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A.T.I.

53414

Stress Analysis of Vertical Surfaces | 53414

Beard, N. W. | (None)

Consolidated Vultee Aircraft Corp., Fort Worth Division, Texas | R-FZS-36-247

USAF Contr. No. W535-ac-22352

(None)

Nov '47 Unclass. U.S. English 117 tables, diagrs, graph

A stress analysis is made of the vertical tail surfaces of the XB-36 bomber. Using methods previously employed, loads, yaw and gust conditions, rudder shears and bending moments, rudder structural characteristics, tab effects and rudder torsions, rudder pressure distributions, and net rudder spar shear flows have been determined. Summaries are included of design loads and rudder hinge loads. Results of the analysis are shown in tables, diagrams, graphs, and formulas.

Copies of this report obtainable from CADO. (1)

Structures (7)

Stress Analysis of Specific Aircraft (6)

B-36 - Stress analysis (14884.005); XB-36 (99409); Tails, Vertical - Stress analysis (91633.68)

USAF C. N. W535-ac-22352

UNCLASSIFIED

CONSOLIDATED VULTEE

MODEL X[illegible]-6

REPORT [illegible]47

DATE [illegible] November 1947

TITLE

STRESS ANALYSIS

OF

VERTICAL TAIL SURFACES

SUBMITTED UNDER

Contract W535-ac-22352

PREPARED BY: M. W. Beard

GROUP: STRUCTURES

REFERENCE:

CHECKED BY: H. Fisberg

APPROVED BY:

NO. OF PAGES 114

NO. OF DIAGRAMS 29

REVISIONS

NO	DATE	BY	CHANGE	PAGES AFFECTED

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

INTRODUCTION

This report contains the stress analysis of the vertical tail surfaces for the XB-36 Airplane.

The fin and dorsal fin of the XB-36 are exactly the same as the YB-36 and B-36A, while the rudder construction is somewhat different. The method employed in this analysis is to determine loadings for the tail surfaces, show a complete analysis for the rudder, and show a comparison of loadings and margins of safety between XB-36 and B-36A for the fin.

In general, the method of analysis used in this report is the same as for the B-36A (FZS-36-147), and wherever possible, reference is made to results obtained therein. For the sake of brevity, and the elimination of duplication of information, any data shown in FZS-36-147 is referred to by page number, and not repeated in this report.

DESIGN CONDITIONS

THE VERTICAL TAIL IS INVESTIGATED FOR THE FOLLOWING CONDITIONS TAKEN FROM C1803-6 DATED SEPT. 16, 1944, PAR. E 3(a) THROUGH E 3(d)

1. STEADY YAW CONDITIONS ~ RUDDER NEUTRAL, AND RUDDER DEFLECTED FOR TRIM.

2. UNSYMMETRICAL THRUST + GUST.

3. GUST.

4. UNSYMMETRICAL THRUST.

TWO DEVIATIONS HAVE BEEN GRANTED FROM C1803-6 ~ REF. SPEC. ZD-36-001B, P.114:

(a) 4.38° STEADY YAW IN LIEU OF 5°.

(b) GUST VELOCITY OF 40 FT./SEC. IN LIEU OF 50 FT./SEC.

RUDDER

REF DWG 36T1145

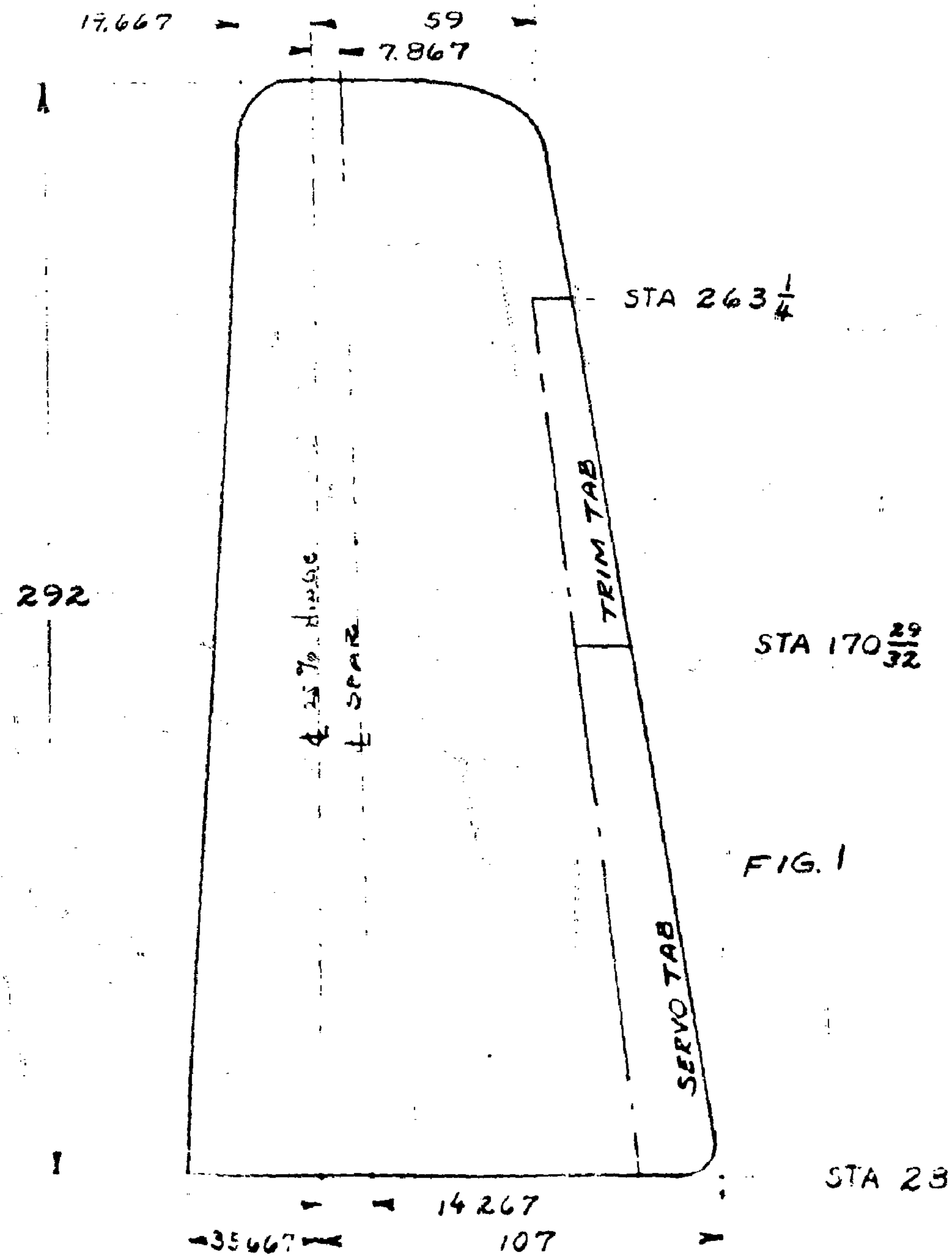


FIG. 1

DETERMINATION OF LOADS

YAW CONDITIONS:

IN ALL YAW CALCULATIONS, THE METHOD DESCRIBED IN FZS-36-147 IS USED, AND THE CURVES ON P.7 OF THAT REPORT ARE EMPLOYED.

$Y.M. = \frac{1}{2} \rho V_D^2 \sigma S_w C_N b$

WHERE:

V_D = 311 M.P.H. @ 5000'

σ = .8616

S_w = 4772 □'

b = 230'

C_N = Y.M. COEFF. FROM FZS-36-147, P.7

$Y.M. = .002558 (311)^2 \times .8616 \times 4772 \times 230 \times C_N = 233,967,360\ C_N$ '#

TAIL ARM = 72.04'

η_t = 1.0

LOAD DUE TO $\delta_R = q S_T \delta_R \times$ (AREA UNDER P_d CURVE)

LOAD FROM α_T = TOTAL LOAD − LOAD FROM δ_R

LOAD FROM $\psi = q S_T \psi_{EFF} \times$ (AREA UNDER P_α CURVE)

NET PRESS DISTRIB. $= q \left[\delta_R P_d + \psi_{EFF} P_\alpha \right]$

CURVES FOR P_α & P_d ARE GIVEN IN REPORT FZS-36-147.

NOTE q = .002558 (311)² × .8616 = 213.17 #/□'

DETERMINATION OF LOADS

STEADY YAW $\psi = 4.38°$ $\delta_R = 0$

C_N (AIRPLANE) = −.0055 C_N (LESS TAIL) = +.0015

$C_N = C_N(\text{AIRPLANE}) - C_N(\text{LESS TAIL}) = -.0055 - .0015 = -.0070$

Y.M. = 233,967,360 (−.0070) = −1,637,772 FT. LBS

$$\text{TAIL LOAD} = \frac{-1,637,772}{-72.04} = 22,734^{*} \text{ (LIMIT)}$$

$$q\, S_T\, \eta_V \times \text{AREA UNDER } \frac{\Delta P_\alpha}{q} \text{ CURVE} = 22,734^{\#}$$

$$\therefore \alpha_V = \frac{22,734}{213.17 \times 522 \times .0431^{*}} = 4.65°$$

$$\text{PRESSURE} = q[\alpha P_\alpha + \delta_R P_\delta] \quad , \delta_R = 0$$

$$= +4.65\, q\, P_\alpha$$

STEADY YAW $\psi = -4.38°$; $\delta_R = 0$

C_N (AIRPLANE) = +.0088 C_N (LESS TAIL) = +.0017

$C_N = .0088 - .0017 = .0071$

Y.M. = 233,967,360 (.0071) = 1,661,168 '#

$$\text{TAIL LOAD} = \frac{1,661,168}{-72.04} = -23,059^{\#} \text{ (LIMIT)}$$

$$\alpha_V = -\frac{23,059}{213.17 \times 522 \times .0431^{*}} = -4.72°$$

PRESSURE = $-4.72\, q\, P_\alpha$

*AREA UNDER P_α CURVE = .0431 (REF. FZS-36-147)

DETERMINATION OF LOADS (CONT'D)

STEADY YAW — $\psi = 4.38$ δ_R FOR TRIM

$C_N = 0$ $\delta_R = -5.6°$ (REF. FZS-36-147 P.7)

LOAD FOR RUDDER TO OVERCOME = 22,734* (LIMIT)

(AS PER $\delta_R = 0$ — P.5)

$\alpha_t = 4.65°$

PRESSURE = $q[\alpha P_\alpha + \delta_R P_\delta] = q[+4.65 P_\alpha - 5.6 P_\delta]$

LOAD = $Sq[\alpha P_\alpha + \delta_R P_\delta]$

$= 522 \times 213.17[4.65 \times .0439 - 5.6 \times .02634]$

$= 6,248$* (LIMIT)

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM

$C_N = 0$ $\delta_R = +1.5°$ (REF FZS-36-147, P.7)

LOAD FOR RUDDER TO OVERCOME = -23,054* (REF. P.5)

$\alpha_t = -4.72°$

PRESSURE = $q[-4.72 P_\alpha + 1.5 P_\delta]$

LOAD = $522 \times 213.17[-4.72 \times .0439 + 1.5 \times .02634)$

$= 4,787$* (LIMIT)

ANALYSIS: VERT TAIL
PREPARED BY: BEARD
CHECKED BY: ZINBERG

TABLE NO. 1

PRESSURE DISTRIBUTION - ABOVE DORSAL - VERTICAL TAIL - STEADY YAW

			$\psi = +4.38°$		$\psi = -4.38°$		$\psi = +4.38°$					
ψ/c	P_α (ABOVE DORSAL)	P_δ (ABOVE DORSAL)	$(\delta_R = 0)$ +4.65 P_α	ΔP #/□' (4) × 213.17	$(\delta_R = 0)$ -4.72 P_α	ΔP #/□' (6) × 213.17	-5.6 P_δ	$\Delta P/q$ (4) + (8)	ΔP #/□' (9) × 213.17	+9.5 P_δ	$\Delta P/q$ (6) + (11)	ΔP #/□' (12) × 213.17
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0	0	0	0	0	0	0	0	0	0	0	0	0
.010	.0470	.0270	.2186	46.38	-.2218	-47.28	-.1512	.0674	14.37	.2565	.0347	7.40
.020	.0960	.0380	.4464	94.71	-.4531	-96.59	-.2128	.2336	49.80	.3610	-.0921	-19.63
.025	.1160	.0395	.5394	114.44	-.5475	-116.71	-.2212	.3182	67.83	.3752	-.1723	-36.73
.030	.1400	.0405	.6510	138.12	-.6608	-140.86	-.2268	.4242	90.43	.3848	-.2760	-58.83
.040	.1520	.0415	.7068	149.96	-.7174	-152.93	-.2324	.4744	101.13	.3943	-.3231	-68.88
.050	.1540	.0405	.7161	151.93	-.7269	-154.95	-.2268	.4893	104.30	.3848	-.3421	-72.93
.060	.1585	.0395	.7138	151.45	-.7245	-154.44	-.2212	.4926	105.01	.3753	-.3492	-74.44
.075	.1500	.0365	.6975	147.99	-.7080	-150.92	-.2044	.4931	105.11	.3468	-.3612	-77.00
.100	.1400	.0330	.6510	138.12	-.6608	-140.86	-.1848	.4662	99.38	.3135	-.3473	-74.03
.150	.1130	.0260	.5255	111.50	-.5334	-113.70	-.1456	.3799	80.98	.2470	-.2864	-61.05
.200	.0875	.0200	.4069	86.33	-.4130	-88.04	-.1120	.2949	62.86	.1900	-.2230	-47.54
.300	.0365	.0100	.1697	36.00	-.1723	-36.73	-.0560	.1137	24.24	.0950	-.0773	-16.48
.350	.0100	.0060	.0465	9.87	-.0472	-10.06	-.0336	.0129	2.75	.0570	.0098	2.09
.375	-.0025	.0040	-.0116	-2.46	.0118	2.52	-.0224	-.0340	-7.25	.0380	.0498	10.62
.400	-.0075	.0025	-.0349	-7.40	.0354	7.55	-.0140	-.0489	-10.42	.0238	.0592	12.62
.425	-.0045	.0010	-.0209	-4.43	.0212	4.52	-.0056	-.0265	-5.65	.0095	.0307	6.54
.450	.0375	.0400	.1744	37.00	-.1770	-37.73	-.2240	-.0496	-10.57	.3800	.2030	43.27
.475	.0720	.0925	.3348	71.03	-.3398	-72.44	-.5180	-.1832	-39.05	.8788	.5390	114.90
.500	.0640	.0870	.2976	63.14	-.3021	-64.40	-.4872	-.1896	-40.42	.8265	.5244	111.79
.550	.0450	[illegible]	.2093	44.41	-.2124	-45.28	-.3584	-.1491	-31.78	.6080	.3956	84.33
.600	.0335	.0495	.1558	33.06	-.1581	-33.70	-.2772	-.1214	-25.88	.4703	.3122	66.55
.650	.0250	.0380	.1163	24.68	-.1180	-25.15	-.2128	-.0965	-20.57	.3610	.2430	51.80
.700	.0200	.0285	.0930	19.73	-.0944	-20.12	-.1596	-.0666	-14.20	.2708	.1764	37.60
.750	.0160	.0210	.0744	15.79	-.0755	-16.09	-.1176	-.0432	-9.21	.1995	.1240	26.43
.800	.0125	.0150	.0581	12.33	-.0590	-12.58	-.0840	-.0259	-5.52	.1425	.0835	17.80
.850	.0095	.0100	.0442	9.38	-.0448	-9.55	-.0560	-.0118	-2.52	.0950	.0502	10.70
.900	.0060	.0060	.0279	5.92	-.0283	-6.03	-.0336	-.0057	-1.22	.0570	.0287	6.12
.950	.0030	.0030	.0140	2.97	-.0142	-3.03	-.0168	-.0028	-.60	.0285	.0143	3.05
1.000	0	0	0	0	0	0	0	0	0	0	0	0

ANALYSIS: VERT. TAIL
PREPARED BY: BEARD
CHECKED BY: ZINBERG

PAGE:
REP. NO.: FZ
MODEL: X
DATE 4-9-4

TABLE NO. 2

ESSURE DISTRIBUTION - INCL. DORSAL - VERT. TAIL - STEADY YAW

			$\psi = +4.38°$		$\psi = -4.38$		$\psi = +4.38°$			$\psi = -4.38°$		
x/c	P_a (INCLUDING DORSAL)	P_δ (INCLUDING DORSAL)	($\delta_R = 0$) +4.65 P_a	ΔP #/□' (4) × 213.17	($\delta_R = 0$) -4.72 P_a	ΔP #/□' (6) × 213.17	-5.6 P_δ	$\Delta P/q$ (4)+(8)	ΔP #/□' (9) × 213.17	.95 P_δ	$\Delta P/q$ (6)+(11)	ΔP #/□'' (12) × 213.17
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0	0	0	0	0	0	0	0	0	0	0	0	0
.010	.0300	.0150	.1395	29.74	-.1416	-30.18	-.0840	.0555	11.83	.1425	.0009	.19
.020	.0610	.0300	.2837	60.48	-.2879	-61.37	-.1680	.1157	24.66	.2850	-.0029	-.62
.025	.0760	.0355	.3534	75.33	-.3587	-76.46	-.1988	.1546	32.96	.3373	-.0214	-4.56
.030	.0920	.0380	.4278	91.19	-.4342	-92.56	-.2128	.2150	45.83	.3610	-.0732	-15.60
.035	.1060	.0395	.4929	105.07	-.5003	-106.65	-.2212	.2717	57.92	.3753	-.1250	-26.65
.050	.1340	.0405	.6231	132.83	-.6325	-134.83	-.2268	.3963	84.48	.3848	-.2477	-52.80
.060	.1375	.0400	.6394	136.30	-.6490	-138.35	-.2240	.4154	88.55	.3800	-.2690	-57.34
.075	.1390	.0380	.6464	137.79	-.6561	-139.86	-.2128	.4336	92.43	.3610	-.2951	-62.91
.100	.1365	.0350	.6347	135.30	-.6443	-137.35	-.1960	.4387	93.52	.3325	-.3118	-66.47
.150	.1195	.0295	.5557	118.46	-.5640	-120.23	-.1652	.3905	83.24	.2803	-.2837	-60.48
.200	.1005	.0245	.4673	99.61	-.4744	-101.13	-.1372	.3301	70.37	.2328	-.2416	-51.50
[illegible]	.0625	.0160	.2906	61.95	-.2950	-62.88	-.0896	.2010	42.85	.1520	-.1430	-30.48
[illegible]	.0440	.0120	.2046	43.61	-.2077	-44.28	-.0672	.1374	29.29	.1140	-.0937	-19.97
[illegible]	.0345	.0105	.1604	34.19	-.1628	-34.70	-.0588	.1016	21.66	.0998	-.0630	-13.43
[illegible]	.0255	.0095	.1186	25.28	-.1204	-25.67	-.0532	.0654	13.94	.0903	-.0301	-6.42
[illegible]	.0155	.0075	.0721	15.37	-.0732	-15.60	-.0420	.0301	6.42	.0713	-.0019	-.41
[illegible]	[illegible]	.0065	.0279	5.95	-.0283	-6.03	-.0364	-.0085	-1.81	.0618	.0335	7.14
[illegible]	[illegible]	.0055	-.0140	-2.98	.0142	3.03	-.0308	-.0448	-9.55	.0523	.0665	14.18
[illegible]	-.0090	.0040	-.0419	-8.93	.0425	9.06	-.0224	-.0643	-13.71	.0380	.0805	17.16
[illegible]	-.0130	.0025	-.0605	-12.90	.0614	13.09	-.0140	-.0745	-15.88	.0238	.0852	18.16
.550	-.0140	.0015	-.0651	-13.88	.0661	14.09	-.0084	-.0735	-15.67	.0143	.0804	17.14
.575	-.0100	.0005	-.0465	-9.91	.0472	10.06	-.0028	-.0493	-10.51	.0048	.0520	11.08
.600	.0760	.0400	.3534	75.33	-.3587	-76.46	-.2240	.1294	27.58	.3800	.0213	4.54
.610	.0805	.0900	.3743	79.79	-.3800	-81.00	-.5040	-.1297	-27.65	.8550	.4750	101.26
.620	.0785	.1095	.3650	77.81	-.3705	-78.98	-.6132	-.2482	-52.91	1.0403	.6698	142.78
.650	.0565	.1010	.2627	56.00	-.2667	-56.85	-.5656	-.3029	-64.57	.9595	.6928	147.68
.700	.0355	.0680	.1651	35.19	-.1676	-35.73	-.3808	-.2157	-45.98	.6460	.4784	101.98
.750	.0225	.0440	.1046	22.30	-.1062	-22.64	-.2464	-.1418	-30.23	.4180	.3118	66.47
.800	.0140	.0280	.0651	13.88	-.0661	-14.09	-.1568	-.0917	-19.55	.2660	.1999	42.61
.850	.0080	.0165	.0372	7.93	-.0378	-8.06	-.0924	-.0552	-11.77	.1568	.1190	25.37
.900	.0040	.0085	.0186	3.96	-.0189	-4.03	-.0476	-.0290	-6.18	.0808	.0619	13.20
.950	.0020	.0025	.0093	1.98	-.0094	-2.00	-.0140	-.0047	-1.00	.0238	.0144	3.07
1.000	0	0	0	0	0	0	0	0	0	0	0	0

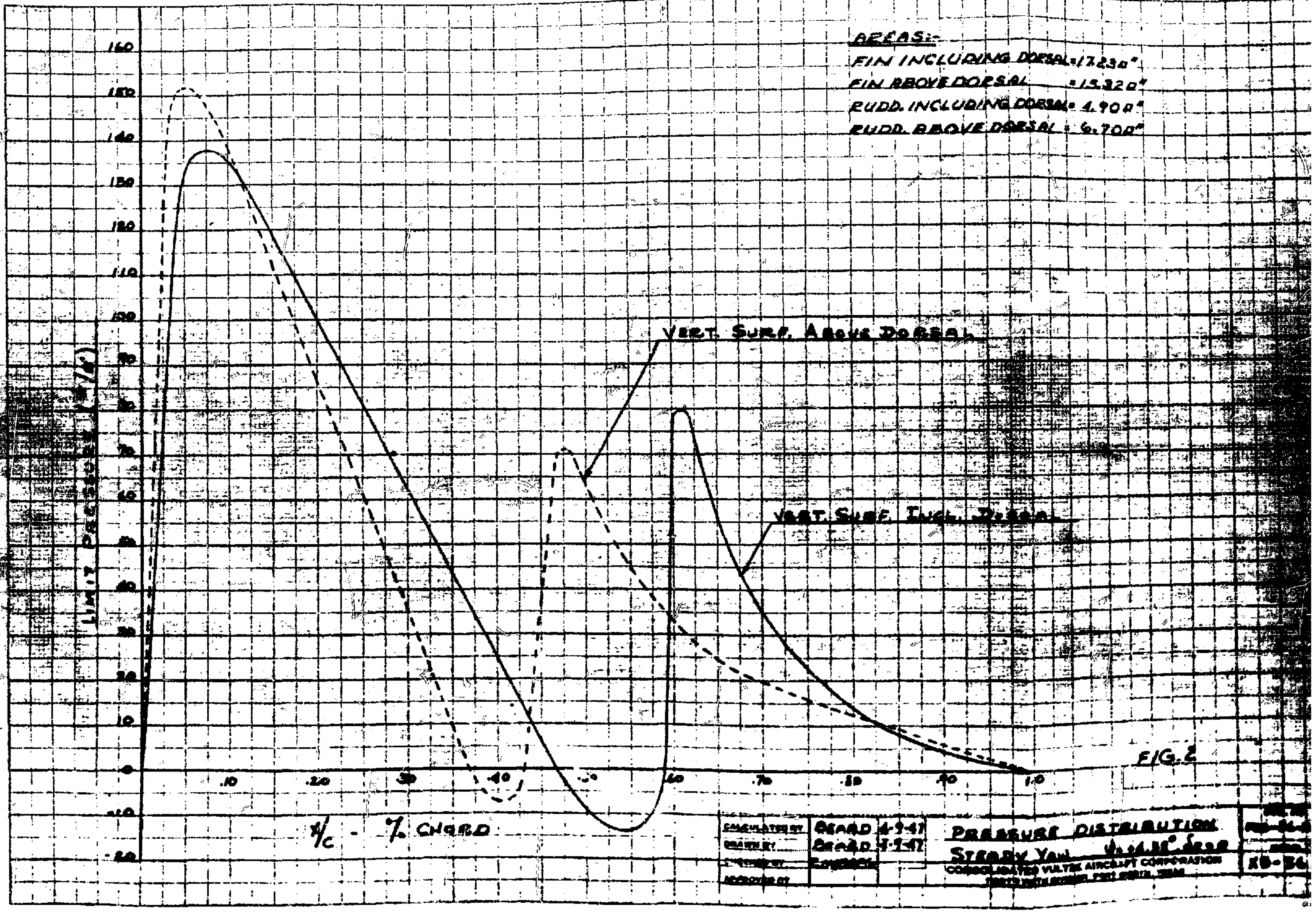

AREAS:-
FIN INCLUDING DORSAL = 17.23 □"
FIN ABOVE DORSAL = 15.32 □"
RUDD. INCLUDING DORSAL = 4.90 □"
RUDD. ABOVE DORSAL = 4.70 □"
VERT. SURF. ABOVE DORSAL
VERT. SURF. INCL. DORSAL
LIMIT PRESSURE
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.0
x/c - % CHORD
CALCULATED BY
DRAWN BY
CHECKED BY
APPROVED BY
BEARD 4-9-47
BEARD 4-9-47
PRESSURE DISTRIBUTION
STEADY YAW
CONSOLIDATED VULTEE AIRCRAFT CORPORATION
XB-36

FIG. 2

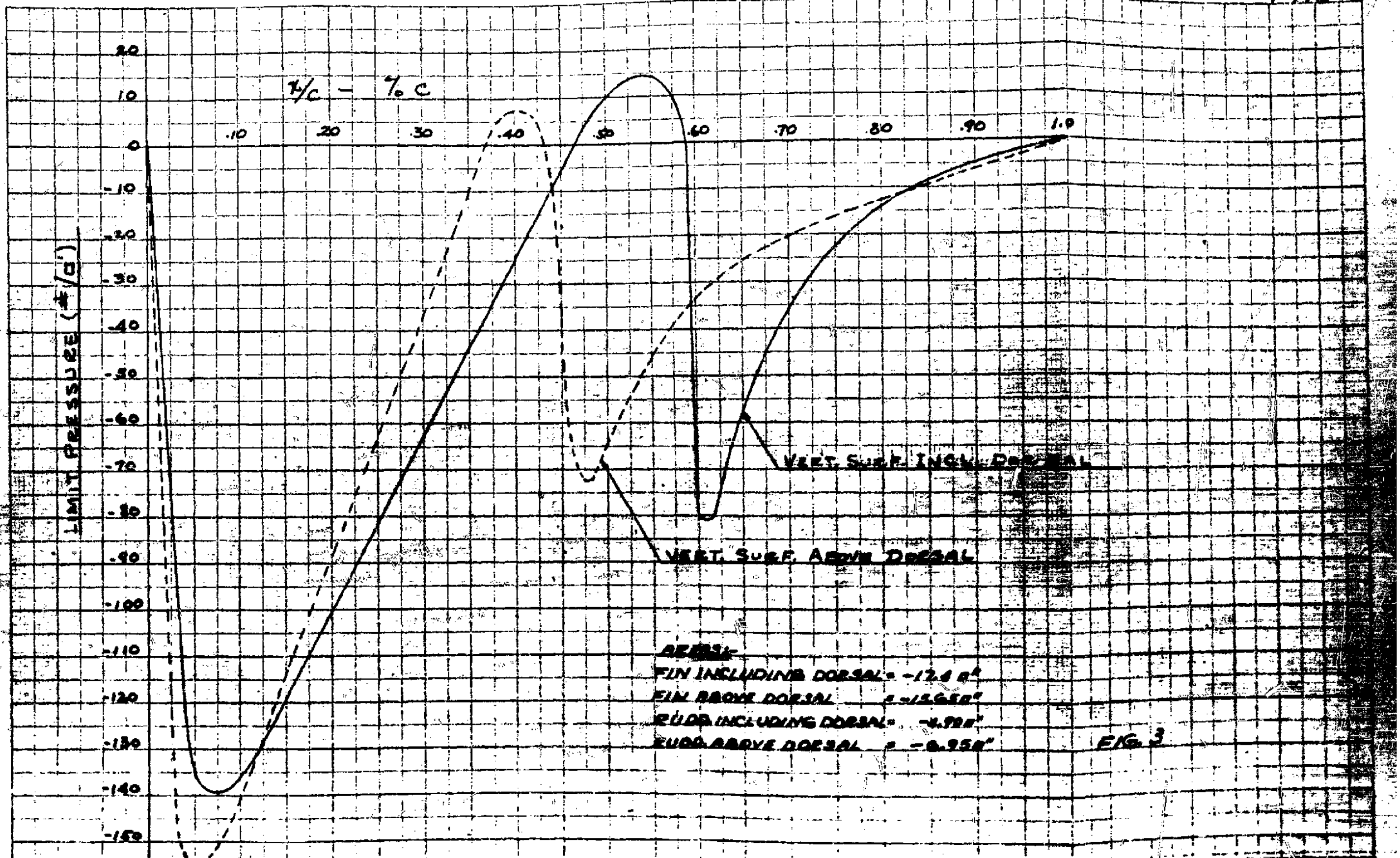
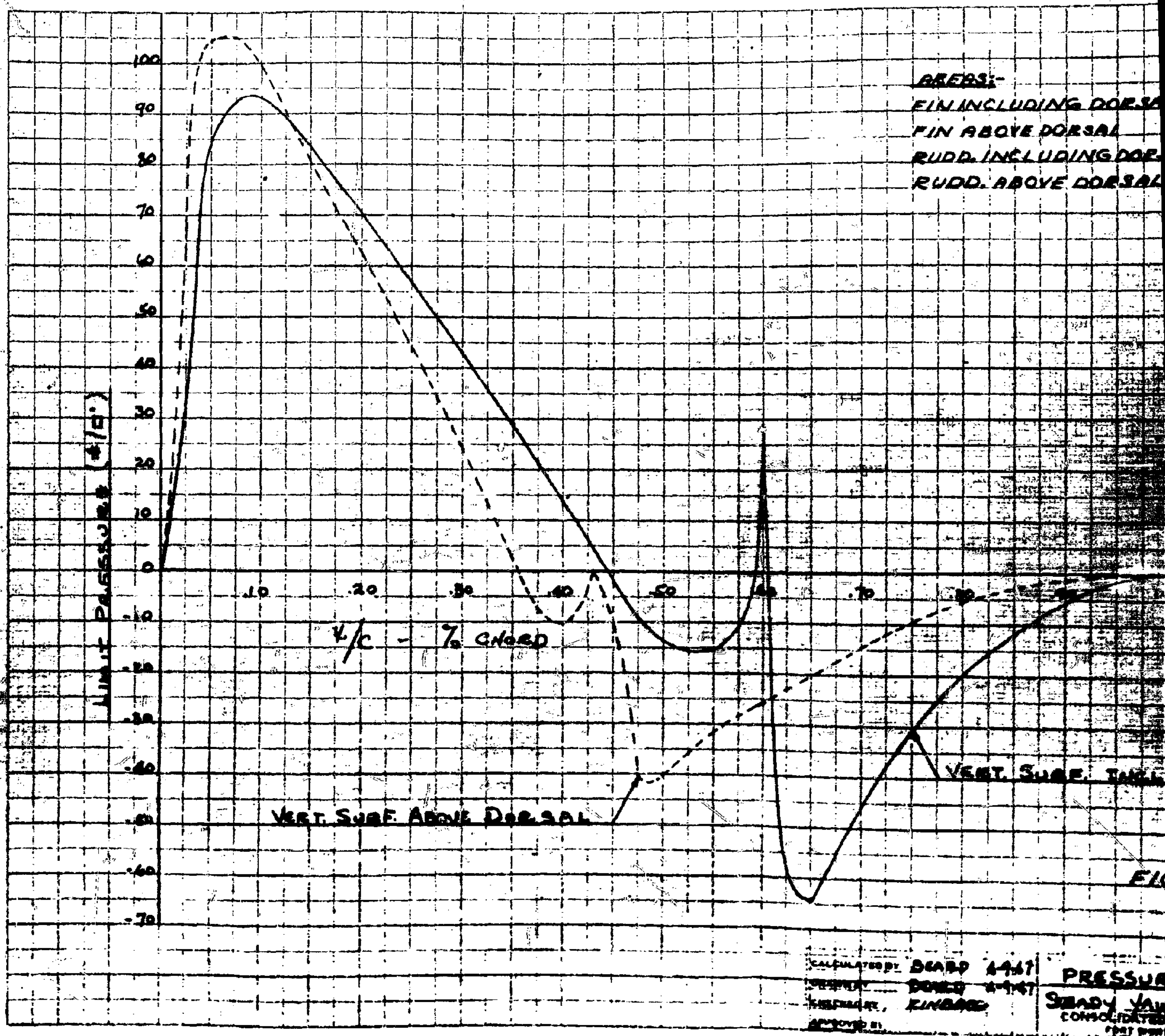


FIG. 3

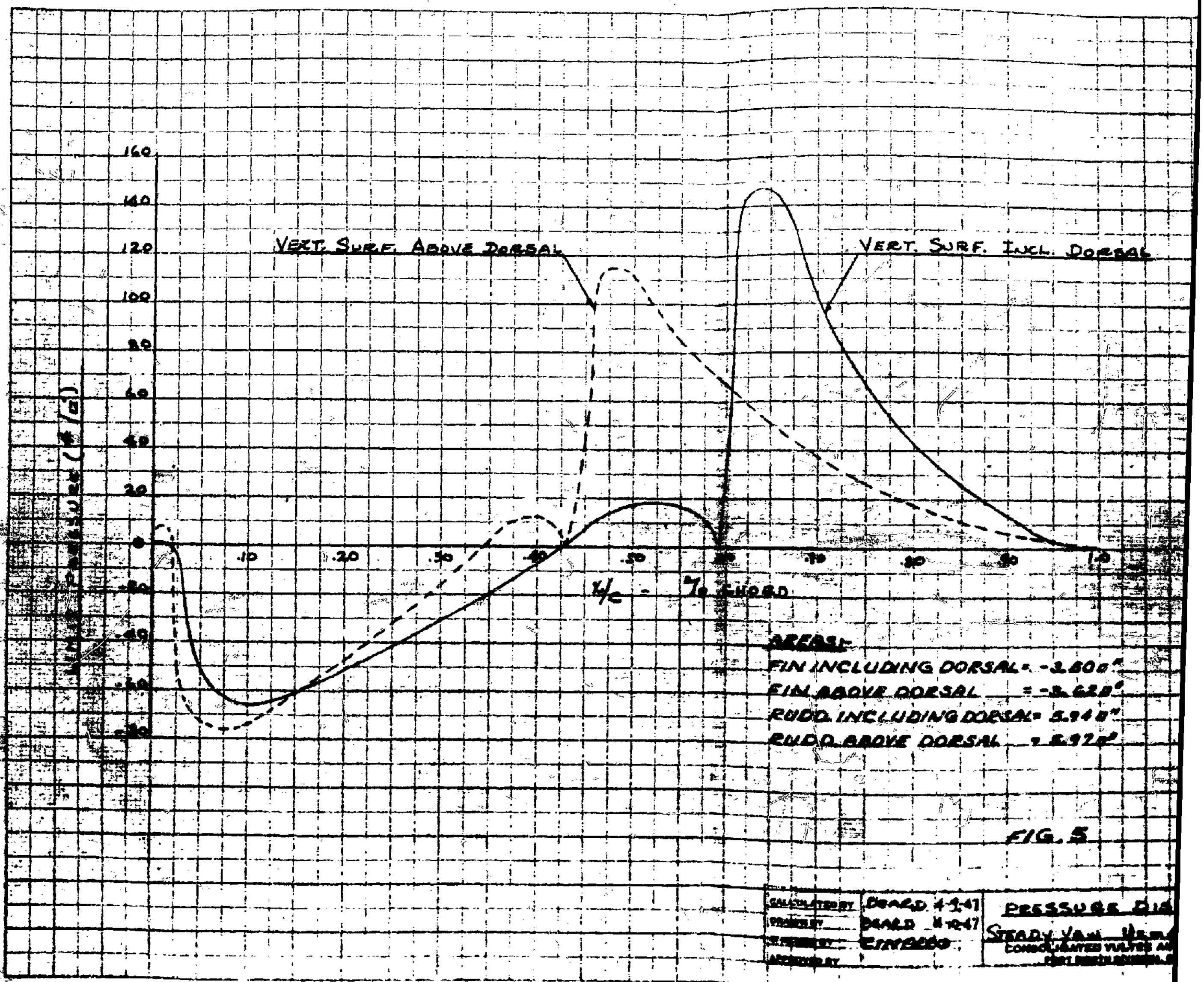
CALCULATED BY BEARD 4-1-47
DRAWN BY BEARD
CHECKED BY ZINBERG
APPROVED BY

PRESSURE DISTRIBUTION
STEADY YAW
CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION, FORT WORTH, TEXAS

[redacted]



100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
.10
.20
.30
.40
.50
.60
.70
.80
LIMIT PRESSURE (#/□')
X/C - % CHORD
AREAS:-
FIN INCLUDING DORSA
FIN ABOVE DORSAL
RUDD. INCLUDING DOR.
RUDD. ABOVE DORSAL
VERT. SURF. ABOVE DORSAL
VERT. SURF. INCL
FIG
CALCULATED BY BEARD 6-9-47
BEARD 6-9-47
CHECKED BY KINBACK
APPROVED BY
PRESSUR
STEADY YAW
CONSOLIDATED
FORT WORTH



VERT. SURF. ABOVE DORSAL
VERT. SURF. INCL. DORSAL
160
140
120
100
20
.10
.20
.30
.40
.50
1.0
x/c - % CHORD
AREAS:-
FIN INCLUDING DORSAL = -3.80 □"
FIN ABOVE DORSAL = -3.62 □"
RUDD. INCLUDING DORSAL = 5.94 □"
RUDD. ABOVE DORSAL = 5.92 □"
CALCULATED BY
DRAWN BY
CHECKED BY
APPROVED BY
PRESSURE DI
STEADY VAW
CONSOLIDATED VULTEE

FIG. 5

DETERMINATION OF LOADS

AREA VERTICAL TAIL INCLUDING DORSAL

(REF. FZS-36-147 FOR DIMENSIONS)

FIN AREA INCLUDING DORSAL = 169.21
RUDDER AREA INCLUDING DORSAL = 88.94
INEFFECTIVE RUDDER AREA = 28.34
AREA INCLUDING DORSAL = 286.49 □'

AREA VERTICAL TAIL ABOVE DORSAL

FIN AREA ABOVE DORSAL = 106.42
RUDDER AREA ABOVE DORSAL = 129.15
AREA ABOVE DORSAL = 235.57 □'

STEADY YAW $\psi = +4.38^\circ$ $\delta_E = 0$

(REF. P.9)

FIN LOAD INCLUDING DORSAL = 17.23×2×286.49 = 9860#
FIN LOAD ABOVE DORSAL = 15.35×2×235.57 = 7230
TOTAL FIN LOAD (LIMIT) = 17090#

RUDDER LD. INC. DORSAL = 4.90×2×286.49 = 2,810#
RUDDER LD. ABOVE " = 6.70×2×235.57 = 3,160
TOTAL RUDDER LOAD (LIMIT) = 5,970#
(NOTE: THIS RUDDER LOAD INCLUDES LOAD ON INEFFECTIVE PORTION OF RUDDER)

VERTICAL TAIL LOAD = 17,090 + 5970 = 23,060# (LIMIT)

STEADY YAW $\psi = -4.38^\circ$ $\delta_E = 0$

(REF. P.10)

FIN LOAD INC. DORSAL = -17.40×2×286.49 = -9,970#
FIN LOAD ABOVE DORSAL = -15.65×2×235.57 = -7,360
TOTAL FIN LOAD (LIMIT) = -17,330#

RUDDER LD. INC. DORSAL = -4.90×2×286.49 = -2,810
RUDDER LD. ABOVE DORSAL = -6.95×2×235.57 = -3,270
TOTAL RUDDER LOAD (LIMIT) = -6,080#

VERT. TAIL LOAD = -23910# (LIMIT)

12
XB-36

DETERMINATION OF LOAD

STEADY YAW $\psi = 4.38°$ δ_R FOR TRIM
(REF. P. 11)

FIN LOAD INCLUDING DORSAL = +11.05 × 2 × 286.49 = 6,340#
FIN LOAD ABOVE DORSAL = +10.36 × 2 × 235.57 = 4,880
TOTAL FIN LOAD (LIMIT) = +11,220#

RUDDER LD. INCL. DORSAL = −4.71 × 2 × 286.49 = −2700#
RUDDER LD ABOVE DORSAL = −4.09 × 2 × 235.57 = −1,925
TOTAL RUDDER LOAD (LIMIT) = −4,625#

VERTICAL TAIL LOAD = 11,220 − 4,625 = 6,595# (LIMIT)

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM
(REF. P. 12)

FIN LOAD INCL. DORSAL = −3.50 × 4 × 286.49 = −4,010#
FIN LOAD ABOVE DORSAL = −3.62 × 4 × 235.57 = −3,410
TOTAL FIN LOAD (LIMIT) = −7,420#

RUDDER LOAD INCL. DORSAL = 5.74 × 4 × 286.49 = 6,590#
RUDDER LOAD ABOVE " = 5.97 × 4 × 235.57 = 5,630
TOTAL RUDDER LOAD (LIMIT) = 12,220#

VERTICAL TAIL LOAD = +4,800#

DETERMINATION OF LOADS

GUST CONDITION

GUST VELOCITY = 40 FT/SEC

$w = 4.0\, m\, V_H\, \sigma^{1/2}$

V_H = 311 m.p.h. @ 5,000'

$m = .0439\ C_L/°$ INCL. END PLATE EFFECT

$\sigma^{1/2} = (.8616)^{1/2} = .928$ @ 5,000'

$w = 4.0 \times .0439 \times 311 \times .928 = 50.7$ #/□' (AVERAGE LIMIT)

TOTAL LOAD = 50.7 × 522.06 = 26,500# (LIMIT)

THE CHORDWISE DISTRIBUTION IS ACCORDING TO C-1803-6, BEING TRIANGULAR IN SHAPE, HAVING ITS PEAK AT THE LEADING EDGE OF THE FIN AND TAPERING TO ZERO AT THE TRAILING EDGE OF THE RUDDER. THE LEADING EDGE PRESSURE IS TWICE THE AVERAGE PRESSURE OR 101.4 #/□' (LIMIT)

SUMMATION OF LOADS ∞ GUST CONDITION

INTEGRATION OF LOADING CURVES FIG. 6 P. 17 GIVE FOLLOWING LOADS:

RUDDER LOAD FROM TIP TO STA 0 = 6,150#

RUDDER LOAD ON INEFFECTIVE PORTION FROM STA 28 TO STA 0 = 528

LOAD ON EFFECTIVE RUDDER = 5,622# (LIMIT) = 8,433# (ULT.)

LOAD ON FIN = 20,350#

AV. RUDDER SPANWISE LOADING = $\frac{6,150}{308.6}$ = 19.93 #/IN (LIMIT)

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH, TEXAS
FW 633 125 PADS 11-43

TABLE NO. 3
FIN & RUDDER SPANWISE LOADING
GUST CONDITION

STA.	TOTAL CHORD	FIN CHORD	RUDDER CHORD	LD. @ FIN L.E. #/□'	LD. @ FIN T.E. #/□'	FIN SPANWISE LD. (#/IN)	RUDDER SPANWISE LD. (#/IN)
①	②	③	④	⑤	⑥	⑦	⑧
						$\frac{⑤+⑥}{2\times144}\times③$	$\frac{⑥}{2\times144}\times④$
308.6	125.37	44.20	81.17	101.4	65.70	25.70	18.53
261.0	156.16	64.56	91.60		59.55	36.08	18.96
206.0	191.74	88.08	103.66		54.30	47.75	19.02
180.0	208.56	99.20	109.36		53.20	53.20	20.23
125.0	244.14	122.72	121.42		50.50	64.60	21.30
100.0	278.50	151.60	126.90		46.20	77.60	20.38
64.0	327.98	193.19	134.79		41.70	96.00	19.51
28.0	377.46	234.78	142.68		38.35	113.90	19.00
0	415.94	267.13	148.81	101.4	36.30	128.50	18.75

REF. FZS-36-247
MODEL XB-36
DATE: 4-10-47
PREP. BY: BEARD
CKD. BY: ZINBERG

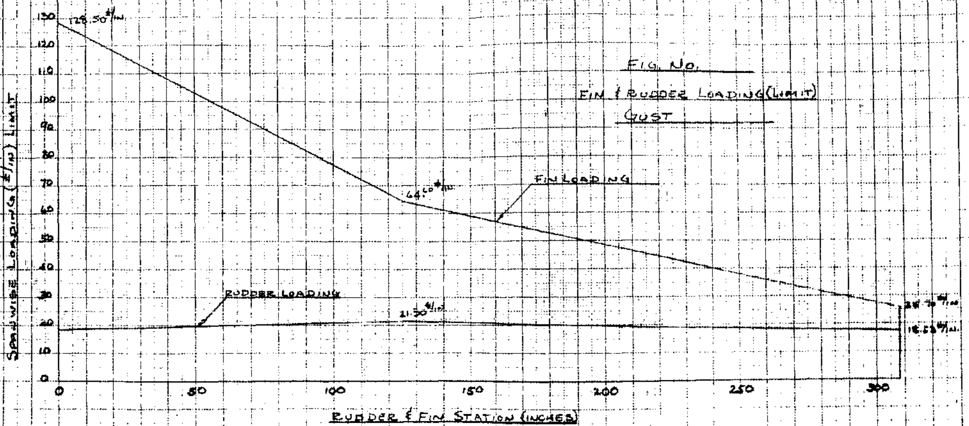


FIG. 6

	BEARD 6-10-47	FIN & RUDDER LOADING	FZS-36-247
	BEARD 6-10-47	GUST CONDITION	
	ZINBERG		XB-36

SUMMARY OF DESIGN LOADS

CONDITION	LIMIT LOADS		ULTIMATE LOADS	
	FIN	RUDDER	FIN	RUDDER
STEADY YAW $\psi = -4.38°$ $\delta_R = 0$	-17,330	-6,080	-25,995	-9,120
STEADY YAW $\psi = +4.38°$ δ_R FOR TRIM	+11,220	-4,625	+16,830	-6,938
STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM	-7,420	+12,220	-11,130	+18,330
* UNSYMMETRICAL THRUST + GUST	+14,755	+7,808	+22,133	+11,712
GUST	+20,350	+6,150	+30,525	+9,225

NOTE: RUDDER LOADS INCLUDE INEFFECTIVE RUDDER BETWEEN STA. 0 & STA. 28

* UNSYMMETRICAL THRUST + GUST SAME AS FOR B-36A & YB-36 - REF. FZS-36-147.

AS IN FZS-36-147, UNSYMMETRIC THRUST IS NOT CRITICAL AND NEED NOT BE INVESTIGATED.

RUDDER SHEARS & BENDING MOMENTS

RUDDER SHEARS AND BENDING MOMENTS ARE COMPUTED IN THIS SECTION OF THE REPORT.

THE METHOD OF ANALYSIS USED HEREIN IS THE SAME AS IS DESCRIBED IN DETAIL IN REPORT FZS-36-147.

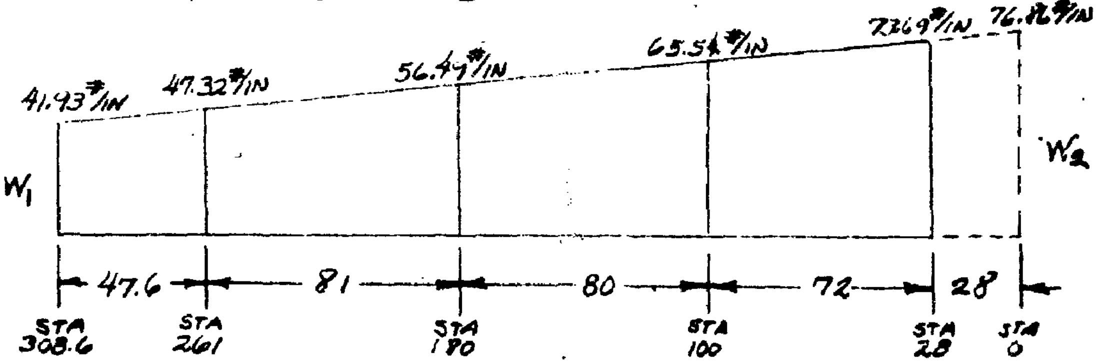
SINCE THE XB36 RUDDER CONSTRUCTION IS CONSIDERABLY DIFFERENT THAN THAT OF THE YB36 AND B36A (FZS-36-147), DIFFERENT STIFFNESS AND CARRY-OVER FACTORS ARE COMPUTED.

A COMPLETE SET OF COMPUTATIONS IS SHOWN FOR THE CONDITION $-4.38°$ YAW, δ_R FOR TRIM. ONLY FINAL RESULTS ARE SHOWN FOR THE REMAINING CONDITIONS.

RUDDER-DETERMINATION OF SPANWISE LOADING

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM

RUDDER LOAD = +18,330# ULTIMATE (INCL. INEFF. LD. REF. P.18)
FIN LOAD = -11,130# ULTIMATE (REF. P.18)
RUDDER CHORD @ STA 0 = 148.81
RUDDER CHORD @ STA 308.6 = 81.17



$$W_2 = \frac{148.81}{81.17} W_1 = 1.833\,W_1$$

$$\frac{W_1 + 1.833\,W_1}{2} \times 308.6 = 18,330^{\#}$$

$W_1 = 41.93$ #/IN
$W_2 = 76.86$ #/IN

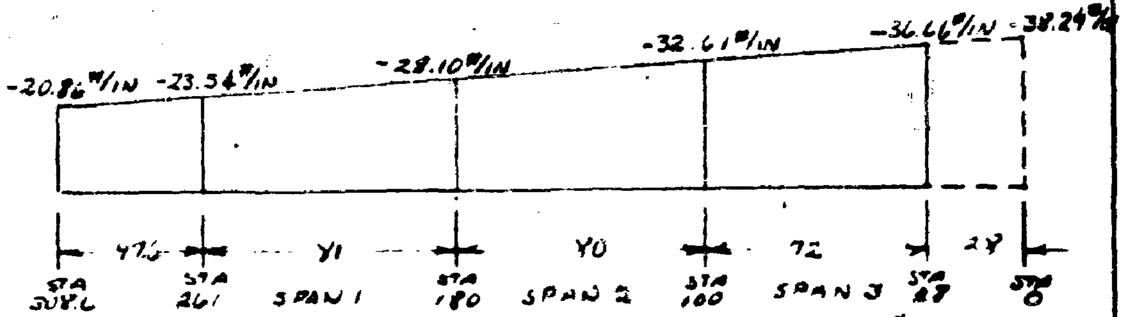
EFFECTIVE RUDDER LOAD = 16,222# (ULT)

STEADY YAW $\psi = -4.38°$ $\delta_R = 0$ (REF. P.18)

RUDDER LOAD = -9,120# (ULT); FIN LOAD = -25,995# (ULT)

$$\frac{W_1 + 1.833\,W_1}{2} \times 308.6 = -9120 \qquad W_1 = -\frac{9120}{437.132} = 20.86^{\#}/IN$$

$$W_2 = 1.833 \times 2086 = 38.24^{\#}/IN$$



EFFECTIVE RUDDER LOAD = -8,070# ULT

RUDDER - DETERMINATION OF SPANWISE LOADING

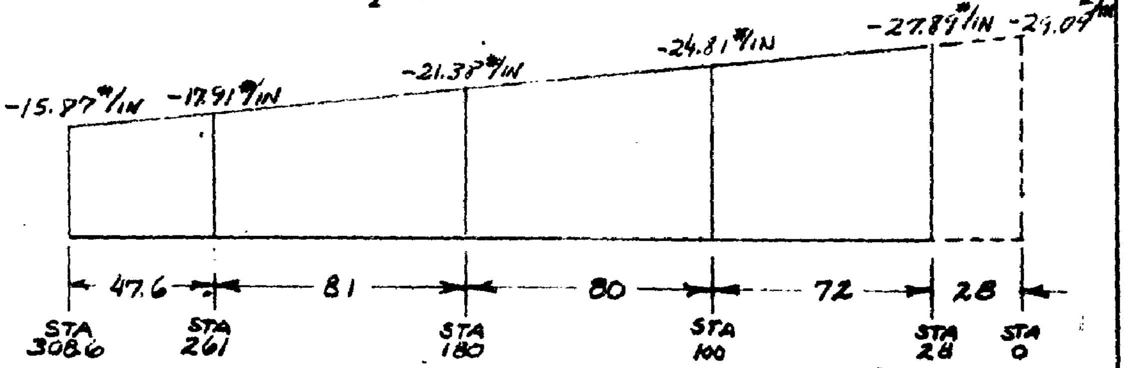
STEADY YAW $\psi = +4.38°$, δ_R FOR TRIM (REF. P. 18)

RUDDER LOAD = -6,938 (ULT), FIN LD = +16,830# (ULT)

$437.132\ W_1 = -6{,}938$

$W_1 = -15.87\ \#/IN$

$W_2 = 1.833 \times -15.87 = -29.09\ \#/IN$



EFFECTIVE RUDDER LOAD = -6,140# (ULT)

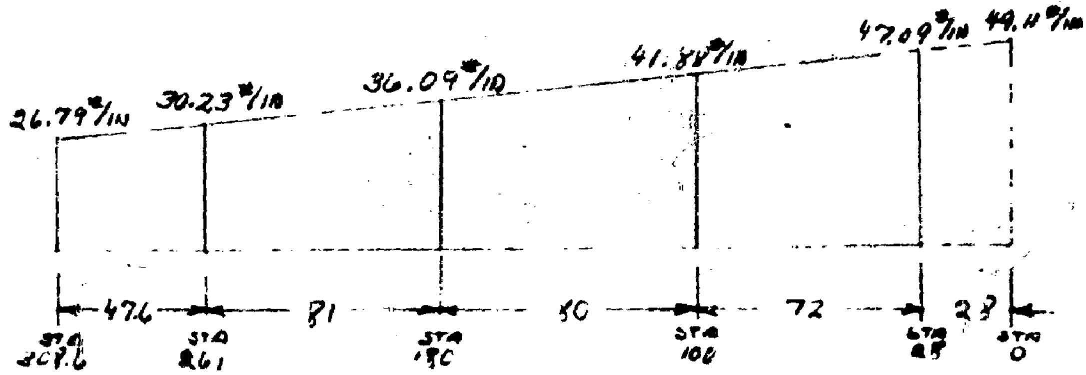
UNSYMMETRICAL THRUST + GUST CONDITION

RUDDER LOAD = 11,712# ULT
FIN LOAD = 22,133# ULT } (REF. FZS-36-147)

$437.132\ W_1 = 11{,}712\#$

$W_1 = 26.79\ \#/IN$

$W_2 = 1.833 \times 26.79 = 49.11\ \#/IN.$



EFFECTIVE RUDDER LOAD = 10,365# ULT

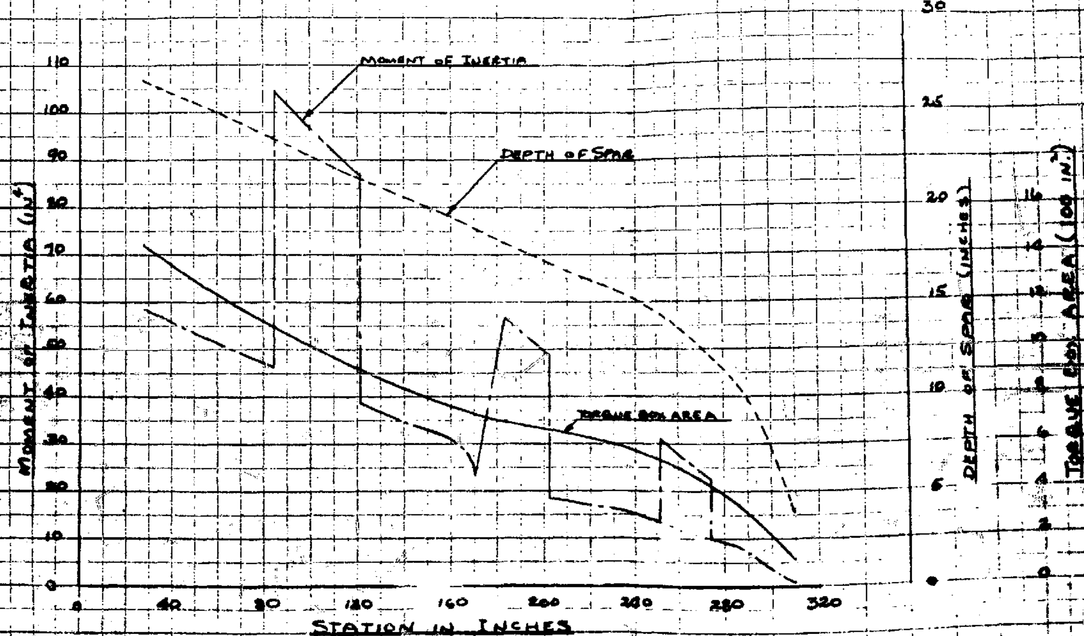
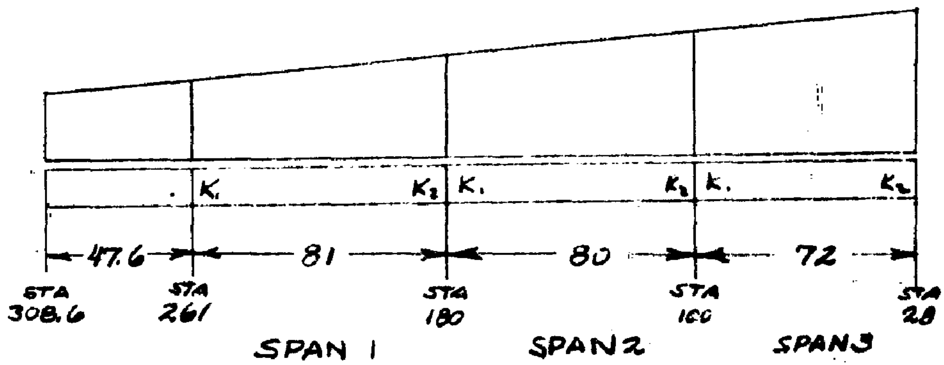


FIG. 7

CALCULATED BY	BEARD 9-10-47	RUDDER STRUCTURAL CHARACTERISTICS	DWG. NO. FZS-36-247
DRAWN BY	BEARD 10-20-47	CONSOLIDATED VULTEE AIRCRAFT CORPORATION FORT WORTH DIVISION, FORT WORTH, TEXAS	MODEL XB-36
CHECKED BY	ZINBERG		
APPROVED BY			

RUDDER

MOMENT DISTRIBUTION FACTORS



SPAN	I	UNIFORM LOAD K_1	UNIFORM LOAD K_2	VARYING LOAD K_1	VARYING LOAD K_2	DEFLECTION K_1	DEFLECTION K_2	CARRY-OVER FACTOR	DISTRIBUTION COEFF.
1	11.8	.0623	.1089	.0230	.0606	.0398	.0623	.713	1.0
	48.2							.346	.375
2	48.2	.0730	.0945	.0280	.0553	.0502	.0642	.594	.625
	96.4							.424	.461
3	96.4	.0915	.0758	.0368	.0446	.0635	.0540	.444	.539
	58.5							.566	1.0

RUDDER

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM

FIXED END MOMENTS - AIRLOADS (REF. LOADING P. 20)

$F.E.M = KWL^2$

SPAN 1

$UM_1 = .0623 \times 47.32 \times (81)^2 = 18,920$
$VM_1 = .0230 \times 9.17 \times (81)^2 = 1,535$
$M_1 = 20,455''\#$

$UM_2 = .1089 \times 47.32 \times (81)^2 = 33,100$
$VM_2 = .0606 \times 9.17 \times (81)^2 = 4,040$
$M_2 = 37,140''\#$

SPAN 2

$UM_2 = .0730 \times 56.49 \times (80)^2 = 26,400$
$VM_2 = .0280 \times 9.05 \times (80)^2 = 1,620$
$M_2 = 28,020''\#$

$UM_3 = .0945 \times 56.49 \times (80)^2 = 34,150$
$VM_3 = .0553 \times 9.05 \times (80)^2 = 3,200$
$M_3 = 37,350''\#$

SPAN 3

$UM_3 = .0915 \times 65.54 \times (72)^2 = 31,100$
$VM_3 = .0368 \times 8.15 \times (72)^2 = 1,556$
$M_3 = 32,656''\#$

$UM_4 = .0758 \times 65.54 \times (72)^2 = 25,750$
$VM_4 = .0446 \times 8.15 \times (72)^2 = 1,885$
$M_4 = 27,635''\#$

CANTILEVER MOMENT

$= 41.93 \times 47.6 \times 23.8 + 4.39 \times 23.8 \times 15.87 = 49,160''\#$

RUDDER

STEADY YAW $\psi = -4.38^\circ$ δ_R FOR TRIM

FIXED END MOMENTS - DEFLECTIONS

RELATIVE DEFLECTIONS $\Delta'_{28} = 0$

$$F.E.M. = \frac{K E I D \times 10^2}{L^2} \qquad I = \frac{I_1 + I_2}{2}$$

$\Delta'_{100} = .1556$

$\Delta'_{180} = .1598$

$\Delta'_{261} = 0$

SPAN 1

$$I = \frac{11.8 + 48.2}{2} = 30$$

$$M_1 = \frac{.0398 \times 10.3 \times 10^6 \times 30 \times .1598 \times 100}{(81)^2} = -29{,}950''\#$$

$$M_2 = \frac{.0623 \times 10.3 \times 10^6 \times 30 \times .1598 \times 100}{(81)^2} = +46{,}850''\#$$

SPAN 2

$$I = \frac{48.2 + 96.4}{2} = 72.3 \qquad \Delta = .1598 - .1556 = .0042$$

$$M_2 = \frac{.0502 \times 10.3 \times 10^6 \times 72.3 \times .0042 \times 100}{(80)^2} = +2{,}455''\#$$

$$M_3 = \frac{.0642 \times 10.3 \times 10^6 \times 72.3 \times .0042 \times 100}{(80)^2} = -3{,}140''\#$$

SPAN 3

$$I = \frac{96.4 + 58.5}{2} = 77.45$$

$$M_3 = \frac{.0635 \times 10.3 \times 10^6 \times 77.45 \times .1556 \times 100}{(72)^2} = +152{,}000''\#$$

$$M_4 = \frac{.0540 \times 10.3 \times 10^6 \times 77.45 \times .1556 \times 100}{(72)^2} = -129{,}200''\#$$

RUDDER

STEADY YAW $\psi = -4.38^{\circ}$ δ_R FOR TRIM

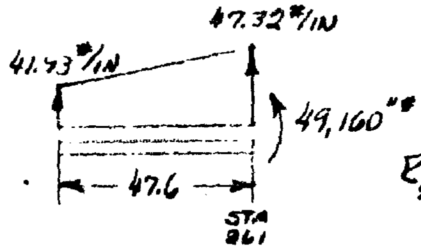
MOMENT DISTRIBUTION

CARRY-OVER FACTORS	.713	.346	.594	.424	.444	.566
DISTRIBUTION COEFFICIENT	1.0	.375	.625	.461	.539	1.0
AIRLOAD MOMENT 49.16	20.46	37.14	28.02	37.35	32.66	27.64
DEFLECTION MOMENT	-29.95	46.85	2.46	-3.14	152.0	-129.20
Σ MOM. 49.16	-9.49	83.99	30.48	34.21	184.66	-101.56
	58.65	-20.10	33.41	69.40	-81.05	101.56
	6.96	-41.85	-29.40	-19.86	-57.50	36.00
	-6.96	+4.66	-7.79	-17.38	20.26	-36.00
	-1.62	4.96	7.36	4.62	20.38	-9.00
	1.62	.90	-1.50	7.26	-8.50	+9.00
	-.31	-1.16	-3.08	+ .89	-5.09	+3.78
	.31	-.72	1.20	-2.76	3.22	-3.78
	.25	-.22	+1.17	-.71	2.14	-1.43
	-.25	.52	-.87	1.31	-1.54	1.43
	-.18	+.18	-.56	.52	-.81	.68
	.18	-.28	.46	-.61	.72	-.68
	.10	-.13	.26	-.27	.38	-.32
	-.10	.15	-.24	.30	-.35	.32
	-.05	+.07	-.13	.14	-.18	.16
	.05	-.07	.13	-.15	.17	-.16
+49.16	+49.16	+30.90	+30.90	+76.91	+76.91	0

MOMENT IN 1000"#

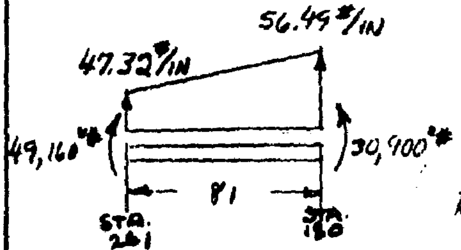
RUDDER
STEADY YAW $\Psi = -4.38°$ δ_R FOR TRIM

REACTIONS:



$$R_{261_L} = \frac{41.93 + 47.32}{2} \times 47.6 = 2,124^{\#}$$

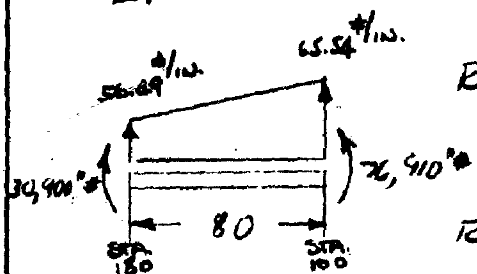
$$R_{261_R} = \frac{47.32 \times 81}{2} + \frac{9.17 \times 81}{6} + \frac{18,260}{81} = 2265^{\#}$$



$$R_{180_L} = \frac{47.32 \times 81}{2} + \frac{9.17 \times 81}{3} - \frac{18,260}{81} = 1939^{\#}$$

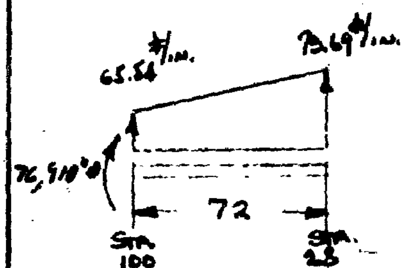
$$R_{180_R} = \frac{56.49 \times 80}{2} + \frac{9.05 \times 80}{6} - \frac{46,010}{80} = 1806^{\#}$$

$$R_{100_L} = \frac{56.49 \times 80}{2} + \frac{9.05 \times 80}{3} + \frac{46,010}{80} = 3077^{\#}$$



$$R_{100_R} = \frac{65.54 \times 72}{2} + \frac{8.15 \times 72}{6} + \frac{76,910}{72} = 3525^{\#}$$

$$R_{28} = \frac{65.54 \times 72}{2} + \frac{8.15 \times 72}{3} - \frac{76,910}{72} = 1487^{\#}$$



FINAL REACTIONS

$R_{261} = 4389^{\#}$

$R_{180} = 3745^{\#}$

$R_{100} = 6602^{\#}$

$R_{28} = 1487^{\#}$

$16,223^{\#}$ VS $16,222^{\#}$ (P.20)

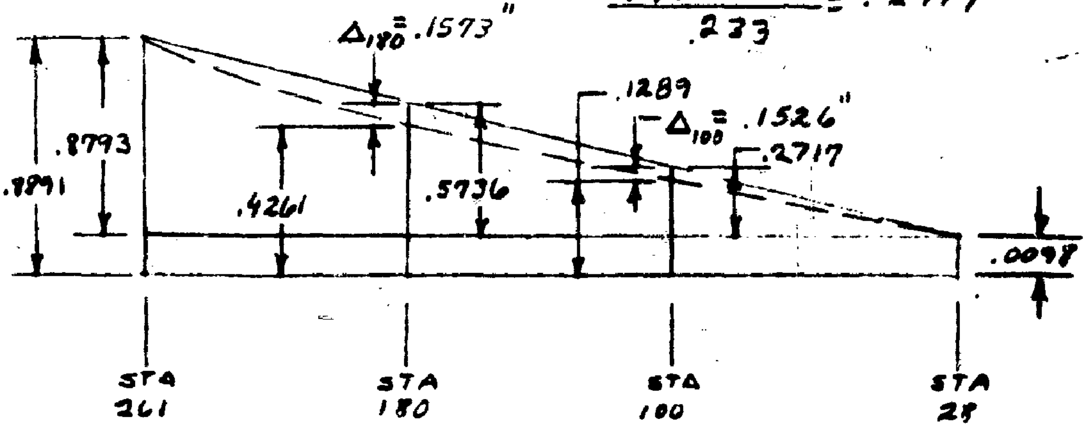
RUDDER DEFLECTIONS

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM

L_{E_M}	LOAD RATIO	STATION 28		STATION 100		STATION 180		STA 261	
		DEFLECTION RATIO	Δ	DEFLECTION RATIO	Δ	DEFLECTION RATIO	Δ	DEFLECTION RATIO	Δ
W_S	-1.1130	.008243	-.0092	.049543	-.1107	.312086	-.3474	.620386	-.6905
R_{28}	1.487	.000149	.0002	.000726	.0011	.001368	.0020	.002018	.0030
R_{100}	6.602	.000727	.0048	.007680	.0507	.017610	.1163	.027665	.1826
R_{180}	3.745	.001368	.0051	.017641	.0661	.056111	.2101	.101148	.3788
R_{261}	4.389	.002018	.0089	.027758	.1218	.101411	.4451	.231313	1.0152
$\Sigma\Delta$			.0098		.1289		.4261		.8891

$$\frac{.8793 \times 152}{233} = .5736$$

$$\frac{.4793 \times 72}{233} = .2717$$



ASSUMED $\Delta_{100} = .1556$ ACTUAL = .1526"
ASSUMED $\Delta_{180} = .1598$ ACTUAL = .1573

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH, TEXAS
FW 833 125 PADS 11-43

ULTIMATE SHEARS & BENDING MOMENT
STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM

TABLE 4

STATION (1)	DISTANCE BETWEEN STATIONS (2)	ULTIMATE LOAD PER INCH (3)	AVERAGE LOAD (4)	LOAD BETWEEN STATIONS (5)	ARM TO CENTROID (6)	MOMENT M' (5)×(6) (7)	SHEAR Σ(5) (8)	MOMENT M'' (8)×(2) (9)	MOMENT AT STATION Σ(7)+(9) (10)
308.6		41.93					0		0
	15.6		42.81	668	7.75	5,177		0	
293		43.69					668		5,177
	15		44.54	668	7.46	4,983		10,020	
278		45.39					1,336		20,180
	17		46.36	788	8.45	6,659		22,712	
261+		47.32					2,124		49,551
	-		-	-4,389	-				
261−		47.32					-2,265		49,551
	15		48.17	723	7.46	5,394		-33,975	
246		49.02					-1,542		20,970
	15		49.87	748	7.46	5,580		-23,130	
231		50.72					-794		3,420
	15		51.57	774	7.46	5,774		-11,910	
216		52.42					-20		-2,761
	15		53.27	799	7.46	5,960		-300	
201		54.12					779		2,944
	15		54.96	824	7.46	6,147		11,685	
186		55.81					1603		20,776
	6		56.15	337	2.99	1,008		9,618	
180+		56.49					1940		31,402
	-		-	-3,744	-				
180−		56.49					-1804		31,402
	15		57.34	860	7.46	6,416		-27,060	
165		58.19					-944		10,758

STATION (1)	DISTANCE BETWEEN STATIONS (2)	ULTIMATE LOAD PER INCH (3)	AVERAGE LOAD (4)	LOAD BETWEEN STATIONS (5)	ARM TO CENTROID (6)	MOMENT M' (5)×(6) (7)	SHEAR Σ(5) (8)	MOMENT M'' (8)×(2) (9)	MOMENT AT STATION Σ(7)+(9) (10)
165									
	15		59.08	886	7.46	6,610		-14,160	
150		59.88					-58		3,208
	15		60.73	911	7.46	6,796		-870	
135		61.58					853		9,134
	15		62.43	936	7.47	6,992		12,795	
120		63.28					1789		28,991
	15		64.13	962	7.47	7,186		26,835	
105		64.98					2751		[illegible]
	5		65.26	326	2.50	815		13,755	
100+		65.54					3077		77,510
	-		-	-4602					
100−		65.54					-3525		[illegible]
	15		66.39	996	7.47	7,440		[illegible]	
85		67.24					-2529		[illegible]
	15		68.09	1021	7.47	7,627		-37,935	
70		68.94					-1508		[illegible]
	15		69.79	1047	7.47	7,821		[illegible]	
55		70.64					-461		[illegible]
	15		71.48	1072	7.47	8,008		-6,915	
40		72.33					611		[illegible]
	12		73.01	876	5.98	5,238		[illegible]	
28+		73.69					1487		[illegible]
	-		-	-1,487	-				
28−		73.69					0		

ANALYSIS: VERT. TAIL SURF.
REPORT: FZJ-36-247
BY: BEARD 7-19-47
MODEL: XB-36
CHECK: ZINBERG

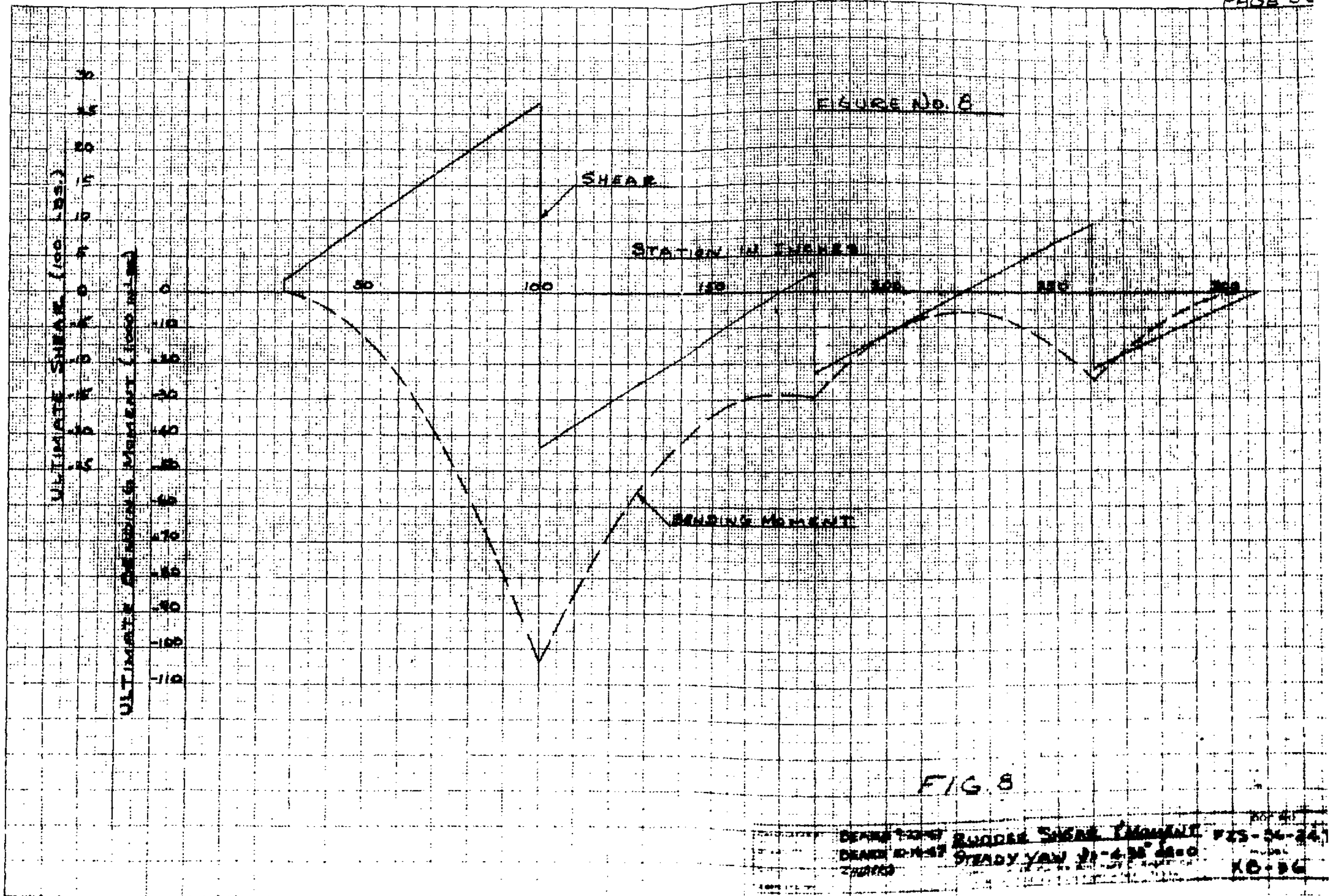


FIGURE NO. 8
SHEAR
STATION IN INCHES
BENDING MOMENT
ULTIMATE SHEAR (100 LBS.)
ULTIMATE BENDING MOMENT (1000 IN.-LBS.)
50
100
150
200
250
300
RUDDER SHEAR & MOMENT
STEADY YAW
KB-3G

FIG. 8

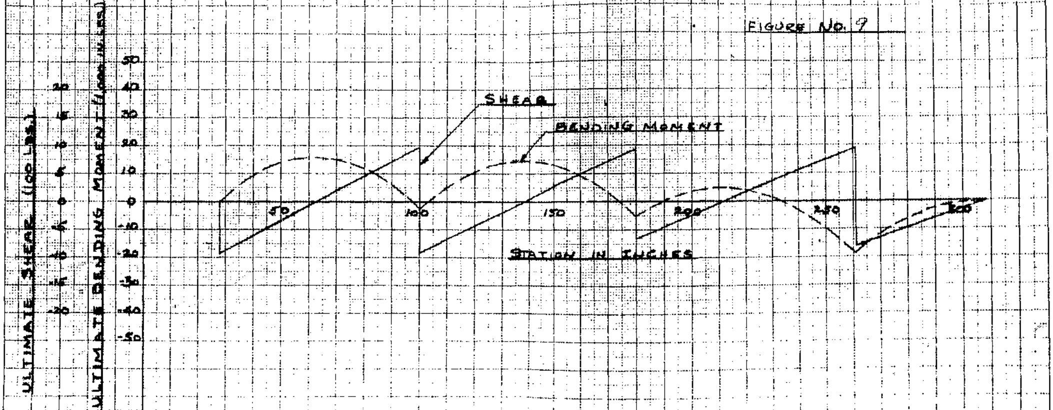


FIG. 9

RUDDER SHEAR & MOMENT
FZS-56-247
XB-36

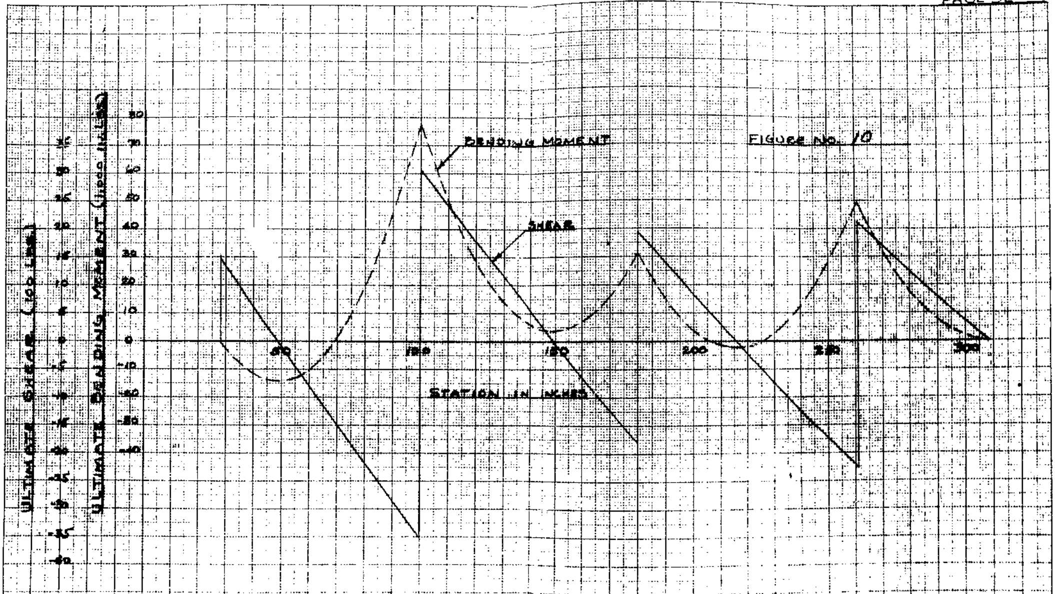


FIG. 10

RUDDER SHEAR & MOMENT
STEADY YAW
XB-36

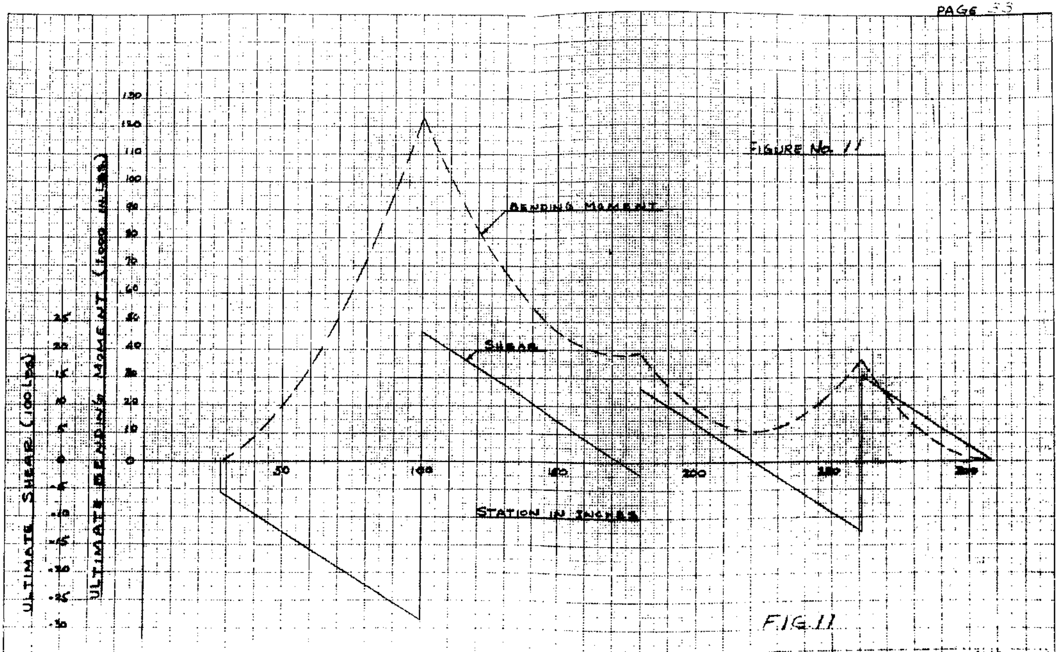


FIG. 11

RUDDER SHEAR & MOMENT
GUST CONDITION

FZS-36-247
XB-36

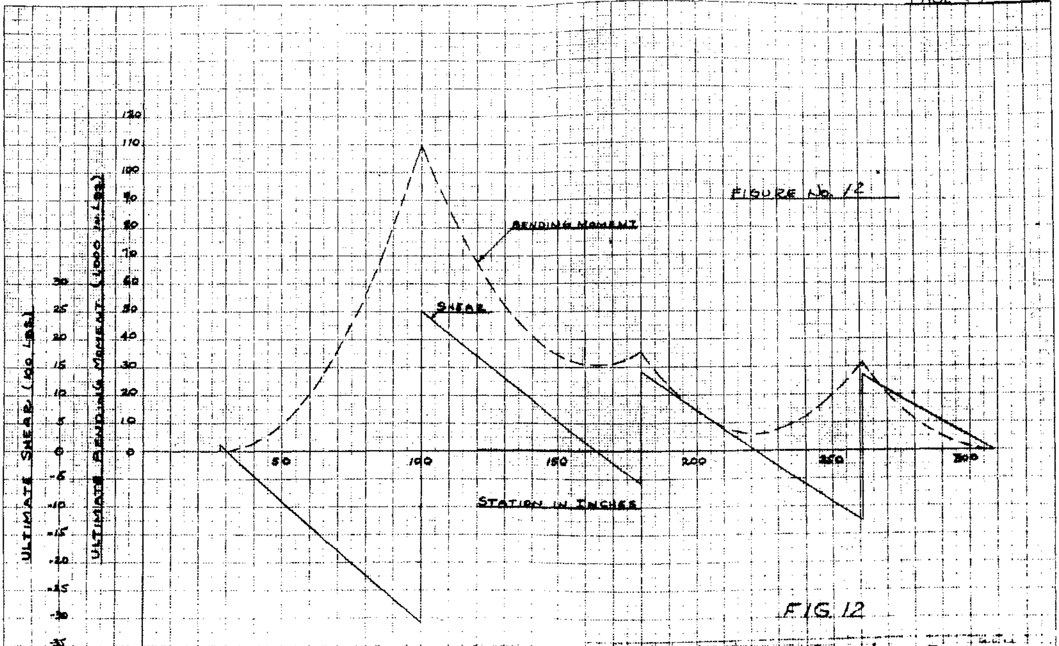


FIG. 12

BEARD 9-22-47
BEARD 10-14-47
EINBERG
RUDDER SHEAR & MOMENT
UNSYMM. THRUST + GUST
FZS-36-247
XB-36

SUMMARY OF RUDDER HINGE LOADS

CONDITION	ULTIMATE LOADS FIN	ULTIMATE LOADS EFFECTIVE RUDDER	P_{261}	P_{180}	P_{111}	P_{38}
STEADY YAW $\psi = -4.38°$ $\delta_R = 0$	-25,945	-8,070	-2,012	-1,391	-4,839	+172
STEADY YAW $\psi = +4.38°$ δ_R TRIM	+16,830	-6,140	-1,744	-1,584	-1,880	-932
STEADY YAW $\psi = -4.38°$ δ_R TRIM	-11,130	+16,222	+4,389	+3,744	+6,602	+1,487
UNSYMMETRICAL THRUST + GUST	+22,133	+10,365	+2,612	+2,026	+5,613	+114
GUST	+30,525	+8,433	+2,615	+1,458	+4,891	-531

SUMMARY OF SERVO TAB LOADS

SEE FOLLOWING SECTION OF REPORT FOR METHOD —

CONDITION	TRIM TAB WITH	TRIM TAB AGAINST
STEADY YAW $\psi = -4.38°$ $\delta_R = 0$	1655	1211
STEADY YAW $\psi = +4.38°$ δ_R FOR TRIM	2022	1110
STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM	2315	773
UNSYMMETRICAL THRUST + GUST	1421	703
GUST	2756	291

DETERMINATION OF TAB EFFECTS AND RUDDER TORSIONS

RUDDER HINGE MOMENTS, TORSIONS, AND SERVO TAB LOADS ARE COMPUTED IN THIS SECTION OF THE REPORT. EFFECTS OF TRIM TAB LOADS ACTING EITHER WITH OR AGAINST AIRLOADS ARE TAKEN INTO ACCOUNT.

A DETAILED DISCUSSION OF THE METHOD USED IS FOUND IN REPORT FZS-36-147.

A COMPLETE SET OF COMPUTATIONS IS SHOWN FOR THE CONDITION OF STEADY YAW, $\psi = -4.38°$, δ_R FOR TRIM. ONLY FINAL RESULTS ARE SHOWN FOR ALL OTHER CONDITIONS INVESTIGATED.

EFFECTS OF TRIM AND SERVO TABS ON RUDDER SHEAR & TORSIONS

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM

ABOVE DORSAL

LOAD = 5,630 × 1.5 = 8,445 # (ULT.) (PAGE 14)

AREA ABOVE DORSAL = 129.15 SQ FT (PAGE 13)

BASIC UNIT LOADING (TRIM TAB NEUTRAL)

$$= \frac{8445}{129.15 \times 144} \times \text{CHORD} \times 1 \text{ LBS/RUNNING INCH}$$

$$= .4541 \times \text{CHORD} \times 1 \text{ LBS/RUNNING INCH}$$

TRIM TAB LOAD

$$= .0012 V_D^2 = .0012 (311)^2 = 116 \ \#/\square' \text{ LIMIT}$$

$$= 174 \ \#/\square' \text{ ULTIMATE}$$

TRIM TAB AREA = 11.22 SQ FT (PAGE 94)

TRIM TAB LOAD = 174 × 11.22 = 1953 # (ULT.)

UNIT LOADING IN REGION OF TAB FOR:

TRIM TAB WITH CONDITION

TRIM TAB CHORD = .17005 × TOTAL RUD. CHORD.

AVERAGE ORDINATE ON BASIC PRESS. DISTRIBUTION CURVE OVER TAB = 4.5 #/SQ FT. ULT (PAGE 51)

$$\text{UNIT TRIM TAB LOAD} = \left(\frac{174 - 4.5}{144}\right) .17005 \times \text{CHORD} \times 1$$

$$= .2002 \times \text{CHORD} \times 1 \ \#/\text{RUNNING INCH.}$$

NET UNIT LOAD ON RUDDER FOR TRIM TAB WITH

$$= (.4541 - .2002) \times \text{CHORD} \times 1 = .2539 \times \text{CHORD} \times 1 \ \#/\text{IN.}$$

TRIM TAB AGAINST CONDITION

$$\text{UNIT LOAD} = \frac{174}{144} \times .17005 \times \text{CHORD} \times 1$$

$$= .2055 \times \text{CHORD} \times 1 \ \#/\text{IN}$$

$$\text{NET LOAD} = (.2055 + .4541) \times \text{CHORD} \times 1$$

$$= .6596 \times \text{CHORD} \times 1 \ \#/\text{IN}$$

RUDDER SERVO TAB
STEADY YAW $\psi = -4.38°$ δR FOR TRIM

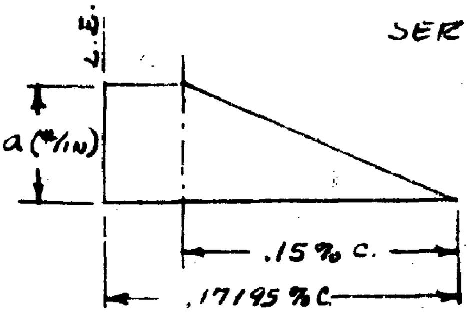
RUDDER LOAD (INCL. DORSAL) = 16,222 − 8,445 = 7,777 # ULT.
RUDDER AREA (INCL. DORSAL) = 88.94 SQ. FT.

BASIC UNIT LOADING (SERVO TAB NEUTRAL)

$$= \frac{7{,}777}{144 \times 88.94} \times \text{CHORD} \times 1 = .6072 \times \text{CHORD} \times 1 \ \#/\text{RUNNING INCH}$$

THE SERVO TAB LOAD CANNOT BE FOUND DIRECTLY FROM FORMULA (AS FOR TRIM TAB) BUT MUST RESULT FROM THE SOLUTION OF TWO SIMULTANEOUS EQUATIONS INVOLVING RUDDER HINGE MOMENTS & THE REDISTRIBUTION OF THE BASIC DISTRIBUTION DUE TO THE PRESENCE OF THE SERVO TAB.

SERVO TAB PRESSURE DISTRIBUTION



SERVO TAB AREA

$$= \frac{24.70 + 19.6}{2} \times 142.91 = 3165 \ \square''$$

SERVO LOAD = x

FROM FIGURE

SERVO LD. $= (.02195a + \frac{.15a}{2})3165$

$= 306.8467a$

EQUATING THESE TWO:

$a = .003259x$

$\therefore$ AREA UNDER PRESSURE DISTRIBUTION CURVE

$= (.02195 \times .003259x) + (.075 \times .003259x)$

$= .00031596x$

$\therefore K_2 = (.00031596x) \times .17195 \ x/c$

$= .000054329 \ "x" \ x/c \ \#/\text{RUNNING IN.}$

RUDDER TRIM TAB

TRIM TAB REACTIONS - STEADY YAW ψ = -4.38° δ_R FOR TRIM

FACTOR FOR TRIM TAB AGAINST = 1.953 (P. 94)

FOR TRIM TAB WITH, THE CORRECTION FACTOR TO APPLY TO TRIM TAB AGAINST = $\frac{.2002}{2055}$ = .974

TRIM TAB REACTIONS ~ 1000# UNIT LD. SOLUTION (P. 93)

STATION	UNIT 1000#	TAB AGAINST	TAB WITH
251.85	228	445	433
228.94	235	459	447
206.12	233	455	443
183.31	304	594	578

MOMENT ARM CONSTANTS (DIST. BETWEEN C.P. OF AIRLOADS TO RUDDER HINGE (25% C)

ABOVE DORSAL = .25 - .2782 = -.0282 CHORD

INCL. DORSAL = .25 - .2822 = -.0322 CHORD

SERVO & TRIM TAB LOADS = .25 - .85 = -.60 CHORD

RUDDER SERVO TAB

$\psi = -4.38^\circ$ δ_R FOR TRIM

DETERMINATION OF SERVO TAB REACTIONS & RUDDER HINGE MOMENTS IN REGION OF SERVO TAB.

SERVO LD. (TRIM TAB WITH) = 2315# (P.41)
SERVO LD. (TRIM TAB AGAINST) = 773# (P.43)

SERVO TAB REACTIONS

(UNIT 1,000# REACTIONS FROM P. 79)

STATION	UNIT 1000#	TRIM TAB WITH FACTOR 2.315	TRIM TAB AGAINST FACTOR .773
158	183	424	141
121.31	290	671	224
73.75	390	903	301
28	137	317	106

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FORT WORTH DIVISION — FORT WORTH, TEXAS

FW 933 125 PADS 11-43

DETERMINATION OF RUDDER HINGE MOMENTS & SERVO TAB LOADS — TABLE 5

STEADY YAW $\psi = -4.38^\circ$ δ_R FOR TRIM — TRIM TAB WITH AIRLOAD

	STATION	DISTANCE FROM TIP	CHORD	K	LOAD AT STATION (3) × (4)	AVERAGE LOAD BETWEEN STATIONS	DISTANCE TO CENTROID IN %	DISTANCE BETWEEN STATIONS	$\bar{X}$ (7) × (8)	LOAD FROM RUDDER (6) × (8)	ARM ABOVE DOE .0282 × (3) INC. DORSAL -.0322 × (3)	MOMENT FROM RUDDER (10) × (11)	EFFECTIVE TAB REACTION	ARM -.6 × (3)	MOMENT FROM TAB (13) × (14)	Σ MOMENT ABOUT 25% HINGE (12) + (15)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
TIP	308.6	0	81.166	.4541	36.86											0
		7.85	82.887			37.64	.5031	15.60	7.85	587	-2.34	-1374				
	293	15.60	84.584		38.41											-1374
		23.14	86.238			39.16	.5030	15.00	7.54	587	-2.43	-1426				
	278	30.60	87.872		39.90											-2800
		38.21	89.541			40.66	.5030	15.12	7.61	615	-2.53	-1556				
BEGIN TRIM TAB	262.88	45.72	91.187	.4541 / .2539	41.41 / 23.15											-4356
		46.66	91.393			23.20	.5004	1.88	.94	44	-2.58	-113				
RUDDER HINGE	261	47.60	91.598		23.26											-4469
		52.19	92.605			23.51	.5018	9.15	4.59	215	-2.61	-561				
TAB HINGE	251.85	56.75	93.604		23.77								433	-56.24	-24,374	-5030 / -27,404
		60.68	94.466			23.43	.5008	5.85	2.93	140	-2.66	-372				
	246	62.60	94.886		24.09											-29,776
		71.18	96.767			24.56	.5032	17.06	8.58	419	-2.73	-1144				
TAB HINGE	228.94	79.66	98.626		25.04								447	-59.18	-26,463	-30,920 / -57,383
		91.16	101.146			25.68	.5040	22.82	11.50	586	-2.85	-1670				
TAB HINGE	206.12	102.48	103.627		26.31								443	-62.18	-27,546	[illegible]
		113.97	106.140			26.94	.5038	22.81	11.49	614	-2.99	-1836				
TAB HINGE	183.31	125.29	108.626		27.58								578	-65.18	-37,674	[illegible]
		126.95	108.491			27.67	.5004	3.31	1.66	92	-3.07	-282				
RUDDER HINGE	180	128.60	109.352		27.76											-126,381
		133.10	110.339			28.01	.5016	8.97	4.50	251	-3.11	-781				
END TRIM TAB	171.03	137.57	111.318	.2539	28.26											-127,162
BEGIN SERVO TAB	171.03	137.57	111.318	.4541+K_2	30.55 + .00605x											
		160.42	116.436			52.787 + .006325x	.5072	46.03	23.35	2432 + .2911x	-3.28	-7977 - .955x				
DORSAL BOUND.	125	183.60	121.406	.4541 + K_2 / .6072 + K_2	55.13 + .0066x / 73.72 + .0066x											-135,159 - .955x
		198.01	124.566			75.62 + .00677x	.5040	28.60	14.41	2163 + .1936x	-4.01	-8,674 - .776x				
C.P. SERVO TAB	96.40	212.20	127.675		77.52 + .006934x								-x	-76.605	76.605x	-143,833 + 75.874x
		247.04	135.312			82.08 + .00735x	.5093	68.40	34.84	5614 + .5021x	-4.36	-24,477 - 2.189x				
END RUDDER	28	280.60	142.667	.6072+K_2	86.634 + .007751x											-168,290 + 72.685x

$\Sigma M = 0 = 168290 - 72.68x$

x = SERVO LOAD = 2315#

$K_2 = .0000\,54329x$ (REF P. 38)

NO TAB — TRIM TAB — SERVO TAB

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RUDDER HINGE MOMENTS REGION OF SERVO TAB TABLE 6
REGION OF SERVO-TAB

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM — TRIM TAB WITH AIRLOAD

	STA.	DIST. FROM TIP	CHORD	K	LOAD AT STA.	AV. LD. BETWEEN STAS.	DIST. TO CENTROID IN %	DIST. BETWEEN STAS.	$\bar{V}$ (7)×(8)	LOAD FROM RUDDER (6)×(8)	ARM ABOVE DOR. INCL. DOR.	MOM. FROM RUDDER (10)×(11)	EFF. TAB REACT.	ARM -.6×(3)	MOM. FROM TAB (13)×(14)	Σ MOM. ABOUT 25% HINGE (12)+(15)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
SERVO BEGINS	171.03	137.57	111.318	.5799	64.55											-127,162	(Ref. P. #.
		144.11	112.752			65.38	.5020	13.03	6.54	852	-3.18	-2,709					
SERVO HINGE	158	150.60	114.174		66.21								-424	-68.50	29,044	-129,761 -100,887	
	148.44	160.16	116.269			67.42	.5029	19.00	9.56	1281	-3.28	-4,202					
	139	169.60	118.339		68.62											-105,021	
	131.97	176.63	119.879			69.51	.5020	14.00	7.03	973	-3.38	-3,289					
DORSAL BOUNDARY	125	183.60	121.406	.5799 .7330	70.40 88.99											-108,318	
	123.15	185.45	121.812			89.28	.5006	3.69	1.85	329	-3.92	-1,290					
SERVO HINGE	121.31	187.29	122.216		89.58								-671	-73.33	49,204	-109,608 -60,404	
		191.96	123.239			90.33	.5013	9.31	4.67	841	-3.47	-3,339					
	112	196.60	124.256		91.08											-63,743	
		202.66	125.576			92.04	.5017	12.00	6.02	1104	-4.04	-4,460					
RUDDER HINGE	100	208.60	126.886		93.01											-68,203	
		214.62	128.206			93.98	.5016	12.00	6.02	1128	-4.13	-4,659					
	88	220.60	129.516		94.94											-72,8[illegible]	
		227.75	131.084			96.08	.5019	14.25	7.15	1369	-4.22	-5,777					
SERVO HINGE	73.75	234.85	132.640		97.22								-903	-79.58	71,861	[illegible]	
		240.74	133.931			98.16	.5015	11.75	5.89	1153	-4.31	-4,969					
	62	246.60	135.215		99.11											-11,747	
		253.12	136.425			100.16	.5016	13.00	6.52	1302	-4.39	-5,716					
	49	259.60	138.064		101.20											-17,462	
		270.16	140.379			102.88	.5028	21.00	10.56	2160	-4.52	-9,763					
SERVO & RUDDER HINGE	28	280.60	142.667	.7330	104.57								-317	-85.60	27,136	-27,[illegible]	✓

Σ SHEAR = 16,228 VS 16,222

.4541 + .000054329 × 2315 = .5799
.6072 + .000054329 × 2315 = .7330

ANALYSIS: VERT. TAIL SURF.
REPORT: FZS-36-147
BY: BEARD
CHECK: ZIMBERG
MODEL: XB36

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FW 533 125 PADS 11-49

RUDDER HINGE MOMENTS & SERVO TAB LOADS — TABLE 7

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM — TRIM TAB AGAINST AIRLOADS — PAGE 6

	STA.	DIST. FROM TIP	CHORD	K	LOAD AT STA.	AV. LD. BETWEEN STAS	DIST. TO CENTROID IN %	DIST. BETWEEN STAS	$\bar{\psi}$ (7)×(8)	LOAD FROM RUDDER (6)×(8)	ARM ABOVE DUE ×(3) INCLUDE ×(8)	MOM. FROM RUDDER (10)×(11)	EFF. TAB REACT.	ARM -.6×(3)	MOM. FROM TAB (13)×(14)	Σ MOM. @25% HINGE Σ(12)+(15)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
TIP	308.6	0	31.166	.4541	36.86											0
		7.85	32.337			37.64	.5031	15.60	7.85	587	-2.34	-1374				
	293	15.60	84.584		38.41											-1374
		23.14	86.238			39.16	.5030	15.00	7.54	587	-2.43	-1426				
	278	30.60	87.872		39.90											-2800
		38.21	89.541			40.66	.5030	15.12	7.61	615	-2.53	-1556				
BEGIN T.TAB	262.88	45.72	91.187	.4541 .6596	41.41 60.15											-4356
		46.66	91.393			60.28	.5004	1.88	.94	113	-2.58	-292				
RUDDER HINGE	261	47.60	91.598		60.42											-4648
		52.19	92.605			61.16	.5018	9.15	4.59	560	-2.61	-1462				
TAB HINGE	251.85	56.75	93.604		61.89								-445	-56.29	+25,049	-6,110 +18,939
		60.68	94.466			62.24	.5008	5.85	2.93	364	-2.66	-968				
	246	62.60	94.886		62.59											+17,971
		71.18	96.767			63.82	.5032	17.06	8.58	1089	-2.73	-2973				
TAB HINGE	228.94	79.66	98.626		65.05								-459	-59.18	+27,164	[illegible]
		91.16	101.146			66.70	.5040	22.82	11.50	1522	-2.85	-4338				
TAB HINGE	206.12	102.48	103.627		68.35								-455	-62.18	+28,292	[illegible]
		113.97	106.140			70.00	.5038	22.81	11.49	1597	-2.99	-4775				
TAB HINGE	183.31	125.29	108.626		71.65								-594	-65.18	+38,717	[illegible]
		126.95	108.991			71.89	.5004	3.31	1.66	238	-3.07	-731				
RUDDER HINGE	180	128.60	109.352		72.13											+99,387
		133.10	110.339			72.78	.5016	8.97	4.50	653	-3.11	-2031				
END TRIM TAB	171.03	137.57	111.318	.6596	73.42											[illegible]
BEGIN SERVO	171.03	137.57	111.318	.4541-K_2	50.55-.00605x											
		160.92	116.036			52.84-.00632x	.5072	46.03	23.35	2432-.2909x	-3.28	-7,977 +.9481x				
DORSAL BOUNDARY	125	183.60	121.406	.4541-K_2 .6072-K_2	55.18-.0066[illegible] 73.72-.0066[illegible]											[illegible]
		198.01	124.566			75.62-.006768x	.5040	28.60	14.41	2163-.1936x	-4.01	-8,674 +.7763x				
C.P. SERVO	96.40	212.20	127.675		77.52-.006936x								x	-76.605	-76.605x	[illegible]
		247.04	135.312			72.08-.007743x	.5093	68.40	30.84	5678-.5023x	-4.36	-24,757 +2.190x				
END RUDDER	28	280.60	142.667	.6072-K_2	56.63-.007751x											+56,168-72.6846x

$K_2 = .000054329x$

$\Sigma M = 0 = 56,168 - 72.6846x$, SERVO LD $= \frac{56,168}{72.6846} = 773$

DETERMINATION OF RUDDER HINGE MOMENTS : TABLE 8
REGION OF SERVO TAB

STEADY YAW $\psi = 4.38°$ δ_R FOR TRIM — TRIM AGAINST AIRLOADS

	STATION	DISTANCE FROM TIP	CHORD	K	LOAD AT STATION	AVERAGE LOAD BETWEEN STATIONS	DISTANCE TO CENTROID IN PERCENT	DISTANCE BETWEEN STATIONS	$\bar{x}$	LOAD FROM RUDDER (6) × (8)	ARM ABOVE DORSAL -.0272 (3) INCL DORSAL -.0322 × (3)	MOMENT FROM RUDDER (10) × (11)	SERVO TAB REACTION	ARM -.6 × (3)	MOMENT FROM TAB (13) × (14)	Σ MOMENT ABOUT 25% HINGE (12) + (15)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
SERVO BEGINS	171.03	137.57	111.318	.4121	45.87											+97,296 (REF P. 43)
						46.46	.5020	13.03	6.54	605	-3.18	-1924				
SERVO HINGE	158	150.6	114.174		47.05								+141	-68.50	-9,658	+95,372 +85,714
						47.91	.5029	19.00	9.56	910	-3.28	-2985				
	139	169.60	118.338		48.77											+82,729
						49.40	.5020	14.00	7.03	692	-3.38	-2339				
DORSAL BOUNDRY	125	183.6	121.407	.4121 .5652	50.03 68.62											+80,390
						68.85	.5006	3.69	1.85	254	-3.92	-996				
SERVO HINGE	121.31	187.24	122.216		69.09								+224	-73.33	-16,426	+79,394 +62,968
						69.66	.5013	9.31	4.67	648	-3.97	-2573				
	112	196.6	124.256		70.23											+60,395
						70.98	.5017	12.00	6.02	852	-4.04	-3442				
RUDDER HINGE	100	208.6	126.886		71.72											+56,953
						72.46	.5016	12.00	6.02	870	-4.13	-3593				
	88	220.6	129.516		73.20											+53,360
						74.08	.5019	14.25	7.15	1056	-4.22	-4456				
SERVO HINGE	73.75	234.85	132.640		74.47								+301	-79.58	-23,954	+48,904 +24,950
						75.69	.5015	11.75	5.89	889	-4.31	-3832				
	62	246.60	135.215		76.42											+21,118
						77.22	.5016	13.00	6.52	1004	-4.39	-4408				
	49	259.60	138.064		78.03											+16,710
						79.34	.5028	21.00	10.56	1666	-4.52	-7530				
[illegible]	28	280.60	142.667	.5652	80.64								+106	-85.60	-9,074	+9,180 [illegible]

Σ SHEAR = 16,190 VS 16,222

(.0420)
.4541 - .00005 4329 × 773 = .4121
.6072 - .00005 4329 × 773 = .5652

ANALYSIS: VERT. TAIL SURF.
BY: BEARD
CHECK: ZINBERG

REPORT: FZS-36-247
MODEL: XB36
DATE: 11-13-47

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH, TEXAS
FW 632 125 PADS 11-43

RUDDER SHEARS AND BOX TORSIONS — TABLE 9

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM TRIM TAB WITH

PAGE No. 4
REF. FZS-36-297
BY: BEARD
MODEL: XB-36 DATE:
CHECK: ZINBERG

	STA.	CHORD	DISTRIBUTED LOAD SHEAR	TAB REACTION SHEAR	RUDDER HINGE SHEAR	Σ SHEAR	DIST. HINGE TO SPAR	HINGE MOMENT @ STATION	CHANGE IN MOMENT	Σ TORSION @ ℄ SPAR
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
TIP	308.6	81.166				0	8.12	0	0	0
			587							
	293	84.584				587	8.46	-1374	4966	3592
			587							
	278	87.872				1174	8.79	-2800	10,319	7519
			615							
BEGIN T. TAB	262.88	91.187				1789	9.12	-4356	16,316	11,960
			44							
RUDDER HINGE	261	91.598			-4,389	1833 -2,556	9.16	-4469	16,790 -23,413	12,321 -27,882
			215							
TAB HINGE	251.85	93.604		433		-2,341 -1,908	9.36	-5,030 -29,404	-21,917 -17,859	-26,947 -47,263
			140							
	246	94.886				-1,768	9.49	-29,776	-16,778	-46,554
			419							
TAB HINGE	228.94	98.626		447		-1,349 -902	9.86	-30,920 -37,373	-13,301 -2,894	-44,221 -66,267
			586							
TAB HINGE	206.12	103.627		443		-316 127	10.36	-37,043 -86,589	-3,274 1,316	-62,317 -85,373
			614							
TAB HINGE	183.31	108.626		578		741 1319	10.86	-88,425 -126,099	8047 15,324	-80,378 -111,775
			92							
RUDDER HINGE	180	109.352			-3,744	1411 -2,333	10.94	-126,381	15,486 -25,523	-110,895 -151,904
			251							
END T. TAB	171.03	111.318				-2082	11.13	-127,162	-23,173	-150,335

RUDDER SHEARS AND BOX TORSIONS

TABLE 10

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM TRIM TAB AGAINST

	STA.	CHORD	DISTRIBUTED LOAD SHEAR	TAB REACTION SHEAR	RUDDER HINGE SHEAR	Σ SHEAR	DIST. HINGE TO SPAR	HINGE MOMENT @ STATION	CHANGE IN MOMENT	Σ TORSION @ ℄ SPAR
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
			P. 43	P. 43	P. 35	③+④+⑤	+ .10×②	P. 43 COL. (16)	⑥×⑦	⑧+⑨
TIP	308.6	81.166				0	8.12	0	0	0
			587							
	293	84.584				587	8.46	-1374	4,966	3,592
			587							
	278	87.872				1174	8.79	-2800	10,319	7,519
			615							
BEGIN T.TAB	262.88	91.187				1789	9.12	-4356	16,316	11,960
			113							
RUDDER HINGE	261	91.598			-4,389	1,806 / -2,487	9.16	-4648	17,422 / -22,781	12,774 / -27,429
			560							
TAB HINGE	251.85	93.604		-445		-1,927 / -2,372	9.36	-6110 / +18,939	-18,037 / -22,202	-24,147 / -3,263
			364							
	246	94.886				-2008	9.49	+17,971	-19,056	-1,085
			1089							
TAB HINGE	228.94	98.626		-459		-919 / -1378	9.86	+14,998 / +42,162	-9,061 / -13,587	5,937 / 28,575
			1522							
TAB HINGE	206.12	103.627		-455		144 / -311	10.36	+37,824 / +66,116	1492 / -3,222	39,316 / 62,894
			1597							
TAB HINGE	183.31	108.626		-594		1286 / 692	10.86	+67,341 / +108,058	13,966 / 7,515	75,307 / 107,573
			238							
RUDDER HINGE	180	109.352			-3744	930 / -2794	10.94	+99,327	10,174 / -30,566	109,501 / 68,761
			653							
END T.TAB	171.03	111.318				-2141	11.13	+97,296	-23,829	73,467

RUDDER SHEARS AND BOX TORSIONS — TABLE II

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM TRIM TAB AGAINST

	STA.	CHORD	DISTRIBUTED LOAD SHEAR	TAB REACTION SHEAR	RUDDER HINGE SHEAR	Σ SHEAR	DIST. HINGE TO SPAR	HINGE MOMENT @ STATION	CHANGE IN MOMENT	Σ TORSION @ ℄ SPAR
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
			P. 43	P. 43	P. 35	③+④+⑤	+.10×②	P. 43 COL. (16)	⑥×⑦	⑧+⑨
SERVO BEGINS	171.03	111.318				-2,141	11.13	97,296	-23,829	73,467
			605							
SERVO HINGE	158	114.174		141		-1,536 -1,395	11.42	95,372 85,714	-17,541 -15,931	77,831 69,783
			910							
	139	118.338				-485	11.83	82,729	-5738	76,991
			692							
DORSAL BOUNDARY	125	121.406				207	12.14	80,390	2513	82,903
			254							
SERVO HINGE	121.31	122.216		224		461 685	12.22	79,394 62,968	5633 8371	85,027 71,339
			648							
	112	124.256				1333	12.43	60,395	16,569	76,964
			852							
RUDDER HINGE	100	126.886			-6,602	2185 -4417	12.69	56,953	27,728 -56,052	84,681 901
			870							
	88	129.516				-3547	12.95	53,360	-45,934	7426
			1056							
SERVO HINGE	73.75	132.640		301		-2491 -2190	13.26	48,904 24,950	-33,031 -29,039	15,873 -4,089
			889							
	62	135.215				-1301	13.52	21,118	-17,590	3,528
			1004							
	49	138.064				-297	13.81	16,710	-4,102	12,608
			1666							
SERVO & RUDDER HINGE	28	142.667		106	-1,487	1369 -12	14.27	9180 0	19,536 0	28,716 0
						VS. 0				

TABLE 12

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH, TEXAS
FW 535 185 PADS 11-43

RUDDER SPAR SHEAR FLOWS

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM TRIM TAB WITH AIRLOADS

STATION	TORSION @ ℄ SPAR	2A P. 22	q_t	SPAR DEPTH P. 22	SPAR SHEAR P	q_s	SPAR SHEAR FLOW
①	②	③	④ ②/③	⑤	⑥	⑦ ⑥/⑤	⑧ ⑦-④
308.6	0	260	0	4.35	0	0	0
293	3,592	564	6.4	9.25	587	63.5	57.1
278	7519	800	9.4	11.70	1174	100.3	90.9
262.88	11,960	964	12.4	13.35	1789	133.9	121.5
261	12,321 -27,882	990	12.4 -28.2	13.50	1833 -2556	135.9 -189.2	123.5 -161.0
251.85	-26,842 -47,263	1070	-25.2 -44.2	14.36	-2341 -1908	-163.1 -132.8	-137.9 -88.6
246	-46,554	1100	-42.4	14.75	-1768	-119.8	-77.4
228.94	-44,221 -66,267	1200	-36.8 -55.2	15.70	-1349 -902	-85.9 -57.5	-49.1 -2.3
206.12	-62,317 -85,273	1300	-48.0 -65.5	16.85	-316 127	-18.8 7.5	29.2 73.0
183.31	-80,378 -111,775	1386	-57.9 -80.6	18.20	747 1319	41.1 72.5	99.0 153.1
180	-110,945 -151,964	1400	-79.2 -108.4	18.30	1411 -2333	77.1 -127.5	156.3 -19.1
171.03	-150,335	1444	-104.1	18.96	-2,082	-109.9	-5.8

STATION	TORSION @ ℄ SPAR	2A	q_t	SPAR DEPTH	SPAR SHEAR	q_s	SPAR SHEAR FLOW
①	② COL(10) P.46	③	④ ②/③	⑤	⑥ P. 22	⑦ ⑥/⑤	⑧ ⑦-④
158	-143,908 -119,716	1516	-95.0 -79.0	19.68	-1230 -1654	-62.5 -84.1	32.5 -5.1
139	-109,442	1680	-65.1	20.65	-373	-18.1	47.0
125	-101,034	1800	-56.1	21.35	600	28.1	84.2
121.31	-98,256 -57,251	1836	-53.5 -31.2	21.56	929 258	43.1 12.0	[illegible]
112	-50,083	1920	-26.1	22.00	1099	50.0	76.1
100	-40,247 -124,026	2040	-19.7 -60.9	22.68	2203 [illegible]	97.1 [illegible]	[illegible]
88	-115,221	2160	-53.4	23.40	-3271	-139.8	[illegible]
73.75	-103,859 -95,972	2318	-44.8 -41.0	24.25	-1905 -2805	-78.5 -115.7	[illegible]
62	-34,082	2440	-14.0	24.88	-1652	-66.5	[illegible]
49	-22,297	2600	-8.6	25.60	-350	-13.7	[illegible]
28	-1387 0	2892	-.5 0	26.72	1810 0	67.8 0	[illegible]

ANALYSIS: VERT. TAIL SURF.
BY: BEARD
CHECK: ZINBERG

REPORT: FZS-36-167
MODEL: XB-36
DATE: 11-13-47

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH, TEXAS
FW 833 125 PADS 11-43

RUDDER SHEARS AND BOX TORSIONS

TABLE 13

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM TRIM TAB WITH

PAGE NO 49
REPORT FZS-36-247
BY: BEARD
MODEL: XB-36 DATE: 11-13-4

	STA.	CHORD	DISTRIBUTED LOAD SHEAR	TAB REACTION SHEAR	RUDDER HINGE SHEAR	Σ SHEAR	DIST. HINGE TO SPAR	HINGE MOMENT @ STATION	CHANGE IN MOMENT	Σ TORSION @ ℄ SPAR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			P. 42 COL. (10)	P. 42 COL. (13)	P. 35	(3)+(4)+(5)	+.10×(2)	P. 42 COL. (16)	(6)×(7)	(8)+(9)
SERVO BEGINS	171.03	111.318				-2,082	11.13	-127,162	-23,173	-150,335
			852							
SERVO HINGE	158	114.174		-424		-1,230 -1,654	11.42	-129,861 -100,827	-14,047 -18,889	-143,908 -119,716
			1281							
	139	118.338				-373	11.83	-105,029	-4,413	-109,442
			973							
DORSAL BOUNDARY	125	121.406				600	12.14	-108,318	7,284	-101,034
			329							
SERVO HINGE	121.31	122.216		-671		929 258	12.22	-109,608 -60,404	11,352 3,153	-98,256 -57,251
			841							
	112	124.256				1099	12.43	-63,743	13,660	-50,083
			1104							
	100	126.886			-6,602	2203 -4399	12.69	-68,203	27,956 -55,823	-40,247 -124,026
			1128							
	88	129.516				-3271	12.95	-72,862	-42,359	-115,221
			1369							
	73.75	132.640		-903		-1902 -2805	13.26	-78,639 -6,778	-25,220 -37,194	-103,859 -43,972
			1153							
	62	135.215				-1652	13.52	-11,747	-22,335	-34,082
			1302							
	49	138.064				-350	13.81	-17,463	-4,834	-22,297
			2160							
[illegible]	28	142.667		-317	-1487	1810 -6	14.27	-27,226 0	+25,829 0	-1,397 0
						-6 VS. 0				

RUDDER SPAR SHEAR FLOWS

TABLE 14

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM TRIM TAB AGAINST AIRLOAD

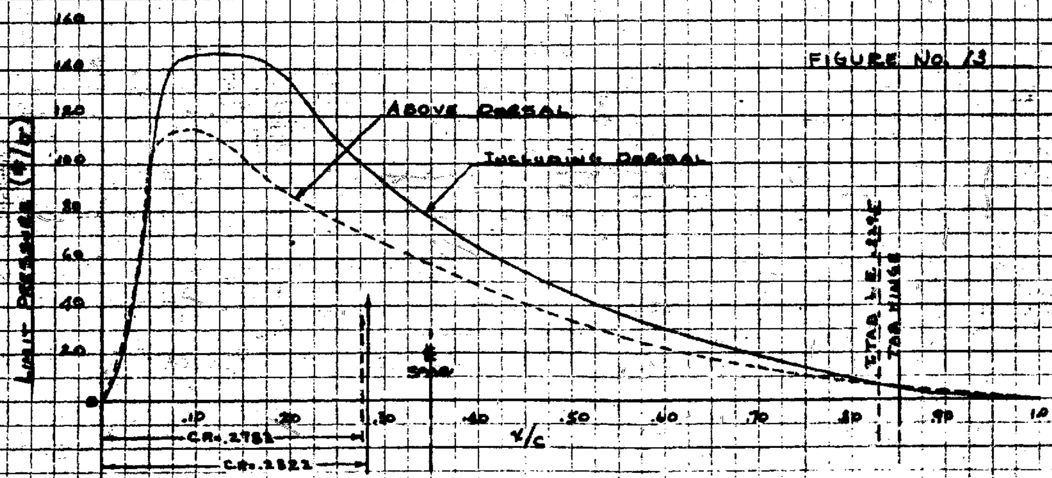
STATION	TORSION @ ℄ SPAR	ZA P.22	q_t	SPAR DEPTH P.22	SPAR SHEAR P.45	q_s	SPAR SHEAR FLOW
1	2	3	4	5	6	7	8
			2/3			6/5	7 - 4
308.6	0	250	0	4.35	0	0	0
293	3,592	564	6.4	9.25	587	63.5	0.1
278	7,519	800	9.4	11.70	1174	100.3	90.9
262.88	11,960	964	12.4	13.35	1789	134.0	121.6
261	12,774 -27,429	990	12.9 -27.7	13.50	1902 -2487	141.0 -184.2	128.1 -156.5
251.85	-24,147 -3,263	1070	-22.6 -3.1	14.36	-1927 -2372	-134.1 -165.1	-111.5 -162.0
246	-1,085	1100	-1.0	14.75	-2008	-136.2	-135.2
228.94	5,937 22,575	1200	4.9 18.8	15.70	-919 -1378	-58.5 -87.7	-63.4 -111.5
206.12	39,316 63,394	1300	30.2 48.4	16.85	144 -311	8.5 -18.5	-21.7 -66.9
183.31	75,307 104,573	1386	54.4 77.6	18.20	1286 692	70.6 38.0	16.2 -39.6
180	105,501 62,761	1400	75.4 44.8	18.30	930 -2794	50.8 -152.8	-27.4 -201.9
171.03	73,467	1444	50.8	18.96	-2141	-113.0	-163.8

STATION	TORSION @ ℄ SPAR	ZA	q_t	SPAR DEPTH	SPAR SHEAR	q_s	SPAR SHEAR FLOW
1	2	3	4	5	6	7	8
			2/3			6/5	7 - 4
158	77,831 69,783	1516	51.4 46.0	19.68	-1536 -1,395	-78.0 -70.9	-129.4 -116.9
139	76,991	1680	45.8	20.65	-485	-23.5	-69.3
125	82,903	1800	46.0	21.35	207	9.7	-36.3
121.31	85,027 71,330	1836	46.3 38.8	21.56	461 685	21.4 31.8	-24.9 -7.0
112	76,964	1920	40.1	22.00	1333	60.6	20.5
100	84,681 901	2040	41.5 0.4	22.68	2185 -4417	96.5 -194.9	55.0 -195.3
88	7,426	2160	3.4	23.40	-3547	-151.8	[illegible]
73.75	15,875 -4,089	2318	6.8 -1.8	24.25	-2491 -2190	-102.8 -90.5	[illegible]
62	3528	2440	1.4	24.88	-1301	-52.3	[illegible]
49	12,608	2600	4.8	25.60	-297	-11.6	-16.4
28	28,716 0	2892	9.9 0	26.72	1384 0	51.8 0	[illegible] 0

ANALYSIS: VERT TAIL SURF.
REPORT: FZS-36-247
MODEL: XB36

BY: BEARD
CHECK: ZINBERG
DATE: 11-13-47

FIGURE NO. 13



CALCULATED BY BEARD 4-9-47
DRAWN BY BEARD 9-25-47
CHECKED BY ZINBERG
APPROVED BY

RUDDER PRESSURE DISTRIBUTION

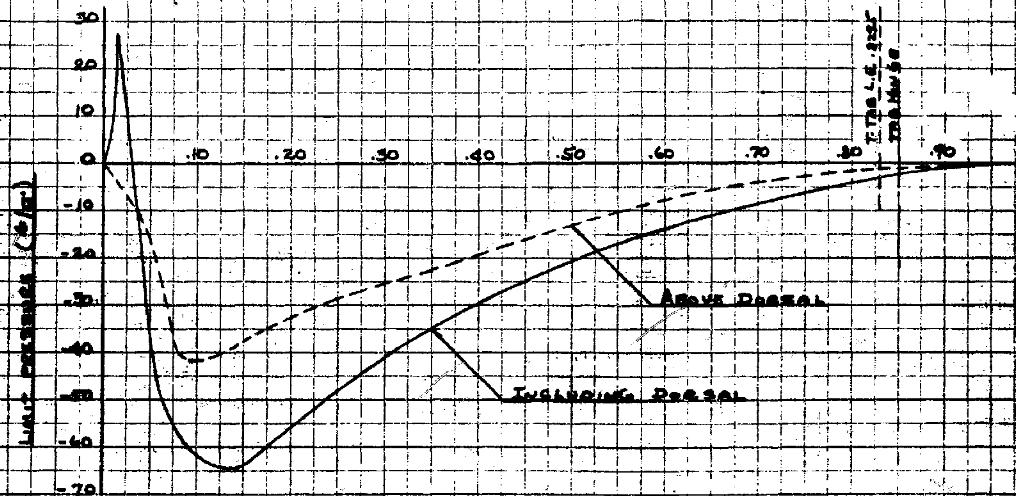
STEADY YAW ψ=-4.35°, δR FOR TRIM

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION, FORT WORTH, TEXAS

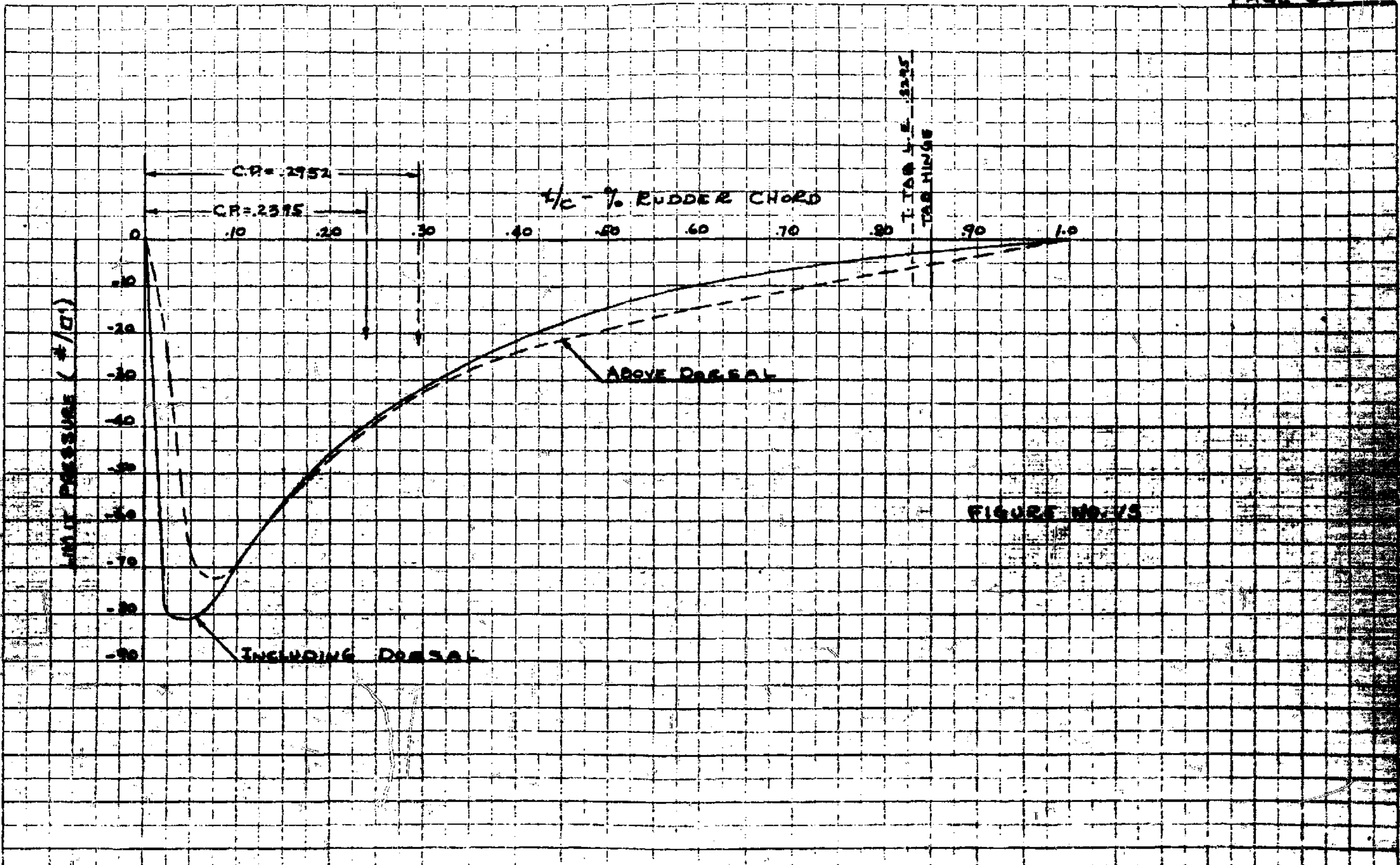
XB-36

FIGURE No. 14

C.P. LOADING INCLUDING DORSAL @ 29.78% CHORD
C.P. LOADING ABOVE DORSAL @ 29.09% CHORD

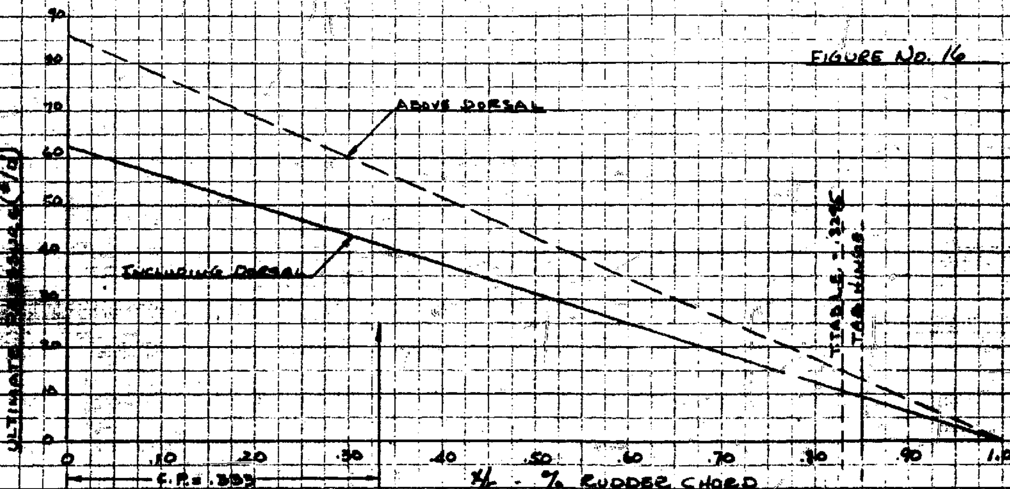


CALCULATED BY			RUDDER PRESSURE DISTRIBUTION
DRAWN BY			STEADY YAW
CHECKED BY			CONSOLIDATED VULTEE AIRCRAFT CORPORATION
APPROVED BY			FORT WORTH DIVISION FORT WORTH, TEXAS



CALCULATED BY BEARD 4-1-47
DRAWN BY BEARD 4-2-47
CHECKED BY Z/ ...
APPROVED BY

RUDDER PRESSURE DISTRIBUTION
STEADY YAW ψ = -4.32° δ = 0
CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH, TEXAS



CALCULATED BY	BEARD	10-14-47	RUDDER PRESSURE DISTRIBUTION GUST CONDITION
DRAWN BY	BEARD	10-14-47	
CHECKED BY	[illegible]		CONSOLIDATED VULTEE AIRCRAFT CORPORATION FORT WORTH DIVISION, FORT WORTH, TEXAS
APPROVED BY			MODEL XB-36

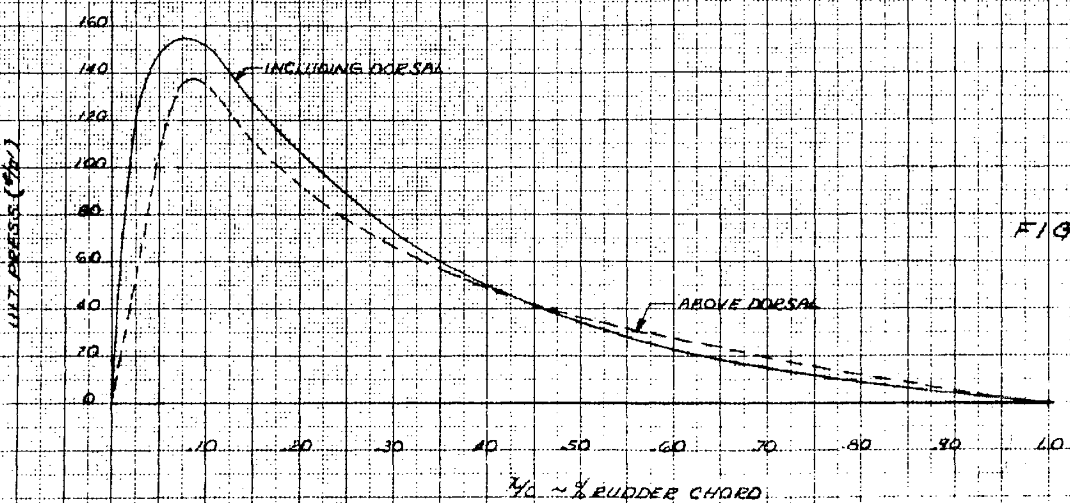
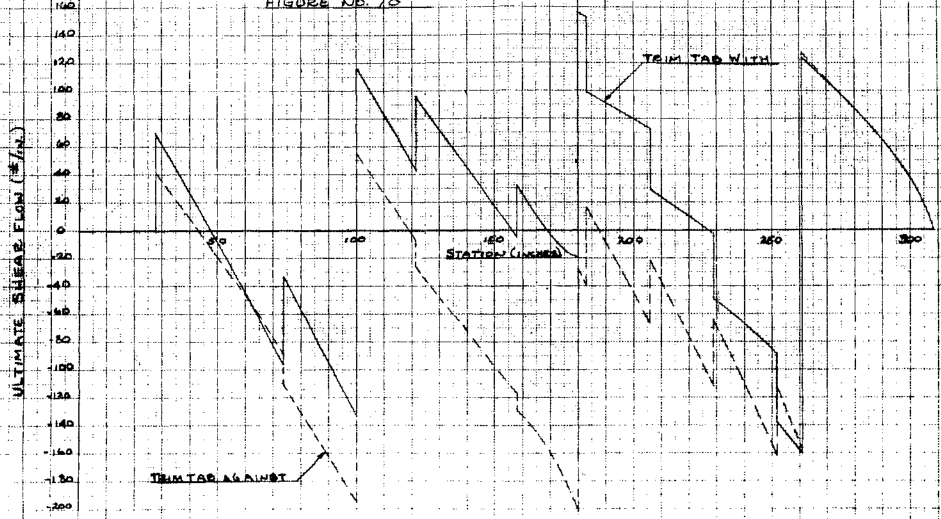


FIG. 17

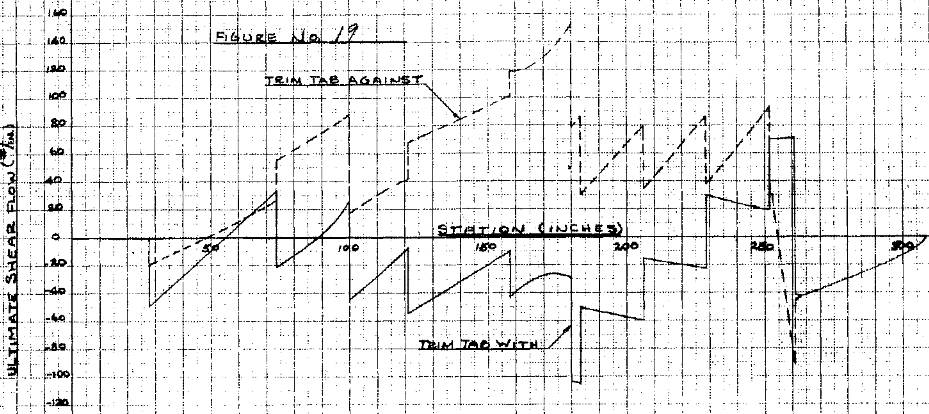
RENOLA ZINBERG 7-1-47 LOWREY	RUDDER PRESSURE DISTRIB. UNSYMM. THRUST + GUST	FZS-36-247 XB-36

FIGURE NO. 18



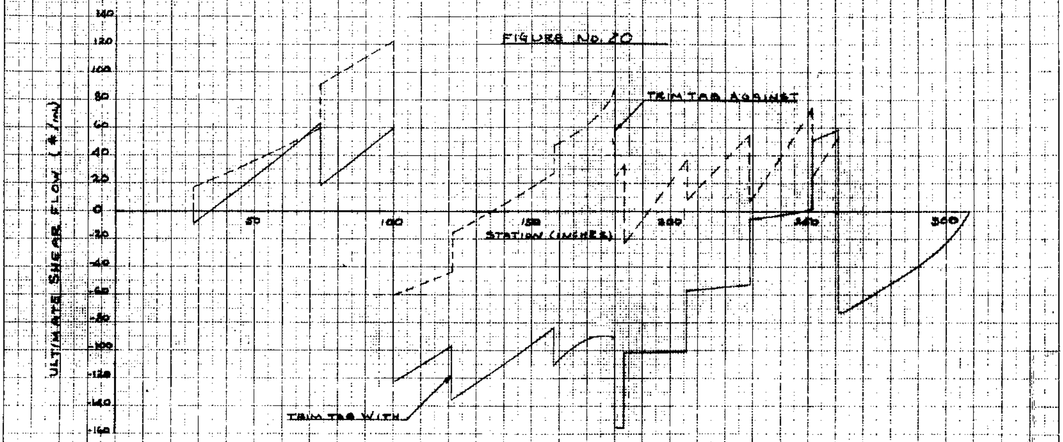
BEARD 10-7-47	RUDDER SPAR SHEAR FLOW	FZS-36-287
BEARD 10-8-47	STEADY YAW ψ = 4.36° FOR TRIM	XB-36
Z11222B		

FIGURE No. 19



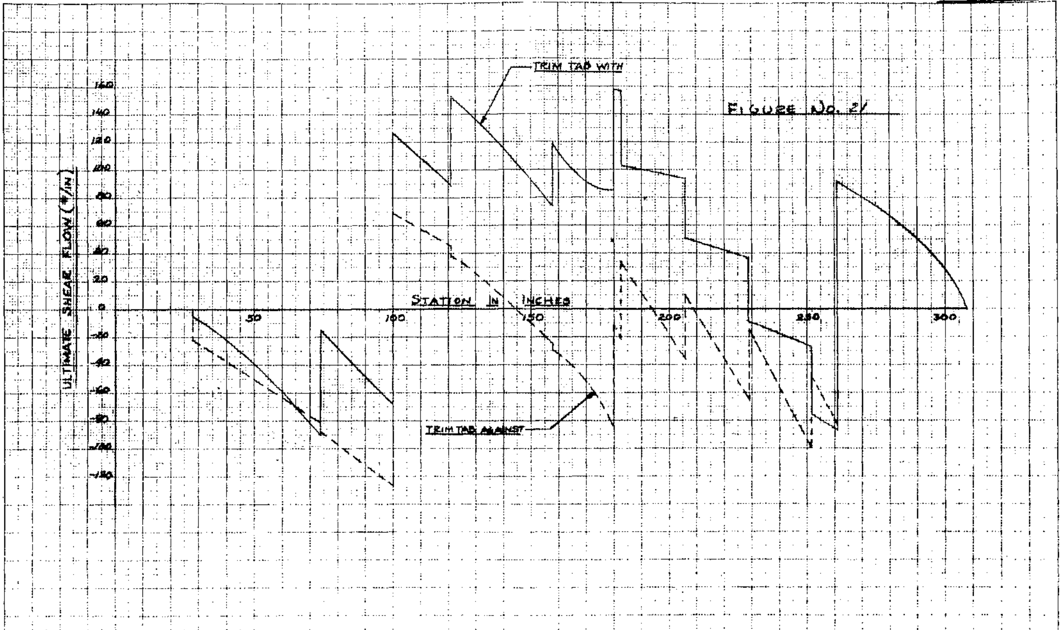
RUDDER SPAR SHEAR FLOW
STEADY YAW ψ=±4.35° & TRIM

F23-36-247
XB-36



RUDDER SPAR SHEAR FLOW
STEADY YAW

FZS-36-247
XB-36

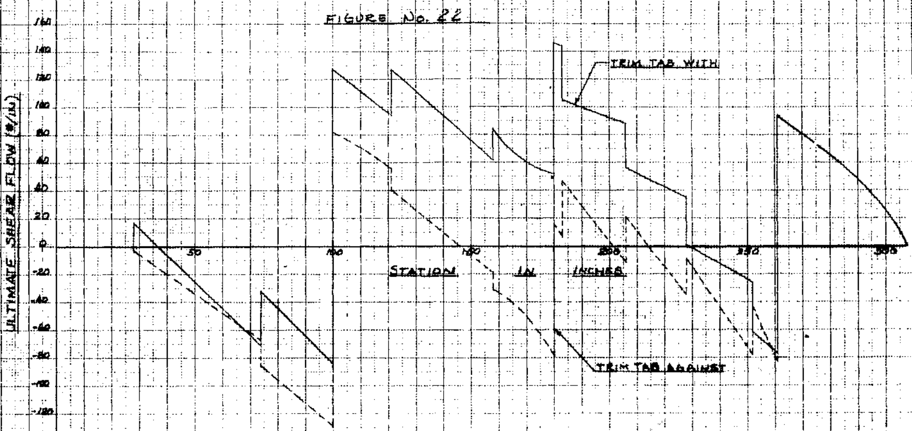


RUDDER SPAR SHEAR FLOW
GUST CONDITION

BEARD
THOMPSON 23 OCT 47
Z TURNER

FZS-36-247

XB-36



RUDDER SPAR SHEAR FLOW
UNSYMMETRICAL THRUST + GUST
FZS-36-247
XB-36

RUDDER SPAR
(REF. DWG. 36T-1147)

STA. 28 - STA. 100

PANEL BETWEEN STA 62 1/4 & STA. 70

WEB .020 24ST 81 7.75" × 23.5"

$h' = 24.5$ (PAGE 22)

GUST CONDITION CRITICAL

$q = 82\ \#/\text{in.}$ $M = 51{,}500$ IN. LBS.

$$\tau = \frac{82}{.020} = 4{,}100 \text{ p.s.i.}$$

SPAR CAP FXM-44-088 (24ST 86 MAT.)

$A_f = .164 \text{ in}^2$ $I_f = .02487 \text{ in}^4$

STF'N'R Y3A 16T84 $A_s = .0409 \text{ in}^2$ $I_s = .00165 \text{ in}^4$

$$\lambda = bt\left[\frac{b^3}{360\,hI_f} + \frac{1}{A_s}\right] = 7.75 \times .020\left(\frac{(7.75)^3}{360 \times 23.5 \times .02487} + \frac{1}{.0409}\right)$$

$= 4.14$

$$\tau_{cr} = K_s E\left(\frac{t}{b}\right)^2 \quad a/b = \frac{23.5}{7.75} = 3.03,\ K_s = 5.23 \text{ (ANC-5)}$$

$$= 5.23 \times 10.2 \times 10^6 \left(\frac{.020}{7.75}\right)^2 = 355 \text{ p.s.i.}$$

$$r = \frac{\tau_{cr}}{25{,}000} = \frac{355}{25{,}000} = .0142$$

$\tan\alpha = .669$ $\alpha = 33.8°$ $\cos\alpha = .831$

$\sec\alpha = 1.202$ $\sin\alpha = .556$

$$C_R = 1 - (d_s/p_s)\sec\alpha + 1/4\tan^2\alpha,\quad d_s/p_s = \frac{.096}{.625} = .1535$$

$$= 1 - .1535 \times 1.202 + 1/4(.669)^2 = .9273 \qquad R_R = .832$$

$$\tau_{cu} = (RR_R C_R F_{cu} + \tau_{cr})\sin\alpha\cos\alpha \qquad R = .958$$

$$= (.958 \times .832 \times .9273 \times 65{,}000 + 355) \times .556 \times .831 = 22{,}300 \text{ p.s.i.}$$

$$\tau_{su} = .9(1 - .1535) \cdot 40{,}000 = 30{,}500 \text{ p.s.i.}$$

$\tau_u = 22{,}300$ p.s.i. $\tau = 4{,}100$ MARGIN HIGH

RUDDER SPAR

STA. 28-STA. 100

PANEL STA. 62¼ - STA. 70

FLANGE RIVETS

$$S_{fr} = bt\sqrt{\left(\frac{\tau}{N + A_{ser}/A_{fr}}\right)^2 + \left(\frac{\tau \tan\alpha - \tau_{cr}}{N}\right)^2}$$

$N = 13$, $A_{ser} = .026$, $A_{fr} = .013$

$$S_{fr} = 7.75 \times .02\sqrt{\left(\frac{4{,}100}{13+2}\right)^2 + \left(\frac{4{,}100 \times .669 - 355}{13}\right)^2} = 51^{\#}$$

AD4 RIVET CRIT. BRG. .020 WEB
ALL. BRG. = 257 # /RIVET

MARGIN HIGH

FLANGES

$\cot\alpha = 1.51$ $\qquad \frac{\tau_{cr}}{\tau} = \frac{355}{4100} = .0865$

$$\Delta f_c = \frac{hq}{2A_f}\left(\cot\alpha - \frac{\tau_s}{\tau}\right) \qquad \frac{\tau_s}{\tau} = .4$$

$$= \frac{23.5 \times 82}{2 \times .164}(1.51 - .400) = 6{,}520 \text{ p.s.i.}$$

$$f_c = 6520 + \frac{51{,}500}{24.5 \times .164} = 19{,}330 \text{ psi}$$

$F_{cr} = 39{,}200$ (C.V.A.C. #1)

$$M.S. = \frac{39{,}200}{19{,}330} - 1 = \underline{+1.03}$$

WEB STIFFENER

$$I_s = .00165$$

$$I_s(\text{REQ}) = 3.4 \times 10^{-18}\left(\frac{b}{t}\right)^2\sqrt{h}\; q^{3.5}$$

$$= \frac{3.4 \times (7.75)^2 \times \sqrt{23.5} \times (82)^{3.5}}{(10)^{18} \times (.020)^2} = .000012 \text{ in}^4$$

STIFFENER SATISFACTORY

RUDDER SPAR

STA. 28 - STA. 100 (CONT'D.)

PANEL STA. 100 -

STEADY YAW $\phi = -4.38°$ δ_R FOR TRIM

$q = 195$ #/IN $M = 77,500$ IN. LBS.

WEB .025 24ST81

$\tau = \frac{195}{.025} = 7,800$ p.s.i.

PANEL 7×21.6 $a/b = \frac{21.6}{7} = 3.085$, $K_s = 5.2$ (ANC-5)

$\tau_{cr} = 5.2 \times 10.2 \times 10^6 \left(\frac{.025}{7}\right)^2 = 678$ p.s.i.

$A_f = .374$ in.^{2} $I_f = .0781$ in.^{4}

WEB STFNR Y14A17 $A_s = .1087$ in.^{2} , $I_s = .01065$ in^4

$$\lambda = 7 \times .025 \left[\frac{(7)^3}{360 \times 21.6 \times .0781} + \frac{1}{.1087}\right] = 1.71$$

$n = \frac{678}{25,000} = .0271$ Cot $\alpha = 1.27$ $\alpha = 38.2°$

tan $\alpha = .787$, Sin $\alpha = .618$, cos $\alpha = .786$, Sec $\alpha = 1.27$

$\frac{d_s}{P_s} = \frac{.096}{.625} = .1535$ $R = 1.014$

$C_R = 1 - .1535 \times 1.27 + \frac{(.787)^2}{4} = .955$, $R_R = .815$

$\tau_{tu} = (1.014 \times .815 \times .955 \times 65,000 + 678) \times .618 \times .786$
$= 25,350$ p.s.i.

$\tau_{su} = .9(1 - .1535) \times 40,000 = 30,500$ p.s.i.

$\tau_u = 25,350$ p.s.i.

$\tau = 7,800$ p.s.i.

MARGIN HIGH

RUDDER SPAR

PANEL STA 100-(CONT'D.)

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM (CONT'D)

FLANGE RIVETS

N = 11 AD5'S   STFNR ATTACHING RIVETS 2-AD5

$$S_{fr} = 7 \times .025 \sqrt{\left(\frac{7{,}800}{11+2}\right)^2 + \left(\frac{7{,}800 \times .787 - 678}{11}\right)^2} = 137\ \#$$

AD5 RIVETS CRIT. BRG., .025 WEB

ALL. BRG. = 397 #/RIVET

$$m.s = \frac{397}{137} - 1 = \underline{\underline{+1.90}}$$

FLANGES

$$\frac{\tau_w}{\tau} = \frac{678}{7800} = .087, \quad \frac{\tau_s}{\tau} = .34$$

$$\Delta f_c = \frac{21.6 \times 195}{2 \times .374}(1.27 - .34) = 5{,}240 \text{ p.s.i.}$$

$$f_c = 5{,}240 + \frac{77{,}500}{22.68 \times .374} = 14{,}380 \text{ p.s.i.}$$

$F_{cc} = 52{,}000$ p.s.i. (C.V.A.C No. 1)

MARGIN HIGH

WEB STIFFENER

$$I_s = .01065 \text{ in}^4$$

$$I_s(\text{REQ}) = \frac{3.4 \times (7.0)^2 \times \sqrt{21.6} \times (195)^{3.5}}{(10)^{12} \times (.025)^2} = .000128 \text{ in}^4$$

STIFFENER SATISFACTORY

GUST COND

q = 127 #/IN   M = 123,000 IN. LBS

FLANGES

$$\Delta f_c = \frac{21.6 \times 127}{2 \times .374}(1.27 - .0271) = 4{,}555 \text{ p.s.i.}$$

$$f_c = 4{,}555 + \frac{123{,}000}{22.68 \times .374} = 19{,}055 \text{ p.s.i.}$$

$F_{cc} = 52{,}000$ p.s.i.   MARGIN HIGH

RUDDER SPAR

PANEL STA. 121 5/16+

GUST COND.

$q = 153$ #/IN. $M = 81{,}500$ IN. LBS.

WEB .020 24ST 81 5.5" × 20.8"

$$\tau = \frac{153}{.020} = 7{,}650 \text{ p.s.i.}$$

SPAR CAP FXM-44-088 (24ST 86 MAT.)

$A_f = .164 \text{ in}^2$ $I_f = .02487 \text{ in}^4$

STIFFENER Y3A-16T84 $A_s = .0409 \text{ in}^2$ $I_s = .00165 \text{ in}^4$

$$\lambda = 5.5 \times .020 \left[\frac{(5.5)^3}{360 \times 20.8 \times .02487} + \frac{1}{.0409} \right] = 2.785$$

$$\tau_{cr} = K_s E \left(\frac{t}{b}\right)^2 \qquad a/b = \frac{20.8}{5.5} = 3.78 \qquad K_s = 5.1 \text{ (ANC-5)}$$

$$= 5.1 \times 10.2 \times 10^6 \left(\frac{.020}{5.5}\right)^2 = 688 \text{ p.s.i.}$$

$$n = \frac{688}{25000} = .0275 \qquad \cot\alpha = 1.357,\ \alpha = 36.4^\circ$$

$$\tan\alpha = .737,\ \sin\alpha = .5934,\ \cos\alpha = .805,\ \sec\alpha = 1.24$$

$$d_s/P_b = \frac{.096}{.625} = .1535 \qquad R = .952$$

$$C_R = 1 - (.1535) \times 1.24 + \frac{(.737)^2}{4} = .946 \qquad R_R = .818$$

$$\tau_{ru} = (.952 \times .818 \times .946 \times 65{,}000 + 688) \times .5934 \times .805$$
$$= 23{,}200 \text{ p.s.i.}$$

$$\tau_{su} = .9(1 - .1535) \times 40{,}000 = 30{,}500 \text{ p.s.i.}$$

$\tau_u = 23{,}200$ p.s.i. $\tau = 7{,}650$ p.s.i.

MARGIN HIGH

RUDDER SPAR

PANEL STA. 121 5/16 + (CONT'D.)

GUST COND. (CONT'D)

FLANGE RIVETS

N = 13 AD4'S   STF'NR ATTACHING RIVETS 2-AD4

$$S_{fR} = 5.5 \times .020 \sqrt{\left(\frac{7{,}650}{13+2}\right)^2 + \left(\frac{7650 \times .737 - 688}{13}\right)^2}$$

$= 70$ #/RIVET

AD4'S CRITICAL IN BRG. IN .020 WEB

ALL. BRG. = 257 #/RIVET

FLANGES

$$\frac{\tau_{cr}}{\tau} = \frac{688}{7650} = .09, \quad \frac{\tau_s}{\tau} = .38 \quad \text{MARGIN HIGH}$$

$$\Delta f_c = \frac{20.8 \times 153}{2 \times .164}(1.357 - .38) = 9{,}480 \text{ p.s.i.}$$

$$f_c = 9{,}480 + \frac{81{,}500}{21.68 \times .164} = 32{,}380 \text{ p.s.i.}$$

$F_{cr} = 39{,}200$ p.s.i.
(C.V.A.C. No. 1)

$$M.S. = \frac{39{,}200}{32{,}380} - 1 = \underline{+.21}$$

WEB STIFFENER

$I_s = .00165 \text{ in}^4$

$$I_s\,(\text{REQ.}) = \frac{34\,(5.5)^2 \times \sqrt{20.8} \times (153)^{3.5}}{(10)^{18} \times (.020)^2} = .00005 \text{ in}^4$$

STIFFENER SATISFACTORY

RUDDER SPAR

STA. 170

WEB PANEL 6.2 × 18 × .025 (24ST81)

STEADY YAW $\psi = -4.38°$ δR FOR TRIM

$q = 160\ \#/\text{IN}$ MOM. = 16.000 IN. LBS.

$\tau = \dfrac{160}{.025} = 6{,}400$ p.s.i.

SPAR CAP Y2A58T34

$A_f = .2101\ \text{in}^2$ $I_f = .0321\ \text{in}^4$ $F_{cc} = 47{,}000$ p.s.i. (C.V.A.C. No. 1)

WEB STF'NR Y3A16T34

$A_s = .0409\ \text{in}^2$ $I_s = .00165\ \text{in}^4$

$$\lambda = 6.2 \times .025 \left[\frac{(6.2)^3}{360 \times 18 \times .0321} + \frac{1}{.0409} \right] = 3.96$$

$$\tau_{cr} = 5.28 \times 10.2 \times 10^6 \left(\frac{.025}{6.2} \right)^2 = 875 \text{ p.s.i.}$$

$$n = \frac{875}{25{,}000} = .035 \qquad \cot\alpha = 1.48 \qquad \alpha = 34.1°$$

$\tan\alpha = .676$, $\sin\alpha = .561$, $\cos\alpha = .826$, $\sec\alpha = 1.21$

$$d_s/p_s = \frac{.096}{.625} = .1535 \qquad R = .954$$

$$C_R = 1 - (.1535)(1.21) + \frac{(.676)^2}{4} = .9285 \qquad R_R = .832$$

$$\tau_{tu} = (.954 \times .832 \times .9285 \times 65{,}000 + 875) \times .561 \times .826$$
$$= 22{,}600 \text{ p.s.i.}$$

$$\tau_{su} = .9(1 - .1535) \times 40{,}000 = 30{,}500 \text{ p.s.i.}$$

$$\tau_u = 22{,}600 \text{ p.s.i.}$$

$$\tau = 6{,}400 \text{ p.s.i.}$$

MARGIN HIGH

RUDDER SPAR

STA. 170 (CONT'D)

STEADY YAW $\psi = -4.38°$ C.R. FOR TRIM (CONT'D)

FLANGE RIVETS

N = 15 AD4 RIVETS

STF'N'R ATTACHING RIVETS 2 AD-4'S

$$S_{fr} = 6.2 \times .025 \sqrt{\left(\frac{6{,}400}{15+2}\right)^2 + \left(\frac{6400 \times .676 - 875}{15}\right)^2} = 69^{\#}$$

AD4'S CRIT. BRG. .025, ALL = 321#

MARGIN HIGH

FLANGES $\quad \frac{\tau_{cr}}{\tau} = \frac{875}{6400} = .137 \quad \frac{\tau_s}{\tau} = .48$

$$\Delta f_c = \frac{18 \times 160}{2 \times .2101}(1.48 - .48) = 6{,}850 \text{ p.s.i.}$$

$$f_c = 6{,}850 + \frac{16{,}000}{18.96 \times .2101} = 10{,}860 \text{ p.s.i.}$$

$F_{cr} = 47{,}000$ p.s.i. MARGIN HIGH

WEB STIFFENER

$I_s = .00165 \text{ in}^4$

$$I_{s\,REQ} = \frac{3.4 \times (6.2)^2 \times \sqrt{18} \times (160)^{3.5}}{(10)^{18} \times (.025)^2} = .000046 \text{ IN.}^4$$

STIFFENER SATISFACTORY

GUST COND.

FLANGES

$q = 92^{\#}/\text{IN}$ MOM. = 38,000 IN. LBS. $\quad \frac{\tau_{cr}}{\tau} = \frac{875}{3{,}680} = .238 \quad \frac{\tau_s}{\tau} = .6$

$$f_c = \frac{18 \times 92}{2 \times .2101}(1.48 - .6) + \frac{38{,}000}{18.96 \times .2101}$$

$$= 3{,}470 + 9{,}550 = 13{,}020 \text{ p.s.i.}$$

$F_{cr} = 47{,}000$ p.s.i.

MARGIN HIGH

RUDDER SPAR

STA. 180 –

WEB PANEL 7.6 × 17.8 × .025 (24ST 81)

STEADY YAW $\phi = -4.38°$ δ_R FOR TRIM

$q = 202$ #/IN. $M = 32{,}000$ IN. LBS.

$\tau = \dfrac{202}{.025} = 8{,}080$ p.s.i.

$A_f = .3400$ in^2. $I_f = .05324$ in^4 $F_{cu} = 49{,}600$ p.s.i.

WEB STF'N'R. Y14 A 17 T 84 $A_s = .1087$ in^2, $I_s = .01065$

$$\lambda = 7.6 \times .025 \left[\frac{(7.6)^3}{360 \times 17.8 \times .05324} + \frac{1}{.1087} \right] = 1.992$$

$a/b = \dfrac{17.6}{7.6} = 2.34$ $K_s = 5.5$ (ANC-5)

$$\tau_{cr} = 5.5 \times 10.2 \times 10^6 \left(\frac{.025}{7.6} \right)^2 = 606 \text{ p.s.i.}$$

$n = \dfrac{606}{25000} = .02425$ $\cot \alpha = 1.30$ $\alpha = 37.6°$

$\tan \alpha = .770$, $\sin \alpha = .610$, $\cos \alpha = .7923$, $\sec \alpha = 1.26$

$d_s/P_s = \dfrac{.096}{.625} = .1535$ $R = .992$

$$C_R = 1 - (.1535)(1.26) + \frac{(.770)^2}{4} = .9549, \quad R_R = .813$$

$$\tau_{tu} = (.992 \times .813 \times .9549 \times 65{,}000 + 606) \times .610 \times .7923$$
$$= 24{,}500 \text{ p.s.i.}$$

$$\tau_{su} = .9(1 - .1535) \times 40{,}000 = 30{,}500 \text{ p.s.i.}$$

$\tau_u = 24{,}500$ p.s.i.

$\tau = 8{,}080$ p.s.i.

MARGIN HIGH

RUDDER SPAR

STA. 180-

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM

FLANGE RIVETS

$N = 11$ AD 5'S, STF'N'R ATTACHING RIVETS, 2-AD5'S

$$S_{fR} = 7.6 \times .025 \sqrt{\left(\frac{8{,}080}{11+2}\right)^2 + \left(\frac{8{,}080 \times .770 - 606}{11}\right)^2} = 153^{\#}$$

RIVETS CRITICAL IN BRG. ON .025 WEB

ALL. BRG. = 397#

$$M.S. = \frac{397}{153} - 1 = \underline{+1.59}$$

FLANGES

$$\cot\alpha = 1.30, \quad \frac{\tau_{cr}}{\tau} = \frac{606}{8{,}080} = .075, \quad \frac{\tau_s}{\tau} = .33$$

$$\Delta f_c = \frac{17.8 \times 202}{2 \times .34}(1.30 - .33) = 5{,}180 \text{ p.s.i.}$$

$$f_c = 5{,}180 + \frac{32{,}000}{18.35 \times .34} = 10{,}310 \text{ p.s.i.}$$

$F_{cc} = 49{,}600$ p.s.i. (C.V.A.C. No. 1) — MARGIN HIGH

WEB STIFFENER

$$I_s = .01065 \text{ in}^4$$

$$I_s(\text{REQ}) = \frac{3.4 \times (7.6)^2 \times \sqrt{17.8} \times (202)^{3.5}}{(10)^{18} \times (.025)^2} = .00016 \text{ in}^4$$

STIFFENER SATISFACTORY

RUDDER SPAR

STA. 261

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM

$q = 161$ #/IN $M = 49,500$ IN. LBS
PANEL SIZE $5.3 \times 13 \times .025$ (24ST81)
WEB STFNR'S Y14 A17 T84
$A_S = .1087$ IN^2 $I_S = .01065$ IN^4
$A_f = .3009$ IN^2 $I_f = .0469$ IN^4 $F_a = 46,000$ p.s.i.

$$\lambda = 5.3 \times .025 \left[\frac{(5.3)^3}{360 \times 13 \times .0469} + \frac{1}{.1087} \right] = 1.31$$

$a/b = \frac{13}{5.3} = 2.45$, $K_s = 5.45$ (ANC-5)

$\tau_a = 5.45 \times 10.2 \times 10^6 \left(\frac{.025}{5.3}\right)^2 = 1,236$ p.s.i

$n = \frac{1,236}{25,000} = .0494$ $\cot\alpha = 1.27$ $\alpha = 38.2°$

$\tan\alpha = .787$, $\sin\alpha = .618$, $\cos\alpha = .786$, $\sec\alpha = 1.272$

$\frac{d_s}{p_s} = \frac{.096}{.625} = .1535$ $R = 1.053$

$C_R = 1 - (.1535 \times 1.272) + \frac{(.787)^2}{4} = .960$, $R_R = .812$

$\tau_{tu} = (1.053 \times .812 \times .960 \times 65,000 + 1,236) \times .618 \times .786$
$= 26,600$ p.s.i.

$\tau_{su} = .9(1 - .1535) \times 40,000 = 30,500$ p.s.i.

$\tau_u = 26,600$ p.s.i

$\tau = \frac{161}{.025} = 6,440$ p.s.i.

MARGIN HIGH

RUDDER SPAR

STA. 261 (CONT'D.)

STEADY YAW $\phi = -4.38°$ δ_R FOR TRIM (CONT'D)

FLANGE RIVETS

N = 7 AD5 RIVETS, STFNR ATTACHING RIVETS, 2-AD5'S

$$S_{fn} = 5.3 \times .025 \sqrt{\left(\frac{6,440}{7+2}\right)^2 + \left(\frac{6,440 \times .787 - 1,236}{7}\right)^2} = 119^{\#}$$

RIVETS CRITICAL BRG .025 WEB

ALL. = 397 #/RIVET

MARGIN HIGH

FLANGES

$$\cot\alpha = 1.27, \quad \frac{\tau_{cr}}{\tau} = \frac{1,236}{6,440} = .192, \quad \frac{\tau_i}{\tau} = .5$$

$$\Delta f_c = \frac{13 \times 161}{2 \times .3009}(1.27 - .5) = 2,680 \text{ p.s.i.}$$

$$f_c = 2,680 + \frac{49,500}{13.5 \times .3009} = 14,880 \text{ p.s.i.}$$

$F_{cu} = 46,000$ p.s.i.
(C.V.A.C. No. 1)

MARGIN HIGH

WEB STIFFENER

$I_s = .01065 \text{ in}^4$

$$I_s \text{ (REQ.)} = \frac{3.4 \times (5.3)^2 \times \sqrt{.3} \times (161)^{3.5}}{(10)^{12} \times (.025)^2} = .000029 \text{ IN}^4$$

STIFFENER SATISFACTORY

RUDDER SERVO TAB

The servo tab is of the single spar, D tube type of construction. As in the main surface, all bending and shear is carried by the spar, while torsion is carried by the box formed by the spar and nose skin. Torque plates are provided for the transfer of torsion across the nose box discontinuities at hinge stations.

The tab is hinged to the main rudder surface at Sta. 28, 73¾, 121 5/16, and 158 1/2. The surface is treated as a continuous beam over four supports. Preliminary investigation showed that relative deflection supports made little or no difference on the bending moments over assuming no support. Therefore, for ease of computation, no relative support deflection is assumed. Variation of moment of inertia of the spar is taken into account in determining bending moments.

The continuous beam analysis is made for a unit 1000# load, and the reactions, shears, and moments are then ratioed to the actual design load.

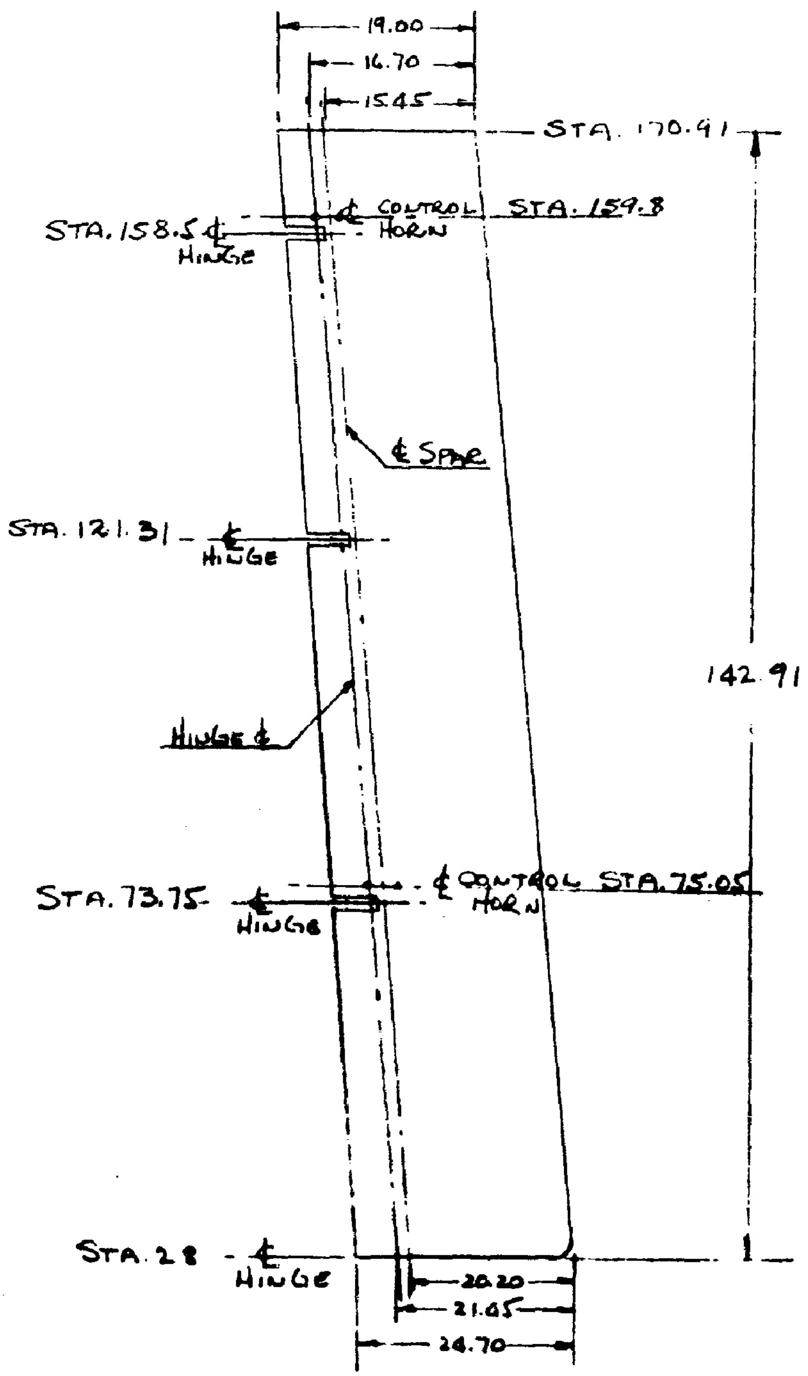
The tab is controlled at Sta. 75.05 and Sta. 159.8. Since two torsional reactions constitute a redundant situation, overlapping designs are made. It is first assumed that 50% of the load is reacted at each control station. Then it is assumed that 60% is reacted at Sta. 75.05, and 40% at Sta. 159.8. It is believed that these two design assumptions will cover any distribution that might occur.

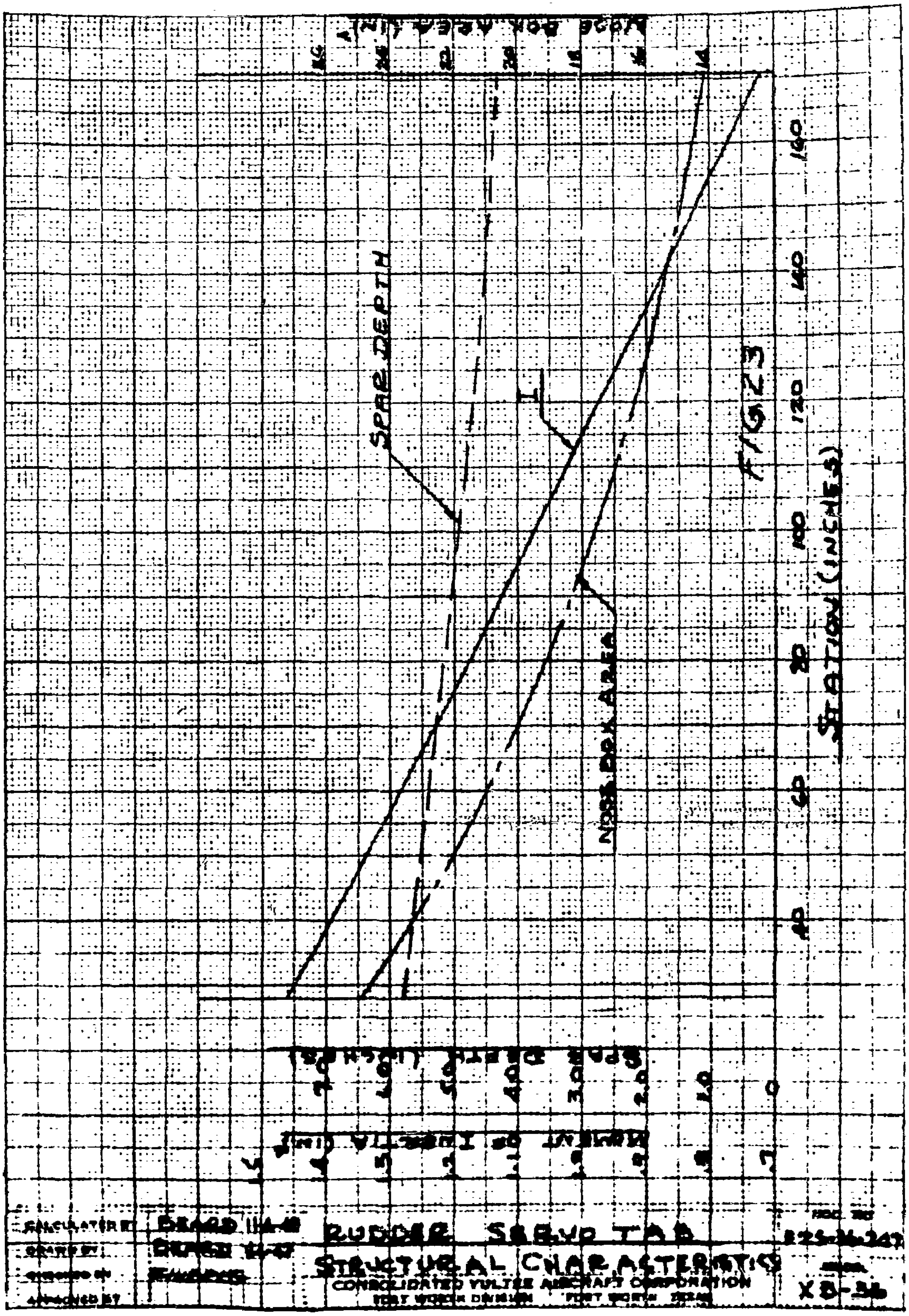
ANALYSIS VERT. SURFACES
PREPARED BY N. BEARD
CHECKED BY ZIIIBELL
REVISED BY

Consolidated Vultee Aircraft Corporation
FORT WORTH DIVISION
FORT WORTH, TEXAS

REPORT NO. FZS-36-247
MODEL XB-36
DATE 11-4-47

RUDDER SERVO TAB
(REF. DWG. 36 T 1130)




SPAR DEPTH
NOSE BOX AREA
FIG 23
STATION (INCHES)
40
60
80
100
120
140
160
SPAR DEPTH (INCHES)
MOMENT OF INERTIA (IN)
NOSE BOX AREA (IN)
RUDDER SERVO TAB
STRUCTURAL CHARACTERISTICS
CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH TEXAS
XB-36

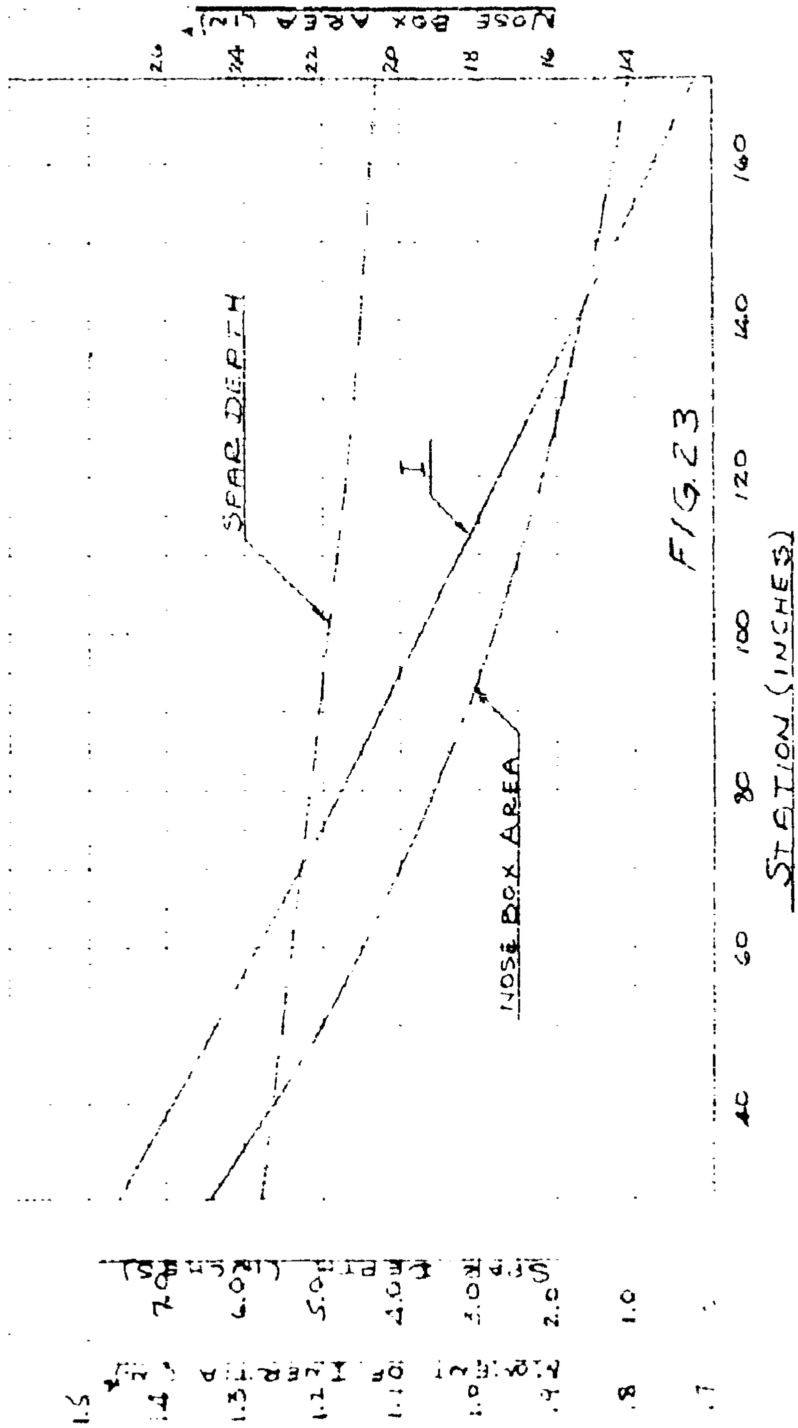
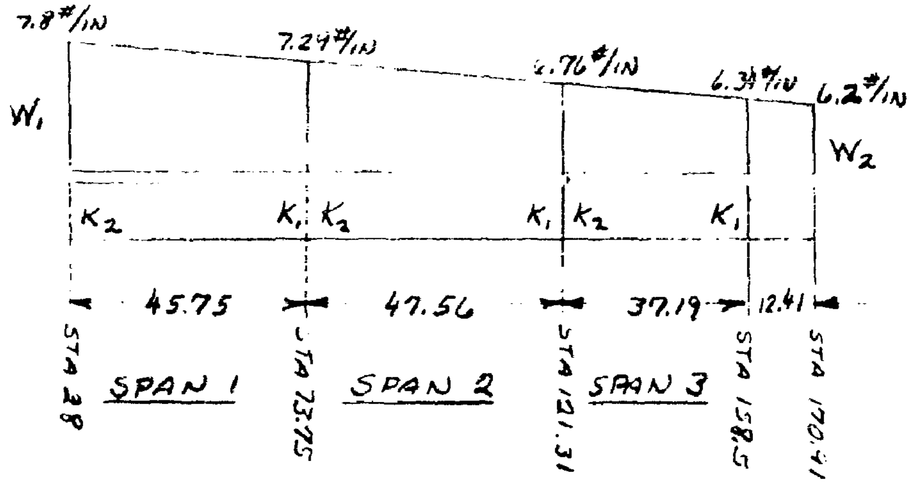


FIG. 23

BEARD 4-47 RUDDER SERVO TAB
BEARD 4-47 STRUCTURAL CHARACTERISTICS
FZS-36-2[illegible]
8-36

RUDDER SERVO TAB

MOMENT DISTRIBUTION FACTORS



SPAN	I_{IN}	I_{OUT}	UNIFORM LOAD K_1	UNIFORM LOAD K_2	VARYING LOAD K_1	VARYING LOAD K_2	CARRY-OVER FACTOR	DISTRIBUTION FACTOR
1	1.460	1.208	.0806	.0860	.0319	.0513	.480	1.0
							.525	.535
2	1.208	.165	.0802	.0865	.0318	.0515	.475	.465
							.530	.459
3	.965	.851	.0815	.0850	.0325	.0508	.495	.541
							.517	1.0

FOR 1000# UNIT LOAD:

LOAD DISTRIBUTION PROPORTIONAL TO CHORD LENGTHS.

CHORD @ STA 28 = 24.7 IN. (W_1 = LOADING @ STA 28)
CHORD @ STA 170.41 = 19.6 IN. (W_2 = LOADING @ STA 170.41)

$w_1 = \frac{24.7}{19.6} w_2 = 1.26\, w_2$ $\quad \frac{w_1 + w_2}{2} \times 142.41 = 1000$

$w_1 + w_2 = 14$

$2.26\, w_2 = 14$; $w_2 = 6.2$

$w_1 = 7.8$

RUDDER SERVO TAB
FOR 100 # UNIT LOAD

CANTILEVER MOMENT STA 108.5

$M = 6.2 \times 12.41 \times 6.205 + .14 \times 6.205 \times 4.14 = 481''\#$

FIXED END MOMENTS - AIRLOADS

SPAN 1

$UM_1 = .0860 \times 7.29 \times (45.75)^2 = 1,312$
$VM_1 = .0513 \times .51 \times (45.75)^2 = 55$
$M_1 = 1,367''\#$

$UM_2 = .0806 \times 7.29 \times (45.75)^2 = 1,230$
$VM_2 = .0319 \times .51 \times (45.75)^2 = 34$
$M_2 = 1264''\#$

SPAN 2

$UM_2 = .0865 \times 6.76 \times (47.56)^2 = 1,323$
$VM_2 = .0515 \times .53 \times (47.56)^2 = 62$
$M_2 = 1,387''\#$

$UM_3 = .0802 \times 6.76 \times (47.56)^2 = 1,328$
$VM_3 = .0318 \times .53 \times (47.56)^2 = 38$
$M_3 = 1,366''\#$

SPAN 3

$UM_3 = .0850 \times 6.34 \times (37.19)^2 = 744$
$VM_3 = .0508 \times .42 \times (37.19)^2 = 30$
$M_3 = 774''\#$

$UM_4 = .0815 \times 6.34 \times (37.19)^2 = 714$
$VM_4 = .0325 \times .42 \times (37.19)^2 = 19$
$M_4 = 733''\#$

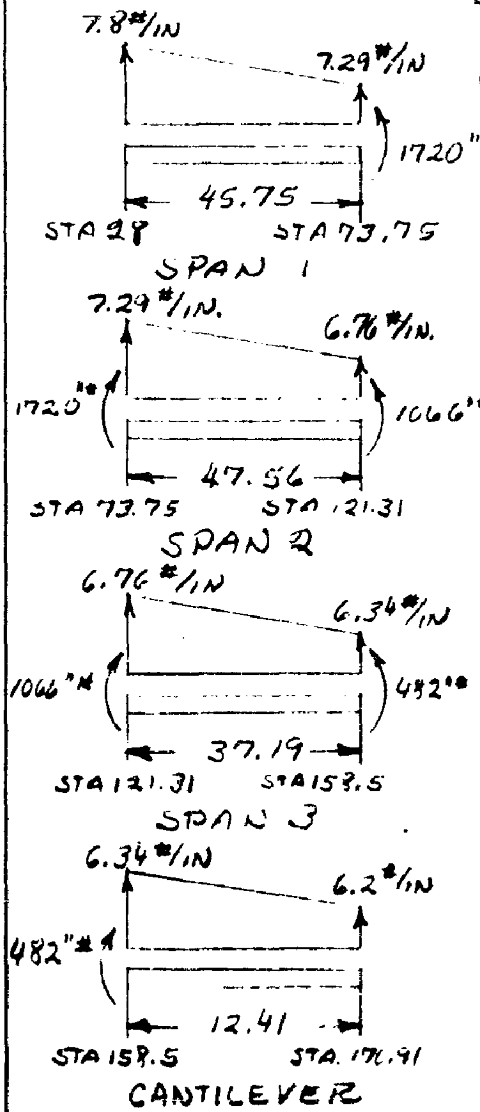
RUDDER SERVO TAB
1000# UNIT LOAD

MOMENT DISTRIBUTION

CARRY-OVER FACTOR	.480	.525	.475	.530	.485	.517	
DISTRIBUTION FACTOR	1.0	.535	.465	.457	.541	1.0	
MOMENT	1,367	+1264	+1387	+1366	+774	+733	+482
	-1,367	+ 66	- 57	- 272	+320	- 251	
	- 35	+ 656	+144	+27	+130	- 155	
	+ 35	- 274	+238	+47	- 56	+ 155	
	+147	- 17	- 25	- 113	- 80	+ 27	
	- 147	- 4	+ 4	+ 15	- 18	- 27	
	+ 2	+ 71	- 8	- 2	+ 14	+ 9	
	- 2	- 42	+ 37	+ 7	- 9	- 9	
	+ 22	+ 1	- 4	- 18	+ 5	+ 4	
	- 22	- 3	+ 2	+ 11	- 12	- 4	
	+ 2	+ 11	- 6	- 1	- 2	+ 6	
	- 2	- 9	+ 8	- 1	+ 1	- 6	
	0	+1720	+1720	+1066	+1066	+482	+482

RUDDER SERVO TAB
1000# UNIT LOAD

REACTIONS



$$R_{28} = \frac{7.29 \times 45.75}{2} + \frac{.51 \times 45.75}{3} - \frac{1720}{45.75} = 137$$

$$R_{73.75L} = 166.7 + 3.1 + 37.6 = 208$$

$$R_{73.75R} = \frac{6.76 \times 47.56}{2} + \frac{.53 \times 47.56}{3} + \frac{654}{47.56} = 183$$

$$R_{121.31L} = 160.9 + 4.2 - 13.7 = 151^{\#}$$

$$R_{121.31R} = \frac{6.34 \times 37.19}{2} + \frac{.42 \times 37.19}{3} + \frac{584}{37.19} = 139^{\#}$$

$$R_{158.5L} = 117.8 + 2.6 - 15.7 = 105^{\#}$$

$$R_{158.5R} = \frac{6.2 + 6.34}{2} \times 12.41 = 78^{\#}$$

$$R_{28} = 137^{\#}$$

$$R_{73.75} = 208 + 183 = 390^{\#}$$

$$R_{121.31} = 151 + 139 = 290^{\#}$$

$$R_{158} = 105 + 78 = 183^{\#}$$

TOTAL = 1000#

RUDDER SERVO TAB

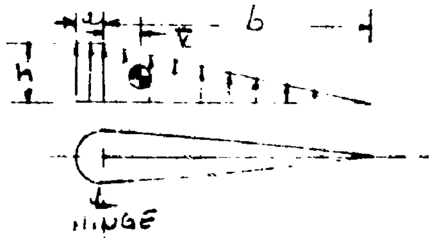
THE MOST CRITICAL LOADING FOR THE SERVO TAB IS GUST CONDITION WITH TRIM TAB LOADS IN THE SAME DIRECTION AS RUDDER AIR LOADS.
LD. = 2756# ULT. (REF. P.40)

THE PRESSURE DISTRIBUTION IS ASSUMED THE SAME AS FOR THE TRIM TAB (PAGE 94), CONSTANT FROM THE LEADING EDGE TO HINGE ℄, AND VARYING TO ZERO AT TRAILING EDGE.

THE HINGE MOMENT IS REACTED AT CONTROL HORN STA 159.8 AND STA 75.05. TWO OVERLAPPING ASSUMPTIONS ARE MADE

1. 40% OF THE MOMENT REACTED AT STA. 159.8, 60% STA. 75.05
2. 50% OF THE MOMENT REACTED AT STA 159.8, 50% STA. 75.05

AS WITH THE TRIM TAB THE CONTROL HORNS ATTACH TO THE SERVO TAB 8° FROM NORMAL TO THE SPAR. THE ATTACHMENT IS ASSUMED TO BE NORMAL SINCE THE ERROR IS SLIGHT



$$\bar{x} = \frac{h \times a \times \frac{a}{2} - h \times \frac{b}{2} \times \frac{b}{3}}{ah + \frac{h}{2} \times b} = \frac{\frac{a^2}{2} - \frac{b^2}{6}}{a + \frac{b}{2}}$$

$\bar{x}$ NEG. C.P. AFT ℄ HINGE

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH, TEXAS
FW 633 125 PADS 11-43

RUDDER SERVO TAB

ULTIMATE HINGE MOMENTS - GUST CONDITION

TABLE NO. 15

PREP. BY: BEARD
CHECKED BY: ZINBERG

PAGE 81
REP. NO. FZS-36-247
MODEL XB-36
DATE 11-5-47

	STA.	DIST. BETWEEN STAS.	CHORD	UNIT LOADING 4000# #/in.	UNIT LOADING 2,756# #/in.	AVERAGE LOADING BETWEEN STAS	ULT. LOAD BETWEEN STAS.	a	$\frac{a^2}{2}$	b	$\frac{b}{2}$	$\frac{b^2}{6}$	ARM TO CENTROID	$\frac{⑨-⑫}{⑧+⑪}$	AIRLOAD HINGE MOM. ⑦ × ⑭	HORN REAC. 40-60 DIST.	Σ HINGE MOM 40-60 DIST.	HORN REAC. 50-50 DIST.	Σ HINGE MOM. 50-50 DIST.
	①	②	③	④	⑤	⑥	⑦	8	9	⑩	11	⑫	⑬	⑭	⑮	⑯	⑰	⑱	⑲
TIP	170.91			6.20	17.09												0		0
	(168.15)	5.50	19.11			17.17	94	2.32	2.69	16.79	8.39	46.95	2.74	-4.13	-388				
	165.41			6.26	17.25												-388		-388
	(162.60)	5.61	19.33			17.32	97	2.36	2.78	16.97	8.48	47.96	2.80	-4.16	-404				
CONTROL HORN	159.8			6.32	17.40											5,102	-793 / 4,310	6,377	-792 / 5,585
	(159.15)	1.30	19.41			17.43	22	2.38	2.84	17.09	8.54	48.60	.65	-4.19	-92				
HINGE	158.5			6.34	17.46												4,218		5,493
	(153.49)	10.0	19.70			17.62	176	2.42	2.93	17.28	8.64	49.70	4.99	-4.23	-744				
	148.5			6.45	17.77												3,474		4,749
	(143.49)	10.0	20.07			17.93	179	2.48	3.08	17.59	8.79	51.50	4.99	-4.30	-770				
	138.5			6.56	18.09												2,704		3,979
	(133.49)	10.0	20.49			18.24	182	2.55	3.12	17.94	8.97	53.65	4.99	-4.39	-800				
	128.5			6.68	18.39												1,904		3,179
	(124.90)	7.19	20.84			18.50	133	2.61	3.41	18.23	9.11	55.45	3.59	-4.44	-590				
HINGE	121.31			6.76	18.62												1,314		2,589
	(116.30)	10.0	21.18			18.77	188	2.66	3.54	18.52	9.26	57.20	4.99	-4.50	-846				
	111.31			6.87	18.92												468		1,743
	(106.30)	10.0	21.58			19.06	191	2.73	3.72	18.85	9.42	59.25	4.99	-4.57	-874				
	101.31			6.98	19.21												-406		869
	(96.30)	10.0	21.98			19.36	194	2.80	3.92	19.18	9.59	61.25	4.99	-4.63	-897				
	91.31			7.09	19.52												-1,303		-28
	(83.14)	16.26	22.50			19.77	321	2.88	4.15	19.62	9.81	64.25	8.09	-4.75	-1524				
CONTROL HORN	75.05			7.27	20.02											7,653	-2827 / 4,826	6,378	-1,552 / 4,826
	(74.40)	1.30	22.85			20.05	26	2.94	4.32	19.91	9.96	66.05	.65	-4.79	-125				
HINGE	73.75			7.29	20.08												4701		4,701
	(68.74)	10.0	23.07			20.23	202	2.98	4.44	20.09	10.04	67.30	4.99	-4.82	-975				
	63.75			7.40	20.38												3,726		3,726
	(58.74)	10.0	23.48			20.53	205	3.05	4.65	20.43	10.22	69.65	4.99	-4.90	-1005				
	53.75			7.51	20.68												2,721		2,721
	(48.74)	10.0	23.87			20.84	208	3.11	4.84	20.76	10.38	71.70	4.99	-4.95	-1030				
	43.75			7.62	21.00												1691		1,691
	(38.74)	10.0	24.27			21.15	212	3.18	5.06	21.09	10.54	74.10	4.99	-5.03	-1066				
	33.75			7.74	21.30												625		625
	(30.87)	5.15	24.58			21.39	123	3.23	5.21	21.35	10.68	75.95	2.87	5.08	-625				
HINGE	28.0			7.80	21.48												0		0
							2753								-12,155				

[redacted]

Consolidated Vultee Aircraft Corporation
Fort Worth Division — Fort Worth, Texas
FW 633 125 PADS 11-43

RUDDER SERVO TAB — TABLE NO. 16
ULTIMATE SHEAR, MOMENTS & TORSION @ SPAR - GUST COND.

PREP BY: BEARD
CHECKED BY: ZINGERY

PAGE 82
REP: FZS-36-247
MODEL: XB-36
DATE: 11-6-47

	STA.	LOAD BETWEEN STAS	HINGE REACTIONS (P.)	ULT. SHEAR $\Sigma(2)+(3)$	ARM TO CENTROID (P. 81)	DIST. BETWEEN STAS	M' (2)×(5)	M'' (4)×(6)	ULT. MOM. Σ(7)+(8)	HINGE MOM. 40-60 DIST.	HINGE MOM. 50-50 DIST.	CHANGE IN MOM. 1.25×(4)	TORSION @SPAR 40-60 DIST.	TORSION @SPAR 50-50 DIST.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
TIP	170.91			0					0	0	0	0	0	0
		94			2.74	5.50	258							
	165.41			94				0	258	-388	-388	117	-271	-271
		97			2.80	5.61	272							
CONTROL HORN	159.8			191				527	1057	-792 4,310	-792 5,585	239	-553 4,549	-553 5,824
		22			.65	1.30	14							
HINGE	158.5		-504	213 -291				248	1319	4,218	5,493	266 -364	4,484 3,854	5,759 5,129
		176			4.99	10.0	879							
	148.5			-115				-2910	-712	3,474	4,749	-144	3,330	4,605
		179			4.99	10.0	894							
	138.5			64				-1150	-968	2,104	3,979	80	2,784	4,059
		182			4.99	10.0	909							
	128.5			246				640	581	1,904	3,179	307	2,211	3,486
		133			3.59	7.19	478							
HINGE	121.31		-799	379 -420				1770	2829	1,314	2,589	474 -525	1,788 789	3,063 2,064
		188			4.99	10.0	939							
	111.31			-232				-4200	-432	468	1,743	-290	178	1,453
		191			4.99	10.0	954							
	101.31			-41				-2320	-1798	-406	869	-51	-457	818
		194			4.99	10.0	969							
	91.31			153				-410	-1239	-1,303	-28	191	-1,112	163
		321			8.09	16.26	2598							
CONTROL HORN	75.05			474				2485	3844	-2,827 4,826	-1,552 4,826	592	-2,235 5,418	-960 5,418
		26			.65	1.30	17							
HINGE	73.75		-1075	500 -575				616	4477	4,701	4,701	625 -719	5,326 3,982	5,326 3,982
		202			4.99	10.0	1008							
	63.75			-373				-5750	-265	3,726	3,726	-466	3,260	3,260
		205			4.99	10.0	1022							
	53.75			-168				-3730	-2973	2,721	2,721	-210	2,511	2,511
		208			4.99	10.0	1038							
	43.75			40				-1680	-3615	1,691	1,691	50	1,741	1,741
		212			4.99	10.0	1058							
	33.75			252				400	-2157	625	625	315	938	938
		123			2.87	5.75	353							
HINGE	28.0		-378	375 -3 VS. 0				1450	-354 VS. 0	0	0	467 0	467 0	469 0

[redacted]

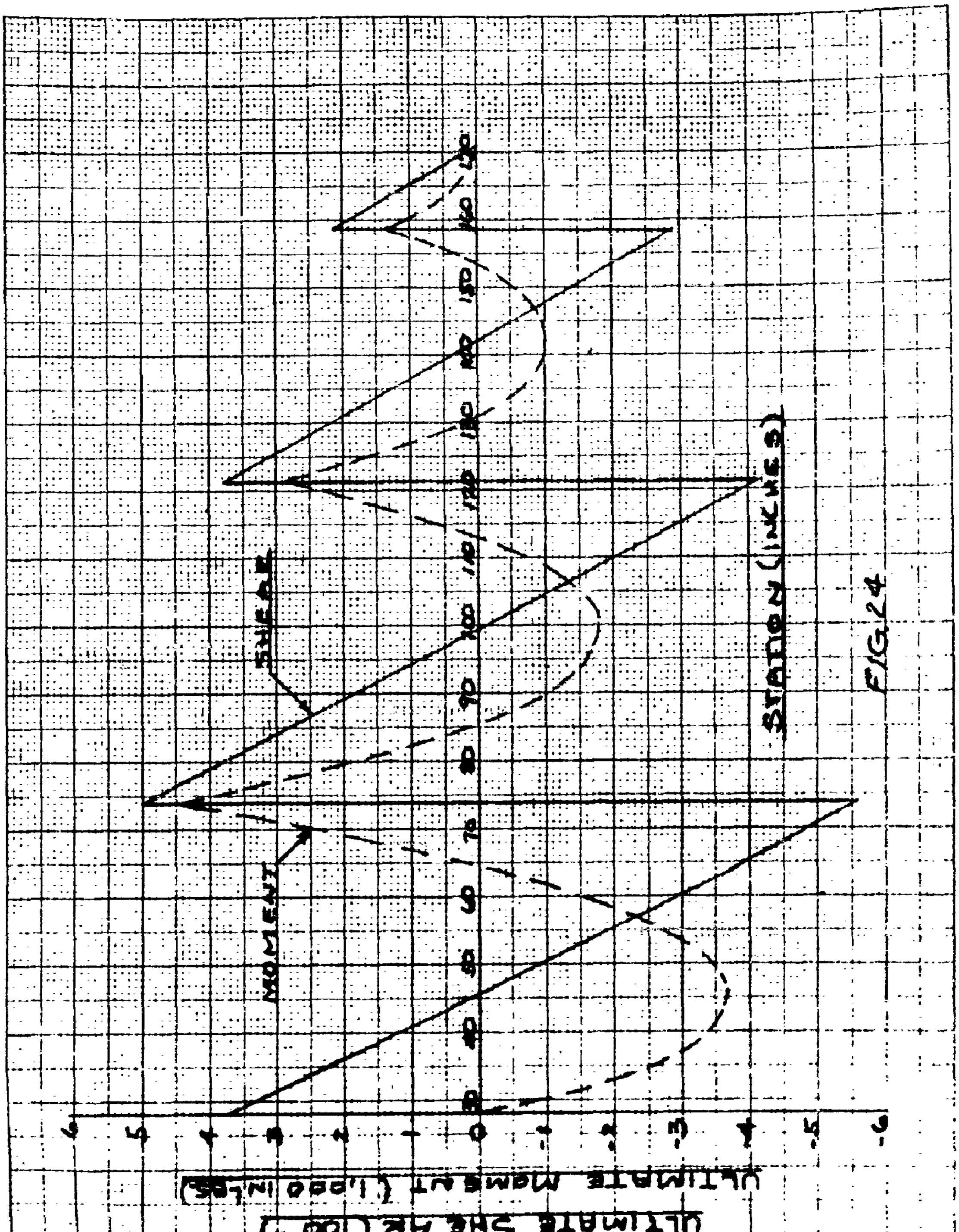


FIG.24

CALCULATED BY BEARD 11-5-47	RUDDER SERVO TAB		REPORT NO FZS-36-247
DRAWN BY BEARD 11-5-47	SHEAR & MOMENT - GUST COND.		MODEL XB-36
CHECKED BY ZINBERG	CONSOLIDATED VULTEE AIRCRAFT CORPORATION		
APPROVED BY	FORT WORTH DIVISION FORT WORTH TEXAS		

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
FORT WORTH DIVISION FORT WORTH, TEXAS
FW 633 125 PADS 11-43

RUDDER SERVO TAB TABLE NO. 17
SPAR SHEAR & BENDING STRESSES - GUST COND.

PREP BY BEARD
CHECKED BY ZINBERG

REP. FZS-36-247
MODEL: XB-36
DATE 11-6-47

	STA.	TORSION @ SPAR .40-.60 DIST.	TORSION @ SPAR .50-.55 DIST.	2A	q_T T/2A 40-60	q_T T/2A 50-50	S (P. 82)	h (P. 75)	$q_s = \frac{S}{h}$	q 40-60 (9)-(5)	q 50-50 (9)-(6)	CRIT. f_s (10) OR (11) / .032 .032	$F_{s_{cr}}$	BENDING MOMENT (P. 82)	Y	I	f_b	F_b *	MIN. M.S.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
TIP	170.91	0	0	—	—	—	0	—	—	—	—	—	—	0	—	—	—	—	—
	165.41	-271	-271	28.6	-9.5	-9.5	94	4.35	21.6	31.1	31.1	972	4,300	258	2.18	.746	754	11,850	HIGH
CONTROL HORN	159.8	-553 4,549	-553 5,824	29.0	-19.0 156.8	-19.0 201.0	191	4.38	43.6	62.6 -113.2	62.6 -157.4	1,960 4,910	18,430	1057	2.19	.776	2,980		HIGH
HINGE	158.5	4,484 3,854	5,759 5,129	29.2	153.4 132.0	197.4 175.7	213 -291	4.40	48.4 -66.1	-105.0 -198.1	-149.0 -241.8	4,650 7,550	18,430	1319	2.20	.780	3,715		+1.44
	148.5	3,330	4,605	30.0	111.0	153.5	-115	4.45	-25.8	-136.8	-179.3	5,605	7,860	-712	2.22	.830	1,905		+.40
	138.5	2,784	4,059	30.8	90.5	131.7	64	4.51	14.2	-76.3	-117.5	3,670	8,410	-968	2.26	.880	2,485		+1.29
	128.5	2,211	3,486	31.8	69.5	109.7	246	4.60	53.5	-16.0	-56.2	1,757	3,110	581	2.30	.930	1,440		+.77
HINGE	121.31	1,788 789	3,063 2,064	32.6	54.8 24.2	94.0 63.4	379 -420	4.68	81.0 -89.8	26.2 -114.0	-13.0 -153.2	820 4,790	5,025	2829	2.34	.965	6,860		+.05
	111.31	178	1,453	33.8	5.3	43.0	-232	4.80	-48.4	-53.7	-91.4	2,850	3,080	-432	2.40	1.015	1,022		+.08
	101.31	-457	818	35.0	-13.1	23.4	-41	4.92	-8.3	4.8	-31.7	990	2,700	-1798	2.46	1.068	4,140		+1.72
	91.31	-1,112	163	36.6	-30.4	4.4	153	5.03	30.4	60.8	26.0	1,900	7,420	-1239	2.52	1.117	2,795		HIGH
CONTROL HORN	75.05	-2,285 5,418	-960 5,418	39.2	-57.0 138.3	-24.5 138.3	474	5.22	90.7	147.7 -47.6	115.2 -47.6	4,610 1,490	11,100	3844	2.61	1.200	8,350		+.42
HINGE	73.75	5,326 3,982	5,326 3,982	39.4	135.1 101.1	135.1 101.1	500 -575	5.25	95.2 -109.5	-39.9 -210.6	-39.9 -210.6	1,247 6,590	8,420	4477	2.62	1.210	9,700		+.22
	63.75	3,260	3,260	41.2	79.1	79.1	-373	5.36	-69.5	-148.6	-148.6	4,640	9,150	-265	2.68	1.263	561		+.97
	53.75	2,511	2,511	43.2	58.1	58.1	-168	5.48	-30.7	-88.8	-88.8	2,770	9,070	-2973	2.74	1.318	6,180		+.92
	43.75	1,741	1,741	45.6	38.2	38.2	40	5.60	7.2	-31.0	-31.0	970	2,930	-3615	2.80	1.372	7,375		+.61
	33.75	938	938	48.2	19.5	19.5	252	5.70	44.2	24.7	24.7	772	9,580	-2157	2.85	1.430	4,300	11,850	+1.76
HINGE	28.0	469 0	469 0	49.8	9.4 0	9.4 0	375 0	5.76	65.0 0	55.6 0	55.6 0	1,740 0	11,230	0	—	—	—	—	HIGH

* BASED ON [illegible] OF FLANGE (VAL. #)

[redacted]

RUDDER SERVO TAB NOSE SKIN

THE NOSE SKIN IS CHECKED BY THE METHOD AS OUTLINED IN N.A.C.A. TECHNICAL NOTE NO. 904. AT STA. 73.75 AND 158.5, WHERE TORSIONAL SHEAR FLOWS ARE HIGHEST. Fs AS GIVEN BY THE T.N. IS

$$F_s = \frac{KE}{\left(\frac{D}{t}\right)^{5/4}\left(\frac{L}{D}\right)^{1/2}}$$, K BEING = .8 FOR MAGNESIUM

NOSE SKIN STA. 73.75

$q_T = 101.1$ #/IN , $t = .025$ AN-M-29 COND. H

$L = 4.1$, $R = 3.0$ IN.

$$f_s = \frac{101.1}{.025} = 4{,}040 \text{ p.s.i.}$$

$$F_s = \frac{.8 \times 6.5 \times 10^6}{\left(\frac{6.0}{.025}\right)^{5/4}\left(\frac{4.1}{6.0}\right)} = 6{,}650 \text{ p.s.i.}$$

M.S. = $\underline{\underline{+.64}}$

STA. 158.5

$L = 4.3$, $R = 2.4$

$q = 175.7$ #/IN. $t = .025$ AN-M-29 COND. H

$$f_s = \frac{175.7}{.025} = 7{,}030 \text{ p.s.i.}$$

$$F_s = \frac{.8 \times 6.5 \times 10^6}{\left(\frac{4.8}{.025}\right)^{5/4}\left(\frac{4.3}{4.8}\right)^{1/2}} = 7{,}700 \text{ p.s.i.}$$

M.S. = $\underline{\underline{+.10}}$

RUDDER TRIM TAB

The trim tab is of the same type of construction as the servo tab. The design of this tab is the same as for the servo. Loadings are taken directly from C1803A. Since the trim tab is controlled at only one station (Sta. 230), no overlapping design such as used in the servo is necessary. With the exception of this one fact, the analyses of the two tabs are identical.

RUDDER TRIM TAB
(REF. DWG. 36T 1090)

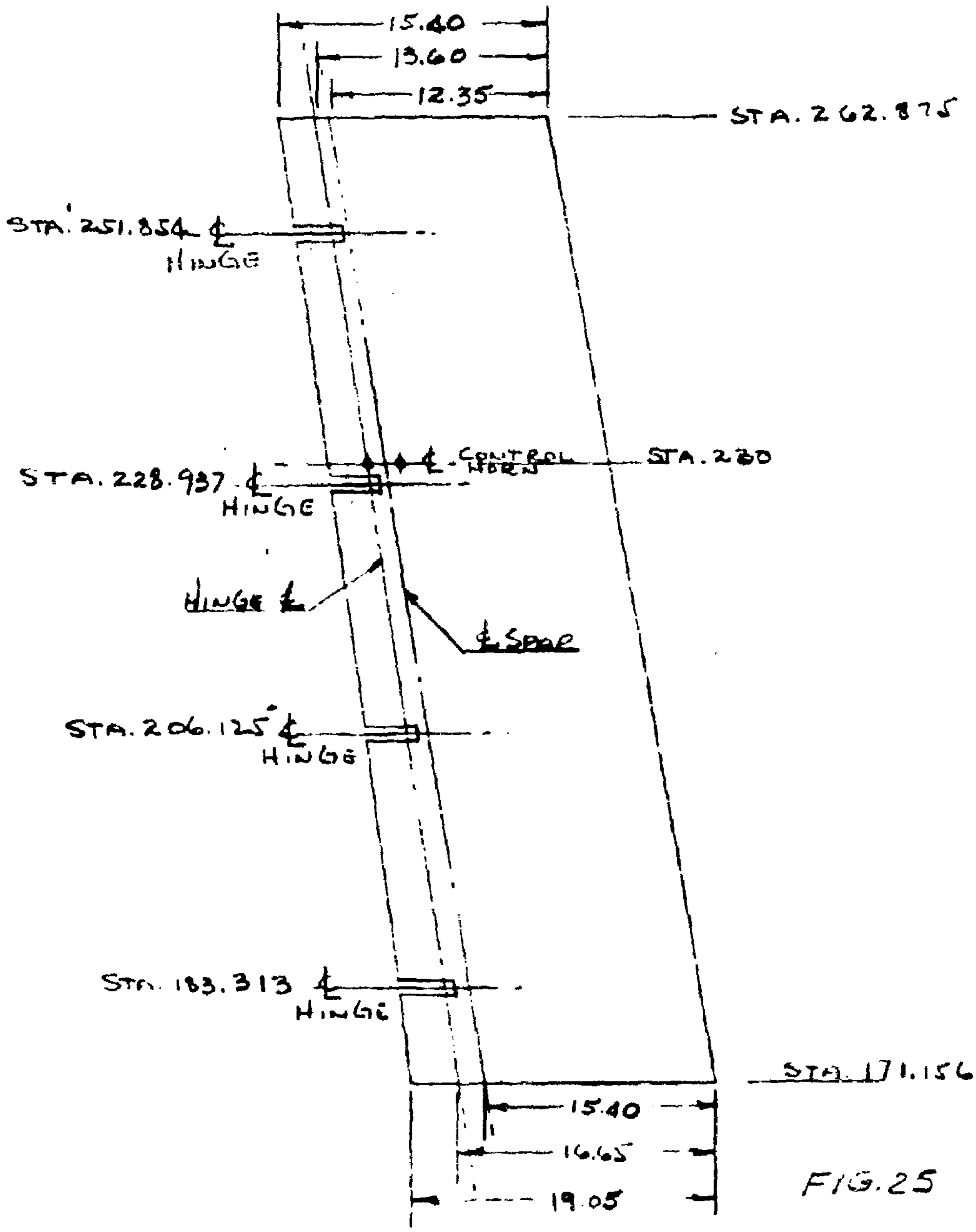
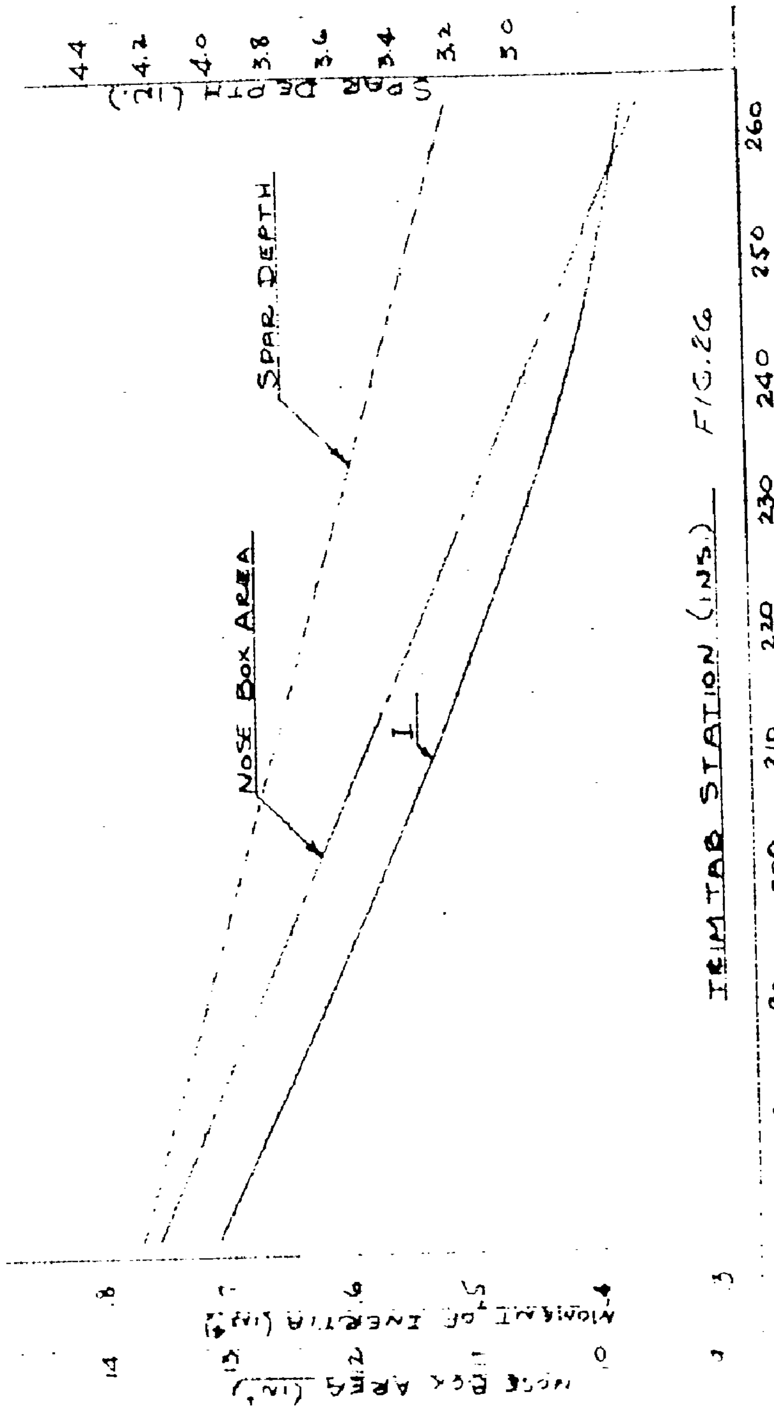


FIG. 25



BEARD 10-3-47 RUDDER TRIM TAB FZS-36-247
BEARD 10-3-47 STRUCTURAL CHARACTERISTICS
ZIMBERG XB 36

RUDDER TRIM TAB
UNIT LOADING

FOR UNIT LOADING = 1,000#

LOAD DISTRIBUTED IN PROPORTION TO CHORD LENGTHS

CHORD @ STA 171.156 = 19.94 IN.
CHORD @ STA 262.875 = 15.29 IN.

W_1 = LOADING @ 171.156
W_2 = LOADING @ 262.875

$$W_1 = \frac{19.94}{15.29} W_2 = 1.305\, W_2$$

$$\frac{W_1 + W_2}{2} \times 91.719 = 1{,}000^{\#}$$

$$W_1 + W_2 = 21.8$$

$$2.305\, W_2 = 21.8$$

$$W_2 = 9.46\ \#/\text{IN.}$$

$$W_1 = 12.34\ \#/\text{IN.}$$

RUDDER TRIM TAB
1000# UNIT LOAD

CANTILEVER MOMENT · STA 183.313

$M = 11.96 \times 12.157 \times 6.078 + .38 \times 6.078 \times 8.104 = 902''\#$

FIXED END MOMENTS – AIRLOADS

SPAN 1

$UM_1 = .0857 \times 11.24 \times (22.812)^2 = 503$
$VM_1 = .0512 \times .72 \times (22.812)^2 = 19$
$M_1 = 522''\#$

$UM_2 = .0808 \times 11.24 \times (22.812)^2 = 474$
$VM_2 = .0320 \times .72 \times (22.812)^2 = 12$
$M_2 = 486''\#$

SPAN 2

$UM_2 = .0860 \times 10.53 \times (22.812)^2 = 472$
$VM_2 = .0514 \times .71 \times (22.812)^2 = 19$
$M_2 = 491''\#$

$UM_3 = .0805 \times 10.53 \times (22.812)^2 = 442$
$VM_3 = .0318 \times .71 \times (22.812)^2 = 12$
$M_3 = 454''\#$

SPAN 3

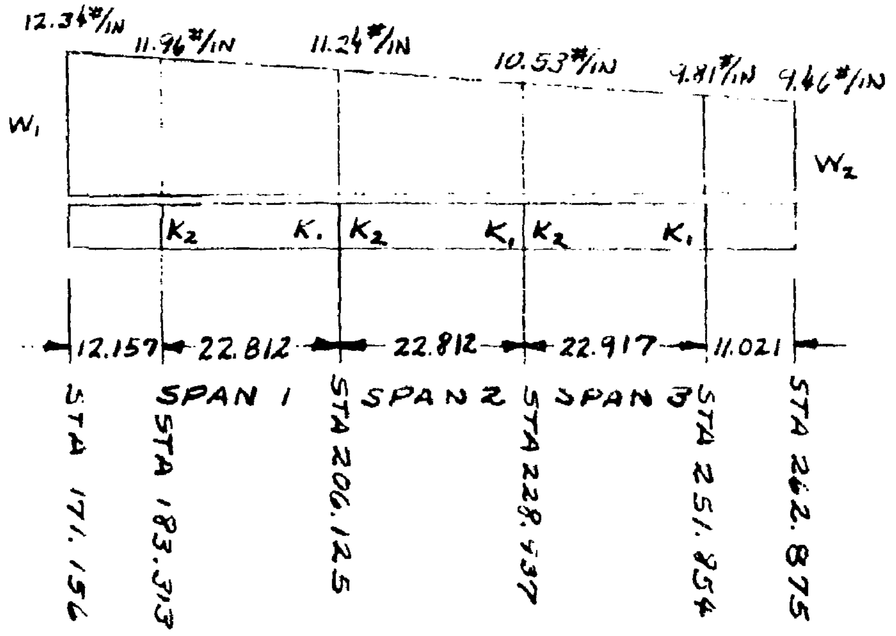
$UM_3 = .0852 \times 9.81 \times (22.917)^2 = 439$
$VM_3 = .0510 \times .72 \times (22.917)^2 = 19$
$M_3 = 458''\#$

$UM_4 = .0814 \times 9.81 \times (22.917)^2 = 419$
$VM_4 = .0323 \times .72 \times (22.917)^2 = 12$
$M_4 = 431''\#$

CANTILEVER MOMENT STA 251.154

$M = 9.46 \times 11.021 \times 5.51 + .35 \times 5.51 \times 3.674 = 582''\#$

RUDDER TRIM TAB
MOMENT DISTRIBUTION FACTORS



SPAN	I_{IN}	I_{OUT}	UNIFORM LOAD K_1	UNIFORM LOAD K_2	VARYING LOAD K_1	VARYING LOAD K_2	CARRY-OVER FACTOR	DISTRIBUTION FACTOR
1	.652	.550	.0808	.0857	.0320	.0312	.480	1.0
							.525	.525
2	.550	.446	.0805	.0860	.0318	.0514	.477	.475
							.526	.522
3	.446	.388	.0814	.0852	.0323	.0510	.484	.478
							.520	1.0

RUDDER TRIM TAB
1000# UNIT LOAD

CANTILEVER MOMENT STA 183.313

$$M = 11.96 \times 12.157 \times 6.078 + .38 \times 6.078 \times 8.104 = 902''\#$$

FIXED END MOMENTS – AIRLOADS

SPAN 1

$UM_1 = .0857 \times 11.24 \times (22.812)^2 = 503$
$VM_1 = .0512 \times .72 \times (22.812)^2 = 19$
$M_1 = 522''\#$

$UM_2 = .0808 \times 11.24 \times (22.812)^2 = 474$
$VM_2 = .0320 \times .72 \times (22.812)^2 = 12$
$M_2 = 486''\#$

SPAN 2

$UM_2 = .0860 \times 10.53 \times (22.812)^2 = 472$
$VM_2 = .0514 \times .71 \times (22.812)^2 = 19$
$M_2 = 491''\#$

$UM_3 = .0805 \times 10.53 \times (22.812)^2 = 442$
$VM_3 = .0318 \times .71 \times (22.812)^2 = 12$
$M_3 = 454''\#$

SPAN 3

$UM_3 = .0852 \times 9.81 \times (22.917)^2 = 439$
$VM_3 = .0510 \times .72 \times (22.917)^2 = 19$
$M_3 = 458''\#$

$UM_4 = .0814 \times 9.81 \times (22.917)^2 = 419$
$VM_4 = .0323 \times .72 \times (22.917)^2 = 12$
$M_4 = 431''\#$

CANTILEVER MOMENT STA 251.154

$$M = 9.46 \times 11.021 \times 5.51 + .35 \times 5.51 \times 3.674 = 582''\#$$

RUDDER TRIM TAB

1000# UNIT LOAD

MOMENT DISTRIBUTION

CARRY-OVER FACTORS		.480	.525	.477	.526	.474	.520	
DISTRIBUTION FACTORS		1.0	.525	.475	.522	.478	1.0	
MOM	+902	+522	+486	+491	+454	+458	+431	+582
		+380	+ 3	- 2	+ 2	- 2	+151	
		-2	-182	- 1	+ 1	- 79	+ 1	
		+2	+ 95	- 86	- 42	+ 38	- 1	
		-50	- 1	+ 22	+ 41	+ 1	- 18	
		+50	+ 12	- 11	- 21	+ 19	+ 18	
		- 6	- 24	+ 11	+ 5	- 9	- 9	
		+ 6	+ 18	- 17	- 7	+ 7	+ 7	
		- 9	- 3	+ 4	+ 8	- 5	- 3	
		+ 9	+ 4	- 3	- 7	+ 6	+ 3	
	+902	+902	+408	+408	+434	+434	+582	+582

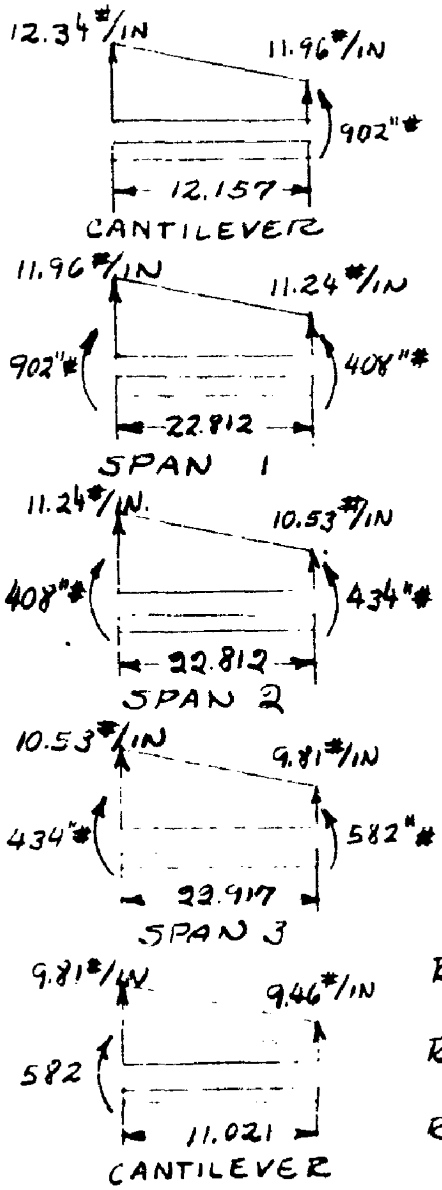
ANALYSIS VERT. SURFACES
PREPARED BY BEARD
CHECKED BY ZINBERG
REVISED BY

Consolidated Vultee Aircraft Corporation
FORT WORTH DIVISION
FORT WORTH, TEXAS

PAGE 93
REPORT NO. FZS-36-241
MODEL XB-36
DATE 10-23-47

RUDDER TRIM TAB

1000# UNIT LOAD



$R_{183L} = \frac{12.34 + 11.96}{2} \times 12.157 = 148^{\#}$

$R_{183R} = \frac{11.24 \times 22.812}{2} + \frac{.72 \times 22.812}{3} + \frac{494}{22.812} = 155^{\#}$

$R_{206L} = 128 + 2.8 - 21.6 = 109^{\#}$

$R_{206R} = \frac{10.53 \times 22.812}{2} + \frac{.71 \times 22.812}{3} - \frac{26}{22.812} = 124^{\#}$

$R_{229L} = 120.2 + 2.7 + 1.1 = 124^{\#}$

$R_{229R} = \frac{9.81 \times 22.917}{2} + \frac{.72 \times 22.917}{3} - \frac{148}{22.917} = 111^{\#}$

$R_{252L} = 112.3 + 2.8 + 6.5 = 122^{\#}$

$R_{252R} = \frac{9.81 + 9.46}{2} \times 11.021 = 106^{\#}$

$R_{183} = 148 + 155 = 303^{\#}$

$R_{206} = 109 + 124 = 233^{\#}$

$R_{229} = 124 + 111 = 235^{\#}$

$R_{252} = 122 + 106 = \underline{228^{\#}}$

999 VS 1000#

FW 444 6-46 UTILITY REPORT SHEET

RUDDER TRIM TAB

TAB LIMIT LOADING = $.0012\, V_D^2$ (REF. C-1803-6)

$V_D = 311$ m.p.h.

$w = .0012\,(311)^2 = 116\ \#/\square'$ LIMIT

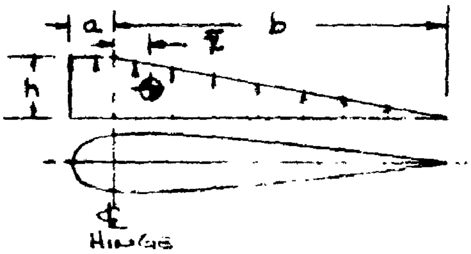
$= 174\ \#/\square'$ ULT.

EFF. TAB AREA = $11.22\ \square'$

LD. = $11.22 \times 174 = 1{,}953\ \#$

CHORDWISE DISTRIBUTION

THE CHORDWISE DISTRIBUTION IS ASSUMED TO BE CONSTANT FROM TAB LEADING EDGE TO HINGE ℄ THEN VARYING TO ZERO AT TRAILING EDGE



$$\bar{x} = \frac{h \times a \times \frac{a}{2} - h \times b \times \frac{b}{3}}{a h + \frac{h}{2} \times b} = \frac{\frac{a^2}{2} - \frac{b^2}{6}}{a + \frac{b}{2}}$$

$\bar{X}$ NEG., C.P. AFT ℄ HINGE

THE TAB CONTROL HORN IS ATTACHED TO THE SPAR 8° FROM NORMAL. INVESTIGATION SHOWED THAT ASSUMING THE ATTACHMENT NORMAL TO THE SPAR GIVES A NEGLIGIBLY SMALL ERROR.

RUDDER TRIM TAB

HINGE MOMENTS

TABLE 18

	STA.	DIST. BETWEEN STAS.	CHORD	UNIT LOADING 1,000# #/IN.	UNIT LOADING 1,953# #/IN	AVERAGE LOADING BETWEEN STAS.	ULT. LOAD BETWEEN STAS.	a	$\frac{a^2}{2}$	b	$\frac{b}{2}$	$\frac{b^2}{6}$	ARM TO CENT.	$\bar{y}$ $\frac{⑨-⑫}{⑧+⑪}$	AIRLOAD HINGE MOM. ⑦×⑭	HINGE MOM. FROM CONTROL HORN	Σ HINGE MOM.
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰
	262.875			9.46	18.48												0
	257.345	11.021	15.62			18.82	208	1.84	1.69	13.78	6.89	31.60	5.491	-3.44	-715		
HINGE	251.854			9.81	19.16												-715
	246.824	10.0	16.04			19.46	195	1.90	1.80	14.14	7.07	33.35	4.970	-3.52	-687		
	241.854			10.12	19.76												-1402
	235.904	11.854	16.47			20.04	238	1.98	1.96	14.49	7.24	34.95	5.904	-3.57	-850		
CONTROL HORN	230			10.40	20.31											7,286	-2252 5034
	229.47	1.063	16.73			20.44	21	2.02	2.04	14.71	7.36	36.05	.533	-3.63	-76		
HINGE	228.937			10.53	20.56												4958
	222.897	12.0	16.99			20.92	251	2.06	2.12	14.93	7.46	37.15	5.960	-3.68	-924		
	216.937			10.90	21.29												4034
	211.507	10.812	17.44			21.62	234	2.14	2.29	15.30	7.65	39.00	5.382	-3.75	-878		
HINGE	206.125			11.24	21.95												3156
	200.085	12.0	17.90			22.32	268	2.21	2.44	15.69	7.84	41.00	5.960	-3.84	-1030		
	194.125			11.62	22.69												2126
	188.695	10.812	18.35			23.02	249	2.28	2.60	16.07	8.04	43.00	5.382	-3.91	-974		
HINGE	183.313			11.96	23.36												1152
	177.213	12.157	18.81			23.73	288	2.36	2.78	16.45	8.22	45.05	6.057	-4.00	-1152		
	171.156			12.34	24.10												0
															-7286		

PREPARED BY: [illegible] 10-31-47
CHECKED BY: ZINBERG
REPORT NO: FZS-36-247
MODEL: XB-36

RUDDER TRIM TAB

ULTIMATE SHEAR & MOMENT & TORSION @ SPAR

	STA.	LOAD BETWEEN STAS. (P. 95)	HINGE REACT. (PAGE 93X)	ULT. SHEAR Σ ②+③	ARM TO CENTROID (P. 95)	DIST. BETWEEN STAS.	M' ⑤ × ②	M" ④ × ⑥	ULT. MOM. Σ ⑦+⑧	HINGE MOM. AT STA. (P. 95)	CHANGE IN MOM. 1.25* ④	TORSION @ ℄ SPAR
	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫ ⑩+⑪
	262.875			0					0	0	0	0
		208			5.491	11.021	1,142	0				
HINGE	251.854		-445	208 -237					1,142	-715	260 -296	-455 -1011
		195			4.970	10.0	970	-2,370				
	241.854			42					-258	-1402	-52	-1454
		238			5.904	11.854	1,405	-498				
CONTROL HORN	230			196					649	-2252 5034	245	-2007 5279
		21			.533	1.063	11	209				
HINGE	228.937		-459	217 -242					869	4958	271 -302	5229 4656
		251			5.960	12.0	1,497	-2903				
	216.937			9					-537	4034	11	4045
		234			5.382	10.812	1,260	98				
HINGE	206.125		-455	243 -212					821	3156	304 -265	3460 2891
		268			5.960	12.0	1,600	-2,542				
	194.125			56					-121	2126	70	2196
		249			5.382	10.812	1,340	606				
HINGE	183.313		-594	305 -289					1825	1152	381 -361	1533 791
		288			6.057	12.157	1,744	-3,510				
	171.156			0					(57) VS. 0	0	0	0

*1.25 = DIST. BETWEEN ℄ HINGE AND ℄ TAB SPAR

PREPARED BY: BEARD 10-31-43
CHECKED BY: ZINBERG
REPORT NO. FZS-36-047
MODEL: XC-36

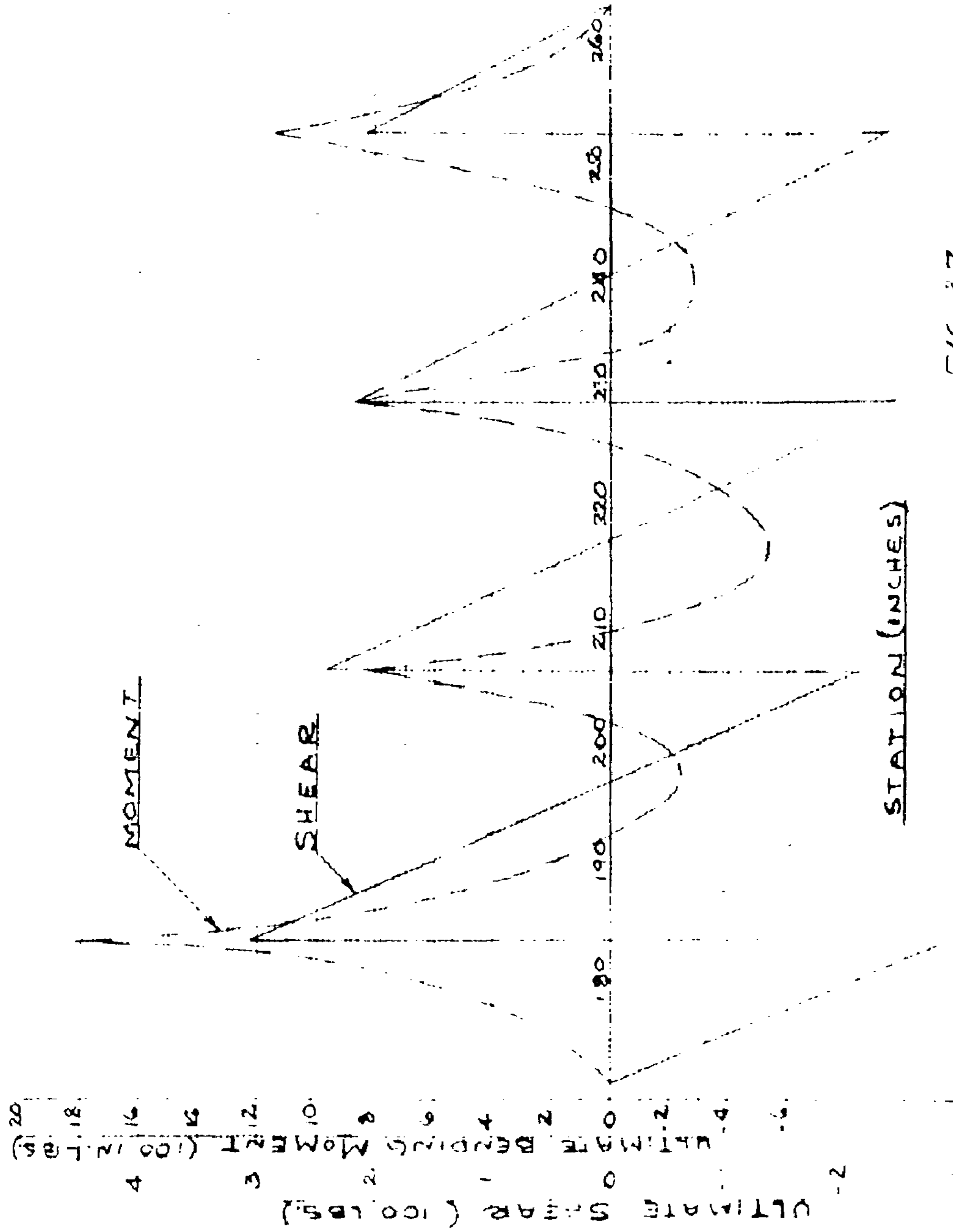


FIG. 27

BEARD 11-3-47 RUDDER TRIM TAB — F25-56-247
BEARD 1-3-47 SHEAR & MOMENT

RUDDER TRIM TAB
SPAR SHEAR & BENDING STRESSES

TABLE 20

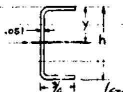
STA.	T TORSION ℄ SPAR	2A (P. 88)	$q_T = \frac{T}{2A}$	S (P. 96)	h (P. 88)	$q_s = \frac{S}{h}$	SPAR SHEAR FLOW ⑦-④	f_s ⑧/.051	$F_{s_{cr}}$	BENDING MOM. (P. 96)	Y	I	$f_b = \frac{My}{I}$	F_b p.s.i.	MIN. M.S.
①	②	③	④	⑤	⑥	⑦	⑧	⑨	10	11	12	⑬	14	15	⑯
262.875	0	19.10	0	0	3.25	0	0	0	10,100	0	1.62	.368	0	10,600	—
251.854	-455 / -1011	20.08	-22.6 / -50.3	208 / -237	3.37	- 61.7 / 70.4	84.3 / -20.1	1,652 / -394	9,390	1,142	1.68	.390	4,915		+1.16
241.854	-1454	20.96	-69.5	-42	3.49	-12.0	57.5	1,128	8,550	-258	1.74	.414	1,830		HIGH
230	-2007 / 5279	22.00	-91.2 / 240.0	196	3.62	54.1	145.5 / -185.9	2,850 / -3,645	8,450	649	1.81	.455	2,580		+1.32
228.937	5229 / 4656	22.20	235.5 / 210.0	217 / -243	3.63	- 59.8 / 66.7	-175.7 / -276.7	-3,440 / -5,430	8,440	869	1.82	.456	3,465		+ .55
216.937	4045	23.16	174.8	9	3.77	2.4	-172.4	-3,380	7,540	-537	1.88	.503	2,010		+1.23
206.125	5460 / 2891	24.10	143.5 / 120.0	543 / -212	3.90	62.3 / -54.4	-81.2 / -174.4	-1,592 / -3,420	6,460	821	1.95	.550	2,910		+ .89
194.125	2196	25.20	87.1	56	4.03	13.9	-73.2	-1,436	6,840	-121	2.02	.604	405		HIGH
183.313	1553 / 791	26.14	58.7 / 30.3	305 / -289	4.16	73.5 / -69.5	14.6 / -99.8	286 / -1,955	6,640	1825	2.08	.654	5,810		+ .82
171.156	0	27.24	0	0	4.30	0	0	0	5,800	0	2.15	.711	0	10,600	—

$F_{s_{cr}}$ FOR CRITICAL PANEL STA. 228.937

MAT. MAG. ALLOY AN-M-29 COND. H

$a/b = \frac{5.2}{3.63} = 1.431 \quad K_s = 6.58$

$F_{s_{cr}} = 6.58 \times 6.5 \times 10^6 \left(\frac{.051}{3.63}\right)^2 = 8,440$ p.s.i.



$1/\sqrt{R} = 1.612$

$\frac{b}{t\sqrt{K}} = \frac{.750 \times 1.612}{.051} = 23.7$

$F_{cr} = 10,600$ p.s.i.
(STRUCTURES BULLETIN C-10)

ANALYSIS: VERT. TAIL SURF.
BY: BEARD
CHECK: ZINBERG
REPORT: FZS-36-147
MODEL: XB36

RUDDER TRIM TAB NOSE SKIN

THE NOSE SKIN IS CHECKED, BY THE METHOD AS OUTLINED IN N.A.C.A. TECH. NOTE NO. 904, AT STA. 230, WHICH IS MOST CRITICAL FOR .032 SKIN AND AT STA. 206, WHICH IS MOST CRITICAL FOR .025 SKIN. THE EQUATION FOR F_s, FROM THE TECH. NOTE IS

$$F_s = \frac{K E}{\left(\frac{D}{t}\right)^{5/4}\left(\frac{L}{D}\right)^{1/2}}$$

THE FACTOR K, IS ASSUMED TO BE .8 FOR MAGNESIUM.

NOSE SKIN STA 230

$t = .032$ MAG. AN-M-29 COND. H

$q_T = 240$ #/IN (REF. TABLE 20 PAGE 98)

$R = 2$ IN. $L = 5.25$

$$f_s = \frac{240}{.032} = 7,500 \text{ p.s.i.}$$

$$F_s = \frac{.8 \times 6.5 \times 10^6}{\left(\frac{4.0}{.032}\right)^{5/4}\left(\frac{5.25}{4.0}\right)^{1/2}} = 10,870 \text{ p.s.i.}$$

$$M.S. = \frac{10,870}{7,500} - 1 = \underline{\underline{+.45}}$$

NOSE SKIN STA. 206

$t = .025$ MAG. AN-M-29 COND. H

$q_T = 143.5$ #/IN (PAGE 98)

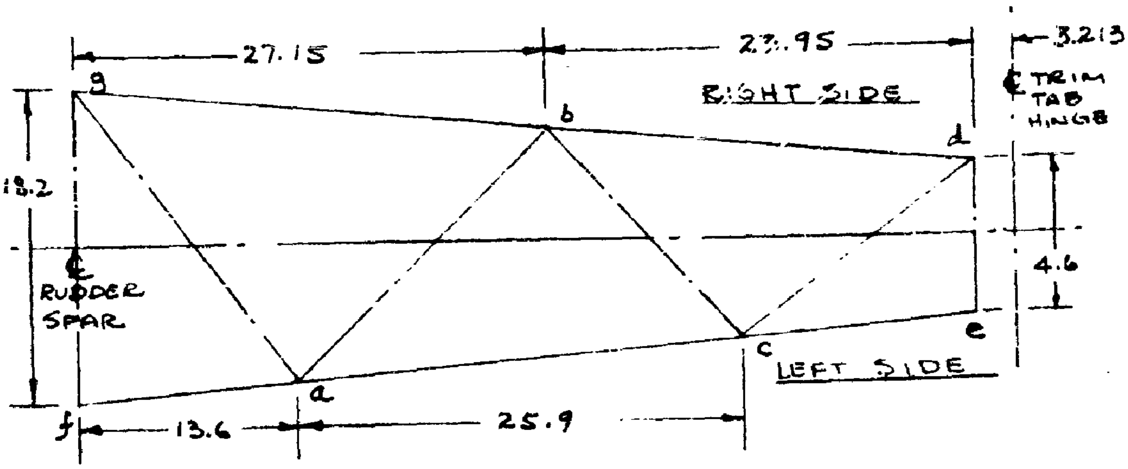
$$f_s = \frac{143.5}{.025} = 5,740 \text{ p.s.i.}$$

$L = 5.65$ $R = 2.1$

$$F_s = \frac{.8 \times 6.5 \times 10^6}{\left(\frac{4.2}{.025}\right)^{5/4}\left(\frac{5.65}{4.2}\right)^{1/2}} = 7,420 \text{ p.s.i.}$$

$$M.S. = \frac{7,420}{5,740} - 1 = \underline{\underline{+.29}}$$

RUDDER HINGE RIB STA. 183 5/16
(REF. DWG. 36T1220)



THE RUDDER TRAILING EDGE RIB AT STA. 183 5/16 IS CHOSEN FOR ANALYSIS, SINCE TO THIS RIB IS ATTACHED THE LOWER TRIM TAB HINGE, WHICH APPLIES THE HIGHEST LOAD. THE MOST CRITICAL CONDITION OF LOADING IS GUST AND SINCE IT IS REVERSIBLE AND THE TRUSS IS NOT SYMMETRICAL, PANEL POINT LOADS ARE DETERMINED FOR BOTH LOADINGS. 80% OF THE AIRLOAD IS APPLIED AS A NEGATIVE, WHILE 20% AS A POSITIVE, PRESSURE. PANEL POINT LOADS ARE DETERMINED BY CONSERVATIVELY ASSUMING THE TRUSS JOINTS PIN-CONNECTED. THE TAB HINGE LOAD AND AIR LOADS ACTING ON THE RIB ARE REACTED AT THE RUDDER SPAR CAPS.

IN THE ANALYSIS OF TRUSS MEMBERS THE ALLOWABLE CRIPLING STRESSES ARE DETERMINED AS PER. C.V.A.C. No. 1

IT MIGHT BE NOTED THAT, IN THIS ANALYSIS, NO REDUCTION IN AIRLOAD PRESSURE IS TAKEN DUE TO TAB EFFECT AS WAS DONE IN FSZ-36-147. THE ANALYSIS IS CONSERVATIVE TO THIS EXTENT.

ANALYSIS VERT. SURFACES
PREPARED BY BEARD
CHECKED BY ZINBERG
REVISED BY

Consolidated Vultee Aircraft Corporation
FORT WORTH DIVISION
FORT WORTH, TEXAS

RUDDER HINGE RIB STA. 183 5/16

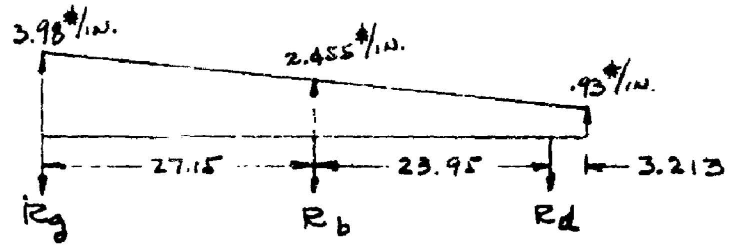
GUST COND. (LOAD ACTING FROM LEFT TO RIGHT)

TRIM TAB HINGE LD. = 574# (REF. PAGE 96)
AVERAGE ADJACENT RIB SPACING = 11.92 IN.
(REF DWG. 36T 1145)
LOADING AT ℄ SPAR = 60 #/□'
LOADING AT ℄ TAB HINGE = 14 #/□'
(PAGE 54)

$$\text{RIB CHORDWISE LOADING AT ℄ SPAR} = \frac{60 \times 11.92}{144} = 4.96\ \#/\text{IN.}$$

$$\text{LOADING @ ℄ TAB HINGE} = \frac{14 \times 11.92}{144} = 1.16\ \#/\text{IN}$$

RIGHT SIDE PANEL PT. LDS. (.80 DISTRIB.)



$$R_g = \frac{2.455 \times 27.15}{2} + \frac{1.525 \times 27.15}{3} = 33.3 + 13.8 = 47.1\#$$

$$R_{b_L} = 33.3 + 6.9 = 40.2\#$$

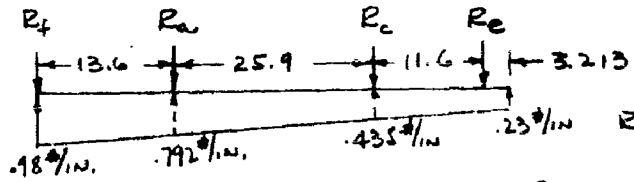
$$R_d = \frac{.93 \times 27.163 \times 13.581 + 1.525 \times 13.581 \times 9.054}{23.95} = 22.15\#$$

$$R_{b_R} = 1.6925 \times 27.163 - 22.15 = 23.85\#$$

$$R_b = 40.2 + 23.85 = 64.05\#$$

RUDDER HINGE RIB STA $183\frac{5}{16}$
GUST COND. (LEFT TO RIGHT) (CONT'D)

LEFT SIDE PANEL PT. LDS.



$R_f = \frac{.792 \times 13.6}{2} + \frac{.198 \times 13.6}{3}$

$= 5.4 + .85 = 6.25^{\#}$

$R_{a_L} = 5.4 + .42 = 5.82^{\#}$

$R_{a_R} = \frac{.435 \times 25.9}{2} + \frac{.357 \times 25.9}{3} = 5.64 + 3.08 = 8.72^{\#}$

$R_{c_L} = 5.64 + 1.54 = 7.18^{\#}$

$R_e = \frac{.23 \times 14.813 \times 7.4065 + .205 \times 7.4065 \times 4.938}{11.6} = 2.82^{\#}$

$R_{c_R} = .23 \times 14.813 + .205 \times 7.4065 - 2.82 = 2.11^{\#}$

$R_a = 5.82 + 8.72 = 14.54^{\#}$
$R_c = 2.11 + 7.18 = 9.29^{\#}$

COUPLE AT PANEL PTS. d & e FROM TAB

$= \frac{594 \times 3.213}{4.6} = 415^{\#}$

TOTAL PANEL PT. LD AT "d" $= 22.15 + \frac{594}{2} = 319.15^{\#}$
PANEL PT. LD. AT "e" $= 2.82 + \frac{594}{2} = 299.82^{\#}$

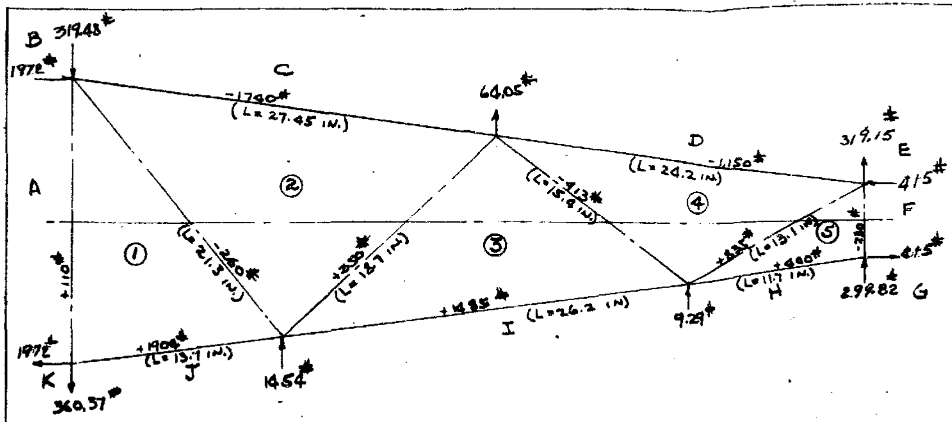
UNBALANCED SHEAR $= 733.24^{\#}$ ↓
AT SPAR CAPS $R_U = \frac{733.24}{2} - 47.14 = 319.48^{\#}$ ↓
$R_L = \frac{733.24}{2} - 6.25 = 360.37^{\#}$

MOM @ ℄ SPAR

$415 \times 4.6 =$	1994
$618.97 \times 51.1 =$	31600
$9.29 \times 39.5 =$	367
$14.54 \times 13.6 =$	198
$64.05 \times 27.15 =$	1,739
Σ MOM $=$	35,898

COUPLE AT SPAR CAPS

$= \frac{35898}{18.2} = 1972^{\#}$



TRUSS SCALE 1" = 6"
FORCE SCALE 1" = 200#

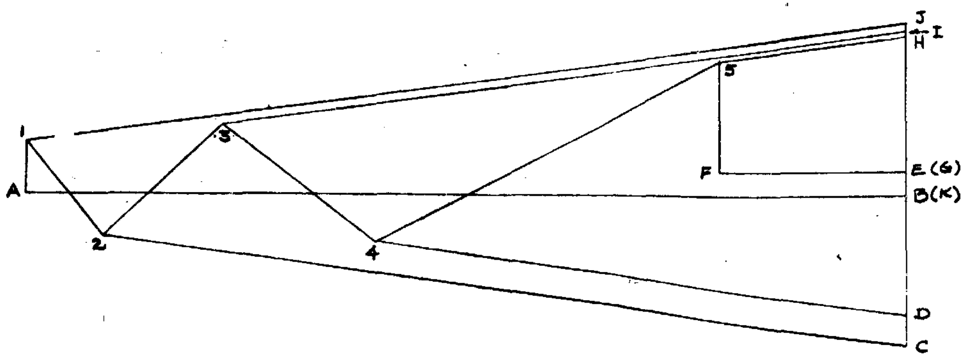
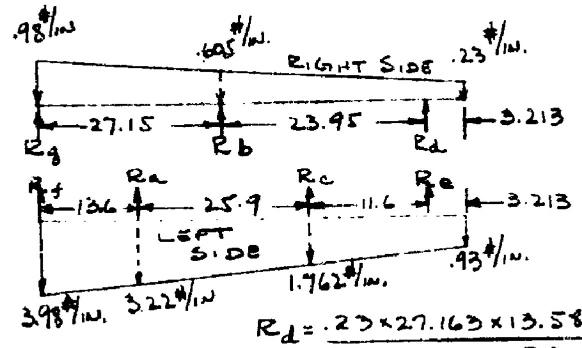


FIG. 28

	DEARD 10-28-47	RUDDER HINGE RIB STA. 183⅞	FZS-36-247
	DEARD 10-28-47	GUST COND. LEFT TO RIGHT	
			XB-36

RUDDER HINGE RIB STA. 133 7/16
GUST COND. (LOADS ACTING FROM RIGHT TO LEFT)



PANEL PT. LDS. RIGHT SIDE

$R_g = \frac{.605 \times 27.15}{2} + \frac{.375 \times 27.15}{3}$

$= 8.21 + 3.49 = \underline{11.70}^{\#}$

$R_{b_L} = 8.21 + 1.74 = 9.95^{\#}$

$R_d = \frac{.23 \times 27.163 \times 13.581 + .375 \times 13.581 \times 9.054}{23.95} = \underline{5.45}^{\#}$

$R_{b_R} = .4175 \times 27.163 - 5.45 = 5.87^{\#}$

$R_b = 5.87 + 9.95 = \underline{15.82}^{\#}$

PANEL PT. LDS. LEFT SIDE

$R_f = \frac{3.22 \times 13.6}{2} + \frac{.76 \times 13.6}{3} = 21.9 + 3.45 = \underline{25.35}^{\#}$

$R_{a_L} = 21.9 + 1.72 = 23.62^{\#}$

$R_{a_R} = \frac{1.762 \times 25.9}{2} + \frac{1.458 \times 25.9}{3} = 22.8 + 12.6 = 35.4^{\#}$

$R_a = 23.62 + 35.4 = \underline{59.02}^{\#}$

$R_{c_L} = 22.8 + 6.3 = 29.1^{\#}$

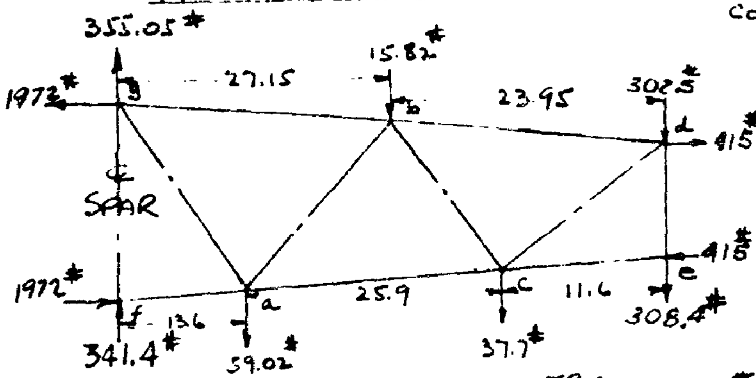
$R_e = \frac{.93 \times 14.813 \times 7.4065 + .832 \times 7.4065 \times 4.938}{11.6} = \underline{11.4}^{\#}$

$R_{c_R} = 1.346 \times 14.813 - 11.4 = 8.6^{\#}$

$R_c = 8.6 + 29.1 = \underline{37.7}^{\#}$

RUDDER HINGE RIB STA. 183 9/16
(GUST COND. (LD RIGHT TO LEFT)

FINAL PANEL PT. LDS.



COUPLE AT "d" & "e"

$= \frac{594 \times 3.213}{4.6} = 415^{\#}$

UNBALANCED SHEAR = 733.5# ↓ EQUALLY REACTED AT SPAR CAPS

LOAD AT "d" = $5.45 + \frac{594}{2} = 302.5^{\#}$

LOAD AT "e" = $11.4 + \frac{594}{2} = 308.4^{\#}$

LOAD AT "g" = $11.70^{\#}\downarrow - \frac{733.5}{2}\uparrow = 355.05^{\#}\uparrow$

LOAD AT "f" = $25.35^{\#}\downarrow - \frac{733.5}{2} = 341.4^{\#}\uparrow$

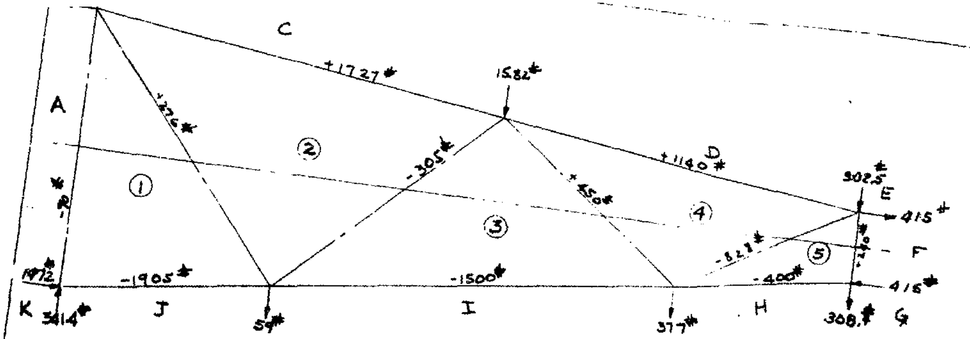
MOM @ ℄ SPAR

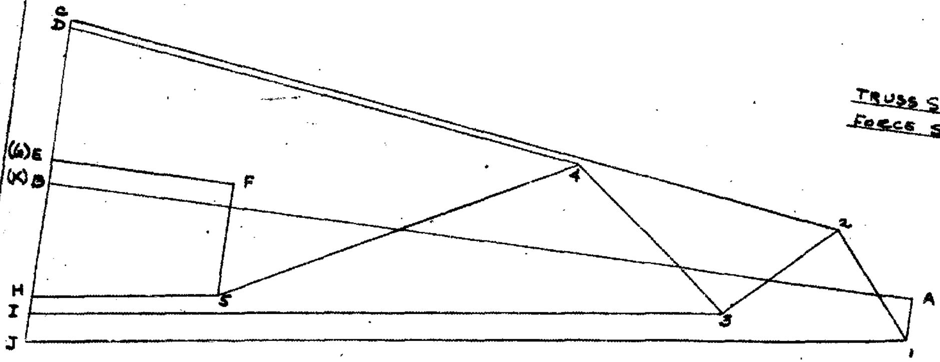
415 × 4.6	=	1994
611 × 51.1	=	31200
15.82 × 27.15	=	430
37.5 × 39.5	=	1,489
59.02 × 13.6	=	803
Σ MOM	=	35916

COUPLE AT SPAR CAPS

$= \frac{35916}{18.2} = 1,972^{\#}$

[redacted]





TRUSS SCALE 1" = 6"
FORCE SCALE 1" = 200#

FIG. 29

CALCULATED BY	BEARD 10-29-47	RUDDER HINGE RIB STA. 183 7/16	DOC NO FZS-36-247
CHECKED BY	BEARD 10-29-47	GUST COND., RIGHT TO LEFT	MODEL XB-36
APPROVED BY		CONSOLIDATED VULTEE AIRCRAFT CORPORATION	

[redacted]

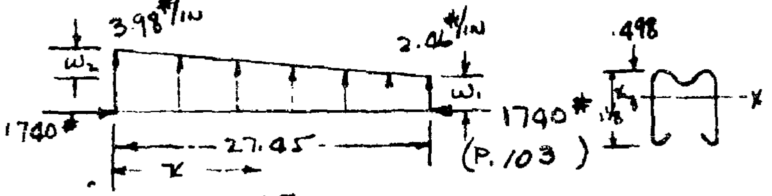
RUDDER HINGE RIB STA. 183 5/16

TRUSS MEMBER "C-2"

MADE FROM FXM-44-079 24ST84

CRIT. LOADING GUST (LD. ACTING LEFT TO RIGHT)

(BEAM-COLUMN FORMULAES REF. NILES & NEWELL VOL. 2)



$A = .1846 \text{ IN}^2$

$I_{xx} = .0286 \text{ IN}^4$

$\rho_{xx} = .3936 \text{ IN.}$

$F_{cc} = 47{,}200$ p.s.i. (C.V.A.C. #1)

$$L'/\rho = \frac{27.45}{.3936} = 69.8$$

$$F_c = 47{,}200\left[1 - \frac{47{,}200\,(69.8)^2}{4\pi^2 \times 10.2\times10^6}\right] = 20{,}300 \text{ p.s.i.}$$

$$M = C_1 \sin x/j + C_2 \cos x/j + f(w)\ , \quad j = \sqrt{\frac{EI}{P}} = \sqrt{\frac{10.2\times10^6 \times .0286}{1740}} = 40.9$$

$$C_1 = \frac{w_1 j^2(\cos L/j - 1)}{\sin L/j} + \frac{w_2 j^2}{\tan L/j}$$

$$L/j = \frac{27.45}{40.9} = .671$$

$\cos L/j = .78320$

$\sin L/j = .62177$

$\tan L/j = .79389$

$$C_2 = -w_1 j^2 - w_2 j^2$$

$$f(w) = w_1 j^2 + w_2 j^2\left(1 - \frac{x}{L}\right)$$

$w_1 = 2.46$#/IN, $w_2 = 1.52$#/IN

$$C_1 = \frac{2.46(40.9)^2(-.2168)}{.62177} + \frac{1.52(40.9)^2}{.79389} = +1772$$

$$C_2 = -2.46(40.9)^2 - 1.52(40.9)^2 = -6340$$

$$f(w) = 2.46(40.9)^2 + 1.52(40.9)^2\left(1 - \frac{x}{27.45}\right) = 6340 - 93x$$

M(MAX) AT $x = 13.9$

$$x/j = \frac{13.9}{40.9} = .34\ , \quad \sin x/j = .33349\ , \quad \cos x/j = .94275$$

$$M = 1772(.33349) - 6340(.94275) + 6340 - 93(13.9) = -342 \text{ IN. LBS}$$

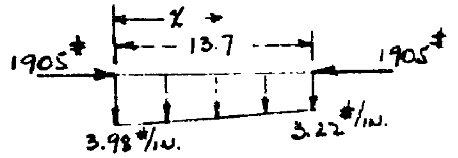
$$f_b = \frac{342\times.627}{.0286} = 7{,}500 \text{ p.s.i.} \qquad f_c = \frac{1740}{.1846} = 1{,}430 \text{ p.s.i.}$$

$$R_b = \frac{7{,}500}{47{,}200} = .159 \qquad R_c = \frac{1{,}430}{20{,}300} = .465 \qquad MS = \frac{1}{.159 + .465} - 1 = \underline{+.60}$$

RUDDER HINGE RIB STA. 183 5/16

TRUSS MEMBER "J-1"

MEMBER SAME AS MEMBER "C-1" (PAGE 106)



$L/\rho = \dfrac{13.7}{.3936} = 34.8$

$$F_c = 47{,}200\left[1 - \frac{47{,}200\,(34.8)^2}{4\pi^2 \times 10.2 \times 10^6}\right] = 40{,}500 \text{ p.s.i.}$$

$$j = \sqrt{\frac{10.2\times10^6 \times .0286}{1905}} = 39.1 \,,\quad L/j = \frac{13.7}{39.1} = .35$$

$\cos L/j = .93937$

$\sin L/j = .34290$

$\tan L/j = .36503$

$\omega_1 = 3.22 \text{ \#/in.},\quad \omega_2 = .76 \text{ \#/in.}$

$$C_1 = \frac{3.22(39.1)^2(-.06063)}{.3429} + \frac{.76(39.1)^2}{.36503} = 2311$$

$$C_2 = -3.22(39.1)^2 - .76(39.1)^2 = -6{,}082$$

$$f(\omega) = 3.22(39.1)^2 + .76(39.1)^2\left(1 - \frac{x}{13.7}\right) = 6082 - 84.8x$$

M(MAX) WHERE $x = 7.04$ $\quad x/j = \dfrac{7.04}{39.1} = .18$

$\sin x/j = .17903 \quad \cos x/j = .98384$

$$M = 2311(.17903) - 6082(.98384) + 6082 - 84.8(7.04)$$
$$= -85 \text{ IN. LBS.}$$

$$f_b = \frac{85 \times .627}{.0286} = 1{,}864 \text{ p.s.i.}$$

$$R_b = \frac{1{,}864}{47{,}200} = .0395$$

$$f_c = \frac{1905}{.1846} = 10{,}310 \text{ p.s.i.}$$

$$R_c = \frac{10{,}310}{40{,}500} = .254$$

$$M.S. = \frac{1}{.0395 + .254} - 1 = \underline{\underline{\text{HIGH}}}$$

RUDDER HINGE RIB STA. 133 5/16

TRUSS MEMBER 1-2

MADE FROM FXM-44-067 24ST84

CRITICAL LD. = 260# COMP. LENGTH = 21.3 IN.

MIN. ρ = .222 IN. A = .0755 IN^2. F_{cu} = 31,600 p.s.i. (C.V.A.C. #1)

$$L'/\rho = \frac{21.3}{.222} = 96$$

$$F_c = 31,600\left[1 - \frac{31,600\,(96)^2}{4\pi^2 \times 10.2 \times 10^6}\right] = 9,490 \text{ p.s.i.}$$

$$f_c = \frac{260}{.0755} = 3,445 \text{ p.s.i.} \qquad M.S. = \frac{9,490}{3,445} - 1 = \underline{\underline{+1.75}}$$

TRUSS MEMBER 2-3

MADE FROM FXM-44-067 24ST84

CRITICAL LD = 305# COMP. LENGTH = 18.7

$$L'/\rho = \frac{18.7}{.222} = 84.2$$

$$F_c = 31,600\left[1 - \frac{31,600\,(84.2)^2}{4\pi^2 \times 10.2 \times 10^6}\right] = 14,050 \text{ p.s.i.}$$

$$f_c = \frac{305}{.0755} = 4,040 \text{ p.s.i.}$$

MARGIN HIGH

TRUSS MEMBER 3-4

MADE FROM FXM-44-067 24ST84

CRITICAL LD. = 413# COMP. LENGTH = 15.4 IN.

$$L'/\rho = \frac{15.4}{.222} = 69.4$$

$$F_c = 31,600\left[1 - \frac{31,600\,(69.4)^2}{4\pi^2 \times 10.2 \times 10^6}\right] = 19,700 \text{ p.s.i.}$$

$$f_c = \frac{413}{.0755} = 5,470 \text{ p.s.i.}$$

MARGIN HIGH

RUDDER HINGE RIB STA. 183 5/16

TRUSS MEMBER 4-5

MADE FROM FXM-44-083 24ST 84

CRITICAL LD. = 828# COMP. LENGTH = 13.1 IN.

MIN. $\rho = .2203$ IN., $A = .0968$ IN.^{2} $F_{cu} = 38{,}400$ p.s.i.

$$L'/\rho = \frac{13.1}{.2203} = 59.5$$

$$F_c = 38{,}400\left[1 - \frac{38{,}400(59.5)^2}{4\pi^2 \times 10.2 \times 10^6}\right] = 25{,}450 \text{ p.s.i.}$$

$$f_c = \frac{828}{.0968} = 8{,}550 \text{ p.s.i.}$$

MARGIN HIGH

FIN

THE FIN STRUCTURE OF THE XB-36 AIRPLANE IS IDENTICAL TO THE FIN OF THE YB-36 & B-36 AIRPLANES. THE FOLLOWING COMPARISON OF THE DESIGN LOADS, CONTAINED IN TABLE NO. 21 PAGE 112, AND MARGINS OF SAFETY, TABLE 22 PAGE 113, IS SUBMITTED TO SHOW THAT THE FIN STRUCTURE OF THE XB-36 AIRPLANE IS STRUCTURALLY SATISFACTORY.

THE GREATEST INCREASE IN NET LOADING OF THE XB-36 AIRPLANE OVER THE B-36A & YB-36 IS IN STEADY YAW $\psi = +4.38^\circ$ δ_R FOR TRIM CONDITION. THIS INCREASE IS 12%, WHICH IS MOSTLY DUE TO A DECREASE IN RUDDER LOAD. THIS CONDITION DOES NOT DESIGN ANY OF THE CRITICAL FIN STRUCTURE.

IN THE GUST CONDITION THE XB-36 LOADS ARE ONLY 3.61% GREATER THAN THE B-36A. IN THE STEADY YAW, $\psi = +4.38^\circ$ $\delta_R = 0$ CONDITION, THE INCREASE IS .2%, WHILE ALL OTHER CONDITIONS OF LOADING ARE LESS FOR THE XB-36 THAN FOR THE B-36A & YB-36 AIRPLANES.

THE MAXIMUM RUDDER HINGE LOADS OCCUR IN STEADY YAW $\psi = -4.38^\circ$ δ_R FOR TRIM CONDITION, AND ARE LESS FOR THE XB-36 THAN FOR THE YB-36 & B-36A.

THE FOLLOWING TABLE NO. 22 OF MARGINS OF SAFETY, LESS THAN .25, TAKEN FROM REP. FZS-36-147, GIVE CONDITION AND THE CORRESPONDING XB-36 LOADING.

FIN

TABLE NO. 21

COMPARISON OF XB-36 ULTIMATE LOADS WITH YB-36 & B-36A

STEADY YAW $\psi = 4.38°$ $\delta_R = 0$	YB-36 & B-36A	XB-36	GUST CONDITION	YB-36 & B-36A	XB-36
FIN LOAD	25,107	25,995	FIN LOAD	29,510	30,525
RUDDER LOAD	8,869	8,070	RUDDER LOAD	8,091	8,433
NET LOAD	33,976	34,065	NET LOAD	37,601	38,958
P_{28}	536	-172	P_{28}	124	-531
P_{100}	3980	4,839	P_{100}	3,556	4,891
P_{180}	2,110	1,391	P_{180}	1,835	1,458
P_{261}	2,242	2,012	P_{261}	2,576	2,615
STEADY YAW $\psi = +4.38°$ δ_R FOR TRIM			**UNSYMMETRICAL THRUST + GUST**		
FIN LOAD	16,531	16,830	FIN LOAD	22,133	22,133
RUDDER LOAD	-6,976	-6,140	RUDDER LOAD	11,712	10,365
NET LOAD	9,555	10,690	NET LOAD	33,845	32,498
P_{28}	-928	-932	P_{28}	807	114
P_{100}	-2361	-1880	P_{100}	5,126	5,613
P_{180}	-1729	-1584	P_{180}	2,753	2,026
P_{261}	-1959	-1744	P_{261}	3,026	2,612

YB-36 & B-36A LOADS REP. FZS-36-147 (PAGES 28 & 62)

XB-36 LOADS REF. PAGE 35

STEADY YAW $\psi = -4.38°$ δ_R FOR TRIM	YB-36 & B-36A	XB-36
FIN LOAD	-10,868	-11,130
RUDDER LOAD	17,796	16,222
NET LOAD	6,928	5,092
P_{28}	1,916	1,487
P_{100}	6,715	6,602
P_{180}	4,332	3,744
P_{261}	4,833	4,389

FIN

TABLE No. 22

MINIMUM MARGINS OF SAFETY FOR XB-36 & B-36A AIRPLANES & CHANGE IN LOADING FOR XB-36

ITEM	*REF. PAGE NO.	M.S.	DESIGN CONDITION	CHANGE IN LOADING XB-36 OVER B-36A
REAR SPAR FLANGE SKIN RIVETS STA. 100	366	+.15	GUST	INCREASE .0361
REAR SPAR FLANGE RIVETS STA. 180	366	+.14	STEADY YAW $\psi = -4.38°$ δ_R TRIM	DECREASE
FRONT SPAR SPLICE STA. 100	368	+.22	GUST	INCREASE .0361
BULKHEAD #14 (STA. 261)	424	+.08	STEADY YAW $\psi = 4.38$ δ_R TRIM	DECREASE

*REF. PAGES ARE FROM REP. FZS-36-147

SUMMARY OF MIN. MARGINS OF SAFETY

RUDDER:

SPAR~
WEB ———— HIGH
FLANGES ———— +.21 (P.66)
FLANGE RIVETS ———— +1.59 (P.70)

SERVO TAB~
SPAR WEB ———— +.05 (P.84)
NOSE SKIN ———— +.10 (P.85)

TRIM TAB~
SPAR WEB ———— +.55 (P.98)
NOSE SKIN ———— +.29 (P.99)

T.E. RIB~
CHORD MEMBER ———— +.60 (P.107)

FIN:

SINCE THE FIN WAS SHOWN TO BE SATISFACTORY BY DIRECT COMPARISON WITH B36A, NO MARGINS OF SAFETY ARE SHOWN.

REEL – C

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A T I

5414

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	REVISION (None)
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ABSTRACT:

A stress analysis is made of the vertical tail surfaces of the XB-36 bomber. Using methods previously employed, loads, yaw and gust conditions, rudder shears and bending moments, rudder structural characteristics, tab effects and rudder torsions, rudder pressure distributions, and net rudder spar shear flows have been determined. Summaries are included of design loads and rudder hinge loads. Results of the analysis are shown in tables, diagrams, graphs, and formulas.

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DIVISION: Structures (7)	SUBJECT HEADINGS: B-36 - Stress analysis (14884.605); XB-36 (99409); Tails, Vertical - Stress analysis (91633.65)
SECTION: Stress Analysis of Specific Aircraft (6)	
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