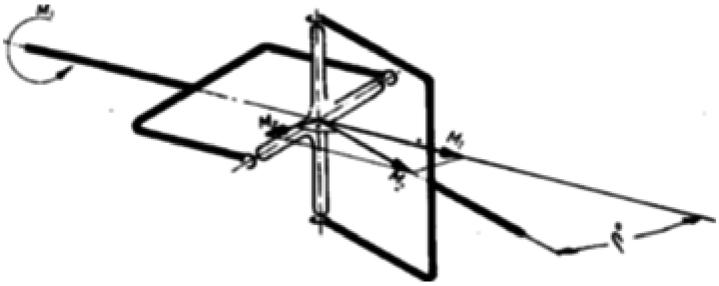
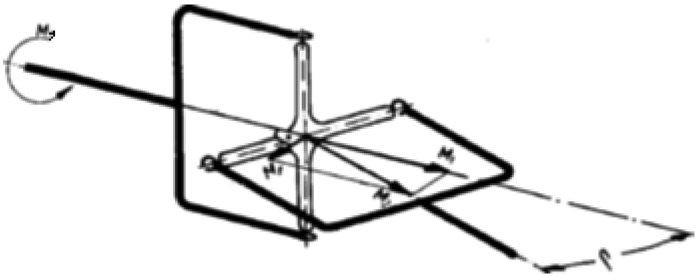
Bearing Forces and Bending Moments

By deflecting the moment in the joint, the additional moment M_Z acts on the fork. For the joint shown in Fig. 21, M_2 and M_Z are calculated by dividing the moments vectors:

Fig. 21:



Position 0° and 180°
$M_2 = M_1 \cdot \cos ß$
$M_Z = M_1 \cdot \sin ß$



Position 90° and 270°
$M_2 = M_1 \cdot 1/\cos ß$
$M_Z = M_1 \cdot \tan ß$

7.1 Bearing Forces in Z-Arrangement

The additional moment M_Z exerts forces on the bearing which apply bending stresses to the shaft. Fig. 22 shows the additional moments and bearing forces in the 0° and 90° position.

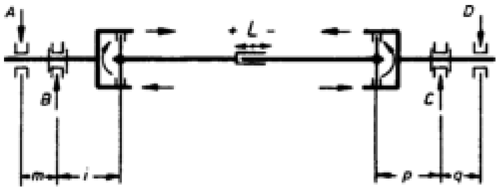
Fig. 22:

side view

top view

Position at $\alpha_1 = 0° = 180°$
Propeller shaft centre under bending stress.

$A = B = C = D = 0$



Position at $\alpha_1 = 90° = 270°$
Input and output shaft under bending stress

$$A = B = \frac{M_1 \cdot \tan\beta}{m}$$

$$C = D = \frac{M_1 \cdot \tan\beta}{q}$$

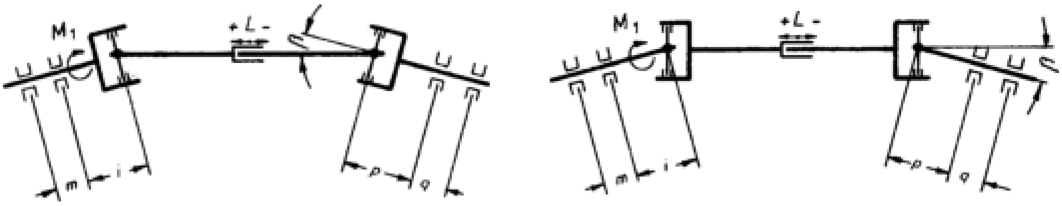
The bearing forces swing between zero and maximum twice per rotation.

7.2 Bearing Forces in W-Arrangement

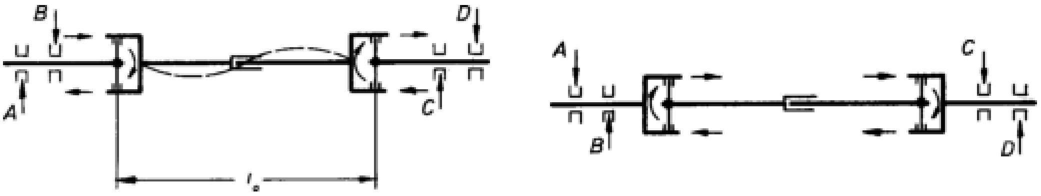
According to Fig. 23, in this arrangement the following additional moments and bearing forces apply:

Fig. 23:

side view



top view



Position $\alpha_1 = 0° = 180°$
Propeller shaft centre and input and output shafts under bending stress.

Position $\alpha_1 = 90° = 270°$
Input and output shafts under bending stress.

$$A = \frac{2 \cdot M_1 \cdot \sin\beta \cdot i}{l_O \cdot m}$$

$$B = \frac{2 \cdot M_1 \cdot \sin\beta \cdot (m + i)}{l_O \cdot m} \qquad A=B= \frac{M_1 \cdot \tan\beta}{m}$$

$$D = \frac{2 \cdot M_1 \cdot \sin\beta \cdot p}{l_O \cdot q} \qquad C=D= \frac{M_1 \cdot \tan\beta}{q}$$

$$C = \frac{2 \cdot M_1 \cdot \sin\beta \cdot (p + q)}{l_O \cdot q}$$

The bearing forces swing between minimum and maximum twice per rotation.

7.3 Displacement Force on Propeller Shafts with Length Extension

To displace the sliding piece under the effect of torque, a displacement force L is required which must be supported by the bearing A, B, C, D.

The maximum displacement force is:

$$L = 2 \cdot \mu \cdot M_1 \cdot \left(\frac{1}{d_t \cdot \mathrm{cost}\,\tau \cdot \cos\beta} + \frac{\tan\beta}{C}\right)$$

where

μ = Coefficient of friction. For hardened, nitrated and/or phosphatized parts, $\mu = 0{,}1$ can be assumed; for rilsan-coated parts, $\mu = 0{,}06$

M_1 = drive torque

d_t = reference diameter of sliding profile (see table)

τ = angle between tooth flank and centre point beam (see table)

C = profile overlap (tooth engagement length, see table)

Table

Profile to DIN 5480	$d_t \cdot \cos \tau$ [m]	C_{min} [m]
38 x 2	0,0310	0,072
52 x 2,5	0,0427	0,100
55 x 2,5	0,0452	0,105
62 x 2	0,0503	0,075
65 x 2,5	0,0539	0,125
75 x 2,5	0,0626	0,145
90 x 2,5	0,0758	0,175
95 x 2	0,0789	0,085

This gives the bearing forces:

$$B_{axial} = C_{axial} = L \cdot \cos \beta$$

$$A = \frac{L \cdot \sin \beta \cdot i}{m}$$

$$B = \frac{L \cdot \sin \beta \, (i + m)}{m}$$

$$C = \frac{L \cdot \sin \beta \, (p + q)}{q}$$

$$D = \frac{L \cdot \sin \beta \cdot p}{q}$$

Usually only axial forces are significant.