E.R. 4071

STRUCTURAL ANALYSIS

EXPEDITOR 3N AIRCRAFT

LONG RANGE FUEL TANK

PREPARED BY ....

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....

APPROVED BY ....

Senior Designer.

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Chief Engineer

JANUARY, 1959.

CHANGE RECORD SHEET

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INTRODUCTION

THIS REPORT CONSISTS OF A STRESS ANALYSIS OF A SPECIAL 95 IMP. GAL. FUEL TANK FOR EXPEDITOR 3N AIRCRAFT.

MANUFACTURING DATA ARE PRESENTED ON BRISTOL DRAWING 111-65006 AND INSTALLATION DATA ARE PRESENTED ON BRISTOL DRAWING 111-65009.

THIS INSTALLATION REPRESENTS A MASS WHICH COULD INJURE THE CREW IF IT CAME LOOSE IN THE EVENT OF AN EMERGENCY LANDING. THEREFORE IT HAS BEEN DESGNED IN ACCORDANCE WITH CAB. CIVIL AIR REGULATIONS PART 4b - AIRPLANE AIRWORTHINESS, TRANSPORT CATEGORIES, PARA. 260 (EMERGENCY LANDING CONDITIONS) WHICH SPECIFIES THE FOLLOWING ULTIMATE INERTIA LOADS:

CASE I	UPWARD	2.0 g
CASE II	DOWNWARD	4.5 g
CASE III	FORWARD	9.0 g
CASE IV	SIDEWARD	1.5 g

THE TANK HAS BEEN DESIGNED TO ATTACH TO FIVE OF THE EXISTING HIGH STRENGTH SEAT ATTACHMENT LUGS IN THE PASSENGER COMPARTMENT OF THE AIRCRAFT. THE LOAD CAPACITIES OF THESE LUGS HAVE BEEN TAKEN FROM BEECH AIRCRAFT CORPN. STRUCTURAL ANALYSIS 24, REPORT 824 (MODEL C18) ENTITLED "INVESTIGATION OF HIGH STRENGTH PASSENGER CHAIR AND SUPPORTING STRUCTURE". LUG POSITIONS ARE TAKEN FROM MEASUREMENTS AND SHOWN ON BRISTOL DRAWING 111-65006

WEIGHTS

A. FUEL

DUE TO THE LOCATION OF THE VENTS, THE MAXIMUM CAPACITY OF EACH TANK IS 47 ½ IMP GALS

∴ WEIGHT AT 7.2 LBS/GAL = 342 LBS

TOTAL FUEL WEIGHT = 684 LBS

B. STRUCTURE

CALCULATED TO BE 76 LBS

C. TOTAL

TOTAL WEIGH = 760 LBS

TANK ANALYSIS

A. MATERIAL AL. ALLOY 5052 H34

F_{t_u} = 34000 psi ANC 5

B. SKIN THICKNESS

SINCE STIFFNESS IS USUALLY THE DESIGN CRITERION FOR THE SKIN GAUGE OF A TANK, THE END PLATES SHALL BE DIVIDED INTO PANELS AND A DEFLECTION OF APPROXIMATELY ONE THICKNESS ALLOWED AT THE PANEL CENTRE. THE MAXIMUM STRESS ALSO SHALL BE CHECKED.

MAXIMUM NORMAL PRESSURE ON THE END PLATES RESULTS FROM CASE III 2

$$\therefore P = \frac{9 \times 342}{\pi \times \frac{23^2}{4}}$$ 3

$$= 7.4 \text{ psi. FOR REAR TANK}$$

$$\therefore P = \frac{9 \times 684}{\pi \times \frac{23^2}{4}}$$ 3

$$= 14.8 \text{ psi FOR FRONT TANK.}$$

NOTE: FRONT TANK LOAD IS DOUBLE REAR TANK LOAD SINCE THE TANKS ARE INTERCONNECTED AND THERE IS NO CHECK VALVE IN THE SYSTEM.

THE END PLATE IS DIVIDED INTO RECTANGULAR PANELS.

REFERENCE R.Ae.S. DATA SHEET 02.09.07 (EDGES FIXED) ENTITLED "DEFLECTIONS AND MAXIMUM STRESSES FOR FLAT RECTANGULAR PLATES UNDER NORMAL PRESSURE"

WHERE

- t = PLATE THICKNESS (IN)
- a = LONGER SIDE OF PLATE (IN)
- b = SHORTER SIDE OF PLATE (IN)
- δ = MAXIMUM DEFLECTION (IN)
- p = NORMAL PRESSURE (psi)
- f_1 = MAXIMUM TENSILE STRESS IN PLATE AT CENTER (psi)
- f_2 = MAXIMUM TENSILE STRESS AT MIDPOINT OF LONGER SIDE (psi)
- f_3 = TENSILE STRESS IN MEDIAN PLANE OF PLATE AT CENTRE (psi)

FOR REAR TANK DIVIDE THE END PLATE INTO PANELS 8" x 6"
SELECT .063 THICKNESS

NOW $\frac{a}{b} = 1.33$

$$\frac{p}{E}\left(\frac{b}{t}\right)^4 = \frac{7.4}{10.5\times10^6}\left(\frac{6}{.063}\right)^4$$

$$= 60$$

$$E\left(\frac{t}{b}\right)^2 = 10.5\times10^6\left(\frac{.063}{6}\right)^2$$

$$= 1139$$

FROM THE DATA SHEET

$$\frac{\delta}{t} = 1.2$$

$$\therefore \delta = 1.2 \times .063$$
$$= .075 \text{ IN}$$

$$\frac{f_1}{E}\left(\frac{b}{t}\right)^2 = 12$$

$$\therefore f_1 = 12 \times 1139$$
$$= 13700 \text{ psi}$$

$$\frac{f_2}{E}\left(\frac{b}{t}\right)^2 = 23$$

$$\therefore f_2 = 23 \times 1139$$
$$= 26200 \text{ psi}$$

$$\frac{f_3}{E}\left(\frac{b}{t}\right)^2 = 5$$

$$\therefore f_3 = 5 \times 1139$$
$$= 5700 \text{ psi}$$

$$\therefore RF_{MIN} = \frac{34000}{26200}$$ ANC-5
$$= \underline{1.30}$$

$\therefore$ ADEQUATE

FOR THE FRONT TANK DIVIDE THE END PLATE INTO PANELS 6" × 6"

NOW $\frac{a}{b} = 1.00$

$$\frac{p}{E}\left(\frac{b}{t}\right)^4 = \frac{14.8}{10.5\times10^6}\left(\frac{6}{.063}\right)^4$$

$$= 120$$

$$E\left(\frac{t}{b}\right)^2 = 10.5\times10^6\left(\frac{.063}{6}\right)^2$$

$$= 1139$$

FROM THE DATA SHEET

$$\frac{\delta}{t} = 1.3$$

$$\therefore \delta = 1.3 \times .063$$
$$= .082 \text{ IN}$$

$$\frac{f_1}{E}\left(\frac{b}{t}\right)^2 = 15$$

$$\therefore f_1 = 15 \times 1139$$
$$= 17100 \text{ psi}$$

$$\frac{f_2}{E}\left(\frac{b}{t}\right)^2 = 28$$

$$\therefore f_2 = 28 \times 1139$$
$$= 31900 \text{ psi}$$

$$\frac{f_3}{E}\left(\frac{b}{t}\right)^2 = 8$$

$$\therefore f_3 = 8 \times 1139$$
$$= 9110 \text{ psi}$$

ANC-5

$$\therefore RF_{MIN} = \frac{34000}{31900} = \underline{1.066}$$

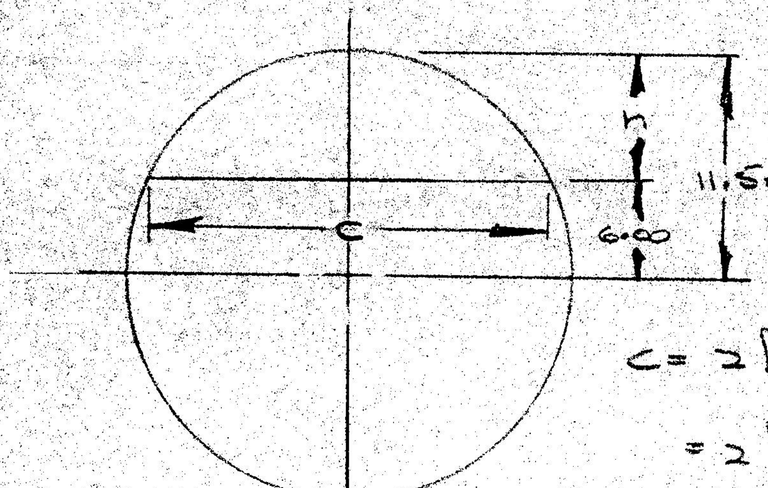
$\therefore$ ADEQUATE.

c. STIFFENERS

TO ENSURE THAT THE PANEL HAS FIXED EDGES, TWO TOP HAT STIFFENERS ON REAR TANK AND THREE TOP HAT STIFFENERS ON FRONT TANK, AND THREE BEADS WILL BE USED TO FRAME THE PANELS.

ASSUME THAT THE VERTICAL TOP HAT SECTIONS EACH SHARE THE TOTAL LOAD IN PROPORTION TO LENGTH.

THE FRONT TANK IS THE MOST SERIOUSLY LOADED SINCE DOUBLE THE LOAD BUT ONLY 1½ THE STIFFENERS



$$c = 2\left[h(2r-h)\right]^{1/2}$$

$$= 2\left[(11.5-6)(2\times 11.5 - 11.5+6)\right]^{1/2}$$

$$= 19.62 \text{ IN.}$$

ASSUME THE LOAD DISTRIBUTED OVER THE LENGTH OF THE STIFFENER UNIFORMLY.

THEN $\Sigma wL = W$

WHERE w IS LOAD / IN
L IS LENGTH (IN)
W IS TOTAL LOAD

$$\Sigma wL = w(2 \times 19.62 + 23)$$

$$= 684$$

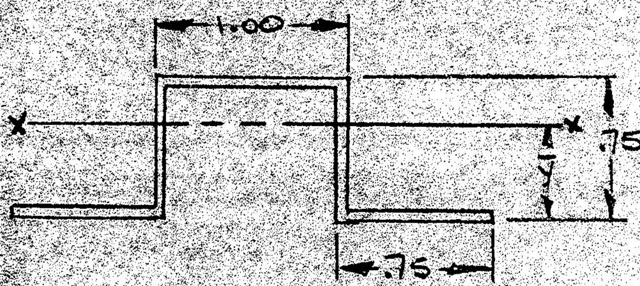
$$\therefore w = 10.99 \text{ LBS/IN}$$

THE CENTRE STIFFENER WILL BE MOST HEAVILY LOADED.

$$M_{MAX} = \frac{wL^2}{8}$$

$$= \frac{10.99 \times 23^2}{8}$$

$$= 727 \text{ IN LBS}$$



$$\bar{y} = \frac{\left[2(.75)\frac{(.063)^2}{2} + 2[.75 - 2(.063)](.063)\left(\frac{.75}{2}\right) + 1.0(.063)\left(.75 - \frac{.063}{2}\right)\right]}{.063[1 + .75 + .75 + 2(.75 - .063 - .063)]}$$

$$= .329 \text{ IN.}$$

$$I_{xx} = \frac{1.5(.063)^3}{12} + 1.5(.063)\left(.329 - \frac{.063}{2}\right)^2 + \frac{1.0(.063)^3}{12}$$
$$+ 1(.063)\left(.75 - .329 - \frac{.063}{2}\right)^2 + \frac{.063(.75 - 2 \times .063)^3}{12}$$
$$+ (.75 - 2 \times .063) \times .063\left(\frac{.75}{2} - .329\right)^2$$

$= .0193 \text{ IN}^4$

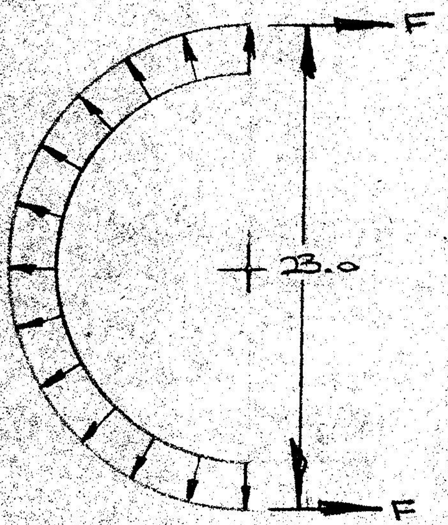
$f = \frac{My}{I}$

$= \frac{450\,(.75 - .329)}{.0193}$

$= \underline{9820 \text{ psi}}$

$\therefore$ RF LARGE

D. CIRCUMFERENTIAL SKIN THICKNESS



UNDER THE LOADING
CONDITIONS OF
CASE III (9g FWD), 2
THE MAXIMUM
PRESSURE = 14.8 psi 4

$f = \frac{pd}{2t}$

WHERE d IS DIAMETER,
t IS THICKNESS

$\therefore f = \frac{14.8 \times 23.0}{2 \times .063}$

$= \underline{2723 \text{ psi}}$

$\therefore$ RF LARGE

ATTACHMENT LUGS

A. CASE I (2.0 g UPWARD) 2

ASSUME THE LOAD ON EACH LUG EQUAL

LOAD ON EACH LUG = $\frac{760 \times 2}{5}$ 3

= 304 LBS.

$f_{br_{allow}} = .250 \times .125 \times 107800$ BEECH REPORT

= 3370 LB

$\therefore RF = \frac{3370}{304}$

= 11

$f_{s_{allow}} = 2(.50 - \frac{.267}{2}) \times .125 \times 36000$ BEECH REPORT

= 3300 LB.

$\therefore RF = \frac{3300}{304}$

= 10.9

$\therefore$ ADEQUATE

B. CASE II (4.5 g DOWNWARD) 2

ASSUME THE LOAD ON EACH LUG EQUAL

LOAD ON EACH LUG $= \frac{760 \times 4.5}{5}$ 3

$= 684$ LB.

$F_{allow} = 3370$ LB BEECH REPORT

$\therefore RE = \frac{3370}{684}$

$= \underline{5}$

$\therefore$ ADEQUATE.

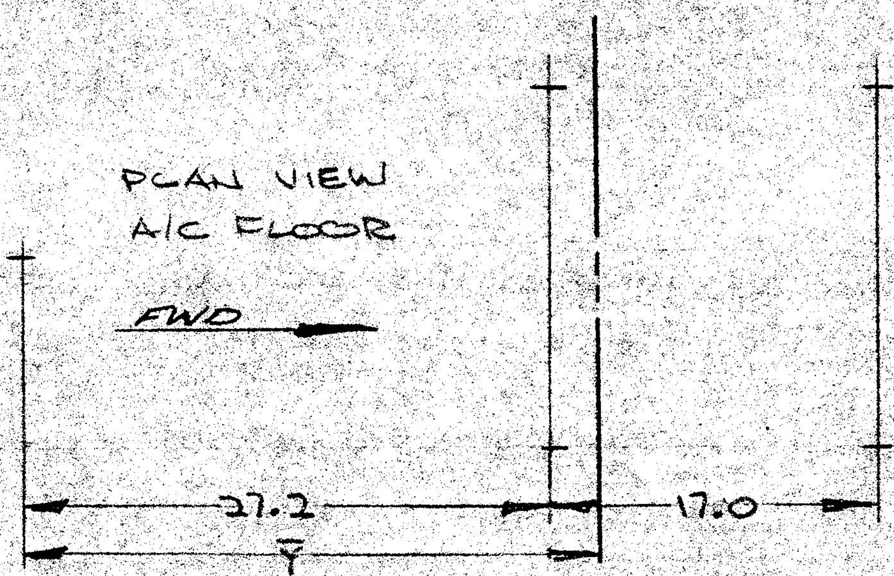
C. CASE III (9.0 g FORWARD) 2

ASSUME THE FORWARD LOAD ON EACH LUG EQUAL

FORWARD LOAD ON EACH LUG $= \frac{760 \times 9}{5}$ 3

$= 1368$ LB

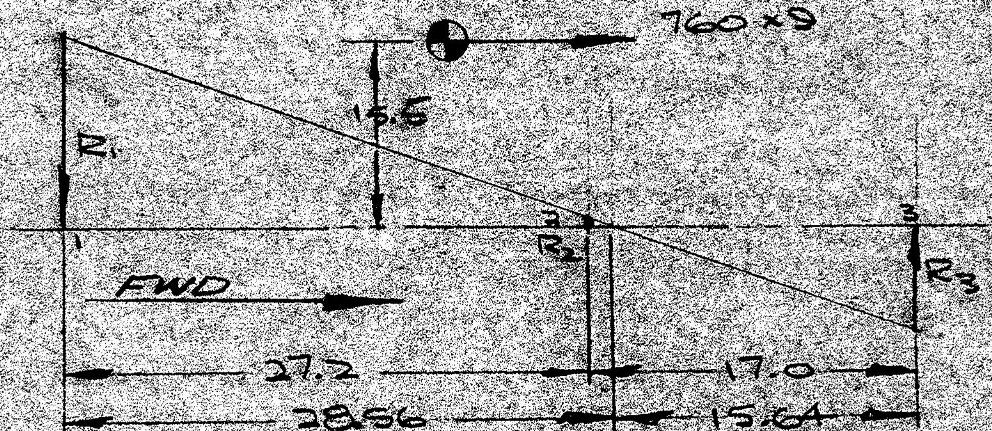
VERTICAL LOADS



ASSUMING THAT THE LUGS ARE OF EQUAL STIFFNESS AND APPLYING BEAM THEORY,

$$\bar{Y} = \frac{2A \times 27.20 + 2A(27.20 + 17.0)}{5A}$$

$$= 28.56 \text{ IN}$$



3

$\Sigma M_3 = 0$

$= R_1(27.2 + 17.0) + 2R_2 \times 17.0 - 760 \times 9 \times 15.5$

$$\frac{R_2}{R_1} = \frac{28.56 - 27.2}{28.56}$$

∴ SOLVING SIMULTANEOUSLY

$R_1 = 2314$ LBS

$R_2 = 110$ LBS

$R_3 = 1267$ LBS (ΣF_V)

∴ R_1 IS THE HIGHEST LOAD.

TOTAL LUG LOAD = $[2314^2 + 1368^2]^{1/2}$ 12

= 2688 LB

THIS IS THE HIGHEST LUG LOAD 11, 12

$f_{br_{allow}}$ = 3370 LB. BEECH REPORT

$f_{s_{allow}}$ = 3300 LB. BEECH REPORT

$\therefore RF_{br} = \frac{3370}{2688}$

= **1.25**

$RF_s = \frac{3300}{2688}$

= **1.23**

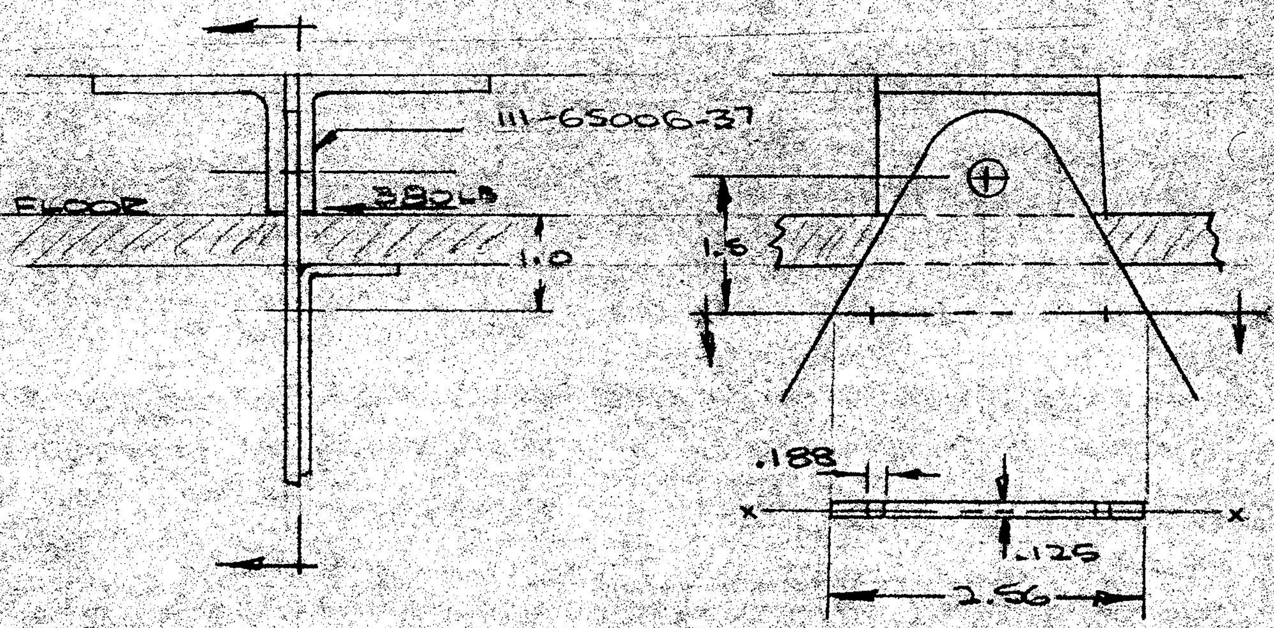
$\therefore$ **ADEQUATE**

D. CASE IV (1.5g SIDEWARD) 2

ASSUME THE SIDE LOAD IS CARRIED EQUALLY BY THE THREE LUG STATIONS. THE LOAD ON THE AFT LUG IS SEEN TO BE CRITICAL

LOAD = $\frac{760 \times 1.5}{3}$ 3

= 380 LB.



MTL - 2024-T4

$$I_{xx} = [2.56 - 2(.188)] \frac{(.125)^3}{12}$$

$$= .000355 \text{ IN}^4$$

$f_{allow} = 63000$ PSI ANC 5

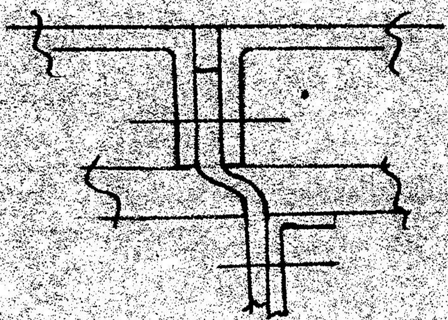
$$\therefore \text{ALLOWABLE LOAD} = \frac{f_{allow}\, I}{D\, y}$$

$$= \frac{63000 \times .000365}{1.0 \times \frac{.125}{2}}$$

$$= 358 \text{ LB.}$$

$$\therefore RF = \frac{358}{380}$$

$$= \underline{.94}$$

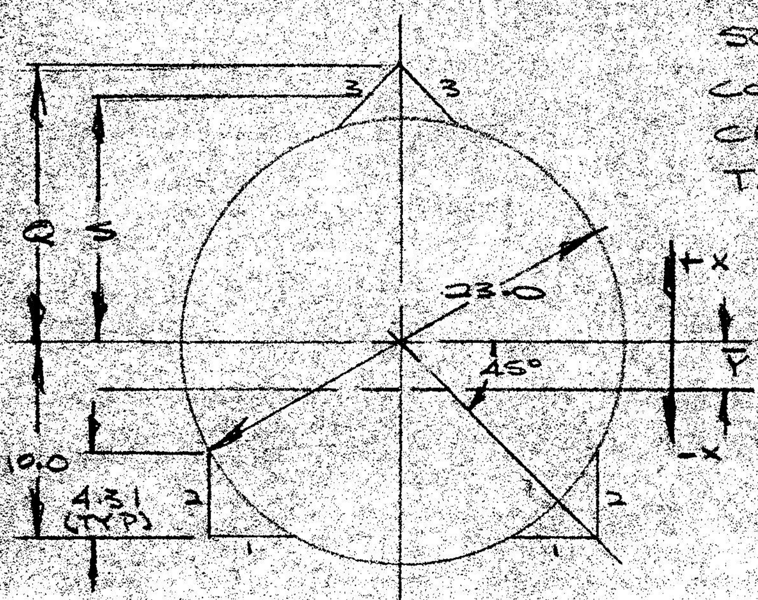


THIS IS NOT CONSIDERED CRITICAL SINCE BENDING WOULD HAVE TO OCCUR AT TWO SECTIONS (AS SHOWN IN SCETCH) BEFORE FAILURE COULD OCCUR. IN ADDITION, THE FLOOR STIFFNESS HAS NOT BEEN CONSIDERED.

LONGITUDINAL ANGLES

A SECTION PROPERTIES

ALL MATERIAL 5052 H34 x .063 TK.
CONTRIBUTION OF THE CIRCULAR PART OF THE TANK IS OMITTED.



$$Q = [10^2 + 10^2]^{1/2} = 14.14$$

$$S = Q - \frac{4.31}{2}\frac{\sqrt{2}}{2}$$

$$= 12.62$$

ELEMENT	A	x	Ax	d	Ad^2	I_{ELEM}	I
1 x 2	.543	-10.00	-5.43	-8.26	37.05	NEG	37.05
2 x 2	.543	-7.84	-4.26	-6.10	20.21	0.84	21.05
3 x 2	.543	12.62	6.85	14.36	111.97	0.42	112.39
TOTAL	1.629	—	-2.84	—	169.23	1.26	170.49

$$\bar{Y} = \frac{\Sigma\, Ax}{\Sigma\, A} = \frac{-2.84}{1.629} = -1.74$$

B. BENDING

a) CASE I (2.0 g UPWARD) 2

SINCE BASICALLY EQUIVALENT TO CASE II EXCEPT AT A LOWER LEVEL OF STRESS IT HAS NOT BEEN ANALYZED.

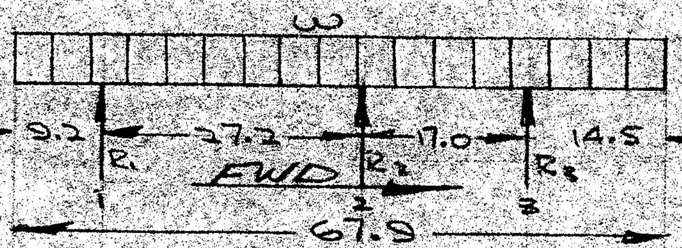
b) CASE II (4.5 g DOWNWARD) 2

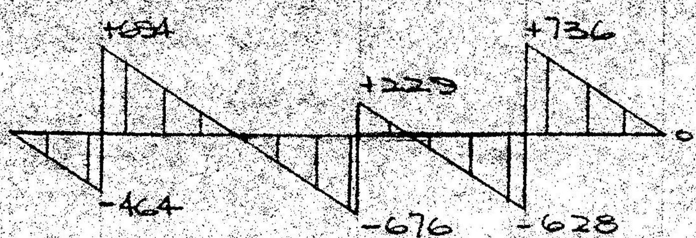
ASSUME CONSTANT I AND UNIFORM LOAD

UNIFORM LOAD

$w = \frac{4.5 \times 760}{67.9}$ 3

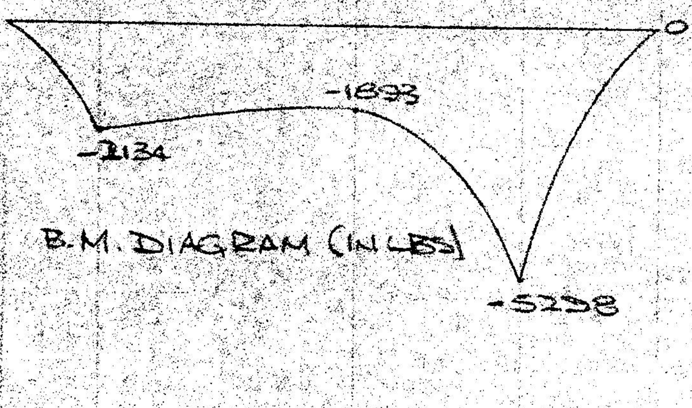
$w = 50.4$ LB/IN





SHEAR DIAGRAM (LBS)

SEE PAGE 18 ET AL FOR CALCULATIONS. DIAGRAMS ONLY SHOWN HERE



B.M. DIAGRAM (IN LBS)

$$M_1 = -\left[\frac{9.2^2}{2}(50.4)\right] = -2134 \text{ IN LB}$$

$$M_3 = -\left[\frac{14.5^2}{2}(50.4)\right] = -5298 \text{ IN LB}$$

APPLYING THE THREE-MOMENT EQUATION

$$M_1L_1 + 2M_2(L_1+L_2) + M_3L_2 = -\frac{w}{4}(L_1^3+L_2^3)$$

$$M_2 = \frac{-\frac{50.4}{4}(27.2^3+17^3) + 2134\times27.2 + 5298\times17.0}{2(27.2+17.0)}$$ 17

$$= -1893 \text{ IN LB}$$

BENDING STRESS

$$M_{MAX} = 5298 \text{ IN LBS}$$

$$\therefore f_{b_{MAX}} = \frac{5298\,(14.14+1.74)}{170.45}$$ 16

$$= 494 \text{ psi}$$

$\therefore$ RF IS VERY LARGE

SHEAR DUE TO BENDING

$$M_2 = -1893 \text{ IN LB}$$

$$R_1 = \frac{-1893 + \frac{(27.2+9.2)^2}{2}50.4}{27.2}$$ 17

$$= 1158 \text{ LB}$$

$$R_2 = \frac{\frac{(9.2 + 27.2 + 17.0)^2}{2} 50.4 - 5298 - 44.2(1158)}{17}$$ 17,18

$= 905$ LBS

$$R_3 = \frac{-1893 + \frac{(17.0 + 14.5)^2}{2} 50.4}{17.0}$$ 17,18

$= 1360$ LBS

CHECK – $1158 + 905 + 1360 = 4.5 \times 760$ ✓

NOW $f_{s_{MAX}} = \frac{SQ}{Ib}$

$Q = A'\bar{y}$

$A' = 4.31 \times .063 \times 2$ 16
$= .543$ IN^2
$\bar{y} = 12.62 + 1.74$ 16
$= 14.36$ IN

$\therefore Q = 7.80$ IN^3

$S_{MAX} = 1360$ LBS

$b = 2 \times .063$
$= .126$ IN

$\therefore f_{s_{MAX}} = \frac{1360 \times 7.80}{170.49 \times .126}$ 16

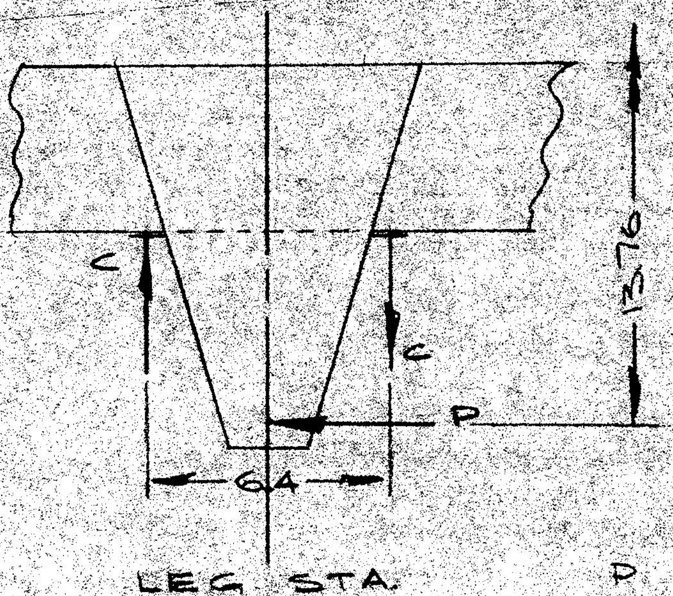
$= 494$ PSI

$\therefore$ RF IS VERY LARGE.

c) CASE III (9.0 g FORWARD) 2

THE CG OF THE FLUID IS AT THE GEOMETRIC CENTRE OF THE TANK, 1.74 IN ABOVE THE NEUTRAL AXIS. 16

=1 IT IS ASSUMED THAT THE BENDING MOMENT DUE TO THE TOTAL WEIGHT UNDER THE 9g FORCE IS SPREAD ALONG THE LENGTH OF THE BEAM AS A UNIFORM MOMENT. THE MOMENT OF THE HORIZONTAL LEG LOADS ARE BROKEN INTO COUPLES AS SHOWN:



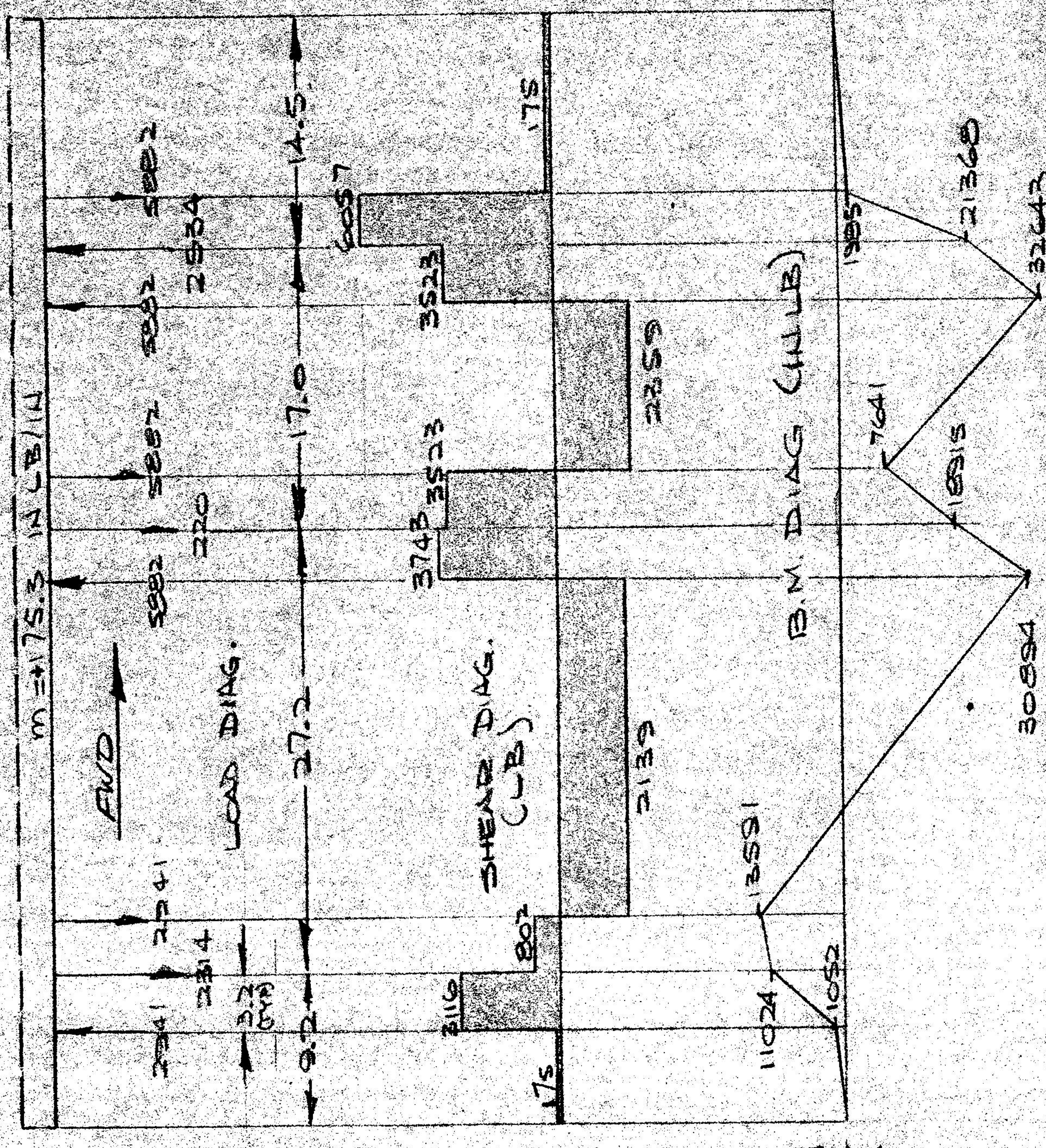
6.4C = 13.76P

THE FORCES FROM THE COUPLES ARE THEN BROUGHT INTO THE DIAGRAM AND CALCULATIONS AS DETAILED. 21

LEG STA.	P	C	
	1368	2941	12
	2736	5882	12

NOTE: THIS METHOD OF ANALYSIS IS CONSERVATIVE FOR CALCULATION OF VERTICAL SHEARS BUT NOT FOR BENDING STRESSES. FOR BENDING STRESSES SEE PAGE 23.

PREPARED BY........ CHECKED BY........ APPROVED BY........	BRISTOL AERO-INDUSTRIES LIMITED WINNIPEG DIVISION WINNIPEG CANADA EXPEDITOR LONG RANGE FUEL TANK	PAGE 21 OF 37 REPORT ER 4071 DATE 1 APRIL/59



$$m = \frac{760 \times 9 \times 1.74}{67.9}$$ 3

$= 175.3$ IN LB/IN

THE BM DIAGRAM IS CALCULATED FIRST AND THE SHEARS EVALUATED BY

$$S = \frac{dM}{dx}$$

BENDING STRESS

$M_{MAX} = 32643$ IN LB 21

$$\therefore f_{b_{MAX}} = \frac{32643(14.14 + 1.74)}{170.49}$$ 16

$= 3041$ psi

$$\therefore RF = \frac{34000}{3041}$$ ANC-5

$= \underline{11}$

SHEARING STRESSES

$S_{MAX} = 6057$ LBS

$$\therefore f_{s_{MAX}} = \frac{6057 \times 7.80}{170.49 \times .126}$$ 19

$= 2200$ psi

$$\therefore RF = \frac{20000}{2200}$$ ANC-5

$= \underline{9}$

$\therefore$ ADEQUATE

-2 IT IS ASSUMED THAT ALL BENDING MOMENTS DUE TO AXIALLY DIRECTED OFFSET FORCES ARE CARRIED IN BY WEIGHTLESS INFINITELY RIGID BARS AS SHOWN IN DIAGRAM. 24

THIS METHOD OF ANALYSIS IS CONSERVATIVE FOR CALCULATION OF BENDING STRESSES (ENGINEERS THEORY) BUT NOT FOR SHEAR STRESSES. FOR SHEAR STRESSES SEE PAGES 20-22 INCL.

THE BM DIAGRAM IS CALCULATED FIRST AND THE SHEARS EVALUATED BY

$$S = \frac{dM}{dx}$$

BENDING STRESS

$M_{MAX} = 38563$ IN LB 24

$$\therefore f_{b_{max}} = \frac{38563\,(14.14 + 1.74)}{170.49}$$ 16

$$= 3592 \text{ PSI}$$

$$\therefore RF = \frac{34000}{3592}$$ ANC5

$$= \underline{9.5}$$

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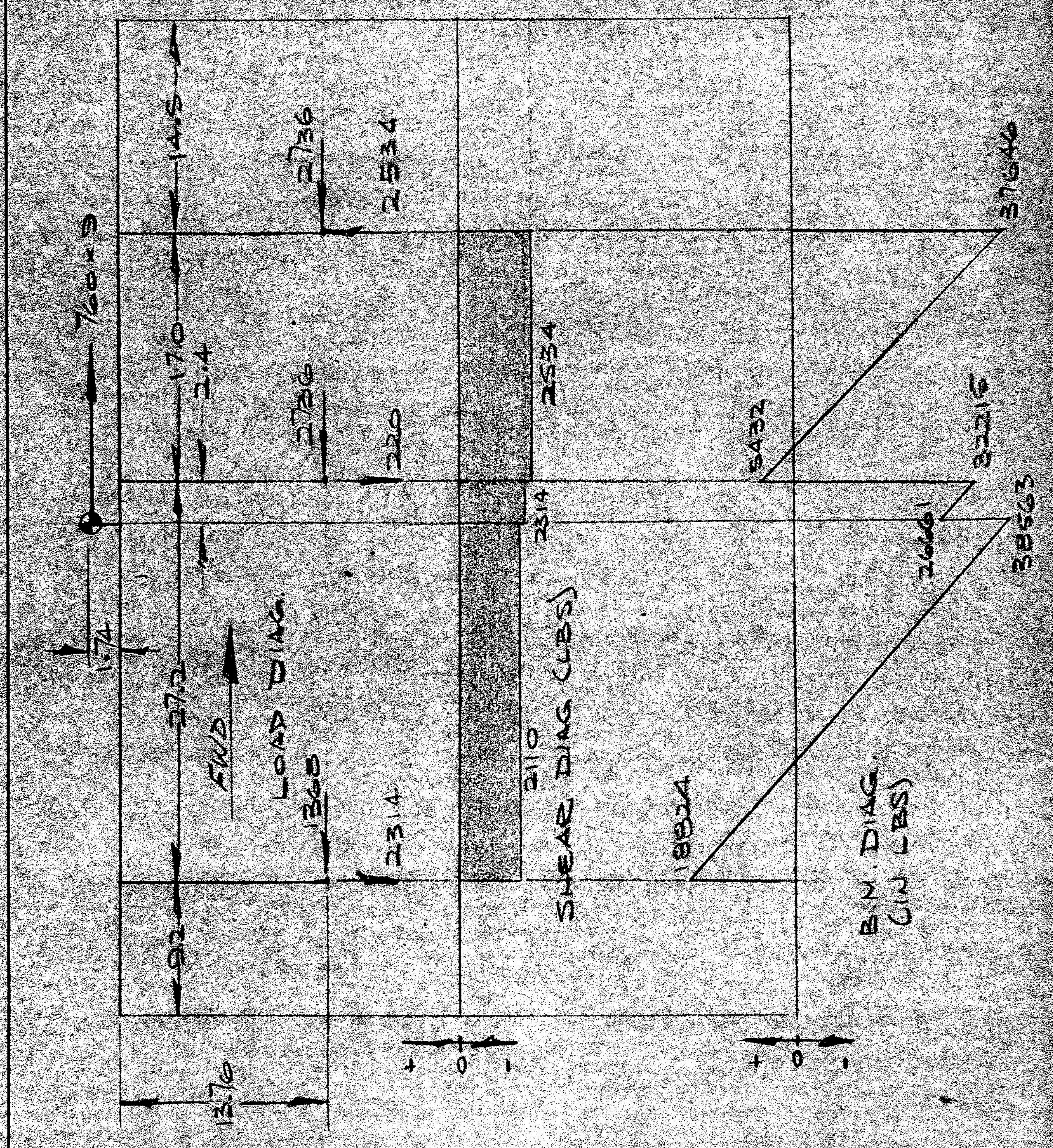


SHEARING STRESSES

$S_{max} = 2534$ LB 24

$\therefore f_{s_{max}} = \frac{2534 \times 7.80}{170.45 \times .126}$ 19

$= 938$ psi

$\therefore$ RF IS LARGE

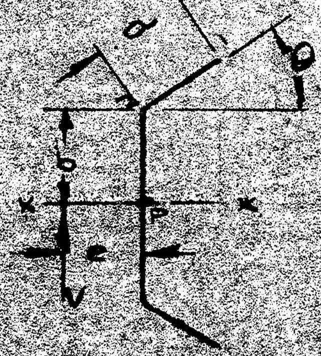
$\therefore$ ADEQUATE

d) CASE IV (1.5g SIDEWARD) 2
AS THE LOAD LEVELS WOULD BE LOW, THIS CASE HAS NOT BEEN ANALYZED

TRANSVERSE BEAM

A. SHEAR CENTRE

THE BEAM IS LOADED BY THE FLOOR LUG AT THE BEAM SHEAR CENTRE TO PREVENT BEAM TWISTING UNDER LOAD



THICKNESS = t

REF CHAPTER A.14, BRUHN BRUHN

$$q_2 = q_1 - \frac{V}{I_{xx}} \int_1^2 z\,dA$$

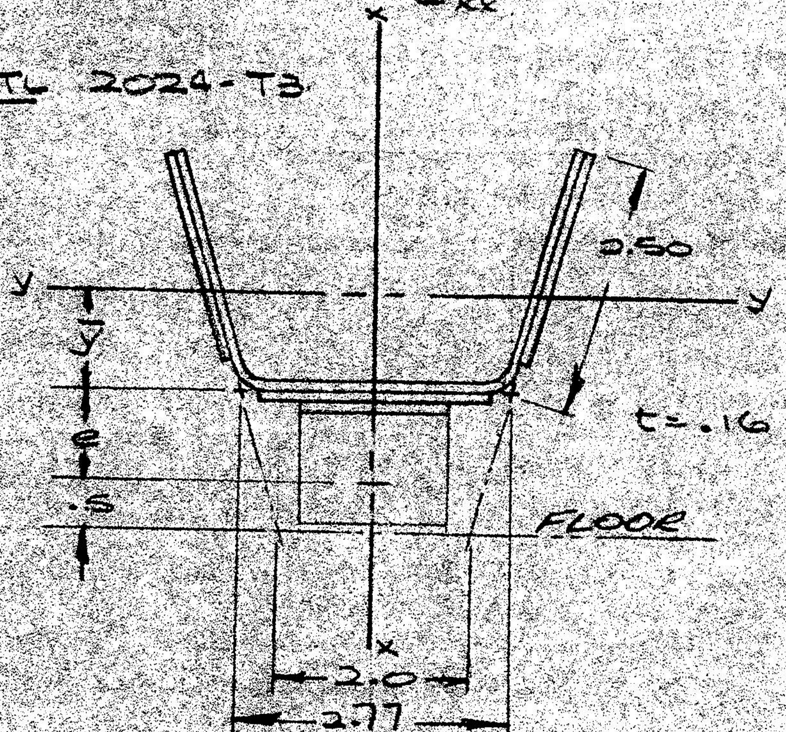
$$= \frac{V}{I_{xx}} at \left[b + \frac{a \sin\theta}{2} \right]$$

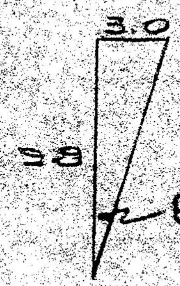
$\Sigma M_p = 0$

$$\therefore V e = \frac{V}{I_{xx}} a^2 t \left(b + \frac{a \sin\theta}{2}\right) b \cos\theta$$

$$\therefore e = \frac{a^2 t}{I_{xx}} b \cos\theta \left(b + \frac{a \sin\theta}{2}\right)$$

MTL 2024-T3





$\sin\theta = .292$
$\cos\theta = .956$
$\theta = 17.0°$

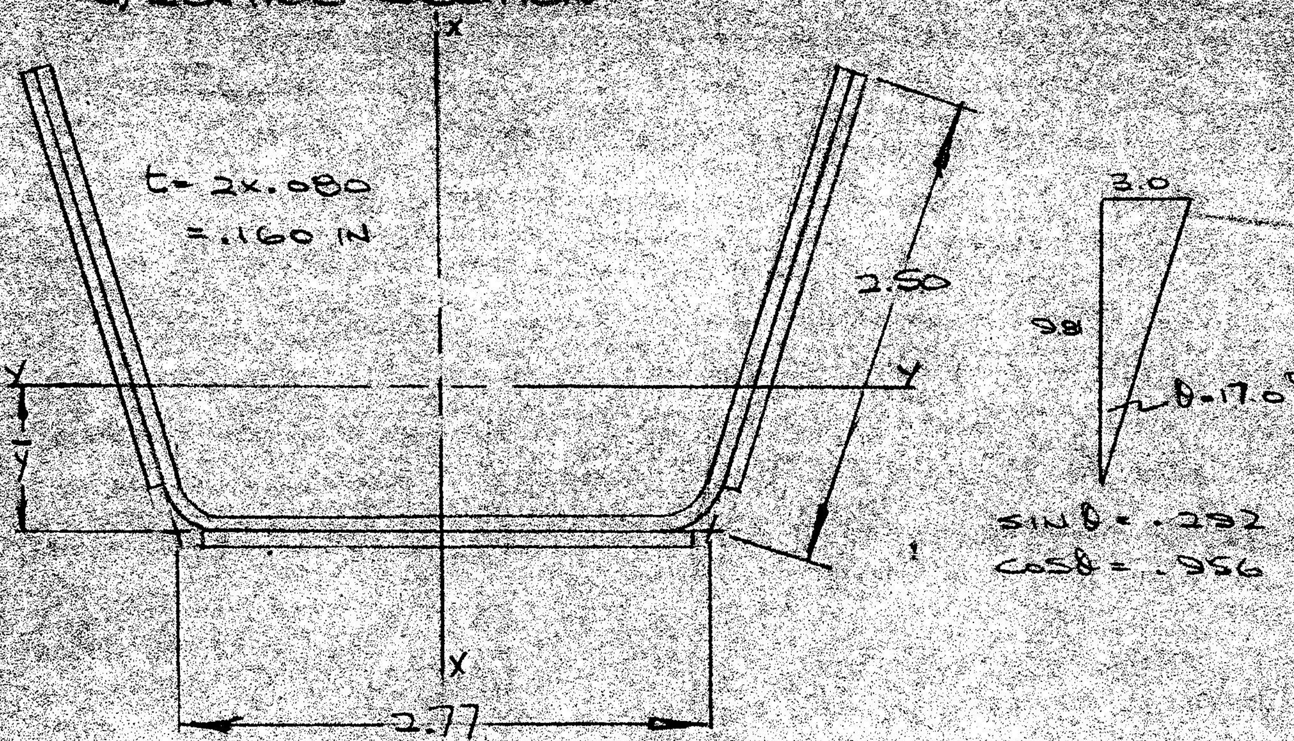
AS b IS A FUNCTION OF e, THE BEAM DETAILED WAS SELECTED BY AN ITERATIVE PROCESS.

$$e = \frac{(2.50)^2 (.16)}{2.769} \left(\frac{2.77}{2}\right) .956 \left[\frac{2.77}{2} + \frac{2.5(.292)}{2}\right]$$ 27

$$= .837 \text{ in}$$

B SECTION PROPERTIES

a) CENTRE SECTION



$$I_{xx} = \frac{1}{12}(.16 \times 2.77)(2.77)^2 + 2\left[\frac{1}{12}(.16 \times 2.50)(2.50 \times .292)^2 + (.16 \times 2.50)\left[\frac{2.77}{2} + \frac{(2.5 \times .292)}{2}\right]^2\right]$$

$$= 2.768 \text{ IN}^4$$

$$Q_{x_{MAX}} = \sum A_i \bar{y}_i$$

$$= \left(\frac{2.77}{2} \times .16\right)\frac{2.77}{4} + (2.50 \times .16)\left(\frac{2.77}{2} + \frac{2.50 \times .292}{2}\right)$$

$$= .853 \text{ IN}^3$$

$$b_x = .16$$

$$\bar{y} = \frac{2 \times 2.5 \times .16 \times \left(\frac{2.5 \times .956}{2}\right)}{.16\,(2.77 + 2 \times 2.5)}$$

$$= .769 \text{ IN}$$

$$I_{yy} = \frac{2.77 \times .16}{12}(.16)^2 + 2.77 \times .16\,(.769)^2 + 2\left[\frac{2.5 \times .16}{12}(2.50 \times .956)^2 + 2.5 \times .16\left(\frac{2.5 \times .956}{2} - .769\right)^2\right]$$

$$= .789 \text{ IN}^4$$

$$Q_{y_{MAX}} = 2\left[\left(2.50 - \frac{.769}{.956}\right).16\left(\frac{2.50 \times .956}{2} - .769\right)\right]$$

$$= .440 \text{ IN}^3$$

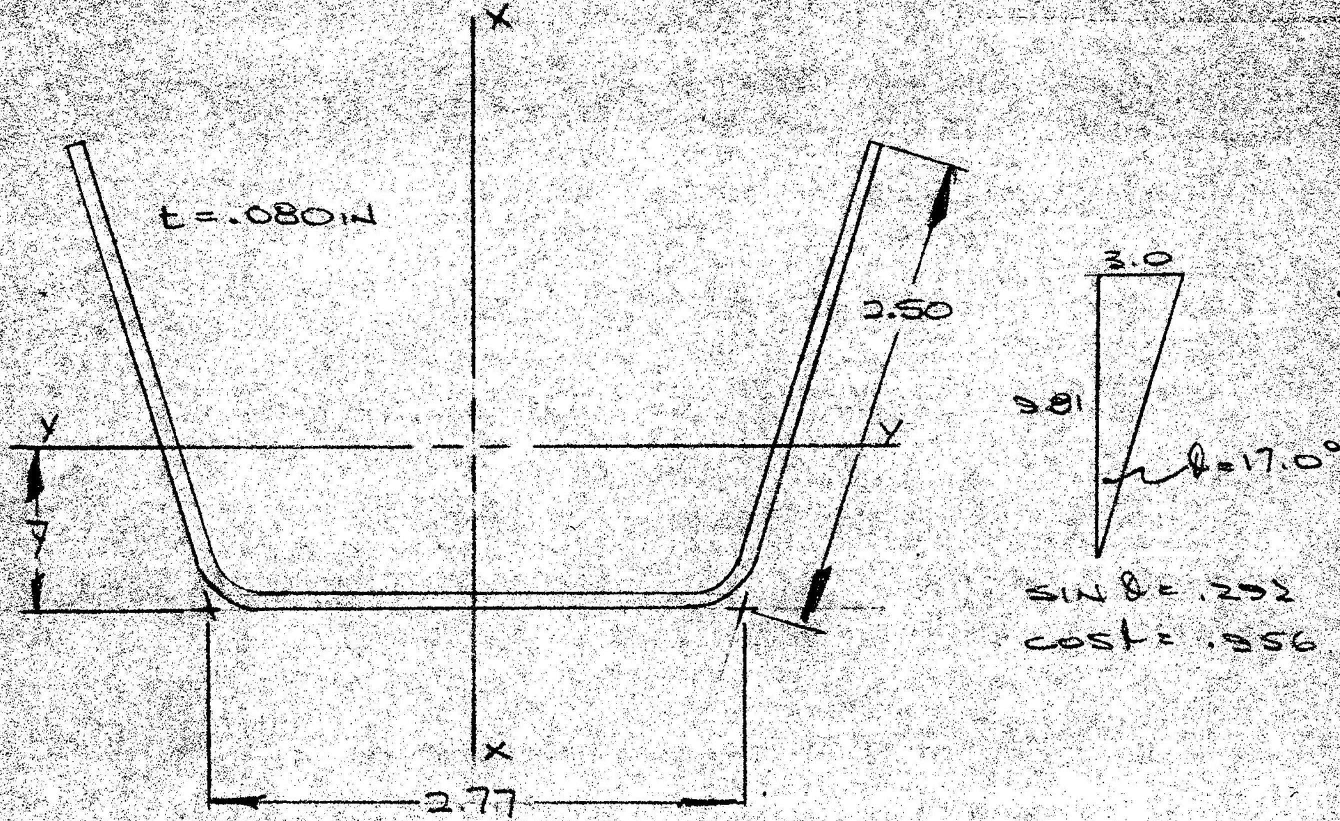
$$b_y = \frac{2 \times .16}{.956}$$

$$= .335$$

b) EDGE OF DOUBLER

$$I_{xx} = \frac{1}{12}(.08 \times 2.77)(2.77)^2 + 2\left[\frac{1}{12}(.08 \times 2.50)(2.50 \times .292)^2 + (.08 \times .250)\left[\frac{2.77}{2} + \frac{2.5 \times .292}{2}\right]^2\right]$$

$$= 1.384 \text{ IN}^4$$



$$Q_{x\,MAX} = \left(\frac{2.77}{2} \times .08\right)\frac{2.77}{4} + (2.50 \times .08)\left(\frac{2.77}{2} + \frac{2.50 \times .292}{2}\right)$$

$$= .427 \text{ IN}^3$$

$$b_x = .08$$

$$\bar{y} = \frac{(2.77 \times .08)\frac{.08}{2} + 2\left[(2.5 \times .08)\left(\frac{2.5 \times .956}{2}\right)\right]}{.08(2.77 + 2 \times 2.5)}$$

$$= .783 \text{ IN}$$

$$I_{YY} = \frac{2.77 \times .08 (.08)^2}{12} + 2.77 \times .08 (.783 - .040)^2$$

$$+ 2\left[\frac{2.5 \times .08 \, (2.50 \times .956)^2}{12} + 2.5 \times .08 \left(\frac{2.5 \times .956}{2} - .783\right)^2\right]$$

$$= .381 \text{ IN}^4$$

$$Q_{Y_{MAX}} = 2\left[\left(2.5 - \frac{.783}{.956}\right) .08 \left(\frac{2.50 \times .956 - .783}{2}\right)\right]$$

$$= .216 \text{ IN}^3$$

$$b_y = \frac{2 \times .08}{.956}$$

$$= .167 \text{ IN.}$$

C. BENDING

THE MAXIMUM LOADS OCCUR UNDER CASE III (9.0 g FORWARD) 11-14

a) SHEARS & MOMENTS

-1 VERTICAL

$$R_1 = \frac{2314 \times 10.44}{20}$$ 31-1

$$= 1208 \text{ LB}$$

$$\therefore R_2 = 1106 \text{ LB}$$

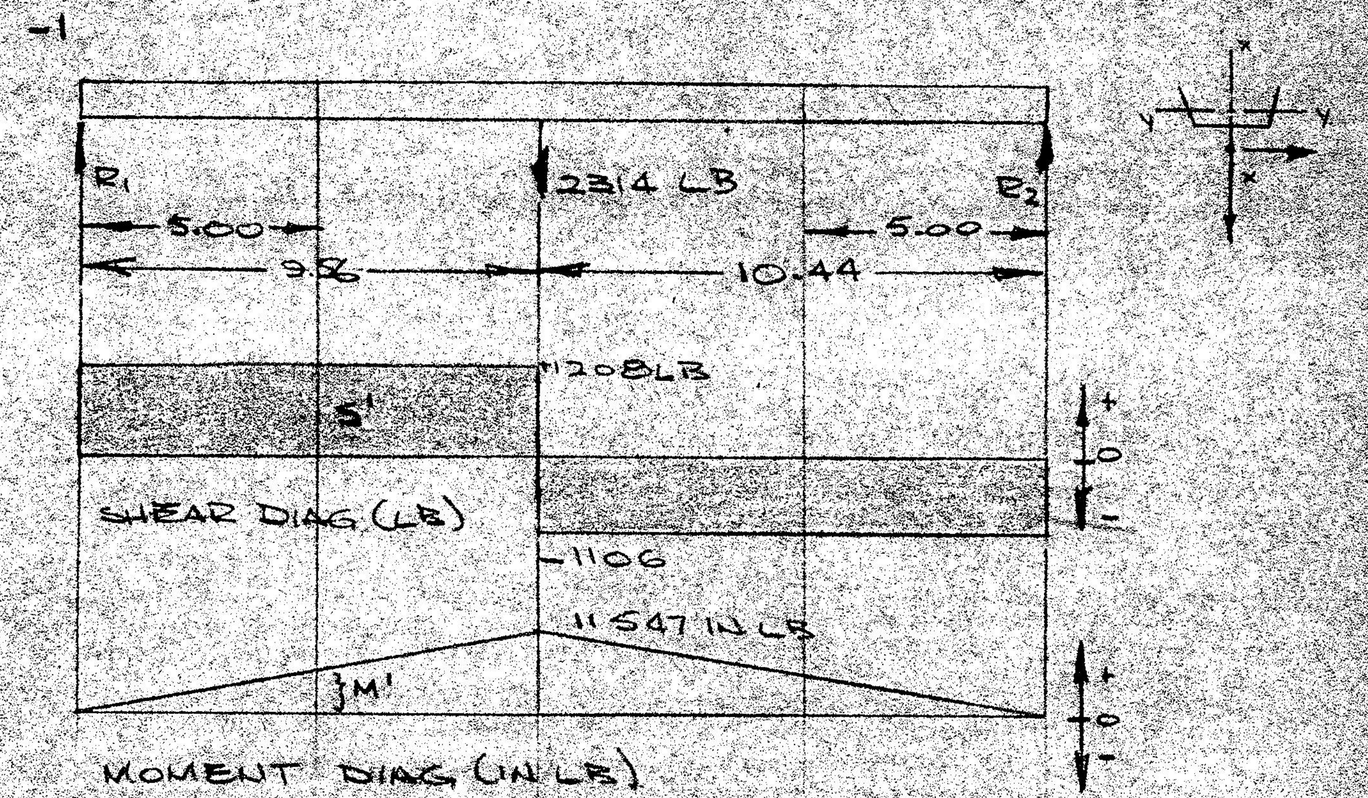
-2 HORIZONTAL

$$R_1 = \frac{1368 \times 10.44}{20}$$ 31-2

$$= 714 \text{ LB}$$

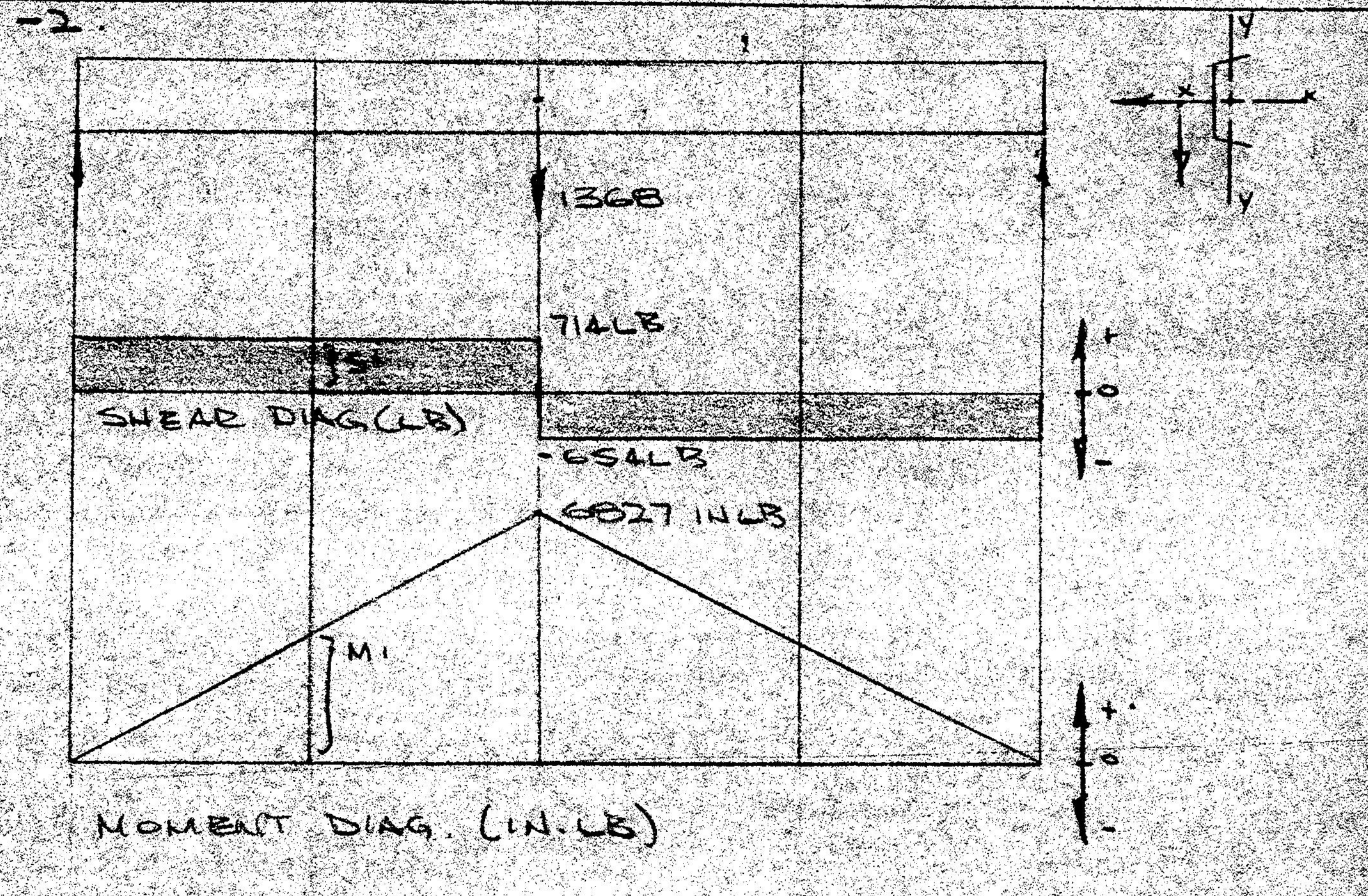
$$\therefore R_2 = 654 \text{ LB}$$

-1



R1
2314 LB
R2
5.00
5.00
9.86
10.44
1208LB
S'
SHEAR DIAG (LB)
-1106
11547 IN LB
M'
MOMENT DIAG (IN LB)

-2.



1368
714LB
S'
SHEAR DIAG (LB)
-654LB
6827 IN LB
M'
MOMENT DIAG. (IN. LB)

b) BENDING STRESSES

-1 CENTRE SECTION

VERTICAL $M_{MAX} = 11547$ IN LBS — 31

$\therefore f_{b_{MAX}} = \dfrac{11547\,(2.50 \times .956 - .769)}{.789}$ — 28

$= 23723$ PSI

HORIZONTAL $M_{MAX} = 6827$ IN LB. — 31

$\therefore f_{b\,MAX} = \dfrac{6827\,(\frac{2.77}{2} + 2.5 \times .292)}{2.769}$ — 27

$= 5215$ PSI

COMBINED BENDING STRESS

$f_{b_{MAX}} = 23723 + 5215$

$= 28938$

$\therefore RF = \dfrac{63000}{28938}$ — ANC5

$= \underline{2.18}$

$\therefore$ ADEQUATE

-2 EDGE OF DOUBLER

VERTICAL $M_{MAX} = \dfrac{11547 \times 5}{9.56}$ — 31

$= 6039$ IN LB

$\therefore f_{b_{max}} = \frac{6039}{.381}(2.50 \times .556 - .783)$ 29, 30

$= 25472$ psi

HORIZONTAL $M_{MAX} = \frac{6827 \times 5}{9.56}$ 31

$= 3571$ IN LB

$\therefore f_{b_{max}} = \frac{3571}{1.384}\left(\frac{2.77}{2} + 2.5 \times .292\right)$ 28

$= 9740$ psi

COMBINED BENDING STRESS

$f_{b_{max}} = 25472 + 9740$

$= 35212$ psi

$\therefore RF = \frac{63000}{35212}$ ANC-5

$= \underline{1.79}$

$\therefore$ ADEQUATE

c) SHEARING STRESSES

1 CENTRE SECTION

VERTICAL $S_{MAX} = 2314$ LB 31

$f_{s_{max}} = \frac{2314 \times .440}{.789 \times .335}$ 28

$= 3854$ psi

HORIZONTAL S_{MAX} = 1368 LB. 31

$\therefore f_{s\,max} = \frac{1368 \times .853}{2.769 \times .16}$ 27

= 2634 psi

COMBINED SHEARING STRESSES

$f_{s\,max} = 2634 + 3854$

= 6488

$\therefore RF = \frac{40000}{6488}$ ANC-5

= 6.2

$\therefore$ ADEQUATE

-2 EDGE OF DOUBLER

VERTICAL S_{MAX} = 1208 LB. 31

$\therefore f_{s\,max} = \frac{1208 \times .216}{.381 \times .167}$ 30

= 4101 psi

HORIZONTAL S_{MAX} = 714 LB 31

$\therefore f_{s\,max} = \frac{714 \times .427}{1.384 \times .08}$ 28, 29

= 2754 psi

COMBINED SHEARING STRESSES,

$f_{s_{max}} = 4101 + 2754$

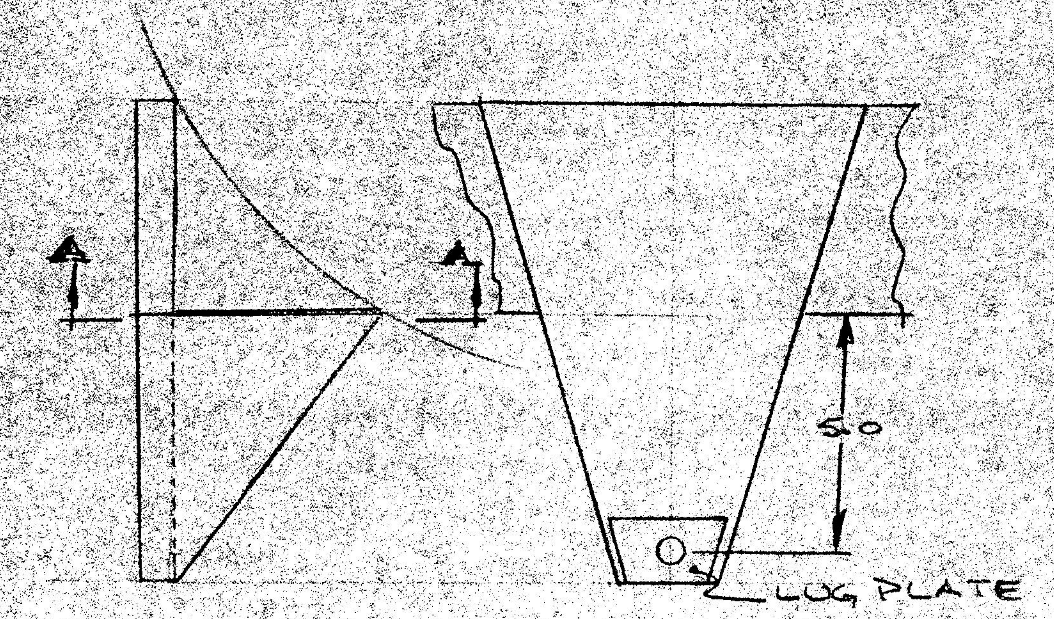
$= 6855$ psi

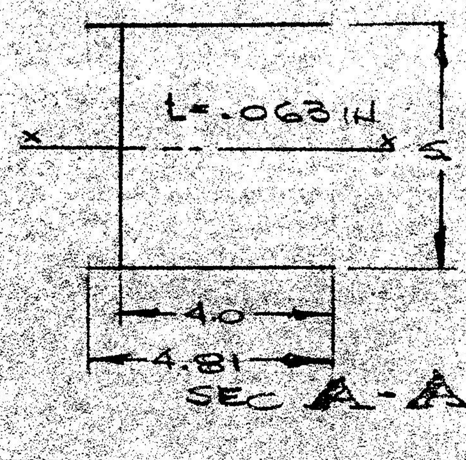
$\therefore RF = \frac{40000}{6855}$ ANC-5

$= \underline{5.8}$

$\therefore$ ADEQUATE

ATTACHMENT LEGS





THE LUGS ARE SATISFACTORY AS THEY ARE HEAVIER THAN THE FLOOR LUGS.

A. LUG PLATE RIVETS

THE MAXIMUM LEG LUG LOAD ARISES FROM CASE III (9.0 g FORWARD) 11-15, 2

$$\text{TOTAL LOAD} = (1368^2 + 1267^2)^{1/2}$$ 12, 13

$$= 1865 \text{ LBS}$$

AS FORWARD LUG CARRIES GREATEST LUG LOAD ON THE LEG

$$\text{LUG PLATE LOAD} = \frac{.08}{.063 + .080} \times 1865$$

$$= 1043 \text{ LB.}$$

FOR AN426AD5 RIVETS IN .063 SHEET SINGLE SHEAR ULTIMATE STRENGTH ANC-5

= 523 LB.

∴ ALLOWABLE RIVET LOAD

$$= 5 \times 523$$

$$= 2615 \text{ LB.}$$

$$\therefore RF = \frac{2615}{1043}$$

$$= \underline{2.5}$$

∴ <u>ADEQUATE</u>

B. BENDING

$$I_{xx} = 2\left[\frac{(4.81 \times .063)\,.063^2}{12} + 4.81 \times .063 \times 2.5^2\right] + \frac{(5 \times .063)\,5^2}{12}$$ 35

$$= 4.44 \text{ IN}^4$$

$M_{MAX} = 1368 \times 5$ 12

$= 6840$ IN LB

$\therefore f_{b\,max} = \frac{6840 \times 2.5}{4.44}$ 36

$= 3851$ PSI

$\therefore RF = \frac{34000}{3851}$

$= \underline{8.8}$

$\therefore$ ADEQUATE