FORMING TOOLS

When curved surfaces or those of stepped, angular or irregular shape are required in connection with turning operations, especially on turret lathes and "automatics," forming tools are used. These tools are so made that the contour of the cutting edge corresponds to the shape required and usually they may be ground repeatedly without changing the shape of the cutting edge. There are two general classes of forming tools—the straight type and the circular type. The circular forming tool is generally used on small narrow forms, whereas the straight type is more suitable for wide forming operations. Some straight forming tools are clamped in a horizontal position upon the cut-off slide, whereas the others are held in a vertical position in a special holder. A common form of holder for these vertical tools is one having a dovetail slot in which the forming tool is clamped; hence they are often called "dovetail forming tools." In many cases, two forming tools are used, especially when a very smooth surface is required, one being employed for roughing and the other for finishing.

There was an American standard for forming tool blanks which covered both straight or dovetailed, and circular forms. The formed part of the finished blanks must be shaped to suit whatever job the tool is to be used for. This former standard includes the important dimensions of holders for both straight and circular forms.

Dimensions of Steps on Straight or Dovetail Forming Tools.—The diagrams at the top of the accompanying table illustrate a straight or "dovetail" forming tool. The upper or cutting face lies in the same plane as the center of the work and there is no rake. (Many forming tools have rake to increase the cutting efficiency, and this type will be referred to later.) In making a forming tool, the various steps measured perpendicular to the front face (as at *d*) must be proportioned so as to obtain the required radial dimensions on the work. For example, if *D* equals the difference between two radial dimensions on the work, then:

$$\text{Step } d = D \times \text{cosine front clearance angle}$$

Angles on Straight Forming Tools.—In making forming tools to the required shape or contour, any angular surfaces (like the steps referred to in the previous paragraph) are affected by the clearance angle. For example, assume that angle *A* on the work (see diagram at top of accompanying table) is 20 degrees. The angle on the tool in plane *x-x,* in that case, will be slightly less than 20 degrees. In making the tool, this modified or reduced angle is required because of the convenience in machining and measuring the angle square to the front face of the tool or in the plane *x–x.*

If the angle on the work is measured from a line parallel to the axis (as at *A* in diagram), then the reduced angle on the tool as measured square to the front face (or in plane *x–x*) is found as follows:

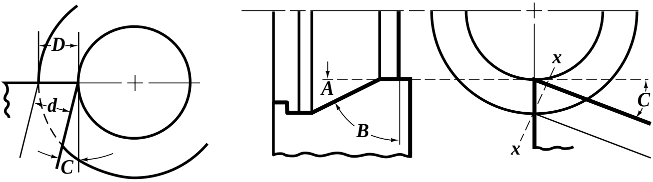
$$\tan \text{ reduced angle on tool} = \tan A \times \cos \text{ front clearance angle}$$

If angle *A* on the work is larger than, say, 45 degrees, it may be given on the drawing as indicated at *B.* In this case, the angle is measured from a plane perpendicular to the axis of the work. When the angle is so specified, the angle on the tool in plane *x–x* may be found as follows:

$$\tan \text{reduced angle on tool} = \frac{\tan B}{\cos \text{ clearance angle}}$$

Table Giving Step Dimensions and Angles on Straight or Dovetailed Forming Tools.—The accompanying table *Dimensions of Steps and Angles on Straight Forming Tools* gives the required dimensions and angles within its range, direct or without calculation.

Dimensions of Steps and Angles on Straight Forming Tools



Upper section of table gives depth *d* of step on forming tool for a given dimension *D* that equals the actual depth of the step on the work, measured radially and along the cutting face of the tool (see diagram at left). First, locate depth *D* required on work; then find depth *d* on tool under tool clearance angle *C*. Depth *d* is measured perpendicular to front face of tool.

Radial Depth of Step *D*	Depth *d* of step on tool, When *C* = 10°	When *C* = 15°	When *C* = 20°	Radial Depth of Step *D*	Depth *d* of step on tool, When *C* = 10°	When *C* = 15°	When *C* = 20°
0.001	0.00098	0.00096	0.00094	0.040	0.03939	0.03863	0.03758
0.002	0.00197	0.00193	0.00187	0.050	0.04924	0.04829	0.04698
0.003	0.00295	0.00289	0.00281	0.060	0.05908	0.05795	0.05638
0.004	0.00393	0.00386	0.00375	0.070	0.06893	0.06761	0.06577
0.005	0.00492	0.00483	0.00469	0.080	0.07878	0.07727	0.07517
0.006	0.00590	0.00579	0.00563	0.090	0.08863	0.08693	0.08457
0.007	0.00689	0.00676	0.00657	0.100	0.09848	0.09659	0.09396
0.008	0.00787	0.00772	0.00751	0.200	0.19696	0.19318	0.18793
0.009	0.00886	0.00869	0.00845	0.300	0.29544	0.28977	0.28190
0.010	0.00984	0.00965	0.00939	0.400	0.39392	0.38637	0.37587
0.020	0.01969	0.01931	0.01879	0.500	0.49240	0.48296	0.46984
0.030	0.02954	0.02897	0.02819	…	…	…	…

Section of table below gives angles as measured in plane *x*–*x* perpendicular to front face of forming tool (see diagram on right). Find in first column the angle *A* required on work; then find reduced angle in plane *x*–*x* under given clearance angle *C*.

Angle *A* in Plane of Tool Cutting Face	Angle on tool in plane *x*–*x*, When *C* = 10°		When *C* = 15°		When *C* = 20°		Angle *A* in Plane of Tool Cutting Face	Angle on tool in plane *x*–*x*, When *C* = 10°		When *C* = 15°		When *C* = 20°	
5°	4°	55′	4°	50′	4°	42′	50°	49°	34′	49°	1′	48°	14′
10	9	51	9	40	9	24	55	54	35	54	4	53	18
15	14	47	14	31	14	8	60	59	37	59	8	58	26
20	19	43	19	22	18	53	65	64	40	64	14	63	36
25	24	40	24	15	23	40	70	69	43	69	21	68	50
30	29	37	29	9	28	29	75	74	47	74	30	74	5
35	34	35	34	4	33	20	80	79	51	79	39	79	22
40	39	34	39	1	38	15	85	84	55	84	49	84	41
45	44	34	44	0	43	13	…	…		…		…	

To Find Dimensions of Steps: The upper section of the table is used in determining the dimensions of steps. The radial depth of the step or the actual cutting depth *D* (see left-hand diagram) is given in the first column of the table. The columns that follow give the corresponding depths *d* for a front clearance angle of 10, 15, or 20 degrees. To illustrate the use of the table, suppose a tool is required for turning the part shown in Fig. 1, which has diameters of 0.75, 1.25, and 1.75 inches, respectively. The difference between the largest and the smallest radius is 0.5 inch, which is the depth of one step. Assume that the clearance angle is 15 degrees. First, locate 0.5 in the column headed "Radial Depth of Step *D*"; then find depth *d* in the column headed "when C = 15°." As will be seen, this depth is 0.48296 inch. Practically the same procedure is followed in determining the depth of the second step on the tool. The difference in the radii in this case equals0.25. This value is not given directly in the table, so first find the depth equivalent to 0.200 and add to it the depth equivalent to 0.050. Thus, we have 0.19318 + 0.04829 = 0.24147. In using this table, it is assumed that the top face of the tool is set at the height of the work axis.

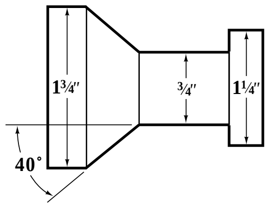


Fig. 1.

To Find Angle: The lower section of the table applies to angles when they are measured relative to the axis of the work. The application of the table will again be illustrated by using the part shown in Fig. 1. The angle used here is 40 degrees (which is also the angle in the plane of the cutting face of the tool). If the clearance angle is 15 degrees, the angle measured in plane *x*–*x* square to the face of the tool is shown by the table to be 39° 1′- a reduction of practically 1 degree.

If a straight forming tool has rake, the depth *x* of each step (see Fig. 2), measured perpendicular to the front or clearance face, is affected not only by the clearance angle, but by the rake angle *F* and the radii *R* and *r* of the steps on the work. First, it is necessary to find three angles, designated *A*, *B*, and *C*, that are not shown on the drawing.

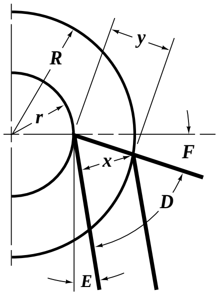


Fig. 2.

$$\text{Angle } A = 180° - \text{ rake angle } F$$

$$\sin B = \frac{r \sin A}{R}$$

$$\text{Angle } C = 180° - (A + B)$$

$$y = \frac{R \sin C}{\sin A}$$

$$\text{Angle } D \text{ of tool} = 90° - (E + F)$$

$$\text{Depth } x = y \sin D$$

If the work has two or more shoulders, the depth x for other steps on the tool may be determined for each radius r. If the work has curved or angular forms, it is more practical to use a tool without rake because its profile, in the plane of the cutting face, duplicates that of the work.

Example: Assume that radius R equals 0.625 inch and radius r equals 0.375 inch, so that the step on the work has a radial depth of 0.25 inch. The tool has a rake angle F of 10 degrees and a clearance angle E of 15 degrees. Then angle $A = 180 - 10 = 170$ degrees.

$$\sin B = \frac{0.375 \times 0.17365}{0.625} = 0.10419$$

$$\text{Angle } B = 5°59' \text{ nearly.} \qquad \text{Angle } C = 180 - (170° + 5°59') = 4°1'$$

$$\text{Dimension } y = \frac{0.625 \times 0.07005}{0.17365} = 0.25212$$

$$\text{Angle } D = 90° - (15 + 10) = 65 \text{ degrees}$$

$$\text{Depth } x \text{ of step} = 0.25212 \times 0.90631 = 0.2285 \text{ inch}$$

Circular Forming Tools.—To provide sufficient peripheral clearance on circular forming tools, the cutting face is offset with relation to the center of the tool a distance C, as shown in Fig. 3. Whenever a circular tool has two or more diameters, the difference in the radii of the steps on the tool will not correspond exactly to the difference in the steps on the work. The form produced with the tool also changes, although the change is very slight, unless the amount of offset C is considerable. Assume that a circular tool is required to produce the piece A having two diameters as shown.

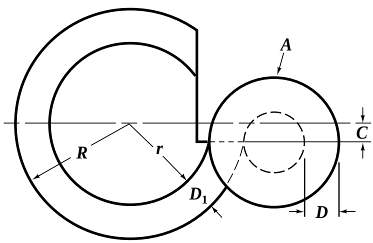


Fig. 3.

If the difference D_1 between the large and small radii of the tool were made equal to dimension D required on the work, D would be a certain amount oversize, depending upon the offset C of the cutting edge. The following formulas can be used to determine the radii of circular forming tools for turning parts to different diameters:

Let R = largest radius of tool in inches; D = difference in radii of steps on work; C = amount cutting edge is offset from center of tool; r = required radius in inches; then

$$r = \sqrt{(\sqrt{R^2 - C^2} - D)^2 + C^2} \qquad (1)$$

If the small radius r is given and the large radius R is required, then

$$R = \sqrt{(\sqrt{r^2 - C^2} + D)^2 + C^2} \qquad (2)$$

To illustrate, if D (Fig. 3) is to be ⅛ inch, the large radius R is 1⅛ inches, and C is 5⁄32 inch, what radius r would be required to compensate for the offset C of the cutting edge? Inserting these values in Formula (1):

$$r = \sqrt{\left(\sqrt{(1\tfrac{1}{8})^2 - (\tfrac{5}{32})^2} - (\tfrac{1}{8})\right)^2 + (\tfrac{5}{32})^2} = 1.0014 \text{ inches}$$

The value of r is thus found to be 1.0014 inches; hence, the diameter = 2 × 1.0014 = 2.0028 inches instead of 2 inches, as it would have been if the cutting edge had been exactly on the center line. Formulas for circular tools used on different makes of screw machines can be simplified when the values R and C are constant for each size of machine. The accompanying table, "Formulas for Circular Forming Tools," gives the standard values of R and C for circular tools used on different automatics. The formulas for determining the radius r (see column at right-hand side of table) contain a constant that represents the value of the expression $\sqrt{R^2 - C^2}$ in Formula (1).

The table "Constants for Determining Diameters of Circular Forming Tools" has been compiled to facilitate proportioning tools of this type and gives constants for computing the various diameters of forming tools, when the cutting face of the tool is ⅛, 3⁄16, ¼, or 5⁄16 inch below the horizontal center line. As there is no standard distance for the location of the cutting face, the table has been prepared to correspond with distances commonly used. As an example, suppose the tool is required for a part having three diameters of 1.75, 0.75, and 1.25 inches, respectively, as shown in Fig. 1, and that the largest diameter of the tool is 3 inches and the cutting face is ¼ inch below the horizontal center line. The first step would be to determine approximately the respective diameters of the forming tool and then correct the diameters by the use of the table. To produce the three diameters shown in Fig. 1, with a 3-inch forming tool, the tool diameters would be approximately 2, 3, and 2.5 inches, respectively. The first dimension (2 inches) is 1 inch less in diameter than that of the tool, and the necessary correction should be given in the column "Correction for Difference in Diameter"; but as the table is only extended to half-inch differences, it will be necessary to obtain this particular correction in two steps. On the line for 3-inch diameter and under corrections for ½ inch, we find 0.0085; then in line with 2½ and under the same heading, we find 0.0129, hence the total correction would be 0.0085 + 0.0129 = 0.0214 inch. This correction is added to the approximate diameter, making the exact diameter of the first step 2 + 0.0214 = 2.0214 inches. The next step would be computed in the same way, by noting on the 3-inch line the correction for ½ inch and adding it to the approximate diameter of the second step, giving an exact diameter of 2.5 + 0.0085 + 2.5085 inches. Therefore, to produce the part shown in Fig. 1, the tool should have three steps of 3, 2.0214, and 2.5085 inches, respectively, provided the cutting face is ¼ inch below the center. All diameters are computed in this way, from the largest diameter of the tool.

Formulas for Circular Forming Tools (For notation, see Fig. 3)

Make of Machine	Size of Machine	Radius *R*, Inches	Offset *C*, Inches	Radius *r*, Inches
Brown & Sharpe	No. 00	0.875	0.125	$r = \sqrt{(0.8660 - D)^2 + 0.0156}$
	No. 0	1.125	0.15625	$r = \sqrt{(1.1141 - D)^2 + 0.0244}$
	No. 2	1.50	0.250	$r = \sqrt{(1.4790 - D)^2 + 0.0625}$
	No. 6	2.00	0.3125	$r = \sqrt{(1.975 - D)^2 + 0.0976}$
Acme	No. 51	0.75	0.09375	$r = \sqrt{(1.7441 - D)^2 + 0.0088}$
	No. 515	0.75	0.09375	$r = \sqrt{(0.7441 - D)^2 + 0.0088}$
	No. 52	1.0	0.09375	$r = \sqrt{(0.9956 - D)^2 + 0.0088}$
	No. 53	1.1875	0.125	$r = \sqrt{(1.1809 - D)^2 + 0.0156}$
	No. 54	1.250	0.15625	$r = \sqrt{(1.2402 - D)^2 + 0.0244}$
	No. 55	1.250	0.15625	$r = \sqrt{(1.2402 - D)^2 + 0.0244}$
	No. 56	1.50	0.1875	$r = \sqrt{(1.4882 - D)^2 + 0.0352}$
Cleveland	1⁄4″	0.625	0.03125	$r = \sqrt{(0.6242 - D)^2 + 0.0010}$
	3⁄8″	0.084375	0.0625	$r = \sqrt{(0.8414 - D)^2 + 0.0039}$
	5⁄8″	1.15625	0.0625	$r = \sqrt{(1.1546 - D)^2 + 0.0039}$
	7⁄8″	1.1875	0.0625	$r = \sqrt{(1.1859 - D)^2 + 0.0039}$
	1 1⁄4″	1.375	0.0625	$r = \sqrt{(1.3736 - D)^2 + 0.0039}$
	2″	1.375	0.0625	$r = \sqrt{(1.3736 - D)^2 + 0.0039}$
	2 1⁄4″	1.625	0.125	$r = \sqrt{(1.6202 - D)^2 + 0.0156}$
	2 3⁄4″	1.875	0.15625	$r = \sqrt{(1.8685 - D)^2 + 0.0244}$
	3 1⁄4″	1.875	0.15625	$r = \sqrt{(1.8685 - D)^2 + 0.0244}$
	4 1⁄4″	2.50	0.250	$r = \sqrt{(2.4875 - D)^2 + 0.0625}$
	6″	2.625	0.250	$r = \sqrt{(2.6131 - D)^2 + 0.0625}$

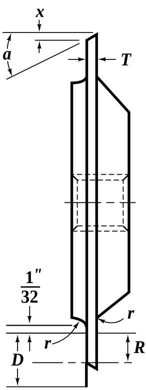
The tables "Corrected Diameters of Circular Forming Tools" are especially applicable to tools used on Brown & Sharpe automatic screw machines. Directions for using these tables are given at the end of Table 4.

Circular Tools Having Top Rake.—Circular forming tools without top rake are satisfactory for brass, but tools for steel or other tough metals cut better when there is a rake angle of 10 or 12 degrees. For such tools, the small radius r (see Fig. 3) for an outside radius R may be found by the formula

$$r = \sqrt{P^2 + R^2 - 2PR\cos\theta}$$

To find the value of P, proceed as follows: sin ϕ = small radius on work × sin rake angle ÷ large radius on work. Angle β = rake angle − ϕ. P = large radius on work × sin β ÷ sin rake angle. Angle θ = rake angle + δ. Sin δ = vertical height C from center of tool to center of work ÷ R. It is assumed that the tool point is to be set at the same height as the work center.

Dimensions for Circular Cut-Off Tools



Dia. of Stock	Soft Brass, Copper		Norway Iron, Machine Steel		Drill Rod, Tool Steel	
	a = 23 Deg.		a = 15 Deg.		a = 12 Deg.	
	T	x	T	x	T	x
1/16	0.031	0.013	0.039	0.010	0.043	0.009
1/8	0.044	0.019	0.055	0.015	0.062	0.013
3/16	0.052	0.022	0.068	0.018	0.076	0.016
1/4	0.062	0.026	0.078	0.021	0.088	0.019
5/16	0.069	0.029	0.087	0.023	0.098	0.021
3/8	0.076	0.032	0.095	0.025	0.107	0.023
7/16	0.082	0.035	0.103	0.028	0.116	0.025
1/2	0.088	0.037	0.110	0.029	0.124	0.026
9/16	0.093	0.039	0.117	0.031	0.131	0.028
5/8	0.098	0.042	0.123	0.033	0.137	0.029
11/16	0.103	0.044	0.129	0.035	0.145	0.031
3/4	0.107	0.045	0.134	0.036	0.152	0.032
13/16	0.112	0.047	0.141	0.038	0.158	0.033
7/8	0.116	0.049	0.146	0.039	0.164	0.035
15/16	0.120	0.051	0.151	0.040	0.170	0.036
1	0.124	0.053	0.156	0.042	0.175	0.037

The length of the blade equals radius of stock $R + x + r + 1/32$ inch (for notation, see illustration above); r = 1/16 inch for 3/8- to 3/4-inch stock, and 3/32 inch for 3/4- to 1-inch stock.

Constant for Determining Diameters of Circular Forming Tools

Dia. of Tool	Radius of Tool	Cutting Face ⅛ Inch Below Center			Cutting Face 3⁄16 Inch Below Center			Cutting Face ¼ Inch Below Center			Cutting Face 5⁄16 Inch Below Center		
		Correction for Difference in Diameter			Correction for Difference in Diameter			Correction for Difference in Diameter			Correction for Difference in Diameter		
		⅛ Inch	¼ Inch	½ Inch	⅛ Inch	¼ Inch	½ Inch	⅛ Inch	¼ Inch	½ Inch	⅛ Inch	¼ Inch	½ Inch
1	0.500	…	…	…	…	…	…	…	…	…	…	…	…
1⅛	0.5625	0.0036	…	…	0.0086	…	…	0.0167	…	…	0.0298	…	…
1¼	0.625	0.0028	0.0065	…	0.0067	0.0154	…	0.0128	0.0296	…	0.0221	0.0519	…
1⅜	0.6875	0.0023	…	…	0.0054	…	…	0.0102	…	…	0.0172	…	…
1½	0.750	0.0019	0.0042	0.0107	0.0045	0.0099	0.0253	0.0083	0.0185	0.0481	0.0138	0.0310	0.0829
1⅝	0.8125	0.0016	…	…	0.0037	…	…	0.0069	…	…	0.0114	…	…
1¾	0.875	0.0014	0.0030	…	0.0032	0.0069	…	0.0058	0.0128	…	0.0095	0.0210	…
1⅞	0.9375	0.0012	…	…	0.0027	…	…	0.0050	…	…	0.0081	…	…
2	1.000	0.0010	0.0022	0.0052	0.0024	0.0051	0.0121	0.0044	0.0094	0.0223	0.0070	0.0152	0.0362
2⅛	1.0625	0.0009	…	…	0.0021	…	…	0.0038	…	…	0.0061	…	…
2¼	1.125	0.0008	0.0017	…	0.0018	0.0040	…	0.0034	0.0072	…	0.0054	0.0116	…
2⅜	1.1875	0.0007	…	…	0.0016	…	…	0.0029	…	…	0.0048	…	…
2½	1.250	0.0006	0.0014	0.0031	0.0015	0.0031	0.0071	0.0027	0.0057	0.0129	0.0043	0.0092	0.0208
2⅝	1.3125	0.0006	…	…	0.0013	…	…	0.0024	…	…	0.0038	…	…
2¾	1.375	0.0005	0.0011	…	0.0012	0.0026	…	0.0022	0.0046	…	0.0035	0.0073	…
2⅞	1.4375	0.0005	…	…	0.0011	…	…	0.0020	…	…	0.0032	…	…
3	1.500	0.0004	0.0009	0.0021	0.0010	0.0021	0.0047	0.0018	0.0038	0.0085	0.0029	0.0061	0.0135
3⅛	1.5625	0.00004	…	…	0.0009	…	…	0.0017	…	…	0.0027	…	…
3¼	1.625	0.0003	0.0008	…	0.0008	0.0018	…	0.0015	0.0032	…	0.0024	0.0051	…
3⅜	1.6875	0.0003	…	…	0.0008	…	…	0.0014	…	…	0.0023	…	…
3½	1.750	0.0003	0.0007	0.0015	0.0007	0.0015	0.0033	0.0013	0.0028	0.0060	0.0021	0.0044	0.0095
3⅝	1.8125	0.0003	…	…	0.0007	…	…	0.0012	…	…	0.0019	…	…
3¾	1.875	0.0002	0.0006	…	0.0.0006	0.0013	…	0.0011	0.0024	…	0.0018	0.0038	…

Corrected Diameters of Circular Forming Tools—1

Length *c* on Tool	Number of B. & S. Automatic Screw Machine			Length *c* on Tool	Number of B. & S. Automatic Screw Machine		
	No. 00	No. 0	No. 2		No. 00	No. 0	No. 2
0.001	1.7480	2.2480	2.9980	0.058	1.6353	2.1352	2.8857
0.002	1.7460	2.2460	2.9961	0.059	1.6333	2.1332	2.8837
0.003	1.7441	2.2441	2.9941	0.060	1.6313	2.1312	2.8818
0.004	1.7421	2.2421	2.9921	0.061	1.6294	2.1293	2.8798
0.005	1.7401	2.2401	2.9901	0.062	1.6274	2.1273	2.8778
0.006	1.7381	2.2381	2.9882	1⁄16	1.6264	2.1263	2.8768
0.007	1.7362	2.2361	2.9862	0.063	1.6254	2.1253	2.8759
0.008	1.7342	2.2341	2.9842	0.064	1.6234	2.1233	2.8739
0.009	1.7322	2.2321	2.9823	0.065	1.6215	2.1213	2.8719
0.010	1.7302	2.2302	2.9803	0.066	1.6195	2.1194	2.8699
0.011	1.7282	2.2282	2.9783	0.067	1.6175	2.1174	2.8680
0.012	1.7263	2.2262	2.9763	0.068	1.6155	2.1154	2.8660
0.013	1.7243	2.2243	2.9744	0.069	1.6136	2.1134	2.8640
0.014	1.7223	2.2222	2.9724	0.070	1.6116	2.1115	2.8621
0.015	1.7203	2.2203	2.9704	0.071	1.6096	2.1095	2.8601
1⁄64	1.7191	2.2191	2.9692	0.072	1.6076	2.1075	2.8581
0.016	1.7184	2.2183	2.9685	0.073	1.6057	2.1055	2.8561
0.017	1.7164	2.2163	2.9665	0.074	1.6037	2.1035	2.8542
0.018	1.7144	2.2143	2.9645	0.075	1.6017	2.1016	2.8522
0.019	1.7124	2.2123	2.9625	0.076	1.5997	2.0996	2.8503
0.020	1.7104	2.2104	2.9606	0.077	1.5978	2.0976	2.8483
0.021	1.7085	2.2084	2.9586	0.078	1.5958	2.0956	2.8463
0.022	1.7065	2.2064	2.9566	5⁄64	1.5955	2.0954	2.8461
0.023	1.7045	2.2045	2.9547	0.079	1.5938	2.0937	2.8443
0.024	1.7025	2.2025	2.9527	0.080	1.5918	2.0917	2.8424
0.025	1.7005	2.2005	2.9507	0.081	1.5899	2.0897	2.8404
0.026	1.6986	2.1985	2.9488	0.082	1.5879	2.0877	2.8384
0.027	1.6966	2.1965	2.9468	0.083	1.5859	2.0857	2.8365
0.028	1.6946	2.1945	2.9448	0.084	1.5839	2.0838	2.8345
0.029	1.6926	2.1925	2.9428	0.085	1.5820	2.0818	2.8325
0.030	1.6907	2.1906	2.9409	0.086	1.5800	2.0798	2.8306
0.031	1.6887	2.1886	2.9389	0.087	1.5780	2.0778	2.8286
1⁄32	1.6882	2.1881	2.9384	0.088	1.5760	2.0759	2.8266
0.032	1.6867	2.1866	2.9369	0.089	1.5740	2.0739	2.8247
0.033	1.6847	2.1847	2.9350	0.090	1.5721	2.0719	2.8227
0.034	1.6827	2.1827	2.9330	0.091	1.5701	2.0699	2.8207
0.035	1.6808	2.1807	2.9310	0.092	1.5681	2.0679	2.8187
0.036	1.6788	2.1787	2.9290	0.093	1.5661	2.0660	2.8168
0.037	1.6768	2.1767	2.9271	3⁄32	1.5647	2.0645	2.8153
0.038	1.6748	2.1747	2.9251	0.094	1.5642	2.0640	2.8148
0.039	1.6729	2.1727	2.9231	0.095	1.5622	2.0620	2.8128
0.040	1.6709	2.1708	2.9211	0.096	1.5602	2.0600	2.8109
0.041	1.6689	2.1688	2.9192	0.097	1.5582	2.0581	2.8089
0.042	1.6669	2.1668	2.9172	0.098	1.5563	2.0561	2.8069
0.043	1.6649	2.1649	2.9152	0.099	1.5543	2.0541	2.8050
0.044	1.6630	2.1629	2.9133	0.100	1.5523	2.0521	2.8030
0.045	1.6610	2.1609	2.9113	0.101	1.5503	2.0502	2.8010
0.046	1.6590	2.1589	2.9093	0.102	1.5484	2.0482	2.7991
3⁄64	1.6573	2.1572	2.9076	0.103	1.5464	2.0462	2.7971
0.047	1.6570	2.1569	2.9073	0.104	1.5444	2.0442	2.7951
0.048	1.6550	2.1549	2.9054	0.105	1.5425	2.0422	2.7932
0.049	1.6531	2.1529	2.9034	0.106	1.5405	2.0403	2.7912
0.050	1.6511	2.1510	2.9014	0.107	1.5385	2.0383	2.7892
0.051	1.6491	2.1490	2.8995	0.108	1.5365	2.0363	2.7873
0.052	1.6471	2.1470	2.8975	0.109	1.5346	2.0343	2.7853
0.053	1.6452	2.1451	2.8955	7⁄64	1.5338	2.0336	2.7846
0.054	1.6432	2.1431	2.8936	0.110	1.5326	2.0324	2.7833
0.055	1.6412	2.1411	2.8916	0.111	1.5306	2.0304	2.7814
0.056	1.6392	2.1391	2.8896	0.112	1.5287	2.0284	2.7794
0.057	1.6373	2.1372	2.8877	0.113	1.5267	2.0264	2.7774

Corrected Diameters of Circular Forming Tools—1 *(Continued)*

Length *c* on Tool	Number of B. & S. Automatic Screw Machine			Length *c* on Tool	Number of B. & S. Automatic Screw Machine		
	No. 00	No. 0	No. 2		No. 00	No. 0	No. 2
0.113	1.5267	2.0264	2.7774	0.171	1.4124	1.9119	2.6634
0.114	1.5247	2.0245	2.7755	11/64	1.4107	1.9103	2.6617
0.115	1.5227	2.0225	2.7735	0.172	1.4104	1.9099	2.6614
0.116	1.5208	2.0205	2.7715	0.173	1.4084	1.9080	2.6595
0.117	1.5188	2.0185	2.7696	0.174	1.4065	1.9060	2.6575
0.118	1.5168	2.0166	2.7676	0.175	1.4045	1.9040	2.6556
0.119	1.5148	2.0146	2.7656	0.176	1.4025	1.9021	2.6536
0.120	1.5129	2.0126	2.7637	0.177	1.4006	1.9001	2.6516
0.121	1.5109	2.0106	2.7617	0.178	1.3986	1.8981	2.6497
0.122	1.5089	2.0087	2.7597	0.179	1.3966	1.8961	2.6477
0.123	1.5070	2.0067	2.7578	0.180	1.3947	1.8942	2.6457
0.124	1.5050	2.0047	2.7558	0.181	1.3927	1.8922	2.6438
0.125	1.5030	2.0027	2.7538	0.182	1.3907	1.8902	2.6418
0.126	1.5010	2.0008	2.7519	0.183	1.3888	1.8882	2.6398
0.127	1.4991	1.9988	2.7499	0.184	1.3868	1.8863	2.6379
0.128	1.4971	1.9968	2.7479	0.185	1.3848	1.8843	2.6359
0.129	1.4951	1.9948	2.7460	0.186	1.3829	1.8823	2.6339
0.130	1.4932	1.9929	2.7440	0.187	1.3809	1.8804	2.6320
0.131	1.4912	1.9909	2.7420	3/16	1.3799	1.8794	2.6310
0.132	1.4892	1.9889	2.7401	0.188	1.3789	1.8784	2.6300
0.133	1.4872	1.9869	2.7381	0.189	1.3770	1.8764	2.6281
0.134	1.4853	1.9850	2.7361	0.190	1.3750	1.8744	2.6261
0.135	1.4833	1.9830	2.7342	0.191	1.3730	1.8725	2.6241
0.136	1.4813	1.9810	2.7322	0.192	1.3711	1.8705	2.6222
0.137	1.4794	1.9790	2.7302	0.193	1.3691	1.8685	2.6202
0.138	1.4774	1.9771	2.7282	0.194	1.3671	1.8665	2.6182
0.139	1.4754	1.9751	2.7263	0.195	1.3652	1.8646	2.6163
0.140	1.4734	1.9731	2.7243	0.196	1.3632	1.8626	2.6143
9/64	1.4722	1.9719	2.7231	0.197	1.3612	1.8606	2.6123
0.141	1.4715	1.9711	2.7224	0.198	1.3592	1.8587	2.6104
0.142	1.4695	1.9692	2.7204	0.199	1.3573	1.8567	2.6084
0.143	1.4675	1.9672	2.7184	0.200	1.3553	1.8547	2.6064
0.144	1.4655	1.9652	2.7165	0.201	…	1.8527	2.6045
0.145	1.4636	1.9632	2.7145	0.202	…	1.8508	2.6025
0.146	1.4616	1.9613	2.7125	0.203	…	1.8488	2.6006
0.147	1.4596	1.9593	2.7106	13/64	…	1.8486	2.6003
0.148	1.4577	1.9573	2.7086	0.204	…	1.8468	2.5986
0.149	1.4557	1.9553	2.7066	0.205	…	1.8449	2.5966
0.150	1.4537	1.9534	2.7047	0.206	…	1.8429	2.5947
0.151	1.4517	1.9514	2.7027	0.207	…	1.8409	2.5927
0.152	1.4498	1.9494	2.7007	0.208	…	1.8390	2.5908
0.153	1.4478	1.9474	2.6988	0.209	…	1.8370	2.5888
0.154	1.4458	1.9455	2.6968	0.210	…	1.8350	2.5868
0.155	1.4439	1.9435	2.6948	0.211	…	1.8330	2.5849
0.156	1.4419	1.9415	2.6929	0.212	…	1.8311	2.5829
5/32	1.4414	1.9410	2.6924	0.213	…	1.8291	2.5809
0.157	1.4399	1.9395	2.6909	0.214	…	1.8271	2.5790
0.158	1.4380	1.9376	2.6889	0.215	…	1.8252	2.5770
0.159	1.4360	1.9356	2.6870	0.216	…	1.8232	2.5751
0.160	1.4340	1.9336	2.6850	0.217	…	1.8212	2.5731
0.161	1.4321	1.9317	2.6830	0.218	…	1.8193	2.5711
0.162	1.4301	1.9297	2.6811	7/32	…	1.8178	2.5697
0.163	1.4281	1.9277	2.6791	0.219	…	1.8173	2.5692
0.164	1.4262	1.9257	2.6772	0.220	…	1.8153	2.5672
0.165	1.4242	1.9238	2.6752	0.221	…	1.8133	2.5653
0.166	1.4222	1.9218	2.6732	0.222	…	1.8114	2.5633
0.167	1.4203	1.9198	2.6713	0.223	…	1.8094	2.5613
0.168	1.4183	1.9178	2.6693	0.224	…	1.8074	2.5594
0.169	1.4163	1.9159	2.6673	0.225	…	1.8055	2.5574
0.170	1.4144	1.9139	2.6654	0.226	....	1.8035	2.5555

Corrected Diameters of Circular Forming Tools—2

Length c on Tool	Number of B. & S. Screw Machine No. 0	Number of B. & S. Screw Machine No. 2	Length c on Tool	Number of B. & S. Screw Machine No. 0	Number of B. & S. Screw Machine No. 2	Length c on Tool	Number 2 B. & S. Machine
0.227	1.8015	2.5535	0.284	1.6894	2.4418	0.341	2.3303
0.228	1.7996	2.5515	0.285	1.6874	2.4398	0.342	2.3284
0.229	1.7976	2.5496	0.286	1.6854	2.4378	0.343	2.3264
0.230	1.7956	2.5476	0.287	1.6835	2.4359	11⁄32	2.3250
0.231	1.7936	2.5456	0.288	1.6815	2.4340	0.344	2.3245
0.232	1.7917	2.5437	0.289	1.6795	2.4320	0.345	2.3225
0.233	1.7897	2.5417	0.290	1.6776	2.4300	0.346	2.3206
0.234	1.7877	2.5398	0.291	1.6756	2.4281	0.347	2.3186
15⁄64	1.7870	2.5390	0.292	1.6736	2.4261	0.348	2.3166
0.235	1.7858	2.5378	0.293	1.6717	2.4242	0.349	2.3147
0.236	1.7838	2.5358	0.294	1.6697	2.4222	0.350	2.3127
0.237	1.7818	2.5339	0.295	1.6677	2.4203	0.351	2.3108
0.238	1.7799	2.5319	0.296	1.6658	2.4183	0.352	2.3088
0.239	1.7779	2.5300	19⁄64	1.6641	2.4166	0.353	2.3069
0.240	1.7759	2.5280	0.297	1.6638	2.4163	0.354	2.3049
0.241	1.7739	2.5260	0.298	1.6618	2.4144	0.355	2.3030
0.242	1.7720	2.5241	0.299	1.6599	2.4124	0.356	2.3010
0.243	1.7700	2.5221	0.300	1.6579	2.4105	0.357	2.2991
0.244	1.7680	2.5201	0.301	…	2.4085	0.358	2.2971
0.245	1.7661	2.5182	0.302	…	2.4066	0.359	2.2952
0.246	1.7641	2.5162	0.303	…	2.4046	23⁄64	2.2945
0.247	1.7621	2.5143	0.304	…	2.4026	0.360	2.2932
0.248	1.7602	2.5123	0.305	…	2.4007	0.361	2.2913
0.249	1.7582	2.5104	0.306	…	2.3987	0.362	2.2893
0.250	1.7562	2.5084	0.307	…	2.3968	0.363	2.2874
0.251	1.7543	2.5064	0.308	…	2.3948	0.364	2.2854
0.252	1.7523	2.5045	0.309	…	2.3929	0.365	2.2835
0.253	1.7503	2.5025	0.310	…	2.3909	0.366	2.2815
0.254	1.7484	2.5005	0.311	…	2.3890	0.367	2.2796
0.255	1.7464	2.4986	0.312	…	2.3870	0.368	2.2776
0.256	1.7444	2.4966	5⁄16	…	2.3860	0.369	2.2757
0.257	1.7425	2.4947	0.313	…	2.3851	0.370	2.2737
0.258	1.7405	2.4927	0.314	…	2.3831	0.371	2.2718
0.259	1.7385	2.4908	0.315	…	2.3811	0.372	2.2698
0.260	1.7366	2.4888	0.316	…	2.3792	0.373	2.2679
0.261	1.7346	2.4868	0.317	…	2.3772	0.374	2.2659
0.262	1.7326	2.4849	0.318	…	2.3753	0.375	2.2640
0.263	1.7306	2.4829	0.319	…	2.3733	0.376	2.2620
0.264	1.7287	2.4810	0.320	…	2.3714	0.377	2.2601
0.265	1.7267	2.4790	0.321	…	2.3694	0.378	2.2581
17⁄64	1.7255	2.4778	0.322	…	2.3675	0.379	2.2562
0.266	1.7248	2.4770	0.323	…	2.3655	0.380	2.2542
0.267	1.7228	2.4751	0.324	…	2.3636	0.381	2.2523
0.268	1.7208	2.4731	0.325	…	2.3616	0.382	2.2503
0.269	1.7189	2.4712	0.326	…	2.3596	0.383	2.2484
0.270	1.7169	2.4692	0.327	…	2.3577	0.384	2.2464
0.271	1.7149	2.4673	0.328	…	2.3557	0.385	2.2445
0.272	1.7130	2.4653	21⁄64	…	2.3555	0.386	2.2425
0.273	1.7110	2.4633	0.329	…	2.3538	0.387	2.2406
0.274	1.7090	2.4614	0.330	…	2.3518	0.388	2.2386
0.275	1.7071	2.4594	0.331	…	2.3499	0.389	2.2367
0.276	1.7051	2.4575	0.332	…	2.3479	0.390	2.2347
0.277	1.7031	2.4555	0.333	…	2.3460	25⁄64	2.2335
0.278	1.7012	2.4535	0.334	…	2.3440	0.391	2.2328
0.279	1.6992	2.4516	0.335	…	2.3421	0.392	2.2308
0.280	1.6972	2.4496	0.336	…	2.3401	0.393	2.2289
0.281	1.6953	2.4477	0.337	…	2.3381	0.394	2.2269
9⁄32	1.6948	2.4472	0.338	…	2.3362	0.395	2.2250
0.282	1.6933	2.4457	0.339	…	2.3342	0.396	2.2230
0.283	1.6913	2.4438	0.340	…	2.3323	0.397	2.2211

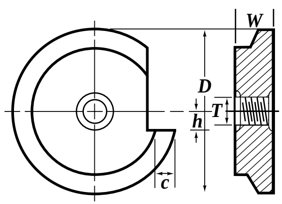
Corrected Diameters of Circular Forming Tools—3

Length *c* on Tool	Number 2 B. & S. Machine	Length *c* on Tool	Number 2 B. & S. Machine	Length *c* on Tool	Number 2 B. & S. Machine	Length *c* on Tool	Number 2 B. & S. Machine
0.398	2.2191	0.423	2.1704	0.449	2.1199	0.474	2.0713
0.399	2.2172	0.424	2.1685	0.450	2.1179	0.475	2.0694
0.400	2.2152	0.425	2.1666	0.451	2.1160	0.476	2.0674
0.401	2.2133	0.426	2.1646	0.452	2.1140	0.477	2.0655
0.402	2.2113	0.427	2.1627	0.453	2.1121	0.478	2.0636
0.403	2.2094	0.428	2.1607	29/64	2.1118	0.479	2.0616
0.404	2.2074	0.429	2.1588	0.454	2.1101	0.480	2.0597
0.405	2.2055	0.430	2.1568	0.455	2.1082	0.481	2.0577
0.406	2.2035	0.431	2.1549	0.456	2.1063	0.482	2.0558
13/32	2.2030	0.432	2.1529	0.457	2.1043	0.483	2.0538
0.407	2.2016	0.433	2.1510	0.458	2.1024	0.484	2.0519
0.408	2.1996	0.434	2.1490	0.459	2.1004	0.485	2.0500
0.409	2.1977	0.435	2.1471	0.460	2.0985	0.486	2.0480
0.410	2.1957	0.436	2.1452	0.461	2.0966	0.487	2.0461
0.411	2.1938	0.437	2.1432	0.462	2.0946	0.488	2.0441
0.412	2.1919	7/16	2.1422	0.463	2.0927	0.489	2.0422
0.413	2.1899	0.438	2.1413	0.464	2.0907	0.490	2.0403
0.414	2.1880	0.439	2.1393	0.465	2.0888	0.491	2.0383
0.415	2.1860	0.440	2.1374	0.466	2.0868	0.492	2.0364
0.416	2.1841	0.441	2.1354	0.467	2.0849	0.493	2.0344
0.417	2.1821	0.442	2.1335	0.468	2.0830	0.494	2.0325
0.418	2.1802	0.443	2.1315	15/32	2.0815	0.495	2.0306
0.419	2.1782	0.444	2.1296	0.469	2.0810	0.496	2.0286
0.420	2.1763	0.445	2.1276	0.470	2.0791	0.497	2.0267
0.421	2.1743	0.446	2.1257	0.471	2.0771	0.498	2.0247
27/64	2.1726	0.447	2.1237	0.472	2.0752	0.499	2.0228
0.422	2.1724	0.448	2.1218	0.473	2.0733	0.500	2.0209

Method of Using Tables for "Corrected Diameters of Circular Forming Tools".—

These tables are especially applicable to Brown & Sharpe automatic screw machines. The maximum diameter *D* of forming tools for these machines should be as follows: For No. 00 machine, 1¾ inches; for No. 0 machine, 2¼ inches; for No. 2 machine, 3 inches. To find the other diameters of the tool for any piece to be formed, proceed as follows: Subtract the smallest diameter of the work from the diameter of the work that is to be formed by the required tool diameter; divide the remainder by 2; locate the quotient obtained in the column headed "Length *c* on Tool," and opposite the figure thus located and in the column headed by the number of the machine used, read off directly the diameter to which the tool is to be made. The quotient obtained, which is located in the column headed "Length *c* on Tool," is the length *c*, as shown in the following table.

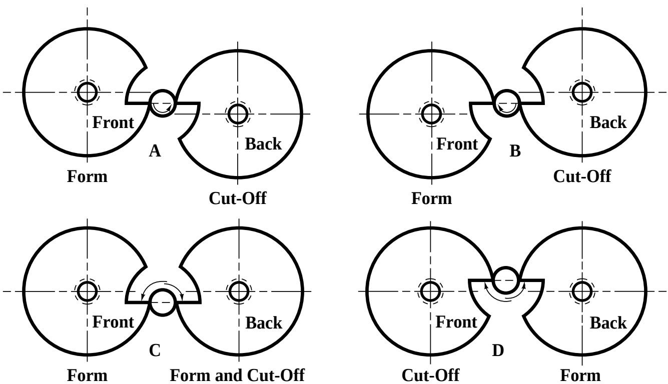
Dimensions of Forming Tools for B. & S. Automatic Screw Machines



No. of Machine	Max. Dia., *D*	*h*	*T*	*W*
00	1¾	1/8	3/8–16	1/4
0	2¼	5/32	1/2–14	5/16
2	3	1/4	5/8–12	3/8
6	4	5/16	3/4–12	3/8

Example: A piece of work is to be formed on a No. 0 machine to two diameters, one being ¼ inch and one 0.550 inch; find the diameters of the tool. The maximum tool diameter is 2¼ inches, or the diameter that will cut the ¼-inch diameter of the work. To find the other diameter, proceed according to the rule given: 0.550 – ¼ = 0.300; 0.300 ÷ 2 = 0.150. In Table 2, opposite 0.150, we find that the required tool diameter is 1.9534 inches. These tables are for tools without rakes.

Arrangement of Circular Tools.—When applying circular tools to automatic screw machines, their arrangement has an important bearing on the results obtained. The various ways of arranging the circular tools, with relation to the rotation of the spindle, are shown at A, B, C, and D in the illustration. These diagrams represent the view obtained when looking toward the chuck. The arrangement shown at A gives good results on long forming operations on brass and steel because the pressure of the cut on the front tool is downward; the support is more rigid than when the forming tool is turned upside down on the front slide, as shown at B; here the stock, turning up toward the tool, has a tendency to lift the cross-slide, causing chattering; therefore, the arrangement shown at A is recommended when a high-quality finish is desired. The arrangement at B works satisfactorily for short steel pieces that do not require a high finish; it allows the chips to drop clear of the work, and is especially advantageous when making screws, when the forming and cut-off tools operate after the die, as no time is lost in reversing the spindle. The arrangement at C is recommended for heavy cutting on large work, when both tools are used for forming the piece; a rigid support is then necessary for both tools and a good supply of oil is also required. The arrangement at D is objectionable and should be avoided; it is used only when a left-hand thread is cut on the piece and when the cut-off tool is used on the front slide, leaving the heavy cutting to be performed from the rear slide. In all "cross-forming" work, it is essential that the spindle bearings be kept in good condition, and that the collet or chuck has a parallel contact upon the bar that is being formed.



Feeds and Speeds for Forming Tools.—Approximate feeds and speeds for forming tools are given in the table beginning on page 1095. The feeds and speeds are average values, and if the job at hand has any features out of the ordinary, the figures given should be altered accordingly.