Chapter XIX.—DRILLS AND CUTTERS FOR DRILLING MACHINES.

Drilling Jigs, Guides, or Fixtures.—When a large number of pieces are to be drilled alike, as in the case when work is done to special gauges, special chucking devices called jigs, or fixtures, are employed to guide the drill, and insure that the holes shall be pierced accurately in the required location, and test pieces or gauges are provided to test the work from time to time to insure that errors have not arisen by reason of the wear of these drill-guiding devices.

Suppose, for example, that we have a link, such as in Fig. 1699, and that we require to have the holes throughout a large number of them of equal diameter at each end and the same distance apart, and if we could prevent the wear of the tools, and

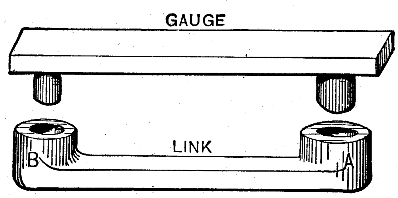


Fig. 1699.

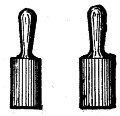


Fig. 1700.

so continue to produce any number of links all exactly alike, we could provide a simple test gauge, such as shown in the figure, making it pass the proper distance apart, and of a diameter to fit the holes; but as we cannot prevent wear to the tools we must fix a limit to which such wear may be permitted to occur, and having reached that point they must be restored and corrected. We must at the same time possess means of testing in what direction the wear has induced error. Let it be assumed that the bore at A should be $\frac{1}{2}$ inch and that at B $\frac{3}{8}$ inch in diameter, that their distance from centre is to be, say, six inches, and that either bore may vary in diameter to the amount of $\frac{1}{1000}$ inch, while the distance from centre to centre of the bores may also vary $\frac{1}{1000}$ inch. Now let it be noted that if one piece be made $\frac{1}{2000}$ inch too short, and another $\frac{1}{2000}$ inch too long we have reached the extent of the limit, there being $\frac{1}{1000}$ inch difference between them, although neither piece varies more than $\frac{1}{2000}$ inch from the standard. Similarly in the bore diameters, if the bore, say at A, is $\frac{1}{2000}$ inch too large in one piece and $\frac{1}{2000}$ too small in another, there is a difference of $\frac{1}{1000}$ between them, although each varies

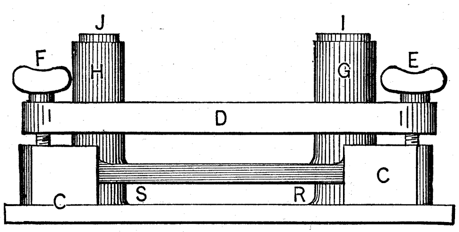


Fig. 1701.

only the $\frac{1}{2000}$ inch from the standard. In making test gauges for the holes, therefore, we must consider in what direction the tool will wear; thus, suppose that the finishing reamer for the holes is made when new to the standard diameter, and it can only wear smaller, hence a plug gauge of the standard diameter and $\frac{1}{1000}$ inch smaller would serve thus, as so long as the smaller one will go in the limit of wear is not reached; when it will not go in sufficiently easily the reamer must be restored to fit the standard gauge. On the other hand, the reamer when new may be made $\frac{1}{1000}$ inch above the standard size and restored when it has worn down to the standard size. In this case the bore diameter is still within the limit as long as the small gauge will enter; but when it fits too tight the reamer must be restored to the large plug gauge, the forms of these gauges being shown in Fig. 1700.

In Figs. 1701 and 1702 we have a jig or fixture for holding the link during the drilling process. It consists of two parts, C and D, between which the link is held by the screws E and F. The two hubs, G and H, are provided with hardened steel bushes, I and J, which are pierced with holes to receive and guide the drilling tool or reamer, and it is evident that in time the bore of these bushes will wear, and if they wear on one side more than on

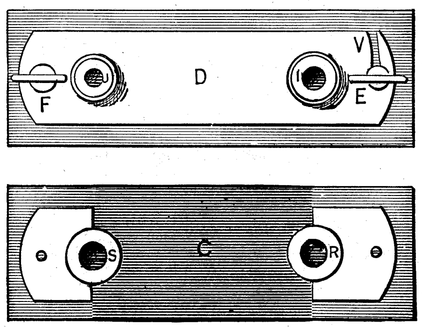


Fig. 1702.

another they may wear longer or shorter between the centres or axis; hence we require gauges such as shown in Fig. 1703, one being longer between centres and the other shorter, in each case to the amount of the prescribed limit. In this case, so long as the holes are kept within the prescribed limit of diameter, the distance apart of the two holes will be within the limit so long as neither of the limit gauges will enter; and when they will enter the bushes I J must be restored.

It is to be remarked, however, that the variation in the diameter of the holes affects these standards, since if the holes are made sufficiently large either gauge would enter, although the axis of the holes and of the pins on the gauge might be the proper distance apart; hence the gauging for length depends to some degree upon the degree of accuracy in gauging for diameter.

Referring now to the construction of the jig, or fixture for

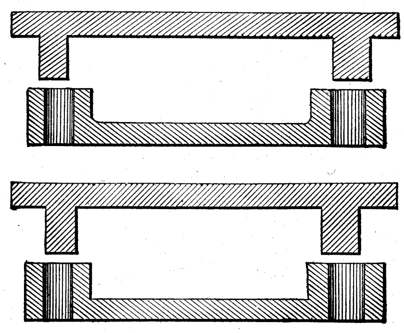


Fig. 1703.

drilling the link shown in Figs. 1701 and 1702: the base piece is provided with two short hubs, R and S, upon which the link is to sit, and it is obvious that these hubs must be faced off true with the bottom face of the base, while the link must also be faced so that it will be level, and not be bent or sprung when clamped by the screws E F. It is obvious that the hubs R and S may be omitted, and the link be flat on the base plate; but this would not be apt to hold the link so steadily, and greater care would be required to keep the surface clean. It is also obvious that in the form of jig shown there is a tendency of the screws E and F to bend the piece D; but in the case of small pieces, as, say, not exceeding 8 inches long, piece D may be made strong enough to resist the screw pressure without bending. If, however, the link were, say, 18 inches long, it would be preferable to have projections in place of the hubs R,S, and to let these projections extend some distance along each end of the link, using four holding screws, and clamping the piece D on the inside of the hubs H G. To

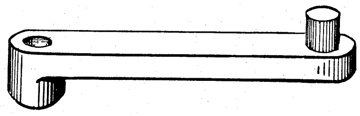


Fig. 1704.

facilitate the rapid insertion and removal of the link into and from the jig cap-piece, D is pivoted on screw F, while a slot V is cut at the other end, so that when the two screws E, F are loosened, the cap-piece D may be swung out of the way without entirely removing it.

In Fig. 1704 we have a link in which a hole is to be bored at one end at a certain distance from a pin at the other, and the fixture, or jig for drilling, is shown in the sectional view, Fig.

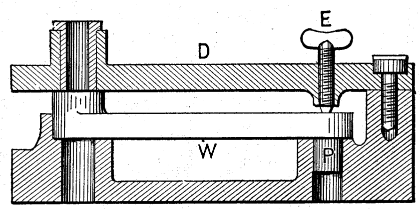


Fig. 1705.

1705, the side view, Fig. 1706, and the top view, Fig. 1707. It is obvious that the pin P and the face W of the link must be made true, and that a hardened steel bush may be placed in the hub to receive the pin P. The screw E binds one end of the cap D, and eye-bolts with thumb-nuts F bind the other, these bolts being pivoted at their lower ends, and passing through slots in D, so that as soon as nuts F are loosened, their bolts may be swung out

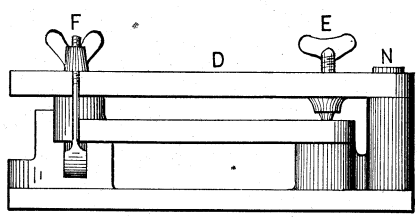


Fig. 1706.

clear of the cap, which may be swung on one side from the pin N as a pivot.

In Fig. 1708 we have a piece containing three holes, which are to be drilled in a certain position with regard to each other, and with regard to the face A. This brings us to the consideration that in all cases the work must be chucked or held true by the faces to which it is necessary that the holes must be true, and as

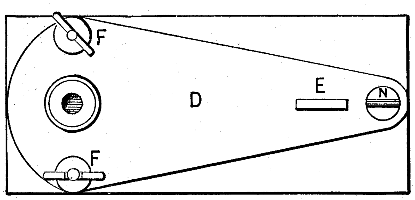


Fig. 1707.

in this case it is the face A, the jig must be made to hold the piece true by A, the construction being as in Fig. 1709, which represents a top view, and a sectional side view. The upper plate D carries three hardened steel bushes, A, B, and C, to receive the drilling tools, and thus determine that the holes shall be drilled at their proper positions with relation to each other, and is provided with a face N, against which the face (A, Fig. 1708) may be secured by the screw H, and thus determine the positions of the holes with regard to that face. At E, F, and G are eye-bolts for clamping the work between the cap and the base plate, which is made large so that it may lie steadily on the table of the drilling machine. When the nuts E, F, and G and the screw H are loosened the cap D may be lifted off and the work removed.

If the holes are required to be made very exact in their positions with relation to one edge, as well as to the face A of the work, two screws K would be required, one binding the cap against the

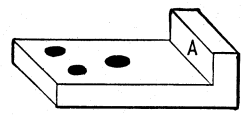


Fig. 1708.

lug M of the base, and the other binding the edge of the work against the same lug.

The usefulness of jigs, or fixtures, is mainly confined to small work in which a great many duplicate pieces are to be made, and their designing calls for a great deal of close study and ingenuity. They can obviously be applied to all kinds of small work, and as a general principle the holes and pins of the work are taken as the prime points from which the work is to be held.

Drilling fixtures may, however, be applied with great advantage to work of considerable size in cases where a number of duplicate

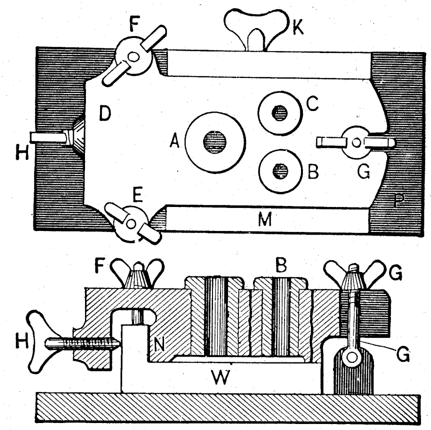


Fig. 1709

parts are to be made, an example of this kind being given in the fixtures for drilling the bolt holes, &c., in locomotive cylinders.

For drilling the cylinder covers and the tapping holes in the cylinder, the following device or fixture is employed: The flanges of the cylinder covers are turned all of one diameter, and a ring is made, the inside diameter of which is, say, an inch smaller than the bore of the cylinder; and its outside diameter is, say, an inch larger than the diameter of the cover. On the outside of the ring is a projecting flange which fits on the cover, as in Fig. 1710, *a* being the cylinder cover, and *b b* a section of the ring, which is

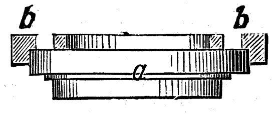


Fig. 1710.

provided with holes, the positions in the ring of which correspond with the required positions of the holes in the cover and cylinder; the diameter of these holes (in the ring, or template, as it is termed) is at least one quarter inch larger than the clearing holes in the cylinder are required to be. Into the holes of the template are fitted two bushes, one having in its centre a hole of the size necessary for the tapping drill, the other a hole the size of the clearing drill; both these bushes are provided with a handle by which to lift them in and out of the template, as shown in Fig. 1711, and both are hardened to prevent the drill cutting them, or the borings of the drill from gradually wearing their holes larger. The operation is to place the cover on the cylinder and the template upon the cover, and to clamp them together, taking care that both cover and template are in their proper positions, the latter having a flat place or deep line across a segment of its circumference, which is placed in line with the part cut away on the inside of the cover to give free ingress to the steam, and the cover being placed in the cylinder so that the part so cut away will be opposite to the port in the cylinder, by which means the holes in the covers will all stand in the same relative position to any definite part of the cylinder, as, say, to the top or bottom, or to the steam port, which is sometimes of great importance (so as

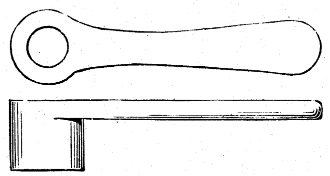


Fig. 1711.

to enable the wrench to be applied to some particular nut, and prevent the latter from coming into contact with a projecting part of the frame or other obstacle): the positions of the cylinder, cover, template, and bush, when placed as described, being such as shown in Fig. 1712, *a a* being the cylinder, B the steam port, C the cylinder cover, D the template, and E the bush placed in position. The bush E having a hole in it of the size of the clearance hole, is the one first used, the drill (the clearance size) is passed through the bush, which guides it while it drills through the cover, and the point cuts a countersink in the cylinder face.

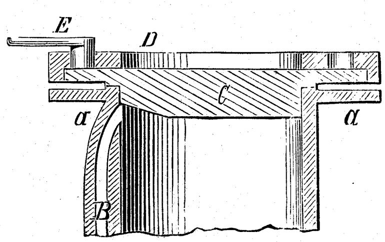


Fig. 1712.

The clearing holes are drilled all round the cover, and the bush, having the tapping size hole in it, is then brought into requisition, the tapping drill being placed in the drilling machine, and the tapping holes drilled in the cylinder flange, the bush serving as a guide to the drill, as shown in Fig. 1712, thus causing the holes in the cover and those in the cylinder to be quite true with each other. A similar template and bush is provided for drilling the holes in the steam chest face on the cylinder, and in the steam chest itself. While, however, the cylinder is in position to have

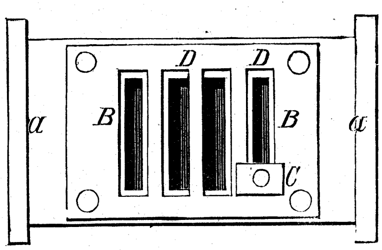


Fig. 1713.

the holes for the steam chest studs drilled, the cylinder ports may be cut as follows:—

The holes in the steam chest face of the cylinder being drilled and tapped, a false face or plate is bolted thereon, which plate is provided with false ports or slots, about three-eighths of an inch wider and three-fourths of an inch longer than the finished width and length of the steam ports in the cylinder (which excess in width and length is to allow for the thickness of the die). Into these false ports or slots is fitted a die to slide (a good fit) from end to end of the slots. Through this die is a hole, the diameter of which is that of the required finished width of the steam ports of the cylinder; the whole appliance, when in position to commence the operation of cutting out the cylinder ports, being as illustrated in Fig. 1713, *a a* being the cylinder, B B the false plate, C the sliding die, and D D the slots or false ports into which the die C fits. Into the hole of the die C is fitted a reamer, with cutting edges on its end face and running about an inch up its sides, terminating in the plain round parallel body of the reamer, whose length is rather more than the depth of the die C. The operation is to place the reamer into the drilling machine, taking care that it runs true. Place the die in one end of the port, as shown in Fig. 1713, and then wind the reamer down through the die so that it will cut its way through the port of the cylinder at one end; the spindle driving the drill is then wound along. The reamer thus carries the die with it, the slot in the false face acting as a guide to the die.

In the case of the exhaust port, only one side is cut out at a time. It is obvious that, in order to perform the above operation,

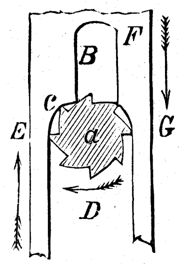


Fig. 1714.

the drilling machine must either have a sliding head or a sliding table, the sliding head being preferable.

The end of the slot at which the die must be placed when the reamer is wound down through the die and cylinder port, that is to say, the end of the port at which the operation of cutting it must be commenced, depends solely on which side of the port in the cylinder requires most metal to be cut off, since the reamer, or cutter, as it may be more properly termed, must cut underneath the heaviest cut, so that the heaviest cut will be forcing the reamer back, as shown in Fig. 1714, *a* being a sectional view of the cutter, B the hole cast in the cylinder for the port, *c* the side of the port having the most cut taken off, D the direction in which the cutter *a* revolves, and the arrow E the direction in which the cutter *a* is travelling up to its cut. If the side F of the port were the one requiring the most to be cut off, the cutter *a* would require to commence at the end F, and to then travel in the direction of the arrow G. The reason for the necessity of observing these

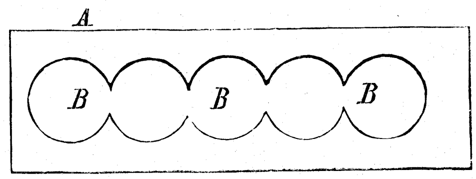


Fig. 1715.

conditions, as to the depth of cut and direction of cutter travel, is that the pressure of the cut upon the reamer is in a direction to force the reamer forward and into its cut on one side, and backward and away from its cut on the other side, the side having the most cut exerting the most pressure. If, therefore, the cutter is fed in such a direction that this pressure is the one tending to force the cutter forward, the cutter will spring forward a trifle, the teeth of the cutter taking, in consequence, a deep cut, and, springing more as the cut deepens, terminate in a pressure which breaks the teeth out of the cutter.

If, however, the side exerting the most pressure upon the reamer is always made the one forcing the cutter back, as shown in Fig. 1714, by reason of the direction in which the cutter is travelled to its cut, the reamer, in springing away from the undue pressure, will also spring away from its cut, and will not, therefore, rip in or break, as in the former case.

In cutting out the exhaust port, only one side, in consequence of its extreme width, may be cut at one operation; hence there are two of the slots D, Fig. 1713, provided in the false plate or template for the exhaust port. The cutter *a* must, in this case, perform its cut so that the pressure of the cut is in a direction to force the cutter backwards from its cut. The time required to cut out the ports of an ordinary locomotive cylinder, by the above appliance, is thirty minutes, the operation making them as true, parallel, and square as can possibly be desired.

DRILLS AND CUTTERS FOR DRILLING MACHINES.—In the drilling machine, as in the lathe, the twist drill is the best tool that can be used for all ordinary work, since it produces the best work with the least skill, and is the cheapest in the end. As, however, the twist drill has been fully discussed with reference to its use upon lathe work, it is unnecessary to refer to it again more than to say that it possesses even greater advantages when used in the drilling machine than it does when used in the lathe; because as the drill stands vertical the flat drill will not relieve itself of the cuttings, and in deep holes must be occasionally withdrawn from the hole in order to permit the cuttings to be extracted, an operation that often consumes more time than is required for the cutting duty. Furthermore, as flat drills rarely run true they place excessive wear upon the drilling machine spindle, causing it to wear loose in its bearings, which is a great detriment to the machine.

Fig. 1715 represents a piece of work that can be readily drilled with a twist drill but not with a flat one, such work being very advantageous in cutting out keyways. All that is necessary is to drill the three holes B first, and if the drill runs true and the work is properly held and the drill fed slowly while run at a quick speed the operation may be readily performed.

The speeds and feeds for twist drills are given in connection with the use of the drill in the lathe, but it may be remarked here that more duty may be obtained by hand than by automatically feeding a drill, because in hand feeding the resistance of the feed motion indicates the amount of pressure on the drill, and the feed may be increased when the conditions (such as soft metal) permits, and reduced for hard spots or places, thus preserving the drill. Furthermore, the dulling of the drill edges becomes more plainly perceptible under hand feeding.

The commercial sizes of both taper and straight shank twist drills are as follows:—

Diameter.	Length.	Diameter.	Length.	Diameter.	Length.	Diameter.	Length.
$\frac{1}{4}$	$6\frac{1}{8}$	$\frac{25}{32}$	$9\frac{7}{8}$	$1\frac{5}{16}$	$14\frac{1}{4}$	$1\frac{27}{32}$	$16\frac{3}{8}$
$\frac{9}{32}$	$6\frac{1}{4}$	$\frac{13}{16}$	10	$1\frac{11}{32}$	$14\frac{3}{8}$	$1\frac{7}{8}$	$16\frac{1}{2}$
$\frac{5}{16}$	$6\frac{3}{8}$	$\frac{27}{32}$	$10\frac{1}{4}$	$1\frac{3}{8}$	$14\frac{1}{2}$	$1\frac{29}{32}$	$16\frac{1}{2}$
$\frac{11}{32}$	$6\frac{1}{2}$	$\frac{7}{8}$	$10\frac{1}{2}$	$1\frac{13}{32}$	$14\frac{5}{8}$	$1\frac{15}{16}$	$16\frac{1}{2}$
$\frac{3}{8}$	$6\frac{3}{4}$	$\frac{29}{32}$	$10\frac{5}{8}$	$1\frac{7}{16}$	$14\frac{3}{4}$	$1\frac{31}{32}$	$16\frac{1}{2}$
$\frac{13}{32}$	7	$\frac{15}{16}$	$10\frac{3}{4}$	$1\frac{15}{32}$	$14\frac{7}{8}$	2	$16\frac{1}{2}$
$\frac{7}{16}$	$7\frac{1}{4}$	$\frac{31}{32}$	$10\frac{7}{8}$	$1\frac{1}{2}$	15	$2\frac{1}{32}$	$16\frac{1}{2}$
$\frac{15}{32}$	$7\frac{1}{2}$	1	11	$1\frac{17}{32}$	$15\frac{1}{8}$	$2\frac{1}{16}$	17
$\frac{1}{2}$	$7\frac{3}{4}$	$1\frac{1}{32}$	$11\frac{1}{8}$	$1\frac{9}{16}$	$15\frac{1}{4}$	$2\frac{1}{8}$	17
$\frac{17}{32}$	8	$1\frac{1}{16}$	$11\frac{1}{4}$	$1\frac{19}{32}$	$15\frac{3}{8}$	$2\frac{3}{16}$	17
$\frac{9}{16}$	$8\frac{1}{4}$	$1\frac{3}{32}$	$11\frac{1}{2}$	$1\frac{5}{8}$	$15\frac{1}{2}$	$2\frac{1}{4}$	$17\frac{1}{2}$
$\frac{19}{32}$	$8\frac{1}{2}$	$1\frac{1}{8}$	$11\frac{3}{4}$	$1\frac{21}{32}$	$15\frac{5}{8}$	$2\frac{5}{16}$	$17\frac{1}{2}$
$\frac{5}{8}$	$8\frac{3}{4}$	$1\frac{5}{32}$	$11\frac{7}{8}$	$1\frac{11}{16}$	$15\frac{3}{4}$	$2\frac{3}{8}$	18
$\frac{21}{32}$	9	$1\frac{3}{16}$	12	$1\frac{23}{32}$	$15\frac{7}{8}$	$2\frac{7}{16}$	$18\frac{1}{2}$
$\frac{11}{16}$	$8\frac{1}{4}$	$1\frac{7}{32}$	$12\frac{1}{8}$	$1\frac{3}{4}$	16	$2\frac{1}{2}$	19
$\frac{23}{32}$	$9\frac{1}{2}$	$1\frac{1}{4}$	$12\frac{1}{2}$	$1\frac{25}{32}$	$16\frac{1}{8}$		
$\frac{3}{4}$	$9\frac{3}{4}$	$1\frac{9}{32}$	$14\frac{1}{8}$	$1\frac{13}{16}$	$16\frac{1}{4}$		

Twist drills are also made to the Stubs wire gauge as follows:—

Numbers by gauge.	Length.	Numbers by gauge.	Length.
1 to 5	4	31 to 35	$2\frac{5}{8}$
6 „ 10	$3\frac{11}{16}$	36 „ 40	$2\frac{7}{16}$
11 „ 15	$3\frac{1}{2}$	41 „ 45	$2\frac{1}{4}$
16 „ 20	$3\frac{1}{4}$	46 „ 50	$2\frac{1}{16}$
21 „ 25	$3\frac{1}{16}$	51 „ 60	$1\frac{3}{4}$
26 „ 30	$2\frac{13}{16}$	61 „ 70	$1\frac{1}{2}$

Fig. 1716 represents the flat drill, which has three cutting edges, A, B, and C. The only advantages possessed by the flat drill are that it will stand rougher usage than the twist drill, and may be fed faster, while it can be more easily made. Furthermore, when the work is unusually hard the flat drill can be conveniently shaped and tempered to suit the conditions.

The drill is flattened out and tapered thinnest at the point C. The side edges that form the diameter of the drill are for rough work given clearance, but for finer work are made nearly cylindrical, as in the figure.

The flattening serves two purposes: first, it reduces the point of the drill down to its proper thinness, enabling it to enter the

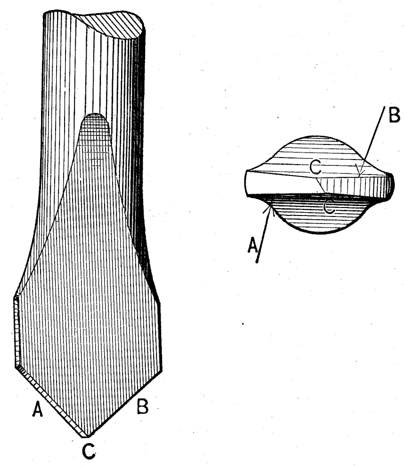


Fig. 1716.

metal of the work easily, and secondly, it enables the cuttings to pass upward and find egress at the top of the hole being drilled.

The cutting edges are formed by grinding the end facets at an angle as shown, and this angle varies from 5° for drilling hard metal, such as steel, to 20° for soft metal, such as brass or copper.

The angle of one cutting edge to the other varies from 45° for steel to about 35° or 40° for soft metals. The object of these two variations of angles is that in hard metal the strain and abrasion is greatest and the cutting edge is stronger with the lesser degree of angle, while in drilling the softer metals the strain being less the cutting edge need not be so strong and the angles may be made more acute, which enables the drill to enter the metal more easily. The most imperfect cutting edge in a drill is that running diagonally across the point, as denoted by A in Fig. 1717, because it is less acute than the other cutting edges, but this becomes more acute and, therefore, more effective, as the angles of the facets forming it are increased as denoted by the dotted lines in

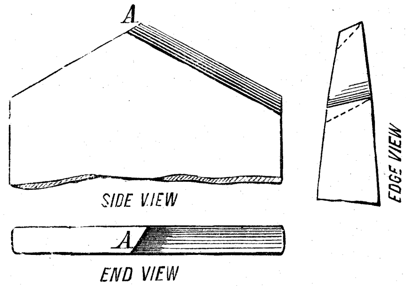


Fig. 1717.

the figure. It is obvious, however, that the more acute these angles the weaker the cutting edge, hence an angle of about 5° is that usually employed.

It is an advantage to make the cutting edge at A, Fig. 1717, as short as possible, which may be done by keeping the drill point thin; but if too thin it will be apt either to break or to operate in jumps (especially upon brass), drilling a hole that is a polygon instead of a true circle.

The cutting edges should not only stand at an equal degree of angle to the axial line of the drill, but should be of equal lengths, so that the point of the drill will be in line with the axial line of the drill. If the drill runs true the point will then be in the axial line of rotation, and the diameter of hole drilled will be equal to the diameter of the drill.

If, however, one cutting edge is longer than the other the hole drilled will be larger than is due to the diameter of the drill.

Suppose, for example, the drill to be ground as in Fig. 1718, the cutting edge F being the longest and at the least angle, then the point G of the drill, when clear of the work, will naturally revolve in a circle around the axial line H of the drill's rotation. But when the drilling begins, the point of the drill meets the metal first and naturally endeavours to become the centre of rotation, drilling a straight conical recess, the work moving around with the point of the drill. If the work is prevented from moving, either

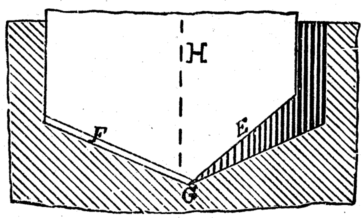


Fig. 1718.

the drill will spring or bend, the point of the drill remaining (at first) the centre of rotation at that end of the drill, or else the recess cut by the drill will be as in the figure, and the hole will be larger in diameter than the drill.

If, however, the drill is ground as shown in Fig. 1719, the edge E being nearest to a right angle to the axial line H of the drill, the drilling will be performed as shown in the figure, the edge E cutting the cone L, the edge F serving simply to enlarge the hole drilled by E. Here, again, if the work is held so that it cannot move, the point of the drill will revolve in a circle, and in either

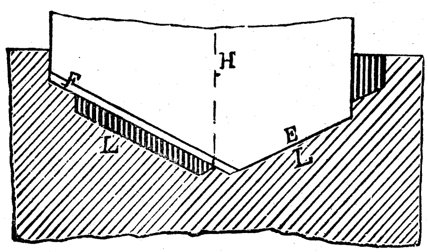


Fig. 1719.

case, so soon as the point of the drill emerges the diameter of the hole drilled will decrease, the finished hole being conical as shown in Fig. 1720 at A.

It may be remarked that the eye of the workman is (for rough work, such as tapping or clearing holes) sufficient guide to enable the grinding of the drill true enough to partly avoid the conditions shown in these two figures (in which the errors are magnified for clearness of illustration), because when the want of truth is less in amount than the thickness of the drill point, the centre of motion of the drill point when the drill has entered the work to its full

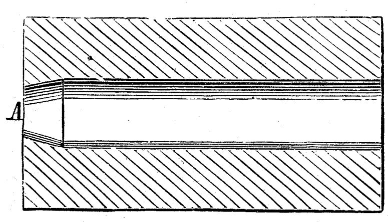


Fig. 1720.

diameter becomes neither at the point of the drill nor in the centre of its diameter, but intermediate between the two.

Thus, in Fig. 1721, A is the centre of the diameter of the drill, but the cutting edge C being shorter than D throws the point of the drill towards E, hence the extra pressure of D on the incline of the recess it cuts, over the like pressure exerted by C tends to throw the centre of rotation towards E, the natural endeavor of the drill point to press into the centre of the recess acting in the same direction. This is in part resisted by the strength of the drill, hence the centre of rotation is intermediate as at B in figure. The dotted circle is drawn from the axial line of the drill as a centre, while the full circle is drawn from B as a centre. The result of this would be that the point of the drill would perform more duty than is due to its thickness, and the recess cut would have a flat place at the bottom, as shown in Fig. 1722 at O. This, from the want of keenness of the cutting edge running diagonally across the drill point, would cause the drill to cut badly and require more power to drive and feed.

The edges at the flat end of the drill, as at A, A in Fig. 1723,

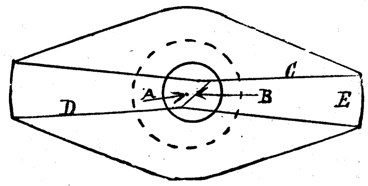


Fig. 1721.

should have a little clearance back from the cutting edge though they may be left the full circle as at A, A, but in any event they should not have clearance sufficient to form them as at B, B, Fig. 1723, because in that case the side edges C, C would cut the sides of the hole. In large drills, especially, it is necessary that the edges have but little clearance, and that the form of the clearance be as shown in Fig. 1044, with reference to twist drills. When no edge clearance whatever is given the edges act to a certain extent as guides to the drill, but if the drill is not ground quite true this

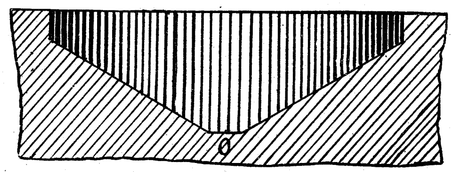


Fig. 1722.

induces a great deal of friction between the edges of the drill and the side of the hole.

In any case of improper grinding the power required to drive the drill will be increased, because of the improper friction induced between the sides of the drill and the walls of the hole.

For use on steel, wrought iron, and cast iron the lip drill shown in Fig. 1724 is a very efficient tool. It is similar to the flat drill but has its cutting edge bent forward. It possesses the keenness of the twist drill and the strength of the flat drill, but as in the case of all drills whose diameters are restored by forging and hand grinding, it is suitable for the rougher classes of work only, and requires great care in order to have it run true and keep both

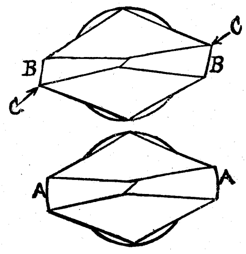


Fig. 1723.

cutting edges in action. It is sometimes attempted to give a greater cutting angle to a flat drill by grinding a recess in the front face, as at A in Fig. 1725, but this is a poor expedient.

Fig. 1726 represents what is known as the tit drill. It is employed to flatten the bottoms of holes, and has a tit T which serves to steady it. The edges A, B of this drill may be turned true and left without clearance, which will also serve to steady the drill. The tit T should be tapered towards the point, as shown, which will enable it to feed more easily and cut more freely. The speed of the drill must be as slow again as for the ordinary flat drill, and not more than one-third as fast as the twist drill.

To enable a drill to start a hole in the intended location the centre-punch recess in the centre of that location should be large enough in diameter at the top to admit the point of the drill, that is to say, the recess should not be less in diameter at the top than the thickness of the drill point.

If the drill does not enter true the alteration is effected as shown in Fig. 1727, in which A represents the work, B a circle of the size of the hole to be drilled, and C the recess cut by the drill, while D is a recess cut with a round-nosed chisel, which recess will cause the drill to run over in that direction.

It is a good plan when the hole requires to be very correctly located to strike two circles, as shown in Fig. 1728, and to define

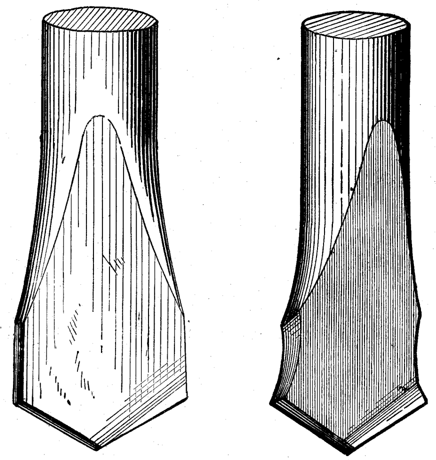


Fig. 1724.

them with centre-punch marks so that the cuttings and oil shall not erase them, as is apt to be the case with lines only. The outer circle is of the size of hole to be drilled, the inner one serves merely as a guide to true the drilling by.

If the work is to be clamped to the work table an alteration in the location of the recess cut by the drill point may be made by moving the work. In this case the point of the drill may be fed up so as to enter into and press against the centre-punch mark made in the centre of the location of the hole to be drilled, which, if the drill runs true will set the work true enough to clamp it by. The alteration to the recess cut by the drill when first starting to

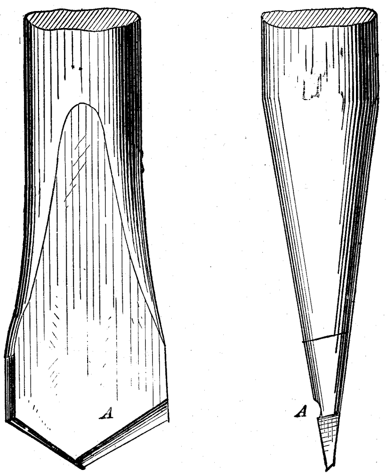


Fig. 1725.

bring the hole in its true position should be made as soon as a want of truth is discernible, because the shallower the recess the more easily the alteration may be made.

Sometimes a small hole is drilled as true to location as may be, and tested, any error discovered being corrected by a file; a larger drill is then used and the location again tested, and so on; in this way great precision of location may be obtained.

The more acute angle the cutting edges form one to the other, or in other words, the longer the cutting edges are in a drill of a given diameter, the more readily the drill will move over if one side of the recess be cut out as in Fig. 1727, and from some experiments made by Messrs. William Sellers and Co., it was determined that if the angle of one cutting edge to the other was more than 104° the drill would cease to move over.

In drilling wrought iron or the commoner qualities of steel the drill should be liberally supplied with either water or oil, but soapy water is better than pure. This keeps the drill cool and keeps the cutting edge clean, whereas otherwise the cuttings under a coarse feed are apt to stick fast to the drill point if the speed of the drill

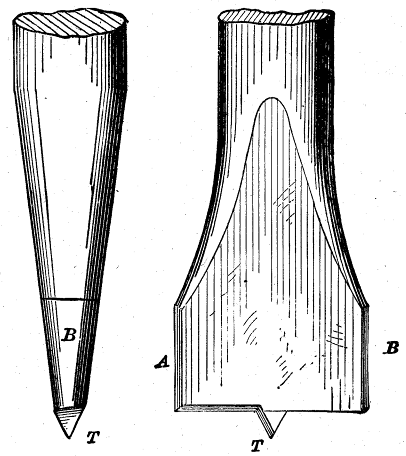


Fig. 1726.

is great. Furthermore, under excessive duty the drill is apt to become heated and softened.

For cast steel oil is preferable, or if the steel be very hard it will cut best dry under a slow speed and heavy pressure.

For brass and cast iron the drill should run dry, otherwise the cuttings clog and jam in the hole. When the drill squeaks either the cutting edge is dulled and the drill requires regrinding, or else the cuttings have jammed in the hole, and either defect should be remedied at once.

As soon as the point of the drill emerges through the work the feed should be lessened, otherwise the drill is apt to force through the weakened metal and become locked, which will very often either break or twist the drill. This may be accomplished when there is any end play to the drilling machine spindle by operating the feed motion in a direction to relieve the feed as soon as the point of the drill has emerged through the bottom of the hole, thus permitting the weight of the spindle to feed the drill. In a drilling machine, however, in which the weight of the spindle is counterbalanced, the feed may be simply reduced while the drill is passing through the bottom of the hole.

Drills for work of ordinary hardness are tempered to an orange

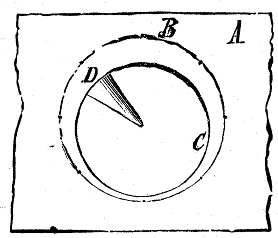


Fig. 1727.

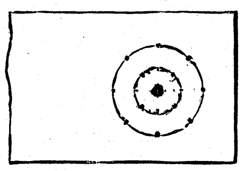


Fig. 1728.

purple, but if the metal to be cut is very hard a straw color is preferable, or the drill may be left as hard as it leaves the water; that is to say hardened, but not tempered. In these cases the speed of the drill must be reduced.

To assist a drill in taking hold of hard metal it is an excellent plan to jag the surface of the metal with a chisel which will often start the drill to its cut when all other means have failed. It is obvious from previous remarks that the harder the drill the less the angle of the end facets.

In cases of extreme hardness two drills may with advantage be used intermittently upon the same hole; one of these should have its cutting edges ground at a more acute angle one to the other than is the case with the other drill, thus the cutting edge will be lessened in length while the drill will retain the strength due to its diameter, so that a maximum of pressure may be placed upon it. When one drill has cut deep enough to bring its full length of cutting edge into action, it may be removed and the other drill employed, and so on.

The drill (for hard steel) should be kept dry until it has begun to cut, when a very little oil may be employed, but for chilled cast iron it should be kept dry.

Small work to be drilled while resting upon a horizontal table may generally be held by hand, and need not therefore be secured in a chuck or to the table, because the pressure of the drill forces the work surface to the table, creating sufficient friction to hold the work from rotating with the drill. For large holes, however, the work may be secured in chucks or by bolts and plates as described for lathe and planer work, or held in a vice.

The following table for the sizes of tapping holes is that issued by the Morse Twist Drill and Machine Co. In reply to a communication upon the subject that company states. "If in our estimate the necessary diameter of a tap drill to give a full thread comes nearest to a $\frac{1}{64}$ inch measurement, we give the size of the drill in 64ths of an inch. If nearest to a 32nd size of drill we give the drill size in 32nds of an inch.

In the following table are given the sizes of tapping drills, to give full threads, the diameters being practically but not decimally correct:—

Diameter of tap.	Number threads to inch.			Drill for V-thread.			Drill for U.S.S. thread.			Drill for Whitworth thread.		
1/4	16	18	20	5/32	5/32	11/64	—	—	3/16	—	—	3/16
9/32	16	18	20	3/16	13/64	13/64	—	—	—	—	—	—
5/16	16	18	—	7/32	15/64	—	—	1/4	—	—	15/64	—
11/32	16	18	—	1/4	17/64	—	—	—	—	—	—	—
3/8	14	16	18	1/4	9/32	9/32	—	9/32	—	—	9/32	—
13/32	14	16	18	19/64	21/64	21/64	—	—	—	—	—	—
7/16	14	16	—	21/64	11/32	—	11/32	—	—	11/32	—	—
15/32	14	16	—	23/64	3/8	—	—	—	—	—	—	—
1/2	12	13	14	3/8	25/64	25/64	—	13/32	—	3/8	—	—
17/32	12	13	14	13/32	27/64	27/64	—	—	—	—	—	—
9/16	12	14	—	7/16	29/64	—	7/16	—	—	—	—	—
19/32	12	14	—	15/32	31/64	—	—	—	—	—	—	—
5/8	10	11	12	15/32	1/2	1/2	—	1/2	—	—	1/2	—
21/32	10	11	12	1/2	17/32	17/32	—	—	—	—	—	—
11/16	11	12	—	9/16	9/16	—	—	—	—	—	—	—
23/32	11	12	—	19/32	19/32	—	—	—	—	—	—	—
3/4	10	11	12	19/32	5/8	5/8	5/8	—	—	5/8	—	—
25/32	10	11	12	5/8	21/32	21/32	—	—	—	—	—	—
13/16	10	—	—	21/32	—	—	—	—	—	—	—	—
27/32	10	—	—	11/16	—	—	—	—	—	—	—	—
7/8	9	10	—	45/64	23/32	—	23/32	—	—	23/32	—	—
29/32	9	10	—	47/64	3/4	—	—	—	—	—	—	—
15/16	9	—	—	49/64	—	—	—	—	—	—	—	—
31/32	9	—	—	51/64	—	—	—	—	—	—	—	—
1	8	—	—	13/16	—	—	27/32	—	—	27/32	—	—
1 1/32	8	—	—	53/64	—	—	—	—	—	—	—	—
1 1/16	8	—	—	55/64	—	—	—	—	—	—	—	—
1 3/32	8	—	—	57/64	—	—	—	—	—	—	—	—
1 1/8	7	8	—	29/32	15/16	—	15/16	—	—	15/16	—	—
1 5/32	7	8	—	15/16	31/32	—	—	—	—	—	—	—
1 3/16	7	8	—	31/32	1	—	—	—	—	—	—	—
1 7/32	7	8	—	1	1 1/32	—	—	—	—	—	—	—
1 1/4	7	—	—	1 1/32	—	—	1 1/16	—	—	1 1/16	—	—
1 9/32	7	—	—	1 1/16	—	—	—	—	—	—	—	—
1 5/16	7	—	—	1 3/32	—	—	—	—	—	—	—	—
1 11/32	7	—	—	1 1/8	—	—	—	—	—	—	—	—
1 3/8	6	—	—	1 1/8	—	—	1 5/32	—	—	1 5/32	—	—
1 13/32	6	—	—	1 5/32	—	—	—	—	—	—	—	—
1 7/16	6	—	—	1 5/32	—	—	—	—	—	—	—	—
1 15/32	6	—	—	1 3/16	—	—	—	—	—	—	—	—
1 1/2	6	—	—	1 15/64	—	—	1 9/32	—	—	1 9/32	—	—
1 17/32	6	—	—	1 9/32	—	—	—	—	—	—	—	—
1 9/16	6	—	—	1 9/32	—	—	—	—	—	—	—	—
1 19/32	6	—	—	1 5/16	—	—	—	—	—	—	—	—
1 5/8	5	5 1/2	—	1 9/32	1 5/16	—	—	1 3/8	—	1 23/64	—	—
1 21/32	5	5 1/2	—	1 5/16	1 11/32	—	—	—	—	—	—	—
1 11/16	5	5 1/2	—	1 11/32	1 3/8	—	—	—	—	—	—	—
1 23/32	5	5 1/2	—	1 3/8	1 13/32	—	—	—	—	—	—	—
1 3/4	5	—	—	1 13/32	—	—	1 1/2	—	—	1 1/2	—	—
1 25/32	5	—	—	1 7/16	—	—	—	—	—	—	—	—
1 13/16	5	—	—	1 15/32	—	—	—	—	—	—	—	—
1 27/32	5	—	—	1 1/2	—	—	—	—	—	—	—	—
1 7/8	4 1/2	5	—	1 17/32	1 17/32	—	—	1 5/8	—	1 37/64	—	—
1 29/32	4 1/2	5	—	1 9/16	1 9/16	—	—	—	—	—	—	—
1 15/16	4 1/2	5	—	1 19/32	1 19/32	—	—	—	—	—	—	—
1 31/32	4 1/2	5	—	1 5/8	1 5/8	—	—	—	—	—	—	—
2	4 1/2	—	—	1 21/32	—	—	1 23/32	—	—	1 45/64	—	—

To drive all drills by placing them directly in the socket of the drilling machine spindle would necessitate that all the drills should have their shanks to fit the drilling machine socket. This would involve a great deal of extra labor in making the drills, because the socket in the machine spindle must be large enough to fit the size of shank that will be strong enough to drive the largest drill used in the machine, hence the small drills would require to be forged down from steel equal to the full diameter of the shank of the largest drill. To obviate this difficulty the sockets already described with reference to drilling in the lathe are used.

The employment of these sockets preserves the truth of the bore of the drilling machine spindle by greatly diminishing the necessity to insert and remove the shank from the drill spindle, because each socket carrying several sizes of drills (as given with reference to lathe work) the sockets require less frequent changing.

Drill shanks are sometimes made parallel, with a flat place as at A in Fig. 1729, to receive the pressure of the set-screw by which it is driven. To enable the shank to run true it must be a close fit to the socket and should be about five diameters long. The objection to this form is that the pressure of the set-screw tends to force the drill out of true, as does also the wear of the socket bore.

These objections will obviously be diminished in proportion as the drill shank is made a tight fit to the socket, and to effect this and still enable the drill to be easily inserted and removed from

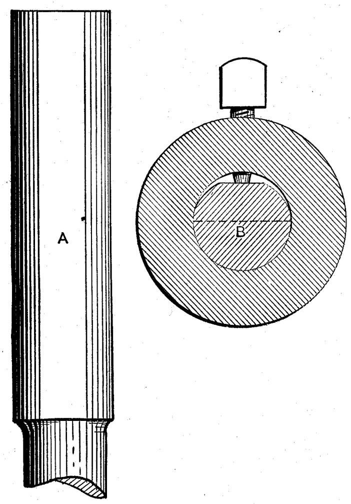


Fig. 1729.

the socket, the drill shank may be first made a tight fit to the socket bore, and then eased away on the half circumference on the side of the flat place, leaving it to fit on the other half circumference which is shown below the dotted line B in the end view in the figure. The set-screw is also objectionable, since it requires the use of a wrench, and is in the way and liable to catch the operator's clothing.

There is, however, one advantage in employing a set-screw for twist drills, inasmuch as that, on account of the front rake on a twist drill, there is a strong tendency for the drill, as soon as the point emerges through the work, to run forward into the work and by ripping in become locked. This is very apt to be the case if there is any end play in the driving spindle, because the pressure of the cut forces the spindle back from the cut; but so soon as the drill point emerges and the pressure is reduced, the weight of the spindle acting in concert with the front rake on the drill causes the spindle to drop, taking up the lost motion in the opposite direction. In addition to this the work will from the same cause lift and run up the drill, often causing an increase in the duty sufficient to break the drill.

If the spindle has no lost motion and the work is bolted or fastened to the table or in a chuck, the drill if it has a taper shank only will sometimes run forward and slip loose in the driving socket. This, however, may be obviated by feeding the drill very slowly after its point emerges through the work.

Yet another form in which the cylindrical shanks of drills have been driven is shown in Fig. 1730. The shank is provided with a longitudinal groove turning at a right angle; at its termination the socket is provided with a screw whose point projects and fits into the shank groove. The drill is inserted and turned to the right, the end of the screw driving the drill and preventing it from coming out or running forward.

Flat drills are usually provided with a square taper shank such as shown in Fig. 1730, an average amount of taper being $1\frac{1}{4}$ inches per foot.

There are several disadvantages in the use of a square shank.

1st. It is difficult to forge the drill true and straight with the shank.

2nd. It is difficult to make the square socket true with the axial line of the machine spindle, and concentric with the same from end to end.

3rd. It is difficult to fit the shank of the drill to the socket and have its square sides true with the axial line of the drill.

4th. It is an expensive form of shank to fit. It is a necessity, however, when the cutting duty is very heavy, as in the case of stocks carrying cutters for holes of large diameter.

In order to properly fit a square shank to a socket it should be pressed into the socket by hand only, and pressed laterally in the

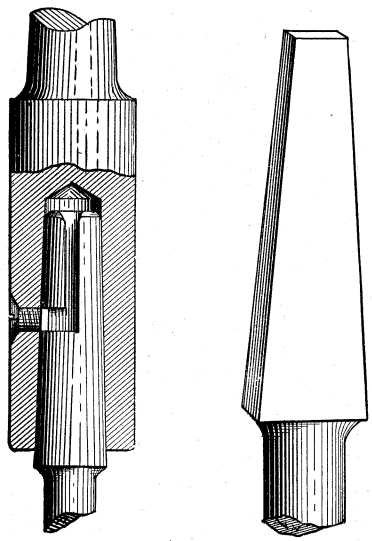


Fig. 1730.

direction of each side of the square. If there is no lateral movement the shank is a fit, and the spindle may be revolved to see if the drill runs true, as it should do if the body of the drill is true with the shank (and this must always be the case to obtain correct results). The drill must be tried for running true at each end of the cylindrical body of the drill, which, being true with the square shank, may be taken as the standard of truth in grinding the drill, so that supposing the hole in the driving spindle to be true and the drill shank to be properly fitted, the drill will run true whichever way inserted. If the body of the drill runs out of true it will cause a great deal of friction by rubbing and forcing the cuttings against the sides of holes, especially if the clearance be small or the hole a deep one.

In fitting the shank, the fitting or bearing marks will show most correctly when the shank is driven very lightly home, for if driven in too firmly the bearing marks will extend too far in consequence of the elasticity of the metal. If the hole in the spindle is not true with the axial line of the spindle, or if the sides of the hole are not a true square or are not equidistant from the axial line of the spindle, the drill must be fitted with one side of its square shank always placed to the same side of the square in the socket, and these two sides must therefore be marked so as to denote how to insert the drill without having to try it in the socket. Usually a centre-punch mark, as at E, Fig. 1731, is made on the drill and another on the collar as at *f*.

To enable the extraction of the drill from the socket the latter is provided with a slot, shown in figure at C, the slot passing through the spindle and the end of the drill protruding into the slot, so that a key driven into the slot will force the drill from the socket. The key employed for this purpose should be of some soft metal, as

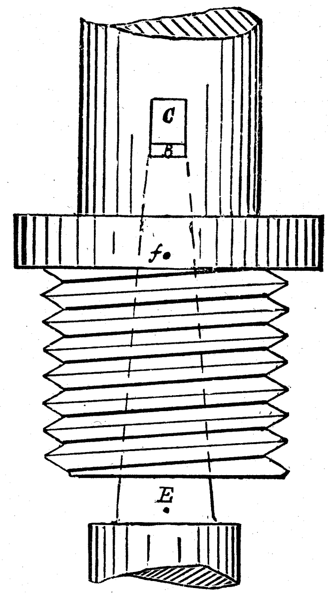


Fig. 1731.

brass or hard composition brass, so that the key shall not condense or press the metal of the keyway, and after the key is inserted it should be lightly tapped with a hammer, travelling in the direction of the line of the spindle and not driven through the keyway.

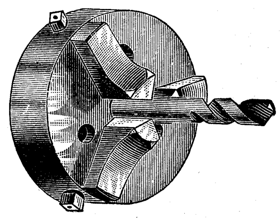


Fig. 1732.

The drill should not be given a blow or tap to loose it in the spindle, as this is sure in time to make its socket hole out of true.

The thread shown on the end of the drill spindle in figure is to receive chucks for holding and driving drills.

The various forms of small drill chucks illustrated in connection

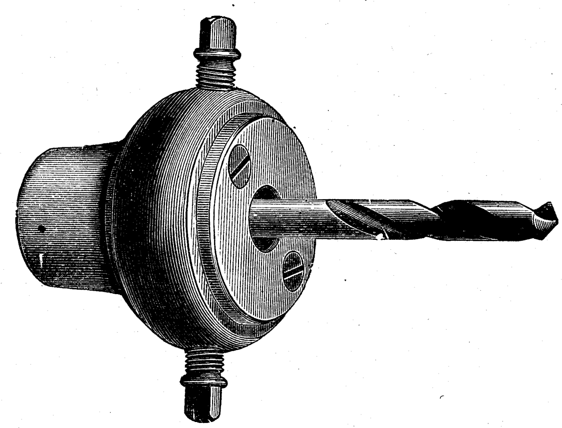


Fig. 1733.

with the subject of lathe chucks are equally suitable for driving drills in the drilling machine.

Fig. 1732, however, represents an excellent three-jawed chuck for driving drills, the bite being very narrow and holding the drill with great firmness.

Fig. 1733 represents a two-jawed drill chuck in which the screws operate a pair of dies for gripping parallel shank drills, the screws being operated independently.

In other forms of similar chucks the bite is a **V** recess parallel to the chuck axis, the only difference between a drill chuck for a drilling machine and one for a lathe being that for the former the jaws do not require outside bites nor to be reversible.

Holes that are to be made parallel, straight, cylindrically true in the drilling machine, are finished by the reamer as already described with reference to lathe work, and it is found as in lathe work that in order that a reamer may finish holes to the same

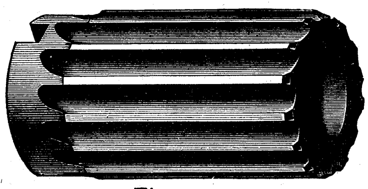


Fig. 1734.

diameter, it is necessary that it take the same depth of finishing cut in each case, an end that is best obtained by the use of three reamers, the first taking out the irregularities of the drilled hole, and the second preparing it for the light finishing cut to be taken by the third.

All the remarks made upon the reamer when considered with reference to lathe work apply equally to its use in the drilling machine.

Another tool for taking a very light cut to smooth out a hole and cut it to exact size is the shell reamer shown in Fig. 1734, which

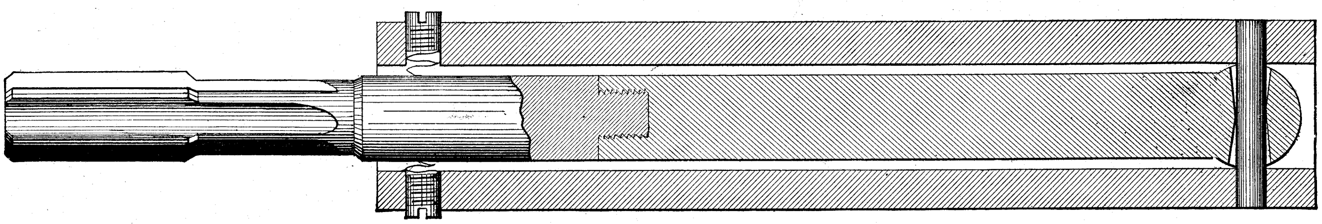
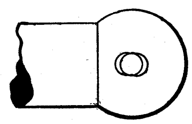


Fig. 1735.



fits on a taper mandrel through which passes a square key fitting into the square slot shown in the shell reamer.

Reamers may be driven by drill chucks, but when very true and parallel work is required, and the holes are made true before using the reamer, it is preferable to drive them by a socket that permits of their moving laterally. Especially is this the case with rose-bits. Fig. 1735, which is taken from *The American Machinist*, represents a socket of this kind, being pivoted at its driving or shank end, and supported at the other by two small spiral springs. The effect is that if the socket does not run quite true the reamer is permitted to adjust itself straight and true in the hole being reamed, instead of rubbing and binding against its walls, which would tend to enlarge its mouth and therefore impair its parallelism.

Cotter drills, slotting drills, or keyway drills, three names designating the same tool, are employed to cut out keyways, mortises, or slots.

Fig. 1736 represents a common form of cotter or keyway drill, the cutting edges being at A, A, and clearance being given by grinding the curve as denoted by the line C. In some cases a stock S and two detachable bits or cutters C, C, are used as in Fig. 1737, the bits being simple tools secured in slots in the stock by set-screws, and thus being adjustable for width so that they may be used to cut keyways of different widths.

The feed of keyway drills should be light, and especial care must be taken where two spindles are used, to keep them in line, or otherwise the keyway will not come fair, as is shown in Fig. 1738, where the half drilled from side A and that drilled from side B are shown not to come fair at their point of junction C. This is more apt to occur when a deep keyway is drilled one half from each side. Hence in such a case great care must be exercised in setting the work true, because the labor in filing out such a keyway is both tedious and expensive.

In producing holes of above or about two inches in diameter, cutters such as shown in Fig. 1739 may be employed. A is a stock

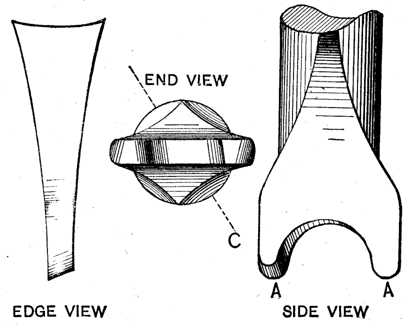


Fig. 1736.

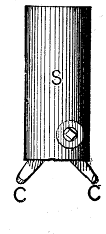


Fig. 1737.

carrying a cutter B secured in place by a key C. Holes are first drilled to receive the pin D, which serves as a guide to steady the stock. The amount of cutting duty is obviously confined to the production of the holes to receive the pin and the metal removed from the groove cut by the cutters, so that at completion of the cutter duty there comes from the work a ferrule or annular ring that has been cut out of the work.

For use on wrought iron or steel the front faces of the cutters may be given rake as denoted by the dotted line at E, and smooth and more rapid duty may be obtained if the cutter be set back, as in Fig. 1740, the cutting edge being about in a line with line A, in which case the front face may be hollowed out as at B, and take a good cut without the digging in and jumping that is apt to occur in large holes if the cutter is not thus set back. The

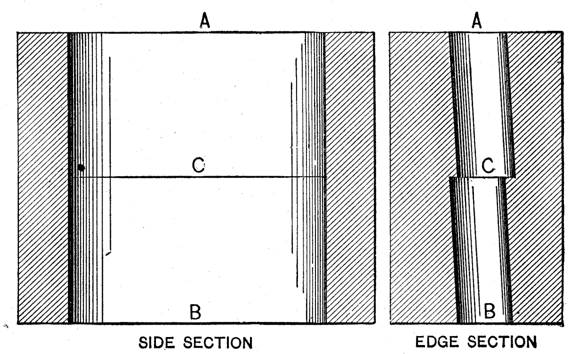


Fig. 1738.

larger the diameter of the work the greater the necessity of setting the cutting edge back, thus in Fig. 1741 the cutter is to be used to cut a large circle out of a plate P, as, say, a man-hole in a boiler sheet. The cutter C is carried in a bar B secured in the stock A by a screw, and unless the cutter is set well back it is liable to dip into the work and break.

It is obvious that the pin E in the figure must be long enough to pass into the hole in the plate before the cutter meets the plate surface and begins to cut, so that the pin shall act as a guide to steady the cutter, and also that in all cutters or cutter driving

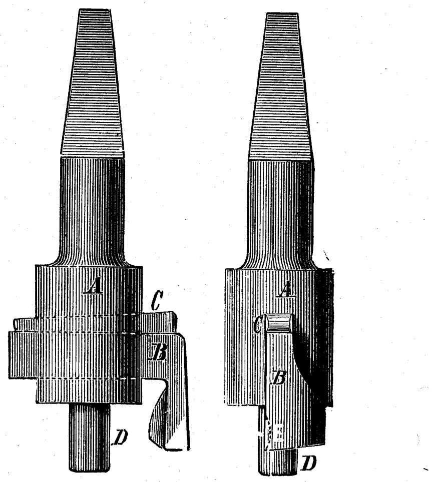


Fig. 1739.

stocks the shank must be either of large diameter or else made square, in order to be able to drive the cut at the increased leverage over that in drilling.

In these forms of tube plate cutters it is necessary to drill a hole to receive the pin D. But this necessity may be removed by

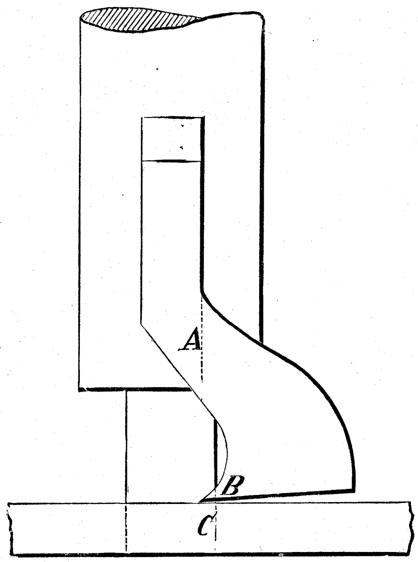


Fig. 1740.

means of a cutter, such as shown in Fig. 1742, which is given simply as a representative of a class of such cutters. A is a cutter stock having the two cutters B B fitted in slots and bolted to it. C is a spiral spring inserted in a hole in A and pressing

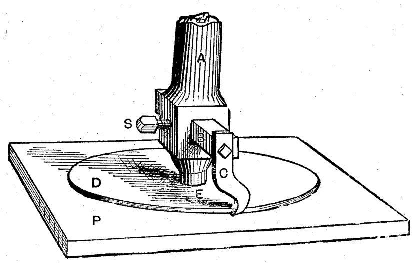


Fig. 1741.

upon the pin D, which has a conical point. The work is provided with a deep centre-punch mark denoting the centre of the hole to be cut. The point of D projects slightly beyond the cutting edges of the cutters, and as it enters the centre-punch mark in the work it forms a guide point to steady the cutters as they rotate. As the cutters are fed to their cut, the pin D simply compresses the spiral spring C and passes further up the cutter stock. Thus the point of D serves instead of a hole and pin guide.

A simple form of adjustable cutter is shown in Figs. 1743 and 1744. It consists of a stock A A with the shank B, made tapering

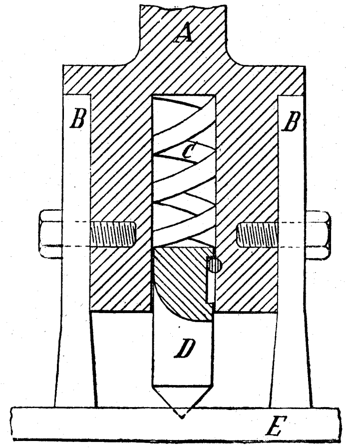


Fig. 1742.

to fit the socket of a boring or drilling machine. Through the body of the stock is a keyway or slot, in which is placed the cutter C, provided in the centre of the upper edge with a notch or recess. Into this slot fits the end of the piece D, which is pivoted upon the pin E. The radial edge of D has female worm teeth upon it. F is a worm screw in gear with the radial edge of D. Upon the outer

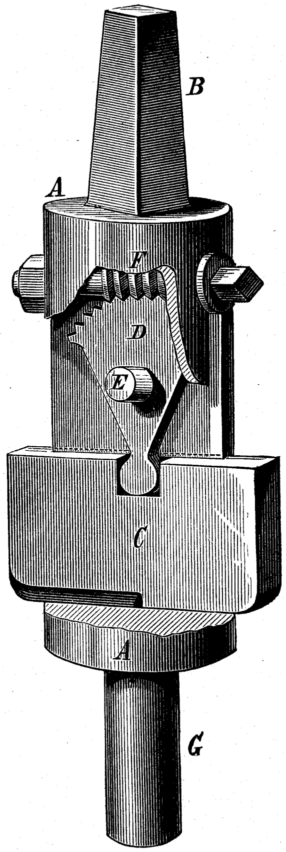


Fig. 1743.

end of F is a square projection to receive a handle, and it is obvious that by revolving the screw F, the cutter C will be moved through the slot in the stock, and hence the size of the circle which the cutter will describe in a revolution of the stock A may be determined by operating the screw F. Thus the tool is adjustable for different sizes of work, while it is rigidly held to any size without any tendency whatever either to slip or alter its form. The pin G is not an absolutely necessary part of the tool, but it is a valuable addition, as it steadies the tool. This is necessary when the spindle of the machine in which it is used has play in the bearings, which is very often the case with boring and drilling machines. The use of G is to act as a guide fixed in the table upon which the work is held, to prevent the tool from springing away from the cut, and hence enabling it to do much smoother work. It is usual to make the width of the cutter C to suit some piece of work of which there is a large quantity to do, because when the cutter is in the centre of the stock both edges may per-

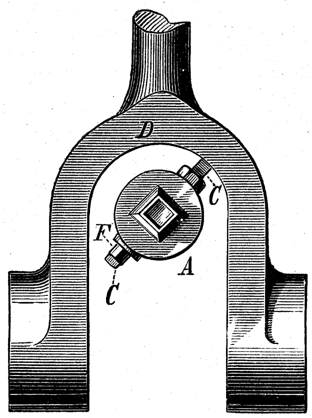


Fig. 1744.

form cutting duty; in which case the tool can be fed to the cut twice as fast as when the cutter is used for an increased diameter, and one cutting edge only is operative. The tool may be put between the lathe centres and revolved, the work being fastened to the lathe saddle. In this way it is exceedingly useful in cutting out plain cores in half-core boxes.

In addition to its value as an adjustable boring tool this device may be used to cut out sweeps and curves, and is especially adapted to cutting those of double eyes. This operation is shown in Fig. 1744, in which D is the double eye, A

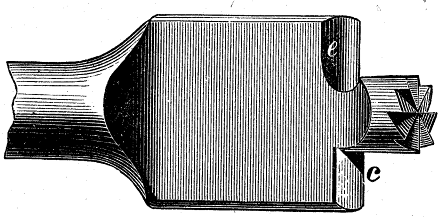


Fig. 1745.

is the tool stock, F is the adjusting screw, and C is the cutter. The circular ends of connecting rod strips and other similar work also fall within the province of this tool, and in the case of such work upon rods too long to be revolved this is an important item, as such work has now to be relegated to that slowest and most unhandy of all machine tools, the slotting machine.

It is obvious that any of the ordinary forms of cutter may be used in this stock.

For enlarging a hole for a certain distance the counterbore is employed. Fig. 1745 represents a counterbore or pin drill, in

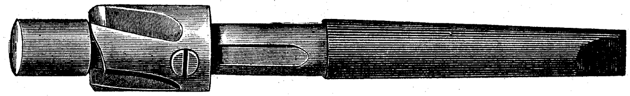


Fig. 1746.

which the pin is cut like a reamer, so as to ream the hole and insure that the pin shall fit accurately. The sides are left with but little clearance and with a dull edge, so that they will not cut, the cutting edges being at *e*, *c* and the clearance on the end faces.

For counterboring small holes or for facing the metal around their ends, the form of counterbore shown in Fig. 1746 is employed. The pin must be an accurate fit to the hole, and to capacitate one tool for various sizes of holes the bit is made interchangeable. The stock has a flat place on it to receive the pressure of the screw that secures the counterbore, and the end of the stock is reduced in diameter, so that the counterbore comes against a shoulder and cannot push up the stock from the pressure of the feed; the end of the counterbore is bored to receive the tit pin, thus making it permissible to exchange the pin, and use various sizes in the same counterbore.

Twist drills for use in wood work are given a conical point, as

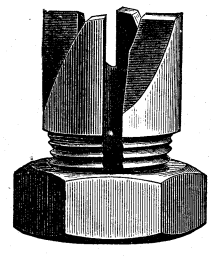


Fig. 1747.

was shown with reference to lathe drills, and when the holes are to be countersunk, an attachment, such as shown in Fig. 1747, may be used. It is a split and threaded taper, so that by operating the nut in one direction it may be locked to the drill, while by operating it in the other it will be loosened, and may be adjusted to any required distance from the point of the drill, as shown in Fig. 1748.

For larger sizes of holes a stock and cutter, such as shown in Fig. 1749, may be employed, receiving a facing or counterboring

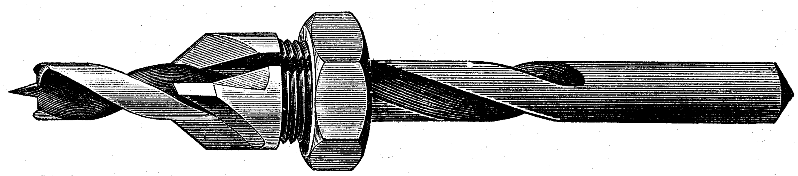


Fig. 1748.

cutter such as A, or a countersink bit such as B, and the bit may be made to suit various sizes of holes by making its diameter suitable for the smallest size of hole the tool is intended for, and putting ferrules to bring it up to size for larger diameters.

The cutters are fastened into the stock by a small key or wedge, as shown. By having the cutter a separate piece from the stock, the cutting edges may be ground with greater facility, while one stock may serve for various sizes of cutters. The slot in the stock should be made to have an amount of taper equal to that given to

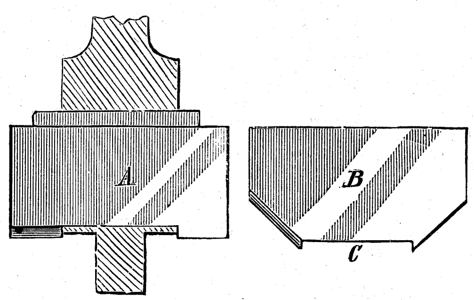


Fig. 1749.

the key, so that all the cutters may be made parallel in their widths or depths, and thus be more easily made, while at the same time the upper edge will serve as a guide to grind the cutting edges parallel to, and thus insure that they shall stand at a right angle to the axis of the stock, and that both will therefore take an equal share of the cutting duty.

When cutters of this kind are used to enlarge holes of large diameter it is necessary that the pin be long enough to pass down into a bushing provided in the table of the machine, and thus steady the bar or stock at that end.

For coning the mouths of holes the countersink is employed, being provided with a pin, as shown in Fig. 1750; and it is obvious that the pin may be provided with bushings or ferrules. The smaller sizes of countersinks are sometimes made as in

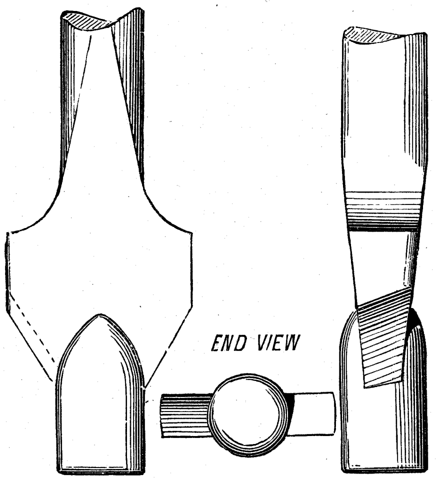


Fig. 1750.

Fig. 1751, the coned end being filed away slightly below the axis so as to give clearance to the cutting edge.

Fig. 1752 refers to a device for drilling square holes. The chuck for driving the drill is so constructed as to permit to the drill a certain amount of lateral motion, which is rendered

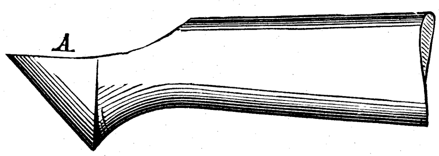


Fig. 1751.

necessary by the peculiar movement of the cutting edges of the drill which does not rotate on a fixed central point, but diverges laterally to a degree proportional to the size of the hole. For the chuck the upper part of the cavity of a metal cylinder is bored out so as to fit on the driving spindle. Below this bore a square

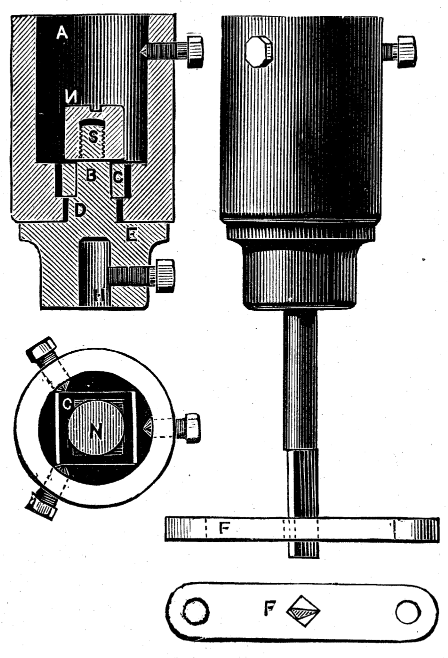


Fig. 1752.

recess is made, and below this latter and coming well within the diameter of the square recess, is a circular hole passing through the end of the chuck. The drill holder or socket is in a separate piece, the bottom portion of which is provided with a square or round recess for holding the drill shanks, and is held firmly in its socket by means of a set-screw. The upper part of the socket consists first of a screw (Fig. 1752) at S; secondly, of a squared shoulder B; thirdly, of a cylindrical shoulder D, and the circular part E, the drill shank being inserted at H. N is a nut holding the drill socket in the chuck. The socket being inserted in the chuck, the loose square collar C, which has an oblong rectangular slot in it, is put in, passing over the squared part of the socket. The nut N is then screwed up, bringing the face of E up to the face of the chuck, but not binding C, because C is thinner than the recess in which it lies. When this is done the socket will readily move in a horizontal plane to such a distance as the play between the two sides of the loose collar C and two of the sides of the recess will permit, while in the other direction it will move in a horizontal plane such distance as the play between the two sides of the square shoulder of the socket and the ends of the rectangular slot in the loose collar C will permit. The amount of this horizontal motion is varied to suit the size of the square hole to be drilled. Near to the lower end or cutting edges of the drill, there is fixed above the work a metal guide plate F having a square hole of the size requiring to be drilled. The drill is made three-sided, as

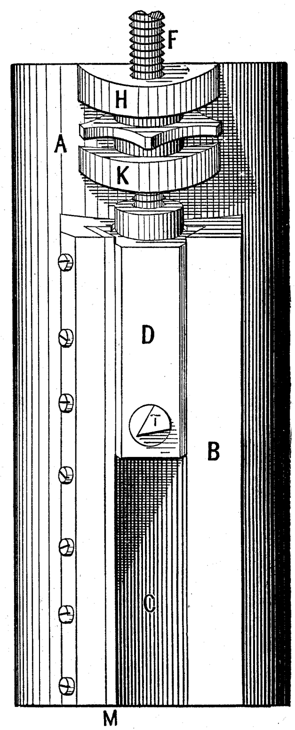


Fig. 1753.

shown, the dimensions of the three sides being such that the distance from the base to the apex of the triangle is the same as the length of the sides of the hole to be drilled. The drill may then be rotated through F as a guide, when it will drill a square hole.

The method of operation is as follows: The three-sided drill being fixed in the self-adjusting chuck, the guide bar with the square guide hole therein rigidly fixed above the point in the work where it is required to drill, the drilling spindle carrying the chuck drill is made to revolve, and is screwed or pressed downwards, upon which the drill works downwards through the square guide hole, and drills holes similar in size and form to that in the guide. The triangular drill for drilling dead square holes may also be used without the self-adjusting drill chuck in any ordinary chuck, when the substance operated upon is not very heavy nor stationary; then, instead of the lateral movement of the drill, such lateral movement will be communicated by the drill to the substance operated upon.

In making oblong dead square-cornered holes, either the substance to be operated upon must be allowed to move in one direction more than another, or the hole in the guide plate must be made to the shape required, and the drill chuck made to give the drill greater play in one direction.

The boring bars and cutters employed in drilling and boring machines are usually solid bars having fixed cutters, the bars feeding to the cut.

Figs. 1753, 1754, 1755, and 1756, however, represent a bar having a device for boring tapers in a drilling or boring machine.

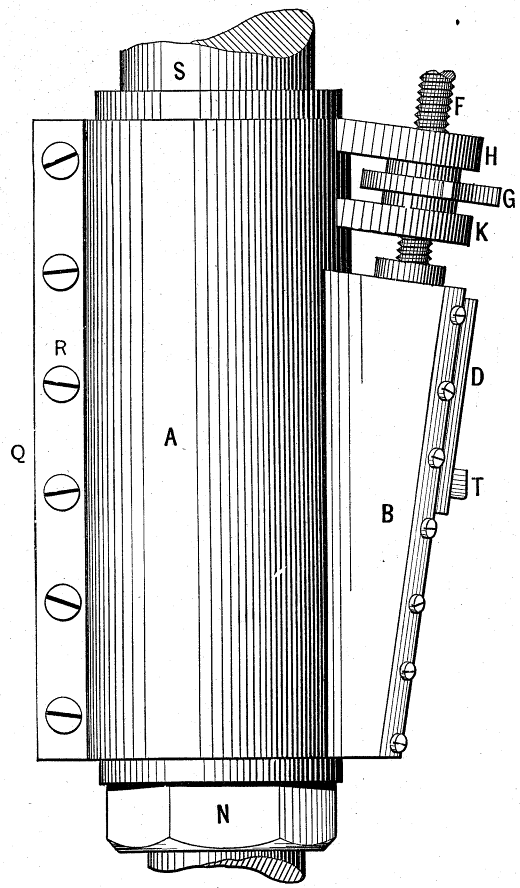


Fig. 1754.

It consists of a sleeve A fixed to the bar S, and having a slideway at an angle to the bar axis. In this slideway is a slide carrying the cutting tool and having at its upper end a feed screw with a star feed. Fig. 1753 shows the device without, and Fig. 1754 with, the boring bar. A is a sleeve having ribs B to provide the slideway C for the slide D carrying the cutting-tool T. The feed screw F is furnished with the star G between two lugs H K. A stationary pin bolted upon the work catches one arm of the star

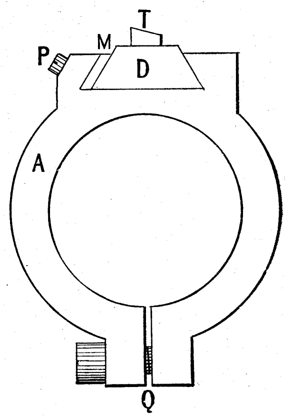


Fig. 1755.

at each revolution of the bar, and thus puts on the feed. To take up the wear of the tool-carrying slide, a gib M and set-screws P are provided, and to clamp the device to the boring-bar it is split

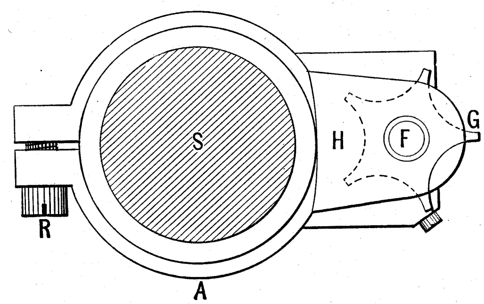


Fig. 1756.

at Q and furnished with screws R. The boring-bar S, furthermore, has a collar at the top and a nut N at the bottom. The tool, it will be observed, can be closely held and guided, the degree of taper of the hole bored being governed by the angle of the slideway C to the axis of the sleeve.