Design of Internal Helical Gears

Earle Buckingham
Eliot K. Buckingham
Buckingham Associates,
Springfield, VT

In principal, the design of internal helical gear teeth is the same as that for external helical gears. Any of the basic rack forms used for external helical gears may be applied to internal helical gears. The internal gear drive, however, has several limitations; not only all those which apply to external gears, but also several others which are peculiar to internal gears. As with external gears, in order to secure effective tooth action, interferences must be avoided. The possible interferences on an internal gear drive are as follows:

1. Involute interference. To avoid this, all of the working profile of the internal tooth must be of involute form.

2. Tip interference. This exists when the tips of the pinion teeth interfere with the tips of the internal gear teeth as the teeth come into and go out of mesh. To avoid this, the size of the pinion must be a sufficient amount smaller than the size of the internal gear.

3. Fillet interference. This exists when the tips of the teeth

AUTHOR:

MR. ELIOT BUCKINGHAM *is President of Buckingham Associates, Inc., a gear consulting firm. He received his B.S. from the Massachusetts Institute of Technology and his M.S. from the University of New Mexico. During his career he has worked as an engineer and supervisor for several companies, and he was also an instructor at the University of Mexico. He has been a gear consultant since 1960. Mr. Buckingham is the author of numerous articles on gearing. A member of ASME, he is also Registered Professional Engineer in the State of Vermont.*

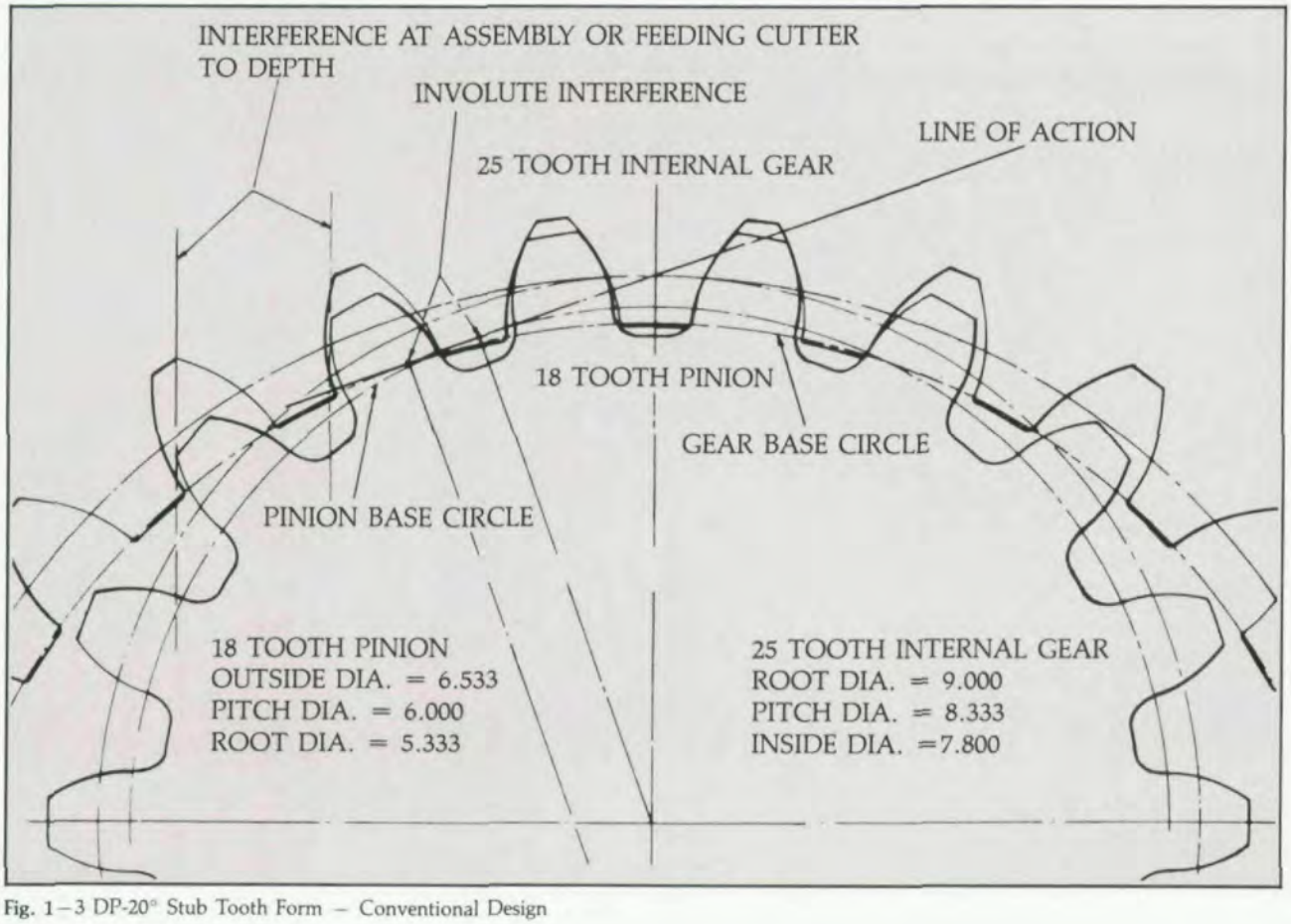

Fig. 1–3 DP-20° Stub Tooth Form – Conventional Design

of one member interfere with the fillets at the roots of the teeth of the mating member. Proper tooth proportions must be selected to avoid this interference.

Another limitation on the assembly of the drive must sometimes be considered. When the difference in the numbers of teeth between the pinion and internal gear is small, the tooth action may be correct, but it may not be possible to assemble the pair, except by sliding them together in an axial direction. In many cases, this may not be objectionable, but in other cases, it may prevent the assembly of the drive.

At the present time, the methods available for producing the internal helical gear tooth forms are limited in number. These internal gear tooth forms may be formed by casting, shaping with a formed tool or by milling with a formed milling cutter. For the more accurate internal gears, however, only one method of generating these internal gear tooth forms is generally available – the use of a pinion-shaped or Fellows' cutter. In this case, the size of the cutter imposes certain restrictions on the tooth proportions of the internal gear. If the cutter is too large, the tips of two or more teeth in the internal gear will be trimmed as the cutter is fed to depth. To avoid this, smaller, special cutters are often employed. However, if the cutter is too small, imperfect tooth forms will be developed on the internal gear.

To secure an effective internal gear drive, much more effort must be put into its design than into that of external gears. The most practical design for generated gears will be one which avoids the need for special cutters.

There are three major uses for internal helical gears; namely, internal gear drives or simple pairs, internal differential drives and internal plantary drives. The following data pertains to these three applications.

The 20° stub involute system (in the plane of rotation) is the form used on standard helical cutters and will, therefore, be used for these drives. In order to avoid involute interference, the internal radius of the internal gear must be increased over the conventional size for the smaller gears. In order to maintain effective contact, the size of the pinion must be increased over the conventional size. In order to generate full involute profiles on the internal gear teeth, the cutter must have not less than 16 teeth.

The following tooth proportions for pinions of 16 teeth and larger will meet the foregoing conditions:

When,

R_0 = Outside Radius of Pinion
R_1 = Pitch Radius of Pinion
N_1 = Number of Teeth in Pinion
N_2 = Number of Teeth in Internal Gear
R_2 = Pitch Radius of Internal Gear
R_i = Internal Radius of Internal Gear
C = Center Distance
P = Diametral Pitch

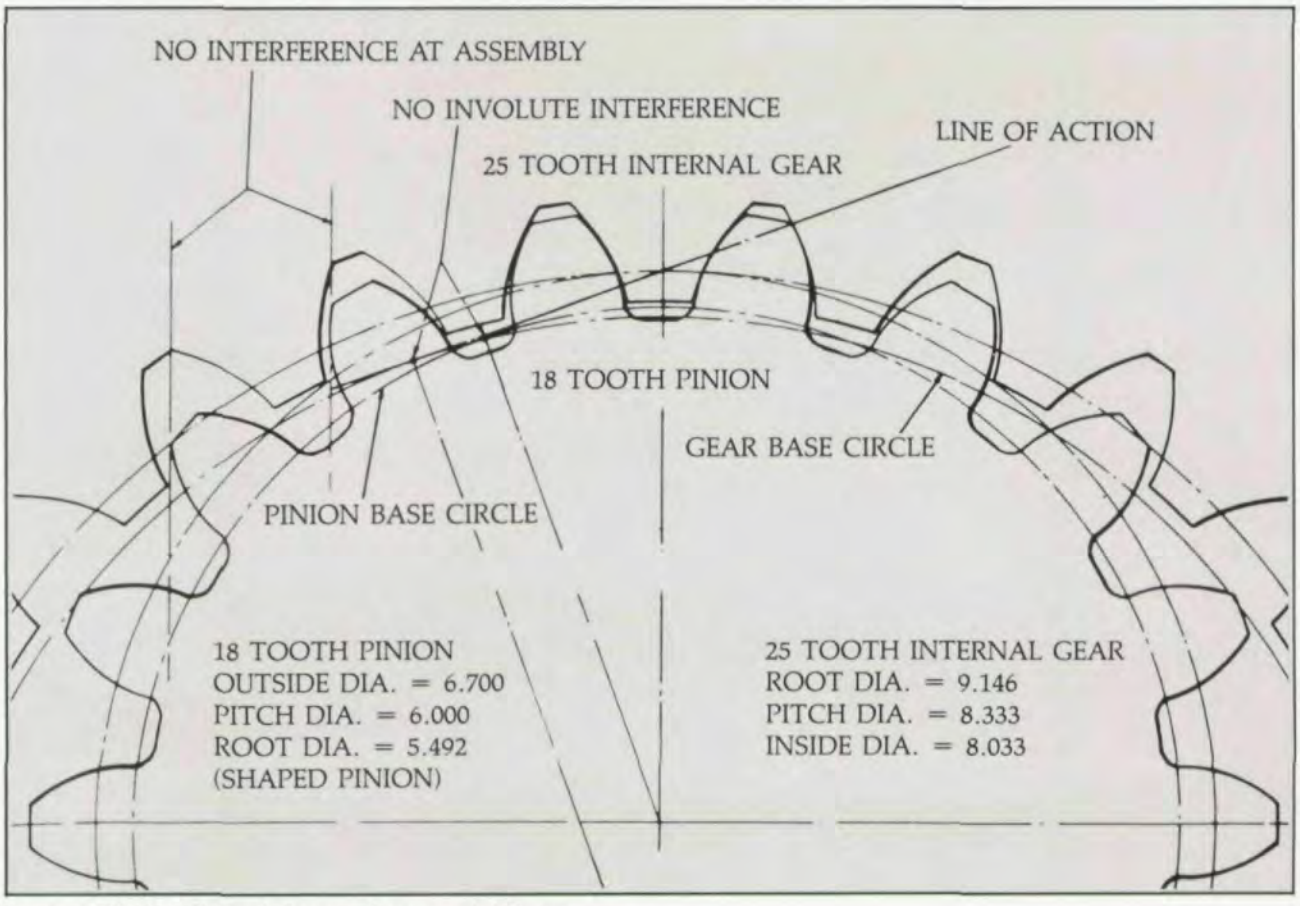

Fig. 2–3 DP-20° Stub Tooth Form – Recommended Design

Then,

$$_1=\frac{N_1}{2P} \qquad R_2=\frac{N_2}{2P}$$

$$C=\frac{N_2-N_1}{2P}=R_2-R_1$$

$$R_0=\frac{N_1+2.100}{2P}=R_1+\frac{1.050}{P}$$

$$R_i=\frac{N_2-.900}{2P}=R_2-\frac{.450}{P}$$

T_1 = Arc Tooth Thickness of Pinion at R_1
T_2 = Arc Tooth Thickness of Internal Gear at R_2

$$T_1=\frac{1.7528}{P} \qquad T_2=\frac{1.3888}{P}$$

When the number of teeth in the pinion is less than 16, the pinion and internal gear must be enlarged still more.

To avoid trimming when feeding the cutter to depth on the internal gear, the gear must be seven or more teeth larger than the cutter.

To avoid dragging on relief while cutting, the gear may need to be up to 15 teeth larger than the cutter.

The following tables give the proportions of 1 DP small pinions from five to 16 teeth, to run at standard center distances with the internal helical gears tabulated on Tables 4-9 inclusive. For other diametral pitches, the tabulated values must be divided by the diametral pitch used. No allowance for backlash has been made in these tables. With these small pinions, the backlash should be obtained by cutting the teeth of the internal helical gear deeply enough to obtain the backlash desired.

ACKNOWLEDGEMENT: *The above material is taken from the* Revised Manual of Gear Design, Section 3, *©1980 by Eliot K. Buckingham. Reprinted by permission of the author.*

TABLE 1
PROPORTIONS OF 1 DP SMALL PINIONS (SHAPED) FOR INTERNAL HELICAL GEAR DRIVES – 20° STUB TOOTH FORM

No. of TEETH	OUTSIDE RADIUS	PITCH RADIUS	BASE RADIUS	TOOTH THICKNESS AT R_1	$\sqrt{R_0^2-R_{b1}^2}$
N_1	R_{01}	R_1	R_{b1}	T_1	
5	3.958	2.500	2.34923	2.0858	3.1863
6	4.466	3.000	2.81908	2.0555	3.4638
7	4.924	3.500	3.28892	2.0253	3.6645
8	5.383	4.000	3.75887	1.9950	3.8532
9	5.841	4.500	4.22862	1.9647	4.0293
10	6.300	5.000	4.69846	1.9344	4.1969
11	6.758	5.500	5.16831	1.9042	4.3542
12	7.216	6.000	5.63816	1.8739	4.5035
13	7.675	6.500	6.10800	1.8436	4.6473
14	8.133	7.000	6.57785	1.8133	4.7830
15	8.592	7.500	7.04769	1.7831	4.9145
16	9.050	8.000	7.51754	1.7528	5.0387

TABLE 2
ROOT RADIUS OF 1 DP SMALL PINIONS (SHAPED) FOR INTERNAL HELICAL GEAR DRIVES
20° STUB TOOTH FORM

PINION TEETH	NUMBER OF TEETH IN CUTTER					
N_1	18	21	25	28	32	35
5	2.1049	2.1126	2.1217	2.1274	2.1337	2.1380
6	2.5765	2.5825	2.5904	2.5953	2.6007	2.6045
7	3.0454	3.0516	3.0570	3.0624	3.0674	3.0707
8	3.5146	3.5196	3.5256	3.5290	3.5334	3.5361
9	3.9827	3.9872	3.9920	3.9950	3.9988	4.0012
10	4.4501	4.4538	4.4579	4.4604	4.4639	4.4653
11	4.9165	4.9197	4.9231	4.9254	4.9277	4.9296
12	5.3824	5.3849	5.3877	5.3895	5.3915	5.3929
13	5.8472	5.8493	5.8515	5.8528	5.8544	5.8559
14	6.3116	6.3132	6.3148	6.3160	6.3174	6.3193
15	6.7751	6.7764	6.7777	6.7786	6.7794	6.7803
16	7.2381	7.2387	7.2397	7.2405	7.2412	7.2416

TABLE 3
ROOT RADIUS OF 1 DP SMALL PINIONS (SHAPED) FOR INTERNAL HELICAL GEAR DRIVES
20° STUB TOOTH FORM

PINION TEETH	NUMBER OF TEETH IN CUTTER					
N_1	42	49	56	63	70	84
5	2.1460	2.1524	2.1575	2.1618	2.1653	2.1721
6	2.6116	2.6170	2.6219	2.6258	2.6286	2.6338
7	3.0767	3.0816	3.0856	3.0890	3.0916	3.0961
8	3.5415	3.5456	3.5491	3.5521	3.5544	3.5580
9	4.0059	4.0091	4.0123	4.0145	4.0166	4.0200
10	4.4693	4.4724	4.4749	4.4770	4.4786	4.4816
11	4.9328	4.9353	4.9374	4.9391	4.9405	4.9429
12	5.3956	5.3976	5.3994	5.4006	5.4019	5.4039
13	5.8579	5.8598	5.8610	5.8622	5.8631	5.8646
14	6.3198	6.3211	6.3222	6.3231	6.3239	6.3250
15	6.7815	6.7824	6.7834	6.7839	6.7846	6.7857
16	7.2425	7.2433	7.2438	7.2445	7.2449	7.2455

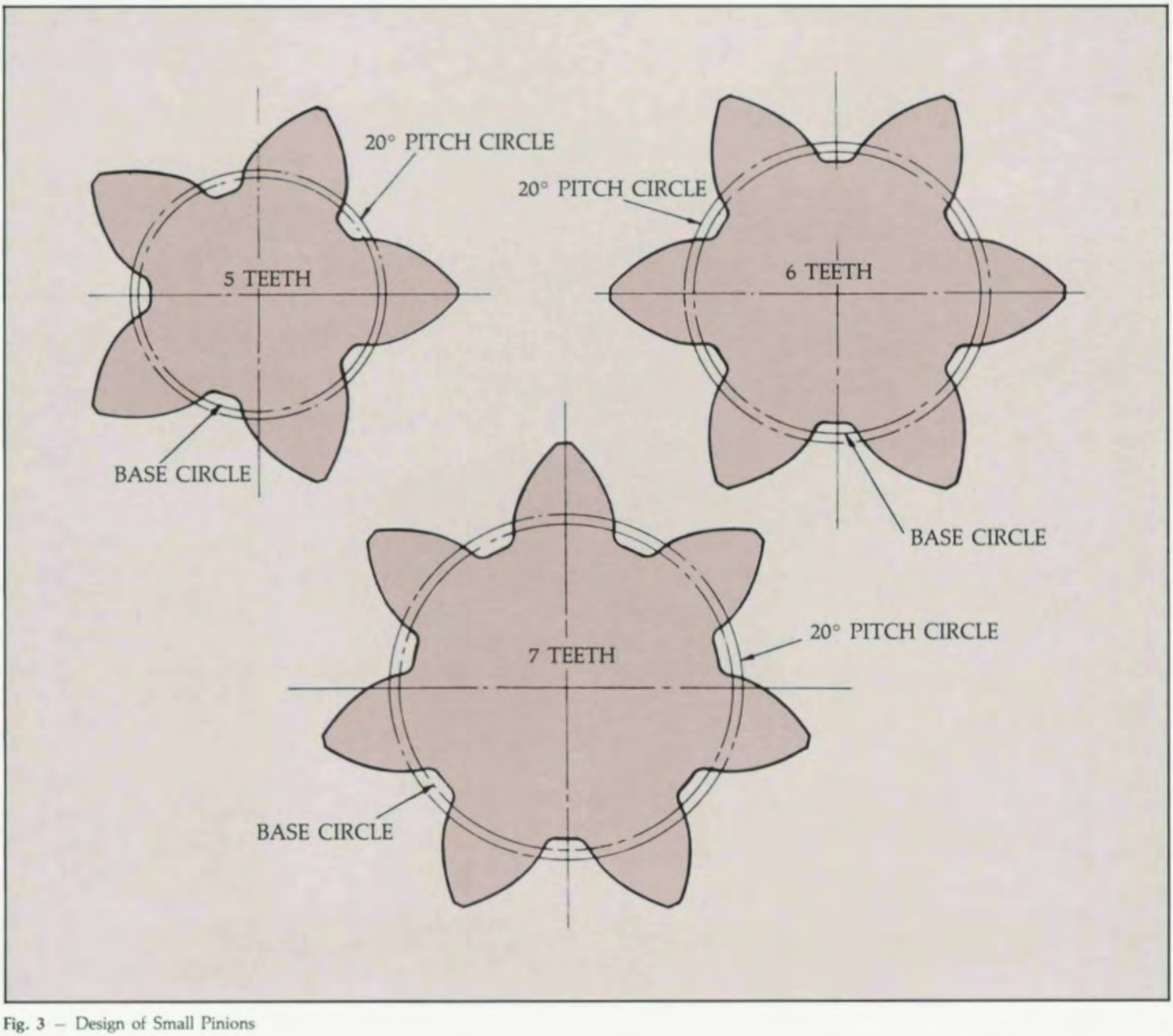

Fig. 3 – Design of Small Pinions

TABLE 4

PROPORTIONS OF 1 DP INTERNAL HELICAL GEARS – 20° STUB INVOLUTE FORM MESHING WITH SMALL PINIONS – 5 TO 16 TEETH							
NO. OF GEAR TEETH		NUMBER OF TEETH IN PINION					
		5	6	7	8	9	10
25	R_r*	14.038	14.010	13.981	13.954	13.924	13.898
	R_i**	12.391	12.360	12.329	12.298	12.267	12.236
26	R_r	14.544	14.516	14.487	14.460	14.430	14.403
	R_i	12.891	12.860	12.829	12.798	12.767	12.736
27	R_r	15.050	15.022	14.993	14.966	14.936	14.908
	R_i	13.391	13.360	13.329	13.298	13.267	13.236
28	R_r	15.556	15.528	15.499	15.471	15.441	15.412
	R_i	13.891	13.860	13.829	13.798	13.767	13.736
29	R_r	16.062	16.034	16.005	15.976	15.946	15.916
	R_i	14.391	14.361	14.329	14.298	14.267	14.236
30	R_r	16.568	16.539	16.510	16.480	16.450	16.420
	R_i	14.891	14.861	14.829	14.798	14.767	14.736
31	R_r	17.073	17.044	17.015	16.984	16.954	16.923
	R_i	15.391	15.360	15.329	15.298	15.267	15.236
32	R_r	17.578	17.549	17.519	17.488	17.457	17.426
	R_i	15.891	15.860	15.829	15.798	15.767	15.736
33	R_r	18.083	18.053	18.023	17.992	17.960	17.929
	R_i	16.391	16.360	16.329	16.298	16.267	16.236
34	R_r	18.587	18.557	18.526	18.295	18.463	18.432
	R_i	16.891	16.860	16.829	16.798	16.767	16.736
35	R_r	19.091	19.061	19.030	18.998	18.966	18.934
	R_i	17.391	17.360	17.329	17.298	17.267	17.236
36	R_r	19.595	19.564	19.533	19.501	19.469	19.436
	R_i	17.891	17.860	17.829	17.798	17.767	17.736
37	R_r	20.099	20.067	20.036	20.004	19.972	19.938
	R_i	18.391	18.360	18.329	18.298	18.267	18.236
38	R_r	20.602	20.570	20.538	20.506	20.474	20.440
	R_i	18.891	18.860	18.829	18.798	18.767	18.736
39	R_r	21.105	21.073	21.041	21.009	20.976	20.942
	R_i	19.391	19.360	19.329	19.298	19.267	19.236
40	R_r	21.608	21.575	21.543	21.511	21.478	21.444
	R_i	19.891	19.860	19.829	19.798	19.767	19.736
41	R_r	22.111	22.078	22.046	22.013	21.980	21.946
	R_i	20.391	20.360	20.329	20.298	20.267	20.236
42	R_r	22.613	22.580	22.548	22.515	22.481	22.447
	R_i	20.891	20.860	20.829	20.798	20.767	20.736
43	R_r	23.116	23.083	23.050	23.017	22.983	22.949
	R_i	21.391	21.360	21.329	21.298	21.267	21.236
44	R_r	23.618	23.585	23.552	23.518	23.484	23.450
	R_i	21.891	21.860	21.829	21.798	21.767	21.736
45	R_r	24.120	24.087	24.054	24.020	23.986	23.952
	R_i	22.391	22.360	22.329	22.298	22.267	22.236
46	R_r	24.622	24.589	24.555	24.521	24.487	24.453
	R_i	22.891	22.860	22.829	22.798	22.767	22.736
47	R_r	25.124	25.091	25.057	25.023	24.989	24.954
	R_i	23.391	23.360	23.329	23.298	23.267	23.236
48	R_r	25.626	25.592	25.558	25.524	25.490	25.455
	R_i	23.891	23.860	23.829	23.798	23.767	23.736
49	R_r	26.128	26.094	26.060	26.026	25.991	25.956
	R_i	24.391	24.360	24.329	24.298	24.267	24.236
50	R_r	26.629	26.595	26.561	26.527	26.492	26.457
	R_i	24.891	24.860	24.829	24.798	24.767	24.736

*R_r – Root radius. **R_i – Internal radius of internal gear.

TABLE 5

PROPORTIONS OF 1 DP INTERNAL HELICAL GEARS – 20° STUB INVOLUTE FORM MESHING WITH SMALL PINIONS – 5 TO 16 TEETH							
NO. OF GEAR TEETH		NUMBER OF TEETH IN PINION					
		5	6	7	8	9	10
51	R_r	27.131	27.097	27.063	27.028	26.993	26.958
	R_i	25.391	25.360	25.329	25.298	25.267	25.236
52	R_r	27.632	27.598	27.564	27.529	27.494	27.459
	R_i	25.891	25.860	25.829	25.798	25.767	25.736
53	R_r	28.134	28.100	28.065	28.030	27.995	27.960
	R_i	26.391	26.360	26.329	26.298	26.267	26.236
54	R_r	28.635	28.601	28.566	28.531	28.496	28.460
	R_i	26.891	26.860	26.829	26.798	26.767	26.736
55	R_r	29.137	29.102	29.067	29.032	28.997	28.961
	R_i	27.391	27.360	27.329	27.298	27.267	27.236
56	R_r	29.638	29.603	29.568	29.533	29.498	29.462
	R_i	27.891	27.860	27.829	27.798	27.767	27.736
57	R_r	30.140	30.104	30.069	30.034	29.999	29.963
	R_i	28.391	28.360	28.329	28.298	28.267	28.236
58	R_r	30.641	30.605	30.570	30.535	30.500	30.464
	R_i	28.891	28.860	28.829	28.798	28.767	28.736
59	R_r	31.142	31.107	31.071	31.036	31.000	30.965
	R_i	29.391	29.360	29.329	29.298	29.267	29.236
60	R_r	31.643	31.608	31.572	31.537	31.501	31.465
	R_i	29.891	29.860	29.829	29.798	29.767	29.736
61	R_r	32.144	32.109	32.073	32.038	32.002	31.966
	R_i	30.391	30.360	30.329	30.298	30.267	30.236
62	R_r	32.645	32.610	32.574	32.539	32.502	32.466
	R_i	30.891	30.860	30.829	30.798	30.767	30.736
63	R_r	33.146	33.111	33.075	33.040	33.003	32.967
	R_i	31.391	31.360	31.329	31.298	31.267	31.236
64	R_r	33.647	33.612	33.575	33.540	33.504	33.467
	R_i	31.891	31.860	31.829	31.798	31.767	31.736
65	R_r	34.148	34.113	34.076	34.041	34.004	33.968
	R_i	32.391	32.360	32.329	32.298	32.267	32.236
66	R_r	34.649	34.613	34.577	34.541	34.504	34.468
	R_i	32.891	32.860	32.829	32.798	32.767	32.736
67	R_r	35.150	35.114	35.078	35.042	35.005	34.969
	R_i	33.391	33.360	33.329	33.298	33.267	33.236
68	R_r	35.651	35.615	35.579	35.543	35.506	35.470
	R_i	33.891	33.860	33.829	33.798	33.767	33.736
69	R_r	36.152	36.116	36.080	36.044	36.007	35.970
	R_i	34.391	34.360	34.329	34.298	34.267	34.236
70	R_r	36.653	36.616	36.580	36.544	36.507	36.470
	R_i	34.891	34.860	34.829	34.798	34.767	34.736
71	R_r	37.154	37.117	37.081	37.045	37.008	36.971
	R_i	35.391	35.360	35.329	35.298	35.267	35.236
72	R_r	37.655	37.618	37.582	37.545	37.508	37.471
	R_i	35.891	35.860	35.829	35.798	35.767	35.736
73	R_r	38.155	38.119	38.082	38.046	38.009	37.971
	R_i	36.391	36.360	36.329	36.298	36.267	36.236
74	R_r	38.656	38.619	36.583	38.546	38.509	38.472
	R_i	36.891	36.860	36.829	36.798	36.767	36.736
75	R_r	39.156	39.120	39.083	39.047	39.009	38.973
	R_i	37.391	37.360	37.329	37.298	37.267	37.236

TABLE 6

PROPORTIONS OF 1 DP INTERNAL HELICAL GEARS – 20° STUB INVOLUTE FORM MESHING WITH SMALL PINIONS – 5 TO 16 TEETH							
NO. OF GEAR TEETH		NUMBER OF TEETH IN PINION					
		5	6	7	8	9	10
76	R_r	39.657	39.621	39.584	39.547	39.510	39.473
	R_i	37.891	37.860	37.829	37.798	37.767	37.736
77	R_r	40.157	40.121	40.084	40.048	40.010	39.973
	R_i	38.391	38.360	38.329	38.298	38.267	38.236
78	R_r	40.658	40.622	40.585	40.548	40.511	40.474
	R_i	38.891	38.860	38.829	38.798	38.767	38.736
79	R_r	41.158	41.122	41.085	41.049	41.011	40.974
	R_i	39.391	39.360	39.329	39.298	39.267	39.236
80	R_r	41.659	41.623	41.586	41.549	41.511	41.474
	R_i	39.891	39.860	39.829	39.798	39.767	39.736
81	R_r	42.160	42.124	42.086	42.050	42.012	41.975
	R_i	40.391	40.360	40.329	40.298	40.267	40.236
82	R_r	42.661	42.624	42.587	42.550	42.512	42.475
	R_i	40.891	40.860	40.829	40.798	40.767	40.736
83	R_r	43.161	43.125	43.087	43.051	43.013	42.975
	R_i	41.391	41.360	41.329	41.298	41.267	41.236
84	R_r	43.662	43.625	43.587	43.551	43.513	43.476
	R_i	41.891	41.860	41.829	41.798	41.767	41.736
85	R_r	44.162	44.126	44.088	44.052	44.013	43.976
	R_i	42.391	42.360	42.329	42.298	42.267	42.236
86	R_r	44.663	44.626	44.588	44.552	44.514	44.476
	R_i	42.891	42.860	42.829	42.798	42.767	42.736
87	R_r	45.163	45.127	45.089	45.052	45.014	44.977
	R_i	43.391	43.360	43.329	43.298	43.267	43.236
88	R_r	45.664	45.627	45.589	45.553	45.514	45.477
	R_i	43.891	43.860	43.829	43.798	43.767	43.736
89	R_r	46.165	46.128	46.090	46.053	46.015	45.977
	R_i	44.391	44.360	44.329	44.298	44.267	44.236
90	R_r	46.665	46.628	46.590	46.553	46.515	46.477
	R_i	44.891	44.860	44.829	44.798	44.767	44.736
91	R_r	47.166	47.129	47.091	47.054	47.016	46.978
	R_i	45.391	45.360	45.329	45.298	45.267	45.236
92	R_r	47.666	47.629	47.591	47.554	47.516	47.478
	R_i	45.891	45.860	45.829	45.798	45.767	45.736
93	R_r	48.167	48.130	48.092	48.054	48.016	47.978
	R_i	46.391	46.360	46.329	46.298	46.267	46.236
94	R_r	48.667	48.630	48.592	48.555	48.517	48.479
	R_i	46.891	46.860	46.829	46.798	46.767	46.736
95	R_r	49.168	49.130	49.092	49.055	49.017	48.979
	R_i	47.391	47.360	47.329	47.298	47.267	47.236
96	R_r	49.668	49.631	49.593	49.555	49.517	49.479
	R_i	47.891	47.860	47.829	47.798	47.767	47.736
97	R_r	50.169	50.131	50.093	50.056	50.018	49.980
	R_i	48.391	48.360	48.329	48.298	48.267	48.236
98	R_r	50.669	50.631	50.593	50.556	50.518	50.480
	R_i	48.891	48.860	48.829	48.798	48.767	48.736
99	R_r	51.170	51.132	51.094	51.056	51.018	50.980
	R_i	49.391	49.360	49.329	49.298	49.267	49.236
100	R_r	51.761	51.632	51.594	51.556	51.518	51.480
	R_i	49.891	49.860	49.829	49.798	49.767	49.736

(continued on page 42)

SHARP!

The CNC Controlled Hob Sharpening Machines

Our advanced hob sharpener, the SNC-30 with its high productivity and field proven design is now complemented with the introduction of Klingelnberg's SNC-50. The model SNC-50 offers the same economical advantages and high accuracies to both large hob manufacturers and users, as the SNC-30 has in the past.

The operator friendly SNC series provides unparalleled speed and accuracy during wet grinding of straight or spiral fluted hobs up to 20.5" OD and flute depths to 5.1".

A host of standard features, like fully programmable grinding cycles, self-diagnostics, automatic wheel dressing and profiling for spiral flutes complement the traditionally excellent Klingelnberg design.

For gear manufacturers using a wide variety of hobs, an expandable program storage capacity (up to 120 part programs) can be provided.

The SNC-30 and -50 models are suitable for grinding with vitrified, CBN or Diamond grinding wheels for total hob sharpening flexibility.

For further details on how you can SHARPEN hobs and your bottom line, contact:

Klingelnberg Corporation, 15200 Foltz Industrial Parkway, Cleveland, OH 44136 .
Phone (216) 572-2100; FAX: (216) 572-0985.

KLINGELNBERG

CIRCLE A-18 ON READER REPLY CARD

(continued from page 40)

TABLE 7

PROPORTIONS OF 1 DP INTERNAL HELICAL GEARS – 20° STUB INVOLUTE FORM MESHING WITH SMALL PINIONS – 5 TO 16 TEETH							
NO. OF GEAR TEETH		NUMBER OF TEETH IN PINION					
		11	12	13	14	15	16
25	R_r	13.869	13.839	13.809	13.779	13.749	13.719
	R_i	12.205	12.174	12.143	12.112	12.081	12.050
26	R_r	14.373	14.343	14.313	14.282	14.251	14.220
	R_i	12.705	12.674	12.643	12.612	12.581	12.550
27	R_r	14.877	14.846	14.815	14.784	14.753	14.721
	R_i	13.205	13.174	13.143	13.112	13.081	13.050
28	R_r	15.381	15.351	15.320	15.288	15.255	15.222
	R_i	13.705	13.674	13.643	13.612	13.581	13.550
29	R_r	15.885	15.854	15.823	15.791	15.757	15.724
	R_i	14.205	14.174	14.143	14.112	14.081	14.050
30	R_r	16.389	16.357	16.325	16.293	16.259	16.225
	R_i	14.705	14.674	14.643	14.612	14.581	14.550
31	R_r	16.892	16.860	16.827	16.795	16.761	16.727
	R_i	15.205	15.174	15.143	15.112	15.081	15.050
32	R_r	17.395	17.362	17.329	17.297	17.263	17.228
	R_i	15.705	15.674	15.643	15.612	15.581	15.550
33	R_r	17.897	17.864	17.831	17.799	17.764	17.729
	R_i	16.205	16.174	16.143	16.112	16.081	16.050
34	R_r	18.399	18.366	18.333	18.300	18.265	18.230
	R_i	16.705	16.674	16.643	16.612	16.581	16.550
35	R_r	18.901	18.868	18.835	18.801	18.766	18.731
	R_i	17.205	17.174	17.143	17.112	17.081	17.050
36	R_r	19.403	19.370	19.336	19.302	19.267	19.231
	R_i	17.705	17.674	17.643	17.612	17.581	17.550
37	R_r	19.905	19.872	19.838	19.803	19.768	19.732
	R_i	18.205	18.174	18.143	18.112	18.081	18.050
38	R_r	20.407	20.373	20.339	20.304	20.269	20.233
	R_i	18.705	18.674	18.643	18.612	18.581	18.550
39	R_r	20.909	20.875	20.840	20.805	20.769	20.733
	R_i	19.205	19.174	19.143	19.112	19.081	19.050
40	R_r	21.410	21.376	21.341	21.306	21.270	21.234
	R_i	19.705	19.674	19.643	19.612	19.581	19.550
41	R_r	21.912	21.877	21.843	21.807	21.771	21.734
	R_i	20.205	20.174	20.143	20.112	20.081	20.050
42	R_r	22.414	22.378	22.343	22.307	22.271	22.235
	R_i	20.705	20.674	20.643	20.612	20.581	20.550
43	R_r	22.915	22.879	22.844	22.808	22.772	22.735
	R_i	21.205	21.174	21.143	21.112	21.081	21.050
44	R_r	23.416	23.380	23.345	23.309	23.273	23.236
	R_i	21.705	21.674	21.643	21.612	21.581	21.550
45	R_r	23.917	23.881	23.846	23.810	23.773	23.736
	R_i	22.205	22.174	22.143	22.112	22.081	22.050
46	R_r	24.418	24.382	24.347	24.310	24.273	24.237
	R_i	22.705	22.674	22.643	22.612	22.581	22.550
47	R_r	24.919	24.883	24.847	24.811	24.774	24.737
	R_i	23.205	23.174	23.143	23.112	23.081	23.050
48	R_r	25.420	25.384	25.348	25.311	25.274	25.237
	R_i	23.705	23.674	23.643	23.612	23.581	23.550
49	R_r	25.921	25.885	25.848	25.812	25.775	25.738
	R_i	24.205	24.174	24.143	24.112	24.081	24.050
50	R_r	26.421	26.386	26.349	26.313	26.276	26.238
	R_i	24.705	24.674	24.643	24.612	24.581	24.550

(continued on page 44)

Forest City Gear...the most modern fine and medium pitch gear job shop in the world!

Come visit our plant.

We have the edge...

- Crown hobbing.
- Hard hobbing with carbide hobs.
- CNC alignment programs for varying teeth and pitches.

The latest in CNC hobbing and shaping machines from:

- Koepfer
- Lorenz
- Liebherr
- Pfauter
- Mitsubishi

Come see our Mini Gear Machine Show. Forest City Gear is just 2 hours northwest of O'Hare Airport. Give us a call today to arrange your personal tour. We welcome our competitors.

FOREST CITY GEAR CO.

The Precision Gear Source

11715 Main Street • P. O. Box 80 • Roscoe, Illinois 61073 • 815/623-2168 • FAX: 815/623-6620

CIRCLE A-19 ON READER REPLY CARD

(continued from page 42)

TABLE 8

PROPORTIONS OF 1 DP INTERNAL HELICAL GEARS – 20° STUB INVOLUTE FORM MESHING WITH SMALL PINIONS – 5 TO 16 TEETH							
NO. OF GEAR TEETH		NUMBER OF TEETH IN PINION					
		11	12	13	14	15	16
51	R_r	26.922	26.887	26.850	26.813	26.776	26.738
	R_i	25.205	25.174	25.143	25.112	25.081	25.050
52	R_r	27.423	27.388	27.350	27.314	27.277	27.239
	R_i	25.705	25.674	25.643	25.612	25.581	25.550
53	R_r	27.924	27.889	27.851	27.814	27.777	27.739
	R_i	26.205	26.174	26.143	26.112	26.081	26.050
54	R_r	28.424	28.389	28.351	28.315	28.277	28.239
	R_i	26.705	26.674	26.643	26.612	26.581	26.550
55	R_r	28.925	28.890	28.852	28.815	28.777	28.739
	R_i	27.205	27.174	27.143	27.112	27.081	27.050
56	R_r	29.425	29.390	29.352	29.315	29.278	29.240
	R_i	27.705	27.674	27.643	27.612	27.581	27.550
57	R_r	29.926	29.891	29.853	29.816	29.778	29.740
	R_i	28.205	28.174	28.143	28.112	28.081	28.050
58	R_r	30.427	30.391	30.353	30.316	30.278	30.240
	R_i	28.705	28.674	28.643	28.612	28.581	28.550
59	R_r	30.927	30.892	30.854	30.817	30.779	30.740
	R_i	29.205	29.174	29.143	29.112	29.081	29.050
60	R_r	31.428	31.392	31.354	31.317	31.279	31.240
	R_i	29.705	29.674	29.643	29.612	29.581	29.550
61	R_r	31.929	31.893	31.855	31.818	31.780	31.740
	R_i	30.205	30.174	30.143	30.112	30.081	30.050
62	R_r	32.429	32.393	32.355	32.318	32.280	32.241
	R_i	30.705	30.674	30.643	30.612	30.581	30.550
63	R_r	32.930	32.893	32.855	32.818	32.780	32.741
	R_i	31.205	31.174	31.143	31.112	31.081	31.050
64	R_r	33.430	33.394	33.356	33.318	33.280	33.241
	R_i	31.705	31.674	31.643	31.612	31.581	31.550
65	R_r	33.931	33.894	33.856	33.818	33.780	33.741
	R_i	32.205	32.174	32.143	32.112	32.081	32.050
66	R_r	34.431	34.394	34.356	34.319	34.281	34.241
	R_i	32.705	32.674	32.643	32.612	32.581	32.550
67	R_r	34.932	34.895	34.857	34.819	34.781	34.741
	R_i	33.205	33.174	33.143	33.112	33.081	33.050
68	R_r	35.432	34.395	35.357	35.319	35.281	35.242
	R_i	33.705	33.674	33.643	33.612	33.581	33.550
69	R_r	35.933	35.895	35.857	35.819	35.781	35.742
	R_i	34.205	34.174	34.143	34.112	34.081	34.050
70	R_r	36.433	36.395	36.357	36.319	36.281	36.242
	R_i	34.705	34.674	34.643	34.612	34.581	34.550
71	R_r	36.934	36.896	36.858	36.820	36.782	36.742
	R_i	35.205	35.174	35.143	35.112	35.081	35.050
72	R_r	37.434	37.396	37.358	37.320	37.282	37.242
	R_i	35.705	35.674	35.643	35.612	35.581	35.550
73	R_r	37.935	37.896	37.858	37.820	37.782	37.742
	R_i	36.205	36.174	36.143	36.112	36.081	36.050
74	R_r	38.435	38.397	38.358	38.320	38.282	38.243
	R_i	36.705	36.674	36.643	36.612	36.581	36.550
75	R_r	38.935	38.897	38.858	38.820	38.782	38.743
	R_i	37.205	37.174	37.143	37.112	37.081	37.050

(continued on page 48)

(continued from page 44)

TABLE 9

PROPORTIONS OF 1 DP INTERNAL HELICAL GEARS – 20° STUB INVOLUTE FORM MESHING WITH SMALL PINIONS – 5 TO 16 TEETH							
NO. OF GEAR TEETH		NUMBER OF TEETH IN PINION					
		11	12	13	14	15	16
76	R_r	39.436	39.397	39.359	39.321	39.282	39.243
	R_i	37.705	37.674	37.643	37.612	37.581	37.550
77	R_r	39.936	39.898	39.859	39.821	39.782	39.743
	R_i	38.205	38.174	38.143	38.112	38.081	38.050
78	R_r	40.437	40.398	40.359	40.321	40.282	40.243
	R_i	38.705	38.674	38.643	38.612	38.581	38.550
79	R_r	40.937	40.898	40.859	40.821	40.782	40.743
	R_i	39.205	39.174	39.143	39.112	39.081	39.050
80	R_r	41.437	41.398	41.359	41.321	41.282	41.244
	R_i	39.705	39.674	39.643	39.612	39.581	39.550
81	R_r	41.938	41.899	41.860	41.822	41.783	41.744
	R_i	40.205	40.174	40.143	40.112	40.081	40.050
82	R_r	42.438	42.399	42.360	42.322	42.283	42.244
	R_i	40.705	40.674	40.643	40.612	40.581	40.550
83	R_r	42.938	42.899	42.860	42.822	42.783	42.744
	R_i	41.205	41.174	41.143	41.112	41.081	41.050
84	R_r	43.438	43.399	43.360	43.322	43.283	43.244
	R_i	41.705	41.674	41.643	41.612	41.581	41.550
85	R_r	43.938	43.899	43.860	43.822	43.783	43.744
	R_i	42.205	42.174	42.143	42.112	42.081	42.050
86	R_r	44.439	44.400	44.361	44.323	44.283	44.244
	R_i	42.705	42.674	42.643	42.612	42.581	42.550
87	R_r	44.939	44.900	44.861	44.823	44.783	44.744
	R_i	43.205	43.174	43.143	43.112	43.081	43.050
88	R_r	45.439	45.400	45.361	45.323	45.283	45.244
	R_i	43.705	43.674	43.643	43.612	43.581	43.550
89	R_r	45.939	45.900	45.861	45.823	45.783	45.744
	R_i	44.205	44.174	44.143	44.112	44.081	44.050
90	R_r	46.439	46.400	46.361	46.323	46.283	46.244
	R_i	44.705	44.674	44.643	44.612	44.581	44.550
91	R_r	46.940	46.901	46.862	46.824	46.784	46.744
	R_i	45.205	45.174	45.143	45.112	45.081	45.050
92	R_r	47.440	47.401	47.362	47.324	47.284	47.244
	R_i	45.705	45.674	45.643	45.612	45.581	45.550
93	R_r	47.940	47.901	47.862	47.824	47.784	47.744
	R_i	46.205	46.174	46.143	46.112	46.081	46.050
94	R_r	48.440	48.401	48.362	48.324	48.284	48.244
	R_i	46.705	46.674	46.643	46.612	46.581	46.550
95	R_r	48.940	48.901	48.862	48.824	48.784	48.744
	R_i	47.205	47.174	47.143	47.112	47.081	47.050
96	R_r	49.441	49.402	49.363	49.324	49.284	49.244
	R_i	47.705	47.674	47.643	47.612	47.581	47.550
97	R_r	49.941	49.902	49.863	49.824	49.784	49.744
	R_i	48.205	48.174	48.143	48.112	48.081	48.050
98	R_r	50.441	50.402	50.363	50.324	50.284	50.244
	R_i	48.705	48.674	48.643	48.612	48.581	48.550
99	R_r	50.941	50.902	50.863	50.824	50.784	50.744
	R_i	49.205	49.174	49.143	49.112	49.081	49.050
100	R_r	51.441	51.402	51.363	51.324	51.284	51.245
	R_i	49.705	49.674	49.643	49.612	49.581	49.550