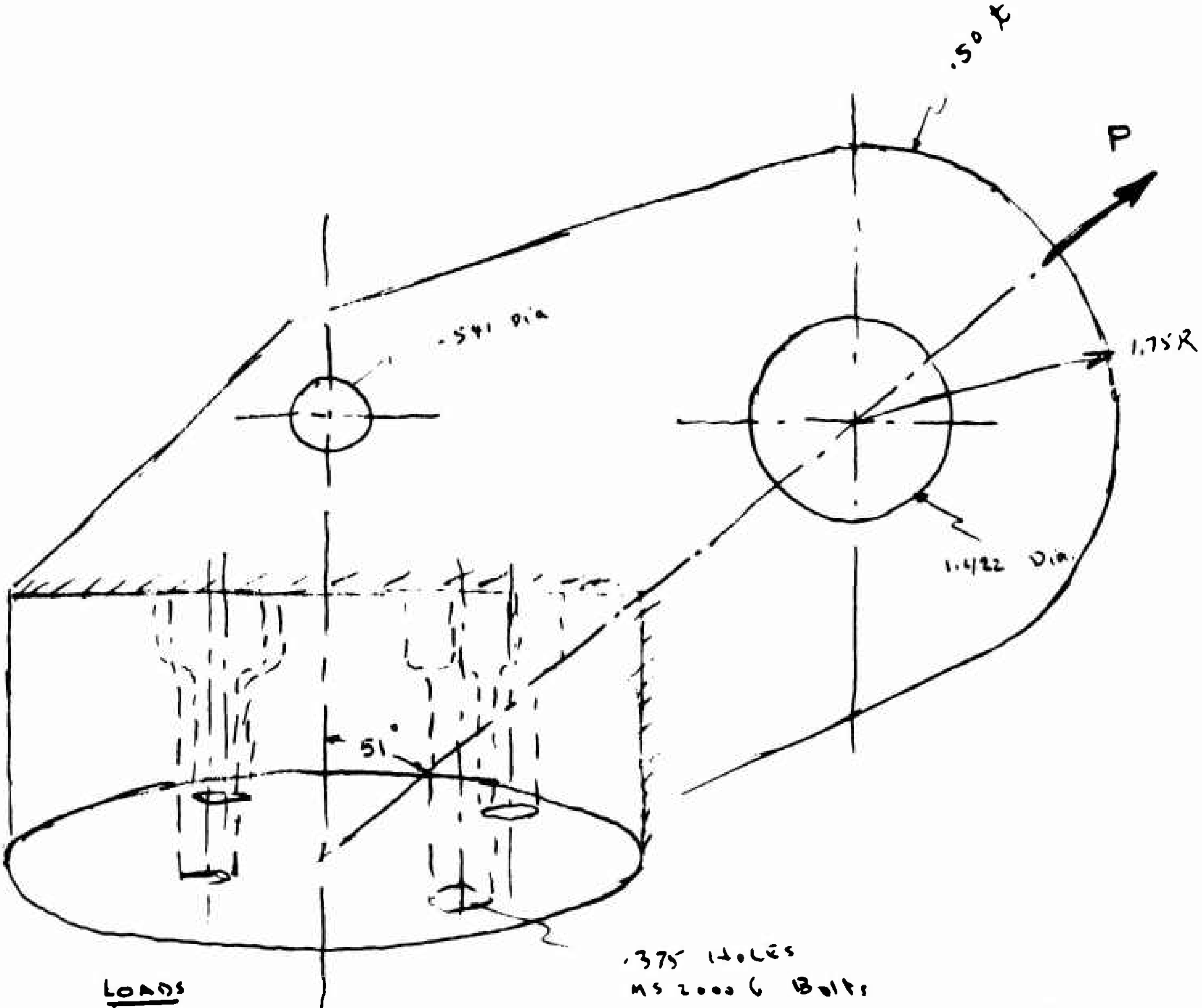
SUMMARY

Provisions for hoisting the airplane incorporate two wing fittings, at F. S. 226. 5 & B. L. ±100. 75, and the fuselage jack fitting at F. S. 384. 21. A sling is also used on the forward fuselage for added safety.

Ultimate loads for the wing and fuselage hoist points were determined for 9200 pound gross weight; an ultimate normal load factor of 3. 0, and two extreme cg positions. Since the wing hoist fitting and attachment is over-strength, a minimum of analysis is included here.

Roach 86
1 July 63

143 G 020 HOIST INSTAL.



LOADS

Consider A/c hoisted in Level attitude & W = 9200 #
Hoisting Load Factor = 3.0 ultimate.
2 Fwd. hoist points on wing at F.S. 226.5.
1 Aft Fus. hoist point at F.S. 384.21 (Jack Ftg.)

C.G Location F.S.	Vertical Component at Jack Ftg. on Fus.		Vertical Component at One Wing Ftg.	
	n = 1g	n = 3g (ult.)	n = 1g	n = 3g (ult.)
240	788	2364	4206	12618
246	1138	3414	4031	12093

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Roselle 87
1 July 63

143W092 HOIST FITTING – WING (CONT'D.)

Cable on this fitting will be inclined aft at a small angle.

Neglecting this angle : $P_{ult.} = \frac{12618}{\cos 51^\circ} = \underline{20100}$ #

Material : 4130 Normalized steel.

Shear-Out

Area > $2(1.75 - .71)(.50) = 1.08$ $''^2$

$P_{allow.\ sh.\ out} > 55000 \times 1.08 = 59{,}400$ #

Ftg is attached by 4 MS 20006 bolts.

Allow. Tens. on 4 bolts = $4 \times 15200 = 60800$ #

Allow. Shear on 4 bolts = $4 \times 10500 = 42000$ #

Action line of load comes close to CG of bolt pattern.

VIII. WING FAN MOUNTS

SUMMARY

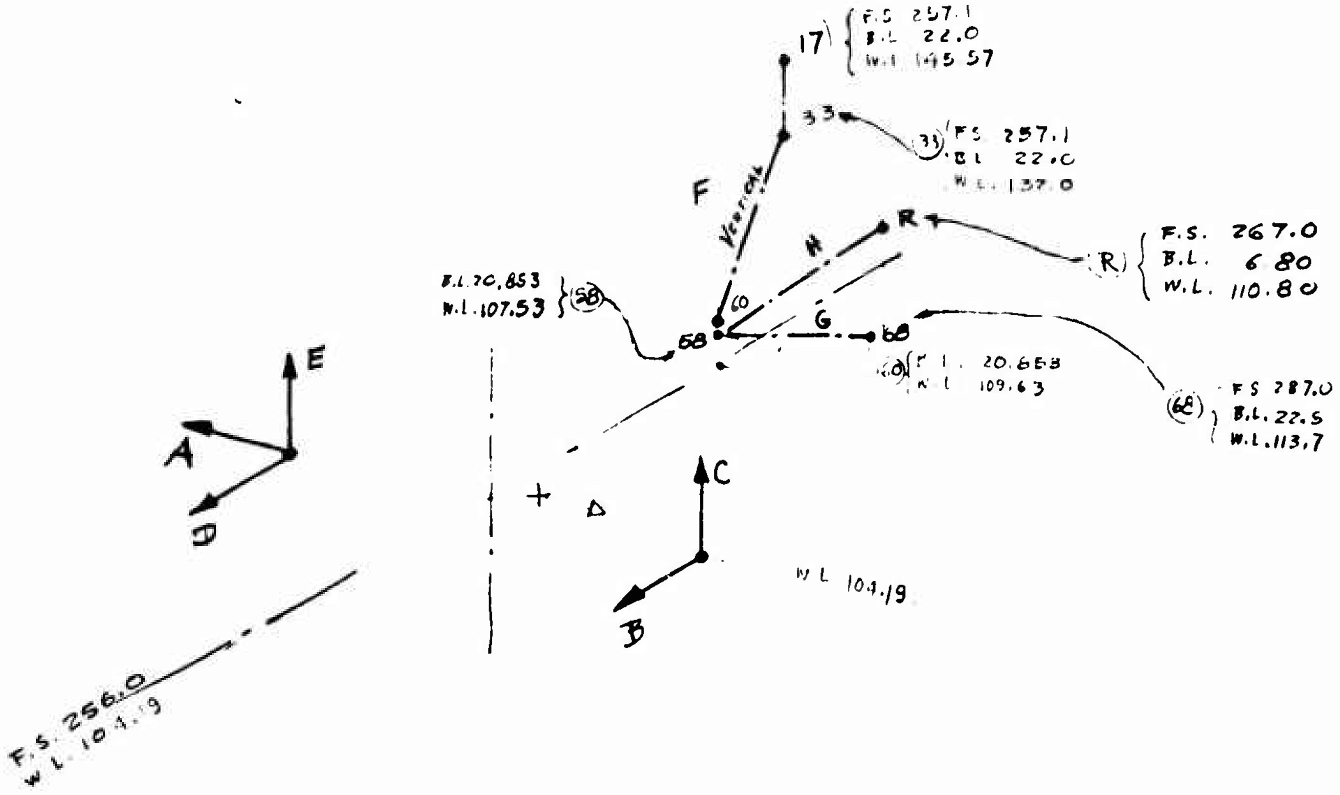
Each wing fan is mounted at 3 points: at an inboard point to the fuselage and at forward and aft points to the wing spars, at B. L. ± 61. The front wing spar fitting furnishes vertical, side, and fore and aft reaction; the rear spar fitting furnishes vertical and side reaction; and the fuselage point furnishes reactions "F" and "G" (See pages 97, 98), which result from two links of known direction. Introduced also at this point is the force "H", which is applied by link "58-R" connecting wing fan scroll to the crossover duct. See pages 97, 98 for fan mount geometry.

The fan mount design reactions were determined from G. E. unit information on pages 100, 101. The summed effects of full power SLS Day thrust and piston forces together with that resulting from 130 K cross flow were conservatively added to effects due to limiting values of linear load factors and roll and pitch rates, which are the specified limits for hovering and transition flight as given in the structural design criteria, Report Number 122. Although these criteria values are actually relative to the aircraft og , they were considered existing at the fan cg for simplicity, (earlier investigations having shown that the axis transfer has no large significance and is not merited where the conservative assumption is made that the most extreme value of every pertinent parameter occurs at the same instant).

During the design phase, the fan mount fittings and attachments were analyzed for preliminary sets of load, assuming a temperature of 400 - 450° F, and using a fitting factor of 1.15. The mounts were also satisfactorily proof tested to the critical preliminary loads, which are only slightly lower than the final ones presented here.

2/8/62

GEOMETRY - L.H. FAN MOUNTS



BAR.	ΔX	ΔY	ΔZ	ℓ	α	β	γ	cos α	cos β	cos γ
33 - 60	1.1	1.147	22.37	22.4264				.049049	.051145	.997478
33 - 58	1.1	1.147	24.47	24.5216				.044858	.046775	.997887
R - 58	11.0	14.053	3.27	14.4285				.762377	.973971	.226634
68 - 58	31.0	1.647	6.17	31.6510				.979414	.052035	.194935

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5/8/67 WD

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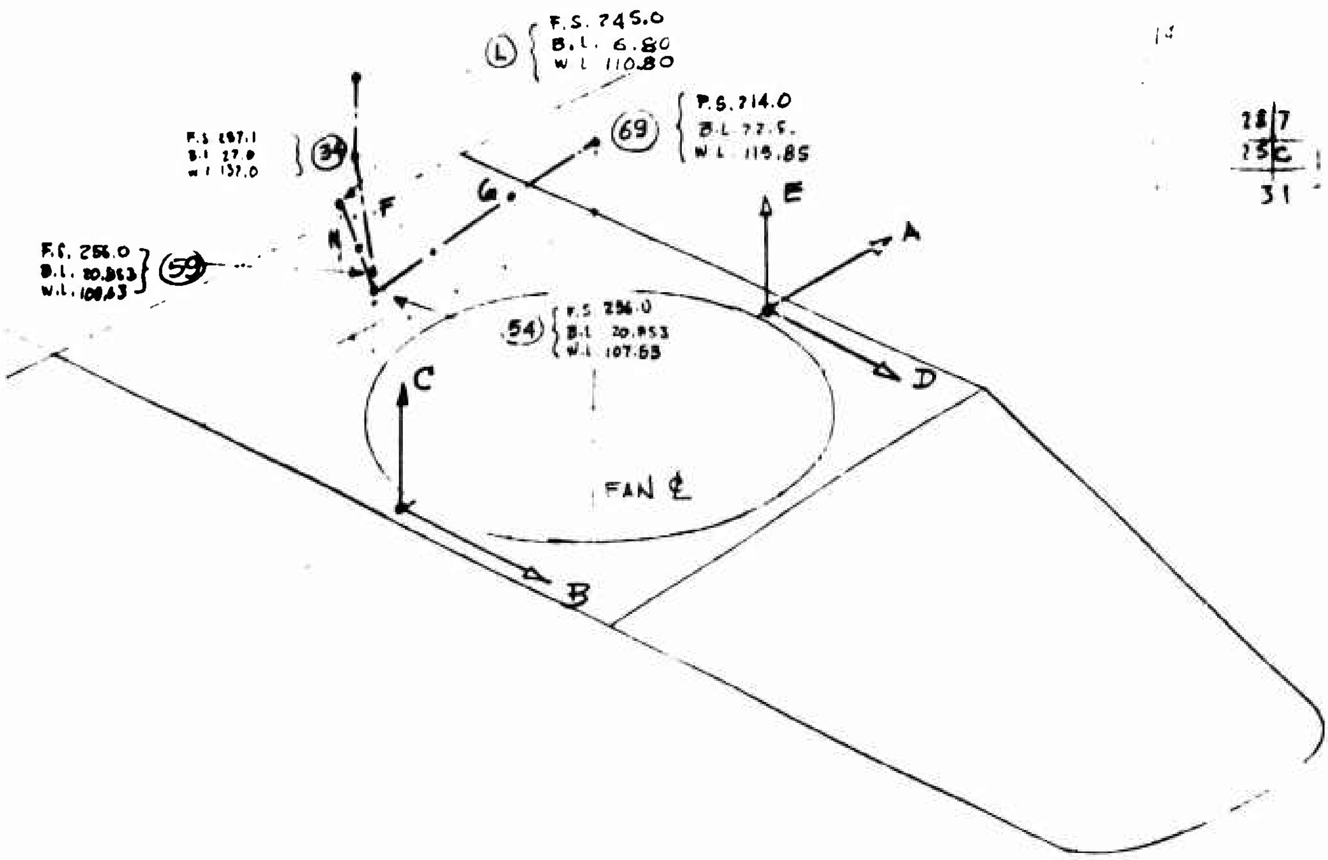
GEOMETRY — R.H. FAN MOUNTS



BAR	Δx	Δy	Δz	ℓ	α	β	γ	cos α	cos β	cos γ
34 - 59	1.1	1.147	22.37	22.4264				.049049	.051145	.997478
34 - 54	1.1	1.147	24.47	24.5216				.044858	.046775	.997887
L - 54	11.0	14.053	3.27	14.4285				.762377	.973971	.226634
69 - 54	42.0	1.647	8.32	42.8482				.980196	.038438	.194172

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GEOMETRY - FAN MOUNTS

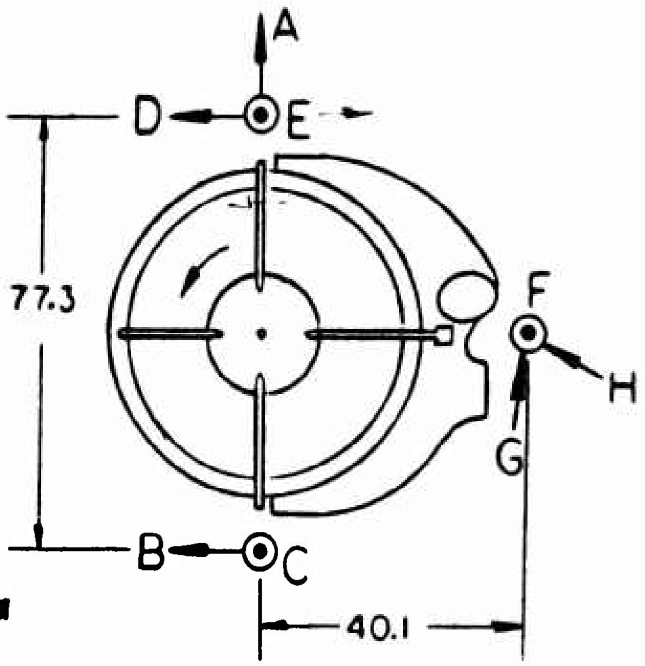
POINT COORDINATES

PT			RYAN		
			F.S.	W.L.	B.L.
17	ENG MT. L.H.		257.1	145.57	22.0 L
19	" " R.H.		257.1	145.57	22.0 (R)
33			257.1	132.0	22.0
34			257.1	132.0	22.0
54	R.H SCROLL MT-LOWER		256.0	107.53	20.853
58	L.H. " " "		256.0	107.53	20.853
59	R.H INB'D FAN MT.		256.0	109.63	20.853
60	L.H INBD " "		256.0	109.63	20.853
68	ALT hook up to pt J (J-58)		287.0	113.70	22.5 (L)
69	ALT " " " " M (M-54)		214.0	115.85	22.5 (R) Ⓑ
R	DUCT R.H. MOUNT	COLD	266.869	110.877	6.837
		HOT	267.00	110.80	6.80
M	DUCT R.H. MOUNT	COLD	251.563	113.577	19.037
E	HORIZONTAL	COLD	266.869	103.247	11.310
E_S E_D	(L H SCROLL INLET ℄ R.H DUCT INLET)	HOT	—	—	—
F	HORIZONTAL	COLD	245.131	103.247	11.310
F_S F_D	(RH SCROLL INLET ℄ L.H DUCT INLET)	HOT	—	—	—
G	VERTICAL	COLD	248.868	113.396	15.856
G_S G_D	L.H - SCROLL ℄ DUCT INLET	HOT	—	—	—
H	VERTICAL	COLD	263.132	113.396	15.856
H_S H_D	R.H - SCROLL ℄ DUCT INLET	HOT	—	—	—
L	× DUCT - LH	COLD	245.131	110.877	6.837
	MOUNT	HOT	245.0	110.80	6.80

FROM V12-0079 5/8/62 JP.

X3

MOUNT

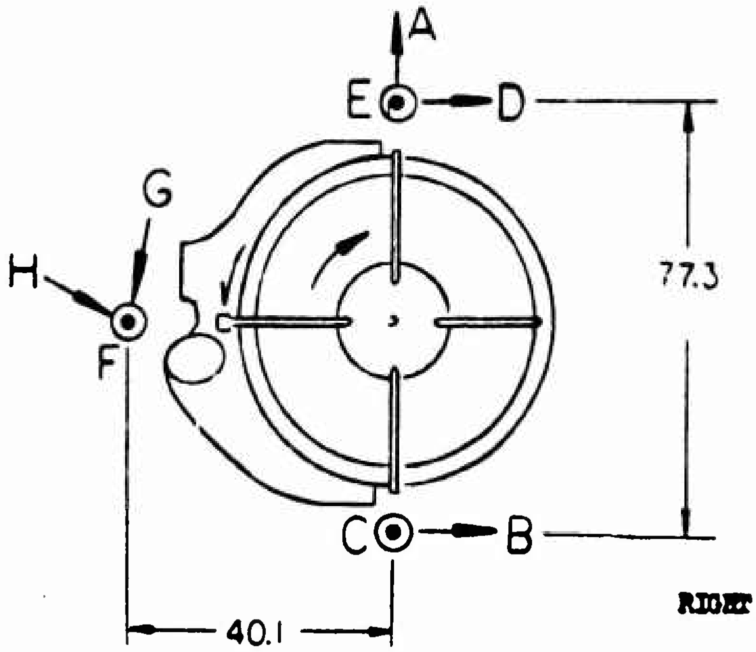


LEFT HAND FAN

	A	B	C	D	E	F	G	H
Thrust (β = 0°)			-2815		-2815	-330		
Thrust (β = 40°)	-3670	+166	-1318	-166	-2322	-340		
Scroll Piston Forces								
Left Engine Only	+30	-230	-485	-260	+85	+2879	-1810	---
Right engine Only	-448	-477	---	-29	---	-155	+2420	-3430
Fan Torque								
Left Engine Only	-1009	+927		-123		+200	+1030	
Right Engine Only	-1009	+167		-883		+200	+1030	
1 g vertical			±383		±383	±93		
1 g side		±429	±37	±429	±37	∓74		
1 g axial	±770		∓ ±37		±37	±20	±91	
Cross Flow (130 k)	+308		-257		-257	+514		
1 rad/sec. pitch			∓1195		∓1195	±2390		
1 rad/sec, roll			∓ ±1240		±1240			
Inlet Closure								
Open								
Open (Yaw)								
Closed								

Thrust reactions are for SLS, Std. day, and exclude lift developed on the wing.

Reactions are positive (+) in the directions indicated and are reactions acting on the fan.

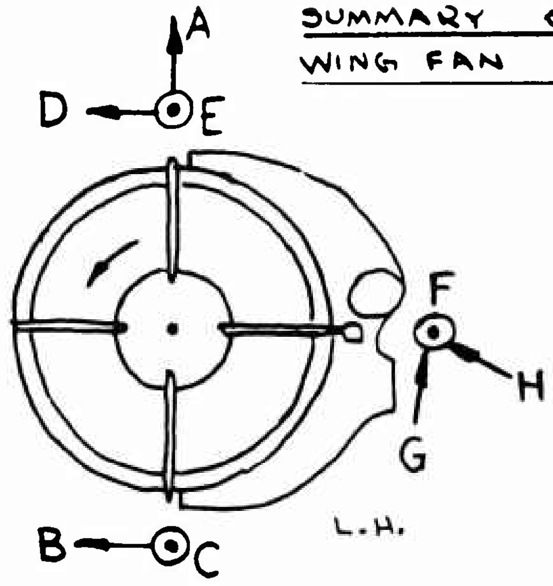


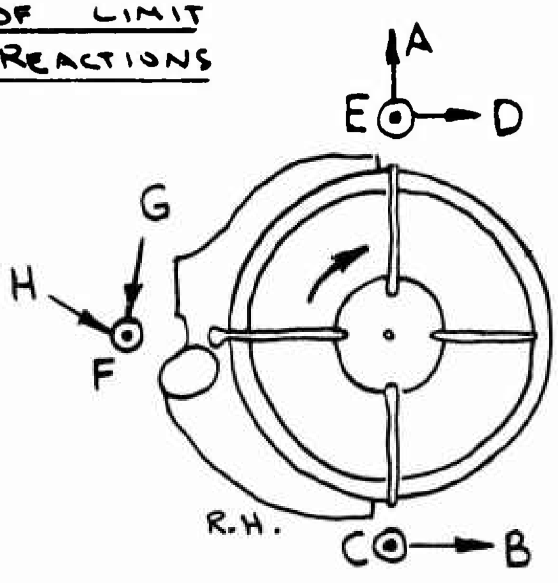
RIGHT HAND FAN

	A	B	C	D	E	F	G	H
Thrust (β = 0°)			-2815		-2815	-330		
Thrust (β = 40°)	-3670	+166	-1318	-166	-2322	-340		
Scroll Piston Forces								
Left Engine Only	+448	-29	---	-477	---	-155	+2420	-3430
Right Engine Only	-30	-260	+85	-230	-485	+2879	-1810	---
Fan Torque								
Left Engine Only	-1009	+883		-167		-200	-1030	
Right Engine Only	-1009	+123		+927		-200	-1030	
1 g vertical			±383		±383	±93		
1 g side		±429	± 37	±429	±37	∓74		
1 g axial	±770		± 37		±37	∓20	∓91	
Cross Flow (130 k)	+308		+257		+257	-514		
1 rad/sec. pitch			±1195		±1195	∓2390		
1 rad/sec. roll			±1240		±1240			
Inlet Closure								
Open								
Open (Yaw)								
Closed								

J. D. Corbett, Jr./ht
November 19, 1962

SUMMARY OF LIMIT WING FAN REACTIONS





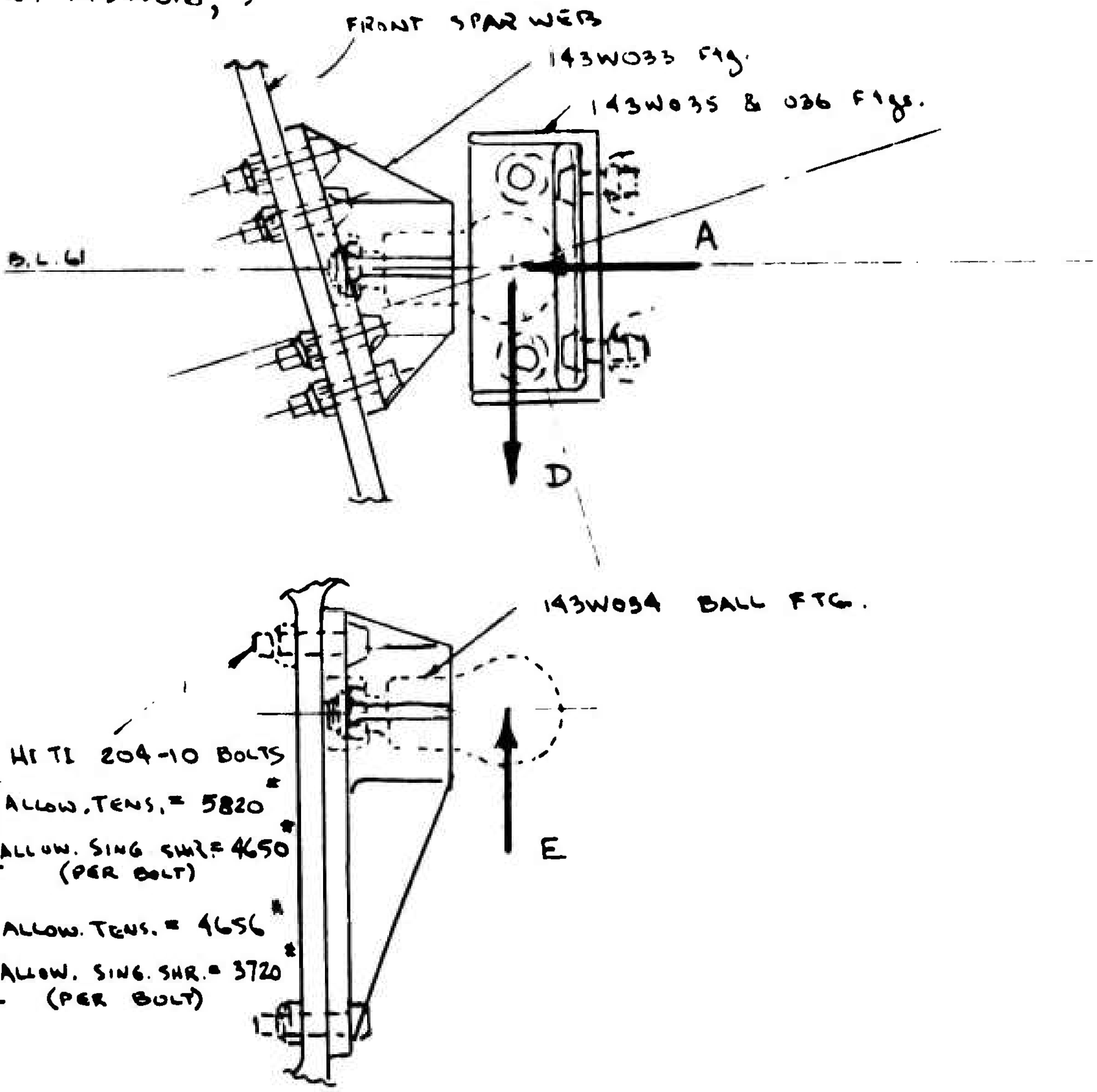
LEFT HAND FAN

COND. NO.	THRUST VECTOR ANG. β°		FULL ENG POWER SLS STR DY		LINEAR LOAD FACTORS			ANGULAR RATES RAD/SEC.		LIMIT REACTIONS							
	0	40	L.H.	R.H.	VERT.	SIDE	AXIAL	PITCH	ROLL	A	B	C	D	E	F	G	H
1	✓		✓		0	0	0	0	0	-671	697	-3557	-383	-2987	3263	-780	0
2	✓			✓	0	0	0	0	0	-1149	-310	-3072	-912	-3072	229	3450	-3430
3	✓		✓	✓	0	0	0	0	0	-2128	387	-3557	-1295	-2987	3308	2670	-3430
4		✓	✓	✓	0	0	0	0	0	-5798	553	-2060	-1461	-2494	3298	2670	-3430
5	✓		✓	✓	0	±.16	0	±1.0	±1.38	-2128	456	-6469	-1364	-5899	5710	2670	-3430
6	✓		✓	✓	2.00	±.16	0	±1.0	±1.38	-2128	456	-5703	-1364	-5133	5896	2670	-3430
7		✓	✓	✓	0	±.16	0	±1.0	±1.38	-5798	622	-4972	-1530	-5406	5700	2670	-3430
8		✓	✓	✓	2.00	±.16	0	±1.0	±1.38	-5798	622	-4206	-1530	-4646	5886	2670	-3430
RIGHT HAND FAN																	
9	✓		✓		0	0	0	0	0	-253	854	-2558	-644	-2558	-1199	1390	-3430
10	✓			✓	0	0	0	0	0	-731	-137	-2473	-1157	-3043	1835	-2840	0
11	✓		✓	✓	0	0	0	0	0	-1292	717	-2473	-1801	-3043	1480	-1450	-3430
12		✓	✓	✓	0	0	0	0	0	-4962	883	-976	-1967	-2550	1470	-1450	-3430
13	✓		✓	✓	0	±.16	0	±1.00	±1.38	-1292	786	-5385	-1870	-5955	3882	-1450	-3430
14	✓		✓	✓	2.00	±.16	0	±1.00	±1.38	-1292	786	-4619	-1870	-5189	4068	-1450	-3430
15		✓	✓	✓	0	±.16	0	±1.00	±1.38	-4962	952	-3888	-2036	-5462	3872	-1450	-3430
16		✓	✓	✓	2.00	±.16	0	±1.00	±1.38	-4962	952	-3122	-2036	-4696	4058	-1450	-3430

NOTE: REACTIONS FOR ALL CONDITIONS INCLUDE EFFECT OF CROSS FLOW (130 K).

FRONT SPAR WING FAN MOUNTING

REF. DWG. 143W016, 3



HI TI 204-10 BOLTS

ROOM TEMP. { ALLOW. TENS. = 5820#
ALLOW. SING SHR. = 4650# (PER BOLT)

FOR 400°F (80 %) { ALLOW. TENS. = 4656#
ALLOW. SING. SHR. = 3720# (PER BOLT)

COND. 7 PRODUCES THE MAXIMUM RESULTANT LOAD ON THE BALL. $A = 5798^{\#}$, $E = 5406^{\#}$, $D = 1530^{\#}$ (LIMIT).
RESULTANT LOAD $= (\overline{5798}^2 + \overline{5406}^2 + \overline{1530}^2)^{1/2} = 8074^{\#}$ LIM. $= 12,111^{\#}$ ULT.

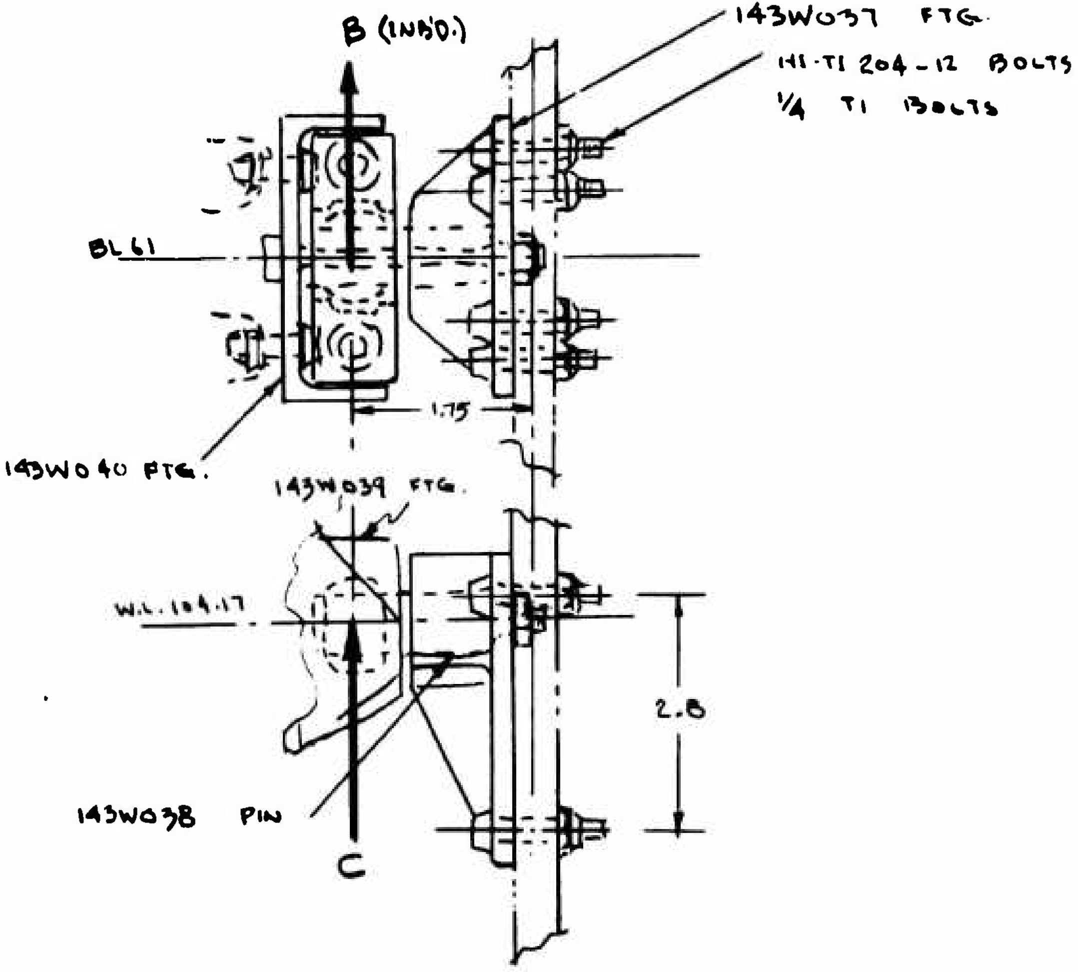
THE FITTING AND BASIC WING STRUCTURE WERE SATISFACTORILY PROOF TESTED TO THE FOLLOWING PRELIMINARY LOADS : (REF. STRUCT. PROOF TEST PROG. REPT. 638048)

6852# FWD.
3581# UP
2262# OUTB'D.
} 8055# RESULTANT

2720# FWD.
5179# UP
2061# OUTB'D.
} 6205# RESULT.

REAR SPAR WING FAN MOUNTING

REF. DWG. 143W016, 3



COND. 5 IS CRITICAL.

B = 456 #, C = 6469 #. RESULTANT = 6485 # LIMIT = 9728 # ULT.

TENSION IN BOTTOM BOLTS ≈ 1.75/2.8 · 9728/2 = 3040 #/BOLT, ULT.

SHEAR PER BOLT = 9728/4 = 2432 #, ULT.

R_T = 3040/4656 = .65 R_S = 2432/3720 = .65 (FOR 400 °F)

USING THE INTERACTION EQ. $R_S^3 + R_T^2 = 1$, U = .65/.75 = .87

(REF MIL·HNDBK·5)

ULT. M.S. = $\frac{1}{.87} - 1$ = **.15**

THE FITTING AND BASIC WING STRUCTURE WERE SATISFACTORILY PROOF TESTED TO A PRELIMINARY UP LOAD OF 5420 #. REF. STRUCT. PROOF TEST PROG. REPT. 63B048.