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HAND BOOK

for Drillers

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HANDBOOK
for
DRILLERS

NINTH EDITION
PRICE 25 CENTS

Published by
The Cleveland Twist Drill Co.
Cleveland
New York **Chicago**

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Introduction

THIS little volume is designed for students of drilling. It is not intended as a complete treatise on the subject, but rather as an introduction to the theory underlying the use of the twist drill.

The subject matter has also been covered in an interesting manner by an educational four-reel motion picture entitled, "*The Uses and Abuses of Twist Drills.*" This film contains no advertising but limits itself to a strict interpretation of the title.

We are always glad to furnish this film to responsible parties. A portable projector operating from any lamp socket is also furnished, where desired.

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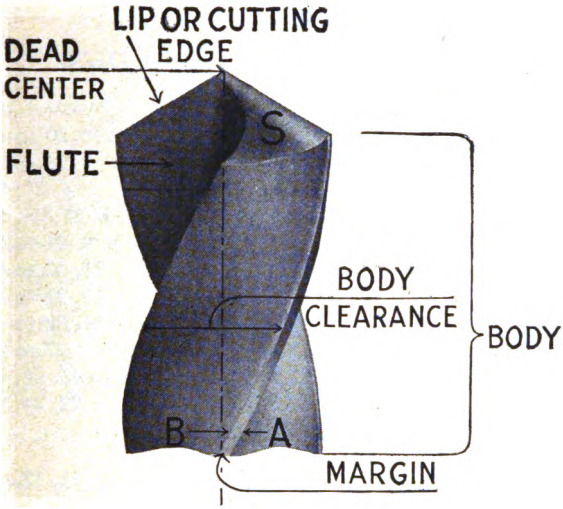
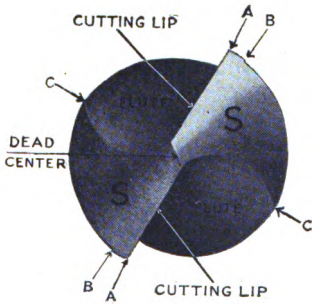


Fig. 1
The Parts of a Twist Drill



The Point

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Parts of and Grinding of a Twist Drill

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HANDBOOK *for* DRILLERS

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CHAPTER I

The Parts of a Twist Drill

(See Chart on Page 3)

1 The twist drill is a special cutting tool — generally formed by milling a cylindrical piece of tool steel, or by forging and twisting grooves in a flat strip of tool steel.

2 A twist drill may be divided into three principal parts — the "Point," the "Body" and the "Shank." The cone-shaped surface at one end is called the "*Point.*"

3 Two spiral grooves run along opposite sides of the drill.

These grooves are known as *Flutes.* They are so shaped as to do four things:

(*a*) They help form the proper cutting edges on the cone-shaped "Point."

(*b*) At their junction with the cutting edges they are so shaped as to curl the chip tightly within itself — so that it occupies minimum space.

(*c*) The flutes also form channels through which the chips escape from the hole —

(*d*) And allow the lubricant to get down to the cutting edges.

4 *The Dead Center* is the sharp edge at the extreme tip end of the drill. It is formed by the intersection of the cone-shaped surfaces of the "Point." It should always be in the exact center of the axis of the drill. (Fig. 1).

5 *The "Point"* of the drill should not be confused with the "Dead Center." The "Point," as we use the word in this little volume, is the *entire cone-shaped* surface at the cutting end of the drill. (Fig. 1.)

6 *The Heel* is the portion of the "Point" back of the "Lips" or Cutting Edges.

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7 *The Lips* (sometimes called "Cutting Lips") are the cutting edges of the drill. They are formed by the intersection of the flutes and the cone-shaped "Point." (See Fig. 1.)

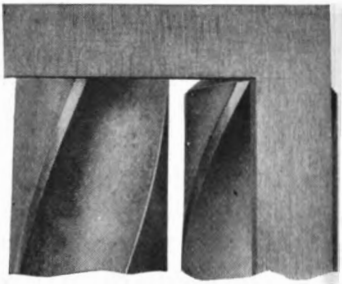

Fig. 2 — Lip Clearanco

The drill on the left has no "lip clearance." The one on the right is properly cleared. See paragraphs 8, 9, 10 and 21 to 31.

8 Of course a real *cutting* edge would not be formed at this intersection, if the surface of the "Point" were at only a 90 degree angle to the plane of rotation (Fig. 2). Under such a condition the "edge" would be merely a square "corner"— too blunt to penetrate.

9 Therefore, in order to give a real *cutting* edge to the Lips, the surface of the "Point" is ground away or "relieved"— just back of the Lips — (See Fig. 2). This relief is called *Lip Clearance.*

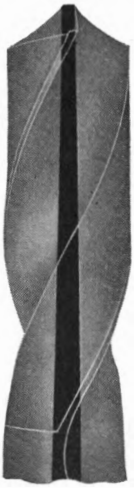

Fig. 3
The Web

The Web is the metal column which separates the flutes.

10 *Lip Clearance* is the shape of the "Point" in relation to the lip. It is one of the most vital subjects discussed in this booklet. Improper grinding of the Lip Clearance is a frequent cause of disaster.

11 *The Margin.* The narrow strip between "A" and "B" (Fig. 1) is called the *Margin.* It is practically the full diameter of the drill and extends the entire length of the flute. Its surface is part of a cylinder which is interrupted by the flutes and by what is known as *Body Clearance.*

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12 *Body Clearance.* From "B" to "C" (Fig. 1) is of less diameter than the Margin. This lessened diameter (called *Body Clearance*) reduces the friction between the drill and the walls of the hole, while the Margin between "A" and "B" (which is a full diameter) insures the hole being of accurate size.

13 If it did not have this "Body Clearance" between "B" and "C," more power would be required to overcome the friction between the drill and the wall of the hole. The friction thus generated might be sufficient to draw the temper of the drill itself.

14 *The Web* is the metal column which separates the flutes. It runs the entire length of the drill between the flutes. (Fig. 3.) This Web is the supporting section of the drill — the drill's "backbone," in fact. It gradually increases in thickness toward the shank. (Fig. 4.) This thickening of the Web gives additional rigidity to the drill.

15 Were the two spiral sections of the drill not tied together by the Web, under pressure they would compress like a spring, and if we were to try to drill with these sections, the twisting strain of the drilling would tend to lengthen the drill by actually *untwisting* the flutes. The Web overcomes both these tendencies.

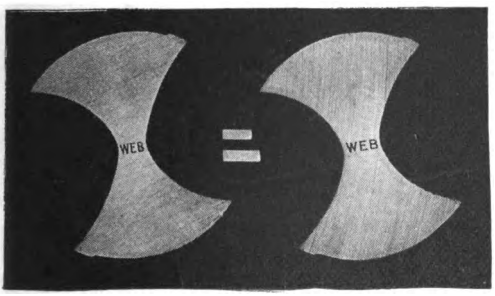

Fig. 4
Sectional View of Web

The section on the left was cut from a drill near the *point* while the section on the right was cut near the *shank*. The difference in the thickness of the web at these two points is shown by the length of the white lines between the two sections in the illustration.

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16 The thickening of the Web as it nears the shank naturally decreases the area of the flutes. Unless compensated for in some manner, it would seriously handicap the chips in their escape from a deep hole.

17 Therefore, to offset the thickening of the web, the flutes *widen* as they approach the shank. Thus the sectional area of the flutes remains substantially the same throughout their length.

18 *The Shank* is the end of the drill which fits into the socket or spindle or chuck of the drill press. There are a number of types of shank, the most common of which are illustrated in Fig. 5.

19 *The Tang* is usually found only on taper shank tools (Fig. 5). It is the portion of the tool which fits into a slot in the socket or spindle. It may bear a portion of the driving strain, although its principal use is to make it easy to remove the drill from the socket — called "Drifting." (See Par. 96 and Fig. 25).

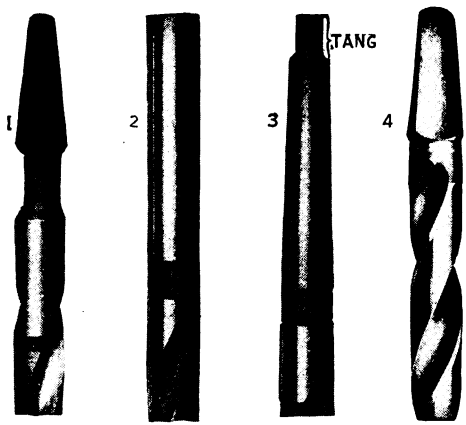

Fig. 5 — Four Popular Shanks

1. The bit stock shank. 2. The straight shank. 3. The taper shank. (Note the "tang.") 4. The rachet shank.

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CHAPTER II

Points on Grinding

20 Fully 95 per cent of the difficulties encountered in drilling arise from a faulty grinding either of the "Point" or the "Lip Clearance."

21 In grinding a drill, three things must be considered:

(*a*) Lip *Clearance*.

(*b*) The *Length* and *Angle* of the Lips.

(*c*) The Location of the "Point" and "Dead Center" in Relation to the Axis or Center of the Drill.

"LIP CLEARANCE"—ITS HOW AND WHY

22 Lip Clearance is most generally misunderstood. Lip Clearance is the "relief" which is given the cutting edges in order to allow them to enter the metal without interference.

23 To make clear just exactly what Lip Clearance *is* and what it *does*, let's look at a drill without *any* Lip Clearance. (Fig. 6.) Imagine this drill trying to cut into a piece of steel. It would be impossible—because the surface "S" would always be in contact with the metal and would effectively prevent the cutting edge from biting further into the metal. Such a drill would merely *rub*—around and around—without penetrating.

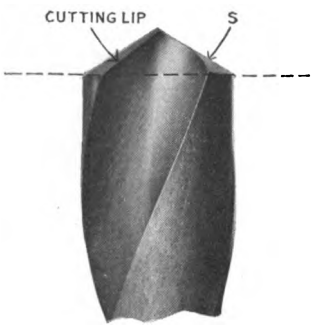

Fig. 6
Showing a drill point without any clearance. Note that both the cutting lip and the heel "S" are in the same plane.

24 Therefore, if the Lip is to penetrate, if its edge is to *cut*, we must grind away the surface "S" back

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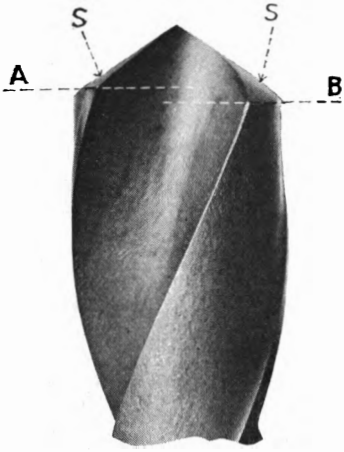

Fig. 7
Proper Lip Clearance
Note how much lower the heel line "B" is than the cutting lip line "A." This difference is the measure of the clearance.

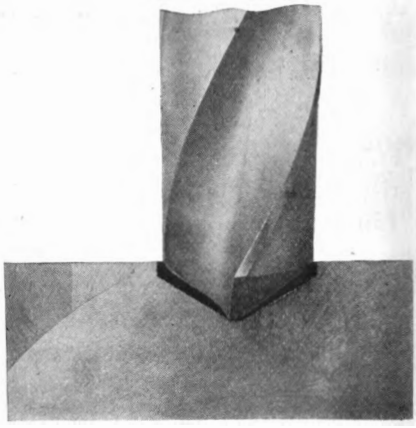

Fig. 8
The cutting lip has already removed considerable metal ahead of the Heel as indicated by the black portions of the hole on each side of the drill.

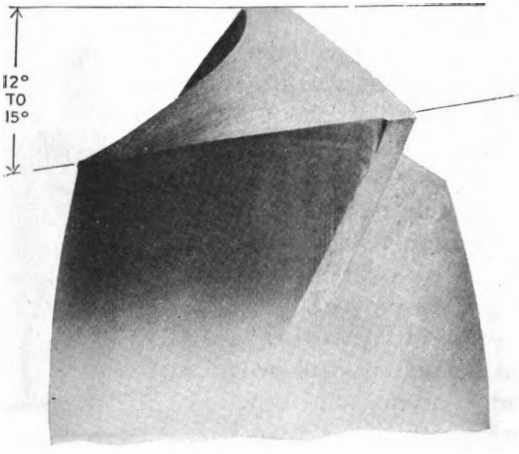

Fig. 9
Showing the proper way to grind the surface back of the cutting lip. The angle indicated is the angle *at the circumference of the drill.* This angle should be *increased*, however, as the center of the drill is approached.

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of the lips (this grinding away is called giving a drill "relief") so that the lip can penetrate the metal. (Figs. 2, 7 and 8.)

25 A somewhat similar purpose is served by the bevel or "relief" or Lip Clearance which is given a carpenter's plane. (Fig. 8A.)

26 This Lip Clearance is very important. In fact the effectiveness and life of a drill depend to a large degree on the correct forming of this Clearance. Bear in mind that it is not merely ground on the *circumference* of the drill but is applied to the *whole surface* of the point "S" (Fig. 1) back of the Lip. (See Par. 8 to 10.)

ANGLE OF LIP CLEARANCE

27 *The Heel* (the surface of the point back of the cutting lip) should be ground away from the cutting lip at an angle of about twelve or fifteen degrees — as in Fig. 9. In all cases, this angle of twelve to fifteen degrees is the angle *at the circumference of the drill.*

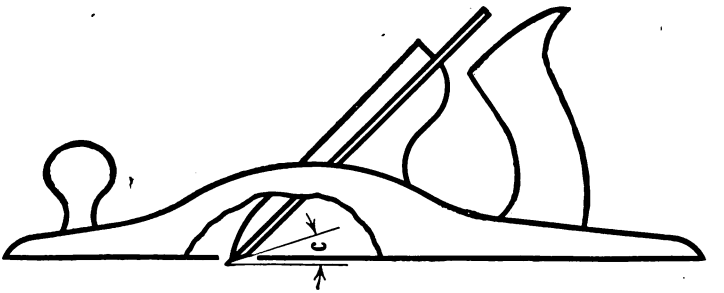

Fig. 8A

Showing the bevel or relief or lip clearance which is given a carpenter's plane — "C" being the clearance angle. Practically the same purpose is accomplished by the lip clearance given a drill — it permits the cutting edge to penetrate.

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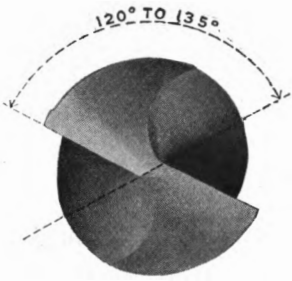

Fig. 10
Showing one way to gauge the correctness of your lip clearance angle.

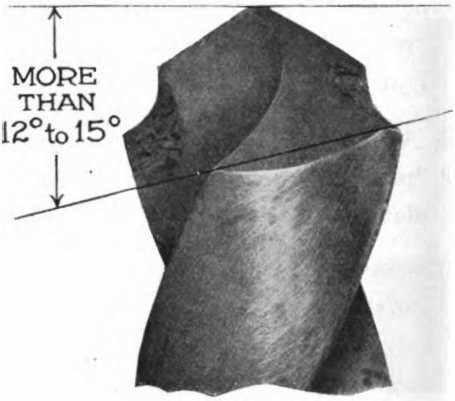

Fig. 11
Showing results of giving a drill too *great* lip clearance — the edges of the cutting lips have broken down because of insufficient support.

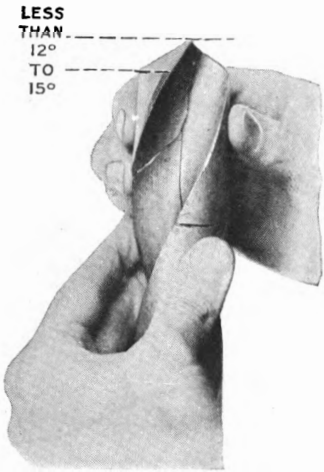

Fig. 12
Here the drill was given insufficient lip clearance. As a result there ceased to be any cutting edges whatsoever and, as the feed pressure was applied, the drill could not enter the work as a result it "splits up the center."

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28 *This angle of lip clearance should be gradually increased, however, as the center of the drill is approached* — until the line across the dead center of the drill stands at an angle with the cutting edges of not less than 120 degrees, or it may be as much as 135 degrees — as in Fig. 10.

29 For heavy feeds in soft material, the angle of lip clearance may be safely increased to the full fifteen degrees. Care should be taken, however, to see that the angle at the *center* of the drill — near the tip — is increased proportionally.

RESULTS OF FAULTY ANGLE OF LIP CLEARANCE

30 If the angle of lip clearance is too great, the edges of the cutting lips will break down (as in Fig. 11) when the drill starts to work, because they will not have sufficient backing to support them—just as a razor edge breaks down if used for cutting tin, because it is too thin and lacks sufficient support to withstand the strain.

31 If *insufficient* surface is ground away, in other words, if the angle is made *less* than twelve degrees, the clearance of the point is so reduced that it ceases to be a cutting edge and refuses to bite into the metal—as in Figs. 2 and 6. This condition may result in splitting the drill up the center. (Fig. 12.)

THE LIPS AND THEIR REQUIREMENTS

32 After we have properly ground the "Point"— so that the angle of lip clearance is correct — our work is only half done. We must next cross-check our point grinding and assure ourselves that:—

(*a*) The two lips are the same length — (Fig. 13).
(*b*) The angles of both lips (in relation to the axis of the drill) are equal and correct — 59 degrees is recommended as the best angle for ordinary purposes. (Fig. 13.)

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33 If the lips are at the same *angle* to the axis and if they are of equal *length*, the third requirement of good grinding (Par. 21) namely, the *central location of the "Point" and "dead center,"* will be fulfilled.

RESULTS OF FAULTY LIP ANGLES

34 If the angle of the cutting edges is *more* than 59 degrees as in Fig. 14, the drill will not center properly, because the cone-shaped "Point," which should hold it in position, will be too nearly flat to perform this work.

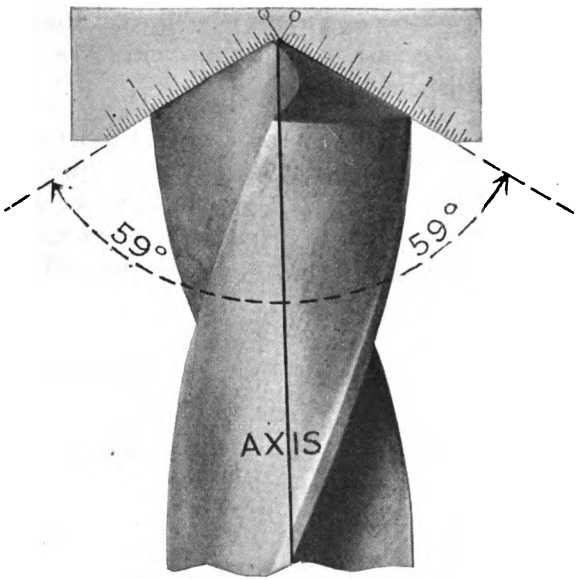

Fig. 13 — Correctly Ground Lips
The two lips of this drill are of the same length and of the same angle to the axis of the drill.

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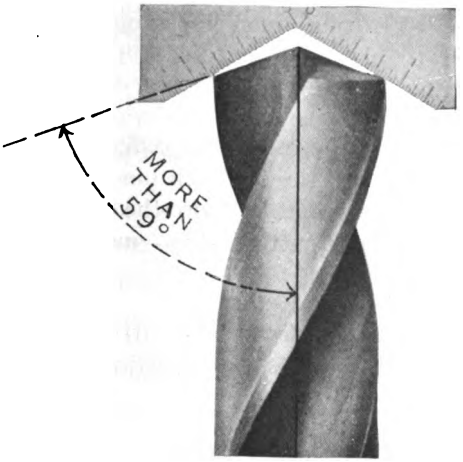

Fig. 14 — Incorrectly Ground Lips
In this case the angle of the lips with the axis of the drill is considerably *more* than 59 degrees. As a result the drill will fail to "center" in the work.

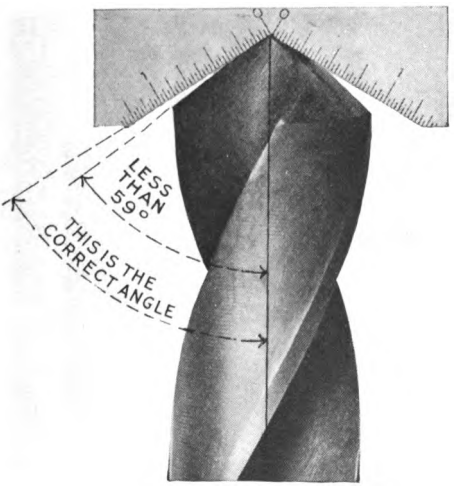

Fig. 15 — Incorrectly Ground Lips
Here the angle of the lips with the axis of the drill is *less* than 59 degrees.

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35 If the angle of the cutting edges is *less* than 59 degrees as in Fig. 15, the tool drills much less rapidly and more power is required to drive it, because of the additional length of the cutting edges.

36 If we get the "Point" in the center but different *angles* on the cutting edges (Fig. 16), the drill will bind on one side. Only one lip or cutting edge will do the work — with resultant rapid wear on this cutting edge—and the hole will be larger than the drill.

37 Or suppose we get equal *angles* on the cutting edges but, on measuring, we find the *lips* are of *different lengths* —

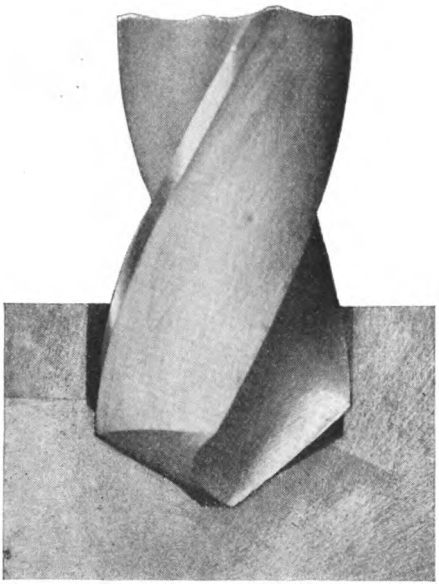

Fig. 16 — Incorrectly Ground Lips
In this case the angle of the two lips are different. As a result the cutting edge on your left is doing most of the work while the one on the right is removing only a small portion of metal. Note that the hole is *larger than the drill.*

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as a result both the "Point" and lip will, of necessity, be off center. The result will be a hole actually *larger than the drill.* (Fig. 17.) The effect of this condition is the same as though you put the axle of a wheel any place but in the exact center of the wheel.

38 The resultant strain on the press is tremendous and causes "weaving" or wobbling of the spindle, rapid wearing away of the drill and breakdowns resulting from strains on spindle bearings, etc.

39 Where we combine both of the above faults — unequal angles and lips of different lengths — we have the very

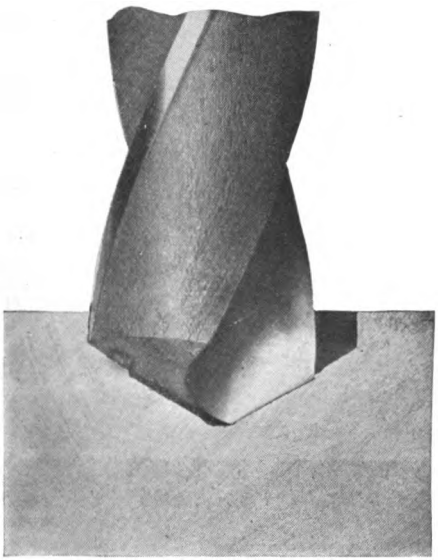

Fig. 17 — Incorrectly Ground Lips
Here the *angles* of the lips are equal but their *lengths* are different. Here again the hole is much larger than the drill and the punishment to the tool is terrific.

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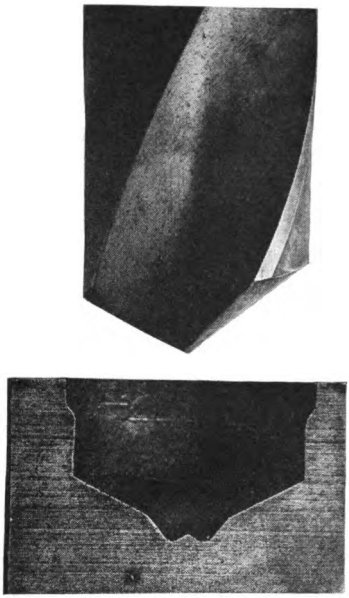

Fig. 18 — Incorrectly Ground Lips
Here the angles of the lips are unequal and the lips are of different lengths. Note the effect on the hole.

peak of abuse. Under these conditions, the hole is larger than the drill and the strain on both the drill and press is terrific. (Fig. 18.)

40 Particular attention is called to Figs. 16, 17 and 18, showing the results of unequal angles of cutting lips and unequal length of cutting lips. Notice how much larger the hole is than the drill. Also notice where the lips are of unequal length (Fig. 17), that the short lip cuts the smaller hole while the long lip cuts the larger hole. Notice also how far from the true center the tip and point of the drill are located in Fig. 16, 17 and 18. This causes a strain which results in a "Side Play" in the drill press spindle.

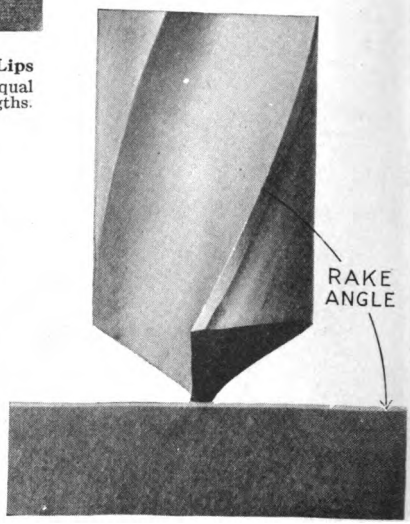

Fig. 19 — The Rake Angle
The "rake angle" is the angle of the flute in relation to the work.

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41 *Rake Angle* — Another part of the drill which performs an important function is the "Rake Angle." This is the *angle of the flute in relation to the work* — as in Fig. 19.

42 If the "Rake Angle" were 90 degrees or more, it would not make a good cutting edge. If it is ground with too *small* an angle, however, it makes the cutting edge so thin that it breaks down under the strain of the work.

43 In addition, the "Rake Angle" also partially governs the *tightness* with which the chips curl (within themselves), and hence the amount of space which the chips occupy. Other conditions being the same, a very great "Rake Angle" makes for a tightly rolled chip while a rather small "Rake Angle" gives the chip a tendency to curl into a more loosely rolled spiral.

44 The "Rake Angle" should not be altered except under special conditions — see Par. 68. For ordinary drilling the "Rake Angle" established by the manufacturer of the drill is correct and should remain untouched.

45 Fig. 19A shows "Rake Angle" on a carpenter's plane and on a lathe tool.

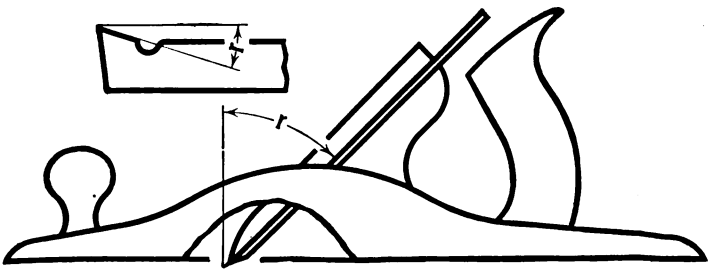

Fig. 19A

This shows rake angle ("r" in the illustration) on a carpenter's plane and on a lathe tool. The similarity with the rake angle of the drill in Fig. 19 is clearly seen.

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CHAPTER III

Drill Speeds and Feeds

46 When we refer to the "Speed" of a drill, we mean the speed at the *circumference* — called the "peripheral speed." "Speed" refers to the distance the drill would travel, if for example, it were laid on its side and rolled. Thus a drill with a peripheral speed of 30 feet a minute would *roll* 30 feet a minute. "Speed" as generally used does *not* refer to "rotation per minute" unless specifically stated.

47 *Feed.* Except under certain rather rare conditions, a drill does not pull itself into the work like a corkscrew — it requires constant pressure or "feed" behind it to advance it. This advance (measured in fractions of an inch per revolution) is called "Feed." Feed *Pressure*, however, is the *pressure* required to maintain the "feed."

48 The feed is operated either by hand or power — to force the drill into the work.

49 Opinions differ regarding the correct speed and feed. Therefore, we must come to the conclusion that no hard and fast rule can be given. The following suggestions should be considered merely as guides.

50 Under any given condition, the correct feed and speed can only be determined by good sound judgment in each particular case.

STARTING SPEEDS AND FEEDS

51 In starting a drill, bring it down to the work by hand feed until it centers itself in the work. *Then* throw in your power feed.

52 It is a safe rule to start drills made of carbon steel with a peripheral speed of 30 feet per minute — if they are working in soft tool or machinery steel. This should be increased

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to 35 feet per minute for cast iron and 60 feet per minute for brass.

53 The starting *feed* should vary from .004 to .007 of an inch per rotation for drills ½ inch and smaller in diameter; for drills larger than ½ inch .005 to .015 inch per rotation.

54 At these speeds and feeds, a good cutting compound is recommended. See Par. 79 to 85.

SPEED AND FEED FOR HIGH SPEED DRILL

55 In the case of high speed drills, the above *feeds* should remain unchanged — the *speeds*, however, should be increased from 2 to 2½ times.

56 We suggest that you start the drill with a moderate speed and feed, increasing either one — or both — after observing the condition of the drill. That your observations may be intelligent and your adjustment of speed and feed based on the requirements, carefully observe the following suggestions:

INDICATION OF TOO MUCH FEED

57 If the drill *chips out* at the cutting edge, it is a sure indication of too heavy a feed or too much lip clearance. (See Par. 22 to 40.)

58 A drill which *splits* up the web (Fig. 12) is also evidence of too much feed for the amount of lip clearance. Decrease the feed or increase the lip clearance — or both. (See Par. 31).

59 The failure to give sufficient lip clearance at the *center* of a drill will cause it to split up the web.

60 On the other hand, *too much* lip clearance at the center (or at any other point on the lip) causes the cutting lips to chip.

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61 Therefore, before blaming the feed, it would be well to make sure that the drill is properly ground. If it is properly ground, decrease your feed.

INDICATIONS OF TOO MUCH SPEED

62 When the extreme outer corners of the cutting edges wear away too rapidly (Fig. 20), it is evidence of too much speed. (See Par. 52.)

63 High speeds in cast iron tend to wear away the margin of the drill; 35 feet per minute peripheral speed is the maximum we would suggest for carbon drills in cast iron. The feed may be from .007 to .015 inches per rotation, according to the hardness of the metal being drilled.

GENERAL RECOMMENDATIONS

64 In general, a high speed and light feed is recommended. It is better to err on the side of too much *speed* than to err on the side of too much *feed* (except for cast iron where the nature of the material may permit an unusually heavy feed).

65 The speed can be increased to the point where the outside corners commence to show signs of wearing away (Par. 62). It can then be slightly reduced and maintained at this reduced figure.

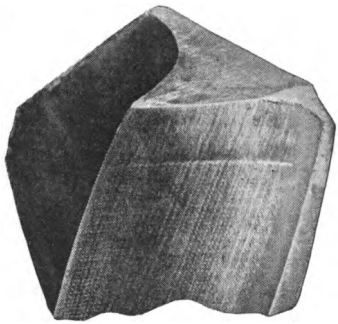

Fig. 20
The Indication of Too Great Speed
The outer corners of the drill have worn away rapidly because excessive speed has drawn the temper.

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CHAPTER IV

Miscellaneous Helps

DRILLING HARD MATERIAL

66 Very often, even after you have ground the drill properly and increased the speed to the extreme limit, the drill still fails to penetrate.

67 This is usually caused by a *hard spot* in the material itself. It can be remedied — or at least materially helped — by liberal application of turpentine directly to the work.

68 The drill may be assisted in almost any hard material by the use of turpentine or kerosene. Another method is to reduce the entering angle of the lips or the "Rake Angle" as it is sometimes called (See Par. 41 to 45), as in Fig. 21, so as to permit the use of a heavy feed pressure. If a heavy feed pressure were used without first grinding the sharp angles off the lip (called "Raking") as in Fig. 21, the drill would chip severely on the lips.

69 This removal of the sharp angle of the lips, however, must be done with extreme care and judgment, or the drill will have to be re-ground throughout.

70 Variations in the hardness of the material drilled can only be met by the skill of the operator and his adjustments of the combination of speeds and feeds.

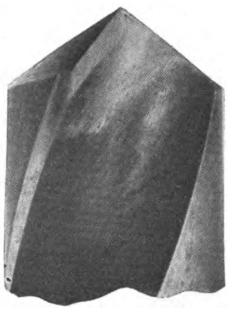

Fig. 21
Special grinding for hard material. See Paragraph 68.

71 The commercial twist drill is tempered for average conditions — to give good

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results in a wide variety of hard and soft material. Sometimes specially tempered drills are used on unusually hard material, but such special drills must be made to order. Their use can usually be avoided by a skilled manipulation of the speed, feed and lubricant.

72 "The harder the metal the lighter the feed and slower the speed" is a rough and ready sort of rule.

SMALL HOLE DRILLING

73 In drilling holes of small diameter, unless the feed and speed are given unusual careful attention, the danger of breakage is very great — especially at the moment the point of the drill *breaks through* the other side of the work.

74 Particularly is this moment dangerous when the hand feed is used, because, when you are using the hand feed, it is difficult to regulate the pressure you apply to the feed lever with any degree of exactness.

75 In some shops, specializing in the manufacture of wool combs and similar products, thousands of holes as small as .013 inch in diameter are drilled daily through brass plates $\frac{7}{16}''$ thick. This work is accomplished without difficulty by carefully grinding the drills, honing them on a whetstone and running at 20,000 revolutions per minute. This speed is increased up to 30,000 revolutions per minute when the holes are as small as .013″. Outside of this particular industry, *it is rare to run across a small drilling machine running at better than one-quarter of its proper speed.*

76 Therefore, let us urge you, when drilling with small drills, to lean rather toward too much speed than toward not enough — and keep the feed light.

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DRILLING BRASS

77 Owing to the nature of brass, a heavier feed than for the harder materials may be used, especially in automatic machines, in order to insure the chips having sufficient body to follow the flutes out of the hole. For brass work, if any lubricant is used, paraffine oil is suggested.

78 The form of point described in Paragraphs 90 to 92, will also be found efficient in drilling soft material such as brass — where the normal point has a tendency to "hog in" or "grab."

CUTTING COMPOUND FOR VARIOUS METALS

79 To maintain the speeds and feeds recommended it will be found necessary to use some good cutting compound, and we recommend the following in the order named.

80 For hard and refractory steel — turpentine, kerosene, soda-water.

81 For soft steel and wrought iron — lard oil, soda-water.

82 For malleable iron — soda-water.

83 For brass — a flood of paraffine oil, if any.

84 For aluminum and soft alloys — kerosene, soda-water.

85 Cast iron — should be worked dry or with a jet of compressed air for a cooling medium.

DRILLING WITH AUTOMATIC MACHINES UNDER FLOOD OF LUBRICANT

86 For automatic machines where holes do not exceed two drill-diameters in depth, and under a flood of cutting lubricant, high speeds and light feeds are especially recommended.

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WHEN THE CHIPS CLOG IN THE HOLE

87 When holes are deeper than two drill-diameters, it is sometimes difficult to get rid of the chips. A point like Fig. 21 is especially efficient under these conditions — with slower speed and heavier feed as the bottom of the hole is approached.

HINT FOR AUTOMATIC DRILLING

88 Always endeavor in automatic drilling to get a small, compactly rolled chip (Fig. 22) and if possible keep it unbroken the entire depth of the hole as such a chip feeds out through the flutes most easily.

ROUGH HOLE

89 Where the drill seems to be drilling fairly well yet the surface of the hole is rough, it is an indication that the drill is dull and should be re-sharpened. (Fig. 23.)

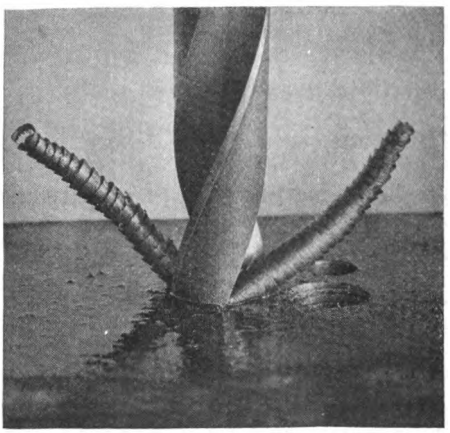

Fig. 22 — The Properly Rolled Chip
Note how compactly these chips fit into each other.

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"THINNING THE POINT"

90 Drills may be made to feed into the work more easily by a process known as "thinning the point." This is an extremely delicate operation, and is not recommended except in the hands of a skillful operator. It is, however, a decided assistance where the hand feed is used, or where you are using high speed drills with unusual heavy webs.

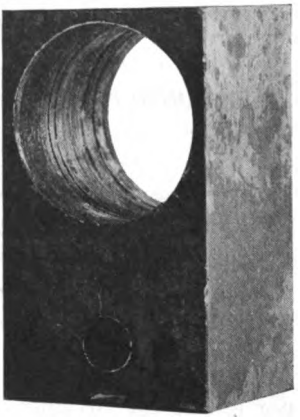

Fig. 23
A rough, inaccurate hole — the result of a dull drill.

91 To properly thin the point, a round-faced emery wheel is necessary. The drill should look like Fig. 24 when finished.

92 Be very careful in "thinning the point" to keep the "Dead Center" of the drill in the exact center and be careful not to weaken the Web too much by running the ground-out section too far up into the flutes.

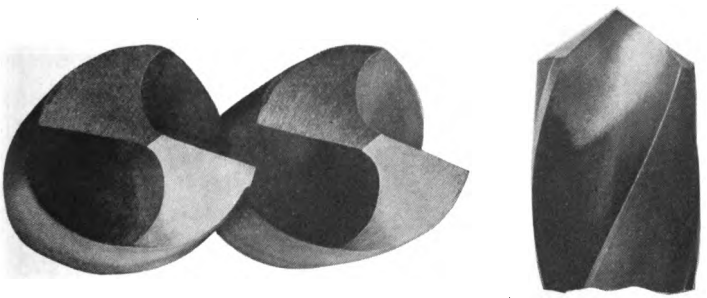

Fig. 24 — Thinned Points
Drills may be made to feed more easily by thinning the point. The drill in the center has not been thinned. The one on the left and the right have been thinned. Note the difference in the thickness of the web at the dead center before and after "thinning." See Paragraph 90 to 92.

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CHAPTER V

Common Errors and Their Results

BROKEN TANGS

93 Broken tangs result from a variety of causes — they may be traced to the use of badly mutilated sockets, to the use of drills whose shanks are so "banged up" that they do not fit snugly into the socket, or to the use of drills with badly mutilated tangs.

94 Although the tang of the drill is designed to carry a portion of the driving strain, the tapered fit between the

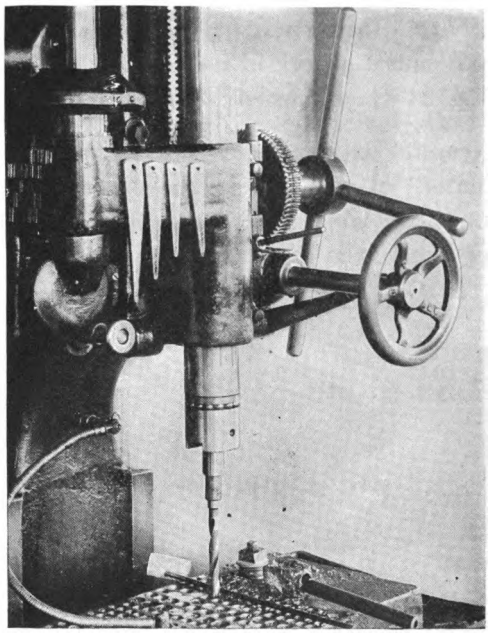

Fig. 25
A convenient way of always having the proper drift handy.

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shank of the drill and the wall of the socket should carry a large share of this strain. As a result, if either the inner wall of the socket or the surface of the shank is mutilated, a perfect fit is impossible. Under such conditions the whole driving strain is thrown on the *tang*. Often the tang breaks through no fault of its own — but rather through faulty treatment of either the drill or the socket.

95 Before inserting a drill in a socket, rub off the shank to make certain it is smooth and free from grit. Also inspect the inside of the *socket* to be sure it is in the same condition.

HOW TO "DRIFT OUT"

96 In drifting a drill out of the socket, never use anything but a drift (Fig. 25). The use of such makeshifts as files or wedges is likely to permanently injure either the drill or the socket or both — with broken tangs resulting therefrom.

97 In removing the drill from the spindle or socket, take great care that the point or tip does not hit the table of the press or the work. It is well to have a bit of wood handy onto which the drill can drop as you drift it out.

USE A LEAD HAMMER

98 In inserting a drill into the socket, never use a machinists' hammer, as this dulls the tip of the drill and nicks the cutting edges. Always use a material considerably softer than the drill itself — such as a lead hammer, or a piece of wood "2 x 4."

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NECESSITY OF RIGIDITY

99 One of the most common causes of drill breakage is lack of rigidity in the press or the work. Drill presses which are too weak to resist the feed pressure without springing, due either to faulty design of the table or of the feeding parts, and drill presses having lost motion in the spindle, invite breakage, because the sudden release of the resist-

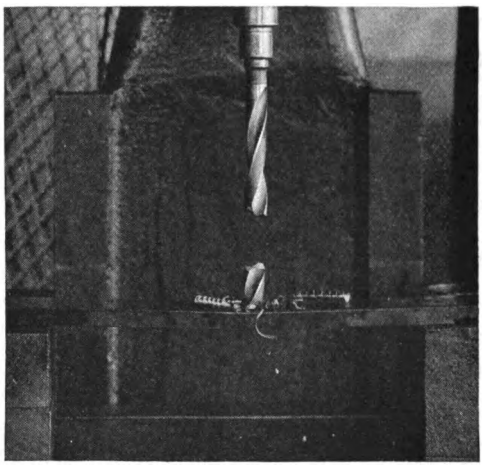

Fig. 26 — The Result of Spring
Spring in the work or the drill press is likely to produce the same result — breakage.

ance to the feed pressure when the point breaks through the far side of the work, causes the lips to bite too deeply into the work. This causes the lips to catch and sufficient strain results to break the drill.

100 The same results come about from faulty setting up of the work. Underneath the drill, the work should be absolutely rigid and free from spring. Otherwise breakage is almost sure to result. (Fig. 26.)

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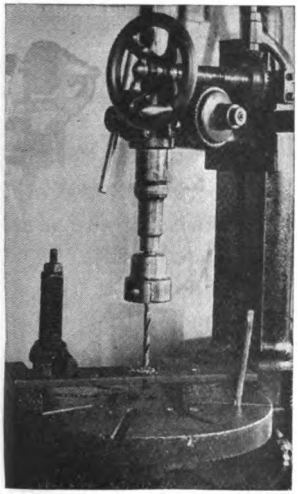

Fig. 27
The work should always be clamped to the table. Otherwise it may catch in the drill and do harm to the operator.

USE THE CLAMP

101 The work should never be held in the hand. It should be rigidly *clamped* to the table of the press. (Fig. 27.) Where the work is held in the hand, the danger of breaking, owing to lack of rigidity and side support, is tremendously increased, and the danger to the operator resulting from whirling work is considerable. (Fig. 28.)

WARM HIGH SPEED DRILLS BEFORE USING

102 It is a good practice to warm the lubricant before using it with high speed tools. Any hard piece of steel is extremely brittle when cold, and high speed drills should never be put to work in that condition. They work much better when warm — often giving good results when the chips are actually turned blue by the head generated.

103 Nothing will "check" (fill full of small cracks) a high speed drill quicker than to turn a stream of cold water onto it after it has become heated while working. It is equally bad to plunge it in cold water after the point

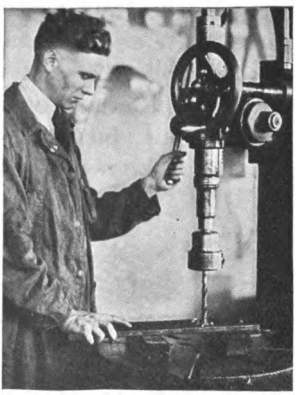

Fig. 28
The wrong way to set up a job — never hold it with your hand. Always clamp it.

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has been heated in grinding. Either of these practices is certain to impair the strength of the drill.

FILING NOT RELIABLE TEST OF CUTTING ABILITY

104 A fact often lost sight of, even by experienced users of drills, is that *cutting ability* and *hardness* are not the same thing. This is especially true of high speed drills. The apparent hardness of a drill varies with the composition of the steel and is no indication of the cutting ability.

105 Some of the best high speed tools we have ever tested could be filed so readily that — if filing were an indication of the work to be expected of them — they would be condemned without a working trial.

106 A high speed drill so hard that it cannot be filed, may by exercising great care, be made to drill extremely hard material. But such a drill will be found so *brittle* as to be worthless if used for softer materials, or where a large amount of work must be done in a given time.

107 Numerous tests have proven that the hardness of files varies quite as much as that of other hardened tools, and this is another reason why file tests are unreliable. No drill that files hard or soft should be condemned for that reason alone, but should first be given a drilling test in material of known hardness.

Key to Table of Cutting Speeds

THE table of Cutting Speeds shown on opposite page, should be used only as a guide and the correct speeds for drills should be determined by good judgment applied to each individual case. It is safe to start carbon drills with a pheripheral speed of 30 feet per minute for soft tool and machinery steel, 35 feet for cast iron and 60 feet for brass, using in all cases a feed of from .004 to .007 inch per rotation for drills ½ inch and

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smaller, and from .005 to .015 inch per rotation for drills larger than ½ inch in diameter. At these speeds a suitable cutting-compound should be used for wrought iron and steel.

109 In the case of High Speed Steel Drills the above feeds should remain unchanged, but the speeds should be increased from two to two and one-half times.

110 All of the speeds recommended are only speeds at which the drilling should be started. They are approximate for average conditions only. They can be greatly exceeded under some conditions, but under others they will have to be reduced. *In all cases* the operator should be guided by observing the condition of the drill in connection with the suggestions on pages 20 to 26.

Feet per Min.	30′	40′	50′	60′	70′	80′	90′	100′	110′	120′	130′	140′	150′
Diameter In.	Revolutions per Minute												
1/16	1833	2445	3056	3667	4278	4889	5500	6111	-----	-----	-----	-----	-----
1/8	917	1222	1528	1833	2139	2445	2750	3056	3361	3667	3973	4278	4584
3/16	611	815	1019	1222	1426	1630	1833	2037	2241	2445	2648	2852	3056
1/4	458	611	764	917	1070	1222	1375	1528	1681	1833	1986	2139	2292
5/16	367	489	611	733	856	978	1100	1222	1345	1467	1589	1711	1833
3/8	306	407	509	611	713	815	917	1019	1120	1222	1324	1426	1528
7/16	262	349	437	524	611	698	786	873	960	1048	1135	1222	1310
1/2	229	306	382	458	535	611	688	764	840	917	993	1070	1146
5/8	183	244	306	367	428	489	550	611	672	733	794	856	917
3/4	153	203	255	306	357	407	458	509	560	611	662	713	764
7/8	131	175	218	262	306	349	393	436	480	524	568	611	655
1	115	153	191	229	267	306	344	382	420	458	497	535	573
1 1/8	102	136	170	204	238	272	306	340	373	407	441	475	509
1 1/4	92	122	153	183	214	244	275	306	336	367	397	428	458
1 3/8	83	111	139	167	194	222	250	278	306	333	361	389	417
1 1/2	76	102	127	153	178	204	229	255	280	306	331	357	382
1 5/8	70	94	117	141	165	188	212	235	259	282	306	329	353
1 3/4	65	87	109	131	153	175	196	218	240	262	284	306	327
1 7/8	61	81	102	122	143	163	183	204	224	244	265	285	306
2	57	76	95	115	134	153	172	191	210	229	248	267	287
2 1/4	51	68	85	102	119	136	153	170	187	204	221	238	255
2 1/2	46	61	76	92	107	122	137	153	168	183	199	214	229
2 3/4	42	56	69	83	97	111	125	139	153	167	181	194	208
3	38	51	64	76	89	102	115	127	140	153	166	178	191

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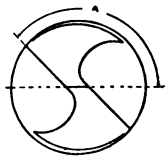
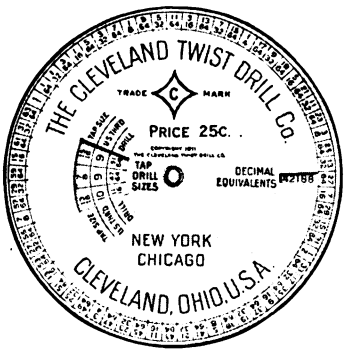
Handy Aids for the Driller

No. 190 — Model Drill Point

THE Model Drill Point will be found especially valuable in learning to grind drills properly, so as to do more and better work and keep the number of broken drills down to a minimum.

The line across the center of the drill point between the cutting edges, known as the "dead center," should be as shown on the Model Drill Point, i. e., the angle between this line and the cutting edges (Angle "A," in attached diagram), should never be less than 120°, though it may be as much as 135°. (See also article on Drill Grinding, par. 28). It is of the utmost importance that this angle should be correct, as in an experience of over forty years we have found that ninety-nine out of every hundred split drills show improper grinding at this point. Price of Drill Point.....55 cents.





Feed and Speed Disc

A handy pocket-size celluloid disc giving decimal equivalents of fractions, tap and drill sizes, and proper feeds and speeds for high speed and carbon drills. Ideal for student and operator alike. Practically indestructible. Price 25 cents each. Not more than one furnished to an individual.

Note — The above prices represent actual cost to us in large quantities and are subject to withdrawal without notice. We will endeavor, however, to give our friends the benefit of the quantity cost at all times. Stamps acceptable as payment.

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The Tools You'll Use

A Few Examples of the Most Popular and Widely Used Drills and Reamers

Drill No. 106 — The regular taper shank drill; furnished in both high speed and carbon steel.

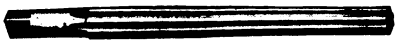
Drill No. 108 — A typical straight shank drill, commonly called "jobbers length" or "short set," implying that the over all length of the tool is somewhat shorter than the same size of drill No. 110 which is "long set." Furnished in both carbon and high speed steel.

Drill No. 110 — A typical straight shank drill, "long set" (see drill No. 108 for meaning of short and "long set"). This tool is, of course, furnished in both high speed and carbon steel.

Reamers

Carbon Expansion Hand Reamer No. 129 — The most popular of carbon expansion reamers; widely used and particularly adapted for fine and accurate work.

Reamer No. 128-A — The standard type of hand reamer; furnished in either carbon or high speed steel.



Standard Taper Pin Reamer No. 137 — These tools taper ¼" per foot in all sizes; thus the point of each will enter the hole reamed by the next size smaller. Used for reaming holes for taper pins.

Taper Bridge Reamers No. 150-A — These tools are furnished in either carbon or high speed steel. They are especially designed for very severe service in structural iron and steel work, boiler making, shipbuilding, etc.

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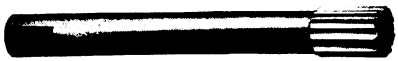
Peerless High Speed Reamers

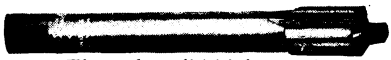
"Peerless" high speed reamers employ an exceedingly *tough* alloy for the body instead of the usual high speed steel. Into this tough, almost unbreakable alloy body, high speed steel blades are "Brazo-Hardened" by a patented process which makes these blades an integral, eternal part of the tool. The result is an extremely high-grade, high speed reamer of hitherto unheard of toughness, at a marked saving in manufacturing cost. The same patented method of manufacture enables us to furnish "Peerless" in *expansion* types. "Peerless" is the only solid high speed reamer which can be had in this type. It is, of course, made in all other styles likewise except the bridge reamer type.



"Peerless" High Speed, Straight Shank Chucking Reamer No. 503 — Typical of the non-expansion type "Peerless" reamer.

"Peerless" High Speed, Expansion Shell Reamer No. 520 — The only solid high speed, expansion shell reamer on the market.

"Peerless" High Speed, Expansion Chucking Reamer No. 516—The only solid high speed expansion chucking reamer on the market.



"Peerless" High Speed Expansion Core Reamer No. 510 — The only solid high speed expansion core reamer on the market.

"Peerless" Expansion Hand Reamer — High Speed—No. 502—Like the other "Peerless" expansion types, it is the only solid high speed expansion reamer on the market. Bear in mind, however, that "Peerless" is also made in a full line of non-expansion reamers.

Miscellaneous Tools

Drill and Countersinks Combined No. 98 —A staple, handy tool that drills and countersinks at a single operation; furnished in either carbon or high speed steel.

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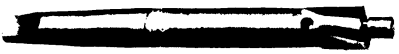
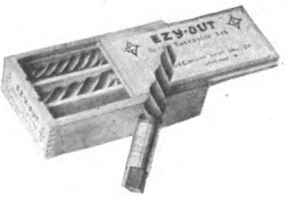
"Perfect Double-Tang" Socket No. 81 —A patented socket widely used for reclaiming taper shank tools with broken tangs. Its application is extremely simple and sure — merely grind a new tang below the old and broken one and slip the tool into a "Perfect Double-Tang" Socket. The result is a true running tool with a tang that is 25 to 60 per cent stronger than originally. A "Perfect Double-Tang" Socket insures full productive life from any taper shank tool — regardless of the life of the original tang.



Taper Shank Counterbores No. 177—For counterboring for machine screw heads; these tools have interchangeable pilots, thus permitting one counterbore to be used for a number of screw sizes. They are furnished in either carbon or high speed steel.



"Ezy-Out" Screw Extractors No. 192— Until the invention of the "Ezy-Out" Screw Extractor, the removal of a broken set or cap screw, stud, pipe fitting, etc., was one of the most annoying and exasperating of jobs as well as one of the most frequent. But with "Ezy-Out"— the only tool especially designed for the job — it is merely necessary to drill a hole in the broken screw, insert "Ezy-Out," slip on a tap wrench and *twist*, whereupon "Ezy-Out's" taper spirals *grip* the sides of the broken screw like steel fingers, and backs it out on its own threads in a fraction of the time heretofore required by the makeshift methods of the past. No. 17 Set of "Ezy-Out" Extractors is illustrated. This set is composed of three "Ezy-Out" Extractors of varied size; ample for most shops.

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The Little Doctor

A First Aid For Drill Press Operators

SYMPTOM	PROBABLE CAUSE	REMEDY
BREAKING of drill.	Spring or back lash in press or work. Too little lip clearance. Too low speed. Improper cutting compound.	Test press and work for rigidity. Regrind properly. Increase speed. Use proper cutting compound (see Par. 79-85).
BREAKING down of outer corner of cutting edges.	Material being drilled is hard or dirty. Too much speed.	Reduce speed and try turpentine.
BREAKING of drill when drilling brass or wood.	Chips clog up flutes.	Use "Cleveland" drills for brass and No. 113A for wood.
BURNING of the heel of the drill.	No lip clearance on drill	Regrind properly.
BROKEN TANG.	Too much feed or, more probably, imperfect fit of taper shank in the socket — due to nicks, dirt, burrs or worn out socket.	Reduce feed — get a new socket or ream old one to prevent recurrence. Recover broken-tanged drill by use of "Perfect Double Tang Socket."
CHIPPING of lip or cutting edges.	Too much feed. Too much lip clearance.	Reduce Feed — see table on page 33. Regrind properly.
CHIPPING or checking of a high speed drill.	Heated and cooled too quickly while grinding or while operating.	Warm slowly before using. Do not throw cold water on hot drill while using or grinding.
CHANGE in character of chips while drilling.	Change in condition of the drill such as chipping of cutting edge, dulling, etc.	Regrind drill and correct the speed.
DRILL REFUSES to enter work.	Dull drill. Hard material. Too little lip clearance.	Sharpen drill. See page 23. Regrind properly.
HOLE larger than drill.	Unequal angle or length of the cutting edges — or both.	Regrind properly.
ONLY one lip cuts.	Unequal length or angle of cutting lips or both.	Regrind drill properly.
ROUGH HOLE.	Dull or improperly ground drill. Lack of lubricant or wrong lubricant.	Lubricate or change lubricant.
SPLITS up center.	Too little lip clearance. Too much feed.	Regrind with proper lip clearance. Reduce feed.

The Cleveland Twist Drill Co.

New York **Cleveland** **Chicago**

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