Chapter X.—CUTTING TOOLS FOR LATHES.

THE cutting tools for lathes are composed of a fine grain of cast steel termed "tool-steel," and are made hard, to enable them to cut, by heating them to a red heat and dipping them in water, and subsequently reheating them to temper them or lower their degree of hardness, which is necessary for weak tools.

These cutting tools may be divided into two principal classes, viz., slide rest tools, or those held in the slide rest, and hand tools, which are held by hand.

The latter, however, have lost most of their former importance

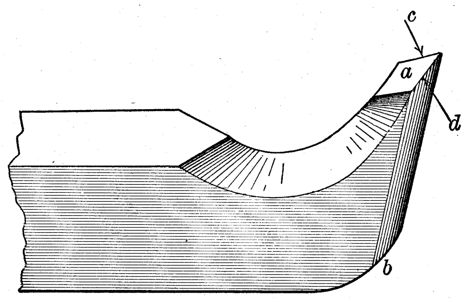


Fig. 916.

in the practice of the machine shop, by reason of the employment of self-acting lathes.

The proper shape for lathe slide rest tools depends upon—

1st. The kind of metal to be cut.

2nd. Upon the amount of metal to be cut off.

3rd. Upon the purpose of the cut, as whether to rough out or to finish the surface.

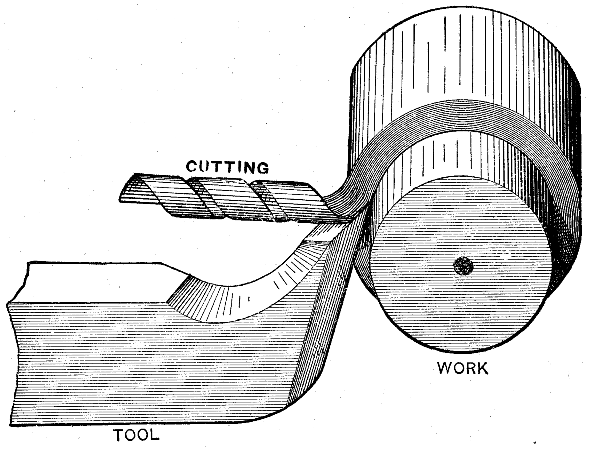


Fig. 917.

4th. Upon the degree of hardness of the metal to be cut.

5th Upon the distance the tool edge is required to stand out from the tool clamp, or part that supports it.

Lathe tools are designated either from the nature of their duty, or from some characteristic peculiar to the tool itself.

The term "diamond point" is given because the face of the tool is diamond shaped; but in England and in some practice in the United States the same tool is termed a front tool, because it is employed on the front of external work.

A side tool is one intended for use on the side faces of the work, as the side of a collar or the face of a face plate. An outside tool is one for use on external surfaces, and an inside one for internal, as the walls or bores of holes, &c.

A spring tool is formed to spring or yield to excessive pressure rather than dig or jump into the work.

A boring tool is one used for boring purposes.

The principal forms of cutting tools for lathes are the diamond points or front tools, the side tools (right and left), and the cutting off or parting tool. The cutting edges of lathe tools are formed by grinding the upper surface, as *a* in Fig. 916, and the bottom or side faces as *b*, so that the cutting edges *c* and *d* shall be brought to a clean and sharp edge, the figure representing a common form of front tool. The manner in which this tool is used to cut is shown in Fig. 917, in which the work is supposed to be revolved between the lathe centres in the manner already described with reference to driving work in the lathe. The tool is firmly held in the tool post or tool clamp, as the case may be, and is fed into the work by the cross-feed screw taking a cut to reduce the work diameter and make it cylindrically true; the depth to which the tool enters the work is the depth of the cut. The tool is traversed, or fed, or moved parallel to the work axis, and the motion in that is termed the feed, or feed traverse.

The cutting action of the tool depends upon the angles one to the other of faces B, D (Fig. 918), and the position in which they are

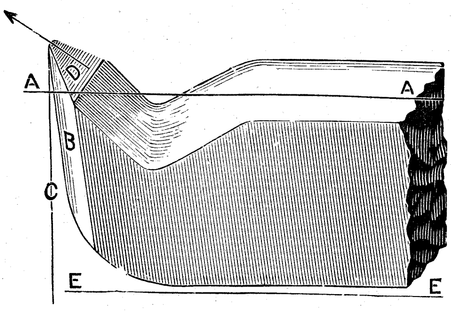


Fig. 918.

presented to the work, and in discussing these elements the face D will be termed the top face, and its inclination or angle above an horizontal line, or in the direction of the arrow in Fig. 918, will be termed the rake, this angle being considered with relation to the top A A, or what is the same thing, the bottom E E of the tool steel. The angle of the bottom face B to the line C is the bottom rake, or more properly, the clearance.

In the form of diamond point or front tool, shown in Fig. 916, there is an unnecessary amount of surface to grind at *b*, hence the

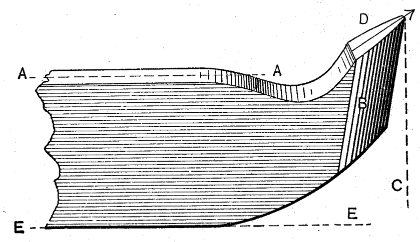


Fig. 919.

form shown in Fig. 919 is also employed on light work, while it is in its main features also employed on large work, hence it will be here employed in preference to that shown in Fig. 916, the cutting action of the two being precisely alike so long as the angles of the faces are equal in the two tools.

The strength of the cutting edge is determined by the angles of the rake and clearance, but in this combination the clearance has the greater strength value. On the other hand the keenness of the tool though dependent in some degree upon the amount of clearance, is much more dependent upon the angle of the top face.

It follows therefore that for copper, tin, lead, and other metals that may be comparatively easily severed, a tool may be given a maximum of top rake, and it is found in practice that top rake can be employed to advantage upon steel, wrought iron, and cast iron, but the amount must be decreased in proportion as the nature of either of those metals is hard.

For the combinations of copper and tin which are generally termed brass or *composition*, either no top rake or negative top rake is employed according to the conditions.

It may be pointed out, however, that in a given tool the cutting qualification is governed to a great extent by the position in which the tool is presented to the work, thus in Fig. 920, let C represent a piece of work and B, B, B, B, four tools having their

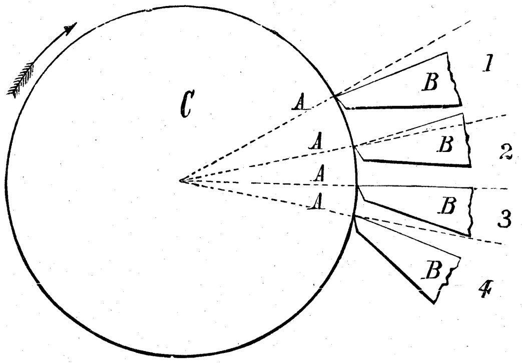


Fig. 920.

top and bottom faces ground at the same angle to each other. In position 1, the top face of the tool is at an acute angle below the radial line A, hence the tool possesses top rake, the amount being about suitable for hard steel or hard cast iron.

In position 2 the top face is at an acute angle above the radial line A, hence the tool has negative top rake, the amount being about suitable for brass work under some conditions.

In position 3 the top face has no rake of any kind, and the tool is suitable (in this respect) for ordinary brass work.

In position 4 the tool possesses an amount of top rake about suitable for ordinary wrought-iron work.

If the tool was presented to brass work in positions 1 or 4 it would rip or tear the metal instead of cutting it, while if the tool was presented to iron or steel (of an ordinary degree of hardness) in positions 2 or 3, it would force rather than cut the metal.

Furthermore it will be readily perceived that though each tool

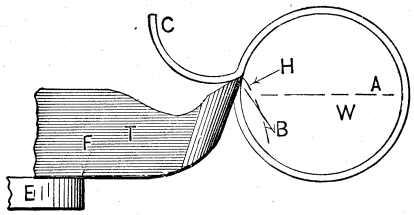


Fig. 921.

may have its faces, whose junction forms the cutting edge, at the same angles, yet the strength of the cutting edge is varied by the position in which the tool is presented to the work, thus the edge in position 2, will be weaker than that in position 4.

We have now to consider another point bearing upon the proper presentment of top rake and the presentment of the tool to the work. It is obvious that the strain of the cut falls upon the top face of the tool, and therefore the direction in which this strain is exerted is the direction in which the tool will endeavour to move if the strain is sufficient to bend the tool and cause motion.

In Fig. 921 let W represent the work having a cut C being taken off by the tool T; let E represent the slide rest, and F the extreme point at which the tool is supported; then the pressure placed by C on the top face of the tool will be at a right angle to the plane of that top face, or in the direction of the arrow B; to whatever amount therefore the tool sprung under the cut pressure (its motion being in an arc of a circle, of which F is the centre) it would enter the work deeper, and as a result, the rough work not being cylindrically true, the tool will dip farthest beyond its proper line of work where the cut is deepest, and therefore will not cut the work cylindrically true; as this, however, naturally leads to a variation in the direction of the top rake, and as the cutting action of the point of such a tool differs from that of the side edge, which also leads to a variation in the direction of the top rake, it becomes

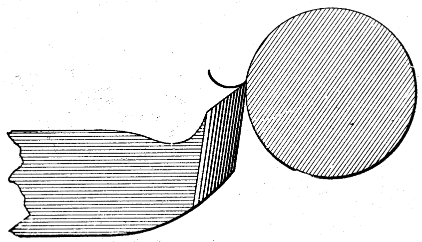


Fig. 922.

necessary to consider just what the cutting action is both at the point and on the side of the tool.

Suppose, then, that the tool carries so fine a cut that it cuts at the point only, and the pressure will be as denoted by the arrow B in Fig. 921.

If the tool be given no traverse, but be merely moved in towards the centre of the work, the cut will move outward and in a line with the body of the tool, the cutting coming off as shown in Fig. 922.

So soon, however, as the tool is fed to its feed traverse the form

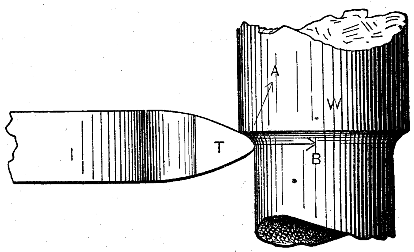


Fig. 923.

of the cutting alters to the special form shown in Fig. 917, and moves to one side of the tool, as well as outwards from the work.

Fig. 923 is a top view of a tool and piece of work, and the arrow A denotes the direction of the resistance of the work to the cut, being at a right angle to plane of the cutting edge.

Now the duty of the side edge is simply to remove metal, while that of the point is to finish the surface, and it is obvious that for finishing purposes the most important part of the tool edge is the point, and this it is that requires to be kept sharp, hence the angle or rake should be in the direction of the point. But when

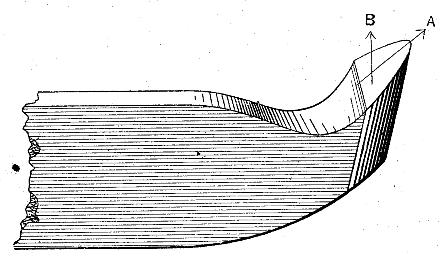


Fig. 924.

the object is to remove metal and prepare the work for the finishing cut the duty falls heavily on the side edge of the tool, and the angle of the top face and the direction of its rake may be varied with a view to increase the efficiency of the side edge, and at the same time to diminish the amount of power necessary to pull the tool along to its feed traverse. This may be accomplished by altering the top rake from front to side rake, which is done in varying degrees according to the nature of the work.

In Fig. 924 the angle of the top face in the direction of A is the front, and that in the direction of B is the side rake.

In small work where the cuts are not great, and where but one roughing cut is taken, it is an object to have the roughing cut leave the work with as smooth a surface as possible, and the amount of side rake may be small as in Fig. 924. For heavy deep cuts, however, a maximum of side rake may be used.

Thus in Fig. 925 is an engraving of a tool used for roughing in the Morgan Iron Works, its top rake being all side rake.

When a tool has side rake, its cutting capacity is obviously increased on one side only, hence it should be fed to cut on that

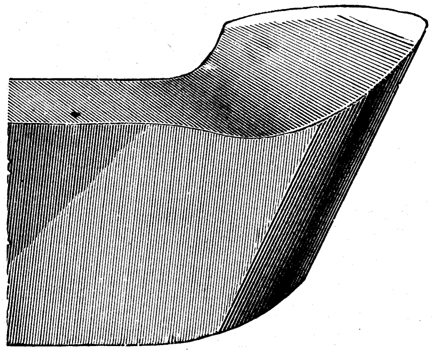


Fig. 925.

side only. It is for this reason that no side rake is given to tools for very small and short work, because it is then more convenient to traverse the tool to cut in either direction at will.

In long and large work, however, where the motion of the slide rest is slow, tools having right and left-hand side rake are used. The tools in Figs. 924 and 925 are right-hand tools, their direction of feed travel being to the left.

In Fig. 926 is a left-hand tool, its direction of feed traverse

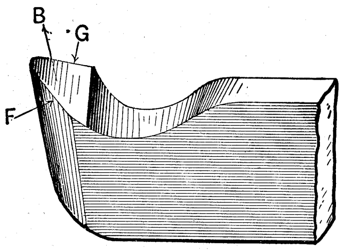


Fig. 926.

being from left to right; hence edge G is the cutting one, edge F being dulled by the side angle B.

It is obvious that various combinations of side rake and front rake may be given to produce the same degree of keenness to the tool. For example, a tool may have its keenness from side rake alone, or it may have the same degree of keenness by using

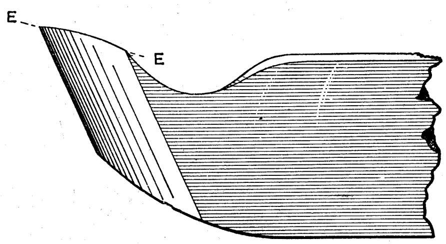


Fig. 927.

less side rake and some front rake. The principles governing the selections of these combinations are as follows :—

Suppose that in addition to say 20 degrees of side rake a tool is given a certain amount of front rake as denoted in Fig. 927 by E E, and suppose that the tool is moved in to its cut by the cross feed screw. During this motion and until the tool point meets the work surface the contact between the cross feed screw and feed nut will be on the sides of the threads facing the line of lathe centres, and all the play between those threads will be on their other sides, but so soon as the tool meets the cut it will jump forward and into the work to the amount that the play between the threads will allow it, and this is very apt to cause the tool to break. Furthermore the point of the tool is apt from its extreme keenness to become dulled quickly.

The amount of side rake may, however, be considerably increased if the heel D, Fig. 928, be made higher than the point A in that

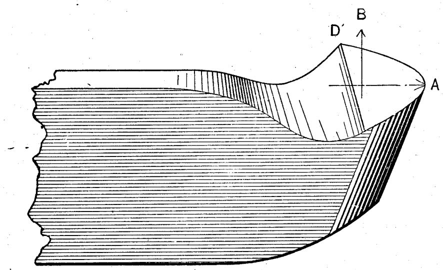


Fig. 928.

figure, the plane of the middle being denoted by the arrow at A; a view of the other side of this tool is shown in Fig. 929, the plane of the cutting edge being denoted by the dotted line.

A tool thus formed will require a slight cross feed screw pressure to force it to its cut, thus causing the cross feed nut to have contact with the sides of the thread in contact when winding the tool into its cut, hence the tendency to jump into the depth of cut

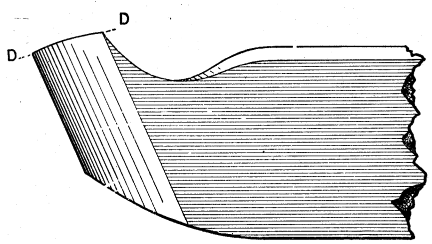


Fig. 929.

is eliminated, and regulating the depth of the cut is much more easily accomplished.

In proportion as a tool is given side rake, it is more easily traversed to its cut, as will be perceived from the following :—

Fig. 930 represents a section of a tool T, whose feed traverse is in the direction of A. Now all the force that is expended in bending the cutting C out of the straight line, or in other words the pressure on the top face of the tool, acts to a great extent to force the tool to the left, and therefore traverse it to its feed. The more side rake a tool has the nearer the thickness of its cutting will accord to the thickness of the feed traverse. For example, if a

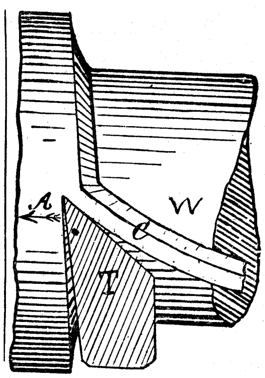


Fig. 930.

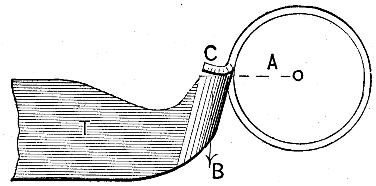


Fig. 931.

tool having a side rake of say 35 degrees of angle feeds forward $\frac{1}{32}$ inch per work revolution, the thickness of the cutting will but slightly exceed $\frac{1}{32}$ inch, but if no top rake at all be given, as shown in Fig. 931, then the cutting will come off nearly straight, will be considerably thicker than $\frac{1}{32}$ inch, and will be ragged and broken up, and it follows that the thickening and the bending of the cutting has required an expenditure of the driving power of the lathe, diminishing the depth of cut the lathe will be capable of driving. With such a tool the pressure of the cut will fall downwards as denoted by the arrow B.

In the practice of many tool makers in the Eastern States the tool is ground to a point A, Fig. 932, that is, ground sharp and merely rounded off with an oil-stone. This may serve when the lathe has an exceedingly fine feed, and the strain being in that case very slight the tool point may be made to stand well above the level of the body of the steel, as in the figure, and thus save forging; but this is a slow method of procedure, and produces no better work than a tool which is rounded at the point, and therefore capable of producing smoother work with a much coarser feed.

The diameter of the curls of the cutting, shaving, or chip produced by a turning and also the direction in which it moves after

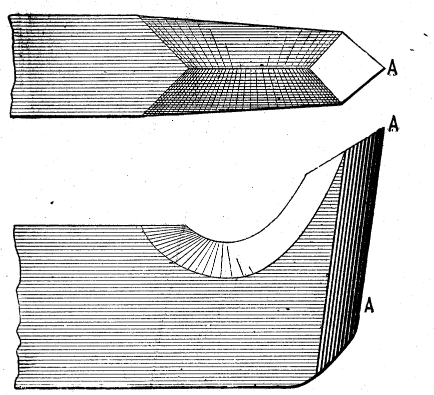


Fig. 932.

leaving the tool, depends upon the amount of the top rake and the direction in which it is provided. The greater the amount of rake, whether it be front or side rake, the larger the coils of the cutting, and, therefore, the less the amount of power expended in bending it. Furthermore, it may be remarked that the thickness of the cutting is always greater than is due to the amount of feed traverse, and it requires power to produce this thickening of the cutting. The larger the coils of the cutting the nearer the thickness accords with the rate of feed.

In these considerations we have referred to the angle of the top face only, but if we consider the angle of the two faces one to the other we shall see that they form a wedge, and that all cutting tools are simply wedges which enter the material the more easily

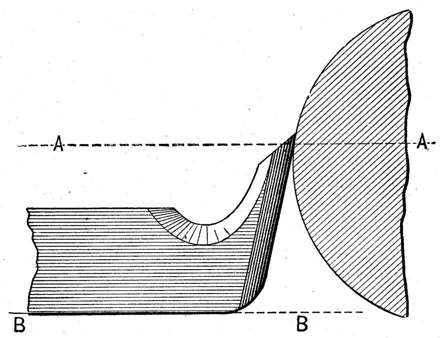


Fig. 933.

in proportion as the angles are more acute, providing always that they are presented to the work in the most desirable position, as was explained with reference to Fig. 920.

We may now consider the degree of a bottom rake or clearance desirable for a tool, and this it can be shown depends entirely upon the conditions of work, diameter, and rate of tool traverse, and cannot, therefore, be made a constant degree of angle. This is shown in Fig. 934, in which a tool T is represented in three positions, marked respectively 1, 2, and 3. Line A A is at a right angle to the axis of the work W, and the side of the tool is given in each case 5° of angle from this line A A. In position 1 the tool has 3° of clearance from the side of the cut; in position 2 it has 2° clearance, but in position 3 it would require to have 2° more clearance given to it to enable the cutting-edge to meet the side of the cut, without even then having the clearance necessary to enable it to cut. This occurs because the side of the cut is not at a right angle to the work axis, but at an angle the degree of which depends upon the rate of feed.

Thus in Fig. 935 the three tools have the same amount of clear-

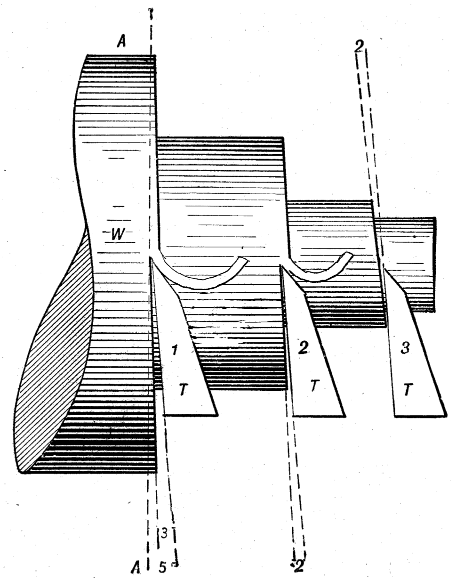


Fig. 934.

ance, and if they are supposed to be facing off the work they will maintain that clearance under all conditions of work, diameter, and rate of feed, but if they were traversed along instead of across the work the angle of the tool (both on the top and bottom face)

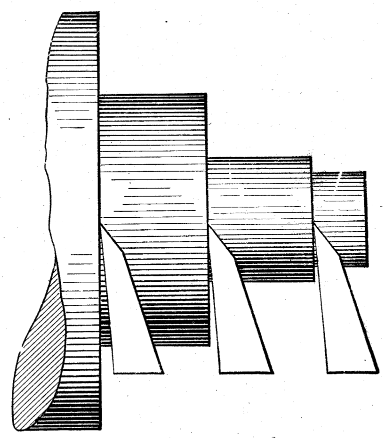


Fig. 935.

to the cut will become changed, and will continue to change with every change of work diameter, so that the same tool stands at a different angle at each successive cut taken off the work, even though the lathe were used at or possessed but one rate of feed.

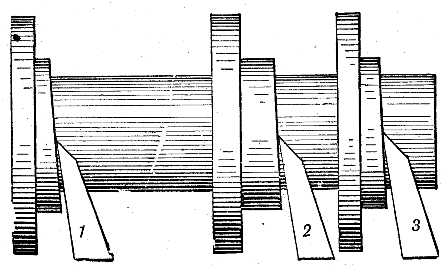


Fig. 936.

But lathe tools are used at widely varying rates of feed, and we may therefore take an example in which a tool is at work taking a cut of the same diameter and depth at different rates of feed.

This is shown in Fig. 936, tool 1 taking the coarsest, and 2 the finest feed, and it is seen that the finer the rate of feed the more clearance the tool has with a given degree of side clearance (for all the three tools have $7°$ of side angle). The only way to obtain an equal degree of clearance from the cut, therefore, clearly lies in giving to a tool a different angle for every variation, either in work diameter or in rate of feed traverse, and to show how much this will affect the shape of the tool, we have Fig. 937, in which the same rate of feed is used for all three cuts, and the tool is given in each position $5°$ of clearance from the cut. In position 1 the tool side stands at $8\frac{1}{2}°$ of angle from line A, which is at a right angle to the work axis. In position 2 it stands at $10\frac{1}{2}°$, and in position 3 at $15°$ of angle from line A, a variation of $6\frac{1}{2}°$. Referring now to the top face of the tool, the variations occur to the same

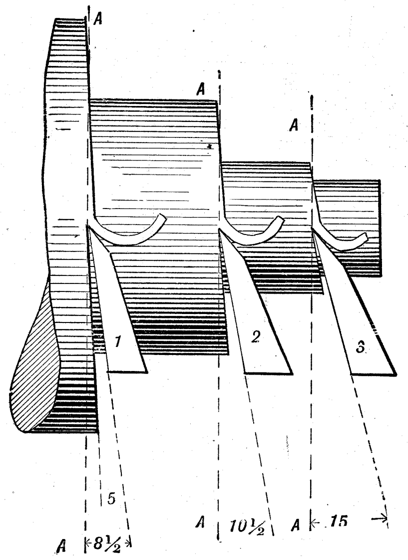


Fig. 937.

extent and from the same causes. It is in a fine degree of perception of these points that constitutes the skill of expert workmen in grinding their lathe tools, varying the angle of the tool at every grinding to suit the varying requirements.

It has been shown that for freedom of cutting and ease of driving a given cut, the direction of top rake as well as its degree needs to be a maximum that the nature of the material and its degree of hardness will admit; but this is not the only consideration, because in a finishing cut the surface requires to be left as smooth and clean cut as possible, and it remains to consider how this may best be accomplished. Now let it again be considered that it is that part of the cutting edge that lies at a right angle to the axial line of the work that removes the metal, while it is that

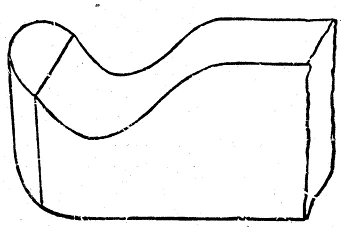


Fig. 938.

part that lies parallel to the work axis (or in other words parallel to the finished work surface) that performs the finishing cutting duty.

Now, in proportion as the length of the cutting edge is disposed parallel to the work axis, the tool has a tendency to spring (under an increase of cut) into the work, and also to dip into soft places or seams in the work, and the amount of its front rake must be decreased, because such rake causes a pressure pulling the tool deeper into its cut, as was explained with reference to Fig 921. Round-nosed front tools, therefore, such as in Fig. 938, cannot be given so much front rake as ordinary ones, such as in the preceding figures.

Round-nosed tools are used to cut out round corners, and the roughing tools are given a less curvature than that to be formed on the work, thus in Fig. 939 is an ordinary form of small round nose shown operating in what is termed a hollow corner, the directions of tool feed being marked by arrows. The tool may be fed by the feed traverse, and the tool gradually withdrawn, thus forming the work to the required curve.

The amount of cut a lathe will drive, the degree of hardness which the tool may be given, the length of time the tool will last

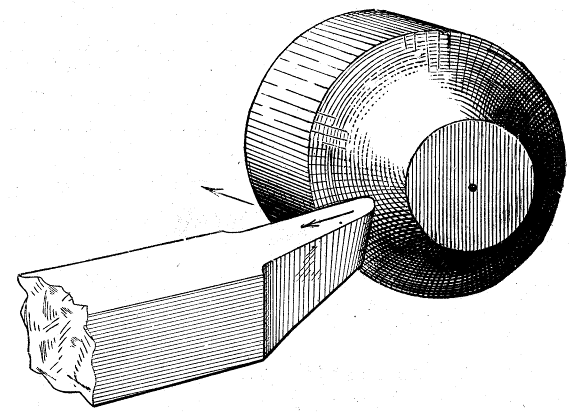


Fig. 939.

without grinding, the speed at which the work may run, and the cleanness and truth of the cut, depend almost entirely upon the perfect adaptability of the tool to the conditions under which it is to be used. Upon the same kind of work, and using the same kind of tools, some workmen will give a tool from $20°$ to $30°$ more angle than others.

It is a difficult matter to determine at just what point the utmost duty is being obtained from cutting tools, because the conditions

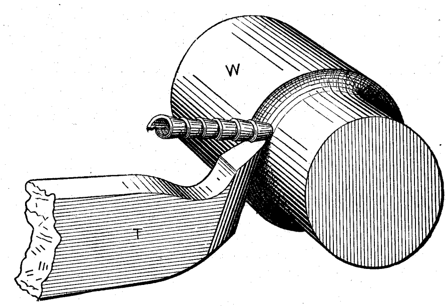


Fig. 940.

of use are so variable; but one good general guide is the speed at which the tool cuts, and another is the appearance of the cuttings or chips.

Both these guides, however, can only be applied to metal not unusually hard, and to tools rigidly held, and having their cutting edges sufficiently close to the tool point or clamp that the tool itself will not bend and spring from the pressure of the cut. The cutting speed for chilled cast-iron rolls, such, for example, as

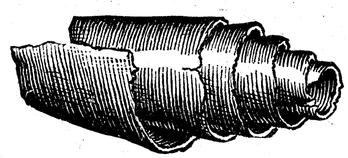


Fig. 941.

calender rolls, is but about 7 feet per minute, and the angles one to the other of the tool faces is about 75 degrees, the top face being horizontally level, and standing level with the axis of the roll.

When a tool has front rake only, the form of its cutting will depend upon the depth of its cut. With a very fine cut the cutting will come off after the manner shown in Fig. 940, while as the depth of the cut is increased, the cutting becomes a coil such as shown in Fig. 941. These coils lie closer together in proportion as the top face of the tool is given less rake, as is necessary for steel and other hard metal. Thus Fig. 940 represents a cutting from steel, the tool having front rake only, while Fig. 941 represents

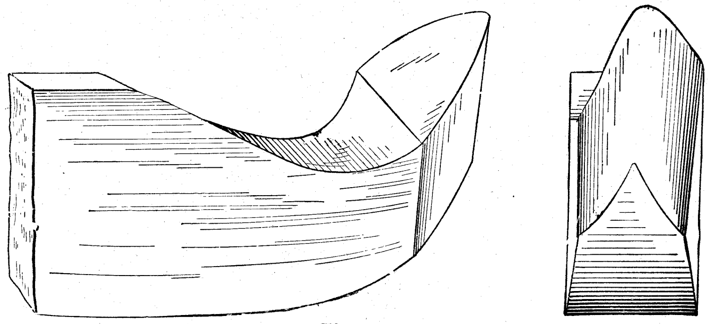


Fig. 942.

a cutting from a steel crank pin, the tool having side rake. The following observations apply generally to the cuttings.

The cleaner the surface of a cutting, and the less ragged its edges are, the keener the tool has cut; thus, in Fig. 941, the raggedness shows that the tool was slightly dulled, although not

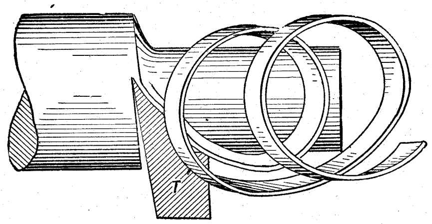


Fig. 943.

sufficiently so to warrant the regrinding of the tool. Such a cutting, however, taken off wrought iron would show a tool too much dulled, or else possessing too little top rake to cut to the best advantage. In wrought iron, the tool having a keener top

In Fig. 945 the point of the tool is made considerably lower than the point B, and as a result the cutting would rise somewhat vertically as in Fig. 946. Indeed the heel B may be raised so as to cause the cutting to move but little to the right, but rise up almost vertically, being thrown over towards the work, and in extreme cases the cutting will rub against the surface of the work and the friction will prevent the cutting from moving to the right, hence it will roll up forming a ball, the direction of the rotation occasionally changing.

Whatever irregularities may appear in the coil of the cuttings

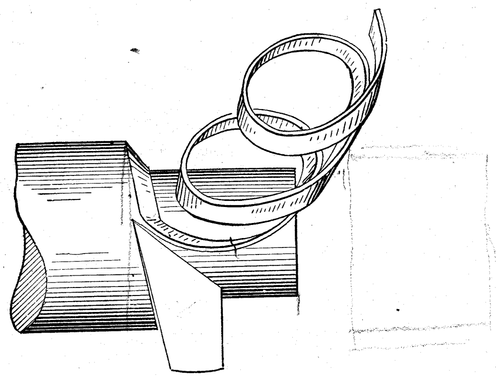


Fig. 946.

will, if the tool is not dulled from use, arise from irregularities in the work and not from any cause attributable to the tool.

The strength of a cutting forms to a great extent a guide as to the quality of the tool, since the stronger the cutting the less it has become disintegrated, and therefore less power has been expended in removing it from the work.

The cutting speed for wrought iron should be sufficiently great that water being allowed to fall upon the work in a quick succession of drops as, say, three per second, the cuttings will leave the work so hot as to be almost unbearable in the hands, if the cut is

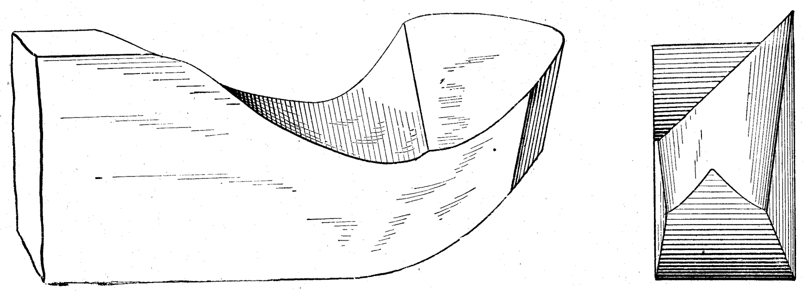


Fig. 944.

face, the cuttings will coil larger, and the direction in which they coil and move as they leave the tool will depend upon the shape of the tool and its height to the work.

In Fig. 942, for example, is a tool having front and side angle in about an equal degree, and its cutting is shown in Fig. 943,

a heavy one, as, say, reducing the work diameter $\frac{1}{2}$ inch at a cut.

If wrought-iron cuttings break off in short pieces it may occur from black seams in the work, but if they break off short and show no tendency to coil, the tool has too little rake. If the tool

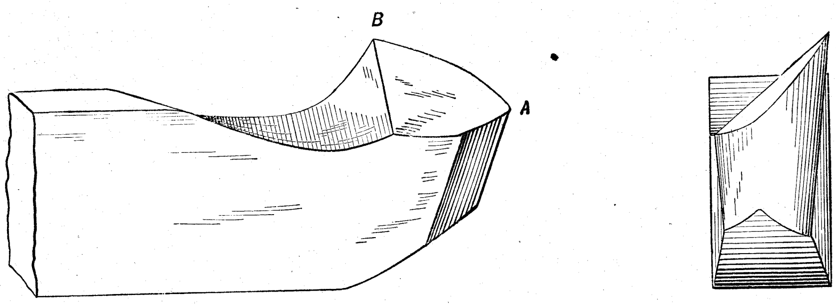


Fig. 945.

the side angle causing it to move to the right, and the front angle causing it to move towards the tool post.

The tool in Fig. 944 has side rake mainly, and the point is slightly depressed, hence its cutting would leave the work moving horizontally and towards the right hand.

gets dull too quickly and the cutting speed is not excessive, then the tool has too much clearance. If the tool edge breaks there is too much rake (providing of course that the tool has not been burnt in the forging or hardening), a fine feed will generally produce longer and closer coiled cuttings (that is of smaller diameter) than a coarse feed, especially if the work be turned dry or without the application of water.

Aside from these general considerations which apply to all tools, there are peculiar characteristics of particular metals; thus, for example, cast iron will admit of the tool having a greater width of cutting edge in a line with the finished surface of the metal than either steel, wrought iron, copper or brass, which renders it possible to use a finishing tool of the form shown in

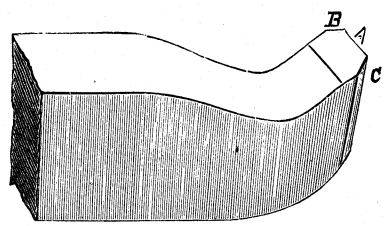


Fig. 947.

Fig. 947, whose breadth of cutting edge A, lying parallel with the line of feed traverse, may always exceed that for other metals, and may in the case of cast iron be increased according to the rigidity of the work, especially when held close in to the tool post.

The corners B C may for roughing the work be rounded so as to be more durable, but for finishing cuts they should be bevelled as shown, because by this means face A can more easily be left straight than would be the case with a rounded corner. In the

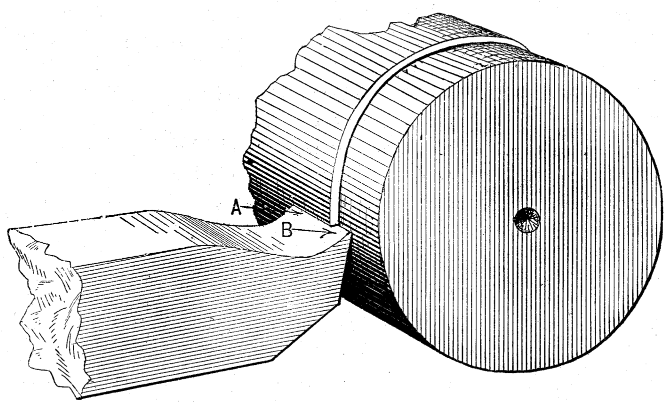


Fig. 948.

absence of the bevels there would be a sharp corner that would soon become dull. For finishing purposes the corners need not be so much bevelled as in figure, but may be very slightly relieved at the corners A and B, in Fig. 948, the width of the flat nose being slightly greater than the amount of feed per lathe revolution. Such tools produce the quickest and best work without chattering when the conditions are such that the work and

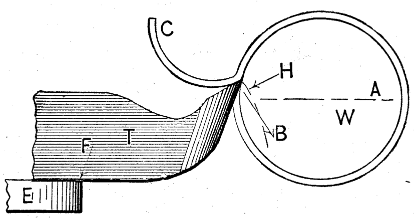


Fig. 949.

the tool are held sufficiently rigid, and in that case may be used for the harder and tougher metals, as wrought iron and steel.

We have now to consider the height of the tool with relation to the work, which is a very important point.

In Fig. 949, for example, let E be the washer or ring under the tool, and F therefore the fulcrum from which the tool will bend. Let the horizontal dotted line A represent the centre of the work, and it is plain that to whatever amount the tool may spring under the pressure of the cut, its motion from this spring will be in the direction of the dotted arc H, causing the tool to dip deeper into the work in proportion as the tool point is set above the work centre line A. Now the amount of tool spring will even under the most rigid conditions vary in a heavy cut with every variation in the depth of cut or in the hardness of the metal. Furthermore, as the cutting edge of the tool becomes dulled from use, its spring will increase, because the pressure required to force it to its cut becomes greater, and as a result when the conditions are such that a perceptible amount of tool spring or deflection occurs, the work will not be turned cylindrically true. Obviously the work under these conditions will be most true when the tool point is set level with the line A, passing through the work axis.

There are two advantages, however, in setting the tool above

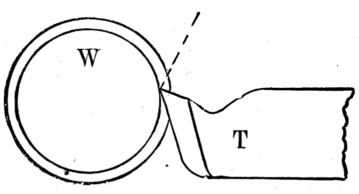


Fig. 950.

the work centre: first it severs the metal easier; and second, it enables the employment of more bottom rake without increasing the bottom clearance.

Thus in Figs. 950 and 951 the diameters of the work W and the top rake of the respective tools are equal, but the tool that is set above the centre, Fig. 950, has more bottom rake but no more clearance, which occurs from the manner in which the cutting edge is presented to the work; the dotted lines represent the line of severance for each, and it is obvious that in Fig. 950, being of the shortest length for the depth of the cut will require least power

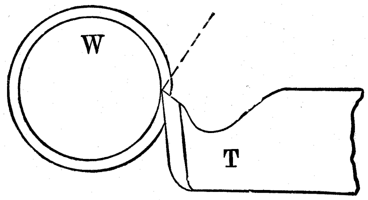


Fig. 951.

to drive, because it is, as presented to the work, the sharpest wedge, as will be perceived by referring to Fig. 952, in which the tool shown in Fig. 950 is simply placed below the work centre, all other conditions as angle, &c., being equal.

From these considerations it appears that while for roughing cuts it is advantageous to set the tool above the centre, it is better where great cylindrical truth is required to set it at the centre for finishing cut.

It may also be observed that if the lathe bed be worn it will usually be most worn at the live centre end, where it is most used, and a tool set above the centre will gradually fall as the cut

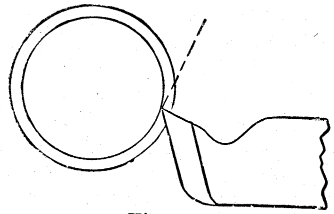


Fig. 952.

proceeds towards the live centre, entering the work farther, and therefore reducing its diameter. This can be offset by setting the tailstock over, but in this case the wear of the work centres is increased, and the work will be more liable to gradually run out of true, as explained with reference to turning taper work. Sir Joseph Whitworth recommends that the tool edge be placed at the "centre" of the work, while at the same time on a line with the middle of the body of the steel. To accomplish this result it is necessary that the form of the tool be such as shown in Fig. 953, in which W represents a piece of work, R the slide rest, A the fulcrum of the tool support, the dotted line the centre of the work, and the arrow the direction in which the tool point would move from its deflection or spring. Now take the conditions shown in Fig. 954, and it will be perceived at once that the least tool deflection will have an appreciable effect in causing the tool point to advance into the work in the direction denoted by the arrow. This would impair the cylindrical truth of the work, because metals are not homogeneous but contain in forged metals seams and harder and softer places, and in cast metals different degrees of density, that part laying at the bottom of the mould being densest (and therefore hardest) by reason of having supported the weight of the metal above it when cooling in the mould.

This brings us to another consideration, inasmuch as supposing the tool edge to be set level with the work centre (as in Figs. 951

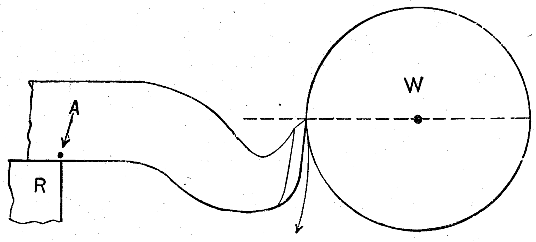


Fig. 953.

and 953), the arc of deflection of the tool point will vary in its direction with relation to the work according to the vertical distance of the top of the tool rest (R in Figs. 953 and 954) from the horizontal centre of the work.

Thus the vertical distance between the point A in Fig. 953 and the work centre is less than that between A and the horizontal work centre in Fig. 954, as may be measured by prolonging the dotted lines in both figures until they pass over A, and then measuring the respective vertical distances between A and those dotted lines. It is to be noted that this distance is governed by the vertical distance of the top of the tool rest R from the work centre, but where this distance is required or desired to be reduced a strip of metal may be placed beneath the tool and between it and the slide rest.

It will now be obvious that to produce work as nearly cylindrical as possible, the tool edge should stand as near to the slide rest

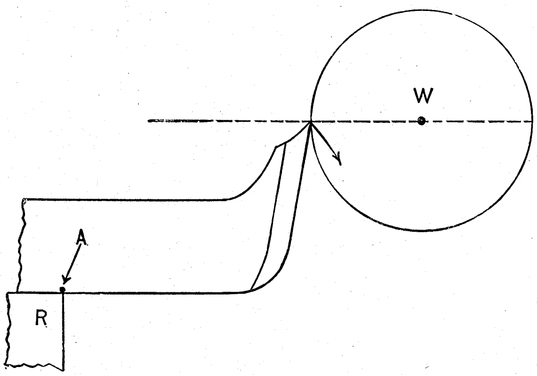


Fig. 954.

as the circumstances will permit, which will hold the tool more firmly and prevent, as far as possible, its deflection or spring from the cut pressure. Both in roughing out and in finishing, this is of great importance, influencing in many cases the depth of cut the tool will carry as well as the cylindrical truth of the work.

We may now present some others of the ordinary forms of tools used in the slide rests on external or outside work, bearing in mind, however, that these are merely the principal forms, and that the conditions of practice require frequent changes in their forms, to suit the conditions of access to the work, &c.

Fig. 955 represents a diamond point tool much used by eastern tool makers. The sides are ground flat and the point is merely oil-stoned to take off the sharp corner. This tool is used with very fine feeds as, say, 180 work revolutions to an inch of tool traverse, taking very fine cuts, and in sharpening it the top face only is ground; hence as the height of the tool varies greatly before it is worn out, the tool elevating device must have a great range of action.

In Fig. 956 is shown a side tool for use on wrought iron; it is bent around so that its cutting edge A may be in advance of the side of the steel, and thus permit the cutting edge to pass up into

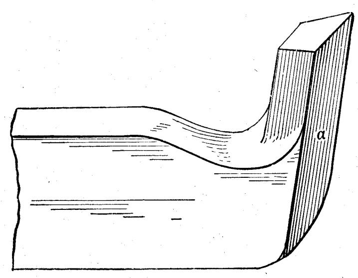


Fig. 955.

a corner. When it is bent to the left as in the figure, it is termed a right-hand side tool, and per contra when bent to the right it is a left-hand tool. The edge A must form an acute angle to edge B, so that when in a corner the point only will cut, or when the edge A meets a radial face, as in Fig. 957, the cutting edge B will be clear of the work as shown.

If the angle of A to B is such that both those edges cut at once, the pressure due to such a broad cutting surface would cause the

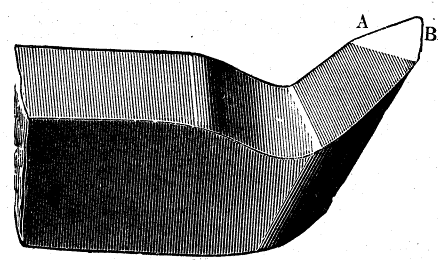


Fig. 956.

tool to spring or dip into the work, breaking off the tool point and perhaps forcing the work from between the lathe centres.

This tool may be fed from right to left on parallel work, or inwards and outwards on radial faces, but it produces the truest work when fed inwards on radial faces, and to the left on parallel work, while it cuts the smoothest in both cases when fed in the opposite direction.

It is a very desirable tool on small work, since it may be used

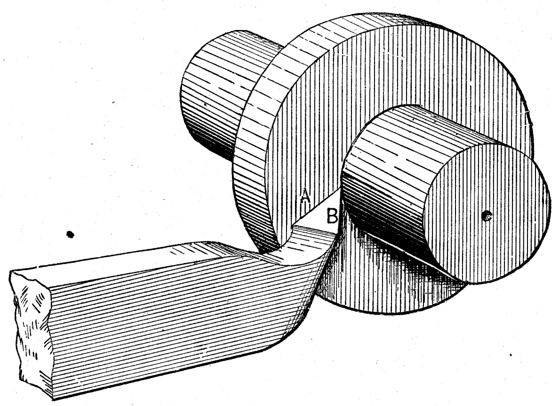


Fig. 957.

on both the stem of the work, and on the radial face, which saves the trouble of having to put in a front tool to turn the stem, and a separate tool for the radial face.

In cutting down a radial face with this tool, it is best (especially if much metal is to be cut off), if the face of the metal is hard, to carry the cut from the circumference to the centre, as shown in the plan view in Fig. 958, in which *a* is the cutting edge of the tool, B a collar on a piece of work, *c* the depth of the cut, and D a hard skin surface. Thus the point of the tool cuts beneath the hard surface, which breaks away without requiring to be actually cut.

Fig. 959 represents a cutting off or parting tool for wrought iron,

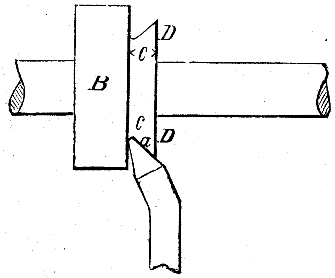


Fig. 958.

its feed being directly into the metal, as denoted by the arrow. This tool should be set exactly level with the work centre when it is desired to completely sever the work. When, however, it is

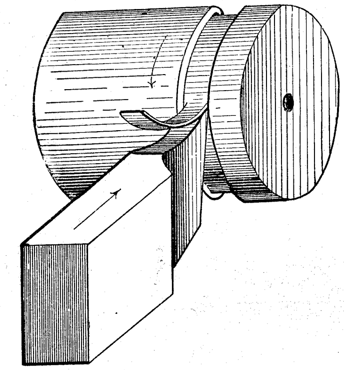


Fig. 959.

used to merely cut a groove, it may be set slightly above the centre.

When the tool is very narrow at *c*, Fig. 960, or long as in Fig.

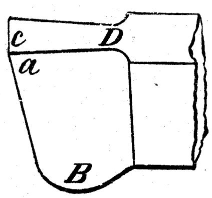


Fig. 960.

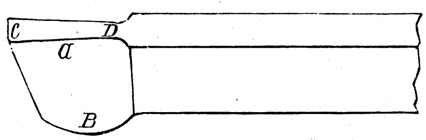


Fig. 961.

961, it may be strengthened by being deepened, the bottom B projecting below the level of the tool steel, which will prevent undue spring and the chattering to which this tool is liable.

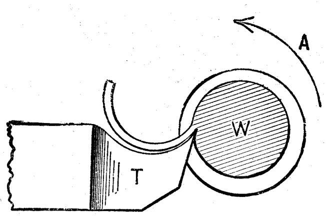


Fig. 962.

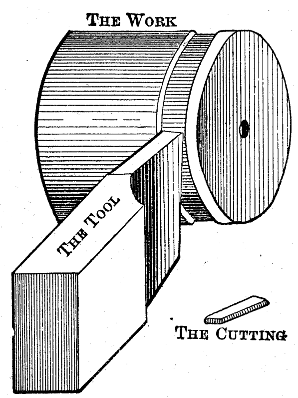


Fig. 963.

To enable the sides of the tool to clear the groove it cuts, the width at *c* should slightly exceed that at D, and the thickness along the top *a* should slightly exceed that at the bottom B.

When the tool is used to cut a wide groove as, say, $\frac{3}{8}$-inch wide, in a small lathe, it is necessary to carry down two cuts, making the tool about $\frac{1}{4}$ inch wide at *c*, which is a convenient size, affording sufficient strength for ordinary uses.

When used on wrought iron the top face may, with advantage, be given top rake as in Fig. 962, which on account of causing the

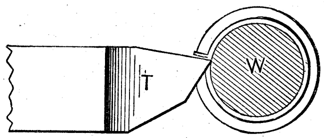


Fig. 964.

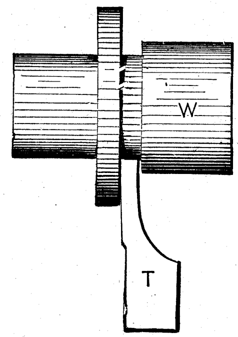


Fig. 965.

tool to cut easier, will reduce the spring of the work W in the direction of arrow A. For brass work, however, the top should be ground in an opposite direction, as in Figs. 963 and 964, which will enable it to cut smoother and with less liability to rip into the metal, especially if the tool requires to be held far out from the

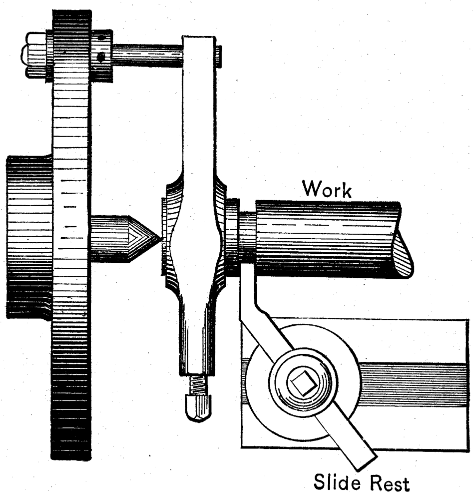


Fig. 966.

tool post. To capacitate the tool to cut a groove close up to a shoulder, it should be forged to the shape shown in Fig. 965. As it is very subject to spring, it should not, unless the conditions are such as to give rigidity to both the work and the tool, be set above the work centres.

When a grooving or parting tool is to be used close up to the

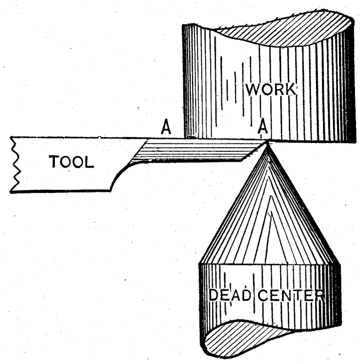


Fig. 967.

lathe dog, its cutting end may be bent at an angle, as in Fig. 966, so that it may be adjusted on the lathe rest, so that the work driver will not strike against the slide rest.

In Figs. 967, 968, and 969, are represented the facing tool, side tool, or knife tool, as it is promiscuously termed, which is sometimes made thicker at the bottom as in Fig. 969. It is mainly used for squaring up side faces, as upon the ends of work or the sides of heads or collars. A is the cutting edge which may be ground so as to cut at and near the end, for large work in which it is

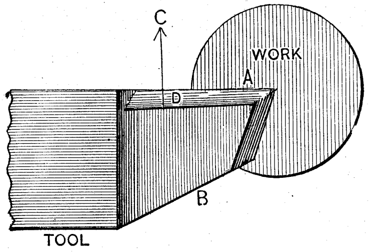


Fig. 968.

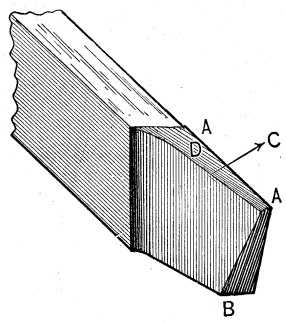


Fig. 969.

necessary to feed the tool in with the cross slide, or to cut along its full length for small work in which the longitudinal feed is used. To facilitate the grinding, the bottom may be cut away, as at B in Fig. 968.

In some practice the bottom B, Fig. 969, of the tool, is made thicker than the top A, which is, however, unnecessary, unless for

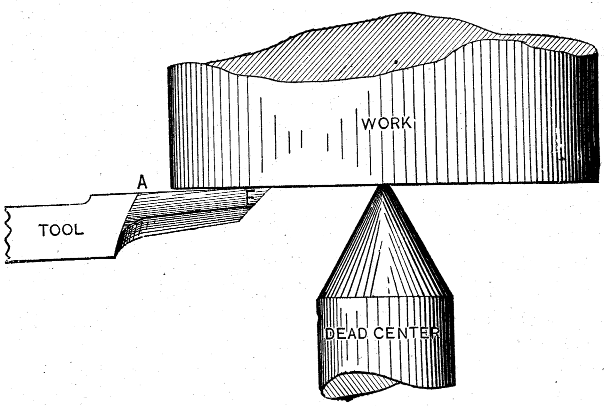


Fig. 970.

heavy cuts, for which the tool would be otherwise unsuitable on account of weakness. For all ordinary facing purposes, it should be made of equal thickness, which will reduce the area to be ground in sharpening the tool.

On small work the edge A A should be ground straight, and set at a right angle to the work, so that it may face off the whole

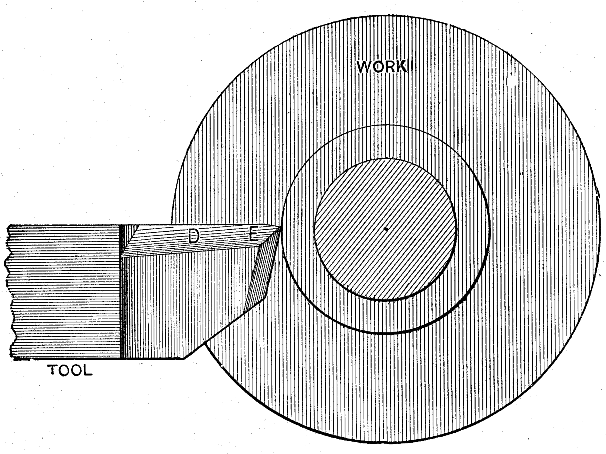


Fig. 971.

surface at once, but for work of large diameter it should be ground and set as in Figs. 970 and 971, so that it will cut deepest at the end E, enabling it to carry a finishing cut from the circumference to the centre, by feeding it with the cross-feed screw.

The cutting edge should be level with the centre of the work, the angle of the top face D being about 35 degrees in the direction of the arrow C for wrought iron, and level if used for brass. When this tool is to be used for a face close to the work driver it should be bent at an angle as in Fig. 972, so as to enable the

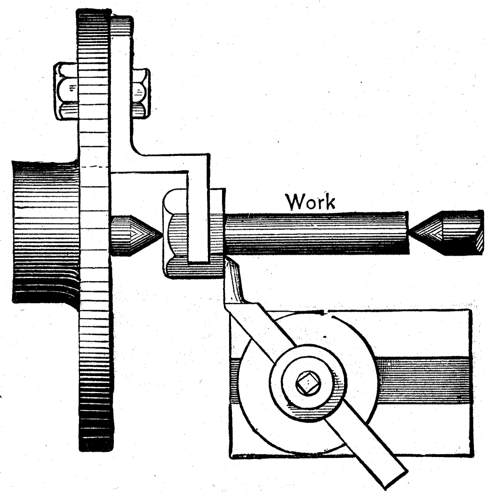


Fig. 972.

driver to clear the slide rest, and when used for countersunk head bolts, it may be bent at an angle as in Fig. 973, so that when it is once set to give the head the correct degree of taper, it will turn successive heads to the correct taper without requiring each head to be fitted to its place.

In Fig. 974 is shown the spring tool which is employed to finish smoothly round corners or sweeps, which it will do to better

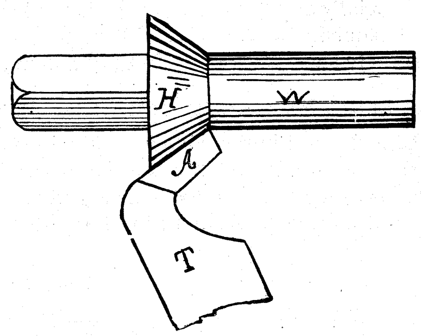


Fig. 973.

advantage than any other slide rest tool, because it is capable of carrying a larger amount of cutting edge in simultaneous operation. This property is due to the shape of the tool, the bend or curve serving as a spring to enable the tool to bend rather than dig into the work.

This form of tool is sometimes objected to on the ground that it does not turn true, but this is not the case if the tool is properly formed and placed at the correct height with relation to the work.

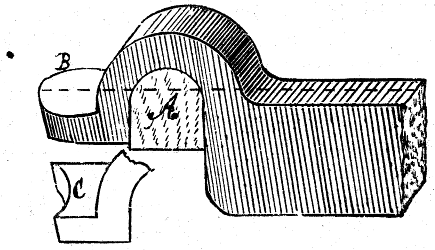


Fig. 974.

In the first place the top face should, even on wrought iron, have but very little top rake, and indeed none at all if held far out from the tool post, while for brass, negative top rake may be employed to advantage. The height of the cutting edge B should be level with the top of the tool steel as denoted by the dotted line in the figure, and in no case should it stand above that level. The cutting edge should be placed about level with the horizontal centre of the work, but in no case above it. It is from this error that the tool is frequently condemned, because if placed above, the broad cutting edge causes the tool to spring slightly and dig into the metal, whereas when placed at the middle of the height of the work the spring will not have that effect, as already explained when referring to front tools. Furthermore, the spring of the tool (from inequalities in the texture or from seams in the metal) will be in a line so nearly coincident with the work surface that the latter will be practically true, and from the smoothness and the evenness of the curve this tool will produce a much better work than any other tool, unless indeed the curve be of a very small radius, as, say, about $\frac{1}{4}$ inch only, in which case a hand

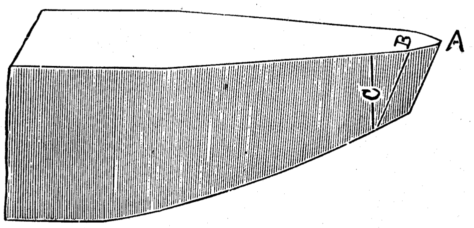


Fig. 975.

tool such as shown in Fig. 1292 may be employed; spring tools are intended to finish only, and not to rough out the work.

The curves, as B in Fig. 974 for a round corner and C for a bead, should be carefully and smoothly finished to the required curve and the top face only ground to sharpen the tool, so as to maintain the curve as nearly as possible; but if the curve is a very large one, the tool will require to be a part of the curve only, and must be operated by the slide rest around the curve.

For finishing the curves or round corners in cast-iron work the spring tool is especially advantageous, as it will produce a polished clean surface of exquisite finish if used with water, and the cutting speed is exceedingly slow, as about 7 feet per minute.

Lathe Slide Rest Tools for Brass Work.

Nearly all the tools used in the slide rest upon iron work may be employed upon brass work, but the top faces should not have rake, that is to say, they should have their top faces lying in the same plane as the bottom plane of the tool steel which rests on

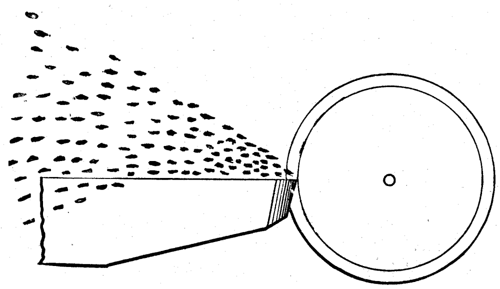


Fig. 976.

the slide rest. For if the top face is too keen it rips rather than cuts the brass, giving it a patchy, mottled appearance.

Fig. 975 represents a front tool for brass, which is used for carrying cuts along outside work or for facing purposes, corresponding, so far as its use is concerned, to the diamond point or front tool for iron. The top face of this tool must in no case be given rake of any kind, as that would cause it to tear rather than to cut the metal, and also to chatter. The point A should be slightly rounded and the width at B and depth at C must be regulated to suit the depth of cut taken, the rule being that slightness in either of these directions causes the tool to chatter. When held far out from the tool post or under other conditions in which the tool cannot be rigidly held, the top face should be ground away towards the end, thus depressing the point A, after the manner shown with reference to the cutting-off tool for brass in Fig. 963. The manner in which the cuttings come off brass work when a front tool is used, depends upon the hardness of the brass and the speed at which the tool cuts.

In the harder kinds of brass, such as that termed gun metal, composition, or bell metal, the cuttings will fly off the tool in short angular grains, such as indicated in Fig. 976, travelling a yard or two after leaving the tool if a fairly quick cutting speed is used. But if the cutting speed is too slow the cuttings will come off slowly and fly but a few inches. In the softer kinds of brass, such as yellow brass, the cuttings are longer and inclined to form

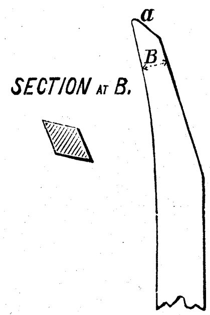


Fig. 977.

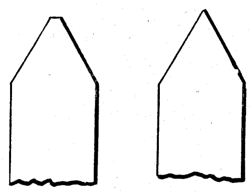


Fig. 978.

short curls, which will, if cut at a high speed, fly a few inches only after leaving the tool.

In Fig. 977 is shown a right-hand side tool for brass work. It is used to carry cuts along short work, and to carry facing cuts at the same time, thus avoiding the necessity to move the position of the tool to enable it to carry a facing cut, as would be necessary if a front tool for brass were used. It is peculiarly adapted, therefore, for brass bolts, or other short work having a head or collar to be faced especially; hence, it may be traversed to its cut in either direction without requiring to be moved in the tool post. It may also be used to advantage for boring purposes. It will be found that this tool will cut smoother and will be less liable to chatter if its top face is ground slightly down towards the point and if it be not forged too slight either in depth or across B. Its clearance on the side is given by forging it to the diamond shape shown in the sectional view. To make the tool a left-handed one it must be bent to the right, the clearance being in any case on the inside of the curve.

The forms of single-pointed slide rest tools employed to cut V-threads in the lathe are shown in Fig. 978, which represents a tool for external, and Fig. 979, which represents one for an

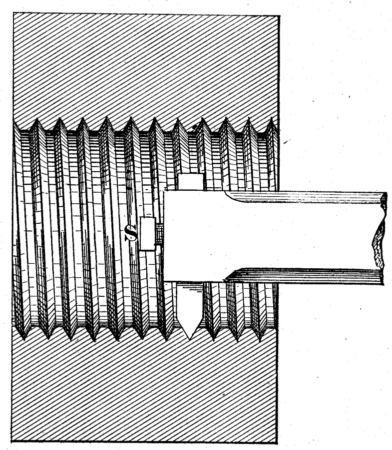


Fig. 979.

internal V-thread, the latter being a tool ground to accurate shape and secured in a holder by the set screw S.

It is obvious that a Whitworth thread might be cut with a single-pointed tool such as shown in Fig. 980, the corner at B being rounded to cut the rounded tops of the thread. It is more usual, however, to employ a chaser set in the tool point in the same manner as a single-pointed tool, or in a holder fixed in the tool post. When a single-pointed tool is employed to cut a thread, the angles of its sides are not the same as the angle of the thread it produces, which occurs because the tool must have clearance to enable it to cut. In Fig. 981, for example, is a single-pointed tool without any clearance, and, as a result, it cannot enter the work to cut it. In Fig. 982 the tool is shown with clearance, and, as a result, the angle of the cutting edge is not the same angle as the sides of the tool are, because the top face is not at a right angle to the sides of the tool. It is obvious that the angle of the sides of the tool must be taken along the dotted line in Fig. 982.

It follows then that a tool whose sides are at a given angle will cut a different angle of thread for every variation in the amount

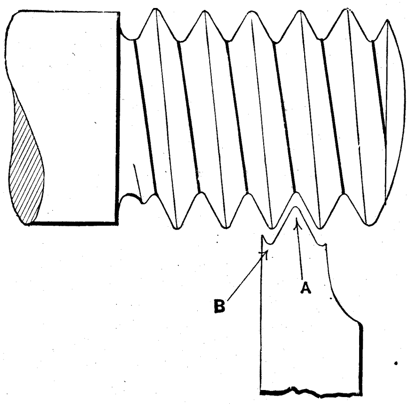


Fig. 980.

of clearance. But whatever the amount of clearance may be, the tool will produce correct results providing that the gauge to which the tool is ground is held level, as in Fig. 983 at A, and not at an angle as at B.

The tool, however, must be set at the correct height with relation to the work, and its top surface must point to the work axis to produce correct results.

Suppose, for example, that in Fig. 984 A is a piece of work, its

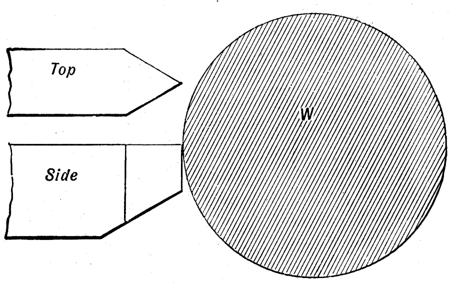


Fig. 981.

horizontal centre being represented by the dotted line C, and its centre of revolution being at C. Now suppose D is a screw-cutting tool cutting a depth of thread denoted by E. G is another lathe tool having teeth of the same form and angle as D, but lifted above the horizontal centre of the work. The depth of thread cut by G is denoted by F, which is shallower, though it will be seen that the point of G has entered the work to the same depth

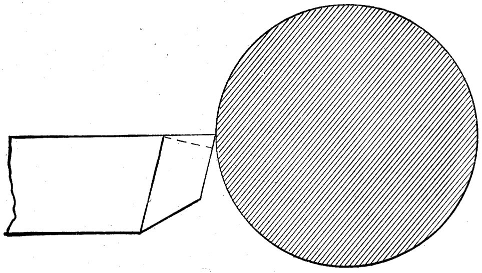


Fig. 982.

or distance (of the tool point) as D has. It is obvious, however, that for any fixed height, a tool suitable to cut any required depth or angle can be made, but it would be difficult to gauge when the tool stood at its proper height.

To facilitate setting the height of the tool, a gauge such as shown in Fig. 985 may be used, the height of the line A from the base equalling the height or distance between the top surface of the cross slides and the axial line of the lathe centres. If the lathe, however, have an elevating slide rest, the rest must be set level before applying the gauge. Or in place of using the gauge, the tool stool or tool holder, as the case may be, may be made of

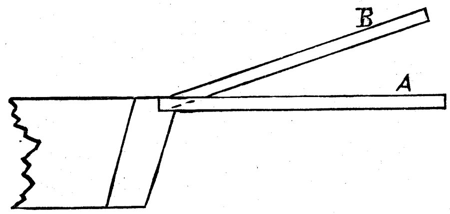


Fig. 983.

such height that when level in the tool post its top face points to the axis of the lathe centre, the tool being sharpened on the angles and not ground on the top face.

But in the case of a tool holder, or of a chaser holder, the tool may be ground on the top face, and adjusted for height by any

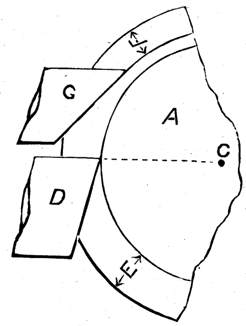


Fig. 984.

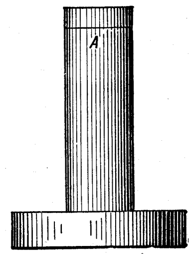


Fig. 985.

suitable means, the top of the holder serving as a guide to set the tool by.

The line of the cutting edge of the tool must, to obtain correct results, be presented to the work in the same manner as it was presented to the gauge to which its angles were ground, so that

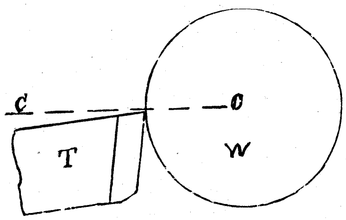


Fig. 986.

if the tool were in position in the tool post, and the gauge were applied, it would point to the axis of the lathe centre, for if this is not the case the thread cut will not be of correct angle or depth. Thus, in Figs. 986 and 987 the tool T would cut threads too shallow, although placed at the correct height, because the cutting edges are at an angle to the radial lines C C.

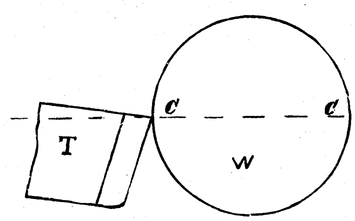


Fig. 987.

It becomes obvious, then, that it is improper to set the height of a screw-cutting tool by means of any tool elevating or setting device that throws it out of the horizontal position. To enable the correct setting of threading tools, and to avoid having to grind the angles correct to gauge every time the tool requires sharpening, various kinds of tool holders have been designed by means of which the tool may be ground on the top face, and set at correct height and in the proper plane.

To facilitate grinding the tools to a correct angle, the gauge shown in Fig. 988 is employed, the various notches being for the pitches of thread for which they are respectively marked, but, the

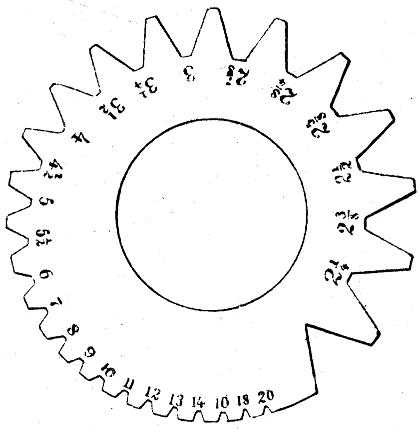


Fig. 988.

edge of the gauge being circular, does not afford much guide to the eye in grinding the angles equal from the sides of the body of the tool; hence the form of gauge shown in Fig. 989 is preferable, because the tool can be so ground that the edge of the gauge stands parallel with the side of the tool steel, so that the tool will, when in correct position, point straight to the work axis. To

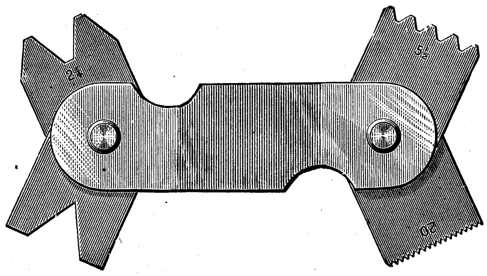


Fig. 989.

insure correctness in setting the tool, it may then be set with a square S in Fig. 990, held firmly with its back against the side of the tool, which may be adjusted in the tool post until the blade B comes fair with the work.

Another method of setting the tool is with a gauge as in Fig. 991, which sets it true with the angle independent of whether the angle is true with the side of the tool or not. In Fig. 992 is a form of gauge that will serve to grind the tool by to correct angle,

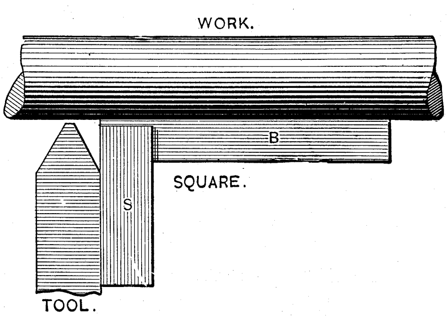


Fig. 990.

and also to set it in the lathe by the angles, independent of the side of the tool.

The same gauge may be used for setting internal threading tools by first facing the work quite true and then applying the gauge as in Fig. 993.

By reason of the comparatively sharp points of thread-cutting tools, they are more readily dulled than the rounder pointed ordinary lathe tool, and by reason of their cutting edges extending along a greater length of the work, and therefore causing it to spring or bend more from the strain of the cut, they cannot be employed to take such heavy cuts as ordinary tools. Hence, in all

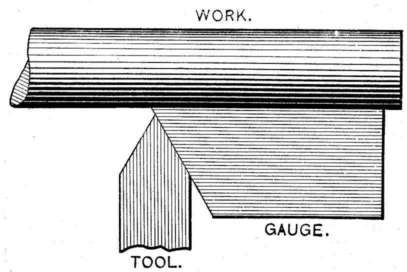


Fig. 991.

thread cutting, it is necessary to turn the work down to the finished diameter before using the threading tool, so that the thread will be finished when it is cut to the proper depth. To test

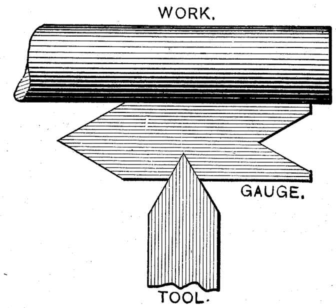


Fig. 992.

that depth on a piece of work having a United States standard, or a sharp V-thread, a gauge such as shown in Fig. 994 may be used, consisting of a piece of sheet steel about $\frac{1}{50}$ inch thick, having a single tooth formed correct for the space of the thread,

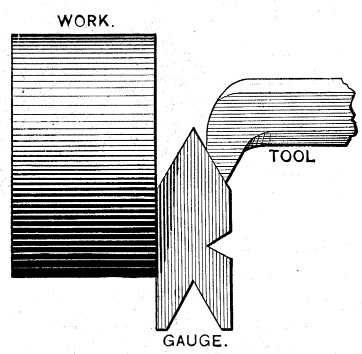


Fig. 993.

so that the edge of the gauge will meet the tops of the thread when the space is cut to admit the tooth on the gauge; the most accurate method of producing such a gauge having been described in the remarks upon screw threads.

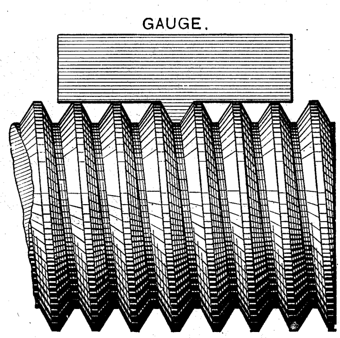


Fig. 994.

If the tool is known to be ground to the correct angle and is set properly, the gauge for depth may be dispensed with by turning the body of the work to correct diameter, and also turning a small part, as A in Fig. 995, down to the correct diameter for the bottom of the thread, so that when the tool point meets A the thread will be cut to correct depth.

Figs. 996 and 997 represent a method of cutting a round top and bottom, or any other form of thread, by means of a single-pointed circular cutting tool, which is mounted on a holder. On

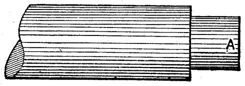


Fig. 995.

the circumference of the cutter is cut a single thread, and a piece is cut out at E to form a cutting edge. To cut a right-hand thread on the work, a left-hand one must be cut on the cutter, so as to make its thread slant in the proper direction. The tool is sharpened by grinding the top face, and moved on the holding

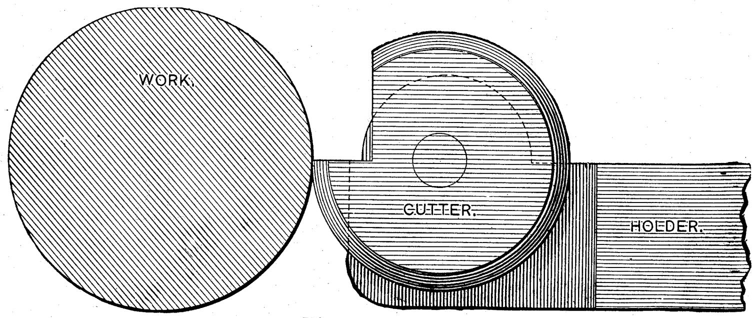


Fig. 996.

pin to set it to the proper height or in position to enable it to cut. A top view of the tool and holder is shown in figure 997.

It is obvious that two gaps may be cut in the wheel or cutter so as to provide two cutting edges, one of which may be used for roughing, and the other for finishing cuts.

In roughing out coarse threads, a single-pointed tool, formed as in Fig. 998, and set considerably above the centre as shown, may

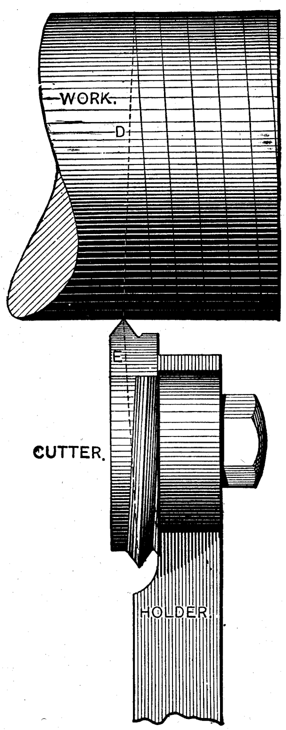


Fig. 997.

be used to great advantage. It will carry a heavy cut and throw off a cutting but very little curved; hence but little power is absorbed in bending the cutting. To preserve the cutting edge, the point of the tool should be slightly rounded. Such a tool, however, requires to be rigidly held, and requires experience to use it to the best advantage.

An English tool holder for a single-pointed tool for cutting coarse pitch threads, such as square threads, is shown in Fig. 999.

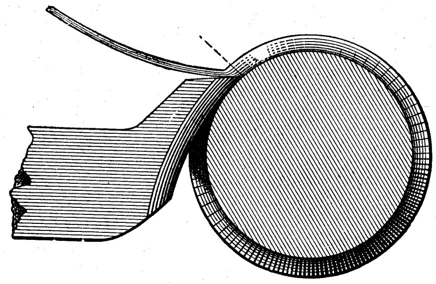
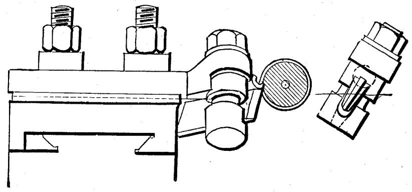


Fig. 998.

The stem of the holder is cylindrical, and is held between two clamping pieces, while the short piece of steel used as a tool (which is thinnest at the bottom, so as to provide for the clearance without grinding it) is clamped in a swiveled post, so that it may be set at the angle sideways required for the particular pitch of thread to be cut, as is shown in the end view.

The difficulty of adjusting the height of threading tools that



Side View. End View.

Fig. 999.

are ground on their top faces to sharpen them is obviated in a very satisfactory manner by the tool holder patented by the Pratt and Whitney Company, and represented in Figs. 1000 and 1001. A is the body of the holder, C is the tool clamp, and B the set screw for C; D is a pin fast in A and projecting into C to adjust it

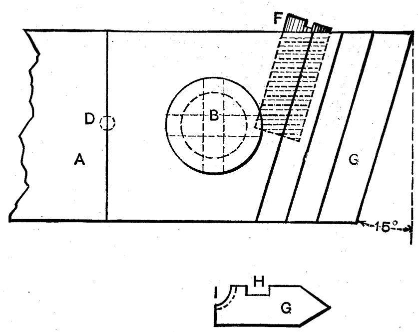


Fig. 1000.

square upon A. The threading tool G has a groove H, into which the projection E fits, so that the tool is held accurately in position. F is the screw which adjusts the height of the tool, being threaded into A and partly into G, as is shown at I. The holder once being

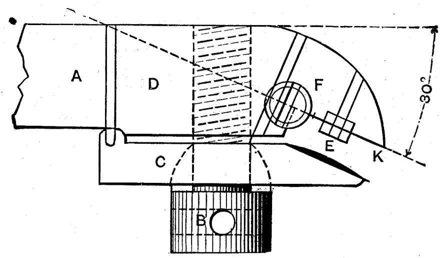


Fig. 1001.

set in correct position, the threading tool may be removed for grinding, and reset with accuracy. The face K of the holder is made at 30° to the front or leading face of the holder, so that the stem or body of the holder will be at an angle and out of the way of the work driver.

If a chaser instead of a single-pointed tool be used to cut a thread, the thread requires to be gauged for its full diameter only, because both the angles of the thread sides and the thread depth are determined by the chaser itself. Chasers are also preferable to a single-pointed tool when the work does not require to be cut to an exact diameter, nor to have a fully developed thread clear up to a shoulder; but when such is the case a single-pointed tool is preferable, because if the leading tooth should happen to

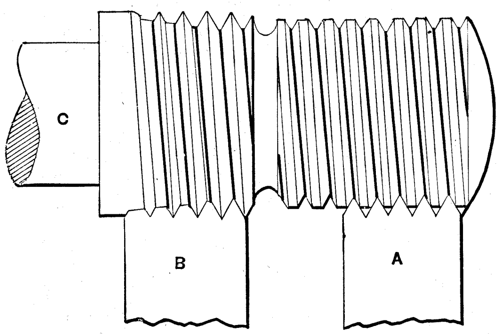


Fig. 1002.

run against the shoulder the whole of the teeth dig into the work, and more damage is done to it than with a single-pointed tool. When the thread does not run up to a shoulder, or in cases where the thread may be permitted to run gradually out, and, again, where the thread is upon a part of enlarged diameter, a chaser may have its efficiency increased in two ways, the first of which is shown in Fig. 1002. When the chaser is set and formed as at A in the figure, the leading tooth takes all the cut, and the following tooth will only cut as it is permitted to do so from the wear of the

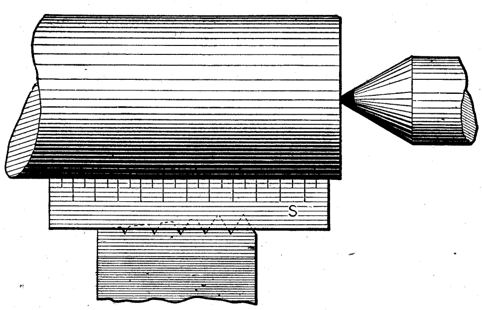


Fig. 1003.

leading bolt. This causes the tooth to wear, but the teeth may be caused to each take a proportion of the cut by chamfering them as at B in the figure, which will relieve the front tooth of a great part of its duty and let the following teeth perform duty, and thus preserve the sharpness of the cutting edges. We are limited in the degree of chamfer that may be given to the teeth, first, because as the cutting edge is broader and the strain of the cut is greater it causes the tool to spring or bend more under the

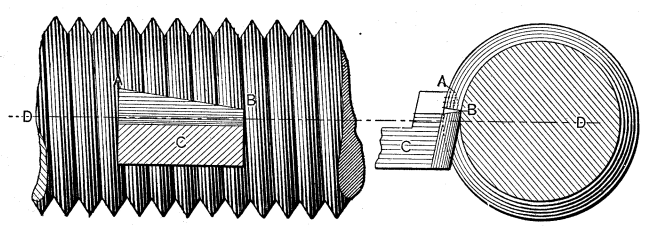


Fig. 1004.

cut pressure; and secondly, because if the tool be given many teeth in order to lengthen the chamfer, then the pitch is altered to a greater extent by reason of the expansion which accompanies the hardening of the chaser.

A chaser thus chamfered may be set square in the tool post by placing a scale against the work as at S in Fig. 1003, and setting the bottoms of the chaser teeth fair with the outer edge of the scale as in the figure.

The second method of increasing the efficiency of a chaser is to grind the top face at an angle as from A to B in Fig. 1004, and set it so that the last tooth B is at or a little above the work axis D. This causes the last tooth B to stand sufficiently nearer the work axis than the other teeth to enable it to take a light scraping cut, producing a smooth cut, because the duty on the last tooth being light it preserves its cutting edge, and therefore its form.

Chasers are often in shops, doing general work, formed in one piece in the same way as an ordinary tool, but it is preferable to use short chasers and secure them in holders.

Figs. 1005 and 1006 show a convenient form of holder, the chaser A being accurately fitted into a recess in the holder D, so

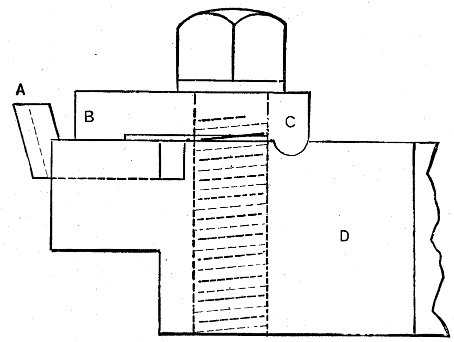


Fig. 1005.

that it may be set square in the holder without requiring to be adjusted to come fair with the thread grooves after having been ground to resharpen it. The short chasers are held by the clamp B, which has at C a projection fitting into a recess in the holder to cause the clamp to adjust itself fairly.

In setting a chaser to correct position in a tool post the points of the teeth may be set to the surface of the work as in Fig. 1007, or if the thread is partly produced and the lathe has a compound slide rest, the tool may be set to the tops of the thread as in Fig. 1008, and then brought into position to meet the thread grooves by operating the slide rest.

It is obvious that the height and position of a chaser require to be as accurately set as a single-pointed tool, but it is more

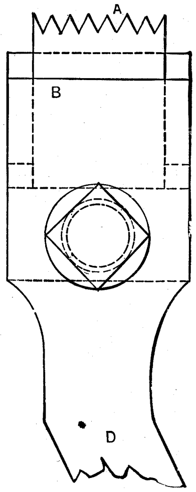


Fig. 1006.

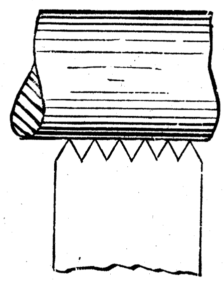


Fig. 1007.

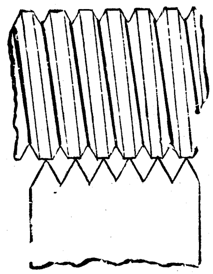


Fig. 1008.

difficult to set it because it can only be sharpened by grinding the top face, and this alters the height at each grinding.

Thus, suppose that when new its teeth are of correct height, when the bottom face I, Fig. 1009, lies upon the rest R, the face H being in line with the centre B B of the work, then as face H is ground the tool must be lifted to adjust its height. On account, however, of the curve of the teeth it is very difficult to find when the chaser is in the exact proper position, which in an ordinary chaser will be when it has just sufficient clearance to enable it to cut, as is explained with reference to cutting up chasers and using them by hand.

To obviate these difficulties, an excellent form of chaser holder is shown in Figs. 1010 and 1011. Its top face C being made of such a height that when the holder rests on the surface of the slide rest and is in the tool box, C will stand horizontally level with the horizontal centre of the work, as denoted by the horizontal line D E; then the tool proper may have long teeth as denoted by A, and the surface of the teeth may always be brought up level with the top surface of the tool holder as tested with a straight-edge. This is a ready and accurate mode of adjustment. A top view of the tool holder is shown in Fig. 1011, in which A is the tool holder, B the threading tool, with a clamp to hold B, and a screw to tighten the clamp.

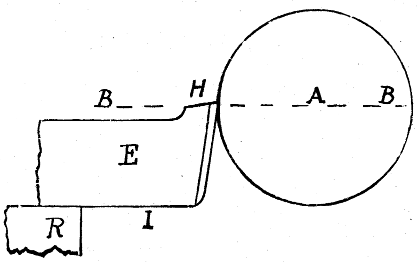


Fig. 1009.

It may now be pointed out that a common sharp V-chaser may be used to cut a United States standard thread by simply grinding off the necessary flats at the points of the teeth, because when the chaser has entered the work to the proper depth it will leave the necessary flat places at the top of the thread, as is shown in Fig. 1012.

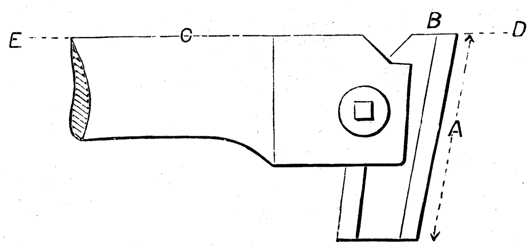


Fig. 1010.

In cutting internal, inside, or female threads (these terms being synonymous) the diameter of the bore or hole requires to be made of the diameter of the male thread *at the root.*

Since, however, it is impracticable to measure male threads at the root, it becomes a problem as to the proper size of hole to bore for any given diameter and pitch of thread. This, however, may be done by the following rules :—

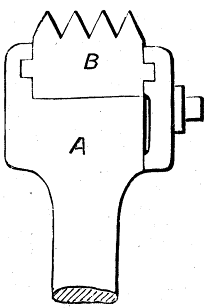


Fig. 1011.

To find the diameter at the roots or bottom of the thread of United States standard threads :

Rule.—Diameter − (1·299 ÷ pitch) = diameter at root.

Example.—What is the diameter at the root of a United States standard thread measuring an inch in diameter at the top of the thread and having an 8 pitch ?

Here 1·299 ÷ 8 = ·162375.

$$\text{Then } 1 - \cdot162375 \left(\begin{array}{r} 1\cdot000000 \\ \cdot162375 \\ \hline \cdot837635 \end{array}\right) = \cdot8376.$$

For the sharp V-thread the following rule is employed :

Rule.—Diameter − (1·73205 ÷ pitch) = diameter at root.

Example.—What is the diameter at the root of a sharp V-thread of 8 pitch, and measuring 1 inch diameter at the top of the thread ?

Here 1·73205 ÷ 8 = ·21650.

$$\text{Then } 1 - \cdot2165 \left(\begin{array}{r} 1\cdot0000 \\ \cdot2165 \\ \hline \cdot7835 \end{array}\right) = \cdot7835.$$

For cutting square threads the class of tool shown in Fig. 1013 is employed, being made wider at the cutting point C than at B or at D, so that the cutting may be done by the edge C, and the sides *a* may clear, which is necessary to reduce the length of cutting edge and prevent an undue pressure of cut from springing the work.

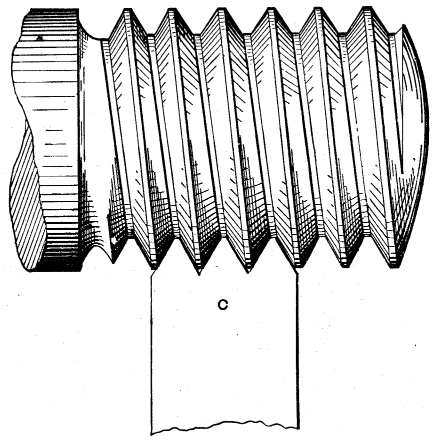


Fig. 1012.

The sides of the tool from *a* to B must be inclined to the body of the tool steel, as shown in Fig. 1014, the degree of the inclination depending upon the pitch of thread to be cut. It may be determined, however, by the means shown in Fig. 1015.

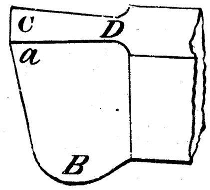


Fig. 1013.

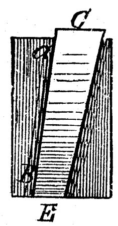


Fig. 1014.

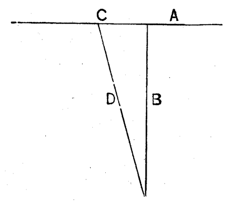


Fig. 1015.

Draw the line A, and at a right angle to it line B, whose length must equal the circumference of the thread to be cut and measured at its root. On the line A set off from B the pitch of thread to be cut as at C, then draw the diagonal D, which will represent the angle of the bottom of the thread to the work axis, and the angle of the tool sides must be sufficiently greater to give the necessary clearance. The width of the point C of the tool should be made sufficiently less than the width of the thread groove to permit of the sides of the thread being pinched (after the thread is cut to depth) with a tool such as was shown in Fig. 968.

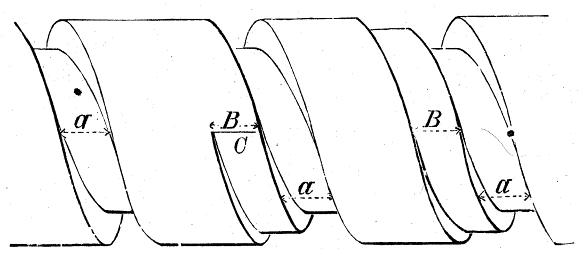


Fig. 1016.

For coarser pitches the thread is cut as shown in Fig. 1016.

The tool is made one-half the width of the thread groove, and a groove, *a*, *a*, *a*, is cut on the work. The tool is then moved laterally and a second cut as at B B is taken, this second cut being shown in the engraving to have progressed as far as C only for clearness of illustration. When the thread has in this manner been cut to its proper depth, the side tools are introduced to finish the sides of the thread. If the thread is a shallow one each side

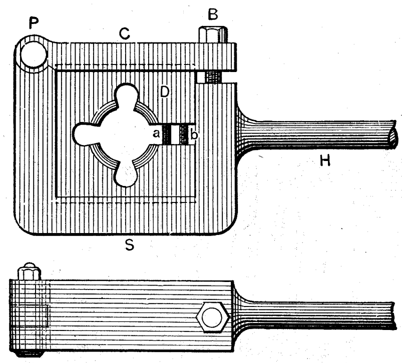


Fig. 1017.

may be finished at one cut by a side tool ground and set very true ; but in the case of a deep one the tool may be made to cut at and wear its end only, and after taking a cut, the tool fed in and another cut taken, and so on until, having begun at the top of the thread, the tool operated or fed, after each traverse, by the cross feed, finally reaches the bottom of the thread. If a very fine or small amount of cut is taken, both sides of the thread may

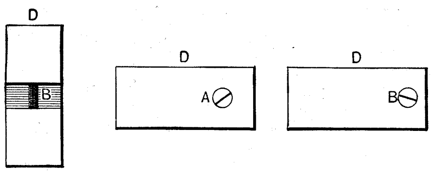


Fig. 1018.

in this way be finished together, the tool being made to the exact proper width.

When used on wrought iron the tool is sometimes given top rake, which greatly facilitates the operation, as the tool will then take a heavier as well as a cleaner cut.

After the first thread cut is taken along the work, it is usual to remove it from the lathe and drill, at the point where it is desired

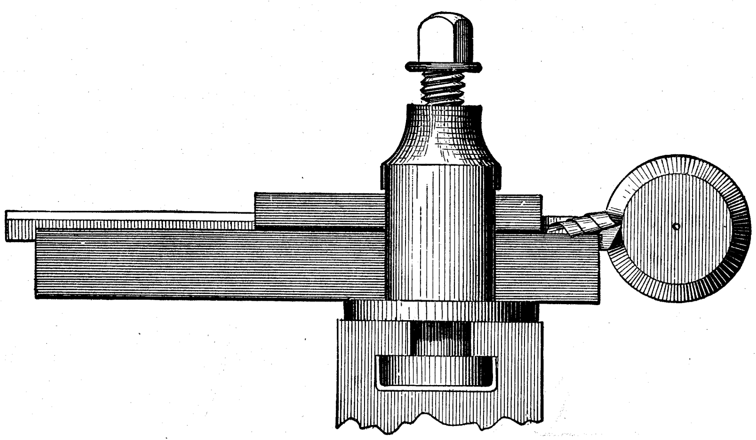


Fig. 1019.

that the thread shall terminate, a hole equal in diameter to the width of the thread groove, and in depth to the depth of the thread. This affords relief to the cutting tool at the end of the cut, enables the thread to end abruptly, and leaves a neat finish.

On account of the broad cutting edge on a screw-cutting tool, the lathe is always run at a slower speed than it would be on the same diameter of work using an ordinary turning tool. After the tool is set to just clear the diameter of the work it is moved (for a right-hand thread) past the end of the work at the dead centre, and a cut is put on by operating the cross-feed screw. The feed nut is then engaged with the feed screw and the tool takes its cut as far along the work as the thread is to be, when the tool is rapidly withdrawn from the work and the lathe carriage traversed back again, ready to take another cut. If, however, the thread to be cut runs close up to a shoulder, head, or collar, the lathe may be run slower as the tool approaches that shoulder by operating the belt shipper and moving the overhead belt partly off the tight

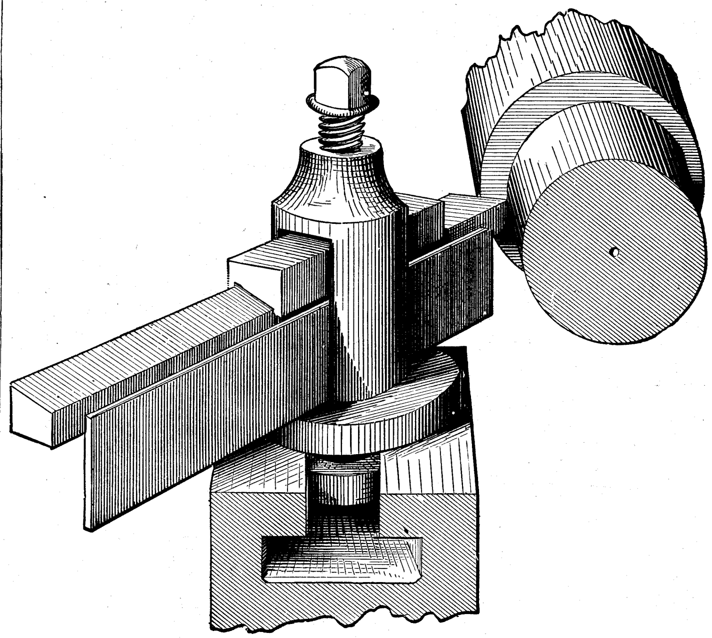


Fig. 1020.

pulley and on to the loose one, or the lathe may be stopped when the tool is near the shoulder and the belt pulled by hand.

An excellent method of finishing square threads after having cut them in the lathe to very nearly the finished dimensions is with an adjustable die in a suitable stock, such as in Figs. 1017 and 1018, in which S is a stock having handle H, and containing a die D, secured by a cap C, pivoted at P. To adjust the size of the die, two screws, *a* and *b*, are used, *a* passing through the top half of the die and threading into the half below the split, while *b* threads into the lower half and abuts against the face of the split in the die, so that, by adjusting these two screws, the wear may be taken up and the size maintained standard. This device is used to take a very light finishing cut only, and is found to answer very well, because it obviates the necessity of fine measurement in finishing the thread. The die D is seated in a recess at the top and at the bottom so as to prevent it moving sideways and coming out.

Lathe Tool Holders for Outside Tools.—When a lathe cutting tool is made from a rectangular bar of steel it requires to be forged to bring it to the required shape at the cutting end, and to avoid this labor, and at the same time attain some other advantages which will be referred to presently, various forms of tool holders are employed.

These holders fasten in the tool post, or tool clamp, and carry short tools, which, from their shapes and the manner in which they are presented to the work, require no forging, and maintain their shapes while requiring a minimum of grinding.

Fig. 1019 represents a side view of Woodbridge's tool holder at work in the lathe, and Fig. 1020 is a view of the same set at an angle to the tool rest. Fig. 1021 is an end view of the tool and holder removed from the lathe.

The tool seat A is at an angle of about 4 degrees to the base of holder (a greater degree being shown in the cut for clearness of illustration), so that the side J of the tool will stand at an angle and have clearance without requiring such clearance to be produced by grinding. The seat B of the cap C upon the tool is curved, so that the cap will bind the middle of the tool and escape the edges, besides binding the tool fair upon its seat A. The top face is formed at the angle necessary for free and clean cutting, and the tools are, when the cutting edge is provided at one end only, hardened for half their length.

The holder, and therefore the tool, may obviously be swung at any chosen angle of the work or to suit the requirements.

Fig. 1022 shows a right and left-hand diamond-point tool in position in the holder with the cap removed, the cutting edge

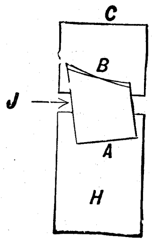


Fig. 1021.

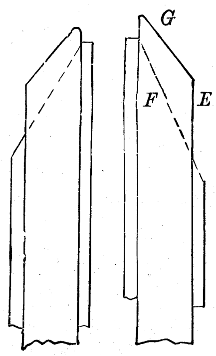


Fig. 1022.

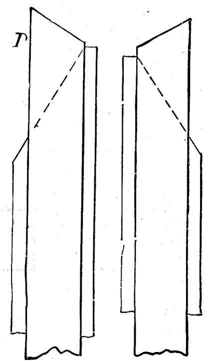


Fig. 1023.

being at G, the angle of the top face being from F to E. The tool, it will be observed from the dotted line, is supported close up to its cutting corner.

Fig. 1023 shows a right and left-hand side tool in position, the dotted line showing that it is supported as close to the cutting edge D as the nature of facing work will permit. When left-hand tools are used the holder is turned end for end, so as to support the tools in the same manner as for right-hand ones, and for this purpose it is that the holder is beveled off at each end.

By grinding both ends of one tool, however, to the necessary shape and angle, one tool may be made to serve for both right and left, the tool holder being simply reversed end for end in the tool post. There are, however, furnished with each holder a right and left-hand diamond point and a right and left-hand side tool, each being hardened for half its full length.

It is obvious, however, that there is no front rake to the tool, and that it therefore derives its keenness from the amount of side rake, which may be regulated to suit the conditions.

When tool holders of this class are employed, the end face only of the tool requires grinding to resharpen the cutting edges; hence the area of metal requiring to be ground is much less than that on forged tools, and therefore the grinding occupies less time; and if the workman grinds the tools, he is enabled to run more lathes and not keep them idle so long while grinding the tool. Or if the tools are kept ground in stock (about 200 of the tools or cutters serving to run 24 lathes a week) the workman has but to slip in a new tool as the old one becomes dull, no adjustment for height being necessary as in the forged tool.

When the tool requires to be set to an exact position, as in the case of screw cutting, it is desirable that the tool holder be so constructed that the tool may be removed therefrom and replaced without disturbing the position of the tool holder in the tool post or tool clamp; and means must therefore be provided for securing the tool to the holder independently of the tool post or clamp screw. Fig. 1024 represents a tool holder possessing these features: H is the holder provided with a clamp C, secured by a screw B, T representing the tool, which is in this case a chaser, having teeth down the full length of its front face; K is a key or feather fast in the holder H, and fitting into a groove provided in the side of the tool. The vertical angle of this feather obviously determines the angle of clearance at which the tool shall stand to the work.

The Pratt and Whitney Company, who are the manufacturers of this holder, make this angle of clearance 15 degrees. The height of the tool in the holder is adjusted by the screw S, which has journal bearing in the holder, and threads to the end edge of the tool.

Now it is obvious that the holder H, once being set to its proper position in the tool post, the tool T may be removed from and replaced in the exact same position, both in the holder and with reference to the work.

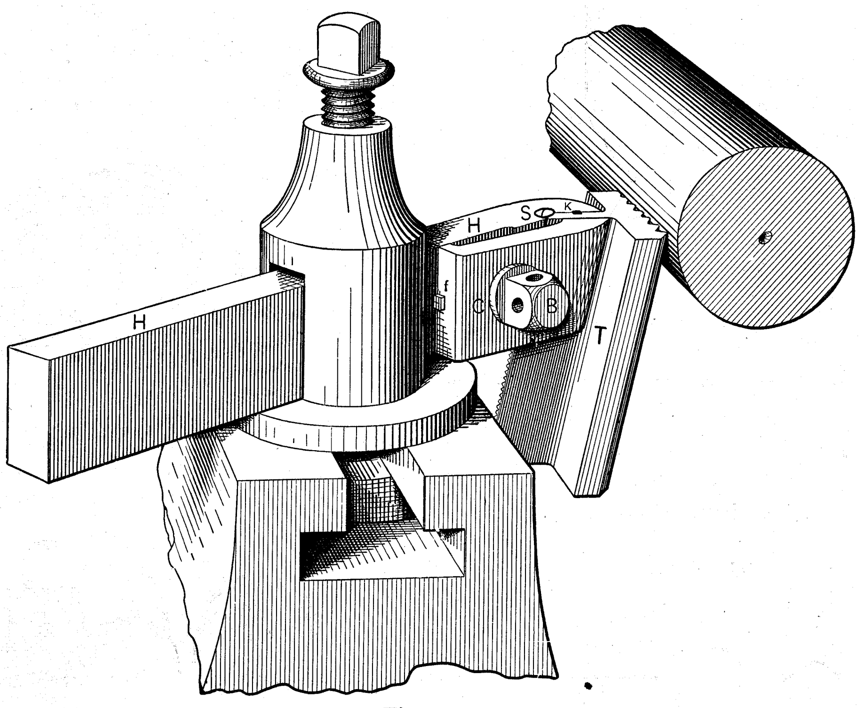


Fig. 1024.

In Fig. 1025, for example, is a top view of the holder with a single-pointed threading tool T in place. W represents a piece of work supposed to be in the lathe, and G a tool-setting gauge; and it is obvious that, if the holder is not moved, the tool T may be removed, ground up, and replaced with the assurance that it will stand in the exact same position as before, producing the exact same effect upon the work, providing that the height is maintained equal, and the tool is not altered in shape by the grinding. To maintain the height equal, all that is necessary is to have the upper face (H, Fig. 1024) of the holder horizontally level and in line with the line of centres of the lathe, and to set the top face of the tool level with that of the holder. In sharpening the tool the top face only is ground; hence the angles are not altered.

Fig. 1026 represents the holder with a tool in position to true up a lathe centre, the angle of the tool holder to the line of centres being the same as in Fig. 1025; and Fig. 1027 represents various forms of tools for curves. All these serve to illustrate the advantages of such a tool holder.

If, for example, a piece of work requires the use of two or more such tools, and the holder is once set, the tools may be removed and interchanged with a certainty that each one put into place

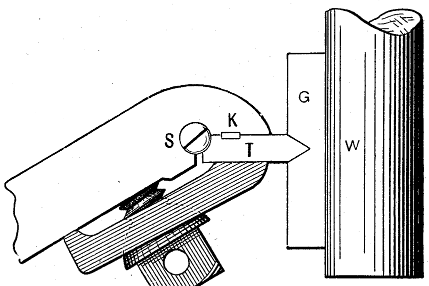


Fig. 1025.

will stand at the exact angle and position required, not only with relation to the work, but also in relation to the other tools that have preceded it. Each hollow or round will not only be correct in its sweep, but will also stand correct in relation to the other sweeps and curves, no matter how often the tools may be changed. Inasmuch as the tool is ground at the top only for the purpose of resharpening, it maintains a correct shape until worn out.

The pin shown at *f* in Fig. 1024 is fast in the holder, and fits

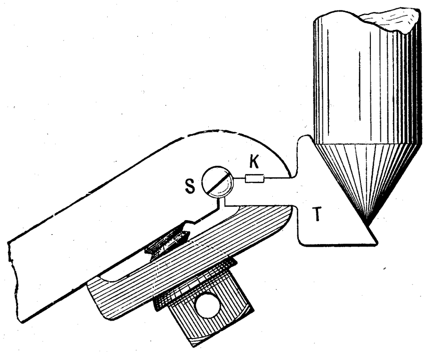


Fig. 1026.

loosely in clamp C to prevent it from swinging around on B when B is loosened.

When the tool requires to preserve its exact shape it may also be made circular with the required form for the cutting edge formed round the perimeter. Thus Figs. 1028 and 1029, which are extracted from *The American Machinist*, represent tool holders with circular cutting tools.

The holder A fits the lathe tool post, carrying the cutting tool B,

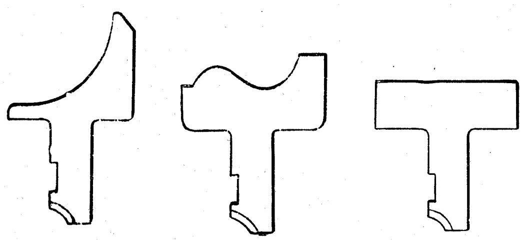


Fig. 1027.

which is bolted to the holder and has at F a piece cut out to form the cutting edge.

To facilitate the grinding, holes are drilled at intervals through B. A plan view of this tool and holder is shown at C, the shape of the cutting edge being shown at D. The cutting edge is shown in the side view to be level with the centre of the tool holder height, but it may be raised to the level of the top of the tool steel by raising the hole to receive the bolt that fastens the cutter, as is shown at E; or the cutter may be mounted on top of the holder as shown at H, having a stem passing down through the holder, and capable of being secured by the taper pin I. A plan view of this arrangement is shown at J.

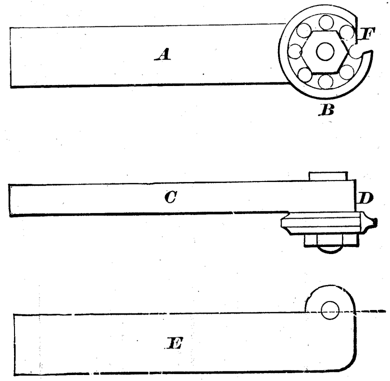


Fig. 1028.

Another form of circular cutter is shown in Fig. 1030. It consists of a disk or cutter secured to a holder fitted to the tool post, the cutter edge being formed by a gap in the disk, as shown in

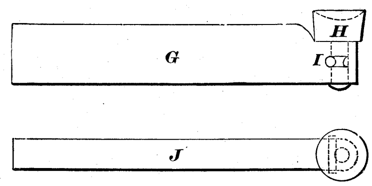


Fig. 1029.

the figure, which represents a cutter for a simple bead or round corner. The front end of the holder has a face A, whose height is level with the line of lathe centre when the holder is set level in

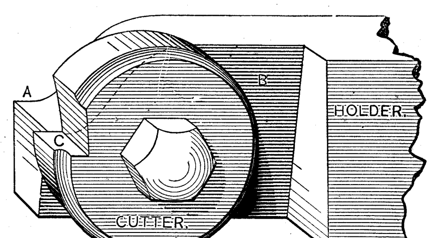


Fig. 1030.

the tool post. Hence the top face of the cutting edge may be known to be set level with the line of centres when it is fair with the face A of the holder. The bottom clearance is given by the

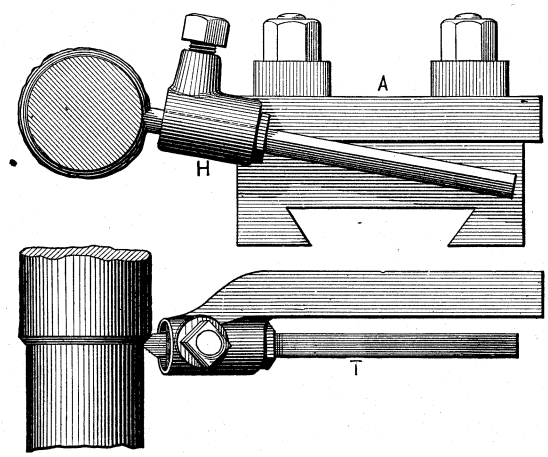


Fig. 1031.

circular shape of the cutter, while side clearance may be given by inclining the face B of the holder (against which the face of the cutter is bolted) to the necessary angle from a vertical line. The face C is ground up to resharpen the cutting edge, and may be reground until the circumference of the wheel is used up.

Figs. 1031, 1032, 1033, and 1034 represent lathe tool holders by Messrs. Bental Brothers, of Fullbridge Works, Maldon, England. The holder consists of a bar A, having at the front end a hub H, containing a bush in two halves, through which the tool T passes; this tool consisting of a piece of **V**-shaped steel. A set screw on top of the hub clamps the two half-bushes together, and these, as their faces do not meet, grip the tool.

The advantage possessed by this form of holder is that the top face of the tool may be given any desired degree of side rake or

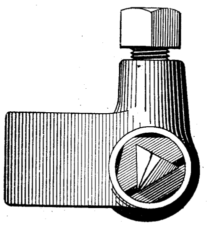


Fig. 1032.

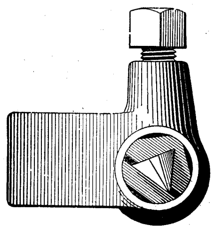


Fig. 1033.

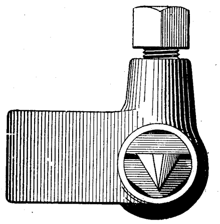


Fig. 1034.

angle required by the nature of the work by simply revolving the bushes in the hub of the holder. Thus, in Fig. 1034 the top face of the tool stands level, as would be required for brass work; in Fig. 1032 the tool is canted over, giving its top face angle a rake in the direction necessary when cutting wrought iron and feeding toward the dead centre; and in Fig. 1033 the tool is in position for carrying a cut on wrought iron, the feed being toward the live centre of the lathe. This capacity to govern the angle of the top face of the tool is a great advantage, and one not possessed by ordinary tool holders, especially since it does not sensibly alter

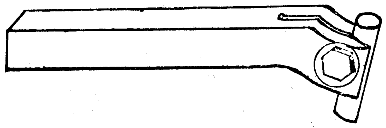


Fig. 1035.

the height of the tool point with relation to the work. Again, the **V**-shape of the tool steel causes the bushes to grip and support the tool sideways, and, by reducing the area of tool surface requiring to be ground, facilitates the tool grinding to that extent. Altogether, this is an exceedingly handy device. It is obvious, however, that it cannot be moved from side to side of the tool rest unless a right and left-hand tool holder be used; that is to say, there must be two holders having the hub on the opposite side of the body A.

Figs. 1035, 1036, 1037, and 1038 represent tool holders in which the tools consist of short pieces of steel held end-wise and at a

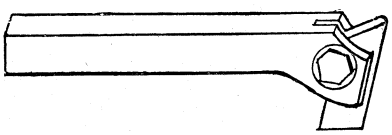


Fig. 1036.

given angle, so that the amount of clearance is constant. The holders Figs. 1035 and 1036 are split, and the tool is secured by the screw shown. Fig. 1037 represents a tool holder in which the tool is held by a clamp, whose stem passes through the body of the holder so as to bring the fastening nut out at the end, where it is more convenient to get at than are the screw heads in Figs. 1035 and 1036. It is obvious, however, that such a holder is weak and unsuitable for any tools save those used for very light duty indeed, while all this class of holders is open to the objection that the side of the holder prevents the tool from passing up into a corner, hence the cut cannot be carried up to a shoulder on the work. This may, however, be accomplished by bending the end of the holder round; but in this case two holders, a right and a left, will be necessary.

Fig. 1038 represents a form of tool holder of this kind in which the tool may be set for height by a set screw beneath it.

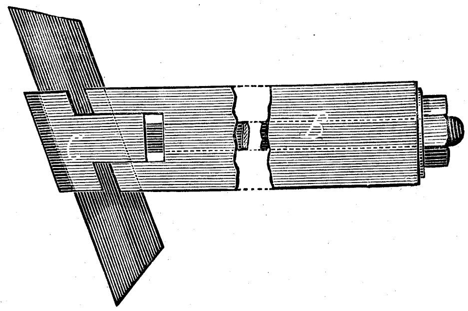


Fig. 1037.

Fig. 1039 represents a tool holder and work-steadying device combined. The holder is held in the lathe tool rest in the usual manner, and affords slideway to a slide operated by the handle shown at the right-hand end.

The tool is carried at the other end of this slide, there being

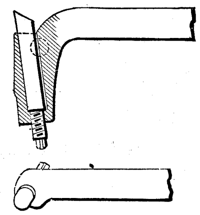


Fig. 1038.

shown in the figure a cutting-off tool in position. At the end of the holder is a hub and three adjusting screws whose ends steady the work, and which are locked in their adjusted position by the chuck nuts shown.

THE POWER REQUIRED TO DRIVE CUTTING TOOLS.—From experiments made by Dr. Hartig, he concluded that by multiplying

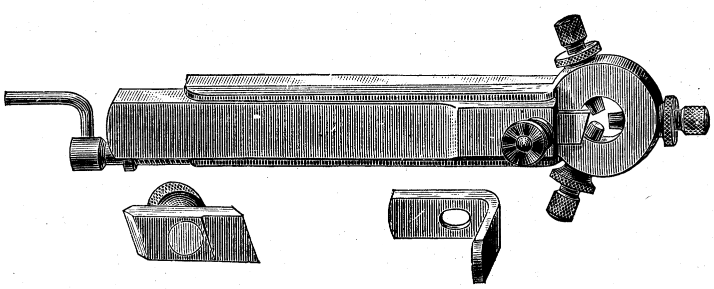


Fig. 1039.

the weight of the metal cuttings removed per hour by certain decimal figures (or constants) the horse-power required to cut off that quantity of metal might be obtained. These decimal constants are as follows:

Lbs. of metal cut off per hour, cast iron	× ·0314	=	horse-power required to drive the lathe.
,, ,, ,, wrought iron	× ·0327	=	,,
,, ,, ,, steel	× ·4470	=	,,

FOR PLANING TOOLS.

Lbs. of steel cut off per hour	× ·1120	=	horse-power required to drive planer.
,, wrought iron ,,	× ·0520	=	,, ,,
,, gun metal ,,	× ·0127	=	,, ,,