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R-7-0510-1

ANALYZED



TECHNICAL REPORT



A. V. ROE CANADA LIMITED
MALTON - ONTARIO

ANALYZED

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C 105

REPORT NO. 7/C510/1

FILE NO.

NO. OF SHEETS:

TITLE: C/105 Fin - Summary of Analysis

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Classification cancelled / Changed to UNCLASS

By authority of AVRS

Date 30 Sept 56

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PREPARED BY R.N. Shearly
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Introduction

The following is a summary of the work performed during the analysis of the fin structure by the method outlined in reports Gen/1090/330 and 331. The assumed structure is a three cell swept box with ribs approximately perpendicular to the spars and supported by four foundation beams as shown in Fig. 1, 2, 3 and 4. Fig. 1 shows the overall idealized structure.

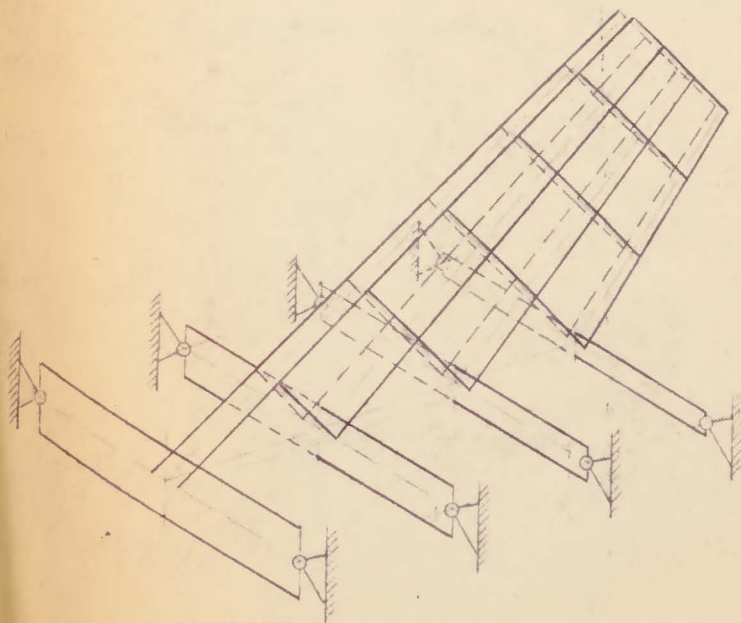


Fig. 1

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Fig. 2 shows that the upper portion of the actual fin has not been included in the assumed structure. However the air loads on the upper structure have been included in the loads acting on the assumed structure, see Fig. 5. The assumed structure consists of three cells of trapezoidal cross sections. Fig. 3 shows the traces on the plane of symmetry of the fin of the skin panel planes for the rear, middle and front cell $y = .56005 x$, $y = 40.609 x$ and $y = -.36462 x$ resp.. Fig. 4 presents the physical properties (as indicated in the code of the figure) of the assumed structure. Fig. 5 shows the selected cross section or stress index, i and k ; redundant group index, p and q , and the load point index, a and b .

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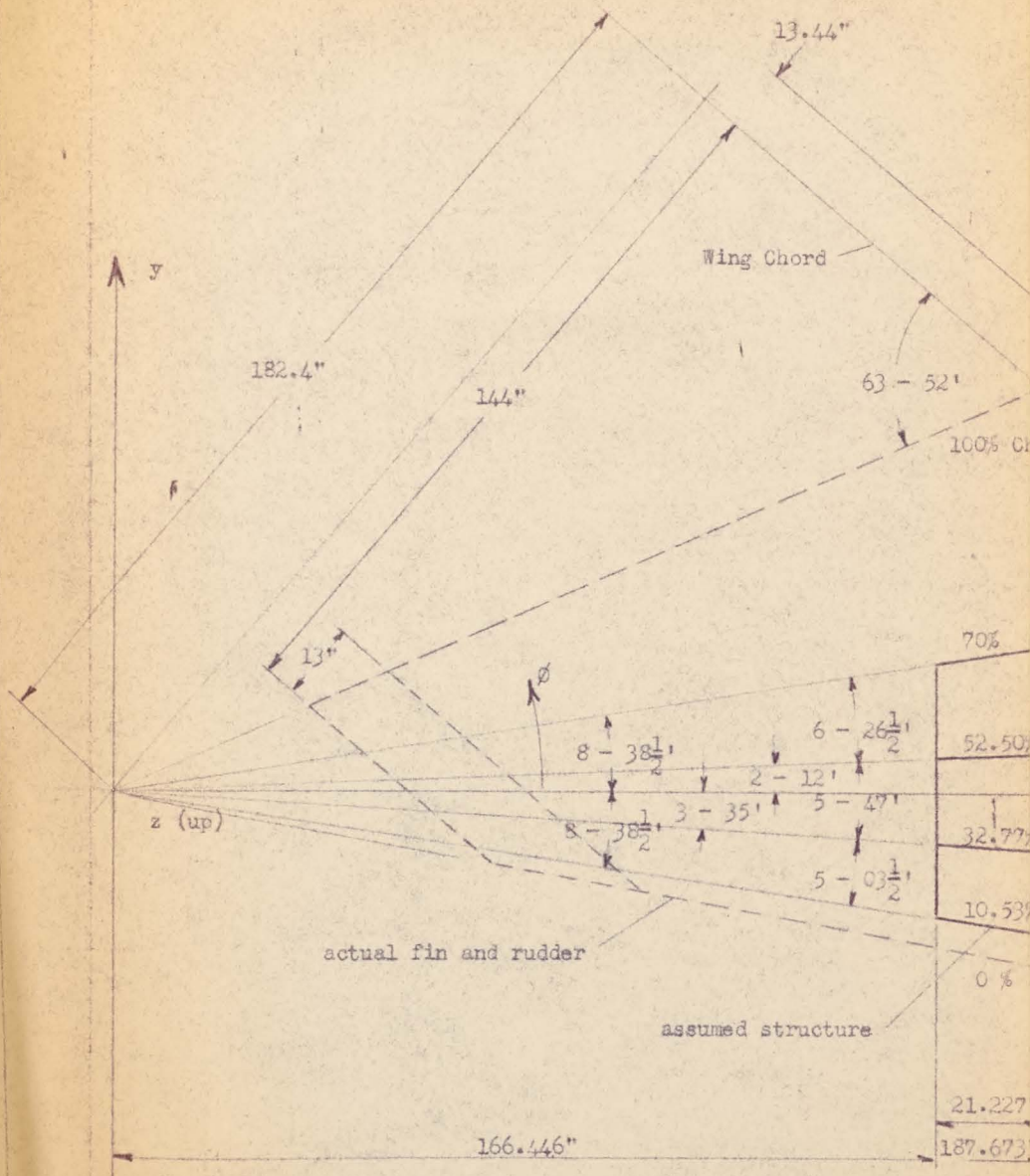


Fig.2

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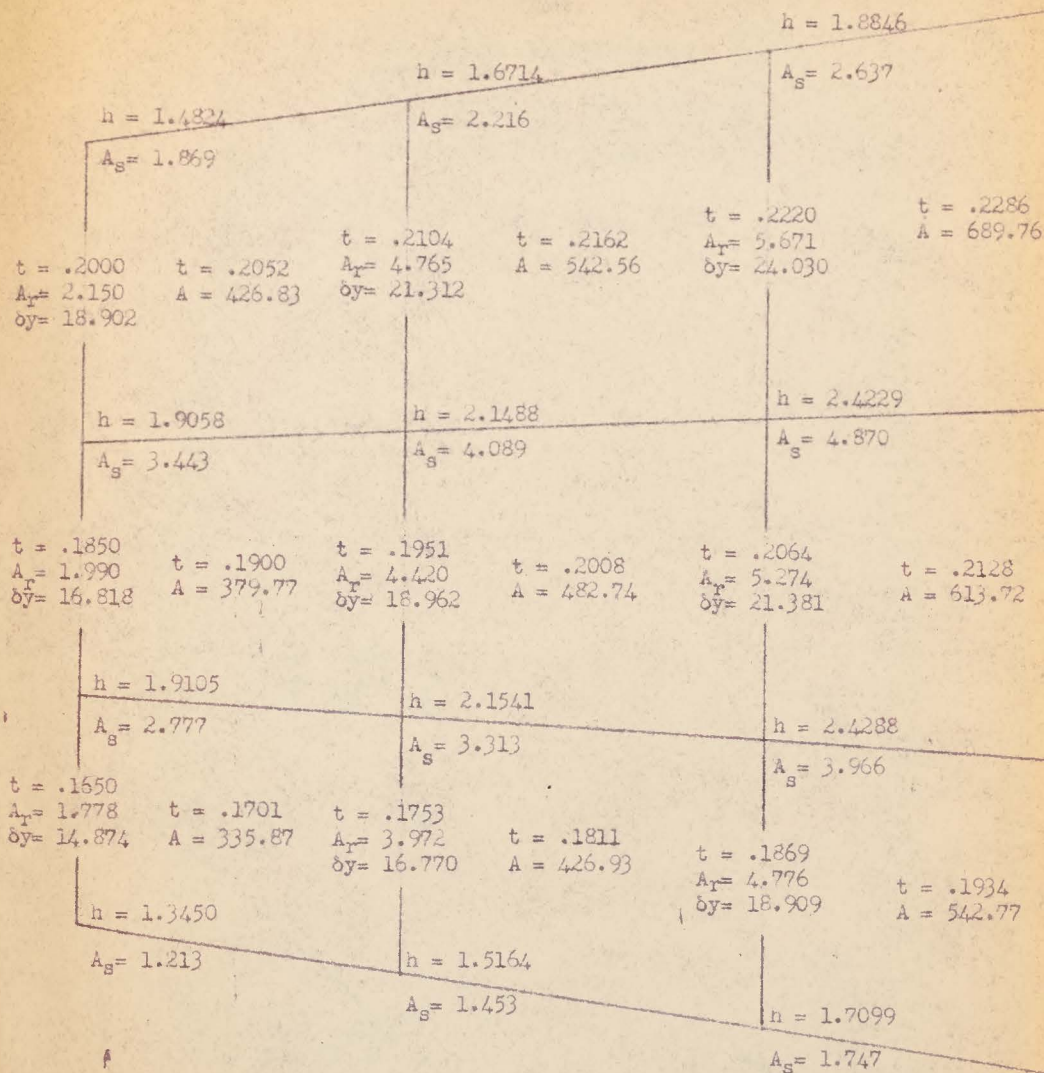


Fig. 4

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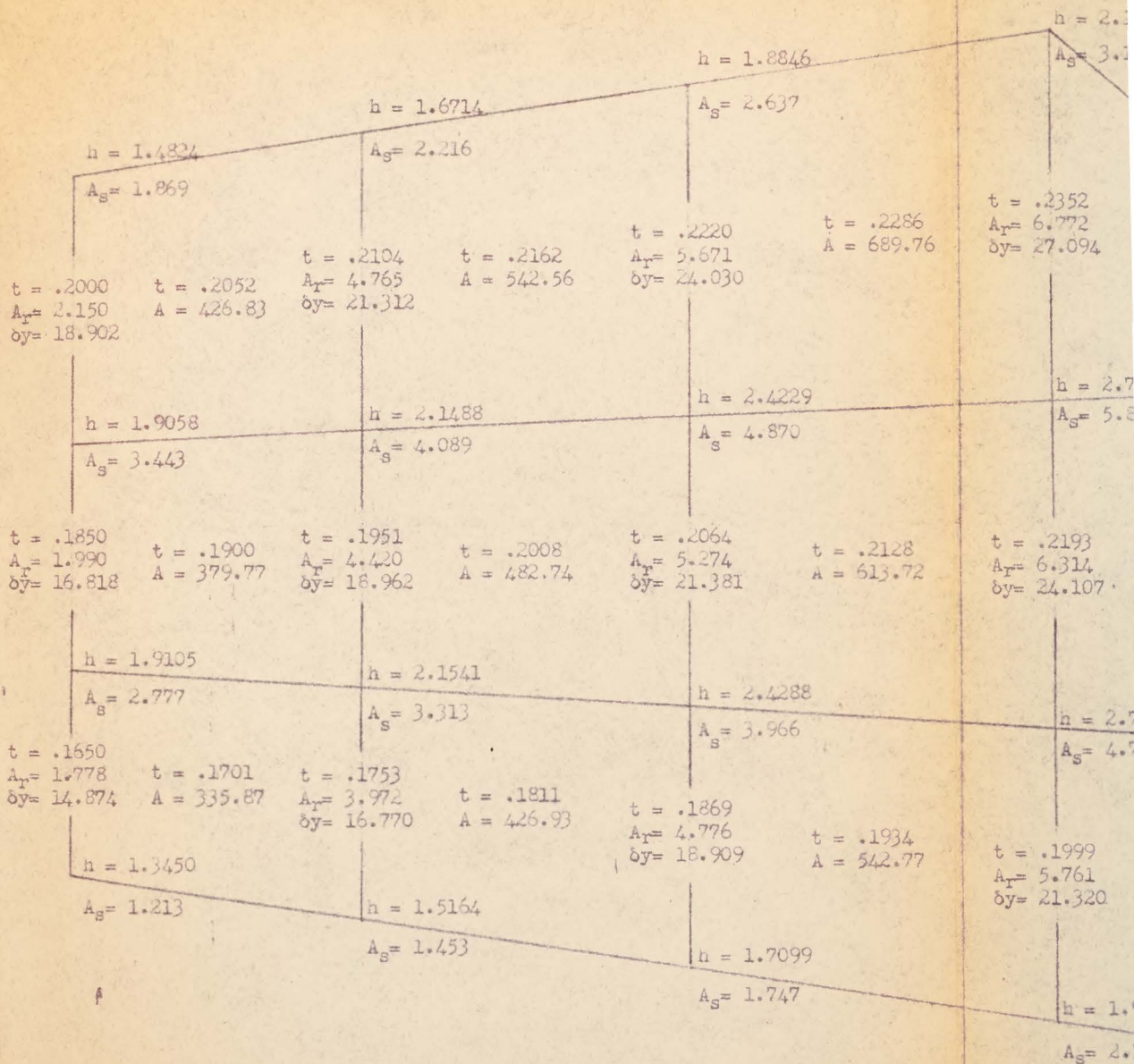


Fig. 4

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$h_f = 1.500$
 $A_r = 7.516$
 $l_f = 116$ } *

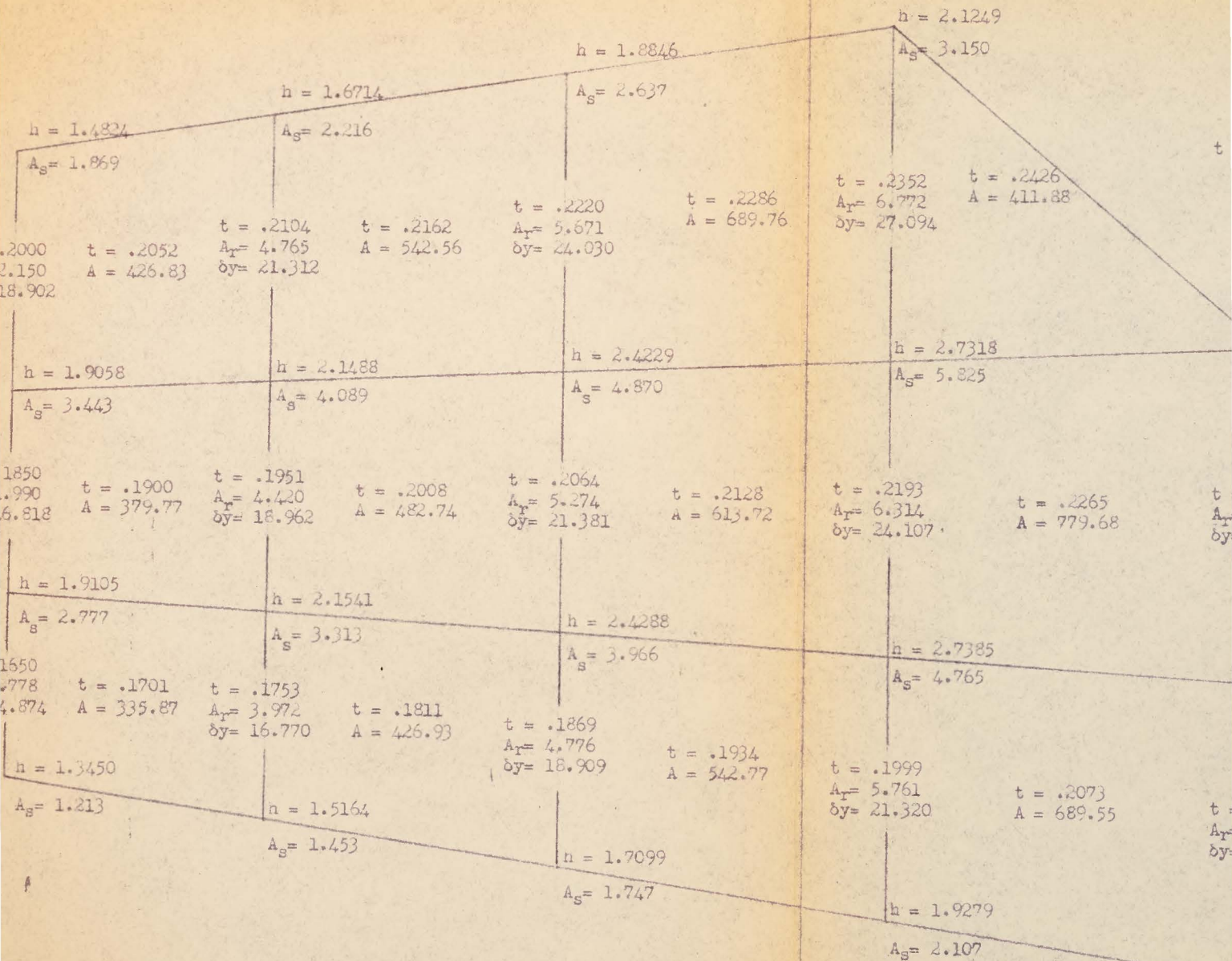
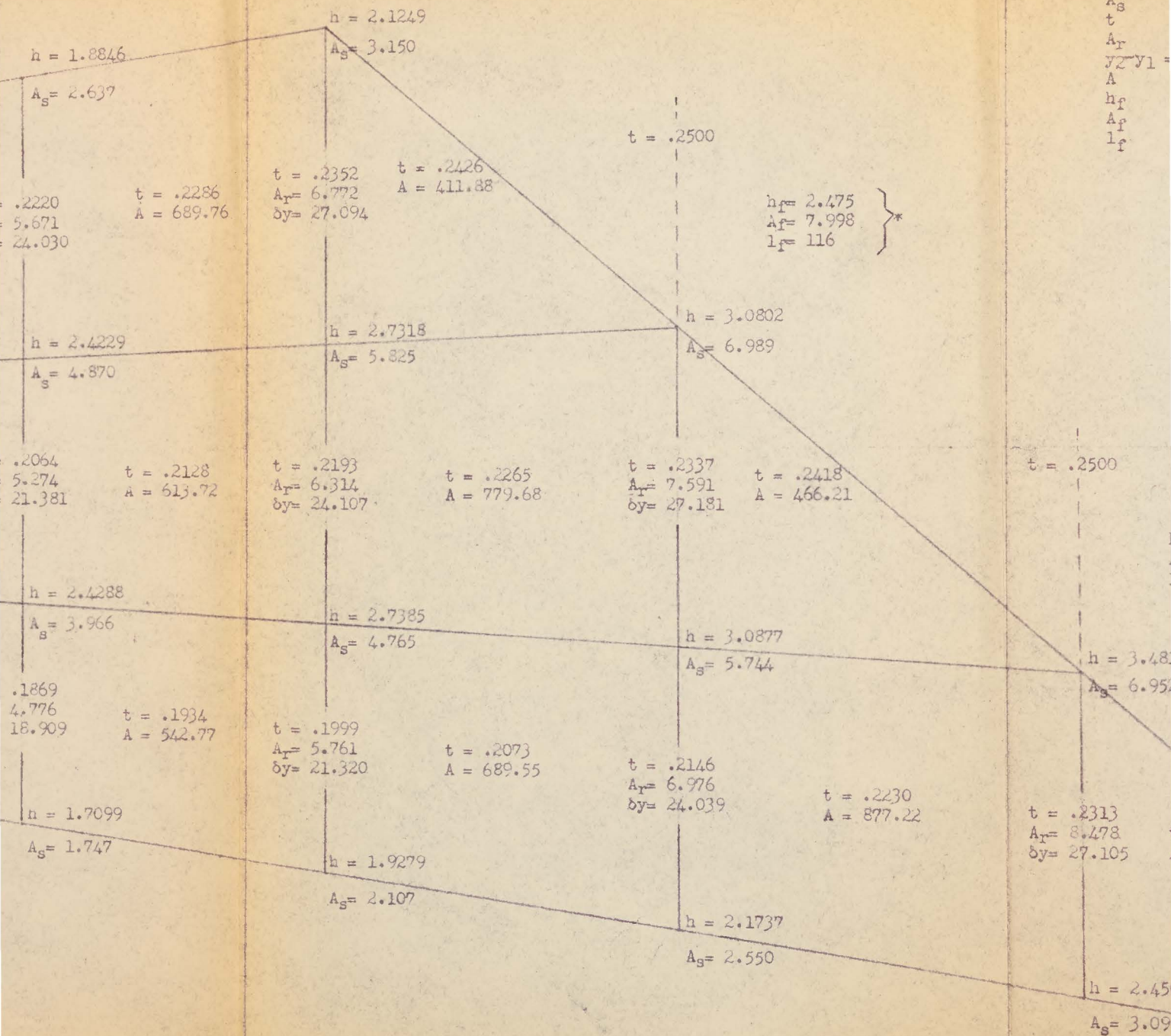


Fig. 4

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05
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$h_f = 1.500$
 $A_f = 7.516$
 $l_f = 116$ }*

h
 A_s
 t
 A_r
 $\sqrt{2} V_1 =$
 A
 h_f
 A_f
 l_f



Code

h = half spar height (in)
 A_s = spar area (in²)
 t = panel thickness (in)
 A_r = rib area (in²)
 $\sqrt{2} l_f = \delta y$ = rib length (spar to spar) (in)
 A = panel area (in²)
 h_f = half foundation beam height (in)
 A_f = foundation beam flange area (in²)
 l_f = foundation beam length (in)

* effective length = $\frac{1}{2} l_f = 58"$

$h_f = 2.475$
 $A_f = 7.998$
 $l_f = 116$

}

0802

989

$t = .2418$
 $A = 466.21$

$t = .2500$

$h_f = 3.600$
 $A_f = 9.016$
 $l_f = 116$

}

377

4

$h = 3.4816$

$A_s = 6.952$

$t = .2230$
 $A = 877.22$

$t = .2313$

$A_r = 8.478$

$\delta y = 27.105$

$t = .2406$

$A = 524.16$

$t = .2500$

$h = 2.4509$

$A_s = 3.099$

* $\left\{ \begin{array}{l} h_f = 4.925 \\ A_f = 9.558 \\ l_f = 116 \end{array} \right.$

$h = 2.7634$

$A_s = 3.776$

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Method

The evaluation of the four basic matrices: influence matrix, C_{ik} ; redundant stress matrix, K_{ip} ; statically determinant stress load matrix, S_{ia}^o and load at the point a for the loading case m matrix, Q_a^m is the only manual computation necessary, for once these matrices are known the remainder of the computation can be carried out by the I. B. M. Card Programmed Electronic Computer.

The following is a brief description of the necessary manual computation.

a) For rigid foundation beams

The elements of the C_{ik} matrix ($i, k = 1$ to 52 incl.) are computed from the assumed physical properties by the following formulae from Report Gen/1090/330 pp. 10, 11 and 08 resp..

$$V = \frac{A_{s2} (x_2 - x_1)}{6E \cos \phi_s} [1 + 3(x_2 - x_1)/4x_2] \sigma_{n2}^2 +$$

$$+ \frac{A_{sm} (x_2 - x_1)}{6E \cos \phi_s} \sigma_{n2} \sigma_{n1} +$$

$$+ \frac{A_{s1} (x_2 - x_1)}{6E \cos \phi_s} [1 - 3(x_2 - x_1)/4x_1] \sigma_{n1}^2$$

$$V = \frac{A_r (y_2 - y_1)}{6E} [\sigma_{y2}^2 + \sigma_{y2} \sigma_{y1} + \sigma_{y1}^2]$$

$$V = \frac{At}{2G} \tau_m^2 [1 + 4G/3E (\tan^2 \phi_2 + \tan \phi_2 \tan \phi_1 + \tan^2 \phi_1)]$$

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and the elements of the K_{ip} matrix ($i, k = 1$ to 52 incl.) by the following formulae from the same report pp. 24, 24 and 23 resp..

$$\tilde{\sigma}_n = - \frac{1}{h \cos \alpha \cos \theta A_s} \delta_\theta (MF_x)$$

$$\tilde{\sigma}_y = - \frac{1}{h \cos \beta \cos \theta A_r} \delta_x (MF_\theta)$$

$$\tau_m = \frac{1}{(x_2 - x_1) t} \delta_x \left\{ \frac{MF_x}{x} \right\} + \frac{\cos \theta_1 \cos \theta_2}{x_1 x_2 \sin(\theta_2 - \theta_1) t} \delta_\theta \left\{ \frac{MF_\theta}{\cos \theta} \right\}$$

The elements of the S_{ia} matrix ($i, k = 1$ to 52 incl.) are computed in the following manner:

In the cell between x_1 and x_2 , see Fig. 6
the shearing stress, τ is

$$\tau = \tau_m \frac{x_1 x_2}{x^2}$$

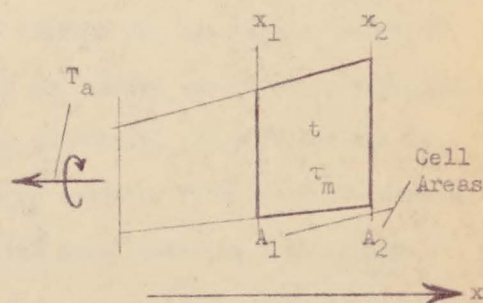


Fig. 6

by Report Gen/1090/330 page 07, which
after manipulation yields

$$\tau_m = \sqrt{\tau_1 \tau_2}$$

By the well known Batho formula

$$\tau_1 = \frac{T_a}{2A_1 t} \quad \text{and} \quad \tau_2 = \frac{T_a}{2A_2 t}$$

Hence

$$\tau_m = \frac{T_a}{2t \sqrt{A_1 A_2}}$$

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The evaluation of the remaining elements is obvious from their corresponding figures.

$$\sigma_{nia} = \frac{Q_a(x_i - x_a)}{2A_{si}h_i \cos\theta_s \cos\alpha_s} \quad \text{see Fig. 7}$$

$$\sigma_{nia} = \frac{M_a}{2A_{si}h_i \cos\alpha_s} \quad \text{see Fig. 8}$$

$$\sigma_{yia}^+ = \frac{T_a}{2A_{ri}h_i \cos\beta} \quad \text{see Fig. 9}$$

b) For flexible foundation beams

In the case of the flexible foundation beams it is necessary to include some additional elements in the C_{ik} matrix to account for the strain energy of these beams. As a result, it is necessary to include also the corresponding elements in the K_{ip} and S_{ia} matrices. The additional elements for the C_{ik} and K_{ip} matrices ($i, k = 53$ to 56 incl.) are computed from the known formula for the strain energy of a simply supported beam loaded by a centrally located moment.

$$V = \frac{M_f^2}{24EI_f} \quad \text{where } I_f = \frac{2h_f^3A_f}{12}$$

By the ordinary bending theory

$$\sigma_f = \frac{M_f h_f}{4h_f^3 A_f} = \frac{M_f}{4h_f^2 A_f}$$

and consequently the strain energy can be evaluated in terms of the foundation

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beam stress, σ_f

$$V = \frac{A_f l_f}{3 E} \sigma_f^2$$

The centrally located moments, M_f in the above expressions are evaluated from the redundant moment groups MF_{16} , MF_{19} , MF_{22} , MF_{24} , MF_{26} and MF_{27} as shown in Fig. 10. Fig. 10a shows these groups acting as they are assumed to act on the extension of the triangular root panels. Since they are self equilibrated groups each group consists of two equal and opposite moments, one of them acting at intersection of a spar and the oblique root rib and the other acting at a fictitious point beyond the root rib. The former part remains where it is but the latter is moved as shown by the broken arrows to an intersection of a spar and the root rib. This stage is shown in Fig. 10b. In Fig. 10c all moments acting on any one intersection have been resolved into moments perpendicular and parallel to the oblique root rib. The perpendicular moments, T_f can have any value as they are not taken into the computations due to the great rigidity of the foundation beams to bending moments in this plane. The parallel, M_f represent the action of the foundation beams on the fin, and are calculated by the following expressions.

$$M_{53} = (MF_{19} \cos 49^\circ 31\frac{1}{2}' - MF_{16} \cos 49^\circ 07')$$

$$M_{54} = (MF_{24} - MF_{19}) \cos 49^\circ 31\frac{1}{2}' + MF_{16} \cos 49^\circ 07' - MF_{22} \cos 40^\circ 40\frac{1}{2}'$$

$$M_{55} = (MF_{27} - MF_{24}) \cos 49^\circ 31\frac{1}{2}' + MF_{22} \cos 40^\circ 40\frac{1}{2}' - MF_{26} \cos 36^\circ 53\frac{1}{2}'$$

$$M_{56} = (-MF_{27}) \cos 49^\circ 31\frac{1}{2}' + MF_{26} \cos 36^\circ 53\frac{1}{2}'$$

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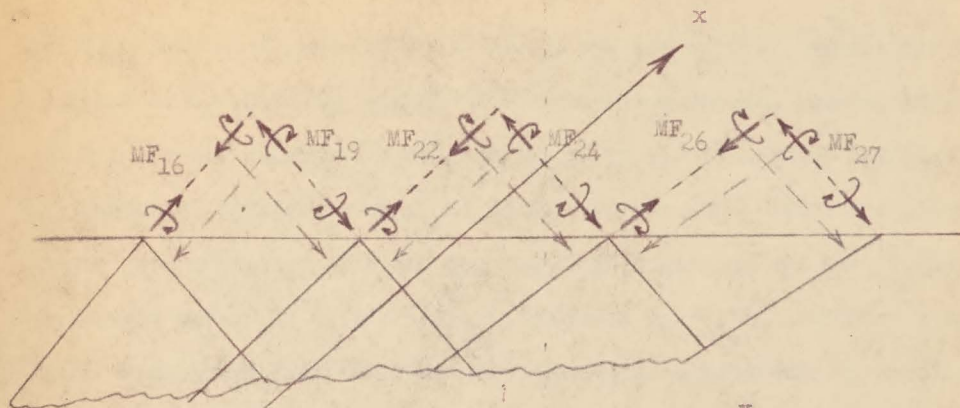


Fig. 10a

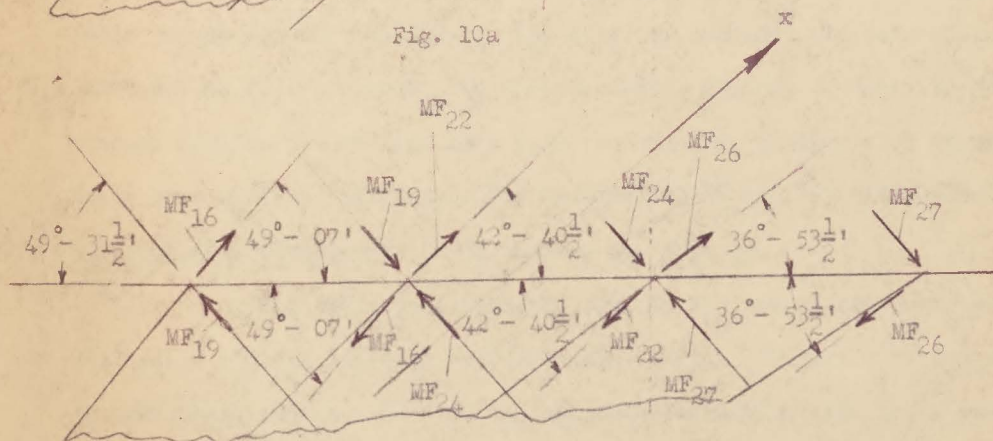


Fig. 10b

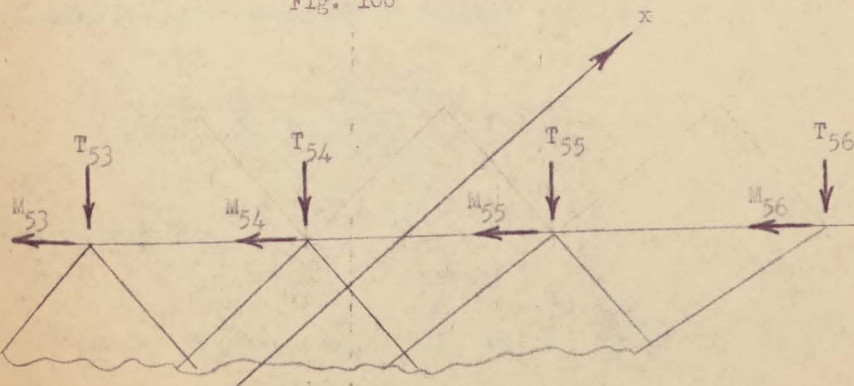


Fig. 10c

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The C_{ik} elements ($i, k = 53$ to 56 incl.) are not exactly correct due to
a) uncertainty as to the effect of plate torsion between foundation beams, which means the effective width and length of the foundation beams and
b) inaccurate boundary conditions which were not known until the computations were completed (for the new boundary conditions see the appendices of Reports Gen/1090/329 and 330). In addition there were structural changes. Rather than correcting the elements which would necessitate the recalculation of the results obtained by the I. B. M. machine; the foundation beam stiffness is made to agree with the calculated figures. In this way the present results can be used as a guide for the fin problem with foundation beams of a modified stiffness. The modified stiffness is calculated by using an effective length of 58 inches, see Fig. 4.

The additional elements for the S_{ia} matrix are computed as follows. A typical fin spar root is shown in Fig. 11 where n is the selected spar cross section and f is the selected foundation beam cross section. The foundation beam stress can be written

$$\sigma_f = \frac{M_f}{2A_f h_f}$$

and by substituting

$$M_f = M_n \sin(\alpha + \phi_s) \quad \text{and} \quad \sigma_n = \frac{M_n}{2A_n h_n}$$

the resulting expression for the foundation beam stress, σ_f can be found

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in terms of the known spar axial stress, σ_n

$$\sigma_f = \frac{A_{sn} h_n}{A_f h_f} \sin(\alpha + \phi_s) \sigma_n$$

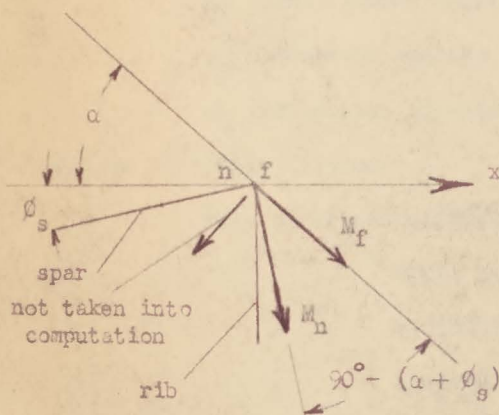


Fig. 11

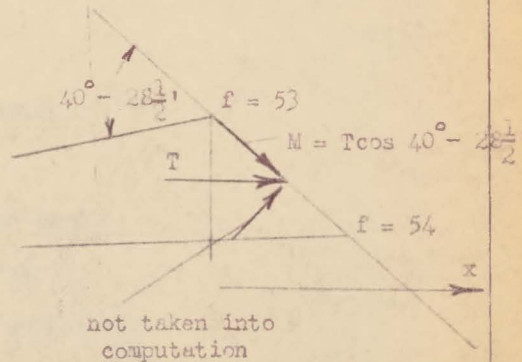


Fig. 12

The torsion in the rear cell is resolved into components perpendicular and parallel to the root rib. The latter is split, half going to the rear spar and half to the forward spar, see Fig. 12. Consequently, the foundation beam stress, σ_f due to torsion in the rear cell is

$$\sigma_f = \frac{T \cos 40^\circ - 28 \frac{1}{2}^\circ}{4 A_f h_f}$$

The elements of the Q_a matrix are computed in Appendix A.

and listed later in this report.

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Results

The results are presented in the form of the following matrices:

- a
- F_p redundant moment unit load matrix
- S_{ia} stress unit load matrix
- S_i final stress distribution
- F_p redundant moments
- z_a deflection (rotation) at point a

and the following figures:

Fig. 13 showing for the applied load

Panel shear stress, τ_m

Foundation beam stress, σ_p

Sparwise axial stress, σ_n

Ribwise axial stress, σ_y^+

Fig. 14 showing the deflection for the applied load

Fig. 15 showing the value along the root rib of the normal stress perpendicular to the root rib and the shear stress tangential to the root rib.

The curves of Fig. 15 are computed as follows. The lumped sparwise and ribwise axial forces which act at a point on the root rib are resolved into forces normal and tangential to the root rib, these in turn are divided by the lumped area along the root rib to yield

$$\sigma_N^1 = \sigma_{na_r}^1 \left[\cos \phi_s \sin \alpha \cos \alpha + \sin \phi_s \cos^2 \alpha \right] + \sigma_y^+ \cos^2 \alpha$$

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$$\tau_T^1 = - \frac{A}{\sin \alpha} [\cos \phi_s \cos^2 \alpha - \sin \phi_s \sin \alpha \cos \alpha] + \frac{A}{y} \sin \alpha \cos \alpha$$

The shearing stress in a triangular root panel when transformed into stresses normal and tangential to the root rib yield

$$\sigma_N^1 = 2 \cos^2 \alpha (\tan \phi + \tan \alpha) \frac{x_1 x_2}{x^2} \tau_m$$

$$\tau_T^1 = \sin^2 \alpha [(1 - \tan^2 \alpha) + 2 \tan \phi \tan \alpha] \frac{x_1 x_2}{x^2} \tau_m$$

By computing σ_N^1 , τ_T^1 , σ_N^2 and τ_T^2 at each intersection of a spar and a rib along the root rib and letting

$$\sigma_N = \sigma_N^1 + \sigma_N^2$$

and

$$\tau_T = \tau_T^1 + \tau_T^2$$

the values of Fig. 15 are obtained.

STRESS DUE TO UNIT LOAD (psi./in.)

	1	2	3	4	5	6	7	8	9	10	11	12
1	180.47				156.85							
2		76.20										
3	17.18	-14.46	8.59	9.66	22.47	409. -	358	168	367	15.7	108	-103
4			96.24									
5	6.40	5.93	-15.83	25.45	6.73	239	80	-353	574	5.4	109	-17
6				306.47								
7	-20.93	1.58	5.19	14.85	-25.62	-415	-12	128	190	-1	-55	-33
8	-11.23	-6.85	9.67	15.54	-5.48	-299	-141	194	374	-5.1	-93	-7
9	-4.07	-4.41	1.39	27.95	-3.07	-149	-81	80	493	-2.6	-69	-5
10	19.09	24.71	13.16	10.25	9.67	516	379	279	430	-19.5	-381	-23
11										62.9		
12	32.25	21.79	26.67	18.71	-5.59	511	567	503	475	4.3	-21	-53
13	-7.96	5.85	-4.32	-2.58	16.03	87	-103	7	138	9.4	161	-172
14	17.01	26.65	21.61	41.05	1.06	490	503	570	531	3.7	173	56
15	-1.68	-3.50	6.70	-13.30	4.26	42	-47	-76	129	2.7	60	2
16	9.18	12.84	28.83	-3.07	2.80	343	306	344	518	3.4	161	73
17	1.78	-1.42	.20	1.40	-13.88	-102	-52	103	200	-14.7	-172	-32
18	-.73	1.16	-.49	.72	-8.35	-214	-45	145	301	-4.6	-172	-48
19	-1.18	.52	1.83	-3.99	-4.38	-126	-24	114	307	-3.0	-93	-23
20	13.73	14.14	13.96	12.16	2.97	659	628	618	617	4.9	371	318
21												
22	19.19	19.15	18.90	20.07	.70	924	908	872	839	-2.4	505	514
23	-2.09	-.72	-1.20	-3.72	.94	-170	-126	-58	12	6.3	95	-133
24	17.58	17.47	13.19	16.23	-1.93	714	765	797	821	.4	361	383
25	-1.62	-.37	-.49	.01	1.08	-36	-78	-37	10	1.2	-2	-57
26	10.70	12.38	11.11	14.21	-1.40	455	469	541	599	.2	247	222
27	2.32	1.55	1.13	1.09	-7.11	-44	99	214	297	-8.2	-98	71
28	1.75	1.51	.72	.04	-5.94	-62	69	166	267	-4.9	-92	34
29	.71	1.40	.43	.01	-4.04	-58	59	129	227	-2.9	-66	30
30	19.11	20.31	20.93	21.37	10.65	1917	1683	1490	1351	11.1	1506	1250
31	-2.88	1.10	-.70	-1.46	-.16	-669	87	148	229	-.6	-479	64
32	10.24	11.93	11.63	11.40		720	846	841	851	-.3	499	593
33	2.03	-.33	.19	-.36	-3.42	46	-51	72	115	-2.9	4	-45
34	13.15	11.24	11.20	11.19	-4.30	782	753	825	869	-4.4	499	514
35	-.63	-.89	-.38	-1.01	-.38	-81	-103	-44	-26	.3	-62	-86
36	8.45	6.93	7.41	6.44	-3.57	441	415	521	570	-2.9	265	266
37	2.38	2.82	2.54	2.24	-2.81	148	260	322	365	-3.0	97	200
38	1.48	2.20	1.27	.96	-3.23	48	184	209	273	-3.1	17	137
39	1.21	1.52	.83	.41	-2.72	28	116	142	196	-2.4	4	84
40	14.67	5.27	6.10	6.18	-9.12	1065	617	722	773	-9.3	749	506
41	-1.25	-3.49	.63	-.68	.12	-165	-291	96	51	.3	-124	-217
42	6.50	3.57	4.42	3.93	-4.51	431	335	481	521	-4.5	232	259
43	.55	.93	.17	.22	-1.26	12	69	43	85	-1.1	1	49
44	5.34	4.18	3.23	3.14	-4.60	233	365	390	459	-4.5	218	276
45	1.69	1.28	.78	.60	-2.59	105	142	161	202	-2.5	69	115
46	.73	.56	.63	.18	-1.49	34	60	111	110	-1.4	19	48
47	4.04	5.07	.16	.75	-6.22	288	528	234	369	-6.2	202	421
48	.04	-.21	-1.11	.46	-.34	-7	-17	-106	69	-.3	-7	-12
49	1.76	1.61	-.19	.73	-2.66	114	173	65	207	-2.6	77	137
50	.39	.46	.53	.15	-.93	24	54	92	43	-.9	16	74
51	.17	.51	1.80	-.85	-.93	11	61	233	-14	-.9	7	50
52	-16.62	-5.10	-7.54	-7.30	8.26	-1239	-901	-784	-754	8.4	-882	-701
53	-7.04	-8.06	-3.75	-2.56	8.30	-512	-808	-635	-627	8.4	-360	-631
54	-1.46	-2.12	-3.71	-.59	3.30	-101	-236	-519	-319	3.2	-70	-19
55	-.07	-1.16	-.45	-2.37	.23	-5	-19	-.62	-331	.3	-2	-1
56												

Note. The S_{ia} elements for 1 = 53, 54, 55 and 56 are not for indiscriminate use in calcu

/kip.)

SHT. No. 17

REPT No. 7/0510/1

PREP. BY A.C.DATE 10 Mar. 54

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
108	-103	22	178	2.4	15	-25	-2	56	-6	1	18	1	6	1
109	-17	-79	132	2.3	23	-19	-10	33	-5	-1	14	1	5	1
-55	-33	36	95	1.2	5	-12	4	31	-2	1	9		3	1
-92	-7	29	95	-1.1	-12	5		5	1		-1		-1	
-69	-5	48	24	-1.3	-15	10	10	-20	3		-7		-3	-1
-81	-23	135	215	2.4	3	-27	19	73	-3	2	17	1	4	1
-21	-53	55	131	-3.0	-28	17	-4	-5	2		-8	-1	-2	-1
182	-172	64	168	7.7	49	-64	15	106	-12	4	-39	3	13	3
173	56	-105	-133	1.8	22	-3	5	-44	1	-1	-2		-1	
63	2	-156	293	1.8	39	-23	-43	87	-11	-2	24	1	11	3
162	73	-105	-457	2.2	37	-15	-35	43	-8		6	1	6	1
-272	-32	86	161	.4	-49	-35	31	91	-10	7	35	2	11	2
-172	-48	126	245	-2.3	-48	10	24	68	7	-1		-1	-3	-1
-92	-23	78	293	-1.8	-35	13	44		11	6	-26	-1	-10	-3
371	318	339	274	-15.8	-347	-14	124	187	-17	25	69	5	18	3
			46.9											
505	514	459	432	5.0	49	-19	60	116	20	-4	-9	-3	-11	-3
95	-133	-17	90	2.9	34	-171	56	147	-51	29	110	11	43	9
361	383	428	405	1.8	93	19	-109	-115	-12	1	-36		2	1
-2	-57	-54	69	.3	19	-7	-121	236	-15	-29	78		21	5
247	222	259	384	.6	80	38	-91	-401	-14	-27	37	1	6	3
-98	71	187	265	-7.8	-117	49	136	194	4	53	99	10	30	4
-92	34	153	262	-1.6	-71	2	118	202	16	19	48	-2	-5	-3
-66	20	113	243	-1.3	-39	9	71	232	15	34	-9	3	-26	-6
1506	1250	1044	905	15.3	1051	724	567	484	144	187	180	18	27	-5
-479	64	163	355	-3.2	-282	55	174	254	66	147	199	73	103	27
499	593	596	601	-3.3	224	322	312	316	-59	29	92	23	4	
4	-45	68	189	1.2	-13	-60	73	166	-92	95	167	-2	88	17
499	514	584	632	-3.2	197	244	317	317	-2	-100	-98	-18	-29	
-62	-86	-36	-6	.7	-26	-61	-48	56	-10	-100	202	-24	72	13
265	266	367	420	-1.7	100	103	165	282	1	-96	-343	27	33	5
97	200	268	316	-3.6	35	137	205	250	68	122	154	17	58	8
17	137	182	253	-2.0	-8	80	152	232	19	107	170	17	38	-3
4	84	124	187	-1.3	-9	44	99	192	10	54	175	8	-21	-16
749	506	592	639	-10.0	390	385	445	472	274	250	247	101	55	-9
-124	-217	83	67	1.0	-74	138	69	97	-74	71	154	-94	162	76
232	259	388	435	-4.5	137	175	281	337	75	160	183	-46	-81	-8
1	49	39	82	-4.5	-4	25	33	81	3	10	112	-48	200	35
218	276	319	393	-3.9	96	175	238	315	64	123	247	71	250	22
69	115	145	189	-2.2	31	83	126	179	41	107	170	25	122	11
19	48	97	106	-1.0	6	33	82	106	13	60	120	211	125	-5
202	421	231	354	-6.0	105	298	228	336	161	222	315	-7	230	-36
-7	-13	-83	60	-.1	-6	-9	-56	52	-7	-27	48	60	85	178
77	139	69	192	-2.4	37	99	73	177	51	79	161	34	176	-160
-16	44	81	47	-.8	7	32	68	52	17	53	62	57	87	103
7	50	194	5	-.8	4	37	151	27	21	103	58	-81	96	235
-882	-708	-624	-597	9.1	-472	-494	-442	-417	-247	-242	-235	-194	-89	-17
-360	-637	-555	-571	8.5	-189	-446	-467	-503	-238	-359	-397	-147	-222	-63
-70	-191	-440	-207	3.0	-36	-139	-352	-296	-77	-253	-292	-17	-294	-204
-3	-16	-52	-280	.3	-1	-12	-41	-224	-7	-29	-162		-97	-48

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use in calculating beam stresses because of the assumption of unconnected foundation beams.

F_p

SELF - EQUILIBRATED REDUNDANT GROUPS MATRIX

 a

1 2 3 4 5 6 7 8 9 10

REDUNDANT GROUPS	1	-.06687	.05703	-.03390	-.03808	-.08866	-1.6164	1.4111	-.6645	-1.4460	-.06204	-
	2	-.02371	-.02132	.05685	-.09143	-.02420	-.8592	-.3891	1.3681	-2.0620	-.01934	-
	3	-.42441	.09048	.04816	.03792	.03539	-8.7236	1.3873	1.3873	1.5367	-.07140	-1
	4	-.14122	-.21781	.18227	.20219	-.01365	-4.2392	-4.2484	5.8037	5.7056	-.03373	-1
	5	-.02001	-.02797	-.06278	.50101	-.00610	-.7466	-.6658	-.7489	9.4853	-.00741	-
	6	.01077	-.00075	.00867	-.01256	-.24677	-2.4711	2.4294	-.7343	-2.8065	-.15531	-2
	7	-.00860	.01016	-.00360	.02854	-.06261	-1.2362	.1373	1.9554	-3.2260	-.04334	-10
	8	-.42687	.06949	.06857	.05976	.01460	-19.3417	3.1343	3.0362	3.0324	.02411	-10
	9	-.20060	-.20445	.29144	.29640	.02273	-8.4107	-8.7354	13.3162	12.9231	-.00400	-4
	10	-.03160	-.03657	-.03283	.45235	.00414	-1.3429	-1.3842	-1.5982	20.8127	-.00072	-
	11	.03840	.00869	.02436	.03651	-.25924	-.2276	4.0936	.0299	-2.9603	-.23807	-
	12	.01108	.01464	.00228	.02862	-.07568	-.2055	1.0819	2.4032	-3.3524	-.05784	-
	13	-.36794	.13439	.13855	.14144	.07042	-23.3892	11.1347	9.8616	8.9432	.07370	-15
	14	-.20518	-.17554	.32332	.32266	.07031	-11.9477	-11.4793	23.2413	22.4716	.06939	-7
	15	-.03394	-.02784	-.02979	.46848	.01436	-1.7695	-1.6676	-2.0923	33.7823	.01157	-1
	16	.12640	-.01565	.00990	.02072	.00233	9.5156	-1.2330	-2.1112	-3.2624	.00895	6
	17	.00214	.01475	.02119	.04285	-.19814	-1.0527	5.0033	-1.2566	-5.0133	-.18704	-1
	18	.02151	.02920	.00850	.04516	-.06953	.5231	2.7842	3.1375	-2.9297	-.06320	-
	19	-.45975	.30021	.27158	.27457	.30152	-32.3636	30.0642	25.0956	22.9204	.30489	-22
	20	-.14423	-.08597	.40255	.40744	.10514	-9.4575	-7.9346	40.6483	39.5475	.10428	-6
	21	-.02929	-.02290	-.01835	.47709	.02525	-1.8234	-1.9986	-2.1373	48.7684	.02474	-1
	22	.04529	.09633	.00662	.05861	-.20077	2.7958	11.7931	-3.5056	-6.2093	-.19433	1
	23	.00921	.00838	.00485	.04035	-.04128	.2489	1.2333	2.1793	-4.8322	-.03833	-
	24	-.11093	-.13451	.49673	.47074	-.17015	-7.3243	-14.0641	62.3892	57.9558	.16911	-5
	25	-.01320	-.01208	.00139	.48883	.01997	-.8588	-1.3001	-.4897	66.8707	.01947	-
	26	.00783	.01449	.03762	.02693	-.03137	.4422	1.7455	5.3074	-6.8761	-.03015	-
	27	-.00170	-.00525	-.01857	.50312	.00961	-.1129	-.6246	-2.4001	87.9191	.00934	-

MATRIX

8	9	10	11	12	13	14	15	16	17	18	19
-1.5645	-1.4760	-.06204	-.4268	.4079	-.0885	-.7006	-.00962	-.0584	.0968	.0066	-.2190
1.5681	-2.0620	-.01934	-.3929	-.0855	.2827	-.4742	-.00831	-.0838	.0668	.0375	-.1173
1.3873	1.5167	-.07140	-1.3956	-.5551	.4946	.7873	.00872	.0093	-.0979	.0713	.2675
5.2037	5.7056	-.03373	-1.5773	-.1593	.9780	1.9414	-.01757	-.2383	.0521	.0385	.2226
.7189	9.4853	-.00741	-.3517	2.1019	.2296	.9959	-.00481	-.0816	.0328	.0764	-.0931
.7843	-2.2065	-.15531	-2.2264	.0450	-.7200	-2.3536	-.08546	-.5448	.7299	-.1402	-1.2620
1.9554	-3.2260	-.04334	-.9567	1.5602	1.6903	-3.1193	-.02443	-.3416	.2713	.4238	-.9036
3.0362	3.0324	.02411	-10.1439	-4.3413	1.6668	1.8400	-.07769	-1.7039	-.0680	.6072	.9198
15.3162	12.9231	-.00400	-4.1841	-.6548	7.0846	6.9391	-.01874	-1.1310	-.2946	1.3117	2.2913
1.5982	20.8127	-.00072	-.7135	3.8609	-.7656	10.8319	-.00162	-.2352	-.1123	.2685	1.1833
.0299	-2.9603	-.23807	-.9766	.7386	-.5012	-3.5424	-.12368	-.9874	2.9875	-.8827	-3.2083
2.4032	-3.1524	-.05784	-.9350	8.2702	2.3490	-3.9494	-.02827	-.5680	.3612	1.8923	-3.7577
9.8616	8.9432	.07370	-15.4948	-7.7601	6.9115	5.9913	.10113	-6.5346	4.7920	3.7532	3.2040
23.2413	22.4716	.06939	-7.5571	-1.0664	16.3826	15.5449	.04851	-2.9693	-3.5849	8.7065	8.2339
3.0923	33.7823	.01157	-1.0627	-.9162	-1.4719	23.7700	.00680	-.4021	-.4137	-.6625	12.3614
2.1112	-3.2624	.00895	6.8208	4.6625	-2.3260	-3.6316	.04521	4.0069	-.7824	-2.4733	-3.6086
1.2566	-5.0133	-.18704	-1.9529	2.1552	-1.7081	-5.8542	-.14460	-.7492	4.0504	-2.1894	-6.1657
3.1375	-2.9297	-.06320	.0925	23.6756	2.9445	-3.8487	-.03913	-.1464	1.3622	2.6887	-4.6734
25.0956	22.9204	.30489	-22.4841	-6.1057	19.3224	17.0659	.31644	-11.3436	16.3597	12.8665	10.8638
10.6383	39.5475	.10428	-6.3683	-1.5129	32.0652	30.8124	.10150	-2.9447	-4.0546	22.4350	21.0065
2.1373	48.7684	.02474	-1.1971	9.7333	-1.7456	38.5147	.02136	-.5285	-.9566	-1.3046	26.9787
1.5056	-6.2098	-.19433	1.8491	1.0492	-3.6523	-7.4123	-.16765	.9847	7.2741	-3.7994	-8.4251
2.1793	-4.8322	-.03833	.0654	-11.2048	2.0748	-5.6818	-.02788	-.0460	.7978	1.9441	-6.5004
5.2802	57.9558	.16911	-5.4462	-1.0423	51.7303	47.8366	.16240	-2.8224	-7.9509	39.8085	36.1068
.4897	66.8707	.01947	-.5782	1.4353	-.5193	56.3814	.01773	-.2788	-.7449	-.5495	44.5254
5.3074	-6.8761	-.03015	.2791	-.5126	4.5065	-7.4447	-.02527	.1355	1.0623	3.6035	-8.0460
2.4001	87.9191	.00934	-.0771		-2.0047	77.1144	.00813	-.0456	-.3798	-1.5606	64.9180

REPT. No. 7/0510/1

SHT. No. 18

PREPARED BY A. Gornitsky

DATE 15 Mar. 1959

	15	16	17	18	19	20	21	22	23	24	25	
006	-.00962	-.0584	.0968	.0066	-.2190	.0238	-.0048	-.0695	-.0047	-.0251	-.0055	1
742	-.00831	-.0838	.0668	.0375	-.1173	.0198	.0019	-.0515	-.0031	-.0194	-.0045	2
872	.00872	.0093	-.0979	.0713	.2675	-.0097	.0086	.0633	.0032	.0165	.0032	3
941	-.01757	-.2383	.0521	.0385	.2226	.0102	.0050	-.0020	-.0019	-.0040	-.0017	4
959	-.00481	-.0816	.0328	.0764	-.0931	.0164	-.0001	-.0132	-.0016	-.0132	-.0030	5
536	-.08546	-.5448	.7299	-.1402	-1.2620	.1403	-.0450	-.1527	-.0299	-.1524	-.0334	6
123	-.02442	-.3416	.2713	.4238	-.9036	.1220	.0233	-.1644	-.0143	-.1168	-.0270	7
8400	-.07769	-1.7039	-.0680	.6072	.9198	-.0826	.1220	.3385	.0239	.0870	.0152	8
391	-.01874	-1.1310	-.2946	1.3117	2.2913	.0417	.0719	.2340	-.0063	-.0396	-.0159	9
319	-.00162	-.2352	-.1123	.2685	1.1832	.8076	-.4331	-1.9013	-.1722	-.7257	-.1573	10
5424	-.12368	-.9874	2.9875	-.8827	-3.2083	.2987	.1755	-1.2038	-.0146	-.3635	-.0928	11
9494	-.02827	-.5680	.3612	1.8923	-2.7577	.9542	1.2264	1.1921	.1168	.1797	-.0309	12
9913	.10113	-6.5346	4.7920	3.7532	3.2040	.0221	1.6897	2.6563	.1213	.2496	-.0270	13
5449	.04851	-2.9693	-3.5849	8.7065	8.2339	-.0049	.3844	1.3776	.0947	-.1328	-.0212	14
7700	.00680	-.4021	-.4137	-.6625	12.3614	-.9426	-2.0941	-2.8278	-1.0419	-1.4694	-.3794	15
316	.04521	4.0069	-.7824	-2.4733	-3.6086	2.4521	-2.1253	-4.8799	-.5764	-2.2892	-.4507	16
5542	-.14460	-.7492	4.0504	-2.1894	-6.1657	.4637	2.0193	-4.5439	.2759	-1.5505	-.3106	17
8487	-.03913	-.1464	1.3622	2.6887	-4.6734	7.6411	6.3311	5.3063	1.7559	1.6267	.2107	18
659	.31644	-11.3436	16.3597	12.8665	10.8638	-1.6695	11.7036	10.6159	1.3223	2.8110	.0202	19
3124	.10150	-2.9447	-4.0546	22.4350	21.0065	-.6724	13.8579	13.8579	.2606	1.3693	-.1209	20
147	.02136	-.5285	-.9566	-1.3046	26.9787	.3959	1.7999	-7.0686	1.3128	-6.0333	-1.1025	21
123	-.16755	.9847	7.2741	-3.7994	-8.4251	4.1755	-3.7915	-8.4789	-2.9246	-6.0735	-2.2410	22
818	-.02788	-.0460	.7978	1.9441	-6.5004	.3959	1.7999	-7.0686	1.3128	-6.0333	-1.1025	23
366	.16240	-2.8224	-7.9509	39.8085	36.4068	-4.2752	26.4081	23.5438	11.6060	10.2760	2.0674	24
814	.01773	-.2783	-.7449	+.5495	44.5254	-.3863	-.5895	31.1562	-.4542	15.8270	1.1978	25
447	-.02527	.1355	1.0623	3.6035	-8.0260	.5922	2.5939	-8.4848	1.5145	-8.5492	-6.3983	26
144	.00813	-.0456	-.3798	-1.5606	64.9180	-.2196	-1.0632	51.1017	-.5831	35.4970	16.9093	27

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0510/1

SHEET No. 19

AIRCRAFT:

PREPARED BY

DATE

R.N. Shearly

Mar. 11/54

CHECKED BY

DATE

1	S_1 psi
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a	Q_a lb or in lb
1	78250
2	238000
3	199900
4	42220
5	2788
6	967
7	5323
8	4372
9	2803
10	6690
11	590
12	516
13	548
14	2220
15	4897
16	670
17	678
18	742
19	2639
20	843
21	925
22	2928
23	1055
24	3106
25	2992

1	14122
2	437
3	18136
4	1040
5	18274
6	1170
7	12939
8	305
9	1093
10	1164
11	16194
12	421
13	20938
14	785
15	20472
16	534
17	13386
18	798
19	1765
20	1824
21	18112
22	230
23	24581
24	- 838
25	21429
26	21
27	13826
28	4648
29	3712
30	3040
31	40502
32	2761
33	21580
34	2080
35	20296
36	- 593
37	11926
38	8146
39	5841
40	4028
41	19229
42	- 553
43	11248
44	2597
45	10026
46	5068
47	2951
48	11316
49	453
50	4291
51	2309
52	3451
53	-22818
54	-19506
55	-10892
56	-3502

p	F_p in lb
1	- 4038
2	- 4209
3	10348
4	18792
5	21462
6	- 11875
7	- 9055
8	21415
9	65961
10	69891
11	- 857
12	- 9313
13	170403
14	180297
15	166204
16	- 39286
17	- 37929
18	436
19	531361
20	499844
21	320266
22	- 24978
23	- 57810
24	814239
25	577863
26	- 71162
27	897243

a	z_a in or rad.
1	.0537
2	.0501
3	.0478
4	.0463
5	- .0160
6	2.5552
7	2.6558
8	2.7420
9	2.8609
10	- .0155
11	1.5142
12	1.7012
13	1.8349
14	1.9732
15	- .0151
16	.6087
17	.8916
18	1.0672
19	1.2160
20	.3109
21	.5000
22	.6368
23	.1587
24	.2571
25	.0679

Note. S_1 for $i = 53, 54, 55$ and 56
are not for indiscriminate use
because of the assumption of un-
connected foundation beams.

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0510/1

SHEET NO. 15

AIRCRAFT:

PREPARED BY

DATE

R.N. Shearly

Mar/54

CHECKED BY

DATE

Results

The results are presented in the form of the following matrices:

- a
- F_p redundant moment unit load matrix
- S_{ia} stress unit load matrix
- S_i final stress distribution
- F_p redundant moments
- z_a deflection (rotation) at point a

and the following figures:

Fig. 13 showing for the applied load

Panel shear stress, τ_m

Foundation beam stress, σ_f

Sparwise axial stress, σ_n

Ribwise axial stress, σ_y^+

Fig. 14 showing the deflection for the applied load

Fig. 15 showing the value along the root rib of the normal stress perpendicular to the root rib and the shear stress tangential to the root rib.

The curves of Fig. 15 are computed as follows. The lumped sparwise and ribwise axial forces which act at a point on the root rib are resolved into forces normal and tangential to the root rib, these in turn are divided by the lumped area along the root rib to yield

$$\sigma_N^1 = \sigma_{na}^1 \left[\cos \theta_s \sin \alpha \cos \alpha + \sin \theta_s \cos^2 \alpha \right] + \sigma_y^+ \cos^2 \alpha$$

Prep. by R.N. Shearly

Mar. 11/54

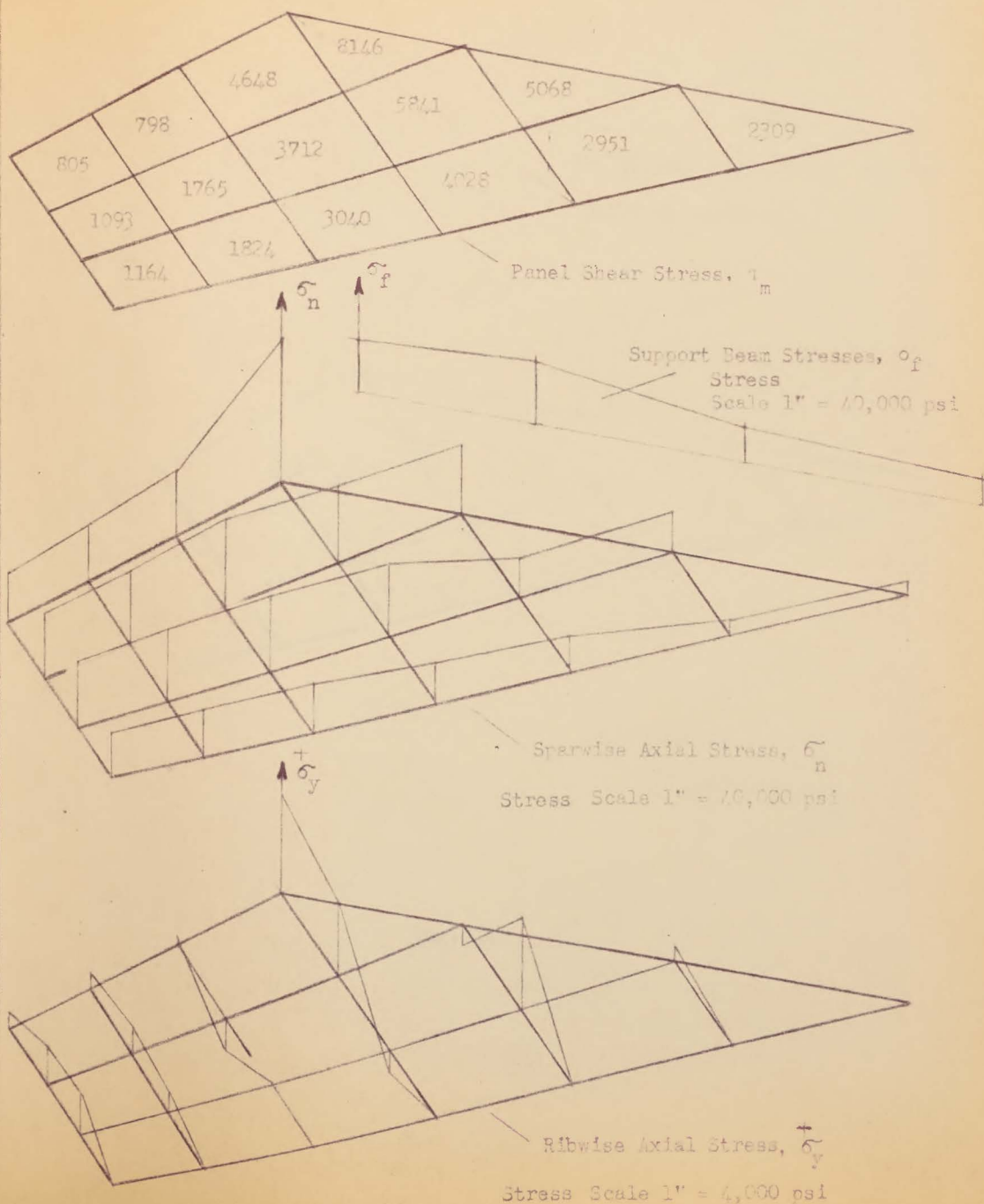


Fig. 13

Report No. 7/C510/1
Sheet No. 21

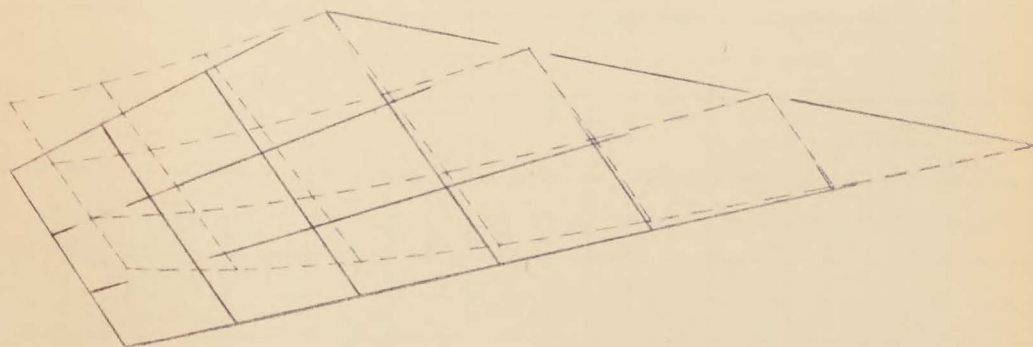
Prep. by R.F. Shearly

Mar. 31/54

Code

Undeformed Structure ————

Deflected Structure - - - - -



Deflection Scale:

1" = 6" defl.

Fig. 14

AIRCRAFT
A. U. W.

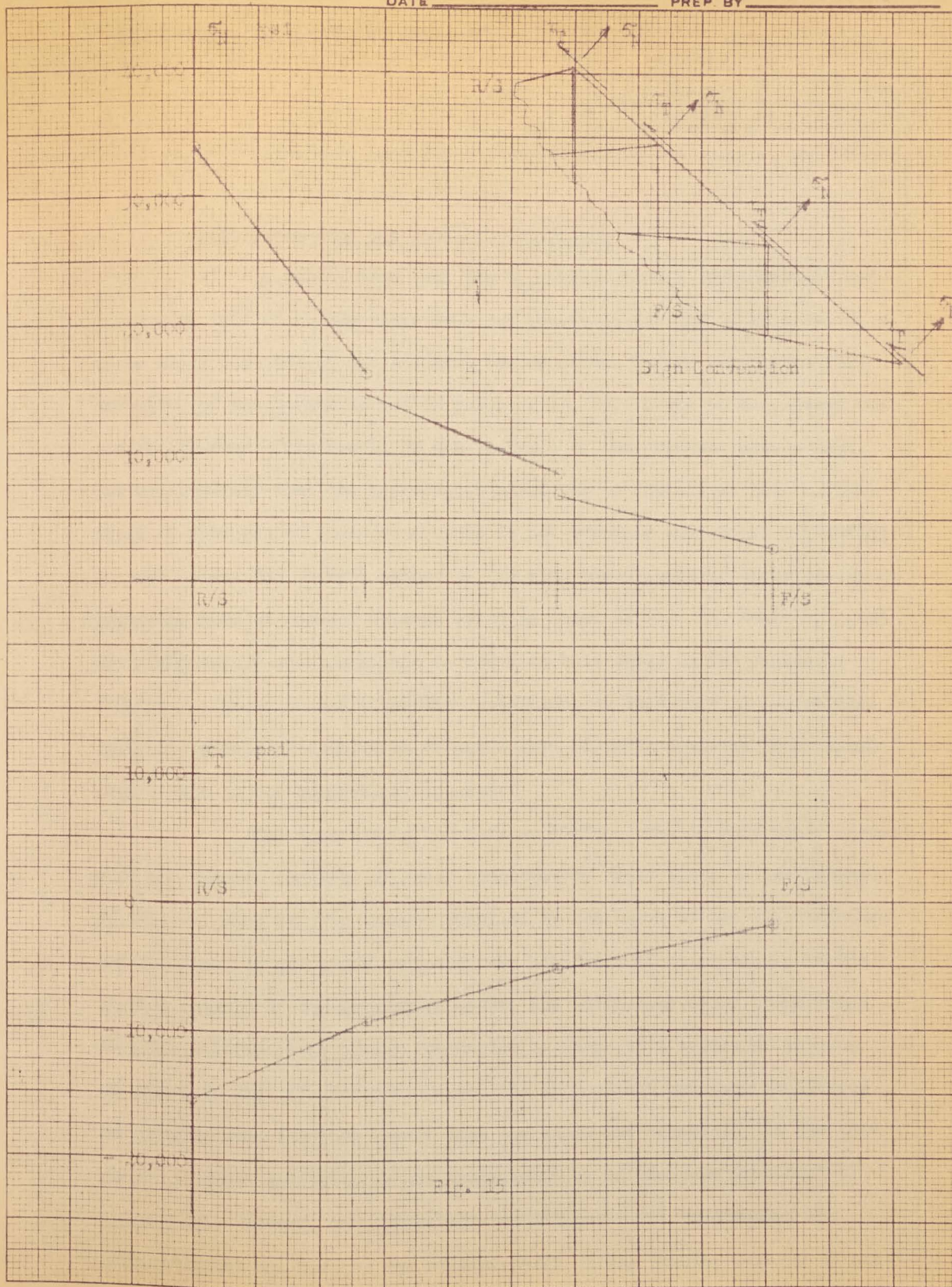
COMPONENT

SHEET No. 38

REPORT No. 70510/2

DATE Oct 27, 54

PREP BY A. J. S. 0012



39-12 KEUFFEL & ESSER CO.
10 - 10000 1/2 inch grid - 10000
10000 1/2 inch grid - 10000

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SHEET No. 23

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Note Concerning the Boundary Conditions

It can be seen from the S_{ia} matrix that a concentrated bending moment applied to the plate does not penetrate far and is absorbed in a quite short distance by the adjacent torque boxes. For an example the distribution of the normal stress in point 3, 13, 23, ... due to the moment (2) can be followed. This result of the analysis of the present paper points out conclusively that the representation of the conditions at the root by means of unconnected foundation beams is not accurate and can be misleading in some cases. The correct method of treating the supporting structure is in providing torsion members between beams as shown in Fig. 16. However, some new redundant quantities should be added in this case, as for instance torques T_i . Hence no exact boundary condition, as explained in report Gen/1090/329, should be considered unless a more rigorous analysis is extended over a part of the supporting structure.

The approximate boundary conditions used in this paper assumes that the support consists of beams connected by rigid links as can be seen in Fig. 17. Here bending moments supplied by the beams of the fin structure are not equal in all spots, and they are not intended to be equal, to the bending moments of the foundation beams, the difference being transferred from the stiffer parts of the foundation by means of a system of torques as quoted in Fig. 17. For that reason the approximate boundary conditions may produce even a better result than the exact one especially in the case where the exact condition is not accompanied by an adequate treatment of the support. However, the approximate condition is not recommended for indiscriminate use because the strain energy of the torsion members is not accounted for in it.

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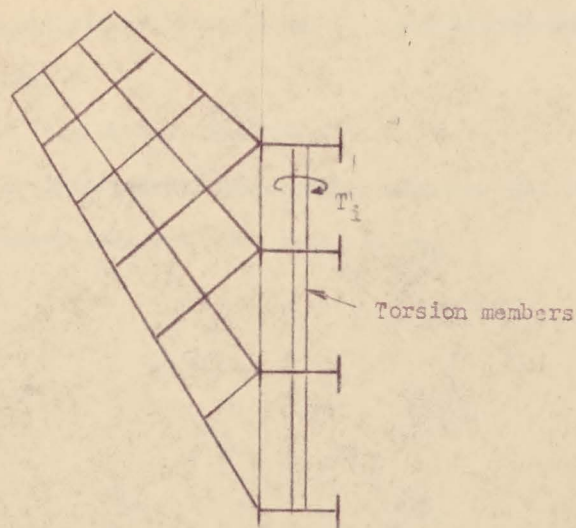


Fig. 16

Moments
supplied
by fin beams *

Moments in
foundation
beams *

Transferred
torque *

670,000

329,000

341,000

976,000

685,000

291,000

613,000

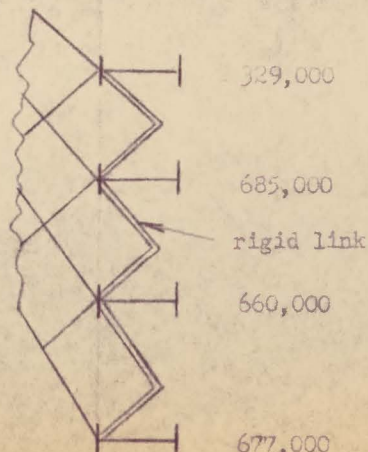
560,000

- 47,000

102,000

677,000

- 575,000



* For derivation
see original
computations

Fig. 17

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References

A.Grzedzielski, R.N.Shearly: Stress Analysis of Multi-Spar and Multi-Rib
Wing Structures, Parts 1 and 2, Gen/1090/329 and Gen/1090/
330 resp.

A.Grzedzielski: Unit Load Method, Gen/1090/331.

J.A.Chamberlin: Inter-Departmental Memorandum, Reference No. 8852/07/J.

..... Geometry Data C-105 Aircraft, F/Geom/32.

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DATE _____

A. COMINSKY

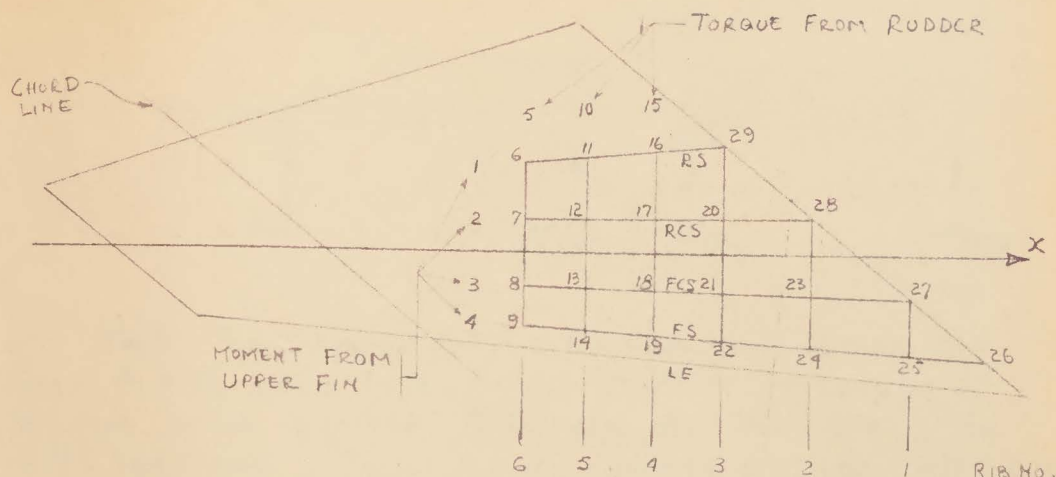
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APPENDIX LIMIT AIRLOADS AT SUBSONIC SPEEDS

INTRODUCTION



ABOVE DIAGRAM SHOWS NUMBERING SYSTEM FOR APPLIED LOADS.

THE AIRLOAD DISTRIBUTION WAS OBTAINED FROM INTER-DEPARTMENTAL MEMORANDUM NO. 8852 /07/J TO WHICH WAS ATTACHED SHEETS 4,7,50-54 OF REPORT NO. P/LOADS/43. UNFORTUNATELY, THE GRAPHS OF CHORDWISE LOADING DISTRIBUTION WERE GIVEN IN UNITS OF P.S.F. x CHORD WHERE THE CHORD DIRECTION WAS AS SHOWN ABOVE (PARALLEL TO FUSELAGE $\hat{L}$). THIS NECESSITATED THE CONVERSION OF THE CHORDWISE DISTRIBUTION TO A RIBWISE DISTRIBUTION WHICH WAS DONE GRAPHICALLY. THE RESULTS ARE GIVEN ON SHEET A-5.

ON SHEETS A-8 TO A-16, THE AIRLOADS ACTING DIRECTLY ON THE STRUCTURE BEING INVESTIGATED ARE DISTRIBUTED TO THE 4 SPARS AS THOUGH EACH SPAR ACTED AS A SIMPLE SUPPORT FOR THE RIBWISE LOADING. SEE DIAGRAM ON FOLLOWING SHEET.

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0510/1

SHEET No. A-2

AIRCRAFT:

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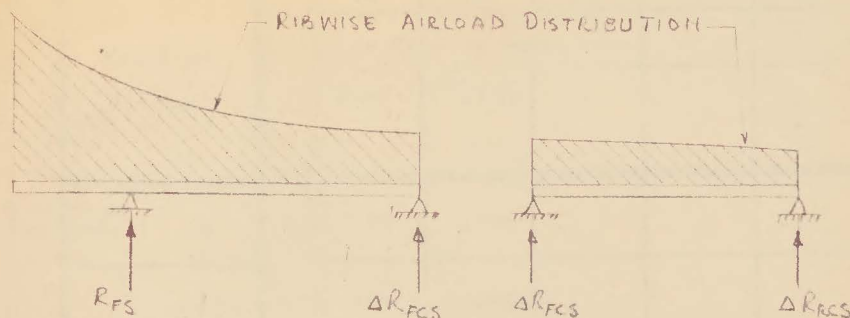
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THEN THE GRAPHS OF THE RUNNING SPAR LOADS ON SHEET No. A-16 WERE INTEGRATED SO THAT APPROPRIATE AIRLOADS WERE LUMPED TOGETHER AT THE RIB SPAR INTERSECTIONS. THESE VALUES APPEAR ON SHEETS A-17 & A-18

ON SHEETS A-19 TO A-30, THE AIRLOAD & ITS CENTRE OF GRAVITY IS CALCULATED FOR THE TIP PORTION OF THE FIN & RUDDER (TIP TO RIB 6).

SHEARS & TORQUES AT REAR SPAR BETWEEN RIBS 3 & 6 DUE TO RUDDER ARE CALCULATED ON SHEETS A-31 TO A-33

LUMPING OF LOADS & MOMENTS AT RIB 6 & REAR SPAR DUE TO LOADS CALCULATED ON SHEETS A-19 TO A-33 IS DONE ON SHEETS A-34 TO A-36

SUMMARY OF LIMIT LOADS AT SUBSONIC SPEEDS ON THE STRUCTURE UNDER CONSIDERATION APPEARS ON SHEET A-37

CHORDWISE LOADING IN LB./FT. OF SPAN

(LIMIT)

SUBSONIC SPEEDS

FRACTION OF CHORD	1	2	3	4	5	6	7	8
	0.75 FT.		3.75 FT.				6.75	
	TOP	BOT.	TOTAL	TOP	BOT.	TOTAL	TOP	BOT.
(L.E.) 0	5250	-8880	14,130	11,200	-6000	17,200	15,000	-5000
.0527	3960	-5000	8960	8300	-3200	11,500	3200	-2700
F/S .1053	3550	-2500	6050	6400	-1750	8150	6600	-1400
.2165	3800	-500	4300	4800	-520	5320	4300	-2000
TCS .3277	3900	250	3650	3900	-50	3950	3200	4000
.4264	3890	500	3390	3220	200	3020	2640	5000
RS .5250	3620	600	3020	2600	300	2300	2200	4000
.6125	3180	560	2620	2000	300	1700	1750	2000
(W) .7000	2560	320	2240	1420	130	1290	1200	-5000
.8	1680	-110	1790	640	-120	760	550	-3200
.9	500	-740	1240	-170	-480	310	-200	-6000
(T.E.) 1.0	-1400	-1400	0	-900	-900	0	-900	-9000
REFERENCE	SHT. 50 *	SHT. 50 *	①-②	SHT. 51 *	SHT. 51 *	④-⑤	SHT. 52 *	SHT. 53 *
*	REPORT No. P/LOADS/43							

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REPORT NO. 7/0510/1

SHEET NO. A-4

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CHORDWISE PRESSURE DISTRIBUTION

SPAN STATION FRACTION OF CHORD	.75 FT.	3.75 FT.	6.75 FT.	9.0 FT.	11.25 FT.
	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>	<i>ref.</i>
L.E.	782.3	1201.8	1893.6	2012.9	1620.4
	496.1	803.5	1126.7	1045.2	820.3
F/S	335.0	569.5	757.4	683.9	534.7
	238.1	371.7	426.1	412.9	303.8
FCS	202.1	276.0	265.1	309.7	245.1
RCS	167.2	160.7	170.4	254.2	251.2
R/S	124.0	90.1	118.3	197.4	216.7
T.E.	0	0	0	0	0
REF. SHT. A-3	COL. (8) 18.062	COL. (9) 14.312	COL. (9) 10.562	COL. (12) 7.750	COL. (15) 4.937

$C = 19.0 - 1.25 Z \quad \text{FT.}$

Z	$1.25 Z$	$19.0 - 1.25 Z$
.75	.9375	18.062
3.75	4.688	14.312
6.75	8.438	10.562
9.0	11.250	7.750
11.25	14.063	4.937

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REPORT No.

7/0510/1

SHEET No.

A-8

AIRCRAFT:

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A. COMMISSIONER

8 FEB, 54

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RIB LOADING AND SPAR REACTIONS

LE.	$\phi = -10^{\circ} 35\frac{1}{2}'$	tan $\phi = -.18699$
RLE.	$\phi = -9^{\circ} 37'$	" = -.16344
FS.	$\phi = -8^{\circ} 38\frac{1}{2}'$	" = -.15123
RFS.	$\phi = -6^{\circ} 6\frac{3}{4}'$	" = -.10703
FCS.	$\phi = -5^{\circ} 35'$	" = -.06262
RCS.	$\phi = 2^{\circ} 12'$	" = .03842
RS.	$\phi = 3^{\circ} 38\frac{1}{2}'$	" = .15123
TE.	$\phi = 23^{\circ} 23\frac{1}{2}'$	" = .43257

	1	2	3	4	5	6	7	8
" X" STATION		166.446	187.673	211.606	238.590	269.014	303.317	341.224
LE. Y = -.18699 X		-31.124	-35.093	-39.568	-44.614	-50.303	-56.717	-63.949
		2.321	3.234	3.713	4.187	4.721	5.323	6.002
RLE. Y = -.16344 X		-28.203	-31.725	-35.855	-40.427	-45.582	-51.334	-57.947
		2.907	3.276	3.625	4.166	4.697	5.236	5.371
FS. Y = -.15123 X		-25.226	-28.523	-32.160	-36.261	-40.885	-46.098	-51.976
		7.471	8.425	9.497	10.710	12.076	13.616	15.252
RFS. Y = -.10703 X		-17.825	-20.098	-22.661	-25.551	-28.809	-32.442	-36.624
		7.402	8.346	9.410	10.610	11.963	13.488	15.207
FCS. Y = -.06262 X		-10.422	-11.752	-13.251	-14.941	-16.846	-18.974	-21.417
		16.813	18.762	21.331	24.103	27.180	30.646	
RCS. Y = .03842 X		6.335	7.210	8.130	9.167	10.334	11.652	
		18.001	21.313	24.030	27.094	30.551		
RS. Y = .15123 X		35.226	38.523	42.160	46.261	50.885	56.098	61.976
		46.704	52.659	59.374				
TE. Y = .43257 X		72.000	81.182	91.534				

RIBWISE DISTANCES BETWEEN SPARS

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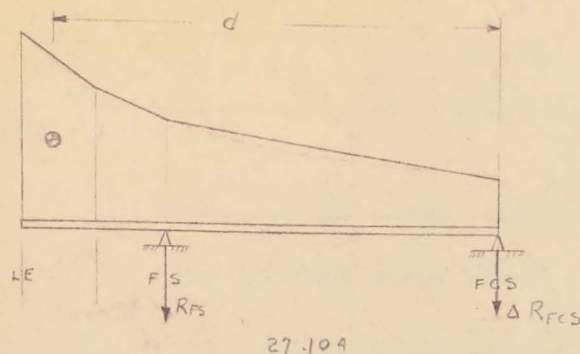
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25 JAN, 59

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RIB LOADING & SPAR REACTIONS



RIB # 1 (STA. 303.317)

1	2	3	4	5	6	7	8	9
LOCATION	ΔC IN.	AIR PRESSURE PSI.	RATIO	C.G.	AVERAGE PRESSURE PSI.	Δ LOAD LB./IN.	d	MOMENT ABOUT FCS
LE		360			5.490			
	5.323	620	1.55	.5359 ΔC	115.700	29.223	35.253	
RILE		615			3.520			
	5.296	400	1.54	.5354 ΔC	73.000	18.642	29.939	
F.S.		400			2.220			
	13.616	240	1.67	.5418 ΔC	46.050	30.228	20.865	
RFS		245			1.421			
	13.488	165	1.48	.5322 ΔC	29.500	19.166	7.178	
FCS								

SHT. A-B SHT. A-6*

③_a
③_b

③ + ⑥

⑦ + ⑧

TOTAL LOAD = 97.259 LB./IN.

TOTAL MOMENT ABOUT FCS = 2356.6 IN. LB./IN.

$R_{Fs} = \frac{2356.6}{27.104} = 86.95$ LB./IN.

$\Delta R_{FCS} = 97.259 - 86.95 = 10.309$ LB./IN.

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RIB LOADING & SPAR REACTIONS

1	2	3	4	5	6	7	8	9
LOCATION	ΔC	AIR PRESSURE psi.	RATIO	C.G.	AVERAGE PRESSURE psi.	Δ LOAD LB./IN.	d	MOMENT ABOUT FCS
RIB #2 (STA. 269.014)								
LE.		1215						
	4.721	770	1.579	.5374 ΔC	6.895	32.551	31.273	
R. LE		780						
	4.697	520	1.500	.5333 ΔC	4.510	21.183	26.544	
F. S.		515						
	12.076	310	1.660	.5413 ΔC	2.860	34.537	18.500	
R. F. S.		330						
	11.963	240	1.375	.5261 ΔC	1.977	23.651	6.294	
F. C. S.		240						
	15.379	200	1.200	.5151 ΔC	1.529	23.514	23.189	
M. C. S.		200						
	15.267	170	1.176	.5135 ΔC	1.285	19.618	7.840	
R. C. S.								
					TOTAL =	43.132	TAL =	699.1

SHT. A-B

$$R_{FS} = \frac{2368.0}{24.039} = 98.507 \text{ LB./IN.}$$

$$\Delta R_{FCS} = 111.922 - 98.507 = 13.415 \text{ LB./IN.}$$

$$\Delta R_{FCS} = \frac{699.1}{30.646} = 22.812 \text{ LB./IN.}$$

$$\Delta R_{RCS} = 43.132 - 22.812 = 20.320 \text{ LB./IN.}$$

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REPORT No. 7/0510/1
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RIB LOADING & SPAR REACTIONS

RIB # 4 (STA. 211.606)

1	2	3	4	5	6	7	8	9
LOCATION	ΔC	AIR PRESSURE psf.	RATIO	C.G.	AVERAGE PRESSURE psf.	Δ LOAD lb./in.	d	MOMENT ABOUT FCS
L.E.	3.713	1760 } 1030 }	1.709	.5436 ΔC	5.695 201,000	35.998	23.983	
R.L.E.	3.695	1064 } 700 }	1.520	.5343 ΔC	6.120 127,000	22.613	20.883	
F.S.	9.499	695 } 388 }	1.790	.5473 ΔC	3.760 78,000	35.716	14.609	
R.F.S.	9.410	410 } 280 }	1.465	.5315 ΔC	2.398 49,900	22.565	5.001	
F.C.S.					TOTAL =	116.892	TOTAL =	1970.2
F.C.S.	10.691	280 } 203 }	1.380	.5267 ΔC	1.679 34,800	17.950	16.321	
M.C.S.	10.690	203 } 160 }	1.269	.5198 ΔC	1.260 26,150	13.469	5.557	
R.C.S.					TOTAL =	31.419	TOTAL =	367.8
R.C.S.	24.030	160 } 110 }	1.455	.5310 ΔC	.923 19,450	22.540	12.760	287.6
R.S.					TOTAL =	22.540	TOTAL =	287.6

$$R_{FS} = \frac{1970.2}{18.909} = 104.194 \text{ LB./IN.}$$

$$\Delta R_{FCS} = 116.892 - 104.194 = 12.698 \text{ LB./IN.}$$

$$\Delta R_{FCS} = \frac{367.8}{21.381} = 17.202 \text{ LB./IN.}$$

$$\Delta R_{RCS} = 31.419 - 17.202 = 14.217 \text{ LB./IN.}$$

$$\Delta R_{RES} = \frac{287.6}{24.030} = 11.968 \text{ LB./IN.}$$

$$\Delta R_{RS} = 22.540 - 11.968 = 10.572 \text{ LB./IN.}$$

AIRCRAFT
A. U. W.

COMPONENT

SHEET No.

A-16

REPORT No.

7105-11

DATE

9 Feb. 54

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A. COMINSKY

SPAR REACTIONS - POUNDS PER INCH SPAN

REF. SAT. A-E

RIB NO.

5

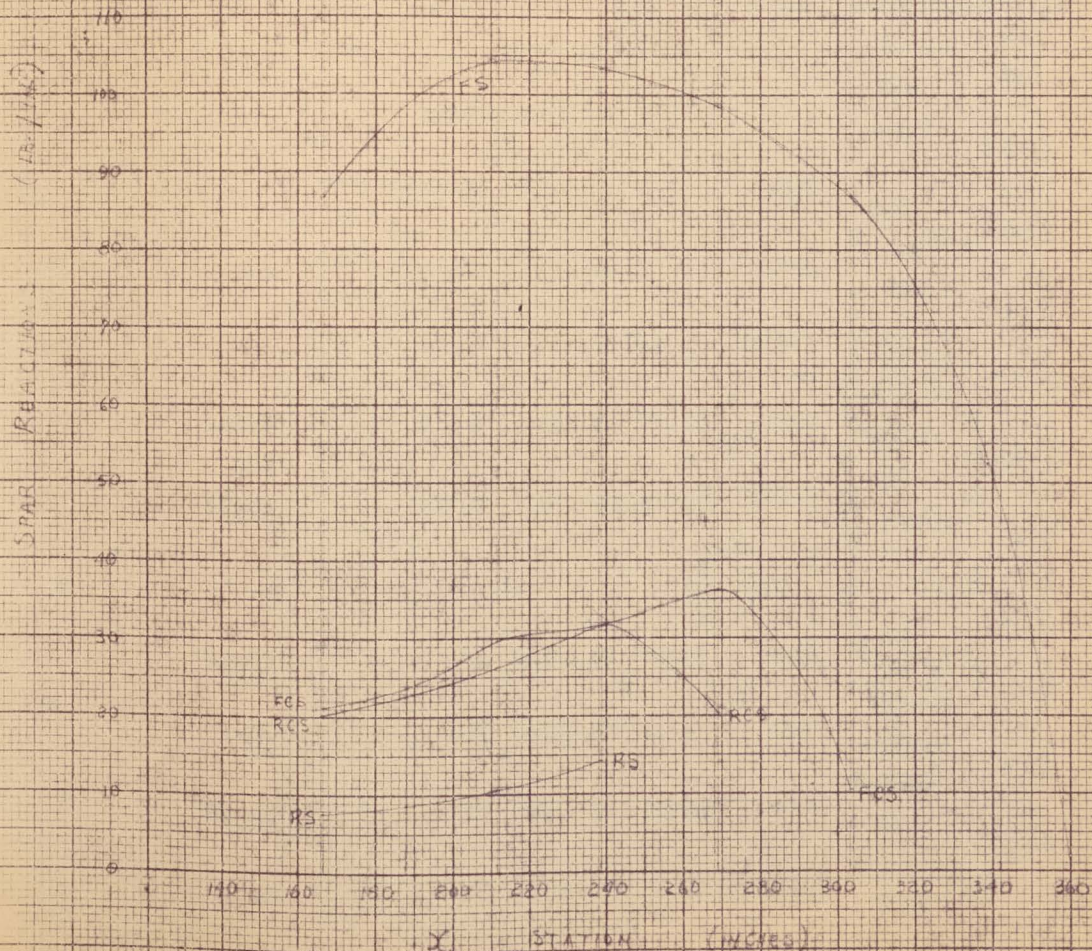
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12

1

SPAR REACTIONS (LB/INCH)



A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0510/1

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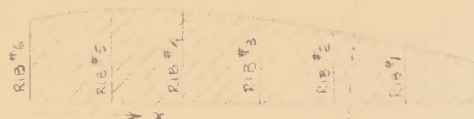
9 FEB. 44

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DATE

LOADS AT RIB - SPAR INTERSECTIONS

POUNDS
PER INCH
SPAN



	1	2	3	4	5	6	7	8	9
SPAR	X STATION IN.	ΔX IN.	SPAR REACTION LB./IN.	RATIO	G.G.	AVG. SPAR REACTION LB./IN.	Δ LOAD LB.	Δ RIB LD. LB.	TOTAL RIB LOAD LB.
FRONT SPAR	166.446		87.3					368	368
		21.227	93.0	1.134	.4895 ΔX	93.15	1277	1009	
	187.673		99.3					1211	2220
		23.933	104.3	1.056	.4955 ΔX	102.1	2444	1233	
	211.606		104.5					1406	2639
		26.984	103.6	1.003	.4993 ΔX	104.05	2805	1402	
	238.590		93.7	1.106	.4915 ΔX	98.65	3001	1526	2928
		30.424	87.3					1475	3106
END. CENTLE SPAR	267.014		87.0	1.134	.4895 ΔX	93.15	3135	1631	
		34.303	47.5	1.832	.4510 ΔX	67.25	2601	1564	2992
	303.317							1423	
		35.677						1173	1173
	341.974								
	166.446		21.0	1.124	.4902 ΔX	22.3	473	232	232
		21.227	23.6					291	
END. CENTLE SPAR	187.673		23.6	1.254	.4813 ΔX	26.6	637	307	548
		23.933	29.6					330	
	211.606		30.0	1.057	.4954 ΔX	30.05	832	412	792
		26.984	31.7					420	
	238.590		31.7	1.142	.4889 ΔX	33.95	1033	505	925
		30.424	36.2					528	
	267.014		39.3	2.869	.4202 ΔX	26.5	909	527	1055
		34.303	13.7					382	
	303.317								382
REF.			SHT. A-16				(2) × (2)	(5) × (2)	

AIRCRAFT
A U. W.

COMPONENT

SHEET No. A-21

REPORT No. 712510/1

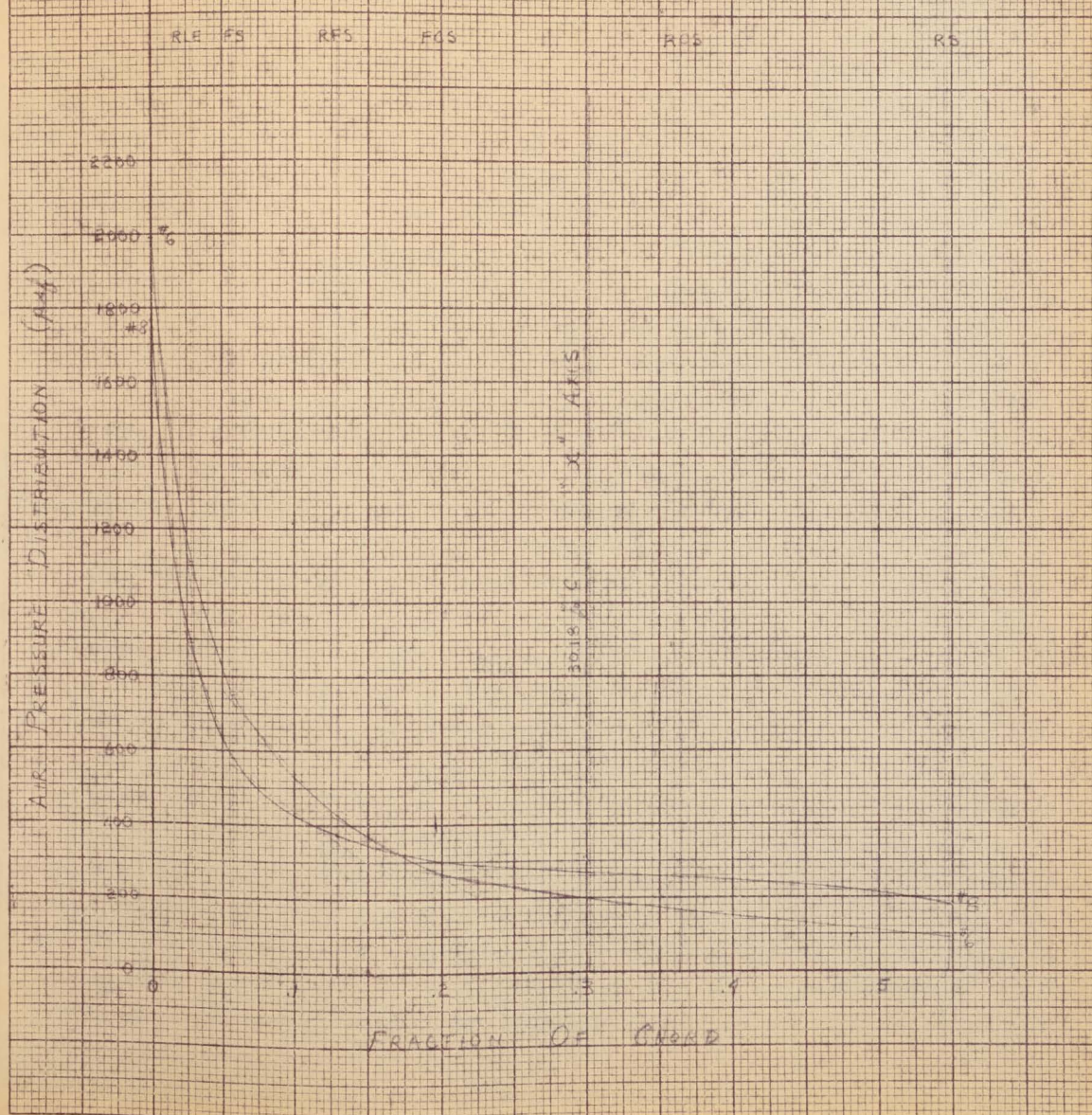
DATE 10 Feb 1959

PREP. BY J. G. Murphy

LIMIT R.E. WISE AIR PRESSURE DISTRIBUTION

SUBSONIC CASE

REF. See A-20



AIRCRAFT
A. U. W.

COMPONENT

SHEET No. A-22

REPORT No. 7/0510/1

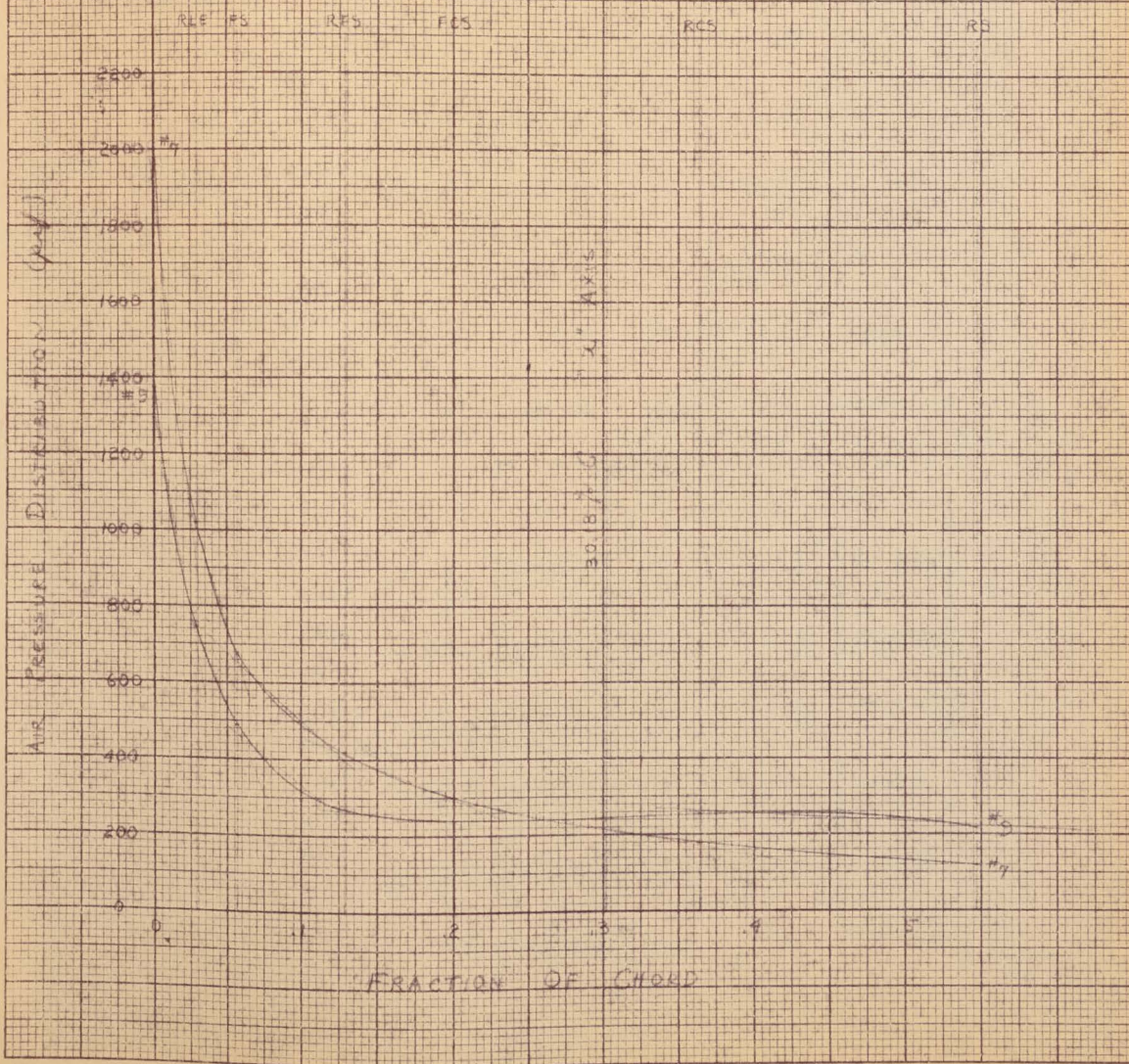
DATE 10 Feb 1954

PREP BY A G. G. G. G.

LIMIT REVERSE AIR PRESSURE DISTRIBUTION

SONOMIC CASE

REF. 541 A-20



A. V. ROE CANADA LIMITED
MALTON - ONTARIO

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REPORT NO. 7/0510/11

SHEET NO. A-24

AIRCRAFT:

PREPARED BY

DATE

A. COMINSKY

10 FEB. 54

CHECKED BY

DATE

AIRLOAD FROM STA. 166.446 To TIP - RIB LOADING C.G.

1	2	3	4	5	6	7	8	9
LOCATION	Δ C	A.P. PRESSURE	RATIO	C.G.	AVERAGE PRESSURE	Δ LOAD	DISTANCE FROM X AXIS	MOM. ABOUT X AXIS
IN.	IN.	PSI			PSI	LB./IN.	IN.	IN.-LB./IN.
REL.	SHT A-19	SHT A-21	③A/③B		①A + ②A 27.144	③ x ⑥	IN.	③ x ⑧
RIB No. 1								
LE	1.568	1640 } 800 }	2.050	.5574 ΔC	3.46	15.80	13.077	
RLE	1.858	865 } 570 }	1.518	.5342 ΔC	4.38	9.25	17.171	
FS	4.278	560 } 255 }	1.577	.5392 ΔC	3.18	15.19	13.967	
RFS	4.734	375 } 300 }	1.250	.5185 ΔC	2.34	11.03	9.121	
FCS	10.256	300 } 255 }	1.176	.5135 ΔC	1.73	23.76	1.433	
RCS	12.088	262 } 130 }	1.409	.5281 ΔC	1.56	18.85	-2.754	
RS					TOTAL =	90.34	TOTAL =	612.5 IN.-LB./IN.
RIB No. 2								
LE	1.330	1320 } 695 }	1.839	.5518 ΔC	7.00	9.31	13.550	
RLE	1.324	740 } 480 }	1.542	.5354 ΔC	4.24	5.61	12.231	
FS	3.103	465 } 240 }	1.338	.5533 ΔC	3.95	8.34	10.902	
RFS	3.372	265 } 235 }	1.128	.5100 ΔC	1.74	5.87	6.465	
FCS	2.660	240 } 255 }	1.063	.5050 ΔC	1.22	13.15	.955	
RCS	8.609	263 } 225 }	1.169	.5120 ΔC	1.69	14.55	-7.106	
RS					TOTAL =	56.35	TOTAL =	230.6 IN.-LB./IN.

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO.

7/2510/1

SHEET NO.

A-25

AIRCRAFT:

PREPARED BY

DATE

A. COMINSKY

10 Feb, 59

CHECKED BY

DATE

AIRLOAD FROM STA. 106.456 TO TIP - L/R LEADING ED.

RIB NO. 10

BETWEEN RIBS # 3 & # 11, FWD. RUDDER GOES FROM FULL CHORD TO ZERO CHORD LENGTH.

$$\begin{aligned} \text{TOTAL LENGTH OF CHORD \# 3} &= 19.176 + 32.785 \quad (\text{SH. A-12}) \\ &= 46.971 \text{ IN.} \end{aligned}$$

$$\begin{aligned} \therefore \text{LENGTH OF RIB \# 10} &= \frac{46.971}{79.814 - 39.260} \quad (57.814 - 39.260) \\ &= \frac{46.971}{36.554} \times 13.554 = 23.812 \text{ IN.} \end{aligned}$$

$$\begin{aligned} \text{LENGTH OF THEORETICAL 100\% CHORD C \# 0} &= 10.811 + 25.009 \quad (\text{SH. A-12}) \\ &= 35.820 \text{ IN.} \end{aligned}$$

$$\begin{aligned} \therefore \text{FWD EDGE RIB \# 10 IS AT} & \frac{35.820 - 43.892}{35.820} \times 100 \\ &= 33.44 \% \text{ C} \end{aligned}$$

$$\begin{aligned} \text{AIR PRESS. AT FWD EDGE} &= 250 \text{ M.Y.} \quad (\text{SH. A-22}) \\ \text{" " " R.S.} &= 220 \text{ M.Y.} \quad (\text{ " " }) \end{aligned}$$

$$\begin{aligned} \therefore \Delta \text{AIR LOAD} &= \frac{1}{2} (250 + 220) \times \frac{1}{144} \times 7.620 \\ &= 12.97 \text{ LB./IN. SPAN} \end{aligned}$$

$$\text{RATIO } \frac{250}{220} = 1.04$$

$$\therefore \text{C.G. IS AT } .5032 \Delta \text{C}$$

$$\begin{aligned} \text{DISTANCE FROM C.G. TO X AXIS} &= - \left[8.787 - .5032 \times 7.620 \right] \\ &= - \left[8.787 - 3.840 \right] = - 4.947 \text{ IN.} \end{aligned}$$

$$\begin{aligned} \therefore \text{MOM. ABOUT 'X' AXIS} &= - 4.947 \times 12.97 \\ &= - 64.20 \text{ IN. LB./IN.} \end{aligned}$$

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0510/1

SHEET No. A-26

AIRCRAFT:

PREPARED BY

DATE

A. COMINSKY

2 FEB. 54

CHECKED BY

DATE

RIB LOADING BETWEEN REAR SPAR & TRAILING EDGE

IT WILL BE ASSUMED THAT THE RIBWISE AIR PRESSURE DISTRIBUTION AFT OF THE REAR SPAR IS TRIANGULAR.

RIB No. 6

AIR PRESSURE AT REAR SPAR = 92 *psf.* (SHT. A-21)

" " " T. E. = 0

AVERAGE AIR PRESSURE = $\frac{1}{2} \times 92 \times \frac{1}{1.44} = .3195$ *psi.*

Δ AIR LOAD = $.3195 \times 46.704 = 14.90$ *LB./IN.* (SHT. A-19)

C.G. DISTANCE FROM "X" AXIS = $-(25.296 + \frac{1}{3} \times 46.704)$ (SHT. A-19)
= - 40.864 *IN.*

MOM. ABOUT "X" AXIS = $- 40.864 \times 14.90$
= - 609.0 *IN.LB./IN.*

RIB No. 7

AIR PRESSURE AT R.S. = 120 *psf.* (SHT. A-22)

AVERAGE AIR PRESSURE = $\frac{1}{2} \times 120 \times \frac{1}{1.44} = .4165$ *psi.*

Δ AIR LOAD = $.4165 \times 38.285 = 15.92$ *LB./IN.* (SHT. A-19)

MOM. ABOUT "X" AXIS = $- 15.92 \times 33.499$ (" ")
= - 533.6 *IN.LB./IN.*

RIB No. 8

AIR PRESSURE AT R.S. = 180 *psf.* (SHT. A-18)

AVERAGE AIR PRESSURE = $\frac{1}{2} \times 186 \times \frac{1}{1.44} = .625$ *psi.*

Δ AIR LOAD = $.625 \times 29.867 = 18.69$ *LB./IN.* (SHT. A-19)

MOM. ABOUT "X" AXIS = $- 18.69 \times 26.134$ (" ")
= - 488.0 *IN.LB./IN.*

RIB No. 9

AIR PRESSURE AT R.S. = 215 *psf.* (SHT. A-18)

AVERAGE AIR PRESSURE = $\frac{1}{2} \times 215 \times \frac{1}{1.44} = .746$ *psi.*

Δ AIR LOAD = $.746 \times 21.273 = 15.88$ *LB./IN.* (SHT. A-19)

MOMENT ABOUT "X" AXIS = $- 15.88 \times 18.613$ (" ")
= - 295.6 *IN.LB./IN.*

A. V. ROE CANADA LIMITED
MALTON, ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0510/1

SHEET NO. A-27

AIRCRAFT:

PREPARED BY

DATE

A. COMINSKY

10 FEB, 54

CHECKED BY

DATE

RIB LOADING BETWEEN REAR SPAR & TRAILING EDGE

RIB NO. 10

AIR PRESSURE AT R.S. = 220 $\frac{\text{lb}}{\text{sq. ft.}}$ (SHT A-20)

AVERAGE AIR PRESSURE = $\frac{1}{2} \times 220 \times \frac{1}{1.44} = 76.5 \frac{\text{lb}}{\text{sq. in.}}$

DISTANCE FROM R.S. TO T.E. = 16.222 IN. (SHT. A-19)

Δ AIR LOAD = $16.222 \times 76.5 = 1240 \text{ LB. / IN.}$

CG. DISTANCE FROM "X" AXIS = $8.787 + \frac{1}{2} \times 16.222$ (SHT. A-19)
= -14.194 IN.

MOM. ABOUT "X" AXIS = -14.194×1240
= -1760 IN. LB. / IN.

SUMMARY

RIB	TOTAL LOAD $\frac{\text{LB.}}{\text{IN.}}$	TOTAL MOMENT ABOUT "X" AXIS $\frac{\text{IN. LB.}}{\text{IN.}}$
6	$137.15 + 14.90 = 152.05$	$2102.3 - 609.0 = 1493.3$
7	$112.41 + 15.92 = 128.33$	$1235.6 - 533.6 = 702.0$
8	$90.94 + 18.63 = 109.57$	$618.5 - 485.0 = 133.5$
9	$56.86 + 15.88 = 72.74$	$225.6 - 295.6 = -70.0$
10	$12.97 + 12.40 = 25.37$	$-64.2 - 176.0 = -240.2$
11	0	0

REF. SHTS. A-23, A-24, A-25 & A-26

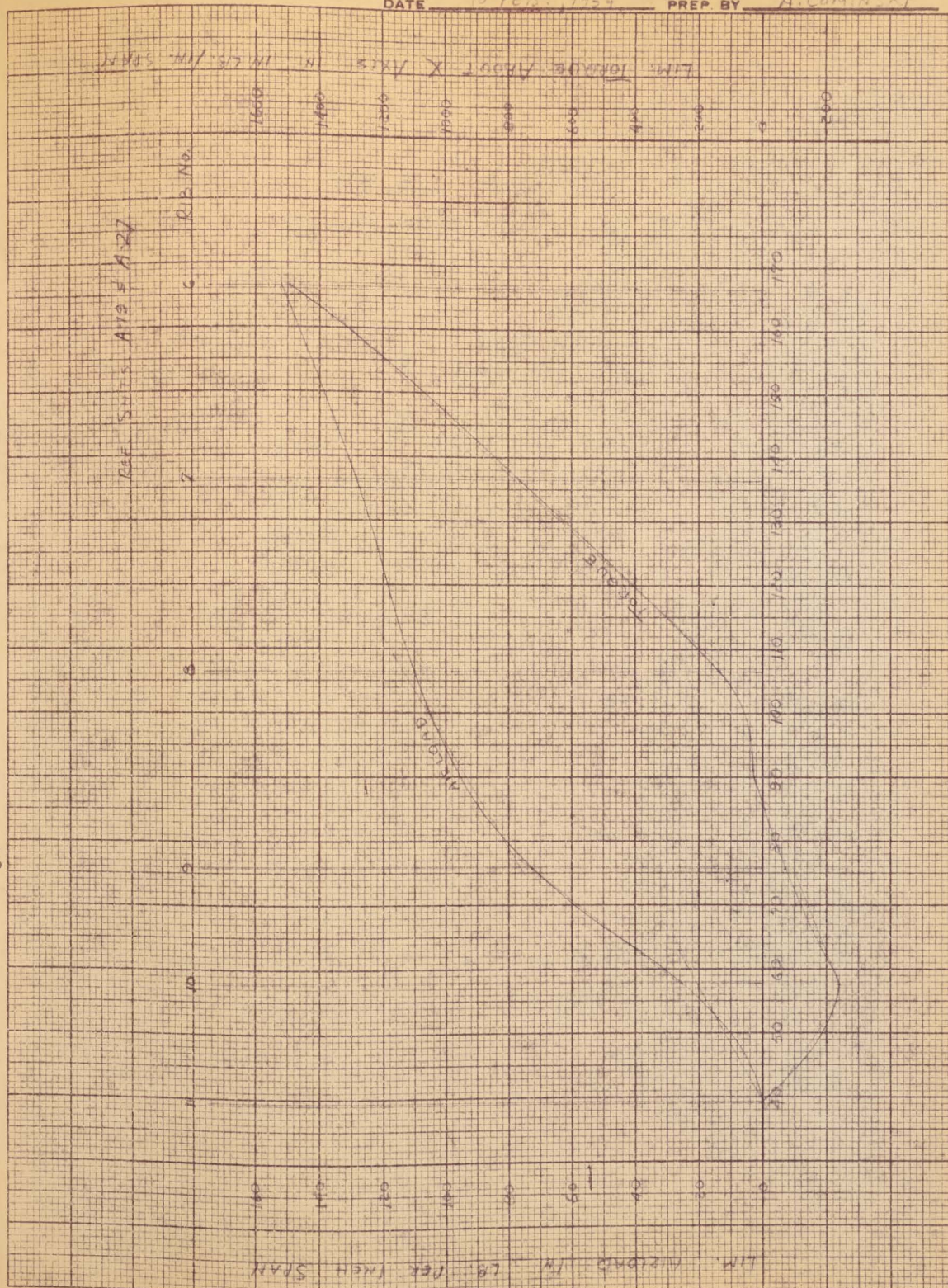
COMPONENT

SHEET No. A-28

REPORT No. 7/DS10/1

DATE 10 FEB. 1959

PREP. BY A. CAMINSKY



FORM 1748

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0510/1

SHEET NO. A-29

AIRCRAFT:

PREPARED BY

DATE

A. COMINSKY

10 FEB, 59

CHECKED BY

DATE

AIRLOADS FROM STA. 106.446 TO TIP

LIMIT AIRLOAD SHEARS, BENDING MOMENTS & TORQUES

1	2	3	4	5	6	7	8
STATION IN X' AXIS	ΔX	AIRLOADING LB./IN.	AIRLOAD LB.	SHEAR LB.	SHEAR LB.	Δ B.M. IN. LB.	P.M. IN. LB.
33.26	18.55	0	193	0	0	1720	
57.81	15.00	20.0	831	113	133	2900	1730
75.81	30.64	73.0	2311	1084	1000	75,650	11,670
106.45	30.00	76.0	3523	3925	1020	172,050	253,420
136.45	30.00	114.0	4208	7573	3920	220,790	550,120
166.45	30.00	128.5		11,781	7500		
		152.0			7600		
REF		SHT A-28	② × ③	Σ ④	SHT. 25	② × ⑥	Σ ⑦

TOTAL LIMIT AIRLOAD TORQUE

$$= \sum (TQ. \text{ PER INCH}) \Delta X \quad (\text{GRAPH SHT A-28})$$

$$= (57.81 - 33.26) \left(\frac{-12 - 222}{2} \right) + (75.81 - 57.81) \left(\frac{-240 - 100}{2} \right) \\ + (166.45 - 106.45) \left(\frac{140 + 1455}{2} \right)$$

$$= -13.55 \times 142 - 18.00 \times 170 + 60 \times 782.5$$

$$= -2640 - 3060 + 47000 = 41,300 \text{ IN. LB.}$$

AIRCRAFT
A. U. W.

COMPONENT

SHEET NO.

A-30

REPORT NO.

710510/1

DATE

3 Feb. 54

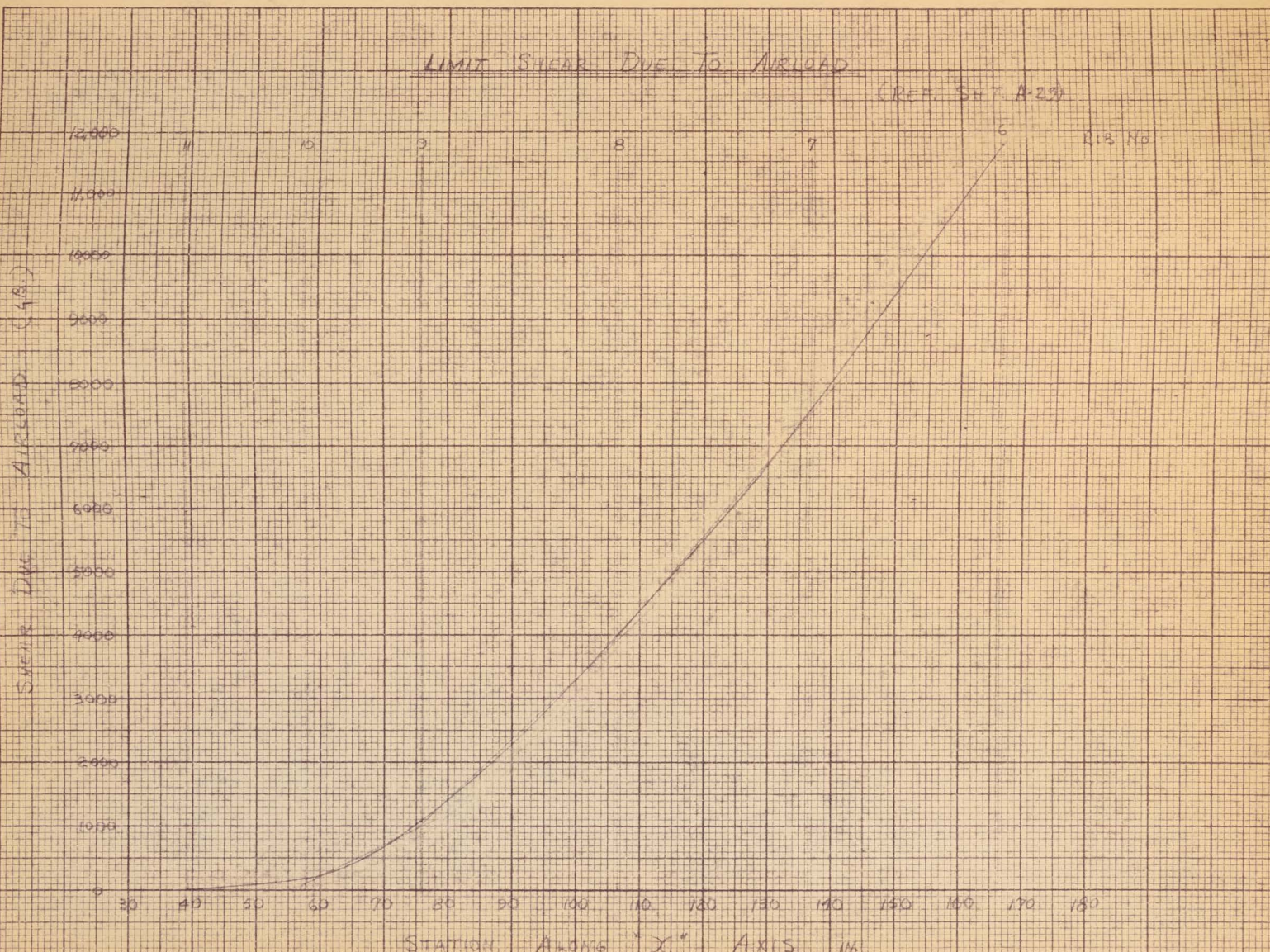
PREP. BY

A. G. HINSKY

LIMIT SHEAR DUE TO AIRLOAD

(REF. SHEET A-29)

Rib No



A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0510/1

SHEET NO. A-31

AIRCRAFT:

PREPARED BY

DATE

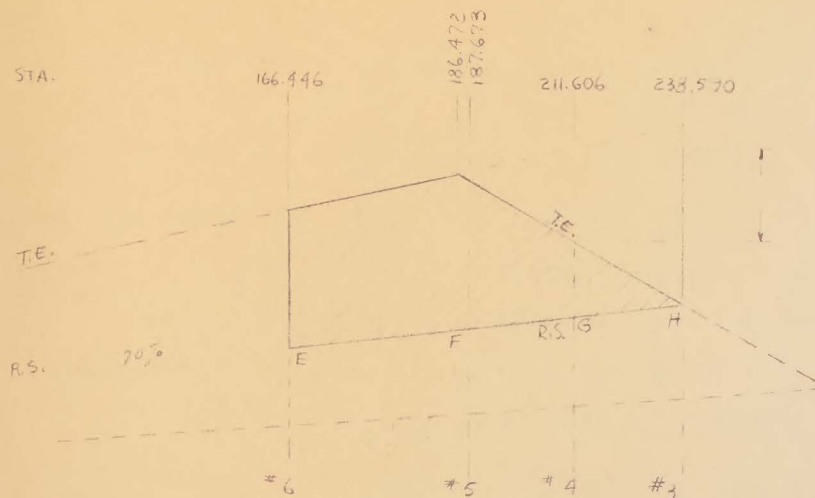
A. GOMINSKY

8 FEB. 54

CHECKED BY

DATE

LIMIT TORQUES & SHEARS DUE TO T.E. PORTION BETWEEN #3 & #6



RIB No. 6

Δ AIR LOAD = 14.90 LB./IN. (SHT. A26)

RIBWISE AIR PRESSURE DISTRIBUTION AFT OF
REAR SPAR IS ASSUMED TO BE TRIANGULAR.

$\therefore$ TORQUE ABOUT R.S. = $14.90 \times \frac{1}{3} \times 46.709$ (SHT. A19)
= 232.0 IN. LB./IN.

RIB No. 5

AIR PRESSURE AT R.S. = 95 psf. (SHT. A5)

" " " T.E. = 0

AVERAGE AIR PRESSURE = $\frac{1}{2} \times 95 \times \frac{1}{144} = .330$ psf.

Δ AIRLOAD = .330 $\times$ 52.659 (SHT. A-8)
= 17.39 LB./IN.

TORQUE ABOUT R.S. = $17.39 \times \frac{1}{3} \times 52.659$
= 305.2 IN. LB./IN.

TECHNICAL DEPARTMENT (Aircraft)

SHEET NO. A-32

DATE _____

10 FEB. 54

DATE _____

RATIO $\frac{110}{58.5} = 1.88$

Δ AIR LOAD = 0

Torque about R.S. = 0

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0510/1

SHEET NO. A-35

AIRCRAFT:

PREPARED BY

DATE

A. COMINLEY

3 FEB., 54

CHECKED BY

DATE

LOADS AT RIB-SPAR INTERSECTIONS AT RIB #6

REAR CENTRE SPAR

$$A = (8.409 \times .185 + 9.451 \times .200) \cos 2^\circ 12' = 3.440 \text{ IN.}$$

$$h = 1.906 \text{ IN.}$$

$$I = \frac{3.440}{2} (1.906)^2 = 6.250 \text{ IN.}^4$$

REAR SPAR

$$A = 9.451 \times .200 \times \cos 8^\circ 35' 12'' = 1.870 \text{ IN.}$$

$$h = 1.483 \text{ IN.}$$

$$I = \frac{1.870}{2} (1.483)^2 = 2.058 \text{ IN.}^4$$

$$\Sigma I = 1.056 + 5.080 + 6.250 + 2.058 = 14.444 \text{ IN.}^4$$

DISTRIBUTION OF AIRLOAD B.M. @ RIB #6

$$M_A = 550,120 \times \frac{2.058}{14.444} \times \frac{1}{.98865} = 78,250 \text{ IN. LB.}$$

$$M_B = 550,120 \times \frac{6.250}{14.444} \times \frac{1}{.99926} = 238,000 \text{ IN. LB.}$$

$$M_C = 550,120 \times \frac{5.080}{14.444} \times \frac{1}{.99805} = 193,900 \text{ IN. LB.}$$

$$M_D = 550,120 \times \frac{1.056}{14.444} \times \frac{1}{.98865} = 42,220 \text{ IN. LB.}$$

$$Q_A = \frac{78,250}{46.70} \times .98865 = 1657 \text{ LB.}$$

$$Q_B = \frac{238,000}{46.70} \times .99926 = 5100 \text{ LB.}$$

$$Q_C = \frac{193,900}{46.70} \times .99805 = 4140 \text{ LB.}$$

$$Q_D = \frac{42,220}{46.70} \times .98865 = 894 \text{ LB.}$$

$$\begin{aligned} \text{NET } T_0 @ \text{ RIB \#6} &= 41,300 - 78,250 \times .15138 - 238,000 \times .038416 \\ &\quad + 193,900 \times .062623 + 42,220 \times .15128 \\ &\quad + 1657 \times 25.296 + 5100 \times 6.395 \\ &\quad - 4140 \times 10.423 - 894 \times 25.296 \\ &= 47,568 \text{ IN. LB.} \end{aligned}$$

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0510/1

SHEET NO. A-36

AIRCRAFT:

PREPARED BY

DATE

A. COMINSKY

4 FEB. 1954

CHECKED BY

DATE

LOADS AT RIB-SPAR INTERSECTIONS AT RIB #6

THE TORQUE OF 7,505 IN. LB. WILL BE PUT INTO THE STRUCTURE AS A COUPLE AT POINTS "A" & "D"

$$\text{COUPLE LOADS} = \frac{97588}{2 \times 25.296} = 991 \text{ LB.}$$

LOADS AT RIB-SPAR INTERSECTIONS AT REAR SPAR

(REF. DIAGRAM, ON SHT. A-31)

POINT "E" OF RIB #6

$$\begin{aligned} \text{LIM. AIRLOAD} &= \frac{1}{2}(187.673 - 166.446) \times \frac{1}{2}(14.30 + 16.40) \quad (\text{SHT A-33}) \\ &= \frac{1}{4} \times 21.227 \times 31.30 = 166 \text{ LB.} \end{aligned}$$

$$\begin{aligned} \text{LIM. AIRLOAD TQ.} &= \frac{1}{4} \times 21.227 (235 + 290) \quad (\text{SHT A-33}) \\ &= \frac{1}{4} \times 21.227 \times 525.0 = 2783 \text{ IN. LB.} \end{aligned}$$

POINT "F" OF RIB #5

$$\begin{aligned} \text{LIM. AIRLOAD} &= \frac{1}{4} \times 21.227 (16.40 + 17.4) \\ &\quad + \frac{1}{2} (211.606 - 187.673) \times \frac{1}{2} (17.5 + 17.8) \\ &= \frac{1}{4} \times 21.227 \times 33.8 + \frac{1}{4} \times 23.933 \times 35.3 \\ &= 180.0 + 211.2 = 391.2 \text{ LB.} \end{aligned}$$

$$\begin{aligned} \text{LIM. AIRLOAD TQ.} &= \frac{1}{4} \times 21.227 (290.0 + 307.0) + \frac{1}{4} \times 23.933 (308.5 + 280) \\ &= \frac{1}{4} \times 21.227 \times 597.0 + \frac{1}{4} \times 23.933 \times 588.5 \\ &= 3170 + 3520 = 6690 \text{ IN. LB.} \end{aligned}$$

POINT "G" OF RIB #4

$$\begin{aligned} \text{LIM. AIRLOAD} &= \frac{1}{4} \times 23.933 (18.0 + 16.5) \\ &\quad + \frac{1}{2} (238.530 - 211.606) \times \frac{1}{2} (16.6 + 11.0) \\ &= \frac{1}{4} \times 23.933 \times 34.5 + \frac{1}{4} \times 26.984 \times 27.6 \\ &= 206 + 186 = 392 \text{ LB.} \end{aligned}$$

$$\begin{aligned} \text{LIM. AIRLOAD TQ.} &= \frac{1}{4} \times 23.933 (275 + 203) + \frac{1}{4} \times 26.984 (203 + 100) \\ &= \frac{1}{4} \times 23.933 \times 478 + \frac{1}{4} \times 26.984 \times 303 \\ &= 2855 + 2042 = 4897 \text{ IN. LB.} \end{aligned}$$

