NEW LIMITATION CHANGE

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AUTHORITY
To A/1 From E/4, per Hq AFMC/PAX, Wright-Patterson AFB, OH 45433 via ltr. dtd February 24, 1999.
The U.S. Government is absolved from any litigation which may ensue from any infringement on domestic or foreign patent rights which may be involved.
A stress analysis was made of the nose gear of the B-36 bomber. The analysis covers the axle, tires and wheel assembly, piston, torque fittings and arms, and shock. 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. A table of the minimum margins of safety is included.
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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 trunion arms extending from the outer cylinder twenty-five inches below the first point. Retraction is accomplished through a lever bolted to one of the trunion 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 ANSI-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 surplus 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 705,000 psi ultimate tensile strength, this is assumed to be the case unless it is otherwise noted. Allowable stresses are obtained from AM-1, 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 covered by an excess margin of safety.
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 $F_{t}$, which is felt to be conservative.
| Subject | Stress Analysis of B-56 Nose Gear | Model | B-56 |

**LIST OF REFERENCES**

1. Consolidated Aircraft Corporation

2. U.S.A.A.V.
   "Drawing (Sheet), Change "C".

3. Army-Navy Civil Committee on Aircraft Design Criteria

4. Requa, R. J.

5. Einzel and Krafts

6. Kundig

7. Oberg and Jones

8. Timoshenko, S.

9. Timoshenko, S.
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SYMBOLS

\( A_g \) = 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)

\( f_R \) = Hoop stress
A--Area of cross section
a--Subscript "allowable"
b--Width of sections; subscript "bending"
br--Subscript "bearing"
c--Distance from neutral axis to extreme fiber; subscript "compressor"
D--Diameter
E--Modulus of elasticity in tension
F--Allowable stress
f--Internal (calculated) stress
Fb--Allowable bending stress, modulus of rupture in bending
F'r--Modulus of rupture in torsion
I--Moment of inertia
Je--Polar moment of inertia
L--Length
L.B.--Lower bearing
M--Applied moment or couple, usually a bending moment
n--Subscript "normal"
Pa--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--Applied moment or couple, positive
V--Vertical-load, positive up
W--Side-load, positive out
X--Drag load, positive back
Y--Vertical load, positive up
Z--Side load, positive out

**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, Rear, to Ground:**
- V--Vertical load, positive up
- D--Drag load, positive back
- H--Side load, positive out

**Loads Perpendicular and Parallel, Rear, to Strut B:**
- 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:

- My--Moment about V axis
- Mx--Moment about D axis
- My--Moment about H axis
- Mx--Moment about X axis
- My--Moment about Y axis
- Mz--Moment about Z axis
GEOMETRY OF STRUT
Ref. Dwg. 69740
Ref. (2)

6. Sprut --
(3y.m.)

4 Wheel

6 Wheel

Housing Bearing 6

26 3/4" - 8.375" = 7.5"

10 3/4" - 22 3/16" = 8.75"

0° 20 1/4"

4 Wheel Brng. 6
**Condition I - SWLIR 60-40 Dist.**

Assume 60% on right wbl.

\[ P_{R1} + P_{R0} = 0.6 (166,200 + 36,900) = 105,000 \text{#} \]

\[ P_{L0} + P_{L1} = 0.4 (166,200 + 54,100) = 70,000 \text{#} \]

\[ P_{R1} = 105,000 \times 5.31/978 = 57,000 \text{#} \]

\[ P_{R0} = 105,000 \times 4.47/978 = 48,000 \text{#} \]

\[ P_{L1} = 70,000 \times 5.31/978 = 33,000 \text{#} \]

\[ P_{L0} = 70,000 \times 4.47/978 = 32,000 \text{#} \]

\[ R_{R} = (105,000 \times 21.4 - 70,000 \times 11.1) / 14.25 = 122,000 \text{#} \]

\[ R_{L} = (70,000 \times 21.4 - 105,000 \times 7.13) / 14.25 = 52,600 \text{#} \]

*Ref. = 8*
**BENDIX PRODUCTS DIVISION**

**DIVISION OF BENDIX AVIATION CORPORATION**

**SOUTH BEND, INDIANA, U. S. A.**

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**Condition II - Side Drift 60°-30° Dist.**

Assume all Side Loads (torque is to be taken by calculation) (1-1 memo of telephone conversation with CSAU, 1/24/46).

Side load torque = \( 42,600 \times 9.69 = 416,200 \) #

Scrubbing load / whl. = \( 481,000 \times 28.5 = 13,900 \) 

Assume an SR coef. of friction \( \mu = 0.5 \)

Vert. load from scrubbing / whl. = \( 13,900 / 5 = 2,780 \) 

---

\[
\begin{align*}
K_e &= \frac{N_e}{P_{e1}} \quad R_e = \frac{P_{e1}}{N_e} \\
K_v &= \frac{N_v}{P_{v1}} \quad R_v = \frac{P_{v1}}{N_v}
\end{align*}
\]

---

\( N_e = 6 \times 42,600 = 25,560 \)

\( H_e = 6 \times 13,900 = 83,400 \)

\( P_{e1} = -13,900 + 13.7 / 9.78 \times 21,100 - 44 \times 4 / 78 = -33,700 \)

\( V_v = 19,300 + 13.7 / 9.78 \times 21,100 - 44 \times 4 / 78 = 54,800 \)

\( P_{v1} = 21,100 + 13.7 / 9.78 \times 21,100 - 44 \times 4 / 78 = 70,200 \)

\( V_v = -21,100 + 13.7 / 9.78 \times 21,100 - 5 \times 4 / 78 = -44,100 \)

\( K_v = 44,100 + 13.7 / 9.78 \times 21,100 = -94,400 \)

\( N_v = 44,100 + 13.7 / 9.78 \times 21,100 = 48,200 \)

\( H_v = 54,800 + 2 = 24,800 \)

Torque on shaft = \( 10,000 \times 93 + 40,000 \times 73 \)
**CONDITION II - SCRUBBING ON AXLE**

\[
\begin{align*}
D_{L0} &= -D_{R0} = 15,100 \times 4.47/1.76 = -3,700 \\
D_{L1} &= -D_{R1} = 15,900 \times 5.31/1.76 = -9,900 \\
R_L &= -R_R = 15,900 \times 28.5/14.25 = 33,800
\end{align*}
\]
Sketch Showing Sections to be Investigated

Ref. Dwg. 69760
SECTION I

CONDITION II CRITICAL

Tension = 29,800#
Torque = 336,000#
Shear = \( \sqrt{(70,200)^2 + (7,700)^2} = 70,600\# \)
\[ M = 70,600 \times 1.8 = 127,000\# \]

SECTION PROPERTIES

\( A_0 = 4.991\, \text{in}^2 \quad I_0 = 4.395\, \text{in}^4 \quad c = 2.32\) \(\text{in} \quad d/e = 2.15 \quad L/O = 2 \)

\[ A_m = 3.46 \quad I_m = 17.86 \quad I/c = 3.95 \]

ALLOWABLES

\[ f_s = 0.71 \times 205,000 = 144,000 \quad f_a = 1.6 \times 144,000 = 230,000 \quad f_t = 245,000 \]

STRESSES

\[ f_e = 29,800/3.46 = 8,660 \]
\[ f_{st} = 336,000/2 \times 7.76 \times 2.32 = 40,500 \]
\[ f_3 = 2 \times 70,600/2.46 = 40,800 \]
\[ f_5 = 127,000/3.95 = 32,200 \]

MS

\[ K_1 = 8,660 \times 706,000 = 642 \]
\[ f_{sc} = 40,500/144,000 = 0.28 \]
\[ K_2 = 40,800/175,000 = 0.23 \]
\[ R_1 = 32,200/144,000 = 0.22 \]
\[ R_2 = 32,200/247,000 = 0.13 \]
\[ M_S = \frac{1}{1 + \frac{1}{4.07}} - \frac{1}{1 - \frac{1}{4.07}} = \frac{0.17}{1 (22.48) + 135.87) (24.25)} \]
SECTION 2

CONDITION II CRITICAL
Tension = 29,800#
Torque = 886,000#
Shear = 70,600# (As in sect. 1)
M = 70,600 x 9 = 635,400#

SECTION PROPERTIES
OD = 4.133" ID = 4.385" t = .224" D/t = 21.6 L/D = 2
As = .342" Am = 16.7 I/c = 3.56

ALLOWABLES - Same as in sect. 1.

STRESSES
s = \frac{29,800}{3.22} = 9,200
\sigma_T = \frac{886,000}{2 \times 16.7 \times 3.22} = 44,900
\sigma_2 = \frac{2 \times 70,600}{3.22} = 43,200
\sigma_3 = \frac{635,400}{3.56} = 176,400

MS
R_3 = \frac{9,200}{205,000} = .045
R_T = \frac{44,900}{144,000} = .308
R_2 = \frac{43,200}{175,000} = .243
R_3 = \frac{176,400}{247,000} = .712

MS = \frac{R_T - 1}{\sqrt{(722 + 0.48)^2 + (308)^2}} = .46
SECTION 3

CONDITION I CRITICAL
Shear = 17,900*
M = 710,000*

SECTION PROPERTIES & ALLOWABLES - Same as for section 2.

STRESSES
\[ f_b = \frac{710,000}{3.56} = 199,400 \]
\[ M_S = \frac{297,000 - 1 = +24}{199,400} \]

CONDITION II
Tension = 3,000*
Torque = 396,000**
Shear = \( \sqrt{(41,000)^2 + (14,000)^2} = 71,300* \)
M = \( \sqrt{(213,000)^2 + (34,000)^2} = 601,000** \)

STRESSES
\[ f_t = 6,000/3.22 = 1,850 \]
\[ f_c = 336,000/2 \times 6.7 \times 3.22 = 44,900 \]
\[ f_s = 2 \times 71,300/3.22 = 44,300 \]
\[ f_s = 601,000/3.58 = 169,000 \]

MS
\[ R_t = 1,850/205,000 = .009 \]
\[ R_c = 44,900/146,000 = .308 \]
\[ R_s = 44,300/175,000 = .253 \]
\[ R_s = 169,000/287,000 = .604 \]

\[ M_S = \frac{1}{\sqrt{(0.009 + 0.253)^2 + (0.308)^2}} = +.32 \]
Subject: AXLE CLUTCH

Ref. Dwg. 61741

Bendix Products Division
Division of Bendix Aviation Corporation
South Bend, Indiana, U.S.A.

Written by: C.J.A. Date: 11/20/46
Checked by: E.D.G. Date: 4-8-47

Model: R-36 N.G.

Splines Ring & Teeth

\( \frac{1}{16} \) bolts
GAGE OF PLATE

CONDITION II CRITICAL

Thrust = 29,800#  
Torque = 44,600 \times 9.41 \times 19.7 = 838,000 in-lb  
Assuming all 3.75 load torque taken by scrubbing in accordance with telephone conversation and memo of 1/21/46.

ALLOWABLES

\[ F_b = 1.5 \times 170,000 = 255,000 \text{ psi} \]

\[ F_a = 117,500 \text{ psi} \]  

STRESSES

In computing the max. bending stress, the plate is considered circular with a hole in the middle, simply supported at the hub 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 as Ref. (4), p. 194, case # 22:

\[ \sigma_{max} = \frac{3W}{2h} \left[ \frac{a^2(m+1) \log(ab) + a^2(m-1) + b^2(m-1)}{a^2(m+1) + b^2(m-1)} \right]. \]

This can be simplified, however, to \( \sigma_{max} = \frac{6W}{\pi} \), where \( W \) is given on p. 209 of loc. cit. Plotting \( \sigma_{max} \) vs \( a/b \) gives \( \beta = 0.388 \) for \( a/b = 3.63/2 \approx 1.45 \). Then:

\[ \sigma_{max} = \frac{6W}{2\pi} = 0.388 \times 27,800 \times 13,000 = 211,000 \text{ psi} \]

\[ t_{sc} = \frac{255,000}{15.5/2.3} \times 234 \times 146,500 \text{ psi} \]

\[ MS = \frac{211,000}{4(255,000)^{1/2}} = 1.12 \]

\[ \left( \frac{255,000}{146,500} \right)^{1/2} - 1 = 1.12 \]

\[ \left( \frac{255,000}{146,500} \right)^{1/2} - 1 = 1.12 \]
SPLINE RING

CONDITION IS CRITICAL

In addition to the load given on the preceding page, the ring will be subject 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.

\[
\tau = \frac{q_t \cdot \text{shear flow from torque}}{\cos \theta}
\]

\[
\text{Thrust} = q_t \cdot \tan \theta
\]

Total minimum thrust = \(20 F \cdot \frac{q_t \cdot \text{torque}}{2 \theta} \cdot \frac{x}{5} \cdot \frac{0.5}{12} \cdot 1000 \cdot 0.572 = 81,200 \text{ lbf} \)

\[
\frac{0.5}{12} \cdot 1000 \cdot 121 = 24,900 \text{ lbf}
\]

Total thrust = 81,200 + 24,900 = 111,100 lbf

\(f_t = \frac{111,100}{27 \cdot 2.57 \cdot 0.228} = 32,000 \text{ psi}
\]

\(f_o = \frac{32,000}{27 \cdot 2.57^2 \cdot 0.228} = 41,000 \text{ psi}
\)

SPLINE TEETH

LEADS - as above

\[
q_t = \frac{111,100}{27 \cdot 0.572 \cdot 5} = 5380 \text{ lbf/Tooth} \quad \text{(Total thrust x tooth)}
\]

\[
\text{Angle of tooth} = \frac{5380 \times 315}{2} = 99.7^\circ
\]

SECTION PROPERTIES

\[l_t = \frac{19}{6} \cdot 39/54 = 0.417 \quad \text{in. \cdot 417} \quad I_t = \frac{417}{6} = 69.5\text{ in.}^3 \]

STRESSES

\(f_t = \frac{111,100}{39} \cdot 0.417 \cdot 2.28 = 33,800 \text{ psi}
\]

\(f_o = \frac{33,800}{417} \cdot 0.228 = 68,000 \text{ psi}
\]

\(f_o = 799,000 \cdot \text{psi} \cdot 0.667 = 521,000 \text{ psi}
\)

\(M_S = \text{Amp.}
\)
BOLTS - PLATE TO WHEEL

Ref. Dwg. 67407

CONDITION II CRITICAL

Thrust = 29,800#

Torque = 336,000"#

SECTION PROPERTIES

Consider made from AN79AlZ; min. OD = .558", min. ID = .45", A = .151

STRESSES

Thrust / bolt = 29,800/3 = 9,933#

Shear / bolt = 336,000/3.638 = 91,570#

f_y = 3720 / .159 = 23,400

f_a = 11,570 / .159 = 72,800

f_y (max) = √(91,570^2 + (23,400 / 2)^2) = 74,900

f_r (on plate) = 11,570 / .588 x .588 = 80,100

f_r (on whl.) = 11,570 / .558 x .558 = 33,400

f_r (avg. thd. dia. for heli-coil) = 3720 / .558 x .558 = 7,180

ALLOWABLES

F_y (bolt) = 75,000

f_a (bolt) = 175,000

f_r (magnesium whl.) = 44,000

f_r (whl.) = 16,000

MS

Bolt shear

f_s = 74,900 / 3.58

f_s (on whl.)

f_s (shear, thds. in whl.)

f_s (whl.)
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.

\[ P_1 = \frac{111,000}{\pi \times 2.22} = 7,740 \text{ #/in.} \]
\[ P_2 = \frac{111,000}{\pi \times 2.5} = 7,140 \text{ #/in.} \]

STRESSES - SECT. A-A
- Hoop comp. = \( \frac{6919}{114} \times 11,000 \times \frac{1.185}{1.185} = 7412 = 21,300 \)
- \( f_v = \frac{111,000}{2.2} \times 2.0 \times 0.412 = 21,400 \)
- \( f_h(threads) = \frac{744}{1.185} = 14,000 \)

FLANGE STRESSES - SECT. B-B
- \( M = 7060 \times 118 = 1260 \text{ #/in.} \)
- \( P_1 = \frac{7060 \sin 23^\circ}{2.2} = 1790 \text{ #/in.} \)
- \( P_2 = \frac{7060 \cos 23^\circ \times 6500}{\pi} \)
- \( A = \frac{368}{7} \times 1.185 = 1.026 \)
- \( f_v = \frac{1260 \times 0.226 + 1760 \times 0.361 = 55700 + 7500 = 63200} {63.68} = 26,500 \)

ALLOW ABLES - H.T. \( 2180,000 \text{ psi} \)
- High margin is maintained to allow for over tightening of nut.

* Select tooth thrust, ref. p. 16.
Ref. Dwgs. # 69 057, 69 059, & 69 660
THRUAST NUT Ref. Dwg. 69742

CONDITION: Critical
Thrust = 49,600#

STRESSES

For = 49,600#/R - .15 x .5 = 4210

For shear: + 49600/R .118 x 42 = 5220

% ( hoop shear) = .0914 x 49,600 / 42 x .5 = 97.0

ALLOWABLE

H.T. = 170,000

M.S.: Amp.

NOTE: Sections 2 were checked under shear section below.

JACK PAD Ref. Dwg. 69739

LOADS

V = 50,600#
D = 112,400#
S = 2,12,800#

SECTION PROPERTIES

These are for webs only. Stresses in direct area are considered to be small and not critical.

L = 28" x 6.28" t (avg) = .06" x

STRESSES

Vert. Id. taken by direct brg.
Shear = 12,600 # t = 17,800#

ALLOWABLE H.T. after welding:

P = 1840 # t (6) x 23 x .75 x 9000 = 50,800#

M.S. : Amp.
SKETCH OF LOWER - BENT PORTION 1/4 Scale

Ref. Dngs. 69458, 69870

(At approx. Center of Taper)

Tapered

Scale to be investigated.

Strut
SECTION AT WELD TO HOUSING

CONDITION (C) CRITICAL: For Jdb. See Appendix (A)

Comp. = 44,200#
Torque = 1,159,000#*
Shear = 81,400#
M = 1,063,000#*

SECTION PROPERTIES
A0 = 7.165"  ID = 6.192"  LE = 0.512"  0/1 = 15.4  L/10 = 8.8
A2 = 11.86  Am = 42.5  L/C = 20.8

STRESSES
f0 = 44,200/11.86 = 3,724
fet = 1,159,000/2 x 42.5 x 0.512 = 26,600
f2 = 2 x 11.400/11.86 = 13,700
f6 = 1,063,000/20.8 = 51,400

ALLOWANCES
F0 = 10,000 (Ref. Dr. # 68864)
F2 = 723 x 90,000 = 65,100
F5 = 120 x 65,100 = 7,810
F6 = 110,000 (ANC-E, Fig. 4-28 for F2 = 70,000).

MS
R2 = 5,890/90,000 = .065
R2t = 26,600/65,100 = .409
R3 = 13,700/78,100 = .175
R6 = 51,400/110,600 = .464

M = \sqrt{(0.474 + 0.611)^2 + 0.392^2}
SECTION IN PARENT METAL ABOVE WELD

CONDITION 1(c) CRITICAL - Use same loads as of welded section; see prec. page.

SECTION PROPERTIES

\[ \begin{align*} 
  d_0 &= 7.562" \quad t_0 = 6.138" \quad c = 0.362" \quad D/I = 20.9 \quad L/D = 3.5 \\
  A_2 &= 8.09 \quad A_m = 46.7 \quad I/c = 13.97 
\end{align*} \]

STRESSES

\[ \begin{align*} 
  f_0 &= 66,200/8.09 \quad = 8,150 \\
  f_{st} &= 1,167,000/3.407 \times 0.362 \quad = 97,400 \\
  f_t &= 2 \times 81,400/9.04 \quad = 20,100 \\
  f_b &= 1,063,000/18.97 \quad = 56,100 
\end{align*} \]

ALLOWABLES

\[ \begin{align*} 
  F_c &= .8 \times 205,000 = 164,000 \\
  F_{st} &= .61 \times 164,000 = 111,600 \\
  F_t &= .12 \times 111,600 = 134,000 \\
  F_b &= .8 \times 249,000 = 199,200 
\end{align*} \]

MS

\[ \begin{align*} 
  R_c &= 8,150/164,000 = .050 \\
  R_{st} &= 97,400/111,600 = .873 \\
  R_t &= 20,100/134,000 = .150 \\
  R_b &= 56,100/199,200 = .282 \\
  MS &= \sqrt{\left(8.73 + \sigma/1.15\right)^2 + (28.2)^2}^{-1} \approx 7.9 
\end{align*} \]
SECTION 1-1

CONDITION 1(C)

Comp. = 74,700#
Torque = 972,000"#
Shear = 61,200#
M = 1,676,000"#

SECTION PROPERTIES

OD = 7.632" ID = 6.338" t = .397" D/I = 17.2 L/D = 3.5
A2 = 9.03 Am = 41.8 I/c = 15.56 x 98 = 15.25

STRESSES

f2 = 74,700/9.03 = 8,300
f1 = 972,000/2 x 41.2 x .397 = 29,700
f5 = 2 x 61,200/9.03 = 15,100
f6 = 1,676,000/15.25 = 110,000

ALLOWABLES

f0 = 170,000 [Ref. (2) p. 297]
fer = .625 x 205,000 = 122,700
f2 = 1.2 x 142,700 = 171,200
f6 = 254,000

MS

E1 = 1,800/170,000 = .010
K11 = .29,700/142,700 = .208
E2 = 110,000/254,000 = .439

MC = \frac{(439 - .52) - .208}{439 - 1.0} = +.20

At a point ten degrees radius from corner is about 0.02, which changes the value about 0.2%.
SECTION 1-1 (Cont'd)

CONDITION 1(6) CRITICAL

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

STRESSES

\[ f_1 = \frac{132,900}{1.2} = 110,750 \]
\[ f_2 = \frac{323,000}{2 \times 41.2 \times 0.297} = 4,870 \]
\[ f_3 = 2 \times 113,700 / 1.03 = 21,900 \]
\[ f_4 = 2,090,000 / 12.25 = 170,000 \]

MS

\[ R_1 = \frac{14,700}{170,000} = 0.087 \]
\[ R_2 = \frac{4,870}{142,700} = 0.034 \]
\[ R_3 = \frac{21,900}{171,200} = 0.129 \]
\[ R_4 = \frac{170,000}{264,000} = 0.644 \]

MS = \[ \frac{1}{\sqrt{(0.087 + 0.034)^2 + (0.129)^2}} \] - 1 = +.59
SECTION 2-2

CONDITION 1(b) CRITICAL
Comp. = 164,000 #
Torque = 185,500 * #
Shear = 54,900 #
M = 3,760,000 * #

SECTION PROPERTIES
OD = 7.708"  ID = 6.838"  \( \epsilon = 0.32^\circ \)  D/E = 17.0  L/E = 3.6
A = 7.82  A0 = 41.6  I/E = 16.90 x .98 = 16.56

STRESSES

\( f_c = \frac{166,000}{7.82} = 21,400 \)
\( f_{sc} = 185,800/2 \times 4.16 = 45,320 \)
\( f_s = \frac{2 \times 54,900}{7.82} = 11,190 \)
\( f_r = \frac{3,760,000}{16.56} = 221,000 \)

ALLOWABLES

\( f_c = 170,000 \)
\( f_{sc} = 190 \times 205,000 = 144,400 \)
\( f_s = 252,000 \)

MS

\( R_c = \frac{166,000}{170,000} = .999 \)
\( R_s = \frac{4,320}{144,400} = .029 \)
\( R_b = \frac{187,000}{252,000} = .747 \)

\[ MS = \left( \frac{R_c}{R_s} \right)^2 = \left( \frac{.999}{.029} \right)^2 \]
SECTION 3-8

CONDITION 1 (a) CRITICAL

Comp. = 168,000
Shear = \( \sqrt{\left(\frac{17000}{2}\right)^2 + \left(\frac{16100}{0.06}\right)^2} = 56,100 \)
\( M_1 = 3,370,000 \) in-lb
\( M_0 = 567,000 \) in-lb
\( M = \sqrt{\left(3,370,000\right)^2 + \left(567,000\right)^2} = 3,910,000 \) in-lb

SECTION PROPERTIES

\( D/D' = 1.359 \) in
\( A_\phi = 0.08 \) in
\( c = 1.74 \)

STRESSES

\( f_x = 16500/10.06 = 165.10 \)
\( f_y = 30 \times 56100/10.06 = 11140 \)
\( f_d = 2920000/17.4 = 228000 \)

ALLOWABLES

\( f_c = 170,000 \)
\( f_y = 240,000 \)

\( M_0 = 16,510/170,000 = 0.097 \)
\( M_d = 236,000/240,000 = 0.98 \)
\( M_\phi = \frac{1}{0.962} = 1.04 \)
SECTION 3-8

CONDITION (CRITICAL)

Comp. = 164,000

Shear = \( \frac{(22,000)(100)}{1 \times 10^6} = 22,000 \) psi

\( M_2 = 2,200,000 \) in-lb, \( M_0 = 567,000 \) in-lb

\( M = \frac{1}{6} \times 2,200,000 \) in-lb

\( \frac{3}{4} \times 567,000 \) in-lb = 3,920,000 psi

SECTION PROPERTIES

\( D = 7360 \), \( T = 6.689 \), \( t = .4355 \), \( D/t = 17.8 \)

\( A = 10.48 \), \( E/t = 17.4 \)

STRESSES

\( F_2 = 164,000 \times 10.06 = 1621 \)

\( F_0 = 22,000 \times 10.06 = 1410 \)

\( F_3 = 3,920,000 \times 17.4 = 525,000 \)

ALLOWABLES

\( F_2 = 170,000 \)

\( F_3 = 260,000 \)

\( M_2 = 16,511/170,000 = .097 \)

\( M_3 = 225,000/260,000 = .86 \quad 8 \)

\( M_0 = -1 + .04 \)
SECTION 4-4

CONDITION 1(a) CRITICAL

\[ \text{Comp.} = \frac{166,000}{\text{in.}} \]

\[ \text{Shear} = \sqrt{(198,600)^2 + (18,200)^2} = 200,600 \text{in.} \]

\[ M_s = 4,030,000 \text{in.-lb} \]

\[ M = \sqrt{(4,030,000)^2 + (572,400)^2} = 4,070,000 \text{in.-lb} \]

SECTION PROPERTIES

\[ \text{OD} = 7.744 \text{ in.} \quad \text{ID} = 6.761 \text{ in.} \quad t = .4445 \text{ in.} \quad \text{D/F} = 15.7 \]

\[ A_h = \pi \times \frac{1}{4} \times (\frac{7.744}{2})^2 = 35.3 \text{ in.} \quad A_s = 11.32 \text{ in.} \quad I/c = 19.28 \]

STRESS:

\[ p = \frac{166,000}{35.3} = 4,690 \text{ psi} \]

\[ f_a = \frac{1660 \times 7.446 \times 2 \times .4445}{2 \times 11.32} = 30,000 \text{ psi} \]

\[ f_s = 2 \times 200,600/11.32 = 28,500 \text{ psi} \]

\[ f_p = 4,070,000/19.28 = 211,000 \text{ psi} \]

ALLOWABLES

\[ F_a = 112,500 \text{ psi} \]

\[ F_s = 272,000 \text{ psi} \]

\[ MS = \frac{30,000}{2 \times 112,500} = .183 \]

\[ E_a = 211,000/272,000 = .776 \]

\[ MS = \frac{1}{.927} = 1.08 \]

Failure under internal pressure occurs when shear at outer dia. reaches yield. Ref (4), p. 389.
SECTION 5-5

CONDITION 1(b) CRITICAL

\[ p = 4440 \text{ psi} \quad \text{(Ref. prec. page)} \]

Shear = 200,600 lb

\[ M_3 = 5,020,000 \text{ in}^2 \quad M_D = 450,000 \text{ in}^2 \]

\[ M = \sqrt{(3,020,000)^2 + (450,000)^2} = 3,055,000 \text{ in}^2 \]

SECTION PROPERTIES

OD = 7.572"  ID = 6.751"  t = 0.205"  D/t = 11.1

\[ A_2 = 9.42 \quad J/G = 16.0 \]

STRESSES

\[ f_3 = 4640 \times 7.17/2 \times 0.205 = 39,600 \]

\[ f_2 = 2 \times 200,600 \times 9.42 = 42,600 \]

\[ f_b = 3,055,000/16.0 = 190,900 \]

ALLOWABLES

\[ F_{dy} = 112,450 \]

\[ F_b = 259,000 \]

\[ M_3 = 24,600/2 \times 18,500 = 1.76 \]

\[ R_b = 190,900/259,000 = 0.737 \]

\[ M_3 \times \frac{1}{1.76} = 75 \]

\[ R_b = 0.913 \]

\[ M_3 = 0.913 \times 75 = 70.425 \]
SECTION 6-E

CONDITION 1(a) CRITICAL

\[ p = 4640 \text{ psi} \quad \text{(Ref. p. 21)} \]

\[ \text{Shear} = 200,000 \text{ psi} \]

\[ M_3 = 1,900,000 \text{ in} \cdot \text{lb} \]

\[ M = \frac{1}{1} \left( \frac{1,900,000}{2} \right) \left( \frac{258,000}{2} \right) = 1,920,000 \text{ in} \cdot \text{lb} \]

SECTION PROPERTIES

OD = 7.383"  ID = 6.751"  \( t = 0.316" \)  D/E = 23.4

\[ A_s = 6.14 \quad I/C = 11.83 \]

STRESSES

\[ f_{3h} = \frac{4640 \times 7.07/2 \times 0.316}{6.14} = 51,900 \]

\[ f_3 = \frac{2 \times 200,000}{0.99} = 57,300 \]

\[ f_6 = \frac{1,920,000}{11.83} = 162,300 \]

ALLOWABLES

\[ F_{3h} = 112,500 \]

\[ F_6 = 242,000 \]

MS

\[ R_{3h} = \frac{51,900}{112,500} = 0.46 \]

\[ R_6 = \frac{162,300}{242,000} = 0.67 \]

\[ MS = \frac{1}{1} - 0.46 + 0.67 = 0.702 \]
SECTION 7-7

CONDITION 1(b) CRITICAL

$P = 1640 \text{ psi}$ (Ref p. 29)
$S_{\text{shear}} = 200,000 \text{ psi}$

$F_y = 700,000 \text{ psi}$
$F_h = 112,000 \text{ psi}$

$M = \sqrt{(700,000)^2 + (112,000)^2} = 748,000 \text{ psi}$

SECTION PROPERTIES

$O_D = 7.163''$, $O_L = 6.75''$, $t = .206''$, $D/E = 3.88$, $L/D = 2.7$

$A_t = 4.45$, $2t/c = 7.58$

STRESSES

$f_m = 1640 \times 6.76/2 \times 206 = 71,500$
$f_h = 200,000/4.45 = 44,600$
$f_t = 748,000/7.58 = 98,700$
$f_b (\text{max. bending}) = (71,500 + 98,700)/2 = 85,600$

ALLOWABLES

$F_m = 205,000$
$F_h = 112,000$
$F_t = 12 \times 4.45 \times 205,000 = 156,000$

$M_S$

$R_s = 71,500/205,000 = .345$
$R_h = 98,700/156,000 = .637$
$R_t = 748,000/156,000 = .480$

$M_S = 1/1.786 = 0.57$

* In check for local instability, shear in column 4 is predominant.

Rev. Apr. 8, 1947, p. 1.633
SECTION THRU BASE OF THREAD WREATH & UPPER BEARING

Condition 7-1(h) CRITICAL
Shear = 202,000 psi (Critical)

SECTION PROPERTIES
\( RD = 7.20 \text{ in} \quad ID = 5.75 \text{ in} \quad A_o = 4.95 \text{ in}^2 \quad t = 235 \text{ psi} \quad d/2 = 32 \text{ in} \quad l/d = 2.9 \)

STRESS
\( f_s = 2 \times 202,000 / 4.95 = 81,700 \text{ psi} \)

ALLOWABLE
\( f_s = 1.2 \times 62.5 \times 200,000 = 154,400 \text{ psi} \)
\( M_s = 154,400 - 1 \times 81,700 = 72,700 \text{ lb-in} \)

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

UPPER AND LOWER BEARINGS
Ref. Docs. 61451, 69672, 69887

Condition 7-1(g) CRITICAL
U. Brg. Ld. = 202,000 psi
L. H. = 272,000 psi

SECTION PROPERTIES
U. Brg. \( A = 3.12 \times 3.37 = 26.1 \text{ in}^2 \)
L. H. \( A = 5.54 \times 7.53 = 41.7 \text{ in}^2 \)

STRESS
U. Brg. \( f_s = 202,000 / 26.1 = 7,750 \text{ psi} \)
L. H. \( f_s = 272,000 / 41.7 = 6,670 \text{ psi} \)
DIAPHRAGM  Ref. Dr. #61669

CONDITION 1(a) or 1(b) CRITICAL
V = 166,000psi

SECTION PROPERTIES
R = 3.925" (Spher.)  h = 3.5" (Spher.) t = 0.12" D of Hyl. A = 6.75"
OD = 6.513" (incl. allowance for chamfer)  ID = 6.802"

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

$p = 166,000 / 2(1.656) = 44,400 psi$

$f_a = p - \frac{2h^2}{2} = \frac{44,400 - 2(3.5^2)1.656}{2(6.802^2 - 6.513^2)} = 34,200 \text{ (at inner surface)}$

$f_c (\text{at outer surface}) = \frac{p + 2h^2}{2} = \frac{44,400 + 2(3.5^2)1.656}{2(6.802^2 - 6.513^2)} = 22,000$

$f_3 (\text{no. 3}) = p = 44,400$

$f_3 (\text{no. 2}) = (22,000 - 44,400) / 2 = 1,180$

$f_3 (\text{punching @ R=2.2"}) = 44,400 \times 3.3 / 24 \times 4.5 \times 0.12 = 13,230$

$f_{cr} = 44,400 \times \frac{1.4 \times 0.691}{2} / \frac{(6.802^2 - 6.513^2)}{2} = 15,100$

ALLOWABLES  M.P. = 1750

$F_{ou} = 25,000$
$F_{om} = 24,000$
$F_{om} = 105,000$

$MS = 105,000 - 1 \times 1.180$

$MS = 103,820 / 13,230$
SECTION 1-1

CONDITION 7-11(c) CRITICAL

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

SECTION PROPERTIES
OD = 8.756" ID = 1.379" t = 0.125" D/8 = 46.4 L/D = 2.6
A_0 = 5.11 I/c = 10.71

STRESSES
f_1 = 76,600/5.11 = 15,000
f_2 = 2 x 222,000/5.11 = 17,000
f_3 = 1,560,000/10.71 = 145,000

ALLOWABLES
F_0 = 208,000
F_0 = 1.2 x 208,000 x 8,000 = 128,160
F_0 = 213,000

M_3
R_1 = 18,000/205,000 = .088
R_2 = 17,000/187,100 = .091
R_3 = 145,000/213,000 = .69

M_3 = \frac{1}{\sqrt{(0.088 - 0.078)^2 + (0.69)^2}}

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_3 is therefore subtracted (Ref. p. 4).
CONDITION 7-(a) CRITICAL

Tension = 76,000#
Shear = 222,000#
Moment = 4,870,000"#

SECTION PROPERTIES
OD = 9.131" ID = 9.077" t = .036" D/t = 24.3 L/D = 2.8
Ae = 10.21 I/c = 21.6

STRESSES
fL = 76,000/10.21 = 7,450
fS = 2x222,000/10.21 = 43,940
fQ = 4,870,000/21.6 = 226,000

ALLOWABLE STRESSES
fL = 285,000
fS = 42 x .678 x 205,000 = 160,000
fQ = 240,000

M3

Rl = 7,450/285,000 = .026
RQ = 226,000/240,000 = .942

M3 = 1 - 4.928 = .978
SECTION 3-3

CONDITION: 7-1(c) CRITICAL

TENSION = 76,000 psi
Shear = 278,000 lb.
Moment = 5,210,000 in. (No net uniform load)

SECTION PROPERTIES

OD = 9.146 in. ID = 7.379 in. 6 = 5.886 in. D/c = 23.9

Assume Sect. as follows:

Assume triangle

\[ I = \frac{b}{6} \left( 9.146^4 - 7.379^4 \right) + \frac{4}{3} \times \frac{5.886}{2} \times 2.76 \times \frac{5.210,000}{12} \]

= 101.7 + 122.70 = 224.47
T/c = 122.70 x 2/5.210,000 = 26.9

\[ A_3 = \frac{4}{3} \left( 9.146^2 - 7.379^2 \right) + 4 \times \frac{5.886}{2} \times 2.76 = 10.60 + 8.62 = 19.22 \]

STRESSES

\[ f_t = 76,000/19.22 = 3,975 \]

\[ f_s = 5,210,000/19.22 = 271,300 \]  For shear check, see Sect. 4-4,

ALLOWABLES

F_{tu} = 205,000
F_{su} = 243,000

MS

\[ R_t = 4,750/205,000 = 0.023 \]

\[ R_s = 197,300/243,000 = 0.817 \]

\[ MS = \frac{1 - 0.023}{0.817} = 0.895 \]
SECTION 4-4

CONDITION 7-(K9) CRITICAL

Shear = 278,000#
M = 4,400,000"lbf

SECTION PROPERTIES

OD = 9.147 ID = 8.374 t = .250" D/C = .248 L/D = 6.9
A = 14.13 I/C = 21.3

STRESSES

\[ f_s = \frac{2 \times 278,000}{0.25} = 54,000 \]
\[ f_b = \frac{4,400,000}{21.3} = 206,000 \]

ALLOWABLES

\[ f_s = \frac{12 \times 690 \times 325,000}{164,000} = 244,000 \]

\[ f_b = 2 \times 2,000 \]

MS

\[ R_3 = \frac{54,000}{244,000} = 0.223 \]
\[ R_4 = \frac{206,000}{244,000} = 0.85 \]

\[ M_0 = \frac{1}{\sqrt{1.223^2 + 0.85^2}} - 1 = 0.09 \]
SECTION 5-E

CONDITION 7-16 CRITICAL
Shear = 278,000#
M = 7,030,000 "#

SECTION PROPERTIES
OD = 1.896 ID = 3.877" t = .2385" D/C = 34.4 L/D = 1.9
Aₚ = 7.02 I/C = 14.73

STRESSES
f₁₀ = 2 x 278,000 / 7.02 = 79,000
f₂₀ = 2,030,000 / 14.73 = 138,000

ALLOWABLES
F₁₀ = 1.2 x .63 x 205,000 = 185,000
F₂₀ = 224,000

M₅
R₁₀ = 79,000 / 185,000 = .425
R₂₀ = 138,000 / 224,000 = .616

M₅ = \[
\frac{1}{\sqrt{(.425)^2 + (.616)^2}} - 1 = .35
\]
SECTION 6-6

CONDITION 7-1(0) CRITICAL
Shear = 278,000 #
M = 1,230,000 #

SECTION PROPERTIES
OD = 9.118" ID = 8.755" C = .2115" D/C = 43.4 L/D = 1.1
A = 5.97 I/C = 13.10

STRESSES
f = 2 x 278,000 / 5.97 = 93,700
f = 1,230,000 / 13.10 = 93,700

ALLOWABLES
F = 12 x 8.5 x 205,000 = 143,800
F = 214,000

MS
E = 93,700 / 143,800 = .658
E = 93,700 / 214,000 = .439

MS = \frac{1}{\sqrt{(6.49)^2 + (0.658)^2}} - 1 = .78
SHEAROUT OF TORQUE YOKE STOPS

CONDITION (C) CRITICAL

\[ L_d = 83,200 \text{ in.} \quad (\text{Ref. p. 79}) \]

**SECTION PROPERTIES**

\[ I = \frac{33.5 \times 3.75^3 + 2 \times 1.125 \times 0.25 \times 1.35^2}{12} = \frac{34.12 + 1.08}{12} = 1.18 \text{ in}^4 \]

**STRESSES**

\[ f_s = 83,200 \times 1.375 \times 1.35/1.85 = 83,500 \]

**ALLOWABLES**

\[ F_{sa} = 157,500 \quad (f_s \text{ to take acct of mod. of repl. effect.}) \]

\[ M_2 = \text{Amp.} \]
SHOULDER FOR TORQUE YOKE

Ref. Digs. #67679 & 67680

CONDITION (G) CRITICAL

$11.50^\circ$ (See also p. 79)

$85,200^\circ$

$M$ causing bry. on shoulder $\tau_{nut} = 85,200 \times 11.50 = 488,000^\circ IN$

SECTION PROPERTIES

Bronze bushing: $OD = 10.05^\circ$ $ID$ (for bry.) = 9.25$; $E = 36,000$

$I/c = 16.8$

Cyl. Shoulder:

$A = \frac{1}{2} \times 3^\circ \times 3^\circ = 3.53 \\ in^2 \;/\; in.$

$I/c = \frac{bh^3}{6} = 18.3/6 = 0.015 \; in.^3 \;/\; in.$

STRESSES

$p_{ess} = \left(\frac{605,000}{16.8}\right) \times 3.53 = 5420 \; \sigma$ in.

$f_s = \frac{5420}{10.1/3}) \times 527/100$

$f_c = \frac{5420 \times 16.8 \times 10}{0.015 \times 10} = 87,100$

ALLOWABLES

$f_{eh} = 205,000$

$MS = \text{AMP}$

*For bushing check, see p. 62.
Sketch of Trunnion 1/2 Scale

Ref. Drawings: # 69677, 69679, 69680

Symmetrical Except for Retracting Arm Lugs

 Though: 3 1/2" 12 N.3 B

15° to Load Removal Pt.
SECTION AT THREADS

\[ \text{CONDITION 1(b)} \]

\[ P_b = 166,700 \text{#} \]
\[ S_a = 0 \]
\[ M = 166,700 \left( 15.00 - 13.625 \times 1.25 \right) = 354,000 \text{#} \]

\[ \text{CONDITION 4(b)} \]

\[ P_b = 158,900 \text{#} \]
\[ S_a = -29,800 \text{#} \]
\[ M = 158,900 \times 1.25 = 330,000 \text{#} \]

SECTION PROPERTIES

P.D. = 5.438"

Min. screw O.D. = 5.438"
Max. nut I.D. = 5.418" [Ref. (7), p. 1188-6]

\[ h_{\text{min. for thrd.}} = (5.418 - 5.438) / 2 = .038" \]

Assume effective L for thrd. = 1.25"

STRESSES

Because of the short thread 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 thread. Deformation of the tube is not considered as it is prevented by the bulkhead.

\[ \text{Condition 1(b)} \]

\[ f_{\text{max.}} = \frac{4M}{\pi d^3} = \frac{4 \times 354,000}{11 \times 4.25 \times 5.438^3} = 22,400 \text{#/in.} \]

\[ P_{\text{max.}} = 22,400 \times 6.25 = 138,000 \text{#/in.} \]

\[ f_{\text{for (bending)}} = \frac{15,250 / 0.83 \times 1.25 \times 12}{101,000} = 29,000 \]

\[ f_{\text{for (direct)}} = \frac{166,700 / 0.83 \times 1.577 \times 5.438 \times 1.25 \times 12}{101,000} = 130,000 \]

Tot. for = 150,000

\[ \text{Design limit stress to use removal point = 15,000} \]
SECTION AT THREADS (Cont'd)

STRESSES (Cont'd)

Condition 4(b)

\[
\sigma_{max} = \frac{4M}{\pi D^2} + \frac{5}{\pi D L} = \frac{4 \times 338,000}{\pi \times 625 \times 5.43^2} + \frac{24,100}{\pi \times 5.43 \times 625} = 29,900 + 2520 = 32,420
\]

\[
f_a (\text{Top of thrld}) = 29,900 - 2520 = 27,380
\]

\[
f_b (\text{Top of thrld}) = 20,980 \times 0.625 = 13,120 \text{ #/in. Cond. 1(b) critical forбр.}
\]

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

ALLOWABLES

\[
f_a = 117,500
\]

\[
f_b = 210,000
\]

\[
M_5 = \text{Amp}
\]

* that is, at top of transition barrel.
SECTION 1-1

CONDITION 1(6) CRITICAL

\[ F_0 = 166,700 \text{#} \]

\[ M = 166,700 \left( \frac{1}{2} + \frac{3}{8} \right) = 780,000 \text{#} \]

SECTION PROPERTIES

\[ OD = 5.287 \quad ID = 4.169 \quad t = 0.209 \quad D/E = 25.3 \quad L/D = 1.6 \]

\[ A_2 = 3.88 \quad I/C = 4.02 \]

STRESSES

\[ F_0 = 2 \times 166,700 \times 0.30 = 101,100 \]

\[ f_1 = 780,000 / 4.02 = 186,800 \]

ALLOWABLES

\[ F_3 = 1.2 \times 0.69 \times 205,000 = 169,800 \]

\[ F_6 = 239,000 \]

MS

\[ R_8 = 101,100 / 169,800 = 0.594 \]

\[ R_6 = 186,800 / 239,000 = 0.780 \]

\[ M_S = \frac{1}{\sqrt{(0.594)^2 + (0.780)^2}} = 1 + 0.02 \]
SECTION 2-2

CONDITION 1(6) CRITICAL

\[ P_0' = 146,700 \]
\[ S_0' = 0 \]
\[ M = 116,700 \left( 1^{\frac{3}{8}} + 1^{\frac{1}{16}} \right) = 1,574,000 \text{ in-lb} \]

SECTION PROPERTIES

\[ OD = 5.521\text{ in} \quad ID = 4.169\text{ in} \quad t = 0.256\text{ in} \quad D/E = 16.9 \quad L/D = 1.5 \]
\[ A_0 = 5.54 \quad I/C = 0.86 \]

STRESSES

\[ f_0 = 2 \times 146,700 / 5.54 = 24,000 \]
\[ f_0 = 1,574,000 / 5.56 = 280,000 \]

ALLOWABLES

\[ f_0 = 1.2 \times 0.75 \times 200,000 = 180,000 \]
\[ f_0 = 265,000 \]

\[ M_0 = 62,400 / 180,000 = 0.35 \]
\[ R_0 = 240,000 / 265,000 = 0.90 \]

\[ MS = \frac{1}{0.35} = 2.86 \]
TEAROUT OF ARM FROM CYLINDER TUBE

CONDITION (b) CRITICAL

\[ P_t = 166,700 \]
\[ M = 166,700 \left( \frac{12}{9} + \frac{9}{9} \right) = 1,854,000 \text{ ft-lbf} \]

SECTION PROPERTIES

\[ OD = 6.0 \text{ in} \quad t = 0.035 \text{ in} \quad (Ref. p. 38) \]

Since the sect. is on the surface of a cylinder and measures 6.6\(^\circ\) 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.

\[ \sigma_{\text{max}} = \frac{P_t M}{\pi D^2 t} = \frac{166,700 \times 1,854,000}{\pi \times 6.0^2 \times 1.1 \times 0.035} = 155,400 \text{ psi} \]

ALLOWABLES

\[ F_t = F_{t0} = 157,500 \] Use \( F_{t0} \) to take account of modulus of rupture effect.

\[ M_0 = 157,500 \times 1 - 0.5 \times 0.5 \]

*Conservative since effect of thickening of section of cylinder reinforcements is not taken into account in the section properties.*
**Threads - Cap to Cylinder**

**Condition 1(b) Critical for Shear**

Thrust = 166,000
Shear = 48,000

**Section Properties**

P.D. = 3.950" Assume effective b = \( \frac{3}{4} \) length of thrd. = \( \frac{3}{4} \times 0.995 = 0.746 \) in

Min. Thrds. h (for mg.) = \( \frac{27110 - 0.746 \times 28}{0.6253} \) in (Ref. 7, pp. 115-7)

**Stresses**

\[
F_{o,m} = \frac{P}{\pi D L} + \frac{6M}{\pi D L} = \frac{16,000}{\pi \times 3.950} + \frac{4 \times 1,130,000}{\pi \times 3.950} = \frac{11,120 + 35,900}{3.950} = 12,080 \text{ psi (off side)} = 12,080 - 4,180 = 7,900 \text{ psi (on side)}
\]

P\(_{om}\) = 47,000 x 0.3525 x 0.6253 = 12,450 psi

P\(_{th}\) = 24,700 x 0.5252 x 11.55 x 16 = 20,800 (off side)

Note: Considerable of the shear can be transferred by the flange shear at the N.A. let us assume \( \frac{1}{4} \) transferred thus.

f\(_s\) (weld) = 2 x 10,800/0.025 x 0.75 x 0.375 = 18,400 (Ref. allowable = 44,100)

f\(_w\) = 10,800/0.025 x 0.75 x 0.375 x 0.002 x 15 = 14,500 (Ref. p. 43)

Total f\(_w\) = 38,600 + 62,600 = 101,000

**Allowables - Weld after N.T.**

F\(_T\) = 70,000 (Ref. 2.25% occ. of max. of rupture effect)

F\(_T\) = 125,000

\[
M_S = \frac{70,000}{47,000} = 1.49
\]

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

**Com. 7-11(a) more critical for bearing, see following page.*
CONDITION 7-1(G) CRITICAL FOR BEARING

Thrust = 276,400#
Shear = 222,000#

σ = 222,000 x 5/16 = 1,235,000#

STRESSES
Note: Some items are computed by proportion from data on preceding page.

\[ f_{max} = \frac{276,400}{\pi \times 0.45} + \frac{4 \times 1,235,000}{\pi \times 0.45 \times 0.2436} \]

\[ = 5,130 + 39,100 = 44,230 \text{ (full side)} \]

\[ f_x(\text{off side}) = 19,100 - 5,130 = 33,970 \]

\[ P_{max} (\text{full side}) = 44,230 \times 0.5625 = 24,900 \text{ #/in.} \]

\[ P_x (\text{off side}) = 33,970 \times 0.5625 = 19,100 \text{ #/in.} \]

\[ f_y (\text{bendy + thrust, off side}) = 30,500 \times 19,100/19,990 = 41,500 \]

\[ f_y (\text{from shear and } f_x) = 42,600 \times 111.800/19,990 = 44,900 \]

\[ \text{Tot for } = 91,700 \]

ALLOWABLES - See prev. page.

\[ MS = 185,000 \div 1 = 185 \text{,000} \]

\[ 91,700 \]
WELD - AIR PRESSURE CHECK

Static load = 28,700 lbs

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

\[ A = \frac{\pi}{4} \times 7.74^2 = 47.1 \]

Static Air Press. = \( \frac{22,700}{47.1} = 480 \) psi

Compression Ratio = 4:1 (Ref. Lwg. # 49650)

Fully Compressed Air Press. = 480 x 4 = 1,920 psi

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

\[ MS = \frac{3300 - 480}{1920} = 1.67 \]

Fully Extended Air Pressure = 610 x 4/17 = 143.5 psi
SECTION I-1

CONDITION (b) CRITICAL

\[ \begin{align*}
T & = 150^\circ F \\
\Delta t & = 108^\circ F \\
\tan & = 20^\circ \\
V & = 10^{15} \times 15 = 1510^{15}
\end{align*} \]

SECTION PROPERTIES

\[ \begin{align*}
CD &= ND + PD - 0.041 = 8.40 - 0.41 = 8.00 \text{ [Ref. 71, p. 257, P.]} \\
TD &= 9.416 \times 1.177 = 11.097 \text{ A, r. 1.91 I/0 = 25.1}
\end{align*} \]

WIRING:

\[ f_i = 100,000; 12.5 = 14.400 \]

\[ f_i = 200,000, 12.5 = 20.400 \]

\[ f_i = 10,000/20.1 = 492,400 \]

\[ F_{max} = (f_n + 0.4) = 20,100 \times 10,000 \times 12,500 \times 11.100 \times 19.500 \times 13.500 \times 11.500 \times 12.500 \times 19.500 \]

\[ P = 20 + 1.1 = 19.140 + 571.4 + 191.5 \]

\[ = 210.5 + 11.000 + 112.000 = 112.000 \times 112.000 \times 112.000 \]

Shedding side:

\[ - (12.500 \times 112.000) = 27,000 \times 12.500 \times 112.000 \times 112.000 \]

The data from the given data are incorrect. The correct data from the given data are incorrect.

\[ E = 1500 \times 112.000 \times 112.000 \times 112.000 \]

\[ F_{max} = \sqrt{\left(12.500^2 + 112.000^2\right) / 2} = 34,000 \]

\[ f_{max} = 20,000 + 11.000 = 31,000 \]

\[ f_{max} = 8 + 9 + 10 + 10 = 37,800 \]

Conclusion from with only.
BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

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<th>Subject</th>
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<td>4/7/47</td>
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<td>6-7-47</td>
<td>QUIK CYLINDR. UPPER END FITTING</td>
<td>8-46 N.G.</td>
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** SECTION I-1 (CONT'D) **

** ALLOWABLES - WEIGH OFF TO 1.0 T. **

<table>
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<tbody>
<tr>
<td>$F_{tu}$</td>
<td>80,000</td>
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<tr>
<td>$F_{m}$</td>
<td>50,000</td>
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<tr>
<td>$F_{y}$</td>
<td>42,500 (See p. 29)</td>
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<tr>
<td>$F_{N}$</td>
<td>mgl. of n. for $F_{tu} = 80,000$</td>
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** MS **

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<td>$R_3$</td>
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<td>$R_e$</td>
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<tr>
<td>$R_a$</td>
<td>43,900</td>
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<tr>
<td>$R_{nc} (fwd. side)$</td>
<td>27,000</td>
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<tr>
<td>$R_{nt} (top. side)$</td>
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** Condition: 7-1(2) **

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<tr>
<td>$T_{max}$</td>
<td>72,000</td>
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<tr>
<td>$S_{max}$</td>
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<td>$N$</td>
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** STRESSES **

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<td>$f_3$</td>
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<td>$F_{max} (fwd. side)$</td>
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<td>$P_{max}$ (top. side)</td>
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<td>$\Psi (\cdot \cdot \cdot)$</td>
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</tr>
</tbody>
</table>

** Ref. # 818 **

** Page No. **

** No. of Pages **

** Model **
SECTION 1-1 (Cont'd)

STRESSES (Cont'd)

\[
f_{nc}(\text{fnd. side}) = (12.730 - 7.913/2 \times .497).35 = -25,440
\]

\[
f_{nc}(\text{rft. side}) = 25,440 \times 21,470/12,770 = -42,700
\]

\[
f_{nc}(\text{N.A.}) = 25,440 \times 19.404/49,530 = -2,940 \quad \text{(Ref. p. 82)}
\]

\[
f_{max} = \sqrt{(26,000)^2 + (4,290 + 3,848)^2} = 26,300
\]

\[
f_{min} = 36,300 + (6,500 - 2,940)/2 = 27,700
\]

\[
f_{min} = 48,000 + 4,200 = 54,200
\]

ALLOWABLES - See prev. page.

MS

\[
R_a = 36,300/50,000 = .726
\]

\[
R_b = 6,200/80,000 = .076
\]

\[
R_{p} = 48,000/100,000 = .480
\]

\[
r_{nc}(\text{fnd. side}) = 25,440 / 2 \times 42,500 = .299
\]

\[
r_{nc}(\text{rft. side}) = 42,700 / 2 \times 42,500 = .503
\]

\[
MS = \frac{.299 + .503}{.726 + .076} = \frac{.802}{.902} = .885
\]
SECTION 2 - C

CONDITION 7 - (0) CRITICAL

Thrust = 76,400#  
Shear = 222,000#  
M = 222,000 x 65/6 = 1,401,000# ft

SECTION PROPERTIES
OD = 9.250", SD = 8.500"  6 = .365"  D/l = 25.4
A0 = 10.22  I/G = 51.8

STRESSES

fL = 76,400/10.22 = 7,560
fr = 2 x 222,000/10.22 = 43,500
fh = 440,000/21.9 = 44,200
p(fwd side) = 12,770  p(aft side) = 21,470  (Ref. p. 55)

fth (fwd. side) = (12,770 x 855/2 x .365)/28 = 38,900

fth (aft. side) = 38,900 x 21,470 / 12,770 = 67,500

fth (N.A.) = 38,900 x 5130/44,200 = 43,500

fth = (43,500)² + (1200 - 4510)² = 49,505

fth = 44,300 + 7,000 = 71,300
SECTION 2-2 (Cont'd)

After 95°C: Wind after 95°C will assume some increase because of distance from weld.

\[ F_{10} = 11.5,000 \]
\[ F_{30} = 75,000 \]
\[ F_{50} = 70,000 \] (See p. 29)
\[ F_{60} = 109,000 \]

**MS**

\[ R_e = 7,500 / 125,000 = 0.06 \]
\[ R_\alpha = 48.5,000 / 75,000 = 0.65 \]
\[ R_\beta = 64.5,000 / 135,000 = 0.48 \]
\[ (a + c) \text{ side} = 38,100 / 2\times 10,000 = 1.9 \]
\[ (a + c) \text{ side} = 65,500, 2\times 70,000 = 4.6 \]

\[ \frac{1}{a} - 1 = 0.75 \]

\[ 100 - 360 + 0.5 \]

\[ 0.870 \]
BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by CSA Date 12/31/44
Checked by D. C. Data 7/5/47
Subject: OUTER CYLINDER UPPER END FITTING

Rept # 848
Page No. 61
No. of Pages 111
Model P-36 N.G.
CHECK OF LUG - SECT. A - D & B - D

Condition 7 - 12/120 CRITICAL

Dirig B族 222,000 lb or 111,000 lb per Lug

Section Properties

Sect. A - D: L = 124" t = .476" A = .590"
Sect. B - D: L = 124" x = .567" A = .703"

Stresses

\[ f_c = \frac{111,000}{2 \times 0.590} = 94,000 \]
\[ f_s = \frac{111,000}{2 \times 0.708} = 79,000 \]
\[ f_{br} = \frac{111,000}{124 \times 2.25} = 39,200 \]

Allowables

\[ F_{bu} = 205,000 \]
\[ F_{su} = 117,500 \]
\[ F_{br} = 210,000 \]

\[ MS = \frac{117,500}{79,000} = 1.49 \]
SECTION 3-8

CONDITION 7-110) CRITICAL

Horizontal load for lug = 111,000 #

Compressive stress = 111,000 \sin 20^\circ = 38,000 #

Shear stress = 111,000 \cos 20^\circ = 104,000 #

Torsional stress = 111,000 \times 2.36^\circ = 262,000 #

SECTION PROPERTIES

\( b = 4.74" \)
\( t = 0.866" \)

\( A = 4.74 \times 0.866 = 4.125 \) sq units

\( I_c = \frac{4.74^2 \times 0.866}{6} = 1.857 \) in

STRESSES

\( f_c = \frac{31,000}{4.125} = 11,700 \)

\( f_s = \frac{202,000}{2.37} = 102,000 \)

\( f_t = \frac{111,000}{4.125} = 26,800 \)

ALLOWABLES

\( f_{allow} = 205,000 \)

MS = App
OUTER CYLINDER UPPER END FITTING

CONDITION 7-(a)
Thrust = 76,600#
Shear = 222,000#
M = 222,000 * 4.25 = 945,000#

CONDITION 1(b)
Thrust = 166,000#
Shear = 203,000#
M = 203,000 * 4.25 = 863,000#

SECTION PROPERTIES
Assumed Tearout Sect:

\[ A = 2 \times 54.41 + 2 \times 74.88 = 4.80 + 6.72 = 11.52 \]
\[ I/C = 2 \times 48 \times \frac{7}{6} + 2 \times 48 \times 8.50 = 24.6 \]

Stresses
7-(a)
\[ f_{c} = \frac{76,600}{222,000} = \frac{4,700}{11.52} = 413 \]
\[ f_{s} = \frac{4,700 + 1.5 \times 222,000}{11.52} = 28,900 + 21,700 = 86,600 \]

1(b)
\[ f_{c} = \frac{166,000}{203,000} = \frac{4,100 + 35,100}{11.52} = 413 \]
\[ f_{s} = \frac{4,100 + 1.5 \times 203,000}{11.52} = 14,400 + 26,400 = 40,800 \]

ALLOWANCES
\[ F_{c} = 205,000 \]
\[ F_{s} = 157,500 \] (F_{s} to take acc. of rise of root effect)
\[ F_{w} = 117,500 \]
MS = ANSI
Gland Nut

Ref. Dwg. # 6968

LOADING

\[ P = 4.5 \times \text{fully ext. air pressure} \times \text{area outer cyl.} \]
\[ = 4.5 \times 143.6 \times \frac{11}{4} \times 0.785 \approx 91,700 \text{ lbf} \]  
(Ref. p. 53)

This load will be considered concentric around circumference of 6.50" dia. circle.

\[ 9.10'0 \]
\[ 1.75'0 \]
\[ 2'0 \]
\[ 2'0 \]
\[ 234' \]

SECTION PROPERTIES

Full cantilever moment will conservatively be assumed.

\[ \text{Sec. 1-1: } I/c = 9.338 \times 11/6 \times 0.260 = 1.264 \]
\[ A = 9.338 \times 0.260 = 6.17 \]

\[ \text{Sec. 2-2: } I/c = 9.704 \times 344/6 \times 0.602 \]
\[ A = 9.704 \times 0.602 = 5.76 \]

\[ \text{Threads: } A = 9.265 \times 754/2 = 10.7 \]

STRESSES

\[ \text{Sec. 1-1: } f_x = 58,800(9.33 - 1.50)/2 \times 0.260 = 60,000 \]
\[ f_z = 58,800 \times 1/2 \times 0.260 = 1,500 \]

\[ \text{Sec. 2-2: } f_x = 38,800(9.70 - 1.50)/2 \times 0.602 = 38,700 \]
\[ f_z = 38,800 / 0.5 \times 0.260 = 3,300 \]

\[ \text{Threads: } f_x = 38,800/10.7 = 3,600 \]

ALLOWABLES

\[ F_{ud} = 170,000 \]  

MS = Amp.
Piston Tube Ref. p. 50 & Drawing # 61728

Condition 1(a) or 1(b) Critical
Comp. = 166,000#

Section Properties
OD = 3.96" ID = 2.53" t = .215" D/C = 18.4 L = 22
A = 2.53 p = 1.33 L'/D = 22/1.33 = 16.5
A_s (at 0.1 ho/2c) = 2.53 - 2 x 0.1 x .215 = 2.53 - .43 = 2.07

Stresses
f_s (primary stress) = 166,000/2.53 = 65,462
f_s (local) = 166,000/2.07 = 79,800

Allowables
Mat. = 753T Ref. Revisions to ANC-5, Minutes of April 4 May 1943 Meetings of ANC-5 Committee.
Fy = 76,000
Fy = 1.275Fy = 91,700
F_y = F_y [1 - F_y/L')^2] = 91,700 [1 - 91,700 x (1.33)^2] = 91,700 x .744

= 77,300

MS = .76,000 - 1 = .04
76,000
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. 208-219 will be used.
ThruAx connecting orifice ring to plate (Ref. p. 65.)

CONDITION (a) or (c) CRITICAL
Hyd. press. = 4040 psi (Ref p. 29)

SECTION PROPERTIES
FD = 2.45"  D/O (of ring) = 1.562"  A = 2.80
Assume eff. L of thrd. = .4/1 = .2
Min. thrd. h = (2.5000 - 2.41/8/2 = .0406"

STRESSES
P = 4640 x 2.80 = 1300#
fs (thrd.) = 1300/11 x 2.45 x .2 = 74
fs/in. = 1300/11 x 2.45 = 169 #/in.
**Orifice Plate - Inner Ring**

**Condition**: 1(a) or (b) Critical

\[ W = 1300 \text{ in}^3 \quad w = 4,640 \text{psi} \quad (\text{Ref. prev. page}) \]

**Section Properties**

\[ a = 2.12'' \quad b = 1.22'' \quad \frac{a}{b} = 1.74 \quad A = \pi \left( \frac{2.12^2 - 1.22^2}{2} \right) = 9.42 \]

**Stress**


\[ \sigma_p (\text{psi}) = \frac{364 \cdot 40 x 10^{-6}}{1.2} + \frac{385 \times 130}{30,000 + 1200 \times 32,600} \cdot \frac{1}{2} \]

\[ P_s (\text{shear @ 4 in. @ 1 in.}) = (1300 + 4640 \times 1.42) \div 2 \times 2.12 = 5310 \text{ @ in.} \]

\[ M_r (r = 8) = 52,600 \times 1.7^2 / 6 = 1360 \text{ @ in.} \]

**Allowables**

\[ M_r = 1437 \]

\[ F_s = 1.5 \times 1.4 = 1.5 \times 52,600 = 78,900 \]

\[ M_s = 1437 \]
CONDITION 1(c) or (d) CRITICAL

\[ \sigma = 3.33 \times 10^3 \text{ psi} \quad a/b = 1.29 \quad A = \pi (3.33^2 - 2.31^2) = 16.8 \]

SECTION PROPERTIES

\[ a = 3.33\,\text{in}, \quad b = 2.31\,\text{in}, \quad a/b = 1.29 \quad A = \pi(3.33^2 - 2.31^2) = 16.8 \]

STRESSES  Ref. (4), p. 209, Case 21:

\[ S_r (r=b) = \frac{8\sigma_0}{3\pi} \quad \text{Use an e = 0.80} \]

\[ = \frac{8 \times 3.33 \times 10^3}{3 \times 3.14} = 14,400\,\text{psi} \]

\[ P_s \text{ (shear @ b in } \text{ in}) = 440 \times 12.8 = 5.89 \times 8^2 \quad \text{Critical} \]

\[ M_r (r=b) = 14,400 \times 3^2 / 12 = 1940\,\text{kip in.} \]

ALLOWABLES

\[ F_0 = 75,000 \quad \text{Ref. Prec. Page} \]

MS = Amp.
ORIFICE PLATE - MIDDLE RING

CONDITION (a) or (b) CRITICAL
For loads as shown above, see pp. 619-621. Total Thrust = 166,000#

SECTION PROPERTIES
$I/c = 0.47 x 1.618^2/6 = 0.204$ Assume eff. thrd. $L = 0.47$

STRESSES
Torque/in. $= 1540 - 1340 + (3330 - 3330) = 0.47/v = 312$#
$f_s = \frac{Me}{I/L} = 312 x 2.36 / 0.204 = 3330$ $[Ref. (4), \text{p}.228]$
$f_m = 0.919 F_c/e = 1049 x 166,000 / 1.6 = 36,100$
$f_{max} = 36,100 - 3330 = 32,700$ (Keep stress from this data considered to reduce radius from open end of ring.)

ALLOWABLES
$M = 10.3 T$
$F_{cu} = 65,000$
$F_{sa} = 40,000$
$M_s = \text{Amp.}$
THREADS CONNECTING ORIFICE PLATE TO TUBE

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

SECTION PROPERTIES
The plate threads are critical being made of less stiff material.
PD = 4.15"  Assume eff. Thrd. L = .9/2 = .45"
Min. Thrd. h = (4.1780 - 4.1246)/2 = .0257"  

STRESSES
Since the plate tends to deflect away from the end of the tube
and the rigidity of the tube in these holes is uncertain, the
force in the thread is to be assumed to take the side load:

\[
F_x = 166,000 \times 4.15 \times 0.45 = 28,350
\]
\[
F_y = 166,000 \times 4.15 \times 0.45 \times 0.1 \times 0.1 = 28,400
\]

ALLOWANCES  Nat. = 1450
\[
F_x = 40,000
\]
\[
F_y = 125,000
\]
\[
\frac{F_x}{F_y} = \frac{40,000}{125,000} = 0.32
\]
CHECK OF PISTON TUBE AT THREADS CONNECTING TO ORIFICE PLATE

CONDITION (4) or (6) CRITICAL
Thrust = 166,000#

SECTION PROPERTIES
RD = 4.18 - 0.09 = 4.09
ID = 3.53
t = .28
Ao = 8.36
Eff. L = .9

STRESSES
fc = 166,000 / 8.36 = 20,000

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

ALLOWABLES
fM = 75,000
fRy = 78,000 (Ref. p. 64)

Assume fc = fRy = 78,000

\[ MS = \frac{78,000}{60,000} - 1 = +.26 \]
BOLT CONNECTING TORQUE ARM TO FITTING

Ref. Dwg. # 69717

CONDITION 1(C) CRITICAL Ref. PG 111

\[ P_0 = 35,200 \times \frac{19}{9.23} = 72,200 \]

\[ P_0 = 35,200 \times 2 = 70,400 \]

SECTION PROPERTIES

Bolt D = \( \frac{7}{16} \)\( A = 0.601 \)
\( I/c = 75.7 \times \frac{20}{32} = 0.657 \)

STRESSES

\[ f_y = \frac{72,200}{0.601} = 17,600 \]
\[ f_x = \frac{70,400}{0.601} = 117,300 \]
\[ f_{max} = \sqrt{\left(\frac{72,200}{60}\right)^2 + \left(\frac{70,400}{60}\right)^2} = 11,700 \]

\[ f_{max} = 11,700 + 29,300 = 102,900 \]
\[ f_{max} = 72,200 \times 0.75 \times 0.75 = 70,600 \]

ALLOWANCES

\[ f_{max} = 70,600 \]
\[ f_{max} = 102,900 \]
\[ f_{max} = 72,200 \]

bearing: \( M_3 = 102,900 \times \frac{75}{79,400} \times 10 \times 0.41 \]
\[ 79,400 \times 20 \]

Shear: \( M_3 = 102,900 \times 10 \times 0.41 \]
\[ 79,400 \]

*Note: Bending is neglected here in accordance with the original design of the 1271 and Ref. (1), p 44
SECTION 1-1

CONDITION (C) CRITICAL. See spec. page.

\[ \text{Brgr. Ld.} = \frac{85,200 \times 14}{12} = 67,700 \]

\[ F_e = 17,600 \]  
\[ M = 67,700 \left( \frac{7.28 - 6.11}{2} \right) = 39,600^* \]

SECTION PROPERTIES

\[ \text{Logarithm coordinates considered true under effect of loads:} \]
\[ 22.5^\circ \text{ To } 45^\circ \text{ D/} \phi = 72 \text{ D/} \phi = 1/8^* \]
\[ A_t = \frac{1}{10} \quad 1/6 = .812 \]

STRESSES

\[ \sigma_1 = \frac{2 \times 67,700}{1/90} = 71,300 \]
\[ \sigma_2 = \frac{2 \times 17,600}{1/90} = 18,500 \]
\[ P = \frac{67,700 + 17,600}{12} = 37,000 \]  
\[ f_{at} = \frac{.52 \times 37,000}{24} = 39,000 \]
\[ f_{ct} = \frac{1.62 \times 39,000}{24} = 40,000 \]

\[ f_e = 39,000 \times 8/12 = 26,000 \]
\[ f_{ae} = 10,500 + 40,120 + 41,740/2 = 53,700 \]

ALLOWABLES:

\[ F_{ax} = 205,000 \quad F_{ay} = 17,500 \quad F_{aw} = 117,500 \]
\[ F_{e} = \frac{12 \times 85 \times 204,000}{243,000} = 203,000 \quad F_e = 350,000 \]

MS

\[ K_3 = \frac{74,000}{209,000} = .34 \]
\[ K_6 = 18,500/170,000 = .109 \]
\[ \lambda = \frac{46,000}{204,000} = .22 \]
\[ R_{ax} = 53,700/117,500 = .46 \]

* Ref. (7), p. 139
DINIX PRODUCTS DIVISION
SOUTH BEND, INDIANA, U.S.A.

SECTION 2-9

CONDITION 1(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.(1), pp. 387-90.

\[ f_{\text{crit}} = \frac{1.15 F}{(2.43)^2} = \frac{1.15 \times 112,500}{(2.43)^2} = 10,000 \text{ psi} \]

\[ f_c = 10,000 \text{ psi} \]

\[ f_{\text{max}} = \frac{(80,000 + 10,000)}{2} = 45,000 \text{ psi} \]

ALLOWABLE

\[ F_{17} = 112,500 \]

\[ \frac{115}{112,500} - 1.20 = 44,250 \text{ psi} \]
WELD-LUG TO INNER CYLINDER

CONDITION (G) CRITICAL

\[ V = D = 0 \]

\[ M_V = 35,200 (3.72 + 1.65) = 868,000 \text{ in-lb} \]

\[ M_D = 35,200 (10.67) = 362,000 \text{ in-lb} \]

SECTION PROPERTIES

\[ L \text{ of weld} = 2 \times 2 \times 3.51 \times 2.60 + 2 \times 2.75 = 15.04 + 4.75 = 19.79 \]

\[ \text{Diag. to CG Top = 86.7 in. Welds = Rain/12 = 3.51 \times 1.875/12 = 0.394} \]

\[ I_u = \frac{2t^3}{12}(k - \sin^2\theta /2 + \Delta x^2) \]

\[ = 2 \times 0.020(76 - 0.75)^2/12 + 15.0(3.51 - 0.01) + 4.75 \times 0.20^2 \]

\[ = 32.2 + 1.0 + 48.7 = 82.0 \text{ in}^4 \]

\[ I_o = \frac{R^2\pi}{4} \times (h^2/12) + \Delta x^2 \]

\[ = 3.51^2(76 - 0.75 \times 0.01) \times 2 \times 0.003325^2/12 + 7.5^2 \times 2 \times 3.51^2 + 150 \times (3.51)^3 \]

\[ = 81.6 + 2.2 + 48.7 + 21.1 = 150.0 \text{ in}^3 \]
WELD - Lug to Inner Cylinder (Gon TH)

STRESSES Max of Pt. "A"

\[ \sigma = \frac{35,200}{19.75} = 1780 \text{ psi} \]
\[ f_{n} = 362,000 \times 3.20 / 112.0 = 10,300 \text{ psi} \]
\[ f_{o} = 384,000 \times 3.41 / 150.4 \times 10,100 = 10,100 \text{ psi} \]

Max. Service stress = \( \sqrt{(1780 + 3420)^2 + (9460)^2 + (10,200)^2} \)
\[ \text{Max. stress} = 15,000 \text{ psi} \]

ALLOWABLE Weld before H.T.
Assume min. for weld = 5/16" 
\[ P = 0.48 \times 150,000 \times 5/16 = 22,500 \text{ psi} \]
\[ MC = \frac{22,500}{15,000} = 1.50 \]
BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U. S. A.

Written by C.S.A. Date 11/13/47
Checked by G. D. C. Date 4-9-47
Subject TORQUE YOKE

Ref Dwg. # 676-4, 67640, 67641, 67692

For analysis of this arm, see pp. 102-5

9 75"

10 3/8"

9.565"

1 1/4"

1 1/2"

1 3/16"

- 1 5/16"

- 1 1/4"

- 1 3/16"

9.565"

1 1/4"

1 3/16"

- 1 5/16"

- 1 1/4"

- 1 3/16"
Torque arm bolt and fitting lugs are the same as for inner cylinder torque fitting. See pp. 73-75.

**Torsion of Fitting from Yoke**

**Condition (C) Critical**

\[ V = 0 \]

\[ S = 85,200 \text{#} \]

\[ \text{Torque} = 467,400 \text{#} \]

\[ L_1 = 48,900 \text{/} 12.64 = 38,300 \text{#} \]

\[ L_4 \text{ from Torque Arm} \]

\[ N = 36,200 \times 1.97 = 31,600 \text{#} \]

\[ V = 36,200 \times 11.86 = 55,600 \text{#} \]

This latter is assumed taken by bearing on the nut and shoulder. Using the distribution as given on p. 43, about 80,000# of the vertical motion will be transferred between a-c and b-d. Then,

\[ V_{a-c} = V_{b-d} = (40,500 - 80,000) \times 1.82 = 97,200 \text{#} \]

There will be some bending at ray c-a due to the big Id. to the right of the coast, but it is small and not critical.

**Section Properties**

\[ I = \frac{bh^3}{12} (b + h) = \frac{3.14}{1.8} (1.8 + 4.25) = .844 \]

\[ A = 2.5(1.25 + .05) = .85 \]

\[ G_h = .85 \times .556 \times 2.5 / 2.2 = .242 \]
TORQUE YOKE

PRODUCTS DIVISION
SOUTH BEND, INDIANA, U.S.A.

Written by: C.S.A. Date: 2/12/47
Checked by: G.D.G. Date: 4-8-47

Subject: TORQUE YOKE

Model: 0-36 H.G.

Page No. 90
No. of Pages: 111

TOLERANCE OF FITTING FROM YOKE (Cont.)

STRESSES

Sect. 0-0:

\[ f_1 = \frac{48,000}{1.46} = 33,300 \]

\[ f_2 = \frac{47,200 \times 1.242}{584 \times 38} = 69,300 \]

\[ f_{max} = \sqrt{(69,300)^2 + (28,200)^2} = 79,800 \]

Sect. 6-6:

\[ f_1 = \frac{38,600 \cos 30^\circ}{1.55} = 26,700 \]

\[ f_2 = \frac{38,400 \sin 30^\circ}{1.55} + 69,300 = 98,500 \]

\[ f_{max} = \sqrt{(98,500)^2 + (7,100)^2} = 100,100 \]

ALLOWABLES

\[ F_{du} = 205,000 \]

\[ F_{du} = 117,500 \]

\[ N = \frac{117,500 - 1}{100,100} = 0.17 \]
Yoke Stop

CONDITION 1(c) CRITICAL

Ld. = 83,200 (See p. 79.)

SECTION PROPERTIES

\[ \begin{align*}
E &= 1.02 \quad h = 1.43 \quad A_c = 1.46 \quad I/c^2 = 0.348 \\
Brg. A (on cyl. step) &= 0.865 	imes 1.02 = 0.882
\end{align*} \]

\[\begin{align*}
G &= 1.5 \times 83,200 / 1.46 = 95,400 \\
f_c &= 93,200 \times 0.544 = 177,000 \\
f_v &= 18,200 / 0.882 = 20,400
\end{align*}\]

ALLOWABLES

Assume H.T. reduced to 200,000

\[\begin{align*}
F_{ax} &= 118,000 \\
F_{ay} &= 1.5 \times 169,000 = 253,500 \\
F_{oz} &= 205,000
\end{align*}\]

\[MS = 247,500 \times \frac{1}{17,000} + 20 = 17\]
NOTE

Ref. Dwg. # 69695

CONDITION 1G CRITICAL

Pm = 5420 psi (Ref. p. 43)

SECTION PROPERTIES

Assume eff. L = L/2 x .8 = 4

STRESS

\[ f_e = \frac{5420}{4} = 1350 \]

ALLOWABLES

\[ F_{e u} = 65,000 \]

\[ F_{e u} = 40,000 \]

BUSHING

Ref. Dwg. 69694, 69690

LOADING - See above.

SECTION PROPERTIES

OD = 10.053
ID = 9.697

(Allow for chemfer on torque yoke.)

g = 1.178

STRESS

\[ f_{or} = \frac{5420}{1.178} = 46,500 \]

ALLOWABLE - For = 80,000 (Cr. 166)

\[ M_S = \frac{80,000}{2.5 \times 40,000} - 1 = 0.85 \]
LUGS AT FITTING END

CONDITION (C) CRITICAL

\[ \begin{align*}
\text{Axial load in lb} &= 35,200 \times 14.77/4.43 = 55,200 \text{ lb} \\
\text{Section Properties: See next page.} \\
\sigma_{t} &= 81.81 \text{ psi} \\
A(\text{Tension factor}) &= \sinh(1.84 - 0.75) = 0.539 \\
A(\text{Shear factor}) &= \sinh(2 \times 0.89) = 0.692 \\
A(\text{Bolt}) &= 0.85 \times 0.72 = 0.627 \\
\text{Stresses:} \\
f_{t} &= 52,800/0.534 = 17,000 \\
f_{s} &= 52,800/0.692 = 77,000 \\
f_{w} &= 52,800/0.627 = 84,000 \\
\text{Allowables:} \\
f_{u} &= 190,000 \\
f_{w} &= 110,000 \\
f_{w} &= 205,000 \text{ (Brg critical on bolt; see p. 73.)} \\
\text{As} &= 110,000 - 1 = 0.98 \\
&= 12,700
\end{align*} \]
LUB AT APEX END

CONDITION 1(c) CRITICAL

\[ S = 35,200 \text{#} \]
\[ M = 35,200 \times 0.77 = 27,600 \text{#} \text{ft} \]
\[ \text{Torque} = 35,200 \times 0.77 = 40,900 \text{#} \text{ft} \]

SECTION PROPERTIES

\[ b = 3.03 \text{ in} \]
\[ h = 0.31 \text{ in} \]
\[ A_s = 8.44 \text{ in}^2 \]
\[ I/c = 3.03 \times 0.31^2 / 6 = 0.331 \]

STRESSES - Sect 1-1

\[ f_{a} = 1.6 \times 35,200 / 2.44 = 21,500 \]
\[ f_{b} = 35,200 / 3.31 = 10,600 \text{#} \text{in} \]
\[ f_{s} = \frac{T}{3.03 \times 0.31^2} = \frac{60,900 / (15 \times 0.31 + 0.2)}{6} \times \frac{2.75}{5} = 107,000 \]

ALLOWABLES

\[ F_{a} = 110,000 \]
\[ F_{b} = 1.6 \times 110,000 = 247,000 \]
\[ F_{s} = 145,000 \]

MS

\[ R_{a} = 92,500 / 247,000 = 0.375 \]
\[ R_{b} = 103,000 / 145,000 = 0.708 \]

\[ M_S = \frac{1}{1 + 2.1} \left( \frac{328}{2} - (788)^2 \right) \]
### SECTION 2-2

**CONDITION 1(C) CRITICAL**

For 101°5, 380 p. 74.

### SECTION PROPERTIES (Ref. pp. 63-64)

<table>
<thead>
<tr>
<th>Section</th>
<th>A</th>
<th>X</th>
<th>AK</th>
<th>AK²</th>
<th>T</th>
<th>Sec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.440 x .54</td>
<td>.134</td>
<td>.24</td>
<td>.634</td>
<td>.0124</td>
<td>.02</td>
<td>.86</td>
</tr>
<tr>
<td>1.77 x .56</td>
<td>.142</td>
<td>.616</td>
<td>.308</td>
<td>.287</td>
<td>.03</td>
<td>3.2</td>
</tr>
<tr>
<td>1.276</td>
<td>.421</td>
<td>.527</td>
<td>.2124</td>
<td>.02</td>
<td>.42</td>
<td></td>
</tr>
</tbody>
</table>

$F_{ax} = 1.49 \times 0.56^{1/2} = 0.73$  
$I = .2724 + 0.042 = 0.276 \times 0.42^{1/2} = 0.171$

### STRESSES

$M = 11,600 \times 37.5 + 52,200 \times .071 = 25,000$  
$f_x = 25,000 \times 389 / 671 = 137,000$  
$f_y = 52,200 / 1.176 = 40,900$  
$f_z = 17,600 \times .132 / 0.01 \times 1.49 = 22,000$

### ALLOWABLES

$F_{c} = f_x = f_y = 160$  
$F_{l} = 1.5 \times 160,000 = 240,000$

$M_{R} = 40,900 / 160,000 = 0.26$  
$R_{x} = 137,000 / 240,000 = 0.57$  
$R_{y} = 40,900 / 240,000 = 0.18$  
$M_{S} = \frac{-1}{1 + \frac{.85}{.801}}$
SECTION 3-6

CONDITION 3(c) CRITICAL

\[ P = 85,200 \text{ lb} \]  (Ref. p. 84)

SECTION PROPERTIES

Assumed sect. for analysis:

\[ A = 1.058 \times 2.5 + 1.125 \times 2.5 = 6.25 \text{ in.}^2 \]

\[ I = \frac{1}{12} \left( 1.058 \times 2.5^3 + 1.125 \times 2.5^3 \right) = 0.0587 \text{ in.}^4 \]

\[ \rho = \frac{6.25}{0.0587} = 107.1 \text{ lb/in.}^3 \]

\[ L'/\rho = \frac{12}{107.1} = 0.291 = 32 \]

STRESS

\[ f_c = \frac{85,200}{6.25} = 13,680 \text{ lb/in.}^2 \]

ALLOWABLE

\[ F_a = \frac{165,000 \left( 1 - \frac{165,000 \times 32.8}{4 \pi^2 \times 129 \times 10^6} \right)}{165,000 \times 845} = 189,400 \text{ lb/in.}^2 \]

\[ MS = \frac{189,400 \times \rho}{107.1} = 18,600 \text{ lb-in.} \]
LOADING = Rebound load or \( \frac{1}{2} \) x fully extended air pressure x inner cylinder area.

Rebound \( P = 24,300 \) psi

Fully extended air pressure = 143.5 psi (Ref. p. 53)

\[ P = 4.5 \times 143.5 \times \frac{\pi}{4} \times 7.75^2 = 30,500 \text{ psi} \]

SECTION PROPERTIES

\( CL = 0.415" \)  \( RD = 0.175" \)  \( \text{Big. } L = 0.190" \)

Shear \( A = 0.292 \)  \( \text{Big. } A = 0.685 \times 0.190 = 0.190 \)

STRESSES

\[ P = 30,500 \times 2 = 61,000 \text{ psi} \]

Load/plug = 61,000/4 = 15,250 psi

\[ f_a = 15,250/0.292 = 52,200 \text{ psi} \]

\[ f_{br} = 15,250/0.130 = 117,000 \text{ psi} \]

ALLOWABLES

\( P_{aw} = 125,000 \)

\( P_{bw} = 75,000 \)

\( P_{aw} = 175,000 \)

\[ MS = 75,000 - 175,000 = 100,000 \]

\[ 61,000 \]
REVS - LOWER CAM

Ref. Dwg.s. # 67615, 67616, 67617

LOADING - 3000 lbs per. page.

\[ P_r = 30,000 \text{ lbs at } 60^\circ = 52,800 \text{#} \]

SECTION PROPERTIES

\[ \text{Sect.} = 5/16'' \times 5/8'' \quad \text{Eff. } L = 1\frac{1}{32}'' \]

\[ \text{Shear } A = 0.512 \times 1.625 = 0.837 \]

\[ \text{Brg. } A = 0.156 \times 1.625 = 0.253 \]

STRESSES

\[ f_s = 52,800 / 0.837 \times 2 = 12,000 \]

\[ f_{br} = 52,800 / 0.253 \times 2 = 104,000 \]

ALLOWABLES

\[ F_{br} = 170,000 \]

\[ F_{br} = 100,000 \]

\[ F_{br} = 197,000 \]

\[ N = 197,000 / 104,000 = 1.9 \]
SKETCH
Ref. Dwg(s). 67730, 67731

Scale 1/2
LUG AND BOLT AT JACK ATTACHING POINT

MAX. RETRACTING JACK LOADS
Comp. = 20,200 lb or
Tension = 21,300 lb

These will be assumed to act at any angle which will produce max. stresses in the lever.

SECTION PROPERTIES
Bolt D = 7/8 in.  Br. A = 2 x 0.341 x 0.66 = 0.384
Shearcut A = 4 x 0.341 x 0.315 = 0.384

STRESSES
\[ f_{ax} = \frac{21,300}{0.384} = 55,000 \]
\[ f_{ax}(0.62) = \frac{21,300}{0.389} = 55,000 \]

ALLOWABLES
Bolt = 132,000 lb ft - Single shear \( '10' \) = 18,600 lb
Firn = 175,000
Firn (10'') = 177,500

M3
Bolt:
\[ M3 = \frac{12 \times 600}{1.57} = 3,920 \]
Lug:
\[ M3 = \frac{177,500}{1.57} = 117,500 \]
LUGS AND BOLTS AT TRUNKION CONNECTION

MAX. LOADING (Ref. pp. 90 & 91)
\[ P = 50,000 \times 7.41 / 3.01 = 79,900 \] 

SECTION PROPERTIES
Bolt \( D = 7 / 8 \) 
Drg. A = 0.176 x 0.944 = 0.17
Shearcon A = 2 x 0.42 x 0.944 = 0.715

STRESSES
\[ f_w = 70,900 / 0.177 = 40,666 \] 
\[ f_a (d_g) = 70,900 / 0.715 = 10,000 \]

ALLOWABLES
Bolt = 125,000 N.T. - single shear sl = 45,000 N
\[ f_{w0} = 175,000 \] 
\[ f_{w0} (d_g) = 117,500 \]

MS
Bolt:
\[ M_S = \frac{3 x 45,000}{70,900} - 10 + 17 \]
\[ M_S = 117,500 - 13 + 17 \]
\[ M_S = 90,300 \] 

Log φ
SECTIONS 1-1 & 2-2

LOADING
Shear = 29,200 lb
Sec 1-1: M = 29,200 x .65 = 19,000 lb
Sec 2-2: M = 29,200 x .28 = 8,040 lb

SECTION PROPERTIES
Sec 1-1: b = 2 x .564" h = 1.06" A = .723 I/c = .128
Sec 2-2: b = 2 x .406" h = 1.56" A = .122 I/c = .304

STRESSES
Sec 1-1: f_s = 29,200 x 1.6 / .723 = 60,600
f_v = 19,000 / .128 = 148,000
Sec 2-2: f_s = 29,200 x 1.5 / .122 = 235,000
f_v = 87,400 / .304 = 289,000

ALLOWABLES
f_s = 206,000
f_v = 117,500
f_p = 1.5 x 70,000 = 285,000

M_S = 285,000 / 1.5 = 183,000
SECTION 3-3

LOADING

Shear \( = 29,200 \) lb

\[ M = 29,200 \times 1.83 = 53,400 \text{ in} \cdot \text{lb} \]

SECTION PROPERTIES

Sect. assumed as follows for analysis:

\[ I = 225 \times 1.75 \times 0.75 \times 0.25 \times 0.375 \times 1.411 \approx 18 \text{ in}^4 \]

\[ I/c = 0.0090 + 0.0322 + 0.0437 = 0.084 \]

\[ O_{ma} = 0.75 \times 0.75 \times 0.49 + 0.75 \times 0.63 \times 0.47 \approx 0.285 \]

STRESSES

\[ f_s = 29,200 \times 0.25 \times 0.75 \times 0.175 = 101,000 \]

\[ f_b = 53,400 \div 0.084 = 640,000 \]

ALLOWABLES

\[ F_{sa} = 225,000 \text{ psi} \]

\[ F_{ba} = 111,500 \text{ psi} \]

\[ F_b = 1.5 \times 10,000 = 25,000 \text{ psi} \]

\[ M3 = 111,500 \times 0.14 \approx 16,000 \text{ in} \cdot \text{lb} \]
SECTION 4-4

LOADING

Shear = 29,200#

\[ M = 29,200 \times 4.53 = 132,300 \text{#} \]

SECTION PROPERTIES

Sec. assumed as follows for analysis:

\[ I = \frac{12 \times 25.216^3 + 2 \times 78x.275 \times 1.675 + 118 \times 2.13^3}{12} \]

\[ = 0.005 + 0.235 + 0.471 = 0.717 \]

\[ I/c = 0.717/1.83 = 0.393 \]

\[ V_{MN} = 0.78 \times 275 \times 1.675 + \frac{1255 \times 1.675}{2} \]

\[ = 0.369 + 0.217 = 0.580 \]

STRESSES

\[ f_s = 29,200 \times 0.580/0.717 \times 1.875 = 33,800 \]

\[ f_o = 132,300/1.83 = 72,000 \]

ALLOWABLES

\[ f_w = 205,000 \]

\[ f_o = 117,500 \]

\[ f_s = 255,000 \]

Computation shows the section to be safe against lateral instability.
LINK LOADS

Position 1: \( P_1 = \frac{285,000}{4.27} = 66,700 \text{#} \)

\( P_2 = 285,000/10.75 = 27,000 \text{#} \)

\( P_3 = 285,000/6.33 = 45,200 \text{#} \)

COMPONENTS OF LINK LOADS L-G-H TO PLANE OF CONNECTING BOLTS

\[
\begin{align*}
A & \quad C \\
B & \quad D
\end{align*}
\]

Position 1: \( D_1 = 66,700 \cos 1^\circ 42' \) \( = 66,700 \text{#} \)

\( S_0 = 66,700 \sin 1^\circ 42' \) \( = 1,980 \text{#} \)

Position 2: \( D_2 = 27,000 \cos 6^\circ 12' \) \( = 27,000 \text{#} \)

\( S_0 = 27,000 \sin 6^\circ 12' \) \( = 2,420 \text{#} \)

Position 3: \( D_3 = 45,200 \cos 17^\circ 02' \) \( = 31,700 \text{#} \)

\( S_0 = 45,200 \sin 17^\circ 02' \) \( = 10,200 \text{#} \)
BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U.S.A.

LOGIC AND MOMENTS ABT. POINT MIDWAY BETWEEN A & B

Position 1

\[ D = 66,700 \text{ lb} \quad 5 = -1,980 \text{ lb} \]

\[ M_1 = 235,000 - 1,980 \times 5.58 = 273,700 \text{ in-lb} \]

\[ M_2 = 4,980 \times 2.81 = 13,960 \text{ in-lb} \]

\[ M_3 = 66,700 \times 2.81 = 187,400 \text{ in-lb} \]

Position 2

\[ D = 27,200 \text{ lb} \quad 5 = -2,480 \text{ lb} \]

\[ M_1 = 294,000 - 2,480 \times 5.58 = 280,200 \text{ in-lb} \]

\[ M_2 = 4,820 \times 2.81 = 6,970 \text{ in-lb} \]

\[ M_3 = 27,200 \times 2.81 = 76,700 \text{ in-lb} \]

Position 3

\[ D = 23,700 \text{ lb} \quad 5 = -10,000 \text{ lb} \]

\[ M_1 = 182,000 - 10,000 \times 5.58 = 229,200 \text{ in-lb} \]

\[ M_2 = 10,000 \times 2.81 = 28,100 \text{ in-lb} \]

\[ M_3 = 23,700 \times 2.81 = 71,900 \text{ in-lb} \]
BENDIX PRODUCTS DIVISION
DIVISION OF BENDIX AVIATION CORPORATION
SOUTH BEND, INDIANA, U.S.A.

Written by C.S.A. Date: 1-8/1-77
Checked by G.D.C. Date: 4-9-77
Subject: SHOCK MOUNT SHOCKER CONNECTION
Model: 0-96 H.G.

LUG & BOLT AT PT. C  Ref. Dugs. 67650, 67679-67681

LOADS (Acting on lug)
Position 1:  \( D = -127,400/10.81 = -13,300 \)  
\( S = 5560/10.81 = -514 \)
Position 2:  \( D = -127,400/10.81 = -7,100 \)  
\( S = 6,770/10.81 = -645 \)
Position 3:  \( D = -127,400/10.81 = -8,500 \)  
\( S = 22,100/10.81 = 2,600 \)
\( P_{max} = \sqrt{17,300^2 + (514)^2} = 17,300 \)

SECTION PROPERTIES
Bolt O.D. 5/8", Brg. A = 0.425 x 0.365 x 0.228
Shear out A = 2 x 0.425 x 0.365 = 0.314

STRESSES
\( f_s = 17,300/0.228 = 75,700 \)
\( f_{s(lug)} = 17,300/0.314 = 55,000 \)

ALLOWABLES
Bolt single shear = 23,000#  
\( f_s(140) = 117,500 \)

MS:
Bolt:  \( MS = 23,000 - 1 = 22,999 \)  
\( 17,800 \)
Lug:  \( MS = 117,500 - 1 = 117,499 \)  
\( 88,600 \)
**BENDIX PRODUCTS DIVISION**

DIVISION OF BENDIX AVIATION CORPORATION

SOUTH BEND, INDIANA, U.S.A.

---

**Subject:** SHIMMY DAMPER CONNECTIONS

**Model:** B-36 N.G.

---

**Lug & Bolt at Pt. A**

**Ref Dws:** 69650, 69679-31, & 155447

---

**LOADS (acting on lug)**

- **Position 1:**
  \[ D = \left( \frac{17,300 + 46,700}{2} \right) / 2 + 273,900 / 7 \]
  \[ = 43,000 + 39,100 = 82,100 \]
  \[ = 1,247 \text{ in.} \]

- **Position 2:**
  \[ D = \left( 7,100 + 27,300 / 2 \right) + 280,200 / 7 \]
  \[ = 17,200 + 40,000 = 57,200 \]
  \[ = 1,563 \text{ in.} \]

- **Position 3:**
  \[ D = \left( 3,500 + 32,700 / 2 \right) + 229,200 / 7 \]
  \[ = 20,600 + 32,700 = 53,300 \]
  \[ = 6,300 \text{ in.} \]

- **Max. Load:**
  \[ V = \frac{81,700}{2} \]

---

**SECTION PROPERTIES**

- **Bolt:**
  \[ D = 0.988 \text{ in.}  \]
  \[ A = 0.718 \text{ in.}^2 \]

- **Brg. A:**
  \[ A = 0.988 \times 0.988 = 0.974 \text{ in.}^2 \]

- **Shearout A:**
  \[ A = 2 \times 0.62 \times 0.978 = 1.25 \text{ in.}^2 \]

---

**STRESSES**

- **f_x (bolt):**
  \[ 81,200 / 2 \times 0.783 = 51,800 \]

- **f_y:**
  \[ 81,200 / 0.986 = 82,400 \]

- **f_x (lug):**
  \[ 81,200 / 1.25 = 65,000 \]

---

**ALLOWABLES**

- **Bolt:**
  \[ F_x = 125,000, \ F_y = 75,000, \ F_{xy} = 175,000 \]

- **Lug:**
  \[ F_x = 117,500 \]

---

**MO**

- **Bolt:**
  \[ M_1 = 75,000 \times 2 = 150,000 \]

- **Lug:**
  \[ M_2 = 75,000 \times 2 = 150,000 \]
LUG & BOLT AT PT. B

Ref. Dwg. 69650-1, 69677-2, C: 35448

LOADS (Acting on lug) (see prec. page)

Position 1: D = 22,000 - 39,100 = 2,900#
S = -4247#

Position 2: D = 17,200 - 40,000 = -22,800#
S = -1458#

Max. Ld. = \sqrt{(22,800)^2 + (2,900)^2}

Position 3: D = 20,600 - 32,700 = -12,100#
S = -6,300#

SECTION PROPERTIES

Bolt D = .498" A = .195
Brg. A = .192 x .986" = .492
Shearout A = 2 x .348 x .986 = .688

STRESSES

f_b (bolt) = 22,900 / .195 = 118,700
f_ar = 22,900 / .492 = 46,800
f_s (lug) = 22,900 / .688 = 33,300

ALLOWANCES - See prec. page.

MS

Bolt: 22,900 / .498 - 1 = 45,800

Lug: 22,900 / .986 - 1 = 23,400
Tongue Yoke Arm - Cl t, 1 / 1 (2.5 ... 78)

Loads (Ref. pp. 96-97)

Position 1
\( P_x = 46,700 \times \cos 23^\circ 20' = 41,400 \) 
\( P_y = 46,700 \times \sin 23^\circ 20' = 26,400 \)

Position 2
\( P_x = 27,400 \times \cos 35^\circ = 20,000 \) 
\( P_y = 27,400 \times \sin 35^\circ = 17,400 \)

Position 3
\( P_x = 34,200 \times \cos 57^\circ 50' = 29,100 \) 
\( P_y = 34,200 \times \sin 57^\circ 50' = 18,900 \)

Section Properties

\[ A = 22 \times 191^3 \times 212 \times 212 = 470 + 264 \times 0.24 \]

\[ I = 470 + 264 \times 0.24 \]

Stresses

\( F_x = 61.2 \times 1.424 = 87,400 \)
\( F_y = 76.40 \times 1.15 \times 1.125 = 106,900 \)
\( F_z = 25.40 \times 2.7 \times 2.17 \times 2 = 87,900 \)

Allowables

\( F_x = 175,000 \)
\( F_y = 150,000 \)
\( F_z = 115,000 \)

\[ E = 37,000 \]

\[ F_x = \frac{1}{4} (1.424) \]

\[ F_y = \frac{1}{4} (1.15) \times 1.125 \times 2.17 \times 2 = 87,900 \]
TONGUE YOKE ARM - Sect. 2-C (Ref. p. 70)

LODGE (See text, page)
F = 61,200#  P = 128,400#
M + 118,400 X 4.38 = 112,200#

SECTION PROPERTIES
Area = 2.42 + .22 + 2 x .97 x 24
A = .184 + 1.816 = 2.000
I = .24 x 2.42 - 2 x .97 x 24 - .466 x 1.28
I = 1.82

= .293 + .002 + .007 = 1.182

STRESSES:
F = 61,200 / 1.182 = 50,000
P = 112,200 / .5 / 1.182 = 142,000

MAXIMUMS
F = 61,200 / 1.182 = 50,000
F = 1.5 x 180,000 = 265,000

M:
C = 61,200 / 170 = 3.60
C = 4.04 x 10 / 25.3 x 10
J = 912

FORKED YOKE ARM - TRACTION FROM YOKE DANGER

LOADS (Ref. p. 102)

\[ P_T = 26,400 + \left( \frac{61,200 + 26,400 \times 5.27}{2} \right) \sin 24^\circ = 63,000 \text{lb} \]

\[ P_0 = \left( \frac{64,200 + 26,400 \times 5.27}{2} \right) \cos 24^\circ = 59,500 \text{lb} \]

In addition, there will be a vertical load caused by the gear housing from the torque arm (Ref. p. 79). Assuming 85% of this force transferred at the critical section A-A, then,

\[ V_{A-A} = 0.85 \times 64,000 / 2 \times 4.48 = 20,000 \text{lb} \]

SECTION PROPERTIES - See p. 79.

STRESSES

\[ f_0 = 55,000 / 1.85 = 30,000 \text{ lb/in}^2 \]
\[ f_0 = 59,700 / 2.5 + 26,400 \times 0.242 / 1.84 = 43,000 \text{ lb/in}^2 \]
\[ f_{\text{max}} = \sqrt{(100,000)^2 + (31,500)^2} = 114,800 \text{ lb/in}^2 \]

ALLOWSABLES

\[ f_{\text{aw}} = 114,800 \text{ lb/in}^2 \]
\[ f_{\text{aw}} = 117,500 \text{ lb/in}^2 \]
TORQUE YOKE ARM LUG

LOADING - \( P_o = 61,700 \) lb (Ref. p. 97)

SECTION PROPERTIES

- Bolt \( D = 7/8" \)
- Bolt A = 0.275 x 1 = 0.275
- Shearout A = 2 x 0.275 x 1 = 0.74

STRENGTHS

- \( f_p = 66,700 / 0.275 = 76,300 \) (Not critical)
- \( f_s(lug) = 66,700 / 0.74 = 90,200 \)

ALLOWABLES

- Bolt single shear = 45,000 lb
- \( f_s(lug) = 117,500 \)

MS

- Bolt:
  \[
  MS = \frac{2 \times 4.174}{1.2} = 8.35
  \]
  \( 66,700 \)

- Lug:
  \[
  MS = \frac{117,500}{1.3} = 89,600
  \]
  \( 90,200 \)
APPENDIX
## Bendix Products Division

**Division of Bendix Aviation Corporation**

**South Bend, Indiana, U.S.A.**

---

**Written by: G.A. Date: 11/15/46**

**Checked by: G. D. G. Date: 11/18/47**

**Model: C-36 N.G.**

---

### Table: Nose Gear Loads

<table>
<thead>
<tr>
<th>Condition</th>
<th>OLEO Position</th>
<th>$V_f$</th>
<th>$D_f$</th>
<th>$Y_f$</th>
<th>LEAD</th>
<th>LOAD AT 1WHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3WLR</td>
<td>FE</td>
<td>168,000</td>
<td>54,900</td>
<td>0</td>
<td>3</td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>Side Drift</td>
<td>FE</td>
<td>0</td>
<td>0</td>
<td>149,600</td>
<td><strong>Ground</strong> 4</td>
<td></td>
</tr>
<tr>
<td>Bearing In</td>
<td>FE</td>
<td>76,600</td>
<td>50,850</td>
<td>0</td>
<td>2</td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>Pushing Out</td>
<td>FE</td>
<td>76,600</td>
<td>50,850</td>
<td>0</td>
<td>2</td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>Static Thrust:</td>
<td>Static</td>
<td>50,850</td>
<td>75,000</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Turning</td>
<td>Static</td>
<td>40,420</td>
<td>13,380</td>
<td>54,810</td>
<td><strong>Ground</strong> 10</td>
<td></td>
</tr>
<tr>
<td>Rebound</td>
<td>FE</td>
<td>-24,300</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

---

*Ref. (1)*

**These loads combine to give a resultant side load on the gear 136,830 lbs.**

**Leads revised 11/18/46, see CVAC letter of 11/22/46.**
<table>
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<th>St.</th>
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<th>Bv</th>
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**Look at Techmod & Grid Grace Point (Red. pp.144)**

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**Reactions at E**

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**Reactions at B**

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WRIGHT-PATTERSON AIR FORCE BASE, DAYTON, OHIO
ABSTRACT:

A stress analysis was made of the nose gear of the B-36 bomber. The analysis covers the axle, lasher 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.