

**TABLES OF REFERENCE****I. CLEARANCE ANGLES — STRAIGHT WHEELS**

***Relief Tables for High-Speed Steel Cutters***  
***I—Using Straight Wheels***

C = Distance in inches to set center of cutter and tip of tooth rest below (or above) center of wheel when grinding with a straight wheel.

<i>Wheel Diameter (Inches)</i>	<i>C for 4° Relief Angle</i>	<i>C for 5° Relief Angle</i>	<i>C for 6° Relief Angle</i>	<i>C for 7° Relief Angle</i>
3	.104	.131	.157	.183
3 $\frac{1}{4}$	.113	.141	.170	.198
3 $\frac{1}{2}$	.122	.152	.183	.213
3 $\frac{3}{4}$	.131	.163	.196	.227
4	.139	.174	.209	.242
4 $\frac{1}{4}$	.150	.185	.222	.259
4 $\frac{1}{2}$	.157	.195	.235	.274
4 $\frac{3}{4}$	.165	.207	.248	.289
5	.174	.218	.261	.305
5 $\frac{1}{4}$	.183	.228	.274	.319
5 $\frac{1}{2}$	.191	.239	.287	.335
5 $\frac{3}{4}$	.200	.250	.300	.350
6	.209	.261	.313	.365
6 $\frac{1}{4}$	.218	.272	.326	.381
6 $\frac{1}{2}$	.226	.283	.339	.396
6 $\frac{3}{4}$	.235	.294	.352	.411
7	.244	.305	.365	.426

## II. CLEARANCE ANGLES — CUP WHEELS

***II—Using Cup Wheels***

C = Distance in inches to set tip of tooth rest below or above center of cutter when grinding the peripheral teeth of cutters with a cup wheel.

<i>Cutter Diameter (Inches)</i>	<i>C for 4° Relief Angle</i>	<i>C for 5° Relief Angle</i>	<i>C for 6° Relief Angle</i>	<i>C for 7° Relief Angle</i>
$\frac{1}{2}$	.017	.022	.026	.031
$\frac{3}{4}$	.026	.033	.040	.046
1	.035	.044	.053	.061
$1\frac{1}{4}$	.044	.055	.066	.077
$1\frac{1}{2}$	.052	.066	.079	.092
$1\frac{3}{4}$	.061	.076	.092	.108
2	.070	.087	.105	.123
$2\frac{1}{2}$	.087	.109	.131	.153
$2\frac{3}{4}$	.096	.120	.144	.168
3	.104	.131	.158	.184
$3\frac{1}{2}$	.122	.153	.184	.215
4	.139	.174	.210	.245
$4\frac{1}{2}$	.157	.197	.237	.276
5	.174	.219	.263	.307
$5\frac{1}{2}$	.192	.241	.289	.338
6	.207	.262	.315	.368

## III. CLEARANCE ANGLES — REAMERS

## Vertical Adjustment of Tooth-rest for Grinding Clearance on Reamers

Size of Reamer	Hand Reamer for Steel. Cutting Clearance Land 0.006 inch Wide		Hand Reamer for Cast Iron and Bronze. Cutting Clearance Land 0.025 inch Wide		Chuckling Reamer for Cast Iron and Bronze. Cutting Clearance Land 0.025 inch Wide		Rose Chuckling Reamers for Steel
	For Cutting Clearance	For Second Clearance	For Cutting Clearance	For Second Clearance	For Cutting Clearance	For Second Clearance	For Cutting Clearance on Angular Edge at End
1/8	0.012	0.052	0.032	0.072	0.040	0.080	0.080
3/16	0.012	0.062	0.032	0.072	0.040	0.090	0.090
1/4	0.012	0.072	0.035	0.095	0.040	0.100	0.100
5/16	0.012	0.082	0.040	0.120	0.045	0.125	0.125
3/8	0.012	0.092	0.040	0.120	0.045	0.125	0.125
7/16	0.012	0.102	0.040	0.120	0.045	0.125	0.125
1/2	0.012	0.112	0.045	0.145	0.050	0.160	0.160
5/8	0.012	0.122	0.045	0.145	0.050	0.160	0.175
3/4	0.012	0.132	0.048	0.168	0.055	0.175	0.175
7/8	0.012	0.142	0.050	0.170	0.060	0.200	0.200
1	0.012	0.152	0.052	0.192	0.060	0.200	0.200
1 1/8	0.012	0.162	0.056	0.196	0.060	0.200	0.200
1 1/4	0.012	0.172	0.056	0.216	0.064	0.224	0.225
1 3/8	0.012	0.172	0.059	0.219	0.064	0.224	0.225
1 1/2	0.012	0.172	0.063	0.223	0.064	0.224	0.225
1 3/4	0.012	0.172	0.063	0.223	0.063	0.228	0.230
1 7/8	0.012	0.172	0.065	0.225	0.072	0.232	0.230
2	0.012	0.172	0.065	0.225	0.075	0.235	0.235
2 1/8	0.012	0.172	0.065	0.225	0.077	0.237	0.240
2 1/4	0.012	0.172	0.070	0.230	0.080	0.240	0.240
2 3/8	0.012	0.172	0.072	0.232	0.080	0.240	0.240
2 1/2	0.012	0.172	0.075	0.235	0.083	0.240	0.240
2 3/4	0.012	0.172	0.078	0.238	0.083	0.243	0.245
2 7/8	0.012	0.172	0.081	0.241	0.087	0.247	0.245
3	0.012	0.172	0.084	0.244	0.090	0.250	0.250
3 1/8	0.012	0.172	0.087	0.247	0.093	0.253	0.250
3 1/4	0.012	0.172	0.090	0.250	0.097	0.257	0.255
3 3/8	0.012	0.172	0.093	0.253	0.100	0.260	0.255
3 1/2	0.012	0.172	0.096	0.256	0.104	0.264	0.260
3 3/4	0.012	0.172	0.096	0.256	0.104	0.264	0.260
3 7/8	0.012	0.172	0.096	0.256	0.106	0.266	0.265
4	0.012	0.172	0.096	0.256	0.108	0.268	0.265
4 1/8	0.012	0.172	0.100	0.260	0.108	0.268	0.265
4 1/4	0.012	0.172	0.100	0.260	0.110	0.270	0.270
4 3/8	0.012	0.172	0.104	0.264	0.114	0.274	0.275
4 1/2	0.012	0.172	0.106	0.266	0.116	0.276	0.275
4 3/4	0.012	0.172	0.110	0.270	0.118	0.278	0.275

**IV. CLEARANCE ANGLES — CARBIDE REAMERS**

RECOMMENDED PRIMARY (RELIEF) &amp; SECONDARY (CLEARANCE) ANGLES:

<i>Reamer Diameter</i>	<i>Relief Angle</i>	<i>Clearance Angle</i>
$\frac{1}{4}''$ to $\frac{3}{8}''$	20° to 15°	40° to 30°
$\frac{3}{8}''$ to $\frac{5}{8}''$	15° to 10°	30° to 20°
$\frac{5}{8}''$ to 1"	10° to 8°	20° to 16°
1" to 1½"	8° to 6°	16° to 12°
Over 1½"	6°	12°

**RECOMMENDED CIRCULAR LAND WIDTHS**

<i>.005"—.010"</i>	<i>.010"—.020"</i>	<i>.020" plus</i>
Aluminum bronze Low lead bronze Copper Magnesium Steel—heat treated Steel forgings Bakelite Hard rubber	Aluminum castings not heat treated Free cutting steel Free cutting brass Cast iron Die castings Bearing bronze	Heat treated aluminum Babbitt

**V. STANDARD CLEARANCE ANGLE SETTINGS FOR H.S.S. CUTTERS AND FOR CARBIDE FACE MILLS**

<i>Cutter</i>	<i>Tool Material</i>	<i>Work Material</i>		
		<i>Steel</i>	<i>Cast Iron</i>	<i>Nonferrous and Nonmetallics</i>
Peripheral or O.D. Cutting Edge	High Speed Steel	5° to 10°	5° to 10°	7° to 12°
	Cast Alloy	4° to 6°	4° to 6°	5° to 10°
	Cemented Carbides	4° to 6°	4° to 6°	5° to 10°
Side or End Cutting Edges	All	1° to 4°	1° to 4°	2° to 7°

\*Smaller diameter cutters require larger relief angles.

## VI. CLEARANCE ANGLES — CORNER

After determining the necessary clearance angle and corner angle, read the correct settings for radial roll and axial tilt of the universal workhead at the horizontal and vertical intersection of these values. **EXAMPLE:** For 7 degrees of clearance and a 45 degree corner angle, the radial roll is 5 degrees and the axial tilt is 5 degrees. To set the radial roll, consult the clearance angle table for cup wheels. Set the axial tilt on the upper swivel of the workhead.

This table is included as an alternate method obtaining the clearance angle on the chamfer of shell end mills, face mills, and other similar tools. In many instances, adequate clearance can be obtained by swiveling the workhead to the necessary corner angle and then tilting the wheelhead or workhead to the desired primary or secondary angle of these lands at the periphery or face of the cutter.

CORNER ANGLE

		5°		10°		15°		20°		22½°		25°		30°		35°		40°		45°		
		Asial tilt	Rad roll	Asial tilt	Rad roll	Asial tilt	Rad roll	Asial tilt	Rad roll	Asial tilt	Rad roll	Asial tilt	Rad roll	Asial tilt	Rad roll	Asial tilt	Rad roll	Asial tilt	Rad roll	Asial tilt	Rad roll	
DESIRE D TRUE CLEARANCE ANGLE	½°	0	0.5	0.1	0.5	0.1	0.5	0.2	0.5	0.2	0.5	0.2	0.5	0.3	0.4	0.3	0.4	0.3	0.4	0.4	0.4	½°
	1°	0.1	1.0	0.2	1.0	0.3	1.0	0.3	0.9	0.4	0.9	0.4	0.9	0.5	0.9	0.6	0.8	0.6	0.8	0.7	0.7	1°
	1½°	0.1	1.5	0.3	1.5	0.4	1.5	0.5	1.4	0.6	1.4	0.6	1.4	0.8	1.3	0.9	1.2	1.0	1.1	1.1	1.1	1½°
	2°	0.2	2.0	0.3	2.0	0.5	1.9	0.7	1.9	0.8	1.8	0.8	1.8	1.0	1.7	1.2	1.6	1.3	1.5	1.4	1.4	2°
	2½°	0.2	2.5	0.4	2.5	0.6	2.4	0.9	2.4	1.0	2.3	1.1	2.3	1.2	2.2	1.4	2.1	1.6	1.9	1.8	1.8	2½°
	3°	0.3	3.0	0.5	3.0	0.8	2.9	1.0	2.8	1.2	2.8	1.3	2.7	1.5	2.6	1.7	2.5	1.9	2.4	2.1	2.1	3°
	3½°	0.3	3.5	0.6	3.4	0.9	3.4	1.2	3.3	1.3	3.2	1.5	3.2	1.8	3.0	2.0	2.9	2.3	2.7	2.5	2.5	3½°
	4°	0.3	4.0	0.7	3.9	1.0	3.9	1.4	3.8	1.5	3.7	1.7	3.6	2.0	3.5	2.3	3.3	2.6	3.1	2.8	2.8	4°
	4½°	0.4	4.5	0.8	4.4	1.2	4.3	1.5	4.2	1.7	4.2	1.9	4.1	2.3	3.9	2.6	3.7	2.9	3.5	3.2	3.2	4½°
	5°	0.4	5.0	0.9	4.9	1.3	4.8	1.7	4.7	1.9	4.6	2.1	4.5	2.5	4.3	2.9	4.1	3.2	3.8	3.5	3.5	5°
	5½°	0.5	5.5	1.0	5.4	1.4	5.3	1.9	5.2	2.1	5.1	2.3	5.0	2.8	4.8	3.2	4.5	3.5	4.2	3.9	3.9	5½°
	6°	0.5	6.0	1.0	5.9	1.6	5.8	2.1	5.6	2.3	5.6	2.5	5.4	3.0	5.2	3.5	4.9	3.9	4.6	4.3	4.3	6°
	6½°	0.6	6.5	1.1	6.4	1.7	6.3	2.2	6.1	2.5	6.0	2.8	5.9	3.3	5.6	3.8	5.3	4.2	5.0	4.6	4.6	6½°
	7°	0.6	7.0	1.2	6.9	1.8	6.8	2.4	6.6	2.7	6.5	3.0	6.4	3.5	6.1	4.0	5.8	4.5	5.4	5.0	5.0	7°
	7½°	0.7	7.5	1.3	7.4	2.0	7.3	2.6	7.0	2.9	6.9	3.2	6.8	3.8	6.5	4.3	6.2	4.8	5.8	5.3	5.3	7½°
8°	0.7	8.0	1.4	7.9	2.1	7.7	2.8	7.5	3.1	7.4	3.4	7.3	4.0	6.9	4.6	6.6	5.2	6.2	5.6	5.6	8°	
9°	0.8	9.0	1.6	8.9	2.4	8.7	3.1	8.5	3.5	8.3	3.8	8.2	4.5	7.8	5.2	7.4	5.8	6.9	6.4	6.4	9°	
10°	0.9	10.0	1.8	9.9	2.6	9.7	3.5	9.4	3.9	9.3	4.3	9.1	5.1	8.7	5.8	8.2	6.5	7.7	7.1	7.1	10°	
11°	1.0	11.0	1.9	10.8	2.9	10.6	3.8	10.4	4.3	10.2	4.7	10.0	5.6	9.6	6.4	9.1	7.1	8.5	7.8	7.8	11°	
12°	1.1	12.0	2.1	11.8	3.2	11.6	4.2	11.3	4.7	11.1	5.2	10.9	6.1	10.4	7.0	9.9	7.8	9.3	8.6	8.6	12°	
13°	1.2	13.0	2.3	12.8	3.4	12.6	4.5	12.3	5.1	12.1	5.6	11.8	6.6	11.3	7.6	10.7	8.5	10.0	9.3	9.3	13°	
14°	1.2	14.0	2.5	13.8	3.7	13.5	4.9	13.2	5.5	13.0	6.0	12.7	7.1	12.2	8.1	11.5	9.1	10.8	10.0	10.0	14°	
15°	1.3	15.0	2.7	14.8	4.0	14.5	5.3	14.2	5.9	13.9	6.5	13.7	7.6	13.1	8.7	12.4	9.8	11.6	10.7	10.7	15°	
																						ANGLE
Rad roll		Asial tilt			Rad roll		Asial tilt			Rad roll		Asial tilt			Rad roll		Asial tilt					
85°		80°		75°		70°		67½°		65°		60°		55°		50°		45°				

## VII. WHEEL R.P.M./S.F.P.M. CHART

*Table of Grinding Wheel Speeds*

To find the number of revolutions of the wheel spindle, having been given the surface or peripheral speed and the diameter of the wheel, divide the surface speed in feet per minute by the circumference (diameter x 3.14) in feet.

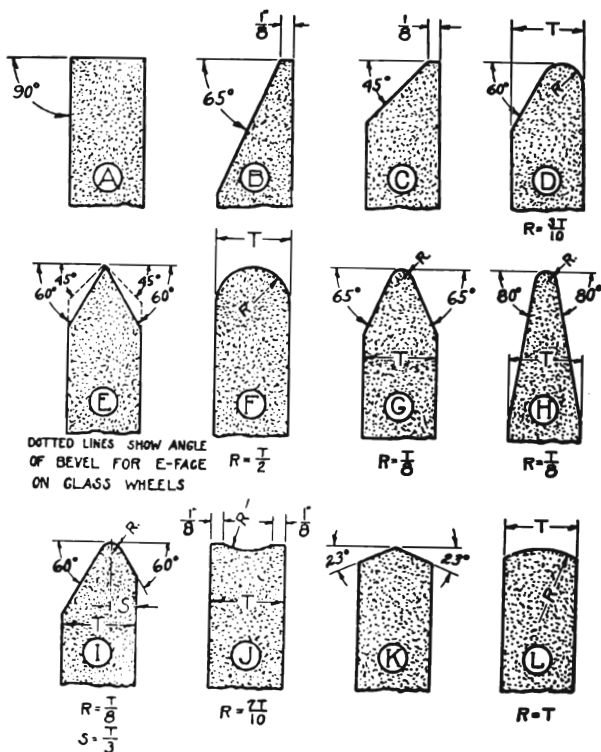
To find the surface speed of a wheel in feet per minute, multiply the circumference in feet by the revolutions per minute.

Diam. of Wheel in Inches	Mm (Approx.)	Peripheral Speed in Feet per Minute					
		4000 Ft 1200 M	4500 Ft 1350 M	5000 Ft 1500 M	5500 Ft 1650 M	6000 Ft 1800 M	6500 Ft 1950 M
		Revolutions per Minute					
1/4	6	61,116	68,756	76,392	84,032	91,672	99,212
3/8	9	40,744	46,594	50,928	56,021	61,115	66,141
1/2	13	30,558	34,378	38,196	42,016	45,836	49,656
5/8	16	24,446	27,502	30,557	33,615	36,669	39,685
3/4	19	20,372	22,918	25,464	28,011	30,557	33,071
7/8	22	17,462	21,826	21,826	24,009	26,192	28,346
1	25	15,279	17,189	19,098	21,008	22,918	24,828
2	50	7,639	8,594	9,549	10,504	11,459	12,414
3	75	5,093	5,729	6,366	7,003	7,639	8,276
4	100	3,820	4,297	4,775	5,252	5,729	6,207
5	125	3,056	3,438	3,820	4,202	4,584	4,966
6	150	2,546	2,865	3,183	3,501	3,820	4,138
7	175	2,183	2,455	2,728	3,001	3,274	3,547
8	200	1,910	2,148	2,387	2,626	2,865	3,103
10	250	1,528	1,719	1,910	2,101	2,292	2,483
12	305	1,273	1,432	1,591	1,751	1,910	2,069
14	355	1,091	1,228	1,364	1,500	1,637	1,773
16	405	955	1,074	1,194	1,313	1,432	1,552
18	455	849	955	1,061	1,167	1,273	1,379
20	505	764	859	955	1,050	1,146	1,241
22	560	694	781	868	955	1,042	1,128
24	610	637	716	796	875	955	1,034
26	660	588	661	734	808	881	955
28	710	546	614	682	750	818	887
30	760	509	573	637	700	764	828
32	810	477	537	597	656	716	776
34	860	449	505	562	618	674	730
36	910	424	477	530	583	637	690

## VIII. STANDARD WHEEL SHAPES

**Standard Shapes of Grinding Wheel Faces**

When no face is specified a straight "A" face wheel is furnished. The different faces which are regularly supplied are designated by letters as shown below:



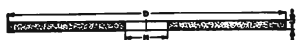
# VIII. STANDARD WHEEL SHAPES

## Key to Letter Dimensions

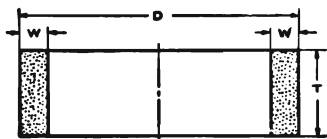
A	= Flat Spot of Beveled Wall.	K	= Diameter of Flat Inside.
D	= Diameter (Over All).	M	= Large Diameter of Bevel.
E	= Center or Back Thickness.	P	= Diameter of Recess.
F	= Depth of Recess.	R	= Radius.
	(See Type 5.)	T	= Thickness (Over All).
G	= Depth of Recess.	U	= Width of Face.
H	= Arbor Hole.	V	= Angle of Bevel.
J	= Diameter of Fat or Small Diameter.	W	= Thickness of Wall.



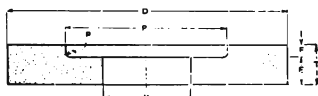
Type No. 1 Straight



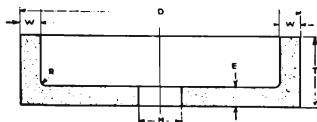
Type No. 1 Cut-off



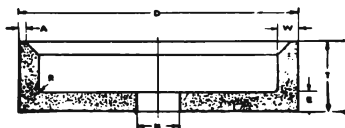
Type No. 2 Cylinder



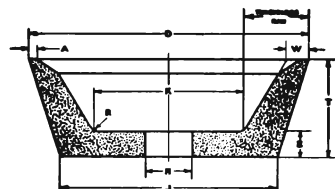
Type No. 5 Recessed One Side



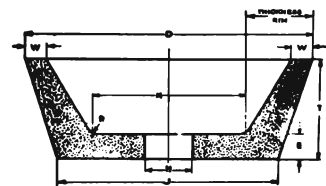
Type No. 6 Straight Cup



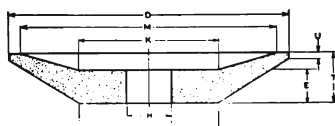
Type No. 6 Beveled Face



Type No. 11 Flaring Cup



Type No. 11 Beveled Face



Type No. 12 Dish



## IX. METRIC AND DECIMAL EQUIVALENTS OF COMMON FRACTIONS

FRACTION OF INCH	DECIMAL OF INCH	MILLIMETERS	FRACTION OF INCH	DECIMAL OF INCH	MILLIMETERS
1/64	.015625	0.3969	33/64	.515625	13.0969
1/32	.03125	0.7938	17/32	.53125	13.4938
3/64	.046875	1.1906	35/64	.546875	13.8906
1/16	.0625	1.5875	9/16	.5625	14.2875
5/64	.078125	1.9844	37/64	.578125	14.6844
3/32	.09375	2.3812	19/32	.59375	15.0812
7/64	.109375	2.7781	39/64	.609375	15.4781
1/8	.125	3.1750	5/8	.625	15.8750
9/64	.140625	3.5719	41/64	.640625	16.2719
5/32	.15625	3.9688	21/32	.65625	16.6688
11/64	.171875	4.3656	43/64	.671875	17.0656
3/16	.1875	4.7625	11/16	.6875	17.4625
13/64	.203125	5.1594	45/64	.703125	17.8594
7/32	.21875	5.5562	23/32	.71875	18.2562
15/64	.234375	5.9531	47/64	.734375	18.6531
1/4	.250	6.3500	3/4	.750	19.0500
17/64	.265625	6.7469	49/64	.765625	19.4469
9/32	.28125	7.1438	25/32	.78125	19.8438
19/64	.296875	7.5406	51/64	.796875	20.2406
5/16	.3125	7.9375	13/16	.8125	20.6375
21/64	.328125	8.3344	53/64	.828125	21.0344
11/32	.34375	8.7312	27/32	.843750	21.4312
23/64	.359375	9.1281	55/64	.859375	21.8281
3/8	.375	9.5250	7/8	.875	22.2250
25/64	.390625	9.9219	57/64	.890625	22.6219
13/32	.40625	10.3188	29/32	.90625	23.0188
27/64	.421875	10.7156	59/64	.921875	23.4156
7/16	.4375	11.1125	15/16	.9375	23.8125
29/64	.453125	11.5094	61/64	.953125	24.2094
15/32	.46875	11.9062	31/32	.96875	24.6062
31/64	.484375	12.3031	63/64	.984375	25.0031
1/2	.500	12.7000	1.000	1.0000	25.4000