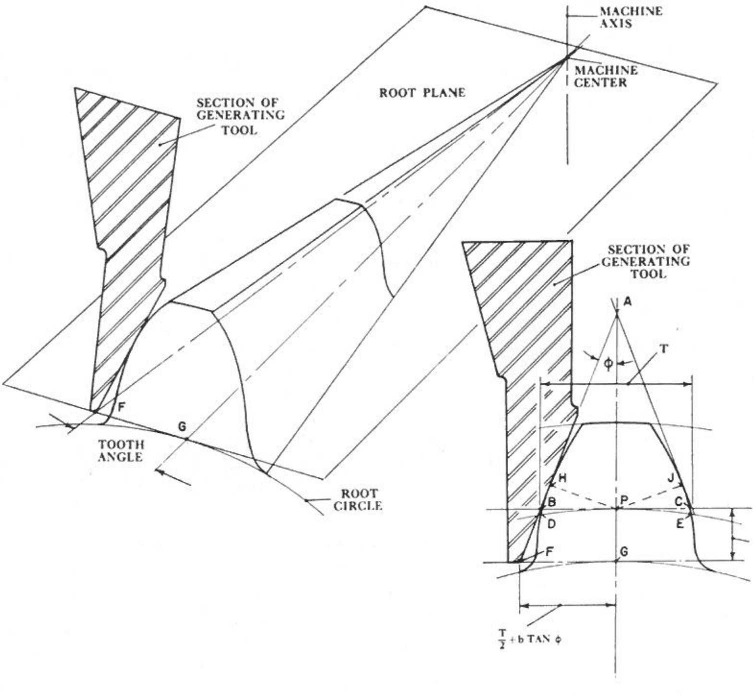

Figure 6—The tooth angle is the angle at the machine center between the line to the center of the tooth and the line to the point of the tool.

CALCULATIONS FOR 20° STRAIGHT BEVEL GEAR DIMENSIONS

Calculations for the dimensions of straight bevel gears should be recorded on a form sheet such as shown on page 9.

The following remarks refer to numbered items on the form sheet:

(4) Face Width. It is strongly recommended that the face width of bevel gears does not exceed one-third of the outer cone distance or $\frac{10\text{ in.}}{DP}$, whichever is smaller. In best design the ratio of face width to outer cone distance will be from 0.25 to 0.3. Increasing the face width over recommended proportions by adding to the small ends of the teeth adds strength and durability theoretically, but at a rapidly diminishing rate. Such practice results in manufacturing difficulties by requiring tools of less point width and decreases possible fillet radii. It may even increase the danger of breakage and wear if the load becomes concentrated on the small ends of the teeth

(6) Whole Depth. Unless smooth bottoms are required, it is recommended that gears of 10 DP and coarser be roughed 0.005 in. deeper than the calculated whole depth so that finishing tools will not cut on their ends. The calculated whole depth is, of course, used for the finishing operation.

(7) Pressure Angle. The standard pressure angle is 20 degrees. However, those who prefer lower pressure angles may use 14½ degrees on the ratios included in Table 3. The 20 degree pressure angle should be used on all aircraft applications where strength is of prime importance, and on all instrument gears which are to run without backlash.

(14) Dedendum. The value computed in this item is used in subsequent calculations. However, the actual dedendum will be greater by 0.002 inches.

(21) Circular Thickness. Values of K are obtained from the graph, Figure 7. Note that K equals zero for ratios from miters to 1.5 to 1 ratio. Also note that K equals zero in all cases when the number of pinion teeth exceeds 24.

(22) Backlash. Table 2 gives the recommended backlash when the gear and pinion are finished and assembled ready to run. The amount to be used should be entered in this item. Because of manufacturing tolerances and changes caused by heat treatment it may be necessary in cutting the teeth to allow for more than one-half the tabular value in item (23) in order to obtain the desired backlash in assembly.

(25) Tooth Angle. The tooth angle is a machine setting in Gleason two-tool straight bevel gear generators. As shown in Figure 6, it is the angle at the machine center between the line to the center of the tooth and the line to the point of the tool.

(26) Limit Point Width at Large End. The limit point width is the point width of a straight-sided V tool of given pressure angle which will touch both sides and the bottom of a finished tooth space.

(27) Limit Point Width at Small End.

(28) Tool Point Width. This value must be less than the limit point width at the small end and greater than one-half the limit point width at the large end.

(29) Tool Advance. The tool advance is a machine setting to extend the tool and cut deeper. Its purpose is to increase the clearance along the full length of the tooth. The 0.002 in. in the formula for clearance is obtained in this way.

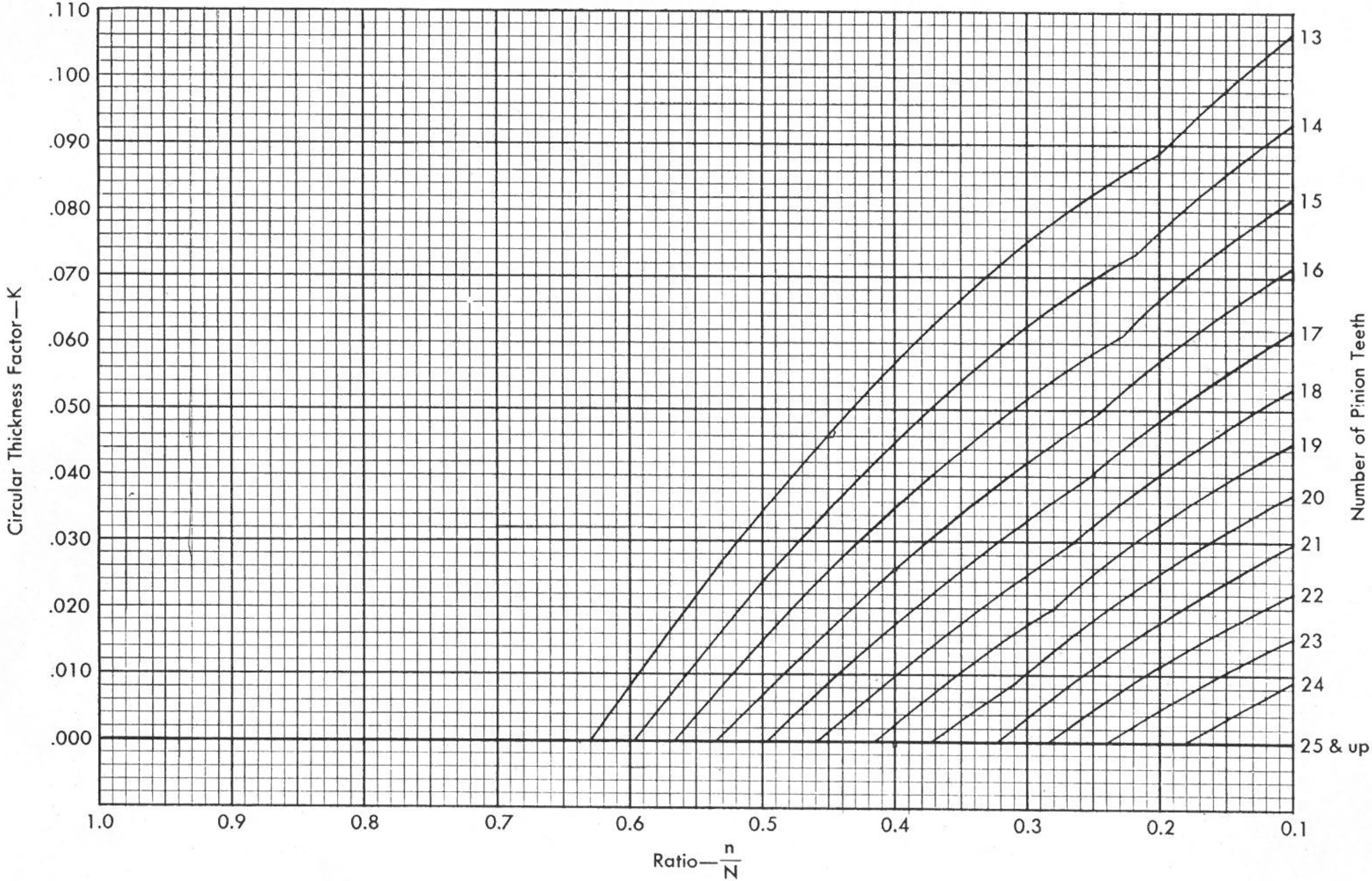

Figure 7 — Circular Thickness Factor.

STRAIGHT BEVEL GEAR DIMENSIONS (All Linear Dimensions in Inches)

1 Number of Pinion Teeth	(Table 1)	n	16	5 Working Depth	$h_k = \frac{2.000}{P_d}$	0.400
2 Number of Gear Teeth	(Table 1)	N	49	6 Whole Depth	$h_t = \frac{2.188}{P_d} + 0.002$	0.440
3 Diametral Pitch		P_d	5	7 Pressure Angle	ϕ	20°
4 Face Width		F	1.5	8 Shaft Angle	Σ	90°

	PINION		GEAR	
9 Pitch Diameter	$d = \frac{n}{P_d}$	3.2000	$D = \frac{N}{P_d}$	9.8000
10 Pitch Angle	$\gamma = \tan^{-1}\frac{n}{N}$	18°5′	$\Gamma = 90° - \gamma$	71°55′
11 Outer Cone Distance	$A_O = \frac{D}{2 \sin \Gamma}$	5.1546		
12 Circular Pitch	$p = \frac{3.1416}{P_d}$	0.6283		
13 Addendum	$a_{OP} = h_k - a_{OG}$	0.282	$a_{OG} = \frac{0.540}{P_d} + \frac{0.460}{P_d(N/n)^2}$	0.118
14 Dedendum*	$b_{OP} = \frac{2.188}{P_d} - a_{OP}$	0.156	$b_{OG} = \frac{2.188}{P_d} - a_{OG}$	0.320
15 Clearance	$c = h_t - h_k$	0.040		
16 Dedendum Angle	$\delta_P = \tan^{-1}\frac{b_{OP}}{A_O}$	1°44′	$\delta_G = \tan^{-1}\frac{b_{OG}}{A_O}$	3°33′
17 Face Angle of Blank	$\gamma_O = \gamma + \delta_G$	21°38′	$\Gamma_O = \Gamma + \delta_P$	73°39′
18 Root Angle	$\gamma_R = \gamma - \delta_P$	16°21′	$\Gamma_R = \Gamma - \delta_G$	68°22′
19 Outside Diameter	$d_O = d + 2a_{OP} \cos \gamma$	3.736	$D_O = D + 2a_{OG} \cos \Gamma$	9.873
20 Pitch Apex to Crown	$x_O = \frac{D}{2} - a_{OP} \sin \gamma$	4.812	$X_O = \frac{d}{2} - a_{OG} \sin \Gamma$	1.488
21 Circular Thickness	$t = p - T$	0.3814	$T = \frac{p}{2} - (a_{OP} - a_{OG}) \tan \phi - \frac{K \text{ (Fig. 7)}}{P_d}$	0.2469
22 Backlash	$B =$ (Table 2)	0.005-0.007		
23 Chordal Thickness	$t_c = t - \frac{t^3}{6d^2} - \frac{B}{2}$	0.378	$T_c = T - \frac{T^3}{6D^2} - \frac{B}{2}$	0.244
24 Chordal Addendum	$a_{CP} = a_{OP} + \frac{t^2 \cos \gamma}{4d}$	0.293	$a_{CG} = a_{OG} + \frac{T^2 \cos \Gamma}{4D}$	0.118
25 Tooth Angle	$\frac{3438}{A_O}\left(\frac{t}{2} + b_{OP} \tan \phi\right)$ Minutes	2°45′	$\frac{3438}{A_O}\left(\frac{T}{2} + b_{OG} \tan \phi\right)$ Minutes	2°40′
26 Limit Point Width (L.E.)	$W_{LOP} = (T - 2b_{OP} \tan \phi) - 0.0015$	0.132	$W_{LOG} = (t - 2b_{OG} \tan \phi) - 0.0015$	0.147
27 Limit Point Width (S.E.)	$W_{LiP} = \frac{A_O - F}{A_O}(T - 2b_{OP} \tan \phi) - 0.0015$	0.093	$W_{LiG} = \frac{A_O - F}{A_O}(t - 2b_{OG} \tan \phi) - 0.0015$	0.104
28 Tool Point Width	$W = W_{LiP}$ − Stock Allowance	0.075	$W = W_{LiG}$ − Stock Allowance	0.075
29 Tool Advance		0.002		0.002

*The actual dedendum will be 0.002 inches greater than calculated.

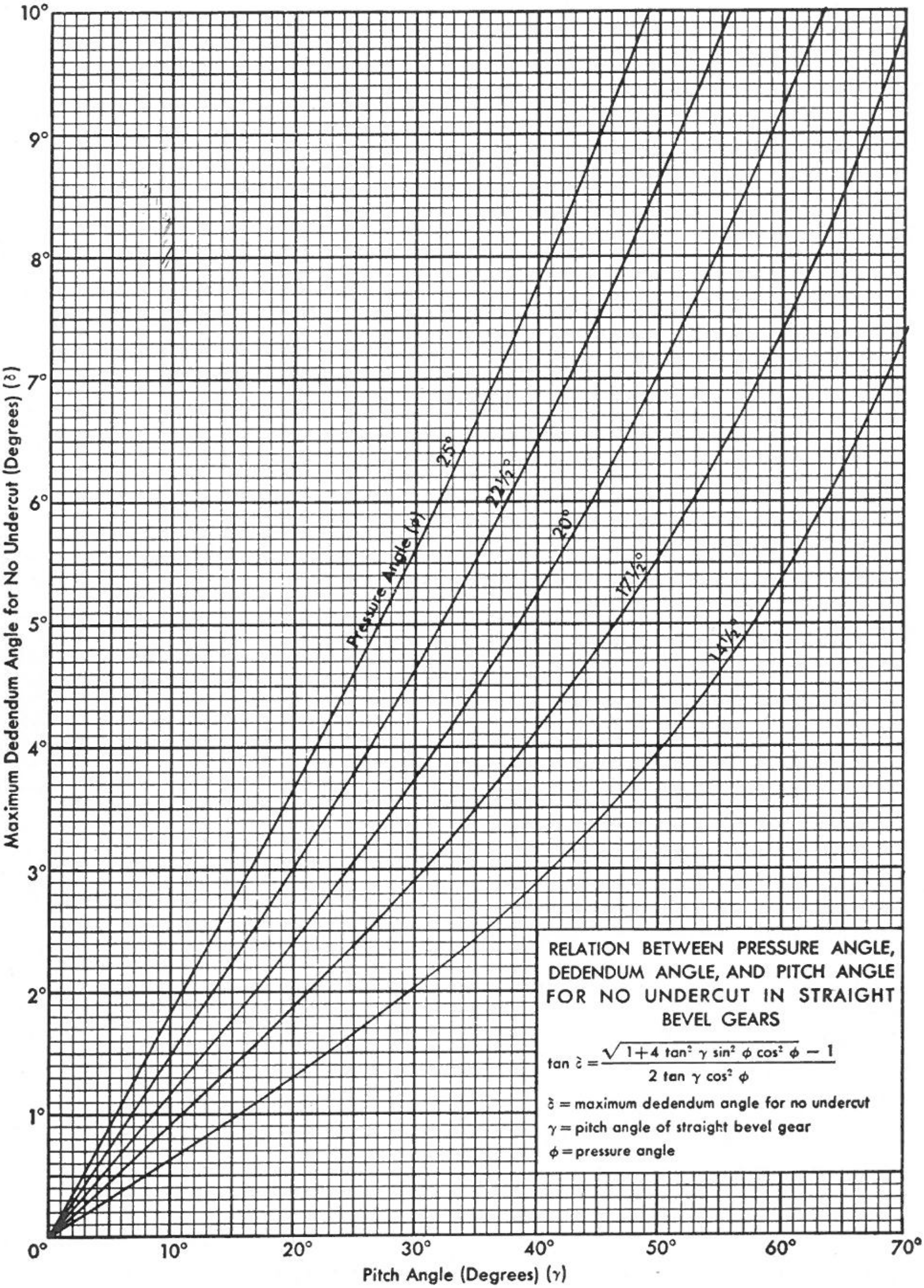

Figure 8—Relation between the dedendum angle and pitch angle at which undercut begins to occur in generating straight bevel gears using sharp-cornered tools.

DATA FOR ANGULAR STRAIGHT BEVEL GEARS

Angular bevel gears are bevel gears whose shafts are at an angle other than 90°. The formulas on page 9 are not directly applicable in calculating the dimensions of angular gears. Therefore, a summary of procedure for angular gears is outlined below in order of calculation, with the item numbers in parentheses referring to the items on page 9:

Using item numbers (1), (2), (3), (4), and (8), which are given, calculate items (5), (6), and (9) from the formulas given.

(10) Pitch Angles

Case I—Shaft Angle (Σ) less than 90°.

$$\tan \gamma = \frac{\sin \Sigma}{\frac{N}{n} + \cos \Sigma}; \ \Gamma = \Sigma - \gamma$$

Case II—Shaft Angle (Σ) greater than 90°. If Γ is greater than 90° (internal gear) calculations should be referred to the Gleason Works to determine whether the gears may be cut.

$$\tan \gamma = \frac{\sin (180° - \Sigma)}{\frac{N}{n} - \cos (180° - \Sigma)}; \ \Gamma = \Sigma - \gamma$$

In either case above $\frac{\sin \gamma}{\sin \Gamma} = \frac{n}{N}$

(11), (12) . . . Formulas same as given.

(13) Determination of the **tooth proportions** necessitates computing the equivalent 90° bevel gear ratio.

$$\text{Equivalent } 90° \text{ ratio } m_{90} = \sqrt{\frac{N \cos \gamma}{n \cos \Gamma}}$$

The value so computed should be used as the ratio $\left(\frac{N}{n}\right)$ when determining the gear addendum in this formula.

(13), (14) . . . Formulas same as given. [See explanation in preceding paragraph for item (13)].

(15), (16), (17), (18), (19) . . . Formulas same as given.

(20) Pitch Apex to Crown

$$x_O = A_O \cos \gamma - a_{OP} \sin \gamma$$
$$X_O = A_O \cos \Gamma - a_{OG} \sin \Gamma$$

(7) Pressure Angle

The pressure angle is given by the graph Fig. 8.

The point of intersection on the graph of the dedendum angle and pitch angle must be on or below the line representing the selected pressure angle.

(21) Except for high ratios, the value of K may be made equal to zero for angular gears.

(22), (23), (24), (25), (26), (27), (28), (29) . . . Formulas same as given.

Angular gears require special **ratio of roll gears** for generating on the Gleason generators. The decimal ratio for the NC/75 ratio gears is found by the following formula:

$$\text{Decimal ratio of gears} = \frac{A_O P_d}{37.5}$$

The work roll is found in the usual manner from the decimal ratio.