Chapter XXV.—VICE WORK.

VICE work may be said to include all those operations performed by the machinist that are not included in the work done by machine tools. In England vice work is divided into two distinct classes, viz., fitting and erecting. The fitter fits the work together after it has been operated upon by the lathe planer and other machine tools, and the erector receives the work from the fitter and erects it in place upon the engine or machine.

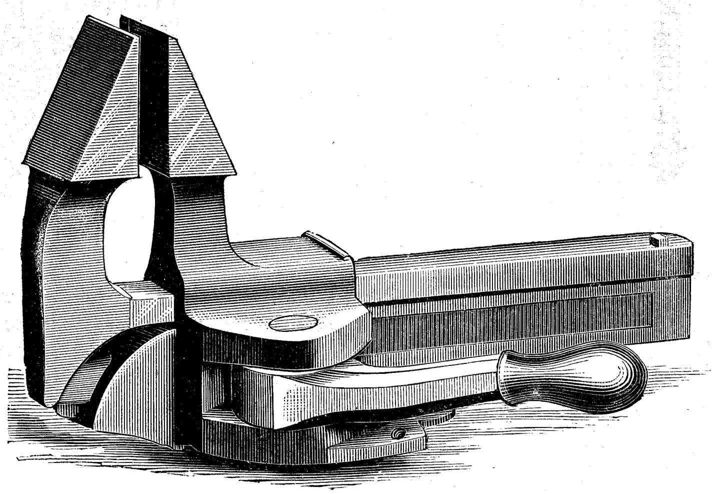


Fig. 2083.

Fitting requires more skill than turning, and erecting still more than fitting, but it is at the same time to be observed that the operations of the erector includes a great many of those of the fitter. In treating of the subjects of vice work and erecting, it appears to the author desirable to treat at the same time of some operations that are not usually included in those trades, because they are performed with tools similar to those used by the fitter, and may be treated equally as well in this way as in any other, while a knowledge of them cannot fail to be of great service to both the fitter and erector. Among the operations here referred to are some of the uses of the hammer; such, for example, as in straightening metal plates.

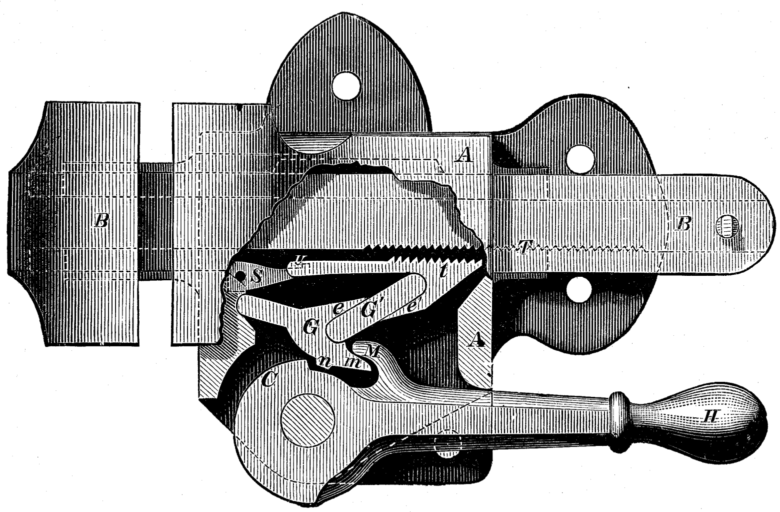


Fig. 2084.

The vice used by the machinist varies both in construction and size according to the class of work it is to hold. For ordinary work the vice may possess the conveniences of swiveling and a quick return motion, but when heavy chipping constitutes a large proportion of the work to be done the legged vice is preferable.

The height of vice jaws from the floor is usually greater for very small work than for the ordinary work of the machine shop, because the work needs to be more clearly observed without compelling the operator to stoop to examine it. The gripping surfaces of vice jaws are usually made to meet a little the closest at the top, so as to grip the work close to the top and enable work cut off with a chisel to be cut clean and level with the jaws.

The jaws of the wood-worker's vice are made then as in Fig. 2083, and reach higher above the screw than the vices used for iron work, because the work is often of considerable depth, and being light will not lie still of its own weight, as is the case with iron.

An example of the ordinary vice of the machine shop is shown in Fig. 2084, which represents partly in section a patent swivel vice. A is the jaw in one piece with the body of the vice, and B is the movable jaw, being the one nearest to the operator. The movable jaw is allowed to slide freely through the fixed one (being pushed or pulled by hand), or is drawn upon and grips the work by operating the handle or lever H. The means of accomplishing this result are as follows: As shown in the cut, B is free to be moved in or out, but if H be pulled away from the vice, the shoulder C, meeting the shoulder *n*, will move the toggle G, and this, through the medium of G′, moves the tooth bar *t*, so as to engage with the teeth on the side of the movable jaw bar shown at T. As soon as the teeth *t* meet the teeth T the two travel together, and the jaw B closes on and grips the work. But as the motion is small in amount, the jaw B should be placed so to nearly or quite touch the work before H is operated. To unloose the work, the handle H is operated in an opposite direction, and the hook M meets *m* and pulls *t* to the position shown. The spring S operates upon a hook at U, to engage the

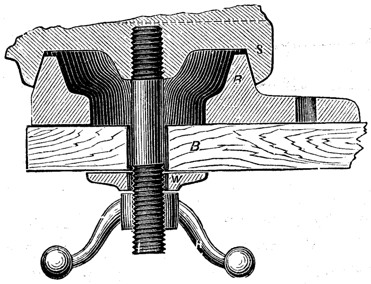


Fig. 2085.

teeth *t*, with the rack T, as soon as the handle H is moved in the tightening direction. The vice grips with great force, because during the tightening the toggle, G is nearly straight, and its movement less than would be the case with a screw-vice having the ordinary pitch of thread and under an equal amount of handle movement.

In this vice the fixed jaw is made to fasten permanently to the work bench, but in others having a similar tightening mechanism the fixed jaw is so attached to the bench as to allow of being swivelled. The method of accomplishing this is shown in Fig. 2085, in which S is the foot of the vice bored conical to receive a cone on the casting R, which is fastened to the bench B. W is a washer and H the double arm nut. Loosening this nut permits of the vice being rotated upon R.

When handle H is operated to release the movable jaw it can be moved rapidly to open and receive the work, and to close upon

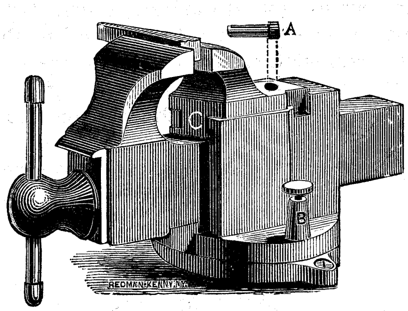


Fig. 2086.

the work, when by a second handle movement the work can be gripped, the operation being much quicker than when the movable jaw is traversed by a screw and nut.

In this vice the gripping surface of the jaws are always parallel one to the other, and attachments are employed to grip taper work as wedges.

In Fig. 2086 is represented a patent adjustable jaw vice, which is also shown in Fig. 2087 with the adjustable jaw removed and upside down. From the construction it is apparent that the groove G, being an arc of a circle of which C is the centre, the jaw is, as it were, pivoted horizontally, and can swing so as to let the plane of the jaw surfaces conform to the plane of the work; hence a wedge can be gripped all along the length enveloped by the jaws, and not at one corner or end only. When the pin A is inserted the jaw stands fixed parallel to the sliding jaw. The pin A engages in a ratchet in the base below it to secure the back vice jaw in position when it is set to any required angle.

A second convenience in this vice is that the whole vice can be swivelled upon the base that bolts to the bench, which is provided with a central hole and annular groove into which the base of the field jaw pivots; at B is a spring pin passing into holes in the bench plate, so that by lifting the pin B, the whole vice can be swung or rotated upon the base or bench plate, until the pin B falls into another hole in the base plate, which is provided

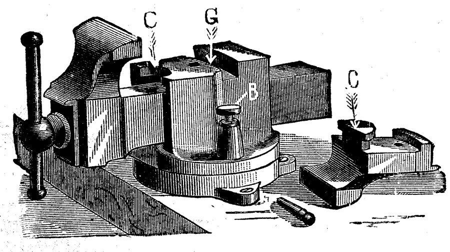


Fig. 2087.

with eight of these holes. The movable jaw is here operated by a screw and nut.

Fig. 2088 represents a form of leg vice for heavy work. In the ordinary forms of this class of vice the two gripping surfaces of the jaws, only stand parallel and vertical when at one position, because the movable leg is pivoted at P; but in that shown in the figure the movable jaw is supported by the arm A, passing through the fixed leg L, which carries a nut N. A screw S, having journal bearing in the movable leg, screws through the nut N, and is connected to the upper screw by the chain C, which passes around a chain wheel provided on each screw, so that the movable leg moves in an upright position and the jaw faces stand parallel, no matter what the width of the work. This is a very substantial method of obtaining a desirable and important object, and greatly enhances the gripping capability of the vice. Fig. 2089 represents a sectional view of another patent vice. A is the sliding and B the fixed jaw. P is the bed plate carrying the steel rack plate H. Attached to each side of the base of the handle is a disk. These disks are carried on the outer end of the movable jaw A, and are held in place by the friction straps T, adjusted by the screws S. On the radial face of the disk is the pin K, which, when the handle or lever is lifted or raised, depresses the end of lever J, which at its other end raises the clutch G, disengaging the same from the rack H, as shown in the engraving. The jaw A is thus free to be moved by

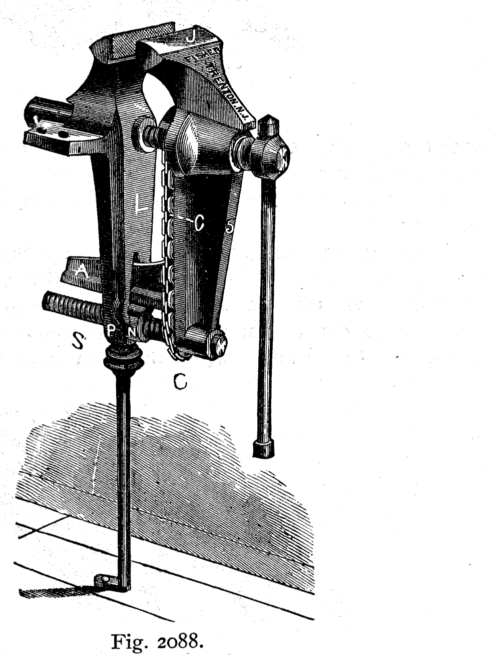


Fig. 2088.

hand, so as to have contact with the work. To tighten the vice the handle is depressed, whereon K releases J and the latter permits the toothed clutch G to engage with the teeth of H At the same time the bar D, which is pivoted to the disks, is drawn outward. The end of the bar D, meeting the surface of the lug shown on A, acts (in conjunction with the toothed clutch H) as a toggle fulcrum from which the disks may force the movable jaw to grip the work.

This action may be more minutely described as follows: The end *d* of D is pivoted upon the disks, as shown; hence when the

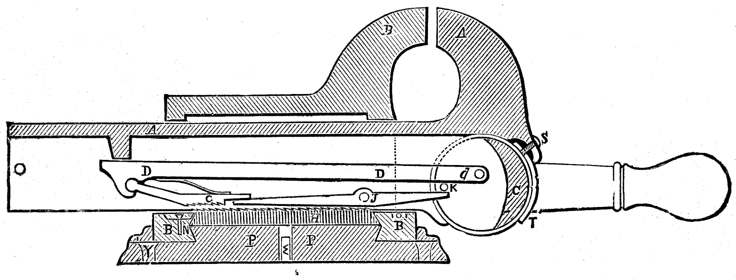


Fig. 2089.

handle is depressed the effort of the end *d* is to move to the right, but D being fixed at the other end the pressure is exerted to force the movable jaw to the left, and therefore upon the work. The amount of jaw movement due to the depression of the handle is such that if that jaw is pushed near or close to the work the handle will stand about vertical downward when the vice firmly grips the work.

For vices whose jaws cannot be swiveled horizontally to enable them to conform to taper work, attachments for the jaws are

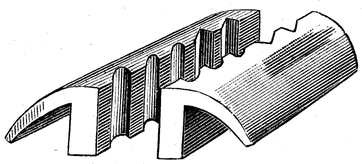


Fig. 2090.

sometimes provided, these attachments having the necessary swiveling feature. So likewise for gripping pipes, and similar purposes, attachments are made having circular recesses to receive the pipes.

To prevent the vice jaws from damaging the work surface, and also to hold some kinds of work more firmly, various forms of clamps, or coverings for the vice jaws are used. Thus Figs. 2090 and 2091 represent clamps for holding round or square pins. In the former the grooves pass entirely through the clamp jaws, so

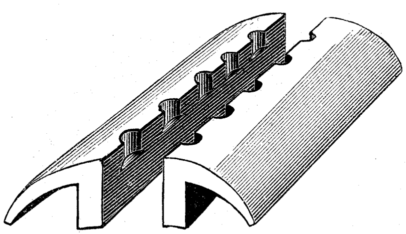


Fig. 2091.

as to receive long pieces of wire, while in the latter the recesses are short, so as to form an abutment for the end of the pins, and act as a gauge in filing or cutting them off to length.

An excellent form of pin clamp is shown in Fig. 2092, the spring bow at the bottom acting to hold the jaws open and force the faces against the vice jaws when the latter are opened. The flanges at B B rest upon the tops of the vice jaws; hence it will be seen that the clamp is not liable to fall off when the vice is opened to receive the work, which is placed either in the hole at A or that at B, as may be most desirable.

Fig. 2093 shows such a clamp holding a screw, the clamp jaws being forced against the screw by the vice jaw pressure, when the vice jaws are opened the spring of the bow will cause the clamp jaws to open and release the screw.

Clamps such as shown in Figs. 2090 and 2091, but without the pin holes, are also provided, being made one pair of copper and another of lead, the latter being preferable for highly finished work. As the filings are apt to imbed in the copper, and, furthermore, as the copper gradually hardens upon its surface, the copper clamps require to be annealed occasionally, which may be done by heating them to a low red heat and dipping them in water. Lead clamps will hold small work very firmly, and are absolutely essential for triangular or other finished work having sharp corners, and also for highly finished cylindrical work, which may

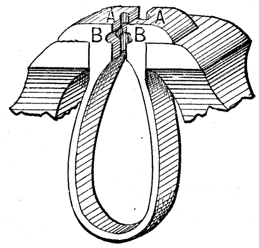


Fig. 2092.

be held in them sufficiently firmly to be clipped without suffering damage from the vice jaws. A piece of thick leather, such as sole leather, also forms a very good clamp for finished work, but to prevent its falling off the vice jaws it is necessary to cut it nearly through on the outside and at the bent corner.

The hammer in some form or other is used in almost all kinds of mechanical manipulation, and in each of these applications it assumes a form varied to suit the nature of its duty, and of the material to be operated upon. In the machine shop it is used to drive, to stretch, and to straighten.

The most skilful of these operations are those involving stretch-

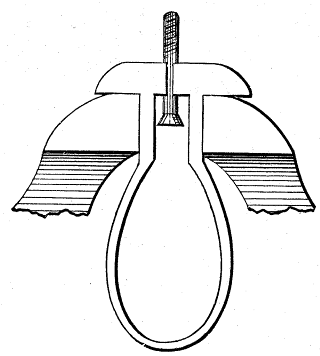


Fig. 2093.

ing operations, as saw and plate straightening, examples of which will be given.

In using a hammer to drive, the weight and velocity of the hammer head are the main considerations. For example, the force of a blow delivered by a hammer weighing 1 lb., and travelling 40 feet in a second, will be equal to that weighing 2 lbs , and travelling 20 feet in a second; but the mechanical effects will be different. If received on the same area of impact the effects will sink deeper into the metal with the greater velocity, and they will extend to a less radius surrounding the area of impact. Thus in driving out a key that is fast in its seat, a quick blow is more effective than a slow one, both being assumed to have at the moment of impact an equal amount of mechanical force stored up in them. On the other hand, for riveting the reverse will be the case. In the stretching processes the hammer requires to fall with as dead a blow as possible. Thus the hammer handle is, for saw stretching, placed at such an angle to the length of the hammer that the latter stands about vertical when the blow is delivered. In straightening, the blow is varied to accommodate the nature of the work; thus a short crook or bend would be best straightened by a quick blow with a light hammer, and a long one by a slower blow with a heavier hammer, which would cause the effects of the blow to affect a greater radius around the part receiving the impact.

As an example of the difference in mechanical effect between a number of blows aggregating a given amount of energy and a single blow having an equal amount of energy, suppose the case of a key requiring a given amount of power to start it from its seat, and every blow delivered upon it with insufficient force to loosen its hold simply tends to swell and rivet it more firmly in the keyway.

Probably the most expert use of the hammer is required in the straightening of engravers' plates, as bank-note plates; and next to this comes the ornamental repoussé work of the manufacturing jeweller.

The most expert hammer process of the machine shop is that of straightening rifle barrels and straightening saws and sheet metal plates.

In straightening rifle barrels, the operator is guided as to the straightness as follows: A black line is drawn across a piece of glass elevated to the light, and the straightener looks through the bore at this line, which throws a dark line of shadow along the rifle bore. If this line appears straight while the barrel is rotated the bore is straight; but if the line waves the barrel requires straightening, the judgment of the operator being relied upon to determine the amount of the error, its location, and the force and nature of the blow necessary to rectify it.

The following information on the duration of a blow is taken from *Engineering*, the results having been obtained from some experiments by Mr. Robert Sabine. These experiments, which were intended as preliminary to a more extended inquiry, were made with a view to find approximately how the duration of a blow varied with the weight of the hammer, its velocity of descent, and with the materials. An iron ball weighing $\frac{1}{4}$ lb. was suspended by a fine wire from an insulated support upon the ceiling, so that when it hung vertically it just grazed the vertical face of an ordinary blacksmith's anvil placed upon its side on a table. By raising the ball and letting it swing against the face of the anvil a blow of varying force could be struck. On rebounding, the ball was arrested whilst the excursion of the galvanometer needle was observed. By measuring the angle through which the ball was separated, its vertical fall and final velocity could be easily deduced. In this way the greatest vertical height from which the iron ball was let fall on to the face of the iron anvil was 4 ft., the least about $\frac{1}{80}$ inch. Six readings were taken for each height, and they were invariably found to agree amongst each other. The averages only are given in the following records:

Vertical fall in inches.	Duration of contact in seconds.
48	0·00008
36	0·00008
28	0·00008
17	0·00009
$9\frac{1}{4}$	0·00010
4	0·00011
1	0·00013
$0\frac{1}{4}$	0·00016
$0\frac{1}{16}$	0·00018
$0\frac{1}{32}$	0·00021
$0\frac{1}{80}$	0·00030

From this it would appear that when the velocity of a blow is increased, the duration is decreased within a certain limit; but that it reaches a minimum. The velocity of impact in the first experiment was about sixty times as great as in the last one; but the duration of the blow appears to be reduced only to about one-fourth of the time. The blows given by two hammers of different weights were compared. No. 1 weighed 4 ozs., No. 2 weighed only $2\frac{1}{4}$ ozs. The durations of the blows were as follows:

Vertical fall.	Duration of contact.	
	Ball No. 1.	Ball No. 2
inch.	seconds.	seconds.
1	0·000135	0·000098
4	0 000096	0·000083

It appears from this that a heavier hammer of the same material gives a longer duration of blow.

In the course of these experiments it was observed that the ball after striking the anvil rebounded irregularly, sometimes to a greater, at others to a less height, and that some relation appeared to exist between the heights to which the ball rebounded and the excursions of the galvanometer needle due to the residue of the charge.

In the next series, therefore, the rebounds of the iron ball from the iron anvil were measured and recorded, from which it appeared that when the rebound was greater the duration of contact was shorter, and *vice versâ*.

Vertical fall.	Vertical rebound.	Duration of blow.
inch.	inch.	seconds.
6	2	0·000120
6	$2\frac{1}{2}$	0 000111
6	$3\frac{1}{4}$	0·000101
6	$3\frac{1}{2}$	0 000091
$14\frac{1}{2}$	$3\frac{1}{4}$	0·000106
$14\frac{1}{2}$	$4\frac{1}{2}$	0 000103
$14\frac{1}{2}$	$5\frac{1}{4}$	0·000095
$14\frac{1}{2}$	$6\frac{1}{2}$	0 000086
25	$7\frac{3}{4}$	0 000096
25	$8\frac{1}{4}$	0·000091
25	$9\frac{1}{2}$	0·000086
25	12	0·000078

The explanation of this is probably that when the energy of the blow is expended in bruising or permanently altering the form of the hammer or anvil by which the contact of the two is prolonged, it has less energy left to enable it to rebound, and *vice versâ*. Substituting a brass anvil and brass ball, it was found that the blow was duller, the rebound much less, and the duration contact nearly three times as great as when the iron ball and anvil were used.

Vertical fall.	Vertical rebound.	Duration of contact.
inch.	inch.	seconds.
$1\frac{3}{4}$	$0\frac{1}{3}$	0·00036
6	1	0·00033
$14\frac{1}{2}$	$1\frac{1}{2}$	0·00026
25	2	0·00027

This series also shows the longer duration of the blow when its velocity is small. Using a brass anvil and iron ball the duration of the blow was greater than when both were of iron, but less than when both were of brass.

Vertical fall.	Vertical rebound.	Duration of contact.
inch.	inch.	seconds.
$1\frac{3}{4}$	$0\frac{1}{8}$	0·00021
6	$0\frac{1}{2}$	0·00018
$14\frac{1}{2}$	$1\frac{1}{3}$	0·00015
25	2	0·00014

Striking the brass anvil with a common hammer, the duration of the blow appeared shorter when struck sharply.

	Duration of contact. seconds.
Moderate blow	0·00027
Harder blow	0·00019

Striking the blacksmith's anvil with a common carpenter's hammer, the duration appeared to be nearly constant.

	Duration of contact. seconds.
Moderate blow	0·00011
Harder blow	0·00010

It was, of course, necessary to allow in each case the hammer to rebound freely, and not to prevent it doing so by continuing to exert any pressure at the instant of the blow. When this condition

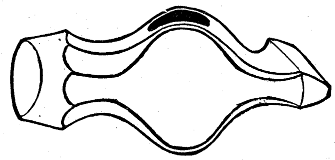


Fig. 2094.

was observed, it was invariably found that the harder and sharper the blow the shorter was its duration. It was also noticed that whenever the anvil gave out a sharp ringing sound, the duration of the blow was much shorter than when the sound was dull.

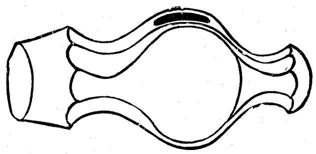


Fig. 2095.

A very slight error would be introduced by reason of thermo-currents set up between the metals at the moment of the blow. By reversing the direction of charge of the accumulator, however, the effect from this cause was found to be quite inappreciable.

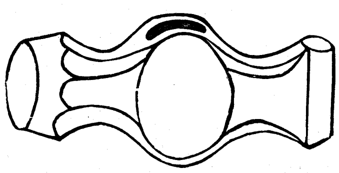


Fig. 2096.

The machinists' hand hammer is usually made in one of the three forms shown in Figs. 2094, 2095 and 2096, and varies in weight from about $1\frac{3}{4}$ lbs. for heavy chipping to about $\frac{1}{2}$ lb. for light work, the handle being about 15 inches long for the heavy,

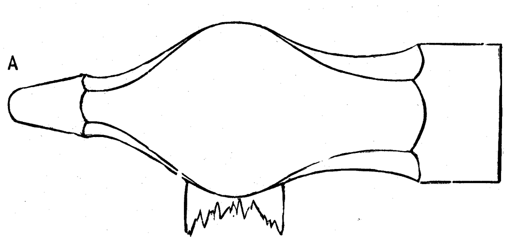


Fig. 2097.

and about 10 or 12 for the light business. The round face is usually somewhat convex on its surface with its edge slightly rounded or beveled. The pane or pene A, Fig. 2097, is usually made in European practice to stand at a right angle to the axis of the handle as shown, while in the United States it is usually made to stand parallel with the handle as in Fig. 2096. The face end is sometimes given taper as in Figs. 2094 and 2095, and at others parallel as in Figs. 2097 and 2098, or nearly so. The pene is mostly used for riveting purposes, and it is obvious that

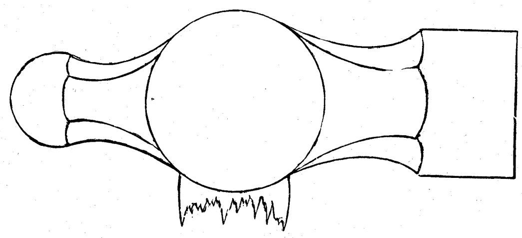


Fig. 2098.

with the pene at a right angle to the handle axis as in Fig. 2097, it will not matter whether the pene meets the work quite fair or not, especially as the pene is made slightly curved in its length, and it is easier to hold the hammer level sideways than it is to

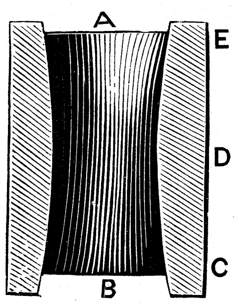


Fig. 2099.

hold it so true lengthways that the pene, when forward, as in Fig. 2096, will meet the work fair.

The proper shape for the eye of a hammer is that shown in Figs. 2099 and 2100, A representing the top of the hammer. The

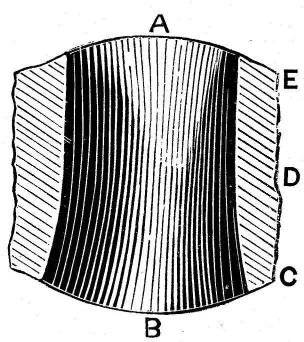


Fig. 2100.

two sides of the eye are rounded out from the centre towards each end, while the ends of the eye are made parallel. The form of the eye as viewed from the top A is as shown in Fig. 2102, while Fig. 2101 represents a view from the bottom B. The handle is

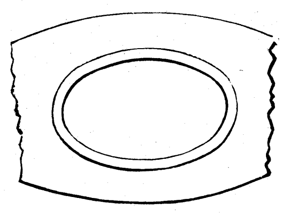


Fig. 2101.

fitted a driving fit and is driven in from side B, and is shaped as in Figs. 2103 and 2104 which are side and edge views.

From C to D the handle fills the eye, but from D to E it fills the eye lengthways only of the oval. A saw-slot, to receive a wedge, is cut in the handle, as shown in Fig. 2104. The wedge is best made of soft wood, which will compress and conform itself to the shape of the slot. To drive the handle into the eye, preparatory to wedging it permanently, it should be placed in the eye held

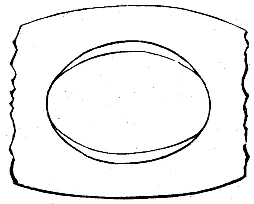


Fig. 2102.

vertically, with the tool head hanging downward, and the upper end struck with a mallet or hammer, which is better than resting the tool head on a block. The wedge should be made longer than will fill the slot, so that its upper end may project well, and the protruding part, which may split or bulge in the driving, may be cut off after the wedge is driven home.

The wedge should be driven first with a mallet and finally with

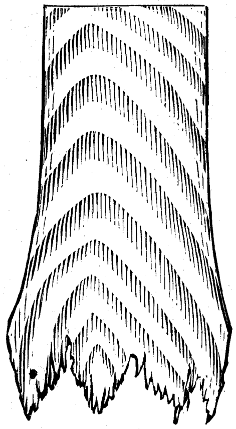


Fig. 2103.

a hammer. After very few blows on the wedge, the tool should be suspended by the handle and the end of the latter struck to keep the handle firmly home in the eye. This is necessary, because driving the wedge in is apt to drive the handle partly out of the eye.

The width of the wedge should equal the full length of the oval

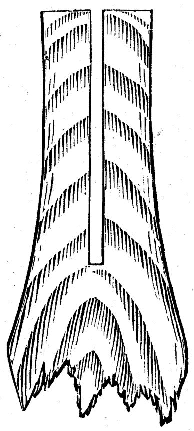


Fig. 2104.

at the top of the eye, so that one wedge will spread the handle out to completely fill the eye, as shown in Fig. 2105. Metal wedges are not so good as wooden ones, because they have less elasticity and do not so readily conform to the shape of the saw-slot, for which reasons they are more apt to get loose. The taper on the wedge should be regulated to suit the amount of taper in the eye, while the thickness of the wedge should be sufficient in excess of the width of the saw-cut, added to the taper in the eye, that there will be no danger of the end of the wedge meeting the bottom of the saw-slot.

By this method, the tool handle is locked to the tool eye by being spread at each end of the same. If the top end of the tool eye were rounded out both ways of the oval, two wedges would be required to spread the handle end to fit the eye, one wedge standing at a right angle to the other. In this case, one wedge may

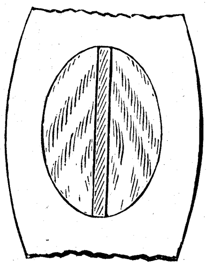


Fig. 2105.

be of wood and one of metal, the one standing across the width of the oval usually being the metal one. The thin edge of the metal wedge is by some twisted, as shown by Fig. 2106, which causes the wedge to become somewhat locked when driven in.

In fitting the handle, care must be taken that its oval is made to stand true with the oval of the tool eye. Especially is this necessary in the case of a hammer. Suppose, for example, that in Fig. 2107 the length of the oval of the handle lies in the plane A B, while that of the eye lies in the plane C D, then the face of the hammer will meet the work on one side, and the hammer will

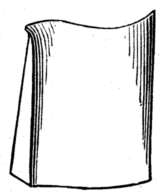


Fig. 2106.

wear on one side, as shown in figure at E. If, however, the eye is not true in the hammer, the handle must be fitted true to the body of the hammer; that is to say, to the line C D. The reason for this is that the hand naturally grasps the handle in such a manner that the length of the oval of the handle lies in the plane of the line of motion when striking a blow, and it is obvious that to strike a fair blow the length of the hammer should also stand in the plane of motion.

The handle should also stand at a right angle to the plane of the length of the hammer head, viewed from the side elevation,

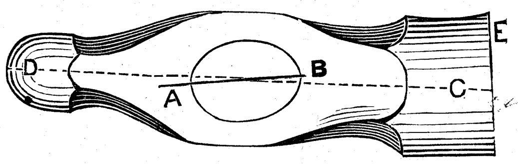


Fig. 2107.

as shown in Fig. 2108, in which the dotted line is the plane of the hammer's length, while B represents a line at a right angle to A, and should, therefore, represent the axial line of the hammer handle. But suppose the handle stood as denoted by the dotted line C, then the face of the hammer would wear to one side, as shown in the figure at D.

In the operation of straightening iron or steel plates by hammer blows, the process when correctly carried out is one of liberating the strains (whose existence throws the plate out of a true plane) by stretching those parts that are unduly contracted. Every hammer blow should, therefore, be directed towards this end, for one misdirected blow entails the delivery of many others to correct its evil influence; hence, if several of such misdirected blows are given, the plate will have upon it a great many more hammer marks, or "hammer sinks" or chops, as they are sometimes termed, than are necessary. As a result, not only will the painter (in fine work) be given extra trouble in stopping the hollows to make a smooth surface, but the following evil will result: Every blow struck by the hammer compresses and proportionately stiffens the small surface upon which it is delivered, and creates a local tension upon the surrounding metal. The misdirected blows then cause a tension acting in opposition to the effect of the properly delivered ones; and though the whole plate may be stiffened by the gross amount of blows, yet there will be created local tensions in various parts of the plate, rendering it very likely to spring or buckle out of truth again. If, for example, we take

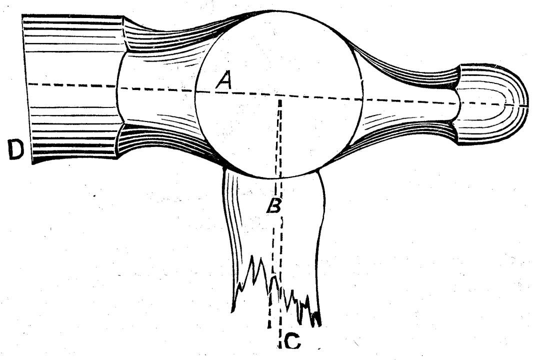


Fig. 2108.

a plate of iron and hammer it indiscriminately all over its surface, we shall find it very difficult to straighten it afterwards, not only on account of the foregoing reasons, but for the additional and most important one that the effect of the straightening blows will be less, on account of the hammered surface of the plate offering increased resistance to the effects of each blow; and after the plate is straightened, there will exist in it conflicting strains, an equilibrium of which holds the plate straight, but the weakening of any of which will cause the preponderance of the others to throw the plate out of straight; for the effects of the blows cannot be permanent unless the whole body of the iron is acted upon to an equal extent by the hammer. Suppose, for example, that we take a flat plate, and deliver upon it a series of blows round about its centre. The effect will be to make it hollow on one side and rounding on the other, the effect of the blows being, not only

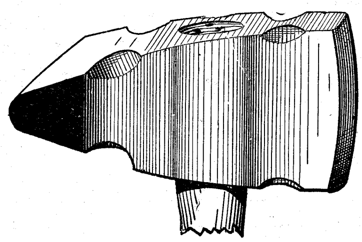


Fig. 2109.

to indent the plate in the spots where they fell, but to carry the whole body of the middle out of true; because, the area of the iron being increased by the stretching effect of the blows, the centre leaves the straight line to accommodate the increased area. Thus, if we mark off a circle of, say, a foot in diameter, in the middle of a plate, and hammer it so as to stretch it and increase its area $\frac{1}{8}$ inch each way, the form of the plate must alter to suit this added area, and the form of a dish or curve is the only one it can assume.

The skilful workman, so soon as he has ascertained where the plate is out of true, sets to work to stretch it, so as to draw the crooked place straight, taking care that the shape and weight of the hammer and the weight of the blows delivered shall bear a proper relation to the thickness of the plate and the material of which it is composed. If it is of consequence that the finished work shall bear no marks of the hammering (as in the case of engravers' plates), an almost flat-faced hammer is employed; but for other work the shapes, as well as the weights, of the hammers vary.

Fig. 2109 represents what is called the long cross-face hammer, used in saw straightening for the first part of the process which is called the smithing. The face that is parallel to the handle is called the long one, and the other is the cross-face. These faces are at a right angle one to the other, so that without changing his position the operator may strike blows that will be lengthways

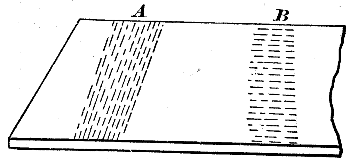


Fig. 2110.

in one direction, as at A, in Fig. 2110, and by turning the other face towards the work he may strike a second series standing as at B. Now, suppose we had a straight plate and delivered these two series of blows upon it, and it will bend to the shape shown in Fig. 2111, there being a straight wave at A, and another across the plate at B, but rounded in its length, so that the plate will be highest in the middle, or at C; if we turn the plate over and repeat the blows against the same places, it will become flat again. Both faces of this hammer are made alike, being rounded across the width and slightly rounded in the length, the amount of this

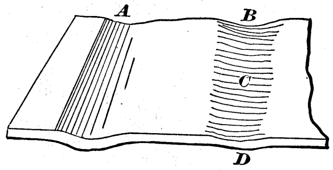


Fig. 2111.

rounding in either direction being important, because if the hammer leaves indentations, or what are technically called "chops," they will appear after the saw has been ground up, even though the marks themselves are ground out, because in the grinding the hard skin of the plate is removed, and it goes back to a certain, but minute, extent towards its original shape. This it will do more in the spaces between the hammer blows than it will where the blows actually fell, giving the surface a slightly waved appearance.

The amount of roundness across the face regulates the widths, and the amount of roundness in the face length regulates the

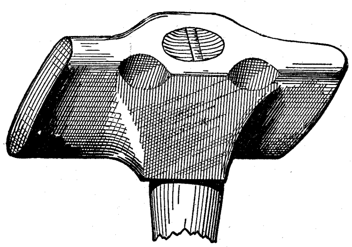


Fig. 2112.

length of the hammer marks under any given force of blow. As the thicker the plate the more forcible the blow, therefore the larger the dimensions of the hammer mark.

The twist hammer, shown in Fig. 2112, is used for precisely the same purposes as the long cross-face, but on long and heavy saws or plates, and for the following reasons, namely: When the operator is engaged in straightening a short saw he can stand close to the spot he is hammering, and the arm using the hammer may be well bent at the elbow, which enables him to see the work plainly, and does not interfere with the use of the hammer, while the shape of the smithing hammer enables him to bend his elbow and still deliver the blows lengthways, in the required direction. But when a long and heavy plate is to be straightened, the end not on the anvil must be supported with the left hand, and it stands so far away from the anvil that he could not bend his elbow and still reach the anvil. With the twist hammer, however, he can reach his arm out straight forward to the anvil, to reach the work there, while still holding up the other end, which he could not do if his elbow were bent. By turning the twist hammer over he can vary the direction of the blow the same as with the long cross-face.

It is obvious that by slightly bending the elbow and turning either of these hammers over the blows may be caused to be in

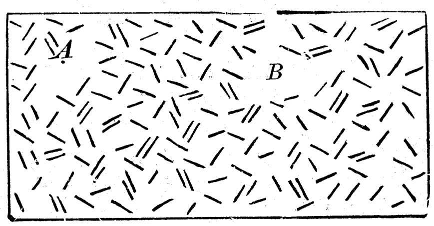


Fig. 2113.

any required direction, as shown in Fig. 2113. These two hammers are used for the straightening or smithing processes, and not to regulate the tension, because the effects of their blows do not extend equally around the part struck, but follow the form of the hammer marks, whose shapes are shown in Fig. 2114, at A and B, the radiating lines denoting the directions in which the effects extend; obviously the size of these marks depends upon the shape of the hammer face and the force of the blow.

An inspection of hammered saw plates, however, will show that

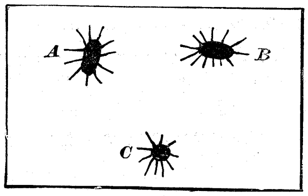


Fig. 2114.

the marks (which are scarcely visible, having a merely dulled surface), are usually about one-half wider than the thickness of the plate, and about four or five times as long as they are wide. Obviously, also, the direction of the effects of a blow follow the direction in which the hammer travels. If, for example, the long cross-face falls vertically its effects will extend equally all around the hammer mark, as at A in Fig. 2115, but if the hammer moved laterally to the left while falling its blows would have more effect on the left-hand side of the mark as at B, or if it moved away

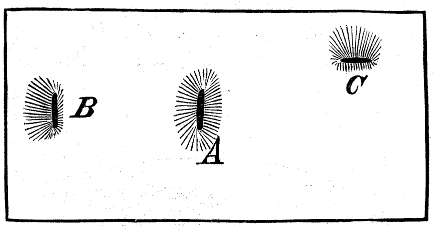


Fig. 2115.

from the operator its effects would extend most in front as at C, the amount increasing with the force of the blow, and it may be remarked that quick blows are not used, because they would produce indentations or chops; hence, the force of the blow is regulated by the weight of the hammer rather than by the velocity it travels at. On account of the oval shape of the blow delivered by the long cross-face and by the twist hammers, the dog-head hammer, shown in Fig. 2116, is used to regulate the tension of the plate or saw, the effects of its blow when delivered vertically being circular, as at A, in Fig. 2117; obviously, however, if in falling it moved vertically in the direction of arrow C the effects would extend as at B. But while the dog-head is used entirely for regulating the tension, it may also be used for the same purposes as either the long cross-face or the twist hammer, because the smith operates to equalize the tension at the same time that he is taking down the lumps; hence he changes from one hammer to the other in an instant, and if after regulating the tension with the dog-head he should happen to require to do some smithing, before regulating the tension in another, he would go right on with the dog-head and do the intermediate smithing without changing to the smithing hammer. Or, in some cases, he may use the long cross-face to produce a similar effect to that of the dog-head, by letting the blows cross each other, thus distributing

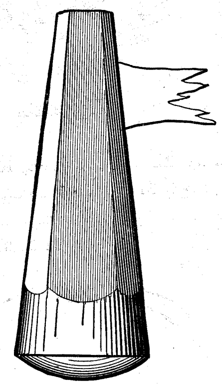


Fig. 2116.

the hammer's effects more equally than if the blows all lay in one direction.

In circular saws, which usually run at high velocity, there is generated a centrifugal force that is sufficient to actually stretch the saw and make it of larger diameter. As the outer edge of the saw runs at a greater velocity than the eye it stretches most, and therefore the equality of tension throughout the saw is destroyed, the outer surface becoming loose and causing the saw to wabble as it revolves, or to run to one side if one side of the timber happens to be harder than the other, as in the case of meeting the edge of a knot.

The amount of looseness obviously depends upon the amount the saw expands from the centrifugal force, and this clearly depends upon the speed the saw is to run at; so the saw straightener requires to know at what speed the saw is to run, and, know-

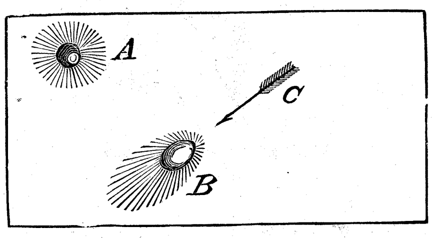


Fig. 2117.

ing this, he gives it more tension at the outside than at the eye; or, in other words, while the eye is the loosest, the tension gradually increases towards the circumference, the amount of increase being such that when the saw is running the centrifugal force, and consequent stretching of the saw, will equalize the tension and cause the saw to run steadily.

If the eye of a circular saw is loose, or, in other words, if it is rim bound when running, it will dish, as in Fig. 2118, and the rounded side rubbing against the side of the saw slot or kerf, will cause the saw to become heated and the eye to expand more than the outer edges, thus increasing the dish. But if the saw strikes a knot on the hollow side it may throw the dish over to the other side of the saw in an instant. The remedy is to hammer the saw with the dog-head as shown in the figure, not touching the eye, and letting the blows fall closer together towards the circumference.

On the other hand, if the eye is tight and the circumference loose the saw will flop from side to side as it runs, and the remedy

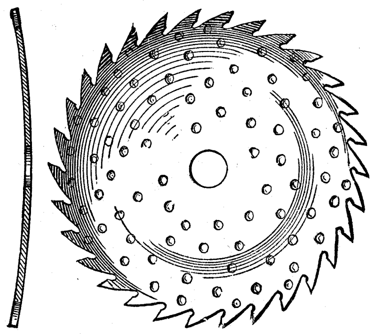


Fig. 2118.

is to stretch it round about the eye, letting the blows fall wider apart as the outer edge of the saw is approached. The combinations of tight and loose places may be so numerous in circular saws that as the smith proceeds in testing with the straight-edge

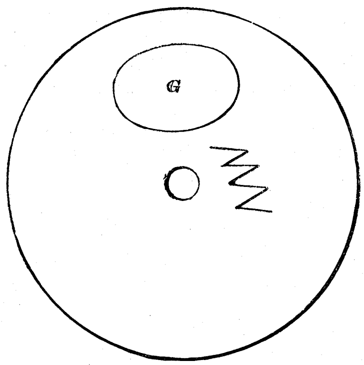


Fig. 2119.

he marks them, drawing a circular mark, as at G, in Fig. 2119, to denote loose, and the zig-zag marks to indicate tight places. To cite some practical examples of the principles here laid down, suppose we have in Fig. 2120 a plate with a kink or bend in the

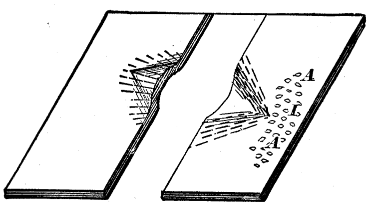


Fig. 2120.

edge, and as this would stiffen the plate there, it would be called a tight place. To take this out, the hammer marks would be delivered on one side, radiating from the top of the convexity, as on the left, and on the other as shown radiating from the other end of the concavity, as on the right, the smithing hammer being

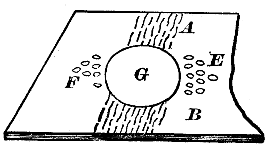


Fig. 2121.

used. This would induce a tight place at A which would be removed by dog-head blows delivered on both sides of the plate. Suppose we had a plate with a loose place, as at G in Fig. 2121. We may take it out by long cross-face blows, as at A and B, delivered on both sides of the plate, or we might run the dog-head on both sides of the plate, both at A and at B, the effect being in either case to stretch out the metal on both sides of the loose place G, and pull it out. In doing this, however, we shall have caused tight places at E and F, which we remove with dog-head blows, as shown. If a plate had a simple bend in it, as in Fig. 2122, hammer blows would first be delivered on one side, as at A,

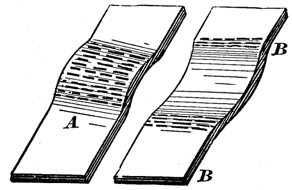


Fig. 2122.

and on the other side, as at B. A much more complicated case would be a loose place at G, in Fig. 2123, with tight places at H, J, K, and L, for which the hammer blows would be delivered as marked, and on both sides of the plate. Another complicated case is given in Fig. 2124, G G being two loose places, with tight places between them and on each side. In this case, the

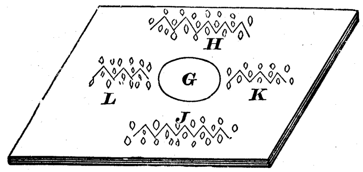


Fig. 2123.

hammering with the long cross-face would induce tight places at D and E, requiring hammer blows as denoted by the marks.

The saw or plate straightener's anvil or block is about 12 by 18 inches on its face, which must be very smooth and is slightly convex, because it is necessary that the plate should be solid on the block, directly beneath the part of its surface which is being

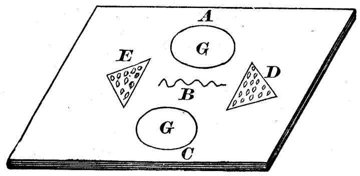


Fig. 2124.

hammered, otherwise the effect of the blows will be entirely altered. If, for instance, A, in Fig. 2125, represents the straightening block, and B a plate resting thereon, then the blows struck upon the plate anywhere save over the very edges of the anvil will have but little effect, because of the spring and rebound of the plate; and the effect of the blow will be distributed over a large area of the metal, tending to spring it rather than give it a permanent set. If the blow is a quick one, it may indeed indent the plate without having any straightening effect. On the other hand, by stretching the skin on the upper side of the plate, it will actually, under a succession of blows, become more bent. In fact, to use a straightening block, so large in proportion to the size of the plate that the latter cannot be adjusted so that the part of the plate struck lies solid on the block, renders all the principles above explained almost valueless, and is a process of

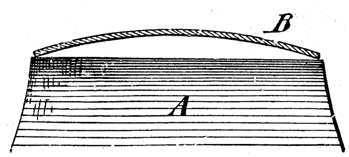


Fig. 2125.

Fig. 2127.

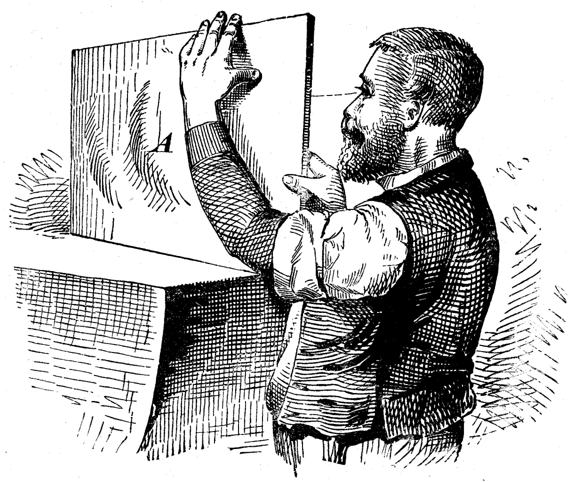


Fig. 2128.

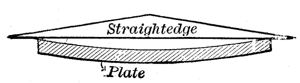


Fig. 2129.

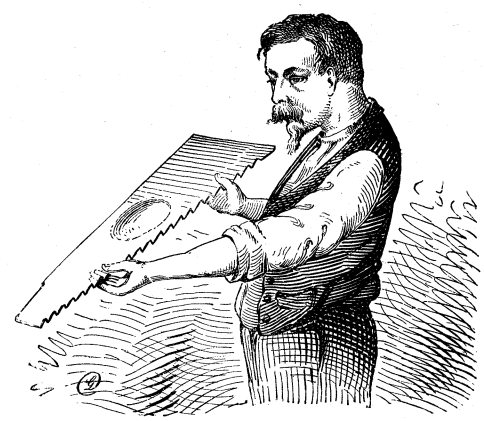


Fig. 2131.

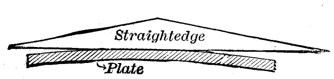


Fig. 2130.

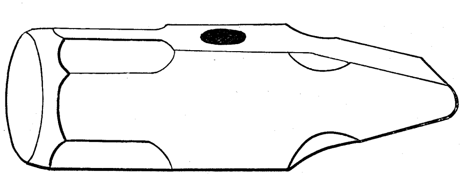


Fig. 2132.

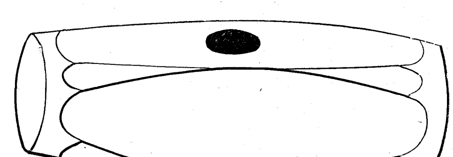


Fig. 2133.

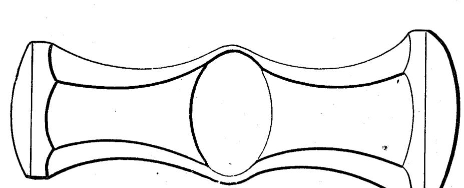


Fig. 2134

pounding, in a promiscuous way, productive of hammer marks, and altogether fatal to the production of true work.

To straighten the plate shown in Fig. 2125, we place it upon the anvil, as shown in Fig. 2126, striking blows as denoted at A, and placing but a very small portion of the plate over the anvil at first; and as it is straightened, we pass it gradually farther over the anvil, taking care that it is not, at any part of the process, placed so far over the anvil as to drum, which will always take

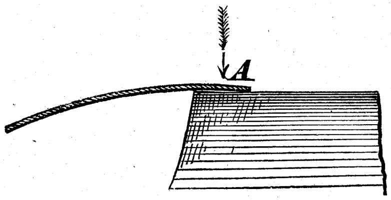


Fig. 2126.

place if the part of the plate struck does not bed, under the force of the blow, well upon the anvil.

The methods employed to discover in what parts a plate requires stretching, in order to straighten it and to equalize its tension, are as follow: Suppose we have a plate, say 18 inches by 24, and having a thickness of 19 gauge, and we rest one end of it upon the block and support the other end in the left hand, as shown in Fig. 2127; then with the right hand we exert a sudden pressure in the middle of the plate; and quickly releasing this pressure, we watch where its bending movement takes place. If it occurs most at the outer edges, it proves that the plate is contracted in the middle; while, if the centre of the plate moves the most, it demonstrates that it is expanded in the middle. And the same rule applies to any part of the

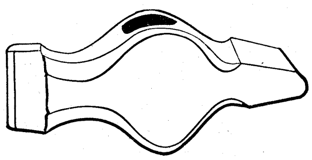


Fig 2135.

plate. This way of testing may be implicitly relied upon for all plates or sheets thin enough to be sprung by hand pressure.

Another plan, applicable for either thick or thin plates, and used conjointly with the first named, is to stand the plate on edge with the light in front, as in Fig. 2128; we then cast one eye along the face of the plate upon which the light falls, and any unevenness will be made plainly visible by the shadows upon the surface of the plate. The eye should also be cast along the edges to note any twist or locate any kinks.

We may take a thin piece of plate in the hands, and if it is loose in the middle and we lay a straight-edge upon its upper surface, and try to bend the middle of the plate downward with the fingers, it will go down under the finger pressure, the straight-

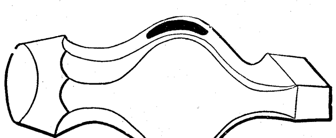


Fig. 2136.

edge showing a hollow place in the middle; and the same thing will occur if the straight-edge be tried with either side of the plate uppermost. But if the piece be tight in the middle and we test with the fingers and straight-edge in the same way, the middle instead of bending downwards, appears to rise up, the straight-edge showing it to be rounded. In the first case the middle moves because it is loose, and in the second the edges move because they are loose.

Fig. 2129 represents a plate for a circular saw that is loose in the middle, and if we bend the middle down it will become concave on the top, as shown in the figure. But if it were tight in the middle and loose at the outer edge, it would become, under the same pressure, convex on the top, as in Fig. 2130, and here again the part that is loose moves the most.

In thin saws, such as hand saws, the workman takes the saw in his hands, as in Fig. 2131, and bends it up and down so that by close observation he may see where it moves the most, and then discover the loose places, or he may watch for the tight places, since these are the places he must attack.

The sledge hammer used by the machinist is usually made in

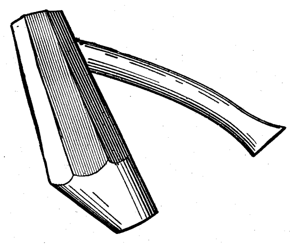


Fig. 2137.

one of the two forms shown in Figs. 2132 and 2133, the latter being the most serviceable because it has two faces which may be used for driving purposes, which is the only use the machinist has for the sledge hammer. The coppersmith varies the shape of his hammer faces to suit the nature of the work, thus Fig. 2134 represents a coppersmith's hammer, its two faces being of different sizes and of different curvature, and both being used to form convex surfaces having different degrees of curvature, it being noted that the curvature of the hammer face is always less than that of the work. In other forms of coppersmith's hammers there are two penes and no face, one being at a right angle to the

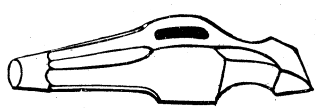


Fig. 2138.

other, as in Fig. 2135, the penes being rounded as in the figure, or sometimes square.

Fig. 2136 represents a coppersmith's hammer with a square nosed pene, which is sometimes made to stand at a right angle to the handle as in the figure, and at others parallel to it.

Fig. 2137 represents the file cutter's hammer, whose handle is at the angle shown because the chisel is held at an angle, the point or cutting edge being nearest to the workman; hence if the handle were at a right angle to the hammer length his arm would require to be considerably elevated in order to let the hammer face fall fair on the chisel head, whereas by setting the handle at

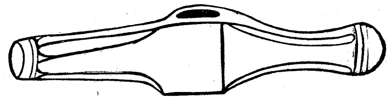


Fig. 2139.

the angle shown the arm need not be elevated, and the blow may be given by a movement of the wrist.

Figs. 2138 and 2139 represent hammers used by boiler-makers for riveting boiler seams. The faces are made small so that if the blows are properly directed the edge of the face will not meet the boiler plate and indent it. These hammers are made long and narrow so that the weight may lie in the same direction as the hammer travels in when delivering the blow, and thus cause the effects of the hammer blows to penetrate deeper than if the hammer was wider.

In the cooper's hammer, shown in Fig. 2140, the face extends flush up to the head, thus enabling it to strike a hoop upon a barrel without danger of the extreme end or top of the hammer meeting the barrel, and preventing the hammer face from meeting the edge of the barrel hoop when driving it on the barrel. The face is square and its front edge therefore a straight line, which is necessary on account of the circular shape of the hoop of the barrel.

The mallet is made in various forms to suit the nature of the work and the tools it is to be used upon. Thus the carpenter's mallet is a rectangular block, such as shown in Fig. 2141. It is composed of wood, because the carpenter's tools are held in

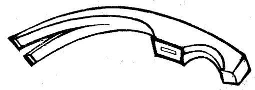


Fig. 2140.

wooden handles, and a metal hammer would split them in course of time. It is rectangular in shape so that it may be applied to tools held in a corner of the work, where a round mallet could not, if of sufficient diameter, give the necessary weight. For such carpenters' or wood-workers' tools as are for heavy duty, and the tools for which have ferrules at the head of their handles to prevent them from splitting, the mallet is made cylindrical or round, as it is termed, and has an iron band at each end to prevent the face from spreading or splitting.

The stonemason's mallet is also of wood, and is disk-shaped, with the handle in the centre, the circumferential surface forming

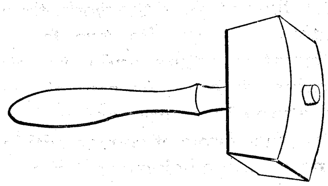


Fig. 2141.

the face. The reason for this is that his tools are of steel and have no handles; hence if the blow continually fell on the same part or spot of the mallet face it would sink or indent holes in it, which is prevented by utilising the whole circumference of the mallet for the face.

An excellent mallet for the machinist's use, for driving finished work without damaging it, is formed of raw hide secured in a metal eye that receives the handle. Or for the same purpose a lead hammer is used, being especially serviceable for setting work in machines.

What is known as pening, or paning, consists of hammering

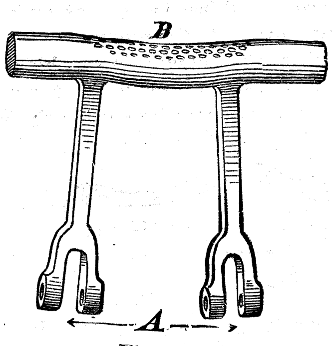


Fig. 2142.

the skin of metal to stretch it on the side that is hammered. It may be employed either to bend or to straighten. Suppose, for example, we have a piece of metal that is bent to a half circle, and if we take a light hammer and hammer it on the concave side and all over its surface the piece will straighten out to an amount depending on the amount of pening. Or if he hammers the convex side the piece will bend to a smaller circle. The principle involved is, that if one side of a piece is elongated and the other remains of its original length, the only shape it can assume to accommodate or permit the elongation is that of a curve of which the convex side is the longest. It follows, therefore, that the hammer blows must in pening be sufficiently light to condense or stretch the metal on one side only of the metal, and not forcible enough to effect it all through.

In order to accomplish this stretching as rapidly as possible it is necessary to use a light hammer, with sufficient force to be expended in condensing the metal at its surface, and to so form the hammer that it shall expend its force upon the work with a dead blow, that is, with as little rebound as possible. These results are best accomplished with a ball pened hammer, such as shown in Fig. 2108 and weighing about $\frac{1}{2}$ lb. The blows should fall dead; that is, the hammer should fall, to a great extent, by its own weight, the number rather than the force of the blows being depended upon; hence, the hammer marks will not be deep.

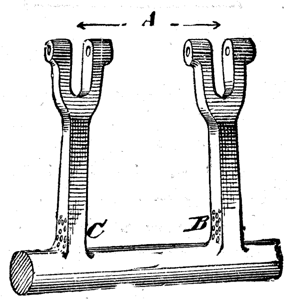


Fig. 2143.

This is of especial importance when pening has to be performed upon finished work, because, if the marks sink deeply, proportionately more grinding or filing is required to efface them; and for this reason the force of the blows should be as near equal as possible. Another and a more important reason, however, is that the effect of the pening does not penetrate deeply; and if much of the pened surface is removed, the effects of the pening will be also removed. The work should not be rested upon metal, but upon wood.

The following are examples of pening. Fig. 2142 represents a shaft bent as shown, the arms being too wide at A, which may be corrected by pening at B. If the error was in the arms themselves and not in the stem, the side faces of the arms would require to

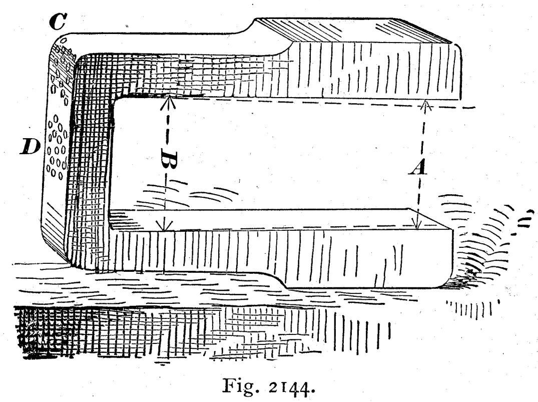


Fig. 2144.

be pened. Thus in Fig. 2143 the distance A is too short, and the pening must be at B C.

Fig. 2144 represents a strap requiring to be closed across A, the pening being at C or D. But as pening at D would bend the crown and unpair the bed of the brasses, it is preferable to pene at C. In either case the jaws will close as denoted by the dotted lines.

Fig. 2145 represents another common form of connecting rod strap, and in this case the pening may be most quickly and effectively done at the crown as denoted by the dots; and as this would alter the inside curve, the brass or box fitting into it must be refitted. In case the pening should be overdone it is better to modify it by filing away some of the pened surface.

Cast iron is more rapidly affected by pening than either wrought iron or steel. One of the most useful applications of pening is in the case of moulding patterns, which in time may become warped from the rapping of the pattern in the mould, and this warping may be corrected by judicious pening, or suppose that a number of plates, such as represented in Fig. 2146, having been cast, it is found that the ends of the tongues A B curl up when cooling in the mould, then the tongues may be pened as at C D, throwing

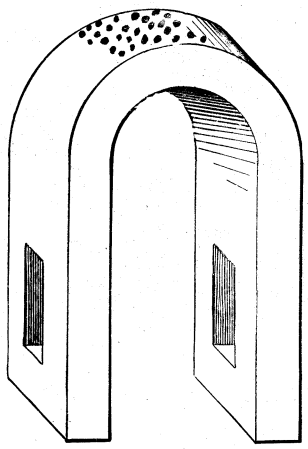


Fig. 2145.

them down to the requisite amount, and thus moulding the pattern to accommodate the curling in cooling.

The riveting usually performed by the machinist is generally upon cold metal. The blows in this case should fall dead and the riveting be performed with a view to stretching the metal uniformly and evenly over the surface to be riveted.

An excellent example of cold riveting is given in the crank

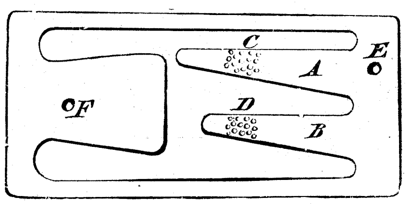


Fig. 2146.

pin P in Figs. 2147 and 2148. C is the crank (both being shown in section). The end of the pin should be recessed as shown at A, so that it may be the more readily riveted outward to fill the countersink shown in the crank at B, B. The crank-pin is rested upon a piece of copper D interposed between it and the

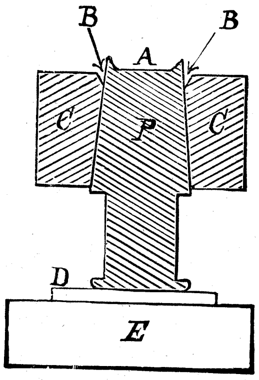


Fig. 2147.

iron block E to prevent damage to the finished face of the crank-pin.

The riveting blows should be given with a ball-faced hammer, and delivered with a view to stretch the whole end face of the crank-pin evenly. Otherwise the riveted surface will be apt to split as shown. This usually occurs from not riveting the area at and near the circumference sufficiently, although it may occur from riveting that part of the area too much. The line of travel of the hammer should not be directly vertical, but somewhat lateral in a direction from the centre towards the circumference. If the countersink is a deep one, it is desirable to leave the crank-pin sufficiently too long, so that after the riveting has proceeded some time the surface of the metal which has become condensed and crystallized from the direct impact of the hammer blows, may be chipped away, leaving a surface that is swollen by the riveting without being so much condensed. This enables a much greater spreading of the metal without splitting it.

If in this class of work the riveted piece (as the crank-pin) is not driven in very tight before riveting, the riveting blows will be

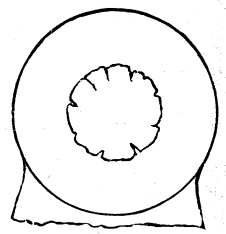


Fig. 2148.

apt to jar the pin back. Hence, it is necessary to occasionally drive the pin home. The riveting should proceed equally all over, as if one side be riveted in advance of the other it tends to throw the pin out of true. When, however, the riveting begins to bed the pin, four equidistant places may be riveted home in advance so as to bring the pin home and hold it firmly.

THE CHISEL.—The machinist's cold chisel is made from the two forms of steel shown in Figs. 2149, 2150, and 2151, and of these the former is preferable because it has two broad flats diametrally opposite and these form a guide to the eye in holding the chisel on the grindstone, and aid in grinding the facets that form

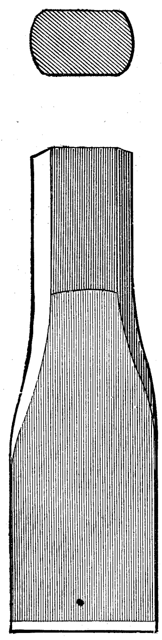


Fig. 2149.

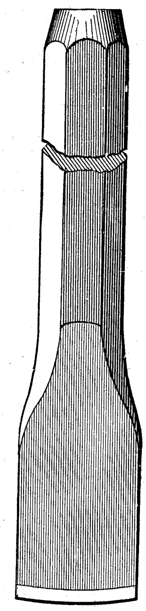


Fig. 2150.

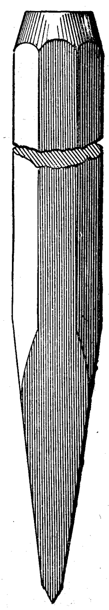


Fig. 2151.

the cutting edge true. Furthermore, as the cutting edge is in the same plane as these flats they serve as a guide to denote when the chisel edge lies parallel to the work surface, which is necessary to produce true and smooth chipping.

The width of the chisel may be made greater, as in Figs. 2152 and 2153, for brass or cast-iron work than for wrought iron or steel for the following reasons. On account of the toughness and hardness of wrought iron and steel the full force of a $1\frac{3}{4}$ lb. hammer, having a handle 13 inches long, may be used on a chisel about $\frac{7}{8}$ inch wide without danger of causing the metal to break out below the chipping line, but if such a chisel be used with full force blows upon cast iron or brass the metal is apt to break out in front of the chisel, the line of fracture often passing below the level it is intended to chip down to. Hence if a narrow chisel is used lighter blows must be delivered. But by using a broader chisel the force of the blow is distributed over a longer length of cutting edge, and full force blows may be used without danger of breaking out the metal.

The cutting end of the chisel should be kept thin, as in that case it cuts both easier and smoother. The total length of a chisel should not when new exceed 8 inches, for if made longer it is not suitable for heavy or smooth chipping, as it will bend and

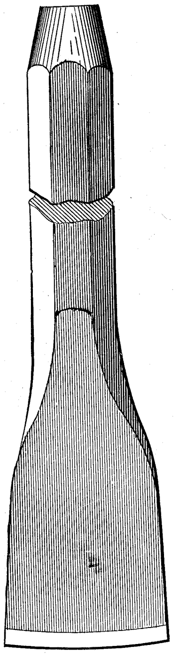


Fig. 2152.

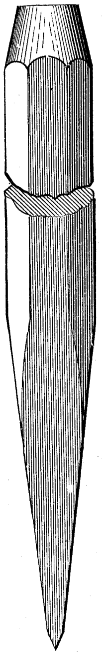


Fig. 2153.

spring under heavy blows, and cannot be held steadily. The forged part should not exceed about 2½ or 3 inches in length, as a long taper greatly conduces to springiness, whereas solidity is of great importance both to rapid and smooth work. The facets forming the cutting edge should be straight in their widths, as at B in Fig. 2154, and not rounded as at A, so that the face next to the work may form a guide in holding the chisel at the proper angle to maintain the depth of the cut. This angle depends upon the nature of the material to be cut; the facets forming an angle one to the other of about 65° for cast steel and about 50° for

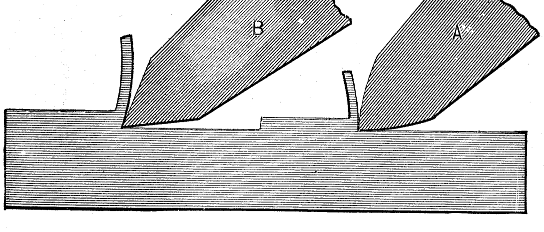


Fig. 2154.

gun metal or brass. The more acute these angles the nearer the body of the chisel lies parallel with the work and the more effective the hammer blows. Thus in Fig. 2155 chisel C is the position of the chisel for wrought iron, and position D is for steel. The angles should always be made, therefore, as acute as the hardness of the material will permit. If they are too acute the cutting edge will be apt to bend in its length, while if not sufficiently acute they will not cut keen enough; hence the object is to make them as acute as possible without causing the cutting edge to bend in its length. For copper and other soft metals the angle may be about 30° or 35°, the chisel end being kept thin so that it may not become wedged between the work and the chipping, which will bend but little, and is, therefore, apt to grip the wedge end of the chisel. The cutting edge should be slightly rounded in its length, which will strengthen it and also enable a fine

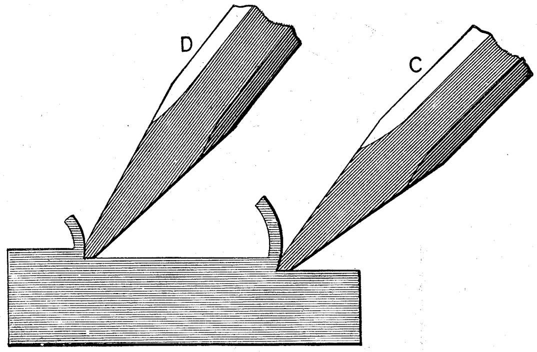


Fig. 2155.

finishing clip to be taken off, as in Fig. 2156, the width of the chip not extending fully across the chisel width so that the corners are not under duty and are not, therefore, liable to break, or dig in and prevent smooth chipping. In some practice the edge is made straight in its length, as shown in Fig. 2149, which is

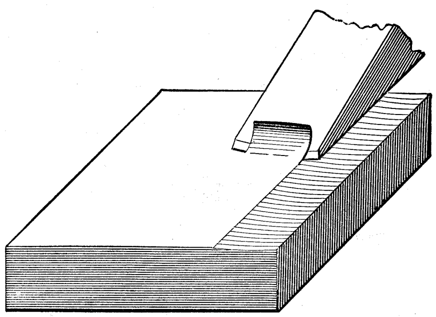


Fig. 2156.

permissible in heavy chipping when a cape chisel has been used, but in any event an edge rounded in its length is preferable. If the edge is hollow in its length, as shown in Fig. 2157, and magnified in Fig. 2158, the chip acts as a wedge to force the corners outwards as denoted by the arrows, causing them to break under

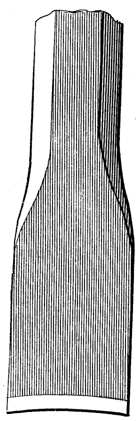


Fig. 2157.

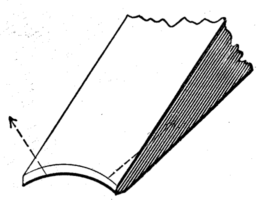


Fig. 2158.

a heavy cut, and, furthermore, a smooth cut cannot be taken when the corners of the chisel meet the work surface.

If the facets are ground under on one side, those on the other, as in Fig. 2159, the edge will not be parallel with the flats of the chisel, so that in holding it the flats will not form a guide to determine when the edge lies parallel to the work surface as it should do. The edge should also be at a right angle to the length of chisel, as denoted by the lines, as in Fig. 2160, for if not at a right angle the chisel will be apt to move sideways after each blow, and cannot be held steadily.

The chisel should be held as close to its head as possible, so that the hand will steady the head as much as possible, and should be pushed forward firmly and steadily to its cut, which will greatly facilitate rapid and smooth chipping, and for wrought iron

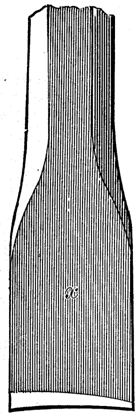


Fig. 2159.

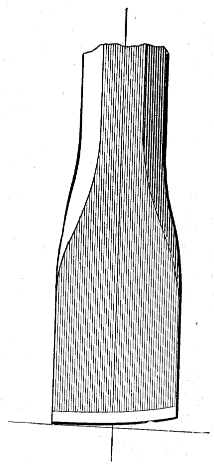


Fig. 2160.

and copper it is found better to occasionally moisten the chisel with oil or water, the former being preferable.

Messrs Tangye, of Birmingham, have introduced the employment of chisel holders, such as shown in Fig. 2161, the object being to fit to each holder a number of short pieces of steel for chisels so that a number can be ground or forged at one time; obviously chisels of different shapes require different forms of handle.

When a heavy cut is to be taken the cape (Fig. 2162) chisel is

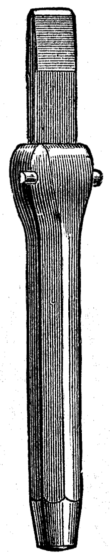


Fig. 2161.

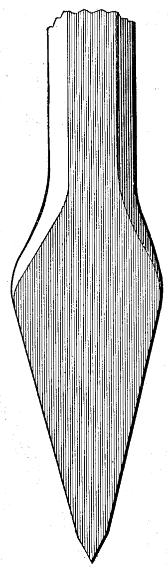


Fig. 2162.

used, first to carry through grooves or channels, such as shown in Fig. 2176 at A, B, and C, the distance apart of these grooves being slightly less than the width of the flat chisel, whose cut is shown partly carried across at D in the figure. The width of a cape chisel should gradually decrease from A to B in Fig 2163, so that its side will be free in the groove it cuts, and the chisel head will be free to be moved sideways, and the direction of the groove may be governed thereby. If the chisel end be made parallel, as at C in Fig. 2164, it will have no play in the groove and the head cannot be moved; hence if the groove is started out of line, as it is apt to be, it will continue so.

The round-nosed chisel, Figs. 2165 and 2166, may be straight from H nearly to the point G, but should be bevelled at and near G, so that the chisel head may be raised or lowered to govern the depth

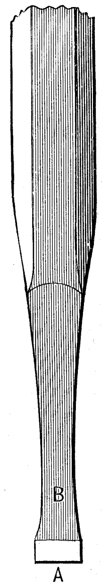


Fig. 2163.

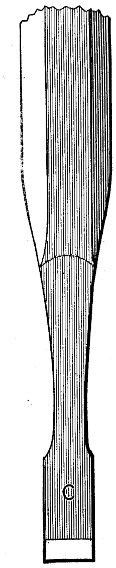


Fig. 2164.

of the cut. Its round nose should also be wider than the metal

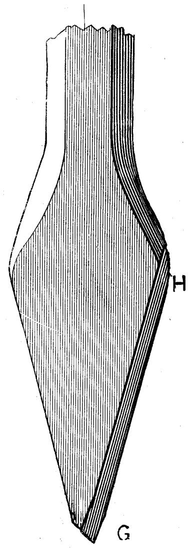


Fig. 2165.

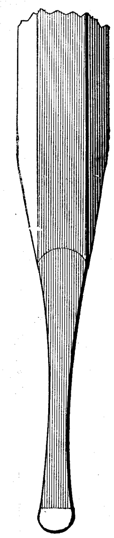


Fig. 2166.

higher up, so that the chisel head may be moved sideways to

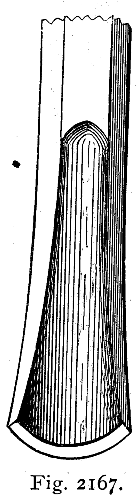


Fig. 2167.

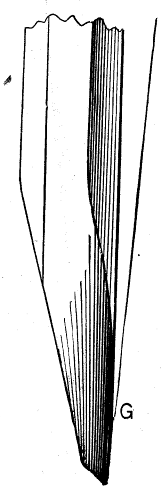


Fig. 2168.

govern the direction of the cut as in the cape chisel. The cow mouth chisel, Figs. 2167 and 2168, should be bevelled from G to the point to enable the governing of the depth of the cut, and should be of greater curvature than the corner it is to cut out, so that its corners cannot wedge in the work.

The oil groove chisel, Figs. 2169 and 2170, should be wider at

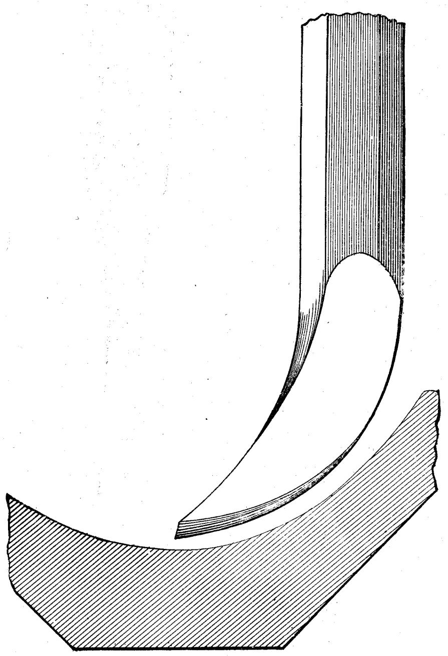


Fig. 2169.

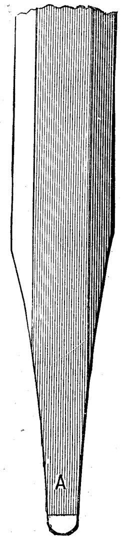


Fig. 2170.

the cutting edge than at A for reasons already stated, and of less curvature than the bore of the brass or bearing it is to cut the oil groove in.

The diamond point chisel, Figs. 2171 and 2172, may be made in two ways. First, as in Figs. 2173 and 2174, for shallow holes, and as in Figs. 2171 and 2172 for deep ones. In shallow holes the chisel can be leaned over, as in Fig. 2176 at *y*, whereas in

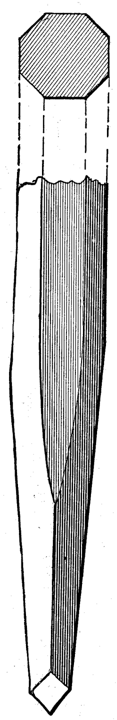


Fig. 2171

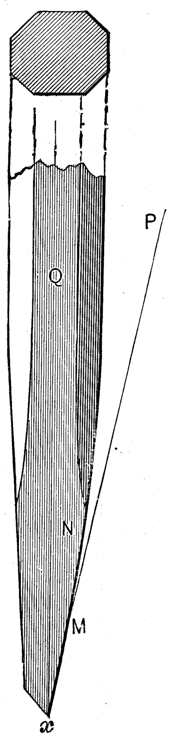


Fig. 2172.

deep ones it must be held straight so that the chisel body may not meet the other side of the hole, slot, or keyway. The form shown in Fig. 2172 is the strongest, because its point is brought into line with the body of the steel, as shown by the line Q. The side chisel, Fig. 2175, for cutting out the sides of keyways or slots, should be bevelled from W to the cutting edge for the reasons already given, and straight from W to V, the line V W projecting slightly above or beyond the body U. An application of the cow mouth chisel is shown at L, and one of the side chisel is shown at Z in Fig. 2176. All these chisels are tempered to a blue color.

The chisel that is driven by hammer blows may be said to be

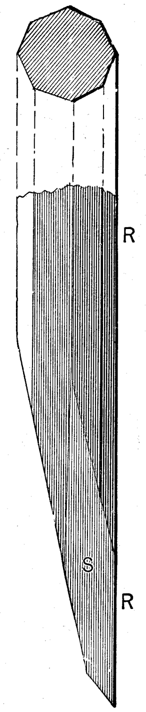


Fig. 2173.

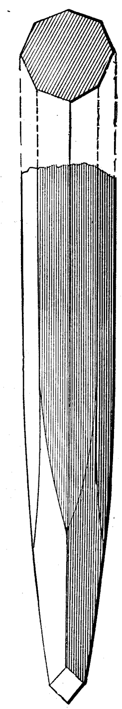


Fig. 2174.

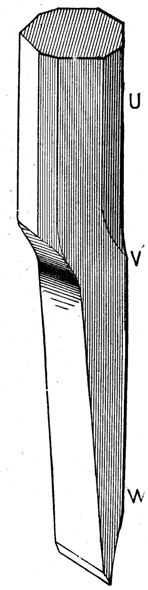


Fig. 2175.

to some extent a connecting link between the hammer and the cutting tool, the main difference being that the chisel moves to the work, while the work generally moves to the cutting tool. In many stone-dressing tools the chisel and hammer are combined, inasmuch as that the end of the hammer is chisel shaped; an example of this kind of tool being given in the pick that flour

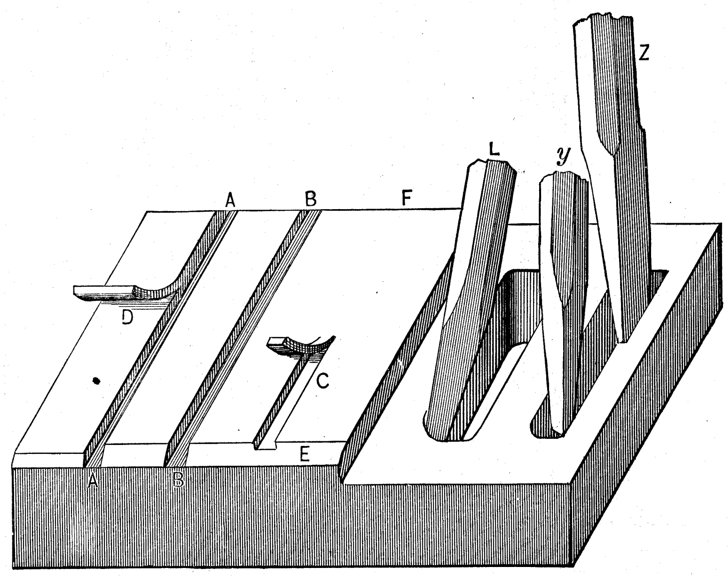


Fig. 2176.

millers use to dress their grinding stones. On the other hand we may show the connection between the chisel and the cutting tool by the fact that the wood-worker uses the chisel by driving it with a mallet, and also by using it for a cutting tool for work driven in the lathe. Indeed, we may take one of these carpenter's chisels and fasten it to the revolving shaft of a wood-planing machine, and it becomes a planing knife; or we may put it into a carpenter's hand plane, and by pushing it to the work it becomes a plane blade. In each case it is simply a wedge whose end is made more or less acute so as to make it as sharp as possible, while still retaining strength enough to sever the material it is to operate upon.

In whatever form we may apply this wedge, there are certain well-defined mechanical principles that govern its use. Thus when we employ it as a hand tool its direction of motion, under hammer blows, is governed by the inclination of the face which meets the strongest side of the work, while it is the weakest side of the material that moves the most to admit the wedge and therefore becomes the chip, cutting, or shaving. In Fig. 2177, for example, we have the carpenter's chisel operating at A and B to cut out a recess or mortise, and it is seen that so long as the

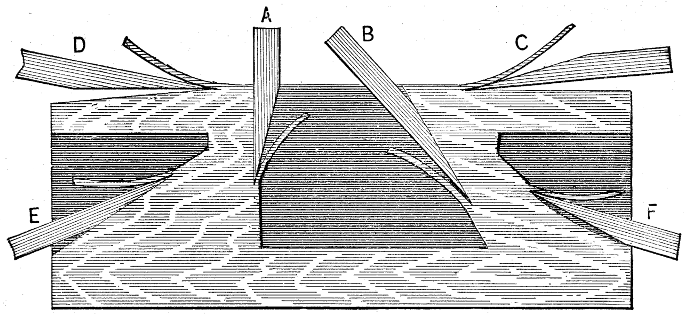


Fig. 2177.

face of the chisel that is next to the work is placed level with the straight surface of the work the depth of cut will be equal; or in other words, the line of motion of the chisel is that of the chisel face that lies against the work. At C and D is a chisel with, in the one instance, the straight, and in the other the bevelled face toward the work surface. In both cases the cut would gradually deepen because the lower surface of the chisel is not parallel to the face of the work.

If now we consider the extreme cutting edge of chisel or wedge-shaped tools it will readily occur that but for the metal behind this fine edge the shaving or cutting would come off in a straight ribbon, and that the bend or curl that the cutting assumes increases with the angle of the face of the wedge that meets the cutting, shaving, or chip.

I may, for example, take a piece of lead, and with a penknife held as at A, Fig. 2178, cut off a curl bent to a large curve, but if

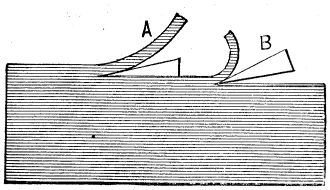


Fig. 2178.

I hold the same knife as at B it will cause the shaving to curl up more. Now it has taken some power to effect this extra bending or curling, and it is therefore desirable to avoid it as far as possible. For the purpose of distinction we may call that face of the chisel which meets the shaving the top face, and that which lies next to the main body of the work the bottom face. Now at whatever angle either face of the chisel may be to the other, and in whatever way we present the chisel to the work, the strength of the cutting edge depends upon the angle of the bottom face to the line of motion of the chisel, and this is a principle that applies to all tools embodying the wedge principle, whether they are moved by a machine or by hand.

Thus, in Fig. 2179 we have placed the bottom face at an angle of 80° to the line of tool motion, which is denoted by the arrow, and we at once perceive its weakness. If the angle of the top face to the line of tool motion is determined upon, we may therefore obtain the strongest cutting edge in a hand-moved tool by causing the bottom angle to lie flat upon the work surface.

But in tools driven by power, and therefore accurately guided in their line of motion, it is preferable to let the bottom face clear the work surface, save at the extreme cutting edge. The front face of the wedge or tool is that which mainly determines its keenness, as may be seen from Fig. 2180, in which we have the wedge or tool differently placed with relation to the work, that in position

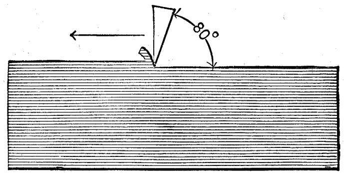


Fig. 2179.

A obviously being the keenest and less liable to break from the strain of the cutting process.

If we now turn our attention to that class of chisel or wedge-shaped tools in which the cutting edge is not a straight line, but may be stepped or curved—as, for example, the carpenter's plane blade—we shall find that so long as the blade stands at a right angle to the surface it is operating upon, as in Fig. 2183 at B, the shape of surface it cuts will exactly correspond to the shape of its

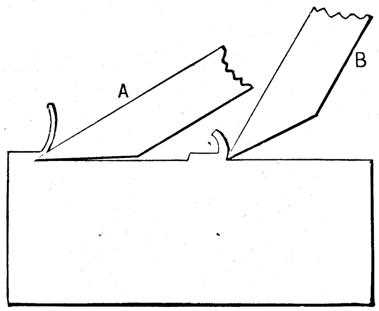


Fig. 2180.

cutting edge; but so soon as the tool is inclined to its line of motion its cutting edge will, if curved, produce a different degree of curvature on the work.

Suppose, for instance, that we have in the figure a piece of moulding M and a plane blade B, and the length of the cutting edge is denoted by A, Fig. 2182; now suppose that the blade is inclined to its line of motion (as in the case of carpenters' planes) and stands at C, Fig. 2183: we then find that the cutting

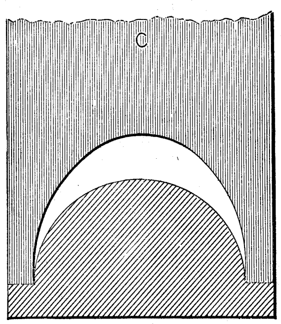


Fig. 2181

edge must extend to the length or depth D, and it is plain that the depth of the curve on the moulding is less than the depth of the cutting edge that produces it; the radius E being less than of D, so that if we place the cutter C upright on the moulding it will appear as shown in Fig. 2181. If, therefore, we are required to make a blade that will produce a given depth of moulding when moved in a straight line and presented at a given angle to the work, we must find out what shape the blade must be to produce the given shape of moulding, which we may do as follows:

In Fig. 2184 let A be a section of the moulding, and if the blade or knife is to stand perpendicular, as shown at B, Fig. 2183, and if it is moved in a straight line in the direction of the length of the work, then its shape would necessarily be that shown at B, Fig. 2184, or merely the reverse of A. In the position mentioned it could be used only as a sweep applicable to some few uses, but

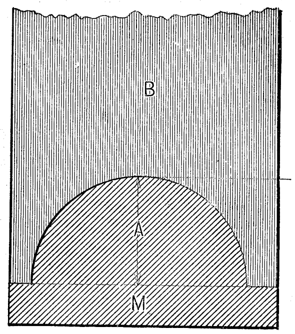


Fig. 2182.

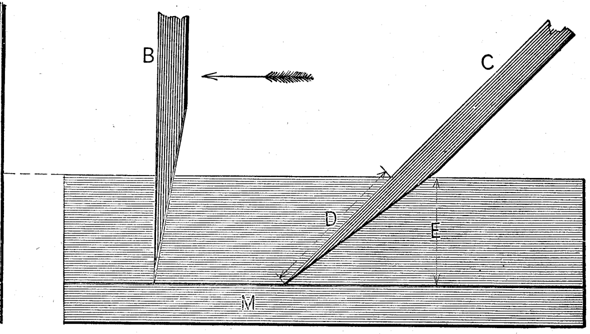


Fig. 2183.

not adapted to cutting. To become a cutting tool it must be inclined and stand at some angle of less than 90° to its line of motion.

Thus in Fig. 2185 D B E represents the bottom of the moulding and line of motion of the cutter, and A B the cutter perpendicular to it, the highest point of the cutting edge, as *c* of Fig. 2184,

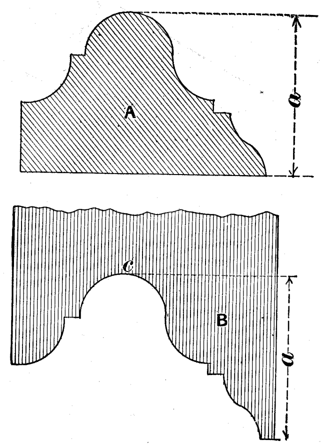


Fig. 2184.

being at *c*, Fig. 2185. The height or thickness of the moulding cut would be the space between the lines E B D and *e c f*, but the cutter assuming the position B C at an angle of 30° from A B, the point *c* is brought to *d;* consequently the highest line of the moulding would now be *g d h*, and its thickness less. This is further exhibited in Fig. 2186, where *a* represents the original

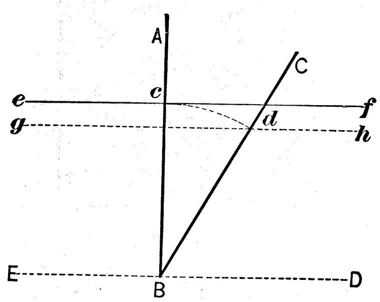


Fig. 2185.

depth section of Fig. 2184 that would be formed by knife B of Fig. 2184 when standing perpendicular; and G shows the depth with the same knife when placed as B C, Fig. 2185, or at 30° inclination, and H shows the depth that would be cut with the same knife or cutter at 45°. It is now evident that every change in the inclination of the same cutter would effect a change in the shape of moulding which it cuts, and to produce a given style of moulding the shape of the cutter must be decided by its inclination, or the angle at which it is used.

The method of projecting a given section of moulding in order to exhibit the form that the curve of the opening should assume on the face of the knife, is shown in Fig. 2187. Upon a horizontal line A B C D draw a section of the required style of moulding, as shown at A E B. To the right of this draw a line, as F C, to meet the base line A B C D, and as F C represents the cutter, it must stand at the same angle that the proposed cutter is to have—in this particular example 30° from the perpendicular. From the highest point of the section A E B draw a horizontal line E G, meeting F C in G. From points G and C draw lines, as C J and

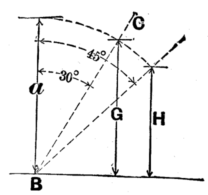


Fig. 2186.

G H, of any convenient length, at right angles to F C. At any distance from G H draw K L parallel to G H, and upon K L trace the section of moulding A E B, as K M L. Draw lines from the extreme edges K and L of K M L, as K N, L J, perpendicular to K L, cutting G H and meeting C J at N and J. E G being parallel to A B C D, G will be the point on the cutter where the top E of the moulding will come on the highest point of the cutting edge, and C G will be the entire length of cutting edge or height of

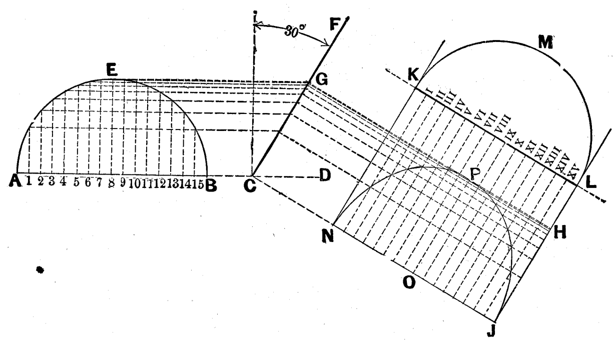


Fig. 2187.

opening measured on the face of the cutter F C. C J being drawn from the lowest point C of the cutter and G H being drawn from G, the highest cutting point, both lines at right angles to G C, then their distance from each other, as P O, must obviously represent the extreme height of opening in the cutter in its new position or front view, and K L, representing the width of moulding transferred to N J by the parallel lines K N and L J, will show the width of opening in the cutter. Having now the height and width, it only remains to project an indefinite number of points and trace the curve through them. Divide A B into a number of parts, and to avoid confusion mark the points of division thus obtained upon A B—1, 2, 3, 4, &c. Divide K L in an exactly similar manner and into the same number of parts, and mark the divisions I., II., III., IV., &c. Erect perpendiculars from points 1, 2, 3, 4, &c., meeting the curve A E B, and from the points thus found on A E B draw horizontal lines to F C; from the termini of these horizontals on F C draw the remaining lines parallel to and between G H and C J. From the divisions I., II., III., IV., &c., on K L, let drop the perpendiculars, cutting the other series of lines at right angles. A point of the curve will then be at the intersection of the line from 1 on A B, with line I. on K L; another at the intersection of the line originating at 2 with that from II, and so on, and the

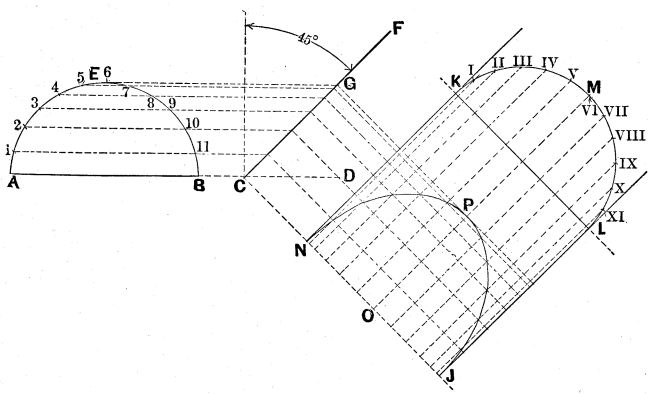


Fig. 2188.

proper curve is found by tracing from N through the intersections to P, and from P to J. Then K N being one side of the cutter and L J the other, N P J is the curve that the opening or cutting edges must have to cut the profile A E B, with the cutter set at F C, or 30°.

The same method is shown in Fig. 2188, except that in this case, instead of dividing A B and K L, the divisions are made directly on the peripheries A 6 B and K VI. L by stepping round with the dividers. The cutter F C is shown in this case at an angle of 45°, in order that the change in form which the curve assumes with the cutter at different angles may be clearly seen by comparing the curve N P J of Fig. 2187 with the same in Fig. 2188. The two figures are similar in other respects, and as the lettering

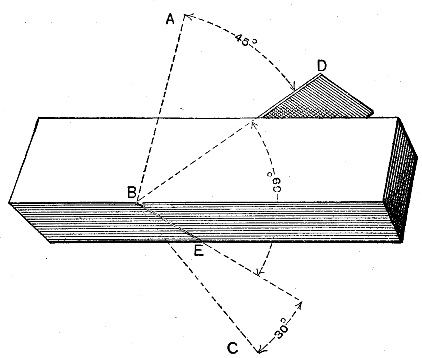


Fig. 2189.

is the same on each, the description of Fig. 2187 will apply equally to Fig. 2188.

There remains one more case of cutters moving in right lines, and that is where, besides having an inclination backward, as at F C, Fig. 2187, making a vertical angle to the line of motion, they are placed at an angle across the guiding piece also, or "skewing," thus making an angle to the line of motion on a horizontal plane as well as on a vertical one. Thus, suppose an ordinary carpenter's plane to have the cutter or "iron" turned partly round and placed so that the cutting edge, instead of lying at a right angle across the body, crosses it at some other angle. Fig. 2189 represents an ordinary carpenter's plane with the blade so placed. Here the edge, or rather side, D B, of the blade inclines back at an angle, as A B D, which is 45° in this case, to the perpendicular line A B on the side of the plane. For convenience call A B D the vertical angle. The lower or cutting edge E B of the blade also crosses the bottom of the plane at an angle E B C—30° in this instance—to a line B C, crossing the bottom at right angles. Now, it is evident that this latter angle E B C will influence the form of the cutter, if, instead of being a flat plane, as represented for clearness in Fig. 2189, it had a cutting edge of curved outline for cutting mouldings or similar work. But in either case the angle that D B or one side of the blade makes to E B, or the cutting edge—that is, the angle D B E—must be found in order to cut off the blank for the cutter or knife at the right "slant."

The method given in Figs. 2187 and 2188 of determining the form of cutter to produce a moulding of given profile now undergoes a modification where there are two angles to be taken into consideration instead of one. As an example, suppose a cutter is required that is to be fixed in such a position in its carrier or block that the handle A B D, or "vertical angle," of Fig. 2189 is, say, 45°, and the angle E B C, or "horizontal angle," of Fig. 2189 shall be 30°. Required the angle at which the bottom of the blank for the cutter must be cut off; or the angle that the side D B and lower edge B E of Fig. 2189 would make to each other, measured on the face of the cutter, and required the outline of cutting edge to be traced on the face of cutter to cut the section of moulding A E B, Fig. 2190: draw a horizontal line, as A B C D, and erect a perpendicular, as C R. From C draw C F,

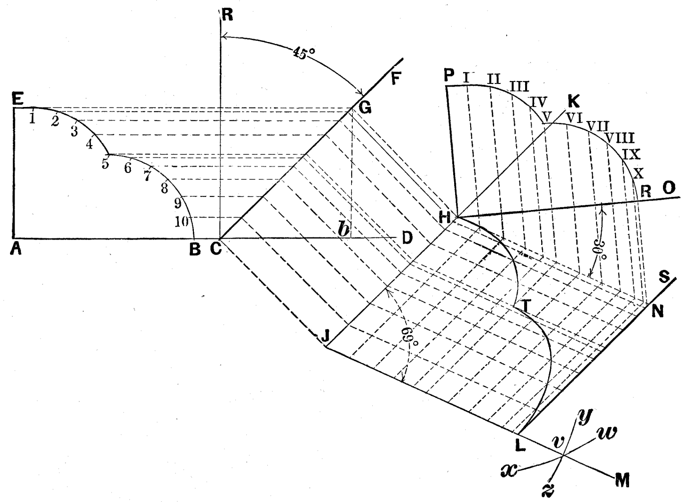


Fig. 2190.

making an angle to C R equal to the "vertical angle," or angle A B D, Fig. 2189, which is 45° in this case. Draw a profile of the required moulding, as A E B, with its back A B coincident to the horizontal line A B C D. Draw a horizontal line from the highest point of the profile, as E, to meet F C in G. Draw parallel lines C J and G H, from C and G respectively, of any convenient length and making right angles to F C. At right angles to G H and C J, and parallel to F C, draw K H J to represent one side or edge of the cutter, but the angle of the lower end or angle D B E of Fig. 2189 must now be determined; to do this, draw an indefinite horizontal line, A B C, Fig. 2191, and from any point, as B, drop a perpendicular B D; now, from B set off on A B C the distance C *b* of Fig. 2190, obtaining point E, and from E extend a perpendicular above and below A B C, as F E H. From E on E F set off distance G *b* of Fig. 2190, obtaining J on E F. From B draw a line, making the same angle to B D that the angle E B C is in Fig. 2189, or 30° in this case, and cutting E H in K. Set off distance E K from E on A C, obtaining L; draw L J. Now, on Fig. 2190, with centre at H, and radius L J of Fig. 2191, describe arc *w x*, and from J as centre, on Fig. 2190, and B K of Fig. 2191 as radius, describe arc *y z*. Through the intersection *v* of arcs *y z* and *w x*, J L M must be drawn, making the proper angle to the side J H K of the cutter; this angle is 69° in this case, as found by construction. From H draw H N parallel to J L, and from H draw H O at the same angle to H N that B K is to B D,

Fig. 2191, or angle E B C, Fig. 2189. Place a duplicate of A E B, with its base coincident to H O and corner A at H, as H P R. From R draw R N at right angles to H R and cutting H N at N; through N draw S N L parallel to K H J. Then while K H J represents one edge of the cutter, S N L will be the other, and J L the cutting edge before the opening is cut out. Divide the curves

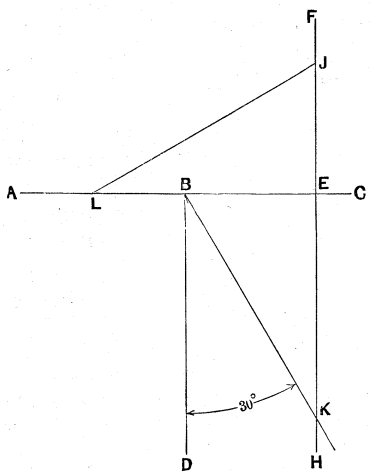


Fig. 2191.

E B and P R similarly, obtaining points 1, 2, 3, &c., and I., II., III., &c., respectively. From points 1, 2, 3, &c., lines are to be drawn parallel to E G, meeting G C, continued from G C parallel to G H, and meeting H J, and from H J parallel to H N, meeting N L. From points I., II., III., &c., lines are to be drawn perpendicular to H R, meeting H N and continued from H N, parallel to H J, to J L, thus intersecting the first series. Lines from points 1, 2, 3, &c., then determine the height of different points of the curve, and those from I., II., III., &c., their location laterally; hence, by tracing through the intersections of 1 with I., 2 with II., &c., the curve H T L is obtained. The two outside lines K H J and S N L may now represent the edges of a piece of steel of which the cutter is to be made, and H T L will be the contour of cutting edge that must be given it in order that when, fixed for use at the angles named, it will form the required moulding A E B.

If the chisel, knife, or cutter revolves in a circle, instead of in a right or straight line, the problem is again different, and the shape of cutting edge necessary to produce a given shape of moulding is again altered. Let Fig. 2192, for example, represent the bar or head of a wood moulding machine, the bar or head revolving in the direction of the arrow, and the moulding being moved beneath it in a straight line endways as denoted by the arrow at N.

In order that the nut that holds the cutter to the head may clear the top of the moulding the highest cutting point of the cutter must not come nearer to the corner of the head than $\frac{1}{4}$ inch. This is shown in the end view of a $2\frac{1}{2}$ inch cutter head in Fig. 2193, the circle B representing the path of revolution of the nut. In larger heads the nut will clear better.

Now we may consider that the cutter simply revolves about a circle whose diameter is the largest that can be described on the end of the square bar that drives it.

If, for instance, we look at the end of the bar as it is presented in Fig. 2195, we see that the circle just fills the square, and that if we cut off all four corners, leaving the bar round, as denoted by the circle, the chisel will revolve in the same path as before. Now suppose we place beneath the revolving chisel a piece of square timber, and raise this timber while holding it horizontally, as would be done by raising the work table. It will cut the work to the shape shown in the two views in the figure, enabling us to observe the important point that the only part of the work that the chisel has cut to its finished shape is that which lies on the line A A. This line passes through the axis on which the bar and cutter revolve, and represents the line of motion of the work in feeding upward to the chisel.

If now we were to move the work endways upon the table, we

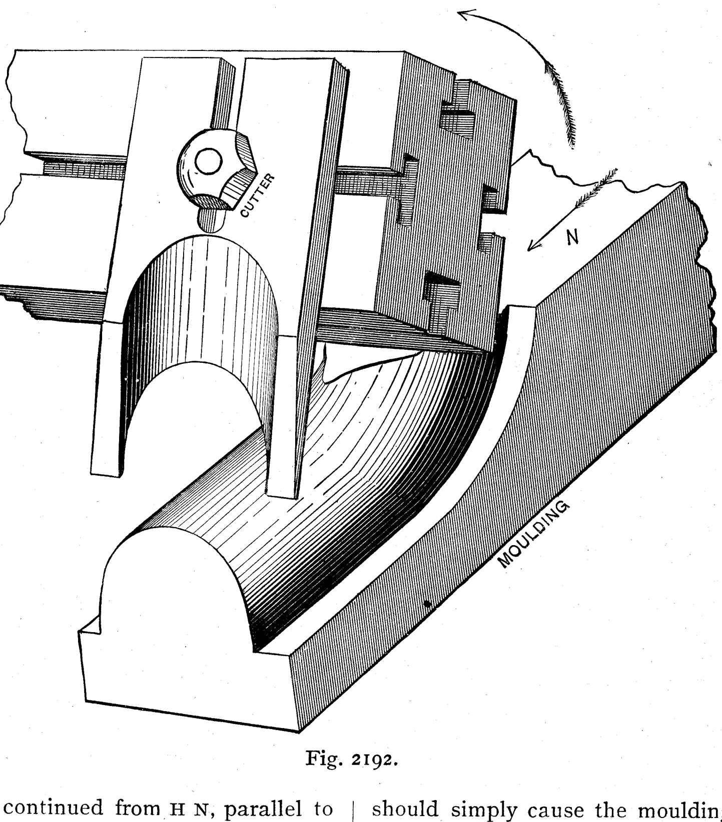


Fig. 2192.

should simply cause the moulding to be finished to shape as it passes the line A; because all the cutting is done before and up to the time that the chisel edge reaches this line; or in other words, each part of the chisel edge begins to cut as soon as it meets the moulding, and ceases to cut as soon as it reaches this line. We may now draw this circle and put on it a chisel in two positions, one at the time its lowest cutting point is crossing the line A and the other at the time the highest point on its cutting edge is passing the line, these positions being marked 1 and 2 in Fig. 2196; the depth of moulding to be cut being shown at S. Now, since the chisel revolves on the centre of the circle, the path will be that of the circle D, while the depth of moulding it will cut is the distance between C and E, measured along the line A A, this depth corresponding to depth shown at S.

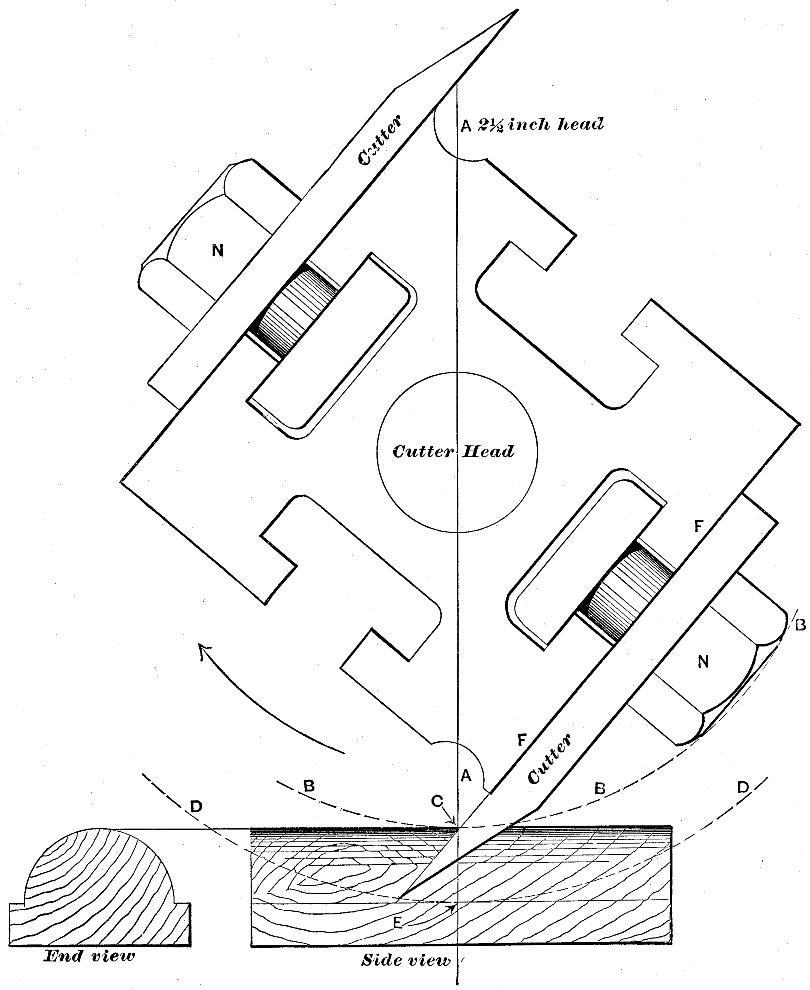


Fig. 2193.

of motion on its highest cutting point C will be as shown by the

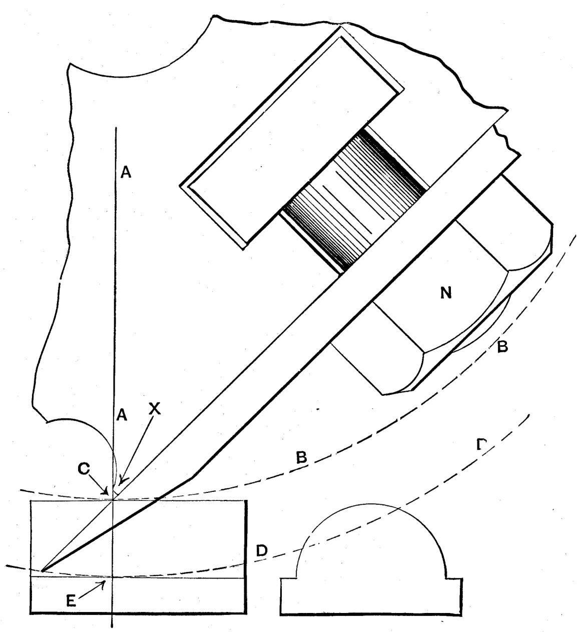


Fig. 2194.

circle B, and that of the lowest point or end E of its cutting edge

Clearly when the chisel has arrived at position 2, the moulding will be finished to shape, and it is therefore plain that it takes a length of cutter-edge from C to F to cut a moulding whose depth is S, or what is the same thing, C E.

But to solve the question in this way, we require for every different depth of moulding to make such a sketch, and the square bar that drives the chisel is made in various sizes, each different size again altering the length or depth of chisel edge necessary for a given depth of moulding.

But we may carry the solution forward to the greatest simplicity for each size of square bar, and for any depth of moulding that can be dressed on that size of bar, by the following means:—In Fig. 2197 we have the circle and the line A as before; the depth from C to E being the greatest depth of moulding to which the square bar is intended to drive the chisels; while point C is the nearest point to the square bar at which the top of the moulding must be placed. Line *a* represents a chisel cutting at its highest point; line *b* a chisel cutting the moulding to final shape at $\frac{1}{4}$ inch below C, on the line A; line *c* a chisel cutting the moulding to final shape at a distance of $\frac{1}{2}$ inch below point C and measured on the line A; lines *d*, *e*, *f*, *g*, *h*, and *i* represent similar chisel positions, the last meeting the point E, which is the lowest point at which the chisel will cut. Suppose, now, we set a pair of compasses one point at the centre A of the circle, and strike the arc *j*; this arc will represent the path of motion of that part of the chisel edge that would finish the moulding to shape at C; similarly arc *k* represents the path of motion of that part of the chisel edge

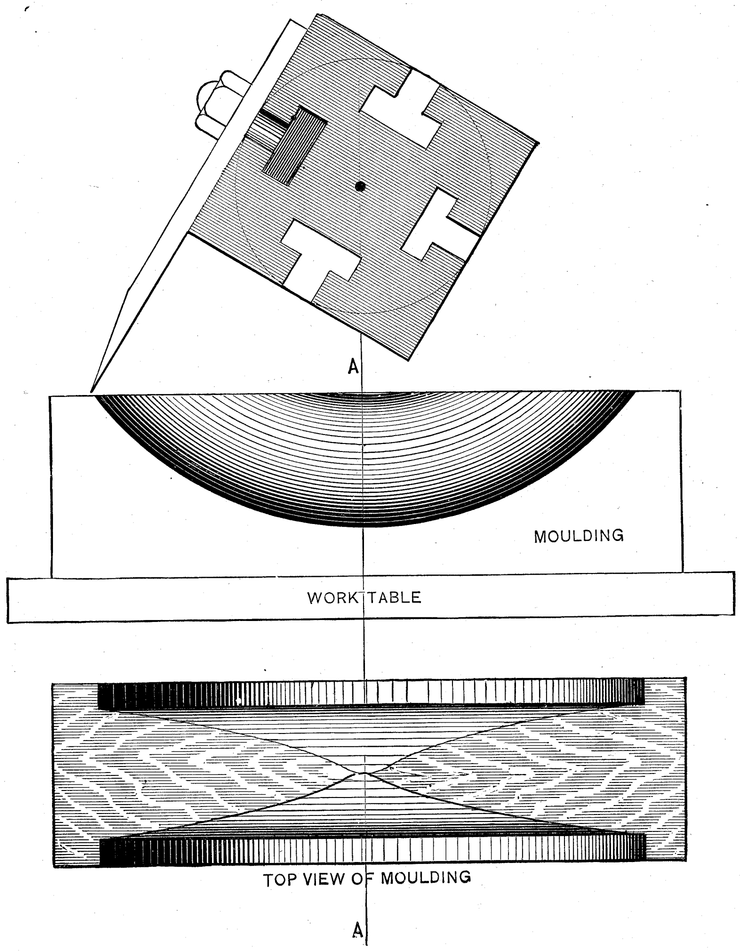


Fig. 2195

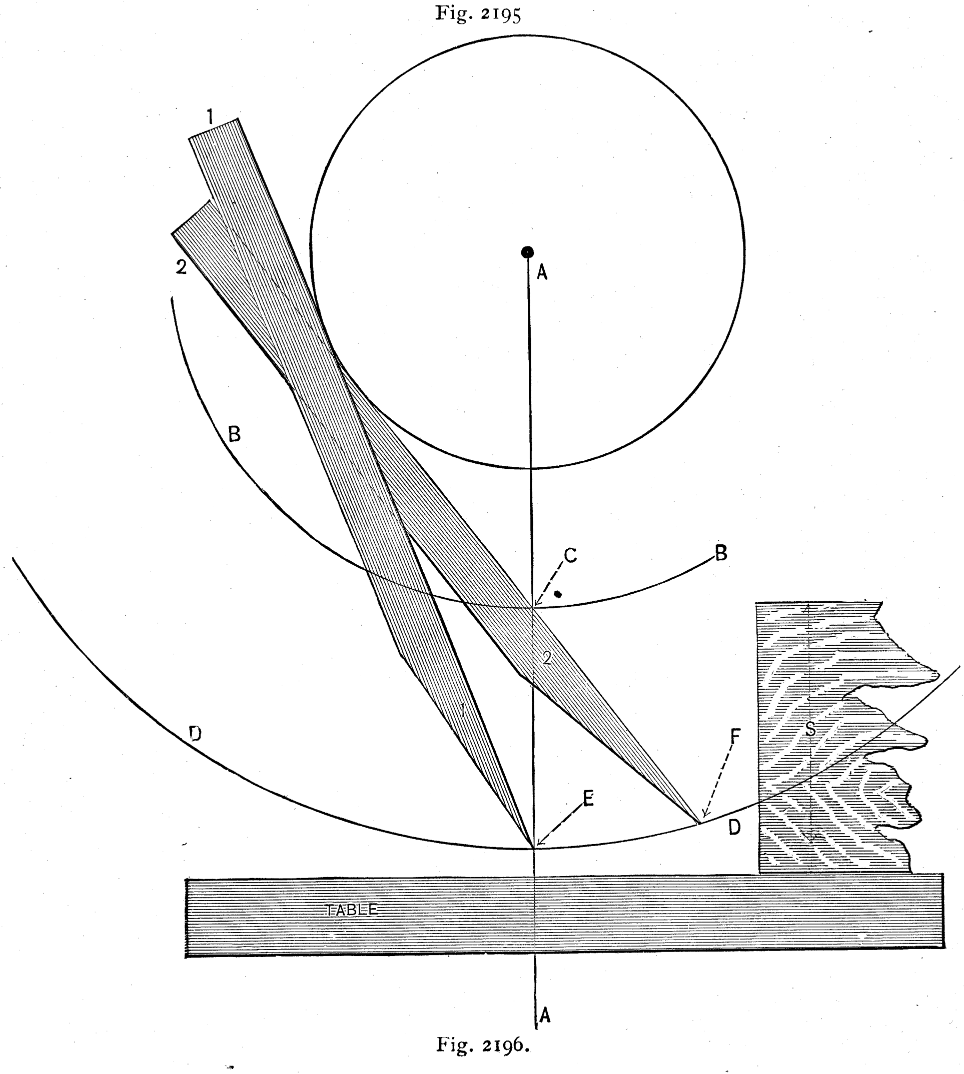


Fig. 2196.

that cuts the moulding to final shape on the line A, and at a distance of $\frac{1}{4}$ inch below C, and so on until we come to arc *r*, which represents the path of motion of the end of the chisel. All these arcs are carried to meet the first chisel position C *a*, and from these points of intersection with this line C *a* we mark lines representing those on a common measuring rule. The first of these from C we mark $\frac{1}{4}$, the next $\frac{1}{2}$, the next $\frac{3}{4}$, and so on to 2, these denoting the measurement or depth of chisel necessary to cut the corresponding depth of moulding. If, for example, we are asked to set a pair of compasses to the depth of cutting edge necessary to cut a moulding that is an inch deep, all we do is to set one leg of the compasses at C, and the other at line 1 on the line C *a;* or if the moulding is to be 2 inches deep, we set the compasses from C to 2 on line C *a*. We have here, in fact, constructed a graduated scale that is destined to be found among the tools of every workman who forms moulding cutters, and if we examine it we shall find that the line that is marked $\frac{1}{4}$ inch from C is not $\frac{1}{4}$ inch but about $\frac{5}{16}$ inch; its distance from C being the depth of chisel edge necessary to cut a moulding that is $\frac{1}{4}$ inch deep.

Again, the line marked 1 measures $1\frac{3}{16}$ inch from C, because it requires a chisel edge $1\frac{3}{16}$ deep to cut a moulding that is one inch deep. But if we measure from *c* to the line marked 2 we find that it is $2\frac{1}{4}$ inches from C, and since it represents a chisel that will cut a moulding two inches deep, we observe that the deeper the moulding is the nearer the depth of cutting edge is to the depth of moulding it will produce. This occurs because the longer the chisel the more nearly it stands parallel to the line A, at the time when its point is crossing the line A. Thus, line *i* is more nearly parallel to A than line *a* is, and our scale has taken this into account, for it has no two lines equally spaced; thus, while that marked $\frac{1}{4}$ is $\frac{5}{16}$ inch distant from C, that marked $\frac{1}{2}$ is less than $\frac{5}{16}$ inch distant from that marked $\frac{1}{4}$, and this continues so that the line marked 2 is but very little more than $\frac{1}{4}$ inch from that marked $1\frac{3}{4}$. Having constructed such a scale we may rub out the circle, the arcs, the line A, and all the lines except the line from C to *a* and its graduations, and we have a permanent scale for any kind of moulding that can be brought to us.

If, for example, the moulding has the four steps or members *s*, *t*, *u*, *v*, in the figure, each $\frac{1}{2}$ inch deep, then we get the depth of cutter edge for the first member *s* on our scale, by measuring from *c* to the line $\frac{1}{2}$ on line C *a*. Now the next member *t* extends from $\frac{1}{2}$ to 1 on the moulding, and we get length of cutter edge necessary to produce it from $\frac{1}{2}$ to 1 on the scale. Member *u* on the moulding extends from 1 to $1\frac{3}{4}$; that is to say, its highest point is 1 inch and its lowest $1\frac{3}{4}$ inch from the top of the moulding, and we get the length for this member on a scale from the 1 to the $1\frac{3}{4}$; and so on for any number of members.

After the depth of cutting edge for each member has thus been found, it remains to find the exact curve of cutting edge for each step, and, in doing this, the same scale may be used, saving much labor in this part also of the process, especially where a new piece of moulding must be inserted to repair part of an old piece that needs renewal in places only, as is often the case in railroad cars.

In Fig. 2197A we have a scale or rule constructed upon the fore-

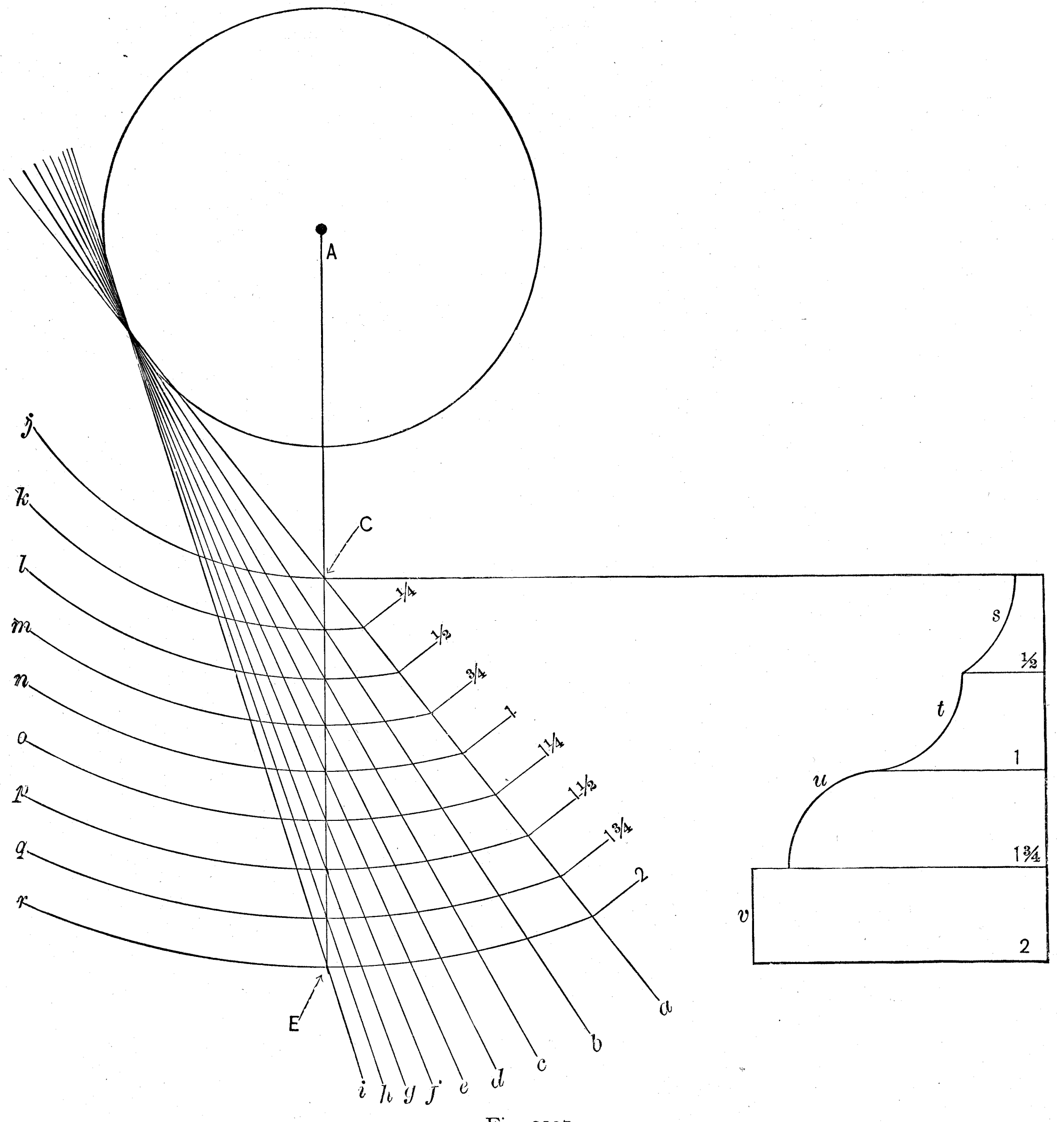


Fig. 2197.

going principles, but marked to sixteenths, and it may now be shown that the same scale may be used in finding the actual curve as well as the depth of cutter edge necessary to produce the moulding of any member of it. Let the lower curves *s*, *t*, for example, represent the moulding to be produced, and the upper

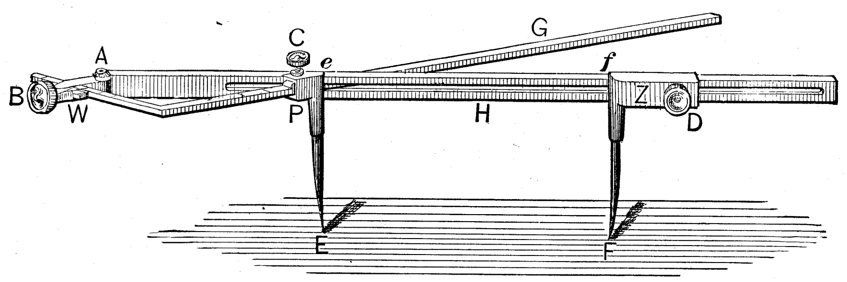


Fig. 2198.

outline represent the blank piece of steel of which the cutter is to be made, the edges C, D being placed in line one with the other. We may then draw across both the moulding and the steel, lines such as E E, F F, G G, H H, I I, J J, all these lines being parallel to the edges C, D. To get the total depth of cutter edge for the moulding we measure with a common measuring rule the total height of the moulding, and supposing it to measure an inch, we set a pair of compasses to an inch on our cutter scale, and with them mark from the base *m* of the steel, the line P giving total depth of cutter edge. We next measure with a common rule the depth of member *s* of the moulding, and as it measures ½ inch we set the compasses to the ½ on the cutter scale, and with these compasses mark from line *m* line B, showing the depth of member *s*. In order to find the exact curve for each member, we have first to find a number of points in the curve and then mark in the curve by hand, and it is for the purpose of finding these points that the lines E E, F F, G G, H H, I I, J J, have been drawn. These lines, it may be remembered, need not be equally spaced, but they must be parallel, and as many of them may be used as convenient, because the greater their number the more correctly the curve can be drawn.

The upper edge or base line, *m m*, both of the steel and of the drawing, is that from which all measurements are to be taken in finding the points in the curve, which is done as follows: With an ordinary measuring rule we measure on the moulding and from line *m m* of the moulding as a base the length of the line F F below *m m*, to the curve, which in this case measures say $\frac{5}{16}$ inch; we then set a pair of compasses or compass calipers to the $\frac{5}{16}$ on the cutter scale, and from base *m m* on the cutter

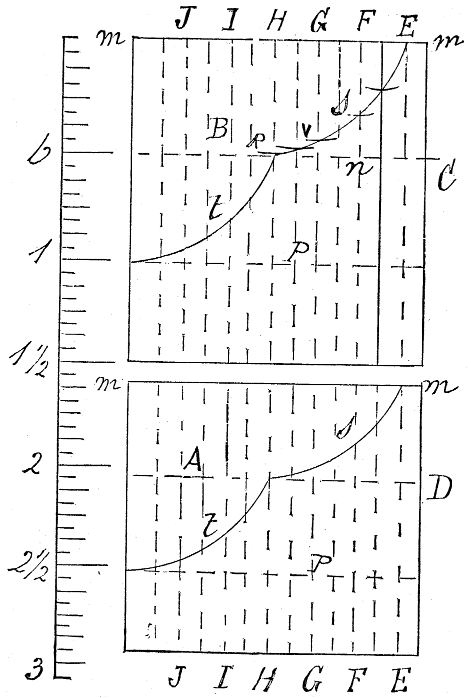


Fig. 2197A.

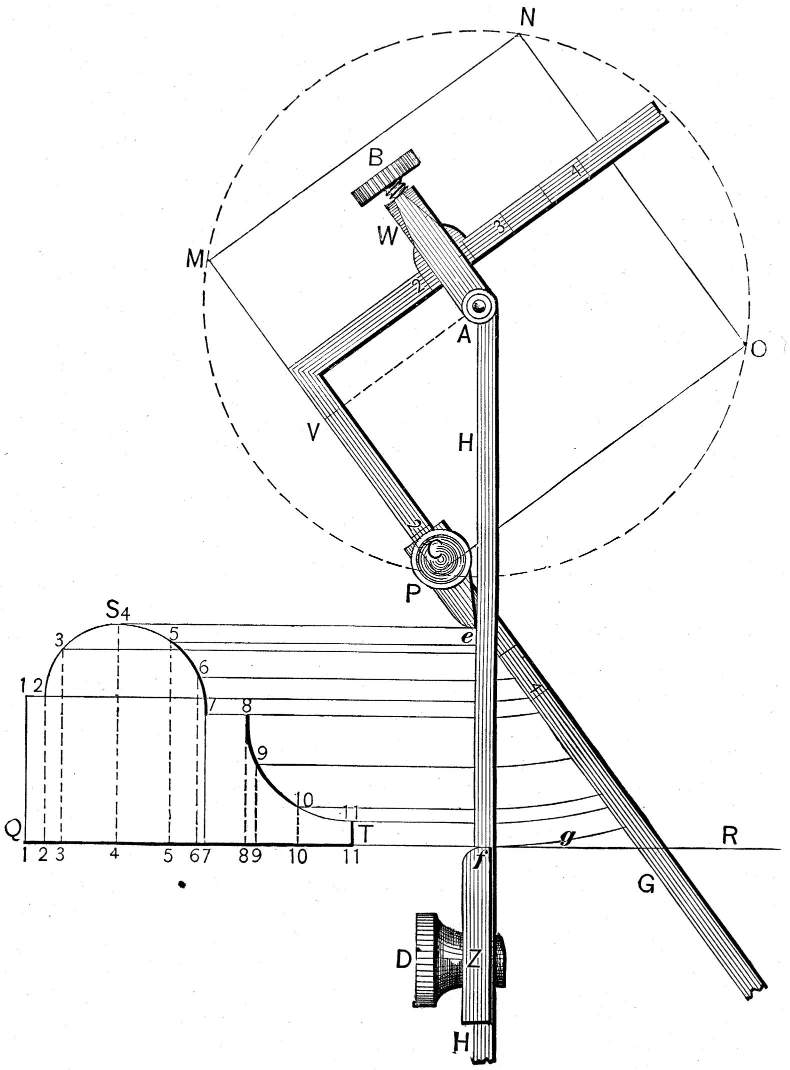


Fig. 2199.

steel, mark, on line F F, an arc, and where the arc cuts F F is one point in the curve.

Similarly we measure on the moulding, or drawing of the moulding, the length of line G G from line *m m* to the moulding curve, and find that it measures, say $\frac{7}{16}$ inch, hence we mark from base line *m m* of the steel, on line G G, arc V, distant $\frac{7}{16}$ according to the cutter scale. Similar measurements are taken at each vertical line of the drawing which represents the moulding, and by means of the corresponding divisions of the cutter scale, arcs are marked on the vertical lines on the cutter steel, and where the arcs cut the vertical lines are points in the curve, and through these points the curve may be drawn by hand. We may make a cutter scale from an ordinary parallel rule, marking one end to correct inches and the other end for a cutter scale. Measurements from the moulding may then be made on one end of the rule; measurements for the cutter may be taken from the other end of the rule, and the rule may be used at the same time to draw

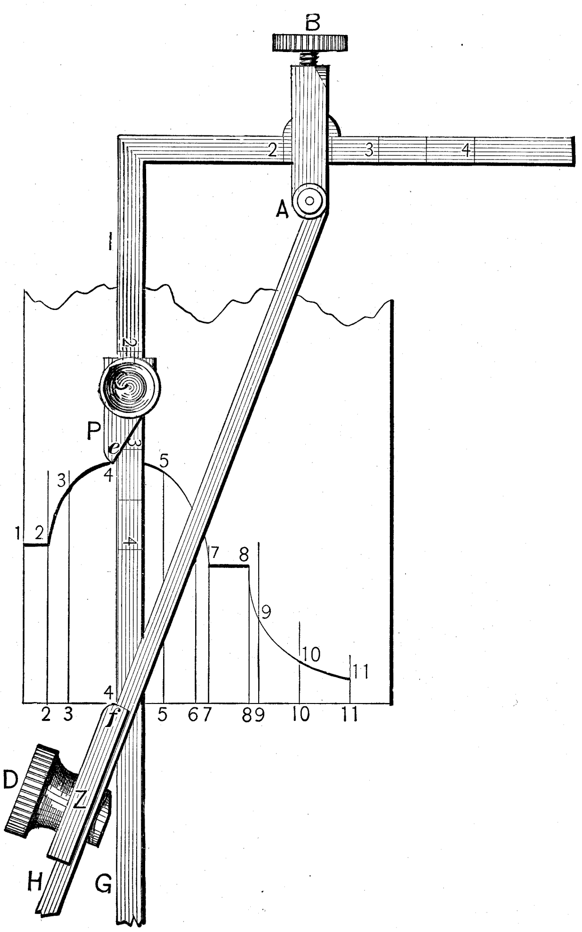


Fig 2200.

the parallel lines E E, &c. . Or, as each size of cutter head requires a different cutter scale, we may make a rule out of a piece of box or other close-grained wood, say $\frac{3}{4}$ inch square, using one side for each size of cutter head. One end of each face of this rule may be marked in correct inches and parts of an inch (the divisions being thirty-seconds of an inch), and the other end may be marked as a cutter scale, the divisions being found as described with reference to Fig. 2197.

An instrument, patented by R. Drummond, for finding the depth of cutting edge and also for finding the curves, is shown in Figs. 2198 and 2199. It consists essentially of a bar G bent at a right angle, thus making two arms. Upon one arm is a slide W (best seen in Fig. 2199) secured by a set-screw B, and having at A a pivot to carry a second bar H, which is slotted throughout its length to permit bar G to slide freely through it. Upon the other arm of G is a slide P secured by a set-screw C, and carrying a compass point E. The bar H carries an adjustable slide Z secured by a set-screw D and carrying the compass point F.

In using the instrument but three very simple operations are necessary. First, the two slides W and P are set to the numerals on the bar, which correspond to the size of the head on the moulding machine the cutter is to be used upon; thus in Fig. 2199 they are shown set to numeral 2, as they would be for a 2-inch cutter head. The instrument is next opened, its two bars occupying the position shown in Fig. 2199, and the two compass points are set to the height of the moulding or to any desired member of it, as the case may be. The bars are then opened out into the position shown in Fig. 2200, and the compass points at

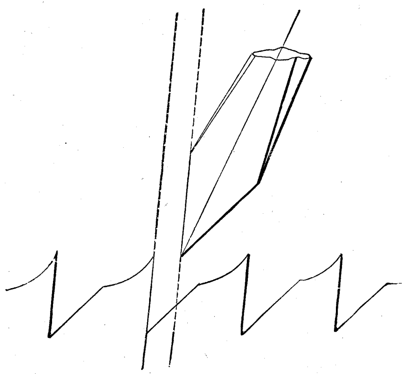


Fig. 2201.

once give the depth of cutter edge necessary to produce the required depth of moulding.

It will be noted that the pivot A represents the centre upon which the cutter revolves, and that while the face of the bar H corresponds to the line of moulding formation answering to line A A in Fig. 2196, the face of bar G corresponds to the face C F of the cutter in Fig. 2196; hence the instrument simply represents a skeleton head and cutter, having motions corresponding to those of an actual cutter head and cutter.

THE FILE.—The file is a piece of hardened steel having teeth produced upon its surface by means of rows of chisel cuts which run more or less diagonally across its width at an angle that is varied to suit the nature of the material the file is to be used upon. The vertical inclination of the tooth depends upon the inclination of the face of the chisel with which it is cut, the two

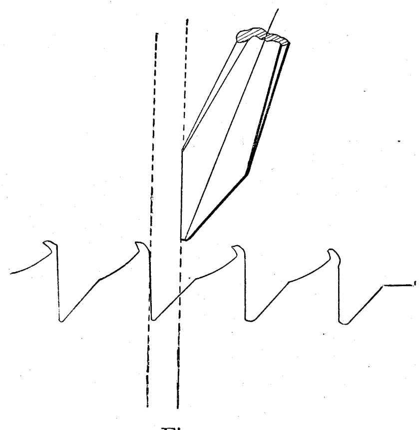


Fig. 2202.

being equal, as is shown in Fig. 2201, which is an enlarged view of a chisel and some file teeth. In order that the tops of the teeth shall be sharp, and not rounded or curved, as in Fig. 2202, it is necessary that the edge of the chisel be kept sharp, an end that is greatly aided by the improved form of chisel shown in Fig. 2203. When a file possesses curved points, or caps, as they are technically termed, a few strokes upon a narrow surface will cause them to break off, reducing the depth of the teeth and causing the cuttings to clog in them. If, however, the file is used upon a broad surface these caps will remain, obviously impairing the cutting qualifications of the file, even when new, and as they soon get dulled the file loses its grip upon the work and becomes comparatively valueless.

Files were, until the past few years, cut entirely by hand—file cutting by machinery having previously been a wide field of mechanical experiment and failure. Among the most prominent causes of failure was that the teeth produced by the earlier machines were cut too regular, both as to their spacing and their height; hence the points of the rear teeth fell into the same

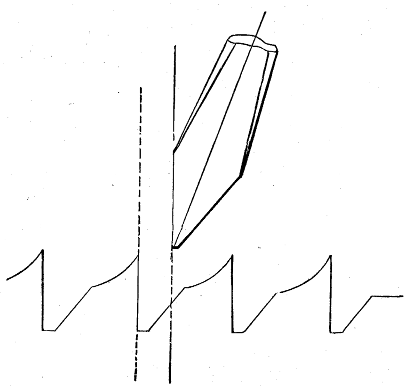


Fig. 2203.

channels as those in advance of them, thus giving the tooth points too little opportunity to grip the work. This also gives too broad a length of cutting edge and causes the file to vibrate on the forward or cutting stroke, an action that is technically known as chattering, and that obviously impairs its cutting capacity. The greatest amount of duty is obtained from a file when the rear tooth cuts off the projection left by the preceding one, because in that case the duty of the tooth is confined to cutting off a projection that is already weakened and partly separated from the main body by having the metal cut away around its base. Workmen always practically recognise this fact, and cause the file marks to

length, which is always measured exclusively of their tangs. 2. Their cut, which relates not only to the character, but also to the relative degree of coarseness of the teeth. 3. Their kind or name, which has reference to the shape or style. In general, the length of files bears no fixed proportion to either their width or thickness, even though of the same kind. The tang is the spiked-shaped portion of the file prepared for the reception of a handle, and in size and shape should always be proportioned to the size of the file and to the work to be performed. The heel is that part of the file to which the tang is affixed.

Of the cut of files we may say that it consists of three distinct forms; viz.: "single cut," "double cut" and "rasp," which have different degrees of coarseness, designated by terms as follows viz.:—

Single-cut.	Double-cut.	Rasp.
Rough	Coarse	Coarse
Coarse	Bastard	Bastard
Bastard	Second-cut	Second-cut
Second-cut	Smooth	Smooth
Smooth	Dead-smooth	

The terms "rough," "coarse," "bastard," "second-cut," "smooth" and "dead-smooth," have reference only to the coarseness of the teeth, while the terms "single-cut," "double-cut" and "rasp" have special reference to the character of the teeth. The single-cut files (the coarser grades of which are sometimes called "floats") are those in which the teeth are unbroken, the blanks having had a single course of chisel-cuts across their surface, arranged parallel to each other, but with a horizontal obliquity to the central line, varying from 5° to 20° in different files, according to requirements. Its several gradations of coarseness are designated by the terms "rough," "coarse," "bastard," "second-cut" and "smooth." The rough and coarse are adapted to files used upon soft metals, as lead, pewter, &c., and, to some extent, upon wood. The bastard and second-cut are applied principally upon files used to sharpen the thin edges of saw teeth, which from their nature are very destructive to

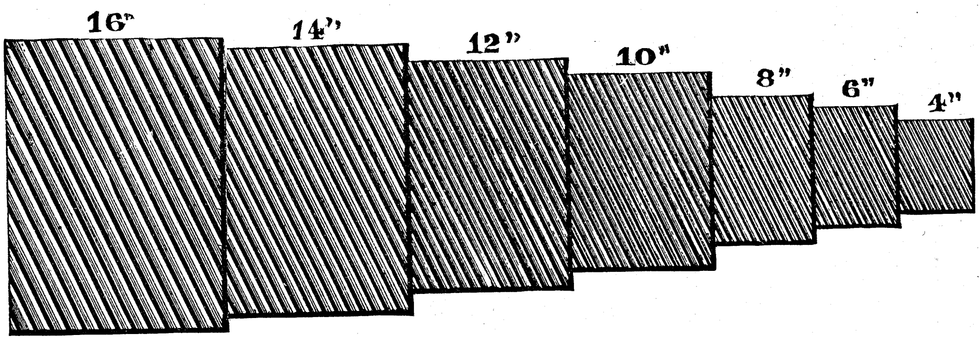


Fig. 2204.

cross each other after every few strokes. In the machine-cut files made by The Nicholson File Co., the teeth are arranged to attain this object by the following means:—1. The rows of teeth are spaced progressively wider apart from the point towards the middle of the file length by regular increments of spacing, and progressively narrower from the middle toward the heel. 2. This general law of the spacing is modified by introducing as the teeth are cut an element of controllable irregularity in the spacing, which irregularity is confined within certain limits, so that neither the increment nor decrement of spacing is entirely regular. 3. In arranging the teeth so that the successive rows shall not be exactly parallel one to the other, the angle of inclination being reversed as necessity requires. The irregularity of spacing, while sufficient to accomplish the intended object, is not enough to practically vary the cut of the file, or, in other words, it is insufficient to vary its degree of coarseness or fineness to any observable extent. But it enables the file to grip the work with as little pressure as possible, and enables the teeth to cut easily without producing deep file marks or furrows.

Files and rasps have three distinguishing features: 1. Their

the delicate points of double-cut files. The smooth is seldom applied upon other than the round files and the backs of the half-rounds. Fig. 2204 represents the cut of single-cut rough files, their lengths ranging from 16 inches down to 4 inches. Fig. 2205 shows the cut of the coarse, bastard, and second-cut, whose lengths also range from 16 to 4 inches, and whose cut is also finer as the length decreases. The float is used to some extent upon bone, horn, and ivory, but principally by plumbers and workers in lead, pewter, and similar soft metals. It will be seen that the teeth are nearly straight across the file and are very open, both of these features being essential requirements for files to be used on the above-named metals.

Double-cut files are those having two courses of chisel cuts crossing each other. The first course is called the over cut, and has a horizontal obliquity with the central line of the file, ranging from 35° to 55°. The second course, which crosses the first, and in most double cuts is finer, is called the up-cut, and has a horizontal obliquity varying from 5° to 15°. These two courses fill the surface of the file with teeth inclined toward its point, the points of which resemble somewhat, when magnified, those of the diamond-shaped cutting tools in general use. This form of cut is made in several gradations of coarseness, which are designated by the terms "coarse," "bastard," "second-cut," "smooth" and "dead-smooth." Fig. 2206 represents the cut of double-cut bastard files, from the 16 inch down to the 4 inch, and Fig. 2207 the cut of the coarse, second-cut, and smooth. For very fine finishing a still finer cut, called the dead-smooth, is made, being like the smooth, but considerably finer. It is a superior file for finishing work in the lathe, or for draw-filing machine work that is to be highly finished. The double-cut is applied to most of the files used by the machinist, and, in fact, to most of the larger number in general use. For unusually fine work, tool-makers and watch-makers use the Swiss or Groubet files—so called from their being made by M. Groubet, of Switzerland. These files are double-cut, and their degree of coarseness is denoted by number; thus, the coarsest is a bastard and the finest number 8. The prominent characteristics of these files are their exceedingly even curvature and straightness, and, in the finer grades, the unusual fineness of the cut, which feels soft and velvety to the touch. They are made in sizes ranging from 2 to 10 inches, and are always double-cut.

Rasps differ from the single or double-cut files in that the teeth are disconnected from each other, each tooth being made by a single-pointed tool, denominated by file-makers a punch, the essential requirement being that the teeth thus formed shall be so

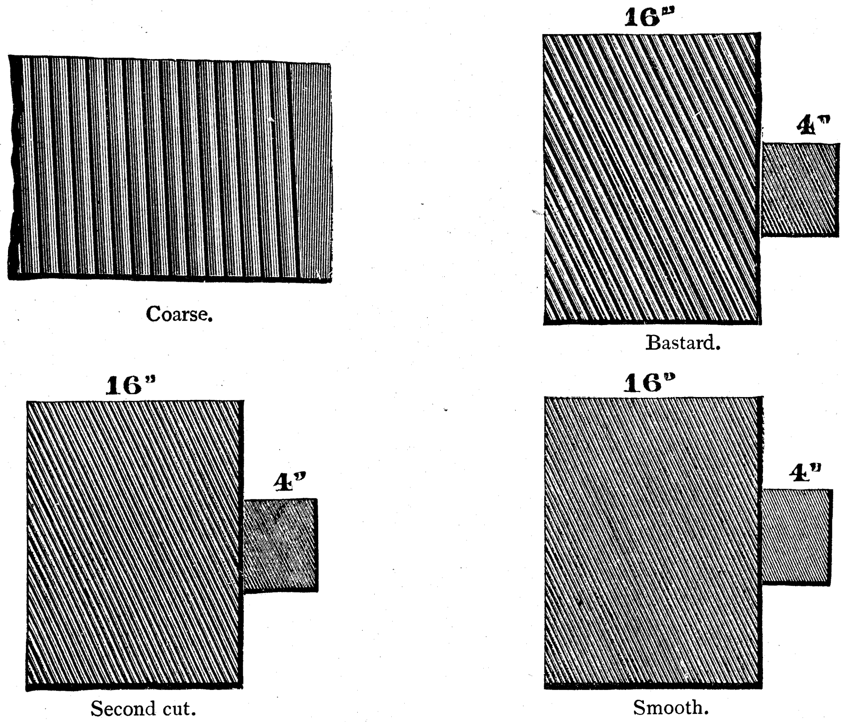


Fig. 2205.

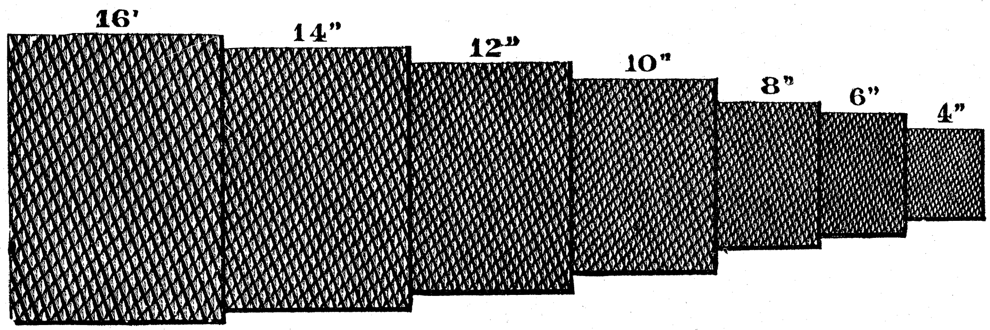


Fig. 2206.

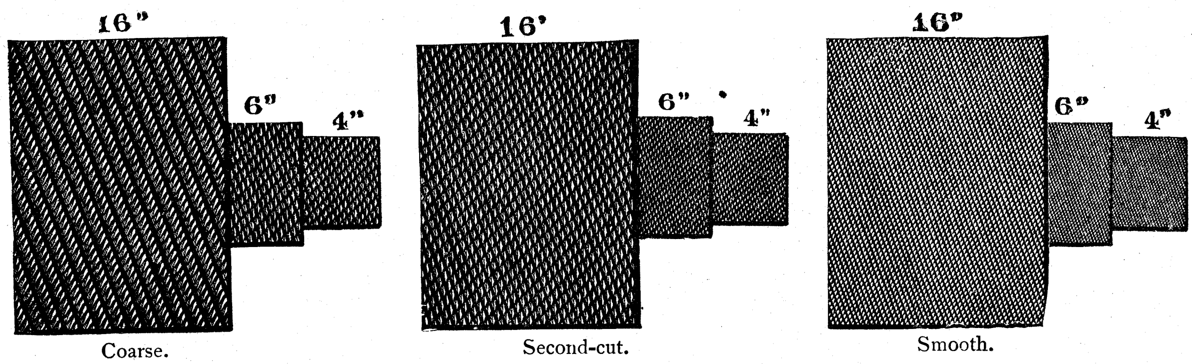


Fig. 2207.

irregularly intermingled as to produce, when put in use, the smoothest possible work consistent with the number of teeth contained in the surface of the rasp. Rasps, like files, have different degrees of coarseness, designated as "coarse," "bastard,"

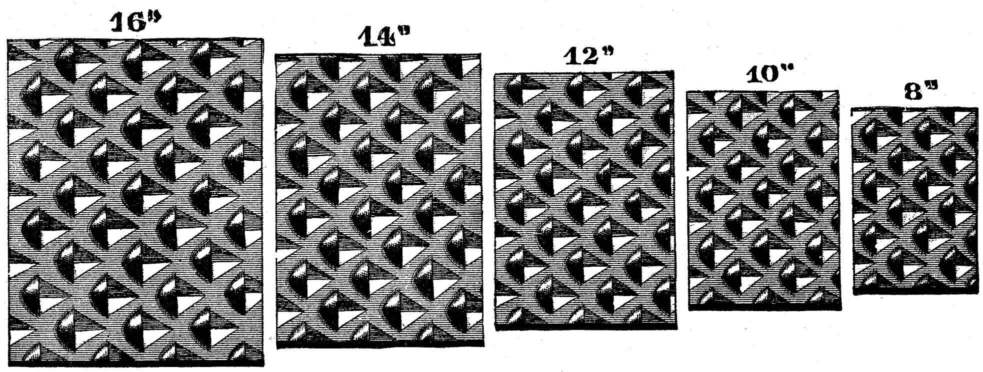
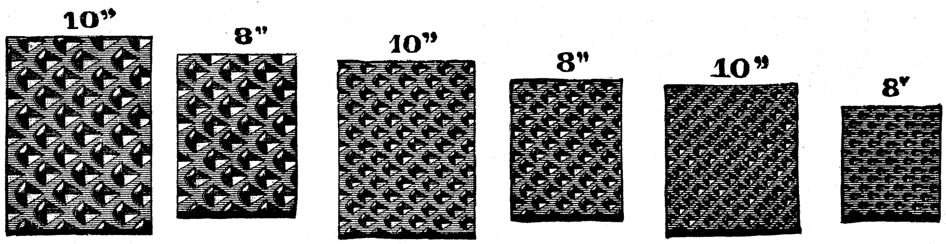


Fig. 2208.

"second-cut" and "smooth." The character and general coarseness of these cuts, as found in the different sizes, are shown in Figs. 2208 and 2209. Generally speaking, the coarse teeth are



Bastard. Second-cut. Smooth.

Fig. 2209.

applied to rasps used by horseshoers, the bastard to those used by carriage makers and wheelwrights, the second-cut to shoe-rasps, and the smooth to the rasps used by cabinet-makers.

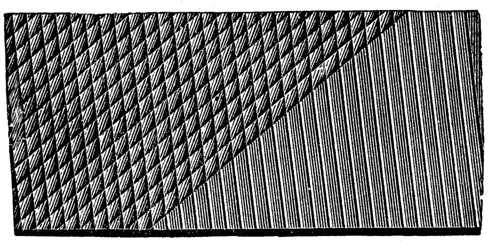


Fig. 2210.

Figs. 2211, 2212 and 2213 are respectively coarse, bastard, and finishing second-cut files, the first two being for brass.

Fig. 2210 represents a file open in both its over and up-cut,

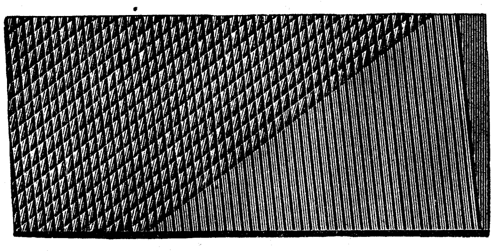


Fig. 2211.

which is not, therefore, expected to file fine, but fast, and is adapted for very rough work on the softer metals, as in filing off sprues from brass and bronze castings, filing the ends of rods, and work of a similar nature. It is also, to some extent, used upon wood. The essential difference between the bastard file shown in Fig. 2211 and that just described is the degree of fineness of the up-cut, which is nearly straight across the tool. This form of teeth, which may be applied to any of the finer cuts, and upon any of the shapes usually made double-cut, is especially adapted to finishing brass, bronze, copper and similar soft metals, and is not so well adapted to the rougher work upon these metals as the coarse brass file previously described. Fig. 2212 is a finishing file. The first or over-cut in this case is very fine, and, contrary to the general rule, has the least obliquity, while the up-cut has an unusual obliquity, and is the coarser of the two cuts. The advantages in this arrangement of the teeth are that the file will finish finer, and by freeing itself from the filings is less liable to clog or pin than files cut for general use. This form of cut is especially useful when a considerable quantity of finishing of a light nature is required upon steel or iron. It is not recommended

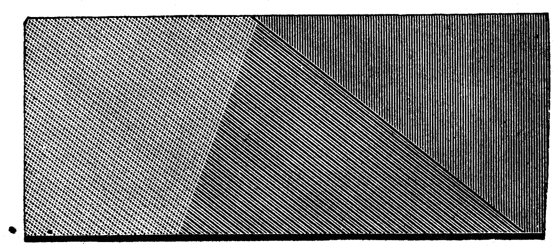


Fig. 2212.

for brass or the softer metals, nor should it be made of a coarser grade than the second-cut.

The names of files are sometimes derived from the purpose for which they are to be used. Thus, we have saw files, slitting files, warding files, and cotter files. The term "warding" implies that the file is suitable for use on the wards of keys, while "cotter" implies that it is suitable for filing the slots for that class of key which the machinist terms a cotter. In other cases files are named from their sections, as in the case of "square," "round," "half-round," and "triangular," or "three-square" files, as they are often termed.

The term "flat" may be considered strictly as meaning any file of rectangular section whose width exceeds the thickness. Hence, "mill files," "hand files," and "pillar files" all come under the head of flat files, although each has its own distinguishing features. The general form of the flat file is shown in Fig.

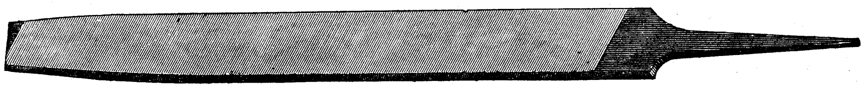


Fig. 2213.

2213, while the cross-sections of various quadrangular files are shown in Figs. from 2214 to 2218. From these views it will be seen that the thicknesses gradually increase from the mill to the square file. Mill files are slightly tapered from the middle to the

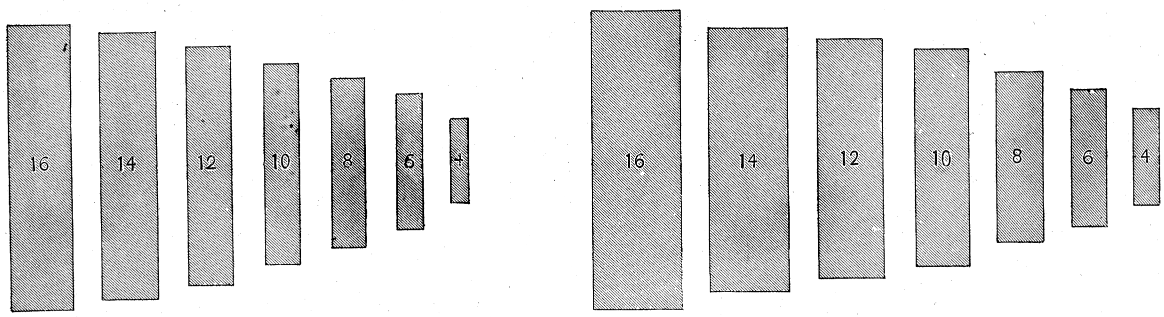


Fig. 2214.

point both in their width and thickness. They are single-cut, and are usually either bastard or second-cut, although they are

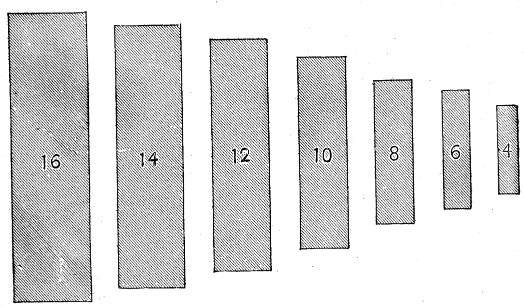


Fig. 2215.

sometimes double-cut. Mill files of both cuts are principally used for sharpening mill saws, mowing-machine knives and ploughs, and

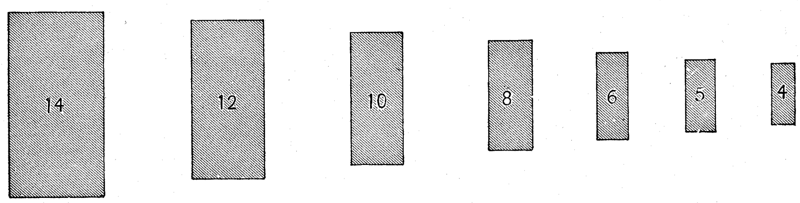


Fig. 2216.

in some machine shops for rough lathe work, and, to some extent, in finishing composition brasswork. Mill sections are occasionally made blunt—that is to say, their sectional shape is alike from end to end—in which case they are mostly double-cut, and

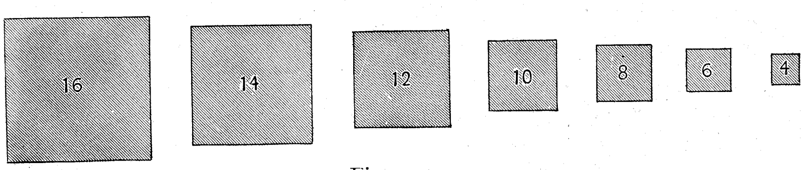


Fig. 2217.

seldom less than 8 inches in length. They are suitable for filing out keyways, mortises, &c., and for these purposes should have at least one safe edge. A safe edge is one having no teeth upon it, which allows the file to be used in a corner without cutting more than one of the work surfaces. When the corner requires to be very sharp it is preferable to take a file that has teeth upon its edge and grind the teeth off, so as to bring the corner of the file up sharp, which it will not be from the cutting, because the teeth do not come fully up to a sharp corner.

Hand-files are tapered in thickness from their middle towards both the point and the tang, and are, therefore, well curved or bellied on each side. This fits them for the most accurate of work, on which account they are generally preferred by expert workmen. They are nearly parallel in width and have one safe edge and one edge cut single, while the face is cut double. Hand-files are also made equaling, the term equaling meaning that, although apparently blunt or of even thickness throughout the length, yet, in fact, there is a slight curvature, due to the file being thickest in the middle of its length. An equaling hand-file is especially suitable for such purposes as filing out long keyways, in which a great part of the file length is in action, and it can, therefore, be easily pushed in a straight line.

The flat file, Fig. 2213, when 10 inches and under in length, is made taper on both its sides and edges, from the middle to the front of the file, and when longer than 10 inches they should be made full taper—that is to say, the taper should extend from the middle toward the heel, as well as toward the point. Flat files are usually double-cut, the coarse-cut being used upon leather, wood, and the soft metals. The flat bastard is that most commonly used, the flat second-cut, smooth, and dead-smooth being used by machinists for finishing purposes, the latter preceding the polishing processes.

Pillar files are tapered in thickness from the middle to each end; the width is nearly parallel, and one of the edges is left safe. They are double-cut, and, although not in general use, are especially adapted to narrow work, such as in making rifles, locks, &c. The square file ranges from 3 to 16 inches in length, and is made for general purposes with considerable taper. It is usually double-cut, the bastard being the principal cut, the second-cut and smooth being mainly used by the machinist.

Square blunt files range from 10 to 20 inches in length, of the same sectional sizes as the square taper, and are cut double,

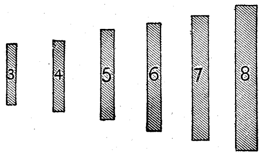


Fig. 2218.

usually bastard. For machinists' use, however, they are used in the second-cut also, and are provided with sometimes one and sometimes two safe sides. Square equalling files are in every respect like the square blunt, except in the care taken to prepare a slight curve or belly in the length of the file, which greatly enhances their value in filing out the edges of keyways, splines,

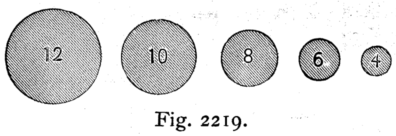


Fig. 2219.

or mortises. The fault of the square blunt, when used for fine or true work, is that the heel, having no belly, is apt to come into too prominent action.

Warding files, Fig. 2218, are made parallel in thickness, but are considerably tapered on their edges. They range in size from 3 to 8 inches in length, progressing by half-inches in the sizes below 6 inches. They are cut double, and usually on both edges,

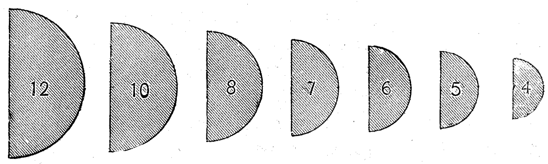


Fig. 2220.

and are mainly used by locksmiths and jewellers, and to but a limited extent by machinists. Some of the warding files are provided with teeth upon their edges only, which are made quite rounding, the cut usually being second-cut, single.

Files deriving their sections from the circle are shown from Figs. 2219 to 2222. "Round files" are circular in section, as shown in Fig. 2219, their lengths ranging from 2 to 16 inches, and are usually of considerable taper. The small bastards are mostly single-cut and the larger sizes double-cut. The second-cuts and smooths are rarely double-cut, except in some of the very large sizes. In imitation of double-cut, however, they are sometimes made with the first, or overcut, very open, called "hopped," which adds, however, but very little to the cutting capacity of the file. The very small sizes—as, say, those of one-quarter inch and less in diameter—are often called "rat-tailed" files. For some classes of work—as, for instance, the circular edges of deep keyways—round, blunt files are used, their sizes running up to 18 and 20 inches, their principal cut being bastard and double.

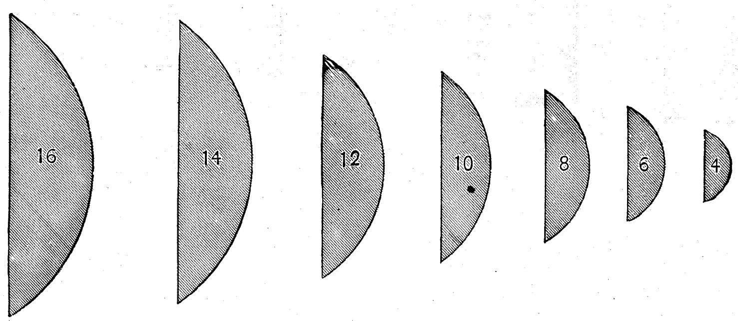


Fig. 2221.

The gulleting file is a round, blunt saw file, and, like most other files for this purpose, is single-cut (except for a small space at the point, which is left uncut). Its principal use is for extending the gullet of what are known as gullet-tooth and briar-toothed saws.

Half-round files are of the cross-section shown in Fig. 2220, and although their name implies a semicircle, yet, as generally made,

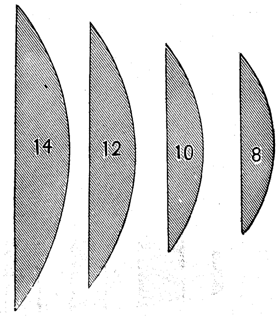


Fig. 2222.

their curvature does not exceed the third part of a circle. They are made taper; the bastard is usually double cut on both its sides; the second-cut and smooth is double-cut on their flat sides, and single-cut on the curve side, except occasionally in the larger sizes, when it is double-cut or hopped. Half-round files for wood usually range in size from 10 to 14 inches, and are of the same shape and taper as the regular half-rounds. They are cut coarse

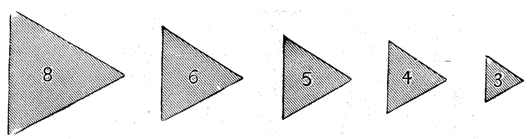


Fig. 2223.

and double, and are used by wood-workers generally. Half-round rasps are also like the regular half-round in shape, the sizes usually called for being 10, 12, and 14-inch. They are used principally by wheelwrights and carriage builders, but are to some extent used by plumbers and marble workers.

Cabinet files are of the section shown in Fig. 2222, being both wider and thinner than the half-rounds, the sectional curvature being somewhat less than the fifth part of a circle. They are made taper from near the middle to the point, while both the files and the rasps are made from 6 to 14 inches in length; 8, 10, and 12 inches are the sizes in most common use. As usually known, the cabinet file is a bastard double-cut. The cabinet rasp is punched smooth, and both the cabinet rasp and file are rarely made of any other degree of coarseness. They are used by cabinet, saddle-tree, pattern, and shoe-last makers, and also by gunstockers and wood-workers generally.

Three-square files are made with equilateral triangular sections, as in Fig. 2223. They are tapered to a small point with considerable curve, and are double-cut. The larger sizes—say, from 10 to 14 inches—are usually bastard, and are used to a considerable extent in rolling mills. The smaller sizes are not unfrequently smooth or dead-smooth, and are used in machine shops quite generally for filing interval angles more acute than the rectangle, clearing out square corners, sharpening cutters, &c. Three-square blued files of sizes from 3 to 6 inches are sometimes made. They are mostly second-cut, or smooth and double-cut, and are principally used in machine shops for filing up cutters for working metals.

Cant files, whose cross-sections are shown in Fig. 2224, are usually made blunt and double-cut, mostly bastard, on all three

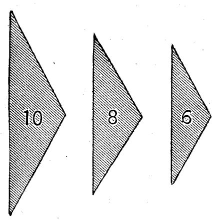


Fig. 2224.

sides. These sizes are usually 6, 8, and 10 inches. Lightning files are of the cross-section shown in Fig. 2225, the term lightning being known principally by those using the saws of this name, and to some extent by those using other cross-cut, M-shaped saw teeth. The obtuse angle of this file is five-canted, while the regular cant is hexagon or six-canted, and it is found to be too obtuse for the purposes required of the saw file. They are made

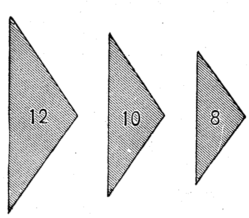


Fig. 2225.

blunt, and range in length from 4 to 12 inches, and are cut (except for a short space near the point) single on their three sides.

Knife files are of the section shown in Fig. 2226, and rarely exceed 10 inches in length, the principal sizes being 4, 5, and 6-inch. They are tapered, resembling somewhat the blade of a knife, and are cut double. The very acute angle of the sides of this file makes it especially useful in filing the inner angles of the rear and main springs of a rifle lock and work of similar shape.

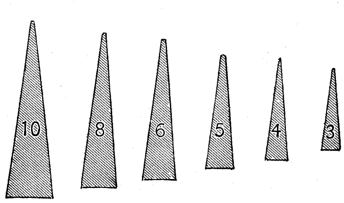


Fig. 2226.

These files are also made blunt. Cross files (sometimes called double half-round or crossing files) are of the section shown in Fig. 2227. They are mostly made to order, either blunt or tapered, and usually double-cut. "Feather-edge" files (Fig. 2227) are but little used by the mechanics of this day. They were formerly used in filing feather springs (as the rear spring of a gun lock is sometimes called), and also the niches in currycombs, which led them to be called by some currycomb files. The few files of this kind which are now made are usually blunt and double-cut. Half-round "shoe rasps" as generally made are of the cross-section shown in Fig. 2228, their sizes ranging from 6 to 12 inches, while 8, 9, and 10-inch are the most common. They are made parallel in width, but with their sides slightly tapered from the middle; the ends are rounded and cut single; the edges are safe or uncut, or if cut are usually made half-file and half-rasp reversed ($\frac{1}{4}$ rasp and $\frac{3}{4}$ file, while sometimes made, are the exception). The file quarters are bastard double-cut, and the rasp quarters second-cut. This form of shoe rasp is the one in general use at this time, having almost entirely superseded the flat and swaged rasps formerly in use.

Reaper files (B, Fig. 2229), so called from their use in sharpening

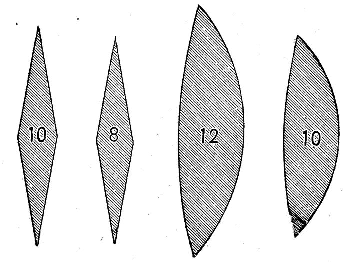


Fig. 2227.

the knives of reaping and mowing machines, are of the cross-section shown. They range in length from 7 to 10 inches, are slightly tapered, and are cut single and on their sides only.

Tumbler files, whose cross-section is shown at A, Fig. 2229, were formerly much used to file the tumblers of gun locks, but are now rarely called for. They are taper and cut double. It will be seen, however, that unless for some special purpose, the pitsaw round or half-round file will be found to answer the same purpose as the tumbler file.

It is obvious that in the use of files the coarser cuts are for use when it is required to remove a maximum quantity of material,

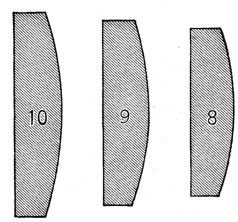
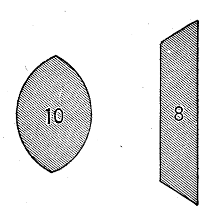


Fig. 2228.

and the finer to produce a more smooth and true surface, and also that the form of file selected is that which will best conform to the shape of the work, or can be best admitted upon or into the work.

In selecting the length of the file, the size of the work and the delicacy of the same are the determining considerations; thus, a 14-inch file would be a clumsy tool upon a small piece of work, as, say, one having an area of $\frac{1}{2}$ inch square. In selecting the shape of the file there are, however, other considerations than the shape of the work. Among these considerations may be enumerated that,



A B
Fig. 2229.

in proportion as the number of teeth on any given file, performing cutting duty simultaneously, is increased, the less metal will be taken off, because the pressure on each tooth is reduced, and the file does not bite or take hold of the work so well; hence it cuts smoother.

To fit the handles to small files, as 6-inch or less, it is simply necessary to bore suitable-sized holes in the handles, and force in the tang of the file. In doing this care should be taken to bore the hole axially true with the handle, so that the latter may stand true with the file, which greatly assists the production of true and rapid filing.

For larger files the handle should have a small hole bored up it as before, the file tang should be made red hot (a piece of wet rag or cotton waste being wrapped around the heel of the file, so that it shall not get hot and be softened), and forced into the handle by hand, the file and handle being rotated during the operation, and sighted to insure that the handle is kept true with the centre line of the file. So soon as the tang of the file has entered three-quarters or thereabouts of its length it should be removed and gradually cooled by dipping in water.

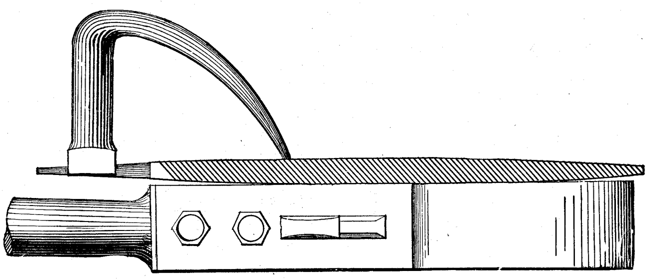


Fig. 2230.

When the surface of the work is so large that the file handle would meet the work before the point had reached fully across it, the raised handle shown in Fig. 2230 is employed. The square end of the handle has a dovetail groove into which the tang of the file is fitted. In the figure the file is shown applied to a connecting rod end, and in such broad surfaces it is especially necessary to vary the line of motion of the file after every few strokes, so as to cause the file marks to cross and recross, as shown in Fig. 2231.

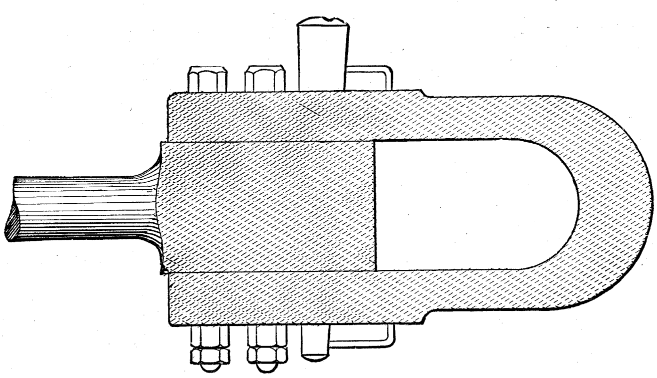


Fig. 2231.

The height at which work should be held to file it to the best advantage depends entirely upon its size, the amount of metal to be filed off, and the precision to which the filing requires to be executed.

Under ordinary conditions the work should stand about level with the operator's elbow when he stands in position to file the work. This is desirable so that the joint of the arm from the elbow to the wrist may be in the same plane as the line of motion of the file, which will give the workman the least fatigue. But when the work surface is very broad it should be lower down, so that the operator may reach over all parts of its surface. On the other hand, on very small round work, or work so small as to require but one hand to hold the file, the work may be so high as to require the operator to stoop but very little, in which case the fatigue will be less, while the work will be more in sight, and can be better scrutinized.

When the file is pushed endways it is termed cross-filing, and the teeth cut on the forward or pushing stroke only, and in this case the file should be held as in Fig. 2232, the end of the file handle abutting against the palm of the right hand. But when the file is held in one hand only, the forefinger may be placed uppermost, and either on the file handle or on the file itself, as may be found most convenient. In cross-filing the file should be relieved of cutting duty on the return or back stroke, but should not be removed from the work surface.

For heavy cross-filing on iron or brass, a 15-inch file is sufficiently large for any of the ordinary duty required by the machinist, and will require all the pressure one man can put on it to enable it to cut freely, and move at a suitable speed.

The workman should for heavy cross-filing stand well off or away from the work so as to require to bend the body well forward. His feet should in this case be spread apart so that when the pressure of the hands is placed upon the file it will relieve the forward foot of a great part of the weight of the workman's body, which will be thrown upon the file. The rear foot operates during the forward stroke as a fulcrum, wherefrom to push the file.

At each forward stroke the workman's body should move somewhat in unison with the file; his arms being less extended than would otherwise be the case, and the file being under more pressure and better control.

During the backward stroke the forward foot should again take the workman's weight, while he recovers the upright position.

For less heavy filing and for smooth filing, the workman should stand more nearly upright and nearer to the work.

The heavier the pressure (either in cross-filing or draw-filing), the coarser the file cuts, and the more liable it is to pin and scratch.

In the case, however, of slim files, the pressure is apt to bend the file, causing it to cut at the edges or ends only of the work, as shown at A, in Fig. 2233. This may be avoided by holding the file as in the figure, the pressure of the fingers in the direction of the arrows causing the file to bend, and produce more straight work.

From the nature of the processes employed to cut the teeth of files, they are unequal in height, and as the file in addition to this varies in its straightness or warps in the process of hardening, it becomes necessary in many cases to choose for certain work files whose shape is best suited for it. Suppose, however, that files were produced whose teeth or tops or points were equal in height from end to end of the file, and it would be necessary for the workman to move the file in a true straight line in order to file a straight surface. This the most expert filers cannot accomplish.

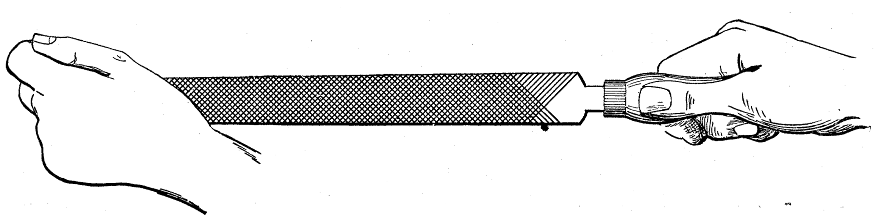


Fig. 2232.

It is for this reason that hand files are made as in Fig. 2234, being thickest in the middle M, and of a curved taper both towards the point P and the heel H, so that when applied to the work the file will bear on the work at A, Fig. 2235, and be clear of it at B and C, which allows the file motion to deviate from a straight line without cutting away the work too much at B and C. The file curvature also enables any part of the file length to be brought into contact with the work or with any required part of the surface of the same, so as to locate or limit its action to any desired part.

If a bellied file (as this shape of file is sometimes termed) be moved in a straight line it will file flat so long as it is moved to have contact clear across the work, but if the file is concave in its length it can only cut at that part which is in contact with the edge of the work, and the latter must be filed convex.

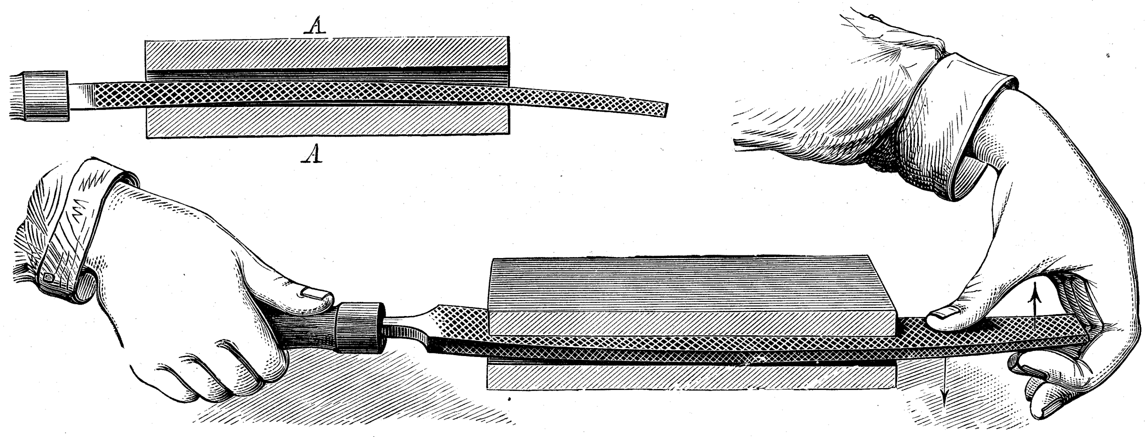


Fig. 2233.

It becomes obvious then that for flat work a bellied file must be used, and that the belly should preferably be of even sweep from end to end.

But files, whatever their shape, and however evenly formed when soft, warp (as already remarked) in the hardening process, sometimes having crooks or bends in them, such as at E and D, in Fig. 2236. In such a file the teeth at E would perform no duty unless upon work narrower than the length of the concavity at E, while on the other side D, the extra convexity would give the file great value for work, in which particular spots only required to be filed, because the teeth at D could be brought to bear on the required spot without fear of cutting elsewhere.

Fig. 2234.

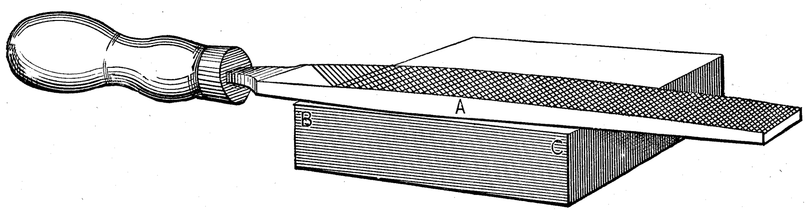


Fig. 2235.

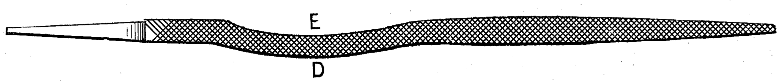


Fig. 2236.

If, however, we have a taper flat file, such as in Fig. 2234, the thickness being equal from H to M, and a curved taper from M to P only, then it would be impossible to file flat unless only that part from M to P be used, because the heel H would meet the work at the same time as M, and it could not be known where the file would cut, more than that the most prominent teeth would cut the most.

Fig. 2237.

An excellent method of testing the truth of a file, and of finding its high spots is to chalk a piece of board, press the file firmly to it and take several strokes and the chalk will be transferred to the highest parts of the file, showing very distinctly every hill and hollow in the teeth, even on the finest of Groubet files, and it will be found from this test that but very few of the best-made files are true, and that very great care is necessary in selecting a file for flat and true work.

The curvature or belly on a file not only enables but few teeth to be brought into action at any one turn, and thus cause it to cut more freely; but it also enables all parts of the file length to be used and worn equally. Thus in Fig. 2238 are shown two positions of a file, one cutting at A and the other at B, these different locations being due to different levels of the file which may be given by elevating or depressing it at the handle end.

If a file is hollow in one side of its width, and rounding on the other, as in Fig. 2239, the hollow side is unfit for any but the roughest of work, since it will not file any kind of work true; but the rounded side is very effective for flat surfaces, since the number of teeth in action is more limited and their grip is therefore greater, while by canting the file any part of its width may be brought into action. The rounded side is especially advantageous for draw-filing (a process to be hereafter explained).

In all cross-filing, whether performed to clean up a surface, remove a maximum of metal, or prepare the work for draw-filing, or for reducing the work to shape, the file should be given a slight lateral as well as a forward motion, and it will be found that this lateral motion is more effective if made from right to left, leaving the file marks in the direction of marks B, in Fig. 2240, because the workman has more control over the file (especially if a large one) than when the lateral motion is from left to right; but this latter motion must be given occasionally to prevent the file from cutting deep scratches, and to keep the file surface true.

A new file should be used at first on broad surfaces so that the teeth may not grip or bite the work so firmly that the strain will

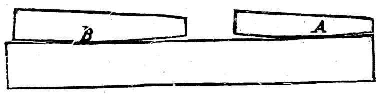


Fig. 2238.

cause their fine sharp edges to break off, which is apt to occur unless their edges are slightly worn off. As a file becomes worn it may be used on narrower work, because the narrower the surface the more readily the file will bite. When a file is much worn, or when it is desired to remove a quantity of metal as quickly as possible, the file may be used at different angles upon the work, as shown in Fig. 2241, which by reducing the number of teeth in action facilitates the cutting, but if this be done with a new file it will break off the points of the teeth.

Cast iron, brass, and copper require a sharper file than do either steel or wrought iron, hence for the first named metals (especially brass and copper) new files are used, and these should not be used upon wrought iron or steel until worn out for the above metals.

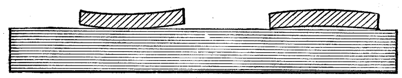


Fig. 2239.

In the case of unusually hard cast iron or tempered steel a second-cut file will cut more freely than a coarser grade.

Work to be draw-filed should first be cross-filed with smooth or at the coarsest with second-cut files, so as to remove the scratches of the bastard or rough file before the draw-filing, which should not be done with a rough or bastard file.

Draw-filing consists in moving the file in a line at a right angle to its length, the file being grasped at each end independently of its handle, which may be removed from the file if it be in the way, as in the case of files used on broad surfaces.

Draw-filing is employed for two purposes: first and most important, to fit work more accurately than can be done by cross-filing, and secondly to finish surfaces more smoothly, and lay the grain of the finish lengthwise of the work. The greater accuracy of draw-filing occurs because the high parts of the file can be selected and

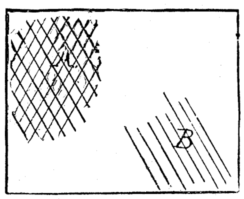


Fig. 2240

the file so balanced that this high part covers the place on the work requiring to be filed, while the strokes may be made to suit the length of the spot to be filed.

In draw-filing the file can be moved more steadily than in cross-filing, and will, therefore, rock so much less that even the novice can with care produce very true work.

Suppose, for example, that a piece of work requires filing in the middle of its length and half way along its width and half along its length, and a well bellied file may be balanced upon C, Fig. 2242, and grasped at its two ends A and B, and used with strokes of a sufficient length to file half the work length as required.

In draw-filing the file should be pressed to the cut on the pushing stroke only, and not on the return or pulling stroke.

Draw-filing produces with a given cut of file a smoother surface than cross-filing, but it will not remove so much metal in a given time.

In draw-filing short strokes will produce better work than long ones, because with the latter the file cuttings are apt to become locked in the teeth of the file, and cut scratches in the work. This is called *pinning*, and the pins cutting deeper than the file teeth produce the scratches.

To avoid this pinning the file surface may be well chalked, which will at the same time cause the file to cut smoother although not quite so freely. It is necessary, however, to clean the file after every

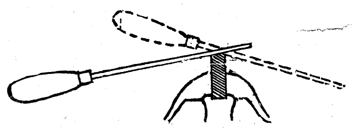


Fig. 2241.

ten or twelve draw-filing strokes so as to remove the filings. This removes the chalk also, hence it requires occasional renewal. For this purpose lumps of chalk are employed, but great care is necessary in its selection, because it sometimes contains small pieces of flint or other stones, and these score and greatly damage the file teeth.

To dislodge the chalk and filings the file surface may be rubbed two or three strokes with the hand, and the file lightly tapped on the vice back. But it will also be found necessary to occasionally

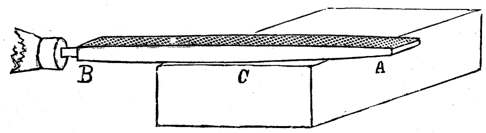


Fig. 2242.

clean the file with a file-brush or file-card. The file-card is brushed across the width of the file so that the wire may reach the bottoms of the rows of teeth and clean them out.

If the pins have lodged too firmly in the teeth to be removed, the scorer shown in Fig. 2243 is employed. This scorer is a piece of copper or brass wire flattened out thin at the end E, which end is pressed firmly to the file teeth and pushed across the width of the file. By this means the thin edge becomes serrated, and the points of the teeth forming the serrations pass down the bottoms of the rows of file teeth and force out the pins. Here it may be

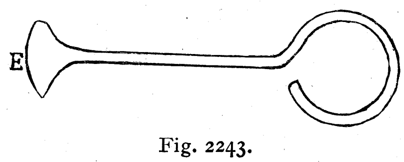


Fig. 2243.

remarked that pinning takes place in cross-filing as well as in draw-filing, and is at all times destructive to either good or quick work.

Oil is sometimes used to prevent pinning and produce a dead finish, which will hide scratches, but it is much more dirty than chalk and no more effective. Neither of these substances, however, is employed upon cast iron, brass, copper, or other than the fibrous metals.

In removing the cross-file marks it will be found that the file will cut more freely if it be slightly canted so that it cuts most at and near the edge, as shown in Fig. 2244, the edge A B meeting the work, the file stroke having progressed from C as shown. This is especially advantageous if the metal be somewhat hard or have a hard skin upon it, or in case of a hard spot, because it will enable the file to bite when, if pressed flat upon the work, it would slip over it.

When draw-filing is resorted to, to obtain a very fine surface, to be finished with emery paper and crocus cloth, it is best to reverse the direction of the file strokes so as to cause the file marks to cross and recross as shown in Fig. 2244, where the marks C cross those previously made, which will not only produce smoother work, but it will partly prevent the file from pinning. It will also be found that the draw-filing will be smoother and pinning less liable to occur when the file strokes cross the fibres or grain of the metal than when they are parallel to that grain; hence when the finishing marks are to be left in a line with the grain and a very smooth surface is required, the draw-filing marks should, just before the final finishing, be across the grain, the final finishing being with the grain simply to reverse the direction of the marks.

Half-round files should be well curved in their lengths on the half-round side, so that when applied to the work any part of the file's length may be brought to bear upon the required spot on the work, as was explained for the flat file, and shown in Fig. 2238. If the flat side is straight or hollow in its length it is of little consequence,

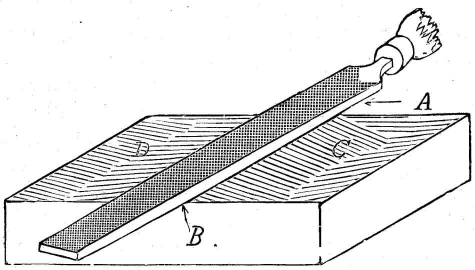


Fig. 2244.

because it can be used upon convex or upon narrow surfaces. The sweep or curve of the file should in its cross-section always be less than the curve of the work it is to operate upon, and the teeth should be brought up sharp on the edges, and over the whole area of the half-round side, which is in inferior files not always the case, because the rows of chisel cuts are too far apart in the width of the file; hence, there is along the length of the file between the rows of full teeth, rows that are not brought fully up, which impair the cutting qualifications of the file.

In using a half-round file to cross file it should at each stroke be swept first from right to left, and after a few strokes from left to

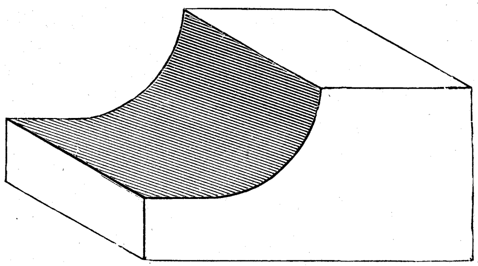


Fig. 2245.

right, so that the file marks appear first as in Fig. 2245, running somewhat diagonal from right to left, and then, when the side sweep of the file is reversed in direction, the file marks will cross after the manner shown exaggerated in Fig. 2247. Unless this is done, the curve will be apt to have a waver in it as in Fig. 2246, or in large curves there may be several waves, and the same thing may occur if the direction of side sweep is not reversed sufficiently often. The file should also be partly swept around the curve, so that if at the beginning of a stroke it meets the work at the upper position in Fig. 2247, then at the end of the stroke it should be as at the lower one, which will also prevent the formation of waves. The larger the curve the less the amount of this sweep can be, the operator giving as much as convenient for the size of curve being filed.

In draw-filing the file should be slightly rotated, so that if at the beginning of a stroke it stands as at A, Fig. 2247, at the end of that stroke it should stand as at position B, and it should at the same time be given sufficient end motion, so as to cause the file marks to cross as shown.

A round file should always be a little smaller at its greatest diameter than the hole in the work. Before inserting it in the hole it should be rotated in the fingers, and the eye cast along it, to select the part having the most belly, which may then be brought to bear on the required spot in the work, without filing any other place, and without filing away the edges at the ends of the hole. For very accurate work it is sometimes desirable to grind on a round file, a flat place forming a safe edge. So likewise a safe edge flat file requires grinding on its safe edge, because in cutting the teeth a burr is

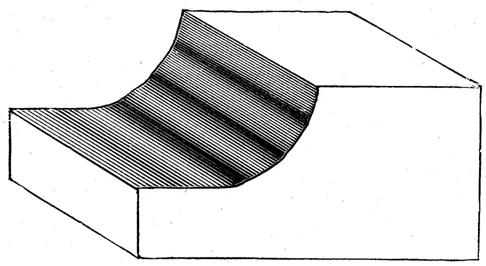


Fig. 2246.

thrown over on the safe edge, rendering it capable of scoring the work when filing close up to a shoulder.

The work should be held as near down to the surface of the jaws of the vice as will allow the required amount of metal to be filed off without danger of the file teeth coming into contact with those jaws, and should be placed so that the filing operation when finished shall be as near as possible parallel with the top of the vice jaws. These jaws then serve somewhat as a guide to the filing operation, showing where the metal requires filing away.

For cutting steel that contains hard spots or places, a second-cut file is more effective than a rough or bastard file.

Rough files are more suitable for soft metals, the bastard cut being usually employed upon wrought iron, cast iron, and steel by the machinist. But in any case the edge of the file is employed to remove small spots that are excessively hard. The file should be clean and dry to cut hard places or spots, and used with short strokes under a heavy pressure, with a slow movement.

When a file has been used until its cutting edges have become too dull for use, it may be to some extent resharpened by immersion in acid solutions; but the degree of resharpening thus obtained has not proved sufficient to bring this process into general or ordinary application; hence, the files are either considered useless, or the teeth are ground off and new ones formed by recutting them.

A recut file is of course thinned by the process, but if properly done

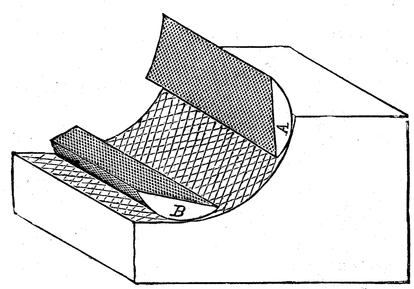


Fig. 2247.

is nearly, if not quite, as serviceable as a new one, providing that in grinding out the old teeth the file be ground properly true to curve; but, unfortunately, this is rarely found to be the case.

An excellent method of resharpening files, and also of increasing the bite of new files (which is an especial advantage for brass work), is by the means of the sand blast. The process consists of injecting fine sand against the backs of the teeth by means of a steam jet, and is applicable to all files, from the rasp to the finest of Groubet files. The action of the sand is to cut away the backs of the file teeth, thus forming a straight bevel on the teeth back, and giving a new cutting edge, and the process occupies from three to five minutes.

Fig. 2248 represents a machine constructed for this purpose. Steam is conveyed by the piping to the nozzles A,A, which connect by rubber hose H,H to sand pipe K, so that the steam jets passing through A,A carry with them the mixture of quartz, sand, and water in the sand box. By means of the overhead guide frame at D,E the file clamp C is caused to travel when moved by hand in a straight line between the nozzles A, A in the steam box, from which the expended sand and water flow down back to the sand box. Thus both sides of the file are sharpened simultaneously, and from the

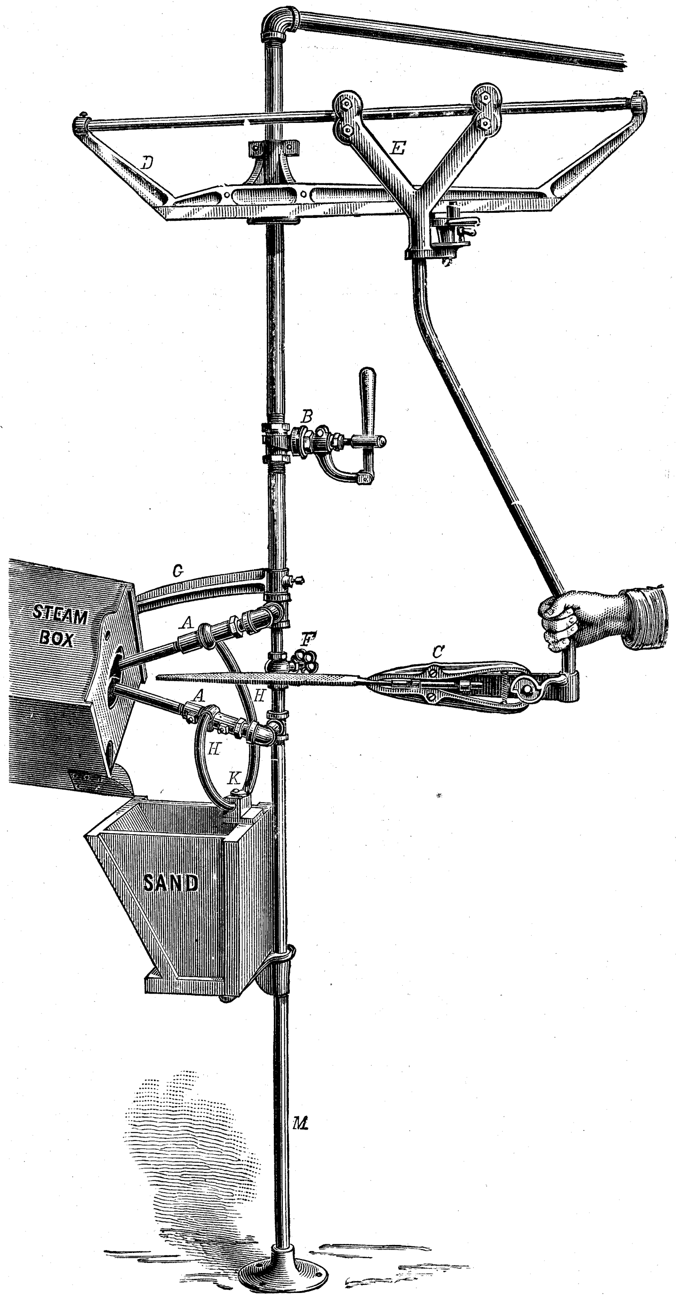


Fig. 2248.

fixed angles of the nozzles and true horizontal motion of the file the angles of all the teeth are equal and uniform.

To distribute the sharpening effects of the sand equally across the width of the file, the carriage has lateral or side motion, as well as endwise, and on the apparatus represented adjustable rollers regulate this side movement. Having the two motions, any part of the file can be presented to the blast.

The following is from *Engineering* :—"A comparative trial of the cutting power of the sharpened files was lately made with the following results : A piece of soft wrought iron was filed clean and weighed ; 1200 strokes were made by a skilled workman with one side of a new 10-inch bastard file, the iron was again weighed, and the loss noted. The other side of this file was then subjected to the sand blast for five seconds, and 1200 strokes were made with this sand-blasted side on the same piece of iron, great care being taken to give strokes of equal length and pressure in both cases. The iron was then weighed, and the loss found to be double as much as in the first case.

"These operations were repeated many times, counting the strokes and weighing the metal each time, and the quantity cut was found to gradually become less for both sides as these became worn. When the weight of metal cut away by 1200 strokes of the sand-blasted side was found to be no greater than had been cut by the first 1200 strokes of the ordinary side when quite new, a second sand blasting was applied to it for 10 seconds, and in the next 1200 strokes its rate of cutting rose to nearly its first figure. When the cut made by the ordinary side of the file fell to about four-tenths of its cut when new, it was considered by the workman as worn out, and a new file of the same size and maker was used to continue the comparison with the one sand-blasted side ; 83 sets of 1200 strokes each and 13 sand-blastings were made on the same side of this file, and in that time it cut as much metal as six ordinary sides. In 99,600 strokes it cut away 14 ozs. avoirdupois of wrought iron, and 16·4 ozs. of steel.

"With an equal number of strokes its average rate of cutting was, on wrought iron, 50 per cent. greater than the average of the ordinary sides, and on steel 20 per cent. greater. As the teeth became more worn, the time of the application of the sand blast was lengthened up to one minute. After the thirteenth re-sharpening its rate of cutting was nine-tenths that of the ordinary side when quite new.

"When the teeth become so much worn that the sand blast ceases to sharpen them effectively, the file can be recut in the usual way, and each set of teeth can be made to do six times as much work as an ordinary file, and to do it with less time and labor, because it is done with edges constantly kept sharp. The time required to sharpen a worn-out 14-inch bastard file is about four minutes, or proportionately less if sharpened before being entirely worn out. Smooth files require much less time. About 4 horse power of 60 lb. steam used during four minutes, and one pint per minute of sand (passed through a No. 120 sieve), and the time of a boy are the elements of cost of the operation."

Red Marking or Marking.—This is a paint used by machinists to try the fit of one piece to another, or to try the work by a test piece or surface plate. It should be composed of dry Venetian red, mixed with lubricating oil of any kind.

Instead of Venetian red, red lead is sometimes used for marking, but it is too heavy and separates from the oil, and furthermore will not spread either evenly or sufficiently thin, and is therefore much inferior to Venetian red.

It is applied to the surface of the test piece or piece of work, and the latter is brought to bear on the surface to be tested, so that it leaves paint marks disclosing where the surfaces had contact, and therefore what parts of the surface require removing in order to make the surfaces have the desired degree of contact.

When either the test piece or the work can be put in motion while testing, one piece is rubbed upon the other or passed along the same in order that the bearing marks may receive the marking more readily and show the bearing spots more plainly, the operation coming under the head of fitting. When neither piece can be given motion, one is made to mark the other by being struck with a mallet or hammer, or to avoid damage to the work from the hammer blows, a piece of wood or copper is interposed. This operation is termed "bedding."

The thickness of the coating of marking varies with the kind of work, the finer fit the work requires to be, the thinner the coat of marking. Thus in chipping a thick coat is applied, for rough filing a thinner, for smooth filing a still thinner coat, and so on, until for the finest of work the coat is so thin as to be barely perceptible to the naked eye. When either the work or the testing piece can be given motion and the surfaces rubbed together, a thinner coat of marking may be used. Marking is usually applied with a piece of rag doubled over and over, and bound round with a piece of twine so as to form a kind of paint-brush. This will give the surface a lighter and more evenly spread coat than would be

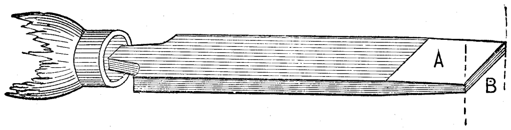


Fig. 2252.

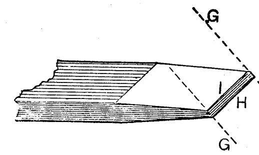


Fig. 2253.

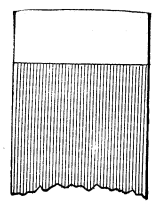


Fig. 2254.

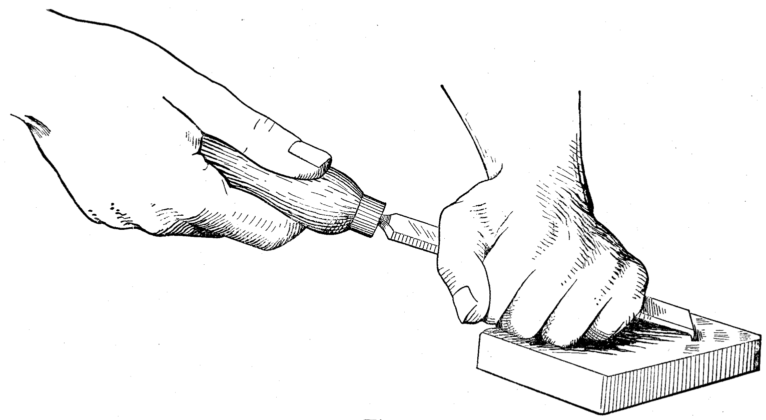


Fig. 2255.

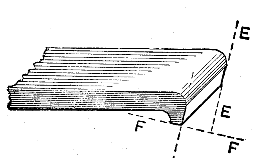


Fig. 2256.

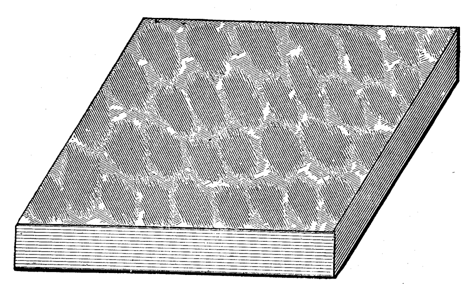


Fig. 2257.

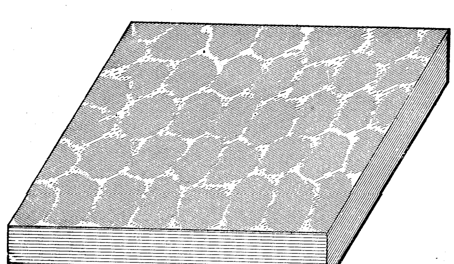


Fig. 2258.

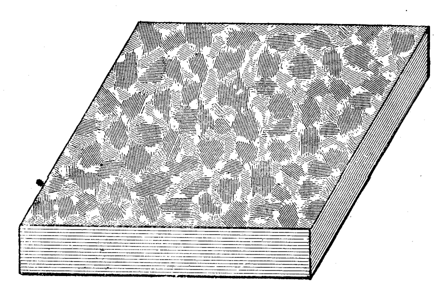


Fig. 2259.

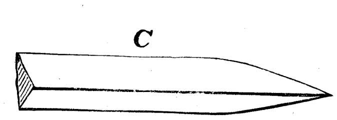


Fig. 2260.

possible with a brush of any kind. For very fine work red marking may be spread the lightest and the most even with the palm of the hand, which will readily detect any grit, dirt, or other foreign substance which the marking may contain from being left exposed.

THE HACK-SAW.—The hack-saw is employed by the machinist for severing purposes, and also for sawing slots in the heads of screws. The blade should be tightly strained in the frame, which will prevent saw breakage. The ordinary method of doing this is to provide the end of the saw frame with a sliding stud threaded at its end to receive a thumb nut. The studs at each end of the blade should be squared where they pass through the frame, as at A, B in Fig. 2249, so that the blade shall not be permitted to twist. An improved form is shown in Fig. 2250, in which the end E has a saw slot to receive the blade F. At the handle end of the blade it is held by a stud sliding through the frame, being squared at B; at C is a nut let into and screwed in the handle, and into or through the nut is threaded the end of the stud, so that by rotating the handle the blade is strained. The curve in the back at A gives a

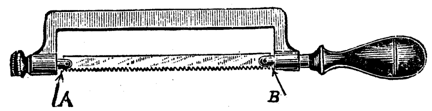


Fig. 2249.

little elasticity to it, and therefore a better strain to the blade. A hack-saw should always be used with oil, which preserves the cutting edge of the teeth.

In sharpening a hack-saw it is best to rest the smooth edge of the blade on a piece of hard wood or a piece of lead, and spread the tops of the teeth by light hammer blows, which serves a two-fold purpose, first it thickens them and enables them to cut a groove wide enough to let the blade pass freely through, and secondly it enables the teeth to be filed up to a sharp cutting edge with less filing.

The screw-driver to be used in saw slots should have its end shaped as at A in Fig. 2251, which will tend to prevent it from slipping out of the saw slot, as it will be apt to do if wedge-shaped as at B, because in that case the action of the torsional pressure or twist is to lift the screw-driver out of the slot.

SCRAPERS AND SCRAPING.—The process of scraping is used by the machinist to true work, and to increase the bearing area of surfaces, while the brass finisher employs it to prepare surfaces for polishing, applying it mainly to hollow corners and sweeps.

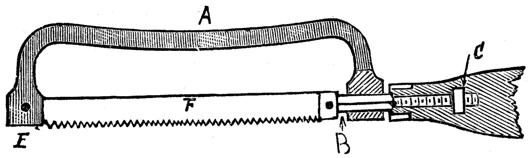


Fig. 2250.

For scraping work to fit it together the flat scraper is used, ordinary forms being shown in Figs. 2252 and 2256.

That shown in Fig. 2252 may be made of a flat smooth file, of about an inch wide, and $\frac{3}{16}$-inch thick, which is large enough for any kind of work. Two opposite faces, one of which is shown at A, are ground beveled so as to leave the end face B about $\frac{1}{16}$-inch thick. This end face is then ground square as denoted by the dotted lines, producing two cutting edges of equal angles, and therefore equally keen. If it were attempted to grind face B at an angle as denoted by the dotted lines G, in Fig. 2253, the lower edge H would cut too keenly, causing the scraper to chatter and cut roughly, while the upper one I would not cut sufficiently easily.

For very smooth work the scraper may be formed as in Fig. 2256, the front face E being ground slightly out of square as shown, and the bot om face F being given considerable angle to the body of the scraper. For very rapid cutting, however, the front face E may be at an angle of less than 90° to the top of the scraper.

The only objection to this form is that the eye lends no assistance in bringing the edge fair with the work surface. The scraper should not exceed about 6 inches in length, exclusive of the handle, for if longer it will not cut well or smoothly, and its end face should be slightly rounded as in Fig. 2254. Its facets should be ground square or straight and carefully oil-stoned after the grinding, the oil-stoning process being repeated for two or three resharpenings, after which it must be reground upon the grindstone.

The scraper should be grasped very firmly in the hands, and held as in Fig. 2255. It requires to be pressed hard to the work during the cutting and lightly during the backward stroke.

The strokes should not exceed for the roughing courses, say, half an inch in length, the first course leaving the work as represented in Fig. 2257.

The second course should be at a right angle to the first, leaving the work as in Fig. 2258, and after these two courses the work should be tested by surface plate, or with the part to which it is to fit, as the case may be. Previous to the testing, however, the work must be carefu.ly wiped clean with old rag, as new rag or waste is apt to leave ravelings behind. The surface plate should be given a light coat of red marking, and then moved backward, forward, and

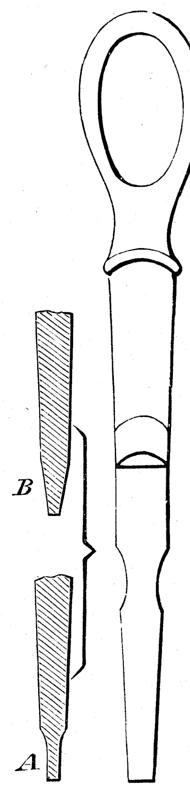


Fig. 2251.

sideways over the work, or, if the work is small, it may be taken from the vice and rubbed upon the surface plate, and the high spots upon the work will be shown very plainly by the marks left by the plate. The harder the plate bears upon the work the darker the marks will appear, so that the darkest parts should be scraped the heaviest.

After applying the plate, the scraper may again be applied, the marks being at an angle to the previous operation, the testing and marking by the plate and scraping process being continued until the job is complete, appearing as shown in Fig. 2259.

It will be noted that the scraper marks are much smaller and finer at and during the last few scrapings; and it may be here remarked that the scrapings are very light during the last few finishing processes.

The strokes of the scraper being made of a length about equal to the acting width of its edge cuts, makes the scraper mark approximately square, on which account it is sometimes termed "block" scraping. It gives an excellent finish, while not sacrificing the truth of the work to obtain the finish.

The scraper will not remove a quantity of metal so quickly as a file, and on this account it is always preferable to surface the work with a file before using the scraper, even though the work be well and smoothly planed. Not until the file has almost entirely removed the planer marks, and the surface plate shows the surface to be level and true, should the scraper be brought into requisition, the first courses being applied vigorously to break down the surface.

It would appear that scraping might be more quickly done by taking long scraper strokes promiscuously over the work, but in this case the bearing marks are not well defined and do not show plainly, which leads to confusion and causes indecision as to where the most or heaviest scraping requires to be done, whereas in the block scraping the marks are clearly defined and the high patches or spots on the work show very plainly, and the workman is able to proceed intelligently and with precision.

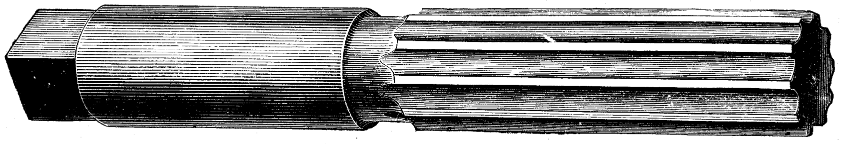


Fig. 2261.

Fig. 2260 represents a three-cornered or "three-square" scraper, which is used principally upon hollow or very small flat surfaces. The half-round scraper is employed upon holes, bores, or large concave surfaces, such as brasses. Both these tools are for vice work, used in the same manner as described for flat scrapers, while all scrapers cut smoother when the edge is kept wetted with water, as is essential when used upon wrought iron, copper, and steel.

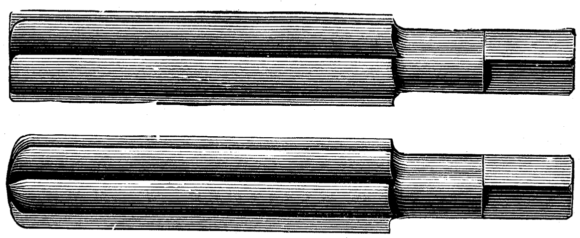


Fig. 2262.

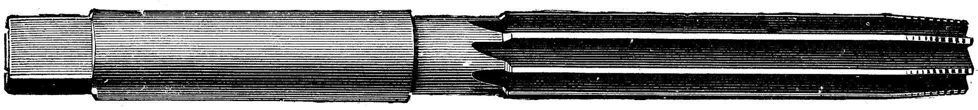


Fig. 2263.

HAND REAMERS OR RYMERS.—The hand reamer is employed for two purposes, first, to make holes of standard diameter and smooth their walls, and second, to bring holes in line one with the other.

Fig. 2261 represents an ordinary solid hand reamer for parallel holes. The teeth are ground so that their tops form a true circle, this grinding being done after the reamer has been hardened and tempered, because in these processes the reamer is apt to get both out of round and out of straight.

In some practice the reamers are formed as shown in Fig. 2262, and are made in sets of three for each size; the first is slightly taper from end to end, the second is slightly tapered at the entering end for a length about or nearly equal to the diameter, and the third is parallel and rounded on the end like the second, and in many cases only three teeth are employed.

Fig. 2263 represents a reamer in which the distance between the cutting edges A B, Fig. 2264, is greater than between B C, and so on, the spacing decreasing from tooth A to tooth *a*. The spacing of *a*, *b*, &c. to *f* on the other side is also irregular, so that if the reamer be given half a revolution no two teeth will have arrived at similar positions except A and *a*, the former arriving at the position occupied by the latter.

Now suppose that a hole to be reamed has a hollow or spongy seam along it, and if the reamer be regularly spaced, there will at this point occur a lateral movement of the reamer that will impair the roundness of the hole, and this lateral movement the irregular spacing tends to prevent.

If a solid reamer is made to standard gauge diameter when new, and the bolts or pins turned to standard diameter, then by reason of the wear of the reamer the work will become gradually a tighter fit and finally will not go together, hence the reamer must be restored to standard diameter, which may be done by upsetting the teeth with a set chisel. Furthermore the workman's measuring gauges are themselves subject to wear, those for measuring the pins wearing larger and those for the holes wearing smaller, and this again is in a direction to prevent the work from fitting together. It is preferable, therefore, to employ adjustable reamers.

Thus Fig. 2265 represents an adjustable reamer in which the teeth fit tightly into dovetail grooves, that are deeper at the entering than at the shank end of the reamer, so that by forcing the teeth up the grooves towards the shank the diameter is increased.

Both castings and forgings are found to alter somewhat in shape in proportion as their surfaces are removed by the machine tools, so that the shape of the work undergoes continuous alteration.

Suppose, for example, that a piece of metal two inches square and four inches long, has a hole cast in it of an inch in diameter, and when finished it is to be $1\frac{3}{4}$ inches square, $3\frac{3}{4}$ inches long, and have a hole $1\frac{1}{8}$ diameter. Let it be chucked in a lathe or shaping machine and have its surfaces cut down to the required dimensions. Removing the metal to true the first surface will reduce the strain on that side of the casting and alter the shape of the whole body, but this alteration of form will not occur to its full extent until the piece is removed from the pressure of the chuck jaws, or other clamping device holding it in the machine, because this pressure holds it; as a result the surface will not be so true after leaving the machine as it was before. On surfacing the second side of the piece, the internal strain is still further reduced, and a second alteration of form ensues, and so on at the surfacing of every side of the piece. Now let the piece be chucked true to have the hole

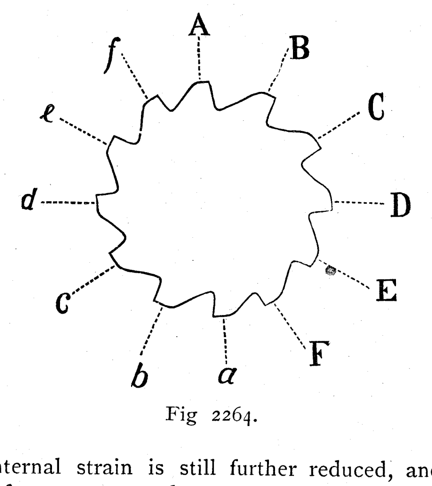


Fig 2264.

bored out, and the removal of the metal in the hole will again reduce the internal strain and the form of the body will again alter.

Suppose, however, that the piece after having its surfaces thus

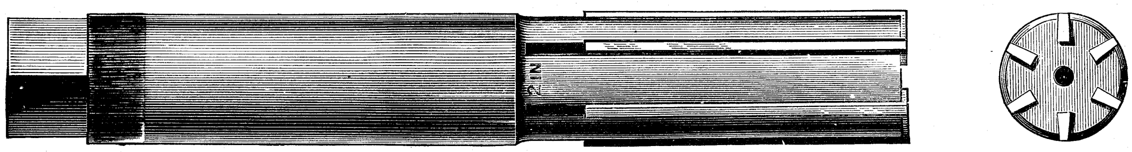


Fig. 2265.

removed, and its hole bored as true as may be, were again trued over each surface, and in its bore there will still be at each surfacing and at the boring an alteration of form, although it may be to

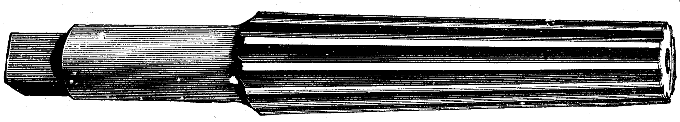


Fig. 2266.

a very minute degree, and from these causes the use of the reamer for work requiring to be very true becomes indispensable.

Fig. 2266 represents a taper hand reamer with straight flutes. It is preferable, however, to give the flutes a left-hand spiral, as was explained with reference to reamers for lathe work.

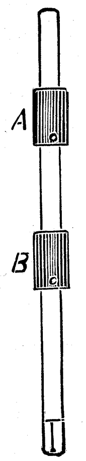


Fig. 2267.

The frames of large machines are frequently composed of parts that are bolted together after having the holes for shafts, &c. bored, and to insure the alignment of these holes after the frames are put together a hand reaming bar, such as in Fig. 2267, is employed, A and B being two shell reamers fastened to the bar by a pin.

Reamers are sometimes employed to enlarge holes or bring them fair one with another, without reference to their being precise to a designated diameter; thus Fig. 2268 represents a half-round reamer of the form used by boiler makers to bring rivet holes fair, and sometimes by machinists to ream the holes for taper securing pins. The flat face is cut down to below the centre line, so that the back requires no clearance ground upon it.

The square reamer shown in Fig. 2269 is used for rough work generally, although with careful grinding and use it will produce excellent results upon work of small diameter. Brass finishers generally prefer a square reamer to all others for reaming the bores of brass cocks, &c., and some of them prefer that one edge only be sharpened to cut, the other three being oil-stoned off so as not to cut, but simply serve as guides. The square reamer is very easily sharpened whether by grinding or oil-stoning; the flat sides are operated on, taking care to keep them straight and the thickness even on the two diameters, so that, the sides being

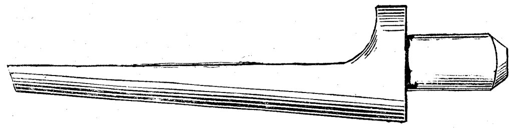


Fig. 2268.

straight and the reamer square, it will cut taper holes whose sides will be straight. If the reamer is not ground square, two only of

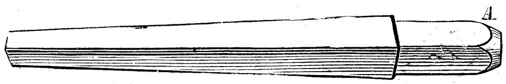


Fig. 2269.

the edges will be liable to have contact with the work bore, causing the reamer to wabble, and rendering it liable to break.

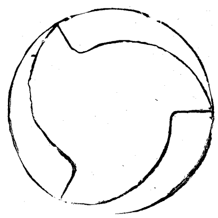


Fig. 2270.

Another and very good form of reamer for the rapid removal of metal is shown in Fig. 2270, having three teeth and a good deal of clearance, which enables it to work steadily and cut freely.