DRILLING PRACTICE

Serial 2220 Edition 1

TOOLS AND OPERATIONS

TOOLS

DRILLS

1. Classification of Drills.—Drills are named from their forms or shapes, from the uses to which they may be put, and from the kinds of steel used to make them. Some of the forms, given in drill maker's catalogs are *twist drills*, *twisted drills*, *flat drills*, *straight-shank* and *taper-shank drills*, *straight-fluted drills*, *oil-tube drills*, *hollow drills*, *drills for angular holes*, *carbon-steel drills*, and *high-speed steel drills*. Drills are also known as *long set* and *short set*, depending upon their lengths.

2. Twist Drills.—Twist drills remove the cuttings from the holes and can be resharpened by grinding the point without the need of reforging and hardening and tempering.

The two most common forms of twist drills are shown in Fig. 1. These drills have a cylindrical body and have two grooves, or *flutes*, and two helical ridges, or *lands*, between the flutes. The lands form the two cutting edges, or *lips*, at the point. The central part between the bottoms of the flutes is the *web*, and the straight part shown in (*a*), and the tapered part in (*b*) that is gripped by the machine to drive the drill, is the *shank*. The flattened end of the shank is the *tang*.

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3. Twist Drill Angles.—The angles of a standard twist drill are shown in Figs. 2 and 3. The angle *a* between either cutting edge, Fig. 2, that forms the point, and the side or center line of the drill body, is commonly 59 degrees. The angle between the cutting edges themselves is twice this, or 118 degrees. The *scraping*, or *chisel*, *edge a b*, Fig. 3, that joins the two cutting edges *a c* and *b d*, forms the end of

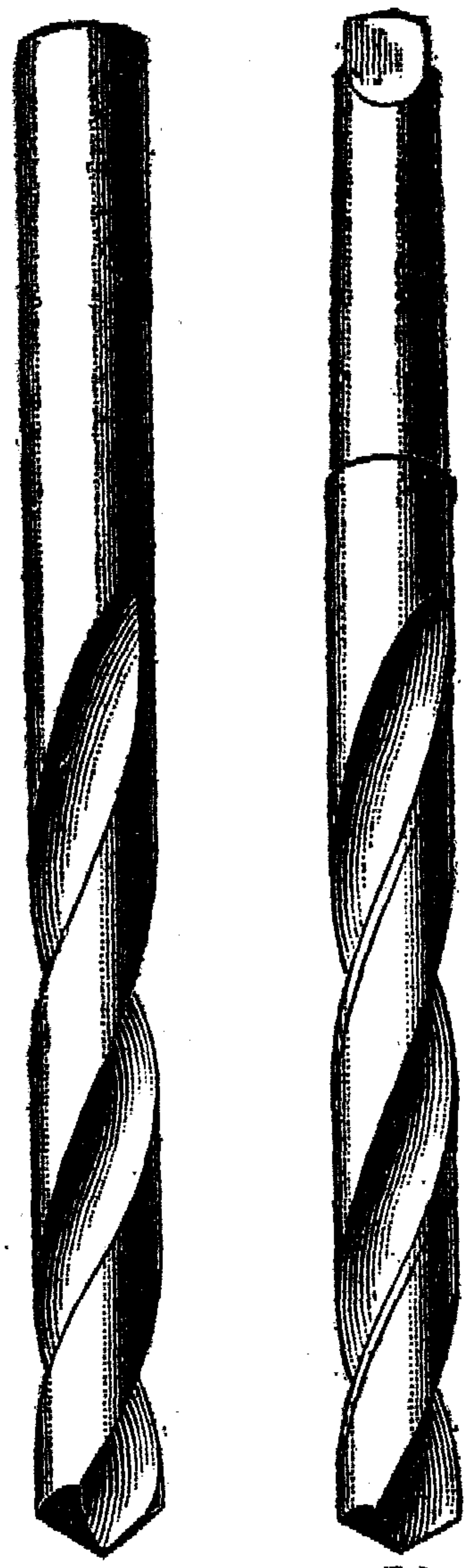

(a) (b)

FIG. 1

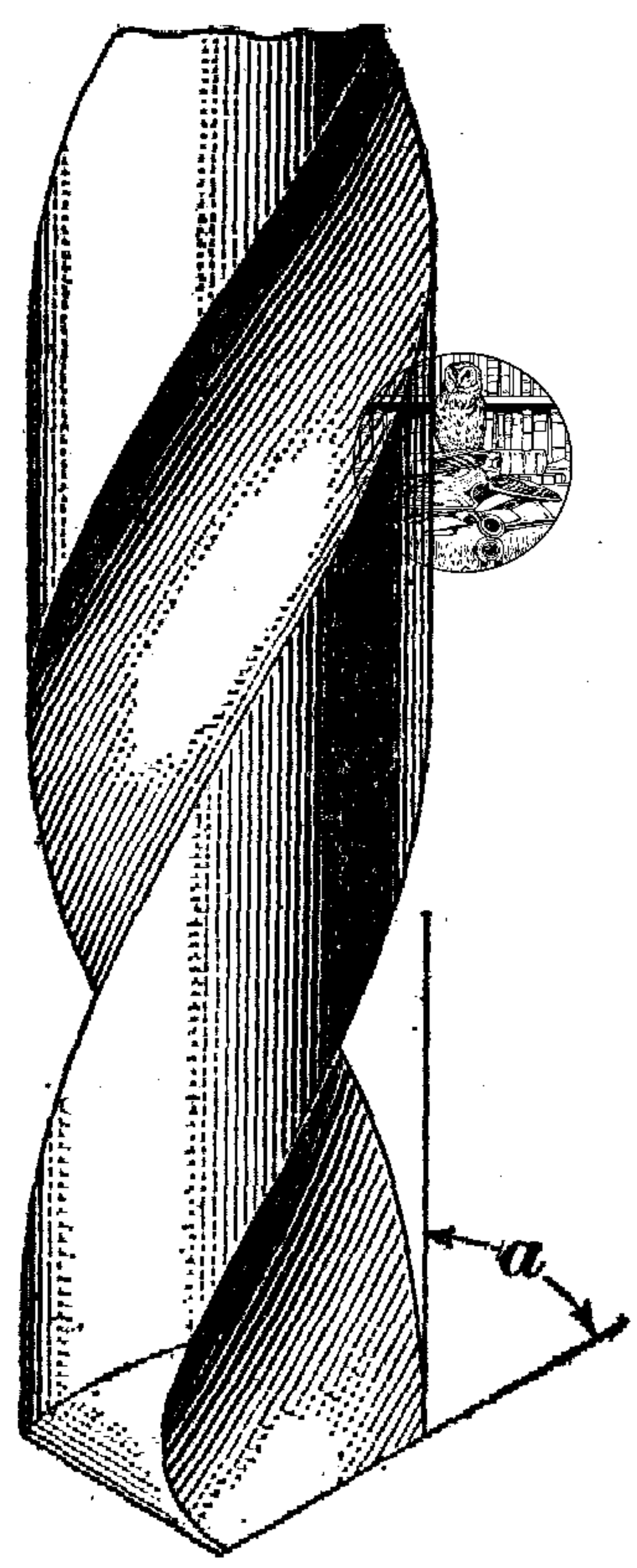


FIG. 2

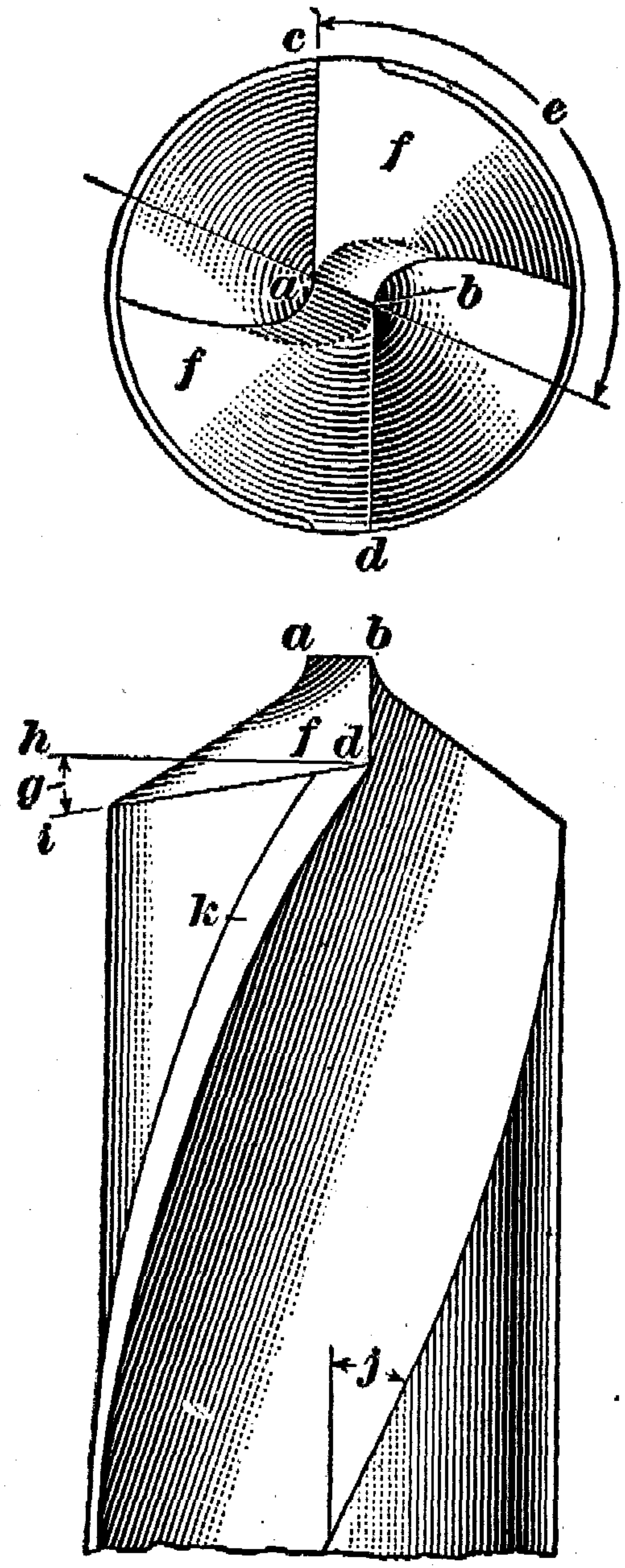


FIG. 3

the point, and the angle *e* between the scraping edge line *a b* and the cutting edge *a c* ahead of it, may be any size from about 125 degrees to 135 degrees, depending on the way in which the point is ground. As seen in the end view of the point, the cutting edges *a c* and *b d* are straight.

4. The end surface, or *heel*, *f* back of each cutting edge is ground down to give clearance and make it possible for the edge to cut into the metal. The *clearance angle g* made by this grinding is indicated by the lines *d h* and *d i*. The line *d h* is perpendicular to the cutting edge *d b*, and the line *d i* follows the slope of the heel *f*. The clearance angle on some drills measures from about 5 degrees to 7 degrees at the circumference of the drill, and sometimes the point is ground so as to increase this angle at the inner end of the cutting edge, as shown by the shading in the illustration.

The clearance angle on some drills is made as great as 12 degrees or 15 degrees at the outer end of the cutting edge. The helix angle *j*, which indicates the slope of the lands and flutes around the body of the drill, is about 32 degrees. The web is made thicker toward the shank to give the additional strength needed at this point. The web is sometimes made thin at the extreme point, as shown in Fig. 4, to shorten the

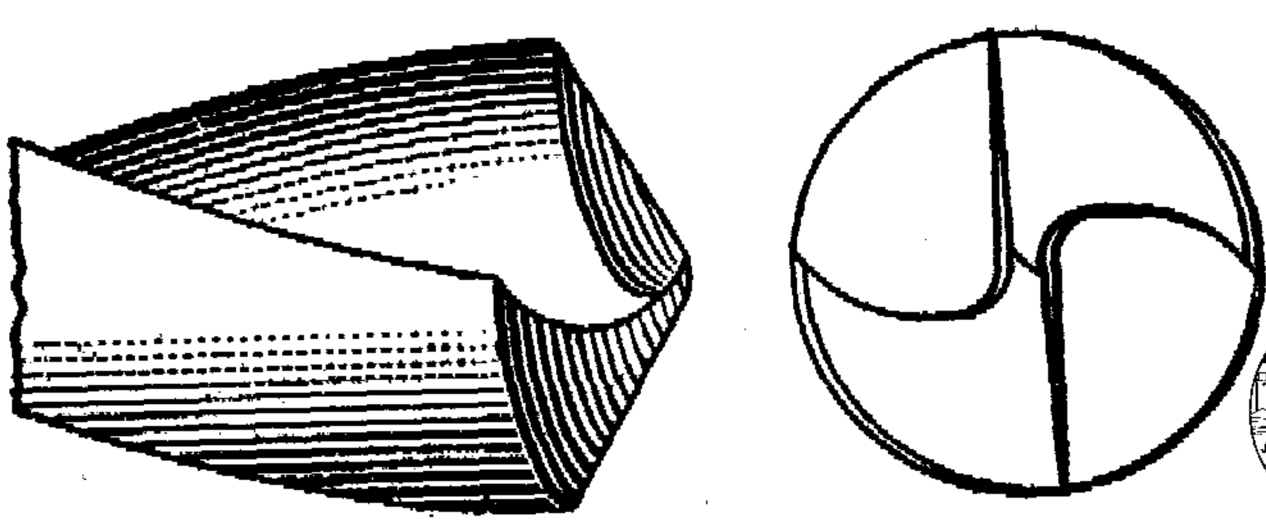


FIG. 4

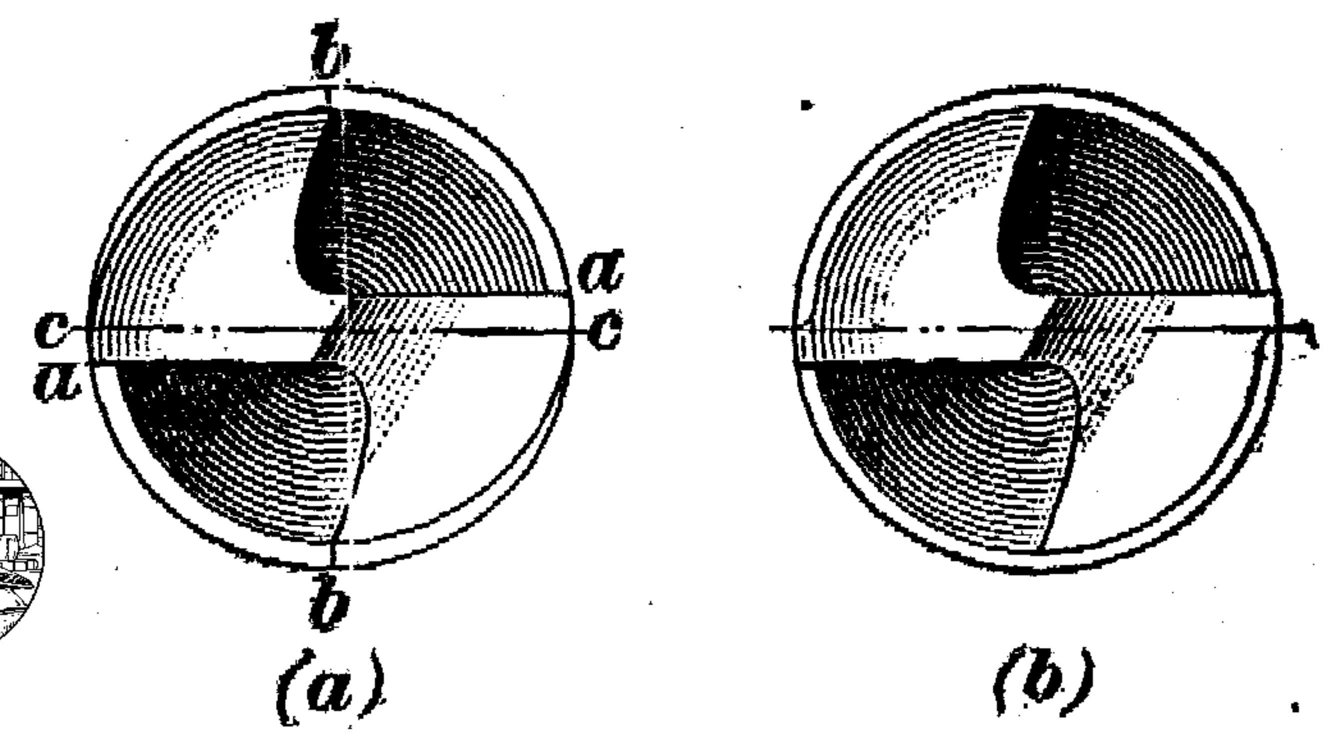


FIG. 5

scraping edge and reduce the feeding pressure, to center the drill more accurately, and to reduce the danger of the splitting of the drill.

5. Body Clearances of Twist Drills.—Twist drills are given a slight clearance both lengthwise and on their diameter. The purpose of these body clearances is to reduce the friction between the drill and the surface of the hole. The body is made slightly tapered from the point to the shank about .001 inch per inch in length, so that it will have a clearance lengthwise to prevent its binding in deep holes.

There are two ways of forming the clearance on the diameter of the drill. In (*a*), Fig. 5, the body is ground away along the length of the lands, the ground portion beginning either at the cutting edge or a very short distance *a c* back of the cutting edge and gradually increasing around the remaining surface of the land to its back edge *b*. In (*b*) the grinding depth begins abruptly and the body clearance is made its full depth throughout the land. This method leaves a narrow strip, or margin, *k*, Fig. 3, along the edge of each land, which has the full diameter to guide the drill.

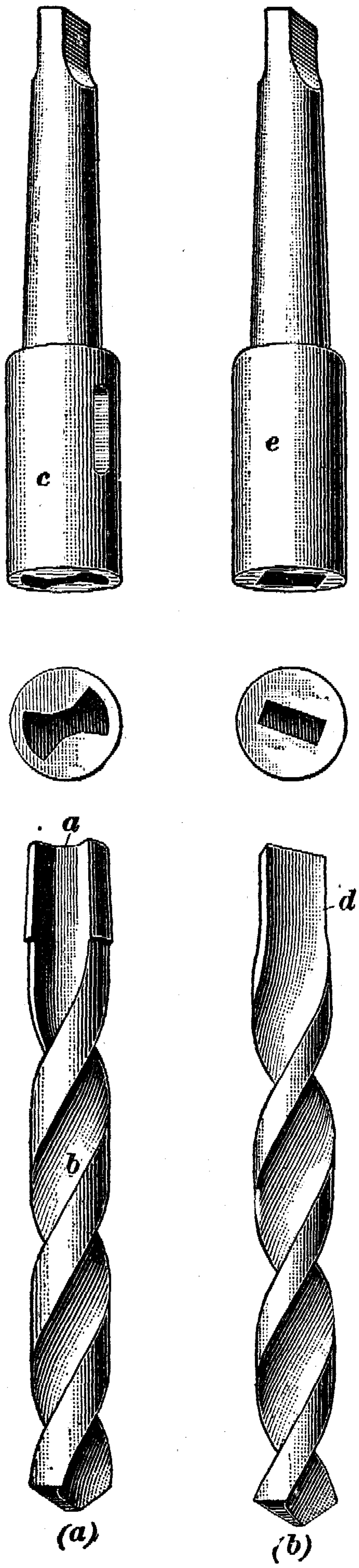
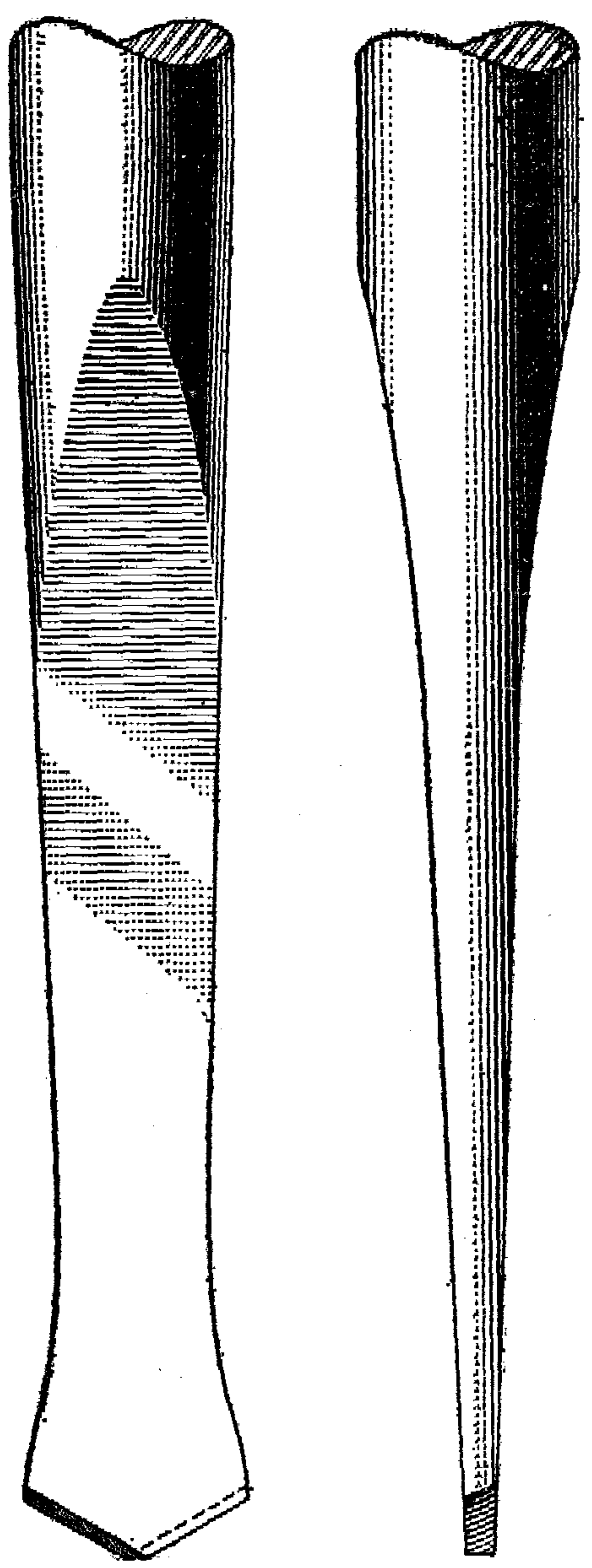


FIG. 6

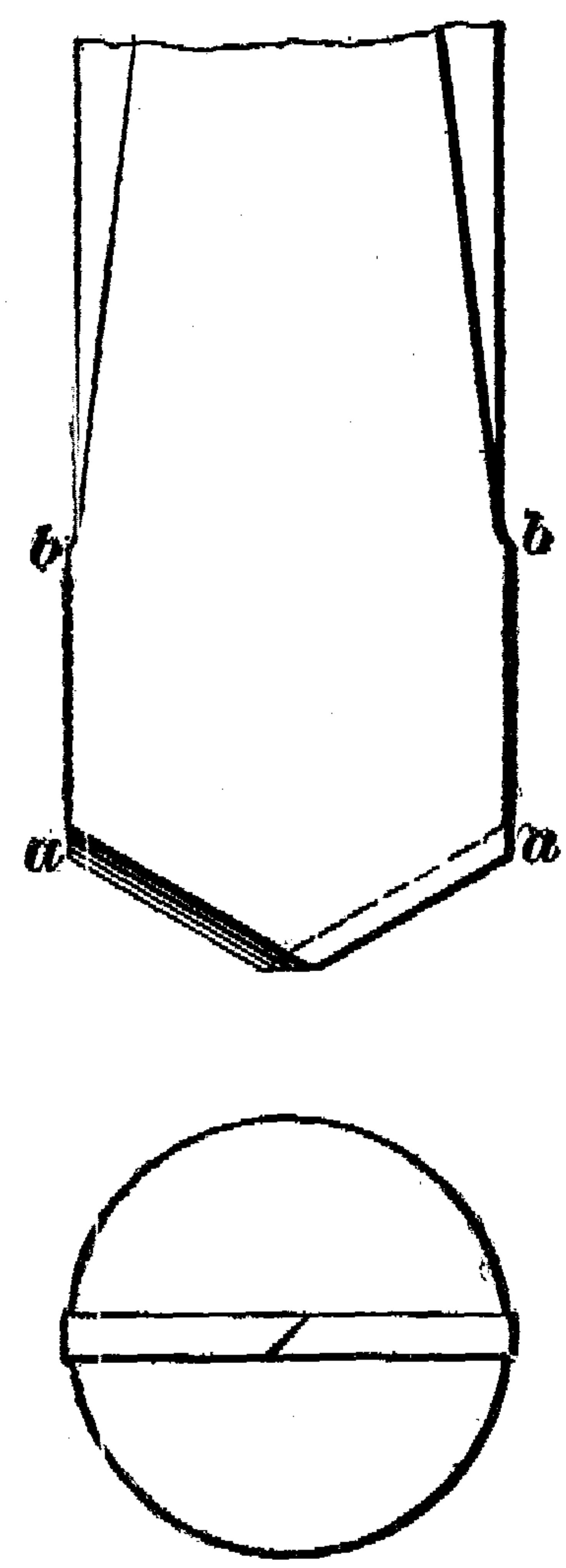
6. Twisted Drills.—Twisted drills, Fig. 6, derive their name from the method of manufacture. They are similar in form to the twist drills, but instead of having their grooves cut entirely from the solid metal, the drills are forged from thick strips of steel, and the grooves *a* in view (*a*) are rolled lengthwise of the strips. These forgings are then hot twisted and machine finished as at *b*. The larger sizes of twisted drills are made in this way for economy in the use of high-speed steel. An interchangeable taper shank *c* is used to adapt these drills to the spindle of the drilling machine.

The type of twisted drill shown in Fig. 6 (*b*) is made of thinner strips than those used in (*a*), and the grooves are formed entirely by the twisting of the strip. The finishing is done by grinding. These drills have a straight, flat tang *d*, which is held either in a chuck or by the use of a special shank *e*. In some cases the tangs of twisted drills are brazed into the shanks.

7. Twist-Drill Sizes.—The diameters of twist drills are indicated by numbers and by capital letters, and by their actual sizes measured in inches and fractions of an inch or in millimeters. Drills are numbered and lettered according to the Stubs' Steel Wire and Drill Rod gauge. They are also numbered to correspond to the dimensions given by the Steel Wire Gauge of the American Society of Mechanical Engineers (A. S. M. E.), or Manufacturers' Standard, which ranges from .001 inch to .002 inch greater than the Stubs'. In Table I are given the twist-drill sizes usually kept in stock by the manufacturers. Thus a number 80 drill has a diameter of .0135 inch; a .5 millimeter drill measures .0197 inch; an R drill is .339 inch in diameter; and so on up to a $3\frac{1}{2}$-inch drill, which is the largest mentioned in the table.



(a)



(b)

FIG. 7

8. **Flat Drills.**—The flat drill is forged from either round or flat stock. It is filed or ground to the required shape and diameter and then hardened and tempered to suit the service required. The final sharpening is done by grinding. Its use is limited to the occasional need for a drill of some special size. Also, the flat drill is useful for drilling very hard materials, such as chilled iron and glass, for the reason that it can be made of a higher carbon steel than that used for twist drills, and, therefore, it can be given greater hardness. The common form of the flat drill having a barb-shaped point as used for

TABLE I

TWIST-DRILL SIZES IN INCHES AND MILLIMETERS

(*The Cleveland Twist Drill Co.*)

Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches
80	.0135	47	.0785	21	.1590	6.25 m/m	.2461	T	.3580
79	.0145	2. m/m	.0787	20	.1610	6.3 m/m	.2480	9.1 m/m	.3583
1/64	.0156	46	.0810	4.1 m/m	.1614	E	.2500	23/64	.3594
78	.0160	45	.0820	4.2 m/m	.1654	1/4	.2500	9.2 m/m	.3622
77	.0180	2.1 m/m	.0827	19	.1660	6.4 m/m	.2520	9.25 m/m	.3642
.5 m/m	.0197	44	.0860	4.25 m/m	.1674	6.5 m/m	.2559	9.3 m/m	.3661
76	.0200	2.2 m/m	.0866	4.3 m/m	.1693	F	.2570	U	.3680
75	.0210	2.25 m/m	.0886	18	.1695	6.6 m/m	.2598	9.4 m/m	.3701
74	.0225	43	.0890	11/64	.1719	G	.2610	9.5 m/m	.3740
.6 m/m	.0236	2.3 m/m	.0905	17	.1730	6.7 m/m	.2638	3/8	.3750
73	.0240	42	.0935	4.4 m/m	.1732	17/64	.2656	V	.3770
72	.0250	3/32	.0937	16	.1770	6.75 m/m	.2658	9.6 m/m	.3780
71	.0260	2.4 m/m	.0945	4.5 m/m	.1771	H	.2660	9.7 m/m	.3819
.7 m/m	.0276	41	.0960	15	.1800	6.8 m/m	.2677	9.75 m/m	.3839
70	.0280	40	.0980	4.6 m/m	.1811	6.9 m/m	.2716	9.8 m/m	.3858
69	.0292	2.5 m/m	.0984	14	.1820	I	.2720	W	.3860
.75 m/m	.0295	39	.0995	13	.1850	7. m/m	.2756	9.9 m/m	.3898
68	.0310	38	.1015	4.7 m/m	.1850	J	.2770	25/64	.3906
1/32	.0313	2.6 m/m	.1024	4.75 m/m	.1870	7.1 m/m	.2795	10. m/m	.3937
.8 m/m	.0315	37	.1040	3/16	.1875	K	.2811	X	.3970
67	.0320	2.7 m/m	.1063	4.8 m/m	.1890	9/32	.2812	Y	.4040
66	.0330	36	.1065	12	.1890	7.2 m/m	.2835	13/32	.4062
65	.0350	2.75 m/m	.1083	11	.1910	7.25 m/m	.2855	Z	.4130
.9 m/m	.0345	7/64	.1093	4.9 m/m	.1929	7.3 m/m	.2874	10.5 m/m	.4134
64	.0360	35	.1100	10	.1935	L	.2900	27/64	.4219
63	.0370	2.8 m/m	.1102	9	.1960	7.4 m/m	.2913	11. m/m	.4330
62	.0380	34	.1110	5. m/m	.1968	M	.2950	7/16	.4375
61	.0390	33	.1130	8	.1990	7.5 m/m	.2953	11.5 m/m	.4528
1. m/m	.0394	2.9 m/m	.1142	5.1 m/m	.2008	19/64	.2968	29/64	.4531
60	.0400	32	.1160	7	.2010	7.6 m/m	.2992	15/32	.4687
59	.0410	3. m/m	.1181	13/64	.2031	N	.3020	12. m/m	.4724
58	.0420	31	.1200	6	.2040	7.7 m/m	.3031	31/64	.4843
57	.0430	3.1 m/m	.1220	5.2 m/m	.2047	7.75 m/m	.3051	12.5 m/m	.4921
1.1 m/m	.0433	1/8	.1250	5	.2055	7.8 m/m	.3071	1/2	.5000
56	.0465	3.2 m/m	.1260	5.25 m/m	.2067	7.9 m/m	.3110	13. m/m	.5118
3/64	.0469	3.25 m/m	.1280	5.3 m/m	.2087	5/16	.3125	33/64	.5156
1.2 m/m	.0472	30	.1285	4	.2090	8. m/m	.3150	17/32	.5312
1.25 m/m	.0492	3.3 m/m	.1299	5.4 m/m	.2126	O	.3160	13.5 m/m	.5315
1.3 m/m	.0512	3.4 m/m	.1339	3	.2130	8.1 m/m	.3189	35/64	.5469
55	.0520	29	.1360	5.5 m/m	.2165	8.2 m/m	.3228	14. m/m	.5512
54	.0550	3.5 m/m	.1378	7/32	.2187	P	.3230	9/16	.5625
1.4 m/m	.0551	28	.1405	5.6 m/m	.2205	8.25 m/m	.3248	14.5 m/m	.5709
1.5 m/m	.0591	9/64	.1406	2	.2210	8.3 m/m	.3268	37/64	.5781
53	.0595	3.6 m/m	.1417	5.7 m/m	.2244	21/64	.3281	15. m/m	.5906
1/16	.0625	27	.1440	5.75 m/m	.2264	8.4 m/m	.3307	19/32	.5937
1.6 m/m	.0629	3.7 m/m	.1457	1	.2280	Q	.3320	39/64	.6094
52	.0635	26	.1470	5.8 m/m	.2283	8.5 m/m	.3346	15.5 m/m	.6102
1.7 m/m	.0669	3.75 m/m	.1477	5.9 m/m	.2323	8.6 m/m	.3386	5/8	.6250
51	.0670	25	.1495	A	.2340	R	.3390	16. m/m	.6299
1.75 m/m	.0689	3.8 m/m	.1496	15/64	.2344	8.7 m/m	.3425	41/64	.6406
50	.0700	24	.1520	6. m/m	.2362	11/32	.3437	16.5 m/m	.6496
1.8 m/m	.0709	3.9 m/m	.1535	B	.2380	8.75 m/m	.3445	21/32	.6562
49	.0730	23	.1540	6.1 m/m	.2401	8.8 m/m	.3465	17. m/m	.6693
1.9 m/m	.0748	5/32	.1562	C	.2420	S	.3480	43/64	.6719
48	.0760	22	.1570	6.2 m/m	.2441	8.9 m/m	.3504	11/16	.6875
5/64	.0781	4. m/m	.1575	D	.2460	9. m/m	.3543	17.5 m/m	.6890

TABLE I—(*Continued*)

Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches	Drill	Diam. Inches
45/64	.7031	1 3/16	1.1875	42.5 m/m	1.6732	55. m/m	2.1654	2 21/32	2.6562
18. m/m	.7087	30.5 m/m	1.2008	1 11/16	1.6875	2 11/64	2.1719	67.5 m/m	2.6575
23/32	.7187	1 13/64	1.2031	43. m/m	1.6929	55.5 m/m	2.1850	2 43/64	2.6719
18.5 m/m	.7283	1 7/32	1.2187	1 45/64	1.7031	2 3/16	2.1875	68. m/m	2.6772
47/64	.7344	31. m/m	1.2205	43.5 m/m	1.7126	2 13/64	2.2031	2 11/16	2.6875
19. m/m	.7480	1 15/64	1.2344	1 23/32	1.7187	56. m/m	2.2047	68.5 m/m	2.6968
3/4	.7500	31.5 m/m	1.2402	44. m/m	1.7323	2 7/32	2.2187	2 45/64	2.7031
49/64	.7656	1 1/4	1.2500	1 47/64	1.7344	56.5 m/m	2.2244	69. m/m	2.7165
19.5 m/m	.7677	32. m/m	1.2599	1 3/4	1.7500	2 15/64	2.2344	2 23/32	2.7187
25/32	.7812	1 17/64	1.2656	44.5 m/m	1.7520	57. m/m	2.2441	2 47/64	2.7344
20. m/m	.7874	32.5 m/m	1.2795	1 49/64	1.7656	2 1/4	2.2500	69.5 m/m	2.7362
51/64	.7969	1 9/32	1.2812	45. m/m	1.7717	57.5 m/m	2.2638	2 3/4	2.7500
20.5 m/m	.8071	1 19/64	1.2969	1 25/32	1.7812	2 17/64	2.2656	70. m/m	2.7559
13/16	.8125	33. m/m	1.2992	45.5 m/m	1.7914	2 9/32	2.2812	2 49/64	2.7656
21. m/m	.8268	1 15/16	1.3125	1 51/64	1.7969	58. m/m	2.2835	70.5 m/m	2.7756
53/64	.8281	33.5 m/m	1.3189	46. m/m	1.8110	2 19/64	2.2969	2 25/32	2.7812
27/32	.8437	1 21/64	1.3281	1 13/16	1.8125	58.5 m/m	2.3031	71. m/m	2.7953
21.5 m/m	.8465	34. m/m	1.3386	1 53/64	1.8281	2 5/16	2.3125	2 51/64	2.7969
55/64	.8594	1 11/32	1.3437	46.5 m/m	1.8307	59. m/m	2.3228	2 13/16	2.8125
22. m/m	.8661	34.5 m/m	1.3583	1 27/32	1.8437	2 21/64	2.3281	71.5 m/m	2.8150
7/8	.8750	1 23/64	1.3594	47. m/m	1.8504	59.5 m/m	2.3425	2 53/64	2.8281
22.5 m/m	.8858	1 3/8	1.3750	1 55/64	1.8594	2 11/32	2.3437	72. m/m	2.8346
57/64	.8906	35. m/m	1.3780	47.5 m/m	1.8701	2 23/64	2.3594	2 27/32	2.8437
23. m/m	.9055	1 25/64	1.3906	1 7/8	1.8750	60. m/m	2.3622	72.5 m/m	2.8543
29/32	.9062	35.5 m/m	1.3977	48. m/m	1.8898	2 3/8	2.3750	2 55/64	2.8594
59/64	.9219	1 13/32	1.4062	1 57/64	1.8906	60.5 m/m	2.3819	73. m/m	2.8740
23.5 m/m	.9252	36. m/m	1.4173	1 29/32	1.9062	2 25/64	2.3906	2 7/8	2.8750
15/16	.9375	1 27/64	1.4219	48.5 m/m	1.9095	61. m/m	2.4016	2 57/64	2.8906
24. m/m	.9449	36.5 m/m	1.4370	1 59/64	1.9219	2 13/32	2.4062	73.5 m/m	2.8937
61/64	.9531	1 7/16	1.4375	49. m/m	1.9291	61.5 m/m	2.4213	2 29/32	2.9062
24.5 m/m	.9646	1 29/64	1.4531	1 15/16	1.9375	2 27/64	2.4219	74. m/m	2.9134
31/32	.9687	37. m/m	1.4567	49.5 m/m	1.9488	2 7/16	2.4375	2 59/64	2.9219
25. m/m	.9843	1 15/32	1.4687	1 61/64	1.9531	62. m/m	2.4409	74.5 m/m	2.9331
63/64	.9844	37.5 m/m	1.4764	50. m/m	1.9685	2 29/64	2.4531	2 15/16	2.9375
1	1.0000	1 31/64	1.4844	1 31/32	1.9687	62.5 m/m	2.4606	75. m/m	2.9527
25.5 m/m	1.0040	38. m/m	1.4961	1 63/64	1.9844	2 15/32	1.4687	2 61/64	2.9531
1 1/64	1.0156	1 1/2	1.5000	50.5 m/m	1.9882	63. m/m	2.4803	2 31/32	2.9687
26. m/m	1.0236	1 33/64	1.5156	2	2.0000	2 31/64	2.4844	75.5 m/m	2.9724
1 1/32	1.0312	38.5 m/m	1.5158	51. m/m	2.0079	63.5 m/m	2.5000	2 63/64	2.9844
26.5 m/m	1.0433	1 17/32	1.5312	2 1/64	2.0156	2 1/2	2.5000	76. m/m	2.9921
1 3/64	1.0469	39. m/m	1.5354	51.5 m/m	2.0276	2 33/64	2.5156	3	3.0000
1 1/16	1.0625	1 35/64	1.5469	2 1/32	2.0312	64. m/m	2.5197	3 1/32	3.0312
27. m/m	1.0630	39.5 m/m	1.5551	2 3/64	2.0469	2 17/32	2.5312	3 1/16	3.0625
1 5/64	1.0781	1 9/16	1.5625	52. m/m	2.0473	64.5 m/m	2.5394	3 3/32	3.0937
27.5 m/m	1.0827	40. m/m	1.5748	2 1/16	2.0625	2 35/64	2.5469	3 1/8	3.1250
1 3/32	1.0937	1 37/64	1.5781	52.5 m/m	2.0669	65. m/m	2.5590	3 5/32	3.1562
28. m/m	1.1024	1 19/32	1.5937	2 5/64	2.0781	2 9/16	2.5625	3 3/16	3.1875
1 7/64	1.1094	40.5 m/m	1.5945	53. m/m	2.0867	2 37/64	2.5781	3 7/32	3.2187
28.5 m/m	1.1220	1 39/64	1.6094	2 3/32	2.0937	65.5 m/m	2.5787	3 1/4	3.2500
1 1/8	1.1250	41. m/m	1.6142	53.5 m/m	2.1063	2 19/32	2.5937	3 9/32	3.2812
1 9/64	1.1406	1 5/8	1.6250	2 7/64	2.1094	66. m/m	2.5984	3 5/16	3.3125
29. m/m	1.1417	41.5 m/m	1.6339	2 1/8	2.1250	2 39/64	2.6093	3 11/32	3.3437
1 5/32	1.1562	1 41/64	1.6406	54. m/m	2.1260	66.5 m/m	2.6181	3 3/8	3.3750
29.5 m/m	1.1614	42. m/m	1.6536	2 9/64	2.1406	2 5/8	2.6250	3 7/16	3.4375
1 11/64	1.1719	1 21/32	1.6562	54.5 m/m	2.1457	67. m/m	2.6378	3 1/2	3.5000
30. m/m	1.1811	1 43/64	1.6719	2 5/32	2.1562	2 41/64	2.6406		

shallow holes is shown in view (*a*), Fig. 7. The front of the lips may be given a hook shape similar to those of the twist drill. For deep holes the sides *a b*, view (*b*), may be made straight with their corners rounded as shown in its end view, to fit the circumference of the hole and guide the drill.

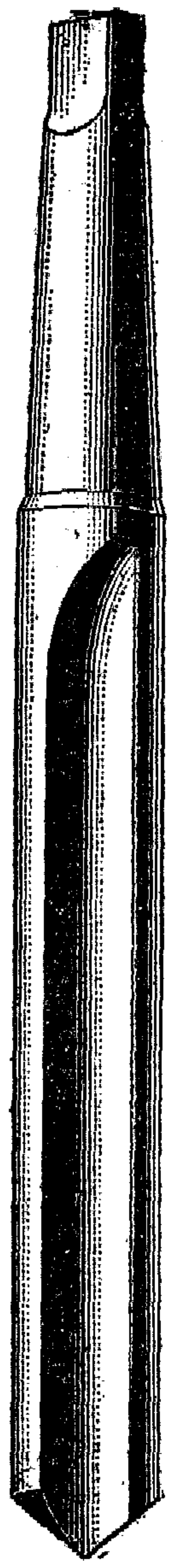


FIG. 8

9. Straight-Fluted Drill.—The straight-fluted drill, shown in Fig. 8, is best suited for drilling thin plates, especially those of brass, copper, or other soft metals. A twist drill has a tendency to plunge forwards, or grab, as its point comes through a thin piece, with the added risk of breaking the drill or spoiling the truth of the hole. By using a straight-fluted drill instead of the twisted form, the drilling is more satisfactory.

10. Single-Fluted Drill.—The single-fluted twist drill, Fig. 9, is largely used for drilling a variety of substances commonly used in shops, such as hard rubber, celluloid, bakelite, wood, etc. It is suitable for deep drilling as well as for making holes in thin stock. The land is ground with central clearance, leaving a raised strip *a* along each edge to form its full diameter.

11. Three- and Four-Fluted Drills.—A three-fluted twist drill is shown in Fig. 10. These drills are not intended to make holes in solid stock but to enlarge holes previously made. Thus when large holes are to be made in solid stock it is a good

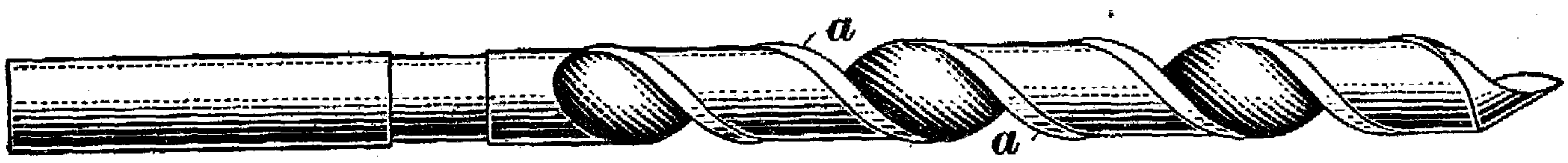


FIG. 9

plan to use an ordinary two-fluted twist drill of small or medium size first. Then finish the hole to the required diameter by the use of a three- or four-fluted drill. The lead hole made by the first drill gives a clearance for the scraping edge of the second one, and also permits the larger drill with its extra cutting edges to remove the stock faster than possible with a large drill in solid stock. The multiple fluted drills have a thicker web than two-fluted drills, and therefore they can be left harder in order to do the heavier cutting. Drills

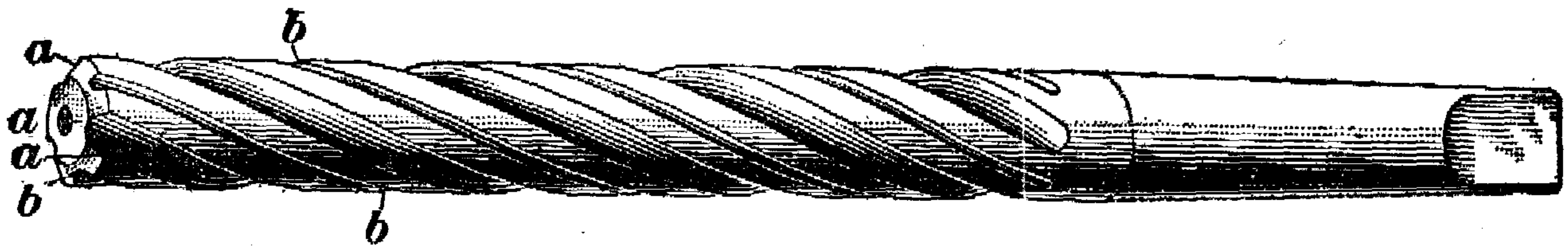


FIG. 10

of this type are also largely used to enlarge and finish the surface of the rough, or cored, holes that have been molded in castings, as their short cutting edges *a* take all the depth of cut required. Sometimes oil grooves *b* are used in the *lands* of these drills.

12. Shell Drills.—The shell drill, as shown in Fig. 11 (*a*), is a form of four-fluted twist drill for enlarging holes, such as those ranging from 1 inch to 3 inches in diameter. These drills have a tapered hole with its large diameter next to the collar

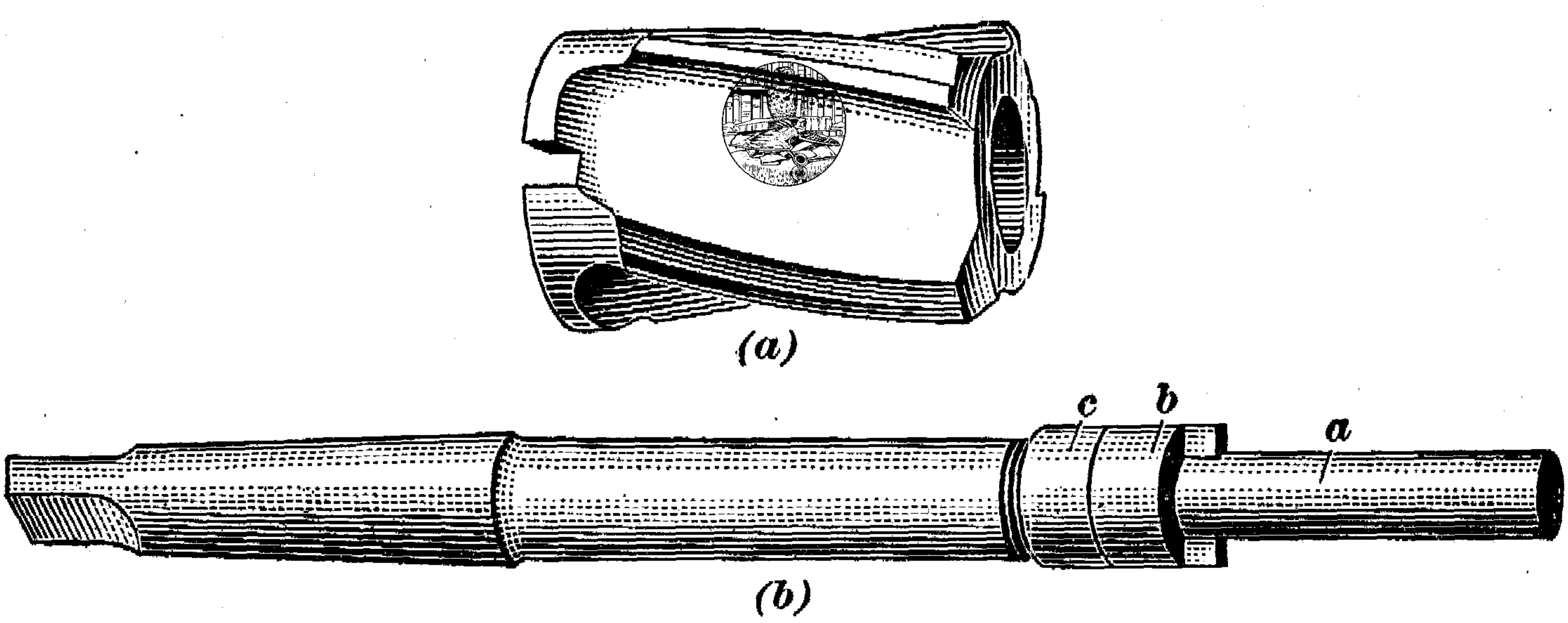


FIG. 11

on the taper-shank arbor shown in view (*b*). The arbor *a* is tapered to fit the hole through the shell, view (*a*). The collar *b* has two driving wings that engage the two slots across the end of the shell. The collar *b* can be forced forwards by a turn or two of the adjusting nut *c*, which will quickly release the shell drill from its tapered arbor.

SPECIAL DRILLS

13. Classification of Special Drills.—There is a great variety of drills that have some special form either of point, body, or shank. Some of the most commonly used special drills are those for deep holes, for extra large holes, for stone and brick and marble, drills and countersinks combined, oil-tube drills, blacksmith's drills, bit-stock drills, drills for glass, drills for angular holes, etc.

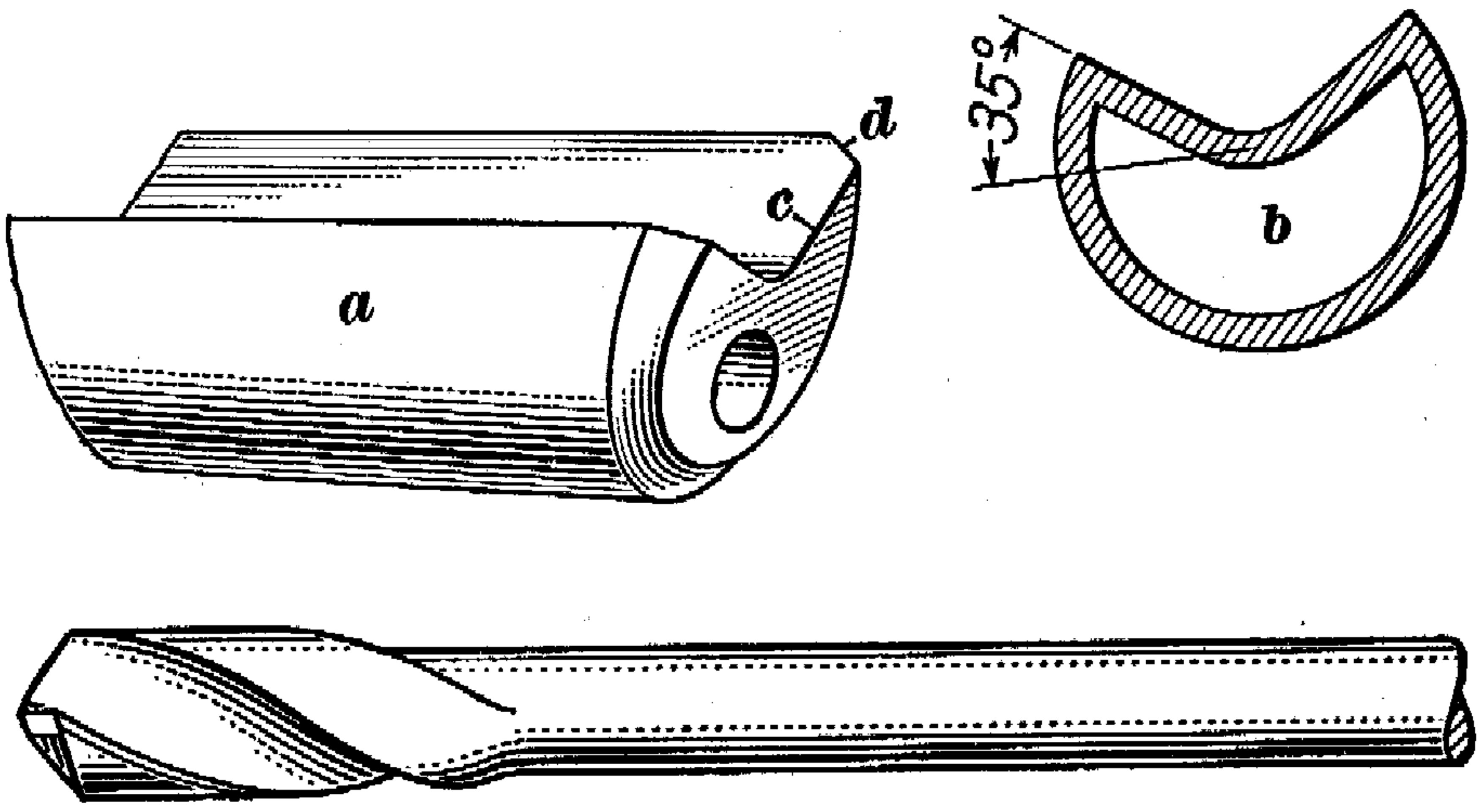
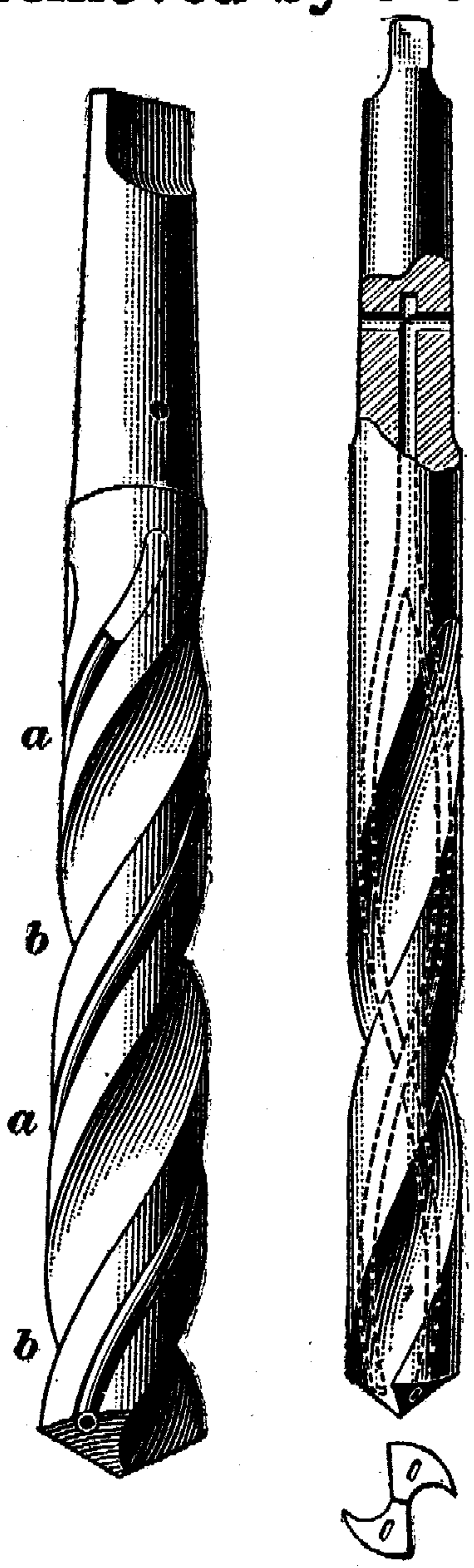


FIG. 12

14. Drills for Deep Holes.—Drills for deep holes, such as gun barrels, are shown in Fig. 12. The cutter *a* of the straight drill is brazed to a long hollow shank *b* having an outside groove for the cuttings. The cutting edge has shear and clearance angles. The sharp corner at *d* was removed by the chamfer around the end, leaving a short cutting edge. The twist drill type has the usual cutting edges but they are backed off by a narrow clearance surface at an angle of about 4°.

15. Oil Tube and Hole Drills.—In drilling wrought iron and steel, the drill point must be lubricated. The lubricant is usually applied by dropping it into the hole and permitting it to run down along the sides of the hole and the drill. This method has been found rather unsatisfactory, as the cuttings, in working their way to the surface, tend to carry the lubricant up, and in some cases very little, if any, reaches the drill point where it is most needed.

16. In Fig. 13 (*a*) is shown a very simple method by means of which better lubricating conditions are obtained. Two spiral grooves *a* are cut parallel with the flutes *b*, thus forming separate channels for the lubricant. There is some danger that these grooves may become clogged by fine particles that work around the drill, and small brass tubes are brazed into the grooves, as shown, in order to insure an unobstructed flow to the drill point.



(*a*) (*b*)

FIG. 13