into existence since the marbles have reposed in the depths of the sea. Seventy-three years ago, the diver's dress and the vulcanized rubber of which it is made were unknown, and the works of ancient art have had to remain in their watery prison until, in the progress of inventive skill, means have developed themselves, by which their liberation, once presenting insurmountable difficulties, is now rendered a comparatively easy proceeding. Lord Elgin gained possession of the marbles through a firman of Sultan Selim III. Greece was then but a province of Turkey; the battle of Navarino had not been fought; and before achieving its independence, the country for many years after remained under the rule of the Turk, who at his pleasure bestowed upon foreigners the relics which, by modern Athenian archæologists, are deemed of priceless value.

Mineral Wool.

The utilization of blast furnace slag recently discovered bids fair to be of some importance. It is stated that if a jet of steam be injected into a current of fluid scoriæ, fine, supple, and elastic filaments are obtained. With certain slags these are of a brilliant white and resemble cotton thread. The material is remarkable for its non-conductibility of heat, and hence may be profitably used for covering boilers and for other purposes in which it is desirable to prevent radiation.

PRACTICAL MECHANISM.

BY JOSHUA ROSE.

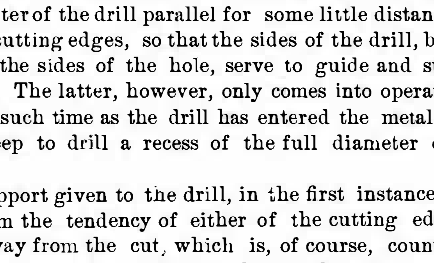
NUMBER XXVII.

DRILLS AND DRILLING.—FLAT DRILLS.

A drill is, all things considered, the most effective tool employed by the machinist; for while its cutting edges are necessarily of decidedly undesirable angles and form, it sustains the very roughest of usage, and yet will bear more strain in proportion to its strength than any other cutting tool. The reason of this is that it is supported by the metal upon which it is operating, and is thus prevented from springing away from its duty. This support may be of two kinds, first, that due to the wedge shape of the main cutting edges, one to the other, and second, that to be derived from making the diameter of the drill parallel for some little distance behind the cutting edges, so that the sides of the drill, by contact with the sides of the hole, serve to guide and support the drill. The latter, however, only comes into operation at and after such time as the drill has entered the metal sufficiently deep to drill a recess of the full diameter of the drill.

The support given to the drill, in the first instance cited, arises from the tendency of either of the cutting edges to spring away from the cut, which is, of course, counterbalanced by the opposite cutting edge having the same tendency, but in an opposite direction, so that between the two the drill is held to a central position; and also from the tendency of the drill point to force itself forward (by reason of the pressure behind it) as far into the cone formed by the end of the hole as possible, as the end of the hole and the cutting end of the drill are two cones, one being forced into the other. In a drill properly ground (that is, having its cutting edges at an equal angle to the center line of the length of the drill, and the cutting edges of an equal length from the center or point of junction of the cutting edges) both the cutting edges and the sides of the drill act as supports and guides, tending to sustain it under the strain and keep it true. If, however, the drill is not ground true, the strain upon it becomes very great, because the whole force of the cut is then placed upon one cutting edge only, and is continuously tending to thrust the point of the drill outwards from the center of the hole being drilled, hence cutting a hole larger in diameter than the cutting part of the drill, that is to say, a hole whose diameter will be twice that of the radius of the longest cutting edge of the drill, measured from the center line of the length of the drill. If, under such conditions, one side of the drill bears against the sides of the hole, as shown in Fig. 98, A being the metal and B the drill, there will be

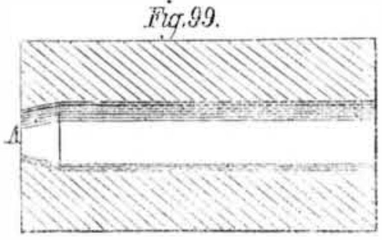
Fig. 98.



created two opposing forces, independent of the strain necessary to sever the metal, one being the endeavor of the point of the drill to keep to the center of the hole, because of the conical shape of the end of the hole and point of the drill, and the other being the endeavor of the cutting edge to force the drill to one side and the point of the drill out of the center of the hole. And as the pressure of the side of the drill against the side of the hole will tend to force the drill to revolve true with that side of the drill so that the point of the drill will revolve in a circle and not upon its own axis the result will be a hole, neither round, straight, nor of any definite diameter, as compared to the diameter of the drill.

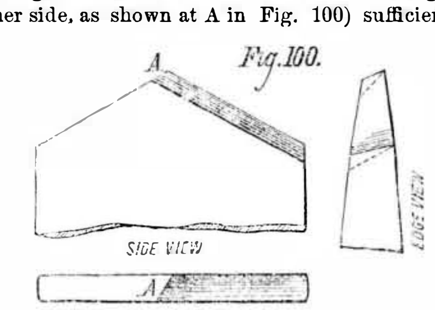
Drills that are a trifle too small for the required size are sometimes purposely ground a little out of true so as to cause the hole to be larger than the drill, but the action of such drills is distorted, and it is impossible to estimate exactly how much deviation is necessary to the required increase of diameter of the hole. Part of the power driving the drill is lost, the loss being due to the creation of the above opposin forces, and the drilling operation is slow by reason of onl one edge of the drill performing any cutting. Hence, th feed of the drill being only half as rapid as it should be, it i an unmechanical expedient and a loss of time, especially i the hole is to be drilled clear through the metal: for in that case, as soon as the point of the drill emerges through the metal and the drill is therefore released from its influence, the cutting edges will gradually adjust themselves to the hole, and drill the remainder of the hole to the size of the diameter of the drill, the hole when finished appearing as in Fig. 99. Thus the end, A, of the hole will require to be filed out, entailing in all more loss of time than would be required to make a drill of the proper diameter.

Fig. 99.



The importance, then, of taking especial pains to grind a drill true being apparent, we may next consider how thick the point of the drill should be. It is here that the main defect of the drill as a cutting tool lies, for it is impossible to make the cutting edge across the center of the drill (that is, the cutting edge across the thickness of the drill, connecting the cutting edge on one side of the drill to the cutting edge of the other side, as shown at A in Fig. 100) sufficiently keen

Fig. 100.



to enable it to enter the metal easily, without grinding the angles of the two cutting edges very acute, as shown, in the edge view of Fig. 100, by the dotted lines, which would so weaken the cutting edges as to cause them to break from the pressure of even the lightest feeding. The only alternative, then, is to make the point of the drill as thin as is compatible with sufficient strength; and this will be found to be of about the following proportion:

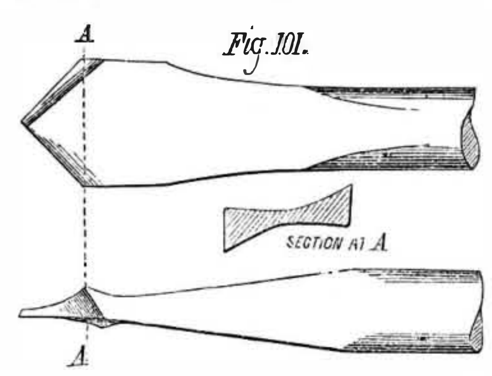
Diameter of drill	Thickness at point
1-8 inch	1-64 inch
1-4 "	1-32 "
3-8 "	3-64 "
1-2 "	1-16 "
5-8 "	1-16 "
3-4 "	1-16 "
7-8 "	1-16 "
1 "	3-32 "

The flat face must be made gradually thicker as the full diameter of the drill is reached.

The angle at which to grind the end of the drill is governed to a large extent by the kind and degree of hardness of the metal to be drilled, the angle shown in Fig. 100 being suitable for wrought iron, steel, or unusually hard cast iron; while, for common cast iron or brass, a little more angle may be given. But no definite angle can be given for any metal, because of the varying conditions under which a drill performs its duty. From these considerations we find that the effectiveness of a drill arises from the support rendered to it by the work, which more than compensates for the want of keenness inherent to its form of cutting edge.

Thus far, however, we have been considering the ordinary flat drill in its most simple form. For use on steel, wrought iron, and cast iron, we may improve the cutting qualifications of the drill by bending each side of the cutting bevel edges forward, thus forming what is termed a lip drill, as shown in Fig. 101. Such a drill will cut with much greater ease and rapidity, because the angle, of the two faces whose

Fig. 101.

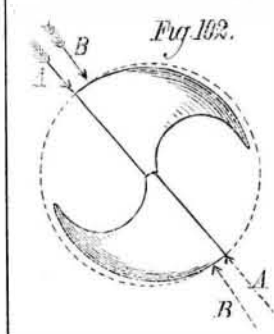


junction forms a cutting edge, is much more acute, while the cutting edge is, at the same time, well supported by the metal behind it, which advantages are to be obtained in no other way. The cutting edges of this drill are similar to those on the twist drill.

TWIST DRILLS.

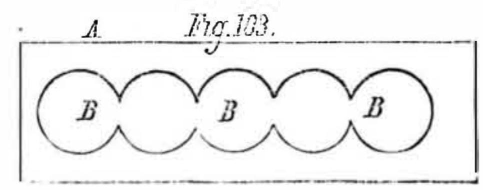
Twist drills are not, as is usually supposed, of the same diameter from end to end of the twist, but are slightly taper, diminishing towards the shank end. The taper is usually, however, so slight as to be of little consequence in actual practice. Neither are twist drills round, the diameter being eased away from a short distance behind the advance or cutting edge of the flute backward to the next flute, so that, were we to grind the cutting end square or level, instead of conical, it would appear as in Fig. 102.

Fig. 102.



The object of this is to give the sides of the drill as much clearance as possible. The part of the diameter from A to B, on each side, is left of a full circle, which maintains the diameter of the drill and steadies it in the hole. If, from excessive duty, that part from A to B should wear away at the cutting end of the drill, leaving the corner of the drill rounded, the drill must be ground sufficiently to cut away entirely the worn part, otherwise it will totally impair the value of the drill, causing it to grind against the metal, and no amount of pressure will cause it to cut. The advantage, over other drills, possessed by twist drills lies first in that the cuttings can find free egress, which effects a great saving of time, for plain drills have to be frequently withdrawn from the hole to extract the cuttings, which would jam between the sides of the hole and the sides of the drill, and the pressure will frequently become so great as to twist or break the shank of the drill, especially in small holes. In point of fact, the advent of twist drills has rendered the employment of any other form for use in small holes (that is to say, from ⅜ inch downwards) totally inexcusable, except it be for metal so hard as to require a drill tempered to suit the work. The other advantages of the twist drill are that it always runs true, requires no reforging or tempering, and, by reason of its shape, fits closely to the hole, and hence drills a very straight and smooth hole. It is also not liable to be influenced so much by an air or other hole or soft spot which may exist in the metal being drilled. These qualifications render the twist drill a very superior tool for the finer classes of work, and for such purposes as drilling metal away to form a key way or slot; for in the latter case, the holes may be drilled so closely together that they will run one into the other, as shown in Fig. 103, A being the piece of metal, and B B, the holes. A com

Fig. 103.



mon flat drill is incapable of performing such work. The twist drill will not, however (in holes of a moderate depth, that is to say, holes whose depth is not more than four times their diameter), do so much duty in a given time as a common drill, especially if, in iron or steel, the latter be slightly lipped: the reason being that the latter, stronger in proportion to its diameter, will stand more strain, and may therefore be fed much more rapidly in all cases wherein the depth is not too great to permit the cuttings from finding egress before becoming jammed in the hole.

FEEDING DRILLS.

Much more duty may be obtained from a drill by feeding it by hand than by permitting the gearing of the machine to feed it, because, in hand feeding, the sense of feeling indicates to the operator how much cut the drill is capable of standing, and he can therefore vary the rate of feed, keeping it up to the maximum obtainable on the degree of hardness of the metal being drilled. Dullness of the cutting edges, hard or soft spots in the metal, or any other variation in the condition of the drill or in the metal being drilled, is at once perceived by hand feeding. Drilling machines have, it is true, several degrees of feed, but the fact is that the human hand can feed the drill at any rate that can be obtained by means of machine gearing; and having behind it the human mind, it is enabled to accommodate itself to the numerous and variable conditions against which no provision can be made in automatic feed gearing. No positive rate of feed, either for any particular size of drill, or for any definite kind of metal, can be given, because of the always present variations in the degree of hardness of the metal to be cut, and furthermore because, in the case of iron and steel, the facility of supplying the cutting edges with oil seriously affects the attainable rate of feed to the drill. If, for instance, the hole is being drilled horizontally, as in a lathe, and is very deep, so that it is difficult to freely supply the cutting end of the drill with oil, the feeding must proceed slowly or the cutting edges of the drill will soon become destroyed. Here, also, it may be well to state that, if oil be supplied to a drill cutting cast iron or brass, it will cause the cuttings to jam between the sides of the drill and the sides of the hole, until the pressure becomes so great as to either stop the drilling machine or lathe, or else twist or break the drill. The rate of feed, and the speed at which the drill should revolve, depend upon the hardness of the metal under operation, although not to a very great extent, except in the event of the metal being unusually hard, in which case the drill should revolve very slowly; for not much latitude in the degree of hardness of the drill is permissible, for fear of impairing the strength of the drill.

TO FIX labels on tin, use French polish or a solution of shellac in naphtha or alcohol.