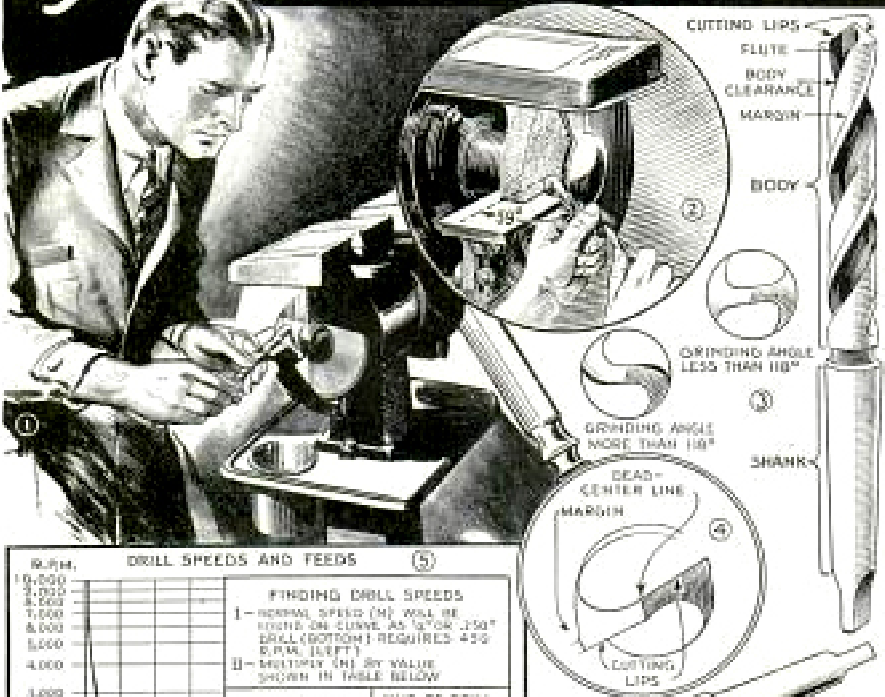
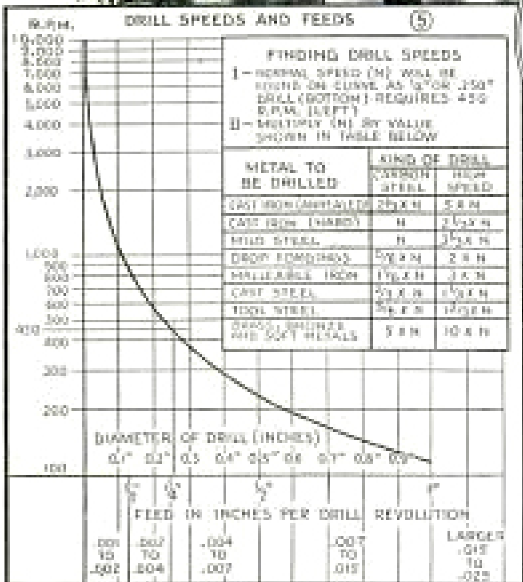
The MECHANICS





FINDING DRILL SPEEDS

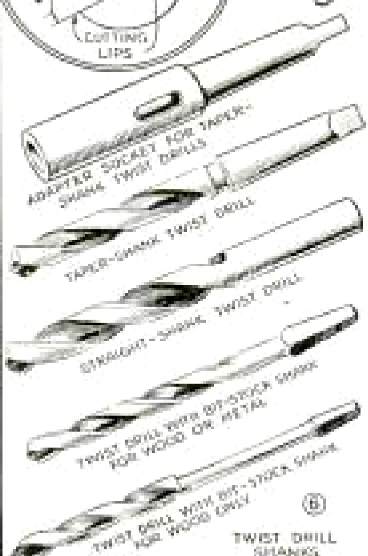
I—NORMAL SPEED (N) WILL BE FOUND ON CURVE AS ¼" OR .250" DRILL (BOTTOM) REQUIRES 450 R.P.M. (LEFT)

II—MULTIPLY (N) BY VALUE SHOWN IN TABLE BELOW

METAL TO BE DRILLED	KIND OF DRILL: CARBON STEEL	KIND OF DRILL: HIGH SPEED
CAST IRON (ANNEALED)	2½ x N	5 x N
CAST IRON (HARD)	N	2½ x N
MILD STEEL	N	2½ x N
DROP FORGINGS	½ x N	2 x N
MALLEABLE IRON	1½ x N	3 x N
CAST STEEL	⅖ x N	1½ x N
TOOL STEEL	⅖ x N	1½ x N
BRASS, BRONZE AND SOFT METALS	5 x N	10 x N

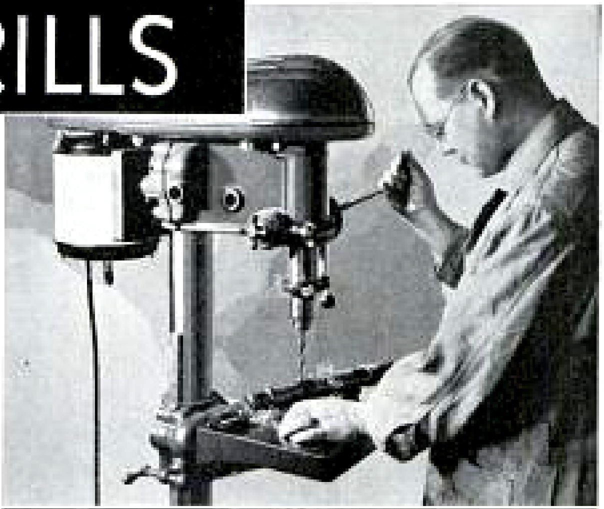
LUBRICANTS

Cast Iron—None
Mild Steel—Lard Oil
Drop Forgings—Lard Oil
Malleable Iron—Soda Water
Tool Steel—Lard Oil
Cast Steel—Lard Oil
Brass and Bronze—Dry or Paraffin Oil
Wrought Iron—Lard Oil
Aluminum—Kerosene



TWIST DRILL SHANKS

# of DRILLS



PART I

Practical data for every shop man on the technique of using drills; how to select the right type for certain jobs, what speeds for efficiency and many other pointers

CLOSE examination of a drill of any size will reveal that there are three main operating parts which enable this tool to do its important job. As you will see from Fig. 3, these are the shank, the fluted body, and the cutting lips. Like all cutting tools which remove material in the form of chips, the lips of the drill must be ground with a clearance and rake angle. Each lip is really a chisel, each must have exactly the same clearance and rake, and, due to the characteristics of the drill and the nature of the materials in which it must work, the uniformity of these angles determines its performance.

Types of Twist-Drill Shanks: Fig. 6 shows the four standard shanks which are in general use. The taper-shank drill is used in a drill press, the hollow spindle of which has an internal taper. When the shank does not fit the drill-press socket, a suitable adapter is used. The straight shank is the type most commonly used. It fits both drill-press and hand-drill chucks. Bit-stock shanks may be used in ordinary bit braces. The type of drill used for wood only has a sharper point than do the others and, by observing the point angle, it is possible to easily distinguish wood-working drills from those made for metal.

Body and Flutes: The body of the drill, Fig. 3, consists of a spirally fluted section to give strength, curl the chips, provide a means whereby they may be ejected, and to allow for the entrance of oil or cutting compounds to lubricate and cool the drill. Note that the outside edges of the flutes are ridged to form a margin of slightly greater over-all diameter than the rest of the body. The recessing back of the margin is very slightly tapered toward the shank to give the drill body clearance and prevent binding. The angle between the flutes and work when the drill stands perpendicularly, Fig. 10, is the rake angle. The steeper this angle, the tighter the chips are rolled. For most jobs the angle produced when the drill is manufactured is satisfactory.

Cutting Lips and Grinding Methods: From the standpoint of shop care, the most important parts of the drill are the point and cutting lips. Fig. 4 shows an enlarged point-on view from which it should be observed that the faces on either side of the dead-center line are ground to a very definite angle and when this is done, the edges of the cutting lips are parallel as shown. If a gauge, Fig. 11, is placed across the tip of a properly ground drill with its edges parallel to the cutting lips, it will be found that the angle is 118°. As it is possible to grind a drill more on one side than on the other and still produce this angle, the marks on the gauge should also be observed. With the point registering with

Fig. 10. The angle between a line drawn squarely across the point with a line drawn between the cutting-edge tip and the heel or trailing edge of the lip should span an angle between 12 and 15° for best results.

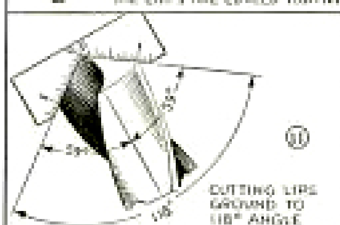
For a practical method of determining when the lips of a drill have been ground to a proper angle compare the two point-on views in Fig. 3 with that in Fig. 4. Note the variations in the curve of the cutting edges caused by varying the angle. On the other hand, when the drill is properly ground as in Figs. 1 and 2, with the correct clearance angle, the cutting edges will be parallel as in Fig. 4. In other words, the cutting edges are in the form of a straight line offset by the dead-center line and the trailing edges back of them are rounding.

When drilling very hard material, it has been found helpful to modify the rake angle slightly, as shown in Fig. 17. The nearer this angle is made to 90° the tighter the chips will be rolled and the less will be the likelihood of breaking or chipping the cutting lip. This modification should not be made except in those cases where very hard material is being drilled and when the use of proper lubricants, as explained later, has failed to produce satisfactory results without damage to the drill.

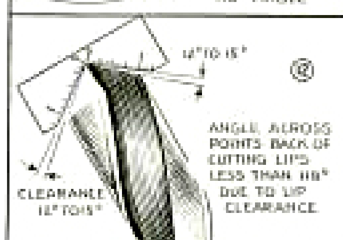
Grinding High-Speed Drills: When grinding carbon-steel drills they are cooled by immersion in water to avoid burning. This practice must not be used with high-speed drills as sudden changes of temperature check, crack, and weaken them. They will stand high temperatures if heated slowly. Accordingly, they should be ground slowly to avoid sudden overheating and must be allowed to cool in the air to prevent checking. For grinding drills, a good grade of vitrified Alundum wheel should be selected, the most acceptable type being grade K, grain M. The grinder should be operated at a surface speed of between 4,000 and 5,000 feet per minute. A good rule for finding the speed in r.p.m. required is to divide the diameter of the wheel in inches into 14,000. Thus, a 10-in. wheel should run at 1,400 r.p.m. The drill is carefully brought up to the edge of the grinder as shown in Figs. 1 and 2, and should be held rigidly, the angle between the wheel and the drill being maintained at 59°. After a little practice, this is a simple operation and the eye will be adequate to insure an accurate job. As the drill is brought up to the wheel, it should be rotated clockwise while at the same time the angle is gradually decreased to produce the clearance.

CLEARANCE ANGLE PERMITS CHISEL TO CUT (9)

(10) WITH A LARGE RAKE ANGLE THE CHIPS ARE CURLED TIGHTLY

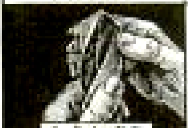
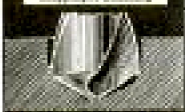
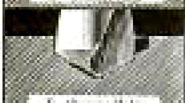
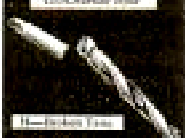
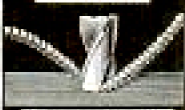


(11) CUTTING LIPS GROUND TO 118° ANGLE



(12) ANGLE ACROSS POINTS BACK OF CUTTING LIPS LESS THAN 118° DUE TO LIP CLEARANCE

Causes and Cures for Drill Troubles ⑦

TROUBLE	CAUSES	CURES
 A—Broken Drill	1—Work mounted so that it is springy 2—Not enough lip clearance 3—Dull drill 4—Speed low or feed too fast 5—If drilling metal, brass or soft metal, chips may pack in flutes	1—Fasten work rigidly so it cannot spring 2—Regrind properly 3—Grind 4—Increase speed or feed slower 5—Increase speed, grind drill with more lip clearance or use drills designed for the material
 B—Breaking of Cutting Edges—Particularly at Corners	1—Too much lip clearance 2—Material has hard spots, sand inclusions or scale 3—Drill running too fast 4—Wrong cutting compound or lubricant 5—Feed too rapid	1—Regrind and reduce lip clearance to between 12 and 15 degrees 2—Reduce speed 3—Reduce speed 4—Use proper lubricant or compound 5—Reduce feed
 C—High Speed Drill Chipped or Checking	1—Drill heated or cooled too rapidly while drilling or grinding 2—Feeding too rapidly	1—Warm drill slowly before using—Do not use cold water while drilling or grinding 2—Reduce feed
 D—Oversize Hole	1—Lip angles are not equal	1—Regrind drill and equalize lip angles
 E—Oversize Hole	2—Length and angle of lips not equal	2—Regrind drill and equalize lip angles and lip lengths
 F—Oversize Hole	3—Length of lips not equal (Lip angles o.k.)	3—Regrind and equalize lip lengths
 G—Oversize Hole	4—Spindle of drill press loose	4—Tighten or adjust until spindle is rigid
 H—Broken Tang	1—Poor fit of tang in socket caused by nicks, burrs, dirt or wear 2—Mutilated tang	1—Ream out socket or replace with new one. Cleaning sockets before use lengthens their life 2—Dress or replace
 I—Hole Is Rough	1—Dull drill 2—Drill not properly ground 3—No lubricant or wrong lubricant 4—Feed too rapid 5—Work poorly supported	1—Grind 2—Inspect and regrind 3—Use proper lubricant 4—Reduce feed 5—Support work rigidly and free from vibration
 J—Form of Chips Tells How Work Is Progressing	1—Chip changes form 2—Lubricant not reaching proper location	1—Drill chipped, dulled or damaged—Inspect and regrind 2—Remove drill and check lubricant


⑧

the center "O" line, the readings at the points where the edges of the lips meet the gauge should be the same to insure that the cutting lips are at the same angle with respect to the center line of the drill. In the case shown, this value reads one in both cases, therefore, the drill has not only been ground to the proper total angle but it is also ground with equal cutting-lip angles. A drill which is ground so that one of the cutting lips is longer than the other will not drill accurately. Fig. 7 shows the troubles which result from improper cutting-lip angles. Other illustrations in Fig. 7 show the cause and cure for other drill difficulties.

Clearance Angle: If the gauge, Fig. 11, is rotated until its edges meet the two points of the faces back of the cutting lips, it will be found that the gauge no longer rests on the flat surfaces. Fig. 12 shows this condition clearly. The angle at this point is therefore less than 118°. The difference between 118° and this angle is the clearance angle. If a drill has no clearance, that is, the angle across the points shown in Fig. 12 is 118°, the flat areas will ride on the work without cutting. To get a better idea of the necessity for lip clearance in all cutting tools, look at Fig. 9 and the left detail in

Sizes, Feed and Speeds: The ordinary jewelers' drills, or, as they are sometimes called, steel wire-gauge drills, are numbered from 1 to 80, the No. 1 drill being the largest and No. 80 being the smallest. Letter-sized drills bear the alphabetical letters from A to Z, the A drill being the smallest and the Z drill the largest of the series. In addition to wire-gauge drills and letter drills, jobbers drills are made in sizes ranging upward in steps of 1/64 in., from 1/32 in. to several inches in diameter. To make it convenient to select the proper size of drill for any purpose, refer to Fig. 13 which includes the various size drills of each type listed in the order of increasing sizes. Although power-driven drill presses constitute the most satisfactory means of using drills, various drill stocks, both manually and electrically driven, Fig. 15, are in common use. Many exacting drilling operations are also handled in the lathe as in Fig. 8. For small drills, light-weight high-speed geared hand-drill stocks should be selected. The larger sizes of hand-drill stocks are made so that the driving wheel can be set for either one of two speed ratios, the low ratio being used for larger drills. The handle also can be adjusted to increase the leverage. Ordinary drill presses are usually equipped with 1/4-hp. motors. These are satisfactory for drilling holes up to 3/8 in. in diameter. For heavier work, larger motors should be

FIG. 13

Steel Wire and Jobbers Drills in Sizes Up to 1/4"

Wire Gauge Drills	Jobbers Drills	Decimal Size	Wire Gauge Drills	Jobbers Drills	Decimal Size
No. 80		0.0135	No. 37		.1040
No. 79		0.0145	No. 36		.1065
No. 78		0.0160		7/64"	.10938
No. 77		0.0180	No. 35		.1100
No. 76		0.0200	No. 34		.1110
No. 75		0.0210	No. 33		.1130
No. 74		.0225	No. 32		.1160
No. 73		.0240	No. 31		.1200
No. 72		.0250		1/8"	.12500
No. 71		.0260	No. 30		.1285
No. 70		.0280	No. 29		.1360
No. 69		.02925	No. 28		.1405
No. 68		.0310		9/64"	.14063
	1/32"	.03125	No. 27		.1440
No. 67		.0320	No. 26		.1470
No. 66		.0330	No. 25		.1495
No. 65		.0350	No. 24		.1520
No. 64		.0360	No. 23		.1540
No. 63		.0370		5/32"	.15625
No. 62		.0380	No. 22		.1570
No. 61		.0390	No. 21		.1590
No. 60		.0400	No. 20		.1610
No. 59		.0410	No. 19		.1660
No. 58		.0420	No. 18		.1695
No. 57		.0430		11/64"	.17188
No. 56		.0465	No. 17		.1730
	3/64"	.04688	No. 16		.1770
No. 55		.0520	No. 15		.1800
No. 54		.0550	No. 14		.1820
No. 53		.0595	No. 13		.1850
	1/16"	.06250		3/16"	.18750
No. 52		.0635	No. 12		.1890
No. 51		.0670	No. 11		.1910
No. 50		.0700	No. 10		.1935
No. 49		.0730	No. 9		.1960
No. 48		.0760	No. 8		.1990
	5/64"	.07813	No. 7		.2010
No. 47		.0785		13/64"	.20313
No. 46		.0810	No. 6		.2040
No. 45		.0820	No. 5		.2055
No. 44		.0860	No. 4		.2090
No. 43		.0890	No. 3		.2130
No. 42		.0935		7/32"	.21875
	3/32"	.09375	No. 2		.2210
No. 41		.0960	No. 1		.2280
No. 40		.0980		15/64"	.23438
No. 39		.0995		1/4"	.25000
No. 38		.1015			

Letter and Jobbers Drills, 15/64" and Larger

Letter Drills	Jobbers Drills	Decimal Size	Jobbers Drills	Decimal Size
A	15/64"	.2344	33/64"	.5156
B		.238	17/32"	.5313
C		.242	35/64"	.5469
D		.246	9/16"	.5625
E	1/4"	.2500	37/64"	.5781
F		.257	19/32"	.5938
G		.261	39/64"	.6094
H	17/64"	.2656	5/8"	.6250
I		.272	41/64"	.6406
J		.277	21/32"	.6563
K	9/32"	.2812	43/64"	.6719
L		.290	11/16"	.6875
M	19/64"	.2969	45/64"	.7031
N		.302	23/32"	.7188
O	5/16"	.3125	47/64"	.7344
P	21/64"	.3281	3/4"	.7500
Q		.332	49/64"	.7656
R	11/32"	.3437	25/32"	.7813
S		.348	51/64"	.7969
T	23/64"	.3594	13/16"	.8125
U		.368	53/64"	.8281
V	3/8"	.3750	27/32"	.8438
W	25/64"	.3906	55/64"	.8594
X		.397	7/8"	.8750
Y	13/32"	.4063	57/64"	.8906
Z		.413	29/32"	.9063
	27/64"	.4219	59/64"	.9219
	7/16"	.4375	15/16"	.9375
	29/64"	.4531	61/64"	.9531
	15/32"	.4688	31/32"	.9688
	31/64"	.4844	63/64"	.9844
	1/2"	.5000	1"	1.0000

used, as indicated in Fig. 18. Small drills must be operated at much higher speeds than larger ones. To calculate the proper speed with the various metals and in connection with both carbon steel and high-speed drills, make use of Fig. 5. This chart will be found a great shop convenience as it condenses several pages of hard-to-read figures into easily used form.

Laying Out Work for Drilling: In laying out drilling jobs, a combination square may be used for measuring angles, for locating centers, etc. A scriber and other tools are indispensable to accurate work. Having located the exact point to be drilled, it next remains to impress into it a center punch mark of sufficient depth to insure that the point of the drill will be guided properly as in Fig. 14.

Drifting a Wandering Drill: Sometimes a drill will show a stubborn tendency to wander off the punch mark when starting the hole. To correct this you first check up on the condition of the drill and see that the work is level. After eliminating these possibilities, remember that the relation between the circle described by the dead-center line of the drill and the diameter of the punch impression has a definite bearing on accurate starting of the drill. If the first circle is larger than the second the punch mark will have no wedging or "drawing" effect on the drill, thus failing to hold it on center until the lips begin to cut. The remedy is to use either a punch with a shorter bevel, Fig. 14, or spot the hole with a smaller drill before introducing the larger size. Where the work requires extreme accuracy, holes are frequently spotted with several progressive drill sizes. Another method used where dimensions are not critical is that in Fig. 16. Here the drill, starting off-center as at A, is drifted back by means of cold-chisel impressions as at B and C.

Drill Blocks: Blocks and flat sections of steel are useful around the drill press. When sections of cold-rolled steel plates about ¼ in. thick are used as pads under the work, the drill may be allowed to go through without damaging the drill-press table. Materials which tend to form a burr on the bottom are drilled clean if a plate is used under the work.

In drilling fiber, soft metal, plastics, and other materials which tend to form a burr

POWER REQUIRED FOR DRILL PRESSES

LARGEST DRILL SIZE	HORSEPOWER OF MOTOR REQUIRED
5/16 IN.	¼
3/8 IN.	¼ TO ½
½ IN.	½ TO ¾
5/8 IN.	½ TO 1
7/8 IN.	1
1⅛ IN.	1 TO 1½

18

or jagged edge as the drill cuts, it is advisable to clamp a thin piece of metal on top of the work as well as place a drill pad under it. If the work, together with the top plate and drill pad, is clamped to the bed of the press, it is possible to drill through the assembly without forming burrs on either top or bottom. Where it is not possible to drill through a top plate, a hole of the required diameter is drilled in a piece of flat metal and this is placed over the center-punched fiber. With the drill lined up with the punch mark, through the hole in the top plate, the clamps are tightened and the job completed.

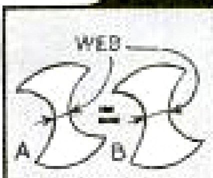
(To be continued)

The Mechanics of DRILLS

PART II

WEB THINNED BY GRINDING ON SQUARE-FACED WHEEL
⑲

Useful information for the shop on setting up work, avoiding drill breakage, drilling hard rubber and plastics and a table of tap and body-drill sizes



A—WEB OF NEW DRILL

B—WEB OF DRILL AFTER SEVERAL GRINDINGS

⑳

PILOT HOLE SAME DIAMETER AS WEB THICKNESS

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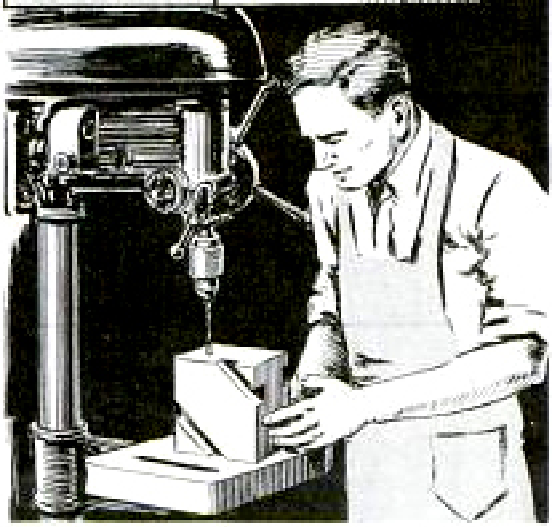
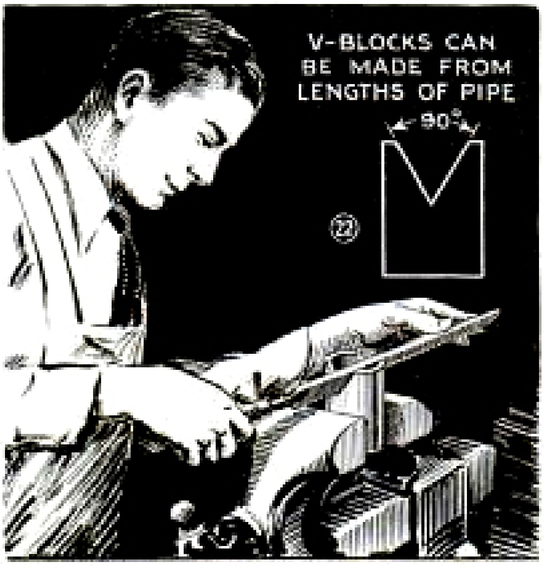
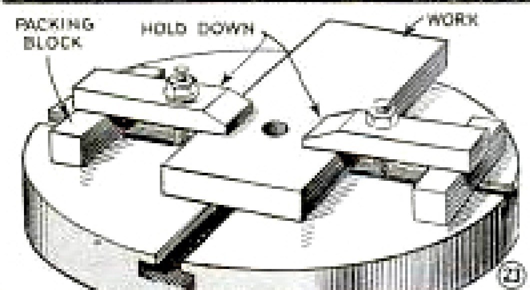


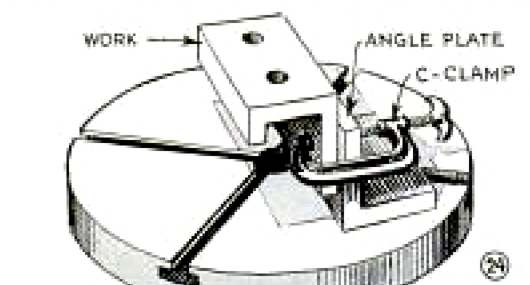
A MAJORITY of drilling operations are carried out with drills which have been ground a number of times. As the web, or central section tapers, repeated grinding causes it to grow thicker as in Fig. 19. There comes a time when the web section at the point is so thick that the drill will no longer operate properly, Fig. 20. To correct this condition the regular grinding procedure should be followed by thinning the web as in Fig. 19. The drill is applied to the wheel as shown, first on one side and then the other. The resultant thinning brings the web back to normal thickness.

Drilling Large Holes: Large drills have thick webs and therefore require considerable power. For many purposes it is more practical to drill a lead or pilot hole as shown in Fig. 21. The pilot hole should be of the same diameter as the thickness of the web. The hole should not be made larger than the thickness

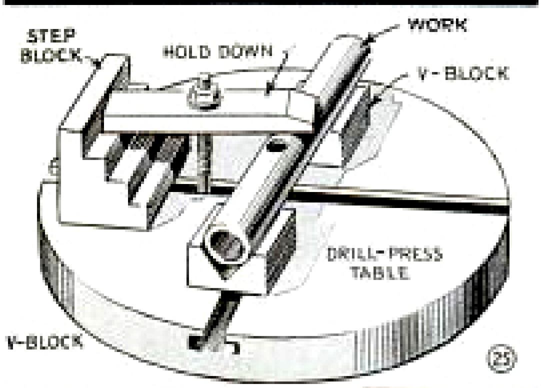




CLAMPING FLAT STOCK FOR DRILLING



IRREGULAR WORK CLAMPED TO ANGLE PLATE



ROUND WORK SET UP FOR DRILLING

of the web as this would result in chattering and possible drifting.

Drilling Deep Holes: If the depth of a hole exceeds the flute length of the drill, Fig. 28, there will be no means for the escape of chips. In this case, it is, of course, advisable to use a longer drill. If this is impossible, then the next best thing is to lift the drill every few seconds and clear the flutes and the hole of chips, continuing this precaution until the hole has been finished to the required depth.

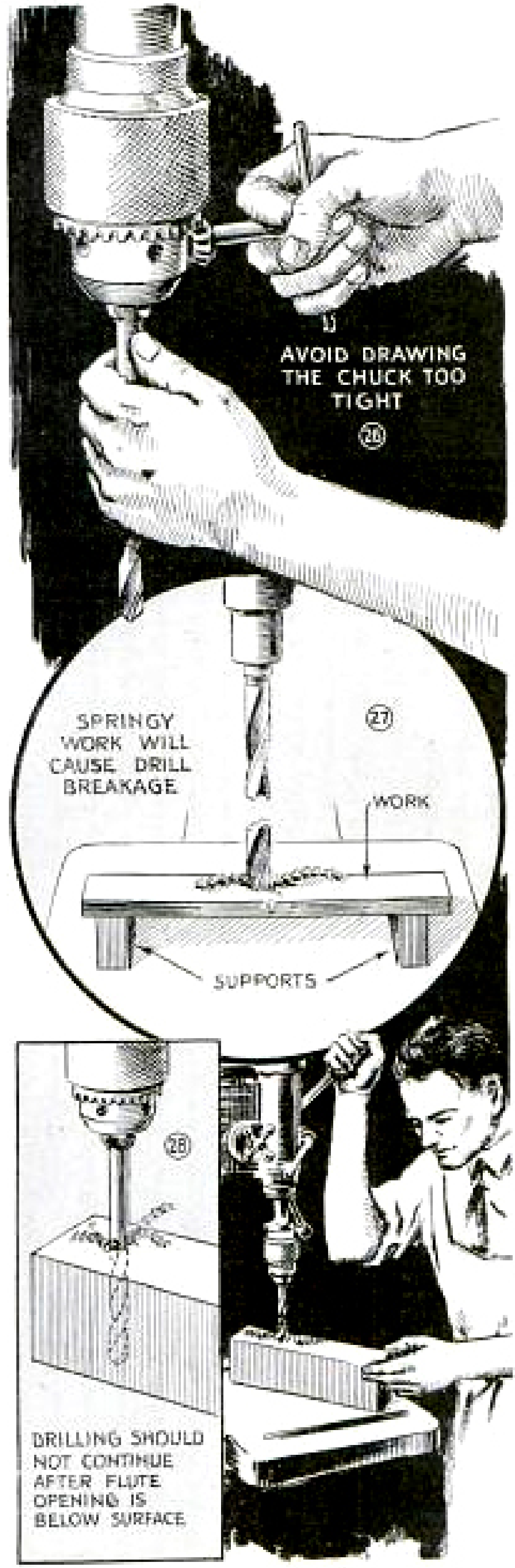
Drilling Out Threads: The enlarging of threaded holes presents a problem which can be overcome most readily by the use of left-handed drills. If an ordinary right-handed drill is used to enlarge a hole which has right-hand threads, it will be drawn into the hole more rapidly than it should, jam, and probably break the drill. Left-hand drills must be revolved in the reverse direction by crossing the belt between the motor and the drill press.

Fixtures and Accessories for Drilling: Although drills will perform fairly well even when improperly used, they can be made to do many apparently impossible jobs if a little time is spent in preparing a number of simple accessories and fixtures. The most useful items are "V" blocks. These can be purchased at little cost or can be made as needed. A form of V block is easily made from a length of pipe as in Fig. 22. The pipe is marked with a scriber and the vee cut out with a hack saw. The base and "veed" surfaces are then filed smooth and true. Fig. 23 illustrates a simple method of securing a piece of stock to the table of the drill press. The hold-down clamps are simply flat pieces of steel with the outer ends supported on packing blocks, holes being drilled through the centers to facilitate bolting down. Fig. 27 shows a common error in supporting work while drilling. Here the drill has been started at a considerable distance from the supporting blocks. Under pressure of drilling the work will spring. The result is almost invariably a broken drill bit. When drilling small holes in solid stock that rests squarely on the drill table, the work can be held safely in the hand but when drilling larger holes in irregular-shaped stock the practice is dangerous, as the drill may "bite" unexpectedly and jerk the piece out of the hands. Better to set up the job as in Figs. 24 and 25 using an angle plate or a step block, both these supporting members being bolted or clamped to the drill table. Another frequent source of trouble and sometimes breakage, is the tendency to undue tightening of a precision drill chuck, Fig. 26. Drawing the chuck unduly tight, particularly on a small drill, will eventually cause the chuck jaws to be inaccurate. Release of the drill is also difficult. Another accessory which is easily made up as needed, is the drill stop, Fig. 33. This is particularly useful when a number of holes must be drilled to the same depth with a drill press which has no scale or adjustable stop.

Drilling Holes in Round Stock: Difficulties in drilling holes through round bars and rods may be overcome easily if the method shown in Fig. 29 is used. A short length of round stock of the size which is to be drilled transversely is drilled longitudinally as in Fig. 29. This section of drilled stock may then be used as a collet to guide the drill. For this purpose it is essential that a drill-press vise be used. A drill block of width slightly less than the diameter of the round stock is placed in the bottom of the vise and on top of this the shaft to be drilled. Next, the collet is set on top of this section at the exact location where the hole is to be drilled.

Making Slots in Shafts: Another problem is that of making slots in shafting. This job is easy if a drill collet of the type just described is set up in the drill-press vise just as shown in Fig. 26. After drilling the first hole, the collet is shifted to the next position and the second, third and other holes as required are drilled. Following the drilling of the required number of holes the excess metal is removed.

Drilling Small Parts: Small parts such as machine screws, rods, etc., present drilling problems which can be handled easily by the application of a few tricks. For example, a small machine screw which must have a tiny hole drilled through it as shown at the left in Fig. 31. The only item needed for this job is a bar of steel dressed true and square. First, lay out scriber marks and center punch for drilling a hole of exactly the size which is to be drilled through the screw. Next, you consult the table of tap-drill sizes, Fig. 30,



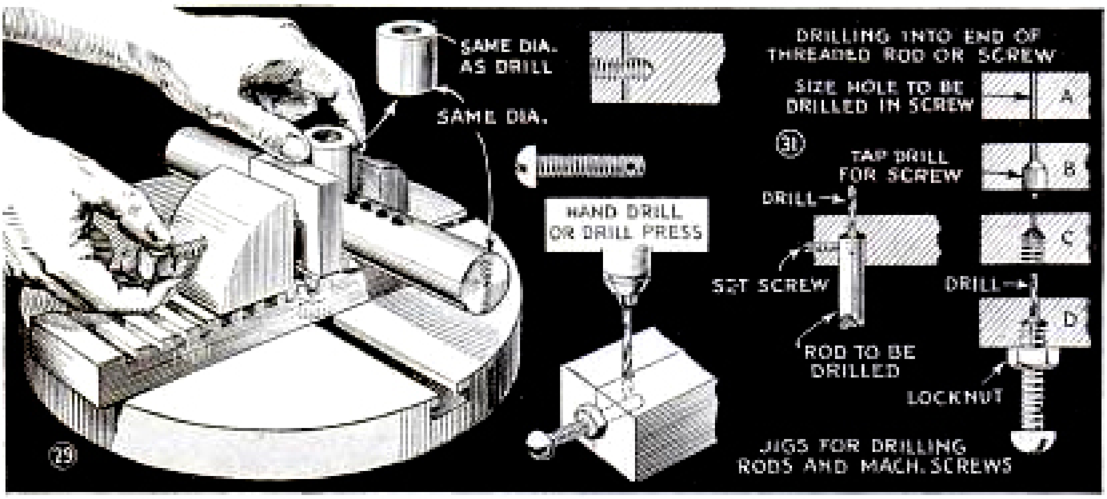
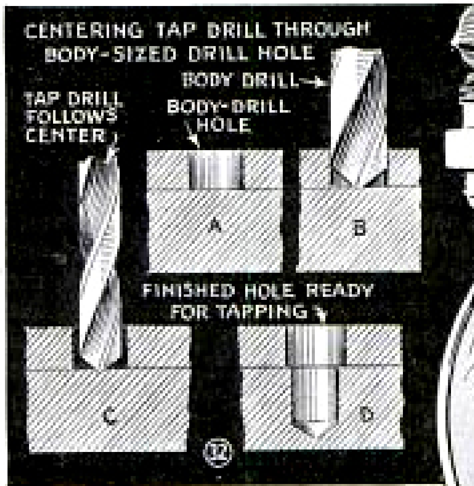


FIG. 30—TAP AND BODY DRILL SIZES FOR MACHINE SCREWS INCLUDING NUMBER SIZES, A.S.M.E., U.S.S. AND S.A.E. STANDARD SCREWS

Body Drill Size	Screw Number or Size	Threads per Inch and (Tap Drill Sizes) (Number in parenthesis is tap drill size for preceding number of threads per inch)
No. 52	0	80 (56)
No. 49	1	56 (54), 64 (53), 72 (53)
No. 44	2	48 (52), 56 (51), 64 (50)
No. 39	3	40 (49), 48 (48), 56 (45)
No. 33	4	32 (45), 36 (45), 40 (44), 48 (42)
No. 30 or ⅛"	5	30 (42), 32 (42), 36 (40), 40 (39), 44 (37)
No. 28	6	30 (38), 32 (36), 36 (34), 40 (33)
No. 24	7	28 (32), 30 (31), 32 (31), 36 (31 or ⅛")
No. 19	8	24 (31 or ⅛"), 30 (30), 32 (29), 36 (29)
No. 16	9	24 (29), 28 (27), 30 (27), 32 (26)
No. 11	10	24 (25), 30 (21), 32 (20)
No. 6	11	24 (19), 28 (18), 30 (16)
7/32"	12	20 (18), 22 (17), 24 (16), 28 (14)
15/64"	13	20 (14), 22 (13), 24 (11)
D	14	18 (12), 20 (9), 22 (7), 24 (6)
F	15	18 (6), 20 (4), 22 (3), 24 (3)
I	16	16 (3), 18 (3), 20 (2), 22 (1)
L	17	16 (2), 18 (1), 20 (15/64")
19/64"	18	16 (15/64"), 18 (C), 20 (D)
5/16"	19	16 (¼"), 18 (F), 20 (G)
P	20	16 (17/64"), 18 (17/64"), 20 (I)
S	22	16 (L), 18 (19/64")
3/8"	24	14 (N), 16 (5/16"), 18 (P)
13/32"	26	14 (Q), 16 (11/32")
7/16"	28	14 (23/64"), 16 (U)
29/64"	30	14 (W), 16 (X)
1/16"	1/16"	64 (3/64"), 72 (3/64")
5/64"	5/64"	60 (1/16"), 72 (52)
3/32"	3/32"	48 (49), 50 (49)
7/64"	7/64"	48 (43)
1/8"	1/8"	32 (3/32"), 40 (38)
9/64"	9/64"	40 (32)
5/32"	5/32"	32 (⅛"), 36 (30)
11/64"	11/64"	32 (9/64")
3/16"	3/16"	24 (26), 32 (22)
13/64"	13/64"	24 (20)
7/32"	7/32"	24 (16), 32 (12)
15/64"	15/64"	24 (10)
1/4"	1/4"	20 (8), 24 (4), 27 (3), 28 (1), 32 (7/32")
5/16"	5/16"	18 (G), 20 (17/64"), 24 (I), 27 (J), 32 (9/32")
3/8"	3/8"	16 (5/16"), 20 (21/64"), 24 (Q), 27 (R)
7/16"	7/16"	14 (U), 20 (25/64"), 24 (X), 27 (Y)
1/2"	1/2"	12 (27/64"), 13 (27/64"), 20 (29/64"), 24 (29/64")
9/16"	9/16"	12 (31/64"), 18 (½")
5/8"	5/8"	11 (17/32"), 18 (9/16")
11/16"	11/16"	16 (⅝")
3/4"	3/4"	10 (21/32"), 16 (11/16")
7/8"	7/8"	9 (49/64"), 14 (13/16")
1"	1"	8 (⅞"), 14 (15/16")

and drill another hole at right angles which can be tapped to a depth sufficient to allow the screw to be inserted far enough to properly locate the transverse hole. Having tapped the hole, the screw is run in over a nut which can be used to lock it in place. Then you drill through the screw, the first hole acting as a guide. This fixture can be used repeatedly. Details at the right in Fig. 31 show another easy method of solving a common problem. In this case it is required to drill a hole into the end of a machine screw or tapped rod. When it is necessary to drill the hole into the end of an unthreaded rod a set screw is provided in the working plate. Holes which are to be threaded should be drilled undersized so that the tap will cut a thread deep enough to hold securely. Although the table presented in Fig. 30 is rather more complete than usual, it is handy to have a rule which can be applied for finding tap-drill sizes for odd screws. The simplest method of doing this is to first divide the number of threads per inch on the screw into .9 and subtract the quotient from the body size of the screw. To illustrate the method, suppose you have a ⅝-in. screw which



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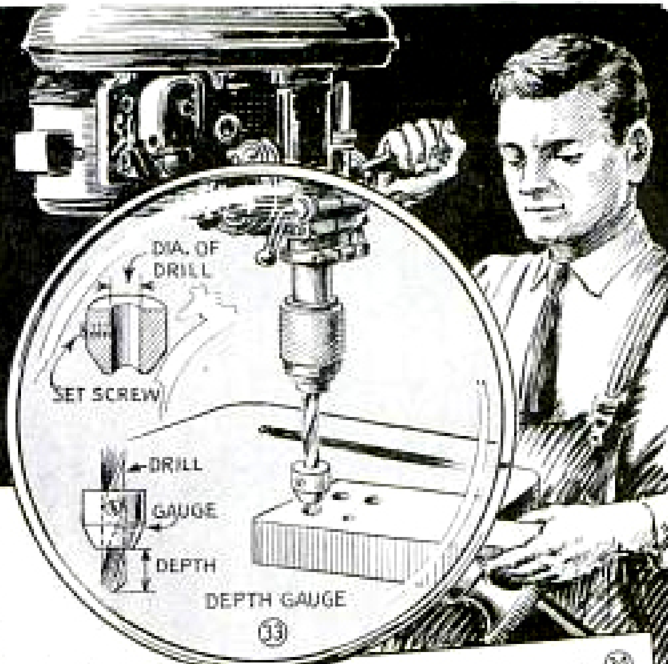

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has 14 threads per inch. Dividing .9 by 14 you get .064. Subtracting this from ⅜ in. which in decimal numbers is .375, leaves .311, the tap-drill size. Next you consult a drill-size table such as was included in Part I of this series of articles and find that the nearest drill less than this diameter is 19/64 in. The "N"-sized drill is also close enough so we may use either of these which is at hand. In the case of screws over ¼ in. in diameter, select the nearest smaller size of tap drill as figured above. For screws smaller than ¼ in., the nearest drill larger than the required size is selected. Centering a tap drill through a larger-sized body drill hole is a job which frequently causes difficulties. A simple method of accomplishing this is illustrated in Fig. 32. First a drill of the same size as the large hole is inserted to locate the center. After this the smaller tap drill will easily follow the start made by the larger drill. Countersinks and counterbores are so much used in connection with drilling operations that Fig. 35 has been included to make clear their application in this work.

Drilling Hard Rubber and Plastics: If standard high-speed drills are used those smaller than ¼ in. should be ground to an angle of 45° rather than the standard 59° angle. Drills larger than ¼ in. should be ground as usual. Fig. 34 contains the values of speeds and feeds which have been found satisfactory for drilling these types of material. The drill should be backed out frequently to insure the removal of chips and prevent overheating.

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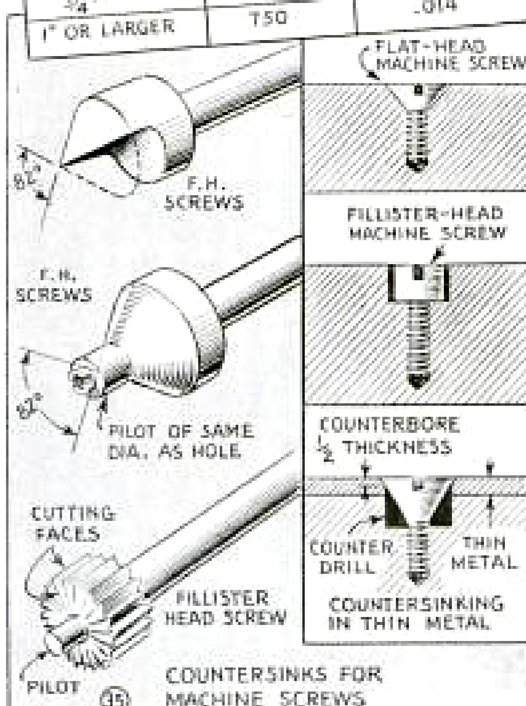
SPEEDS AND FEEDS FOR DRILLING RUBBER AND PLASTIC MATERIALS

SIZE OF DRILL (DIAMETER)	SPEED (R.P.M.)	FEED IN INCHES PER REV. OF DRILL
3/16" AND SMALLER	4000	.005
¼"	3000	.006
⅜"	2000	.008
½"	1550	.010
⅝"	1200	.011
¾"	1000	.012
1" OR LARGER	750	.014



35 COUNTERSINKS FOR MACHINE SCREWS