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.

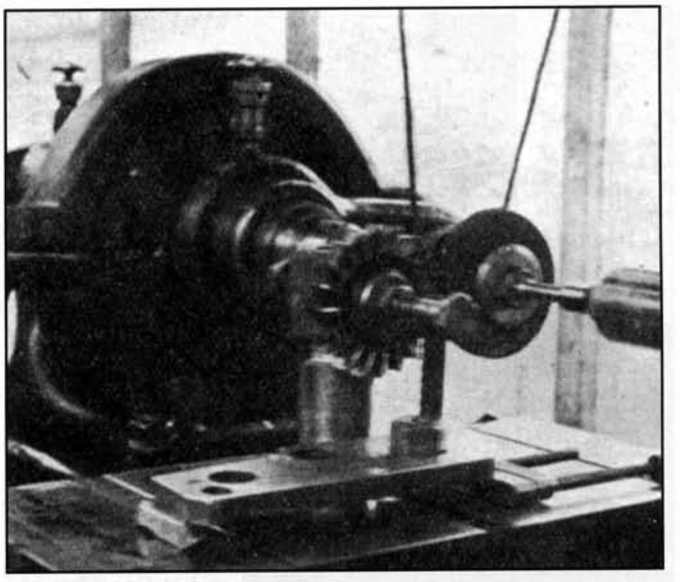

*Fig. 5. The cutter set up for grinding teeth.*

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?

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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.

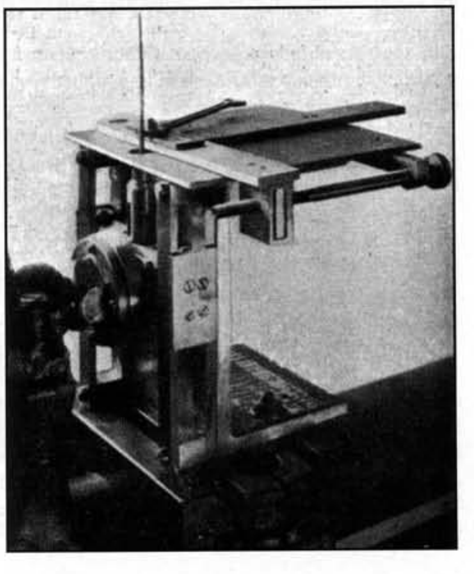


*Fig. 12. The machine complete on lathe, with a small coupling rod and pivot in position.*

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 3/16th-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 3/16th-in. countersunk screws, and the 3/16th-in. by ½-in. bars are fixed by 3/16th-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

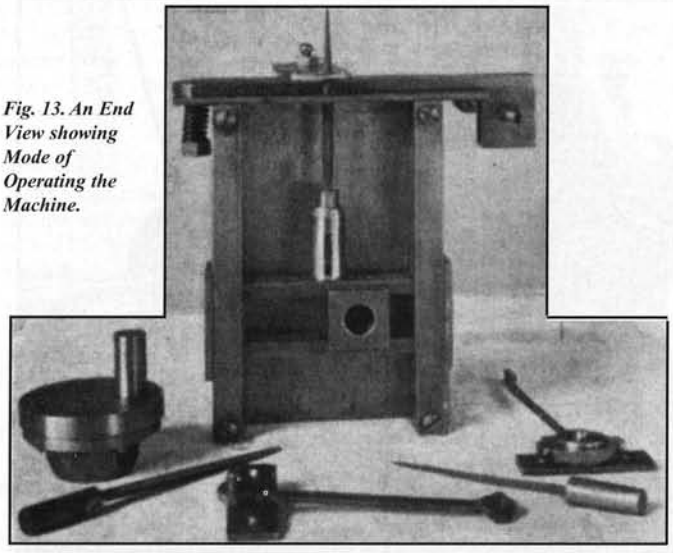


*Fig. 13. An End View showing Mode of Operating the Machine.*

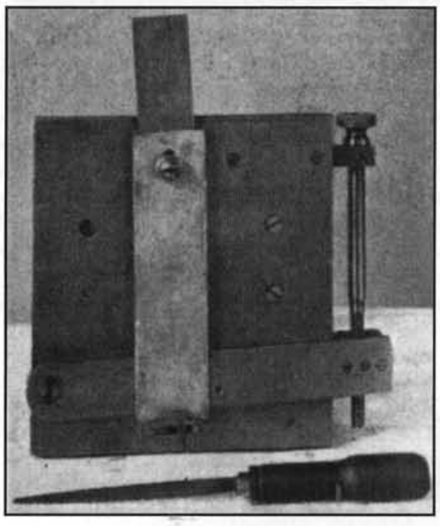


*Fig. 14. Face of Table of Filing Arranged for long Radius Work with a Model Link Set up. File in Fibre Handle at Front.*

end, which passes through 1/4-in. hole in the guide bars, and two nuts at end end clamp the bars in position. I afterwards found countersunk screws would have been better, as the nuts fouled the side guide plates and had to be filed smaller.

The top bar will have to be drilled and tapped 3/8-in. (26 threads I found to be most suitable), and this must be central to take a pillar or stalk 5/8 in. diameter and reduced to 3/8 in. to screw truly into the guide bar; this will be the file holder, which has a taper hole to fit the taper pins and files.

The crosshead is made from mild steel, and is milled to slide in the bars, the crankpin pole being 1/2 in. Gunmetal could be used if a piece the size required is handy.

The stroke of the machine is 1 1/4ins., and I sometimes use a crank giving 1 1/2 in. but the 1 1/4 ins. suites the lathe centres best, and does not allow the stalk to travel too near the table.

The crankpin is a piece of 1/2-in. steel shouldered down to 3/8 in. and screwed into a piece of 2 1/4-in. by 3/8-in. steel fitted to a small chuck back by four screws.

My chief difficulty was finding means of holding the files without using screws, and I eventually decided to use the centre portion of a No. 7 taper pin. I happened to have a broken reamer to suit. These reamers and pins are about 4 1/2 ins. long, and as my reamer was broken about 2 ins. from the end, I cut the taper pins 2 ins. from the end; they were again sawn about 1 in. further along.

To ensure these all being the same length, a jig was made from a piece of 1 1/8-in. round mild steel, which was faced to the length required, then drilled and reamered, and the short pieces of taper pins were faced to length in this as required. At present small needle or jeweller files are used, these having round handles about 1/8 in. diameter; these handles are shortened and a hole is drilled a shade smaller than the file handle in the taper pin, which will, of course, be drilled in the lathe. The file is held carefully in the vice and the taper pin gently tapped on to the file.

The ordinary small flat and half-round files are also used, and a slot must be cut in the taper pins to hold these. A jig is made from 3/8-in. square steel drilled and reamered; this, with the taper pin, is held in a vice on a vertical slide, and the slot cut with a circular saw. The slot should fit the file snugly, and the holder and file are then tinned and sweated together.

I found difficulty in soldering these together, as the files would persist in getting out of square, so I drilled a small hole in the side of holder and tapped it 3/32nd in. and held the file in position with a screw until soldered.

All the files can be used by hand by making a special holder from vulcanised fibre, as shown in Figs. 11 and 14; this is drilled and reamered to take the file holders, which can easily be removed when required by drilling a hole right through the handle to allow a piece of steel to be pushed through.

The number of files required is very small and the various shapes will suggest themselves as experience is gained with the machine.

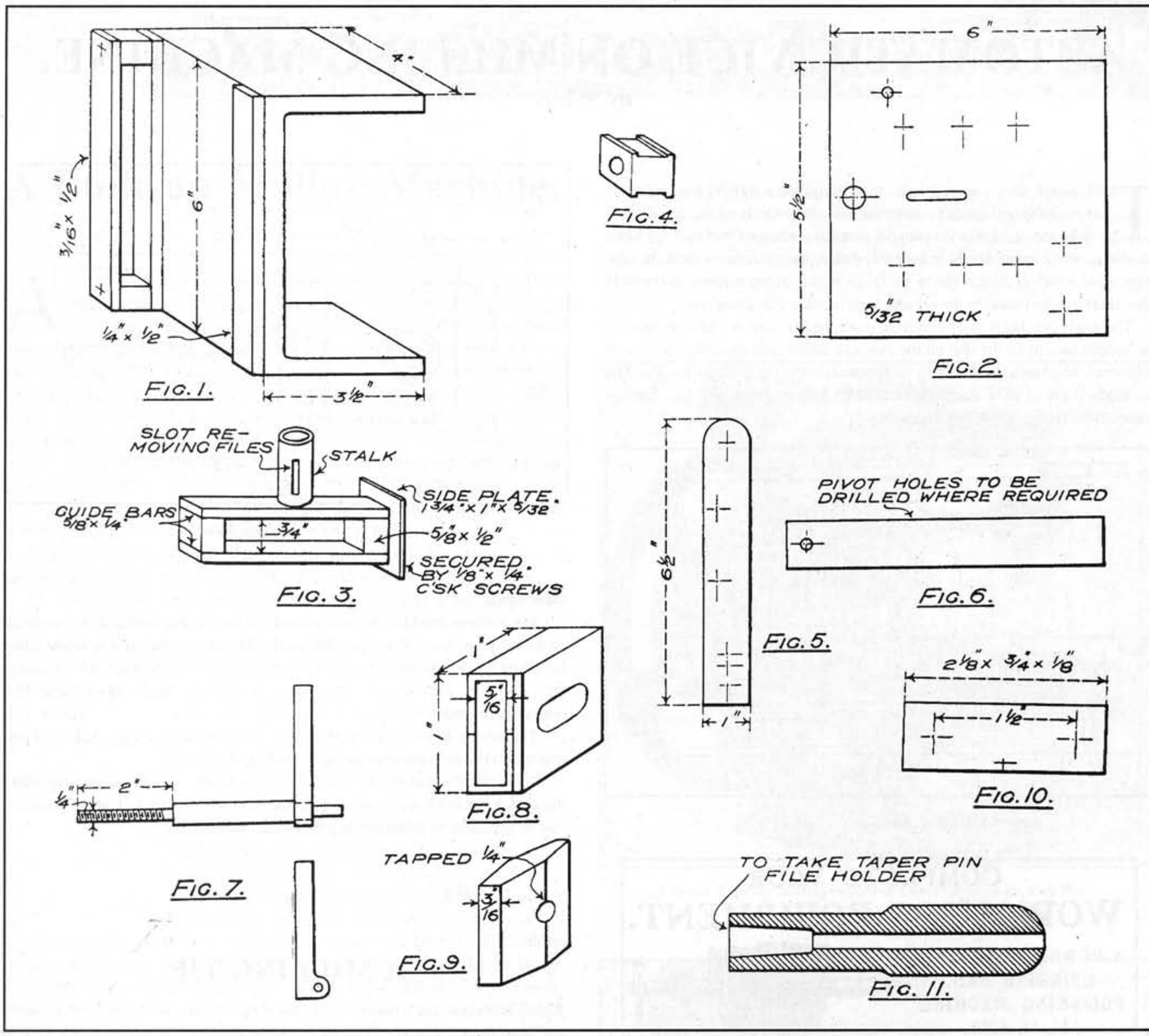
The next problem was to find a means of feeding the work to the files. I thought of various methods, and eventually adopted the idea shown in photograph (Fig. 12). This consists of a piece of flat bright drain steel 1in. by 3/16th in. by 6 1/2 ins. pivoted at one end by a countersunk screw 1/4 in. by 1 in.; this is fitted with a nut and spring underneath the table, and holds the adjusting bar firmly. The movement of the bar is effected by a box and special nut; this is made from 5/16th in. channel brass, two pieces being held together by a piece of 3/32nd in. brass plate held by four 3/32nd in. screws. Making the box in this manner saved a great amount of work in drilling and cutting out of solid.

The nut is made in the manner shown in the drawing, and should be a good fit so that it may slide and adjust itself to any angle when the bar is moved; a slot is cut in the box front to allow the screw to clear when the box is moved to the different angles.

The adjusting screw (Fig. 7) is made from a piece of 5/16th-in. round steel reduced to 1/4 in. at the screw end for about 2 ins., also reduced for the bearing to 1/4 in. by 3/8 in., and then to 5/32nd in. to take the knurled knob, which is made from 1-in. round brass.

A piece of steel 6 ins. square is used for the top of the table, and is screwed to the 6-in. by 3 1/2 in. channel by six 3/16th-in. countersunk screws. A 7/16th-in. hole is drilled about 1/2 in. from the edge of the front to allow the files and holders to be put through into the stalk, and also to allow the files to work up and down when filing. A slot is also cut about 1 in. from this hole along the centre line, and is about 1 1/4 ins. by 1/4 in.; this is to allow another adjusting bar to be moved at right angles to the main adjusting bar. When using this bar to file an expansion link, the latter must be roughly filed to shape in the first place, and then fixed on to a piece of 1/16th-in. plate to suit the radius or length of the eccentric rod, and a half-round file is placed in the stalk; the link is dropped over the file, the main adjusting bar is moved in position, the other adjusting bar is tapped along until it touches the main bar, and a hole corresponding with the hole in the link radius plate is marked off and drilled, say, about 1/8 in. A peg is then placed in this hole, which will allow the link and plate to swing. Upon setting the lathe in motion, the file will move up and down. Now move the work and adjust the bars as required. In the course of the work the file will have to be altered to different angles so as to get into the corners at each end according to the design of the link. By this method the link can be filed to the exact radius and the faces are sure to be square.

For coupling and eccentric rod ends and similar work, a pivot plate will have to be used. Radius, such as expansion links, reversing quadrants, etc. Fig. 14 shows a small link with radius plate, which is equal in length to the eccentric rods. It is also made from 1-in. by 3/16th-in. steel. A 1/4-in. stud about 1-in. long is fixed in this about 1/2 in. from the end, then passed through the slot, and a nut and spring is fitted with sufficient tension to hold the bar down, but will allow it. These plates are made from 3/4-in. by 1/8-in. steel and are screwed to the main adjusting bar by two 1/8-in. countersunk screws, the holes for these being drilled to a jig, and are 1 1/2 ins. centre. To save making a large number of pivot plates, each rod should be drilled with the same size hole, which will, of course, be the smallest, and afterwards opened out to the right size. A piece of steel the size of the hole in the rods is screwed into the plate near the front edge, and centrally between the two 1/8-in. holes. Any pivots above 5/32nd in. should be shouldered down or they will not stand true, that is, they will lean over the amount equal to the angle of the thread. The rods are now filed roughly to shape, and then placed over the pivot which has been screwed on to the main adjusting bar, and a suitable file placed in position. The lathe is set in motion and the work set up to the file and moved round, or to and fro, until the desired effect is obtained. Coupling rods, which have the oil cups included with the boss, will be best treated with a half-round file, as




this can be adjusted to work in the corners.

Eccentric straps will have to have a pivot the size of the sheave, and this pivot can easily be made of brass. The edges of the straps will be filed beautifully square, and if a half-round file is used, this can be adjusted to work in all the corners, both square and radial.

It will be observed the file marks will be in a vertical plane, but if thought necessary, a slight amount of draw filing will take them out. The different kinds of work that can thus be filed to shape, so saving a great amount of vice work, are many, and include such parts as the end of lifting links, and connecting and coupling rod ends, in fact all work whose outline is partly radial, such as double and single eyes. Small straight work could be filed if a suitable fence were arranged, also work could be filed to any angle if the top or table of the machine were made to tilt.

I must impress upon all who fancy making this machine that it was made primarily for finishing work to a radius, and I have not tried it on rough work, for I file all my work by hand roughly to shape. I intend, eventually, to fit a small tray on the top of the stalk to catch the filings and prevent them falling on the working parts; the top of the stalk is already turned down to accommodate a tray. I must mention that a slot is necessary in the stalk to remove the files, and will be best cut in the side. I cut the slot in the present machine in the front, and it is rather difficult to remove the files owing to the limited space.

To fit up the machine on the lathe for working, the crank is screwed on to the lathe nose, the cross-slide removed, two 3/8-in. bolts are put into slots in saddle table, the machine is bolted down centrally, and the saddle is moved along until the crankpin enters the crosshead to within 1/16th in. of the end. The crankpin and bars should be well oiled before using. If well made, there is very little noise when the machine is in motion, and it can be made to suit any kind of lathe.

Before concluding, I would like to say that the reason I use taper pins is because they are cheap and are easily adapted to the work, and any size or part of a No. 7 or No. 8 can be used according to the size of reamer that may be to hand.

Half-round files will be found the best to use, as the flat portion is flat the full length, whereas the ordinary flat files taper towards the end.

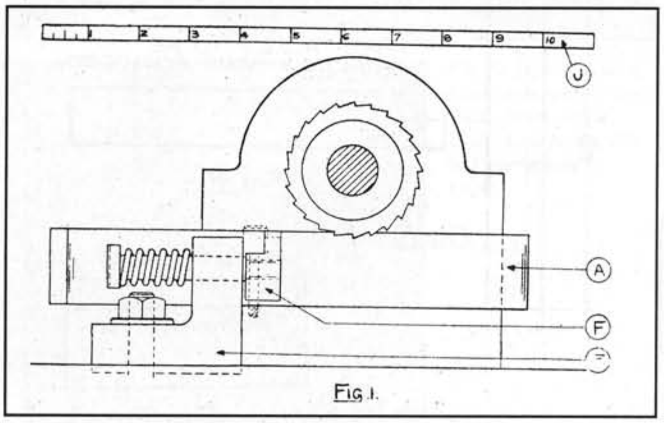
March 22, 1928.

# AUTOMATIC VICE ON MILLING MACHINE.

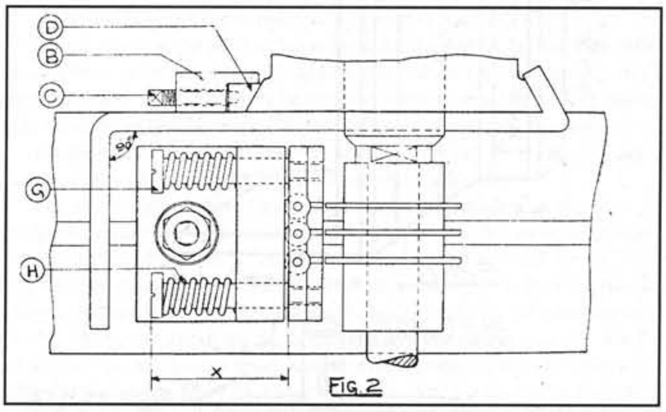
By N. F. F.

THE sketch shows an automatic vice for use on a milling machine; it is very reliable and quick in operation and can be easily made. Fig. 1 gives a front view and Fig. 2 a plan. The device is shown fixed up for milling the slots in three screw heads at once. The first part to make is the mild steel plate, A, to which is riveted the block B; by means of the screw C and pad D adjustment can be made on the vertical slide of the milling machine.

The angle bracket E is of cast iron, machined as shown with a tongue on the bottom face to fit the slot on the machine table. The movable jaw F is of mild steel, machined as shown to accommodate the three screw heads. The two studs G are of mild steel; length marked X being exactly alike. Springs H should be fairly stiff to be satisfactory.




*Elevation showing Vice in Use.*




*Plan of Vice on Milling Machine.*

**Operation.**

The milling machine table is moved back until the heads of the studs G strike the plate A and thus open the jaw F; the vice is now loaded; as the table is moved away towards the cutters the springs H close the vice; after milling the slots in the screws, the table is moved back again and the operation repeated.

The device is handy for numberless small jobs requiring a light milling operation; the only expense being a jaw F to suit.

To enable this automatic vice to be made to suit individual requirements, the sketch has not been dimensioned, but is drawn to scale so that proportions can be obtained by reference to any chosen scale.

April 25, 1929.

# A MILLING TIP.

CHATTER in milling machines, says a writer in The Machine Tool Review, can arise from a variety of causes, but unfortunately it is not very well known that chatter can originate from a cutter that is too sharp.

When next you get chatter on a horizontal milling machine, in spite of correctly arranged arm braces and well-supported work, try the effect of running the cutter slowly in the reverse direction and removing the extreme keenness by stroking with a smooth flat oilstone. The way chatter disappears after this treatment is little short of miraculous.

WORKSHOP TOPICS

# A Built-up Milling Machine.

By B. Burrows.

*While on the subject of hand built machines, here is a design for a milling machine that requires no castings. No drawings were made and the machine is smaller than it appears but the design has some novel features and could be adapted for modern ideas and a self-contained motor.*

AS FAR as I know the method of building this machine is new for a machine of any dimensions on account of the absence of castings. Like many others of the model engineer genus, I have a rooted objection to spending time on a pattern, to say nothing of the difficulty of machining the casting. However, the building up process has made it possible to put many interesting features into a small space. The machine is in no sense a model, but is intended to do real work. Another point I might mention is that starting with the two cross slides, the machine grew as various requirements became apparent, these being more or less governed by material to hand or easily procurable, i.e., beyond the roughest of sketches, no attempt was made to get out detailed drawings. If this had been the case, I am quite sure that the machine would never have been made!

One result of this method of working is that many of the dimensions are haphazard, and many small improvements could be made in this direction.

In order to make the construction as clear as possible in the absence of drawings, a detailed description of the component parts follows, references being made to the photographs (Figs. 1, 2, 3).

**1.- Framework.**

UPRIGHTS A, two M.S. pillars, ½ in. by ½ in. by 9 ins. to take vertical slide.

B, iron plate ⅜ in. by 2 ins. by 9 ins.

These are braced by -

C, two ¼ - in. steel tubes.

D, one short length of gas piping.

E, M.S. plate, 3 ins. by 2½ ins. by 3/16th in.

F, cross piece, 4 ins. by 1¼ ins. by ¼ in.

G, cross piece running across top of machine.

H, connecting G with the beam carrying "tailstock".

This is made secure by a 3/16th-in. screw at one end, has a brass shoulder soldered and pinned so as to bed up to E, passes through the gas pipe D and the upright B, and is locked rigid by a ¼-in. nut at the other end. A pin passes through top of E into the beam, preventing it from turning. Members G and H were added to stiffen the beam, which could with advantage be made of ⅝-in. or ¾-in. stuff instead of ½ in.

The first job done on the machine was the cutting of a small slot (not shown) in H into which fits G.

In practically every case where accuracy was an essential, clearance holes for screws were made, the parts adjusted square or in line, or whatever the particular requirement was, and then additional screws or set pins were inserted.

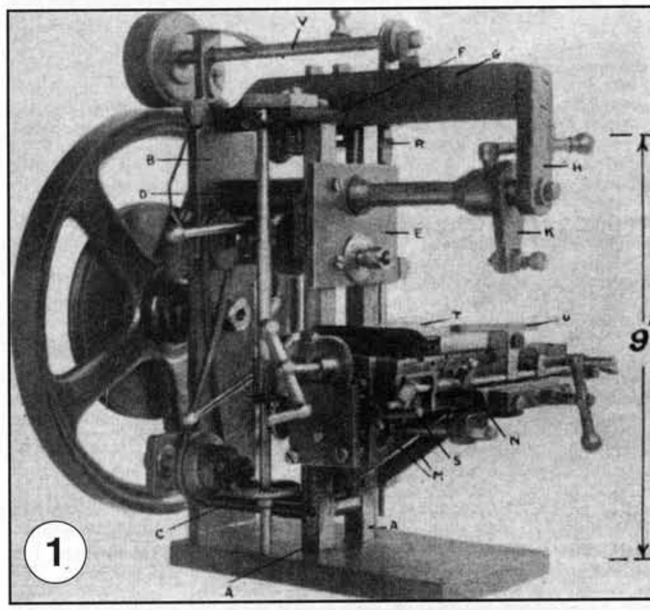
**Tailstock** (K, Figs. 1-3).

This is made from 1-in. round brass and ¼-in. by 1¼-in. iron. The brass was turned a driving fit in a bored hole in the iron, and then both parts were tinned and pressed together while hot. The iron has stood many a kick and has not up to the present parted company with the brass! But no doubt two set pins or small screws would prevent a possible accident. However, personally, I prefer to wait for the accident. On small work, points which can easily be remedied if broken act as safety valves. [N.B. - There are several "safety valves"].

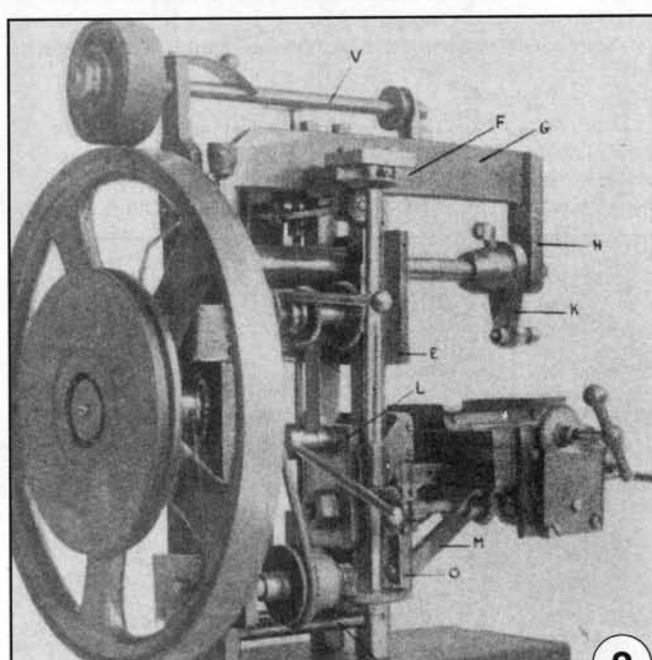
**2.- Slides.**

The slides and vee strip were cut out of ⅜-in. and ¼-in. flat iron. In making the vees, a line was set out and the strip hacksawn off length-wise, and the faces filed and scraped to a surface plate, and to each other. This was a tedious business, and I was very relieved when the last vee had been cut and trued up.

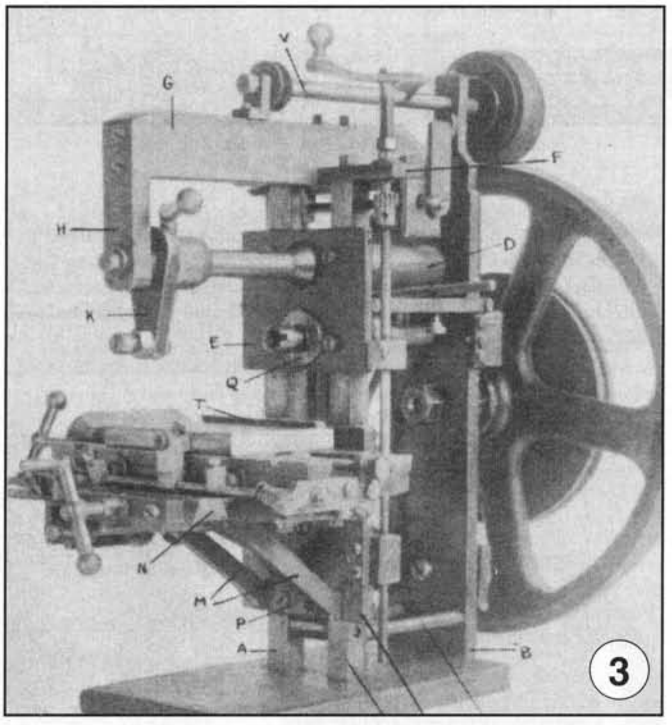
The most awkward part of this section was the making of the angle-plate. One side of this carries the cross-slide and the other forms part of the vertical slide, riding on the two pillars. The part N was attached to the M.S. plate O




*A Small Built-up Milling Machine Constructed to do Real Work.*




*The Drive Side of Built-up Milling Machine.*




*Built-up Milling Machine.*

by two screws, and then set up over a spirit lamp and stays M sweated on to O. It was then easy to put screws through into O, and also to attach the other end securely to N. Some time after a piece of 1-in. by ¼-in. iron (P) was bent to shape and screwed in between the two stays to give additional support.

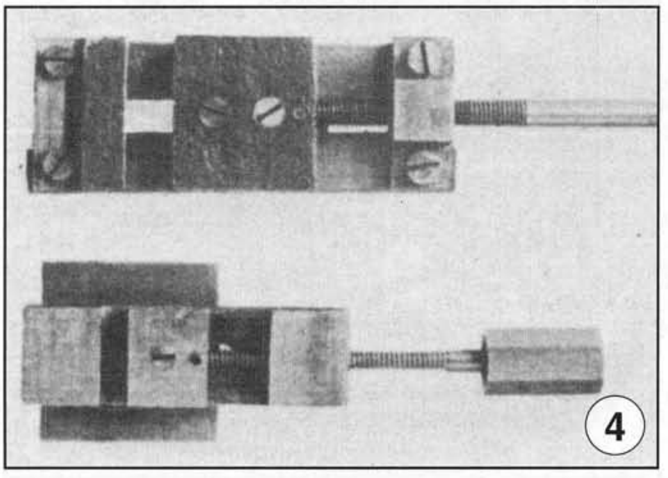
The back-plate O forming part of the vertical slide is kept in position by two pieces of ½-in. by ⅛-in. angle iron, and a M.S. plate (L, Fig. 2) at the back of the pillars. Slack is taken up by screws bearing on a brass strip and by two nuts. The lower of the two nuts is set to give a convenient friction, and the other is provided with a handle and locks the vertical slide in any required position (shown in Fig. 2).

Friction on the traverse and cross-traverse slides can be regulated by two screws in the one case, and a cam, controlled by a lever, in the other. In the latter case the slide can, of course, be locked.

The three lead-screws are all 5/16th-in. silver-steel screwed Whitworth thread.

**3.-Drive and Spindle.**

From previous experience in attempted milling in a lathe, I knew that plenty of reserve power would be required and after considering alternatives, decided to put a fairly heavy fly-wheel (providentially discovered in a second-hand shop just about that time) on a separate stud and gear it to the spindle.



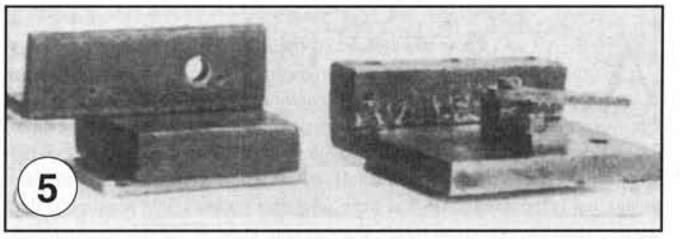

*Two Machine Vice.*

The flywheel has a wood pulley screwed to it, and is secured on the stud by a small screw passing through a brass disc.

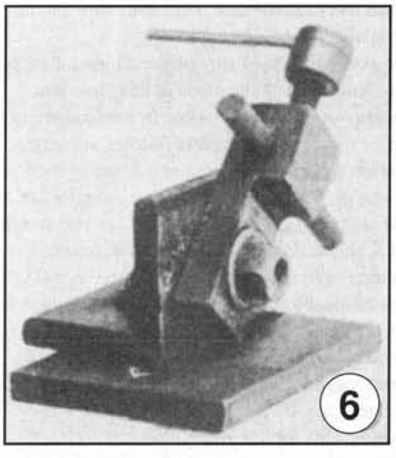
The back centre of spindle is carried in a small plate screwed to a rectangular bracket, this in turn being held in position on the back upright by six screws.

The front bearing is a steel cone running in a brass bush.

Difficulty was experienced at first in holding the brass bush securely. I had a No. 6 B.A. set-screw in addition to the pin in bush, but the screw broke in the hole. Rather than take the framework down to drill out and replace the screw, I screw-cut projecting end of bush 40 threads, and a 7/16th-in. steel




*Two Fixtures, with Vee Base.*




*Fixture for Holding Work at any Required Angle.*

washer to fit (Q, Fig. 3), and have since had no further trouble. The washer has two sunk holes enabling it to be knocked round for tightening up.

The 1/16th-in. pin holding the carrying device on the nose of spindle is another "safety valve." If there is a severe "kick" this shears. These kicks were fairly frequent in occurrence until I learnt how to manage things better.

**4.-Feeds.**

The shafts and gearing were fitted up to the machine in the same way that a tailor fits a man's suit!

Most of the gear wheels are Meccano. The worm wheel R (Fig. 1) was cut on the machine in the attachment to be described later.

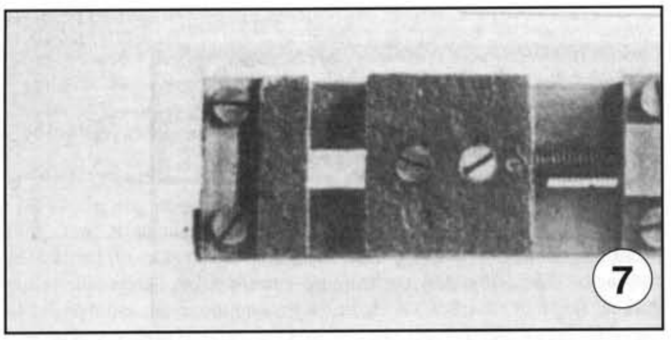
The control of traverse looks simple enough, but I was a long time arriving at the solution of the difficulty. The arm controlling gears (S, Fig. 1) is drawn up and held fairly tightly when in gear, owing to the action of the wheels, and requires a smart knock to pull it down and its accompanying wheel out of mesh. The parts of the mechanism are shown quite clearly in Figs. 1 and 3, and I hope the solution of the problem will be found.

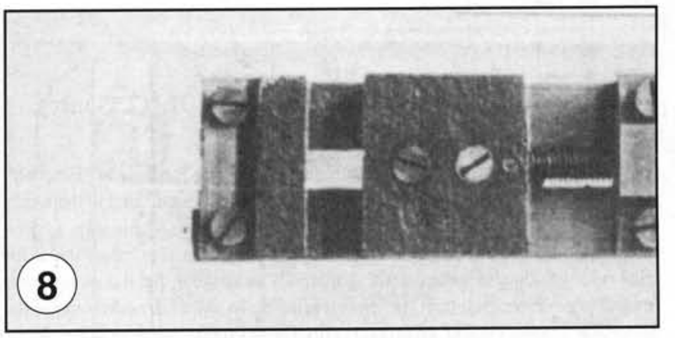
**5.-Fixtures.**

The first trials were made by means of a vice (home-made) held down by two screws in top-slide. In order to avoid loss of time in the setting up of work at each operation I fitted a vee aligning strip T and a cam U (Fig. 1), making bases of fixtures to fit. The vees were cut by a hand-made cutter (see photo), the work being held in a small angle-plate. I was surprised by the ease with which this operation was carried out, and I leave you to judge the satisfaction with which I contemplated the first pair of vees, which fitted quite well without having had any setting out, filing, scraping, or other comparatively lengthy processes.

The small vice (lower of the two in photograph 4) has two vees at right angles to each other, and consequently can be set to two positions. The second vice is unfinished, and I must apologise for the rough work apparent not only in this case but in many others, I am afraid.

The two fixtures shown in photograph 5 both have a vee base. That on R.H. has a movable block carrying a cam, and is useful when machining fairly long and flat stuff. The other fixtures is used for holding long stuff on which the ends are to be machined. The cutter may pass down below level of the work.





*Two Dividing Attachments.*

**Section 6. - Fixture for Work on End of Rod** (photograph 6).

This, up to the present, has only been used for making small taper reamers and square centres.

The upright can be set over and locked at any required angle. One nice little problem presented itself when a square centre was required, which might suit some of our non-theoretical mechanics. Here it is: The table passes horizontally beneath the cutter. At what angle should the blank be set in order to leave the cutting edges (of the finished centre) at 30° (for cutting 60° hollow centres)?

I did not see the "catch" in this at first, and set the upright to 30° from vertical. It gradually dawned on me that this could not possibly work out correctly, and for the time I was completely at a standstill. However, I set out the problem on paper as well as I could (being neither theorist or draughtsman), and found the exact angle at which to set the upright.

Both reamers and punches were divided by a small collar bearing divisions upon it and attached to a blank. Each division was in turn brought opposite to a dot punched on upright. The collar also serves as a stop. The reamers were merely gashed (after being turned the proper taper) for the required length, and the edges backed off by hand, as the method of division, while answering quite well for the centres, would not be accurate enough in this case.

**Dividing Attachment** (photographs 7 and 8).

Points of interest are:-

Wormwheel, slot and ornamenting of tailstock, flats on spindle arm and carrier, all made on the machine.

Worm is ½ -in. Whitworth.

Division plate gives eight divisions.

The attachment is mounted on a base. By this means it can be set over to any angle for such jobs as gashing teeth of wormwheel preparatory to hobbing.

**Section 7 - Cutters** (photograph 9).

1. - Hob for cutting wormwheels (to gear with ½-in. thread).

The job is cast steel and was screw cut and then gashed on the machine.

2. - Cutter for vees. This was turned to shape and the teeth filed up.
3,4,5.- Surface cutters (all cut on machine).
6. - Cutter for gashing wormwheel previous to hobbing.
7. - Slitting saw.
8. - Surface cutter (cut on machine).
9. - Cutter for making vee blocks. A slot is first hack sawn and then passed under cutter.
10.- The first cutter made. This was necessarily made by filing in the absence of a cutter to start with.
11.- Cut by No. 10.
12.- Angular cutter made in order to vary the rake on cutters for mild steel.

**Method of Securing Cutters on Arbors.**

At first I intended to key each one, and as can be seen in photograph, No. 10 was made that way. This took rather a long time, so I then tried knocking the cutter on to a fine taper, this method answering quite well with care. The process was to fit the arbor to the blank, and again after hardening, the cutters being left dead hard.

The smaller cutters (3-6) are driven on and pinned.

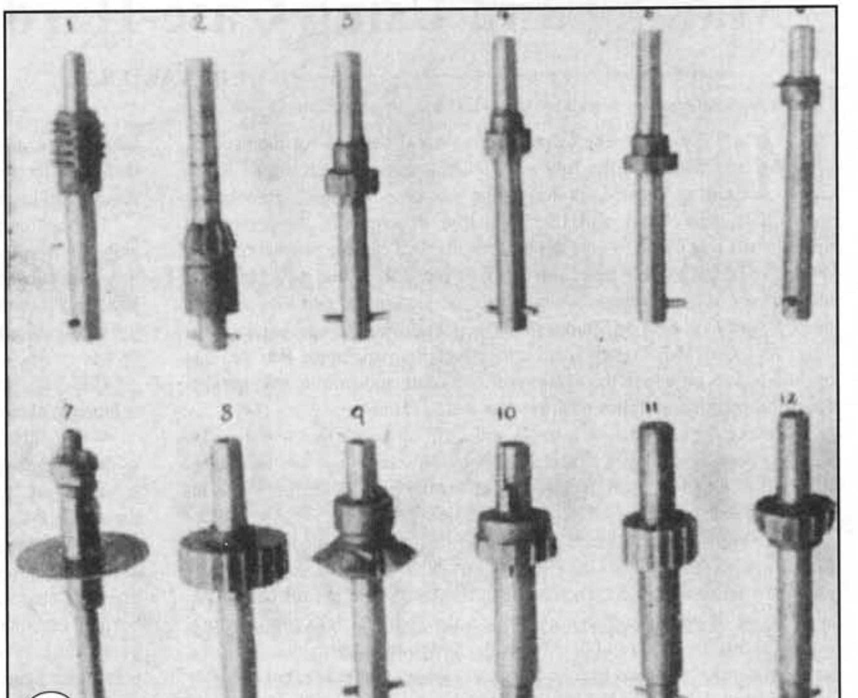
The spindle running along the top of machine (V, Figs. 1-3) is for use in grinding. A cam allows the large flywheel (faced with leather) to drop on to flywheel. A belt is connected from small pulley to a pulley on spindle between centres carrying stone. A fairly good speed is thus possible.

Among things made may be mentioned a sensitive drilling machine (1/16th in. to No. o) having machined slides, vee blocks, vice (photograph 4), slide-rest of small lathe trimmed up, and various keyways, screw slots and featherways. The last attempt was to cut gear wheels using a flycutter.

Contemplated additions are scales to traverse and vertical slides showing exact distances, and a fixture for cutting helical cutters. I have plans of action worked out but unfortunately there is not time for everything.

In conclusion, I have to thank Mr. V. F. O'Connor for his excellent photographs.

This machine was awarded a William Taylor prize by the Leicester Association of Engineers in 1926.



*Some of the Cutters Used in Built-up Milling Machine.*

*Here we look at a couple of items from the 1930's. Using a brass polish is a widely used method of final lapping a shaft to a bearing, but perhaps you did not know that this idea was 70 years old. George Gentry was a well-known model engineer of the period. The other extract is making a Case-Hardening Compound. Imagine trying to buy ferro-cyanide at your local chemist.*

May 29, 1930.

## Fine Fitting by Abrasion. By G. Gentry.

THE idea of using the body material or polishing medium in "Bluebell" metal polish for fine fitting by abrasion was communicated to the writer by Mr. G. S. Willoughby, who thought of the idea on his own, experimented, and now adopts it on suitable occasions. Motor mechanics use it for fine valve grinding to some extent. Apparently its virtue is that it does not enter metal parts between which it is used as a grinding-in material, as do some of the other and quicker cutting varieties of grinding-in powder, such as flour emery, corundum, or carborundum.

From experiments we have made we find that every vestige of the powder can be washed out after the grinding-in is finished by using fine oil or spirit in the first place, then heavier oil. The idea is to commandeer empty tins of "Bluebell," after they have ended their domestic life, and to cut them open and collect the heavy sludge, large quantities of which must be wasted by the throwing away of apparently empty tins.

This sludge is in the form of a pinkish-white powder and is stated to be Cornish silica, which, if correct, means that it is the amorphous form of quartz or silicon oxide.

It is an extremely fine and hard amorphous powder, has no crystalline characteristics, and is therefore neither angular nor sub-angular. It is probably due to its form that it cannot cut its way or embed in solid metal.

It must not be used dry, but with a liquid resembling that used in the polish, such as paraffin, with petrol, naphtha, or even thin oil, as "Three-in-one." Do not apply with water.

In grinding-in such things as the slides of a small slide-rest, fit the slide up to the point where either stoppage or seizure has been eliminated, and where only the hardness due to lack of polish on the surface points is apparent.

Then copiously coat the slide surfaces (introducing the fine paste between surfaces where it is not so likely to penetrate) and maintain it "wet" with paraffin, working the slides together so that the saddle passes off the slide at both ends. The action will gradually get smoother, but tighter, due to the packing action of the silica, which cannot get into the metal, and thus out of the joints. As soon as this packaging becomes aggressive, apply petrol or benzine in excess, and continue working the slides, which, as the powder is washed out, will become gradually freer. Continue the operation with an excess of paraffin and finally machine oil.

As the rubbing surfaces become apparent (because if the cutting action is good, while grinding it quickly becomes coated with black) by the washing action, they will be seen to be highly polished on the bearing points. In the writer's opinion it is this polishing which helps to harden the slide surfaces, and so resist in some measure the ingress of the grain of silica; but opinions differ on this point, because some maintain that only a polished surface that has been polished under pressure is hard, and that hardness is not necessarily accessory to polishing alone.

In any case the surfaces exposed are clean looking, in sharp contrast to surfaces similarly treated with other flour abrasives, which generally are blackened more or less by the grains of power embedded.

It has been suggested that water should not be used as a medium, as the material is partially soluble in water. If, however, it is silica, which is notoriously insoluble in water, this is not the reason. With water there would be no admixture with remains of the liquid in the paste, and if applied with dry powder it would most likely increase the clogging or packing action of the powder.

September 5, 1935.

# Making and Using Case-Hardening Compound.

By V.W.D.B.

MANY workers like to make everything they use for themselves, and for these, the following receipt may be interesting. It has been well tested, as during the war case-hardening compounds were difficult to obtain, and after numerous experiments, the compound given below was found to give the best results. All carbonising compounds consist of charcoal as a base, and the best charcoal is that obtained from nuts, cherry or plus stones, coconut shells, or anything of that sort, as these make a very hard base which does not contract during the carbonising process. As most "M.E." readers will remember, plum and apple jam was one of the luxuries on which the "Tommies" were fed, and from one of the jam factories, plentiful supplies of the stones were available.

To make the charcoal on a small scale, fill up cocoa tins with the raw stones, wire the lid down, make a small hole to allow the gas to escape. Place on a fire to gradually warm up, and finally heat to a bright red heat, till no trace of gas escapes from the vent hole.

When cold, crush, so that it will pass through a sieve with about 6 wires to the inch, making as little dust as possible. Next take 4 oz. of soda (commercially pure anhydrous carbonate of soda) and 2 oz. of barium carbonate, add ½ pint of water, and thoroughly stir the charcoal into this mixture. Finally spread on trays, and place over the fire to thoroughly dry.

Cocoa or similar cans make quite good carbonising boxes, but can only be used once. In packing the boxes, place about one inch of the compound at the bottom of the boxes, and fill up with alternate layers of the objects to be carbonised and more compound, taking care that there is an inch or more of the compound between the various items and the walls of the box. Pack as tightly as possible, and lute the lids down with "Purimachos" or some similar clay compound. The lids should be wired down. Place in the kitchen fire, and after the boxes have become thoroughly red hot, maintain that heat for six to twelve hours, according to the depth to which it is required to harden the surface.

If the strength of the core is unimportant, the objects can be immediately plunged into cold water. If, however, a thoroughly touch core is required, it is advisable to allow the objects to cool off in the carbonising box, and then to reheat to 1,650° Fahr. (cherry red heat) and quench in water. Again reheat to 1,450° (verging on cherry red), and quench in tallow or oil.

On no account should the heat during carbonising exceed 1,800°, which is a bright cherry red verging on yellow heat.

When only a slight depth of case hardening is required, what is known as the "open hearth process" can be employed.

There are two objections to this process, the first being that the core of the article is not toughened as in the former process, and the second is that a slight scale is formed during the process.

The compound required for this process is of the following composition: 1lb. charcoal dust, 4 oz. soda ash (anhydrous carbonate of soda), 4 oz. borium carbonate, 4 oz. ferro-cyanide of potassium (yellow cyanide of potassium). These should be well pounded together and ladled on to the previously heated (to a bright cherry red) article, which is then allowed to cool to a dull red heat.

This process is repeated three or four times, when it will be found that the carbonisation has penetrated to a depth of about 1/64 in. This process serves well for drilling jig bushes and the like, but should not be employed for gudgeon pins and similar objects which are subjected to stresses as well as wear.

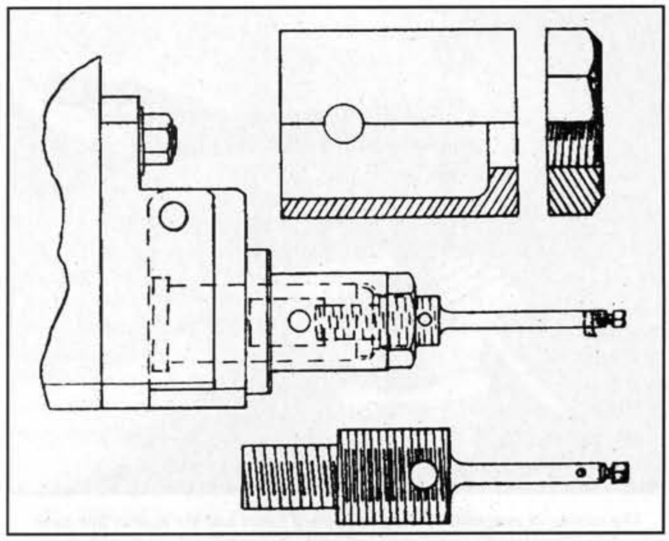
April 16, 1936.

## Internal Slotting on the Shaper.

TO THOSE who like to make up accessories that enhance the utility of their machines, the writer can recommend the following simple slotting equipment for the shaper or planer in preference to the usual cranked tool holder. The arrangement is stiffer, having a direct thrust, and is more adaptable for use over a wide range of hole diameters, as the largest possible cutter bar can be used for a hole of any given size.

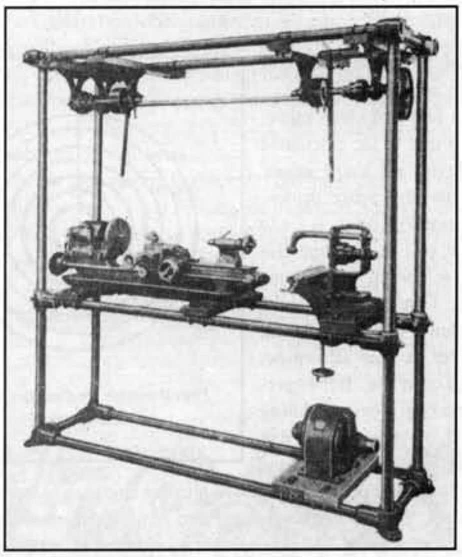
As will be seen from the sketches, it consists of a set of cutter bars, a distance collar to slip over tool post and a lock nut. Tommy holes are provided to rotate and hold the bars in position at any required angle for the cutter while the lock nut is tightened.

A set of six bars having the dimensions A and B ranging from $\frac{5}{32}$ in. x $\frac{7}{8}$ in. to $\frac{11}{16}$ in. x $3\frac{1}{2}$ in. with cutters from $\frac{3}{64}$ in. to $\frac{1}{4}$ in. wide will be found to cover most of the requirements of model work - W. G. BARLOW.



## A Self-contained Machine Shop

WE illustrate herewith a novel form of machine-tool stand, particularly suitable for home workshops, or other locations where the bolting of countershafts to ceiling or walls is not practicable. It consists of a framework of $1\frac{1}{2}$ in. steam tubing, with corner fittings, and feet, made of castings of heavy design. Holes are provided in the feet for fixing to the floor, and the horizontal members of the framework are provided with set-screws for fixing at convenient places. The overall length is 6ft 5in. the height is 6ft. 7in., and the width 1ft. 9in. The frame, as illustrated, carries both a lathe and a milling machine, and the necessary countershaft, and electric motor; but a similar unit can be supplied for the lathe only. It is important to note that the machines may be set at any height to suit the build of the operator. This convenient and well designed workshop unit is being marketed by Messrs. Pools Tool Co., Ltd., Carlton Street, Nottingham. They had a similar arrangement on view on their stand at the last "M.E." Exhibition, for their own convenience in displaying their tools at work, and, as the result of enquiries then received, they have decided to market the equipment in the form shown in our illustration.



*A Self-Contained Lathe and Machine Tool Bench, by Pools Tool Co. Ltd.*

August 19, 1937.

# Making Model Locomotive Domes and Similar Hollow Shapes

### Describing the "Raising" Method of Hammering Out Domes and other Hollow Shapes, from Flat Sheet Metal

**By By E. M. Graville**

*While this may not normally be within the milling and shaping remit the working of metal with a hammer is the earliest method of shaping metal there was. It adds another technique to the engineers' repertoire and has applications in other fields.*

THE amateur worker is, sometimes, confronted with the task of making a cup-shape in metal, such as an engine dome. As there is something intrinsically satisfactory in a jointless job, the hammering process, known as "raising", offers a special attraction, since, it is possible to mould a piece of sheet metal into the shape required, without the use of any machine tools. The principles are readily mastered, but, as with all other worth-while things, only practice makes perfect.

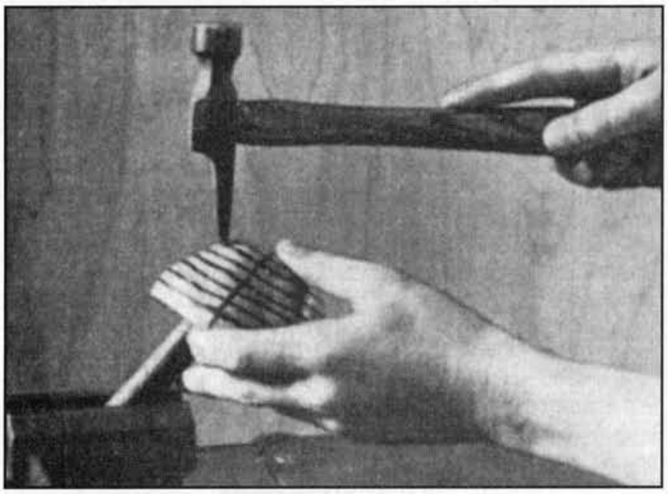
**Suitable Metals**

Some metals are more appropriate to the process than others, as malleability is essential. Excluding the precious metals, copper is most suitable, as it raises easily, and does not readily crack. Gilding metal and bronze (alloys of copper) are more difficult to raise, but give a slightly harder and more rigid result. Brass is preferred by some workers, but, if it is used, beware of cracks.

The metals are obtainable "hot-rolled" and "cold-rolled". Choose the cold-rolled variety, as the surface is much smoother. Gauge 22 (S.W.G.) is suitable for small domes, up to an inch across, gauge 20 for domes up to about 2", and gauge 18 for larger domes. The thinner metal raises more quickly, but, if used for large domes, is inclined to kink and whip, and sorely try one's patience.

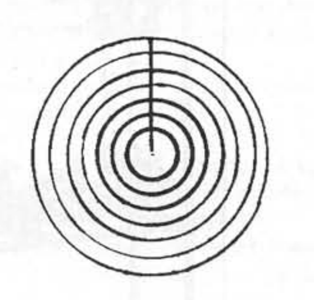
**Preparing for Work**

First, make a full-size outline sketch of the dome. Measure the greatest depth, add the greatest width, and divide by two. Approximately, this will give



*The raising in progress. Some of the pencil Lines and the Radius line have been inked over to make them clearer.*

the radius of a disc of metal just large enough to form the dome.



*Pencil circles and radius to guide hammering*

Obtain a piece of clean metal, and cut out a disc of the calculated radius. File off all sharp edges. Make sure that the centre depression, while not too deep, is quite distinct, as it will be required frequently in following operations. Anneal (i.e., soften) the metal by bringing it slowly to a dull red heat, by means of a gas blowpipe, blowlamp, or open fire. If the operation is carried out where soldering is performed, be most careful that no stray soft solder adheres to the metal, as even a small piece is capable of burning a hole right through. Allow the disc to cool. Copper can be plunged into water to hasten the cooling, but the method is not advised. Alloys must not be plunged, as cracks are likely to appear. When the metal is cool, it is gently placed in an acid bath (pickle), made of twelve parts of water, to which one part of strong sulphuric acid has been added (don't add water to acid), and left there for two or three minutes. It is then removed and scoured, under running water, with a nail-brush and an abrasive cleaner, such as "Vim" or "Gospo". Finally, the metal is dried on a cloth, when it should have a perfectly clean surface. If black marks exist, pickle and scour again. This sequence of heating, cooling, pickling, washing, scouring and drying is implied wherever the term "anneal" is hereafter used.

**Blocking the Disc**

The raising is, to some extent, simplified if the disc is now blocked by beating it with a pear-shaped mallet, or a ball-pene hammer, into a depression in a block of wood, until it takes the shape of a deep saucer. The centre-spot should be on the convex side. Begin the beating at the edges, and work in circles towards the middle. Beat out all wrinkles at the edge as soon as they appear. Now, with a pencil compass, draw circles, about ¼" apart, on the outside of the bowl, from the centre to the edge, so that the metal resembles a target, and strike a radius (Fig. 1). These lines are for guidance in hammering.

**Raising a Hammer and Stake**

A proper raising hammer is of special design, but, as it was thought unlikely that one of professional pattern would be found in the amateur's workshop, an ordinary Exeter-pattern carpenter's hammer was used to produce the dome illustrated. The face measured 1" by ¼", with a slight radius in each direction, and was carefully polished before used, as all dents and scratches are reproduced, in reverse, on the work.

The stake was found in the junk-box. It proved to be a spoke that had, previously held down permanent-way chairs. Perhaps, the association of ideas was an advantage! Anything of a similar nature can be used, and it is unlikely that a visit to the junk-box, or old iron yard, will fail to produce a serviceable stake.

**The "Raising" Process**

Fix the stake in the vice, and take up a position to the right of, and facing, the stake. The placing of the metal on the stake, and the hammer-blow upon the metal, are of the utmost importance, and great care is needed. Rest the concave side of the metal on the knob of the stake, so that the point of contact is immediately beneath the spot at which the pencilled radius-line cuts the innermost circle. Imagine, for the moment that the metal is transparent and the contact point can be seen through the intersecting lines.

Strike a blow at the spot where the radius cuts the second circle, and the metal (which, here, does not touch the stake) will dent. Examine Fig. 2.

Revolve the disc, clockwise, about the equivalent of two or three minutes on the clock-face, when a new point of contact is obtained along the same circle as the first. Strike a second blow to the unsupported metal above, making the second dent join the first. Continue the process until an even depression is formed round the disc, eventually joining the first blow at the radius-line. This depression is known as a "course," and the operation is known as "coursing." Now move the disc slightly downwards, until the point of contact with the stake is beneath the second circle, which, also, coincides with the first course. By hammering uniformly along (approximately) the third circle, form a second course that merged into the first, to make one wide depression. The circles are to guide one in hammering concentrically; it is not necessary to hammer exactly on a circle. The distance between courses should be adjusted, so that each merges into the one before, leaving no unhammered spaces. After each complete revolution of the metal, move it downwards on the stake, and begin a new course. The depression will gradually spread to, and reach, the edge, when the job will be seen to be considerably more bowl-shaped than before. Be most patient at the edges, because here, the compression of the metal is greatest; hammer steadily, without missing any spots. The strength of the hammer-blow must be decided by practice. It will, inevitably, mark the metal, but must not be so hard as to spread or cut it, or the work will be spoilt.

When the first coursing has covered the entire surface, the metal is annealed, fresh pencil-lines are drawn, and the whole process is repeated. As the metal takes shape, it is compared with the sketch. When the centre part

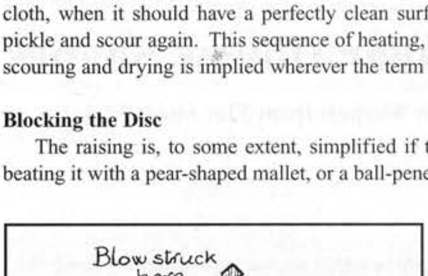



*Fig. 2.*

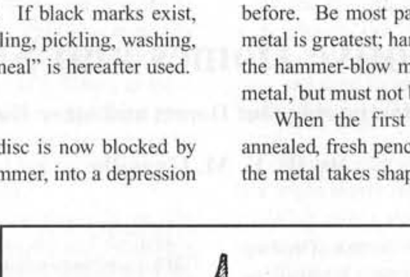



*Fig. 3.*

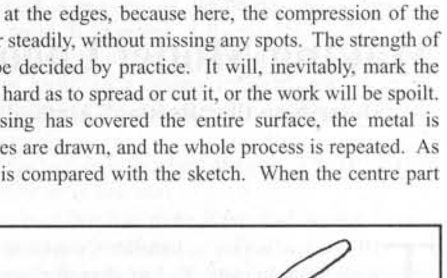
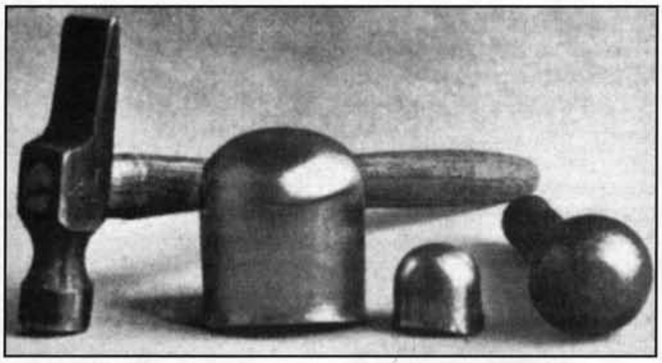



*Fig. 4.*



*Two finished Domes. The hammer was used for raising both domes, but the stake shown was used only for the larger one.*

conforms to the curve, hammering is discontinued there, and the coursing begun with, say, the fifth ring from the centre. When the metal around the fifth ring begins to match the sketch, coursing is begun still farther out. It takes about an hour to raise and finish a dome shape roughly 2" deep and 1½" across, but, of course, speed is greatly dependent upon the worker.

**Planishing and Finishing**

The raising will produce the desired shape, but the surface will be uneven, and altogether unsatisfactory. Planishing removes the unevenness and substitutes a smooth, regular surface. For this process, the other end of the hammer is used, and, for best results, the face should be highly polished.

The work is annealed, and pencil-lines are drawn, as before.

Then, with the job resting firmly on the stake, hammering is begun from the centre making sure that each blow falls on a spot that is firmly supported. This is the fundamental difference between raising and planishing. In raising, the blow falls on a spot just away from the supported part depressing the metal, while, in planishing, the blow falls on a supported part and compresses the metal.

In practice, the sound of the blow is the best guide; a hollow sound is required when raising, and a solid ringing sound when planishing.

The stake already used will serve for the curved part of the dome, but, for the straight vertical portion, a piece of round mild steel will be more suitable (Fig. 3). Providing only that it will fit inside the job, the larger it is, the better. A slight radius should be turned or filed on its outer end, to remove the sharpness.

Remember that the planishing is intended to smooth (and harden) the metal; therefore, hammer with a moderate blow. Hammer-marks will appear, but they are merely incidental. The better the planishing, the less obvious the hammering. If you have ever seen "Planished Pewter Work" (machine done), as sold by some jewellers, forget it, except, perhaps, as a reminder of how planishing should be done.

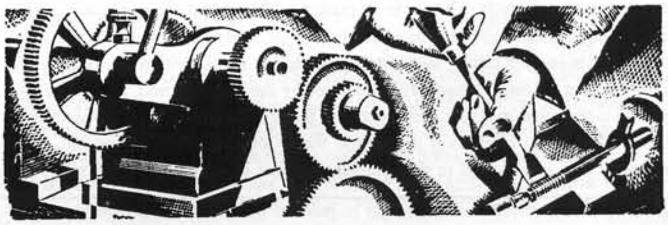
As, however, hammer-marks of any description would be out of place on an engine dome, the surface is rubbed all over with emery-cloth, of progressively finer grades, until all marks have been removed.

The fitting of the dome to the boiler should not present much difficulty, since it is a straightforward shearing and filing job, of the trial-and-error type. There is one point of importance. Most engine domes are slightly splayed at the foot. This is best achieved by resting the edge on the round steel planishing stake, and repeatedly hammering round the rim with the "raising" end of the hammer (Fig. 4). The metal is stretched, and, in its endeavour to find more room, inevitably curves outward.

More accurate hammering is assured if the index-finger is stretched along the shaft of the hammer, when striking the blows. If, when planishing, a crop of "crescent moons" appear, due to the edge, and not the face of the hammer, meeting the work, grind the face into a very slight curve. This will cure the trouble, but, with a little practice, the flat hammer can be used successfully. The centre pip, at the top, can be hammered away quite easily.

September 23, 1937

# TOOL-ROOM TOPICS



## The Universal Dividing-Head - Its Construction

By R. HUTCHESON

***Go to any model engineering exhibition and you will see most tool suppliers have universal dividing heads at what can only be described as very reasonable prices (one hesitates to use the word cheap). Unfortunately, most of these are of foreign manufacture but they are excellent value for money. This series of articles from 1937 are probably the most comprehensive ever published in "Ours" and I have no hesitation in reprinting all three articles.***

THIS article has been written at the request of correspondents who are unfamiliar with the principles and method of operation of the universal dividing-head. This very useful piece of apparatus is employed every day in the tool-room for indexing work-pieces which are to be divided circumferentially. Its popularity is due to the accuracy with which a job may be divided, and the very wide range of divisions obtainable, e.g., in the case of the "Parkson" head, made by messrs. J. Parkinson and son, which we will consider as our example, the following numbers of divisions can be obtained: by direct indexing any numbers that are factors of 24, 30 or 36; all even numbers, and all those divisible by five up to 120, and, also, most numbers up to 400; by differential indexing, the scope of the dividing-head is increased to include almost every number of divisions up to 500. In addition to the above, the head is adjustable to permit of the axis of the work-piece being set at any angle between the horizontal and the vertical (in this make of head, the range is, actually, from 5° below horizontal to 50°( beyond vertical), and it is used in order to permit the cutting of spirals, or, more properly, helices - e.g., the teeth of spirally-fluted reamers.

Dealing now with the construction of the head, there are two main castings, one forming a stationary housing, which is bolted to the table and acts as a support for the second casting. Referring to Fig. 1, the second casting or body can swivel in the housing, in order that the spindle, which extends right through it, may be set at any angle between 5° below horizontal and 50° beyond vertical, a scale of degrees graduated on the body facilitating this setting. The front end of the spindles, which is hollow, is similar to that of a lathe-spindle, in that it is taper-bored to receive a centre or other fitting, and is screwed outside to receive a dog-plate, or a chuck, the centre and dog-plate being shown in the illustration.

Figs. 2 and 3 show the main parts of the "works." The spindle, best seen in Fig. 2, is rotated as desired, by means of the hand crank. The shaft of the crank is connected by spur-gearing to a worm-shaft, the worm of which has a single start and meshes with a 40-tooth worm on the spindle. The ratio of the spur-gearing is 1 to 1, so that one turn of the hand crank moves the spindle one-fortieth of a revolution. The worm-shaft is eccentrically mounted, so that

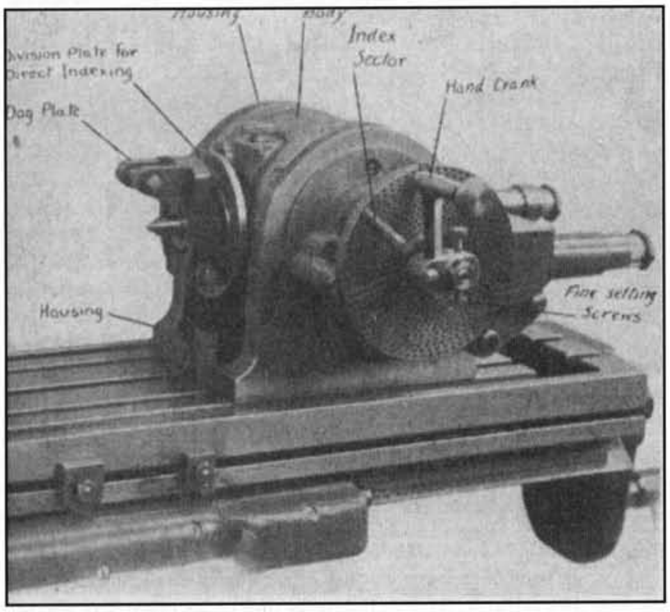



*Fig. 1. A front view of the "Parkson" dividing head, set for plain indexing.*

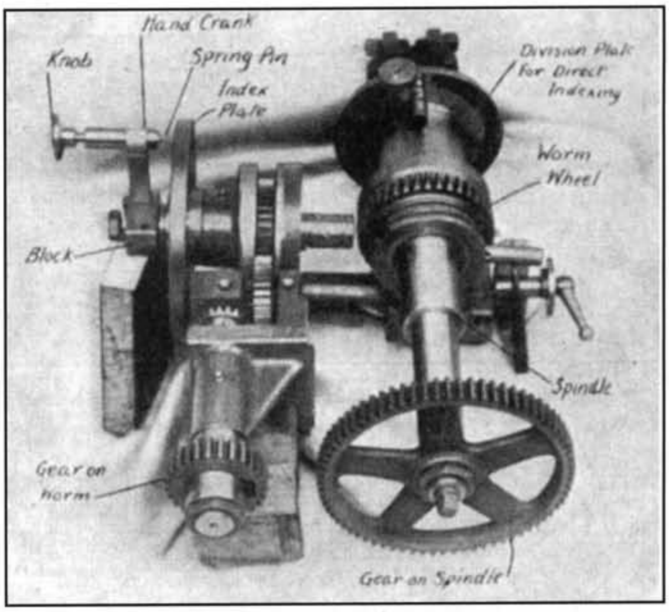



*Fig. 2. A view of the internal mechanism, looking from the rear of the spindle end on to the top.*

the worm may be disengaged from the wheel (as is shown in Fig. 3) by a partial turn of a small handle, which is situated at the rear of the head.

Direct indexing of the spindle can be performed by disengaging the worm and turning the spindle by hand, the divisions being determined by a pin, which can be engaged with any of a circle of holes in a division-plate secured to the forward end of the spindle, the pin being moved into, and out of, engagement by a rack-and-pinion movement.

Plain and differential indexing are accomplished by rotating the spindle by means of the hand crank. In order that a wide range of indexing shall be possible, provision is made to permit of the turning of the hand crank through definite fractions of a turn. These means comprise an index-plate, with eleven circles of equally-spaced holes in each of its sides, there being a different number of holes in each circle, and a spring-pin in the crank, which can be moved into, and out of, engagement with the holes by means of a knob, the pin being shown withdrawn in Fig. 2. In order that the spring-pin may engage with the holes of circles of differing diameters, the crank is radially adjustable in a block, which is attached to the crankshaft. The index-plate is reversible, in order that the holes on either side may be outermost to receive the spring-pin of the crank. The index-plate may be held against rotation by a spring-pin, which is in the main part of the head, and enters a hole in the rear side of the plate. The Brown and Sharpe dividing-head, and some heads of similar type, are provided with several single-sided index-plates, instead of the double-sided plate.

The two gear-wheels, shown in Fig. 2, named "gear on worm" and "gear on spindle," are not, strictly speaking, parts of the dividing-head; they are two of a set of change-wheels that are employed when the head is to be used for differential indexing and spiral cutting. The term "gear on worm" may be a little misleading, because the gear is not mounted on the worm-shaft, but its spindle is geared, through bevel and spur-gearing of 1 to 1 ratio, to the worm-shaft, and the effect is the same as if the gear were mounted directly on the worm-shaft.

The blocks from which the illustrations have been printed, were prepared from photographs supplied by Messrs. J. Parkinson and Son. Next week, we hope to deal with the operation of the head, and the principles of plain indexing.

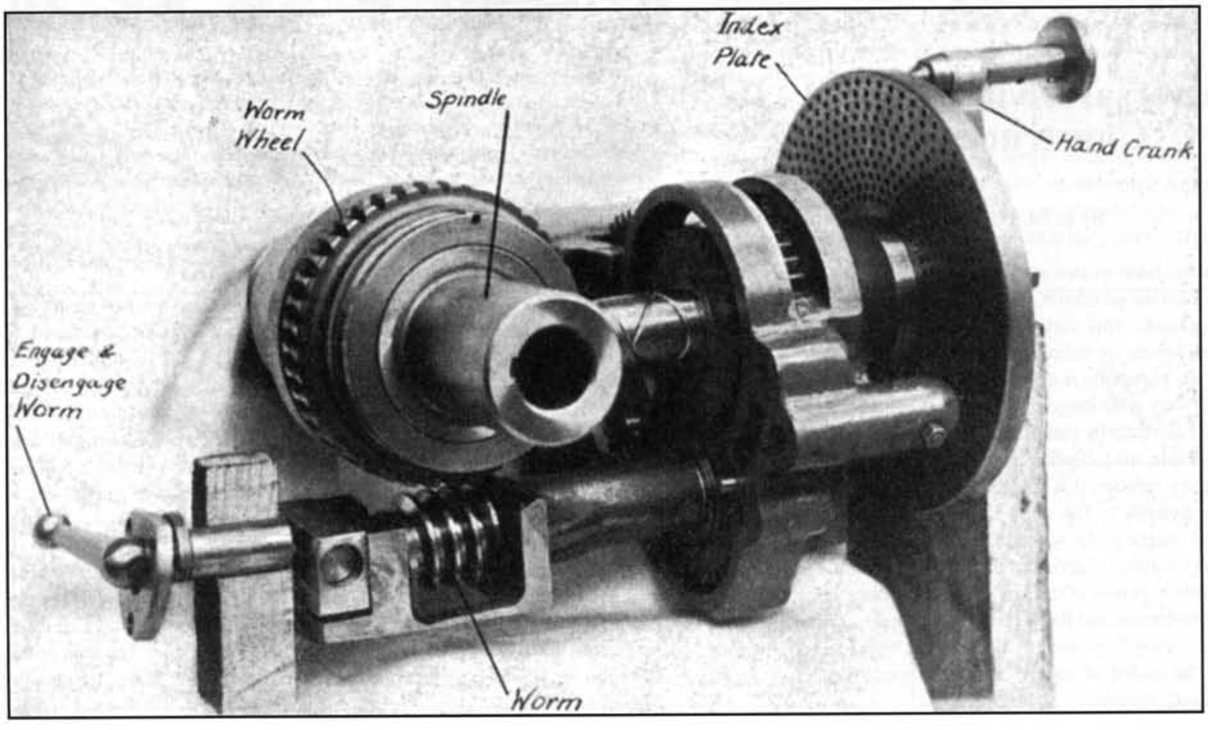



*Fig. 3. A view of the worm and worm wheel, with the worm in a lowered disengaged position.*

September 30, 1937

# Direct and Plain Indexing

**By R. HUTCHESON**

DIRECT indexing is performed when the worm is dropped out of engagement with the worm-wheel on the spindle, so that the spindle can be pulled round by hand quite independently of the hand crank. The division-plate, mounted on the spindle-nose, is employed in conjunction with the small rack-and-pinion-operated plunger at the top of the dividing-head. Direct indexing is, of course, limited to numbers of divisions that are factors of the number of holes in the circle on the division plate.

**Plain Indexing**

Plain indexing is performed by turning the hand crank. The small plunger, used for direct indexing, must be withdrawn before an attempt is made to turn the spindle by the crank. This is most important, as the gear ratio between the crank and spindle will afford such a purchase that the direct indexing-pin could be bent or sheared off. As the worm most be re-engaged before plain indexing can be performed, it is best to make sure that the plunger is withdrawn before the worm is engaged. The plunger at the rear of the multi-circled index-plate and hand-crank must be engaged with the rear of the index-plate, to lock it against rotation.

When commencing work with a dividing-head of an unfamiliar make, check the ratio of the gearing by rotating the hand-crank and noting the number of turns necessary to give one complete revolution of the spindle. In the majority of cases, this ratio is 40 to 1, the worm having a single start, and meshing with a wheel of 40 teeth.

Tables are available, showing the number of turns of the hand-crank needed for all the numbers of divisions capable of being indexed by the head, but all tool-makers should know how to calculate this information for themselves. Taking the commonest ratio of 40:1, forty complete turns of the hand-crank result in one complete revolution of the spindle. If the spindle is to be rotated only half a revolution (indexing a job into two divisions), then it will be moved this amount by twenty turns of the crank. Similarly, to index a job into ten divisions, the spindle must make one-tenth of a revolution for each division, and this is obtained by giving the crank-handle four turns per division. From these simple considerations, it will be seen that the following rule holds good:-

$$\frac{40}{\text{No. of divisions to be indexed}} = \text{No. of turns of crank per division}$$

So long as the hand-crank is to be given a whole number of turns, no difficulty arises. The spring-pin of the crank is allowed to enter a hole in the index-plate, and this locates the starting-point of the crank. The pin is withdrawn and the crank given the desired number of turns, the pin being returned to its hole to complete, definitely, the final turn.

What is to be done when the number of divisions is such as not to divide exactly into 40, so that a fraction of a turn of the crank is necessary, alone or in addition to one or more complete turns? In such cases, use is made of the various circles of holes in the index-plate, and we will consider one or two examples involving partial turns of the hand-crank.

Suppose a job is to be indexed into 37 divisions; then, for each division, the movement of the hand-crank is 40 - turns, i.e., 1 3/37 37 turns. Now, one of the circles on the index-plate has 37 holes, and so, the crank is adjusted radially, so that its spring-pin can enter a hole in this circle. Starting from the hole in which the pin has entered, the pin is withdrawn and the crank given one complete turn to bring the pin back to the hole; the hand-crank is then moved further, until the pin can enter the third hole past the initial hole, this extra movement being equal to 3/37 turn. The pin is allowed to enter the new hole and the cut taken over the job, the next indexing movement of the crank commencing from this new hole, and finishing (after one complete turn) three holes further on.

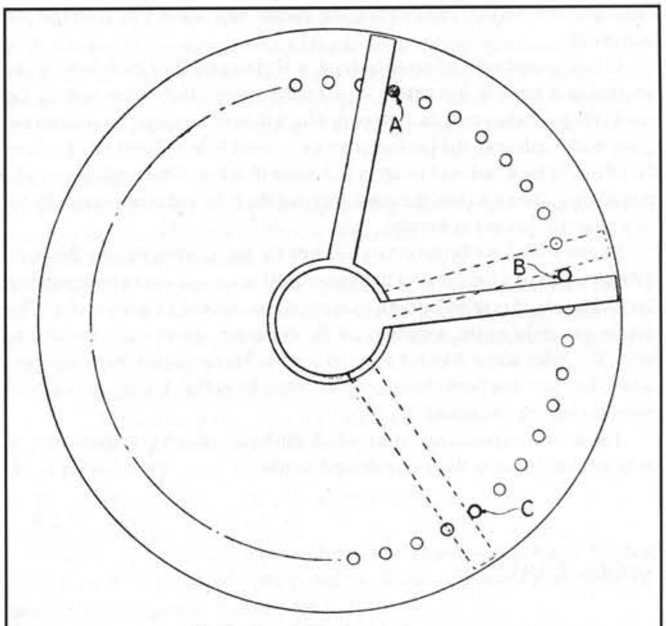



*Fig. 1. Diagram illustrating the use of the index sector.*

As another example, suppose we have to index a work-piece into 50 divisions, then the number of turns of the hand-crank per division is given by dividing 40 by 50, and this is $\frac{40}{50} = 4/5$ turn. Now, we have not got a circle of 50 holes, nor one of five holes, but, from the foregoing, it will, perhaps, have been realised that, in our fraction, the denominator (or lower number) represents the number of holes in the circle we are to use, while the numerator (or upper number) represents the number of holes through which the crank must pass. In the present case, our fraction is $\frac{4}{5}$, and we must look through our circles to find one with a number of holes that is a multiple of 5. In the case of the "Parkson" head, there is only one - i.e., the circle of 30 holes. Using 30 as the denominator, we must obtain a fraction equal to $\frac{4}{5}$, and this is, obviously, $\frac{24}{30}$, obtained thus: 5 x 6 = 30, and, therefore, 4 must be multiplied by 6 to give us 24 to maintain equality.

Let us take just one more example, the indexing of a job into 17 divisions. The number of turns of the hand-crank per division is equal to $\frac{40}{17}$, where 17 represents the number of holes in the circle to be employed, and 40 represents the distance through which the crank must turn. As this is an improper fraction, we are best simplifying it to $2\frac{6}{17}$, because the whole number (2, in this case) thus obtained represents whole turns. We have thus to move the crank two whole turns and $\frac{6}{17}$ turn, but we have not a circle of 17 holes on our index-plate. However, if we multiply both the numerator and denominator by two, we have $\frac{6 \times 2}{17 \times 2} = \frac{12}{34}$, and we have a circle of 34 holes, and a movement of the crank through a distance of 12 holes on this circle, is a movement of $\frac{6}{17}$ turn. The required indexing movement can thus be obtained if the crank is moved two complete turns and an extra distance of 12 holes on the 34 circle.

However, had we multiplied the top and bottom of our fraction by three, we would have obtained $\frac{6 \times 3}{17 \times 3} = \frac{18}{51}$, and we have a circle of 51 holes on the opposite side of the index-plate, so that we could also index our job into 17 divisions by moving the crank through two complete turns and

18 holes on the 51 circle.

The rule for plain indexing is:-

$$\text{No. of turns of hand crank} = \frac{40}{\text{No. of divisions to be indexed}}$$

and, in this fraction, the denominator represents the number of holes in the index circle to be used, while the numerator represents the number of holes on the circle through which the crank must pass per division. If the fraction is an improper one, it should be simplified to a whole number and a fraction, the whole number representing complete turns of the crank and the fraction representing the partial turn needed to complete the movement.

In any geared type of dividing-head, a slight amount of back-lash, in the internal gear-train, is inevitable. If it should happen that, when turning the crank, the pin moves past the hole with which it should engage, do not turn the crank backwards until the pin can enter the correct hole. Should this be done, the effects of back-lash will result in inaccurate dividing of the work-piece. The proper thing to do is to turn the crank well past the hole, and then engage the pin on a renewed forward movement.

So that it shall not be necessary to count the holes, when moving the crank through a part of a turn, and so that errors shall not occur due to mis-counting, the dividing-head is provided with a simple devise, termed an *index sector*. This device also reduces the possibility of the crank-pin overshooting the desired hole. The index sector does not show up very well in the photos previously published, and so it has been shown diagrammatically in Fig. 1, only one circle of holes having been indicated.

The sector comprises two arms, which can be set relatively to each other, so as to include, between them, any desired number of holes, and it is used as follows. The pin of the hand-crank is in the initial hole at A, and is to be moved to the hole B. This partial turn may be the total movement of the crank, or it may be additional to one or more complete turns. The sector-arms are so set that they just embrace the two holes, A and B - i.e., they are a distance of nine holes apart on the particular circle. When the pin is to be moved, it is simply moved from one arm to the next, so that it reaches the hole B, having moved a distance of eight holes. The sector is then set so that its first arm is in contact with the pin in its new position, as is indicated by dotted lines, when its second arm will be adjacent to the hole C to indicate clearly the hole into which the pin must enter at the next indexing movement. It will be noted that the arms embrace both the initial hole which contains the pin, and the hole in which the pin is to be received - i.e., the arms enclose one more hole than the movement the pin is to be given.

When a job is being set up for machining, and an indexing process is involved, it is often necessary to rotate the job to adjust it relatively to the cutter, and use of the hand-crank naturally suggests itself as a means of fine adjustment. Now when a job has been so adjusted, it is very likely that the spring-pin of the crank will not enter a hole in the desired circle. Provision is made to permit of adjustment of the crank and spring-pin independently of the crank shaft.

The front view of the dividing-head, published in the last article, shows the crank mounted in a block on its shaft, and two opposed thumb-screws can be seen in the block. By slackening-off one screw, and tightening the other, the crank can be rotated very slightly about the crankshaft. This adjustment is made so that the pin can just enter a hole in the index-plate, and, when the crank is so adjusted, screws must be both tight, so that there is no backlash between the crank and its shaft.

October 7, 1937

# Differential Indexing

**By R. HUTCHESON**

VARIOUS makes of dividing-head are provided with various index-plates. The "Parkson" head has a single plate, with eleven different circles of holes on each side, giving, in all, twenty-two different circles. the "Cincinnatti" head is provided with a similar double-sided plate, and extra plates are available for indexing high numbers of divisions. The Brown & Sharpe head, which is very popular, has three single-sided plates, having between them eighteen different circles. The numbers of divisions that can be indexed by plain indexing are limited by the circles of holes available on the index-plate(s), and, in order that its use shall not be restricted in this manner, the universal head is so adapted that its indexing range may be greatly extended by the process of *differential indexing*.

#### The Process of Differential Indexing

Suppose we wish to index a job into 71 equal divisions, then the hand-crank must be given exactly $\frac{40}{71}$ turn. It will be found that we have not, at any rate in the case of the "Parkson" head, any circle of holes on the index-plate that can be employed as the denominator of a fraction equal to $\frac{40}{71}$. However, had we desired to index the job into 72 divisions, our task would have been simple, because $\frac{40}{72} = \frac{5}{9}$, and $\frac{5}{9} \times \frac{6}{6} = \frac{30}{54}$, indicating that each indexing movement could be obtained by turning the crank a distance of thirty holes on the fifty-four hole circle. In order that the job may be indexed into 71 divisions, it is necessary to turn the crank slightly more than the $\frac{30}{54}$ turn needed for 72 divisions. If, then, the head were set to index 72 divisions and the crank were moved through 30 holes, it would be necessary to move it a further $\frac{5}{639}$ turn, in order to move the job $\frac{1}{71}$ revolution, but, were done, there would not be a conveniently situated hole, in the plate, to receive the crank-pin and to locate it definitely. If, however, the plate were given a movement, in the same direction as the crank, equal to 5/639 turn, then the thirtieth hole would be moved into a position to receive the pin on the crank.

This is the principle of differential indexing. The dividing-head is set to index an approximately correct number of divisions (72 divisions in the above case, instead of 71), and the index-plate is given a differential movement, equal to the difference between the approximate and correct number of crank turns, in order to compensate for the error in approximation.

In practice, *the spring-pin which holds stationary the index-plate must be withdrawn*, and the index-plate is geared, by means of change-wheels, to the crankshaft, so that the slight movement of the index-plate is made progressively as the crank is turned. The gear ratio is so chosen that the plate receives exactly the correct movement, and the train is arranged so that the plate rotates in the same, or opposite, direction as the crank accordingly, as the approximated number of divisions is greater or smaller than the true number.

#### Determining the Change-Wheels

The index charts that are published for the dividing-head user, give all the information needed to enable the head to be set for differential indexing. They give the numbers of teeth for the various wheels (just as do charts for screw-cutting change-wheels), the number of turns of the crank, and the division-circle to employ. In spite of this, every tool-maker should be able to make for himself the necessary calculations from which can be obtained the crank-turns and wheel-trains.

The change-wheels are adapted to transmit the movement of the dividing-head spindle to a short shaft, which is connected by bevel gearing (shown in an earlier illustration) and spur gearing to a sleeve, which is loose on the crankshaft, the sleeve carrying the index-plate. The drive from the crank to the index-plate is, therefore, transmitted through the internal worm and

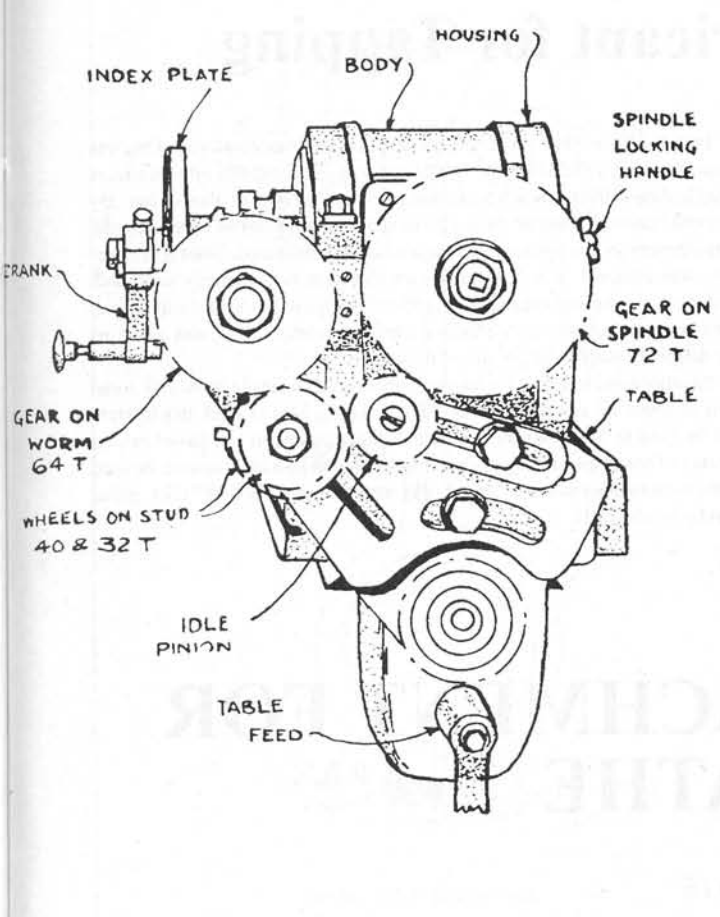



*Fig. 1. End view of the "Parkson" head set to index 409 divisions by differential indexing.*

worm-wheel, so that the ratio (usually 40 to 1) of crank turns to spindle revolutions must be taken as a constant factor in the change-wheel calculations.

Fig. 1 shows an end view of the "Parkson" head, with gears in position, to permit of the indexing of 409 divisions. The first driving wheel is secured to an arbor, which is inserted in the rear end of the spindle. The train shown is compound, and contains one idle wheel. According to the number of divisions to be indexed, so is a simple or a compound train of change gears employed, and idle pinions are introduced to determine the direction of rotation of the index-plate.

When the approximate number of divisions for which the crank and plate are set is greater than the actual number required, so that each approximate division is short, the index-plate must move in the same direction as the crank in compensation, and this is ensured by using one idle wheel in a simple train and none in a compound train, the first driven and second driving wheels on a common stud being the equivalent of an idle wheel (so far as change of direction of rotation is concerned) in the compound train. However, when the approximate number of divisions chosen is less than that desired, so that each approximate division would be grater than is desired, compensation is made by causing the index-plate to move in a reverse direction to the hand-crank. For this purpose, two idlers are required in a simple train, and one in a compound train.

The "Parkson" and the Brown & Sharpe heads are provided with the same set of change-wheels, namely, 24 (two wheels), 28, 32, 40, 44, 48, 56, 64, 72, 86 and 100 teeth.

In differential indexing, the ratio between the driving and driven gears can be obtained from the formula:-

$$\frac{\text{Driven Gear (s)}}{\text{Driving Gear(s)}} = \frac{(A - N)\,r}{A}$$

where r is the ratio of the internal gearing, usually 40, N is the number of divisions required, and A is the approximate number of divisions chosen.

A *positive* result is an indication that the index-plate and crank must rotate in the same direction, and, therefore, one idle pinion must be included in a simple train, but none in a compound train. A negative result, however, indicates that the index-plate must move in a direction opposite to that of the crank, and that two idle pinions must be included in a simple train and one in a compound train. When the gear ratio is calculated, one must, just as for screw-cutting, cast about among the change-gears for a combination which can be made to give the ratio. However, if it appears that no such combination can be found, a new ratio should be calculated, based on another approximate number of divisions, and this ratio tested for a gear combination. When a ratio is calculated, it is not necessarily best to reduce it to its lowest terms but, as is often an aid in selecting wheels for screw-cutting, the denominator and numerator may be factorised as an aid to spotting suitable wheels.

**Some Examples**

We will take four examples, introducing positive and negative ratios requiring simple and compound trains of wheels.

(1) To index 107 divisions:-

Taking 110 divisions as a close approximation, you should find that, to index 110 divisions by plain indexing, we should have to move the crank a distance of 24 holes on the 66 circle, so we would first set the crank and index-plate for this.

Then, using our formula -

$$\frac{\text{Driving Gear (s)}}{\text{Driven Gear(s)}} = \frac{(A - N)\,r}{A}\text{, we have}$$

$$\frac{Dg}{Dn} = \frac{(110 - 107)\,40}{110} = \frac{120}{110} = \frac{12}{11}\text{, and we can select}$$

from our change-wheels those with 48 and 44 teeth, so that the 48-toothed wheel goes on to the spindle arbor, and the 44-toothed wheel goes on to the "gear on worm" spindle. Because the ratio $\frac{12}{11}$ is *positive*, and we are using a *simple* train, one idle wheel must be included between the two gears.

(2) To index 142 divisions:-

140 divisions can be taken as approximately correct, and indexed by moving the crank eight holes on the 28 circle.

$$\frac{Dg}{Dn} = \frac{(140 - 142)\,40}{140} = \frac{-80}{140} = \frac{-8 \times 4}{14\ \ 4} = \frac{-32}{56}\text{,}$$

our wheels being 32 teeth on the spindle and 56 teeth on the worm, the negative result and the use of a simple train demanding two idle pinions.

(3) To index 179 divisions:-

180 divisions can be indexed by moving the crank 12 holes on the 54 circle. $\frac{Dg}{Dn} = \frac{(180 - 179)\,40}{180} = \frac{40}{180} = \frac{4}{18}$, and we can make up this ratio by means of a compound train, $\frac{32 \times 24}{72 \times 48}$,

the 32-toothed wheel being placed on the spindle, the 72-toothed wheel on the worm, the 24- and 48-toothed wheels being employed as the second driver and first driven respectively on the stud. The positive character of the ratio and use of a compound train denotes that an idle pinion is not required.

(4) To index 161 divisions:-

The approximate number of 160 divisions can be indexed by turning the crank through six holes on the 24 circle.

$$\frac{Dg}{Dn} = \frac{(160 - 161)\,40}{160} = \frac{-40}{160} = \frac{-4}{16}\text{, and wheels giving this ratio are } \frac{28 \times 32}{64 \times 56}\text{;}$$

arranged, the 28-toothed wheel on the spindle and the 64-toothed wheel on the worm, the 32- and 56-toothed wheels constituting the second driver and first driven respectively on the stud. The negative sign to the ratio and employment of a compound train call for the use of *one* idle pinion.

To index a job by the differential method, the necessary change-wheels are set up, and the crank and index-plate are set as for indexing the approximate number of divisions, the index sectors being set up to include the number of holes for indexing the approximate number of divisions. The spring-pin, at the rear of the index-plate, is released so that the plate can be rotated as the crank is being turned from one arm to the other of the index sector.

September 30, 1937

# Castor Oil as a Lubricant for Tapping

THE advantages and usefulness of castor oil as a lubricant for tapping operations, especially those where very fine threads on small diameters are being formed, are not sufficiently realised by engineers, due to the relatively high cost of this material in comparison with the more commonly used lubricants. However, from extensive experiments, the present writer has found castor oil to be superior, in that it gives easier tapping, greater freedom from broken taps, and, also, better finish on the work. Given an economical use of this material, it should prove no costlier than the better-known and more widely used oils. The method adopted by the writer for handling castor oil economically will, perhaps, be of interest.

The first experiments were conducted by means of a small brush, this being dipped frequently into the oil container, then brushing the tap with it. It was found that this method led to flooding of the tap immediately after dipping in tin, and thus to waste of oil. A small brush can retain a fair volume of oil.

Instead of a brush, a small "popple" type oil-can was employed. One was selected having a specially fine nozzle aperture. This type of oiler produces a single-drop delivery at each act of pressure upon the bottom plate of can. By a careful "peening" over of the nozzle of spout, it was possible to regulate the drop-delivery so that just the requisite amount was delivered. Tests will determine this amount. It will be much smaller than is commonly supposed. Castor oil also proved exceedingly useful when having to drill small-diametered holes. It acts as a very effective lubricant to small drills, and, again, its use definitely leads to longer life of these tools.

Another good lubricant for tapping purposes can be made by mixing equal parts of castor oil and rape-seed oil. For certain grades of steel, this mixture will be hard to beat. Where it is found impracticable to use castor oil, on account of cost, rape oil is a very good substitute. It should, of course, be used in the same manner as castor oil - viz., by small-nozzled "popple" oiler, rather than by brush - W.H.

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February 11, 1937

# A MILLING ATTACHMENT FOR THE LATHE

By G.P. POTTS

***One of the best known lathe attachments for which drawings and castings were available is the "Potts" milling attachment, although I think many model engineers will be surprised that the design is now over 60 years old. Over the years of Model Engineer's history a number of similar designs have been published, this one seems to have stood the test of time. With a modern self-contained motor it would be a most useful addition to anybody's workshop.***

THE attachment described was made for use on a 3½" Drummond lathe. The design follows, generally, those described by Mr. Goldsworthy Crump, and others, many moons ago, in the "M.E.," with certain modifications and additions. It was required to be sturdy, compact, and adaptable to any position. The parts were machined in the following order:-

The spindle holder was clamped to faceplate, and the edge and face of the flange turned, drilled through for clamping-bolt, and counter-bored for spigot of slide. Alternatively, it could be held in a four-jaw chuck. The edge was then divided every 5 deg. over 180 deg. The casting was then held in three-jaw chuck and the seat for nut faced. It was next fixed on angle plate, and bored for the spindle sleeve, and then reamed to size. One end was faced to length and turned to 1⅜" diameter, to take clamp for jockey pulleys. The other end was similarly treated, with the casting on a mandrel. It was then drilled tapped, for locking-bolt, and split. A flat was machined across the front face to facilitate setting on the lathe.

The slide was held in a four-jaw chuck, and bored for column, and end faced. The other end was faced by holding by the bore on outside jaws of self-centring chuck. The angle plate was used when facing and turning spigot a tight fit in counterbore of mandrel holder. It was then drilled, tapped, and counterbored for the bolt. The keyway was next cut, and the lug for locking bolt was drilled, tapped, and split.

The hole for lead-screw was left until the slide could be erected on the column with end-plates fitted. A bush with a 9/32" hole was inserted in hole in top plate, and a 9/32" drill put through lug. The axis of this hole must be parallel with the axis of the column. The bush was then removed and tap put through. The tap had to be made, as one was not easily procurable.

The clamping bolt was turned from mild steel and screw-cut.

**The Column**

The column is of cast iron, and was turned on a wood mandrel with metal inserts for centres. Steel plate punchings are ideal for this purpose, driven into a hole just to take the smaller diameter. The column should be a good sliding fit in the slide, and may be ground or lapped to ensure parallelism. A keyway 3/16" x 1/16" deep is milled the entire length. The key, of silver steel, fits tightly in slide, and may be pegged.

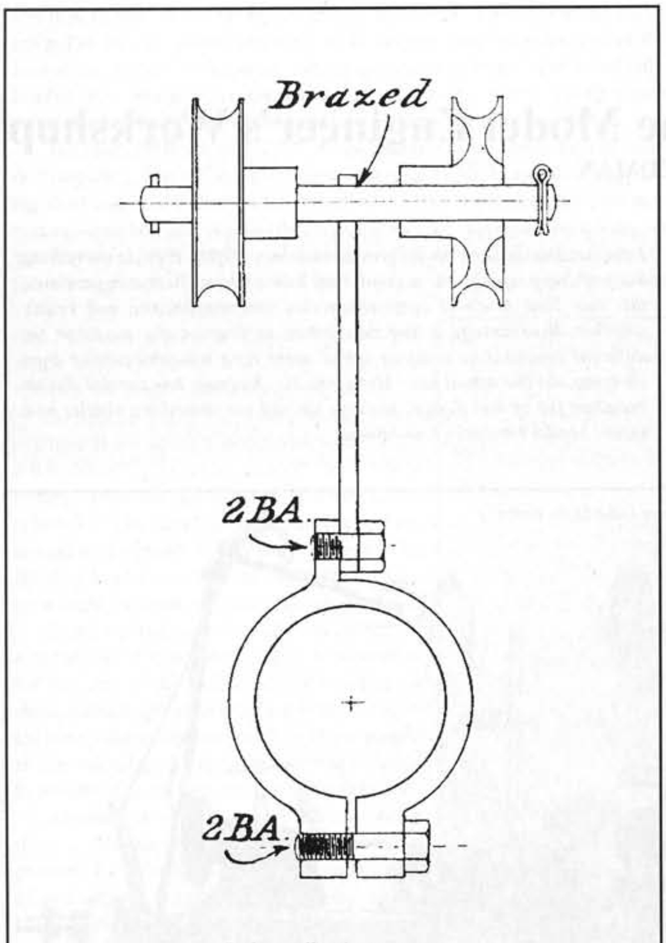
The end plates are a tight fit on the column. The bottom plate was cast with a spigot, so that both the recess and bottom face could be machined at one setting, so ensuring that the column would stand truly vertical on the lathe slides. The top plate is further secured by two 6 B.A. screws, which position the hole for lead-screw. This hole was bored and the outside of boss turned with the plate mounted on faceplate.

The spindle sleeve is of steel tube, bored out to 7/8" diameter. The outside was turned a push to fit in the holder, after the bushes were fitted and mounted on its own spindle.

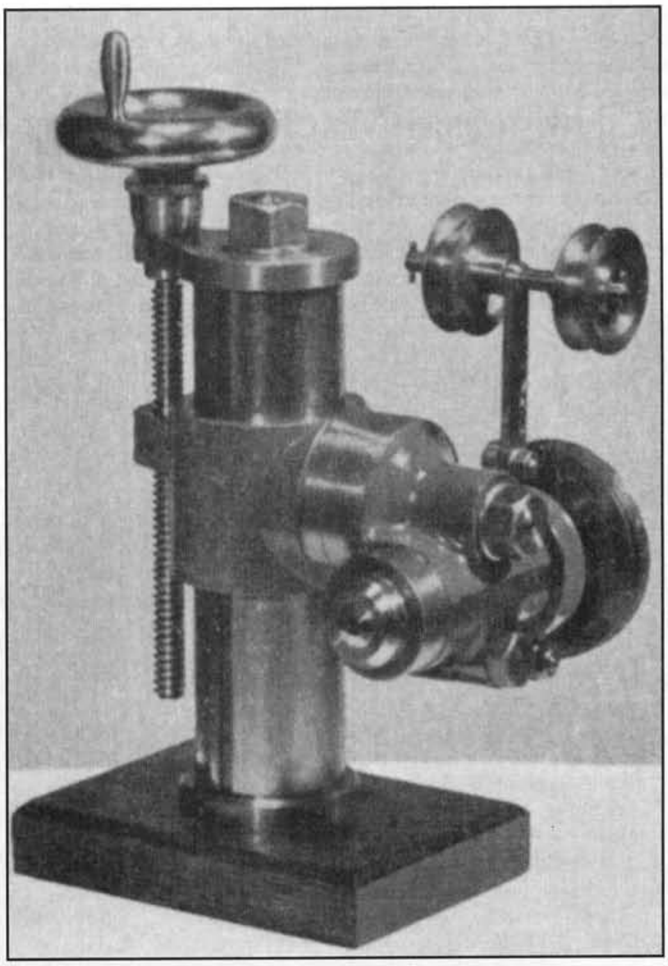
The bushes, of phosphor bronze, are bored, and turned a press fit in sleeve. Oil-ways are cut and two small oil-holes drilled in sleeve between the bushes, so forming a good oil-well.

The spindle is of mild steel, turned and lapped to fit its bushes, screw-cut 9/16" x 26 t.p.i. for locknuts, and keyway cut for the pulley. The fixed-steady was used for boring out for drawbolt. Long 3/16" and 1/4" twist drills were used, followed by a 5/16" diameter D-bit. The nose was then reamed and countersunk for "A" size split chucks. An alternative method is to bore the spindle first, and turn up a mandrel on which to mount it for turning.

The drawbolt is of 5/16" silver steel, reduced slightly over most of its length.




*Jockey-pulley Arrangement.*



*The completed Milling Attachment.*

The brass knob is sweated on.

The lead-screw is turned from mild steel, and screw-cut 10 t.p.i. square thread. Keyway is cut for handwheel, and the end screwed ⅜" by 26 t.p.i. for locknut.

The handwheel is bored an accurate fit on lead-screw, and keyway cut. The boss is turned parallel for micrometer. The latter is of mild steel, bored to fit boss of wheel, and recessed to take a short piece of watch spring to give friction grip. The edge is marked with 100 divisions, so giving readings to 1/1000".

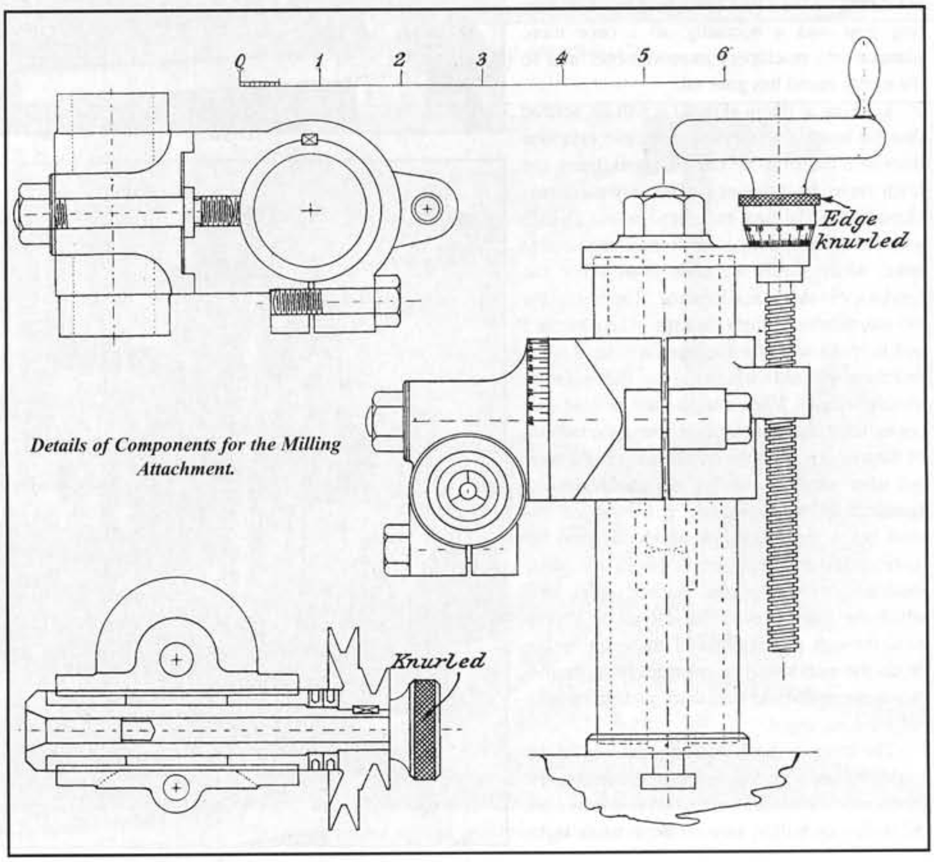
The holding-down bolt was made in two pieces, joined by a screwed ferrule. The bottom part is of the same length as the stud on the top side of the lathe, so that the attachment may be used in this position when required. The top part is pinned in ferrule.

The pulley and jockey-pulley arrangement call for no description.

It will be seen that the arrangement of the spindle, allows of different spindles with their sleeves being used, and the writer has one with ball bearings for grinding.

A further accessory (not illustrated) is a saddle to fit lathe bed, on which the attachment can be mounted, so that work can be fixed to the cross-slide while being milled.

The uses to which the attachment can be put are many, and will be familiar to most readers.




*Details of Components for the Milling Attachment.*

# A Universal Machine Tool for the Model Engineer's Workshop

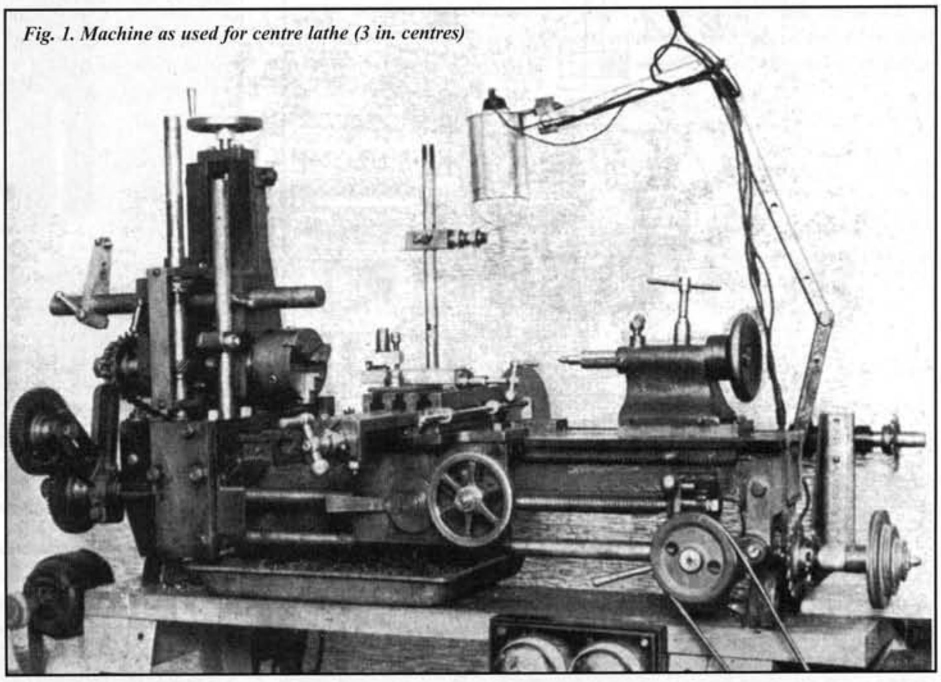
**By L. F. REDMAN**

***I am not always keen on universal machines. Often they do everything but nothing properly. As a result they can be most frustrating at times, this can lead to short cuts which can compromise the end result. Another disadvantage is the time taken to prepare the machine for different procedures, you can spend more time machine setting than carrying out the actual job. However, Mr. Redman has carried out an excellent job of tool design, perhaps we will see something similar at a future Model Engineer Exhibition?***

THE machine about to be described is the result of several years' experience and experiments in developing a machine and accessories which would cover a wide range of utility for both experimental and model-making requirements. As will be realised, a machine of this description can only be the outcome of development extended over a period of time, working a great deal by rule of thumb and benefiting from the knowledge acquired from previous try-outs.

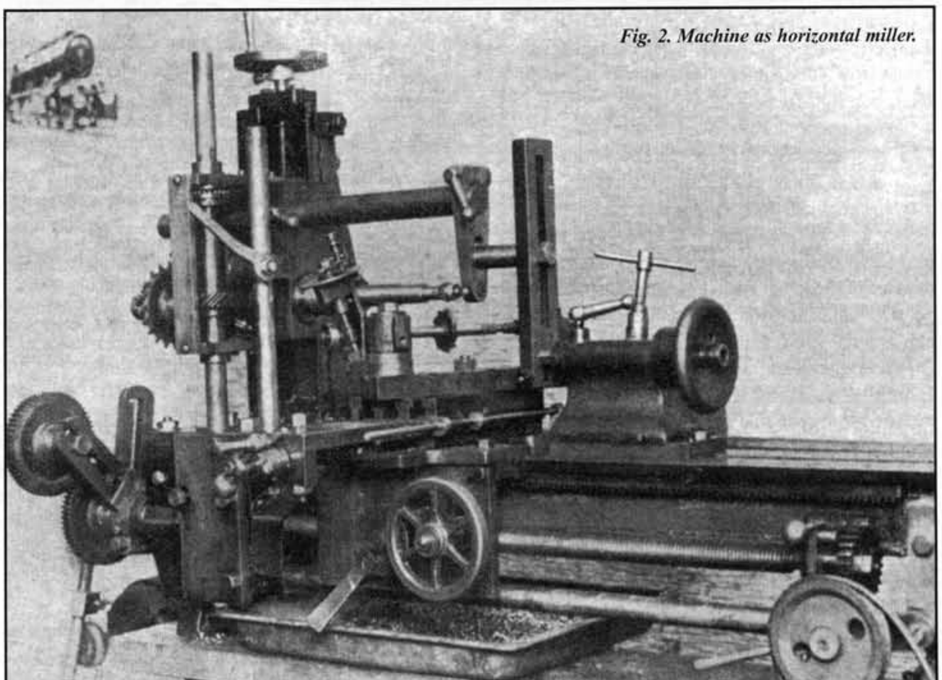
I started model engineering when about sixteen years of age and had about four shots at making a vertical marine engine, one inch bore and stroke, before I succeeded in making a successful working model. Having got so far by the aid of a lathe, I had contrived from angle iron and various oddments, I decided, before continuing model work, to make myself something more presentable in the way of a lathe. To purchase one at this time was out of the question, as my age and finance was very limited.

*Fig. 1. Machine as used for centre lathe (3 in. centres)*



I therefore, began building another lathe using the existing one to make the bits and pieces. This machine took me about three months to build and was a decided improvement on the last. The bed was constructed of seven-eights square B.M.S. bar, two lengths forming the bed, and separated by two pieces of the same section at either end. I made some simple wood patterns for the headstock and tailstock, whilst a slide-rest was constructed of M.S. flat bar. This brought the job to the end of the three months' programme. Another start was made on a model but I soon realised that some kind of screw-cutting gear was a necessity, so I once more plunged into machinery improvements; and so the merry round has gone on.

*Fig. 2. Machine as horizontal miller.*



Looking at photo (Fig. 1) it will be noticed that the machine follows closely the orthodox lines of a centre lathe, the headstock being the main centre of difference. The only parts purchased were the bed, rack, lead screw, change wheels and an old top slide from a large centre lathe, which forms the slide upon which the headstock is raised and lowered. The rest of the job was machined from castings. The patterns I had to make were for the box-form head-stock and the standard to which the top slide referred to was bolted. When the machine is used as a centre lathe, the drive is direct on to the tail end of the mandrel from the countershaft at the rear; but when used as a miller, the chain is transferred to the tailstock end. It then drives the shaft below the lead-screw, which transmits the motion through bevel gears (from a sewing machine), to the vertical splined shaft over which the sliding keyed sleeve rotates. This in turn, through the medium of the spiral gears, drives the mandrel. The spiral gears are from a motor-car over-head camshaft picked up at a car-breaking depot.

The drive, to be seen at the tail end of the lead-screw is to give an independent feed to the lead-screw. A small countershaft is driven from the three-step pulley, seen on the extreme right, and this, in turn, drives the pulley facing the camera. The lever to the left of the pulley lifts the worm into mesh with the gear attached to the end of the lead-screw, a small spring-loaded latch keeping it in mesh. The small ball-headed lever above, when pressed down, releases the worm spindle which drops quickly out of mesh, due to the tensional pull of the round belt.

The feeds obtained are 0.002", 0.004" and 0.006" per revolution of mandrel (approx.). The milling-mandrel steady is exceedingly useful for supporting short ends in the chuck when the tailstock is not convenient; also, for supporting work between centres (that is a centre in the milling-arbor steady) for taper turning. When the headstock is raised to the top of the slide, it is possible to bore out the boss of a wheel twenty inches in diameter in the gap. The vertical bar, to the right of the vertical drive shaft, forms a steady for the headstock, a split clamp locks the head when set for height, and makes it very rigid under cutting strains.

Turning to Fig. 2, it will be seen that the machine is set up as a horizontal miller. The arbor-steady gains extra support for "heavy milling" from the slotted steady attached to the tailstock. The dividing-head has been slung around in the photo, to give a better view. The dividing-head gives a useful range of divisions up to eight hundred with the existing plate.

To the right of the cross slide will be noticed a round rod of silver steel, which is secured at the rear end of the saddle, and is a sliding fit through the small plate attached to the tee-slotted table. The collars are locked with set-screws at determined positions, and form useful stops to prevent over-running when milling slots, etc.

Another set-up for vertical milling operations is that shown in Fig. 3. The drive is obtained by utilising the change wheels, which gives a varying range of speeds. The bar-steady used on the horizontal arrangement is slipped out of the headstock, and the tubular one, to which the vertical head is fixed, is slipped through in its place. This tube is bushed at either end, to form the bearings of the horizontal shaft, which runs through the centre and drives the vertical cutter spindle by means of the bevel gears seen. These gears, before modification saw service on a printing machine. The cutter-spindle is bored throughout its length, and is reamed 0.375" to take cutters, which are locked by means of a ¼" Whitworth Allen grub-screw. The outstanding feature of this arrangement is that the head can be set at any angle through 360°, enabling one to tackle a wide range of milling operations.

After using this arrangement for some time, experience provided that the equipment left much to be desired - mainly, that spindle speeds were too low for using small-diameter fly-cutters and end-mills. Fig. 4 shows yet another experimental try-out which has proved very efficient. As will be seen, the vertical spindle-head is fixed by means of a stud and nut to the steady, as used for horizontal milling. This head, when removed from the steady, fits on the lathe bed, and is located by means of a tenon, and converts the machine into a high-speed lathe for fine work. The centre-height (3") corresponds with that of the lathe centres, actually, the drive being obtained from the pulley, seen on the countershaft at the rear. the belt is of ⅛" diameter gut, and drives in a very positive manner, the slip being almost nil. The bores in the circular table, dividing-head and vertical spindle, in Fig. 3, are all reamed to 0.375" diameter, as, also, are the other chucks and fixtures used in conjunction with the set-ups, so as to be interchangeable. For example, a job can be turned in a chuck, or on a screwed adapter, with 0.375" diameter shank, and then transferred to the circular table, or other apparatus without disturbing its setting. This enables either drilled holes or milled faces to be in correct relation to each other. This machine has turned out a great many parts, of an intricate nature, for a friend, who has been experimenting for some time on carburettors, and I hope, at some future date, to send along some photos of the components produced.

In conclusion, I would like to say that the photos were taken by Mr. Porter, of the Bristol Model Power Boat Club, and I think you will agree that he has made an excellent job of them.

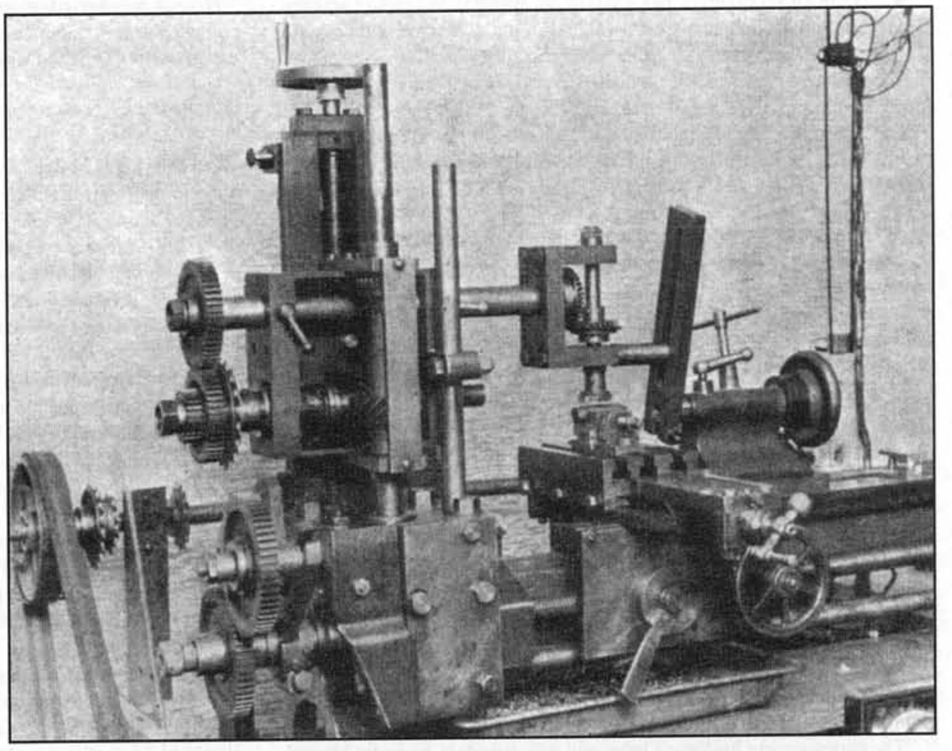


*Fig. 3. Machine as vertical mill ("heavy")*

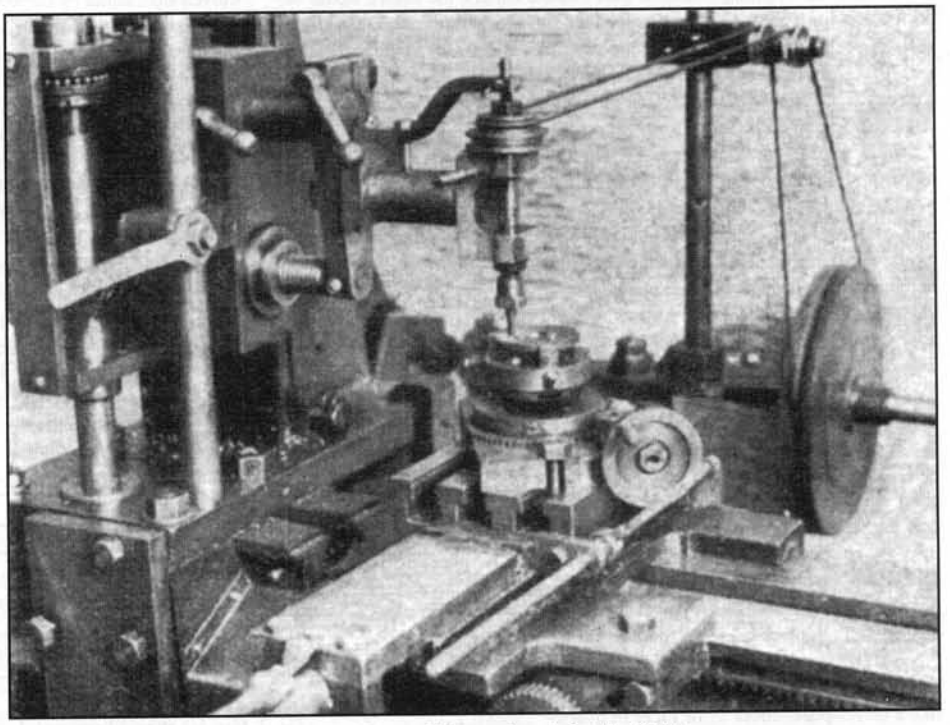


*Fig. 4. Machine as high speed vertical miller (light).*

September 29, 1938

# Milling Square Ends in the Lathe

**By GEO. GENTRY**

***Here is another contribution from friend George Gentry. For model engineers with a horizontal or vertical milling machine in their workshop the task to hand would be very easy indeed, but for those of limited means and only a lathe as a machine tool, the problem requires some thought, but is that not half the fun of the hobby?***

A CORRESPONDENT has a job to do, which is to produce squared ends to a round bar of steel, which ends must coincide, and be cut to a given width across the flats, and be axially coincident with the bar.

Fig. 1, top view, gives the particulars and sizes of the job. That is, to square the ends of a 12" x 1¼" round steel bar, for 2" along, and to a square 1" across the flats. It will be noticed that a complete 1" square cannot be cut from a bar 1.25" in diameter, because a square 1" across measures 1.414" nearly across corners, which is about 15/16", less a full 1/64". This, however, does not affect the method.

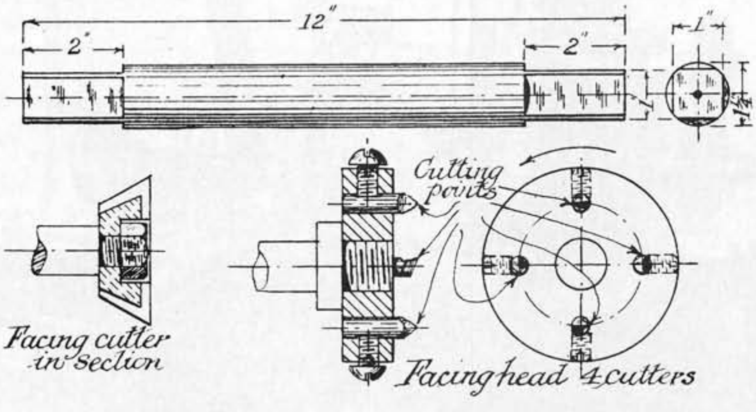



*Fig. 1. Detail of the Finished job, and some suitable cutters.*

**Comparisons of Methods in Lathe and Miller**

The correspondent has only a lathe, and will, therefore, be better advised to cut each face separately, by one of two methods, measuring the differences in one case. In a milling machine, with suitable cutters, the square would be milled between a pair of large facing-cutters, set on the arbor 1" apart, or made such as one profile-cutter, thus cutting two faces at once, opposite and parallel. Then the job needs only a ¼-turn by the dividing head to produce the square. The difficulty here is to set the work so that the centre between cutters is coincident with the bar axis.

To overcome the last mentioned, the bar could be first produced 12¼" long, and turned concentrically at each end, ⅛" along to exactly 1" diameter, or a shade under (not more than ½-thou.). This extra nose would be set up so that it went between the cutters without either cutting it, or appreciably scraping it, which, if the setting is arranged parallel with the slide-ways, will maintain the flats coincident with the bar axis.

The following, however, is how the correspondent was advised, which advice is followed here with some further notes on the sketches which are included, a copy of which he had sent him:-

**Milling Square Ends in Lathe**

The job can be done by means of a recessed side-cutting milling-cutter set up on arbor held short in a self-centring chuck on the lathe-nose (see Fig. 1, lower views, left hand). The cutter must be rather over 1" in diameter and either screwed to the arbor, or secured on a screwed-nose of the arbor, by means of a nut in the recess. In both cases held to a shoulder on the arbor. If such a cutter is not available, make a facing-head in the form of a small face-plate, like a driver-plate, about 2" or more in diameter, and either screw it to nose or operate in a chuck (see Fig. 1, lower views, right hand). Scribe on it by turning a 1½" circle and drill into the plate two or more holes on the circle fairly equally spaced. Into these holes fit small bit-cutters of 3/16" or ¼" round silver-steel, *with cutting-points all set to the same projection*, and in such facing position that they cut as the head revolves. Each cutter is secured by a setscrew into the periphery of the head and bearing on the cutter-shank, which is flatted to prevent turning.

**The Setting-up (see Fig. 2)**

Set the job up resting in a pair of vee-blocks on the cross boring-table, one at each end, but over 2" from the end to be acted on, the top-slide being removed. The centre of bar must be set horizontal, and about level with the lathe-centre. Further, it must align in parallel with the cross-slide, and put a clamp over each vee-block, clamping the job down to the table. The cross parallelism can be checked by traversing across in front of the cutter (not revolving), and see that the same thickness feeler-gauge slips in between the cutter and the work in all positions.

**How the Milling is Done**

When set up, start the cutter clear beyond the end of the work, and feed the work by the lead-screw to put on the cut, then traverse forward slowly, by cross-slide, to effect the facing, for a distance of 2" along. Continue this in a series of cuts till the flatted cylinder measures 1⅛" from the other curved side, either by correctly set calipers, slide-gauge, or screw-micrometer. When so far finished, release the setting (without moving the vees), and give the job half turn in vees, and re-set with the cut flat set upright by try-square standing on the boring-table (see Fig. 3, left hand). Re-clamp and again face, as before described, till the two opposite faces caliper 1".

In the third setting, the job is given a quarter turn and a small try-square stood on the top-flat is made to agree with the try-square on the table (see Fig. 3, right hand). The setting for the fourth is as the second.

**Both Ends in One Setting**

If the cross-traverse of lathe is long enough (though not likely), the nearer end may be milled, working backward from the forward position against the cutter, and each end will be milled in the one setting, ensuring parallelism per end. If not, having done one end, secure both vee-blocks, release the job and turn it end for end, re-clamping with the milled-square set up to a try-square off table or lathe-bed. Then proceed as before described.

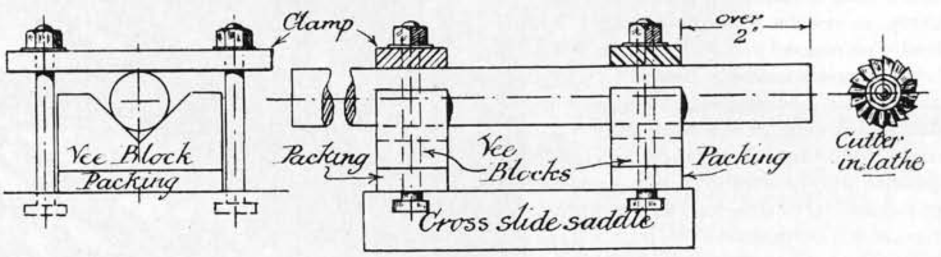



*Fig. 2. How job should be mounted on the cross-slide table.*

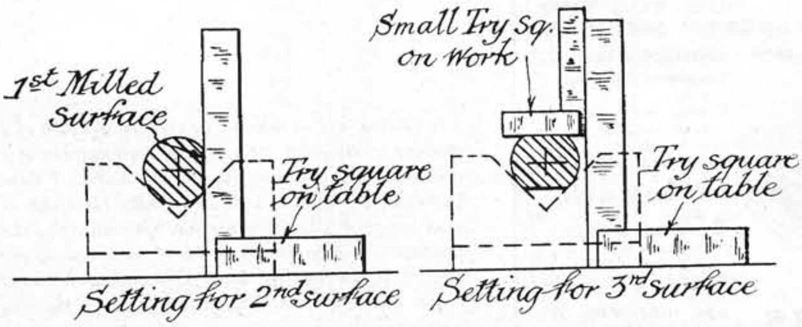



*Fig. 3. How to set up the change positions.*

### Doing the Job Between Centres

A simpler way to do it, but involving more accessory apparatus, is to set the job up, one end in the chuck on nose, and the other end truly centred and supported on the tailstock-centre. The same kind or kinds of cutter is used running on a milling-spindle held level with centre and set up on the slide-rest. The spindle is to be operated by over-head, or some kind of independent-drive, and it is, of course, set axially at right-angles to lathe-axis, and with cutter faces square with the bed. In this case, the cut is put on by the cross-feed, and the traverse done by the lead-screw, or top-slide, and the lathe-spindle held is rigid. No re-setting is necessary, but the divisions of four can be effected by indexing against a change wheel on spindle or by a division plate of four or its multiple. None of these, however, will be necessary if a four-jaw independent chuck is available (used as shown in Fig. 4, left hand). The job, previously centred at both ends, accurately, is set in the chuck-jaws with tail-centre support, and chuck adjusted till both ends run truly. Now set the chuck visually upright (i.e., with one opposite pair of jaws vertical, and the other pair horizontal). Fit a block under the nearer horizontal jaw and standing on bed, so that the chuck is held to it during the first facing. Now for successive faces, use the same block under successive jaws. the jaws are quite accurately placed in squareness to give an accurate square result.

On changing end for end, set the squared end up in the chuck, one jaw on each flat face, and adjust till the cylindrical portion runs true. If a small portion of the squared end is allowed to project from the chuck, one flat may be set vertical to try-square on the lathe-bed and the supporting block under the horizontal-jaw adjusted, if necessary, to effect the indexing for the other square (Fig. 4, left hand).

### Further Notes on the Sketches

In Fig. 1, bottom left-hand, the cutter is shown in section. It is recessed, so that, if a binding or lock-nut be used, which is practically necessary with or without a threaded bore, such nut will lie below or under flush of the facing edges. The cutter shown is angular and facing, but may be flat-edged (90°) and facing; but must cut both on the face and edge. This cutter is also seen in Fig. 2. The facing-head detail, to right in the same figure, is a useful all-round tool to make. It is better mounted on an arbor and chucked, in preference to being screwed directly on the lathe-nose, as it then will project well over the cross-table to reach the work, and avoid having the saddle projecting over the gap, or, maybe, hard up against lathe head-stock. The round-head screws, securing the cutters against a flat on the cutter-shank, are the most convenient, generally, and safer against knuckles, as they can be flattened on edge, each side, parallel with the drive-slot, for spanner or wrench tightening, but, in the case of this job, they would foul the vee-block unless the job had excessive overhang. It is, therefore, suggested, in this case, that grub-screws be used, as indicated in the face view to right, to obviate the excess in overhang.

### Fig. 2: The Setting

In this, the use of the end slots of table are indicated, and the side view shows the clamps in section with the nearer bolts omitted. The position of these bolts, however, can be varied to suit the size of cross-table available. They should be put as far apart as the table and length of job permit, but, preferably, well over the vee-blocks. Such bolts must hug the ends of vee-blocks, which should of necessity be as short in their length as can be procured from the tool stocks, to suit the width of the table. From this sketch, it will be seen that the cutter finishes with a concave shoulder. If this matters, shoulders can be easily corrected to that shown in Fig. 1, top view, by the application of a safe-edged file. In the alternative method, the use of a vertical-slide will correct this, and will be mentioned later.

### Fig. 3: Setting for the Changes

In setting for the second surface, the coincidence to the square must be very carefully observed, and it will be found convenient to get to the back of the lathe for the purpose. Also, it will save much trouble if the vee-blocks can be kept secured to position on table during the change, and while the main clamps are relaxed. Independent clamps on each block or one clamp across both blocks and secured to the centre-slot of table might be considered in this connection. In any case, careful tests in cutting the second surface, and which will be referred to in Fig. 4, will be advisable.

The setting for the third surface also needs double care and will have to be checked as described later.

### Fig. 4: The Alternative Method

In this case, a horizontally-placed cutter-spindle is mounted on the slide-rest and carries the cutter, which cutter-face comes axially opposite the lathe axis, is axially square with it on plan, and has the cutter-face square with the lathe-bed. Vertical-slides are made carrying such cutter-spindles, which can be mounted on the cross-slide table in place of the top-slide. With an accessory like this, and with its spindle (which is usually capable of being swivelled) set as described, having finished one face, by operating the vertical-slide up and down with the cutter up to the shoulder, the concavity can be levelled on the horns, and no filing for correction necessary.

In setting the chuck for the first square, the lathe-jaws are set vertical against a square on bed, and then the front horizontal-jaw equipped with packing. The sketch, however, indicates the chuck setting for the second square by chucking the first as seen in section. In this case, the cut square is set coincident with the square to bed, as indicated dotted, and it may be necessary to vary the support packing to suit that setting, although, if the first setting of chuck is accurate, it should not arise. •

### Testing for Parallelism

In the chuck setting no need for test for squareness should arise, if accurate jaw-indexing is maintained. In the other, however, in cutting the second face, proceed as seen in Fig. 4, right-hand. Having cut the second face to half, or a little more, depth, test with calipers, as shown, down from top and up from bottom, just on, and check, if feel is uneven, by micrometer. Then correct position, if necessary, before finishing. Similarly, in cutting the third face, test early with the little square and correct if inaccuracy shows up.

### A Warning

In this, and, indeed, in all milling operations carried out in the lathe, all securing nuts and settings must be firmly applied, and maintained, and all slides kept up to sliding register. The vibratory cutting action of mills can be so aggressive that movement in setting, and loosening of nuts on screws take place gradually, and error unknown to the operator; till he suddenly realises that the job is going off accuracy of finish, due to accumulative movement of the work.

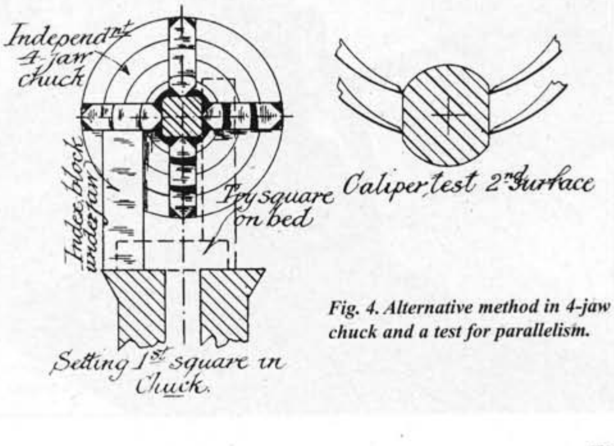



*Fig. 4. Alternative method in 4-jaw chuck and a test for parallelism.*

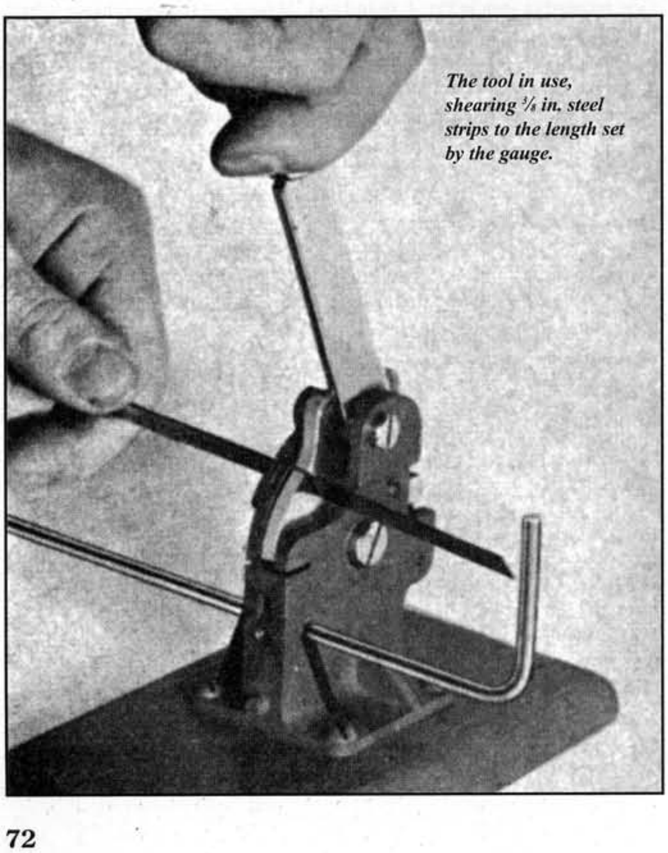
*The "Juneero" tool may not be everybody's idea of a shaping machine but it certainly shapes metal even if not in the conventional idea of the word. I have included this item as it is still fondly remembered even today. Model engineers may not realise that the product is nearly 60 years old. I have one in my workshop although its use is very limited in model engineering. It is still useful to bend up the odd bracket or two.*

January 9, 1941

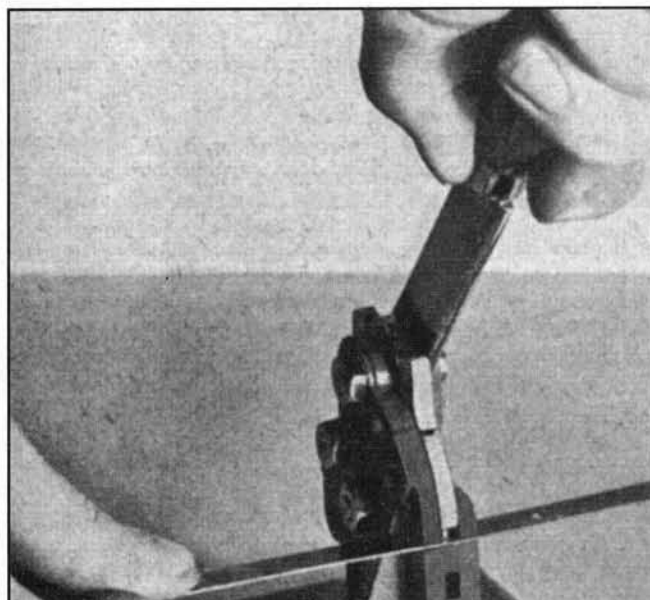
# "JUNEERO"

## A new method of constructional modelling

ALL readers are familiar with the many types of constructional model outfits which have been introduced at various times for the amusement and instruction of juvenile model engineers. These vary greatly in elaboration and complexity, and without going into details, it may be said that they all have their own particular merits and limitations. All of them offer considerable scope for the ingenuity of the constructor, and are capable of being built up into a very wide and diverse range of models; also, they can be employed to teach constructional engineering principles, and to demonstrate mechanical motions, work out inventions, and so on. But in practically all cases they suffer from one common limitation, in that they only deal with one aspect of engineering practice - that of assembly; and while it is quite true that this is a most important part of the engineer's work, the fact that it is only a part should not be lost sight of. Personal experience of the use of constructional modelling outfits leads us to believe that many users tend to regard the technique of using them as a complete craft in itself, whereas, in actual fact, the interest and instruction obtainable from the use of such outfits would be vastly enhanced if they were employed in conjunction with other methods of construction. Practical engineers, although by no means reluctant to make every possible use of "stock" standard parts which need no treatment except assembly, are in most cases obliged to make most of their components from raw or semi-formed materials; and it is the working of these materials by machining, filing, cutting, bending, drilling and punching that constitutes the major part of engineering craftsmanship.

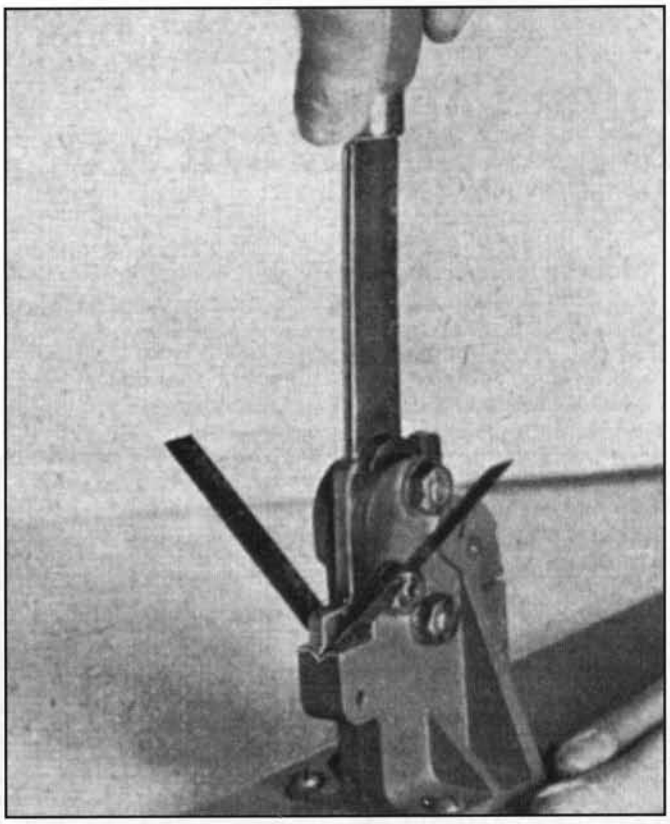


*The tool in use, shearing ¾ in. steel strips to the length set by the gauge.*



*Punching holes in strips.*

The methods employed in the constructional outfit under consideration, however, differ from nearly all others in that it does not depend on the use of completely pre-formed components, but provides facility for the working, in



*Bending strips to right-angles.*

various ways, of raw materials, and thus not only gives much greater flexibility, and wider scope for building a diversity of models with a simple range of materials, but also brings the user in much closer touch with real engineering practice. In this respect we consider that it is a great advance on previous systems, and we are very enthusiastic about its possibilities in the hands of either the junior or the more advanced model engineer.

As every model engineer knows, tools are the most vital factor in engineering craft, and it follows, therefore, that any method in which raw materials are used for making components must involve the employment of other tools than the usual spanner and screwdriver. In the "Juneero" outfits, most of the essential operations are carried out by means of a most ingenious combination tool which performs, efficiently and accurately, the processes of bending, punching and shearing steel strip ⅜ in. wide, and also shearing rods ⅛ in. diameter.

The photographs provide a better description of this tool than can be conveyed by written words, and it remains only to say that it works on exactly the same principles as the shearing, punching and bending machines employed in full-sized practice, such as in shipbuilding yards, and the materials of which it is constructed are adequately strong and durable for continuous use. A die casting forms the body of the tool, and a steel blade, operated by a cam action from the hand lever, incorporates the cutting and forming elements. By means of an ingenious vice attachment, round rods may be gripped in a horizontal position across the end of the tool, and a gauge rod is provided as an alternative fitting, which greatly facilitates "repetition work" in shearing strips to identical lengths, or punching holes at exact distances from the end.

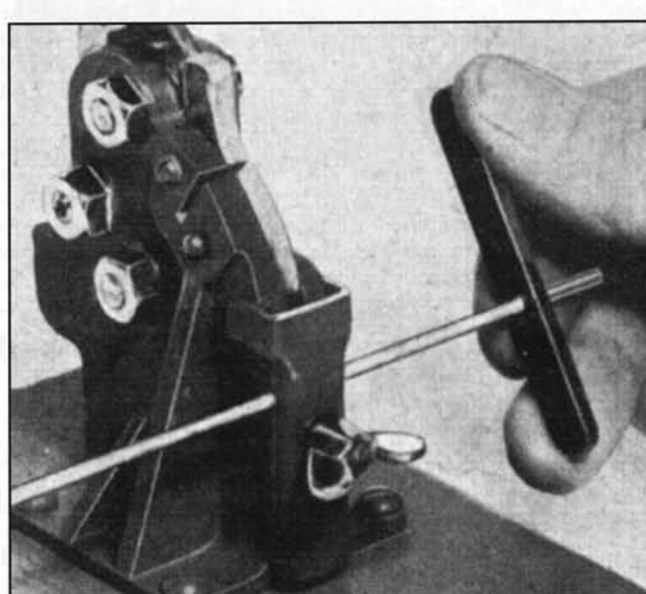
Other operations on metal strips and rods can be carried out by equally ingenious tools, which include the "Juneero" scroll tool for forming simple or compound swept bends of various radii in the steel strips, and also a screw-cutting die which enables threads to be cut on the ⅛ in. steel rods, held by the vice attachment already described. A pair of strong metal-cutting shears is also available for cutting thin sheet metal, and spanners to fit the "Juneero" nuts and bolts. All these tools are well made and designed, and we have no hesitation in stating that they would be useful in any model engineering workshop, altogether apart from their designed purposes in connection with the outfit.

In addition to the rods and strips already mentioned, the materials available include angle strips, nuts and bolts in two standard lengths, assorted sheet metal, tinned or variously coloured, flat and corrugated, sheet metal discs, sheets of glass substitute, plain and coloured, and assorted springs. These enable a very wide range of constructional or mechanical models to be constructed, and extra supplies of all the various items are separately available. New lines of both materials and equipment are constantly being added.

We have been given facilities for testing out the use of the "Juneero" outfit, and have assured ourselves that the claims made for it by the makers are fully justified. The combination tool, in common with the other tools provided, works easily and efficiently, producing cleanly-sheared cuts and punched holes, also sharp right-angled bends, in the metal strips. It should be fully understood that our efforts were directed towards demonstrating not merely the use of the system as an end in itself (that is to say, for the construction of complete models by the exclusive use of these tools and materials) but rather its use in general model engineering, and in conjunction with other methods and materials. The standard designs provided with the outfits constitute good exercises in its normal use, however, and are undoubtedly useful to the beginner.

The types of models in which we found the use of "Juneero" method most useful included (besides the rather obvious cranes and bridges), the construction of model railway stations, signal gantries, conveyor and transporter systems, also the superstructure and framing of model ships. Other interesting mechanical models made by the aid of "Juneero" included the framework of a feathering paddle-wheel, and two or three different kinds of valve gear demonstration models. In all cases, the standard strips and rods were used in conjunction with turned or otherwise machined parts. It was particularly noted that the particular sizes of strips and rods employed appear to conform more nearly to the usual model engineering requirements than those of most constructional model outfits, while the absence of regularly-spaced holes in parts which do not require them is also an advantage in respect of realistic appearance.

One very important feature in the use of "Juneero," which was very quickly grasped, is that accuracy is in the hands of the user, who thus cannot fail to understand how vital a factor this is in engineering practice. If the members of a structure are not cut, punched and bent accurately, it either will not go together at all, or will be badly out of shape when assembled. In other constructional outfits, where lengths of members and positions of holes are pre-determined, the accuracy is inherent and automatic, and thus the constructor often fails to realise what care and skill is necessary in practical engineering to obtain and preserve this most essential property. For this reason, it would not be correct to claim that "Juneero" is the simplest of all constructional outfits to use; but so far from this being a disadvantage, we consider it quite the reverse.



***Cutting threads on ⅛ in. steel rods with the "Juneero" screw-cutting die. Note the use of the vice attachment to the "Juneero" Universal Tool.***