April 15, 1930.

Over the years there have been many designs published for accurately grinding lathe and other tools. This Universal head from 1920 and designed by W. F. Fisher would be a most useful accessory for the amateurs' workshop and can be used for light milling. At this date the Model Engineer had a workshop at Farringdon Street, London which was available to model engineers on a fee basis and courses were held on various aspects of the model engineering hobby.

Workshop Topics.

The principal items appearing under this heading relate to work done and other matters dealt with in The Model Engineer Workshop at 66, Farringdon Street, London E.C.4.

A Universal Head for Grinding Small Tools and for Light Milling.

REGULAR readers of THE MODEL ENGINEER are familiar with the experimental work of Mr W. F. Fisher of Althrincham, in the matter of light grinding and milling jigs; several articles having been written on the subject both under this name and in this column when called "Lessons from the Laboratory." The subject of this note is a short description of his latest development in this respect, and it should prove of great use to those readers interested in precision grinding and small milling; as well as of general mechanical interest.

Fig. 1 is a photo of the head complete, holding in its adaptor a short square lathe cutter for grinding and ultimate application in a cutter bar. Fig 2 is a photo of a portion of another, reproduced in order to make clearer allusions to certain parts not easily seen in Fig. 1. In this, however, there are fittings which the designer now considers unnecessary and have been omitted from the later one.

In these two photos the parts, as designated by Mr. Fisher, are A the slide-plate carrying the bracket frame G of head pivotted at *b* (Fig. 2) and running round a concentric slot *c*, which is graduated to read in degrees, being marked at every 2½ degrees. It can be clamped at any position by the nutted screw d (Fig. 1) and reads against the scale by an engraved index on the bottom edge just below the nut *d*. E is the trunnion of the swivelling-block F, which is mounted, a nice running fit, in a horizontally-bored hole in the bracket-frame G. The general construction of the bracket-frame is more clearly seen in Fig. 2. Upon its base, in addition to the vertical member carrying the trunnion, there is an outlying block *h*, which supports the overhang of the swivelling-block. This bearing-block is bored concave on top, with an open arc bearing, the curvature of which is concentric with the trunnion axis, and takes, a sliding fit, the turned bottom edge of the swivelling-block. The swivelling-block is bored transversely with a hole in axial square alignment with the trunnion and carries therein the various adapters for tool and work-holding. The swivelling-block is split and fitted with a wing-head set-screw *i* to clamp the adapters in any circular position they may be required. When the outside face of swivelling-block is flush with the outside face of open-arc bearing the axial centre of the adapter is vertically over the diameter line, of the big graduated arc on slide-plate and therefore vertically over the pivot *b* (Fig. 2). Further to this, the adapter can be set on either side of this position by a sliding action with key and featherway of the trunnion, but the end-screw, adjustment for which is shown in Fig. 2, Mr. Fisher now thinks not necessary. The trunnion adjustment is recorded in degrees by means of a scale engraved on the edge of a brass disc *k* (or portion of a disc) which is keyed to the featherway of trunnion. This scale, which is divided to 5-degree divisions, reads up to 45 degrees on either side of zero, and, as the disc can be kept against the outside face of bracket-frame G and stands level with its top, it is indexed by an engraved line on the same. The zero setting corresponds with the horizontal position of the adapter axis. That is when it is parallel with the slide-plate. This bearing, again, can be clamped tight.

An adapter l is shown in position in Fig. 1. It is an inch in diameter, and passes, a sliding-fit, through the transverse bore of the swivelling-block. This is a cutter-holding adapter and is slotted lengthways, ¼ inch wide, down to its axis, so that a ¼-inch square cutter stands in axial alignment with it when standing on the bottom. At the rear end of adapter a knurled collar is fitted, which is engraved to degrees right round. Mr. Fisher usually gives 5- or a 6-degree divisions. When this collar is clamped on adapter the zero of scale is in alignment with the cutter slot, so that when the zero is opposite the index at top of swivelling-block (see Fig. 1) the slot is standing vertically at right angles to the slide-plate. Tools are clamped in the slot by means of a 3-16th Whitworth set-screw passing through a radially-tapped hole in a steel ring, which is bored a nice sliding fit to adapter nose.

The slide-plate has a fillet on the underside which articulates with a transverse slot on the saddle of a top-slide of a rest, which is used to apply the contrivance to a grinding wheel. The cross-feed is obtained by sliding the plate along this groove, and the traverse by operating the screw of top-slide.

To obtain the various angles, it will be seen by further reference to Fig. 1 that side clearances are gauged by the adapter scale, front clearances by the trunnion scale and angularity of face by the scale on the slide-plate.

Applications of types of cutting tool are shown in position for grinding in the sheet of sketches, Fig. 3. Here the shape of wheel, as recommended by Mr. Fisher, is shown in section to the left. To maintain flatness of grinding face on side of wheel the same is limited to about ⅜ in. wide, for the rest, the wheel being dished. It is necessary to traverse the cutter across this face to prevent the same being scored. Taking the views in order from left to right, the first shows the position for angularity of sides of a pointed tool. The faces must, of course, be brought up to the wheel and traverse carried out in the direction of the dotted arrows. Here the angularity is measured by the scale on the slide-plate and side

Fig. 1. Mr. Fisher's Latest Grinding Jig.

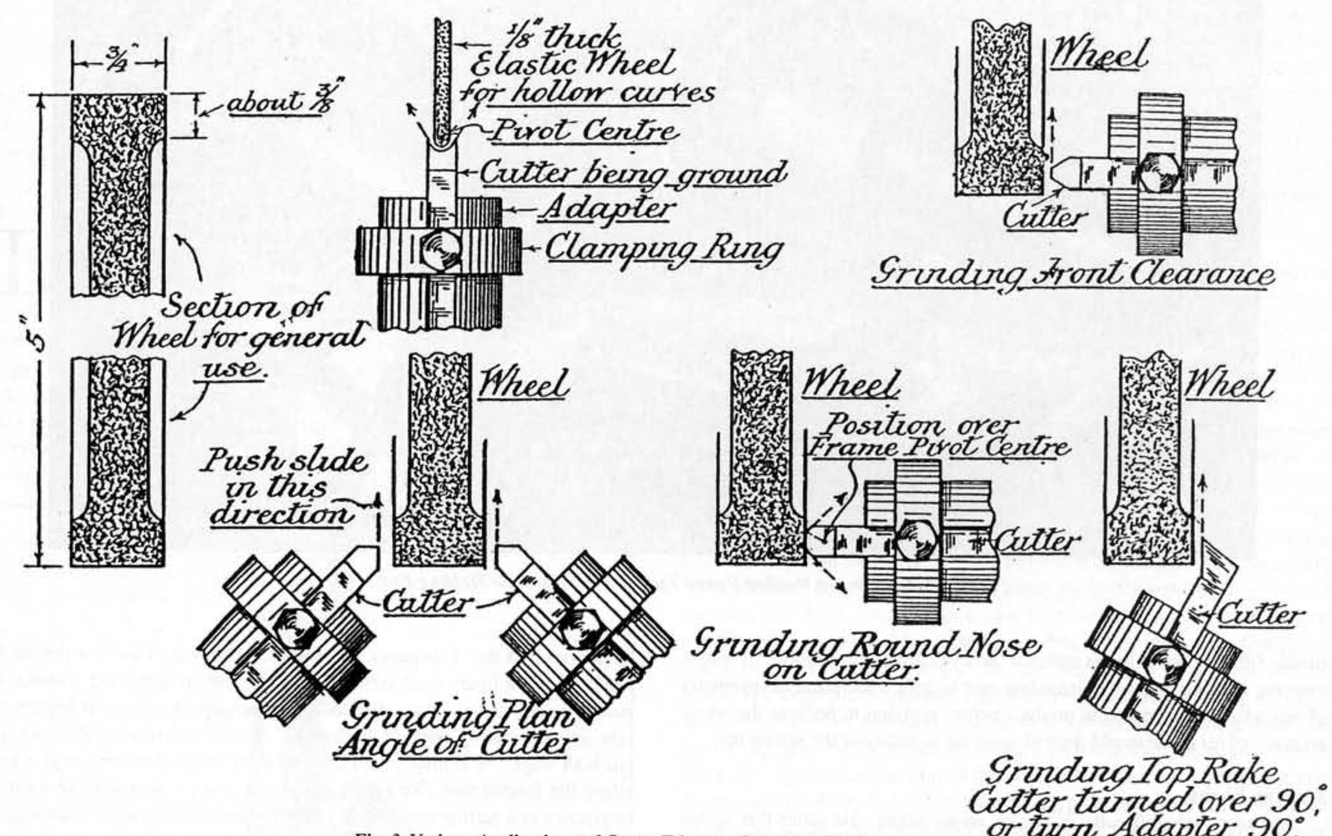


Fig. 3. Various Applications of Cutter Edges to Grinding Wheel.

clearances by the adapter. These latter are not indicated in the sketches to avoid confusion. The tool is also tilted by the trunnion and the scale set to correspond to angle that tool is set in its holder to give top rake.

The next view at top shows method of grinding a hollow tool by means of a thin elastic wheel with rounded edge. The adapter is set in alignment with the pivot *b*, and the centre of wheel; the pivot being also set vertically under the centre of circularity of the tool hollow.

By setting a combination of side and front clearance, bringing the face to wheel and operating the head about its pivot, half the round can be ground, but it will be necessary to alter the side-clearance angle to grind the opposite half. No doubt a satisfactory clearance all round could be effected by tilting the adapter only, but the clearance would vary a little from centre to edge. The pivot position must be set last of all, to get it in exact position to give any particular radius.

The next view at top shows a similar operation on a round-nose tool. Here the tool can be traversed during the grinding, as well as swivelled about the pivot. The top view to the right is self-explanatory, that at the bottom shows one application in grinding the top rake of a straight tool. Instead of angling the tool in its slot, the adapter can be turned and set to 90 degs. Indeed, if top-side rake is required this would be the only way to do it.

The final illustration, Fig. 4, shows a few adapters for various purposes, such as dealing with round and revolving cutters. These latter are held on the draw in principle by means of a short knurled-headed screw spindle at the back. Regular types of split collets are used, or special slotted, split or solid holders for gripping flat cutters, to produce end-mills, as shown at the bottom of the illustration. The end-mill thus shaped can be transferred to its lathe, the spindle of which it will, of course, fit, with the assurance that it runs quite truly.

Enough has now been written on this interesting little contrivance of Mr. Fisher's for interested readers to devise for themselves an enormous range of applications of the tool, not only for grinding, but for milling, either in the lathe or on a milling machine table. In the latter application it is easy to see

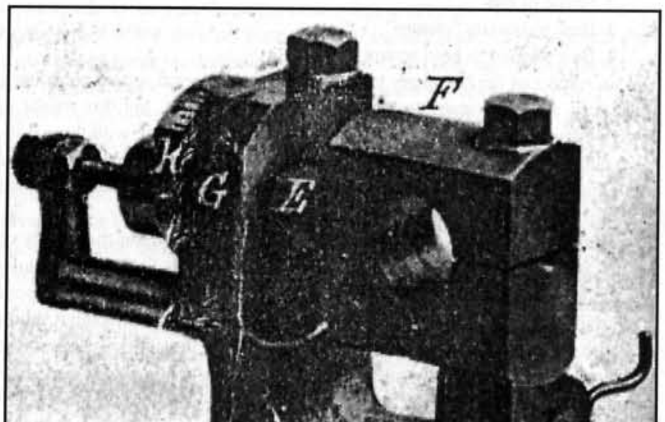


Fig. 2. Previous Type of Grinding Head.

that squares, pentagons, hexagons, octagons and so on can be easily produced upon round work by applying this jig fixed to a compound slide-rest and traversing the same over the front end of an end-mill chucked in the lathe. By adding a lever feed to a special adapter irregular and concentric cam faces could be milled upon cams mounted in split collets on the same. The ends of

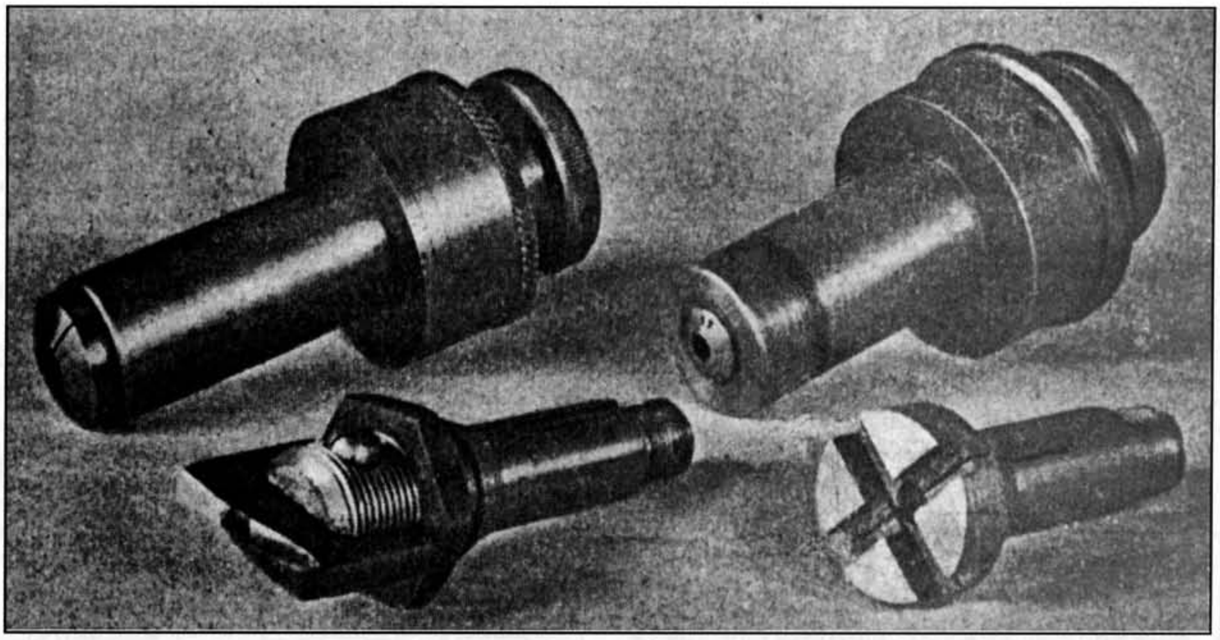


Fig. 4. Adapters for Holding Round Tools or Works, and for Holding End Mills.

similar fittings could also be milled to arcs of circles and so forth. It would, however, be advisable for an intending user to quite understand the geometry of that which he proposed to produce before applying it, because the whole accuracy of his result would depend upon the accuracy of the setting up.

Turning Ebony

A reader finds difficulty in turning ebony rulers. He states that he has tried everything he knows to stop chatter, and can do so up to 6 ins., but above that the work is badly marked. Presumably he means 6 ins. in length, but does not definitely state so. His queries are as follows:-

1. Speed in turning ebony.
2. Shape of tool.
3. How to obviate "chatter".
4. Best method to hold square lengths.

In respect of the last query he has tried a solid tapered square hole chuck (wood or metal not stated) with tailstock centre support, but this results in varying truth in the work. Also a solid box-wood face chuck with three driving pins projecting, one in centre and two eccentric, presumably a sort of rough and ready prong chuck. This tears round in the wood, or splits wood when it is being driven on, or pressed on by tailstock.

With respect to the first query, a good deal depends upon the quality of ebony used, because some of this wood, when very dry, is liable to split along the grain. As a general thing, all hard-woods are best driven at as high a speed as possible, consistent with keeping the tool point cool. At this stage it is best to state that in turning hardwood, especially ebony, the slide-rest should be employed. If an inch ebony ruler be in course of production, under these conditions, a speed of 360 to 400 r.p.m. should do, or, to put it more generally, a surface speed of 100 ft. per minute. The tool will probably stand a slightly faster speed, but if a treadle lathe be used and moderately deep cuts employed, this will be quite hard enough work. In finishing, where only scraping cuts are used, the speed may be increased to 130 ft. per minute.

Referring to query 2, for roughing out use an ordinary slide-rest cutter holder (such as the "Conqueror," or similar). The type of tool for getting the stuff off, an ordinary steel turning roughing tool, pointed and rounded on point. Twenty degrees front clearance, and increased to about 30 degrees top rake giving a cutting angle of 40 degrees. No side top rake, so that tool will cut both ways. A similar round nose tool for rough finishing, and a keen edged flat fronted tool, like a parting tool, say about ¼ in. wide, but contrary to practice in a parting tool having slightly rounded corners, for finishing.

"Chatter" is nearly always the result of insecurity in the fit of lathe mandrel, chuck fitting, slides of rest, or insecure setting of the tool. One or all of these may account for it. The first is the most likely. See that the mandrel bearings are gibbed right up and there is no end play because the pressure due to the tail centre, while taking up end play, only tends to increase any side play in the cone bearing of a wood turning lathe. Hardwood turning tools must be kept keen edged by the frequent application of an oil-stone slip, otherwise a dull cutting edge may account for chatter in the centre of long work, such as a ruler.

The best method to hold square stock is by means of a four-jaw independent chuck with the jaws in the "drill" position. That is with the long gripping edges in the centre. Sheath the point of the square stock in stout tin plate or sheet iron. Cut the plate a little less than four times the side of square by the depth of chuck jaws, and bend it to fit the work with an open joint at one corner. A number of these may be fitted to different sized squares, and preserved for repeated use. Having once set the chuck for a given size to run truly at the corner, the work may be removed by loosening two adjacent jaws only (say Nos. 1 and 2), and putting back the work with the same surface of square opposite the same jaw it came from, and tightening the two jaws originally loosened to the same intensity. The latter may be done by chalking the position of one corner of the square on chuck adjusting screws before loosening same, and seeing that they go back to this position.

In any case, do not drive ebony on to a prong chuck. Drill holes to take prong points or shape by means of a firmer chisel the indentations for the blades of a prong.

Workshop Topics.

The principal items appearing under this heading relate to work done and other matters dealt with in THE MODEL ENGINEER Workshop at 66, Farringdon Street, London, E.C.4.

There are few model engineers today who would contemplate making their own taps but for the very odd and special threads the skill is well worth having. Some years ago I was repairing a locomotive boiler and had to open out and tap a hole in the front tubeplate. Normally this would have been very straightforward but there was a pipe coming through the centre of the hole so I could not use a drill to open out the hole, nor a standard tap. I ended up making a combination taper reamer and tap which was hollow to accommodate the centre tube. This enlarged the hole and tapped it in one operation. The boiler being made of copper the tap was made of mild steel and case hardened. It did the job well.

Tap Making.

TAP making is an interesting series of operations throughout, till the maker has produced two or three. After this he will go back to buying them again. In short, the processes for any one tap are so limited, and require such care as to precision, that even the most enthusiastic tool maker is apt to tire of it. As a general thing, even now, standard taps are so cheap that it pays even the out-and-out home mechanic to buy them rather than make them. If, however, a special size tap is required, the opportunity occurs to turn one's energy in this direction, and profitably, because it is here that the reader will have to pay "through the nose" if he places an order for anything out of the ordinary.

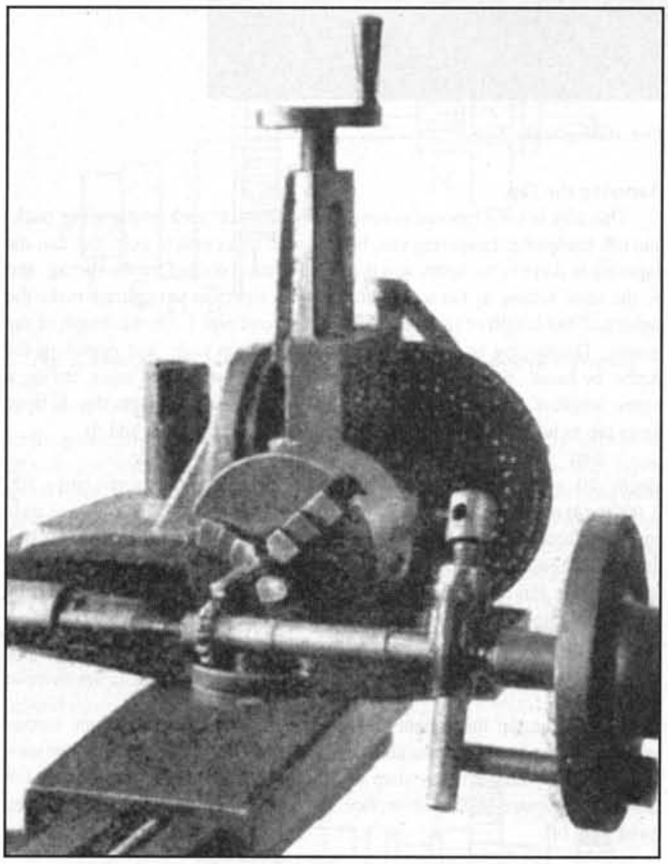


Fig. 1. Tap-fluting by Milling in the Lathe.

Start off with a piece of dead-size silver steel, or a piece a few "thou." over size - certainly not under; chuck this, and centre the outer end to be supported by the tailstock centre. It must, of course, run quite truly. Now screw-cut it, and, if a precision screw-plate be handy, run this once along, with oil. Failing which, the thread should be cut just under depth, and finished with a good chaser. Chase by hand a micrometer, leaving it, if possible, 1 "thou." over size, but parallel. Turpentine is a good lubricant to use, both for screw-cutting and chasing, especially the latter; but if not used in the screw-cutting, the same should be done dry, rather than use water.

Fluting the Tap.

The setting for this is given in Fig. 1, wherein the screw-cut tap is mounted, transferred from its lathe, chuck and all, on to the screw-nose mandrel of a vertical milling and dividing apparatus. The cutting is done by a small fluting milling cutter, mounted on a screw arbor between centres, and driven in the ordinary direction by means of a carrier. The dividing is effected by taking every 24 holes of the 96 circle of division plate, thus giving four flutes. It is essential in this setting that the vertical slide be set quite square with the lathe axis, and, for a plug or second tap, quite upright. In the case of a taper tap, it is advisable to set the slide leaning about one degree forward, so that the flute is a shade deeper towards the front. The effect of the latter gives a better appearance to the tap when tapered, and also gives a maximum of clearance space where it is most wanted. The chuck must run quite truly with its mandrel, otherwise the flute depths will not be constant for any one setting. The flutes should be made in two cuts of half depth first, taking all four flutes, and following with the full depth. The traverse is carried out by the cross-feed of the sliderest, and, to ensure that the cutter can go far enough along without touching the chuck jaws, for its centre to come opposite the inner end of thread, the job must stand far enough out of the chuck jaws in the first place, that is, when set for screw-cutting. The feed for depth is done by the vertical screw. The longitudinal traverse of the sliderest is used to get the tap axis vertically over the cutter axis plane, which, when satisfactory, the slide should be screwed up tight, and the handle removed to prevent accidental side movement of the tap. Upon taking a cut feed forward against the teeth of the cutter, and it is advisable to bear slightly down on the tap point with a piece of hardwood about 1 in. square, while the cutter takes the point and passes about halfway along the tap. This last prevents jar, and also obviates the tendency to throw the work off its cut, both due to the overhang.

Never try to take a cut with this contrivance unless the mandrel of the slide be locked by the clamping screw, which should be provided for this purpose. It is not safe to leave all the stress endeavouring to revolve the tap to be taken by the index of the division plate. Before starting make quite sure that the chuck is well home to its shoulder, otherwise the jar may loosen it on the nose, with the ill effect which we have already obviated by locking the mandrel, as mentioned just above. Never either start a job like this without first ensuring that the lathe centres are right home in their tapers. This is to avoid side movement of the cutter. Run the cutter by the slowest single gear speed of the lathe. To look well the flutes must be all the same length; having therefore advanced the tap for the first flute till the centre line of cutter is immediately under the shank end of thread, mark the top of cross-feed screw handle with a chalk mark, and carry all subsequent cuts to that mark. On no account put on a cut and traverse backward, because the cutter will gather up the back lash of feed screw, with several bad results. Always traverse back on the cut just taken; it is not necessary to withdraw the feed. See that the tap point is well clear of cutter before indexing for another flute.

Size of Flute and Cutter.

The size of flute, as to width, should not be guessed by its appearance. This is very deceptive. In round figures, take a width of about 2-3rds of the tap circumference covered by a flute and its corresponding thread ridge. The circumference is 3 1-7th times the diameter, but the multipliers 3⅙, 3 1-7th, 3⅛ and 3 1-9th can all be used, and give near enough results, and may avoid close figures, as note the following: - Our tap is

9-32nds in. diameter. This multiplied by 3 1-9th equals 28-32nds as the circumference. Divide this by the number of flutes (four), and we have 7-32nds, covering a flute and its ridge; 2-3rds of this is nearly enough, 5-32nds in. bare as the width of flute.

Use that size half-round cutter if possible. We used a 3-16th in. half-round cutter, but only fed it in deep enough to give a flute width of 5-32nd in. bare. This gives rather a shallow flute, but the tap has a fine thread (32 t.p.i.), which suites the depth obtained. If a deeper flute is required, a 5-32nd in. half-round cutter would give it nicely. The size of cutter used is ⅞ in. in diameter, but anything up to 1¼ ins. will do for the lathe speed given.

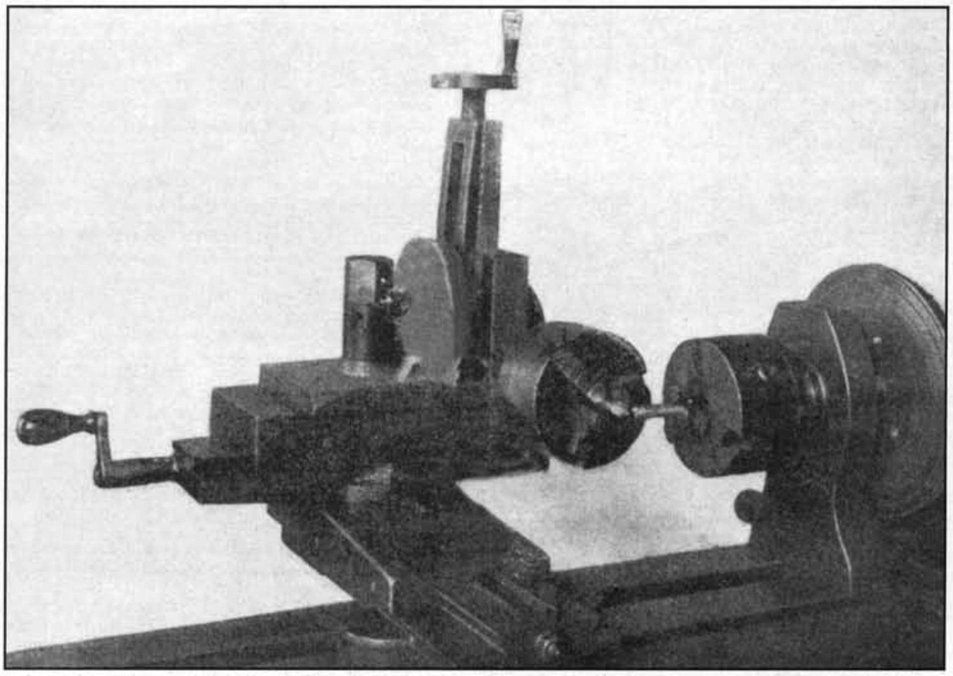


Fig. 2. Squaring the tap Shank by End Milling in the Lathe.

Squaring the Tap Shank.

Fig 2. shows this operation, in which the same setting of slide is used, but the tap is reversed in the chuck, leaving only about twice the length of square required projecting. The milling is done by a long end-mill held in the chuck, and made, in this case, from a broken centre drill. A note in this column, on page 98 of Vol. XXIII (August 4, 1910), describes how to make them; but an ordinary end mill will do the job if anything better. It must at least be of equal diameter to the tap shank, and larger if possible. Why the end mill has to be set out from its chuck a long way is so that the chucks will not conflict. Mark a circle on the tap shank where the square should end, and mill the first face up to it and mark the screw as described before for the fluting, and carry all four sides to the same point. The work must be set exactly level with the lathe centre, and the milling will end with a rounded shoulder, the wings of which can be filed to the circle afterwards.

As to the size of square, the ratio of the shank diameter to the flats of a square which will just fill it is as 7 to 5, but this results in a square having sharp corners. The usual practice is to make a square to the ratio of 5 to 4, which leaves rounded corners. If, therefore, we are squaring a tap having a shank 5-16ths in. diameter, the flats of the square will be 4-16ths or ¼. Mill the first side till the measurement from the rounded side equals half this variation; that is, till it measures 9-32nds by micrometer, and then cut all the other sides to that setting, and the result of the square will be near enough. In the case of our tap, which had a 9-32nd in. shank, the resultant square came out very nearly 7-32nd inch. The measurement for the first cut was so that it measured ¼ in. from the rounded side, and the result was very close to size.

Tapering the Tap.

This note is not supposed to cover the hand work, such as stamping, backing off, hardening, tempering etc., but it would be as well to point out that the tapering is done in the lathe, and is as well carried out before the fluting, and to the same setting as the screw-cutting. If a taper tap is required, make the taper half the length of the screw, and if a second tap, 1-5th the length of the screw. The turning is done by setting over the top slide, and operating the screw by hand. Suppose we have a ¼-in. Whitworth tap to taper, having a screw length of 1 in., the taper will be ½in. long and in this length should taper from top to bottom of the thread. The thread is 20 per inch, and its depth $\frac{640}{20} = 32$ thousandths. The angle then is 32 in 500, there being 500 1,000ths in a ½ inch; near enough 1 in 16. This corresponds by a table of cone angles, to about 3 3-5ths degrees, which set over. Now, with the saddle locked, feed in the tool till it just touches the crest of the thread at the point of the tap, and, making this the zero carry the cut from this point to a shade over the depth of the thread, so that at the extreme point the thread groove is just cut away. This will taper the tap to nearly enough half its thread length.

Hardening.

Harden the tap throughout and, after having tempered it for the cutting edges, draw the square portion and upper end of shank, down nearly to blue temper, otherwise this part may snap off in use. It should, however, not be left soft at the square end as it is then likely to twist at the square, or even twist right off.

Small Machine Shop Calculations. - V.

By Hubert Bentley, A.M.I.M.E.

Shaping and Slotting Machines.

IN THIS concluding article it is proposed to deal with the calculations involved in the shaping and slotting machines. Usually one or more examples of both these machines are to be found in the majority of engineering works. The large variety of work that can be accomplished upon same makes them especially useful in the small repair shops. There is, of course, a similarity between the two machines; in both cases the tool is reciprocated backwards and forwards across the work, in the shaping machine in a horizontal direction, while in the slotting machine the movement is vertical.

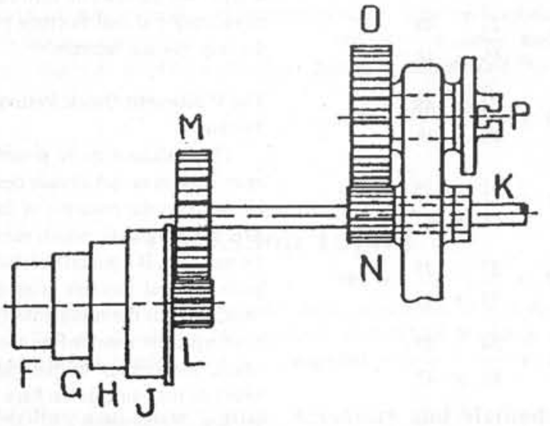


Fig. 1. Arrangement of Cone and Gearing on a Double-Geared Traversing Head Shaping Machine.

Shaping machines may be divided into two classes, viz., the traversing head or British type and the pillar or American type. This latter class has been taken up by many British manufacturers during recent years. In the traversing head machine, in addition to the reciprocation of the tool ram, there is also an end movement or traverse along the bed of the machine itself. In the pillar type machine there is no endwise movement of the tool ram, the feed or traverse in this case being given to the table of the machine. This latter type, while more compact and convenient to operate than the other machine, has not quite the same range of usefulness. In the slotting machine, the feeding or traversing motions are all connected to the machine table, the tool ram having simply an up-and-down movement.

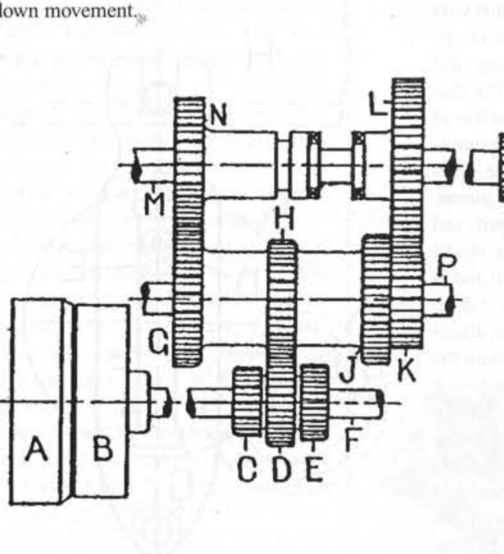


Fig. 2. A six-speed Gearbox for Shaping Machine Drive.

While the cone type of drive has been retained on these machines, perhaps more so than on other types, there is now a considerable movement in the direction of all-gear driving, as well as the adoption of the electric drive. When motor-driven, the motor is usually mounted on a bracket or a foundation plate secured to the machine, and the subsequent drive is either through chain and sprocket wheels, spur gearing or direct to a suitable gear-box which in turn is geared up to the machine. It will be noticed that both these machines usually embody a flywheel in their design, the object being to balance the cutting and non-cutting strokes. The flywheel is not embodied in the pillar type machines, and even on some of the later examples of the other types the flywheels have been dropped where the weight of the flywheel had very little effect in balancing compared with the weight of other rotating parts. The flywheel is very useful when stroke setting on either the traversing head shaping machine or on the slotting machine, and no doubt this accounts for many firms still retaining the fly-wheel in their designs.

As the cutting speed is a variable quantity in crank-driven machines, ranging from zero at the end of the strokes to a maximum at the centre, it is usual to give the number of cutting strokes per minute instead of the cutting speed. The method of obtaining the quick return is described later in the article. The feed of either the carriage or the table is expressed as a fraction of an inch per cutting stroke. The number of speed changes on these machines usually range from four to eight, while the rates of feed may vary from four to six.

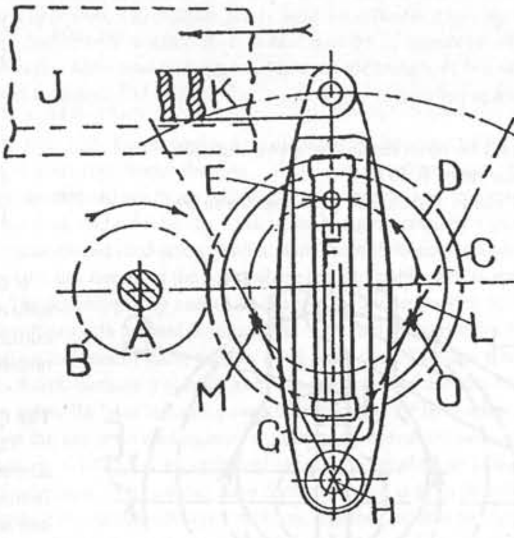


Fig. 3. Slotted Link Drive of Quick Return Motion.

Shaping Machines.

The shaping machine may be almost described as a short-stroke planing machine, though in the planing machine the tool is stationary while the work reciprocates, whereas in the shaping machine the work is stationary while the tool reciprocates. Each type of machine is for the production of flat surfaces, the work of the shaper being of smaller dimensions than that to be found on the planer. In the traversing head type of machine the action is as follows, viz.:- The driving cone operates, through gearing, a shaft which runs the length of the bed of the machine. On this shaft is a pinion, which while keyed to the shaft can move endwise with the shaper carriage, and this gears with what is usually known as the stroke wheel. The stroke wheel is slotted and carries an adjustable die which engages with the link, which is secured at its top end, either direct to the tool ram or to connecting rods which are themselves secured to the tool ram. Rotation of the stroke wheel gives a to-and-for motion to the link and the tool ram. By altering the position of the die in the stroke wheel any length of stroke from zero to the capacity of the machine can be obtained. In some designs a stroke disc is used for driving the link, in which case the stroke wheel would be keyed to the disc and take its motion from the back-shaft pinion as described above. It is also possible by means of a slot that is provided in the top of the ram to obtain a variety of positions for the various lengths of stroke. Reference to Fig. 1 shows the arrangement of the cone and gearing on a double-geared traversing head shaping machine, and if the following information is known the cutting strokes per minute can be readily obtained:- Speed of countershaft 400 revolutions per minute. Four-speed cone

B C D E on countershaft has 11 ins., 9½ ins., 8 ins., and 6½ ins. diameters, while the machine cone F G H J has the same diameters in a reversed order. K is the backshaft, which runs the length of the machine. L is the cone pinion and has 15 teeth, while the backshaft wheel M, which gears with this, has 50 teeth. The stroke pinion N, which is keyed to the backshaft, has 15 teeth, and this drives the stroke wheel O, which has 45 teeth. The revolutions of the stroke wheel O will also be the number of the cutting and return strokes of the rams, which gives the reciprocating motion to the tool. P is the stroke disc. The above dimensions are from a 10-in. stroke machine, and the four cutting strokes per minute would work out as follows:-

$$(1)\quad 400 \times \frac{11}{6\frac{1}{2}} \times \frac{15}{50} \times \frac{15}{45} = 67$$

$$(2)\quad 400 \times \frac{9\frac{1}{2}}{8} \times \frac{15}{50} \times \frac{15}{45} = 47$$

$$(3)\quad 400 \times \frac{8}{9\frac{1}{2}} \times \frac{15}{50} \times \frac{15}{45} = 33$$

$$(4)\quad 400 \times \frac{6\frac{1}{2}}{11} \times \frac{15}{50} \times \frac{15}{45} = 23$$

cutting strokes per min.

It should be observed in the above example that the gear ration is 10 to 1.

Fig. 2 shows a six-speed gear-box driven by fast and loose pulleys and suitable for taking the place of the speed cone in the last example. The pinion O will replace the pinion L in Fig. 1, so that if the speeds of the gear-box are calculated and these speeds are multiplied by the gear ratio of the machine gears we shall obtain the various cutting strokes per minute. For example: - If the fast and loose pulleys A and B make 600 revolutions per minute (the loose pulley is turned rather smaller in diameter to reduce the tension on the belt when the machine is running light) and the nest of gears C D E on the first shaft F have respectively 24, 31 and 27 teeth. These gears are slidable on the shaft, so that they can mate with their corresponding gear on the second shaft P. The gears on the second shaft are G H J and have the following teeth:- 38, 41 and 45. A fourth gear on this shaft K has 25 teeth and this is always in mesh with L on the top shaft M of the gear-box. N is another gear on this shaft which can be slid into or out of mesh with G and moved along the shaft so that the clutch teeth engage the clutch teeth in L when this latter wheel becomes the driver. The clutch wheel N is keyed to the top shaft, while L runs loose and only drives the top shaft when the clutch teeth are brought into contact. Wheels L and N have 47 and 48 teeth respectively. The six speeds of the gear-box would be calculated as below:-

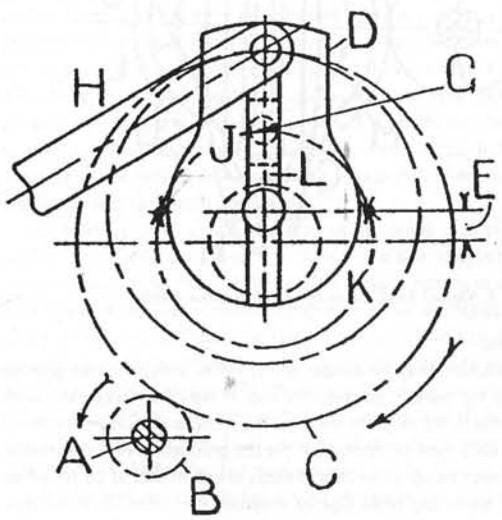


Fig. 4. The Whitworth Quick Return motion.

$$(1)\quad 600 \times \frac{D}{H} \times \frac{G}{N} = 600 \times \frac{31}{41} \times \frac{48}{48} = 450$$

$$(2)\quad 600 \times \frac{E}{J} \times \frac{G}{N} = 600 \times \frac{27}{45} \times \frac{48}{48} = 360$$

$$(3)\quad 600 \times \frac{C}{G} \times \frac{G}{N} = 600 \times \frac{24}{48} \times \frac{48}{48} = 300$$

$$(4)\quad 600 \times \frac{D}{H} \times \frac{K}{L} = 600 \times \frac{31}{41} \times \frac{25}{47} = 235$$

$$(5)\quad 600 \times \frac{E}{J} \times \frac{K}{L} = 600 = \frac{27}{45} \times \frac{25}{47} = 190$$

$$(6)\quad 600 \times \frac{C}{G} \times \frac{K}{L} = 600 \times \frac{24}{48} \times \frac{25}{47} = 160 \text{ r.p.m.}$$

If these six speeds are divided by the ratio of the gears on the machine the six cutting strokes per minute will be obtained.

The Quick Return Motion.

The two principal methods which are adopted on both shaping machines and slotting machines for returning the tool ram at a greater speed than on the cutting stroke are (1) the slotted link drive, (2) the Whitworth drive. Combinations and modifications of both these are occasionally met with and they are designed to give a more uniform and constant cutting and return speed to the ram. The diagram (Fig. 3) shows the outline of the slotted link drive. A is the backshaft, which is rotated by the gears at the bed end, and B is the pinion, which is keyed to this shaft and moves with the carriage. C is the stroke wheel, which engages with the pinion and is attached to the slotted disc D. A bolt E, which fits the link block F, can be secured in different positions in the slot, in order to obtain the different lengths of stoke. G is the link, which is pivoted on a stud H supported by the machine carriage. As the stroke disc rotates the link block moves up and down in the link slot and, of course, causes a backward and forward movement to the link and also to the ram J, which is connected by the link by connecting rods K. The path of the link bolt circle is shown by the circle L and the points lettered M and O are the points of reversal. It will be observed that considerably more than half the revolution is taken up with one stroke and considerably less than a half revolution with the other. From the arrows which indicate the direction of movement it will be seen that the larger portion is taken up with the cutting stroke so that the return stroke is made at an increased speed. It varies a little according to the length of the stroke and usually ranges from 1½ to twice the speed of the cutting stroke. At the end of the strokes the speed is zero, and the tool is generally clear of the work. At the centre the cutting speed is at the maximum and this may be calculated by multiplying the revolutions per minute of the stroke disc by the circumference of the link bolt circle in feet and by the ratio of the two arms of the slotted link formed by the connecting rod and fulcrum pins and the link bolt and fulcrum.

The Whitworth Quick Return Motion.

This mechanism is preferred by many makers to that already described. Fig. 4 shows the principle of the drive. A is the backshaft, which runs along the machine, B a pinion slidable on the backshaft and movable with the carriage, and C is the stroke wheel. D is a plate which is mounted on the stroke wheel, the centres of the plate and wheel do not coincide but have a small amount of eccentricity E. Motion is transferred to the plate from the stroke wheel by a bolt and block G, which works in a slot at the back of the plate. The variation in the length of the stroke is made by adjusting the connecting rod H in the slot L in the face of the plate. The nearer the rod joint is moved to the centre the shorter the stroke that is taken. The connecting rod H is attached to the tool ram. A careful study of the diagram will show how the quick return is affected. The block G has a uniform motion, but

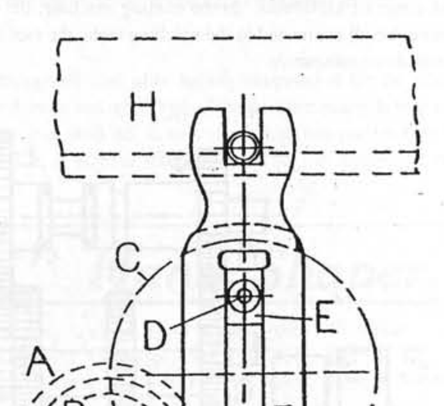


Fig. 5. Drive for a Pillar Type Shaping Machine.

it moves through considerably more than half a revolution in bringing the tool ram to the ends of its stroke (cutting stroke), so that if the return stroke is made in less than the half revolution, it follows, seeing that both strokes are equal in length, that the return stroke must be taken at an increased speed. The respective travels for the cutting and return strokes are indicated by K and J in the diagram and the direction of movement is shown by the arrows. It is usual to mount both the wheel and the plate on a suitable sleeve, which is also supported by the shaping machine carriage. In the position shown in the diagram the ram would be on its return stroke. As in the last example on the full stroke, it is possible to get a quick return of 2 to 1, while on the shorter strokes the ratio is rather less. In both slotting machines and shaping machines it is not unusual to find both mechanisms combined, and a more uniform cutting stroke and increased return speed is then possible.

Fig. 5 shows the drive for a pillar type shaping machine. In this example for a short stroke machine there is only one set of gears In the larger machines a double reduction is usually employed. The drive may be either by speed cones, as shown in the drawing, or by means of a gear-box or motor drive. In some cases a variable speed motor drive is used and this, of course, dispenses with the gear-box. But this generally applies only to the smaller type machines, as the range of speeds to be obtained from a variable speed motor is limited. The more usual way is to drive to a gear-box, which may be mounted on a bracket or foundation plate either direct by gearing or through chain and sprocket wheels. Referring to the drawing, A is the driving cone and B a pinion mounted on the cone shaft, while C is the stroke wheel, which carries the link bolt D, which operates the sliding block E in the slotted link F. The link is pivoted at G and at the top is connected to the ram H. The method of calculating the cutting strokes will be quickly understood. For example, if the three speeds of the cone are worked out in the usual manner and found to be 300 and 210 and 120 revolutions per minute, and the gears B and C have respectively 18 and 108 teeth, we should proceed first to find the gear ratio.

Gear ratio = $\frac{18}{108} = \frac{1}{6}$ or 6 to 1. If we now divide the three cone speeds by the gear ratio we get the cutting strokes per minute, viz:-

(*a*) $\frac{390}{6} = 50$ *b*) $\frac{210}{6} = 35$ (*c*) $\frac{120}{6} = 20$ cutting strokes per minute.

An advantage of some importance connected with the pillar type machine lies in the fact that the stroke can be altered while the machine is running. This is usually accomplished by a handle at the side of the machine, which turns a shaft connected to mitre gears on a screw which is in engagement with the link block inside the machine frame. In the transversing head type machine it is necessary to go round the back of the machine to alter the stroke.

January 5, 1922.

I doubt it there are many readers with a Wheeler milling accessory in their cupboards, but I know many model engineers enjoy making fixtures and fittings to assist their model making. I hope that this article gives a few ideas and perhaps we may see an example or two at a future Model Engineer Exhibition.

Workshop Topics

The principal items appearing under this heading relate to work done and other matters dealt with in THE MODEL ENGINEER Workshop at 66, Farringdon Street, London E.C.4.

A Milling and Gear Cutting Accessory and Methods of Using it.

WE HAVE in the equipment of THE MODEL ENGINEER workshop, a particularly interesting and useful lathe attachment, in the form of a general milling accessory, which is made and sold by The Wheeler Manufacturing Co., Ltd., of Trench Crossing, near Wellington, Shropshire. This tool, or, rather, set of tools, is so complete, and has such a range of uses, that it would be to the reader's advantage, not only to have his attention called to it, but also to use, in this column, such settings of the apparatus, as occur from time to time, in the practice of the workshop to enlarge upon the matter of milling in lathes. There has of late been quite a lot of inquiry correspondence in relation to gear-cutting, and, in this connection there appears to be information wanted upon bevel-gear-cutting particularly. Therefore, parallel with these matters, the present writer proposes dealing with the subject of set-out and gear-cutting bevel wheels, wherein both this and other attachments we have in the workshops will be called into use. For the moment, however, we will confine ourselves to the "Wheeler" attachment and some of its applications.

Fig. 1 shows the equipment as we have it, and Fig. 2 a dissembled view of the milling head, given in order to make the first illustration more clear. In Fig. 2 is seen, to the left, the vertical slide, consisting of a hollow tubular upright casting with base piece, or foot, in one. The foot is 5½ ins. but 2¾ ins. planed on the base square with the upright, and is pierced with three slots for adaptation of bolts to the slots of a boring table. The upright carries on the front, and projecting clear of the foot, a machined vee slide for the vertical saddle. The tubular upright does duty to house a long bolt, making a fourth attachment to the boring table, and one which has the particular duty of taking up the stress on the upright, so that it is held free from vibration. This is an excellent point, because, in milling operations, anything which takes up tremor and vibration has two cross tee slots, and is 5½ ins. by 4 ins. wide, being operated by a substantial 10 t.p.i. square-thread feed-screw, which, with the slide capacity, allows of a traverse of 3½ ins. rise from the point where the adjustable strip is level with the base. The adjusting strip cannot be seen in the photo, as it is on the further side, but it projects top and bottom about ¼ in. and thus provides 6ins. of flat bearing on the vees of slide; another good point this. The total traverse of the table is 4⅞ins. because it is enabled by the projection of the vees to pass down 1⅜ ins. below the base before it passes off the end of the feed-screw. The feed-screw at the top is divided against an index line to ten divisions, giving feed distances in 1-100ths of an inch, and allowing of reading to half hundredths by sight division. We however have further divided ours to 50 sub-divisions, thus getting two-thousandths per division, and thousandths by sight division; and we think that the makers should follow suit here, because this means of

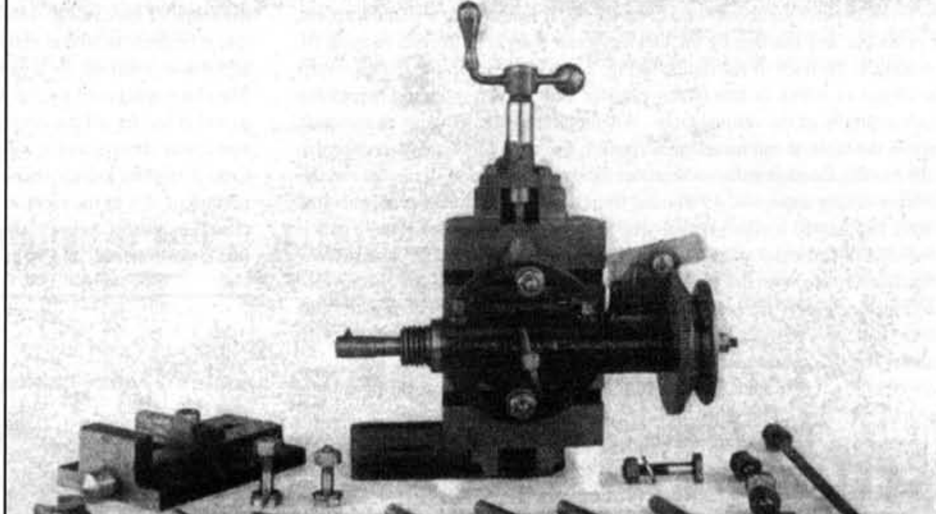


Fig. 1. The Wheeler Manufacturing Co.'s Milling Attachment and Cutters.

fine measurement is particularly useful in depthing gear teeth. Thus far the accessory is a vertical milling slide, and later we will show and describe a simple setting on the same for slot milling, a job where the job is clamped directly to the vertical table.

To the left at the back of Fig. 1 is seen a machine vice. This also is part of the equipment, and it is intended for attachment to the vertical table for holding such work as is more suitably gripped by a vice. The vice is set on the table with its length vertical and then the four-bolt holes tally with the slots. Two of the tee-bolts are seen by the vice, the other two being in use to attach the rotary milling spindle, which is also mounted in the same illustration. The vice has jaws 2 ins. wide by 11-16ths in. depth, the movable jaw being capable, by the usual swivel, of adapting the grip to work out of parallel. The traverse allows of an opening of 2¾ ins., and it will be noted that the jaws may be either at the foot or top of the table. A tommy seen in front of the vice is provided for its operation.

The next point is the milling spindle, in position in Fig. 1, and showing its back view in Fig. 2, to the right. The casting of this is a swivelling flange, carrying diametrically across the front a long cast-iron bearing, as much as 5½ ins. in length. Within the bearing is mounted, an excellent running fit, virtually a hollow lathe mandrel. This mandrel is ¾ in. parallel diameter, and bears evenly in the whole length of the bearing. It is equipped with a thrust shoulder at the front, and a 1-in. Whitworth-threaded shouldered-nose for attaching chucks. Further it is bored No. 1 Morse taper at the nose end, and is ⅜ in. full parallel bore throughout, so that, not only can long work up to this diameter be chuck mounted, but also such No. 1 Morse taper adapters as are provided can be drawn in by a special nutted stud, also part of the equipment.

One of the Morse adapters is apparent mounted in Fig. 1, and this, in common with the others, is tapped ¼ in. Whitworth centrally up the inner end. By the draw-in these adapters are all rendered positively driven in either direction, as it is extremely unlikely that this form of attachment would shake loose, having a taper of 1 in 20 pulled in tightly as described. Upon the tail of the mandrel is a pulley for driving the spindle and division wheel combined, firmly attached by a sunk grub-screw with internal hexagon control. The division plate 3½ ins. diameter is cut to 120 notches (which would be better numbered in groups of ten), and stands inside the pulley in such position that it can be indexed, and also held, by a knife-edged bar, particularly solidly mounted in a long slot, and swivelling therein on a pin in and out of register with the plate. When the spindle is being used for rotary cutting, or rather carrying the rotary cutters, the edged index is held permanently up out of register by a knurled-headed taper pin, on the withdrawal of which the blade goes automatically into register by the action of a spiral spring acting upward under its tail. In conformity with the two actions, rotary and divisional, there are provided oil cups for the necessary lubrication and a locking-screw - seen with a tee head in the centre of flange in Fig.1 - for firmly holding the mandrel rigid, in addition to the wedging action of the knife edge in the notches of the division plate. The only point where the mandrel does not bear in its bearing is under this locking screw, where, for about ½ in. of its length, it is turned to a shallow recess, in order that any marring by the locking screw does not affect its running fit. Looking at the back of the flange in Fig. 2, we see a pip in the flange centre, the object of which is that it may register with a corresponding depression made centrally of the vertical table. When therefore the flange is so mounted, face to the table, it can be securely fixed to the same by the bolts in the table slots passing through radial slots in the flange and nutted at the front, and any position within a range of 45 degrees from the horizontal can be given to and firmly maintained by the spindle. The angular position of the spindle axis is read off from an index mark on a projection at the top of flange, and running round a divided arc on the table, marked out into ten degrees, and sub-divided to single degrees. When we say that this spindle has thrust faces at either end, and mounted as described, with no end shake, and can be used upon its vertically adjustable mounting as a supplementary parallel or angular mandrel, it will be realised that there are possibilities in this attachment covering supplementary turning and eccentric drilling as well as milling of all kinds. In fact, it opens up the avenue to many complex turning operations which would take time to think out, and machining operations which probably could not be effected in any other manner than by a special machine.

Returning to the smaller details in Fig. 1: To the right are to be seen the fixing bolts, showing the long one at the outside. The four taper-shank tools in the mid-centre are, respectively, from the right, a tee-slotting or edge-slotting cutter, an end and side mill, an end and vee-edge mill or angular cutter, and an edge-fluting mill, all of which have the ¼ in. Whitworth tapped shank

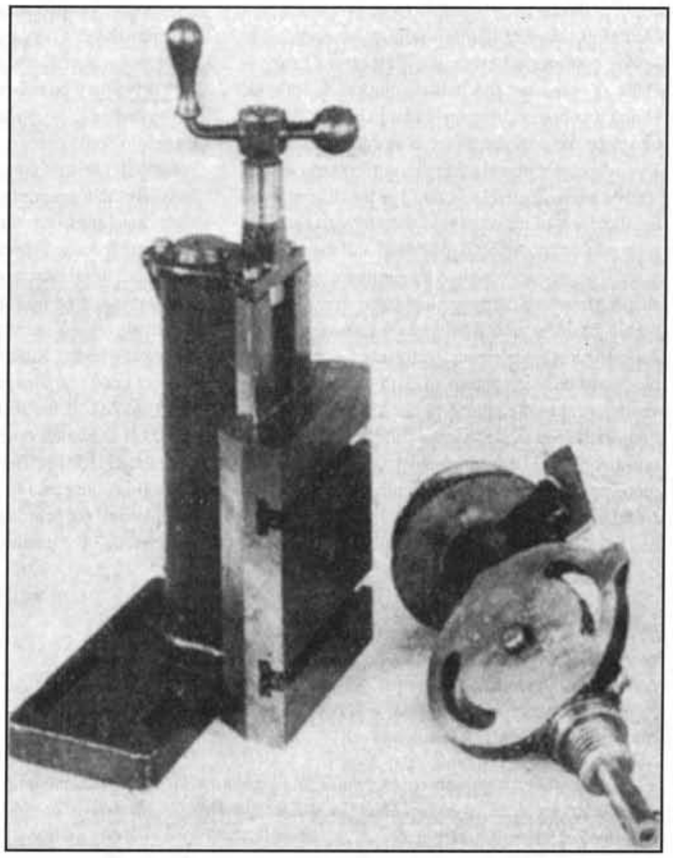


Fig. 2. The milling head dissembled and vertical slide.

for drawing in. The next in order is a taper-shank screw arbor for taking circular cutters by nut attachment. The final adapter is in the spindle, and this is a fly-cutter holder wherein gear or other fly-cutters can be mounted held by a flush grub screw in the end, having internal hexagon control, the key for which lies in front of the picture. The single-ended spanner fits all the nuts in the set with the exception of the draw-in stud. For the present this completes the description of the plant, and future note will explain some of the uses of the various cutters and will also describe a gear-cutting job we have carried out.

Fig. 3 shows the setting up of the contrivance for one of the simpler milling jobs, viz., slot milling a special casting, the application of which will form subject matter for other notes in this column. Fig. 4 shows, to the left, the shape of the casting, which is about ½ in. thick, in cast iron. It is essential that it be made to swivel about a stud centre at point *a*, and be attached in two adjustable positions by means of a sunk cheese-head screw in a radial slot. The slot *b* was cored for the purpose, but it is not cut radially about the centre *a*, and is too far off the centre of the casting for the particular job. The position *c* was chosen, and it was decided to cut a straight slot, and afterwards to form it slightly kidney shape to conform to the radial action. The top cross section of slot to the right in the Fig. shows the shape. It is to be of size to clear a 3-16th-in. screw, by 5-16th-in. cheese-head, and therefore requires two lots superimposed, and with a flat shoulder, both slightly wider than these

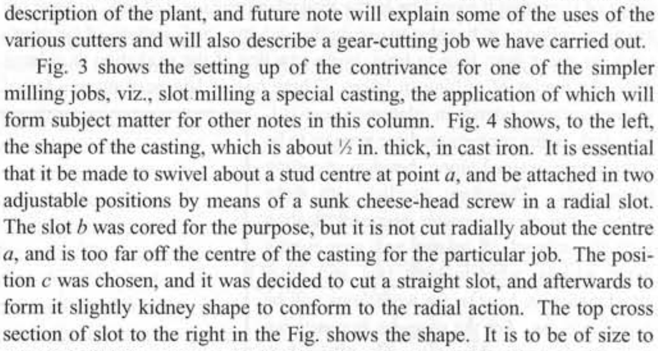


Fig. 4. The casting to be machined.

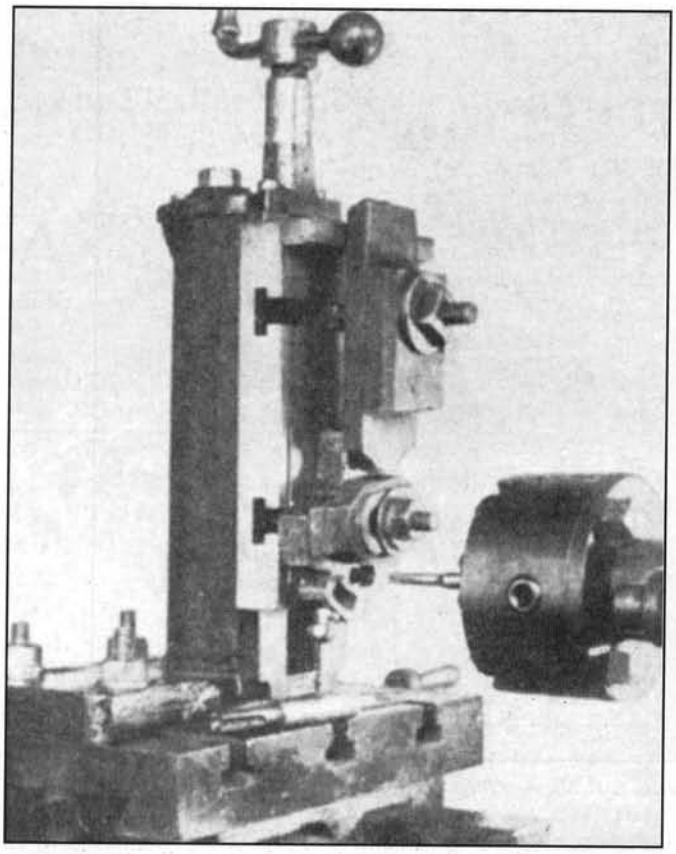


Fig. 3. The wheeler attachment set up for milling in the lathe.

dimensions. The slot was marked off first, and the end centres driven deeply. At these centres compound holes were drilled, first with a 21-64th-in. drill, shallow, and followed on concentrically with a 3-16th-in. clearing right through. The two holes were as the middle section shows. The actual drilling of the first hole is rather important, as shown in the enlarged section at bottom to the right. The finished depth *d*, to the shoulder is 5-32nd in. full, but the lips of the large drill must not enter to this depth or the shoulder at the ends will be sloping. If the first drill is entered to a point depth D, which is about 3-16th in., it then leaves a sloping shoulder sloping above the actual finished depth, which depth is cut out square to the dotted lines by the larger end mill. This part of the milling has to be done end on, which is not good for an end mill, as such a tool is not a drill. But in this case, the middle being cleared by the smaller hole, the end mill was easily made to shoulder up just the ledge. Reverting to Fig. 3, we see the vertical slide mounted by its bolts to the cross boring table, and with its table facing square to the axis of the mandrel of a 3½ in. lathe. In this position it has the compound movement of the lead screw and cross-feed; the first to put on the cut, and the second to traverse across. In addition the vertical slide places the work exactly to the height to register with the cutters, which are mounted in an ordinary self-centring chuck on the lathe nose. The cutters used are of high-speed steel, parallel shank, and double-ended with four cutting edges. They are ex-Government stock and can be bought at as low a price as 3d. per end. Both cutters are about 10-1,000ths undersize, which is a good fault. At this stage the reader may inquire: why an expensive third slide when a job like this can be clamped directly to an angle-plate on the boring table? If, however, he does much setting up for milling he will find that the exact setting to tally with a cutter is a matter likely to absorb much time and patience. Milling cutters are such rapid-cutting tools, and so accurate to the setting, that, before one is aware, they have removed a body of metal from just where it is needed, and left a corresponding quantity where it is unnecessary, and maybe is an obstruction. To do good milling a setting to a thousandth of an inch is more often than not necessary, because one does milling generally to quite as close limits as this. The effect of the vertical slide to enable rapidity of exact setting is such a feature in actual practice that when the critic becomes an actual user, he will soon admit the great advantage of a vertical adjustment.

As seen in Fig. 3, the main clamping is done by a slotted saddle clamp bolted through the opening in casting, and with the clamp close down on to the point of operation. The drilled holes are set sufficiently parallel to ensure that the smaller mill enters and passes through both holes, when either is traversed in front of it. The mill must of course run truly, or it will slot oversize. Here the undersize of the cutter is an advantage, as allowing a limit for inaccuracy in this respect. A thin sheet of copper or brass is placed under the work to admit of milling right through without cutting the table. As soon as the job is thus accurately set, the top clamp is added to give additional solidity and to avoid the work swivelling on its main clamping bolt under the vibratory effect, always apparent in milling. The actual cutting of the slot is done first by the big mill, which is depthed by noting the number of revs. of the lead screw from the point when the mill is level with the face of work. As the depth was 5-32nd in. full, and there are eight t.p.i., it required just over 1¼ revs. to get the necessary depth. This is, of course, done in a series of cuts, say five of 1-32nd in. depth each, or a quarter turn of the screw. The cutters ran at several hundred revolutions per minute and the actual milling took only a few minutes to do. In order that the bottom should be curved after each slot was milled straight we raised the vertical slide slightly and milled a series of cuts at short and then shorter traverse which effected the bottom curvature, but left the top straight.

A good way to do radial slot milling where the slot is long, and cannot be made straight in the first place, is to mark off the slot and drill the end holes, then mount the job on the faceplate concentric with the radius centre of slot. Then use the cutter in the rotary spindle mounted on the boring table, and having an independent drive. Traverse is effected by pulling round the lathe on double gear. The mandrel must be adjusted firmly.

May 18, 1922.

Model Engineering Equipment and Supplies.

A Review of Current Technical Progress.

3¼-in. Centre Bench Precision Lathes

Mr R. H. MORSE, of 26 and 27, Elder Place, Brighton, manufactures a most interesting line of precision lathes, one of which he had on show at the M. E. Exhibition. This machine is a regular, heavy pattern bench lathe, of precision quality, at quite a nominal price, which is £20 complete. Fig. 1 is an illustration of it, and from this it will be seen that it is a tool of capacity, especially in the matter of the slide-rest. The headstock

I include this for two reasons. Firstly, Brighton is my home town and it is nice to include machinery made on the sunny South Coast. Secondly, the design for the shaper is very, very similar to the Leyland, Barlow & Co. machine shown on page 8. As Leyland, Barlow introduced their shaper in 1905 perhaps the design had lapsed or the company had ceased trading by 1922. R. H. Morse is probably better known for his building and restoration of large gauge steam locomotives. He later located to his house at Woodmancote, a village just outside Brighton.

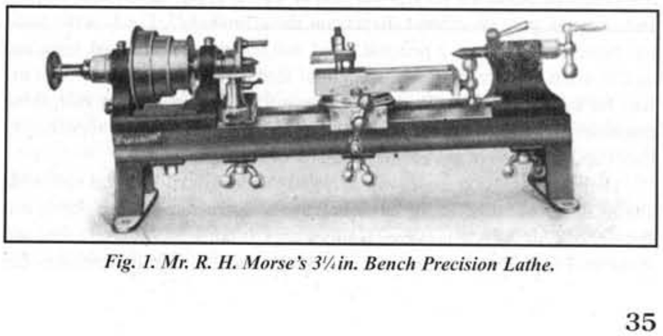


Fig. 1. Mr. R. H. Morse's 3¼ in. Bench Precision Lathe.

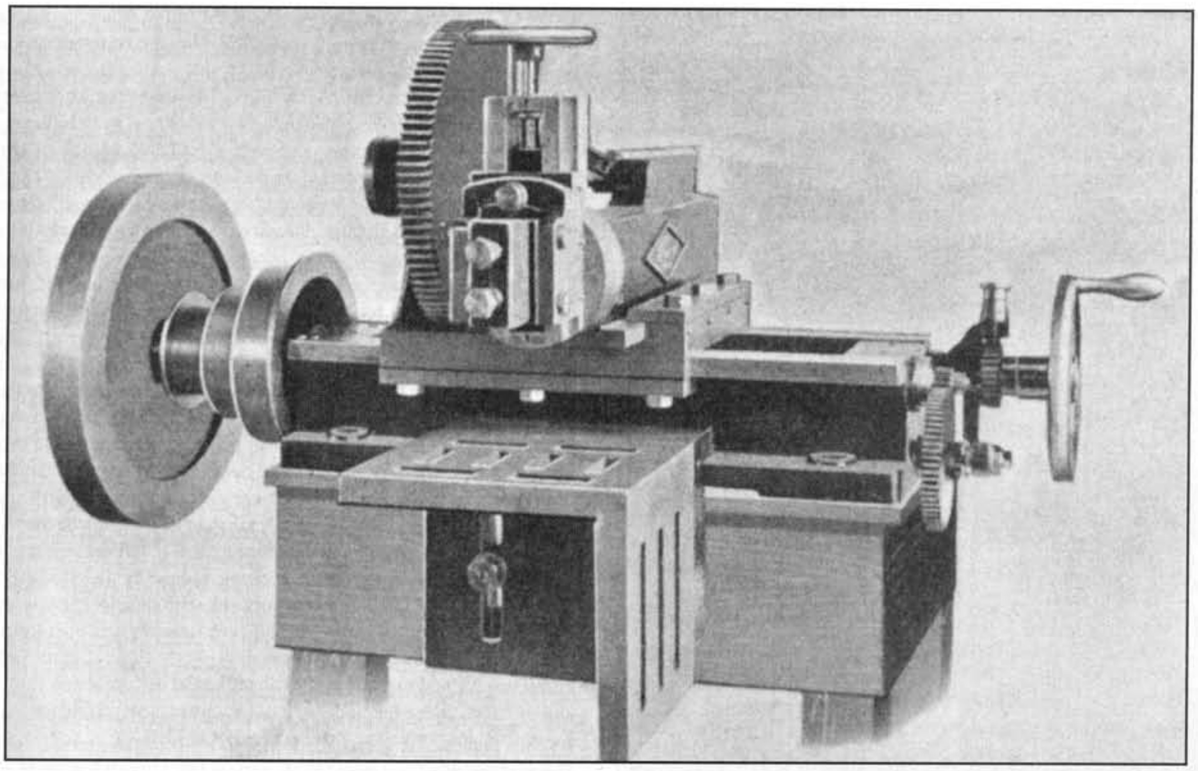


Fig. 2. A solidly built power shaper, by R. H. Morse, of Brighton.

is or particularly massive design, and has long, special bronze bearings, which are adjusted by lock rings. The lubrication is effected by wick feed, and the running surfaces are therefore kept well oiled for high speeds, and are, at the same time, protected from dust.

The tailstock is of proportionate design, having a full 2-in. traverse to the 11-16th-in. diameter steel spindle.

Particular note should be taken of the slide-rest, which has no less than 5 ins. travel, and the convenient form of tool clamp can be used at any point in a slot in top-slide running the whole length of it.

The form of the bed, with a front raised vee and back flat surfaces, adds to the general rigidity. It is 28ins. long, and allows 12 ins. admitted between centres.

Other dimensions are: Bore of mandrel 13-32nd in., nose 1 in. diameter, and the cone pulleys are 3 ins., 3¾ ins., and 4½ ins., of width for 1-in. belt. Weight 78 lbs.

The equipment consists of countershaft, driving-plate, centres, hand-rest with tee, and draw-in spindle for centre and for collets; but the collets are extra.

Taking into consideration the special feature of a long mandrel, together with the points mentioned above, this tool should be just the thing for precision production, and at a price that is much below that usually charged for tools of this type, which have to be very well built.

We think that instrument makers, as well as manufacturing model engineers, should take particular note of this little tool - more especially if they propose producing small, accurate work in quantities.

6-in. Shaping Machine.

Another machine tool by the above-mentioned firm is shown in Fig. 2. This, again, bears all the characteristics of solidity and capacity, and it has the distinction of being the only power shaper shown at our Exhibition. (There were several quite good hand shapers on show, however.) Fig 3. is the same machine, mounted upon a pedestal stand, and its price, so mounted, is quoted as £28 4s.; 6 ins. stroke by 9 ins. length of feed is something rather out of the way for such a compact form of shaping machine, because as a rule, these machines, when power driven, occupy a space altogether out of proportion to their capacities, as compared with a planer of equal bulk.

The vertical feed is 3½ in. traverse, and the horizontal feed has reversible automatic action. All sliding surfaces are hand-scraped to surface plates, and the size of table, which has vertical adjustment, is 8 ins. by 7 ins. one way, and 7 ins. by 7 ins. on the angle-plate. In addition there is a central through-way to take shafts up to 1⅛ ins. diameter for keyway cutting. The cone pulley for flat belt has diameters of 6 ins., 4 ins., and 3 ins., and the machine is increased in efficiency by the addition of a well-balanced and heavy flywheel.

The weight of the bench form of machine, as in Fig. 2, is 2 cwt., and that of the pedestal stand another 3 cwt.

The proportions of the ram and its head are particularly noticeable in Fig 2, as being of compact and solid construction, and the method of setting over the head for angular traverse to the vertical slide is quite good.

Home workers and others possessing the necessary power plant, and particularly factory owners who need good small shapers, would be well advised to consider this machine, especially in view of its price.

Fig. 3. The Morse 6 in. Power Shaper mounted on Pedestal Column.

April 12, 1923.

The Flexible Shaft in the Workshop.

By T W Averill.

In the 100 years of Model Engineer I cannot remember many articles on the use of flexible shafts. I have no doubt that many readers will write and put me right. The writer of this feature of 1923 was Tom Averill, a well-known model engineer of the period and a great friend of LBSC. A number of Tom's models are in the safe keeping of the Society of Model and Experimental Engineers.

A VERY useful article in an engineer's workshop is a flexible shaft; I do not think that many model engineers appreciate just how useful such a shaft can be. It can be used for drive grinding wheels, drilling spindles, polishing mops, etc., with the advantage that the tools instead of being fixtures, can be taken to the work and moved over its surface. As an instance of what it will do, supposing some holes are required to be drilled in a casting which is much too large to be got on the drilling machine or in the lathe. This usually means getting out the breast-drill, and breast-drilling

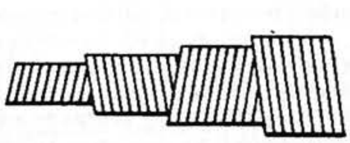


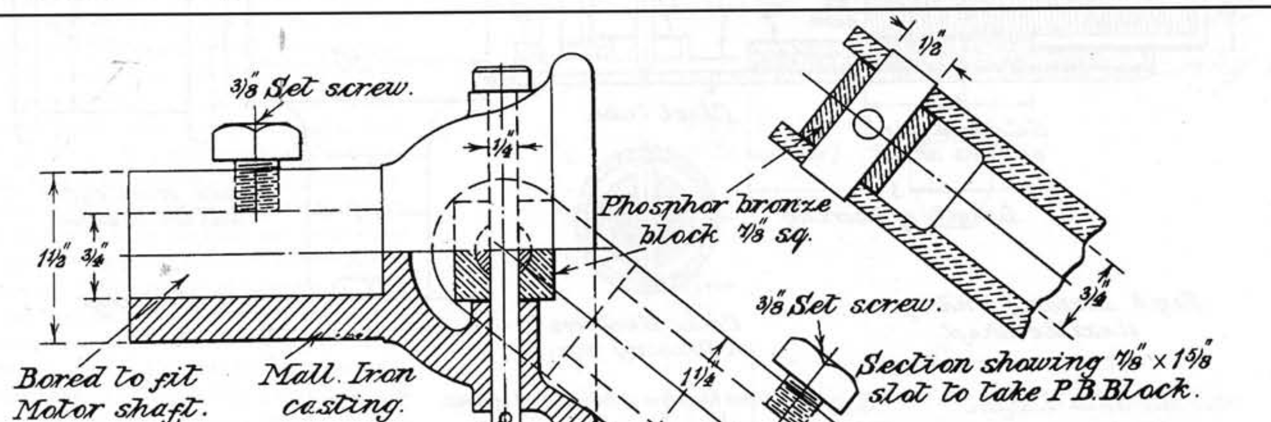
Fig. 1.

Diagram showing construction of a Flexible Shaft.

always mean exceedingly hard work; but if you possess a flexible shaft to drive the drill it is a much easier job, and by drilling a small hole first and gradually increasing the size of the drills used it is quite possible, as I have found to my own satisfaction, to drill ¾-in. diameter holes in cast-iron ⅝-in. thick without any great exertion. And if the drilling apparatus is fitted with a self-contained feed screw, and the drill suitably packed up or cramped to the work, there is no exertion required at all, and holes can be drilled or counter-bored as easily as they could be done in a drilling machine.

the driving-shaft is 9-16th in. I purchased my shaft and casing from Messrs H. Terry & Sons, the spring specialists, and one of their factories is situated in Alcester. This sounds very much like a free advertisement for Messrs. Terry and Sons, but I expect that unless I state where this shafting can be obtained I shall be required to answer a lot of separate enquiries later on. My shaft is, I believe, one of Messrs. Terry's own patent spring shafts, and consists of several close-coiled steel springs wound on the top of each other, each coil being wound in the opposite direction to the one it is wound on (see Fig. 1). The springs are thoroughly sweated together at the ends with soft solder for about 1½ to 2 ins. Incidentally, the flexible shafts are fixed into the revolving parts of the end fittings by seating with solder, this being the only possible way to fix them as they cannot be drilled. Anyone examining one of these shafts at first appearance would naturally expect there would be a lot of torsional spring in the drive, but in practice it is almost as rigid as a solid bar, and in a length of shaft 12 ft. long the slightest movement at one end is instantly transmitted to the other.

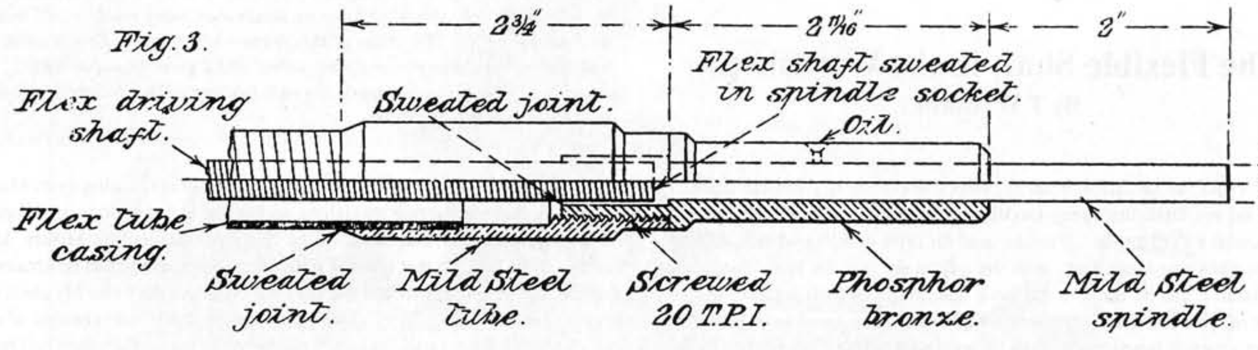
Now, to get any appreciable power through a small shaft, the only thing to do is to run it fast and gear down for power at the business end. My own shaft runs at 3,000 r.p.m., it is 12 feet long and being fitted up in a fairly central position in the workshop has a wide radius of action. I originally fitted up this shaft to drive a grinding head on my 7-in. lathe, the flexible shaft being driven and controlled by a separate countershaft. When in use, the grinding wheel spindle is coupled direct to the flexible shaft and runs at the same speed, the wheel usually used is about 6 ins. diameter and the shaft gives plenty of power to drive it with a good cut on. The shaft can also be used to drive a milling-spindle, here of course the speed must be greatly reduced and the most convenient method of doing this by means of a worm and wheel. A method of arranging this will be mentioned later. The professionally built-up shafts are usually made with plain spindle ends projecting from the end bearings of the casing fittings, so that they can be clamped into any convenient



Half Sectional Elevation of Universal Joint for Flexible Shaft.

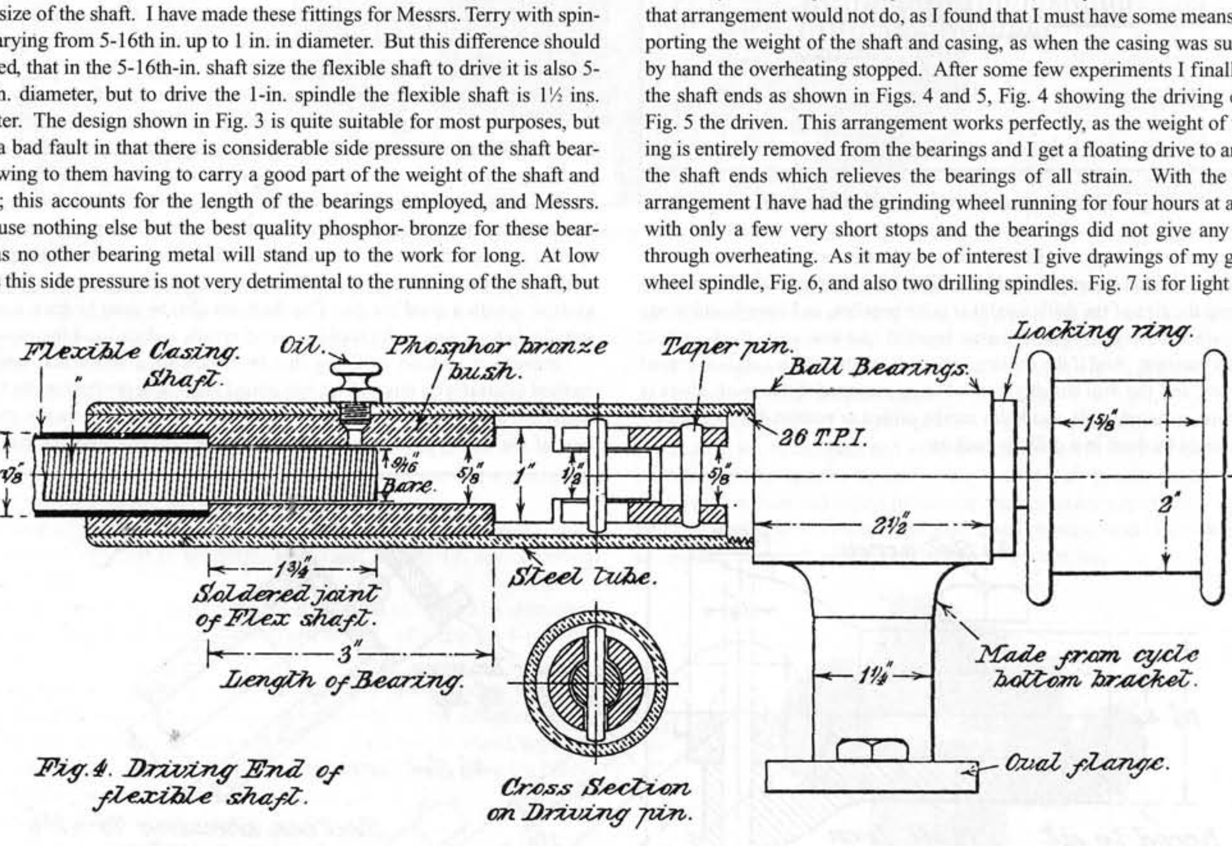
Unfortunately, flexible shafts are rather expensive things to buy, when they are fitted up completely ready for use; but there is no necessity to go to this expense, for any model engineer, with ordinary ability and who possesses a lathe, can quite easily make up the end fittings required for such a shaper, and then the only outlay required would be for the length of flexible shafting and the corresponding length of flexible casing for the shaft to run in. My own shaft is a fairly powerful one, the outside casing is about ⅞ in. diameter and

piece of revolving apparatus which is running at the correct speed, such as a lathe chuck, drilling-machine, or electric motor. When these shafts are driven direct by an electric motor, instead of coupling the shaft directly to the motor spindle, a universal joint of the type shown in Fig. 2 is generally fitted. The end of the universal fitted to the motor-shaft has a bell mouth which limits the angle at which the joint can work and so prevents it locking. This joint not only allows a greater radius of action to the shaft but it also relieves the end

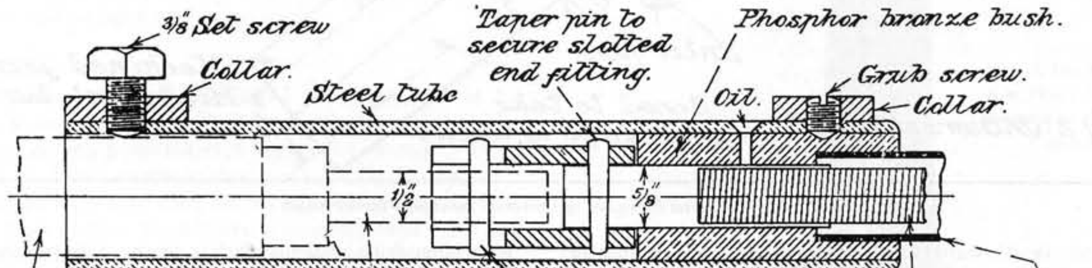


The Usual Arrangement of Bearings for Professionally Made Shafts.

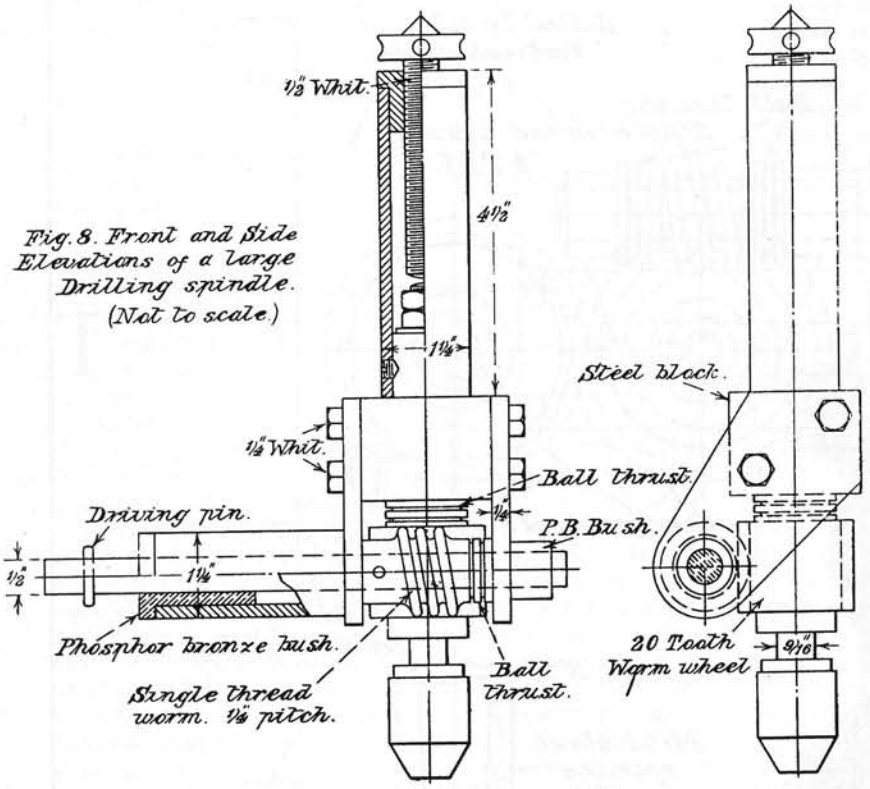
bearings of the shaft of some of the side strain of the weight of the shaft and casing. Fig. 3 shows the usual arrangement of the end bearings of the professionally-built shafts. The drawing is dimensioned for a shaft end, having a 5-16th-in. diameter plain spindle; but of course these end fittings vary according to size of the shaft. I have made these fittings for Messrs. Terry with spindles varying from 5-16th in. up to 1 in. in diameter. But this difference should be noted, that in the 5-16th-in. shaft size the flexible shaft to drive it is also 5-16th in. diameter, but to drive the 1-in. spindle the flexible shaft is 1½ ins. diameter. The design shown in Fig. 3 is quite suitable for most purposes, but it has a bad fault in that there is considerable side pressure on the shaft bearings owing to them having to carry a good part of the weight of the shaft and casing; this accounts for the length of the bearings employed, and Messrs. Terry use nothing else but the best quality phosphor- bronze for these bearings, as no other bearing metal will stand up to the work for long. At low speeds this side pressure is not very detrimental to the running of the shaft, but I found that at high speeds it was quite another matter. I at first fitted up my shaft with ends similar in pattern to Fig. 3, to drive my grinding wheel, but on putting it to work, owing to the high speed it was running at the end bearings were very soon, in spite of copious lubrication, nearly red hot. I could see that that arrangement would not do, as I found that I must have some means of supporting the weight of the shaft and casing, as when the casing was supported by hand the overheating stopped. After some few experiments I finally made the shaft ends as shown in Figs. 4 and 5, Fig. 4 showing the driving end and Fig. 5 the driven. This arrangement works perfectly, as the weight of the casing is entirely removed from the bearings and I get a floating drive to and from the shaft ends which relieves the bearings of all strain. With the present arrangement I have had the grinding wheel running for four hours at a stretch with only a few very short stops and the bearings did not give any trouble through overheating. As it may be of interest I give drawings of my grinding wheel spindle, Fig. 6, and also two drilling spindles. Fig. 7 is for light drilling



Sectional Elevation of Driving End of Shaft.



Sectional Elevation of Diven End of Shaft.



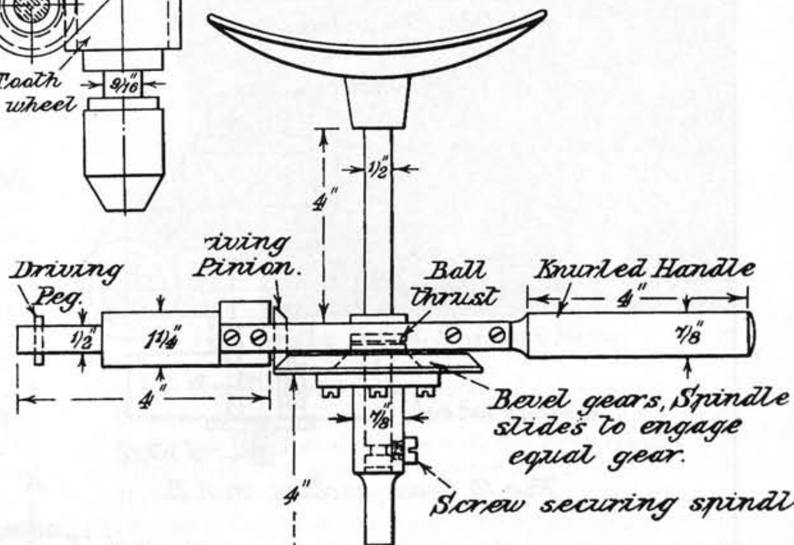
Front and Side Elevations of a Large Drilling Spindle.

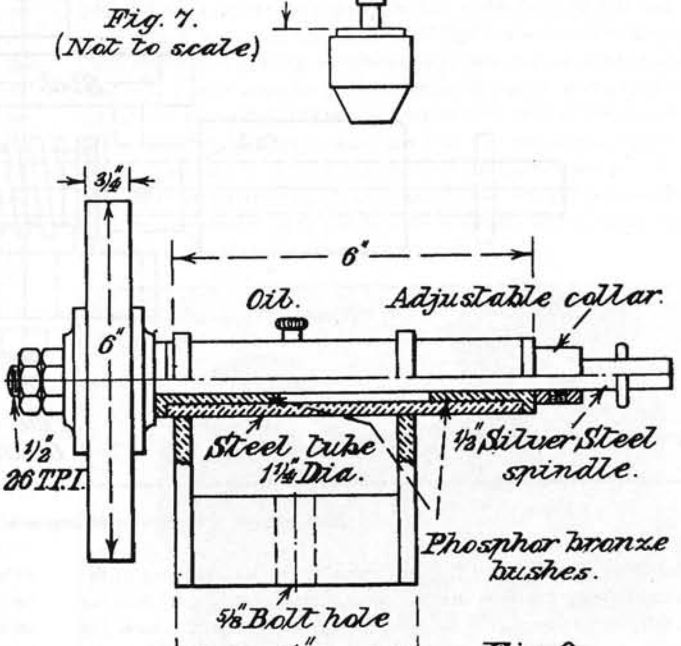
Front and Side Elevations of a Large Drilling Spindle.

and is driven by bevel gears and has two speeds, one equal to shaft speed (this is useful for polishing bobs) and the other geared down 4 to 1. It is fitted with a chuck, holding from 0 to ⅜ in. Fig. 8 is for heavier work, it is geared down 20 to 1 by worm and wheel, it is fitted with ball thrusts and the chuck holds up to ½ in. It will easily drive a ¾-in. drill if a small pilot hole is drilled first. This spindle is fitted with a self-contained screw feed and must be either cramped to the work or packed up to it, as a fulcrum to take the pressure of the feed if needed. Another use I put my shaft-driven grinder to is for surface grinding. I mount the grinding head on the tool post of my planing machine; and when so fitted, it transforms the planer into a very useful surface grinding machine, and I was rather astonished at the accurate work that this arrangement will turn out. I have ground up parallel strips 3 ins. long and ⅝ in. thick that did not vary more than a quarter-of-a-thousandth of an inch in any portion of their length. Figs. 9, 10, and 11 show an arrangement for driving a milling spindle. The flexible shaft is geared down by a single thread worm of ¼ in. pitch to a ratio of 20 to 1, but instead of driving direct on to the milling spindle it drives a short gun-metal bush, which forms part of the worm wheel, and on one end of this bush lathe change wheels can be mounted, wheels about ⅝ in. wide and 16 diametral pitch are suitable. The wheel mounted on this bush gears into another wheel fitted on the end of the milling spindle. The spindle which carries the worm wheel is adjustable along a slot in the carrying arm which swings on a projecting spigot of one of the milling spindle bearings; this slot allows for several combinations of change wheels so that practically any speed may be obtained to suit the cutter that is being used.

It will be seen from Fig. 9 that the milling spindle instead of having a screwed nose, is bored out to No. 2 Morse taper, it is also drilled right through and a

Elevation of a Light Drilling Spindle with Bevel Gear Drive.





Half Sectional Elevation of Grinding Wheel Spindle.

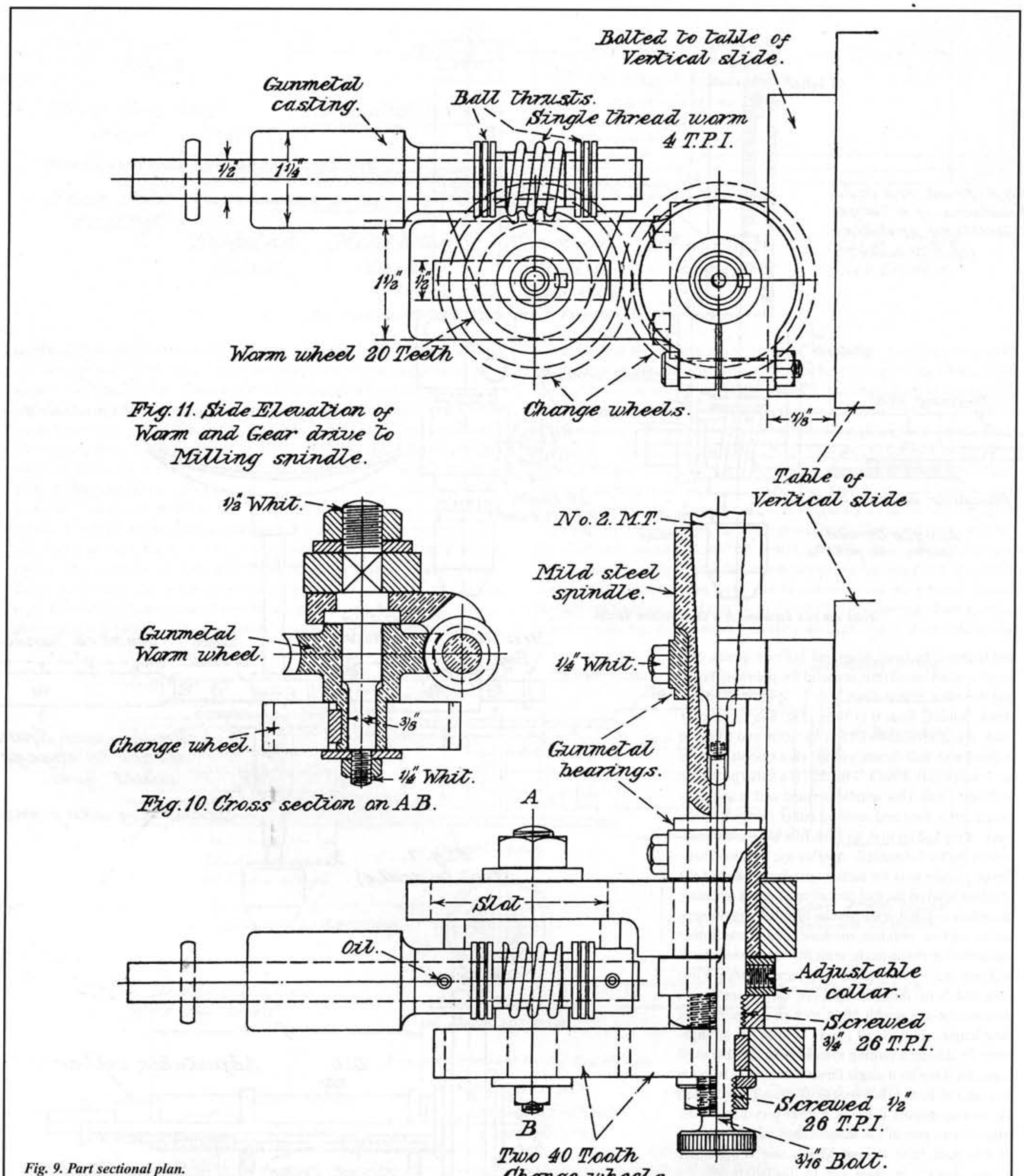


Fig. 11. Side Elevation of Worm and Gear drive to Milling spindle.

Fig. 10. Cross section on A.B.

Fig. 9. Part sectional plan.

Part sectional views showing arrangement for driving a milling spindle.

long 3-16th-in. diameter bolt is fitted which screws into the tang of the Morse taper fitting that is in use, thus preventing the taper from working loose owing to the vibration of the cutter. I find with this arrangement that it is much easier to mount the cutters and to get them to run true, as with chucks mounted on a screwed nose, unless the fittings carrying the cutters are actually turned up in position on the milling spindle (which is not very convenient to do) the cutters very seldom run quite true. Another advantage of being able to carry the speed of milling spindle is that if necessary it can be geared up fast enough to drive a grinding wheel. In conclusion, I might mention that the grinding head, drilling and milling spindles, which have been described, are not commercial articles, but are my own design and make, and they have been all built up from odds and ends most of which were obtained from the scrap pile, scarcely any new material in the shape of castings being used.

May 3, 1923.

Workshop Topics

The principal items appearing under this heading relate to work done and other matters dealt with in THE MODEL ENGINEER Workshop at 66, Farringdon Street, London, E.C.4.

Gear Cutting a Toothed Quadrant.

THIS is a job carried out in THE MODEL ENGINEER Workshop. A student had devised a quick lever action for a special machine, to take the place of a screw and hand wheel action, with which it was previously fitted. The idea in this was, of course, to save time in use. For this it was decided to cut a short 10 D.P. rack in steel, the cutting of which was carried out on the shaper, using its longitudinal feed screw as a means of dividing. The setting up and description of the operations in making the rack will be deferred to a later paragraph in this column. The quadrant, also of 10 D.P., which, by the lever action, gears with and drives the rack, was also cut in the shaper by the setting, as seen in Fig. 1. A point or two, however, about the making up of this quadrant will be of interest. It is shaped as seen in Fig. 2, where it is shown mounted on the angle-plate. Starting with the assumption that it should be part of a gear having 3 ins. throw and about 1 in. width of teeth, and, further to match the rack, and give the same about 2 ins. full traverse, the following was found to fill the bill:- The rack has 10 D.P. teeth, therefore, to give 3 ins. throw of quadrant, we require the equivalent of a 6 ins. pitch diameter wheel; and a 6 ins. P.D. 10 D.P. wheel has 6 by 10 = 60 teeth as the size to be cut. The quadrant, therefore, was made with a blank throw of 3.1 ins., made up of 3 ins. to the pitch line, and 1-10 in., which is the addendum of a 10 D.P. tooth. The circular pitch is .314, or 3-10th in., and, calculating roughly 3½ teeth to the inch, it requires 7 teeth to 2 ins. of traverse, and the rack was therefore made with eight teeth and eight spaces and the quadrant with nine complete teeth and eight complete spaces, cut on a segment about 3 ins. wide. The quadrant was not forged, but cut from three pieces of ¼-in. mild steel plate, and a fourth piece, fan-shaped, to make up the inch width of teeth, leaving the boss portion ¾ in. wide only. These, after cutting, were assembled and riveted together, three rivets in the fan and three in the boss. It was then chucked in a 3-jaw chuck, drilled and bored 1 in., and turned on the periphery to the required 3.1 ins. radius, centre to face of periphery.

We come now to the setting for shaping the teeth. The idea was to mount the quadrant a driving fit by its bore upon a mandrel, the mandrel to pass through a bearing fit hole in an angle-plate, and to rest upon a clamped vee block at the back, with a sufficient projection to take a 60-wheel, to use the same as a division-plate. During the actual cutting the quadrant is clamped by its boss against the fact of angle-plate, as seen in Fig. 2, which clamps are loosened when indexing. The angle-plate used is 4½ ins. by 4 ins. high by 7 ins. long, and the mandrel is made from a 6-in. length of ¾-in. W.I. gaspipe, which was chucked end for end, faced off, and bevelled on the inside edges to 60° included, to run on large centres. It was then turned 1 in. at either end to take a driving fit, the quadrant at one end, and a 60 change-wheel a tight push fit at the other. The main portion is turned to about 1 1-16 in., except for the journal portion, about 1 in length behind the quadrant, which is 1 1-32 in diameter, and only just cleaned up at that.

The bearing hole was made in the angle-plate by bolting the plate by its base to another angle-plate on a faceplate, and, when set true to position - the upright side being out-ward - first drilling it with a chuck on tailstock, and finally boring it to a nice running fit for the 1 1-32nd in. journal of the mandrel. The position for hole was found by standing the angle-plate base down on a setting out table, and standing the vee-block with the mandrel in the vee in position. Then a scribing block was set to the centre of mandrel, and the height thus found transferred by the scribing block to the front of the angle-plate, thus giving a horizontal centre line. A vertical line crossed this in centre of plate, and at the intersection a dot was put and an inch circle scribed from it. This circle was set running true in the lathe, which then produced the bearing hole at correct height for the mandrel to rest in the vee block.

As seen in Fig. 1, the vee block stands on the top side of angle-plate base, and not only is the angle-plate bolted to the machine table but on the further side, a long bolt passing through both the table and long slot of angle secures a clamp which holds the vee block rigid to position.

Here we have another item from the M. E. Workshop. It shows another application for the shaper and one that may not be obvious at first. The machine featured is the Leyland, Barlow shaper and it will be noted that the main drive and the ratchet feed can be swopped end for end in order to make the best use of space, ideal for the model engineers' workshop. Compare this view with that shown on page 8.

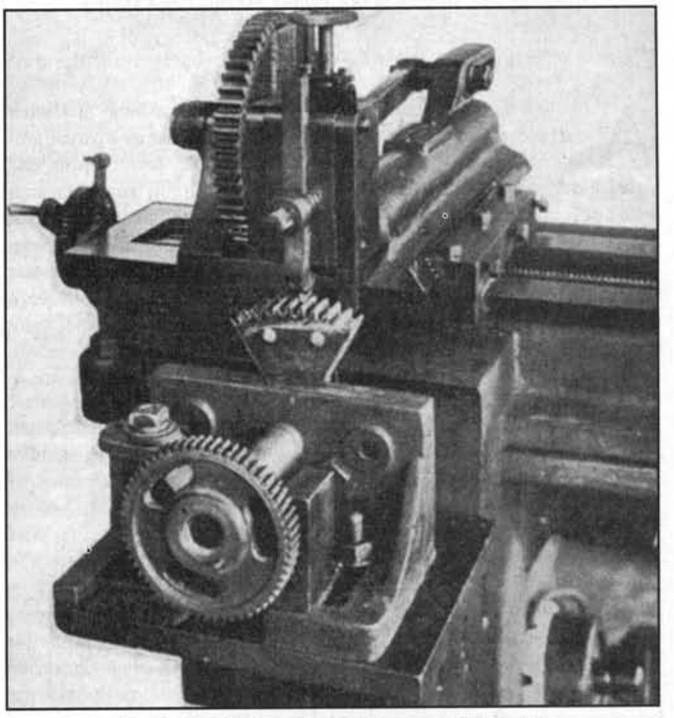


Fig. 1. Gear Cutting a Toothed Quadrant by Shaping.

We did not use any index with the dividing wheel but found it near enough for the few teeth cut to sight the position of the dividing wheel teeth in relation to the top side of the vee block on the right-hand side.

The first series of cuts was made with the same tool as used to cut the rack, viz., a shaper tool made with straight sides to the included angle of 29°, and truncated according to the required bottom width for a 10 D.P. rack tooth space. When this was carried round to full depth, as measured by the top feed wheel rigged up as a micrometer, the tool was taken out and softened, and then filed up to correct shape for the tooth space. We set the correct tooth space out full size for 60 teeth 10 D.P. and filed the tool - with hollow curved sides in this case - to the pencil lines, and find that the quadrant gears quite smoothly with the rack; but it must be remembered that not quite so much accuracy of tooth form is required in a job like this, which only transmits hand leverage, as would be required in the case of running wheels, which might, if of the form we obtained, run somewhat noisily.

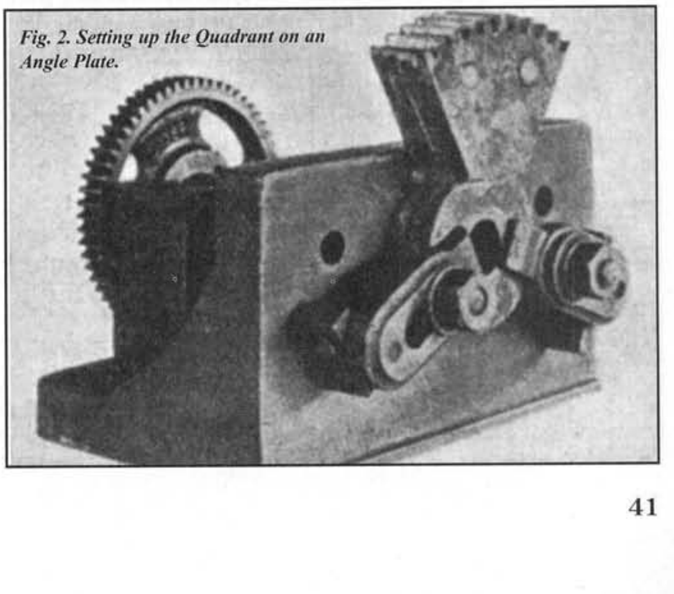


Fig. 2. Setting up the Quadrant on an Angle Plate.

May 3, 1923.

Troubles in Grooving and Parting.

Some Elementary Notes on the Parting of Material in the Lathe and on Grooving and Slotting in the Milling Machine and Shaper.

By Fred Horner.

We last met Fred Horner in 1916 with his series of articles on 'How Machine Tools Work'. Here we have an article giving useful hints and tips not only for the lathe but for the planer and shaper. You may think that it was not possible to cut tee slots on the shaper or planer but with a special adaptor it is perfectly feasible.

AMONG the more troublesome operations in the lathe and other machines is the making of grooves and slots, either as a partial process or for complete severance. The difficulties are numerous and varied and arise from several causes, but, speaking generally, the main reason is that of confined space - leaving the tool or cutter insufficient freedom for its work and rendering lubrication and the escape of chips difficult. The problems usually become enhanced with increase in depth, for these three reasons, in addition to which the fact must be noted that greater penetration means a more slender tool or cutter. Hence the matter of side clearance demands more attention and careful tempering, and feeding must be done to avoid breakage. A detailed examination of the conditions for different styles of tooling many now be made.

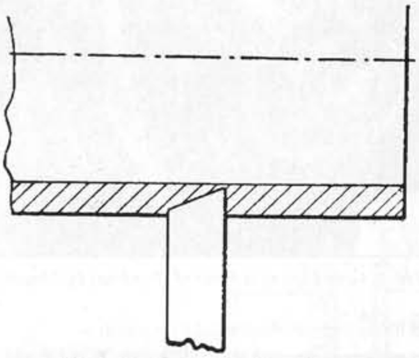


Fig. 1. Parting a tube without burr.

In the Lathe.

A goodly proportion of the failures in grooving and parting-off in the lathe arise from defects in the manner of holding the work, or tool, or faults in the fitting of the lathe. The tool itself may be in perfect shape and condition, yet one or other of these defects will prevent if from acting properly. The work must be held so that it does not spring, or draw in towards the tool, so also must the latter stand firmly on the clean slide-rest top, and not project more than necessary. Slackness in the spindle fitting, or in the slide-rest joints usually prevent successful cutting, producing a sudden dig-in and fracture of the tool, or damage to the piece. Given stiff conditions of holding, it does not matter very much whether the tool edge stands either a trifle above or below the centre, but any weakness of the sort just specified is taken advantage of, particularly if the edge is below, when a climb-over occurs until something gives way. Complete cutting-off is also impracticable (on bars) unless the edge

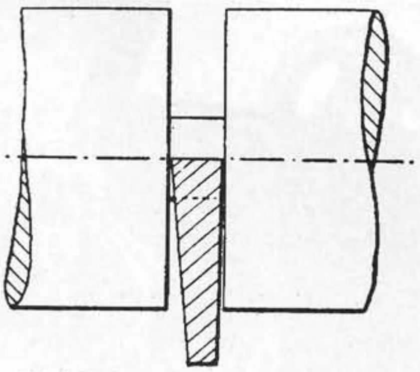


Fig. 2. Parting tool with unequal clearence.

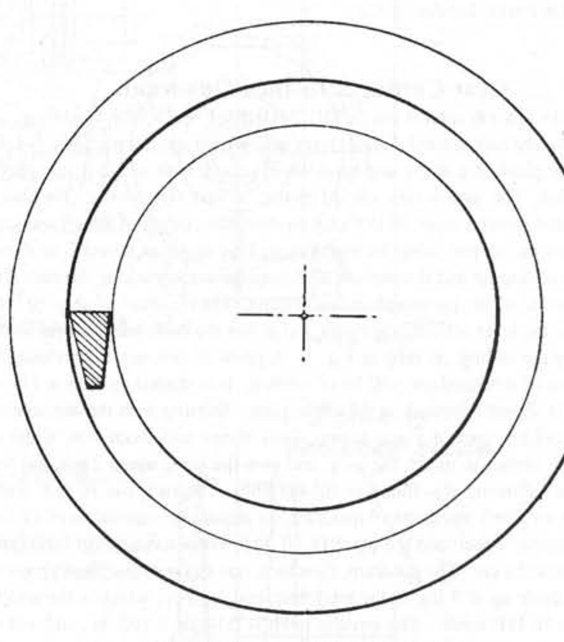


Fig. 3. Clearance for Severing Disc.

stands level with the centre, as a certain diameter of it remains, and in some classes of work leaves a lump that is objectionable, involving extra work for trimming off. Unavoidable breaking-off of the severed end generally leaves a tiny trifle of parallel diameter, in any case, on one or other severed surface; but in dealing with tubes, especially of soft stuff, the nuisance of an irregular ragged edge may be incurred, because the parted end wobbles about before severance, and in any event there is a tearing up of the last thin parallel shell of metal, representing the width of the tool. To cure this, a good dodge consists in grinding the end off at an angle (Fig. 1), thereby producing a clean cut through on the right-hand face, leaving that with no arris, or practically none. Continuing the feed across after this portion has dropped off cleans the left-hand part of the tube, which is held in the chuck.

The troubles that develop when endeavouring to cut deeply may often depend on the grinding of the tool, in such fashion that its nose strays to right or left, and leaves a convex face on one side and a concave on the other. Such errors may be detrimental in regard to deep grooves, as also with pieces intended to be parted off with flat faces. Presuming that the tool stands quite upright, and is pointed in quite squarely, and has no liability to slip under the clamping straps, a defect in the equal keenness of the two corners is liable to make it stray to one side. More likely, however, is the presence of unequal clearance on the flanks, equivalent to the fault of tipping the tool over out of the vertical. One side (the left in Fig. 2) may therefore attack the metal with greater avidity and continually draw that way. Whether the tool will twist and bend more in the horizontal (lateral) or the vertical direction depends on its strength and the degree of projection from the slide-rest.

Helical grooves (corresponding to screw threads) and grooves on flat faces, or where the latter has to be parted through to leave discs, give most trouble in regard to clearance. In the helical type running around a cylinder it is necessary to be very careful as to the relative clearance on each flank, making a sketch of the groove or worm and drawing the tool in section thereon. The flank clearance on either side exhibits a marked difference with quick pitches. The same precaution is needful in face grooving (Fig. 3), and it is obviously easier to be content with a tool of moderate depth than one like that employed for ordinary bar parting, where the conditions of side clearance are absolutely different.

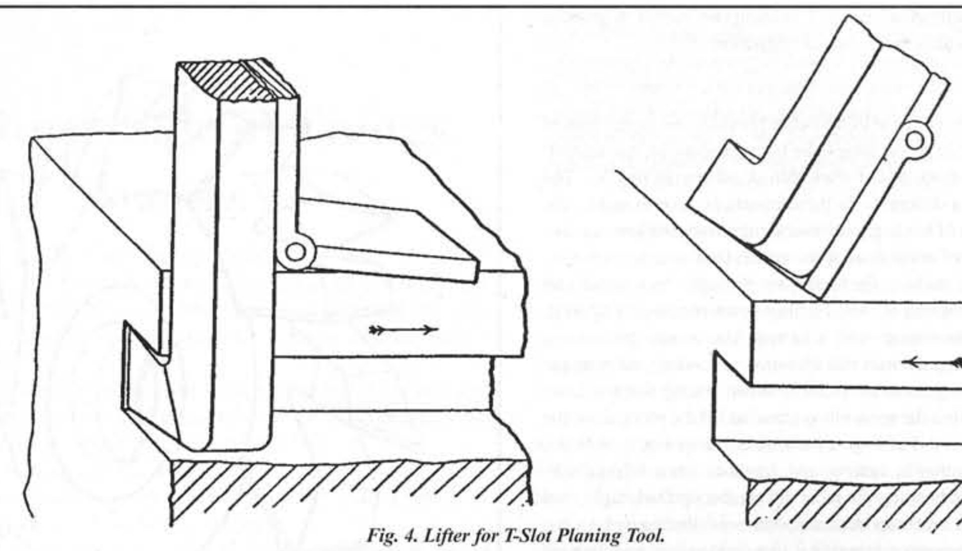


Fig. 4. Lifter for T-Slot Planing Tool.

In Planer and Shaper.

Grooving becomes rather more awkward in the reciprocating machines, principally because of the shock at each fresh stroke, and the consequent liability of the tool to jump in too far. Milk steel in particular offers troubles in such manner that do not obtain in the case of cast-iron or brass. The tool must not have too free-cutting qualities for soft steel, nor be projected too far, and

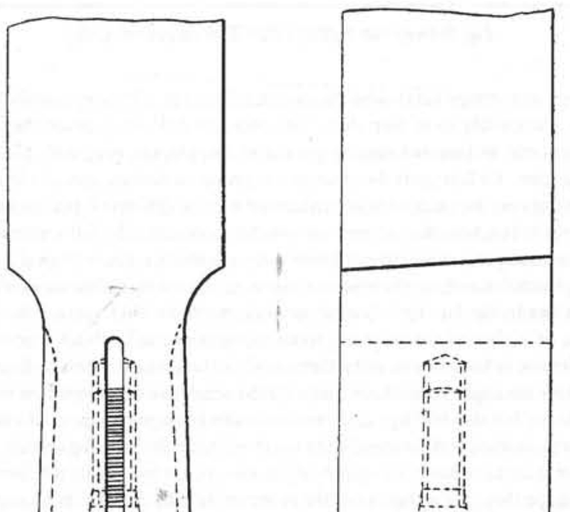


Fig. 5. Groove Planing Tool with Adjustment for Sizing.

the tool-box and fixings generally need to be well attended to. The writer has sometimes found that grooving in steel shafts and other articles of a tough nature is best accomplished by using a round-nosed tool at first, getting out the bulk of the metal, and then finishing with a square-edge tool to clean out the corners. Should the operation be one of complete parting through, the round-nose does not require changing, each section of the work being firmly held by clamps as the tool ploughs through the metal at the bottom.

Undercut operations - of which the tee-slot is the most common specimen - require attention as to the lifting of the tool each time. Either the operator must raise it out at an angle clear of the work by hand, or must clamp a hinged lifter under the tool when putting in the box. Fig. 4 illustrates a lifter in the two respective positions.

Sizing tools are more often used on planing machines than in the ordinary lathe, because of the essentially different conditions. In the lathe it is a matter of a few seconds to withdraw a grooving tool, set to right or left by a few thousandths or a considerably greater distance, and feed in again, to widen the groove by the desired amount more than the actual tool width. But in the planer, especially on long work and deep slots, a number of table passes are required before the one flank of the groove has been again gone down for the second sizing cut. Therefore it pays to utilise a sizing tool which will trim down both walls simultaneously. One device is that of having a holder with a stem-shaped cutter pinched in, the top of the cutter being circular, and ground to the diameter equal to the slot width. Such a cutter may be revolved slightly in the holder when dull, enabling it to last for a long time with keen edges. Or a square-edged tool is prepared, and made adjustable by the expedient of sawing it, and inserting a screw (Fig. 5) for expansion. Or the screw can be tapped in transversely, so as to press with its point against one-half of the split part and thrust the two asunder. As the duties of these tools are light - after the roughing cut - they last for a long while. Greater widths than those possible to cut with one tool are dealt with by double tools clamped in the box, and if necessary distanced with a wood or other stretcher of this wider class, it pays

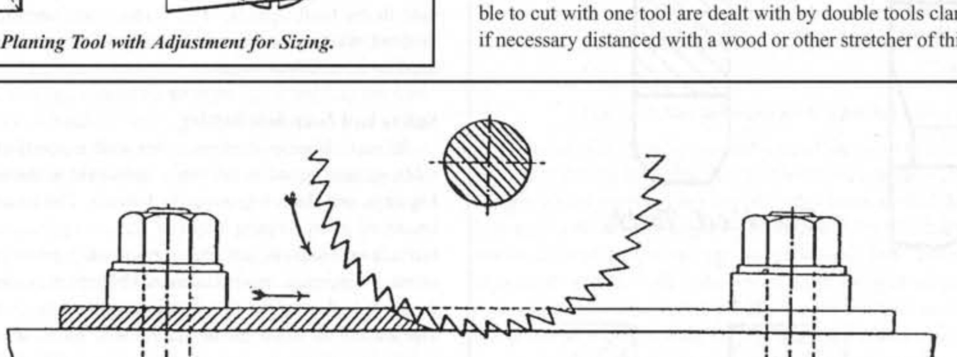


Fig. 6. Method of Slitting Thin Stock.

to prepare a special holder with enlarged head, holding two cutters in grooves inclined outwards, thus affording the means of regulation.

In Milling Machines.

Cutting slots and grooves with a milling-cutter provides the fastest rate of production, but numerous little points have to be taken account of, particularly if the slots are narrow and deep, or the work thin or otherwise fragile. The direction of feeding makes a difference in these instances. For example, the usual and preferable method of feeding in ordinary circumstances goes against or opposite to the direction of revolution of the cutter, thus securing a steady movement of the table, and making the teeth pass through clean metal and prise off the scale upward, instead of their coming down continually upon it, with damaging effects to the edges. But a narrow saw or one penetrating deeply is likely to crowd sideways with this direction of feeding and produce a crooked slot, as well as being liable to fracture. When slitting thin stuff, not only is this crowding likely, but the teeth always tend to lift the piece from the table and so wedge themselves. Feeding in the way drawn in Fig. 6, with the consequent advantages of straight cutting and freedom from lifting, only demands a little extra care in keeping the table gib screws up fairly tight, and seeing that the feed-screw is free from backlash, otherwise there may be a run forward and a catching of the cutter, bringing it to a sudden stop and perhaps fracturing off some teeth. A counter-weight applied to exert a backward pull on the table supplies a good method of absorbing all backlash and jumpy tendency.

Obviously a fine pitch of teeth should be adopted for thin stuff, to avoid catching in, for the same reason that fine-pitched hacksaw blades are applied for thin tubing. Also, a rapid rate of rotation and a slow feed are better and safer for delicate saws and work than the opposite way of procedure.

Clip-Breaking Devices.

Clogging of the teeth and slots with cuttings frequently gives cause for anxiety, lest the teeth should be snapped off, and the slowing down entailed by this necessary watchfulness interferes with output. In some materials, also of

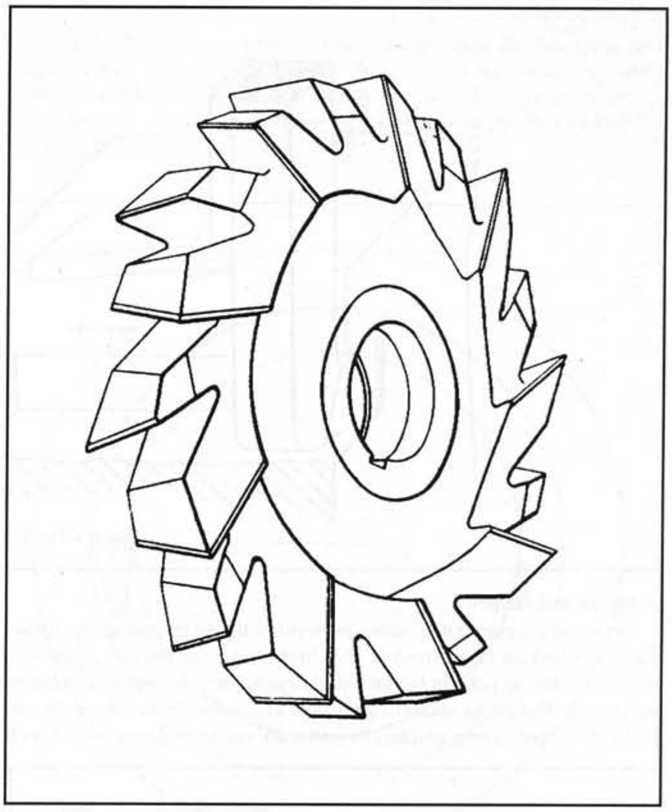


Fig. 8. Deep slot milling cutter with staggered teeth.

a tough and stringy nature, the duties of a mill or saw are exceptionally strenuous, particularly so in deep slots. The chips are difficult to sever, they cling to the teeth, and are not easy to get out of the grooves even with plenty of lubrication. Of late years the practice has grown of making special slitting or grooving saws for such work with alternate teeth of different types, so that the effect is to break-up the cuttings into smaller pieces than the full width of saw. Two advantages accrue, the one being that such smaller pieces of swarf do not wedge into the kerf, or the spaces of the teeth, but easily fall or wash out; the other lies in the fact the alternate teeth do not have to cut across the same shape of surface as the preceding tooth, but gets a relief in this respect. As a result there is less friction, and a faster feed can be adopted. Various forms are used for the alternate teeth, not only for the small saws employed on milling machines, but also for large diameters of blades belonging to the cold saw cutting-off machines. A favoured style is to have the chip-breaking teeth slightly higher than the ordinary or square-edged ones, hence by making the former of vee-shape they take a chip out of the centre of the cut, and then the square-top tooth follows, taking a chip out of each corner. The smaller size of chips consequently produced flow readily away with little friction and no tendency to clog in the tooth spaces. Fig. 7 represents such teeth and the shape of cut evolved, while a variation in the way of a round-ended tooth is occasionally used for inserted-tooth saws.

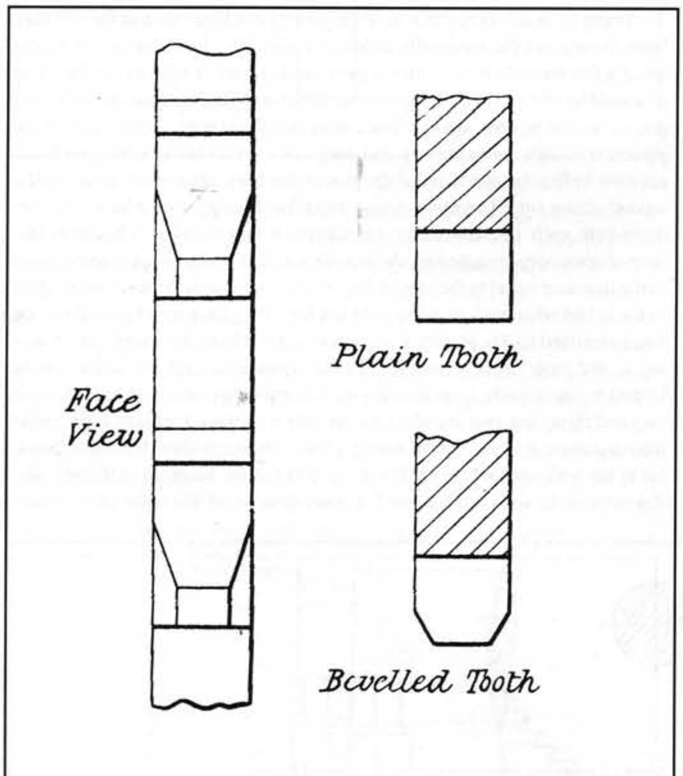


Fig. 7. Saw with alternate chip breaking teeth.

Spline and Deep Slot Milling.

In accordance with recent endeavours to speed-up the cutting rates of most tools, greater attention has lately been paid to the teeth of cutters for milling keyways and deeper grooves and slots. The usual straight tooth has been improved on by sloping alternate teeth in opposite directions, so as to afford top side rake and also a shearing cut to the front of each tooth. Not only is the cutting efficiency much enhanced, but the throwing out of chips becomes facilitated. A cutter of the class is shown in Fig. 8. The shearing process now also occurs in some of the interlocked mills, that is, two half-cutters laid together with certain teeth interlocked, and packing between the hubs to cause the tool to cut an exact width of groove. Formerly the teeth were left straight across in the narrower mills, but now they are formed with slopes in opposite directions, so as to produce a top rake, as well as shearing cut, yet without causing any side thrust (the push of the two-angled edges neutralise one another) to interfere with the accuracy of milling.

May 3, 1923.

The Other Side of Things.

Scraping.

By The Cheery Critic.

SOME weeks ago the Cheery Critic mentioned that scraping was the most accurate method of finishing work. There are, however, several little matters which are necessary to understand before accurate work can be executed by this means.

First the scraper should be properly hardened, ground and sharpened; secondly, an accurate surface plate must be employed to test the work during the process; and lastly, the right "touch" must be attained.

The scraper can be made from an old hand file or for small work a narrow "pillar file", and, according to the work in hand, should vary from about ¼ to ⅜ in. in width and from a bare 1-16 to 1-32 in. thickness.

When looked at in plan the cutting edge of the scraper should be square across, with the corners very slightly rounded, so that they will not tend to dig in.

In elevation the edge should be dead square, i.e., the tool should work equally well on both sides.

Files are rarely tempered hard enough to cut well when made into

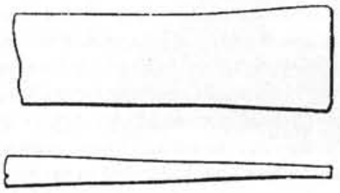


Fig. 1. Top and slide view of an ordinary scraper.

scrapers, but the following methods have been found to give good results:- The tool is ground to shape, then heated to a cherry red, neither too bright nor too dull, and quenched off by plunging into a small tin pot with ¼ in. of lard or lard oil at the bottom and surrounded by a larger vessel containing cold water.

The second method is to quench out in the same depth of brine formed of a saturated solution of common salt in water.

The first method requires no subsequent tempering, but after the brine bath the tool should be polished and heated till it just begins to show a straw tint at the edge, and then quenched out in oil.

Much depends upon the steel used, but if one method does not succeed the other probably will.

The scraper should be sharpened by rubbing the tool on an oil stone (Washita or carborundum lubricated with plenty of paraffin), first in a direction across the thin edge, with the scraper held vertical, and finished off by rubbing the tool flat on the stone.

This sounds a simple operation, but it is just where most novices fail - they cannot get the tool sharpened square across, but make a rounded edge which will not bite. If a satisfactory edge cannot be attained when holding the tool in the hand a slot can be cut in a block of wood, into which the thin part of the tool is pushed by the left hand whilst the block is pushed backwards and forwards over the stone, thus ensuring the tool being held vertical and not rocked.

The next think to make sure of is that surface plate on which the object is being faced up is true.

This should be as large or larger than the object being operated upon, and must not only be generally true but free from minute bumps and hollows, and, of course, kept scrupulously clean and free from grit and hairs.

A single fibre of cotton from a bit of waste about .0002 in. introduced between two true surfaces 10 by 15 ins. is quite sufficient to prevent the reddle from marking on any part of the surface under test except the extreme edges.

Paper, followed by a clean leather pad, is the best medium that the writer has found for cleaning off dust and dirt, but the test surface should be kept covered with a dustproof cover except when absolutely in use, and a sheet of American cloth with the enamelled side next to the surface plate or a double thickness with the two exposed surfaces enamelled.

I don't know who wrote under the pen name of "The Cheery Critic", but the process of scraping to form a flat surface is one of the oldest skills in the engineer's armoury, although with the introduction of the surface grinder it is in many cases a lost art. I have often seen old files being converted to scrapers, but I cannot recollect old hacksaw blades being used. One more for the recycling lobby.

If the surface plate is not as large as the piece under test complications will arise, as one part may show perfect contact and when shifted over an inch or so only touch on the extreme ends. It is a little difficult to explain, but it becomes very evident when tried in practice. The result, however, is that one portion of the piece being tested may show contact over a large surface and at each end and a hollow in the middle, whereas the centre is really the highest part.

The angle at which the scraper should be held to the surface being operated upon cannot be stated, as this varies with several conditions found in the process of the work, such as the hardness and nature of the material, the amount of metal being removed, and perhaps the most important - the operator.

One particular angle will be found to give the "fiercest bite," and one operator will raise his hands to take a lighter cut whilst another will lower them. It is quite a matter of fancy which method is used.

On starting work on an object straight from the planer, surface grinder, or other tool, the operator will apply reddle to the surface plate (artists' Prussian blue obtained in tubes and thinned with lubricating oil is now generally used, but artists' vermilion treated in the same manner is preferred by the writer) moderately thickly, and the object applied and just given a slight movement, applying a slight pressure to one corner only. This will leave a series of patches of black on the parts which have touched, and should be scratched round with a scriber. Next wipe off all the reddle marks and again apply with pressure on another corner, scribe round, and make a line across the reddle mark. Repeat the operations till all four corners have been tested, marking with a cross the spots from the third corner and two parallel lines for the fourth corner.

Observe which corner gives the greatest area of contact, and work from that corner, and as the contact spots extend apply the pressure more and more to the centre of the object being operated upon.

This method will save much time and trouble, as much less metal will have to be removed than had the pressure being applied to the centre in the first instance.

As the points of contact spread over the surface the amount of reddle used will have to be reduced till at last practically none is left, and as the points of contact approach one another they will become smaller and smaller as the work proceeds, and narrower scrapers will have to be used and less energy expended.

There are several manners of holding a scraper, but the writer finds the method best suited to his hands is to employ a scraper projecting about 6 ins. from the handle, which should be about 14 ins. long, and a suitable size to hold in the hand.

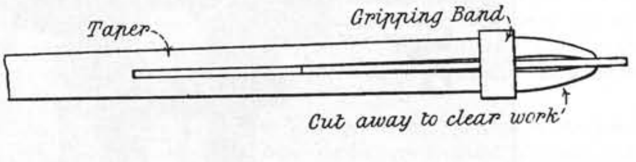


Fig. 2. Holder for using broken hacksaw as a scraper.

The end of the handle is rested against the palm of one hand whilst the fingers grasp it from the under side, that hand being used to give the tool a forward motion, whilst the four fingers of the other hand are laid flat on the tool, which is gripped between the finger tips and thumb, by which an alternating circular motion is given first to the right and then to the left. The arms are held practically rigid, and the work is done by a slight swing or wriggle of the shoulders. In this manner the correct angle at which to hold the scraper once it has been found is maintained, and the cut can be regulated to a nicety.

Fig. 1 shows an ordinary scraper and Fig. 2 shows a holder made on the principle of a crayon holder in which broken hack-saw blades are fitted and used as an ordinary scraper. The writer has not tried this system, but the idea seems good, as a number of blades could be ground up and sharpened and changed as they become blunt. The toolmaker who was using this tool told the writer that Starrett's hack-saw blades were perfectly tempered for the work.

June 28, 1923.

Model Engineering Equipment and Supplies.

A review of Current Technical Progress.

The Triplex No.1 Combination Machine Tool.

Model engineers may think that the multi or combination lathes that have come onto the market in the last few years are a new idea. Here is an example from 75 years ago which goes farther than its modern counterpart as it incorporates a horizontal milling mode. The one difficulty of these machines is the time spent changing from one set up to another, but for anyone with limited space it could be the ideal answer.

THIS is a most interesting little tool, which derives its uncommon name from the fact that it is designed to be used either as a lathe, milling, or drilling machine. As a turning lathe, however, it has the additional distinction of being a traversing mandrel tool, and therefore can be used for screw-cutting chuck work. Also, as either a milling or drilling machine, it may be used horizontal, vertical, or angular.

Fig. 1 is a view of it set up as a centre turning bench lathe, and Fig. 2 shows it similarly set up on a bench in operation. The base space occupied on the bench is 30 ins. long by16 ins. wide, and these dimensions, in conjunction with its general proportions as against the operator in Fig. 2, will give the reader some clear idea of its size and compact design.

This tool hails from the other side, being manufactured in the shops of the B. G. Ames Co., of Waltham, Mass., and is factored by the Triplex Machine Tool Corporation of 18, East 41st Street, New York City.

In point of power drive it is a self-contained machine, and includes, in its regular equipment, and attached to the head, as seen in Fig. 2 a ¼-h.p. reversible constant-speed direct or alternating current motor.

Referring more especially to Fig. 1, it is seen to consist of a slotted base table of the dimensions given. At the left-hand end, and clear of the table portion, is stepped a substantial turned column, upon which by a large swivel boss is fitted the cantilever bed. This bed is capable of being swivelled right away from the base, and is fitted with a graduated protractor reading to 45° upon either side of the zero or parallel point, which sets it parallel with the head spindle. It is also controlled for height, apparently, by a hand-wheel nut, acting upon a vertical screw, which is so mounted that it can swivel with the bed. The hand-wheel is that to the left, and the lever for locking the bed is the one upon the outside.

The bed carries a saddle, controlled for traverse lengthways by the centre handwheel, and the saddle has mounted a cross slide table of dimensions 5 ins. by 14½ ins., controlled by the right-hand wheel. The traverse distances are longitudinal 10 ins., cross 6 ins., and vertical 4¾ ins. The greatest swing over the cross table is 10 ins. diameter, and the greatest swing to the bed is 16 ins. The head is mounted on the column top, and carries a spindle capable of end traverse, and running in adjustable phosphor-bronze bearings. The head is in two portions - one, the base, permanently set with its quadrant arm parallel with the base table, the other the main bearings, gears and motor, which can be radially run upon the quadrant, and locked in any position from horizontal to vertical. The adjustment in the latter case is aided by a counterbalance

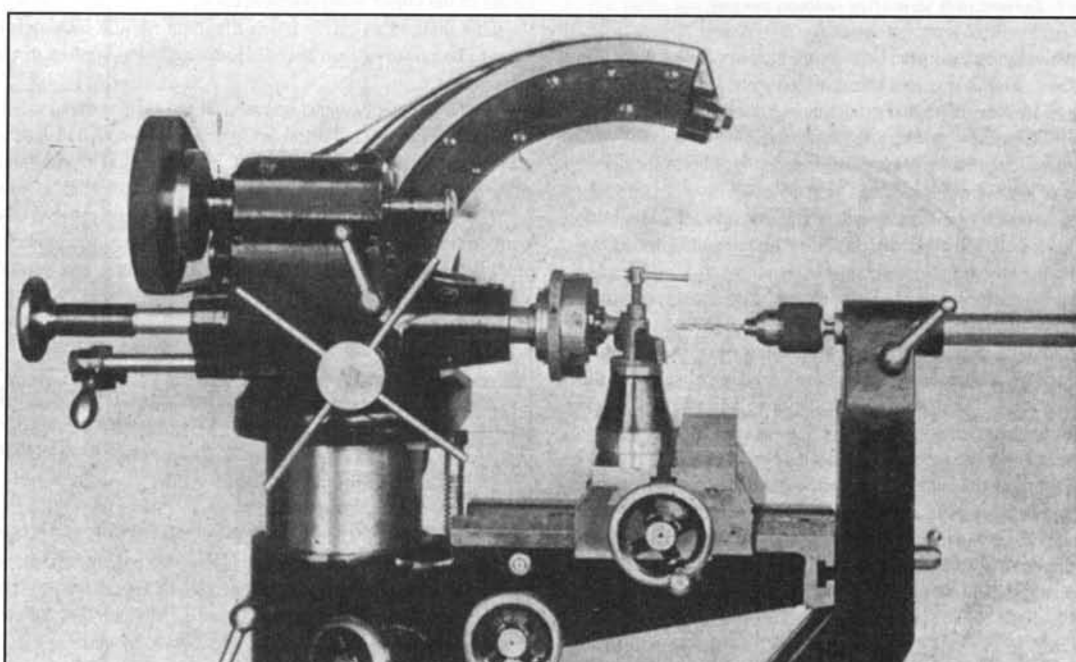


Fig. 3. The "Triplex" Tool Arranged as a Traversing Mandrel Lathe.

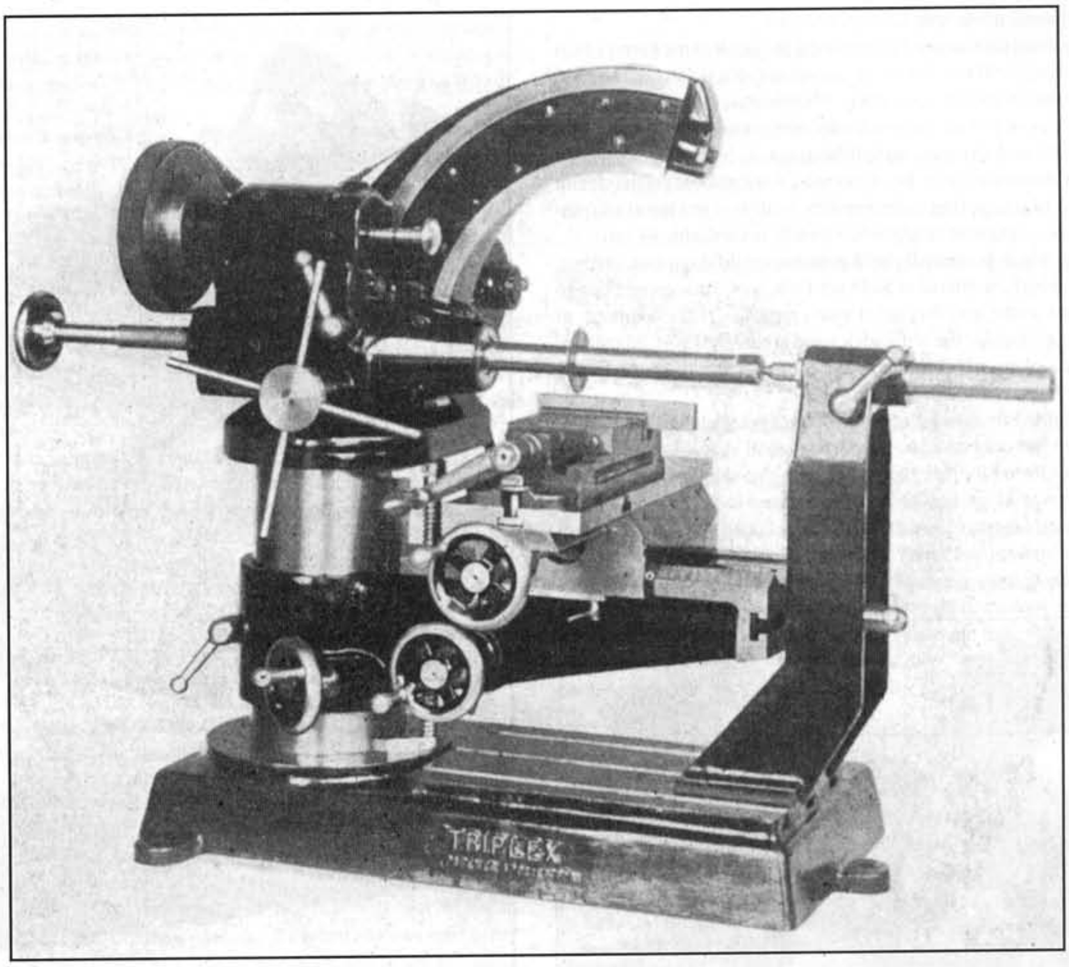


Fig. 4. The "Triplex" Tool as a Horizontal Miller.

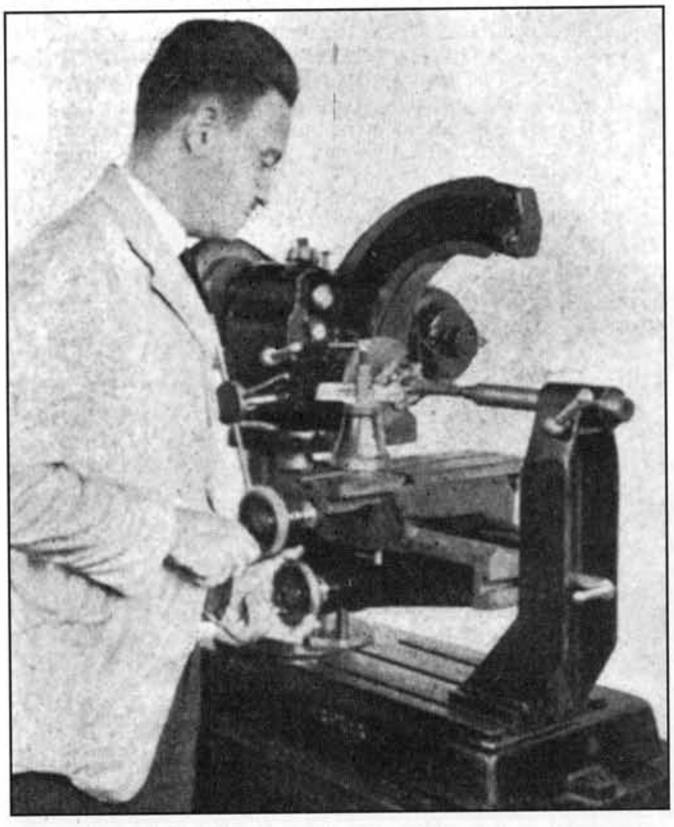


Fig. 2. The "Triplex" Lathe in Operation.

weight in the column, acting by a line over pulleys, one of which is near the point of the quadrant. Accuracy of adjustment for radial position is effected by a ½° protractor engraved on the quadrant, and reading against an index on the movable portion of the head.

The tailstock is of special bracket form, bolted to the base table, and equipped with a lock bolt which tees into a transverse slot in the vertical end of bed. The barrel of tailstock carries a runner spindle, which spindle, by the way, is generally inoperative as a feed, being always locked when in use. To explain this, look at Fig. 3, wherein we see the machine arranged as a traversing mandrel lathe. Here, chucked work is being screwcut by means of the hob controlled spindle against a stationary tool. With the same setting, and with the hob de-geared, the work can be concentrically end-drilled by hand-traversing the spindle and its revolving work up to the stationary drill chucked to the locked runner of tailstock.

Fig. 4 shows another horizontal setting, where the machine is arranged as a horizontal miller. Here a machine vice replaces the tool-holder, and a substantial cutter mandrel, carrying a cutter, is collet-chucked and tail-centre supported, and most conveniently placed for edge-slotting, grooving, slab-milling, and other operations, the work being set on the cross table. End-milling can also be done in this setting.

Fig. 5 is an example of an angular spindle setting, either for milling or drilling. In the latter case the end traverse of the spindle controlled by the cross cut arms comes in as a necessity. In this we see clearly the advantages of the six movements. Spindle angularity and end movement, vertical bed, longitudinal and cross table, and the capacity for angling the bed by its swivel, which, by the way is the method for setting for taper turning and screwing when used as a lathe, and, for which purpose, the swivel protractor is not only marked in degrees but in inches per foot of taper. In this connection, viz., the use of the spindle either horizontally, angularly, or vertically, for drilling or milling, comparatively large jobs can be operated upon by entirely swinging the bed away from the base, and mounting the job directly upon the base table.

Fig. 6 shows the machine in its vertical position, which, in the light of the foregoing descriptions, needs little further comment.

Among the general details may be mentioned the fact that the gears, which provide six speeds from 90 to 1,050 r.p.m., are all cut in solid steel. The head and tail spindles are of special alloy steel. Micrometers are provided on all feeds. All slides can be locked, and practically every movement by one lever-nut. The gear shafts and thrust are on ball-bearings.

Several other dimensions may be of interest. For instance, the maximum centre-distance is 14 ins.; spring collet capacity is up to ½ in.; travel of spindle end-on is 3 ins.; maximum height when spindle is vertical is 43 ins.

The machine, which is normally sold with motor, driving-plate, centres, tool-post, and a wrench, is offered at $485 net f.o.b. New York, an addition to which of $24 adds a cast iron floorstand with chip-pan. Other additions, at proportionate prices, include the milling vice and arbor - which is ⅞ in. diameter - an 8-in. face-plate, self-centring and drill chuck, threading attachment including master hobs, and sprint collets.

The points claimed are the ease of change and consequent universal nature of the tool, which not only takes comparatively small space, but does away with the necessity for costly jigs, more especially due to its angular spindle adjustment. Some of its applications are represented in the practice of tool rooms, experimental laboratories, and vocational schools. Model and pattern shops, instrument makers and repair shops and private estates, and so forth, and it would appear to those devoted to the rapid production of the better-class wireless apparatus such a machine would be invaluable. The more one studies its universal characteristics the more remarkable appear its possibilities in the matter of range of production. With all this it has the general appearance of a well made and finished appliance which should appeal to all lovers of good machine tools.

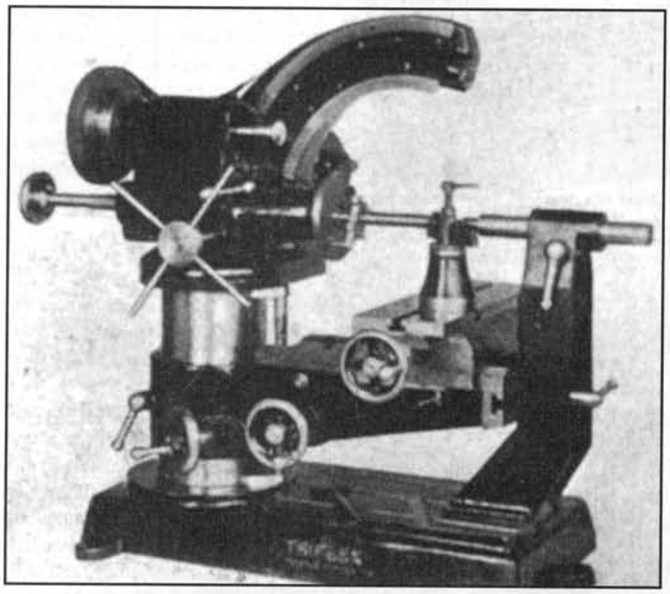


Fig. 1. "Triplex" Tool Set up as a Centre Lathe.

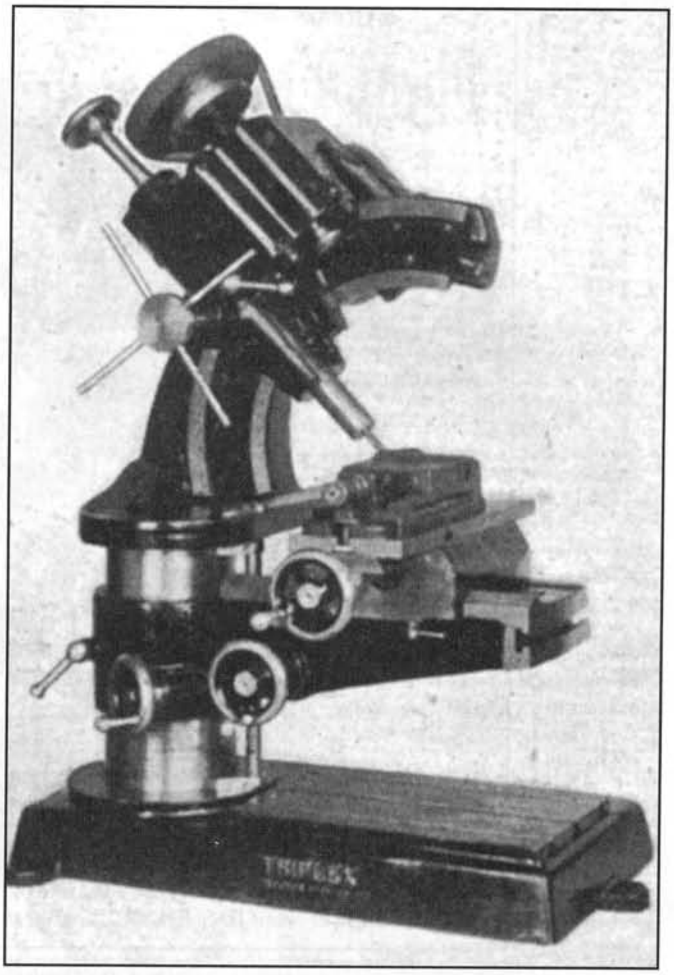


Fig. 5. The Combination Tool arranged for Angular Milling and Drilling.

July 10,1924.

The knowledge to make special milling cutters could be a useful skill for the one-off job. I assume that the writer of this article in 1924 wished to remain anonymous unless John Doe really existed. The idea contained here could be used to sharpen cutters for those without access to a purpose-built tool grinder.

Workshop Topics. Milling Cutter Notes.

By John Doe.

THE added usefulness which the possession of a milling attachment gives to a lathe is generally not fully utilised, often because of the trouble of procuring suitable cutters, and the supposed difficulty of making efficient ones. The purpose of this article is to show that really good cutters can be made without great effort, and how they may be maintained in true-running and sharp condition - an often neglected point.

General Considerations.

For working brass and soft bronze the fly-cutter and "fishtail" give a very good service, as they may be used in a light attachment and run at a high speed without injury; but when cast iron or steel work is attempted, or even some of the hard bronzes, the speed of the cutter has to be so much reduced if it is to be kept sharp that the work is only very slowly done. This is the province of the milling cutter proper; by their use better work may be done more quickly; but the milling attachment will require to be more rigid than the cutter frame type, and to have a more powerful drive; some form of reduction gear, worm, bevel or spur is required to maintain a belt speed sufficiently high to transmit the power required. Speed of the cutter may be 40 to 50 feet per minute for steel, if lubricated.

Good cast steel is suitable for making these cutters - only very light tempering is needed as the work they do is not heavy. High-speed steel is not recommended, as it is seldom done justice to either in the hardening or the subsequent use.

After the material the question of tooth pitch and shape arises. The angle of tooth may be anything from 40° to 60° with a generous radius at the foot of the tooth, and a front rake of 10° to 20°, all of which is shown diagramatically in Fig. 1.

For light work a fairly fine pitch of tooth gives the best results - about ⅛ in. to ⅜ in., depending on the size of cutter and the purpose for which it is intended; a slotting cutter, for instance, would have finer tooth spacing than one intended for facing.

This may seem counter to the modern ideas of tooth spacing; very wide spacing is practically the rule, but so long as there is "chip room" between the teeth no more is required. Feed per tooth is the thing, and so long as the cutter does not choke and the machine can drive it, the finer pitch cutter will do more work. For light work and light equipment the wide-pitch cutter is too jerky, the light cuts and feeds taken render it very difficult to have more than one tooth cutting at a time, a desirable condition for steady working and absence of "chatter."

True running, too, is most important, for if the cutter be not true only three or four out of the total number of teeth will be cutting, giving an approximation to the fly-cutter and consequent slow feed and slow accomplishment.

Accurately running arbours on which the cutters are a good fit are essential unless the cutter is permanently attached, in which case it should be turned, finished and ground on the arbour. The turning of cutter blanks is too straightforward to need any mention, except that the material should be discs from a bar, not a piece of plate, and annealed before use.

Cutting the Teeth.

Teeth may be formed in a great variety of ways, the most common being to saw out the spaces and file up; but to make an accurate cutter by these means requires considerable skill and time. End mills must have a small shank to be conveniently made by this method.

Now skill should not be required for such a job, one than can be done quicker and more easily mechanically, the first step towards which is to rig up "something on the slide-rest." Fig. 2 is an example; milling teeth in the side of one of a set of four angle cutters, the teeth of the two "side and face" cutters shown in Fig. 4 being cut in the same way. This method was used rather than the milling attachment because it was more rigid, easier to see and easier to feed - feeding with the top-slide swung round being anything but convenient. The "rig up" is the usual junk, amongst which was a spigot which fitted the cutter bore with a screwed collar enabling height adjustment to be made after setting the angle of the blank.

This angle is rather important, as if it is incorrect the resulting "lands" on the teeth will not be parallel. The required angle is easily found by the formula tan A x cot. B = sine X.

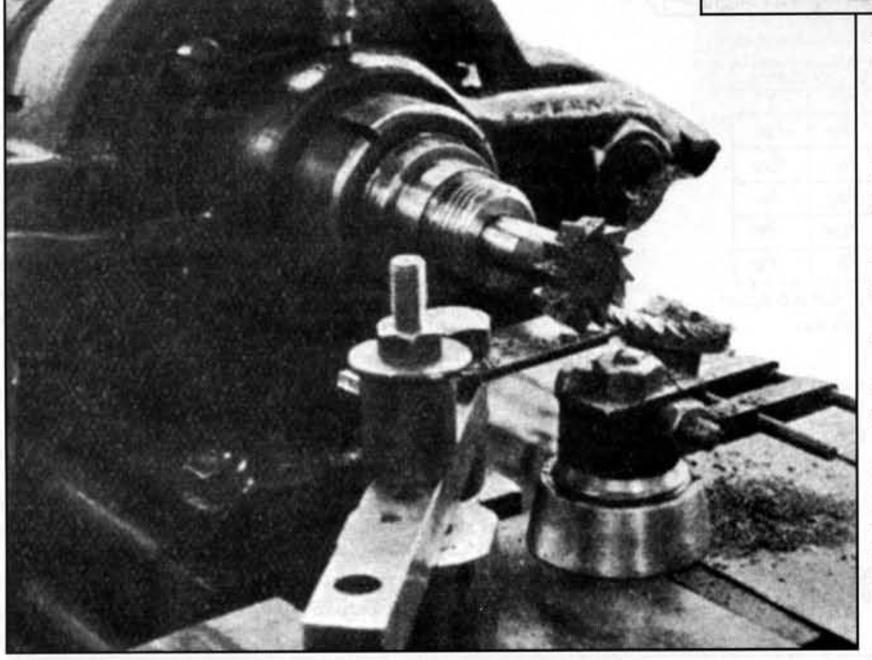


Fig. 2. Milling Teeth on Face of Angle Cutter.

Where A - angle between teeth = $\frac{360°}{\text{No. of teeth.}}$

B = angle of milling cutter.

X = angle required.

An example will make this clear:–

Blank to have 20 teeth, cut with a 60° cutter, find X.

A = tan 180° - .3249

B = cotan 60° = .577 = .3249 x .577 = .1875, and sine .1875 = 10° 48", 10¾° roughly.

The face tooth angle is more difficult to find, but may be got at as follows:-

$\frac{\text{Cos A}}{\text{Tan B}}$ = Tan Y.

Tan A x cot. G x sine Y = sine R.

Then Y - R = X.

Where A = angle between teeth = $\frac{360°}{\text{No. of teeth.}}$

B = angle of blank.

G = angle of grooving cutter.

X = angle required.

In practice it is better to neglect this formula and work by trial as being the quicker method!

So much for the angular setting. The actual cutting was done by using a

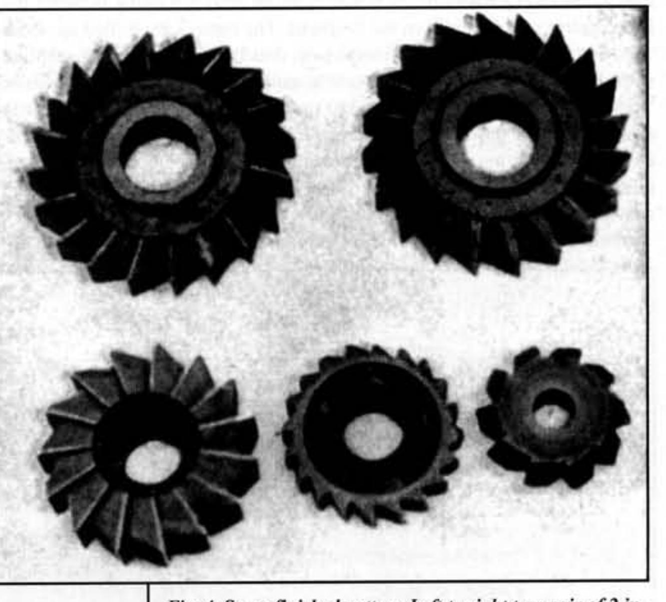


Fig. 4. Some finished cutters. Left to right top: pair of 2 in. side and face. Bottom: face mill, slotting cutter, and double angle relieved cutter.

small angle mill in the lathe head, as the photo clearly shows, a stop being fixed up to register with lines scribed on the edge of blank, thus giving even spacing.

Once setting sufficed for the cutting of the face-teeth in the set of cutters, but as the angles vary separate settings were necessary for the edge-teeth.

Paraffin, turpentine, or a 50 per cent, mixture forms a good lubricant for this work and should be liberally used.

Teeth on angle cutters are, perhaps, the most difficult to cut; edge teeth in slotting cutters and the gashing of blanks to be relieved present few difficulties.

Perhaps the easiest method of producing such teeth is to use a fairly large diameter saw and sink it into the blank, as shown in Fig. 3., the blank being arranged at centre height and two cuts made to each tooth, the roots being afterwards touched up with a file; this will be found easier than milling the metal away on cutters over about 1½ ins. diameter.

After the teeth are cut any inequalities in the width of the "lands" or the blending of the faces in cutters having more than one working face should be carefully corrected by filing, as the satisfactory grinding of the cutter depends on this regularity in a large measure. The "lands" may be quite narrow - 1/64th in. in a 2-in. diameter cutter is ample. Any burrs on the working edges need not be removed, but all others should be, as well as unnecessary sharp corners, when the blank is ready for hardening.

Hardening.

The points requiring attention in the hardening are: Steady heating at a fairly low rate, the cutter being sprinkled with charcoal dust to prevent oxidation, and care being taken not to overheat. On quenching remove the cutter as soon as the water stops boiling, dip in "air-cooled" oil and gently re-heat until the oil smokes freely; leave to cool in the air and the temper will not require further drawing.

Grinding.

Preparatory to grinding, any scale in the bore or on the clamping faces of the cutter should be removed.

If the arbours they fit are true the cutters may be ground on a "dead" spigot; if not they should be ground on the arbour.

End mills and all cutters with integral shanks should be ground from this shank.

A grinding attachment is not required, as may be seen by reference to Fig. 5, the emery wheel being mounted on an arbour running between the lathe centres and driven from the overhead. The centres are drilled up about ½ in. and the hole filled with cotton waste, thus keeping the centres supplied with oil, while the cutter to be ground is mounted on another assemblage of "junk" consisting of a bar clamped to the boring table on which a collar is fitted capable of movement up and down and also of rotating. On this collar is a spigot fitting the bore of cutter and with a tapped hole in the centre, allowing of a bolt with a nut and washer being used to eliminate possible side-shake.

NOTE: When cutters are being ground the slides and bed of lathe are covered with a rag, which has been removed for the purpose of taking the photograph.

Next a stop for the cutter is required - a piece of hacksaw blade held in a small clamp is used here.

Clearance, 5° to 7°, is obtained by adjusting the height of the cutter relative to the lathe centres, and the cutter is traversed past the wheel by means of the lead screw, the wheel revolving in the reverse direction to which the lathe mandrel normally runs.

(The lathe mandrel is, of course, stationary during this grinding, the emery wheel running on "dead centres".)

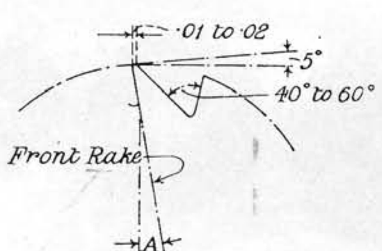
Fig. 6 and the table given will make the setting clear, the wheel revolving against the cutter, which must be held down on the stop, prevents that small "grinding burr" forming.

When all the teeth have been brought to a sharp edge a final and exceedingly light cut should be taken round the cutter to compensate for possible wheel-wear.

Side teeth are ground in the same way, the cutter being set with its axis at 90° to that of the lathe.

Side teeth are rather awkward, as there is not much room to spare at the inner ends of the teeth and the necessity of using a small wheel to give the required clearance brings the cutter very near to the wheel arbour. For cutter grinding with these small wheels, averaging about 1½ ins. diameter, a driving pulley on the arbour is not necessary; if the arbour is about 7/16th-in. diameter, knurled, plenty of driving power will be obtained, and, in addition, a reasonably high speed will be more easily maintained - 6,000 to 8,000 revs. per minute is not too high. A caution is required with regard to the setting of angle cutters for grinding. The stop must be at the same height as the centre of cutter if a true angle is to be produced - much the same thing as the necessity of having the tool at centre height when taper-turning.

Cutters with shanks are held in a "V" block instead of on a spigot, and the grinding process is identical with that described. This description of the method of grinding new cutters is suitable to the operation of re-sharpening



Tooth Shape Diagram

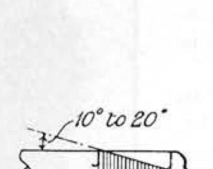


Fig. 1.

Front Rake

Cutter dia.	10°	20°
·5	3/64	3/32
·75	1/16	1/8
1·0	5/64	5/32
1·25	3/32	3/16
1·5	1/8	1/4
2·0	5/32	5/16
2·5	3/16	3/8

Offset of Cutter A in drawg.

Wheel Dia.	Clearance	
	5°	7°
1	3/64	1/16
1½	1/16	3/32
2	3/32	1/8
2½	7/64	5/32
3	1/8	3/16

Distance X for various Wheel dias.

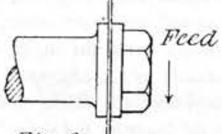
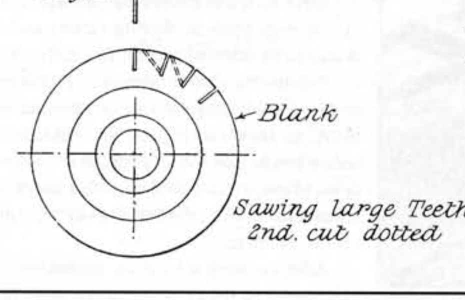


Fig. 3.



Sawing large Teeth 2nd. cut dotted

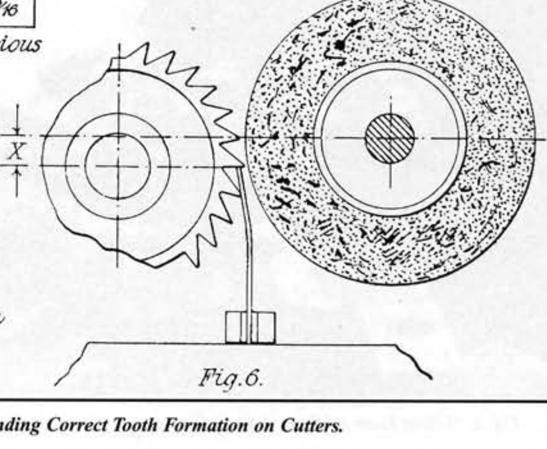


Fig. 6.

Details relating to Grinding Correct Tooth Formation on Cutters.

those which have become blunt, and the re-grinding should be frequent, particularly so in the case of cutters having corners, as once these "go" they rapidly become worse and necessitate the removal of a large amount of metal from the cutting edges before they are again in good condition.

The chief thing in either the first or subsequent grindings is to have the cutter accurately set for angle of face and clearance angle, and to finish with an extremely light cut.

Conclusion.

This sketch of a method of cutter-making showing the comparative ease with which many types may be produced can be best rounded off with a few warnings and suggestions: When milling the teeth do not force the cut as the consequent rough tooth face leaves a badly-finished surface when the cutter is used.

If spiral-fluted cutters are attempted the milling attachment will have to be used, and the angle of lead of the spiral by means of the formula -

$$\text{lead} = \frac{\pi d}{\text{Cot A}} \text{ or Cot A } = \frac{\pi d}{L} \text{ for angle}$$

when A = spiral angle, *d* mean diameter cutter, and L = lead. The flutes should be cut with a double-angle cutter to avoid interference, its angles being about 12° and 48°. Some "wangling" of the lead may make the cutting easier, for it is requisite to index the blank relative to the lathe mandrel for each tooth.

As an example, suppose an end-mill is to be made with a spiral lead of 2½ ins., the lathe having an 8 t.p.i. lead screw, it will be policy to have either five or ten teeth in the cutter, for 2½-in. lead = 20 turns of the lead screw, five teeth could be got by moving the slide-rest along four turns of the screw after each cut and then re-engaging - or two turns in the case of a 10-toothed cutter. By this method an index mechanism is rendered unnecessary; the same end may be accomplished by dividing the lead by the number of teeth and moving the top-slide forward this amount before starting each new cut; either method requires that the setting shall allow free travel to the slide-rest for a distance equal to at least twice the lead being cut.

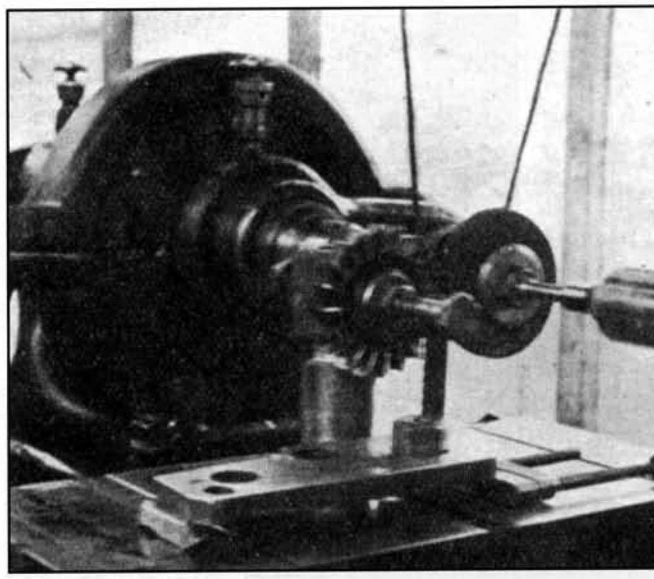


Fig. 5. The cutter set up for grinding teeth.

Although a backed-off cutter is shown in Fig. 4, no mention has been made of the method used - mounting the cutter on the face-plate and relieving one tooth at a time by rocking the face-plate by hand - as I believe it is well known, but the making of ordinary cutters does not seem to have received so much attention.

There are few difficulties in the making, but where the milling attachment fails to give satisfaction the trouble can nearly always be traced to blunt or hand-ground, and consequently out of truth, cutters; proper grinding as soon as needed will work wonders, and, after all, if a cutter has 30 teeth, why use only three if grinding will bring them all into service?

July 30, 1925.

WORKSHOP TOPICS

A Filing Machine for Finishing Small Parts.

Small filing machines are rarely found in the amateurs' workshop although they can be a labour saving device for many applications. The filing machine described here is quite a simple piece of apparatus to make but being mindful of current thoughts on safety I would include a guard for the end of the file. The point of the file sticking up as it does in Fig. 12 could cause a nasty wound even if the machine was not working.

By W. H. Spiers.

FINDING at times that the finishing of the ends of eccentric rods and similar work became rather tedious when done by hand, I thought that something could be devised that would accomplish the work quicker and more accurately than by hand filing, and simpler than milling, so after some months of scheming, the filing machine to fit my 4-in. Drummond lathe was developed and built. The machine is very simple, and could be easily made in two or three nights, as it is built up from stock material.

The body (Fig. 1) is a piece of 6-in. by 3½-in. steel channel, which no doubt could be picked up at any scrap dealer's, and this will have to be machined on all outside faces. The sketches and photographs will give a good idea of the machine and the principle on which it works.

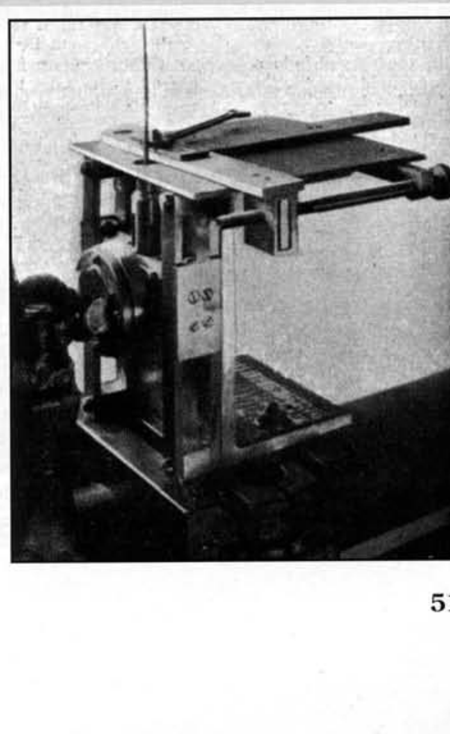


Fig. 12. The machine complete on lathe, with a small coupling rod and pivot in position.

Guide bars similar to those used in a horizontal engine are fitted to the front of the channel, and are made from ¼-in. by ½-in. and 5/16th-in. by ½-in. bright steel, the distance pieces being ½-in. square bright steel.

The ¼-in. by ½-in. bars are fixed to the body or base of the machine by 5/16th-in. countersunk screws, and the 5/16th-in. by ½-in. bars are fixed by 5/16th-in. cheese-headed screws, passing through the distance pieces and screwed into the base.

The crosshead guide bars are ¼-in. by ⅝-in., and the distance pieces are ⅝-in. by ½-in. by ¾-in. These distance pieces have a ¼-in. spigot turned on each