Bendix Aerospace Systems Division

NO. ATM 1042	REV. NO.
PAGE I OF ?	
DATE 9 August 1971	

STRUCTURAL ANALYSIS REPORT

LUNAR MASS SPECTROMETER

Prepared by:

J. H. Owens, Jr.

J. H. Owens, Jr.

Approved by:

C. Kern

C. Kern

D. Dewhirst

D. Dewhirst

INTRODUCTION

This report consists of the stress analysis performed to substantiate the structural integrity of the LMS experiment as defined in Reference (1).

The analysis is based on a breakdown of weights of the experiment components based on a total weight of 20 lbs. from Reference (1) and (2). Final experiment weight was slightly over this but not enough to significantly affect the analysis.

The load factors used for analysis are 20 g's limit acting independently along each major axis. This conforms to environmental criteria in Reference (2). Analyses based on Stardyne computer data have 20 g's acting together along all major axes since this conservative approach was taken in the dynamic analysis.

The handling socket (pages 27-37) load is based on loads from Reference (3).

Rigorous analyses have not been conducted since conservative approaches show ample margins of safety in all components.

TABLE OF CONTENTS

REFERENCES

(1) AL 900132 Performance and Design Requirements for Lunar Mass Spectrometer Subsystem

(2) IC 314132 Interface Control Specification for Lunar Mass Spectrometer Experiment

(3) Letter No. 9783-951-009 Bendix Internal Memorandum, "Force Emission Capability of the Suited Astronaut".

(4) Roark, E. J., "Formulas for Stress and Strain", McGraw-Hill Book Company, Inc., 1943

(5) MIL-HDBK-5A"Metallic Materials and Elements for Aerospace Vehicle Structures", Dept. of Defense, Washington, D. C.

(6) Letter No. 71-210-84 Bendix Internal Memorandum, "Torque Requirements for Fasteners".

(7) Report No. 1640 Bendix Energy Controls Division, "Structures Manual".

(8) Pratt and Whitney Aircraft Design Manual

(9) U. S. Polymeric Chemicals, Inc., "Structures Materials Handbook".

CRITERIA SUMMARY

Analysis Conditions

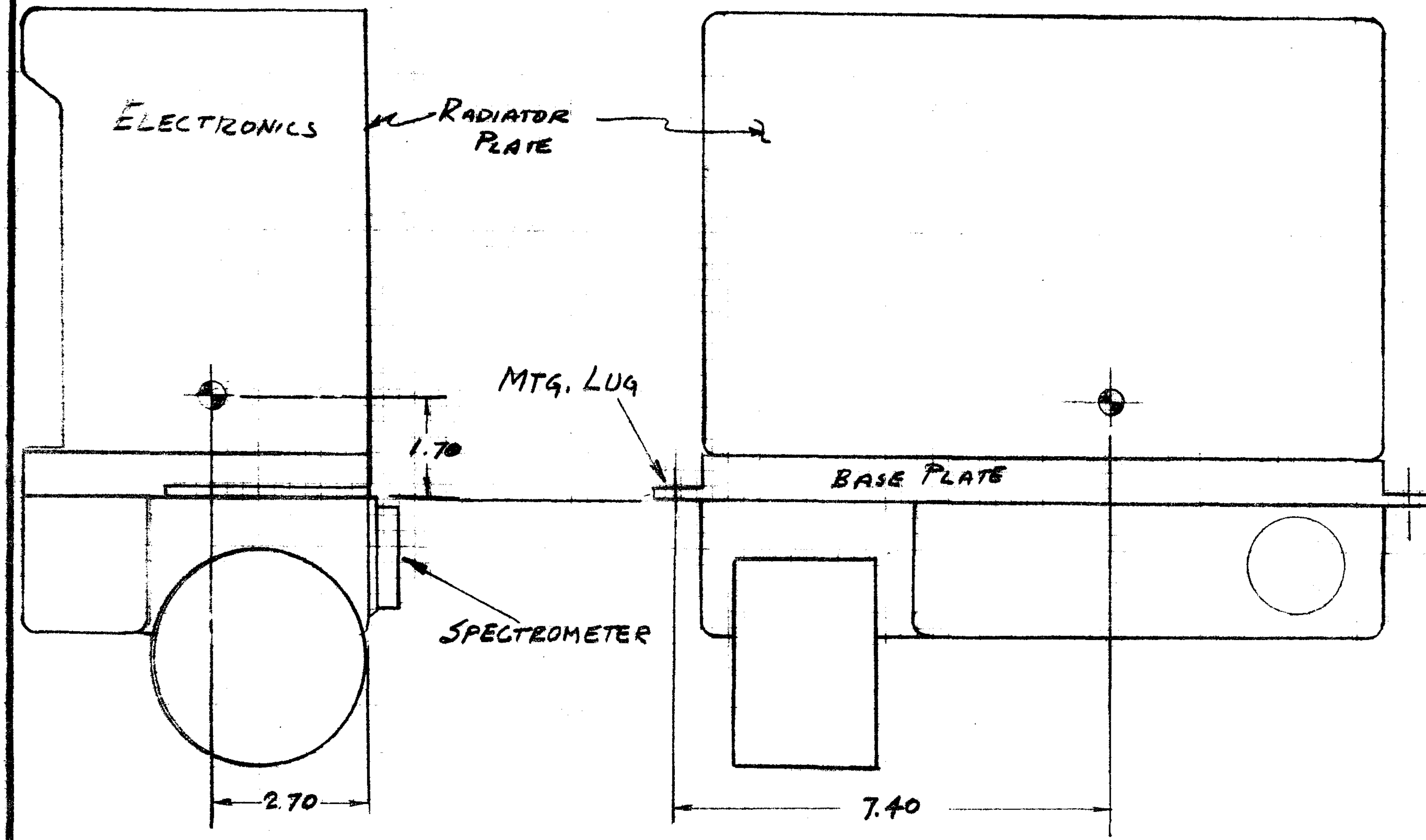
1. 20 g limit load factor along each major axis acting independently
2. 30 lbs. handling load on end of UHT (Universal Handling Tool - Dwg. 2338102) per Reference (3).

Factor of Safety

Ult. Load/Limit Load = 1.5

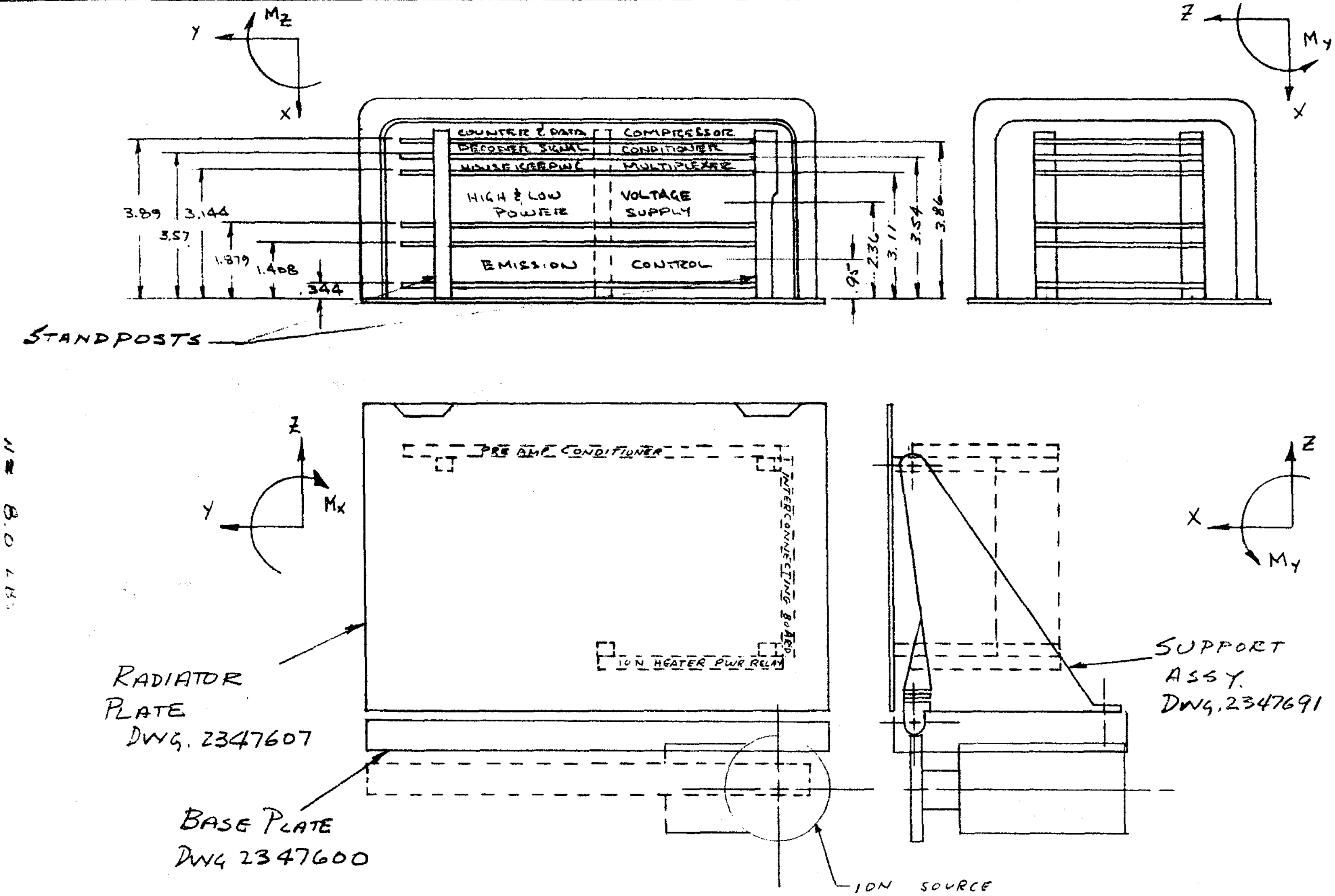
Design Weight Summary

Electronics Compartment	8.12 lbs.
Baseplate Assembly	2.09 lbs.
Thermal Assembly	1.38 lbs.
Analyzer Assembly	8.41 lbs.
TOTAL	20.00 lbs.



LMS CG. LOCATIONS
(WT = 20.00 LBS)

BxA 542



LMS ELECTRONICS ASSEMBLY

PREPARED BY J.F.C.
CHECKED BY
REVISED BY

ENGINEERING REPORT
Bendix Aerospace Systems Division

DATE 8-3-71 PAGE vii
REPORT No. ATM 1042
MODEL LMS

LUNAR MASS SPECTROMETER

C.G. CALCULATION OF ITEMS ATTACHED TO RADIATOR SUPPORTS

ITEM	
RADIATOR PLATE	1.57
RADIATOR STAND POSTS	
"A" & "B"	.0309
"C" & "D"	.032
CARD SUPPORT BOLTS	
BOLTS (1) & (3)	.0828
BOLTS (2),(4),(5),(7),(10) & (11)	.0455
BOLTS (6),(8),(9), & (12)	.1173
ELECTRONIC CARDS	
EMISSION CONTROL	1.25
HIGH & LOW VOLTAGE POWER SUPPLY	1.79
HOUSEKEEPING MULTIPLEXER	.27
DECODER SIGNAL CONDITIONER	.26
COUNTER & DATA COMPRESSOR	.25
PREAMP DISCRIMINATOR	.75
ION HEATER POWER RELAY	.75
MOTHER BOARD	.25
ELECTRICAL MOUNTING HARDWARE	.63
CABLING ASSY	.65
THERMAL HOUSING	.70
OUTER HOUSING	1.08
DUST COVER	.20
TOTAL	11.43 LBS.

LUNAR MASS SPECTROMETER

CALCULATED C.G. OF ITEMS ATTACHED TO RADIATOR SUPPORTS

C.G. IN X-DIRECTION

TOTAL WEIGHT OF ATTACHED ITEMS, $WT_{TOT} = 11.43$ lbs

$$\bar{X}_{C.G.} = \frac{\Sigma WT_{ITEM}(x)}{WT_{TOT}}$$

$$\Sigma WT_{ITEM}(x) = .25(-3.48) + .064(-2.07) + .1656(-1.50) + .091(-.83) + 1.79(-2.36) + .75(-2.36) + .0309(-1.77) + .70(-2.78) + 1.57(.08) + .20(.31) + 1.08(-3.92) + .091(-.83) + .25(-3.86) + .26(-3.54) + .27(-3.11) + 1.79(-2.36) + 1.25(-.95) + .2346(-2.12) + .0309(-1.77) + .2346(-2.12) + .091(-.83) = -22.70$$

$$\bar{X}_{C.G.} = \frac{-22.70}{11.43} \cong -2.0$$

C.G. IN Y-DIRECTION

$$\bar{Y}_{C.G.} = \frac{\Sigma WT_{ITEM}(Y)}{WT_{TOT}}$$

$$\Sigma WT_{ITEM}(Y) = .25(-4.98) + .064(-4.56) + .1656(-4.11) + .091(-3.60) + 1.79(-2.45) + .75(-.55) + .0309(-.55) + .70(-.27) + 1.57(-.27) + .20(-.27) + 1.08(-.22) + .091(-.22) + .2346(.28) + .0309(3.44) + .2346(4.28) + .091(4.28) = -6.72$$

$$\bar{Y}_{C.G.} = \frac{-6.72}{11.43} = -.59$$

C.G. IN Z-DIRECTION

$$\bar{Z}_{C.G.} = \frac{\Sigma WT_{ITEM}(Z)}{WT_{TOT}}$$

$$\Sigma WT_{ITEM}(Z) = .75(2.45) + 1.08(1.08) + 1.79(-2.45) = -1.38$$

$$\bar{Z}_{C.G.} = \frac{-1.38}{11.43} = -.12$$

PREPARED BY JFC	DATE 1-25-71 PAGE 1
CHECKED BY	REPORT No. ATM 1042
REVISED BY	MODEL LMS

ENGINEERING REPORT
Bendix Aerospace Systems Division

LUNAR MASS SPECTROMETER

RADIATOR PLATE SUPPORT TEES

LUG ANALYSIS

DWG NO. 2347607

LUG LOADS

WEIGHT OF ITEMS ATTACHED TO RADIATOR SUPPORTS, $WT_{TOT} = 11.43$ lbs (2)
ASSUME G LOAD TAKEN OUT BY ONE SET OF SUPPORT TEE LUGS (LUGS A-A' OR B-B') AS SHOWN IN SKETCH.

G LOAD, P:

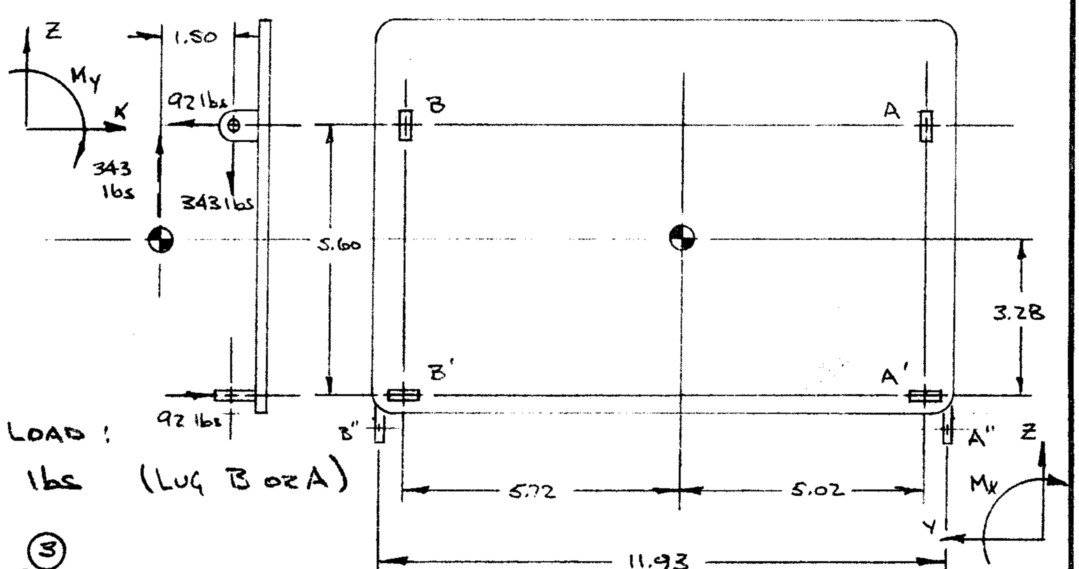
$P = 30(11.43)$

$= 343$ lbs

AXIAL LUG LOAD:

$P_a = \frac{1.5(343)}{5.60}$

$= 92$ lbs



TRANSVERSE LUG LOAD:

(1) $P_{tr} = P = 343$ lbs (LUG B OR A)

LUG PROPERTIES (3)

$D = .191$	$A_{br} = Dt = .019$	$\theta = 0°$	$R = .095$ $E = a - R = .215$
$t = .10$	$A_t = (W-D)t = .043$		$R/E = .44$ $K_1 = 1.08$
$a = .31$	$a/D = 1.62$	$K_{br} = 1.1$	$\frac{A_{AV}}{A_{br}} = \frac{K_1 E}{2R} = 1.22$ (4)
$W = .62$	$W/D = 3.24$	$K_t = .78$	$K_{tru} = .34$

ALLOWABLE LUG LOADS

MAT'L: Ti - 4AL - 3MO - 1V TITANIUM

$F_{tu} = 145$ KSI

TENSION

$P_{tu} = K_t A_t F_{tu} = .78(.043)145000 = 4860$ lbs

SHEAR - BEARING

$P_{bru} = K_{br} A_{br} F_{tu} = 1.1(.019)145000 = 3030$ lbs $\qquad R_a = .030$

TRANSVERSE

$P_{tru} = K_{tru} A_{br} F_{tu} = .34(.019)145000 = 938$ lbs $\qquad R_{tr} = .366$

$M.S. = \left[1/(R_a^{1.6} + R_{tr}^{1.6})^{1/1.6}\right] - 1 = 1.73$

(2) REF PAGE viii (3) REF. No. 7 SECTION 2.30 (4) CONSERVATIVE

(1) TOTAL LOAD ASSUMED TAKEN OUT ON LUG (A) OR (B) DUE TO CLOSE TOLERANCE OF LUG HOLE.

LUNAR MASS SPECTROMETER — DWG NO. 2347607

RADIATOR PLATE SUPPORT TEES

SECTION AT BASE OF LUG - SECTION (A-A)

LOADS

G-LOAD APPLIED IN Y-DIRECTION
CONSERVATIVELY ASSUME TOTAL LOAD OF THE
ELECTRONICS COMPARTMENT IS TAKEN OUT ON LUGS
B-B'. (SEE SKETCH, PAGE 11)

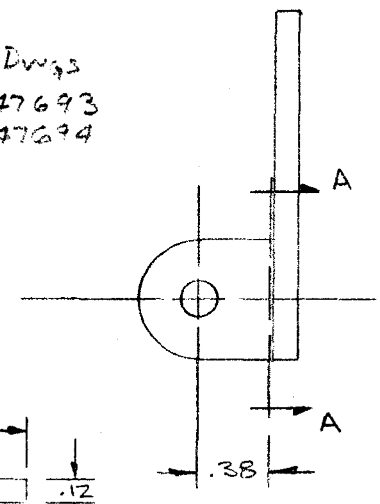
$P_{G\,LOAD} = 343 \text{ lbs}$

REF DWGS
2347693
2347694

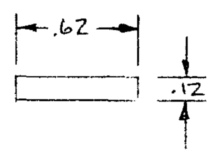
$P_{Y_B} = \dfrac{3.28\,(343)}{5.60} = 201 \text{ lbs}$

$M_{Y_{A\text{-}A}} = .38\,(201) = 76.5 \text{ in-lbs}$

$P_{TENS.} = \dfrac{1.50\,(343)}{10.74} = 47.9 \text{ lbs}$



SECTION PROPERTIES



$A = .10\,(.62) = .062$

$I/c = \dfrac{.62\,(.10)^2}{6} = .00103$

$K = 1.5$

STRESSES — MAT'L: TITANIUM 6AL-4V A — $F_{tu} = 130$ KSI

$F_b = 1.45\,F_{tu} = 188.5$ KSI — $f_b = \dfrac{76.5}{.00103} = 74.3$ KSI — $R_b = .395$

$F_{tu} = 130$ KSI — $f_t = \dfrac{47.9}{.062} = .77$ KSI — $R_t = .006$

$F_{su} = 80$ KSI — $f_s = \dfrac{201}{.062} = 3.24$ KSI — $R_s = .041$

$U = \left[(R_b + R_t)^2 + R_s^{\,2}\right]^{1/2} = .402$

$M.S. = \dfrac{1}{U} - 1 = \underline{+1.49}$

LUNAR MASS SPECTROMETER

RADIATOR PLATE ASSEMBLY

LUG ANALYSIS (AT SUPPORT TEE ATTACHMENT)

LUG LOAD

$P_{LUG} = F_{TOT_{BOLT}} = 467.5$ lbs (CONSERVATIVE)

ASSUME LUG TO BE TRANSVERSELY LOADED

LUG PROPERTIES (1)

$D = .20$ $\quad A_{br} = Dt = .020$

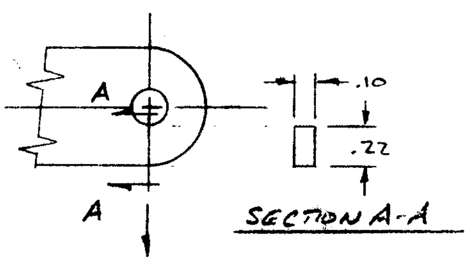
$t = .10$ $\quad A_t = (W-D)t = .044$

$a = .32$ $\quad a/D = 1.60$ $\quad K_{br} = 1.10$

$W = .64$ $\quad W/D = 3.20$ $\quad K_t = .785$

$R = .10$ $\quad E = a - R = .22$ $\quad R/E = .455$ $\quad \theta = 0°$

$K_1 = 1.08$ $\quad \dfrac{A_{AV}}{A_{br}} = \dfrac{K_1 E}{2R} = \dfrac{1.08(.22)}{.20} = 1.19$



$I/c = \dfrac{.10(.22)^2}{6} = .0008$

$F_b = 1.45\, F_{tu} = 1.45(56) = 81.1$ KSI

$l = R = .10$

ALLOWABLE LUG LOADS $\quad$ MAT'L: AL. ALLOY 2024-T351

$F_{tu} = 56$ KSI

$$P_{tru} = \frac{F_b\, I/c}{l} = \frac{81.1(.0008)}{.10} = 649 \text{ lbs}$$

$$M.S. = \frac{P_{tru}}{1.15\, P_{LUG}} - 1 = +.21$$

(2)

(2) FITTING FACTOR

(1) REF. NO. 7 SECTION 2.3

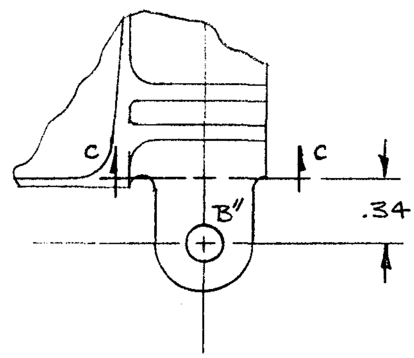
LUNAR MASS SPECTROMETER

SUPPORT ASS'Y P/N 2347691-2

LUG AT (B") SECTION C-C

ASSUMPTIONS:

1. DUE TO STIFFNESS OF RADIATOR PLATE THE G LOAD IS TAKEN OUT ON LUGS (A") & (B").
2. 55-45 LOAD DISTRIBUTION ON LUGS (A") & (B") IN THE (Y) DIRECTION.
3. LOAD BASED ON 30 G'S



G-LOAD, $P_Y = 343$ lbs

$P_{Y_{B''}} = .55\ P_Y = 189$ lbs

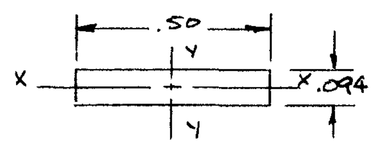
$P_{Z_{B''}} = \dfrac{3.96\ (343)}{11.93} = 114$ lbs

$P_{X_{B''}} = \dfrac{1.50\ (343)}{11.93} = 43.2$ lbs

$M_{X_{C\text{-}C}} = .34\ P_{Y_{B''}} = 64.3$ in-lbs

$M_{Y_{C\text{-}C}} = .34\ P_{X_{B''}} = 14.7$ in-lbs

SHEAR $= (P_{Y_{B''}}{}^2 + P_{X_{B''}}{}^2)^{1/2} = 194$ lbs



SECTION PROPERTIES

$A = .50(.094) = .047$

$I_x = \dfrac{.50\ (.094)^3}{12} = .0000346$ $\quad I_x/c = .000736$ $\quad K_y = 1.5$

$I_y = \dfrac{.094\ (.50)^3}{12} = .00097$ $\quad I_y/c = .00388$ $\quad K_y = 1.5$

STRESSES MAT'L: Ti-6AL-4V-A $\quad F_{tu} = 130$ KSI

$F_b = 191$ KSI $\quad f_{bx} = \dfrac{64.3}{.000736} = 87.4$ KSI $\quad R_{bx} = .458$

$f_{by} = \dfrac{14.7}{.00388} = 3.8$ KSI $\quad R_{by} = .020$

$F_{cy} = 126$ KSI $\quad f_c = \dfrac{114}{.047} = 2.43$ KSI $\quad R_c = .019$

$F_{su} = 80$ KSI $\quad f_s = \dfrac{194}{.047} = 4.13$ KSI $\quad R_s = .052$

$U = \left[(R_{bx} + R_{by} + R_c)^2 + R_s{}^2 \right]^{1/2} = .50 \qquad M.S. = \dfrac{1}{U} - 1 = \underline{+1.00}$

LUNAR MASS SPECTROMETER
RADIATOR PLATE SUPPORT TEES
BOLT PATTERN ANALYSIS

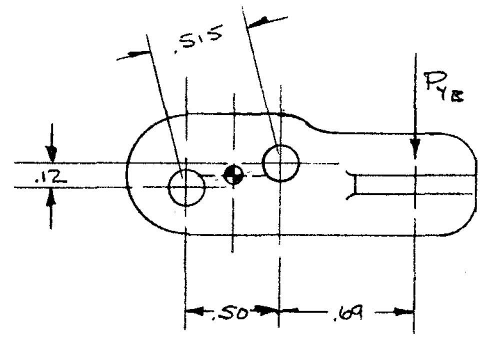
DWG NO. 2347607

DWG 2347693
2347694

LOADS

CRITICAL BOLT PATTERN LOAD:

$P_{Y_B} = 201$ lbs



DIRECT FORCE ON BOLTS:

$F = \frac{201}{2} = 100.5$ lbs

BOLT PATTERN MOMENT:

$M_{BP} = .94(201) = 189$ in-lbs

MOMENT FORCE ON BOLTS:

$F_M = \frac{189}{.515} = 367$ lbs

TOTAL FORCE ON BOLTS:

$F_{TOT} = F + F_M = 467.5$ lbs

BOLT DESIGNATION

AN 3 CRES BOLT SINGLE SHEAR STRENGTH = 2125 lbs

BOLT MARGIN OF SAFETY

$M.S. = \frac{2125}{467.5} - 1 = +3.55$

LUNAR MASS SPECTROMETER

SUPPORT ASS'Y P/N 2347691-2

SECTION A-A COLUMN ANALYSIS

ASSUMPTIONS:

1. TOTAL G-LOAD ACTS UPON ONE SUPPORT ASS'Y.
2. SUPPORT ASS'Y ACTS AS A PIN ENDED TRUSS
3. SUPPORT ASS'Y SUBJECTED TO A 30-G LOAD.
4. G-LOAD APPLIED IN THE (-x) DIRECTION.

$P = 343$ lbs

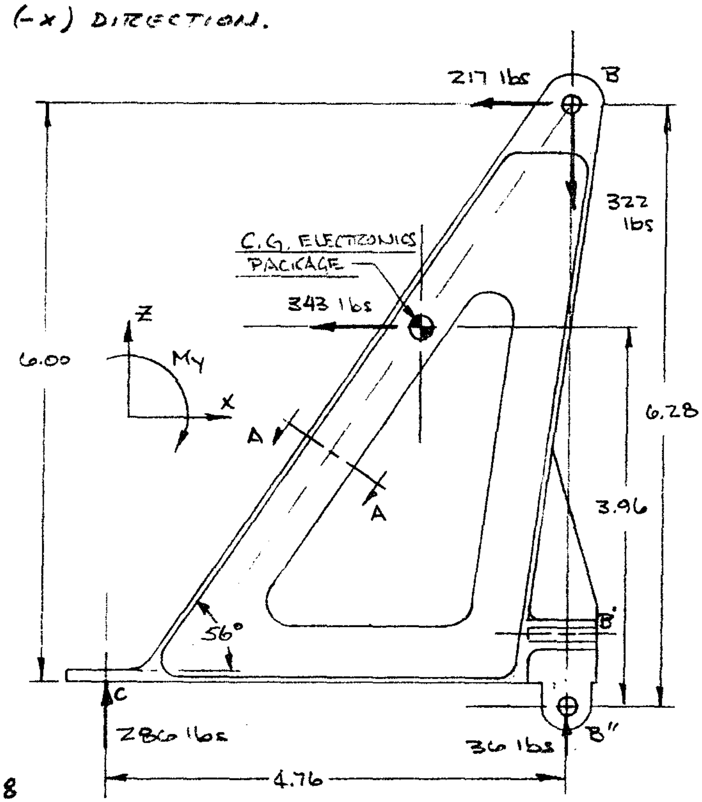
$R_{B_x} = \dfrac{-343(3.96)}{6.28} = -217$ lbs

$P_{Col_{BC}} = \dfrac{R_{Bx}}{\cos 56^\circ} = 388$ lbs

$R_{B_z} = \dfrac{R_{Bx}}{\tan 56^\circ} = -322$ lbs

$R_{C_z} = \dfrac{-6.28\, R_{Bx}}{4.76} = 286$ lbs

$R_{B''_z} = 36$ lbs



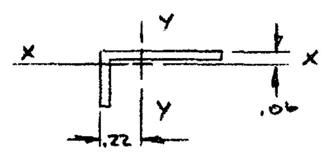
SECTION PROPERTIES

REF. PAGE

$A = .0338$ $\quad E = 16\times10^6$

$I_x = .0002$ $\quad I_x/c = .00088$

$I_y = .00127$ $\quad I_y/c = .00334$



STRESSES $\quad F_{tu} = 130$ KSI $\quad$ Ti-6AL-4V-A

$P_{cr} = \dfrac{\pi^2 E I_x}{l^2} = \dfrac{\pi^2(16\times10^6).0002}{(7.25)^2} = 600$ lbs $\qquad R_c = .647$

(1) $F_{b_x} = 253$ KSI $\quad f_{b_x} = \dfrac{388(.08)}{.00088} = 35.3$ KSI $\qquad R_{b_x} = .140$

(1) $F_{b_y} = 218$ KSI $\quad f_{b_y} = \dfrac{388(.09)}{.00334} = 10.5$ KSI $\qquad R_{b_y} = .048$

$U = R_c + R_{b_x} + R_{b_y} = .835$

$M.S. = \dfrac{1}{U} - 1 = +.20$

(1) REF. No. 7 PAGE 3.61-1

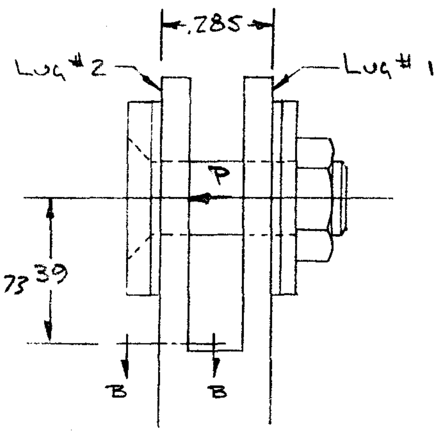
LUNAR MASS SPECTROMETER

SUPPORT ASSY DWG. 2350691

LUGS AT POINT (B) SECTION B-B

LUG LOAD

$P = P_{1B} = 201$ lbs



LOAD DISTRIBUTION ACROSS LUGS:

LUG PROPERTIES

$I_1 = I_2 = \frac{.90(.07)^3}{12} = .0000257$ $\quad I_b = .000739$

$A_{BOLT} = .02835$ $\quad L_1 = L_2 = .39$

DIA = .19

$E_1 = E_2 = E_{BOLT} = 16 \times 10^6$ $\quad A_1 = A_2 = .063$ $\quad K = 1.5$

$P_1/P_2 = \frac{L_2^3/3I_2}{L_b/A_b + L_1^3/3I_1} = \frac{(.39)^3/3(.0000257)}{.285/.02835 + (.39)^3/3(.0000257)} = .987$

$P_1 = .987 P_2$

$P_1 + P_2 = P$ $\quad P_2 = \frac{P}{1.987} = 50.5\,P$

LOADS ON LUG #2

$P_2 = 50.5\,P = 50.5\,(201) = 101.5$ lbs

$B.M. = .39\,(101.5) = 39.6$ IN-lbs $\quad P_{COMP} = 47.9$ lbs

STRESSES $\quad$ Ti-6AL-4V-a $\quad F_{tu} = 130$ KSI

$F_b = 191$ KSI $\quad f_b = \frac{39.6\,(.035)}{.0000257} = 53.9$ KSI $\quad R_b = .282$

$F_{cy} = 126$ KSI $\quad f_c = \frac{47.9}{.063} = .76$ KSI $\quad R_c =$ NIL

$F_{su} = 80$ KSI $\quad f_s = \frac{101.5}{.063} = 1.61$ KSI $\quad R_s = .020$

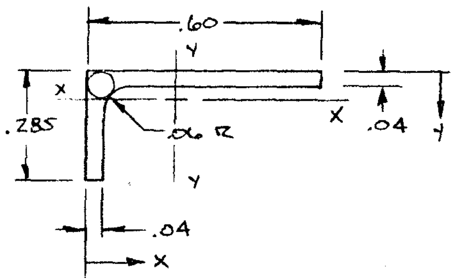
$M.S. = \frac{1}{R_b + R_c + R_s} - 1 = \underline{+2.31}$

LUNAR MASS SPECTROMETER
RADIATOR PLATE SUPPORT

DWG 2347691

SECTION PROPERTIES OF LEGS

SECTION A-A (FILLETS NEGLECTED)



$$A = .60(.285) - .56(.245) = .0338$$

$$Ay = .171(.1425) - .1372(.1625) = .00207$$

$$\bar{y} = \frac{.00207}{.0338} = .061$$

$$Ax = .171(.30) - .1372(.32) = .0074$$

$$\bar{x} = \frac{.0074}{.0338} = .22$$

$$I_y = \frac{.285(.60)^3}{12} + .171(.08)^2 - \frac{.245(.56)^3}{12} - .1372(.10)^2 = .00127$$

$$I_Y/c = .00334$$

$$I_x = \frac{.60(.285)^3}{12} + .171(.0815)^2 - \frac{.56(.245)^3}{12} - .1372(.1015)^2 = .00020$$

$$I_x/c = .00088$$

$$J = J_1 + J_2 + \alpha D^4 \qquad a = .285 \quad b = d = .04 \quad c = .56 \quad D = .07 \quad r = .06$$

$$J_1 = ab^3\left[\frac{1}{3} - .21\frac{b}{a}\right] = .285(.04)^3\left[\frac{1}{3} - .21\left(\frac{.04}{.285}\right)\right] = .00000559$$

$$J_2 = cd^3\left[\frac{1}{3} - .105\frac{d}{c}\right] = .56(.04)^3\left[\frac{1}{3} - .105\left(\frac{.04}{.56}\right)\right] = .0000116$$

$$\alpha = \frac{d}{b}\left[.07 + .076\frac{r}{b}\right] = \frac{.04}{.04}\left[.07 + .076\left(\frac{.06}{.04}\right)\right] = .184$$

$$J = .00000559 + .0000116 + .184(.07)^4 = .0000216$$

$$Q_y = \frac{.04(.38)^2}{2} = .00289 \qquad K_{SM_Y} = \frac{2Q_Y}{I_Y/c} = \frac{2(.00289)}{.00334} = 1.73$$

$$Q_x = \frac{.04(.224)^2}{2} = .0010 \qquad K_{SM_x} = \frac{2Q_x}{I_x/c} = \frac{2(.001)}{.00088} = 2.27$$

USE 2.0

$$K_y = \frac{I_Y b_Y}{Q_1 A} = \frac{.00127(.04)}{.00289(.0338)} = .5201$$

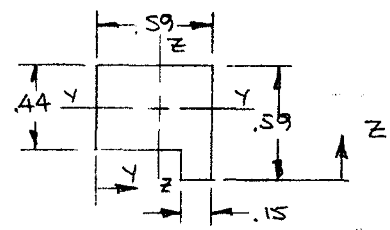
$$K_x = \frac{I_x b_x}{Q_x A} = \frac{.0002(.04)}{.001(.0338)} = .2367$$

LUNAR MASS SPECTROMETER

RADIATOR PLATE ASSY

STANDPOSTS

SECTION PROPERTIES



$$A = \overset{.3481}{(.59)^2} - \overset{.0885}{.15(.59)} = .2596$$

$$A_Y = .3481(.295) - .0885(.22) = .0832$$

$$\bar{Y} = \frac{.0832}{.2596} = .32$$

$$A_Z = .3481(.295) - .0885(.075) = .096$$

$$\bar{Z} = \frac{.096}{.2596} = .37$$

$$I_Y = \frac{(.59)^4}{12} + .3481(.075)^2 - \frac{.44(.15)^3}{12} - .0885(.274)^2$$

$$= .01009 + .00196 - .00012 - .00664 = .00529$$

$$I_Z = \frac{(.59)^4}{12} + .3481(.025)^2 - \frac{.15(.44)^3}{12} - .0885(.10)^2$$

$$= .01009 + .00022 - .00106 - .00089 = .00836$$

TORSIONAL CONSTANT J

$a = .59 \quad b = .44 \quad c = .15 \quad d = .15 \quad r = 0 \quad D = .44$

$$J = J_1 + J_2 + \alpha D^4$$

$$J_1 = ab^3\left[\frac{1}{3} - .21\frac{b}{a}\right] = .59(.44)^3\left[\frac{1}{3} - .21\left(\frac{.44}{.59}\right)\right] = .00888$$

$$J_2 = cd^3\left[\frac{1}{3} - .105\frac{d}{c}\right] = (.15)^4\left[\frac{1}{3} - .105\left(\frac{.15}{.15}\right)\right] = .00012$$

$$\alpha = \frac{d}{b}(.07) = .07\left(\frac{.15}{.15}\right) = .07$$

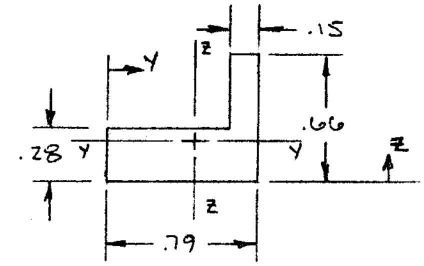
$$J = .00888 + .00012 + .07(.44)^4 = .01162$$

LUNAR MASS SPECTROMETER

RADIATOR PLATE ASSY

STANDPOSTS

SECTION PROPERTIES



$A = .66(.79) - .38(.64) = .2782$

$A_Y = .5214(.395) - .2432(.32) = .128$

$\bar{Y} = \dfrac{A_Y}{A} = \dfrac{.128}{.2782} = .46$

$A_Z = .5214(.33) - .2432(.47) = .058$

$\bar{Z} = \dfrac{.058}{.2782} = .21$

$I_Y = \dfrac{.79(.66)^3}{12} + .5214(.12)^2 - \dfrac{.64(.38)^3}{12} - .2432(.26)^2$

$= .01892 + .00751 - .00292 - .01644 = .00707$

$I_Z = \dfrac{.66(.79)^3}{12} + .5214(.065)^2 - \dfrac{.38(.64)^3}{12} - .2432(.14)^2$

$= .02711 + .00220 - .00830 - .00477 = .01624$

TORSIONAL CONSTANT J:

$a = .79 \quad b = .28 \quad c = .38 \quad d = .15 \quad r = 0 \quad D = .28$

$J = J_1 + J_2 + \alpha D^4$

$J_1 = ab^3\left[\frac{1}{3} - .21\frac{b}{a}\right] = .79(.28)^3\left[\frac{1}{3} - .21\left(\frac{.28}{.79}\right)\right] = .00449$

$J_2 = cd^3\left[\frac{1}{3} - .105\frac{d}{c}\right] = .38(.15)^3\left[\frac{1}{3} - .105\left(\frac{.15}{.38}\right)\right] = .00038$

$\alpha = \frac{d}{b}(.07) = .07\left(\frac{.15}{.28}\right) = .0375$

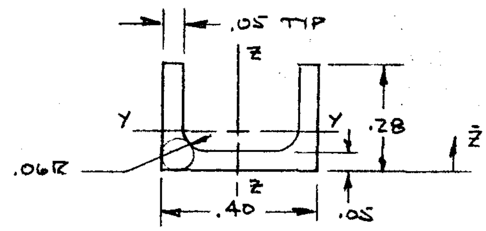
$J = .00449 + .00038 + .0375(.28)^4 = .0051$

LUNAR MASS SPECTROMETER

RADIATOR PLATE ASS'Y

SECTION PROPERTIES OF STAND POSTS

SECTION A-A (FILLETS NEGLECTED)



$A = .40(.28) - .30(.23) = .043$

$A\bar{z} = .40(.28).14 - .30(.23).165 = .0043$

$\bar{z} = \dfrac{.0043}{.043} = .10$

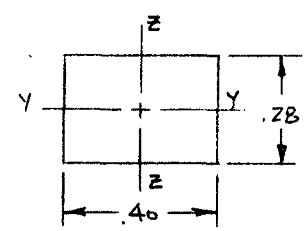
$I_Y = \dfrac{.40(.28)^3}{12} + .112(.04)^2 - \dfrac{.30(.23)^3}{12} - .069(.065)^2$

$.00073 + .00018 - .00030 - .00029 = .00032$

$I_Z = \dfrac{.28(.40)^3}{12} - \dfrac{.23(.30)^3}{12} = .00149 - .00052 = .00097$

J_{AA} (SEE NEXT PAGE) $= .000049$

SECTION B-B



$A = .40(.28) = .112$ $\quad b = .40$

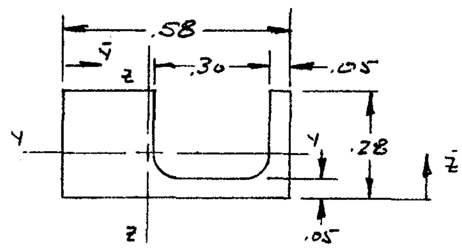
$I_Y = \dfrac{.40(.28)^3}{12} = .00073$ $\quad t = .28$

$I_Z = \dfrac{.28(.40)^3}{12} = .00149$ $\quad b/t = 1.43$

$\beta = .192$ $\quad K_Y = K_Z = .67$

$J_{BB} = \beta b t^3 = .192(.40)(.28)^3 = .00169$

SECTION C-C (FILLETS NEGLECTED)



$A = .58(.28) - .30(.23) = .0934$

$A\bar{z} = .1624(.14) - .069(.165) = .01135$

$\bar{z} = \dfrac{.01135}{.0934} = .12$

J_{CC} (SEE NEXT PAGE) $= .000632$

$A\bar{y} = .1624(.29) - .069(.38) = .0209$

$\bar{y} = \dfrac{.0209}{.0934} = .22$

$I_Y = \dfrac{.58(.28)^3}{12} + .1624(.02)^2 - .00030 - .069(.045)^2 = .00068$

$I_Z = \dfrac{.28(.58)^3}{12} + .1624(.07)^2 - .00052 - .069(.16)^2 = .00306$

LUNAR MASS SPECTROMETER

RADIATOR PLATE ASS'Y

SECTION PROPERTIES OF STANDPOSTS (CONT'D)

SECTION A-A

TORSIONAL CONSTANT, J

$a = .28 \quad b = d = .05 \quad c = .15 \quad r = .06 \quad D = .085$

$$J_{A\text{-}A} = 2\left[J_1 + J_2 + \alpha D^4\right]$$

$$J_1 = ab^3\left[\frac{1}{3} - .21\frac{b}{a}\right] = .28(.05)^3\left[\frac{1}{3} - .21\left(\frac{.05}{.28}\right)\right] = .0000104$$

$$J_2 = cd^3\left[\frac{1}{3} - .105\frac{d}{c}\right] = .15(.05)^3\left[\frac{1}{3} - .105\left(\frac{.05}{.15}\right)\right] = .0000056$$

$$\alpha = \frac{d}{b}\left(.07 + .076\frac{r}{b}\right) = \left[.07 + .076\left(\frac{.06}{.05}\right)\right] = .1612$$

$$J_{A\text{-}A} = 2\left[.0000104 + .0000056 + .1612(.085)^4\right] = .000049$$

SECTION C-C

TORSIONAL CONSTANT, J

$a = .28 \quad b = .23 \quad c = .15 \quad D = .23 \quad r = .06 \quad d = .05$

$$J_{C\text{-}C} = J_1 + J_2 + \alpha D^4 + J_{A\text{-}A}/2$$

$$J_1 = ab^3\left[\frac{1}{3} - .21\frac{b}{a}\right] = .28(.23)^3\left[\frac{1}{3} - .21\left(\frac{.23}{.28}\right)\right] = .000547$$

$$J_2 = cd^3\left[\frac{1}{3} - .105\frac{d}{c}\right] = .15(.05)^3\left[\frac{1}{3} - .105\left(\frac{.05}{.15}\right)\right] = .0000056$$

$$\alpha = \frac{d}{b}\left(.07 + .076\frac{r}{b}\right) = \frac{.05}{.23}\left[.07 + .076\left(\frac{.06}{.23}\right)\right] = .0195$$

$$J_{C\text{-}C} = .000547 + .0000056 + .0195(.23)^4 + .0000245 = .000632$$

LUNAR MASS SPECTROMETER

RADIATOR PLATE ASS'Y

SECTION PROPERTIES OF STANDPOSTS (CONT'D)

SECTION A-A

$$Q_Y = \frac{.10(.18)^2}{2} = .00162$$

$$Q_Z = \frac{.28(.20)^2}{2} - \frac{.23(.15)^2}{2} = .003$$

$$K_Y = \frac{I_Y b_Y}{Q_Y A} = \frac{.00032(.10)}{.00162(.043)} = .0376$$

$$K_Z = \frac{I_Z b_Z}{Q_Z A} = \frac{.00097(.05)}{.0376(.043)} = .0299$$

SECTION C-C

$$Q_Y = \frac{.28(.16)^2}{2} = .00358$$

$$Q_Z = \frac{.28(.22)^2}{2} = .00678$$

$$K_Y = \frac{I_Y b_Y}{Q_Y A} = \frac{.00068(.28)}{.00358(.0934)} = .569$$

$$K_Z = \frac{I_Z b_Z}{Q_Z A} = \frac{.00306(.05)}{.00678(.0934)} = .242$$

LUNAR MASS SPECTROMETER
MOUNTING SCREW NAS 1221-3C

LOADS AND MOMENTS (REF STARDYNE COMPUTER OUTPUT)

MEMBER NO. 49 NODAL POINTS 174 & 219

$V_2 = -41.1$ lbs

$V_3 = 21.0$ lbs

RES. SHEAR $= (V_2^2 + V_3^2)^{1/2} = 46.2$ lbs

$M_{A_2} = -27.3$ IN-lbs

$M_{A_3} = -51.6$ IN-lbs

RES. MOMENT $= (M_{A_2}^2 + M_{A_3}^2)^{1/2} = 58.4$ IN-lbs

P_{AXIAL} DUE TO TURN-UP TORQUE: (1)

$$P_{AXIAL} = \frac{T}{K} = \frac{T}{\frac{D_M}{2}\left[\frac{\tan\alpha + f_1 \sec\beta}{1 - f_1 \sec\beta \tan\alpha} + 1.25 f_2 \frac{d}{d_M}\right]}$$

WHERE: T = TURN-UP TORQUE = 30 IN-lbs
α = LEAD ANGLE OF THREAD AT PITCH DIA
β = HALF THREAD ANGLE
D_M = MEAN THREAD DIA.
d = NOMINAL O.D. OF THREAD
f_1 = THREAD COEFFICIENT OF FRICTION
f_2 = COLLAR " " "
$f_1 = f_2 = .10$
THREAD = 10-32 UNF 3A

$$P_{AXIAL} = \frac{30}{.0267} = 1123 \text{ lbs}$$

SECTION PROPERTIES

DIA = .188 A = .02761 I = .000061 I/c = .00065 D/t = 2.0

STRESSES MAT'L: A286 F_{tu} = 150 KSI (USE F_{tu} = 140 KSI)

$F_b = 232$ KSI $\quad f_b = \frac{58.4}{.00065} = 90$ KSI $\quad R_b = .388$

$F_{tu} = 140$ KSI $\quad f_t = \frac{1123}{.02761} = 40.7$ KSI $\quad R_t = .291$

$F_{su} = 91$ KSI $\quad f_s = \frac{46.2}{.02761} = 1.67$ KSI $\quad R_s = .018$

$$U = \left[(R_b + R_t)^2 + R_s^2\right]^{1/2} = .679$$

$$M.S. = \frac{1}{U} - 1 = +.47$$

(1) REF. PRATT & WHITNEY DESIGN MANUAL PAGE 10.1.1

LUNAR MASS SPECTROMETER

MOUNTING SCREW NAS 1221-3C

LOADS AND MOMENTS ① (REF. STARDYNE COMPUTER OUTPUT)

MEMBER NO. 70 NODAL POINTS 187 & 208

$V_2 = 30.7$ lbs

$V_3 = 36.4$ lbs

RES. SHEAR $= (V_2{}^2 + V_3{}^2)^{1/2} = 47.5$ lbs

$MA_2 = -41.5$ IN-lbs

$MA_3 = 33.7$ IN-lbs

RES. MOMENT $= (M_{A_2}{}^2 + M_{A_3}{}^2)^{1/2} = 53.5$ IN-lbs

P_{AXIAL} DUE TO TURN-UP TORQUE: ②

$$P_{AXIAL} = \frac{T}{K} = \frac{30}{.0267} = 1123 \text{ lbs}$$

SECTION PROPERTIES

DIA = .188 $\quad D/t = 2.0$

A = .02761

I = .0000061 $\quad I/c = .000065$

STRESSES MAT'L: A 286 ③ $F_{tu} = 150$ KSI (USE $F_{tu} = 140$ KSI)

$F_b = 232$ KSI $\quad f_b = \frac{53.5}{.000065} = 82.4$ KSI $\quad R_b = .355$

$F_{tu} = 140$ KSI $\quad f_t = \frac{1123}{.02761} = 40.7$ KSI $\quad R_t = .291$

$F_{su} = 91$ KSI $\quad f_s = \frac{47.5}{.02761} = 1.72$ KSI $\quad R_s = .019$

$$U = [(R_b + R_t)^2 + R_s{}^2]^{1/2} = .646$$

$$M.S. = \frac{1}{U} - 1 = \underline{+.55}$$

③ REF. 5

② REF. PAGE 14

① BASED ON A 30-G LOAD APPLIED SIMULTANEOUSLY ALONG EACH MAJOR AXIS

STARDYNE COMPUTER OUTPUT

LOADS AND MOMENTS ON ELECTRONIC COMPARTMENT MOUNTING SCREWS AT RADIATOR PLATE SURFACE (lbs & in-lbs)

MEMBER No.	A - B	M_{A_2}	M_{A_3}	M_{B_2}	M_{B_3}	V_2	V_3	P (AXIAL)	M_T (TORQUE)
45	146-191	1.91×10^{1}	-2.19×10^{1}	1.98×10^{1}	-3.60×10^{0}	-1.32×10^{1}	-2.01×10^{1}	-5.74×10^{0}	0
46	170-205	1.77×10^{1}	-1.76×10^{1}	1.99×10^{1}	-1.05×10^{1}	-1.45×10^{1}	-1.94×10^{1}	1.16×10^{1}	0
47	181-228	-3.43×10^{1}	1.64×10^{1}	-2.41×10^{1}	5.68×10^{0}	1.14×10^{1}	3.01×10^{1}	-4.05×10^{1}	—
48	212-238	1.36×10^{1}	7.71×10^{-1}	1.43×10^{1}	-1.01×10^{1}	-4.82×10^{0}	-1.44×10^{1}	1.85×10^{1}	—
49	174-219	-2.73×10^{1}	-5.16×10^{1}	-1.34×10^{1}	-2.85×10^{1}	-4.11×10^{1}	2.10×10^{1}	3.94×10^{1}	—
50	164-215	1.78×10^{1}	-2.01×10^{1}	1.11×10^{1}	-1.65×10^{1}	-1.89×10^{1}	-1.49×10^{1}	3.03×10^{1}	—
69	173-225	9.51×10^{0}	-2.96×10^{1}	8.34×10^{0}	-1.26×10^{1}	-2.39×10^{1}	-1.01×10^{1}	-1.72×10^{0}	0
70	187-208	-4.15×10^{1}	3.37×10^{1}	-2.26×10^{1}	2.04×10^{1}	3.07×10^{1}	3.64×10^{1}	-7.63×10^{1}	—
71	139-156	-6.64×10^{0}	-2.52×10^{1}	-5.26×10^{0}	-1.61×10^{1}	-2.34×10^{1}	6.75×10^{0}	1.06×10^{2}	0
72	196-244	6.35×10^{-1}	-9.45×10^{0}	3.22×10^{0}	-8.59×10^{0}	-1.02×10^{1}	-2.19×10^{0}	7.35×10^{1}	0
73	200-241	-9.63×10^{0}	1.59×10^{1}	-4.95×10^{0}	4.38×10^{0}	1.15×10^{1}	8.27×10^{0}	-2.45×10^{1}	0
74	159-207	1.48×10^{1}	-1.09×10^{1}	6.83×10^{0}	-7.95×10^{0}	-1.07×10^{1}	-1.23×10^{1}	-4.72×10^{1}	0

PREPARED BY JFC
CHECKED BY
REVISED BY

ENGINEERING REPORT
Bendix Aerospace Systems Division

DATE 2-10-71 PAGE 16
REPORT No. ATM 1042
MODEL LMS

PREPARED BY JFC CHECKED BY REVISED BY	**ENGINEERING REPORT** Bendix Aerospace Systems Division	DATE 2-18-71 PAGE 17 REPORT No. ATM 1042 MODEL LMS

LUNAR MASS SPECTROMETER

RADIATOR PLATE

(1) SOCKET ANALYSIS OF BOSS FOR MOUNTING SCREWS

SOCKET LOADS

REF. STARDYNE COMPUTER OUTPUT

MEMBER No. 70 NODAL POINTS 187 & 208

$V_2 = 30.7$ lbs

$V_3 = 36.4$ lbs

RESULTANT $= (V_2^2 + V_3^2)^{1/2} = 47.5$ lbs

$M_{A_2} = -41.5$ IN-lbs

$M_{A_3} = 33.7$ IN-lbs

RESULTANT MOMENT $= (M_{A_2}^2 + M_{A_3}^2)^{1/2} = 53.5$ IN-lbs

$$V_1 = \frac{\text{RES MOMENT}}{L - L_{br}} + \frac{\text{RESULTANT LOAD}}{2} = 396 \text{ lbs}$$

SOCKET PROPERTIES

$D = .246$ (NOMINAL)

$L = .215$ (LENGTH OF HELICAL COIL)

$L/D = \frac{.215}{.246} = .875$

$L_{br}/L = .33 \qquad L_{br} = .33(.215) = .071$

$t = t_1 = .077$

$a = .20 \qquad a/D = .814 \qquad C_U = .80$ (2)

ALLOWABLE SOCKET LOAD MAT'L : AL. ALLOY 2024-T351

$$V_U = C_U D L_{br} F_{tu} = .80(.246).071(62000) = 866 \text{ lbs}$$

$$M.S. = \frac{V_U}{V_1} - 1 = +1.19$$

(2) BASED ON L/D = 1.0

(1) REF NO. 1 SECTION 2.60

BxA 542

LUNAR MASS SPECTROMETER 2347607

ATTACH BOLT - SUPPORT TEE TO RADIATOR PLATE

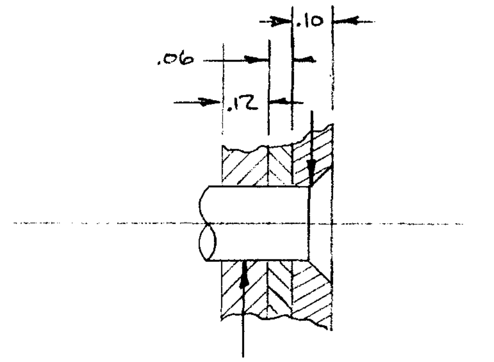
LOADS

TOTAL BOLT FORCE

$F_{TOT} = 467.5$ lbs

BENDING MOMENT

$B.M. = .17(467.5) = 79.5$ IN-lbs



BOLT SECTION PROPERTIES

$DIA = .19$ $\quad D/t = 2.0$

$A = .02835$

$I = .000064$ $\quad I/c = .000674$

STRESSES $\quad F_{tu} = 125$ KSI

SHEAR CHECK

$F_{su} = 75$ KSI $\quad f_s = \frac{467.5}{.02835} = 16.5$ KSI

$M.S. = \frac{F_s}{f_s} - 1 = \underline{+3.55}$

BENDING CHECK

$F_b = 204$ KSI $\quad f_b = \frac{79.5}{.00674} = 11.8$ KSI

$M.S. = \frac{F_b}{1.15 f_b} - 1 =$ AMPLE

(1) FITTING FACTOR

PREPARED BY JFC	ENGINEERING REPORT	DATE 2-17-71 PAGE 19
CHECKED BY	Bendix Aerospace Systems Division	REPORT No. ATM 1042
REVISED BY		MODEL LMS

LUNAR MASS SPECTROMETER

ATTACH SCREW - PREAMP DISCRIMINATOR TO RADIATOR PLATE STANDPOST

LOADS DUE TO TURN-UP TORQUE

SCREW SIZE = #8 (.164) -32 UNF 3A

TURN-UP TORQUE, T = 19.8 (1) IN-LBS

FRICTION COEFFICIENT, $f = f_1 = f_2 = .20$ (2)

AXIAL LOAD DUE TO TURN UP TORQUE, F

(3)
$$F = \frac{T}{K} = \frac{T}{\frac{D_M}{2}\left[\frac{\tan\alpha + f\sec\beta}{1 - f_1\sec\beta\tan\alpha} + 1.25\, f_2 \frac{d}{d_M}\right]}$$

WHERE: α = LEAD ANGLE OF THREAD AT PITCH DIA.

β = HALF THREAD ANGLE

D_M = MEAN THREAD DIA.

d = NOMINAL O.D. OF THREAD

$$F = \frac{19.8}{.0423} = 468 \text{ lbs}$$

AXIAL LOAD DUE TO G-LOAD ON PREAMP DISCRIMINATOR, F_G

PREAMP DISCRIMINATOR WEIGHT = .75 lbs

$$F_G = .75\,(30) = 22.5 \text{ lbs}$$

TOTAL AXIAL LOAD, F_{TOT}

$$F_{TOT} = F + F_G = 490.5 \text{ lbs}$$

SECTION PROPERTIES OF SCREW

STRESS AREA = .0139 IN²

STRESSES   MAT'L : 18-8 STAINLESS STEEL $F_{tu} = 75$ KSI

$$F_{tu} = 75 \text{ KSI} \qquad f_t = \frac{490.5}{.0139} = 35.3 \text{ KSI}$$

$$M.S. = \frac{F_{tu}}{f_t} - 1 = +1.12$$

(3) REF. PRATT & WHITNEY AIRCRAFT DESIGN MANUAL, PAGE 10.1.1

(2) DUE TO SCREW THREADING INTO A SELF LOCKING HELICAL COIL

(1) REF 6BX INTERNAL MEMO No. 71-210-84

LUNAR MASS SPECTROMETER

ATTACH SCREW - PREAMP DISCRIMINATOR TO RADIATOR PLATE STAND POST

STRESSES DEVELOPED DURING TURN-UP TORQUE OPERATION

TURN-UP TORQUE, T = 19.8 IN-lbs

(1) AXIAL LOAD = 468 lbs

SECTION PROPERTIES OF SCREW

#8 (.164) - 32 UNF 3A THREAD

MINOR DIA = .1257

AREA = .0120

STRESS AREA = .0139 (2)

POLAR SECTION MODULUS $= \frac{\pi r^3}{2} = \frac{\pi (.06285)^3}{2} = .00039$

STRESS   MAT'L: 18-8 STAINLESS STEEL $F_{tu} = 75$ KSI

$$f_t = \frac{468}{.0139} = 33.7 \text{ KSI}$$

$$f_{st} = \frac{T}{2Z_p} = \frac{19.8}{2(.00039)} = 25.4 \text{ KSI}$$

MAXIMUM PRINCIPAL STRESS:

$$f_t' = \left[\left(\frac{f_t}{2}\right)^2 + f_{st}^2\right]^{1/2} + \frac{f_t}{2} = 47.4 \text{ KSI}$$

$$M.S. = \frac{F_{tu}}{f_t'} - 1 = \underline{+.58}$$

(2) BASED ON MEAN OF PITCH & MINOR DIA'S TO ALLOW FOR STRENGTHENING EFFECT OF THE THREADS

(1) REF. PAGE 19

LUNAR MASS SPECTROMETER

SHOULDER SCREW P/N 2347698

LOADS COND. 30 G'S

LUG (B) (SEE SKETCH, PAGE)

$P_x = -92$ lbs

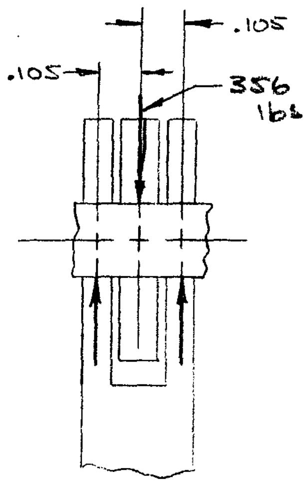
$P_z = -343$ lbs

RES $P = (P_x^2 + P_z^2)^{1/2} = 356$ lbs

ASSUME A 60-40 LOAD DISTRIBUTION BETWEEN LUGS ON THE SUPPORT ASSY

$P_{LUG} = .60\, P_{RES} = 214$ lbs

B.M. $= .105\,(214) = 22.5$ IN-lbs



SECTION PROPERTIES

DIA $= .190$ $D/t = 2.0$

$A = .02835$

$I = .000064$ $I/c = .000674$

STRESSES MAT'L: 6AL 4V - A $F_{tu} = 130$ KSI

SHEAR CHECK

$F_{su} = 80$ KSI $f_s = \dfrac{356}{.02835} = 12.8$ KSI

$$M.S. = \frac{F_{su}}{f_s} - 1 = \underline{+5.25}$$

BENDING CHECK

$F_b = F_{tu} = 130$ KSI $f_b = \dfrac{22.5}{.000674} = 33.4$ KSI

$$M.S. = \frac{F_b}{1.15 f_b} - 1 = \underline{\text{AMPLE}}$$

① FITTING FACTOR

LUNAR MASS SPECTROMETER

BASEPLATE P/N 2347600

LUG ANALYSIS

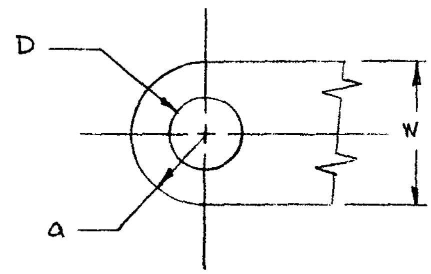
ASSUME TOTAL G LOAD OF LMS IS TAKEN OUT ON ONE LUG & LUG DIAMETER CONTAINS A SOLID PIN RATHER THAN A SHOCK MOUNT.

TOTAL WEIGHT OF LMS = 20.54 lbs

30-G LOAD, $P = 30(20.54) = 615$ lbs

$P = P_{LUG} = P_{AXIAL}$ (1) $= P_{TRANSVERSE}$ (1) $= 615$ lbs

LUG PROPERTIES (2)



$D = .36$ (4) $\quad A_{br} = Dt = .0675$

$t = .188 \quad A_t = (W-D)t = .0976$

$a = .44 \quad a/D = 1.22 \quad K_{br} = .98$

$W = .88 \quad W/D = 2.44 \quad K_t = .85$

$\theta° = 0 \quad R = .18 \quad E = a - R = .26$

$R/E = .693 \quad K_1 = 1.12 \quad \dfrac{A_{AV}}{A_{br}} = \dfrac{K_1 E}{2R} = \dfrac{1.12(.26)}{.36} = .807$

$K_{tru} = .32$

LUG ALLOWABLES MAT'L: AL. ALLOY 2024-T351 $F_{tu} = 62$ KSI

TENSION

$P_{tu} = K_t A_t F_{tu} = .85(.0976)\,62000 = 5150$ lbs

$M.S. = \dfrac{P_{tu}}{1.15 P_a} - 1 = +6.27$ (3)

SHEAR-BEARING

$P_{bru} = K_{br} A_{br} F_{tu} = .98(.0675)\,62000 = 4100$ lbs

$M.S. = \dfrac{P_{bru}}{1.15 P_a} - 1 = +4.80$ (3)

TRANSVERSE

$P_{tru} = K_{tru} A_{br} F_{tu} = .32(.0675)\,62000 = 1340$ lbs

$M.S. = \dfrac{P_{tru}}{1.15 P_{tr}} - 1 = +.89$ (3)

(3) FITTING FACTOR

(2) REF. No. 7 SECTION 2.30

(1) ACTING SEPARATELY

(4) CONSERVATIVELY ASSUME A SOLID PIN IN LUG

LUNAR MASS SPECTROMETER

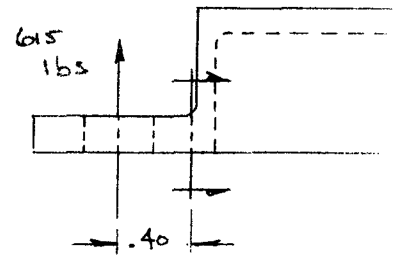
BASEPLATE P/N 2347600

SECTION AT BASE OF INTERFACE LUG

LOAD & MOMENT

$P = 30(20.54) = 615 \text{ lbs}$

$B.M. = .40(615) = 246 \text{ in-lbs}$

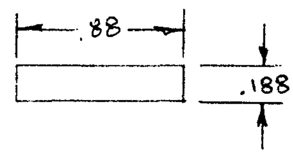


SECTION PROPERTIES

$A = .188(.88) = .165$

$I = \dfrac{.88(.188)^3}{12} = .00048$

$I/c = .0051 \qquad K = 1.5$



STRESSES MAT'L: AL. ALLOY 2024-T351 $F_{tu} = 62$ KSI

$F_b = 1.45 F_{tu} = 90 \text{ KSI} \qquad f_b = \dfrac{246}{.0051} = 48.3 \text{ KSI} \qquad R_b = .537$

$F_s = 37 \text{ KSI} \qquad f_s = \dfrac{615}{.165} = 3.73 \text{ KSI} \qquad R_s = .101$

$U = (R_b^2 + R_s^2)^{1/2} = .547$

$M.S. = \dfrac{1}{U} - 1 = \underline{+.83}$

PREPARED BY JFC CHECKED BY REVISED BY	**ENGINEERING REPORT** Bendix Aerospace Systems Division	DATE 1-22-71 PAGE 24 REPORT No. ATM 1042 MODEL LMS

LUNAR MASS SPECTROMETER

THERMAL COVER ASSEMBLY P/N 2347510

ASSUMPTIONS :

1. COVER ASSY WEIGHT = .70 lb
2. LOADING - 30 G'S ULTIMATE
3. TOTAL LOAD TAKEN BY ONE RIVET.

LOADS

$$P = 30(.70) = 21 \text{ lbs}$$

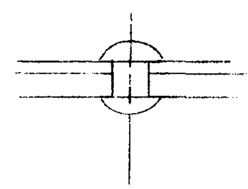
COMPRESSION OF RIVET HOLE EDGE :

BEARING PROPERTIES

DIA = .094

THICKNESS = .06

$A_{br} = .094(.06) = .00564$



STRESSES MAT'L : B STAGE PHENOLIC - GLASS VOLAN A CTL 91 LD

(1) COMPRESSIVE STRENGTH, EDGEWISE = 47.5 KSI

$$f_c = \frac{21}{.00564} = 3.72 \text{ KSI}$$

M.S. = AMPLE

TANGENTIAL STRESS AT RIVET HOLE

$b = .047$ $a/b = 5.0$ (ASSUMED) $\beta = 2.34$

$t = .06$

STRESSES $F_t = 58$ KSI

(1) $F_t = 58$ KSI $f = \frac{\beta P}{t^2} = \frac{2.34(21)}{(.06)^2} = 13.7$ KSI

$$M.S. = \frac{F_t}{f} - 1 = 3.23$$

(1) REF 9 [illegible]

LUNAR MASS SPECTROMETER

DUST COVER HINGE SPRING P/N 2347685

SPRING PROPERTIES

SPRING MAT'L : A.S. 5 MUSIC WIRE

SPRING MEAN DIA, D = .233 IN

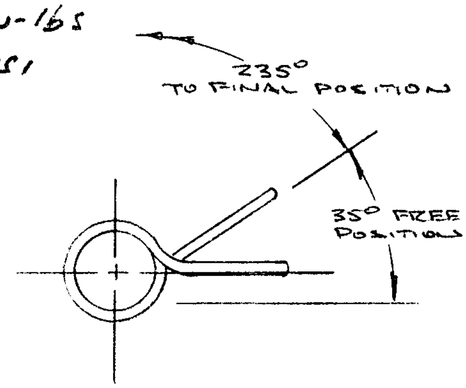
WIRE DIA, d = .033 IN

SPRING DEFLECTION, F° = 235°

E = 30×10^6 PSI

MOMENT AT FINAL POSITION, M = .64 IN-LBS

MINIMUM TENSILE STRENGTH = 336 KSI



SPRING CORRECTION FACTOR FOR CURVATURE

$R = .10 + .0165 = .1165$

$C = .0165$

$R/C = 7.06$

$K = 1.2$

SPRING STRESSES

$$S_b = \frac{10.2\ M}{d^3} = \frac{10.2\,(.64)}{(.033)^3} = 181.5 \text{ KSI}$$

$$S_{b_{MAX}} = K S_b = 1.2\,(181.5) = 218 \text{ KSI}$$

WORKING STRESS (LIGHT SERVICE)

$$S_{WORKING} = 146 \text{ KSI}$$

$$S_{MAX\ WORKING} = 146\,(1.5) = 219 \text{ KSI}$$

NUMBER OF ACTIVE COILS

$$N = \frac{E d^4 F^\circ}{4000\ M\ D} = \frac{30 \times 10^6\,(.033)^4\,235^\circ}{4000\,(.64)\,.233} = 14$$

LUNAR MASS SPECTROMETER

DUST COVER HINGE SPRING P/N 2347685

SPRING PROPERTIES

SPRING MAT'L: 18-8 STAINLESS STEEL S.A.E. 30302

SPRING MEAN DIA, D = .236 IN.

WIRE DIA, d = .036 IN.

SPRING DEFLECTION, F° = 235°

E = 28×10^6 PSI

MOMENT AT FINAL POSITION, M = .64 IN-LBS

MINIMUM TENSILE STRENGTH = 273 KSI

SPRING CORRECTION FACTOR FOR CURVATURE

$R = .10 + .0165 = .1165$

$C = .0165$

$R/C = 7.06$

$K = 1.2$

SPRING STRESSES

$$S_b = \frac{10.2\,M}{d^3} = \frac{10.2(.64)}{(.036)^3} = 140 \text{ KSI}$$

$$S_{b_{MAX}} = KS_b = 1.2(140) = 168 \text{ KSI}$$

WORKING STRESS (LIGHT SERVICE)

$$S_{WORKING} = 113 \text{ KSI}$$

$$S_{MAX\,WORKING} = 113(1.5) = 169.5 \text{ KSI}$$

NUMBER OF ACTIVE COILS

$$N = \frac{E d^4 F^\circ}{4000\,M\,D} = \frac{28 \times 10^6 (.036)^4\, 235^\circ}{4000(.64).236} = 18.3$$

PREPARED BY JFC	ENGINEERING REPORT	DATE 1-26-71 PAGE 27
CHECKED BY	Bendix Aerospace Systems Division	REPORT No. ATM 1042
REVISED BY		MODEL LMS

LUNAR MASS SPECTROMETER

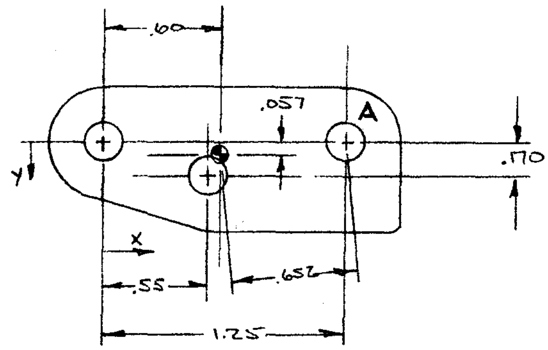
UHT HANDLING SOCKET - ATTACHMENT TO BASEPLATE

BOLT PATTERN ANALYSIS

C.G. LOCATION:

$$\bar{x} = \frac{1.25 + .55}{3} = .60$$

$$\bar{y} = \frac{.17}{3} = .057$$



LOADS

1. ASTRONAUT FORCE = 45 lbs (ULT.)
2. BOLT PATTERN TAKES TOTAL ASTRONAUT FORCE.
3. FRICTION BETWEEN SOCKET & BASE PLATE NEGLECTED.

BOLT PATTERN LOAD:

$$P_{BP} = 45 \text{ lbs}$$

DIRECT FORCE ON BOLTS:

$$F = \frac{45}{3} = 15 \text{ lbs}$$

BOLT PATTERN MOMENT:

$$M_{BP} = \left[(.62 + 26.0)\cos 45^\circ + 3.0 \sin 45^\circ\right] 45.0 = 940 \text{ in-lbs}$$

CONSTANT OF PROPORTIONALITY OF BOLT PATTERN, K:

$$K = \frac{940}{(.602)^2 + (.123)^2 + (.652)^2} = 1170$$

MOMENT FORCE ON BOLT (A):

$$F_A = K r_A = 1170(.652) = 764 \text{ lbs}$$

TOTAL FORCE AT BOLT (A)

$$F_{TOT} = F + F_A = 779 \text{ lbs}$$

BOLT DESIGNATION:

AN 3 CRES BOLT — SINGLE SHEAR STRENGTH = 2125 lbs.

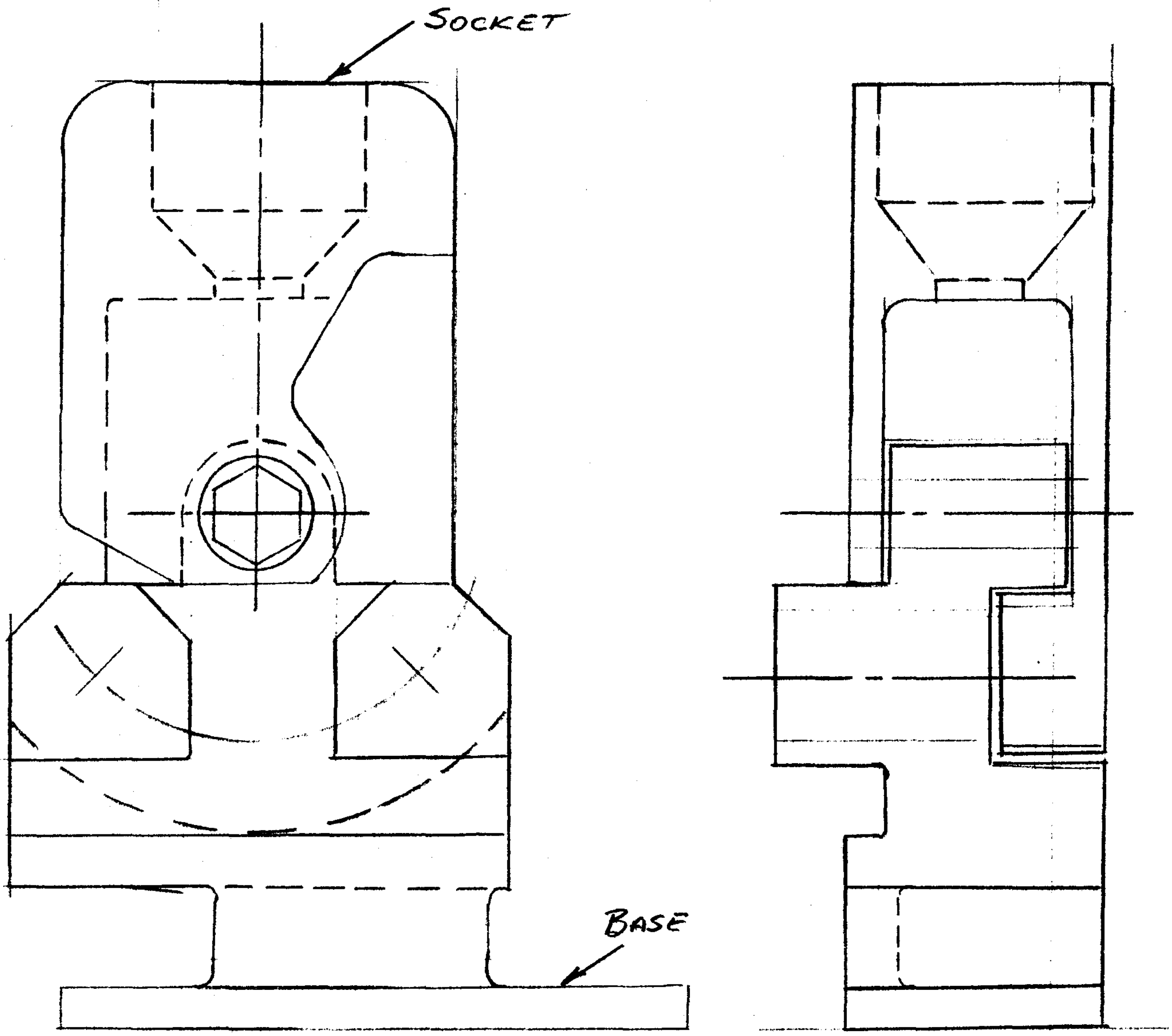
BOLT MARGIN OF SAFETY:

$$M.S. = \frac{2125}{779} - 1 = +1.73$$

LUNAR MASS SPECTROMETER

UHT HANDLING SOCKET

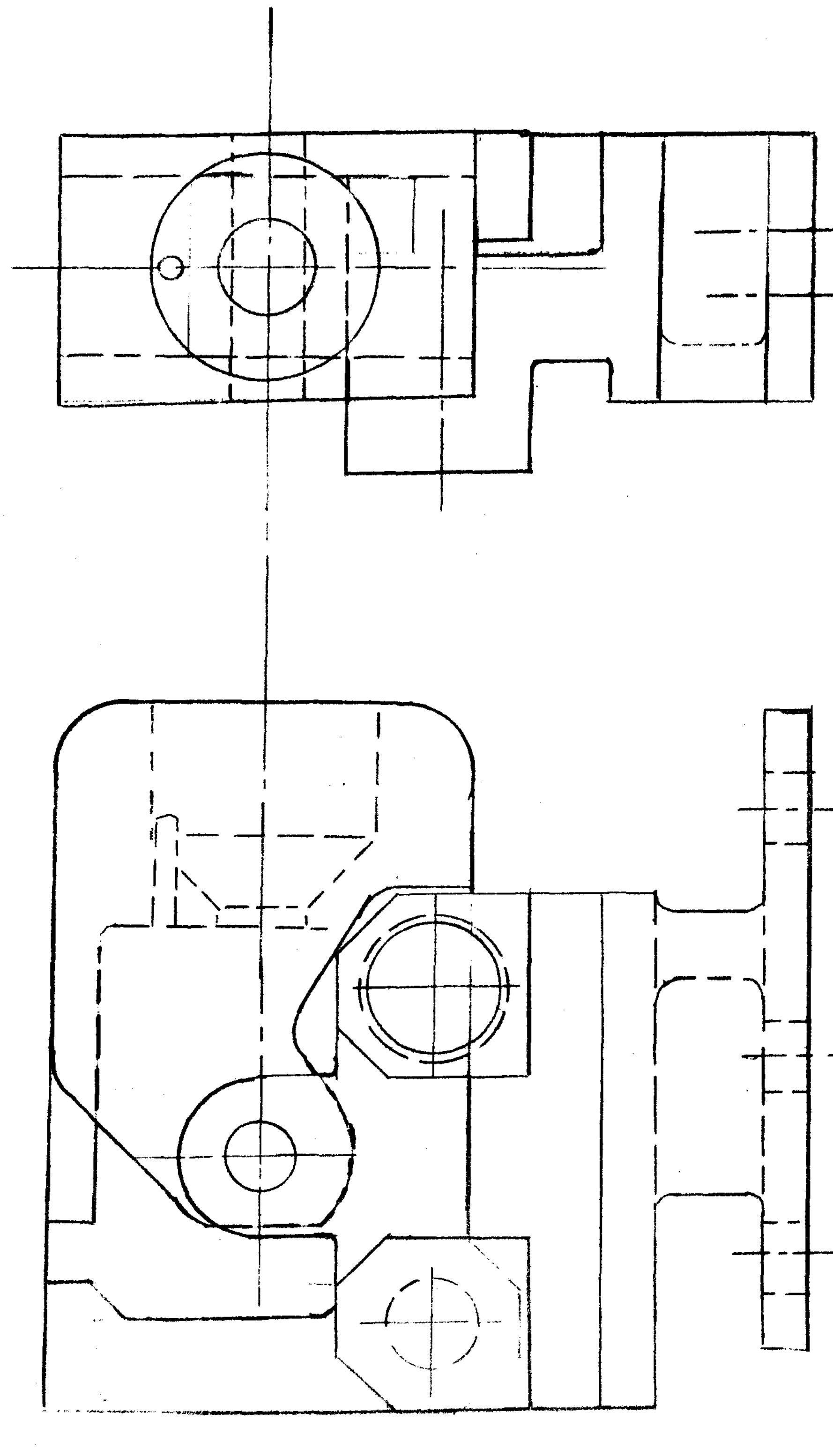
REF. DWG. 2347483



VERTICAL POSITION

SCALE 2/1

LUNAR MASS SPECTROMETER
UHT HANDLING SOCKET DWG. 2347483



HORIZONTAL POSITION SCALE 2/1

LUNAR MASS SPECTROMETER

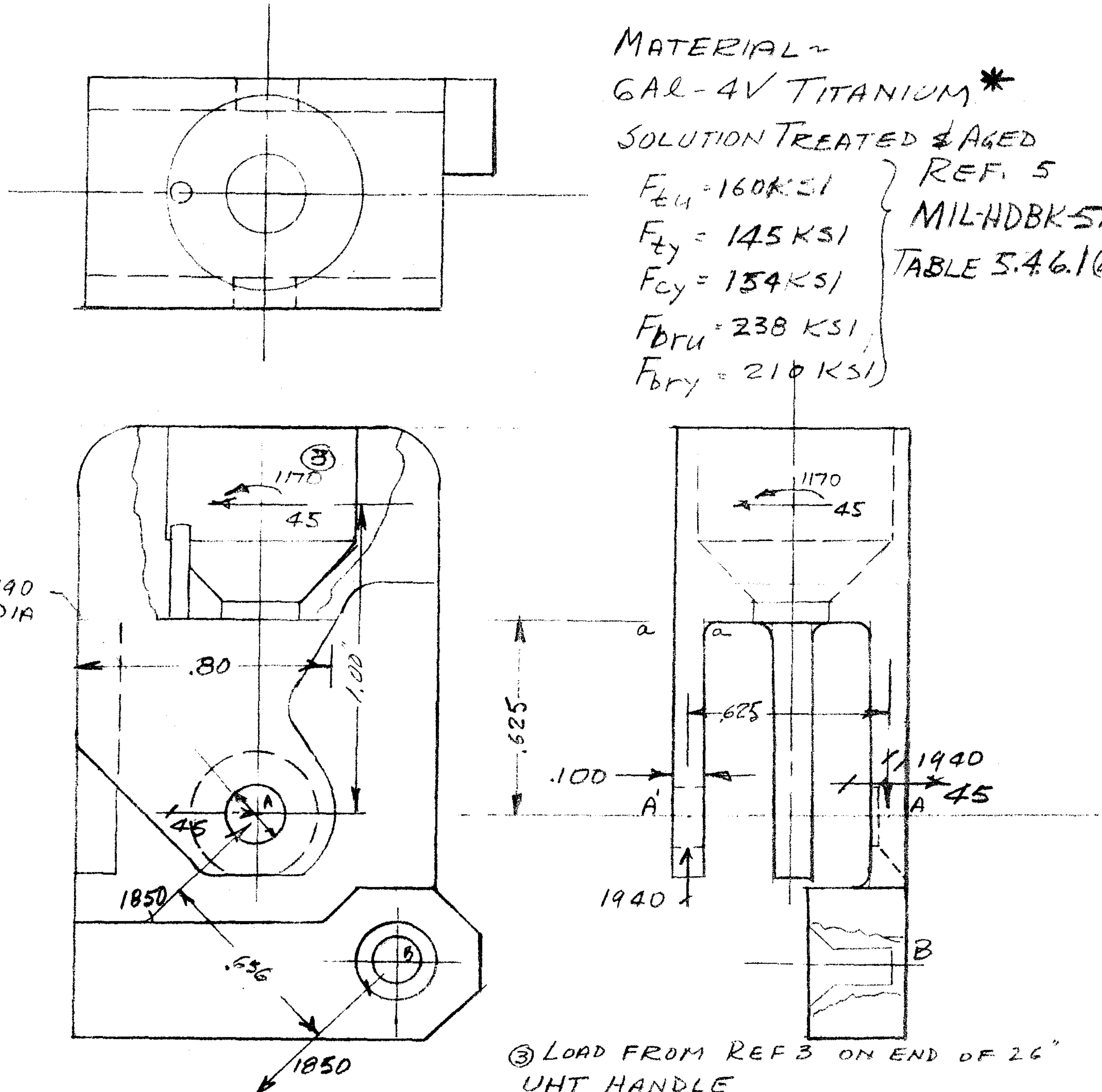
UHT HANDLING SOCKET ~

SWIVEL SOCKET FITTING ~ DWG. NO. 2347484

MATERIAL ~
6Al - 4V TITANIUM *
SOLUTION TREATED & AGED

F_{tu} = 160 KSI
F_{ty} = 145 KSI
F_{cy} = 154 KSI
F_{bru} = 238 KSI
F_{bry} = 210 KSI

REF. 5 MIL-HDBK-5A TABLE 5.4.6.1(a)



③ LOAD FROM REF 3 ON END OF 26" UHT HANDLE

* NOTE:- FINAL DESIGN OF THIS ITEM IS 17-4PH H900 STEEL. SINCE THIS WILL GIVE HIGHER M.S.'s NO FURTHER ANALYSIS IS NECESSARY.

LUNAR MASS SPECTROMETER

UHT HANDLING SOCKET

SWIVEL SOCKET FITTING (CONTINUED)

POINT A

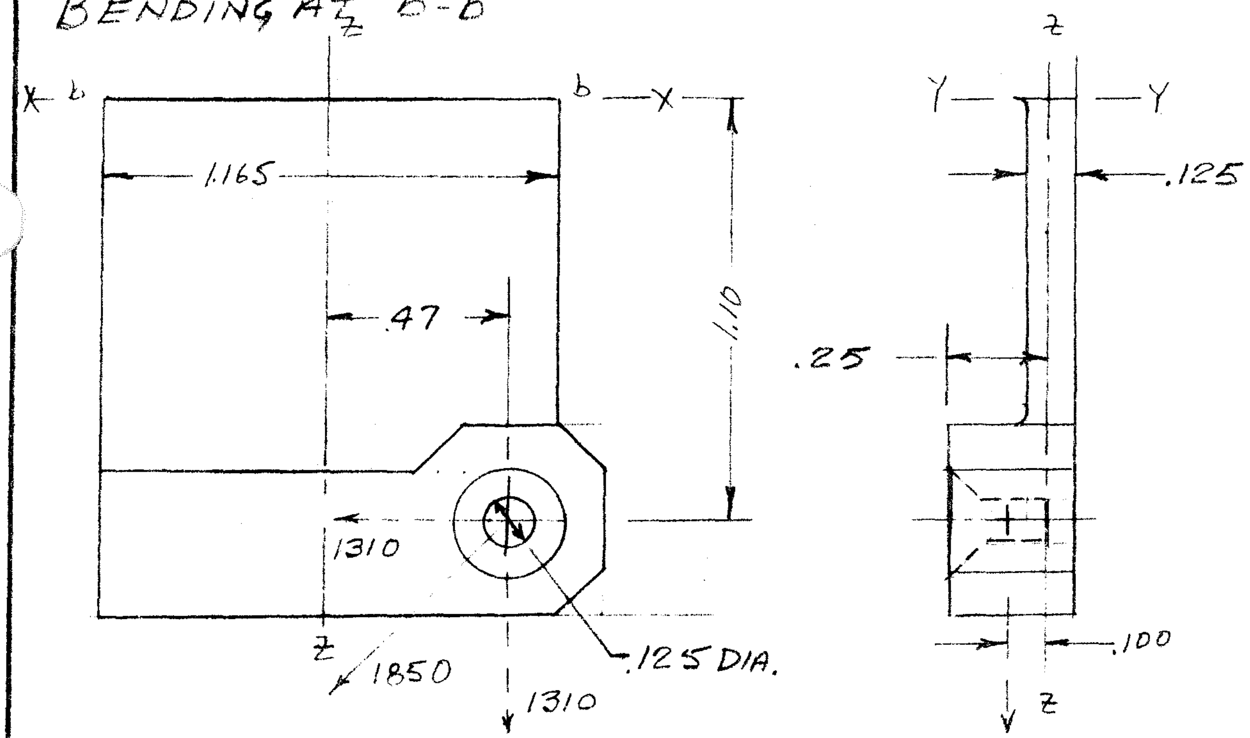
$\sigma_{br} = \frac{1940}{.10 \times .190} \quad 102000 \qquad M.S. = \frac{238000}{102000} - 1 = 1.34$

BENDING AT a-a

B.M. = 45 X .625 = 28.2 IN. LBS

$\sigma_b = \frac{6 \times 28.2}{.8 \times .1^2} = 21000$ PSI M.S. AMPLE

BENDING AT b-b



$M_x = .10 \times 1310 = 131$ IN. LBS.

$M_y = .47 \times 1310 + 1.10 \times 1310 = 615 + 1440 = 2055$ IN. LBS.

$M_z = .10 \times 1310 = 131$ IN. LBS.

LUNAR MASS SPECTROMETER
UHT HANDLING SOCKET ~
SWIVEL SOCKET FITTING ~ (CONTINUED)
BENDING AT b-b (CONTINUED)

$$\sigma_{xx} = \frac{131 \times 6}{1.165 \times .125^2} = 43200 \qquad M.S. = \frac{160000}{115700} - 1 = .38$$

$$\sigma_{yy} = \frac{2055 \times 6}{.125 \times 1.165^2} = \frac{72500}{115700}$$

$$\tau_{zz} = \frac{3 \times 131}{1.165 \times .125^2} = 21600$$

SMALL

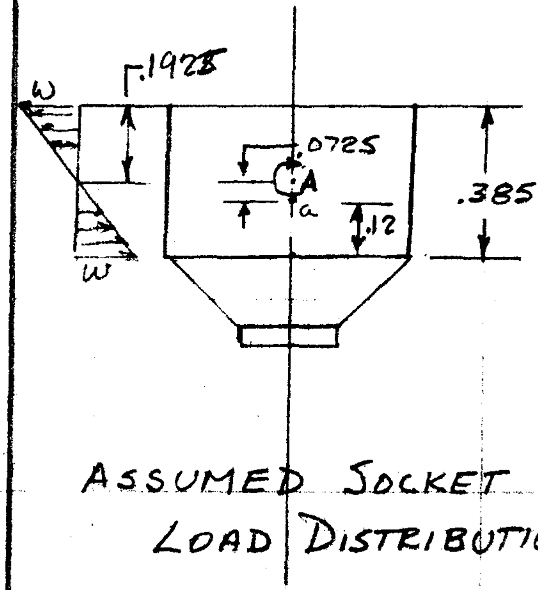
BEARING STRESS AT B

$$\sigma_{br} = \frac{1850}{.125 \times .25} = 59300 \quad M.S. \text{ AMPLE}$$

LUNAR MASS SPECTROMETER

UHT HANDLING SOCKET

SWIVEL SOCKET ~ UHT INTERFACE



ASSUMED SOCKET LOAD DISTRIBUTION

$M_a = 1170$ (REF. 1

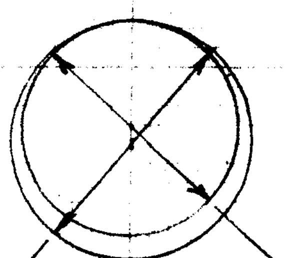
$M_A = 1170 - 45 \times .0725 = 1167$ IN. LBS

$$\frac{W \times .385}{4} \times \frac{.385 \times 2}{3} = 1167$$

$p = W = 47300$ LBS/IN.

$$\sigma_c = .798 \sqrt{\frac{\dfrac{P(D_1 - D_2)}{D_1 D_2}}{\left[\left(\dfrac{1-\nu_1^2}{E_1}\right) + \left(\dfrac{1-\nu_2^2}{E_2}\right)\right]}}$$

REF. 4 - ROARK ~ TABLE XIV CASE 6



$$\sigma_c = .798 \sqrt{\frac{\dfrac{47300(.633 - .621)}{.633 \times .621}}{\dfrac{.93}{30 \times 10^6} + \dfrac{.91}{16 \times 10^6}}}$$

$$\sigma_c = 798 \sqrt{\frac{1445}{.031 + .057}} = 102000$$

$$\sigma_{c_y} = \frac{102000}{1.22} = 83500$$

$F_{cy} = 154000$

REF. 5 - MIL HDBK 5A TABLE 5.4.6.1(a)

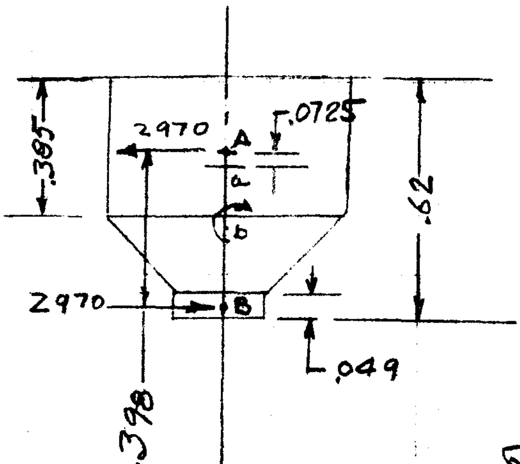
$$M.S. = \frac{154000}{83500} - 1$$

$= .85$

LUNAR MASS SPECTROMETER

UHT HANDLING SOCKET

SWIVEL SOCKET ~ UHT INTERFACE



$M_a = 1170$

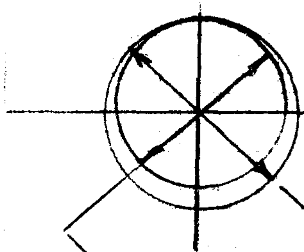
$M_b = 1170 + 45 \times .272 = 1170 + 12 = 1182$

$P_B = \dfrac{1182}{.398} = 2970 \text{ LBS}$

$p = \dfrac{2970}{.049} = 60700 \text{ LBS/IN}$

$$\sigma_c = .798 \sqrt{\dfrac{p \dfrac{D_1 - D_2}{D_1 D_2}}{\left[\dfrac{1-\nu_1^2}{E_1} + \dfrac{1-\nu_2^2}{E_2}\right]}}$$

ASSUMED SOCKET
LOAD DISTRIBUTION



.250 SOCKET
DIA ~ 6Al-4V TITANIUM

.241
TOOL DIA.
174PH STEEL

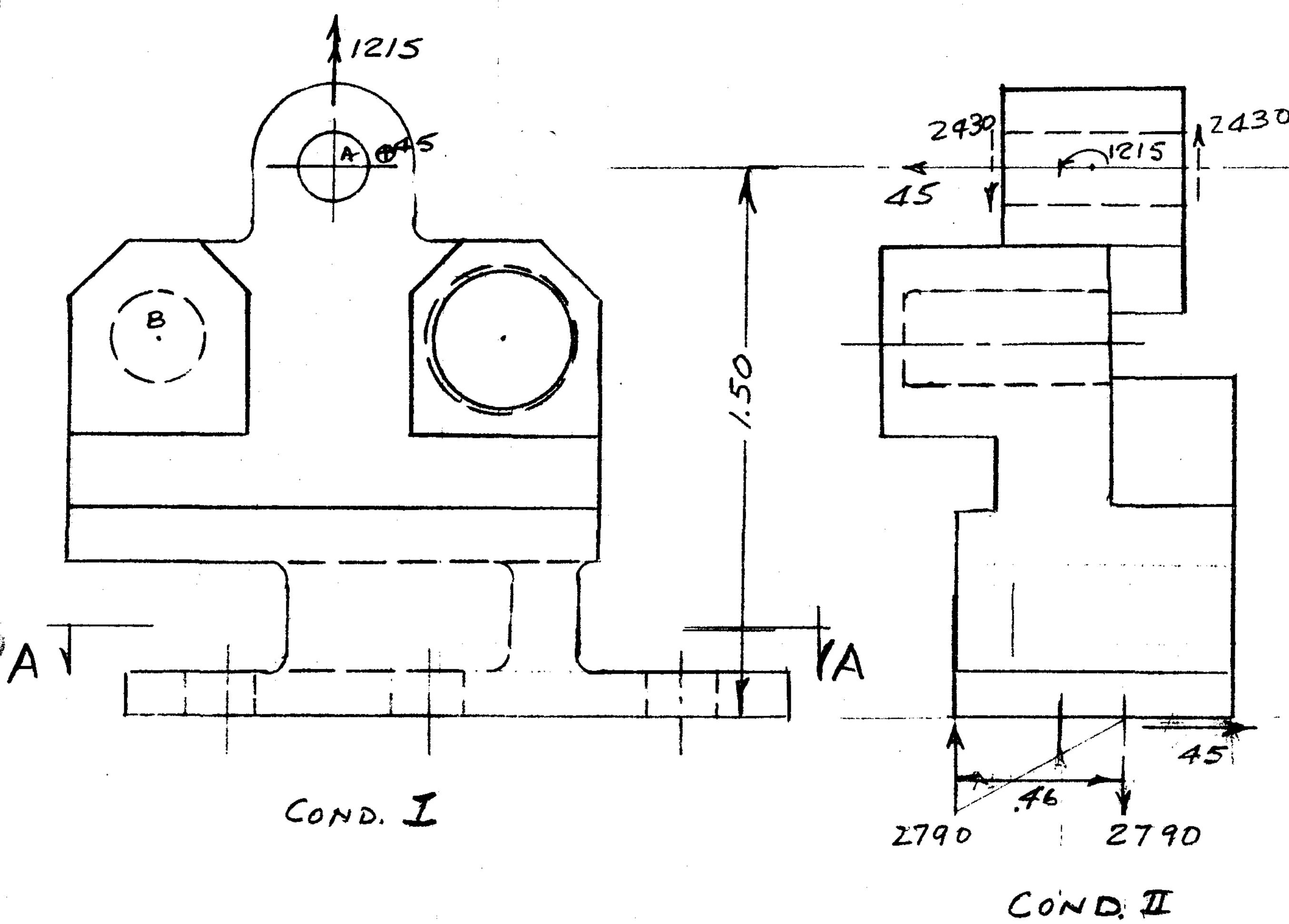
$$\sigma_c = .798 \sqrt{\dfrac{60700\left(\dfrac{.250-.241}{.250 \times .241}\right)}{\dfrac{.93}{30 \times 10^6} + \dfrac{.91}{16 \times 10^6}}}$$

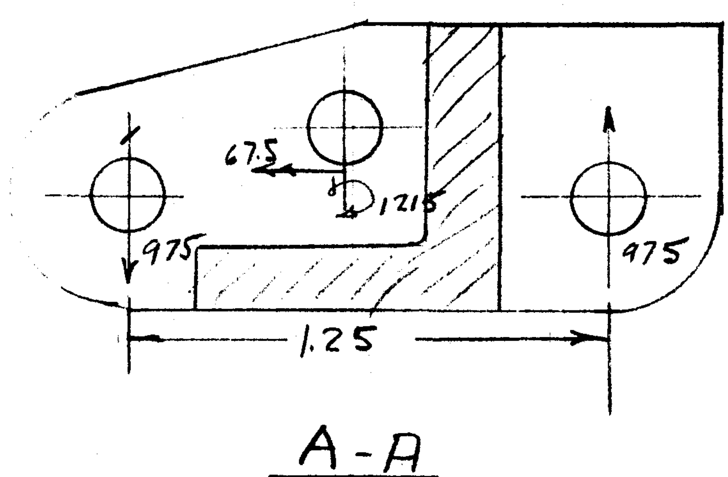
$$= .798 \sqrt{\dfrac{60700 \times .009}{.0623} \Big/ (.031 + .057) 10^{-6}}$$

$$.798 \sqrt{99500} = 251000$$

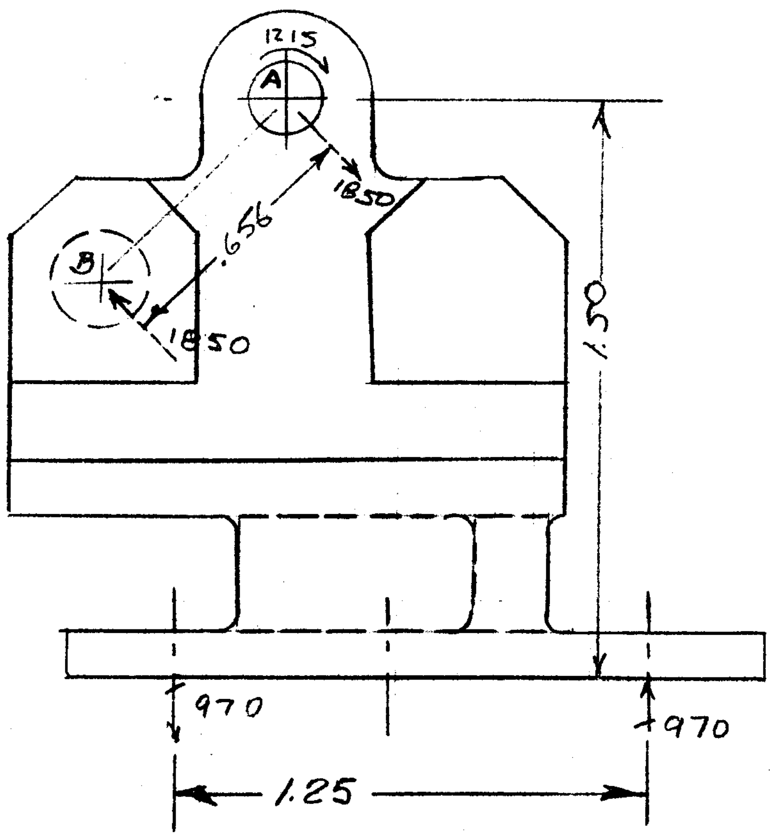
$\sigma_{c_{LIM}} = \dfrac{251000}{1.22} = 206000 \qquad M.S. = \dfrac{210000}{206000} - 1 = .02$

LUNAR MASS SPECTROMETER
UHT HANDLING SOCKET
SWIVEL SOCKET BASE ~ DWG. 2347485





LUNAR MASS SPECTROMETER
UHT HANDLING SOCKET
SWIVEL SOCKET BASE



COND. III

LUNAR MASS SPECTROMETER
UHT HANDLING SOCKET
SWIVEL SOCKET BASE
SECT A-A ~ SHEARING STRESSES

COND. I (SEE FIG. FOR COND. III)

$M_T = 1215$

$\tau = \dfrac{3 \times 1215}{(.81 + .57).28^2} = 33800$

MATERIAL
7075 AL. ALLOY PLATE

$\tau_{ALLOW} = 45000$ REF. 5 MIL-HDBK-5A TABLE 3.2.7.0(b)

$M.S. = \dfrac{45000}{33800} - 1 = .33$

OTHER CONDITIONS INVESTIGATED AND ARE NOT CRITICAL.