## PRACTICAL MECHANISM.

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### HAND TURNING.—FORGING DRILLS.

Here it will be as well to give instructions as to how to forge the drill. First heat the steel wire slowly, otherwise the extreme point will become heated before the rest of the drill; and bear in mind that the steel must not be made hot enough to scale, that is to say, it may be made to a bright red but not in any case to a yellow heat, for at that heat it will become what is called burnt, by which the virtue of the steel will be destroyed, and it will fall to pieces when struck by the hammer. But there is a stage of overheating in which the steel, while not sufficiently burnt to cause it to crumble in forging, will yet be sufficiently deteriorated to nearly destroy its value as a cutting tool, and the only way to avoid this evil is to heat the steel slowly and evenly to a bright red.

In forging the steel down to the required size, hammer it square, that is, forge it into a square bar to prevent it from becoming hammered hollow, or splitting, as it is almost sure to do if hammered all over its circumference; and take care at first to forge the point least, so as to leave a body of metal there which will tend to prevent the steel from splitting. By following these directions, the shape of the drill, when forged down to the required size and ready to be rounded up and finished, will be as shown in Fig. 62.

Fig. 62.


The corners of the square part, from A to B, may then be hammered down, making the stem round; and the bulbous end, C, may then be forged to the required finished size. A side view of such a drill is shown in Fig. 61, and Fig. 63 presents an edge view.

Fig. 63.

### HARDENING AND TEMPERING.

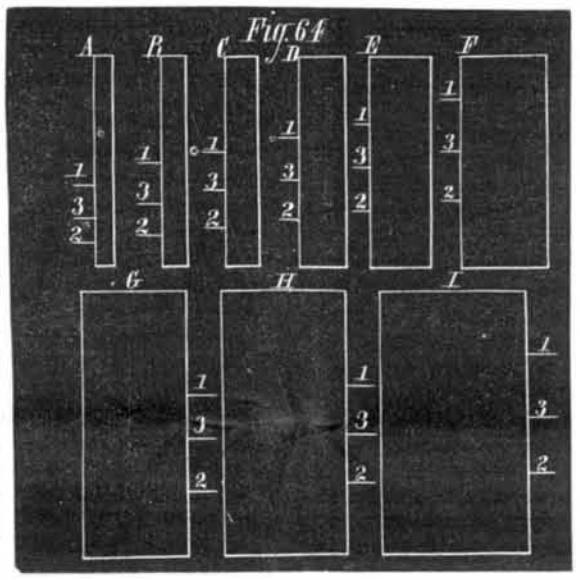
Our next duty is to harden and temper the cutting end of the drill. Steel is said to be hardened when it is as hard as it is practicable to make it, and to be tempered when, after having been hardened, it is subjected to a less degree of heat, which partly but not altogether destroys or removes the hardness. The degree to which this tempering is performed, or in other words the degree of the temper, is made perceptible and estimated as follows: By heating a piece of steel to a red heat (not so hot as to cause it to scale), and then plunging it into cold water and allowing it to remain there until it is cold, it will be hardened right out, as it is termed, that is, it will be made hard to the greatest practicable degree. If it is then slowly reheated, its outer surface will, as the temperature increases, assume various shades of color, commencing with a very light straw color, which deepens successively to a deep yellow, red, brown, purple, blue, and green, which latter fades away as the steel becomes heated to redness again, when the effects of the first hardening will have been entirely removed. It becomes apparent, then, that the colors which appear upon the surface of the steel denote the degree to which the tempering or resoftening operation has taken place. Having then by practice ascertained the color which denotes the particular degree of hardness requisite for any specified tool, we are enabled to always temper it to that degree, sufficiently near for all practical purposes. It is undoubtedly true that, if the conditions of tempering which will be laid down in all our instructions are (for want of sufficient experience in the operator) varied, the colors will not present, to positive exactitude, the precise degree of temper: the difference being that, if the color forms very rapidly, the tool may be left of a lighter color; and that if the colors form very slowly, the tool may be left of a slightly deeper hue. The difference in temper, however, as compared to the color, will in no case be sufficient to be perceptible in ordinary tool practice, and need not, save under circumstances requiring great minuteness in the degree of temper, be paid any attention to.

When a tool (such as a drill) requires to be tempered at and near the cutting edge only, and it is desirable to leave the other part or parts soft, the tempering is performed by heating the steel for some little distance back from the cutting edge, and then immersing the cutting edge and about one half of the rest of the steel, which is heated to as high a degree as a red heat, in the water until it is cold; then withdraw the tool and brighten the surface which has been immersed by rubbing it with a piece of soft stone (such as a piece of a worn-out grindstone) or a piece of coarse emery cloth, the object of brightening the surface being to cause the colors to show themselves distinctly to indicate the state of the steel. The instant this operation has been performed, the brightened surface should be lightly brushed by switching the finger rapidly over it; for unless this is done, the colors appearing will be false colors, as will be found by neglecting this latter operation, in which case the steel after quenching will be of one color: and if then wiped, will appear of a different hue. A piece of waste or other material may of course be used in place of the hand. The heat of that part of the tool which has not been immersed will become imparted to that part which was hardened, and, by the deepening of the colors, denote the point of time at which it is necessary to again immerse the tool and quench it altogether cold.

The operation of the first dipping requires some little judgment and care; for if the tool is dipped a certain distance and held in that position without being moved till the end dipped is cold, and the tempering process is proceeded with, the colors from yellow to green will appear in a narrow band, and it will be impossible to directly perceive when the cutting edge is at the exact shade of color required; then again, the breadth of metal of any one degree of color will be so small that once grinding the tool will remove it and give us a cutting edge having a different degree of temper or of hardness. The first dipping should be performed thus: Lower the tool vertically into the water to about one third of the distance to which it is red hot, hold it still for about sufficient time to cool the end immersed, then suddenly plunge it another third of the distance to which it is heated red, and withdraw it before it has had time to become more than half cooled. By this means the body of metal between the cutting edge and the part behind, which is still red hot, will be sufficiently long to cause the variation in the temperature of the tool end to be extended in a broad band, so that the band of yellow will extend some little distance before it deepens into a red; hence it will be easy to ascertain when the precise degree of color and of temper is obtained, when the tool may be entirely quenched. A further advantage to the credit of this plan of dipping is that the required degree of hardness will vary but very little in consequence of grinding the tool; and if the operation is carefully performed, the tool can be so tempered that, by the time the tool has lost the required degree of temper from being ground back, it will also require reforging or reforming.

The distance a tool requires to be heated and dipped at the first dipping, and the distance to which the transient dipping should be performed, vary so much with the substance of the metal that a definite idea can only be obtained by an

Fig. 64.




illustration, as shown in Fig. 64, A, B, C, etc., representing pieces of steel, either round or square, the line marked 1 being the distance to which the steel is made red hot, the line 2 (in each case) representing the distance to which the first dipping should be made, and the line 3 representing the distance to which the sudden and transient plunging should be performed.

Having tempered our drill according to these rules, to a dark purple, our next operation is to grind it. The flat sides of the cutting end should be ground on that side of the stone on which the latter is running from you, the faces being ground to a gradual level, of which the extreme point is the thinnest part. The thinner the point is, the more easily the drill will enter the metal, and, but for the liability of its breaking, it might be ground almost to a sharp edge. The correct thickness cannot be determined because it increases with the size of the drill; but a very little practice will enable the artisan to estimate it for any size of drill.

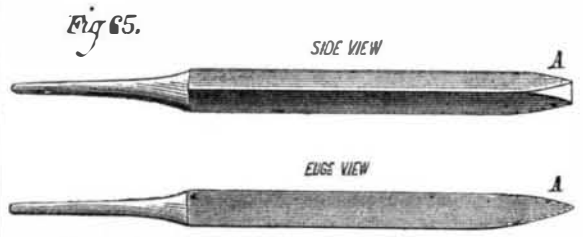
The angle of one cutting edge to the other varies with the kind of work upon which the drill is to be used, the rule being that, for ordinary work, a right angle will suffice; but for drilling sheet metal a more acute angle should be employed, so that the drill will emerge from the work gradually: otherwise, when, by reason of the point having emerged, the drill is released from the pressure necessary to force it into the metal, the remainder of the cutting edge will enter the metal very readily, and, taking an excessive cut, will twist or break the drill. For this reason the drill should be fed to its cut very slowly after its point has come through. Care must be taken to grind the drill so that the point is in the exact center of the diameter, otherwise the drill will bore a hole larger in diameter than itself; and the angle of the cutting edge should be equal on each side of the point, or else one cutting edge only will perform any duty. The angles should be ground with the grindstone running towards you, the flat side of the drill being rested upon the grindstone rest. When the drill is placed in the lathe ready for operation, it may easily be made to run true by tapping it lightly with a hammer.

Small drills may be run very fast in the lathe, which will cause them to cut freely, and to drill the hole straight; if, however, the metal to be drilled is unusually hard, the speed must be reduced.

### SQUARING THE ENDS OF THE WORK.

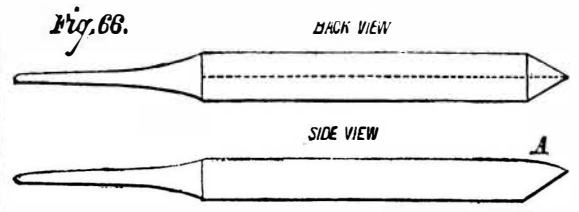
The work being centerdrilled, it must be placed in the lathe, with a driving dog on one end, the back center being screwed up only just so tight that the work may be moved by the fingers, and yet it must have a firm bearing against the lathe centers. The hand rest should then be placed as close to the work as possible without touching it, when the ends of the work must be trued up. The object of first truing the ends is to prevent the centers in the work from wearing on one side more than the other, as they would do if one side of the end face of the work was, at either end, higher than the other. The operation is called "squaring the ends" and is performed with a side tool, of which there are two kinds, both being made of three-cornered (or three-square, as it is generally termed) steel, the only point of difference being in the manner of grinding them. A worn-out saw file is an excellent thing to make a side tool of, because the teeth grip the rest and prevent the tool from slipping. It is not necessary to soften the file at all, but (for either kind) merely to grind it as shown in Figs. 65 and 66. A being in each case

Fig. 65.




the cutting edge. The tool shown in Fig. 65 has two cutting edges, one of which rests upon the hand rest while the other is cutting, which does not in any way damage the edge but causes the tool to hold very firmly to the rest, and hence to turn very true. It possesses the further advantages that it cuts very freely, and that its point can, by reason of its thinness, approach much nearer to the center of the work without coming into contact with the lathe center. Except for heavy work, it is by far the best tool in every respect, nor would the other have been presented at all, save that it is very largely employed when it is required to perform heavy duty. Both of these tools are slightly rounded in the length of their cutting edges, and are kept sharpened from the end about half an inch back.

Fig. 66.




If their cutting edges are smoothed by the application of an oilstone, they will give a very clean and smooth polish to the work. The rest should be set at such a hight that the cutting edge of the tool is slightly above the horizontal center of the work; and the tool should be so held that its side face stands nearly parallel with the end face of the work, the cutting edge being held slightly inclined towards the work, which will give to the tool edge the necessary clearance. Any excess of this inclination renders the tool liable to turn out of true, and destroys its cutting edge very rapidly. Having squared each end of the work, it must be taken from the lathe, and the burr left by the turning tool around the center filed off, when the work will be ready to countersink, that is, to bevel off the edge of the hole made by the centerdrilling, and thus to form a recess in which the lathe center will fit. And here it becomes necessary to explain one of those fine points for which the purely practical man is apt to sneer at the theoretical workman. Nine out of ten practical men will countersink by simply centerpunching, or else neglect the operation altogether, and force up the back center of the lathe and thus wear a countersink in the work. The wear and damage caused to the lathe center is sufficient condemnation of this system, unless it be applied to work that requires to be reduced in size regardless of its being either true or uniform, and this should be done in a lathe used only for such work. Countersinking by centerpunching will answer very well for jobs that require sufficient work to be performed on them at each end to give them time to wear and fit the center; and as this is nearly always the case, this system is considered sufficient for all practical purposes. It is, however, mechanically incorrect, because (even supposing the artisan to be able to grind the centerpunch true so far as roundness is concerned, and true in its bevel with relation to the bevel of the lathe center), unless he holds the centerpunch so that the center line of its length is dead true with the center line of the work, the countersinking will be deeper on one side of the work than on the other, and hence will throw the work out of true. It will, however, right itself after running a little time in the lathe. Now it is quite true that the amount to which the work will thus be thrown out of true is very slight, and (as stated) soon rights itself; but even when the end of the work running on the still or dead center has worn itself true, it must be turned end for end in the lathe before the other end will become true. Then, again, when there are many pieces of work to countersink, that operation may be as quickly performed by means of the square center as with the centerpunch, while the square center will cut true and uniform. The only possible claim that countersinking by centerpunching can possess is the saving of the time required to place the square center in the lathe; for after it is once placed there, the operation may be as quickly performed in the one case as in the other.

Countersinking by the square center is performed by making the square center the running center of the lathe, and by feeding the work up to it by the back lathe center, as described in the instructions upon centerdrilling.