Chapter XXVI.—VICE WORK—(*Continued*).

In most of the operations of the machine-shop, the work of the chisel is followed by that of the file; hence, as an example in the use of the chisel independent of that of the file, the cutting of the teeth upon files may be given as follows:—

The largest and smallest chisels commonly used in cutting files are represented in two views and half size in Figs. 2271 and 2272. The first is a chisel for large rough files; the length is about 3 inches, the width $2\frac{1}{2}$ inches, and the angle of the edge about 50°; the edge is perfectly straight, but the one bevel is a little more inclined than the other; this chisel requires a hammer of about 7 or 8 pounds weight. Fig. 2272 is the chisel used for small superfine files; its length is 2 inches, the width $\frac{1}{2}$ inch; it is very thin, and sharpened at about the angle of 35°; it is used with a hammer weighing only 1 or 2 ounces; as it will be seen, the weight of the

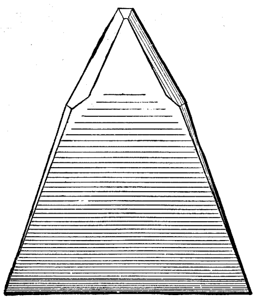

Fig. 2271.

blow mainly determines the distance between the teeth. Other chisels are made of intermediate proportions, but the width of the edge always exceeds that of the file to be cut. The first cut is made at the point of the file; the chisel is held in the left hand, at a horizontal angle of about 55° with the central line of the file, as at *a a*, 2273, and with a vertical inclination of about 12° to 4° from the perpendicular, as represented in Fig. 2274, supposing the tang of the file to be on the left-hand side. The following are nearly the usual angles for the vertical inclination of the chisels, namely: For rough rasps, 15° beyond the perpendicular; rough files, 12°; bastard

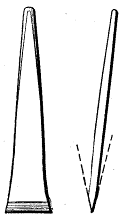

Fig. 2272.

files, 10°; second-cut files 5°, and dead-smooth-cut files 4°. The blow of the hammer upon the chisel causes the latter to indent and slightly to drive forward the steel, thereby throwing up a trifling ridge or burr; the chisel is immediately replaced on the blank, and slid from the operator until it encounters the ridge previously thrown up, which arrests the chisel or prevents it from slipping farther back, and thereby determines the succeeding position of the chisel. The chisel having been placed in its second position, is again struck with the hammer, which is made to give the blows as nearly as possible of uniform strength, and the process is repeated with considerable rapidity and regularity, 60 to 80 cuts being made in one minute, until the entire length of the file has been cut with inclined parallel and equidistant ridges, which are collectively denominated the "first course." So far as this one face is concerned, the file, if intended to be single-cut, would be then ready for hardening, and when greatly enlarged its section would be somewhat as in Fig. 2274.

The teeth of some single-cut files are much less inclined than 58°; those of floats are in general square across the instrument. Most files, however, are double-cut, and for these the surface of the file is now smoothed by passing a smooth file once or twice along the face of the teeth, to remove only so much of the roughness as would obstruct the chisel from sliding along the face in receiving its

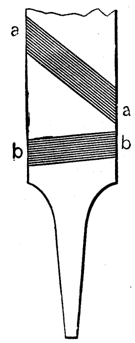

Fig. 2273.

successive positions, and the file is again greased. The second course of teeth is now cut, the chisel being inclined vertically as before, or at about 12°, but horizontally about 5° to 10° from the rectangle, as at *b b*, Fig. 2273. The blows are now given a little less strongly, so as barely to penetrate to the bottom of the first cuts, and consequently the second course of cuts is somewhat finer than the first. The two series of courses fill the surface of the file with teeth which are inclined toward the point of the file. If the file is flat and to be cut on two faces, it is now turned over; but to protect the teeth from the hard face of the anvil a thin plate of pewter is interposed. Triangular and other files require blocks of lead having grooves of the appropriate sections to support the blanks, so that the surface to be cut may be placed horizontally. Taper files require the teeth to be somewhat finer toward the point, to avoid the risk

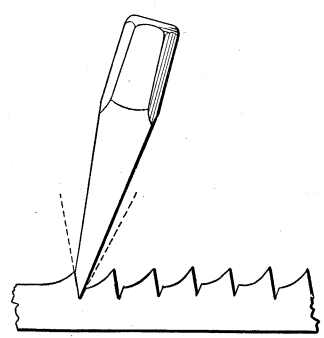

Fig. 2274.

of the blank being weakened or broken in the act of its being cut, which might occur if as much force were used in cutting the teeth at the point of the file as in those at its central and stronger part. Eight courses of cuts are required to complete a double-cut rectangular file that is cut on all faces, but eight, ten, or even more courses are required in cutting only the one rounded face of a half-round file. There are various objections to employing chisels with concave edges, and therefore, in cutting round and half-round files, the ordinary straight chisel is used and applied as a tangent to the curve. It will be found that in a smooth, half-round file 1 inch in width, about twenty courses are required for the convex side, and two courses alone serve for the flat side. In some of the double-cut, gullet-tooth saw-files, as many as twenty-three courses are sometimes used for the convex face, and but two for the flat. The same difficulty occurs in a round file, and the surfaces of curvilinear files

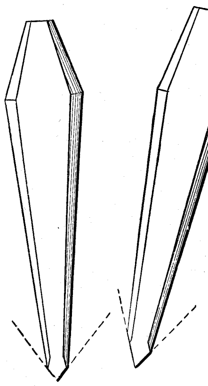

Fig. 2275.

do not therefore present, under ordinary circumstances, the same uniformity as those of flat files.

The teeth of rasps are cut with a punch, which is represented in two views, Fig. 2275. The punch for a fine cabinet rasp is about $3\frac{1}{2}$ inches long and $\frac{5}{8}$ inch square at its widest part. Viewed in front, the two sides of the point meet at an angle of about 60°;

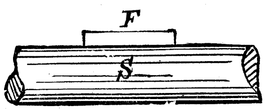

Fig 2276.

viewed edgewise, or on profile, the edge forms an angle of about 50°, the one face being only a little inclined to the body of the tool. In cutting rasps, the punch is sloped rather more from the operator than the chisel in cutting files, but the distance between the teeth of the rasp cannot be determined, as in the file, by placing the punch in contact with the burr of the tooth previously made. By

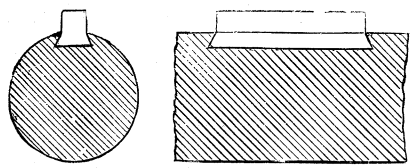

Fig. 2277.

dint of habit the workman moves—or, technically, hops—the punch the required distance; to facilitate this movement, he places a piece of woollen cloth under his left hand, which prevents his hand from coming immediately in contact with and adhering to the anvil.

As an example in the use of the chisel for chipping purposes, let it be required to fasten a feather on a shaft.

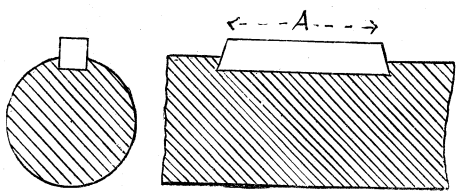

Fig. 2278.

There are four methods of inserting feathers: First, a shaft may have a parallel recess sunk into it and a parallel feather may be driven in; second, the feather may be made slightly taper and driven in; third, the feather may be dovetailed on the sides and ends both, or on the ends only, and as one or the other of these is the proper method, and the process is the same for both, one only need be described.

In Fig. 2276 let S represent a shaft and F a feather, required by the drawing to be permanently fixed therein. The drawing will not, in ordinary shop practice, give any instructions as to how the feather is to be fastened; hence the mechanic usually exercises his own judgment about the matter, or is governed by the practice of

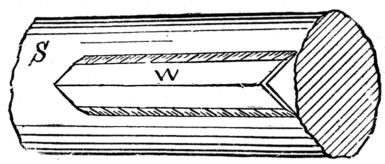

Fig. 2279.

the shop. If left to his own judgment he may determine to so fix it that it may be locked on all four sides, as in Fig. 2277, or he may simply set it in as in the similar views shown in Fig. 2278.

The method shown in Fig. 2277 is the most secure and best job; but, on the other hand, it is the most difficult and costly. The difficulty consists in filing the parallel part above the surface of the shaft to a line that shall be quite even with the surface of the shaft.

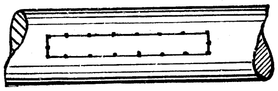

Fig. 2280.

This difficulty may be overcome by leaving the sides parallel, and making the length A equal to the length of the acting part of the key, and the bottom B as much longer as may be required to get the required amount of dovetail on the feather ends.

The first thing to do is to mark off the keyway by scribing lines on the surface of the shaft, indicating the location for the feather

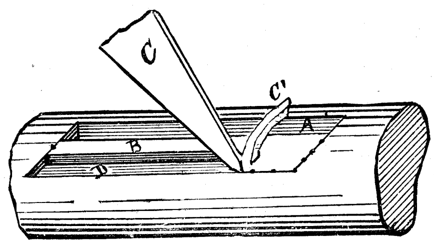

Fig. 2281.

seat; and for this purpose nothing is better than the key seat rule shown in Fig. 2279, in which W is the key seat rule, and S the shaft. After the lines are drawn they should be defined by centre-punch dots, as in Fig. 2280, and then the metal should be cut out on the sides first, using a cape chisel, and cutting close to the side lines, as in Fig. 2281, in which A is a cape chisel cut taken along one side, D a second cape chisel cut, being carried along the other side, C the

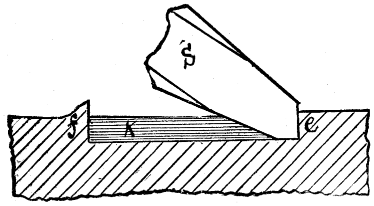

Fig. 2282.

cape chisel, C′ the cut taken by the chisel, and B a piece of metal to be cut out after the cape chisel has done its work. Suppose, now, the mass of the metal is removed, then the dovetailing is performed as follows: Next the *setting* or *upsetting* is proceeded with as shown in Fig. 2282, which is a side sectional view. S is a set chisel driven by hammer blows against the walls of the feather seat (as against the end *e*), causing it to bulge up, as shown at *f*. This setting will enlarge the feather seat or recess, so that the wide part of the dovetail on the feather will just pass in (the dotted lines shown in Fig. 2281 having, of course, been marked to the size of the feather, where it will, when fixed, meet the surface of the shaft) The feather is then placed in its seat and bedded properly by red marking applied to its bottom surface to show the high spots on the seat of the recess,

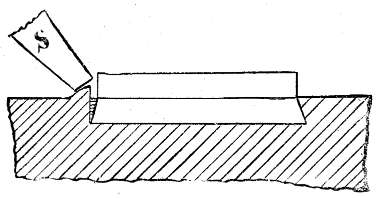

Fig. 2283.

and when properly bedded it is fastened, as in Fig. 2283, in which S is a set chisel, which, by being struck with hammer blows, closes the bulged metal back again on the dovetail of the feather, and firmly locks it in the shaft. And all that remains is to file the shaft surface around the feather level with the surrounding surface, there being usually a little surplus metal from the upsetting.

As an example of chipping and filing let it be required to chip and file to shape and to fit a knuckle joint (or a double and single eye,

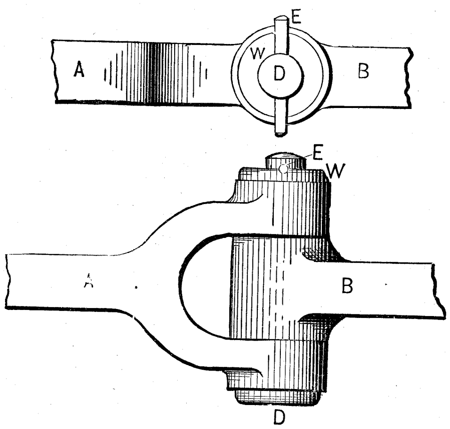

Fig. 2284.

as it may more properly be termed), such as in Fig. 2284. The eye being marked out by lines, the first operation will be to remove the surplus metal around the edges by chipping, which should be done (with the pin in place, so that it may support the eye) before the joint faces are filed at all, and should be carried in a direction around the eye, as shown in Fig. 2285, in which *v* is the vice jaw, E a lead clamp, C the cut, and D the chisel. By chipping in this direction two ends are served: first, the force of the chipping blows

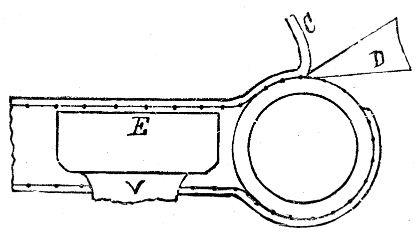

Fig. 2285.

is less likely to bend the eye if it is a light one, and, secondly, the chipping will not break out the metal at the edge of the eye, which it would be apt to do if the chipping was carried across. This is shown in Fig. 2286, where a chisel cut is supposed to have been carried across from A to B and a piece has broken out at B. If the width of the eye is too broad for one chisel cut, a cape chisel should be run around it, as in Fig. 2287, A D showing the cutting, the flat chisel cuts B,C being taken separately afterwards.

In order to illustrate the filing clearly, it will be necessary to show more metal to be filed off than would be the case in practice, unless the eye were very small, in which case it would not pay to chip.

Put the eyes together with the pin in and let the two lowest places on the edges coincide. Then file a flat place clear across them, as

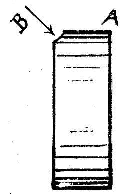

Fig. 2286.

shown in Fig. 2288 at F, making it parallel to the pin, and, say, down to within $\frac{1}{100}$ of the finished depth. To test the parallelism of the flat place, take out the pin and apply to the flat place a square, rested against the radial face of the double eye, or measure its

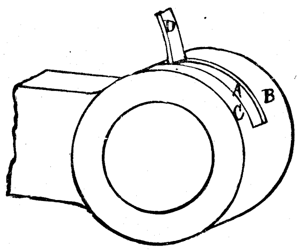

Fig. 2287.

distance from the hole of the eye on each side of the double eye, that is at each end of the hole.

When it is true and down to the required size, put the eyes together and let their relative positions be such that the flat places do not coincide, and that on the double eye will serve as a guide to

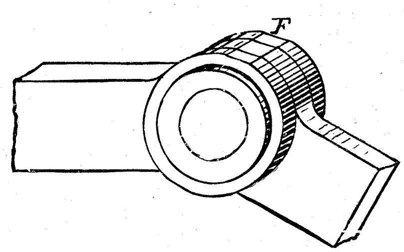

Fig. 2288.

carry the filing around the single eye, while that on the single eye will serve as a guide to carry the filing around the double eye, as will be seen on reference to Fig. 2289, in which the flat places A,B on the double eye serve as a guide to file C down to, while the flat place on the single eye at D is a guide to file the metal at E,F down to, and it

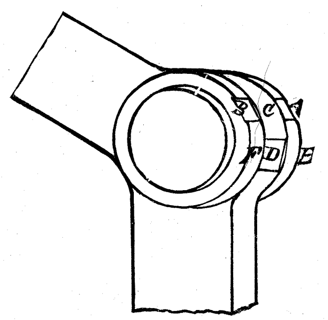

Fig. 2289.

is obvious that by moving the eyes to different positions the eye may on that side be filed true and to circle.

When the filing has thus been carried around as far as the movement of the eyes permits on that side, turn the single eye over in the double eye, and they will appear as shown in the end view,

Fig. 2290, A being the filed side of the single and E D that of the double eye; hence the metal at C,B must be filed down level with A, and that at F down level with E,D.

We have assumed that the edges only required finishing irrespective of the joint faces; but let it be assumed that the whole of the eye has been dressed up by machine tools, and that it requires fitting and finishing by the file both on its joint faces and on its edges.

If the eye has been bored and faced in the lathe the faces will be about true with the hole, but if it has had its faces trued in a machine, as a planer or slotter, and the hole bored subsequently in a slotting machine, the hole may not be true to the faces. This may occur from want of truth in the chucking devices, from these devices having been held to a table or carriage moving on slides, and having lost motion or play, in which case from the leverage of the pressure of the boring tool-reamer or bit, this table may have lifted to the

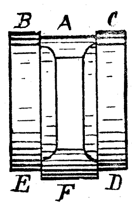

Fig. 2290.

extent of such play, in which case the hole will not be at a right angle to the face or faces.

First, then, these faces must be tested for truth and smoothed by filing. The best testing device is a pin and washer, the pin neatly fitting the hole in the eye and the washer neatly fitting the pin. The radial face of the pin head and of the washer should then be given a light coat of marking, and be inserted in the eye, as shown in Fig. 2291, in which *a* is the pin head and B the washer. If each be then rotated under pressure against the eye, they will mark the high spots, which may be filed and draw-filed until an even contact all around is shown.

The single eye should be similarly faced and fitted, a somewhat tight fit, into the double eye. In a job of this kind, where accuracy of fit is essential, it is usual to bore the hole about $\frac{1}{100}$ inch smaller than its finished diameter, and after fitting the two eyes, to ream out the eyes while bolted together.

For the reaming the two eyes should be clamped together. The single eye is left somewhat too tight a fit to the double eye to permit of the finishing being done after the holes are reamed, because the reaming may slightly alter the axial line of the hole. The two bolts

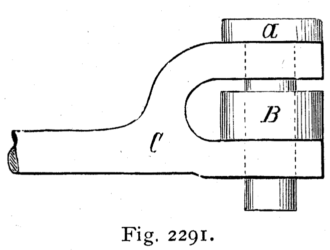

Fig. 2291.

holding the clamping plates should be brought just home on the plates, and then tightened up gradually and alternately, so that the eyes may be gripped fair, and not liable to move during the reaming. The bores of the eyes should be set as true as possible one with the other before the plates are tightened upon the eyes, for if it is attempted to set the eyes true by hammer blows afterwards, the pressure of the plates would cause the arm or hub of the double eye which received the hammer blow to move more than the other, or, in other words, to spring out of its normal position, and the eye will be distorted. But when released from the pressure of the clamping plate the double eye will resume its normal shape, and the holes will not be axially true in the two eyes.

After the holes are reamed the temporary pin and washer used for the facing will be too loose, and the proper pin should be used for all future operations. The eyes should be put together with a light coat of marking on both faces of the single eye, and, with the pin in place, one eye should be moved back and forth, when they may be taken apart again and filed on the high spots. When by repetition of this process they fit properly the outside edges may be filed up, as already described.

It is obvious, however, that the pin and washer shown in the figure may be hardened and used to file the edges up before the reaming, in which case, their diameters being equal, and equal to that of the required finished diameter of the eye, it is easy to file the eye edges true and to size; but even in this case the eyes should be finished by reversing and moving as before described. There is, however, the objection to filing the edges—first, that the joint will show plainer, because in filing the side faces to fit the single into the double eye, that part of each face near the edge is apt to be filed away slightly too much, causing the joint to show; but if the circumferential edges of the eye be filed last, the part so filed away is removed and the joint may be made almost invisible.

The best plan of all is to first fit the eyes, then ream them out and then provide a hardened pin and washer to fit the reamed hole, then file down the circumferential edges nearly level with the pin and washer and finish by reversing and moving the eyes as before described.

In the absence of any pin and washer, such as shown in Fig. 2291, the inside faces of the jaws of the double eye must be filed parallel to the outside radial faces of the single eye, the outside surfaces being trued when the hole is bored. If none of the surfaces have been trued with the hole, the outer ones should first be trued, using a T-square (if there is no pin) to test the truth of the face with the hole, and the inside jaw faces must be trued with the

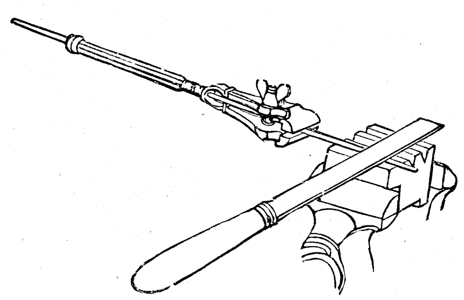

Fig. 2292.

outside, measuring each jaw with outside calipers, and the width between the jaws with inside calipers.

Let us now suppose that it were attempted to first fit the single to the double eye a tight fit, then to ream the hole and then to make the joint an easy working fit. In this case the finished hole in one eye may become out of true with that in the other, that is, it may not be parallel with that in the other, and for the following reasons:—The holes of the two eyes will rarely come quite true with each other, even though the radial faces of the eyes be turned in the lathe or faced in a machine when the holes are bored, and it is the duty of the reamer to true as well as smooth them in whatever direction they may be out of true or face one with the other until they are put together. Now, if they be put together a tight fit, the outside jaws are sprung open to some extent. Again, they may be sprung slightly atwist, and if the hole be reamed true and this twist taken out afterwards the hole will come atwist or out of fair in proportion as the jaws lose their twist from being fitted.

Again, reaming the hole slightly alters its axial line, and the radial faces, if at a right angle to the hole before reaming, will not be so after reaming, and it is not practicable to discover in just what direction and to what degree reaming the hole will alter its axial direction; hence, the single eye must be fitted as near as may be before the holes are reamed, and finished afterwards as described.

Let it be required to reduce by filing, the diameter of a round pin or to file it to fit a taper hole, and the diameter of the pin being small it may be held by one end in the vice jaws or by means of the clamps, shown in Fig. 2091 or those in Fig. 2092. But the filing can be more truly and easily finished as in Fig. 2292, in which there is shown fastened in the vice a filing block having **V**-grooves (of varying width to suit varying diameters of work), in which the pin to be filed may be rested.

The pin is held by the hand vice shown, and is rotated towards the operator during the forward file stroke (one hand holding the hand vice and the other the file), and in the opposite direction during the back stroke. After every few file strokes the hand vice

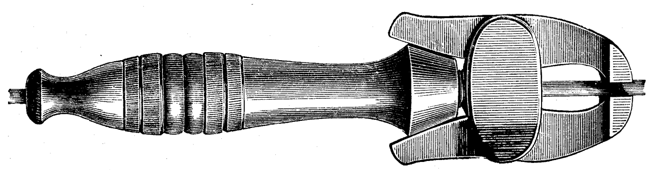

Fig. 2293.

is partly rotated in the hand so that the whole of the pin surface may be subjected to the file. The hand vice enables the pin to be forced into its hole and rotated, to show by the contact or bearing marks where it requires filing to adjust the fit.

Fig. 2293 represents an excellent form of hand vice for holding pins, &c., the jaws being pivoted to a cross piece and opened by a cone, the handle threading to the stem of the cross piece, and being hollow so that the work may pass through it. The work is thus very firmly gripped and not liable to move in the jaws as it is when the hand vice is fastened upon the work by a thumb nut.

Very thin pieces of metal cannot be well held in the vice jaws,

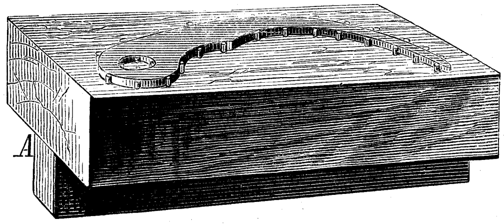

Fig. 2294.

and as an example of this kind of work holding, let it be required to file up a caliper leg, which being curved cannot well be held in any of the vice fixtures heretofore shown.

In Fig. 2294 there is a block of wood having an extension at A that may be gripped in the vice jaws. Upon the surface of the block the caliper leg is held by brads or nails driven around its edge, as shown, or it is obvious screws may be used.

An excellent example of filing is to file up a hexagon nut or a bolt head. This is apparently a simple piece of work, but it is in

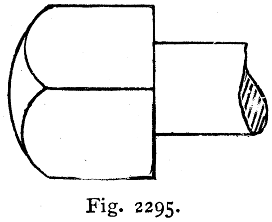

Fig. 2295.

fact a job that requires a good deal of care and precision to properly accomplish. The requirements are that the nut shall measure alike across the flats, that each flat shall be parallel to the axial line of the bolt, and at a proper and equal angle to both of its neighbors, and that the nut shall be of equal thickness all round. The method of accomplishing this result is as follows: Let Fig. 2295 represent a bolt head, after it has been turned in the lathe. It will be observed that the end face of the bolt head is rounded. Now a bolt head of this form gives a very neat appearance, but it presents difficulties in the filing up, as we shall see presently.

Suppose that one flat (which we will call flat A) of a nut, is nearest to the bore, then to make the nut of equal thickness all around, the other flats must be so filed down as to approach the

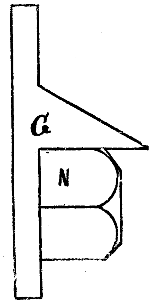

Fig. 2296.

bore as nearly as A does, and it is assumed that there is metal enough to permit this. The flat A will then be the first one to be filed up, taking off just sufficient to make it true when tested by the

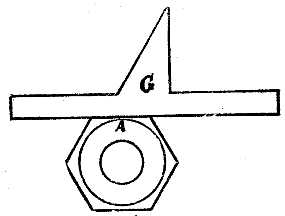

Fig. 2297.

nut gauge, applied as in Fig. 2296, in which N is the nut, and G the gauge. The flat must also be filed true when tested by the gauge, as in Figs. 2297 and 2298, the gauge G being tried rested on A and

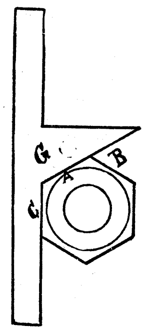

Fig. 2298.

applied to B, and then rested on A and applied to C. A should be filed so that, if possible, it will be at the proper angle to both B and C, but if, from errors in the angles of B and C, this is impossible,

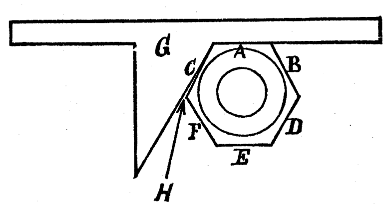

Fig. 2299.

the error should be divided between the two, as shown, for example, in Figs. 2299 and 2300, where the gauge is shown in the two positions necessary to test each respective flat, B and C; the amount of error being equal at H and I.

The next flat to file will be E, Fig. 2299. Now, in a small nut, the chamfer of the nut edge will be sufficient guide to the eye in filing E to an equal thickness (that is, equal for distance from the bore to A)

In order that the finished nut shall be so true that the nut gauge shall show that the flats or angles are true one with the other all around the nut, it is necessary that the flat E shall stand parallel to A; hence it should be made so by measurement with calipers, irrespective of its angle to either D or F. After E is filed it will serve as a base from which D and F may be filed to angle, while A will serve as a base from which the flats D and C may be filed to angle; but, while testing the angle with the gauge, C and D should

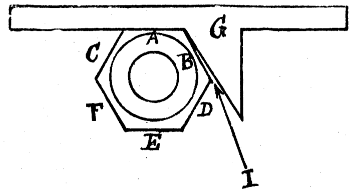

Fig. 2300.

be tried for parallelism, and F and B for parallelism, while the diameters across these flats should be equal on all sides.

If it were attempted to go all around the nut, filing to the gauge, as, for example, filing C, Fig. 2300, from A, F from C, E from F, D from E, and B from D, all the error in the angle of the gauge, or errors of workmanship, will (supposing the latter to be always in the same direction) be multiplied upon, or rather added to B when tested with A, and these two will not be of correct angle. Again, any error made upon one flat will be copied upon the one filed to gauge angle from it; whereas, filing E parallel to A insures the correctness of these two, and testing the parallelism of the others, as B, F, serves to discover and correct any error of angle that may exist. It is obvious that in filing each flat the gauge must be applied as in Fig. 2296, as well as in Fig. 2298.

In filing the opposite flats to diameter to fit the wrench or gauge, if one be used, it is best to leave them a tight fit until all are nearly finished, so that any error that may be discovered may be corrected while finishing them.

In small nuts, if two are to be filed, a better plan may be followed. The two nuts may be put upon a short piece of screw, as shown in

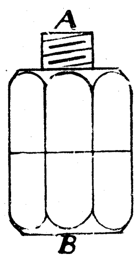

Fig. 2301

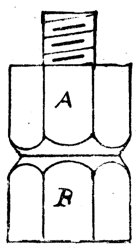

Fig. 2302.

Fig. 2301, and screwed firmly together. In doing this, however, it may be found that the nuts will not tighten against each other, with the flats fair one with the other. This, however, may be accomplished by winding around the piece of screw, and between the nuts, a piece of waste, twine, or rag, and then screwing them together until they bind sufficiently and the sides come fair; the nuts may then be put in the vice, the jaws of the latter meeting the end A of the screw and the face B of the nut in the figure. Select the thinnest flat on either of the two nuts, and file it and the one coincident to it, but on the other nut, at the same time taking care that both are filed equidistant from the screw. To test this, apply the gauge as shown in Fig. 2296. File these faces down a little above size, and then loose the nuts and put in an addition of waste or twine, so that the same faces shall not coincide, and the two filed faces will serve as guides, down to which their new contiguous faces may be filed, the hexagon gauge being applied as before. By adding waste or twine, this process may be repeated, the original, or first-filed faces serving as guides down to which to file all the others, which will insure equal thickness of all the flats. After roughing out all the flats in this manner, reverse the nuts on the screw, so that the two chamfered faces come together, as in Fig. 2302, and any want of truth in the parallelism of the flats one with the other, or with the axial line of the screw, will become at once apparent, and will be corrected in the finishing, providing that an equal amount be filed off the respective sides that are in the same plane as are A and B in the figure. Of course nuts filed in this way require the application of the calipers and gauges, the same as described for a single nut; but uniformity will be assured and the filing truer, because the filing in small nuts, as an inch or less, will be more true on account of there being a larger area for the file to rest and steady upon. It is obvious that a plain cylindrical piece, instead of a piece of screw, may be used, in which case the waste or twine will be unnecessary; but in this case the plug, or cylindrical piece, should be shorter than the length of the two nuts, and should not be so tight a fit to the bores as to damage the threads.

In small nuts it will not pay to chip off the surplus metal, because they cannot be held sufficiently firmly in the vice without suffering damage from the vice-jaws, or even from copper clamps, while lead ones are too soft to hold them.

The finishing marks, if any, should be in a line with the bore of the nut, which gives the neatest appearance. The process is the

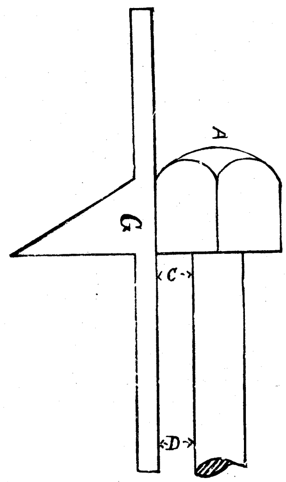

Fig. 2303.

same for a bolt head, such as shown in Fig. 2295, as for a single nut, with the exception that the gauge must be applied as in Fig. 2303, when testing the truth of the flats with the axial line of the bolt, this being necessary because of the roundness of the end face A, in Fig. 2303. The distances D and C will be equal when the flat is true in that direction.

A pair of outside calipers form an excellent example in vice work. The material should be good cast steel of an even thickness, and therefore (unless for very large ones) saw blade will answer the purpose. It should be well softened by being made to a low red heat and buried in fine cinder ashes or lime, and allowed to cool there; the proper width of this piece of steel being sufficiently greater than the size of the caliper washer, to allow room for a chisel cut and leave a little to file off in truing up the joint. The length should be somewhat more than that required to make the legs, because a piece will be required to be cut off the narrow end to give substance enough for the points. The size of the washer should be drawn at each end of the steel, the centre of the washer should be centrepunch-marked, and a line should then be drawn to set off the two legs. The steel is then severed along this line, thus getting out the two rough legs. When shears are not at hand, or when it is not designed to use them for this purpose, three methods of dividing may be pursued: First, we may drill small holes along the line, and cut between the holes with a chisel. The objection to this is that the blade is sometimes very hard to drill. Secondly, we may make centrepunch marks along the line, and then cut along the line with a chisel ; and thirdly, we may drill a few holes at each end, and cut the middle with the centrepunch and chisel. The entire drilling is the safest, and the centrepunching the most hazardous, but it can be accomplished if the centrepunching is done lightly and gone over several times, with the chisel applied between the centrepunch marks, which will be much the quickest plan of the three.

The hole is next drilled for the rivet, care being taken to make it about $\frac{1}{32}$ inch smaller than the proper size, because the drill will not make a sufficiently true and parallel hole, and the latter must be reamed or trued out ; and again because the legs have to go into the fire to be bent, and hence the holes may become damaged. There is another consideration, however, in determining the size to drill this hole, which is that the two legs require to be riveted together to bend them, and it is as well to drill the hole to suit the piece of metal intended to be used for this temporary rivet, which should be of brass or copper, so as to drive out easily after the bending is done. During the bending process the points should be thickened, care being taken not to twist them in the process. If the vice hand does the bending, the following instructions are pertinent : Heat the steel slowly and turn it over and over in the fire so that the points may not get burned before the wider parts are sufficiently heated. Let the fire be a clean one, that is, with no gaseous or blazing coal about it, or the coal will stick to the sides of the calipers, and they will get cool while being cleaned of adhering coal after being taken from the fire. Begin the bending from the thick end, carrying it forward by degrees. Strike light but rapidly succeeding blows, placing the steel upon the round point of the anvil.

The bending completed, and the points being thickened, the edges of the legs are trimmed upon an emery wheel or with a file, using the latter lengthwise of the edges if a new one, or crosswise if an old one. A full $\frac{1}{32}$ inch may be left to trim off after the calipers are put together. The temporary rivet may next be driven out, first, however, gripping the legs firmly and near to the rivet end with a hand vice, putting a piece of sheet brass between each jaw of the hand vice and the steel ; otherwise the teeth of the latter will mark the steel, entailing a great deal of extra labor to file the marks out. The rivet hole is then reamed out to the required size, the two legs being held together by the hand vice to render the reaming more steady and true by making the hole longer when the two are together.

The next operation is to turn the rivet and washers. It is a very common practice to turn two separate washers and a rivet. On account, however, of the small amount of bearing in the washer holes, such washers are apt to rivet up out of fair one with the other, making an unsightly joint and causing them to be out of round when the edges of the joint are filed up. A better plan is to turn a pin and washer, taking care to make the diameters of the two exactly equal and the flat faces of each quite level. The pin should be turned about $\frac{1}{64}$ inch taper, the small end being made a neat fit to the holes in the caliper legs, and should be made of cast steel properly annealed. When finished, the head of the pin should be gripped by a pair of lead clamps in the vice, the end being left protruding so that the legs can be put upon it and revolved back and forth with a good supply of oil and under hard pressure, so that the pin will be forced a good and rather tight fit into the holes. This process will also smooth out the holes and condense the metal around both the holes and the pin. It is well to leave the pin to fit about one half as tight as the finished joint requires to be. The washer should be countersunk about three-quarters of the way through the hole, the latter being left a close working fit to the pin.

The legs should be rough filed, second-cut filed, and smooth filed before being draw-filed, care being used to keep the files clean, so as to avoid scratches. During this filing, however, the pin should be tried in the hole to see if the head comes fair down upon the face ; thus the pin forms a guide and test in facing up the joint of the leg, and this is one of its advantages over the two-washer plan. After carefully draw-filing and polishing the sides of the legs the fitting of the joint is finished as follows : Place the two legs upon the pin in their proper position, and then put the washer into its place. Then behind the washer place another temporary one that will protrude beyond the end of the pin ; then grip the whole tightly between a pair of lead clamps or pieces of thick leather in the vice ; this will bring all parts of the joint home. Take hold of one leg in each hand and move them backward and forward as far as the vice will let them go, repeating the operation about a dozen times or more. This will mark the high spots upon the legs, which may then be taken apart again and have the bright parts removed by a scraper. It is also well to place the flat face of the washer upon a smooth file and rub it backward and forward under finger pressure, which will tend to correct any defect in its flatness. When the faces of the joint bear all over, it may be put together with oil and placed in the vice as before. Work it well back and forth, take it apart again and cut off the rivet to the required length, taking care very slightly to recess the end to assist the riveting. The whole joint should then be wiped quite clean, freely oiled, and put together ready to rivet. The head of the pin should be rested upon a block of lead, so that it will not get damaged. The riveting should be done with a small light ball-pened hammer, the blows being delivered very lightly and evenly all round the edge. As the riveting continues it is necessary to move the legs occasionally to see how the tightening proceeds, and when the legs are sufficiently tight, one of them may be gripped between pieces of leather in the vice, while the other is well worked and lubricated with oil. Then the riveted end should be filed off to very nearly its proper height and shape, and the joint well worked back and forth and round and round in the hand until it gets quite warm, when it may be cooled in water and tried for tightness. If too tight, it may be either worked until easy, or the riveted end of the pin may be tapped with a hammer to loosen it slightly. The riveting being completed, and the end filed smooth, the rounded part of the washer and the pin head should be draw-filed with a very fine file moved in varying directions, and then the polishing may be done with emery paper.

FITTING KEYS.—Keys that have been planed or milled will still require fitting with the file to insure that they bed properly. If the key to be fitted is taper and intended to fit top and bottom, the sides should first be filed true to a surface plate, and fitted into the keyway in the shaft, so that it can be slid up and down a good working fit. While fitting it, however, it is well to try it once or twice in the keyway in the wheel, as well as in the shaft, so as to see by the marks whether the keyways in the shaft and wheel require any fitting at all, either to make them quite square with the outside face, supposing it to be turned off, or to give them a good even bearing surface. The key being fitted sideways we must give the two keyseats a coating of red marking just sufficient to show that the surface is of a red tint, and then put the wheel in its place on the shaft. Then we bevel off the edges of the key at each end, leaving a chamfer of $\frac{1}{16}$ inch, and after facing off the top of the key with a bastard file, we place it in the keyway and tap it very lightly to a gentle bearing. After driving the key lightly home and taking it out again, we may file it on the top and bed it on the bottom, according to the indication of the marking, and re-insert it, tapping it up until it is home, top and bottom, without being a driven fit at all ; on taking it out we file it according to the marks again, and if we continue this process until the key is a good fit, it will not spring the wheel the least out of true, no matter how tight, reasonably, it is finally driven. The key must never be driven in or out dry, for it will, in that case, inevitably cut during the first part of the operation ; the marking put on the keyway is sufficient lubrication, but after two or three insertions the key also should be itself given a light coat, which will serve as lubrication, as well as denote the fit.

The bearing or contact marks upon a key driven home very lightly may show at one end or on one side only, while if the key was driven farther in those marks may show all over, making the key appear to fit much better than it actually does. This occurs from the elasticity and compression of the metal of the keyway and key, the metal giving most where the contact is hardest ; from this it is apparent that a wheel truly bored and a good fit may be set out of true by the key.

In Fig. 2304, for example, is a wheel hub W, assumed to be a good fit to the shaft S, while the key K fits at the end A only. If the key be driven tightly home, the wheel will spring over, so that instead of the plane of its diameter standing at a right angle to the axial line of the shaft as at D in Fig. 2305, it will stand at an angle as at E, throwing the wheel out of true in that direction. This would occur not only on account of the elasticity and compression of the metal of the keyway, but also because the surface of the bore of the wheel and of the shaft is not, even under the best of turning, smooth enough to come into close contact all over, but are covered with slight projections or protuberances, which may occur in spirals because of the turning tool marks, or in localities because of differences in the texture of the metal. In driving the key home

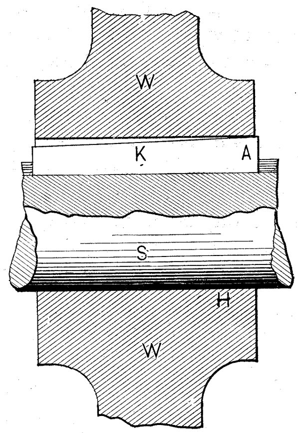

Fig. 2304.

these protuberances give way, and they do so most where the contact pressure is greatest, which would be at G in Fig. 2305, causing the wheel to cant over. If the wheel is not a good fit to the shaft it will not in this case touch the shaft at C, Fig. 2305.

Now suppose the key to bear at *a* and *b*, Fig. 2306, only, then the wheel would be thrown out of true in a direction at a right angle to the length of the key as denoted by the line E, which should stand as at D.

A properly bedded key binds the opposite half of the circumference of the wheel bore to the corresponding half circumference of the shaft; but if the key binds at one end only, as in Fig. 2304,

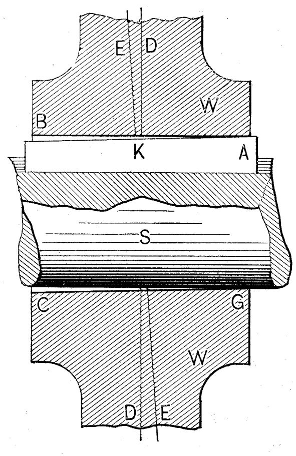

Fig. 2305.

the contact will be at the end H only; hence the surfaces will soon compress, on account of all the strain of the key falling on a small area, and the key will get loose.

It is obvious then that if a wheel has not been bored to run true the error may be to some extent corrected in fitting the key, but in this case the key must be driven well home, and the wheel rim tried for running true during the fitting process, the key being so bedded as to true the wheel as far as the elasticity and compression will permit; but a key thus bedded will not hold so firmly.

The distance a key of a certain length, breadth, and thickness, and of a given taper, will drive after being pushed home by hand or lightly tapped in with a hand hammer depends upon how closely it fits to its seat, and upon the elasticity of the metal, as well as upon the force with which it is driven. The workman usually, while fitting the key, drives it well home occasionally, to see how much of its length to allow for the final driving, and while doing so, if the key is a small one, a hand set chisel or a piece of copper should be interposed between the key head and the hammer (a blacksmith's set chisel is used for large keys) to prevent the hammer from damaging the key.

In fitting keys to old keyways the key is made too long, and cut off after being driven home. A long key is apt to bend in the driving, hence it is not unusual to support it by holding a second hammer beneath and against it to support it while being driven. In driving a key out, especially if it is fast home, a quick heavy blow is best, as it is less likely to burr, swell, or bulge the end of the key. But after the key has started lighter blows will answer.

To make a key for an old sunk keyway, it is as well to fit a piece of wood thereto as a guide in forging and fitting the key. If a *fast* running grindstone or emery wheel is at hand, many will forge the key a trifle large and then grind it as near as possible, and finish by filing. This, however, does not produce good work; it is better to plane the key all over, leaving a little in size for fitting. In preparing the piece of wood referred to, it should not in the fitting be driven or even forced in and out to try the fit, for the wood will compress

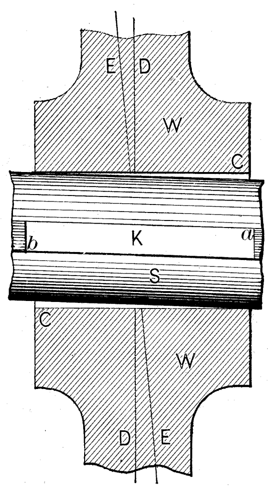

Fig. 2306.

and the marks mislead as to the actual fit. The proper way is to chalk the piece of wood and push it up the keyway just tightly home, then withdraw and fit it again.

In cases where the key is forged to very nearly the finished size, and is finished by the file, as sometimes occurs when away from the shop, it is best to forge the key with a gib head, as in Fig. 462, to assist in extracting it, especially when it is difficult to drive the key out from the back end, or when the keyway does not pass entirely through. The key should be finished with a smooth file and with the file marks lengthways; it is, in fact, better to use a small smooth file and draw-file it, taking care to ease the high spots the most; and before driving it home both it and the keyway should be oiled.

If a keyway is to be cut by hand through a bore, as in a pulley or gear-wheel bore, its width should be marked with a T-square. If its width does not exceed $\frac{1}{2}$ inch a cape chisel a little less (say $\frac{1}{32}$ inch less) than the finished width of keyway should be used, which will leave a little metal for the sides to be filed true. If the keyway be an inch wide it is better to take a cape chisel about $\frac{1}{4}$ inch wide and cut a groove along each side of the keyway (keeping close to the marked line), and then cut out the middle with a flat chisel. The sides and bottom of the keyway should be surfaced true with the file.

If a keyway is to be cut in a shaft the cape chisel should be used in the same manner as above. But in both cases it is best, when filing, to occasionally ease out the corners with the edge of a half-round file, for reasons which will be explained presently.

In chipping a keyway in a bore the cut must not be carried entirely through from one side, or the metal at the end of the cut will break out, and even in wrought iron this is apt to occur, so that it is necessary to cut the keyway from each end, or, at least, nick it in at one and cut it from the other end. In long keyways it is handiest to cut them half-way from each side, using, in the absence of anything better, a piece of planed wood and red marking or chalk to try the keyway with.

In cutting out through keyways by hand the location of the keyway is marked off by lines on both sides of the stub end of the rod, and then the mass of the metal is removed by drilling through as many holes as can be got in the size of keyway required, as shown in Fig. 2307, in which W is the work, B C D E the location of the keyway, and 1, 2, 3, 4 are the holes, taking care to have the drill rather smaller than the width of requisite keyway. The holes are drilled half-way through from each side, which is done to keep the keyway true; for if the drills were to run a little to one side, as they

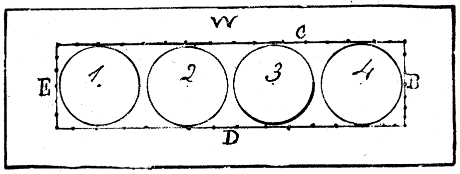

Fig. 2307.

are apt to do from a variety of causes, a great deal of work would be required to correct the error.

If the keyway is of sufficient dimensions to admit of the use of a chisel, the pieces left between the drilled holes are chipped out, and for this purpose a side chisel is found very useful, not only to nick the sides of the pieces left by the drilling, but also to take the finishing chipping cuts on the sides of the keyway. To cut out the square corners of the keyway, the diamond-point chisel shown in Fig. 2171 is employed.

If, however, the keyway is a very deep one, requiring long and slight chisels, the chipping process may be greatly reduced, or in fact entirely dispensed with, by plugging up the holes first drilled in the stub end by driving pieces of round iron tightly into them, and then drilling new holes, having their centres midway between the pieces so driven in, as at A in Fig. 2308. After the latter drilling, the remaining pieces of plugs are driven out, leaving the centre of the keyway cut clear through and the sides with a series of flutes in them, as shown at B, Fig. 2308 (in which 1 2 are the plugs and A is a centre for the new hole at that end), which should be filed away with a file as thick or strong as the clear space will allow. These

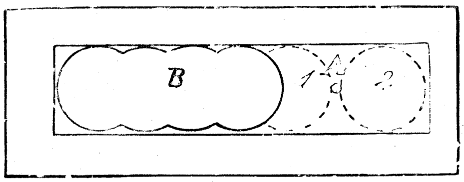

Fig. 2308.

plugs must be of the same metal as that in which the keyway is cut, otherwise the drill will be apt to run to one side.

To insure truth in the surfaces, a surface plate to test with is an absolute necessity, while to test the parallelism, a small sheet iron gauge is used, which gauge may afterwards be employed as a guide whereby to plane the thickness of the gib and key.

In cases where a slotting machine is at hand, it is sometimes the practice to cut out one end of the keyway to a sufficient length to admit a slotting tool, and then to slot out the remainder. This plan is often resorted to in getting out keyways of unusually large dimensions.

A much more usual method, however, is to employ slotting or keyway drills.

It is obvious that the ends of the keyways cut by drills are half round; hence, if square corners are required, they must be cut out square with the chisel shown in Fig. 2176, and afterwards filed out true. As a general rule, keyways cut with these drills require filing on the sides to get proper smoothness and bearing for the keys; and here it may be remarked that, in filing the corners of the keyway, a safe-edge file must be used, so that the two faces forming the corner will not be operated upon simultaneously, because that would require that the file be used in a straight line laterally as well as horizontally, and this is impracticable even in the hands of the most skilful.

Even the square file should have a safe edge upon it, and such an edge is usually produced by grinding the teeth off one face of the file. In selecting the face to have the teeth ground off, choose a face that is hollow in its length, or, if none of the faces is hollow, then select a face that is at a right angle to a good face of the file. It will be noted that with one safe edge only the square file will require turning over in order to operate upon both corners and maintain in each case a safe edge of the file against the flat sides of the keyway. For this reason many workmen select the two best parallel faces of the file and grind off the two other faces, giving to the file two safe edges, one opposite to the other. In this case either of the cutting faces of the file may be used upon the whole end face of the keyway operating close up to the corner, or if the file is much narrower than the keyway it may be used with a side sweep that will prevent the file from pinning, and produce much truer filing.

It is useless to attempt to cut out a square corner with a square file unless one edge of the latter is ground safe, because the teeth of

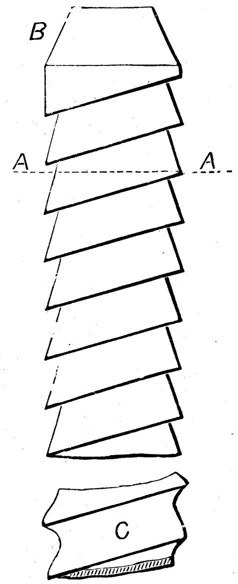

Fig. 2309.

the file itself do not form a square corner, and it is therefore only by grinding the teeth off one side that the points of the file teeth can be brought full up to a sharp angle. Here, however, it may be noted that even if the filing is performed with the best of safe-edge files, and as carefully as possible, it will still be necessary to square out the fine corners with the edge of a fine smooth half-round file.

If the edges of the keyways are rounding, as they are sometimes made where strength is required in the strap, it is better to take a file nearly or about $\frac{1}{8}$ inch larger in diameter than the width of the keyway, and grind two safe edges on it, otherwise the round file is very apt to go astray and cut the sides as well as the edge of the keyway.

An equaling file is much better for keyways than one actually parallel.

Another way employed to finish small keyways is by the aid of the tools shown in Figs. 2309 and 2310, which are termed drifts, because they are driven through with a hand hammer. That shown in Fig. 2309 is intended for holes having but little depth and not requiring to be very true, such, for instance, as those cut in the ends of keyways or bolts to receive cotters; the thickness at A A is made greater than at B C to give the cutting edge clearance.

The form shown in Fig. 2309 is for use by hand, the teeth being cut diagonally instead of across, as at A A, to preserve the strength.

This end may also be attained by making the serrations round at the bottom, as shown in the figure.

The slant of the teeth on one side of the drift should cross the slant of the teeth on the diametrally opposite side, because if the teeth on opposite sides were parallel one to the other the drift would have a tendency to move over to one side, and crowd there during the process of drifting.

In using these drifts the keyway should first be filed out to very nearly the finished size, leaving very little duty for the drift to perform, although the drift may be driven a short distance into the keyway occasionally during the filing, so as to show where filing is requisite. The work must lie flat and level upon a metal block, lead being preferable, and oil freely supplied to the drift. "If the hole is a deep one, and the cuttings clog in the teeth, or if the cut becomes too great (which may be detected by the drift making but little progress, or by the blows sounding solid) the drift must be driven out again, the cuttings removed, and the surplus metal, if any, removed by filing. The drift must again be freely oiled, and driven in as before, and the operation continued until the drift is driven through the keyway. After the drift has passed once through it should be reversed (or, if a square one, turned a quarter revolution) and again driven through, so that each side of the drift will have

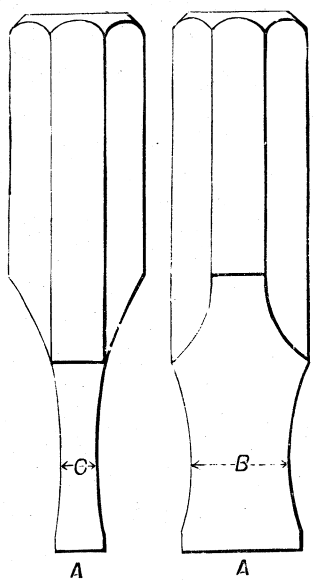

Fig. 2310.

cut on each side of the hole, which is done to correct any variation in the size of the drift" ("Complete Practical Machinist").

The great desideratum in using these drifts is to drive them true, and to strike fair blows, otherwise they will break. While the drift is first used, it should be examined for straightness at almost every blow; and if it requires drawing to one side, it should be done by altering the direction in which the hammer travels, and not by tilting the hammer face.

In Fig. 2311, suppose A to be a piece of wood and B and C drifts which have entered the keyways out of plumb, as shown by the dotted lines D and E. If, to right the drift C, it was struck by the hammer F in the position shown, and travelling in the direction denoted by G, the drift C would be almost sure to break; but if the drift B was struck by the hammer H, as shown, and travelling in the direction denoted by I, it would draw the drift B upright without breaking; or, in other words, the hammer face should always strike the head of the drift level and true with it, the drawing of the drift, if any is required, being done by the direction in which the hammer travels. When it is desired to cut a very smooth hole, two or more drifts should be used, each successive one being a trifle larger in diameter than its predecessor. Drifts slight in cross-section or slight in proportion to their lengths would be tempered evenly all over to a blue, while those of stout proportions would be tempered to a deep brown, bordering upon a bright purple.

For cutting out long narrow keyways, that are too narrow to admit of a machine cutting tool, and for very true holes, not to be cut out in quantities all of the same dimensions, it has no equal.

Hand drifts are sometimes used to cut keyways in small bores, as in small hubs, the method being shown in Fig. 2312, in which A represents a pulley with a keyway to be cut in the hub *b*; *c* is a plug, and *d* slips of iron placed between *c* and the drift *e* to press the latter to its cut. It is obvious that in this case the keyway in the pulley will be cut parallel, and the taper must be provided for in the key seat in the shaft. Keyways cut in this way are more true than those filed out. It is also obvious that the sides of the

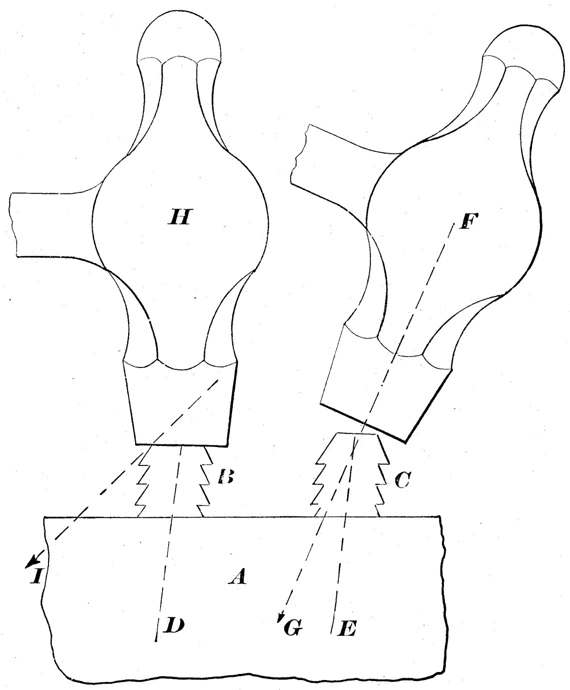

Fig. 2311.

keyway, as well as its depth, may be finished by a drift, and this is very desirable (on account of insuring parallelism) when the key is to act as a feather that is to have contact on the sides and not bind top and bottom.

The most improved form and method of using this class of tool, however, is as follows:—If a keyway is to be cut out of solid metal, holes are drilled as closely together as the length of the keyway will admit, their diameter nearly equaling the required width of keyway, after these holes are drilled through the metal remaining between them.

TEMPLATES.—Templates for vice work are used for two purposes: first to serve as guides in filing work to shape and size, and

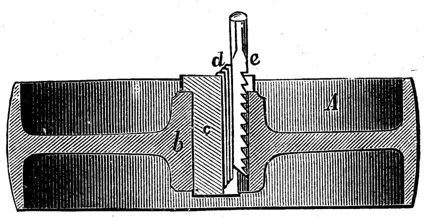

Fig. 2312.

secondly to test the finished work. When used as guides to file the work they are mainly used to work of irregular, curved, or angular form, to which the square and other ordinary vice tools cannot be applied.

Fig. 2313 represents a template for filing out a square hole. The edges A, B are at a right angle to each other, the wire simply serving as a handle.

There are two methods of applying this template; the first is to file out two opposite surfaces of the hole to the required diameter, making them true and parallel one to the other, and to then employ the template while filing out the remaining two sides; the other is to file out one side and apply the template from that as a base for the other sides. The first is preferable because the liability to error is a minimum.

When work is to be from a template, the latter obviously becomes the original standard, and in many cases the best method of forming it so as to insure correctness and enable its proper application to the work is a matter of great consideration. The shape of the

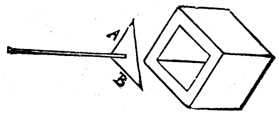

Fig. 2313.

template must, of course, be marked by lines which should be as fine and as deep as possible. But it does not matter how closely the template may be filed to these lines, it will still have some error, and this can in many cases be discovered and corrected during its application to the work. In the following examples there are principles which will be found of general application :—

Let it be required to make or test a piece of work such as in Fig. 2314, the teeth to be equally spaced, of the same angle, and of equal

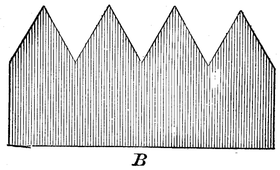

Fig. 2314.

height. A template must be made of one of the two forms shown in Fig. 2315. To begin with, take a piece of sheet metal equal in width to at least two teeth, and, assuming that the template is to have two teeth, file its sides P Q, in Fig. 2316, parallel, and make the width equal to twice the pitch of the teeth. We next divide its width into four equal parts by lines, and mark the height, as shown in Fig. 2316. If we desire to make the template such as at A, we cut out the shaded portion; or for the template at B, the shaded

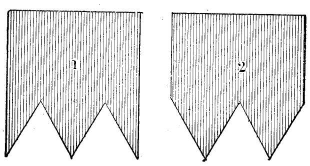

Fig. 2315.

portion. It will be observed, however, that in template A there are two corners C and D to be filed out, while at B there is but one E, the latter being the easier to make, since the corners are the most difficult to file and keep true. The best method of producing such a corner is to grind the teeth off the convex side and at the edge of a half-round file, producing a sharper corner than the teeth possess, while giving at the same time a safe edge on the rounded side that

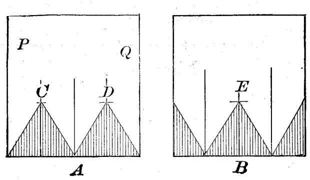

Fig. 2316.

will not cut one angle while the other is being filed. But when we come to apply these templates to the work, we shall find that A is the better of the two, because we can apply the square S, Fig. 2317, to the outside of the template, and also to the edge F of the work, which cannot be done to the edges G of the work and H of the template, because the template edge overhangs. We can, however, apply a square S′ to the other edge of B, but this is not so convenient unless the tops of the teeth are level.

Assuming, therefore, that the template A is the one to be made, we proceed to test its accuracy, bearing in mind that for this purpose the same method is to be employed whatever shape the

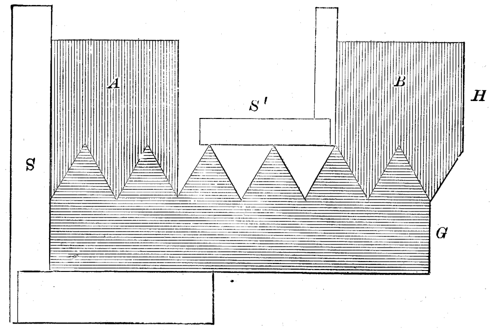

Fig. 2317.

template may be. Consequently, we make from the male template A, Fig. 2318, a female template K, beginning at one end of K and filing it to fit A until the edges of A and K are in line when tested by a straight-edge S. We then move the template A one tooth to

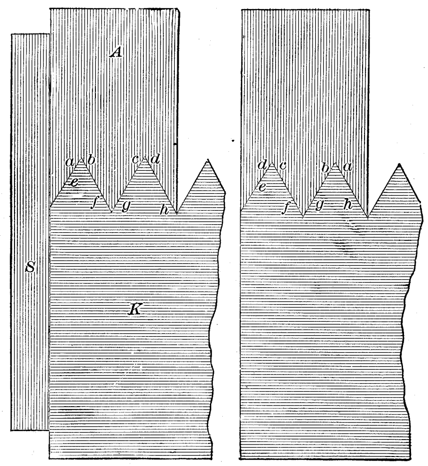

Fig. 2318.

the right, and file another tooth in K, and proceed in this way until a number of teeth have been made, applying a square as at S, Fig. 2319, to see that the template A is kept upright upon K. When K has been thus provided with several teeth that would fit A in any position in which the latter may be placed, we must turn template

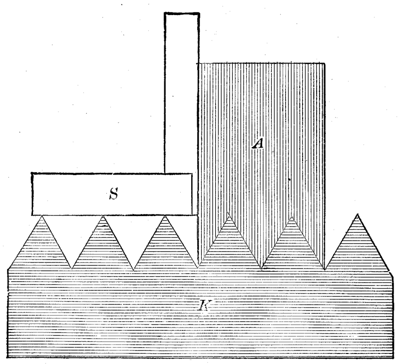

Fig. 2319.

A around upon K to test the equality of the angles. Thus, suppose at the first filing the edges *a*, *b*, *c*, *d*, upon A accurately fit the template K, and the straight-edge shows the edges fair; then if we simply turn the template A around, its angles, which were before on the right, will now be on the left, as is shown at the right of Fig. 2318.

Thus in one position *a* fits to *e*, in the other it fits to *h*, or *b* fits to *f*, and when turned around it fits to *g*, and so on. Supposing that when thus turned around the angles do not coincide, then half the error will be in the teeth of A and one-half in those of K, and the best plan will be to correct them on A to the necessary amount as near as judgment will dictate, and then to apply K as before, continuing this process until A will fit anywhere in K, and may be turned around without showing any error. But at each correction the straight-edge must be applied, and finally should be tried to

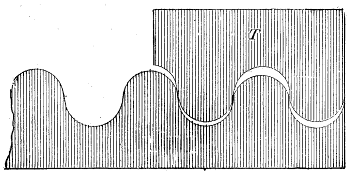

Fig. 2320.

prove if the teeth tops are level. We thus have two interchangeable templates, of which A may be used on the work and K kept to correct A when the latter becomes worn. It may be as well to add, however, that in first applying A to K it is best to press the straight-edge S against the edge of K, and hold it there, and then to place A against S, and slide it down into K.

Fig. 2320 represents an example in which, the form being a curve, it would be best to have the template touch more than two teeth, as shown in the cut. By letting the side A, Fig. 2321, of the

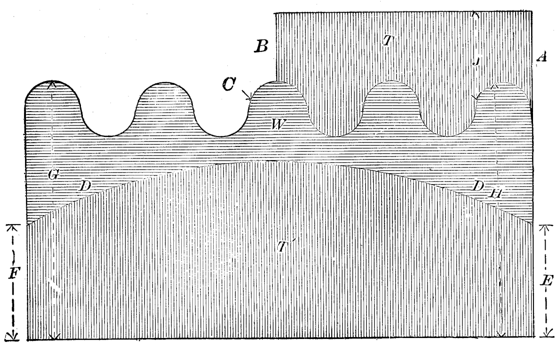

Fig. 2321.

template T terminate at the centre line of the two curves, and the end B terminate at the top of a curve, turning the template around would cause end A to envelop side C of the middle curve, thus increasing the scope of the template. Suppose, however, that the base curve D required to be true with the teeth, then a second template T′ must be used, its ends at E and F measuring an equal length or height, so that when they are placed even with the ends of the work, the distances G H being equal, the corrugations will be

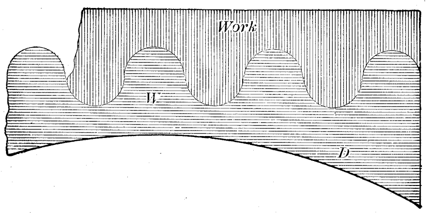

Fig. 2322.

true to the curve D D. Now let it be supposed that, instead of making a template to test a piece of work such as in Fig. 2321, it is required to make a template for use in making another piece of work that is to fit to piece W, then template T in Fig. 2321 will not answer, because it is a female template, whereas a male one is required, so that the edge of the template may coincide with that of the work. But we may convert T, Fig. 2321, into a male template by simply cutting off the edge A as far as the line J, and causing its right-hand edge to coincide with the edge of the work so that the latter, after being fitted to the template, may be turned upside down and fit upon the piece of work.

In Fig. 2323 is an example in which the forms of both sides of a piece require to be exactly alike, and the easiest method of accomplishing this is as follows:—The face A should first be made true,

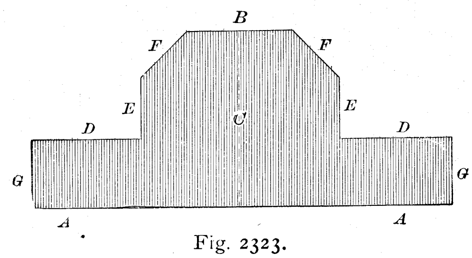

Fig. 2323.

and face B made parallel to A. A centre line C may then be drawn, and from it the lines E, E may be marked. The lines D are then drawn parallel to A A, lines E being made square to D and to A. The sides E may be calipered to width and parallelism, and all that will then remain is to file the angles F, F and the ends G, G to their

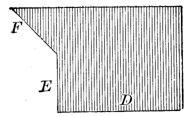

Fig. 2324.

required lengths. For F, F all that is necessary is a template formed as in Fig. 2324. The object of dressing the ends G, G last is that if they were finished before, their faces E would have to be made at exactly correct distances from them, which would render the job considerably more difficult.

Fig. 2325 represents a sketch for a piece of work whose two sides

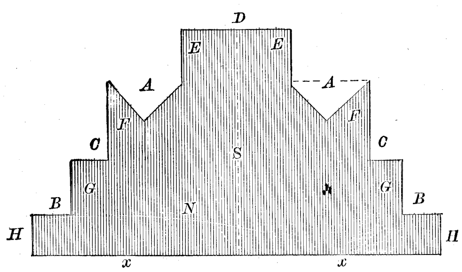

Fig. 2325.

are to be shaped exactly alike, requiring a template of the form of the work, as shown. From this a second template, Fig. 2326, is made, and to this latter the work may be filed. To make the template in Fig. 2325, which represents the work, the edge *x x* must be made straight, and the edge D parallel to it at the proper

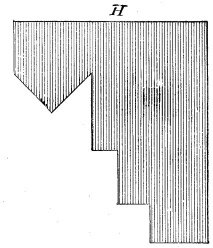

Fig. 2326.

height. A centre line S is then marked, and the edges at E may be filed equidistant from S and square to D; hence they will be parallel to each other. The side sections F should then be filed equidistant from S and parallel to each other. They should be the proper width apart and square to D, being tested in each of these respects. The line joining E and F should be left full, as denoted by the dotted line at A on the right. The edges at C,C should then

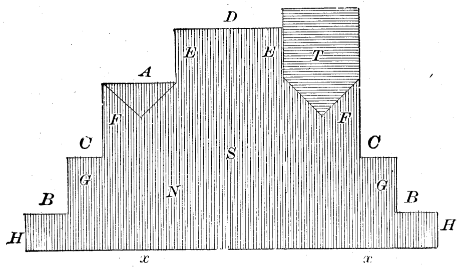

Fig. 2327.

be filed, calipering them from the edge *x x*. Edges G, G are obviously equidistant from S and parallel to S, or, what is the same thing, at a right angle to *x x*, from which they may therefore be tested with a square, and, finally, the edges B are made parallel to *x x*, and the ends H made square to *x* and equidistant from S. We have now to file the angular groove at A, and to get this true after marking its depth from the lines at A, we file it first to the lines as near as may be by the eye and very nearly to the full depth. We then make a small supplemental male template T, Fig. 2327, equal in width to the distance E F, or, in other words, to the width of the step at A, and having its edges quite parallel. Its end is then filed to fit the groove at A, when its edge meets and coincides with edge E, as in Fig. 2327, T representing the supplemental template. It is clear that when the **V**-groove A is so filed that T will fit it with either of its edges against E, the angles of the groove will be alike, and we may then make a male gauge, as in Fig. 2326, that may be used to mark or line out the work and to use as a template to file it to, its edge H being kept parallel to face D, Fig. 2325, of the work.