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Stress Analysis of the B-36 Nose Gear 50803

(None)

Ades, C.S.
Bendix Aviation Corp., Bendix Products Div., South Bend, Ind. R-813
(Same) (Same)

Feb '47 Unclass. U.S. English 21 diagrs, graphs, drwgs

A stress analysis was made of the nose gear of the B-36 bomber. The analysis covers the axle, inner and outer cylinder, piston, torque fittings and arms, and [illegible]. The appendix shows the computations for the nose gear loads, loads at points O,O' and O'', loads at sections in the fork, torque arm geometry, and loads at the upper and lower bearings, trunnion and drag brace. A table of the minimum margins of safety is included.

StrucCopies of this report obtainable from CADO. (1)
Structures (7) Landing gears - Stress analysis
Stress Analysis of Specific Aircraft (54537); Landing gears, Nose - Static Tests (54538.6);
(6) B-36 ([illegible].6)

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**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

ENGINEERING DEPARTMENT

REPORT NO. 813

TITLE STRESS ANALYSIS OF THE B-36 NOSE GEAR

C. S. Ades

PREPARED BY:

C. S. Ades

Date 2-20-47

APPROVED BY:

J. A. Marchear

Date 4-18-47

No. of Pages

Report #815

Written by C.S.A. Date 2-20-47
Checked by E.D.G Date 4-8-47
Subject Stress Analysis of B-36 Nose Gear

Page No.
No. of Pages
Model B-36

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SOUTH BEND, INDIANA, U. S. A.

Report #813

Written by C.S.A. Date 2-20-47 Page No. 1
Checked by E.D.G Date 4-8-47 No. of Pages
Subject Stress Analysis of the B-36 Nose Gear Model B-36

## INTRODUCTION

The nose landing gear of the Consolidated B-36 airplane is of the semi-cantilever retracting type. It is supported in the airplane at three hinge points: one at the top of the gear where it is connected to the drag brace, and two at the ends of two trunnion arms extending from the outer cylinder twenty-five inches below the first point. Retraction is accomplished through a lever bolted to one of the trunnion arms. In landing position, an inner cylinder sliding within the outer cylinder, is "fully extended," at which time the overall length of the gear from drag brace to axle is about ninety inches. The shock of landing is absorbed by hydraulic fluid contained within the inner cylinder, the pressure being gradually relieved by the escape of the fluid through a fixed orifice (no metering pin). The axle contains dual wheels, splined to it so as to be co-rotating.

The loads imposed on the gear are in general in accordance with ANC-2. In addition, due to the dual wheels, the following distribution of loads to the wheels is used: 50% - 50%, 60% - 40% and 60% - 0%. Since also the wheels are co-rotating, the torque from side load is assumed taken by tire scrubbing. This makes the 60-0 conditions critical for torque, but the result is practically the same in either case. For ready reference, all loads tables will be found in the Appendix. Loads used in the analysis are assumed in general to come from this source without further reference. The two obviously critical conditions for the axle were for convenience numbered Conditions I and II.

Sketches are freely used throughout the analysis to indicate the sections and dimensions checked. Dimensions given at critical sections take into consideration the machining allowances so that the "minimum" section is obtained. Critical margins of safety are computed and indicated; although where it is evident that the margin is large (.50 or greater), the abbreviation "amp." for ample is quite often used. The following general remarks also apply:

1. Since most of the material of the strut is steel with a minimum heat treat value of 205,000 psi ultimate tensile strength, this is assumed to be the case unless it is otherwise noted. Allowable stresses are obtained from ANC-5, extrapolated where necessary.

2. Since scaling is known to be small for this type of material, no allowance is made for it except as it is cared for by an excess margin of safety.

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Written by C.S.A. Date 2-20-47 Page No. 11
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## INTRODUCTION (CONT'D)

3. No special allowance is made for the fact that the lower end of the inner cylinder is a bent tube. This agrees with Bendix's experience in testing struts containing such tubes.

4. Thin tubes, D/t ≥ 25, are checked for local instability by the method of ANC-5, paragraph 1.633.

5. Bending modulus of rupture values for tubes are taken from ANC-5, Fig. 4-20. This value for non-circular sections is taken equal to 1.5 x $F_{ty}$, which is felt to be conservative.

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Report #813

Written by C.S.A. Date 2-20-47 Page No. iii
Checked by S.D.G. Date 4-5-47 No. of Pages
Subject Stress Analysis of B-36 Nose Gear Model B-36

## LIST OF REFERENCES


(1) Consolidated Vultee Aircraft Corporation — "Preliminary Nose Gear Stress Analysis YB-36, YB-36A, and B-36A Airplanes." Rept. FES-36-157. Fort Worth Div., January, 1946.

(2) U.S.A.A.F. — Drawing #S46R81[illegible], Change "C".

(3) Army-Navy Civil Committee on Aircraft Design Criteria — "ANC-5, Strength of Aircraft Elements," Dec., 1942.

(4) Roark, R. J. — "Formulas for Stress & Strain." McGraw-Hill Book Co., New York, 1943.

(5) Kinzel and Crafts — "The Alloys of Iron and Chromium," Vol. I. McGraw Hill Book Co., New York, 1937.

(6) Lundquist — "Strength Tests of Thin Walled Duralumin Cylinders in Combined Transverse Shear and Bending." N.A.C.A. T.N. #523.

(7) Oberg and Jones — "Machinery's Handbook." The Industrial Press, New York, 1944.

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(9) Timoshenko, S. — "Strength of Materials," Part II. D. Van Nostrand Co., New York, 1941.

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Written by C.S.A. Date 3-20-47 Page No. iv
Checked by C.D.G. Date 4-8-47 No. of Pages
Subject Stress Analysis of B-36 Nose Gear Model B-36

TABLE OF MARGINS OF SAFETY


| Section | Page | Crit. Load Cond. | M.S. |
|---|---|---|---|
| Axle (Ref. Sketch, page 10) | | | |
| Section 1 | 11 | II | Amp. |
| Section 2 | 12 | II | + .21 |
| Section 3 | 13 | I | + .24 |
| Clutch-Face of Plate | 16 | II | + .13 |
| -Spline Ring and Teeth | 16 | II | Amp. |
| -Wheel Bolts | 17 | II | + .01 |
| Nut | 18 | II | Amp. |
| Housing-Thrust Nut | 20 | II | Amp. |
| -Jack Pad | 20 | | Amp. |
| Inner Cylinder (Ref. Sketches, pp. 23 & 27) | | | |
| Section at Weld to Housing | 22 | 1(c) | + .46 |
| Section in Parent Metal Above Weld | 23 | 1(c) | + .79 |
| Section 1-1 | 25 | 1(b) | + .59 |
| Section 2-2 | 26 | 1(b) | + .34 |
| Section 3-3 | 28 | 1(b) | + .04 |
| Section 4-4 | 29 | 1(b) | + .06 |
| Section 5-5 | 30 | 1(b) | + .10 |
| Section 6-6 | 31 | 1(b) | + .11 |
| Section 7-7 | 32 | 1(b) | + .27 |
| Section thru Base of Thread Near Centerline Upper Bearing | 33 | 7-1(a) | + .85 |
| Diaphragm | 34 | 1(a) | + .23 |
| Outer Cylinder Analysis (Ref. Sketch p.35) | | | |
| Section 1-1 | 36 | 7-1(a) | + .13 |
| Section 2-2 | 37 | 7-1(a) | + .02 |
| Section 3-3 | 38 | 7-1(a) | + .20 |
| Section 4-4 | 39 | 7-1(a) | + .09 |
| Section 5-5 | 40 | 7-1(a) | + .25 |
| Section 6-6 | 41 | 7-1(a) | + .28 |
| Shearout of Torque Yoke Stops | 42 | 1(c) | Amp. |
| Shoulder for Torque Yoke | 43 | 1(c) | Amp. |
| Trunnion (Ref. Sketch on p. 44) | | | |
| -Section at Threads | 45 | 1(b) | Amp. |
| -Section 1-1 | 46 | 1(b) | + .02 |
| -Section 2-2 | 48 | 1(b) | + .10 |
| -Tear it from Cylinder Tube | 49 | 1(b) | + .01 |
| Upper End Fitting (Ref. Sketch p. 50) | | | |
| -Threads Cap to Cylinder | 51 | 7-1(a) | + .16 |
| -Weld-Air Pressure Check | 52 | 1(c) | + .32 |

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Written by C.S.A. Date 2-20-47 Page No. V
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Subject Stress Analysis of B-36 Nose Gear Model B-36

TABLE OF MARGINS OF SAFETY (CONT'D)

| Sections | Page | Crit. Load Cond. | M. S. |
|---|---|---|---|
| Outer Cylinder Analysis (Cont'd.) | | | |
| Upper End Fitting (Cont'd.) | | | |
| -Section 1-1 | 51 | 1(b) | + .50 |
| -Section 2-2 | 52 | 7-1(a) | + .15 |
| -Tearout of Lugs | 53 | 7-1(a) | + .49 |
| -Bending of Lugs | 54 | 7-1(a) | Amp. |
| -Tearout from Cylinder Head | 55 | 7-1(a) | Amp. |
| Gland Nut | 56 | | Amp. |
| Piston | | | |
| Tube | 64 | 1(a) | +.08 |
| Orifice Plate-Threads Connecting Ring to Plate | 66 | 1(a) | Amp. |
| -Inner Ring | 67 | 1(a) | Amp. |
| -Outer Ring | 68 | 1(a) | Amp. |
| -Middle Ring | 69 | 1(a) | Amp. |
| -Threads Connecting to Piston Tube | 70 | 1(a) | + .43 |
| Tube at Threads Connecting to Orifice Plate | 71 | 1(a) | + .26 |
| Inner Cylinder Torque Fitting (Ref. Sketch, p. 72) | | | |
| Bolt Connecting Arm to Fitting | 73 | 1(c) | + .01 |
| Section 1-1 | 74 | 1(c) | +1.16 |
| Section 2-2 | 75 | 1(c) | +1.28 |
| Weld | 76 | 1(c) | + .50 |
| Torque Yoke (Ref. Sketch, p. 76) | | | |
| Tearout of Fitting from Yoke | 77 | 1(c) | + .17 |
| Yoke Stop | 81 | 1(c) | + .27 |
| Nut | 82 | 1(c) | Amp. |
| Bushing | 83 | 1(c) | + .35 |
| Torque Arms (Ref. Sketch, p. 83) | | | |
| Lugs at Fitting End | 84 | 1(c) | + .33 |
| Lug at Apex End-Section 1-1 | 85 | 1(c) | + .21 |
| Section 2-2 | 86 | 1(c) | + .25 |
| Section 3-3 | 87 | 1(c) | + .56 |
| Jams | | | |
| Plug-Upper Jam Lock | 88 | | + .44 |
| Keys-Lower Jam | 89 | | + .39 |
| Retracting Lever (Ref. Sketch, p. 91) | | | |
| Lug and Bolt at Jack Attaching Point | | | + .[illegible] |
| Lug and Bolt at Trunnion Connection | | | + .[illegible] |

Written by C.S.A. Date 2-20-47
Checked by C.D.G. Date 4-8-47
Subject Stress Analysis of B-36 Nose Gear



TABLE OF MARGINS OF SAFETY (CONT'D)

| Section | Page | Crit. Load Cond. | M. S. |
|---|---|---|---|
| Retracting Lever (Cont'd.) | | | |
| Sections 1-1 and 2-2 | 93 | | + .72 |
| Section 3-3 | 94 | | + .16 |
| Section 4-4 | 95 | | Amp. |
| Shimmy Damper Connections | | | |
| Upper Lug and Bolt | 99 | | + .33 |
| Lower Lug and Bolt | 100 | | + .45 |
| Lower Lug and Bolt | 101 | | + .28 |
| Torque Yoke Arm- Section 1-1 | 102 | | + .05 |
| -Section 2-2 | 103 | | + .10 |
| -Tearout from Yoke Barrel | 104 | | + .12 |
| -Lug | 105 | | + .30 |

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Written by C.S.A. Date 2-20-47 Page No. viii

Checked by S.D.G. Date 4-8-47 No. of Pages

Subject Stress Analysis of B-36 Nose Gear Model B-36

## SYMBOLS

$A_s$ = Area of cross-section

$A_m$ = Area enclosed by median line of section

R (subscript) = Radial

$A_H$ = Hydraulic area

p = Hydraulic pressure or radial pressure (on cylinder)

$f_h$ = Hoop stress

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Written by _____ Date 12-29-38 Page No. _____
Checked by _____ Date 12-29-38 No. of Pages _____
Subject Standard Structural Symbols M&M S-1T

A--Area of cross section
a--Subscript "allowable"
b--Width of section; subscript "bending"
br--Subscript "bearing"
c--Distance from neutral axis to extreme fiber; subscript "compression"
D--Diameter
E--Modulus of elasticity in tension
F--Allowable stress
f--Internal (calculated) stress
$F_b$--Allowable bending stress, modulus of rupture in bending
$F_{st}$--Modulus of rupture in torsion
G--Modulus of elasticity in shear
I--Moment of inertia
$I_p$--Polar moment of inertia
L--Length
L.B.--Lower bearing
M--Applied moment or couple, usually a bending moment
n--Subscript "normal"
P--Applied load
psi--Pounds per square inch
Q--Static moment of a cross section
R--Subscript "resultant"
r--Radius
S--Shear force
s--Subscript "shear"
T--Applied torsional moment, torque
t--Thickness, subscript "tensile"
U.B.--Upper bearing
u--Subscript "ultimate
y--Subscript "yield"
$\rho$(RHO)--Radius of gyration
CG--Center of gravity
MS--Margin of safety
O.D.--Outside diameter
I.D.--Inside diameter

STANDARD LOAD SYMBOLS:
In analyzing the main landing gear, the left wheel (from cockpit, looking forward) is considered. The following symbols are used for loads:

Loads Perpendicular and Parallel, Resp., to Ground:
V--Vertical load, positive up  D--Drag load, positive back
R--Side load, positive out

Loads Perpendicular and Parallel, Resp., to Strut A:
X--Drag load, positive back  Y--Vertical load, positive up
Z--Side load, positive out

Positive directions of moments are determined by the right hand rule; i.e., a positive moment is one that is clockwise, looking along the positive direction of the corresponding force vector. The symbols for moments are:--

$M_V$--Moment about V axis
$M_D$--Moment about D axis
$M_R$--Moment about R axis
$M_X$--Moment about X axis
$M_Y$--Moment about Y axis
$M_Z$--Moment about Z axis

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Written by CSA Date 2/13/47
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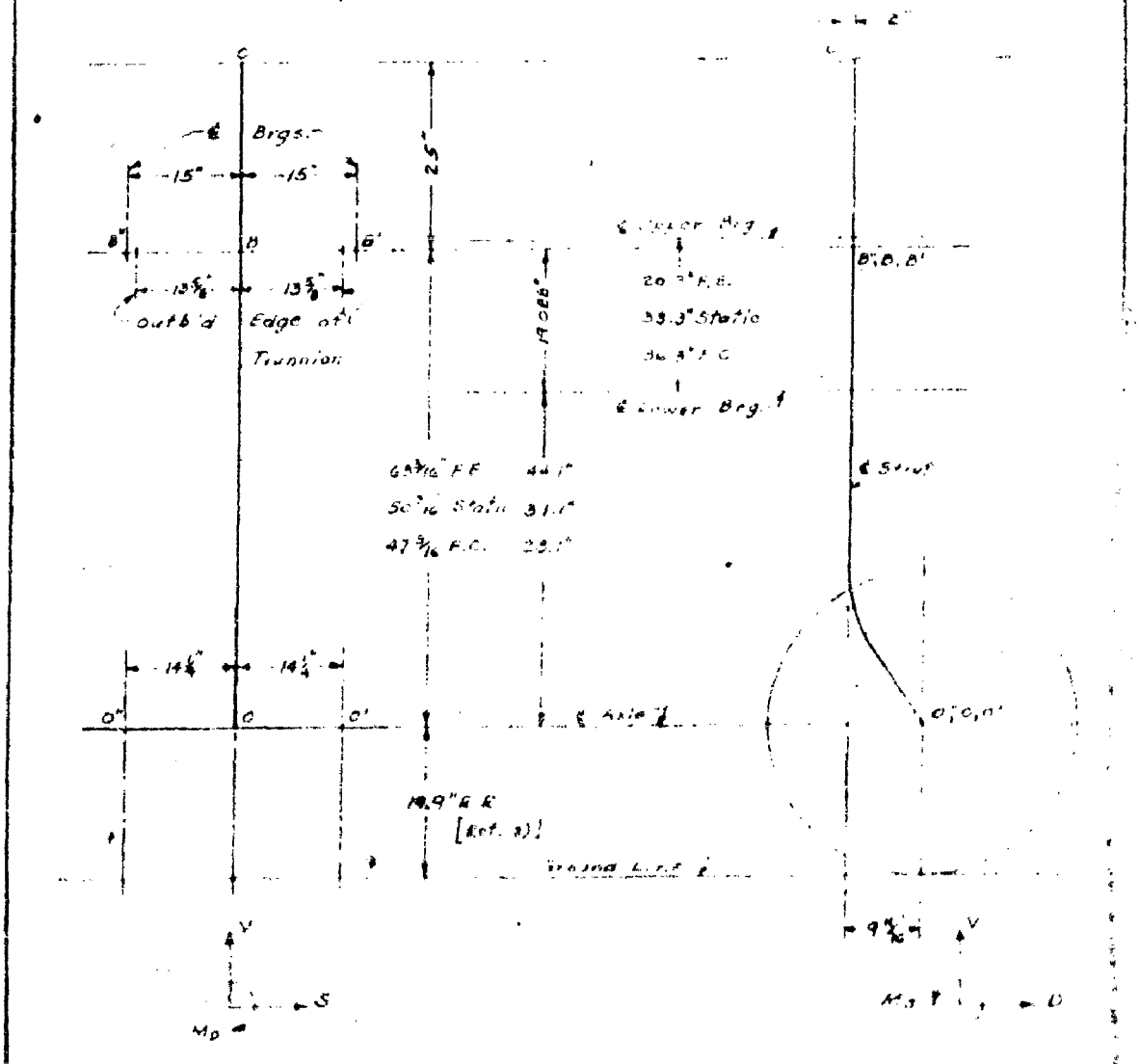
Subject GEOMETRY OF STRUT

Page No. 1
No. of Pages 111
Model [illegible]



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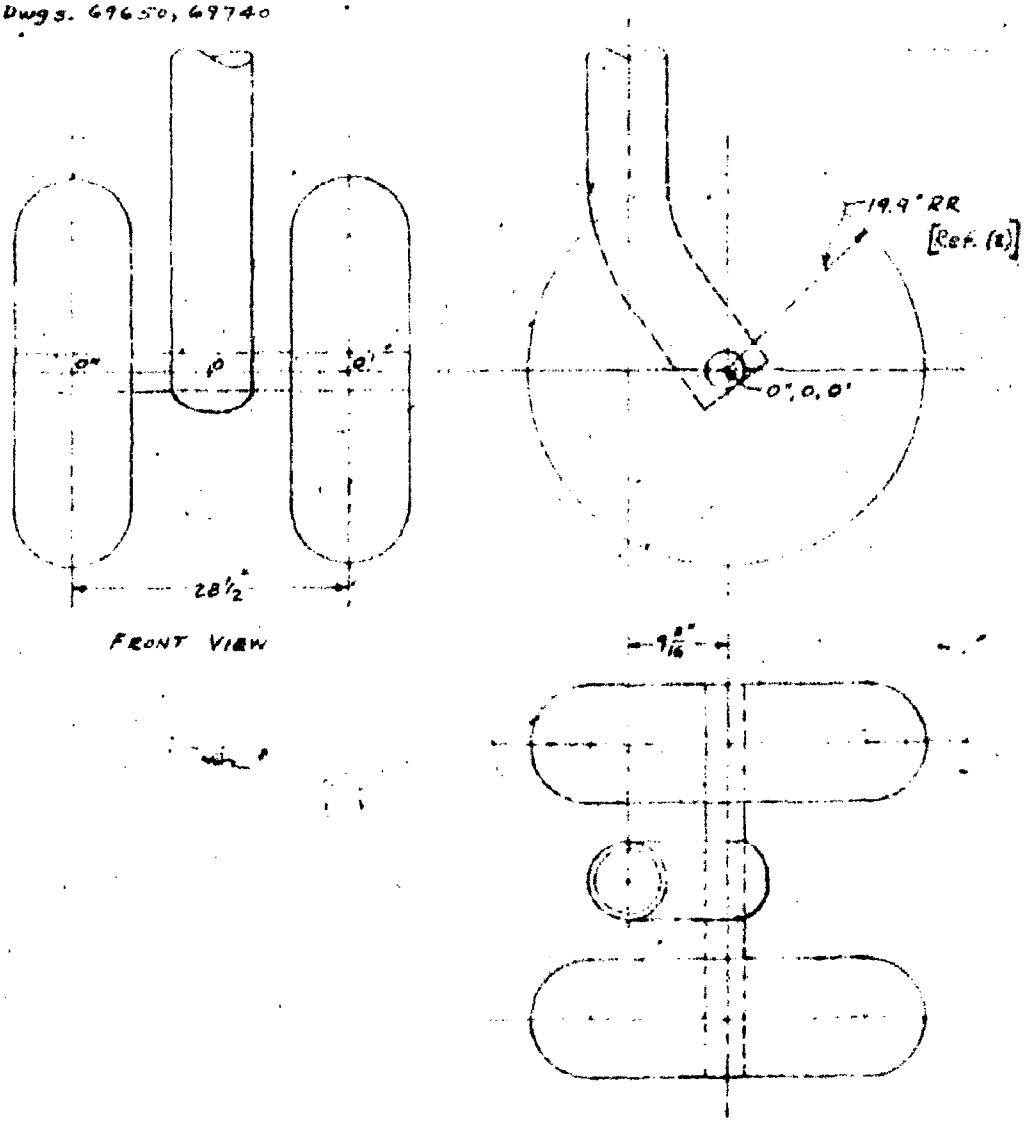
Written by CSA Date 11/15/46
Checked by E. D. Y. Date 4-8-47
Subject AXLE & ADJACENT STRUCTURE

Rept. # 814
Page No. 2
No. of Pages 111
Model B-36 N.G.

Ref. Dwgs. 69650, 69740



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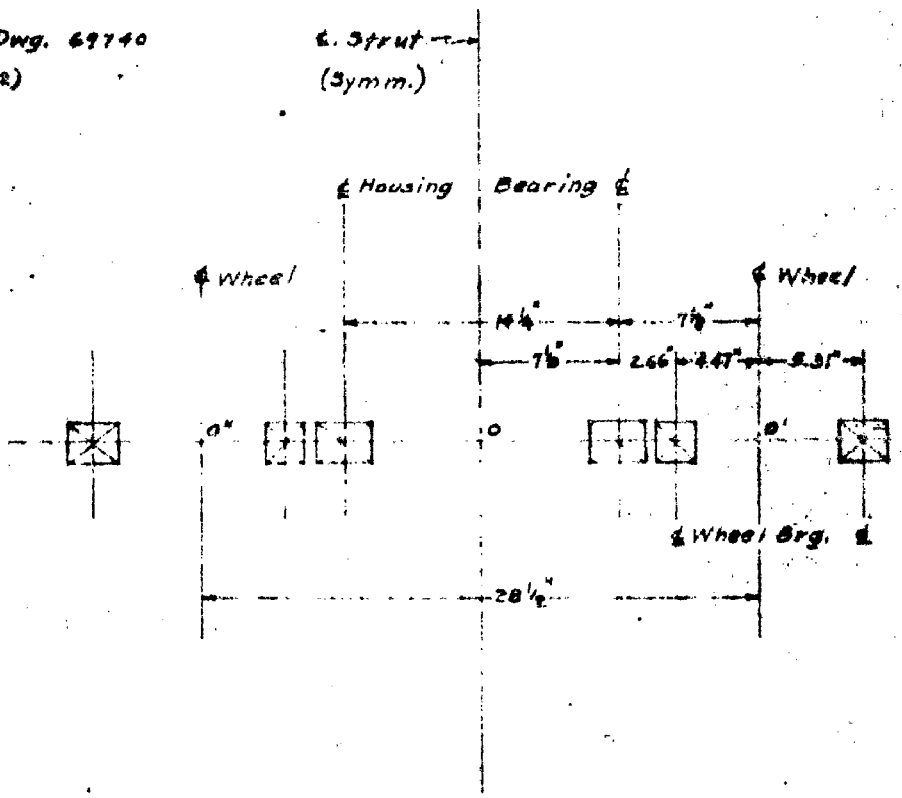
Written by: CBA Date: 11/15/46
Checked by: G.D.G Date: 4-8-47
Subject: AXLE PLAN

Rept. # 813
Page No. 3
No. of Pages 111
Model B-25 N.S.

Ref. Dwg. 69740
Ref. (2)

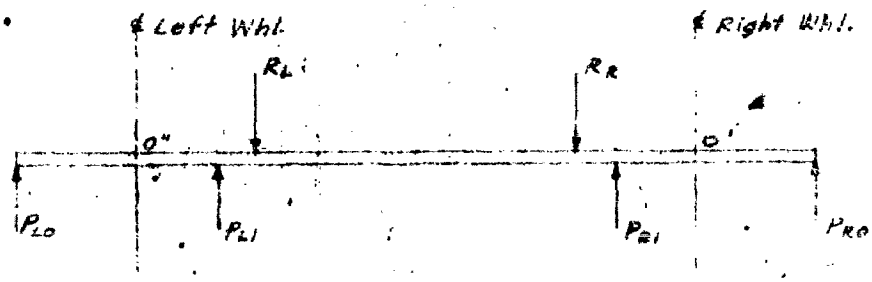



B-128

Written by C.S.A. Date 11/15/46
Checked by G.D.G Date 4-8-47
Subject AXLE LOADS

Dept. # 813
Page No. 4
No. of Pages 111
Model B-36 N.G

CONDITION I - 3WLIR 60-40 DIST.




Assume 60% on right whl.

$P_{RI} + P_{RO} = .6(166{,}200^2 + 44{,}900^2)^{\frac{1}{2}} = 105{,}000\#$

$P_{LO} + P_{LI} = .4(166{,}200^2 + 54{,}700^2)^{\frac{1}{2}} = 70{,}000\#$

$P_{RI} = 105{,}000\,(5.31/9.78) = 57{,}000\#$

$P_{RO} = 105{,}000\,(4.47/9.78) = 48{,}000\#$

$P_{LI} = 70{,}000\,(5.31/9.78) = 38{,}000\#$

$P_{LO} = 70{,}000\,(4.47/9.78) = 32{,}000\#$

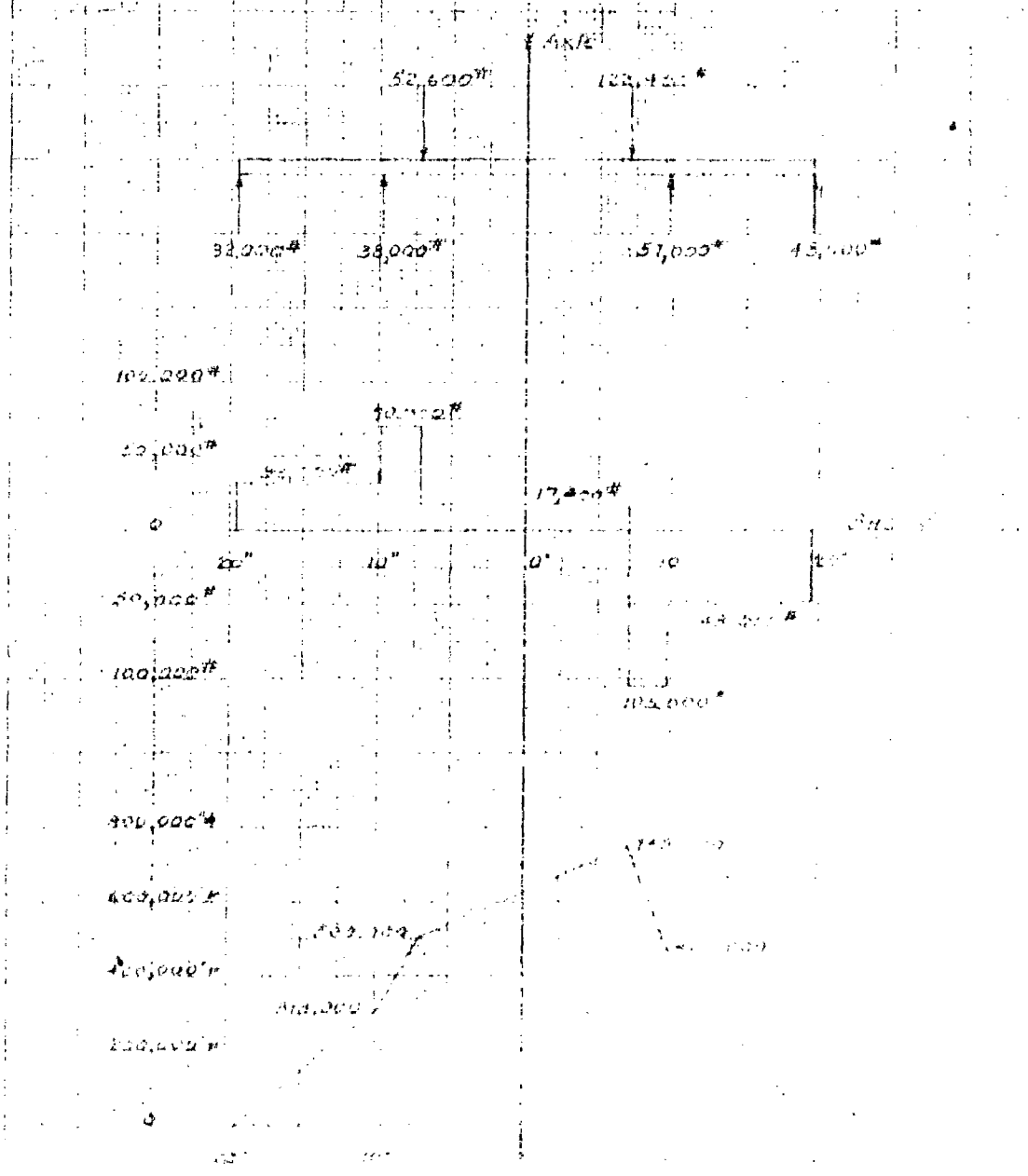
$R_R = (105{,}000 \times 21.4 - 70{,}000 \times 7.13)/14.25 = 128{,}400\#$

$R_L = (70{,}000 \times 21.4 - 105{,}000 \times 7.13)/14.25 = 52{,}600\#$

* Ref. # 3

B-36 N.G. ~ AXLE

CONDITION I - 3 WDR 60-40 DIST.



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Written by CSA Date 11/21/46
Checked by [illegible] Date 4-8-47
Subject AXLE LOADS

Rept # 813
Page No. 6
No. of Pages 111
Model B-36 N.G.

CONDITION II - SIDE DRIFT 60-40 DIST

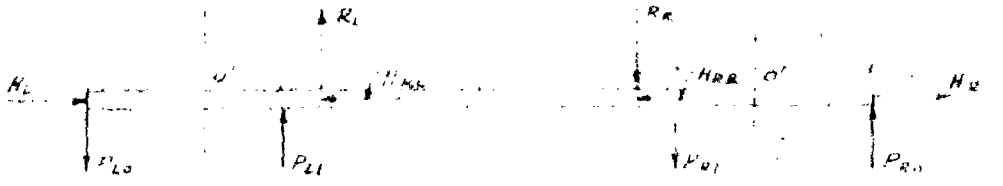
Assume all side load torque to be taken by scrubbing (Ref. memo of telephone conversation with CVAG, 1/21/46).

Side load torque = 49,600 × 9.69 = 481,000"#

Scrubbing load/whl. = 481,000/28.5 = 16,900#

Assume an .8 coef. of friction [Ref. (1)]

Vert. load from scrubbing/whl. = 16,900/.8 = 21,100#




$H_L$ = .4 × 49,600 = 19,800

$H_R$ = .6 × 49,600 = 29,800

$P_{LO}$ = − 19,800 × 19.9/9.78 + 21,100 × 4.47/9.78 = − 30,700#

$P_{LI}$ = 19,800 × 19.9/9.78 + 21,100 × 5.31/9.78 = 51,800#

$P_{RO}$ = 29,800 × 19.9/9.78 + 21,100 × 4.47/9.78 = 70,200#

$P_{RI}$ = − 29,800 × 19.9/9.78 + 21,100 × 5.31/9.78 = − 49,100#

$R_R$ = − 49,600 × 19.9/14.25 − 21,100 = − 90,400#

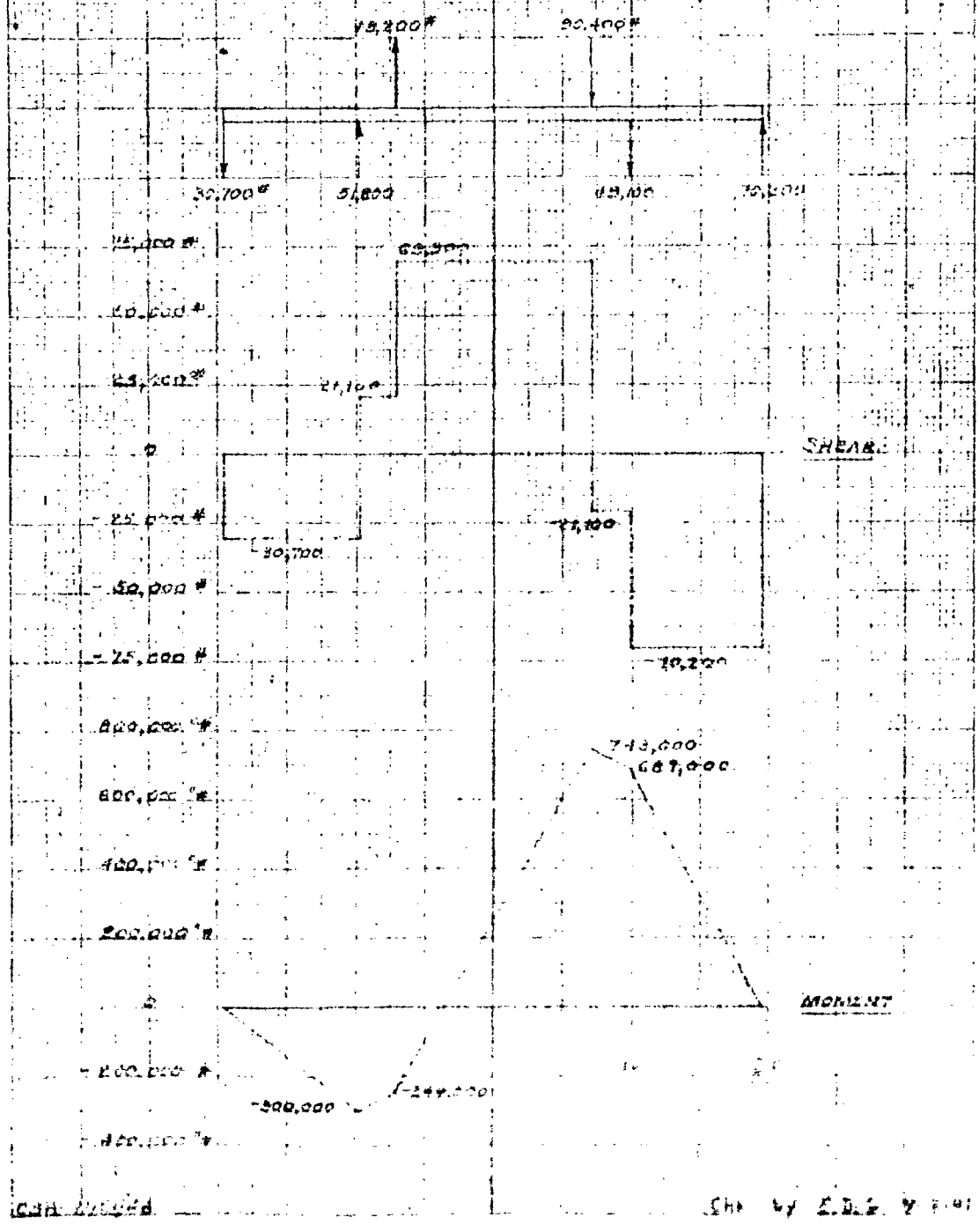
$R_L$ = 49,600 × 19.9/14.25 − 21,100 = 48,200#

$H_{RI}$ = $H_{RR}$ = 49,600/2 = 24,800#

Torque on shaft = 16,900 × 9.9 = 336,000"#

B-36 N.G. ~ AXLE

CONDITION II — SIDE DRIFT (60-40 PIST.)



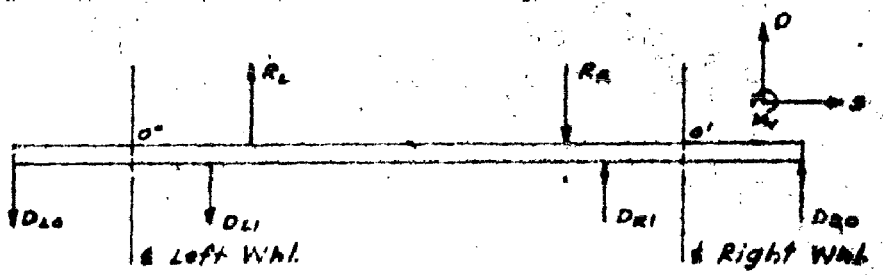

CSH [illegible]

Chk by E.D.G. [illegible]

Written by CSA Date 11/19/46
Checked by E.D.G Date 4-8-47
Subject AXLE LOADS

Rept. # [illegible]
Page No. [illegible]
No. of Pages 111
Model B-36 N.B.

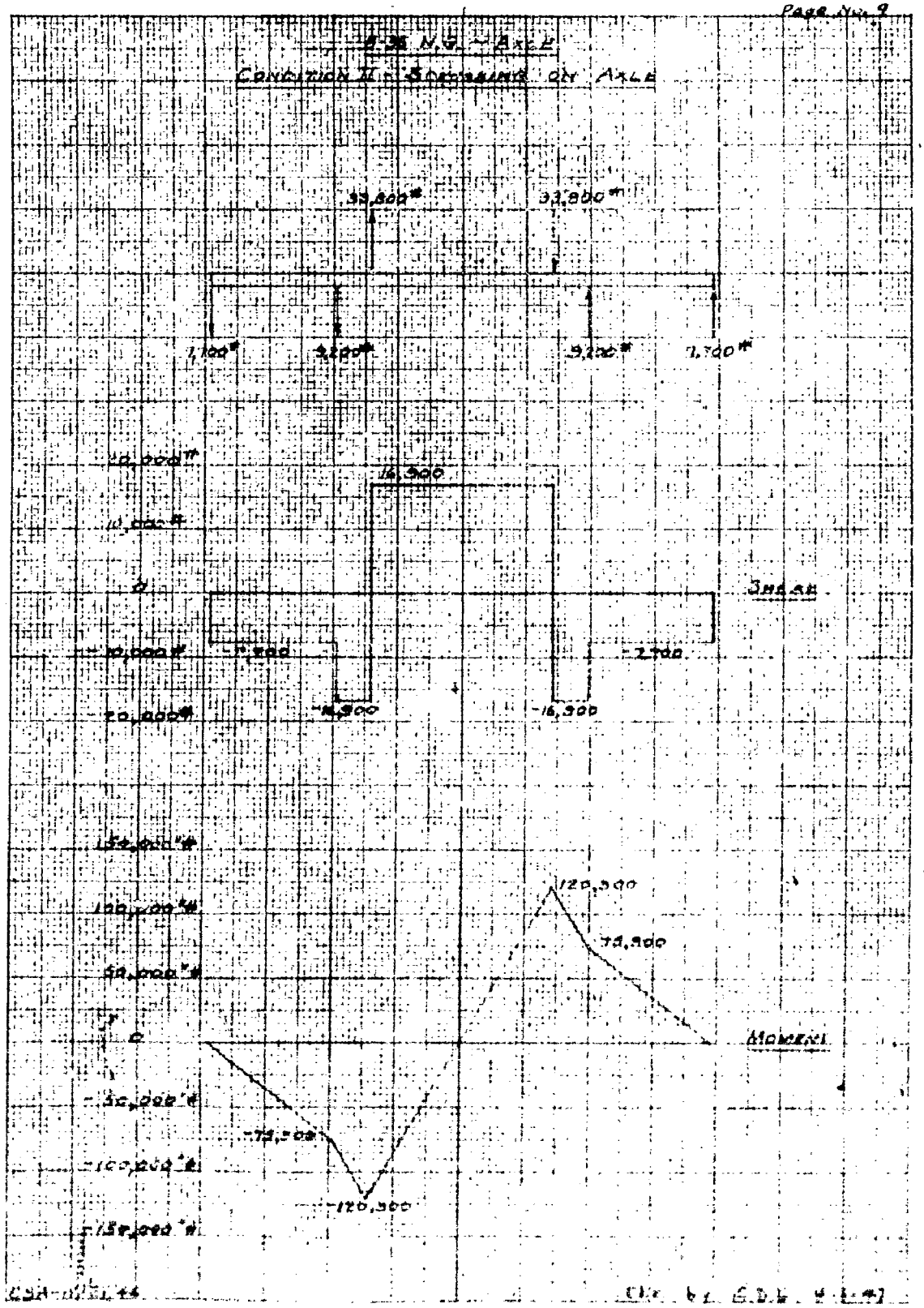
CONDITION II - SCRUBBING ON AXLE




$D_{L0} = -D_{R0} = 16,900 \times 4.47/9.78 = -7,700^{\#}$

$D_{L1} = -D_{R1} = 16,900 \times 5.31/9.78 = -9,200^{\#}$

$R_L = -R_R = 16,900 \times 28.5/14.25 = 33,800^{\#}$


CONDITION II - SCREENING ON AXLE
33,800#
33,800#
7,700#
9,200#
9,200#
7,700#
20,000#
16,900
10,000#
0
SHEAR
-10,000#
-7,700
-7,700
-20,000#
-16,900
-16,900
150,000"#
120,900
100,000"#
75,900
50,000"#
0
MOMENT
-50,000"#
-75,900
-100,000"#
-120,900
-150,000"#

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 11/19/46
Checked by E. D. G Date 4-8-47
Subject AXLE SECTION

Rept. # 818
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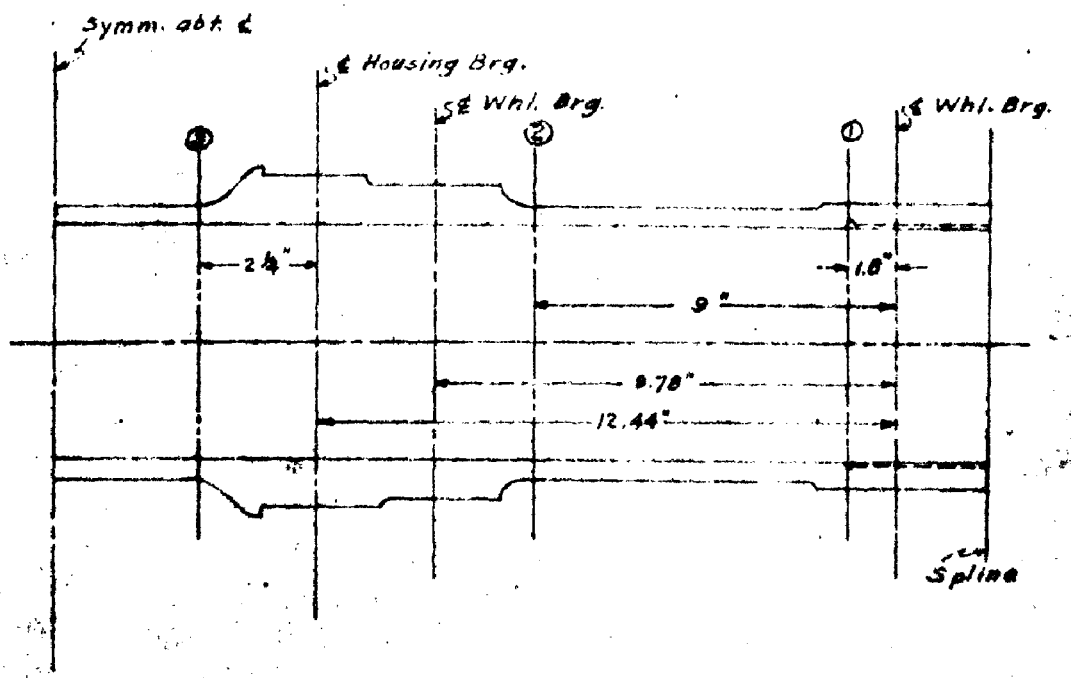
Model B-36 N.G.

SKETCH SHOWING SECTIONS TO BE INVESTIGATED

Ref. Dwg. 69740



# BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Rept. # 813
Written by CSA Date 11/21/46 Page No. 11
Checked by E.D.G. Date 4-8-47 No. of Pages 111
Subject AXLE SECTIONS Model B-36 N.S.

SECTION I

CONDITION II CRITICAL

Tension = 29,800 #

Torque = 336,000 #

Shear = $\sqrt{(70,200)^2 + (7,700)^2}$ = 70,600 #

M = 70,600 × 1.8 = 127,000 "#

SECTION PROPERTIES

OD = 4.998" ID = 4.535" t = .232" D/t = 21.6" L/D = 2

$A_s$ = 3.46 $A_{mi}$ = 17.86 I/c = 3.95

ALLOWABLES

$F_{st}$ = .71 × 205,000 = 146,000 $F_s$ = .72 × 146,000 = 175,000 $f_b$ = 247,000

STRESSES

$f_t$ = 29,800/3.46 = 8,600

$f_{sc}$ = 336,000/2 × 17.86 × .232 = 40,500

$f_s$ = 2 × 70,000/3.46 = 40,800

$f_b$ = 127,000/3.95 = 32,200

MS

$R_t$ = 8,600 / 205,000 = .042

$R_{st}$ = 40,500/146,000 = .278

$R_s$ = 40,800/175,000 = .233

$R_b$ = 32,200/247,000 = .130

$MS = \frac{1}{\sqrt{(.278 + .233)^2 + (.042)^2}} - 1 = \underline{.411}$

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Written by C.S.A. Date 11/21/46
Checked by E.D.G. Date 4-8-47
Subject AXLE SECTIONS

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## SECTION 2

CONDITION II CRITICAL

Tension = 29,800#
Torque = 336,000"#
Shear = 70,600# (As in sect. 1)
M = 70,600 x 9 = 635,000"#

SECTION PROPERTIES

OD = 4.833" ID = 4.385" t = .224" D/t = 21.6 L/D = 2
As = 3.22 Am = 16.7 I/c = 3.56

ALLOWABLES = Same as for section 1.

STRESSES

$f_t$ = 29,800/3.22 = 9,300
$f_{sc}$ = 336,000/2 x 16.7 x .224 = 44,900
$f_s$ = 2 x 70,600/3.22 = 43,900
$f_b$ = 635,000/3.56 = 178,400

MS

$R_t$ = 9,300/205,000 = .045
$R_{sc}$ = 44,900/146,000 = .308
$R_s$ = 43,900/175,000 = .251
$R_b$ = 178,400/247,000 = .722

$$MS = \frac{1}{\sqrt{(.722 + .045)^2 + (.308)^2}} - 1 = +.21$$

Written by C.S.A. Date 11/21/46
Checked by E.D.G. Date 4-8-47
Subject AXLE SECTIONS

Rept. # 313
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Model B-36 N.G.

## SECTION 3

CONDITION I CRITICAL

Shear = 17,400#

M = 710,000"#

SECTION PROPERTIES & ALLOWABLES - Same as for section 2.

STRESSES

$f_b$ = 710,000/3.56 = 199,400

MS = $\frac{217,000}{199,400} - 1 = +.24$

CONDITION II

Tension = 5,000#

Torque = 336,000"#

Shear = $\sqrt{(69,300)^2 + (16,900)^2}$ = 71,300#

M = $\sqrt{(595,000)^2 + (84,000)^2}$ = 601,000"#

STRESSES

$f_t$ = 5,000/3.22 = 1,550

$f_{sc}$ = 336,000/2 × 16.7 × .224 = 44,900

$f_s$ = 2 × 71,300/3.22 = 44,300

$f_b$ = 601,000/3.56 = 169,000

MS

$R_t$ = 1,550/205,000 = .008

$R_{sc}$ = 44,900/146,000 = .308

$R_s$ = 44,300/175,000 = .253

$R_b$ = 169,000/247,000 = .684

$MS = \frac{1}{\sqrt{(.008+.684)^2 + (.308)^2}} - 1 = +.32$

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 11/20/46
Checked by E.D.G. Date 4-8-47
Subject AXLE CLUTCH

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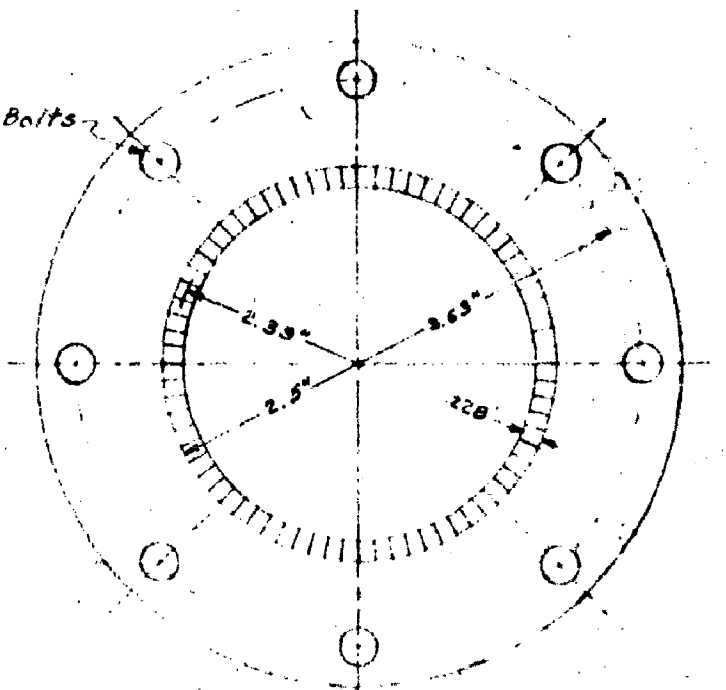
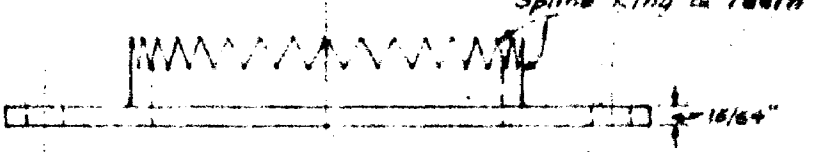
Model B-36 M.G.

Ref. Dwg. 69741




Spline Ring & Teeth




S-115

Written by CSA Date 11/20/46
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Subject AXLE CLUTCH

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## GAGE OF PLATE

CONDITION II CRITICAL

Thrust = 29,800#

Torque = 49,600 × 9.69 × 19.9/28.5 = 336,000 "# Assuming all side load torque taken by scrubbing in accordance with telephone conversation and memo of, 1/21/46.

ALLOWABLES

$F_b$ = 1.5 × yld. = 1.5 × 170,000 = 255,000 psi

$F_s$ = 117,500 psi Ref. (5), p 297

STRESSES

In computing the max. bending stress, the plate is considered circular with a hole in the middle, simply supported at the bolt ℄ and fixed at the spline ring. The presence of the latter is considered to reduce the tangential stress to a negligible value, and the fixed end condition is conservative for the radial stress. The latter is computed by the formula at ref. (4), p. 194, case # 22:

$$f_{br} = \frac{3W}{2\pi t^2}\left[\frac{2a^2(m+1)\log(a/b) + a^2(m-1) - b^2(m-1)}{a^2(m+1) + b^2(m-1)}\right].$$

This can be simplified, however, to $f_{br} = \frac{\beta W}{t^2}$, where $\beta$ is given on p. 209 of loc. cit. Plotting $\beta$ vs $a/b$ gives $\beta = .388$ for $a/b = 3.63/2.5 = 1.45$. Then,

$f_{br} = \beta W/t^2 = .388 \times 29,800/.234^2 = 211,000$ psi

$f_{sc} = 336,000/2\pi \times 2.5^2 \times .234 = 34,500$ psi

$$MS = \frac{1}{\sqrt{\left(\frac{211,000}{255,000}\right)^2 + \left(\frac{34,500}{117,500}\right)^2}} - 1 = +.19$$

# BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 11/22/44
Checked by E.D.G Date 4-8-47
Subject AXLE CLUTCH

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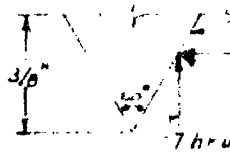
SPLINE RING

CONDITION 1" CRITICAL

In addition to the loads given on the preceding page, the ring will be subjected to a thrust from the torsion acting thru the teeth. This will be computed, conservatively neglecting the friction acting between the axle, ring, and nut.




$q_t$ = shear flow from torque

$= q_t / \cos 30°$

Thrust $= q_t \tan 30°$

Tot. Induced Thrust $= 2\pi F q_t \tan 30°$

$= \frac{2\pi \times 2.39 \times 336{,}000 \times .572}{2\pi \times 2.39^2} = 81{,}200$ #

Tot. thrust = 81,200 + 29,800 = 111,000 #

$f_c$ = 111,000/2π × 2.39 × .228 = 32,400

$f_{sc}$ = 336,000/2π × 2.39² × .228 = 41,000 MS = Amp.

SPLINE TEETH

LOADS - as above

$q'_t$ = 111,000/.572 × 36 = 5390 #/Tooth (Tot from thrust + torque)

M (base of tooth) = 5390 × .375/2 = 999 "#

SECTION PROPERTIES

$L_t$ = Tooth length = 1" - 2.39/36 = .417" t = .228" $I/c = Lt^2/6$ = .00661

STRESSES

$f_c$ = 111,000/36 × .417 × .228 = 32,400

$f_s$ = 5 × 5390/.417 × .228 = 84,000

$f_b$ = 999/.00661 = 151,000 MS = Amp.

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Checked by E.P.G Date 4-8-47
Subject AXLE CLUTCH

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## BOLTS - PLATE TO WHEEL  Ref. Dwg. 67407

CONDITION II CRITICAL

Thrust = 29,800#

Torque = 336,000"#

SECTION PROPERTIES

Consider made from AN 79A12; min. O.D. = .558"; min. R.D. = .45," A = .159

STRESSES

Thrust/bolt = 29,800/8 = 3,720#

Shear/bolt = 336,000/3.63×8 = 11,570#

$f_t$ = 3720/.159 = 23,400

$f_s$ = 11,570/.159 = 72,800

$(f_s)_{max.} = \sqrt{(72,800)^2 + (23,400/2)^2}$ = 74,000

$f_{br}$ (on plate) = 11,570/.234 × .558 = 88,700

$f_{br}$ (on whl.) = 11,570/.558 × .585 = 35,400
(.558 = av. thd. dia. for heli-coil.)

$f_s$ (whl. threads) = 3,720/$\frac{.558}{2}$ × .558π = 7,260

ALLOWABLES

$F_s$ (bolt) = 75,000

$F_{br}$ (bolt) = 175,000

$F_{br}$ (magnesium whl.) = 44,000

$F_s$ ( " " ) = 16,000

MS

Bolt shear  MS = 75,000/74,401 − 1 = .01

Brg. on whl.  MS = 44,000/35,400 − 1 = .24

Shear, thrds. in whl.  MS = 16,000/7,260 − 1 = 1.21

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Subject AXLE

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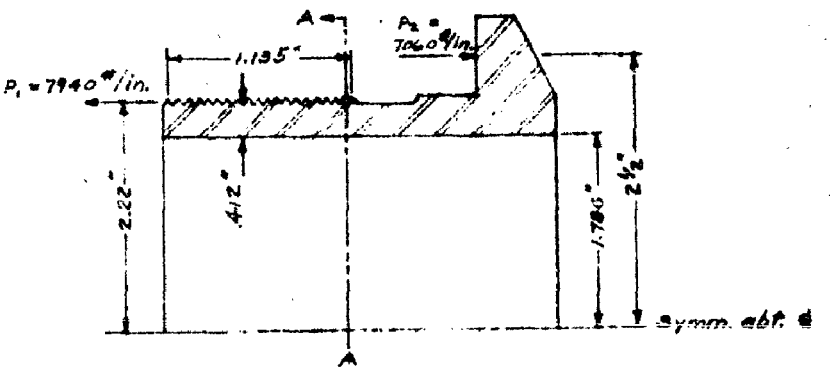
AXLE NUT Ref. Dwg. 69743

CONDITION II CRITICAL

The nut is subjected to axial tension from spline action and side load, and to hoop compression from thread action.




$P_1$ = 111,000*/ 2π x 2.22 = 7,940 #/in.

$P_2$ = 111,000/ 2π x 2.5 = 7,060 #/in.

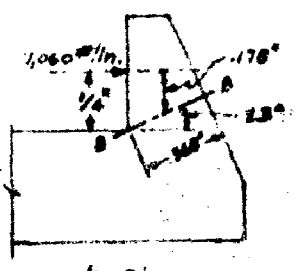
STRESSES - SECT. A-A

Hoop comp = .0919 P/Lt = .0919 x 111,000 / 1.135 x .412 = 21,800

$f_t$ = 111,000/2π x 2.0 x .412 = 21,400

$f_s$ (thrds.) = 7940 / 1.135/2 = 14,000

FLANGE STRESSES - SECT. B-B




M = 7060 x .178 = 1260 #/in.

$P_t$ = 7060 sin 23° = 2760 #/in. $P_n$ = 7060 cos 23° = 6500 #/in.

A = .368" I/C = 1 x .368³/4 = .0226

$f_b$ = 1260/.0226 + 2760/.368 = 55,700 + 7500 = 63,200

$f_s$ = 1.5 x 6500/.368 = 26,500

1½ Size

ALLOWABLES - H.T. = 180,000 psi MS = Amp

High energy is maintained to allow for over tightening of nut.

*Spline tooth thrust, ref. p. 16.

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 11/26/46
Checked by E.D.G. Date 4-8-47
Subject AXLE HOUSING

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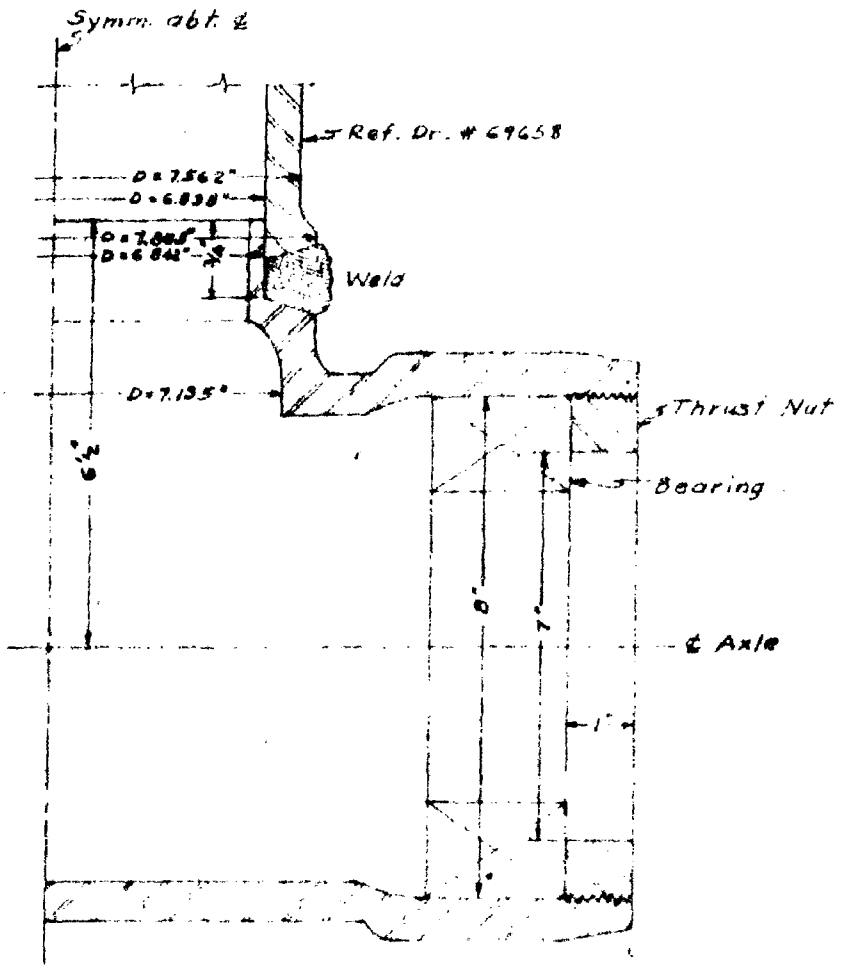
Ref. Dwgs. # 69 657, 69 659, & 69 660



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Written by CSA Date 12/4/46
Checked by E.D.G. Date 4-8-47
Subject AXLE HOUSING

THRUST NUT Ref. Dwg. 69742

CONDITION I. CRITICAL
Thrust = 49,600#

STRESSES
$f_{bv}$ = 49,600/π · 7.5 × .5 = 4210
$f_s$ (on thrds.) = 49,600/8.115π × 46 = 4,230
$f_c$ (hoop comp.) = .0919 × 49,600 / 92 × .5 = 9910

ALLOWABLES
H.T. = 170,000 MS = Amp.

NOTE: Sections at weld checked under inner cylinder below.

JACK PAD Ref. Dwg. 69739

LOADS
V = 50,400# D = ±12,600# S = ±12,600#

SECTION PROPERTIES
These are for weld only. Stresses in base metal are considered to be small and not critical.
L = 2π = 6.28" t(av.) = 3/16"

STRESSES
Vert ld. taken by direct brg.
Shear = 12,600/2 = 17,800#

ALLOWABLE H.T. after welding.
P = .48 t s = .48 × 6.28 × 3/16 × 90,000 = 50,800# MS = Amp.

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 12/4/46
Checked by E.D.G. Date 1-8-47
Subject INNER CYLINDER

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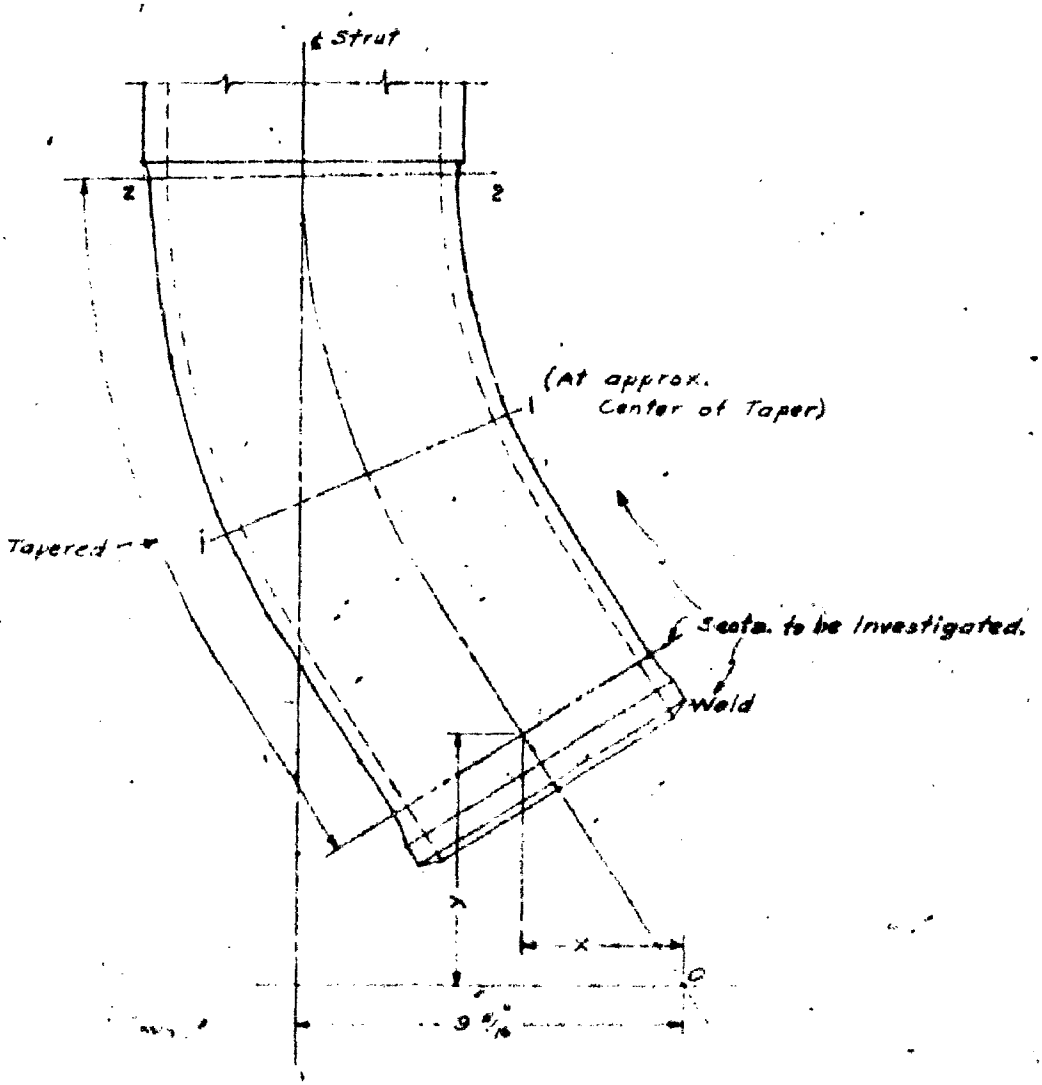
SKETCH OF LOWER - BENT PORTION 1/4 Scale

Ref Dwgs. 69458, 69870

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Checked by E.R.G. Date 4-5-47
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SECTION AT WELD TO HOUSING

CONDITION 1(C) CRITICAL For Lds, see Appendix

Comp. = 66,200#
Torque = 1,159,000"#
Shear = 81,400#
M = 1,063,000"#

SECTION PROPERTIES

OD = 7.865" ID = 6.842" t = .512" D/t = 15.4 L/D = 5.5
$A_s$ = 11.86 $A_{in}$ = 42.5 I/c = 20.3

STRESSES

$f_c$ = 66,200/11.86 = 5,590
$f_{st}$ = 1,159,000/2 × 42.5 × .512 = 26,600
$f_s$ = 2 × 81,400/11.86 = 13,700
$f_b$ = 1,063,000/20.3 = 52,400

ALLOWABLES

$F_c$ = 90,000 (Ref. Dr. # 69869)
$F_{st}$ = .723 × 90,000 = 65,100
$F_s$ = 1.20 × 65,100 = 78,100
$F_b$ = 110,600 (ANC-5, fig. 4-2a for $F_{tu}$ = 90,000).

MS

$R_c$ = 5,590/90,000 = .062
$R_{st}$ = 26,600/65,100 = .409
$R_s$ = 13,700/78,100 = .175
$R_b$ = 52,400/110,600 = .474

$$MS = \frac{1}{\sqrt{(.474 + .062)^2 + (.409)^2}} - 1 = .48$$

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SECTION IN PARENT METAL ABOVE WELD

CONDITION I(c) CRITICAL - Use same loads as at welded section; see prec. page.

SECTION PROPERTIES

OD = 7.562" ID = 6.838" t = .362" D/t = 20.9 L/D = 3.5

$A_s$ = 8.09 $A_m$ = 40.7 I/c = 13.97

STRESSES

$f_c$ = 44,200/8.09 = 11,180

$f_{st}$ = 1,159,000/2 x 40.7 x .362 = 39,400

$f_s$ = 2 x 81,400/8.09 = 20,100

$f_b$ = 1,063,000/13.97 = 76,100

ALLOWABLES

$F_c$ = .8 x 205,000 = 164,000

$F_{st}$ = .68 x 164,000 = 111,600

$F_s$ = 1.2 x 111,600 = 134,000

$F_b$ = .8 x 249,000 = 199,200

MS

$R_c$ = 8,180/164,000 = .050

$R_{st}$ = 39,400/111,600 = .353

$R_s$ = 20,100/134,000 = .150

$R_b$ = 76,100/199,200 = .382

$$MS = \frac{1}{\sqrt{(.382+.050)^2 + (.353)^2}} - 1 = +.79$$

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SECTION 1-1

CONDITION 1(C)

Comp. = 79,700#
Torque = 972,000"#
Shear = 68,200#
M = 1,676,000"#

SECTION PROPERTIES

OD = 7.632" ID = 6.838" t = .397" D/t = 19.2 L/D = 3.5
$A_s$ = 9.03 Am = 41.2 I/c = 15.56 × .98* = 15.25

STRESSES

$f_c$ = 79,700/9.03 = 8,800
$f_{st}$ = 972,000/2 × 41.2 × .397 = 29,700
$f_s$ = 2 × 68,200/9.03 = 15,100
$f_b$ = 1,676,000/15.25 = 110,000

ALLOWABLES

$F_c$ = 170,000 [Ref.(5), p.297]
$F_{st}$ = .696 × 205,000 = 142,700
$F_s$ = 1.2 × 142,700 = 171,300
$F_b$ = 254,000

MS

$R_c$ = 8,800/170,000 = .052
$R_{st}$ = 29,700/142,700 = .208
$R_b$ = 110,000/254,000 = .433

$$MS = \frac{1}{\sqrt{(.433 + .052)^2 + (.208)^2}} - 1 = +.90$$

*Evaluation from bending is about ½ which changes I/c about 2%.

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SECTION 1-1 (Cont'd)

CONDITION 1(6) CRITICAL

Comp. = 132,900#
Torque = 323,000"#
Shear = 113,700#
M = 2,090,040"#

STRESSES

$f_c$ = 132,900/9.03 = 14,700
$f_{sy}$ = 323,000/2×41.2×.397 = 9,870
$f_s$ = 2×113,700/9.03 = 26,200
$f_b$ = 2,090,000/15.28 = 137,000

MS

$R_c$ = 14,700/170,000 = .087
$R_{sy}$ = 9,870/142,700 = .069
$R_s$ = 26,200/171,300 = .147
$R_b$ = 137,000/254,000 = .539

$$MS = \frac{1}{\sqrt{(.539+.087)^2 + (.069)^2}} - 1 = +.59$$

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SECTION 2-2

CONDITION 1(b) CRITICAL

Comp. = 166,000#
Torque = 155,300"#
Shear = 54,900 #
M = 2,760,000"#

SECTION PROPERTIES

OD = 7.708" ID = 6.838" t = .432" D/t = 17.8 L/D = 3.5
As = 9.82 Am = 41.6 I/c = 16.90 × .98 = 16.56

STRESSES

$f_c$ = 166,000/9.82 = 16,900
$f_{sc}$ = 155,300/2×41.6×.432 = 4,320
$f_s$ = 2×54,900/9.82 = 11,190
$f_b$ = 2,760,000/16.56 = 167,000

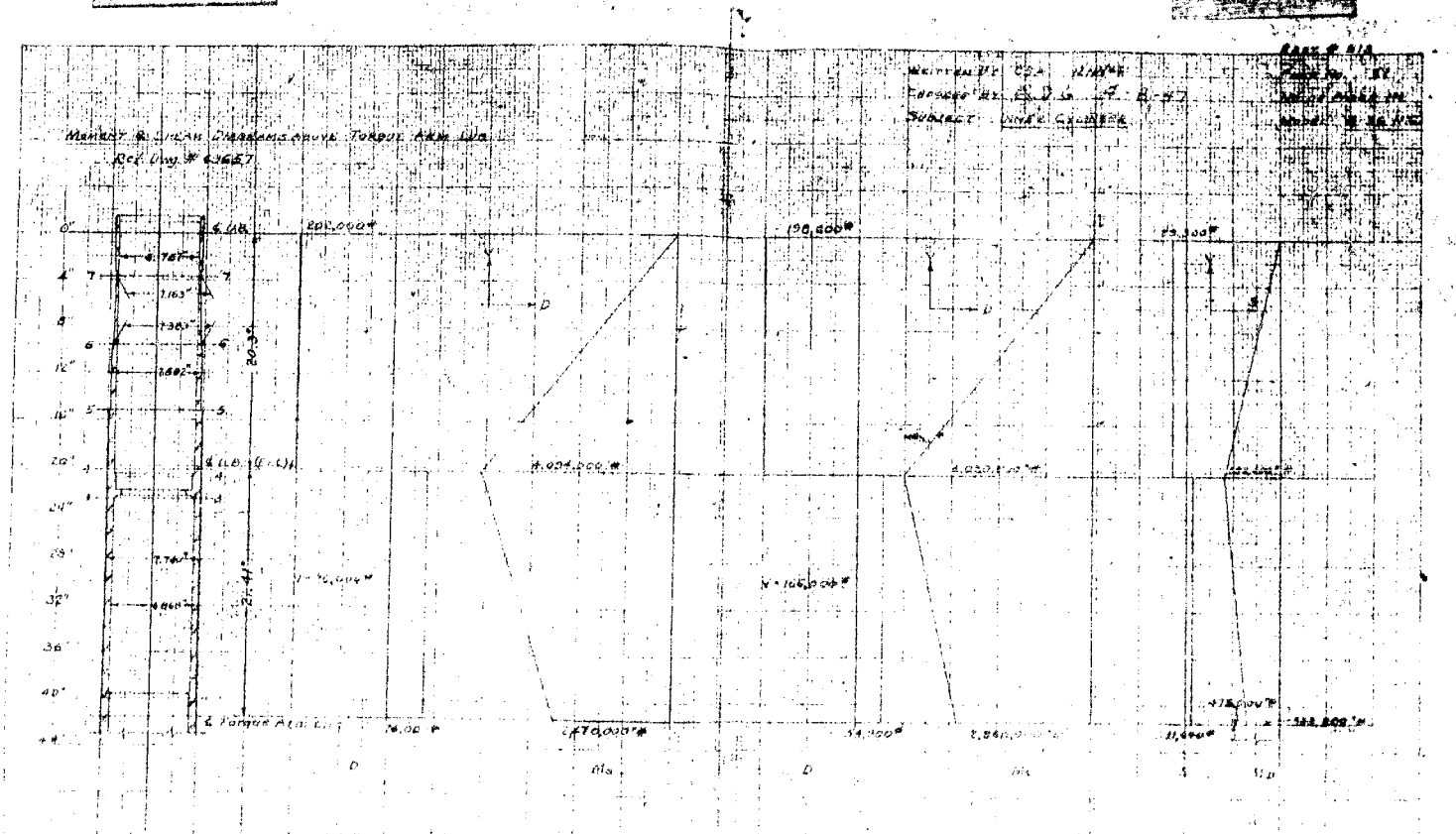
ALLOWABLES

$F_c$ = 170,000
$F_{sc}$ = .704×205,000 = 144,400
$F_b$ = 258,000

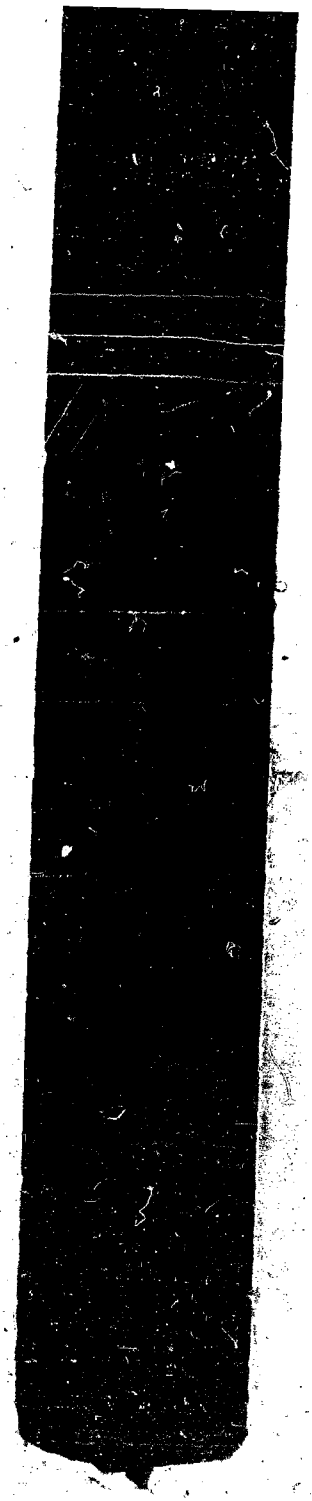
MS

$R_c$ = 16,900/170,000 = .099
$R_{sc}$ = 4,320/144,400 = .030
$R_b$ = 167,000/258,000 = .647

$$MS = \frac{1}{\sqrt{(.647+.099)^2+(.030)^2}} - 1 = +.34$$



Moment & Shear Diagrams Above Torque Arm Line
Ref. Dwg. # 63657
Written by CSA
Checked by
Subject Inner Cylinder
202,000#
198,000#
4,094,000#
4,030,000#
V = 105,000#
V = 96,000#
20.3"
21.41"
Torque Arm Line



**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by: CSA Date: 12/11/46
Checked by: G.D.G Date: 4-8-47
Subject: INNER CYLINDER

Rept. # 818
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SECTION 3-B

CONDITION I(4) CRITICAL

Comp. = 166,000#

Shear = $\sqrt{(\quad,900)^2+(11,640)^2}$ = 56,100#

$M_S$ = 3,880,000"# $M_D$ = 567,000"#

$M = \sqrt{(3,880,000)^2 + (567,000)^2}$ = 3,920,000"#

SECTION PROPERTIES

OD = 7.260" ID = 6.389" t = .4355" D/t = 17.8

$A_S$ = 10.06 I/c = 17.4

STRESSES

$f_c$ = 166,000/10.06 = 16,510

$f_s$ = 2 x 56,100/10.06 = 11,140

$f_b$ = 3,920,000/17.4 = 225,000

ALLOWABLES

$F_c$ = 170,000

$F_b$ = 260,000

MS

$R_c$ = 16,510/170,000 = .097

$R_b$ = 225,000/260,000 = .865

.962

$MS = \frac{1}{.962} - 1 = +.04$

**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Report # 813
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Model B-36 N.G.

Written by: CSA Date: 12/11/46
Checked by: G. D. E Date: 4-8-47
Subject: INNER CYLINDER

SECTION 3-B

CONDITION 1(A) CRITICAL

Comp. = 164,000#

Shear = $\sqrt{(\quad,900)^2+(11,640)^2}$ = 56,100#

$M_A$ = 3,380,900"# $M_D$ = 567,000"#

$M = \sqrt{(3,380,000)^2 + (567,000)^2}$ = 3,420,000"#

SECTION PROPERTIES

OD = 7.740" ID = 6.869" t = .4355" D/t = 17.8

$A_c$ = 10.06 I/c = 17.4

STRESSES

$f_c$ = 164,000/10.06 = 16,310

$f_s$ = 2x 56,100/10.06 = 11,140

$f_b$ = 3,420,000/17.4 = 225,000

ALLOWABLES

$F_c$ = 170,000

$F_b$ = 260,000

MS

$R_c$ = 16,310/170,000 = .097

$R_b$ = 225,000/260,000 = .865

.962

$MS = \frac{1}{.962} - 1 = +.04$

Written by CSA Date 12/11/46
Checked by E.D.G Date 4-8-47
Subject INNER CYLINDER

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SECTION 4-4

CONDITION 1(6) CRITICAL

Comp. = 166,000#

Shear = $\sqrt{(198,600)^2 + (29,300)^2}$ = 200,600#

$M_S$ = 4,030,000"# $M_D$ = 592,400"#

M = $\sqrt{(4,030,000)^2 + (592,400)^2}$ = 4,070,000"#

SECTION PROPERTIES

OD = 7.740" ID = 6.751" t = .4945" D/t = 15.7

$A_H = \frac{\pi}{4} \times 6.751^2$ = 35.8 $A_S$ = 11.32 I/c = 19.25

STRESSES

p = 166,000/35.8 = 4,640 psi

$f_{ss}$ = 4640 x 7.246/2x.4945 = 34,000

$f_s$ = 2x200,600/11.32 = 35,500

$f_b$ = 4,070,000/19.25 = 211,000

ALLOWABLES

$F_{sy}$ = 112,500*

$F_b$ = 272,000

MS

$R_{ts}$ = 34,000/2x112,500* = .153

$R_b$ = 211,000/272,000 = .774

.927

$MS = \frac{1}{.927} - 1 = +.08$

* Failure under internal pressure occurs when shear at outer dia. reaches yield. Ref (4), p. 389.

Written by CSA Date 12/18/46
Checked by E.D.G. Date 4-8-47
Subject INNER CYLINDER

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SECTION 5-5

CONDITION 1(b) CRITICAL

$p = 4640$ psi (Ref. prec. page)

Shear = 200,600 #

$M_S = 3{,}020{,}000$ "# $M_P = 450{,}000$ "#

$M = \sqrt{(3{,}020{,}000)^2 + (450{,}000)^2} = 3{,}055{,}000$ "#

SECTION PROPERTIES

OD = 7.592" ID = 6.751" $t = .4205$" $D/t = 18.1$

$A_s = 9.42$ $I/c = 16.0$

STRESSES

$f_{sc} = 4640 \times 7.17/2 \times .4205 = 39{,}500$

$f_s = 2 \times 200{,}600/9.42 = 42{,}600$

$f_b = 3{,}055{,}000/16.0 = 190{,}900$

ALLOWABLES

$F_{sy} = 112{,}500$

$F_b = 259{,}000$

MS

$R_{cs} = 39{,}500/2 \times 112{,}500 = .176$

$R_b = 190{,}900/259{,}000 = .737$

$.913$

$MS = \frac{1}{.913} - 1 = +.10$

Written by CSA Date 12/12/46
Checked by E.D.G. Date 4-8-47
Subject INNER CYLINDER

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## SECTION 6-6

CONDITION 1(b) CRITICAL

$p$ = 4,640 psi (Ref. p. 29)

Shear = 200,600#

$M_S$ = 1,900,000 "# $M_D$ = 258,000 "#

$M = \sqrt{(1,900,000)^2 + (258,000)^2}$ = 1,920,000 "#

SECTION PROPERTIES

OD = 7.383" ID = 6.751" $t$ = .316" $D/t$ = 23.4

$A_s$ = 6.99 $I/c$ = 11.83

STRESSES

$f_{ss}$ = 4,640 × 7.07/2 × .316 = 51,900

$f_s$ = 2 × 200,600/6.99 = 57,300

$f_b$ = 1,920,000/11.83 = 162,300

ALLOWABLES

$F_{sy}$ = 112,500

$F_b$ = 242,000

MS

$R_{fs}$ = 51,900/2 × 112,500 = .231

$R_b$ = 162,300/242,000 = .671

.902

$MS = \frac{1}{.902} - 1 = +.11$

Written by C&A Date 11/10/47
Checked by E.D.G Date 4-8-47
Subject INNER CYLINDER



## SECTION 7-7

CONDITION 1(b) CRITICAL

$p$ = 1440 psi (Ref p. 29)

Shear = 206,600#

$M_A$ = 740,000"# $M_B$ = 110,000"#

$M = \sqrt{(740,000)^2 + (110,000)^2}$ = 748,000"#

SECTION PROPERTIES

OD = 7.168" ID = 6.751" $t$ = .206" D/t = 34.8" L/D = 2.7

$A_s$ = 4.48 $I/c$ = 7.58

STRESSES

$f_{bt}$ = 1440 × 6.96/2×.206 = 48,500

$f_s$ = 2×206,600/4.48 = 89,600

$f_b$ = 748,000/7.58 = 98,700

$f_b$ (pt. max. bending) = (48,500 + 98,700)/2 = 88,600

ALLOWABLES

$F_{bu}$ = 205,000 $F_{by}$ = 112,500

$F_{su}$ = 117,500 $F_b$ = 224,000

$F_{sy}$ = .72 × .61 × 205,000 = 150,000

MS

$R_t$ = 48,500/205,000 = .237
$R_{sy}$ = 89,600/150,000 = .597
$R_b$ = 98,700/224,000 = .437
$R_{ss}$ = 48,500/2×117,500 = .349

MS = $\frac{1}{\sqrt{(.237)^2 + (.597)^2}} - 1 = +.41$

MS = 1.786 = +.27

* In check for local instability, shear is considered to predominate.
Ref ANC-, par. 1.6.3.3

Written by G.S.A. Date 12/12/46
Checked by [illegible] Date 4-2-47
Subject INNER CYLINDER

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SECTION THRU BASE OF THREAD NEAR U. UPPER BEARING

CONDITION 7-1(a) CRITICAL
Shear = 202,000# (Critical)

SECTION PROPERTIES
RD = 7.201" ID = 6.751 $A_s$ = 4.95 t = .225" D/t = 32 L/D = 2.9

STRESS
$f_s$ = 2 x 202,000/4.95 = 81,700

ALLOWABLE
$F_s$ = 1.2 x .628 x 205,000 = 154,400 MS = 154,400/81,700 - 1 = 1.89

Rebound load causing possibly some tension on root area is not critical.

UPPER AND LOWER BEARINGS Ref. Dwgs. 67651, 69672, 69687

CONDITION 7-1(a) CRITICAL
U. Brg. Ld. = 202,000#
L. " " = 278,000#

SECTION PROPERTIES
U. Brg. A = 3.12" x 8.37" = 26.1
L. " " = 5.54 x 7.55 = 41.7

STRESSES
U. Brg. $f_{br}$ = 202,000/26.1 = 7,730 psi
L. " $f_{br}$ = 278,000/41.7 = 6,670 "

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Written by CSA Date 12/13/46
Checked by E.D.G. Date 4-8-47
Subject INNER CYLINDER

DIAPHRAGM Ref. Dr. # 69669

CONDITION 1(a) or 1(b) CRITICAL

$V = 166{,}000\#$

SECTION PROPERTIES

$R_2 = 3.928''$ (Spher.) $R_1 = 3.51''$ (Spher.) $t = .418''$ D of Hyd. A. = 6.75"

OD = 6.513" (inc. allowance for chamfer) Brg. ID = 6.383"

STRESSES

Consider to be thick sphere, and use formulas of Ref. (4), p. 264.

$p = 166{,}000 / \frac{\pi \times \overline{6.75}^2}{4} = 4640$ psi

$f_{c\,max} = p \frac{3R_2^3}{2(R_2^3 - R_1^3)} = \frac{4640 \times 3 \times \overline{3.928}^3}{2(\overline{3.928}^3 - \overline{3.51}^3)} = 24{,}300$ (at inner surface)

$f_c$ (at outer surface) $= p \frac{R_1^3 + 2R_2^3}{2(R_2^3 - R_1^3)} = \frac{4640(\overline{3.51}^3 + 2 \times \overline{3.928}^3)}{2(\overline{3.928}^3 - \overline{3.51}^3)} = 22{,}000$

$f_{c_3}$ ( " " " ) $= p = 4640$

$f_s$ ( " " " ) $= (22{,}000 - 4640)/2 = 8{,}680$

$f_s$ (punching @ R = 2.2") $= 4640 \times \pi \times \overline{2.2}^2 / 2\pi \times 2.2 \times .418 = 12{,}230$

$f_{br} = 4640 \times \pi/4 \times \overline{6.691}^2 / \frac{\pi}{4}(\overline{6.513}^2 - \overline{6.383}^2) = 85{,}100$

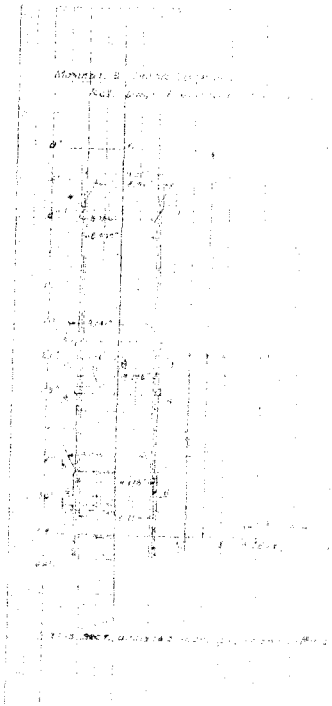
ALLOWABLES Mat. = 17ST

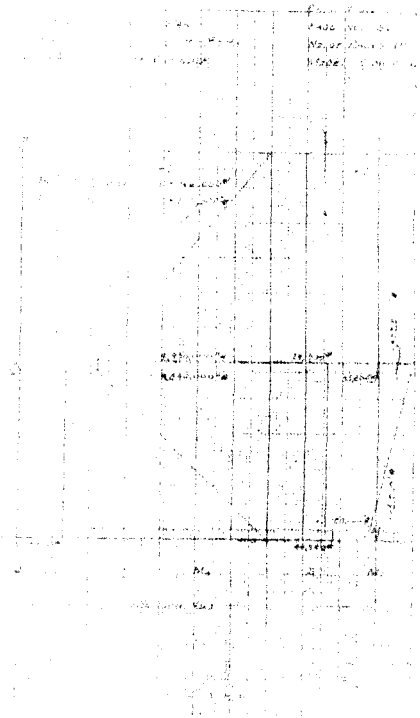
$F_{cu} = 55{,}000$

$F_{su} = 34{,}000$

$F_{bru} = 105{,}000$

$MS = \frac{105{,}000}{85{,}100} - 1 = +.23$





Written by C.S.A. Date 12/17/46
Checked by E.D.G. Date 4-8-47
Subject OUTER CYLINDER

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SECTION 1-1

CONDITION 7-1(a) CRITICAL

Tension = 76,600 #
Shear = 222,000 #
M = 1,560,000 "#

SECTION PROPERTIES

OD = 8.756" ID = 8.379" t = .1885" D/t = 46.4 L/D = 2.6
$A_s$ = 5.11 I/C = 10.71

STRESSES

$f_t$ = 76,600/5.11 = 15,000
$f_s$ = 2×222,000/5.11 = 87,000
$f_b$ = 1,560,000/10.71 = 145,600

ALLOWABLES

$F_{tu}$ = 205,000
$F_s$ = 1.2 × .587 × 205,000 = 137,100
$F_b$ = 213,000

MS

$R_t$ = 15,000/205,000 = .073
$R_s$ = 87,000/137,100 = .635
$R_b$ = 145,600/213,000 = .683

$$MS = \frac{1}{\sqrt{(.683-.073)^2+(.635)^2}} - 1 = +.$$

*Note: Since this is a check for local instability (see "Introduction"), it is considered safe to neglect the small amount of air pressure present (Ref. p. 53). This is further true since the failure would occur on the compression side of the cylinder, and the $R_t$ is therefore subtracted [Ref. (6)].

Written by CSA Date 12/18/46
Checked by E.D.G. Date 4-8-47
Subject OUTER CYLINDER

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SECTION 2-2

CONDITION 7-1(a) CRITICAL

Tension = 76,600#

Shear = 222,000#

Moment = 4,890,000"#

SECTION PROPERTIES

OD = 9.131" ID = 8.379" t = .376" D/t = 24.3 L/D = 2.5

$A_s$ = 10.28 I/c = 21.6

STRESSES

$f_t$ = 76,600/10.28 = 7,450

$f_s$ = 2×222,000/10.28 = 43,200

$f_b$ = 4,890,000/21.6 = 226,000

ALLOWABLE STRESSES

$F_{tu}$ = 205,000

$F_s$ = 1.2 × .678 × 205,000 = 168,800

$F_b$ = 240,000

$M_s$

$R_t$ = 7,450/205,000 = .036

$R_b$ = 226,000/240,000 = .942

.978

$$MS = \frac{1}{.978} - 1 = +.023$$

Written by C.S.A. Date 12/18/46
Checked by G.D.G. Date 4-8-47
Subject OUTER CYLINDER

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SECTION 3-3

CONDITION 7-1(a) CRITICAL
Tension = 76,600 #
Shear = 278,000 #
Moment = 5,310,000" (NO DEFLECTION LOAD)

SECTION PROPERTIES
OD = 9.146" ID = 8.379" t = .8335" D/t = 23.9
Assume Sect. as Follows:

$$I = \frac{\pi}{64}\left(\overline{9.146}^4 - \overline{8.379}^4\right) + \frac{4 \times 1 \times \overline{2.76}^3}{36} + 4 \times \frac{1}{2} \times 1 \times 2.76 \times \left(\frac{2}{3} \times 2.76\right)^2$$

$$= 101.7 + 2.33 + 18.67 = 122.70 \quad I/c = 122.70 \times 2/9.146 = 26.9$$

$$A_3 = \frac{\pi}{4}\left(\overline{9.146}^2 - \overline{8.379}^2\right) + 4 \times \frac{1}{2} \times 1 \times 2.76 = 10.60 + 5.52 = 16.12$$

STRESSES
$f_t$ = 76,600/16.12 = 4,750
$f_b$ = 5,310,000/26.9 = 197,300 For shear check, see Sect. 4-4, following page.

ALLOWABLES
$F_{tu}$ = 205,000
$F_b$ = 243,000

MS
$R_t$ = 4,750/205,000 = .023
$R_b$ = 197,300/243,000 = .812
.835

$$MS = \frac{1}{.835} - 1 = +.20$$

Written by CSA Date 12/18/[illegible]
Checked by E. D. G. Date 4-8-47
Subject OUTER CYLINDER

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SECTION 4-4

CONDITION 7-K(a) CRITICAL

Shear = 278,000#

M = 4,400,000" #

SECTION PROPERTIES

OD = 9.115" ID = 8.379" t = .3[illegible]" D/t = 24.8 L/D = [illegible]

$A_s$ = 10.13 I/C = 21.3

STRESSES

$f_s$ = 2 × 278,000/10.13 = 54,900

$f_b$ = 4,400,000/21.3 = 206,500

ALLOWABLES

$F_s$ = 1.2 × .690 × 205,000 = 169,800

$F_b$ = 242,000

MS

$R_s$ = 54,900/169,800 = .323

$R_b$ = 206,500/242,000 = .854

$$MS = \frac{1}{\sqrt{(.854)^2 + (.323)^2}} - 1 = +.09$$

Written by C.S.A. Date 12/19/46
Checked by E.D.G. Date 4-8-47
Subject OUTER CYLINDER



SECTION 5-5

CONDITION 7-1(a) CRITICAL

Shear = 278,000#

M = 2,030,000"#

SECTION PROPERTIES

OD = 8.896 ID = 8.379" t = .2585" D/t = 34.4 L/D = 1.9

$A_s$ = 7.02 I/c = 14.73

STRESSES

$f_s$ = 2 × 278,000/7.02 = 79,200

$f_b$ = 2,030,000/14.73 = 138,000

ALLOWABLES

$F_s$ = 1.2 × .63 × 205,000 = 155,000

$F_b$ = 224,000

MS

$R_s$ = 79,200/155,000 = .511

$R_b$ = 138,000/224,000 = .616

$$MS = \frac{1}{\sqrt{(.511)^2 + (.616)^2}} - 1 = +.38$$

Written by CSA Date 12/14/46
Checked by E.D.G. Date 4-8-47
Subject OUTER CYLINDER

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SECTION 6-6

CONDITION 7-1(a) CRITICAL

Shear = 278,000 #

M = 1,230,000 "#

SECTION PROPERTIES

OD = 9.178" ID = 8.755" t = .2115" D/t = 43.4 L/D = 1.9

$A_s$ = 5.97 I/C = 13.10

STRESSES

$f_s$ = 2 x 278,000 / 5.97 = 93,200

$f_b$ = 1,230,000 / 13.10 = 93,900

ALLOWABLES

$F_s$ = 1.2 x .585 x 205,000 = 143,800

$F_b$ = 214,000

MS

$R_s$ = 93,200 / 143,800 = .648

$R_b$ = 93,900 / 214,000 = .439

$$MS = \frac{1}{\sqrt{(.648)^2 + (.439)^2}} - 1 = +.28$$

Written by C.S.A. Date 1/20/47
Checked by E.I.G. Date 4-8-47
Subject OUTER CYLINDER

Rept # 918
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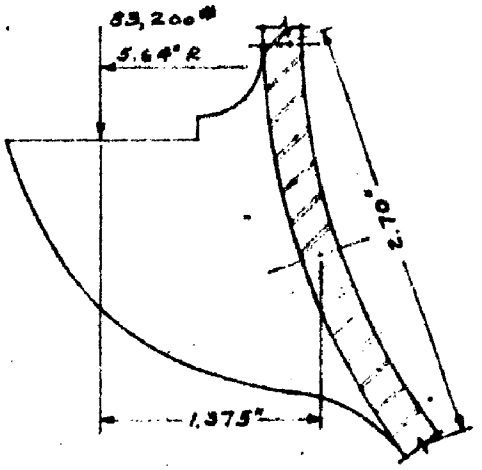
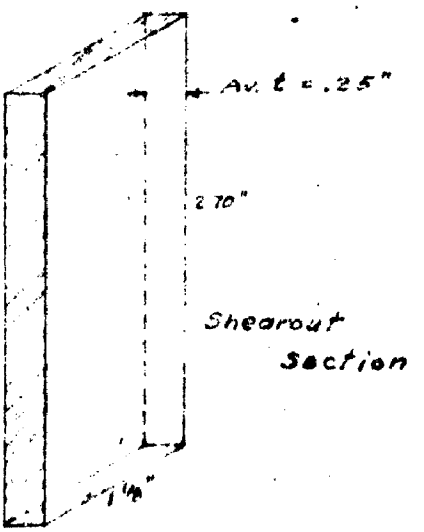
## SHEAROUT OF TORQUE YOKE STOPS

CONDITION I(c) CRITICAL
Ld. = 89,200# (Ref. p. 79)

SECTION PROPERTIES




$$I = \frac{2 \times .25 \times \overline{2.70}^3}{12} + 2 \times 1.125 \times .25 \times \overline{1.35}^2 = .82 + 1.08 = 1.85 \text{ ins.}^4$$

STRESSES

$f_s$ = 89,200 × 1.375 × 1.35/1.85 = 89,500

ALLOWABLES

$F_{su}$ = 157,500 (Fsu to take acct of mod. of rept. effect.)

MS = Amp.

Written by CBA Date 1/21/47
Checked by G.D.G Date 4-8-47
Subject OUTER CYLINDER

Dept. # 813
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SHOULDER FOR TORQUE YOKE  Ref. Dwgs. # 69679 & 69680

CONDITION 1(C) CRITICAL

(See also p. 79)

M causing brg. on shoulder thut = 35,200 x 11.50 = 405,000"#

SECTION PROPERTIES

Bronze bushing: OD = 10.05" ID (for brg.) = 9.80" [illegible] = 9.825"
I/c = 16.8

Cyl. Shoulder:

A = .3 x 1 = .3 ins.²/in.
I/c = bh²/6 = 1 x .3²/6 = .015 ins.³/in.

STRESSES

$P_{max}$: (405,000/16.8).225 = 5420#/in.
$f_c$ = 5420 x 1.5/.3 = 27,100
$f_b$ = 5420 x .16/.015 = 57,800

ALLOWABLES

$S_{tu}$ = 105,000

MS = Amp.

* For bushing check, see p. 82.

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 12/20/46
Checked by E.D.G. Date 4-8-47
Subject OUTER CYLINDER TRUNNION

Rept. # 813
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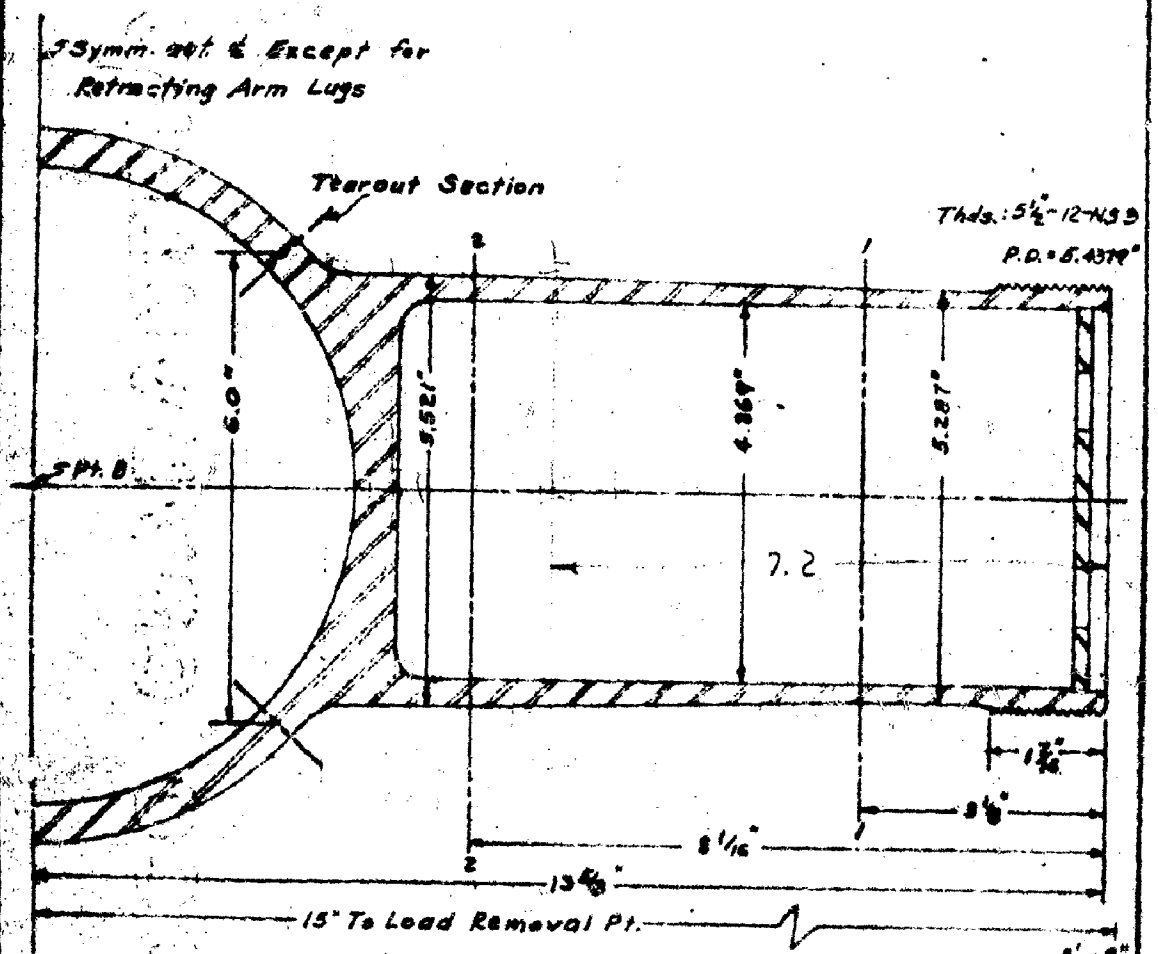
SKETCH OF TRUNNION ½ Scale

Ref. Dwgs. # 69677, 69679, 69680



Written by CSA Date 12/20/46
Checked by E. D. G Date 4-8-47
Subject OUTER CYLINDER TRUNNION

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SECTION AT THREADS

CONDITION 1(b)

$P_{B'} = 166{,}700\#$

$S_{B'} = 0$

$M = 166{,}700(15.00^{*} - 13.625 + .75) = 354{,}000''\#$ ($2\frac{1}{8}''$)

CONDITION 4(b)

$P_{B'} = 158{,}900\#$

$S_{B'} = -24{,}800\#$

$M = 158{,}400 \times 2\frac{1}{8} = 338{,}000''\#$

SECTION PROPERTIES

P.D. = 5.438"

Min. screw O.D. = 5.4888" Max. nut I.D. = 5.4188" [Ref. (7), pp. 1155-6]

h (min. for thrd.) = (5.4888 − 5.4188)/2 = .035"

Assume effective L for thrd. = 1.25"

STRESSES

Because of the short thrd. length with respect to the diameter, little socket action is obtained, and for stress analysis, the bending moment is considered transferred by shear stresses in the thrds. Deformation of the tube is not considered as it is prevented by the bulkhead.

Condition 1(b)

$f_{s\,max.} = 4M/\pi L D^2 = 4 \times 354{,}000/\pi \times .625 \times \overline{5.438}^2 = 24{,}400$

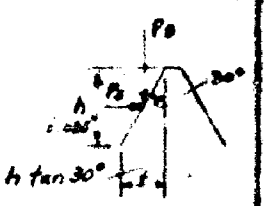
$P_{s\,max.} = 24{,}400 \times .625 = 15{,}250\ \#/in.$

$f_{br}$ (bending) $= 15{,}250/.035 \times 1.25 \times 12 = 29{,}000$

$f_{br}$ (direct) $= 166{,}700/.035 \times .577 \times 5.438 \times 1.25 \times 12$

$= 101{,}000$

Tot. $f_{br} = 130{,}000$




*Distance of strut to load removal point = 15.00"

S-135

Written by C9A Date 12/20/46
Checked by G.D.G Date 4-8-47
Subject OUTER CYLINDER TRUNNION

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SECTION AT THREADS (Cont'd)

STRESSES (Cont'd)

Condition ~~1(b)~~

$$f_{s\,max.} = \frac{4M}{\pi L D^2} + \frac{S}{\pi D L} = \frac{4 \times 338{,}000}{\pi \times .625 \times 5.438^2} + \frac{24{,}300}{\pi \times 5.438 \times .625}$$

$$= 23{,}300 + 2320 = 25{,}620$$

$f_s$ (Top of thrd.*) = 23,300 − 2320 = 20,980

$P_s$ ( " " ) = 20,980 × .625 = 13,120 #/in. Cond. 1(b) critical for brg.

Note: Bending + shear on total sect., more critical at Sect. 1-1.

ALLOWABLES

$F_{su}$ = 117,500

$f_{br}$ = 210,000

MS = Amp.

* that is, at top of trunnion barrel.

Written by C.S.A. Date 12/23/46
Checked by E.D.G. Date 4-8-47
Subject OUTER CYLINDER TRUNNION

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SECTION 1-1

CONDITION 1(b) CRITICAL

$P_{B'} = 166{,}700\#$

$S_{B'} = 0$

$M = 166{,}700\,(1\tfrac{3}{8} + 3\tfrac{1}{16}) = 750{,}000\text{"}\#$

SECTION PROPERTIES

OD = 5.287" ID = 4.869" $t$ = .209" D/t = 25.3 L/D = 1.6

$A_s$ = 3.88 I/C = 4.02

STRESSES

$f_s = 2 \times 166{,}700/3.30 = 101{,}100$

$f_b = 750{,}000/4.02 = 186{,}500$

ALLOWABLES

$F_s = 1.2 \times .69 \times 205{,}000 = 169{,}800$

$F_b = 239{,}000$

MS

$R_s = 101{,}100/169{,}800 = .594$

$R_b = 186{,}500/239{,}000 = .780$

$$MS = \frac{1}{\sqrt{(.594)^2 + (.780)^2}} - 1 = +.02$$

**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 12/23/46
Checked by E.D.G. Date 4-5-47
Subject OUTER CYLINDER TRUNNION

Rep't. # 813
Page No. 48
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Model B-36 N.G.

## SECTION 2-2

CONDITION 1(6) CRITICAL

$P_B' = 166,700$

$S_B' = 0$

$M = 166,700(1\frac{3}{8} + 8\frac{1}{16}) = 1,574,000$ "#

SECTION PROPERTIES

OD = 5.521" ID = 4.869" t = .326" D/t = 16.9 L/D = 1.5

$A_s = 5.34$ $I/c = 6.56$

STRESSES

$f_s = 2 \times 166,700/5.34 = 62,400$

$f_b = 1,574,000/6.56 = 240,000$

ALLOWABLES

$F_s = 1.2 \times .75 \times 205,000 = 184,500$

$F_b = 265,000$

MS

$R_s = 62,400/184,500 = .338$

$R_b = 240,000/265,000 = .905$

$MS = \frac{1}{.905} - 1 = +.10$

Written by C3A Date 12/23/46
Checked by C.D.G Date 4-8-47
Subject OUTER CYLINDER TRUNNION

Rept. # 313
Page No. 49
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Model B-36 N.G.

TEAROUT OF ARM FROM CYLINDER TUBE

CONDITION 1(b) CRITICAL

$P_{81} = 166{,}700$

$M = 166{,}700\ (1\tfrac{3}{8} + 9\tfrac{3}{4}) = 1{,}854{,}000$ "#

SECTION PROPERTIES

OD = 6.0" t = .3135" (Ref. p.38)

Since the sect. is on the surface of a cylinder and measures 6.6" approx. on the curve, the sect. props. will be increased by the ratio 6.6/6.0 = 1.1.

STRESSES

The load will be assumed transferred by shear near the neutral axis, which is at the reinforced portions of the cylinder.

$$f_{s\,max.} = \frac{4M}{\pi D^2 t} = \frac{4 \times 1{,}854{,}000}{\pi \times 6.0^2 \times 1.1 \times .3135} = 155{,}400$$

ALLOWABLES

$F_s = F_{sc} = 157{,}500$ Use $F_{sc}$ to take acct. of modulus of rupture effect.*

$$MS = \frac{157{,}500}{155{,}400} - 1 = +.013$$

* Conservative since effect of thickening of section at cylinder reinforcements is not taken into account in the section properties.

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 12/24/46
Checked by E. D. G. Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING

Dept. # 213
Page No. 60
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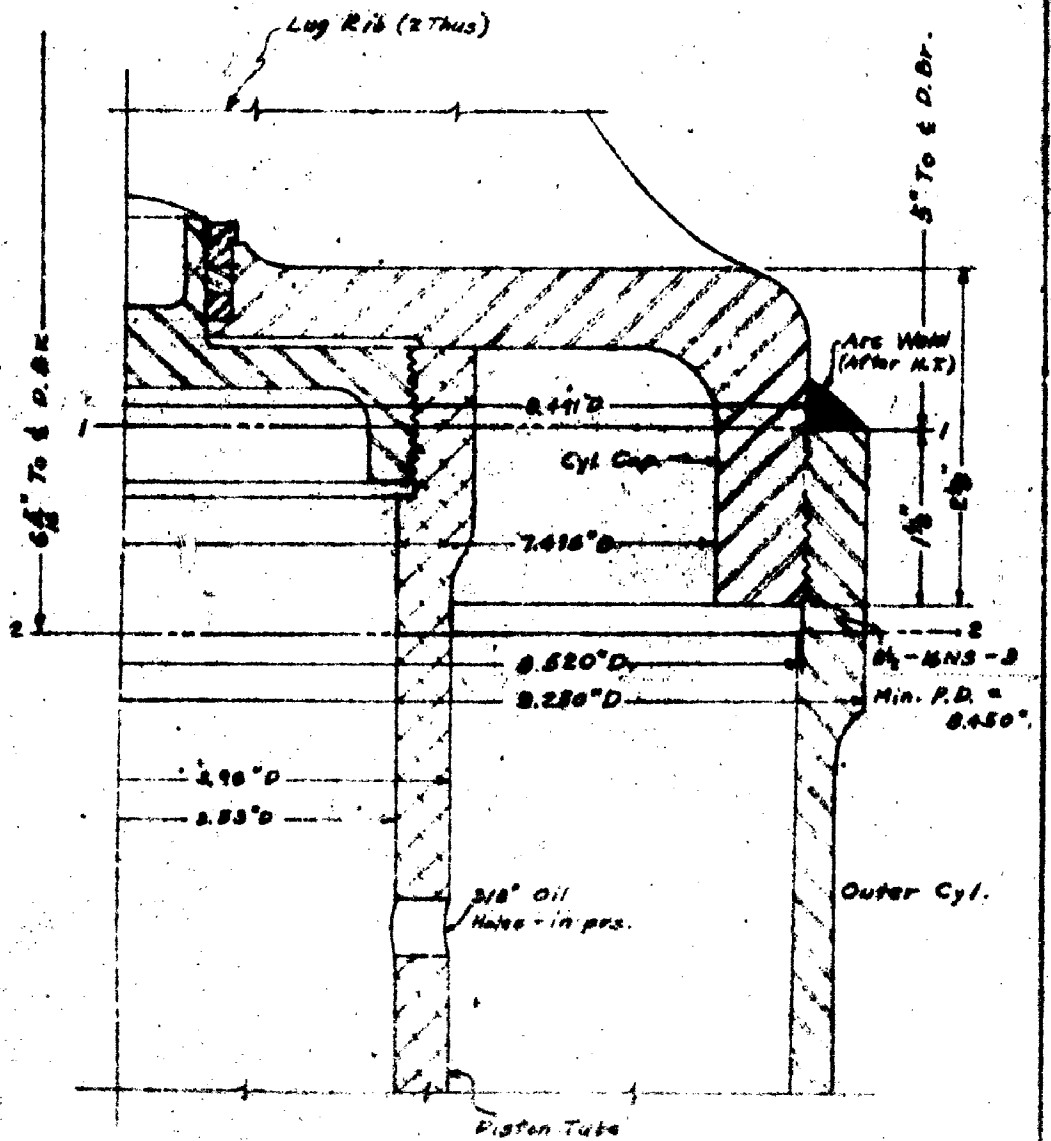
Model B-36 N.G.

SECTION Full Scale Ref. Dwgs. # 69652, 69677, 69678, 69698, 69699



Written by CSA Date 12/30/46 Rept. # 813
Checked by E.D.G Date 4-8-47 Page No. 51
Subject OUTER CYLINDER UPPER END FITTING No. of Pages 111
Model B-36 N.G.

THREADS - CAP TO CYLINDER

CONDITION 1(b) CRITICAL FOR SHEAR

Thrust = 166,000.

Shear = 203,000

M = 203,000 × 5 9/16 = 1,130,000"#

SECTION PROPERTIES

P.D. = 8.450" Assume effective L = ½ length of thrd. = ½ × 1⅛" = 9/16"

Min. thrd. h (for brg.) = (3.9910 - 3.9403)/2 = .02535" [Ref. (7), pp. 1157-8]

STRESSES

$$f_{s\,max.}^{*} \text{ (fwd. side)} = \frac{P}{\pi D L} + \frac{4M}{\pi D^2 L} = \frac{166{,}000}{\pi \times 8.45 \times .5625} + \frac{4 \times 1{,}130{,}000}{\pi \times 8.45^2 \times .5625}$$

= 11,120 + 35,900 = 47,020 $f_s$(aft side) = 35,900 - 11,120 = 24,780

$P_{s\,max.}$ = 47,020 × .5625 = 26,450 #/in. $P_s$( " " ) = 24,780 × .5625 = 13,940

$f_{br}$ (bend'g + thrust) = 13,940/.02535 × 1.125 × 16 = 30,500 (aft side)

Note: Considerable of the shear can be transferred by the weld thru shear at the N.A. Let us assume ½ transferred thus.

$f_s$ (weld) = 2 × 101,500/π × 8.875 × .375 = 19,400 (o.k., allowable = 48,200)

$f_{br}$ = 101,500/.02535 × .577 × 8.450 × 1.125 × 16 = 45,600 (Ref. p. 45)

Tot. $f_{br}$ = 30,500 + 45,600 = 76,100

ALLOWABLES - Weld after H.T.

$F_s$ = 70,000 ($F_{bs}$ to take acct. of mod. of rupture effect.)

$F_{br}$ = 125,000.

$$MS = \frac{70{,}000}{47{,}020} - 1 = +.49^{**}$$

* The weld is not considered to resist any bending or direct stress at the pt. of max. bending. Computation shows it to be stressed rather highly by the radial stresses between the threads.

** Cond. 7-1(a) more critical for bearing; see following page.

Written by CSA Date 12/31/46
Checked by G.D.G Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING



THREADS - CAP TO CYLINDER (Cont'd)

CONDITION 7-1(a) CRITICAL FOR BEARING

Thrust = 76,600#

Shear = 222,000#

M = 222,000 x 5 9/16 = 1,233,000"#

STRESSES

Note: Some items are computed by proportion from data on preced'g page.

$$f_{s\,max} = \frac{76,600}{\pi \times 8.45 \times .5625} + \frac{4 \times 1,233,000}{\pi \times 8.45^2 \times .5625}$$

= 5,130 + 39,100 = 44,230 (fwd. side)

$f_s$ (aft side) = 39,100 - 5,130 = 33,970

$P_{s\,max}$ (fwd. side) = 44,230 x .5625 = 24,900 #/in.

$P_s$ (aft " ) = 33,970 x .5625 = 19,100 #/in.

$f_{br}$ (bend'g + thrust, aft side) = 30,500 x 19,100/13,940 = 41,800

$f_{br}$ (from ½ shear Id., " " ) = 48,600 x 111,000/201,500 = 49,900

Tot. $f_{br}$ ( " " ) = 91,700

ALLOWABLES - See prec. page. $MS = \frac{125,000}{91,700} - 1 = +.36$

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SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 12/26/46
Checked by G.D.G Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING

Rept. # 813
Page No. 53
No. of Pages 111
Model B-36 N.G.

WELD - AIR PRESSURE CHECK

Static Ld. = 28,700#

O.D. inner cyl. = 7.740" (Ref. p. 27)

A " = $\frac{\pi}{4} \times 7.74^2 = 47.1$

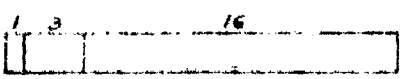
Static Air Press. = 28,700/47.1 = 610 psi

Compression Ratio = 4-1 (Ref. Dwg. # 69450)

Fully Compressed Air Press. = 610 x 4 = 2440 psi

Weld to withstand 3300 psi (Ref. Dwg. # 69652)

$MS = \frac{3300}{2440} - 1 = +.35$




Fully Extended Air Pressure = 610 x 4/17 = 143.5 psi

B-132

Written by C.S.A. Date 4/4/47
Checked by E.D.E. Date 4-5-47
Subject OUTER CYLINDER UPPER END FITTING

Rept. # 813
Page No. 54
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Model B-36 N.G.

SECTION I-I

CONDITION I(b) CRITICAL

$T_{I-I}$ = 166,000 #

$S_{I-I}$ = 203,000 #

$M$ = 203,000 × 5 = 1,015,000 #

SECTION PROPERTIES

OD = RD + PD − .041 = 8.459 − .041 = 8.418 [Ref: 9, p. 157 - A]

ID = 7.416" $t$ = .377" $I_1/I_0$ = .69 $A_0$ = 12.[illegible] $I/c$ = 23.1

STRESSES

$f_t$ = 166,000/12.35 = 13,400

$f_s$ = 2 × 203,000/12.35 = 32,800

$f_b$ = 1,015,000/23.1 = 43,900

$P_{S\,max}$ (two sides) = 26,450 #/in. (Ref p. 51)

$p$ = $P_S$ lon 30°/L = 26,450 × 577/1125 = 13,570 [illegible]

$P_S$ (off side) = (26,700 − 11,120) .5626 = 13,14[illegible] #/in.

$p = P_S + f_{cc} = \frac{13,140 \times 577}{1125} + \frac{191.5}{1125 \times .456} = 1,150 + 10,400 = 12,21[illegible]$ (off side)

$f_{hz}$ (two sides) = −(13,570 × 7.912/2 × .497) .25 = −27,000 * 11 = 29

cent is used since it is known if the stress is [illegible] the dist. from the outer end of the [illegible] material is up [illegible] also the web is reduced for ring stress by reducing the radial section from three sixths

$f_{cc}$ (off side) = −27,000 × 7.[illegible] (13,570) = 25.4c By ratio

$f_{cc}$ [illegible] = −27,000 × 11,120 [illegible] = −6.0[illegible] by ratio [illegible]

$f_{SHA} = \sqrt{(32,800)^2 + \left(\frac{43,900 + 43,900}{2}\right)^2} = 34,300$

$f_{t\,HA}$ = 34,300 + 13,400 − 6270/2 = 37,800

$f_{t\,max}$ = 47,9[illegible] + 13,400 = 51,3[illegible]

[illegible] ension from thrust only.

Written by CSA Date 4/7/47
Checked by [illegible] Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING

Rept. # 813
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SECTION 1-1 (Cont'd)

ALLOWABLES Weld after H.T.

$F_{tu}$ = 80,000

$F_{su}$ = 50,000

$F_{sy}$ = 42,500 (See p. 2[illegible])

$F_b$ = mod. of rupt. for $F_{tu}$ = 80,000
= 100,000

MS

$R_s$ = 34,300/50,000 = .686

$R_t$ = 13,400/80,000 = .168

$R_b$ = 43,900/100,000 = .439

$R_{nc}$ (fwd side) = 27,000/2 × 42,500 = .318

$R_{nc}$ (aft side) = 35,400/2 × 42,500 = .417 ([illegible] aft side)

MS = [illegible] / [illegible] / [illegible] + .08
.168 + .439 + .318
.925

CONDITION 7-1(a)

Thrust = 76,600#

Shear = 222,000#

M = 222,000 × 5 = 1,110,000 #

STRESSES

$f_t$ = 76,600/12.35 = [illegible]

$f_s$ = 2 × 222,000/12.35 = 36,000

$f_b$ = 1,100,000/23.1 = 48,000

$F_{s_{max}}$ (fwd. side) = 24,[illegible] #/in. (Ref. p. [illegible])

$P$ (fwd. side) = 24,900 × .517/1.125 = 12,[illegible]

$P_s$ (aft. side) = 19,10[illegible] #/in. (Ref. p. [illegible])

$P$ ( " " ) = 19,100 × .517/1.125 + 111,000/1.125 × 8450 = 9,200 + 11,[illegible] = 2[illegible],470

Written by CSA Date 4/7/47
Checked by G.D.G Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING

Rept. # 813
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Model B-36 N.G.

SECTION 1-1 (cont'd)

STRESSES (Cont'd)

$f_{hc}$ (fwd. side) = (12,770 × 7.913/2×.497).25 = -25,400

$f_{hc}$ (aft side) = 25,400 × 21,470/12,770 = -42,700

$f_{hc}$ (N.A.) = 25,400 × 5,130/44,230 = - 2,940 (Ref. p. 52)

$f_{s\,N.A.} = \sqrt{(26,000)^2 + \left(\frac{6200 + 3849}{2}\right)^2} = 36,300$

$f_{ex.} = 36,300 + (6,200 - 2,940)/2 = 37,700$

$f_{s\,max.} = 48,000 + 6,200 = 54,200$

ALLOWABLES - See prec. page.

MS

$R_s = 36,300/50,000 = .726$

$R_t = 6,200/80,000 = .078$

$R_b = 48,000/100,000 = .480$

$R_{hc}$ (fwd side) = 25,400/2×42,500 = .299

$R_{hc}$ (aft " ) = 42,700/2×42,500 = .503

$$MS = \frac{1}{.480 + .503 - .078} - 1 = +.10$$

.905

Written by CSA Date 12/27/46
Checked by E.D.G Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING

Rept. # 813
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SECTION 2-2

CONDITION 7-1(a) CRITICAL

Thrust = 76,600#

Shear = 222,000#

M = 222,000 × 6 5/16 = 1,401,000"#

SECTION PROPERTIES

OD = 9.250" ID = 8.570" t = .365" D/t = 25.4

$A_s$ = 10.22 I/c = 21.8

STRESSES

$f_t$ = 76,600/10.22 = 7,500

$f_s$ = 2 × 222,000/10.22 = 43,500

$f_b$ = 1,401,000/21.8 = 64,300

p(fwd. side) = 12,770 p(aft side) = 21,470 (Ref. p. 55)

$f_{ht}$ (fwd. side) = (12,770 × 8.885/2 × .365).25 = 38,900

$f_{ht}$ (aft. side) = 38,900 × 21,470/12,770 = 65,800

$f_{ht}$ (N.A.) = 38,900 × 5,130/44,230 = 4,510

$$f_{s_{NA}} = \sqrt{(43,500)^2 + \left(\frac{7500 - 4510}{2}\right)^2} = 43,500$$

$f_{t_{NA}}$ = 43,500 + (7500 + 4510)/2 = 49,505

$f_{t_{max}}$ = 64,300 + 7,500 = 71,800

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SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 2/22/47 Rept # 8.3
Checked by [illegible] Date 7-8-47 Page No. 58
Subject OUTER CYLINDER UPPER END FITTING No. of Pages 111
Model B-36 N.G.

SECTION 2-2 (Cont'd)

ALLOWABLES - Weld after H.T. but assume some increase because of distance from weld.

$F_{tu}$ = 125,000
$F_{su}$ = 75,000
$F_{sy}$ = 70,000 (See p. 29)
$F_b$ = 139,000

MS

$R_t$ = 7,500/125,000 = .060
$R_s$ = 43,500/75,000 = .580
$R_b$ = 64,500/139,000 = .4[illegible]
$R_{bt}$ (fwd. side) = 38,700/2×70,000 = .278
" (aft side) = 65,500/2×70,000 = .468

$$MS = \frac{1}{.462 - .060 + .46} - 1 = \frac{1}{.870} = \underline{+.15}$$

# BENDIX PRODUCTS DIVISION

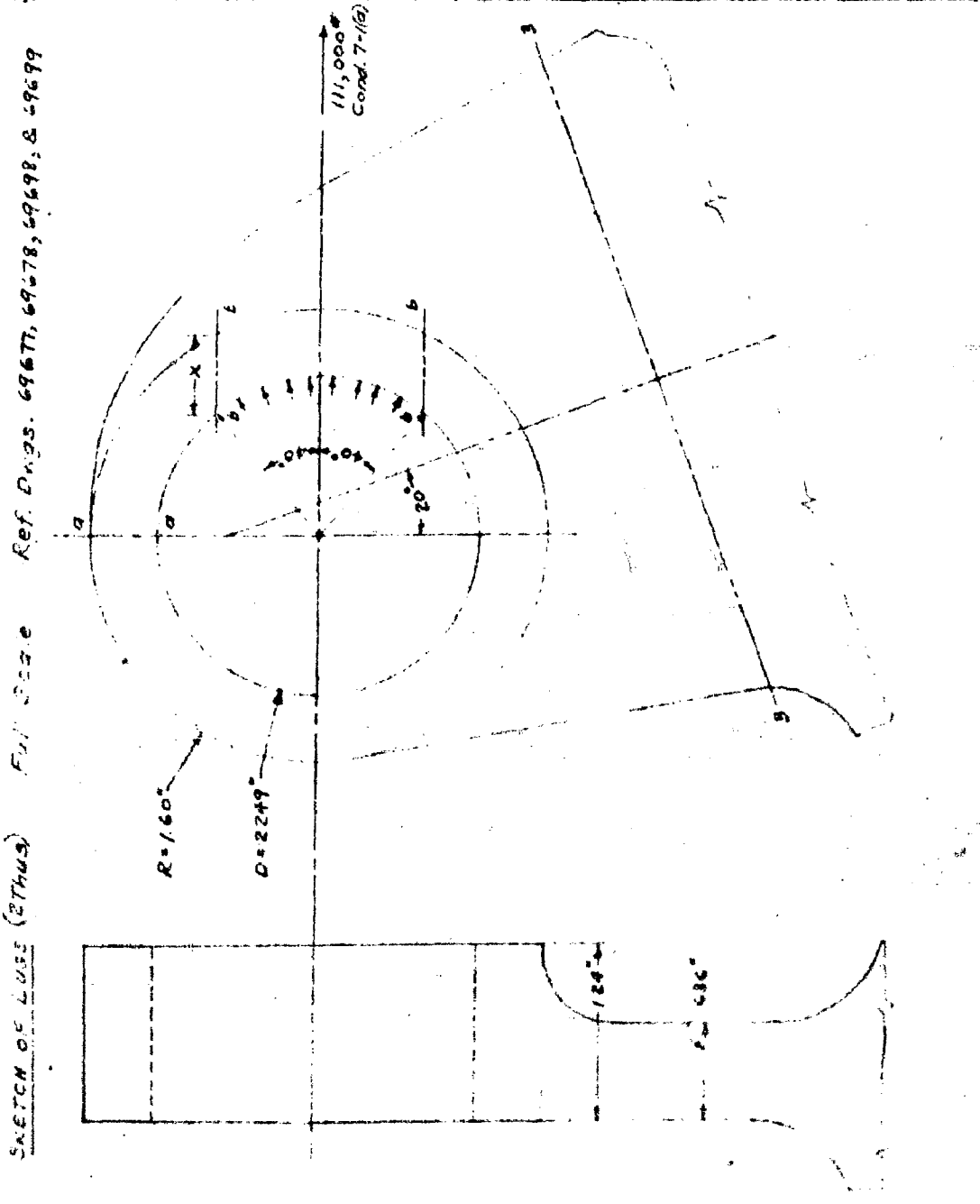
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Rept # 813

Written by CSA Date 12/31/46 Page No. 59

Checked by G.D.G Date 4-8-47 No. of Pages 111

Subject OUTER CYLINDER UPPER END FITTING Model B-36 N.G.




S-133

Written by CSA Date 1/2/47
Checked by G.D.G Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING



CHECK OF LUG - SECTS. a-a & b-b

CONDITION 7-1(a) CRITICAL

Drag Brace Ld. = 222,000# or 111,000# per Lug

SECTION PROPERTIES

Sect. a-a : L = 1.24" t = .476" A = .590"

Sect. b-b : L = 1.24" x = .567" A = .703

STRESSES

$f_t$ = 111,000/2 × .590 = 94,000

$f_s$ = 111,000/2 × .703 = 79,000

$f_{br}$ = 111,000/1.24 × 2.25 = 39,800

ALLOWABLES

$F_{tu}$ = 205,000

$F_{su}$ = 117,500

$F_{br}$ = 210,000

$$MS = \frac{117,500}{79,000} - 1 = +.49$$

Written by C.J.A. Date 1/2/47
Checked by C. D. G. Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING

Rept. # 813
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## SECTION 3-3

CONDITION 7-1(a) CRITICAL

Horiz. Ld. per Lug = 111,000 #

Comp. = 111,000 sin 20° = 38,000 #

Shear = 111,000 Cos 20° = 104,000 #

M = 111,000 x 2.36" = 262,000 "#

SECTION PROPERTIES

$b = 4.74"$ $t = .686"$ $A = 4.74 \times .686 = 3.25$ $I/c = \frac{4.74^3 \times .686}{6} = 8.57$

STRESSES

$f_c = 38,000/3.25 = 11,700$

$f_b = 262,000/2.57 = 102,000$

$f_s = 1.5 \times 104,000/3.25 = 48,000$

ALLOWABLES

$F_{cy} = 205,000$ MS = Amp

Written by CSA Date 1/2/47
Checked by E.D.G. Date 4-8-47
Subject OUTER CYLINDER UPPER END FITTING

Rept. # 813
Page No. 62
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Model 2-36 N.G.

TEAROUT OF LUGS FROM CYLINDER HEAD

CONDITION 7-1(a)

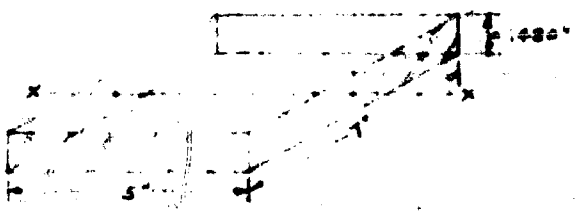
Thrust = 76,600#
Shear = 222,000#
M = 222,000 × 4.25 = 943,000"#

CONDITION 1(b)

Thrust = 166,000#
Shear = 203,000#
M = 203,000 × 4.25 = 863,000"#

SECTION PROPERTIES

Assumed Tearout Sect.:




$A = 2 \times 5 \times .48 + 2 \times 7 \times .48 = 4.80 + 6.72 = 11.52$

$I/c = 2 \times .48 \times \bar{7}^2/6 + 2 \times .48 \times 5 \times 3.50 = 24.6$

Stresses

7-1(a)

$f_{sb} = \frac{76,600}{11.52} + \frac{943,000}{24.6} = 6,700 + 38,300 = 45,000$

$f_{sNA} = 6,700 + 1.5 \times 222,000/11.52 = 6700 + 28,900 = 35,600$

1(b)

$f_{sb} = \frac{166,000}{11.52} + \frac{863,000}{24.6} = 14,400 + 35,100 = 49,500$

$f_{sNA} = 14,400 + 1.5 \times 203,000/11.52 = 14,400 + 26,400 = 40,800$

ALLOWABLES

$F_{tu} = 205,000$

$F_{sb} = 157,500$ ($F_{st}$ to take acc't of [illegible] effect.)

$F_{su} = 117,500$

MS = Amp.

Written by C.S.A. Date 1/27/47
Checked by C.D.G. Date 4-8-47
Subject OUTER CYLINDER

Rept. # 813
Page No. 63
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Model B-36 N.G.

## GLAND NUT  Ref. Dwg. # 69688

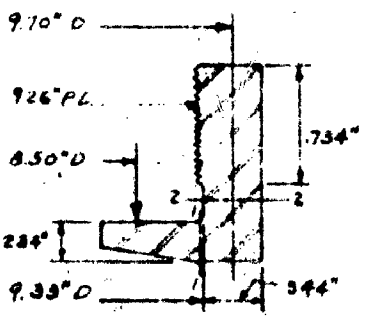
### LOADING

$P$ = 4.5 × fully ext. air pressure × area outer cyl.
= 4.5 × 143.5 × $\frac{\pi}{4}$ × $\overline{8.75}^2$ = 38,800# (Ref. p. 53.)

This load will be considered concentrated around circum. of 8.50" dia. circle.

### SECTION PROPERTIES

Full cantilever moment will conservatively be assumed.




Sect. 1-1: $I/c$ = 9.33π × $\overline{.734}^2/6$ = .268
$A$ = 9.33π × .284 = 6.87
Sect. 2-2: $I/c$ = 9.70π × $\overline{.344}^2/6$ = .602
$A$ = 9.70π × .844 = 10.5
Threads: $A$ = 9.26π × 734/2 = 10.7

### STRESSES

Sect. 1-1: $f_b$ = 38,800(9.33 − 8.50)/2 × .268 = 60,000
$f_c$ = 38,800 × 1.5/6.87 = 8,500
Sect. 2-2: $f_b$ = 38,800(9.70 − 8.50)/2 × .602 = 38,700
$f_c$ = 38,800/10.5 = 3,700
Threads: $f_s$ = 38,800/10.7 = 3,600

### ALLOWABLES

$F_{cy}$ = 170,000

MS = Amp.

Written by CSA Date 1/15/47
Checked by G.D.G Date 4-8-47
Subject PISTON

Rept. # 813
Page No. 64
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Model 8-36 N.B.

PISTON TUBE Ref. p. 50 & Dwg. # 61723

CONDITION 1(a) or 1(b) CRITICAL
Comp. = 166,000 #

SECTION PROPERTIES
OD = 3.96" ID = 2.53" t = .215" D/t = 18.4 L = 22"
$A_s$ = 2.53 $\rho$ = 1.33 L'/$\rho$ = 22/1.33 = 16.5
$A_s$ (at oil holes) = 2.53 - 2 × $\frac{5}{8}$ × .215 = 2.53 - .16 = 2.37

STRESSES
$f_c$ (primary instab.) = 166,000/2.53 = 65,400
$f_c$ (local " ) = 166,000/2.37 = 70,000

ALLOWABLES Mat. = 75ST Ref. Revisions to ANC-5, Minutes of April + May, 1946 meetings of ANC-5 Committee.
$F_{cy}$ = 76,000
$F_{co}$ = 1.075 $F_{cy}$ = 81,700

$$F_c = F_{co}\left[1 - \frac{F_{co}(L'/\rho)^2}{4\pi^2 E}\right] = 81,700\left[1 - \frac{81,700 \times 16.5^2}{4\pi^2 \times 10,500,000}\right] = 81,700 \times .946$$

= 77,300

$$MS = \frac{76,000}{70,000} - 1 = +.08$$

**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/3/47
Checked by S.E.G. Date 4-8-47
Subject PISTON

Rept. #813
Page No. 68
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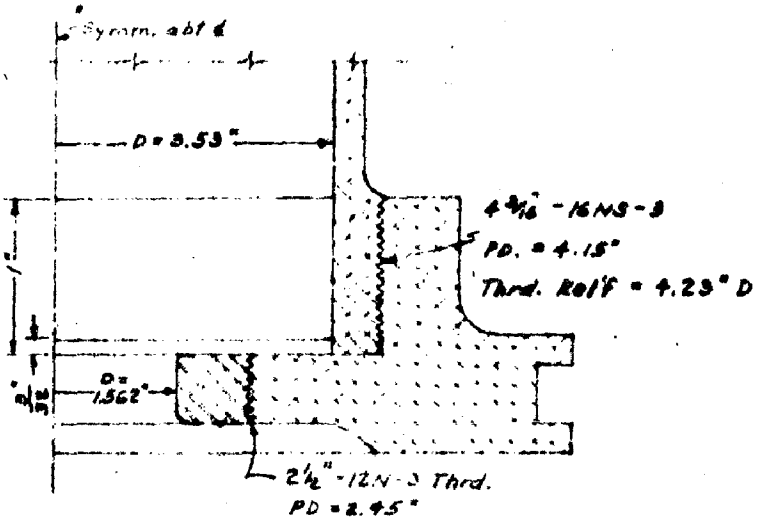
Model D-38 N.B.

SKETCH OF ORIFICE PLATE Full Scale Ref. Dwgs. #69724, 69726, 69727




For analysis, the plate will be considered split into circular rings, free at one edge and fixed at the central portion or ring containing the thread for connection to the piston tube. The formulas of ref. (4), pp. 208-9 will be used.

2-138

Written by C.S.A. Date 1/6/46
Checked by C.D.G. Date 4-8-47
Subject PISTON



THREADS CONNECTING ORIFICE RING TO PLATE (Ref. p. 65)

CONDITION (a) or (b) CRITICAL

Hyd. press. = 4,640 psi (Ref. p. 29)

SECTION PROPERTIES

PD = 2.45" ID (of ring) = 1.562" A = 2.80

Assume eff. L of thrd. = .4/2 = .2"

Min. thrd. h = (2.5000 - 2.4188)/2 = .0406"

STRESSES

P = 4640 × 2.80 = 1300#

$f_s$ (thrds.) = 1300/π × 2.45 × .2 = 844 M = Amp.

$f_s$ (in.) = 1300/π × 2.45 = 169 #/in.

Written by CSA Date 1/6/47
Checked by E. D. G Date 4-8-47
Subject PISTON

Rept. # 813
Page No. 67
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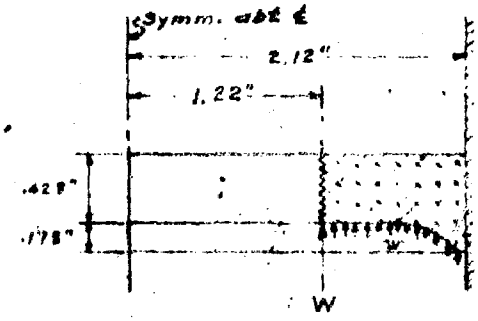
Model B-36 N.G.

ORIFICE PLATE - INNER RING




CONDITION 1(a) or (b) CRITICAL

W = 1300# w = 4,640 psi (Ref. prec. page)

SECTION PROPERTIES

a = 2.12" b = 1.22" a/b = 1.74 $A = \pi\left(\overline{2.12}^2 - \overline{1.22}^2\right) = 9.42$

STRESSES Ref. (4), p. 209, Cases 17 & 18.

$S_r (r=a) = \frac{\beta w a^2}{t^2} + \frac{\beta' W}{t^2}$ Use av. t = .5

$= \frac{.366 \times 4640 \times \overline{2.12}^2}{.5^2} + \frac{.385 \times 1300}{.5^2} = 30,600 + 1000 = 32,600$

$P_s$ (shear @ a in #/in.) = $(1300 + 4640 \times 9.42)/2\pi \times 2.12 = 3380$ #/in. } Critical

$M_r (r=a) = 32,600 \times .5^2/6 = 1360$ #/in.

ALLOWABLES Mat. = 14ST

$F_b = 1.5 \times$ yld. $= 1.5 \times 50,000 = 75,000$ MS - Amp.

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SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/6/47
Checked by G. D. G Date 4-8-47
Subject PISTON

Rept. # 813
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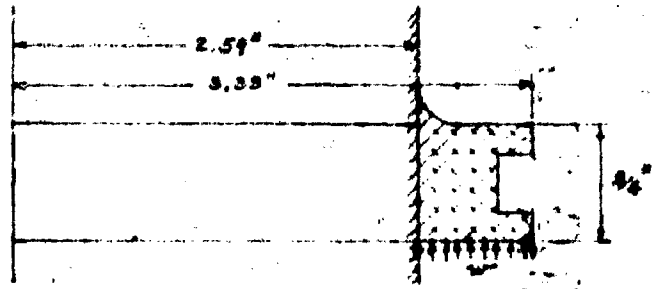
ORIFICE PLATE - OUTER RING.




CONDITION 1(a) or (b) CRITICAL
$W = 4,640$ psi (Ref. p. 68)

SECTION PROPERTIES
$a = 3.33"$ $b = 2.54"$ $a/b = 1.31$ $A = \pi(3.33^2 - 2.54^2) = 10.8$

STRESSES Ref. (4), p. 209, Case 21.
$S_r\ (r=b) = \beta w a^2/t^2$ Use an $\ell = .80"$
$= .174 \times 4640 \times 3.33^2/.80^2 = 14,400$
$P_s$ (Shear @ b in #/in) $= 4640 \times 13.8/2\pi \times 2.54 = 3940$ #/in. {Not Critical}
$M_r\ (r=b) = 14,400 \times .8^2/6 = 1540$ "#/in.

ALLOWABLES
$F_b = 75,000$ Ref. prec. page MS = Amp.

B-120

**BENDIX PRODUCTS DIVISION**
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Written by CSA Date 1/6/47
Checked by E.D.G. Date 4-8-47
Subject PISTON

Rept. # 813
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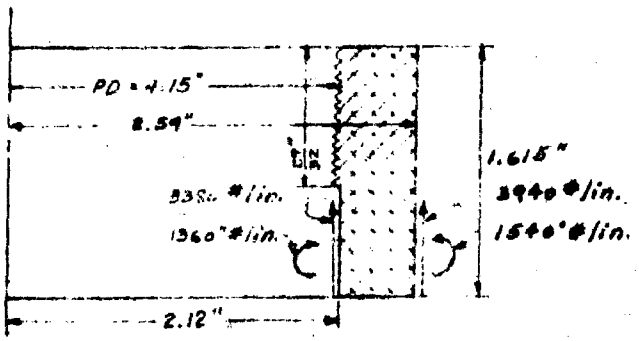
ORIFICE PLATE - MIDDLE RING




CONDITION 1(a) or (b) CRITICAL

For loads as shown above, see pp. 67 & 68. Tot. Thrust = 166,000#

SECTION PROPERTIES

$I/c = .47 \times 1.615^2/6 = .204$ Assume eff. thrd. L = .47"

STRESSES

Torque/in. = 1540 - 1360 + (3940 - 3380) .47/2 = 312 "#

$f_b = Me\,R\,c/I = 312 \times 2.36/.204 = 3830$ [Ref. (4) p. 223]

$f_{bt} = .0919\,F/Lt = .0919 \times 166{,}000/.9 \times 1.7 = 36{,}100$

$f_{hoop} = 36{,}100 - 3330 = 32{,}800$ (Hoop tens. from shear action considered to reduce rapidly from open end of ring.)

ALLOWABLES Mat. = 14ST

$F_{cu} = 65{,}000$

$F_{su} = 40{,}000$

MS = Amp.

**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/7/47
Checked by S. D. S. Date 4-8-47
Subject PISTON

Rept. # 813
Page No. 70
No. of Pages 111
Model B-36 N.G.

THREADS CONNECTING ORIFICE PLATE TO TUBE

CONDITION 1(a) or (b) CRITICAL

Thrust = 166,000#

SECTION PROPERTIES

The plate thrds. are critical being made of lower stress material.

PD = 4.15" Assume eff. thrd. L = .9/2 = .45"

Min. thrd. h = (4.1780 - 4.1266)/2 = .0257"

STRESSES

Since the plate tends to deflect away from the end of the tube and the tightness of the [illegible] in their holes is uncertain, the threads [illegible] be assumed to take the total load.

$f_s$ = 166,000/π × 4.15 × .45 = 28,300

$f_{br}$ = 166,000/π × 4.15 × .025 × 6 × .9 = 35,400

ALLOWABLES Mat. = 14ST

$F_{su}$ = 40,000

$F_{br}$ = 124,000

$$MS = \frac{40,000}{28,300} - 1 = +.41$$

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# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/7/47
Checked by G.P.G. Date 4-8-47
Subject PISTON

Rept. # 813
Page No. 71
No. of Pages 111
Model B-36 N.G.

CHECK OF PISTON TUBE AT THREADS CONNECTING TO ORIFICE PLATE

CONDITION 1(a) or (b) CRITICAL

Thrust = 166,000 #

SECTION PROPERTIES

RD = 4.18 - .09 = 4.09" ID = 3.53" t = .28" $A_s$ = 3.36 Eff. L = .9"

STRESSES

$f_c$ = 166,000/3.36 = 49,400

$f_{bc}$ = .0919 P/Lt = .0919 × 166,000/.9 × .28 = 60,500

Since both are comp., the combination is not critical.

ALLOWABLES Mat. = 75ST

$F_{cy}$ = 76,000 (Ref. p. 64)

Assume $F_{cb} = F_{cy}$ = 76,000

$$MS = \frac{76,000}{60,500} - 1 = +.26$$

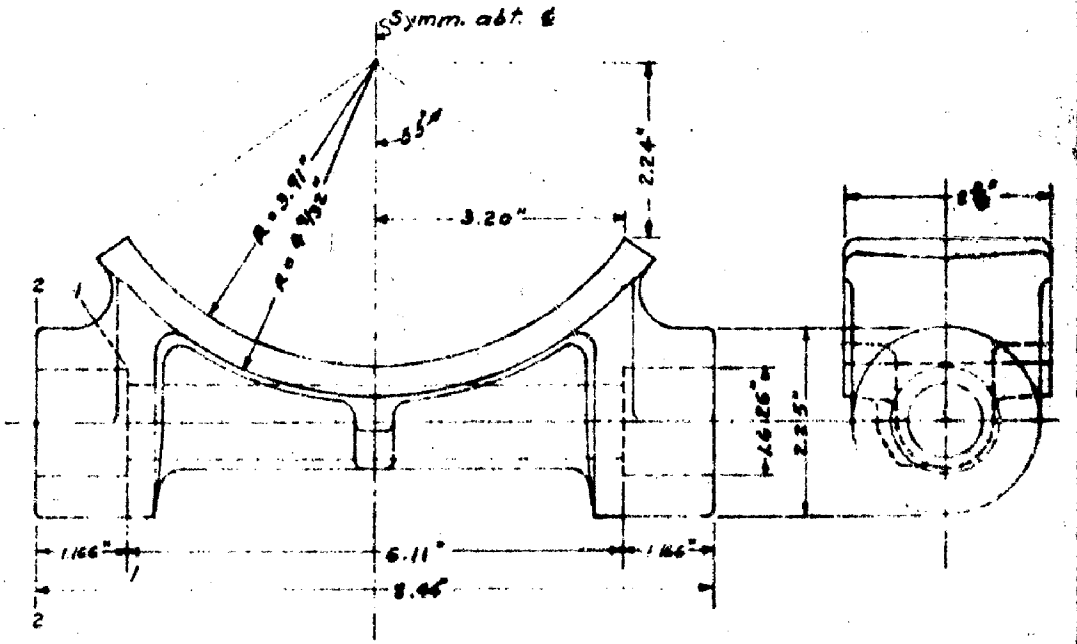
# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/8/47
Checked by C.D.G Date 4-8-47
Subject INNER CYLINDER TORQUE FITTING

Dept. # 813
Page No. 72
No. of Pages 111
Model B-36 N.G.

SKETCH 1/2 Scale Ref. Dwgs. # 69666, 69667, 69657



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DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/8/47
Checked by E.D.G Date 4-8-47
Subject INNER CYLINDER TORQUE FITTING

Rept. # 813
Page No. 73
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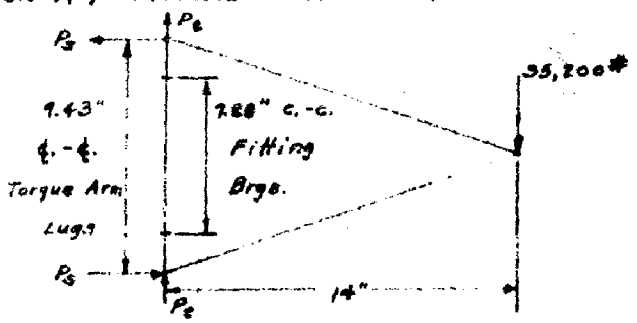
Model B-36 N.G.

BOLT CONNECTING TORQUE ARM TO FITTING  Ref. Dwg. # 69717

CONDITION 1(C) CRITICAL  Ref. PG 111




$P_s = 35,200 \times 14/9.43 = 52,200^{\#}$

$P_t = 35,200/2 = 17,600^{\#}$

SECTION PROPERTIES

Bolt D = 7/8"  A = .601  $I/c = \pi \times .875^2/32 = .0658^*$

STRESSES

$f_s = 52,200/.601 = 87,000$

$f_t = 17,600/.601 = 29,300$

$f_{s\,max.} = \sqrt{(87,000)^2 + \left(\frac{29,300}{2}\right)^2} = 88,200$

$f_{n\,max.} = 88,200 + 29,300/2 = 102,850$

$f_{br} = 52,200/.875 \times .75 = 79,600$

ALLOWABLES

$F_{su} = 180,000$

$F_{su} = 105,000$

$F_{br} = 200,000$

Bearing: $MS = \frac{200,000}{79,600 \times 2.5} - 1 = 0.01$

Shear: $MS = \frac{105,000}{88,200} - 1 = 0.19$

* Note: Bending is neglected here in accordance with the original design of the part # Ref. (1), p. 46

**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Rept. # 813
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Model B-36 N.G.

Written by CSA Date 1/16/47
Checked by E.D.G. Date 4-3-47
Subject INNER CYLINDER TORQUE FITTING

SECTION 1-1

CONDITION 1(c) CRITICAL. See prec. page.

Brg. Ld. = 35,200 × 14/7.28 = 67,700

$P_t$ = 17,600#

M = 67,700 (7.28 − 6.11)/2 = 39,600"#

SECTION PROPERTIES

Lug will be considered cantilevered tube subjected to above loads.

OD = 2.25" ID = 1.626" t = .312" D/t = 7.2 Brg L = 1.18"

$A_s$ = 1.90 I/c = .812

STRESSES

$f_s$ = 2 × 67,700/1.90 = 71,300

$f_c$ = 35,200/1.90 = 18,500

p = 67,700/1.626 × 1.125 = 37,000 psi

$f_{ht} = .5^{*} \cdot \frac{2 \times ID^2 \cdot p}{OD^2 - ID^2}$ ** {* The .5 coef. is used because the [illegible] at the [illegible] cyl. (Ref. p.54)

$= \frac{1.626^2 \times 37,000}{2.25^2 - 1.626^2} = 40,000$

$f_b$ = 39,600/.812 = 48,[illegible]

$f_s$ (3 max. $f_b$) = (18,500 + 40,000 + 48,800)/2 = 53,700

ALLOWABLES

$F_{tu}$ = 205,000 $F_c$ = 170,000 $F_{su}$ = 117,500

$F_{sy}$ = 1.2 × .85 × 205,000 = 209,000 $F_b$ = 330,000

MS

$R_s$ = 71,300/209,000 = .341

$R_c$ = 18,500/170,000 = .109 $MS = \frac{1}{\sqrt{(.341)^2 + (.109 + 19.5)^2}} - 1 = +1.18$

$R_{ht}$ = 44,000/205,000 = .195

$R_s$ (3 max. $f_b$) = 53,700/117,500 = .457 $MS = \frac{1}{.457} - 1 = +1.19$

** Ref. (9), p. 239

Written by C.S.A. Date 1/16/47
Checked by E.D.G Date 4-8-47
Subject INNER CYLINDER TORQUE FITTING



SECTION 2-7

CONDITION I(c) CRITICAL

$p = 37,000$ psi See prec. page.

SECTION PROPERTIES

OD = 2.25" ID = 1.626"

STRESSES

The lug will be considered a thick cylinder subjected to internal pressure, and checked by the method of Ref.(9), pp. 389-90.

$f_{hc}$ (@ OD) $= \frac{2\overline{ID}^2 p}{\overline{OD}^2 - \overline{ID}^2} = \frac{2 \times 2.63 \times 37,500}{2.43} = 80,000$

$f_c = 18,500$ See prec. page

$f_{s\,max.} = (80,000 + 18,500)/2 = 49,250$

ALLOWABLE

$F_{sy} = 112,500$

$MS = \frac{112,500}{49,250} - 1 = +1.28$

Written by C.S.A. Date 1/16/47
Checked by C.D.G. Date 4-8-47
Subject INNER CYLINDER TORQUE FITTING

Ref. # 813
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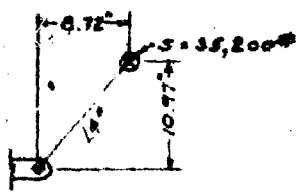
## WELD - LUG TO INNER CYLINDER

CONDITION 1(c) CRITICAL



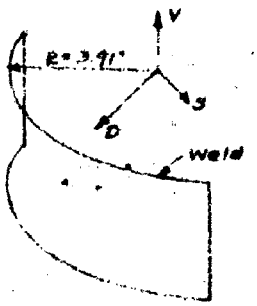

$V = D = 0$

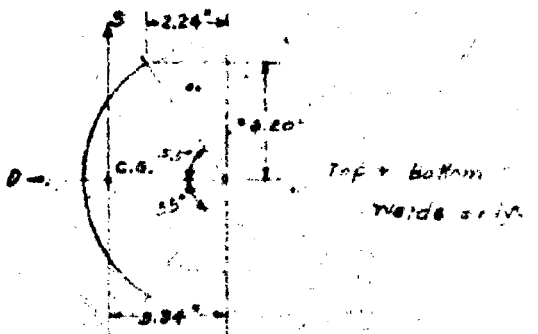
$M_V = 35,200(8.72 + 1.55) = 362,000$ "#

$M_D = 35,200(10.97) = 386,000$ "#

SECTION PROPERTIES

L of weld = $2 \times 2 \times 3.91 \times .960 + 2 \times 2\frac{3}{8} = 15.0 + 4.75 = 19.75$"




Dist. to CG Top + Bott. Welds = $R \sin\alpha/\alpha = 3.91 \times .849/.96 = 3.34$"

" " " all Welds = $15.0 \times 3.34 + 4.75 \times 2.24 / 19.75 = 3.08$"

$I_V = 2R^2(\alpha - \sin^2\alpha/\alpha) + 4x^2$

$= 2 \times \overline{3.91}^2(.96 - \overline{.849}^2/.96) = 2 + 15.0(3.34 - 3.08)^2 + 4.75 \times 3.20^2$

$= 62.2 + 1.0 + 48.7 = 112.0$ $\overline{ins}^3$

$I_D = R^2(\alpha - \sin\alpha\cos\alpha) + h^2/12 + 4x^2$

$= \overline{3.91}^2(.96 - .849 \times .574) + 2 \times 2\overline{.375}^3/12 + 2 \times 2 \times 3.20^2 + 15.0 \times \left(\frac{3.75}{2}\right)^2$

$= 58.6 + 2.2 + 48.7 + 21.1 = 130.6$ $\overline{ins}^3$

Written by CSA Date 1/10/47
Checked by E.D.G Date 4-8-47
Subject INNER CYLINDER TORQUE FITTING

Rept. # 813
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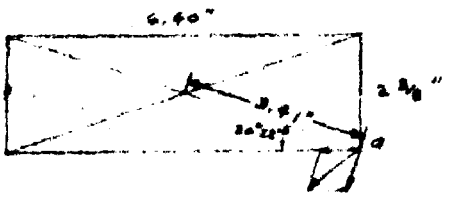
Model E-96 N.S.

WELD - LUG TO INNER CYLINDER (Cont'd)

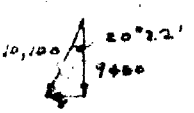
STRESSES Max. at Pt. "a"




$f_S = 35,200/19.75 = 1780$ #/in. (—)

$f_{BV} = 362,000 \times 3.20/112.0 = 10,300$ #/in.

$f_{BD} = 386,000 \times 3.41/131.6 = 10,100$ #/in




Max. Resultant $f_s = \sqrt{(1780+3520)^2 + (9460)^2 + (10,300)^2}$
$= 15,000$ #/in.

ALLOWABLE Weld before H.T.

Assume min. t for weld = 5/16"

$P = .48 \times 150,000 \times 5/16 = 22,500$ #/in.

$MS = \frac{22,500}{15,000} - 1 = +.50$

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 1/16/47.
Checked by E.D.S. Date 4-8-47
Subject TORQUE YOKE

Rept. # 813
Page No. 78
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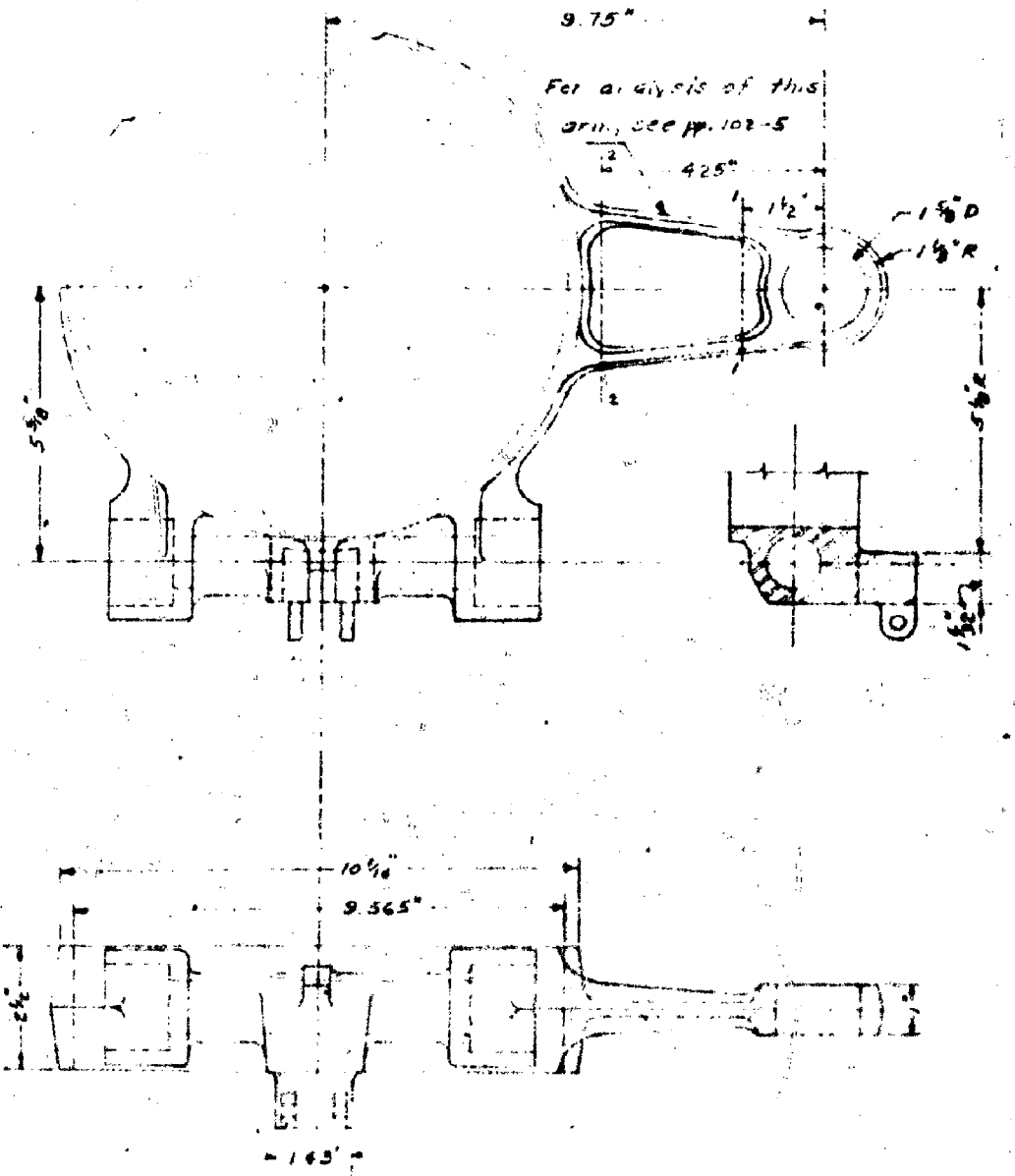
Model B-36 N.G.

SHEET H Ref. Dwgs. # 696-3, 69640, 69691, 69692



Written by CSA Date 2/12/47
Checked by G.D.G Date 4-8-47
Subject TORQUE YOKE

Dept. # 813
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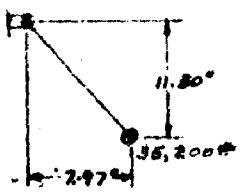
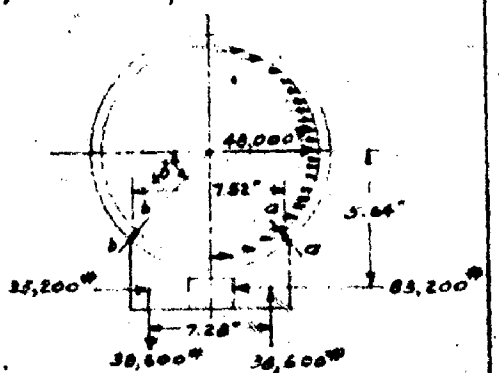
Torque arm bolt and fitting lugs are the same as for inner cylinder torque fitting. See pp. 73-75.

TEAROUT OF FITTING FROM YOKE

CONDITION 1(c) CRITICAL V & D = 0 S = 35,200# Torque = 461,000 "#




Ld. on step = 461,000/5.64 = 83,200#

Lds. from Torque Arm

H = 35,200 × 7.97/7.28 = 38,600#

V = 35,200 × 11.50/7.28 = 55,600#

This latter is assumed taken by bearing on the nut and shoulder. Using the distribution as given on p. 43, about 50,000"# of the vert. mom. will be transferred between a-a and b-b. Then,

$V_{a-a} = -V_{b-b} = (105,000 - 50,000)\,7.52 = 47,200\#$

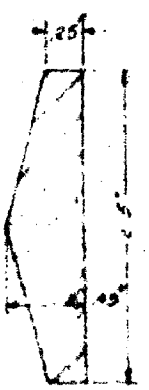
There will be some bending at say a-a due to the big. ld. to the right of the sect., but it is small and not critical.

SECTION PROPERTIES

$$I = \frac{h^3}{48}(b + 4b_1) = \frac{2.5^3}{48}(.18 + 4 \times 2.5) = .334$$

$$A = 2.5(.25 + .09) = .85$$

$$Q_{NA} = .85 \times .456 \times 2.5/2 \times 2 = .242$$



Written by CSA Date 2/12/47
Checked by G.D.G Date 4-8-47
Subject TORQUE YOKE

Rept. # 813
Page No. 80
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Model B-36 N.G.

TEAROUT OF FITTING FROM YOKE (Cont.)

STRESSES

Sect. a-a

$f_t = 48,000/.85 = 56,400$

$f_s = 47,200 \times .242/.384 \times 43 = 69,300$

$f_{s\,max.} = \sqrt{(69,300)^2 + (28,200)^2} = 74,800$

Sect. b-b

$f_t = 38,600 \cos 40°/.85 = 34,$

$f_s = 38,000 \sin 40°/.85 + 69,300 = 98,$

$f_{s\,max.} = \sqrt{(98,500)^2 + (17,400)^2} = 100,600$

ALLOWABLES

$F_{tu} = 205,000$

$F_{su} = 117,500$

$MS = \frac{117,500}{100,600} - 1 = +.17$

Written by C.S.A. Date 1/20/47
Checked by C.D.C. Date 4-8-47
Subject TORQUE YOKE



YOKE STOP

CONDITION 1(c) CRITICAL
Ld. = 83,200# (See p. 79.)

SECTION PROPERTIES
$b$ = 1.02" $h$ = 1.43" $A_x$ = 1.46 $I/c$ = .348
Brg. A (on cyl. stop) = .865 × 1.02 = .882

STRESSES
$f_c$ = 1.5 × 83,200 / 1.46 = 85,400
$f_b$ = 83,200 × .823 / .348 = 197,000
$f_{br}$ = 83,200 / .882 = 94,400

ALLOWABLES Assume H.T. reduced to 200,000
$F_{bc}$ = 115,000
$F_b$ = 1.5 × 165,000 = 247,500
$F_{br}$ = 205,000

$$MS = \frac{247,500}{197,000} - 1 = +.26$$

**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/21/47
Checked by E.D.G Date 4-8-47
Subject TORQUE YOKE

Rept. # 819
Page No. 82
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Model B-26 N.G.

NUT Ref. Dwg. # 69695

CONDITION 1(c) CRITICAL
$P_{max.}$ = 5420 #/in. (Ref. p. 43)

SECTION PROPERTIES
Assume eff. L = 1/2 × .8 = .4"

STRESSES
$f_s$ = 5420/.4 = 13,600

ALLOWABLES Mat. = 14ST
$F_{su}$ = 65,000
$F_{su}$ = 40,000

MS = Amp.

BUSHING Ref. Dwgs. 69694, 69690

LOADING - See above.

SECTION PROPERTIES
OD = 10.053 ID = 9.697 (Allows for chamfer on torque yoke.)
t = .178"

STRESS
$f_{br}$ = 5420/.178 = 30,500

ALLOWABLE - $F_{br}$ = 80,000 (Bronze)

$$MS = \frac{80,000}{2.5 \times 30,500} - 1 = +.05$$

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# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/22/47
Checked by E.D.G Date 4-8-47
Subject TORQUE ARMS

Rept. # 813
Page No. 93
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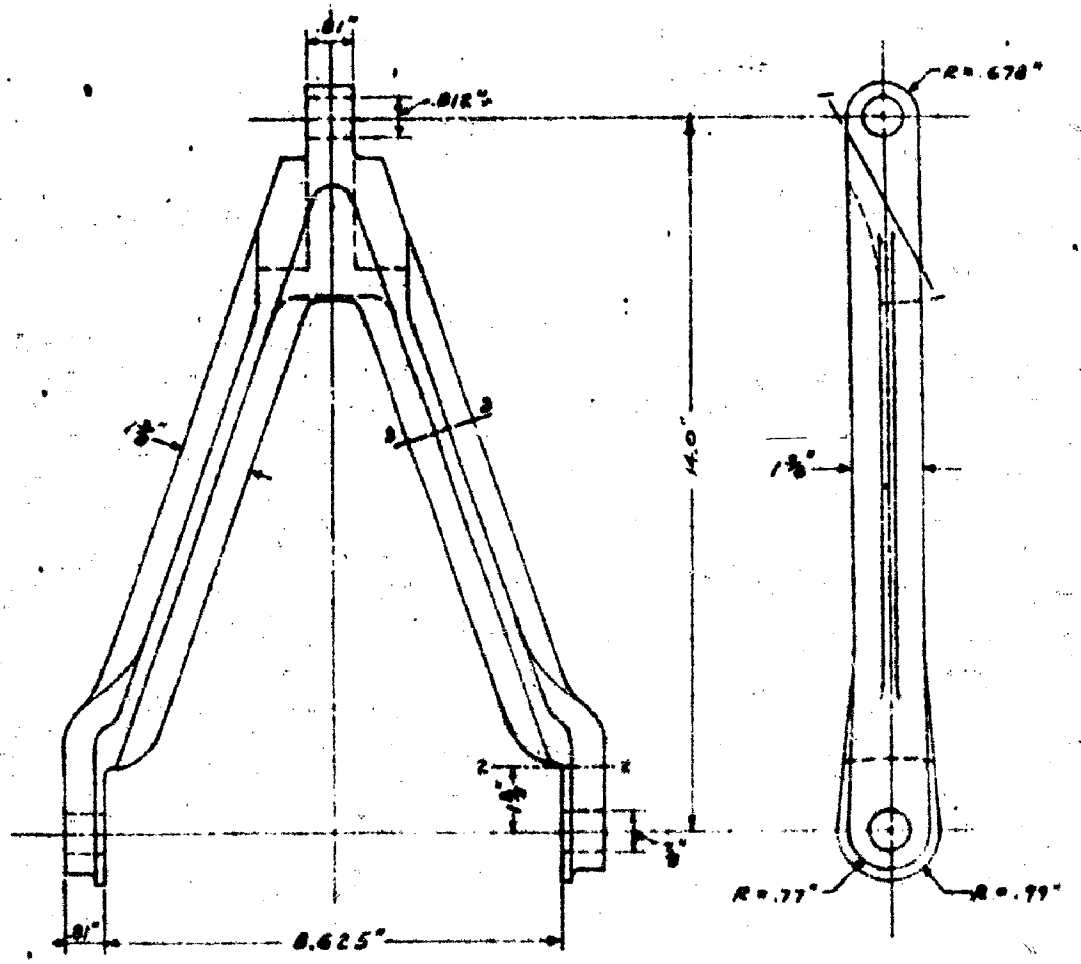
Model B-36 N.G.

SKETCH - LOWER TORQUE ARM Ref. Dwgs # 69703, 69705, 69878



# BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/22/47
Checked by G.D.G Date 4-8-47
Subject TORQUE ARMS

Rept. # 813
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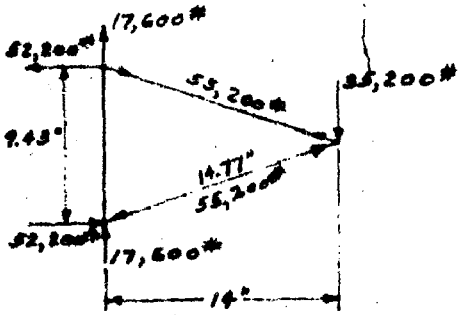
Model B-35 N.G.

## LUGS AT FITTING END

CONDITION 1(c) CRITICAL




Axial Ld. in leg = 35,200 x 14.77/9.43 = 55,200#

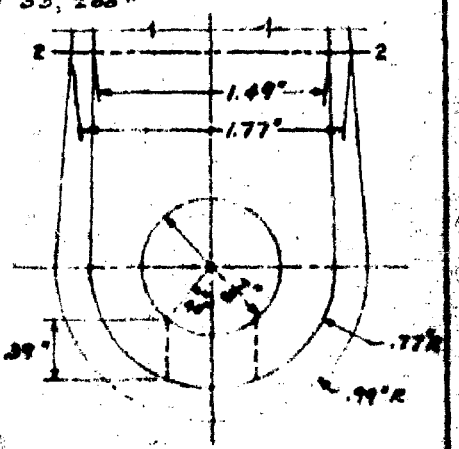
SECTION PROPERTIES See prec. page.

t = .81"

A(tension fracture) = .81(1.54 - .875) = .539

A(shear " ) = .81(2 x .89 ) = .692

A(brg.) = .81 x .875 = .687




STRESSES

$f_t$ = 52,800/.539 = 97,900

$f_s$ = 52,800/.692 = 82,700

$f_{br}$ = 52,800/.687 = 76,800

ALLOWABLES

$F_{tu}$ = 190,000

$F_{su}$ = 110,000

$F_{br}$ = 205,000 (Brg. critical on bolt; see p. 73.)

MS = 110,000/82,700 - 1 = +.33

Written by C.S.A. Date 1/22/47
Checked by G.D.G Date 4-8-47
Subject TORQUE ARMS

Rept. # 813
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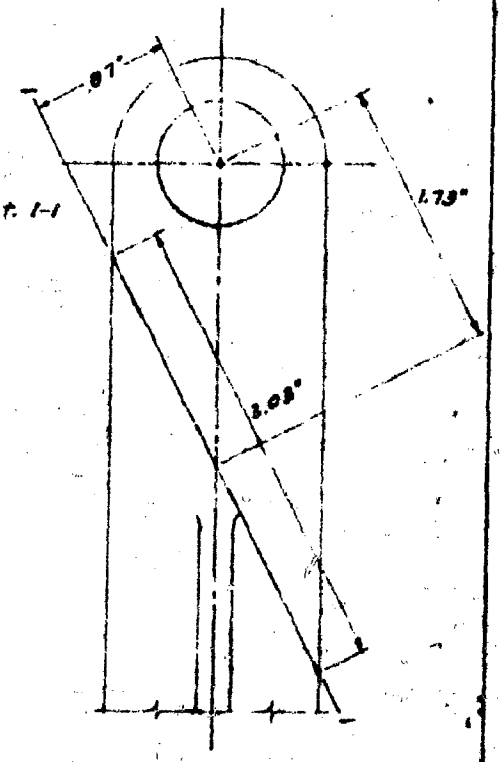
Model B-36 N.G.

## LUG AT APEX END




### CONDITION 1(c) CRITICAL

S = 35,200#

M = 35,200 × .87 = 30,600"# } Sect. 1-1

Torque = 35,200 × 1.73 = 60,900"#

### SECTION PROPERTIES

$b = 3.03"$ $h = .81"$

$A_s = 2.46$ $I/c = 3.03 \times .81^2/6 = .331$

### STRESSES - SECT. 1-1

$f_a = 1.5 \times 35,200/2.46 = 21,500$

$f_b = 30,600/.331 = 92,300$ #

$f_{st} = \frac{T}{5}\left(\frac{15b + 9h}{b^2 h^2}\right)$

$= \frac{60,900}{5}\left(\frac{15 \times 3.03 + 9 \times .81}{3.03^2 \times .81^2}\right)$

$= \frac{60,900}{5} \times 2.75 = 107,000$

### ALLOWABLES

$F_{cy} = 190,000$ $F_{su} = 110,000$

$F_b = 1.5 \times 165,000 = 247,500$

$F_{st} = 145,000$

### MS

$R_b = 92,300/247,500 = .373$

$R_{st} = 107,000/145,000 = .738$

$MS = \frac{1}{\sqrt{(.373)^2 + (.738)^2}} - 1 = +.21$

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/23/47
Checked by G.D.G Date 4-8-47
Subject TORQUE ARMS

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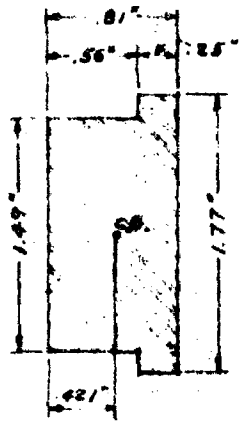
Model B-36 N.G.

SECTION 2-2




CONDITION 1(C) CRITICAL

For loads, see p. 84.

SECTION PROPERTIES (Ref. pp 83+84)

| Section | A | X | AX | $AX^2$ | Each Sect. $I_{cc}$ |
|---|---|---|---|---|---|
| 1.49 x .56 | .834 | .28 | .234 | .0654 | .0219 |
| 1.77 x .25 | .442 | .685 | .303 | .207 | .0023 |
| | 1.276 | .421 | .537 | .2724 | .0242 |

$q_{NA} = 1.49 \times .421^2/2 = .132$

$I = .2724 + .0242 - 1.276 \times .421^2 = .071$

STRESSES

$M = 17,600 \times 1.375 + 52,200 \times .016 = 25,000$ "#

$f_b = 25,000 \times .389/.071 = 137,000$

$f_c = 52,200/1.276 = 40,900$

$f_s = 17,600 \times .132/.071 \times 1.49 = 22,000$

ALLOWABLES

$F_c = F_{cy} = 165,000$

$F_b = 1.5 \times 165,000 = 247,500$

MS

$R_c = 40,900/165,000 = .248$

$R_b = 137,000/247,500 = .553$

$.801$

$MS = \frac{1}{.801} - 1 = +.25$

Written by CSA Date 1/23/47
Checked by E. D. C Date 4-8-47
Subject TORQUE ARMS

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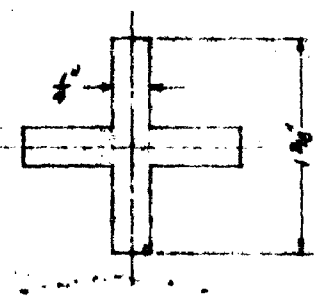
SECTION 3-8

CONDITION 1(C) CRITICAL

$P = 55,200\#$ (Ref. p. 84)




SECTION PROPERTIES

Assumed sect. for analysis :-

$A = 1.375 \times .25 + 1.125 \times .25 = .625$

$I = \frac{.25 \times 1.375^3}{12} + \frac{1.125 \times .25^3}{12} = .0557$

$\rho = \sqrt{.0557/.625} = .299$

$L'/\rho = 12/\sqrt{1.5} \times .299 = 32.8$

STRESS

$f_c = 55,200/.625 = 88,300$

ALLOWABLE

$F_c = 165,000\left[1 - \frac{165,000 \times 32.8^2}{4 \pi^2 \times 29 \times 10^6}\right] = 165,000 \times .845 = 139,400$

$MS = \frac{139,400}{88,300} - 1 = +.58$

**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 1/27/47
Checked by E.D.G. Date 4-8-47
Subject CAMS

Rept. # 813
Page No. 11
No. of Pages 111
Model B-36 N.G.

PLUG - UPPER CAM LOCK  Ref. Dwgs: # 69675, 69651, 69674

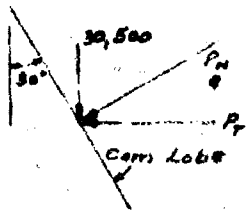
LOADING = Rebound load or 4½ x fully extended air pressure x inner cylinder area.

Rebound P = 24,300#
Fully extended air pressure = 143.5 psi (Ref. p. 53)
$P = 4.5 \times 143.5 \times \frac{\pi}{4} \times 7.75^2 = 30,500$#

SECTION PROPERTIES

OD = .685"  RD = .5175"  Brg. L = .190"
Shear A = .292  Brg. A = .685 x .190 = .130

STRESSES




$P_N = 30,500 \times 2 = 61,000$#
Ld./plug = 61,000/4 = 15,250#

$f_s = 15,250/.292 = 52,200$
$f_{br} = 15,250/.130 = 117,000$

ALLOWABLES

$F_{tu} = 125,000$
$F_{su} = 75,000$
$F_{brn} = 175,000$

$MS = \frac{75,000}{52,200} - 1 = +.44$

B-13a

Written by CSA Date 1/27/47
Checked by G.D.G Date 4-8-47
Subject CAMS

Rept. # 813
Page No. 89
No. of Pages 111
Model B-36 N.G.

KEYS - LOWER CAM  Ref. Dwgs. # 69685, 69686, 69689

LOADING - See prec. page.

$P_T$ = 30,500 tan 60° = 52,800#

SECTION PROPERTIES

Sect. = 5/16" × 5/16"  Eff. L = 1 5/8"

Shear A = .312 × 1.625 = .507

Brg. A = .156 × 1.625 = .253

STRESSES

$f_s$ = 52,800 / .507 × 2 = 52,000

$f_{br}$ = 52,800 / .253 × 2 = 104,000

ALLOWABLES

$F_{tu}$ = 170,000

$F_{su}$ = 100,000

$F_{bru}$ = 197,000

$$MS = \frac{197,000}{104,000} - 1 = +.89$$

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/28/47
Checked by E. D. G. Date 4-8-47
Subject RETRACTING LEVER

Rept. # 813
Page No. 90
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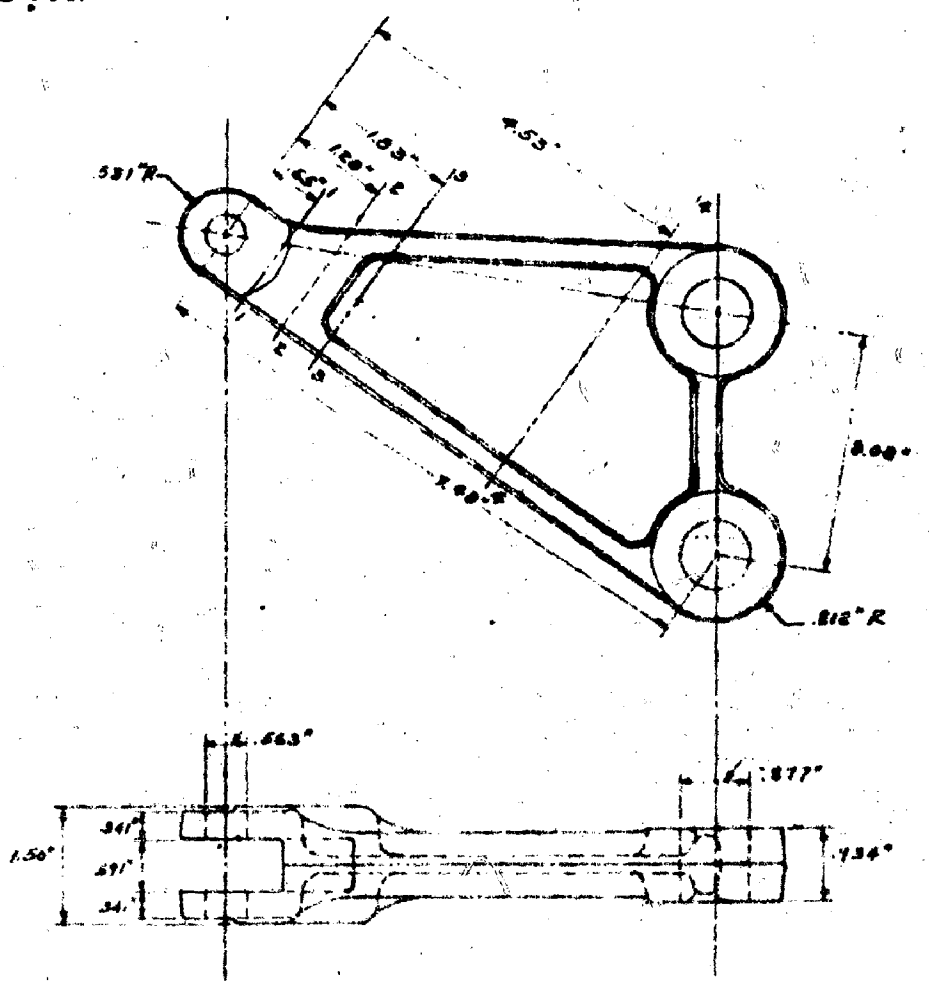
Model B-36 N.G.

SKETCH Ref. Dwgs. 69730, 69731
½ Scale




B-434

Written by CSA Date 12/22/47
Checked by C.D.G Date 1-8-48
Subject RETRACTING LEVER

Rept. # 813
Page No. 91
No. of Pages 111
Model B-36 N.G.

## LUG AND BOLT AT JACK ATTACHING POINT

MAX. RETRACTING JACK LOADS

Comp. = 29,200# or
Tension = 21,300# }

These will be assumed to act at any angle which will produce max. stresses in the lever.

SECTION PROPERTIES

Bolt D = 9/16" Brg. A = 2 x .341 x .563 = .384
Shearout A = 4 x .341 x .285 = .389

STRESSES

$f_{br}$ = 29,200/.384 = 76,000
$f_s$ (lug) = 29,200/.389 = 75,000

ALLOWABLES

Bolt = 125,000 H.T. - Single shear $P_{all}$ = 18,630#
$F_{bru}$ = 175,000
$F_{su}$ (lug) = 117,500

MS.

Bolt : $MS = \frac{2 \times 18,630}{29,200} - 1 = +.27$

Lug : $MS = \frac{117,500}{75,000} - 1 = +.57$

BENDIX PRODUCTS DIVISION
[illegible] CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Rept. # 813
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Model B-24 N.G.

Written by CSA Date 1/28/47
Checked by G. D. G. Date 4-8-47
Subject RETRACTING LEVER

LUGS AND BOLTS AT TRUNNION CONNECTION

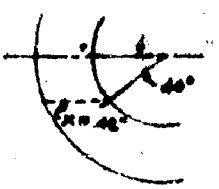
MAX. LOADING (Ref. pp. 90 + 91.)

$P = 29,200 \times 7.48/3.08 = 70,900\#$

SECTION PROPERTIES

Bolt $D = 7/8"$ Brg. $A = .875 \times .934 = .817$

Shearout $A = 2 \times .42 \times .934 = .785$




STRESSES

$f_{br} = 70,900/.817 = 86,800$

$f_s(lug) = 70,900/.785 = 90,300$

ALLOWABLES

Bolt = 125,000 H.T. - single shear ld. = 45,050#

$F_{bru} = 175,000$

$F_{su}(lug) = 117,500$

MS

Bolt: $MS = \frac{2 \times 45,050}{70,900} - 1 = +.27$

Lug: $MS = \frac{117,500}{90,300} - 1 = +.30$

**BENDIX PRODUCTS DIVISION**
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/28/47
Checked by C.D.G. Date 4-8-47
Subject RETRACTING LEVER

Rept. # 813
Page No. 93
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Model B-36 N.G.

## SECTIONS 1-1 & 2-2

### LOADING

Shear = 29,200#

Sect. 1-1: M = 29,200 × .65 = 19,000"#

" 2-2: M = 29,200 × 1.28 = 37,400"#

### SECTION PROPERTIES

Sect. 1-1: b = 2×.341" h = 1.06" $A_s$ = .723 I/c = .128

" 2-2: b = 2×.405 h = 1.50" $A_s$ = 1.22 I/c = .304

### STRESSES

Sect. 1-1: $f_s$ = 29,200 × 1.5 / .723 = 60,600

$f_b$ = 19,000 / .128 = 148,000

Sect. 2-2: $f_s$ = 29,200 × 1.5 / 1.22 = 35,900

$f_b$ = 37,400 / .304 = 123,000

### ALLOWABLES

$F_{tu}$ = 205,000

$F_{su}$ = 117,500

$F_b$ = 1.5 × 170,000 = 255,000

$MS = \frac{255,000}{148,000} - 1 = +.72$

# BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 1/29/47
Checked by G.D.G Date 4-8-47
Subject RETRACTING LEVER

Rept. # 813
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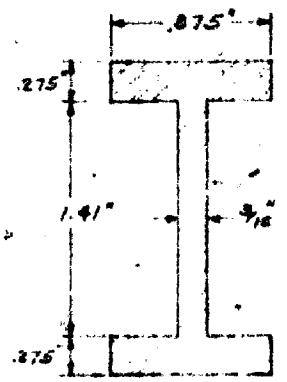
Model B-36 M.G.

SECTION 3-3

LOADING

Shear = 29,200#

M = 29,200 x 1.83 = 53,400"#




SECTION PROPERTIES

Sect. assumed as follows for analysis:

$I = 2\left(\frac{.875 \times .275^3}{12} + .875 \times .275 \times .843^2\right) + \frac{.1875 \times 1.41^3}{12}$

= .0030 + .342 + .0437 = .389

I/c = .389/.98 = .397

$Q_{NA}$ = .875 x .275 x .843 + .706 x .1875 x .352

= .205 + .047 = .252

STRESSES

$f_s$ = 29,200 x .252/.389 x .1875 = 101,000

$f_b$ = 53,400/.397 = 135,000

ALLOWABLES

$F_{su}$ = 205,000

$F_{su}$ = 117,500

$F_b$ = 1.5 x 170,000 = 255,000

MS = 117,500/101,000 - 1 = .16

B-122

Written by C.S.A. Date 1/29/47
Checked by S.D.G. Date 4-6-47
Subject RETRACTING LEVER

Rept. # 813
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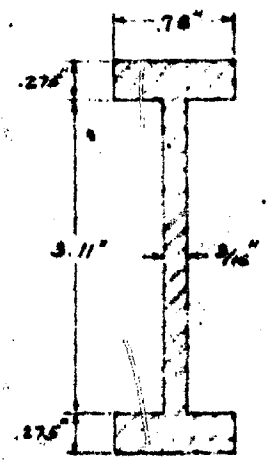
Model B-36 N.G.

## SECTION 4-4

LOADING

Shear = 29,200#

M = 29,200 x 4.53 = 132,300"#




SECTION PROPERTIES

Sect. assumed as follows for analysis:

$I = \frac{.78 \times 2 \times .275^3}{12} + 2 \times .78 \times .275 \times 1.693^2 + \frac{.1875 \times 3.11^3}{12}$

$= .003 + 1.233 + .471 = 1.707$

$I/c = 1.707 / 1.83 = .933$

$Q_{NA} = .78 \times .275 \times 1.693 + \frac{1.555^2}{2} \times .1875$

$= .363 + .227 = .590$

STRESSES

$f_s = 29,200 \times .590 / 1.707 \times .1875 = 53,800$

$f_b = 132,300 / .933 = 142,000$

ALLOWABLES

$F_{su} = 205,000$

$F_{sy} = 117,500$

$F_b = 255,000$

M.S. = Amp.

Computation shows the section to be safe against lateral instability.

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Written By GSA | Page No. 96
Checked By G.D.G 9-8-47 | Total Pages 111

SHIMMY DAMPER CONNECTIONS ½ Scale Ref. ...

Notes

... compressions ...

Max. ... at ... position.

... at ... position

... attaching bolts ...

Ref. ...

Written by CSA Date 1/30/47
Checked by G.D.S Date 2-8-47
Subject SHIMMY DAMPER CONNECTIONS

Rept. # 813
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Model D-36 N.G.

## LINK LOADS

Position ① $P_D = 285,000/4.27 = 66,700\#$
" ② $P_D = 284,000/10.75 = 27,400\#$
" ③ $P_D = 285,000/8.33 = 34,200\#$

## COMPONENTS OF LINK LOADS ⊥ & ∥ TO PLANE OF CONNECTING BOLTS

Position ① $D_D = 66,700 \cos 1°42' = 66,700\#$
$S_D = -66,700 \sin 1°42' = -1,980\#$
Position ② $D_D = 27,400 \cos 5°12' = 27,300\#$
$S_D = -27,400 \sin 5°12' = -2,480\#$
Position ③ $D_D = 34,200 \cos 17°02' = 32,700\#$
$S_D = -34,200 \sin 17°02' = -10,000\#$

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 11/31/41
Checked by C.D.G. Date 4-8-42
Subject SHIMMY DAMPER CONNECTIONS

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Page No. 98
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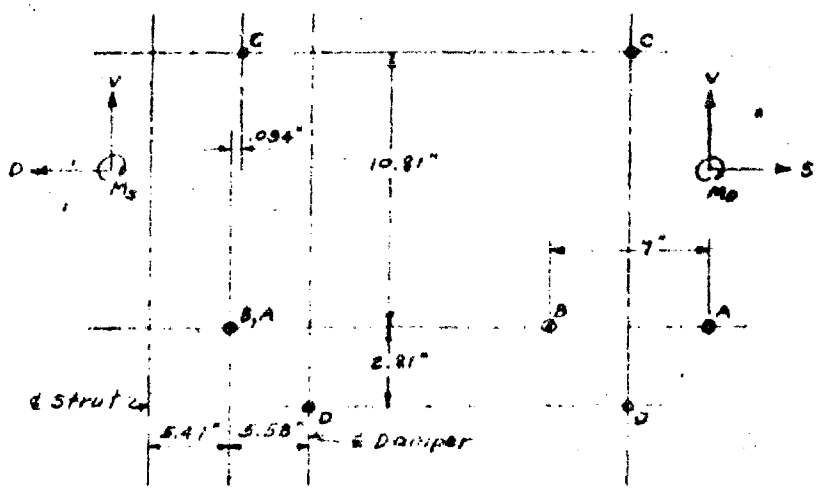
Model B-36 N.G.

LOADS & MOMENTS ABT. POINT MIDWAY BETWEEN A & B




Position ①

$D = 66,700\#$ $S = -1,980\#$

$M_V = 285,000 - 1,980 \times 5.58 = 273,900"\#$

$M_D = 1,980 \times 2.81 = 5,560"\#$

$M_S = 66,700 \times 2.81 = 187,400"\#$

Position ②

$D = 27,200\#$ $S = -2,480\#$

$M_V = 294,000 - 2,480 \times 5.58 = 280,200"\#$

$M_D = 2,480 \times 2.81 = 6,970"\#$

$M_S = 27,200 \times 2.81 = 76,700"\#$

Position ③

$D = 32,700\#$ $S = -10,000\#$

$M_V = 285,000 - 10,000 \times 5.58 = 229,200"\#$

$M_D = 10,000 \times 2.81 = 28,100"\#$

$M_S = 32,700 \times 2.81 = 91,900"\#$

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 1/31/47
Checked by G.D.G Date 4-8-47
Subject SHIMMY DAMPER CONNECTIONS

Rept. # 813
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Model B-36 N.G.

LUG & BOLT AT PT. C  Ref. Dwgs. 69650, 69679-69681

LOADS (Acting on lug)

Position ①  D = -187,400/10.81 = - 17,300#
S = 5560/10.81 = 514#

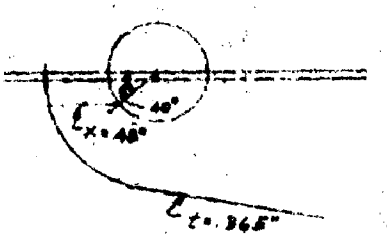
Position ②  D = - 76,700/10.81 = - 7,100#
S = 6,970/10.81 = 645#

Position ③  D = -91,900/10.81 = - 8,500#
S = 28,100/10.81 = 2,600#

$P_{max.} = \sqrt{(17,300)^2 + (514)^2} = 17,300$#

SECTION PROPERTIES

Bolt D = 5/8"  Brg. A = .625 × .365 = .228
Shearout A = 2 × .49 × .365 = .314




STRESSES

$f_{br}$ = 17,300/.228 = 75,800
$f_s$ (lug) = 17,300/.314 = 55,000

ALLOWABLES

Bolt single shear = 23,000#
$f_s$ (lug) = 117,500

M.S.

Bolt :  $MS = \frac{23,000}{17,300} - 1 = +.33$

Lug :  $MS = \frac{117,500}{55,000} - 1 = +1.14$

# BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.J.A. Date 2/8/47
Checked by G. & D.G. Date 4-8-47
Subject SHIMMY DAMPER CONNECTIONS

Rept. # 313
Page No. 100
No. of Pages 111
Model B-36 N.G.

LUG & BOLT AT PT. A  Ref. Dwgs. 69650, 69679-81, & 155449

LOADS (Acting on lug)

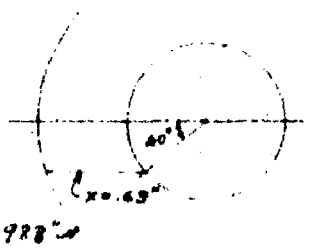
Position ①  D = (17,300 + 66,700)/2 + 273,900/7
= 42,000 + 39,100 = 81,100#
S = (-1,980 - 514)/2 = - 1,247#

Position ②  D = (7,100 + 27,300)/2 + 280,200/7
= 17,200 + 40,000 = 57,200#
S = (-2480 - 643)/2 = - 1,563#

Position ③  D = (3,500 + 32,700)/2 + 229,200/7
= 20,600 + 32,700 = 53,300#
S = (-10,000 - 2,600)/2 = - 6,300#

Note: These loads can be opposite in sign.

Max. Ld. = $\sqrt{(81,100)^2 + (1,247)^2}$ = 81,200#




SECTION PROPERTIES

Bolt D = .998"  A = .783
Brg. A = .998 × .988 = .986
Shearout A = 2 × .63 × .988 = 1.25

STRESSES

$f_s$ (bolt) = 81,200 / 2 × .783 = 51,800
$f_{br}$ = 81,200 / .986 = 82,400
$f_s$ (lug) = 81,200 / 1.25 = 65,000

ALLOWABLES

Bolt: $F_{su}$ = 125,000, $F_{su}$ = 75,000, $F_{br}$ = 175,000
Lug: $F_{su}$ = 117,500

M.S.

Bolt: M.S. = 75,000 / 51,800 - 1 = + .45

Lug: M.S. = 117,500 / 65,000 - 1 = + .81

S-123

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 2/10/47
Checked by G.D.G Date 4-8-47
Subject SHIMMY DAMPER CONNECTIONS

Rept. # 813
Page No. 101
No. of Pages 111
Model B-36 N.G.

LUG & BOLT AT PT. B  Ref. Dwgs. 69650, 69679-81, & 155448

LOADS (Acting on lug) (Ref prec. page)

Position ① D = 42,000 − 39,100 = 2,900#
S = −1,247#

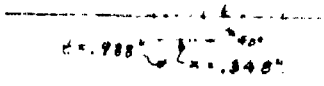
Position ② D = 17,200 − 40,000 = −22,800#
S = −1,563#

Position ③ D = 20,600 − 32,700 = −12,100#
S = −6,300#

Max. Ld. = $\sqrt{(22,800)^2 + (1,563)^2}$ = 22,900#

SECTION PROPERTIES

Bolt D = .498" A = .195
Brg. A = .498 × .988" = .492
Shearout A = 2 × .348 × .988 = .688




STRESSES

$f_s$ (bolt) = 22,900 / 2 × .195 = 58,700
$f_{br}$ = 22,900 / .492 = 46,500
$f_s$ (lug) = 22,900 / .688 = 33,300

ALLOWABLES - See prec. page.

MS

Bolt : MS = 75,000 / 58,700 − 1 = +.28

Lug : MS = 1,7,500 / [illegible] − 1 = +2.53

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 2/10/47
Checked by G.D.G Date 4-8-47
Subject SHIMMY DAMPER CONNECTIONS

Rept. #813
Page No. 102
No. of Pages 111
Model B-36 N.G.

TORQUE YOKE ARM - SHEET 1-1 (Rept. # 78)

LOADS (Ref pp. 96+97)

Position ① $P_x = 66,700 \cos 23°20' = 61,200\#$

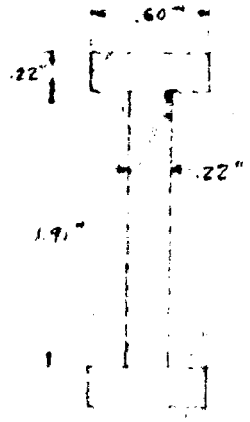
$P_y = 66,700 \sin 23°20' = 26,400\#$

Position ② $P_x = 27,400 \cos 90° = 0$

$P_y = 27,400 \sin 90° = 27,400\#$

Position ③ $P_x = 34,200 \cos 31°50' = 29,100\#$

$P_y = 34,200 \sin 31°50' = 18,100\#$




SECTION PROPERTIES

Sect. assumed as follows for analysis:

$A = .22 \times 1.91^2 + 2 \times .60 \times .22 = .420 + .264 = .684$

$I = \frac{.22 \times 1.91^3}{12} + \frac{2 \times .60 \times .22^3}{12} + .264 \times 1.065^2$

$= .128 + .001 + .300 = .429$

$Q_{NA} = .132 \times 1.065 + .210 \times 1.91/4$

$= .141 + .100 = .241$

STRESSES

$f_c = 61,200 / .684 = 89,400$

$f_b = 26,400 \times 1.5 \times 1.175 / .429 = 108,400$

$f_s = 26,400 \times .241 / .429 \times .22 = 67,300$

ALLOWABLES

$F_c = 170,000$

$F_t = 1.5 \times 70,000 = 250,000$

$F_s = 1.75$

[illegible]

$k_a = 89,400$ [illegible]

$F_t$ [illegible]

[illegible]

[illegible] $-1 = +.05$

[illegible] $+ .42$

B-134

# BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 2/10/47
Checked by G.D.G. Date 4-8-47
Subject SHIMMEY DAMPER CONNECTIONS

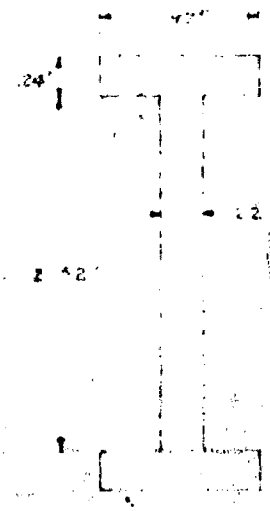
Rept # 813
Page No. 103
No. of Pages 111
Model B-36 N.G.

TORQUE YOKE ARM - SECT. 2-2 (Ref. p. 78)

LOADS (See prec. page.)

$P_x$ = 61,200# $P_y$ = 24,400#

M = 24,400 × 4.25 = 112,200"#




SECTION PROPERTIES

Assume sect a follows for analysis:

$A = 2.52 \times .22 + 2 \times .97 \times .24$

$= .554 + .466 = 1.020$

$I = \frac{.22 \times 2.52^3}{12} + 2 \times .97 \times .24^3 + .466 \times \overline{1.38}^2$

$= .293 + .002 + .887 = 1.182$

STRESSES

$f_c$ = 61,200/1.020 = 60,000

$f_b$ = 112,200 × 1.5/1.182 = 142,400

ALLOWABLES

$F_c$ = 170,000

$f_b$ = 1.5 × 170,000 = 255,000

M.S.

$R_c$ = 61,200/170,000 = .359

$R_b$ = 42,600/255,000 = .167

.912

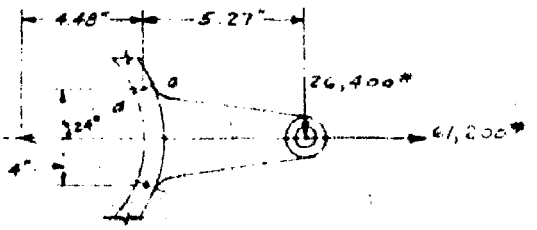
M.S. = 1/.912 − 1 = +.10

Written by GSA Date 2/13/47
Checked by G.D.G Date 4-5-47
Subject SHIMMY DAMPER CONNECTIONS

Rept # 513
Page No. 104
No. of Pages 111
Model B-36 N.G.

TORQUE YOKE ARM - TEAROUT FROM YOKE BARREL

LOADS (Ref. p 102)




$$P_T = 26,400 + \left(\frac{61,200}{2} + \frac{26,400 \times 5.27}{4}\right) \sin 24° = 53,000\#$$

$$P_S = \left(\frac{61,200}{2} + \frac{26,400 \times 5.27}{4}\right) \cos 24° = 59,700\#$$

In addition, there will be a vertical load caused by the [illegible] from the torque arm (Ref. p. 79). Assuming 45% of this [illegible] transferred at the critical sect. a-a, then,

$V_{a-a} = .45 \times 405,000/2 \times 4.48 = 20,300\#$

SECTION PROPERTIES - See p. 79.

STRESSES

$f_t = 53,000/.85 = 62,300$

$f_s = 59,700/.85 + 20,300 \times .242/.284 \times 4.2 = 100,$ [illegible]

$f_{s\,max.} = \sqrt{(100,000)^2 + (31,150)^2} = 104,800$

ALLOWABLES

$F_{su} = 111,500$

M.S. $= \frac{111,500}{104,800} - 1 = +.12$

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 2/13/47
Checked by C.D.G. Date 4-8-47
Subject SHIMMY DAMPER CONNECTIONS

Rept. # 813
Page No. 105
No. of Pages 111
Model B-36 N.G.

TORQUE YOKE ARM LUG

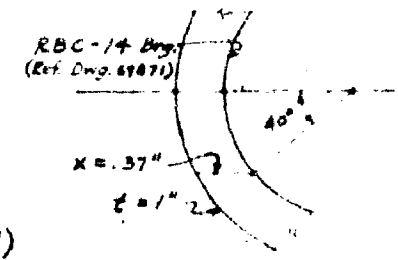
LOADING - $P_D$ = 66,700# (Ref. p. 97)

SECTION PROPERTIES

Bolt D = 7/8"

Brg. A = .875 x 1 = .875

Shearout A = 2 x .37 x 1 = .74




STRESSES

$f_{br}$ = 66,700 / .875 = 76,300 (Not critical)

$f_s$ (lug) = 66,700 / .74 = 90,200

ALLOWABLES

Bolt single shear = 45,050#

$F_{su}$ (lug) = 117,500

MS

Bolt: $MS = \frac{2 \times 44,050}{66,700} - 1 = +.35$

Lug: $MS = \frac{117,500}{90,200} - 1 = +.30$

Written by CSR Date 2/21/47
Checked by E.D.G Date 4-5-47
Subject

Rept. # 813
Page No. 106
No. of Pages 111
Model B-36 N.G.

# APPENDIX

# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by G2A Date 11/15/46
Checked by E.D.G Date 4-8-47
Subject NOSE GEAR LOADS *

Rept. # 813
Page No. 107
No. of Pages 111
Model B-36 N.G.

| CONDITION | OLEO POSITION | $V_f$ | $D_f$ | $S_f$ | LOAD APPLIED AT | COND. No. |
|---|---|---|---|---|---|---|
| 3WL/R | FE | 168,000 | 54,900 | 0 | 2 Whl. | 1 |
| Side Drift | FE | 0 | 0 | ±49,600 | Ground | 4 |
| Bearing in Nose Strut | FE | 76,600 | 76,000<br>-30,650 | 0 | 4 Axle | 7-1<br>7-2 |
| Symm * Static Thrust | Static | 58,850 | 75,800 | 0 | " | 9 |
| Ground * Turning | Static | 48,420 | 13,380** | 34,810** | Ground | 10 |
| Rebound | FE | -24,300 | 0 | 0 | 2 Whl. | 8 |

* Ref. (1)

** These loads combine to give a resultant side load on the gear = ±36,830#.

* Loads revised 12/2/46, see CVAC letter of 11/22/46.

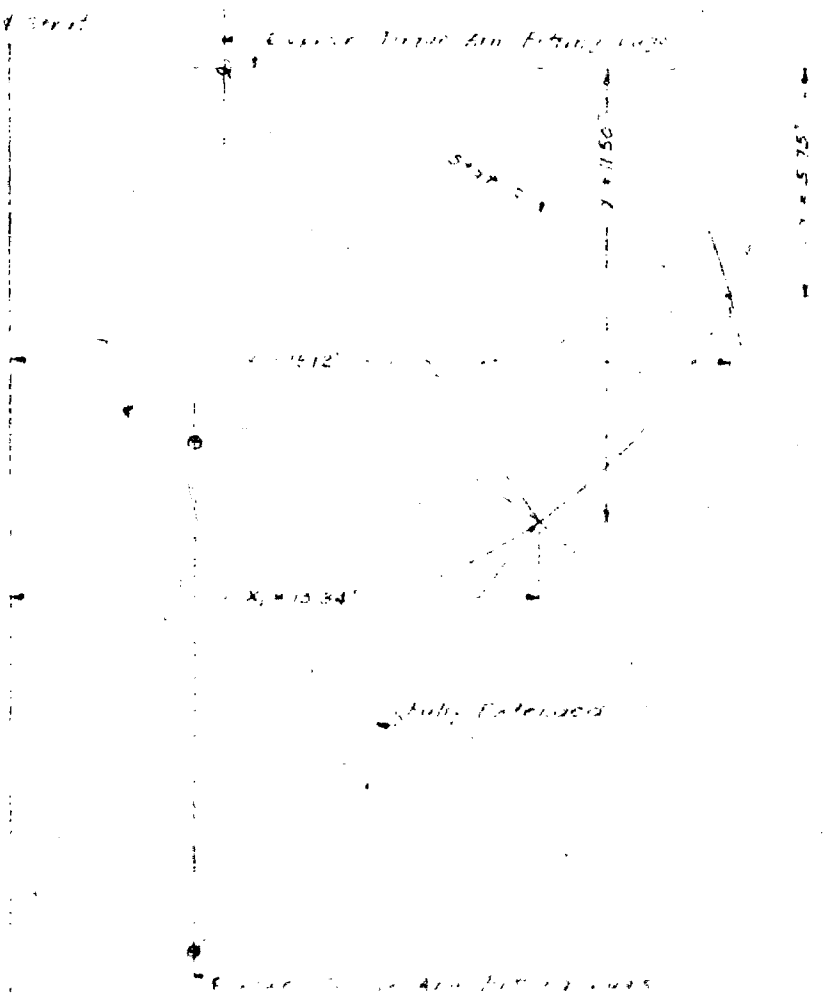
# BENDIX PRODUCTS DIVISION

DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

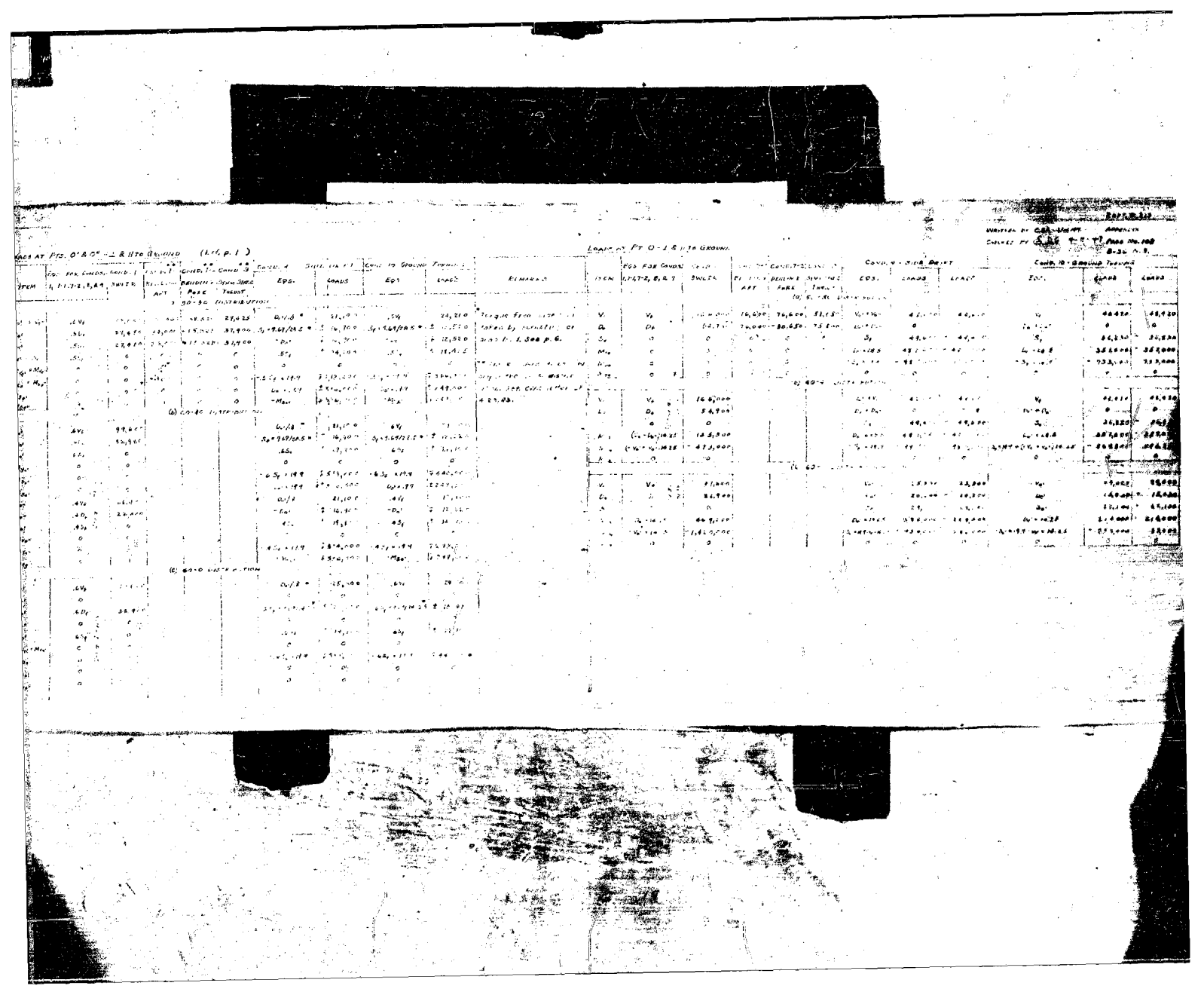
Written by CSA Date 2/24/41
Checked by [illegible] Date [illegible]
Subject TORQUE ARM [illegible]

Rept # 813
Page No. 110
No. of Pages 111
Model B-36 N G.

¼ Scale




S-13D



## UPPER & LOWER BEARING LOADS

| ITEM / CONDITION | Sym. | (1) $V_B = V_A$ | (2) $D_B = D_A$ | (3) $S_B = S_A$ | (4) TORQUE REF. STRUT & $S_B$ ON TORQUE ARMS $M_{TB} = M_{TA} - S_A \times 9.00$ | (5) $S_B$ ON TORQUE ARMS $X_i =$ | (6) $\Delta S_B = -S_A(5)$ | (7) $\Delta M_B = -S_B(y)$ | (8) $M_{MB}$ $-M_{TB} + (7)$ | (9) $M_{RB}$ $M_{MB} + V_B(x)$ $+ D_B(y)$ | (10) $R_B = \sqrt{(8)^2 + (9)^2}$ | (11) $D_{LB} = \frac{(9)}{Y_B}$ | (12) $S_{LB} = -\frac{(8)}{Y_B}$ | (13) UPPER BOLT $(11) - (12) = (21)$ | (14) $D_{UB}$ $(11) + (12) = (22)$ | (15) $S_{UB}$ $(12) - (11) = (23)$ | (16) LOWER BOLT $\sqrt{(21)^2 + (23)^2}$ | (17) $\sqrt{(14)^2 + (15)^2}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a) 50-50 DISTRIBUTION | | | | | | | | | | | | | | | | | | |
| 1 | F.E. | 68,400 | 39,900 | 0 | 0 | 0 | 0 | 0 | 0 | 4,103,400 | 4,103,400 | 119,400 | 0 | 119,400 | 119,400 | 0 | 119,400 | |
| 4 | " | 42,200 | 0 | 49,600 | 0 | 0 | 0 | -2,182,000 | -2,182,000 | 304,200 | 2,200,000 | 152,200 | 152,200 | 0 | 304,200 | 304,200 | 0 | |
| 7-1 | " | 76,600 | 76,600 | 0 | 0 | 0 | 0 | 0 | 0 | 4,596,000 | 4,596,000 | 229,800 | 0 | 229,800 | 229,800 | 0 | 229,800 | |
| 7-2 | " | 76,600 | 40,850 | 0 | 0 | 0 | 0 | 0 | 0 | 2,451,000 | 2,451,000 | 122,500 | 0 | 122,500 | 122,500 | 0 | 122,500 | |
| 9 | Static | 81,850 | 75,800 | 0 | 0 | 0 | 0 | 0 | 0 | 4,548,000 | 4,548,000 | 227,400 | 0 | 227,400 | 227,400 | 0 | 227,400 | |
| 10 | " | 46,450 | 0 | 34,350 | 0 | 0 | 0 | -1,147,500 | -1,147,500 | 2,787,000 | 2,787,000 | 139,350 | 139,350 | 0 | 139,350 | 139,350 | 0 | |
| b) 60-40 DISTRIBUTION | | | | | | | | | | | | | | | | | | |
| 1 | F.E. | 68,400 | 39,900 | 0 | 15,360 | 11,640 | 0 | 0 | 0 | 4,103,400 | 4,103,400 | 119,400 | 23,800 | 143,200 | 95,600 | 23,800 | 96,000 | |
| 4 | " | 42,200 | 0 | 49,600 | 0 | 0 | 0 | -2,182,000 | -2,182,000 | 304,200 | 2,200,000 | 152,200 | 152,200 | 0 | 304,200 | 304,200 | 0 | |
| 7-1 | " | 76,600 | 76,600 | 0 | 0 | 0 | 0 | 0 | 0 | 4,596,000 | 4,596,000 | 229,800 | 0 | 229,800 | 229,800 | 0 | 229,800 | |
| 7-2 | " | 76,600 | 40,850 | 0 | 0 | 0 | 0 | 0 | 0 | 2,451,000 | 2,451,000 | 122,500 | 0 | 122,500 | 122,500 | 0 | 122,500 | |
| 9 | Static | 81,850 | 75,800 | 0 | 0 | 0 | 0 | 0 | 0 | 4,548,000 | 4,548,000 | 227,400 | 0 | 227,400 | 227,400 | 0 | 227,400 | |
| 10 | " | 46,450 | 0 | 34,350 | 0 | 0 | 0 | -1,147,500 | -1,147,500 | 2,787,000 | 2,787,000 | 139,350 | 139,350 | 0 | 139,350 | 139,350 | 0 | |
| c) 60-0 DISTRIBUTION | | | | | | | | | | | | | | | | | | |
| 1 | F.E. | 91,200 | 53,200 | 0 | 46,080 | 35,200 | -36,000 | 0 | -1,728,000 | 2,412,000 | 3,000,000 | 119,400 | 87,700 | 149,200 | 119,400 | 87,700 | 153,500 | |
| 4 | " | 56,300 | 30,200 | 29,200 | 0 | 0 | 0 | -1,314,000 | -1,314,000 | 1,314,000 | 2,586,000 | 26,400 | 131,800 | 158,200 | 26,400 | 131,800 | 134,400 | |
| 9 | " | 109,200 | 101,200 | 19,200 | 0 | 0 | 0 | -1,314,000 | -1,314,000 | 66,600 | | | | | | | | |
| 10 | Static | 62,000 | 15,800 | 22,100 | 0 | 0 | 0 | -827,000 | -1,314,000 | 748,000 | 1,771,000 | 28,800 | 46,200 | 81,000 | 28,800 | 37,200 | 48,300 | |

* SYMBOLS & DIMENSIONS (SEE ALSO REPT. #513)

$X_A$ = DIST. FROM C.G. TO F.E. STRUT = 52.4"

$y$ = VERT. DIST. FROM C.G. TO C. OF TORQUE ARMS = 44.1" F.S.

$X_i$ = DIST. FROM C.G. TO EACH TORQUE ARM = 31.0" STARTS

$X_B$ = DIST. FROM C.G. TO BEARING = 15.25" F.S.

$Y_B$ = VERT. DIST. FROM C.G. TO BEARING = 49.25" F.S.

$X_A$ = DIST. FROM C.G. TO F.E. STRUT = 52.4"

$y$ = VERT. DIST. FROM C.G. TO C. OF TORQUE ARMS = 44.1" F.S.

$X_i$ = DIST. FROM C.G. TO EACH TORQUE ARM = 31.0" STARTS

$X_B$ = DIST. FROM C.G. TO BEARING = 15.25" F.S.

$Y_B$ = VERT. DIST. FROM C.G. TO BEARING = 49.25" F.S.

## LOADS AT TRUNNIONS & DRAG BRACE LOADS (Ref. pp. 1 & 44)

| ITEM / CONDITION | EXT. | $V_B = V_A$ | $D_B$ $= D_A + P_B$ | $S_B = S_A$ | TORQUE MOMENT TRUNNION $M_{TB} = M_{TA}$ | $M_{RB}$ $M_{TB} - S_B(63.18)$ | $M_{MB}$ $M_{RB} + P_B \times$ | DRAG BRACE LOADS $D_B - V_B(15.5/63.18) + M_{MB}/36$ | REACTIONS AT 8' $V_B' = \frac{V_B}{2}$ | $D_B' = \frac{D_B}{2}$ | $S_B' = \frac{S_B}{2}$ | $P_B' = \frac{P_B}{\sqrt{2}}$ | REACTIONS AT 0' $V_B' = \frac{V_B}{2}$ | $D_B' = \frac{D_B}{2}$ | $S_B' = \frac{S_B}{2}$ | $P_B' = \frac{P_B}{\sqrt{2}}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1(a) | F.E. | 76,600 | 47,500 | 0 | 0 | 0 | 0 | 2,564,000 | 38,300 | 23,800 | 0 | 45,200 | 38,300 | 23,800 | 0 | 45,200 |
| 7-1(b) | " | 76,600 | 38,450 | 0 | 0 | 0 | 0 | 1,419,000 | 38,300 | 19,200 | 0 | 27,200 | 38,300 | 19,200 | 0 | 27,200 |
| 1(c) | " | 68,400 | 39,900 | 0 | 15,360 | 11,640 | 0 | 0 | 34,200 | 19,950 | 0 | 39,300 | 34,200 | 19,950 | 0 | 39,300 |
| 4-1(b) | " | 42,200 | 0 | 49,600 | 0 | 0 | 0 | -2,182,000 | 21,100 | 0 | 24,800 | 24,800 | 21,100 | 0 | 24,800 | 24,800 |
| 4(c) | " | 42,200 | 0 | 49,600 | 0 | 0 | 0 | -2,182,000 | 21,100 | 0 | 24,800 | 24,800 | 21,100 | 0 | 24,800 | 24,800 |
| 7-2(b) | " | 76,600 | 20,850 | 0 | 0 | 0 | 0 | 0 | 38,300 | 10,400 | 0 | 39,700 | 38,300 | 10,400 | 0 | 39,700 |
| 7(c) | " | 76,600 | 40,850 | 0 | 0 | 0 | 0 | 0 | 38,300 | 20,400 | 0 | 42,800 | 38,300 | 20,400 | 0 | 42,800 |
| 9-1(b) | Static | 81,850 | 75,800 | 0 | 0 | 0 | 0 | 0 | 40,900 | 37,900 | 0 | 55,800 | 40,900 | 37,900 | 0 | 55,800 |
| 9(c) | " | 81,850 | 75,800 | 0 | 0 | 0 | 0 | 0 | 40,900 | 37,900 | 0 | 55,800 | 40,900 | 37,900 | 0 | 55,800 |
| 10-1(b) | " | 46,450 | 34,350 | 0 | 0 | 0 | 0 | -1,147,500 | 23,200 | 17,200 | 0 | 29,000 | 23,200 | 17,200 | 0 | 29,000 |
| 10(c) | " | 46,450 | 34,350 | 0 | 0 | 0 | 0 | -1,147,500 | 23,200 | 17,200 | 0 | 29,000 | 23,200 | 17,200 | 0 | 29,000 |
| 10-2(b) | F.E. | 23,200 | 16,150 | 25,800 | 0 | 0 | 0 | -1,147,500 | 11,600 | 8,100 | 12,900 | 18,900 | 11,600 | 8,100 | 12,900 | 18,900 |

SECTIONS IN FORK - LOADS ⊥ & ∥ TO SECTION (Ref. p. 21)

| ITEM / CONDITION | $V_p = V_0$ | $D_p = D_0$ | $S_p = S_0$ | $M_{Vp} = M_{V_0} - S_0(x)$ | $M_{Dp} = M_{D_0} - S_0(y)$ | $M_{Sp} = M_{S_0} + V_0(x) + D_0(y)$ | $A = D_p = Y_p$ $V_p \cos\alpha - D_p \sin\alpha$ | $X_p = V_p \sin\alpha + D_p \cos\alpha$ | $Z_p = S_p$ | TORQUE $= M_{Yp} = M_{Vp}\cos\alpha - M_{Dp}\sin\alpha$ | $M_{Xp} = M_{Vp}\sin\alpha + M_{Dp}\cos\alpha$ | $M_{Zp} = M_{Sp}$ | CRITICAL SHEARS | CRITICAL MOMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sect. 3 Weld: $x = 3.20"$, $y = 5.05"$, $\alpha = 32°34'59"$ | | | | | | | $\cos\alpha = .84261$ | $\sin\alpha = .53853$ | | | | | | |
| 7-1(a) | 76,600 | 76,000 | 0 | 0 | 0 | 629,000 | | | | | | | | |
| 1(b) | 166,000 | 54,900 | 0 | 155,300 | - 473,000 | 808,000 | 110,100 | 135,600 | 0 | 386,000 | - 314,400 | 808,000 | | |
| 4(b) | 42,200 | 0 | ±49,600 | ± 322,400 | ∓ 1,237,000 | 135,000 | 35,600 | 22,800 | ± 49,600 | ± 937,000 | ∓ 869,000 | 135,000 | | |
| 10(b) | 48,420 | 0 | 36,830 | 239,000 | - 1,055,800 | 155,000 | 40,800 | 26,100 | 36,830 | 771,000 | - 761,000 | 155,000 | | |
| | 48,420 | 0 | - 36,830 | - 239,000 | 782,200 | 155,000 | 40,800 | 26,100 | - 36,830 | - 623,000 | 530,000 | 155,000 | | |
| 1(c) | 99,600 | 32,900 | 0 | 469,000 | - 1,420,000 | 485,200 | 86,200 | 81,400 | 0 | 1,159,000 | - 445,000 | 485,200 | 81,400 | 1,063,000 |
| 4(c) | 25,300 | 20,200 | 29,800 | 192,600 | - 1,104,500 | 183,000 | 10,420 | 30,660 | 29,800 | 757,300 | - 827,300 | 183,000 | | |
| Sect. 1-1: $x = 8.00"$, $y = 13.20"$, $\alpha = 22°15'$ | | | | | | | $\cos\alpha = .92554$ | $\sin\alpha = .37865$ | | | | | | |
| 7-1(a) | 76,600 | 76,000 | 0 | 0 | 0 | 1,616,000 | | | | | | | | |
| 1(b) | 166,000 | 54,900 | 0 | 155,300 | - 473,000 | 2,058,000 | 132,900 | 113,700 | 0 | 323,000 | - 379,200 | 2,058,000 | 113,700 | 2,090,000 |
| 4(b) | 42,200 | 0 | 49,600 | 84,000 | - 1,042,000 | 338,000 | 37,100 | 16,000 | 49,600 | 699,000 | - 1,488,200 | 338,000 | 52,200 | 1,527,000 |
| 10(b) | 48,420 | 0 | 36,830 | [illegible] | - 1,356,000 | 387,400 | | | | | | | | |
| 1(c) | 99,600 | 32,900 | 0 | 469,000 | - 1,420,000 | 1,231,000 | 79,700 | 68,200 | 0 | 972,000 | - 1,137,200 | 1,231,000 | 68,200 | 1,676,000 |
| 4(c) | 25,300 | 20,200 | 29,800 | [illegible] | - 1,347,000 | 468,400 | | | | | | | | |
| Sect. 2-2: $x = 9.67"$, $y = 20.35"$, $\alpha = [illegible]$, $\theta = 0°$ | | | | | | | | | | | | | | |
| 7-1(a) | 76,600 | 76,000 | 0 | 0 | 0 | 2,282,000 | | | | | | | | |
| 1(b) | 166,000 | 54,900 | 0 | 155,300 | - 473,000 | [illegible] | [illegible] | 54,900 | 0 | 155,300 | - 473,000 | 2,726,000 | 54,900 | 2,760,000 |
| 4(b) | 42,200 | 0 | 49,600 | 2,000 | - 1,995,000 | 482,000 | | | | | | | | |
| 10(b) | 48,420 | 0 | 36,830 | [illegible] | - 1,619,000 | 467,000 | | | | | | | | |
| 1(c) | 99,600 | 32,900 | 0 | 469,000 | - 1,420,000 | 1,634,000 | 99,600 | 32,900 | 0 | 469,000 | - 1,420,000 | 1,634,000 | 32,900 | 2,167,000 |
| 4(c) | 25,300 | 20,200 | 29,800 | - 200 | - 1,567,000 | [illegible] | | | | | | | | |

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UNCLASSIFIED

TITLE: Stress Analysis of the B-36 Nose Gear

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ABSTRACT:

A stress analysis was made of the nose gear of the B-36 bomber. The analysis covers the axle, inner and outer cylinder, piston, torque fittings and arms, and cams. The appendix shows the computations for the nose gear loads, loads at points O,O' and O'', loads at sections in the fork, torque arm geometry, and loads at the upper and lower bearings, trunnion and drag brace. A table of the minimum margins of safety is included.

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DIVISION: Structures (7)
SECTION: Stress Analysis of Specific Aircraft (6)

SUBJECT HEADINGS: Landing gears - Stress analysis (54537); Landing gears, Nose - Static Tests (54538.6); B-36 (14884.6)

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