CONTINENTAL AIRCRAFT ENGINE CO.

DETROIT, MICHIGAN

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11 Sheets

CONTINENTAL O-1430-1 ENGINE

LOAD ANALYSIS FOR TWO PROPELLER REDUCTION GEAR ARRANGEMENTS

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LOAD ANALYSIS FOR TWO PROPELLER REDUCTION GEAR ARRANGEMENTS

Object:- The purpose of this analysis was to determine the loads on the bearings, and surrounding case of the reduction gears, in order that proper consideration might be given to other types of construction than that shown in Continental Report "Design of 1000 H.P. Flat Engine" dated June 22, 1933.

Summary:- The following pages contain an analysis in detail of the original type of construction with a center bearing, called "Construction #1", and an analysis of a compact type without a center bearing, herinafter referred to as "Construction #2".

The employment of one diaphragm (Construction "2) to carry, and hence consentrate, the front end loadings into one plane, minimizes the loading on the outer shell of the reduction gear housing.

While the two constructions show differences in rear diaphragm loadings, this is due to the more spread out supports for #1.

The stiffness of the propeller shaft is sufficient to avoid cramping of front end bearing of 1st stage pinion, or throwing of gear teeth out of alignment.

Construction #2 appears somewhat lighter than #1 for same strength and stiffness.

Conclusions: Construction #2 is believed to be best suited for our purpose and is the basis of the present design for the Continental O-1430-1 Engine.

Bearing Loads - Construction #1 with Center bearing

Ratio in first stage = 1.45 Center distance = 6.25 in.

P. D. Pinion = 5.10 in. P. D. Gear 7.40 in.

Pitch line velocity = $\frac{5.10 \times 3.1416 \times 3000}{12}$ = 4000 ft./min.

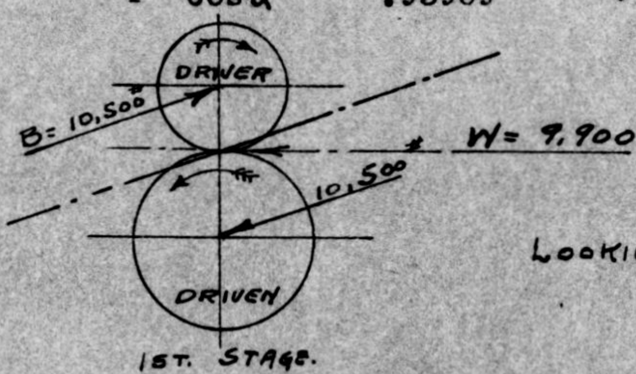
Tangential load = $\frac{1000 \times 33,000}{4000}$ = 8250 lb. mean

Torque $\frac{\text{Max}}{\text{Mean}}$ for 12 cylinder flat engine = 1.2

8250 x 1.2 9,900 lb Max.

P = Bearing pressure for 20° pressure angle (assumed)

$P = \frac{W}{\cos\alpha} = \frac{9,900}{.93969}$ = 10,500 lb.



LOOKING TOWARD PROP. END OF ENGINE

2nd Stage

Ratio = 1.38 Center distance 6.25 in

P. D. Pinion = 5.250 in. P. D. Gear = 7.250 in.

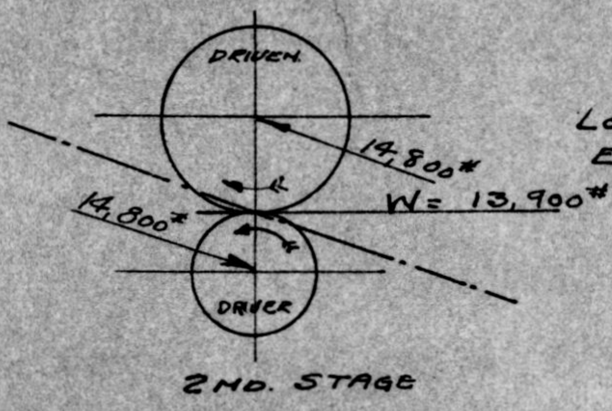
Pitch Line velocity = $\frac{5.250 \times 3.1416 \times 2070}{12}$ = 2843 ft./min.

Tangential load = $\frac{1000 \times 33000}{2843}$ = 11,580 lb. mean

11,580 x 1.2 = 13,900 lb. max.

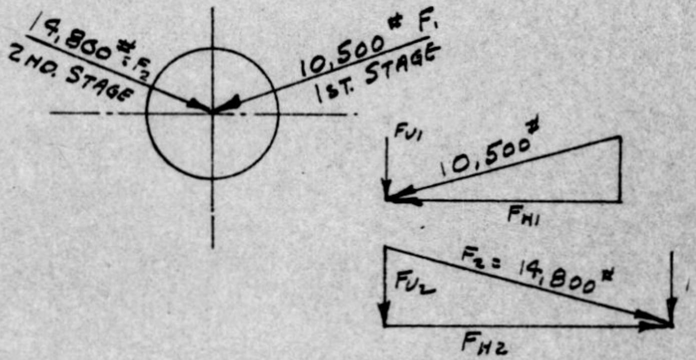
P for bearing pressure α = 20°

$P = \frac{W}{\cos\alpha}$ $\frac{13,900}{.93969}$ = 14,800 lb.



LOOKING TOWARD PROP. END OF ENGINE

Facing forward looking at the end of the jack shaft, we will resolve these forces into their vertical and horizontal components.



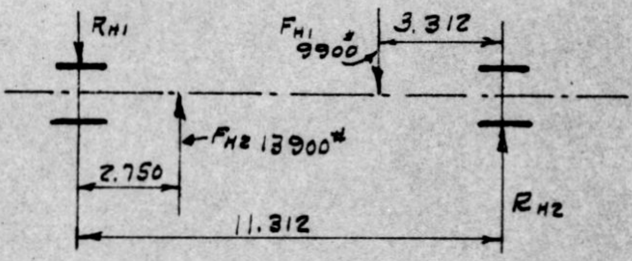
$F_{V1} = 10{,}500 \quad \sin 20^\circ = 3600$ lb.

$F_{H1} = 10{,}500 \quad \cos 20^\circ = 9900$ lb.

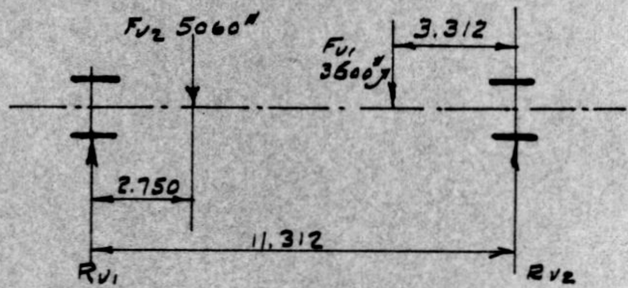
$F_{V2} = 14{,}800 \times .342 = 5060$ lb.

$F_{H2} = 14{,}800 \times .939 = 13{,}900$ lb.

We will now pass planes thru the vectors of the forces on the jack shaft.



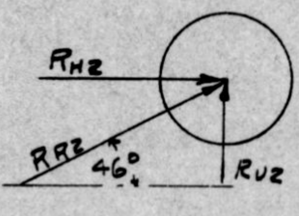
Forces in horizontal plane
$R_{H1} = 7620$# $R_{H2} = 3620$#



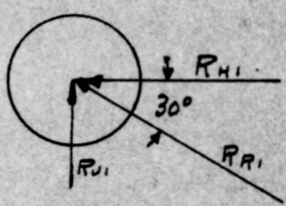
Forces in vertical plane
$R_{V1} = 4880$# $R_{V2} = 3780$#

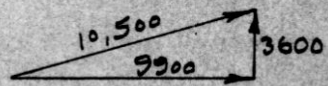
We will now consider the total load on each bearing of the jack shaft.

$$R_{R2} = \sqrt{3780^2 + 3620^2} = 5230 \ @ \ 46^\circ$$

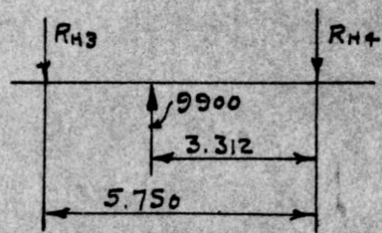


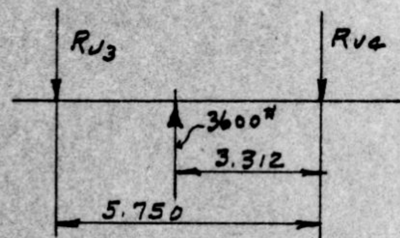
$$R_{R1} = 8850 \ @ \ 30^\circ$$





1st. Stage pinion

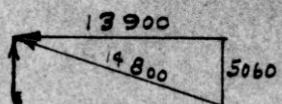




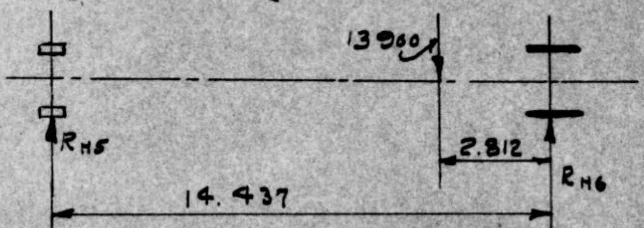
Forces in horizontal plane
R_{H3} = 5700 R_{H4} = 4200

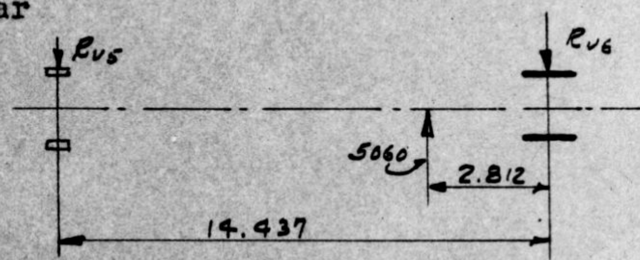
Forces in vertical plane
R_{V3} = 2070 R_{V4} = 1530

R_{R4} = 4500# @ 20° R_{R3} = 6000# @ 20°



Propeller Shaft Gear



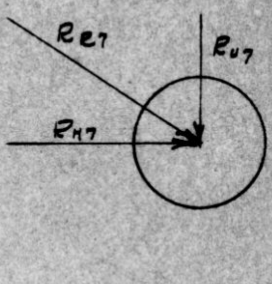


Forces in Horizontal plane
R_{H5} = 2700 R_{H6} = 11200

Forces in vertical plane
R_{V5} = 980 R_{V6} = 4080

R_{R6} = 12000# @ 20°

We will consider the total load on the rear bearing of the propeller shaft.

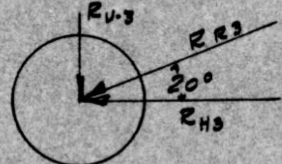


$R_{H6} - R_{H3}$ = 11200 - 5700 = R_{H7} = 5500 lb.

$R_{V3} + R_{V6}$ = 4080 + 2070 = R_{V7} = 6150 lb.

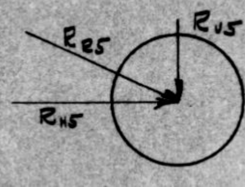
R_{R7} = 8250 lb. @48° above horizontal

Inside of prop shaft



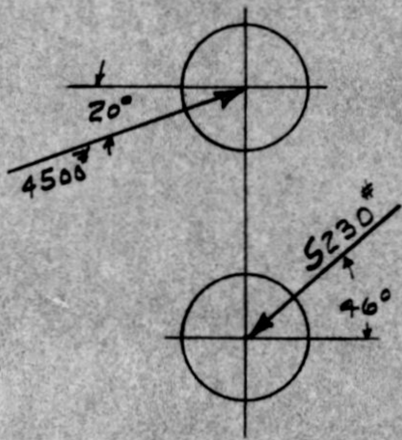
R_{R3} = 6000 lb. @ 20° above horiz

Front bearing of prop shaft

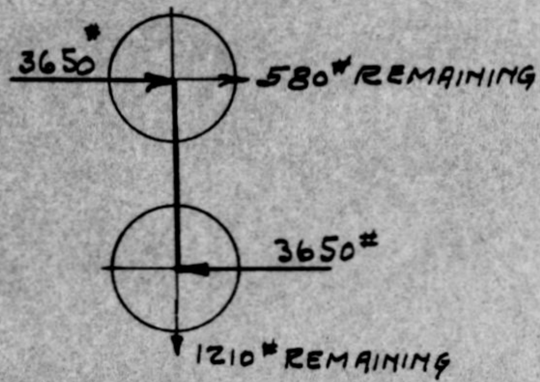


R_{R5} = 2900 lb. at 20°

By passing a plane thru the diaphragm containing the first stage end bearings,



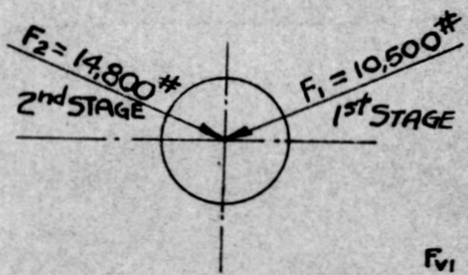
these two forces may be resolved into horizontal and vertical components, leaving a force and a couple acting on the diaphragm.



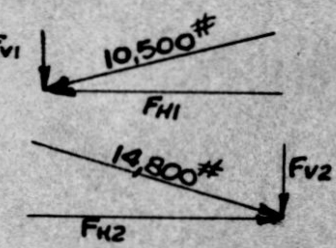
The remaining diaphragms contain only one forse as shown on assembly sketch. The reactions of these forces must be taken by the gear case necessitating heavy construction in order to obtain any reasonable degree of rigidity.

Construction #2 -- Without Center Bearing

Facing forward, looking at the end of jack shaft.



We will resolve these forces into their vertical and horizontal components



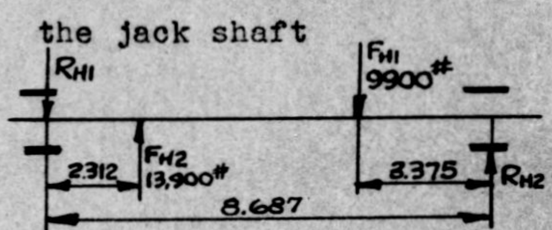
F_{V1} = 3600 lb.

F_{H1} = 9900 lb.

F_{V2} = 5060 lb.

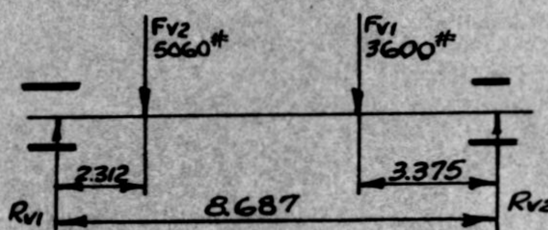
F_{H2} = 13,900 lb.

We will now pass a plane thru the vectors of the forces on the jack shaft



Forces in horizontal plane

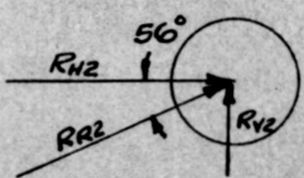
R_{H1} = 6350# R_{H2} = 2350#



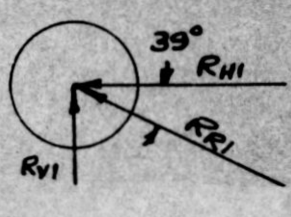
Forces in vertical plane

R_{V1} = 5120# R_{V2} = 3540#

We will now consider the total load on each bearing of the jack shaft.

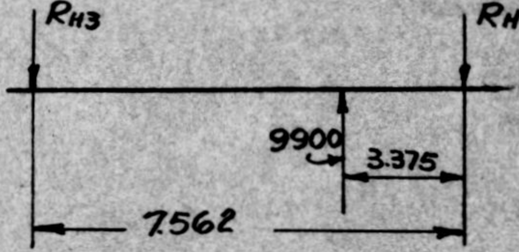


R_{R2} = 4250# @ 56°



R_{R1} = 8160# @ 39°

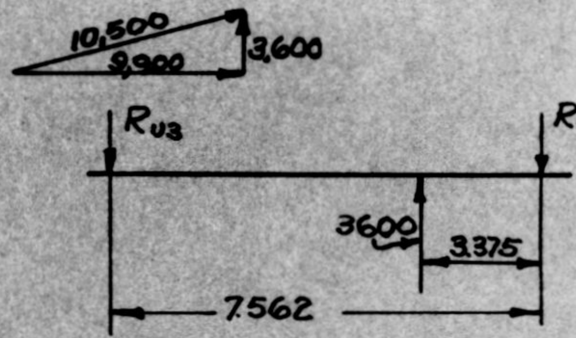
1st Stage Pinion



Forces in horizontal plane

$R_{H3} = 4400^{\#}$ $R_{H4} = 5500^{\#}$

$R_{R4} = 5820^{\#}$ @ 20°

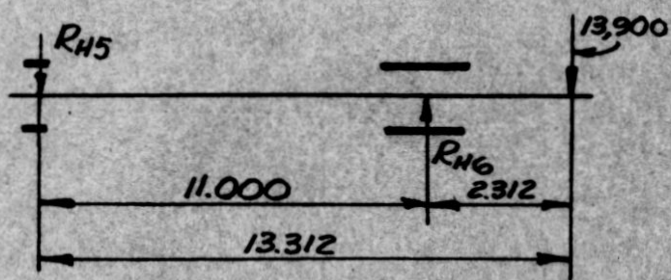


Forces in vertical plane

$R_{V3} = 1600^{\#}$ $R_{V4} = 2000^{\#}$

$R_{R3} = 4680^{\#}$ @ 20°

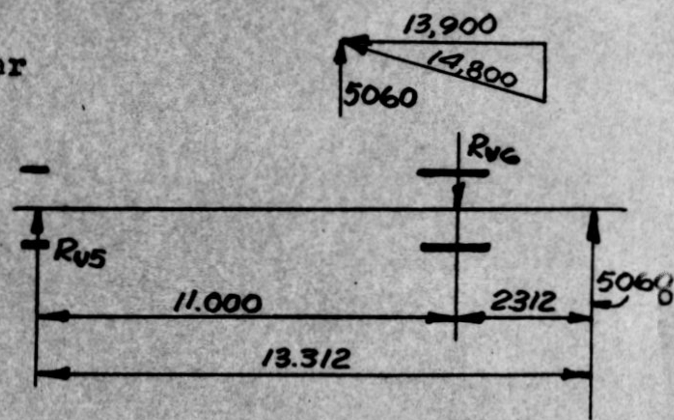
Propeller Shaft Gear



Forces in horizontal plane

$R_{H5} = 2920^{\#}$ $R_{H6} = 13,900^{\#}$

$R_{R5} = 3110^{\#}$ @ 20°



Forces in vertical plane

$R_{V5} = 1060^{\#}$ $R_{V6} = 5060^{\#}$

$R_{R6} = 14,800^{\#}$ @ 20°

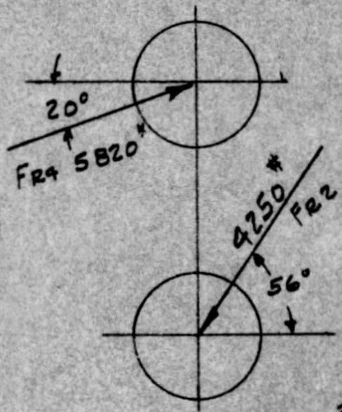
We will now consider the total load on the rear bearing of the propeller shaft.

$$R_{H6} - R_{H3} = R_{H7} = 9,500 \text{ lb.}$$

$$R_{V6} + R_{V3} = R_{V7} = 6,660 \text{ lb.}$$

$R_{R7} = 11,500$ lb. @ 35° above horizontal

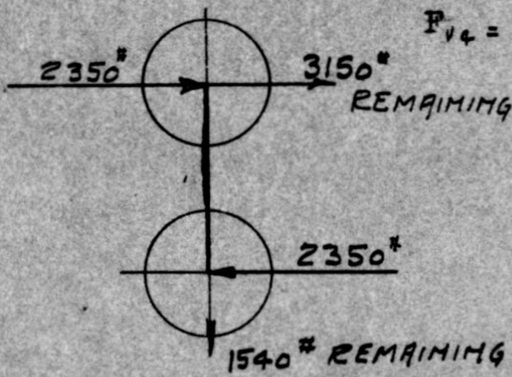
By passing a plane thru the diaphragm containing the first stage end bearing,



these two forces may be resolved into horizontal and vertical components leaving a force and a couple acting on the engine.

F_{V2} = 3540 lb. F_{H2} = 2350 lb.

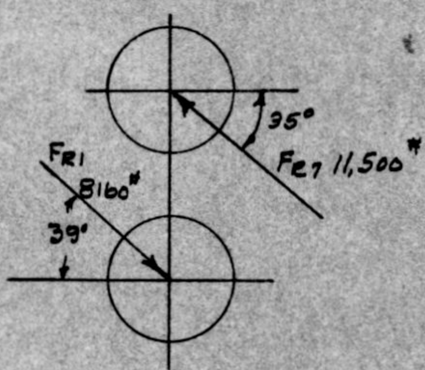
F_{V4} = 2000 lb. F_{H4} = 5500 lb.

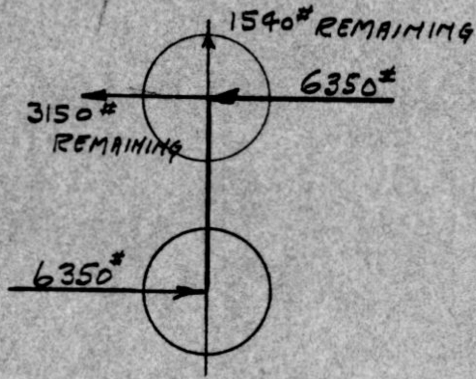


By passing a plane thru the diaphragm containing the second stage forward bearings

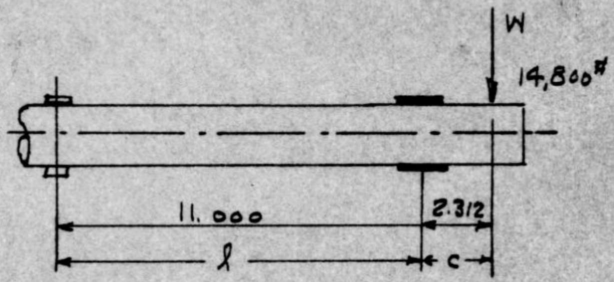
F_{H7} = 9500 lb. F_{V7} = 6660 lb.

F_{H-1} = 6350 lb. F_{V1} = 5120 lb.





Deflection of Propeller Shaft



I.D. of shaft 3.437

O.D. of shaft 4.125

$d = \frac{Wc^2}{3EI}(c + l)$; $I = \frac{\pi}{64}(D^4 - d^4)$

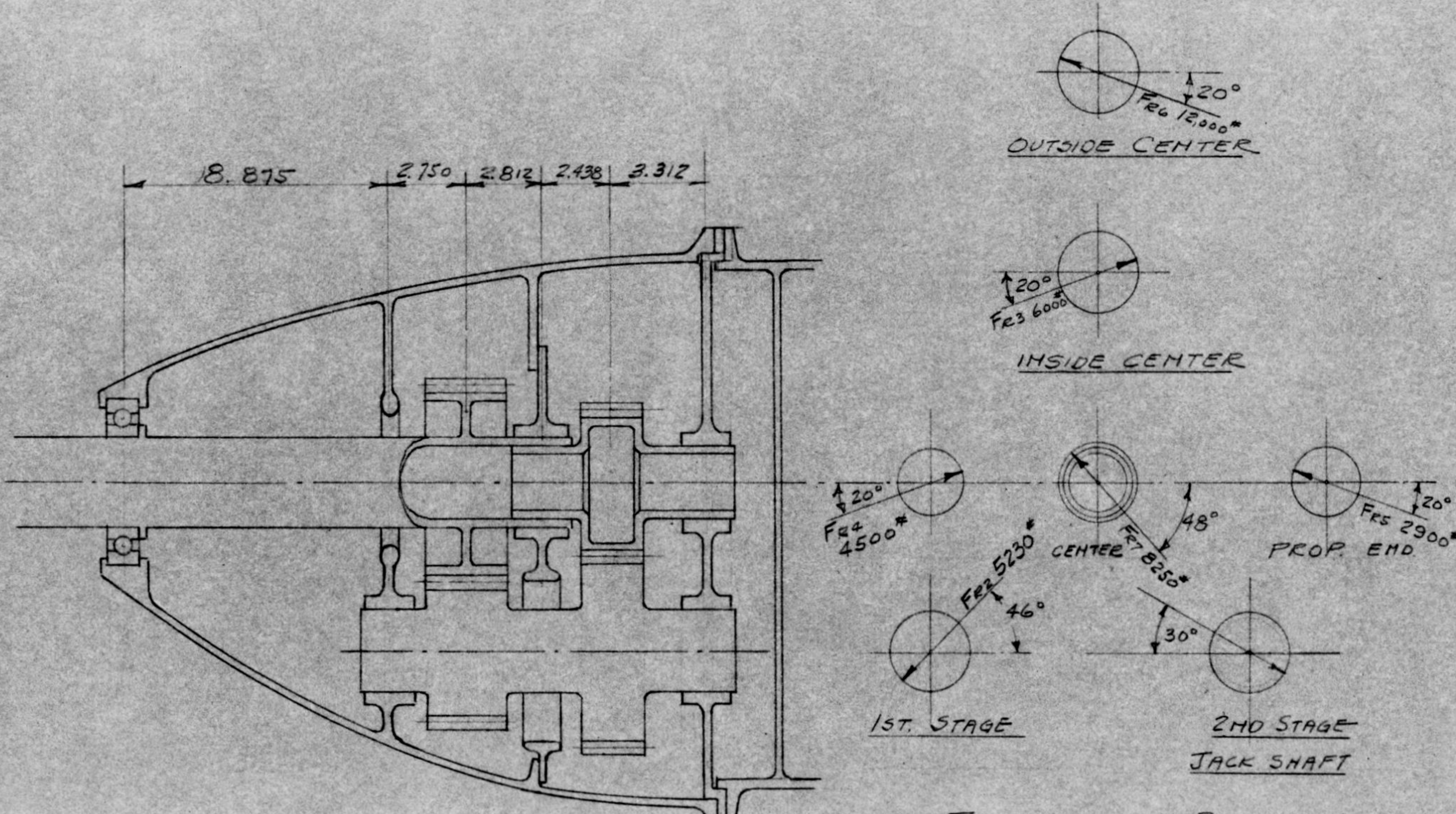
Mchery - Page 343 (Case 8) Max stress $\frac{Wc}{Z}$; $Z = \frac{\pi}{32}\frac{D^4 - d^4}{D}$

$I = 7.35$ $c = 2.312$ $c^2 = 5.34$

$$d = \frac{14{,}800 \times 5.34}{3 \times 29{,}000{,}000 \times 7.35} = \frac{79{,}000}{640{,}000{,}000} = .000123 \text{ inch}$$

Max stress $Z = \frac{I}{R} = \frac{7.35}{2.062} = 3.56$

$$s = \frac{14{,}800 \times 2.312}{3.56} = 9{,}600 \text{ lb. per sq. inch}$$



FORCES ON BEARINGS

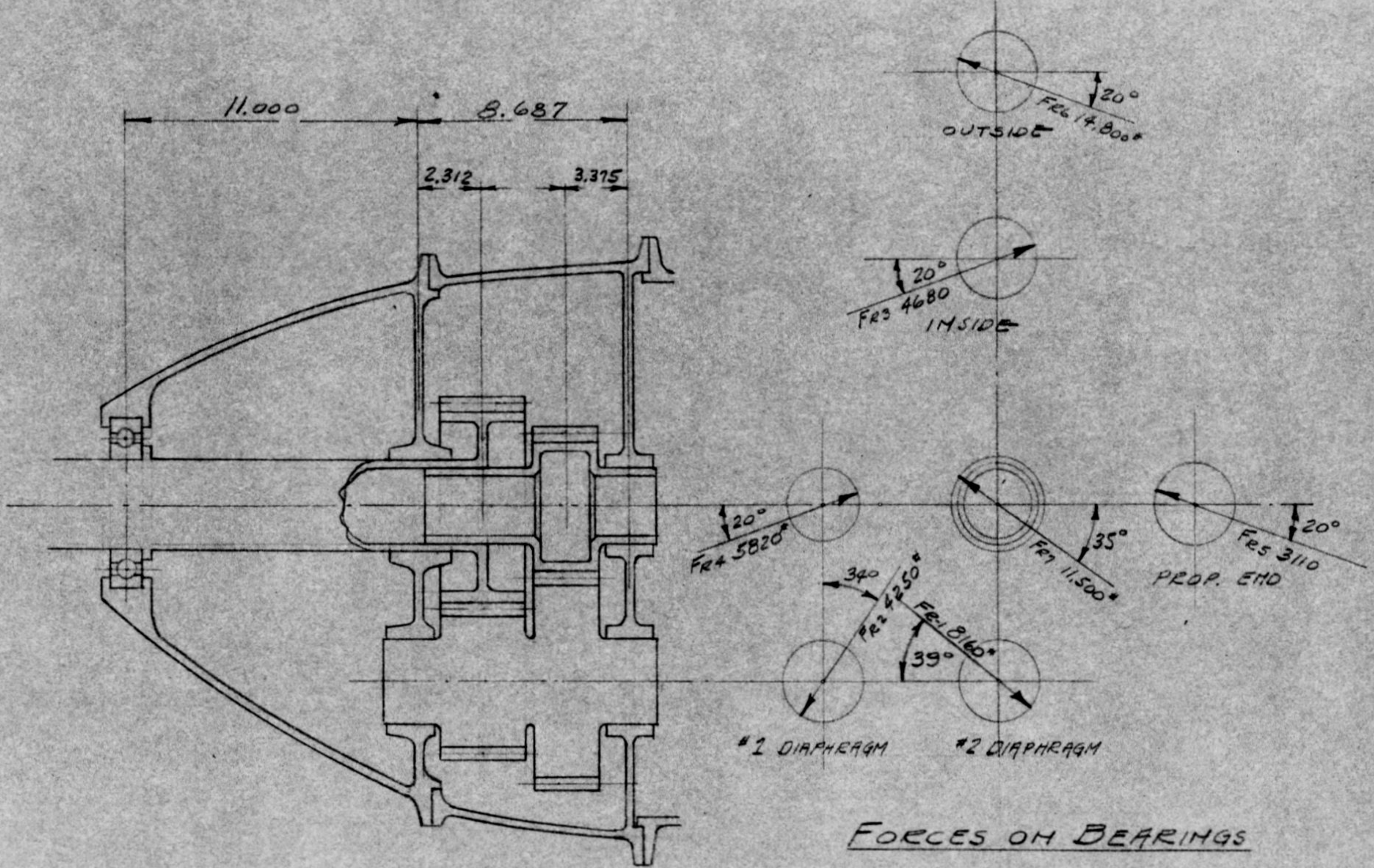
1000 H.P. REDUCTION GEARS

CONSTRUCTION NO 1

FOR O-1430-1 ENGINE

APR. 3-34

D.R. #56
SHEET 10



FORCES ON BEARINGS

1000 H.P. REDUCTION GEARS

CONSTRUCTION NO. 2

FOR O-1430-1 ENGINE

D.R #56
SHEET 11

APR. 3-34