

QCX
AVRO
CF105
R-7-0558-67
ANALYST



TECHNICAL REPORT



A V ROE CANADA LIMITED
MALTOE - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

ANALYSED

ANALYSED

AIRCRAFT:

REPORT NO. 7/0558/67

FILE NO.

NO OF SHEETS: 96

TITLE: ONE-WAY COOLING
AIR VENTS

~~CONFIDENTIAL~~

Classification cancelled / Changed to UNCLASS

By authority of AVRS

Date 30 Sept 66

Signature R. Sullivan

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PREPARED BY M. SEWIK
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AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

REPORT No. 710558/67

SHEET No. A

AIRCRAFT:

C 105

AIR VENTS

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DATE

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5/25/56

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REPORT NO. 7/0558/67

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INTRODUCTION

THE PURPOSE OF THIS REPORT IS TO ANALYZE THE REINFORCING STRUCTURE AROUND THE AIR VENTS IN THE SIDE & BOTTOM OF THE FUSELAGE, THE DUCTS & THE DUCT DOORS.

THE REINFORCEMENTS AROUND VENTS 1 & 2, 3 & 4, & THE VENT BETWEEN STN 702.30 & STN 707.32 REQUIRE SPECIAL ATTENTION BECAUSE OF THE NATURE OF THE STRUCTURE. THIS STRUCTURE IS IN THE FORM OF A TRUSS & IS MADE OF ALLOY STEEL. THE ASSUMPTIONS MADE IN THE ANALYSIS OF THIS STRUCTURE ARE AS FOLLOWS:

- 1) TRUSS STRUCTURE IS PIN-JOINTED.
- 2) SHEAR FLOW ON ALL SIDES OF TRUSS IS A UNIFORM 1600 #/in

THE TRUSSES WERE STRESSED ON THESE ASSUMPTIONS, I.E. AXIAL LOAD ONLY IN THE TRUSS.

ASSUMPTION (2), ABOVE, MEANS THAT THE TRUSS IS EXPECTED TO CARRY THE SAME AMOUNT OF LOAD AS WOULD BE CARRIED BY THE SKIN IF THERE WERE NO CUTOUT, I.E. 1600 #/in . THIS IN TURN, MEANS THAT THE SKIN ABOVE & BELOW THE CUTOUTS WILL HAVE THE SAME STIFFNESS AS THE TRUSS REINFORCEMENT. SINCE THE TRUSS IS FAR FROM BEING PIN-JOINTED, & SINCE THE CONDITIONS WHICH ASSUMPTION (2) IMPOSES ARE NOT LIKELY TO BE MET, AN ATTEMPT WAS MADE TO JUSTIFY THEM. THIS WAS DONE IN SECTION 2. THE CONCLUSIONS & RECOMMENDATIONS RESULTING FROM THIS STUDY ARE PRESENTED ON SHT. 0.2.



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REPORT NO. 7/0558/67.

SHEET NO. 0.2.

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INTRODUCTION CONT'D.

DRAWINGS COVERED.

- 7-1058-5075/6 - VENTS 1 AND 2.
- 7-1058-5105/6 - VENTS 3 AND 4.
- 7-1058-5755/6 - VENTS 5 AND 6.
- 7-1058-6413 - COILED SPRING.
- 7-1058-6415 - FLAT SPRING.
- 7-1058-4707/8 - VENT BETWEEN STA: 702.3 AND 707.32.
- 7-1058-6217 - PRESSURE VENTS 7 AND 8.

DRAWINGS REFERRED TO

- 7-1058-57/8 - FORMER - STA 668.45 SIDE STRUCTURE.
- 7-1058-5105/6 - PRESSURE VENTS 3 AND 4. (MENTIONED ABOVE)
- 7-1058-5075/6 - FORMER - STA 668.45 SIDE STRUCTURE. (MENTIONED ABOVE)



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REPORT NO. 7/0558/67

SHEET NO. 0.3

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CONCLUSIONS & RECOMMENDATIONS

THESE ARE CONCERNED WITH THE STUDY MADE IN SECTION 2 ONLY.

THE MAXIMUM VERTICAL DEFLECTION OF ANY TRUSS JOINT WITH RESPECT TO ANY OTHER JOINT IS JOINT © WITH RESPECT TO JOINT Ⓓ (REF. DIAGRAM, SHT. 2.1). A WILLIOT DIAGRAM WAS CONSTRUCTED, ASSUMING THE TRUSS TO BE PIN-JOINTED. THE RELATIVE VERTICAL DEFLECTION OF JOINT © WITH RESPECT TO JOINT Ⓓ WAS FOUND TO BE .1471" (SAME AS FOR ANALYTICAL SOLUTION, SEE SHT. 2.3) THEN THE FACT THAT THE TRUSS IS NOT PIN-JOINTED WAS TAKEN INTO ACCOUNT, & THE MOMENTS AT THE JOINTS DUE TO THE DEFLECTIONS AS DETERMINED FROM THE WILLIOT DIAGRAM WERE CALCULATED BY MEANS OF THE MOMENT DISTRIBUTION (HARDY CROSS) METHOD. THE JOINT MOMENTS WERE FOUND TO BE OF SUCH A MAGNITUDE AS TO CHANGE THE TRUSS AXIAL LOADS APPRECIABLY. THEREFORE, THE EFFECT OF THE AXIAL LOADS WAS DETERMINED (SHTS. 2.13-2.15), & A NEW WILLIOT DIAGRAM WAS CONSTRUCTED (SHT. 2.17). THE VERTICAL DEFLECTION OF JOINT © WITH RESPECT TO JOINT Ⓓ WAS FOUND TO BE .1170" FOR THE NEW AXIAL LOADS. NEW JOINT MOMENTS WERE CALCULATED. AT THIS POINT, LACK OF TIME, PREVENTED ANY FURTHER REFINEMENT OF THE ANALYSIS. HOWEVER, THE FOLLOWING CONCLUSIONS MAY BE DRAWN:

- A) IF THE EFFECT OF THE NEW MOMENTS (SHT. 2.20) ON AXIAL LOADS IS CALCULATED, THE NEW AXIAL LOADS WILL BE SLIGHTLY HIGHER THAN THOSE SHOWN ON SHT. 2.15, BUT CONSIDERABLY LOWER THAN THOSE CALCULATED ASSUMING PIN JOINTS (SHT. 2.7).
- B) IF A NEW WILLIOT DIAGRAM WERE CONSTRUCTED USING AXIAL LOADS OF (A) ABOVE, THE VERTICAL DEFLECTION OF JOINT © WITH RESPECT TO JOINT Ⓓ WILL BE FOUND TO BE SLIGHTLY GREATER THAN THAT FOUND FROM THE WILLIOT DIAGRAM (SHT. 17) BUT CONSIDERABLY LESS THAN THAT FOUND FROM THE FIRST DIAGRAM (SHT. 2.8).
- C) IF THE PROCEDURE OUTLINED IN (A) & (B) IS CARRIED OUT, & NEW JOINT MOMENTS CALCULATED (WHICH SHOULD BE SLIGHTLY HIGHER THAN THOSE OF SHT. 2.20), THE PROCESS WILL HAVE CONVERGED ENOUGH TO GIVE A REASONABLY ACCURATE PICTURE LOAD DISTRIBUTION FOR THE LOADING OF ASSUMPTION (2), SHT. 0.1.



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TECHNICAL DEPARTMENT

REPORT NO. 7/0558/67

SHEET NO. 0.4

AIRCRAFT:

C.105

AIR VENTS

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CONCLUSIONS & RECOMMENDATIONS (CONT.)

THE SHEAR DEFLECTION OF STN 678.05 RELATIVE TO STN 668.45 UNDER THE LOADING OF ASSUMPTION (2) SHT. 0.2, WAS FOUND TO BE .096" (REF SHT. 2.3), USING A REDUCED SHEAR MODULUS BECAUSE OF THE BUCKLED CONDITION OF THE SKIN. SINCE THIS IS LESS THAN THE DEFLECTION OF .117" CALCULATED FOR THE TRUSS, IT WOULD APPEAR THAT THE TRUSS DOES NOT PICK UP AS MUCH LOAD AS ASSUMPTION (2) SHT. 0.1 SHOWS. THUS THE TRUSS WILL VERY PROBABLY NOT FAIL UNDER THE LOADS IT WILL PICK UP. HOWEVER, THIS MEANS THAT THE SKIN PANELS ABOVE & BELOW THE TRUSS WILL BE CARRYING MORE THAN THE ASSUMED 1600 #/IN SHEAR FLOW, & THAT FRAMES AT STN 668.45 & STN 678.05 WILL PICK UP SOME AXIAL LOAD DUE TO THE REDISTRIBUTION OF SHEAR FLOW.

SINCE IT IS VERY DIFFICULT TO DETERMINE THE SHEAR DEFLECTION OF THE SKIN BETWEEN STN 678.05 & STN 668.45 BECAUSE OF DIFFICULTY IN OBTAINING AN ACCURATE VALUE FOR THE SHEAR MODULUS, THE FOLLOWING RECOMMENDATIONS ARE MADE:

- 1) STEPS (A), (B), & (C) OF SHT. 0.2 BE CARRIED OUT.
- 2) THE STRESSING OF SECTION I BE DONE WITH THE LOADS OBTAINED FROM (1), TAKING INTO ACCOUNT BENDING, AS WELL AS AXIAL LOADS. THIS WILL DETERMINE WHETHER THE TRUSS IS ADEQUATE FOR THE LOADING OF ASSUMPTION (2) SHT. 0.1.
- 3) THE STRESSES IN THE AREA OF THE VENTS BE OBTAINED BY STRAIN GAGE MEASUREMENTS DURING STATIC TEST OF THE AIRCRAFT.

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE WAY COOLING AIR
VALVES

DWG 7-0158-353

REPORT NO. 7-0358-67

SHEET NO. 1.1

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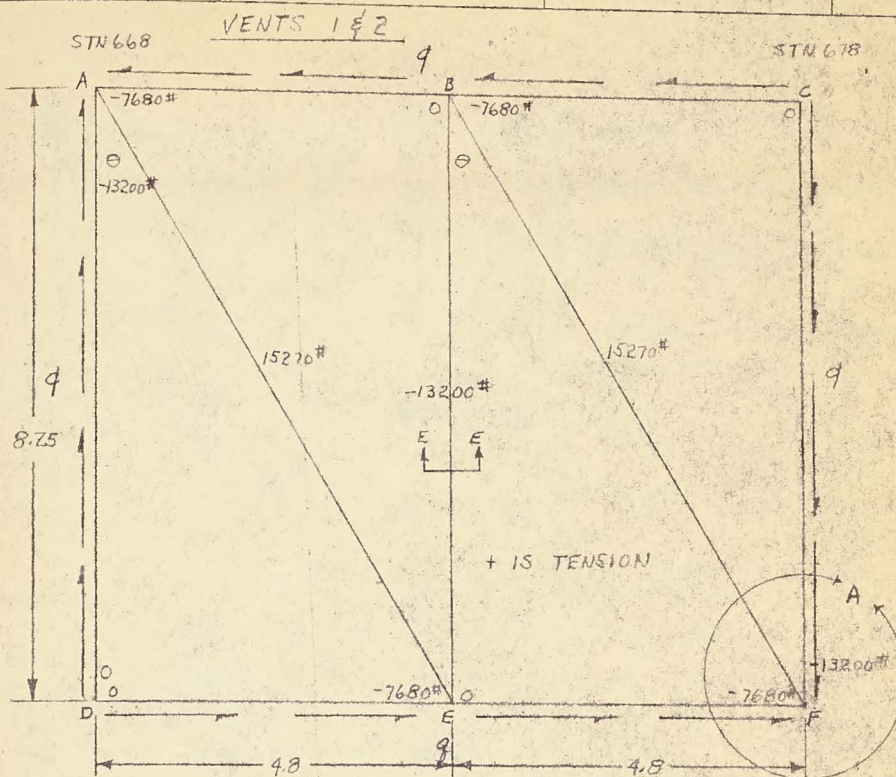
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THE STRUCTURE AROUND THE ONE-WAY COOLING AIR VENTS IS CONSIDERED TO BE A PIN-ENDED TRUSS LOADED BY THE SHEAR FLOWS q AS SHOWN IN THE ABOVE SKETCH. $q = 1600 \text{ #/in}$

TRUSS MEMBER LOADS

$$\theta = \tan^{-1} \frac{48}{8.25} = 30.2^\circ$$

MEMBER CF

THE LOAD IN CF VARIES FROM 0 AT C TO $8.25q = 13200 \text{ # (COMP)}$ AT F

MEMBER EF

THE LOAD IN EF VARIES FROM 0 AT E TO $48q = 7680 \text{ # (COMP)}$ AT F

MEMBER BF

$$\text{THE LOAD IN BF} = \sqrt{(13200)^2 + (7680)^2} = 15270 \text{ # (TENS)}$$

MEMBER BE

$$\text{THE LOAD IN MEMBER BE} = BF \cos \theta = 13200 \text{ # (COMP)}$$

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MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0558/67

SHEET No. 1.4

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS
DWG 7-0158-353

PREPARED BY

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MEMBER BF (CONT.)

THE NET AREA ACROSS A RIVET HOLE IN BF IS:

$$A_{ST} = (.52 - .1285)(.18) = .07047 \text{ "}^2$$

$$A_{AL} = (.52 - .1285)(.064) = .025056 \text{ "}^2$$

STRESS IN STEEL:

$$f_{ST} = \frac{13528}{.07047} = 192000 \text{ PSI}$$

$$F_{tu} = 180000 \text{ PSI}$$

$$MS = \frac{180000}{192000} - 1 = -.06$$

STRESS IN ALUM:

$$f_{AL} = \frac{1742}{.025056} = 69530 \text{ PSI}$$

$$F_{tu} = 72000 \text{ PSI}$$

$$MS = \frac{72000}{69530} - 1 = .03$$

MEMBER BF HAS AN .051 755-T6 CHANNEL ATTACHED BY $\frac{1}{8}$ MONEL CHERRY RIVETS. THIS CHANNEL PROVIDES A PLACE TO ATTACH THE DOORS, & ALSO STIFFENS THE MEMBER. ALTHO IT IS CLIPPED TO THE FRAMES AT B & F, IT DOES NOT PICK UP END LOAD DIRECTLY. AS BF DEFLECTS UNDER LOAD, THE CHANNEL WILL PICK UP LOAD THRU THE RIVETS ATTACHING IT. A $\frac{1}{8}$ CHERRY MONEL IN .051 CAN TRANSMIT 660# (REF ANC-5). THERE ARE 3 RIVETS BEFORE SECTION B-B. THUS THE TOTAL LOAD IN BF AT SECTION B-B WILL BE

$$P = 15270 - (3)(660) = 13290 \text{ #}$$

$$P_{AL} = \frac{13290}{8.76786} = 1516 \text{ #} \quad P_{ST} = 7.76786 \times 1516 = 11774 \text{ #}$$

$$f_{ST} = \frac{11774}{.07047} = 167000 \text{ PSI}$$

$$MS = \frac{180000}{167000} - 1 = .07$$

$$f_{AL} = \frac{1516}{.025056} = 60500 \text{ PSI}$$

$$MS = \frac{72000}{60500} - 1 = .19$$

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C105

ONE WAY COOLING AIR
VENTS

DWG 7-0158-353

REPORT NO. 710558/67

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MEMBER EF (SECTION D-D)

THE HORIZONTAL MEMBER EF CONSISTS OF THE .064 755-T6 SKIN & .051 STEEL PLATE, WHICH ARE CONNECTED BY TWO ROWS OF AN 426 ADS RIVETS AT .65" PITCH.

MAKING THE SAME ASSUMPTION AS FOR SECTION B-B:

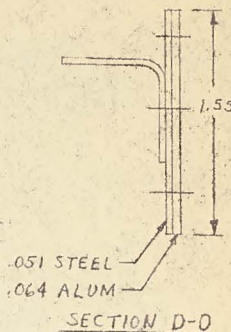
$$P_{ST} = 2.201 P_{AL} \text{ (REF. SHT. 5)}$$

$$P_{ST} + P_{AL} = -5600 \# \text{ (REF. SHT. 2)}$$

$$P_{AL} = \frac{-5600}{3.201} = -1750 \#$$

$$P_{ST} = 2.201 \times -1750 = -3850 \#$$

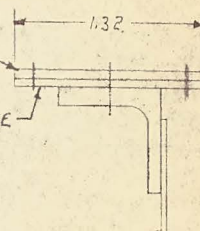
SECTION D-D IS OK BY COMPARISON TO SECT. C-C, SHT 5



MEMBER BE (SECTION E-E)

THE VERTICAL MEMBER, BE, CONSISTS OF THE .064 755-T6 SKIN & .051 STEEL PLATE, WHICH ARE CONNECTED & ATTACHED TO THE FRAME BY AN 426-ADS RIVETS AT .65" PITCH.

USING THE SAME ASSUMPTION AS IN D-D, ABOVE,



$$P_{ST} = 2.201 P_{AL}$$

$$P_{ST} + P_{AL} = -13200 \# \text{ (REF. SHT. 3)}$$

$$P_{AL} = \frac{-13200}{3.201} = -4124 \#$$

$$P_{ST} = 2.201 (-4124) = -9076 \#$$

$$A_{ST} = 1.32 \times .051 = .0673 \text{ "}^2$$

$$A_{AL} = 1.32 \times .064 = .0845 \text{ "}^2$$

$$f_{ST} = \frac{-9076}{.0673} = -135000 \text{ PSI}$$

$$F_{cr} = 147000 \text{ PSI (REF. SHT. 5)}$$

$$f_{AL} = \frac{-4124}{.0845} = -48800 \text{ PSI}$$

$$F_{cr} = 63000 \text{ PSI (REF. SHT. 5)}$$

$$MS = \frac{147000}{135000} - 1 = .09$$

$$MS = \frac{63000}{48800} - 1 = .29$$

A. V. ROE CANADA LIMITED
MALTON, ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE WAY COOLING AIR
VENTS
DWG 7-0158-353

REPORT NO. 7/0558/67

SHEET NO. 17

PREPARED BY

E. KAUFF

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MEMBER BE (TENSION CASE)

WHEN MEMBER BE IS IN TENSION, THE AREA MUST BE REDUCED BY THE AREA OF THE HOLE FOR AN AD 426 ADS RIVET.

$$A_{ST} = (1.32 - .159)(.051) = .0592''^2$$

$$A_{AL} = (1.32 - .159)(.064) = .0742''^2$$

$$P_{ST} = 9076 \text{ (REF. SHT. 6)}$$

$$f_{ST} = \frac{9076}{.0592} = 153000 \text{ PSI}$$

$$MS = \frac{180000}{153000} - 1 = .17$$

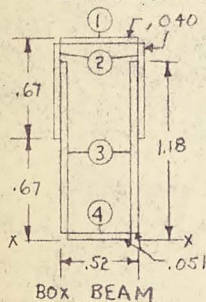
$$P_{AL} = 4124'' \text{ (REF. SHT. 6)}$$

$$f_{ST} = \frac{4124}{.0742} = 55600$$

$$MS = \frac{12000}{55600} - 1 = .29$$

MEMBER BF (COMPRESSION CASE)

THE DIAGONAL MEMBER BF, IS ATTACHED TO A BOX BEAM WHICH, ALTHO IT DOESN'T TAKE END LOAD, DOES STABILIZE BF WHEN BF IS IN COMPRESSION. THIS IS CHECKED BY THE METHOD IN "THEORY OF ELASTIC STABILITY" BY TIMOSHENKO, 1936, SHTS 108-111. THE BOX BEAM IS MADE UP OF AN .040 & AN .051 75S-T6 CHANNEL.



ITEM	A	y	AY	AY ²	I ₀
1	.0208	1.32	.0274	.0362	—
2	.0504	.96	.0484	.0464	.0017
3	.1152	.64	.0737	.0472	.0123
4	.0214	.03	.0064	.0002	—
Σ	.2078	—	.1559	.1300	.0140

$$\bar{y} = \frac{.1559}{.2078} = .75'' \quad I = .1440 - .1170 = .027''^4$$

$$L = 7.7'' \quad E = 10.5 \times 10^6 \text{ PSI}$$

$$\alpha = \frac{384EI}{5L^3} = \frac{(384)(10.5)(10^6)(.027)}{(5)(7.7)^3} = 47690$$

CONSIDERING THE .064 75S-T6 TO BE EQUIVALENT TO .02" OF STEEL, THE I OF SECT. B-B IS:

$$I = \frac{.52 \times (.02)^3}{12} = .000347''^4$$

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE WAY COOLING AIR
VALVES

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REPORT NO. 7/0558/67

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MEMBER BF (CONT.)

$$\beta = \frac{\alpha}{a} = \frac{47690}{7.7} = 6195$$

$$\frac{\beta L^4}{16EI} = \frac{(6195)(7.7)^4}{(16)(29)(10^6)(.000347)} = 135$$

$$L/l = .328$$

$$L = .328 \times 7.7 = 2.52"$$

$$P_{cr} = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 (29)(10^6)(.000347)}{(2.52)^2} = 15630 \#$$

$$P = 15270 \# \text{ (COMP) REF SHT 3}$$

$$MS = \frac{15630}{15270} - 1 = .025$$

IN THE ABOVE ANALYSIS, NO CONSIDERATION WAS TAKEN OF THE AMOUNT OF FIXITY AT THE ENDS, NOR OF A POSSIBLE FURTHER REDUCTION IN THE LENGTH.

COMPRESSION STRESS IN BF

$$A_{st} = (.52)(.18) = .0936 \text{ in}^2$$

$$A_{al} = (.52)(.064) = .0333 \text{ in}^2$$

$$P_{st} = -13528 \# \text{ (REF. SHT. 3)}$$

$$P_{al} = -1742 \# \text{ (" " 3)}$$

$$f_{st} = \frac{-13528}{.0936} = -144500 \text{ PSI}$$

$$f_{al} = \frac{-1742}{.0333} = -52400 \text{ PSI}$$

INTER RIVET BUCKLING STRESS FOR AL = 63000 PSI (REF. SHT. 5)

$$MS = \frac{63000}{52400} - 1 = .20$$

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ONE WAY COOLING AIR
VALVES
DWG 7-0158-353

REPORT NO. 7/0558/67

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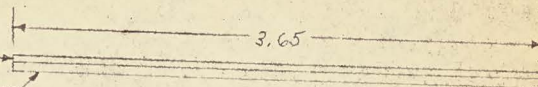
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SECTION F-F (SHT. 2)

.051 STEEL PLATE
.064 75S-T6 SKIN



THE .064 ALUM IS EQUIVALENT TO $.064 \times \frac{10.5}{29} = .023$ " THICK STEEL.
THICKNESS OF EQUIVALENT STEEL PLATE = $.051 + .023 = .074$ "

$$\text{EQUIVALENT AREA} = .074 \times 3.65 = .270 \text{ "}^2$$

$$\text{SHEAR ON SECT. F-F} = CF \cos \theta = 13200 \cos 30.2^\circ = 11400 \#$$

$$\text{TENSION ON SECT. F-F} = CF \sin \theta = 6650 \#$$

$$f_s = \frac{11400}{.27} = 42200 \text{ PSI}$$

$$f_t = \frac{6650}{.27} = 24600 \text{ PSI}$$

$$F_{su} = 109000 \text{ PSI}$$

$$F_{tu} = 180000 \text{ PSI}$$

$$R_s = \frac{42200}{109000} = .387$$

$$R_t = \frac{24600}{180000} = .137$$

* USING INTERACTION FORMULA OF $R_t^{2.2} + R_s^{2.2} = 1$

$$MS = \frac{.35}{.137} - 1 = 1.55$$

$$\text{SHEAR IN ALUM} = 42200 \times \frac{.023}{.064} = 15200 \text{ PSI}$$

$$\text{TENSION IN ALUM} = 24600 \times \frac{.023}{.064} = 8830 \text{ PSI}$$

FROM LOCKHEED SM 70a FIG. 8

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0558/67

SHEET No. 1.11

AIRCRAFT:

C 105

ONE WAY COOLING AIR
VENTS

DWG 7-0658-353

PREPARED BY

K. RUTT

DATE

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ATTACHMENT OF STEEL PLATE TO SKIN

THE STEEL PLATE IS ATTACHED TO THE SKIN BY A DOUBLE ROW
OF AN 426 AD5* RIVETS C'SUNK IN THE SKIN. .65" PITCH.

ASSUMING THE DISTRIBUTION OF LOAD BETWEEN SKIN & PLATE TO
BE THAT SHOWN ON SHEET 5, THE AMOUNT OF LOAD TRANSFERRED
TO THE STEEL PLATE IS:

$$q_{st} = \frac{3.201}{3.201} (1600) = 1100 \text{ #/"}$$

THIS IS THE AMOUNT OF SHEAR FLOW TRANSFERRED TO THE STEEL
PLATE BY THE RIVETS FROM THE SKIN.

$$\text{LOAD/RIV} = \frac{1100 \times .65}{2} = 357 \text{ #}$$

ALLOWABLE LOAD OF AN 426 AD5 RIVET IN C'SUNK .064 255-T6 = 523*
(REF. ANC-5)

$$MS = \frac{523}{357} - 1 = .46$$

* SEE NOTE, SHT. 2



AVRO AIRCRAFT LIMITED
MALTON, ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C. 105

PRESSURE VENT

REPORT NO.

7/0558/67

SHEET NO.

1.15

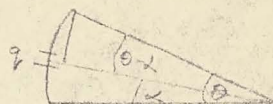
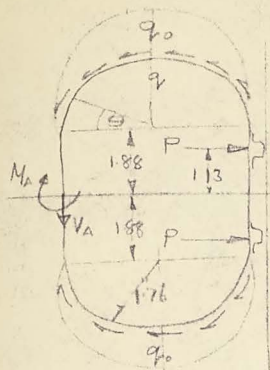
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$$q = q_0 \sin \theta$$

$$P = \int_0^{\pi} q r d\theta \sin^2 \theta = \left[q_0 r \left(\frac{\theta}{2} - \frac{\sin 2\theta}{4} \right) \right]_0^{\pi}$$

$$= q_0 r \frac{\pi}{2} - 0 = \frac{1}{2} q_0 r$$

$$q_0 = \frac{2P}{r}$$

$$\textcircled{1} \frac{AB}{0 < \theta < 180}$$

$$M = M_A$$

$$\textcircled{2} \frac{BC}{0 < \theta < \pi}$$

$$M_{\theta} = M_A - V_A r (1 - \cos \theta)$$

$$- q_0 r^2 \int_0^{\theta} \sin x [1 - \cos(\theta - x)] dx$$

$$= M_A - V_A r (1 - \cos \theta) - q_0 r^2 \int_0^{\theta} \sin x [1 - \cos \theta \cos x - \sin \theta \sin x] dx$$

$$= M_A - V_A r (1 - \cos \theta) - q_0 r^2 \int_0^{\theta} (\sin x - \cos \theta \sin x \cos x - \sin \theta \sin^2 x) dx$$

$$= M_A - V_A r (1 - \cos \theta) - q_0 r^2 \left[-\cos x - \cos \theta \frac{\sin^2 x}{2} - \sin \theta \left(\frac{x}{2} - \frac{\sin 2x}{4} \right) \right]_0^{\theta}$$

$$= M_A - V_A (r - r \cos \theta) - q_0 r^2 \left[-\cos \theta + 1 - \cos \theta \frac{\sin^2 \theta}{2} - \sin \theta \left(\frac{\theta}{2} - \frac{\sin 2\theta}{4} \right) \right]$$

$$= M_A - V_A (r - r \cos \theta) - q_0 r^2 \left[1 - 2 \cos \theta - \frac{\theta}{2} \sin \theta \right]$$

ED

$$\textcircled{3} 1.88 > x > 1.13 \quad M_x = M_A - 2V_A r - 3q_0 r^2 - P(1.88 - x)$$

DE

$$\textcircled{1} 1.13 > x > 0 \quad M_x = M_A - 2V_A r - 3q_0 r^2 - 75 P$$

CONTINUED



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C-105

PRESSURE VENT

REPORT NO.

7/0558/67.

SHEET NO.

1.18.

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$$\textcircled{1} \frac{\partial B}{\partial M_A} \frac{\partial H}{\partial M_A} = 1 \quad \frac{\partial H}{\partial V_A} = 0$$

$$\textcircled{2} \frac{\partial D}{\partial M_A} \frac{\partial H}{\partial M_A} = 1 \quad \frac{\partial H}{\partial V_A} = -2V$$

$$\textcircled{3} \frac{\partial C}{\partial M_A} \frac{\partial H}{\partial M_A} = 1 \quad \frac{\partial H}{\partial V_A} = -V(1-\cos\theta)$$

$$\textcircled{4} \frac{\partial E}{\partial M_A} \frac{\partial H}{\partial M_A} = 1 \quad \frac{\partial H}{\partial V_A} = -2V$$

$$\textcircled{1} \frac{\partial B}{\partial M_A} EI = \int_0^{1.88} M_A dx + \int_0^\pi \{ M_A - V_A V (1-\cos\theta) - q_0 V^2 (1-2\cos\theta - \frac{q_2}{2} \sin\theta) \} d\theta \\ + \int_{1.13}^{1.88} \{ M_A - 2V_A V - 3q_0 V^2 - P(1.88-x) \} dx \\ + \int_0^{1.13} \{ M_A - 2V_A V - 3q_0 V^2 - .75P \} dx$$

$$\textcircled{2} \frac{\partial D}{\partial V_A} EI = \int_0^\pi - \{ M_A - V_A V (1-\cos\theta) - q_0 V^2 (1-2\cos\theta - \frac{q_2}{2} \sin\theta) \} V (1-\cos\theta) d\theta \\ + \int_{1.13}^{1.88} - \{ M_A - 2V_A V - 3q_0 V^2 - P(1.88-x) \} 2V dx \\ + \int_0^{1.13} - \{ M_A - 2V_A V - 3q_0 V^2 - .75P \} 2V dx$$

$$\therefore \textcircled{1} \quad 1.88 M_A + \pi M_A - \pi V_A V - q_0 V^2 \pi + 2q_0 V^2 \pi + .75 M_A \\ - 1.5 V_A V - 2.25 q_0 V^2 - 1.41 + .281 P + 1.13 M_A \\ - 2.26 V_A V - 3.39 q_0 V^2 - .8475 P = 0 \\ \text{AND} \quad 6.9 M_A - 12.15 V_A - 10.75 P = 0 \quad (A)$$

$$\textcircled{2} \quad -\pi V M_A + \pi V^2 V_A + \frac{\pi}{2} V_A V^2 + 2P V^2 \pi + 4P V^2 \frac{\pi}{2} - 2P V^2 \pi \\ + P V^2 \frac{\pi}{2} - 2.64 M_A + 5.26 V_A V + 7.9 q_0 V^2 + 4.95 P \\ - .988 P - 3.97 M_A + .795 V_A V + 11.91 q_0 V^2 + 2.98 P = 0$$

$$\text{AND} \quad -12.14 M_A + 37.87 V_A + 98.76 P = 0 \quad (B) \\ 12.14 M_A - 21.4 V_A - 18.91 P = 0 \\ + 16.47 V_A + 79.85 P = 0$$

$$\therefore V_A = -4.85 P \quad M_A = -6.83 P$$

CONTINUED -



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C-105

PRESSURE VENT

REPORT NO.

7/0558/67

SHEET NO.

1.17

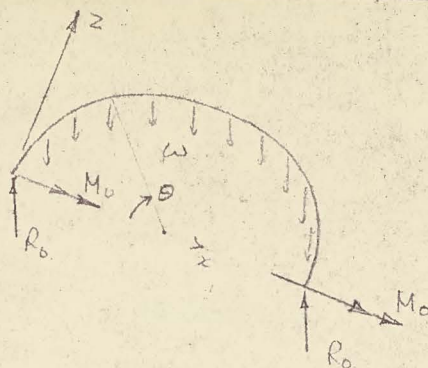
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$$R_0 = \frac{w \pi r}{2 \pi}$$

$$M_{0xx} = \frac{1}{2} \int_0^\pi w r^2 d\theta \sin \theta = \frac{1}{2} w r^2 [-\cos \theta]_0^\pi$$

$$= \frac{1}{2} w r^2 [1+1] = w r^2$$

$$M_{\theta xx} = M_0 - R_0 r \sin \theta + \int_0^\theta w r^2 d\alpha (\sin \theta - \sin \alpha)$$

$$= w r^2 - \frac{\pi}{2} w r^2 \sin \theta + w r^2 [\alpha \sin \theta + \cos \alpha]_0^\theta$$

$$= w r^2 \left\{ 1 - \frac{\pi}{2} \sin \theta + \theta \sin \theta + \cos \theta - 1 \right\}$$

$$= w r^2 \left\{ \sin \theta \left(\theta - \frac{\pi}{2} \right) + \cos \theta \right\}$$

$$M_{\theta 22} = R_0 r (1 - \cos \theta) - \int_0^\theta w r^2 d\alpha (\cos \alpha - \cos \theta)$$

$$= \frac{\pi}{2} w r^2 (1 - \cos \theta) - w r^2 [\sin \alpha - \alpha \cos \theta]_0^\theta$$

$$= w r^2 \left\{ \frac{\pi}{2} - \frac{\pi}{2} \cos \theta - \sin \theta + \theta \cos \theta \right\}$$

$$= w r^2 \left\{ 1 + \frac{\pi}{2} + \cos \theta \left\{ \theta - \frac{\pi}{2} \right\} - \sin \theta \right\}$$

$$\text{At } \theta = \frac{\pi}{2} \quad M_{\theta xx} = w r^2 \left\{ 1 \left(\frac{\pi}{2} - \frac{\pi}{2} \right) + 0 \right\} = 0$$

$$M_{\theta 22} = w r^2 \left\{ 1 + \frac{\pi}{2} + 0 - 1 \right\} = \frac{\pi}{2} w r^2$$

$$\text{SECTION DEPTH} = 5.0 \quad t = 0.32 \quad z = \frac{5.0^2 \times 0.32}{6} = .133 \text{ in}^3$$

$$f_b = \frac{\pi \cdot 33 \cdot 1.76}{.133} = 655 \text{ lb/in}^2$$

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VALVES
DWG 7-0158-353

REPORT NO. 7/0558/67

SHEET NO. 2.2

PREPARED BY

DATE

E. KAUTT

1/31/56

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DATE

TRUSS DEFLECTIONS (CONT)

THE DEFLECTION OF POINT (C) WITH RESPECT TO POINT (D) MAY BE FOUND BY REPLACING THE 6600# LOAD AT (C) BY THE LOAD W_C . THEN

$$\Delta C = \frac{1}{E} \sum \frac{P_0 L}{A} \cdot \frac{\partial P_0}{\partial W_C}$$

WHERE:

$E = 29 \times 10^6$ PSI (FOR STEEL)

L = LENGTH OF MEMBER

A = CROSS SECTIONAL AREA OF TRUSS MEMBER

$P_0 = f(W) + f(P_n)$ P_n = OTHER LOADS SHOWN

THE TRUSS CONSISTS OF A STEEL PLATE .051" THICK (EXCEPT FOR AE & BF WHICH ARE .180" THICK) RIVETED TO AN .064" 75S-76 ALUM. SHEET. TO SIMPLIFY THE ANALYSIS, THE .064 SHEET IS REDUCED TO AN EQUIVALENT THICKNESS OF STEEL BY THE RATIO OF E_{AL} TO E_{ST} .

$$E_{AL} = 10.5 \times 10^6 \text{ PSI}$$

$$t_{EQ} = .064 \times \frac{10.5}{29} = .023"$$

MEMBER	t	t+t _{EQ}	b	A*	L
CF	.051	.074	1.65	.12210	8.25
BC	.051	.074	1.55	.11470	4.80
BF	.180	.203	.52	.10556	9.545
EF	.051	.074	1.55	.11470	4.80
DE	.051	.074	1.55	.11470	4.80
AB	.051	.074	1.55	.11470	4.80
BE	.051	.074	1.32	.09768	8.25
AD	.051	.074	1.65	.12210	8.25
AE	.180	.203	.52	.10556	9.545

*NOTE: DEFLECTION RECALCULATED USING AREAS SHOWN ON SHT 27 (2/2/56)

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS

DWG 7-0158-353

REPORT No. 7/0558/67

SHEET No. 2.3

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TRUSS DEFLECTIONS (CONT)

TRUSS MEMBER	P ₀ DUE TO:		$\frac{\partial P_0}{\partial W_c}$
	W _c	OTHER LOADS	
CF	-W _c	0	-1
BC	0	-3840	0
BF	$\frac{W_c \sqrt{(8.25)^2 + (4.8)^2}}{8.25}$	$\frac{72882}{\sqrt{(8.25)^2 + (4.8)^2}}$	$\frac{\sqrt{(8.25)^2 + (4.8)^2}}{8.25}$
EF	$\frac{-4.8 W_c}{8.25}$	0	$\frac{-4.8}{8.25}$
DE	$\frac{-9.6 W_c}{8.25}$	3840	$\frac{-9.6}{8.25}$
AB	$\frac{4.8 W_c}{8.25}$	-7680	$\frac{4.8}{8.25}$
BE	-W _c	-6600	-1
AD	-W _c	0	-1
AE	$\frac{W_c \sqrt{(8.25)^2 + (4.8)^2}}{8.25}$	$\frac{72882}{\sqrt{(8.25)^2 + (4.8)^2}}$	$\frac{\sqrt{(8.25)^2 + (4.8)^2}}{8.25}$

THE SOLUTION FOR ΔC IS GIVEN IN TABULAR FORM ON SHET 2.4
THIS GIVES A VALUE FOR ΔC OF;

$$\Delta C = .1471''$$

THE DEFLECTION OF THE STRUCTURE ABOVE $\frac{1}{2}$ BELOW THE TRUSS
IS DETERMINED FROM

$$\Delta = \frac{\sigma_s L}{G}$$

WHERE,

$$\sigma_s = \frac{q}{t} = \frac{1600}{.064} = 25000 \text{ PSI}$$

L = HORIZONTAL DISTANCE BETWEEN POINTS C & D = 9.6"

G = SHEAR MODULUS OF ELASTICITY = 2.5×10^6 PSI*

$$\Delta = \frac{2.5 \times 10^4 \times 9.6}{2.5 \times 10^6} = .096''$$

* A REDUCED MODULUS IS USED, ASSUMING THE SHEET TO BE BUCKLED

BAR	1	2	3	4	5	6	7	8	9	$\frac{\partial P_0}{\partial W_c}$
	1	2	3	4	5	6	7	8		
	$L (IN)$	$A (IN^2)$	W_c	P_0		OTHER LOADS	$\frac{\partial P_0}{\partial W_c}$	$\frac{\partial P_0}{\partial W_c}$	$\frac{\partial P_0}{\partial W_c}$	
CF	8.25	.1708	$-W_c$		0		-1	$\frac{+68.0625 W_c}{68.0625}$		
BC	4.80	.1150	0		-3840		0	0		
BF	$\sqrt{(8.25)^2 + (4.8)^2}$	.1214	$\frac{W_c \sqrt{(8.25)^2 + (4.8)^2}}{8.25}$		72882		$\frac{\sqrt{(8.25)^2 + (4.8)^2}}{8.25}$	$\frac{91.1025 W_c}{68.0625}$		
EF	4.80	.1150	$\frac{-4.8 W_c}{8.25}$		0		$\frac{-4.8}{8.25}$	$\frac{+23.04 W_c}{68.0625}$		
DE	4.80	.1150	$\frac{-9.6 W_c}{8.25}$		3840		$\frac{-9.6}{8.25}$	$\frac{92.16 W_c}{68.0625}$		
AB	4.80	.1150	$\frac{4.8 W_c}{8.25}$		-7680		$\frac{4.8}{8.25}$	$\frac{23.04 W_c}{68.0625}$		
BE	8.25	.1642	$-W_c$		-6600		-1	$\frac{68.0625 W_c}{68.0625}$		
AD	8.25	.1708	$-W_c$		0		-1	$\frac{68.0625 W_c}{68.0625}$		
AE	$\sqrt{(8.25)^2 + (4.8)^2}$	.1214	$\frac{W_c \sqrt{(8.25)^2 + (4.8)^2}}{8.25}$		72892		$\frac{\sqrt{(8.25)^2 + (4.8)^2}}{8.25}$	$\frac{91.1025 W_c}{68.0625}$		
Σ										
			$\Delta C = \frac{1}{29 \times 10^6} \left[\frac{30290.6 W_c}{68.0625} + \frac{11,18,856}{8.25} \right] = \frac{1}{29 \times 10^6} [291.83 \times 10^6]$							

MALTON, ONTARIO
TECHNICAL DEPT. (AIRFRAME)

WEIGHT

C. G. POSITION

SHEET

DATE _____

PREPARED BY -

7/0558/67

2.4

1/31/56

E. KAUTT

[illegible]



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C.105

FLAT SPRINGS

REPORT NO. 7/0558/67

SHEET NO. 7.2

PREPARED BY

DATE

A.J. QUIGLEY

MAY 1956

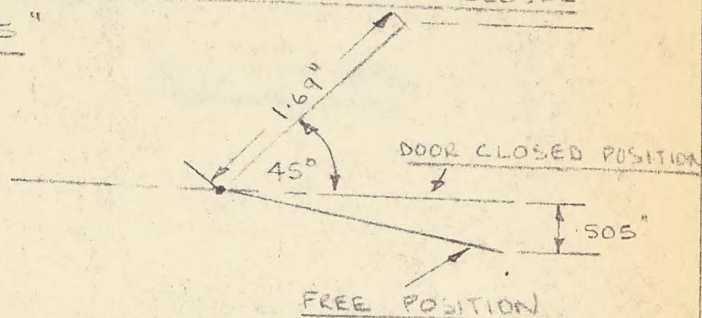
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REF DRG 7-1058-6415

SPRING BENT AT 45° TO NORMAL CLOSED POSITION

DEFLECTION FROM FREE POSITION TO DOOR-CLOSED POSITION IS .505"



$$\begin{aligned} \text{DEFLECTION AT } 45^\circ \text{ POSITION} &= .505 + 1.69 \sin 45 \\ &= .505 + 1.69 \times .7071 \end{aligned}$$

$$\underline{\underline{\delta = 1.7''}}$$

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

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

$$= \frac{3 \times 30 \times 10^6 \times 1.7 \times .9 \times .015^3}{12 \times 1.69^3}$$

$$\underline{\underline{W = 8.0 \text{ LB}}}$$

$$\begin{aligned} \text{BENDING STRESS} &= \frac{MY}{I} = \frac{8 \times 1.69 \times .0075}{.253 \times 10^{-6}} \\ &= \underline{\underline{402,000 \text{ LB/IN}^2}} \end{aligned}$$

THE HIGH STRESS QUOTED ABOVE IS CONSIDERED
ACCEPTABLE BECAUSE OF THE DEFORMATIONS
WHICH THE LOADING WILL IMPOSE ON THE SPRING.



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

REPORT NO. 710558/67

SHEET NO. 8.1

AIRCRAFT:

C. 105

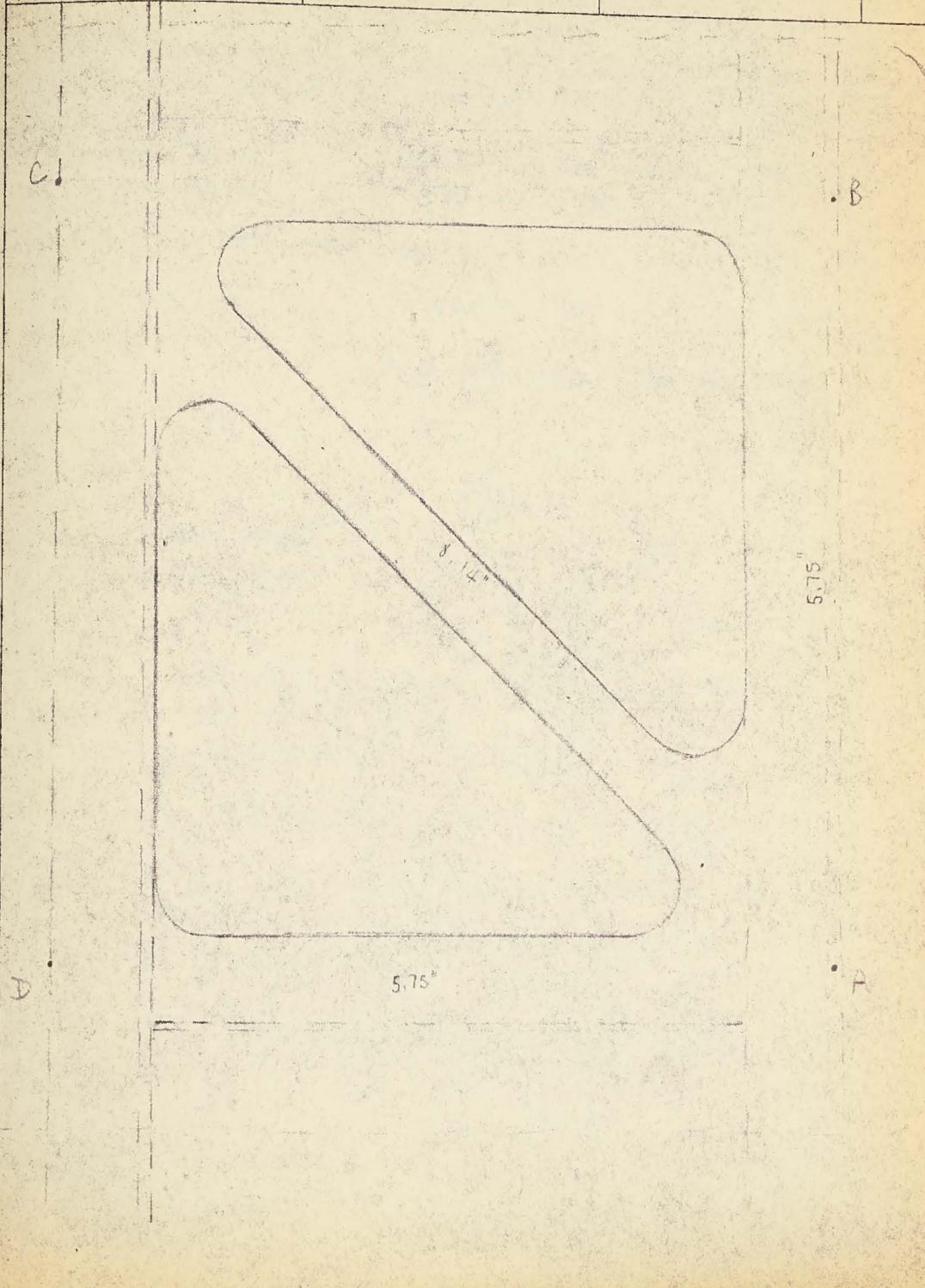
VENT STA. 702.30
-707.32

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AVRO AIRCRAFT LIMITED
MALTON, ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C.105

VENT STA 70230 -
707.32

REPORT NO. 7/0558/67

SHEET NO. 8.2

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THE APPLIED SHEAR IS 1600 LBS/INCH IN THE 106 CASE.
THE DIAGONAL MEMBER IS SO PLACED AS TO BE IN TENSION IN THIS CASE.

THE MAX. VALUE OF THE SHEAR IN THE REVERSE DIRECTION IS 41% OF 1600 LBS/INCH, I.E. 656 LB/IN. ULT.

CONSIDER THE MAX. SHEAR CASE FIRST:

THE MAX. LOAD AT 'A' IN DIRECTION BA = $5.75 \times 1600 = 9200$ LBS.

TENSILE LOAD IN CA = 13000 LBS (ULT.)

GROSS AREAS:

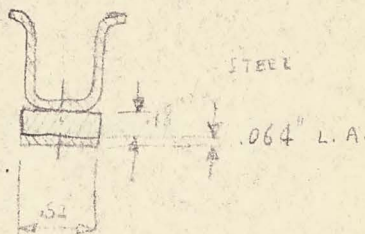
$$\text{STEEL} = .18 \times .52 = .0936 \text{ in}^2$$

$$\text{ALUM.} = .064 \times .52 = .0333 \text{ in}^2$$

NET AREAS:

$$\begin{aligned} \text{STEEL} &= .0936 - .1235 \times .15 \\ &= .0936 - .0231 = .0705 \text{ in}^2 \end{aligned}$$

$$\text{ALUM.} = .0333 - .009 = .024 \text{ in}^2$$



$$\text{EQUIVALENT NET STEEL AREA} = .0705 + \frac{10.5}{29.0} \times .024 = .0792 \text{ in}^2$$

$$\text{STRESS IN STEEL} = \frac{13000}{.0792} = 164000 \text{ LB/IN}^2$$

$$M.S. = \frac{164000}{170000} - 1 = .10$$



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- 707.34

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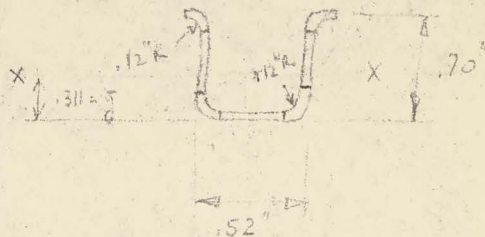
AREA = .0736 in²

.040" 7550

$$\bar{y} = \frac{.0176 \times .7 + .0304 \times .35}{.0736}$$

$$= \frac{.02196}{.0736}$$

$$= .311"$$



$$I_x = .688 \times (.291)^2 + .0176 \times (.231)^2 + .076 \times (.287)^2 + 2 \times \frac{1}{12} \times .012 \times (.70)^3$$

$$= 6.776 \times 10^{-4} + 9.38 \times 10^{-4} + 14.70 \times 10^{-4} + 3.65 \times 10^{-4}$$

$$= 34.51 \times 10^{-4} \text{ in}^4$$

TO CALCULATE THE ALLOWABLE COMPRESSIVE LOAD ON 'CA' :

LENGTH BETWEEN CLIPS = 6.0"

[REF: TIMOSHENKO THEORY OF ELASTIC STABILITY page 103]

DEFLECTION AT CLIP END ASSUMING 'CA' UNIFORMLY LOADED:

$$\frac{w}{\delta} = \frac{3/4 E I}{5 L^3} = \frac{304 \times 10^7 \times 34.51 \times 10^{-4}}{5 \times 36 \times 6} = 12290 \text{ LB/in}$$

$$\beta = \frac{12290}{5} = 4047 \text{ LB/in}^2$$

$$\frac{\beta L^2}{16 E I} = \frac{4047 \times 36 \times 36}{16 \times 30 \times 10^7 \times 34.51 \times 10^{-4}} = 33.0$$

$$\frac{L}{\rho} = .432$$

$$L = 2.59"$$



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

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AIRCRAFT:

C.110S

VENT STR. 702.30"

707.32

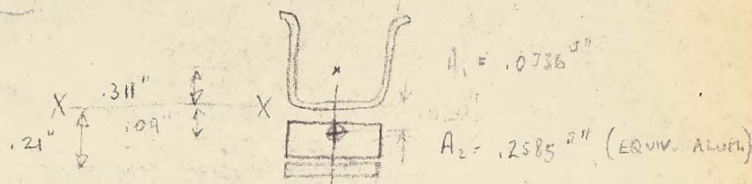
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EFFECT OF OFFSET
DUE TO WRMATURE:



$$\bar{y} = \frac{.0736 \times .311 - .2585 \times .09 - .0333 \times .21}{.3654}$$

$$= \frac{.0229 - .02325 - .00699}{.3654} = -.020" \text{ FROM X X}$$

$$I = .003416 + .0736 \times (.311)^2 + .000347 + .2918 \times (.09)^2$$

$$= .003416 + .00809 + .000347 + .00187 = .01372$$

(ABOUT CENTROID)

DUE TO CURVATURE, A MOMENT RESULTS FROM THE APPLICATION OF END LOAD.

$$\text{OFFSET} = .10"$$

$$\text{END LOAD} = 13000 \text{ LB (ULT. TENSION)}$$

$$\text{LENGTH} = 6.0"$$

THE MAX B.M. IS APPROXIMATELY GIVEN AS FOLLOWS.

$$M' = \frac{13000 \times .1}{1 + \alpha \frac{P L^2}{E I}}$$

(REF. ROARK, PAGE 133)

$$\frac{P L^2}{E I} = \frac{13000 \times 1^2}{10^6 \times .01372} = 3.41$$

$$\alpha = \frac{1}{2} \text{ (PIN ENDED - EQUAL & OPPOSITE END COUPERS)}$$



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MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

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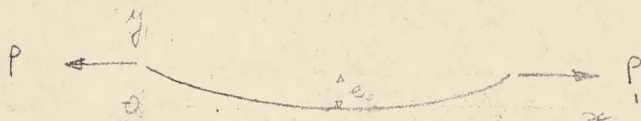
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$$M' = \frac{1300}{1+1.7} = 482 \text{ LB-IN (ULT.)}$$

MAKING A MORE EXACT ANALYSIS:

CONSIDER A STRUT WITH AN INITIAL BOW UNDER TENSION, AS SHOWN:



THE INITIAL CURVATURE IS GIVEN AS $e = e_0 \sin \frac{\pi x}{l}$

THE MOMENT AT ANY POINT IS $M = P(l - y)$

DIFFERENTIATING TWICE $\ddot{M} = P(\ddot{e} - \ddot{y})$

NOW $\ddot{e} = e_0 \left(\frac{\pi}{l} \right)^2 \sin \frac{\pi x}{l}$

$$\ddot{y} = -\frac{1}{EI} M$$

LET $\mu^2 = \frac{P}{EI}$

THE MOMENT CAN THEREFORE BE EXPRESSED BY THE FOLLOWING DIFFERENTIAL EQUATION

$$\ddot{M} - \mu^2 M = -P e_0 \left(\frac{\pi}{l} \right)^2 \sin \frac{\pi x}{l}$$

WHOSE SOLUTION IS

$$M = A \sinh \mu x + B \cosh \mu x + P e_0 \left[\frac{l}{l + l} \right] \sin \frac{\pi x}{l}$$

WHERE $\mu^2 = \frac{\pi^2 EI}{l^2}$



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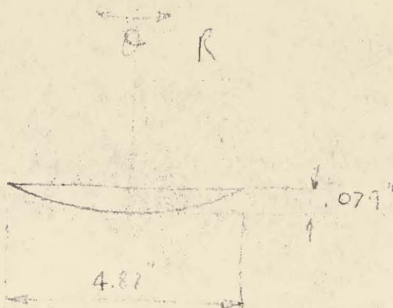
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Local CURVATURE:

$$(R - .079)^2 + (2.43)^2 = R^2$$

$$R^2 - .158R + .00624 + 5.9292 = R^2$$

$$R = 37.57"$$



Referring to Report ON "WINDS FOR ONE WAY AIR COOLING VALVES, #3 & #4 VENTS" SECTION 3

THE INCLUDED ANGLE θ IS θ BETWEEN POINTS 'A' & 'B'.

$\therefore$ MOMENT DUE TO CURVATURE BETWEEN POINTS 'A' & 'B' IS

$$M = \frac{q}{r} R^2 \left[\theta - \sin \theta \right]_0^{\theta}$$

$$= 1600 \times (37.57)^2 \left[.13963 - .13917 \right]$$

$$= 1600 \times 1411.5 \times .00046$$

$$M = 1039 \text{ LB-IN}$$

In accordance WITH CALCULATIONS MADE BY Mr. J. WATTS, THIS MOMENT CAN BE REACTED BY THE FRAMES WITHOUT ANY REINFORCING.



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C 105

AIR VENTS

REPORT No. 7-1058/67

SHEET No. 5.0

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SECTION 5

STRESSING

FRAME WEB STIFFENERS

SEE DRG: 7-1058-57/8.



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C-105

VENTS #1 & #2
to #2

REPORT NO. 7/0558/67

SHEET NO. 51

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DATE

FRAME WEB STIFFENERS:

IN THE REGION OF THE VENT DUCTS, THESE STIFFENERS HAVE TO PERFORM AN ADDITIONAL FUNCTION, NAMELY RESIST PRESSURES IN THE DUCT.

$$\text{PRESS. IN DUCT} = 16.65 \text{ LBS/SQ. (ULT)}$$

$$\text{PITCH OF STIFFENERS} = .27"$$

$$\text{DEPTH OF FRAME} = 3.0"$$

$$\text{AREA OF PANEL} = 8.1"$$

$$\text{FORCE ON PANEL} = 8.1 \times 16.65 = 134.9 \text{ LBS}$$

$$\text{PERIPHERY} = 11.4"$$

$$\text{LOAD/INCH} = \frac{134.9}{11.4} = 11.82 \text{ LB/IN}$$

$$\text{MAX. B.M.} = \frac{11.82 \times 9}{8} = 13.5 \text{ LB-IN}$$

TAKING 1" EFFECTIVE WEB AS ACTING WITH STIFFENER:

SKIN	$\bar{x}$	$A\bar{x}$
1 = .032"	0	0
2 = .0176"	0	0
3 = .016"	.25"	.004
4 = .0064"	.50"	.0032

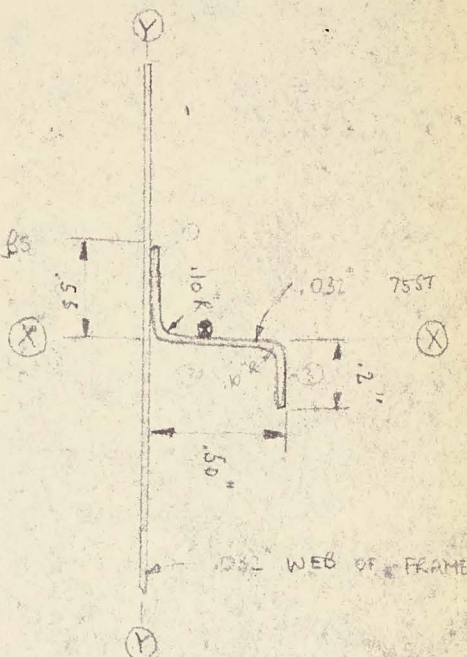
$$\Sigma A = .0720"$$

$$\Sigma A\bar{x} = .0072$$

$$\bar{x} = \frac{.0072}{.072} = .10"$$

MOMENT OF INERTIA ABOUT CENTROID

$$\begin{aligned} I &= .032 \times (.10)^2 + (.0176) \times (.10)^2 + .016 \times (.19)^2 + .0064 \times (.40)^2 + \frac{1}{12} \times .032 \times (.50)^3 \\ &= .000496 + .000360 + .001022 + .000333 \\ &= .00221 \text{ IN}^4 \end{aligned}$$





AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS

DWG 7-0158-290

REPORT No. 7/0558/67

SHEET No. 6.1

PREPARED BY

DATE

KAUTT

2/2/56

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BOTTOM DOORS
(VENTS 7 & 8)

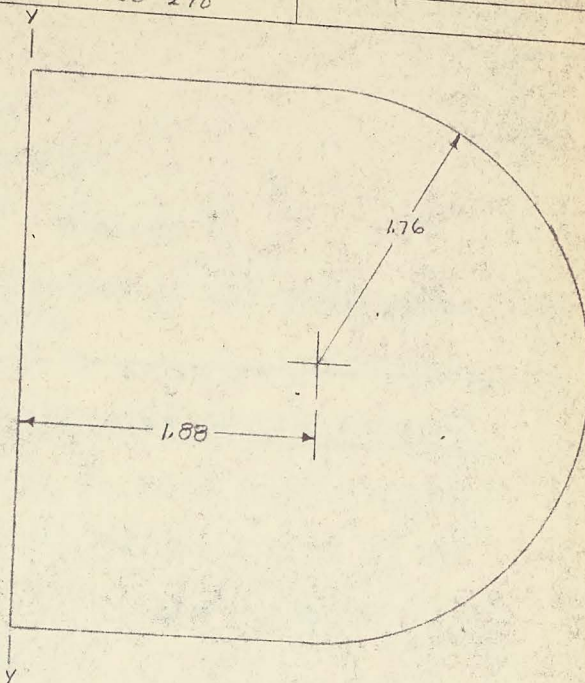
THE VENT DOORS ARE
CONSIDERED TO BE OF
THE DIMENSIONS SHOWN.
AXIS Y-Y REPRESENTS
THE HINGE LINE. NORMAL
PRESSURE ON THE DOOR
IS 24.85 PSIU

$$A = (2 \times 1.76)(1.88) + (.5)(1.76)^2 \pi$$

$$= 11.5 \text{ in}^2$$

TOTAL LOAD $W = PA$

$$W = 24.85 \times 11.5 = 286 \text{ \#}$$



THE TOTAL LOAD, W , IS CONSIDERED TO BE UNIFORMLY DISTRIBUTED
AROUND THE PERIMETER, S .

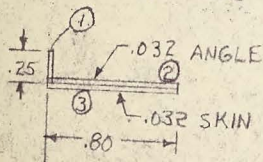
$$S = (2)(1.88) + 1.76\pi + (2)(1.76) = 12.8 \text{ in}$$

$$w = \frac{W}{S} = \frac{286}{12.8} = 22.3 \text{ \#/in}$$

THE STRUCTURE ALONG THE HINGE LINE IS CONSIDERED TO CARRY THE
UNIFORM LOAD w AS BENDING OF A SIMPLY SUPPORTED BEAM.

$$M_{MAX} = \frac{wL^2}{8} = \frac{(22.3)(3.52)^2}{8} = 34.6 \text{ in}\cdot\text{\#}$$

THE STRUCTURE ALONG THE HINGE LINE CONSISTS OF .032 755-T6 SKIN
PLUS AN .032 755-T6 LIPPED ANGLE SHOWN BELOW.



ITEM	b	A	Y	AY	AY ²	I ₀
1	.22	.00704	.174	.001225	.000213	.000028
2	.77	.02464	.048	.001183	.000057	.000002
3	.80	.02560	.016	.000410	.000007	.000002
Σ	—	.05728	—	.002818	.000277	.000032

$$\bar{y} = \frac{.002818}{.05728} = .0492 \text{ in}$$

$$I = .000309 - .000139 = .00017 \text{ in}^4$$

* NOTE: INCREASE SKIN TO .051 TO TAKE CARE OF PLATE STRESSES



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ONE-WAY COOLING AIR
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BOTTOM DOORS (CONT)

$$C = .25 + .032 - .049 = .233"$$

$$f = \frac{MC}{I} = \frac{34.6 \times .233}{.00017} = 47400 \text{ PSI}$$

THIS ANALYSIS IS CONSERVATIVE AS THE HINGE SHOULD CARRY LESS LOAD THAN WAS ASSUMED.

CHECK OF DOOR AS A PLATE UNDER UNIFORM PRESSURE

THE DOOR IS CONSIDERED TO BE A SQUARE PLATE.

FROM ROARK, 2nd EDITION, THE MAX STRESS, S, IS:

$$S = .2208 w d^2 (1 + \nu^2) / t^2 \quad \text{CASE 30, Pg 196}$$

WHERE: $w = 24.85 \text{ PSI}$

$d = 3.52"$

$\nu = .3$

$t = .051$

$$S = \frac{(.2208)(24.85)(3.52)^2(1.3)}{(.051)^2} = 34000 \text{ PSI}$$

PLATE IS OK

$F_y = 35,000 \text{ PSI}$



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ONE-WAY COOLING AIR
VENTS

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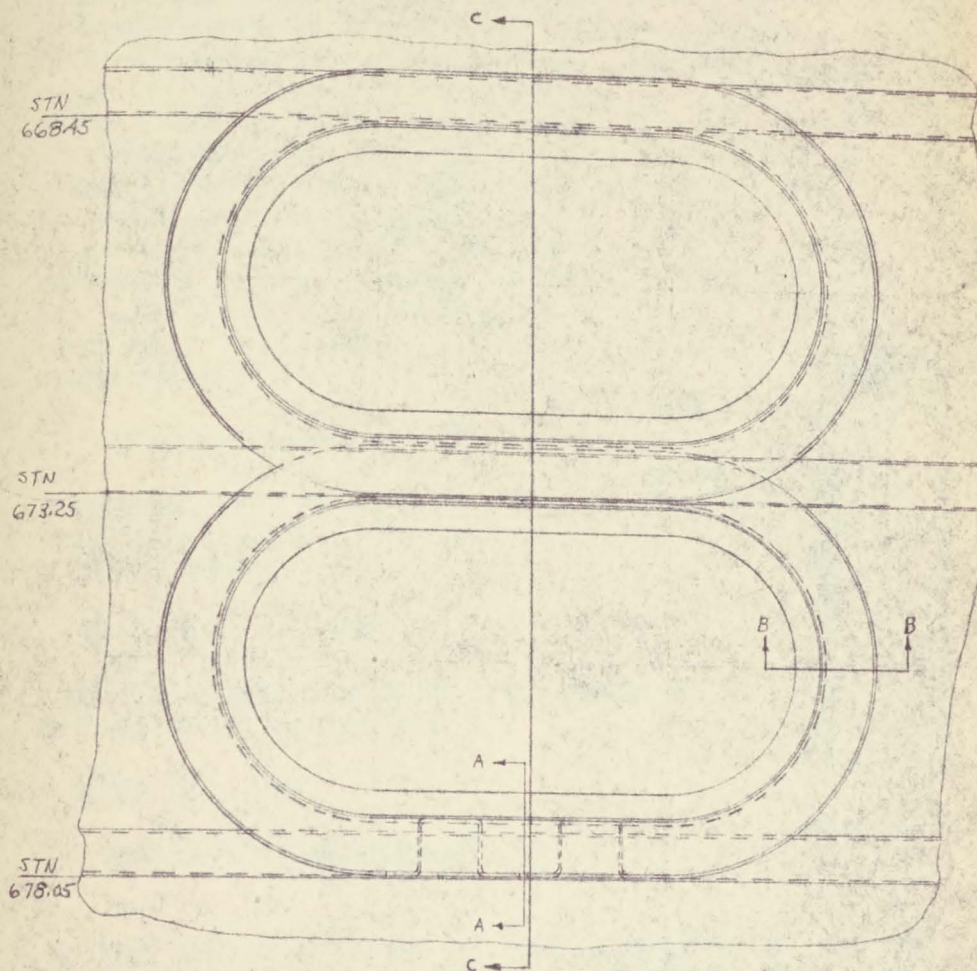
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VENTS 7' x 8'





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AIRCRAFT:

C105

CNE-WAY COOLING AIR
VENTS

DWG 7-0158-290

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VENTS 7 & 8 (CONT)

THE DUCT IS SUPPORTED BY TWO .032" 75S-T6 ZEE SECTIONS WHICH ACT AS FRAMES TO REACT THE INTERNAL PRESSURE LOADING IN THE DUCT. IT IS ASSUMED THAT THE UPPER FRAME SUPPORTS $2.42/2 = 1.21"$ OF PRESSURE LOAD, THE LOWER FRAME SUPPORTS $(2.42 + 2.62)/2 = 2.52"$ OF PRESSURE LOAD, & THAT $2.62/2 = 1.31"$ OF PRESSURE LOAD ARE SUPPORTED BY THE FUSELAGE SKIN & DUCT LIP. SINCE THE PRESSURE IS 24.85 PSID, THE LOADING ON THE LOWER FRAME IS:

$$W = 2.52 \times 24.85 = 62.6 \text{ \#/"} \text{ ULT.}$$

ASSUMING THE FRAMES TO BE ELLIPTICAL SHAPED WITH $a = 3.5"$ & $b = 2.0"$, THEN;

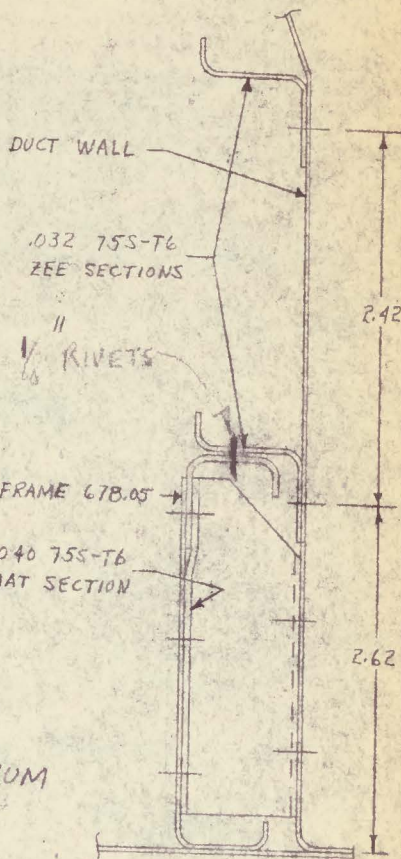
$$\frac{b}{a} = .57, \text{ \& FROM}$$

R.A.S. DATA SHEET 03.06.05, THE MAXIMUM MOMENT IS AT SECTION B-B, &

$$\frac{M}{W a^2} = .2, \text{ OR}$$

$$M = .2 W a^2 = (.2)(62.6)(3.5)^2 = 153 \text{ \#"} \text{ }$$

SECTION B-B IS THE SAME AS SECTION, IN SO FAR AS THE ZEE SECTIONS ARE CONCERNED. IT IS ASSUMED THAT 1" OF THE DUCT WALL ACTS WITH THE "Z" TO RESIST BENDING & AXIAL LOAD.



SECTION A-A



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VENTS
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VENTS 7 & 8

THE INTERNAL DUCT PRESSURE IS 24.85 PSIU. IT IS ASSUMED
THAT THE PRESSURE LOADING
IS RESISTED BY THE ZEE SECTIONS
PROVIDED FOR THAT PURPOSE

$$\text{HOOP TENSION} = PR = 24.85 \times 2 = 49.7 \text{ #/in}$$

$$\text{DUCT IS .032 75S-T6 SHT } f_c = \frac{49.7}{.032} = 1553 \text{ PSIU}$$

MS = HIGH

LOAD ON HAT SECTIONS

$$W = 3.75 P = 3.75 \times 24.85 = 93.2 \text{ #/in}$$

W IS RESISTED BY THE FOUR LEGS OF THE TWO HAT SECTIONS
AS COLUMNS. LOAD PER LEG = $93.2/4 = 23.3 \text{ #}$

CONSIDER LEGS AS PIN-ENDED COLUMNS WITH $L = .7 \text{ '}$

$$t = .04 \quad P = \frac{C}{t} = .0115 \quad \frac{L}{P} = \frac{.7}{.0115} = 61$$

FROM FIG. 6.1.3-3 AVRO E.M. $f_c = 26000 \text{ PSI}$

$$f = \frac{23.3}{.04} = 583 \text{ PSI}$$

MS = HIGH

TOTAL LOAD ON DOORS.

$$A = (3.75)(4) + \pi(2)^2 = 27.6 \text{ in}^2$$

$$W = PA = 24.85 \times 27.6 = 685 \text{ #}$$

ASSUMING THAT W IS REACTED BY 4 AD4 RIVETS AT EACH
SIDE OF DUCT, LOAD/RIV = $(.125)(685) = 86 \text{ #}$

$$\text{SHEAR VALUE} = 388 \times .964 = 374 \text{ #}$$

MS = HIGH



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ONE-WAY COOLING AIR
VENTS
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VENTS 7 & 8 (CONT)

ASSUME THAT w IS RESISTED EQUALLY AROUND PERIMETER (s) OF DUCT.

$$s = (3.75)(2) + 2\pi(2) = 20.1"$$

$$w = \frac{W}{s} = \frac{685}{20.1} = 34.1 \#/\text{in}$$

ASSUME THAT w IS TRANSFERRED TO SIDE RIVETS BY THE DUCT SIDEWALL BY BEAM ACTION. ASSUMED LENGTH IS 4"

$$M_{\text{MAX}} = \frac{wL^2}{8} = \frac{34.1 \times 16}{8} = 68.2 \text{ "#}$$

SIDE WALL IS 5" DEEP, $t = .032"$

$$f = \frac{6M}{th^2} = \frac{6 \times 68.2}{.032 \times (5)^2} = 512 \text{ PSI}$$

HOOP TENSION IS 1430 PSI SO THERE IS NO RESULTANT COMPRESSION.

$$f_{t\text{MAX}} = 512 + 1430 = 1942 \text{ PSI}$$

MS = HIGH

~~TOTAL SIDE LOAD = 93.2 #/in ASSUMING HALF GOES TO EACH HAT SECTION & IS REACTED BY FRAME CAPS. THE MAXIMUM SIDE LOAD ON A FRAME CAP (FROM EACH HAT) IS: ($h = 5"$)~~

~~$$R = 93.2 \times \frac{1}{2} \times \frac{1}{2} \times 5 = 116.5 \#$$~~



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AIR VENTS
DWG 7-0158 290

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VENTS 7 & 8 (CONT)

CHECK OF SIDE WALL, COMBINED TENSION & SHEAR.

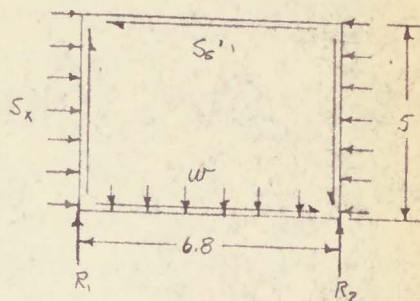
CONSIDER, THE DEVELOPED LENGTH OF THE END PORTION OF THE DUCT AS A FLAT PANEL.

$$R_1 = R_2 = .5 \times 6.8 \times w \\ 3.4 \times 34.1 = 116 \text{ #}$$

$$\text{SHEAR STRESS} = \frac{R}{bt} = S_s$$

$$b = 5 \quad t = .032$$

$$S_s = \frac{116}{.032 \times 5} = 725 \text{ PSI}$$



FROM ROARK, 2nd ED, SHT 302, CASE E:

$$S'_s = \sqrt{C^2 \left(2\sqrt{1 - \frac{S_y}{C}} + 2 - \frac{S_x}{C} \right) \left(2\sqrt{1 - \frac{S_y}{C}} + 6 - \frac{S_y}{C} \right)}$$

$$\text{WHERE: } C = \frac{.823 \left(\frac{t}{b} \right) E}{1 - \nu^2}$$

$$\nu = .3$$

$$E = 10.5 \times 10^6 \text{ PSI}$$

$$t = .032 \text{ "}$$

$$b = 5 \text{ "}$$

$$C = 389 \text{ PSI}$$

$$S_x = -1430 \text{ PSI (HOOP TENSION)}$$

$$S_y = 0$$

THEN:

$$S'_s = 3049 \text{ PSI}$$

$$MS = \frac{3049}{725} - 1 > 1$$



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C 105

ONE-WAY COOLING AIR
VENTS

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REPORT NO 7/0558/67

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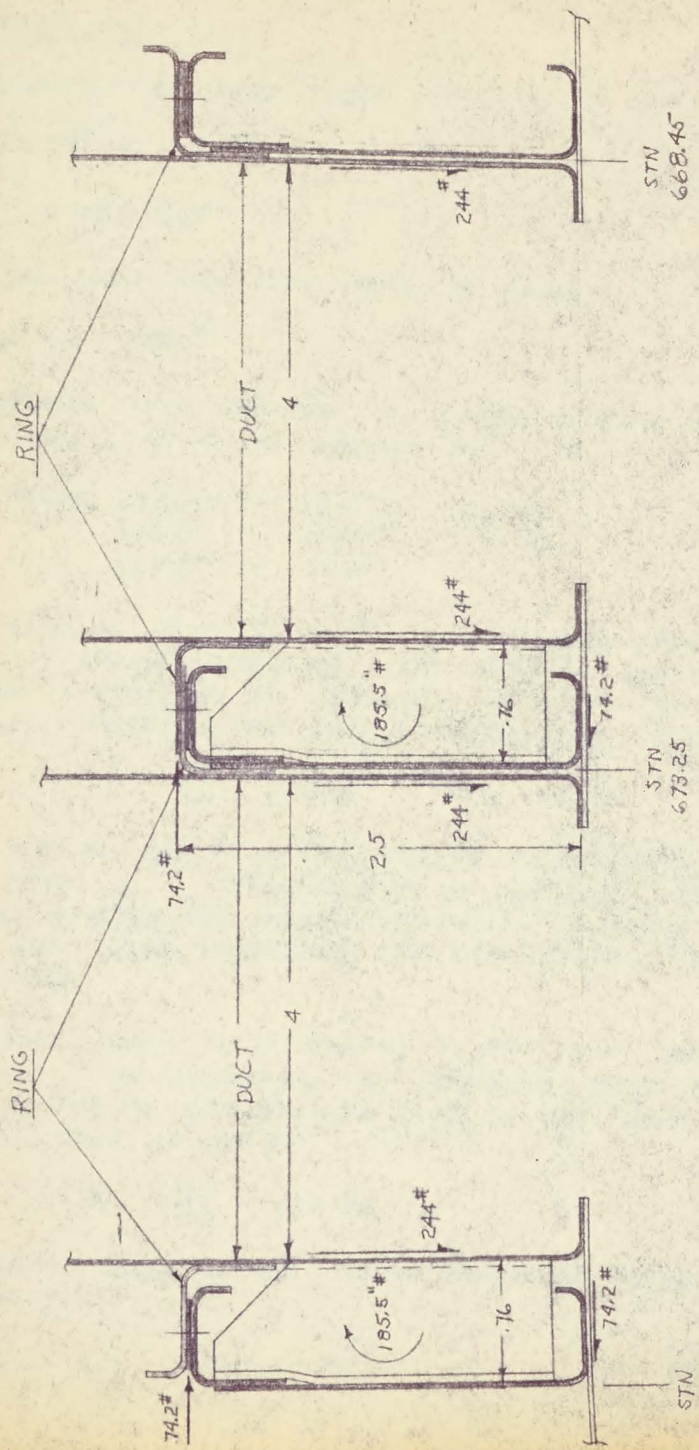
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SECTION C-C



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AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS
DWG 7-0158-290

REPORT NO. 7/0558/67

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SECTION C-C

DIAMETER OF VENT TUBES = 5"

$$A = \frac{\pi D^2}{4} = 19.65 \text{ in}^2$$

$$P = 24.85 \text{ PSI}$$

TOTAL LOAD FROM TUBE GOING TO FRAMES

$$W = PA = 488 \text{ #}$$

ASSUMING THAT ONE-HALF OF W GOES TO EACH FRAME, THE VERTICAL LOAD ON THE FRAMES IS:

$$\text{FRAME } 678.05 \sim 244 \text{ #}$$

$$\text{" } 673.25 \sim 488 \text{ #}$$

$$\text{" } 668.45 \sim 244 \text{ #}$$

AS SEEN IN SECT. C-C, 244 # IS TRANSFERRED FROM THE DUCT SIDE WALL TO FRAMES 678.04 & 673.25 THRU THE HAT SECTIONS. THIS CAUSES A MOMENT OF $244 \times .76 = 185.5 \text{ #}$. THIS MOMENT WILL BE REACTED BETWEEN THE SKIN & LOWER RING. COUPLE LOAD IS

$$P' = \frac{M}{2.5} = 74.2 \text{ #}$$

THE INDUCED LOAD P' IN THE RING IS TRANSFERRED TO THE DUCT SIDE WALL, & IS SHEARED DOWN TO THE SKIN. THE LOAD P' ACTS ON THE RING IN THE OPPOSITE DIRECTION FROM THE PRESSURE LOAD. THIS WILL TEND TO REDUCE THE RING BENDING MOMENT SHOWN ON SHT. 64.

ASSUMING THAT P' IS REACTED BY THE DUCT WALL IN A SINUSOIDAL DISTRIBUTION, THE MAXIMUM SHEAR WILL OCCUR AT THE CENTER OF THE ROUNDED ENDS OF THE DUCT & WILL HAVE A MAGNITUDE OF 11.8 #/in .

$$f_s = \frac{11.8}{.032} = 368 \text{ PSI}$$

IF THIS IS ADDED TO THE STRESS FOUND ON SHT. 64, THE TOTAL STRESS IS

$$f_{\text{TOT}} = 725 + 368 = 1093 \text{ PSI}$$

$$MS = \frac{3049}{1093} - 1 > 1$$



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AIRCRAFT:

C 105

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AIR VENTS
DWG 7-0158-290

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SECTION C-C (CONT.)

AS THE SHEAR LOAD OF 74.2#, INTRODUCED INTO THE DUCT BY THE RING, IS TRANSFERRED DOWN TO BE REACTED BY THE SKIN, A MOMENT OF $74.1 \times 2.3 = 185.5$ # IS INDUCED IN THE DUCT. THIS MOMENT WILL BE REACTED BY THE FRAMES AS A COUPLE. THIS COUPLE LOAD IS

$$P'' = \frac{185.5}{4.8} = 39.7 \#$$

P'' WILL REDUCE THE LOAD ON FRAME 678.05 & ADD TO THE LOAD ON FRAME 668.45. THE FRAME LOADS WILL THEN BE:

$$\begin{aligned} \text{FRAME } 678.05 &\sim 244 - 39.7 = 204.3 \# \\ \text{" } 673.25 &\sim 488 \# \\ \text{" } 668.45 &\sim 244 + 39.7 = 283.7 \# \end{aligned}$$



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AIRCRAFT:

C 105

PRESSURE VENT
DOORS 5 & 6
DWG 7-105B-5755

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THE ANALYSIS OF DOORS 5 & 6 IS THE SAME AS FOR DOORS 7 & 8, SHEETS 6.1 & 6.2, EXCEPT THAT THE 1.88" DIMENSION IS 3.36", & THE NORMAL PRESSURE ON THE DOOR IS 16.65 PSI ULT (REF. M. SEVIK)

$$A = (2)(1.76)(3.36) + (1.5)(1.76)^2 \pi = 16.7 \text{ "}^2$$

$$W = PA = 16.65 \times 16.7 = 278 \text{ #}$$

SINCE THE TOTAL LOAD W IS LESS THAN FOR DOORS 7 & 8, WHICH IS 286 # (REF. SHT. 6.1) THE PERIMETER LOADING WILL BE LESS, & THE HINGE IS OK BY COMPARISON.

CHECK OF DOOR AS RECTANGULAR PLATE

FROM. ROARK, 2ND EDITION CASE 36, Pg 197, THE MAXIMUM STRESS IS:

$$S_b = \frac{-1.75wb^2}{t^2(1 + 1.61\alpha^2)}$$

WHERE: $w = 16.65 \text{ PSI}$

$$b = 2 \times 1.76 = 3.52 \text{ "}$$

$$a = 1.76 + 3.36 = 5.12 \text{ "}$$

$$t = .051 \text{ "}$$

$$\alpha = b/a = 3.52/5.12 = .688$$

$$S_b = \frac{(-.75)(16.65)(3.52)^2}{(.051)^2 [1 + (1.61)(.688)^2]} = \frac{154.6}{.00345} = 44800 \text{ PSI}$$



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VENTS

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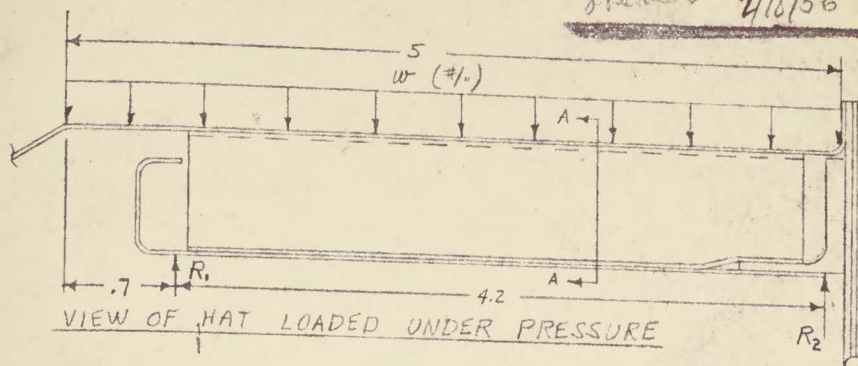
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VENTS 7 & 8 (CONT)

sketch 2/10/56



TOTAL SIDE LOAD = 93.2 #/". ASSUMING THAT 50% GOES TO EACH HAT SECTION;

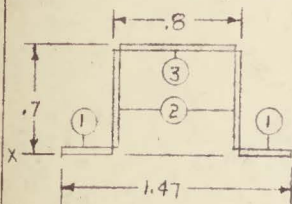
$$W = 93.2 \times .5 = 46.6 \text{ #/"}$$

$$R_1 = \frac{(5)(46.6)(.25-.1)}{4.2} = 133 \text{ #}$$

$$R_2 = (5)(46.6) - 133 = 100 \text{ #}$$

MAXIMUM MOMENT ON HAT SECTION = 108" #

HAT IS MADE FROM .040 75S-T6



ITEM	A	Y	AY	AY ²	I ₀
1	.0268	.02	.00054	.00001	
2	.0496	.35	.01736	.00608	.00159
3	.0288	.68	.01958	.01332	
Σ	.1052		.03748	.01941	.00159

$$\bar{Y} = \frac{.03748}{.1052} = .356 \text{"}$$

$$I = .02100 - .01335 = .00765 \text{"}^4$$

$$f_t = \frac{108 \times .356}{.00765} = 5026 \text{ PSI}$$

MS = HIGH

$$f_c = \frac{108 \times .344}{.00765} = 4856 \text{ PSI}$$

CRIPPLING OF ITEM ③

$$\frac{b}{L} = \frac{.62}{.04} = 15.5$$

$$F_{cc} = 44500 \text{ PSI REF LOCKHEED SB 1151}$$

MS = HIGH



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C.105

CUT-OUT FOR ONE WAY

AIR LOADING VALVE
#3 & #4 VENTS

REPORT NO. 7/2555/67

SHEET NO. 3.8

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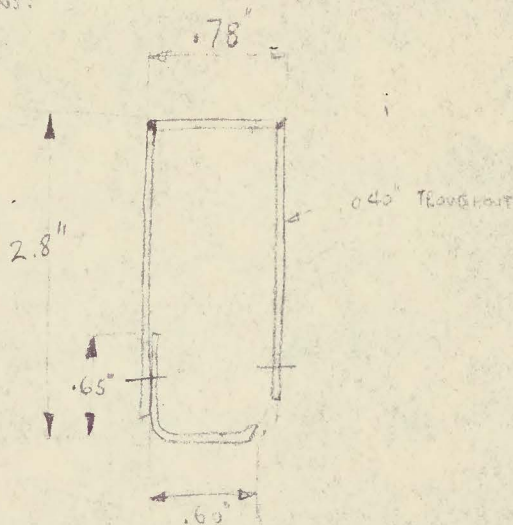
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MEMBER EB IS SUBJECTED TO AN END LOAD AND A MOMENT DUE TO ECCENTRICITY. AGAIN THE STRESSES PRODUCED BY THE MOMENT RELIEVE THOSE DUE TO THE END LOAD AND HENCE THE STEEL & SKIN ARE O.K.

$$\text{Moment} = .24 \times 13070 = 3140 \text{ LB-IN (ULT)}$$

THIS MOMENT IS LOCALIZED IN THE REGION OF THE CUT-OUT ONLY. THIS REGION IS ALREADY REINFORCED BY VIRTUE OF DESIGN REQUIREMENTS OTHER THAN STRESS. USE CAN BE MADE THEREFORE, OF AVAILABLE MATERIAL TO CARRY THIS ADDITIONAL B.M.

THE MATERIAL ADDED (OR PURCHASED OTHER THAN STRENGTH REQUIREMENTS) IS AS FOLLOWS:



$$I = \frac{1}{12} \times .78 \times (2.8)^3 - \frac{1}{12} \times .70 \times (2.72)^3$$

$$= \frac{1}{12} \left[.78 \times 21.9520 - .70 \times 20.1436 \right] = \frac{3.036}{12} = .253 \text{ in}^4$$

$$f = \frac{3140 \times 1.4}{.253} = 17400 \text{ LB/IN}^2 \quad \text{O.K.}$$



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MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C 105

CUT - OUTS FOR ONE
WAY AIR COOLING
VALVES "S&A VENT"

REPORT NO. 7/0558/67

SHEET NO. 3.9

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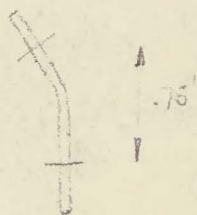
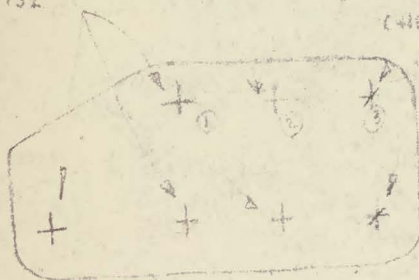
CLIPS AT CORNERS OF DIAGONAL MEMBERS:



$$V = 13070 \times \sin 7.9^\circ = 13070 \times .13744 = 1794 \text{ LBS (ULT)}$$

5/32" AN 420

2-1/8" DIA
CHERRY WOOD



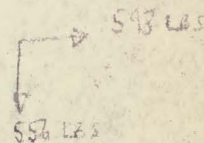
$$\text{MOMENT DUE TO OFFSET} = 1794 \times .375 = 674 \text{ LB IN}$$

CONSIDER RIVETS 1, 2, 3, 4:

$$\text{VERT LOAD} = \frac{1794}{2 \times 1} = 598 \text{ LBS}$$

$$\text{DUE TO MOMENT} = \frac{674}{2 \times 1.21} = 556 \text{ LBS}$$

$$\text{VECTORIAL SUM} = 816 \text{ LBS} = 408 \text{ LBS}$$



ALLOW. LOAD ON A 1/8" CHERRY
WOOD IS 251 POUNDS PER LINEAL INCH

ALLOW. BENDING

(SEE PAGE 10)

$$.655 \times 1.37 \times 60 = 719 \text{ LBS}$$

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C-105

REPORT NO. 710558/67

SHEET NO. 4.1

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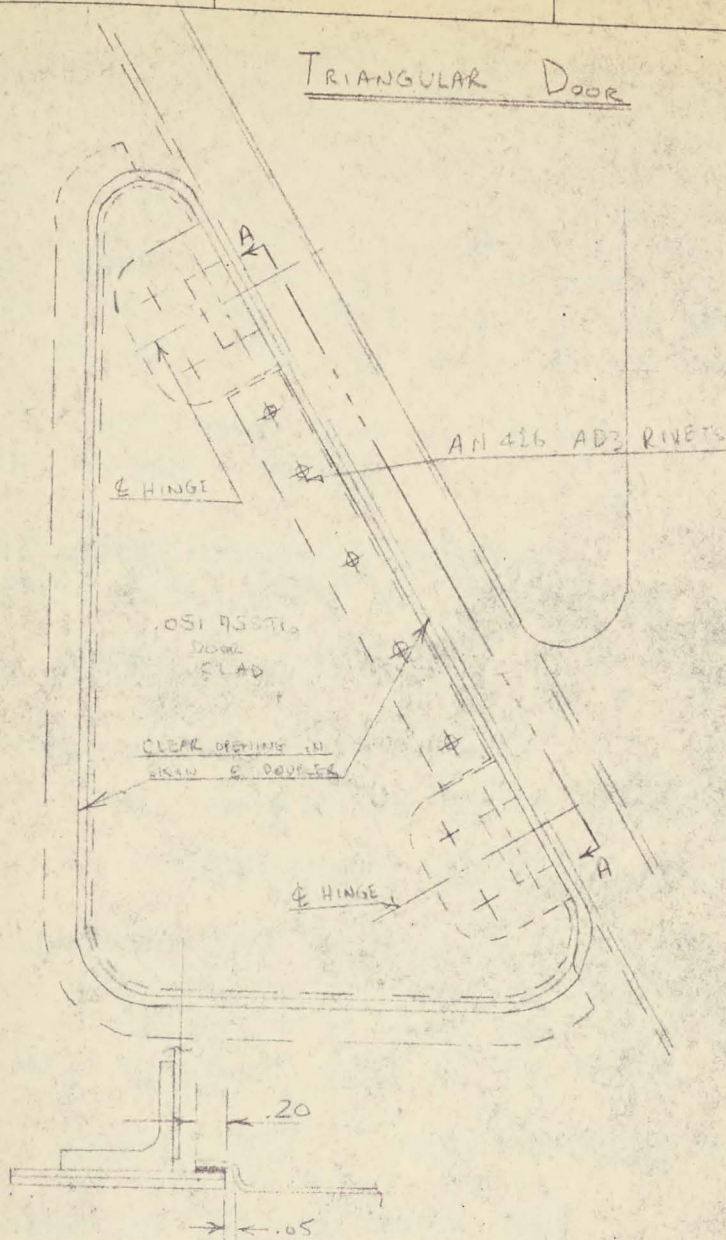
R. MELVILLE

9 FEB 1956

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TRIANGULAR DOOR



TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C-105

REPORT NO. 7/0558/67

SHEET NO. 4.2

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TRIANGULAR DOOR (CONTINUED)

IT IS REQUIRED TO FIND THE STRESSES IN THE TRIANGULAR DOOR SHOWN ON THE PREVIOUS PAGE. THE DOOR SURFACE, WHICH IS CURVED SLIGHTLY, WILL BE ASSUMED TO BE FLAT.

THE SHAPE OF THE DOOR, APPROXIMATES TWO DIFFERENT SHAPES FOR WHICH THE STRESSES CAN EASILY BE FOUND. THE MAXIMUM DOOR STRESS WILL BE FOUND BY ASSUMING THAT THE DOOR IS

- 1) A RIGHT ANGLE ISOSCELES TRIANGLE AND
- 2) A CIRCULAR SECTOR.

1) RIGHT ANGLE ISOSCELES TRIANGLE

(REFERENCE ROARK, TABLE X CASE 66)

$$\text{Max } S = \text{Max } S_x = .131 \frac{w a^2}{t^2} \quad \text{IF } \nu \text{ IS TAKEN AS } .3$$

AND WHERE w = UNIT APPLIED LOAD, $\frac{\#}{\text{IN}^2}$

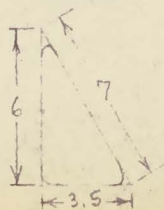
a = LENGTH OF ONE OF THE EQUAL SIDES, INCHES

t = THICKNESS OF PLATE, INCHES

A CHECK WILL FIRST BE MADE TO SEE IF THE DEFLECTION REQUIREMENT IS FULFILLED. THAT IS, THE DERIVATIONS ARE BASED UPON THE ASSUMPTION THAT THE DEFLECTION DOES NOT EXCEED $\frac{1}{2}$ THE THICKNESS OF THE PLATE.

$$\text{Max } y = .0055 \frac{w a^4}{E t^3} \quad \text{WHERE } E = \text{MODULUS OF ELASTICITY } \frac{\#}{\text{IN}^2}$$

THE DIMENSIONS OF THE PLATE ARE:



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TRIANGULAR DOOR (CONTINUED)

THE DEFLECTION IS A MAXIMUM WHEN "a" IS A MAXIMUM.
∴ LET $a = 6$ IN.

$$w = 16 \text{ #/IN}^2$$

$$t = .051 \text{ IN}$$

$$E = 1.03 \times 10^7 \frac{\text{#}}{\text{IN}^2} \xrightarrow{\text{TEMP. CORRECTION}} (.933) = 9.51 \times 10^6 \frac{\text{#}}{\text{IN}^2}$$

$$\text{MAX } y = .0095 \frac{16 \text{ #/IN}^2 (6 \text{ IN})^4}{9.51 \times 10^6 \text{ #/IN}^2 (.051 \text{ IN})^3} = .155 \text{ IN}$$

THE DEFLECTION IS TOO GREAT FOR ACCURATE ANSWERS FROM THE DERIVED FORMULAS. THE DEFLECTION SHOULD NOT BE GREATER THAN $\frac{t}{2} = \frac{.051}{2} = .0255 \text{ IN}$

$$\text{IF } a = 3.5 \text{ IN. } \text{MAX } y = .155 \text{ IN} \left(\frac{3.5^4}{1300} \right) = .0179 \text{ IN O.K.}$$

BY REFERRING TO THE SECOND PARAGRAPH IN ARTICLE 58 OF ROARK WE SEE THAT IT WOULD BE CONSERVATIVE TO CALCULATE THE, DUE TO THE GIVEN LOAD, ACCORDING TO ORDINARY THEORY. THIS IS BECAUSE THE DEFLECTION IS SO LARGE.

THE MAXIMUM STRESSES WILL BE CALCULATED FOR BOTH THE $a = 6$ INCH CASE AND THE $a = 3.5$ INCH CASE.

FOR $a = 6$ INCHES

$$\text{MAX } S = \text{MAX } S_x = .131 \frac{w a^2}{t^2} = .131 \frac{16 \text{ #/IN}^2 (6 \text{ IN})^2}{(.051 \text{ IN})^2}$$

$$\text{MAX } S = 29,000 \text{ PSI}$$

FOR $a = 3.5$ INCHES

$$\text{MAX } S = 29000 \left(\frac{3.5^2}{36} \right) = 9900 \text{ PSI}$$

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TRIANGULAR DOOR (CONTINUED)

2) CIRCULAR SECTOR (REF. ROARK, TABLE X CASE 67)

AGAIN THE DEFLECTION WILL BE TESTED, FIRST.

$$\text{MAX } y = \alpha \frac{w a^4}{E t^3}$$

WHERE a = RADIUS OF CIRCULAR SECTOR

α = COEFFICIENT GIVEN BY TABLE IN THE REFERENCE LISTED ABOVE.

$\theta = 30^\circ$ SINCE α FOR $\theta = 30^\circ$ IS NOT GIVEN, WE WILL USE α FOR $\theta = 45^\circ$ $\alpha = .0054$

$$\text{MAX } y = \alpha \frac{w a^4}{E t^3} = .0054 \frac{16 \#/\text{IN}^2 (6 \text{ IN})^4}{9.51 \times 10^6 \#/\text{IN}^2 (.051)^3} = .088 \text{ IN.}$$

DEFLECTION IS LARGER $\frac{t}{2}$

A PLOT OF α VS. θ IS SHOWN ON THE FOLLOWING PAGE. EXTRAPOLATING THE CURVE OF α TO ZERO GIVES A VALUE OF $\alpha = .003$. THEN

$$\text{MAX } y = .088 \left(\frac{.003}{.0054} \right) = .049 \text{ IN.}$$

DEFLECTION STILL TOO LARGE.

IT IS OBVIOUS THAT IF 7 INCHES WERE USED FOR "a" THE DEFLECTION WOULD EVEN BE LARGER, HOWEVER AS EXPLAINED ABOVE, THE CALCULATED STRESSES WILL BE LARGER THAN THE ACTUAL STRESSES.

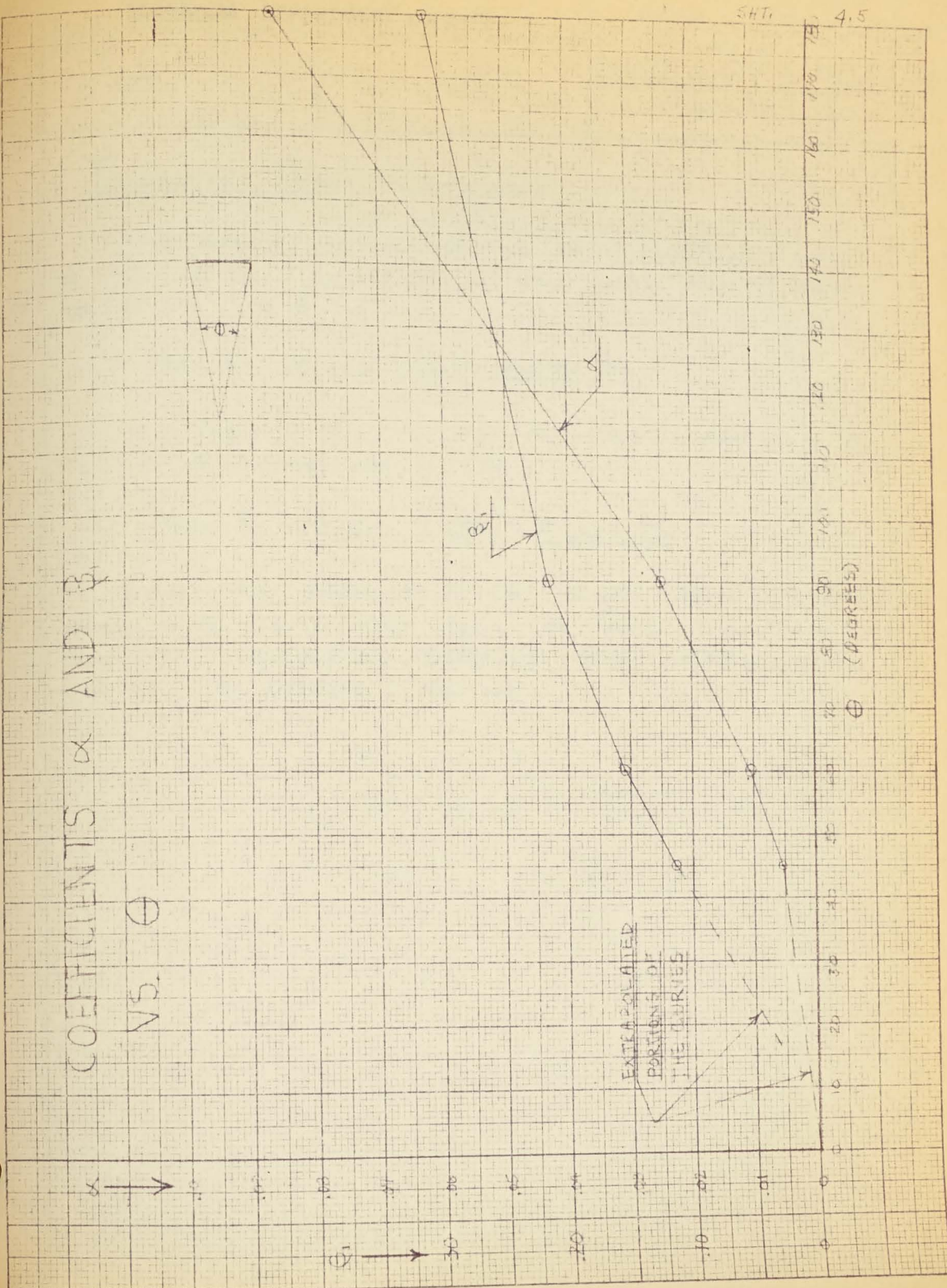
MAX S = MAX S_t = MAX. TANGENTIAL STRESS (FOR $\theta = 45^\circ$)

$$\text{MAX } S = R, \frac{w a^2}{t^2} = .114 \frac{16 \#/\text{IN}^2 (6 \text{ IN})^2}{(.051 \text{ IN})^2} = \underline{25,300 \text{ PSI}}$$

RPT 7/0558/61

R. MELVILLE
10 FEB 1966
SHT 4.5

COEFFICIENTS α AND β VS. θ



TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

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TRIANGULAR DOOR (CONTINUED)

THE GRAPH ON THE PREVIOUS PAGE SHOWS A PLOT OF β_1 VS. θ . EXTRAPOLATING THIS CURVE GIVES A VALUE FOR $\theta = 30^\circ$ OF $\beta_1 = .07$

$$\text{Max } S = 25,300 \left(\frac{.07}{.114} \right) = \underline{15,500 \text{ PSI}}$$

IF THE 7 INCH SIDE OF THE TRIANGLE WERE USED AS THE CIRCULAR SECTOR RADIUS, THE

$$\text{Max } S = 15,500 \left(\frac{7^2}{36} \right) = \underline{21,100 \text{ PSI}}$$

EVEN THE LARGEST OF THE VALUES ABOVE (29,000 PSI) WOULD NOT CAUSE THE DOOR TO FAIL. IN EACH CASE THE CALCULATED STRESSES ARE CONSERVATIVELY HIGH. (DUE TO EXCESSIVE DEFLECTION)

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

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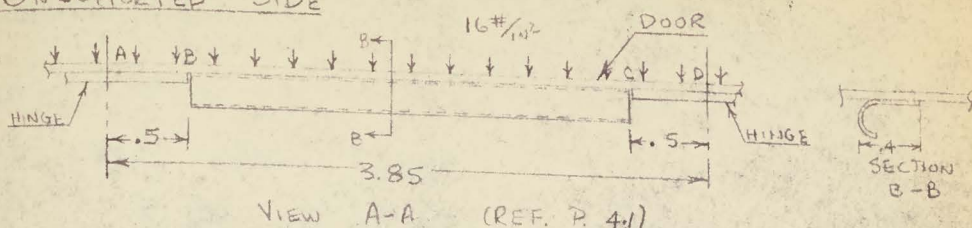
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TRIANGULAR DOOR (CONTINUED)

UNSUPPORTED SIDE



THE PART OF THE DOOR BETWEEN THE TWO HINGES IS UNSUPPORTED.

CONSIDERING THAT PART OF THE DOOR AS A BEAM (BETWEEN POINTS "A" AND "D"), THERE WILL BE CRITICAL POINTS AT "B" AND "C". THE STRESSES AT POINTS "B" AND "C" WILL BE INVESTIGATED, ASSUMING FIRST 100% FIXITY AT POINTS "A" AND "D" AND SECOND ASSUMING A PIN JOINT.

SIMPLY SUPPORTED

MOMENT AT POINT "B"

$$M_x = \frac{w l x}{2} - \frac{w x^2}{2} = \frac{16 (3.85)(.5)}{2} - \frac{16 (.5)^2}{2}$$

$$= 13.4 \text{ IN-}\#$$

FIXED

MOMENT AT POINT "B"

$$M_x = \frac{w l^2}{2} \left(\frac{1}{6} - \frac{x}{l} + \frac{x^2}{l^2} \right) = \frac{16 (3.85)^2}{2} \left(\frac{1}{6} - \frac{.5}{3.85} + \frac{.5^2}{3.85^2} \right)$$

$$M_x = 6.36 \text{ IN-}\#$$

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

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REPORT NO. 7/0558/67

SHEET NO. 4.8

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TRIANGULAR DOOR (CONTINUED)

UNSUPPORTED SIDE (CONTINUED)

THE STRESS WILL BE

A) FOR SIMPLE SUPPORT

$$f = \frac{MC}{I} = \frac{M \frac{t}{2}}{\frac{bt^3}{12}} = \frac{6M}{bt^2} = \frac{6(13.4)}{.4(.057)^2} = 77,000 \text{ PSI}$$

B) FOR FIXED

$$f = 77,000 \left(\frac{6.36}{13.4} \right) = 36,500 \text{ PSI}$$

ASSUME A 50% FIXITY

THE STRESS IS:

$$f = [77,000 - 36,500(.50)] + 36,500$$

$$= 56,750 \text{ PSI}$$

$$F_{TU} = 72,000(.795) = 57,100$$

$$M.S. = \frac{57,100}{56,750} - 1 = .01$$

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS
DWG 7-0158-353

REPORT NO. 7/0558/67

SHEET NO. 2.15

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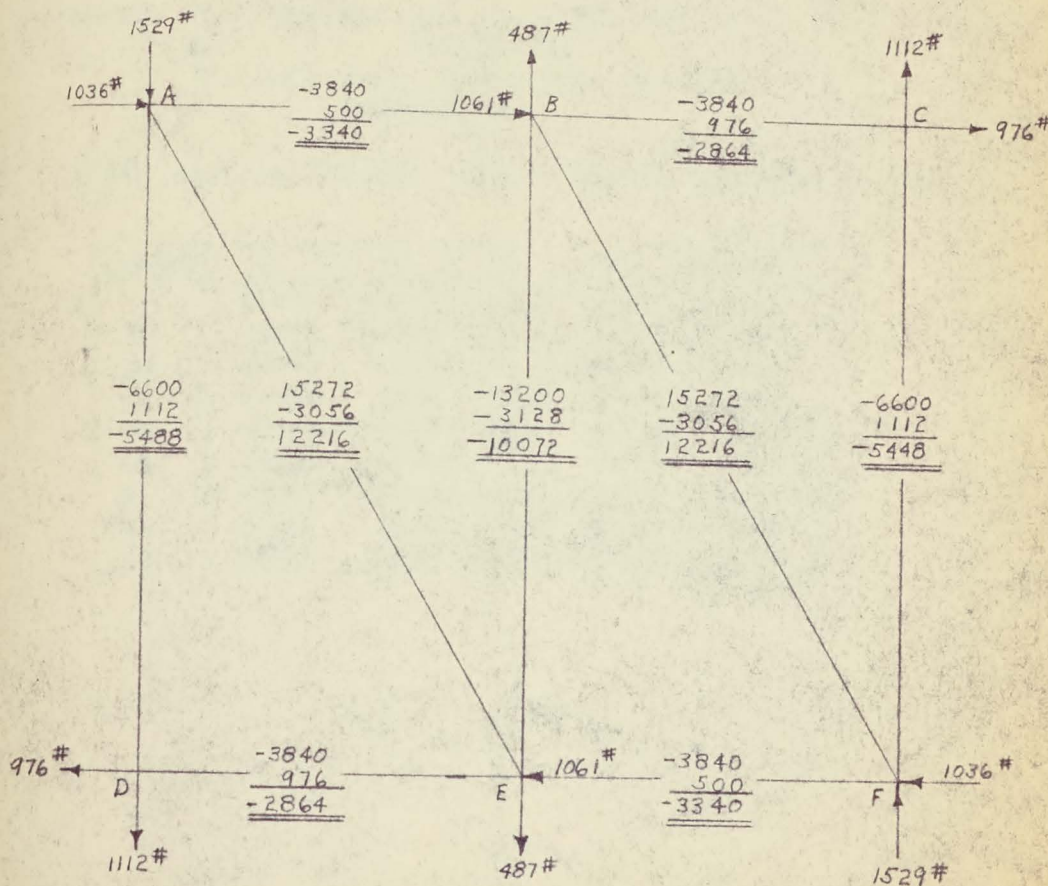
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CHANGE IN TRUSS AXIAL LOADS (CONT.)

THE JOINT LOADS SHOWN ON SHT. 2.14 ARE RESOLVED INTO HORIZONTAL & VERTICAL COMPONENTS & SUMMED UP AT EACH JOINT. THESE VALUES ARE SHOWN IN THE SKETCH BELOW. FROM THESE LOADS, CORRECTING AXIAL LOADS ARE FOUND & SUPERIMPOSED ON THE ORIGINAL LOADS. THESE ARE ALSO SHOWN ON THE SKETCH BELOW. THE TOP NUMBER IS THE ORIGINAL AXIAL LOAD (REF. SHT. 2.1) THE MIDDLE NUMBER IS THE CORRECTING LOAD DUE TO MOMENT, & THE LOWER NUMBER (UNDERScoreD) IS THE RESULTANT, (OR CORRECT) AXIAL LOAD.



NOTE: PLUS AXIAL LOAD IS TENSION.



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AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS

DWG 7-0158-353

REPORT NO. 710558/67

SHEET NO. 2.16

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CHANGE IN TRUSS DEFLECTIONS

THE TRUSS AXIAL LOADS (SHT. 215) ARE CHANGED ENOUGH BY THE JOINT STIFFNESS TO WARRANT FURTHER INVESTIGATION INTO THE TRUSS DEFLECTIONS. THIS IS DONE BY MEANS OF ANOTHER WILLIOT DIAGRAM (REF. SHTS. 25-28). SINCE A, L, & E REMAIN THE SAME, THE DEFORMATIONS OF THE TRUSS WILL BE IN THE RATIO OF THEIR AXIAL LOADS. THUS:

$$\Delta' = \frac{P'\Delta}{P}$$

WHERE: P = ORIGINAL AXIAL LOAD (REF. SHT. 21)

Δ = " DEFORMATION " " "

P' = NEW AXIAL LOAD (REF. SHT. 215)

Δ' = " DEFORMATION.

THESE NEW VALUES ARE SUMMARIZED IN THE TABLE BELOW.

MEMBER	Δ	P	P'	$P'\Delta$	$\Delta' = P'\Delta/P$
CF	-.01099	-6600	-5488	60.313	-.0091
BC	-.00553	-3840	-2864	15.838	-.0041
BF	.04141	15272	12216	505.865	.0331
EF	-.00553	-3840	-3340	18.470	-.0048
DE	-.00553	-3840	-2864	15.838	-.0041
AB	-.00553	-3840	-3340	18.470	-.0048
BE	-.02287	-13200	-10072	230.347	-.0175
AD	-.01099	-6600	-5488	60.313	-.0091
AE	.04141	15272	12216	505.865	.0331

A. V. ROE CANADA LIMITED

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TECHNICAL DEPT. (AIRFRAME)

AIRCRAFT

C 105

WEIGHT

C. G. POSITION

REPORT NO.

7/0558/67

SHEET

2.17

DATE

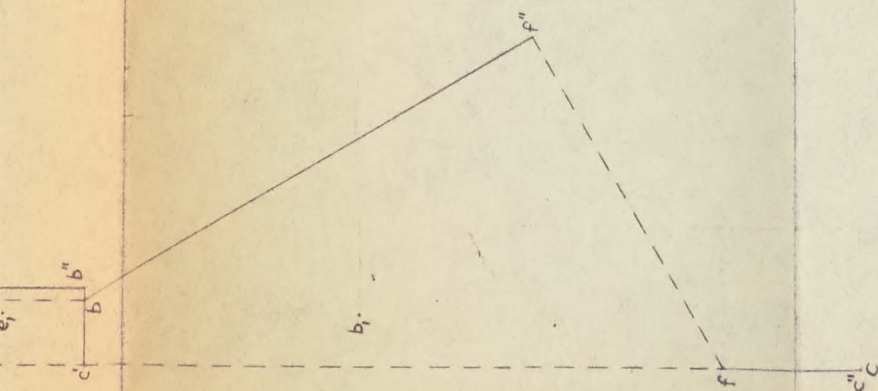
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E. KAUTT

DIAGRAM FOR CORRECTED TRUSS DEFLECTIONS
DEFLECTIONS FROM SHT. 2.8 SHOWN FOR COMPARISON. (DENOTED BY SUBSCRIPT 1)

SCALE: 1" = .01"





AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VALVES
DWG 7-0158-353

REPORT NO. 7/0558/67

SHEET NO. 2.18

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CORRECTED JOINT MOMENT DISTRIBUTION

DUE TO THE CHANGE IN DEFLECTIONS (SHOWN IN THE WILLIOT DIAGRAM, SHT. 2.17) THE MOMENTS IN THE MEMBERS WILL CHANGE, THEREFORE, THE WORK OF SHTS 2.9-2.11 IS REPEATED, USING THE NEW DEFLECTIONS, TO OBTAIN THIS NEW DISTRIBUTION. THE RELATIVE STIFFNESS FACTORS & DISTRIBUTION FACTORS REMAIN THE SAME; ONLY THE FIXED-END MOMENTS CHANGE.

	1	2	3	4	5
MEMBER	I	δ^*	6EI δ	L ²	FE·M
CF	.02778	0	0	68.06	0
BC	.02303	.0497	199,159	23.04	-8644
BF	.00238	.0239	9,897	91.10	-109
EF	.02303	.0581	232,819	23.04	-10105
DE	.02303	.0497	199,159	23.04	-8644
AB	.02303	.0581	232,819	23.04	-10105
BE	.01422	-.0007	-1,732	68.06	25
AD	.02778	0	0	68.06	0
AE	.00238	.0239	9,897	91.10	-109

* SCALED FROM WILLIOT DIAGRAM, SHT. 2.17

SOLUTION BY HARDY-CROSS FOR MOMENTS AT JOINTS (CORRECTED)

JOINT	A				B				
	1	2	3	4	5	6	7	8	9
MEMBER	AD	AE	AB		BA	BE	BF	BC	
DIST. FACTOR	.400	.030	.570		.415	.149	.021	.415	
0		-109.0	-10105.0		-10105.0	25.0	-109.0	-8644.0	
	4785.6	306.4	5822.0		7815.7	2806.1	395.5	7815.7	
	+1780.7	+197.8	+3907.8		+2911.0	+1403.0	+153.2	+2541.3	
	-2354.5	-176.6	-3355.2		-2908.5	-1044.3	-147.2	-2908.5	
	-1225.8	-73.6	-1454.2		-1677.6	-522.2	-88.3	-1749.5	
	1101.4	82.6	1567.6		1675.6	601.6	84.8	1675.6	
	542.1	42.4	837.8		784.8	300.8	41.3	773.6	
	-568.9	-42.7	-810.7		-788.7	-283.2	-39.9	-788.7	
	-286.0	-20.0	-344.4		-405.4	-141.6	-21.4	-408.2	
	280.2	21.0	399.2		405.3	145.5	20.5	405.3	
	139.8	10.2	202.6		199.6	72.8	10.5	199.6	
	-141.0	-10.6	-201.0		-200.2	-71.9	-10.1	-200.2	
Σ	3353.6	227.9	-3581.5		-2293.4	3291.6	289.9	-1288.0	
JOINT	D				E				
MEMBER	DA		DE		ED	EA	EB	EF	
DIST. FACTOR	.412		.588		.415	.021	.149	.415	
0			-8644.0		-8644.0	-109.0	25.0	-10105.0	
	3561.4		5082.6		7815.7	395.5	2806.1	7815.7	
	+2042.8		+3907.8		+2541.3	+153.2	+1403.0	+2911.0	
	-2451.6		-3499.0		-2908.5	-147.2	-1044.3	-2908.5	
	-1177.2		-1454.2		-1749.5	-88.3	-522.2	-1677.6	
	1084.2		1547.2		1675.6	84.8	601.6	1675.6	
	550.7		837.8		773.6	41.3	300.8	784.8	
	-572.1		-816.4		-788.7	-39.9	-283.2	-788.7	
	-284.4		-344.4		-408.2	-21.4	-141.6	-405.4	
	279.7		399.1		405.3	20.5	145.5	405.3	
	140.1		202.6		199.6	10.5	72.8	199.6	
	-141.2		-201.5		-200.2	-10.1	-71.9	-200.2	
Σ	3032.4		-3032.4		-1288.0	289.9	3291.6	-2293.4	



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MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VALVES

DWG 7-0158-353

REPORT NO. 7/0558/67

SHEET NO. 2.20

PREPARED BY

DATE

KAUTT

2/8/56

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SUMMARY OF MOMENTS IN MEMBERS

REF SHT.	25	32
TRUSS*	ORIGINAL**	CORRECTED
MEMBER	MOMENT	MOMENT**
AD	4258	3354
DA	3795	3032
AB	-4549	-3582
BA	-2956	-2293
AE	291	228
EA	368	290
BC	-1543	-1288
CB	-3795	-3032
BE	4131	3292
EB	4131	3292
BF	368	290
FB	291	228
CF	3795	3032
FC	4258	3354
DE	-3795	-3032
ED	-1543	-1288
EF	-2956	-2293
FE	-4549	-3582

* FIRST LETTER INDICATES JOINT AT WHICH MOMENT ACTS.

** PLUS MOMENT IS CLOCKWISE ACTING ON TRUSS MEMBER.



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AIRCRAFT:

C, 105

#3 #4 VENTS
CUT-OUTS FOR ONE
WAY AIR COOLING VALVES

REPORT NO. 7/0558/67

SHEET NO. 3.1

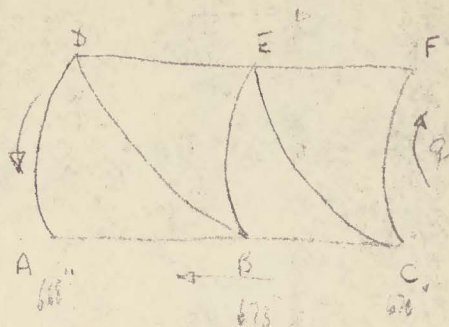
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THE LAY-OUT OF THE STRUCTURE IS AS SHOWN ON 11K. E. KAUFF'S REPORT. THE STRUCTURE DIFFERS, HOWEVER, IN THE FACT THAT THE SKIN HAS A CURVATURE. THE FRAMEWORK IS THEREFORE LYING ON A CURVED SURFACE.



THE SHEAR FLOW $q = \pm 1500 \text{ lb/in}$

CONSIDER MEMBER FC:

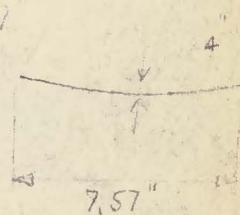
THE BOW IS .24" OVER A CHORD OF 7.57

RADIUS OF CURVATURE

$$R^2 - (R - .24)^2 = (3.785)^2$$

$$R^2 - R^2 + .48R - .0576 = 14.3262$$

$$R = \frac{14.3838}{.48} = 29.966"$$



A LOCAL RADIUS OF CURVATURE OF 30" WILL BE TAKEN. ANGLE SUBTENDED BY CUT OUT (FROM POINTS OF INTERSECTION OF CENTROIDS)

$$\sin \frac{\theta}{2} = \frac{8.25}{2 \times 30} = .1375$$

$$\theta = 15.8^\circ$$



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TECHNICAL DEPARTMENT

AIRCRAFT:

C.105

CUT-OUTS FOR ONE
WAY AIR COOLING #3 &
VALVES #4 VENTS

REPORT NO. 7/0558/67

SHEET NO. 3, 4

PREPARED BY

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THE RELATIVE STIFFNESSES OF TORSION BOX & FRAME AT THE POINT OF APPLICATION OF THE MOMENT ARE AS FOLLOWS:

A) TORSION BOX

$$\frac{I}{\theta} = \frac{4A^2G}{L \oint \frac{ds}{t}}$$

$$A = 11.1 \text{ in}^2$$

$$G = 4 \times 10^6$$

$$L = 4.8 \text{ in}$$

$$\oint \frac{ds}{t} = \frac{5}{.064} + \frac{3.95 + 3}{.040} + \frac{2.4}{.065} = 78 + 174 + 37 = 289$$

$$\frac{I}{\theta} = \frac{4 \times 1235 \times 4 \times 10^6}{4.8 \times 289} = 1.43 \times 10^6 \text{ LB-IN/RADIANT} \quad *$$

[* SEE PAGE 3, 6]

B) IN VIEW OF ITS IRREGULAR SHAPE & OF THE PRESENCE OF THE CUT-OUTS, THE LOCAL ROTATION OF THE FRAME IS DIFFICULT TO ESTIMATE.

THE LOCAL MOMENT OF INERTIA IS $= 1.50 \text{ in}^4$ (AVERAGE)

LOCAL RADIUS OF GYRATION $= 1.1 \text{ in}$

REFERRING TO NACA 929:

IF THE FRAME IS CONSIDERED AS SUPPORTED BY THE SKIN IT WILL BE ASSUMED THAT, LOCALLY, THE EFFECTIVE SKIN THICKNESS IS HALVED DOWNSIDE TO THE CUT-OUTS.



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MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C.105

CUT-OUT, FOR ONE WAY

AIR COUPLING VALVE
#3 & #4 VALVES

REPORT NO. 7/0558/67

SHEET NO. 3.5

PREPARED BY

DATE

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$$d = \frac{KR^2}{EI} = \frac{.40 \times 10^3 \times 27 \times 10^3}{10^7 \times .50} = 2160 \quad (\text{NACA 929})$$

$$K = \frac{RLG}{L} = \frac{30 \times .032 \times 4 \times 10^6}{9.6} = .40 \times 10^6$$

$$\Delta C_{m \frac{1}{2}} = 200$$

$$\frac{M}{\Delta \phi} = \frac{.40 \times 10^6 \times 900}{200} = 1.80 \times 10^6 \quad \text{LB-IN/RADIAN}$$

FROM THE ORDER OF RELATIVE STIFFNESSES IT IS FAIR TO ASSUME THAT THE APPLIED MOMENT IS REJECTED BY FRAMES & TORSION BOX IN EQUAL PROPORTIONS.

REFERRING AGAIN TO NACA 929:

WITHIN A DISTANCE OF $\pm 20^\circ$ OF THE POINT OF APPLICATION OF THE MOMENT, THE BENDING MOMENT COEFFICIENT WILL DROP FROM ITS INITIAL VALUE OF .5 TO A VALUE OF .1

THUS, THE B.M. IN THE WING IS

$$.5 \times \left(\frac{6000}{2} \right) = 1250 \text{ LB-IN. (ULT.) AT CUT-OUT}$$

ABOUT 10.5" ON EITHER SIDE, THE B.M. DROPS OFF (LINEARLY) TO 250 LB-IN AND BECOMES NEGLECTABLE THEREAFTER.

REFERRING TO REPORT 7-0558-12/2 THESE B.M. CAN BE TAKEN BY THE FRAMES WITHOUT NEED OF REINFORCING.

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C.105

CUT-OUTS #3 & #4
VENTS

REPORT NO. 7-0566-67

SHEET NO. 3.6

PREPARED BY

DATE

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REFERRING TO DRAWING 7-0158-210 SHEET 3:

THE TORSION BOX AS SHOWN ON PAGE 3.3 HAS BEEN MODIFIED. IT NOW CONSISTS OF TWO BOXES, ONE ON THE TOP & ONE ON THE BOTTOM EDGE OF THE CUT-OUT.

$$\text{AREA OF EACH BOX} = 3.0 \times 2.5 = 7.5 \text{ in}^2$$

$$\text{TOTAL } A = 15.0 \text{ in}^2$$

$$G = 4 \times 10^6$$

$$L = 4.8$$

$$\oint \frac{ds}{t} = \left[\frac{2.5}{.064} + \frac{6}{.040} + \frac{2.5}{1.5 \times .048} \right] \times 2 = 2 \left[39.0 + 150 + \frac{52}{1.5} \right] = 448$$

$$\therefore \frac{I}{\theta} = \frac{4 \times 225 \times 4 \times 10^6}{4.8 \times 448} = 1.68 \times 10^6 \text{ LB-IN/RADIAN}$$

REFERRING TO PREVIOUS CALCS., THIS STIFFNESS IS SATISFACTORY.

ON THE ASSUMPTION THAT HALF THE APPLIED B.M. IS REACTED HALF BY THE FRAME AND HALF BY THE TORSION BOXES,

$$\text{SHEAR/INCH} = \left(\frac{5010}{2} \right) \times \frac{1}{2} \times \frac{1}{2 \times 7.5} = \frac{5010}{60} = 83.6 \text{ LB/IN}$$

WHICH RESULTS IN A VERY LOW STRESS IN .040 SHEET. THE MATERIAL, HOWEVER, IS REQUIRED FOR STIFFNESS. (N.B. LATEST CHANGES INDICATE THAT USE IS MADE OF THE WARPED DIAPHRAGM TO RESIST SHROUD STIFFENING LOADS - SEE MR. K. (DDON)).



AVRO AIRCRAFT LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT

AIRCRAFT:

C.105

CUT-OUTS FOR ONE WAY
AIR COOLING FANES
#3 & #4 VENTS

REPORT NO. 7/0558/67

SHEET NO. 3.7

PREPARED BY

DATE

CHECKED BY

DATE

CONSIDER DIAGONAL MEMBER EC:

THE END LOAD REMAINS MAINLY IN THE STEEL REINFORCEMENT STRAP AND SKIN. DUE TO THEIR CURVATURE, A MOMENT HAS TO BE REACTED.

$$\text{OFFSET} = .24"$$

$$\text{LOAD} = 15100 \text{ LB.}$$

$$\therefore \text{MOMENT} = 15100 \times .24 = 3620 \text{ LB-IN}$$

THIS MOMENT PRODUCES A STRESS IN THE STEEL & SKIN OPPOSITE TO THAT PRODUCED BY THE END LOADS. HENCE THE SIZES CALCULATED BY MR KAUFF MUST BE ADEQUATE.

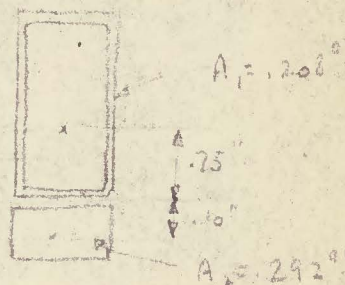
$$\bar{y} = \frac{.85 \times .208}{.500} = .354"$$

$$\bar{y} = .354"$$

$$I = .027 + .292 \times (.354)^2 + .208 \times (.446)^2$$

$$= .027 + .0366 + .0416$$

$$= .105 \text{ in}^4$$



$$f = \frac{3620 \times 1.10}{.105} = 37900 \text{ LB/in}^2$$

O.K.

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS
DWG 7-0158-353

REPORT NO. 7/0558/67

SHEET NO. 2.5

PREPARED BY

DATE

E. KAUTT

2/1/56

CHECKED BY

DATE

TRUSS DEFLECTION (CONT)

THE DEFLECTION OF THE TRUSS JOINTS WILL BE DETERMINED GRAPHICALLY BY MEANS OF A WILLIOT DIAGRAM. THIS IS MORE USEFUL THAN THE ANALYTICAL SOLUTION ON THE PREVIOUS PAGES BECAUSE IT SHOWS THE DISPLACEMENT OF ANY JOINT WITH RESPECT TO ANY OTHER JOINT. THIS WILL BE USEFUL IN DETERMINING MOMENTS AT THE JOINTS & SECONDARY STRESSES IN THE TRUSS MEMBERS.

ASSUMPTIONS:

- 1) TRUSS MEMBERS AD, BE, & CF REMAIN PARALLEL
- 2) POINT D IS FIXED IN SPACE
- 3) JOINT RIGIDITY DOES NOT AFFECT DEFLECTION OF TRUSS

AREA OF TRUSS MEMBERS

THE TRUSS MEMBERS, WHICH ARE BASICLY STEEL, ARE CONSIDERED TO HAVE THE .064 755-T6 SKIN PLUS AN ADDITIONAL PORTION OF FRAME OR STIFFENER WORKING WITH THEM. TO SIMPLIFY THE ANALYSIS, ANY ALUMINUM IS CHANGED TO AN EQUIVALENT AREA OF STEEL. THE SECTION PROPERTIES OF THESE EQUIVALENT SECTIONS ARE CALCULATED ON THE FOLLOWING PAGES. IN CALCULATING THE MOMENT OF INERTIA, ONLY THE STEEL & THE .064 SKIN ARE CONSIDERED.. THE ALUMINUM IS CHANGED TO AN EQUIVALENT AREA OF STEEL BY THE RATIO OF E_{AL} TO E_{ST} . THEREFORE,

$$\text{EQUIVALENT AREA OF STEEL, } A_{EQ} = A_{AL} \frac{E_{AL}}{E_{ST}}$$

$$\text{OR, } A_{EQ} = A_{AL} \frac{10.5 \times 10^6}{29 \times 10^6} = .362 A_{AL}$$

MEMBERS AB, BC, DE, & EF

THESE MEMBERS ARE CONSIDERED TO CONSIST OF THE .051 STEEL STRAP & THE .064 AL SKIN ONLY. WIDTH = 1.55"

$$A_{ST} = (1.55)(.051) + (.362)(1.55)(.064) = .1150 \text{ "}^2$$

$$\text{EQUIVALENT THICKNESS} = .051 + (.064)(.362) = .0742 \text{ "}$$

$$I_{EQ} = \frac{(.0742)(1.55)^3}{12} = .02303 \text{ "}^4$$

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0558/67

SHEET No. 2.6

AIRCRAFT:

C105

ONE-WAY COOLING AIR
VENTS

DWG 7-0158-353

PREPARED BY

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E. KAUTT

2/1/56

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TRUSS DEFLECTIONS (CONT)

MEMBERS AD & CF

THE FRAME CAP IS MADE FROM
75S-T6 EXT; LEGS ARE .08x.7, & 1
.12x.7. $A = .13375 \text{ "}^2$

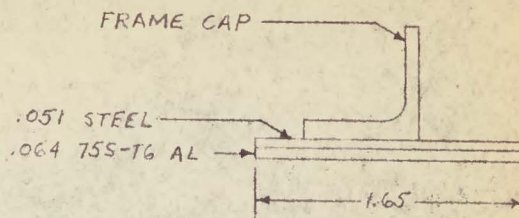
$$A_{\text{SKIN}} = 1.65 \times .064 = .1056 \text{ "}^2$$

$$\text{TOTAL AREA OF ALUM: } A_{\text{AL}} = .13375 + .1056 = .23935 \text{ "}^2$$

$$A_{\text{ST}} = (1.65)(.051) + (.23935)(.362) = .1708 \text{ "}^2$$

$$t_{\text{EQ}} = .0742 \text{ "}$$

$$I_{\text{EQ}} = \frac{(.0742)(1.65)^3}{12} = .02778 \text{ "}^4$$



MEMBER BE

THE FRAME CAP IS THE SAME AS
FOR MEMBERS AD & CF. $A = .13375 \text{ "}^2$

$$\text{AREA OF .040 ANGLE} = .04944 \text{ "}^2$$

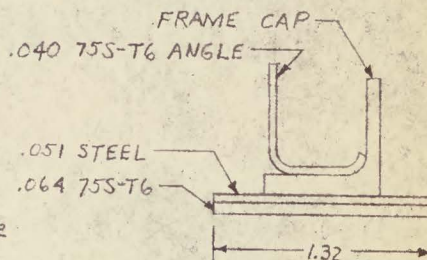
$$\text{AREA OF SKIN} = (1.32)(.064) = .08448 \text{ "}^2$$

$$\text{TOTAL AREA OF ALUM} = .13375 + .04944 + .08448 = .26767 \text{ "}^2$$

$$A_{\text{ST}} = (1.32)(.051) + (.26767)(.362) = .1642 \text{ "}^2$$

$$t_{\text{EQ}} = .0742 \text{ "}$$

$$I_{\text{EQ}} = \frac{(.0742)(1.32)^3}{12} = .01422 \text{ "}^4$$



TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0558/67

SHEET NO. 2.7

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS

DWG 7-0158-353

PREPARED BY

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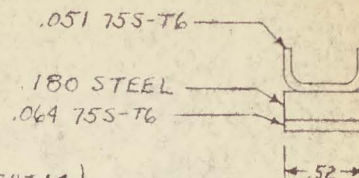
TRUSS DEFLECTIONS (CONT.)

MEMBERS AE & BF

THE AMOUNT OF .051 755-T6
WORKING WITH AE & BF IS
BASED ON EQUAL STRAINS.
THE TOTAL LOAD IN THESE
MEMBERS IS 15272 # (REF. SHT. 1.1)

IT HAS ALREADY BEEN ASSUMED (REF. SHT. 1.4)

THAT 1980 # OF THIS LOAD IS CARRIED IN THE BOX BEAMS WHICH
SUPPORTS AE & BF. AN EQUIVALENT AREA OF STEEL FOR THE .051
ALUM. CHANNEL WAS CHOSEN SUCH THAT 1980 # ACTING ON IT WOULD
PRODUCE THE SAME STRESS AS 15272-1980 = 13292 # WOULD PRODUCE
IN THE STEEL. THIS AREA OF ALUM. IS .04351 "2



$$A_{sk} = (.52)(.064) = .03328 \text{ "2}$$

$$\text{TOTAL AREA OF ALUM} = .03328 + .04351 = .07679 \text{ "2}$$

$$A_{st} = (.52)(.18) + (.362)(.07679) = .1214 \text{ "2}$$

$$t_{eq} = .180 + (.064)(.362) = .2032 \text{ "}$$

$$I_{eq} = \frac{(.2032)(.52)^3}{12} = .00238 \text{ "4}$$

DEFORMATIONS OF TRUSS MEMBERS (Δ)*

E = 29x10⁶ PSI

MEMBER	A	L	** P _{AVG}	P _{AVG} L	.AE	$\Delta = P_{AVG} L / AE$
CF	.1708	8.250	-6600	-54450	4,953,200	-.01099
BC	.1150	4.800	-3840	-18432	3,335,000	-.00553
BF	.1214	9.545	15272	145771	3,520,600	.04141
EF	.1150	4.800	-3840	-18432	3,335,000	-.00553
DE	.1150	4.800	-3840	-18432	3,335,000	-.00553
AB	.1150	4.800	-3840	-18432	3,335,000	-.00553
BE	.1642	8.250	-13200	-108900	4,761,800	-.02287
AD	.1708	8.250	-6600	-54450	4,953,200	-.01099
AE	.1214	9.545	15272	145771	3,520,600	.04141

* PLUS Δ IS LENGTHENING OF MEMBER.

** P_{AVG} IS THE AVERAGE LOAD IN THOSE MEMBERS WHICH ARE LOADED BY
SHEAR FLOW

A. V. ROE CANADA LIMITED
MALTON, ONTARIO
TECHNICAL DEPT. (AIRFRAME)

AIRCRAFT

C 105

WEIGHT

C. G. POSITION

REPORT NO.

7/0558/67

SHEET

2.8

DATE

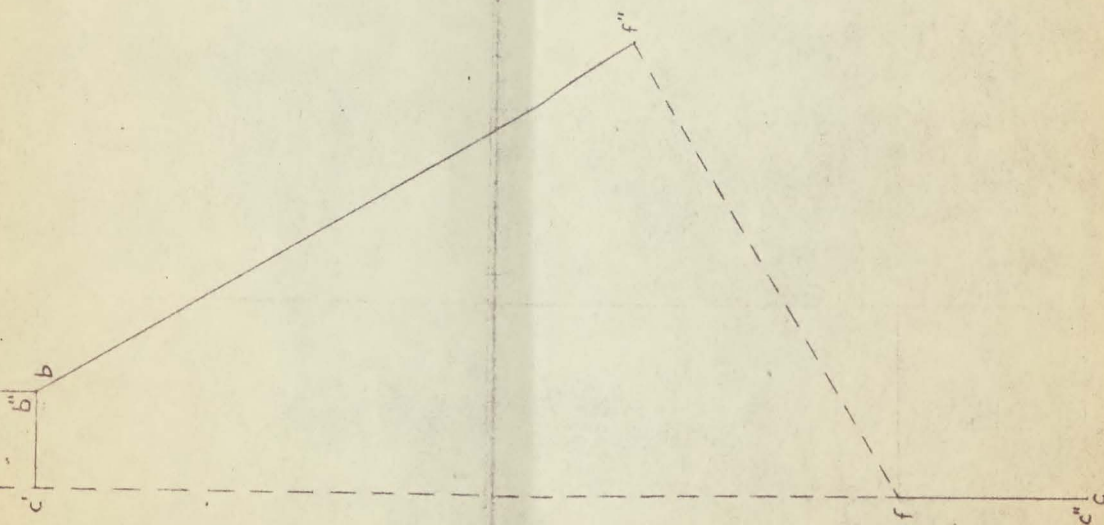
2/2/56

PREPARED BY

E. KAUTT

ELLIPT DIAGRAM FOR TRUSS DEFLECTION

SCALE: 1" = .01"



TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VALVES

DWG. 7-0458-353

REPORT NO. 7/0558/67

SHEET NO. 2.9

PREPARED BY

KAUTT

DATE

2/6/56

CHECKED BY

DATE

MOMENTS AT JOINTS.

THE MOMENTS IN THE VARIOUS MEMBERS ARE DETERMINED BY THE METHOD OF RELAXATION (HARDY-CROSS). SINCE ALL TRUSS MEMBERS ARE CONSIDERED TO BE FIXED AT BOTH ENDS, & E CONSTANT THROUGHOUT, A RELATIVE STIFFNESS FACTOR OF I/L IS USED. THE FIXED-END MOMENT OF EACH MEMBER IS DETERMINED FROM:

$$F.E.M. = \frac{-6E\delta}{L^2}$$

WHERE: $E = 29 \times 10^6$ PSI

I = MOMENT OF INERTIA OF MEMBER

L = LENGTH OF MEMBER

δ = DEFLECTION OF ONE END OF MEMBER WITH RESPECT TO OTHER END, MEASURED NORMAL TO MEMBER. DEFLECTIONS ARE SCALED FROM WILLIOT DIAGRAM, SHT 2.8.

	1	2	3	4	5	6	7
			RELATIVE STIFFNESS FACTOR		$6 \times 29 \times (2) \times (4)$	$(1)^2$	$-(5)$ (6)
MEMBER	L	I	I/L	δ^*	$6E\delta$	L^2	F.E.M.
CF	8.250	.02778	.003367	0	0		0
BC	4.800	.02303	.004798	.0621	248,848	23.04	-10800
BF	9.545	.00238	.000249	.0306	12,672	91.10	-139
EF	4.800	.02303	.004798	.0740	296,534	23.04	-12870
DE	4.800	.02303	.004798	.0621	248,848	23.04	-10800
AB	4.800	.02303	.004798	.0740	296,534	23.04	-12870
BE	8.250	.01422	.001724	0	0		0
AD	8.250	.02778	.003367	0	0		0
AE	9.545	.00238	.000249	.0306	12,672	91.10	-139

* SCALED FROM WILLIOT DIAGRAM, SHT. 2.8

DISTRIBUTION FACTORS

THE MOMENT AT ANY JOINT IS DISTRIBUTED TO THE MEMBERS TERMINATING AT THAT JOINT ACCORDING TO EACH MEMBER'S DISTRIBUTION FACTOR (D.F.), WHERE

$$DF = \frac{R.S.F.}{\sum R.S.F.}$$

WHERE: R.S.F. IS THE RELATIVE STIFFNESS FACTOR OF THE MEMBER.
 $\sum R.S.F.$ IS THE SUM OF THE R.S.F.'S OF ALL MEMBERS TERMINATING AT THE JOINT.

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0558/67

SHEET No. 2.10

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VALVES

DWG 7-0558-353

PREPARED BY

DATE

KAUTT

2/6/56

CHECKED BY

DATE

MOMENTS AT JOINTS (CONT)

DISTRIBUTION FACTORS (CONT)

JOINT A

MEMBER	R.S.F.	D.F.
AD	.003367	.400
AE	.000249	.030
AB	.004798	.570
Σ	.008414	1.000

JOINT B

MEMBER	R.S.F.	D.F.
BA	.004798	.415
BE	.001724	.149
BF	.000249	.021
BC	.004798	.415
Σ	.011569	1.000

JOINT C

MEMBER	R.S.F.	D.F.
CF	.003367	.412
CB	.004798	.588
Σ	.008165	1.000

JOINT D

MEMBER	R.S.F.	D.F.
DA	.003367	.412
DE	.004798	.588
Σ	.008165	1.000

JOINT E

MEMBER	R.S.F.	D.F.
ED	.004798	.415
EA	.000249	.021
EB	.001724	.149
EF	.004798	.415
Σ	.011569	1.000

JOINT F

MEMBER	R.S.F.	D.F.
FE	.004798	.570
FB	.000249	.030
FC	.003367	.400
Σ	.008414	1.000

SOLUTION BY HARDY-CROSS FOR MOMENTS AT JOINTS

JOINT	A				B			
	1	2	3	4	5	6	7	8
MEMBER	AD	AE	AB		BA	BE	BF	BC
DIST. FACTOR	.400	.030	.570		.415	.149	.021	.415
	0	-139.0	-12870.0		-12870.0	0	-139.0	-10800.0
	5203.6	390.3	7415.1		9880.8	3547.4	500.0	9880.8
	2224.8	250.0	4940.4		3707.6	1773.7	195.2	3175.2
	-2966.2	-222.4	-4226.6		-3673.4	-1318.9	-185.9	-3673.4
	-1553.7	-93.0	-1836.7		-2113.3	-659.4	-111.2	-2217.4
	1393.4	104.4	1985.6		2117.0	760.0	107.2	2117.0
	683.9	53.6	1058.5		992.8	380.0	52.2	976.0
	-718.4	-53.8	-1023.8		-996.4	-357.8	-50.4	-996.4
	-361.6	-25.2	-498.2		-511.9	-178.9	-26.9	-516.0
	354.0	26.6	504.4		512.0	183.8	25.9	512.0
	176.6	13.0	256.0		252.2	91.9	13.3	252.1
	-178.2	-13.4	-254.0		-253.0	-90.8	-12.8	-253.0
Σ	4258.2	291.1	-4549.3		-2955.6	4131.0	367.6	-1543.1
JOINT	D				E			
MEMBER	DA		DE		ED	EA	EB	EF
DIST. FACTOR	.412		.588		.415	.021	.149	.415
	0		-10800.0		-10800.0	-139.0	0	-12870.0
	4449.6		6350.4		9880.8	500.0	3547.4	9880.8
	2601.8		4940.4		3175.2	195.2	1773.7	3707.6
	-3107.4		-4434.8		-3673.4	-185.9	-1318.9	-3673.4
	-1483.1		-1836.7		-2217.4	-111.2	-659.4	-2113.3
	1367.8		1952.0		2117.0	107.2	760.0	2117.0
	696.7		1058.5		976.0	52.2	380.0	992.8
	-723.2		-1032.0		-996.4	-50.4	-357.8	-996.4
	-359.2		-498.2		-516.0	-26.9	-178.9	-511.9
	353.2		504.2		512.0	25.9	183.8	512.0
	177.0		256.0		252.1	13.3	91.9	252.2
	-178.4		-254.6		-253.0	-12.8	-90.8	-253.0
Σ	3794.8		-3794.8		-1543.1	367.6	4131.0	-2955.6

MALTON, ONTARIO
TECHNICAL DEPT. (AIRFRAME)

PREPARED BY - KAUTT

WEIGHT

C. G. POSITION

JOINTS

C. G. POSITION						PREPARED BY - KAUTT						
7	8	9	10	11	12	13	14	15	16	17	18	19
BF	BC		CB		CF							
.021	.415		.588		.412							
-137.0	-10800.0		-10800.0		0							
500.0	9880.8		6350.4		4449.6							
195.2	3175.2		4940.4		2601.8							
-185.9	-3673.4		-4434.8		-3107.4							
111.2	-2217.4		-1836.7		-1483.1							
107.2	2117.0		1952.0		1367.8							
52.2	976.0		1058.5		696.7							
-50.4	-996.4		-1032.0		-723.2							
-26.9	-516.0		-498.2		-359.2							
25.9	512.0		504.2		353.2							
13.3	252.1		256.0		177.0							
-12.8	-253.0		-254.6		-178.4							
367.6	-1543.1		-3794.8		3794.8							
				F								
EB	EF		FE	FB	FC							
149	.415		.570	.030	.400							
0	-12810.0		-12810.0	-139.0	0							
3547.4	9880.8		7415.1	390.3	5203.6							
1773.7	3707.6		4940.4	250.0	2224.8							
-1318.9	-3673.4		-4226.6	-222.4	-2966.2							
-659.4	-2113.3		-1836.7	-93.0	-1553.1							
760.0	2117.0		1985.6	104.4	1393.4							
380.0	992.8		1058.5	53.6	683.9							
-357.8	-996.4		-1023.8	-53.8	-718.4							
-178.9	-511.9		-498.2	-25.2	-361.6							
183.8	512.0		504.4	26.6	354.0							
91.9	252.2		256.0	13.0	176.6							
-90.8	-253.0		-254.0	-13.4	-178.2							
4131.0	-2955.6		-4549.3	291.1	4258.2							

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VENTS

DWG 7-0158-353

REPORT NO. 7/0558/67

SHEET NO. 2.12

PREPARED BY

DATE

KAUTT

2/7/56

CHECKED BY

DATE

SUMMARY OF MOMENTS IN MEMBERS

*TRUSS MEMBER	** MOMENT
AD	4258
DA	3795
AB	-4549
BA	-2956
AE	291
EA	368
BC	-1543
CB	-3795
BE	4131
EB	4131
BF	368
FB	291
CF	3795
FC	4258
DE	-3795
ED	-1543
EF	-2956
FE	-4549

* FIRST LETTER INDICATES JOINT AT WHICH MOMENT ACTS.

** PLUS MOMENT IS CLOCKWISE MOMENT ACTING ON TRUSS MEMBER.

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:

C 105

ONE-WAY COOLING AIR
VALVES
DWG 7-0158-353

REPORT NO. 7/0558/67

SHEET NO. 2.13

PREPARED BY

DATE

KAUTT

2/7/56

CHECKED BY

DATE

CHANGE IN TRUSS AXIAL LOADS

THE MOMENTS IN THE TRUSS MEMBERS (SHOWN ON SHT. 2.12) INDICATE THAT A PORTION OF THE LOAD IS CARRIED AS SHEAR IN THE MEMBERS INSTEAD OF ALL THE LOAD BEING TAKEN AS AXIAL LOAD. THE AXIAL LOADS SHOWN ON SHT. 2.1 WILL NOW BE CORRECTED, TAKING THE EFFECT OF THE MOMENTS INTO ACCOUNT. THIS WILL BE DONE BY FINDING THE LOADS AT THE JOINTS DUE TO THE MOMENTS ACTING ON THE MEMBERS, FINDING AXIAL LOADS IN THE MEMBERS DUE TO THESE LOADS, & SUPERIMPOSING THESE NEW AXIAL LOADS ON THE ORIGINAL LOADS.

THE LOAD AT A JOINT IS FOUND BY ADDING THE MOMENTS AT EACH END OF A MEMBER & DIVIDING BY THE LENGTH OF THE MEMBER, SUCH THAT THE MOMENT ACTING ON THE MEMBER IS CONVERTED TO A COUPLE WITH AN ARM EQUAL TO THE LENGTH OF THE MEMBER. THE MOMENTS ACTING ON THE MEMBERS ARE SHOWN IN THE SKETCH BELOW.

