MACHINERY'S DATA SHEETS

REVISED AND RE-ARRANGED IN LIBRARY FORM

No. 4

Reamers, Sockets, Drills and Milling Cutters

PRICE 25 CENTS

CONTENTS

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MACHINERY'S DATA SHEET SERIES

COMPILED FROM MACHINERY'S MONTHLY DATA SHEETS AND ARRANGED WITH EXPLANATORY MATTER

No. 4

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49-55 Lafayette Street, New York City

In the following pages are compiled a number of concise tables relating to reamers, sockets, drills, and milling cutters, carefully selected from Machinery's monthly Data Sheets, issued as supplements to the Engineering and Railway editions of Machinery since September, 1898. A number of additional tables are also included which are published here for the first time.

In order to enhance the value of the tables, brief explanatory notes have been provided. In these notes a complete list of references is given to articles which have appeared in Machinery, and to matter published in Machinery's Reference Series, giving additional information on the subject. These references will be of considerable value to readers who wish to make a more thorough study of the subject. In a note at the foot of each table, reference is made to the page on which the explanatory note relating to the table appears.

REAMERS, SOCKETS, DRILLS AND MILLING CUTTERS

Dimensions of Hand Reamers

On pages 4 and 5 are given dimensions for ordinary hand reamers provided with a guide of the length *G*. All hand reamers should be provided with a guide of this type in order to obtain a straight reamed hole. This provision is not generally made in reamers manufactured for the market, but it is of great importance in a tool expected to produce accurate work. The guide portion *G* at the end of the reamer is not relieved, but is left cylindrical; the flutes, of course, are cut through it in the usual manner. The amount that this pilot should be less in diameter than the reamer itself is determined by the maximum amount of metal that the reamer should be expected to remove.

While not so shown in the engraving on page 4, the diameter of the shank at the end where the square is milled should be turned down slightly below the diameter of the shank proper. The purpose of this is to prevent any burrs that may be raised on the edges of the square by the wrench by which the reamer is turned from projecting outside of the diameter of the shank. These burrs would prevent the reamer from being drawn clear through the hole reamed, or, at least, would scratch the inside of the hole when the reamer is pulled through. As seen from the table, all the reamers are made with an even number of flutes in order to facilitate the measuring of the diameter. The flutes, however, should be "broken up," that is, the cutting edges should not be equally spaced, but a slight difference in spacing of all the cutting edges around the reamer should be introduced. This ununiformity in spacing need not be greater than two or at most three degrees, which will still permit of measuring the diameter of the reamer over two opposite cutting edges. This measurement will be nearly correct enough for all practical purposes.

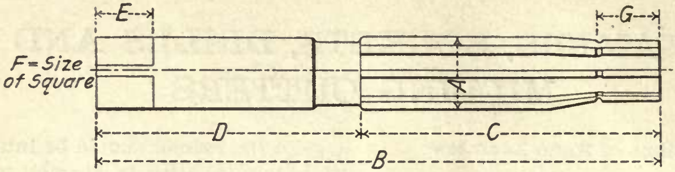
The relief of the cutting edges should preferably be eccentric, that is, the land back of the cutting edge should be convex rather than flat. This makes it possible for the reamer to hold its size longer, but an eccentrically relieved reamer should be used purely for finishing, as it cannot, with advantage, be used to remove any considerable amount of metal; for hand reamers used merely for removing stock or simply for enlarging holes, the flat relief is superior. For straight, smooth and accurate work, again, the eccentric relief is better. [MACHINERY, January, 1906, Hand Reamers; August and September, 1907, Reamers; May, 1910, Irregular Spacing of the Cutting Edges of Reamers.]

Shell Reamers and Arbors

Dimensions of shell reamers and arbors are given on page 6. It will be seen that one arbor can be used for a considerable number of sizes of reamers, and the material that would otherwise be used in the shank of each individual reamer is saved. The reamer has a keyway *F*, which fits the key on the arbor with 1/64 inch play. The hole through the reamer tapers ⅛ inch per foot, as shown. The tapered part of the arbor as well as the hole in the reamer must be ground after hardening to in-

(Continued on page 16.)

DIMENSIONS OF HAND REAMERS—I



Diam.	Total Length	Length of Flute	Length of Shank	Length of Squared Part	Size of Square	Length of Guide	Number of Flutes
A	B	C	D	E	F	G	
1/16	2 3/16	7/8	1 5/16	7/32	3/64	3/16	6
1/8	2 5/8	1 1/8	1 1/2	1/4	3/32	7/32	6
3/16	3 1/16	1 3/8	1 11/16	9/32	9/64	1/4	6
1/4	3 1/2	1 5/8	1 7/8	5/16	3/16	5/16	6
5/16	3 15/16	1 7/8	2 1/16	11/32	15/64	3/8	6
3/8	4 3/8	2 1/8	2 1/4	3/8	9/32	13/32	6
7/16	4 13/16	2 3/8	2 7/16	13/32	21/64	7/16	6
1/2	5 1/4	2 5/8	2 5/8	7/16	3/8	1/2	6
9/16	5 11/16	2 7/8	2 13/16	15/32	27/64	9/16	8
5/8	6 1/8	3 1/8	3	1/2	15/32	19/32	8
11/16	6 9/16	3 3/8	3 3/16	17/32	33/64	5/8	8
3/4	7	3 5/8	3 3/8	9/16	9/16	11/16	8
13/16	7 7/16	3 7/8	3 9/16	19/32	39/64	3/4	8
7/8	7 7/8	4 1/8	3 3/4	5/8	21/32	25/32	8
15/16	8 5/16	4 3/8	3 15/16	21/32	45/64	13/16	8
1	8 3/4	4 5/8	4 1/8	11/16	3/4	7/8	8
1 1/16	9 3/16	4 7/8	4 5/16	23/32	51/64	29/32	8
1 1/8	9 3/8	4 15/16	4 7/16	3/4	27/32	15/16	8
1 3/16	9 9/16	5 1/16	4 1/2	25/32	57/64	31/32	8

Explanatory note: Page 3

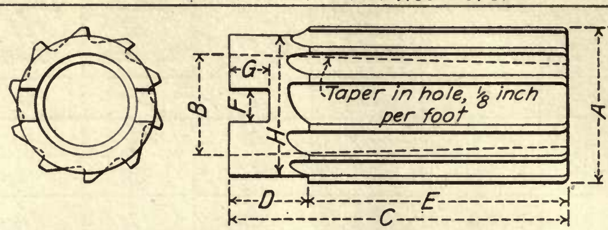
DIMENSIONS OF HAND REAMERS—II

Diam.	Total Length	Length of Flute	Length of Shank	Length of Squared Part	Size of Square	Length of Guide	Number of Flutes
A	B	C	D	E	F	G	
1 1/4	9 3/4	5 3/16	4 9/16	13/16	15/16	1	8
1 5/16	9 15/16	5 5/16	4 5/8	27/32	63/64	1 1/32	10
1 3/8	10 1/8	5 3/8	4 3/4	7/8	1 1/32	1 1/16	10
1 7/16	10 5/16	5 1/2	4 13/16	29/32	1 5/64	1 3/32	10
1 1/2	10 1/2	5 5/8	4 7/8	15/16	1 1/8	1 1/8	10
1 9/16	10 11/16	5 3/4	4 15/16	31/32	1 11/64	1 5/32	10
1 5/8	10 7/8	5 13/16	5 1/16	1	1 7/32	1 3/16	10
1 11/16	11 1/16	5 15/16	5 1/8	1 1/32	1 17/64	1 7/32	10
1 3/4	11 1/4	6 1/16	5 3/16	1 1/16	1 5/16	1 1/4	10
1 13/16	11 7/16	6 3/16	5 1/4	1 3/32	1 23/64	1 9/32	12
1 7/8	11 5/8	6 1/4	5 3/8	1 1/8	1 13/32	1 5/16	12
1 15/16	11 13/16	6 3/8	5 7/16	1 5/32	1 29/64	1 11/32	12
2	12	6 1/2	5 1/2	1 3/16	1 1/2	1 3/8	12
2 1/8	12 3/8	6 11/16	5 11/16	1 1/4	1 19/32	1 7/16	12
2 1/4	12 3/4	6 15/16	5 13/16	1 5/16	1 11/16	1 1/2	12
2 3/8	13 1/8	7 1/8	6	1 3/8	1 25/32	1 9/16	14
2 1/2	13 1/2	7 3/8	6 1/8	1 7/16	1 7/8	1 5/8	14
2 5/8	13 7/8	7 9/16	6 5/16	1 1/2	1 31/32	1 11/16	14
2 3/4	14 1/4	7 13/16	6 7/16	1 9/16	2 1/16	1 3/4	14
2 7/8	14 5/8	8	6 5/8	1 5/8	2 5/32	1 13/16	16
3	15	8 1/4	6 3/4	1 11/16	2 1/4	1 7/8	16
3 1/8	15 3/8	8 7/16	6 15/16	1 3/4	2 11/32	1 15/16	16
3 1/4	15 3/4	8 11/16	7 1/16	1 13/16	2 7/16	2	18
3 3/8	16 1/8	8 7/8	7 1/4	1 7/8	2 17/32	2 1/16	18
3 1/2	16 1/2	9 1/8	7 3/8	1 15/16	2 5/8	2 1/8	18
3 5/8	16 7/8	9 5/16	7 9/16	2	2 23/32	2 3/16	18
3 3/4	17 1/4	9 9/16	7 11/16	2 1/16	2 13/16	2 1/4	18
3 7/8	17 5/8	9 3/4	7 7/8	2 1/8	2 29/32	2 5/16	20
4	18	10	8	2 3/16	3	2 3/8	20

Explanatory note: Page 3.

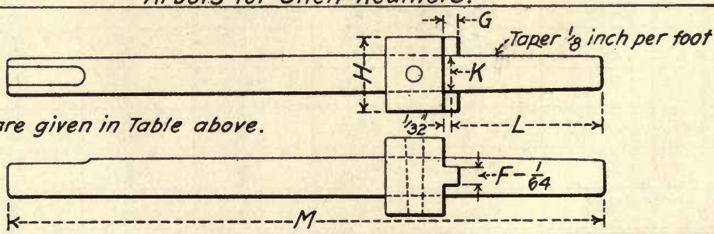
SHELL REAMERS AND ARBORS

Dimensions of Shell Reamers.



Diam. of Reamers	Diam. of Hole, Large End	Total Length	Length of Turned-down Portion	Length of Flutes	Width of Keyway	Depth of Keyway	Constant for finding Diam. of Recess	Number of Flutes
A	B	C	D	E	F	G	A-H	
1/4 – 5/16	1/8	1 1/2	3/8	1 1/8	1/16	1/8	0.006	6
11/32 – 7/16	3/16	1 3/4	3/8	1 3/8	3/32	1/8	0.006	6
15/32 – 9/16	1/4	2	1/2	1 1/2	7/64	5/32	1/64	8
19/32 – 11/16	3/8	2 1/4	1/2	1 3/4	9/64	3/16	1/64	8
23/32 – 15/16	1/2	2 1/2	1/2	2	11/64	1/4	1/32	10
31/32 – 1 1/4	5/8	2 3/4	5/8	2 1/8	13/64	1/4	1/16	10
1 9/32 – 1 5/8	3/4	3	5/8	2 3/8	1/4	5/16	1/8	12
1 21/32 – 2	1	3 1/2	5/8	2 7/8	1/4	5/16	1/8	12
2 1/32 – 2 1/2	1 1/4	3 3/4	3/4	3	5/16	3/8	1/8	14
2 17/32 – 3	1 1/2	4	3/4	3 1/4	5/16	3/8	1/8	14
3 1/32 – 3 1/2	1 3/4	4 1/2	1	3 1/2	5/16	3/8	1/8	16
3 17/32 – 4	2	5	1	4	5/16	3/8	1/8	16
4 1/32 – 4 1/2	2 1/4	5 1/2	1	4 1/2	5/16	3/8	1/8	18
4 17/32 – 5	2 1/2	6	1	5	5/16	3/8	1/8	18

Arbors for Shell Reamers.



F, G and H are given in Table above.

Diam. at Size Line	Length from Size Line to End of Arbor	Total Length	Diam. at Size Line	Length from Size Line to End of Arbor	Total Length	Diam. at Size Line	Length from Size Line to End of Arbor	Total Length
K	L	M	K	L	M	K	L	M
1/8	1 1/2	6	5/8	2 3/4	10	1 3/4	4 1/2	15
3/16	1 3/4	7	3/4	3	11	2	5	16
1/4	2	8	1	3 1/2	12	2 1/4	5 1/2	17
3/8	2 1/4	9	1 1/4	3 3/4	13	2 1/2	6	18
1/2	2 1/2	9 1/2	1 1/2	4	14			

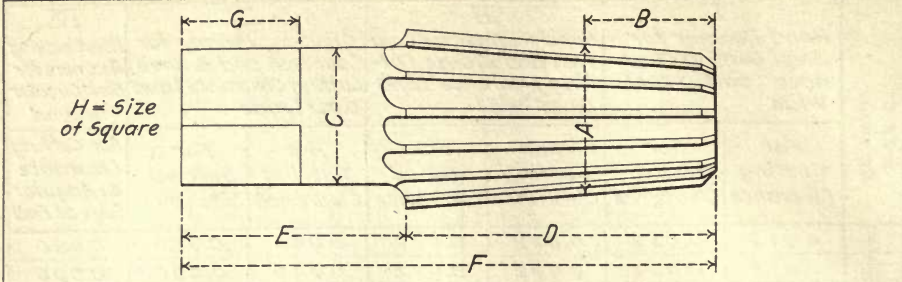
Explanatory note: Page 3.

SETTING OF TOOTH-REST FOR GRINDING CLEARANCE ON REAMERS

Size of Reamer	I Hand Reamer for Steel Cutting Clearance Land 0.006" wide		II Hand Reamer for Cast Iron and Bronze. Cutting Clearance Land 0.025" wide		III Chucking Reamer for Cast Iron and Bronze. Cutting Clearance Land 0.025" wide		IV Rose Chucking Reamers for Steel, Circular Ground
	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
1/2	0.012	0.052	0.032	0.072	0.040	0.080	0.080
5/8	0.012	0.062	0.032	0.072	0.040	0.090	0.090
3/4	0.012	0.072	0.035	0.095	0.040	0.100	0.100
7/8	0.012	0.082	0.040	0.120	0.045	0.125	0.125
1	0.012	0.092	0.040	0.120	0.045	0.125	0.125
1 1/8	0.012	0.102	0.040	0.120	0.045	0.125	0.125
1 1/4	0.012	0.112	0.045	0.145	0.050	0.160	0.160
1 3/8	0.012	0.122	0.045	0.145	0.050	0.160	0.175
1 1/2	0.012	0.132	0.048	0.168	0.055	0.175	0.175
1 5/8	0.012	0.142	0.050	0.170	0.060	0.200	0.200
1 3/4	0.012	0.152	0.052	0.192	0.060	0.200	0.200
1 7/8	0.012	0.162	0.056	0.196	0.060	0.200	0.200
2	0.012	0.172	0.056	0.216	0.064	0.224	0.225
2 1/8	0.012	0.172	0.059	0.219	0.064	0.224	0.225
2 1/4	0.012	0.172	0.063	0.223	0.064	0.224	0.225
2 3/8	0.012	0.172	0.063	0.223	0.068	0.228	0.230
2 1/2	0.012	0.172	0.065	0.225	0.072	0.232	0.230
2 5/8	0.012	0.172	0.065	0.225	0.075	0.235	0.235
2 3/4	0.012	0.172	0.065	0.225	0.077	0.237	0.240
2 7/8	0.012	0.172	0.070	0.230	0.080	0.240	0.240
3	0.012	0.172	0.072	0.232	0.080	0.240	0.240
3 1/8	0.012	0.172	0.075	0.235	0.083	0.240	0.240
3 1/4	0.012	0.172	0.078	0.238	0.083	0.243	0.245
3 3/8	0.012	0.172	0.081	0.241	0.087	0.247	0.245
3 1/2	0.012	0.172	0.084	0.244	0.090	0.250	0.250
3 5/8	0.012	0.172	0.087	0.247	0.093	0.253	0.250
3 3/4	0.012	0.172	0.090	0.250	0.097	0.257	0.255
3 7/8	0.012	0.172	0.093	0.253	0.100	0.260	0.255
4	0.012	0.172	0.096	0.256	0.104	0.264	0.260
4 1/8	0.012	0.172	0.096	0.256	0.104	0.264	0.260
4 1/4	0.012	0.172	0.096	0.256	0.106	0.266	0.265
4 3/8	0.012	0.172	0.096	0.256	0.108	0.268	0.265
4 1/2	0.012	0.172	0.100	0.260	0.108	0.268	0.265
4 5/8	0.012	0.172	0.100	0.260	0.110	0.270	0.270
4 3/4	0.012	0.172	0.104	0.264	0.114	0.274	0.275
4 7/8	0.012	0.172	0.106	0.266	0.116	0.276	0.275
5	0.012	0.172	0.110	0.270	0.118	0.278	0.275

Explanatory note: Page 16.

DIMENSIONS OF PIPE REAMERS

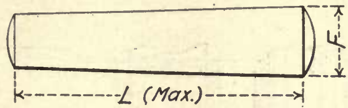


Pipe Size	Diam. at Size Line	Distance from Size Line to Small End	Diam. of Shank	Length of Fluted Part	Length of Shank	Total Length	Length of Square	Size of Square	Number of Flutes
	A	B	C	D	E	F	G	H	
1/8	0.343	25/64	11/32	1	1 5/8	2 5/8	1/2	1/4	6
1/4	0.447	9/16	7/16	1 1/8	1 3/4	2 7/8	9/16	5/16	6
3/8	0.582	9/16	9/16	1 1/4	1 7/8	3 1/8	5/8	7/16	6
1/2	0.721	3/4	3/4	1 1/2	2	3 1/2	11/16	9/16	8
3/4	0.931	3/4	15/16	1 5/8	2 1/4	3 7/8	3/4	11/16	8
1	1.170	15/16	1 1/8	1 3/4	2 1/2	4 1/4	13/16	13/16	10
1 1/4	1.515	31/32	1 5/16	1 7/8	2 3/4	4 5/8	1	1	10
1 1/2	1.755	1	1 1/2	2	3	5	1 1/8	1 1/8	12
2	2.230	1	1 7/8	2 1/4	3 1/2	5 3/4	1 3/8	1 3/8	12
2 1/2	2.667	1 1/2	2 1/4	2 7/8	4	6 7/8	1 11/16	1 11/16	14
3	3.292	1 9/16	2 5/8	3 1/4	4 1/2	7 3/4	1 15/16	1 15/16	14
3 1/2	3.792	1 5/8	2 13/16	3 5/8	4 9/16	8 3/16	2 1/8	2 1/8	16
4	4.292	1 11/16	3	3 3/4	4 5/8	8 3/8	2 1/4	2 1/4	18

Explanatory note: Page 22.

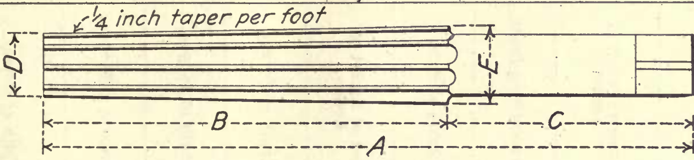
STANDARD TAPER PINS AND REAMERS

Standard Taper Pins.



No. of Taper Pin	Diameter at Large End of Pin	Approximate Fractional Size at Large End of Pin	Length of Longest Pin of this Size	No. of Taper Pin	Diameter at Large End of Pin	Approximate Fractional Size at Large End of Pin	Length of Longest Pin of this Size
	F		L		F		L
000000	0.0715	5/64	5/8	3	0.219	7/32	1 3/4
00000	0.092	3/32	5/8	4	0.250	1/4	2
0000	0.108	7/64	3/4	5	0.289	19/64	2 1/4
000	0.125	1/8	3/4	6	0.341	11/32	3 1/4
00	0.147	9/64	1	7	0.409	13/32	3 3/4
0	0.156	5/32	1	8	0.492	1/2	4 1/2
1	0.172	11/64	1 1/4	9	0.591	19/32	5 1/4
2	0.193	3/16	1 1/2	10	0.706	23/32	6

Dimensions of Taper Pin Reamers.

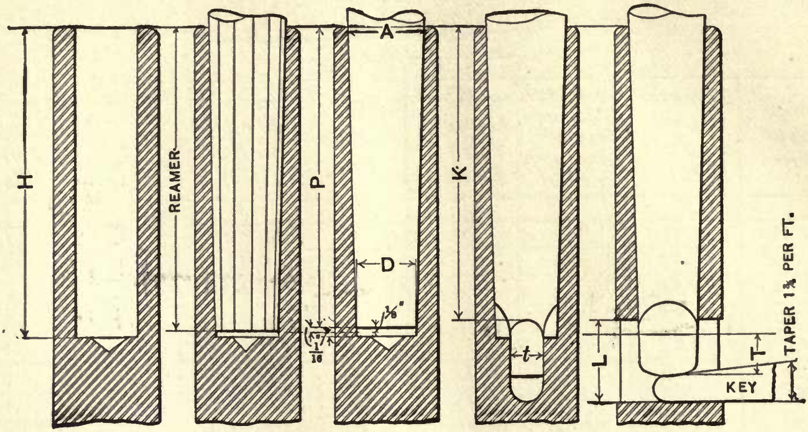


No. of Taper Pin Reamer	Total Length of Reamer	Length of Cutting Edges	Length of Shank	Diameter at Small End of Reamer	Diameter at Large End of Reamer	Number of Flutes
	A	B	C	D	E	
000000	1 1/2	1	1/2	0.057	0.078	4
00000	1 1/2	1	1/2	0.078	0.099	4
0000	1 3/4	1 1/8	5/8	0.091	0.114	4
000	1 3/4	1 1/8	5/8	0.108	0.131	4
00	2 1/4	1 7/16	13/16	0.125	0.155	4
0	2 3/8	1 1/2	7/8	0.134	0.165	6
1	2 3/4	1 3/4	1	0.145	0.181	6
2	3	2	1	0.161	0.203	6
3	3 3/8	2 1/4	1 1/8	0.182	0.229	6
4	3 7/8	2 5/8	1 1/4	0.205	0.260	6
5	4 3/8	3	1 3/8	0.239	0.301	6
6	5 1/2	4	1 1/2	0.270	0.353	6
7	6 1/4	4 1/2	1 3/4	0.328	0.422	6
8	7 1/4	5 1/4	2	0.395	0.504	8
9	8 3/8	6 1/8	2 1/4	0.479	0.607	8
10	9 1/2	7	2 1/2	0.578	0.724	8

Explanatory note: Page 22.

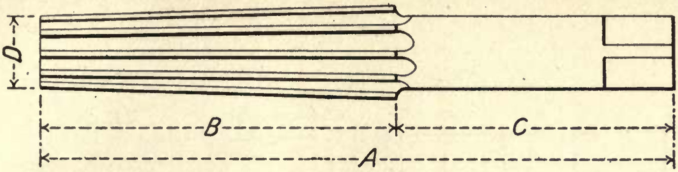
DIMENSIONS OF BROWN & SHARPE STANDARD TAPERS

BROWN & SHARPE STANDARD TAPERS.



Number of Taper.	Diameter of Plug at Small End.	Diameter at End of Socket.	Standard Plug Depth.	Depth of Hole.	End of Socket to Keyway.	Length of Keyway.	Length of Tongue.	Thickness of Tongue.	Width of Keyway.	Taper per Foot.
	D	A	P	H	K	L	T	t	W	
1	.20	.239	15/16	1 1/16	15/16	3/8	3/16	1/8	.135	.500
2	.25	.299	1 3/16	1 5/16	1 11/64	1/2	1/4	5/32	.166	.500
3	.312	.385	1 3/4	1 7/8	1 23/32	5/8	5/16	3/16	.197	.500
3	.312	.395	2	2 1/8	1 31/32	5/8	5/16	3/16	.197	.500
4	.35	.402	1 1/4	1 3/8	1 13/64	11/16	11/32	7/32	.228	.500
5	.45	.523	1 3/4	1 7/8	1 11/16	3/4	3/8	1/4	.260	.500
6	.50	.599	2 3/8	2 1/2	2 19/64	7/8	7/16	9/32	.291	.500
6	.50	.635	3 1/4	3 3/8	3 11/64	7/8	7/16	9/32	.291	.500
7	.60	.725	3	3 1/8	2 29/32	15/16	15/32	5/16	.322	.500
7	.60	.766	4	4 1/8	3 29/32	15/16	15/32	5/16	.322	.500
8	.75	.898	3 9/16	3 11/16	3 29/64	1	1/2	11/32	.353	.500
9	.90	1.066	4	4 1/8	3 7/8	1 1/8	9/16	3/8	.385	.500
10	1.0446	1.260	5	5 1/8	4 27/32	1 5/16	21/32	7/16	.447	.5161
10	1.0446	1.289	5 11/16	5 13/16	5 17/32	1 5/16	21/32	7/16	.447	.5161
10	1.0446	1.312	6 7/32	6 11/32	6 1/16	1 5/16	21/32	7/16	.447	.5161
11	1.25	1.531	6 3/4	6 7/8	6 19/32	1 5/16	21/32	7/16	.447	.500
12	1.50	1.796	7 1/8	7 1/4	6 15/16	1 1/2	3/4	1/2	.510	.500

REAMERS FOR BROWN & SHARPE STANDARD TAPER SOCKETS

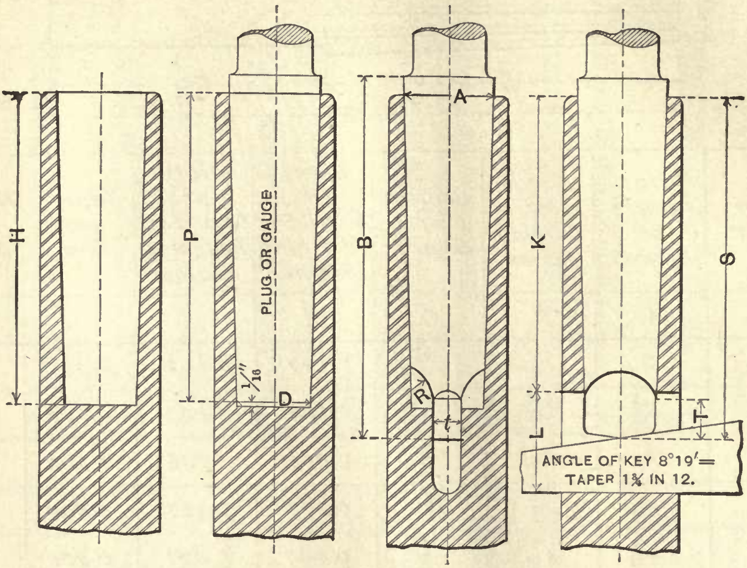


No. of Taper	Total Length of Reamer	Length of Cutting Edges	Length of Shank	Diam. at Small End Finishing Reamer	Diam. at Small End Roughing Reamer	Taper per foot	Number of Flutes
	A	B	C	D			
1	2	1¼	¾	0.197	0.187	0.500	6
2	2¾	1⅝	1⅛	0.247	0.237	0.500	6
3	4	2½	1½	0.309	0.299	0.500	6
4	4	2½	1½	0.347	0.337	0.500	6
5	4¾	2⅞	1⅞	0.447	0.437	0.500	6
6	6¼	4	2¼	0.497	0.487	0.500	8
7	7¼	4¾	2½	0.597	0.587	0.500	8
8	7¼	4¾	2½	0.747	0.737	0.500	8
9	7¾	5	2¾	0.897	0.887	0.500	8
10	10¼	7⅛	3⅛	1.042	1.032	0.516	8
11	11	7¾	3¼	1.247	1.237	0.500	10
12	11½	8⅛	3⅜	1.497	1.487	0.500	10
13	12¼	8¾	3½	1.747	1.737	0.500	12
14	13	9¼	3¾	1.997	1.987	0.500	14
15	13½	9¾	3¾	2.247	2.237	0.500	14
16	14	10¼	3¾	2.497	2.487	0.500	16
17	15	11	4	2.747	2.737	0.500	16
18	15½	11½	4	2.997	2.987	0.500	16

Explanatory note: Page 22.

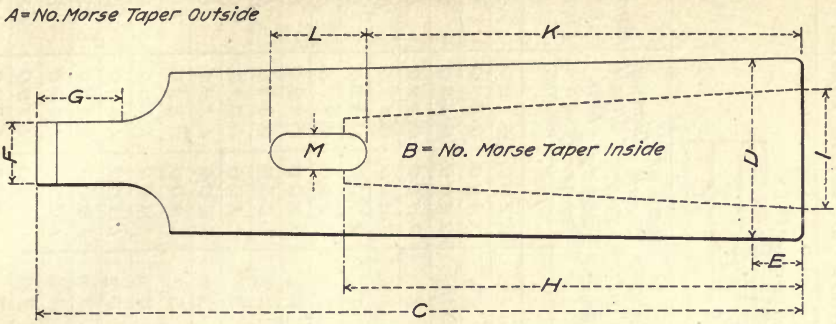
DIMENSIONS OF MORSE STANDARD TAPERS

MORSE STANDARD TAPERS.



Number of Taper.	Diameter of Plug at Small End.	Diameter at End of Socket.	Standard Plug Depth	Whole Length of Shank.	Depth of Hole.	End of Socket to Keyway.	Length of Keyway.	Length of Tongue.	Thickness of Tongue.	Width of Keyway.	Shank Depth.	Taper per Foot.
	D	A	P	B	H	K	L	T	t	W	S	
1	.369	.475	2 1/8	2 9/16	2 3/16	2 1/16	3/4	5/16	13/64	.213	2 3/8	.600
2	.572	.700	2 9/16	3 1/16	2 5/8	2 1/2	7/8	3/8	1/4	.260	2 7/8	.602
3	.778	.938	3 3/16	3 3/4	3 1/4	3 1/16	1 1/16	7/16	5/16	.322	3 9/16	.602
4	1.020	1.231	4 1/16	4 3/4	4 1/8	3 7/8	1 1/4	1/2	15/32	.478	4 1/2	.623
5	1.475	1.748	5 3/16	6	5 1/4	4 15/16	1 1/2	5/8	5/8	.635	5 3/4	.630
6	2.116	2.494	7 1/4	8 5/16	7 3/8	7	1 3/4	7/8	3/4	.760	8	.626

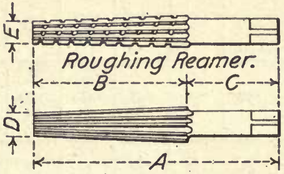
DIMENSIONS OF MORSE TAPER SOCKETS



A	B	C	D	E	F	G	H	I	K	L	M
2	1	3 5/8	.700	3/4	1/4	3/8	2 3/16	.475	2 1/16	3/4	.213
3	1	3 3/4	.938	3/16	5/16	7/16	2 3/16	.475	2 1/16	3/4	.213
3	2	4 1/4	.938	11/16	5/16	7/16	2 5/8	.700	2 1/2	7/8	.260
4	1	4 3/4	1.231	1/4	15/32	1/2	2 3/16	.475	2 1/16	3/4	.213
4	2	4 3/4	1.231	1/4	15/32	1/2	2 5/8	.700	2 1/2	7/8	.260
4	3	5 1/4	1.231	3/4	15/32	1/2	3 1/4	.938	3 1/16	1 1/16	.322
5	1	6	1.748	1/4	5/8	5/8	2 3/16	.475	2 1/16	3/4	.213
5	2	6	1.748	1/4	5/8	5/8	2 5/8	.700	2 1/2	7/8	.260
5	3	6	1.748	1/4	5/8	5/8	3 1/4	.938	3 1/16	1 1/16	.322
5	4	6 3/8	1.748	5/8	5/8	5/8	4 1/8	1.231	3 7/8	1 1/4	.478
6	1	8 5/16	2.494	5/16	3/4	7/8	2 3/16	.475	2 1/16	3/4	.213
6	2	8 5/16	2.494	5/16	3/4	7/8	2 5/8	.700	2 1/2	7/8	.260
6	3	8 5/16	2.494	5/16	3/4	7/8	3 1/4	.938	3 1/16	1 1/16	.322
6	4	8 5/16	2.494	5/16	3/4	7/8	4 1/8	1.231	3 7/8	1 1/4	.478
6	5	8 11/16	2.494	11/16	3/4	7/8	5 1/4	1.748	4 15/16	1 1/2	.635

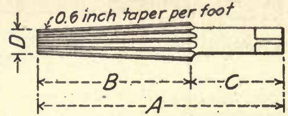
REAMERS FOR MORSE AND JARNO STANDARD TAPER SOCKETS

Dimensions of Reamers for Morse Standard Tapers.



No. of Morse Standard Taper	Total Length of Reamer A	Length of Cutting Edges B	Length of Shank C	Diam. at Small End, Finishing Reamer D	Diam. at Small End, Roughing Reamer E	Taper per foot	Number of Flutes
0	4	2 1/2	1 1/2	0.252	0.242	0.625	6
1	4 5/8	2 3/4	1 7/8	0.369	0.359	0.600	6
2	5 1/2	3 1/4	2 1/4	0.572	0.562	0.602	8
3	6 5/8	4	2 5/8	0.778	0.768	0.602	8
4	8	5	3	1.020	1.010	0.623	8
5	9 1/2	6 1/8	3 3/8	1.475	1.465	0.630	10
6	12	8 1/4	3 3/4	2.116	2.106	0.626	14
7	15	11	4	2.750	2.740	0.625	16

Dimensions of Reamers for Jarno Tapers.

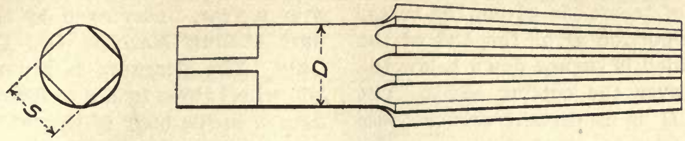


No. of Jarno Taper	Total Length of Reamer A	Length of Cutting Edge B	Length of Shank C	Diam. at Small End, Finishing Reamer D	Diam. at Small End, Roughing Reamer	Number of Flutes
2	2 5/8	1 3/8	1 1/4	0.200	0.190	4
3	3 1/2	2	1 1/2	0.300	0.290	6
4	4 3/8	2 5/8	1 3/4	0.400	0.390	6
5	5 1/4	3 1/4	2	0.500	0.490	8
6	5 7/8	3 3/4	2 1/8	0.600	0.590	8
7	6 1/2	4 1/4	2 1/4	0.700	0.690	8
8	7 3/8	4 7/8	2 1/2	0.800	0.790	8
9	8 1/8	5 3/8	2 3/4	0.900	0.890	8
10	8 7/8	6	2 7/8	1.000	0.990	8
11	9 1/2	6 1/2	3	1.100	1.090	10
12	10 1/8	7	3 1/8	1.200	1.190	10
13	10 3/4	7 1/2	3 1/4	1.300	1.290	10
14	11 3/8	8	3 3/8	1.400	1.390	10
15	12	8 1/2	3 1/2	1.500	1.490	10
16	12 5/8	9	3 5/8	1.600	1.590	12
17	13 3/8	9 5/8	3 3/4	1.700	1.690	12
18	14	10 1/8	3 7/8	1.800	1.790	12
19	14 5/8	10 5/8	4	1.900	1.890	14
20	15 1/4	11 1/8	4 1/8	2.000	1.990	14

Explanatory notes: Pages 22 and 26.

SQUARES ON SHANKS OF REAMERS AND TAPS

Sizes of Squares of Tools Corresponding to certain Shank Diameters



Diam. of Shank	Square	Diam. of Shank	Square	Diam. of Shank	Square	Diam. of Shank	Square	Diam. of Shank	Square	Diam. of Shank	Square	Diam. of Shank	Square
D	S	D	S	D	S	D	S	D	S	D	S	D	S
1/16	3/64	27/64	5/16	25/32	19/32	1 9/64	55/64	1 1/2	1 1/8	2 7/32	1 43/64	2 15/16	2 13/64
5/64	1/16	7/16	21/64	51/64	19/32	1 5/32	7/8	1 17/32	1 5/32	2 1/4	1 11/16	2 31/32	2 15/64
3/32	5/64	29/64	11/32	13/16	39/64	1 11/64	7/8	1 9/16	1 11/64	2 9/32	1 23/32	3	2 1/4
7/64	5/64	15/32	23/64	53/64	5/8	1 3/16	57/64	1 19/32	1 13/64	2 5/16	1 47/64	3 1/32	2 9/32
1/8	3/32	31/64	23/64	27/32	41/64	1 13/64	29/32	1 5/8	1 7/32	2 11/32	1 49/64	3 1/16	2 19/64
9/64	7/64	1/2	3/8	55/64	41/64	1 7/32	59/64	1 21/32	1 1/4	2 3/8	1 25/32	3 3/32	2 21/64
5/32	1/8	33/64	25/64	7/8	21/32	1 15/64	59/64	1 11/16	1 17/64	2 13/32	1 13/16	3 1/8	2 11/32
11/64	1/8	17/32	13/32	57/64	43/64	1 1/4	15/16	1 23/32	1 19/64	2 7/16	1 53/64	3 5/32	2 3/8
3/16	9/64	35/64	13/32	29/32	11/16	1 17/64	61/64	1 3/4	1 5/16	2 15/32	1 55/64	3 3/16	2 25/64
13/64	5/32	9/16	27/64	59/64	11/16	1 9/32	31/32	1 25/32	1 11/32	2 1/2	1 7/8	3 7/32	2 27/64
7/32	11/64	37/64	7/16	15/16	45/64	1 19/64	31/32	1 13/16	1 23/64	2 17/32	1 29/32	3 1/4	2 7/16
15/64	11/64	19/32	29/64	61/64	23/32	1 5/16	63/64	1 27/32	1 25/64	2 9/16	1 59/64	3 5/16	2 31/64
1/4	3/16	39/64	29/64	31/32	47/64	1 21/64	1	1 7/8	1 13/32	2 19/32	1 61/64	3 3/8	2 17/32
17/64	13/64	5/8	15/32	63/64	47/64	1 11/32	1 1/64	1 29/32	1 7/16	2 5/8	1 31/32	3 7/16	2 37/64
9/32	7/32	41/64	31/64	1	3/4	1 23/64	1 1/64	1 15/16	1 29/64	2 21/32	2	3 1/2	2 5/8
19/64	7/32	21/32	1/2	1 1/64	49/64	1 3/8	1 1/32	1 31/32	1 31/64	2 11/16	2 1/64	3 9/16	2 43/64
5/16	15/64	43/64	1/2	1 1/32	25/32	1 25/64	1 3/64	2	1 1/2	2 23/32	2 3/64	3 5/8	2 23/32
21/64	1/4	11/16	33/64	1 3/64	25/32	1 13/32	1 1/16	2 1/32	1 17/32	2 3/4	2 1/16	3 11/16	2 49/64
11/32	17/64	45/64	17/32	1 1/16	51/64	1 27/64	1 1/16	2 1/16	1 35/64	2 25/32	2 3/32	3 3/4	2 13/16
23/64	17/64	23/32	35/64	1 5/64	13/16	1 7/16	1 5/64	2 3/32	1 37/64	2 13/16	2 7/64	3 13/16	2 55/64
3/8	9/32	47/64	35/64	1 3/32	53/64	1 29/64	1 3/32	2 1/8	1 19/32	2 27/32	2 9/64	3 7/8	2 29/32
25/64	19/64	3/4	9/16	1 7/64	53/64	1 15/32	1 7/64	2 5/32	1 5/8	2 7/8	2 5/32	3 15/16	2 61/64
13/32	5/16	49/64	37/64	1 1/8	27/32	1 31/64	1 7/64	2 3/16	1 41/64	2 29/32	2 3/16	4	3

sure that the reamer will run true. Referring to the use of the table, it will be seen that in the second column from the right a heading "Constant for finding diameter of recess" is given, the recess being the portion *D* at the end of the reamer which is turned down below the diameter over the cutting edges. The diameter *H* is a certain amount less than the diameter *A* of the reamer, according to the size, and the amount which *H* is less than *A* is given in the column referred to. For example, if *A* is 1 inch, then, according to the table, $A - H$ is 1/16 inch, and hence *H* is 15/16 inch. In other words, the constant given in this table is subtracted from the diameter of the reamer in order to obtain the diameter of the turned down portion.

The arbor used for driving shell reamers consists of a stem or arbor provided with a collar which is fastened to the arbor by means of a taper pin, as shown. The collar is provided with a key, as already mentioned, which engages into the keyway of the reamer. Precaution must be taken in milling this key or tongue so that it will be exactly in the center of the collar. The same care must, of course, be used when milling the keyway in the mill, which must be exactly in the center in order that the key and keyway may fit properly together. When grinding the outside of the reamer to size it should preferably be ground on an arbor similar to that on which it is to be used. At the front end the corners are slightly rounded as shown. The arbors and driving collars should preferably be made of tool steel and the collars should be hardened. The end of the arbor is provided with a small flat milled on the shank for the set-screws by which it is clamped in a tool-holder. [MACHINERY, October, 1907, Reamers.]

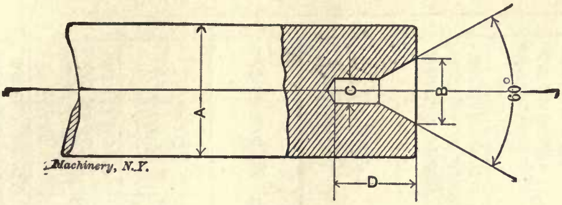
Clearance for Reamers

The table on page 7 will be found useful when grinding the clearance on hand and chucking reamers of various sizes. These clearances were decided upon as giving the best results by experiments extending over a period of over a year, undertaken by the Cincinnati Milling Machine Co., Cincinnati, Ohio. The clearance is ground with a cup wheel three inches in diameter. The figures in the body of the table give the amount in inches which the work-holding centers should be above the tooth-rest.

In the cases marked I, II, and III the tooth-rest is mounted on the emery wheel head and should be set centrally with the emery wheel spindle. In the case marked IV the tooth-rest is mounted on the table of the machine. By setting the tooth-rest and the work-holding centers as called for by this table the reamers will be provided with clearance of such an amount as to ream the greatest number of smooth holes with the minimum amount of wear. It will be seen that in the table two columns of dimensions for setting the work-holding centers above the tooth-rest, are given for each class of reamer specified, except for the rose chucking reamers. The first of these columns is headed "For cutting clearance," and the second, "For second clearance." The first clearance is that on the actual land of the reamer, while the second clearance is that back of the cutting land. The chucking reamers for cast iron or bronze have 23-degree beveled ends, and are provided with two clearances along the blades, the same as the hand reamers, but the beveled ends have only one clearance, which is ground by setting the work-holding centers to the figures in the second column under III. Chucking reamers for reaming steel are ground circular to the exact size of the hole to be reamed, and the 45-degree beveled ends only have clearance, the setting for the grinding of which is given in the table under IV. [MACHINERY, June, 1904, Reamer Clearances.]

DIMENSIONS OF CENTERS FOR REAMERS AND ARBORS

CENTERS FOR REAMERS AND ARBORS.



Formulas:

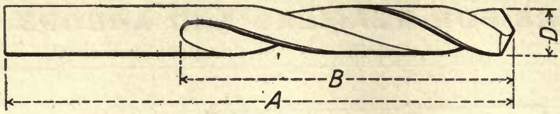
Arbors to 1″ diam.: $B = \frac{1}{2}A$; $C = \frac{1}{5}A$; $D = \frac{3}{5}A$;

Arbors from 1⅛″ diam. to 5″ diam.: $B = \frac{1}{2} + \frac{A-1}{8}$; $C = .2 + \frac{A-1}{20}$; $D = .6 + \frac{A-1}{6}$.

APPROXIMATE VALUES FOR PRACTICAL USE.

A Diam. of Arbor.	B Largest Diam. of Center.	C No. of Drill.	D Depth of Hole.	A Diam. of Arbor.	B Largest Diam. of Center.	C Letter of Drill.	D Depth of Hole.
1/4	1/8	55	5/32	2 1/4	21/32	G	13/16
5/16	5/32	52	3/16	2 3/8	43/64	H	27/32
3/8	3/16	48	7/32	2 1/2	11/16	J	27/32
7/16	7/32	43	1/4	2 5/8	45/64	K	7/8
1/2	1/4	39	5/16	2 3/4	23/32	L	29/32
9/16	9/32	33	11/32	2 7/8	47/64	M	29/32
5/8	5/16	30	3/8	3	3/4	N	15/16
11/16	11/32	29	13/32	3 1/8	49/64	N	31/32
3/4	3/8	25	7/16	3 1/4	25/32	O	31/32
13/16	13/32	20	1/2	3 3/8	51/64	O	1
7/8	7/16	17	17/32	3 1/2	13/16	P	1
15/16	15/32	12	9/16	3 5/8	53/64	Q	1 1/16
1	1/2	8	19/32	3 3/4	27/32	R	1 1/16
1 1/8	33/64	5	5/8	3 7/8	55/64	R	1 1/16
1 1/4	17/32	3	21/32	4	7/8	S	1 1/8
1 3/8	35/64	2	21/32	4 1/8	57/64	T	1 1/8
1 1/2	9/16	1	11/16	4 1/4	29/32	T	1 1/8
		Letter.		4 3/8	59/64	U	1 3/16
1 5/8	37/64	A	23/32	4 1/2	15/16	V	1 3/16
1 3/4	19/32	B	23/32	4 5/8	61/64	V	1 3/16
1 7/8	39/64	C	3/4	4 3/4	31/32	W	1 1/4
2	5/8	E	3/4	4 7/8	63/64	X	1 1/4
2 1/8	41/64	F	25/32	5	1	X	1 1/4

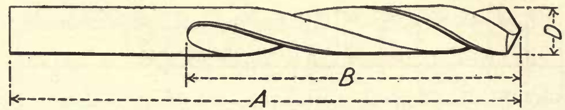
DIMENSIONS OF TWIST DRILLS—I



Diameter D	Total Length. A	Length of Groove on Straight Shank Drills B	No. of Morse Taper on Morse Taper Shank Drills	Lead of Grooves	Diameter D	Total Length A	Length of Groove on Straight Shank Drills B	No. of Morse Taper on Morse Taper Shank Drills	Lead of Grooves
1/4	6 1/2	4 1/8	1	1 3/4	1 11/16	15 1/8	10 5/8	4	11 13/16
5/16	6 7/8	4 3/8	1	2 3/16	1 3/4	15 1/2	10 7/8	4	12 1/4
3/8	7 1/4	4 11/16	1	2 5/8	1 13/16	15 7/8	11 3/16	4	12 11/16
7/16	7 5/8	4 15/16	1	3 1/16	1 7/8	16 1/4	11 7/16	4	13 1/8
1/2	8	5 1/4	1	3 1/2	1 15/16	16 5/8	11 3/4	4	13 9/16
9/16	8 3/8	5 1/2	1	3 15/16	2	17	12	4	14
5/8	8 3/4	5 13/16	2	4 3/8	2 1/16	17 1/4	12 3/16	5	14 7/16
11/16	9 1/8	6 1/16	2	4 13/16	2 1/8	17 1/2	12 3/8	5	14 7/8
3/4	9 1/2	6 3/8	2	5 1/4	2 3/16	17 3/4	12 9/16	5	15 5/16
13/16	9 7/8	6 5/8	2	5 11/16	2 1/4	18	12 3/4	5	15 3/4
7/8	10 1/4	6 15/16	2	6 1/8	2 5/16	18 1/4	12 15/16	5	16 3/16
15/16	10 5/8	7 3/16	3	6 9/16	2 3/8	18 1/2	13 1/8	5	16 5/8
1	11	7 1/2	3	7	2 7/16	18 3/4	13 5/16	5	17 1/16
1 1/16	11 3/8	7 3/4	3	7 7/16	2 1/2	19	13 1/2	5	17 1/2
1 1/8	11 3/4	8 1/16	3	7 7/8	2 9/16	19 1/4	13 11/16	5	17 15/16
1 3/16	12 1/8	8 3/8	3	8 5/16	2 5/8	19 1/2	13 7/8	5	18 3/8
1 1/4	12 1/2	8 5/8	3	8 3/4	2 11/16	19 3/4	14 1/16	5	18 13/16
1 5/16	12 7/8	8 15/16	4	9 3/16	2 3/4	20	14 1/4	5	19 1/4
1 3/8	13 1/4	9 3/16	4	9 5/8	2 13/16	20 1/4	14 7/16	5	19 11/16
1 7/16	13 5/8	9 1/2	4	10 1/16	2 7/8	20 1/2	14 5/8	5	20 1/8
1 1/2	14	9 3/4	4	10 1/2	2 15/16	20 3/4	14 13/16	5	20 9/16
1 9/16	14 3/8	10 1/16	4	10 15/16	3	21	15	5	21
1 5/8	14 3/4	10 5/16	4	11 3/8					

Explanatory note: Page 26.

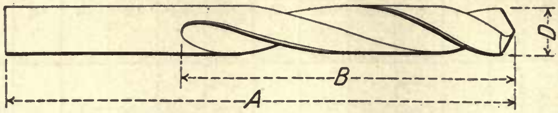
DIMENSIONS OF TWIST DRILLS—II



Letter Denoting Drill Size	Diameter in Inches D	Total Length A	Length of Groove B	Lead of Grooves	Letter Denoting Drill Size	Diameter in Inches D	Total Length A	Length of Groove B	Lead of Grooves
A	0.234	$6\frac{3}{8}$	$4\frac{1}{16}$	$1\frac{5}{8}$	N	0.302	$6\frac{13}{16}$	$4\frac{3}{8}$	$2\frac{1}{8}$
B	0.238	$6\frac{7}{16}$	$4\frac{1}{16}$	$1\frac{11}{16}$	O	0.316	$6\frac{7}{8}$	$4\frac{7}{16}$	$2\frac{3}{16}$
C	0.242	$6\frac{7}{16}$	$4\frac{1}{16}$	$1\frac{11}{16}$	P	0.323	$6\frac{15}{16}$	$4\frac{7}{16}$	$2\frac{1}{4}$
D	0.246	$6\frac{1}{2}$	$4\frac{1}{8}$	$1\frac{3}{4}$	Q	0.332	7	$4\frac{1}{2}$	$2\frac{5}{16}$
E	0.250	$6\frac{1}{2}$	$4\frac{1}{8}$	$1\frac{3}{4}$	R	0.339	$7\frac{1}{16}$	$4\frac{1}{2}$	$2\frac{3}{8}$
F	0.257	$6\frac{9}{16}$	$4\frac{3}{16}$	$1\frac{13}{16}$	S	0.348	$7\frac{1}{16}$	$4\frac{9}{16}$	$2\frac{7}{16}$
G	0.261	$6\frac{9}{16}$	$4\frac{3}{16}$	$1\frac{13}{16}$	T	0.358	$7\frac{1}{8}$	$4\frac{5}{8}$	$2\frac{1}{2}$
H	0.266	$6\frac{5}{8}$	$4\frac{3}{16}$	$1\frac{7}{8}$	U	0.368	$7\frac{3}{16}$	$4\frac{5}{8}$	$2\frac{9}{16}$
I	0.272	$6\frac{5}{8}$	$4\frac{1}{4}$	$1\frac{7}{8}$	V	0.377	$7\frac{1}{4}$	$4\frac{11}{16}$	$2\frac{5}{8}$
J	0.277	$6\frac{11}{16}$	$4\frac{1}{4}$	$1\frac{15}{16}$	W	0.386	$7\frac{5}{16}$	$4\frac{3}{4}$	$2\frac{11}{16}$
K	0.281	$6\frac{11}{16}$	$4\frac{1}{4}$	$1\frac{15}{16}$	X	0.397	$7\frac{3}{8}$	$4\frac{13}{16}$	$2\frac{3}{4}$
L	0.290	$6\frac{3}{4}$	$4\frac{5}{16}$	2	Y	0.404	$7\frac{7}{16}$	$4\frac{13}{16}$	$2\frac{13}{16}$
M	0.295	$6\frac{3}{4}$	$4\frac{5}{16}$	$2\frac{1}{16}$	Z	0.413	$7\frac{1}{2}$	$4\frac{7}{8}$	$2\frac{7}{8}$

Explanatory note: Page 26.

DIMENSIONS OF TWIST DRILLS—III



No. of Steel Wire Gage	Diam. in Inches D	Total Length A	Length of Groove B	Lead of Grooves	No. of Steel Wire Gage	Diam. in Inches D	Total Length A	Length of Groove B	Lead of Grooves
1	0.2280	4	2 3/4	1 5/8	31	0.1200	2 13/16	1 9/16	13/16
2	.2210	3 15/16	2 11/16	1 9/16	32	.1160	2 3/4	1 1/2	13/16
3	.2130	3 7/8	2 5/8	1 1/2	33	.1130	2 3/4	1 1/2	13/16
4	.2090	3 13/16	2 9/16	1 7/16	34	.1110	2 3/4	1 1/2	3/4
5	.2055	3 3/4	2 1/2	1 7/16	35	.1100	2 11/16	1 7/16	3/4
6	.2040	3 3/4	2 1/2	1 7/16	36	.1065	2 11/16	1 7/16	3/4
7	.2010	3 3/4	2 1/2	1 7/16	37	.1040	2 5/8	1 3/8	3/4
8	.1990	3 11/16	2 7/16	1 3/8	38	.1015	2 5/8	1 3/8	11/16
9	.1960	3 11/16	2 7/16	1 3/8	39	.0995	2 9/16	1 5/16	11/16
10	.1935	3 5/8	2 3/8	1 3/8	40	.0980	2 9/16	1 5/16	11/16
11	.1910	3 5/8	2 3/8	1 5/16	41	.0960	2 3/8	1 3/16	11/16
12	.1890	3 9/16	2 5/16	1 5/16	42	.0935	2 5/16	1 3/16	5/8
13	.1850	3 9/16	2 5/16	1 5/16	43	.0890	2 1/4	1 1/8	5/8
14	.1820	3 1/2	2 1/4	1 1/4	44	.0860	2 1/4	1 1/8	5/8
15	.1800	3 1/2	2 1/4	1 1/4	45	.0820	2 3/16	1 1/16	9/16
16	.1770	3 7/16	2 3/16	1 1/4	46	.0810	2 3/16	1 1/16	9/16
17	.1730	3 3/8	2 1/8	1 3/16	47	.0785	2 1/8	1 1/16	9/16
18	.1695	3 3/8	2 1/8	1 3/16	48	.0760	2 1/8	1	9/16
19	.1660	3 5/16	2 1/16	1 3/16	49	.0730	2 1/16	1	1/2
20	.1610	3 1/4	2	1 1/8	50	.0700	2	15/16	1/2
21	.1590	3 1/4	2	1 1/8	51	.0670	2	15/16	1/2
22	.1570	3 1/4	2	1 1/8	52	.0635	1 15/16	7/8	7/16
23	.1540	3 3/16	1 15/16	1 1/16	53	.0595	1 7/8	7/8	7/16
24	.1520	3 3/16	1 15/16	1 1/16	54	.0550	1 7/8	13/16	3/8
25	.1495	3 1/8	1 7/8	1 1/16	55	.0520	1 13/16	3/4	3/8
26	.1470	3 1/8	1 7/8	1	56	.0465	1 3/4	11/16	5/16
27	.1440	3 1/16	1 13/16	1	57	.0430	1 11/16	11/16	5/16
28	.1405	3 1/16	1 13/16	1	58	.0420	1 11/16	11/16	5/16
29	.1360	3	1 3/4	15/16	59	.0410	1 11/16	11/16	5/16
30	.1285	2 15/16	1 11/16	7/8	60	.0400	1 11/16	5/8	5/16

Explanatory note: Page 26.

WIRE GAGES

Number of Wire Gage	American or Brown & Sharpe	Birmingham or Stubs' Iron Wire	Washburn & Moen Mfg. Co.	Stubs' Steel Wire	Trenton Iron Co.	Imperial Wire	U.S. Standard for Plate	Number of Wire Gage	American or Brown & Sharpe	Birmingham or Stubs' Iron Wire	Washburn & Moen Mfg. Co.	Stubs' Steel Wire	Trenton Iron Co.	Imperial Wire	U.S. Standard for Plate
000000	—	—	—	—	—	0.464	0.4688	18	0.0403	0.049	0.0475	0.168	0.0450	0.0480	0.0500
00000	—	—	—	—	0.450	.432	.4375	19	.0359	.042	.0410	.164	.0400	.0400	.0438
0000	0.4600	0.454	0.3938	—	.400	.400	.4063	20	.0320	.035	.0348	.161	.0350	.0360	.0375
000	.4096	.425	.3625	—	.360	.372	.3750	21	.0285	.032	.0318	.157	.0310	.0320	.0344
00	.3648	.380	.3310	—	.330	.348	.3438	22	.0253	.028	.0286	.155	.0280	.0280	.0313
0	.3249	.340	.3065	—	.305	.324	.3125	23	.0226	.025	.0258	.153	.0250	.0240	.0281
1	.2893	.300	.2830	0.227	.285	.300	.2813	24	.0201	.022	.0230	.151	.0225	.0220	.0250
2	.2576	.284	.2625	.219	.265	.276	.2656	25	.0179	.020	.0204	.148	.0200	.0200	.0219
3	.2294	.259	.2437	.212	.245	.252	.2500	26	.0159	.018	.0181	.146	.0180	.0180	.0188
4	.2043	.238	.2253	.207	.225	.232	.2344	27	.0142	.016	.0173	.143	.0170	.0164	.0172
5	.1819	.220	.2070	.204	.205	.212	.2188	28	.0126	.014	.0162	.139	.0160	.0149	.0156
6	.1620	.203	.1920	.201	.190	.192	.2031	29	.0113	.013	.0150	.134	.0150	.0136	.0141
7	.1443	.180	.1770	.199	.175	.176	.1875	30	.0100	.012	.0140	.127	.0140	.0124	.0125
8	.1285	.165	.1620	.197	.160	.160	.1719	31	.0089	.010	.0132	.120	.0130	.0116	.0109
9	.1144	.148	.1483	.194	.145	.144	.1563	32	.0080	.009	.0128	.115	.0120	.0108	.0102
10	.1019	.134	.1350	.191	.130	.128	.1406	33	.0071	.008	.0118	.112	.0110	.0100	.0094
11	.0907	.120	.1205	.188	.1175	.116	.1250	34	.0063	.007	.0104	.110	.0100	.0092	.0086
12	.0808	.109	.1055	.185	.105	.104	.1094	35	.0056	.005	.0095	.108	.0095	.0084	.0078
13	.0720	.095	.0915	.182	.0925	.092	.0938	36	.0050	.004	.0090	.106	.0090	.0076	.0070
14	.0641	.083	.0800	.180	.080	.080	.0781	37	.0045	—	—	.103	.0085	.0068	.0066
15	.0571	.072	.0720	.178	.070	.072	.0703	38	.0040	—	—	.101	.0080	.0060	.0063
16	.0508	.065	.0625	.175	.061	.064	.0625	39	.0035	—	—	.099	.0075	.0052	—
17	.0453	.058	.0540	.172	.0525	.056	.0563	40	.0031	—	—	.097	.0070	.0048	—

American Gage: Standard for sheet brass, copper or German silver, and for wire of the same material.
Birmingham Gage: For soft iron wire or rods.
Washburn & Moen Gage: Used for iron or copper telegraph and telephone wire.
Stubs' Steel Wire Gage: For Stubs' drill rods. Not same as Stubs' Iron Wire Gage.
U.S. Standard Gage: Recognized as standard for sheet iron and steel.

Explanatory note: Page 29.

Pipe Reamers

Dimensions of pipe reamers are given on page 8. These reamers are used to precede pipe taps. They are made of the same sizes as pipe taps, except that the dimensions of the pipe reamer correspond to the root diameter of the thread of the pipe taps, the taper being, of course, the same, or ¾ inch per foot. The small end of pipe reamers is slightly chamfered in order to facilitate the entering of the reamer in holes which are of about the same size as the small diameter of the reamer. [MACHINERY, December, 1907, Reamers.]

Dimensions of Taper Pin Reamers

Dimensions of taper pin reamers are given on page 9. These reamers are intended for reaming holes for standard taper pins, the dimensions of which are given on the same page. These pins are made of various lengths, and the length specified in the table is the maximum length of each size. The pins and reamers taper one-fourth inch per foot. The diameter at the small end of the reamer should be made to such a dimension that the reamer will project at least 1/16 inch, or on the larger sizes ⅛ inch, through the hole reamed for the longest standard taper pin of the size to which it corresponds. The length of the cutting edges should also be enough longer than the longest pin to permit the reamer to be ground a number of times without it becoming too small in diameter at the upper end of the flutes for the size of pin for which it is intended. The length of the square on the end of the shank should be about 1½ times the diameter of the shank, and the size of the square should be ¾ the diameter of the shank. The exact diameter of the shank portion, of course, is of little importance, it being usually turned down a slight amount below the diameter at the large end of the fluted portion of the reamer. [MACHINERY, November, 1907, Reamers; December, 1909, Errors in Grinding Taper Reamers.]

Sockets and Taper Reamers for Brown & Sharpe Standard Tapers

On page 10 are given the dimensions of the various Brown & Sharpe standard tapers. As will be seen from the table, the taper is ½ inch per foot in all cases, except for taper No. 10, which has a taper of 0.5161 inch per foot. It will be observed that in certain cases there are several different lengths corresponding to the same number of taper, all the tapers of the same number, however, being of the same diameter at the small end. While the lengths of the taper shanks thus are different, the reamers, the dimensions for which are specified on page 11, can all be made the same for the same number of taper, inasmuch as the diameter at the small end is the same. The only thing necessary to consider is to make the length of the cutting edges of the reamers long enough for the longest or deepest taper socket of a given size, in which case they, of course, will be sufficient for the shorter lengths. The Brown & Sharpe taper shanks are used mostly on shank end mills and T-slot cutters, as well as on several other tools for the machines manufactured by the Brown & Sharpe Mfg. Co. The sizes of the taper sockets have been carried up to No. 12 only, larger sizes being seldom used. As will be seen on page 11, dimensions are given for the diameters at the small end both for roughing and finishing reamers, the roughing reamer being in all cases 0.010 inch smaller in diameter than the finishing reamer. [MACHINERY, November, 1907, Reamers; December, 1909, Errors in Grinding Taper Reamers.]

Sockets and Taper Reamers for Morse Standard Tapers

On page 12 dimensions are given for Morse standard tapers, and on page 14 dimensions for the reamers for reaming these taper sockets. As shown on page

(Continued on page 26.)

Diameter or Thickness	American or B. & S.	Birmingham or Stubbs	American Screw Gage	Steel Music Wire	Wire Gage Drills	Letter Drill Gage
0.00314	40					
0.00353	39					
0.00397	38					
0.004		36				
0.0045	37					
0.005	36	35				
0.0056	35					
0.0063	34					
0.007		34				
0.0071	33					
0.008	32	33				
0.0083				8—0		
0.0087				7—0		
0.0089	31					
0.009		32				
0.0095				6—0		
0.01	30	31		5—0		
0.011				4—0		
0.0113	29					
0.012		30		3—0		
0.0126	23					
0.013		29				
0.0133				2—0		
0.0135					80	
0.014		28				
0.0142	27					
0.0144				1—0		
0.0145					79	
0.0156				1		
0.0159	26					
0.016		27			78	
0.0166				2		
0.0178				3		
0.0179	25					
0.018		26			77	
0.0188				4		
0.02		25			76	
0.0201	24					
0.0202				5		
0.021					75	
0.0215				6		
0.022		24				
0.0225					74	
0.0226	23					
0.023				7		
0.024					73	
0.0243				8		
0.025		23			72	
0.0253	22					
0.0256				9		
0.026					71	
0.027				10		
0.028		22			70	
0.0284				11		
0.0285	21					
0.02925					69	
0.0296				12		
0.031					68	
0.0314				13		
0.032	20	21			67	
0.0326				14		
0.033					66	
0.0345				15		
0.035		20			65	
0.0359	19					
0.036				16	64	
0.037					63	
0.0377				17		
0.038					62	
0.039					61	
0.0395				18		
0.04					60	
0.0403	18					
0.041					59	
0.0414				19		
0.042		19			58	
0.043					57	
0.0434				20		
0.0453	17					
0.046				21		

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 35. Explanatory note: Page 29.

SIZES OF WIRE, DRILLS OR SHEETS, ARRANGED PROGRESSIVELY BY DIAMETERS OR THICKNESSES—II

Diameter or Thickness	American or B. & S.	Birmingham or Stubbs	American Screw Gage	Steel Music Wire	Wire Gage Drills	Letter Drill Gage
0.0465					56	
0.0483				22		
0.049		18				
0.0508	16					
0.051				23		
0.052					55	
0.055				24	54	
0.0571	15					
0.0578			0			
0.058		17				
0.0586				25		
0.0595					53	
0.0626				26		
0.0635					52	
0.0641	14					
0.065		16•				
0.0658				27		
0.067					51	
0.07					50	
0.071			1			
0.072	13	15		28		
0.073					49	
0.076				29	48	
0.0785					47	
0.08				30		
0.0808	12					
0.081					46	
0.082					45	
0.083		14				
0.0842			2			
0.086					44	
0.089					43	
0.0907	11					
0.0935					42	
0.095		13				
0.096					41	
0.0973			3			
0.098					40	
0.0995					39	
0.1015					38	

Diameter or Thickness	American or B. & S.	Birmingham or Stubbs	American Screw Gage	Steel Music Wire	Wire Gage Drills	Letter Drill Gage
0.1019	10					
0.104					37	
0.1065					36	
0.109		12				
0.110					35	
0.1105			4			
0.111					34	
0.113					33	
0.1144	9					
0.116					32	
0.12		11			31	
0.1236			5			
0.1285	8				30	
0.134		10				
0.136					29	
0.1368			6			
0.1405					28	
0.144					27	
0.1443	7					
0.147					26	
0.148		9				
0.1495					25	
0.150			7			
0.152					24	
0.154					23	
0.157					22	
0.159					21	
0.161					20	
0.162	6					
0.1631			8			
0.165		8				
0.166					19	
0.1695					18	
0.173					17	
0.1763			9			
0.177					16	
0.18		7			15	
0.1819	5					
0.182					14	
0.185					13	

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Diameter or Thickness	American or B. & S.	Birmingham or Stubbs	American Screw Gage	Steel Music Wire	Wire Gage Drills	Letter Drill Gage
0.189					12	
0.1894			10			
0.191					11	
0.1935					10	
0.196					9	
0.199					8	
0.201					7	
0.2026			11			
0.203		6				
0.204					6	
0.2043	4					
0.2055					5	
0.209					4	
0.213					3	
0.2158			12			
0.22		5				
0.221					2	
0.228					1	
0.2289			13			
0.2294	3					
0.234						A
0.238		4				B
0.242						C
0.2421			14			
0.246						D
0.2552			15			
0.257						F
0.2576	2					
0.259		3				
0.261						G
0.266						H
0.2684			16			
0.272						I
0.277						J
0.281						K
0.2816			17			
0.284		2				
0.2893	1					
0.290						L
0.2947			18			

Diameter or Thickness	American or B. & S.	Birmingham or Stubbs	American Screw Gage	Steel Music Wire	Wire Gage Drills	Letter Drill Gage
0.295						M
0.3		1				
0.302						N
0.316						O
0.321			20			
0.323						P
0.3249	0					
0.332						Q
0.339						R
0.34		0				
0.3474			22			
0.348						S
0.358						T
0.3648	00					
0.368						U
0.3737			24			
0.377						V
0.38		00				
0.386						W
0.397						X
0.40			26			
0.404						Y
0.4096	000					
0.413						Z
0.425		000				
0.4263			28			
0.4520			30			
0.454		0000				
0.46	0000					

These tables are prepared with reference to the diameter so as to enable any one to tell at a glance what size of drill or wire is nearest to it. Thus, if we need a hole or wire 0.0257 in diameter, we look down the first column and find that 0.0256 is the nearest, being 0.0001 small. No. 9 steel music wire is then the nearest to the desired size. If we want a wire to drive in a 1/8 hole, we see that No. 8 B. & S. gage comes nearest to it.

Contributed by Fred H. Colvin, MACHINERY'S Data Sheet No. 35. Explanatory note: Page 29.

14, both a finishing reamer and roughing reamer are used, the latter being provided with a spiral groove cut like a thread all around the cutting edges, as shown in the top view. This thread or groove breaks up the chips in the same manner as the nicks in the cutting edges of plain "nicked" milling cutters. The thread is cut left-hand with a tool similar to a square threading tool, but having the corners slightly rounded. The width of the tool should vary from about 1/32 inch for the smallest size reamer for Morse taper sockets to 3/32 inch for the largest sizes, the depth of the groove being a little more than half the width of the tool. The pitch of the thread should be about 1/5 inch for the smallest size, increasing up to 1/3 inch for the largest sizes. On page 13 are given dimensions of Morse standard taper sockots with a Morse taper both on the inside and outside. [MACHINERY, November, 1907, Reamers.]

Taper Reamers for Jarno Standard Tapers

On page 14 are given dimensions for the reamers for Jarno tapers. The Jarno taper was originally proposed by Mr. Oscar J. Beale of the Brown & Sharpe Mfg. Co. The taper per foot of all the Jarno tapers is 0.600 inch on the diameter. All the dimensions necessary for Jarno tapers are determined by the number of the taper. The diameter at the large end of the taper is as many eighths, the diameter at the small end of the taper as many tenths, and the length of the taper between the large and small diameter as many half inches as is expressed by the number of the taper. For example, the No. 7 Jarno taper is 7/8 inch in diameter at the large end, 7/10 or 0.7 inch in diameter at the small end, and the length is 7/2 inches or 3½ inches. [MACHINERY, November, 1907, Reamers.]

Squares on Shanks of Reamers and Taps

On page 15 a table is given by means of which the proper size of square corresponding to a given diameter of shank can be seen at a glance. If the diameter of the shank *D*, for example, is 1 9/64 inch, then we find directly from the table that the square *S* should be 55/64 inch across flats. The table, extending from 1/16 inch up to 4 inches, covers the whole range ordinarily met with in the machine shop. The size of the square is, on an average, ¾ times the diameter of the shank.

Centers for Reamers and Arbors

On page 17 a table of well proportioned reamer and arbor centers is given, together with the general formulas by means of which the dimensions are determined. These centers are laid out so as to be large enough for heavy duty. Care should be exercised in drilling the hole *C* so that it is of the full depth *D*, and when countersinking care should be taken not to exceed the diameter *B*.

Dimensions of Twist Drills

On pages 18, 19 and 20 are given dimensions for twist drills. The first table gives the dimensions for drills from ¼ inch up to 3 inches in diameter, the second for the so-called letter-size drills, and the third for steel wire gage drills, from No. 1 down to No. 60 steel wire gage. Referring first to the table for drills from ¼- to 3-inch size, the dimensions provided give the total length and the length of the fluted portion on straight shank drills, the size of shank of Morse taper shank drills, and the lead of spiral of the grooves or flutes. In order to establish uniformity in regard to the total lengths, taper shank and straight shank drills ought to be made of the same total lengths. As the length of the taper shank always must be its regular standard length, dimensions are not given for the lengths of the grooved parts on taper shank drills, as these lengths will, when the total length is given, depend entirely upon

(Continued on page 29.)

NUMBER OF TEETH AND KEYWAYS IN MILLING CUTTERS

Number of Teeth and Lead of Spiral of Plain Milling Cutters.

$$\text{No. of Teeth} = \frac{5 \times \text{Diam.} + 24}{2}$$

$$\text{Lead of Spiral} = 9 \times \text{Diam.} + 4$$

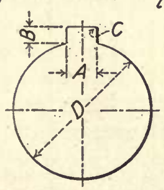
Diam. of Cutter	Number of Teeth	Lead of Spiral of Teeth, Inches	Diam. of Cutter	Number of Teeth	Lead of Spiral of Teeth, Inches
2	16	22	5½	26	53½
2¼	18	24¼	6	26	58
2½	18	26½	6½	28	62½
2¾	18	28¾	7	30	67
3	20	31	7½	30	71½
3½	20	35½	8	32	76
4	22	40	9	34	85
4½	24	44½	10	36	94
5	24	49			

Number of Teeth in Side Milling Cutters.

$$\text{No. of teeth} = 3.1\ \text{Diam.} + 11.$$

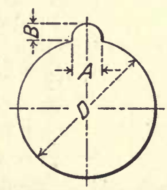
Diam. of Cutter	Number of Teeth	Diam. of Cutter	Number of Teeth
2	18	5½	28
2¼	18	6	30
2½	18	6½	32
2¾	20	7	32
3	20	7½	34
3½	22	8	36
4	24	9	38
4½	24	10	42
5	26		

Standard Keyways for Milling Cutters.—Square.



D = Diam. of Hole	A = Width of Keyway	B = Depth of Keyway	C = Radius of Corners
3/8 to 9/16 inch	3/32	3/64	0.020
5/8 to 7/8 inch	1/8	1/16	0.030
15/16 to 1 1/8 inch	5/32	5/64	0.035
1 3/16 to 1 3/8 inch	3/16	3/32	0.040
1 7/16 to 1 3/4 inch	1/4	1/8	0.050
1 13/16 to 2 inch	5/16	5/32	0.060
2 1/16 to 2 1/2 inch	3/8	3/16	0.060
2 9/16 to 3 inch	7/16	3/16	0.060

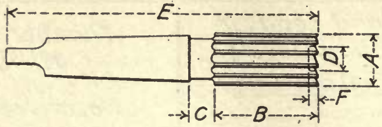
Standard Keyways for Milling Cutters.—Halfround.



D = Diam. of Hole	A = Width of Keyway	B = Depth of Keyway
3/8 to 5/8 inch	1/8	1/16
11/16 to 13/16 inch	3/16	3/32
7/8 to 1 3/16 inch	1/4	1/8
1 1/4 to 1 7/16 inch	5/16	5/32
1 1/2 to 2 inch	3/8	3/16
2 1/16 to 2 7/16 inch	7/16	7/32
2 1/2 to 3 inch	1/2	1/4

Explanatory note: Page 29.

DIMENSIONS OF END MILLS



Depth of recess F = 1/16" for sizes up to 7/8" diam., 3/32" for sizes from 7/8" to 1 1/4" diam., and 1/8" for sizes 1 1/4" diam. and up.

Diam. A	Length of Cut B	Length of Neck C	Diam. of End Recess D	Morse Taper Shank End Mills: No. of Morse Taper	Morse Taper Shank End Mills: Total Length E	Brown & Sharpe Taper Shank End Mills: No. of B. & S. Taper	Brown & Sharpe Taper Shank End Mills: Total Length E	Number of Flutes
1/4	3/4	1/4	5/64	1	3 9/16	4	2 3/8	5
1/4	3/4	5/16	5/64	—	—	5	2 15/16	5
5/16	7/8	1/4	3/32	1	3 11/16	4	2 1/2	5
5/16	7/8	5/16	3/32	—	—	5	3 1/16	5
3/8	7/8	1/4	1/8	1	3 11/16	4	2 1/2	6
3/8	7/8	5/16	1/8	—	—	5	3 1/16	6
7/16	1	1/4	3/16	1	3 13/16	4	2 5/8	6
7/16	1	5/16	3/16	2	4 3/8	5	3 3/16	6
1/2	1 1/8	5/16	1/4	1	4	5	3 5/16	6
1/2	1 1/8	3/8	1/4	2	4 9/16	7	5 1/8	6
9/16	1 1/4	5/16	1/4	1	4 1/8	5	3 7/16	6
9/16	1 1/4	3/8	1/4	2	4 11/16	7	5 1/4	6
5/8	1 3/8	5/16	1/4	—	—	5	3 9/16	7
5/8	1 3/8	3/8	1/4	2	4 13/16	7	5 3/8	7
11/16	1 1/2	3/8	1/4	2	4 15/16	7	5 1/2	7
11/16	1 1/2	1/2	1/4	—	—	9	6 3/4	7
3/4	1 5/8	3/8	5/16	2	5 1/16	7	5 5/8	7
3/4	1 5/8	1/2	5/16	3	5 7/8	9	6 7/8	7
7/8	1 3/4	3/8	3/8	2	5 3/16	7	5 3/4	8
7/8	1 3/4	1/2	3/8	3	6	9	7	8
1	1 7/8	3/8	3/8	2	5 5/16	7	5 7/8	8
1	1 7/8	1/2	3/8	3	6 1/8	9	7 1/8	8
1 1/8	2	3/8	7/16	—	—	7	6	9
1 1/8	2	1/2	7/16	3	6 1/4	9	7 1/4	9
1 1/4	2	1/2	1/2	3	6 1/4	7	6 1/8	9
1 1/4	2	1/2	1/2	4	7 1/4	9	7 1/4	9
1 3/8	2 1/8	1/2	5/8	3	6 3/8	9	7 3/8	10
1 3/8	2 1/8	1/2	5/8	4	7 3/8	—	—	10
1 1/2	2 1/4	1/2	3/4	3	6 1/2	9	7 1/2	10
1 1/2	2 1/4	1/2	3/4	4	7 1/2	—	—	10
1 5/8	2 1/4	1/2	13/16	4	7 1/2	9	7 1/2	10
1 3/4	2 3/8	1/2	7/8	4	7 5/8	9	7 5/8	11
1 7/8	2 1/2	1/2	15/16	4	7 3/4	11	9 3/4	11
2	2 1/2	1/2	1	4	7 3/4	11	9 3/4	11

Explanatory note: Page 29.

the length of the standard taper used. It is obvious that after the length of the taper shank is deducted from the total length and provision has been made for a short "neck" between the taper shank and the grooved part, the remaining portion will be the fluted length. The lead of the flutes or grooves is 7 times the diameter of the drill. In the case of the letter-size and steel wire gage drills no taper shanks are specified, as drills of these sizes are almost exclusively provided with straight shanks. The letter-size drills over ¼ inch in diameter, however, may be provided with a No. 1 Morse taper shank if required. [MACHINERY, August, 1905, Proportions of Twist Drills.]

Wire Gages

On page 21 is given a table by means of which the dimensions in inches may be found for given wire and plate gage numbers. The table includes all the commonly used gages. On pages 23, 24 and 25 a set of tables is given by means of which the corresponding number of any wire gage may be easily found when the dimension in inches is known. These tables are, in a measure, a reversal of the table on page 21, and all the tables may profitably be used in conjunction with each other. The explanatory note on page 25 illustrates more fully the use of these tables.

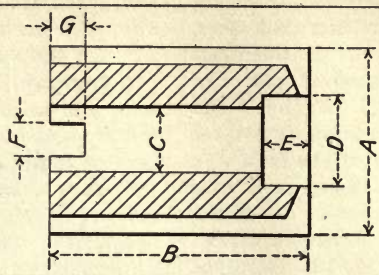
Plain and Side Milling Cutters

On page 27 are given the number of teeth and the lead of spiral for plain milling cutters of diameters from 2 to 10 inches. Cutters with the width of face greater than 4 inches should preferably be made in two or more interlocking sections. Cutters larger than 5 inches in diameter should preferably be made with inserted teeth, in which case, of course, the number of teeth cannot be as large as that given in the table. A 6-inch inserted blade cutter should not have more than about 12 teeth; an 8-inch, 16 teeth; and a 10-inch, 18 teeth. The number of teeth to be used in side milling cutters is somewhat greater than that used in plain milling cutters, as shown in the table to the right on page 27. On the same page tables of standard keyways to be used in milling cutters, and as adopted by leading milling cutter manufacturers, are given. In case of the square keyway shown to the left, care should be taken to have the corners at *C* well rounded to the radius specified. The half-round keyway is preferable, as there is less likelihood of a crack starting, as is often the case at the corner of the square keyway. [MACHINERY, April, 1906, Milling Cutters.]

Dimensions of End Mills

Dimensions of end mills provided with a solid taper shank are given on page 28. The teeth on the cylindrical surface are usually cut straight, but may also be cut on a spiral. The amount of the spiral should not exceed 20 degrees. The direction of spiral should be left-hand for right-hand end mills, and *vice versa*, especially if the mill is to be used for cutting both with its end and with its side. If the mill is to be used exclusively as an end mill, cutting only with the teeth on its extreme end, then the spiral on a right-hand end mill should preferably be right-hand, because in that case it is possible to give the teeth a positive front rake. Solid shank end mills are commonly provided with either Brown & Sharpe or Morse taper shank. In the table of these mills, columns are given for both, and in some cases two numbers of shanks are specified for the same size of mill, indicating that in usual practice the mills in question may be provided with either of the two shanks. The numbers of shanks given, and the dimensions in general correspond to the practice of prominent end mill manufacturers. The total length, of course, differs according to the number of taper shank used, as indicated.

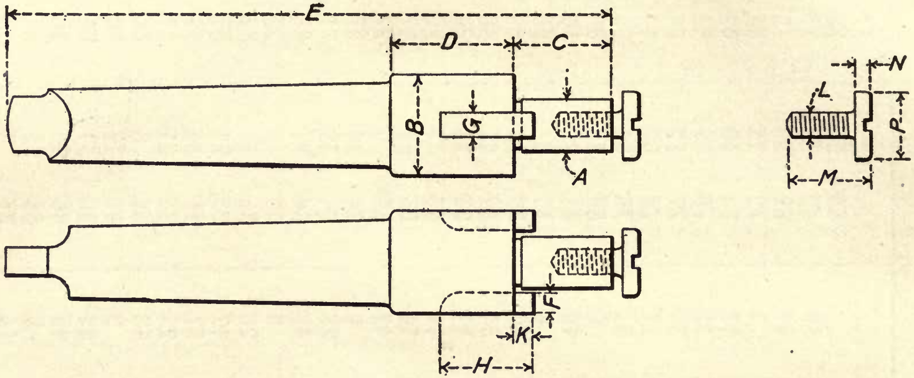
DIMENSIONS OF SHELL END MILLS



Diam. A	Total Length B	Diam. of Hole C	Diam. of Recess D	Depth of Recess E	Width of Keyway F	Depth of Keyway G	No. of Teeth
1 1/4	1 1/4	1/2	3/4	5/16	3/16	3/16	16
1 5/16	1 1/4	1/2	3/4	5/16	3/16	3/16	16
1 3/8	1 1/4	1/2	3/4	5/16	3/16	3/16	16
1 7/16	1 1/4	1/2	3/4	5/16	3/16	3/16	16
1 1/2	1 1/4	5/8	7/8	5/16	3/16	3/16	16
1 5/8	1 1/4	5/8	7/8	5/16	3/16	3/16	18
1 3/4	1 1/4	5/8	7/8	5/16	3/16	3/16	18
1 7/8	1 1/4	5/8	7/8	5/16	3/16	3/16	18
2	1 1/4	5/8	7/8	5/16	3/16	3/16	18
2 1/8	2	3/4	1	7/16	1/4	1/4	18
2 1/4	2	3/4	1	7/16	1/4	1/4	18
2 3/8	2	3/4	1	7/16	1/4	1/4	18
2 1/2	2	3/4	1	7/16	1/4	1/4	18
2 5/8	2	1	1 5/16	1/2	5/16	5/16	20
2 3/4	2	1	1 5/16	1/2	5/16	5/16	20
2 7/8	2	1	1 5/16	1/2	5/16	5/16	20
3	2	1	1 5/16	1/2	5/16	5/16	20

Explanatory note: Page 38.

DIMENSIONS OF ARBORS FOR SHELL END MILLS



Diam. of Arbor A*	Shell End Mill Sizes used for	Diam. of Body B	Length of Arbor C	Length of Body D	No. of Morse Taper	Total Length E	Depth of Key F	Width of Key G	Length of Key H	Projection of Key K	Diam. of Screw L	No. of Threads per Inch of Screw	Length of Screw M	Thickness of Head N	Diam. of Head P
1/2	1 1/4—1 7/16	1 3/16	7/8	2 1/8	3	7	5/16	11/64	1 1/4	5/32	1/4	24	5/8	7/32	11/16
5/8	1 1/2—2	1 3/8	7/8	2 1/8	3	7	3/8	11/64	1 3/8	5/32	5/16	22	3/4	3/16	13/16
3/4	2 1/8—2 1/2	1 3/4	1 7/16	2 3/16	4	8 5/8	7/16	15/64	1 1/2	7/32	3/8	20	15/16	1/4	15/16
1	2 5/8—3	2	1 7/16	2 3/16	4	8 5/8	7/16	19/64	1 5/8	9/32	1/2	16	1 1/8	5/16	1 1/4

* This dimension should be made from 0.00025" to 0.0005" under size.

Explanatory note: Page 88.

SETTING ANGLES FOR MILLING END MILLS

TABLE OF ANGLES FOR HEADSTOCK OF MILLING MACHINE WHEN CUTTING END TEETH IN MILLS, ETC.

No. of Teeth Cut.	Angle of Cutter with which the Teeth are Cut.									
	45°		50°		60°		70°		80°	
5	....	....	....	....	....	....	....	....	57°	8′
6	....	....	....	....	....	....	50°	55′	72	13
7	....	....	....	....	43°	36′	62	50	77	13
8	....	....	32°	57′	54	44	68	39	79	51
9	32°	58′	45	15	61	1	72	13	81	29
10	43	24	52	26	65	12	74	40	82	38
11	50	0	57	22	68	13	76	28	83	29
12	54	44	61	2	70	32	77	52	84	9
13	58	20	63	52	72	21	78	59	84	41
14	61	12	66	10	73	51	79	54	85	8
15	63	34	68	4	75	6	80	40	85	30
16	65	32	69	40	76	10	81	20	85	49
17	67	12	71	1	77	4	81	53	86	5
18	68	39	72	13	77	52	82	23	86	19
19	69	55	73	15	78	34	82	49	86	32
20	71	3	74	11	79	11	83	13	86	43
21	72	2	74	59	79	44	83	33	86	53
22	72	55	75	44	80	14	83	52	87	2
23	73	44	76	24	80	42	84	9	87	10
24	74	28	77	0	81	6	84	24	87	18
25	75	7	77	33	81	28	84	38	87	24
26	75	44	78	4	81	49	84	51	87	30
27	76	17	78	32	82	8	85	3	87	36
28	76	49	78	58	82	26	85	14	87	42
29	77	17	79	21	82	42	85	24	87	46
30	77	44	79	43	82	57	85	34	87	51
32	78	32	80	23	83	24	85	51	87	59
34	79	14	80	59	83	48	86	6	88	7
36	79	51	81	29	84	9	86	19	88	13
38	80	24	81	58	84	29	86	31	88	19
40	80	53	82	22	84	45	86	42	88	24
42	81	20	82	44	85	0	86	51	88	29
44	81	44	83	4	85	14	87	0	..	..
46	82	7	83	23	85	27	87	8	88	37
48	82	26	83	39	85	38	87	16	..	..
50	82	45	83	55	85	49	87	22	88	43
52	83	3	84	9	85	59	87	28	..	..
54	83	17	84	22	86	8	87	34	88	49
56	83	31	84	34	86	16	87	39	..	..
58	83	46	84	46	86	24	87	44	..	..
60	83	58	84	57	86	31	87	49	88	56

Contributed by E. J. Bates, MACHINERY'S Data Sheet No. 32. Explanatory note: Page 38.

SETTING ANGLES FOR MILLING ANGULAR CUTTERS—I

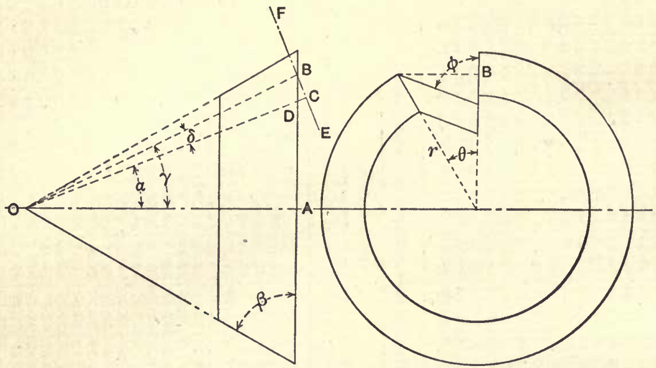


Fig. 1. Diagram for Calculating Setting-angle for Angular Cutters.

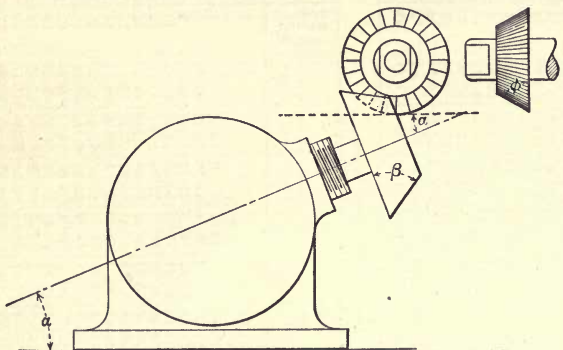


Fig. 2. Diagram of Head, Blank, and Cutter for Milling Teeth.

Let r = radius of blank,
n = the number of teeth,
β = the angle of blank,
ϕ = angle of cutter,
θ = tooth angle $= \frac{360}{n}$,
γ and δ angles, as shown in Fig. 1.

In Fig. 1, the line OA is the axis of a cone which would result from prolonging the blank down to a point. The line OC is the intersection of the two planes which form the sides of the tooth space, and hence the cutter must run parallel to this line while cutting a space. The head must then be elevated so that the line OC is parallel with the table, and in doing so we will have turned it through an angle equal to AOC, or α. Line EF is drawn perpendicular to OC.

From the figure,

$$\tan\gamma = \frac{AB}{AO}; \text{ but } AB = r\cos\theta; \text{ and } AO = r\tan\beta.$$

$$\text{Therefore } \tan\gamma = \frac{\cos\theta}{\tan\beta} \qquad (1)$$

$$\text{Also } \sin\delta = \frac{BC}{OB}; \text{ but } BC = r\sin\theta\cot\phi; \text{ and } OB = \frac{r\cos\theta}{\sin\gamma}.$$

$$\text{Therefore } \sin\delta = \frac{r\sin\theta\cot\phi}{\frac{r\cos\theta}{\sin\gamma}}$$

$$\text{or } \sin\delta = \tan\theta\cot\phi\sin\gamma. \qquad (2)$$

With equations (1) and (2) we can find the value of γ and δ, and their difference is the angle of elevation.

For $\beta = 0$ (case of an end mill, teeth on the end) equation (1) becomes $\tan\gamma = \frac{\cos\theta}{0}$, or $\tan\gamma$ is infinite, from which $\gamma = 90°$. Substituting sin 90 for $\sin\gamma$ in (2) gives $\sin\delta = \tan\theta\cot\phi$. But $\alpha = \gamma - \delta = 90 - \delta$, or $\cos\alpha = \cos(90 - \delta) = \sin\delta$, and since $\sin\delta = \tan\theta\cot\phi$ we have, finally, for the end mill

$$\cos\alpha = \tan\theta\cot\phi$$

SETTING ANGLES FOR MILLING ANGULAR CUTTERS—II

ANGLES OF ELEVATION FOR END MILLS.

Number of Teeth.	Angle of Cutter. 85	80	75	70	65	60	55	50
5	74°23′	57° 8′	34°27′	......	......	......	......	......
6	81 17	72 13	62 21	50°55′	36° 8′	......	......	......
7	83 42	77 13	70 22	62 50	54 12	43°36′	......	......
8	84 59	79 51	74 27	68 39	62 12	54 44	44°27′	32°37′
9	85 47	81 29	77 0	72 13	66 58	61 1	54 1	45 15
10	86 21	82 38	78 46	74 40	70 12	65 12	59 25	52 26
11	86 47	83 29	80 5	76 28	72 34	68 13	63 15	57 22
12	87 6	84 9	81 6	77 52	74 23	70 32	66 9	61 2
13	87 22	84 41	81 54	78 59	75 48	72 21	68 26	63 52
14	87 35	85 8	82 35	79 54	77 1	73 51	70 17	66 10
15	87 46	85 30	83 9	80 40	78 1	75 6	71 50	68 4
16	87 55	85 49	83 38	81 20	78 52	76 10	73 8	69 40
17	88 3	86 5	84 3	81 53	79 36	77 4	74 15	71 1
18	88 11	86 19	84 24	82 23	80 14	77 52	75 14	72 13
19	88 17	86 32	84 43	82 49	80 47	78 34	76 6	73 15
20	88 22	86 43	85 0	83 18	81 17	79 11	76 51	74 11
21	88 27	86 53	85 15	83 33	81 44	79 44	77 31	74 59
22	88 32	87 2	85 29	83 52	82 8	80 14	78 8	75 44
23	88 36	87 10	85 42	84 9	82 30	80 42	78 41	76 24
24	88 39	87 18	85 53	84 24	82 49	81 6	79 11	77 0

ANGLES OF ELEVATION FOR 15 DEGREE BLANK.

Number of Teeth.	Angle of Cutter. 90	85	80	75	70	65	60	55	50
5	49° 4′	37° 3′	24°52′	10°32′	......	......	......	......	......
6	61 49	54 9	46 12	37 40	28° 4′	16°26′	......	......	......
7	66 44	60 57	55 1	48 45	41 57	34 14	25° 2′	12°57′	......
8	69 15	64 33	59 46	54 44	49 21	43 24	36 34	28 21	17°34′
9	70 43	66 45	62 41	58 28	53 58	49 3	43 30	37 2	29 4
10	71 40	68 12	64 41	61 1	57 8	52 55	48 12	42 47	36 18
11	72 20	69 16	66 8	62 54	59 27	55 44	51 37	46 56	41 24
12	72 48	70 2	67 13	64 18	61 13	57 54	54 14	50 5	45 13
13	73 10	70 39	68 5	65 26	62 38	59 37	56 18	52 34	48 14
14	73 26	71 7	68 46	66 20	63 46	61 0	57 59	54 35	50 38
15	73 39	71 30	69 20	67 5	64 42	62 10	59 22	56 15	52 39
16	73 50	71 50	69 49	67 43	65 30	63 9	60 33	57 40	54 20
17	73 58	72 0	70 12	68 14	66 11	63 58	61 33	58 51	55 46
18	74 5	72 20	70 33	68 42	66 46	64 41	62 26	59 54	57 0
19	74 11	72 32	70 51	69 6	67 17	65 19	63 11	60 49	58 6
20	74 16	72 42	71 6	69 28	67 44	65 53	63 52	61 37	59 3
21	74 20	72 51	71 20	69 46	68 7	66 22	64 27	62 20	59 54
22	74 24	72 59	71 32	70 3	68 29	66 49	65 0	62 59	60 40
23	74 27	73 6	71 43	70 18	68 49	67 13	65 29	63 33	61 22
24	74 30	73 12	71 53	70 32	69 6	67 35	65 56	64 5	61 59

ANGLES OF ELEVATION FOR 5 DEGREE BLANK.

Number of Teeth.	Angle of Cutter. 90	85	80	75	70	65	60	55	50
5	74°12	59°11′	42°43′	21°41′	......	......	......	......	......
6	80 4	71 29	62 34	53 52	41°41′	27°22′	......	......	......
7	82 1	75 47	69 22	62 35	55 9	46 33	36°12′	21°36′	......
8	82 57	77 58	72 52	67 32	61 47	55 23	48 0	38 56	25°40′
9	83 29	79 18	75 2	70 35	65 49	60 36	54 43	47 46	38 30
10	83 50	80 13	76 31	72 41	68 35	64 9	59 11	53 27	46 4
11	84 4	80 52	77 36	74 12	70 37	66 43	62 24	57 28	51 15
12	84 14	81 21	78 25	75 23	72 10	68 42	64 52	60 31	55 5
13	84 21	81 44	79 4	76 13	73 23	70 15	66 48	62 54	58 4
14	84 27	82 3	79 36	77 4	74 24	71 32	68 23	64 50	60 28
15	84 32	82 19	80 3	77 43	75 15	72 30	69 42	66 27	62 28
16	84 35	82 31	80 25	78 14	75 57	73 30	70 49	67 48	64 7
17	84 38	82 42	80 44	78 42	76 34	74 16	71 46	68 58	65 33
18	84 41	82 52	81 1	79 7	77 6	74 57	72 36	69 59	66 47
19	84 43	83 0	81 16	79 28	77 34	75 33	73 20	70 52	67 42
20	84 45	83 8	81 29	79 47	77 59	76 4	73 59	71 39	68 50
21	84 46	83 14	81 40	80 3	77 21	76 32	74 33	72 20	69 40
22	84 47	83 19	81 50	80 17	78 40	76 57	75 4	72 58	70 26
23	84 48	83 24	81 59	80 30	78 58	77 20	75 32	73 32	71 7
24	84 49	83 29	82 7	80 43	79 15	77 40	75 57	74 3	71 44

ANGLES OF ELEVATION FOR 20 DEGREE BLANK.

Number of Teeth	Angle of Cutter. 90	85	80	75	70	65	60	55	50
5	40°20′	30° 4	19°46′	8° 4′	......	......	......	......	......
6	53 57	46 55	39 39	31 55	23°18′	13°11	......	......	......
7	59 43	54 17	48 42	42 51	36 30	29 23	21° 1′	10°23′	......
8	62 46	58 18	53 45	48 59	43 53	38 16	31 53	24 16	14°31
9	64 35	60 47	56 54	52 52	48 34	43 53	38 38	32 32	25 5
10	65 47	62 28	59 4	55 33	51 50	47 47	43 18	38 9	32 1
11	66 36	63 39	60 38	57 30	54 12	50 38	46 11	42 12	36 56
12	67 12	64 32	61 49	59 0	56 2	52 50	49 18	45 19	40 40
13	67 39	65 13	62 44	60 11	57 28	54 34	51 22	47 47	43 36
14	68 0	65 46	63 29	61 8	58 39	55 59	53 4	49 47	46 0
15	68 17	66 13	64 6	61 55	59 38	57 10	54 28	51 27	47 58
16	68 30	66 34	64 36	62 34	60 26	58 9	55 39	52 51	49 38
17	68 41	66 53	65 2	63 8	61 8	59 0	56 40	54 3	51 4
18	68 50	67 8	65 24	63 37	61 44	59 44	57 32	55 5	52 17
19	68 57	67 21	65 43	64 2	62 15	60 22	58 18	55 59	53 21
20	69 3	67 32	65 59	64 23	62 43	60 55	58 58	56 47	54 18
21	69 9	67 42	66 14	64 42	63 8	61 25	59 34	57 30	55 9
22	69 14	67 51	66 28	64 59	63 30	61 52	60 7	58 9	55 55
23	69 18	67 59	66 39	65 15	63 50	62 16	60 36	58 44	56 36
24	69 21	68 5	66 49	65 30	64 7	62 38	61 2	59 14	57 12

ANGLES OF ELEVATION FOR 10 DEGREE BLANK.

Number of Teeth.	Angle of Cutter. 90	85	80	75	70	65	60	55	50
5	60°16′	46°45′	32° 9′	14°31′	......	......	......	......	......
6	70 34	62 11	53 50	44 37	34° 5′	20°57′	......	......	......
7	74 12	68 8	61 55	55 20	48 9	39 57	30° 2′	16°32′	......
8	76 0	71 8	66 9	60 56	55 19	49 6	41 56	33 12	20°39′
9	77 2	72 56	68 45	64 23	59 21	54 7	48 52	42 6	33 8
10	77 42	74 8	70 31	66 44	62 44	57 22	53 30	47 54	40 42
11	78 10	75 1	71 48	68 28	64 56	61 6	56 52	52 2	45 56
12	78 30	75 40	72 46	69 47	66 37	63 12	59 26	55 10	49 50
13	78 44	76 9	73 31	70 48	67 56	64 51	61 26	57 36	52 51
14	78 56	76 34	74 9	71 39	69 2	66 12	63 6	59 36	55 19
15	79 5	76 54	74 40	72 21	69 56	67 19	64 28	61 15	57 20
16	79 12	77 10	75 5	72 57	70 41	68 16	65 37	62 39	59 1
17	79 18	77 23	75 27	73 27	71 20	69 4	66 36	63 51	60 28
18	79 22	77 34	75 45	73 52	71 53	69 46	67 27	64 58	61 48
19	79 26	77 44	76 1	74 15	72 23	70 23	68 12	65 46	62 48
20	79 30	77 54	76 16	74 35	72 44	70 56	68 52	66 34	63 47
21	79 33	78 2	76 29	74 53	73 12	71 25	69 28	67 17	64 38
22	79 35	78 8	76 40	75 9	73 33	71 51	69 59	67 55	65 25
23	79 37	78 18	76 50	75 23	73 52	72 14	70 28	68 29	66 6
24	79 39	78 20	76 59	75 30	74 9	72 35	70 54	69 1	66 44

ANGLES OF ELEVATION FOR 25 DEGREE BLANK.

Number of Teeth.	Angle of Cutter. 90	85	80	75	70	65	60	55	50
5	33°32′	25° 0′	16° 5′	6° 27′	......	......	......	......	......
6	47 0	40 38	34 6	27 10	19°33	10°48′	......	......	......
7	53 12	48 10	43 0	37 35	31 43	25 17	17°44′	8°31′	......
8	56 36	52 25	48 8	43 40	38 55	33 41	27 47	20°50	11°33′
9	58 40	55 4	51 24	47 36	43 33	39 8	34 13	28 33	21 15
10	60 2	56 53	53 40	50 21	46 47	42 58	38 43	32 53	27 47
11	61 0	58 11	55 18	52 20	49 12	45 48	42 4	37 49	32 32
12	61 42	59 9	56 33	53 52	51 2	47 59	44 38	40 51	36 10
13	62 14	59 54	57 32	55 5	52 30	49 44	46 41	43 15	39 2
14	62 38	60 29	58 19	56 3	53 41	51 8	48 20	45 12	41 22
15	62 57	61 0	58 57	56 52	54 39	52 18	49 43	46 50	43 18
16	63 13	61 22	59 29	57 32	55 29	53 17	50 53	48 18	44 57
17	63 26	61 42	59 54	58 6	56 11	54 8	51 54	49 23	46 21
18	63 37	61 59	60 19	58 36	56 48	54 52	52 46	50 25	47 34
19	63 46	62 13	60 38	51 1	57 20	55 30	53 31	51 19	48 38
20	63 53	62 25	60 56	59 23	57 47	56 4	54 11	52 6	49 33
21	63 59	62 36	61 11	59 43	58 11	56 34	54 47	52 48	50 23
22	64 5	62 46	61 25	60 1	58 34	57 1	55 19	53 26	51 9
23	64 10	62 55	61 37	60 17	58 54	57 25	55 48	54 0	51 50
24	64 14	63 3	61 47	60 31	59 12	57 46	56 13	54 30	52 26

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SETTING ANGLES FOR MILLING ANGULAR CUTTERS—III

ANGLES OF ELEVATION FOR 30 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	28° 9'	20°51'	13°17	......	......	......	......	......	......
6	40 54	35 12	29 22	23°13'	16°32'	8°59'	......	......	......
7	47 12	42 35	37 52	32 56	27 38	21 47	15° 6'	7° 5'	......
8	50 46	46 53	42 55	38 47	34 24	29 36	24 12	17 55	10°14'
9	53 0	49 38	46 13	42 40	38 53	34 48	30 14	25 1	18 47
10	54 29	51 31	48 30	45 22	42 8	38 29	34 31	30 1	24 44
11	55 32	52 53	50 10	47 22	44 25	41 13	37 43	33 45	29 8
12	56 18	53 58	51 26	48 54	46 14	43 21	40 12	36 38	32 32
13	56 54	54 42	52 27	50 8	47 41	45 4	42 12	38 58	35 15
14	57 21	55 19	53 15	51 7	48 52	46 27	43 49	40 51	37 27
15	57 42	55 49	53 54	51 55	49 50	47 35	45 9	42 25	39 17
16	58 0	56 14	54 27	52 36	50 39	48 34	46 19	43 47	40 52
17	58 14	56 35	54 54	53 10	51 21	49 24	47 17	44 55	42 12
18	58 26	56 53	55 18	53 40	51 57	50 7	48 7	45 53	43 20
19	58 36	57 8	55 38	54 6	52 29	50 45	48 51	46 46	44 22
20	58 44	57 21	55 55	54 28	52 56	51 18	49 30	47 31	45 15
21	58 51	57 32	56 10	54 47	53 20	51 47	50 5	48 12	46 8
22	58 57	57 42	56 24	55 5	53 42	52 13	50 36	44 48	46 46
23	59 3	57 51	56 37	55 21	54 2	52 37	51 4	49 21	47 25
24	59 8	57 59	56 48	55 36	54 20	52 59	51 30	49 52	48 0

ANGLES OF ELEVATION FOR 45 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	17°10'	12°36'	7°57'	3° 5'	......	......	......	......	......
6	26 34	22 41	18 43	14 35	10°11'	5°23'	......	......	......
7	31 56	28 36	25 13	21 42	17 56	13 55	9°24'	4°15'	......
8	35 16	32 22	29 25	26 22	23 8	19 39	15 48	11 25	5°58'
9	37 27	34 54	32 17	29 36	26 45	23 41	20 19	16 31	11 49
10	38 58	36 41	34 21	31 57	29 24	26 40	23 40	20 18	16 10
11	40 4	38 0	35 53	33 42	31 24	28 57	26 15	23 14	19 32
12	40 54	39 0	37 5	35 5	33 0	30 45	28 18	25 33	22 13
13	41 32	39 47	38 1	36 11	34 15	32 12	29 57	27 36	24 23
14	42 1	40 24	38 46	37 4	35 17	33 22	31 18	28 58	26 9
15	42 25	40 55	39 23	37 48	36 9	34 22	32 26	30 17	27 40
16	42 44	41 20	39 54	38 25	36 52	35 12	33 24	31 23	28 57
17	43 0	41 41	40 20	38 57	37 29	35 55	34 14	32 20	30 4
18	43 13	41 58	40 42	39 24	38 1	36 33	34 56	33 10	31 1
19	43 24	42 13	41 1	39 47	38 28	37 5	35 34	33 54	31 51
20	43 34	42 26	41 18	40 8	38 53	37 34	36 8	34 33	32 37
21	43 42	42 37	41 33	40 26	39 15	38 0	36 38	35 7	33 17
22	43 49	42 47	41 46	40 42	39 34	38 23	37 5	35 38	34 53
23	43 55	42 56	41 57	40 56	39 52	38 43	37 29	36 6	35 26
24	44 0	43 4	42 7	41 9	40 7	39 1	37 50	36 31	35 55

ANGLES OF ELEVATION FOR 35 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	23°49'	17°35'	11°10'	4°22'	......	......	......	......	......
6	35 32	30 29	25 19	19 53	14° 3'	7° 1'	......	......	......
7	41 41	37 20	33 14	28 46	24 1	18 48	12°54'	5°58'	......
8	45 17	41 43	38 5	34 19	30 18	25 56	21 4	15 27	8°41'
9	47 34	44 28	41 18	38 1	34 32	30 47	26 37	21 52	16 16
10	49 7	46 22	43 33	40 39	37 35	34 17	30 38	26 30	21 40
11	50 14	47 46	45 14	42 38	39 58	36 55	33 40	30 0	25 44
12	51 3	48 48	46 30	44 8	41 39	38 58	36 2	32 44	28 55
13	51 40	49 36	47 30	45 20	43 3	40 36	37 55	34 55	31 28
14	52 9	50 15	48 19	46 18	44 12	41 57	39 28	36 42	33 33
15	52 32	50 46	48 58	47 6	45 9	43 4	40 46	38 12	35 17
16	52 50	51 11	49 20	47 46	45 56	43 59	41 51	39 28	36 45
17	53 5	51 32	49 57	48 20	46 37	44 47	42 47	40 33	38 1
18	53 18	51 50	50 21	48 49	47 12	45 29	43 36	41 31	39 8
19	53 29	52 6	50 42	49 14	47 43	46 5	44 19	42 21	40 6
20	53 38	52 19	50 59	49 36	48 10	46 37	44 57	43 5	40 57
21	53 46	52 31	51 15	49 56	48 34	47 6	45 31	43 44	41 43
22	53 53	52 42	51 29	50 14	48 56	47 32	46 1	44 19	42 24
23	53 59	52 51	51 42	50 30	49 15	47 55	46 28	44 51	43 1
24	54 4	52 59	51 53	50 44	49 32	48 16	46 52	45 20	43 35

ANGLES OF ELEVATION FOR 50 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	14°32'	10°39'	6°42'	2°33'	......	......	......	......	......
6	22 45	19 23	15 58	12 24	8°38'	4°32'	......	......	......
7	27 37	24 42	21 44	18 39	15 24	11 54	8° 1'	3°36'	......
8	30 41	28 8	25 31	22 50	19 59	16 55	13 33	9 45	5°20'
9	32 44	30 28	28 9	25 45	23 14	20 31	17 32	14 13	10 22
10	34 10	32 7	30 2	27 54	25 39	23 12	20 32	17 34	14 9
11	35 13	33 22	31 28	29 31	27 28	25 16	22 52	20 11	17 6
12	36 0	34 18	32 34	30 47	28 53	26 54	24 42	22 15	19 27
13	36 36	35 2	33 26	31 48	30 3	28 13	26 11	23 56	21 22
14	37 5	35 38	34 9	32 47	31 1	29 18	27 26	25 21	22 58
15	37 28	36 7	34 44	33 18	31 49	30 13	28 28	26 32	24 20
16	37 47	36 31	35 13	33 53	32 29	31 0	29 22	27 33	25 30
17	38 2	36 50	35 37	34 22	33 3	31 38	30 7	28 24	26 29
18	38 15	37 7	35 58	34 47	33 33	32 13	30 46	29 10	27 21
19	38 26	37 22	36 17	35 9	33 59	32 43	31 21	29 50	28 7
20	38 35	37 34	36 32	35 28	34 21	33 9	31 52	30 25	28 47
21	38 43	37 45	36 46	35 45	34 41	33 33	32 19	30 57	29 24
22	38 50	37 55	36 58	36 0	34 59	33 55	32 44	31 26	29 57
23	38 56	38 3	37 9	36 14	35 15	34 14	33 6	31 51	30 26
24	39 1	38 10	37 19	36 25	35 30	34 30	33 25	32 14	30 52

ANGLES OF ELEVATION FOR 40 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	20°13'	14°53'	9°24'	3°39	......	......	......	......	......
6	30 48	26 21	21 48	17 3	11°58'	6°22'	......	......	......
7	36 37	32 52	29 2	25 3	20 49	16 12	11° 1'	5° 2'	......
8	40 7	36 53	33 36	30 10	26 33	22 38	18 16	13 20	7°23'
9	42 24	39 34	36 41	33 41	30 31	27 26	23 20	19 4	14 3
10	43 57	41 26	38 51	36 11	33 32	30 21	27 8	23 16	18 55
11	45 4	42 48	40 28	38 4	35 32	32 49	29 50	26 29	22 38
12	45 54	43 50	41 43	39 32	37 14	34 45	32 3	29 2	25 33
13	46 33	44 38	42 42	40 41	38 35	36 19	33 50	31 4	27 54
14	47 3	45 17	43 29	41 38	39 41	37 36	35 19	32 46	29 51
15	47 26	45 47	44 7	42 24	40 35	38 39	36 32	34 10	31 28
16	47 45	46 13	44 39	43 3	41 21	39 32	37 33	35 21	32 50
17	48 1	46 34	45 6	43 36	42 0	40 18	38 27	36 23	34 2
18	48 14	46 52	45 29	44 4	42 34	40 58	39 13	37 17	35 5
19	48 25	47 8	45 49	44 28	43 3	41 33	39 54	38 4	35 59
20	48 35	47 22	46 7	44 50	43 30	42 4	40 30	38 46	36 47
21	48 43	47 33	46 23	45 9	43 53	42 31	41 2	39 23	37 30
22	48 50	47 43	46 36	45 26	44 13	42 55	41 30	39 56	38 8
23	48 56	47 52	46 48	45 41	44 31	43 17	41 55	40 25	38 42
24	49 1	48 0	46 58	45 55	44 48	43 36	42 19	40 52	39 15

ANGLES OF ELEVATION FOR 55 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	12°13'	8°57'	5°37'	2°10'	......	......	......	......	......
6	19 17	16 25	13 30	10 28	7°15'	3°48'	......	......	......
7	23 35	21 4	18 31	15 51	13 4	10 3	6°44'	3° 1'	......
8	26 21	24 8	21 52	19 31	17 3	14 25	11 30	8 17	4°17'
9	28 13	26 14	24 12	22 7	19 55	17 34	14 59	12 6	8 34
10	29 32	27 45	25 55	24 2	22 3	19 55	17 36	15 1	11 52
11	30 30	28 52	27 12	25 29	23 41	21 45	19 39	17 18	14 27
12	31 14	29 44	28 12	26 38	24 59	23 13	21 17	19 8	16 32
13	31 48	30 25	29 0	27 33	26 2	24 24	22 37	20 38	18 15
14	32 15	30 58	29 39	28 18	26 53	25 25	23 43	21 53	19 40
15	32 36	31 24	30 11	28 55	27 35	26 11	24 38	22 56	20 52
16	32 54	31 47	30 38	29 27	28 12	26 53	25 26	23 51	21 54
17	33 9	32 6	31 1	29 54	28 44	27 29	26 7	24 38	22 49
18	33 21	32 21	31 20	30 17	29 10	28 0	26 43	25 18	23 35
19	33 31	32 34	31 36	30 36	29 33	28 27	27 14	25 54	24 17
20	33 40	32 46	31 51	30 54	29 54	28 51	27 42	26 25	24 53
21	33 47	32 56	32 3	31 9	30 12	29 12	28 6	26 53	25 25
22	33 54	33 5	32 15	31 23	30 29	29 31	28 28	27 19	25 55
23	34 0	33 13	32 25	31 36	30 44	29 48	28 48	27 42	26 22
24	34 5	33 20	32 34	31 47	30 57	30 4	29 7	28 3	26 46

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SETTING ANGLES FOR MILLING ANGULAR CUTTERS—IV

ANGLES OF ELEVATION FOR 60 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	10° 7′	7°25′	4°39′	1°47′	......	......	......	......	......
6	16 6	13 41	11 12	8 42	6° 2′	3° 9′	......	......	......
7	19 48	17 40	15 30	13 16	10 55	8 22	5°36	2°30′	......
8	22 13	20 19	18 24	16 24	14 19	12 4	9 37	6 53	3°44
9	23 52	22 10	20 26	18 39	16 46	14 46	12 34	10 7	7 19
10	25 2	23 30	21 56	20 19	18 37	16 48	14 49	12 36	10 5
11	25 54	24 30	23 4	21 35	20 2	18 23	16 34	14 34	12 16
12	26 34	25 16	23 57	22 36	21 10	19 39	17 59	16 9	14 13
13	27 5	25 53	24 40	23 25	22 6	20 41	19 9	17 27	15 31
14	27 29	26 22	25 14	24 4	22 51	21 32	20 6	18 32	16 44
15	27 49	26 46	25 43	24 37	23 29	22 15	20 55	19 27	17 47
16	28 5	27 6	26 7	25 5	24 1	22 52	21 37	20 14	18 40
17	28 18	27 23	26 27	25 29	24 28	23 23	22 13	20 55	19 26
18	28 29	27 37	26 44	25 49	24 52	23 50	22 44	21 30	20 6
19	28 38	27 49	26 58	26 7	25 12	24 14	23 11	22 1	20 42
20	28 46	27 59	27 11	26 22	25 30	24 35	23 35	22 29	21 14
21	28 53	28 8	27 23	26 36	25 46	24 54	23 57	22 54	21 42
22	29 0	28 17	27 34	26 49	26 2	25 12	24 17	23 17	22 8
23	29 5	28 24	27 43	27 0	26 15	25 27	24 35	23 37	22 32
24	29 9	28 30	27 50	27 9	26 26	25 40	24 50	23 55	22 52

ANGLES OF ELEVATION FOR 75 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	4°44′	3°28′	2°10′	......	......	......	......	......	......
6	7 38	6 29	5 19	4° 6′	2°50′	1°29′	......	......	......
7	9 29	8 27	7 24	6 17	5 10	3 57	2°38′	1°10′	......
8	10 44	9 48	8 51	7 50	6 51	5 45	4 34	3 14	1°45
9	11 36	10 46	9 54	9 0	8 5	7 5	6 0	4 49	3 27
10	12 14	11 28	10 40	9 52	9 1	8 7	7 8	6 3	4 49
11	12 42	12 6	11 16	10 32	9 45	8 56	8 2	7 1	5 54
12	13 4	12 25	11 45	11 4	10 21	9 35	8 45	7 49	6 47
13	13 21	12 45	12 8	11 29	10 50	10 7	9 21	8 29	7 31
14	13 34	13 0	12 26	11 50	11 13	10 33	9 50	9 2	8 7
15	13 45	13 13	12 41	12 7	11 33	10 55	10 15	9 30	8 39
16	13 54	13 24	12 54	12 22	11 50	11 14	10 37	9 54	9 7
17	14 2	13 33	13 5	12 35	12 5	11 31	10 56	10 16	9 31
18	14 8	13 41	13 14	12 46	12 17	11 45	11 12	10 34	9 51
19	14 13	13 48	13 22	12 55	12 28	11 58	11 26	10 50	10 10
20	14 18	13 54	13 29	13 4	12 38	12 9	11 39	11 5	10 27
21	14 22	13 59	13 36	13 12	12 46	12 19	11 50	11 17	10 41
22	14 25	14 3	13 41	13 18	12 53	12 28	12 0	11 29	10 54
23	14 28	14 7	13 46	13 24	13 0	12 36	12 9	11 40	11 6
24	14 31	14 11	13 50	13 29	13 7	12 44	12 18	11 50	11 18

ANGLES OF ELEVATION FOR 65 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	8°12′	6° 0′	3°46′	1°27′	......	......	......	......	......
6	13 7	11 10	9 8	7 4	4°53′	2°33′	......	......	......
7	16 13	14 28	12 41	10 50	8 54	6 49	4°33′	2° 1′	......
8	18 15	16 40	15 6	13 26	11 42	9 51	7 50	5 30	3° 1
9	19 39	18 14	16 48	15 19	13 45	12 5	10 16	8 14	5 57
10	20 40	19 23	18 4	16 44	15 19	13 48	12 9	10 19	8 15
11	21 25	20 14	19 8	17 49	16 31	15 9	13 38	11 58	10 4
12	21 59	20 54	19 48	18 40	17 28	16 12	14 49	13 17	11 32
13	22 26	21 26	20 35	19 22	18 15	17 5	15 48	14 23	12 46
14	22 48	21 52	20 55	19 56	18 54	17 48	16 37	15 17	13 48
15	23 5	22 13	21 19	20 24	19 26	18 24	17 18	16 4	14 40
16	23 18	22 29	21 39	20 47	19 53	18 55	17 53	16 43	15 24
17	23 30	22 43	21 56	21 8	20 17	19 22	18 23	17 17	16 8
18	23 40	22 55	22 11	21 25	20 37	19 46	18 50	17 47	16 37
19	23 48	23 5	22 24	21 40	20 55	20 6	19 13	18 14	17 7
20	23 55	23 14	22 35	21 54	21 10	20 24	19 33	18 38	17 34
21	24 1	23 22	22 45	22 6	21 24	20 39	19 51	18 58	17 58
22	24 6	23 29	22 53	22 16	21 36	20 53	20 8	19 17	18 20
23	24 11	23 36	23 1	22 26	21 47	21 7	20 23	19 34	18 39
24	24 15	23 43	23 8	22 34	21 57	21 18	20 36	19 50	18 57

ANGLES OF ELEVATION FOR 80 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	3° 7′	2°17′	1°26′	0°43′	......	......	......	......	......
6	5 2	4 16	3 30	2 42	1°52′	0°58′	......	......	......
7	6 16	5 35	4 53	4 10	3 25	2 36	1°45′	0°46′	......
8	7 6	6 29	5 51	5 12	4 31	3 48	3 2	2 8	1° 8′
9	7 42	7 8	6 34	5 58	5 21	4 42	3 59	3 11	2 17
10	8 7	7 36	7 5	6 33	5 59	5 22	4 44	4 0	3 11
11	8 26	7 58	7 29	7 0	6 28	5 55	5 19	4 39	3 54
12	8 41	8 15	7 48	7 21	6 52	6 22	5 48	5 11	4 29
13	8 53	8 29	8 4	7 38	7 12	6 43	6 12	5 38	4 59
14	9 2	8 40	8 16	7 52	7 28	7 1	6 32	6 0	5 24
15	9 9	8 48	8 26	8 4	7 40	7 16	6 48	6 19	5 45
16	9 15	8 55	8 35	8 14	7 51	7 28	7 3	6 33	6 3
17	9 20	9 1	8 42	8 22	8 1	7 39	7 15	6 49	6 19
18	9 24	9 6	8 48	8 29	8 10	7 49	7 26	7 1	6 33
19	9 28	9 11	8 53	8 36	8 17	7 58	7 36	7 12	6 45
20	9 31	9 15	8 58	8 42	8 24	8 5	7 44	7 21	6 56
21	9 34	9 19	9 3	8 47	8 30	8 12	7 52	7 30	7 6
22	9 36	9 22	9 6	8 51	8 35	8 18	7 59	7 38	7 15
23	9 38	9 24	9 9	8 55	8 39	8 23	8 5	7 45	7 23
24	9 40	9 26	9 13	8 59	8 43	8 28	8 11	7 51	7 30

ANGLES OF ELEVATION FOR 70 DEGREE BLANK.

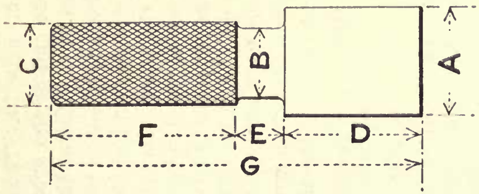
Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	6°25′	4°42′	2°57′	......	......	......	......	......	......
6	10 18	8 44	7 9	5°32′	3°48	......	......	......	......
7	12 47	11 23	9 59	8 31	6 58	5°21′	3°33′	......	......
8	14 26	13 11	11 55	10 36	9 14	7 45	6 9	4°23′	2°21
9	15 35	14 27	13 18	12 7	10 53	9 33	8 6	6 30	4 41
10	16 25	15 23	14 21	13 15	12 8	10 55	9 37	8 9	6 30
11	17 2	16 5	15 8	14 8	13 7	12 0	10 48	9 28	7 57
12	17 30	16 38	15 45	14 50	13 53	12 51	11 45	10 31	9 8
13	17 52	17 4	16 15	15 24	14 30	13 33	12 32	11 23	10 6
14	18 9	17 24	16 38	15 51	15 1	14 8	13 11	12 7	10 55
15	18 23	17 41	16 58	16 14	15 28	14 38	13 44	12 44	11 37
16	18 35	17 55	17 15	16 33	15 50	15 3	14 13	13 17	12 13
17	18 45	18 7	17 30	16 50	16 9	15 25	14 38	13 46	12 45
18	18 53	18 17	17 42	17 5	16 26	15 44	14 59	14 10	13 13
19	19 0	18 26	17 52	17 17	16 40	16 1	15 18	14 32	13 38
20	19 6	18 35	18 1	17 28	16 53	16 16	15 35	14 51	13 59
21	19 11	18 41	18 9	17 38	17 5	16 29	15 50	15 8	14 18
22	19 15	18 46	18 16	17 46	17 15	16 40	16 3	15 22	14 35
23	19 19	18 51	18 23	17 54	17 25	16 50	16 15	15 36	14 51
24	19 22	18 55	18 29	18 0	17 33	16 59	16 25	15 48	15 5

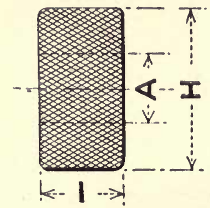
ANGLES OF ELEVATION FOR 85 DEGREE BLANK.

Number of Teeth.	Angle of Cutter.								
	90	85	80	75	70	65	60	55	50
5	1°33′	1° 8′	......	......	......	......	......	......	......
6	2 30	2 7	1°44′	1°20′	0°55′	......	......	......	......
7	3 7	2 46	2 26	2 4	1 42	1°18′	0°50′	......	......
8	3 32	3 13	2 55	2 35	2 15	1 53	1 29	1° 8′	0°34′
9	3 50	3 33	3 16	2 58	2 40	2 20	1 59	1 35	1 8
10	4 3	3 48	3 32	3 16	2 59	2 41	2 21	1 59	1 35
11	4 13	3 59	3 44	3 30	3 14	2 57	2 39	2 19	1 57
12	4 20	4 7	3 53	3 40	3 25	3 10	2 53	2 35	2 15
13	4 26	4 14	4 1	3 48	3 35	3 21	3 6	2 48	2 30
14	4 30	4 19	4 7	3 55	3 43	3 29	3 15	2 59	2 42
15	4 34	4 23	4 12	4 1	3 50	3 37	3 24	3 9	2 52
16	4 37	4 27	4 17	4 6	3 56	3 44	3 30	3 17	3 1
17	4 40	4 30	4 21	4 11	4 1	3 50	3 37	3 24	3 9
18	4 42	4 33	4 24	4 15	4 5	3 55	3 43	3 30	3 16
19	4 44	4 35	4 27	4 18	4 9	3 59	3 48	3 36	3 22
20	4 46	4 37	4 29	4 21	4 12	4 3	3 52	3 41	3 28
21	4 47	4 39	4 31	4 23	4 15	4 6	3 56	3 45	3 33
22	4 48	4 41	4 33	4 25	4 18	4 9	3 59	3 49	3 37
23	4 49	4 42	4 35	4 27	4 20	4 12	4 2	3 53	3 41
24	4 50	4 43	4 36	4 29	4 22	4 14	4 5	3 56	3 45

Contributed by W. A. Knight, MACHINERY'S Data Sheet No. 118. Explanatory note: Page 38.

DIMENSIONS OF PLUG AND RING GAGES.





A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
1/4	7/32	7/16	15/16	5/16	1 7/8	3 1/8	1	1/2	1 1/8	7/8	1	1 5/8	1/2	3 1/4	5 3/8	2 3/8	1 1/8
5/16	9/32	1/2	1	5/16	2	3 5/16	1 1/16	1/2	1 1/4	1	1 1/8	1 3/4	1/2	3 1/4	5 1/2	2 1/2	1 1/8
3/8	5/16	1/2	1 1/16	5/16	2 1/8	3 1/2	1 1/8	9/16	1 3/8	1 1/8	1 1/4	1 3/4	1/2	3 3/8	5 5/8	2 5/8	1 1/4
7/16	3/8	9/16	1 1/8	5/16	2 1/4	3 11/16	1 3/16	9/16	1 1/2	1 1/4	1 3/8	1 7/8	5/8	3 3/8	5 7/8	2 3/4	1 1/4
1/2	7/16	9/16	1 3/16	3/8	2 3/8	3 15/16	1 1/4	5/8	1 5/8	1 3/8	1 1/2	1 7/8	5/8	3 1/2	6	2 7/8	1 1/2
9/16	1/2	5/8	1 1/4	3/8	2 1/2	4 1/8	1 5/16	5/8	1 3/4	1 3/8	1 1/2	2	3/4	3 1/2	6 1/4	3	1 1/2
5/8	9/16	5/8	1 5/16	3/8	2 5/8	4 5/16	1 7/16	11/16	1 7/8	1 1/2	1 5/8	2	3/4	3 1/2	6 1/4	3 1/8	1 1/2
11/16	5/8	11/16	1 3/8	3/8	2 3/4	4 1/2	1 9/16	11/16	2	1 1/2	1 5/8	2 1/8	3/4	3 1/2	6 3/8	3 1/4	1 5/8
3/4	5/8	11/16	1 7/16	7/16	2 7/8	4 3/4	1 11/16	3/4	2 1/4	1 5/8	1 3/4	2 1/8	3/4	3 5/8	6 1/2	3 1/2	1 5/8
13/16	11/16	3/4	1 1/2	7/16	3	4 15/16	1 13/16	13/16	2 1/2	1 5/8	1 3/4	2 1/4	3/4	3 5/8	6 5/8	3 3/4	1 5/8
7/8	11/16	3/4	1 9/16	7/16	3 1/8	5 1/8	1 15/16	7/8	2 3/4	1 5/8	1 3/4	2 1/4	3/4	3 5/8	6 5/8	4 1/8	1 3/4
15/16	3/4	13/16	1 9/16	7/16	3 1/8	5 1/8	2 1/16	15/16	3	1 5/8	1 3/4	2 1/2	3/4	3 5/8	6 7/8	4 1/2	1 3/4
1	13/16	7/8	1 5/8	1/2	3 1/4	5 3/8	2 3/16	1									

MACHINERY'S Data Sheet No. 57. Explanatory note: Page 38.

Dimensions of Shell End Mills

Dimensions for shell end mills are given on page 30, and for the arbors on which these mills are mounted when in use, on page 31. The head of the screw on the end of the arbor enters into the recess in the end of the mill. The keys in the arbor enter into the keyway *F* at the upper end of the mill and constitute the drive. It will be seen that the number of teeth in these mills is greater for the same diameters than the number in solid end mills. This is because the coarser teeth of the latter would require a deeper flute than would be possible in the thin shell of the shell end mill.

Milling the Teeth in End Mills and Angular Cutters

On page 32 is given a table of angles for setting the dividing head of the milling machine when cutting teeth in the end of end mills. The angle to which the dividing head must be set depends on two factors, the number of the teeth in the mill to be cut, and the angle of the cutter with which the teeth are to be cut. When the number of teeth in the cutter and the angle of the cutter used for milling the teeth are given, the setting angle of the dividing head is found in the body of the table. For example, assume that 12 teeth are to be cut in the end of an end mill with a 60-degree cutter. Then by following the horizontal line from 12 teeth we read in the column under 60 degrees that the dividing head should be set to an angle of 70 degrees 32 minutes for this job. On pages 34 to 36 are given similar tables for milling angular cutters, an explanation of the formulas by which these angles are obtained being given on page 33. [MACHINERY, April, 1904, To Calculate the Setting of the Dividing Head when Cutting the Teeth of End Mills; November, 1908, Setting Angles for Milling Angular Cutters and Taper Reamers.]

Dimensions of Plug and Ring Gages

On page 37 are given dimensions of plain plug and ring gages for ordinary use. These dimensions are based upon the dimensions used for these gages by one of the most prominent gage makers in the country. The proportions will be found suitable for every-day use, although for special requirements some of the dimensions may have to be modified.

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