Chapter XXIII.—EMERY WHEELS AND GRINDING MACHINERY.

Emery Wheels and Grinding.—Emery grinding operations may be divided into four classes as follow :—

1st. Tool or cutter grinding, in which the emery wheel is used to sharpen tools which, from their shape, were formerly softened and sharpened by the file, already largely treated in the preceding chapter.

2nd. Cylindrical grinding, in which both the work and the emery wheel are revolved, as has been explained with reference to grinding-lathes.

3rd. Flat surface grinding, in which the emery wheel takes the place of the ordinary steel cutting tool ; and

4th. Surface grinding, in which the object is to remove metal or to smoothen surfaces.

The distinctive feature of the various makes of solid emery wheels lies in the material used to cement the emery together, and much thought and experiment are now directed to the end of discovering some cementing substance which will completely meet all the requisite qualifications. Such a material must bind the emery together with sufficient strength to withstand the centrifugal force due to the high speeds at which these wheels must be run to work economically ; and it must neither soften by heat nor become brittle by cold. It must not be so hard as to project above the surface of the wheel ; or in other words, it should wear away about as fast as does the emery. It must be capable of being mixed uniformly throughout the emery, so that the wheel may be uniform in strength, texture, and density. It must be of a nature that will not spread over the surface of the emery, or combine with the cuttings and form a glaze on the wheel, which will prevent it from cutting. This glazing is, in fact, one of the most serious difficulties to be encountered in the use of emery wheels for grinding purposes, while it is a requisite for polishing uses, as will be explained farther on. Many of the experiments to prevent glazing have been in the direction of discovering a cement which would wear away under about the same amount of duty as is necessary to wear away the cutting angles of the grains of emery, thus allowing the emery to become detached from the wheel, rather than to remain upon it in a glazed condition.

With the same grade of emery the wheel will cut more freely and glaze less in proportion as the cementing material leaves the wheel softer, but the softer the wheel the more rapidly it will wear away ; indeed it is the dislodgement of the emery points as soon as they have become dulled that produces freedom from glazing. It may be remarked, however, that the nature of the material operated upon has a good deal to do with the glazing ; thus wrought iron will glaze a wheel more quickly than hardened steel, and brass more quickly than wrought iron, while on the other hand soft cast iron has less tendency than either of them to glaze. Glazing occurs more readily in all cases upon fine than upon coarse wheels. Glazing is more apt to occur as the work is pressed more firmly to the wheel, and with broad and flat surfaces rather than with cylindrical ones. An excellent material for removing the glaze from an emery wheel is a piece of ordinary pumice stone.

The principal cements used in the manufacture of emery wheels are as follows, each representing the cement for one make of wheel :—

1. Hard rubber. 2. Chemical charcoal (leather cut down by acid and used to prevent shrinkage), and glue. 3. Oxychloride of zinc. 4. Shellac. 5. Linseed oil and litharge. 6. Silicate of soda and chloride of calcium. 7. Celluloid. 8. Oxychloride of magnesium. 9. Infusoria. 10. Ordinary glue.

The vitrified emery wheel is made with a cement which contracts slightly while cooling, leaving small pores or cells through which water, introduced at the centre, is thrown (by centrifugal force) to the surface. This causes, when the wheel is rotating, a constant flow of water from the centre to the surface, carrying off the cuttings and the detached emery.

In order that an emery wheel shall run true with its bore it must fit the driving spindle, and in order that it may do this closely the wheel bore is sometimes filled with lead, the latter being bored out to fit the spindle. If the bore of the emery wheel itself were made a tight fit to the spindle it would abrade the spindle in being put on, and the pressure of the fit if any would tend to split the wheel. A common method of securing emery wheels to their spindles is to fill the bore of the wheel with lead, and bore it out to fit the spindle of the emery grinding machine. The flanges between which the wheel is held are recessed so as to grip the wheel at and near their perimeters only. Between the flange and the wheel a thin disk of sheet-rubber is sometimes used to afford a good bedding for the flange.

The forms of the perimeters of emery wheels are conformed to suit the form of the work to be ground, and it is found that from the great strength of the emery wheel it can be used to a degree of thinness that cannot be approached in any kind of grinding stone. For instance, vulcanite emery wheels 18 inches in diameter and having $\frac{3}{16}$ inch thickness, or face as it is commonly termed, are not unfrequently used at a speed of some 5,000 feet of circumferential feet per minute, whereas it would be altogether impracticable to use a grindstone of such size and shape, because the side pressure would break it, no matter at what speed it were run. Indeed, in the superior strength of the emery wheels of the smaller sizes lies their main advantage, because they can be made to suit narrow curvatures, sweeps, recesses, &c., and run at any requisite speed under 5,000 feet per minute, and with considerable pressure upon either their circumferential or radial faces.

Grades of Coarseness or Fineness of Emery Wheels.—Emery is found in the form of rock, and is crushed into the various grades of fineness. The crushing is done either between rollers or by means of stamps, the latter, however, leaves the corners of the grains the sharpest, and hence the best for cutting, though not for polishing purposes. The grades of emery are determined by passing the crushed rock through sieves or wire cloths having from eight to ninety wires to the inch ; thus, emery that will pass through a sieve of sixty wires to the inch is called No. 60 grade.

The finest grade obtained from the manufactory is that which floats in the atmosphere of the stamping room, and is deposited on the beams and shelves, from where it is occasionally collected. Washed emery is used by plate-glass workers, opticians, and others that require a greater degree of fineness than can be obtained by the sieve.

The numbers representing the grades of emery run from 8 to 120, and the degree of smoothness of surface they leave may be compared to that left by files as follows :

8 and 10	represent the cut of a	wood rasp	
16 ,, 20	,, ,,	coarse rough file	
24 ,, 30	,, ,,	ordinary rough file	
36 ,, 40	,, ,,	bastard	,,
46 ,, 60	,, ,,	second cut	,,
70 ,, 80	,, ,,	smooth	,,
90 ,, 100	,, ,,	superfine	,,
120, F & FF	,, ,,	dead smooth	,,

The F and FF emery is flour emery which has been washed to purify it.

The following are the kinds of wheel suitable for the respective purposes named :—

Kind of work.	Kind of wheel.
For rough grinding, such as on the edges of iron or steel plates, for removing the protuberances on castings or on narrow surfaces where rough grinding is sufficient	Coarse grain and hard texture.
For narrow surfaces, such as moulding knives, lathe tools, saw gumming, &c.	Medium grain and hard texture.
For free cutting without gumming on broad surfaces on iron, steel, or brass.	Medium grain and soft texture.
For grinding fine tools, such as milling machine cutters, or for work in which the duty is not great while the wheel requires to keep its shape and keep true.	Fine grain and soft texture.
For smooth grinding on soft metals, as cast iron and brass.	Fine grain and hard texture.

When the work is presented to the wheel unguided, the wheel wears out of true, because the work can follow the wheel, hence it becomes necessary to true the wheel occasionally. This can be done by a tool such as in Fig. 2014, which is applied by hand on the hand rest, and corresponds to the tool shown in Fig. 2061 for grindstones, or by the use of a diamond set in a tool to be held by hand or in a slide rest. The diamond produces the most true

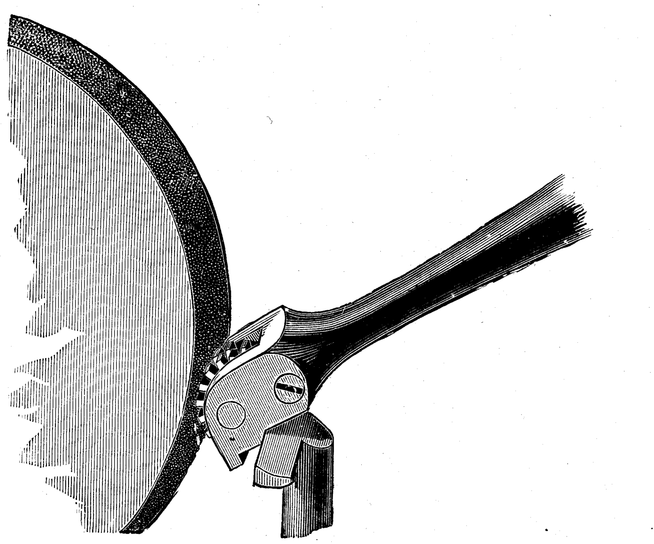


Fig. 2014.

and smooth work, but the cut of the wheel is at first impaired by the action of the diamond, which is not the case with the tool in Fig. 2014.

Corundum is a mineral similar to emery, and corundum wheels are made and used in the same manner as emery wheels. Their cutting qualifications are, however, superior to those of the emery wheel, both cutting more freely and being more durable with less liability to glaze.

Speeds for Emery Wheels.—The speed at which an emery wheel may be run without danger of bursting varies according to the thickness or breadth of face of the wheel, as well as according to the quality of the cementing material and excellence of manufacture. Hence, although a majority of manufacturers recommend a speed of about 5,000 circumferential feet per minute, that speed may be largely exceeded in some cases, while it would be positively dangerous in others. It is, in fact, impracticable in the operations of the workshop to maintain a stated circumferential speed, because that would entail a constant increase of revolutions to compensate for the wear in the diameter of the wheel. Suppose, for example, that a wheel when new is a foot in diameter: a speed of about 1,600 revolutions per minute would equal about 5,000 circumferential feet; whereas, when worn down to 2 inches in diameter, the revolutions would require, to maintain the same circumferential speed, to be about 9,500 per minute, entailing so many changes of pulleys and counter-shafting as to be impracticable. In practice, therefore, a uniform circumferential speed does not exist, the usual plan adopted being to run the large-sized wheels, when new, at about the speed recommended by the manufacturer of the kind of wheel used, and to make such changes in the speed of the wheel during wear as can be accomplished by changing the belt upon a three-stepped cone pulley, and perhaps one, or at most two, changes of pulley upon the counter-shaft. It is sometimes practicable to use wheels of a certain diameter upon machines speeded to suit that diameter, and to transfer them to faster speeded machines as they diminish in diameter. Even by this plan, however, only an approximation to a uniform speed can in most cases be obtained, because as a rule certain machines are adapted to certain work, and the breadth of face and form of the edge of the emery wheel are very often made to suit that particular work. Furthermore, a new wheel is generally purchased of such a size, form, and grade of emery as are demanded by the work it is intended at first to perform. Neither is it, as a rule, practicable to transfer the work with the diametrically reduced wheel to the lighter and faster-speeded grinding machine. So that, while it is desirable to run all emery wheels as fast as their composition will with safety admit, yet there are practical objections to running small wheels at a rate of speed sufficient to make their circumferential velocities equal to those of large wheels. The speeds recommended for the various kinds of wheels now in use vary from about 2,700 to 5,600 circumferential feet per minute; but the speeds obtaining in workshops average between 2,000 and 4 000 feet for wheels 3 inches and less in diameter, and from about 3,000 to 5,600 feet for wheels above 12 inches in diameter. Wheels above 15 inches in diameter, and of ample breadth of face, are not unfrequently run at much greater velocities.

On account of the high velocity at which emery wheels operate, it is necessary that they be very accurately balanced, otherwise the unequal centrifugal motion causes them to vibrate very rapidly, every vibration leaving its mark upon the work.

The method of balancing adopted by one firm is as follows: The arbors are of cast iron, and are cast standing vertical so as to induce equal density in the metal, it having been found that if the arbors were cast horizontally the lower part of the metal would from the weight of the molten metal be more dense than that at the top of the casting. In casting the arbors upright, the difference in the density of metal simply causes one end of the arbor to be more dense than the other, and the difference being at a right angle to the plane of revolution has no tendency to cause vibration. The driving pulleys are cast horizontal to obtain equal density, and after being turned are carefully balanced. The driving pulleys are held to the arbors by being bored a driving fit, and are driven on so as to avoid the use of keys, which would throw the wheels out of balance.

The centrepiece and flange to hold the wheel to the arbor are turned and balanced. The nut to hold the wheel is a round one, which is easier to balance than a hexagon nut. After the centrepiece is put on the arbor, the whole is tried for balance, and corrected if necessary. The pulley is then put on and the whole

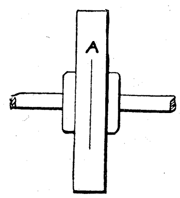


Fig. 2015.

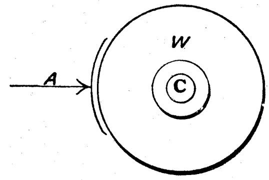


Fig. 2016.

is again balanced, and so on, the arbor being balanced after each piece is added, so that while each piece is balanced of itself the whole is balanced after the addition of each separate piece.

The emery or corundum wheel is then put on the arbor and tried for being in balance. The method of correcting the balance of the wheel is as follows: The arbor with the wheel on is placed in the lathe, the wheel turned true with a diamond tool (the wheel revolving at a comparatively slow speed). The arbor is then revolved at its proper speed (5,000 circumferential feet per minute), and a point applied to just meet the circumference will touch the wheel where it is heaviest, leaving a line as shown in Fig. 2015 at A. The centre of the arbor is then moved over towards this line as shown in Fig. 2016, in which W is the wheel, the location of the line A (marked as above) being as denoted by the arc A, and C represents the arbor whose centre is moved over towards the arc A. When therefore the arbor is again put in the lathe, it will run out of true by reason of the centre at one end having been altered. A cut is taken down that radial face of the wheel which faces the end of the arbor that has had its centre moved so that the wheel is turned thinner where the mark (A, Fig. 2016) is. The amount of cut to be taken off is a matter of judgment and trial, since it must be just sufficient to compensate for the greater density of the wheel on that side. This greater density, be it noted, occurs from the difficulty in mixing the corundum or other abrasive grains with the cementing material with entire uniformity throughout the mass.

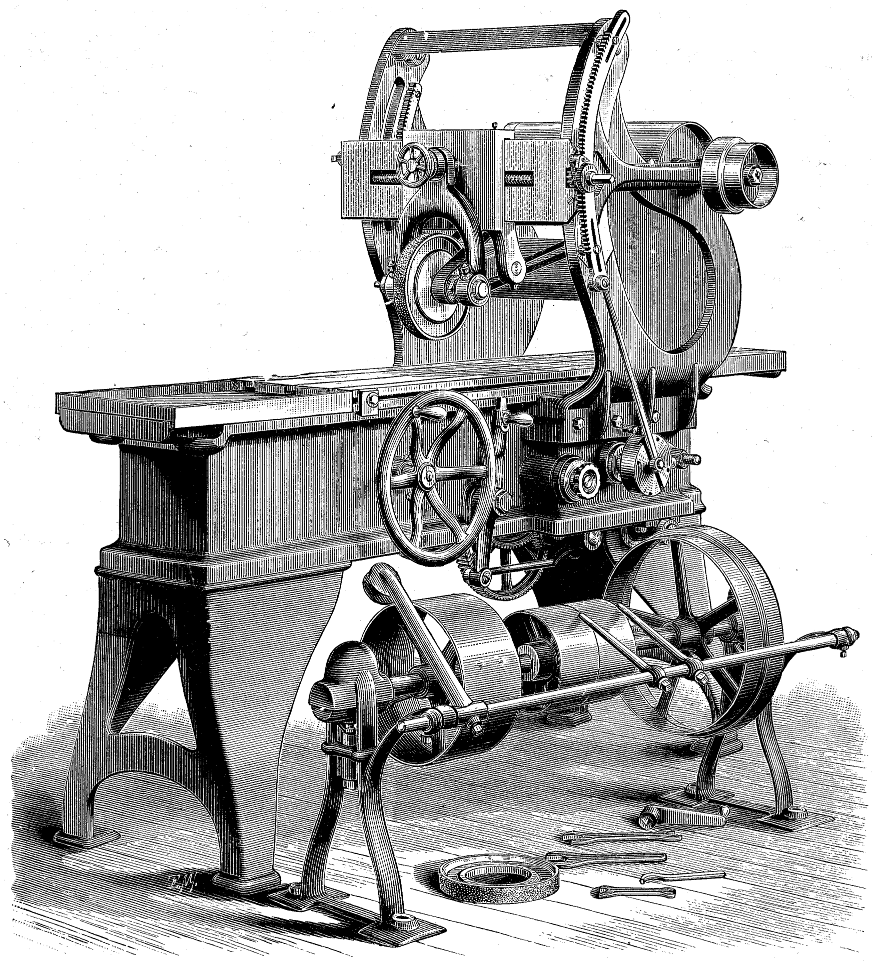


Fig. 2017.

By this method of balancing, the wheel will remain in true balance notwithstanding its wear, because the balancing proceeds equally from the perimeter towards the centre of the wheel.

Emery Grinding Machines. (For grinding-lathes and roll grinding, see article on Lathes.)—Fig. 2017 represents Brown & Sharpe's grinding machine. The bed, the table, and the cross-feed motion of this machine closely resemble those of the planing machine, but its work is far more smoothly and accurately done than can be performed in a planing machine. The table traverses to and fro, accurately guided in ways, and the revolving emery wheel takes the place of the ordinary cutting tool, being carried in a sliding head upon a cross slide or cross bar. The drum for driving the emery wheel is at the back of the machine, as shown in the cut.

The vertical feed motion for adjusting the depth of cut of the emery wheel is capable of very minute adjustment, thus avoiding a difficulty commonly experienced in iron planing machines on account of the coarseness of feed-screw pitch, which coarseness is necessary to insure their durability. The means by which this capability of minute adjustment is effected is shown in Fig. 2018, in which D is the cross head of the machine and C the sliding head having the arm C′, which provides at B a pivot for the wheel-carrying arm A. F is a stud fast in C and carrying E, which forms the nut for the feed screw. Outside this nut is the spiral spring S, whose force steadies the upper end of A.

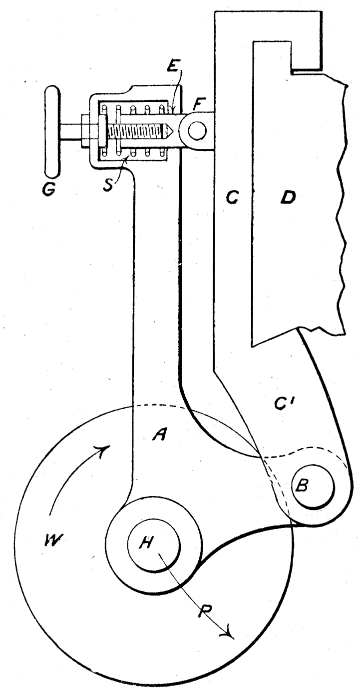


Fig. 2018.

Now suppose the feed wheel G be operated a full rotation, and the motion of that end of A will be that due to the pitch of the feed screw, but the motion at the centre H of the emery wheel will be the pitch of the screw divided by the difference between

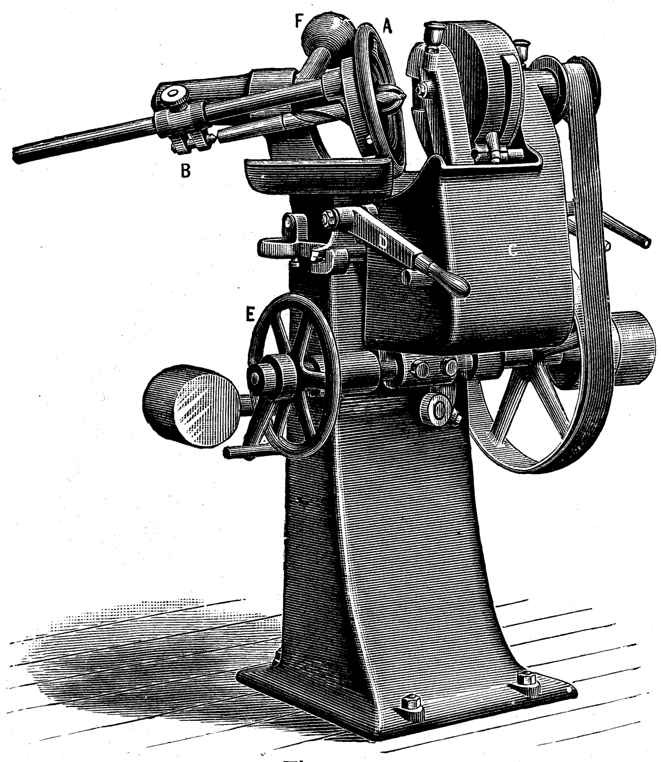


Fig. 2019.

the length from the centre of H to the centre of the feed screw, and that from the centre of H to the centre of B. But even this enable the raising and lowering of the cross slide, and maintain a uniform tension on the belt driving the emery wheel without employing an idler wheel or belt tightener.

Fig. 2019 represents Wm. Sellers & Co.'s drill-grinding machine, in which the drill is held in a chuck operated by the hand wheel A. The jaws of the chuck grip the drill at the outer corners of the cutting edge as shown in Fig. 2020, and so as to grind the point of the drill central to those corners. In order to give to the cutting edges a suitable degree of clearance in their lengths, and to allow for the difference in thickness at their points between large and small drills, the following construction is employed.

Fig. 2020 represents the jaws J J holding on the left a small, and on the right a large drill. The line of motion of the right-hand jaw in opening and closing to grip the drill is along the line *r*, while that of the left-hand is along the line *p p*, the centre upon which the chuck is revolved to grind the drill being denoted by the small circle at S. *x'* represents the centre line of the large drill when held in the chuck, and it is seen that the action of the jaws in closing upon small drills is to lift the drill point closer to the centre S upon which the chuck revolves (the cutting edge being ground to be on the line *y' y'*). The reason for this peculiar and simple but exceedingly ingenious construction is, as before remarked, to maintain the cutting edge in its proper relation to the thickness of the drill point (which thickness varies in different diameters of drills), and to maintain a proper degree of clearance at every point along the length of the cutting edge. In other drill grinding machines the drill when rotated to grind the clearance is moved on the axis A A in Fig. 2022 as a centre of motion, and as this line is parallel to the face of the emery wheel it follows that if the drill were given a full revolution its circumference would be ground to a cylinder as shown in Fig. 2021 by the dotted lines.

In this machine the drill is rocked on the line B, Fig. 2023, as a centre of motion, this line corresponding to the axis of the shaft of lever F in Fig. 2019 upon which the chuck swings, and

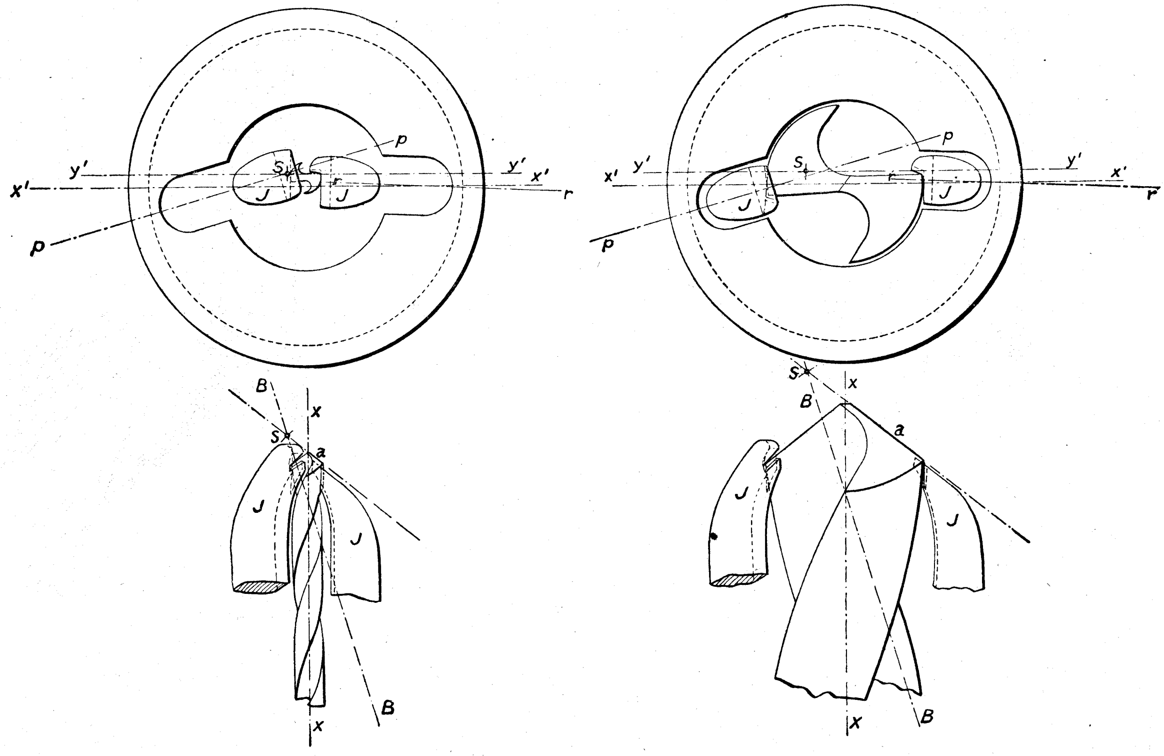


Fig. 2020.

diminished motion at H is still further reduced, so far as the depth of cut put on is concerned, because the motion of H is not directly vertical, but an arc P, of which B is the centre.

The standards carrying the cross slide are segments of a circle struck from the centre of the driving drum, which is necessary to

to the line B in Fig. 2024. As a result the surface is ground to the form of a cone as denoted by the dotted lines in Fig. 2024. The results of the two systems are shown in Figs. 2025 and 2026, which represent the conical holes made by a drill.

In Fig. 2025 a cylinder R is shown lying in a conical recess, and end views of the cylinder are shown at V and W. Now suppose the line of contact of the roll or cylinder upon the recess represents the cutting edge of the drill, and that we consider the clearance at the outer end, and at that part that in revolving would describe the circle Q, and on referring to circle V and the outer circle of the recess, and also to circles W and Q, it is seen that there is more clearance for V than there is for W, and that

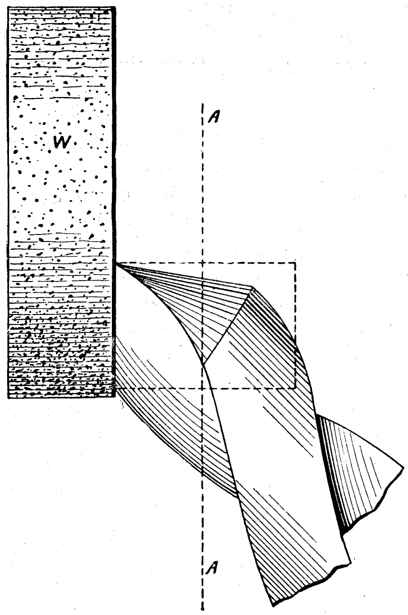


Fig. 2021.

the clearance of the latter would be still less if Q were of smaller diameter, and it follows that the clearance is less in proportion as the point of the drill is approached. In determining the amount of clearance, therefore, we are compelled to make it sufficient for the point of the drill, and this under this system of grinding is excessive for the outer diameter of the drill, causing

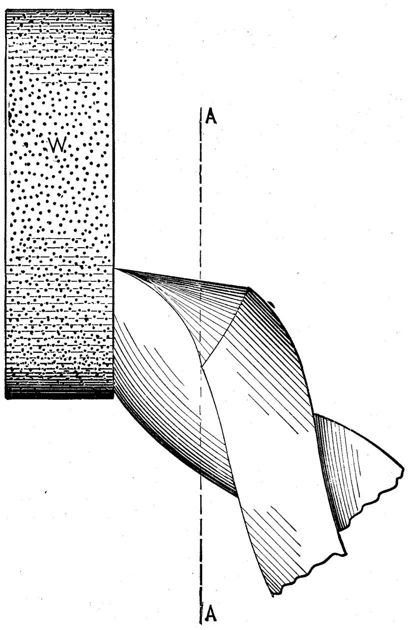


Fig. 2022.

it to dull quickly, it being borne in mind that as the outer corner of the cutting edge of a drill describes the largest circle of any point of the cutting edge it obviously performs the most cutting duty in removing metal, and furthermore revolves at the highest rate of cutting speed, both of which cause it to dull the most rapidly. In Fig. 2026 we have a cone R lying in the coned recess, an end view of the cone being shown at V and W, and if we again consider the line of contact of the cone on the recess to represent the cutting edge and the circumferential surface of the cone as the end surface of the drill, we observe in the end views V and W that the clearance is equal for the two positions, or by

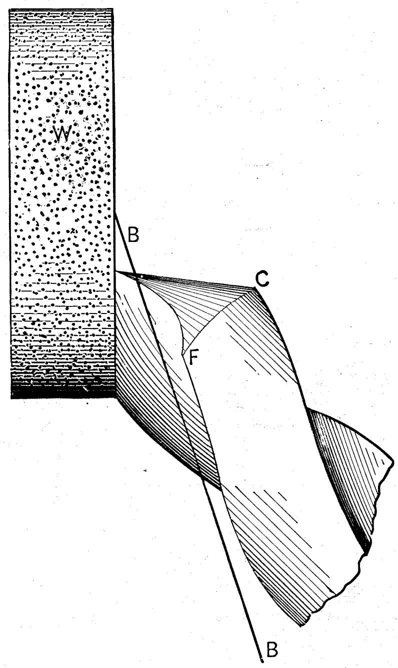


Fig. 2023.

varying the degree of taper of the cone we may regulate the amount of clearance at will. It is found preferable, however, to give more clearance as the point of the drill is approached so as to increase the cutting capacity; hence, in this case, the outer corner of the drill has the least clearance, which greatly increases its endurance for the reasons already mentioned, and which were further pointed out in the remarks upon drilling in the lathe. There remains, however, an additional advantage in this method of grinding which may be pointed out, inasmuch as that the clear-

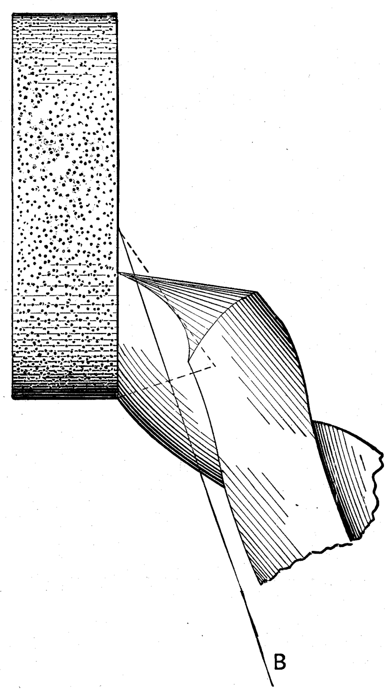
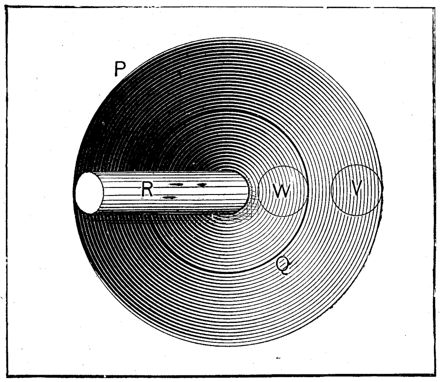


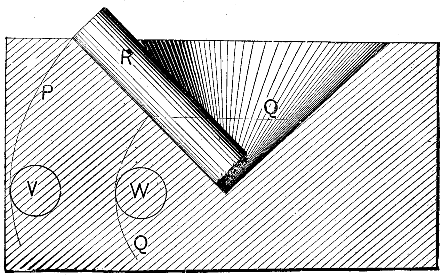
Fig. 2024.

ance produced by the method shown in Fig. 2019, while capable of being governed from end to end of the cutting edge, yet increases as the heel of the *land* is approached, making the central cutting edge (C, Fig. 2028) more curved in its length so that it approaches the form of cutting edge of the fiddle drill and this enhances its cutting capability.

Referring again to the general view of the machine in Fig. 2019, the chuck is supported or carried by the shaft having the ball lever F, which is clearly seen in the rear view, Fig. 2027, and the rod carrying the sleeve B (which holds the centre for supporting the shank end of the drill) is secured to the back of the chuck, as seen in the same figure. When, therefore, lever F is moved over, the drill is moved through an arc of a circle of which the axis of the shaft of F is the centre, and this it is that gives clearance to the cutting edge of the drill.



Top View.



Section.

Fig. 2025.

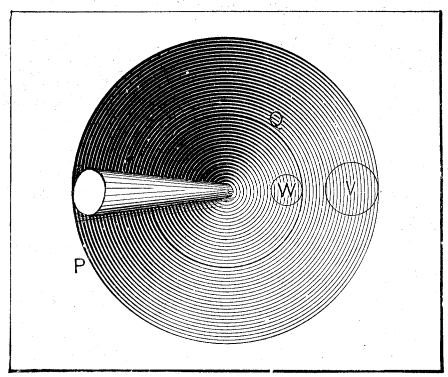
The drill being chucked, the emery wheel is brought up to it by means of the hand wheel E, which moves the frame C laterally, the grinding being done by the side face of the emery wheel. On the same shaft as E is a lever which may be used in connection with the stop or pin (against which it is shown lying) to enable an adjustment of the depth of cut taken by the wheel separately when grinding each lip, and yet to permit both cutting edges of the drill to be gauged to the same length.

Suppose, for example, that the point of a drill has been broken so that it requires several cuts or traverses of the emery wheel to bring it up to a point again; then when this has been done on one cutting edge the lever may be set to the stop, so that when the grinding of the second cutting edge has proceeded until the lever meets the stop both edges will be known to be ground of the same length, and will, therefore, perform equal cutting duty when at work.

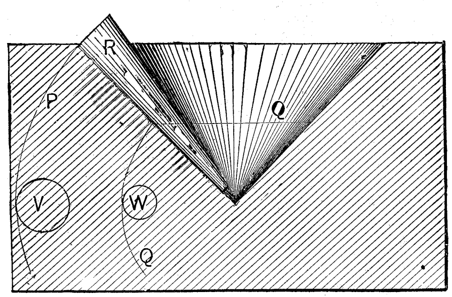
The depth of cut being adjusted, the lever D is operated to pass the side face of the emery wheel back and forth along the cutting edge of the drill, this lever rocking the frame C on which the emery wheel is mounted back and forth in a line parallel to the cutting edge of the drill. Different angles of one cutting edge of the drill to the other are obtained by swivelling the frame carrying the shaft of lever F. The emery wheel is cased in except at a small opening where it operates upon the drill, and may, therefore, be liberally supplied with water without the latter splashing over. Water is continuously supplied to the emery wheel by an endless belt pump, which also delivers water on the end of the drill, enabling heavy grinding cuts to be taken without danger of softening the drill at the cutting edge, which is otherwise apt to occur. The following is the method of operating the machine: Open the jaws of the chuck by means of the hand wheel A, insert the drill from the back of the chuck towards the face of the stone, letting the end of the drill rest on the lower jaw, with the cutting edge just touching the end stop; close the jaws temporarily, while the back centre B is run up and clamped; then release the jaws, hold the drill back against the back centre B with the left hand, at the same time rotating hard against the two side stops on the jaws; then tightly closing the jaws, clamp the drill by means of the hand wheel A, using the right hand for this purpose. Throw ball-handle F part way back, and by means of hand wheel E feed up the stone until it just touches the drill. Bring ball-handle F forward and give additional feed; pass the stone over the face of the drill, back and forth, by lever D, moving ball-handle F back a little between each two cuts. This slices off the stock to be removed; then when entirely over the face of the lip being ground, hold lever D stationary, and rotate the drill against the stone by means of ball-handle F. By this means a heavy slicing cut can be taken and a final smooth finish obtained without any risk of drawing the temper of the drill.

When one lip has been thus formed, slack up the jaws of the chuck, turn the drill half around, pressing its lips as before against the side stops on jaws, and at the same time be sure to hold the drill firmly back against the back centre B (pay no attention to the end stop, which is only used in locating the drill endways in the first setting), tighten chuck, and grind the second lip without any readjustment of the stone. The lips will then be of equal length. During all these manipulations the stop that is arranged in connection with hand wheel E can be slack, and may rest against the pin in the bed made to receive it.

Fig. 2027 represents a rear view of the machine, at which there is an attachment for thinning the point of the drill, which is advantageous for the following reasons. In Fig. 2028 we have a side and an end view of a twist drill, and it can be shown that the angular piece of cutting edge C that connects the two edges A and B cannot be given sufficient angle to make it efficient as a cutting edge without giving clearance and angle excessive to the edges A and B.



Top View.



Section.

Fig. 2026.

In Fig. 2029 we may consider the angle of the cutting edge at the corner H and at the points F and G. First, then, it is obvious that the front face for the point H is represented by the line H *h*, that for F by line F *f*, and that for G by G *g*, and it appears that on account of the spiral of the flute the front face has less angle to the drill axis as the point of the drill is approached.

Considering the end of the drill, therefore, as a cutting wedge, and considering the cutting edge at the two points C and E, in Fig. 2030, the end face being at the same angle, we see that the point C has the angle A and point E the angle B; at the drill point there will be still less cutting angle, and it has, therefore, the least

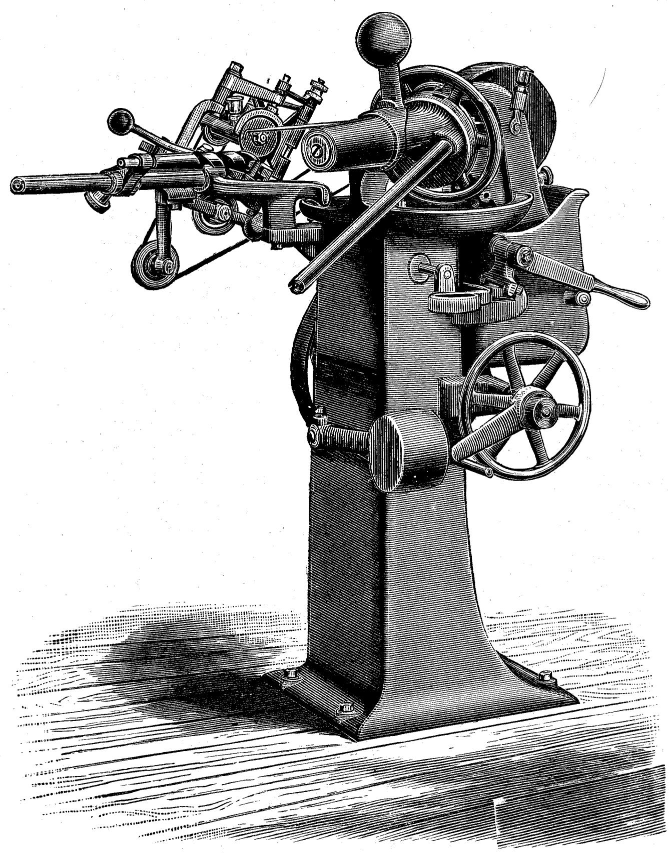


Fig. 2027.

cutting capacity. To remedy this the attachment shown in the figure is employed, consisting of a frame or head carrying a thin emery wheel, and capable of adjustment to any angle to suit the degree of spiral of the drill flute.

By means of this emery wheel a groove is cut in the flute at the point of the drill, as shown in Fig. 2031, at A and B, thus reducing the length of C, and therefore increasing the cutting

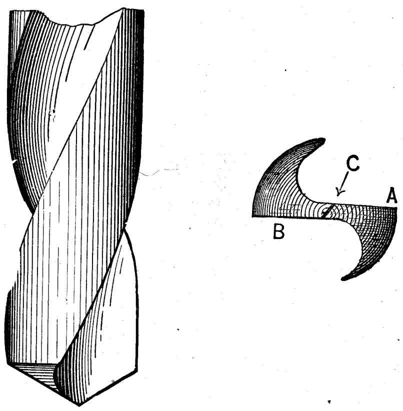


Fig. 2028.

capacity and correspondingly facilitating the feed of the drill. It is found, indeed, that by this means the drill will perform 15 per cent. more duty.

It is obvious, however, that as the thickness of drills at the point increases in proportion to the diameter of the drill, this improvement is of greater advantage with large than with small drills. The reason for augmenting the thickness at the centre with the drill diameter is that the pressure of the cut acts to unwind the spiral of the drill, and if the drill were sufficiently

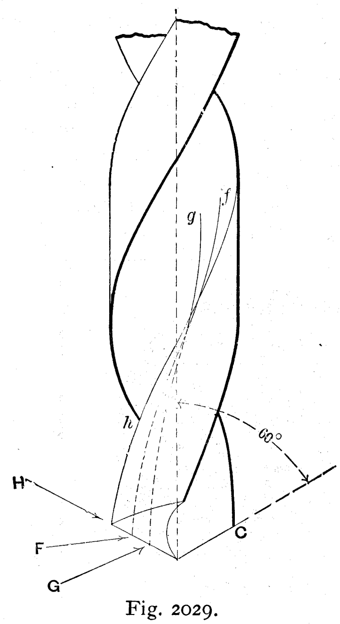


Fig. 2029.

weak at its axis this unwinding would occur, sensibly enlarging the diameter of hole drilled, more especially when the drill

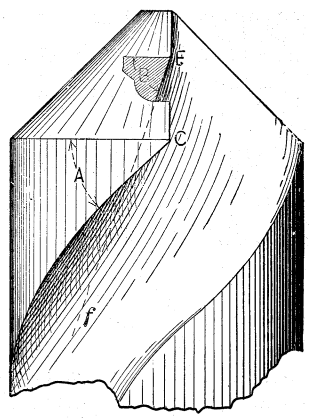


Fig. 2030.

became partly dulled and the resistance of the cut increased.

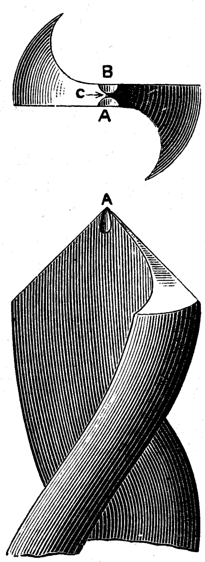


Fig. 2031.

By means of the small grooves A and B, however, the point is thinned while the strength of the drill is left unimpaired.

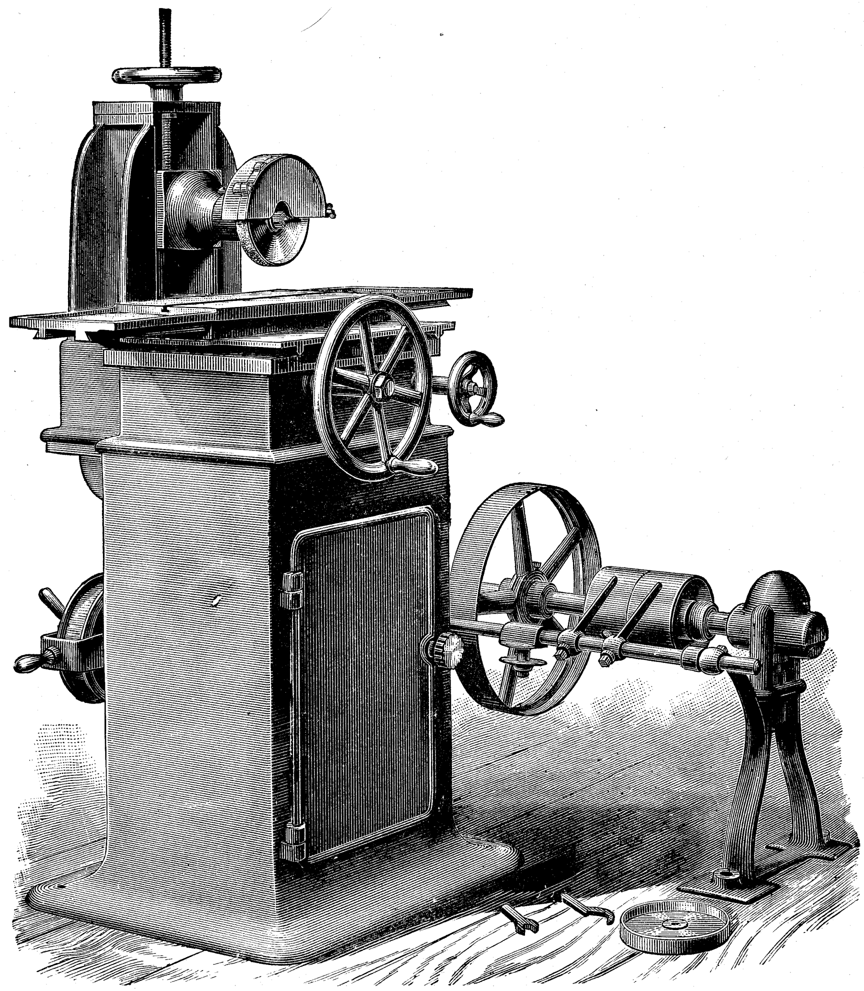


Fig. 2032.

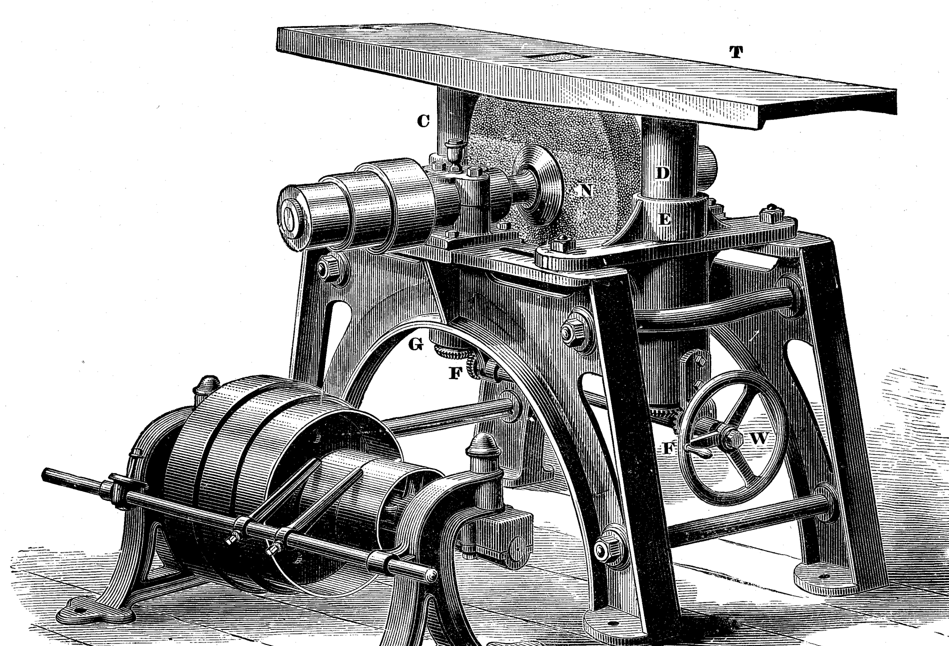


Fig. 2033.

Fig. 2032 represents Brown & Sharpe's surfacing grinder, designed to produce true and smooth surfaces by grinding instead of by filing. In truing surfaces with a file a great part of the operator's time is occupied in testing the work for parallelism, and applying it to the surface plate to test its flatness or truth, whereas in a machine of this kind both the parallelism and the truth of the work are effected by the accurate guiding of the machine table in its guideways. Furthermore, a high order of skill is essential to the production of work by filing that shall equal for parallelism and truth work that is much more easily operated upon in the machine. The machine is provided with two feed motions, the first of which is in a line parallel with the axis of the emery wheel driving spindle, and is communicated (by means of the small hand wheel on the right) to the lower table, which moves in **V**-guides provided upon the base plate of the machine. Upon this lower, and what may be termed cross-feed table slides, in suitable guideways, the work-holding or upper table, which is operated (by the large hand wheel) to traverse the work back and forth beneath the grinding wheel.

The surface to be ground is laid upon the face of the table, and the operator moves it by hand, slowly passing it over the emery wheel, which projects slightly through the opening shown through the centre of the table. The operator stands at the end of the machine so as to be within reach of the wheel, and the direction of rotation is towards him, so that the work requires to be pushed to the cut and is not liable to be pulled too quickly across the table by the emery wheel.

Fig. 2034 represents an emery grinding machine for grinding the bores of railroad car axle-boxes. The circumference of the emery wheel is dressed to the curvature of the box bore by a diamond tool A which swings on a centre in its frame, and can be adjusted to any arc. Once set, it can only turn the prescribed arc with accuracy. In order to avoid the necessity of the foreman having to set the tool, a gauge is also furnished. This consists of a spindle adjustable with a nut in such a way that its two points rest in the centres on which the diamond tool revolves. It is only necessary for a disk B turned accurately to the diameter of the bearing, to be prepared, and this the apprentice can place

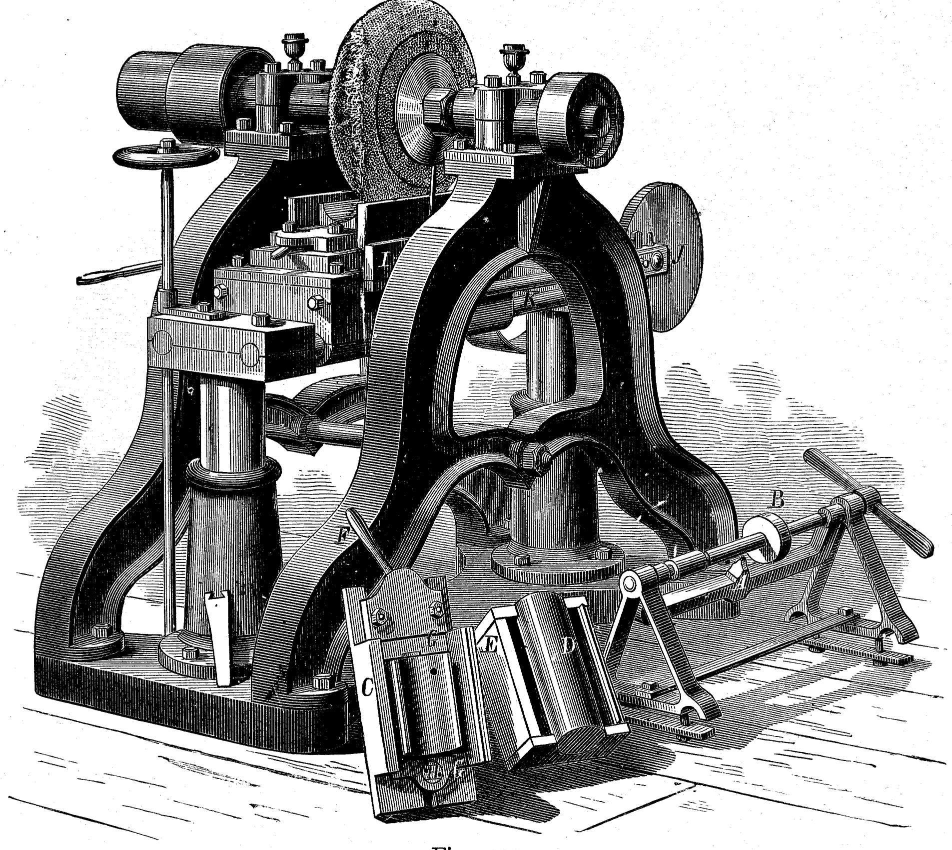


Fig. 2034.

Both these feed motions are operated by hand, automatic feed motions being unnecessary for work of the size intended to be operated upon in this machine. The grinding wheel spindle is carried in a bearing carried in a vertical slide, and is fed to its depth of cut by means of the vertical feed screw and hand wheel shown. The spindle passes through the bearing and carries a pulley at the back of the machine, which pulley is driven by a belt passing over idler pulleys at the back of the machine, by means of which the tension of the driving belt may be regulated.

Fig. 2033 represents The Tanite Co.'s machine for surface grinding such work as locomotive guide bars. The emery wheel N is mounted beneath a table T, whose upper surface is planed true, and which has two cylindrical stems C D fitting into the bored guides E. The stems are threaded at their lower ends to receive a screw, on the lower end of which is a bevel-gear F meshing into a similar gear G on the shaft actuated by the hand wheel W, hence by operating W the height of the table face may be adjusted to suit the diameter of the wheel.

on the spindle, adjust the latter, and screw down the diamond tool until it touches the periphery of the disk. A nut is then fastened on the diamond tool, and the frame is lifted on the ways beneath the wheel, when the moving of the handle turns the face of the wheel to the exact circle desired.

To adjust the brass in the chuck C, it is first set on the axle D. The chuck is then placed on frame E, in such a way that the **V** s fit. Handle F then moves a cam that clamps the brass between the jaws G, one set of which swings on a pivot at H. The brass is thus adjusted in such a manner that, despite the imperfections in moulding, it is ground accurately with the least removal of metal. The chuck C fits into planed guides on the table I, and is thus brought in exact line with the motion of the wheel. The crank J serves to move the table to and fro on the rods K, and the table also rises and falls on planed ways, being pressed up by springs. The hand wheel gives vertical adjustment to the whole bed by means of a chain beneath it. There is a pulley by which a suction fan, to remove dust, &c., may be driven. The machine is capable of fitting from 150 to 500 car brasses per day.

Fig. 2035 represents an emery planing machine. The emery wheel, which takes the place of the cutting tool of an ordinary shaping machine, is upon a spindle driven by the pulley A upon the spindle B, which is traversed endways by means of the connecting rod which is actuated by a crank E driven by the cone pulley C. The work-holding table G is traversed by the handle K or automatically through wheel H, which through suitable gearing drives the spindle I. The blower or fan is to draw off the cuttings and emery. It is obvious that any of the usual forms of work-holding devices may be employed.

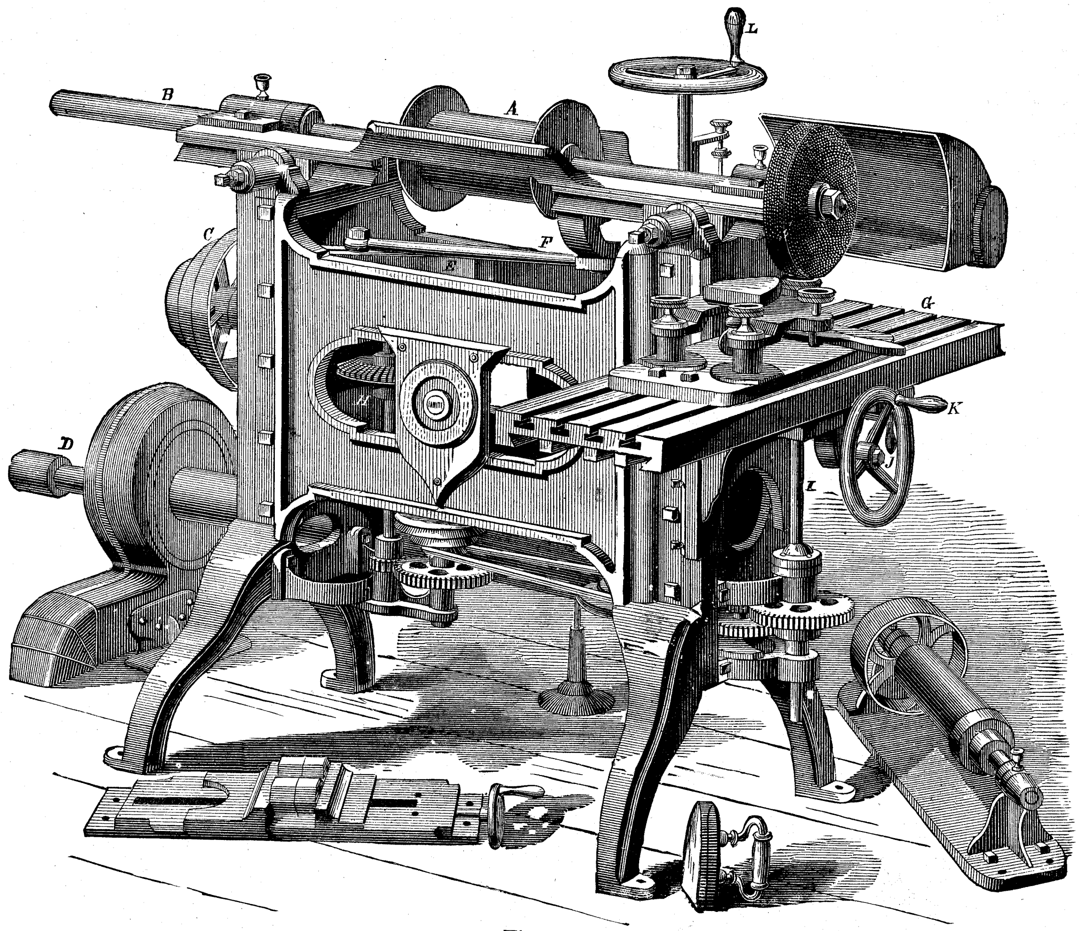


Fig. 2035.

Fig. 2036 represents an ordinary form of emery grinding machine for general purposes. A represents the frame affording journal bearing for the driving spindle driven by the cone pulley P, having the fast flanges *f* and collars C, which are screwed up to hold the emery wheel by the nut N, the direction of spindle rotation being denoted by the arrows. The thread at the end K of the spindle must be a right-hand one, and that at the other end L must be a left-hand, so that the resistance against the nut shall in both cases be in a direction to screw the nuts up and cause them to bind or grip the wheels more firmly, and not unscrew and release the wheels. Upon the frame A are the lugs D to carry the hand rests R and S, which are adjustable, and are secured in their adjusted position by the handle nuts E. The rest S is of the same form and construction as a lathe hand rest, while that at R is angular, to support the tool while applying it to the side as well as to the circumference of the wheel.

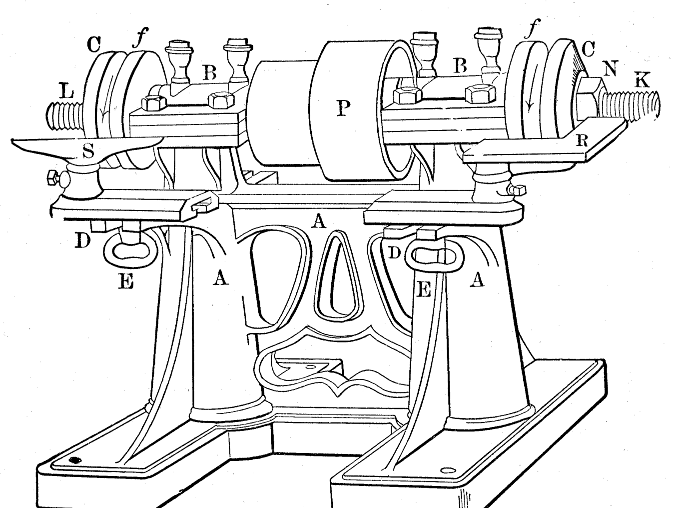


Fig. 2036.

Fig. 2037 represents a machine for grinding the knives for wood-planing machines, and having a hand feed only. It consists of an emery wheel mounted upon a spindle and with a slide rest in front of it. Mounted on the slide rest is a frame for holding the knife, and a set-screw for adjusting the angle of the knife to the wheel. The slide rest is traversed by means of the hand wheel operating a pinion in the rack shown.

Fig. 2038 represents a swing frame for carrying and driving an emery wheel to be used on the surfaces of castings, its construction permitting it to be moved about the casting to dress its surface. The overhead countershaft carries the grooved driving wheel A. At B is a vertical shaft pivoted at I by the forked bearing which swings upon the countershaft. The fork L at the lower end of shaft B carries a shaft on which is the fork C′, C having journal bearing on it, and the driving pulley J. Fork D has journal bearing on the same shaft as pulley J, and is fast upon the rod or arm E, which affords journal bearing to the emery wheel K on a shaft having handles H H. Motion to the emery wheel is conveyed through the belts F and G. To counterbalance the frame the weight W is employed, permitting the frame to be readily swung. The upper fork carrying B, being pivoted to the shaft of A, permits B to swing to any required position. The pivot at I permits B to rotate in a vertical plane; the pivot of C′ C at D affords vertical movement to E; the pivot at D allows E to rotate about its own axis, hence the wheel K can be moved about laterally, raised, lowered, or have its plane of revolution varied at will by simply swinging the handles H H to the required plane. The emery-wheel shaft is pivoted upon the fork carrying it, so that the emery wheel can be turned to stand in a horizontal plane if desired.

Fig. 2039 represents an emery belt machine, in which the belt direction of D and E to cause it to traverse across the full width of the wheel face, and as this motion would require to be simultaneous with the vertical motion explained with reference to Fig. 2040, it is not practicable to grind true level surfaces upon the perimeter of the wheel. As the sides of the wheel are flat, however, it is self-suggestive to apply the work to the side faces. But in this case, also, that part of the wheel surface that performs

Fig. 2037.

runs vertically and its tension is adjusted by the idler pulley shown at the top of the frame.

It is obvious that if a piece of work, as A in Fig. 2040, be held steadily upon the rest R, its end will be ground to the curvature of the emery wheel W, and that if it be required to grind the surface

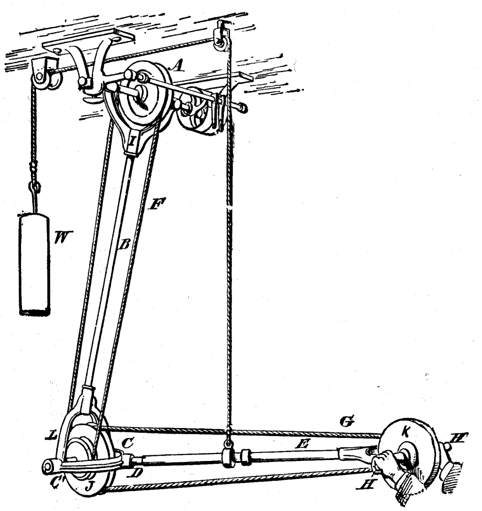


Fig. 2038.

flat the piece must be raised and lowered as denoted by the dotted lines, the amount of this motion being determined by the thickness of the piece.

Furthermore, if the piece of work be of a less width than the thickness of the wheel, as in the top view in Fig. 2041, the work A will wear a groove on the wheel, and its side edges will therefore become rounded off unless it be given sufficient motion in the grinding duty will gradually wear away, leaving a shoulder or projecting surface upon the wheel.

Suppose, for example, that in Fig. 2042 the duty has been confined to that part of the wheel face from A to the perimeter and the wheel would wear as shown, the result being the same whether the width or distance from the shoulder A to the perimeter of the wheel represents the width of the work held steadily against the wheel or the traverse of a narrower piece of work.

This difficulty may be overcome by recessing the wheel face, as in Fig. 2043, in which the wheel is shown in section.

In some cases, as for grinding the knives for wood-working machines, hollow cylindrical wheels, such as in Fig. 2044, are used, the duty being performed on the end face B B of the wheel, and the work being traversed in the direction of the arrows. The wheel is here gripped between the flange F and the collar C, which fits accurately to the end of the driving spindle S, so as to be held true, and secured by screws passing through C and into F, or the end of S may be threaded to receive a nut to screw against C.

The circumferential surface of a wheel may be employed to grind a flat surface, providing that the work be traversed to the wheel, as in the side view in Fig. 2045. In this case, however, the cut must be taken while the work P is travelling in the direction denoted by the arrow J, and no cutting must be done while the work is travelling back in the direction of K. After the work has traversed back in the direction of K, and is clear of the wheel, the cut is carried farther across the work by moving or feeding the work in the direction of the arrow in the front view, Fig. 2046. In this case the whole surface of the work passes beneath the wheel thickness, and the wheel face wears parallel to the wheel axis, producing a true plane (supposing the work to be moved in straight lines), save in so far as it may have been affected by the reduction of the diameter of the emery wheel from wear, which is not found sufficient to be of practical importance. If the whole surface of the work does not pass across or beneath

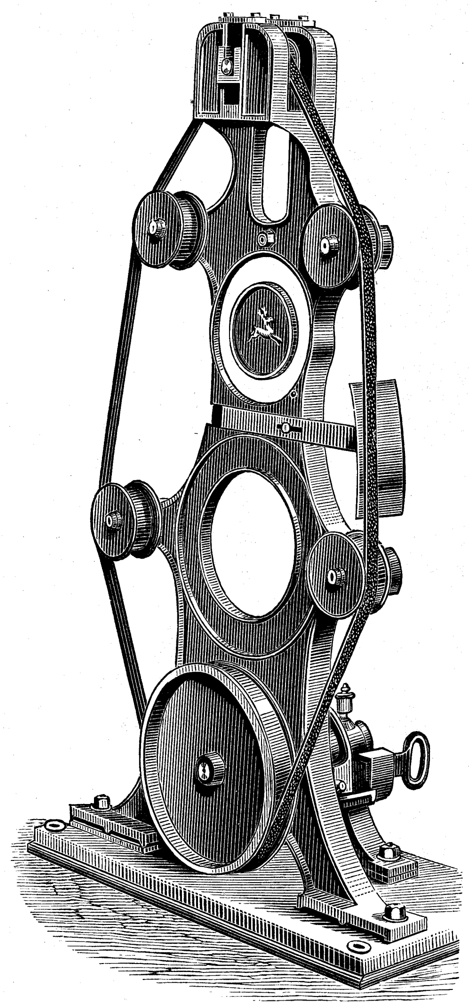


Fig. 2039.

the wheel thickness the wheel face may wear taper. Suppose, for example, that in Fig. 2047, P is a piece of work requiring

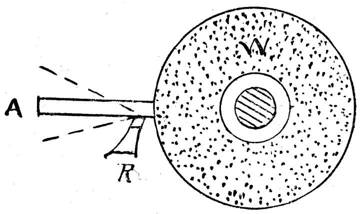


Fig. 2040.

to have produced in it a groove whose bottom is to be parallel

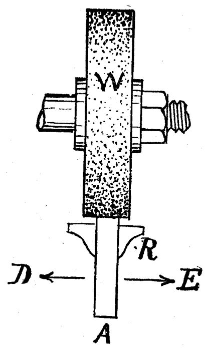


Fig. 2041.

to the lower surface F. Then the upper work surface being taper the thick side A would wear away the side B of the wheel, and the groove ground would not be parallel to F.

Another method of grinding flat surfaces is to mount the emery wheel beneath a table T in Fig. 2048, letting the top of the wheel

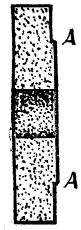


Fig. 2042.

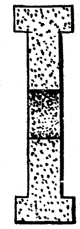


Fig. 2043.

emerge through an opening in the table, and sliding the work upon the trued upper surface of the table. The surface of the table thus becomes a guide for the work. To obtain true work in this way, however, it is necessary that the cut taken by the

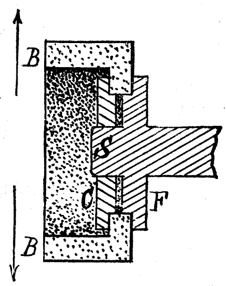


Fig. 2044.

emery wheel be a very light one, as will be perceived from the following considerations.

In Fig. 2049 T represents a table and B a guide bar thereon. The depth of cut taken will be equal to the height the emery

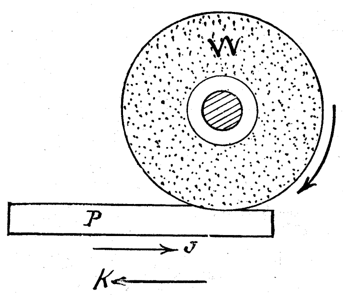


Fig. 2045.

wheel projects above the surface A of the table, hence when the bar has been moved nearly half-way across the table its surface will be as in Fig. 2050, the bar occupying the position shown in Fig. 2051. Now the part of the bar that has passed over the

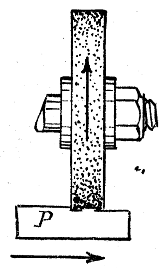


Fig. 2046.

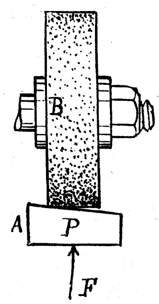


Fig. 2047.

table will not rest upon it as is shown in Fig. 2051. When the bar has passed over the emery wheel more than half of the bar length, its end F, Fig. 2052, will fall to meet the half D of the table, and end E will lift from the half C of the table, causing the bar surface to be ground rounding in its length. If, however, the cut taken be a very light one the surface may be ground practically true, because the bar will bend of its own weight and lap down to fit the table at both ends. Furthermore it will be noted that in the case of a large surface in which the wheel might sensibly wear in diameter before it had operated over the whole of the work surface, the table may be lowered or the wheel

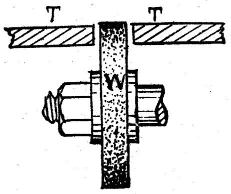


Fig. 2048.

may be raised (according to the construction of the machine), to offset the wear of the wheel, or rather to take it up as it were.

POLISHING WHEELS.—For polishing purposes as distinguished from that of grinding, various forms of polishing wheels are employed. For the rougher class of polishing, wooden wheels

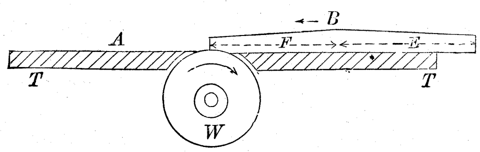


Fig. 2049.

covered with leather coated with fine emery that is allowed to glaze are employed. For a finer degree of polish the wheels are covered with lead to which various polishing materials are occasionally applied, while for the finest polishing rag or buff wheels are the best. Wooden polishing wheels are built up of

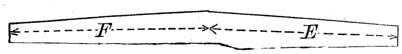


Fig. 2050.

sections of soft wood fastened together by gluing, and with wooden pegs in place of nails or screws.

The joints of the sections or segments are broken—that is to say, suppose in Fig. 2053 that 1, 2, 3, &c., up to 6, represent the joints of the six sections of wood forming one layer of the wheel, the next six sections would have their joints come at the dotted

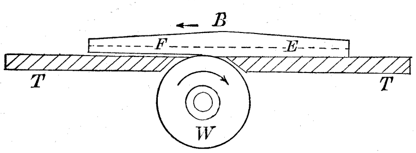


Fig. 2051.

lines A, B, C, &c., up to F. To prevent them from warping after being made into a wheel it is advisable to cut out the sections somewhere near the size in the rough and allow them to lie a day or two before planing them up and fitting them together; the object being to allow any warping that may take place to do so before the pieces

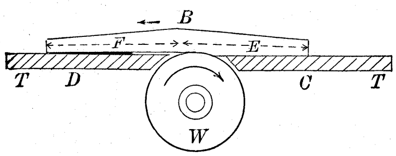


Fig. 2052.

are worked up into the wheel, because if the warping takes place afterwards it will be apt to throw the wheel out of true, whereas it is necessary that these wheels be very true, not only so that they may not prove destructive to their shaft bearings, but that they may run steady, and not shake or tremble, and because the work can be made much more true and smooth with a true than with an untrue wheel. Only one layer of segments should be put on in one day, and they should be put on as quickly as possible after the glue is applied, so that the latter shall not get cold. So soon as each segment is put into its place it should be clamped firmly to its seat and driven firmly up to the joint of the next one, and when the layer is completed it should be left clamped all night

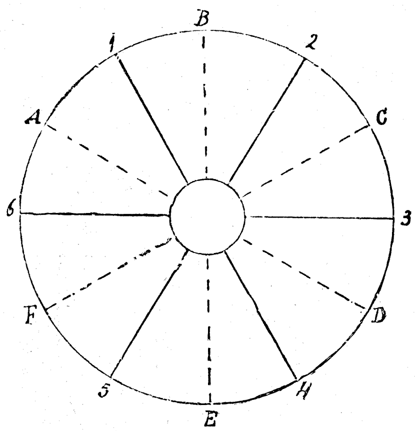


Fig. 2053.

to dry. In the morning one clamp should be removed, and that section fastened by boring small holes and driving therein round and slightly tapered soft-wood pegs of about $\frac{1}{4}$ inch diameter. The whole of the sections being pegged the next layer of segments may be added, and so on until the required width of wheel is attained. The whole wheel should then be kept two days before it is turned, and as little as possible should be taken off

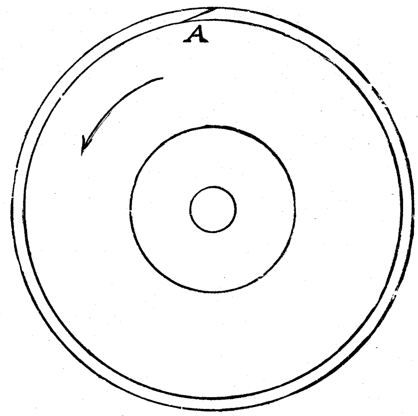


Fig. 2054.

in the turning process. The circumferential surface should be turned slightly rounding across its width, and as smoothly as possible. It is practicable to proceed with the construction of the wheel without waiting between the various operations so long as here advised, but the wheel will in that case be more apt to get, in time, out of true. To cover the circumference of the wheel sole leather is used, its thickness being about $\frac{1}{4}$ inch; it should

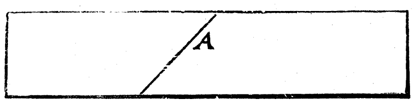


Fig. 2055.

be put on soft and not hardened by hammering at all, and with the flesh side to the wood. The joint of the leather should not be made straight but diagonal with the wheel face, the leather at the edge of the joint being chamfered off, as shown in Fig. 2054 at A, and the joint made diagonal, as shown in Fig. 2055 at A.

If the leather were put on with a square butt joint there would likely be a crease in the joint, and the emery or other polishing material would then strike the work with a blow, as well as presenting a keener cutting edge, which would make marks in the work no matter what pains might be taken to prevent it. This, indeed, is found to occur to a slight extent upon very fine polishing, even when the joint of the leather is made as above; and the means taken to obviate it is to not put any polishing material on the immediate joint and to wipe off any that may get there, leaving $\frac{1}{10}$ inch clear of polishing material. It is obvious that in fastening the wheel to its shaft it should be put on so that it will run in the direction of the arrow, providing the operator works with the wheel running from him, as is usually the case with large wheels, that is to say, wheels over 18 inches in diameter. In any event, however, the wheel should be put on

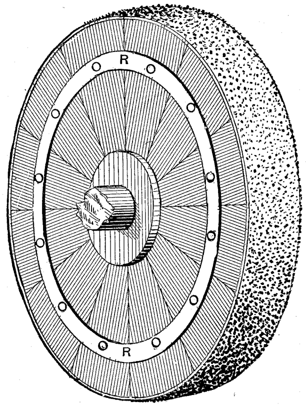


Fig. 2056.

so that the action of the work is to smooth the edge of the leather joint down upon the wheel, and not catch against the edge of the joint, which would tend to rough it up and tear it apart. The leather should be glued to the wheel, which may be slightly soaked first in hot water. The glue should be applied very hot, and the leather applied quickly and bound tightly to the wheel with a band. One end of the leather may be first glued to the wheel and fastened with a few tacks to hold it while it is stretched tightly round the wheel; the leather itself should be softened by an application of hot water, but not too much should be applied. After the leather is glued to the wheel it is fastened with soft wooden pegs, about $\frac{3}{16}$ inch in diameter, driven through the leather into the wood and cut off slightly below the surface of the leather.

Wheels of this kind are sometimes made as large as 5 or 6 feet in diameter, in which case the truth of the wheel may be preserved by letting in a wrought-iron ring, as shown in Fig. 2056, fastening the rings with wood screws. The wheels thus constructed are covered with emery of grades varying from No. 60 to 120, and flour emery. The coarser grades perform considerable cutting duty as well as polishing. The manner of putting the emery, and fastening it, upon the wheel is as follows:—The face of the wheel is well supplied with hot glue of the best quality, and some roll the wheel in the emery, in which case the emery does not adhere so well to the leather as it does when the operation is performed as follows:—Let the wheel either remain in its place upon the shaft, or else rest it upon a round mandrel, so that the wheel can revolve upon the same. Then apply the hot glue to about a foot of the circumference of the wheel, and cover it as quickly as possible with the emery. Then take a piece of board about $\frac{3}{4}$ inch thick and 28 inches long, the width being somewhat greater than that of the polishing wheel, and placing the flat face of the board upon the circumferential surface of the wheel, work it by hand, and under as much pressure as possible, back and forth, so that each end will alternately approach the circumference of the wheel, as illustrated in Fig. 2057, the movement being indicated by the dotted lines. By adopting this method the whole pressure placed upon the board is brought to bear upon a small area of the emery and leather, and the two hold much more firmly together than would be the case if the circumference of the wheel were glued and then rolled in a trough of emery, because the time occupied in spreading the glue evenly and properly over the whole wheel surface would permit it to cool before receiving the emery, whereas it is essential that the glue be hot so that it may conform itself to the shape of the grains of emery and hold them firmly.

The speed at which such wheels are used is about 7,000 feet per minute. The finest of emery applied upon such wheels is used for cast iron, wrought iron, and steel, to give to the work a good ordinary machine finish; but if a high polish or glaze is required, the wheels are coated with flour emery, and the wheel is made into a glaze-wheel by wearing the emery down until it gets glazed, applying occasionally a little grease to the surface of the wheel. Another kind of glaze-wheel is made by covering the wooden wheel with a band of lead instead of a band of leather, and then applying to the lead surface a mixture of rouge, crocus and wax, worn smooth by applying to it a piece of sheet steel or a piece of flint-stone before applying the work. Others add to this composition a little Vienna lime. For flat surfaces, or those requiring to have the corners or edges kept sharp, it is imperative that such wheels as above described—that is to say, those having an unyielding surface—be used; but where such a consideration does not exist, brush and rag wheels may be used. In Europe comparatively large flat surfaces requiring a high polish are finished upon wooden wheels made of soft wood and not emeried, the polishing material employed being Vienna lime. The lime for ordinary use is mixed with water, and is applied by an assistant on the opposite side of the wheel to the operator. For superfine surfaces the Vienna lime is mixed with alcohol, which increases its efficiency; and here it may be as well to note that Vienna lime rapidly deteriorates from exposure to the air, so that it should be kept as little exposed as possible.

BRUSH-WHEELS.—These are polishing wheels of wood with a hair brush provided around the circumference. These wheels are excellent appliances, whether employed upon iron, steel, or brass. Their sizes run from $1\frac{1}{2}$ inch to about 8 inches in diameter, and the hair of the brush should not exceed from 1 to $1\frac{1}{4}$ inches in length. The speed at which they should be run is about 2,500 for the largest, and up to 4,500 revolutions per minute for the smaller sizes. In ordinary grinding and polishing practice in the United States, brush wheels are used with Vienna lime in all cases in which the lime is used by itself—that is to say, unmixed with wax, crocus, or rouge, or a mixture of the same. In watch-making, however, and for other purposes in which the truth of the work is an important element, Vienna lime is applied to wooden or even metal, such as steel, polishing wheels, which are in this latter case always of small diameter. An excellent polishing composition is formed of water 1 gill, sperm oil 3 drops, and

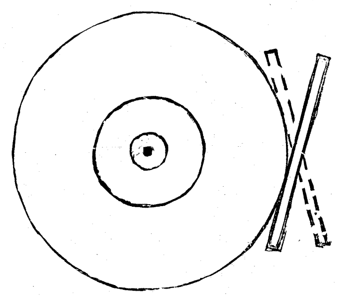


Fig. 2057.

sufficient Vienna lime to well whiten the mixture. The brush may be let run dry during the final finishing. For polishing articles of intricate shape, brush wheels are superior to all others. If the articles to be polished are of iron, or steel, the first stage of the process is performed with a mixture of oil and emery, Vienna lime being used for final finishing only. The wheels to which Vienna lime is applied should not be used with any other polishing material, and should be kept covered when not in use, so as to keep them free from dust.

For brass work, brush wheels are used with crocus, with rouge, or with a mixture of the two, with sufficient water, and sometimes with oil, to cause the material to hold to the brush and not fly off from the centrifugal force. For very fine brass polishing, the first stages are performed with powdered pumice-stone mixed with sufficient oil to hold it together. This material has considerable cutting qualifications. The next process is with rouge and crocus mixed, and for very fine finishing rotten-stone.

Solid leather wheels are much used by brass-finishers. The wheels are made of walrus hide glued together in disks, so as to obtain the necessary thickness of wheel. The disks are clamped between pieces of board so soon as the glue is applied, so as to make a good joint, and also keep the wheel flat and prevent it from warping during the drying process. Such wheels may be run at a velocity of 8,000 feet per minute, and with any of the polishing materials alread referred to. After the wheel is made and placed upon its spindle or mandrel it may be turned true with ordinary wood-turning tools—and it may here be remarked that rag wheels may be trued in the same way. The spongy nature of these wheels renders them very efficient for polishing purposes, for the following reasons: The polishing materials become imbedded in the leather and are retained, and become mixed and glazed with a fine film of the material being polished, which film possesses the very highest polishing qualifications. These walrus wheels may be used with pumice, crocus, rouge, or Vienna lime, according to the requirements of the case, or even with a mixture of flour emery and oil; and they possess the advantage of being less harsh than leather or lead-covered wheels, while they are more effectual than the latter, and will answer very well for flat surfaces.

Rag polishing wheels are formed of disks of rags, either woollen or strong cotton, placed loosely side by side, and clamped together upon the mandrel at the centre only. Their sizes range usually from 4 to 8 inches in diameter, and they are run at a speed of about 7,000 feet per minute. They assume a disk form when in motion from the centrifugal force generated from the great speed of rotation. They are used for the fine polishing only, and not upon work requiring the surfaces to be kept very flat or the corners very sharp. For use upon steel or iron, they are supplied with a polishing material composed of Vienna lime 3 parts, crocus 3 parts, beeswax 3 parts, boiled up together, allowed to cool off, and then cut into cakes. These cakes are dipped in oil at the end, which is then applied to the rag wheel occasionally during the polishing process. For brass-work, an excellent polishing composition is composed of crocus 2 parts, wax 1 part, rouge $\frac{1}{8}$ part, the wax being melted, and the ingredients thoroughly mixed. This mixture gives to the metal a rich color. It is dipped in oil and then applied to the rag wheel. It may be used to polish fine nickel-plating, for which purpose it is an excellent material. Nickel-plated articles having sharp corners should be polished with fine rouge mixed with clear water and a drop of oil, the mixture being applied to the rag wheel with the finger of the operator. Any of the compositions of rouge, crocus, and rotten-stone may be used for brass, copper, or nickel-plated work upon rag wheels, while for iron or steel work the same materials, separate or in combination, may be used, though they are greatly improved by the addition of Vienna lime. When, however, either of these materials is used singly, it should be applied to the rag wheels with a brush; and if it is used dry, it must be at a greatly reduced speed for the wheel, which is sometimes resorted to for very fine polishing.

Fig. 2058 represents a polishing device used to polish the surface of engravers' plates. It consists of a spindle D, carried in bearings B, and, having no collars, it is capable of end motion through those bearings. The spindle is pressed downward by a spring A, carrying at its end a piece C, which is capped to receive the end of the spindle D and the piece E which threads into the spindle, thus making a sort of universal joint. The spindle D is run by the pulley P, and carries a piece of stone S, the work W resting upon the plate or table T. The stone being set to one side of the centre of the spindle, each part of its surface describes a circle, the centre of which is outside of the stone, thus making the effectiveness of the centre of the stone greater by increase of motion. To raise the stone from the work the spindle is raised by means of the chord F, or the table T may have a simple lever motion. The work is moved about and around and beneath the revolving stone. Water, oil, benzine or alcohol is used to keep the stone clear and wash away the cuttings. The device saves a good deal of hand work in the preparatory stages of grinding, although it can be used only with soft stones.

Grindstones and Tool Grinding.—The general characteristics of grindstones are as follow:—

For rapid grinding a coarse and an open grit is the most effective. The harder the grit the more durable the stone, but the liability of the stone to become coated or glazed with particles of the metal ground from the work is increased. With a given degree of coarseness a soft grit stone will grind a smoother surface than a hard grit one.

The finer the grit the smoother the surface it will grind. In all stones, however, it is of prime importance that the texture be even throughout the stone, because the soft or open-grained part will wear more rapidly than the close or hard grained. All grindstones are softer when water-soaked than when dry, and will cut

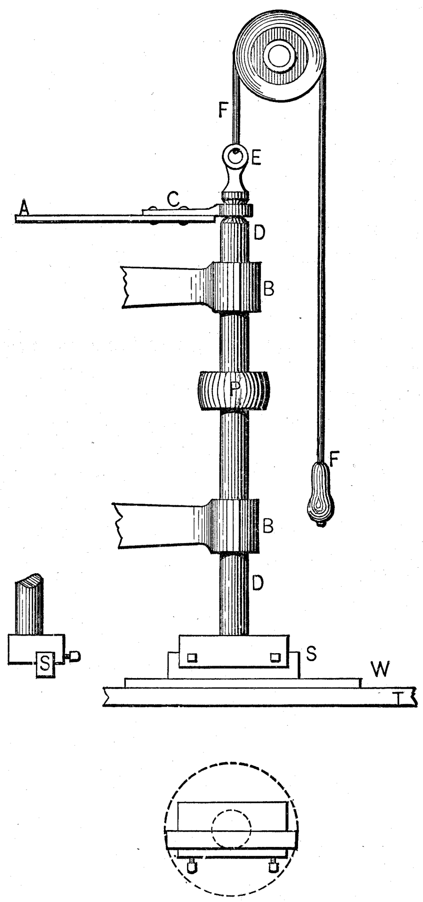


Fig. 2058.

more freely, because the water washes away the particles of metal ground from the work, and prevents them from glazing the stone. It follows from this, however, that a stone should not be allowed to rest overnight with its lower part resting in water, as the wear of the stone will be unequal until such time as it has become equally saturated. Furthermore the balance of the stone is destroyed, and if run at a maximum speed, as in the case of stones used to grind up large edge tools, the unbalanced centrifugal force generated on the water-soaked side may cause the stone to burst. The following stones are suitable for the class of work named:—

FOR GRINDING MACHINISTS' TOOLS.

Name of stone.	Kind of grit.	Texture of stone.	Color of stone.
Nova Scotia.	All kinds, from finest to coarsest.	All kinds, from hardest to softest	Blue or yellowish grey.
Bay Chaleur (New Brunswick).	Medium to finest.	Soft and sharp.	Uniformly light blue.
Liverpool or Melling.	Medium to fine.	Soft, with sharp grit.	Reddish.

FOR WOOD-WORKING TOOLS.

Name of stone.	Kind of grit.	Texture of stone.	Color of stone.
Wickersly.	Medium to fine.	Very soft.	Greyish yellow.
Liverpool or Melling.	Medium to fine.	Soft, with sharp grit.	Reddish.
Bay Chaleur (New Brunswick).	Medium to finest.	Soft and sharp.	Uniform light blue.
Huron, Michigan.	Fine.	Soft and sharp.	Uniform light blue.

FOR GRINDING BROAD SURFACES, AS SAWS OR IRON PLATES.

Name of stone.	Kind of grit.	Texture of stone.	Color of stone.
Newcastle.	Coarse to medium.	The hard ones.	Yellow.
Independence.	Coarse.	Hard to medium.	Greyish white.
Massillon.	Coarse.	Hard to medium.	Yellowish white.

The flanges for grindstones should be trued on both faces, and should pass easily over the grindstone shaft, and there should be between these collars and the stone an elastic disk, as of wood or felt, which will bed fully against the surface of the stone. It is preferable also if the under faces of these collars be recessed to within an inch of their perimeters so as to confine the grip to the outer edges of the faces.

The process of grinding large surfaces is entirely distinct from that of small ones, because of the difficulty in the former of getting rid of the cuttings. As an illustration of this point it may be remarked that a stone that has become dulled and glazed from operating upon a broad area of surface, as say a large plate, may be both cleaned of the cuttings and sharpened by grinding upon it a roller of, say, 1 or 1¼ inches in diameter. This roller is laid across the "horn" or rut of the stone, and pressed firmly against it, the bar being allowed to slowly rotate. What is commonly termed grinding is the class of grinding that is followed as a trade, such as file grinding, saw grinding, plate grinding, edge tool and cutlery grinding. In all this class of grinding the speeds of the stones is very much greater than for machine-shop tool grinding. For all the above, save cutlery grinding, the stones when new are of a diameter from 5 to 8 feet, and of a width of from 8 to 15 inches. The stones used by cutlers are about 15 inches in diameter, and from ½ inch to 3 inches thick. The average speed of grindstones in workshops may be given as follows :—

	Circumferential speed of stone.
For grinding machinists' tools, about . .	900 feet per minute.
" carpenters' " . .	600 "

The speeds of stones for file grinding and other similar rapid grinding is thus given in the "Grinders' List."

Diameter of stone. ft.	in.	Revolutions per minute.
8	0	135
7	6	144
7	0	154
6	6	166
6	0	180
5	6	196
5	0	216
4	6	240
4	0	270
3	6	308
3	0	360

These speeds are obviously obtained by reducing the diameter of the pulley on the grindstone shaft each time the stone has worn down 6 inches less in diameter, and give a uniform velocity of stone if the 8 feet stone be driven with a pulley 32 inches in diameter. Each shift (or change of pulley) giving a pulley 2 inches less in diameter.

The following table (from the *Mechanical World*) is for the diameter of stones and the number of revolutions they should run per minute (not to be exceeded), with the diameter of change or shift pulleys required, varying each shift or change 2½ inches, 2¼ inches, or 2 inches in diameter for each reduction of 6 inches in the diameter of the stone :—

Diameter of stone. ft.	in.	Revolutions per minute.	Shift of pulleys in inches. 2½	2¼	2
8	0	135	40	36	32
7	6	144	37½	33¾	30
7	0	154	35	31½	28
6	6	166	32½	29¼	26
6	0	180	30	27	24
5	6	196	27½	24¾	22
5	0	216	25	22½	20
4	6	240	22½	20¼	18
4	0	270	20	18	16
3	6	308	17½	15¾	14
3	0	360	15	13½	12
1		2	3	4	5

"Columns 3, 4, and 5 are given to show that if you start an 8 feet stone with, say, a countershaft pulley driving a 40 inch pulley on the grindstone spindle, and the stone makes the right number (135) of revolutions per minute, the reduction in the diameter of the pulley on the grinding-stone spindle, when the stone

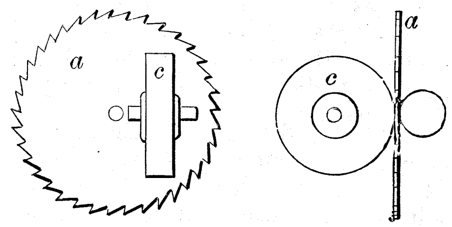


Fig. 2059.

has been reduced 6 inches in diameter, will require to be also reduced 2½ inches in diameter, or to shift from 40 inches to 37½ inches, and so on similarly for columns 4 and 5. Any other suitable dimensions of pulley may be used for the stone when 8 feet in diameter, but the number of inches in each shift named, in order to be correct, will have to be proportional to the number of revolutions the stone should run, as given in column 2 of the table."

In all grinding operations it is necessary that the stone should run true. This is sometimes accomplished by so mounting the

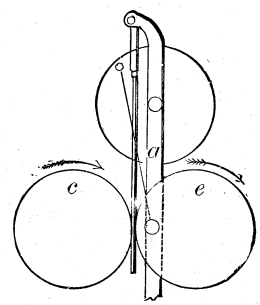


Fig. 2060.

stones in their frames that their perimeters touch at the back of each stone, one stone running slightly faster than the other. Or sometimes the work is placed between the two stones, as in Fig. 2059, which represents a plan frequently used to grind circular saws ; *c* in the figure represents the grinding-stone and *a* the saw. Long saws are mounted vertically as in Fig. 2060, *a* representing a frame to which the upper end of the saw is attached and driven by a disk crank and connecting rod as shown, the two stones *c e* may, in this case, be of equal diameter.

Fig. 2061 represents a grindstone truing device (for tool-grinding stones) in which a series of serrated disks are employed in place of a threaded roll. The disks are fed to the stone by the hand wheel and screw, and are traversed back and forth across the stone face by means of the lever handle shown.

The fast running grindstones used for heavy and coarse grinding are trued by a process known as hacking. The high spots of the stone are marked by holding a piece of coal to the stone while it revolves slowly, and a tool similar to an adze is used to cut or chop indentations in the stone. The highest spots will be most plainly marked by the coal, and the hacking is spaced closer together in these places, the hacking marks crossing each other and varying in depth to suit, obviously being deepest where the marks are blackest. The hacking also sharpens the stone. To prevent the stone from wearing uneven across its face the file grinder mounts the stone in a very ingenious manner, causing it to traverse automatically, back and forth, while rotating.

This device is shown in Fig. 2062, in which A represents the grindstone spindle having journal bearing at B B, but as there are no collars on the journals, A can move endwise through B B. Fast to A are the collars C and C′ (sometimes the face of the pulley hub is made to serve instead of C′); S is a sleeve fitting easily to A, and containing a return groove, as shown; D is a fixed arm carrying a pin which projects down into the groove of S, as shown; P is the pulley driving A, and W W are suspended weights. The operation is self-acting, as follows: The shaft revolving causes the sleeve to revolve by friction, and the pin causes the sleeve to move endwise; its end face abutting against the face of the collar on one side, or the face of the pulley on the other side, as the case may be, causing the shaft to travel in that lateral direction. When the pin has arrived at the end of the groove, the stone ceases lateral motion (there being left a little play between the faces of the sleeve and of the collar and pulley face for this special purpose), while the cam travels in the opposite lateral direction, getting fairly in motion until it strikes the face, when it slowly crowds the face over. In travelling to the right it crowds against the face of the collar C′, and in traveling to the left, as shown in the figure, against the face of the collar C. The swing thus given to the stone is a slow and very regular one, the motion exciting surprise from its simplicity and effectiveness, especially when it is considered that the friction of the rotation of a shaft about $2\frac{1}{2}$ inches diameter in a smooth hole about 6 inches long is all that is relied upon to swing a ponderous stone.

The following are the considerations that determine in grinding tools or pieces held by the hands to the grindstone. Upon the edge of a tool that last receives the action of the stone there is formed what is termed a feather-edge, which consists of a fine web of metal that bends as the tool is ground, and does not become detached from the tool in the grinding. The amount or length of this feather-edge increases as the work is thinner, and is greater in soft than in hardened steel. It also increases as the tool or piece is pressed more firmly to the stone.

To prevent its formation on such tools as plane blades or others having thin edges, the tool is held as at G in Fig. 2063, the top

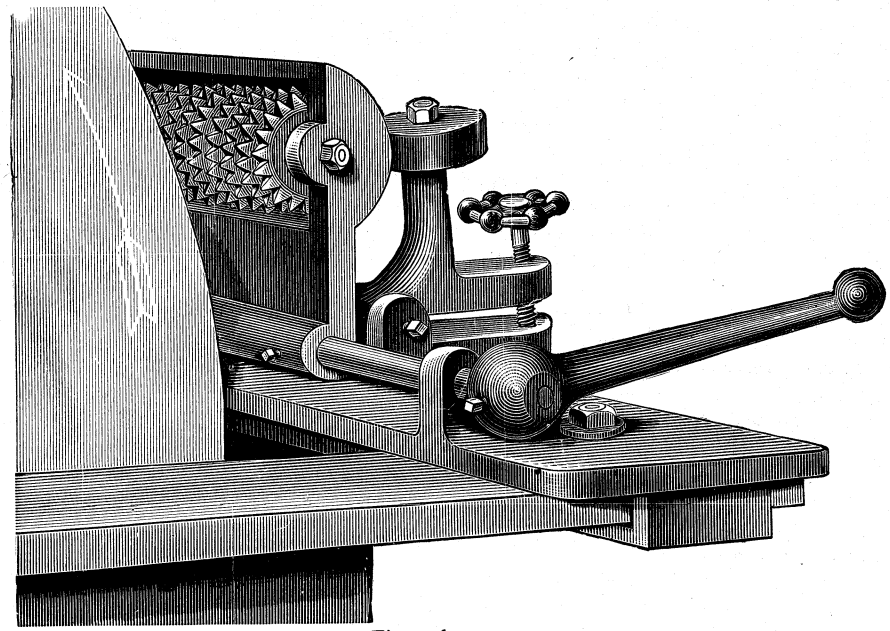


Fig. 2061.

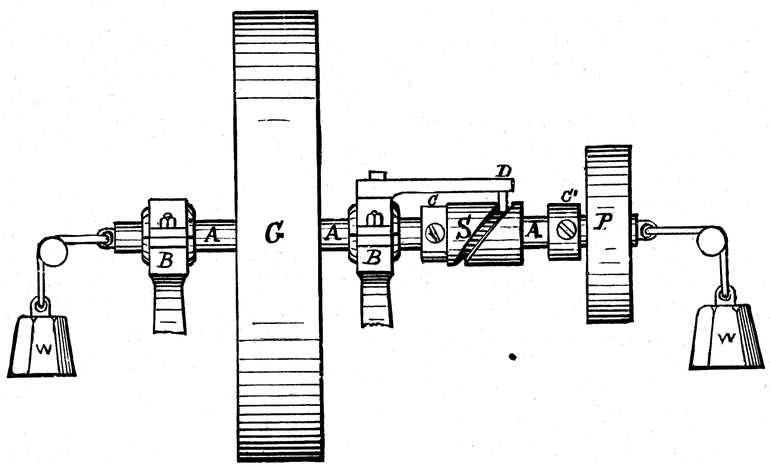


Fig. 2062.

of the stone running towards the workman, and the tool is held lightly to the stone during the latter part of the grinding operation. With the tool held on the other side of the stone as at C, and pressed heavily to the stone, a feather-edge extending as long as from D to E may be formed if the tool has a moderate degree only of temper, as, say, tempered to a dark purple. The feather-edge breaks off when the tool is put to work, or when it is applied to an oil-stone, leaving a flat place instead of a sharp cutting edge. In well-hardened and massive tools, such as the majority of lathe tools, the amount of feather-edge is very small and of little moment, but in thin tapered edges, even in well-hardened tools, it is a matter of importance.

After a tool is ground it is often necessary to remove the feather-edge without having recourse to an oil stone. This may be accomplished by pressing the edge into a piece of wood lengthways with the grain of the wood, and while holding the cutting edge parallel with the line of motion, draw it towards you and along the grain of the wood, which removes the feather-edge without breaking it off low down, as would be the case if the length of the cutting edge stood at a right angle to the line of motion.

The positions in which to hold cutting tools while grinding them are as follows: The bottom faces of lathe tools and the end faces of tools such as scrapers should be ground with the tool laid upon the grindstone rest as in Fig. 2064, the stone running in the direction of the arrow. The best position for thin work as blades is at F providing the stone runs true, for otherwise the tool edge will be liable to catch in the stone. With an untrue stone the position shown in Fig. 2065 is the best, the blade being slowly reciprocated across the face of the stone.

If the facet requires to be ground rounding and not flat the position at C, Fig. 2064, is the best, the work being moved to produce the roundness of surface. If the tool is to be ground hollow or somewhat to the curvature of the stone, as in Fig. 2066, the curve being from *b* to *c*, the position at B is the best. At position D the tool cannot be held steadily; hence, that position is altogether unsuitable for tool grinding purposes.

For grinding the top faces of lathe or planer tools or other similar shaped pieces that must be held with their length at a right angle (or thereabouts) to the plane of the rotation of the stone, the tool is held in the hands, and the hands are supported by the grindstone rest as in Fig. 2067, the fingers being so placed that should the tool catch in the stone it will slip from between the fingers and not carry them down with it upon the tool rest.

Tools to be ground to a sharp point should be ground at the back of the stone, that is to say, with the top of the stone running away from the operator, and the point should be slowly moved across the width of the stone to prevent wearing grooves in its surface.

To produce a finer edge than is possible with the grindstone, the oil-stone is brought into requisition, the shape of the oil-stone being varied to suit the shape of the tool. Three kinds of oil-stone are in general use, Turkey stone, Arkansas stone, and Washita stone, the latter being softer and of inferior quality to the two former. The best quality of Arkansas stone is of a milky white color, of very fine and even grain, and very hard, being impervious to a file; but there are softer grades. An oil-stone should be of even grain throughout, so that it may wear even throughout, and produce a smooth and unscored edge. Arkansas stone is rarely obtainable in lengths above 6 inches, on account of the presence of fine seams of hard quartz, which wears less than the stone, and forms a projection that scores the cutting edge of the tool, and the same applies to the Turkey stones.

For tools fully hardened and not tempered the hardest oil-stones are best; but for tools that are tempered, as tools for wood-work, a softer grade of stone is preferable, since it will cut the most free.

When an oil-stone has worn out of shape it may be dressed on a grindstone; but if a flat surface is required it is best to true it by a piece of coarse sand-paper laid upon a flat true surface.

The action of an oil-stone is to smooth the surfaces; but while doing this the oil-stone itself forms what is termed a wire-edge, which resembles a feather-edge, except that it is smoother and more continuous. It is caused by the weak edge of the blade giving way under the pressure with which it is held to the stone. To reduce the wire-edge as much as possible the tool is pressed very lightly to the oil-stone during the latter part of the stoning, and is frequently turned over. If the motion of the tool upon the oil-stone is parallel with the line of cutting edge, the wire-edge will be greater than if the line of motion were at a right angle to it.

Again, the strokes performed while the cutting edge is advancing upon the oil-stone produce less wire-edge than the return strokes, hence the finishing process consists of a few light strokes upon one and then upon the other facet repeated several times.

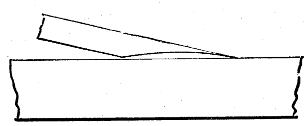


Fig. 2068.

Now let it be observed that the wire-edge will never be turned toward the facet last oil-stoned, and cannot be obviated by the most delicate use of the stone; but after the stoning proper is finished, the operator will lay one facet quite level with the face of the stone, and then give to the blade, under a very light pressure, forward diagonal motion, and then perform the same operation with the other facet upon the stone, the last facet operated upon being usually the straight and not the bevelled one. To still further reduce the wire-edge for very fine work, the operator sometimes uses a piece of leather belt, either glued to a piece of wood, as upon the lid of the oil-stone box, or some attach it at each end to projecting pieces of wood, while yet others lap the tool upon the palm of the hand. In giving an edge to a razor, the process may be carried forward in the usual way by means of straps, the first strokes being long ones made under a slight pressure, the strokes getting shorter and the pressure lighter as the process proceeds, until at last the motion and contact are scarcely perceptible.

When, as in the case of plane blades and carpenters' chisels, the area of face is large, it is advantageous to grind the face somewhat concave, as in Fig. 2068, so that the heel and the point only of the tool has contact with the oil-stone, thus reducing the area to be stoned and steadying the tool, because, the area being small, the heel as well as the edge may be allowed to rest upon the oil-stone without unduly prolonging the stoning operation.

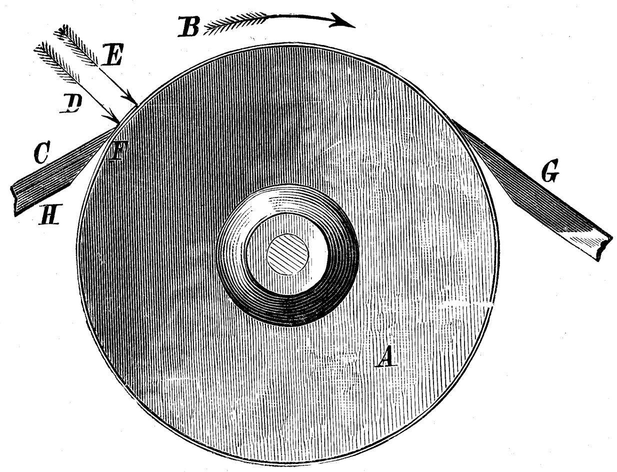


Fig. 2063.

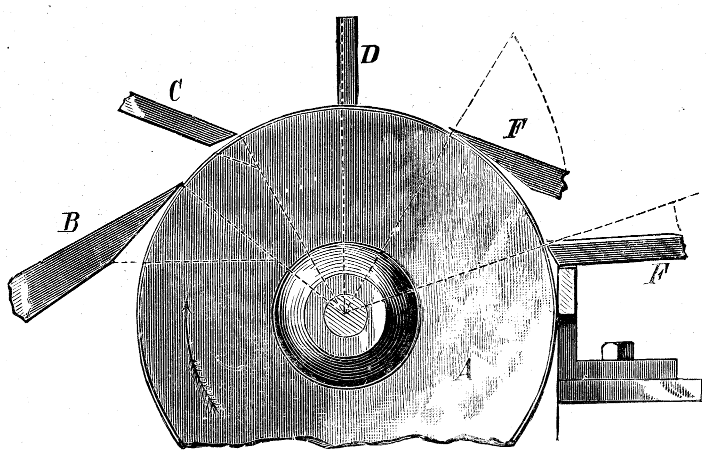


Fig 2064.

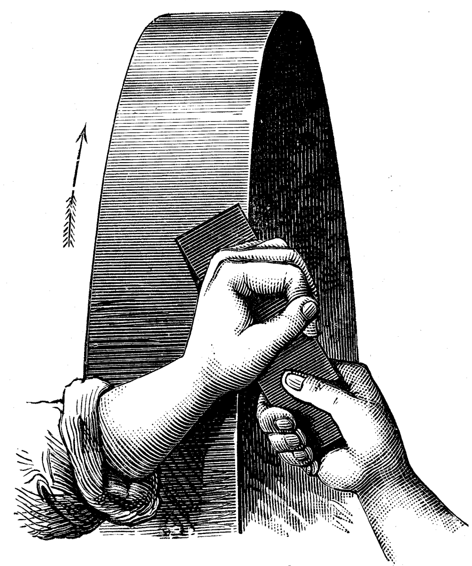


Fig. 2065.

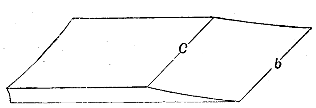


Fig. 2066.

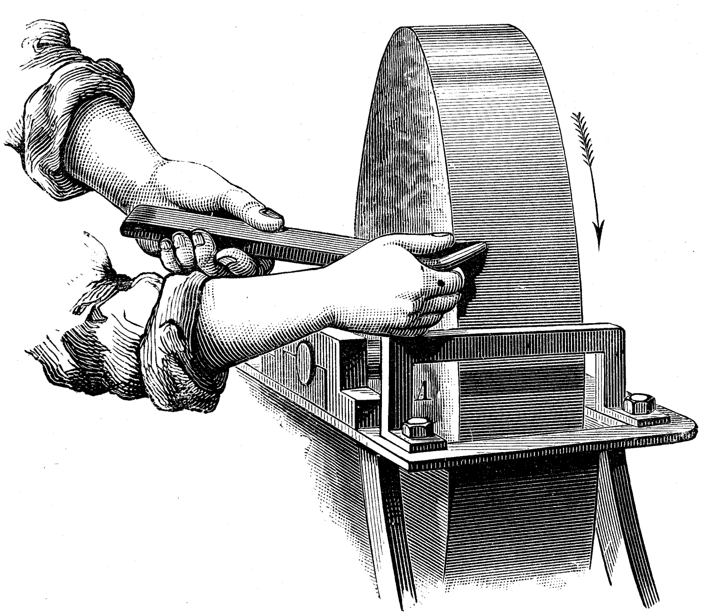


Fig. 2067.

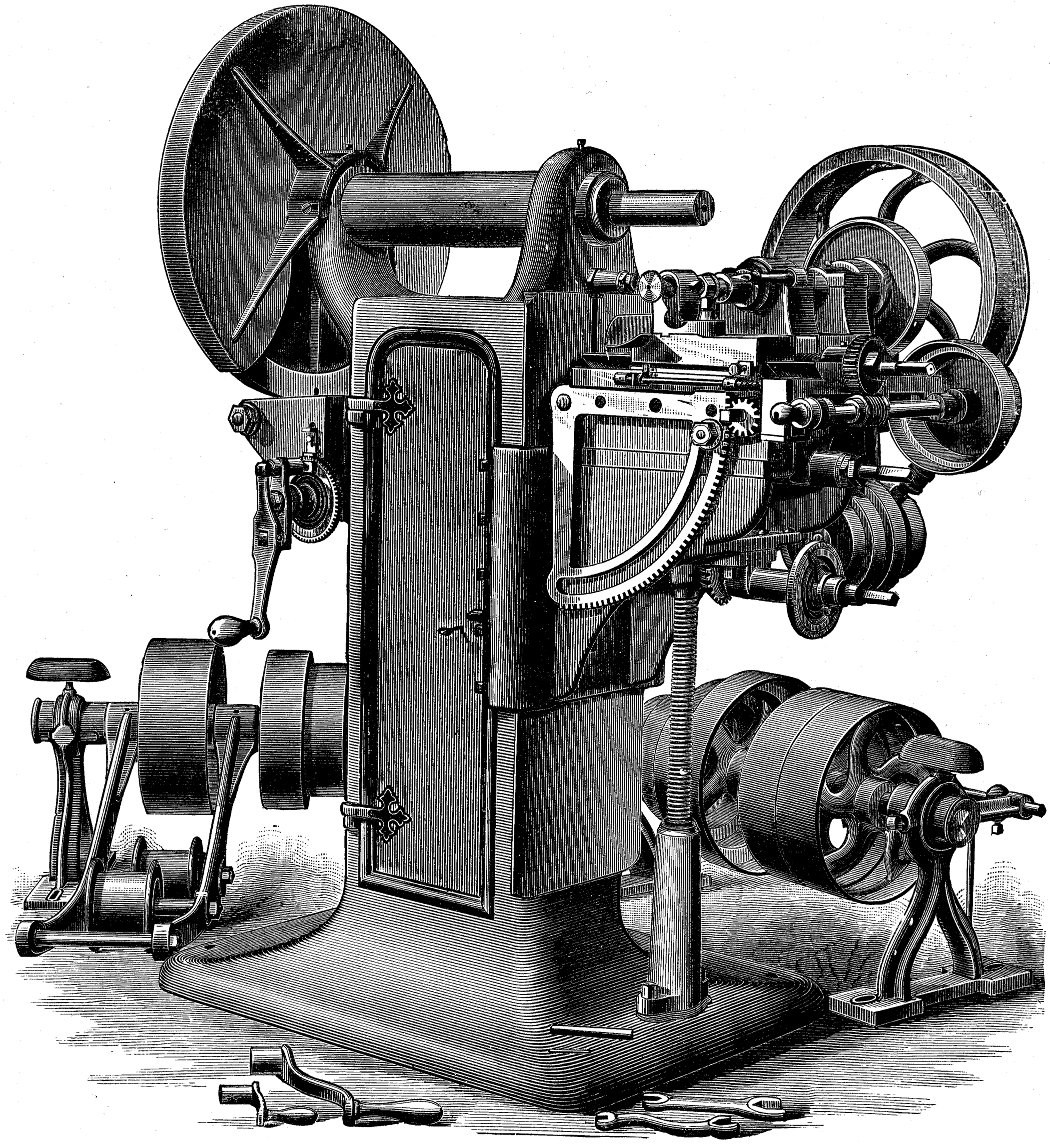


Fig. 2069.

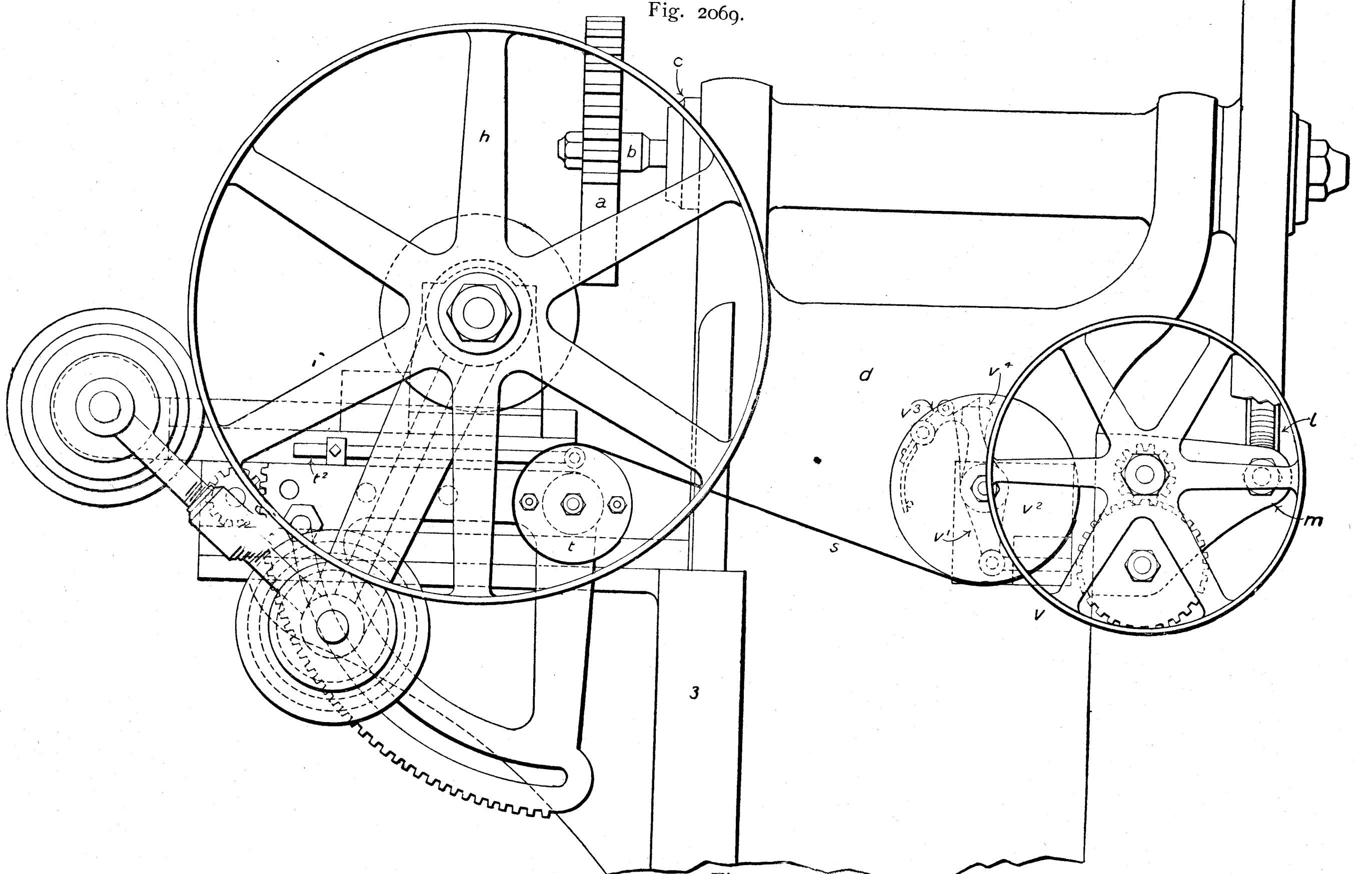


Fig. 2070.