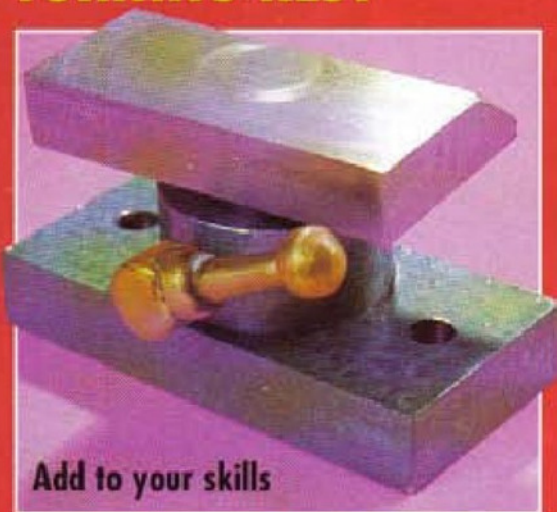


MODEL ENGINEERS' WORKSHOP

THE NEW, PRACTICAL HOBBY MAGAZINE

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TURNING REST**



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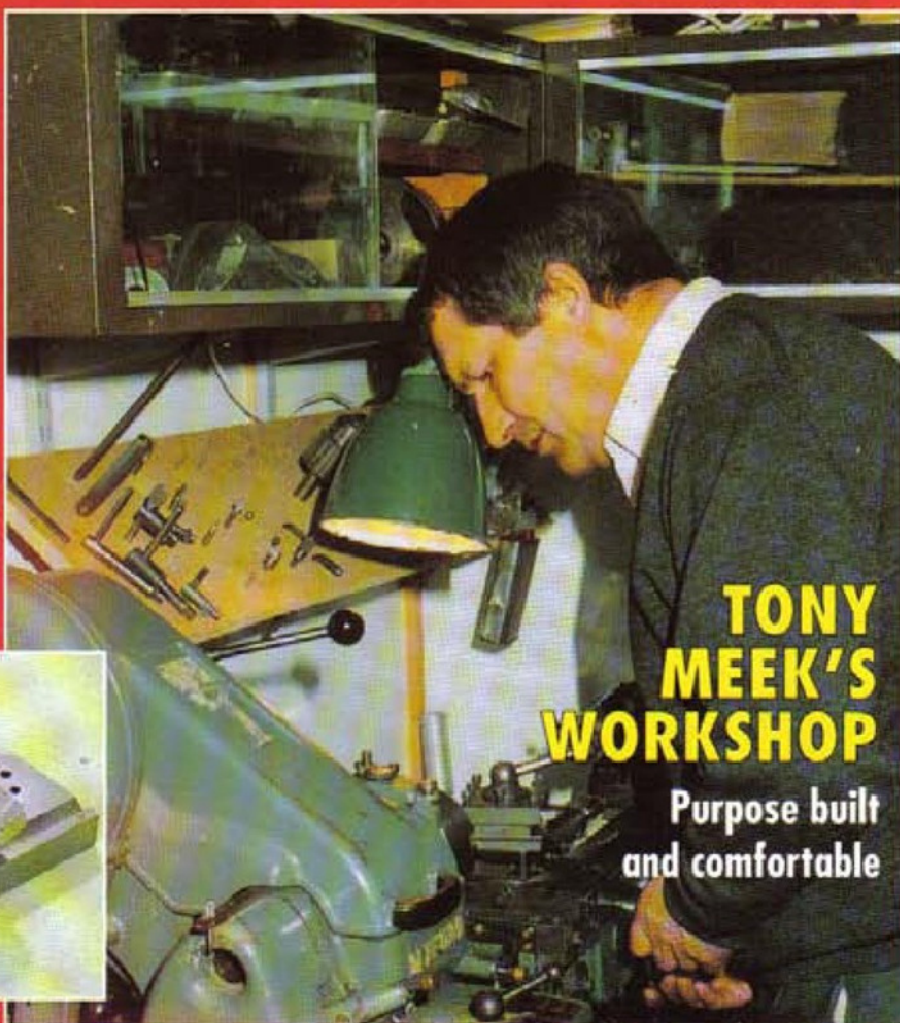
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PLATE**

How could you
work without one?



**KNURLING
FROM THE
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For
slender
workpieces



**TONY
MEEK'S
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With fine adjustment

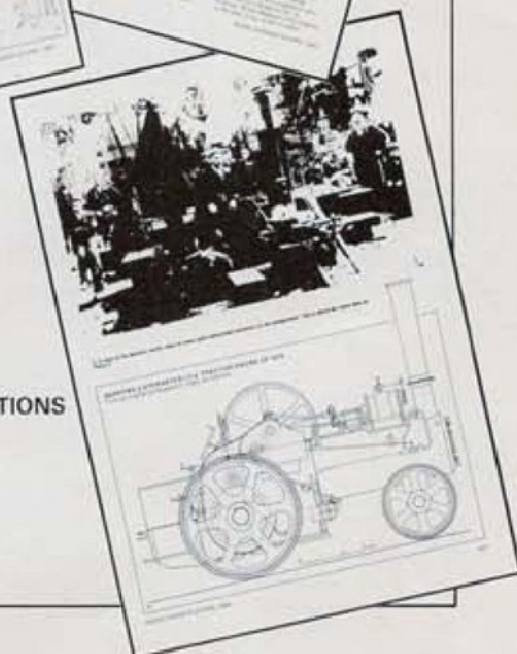
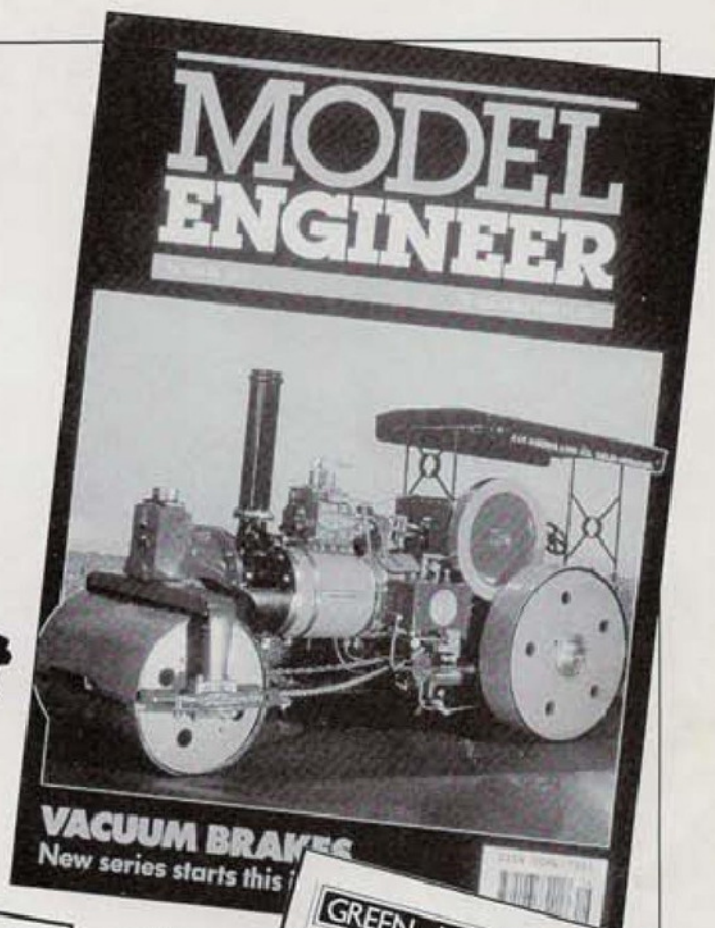


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...every fortnight



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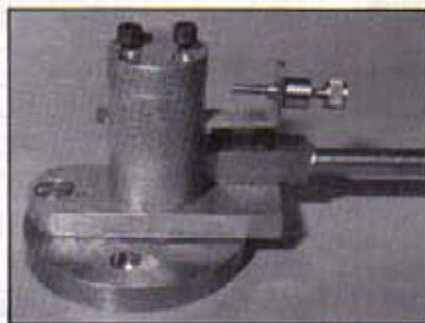
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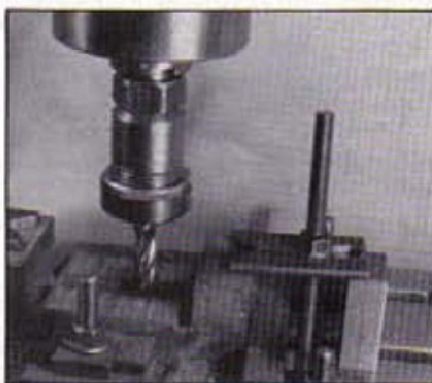
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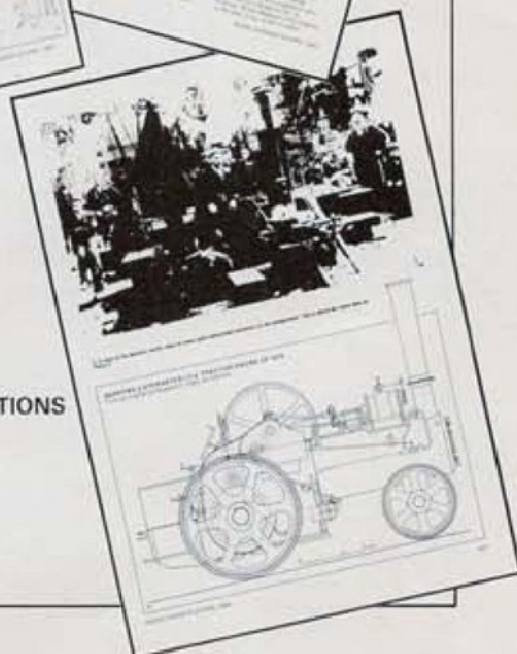
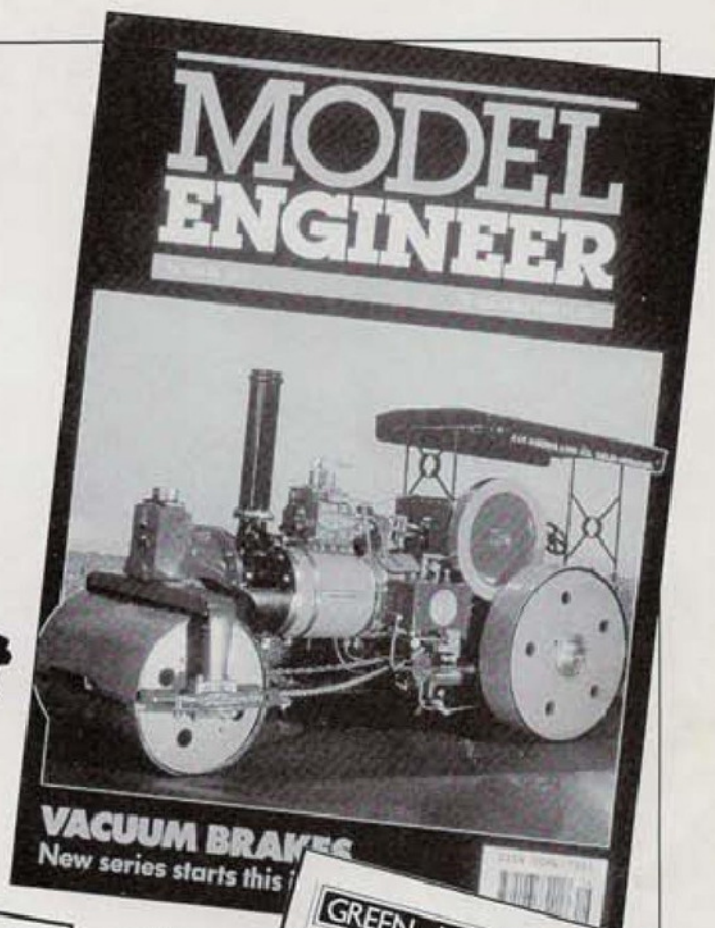
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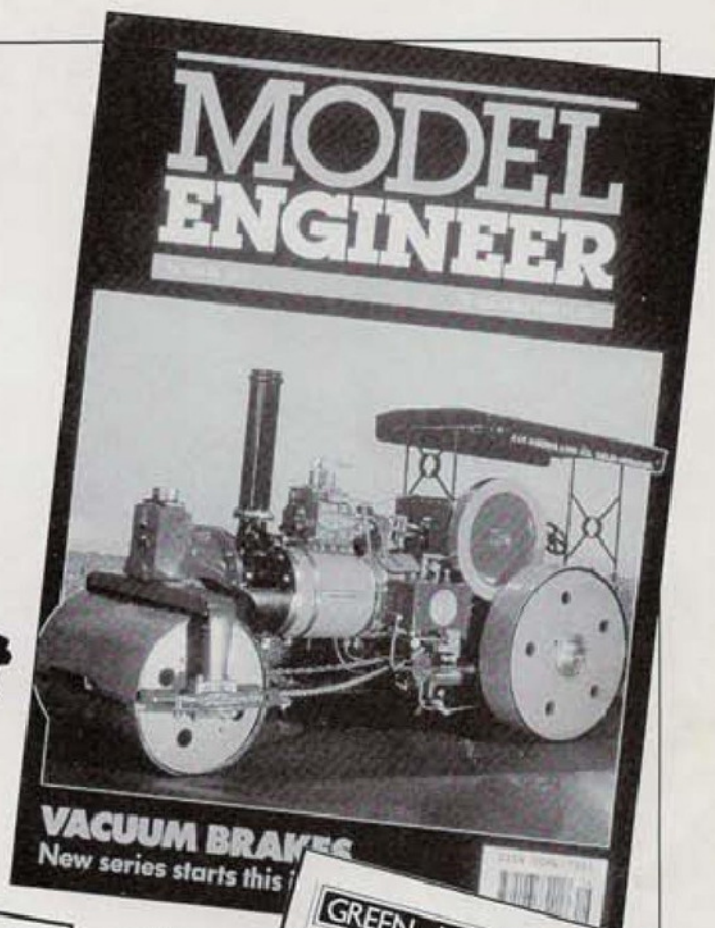


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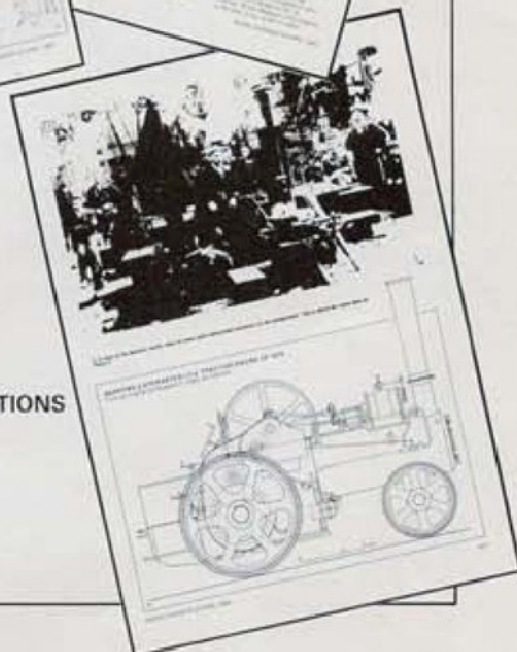
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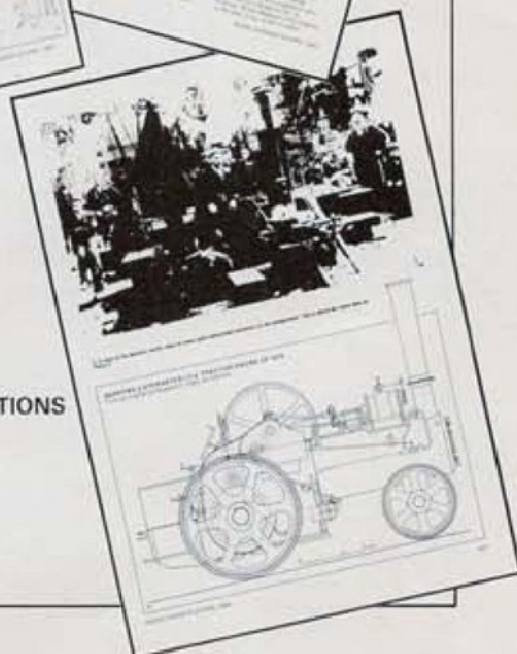
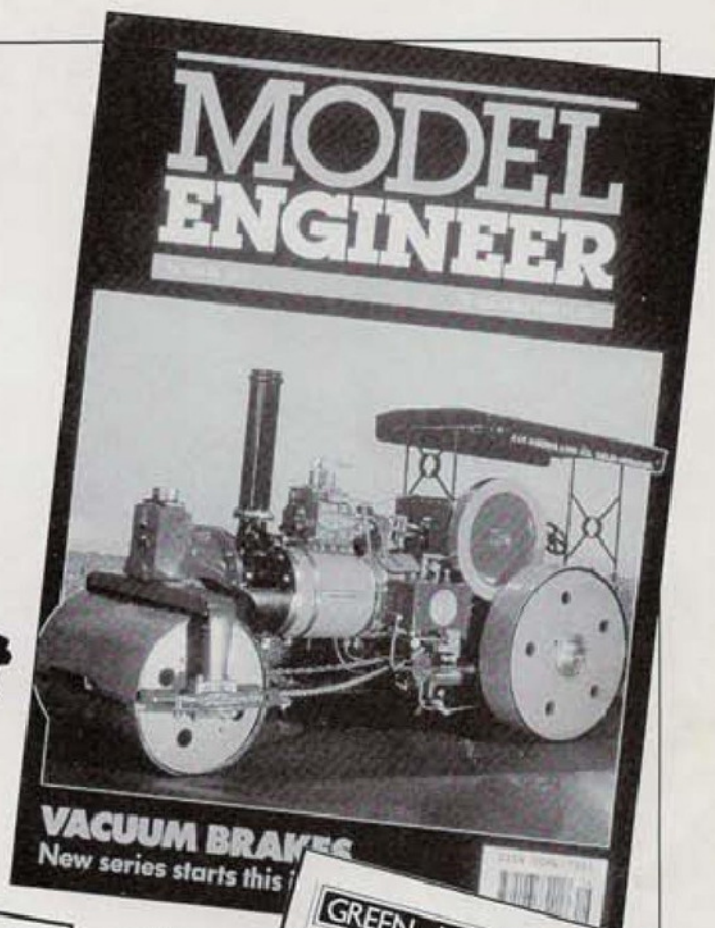
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Stan Bray

ON THE EDITOR'S BENCH

I would like to start this, my last editorial for *Model Engineers' Workshop*, with a reference to a letter sent in by Mr. L. Stevenson of Morpeth. Mr Stevenson saw a Zeiss Dial vernier advertised in the magazine by Messrs Chronos Ltd. He sent for, and received one - the firm does a return service of stock items within forty-eight hours. He had the tool for about ten days and was unlucky enough to drop it, ruining the rack and pinion. More in desperation than hope he returned it to Chronos and asked if it was possible to have it repaired. Without hesitation Messrs Chronos replaced the vernier for him free of charge. They had no need to do so and it speaks highly of the firm that they should be so kind. How nice it is to see a generous attitude such as this from a supplier.

This issue of *Model Engineers' Workshop* is the sixth; we have now been going for nearly eighteen months and have gone from strength to strength! But how time has flown. Once more, I believe we have a nice mix of subjects. It is quite incredible the range of interests amongst our readership. Many just like to potter in the workshop and make the odd tool or so. Others like to see just how far they can advance their machining ability with new home-made tooling. Quite a few, it would appear, are rebuilding old cars and motor cycles. Then of course there are the many modellers, and amongst those is a wide range of individual interests as well.

As I pointed out at the beginning, this is my last editorial. I say this with more than a few regrets. I am, however, not a young man, having already retired more times than I can recall, each time to start something different! With the magazine now published on a two-monthly basis I feel it will take more of my time than I am willing to spare, and so it is time to stand down and let someone else have a go. That someone is Harold Hall. A man with a lifetime of experience in the engineering and electronics industry who will, I am quite certain, be ensuring for a long time that the magazine stays as popular and continues to increase in popularity.

Harold has made many pieces of workshop equipment in his home workshop and on his first venture into modelmaking achieved a bronze medal at the Model Engineer Exhibition. There are few who have succeeded as well as that. He also lives far nearer to Hemel Hempstead than I do and so will have a considerable advantage in dealing with correspondence, etc. There is, at the moment, a long delay while items are forwarded to me in the post, and this will no longer apply. All in all, I can see a bright future for the magazine under Harold's guidance.

I would like to express my thanks to the readers, without whom the success could not have been achieved. To the many hundreds who have written letters, some were too flattering for words, and it gave me a lot of encouragement. I would also like to thank the contributors; without them we would have been lost. Some were kind enough to volunteer to write articles, others I had to lean on a little but they came up trumps. I hope you will all continue to support the new editor as well as I have been supported.

It is, then, with more than a little regret but with a great deal of pride, that I take my leave of readers, who have almost become a family to me during my period as editor. I wish you all the very best, good luck to the new editor, and may the magazine continue to succeed!

We aren't going to let Stan Bray off the hook as easily as this! He has kindly agreed to act as Consultant to *Model Engineers' Workshop* so his guidance and influence will be much in evidence over future issues. MEW was Stan's brainchild from the outset and it would be unthinkable that he should cease to be associated with the magazine he single-handedly created. I'm sure that *Model Engineers' Workshop* readers everywhere will join us in offering hearty thanks to Stan for such an inspired idea!

Alec Gee
Group Editor

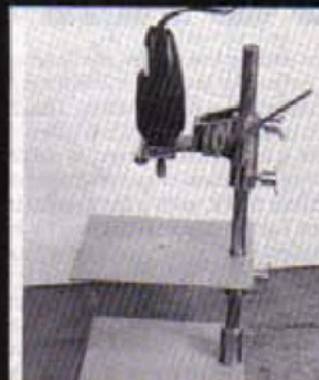
IN OUR NEXT ISSUE!

Coming up in the October/November issue will be:



A MINI DRILLING MACHINE, IDEAL FOR THOSE WHO MODEL IN MINIATURE.

LATHE COLLETS FOR THE ML7, DESIRABLE FOR THE HIGH-SPEED TURNING OF SMALL PARTS.



SCRIBING ATTACHMENTS FOR A HAND VERNIER, IMPROVE YOUR MARKING-OUT ACCURACY.

TRYING TO KEEP RUST WHERE IT BELONGS, IN THE SCRAPYARD.

CALIBRATED TAPER TURNING ATTACHMENTS FOR THE TOYO LATHE - CUT OUT THE GUESSWORK.



INSTRUCTIONS FOR USING THE WIGGLER AND TESTS TO ESTABLISH ITS ACCURACY.

MAKING AND USING DRILLING JIGS. MILLING MACHINE FRICTION DIALS. TOOLMAKERS' CLAMPS.



AND MUCH MORE!
Oct/Nov issue on sale Sept 13th.

An adjustable boring head is a useful addition to a vertical milling machine, or a horizontal with a vertical head. However, an automatic facing and boring head adds a new dimension to the possible activities that can be undertaken on the milling machine, as it enables turning operations on work too large or awkward to swing in the lathe. Such a device is an interesting project and not particularly difficult to make, although requiring careful workmanship, but well repaying the effort involved.

Mine, which was made a few years ago, is shown in **Figure 1**. The taper shank in my case is No. 2 Morse but it can be any size to suit your machine. Whatever size is used, some form of retention is essential, e.g. a draw bolt as in my case. Readers using collet chucks can make screwed shanks using the largest collet available.



Calibration screw threads

I normally work in the most appropriate units of measure, metric or Imperial, but metric for preference, so I used an 8mm diameter 1mm pitch feed screw. However, if you have not got a tap, then use $\frac{1}{16}$ in. $\times$ 26 TPI, the error will only be 0.024mm over each millimeter of radial travel. An M6 or 0 BA could be used but I feel this diameter is a little too small for the job. Should you prefer Imperial calibration the only suitable standard thread is $\frac{1}{8}$ in. $\times$ 20 TPI, again a bit small, which gives 0.05in. travel per revolution of the feed screw or 0.0005in. per division of the index dial whilst the automatic feed would be 0.0025in. per revolution. The other alternative is to make a $\frac{1}{8}$ in. $\times$ 25 TPI tap and screw cut the feed screw.

Now let us pass onto the constructional details for which I have included drawings

AN AUTOMATIC BORING & FACING HEAD

For setting the radius, the feed screw with index dial seen on the front in **Figure 1** is rotated by a hexagon key. The dial, which is friction tight on the screw to enable it to be reset to zero, is calibrated in 0.01 mm divisions of radial movement of the cutter block, with a total radial travel of 20mm. Facing is accomplished by holding the milled edge ring seen at the top of the body, by means of a rod inserted in a hole in the ring, or even by hand. As soon as this ring is released by pulling out the rod, the traverse stops. Two feed rates are available, 0.05mm or 0.1mm per revolution. Various sockets are provided in the cutter block, seen in **Figure 1**, so that different cutter bars can be fitted to suit the type of work and the tools to be held. I have found those

A boring and facing head is a highly desirable piece of equipment and an automatic version that will adjust itself with each cut is even more so! Such tools demand very high prices but this excellent article by Don Unwin shows how to make an automatic boring and facing head in the simplest possible way, while finishing up with an excellent, highly accurate tool

shown have covered all the jobs I have encountered. Boring and facing tools can be purchased from the trade but can be made quite easily from cast steel whilst toolbits, too short for use in the lathe, can be used in the cutter bars.

of the component parts supported by some photographs. Dimensions are in millimeters except for the occasional Imperial dimension such as the 0.5in. diameter cutter bar socket holes for example, the measurements being taken from my completed head which was originally made without drawings.

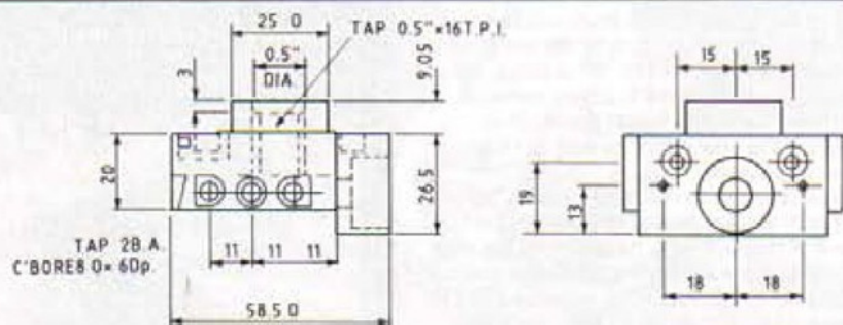
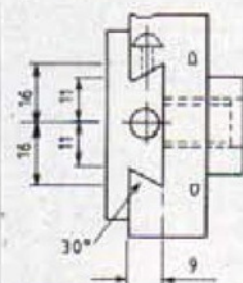


FIG. 2

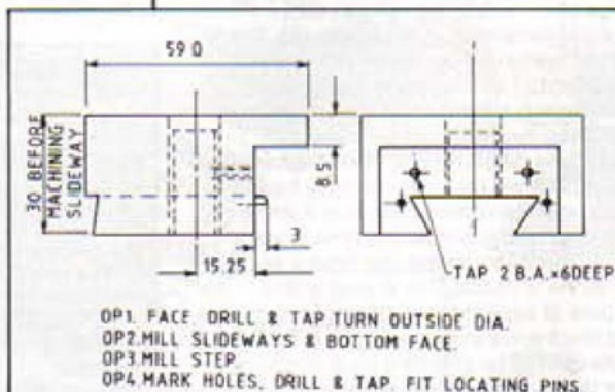


SLIDE CLAMP SCREW
28 A. CAPHEAD,
END MODIFIED.

The body

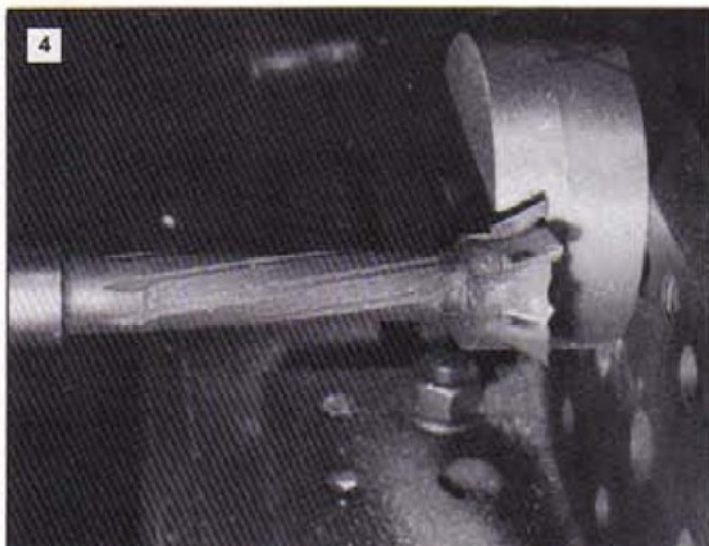
A start should be made on the body, **Figure 2**. Although not essential, this is best made of cast iron; I used an old cast-iron weight found in a scrap yard. Rough turn all over about 1mm oversize, face the top surface, drill, bore and tap the 0.5in. $\times$ 16 TPI hole but do not turn the 25mm by 9mm step at this stage, **Figure 3**, Op. 1.

Make a 0.5in. $\times$ 16 TPI screwed stub mandril to hold the body while turning the



OP1. FACE, DRILL & TAP TURN OUTSIDE DIA.
OP2. MILL SLIDWAYS & BOTTOM FACE
OP3. MILL STEP
OP4. MARK HOLES, DRILL & TAP. FIT LOCATING PINS

FIG. 3. BODY OPERATIONS 1-4.



outside and bottom faces. Hold the material in a separate chuck or mark it so that it can be replaced in the lathe running true for later operations. The mandril shoulder needs to be 16mm out from the chuck jaws. For my stub mandril I used the boring head arbor, a piece of hexagon steel, before the Morse taper was turned on it. Leave the body 0.5mm oversize, these operations are in **Figure 3**.

The slideways

A 30 degree angle end mill is needed for machining the slideways. These are available but I made mine by welding a short piece of cast steel $\frac{1}{4}$ in. diameter on to a shank then turning it to the correct form, milling and filing the teeth, and hardening and tempering to light straw. Provided that the cutting speed is kept slow such a cutter is perfectly satisfactory. It can be seen in **Figure 4** machining the vees in the body block which is held to an angle plate by a $\frac{1}{2}$ in. diameter bolt. First machine a slot 9.5mm deep by 22mm wide in the bottom of the body, then take a cut across the whole surface until the slot is 9mm deep and finally machine the vee surfaces, **Figure 3** Op. 2, leaving a slight flat on the corner of each vee. Now machine the step, **Figure 3** Op. 3, on one end of the slide, ensuring that this is square with the vees and end faces. This can be achieved by doing this operation whilst the block is still mounted on the angle plate. The step should be cut to 8.5mm from the top surface and to the distance shown on **Figure 3** Op. 3.

Put the body block aside for a while and prepare a rectangular piece of cast iron for the feed screw block **Figure 5**. Drill 4.7mm diameter and counterbore 8mm diameter the two 2BA clearing holes, two 21mm diameter location pinholes and also machine the feed screw hole and index ring recess.

Clamp this block to the body, ensuring that the feed screw hole is central in the vees, and mark the 4.7 diameter and 2.1 diameter through onto the body. Drill the 2 BA holes 3.6 diameter and tap, the location pinholes 2mm and fit two short pins, either a tight fit or a touch of Loctite. **Figure 3** op 4. Fix the feed block to the body with 2 BA cheesehead screws which should be pulled up as tightly as possible. The body with feed screw block attached is screwed onto the stub mandril and the feed

screw block turned down to the same diameter as the body which can now be turned to final size. Whilst still on the mandril, turn the 25mm diameter $\times$ 9mm spigot on the top surface using a left-hand tool, **Figure 6**. Leave a good finish as this is a bearing surface. The heads of the two 2 BA screws will be partly cut away but they are to be discarded and replaced by 2 BA socket head cap screws. Remove the work from the mandril and thread it on the opposite way round. A parallel washer about 5mm thick will need to be slipped on to it so that the body pulls up to the shoulder. Now machine the groove, **Figure 7**.

The body can be removed from the mandril and the feed screw block taken off. Drill the spring pocket, end mill the little recess in the groove on the top, the two little pads on the circumference and the pads for the gib strip screws. Drill and tap all the holes, preferably marking and drilling the 2.4mm

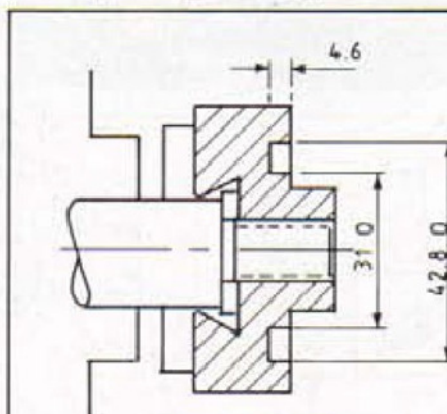


FIG. 7. BODY OP6.

diameter hole from each end, (**Figure 8** and **Figure 2**).

Feed screw block

Next carry on with the feed screw block. First drill counterbore and tap the 6 BA hole, **Figure 9**. I give dimensions for the position but it really needs to be as close to the corner as possible as there is a risk of it breaking into the 4.7mm diameter hole. Now comes the tricky bit, milling the 3.2mm wide slot 19mm deep. If you have a $\frac{1}{4}$ in. diameter end mill long enough, use it

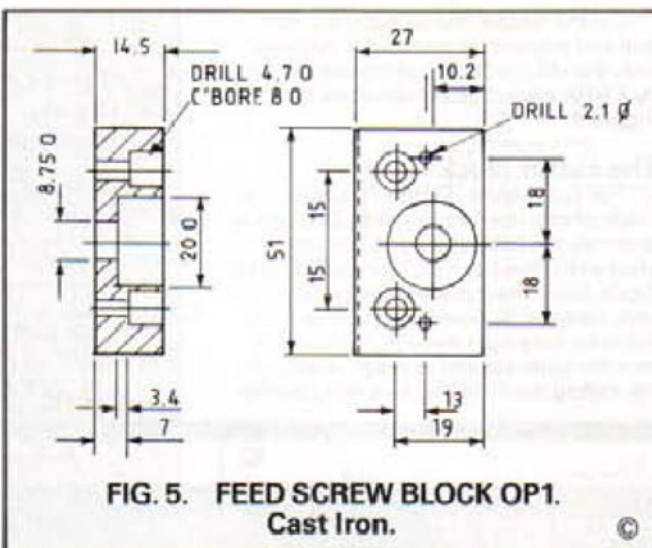


FIG. 5. FEED SCREW BLOCK OP1.
Cast Iron.

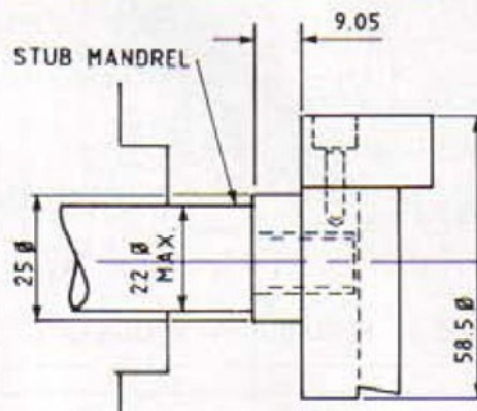
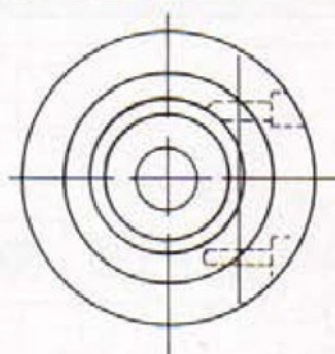


FIG. 6. BODY OP5.

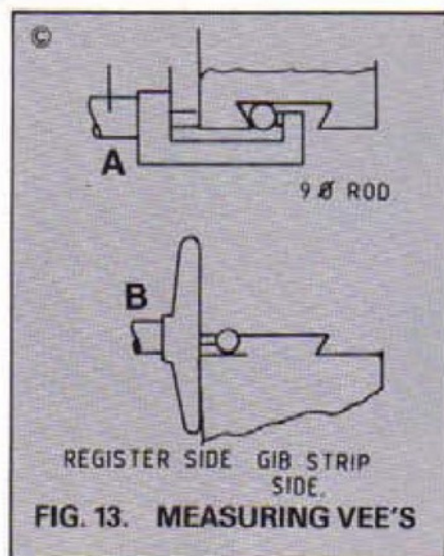
FIX FEEDSCREW BLOCK
MOUNT ON STUB IN MANDREL
TURN 25 ϕ SHOULDER
TURN OUTSIDE DIAMETER.



REVERSE ON STUB MANDREL
MACHINE COAMING RECESS.

setting the end stops on the machine travel and taking light cuts. However I had not got one so I used one I made some 35 years ago **Figure 10**. It is a very simple and quick to make from a piece of $\frac{1}{4}$ in. diameter silver steel with the two flutes and clearances filed. I have made them down to 1.5mm diameter and up to 10mm diameter. One advantage was that it was held in a collet chuck in the vertical head and the length projecting gradually increased as the slot got deeper thus ensuring maximum stiffness.

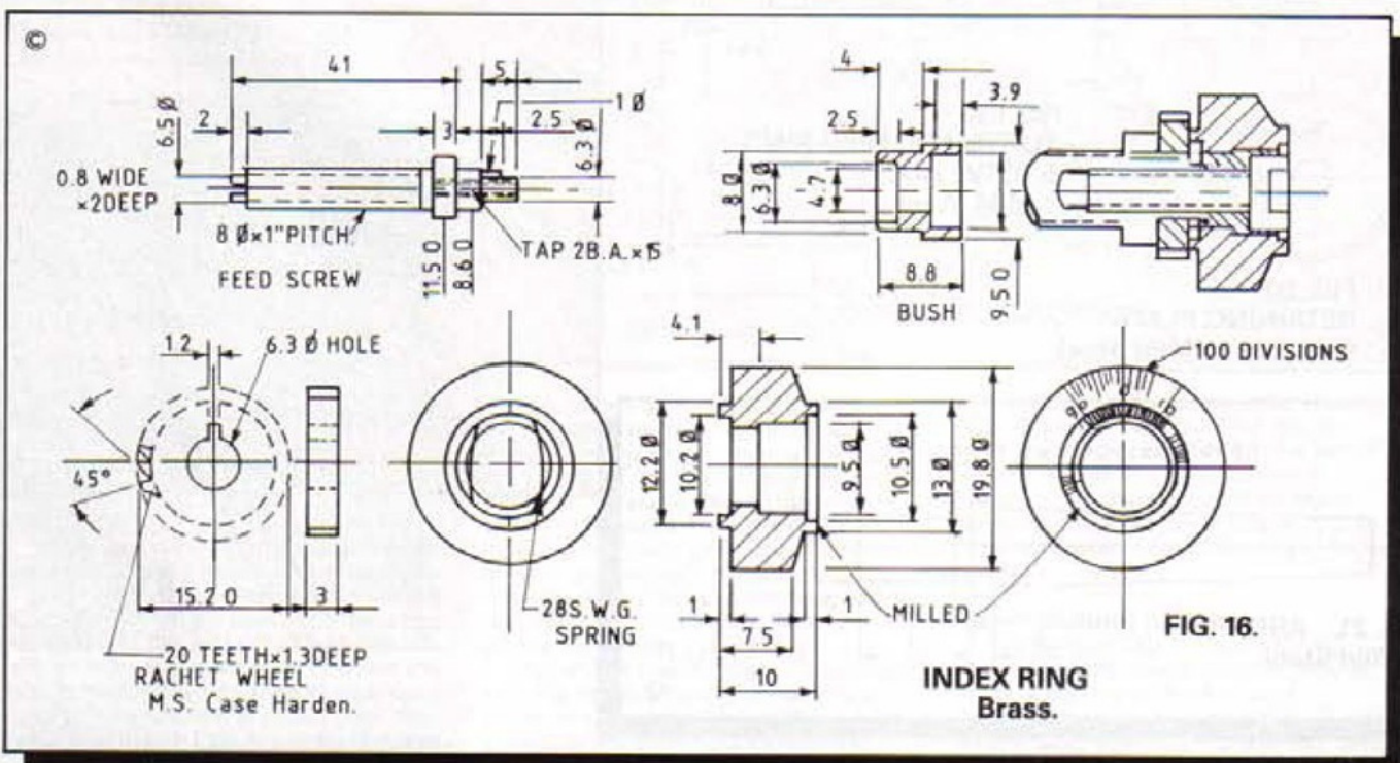
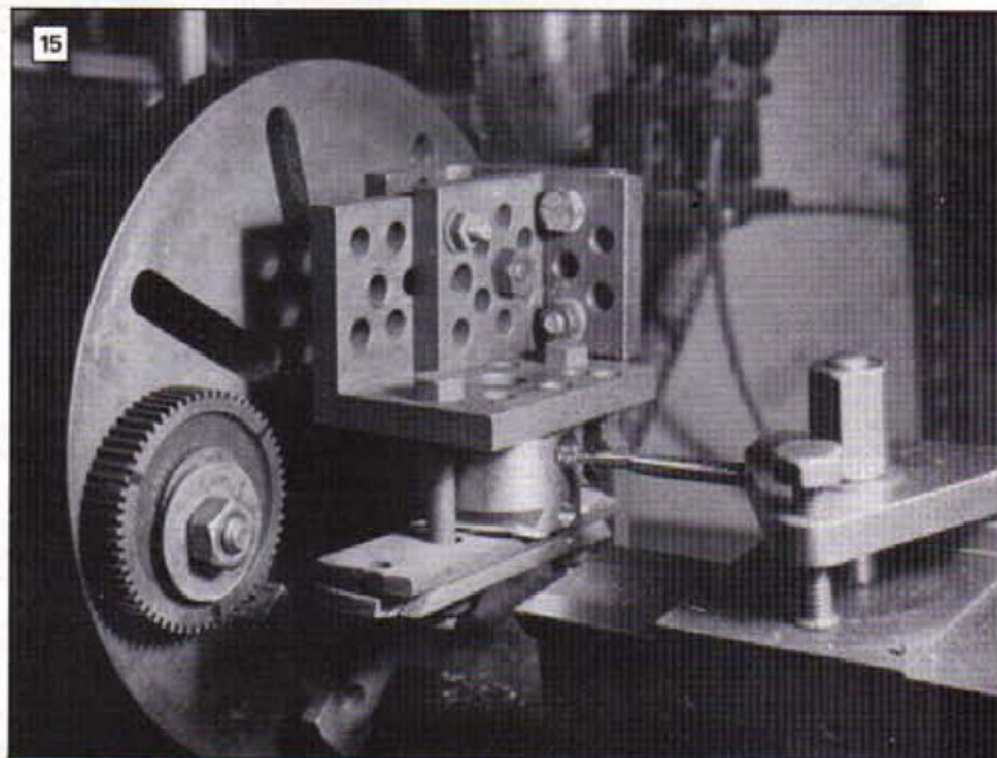
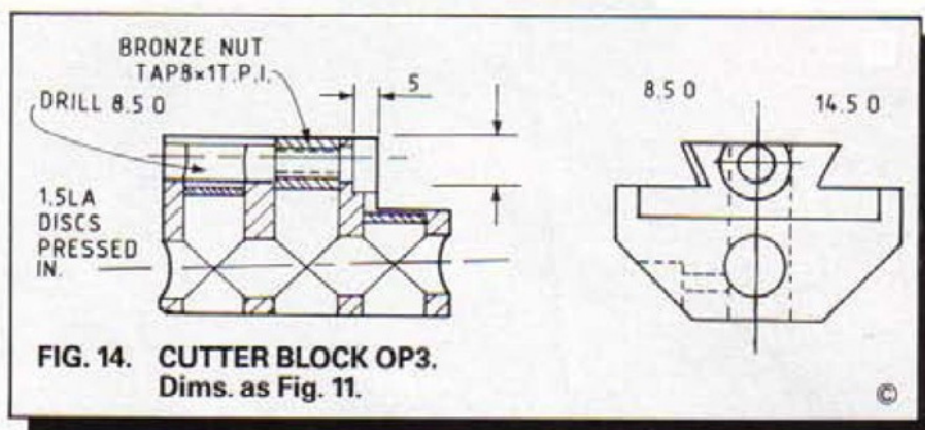
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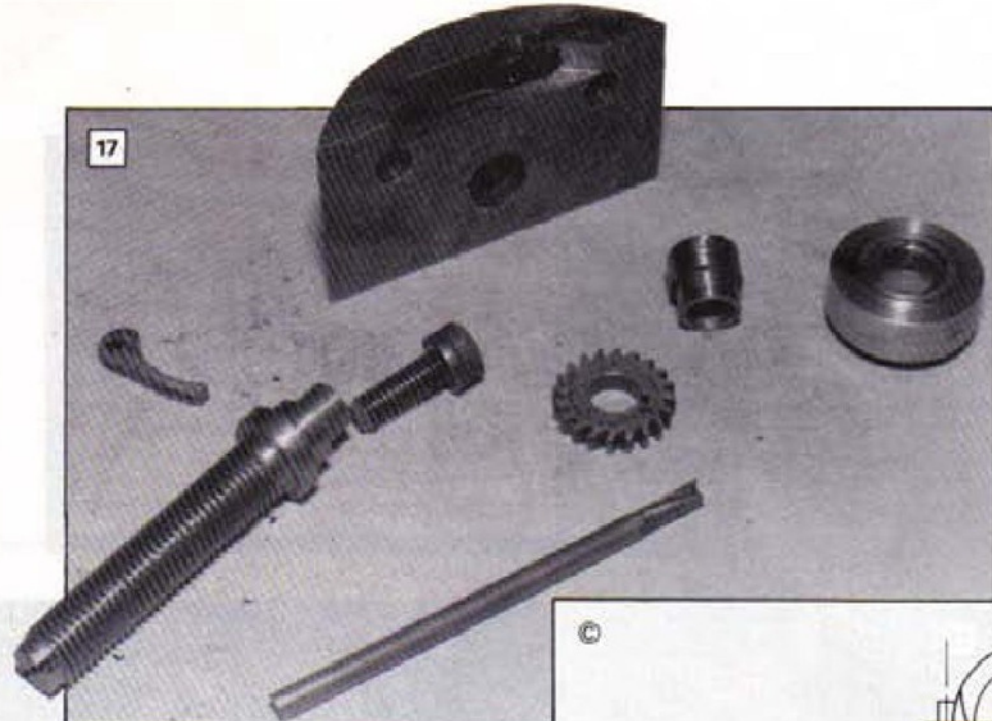
with the edges angled to 60 degrees, fits snugly.

Fit the feed screw block onto the body, mill the step on the cutter block so that it slides onto the body neatly with the two parts co-axial (Figure 11).

Lock it in position with a screw in one of the gib strip adjusting screw holes and mark the feed screw hole through on to the cutter block. While you've got these together, mark through the gib strip screw holes with a 3.6mm diameter flat ended drill. Drill the 8.5mm diameter clearance hole for the feed screw. To ensure that it is parallel to the slide, it is worth clamping the block on an angle plate mounted on the faceplate on the lathe. Machine the 14.5mm diameter counterbore at the same time (Figure 14). Next drill, bore and ream the remaining 0.5in. diameter cutter bar holes. For the two in the bottom face, the block can be conveniently held in a Keats angle plate on the lathe. The cross hole, which is at a slight angle, requires a little more rigging up, for which I used a multiplicity of angle plates seen in Figure 15. Machine the two angle faces by the method most



17



convenient to you, lathe or milling machine, and mill the set screw pads and drill and tap for 0 BA socket grub screws.

Make an odd bit of bronze to be a light drive fit into the top of the central 0.5in. diameter hole and press it in. Mark through the feed screw hole with a 8.5mm diameter drill then drill and tap 8mm diameter $\times$ 1mm or whatever thread you intend to use. The top ends of the other two cutter bar holes are plugged by 1.5mm thick light alloy discs pressed in (Figure 14). I finished the outer diameter of the cutter block by sliding

it fully into the body, locking the gib strip screws then mounting the body on the stub mandril and turning the cutter block to the same diameter as the body.

Feed screw assembly

The feed screw assembly is all simple turning work, details being given in Figure 16. A little experimentation is necessary to get the 28 standard wire gauge friction spring in the index dial to grip the sleeve just the right amount, stiff enough to prevent accidental movement but easy enough to reset. The index lines can be cut on the lathe with a sharp vee tool on its side and traversed by the top slide, using a 100 divider on the mandril. I used my own division cutting head and dividing head on

C

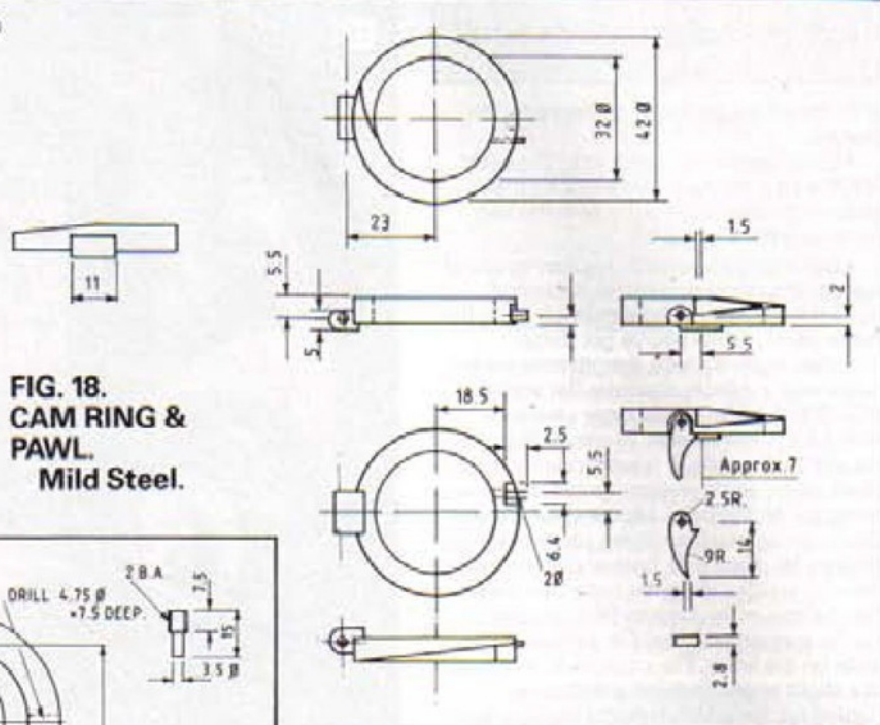


FIG. 18.
CAM RING &
PAWL.
Mild Steel.

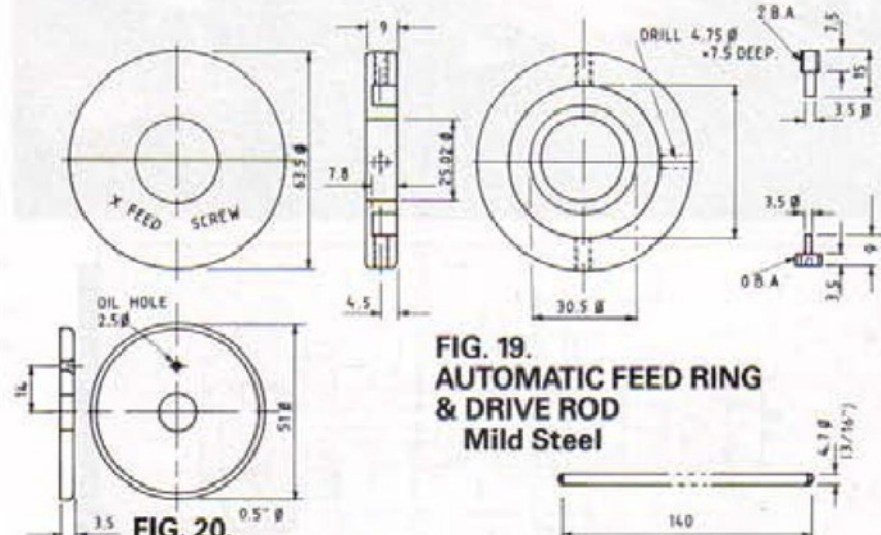


FIG. 19.
AUTOMATIC FEED RING
& DRIVE ROD
Mild Steel

FIG. 20.
RETAINING PLATE
Cast Iron or Mild Steel

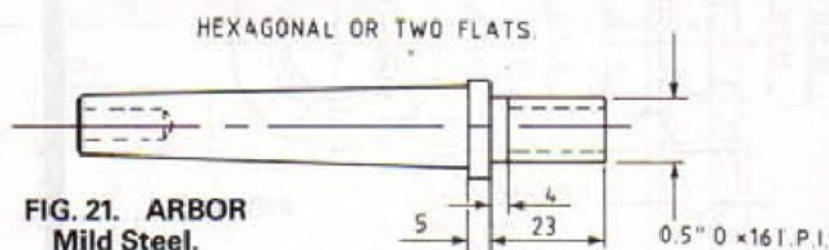


FIG. 21. ARBOR
Mild Steel.

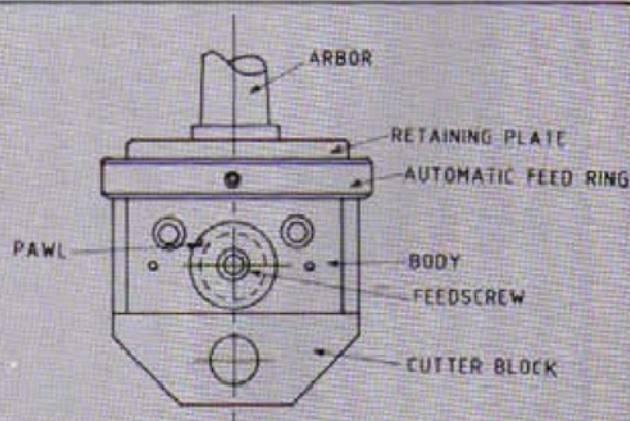
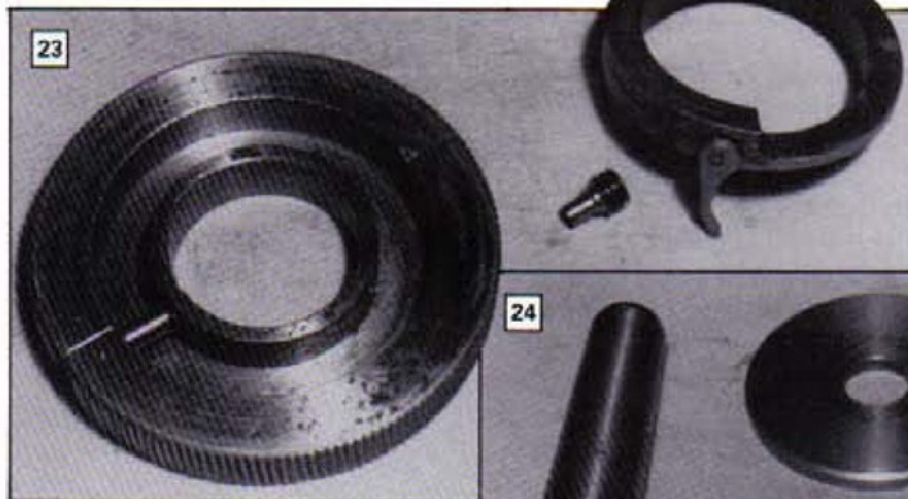


FIG. 22. FRONT VIEW. - INDEX RING REMOVED
POSITION OF PAWL AFTER "CLICK"
i.e. CAM RING IN UP POSITION.

the milling machine. The numbers can be engraved as I did, or stamped, but if you do this take off the raised burr that stamping produces. If you have not got a straight milling wheel for the face, cut a number of vee cuts with the same tool as used for the index lines. Note that the ratchet wheel teeth have a slight undercut produced by setting the cutter about 1mm offset.



bottom grooved face. The 2 BA hole is tapped right through but the 0 BA hole tapping stops just short to prevent the special screw from going too far inwards. In my case I tapped right through and then punched a little indent on the inner end to act as a stop. This is possibly easier to get just right and quite satisfactory.

The 3.5mm diameters turned on the two socket grub screws need to be concentric

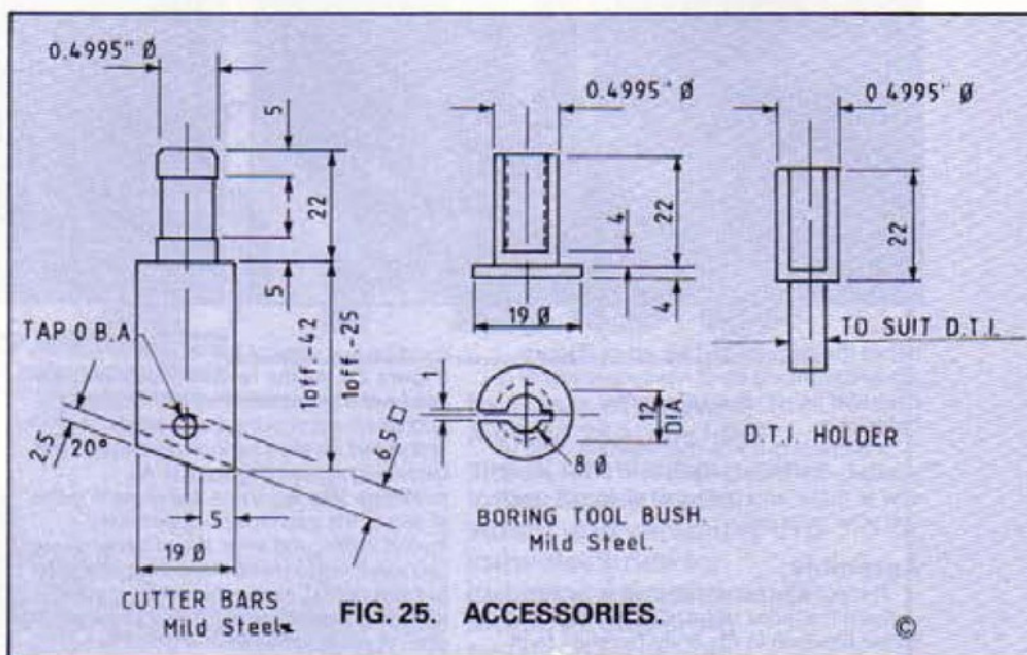
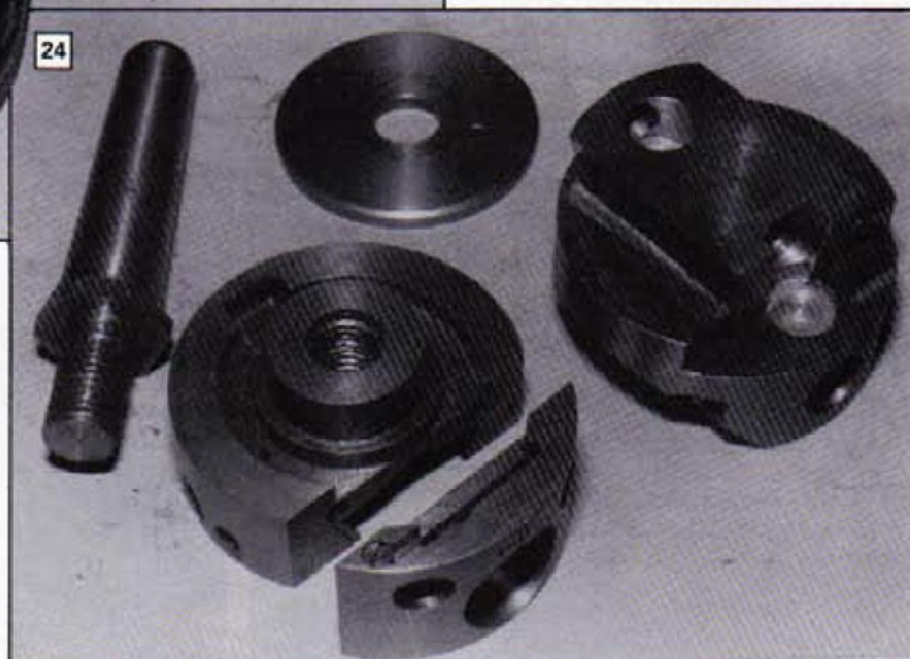
Caseharden this wheel when completed. As the 2 BA central socket head screw is used for the slide adjustment it needs to be tightened very securely with a touch of Loctite when finally assembled.

When coming to the final assembly, do it with the feed screw block removed from the body so that the feed screw can be gripped in a collet chuck or split tapped whilst tightening the socket screw. However, do not do this until the rest of the job is finished and working properly. The slot in the end of the feed screw enables it to be removed if the cap head screw does inadvertently become undone.

The cam ring

Now move on to the cam ring (Figure 18.) You can either machine it from solid including the little boss or hard solder it onto the ring as I did.

As the ring needs to be casehardened, machine it without the block, caseharden, then braze on the block and quench again. If made from solid, drill the 2.4mm diameter before hardening. The easiest way to position this hole is to clamp the ring in the groove in the body and mark through and drill *in situ*. Clockmaker's pivot rod is the best material for the 2mm diameter pin but if not, use a piece of silver steel hardened and tempered down to dark blue.



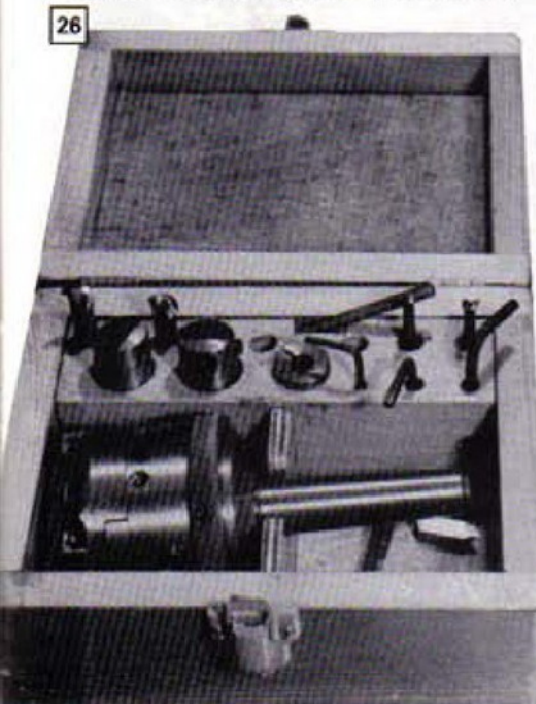
It needs to be a good press fit in the ring. The ramp can be milled by setting the machine vice to a slight angle whilst the pawl is a filing job, being shaped so that the end sits approximately in the position shown in Figure 18 when pushed to the right. Again it has to be casehardened but not until you have got things working correctly. A bit of trial and error may well be necessary later! Don't forget the little groove in the back.

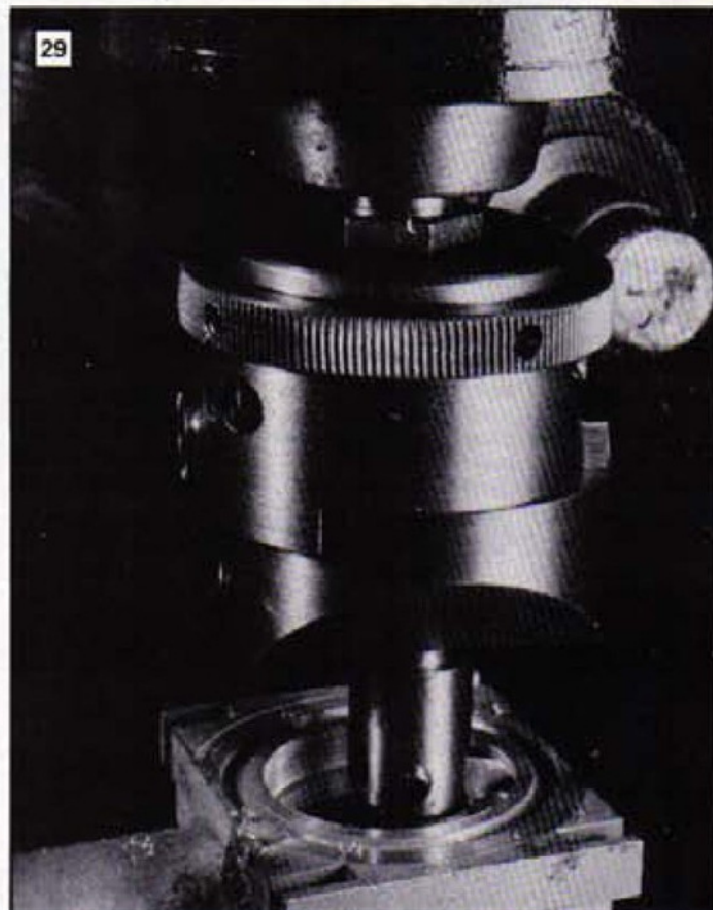
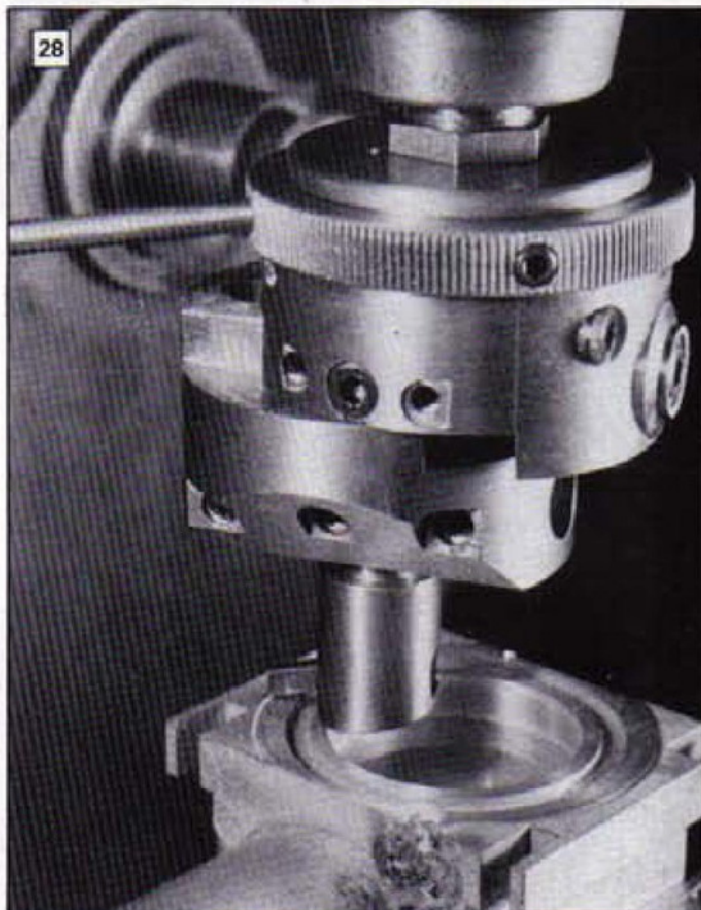
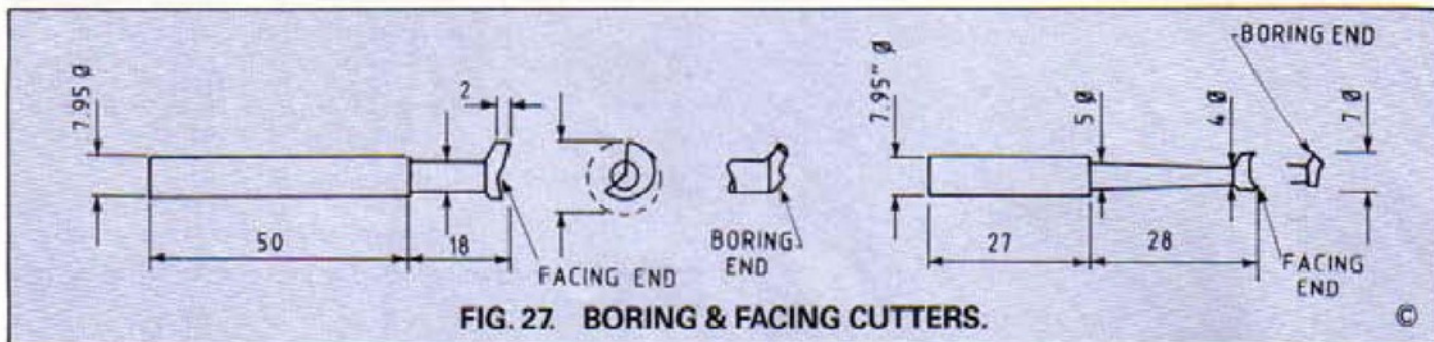
Mild steel is used for the automatic feed ring (Figure 19), all straightforward work. Ensure that both the 2BA and 0BA centres are exactly the same distance from the

with the threads. If you have collet chucks, this is a piece of cake but if not, you will have to make tapped bushes in the lathe. I just don't know how people manage without collet chucks, I use them much more than the three-jaw and those on my small lathe which I made, also fit my milling machine.

Top-retaining plate

Two items remain, the top-retaining plate (Figure 20), which ideally should be made of cast iron as the mild steel automatic feed ring runs against it – if mild steel is used, make sure it is kept well oiled,





hence the oil hole) and the arbor (Figure 21) which should be of hexagon material or have two flats to fit a spanner for tightening.

It is important that the retaining plate is parallel – my home-made step collet chuck saw to that – and of course the arbor must suit your machine.

Assembly

Temporarily assemble the feed screw without the index ring and screw the feed screw block on to the body. No need to fit the cutter block. Put the coil spring in the pocket in the body, drop the cam ring with the pawl into the annular groove pressing it down so that the 2.4mm diameter silver steel pivot pin can be pushed through. Screw the special 2 BA socket grub screw fully home in the automatic feed ring and fit into the body to hold the feed ring in place. If the feed ring is rotated anti-clockwise, the parallel portion of the 2 BA grub screw will cause the cam ring to be depressed and released. The 28swg spring wire should press in the little groove in the back of the pawl keeping it in engagement with the ratchet wheel.

However, when the cam ring is fully upwards, this is just after the click, the pawl

must be just clear of the ratchet wheel (Figure 22). As the feed ring is rotated the pawl will move downwards to engage the ratchet wheel, moving it one tooth. The action can be seen by looking through the index ring recess (Figure 22). As mentioned earlier, some adjustment in the shape of the pawl may be necessary involving trial and error. If you have my luck you will have to make more than one pawl to get it right! Caseharden when correct. If the 0 BA grub screw is screwed in, it will be seen that the feed screw is given two advances per revolution of the automatic feed ring.

This 0 BA grub screw should only be screwed in when it is opposite the index dial. Similarly, the feed screw should only be adjusted manually just after a click, that is when one of the grub screws is over the index dial. It is a good plan to always leave the head in this position. Figure 23 and Figure 24 show the various parts before assembly.

When doing the final assembling, lubricate all surfaces well, and grease the top of the cam ring. Oil is best for the automatic feed ring as grease causes it to drag too much to hold easily.

To tighten the arbor securely the cross

hole in the cutter block can be slipped over a piece of $\frac{1}{8}$ in. diameter steel bar held in the vice.

The cutter bars (Figure 25) should present no problems. The square holes can be drilled and filed although I squared mine using my homemade slotting attachment on the milling machine. You may prefer to use round cutters or some other size.

It is worth making a box to keep the head and accessories together (Figure 26).

Another useful gadget is a piece of $\frac{1}{8}$ in. diameter steel to fit the cutter bar sockets, turned on the end to fit your dial test indicator, very necessary for lining up on an existing bore.

Figure 27 is a drawing of commercial boring and facing cutters which can easily be turned and filed from cast or silver steel.

When the head is used for facing, the 4.7mm diameter rod is inserted in the hole in the circumference of the automatic feed ring. This rod can be held in the hand and pulled out when the required limit of travel has been reached.

The direction of travel, towards or away from the centre depends on how the tool is positioned. From centre outwards is more usual. If you prefer, the rod can be arranged to touch some part of the machine, in



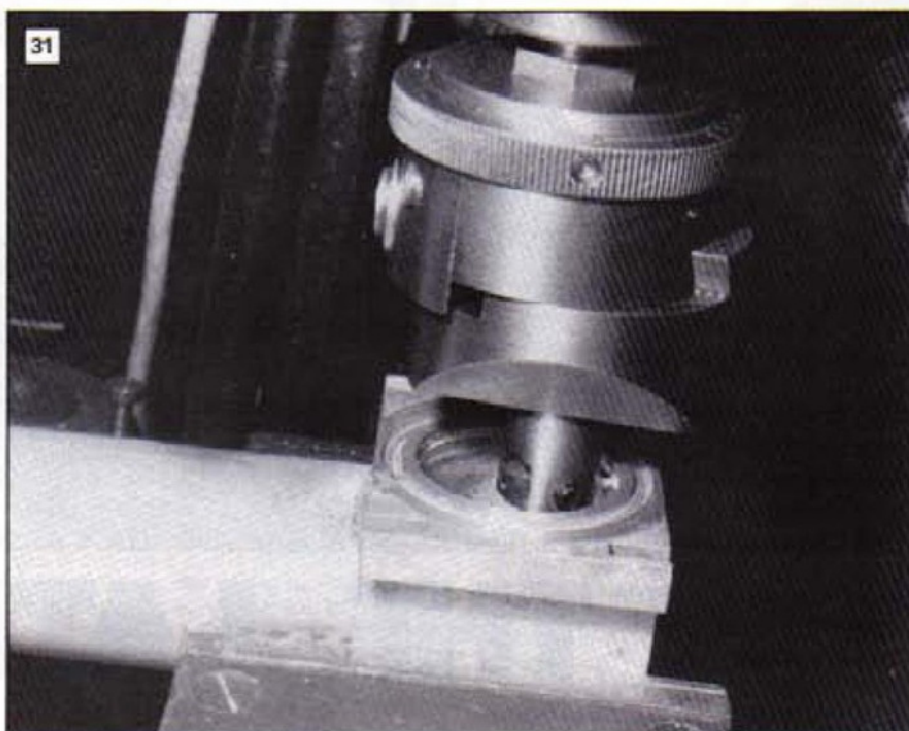
with my fingers, allowing it to slip slightly as the cutting proceeds until the correct depth has been reached. If you do this, take care to keep your hand above the head to avoid being hit by the projecting cutter block.

I hope that your boring and feeding head proves to be as interesting to make and as useful as mine has been.



QUICK TIP

Using countersink bits is not all that easy; chatter is the common problem, resulting in an untidy finish. Lay a small piece of emery cloth, abrasive side down, over the hole when the countersink is run in to the work. This will prevent chatter marks.



which case the head rotation must be stopped at the required limit of travel.

More sophisticated and very expensive heads have automatic release trips but I felt that the simple type of head was quite adequate for my use.

Three photographs show the head working on a component too long to swing in the lathe. **Figure 28** is facing the top surface, **Figure 29** boring the central hole, **Figure 30** cutting an 'O' ring groove in the bore.

When cutting re-entrants such as this 'O' ring groove I hold the auto-feed ring

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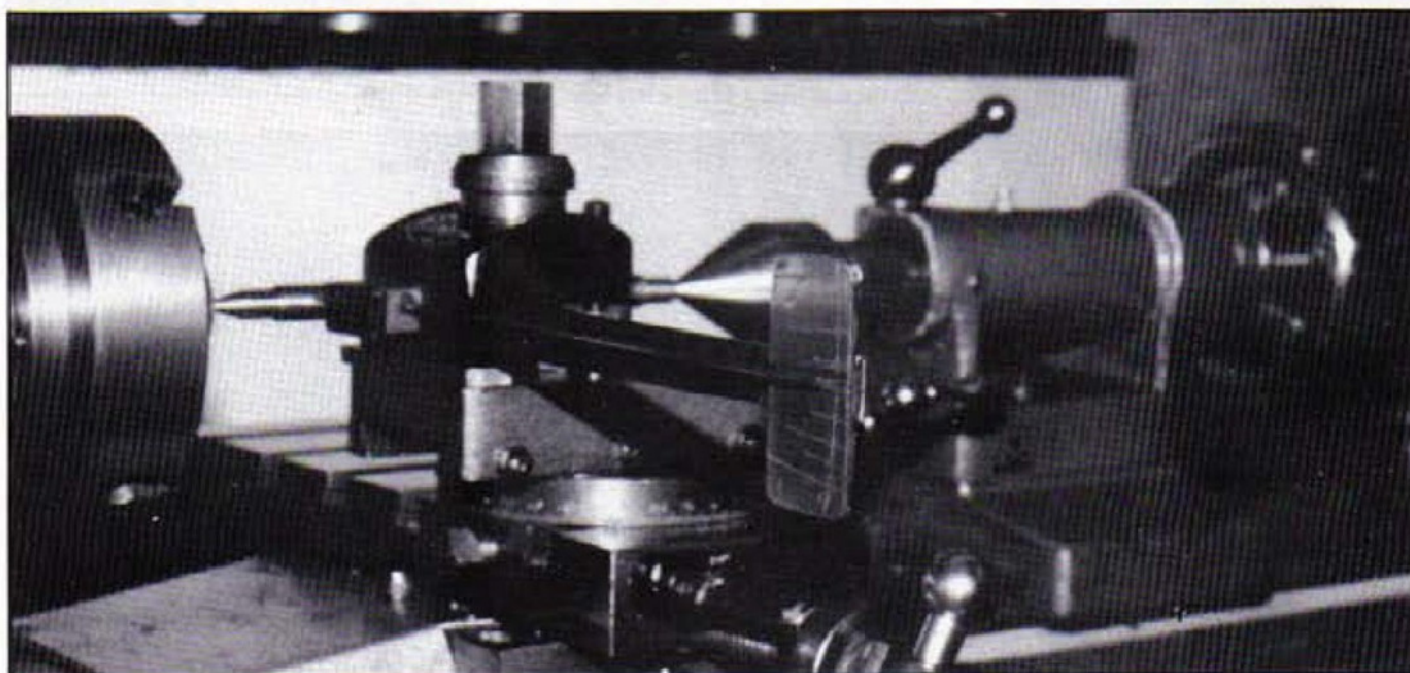
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A CENTRING DEVICE



FOR THE LATHE

Bob Fletcher, whose description of the holding down clamps in our Winter 1990/91 issue proved so popular with readers, in this article shows how to make a simple indicator as an aid to setting-up

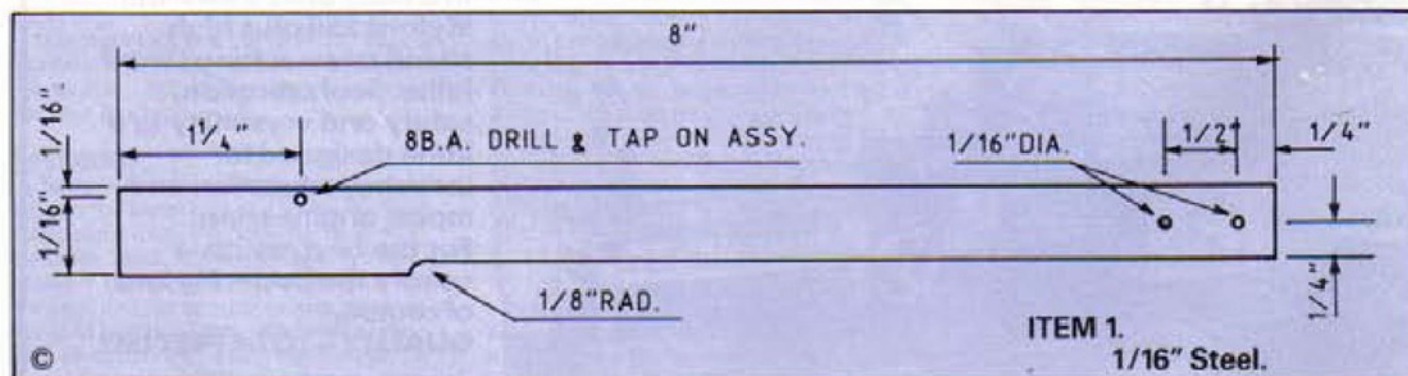
I am not a toolmaker, but it is obvious that in the pursuit of my hobby of model and experimental engineering it becomes necessary to make tools, gadgets and jigs, etc.

The gadget I am about to describe is used as an aid to setting up work in the four-jaw chuck or faceplate of the lathe. When I am setting up work which is required to run true to a great deal of accuracy, I use a dial test indicator (D.T.I.) and I believe that the D.T.I. method, used in the home workshop environment cannot be beaten. There are times when the work is required to run true but the degree of accuracy does not warrant the use of such expensive equipment. There are many recognised ways of doing this but most of them rely on the ability to see a small gap between the workpiece and a pointer or

using a mechanical lever system to multiply this. The tool is in no way intended to replace higher grade equipment for setting up accurate work. The material I chose to use was steel but I have no doubt that the use of polished brass would give a better appearance to the finished products.

The design

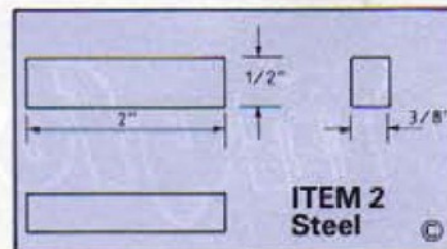
An examination of the general arrangement drawing will show the principle on which the tool works. A spring-loaded plunger bears up against a small lever which is pivoted at the top. A long silver steel rod is fixed to this lever, as the plunger moves in



I do not spend time knurling, polishing or doing fancy engraving if it is not necessary to the function of the tool. I know that there are a great many home workshop enthusiasts that do derive a lot of pleasure from making tools of all types, and one only has to go along to a model exhibition to see some beautifully finished examples of homemade tools and equipment.

some form of datum post. Possibly with the advancement of age and dimming of the eyesight I found it increasingly difficult to recognize the amount of run out and consequently the D.T.I. was brought into play when sometimes the degree of accuracy did not warrant its use.

I started to look around for ideas which would magnify or multiply the degree of run out. I finally came up with the ideas of



and out the lever rocks back and forth, this movement will cause the end of the long rod to move up and down. Due to the mechanical leverage, the movement at the plunger is multiplied many times at the pointer end.

Notes on construction

From the working drawing item No. 1 is the main backplate. This is made from mild steel $\frac{1}{16}$ in. $\times$ $\frac{1}{8}$ in. $\times$ 8 in. after cutting to length and cleaning up with fine emery cloth, the face is coated with marking-out blue. (I use a spirit-based ink felt-tipped marker, the type with a large wedge-shaped tip). The shape to the dimensions shown on the working drawing can be marked out. The next job is to cut it out to the required shape. I am lucky enough to own a bandsaw, so mine was done using this, but there is no reason why it could not be cut with a hacksaw just as quickly and easily, especially if the saw blade is given a rub with carbollic soap before you start, or any other soap for that matter. The $\frac{1}{16}$ in. diameter holes at the end of the backplate are drilled at this stage but I left the hole for the lever pivot pin to be drilled later.

Item No. 2.

This item will be the piece which is used to clamp the tool to the toolpost, it consists of no more than a piece of $\frac{1}{16}$ in. $\times$ $\frac{1}{8}$ in. $\times$ 2 in. mild steel cut to length and cleaned up, then put to one side ready for the assembly stage.

Item No. 3

This item will be used to support a brass datum plate and is made from a piece of $\frac{1}{16}$ in. $\times$ 2 in. $\times$ 1 in. mild steel cut and filed to shape. The two holes are drilled to match

the two holes in the end of the backplate, the holes are given the required amount of countersink and then riveted together using $\frac{1}{16}$ in. copper rivets. The rivet heads should be filed nice and flat.

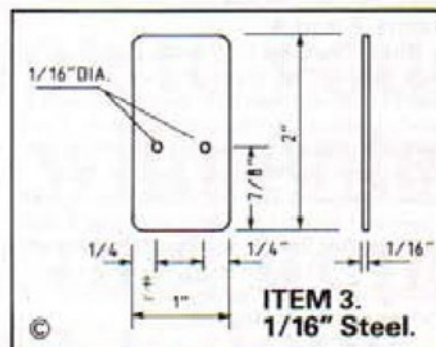
Item No. 4 The Body

On the working drawing is shown the body of the plunger assembly. A piece of $\frac{1}{16}$ in. $\times$ $\frac{1}{8}$ in. $\times$ 1 in. mild steel is cut to length and set up in the four-jaw chuck, the ends are faced off square and a $\frac{1}{16}$ in. diameter hole is drilled through its length and a counterbore tapping size for $\frac{1}{16}$ in. $\times$ 40 TPI is drilled. It is best to do the final deepthing to $\frac{1}{16}$ in. with a 'D' bit which will put a flat bottom to the hole. The unit will still work if an ordinary drill is used, if a 'D' bit is not available, but an allowance must be made for the point of the drill so as not to make the end too thin where the plunger is going to slide back and forth. Next, tap down $\frac{1}{16}$ in. $\times$ 40 TPI to a depth of approximately $\frac{1}{8}$ inch.

Item No. 4. The pin

This pin or plunger is a straightforward turning job. A piece of $\frac{1}{16}$ in. diameter silver steel is placed in the three-jaw chuck and turned to the dimensions shown in the working drawing. Note that one end of the plunger is rounded off. I hardened and tempered mine with the thought that wear would take place due to its movement in the body. In practice, I have found that the movement is so very small and for such short periods, that I am now of the opinion that it was not necessary. The choice is yours.

Just a thought for the newcomer who may like to have a go at hardening and tempering the plunger but has difficulty in recognizing the temperature colour of mid-straw required for this plunger. There is an excellent article on the subject published in



the Winter 1990/91 edition of *Model Engineers Workshop* which is well worth studying. If I may pass on a little wrinkle which was passed to me many years ago and which I still use today, the job may become a little easier: When you are turning brass in the lathe, carefully save the brass swarf and when a reasonable amount has been collected, obtain or fold up a flat steel tray (mine measures 6 in. $\times$ 4 in. $\times$ 1 in. deep) and three quarter fill the tray with the brass swarf, press down to consolidate the swarf and to make a level surface. After hardening the workpiece by heating to red heat and plunging into cold water, it must be cleaned and polished to a bright steel colour. The tray is supported over a heat source, I use a Camping Gaz picnic stove for this kind of job.

The workpiece is placed on the surface of the brass swarf, the heat from the swarf transfers into the workpiece very slowly, consequently the temperature colours also change very slowly making it surprisingly easy to judge the colour required and at which stage to replunge into cold water.

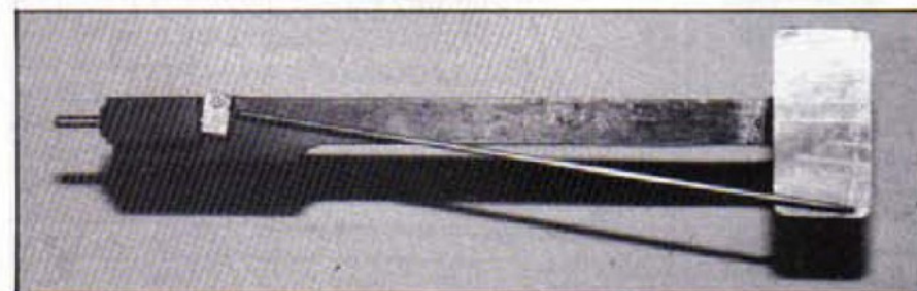
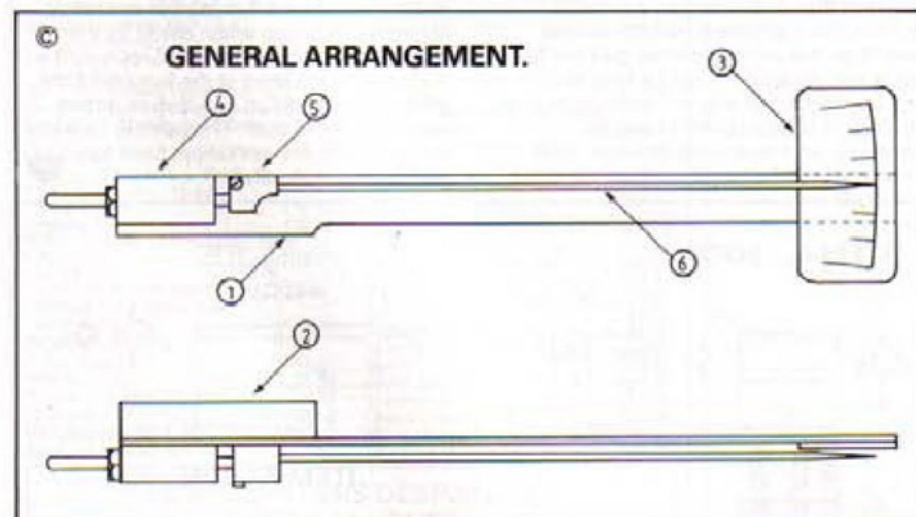
Item No. 4. The end cap

This is a brass cap which holds the plunger in place, it is made from $\frac{1}{16}$ in. hexagon brass and is turned and threaded $\frac{1}{16}$ in. $\times$ 40 TPI as shown in the drawing.

There is a spring which will be required (not shown in the drawing) to hold the plunger in the forward position. Obtaining a spring of the right size and strength presented me with a problem. Under the bench in my workshop is stored a large biscuit tin and it is full of springs which I have collected over the years from all sorts of dismantled unit. When I require a spring, I wade through those in this box and usually come to the conclusion that there must be every spring known to man in this tin box, except the one I need! I keep threatening to throw the whole lot away, then again it may come in handy one day, so it is returned to its place under the bench. There must be a moral in this somewhere.

I was faced with the possibility of making a mandrel and winding up a spring to the size required. A day or two later I was cleaning out my desk drawer and came across a retractable ballpoint pen which had been made redundant due to lack of ink. On stripping the pen down, hey presto! there it was, the very spring I was looking for.

The plunger can be assembled into the body and the type of fit we require is a good sliding movement with no tendency to stick; it may be necessary to lap the plunger in by coating the plunger with a spot of metal polish and sliding the plunger back and forth in the body until the required fit is obtained.



Opposite page: indicator in action on the author's lathe. Above: the finished item.

Items 2 and 4

These items are held to the backplate by silver solder. They are cleaned up and coated with wet flux then positioned and lightly clamped to the backplate. Item 2 and the backplate are heated to dull red heat and a touch with Easy Flo 2 should flash around the joint. The unit is allowed to cool down and then turned over and item 4 and the backplate are given the same treatment. After the unit has cooled down, it can be cleaned up and the spring, plunger and endcap can be assembled.

Item No 5 lever

This lever is cut and filed to shape from a length of $\frac{1}{2}$ in. $\times \frac{3}{16}$ in. mild steel. The hole for the pivot pin and extension rod are drilled as shown on the drawing. A length of $\frac{1}{8}$ in. diameter silver steel rod is cut to a length of $\frac{3}{8}$ in., the end of this rod is brought to a gradual taper point. The other end is fixed into the lever using Loctite 601 and put to one side for the adhesive to cure.

Brass datum plate

A piece of 0.010 in. brass shim is cut to shape and glued to Item 3 using epoxy resin such as Araldite. After a suitable curing time for the Loctite and epoxy resin, the lever and pointer can be positioned on the backplate so that the face of the lever touches the end of the plunger and the pointer is at the lower end of the datum plate. The position for the pivot pin can be marked through the pivot pinhole in the lever using a fine-pointed scribe.

The pivot pin

This pin is a bit of a watchmaker's job but I found that, with a little care, it was quite straightforward to produce. A piece of $\frac{1}{8}$ in. diameter rod is set up in the three-jaw chuck and turned down to $\frac{3}{16}$ in. diameter for a length of $\frac{1}{2}$ in. using a small knife tool. The first $\frac{1}{8}$ in. is further reduced to a suitable size diameter for an 8 BA thread. An 8 BA die is used to produce the thread on the short stub end. The pin is parted off leaving approx. $\frac{1}{8}$ in. for the head; a slot for a screwdriver is cut across the head using a junior hacksaw.

The lever and pointer are positioned and the pivot pin screwed home. The lever must be perfectly free and with as little shake as possible and the lever should fall through its stroke under the weight of the pointer rod.

Centre height

When the tool is clamped into the lathe toolpost, the centreline of the plunger must be at the centre height of the lathe. If the plunger centreline is too high for your lathe, the base of the tool will require milling or filing down to make the centreline correct with the lathe. If the plunger centre line is too low as it was with my lathe, short lengths of shim steel are progressively placed under the tool until the correct height is achieved. The pack of shim steel is then measured with a micrometer and a steel packing piece milled to this size. It is held in place by coating the joint surface with epoxy resin and clamping to the base of the tool until cured. This has proved to be satisfactory ever since.

Marking the datum plate

A short length of round bar is placed in the three-jaw chuck, the brass datum plate

is coated with marking blue and the tool is set up in the toolpost. The cross slide is taken in so that the plunger makes contact with the round bar in the chuck. Continue to screw in the cross slide until the pointer rod lies horizontal and the pointer is at the centre of the datum plate. This position is then marked on the datum plate. The cross slide reading is noted or zeroed and the cross slide is moved in 0.005 in. The pointer will rise and this position is marked. Screw in a further 0.005 in. and mark again and so on until the pointer has reached the top of the datum plate.

Screw out the cross slide until the pointer has returned to the centre mark on the datum plate; the cross slide reading is again noted or zeroed and the cross slide screwed out 0.005 in. at a time and each position marked on the plate. Make allowance for any backlash that may be present.

Remove the tool from the toolpost and, as these graduation marks are only intended as a guide, the tool is placed on the bench and the pointer rod is swung up out of the way. Using a steel ruler, the datum plate is marked out as shown in the G.A. drawing. A good sharp scribe will make it easy to see graduation marks on the brass plate.

Note that it is unnecessary to have a sharp point on the end of the pointer rod; if you feel there is a possibility of you catching your hand on the pointer, then a piece of clear Perspex can be cut to shape and set over it and held clear of the pointer rod by Perspex packing pieces top and bottom. It can be held in place by 8 BA screws or a spot of epoxy resin at each corner.

To use the tool

The instrument is quite straightforward to use. If the workpiece has a suitable register, the instrument plunger can be placed on this and even if the tool has to be set at a slight angle, it can be tolerated. I find that most odd shaped castings, etc., do not have a suitable point to use for centring, so a centre rod must be used. This consists of a length of silver steel rod

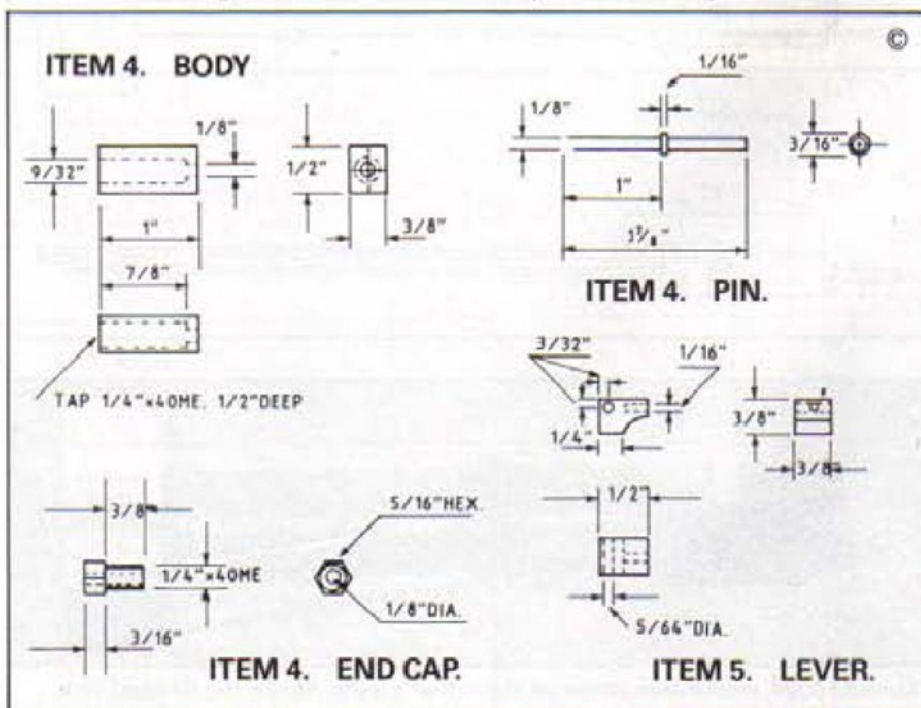
with a point machined at one end and a centre drilling at the other end. The required centre is marked out on the workpiece and a light centre dot is made. The workpiece is set up on the faceplate or four-jaw chuck, the pointed end of the rod is located in the centre dot and the other end supported by a centre in the tailstock. The instrument plunger is brought into contact with the rod, as close to the workpiece as practicable.

The lathe mandrel is turned by hand until the pointer shows the lowest point; this will indicate that the run out is at the furthest point away from you. With the mandrel held in this position, the cross slide is moved in until the pointer is at the centreline on the datum plate. The lathe mandrel is again turned by hand until the pointer has lifted to the highest point. This will indicate that the total run out is at the nearest point towards you. The workpiece is now adjusted away from you until the instrument pointer shows half the total run out. The process is repeated until the pointer shows no movement when the mandrel is given one full turn.

It should be remembered that the movement at the pointer is a multiple of the actual run out of the workpiece and even with a slight tremble or movement at the pointer, the workpiece will be running quite reasonably true.

One of my other hobbies is chemistry experimentation, so I chemically blacked mine as a precaution against possible rusting but this process is possibly something for another time. A nice refinement could be a polished wooden box to keep the tool in, I am afraid mine is relegated to hanging on a nail at the rear of my lathe, so that I can just reach out and retrieve it as and when it is required, but that is me!

I hope the foregoing is of help and interest – and have fun in your workshop. My wife sums it up when asked by visitors of my whereabouts; her usual reply is "he is playing in the shed at the bottom of the garden, he will be up in a minute or two chasing a pot of teal". The point is, when it is playtime in the workshop, have fun and please work safely.



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Ins. Blade Parting Tool

c/w 1/4 Blade

Set 5 TCT Turning Tools 8mm sq

Set 6 TCT Turning Tools 8mm sq

Set 11 TCT Turning Tools 8mm sq

£19.50

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Knurling Tool Pivot Head

1/2 sq Shank

Knurling Tool 1/2 Shank

Set of 4 Double Ended Boring Tools

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HSS British Countersink 8.3mm

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TRADE COUNTER

New products are constantly under review; this time a new type of plastic material was tested and proved to be better than could possibly have been expected!

Try Cut is a form of hard plastic, samples of which were sent to us to use for test purposes. It comes in the form of blocks or round bars and can be machined in any way one wishes. It was drilled, tapped, turned and milled, all with equal ease. Once it has been used, if the swarf is kept reasonably clean, it can be



Basic Try Cut material in block or bar form.

melted and poured into a mould and reused. The melting was done with an ordinary household ladle and it was poured into a mould made of a piece of steel pipe sawn in half and reassembled by being bound up with wire. It was poured through a tea-strainer to remove any bits of metal that might have become mixed up with the plastic. The suppliers recommend using a silicone release agent but this not being

available, the mould was sprayed with a silicone car polish and the material released easily from the mould.

The material would seem to have quite a few uses. One is that of trying out the manufacture of components before committing the construction to metal.



Try Cut can be turned, threaded, milled, etc.; lots of workshop applications.

Being quick and easy to machine and leaving a superb finish, such projects can be rapidly carried out. Another is for making patterns for castings. The material itself can be cast into shapes as well if one so wishes and so it could be used to test patterns before sending them to a foundry. As it melts at a fairly low temperature it could be used with plaster moulds. Another

use is, for the beginner wishing to feel his or her way with a machine, to practise screw cutting as easily as you wish, or if a youngster wants to have a try then there is no danger of splinters from swarf, etc. The material can also be sawn and carved with a heavy knife.

There is no doubt that the material is ideal for many purposes and apparently is widely used in technical colleges where the

for users of the Unimat lathe although, no doubt, the products can be adapted for similar small lathes. They consist of a four-way toolpost and a device to prevent the head of the milling attachment from moving out of line as it is raised and lowered. The third item is a new design of tool grinder which comes pre-welded and partly premachined. It is designed to be completed on a lathe of 3 1/2 in. centre height but one with 2 1/2 in. centre and 12 in. between centres could be used. It is produced to a standard of very high precision and is capable of putting correct angles on all lathe cutting tools and sharpening end milling cutters up to 1/2 in. diameter. For



Classy cabinets from Bott; high quality is reflected in the price.

savings in cost against the use of metal is considerable. The main agent for the material is Apple Equipment of Bristol. However, they are not willing to supply in small quantities as they are not geared to the sales. They do have agents and no doubt many model engineering suppliers will be taking up the material in due course. In the meantime, readers wishing to obtain it can send a stamped addressed envelope to College Engineering Supply, 2 Sandy Lane, Codsall, Wolverhampton WV8 1EG, Tel: 09074 2284 who are the agents at present supplying to the colleges in the Midlands and are willing to allow the purchase of small quantities by model engineers.

New products from NS & A Hemingway

One of the leading suppliers of castings and equipment for the model engineer, we have received details of three of the latest products from this firm. Two are designed

further enquiries in relation to all three items, contact NS & A Hemingway, 30 Links View, Half Acre, Rochdale, OL11 4DD, Tel: 0706 45404.

Top-class cabinets

We have received a considerable amount of information on equipment supplied by Bott Ltd, of Kings Hill Industrial Estate, Bude, Cornwall, EX23 8PW, Tel: 0288 355666. Specialising in tool cabinets, benches, etc., the products are of the highest possible quality and include useful items such as milling machine cabinets. They are really designed for industrial use and, as such, it must be said that this is reflected in the prices. However, for readers looking for really high-quality equipment, the firm has a great deal to offer, with a range to fit just about every possible requirement. Some are firm standing, others are fitted with rollers to enable them to be transported around the workshop.



Some tool cabinets in the Cornish firm's range come with casters for portability. Very nice...

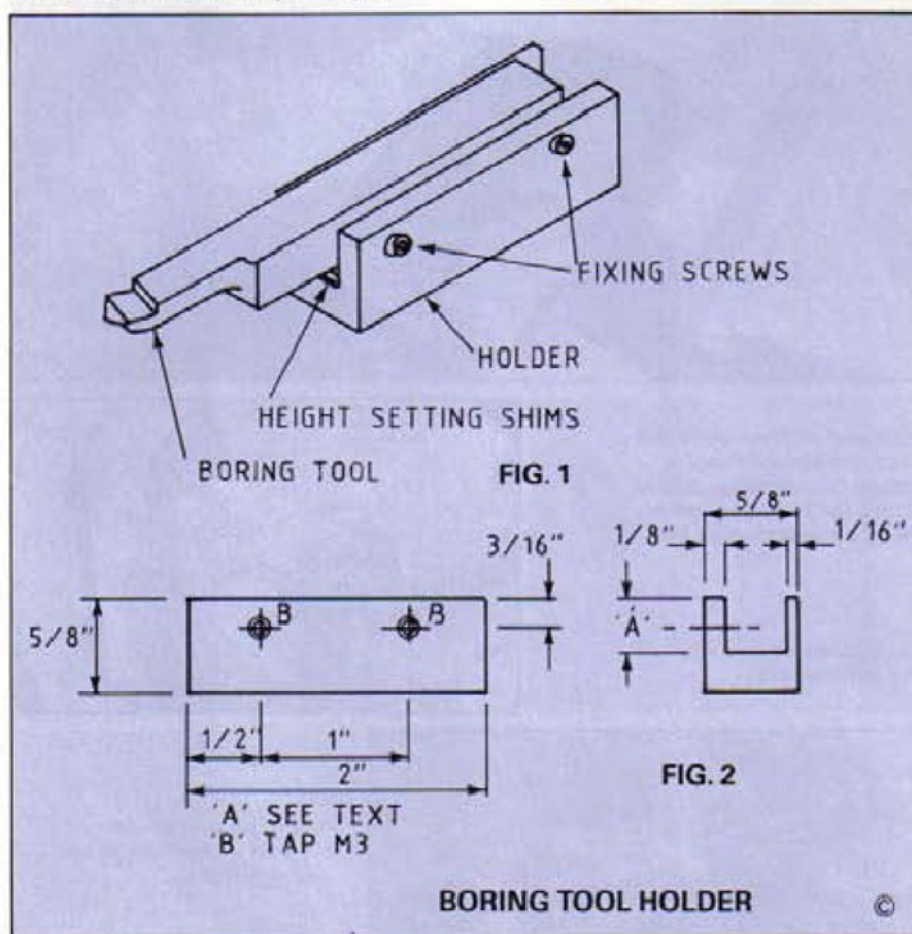
My four-way toolpost is equipped with (1) Knife tool, (2) Roughing tool, (3) Bullnose tool, (4) Chamfer and radius tool – and I find these adequate for almost all normal turning operations. With one exception – this being the absence of a boring tool.

As it is impracticable to fit a boring tool in a four-way toolpost, as two tools would require to be removed, the post has to be removed and the tool mounted on the top slide using packing for height setting, and held by the standard clamp. Having to carry out this height setting procedure each time led me to consider retaining the packing with the cutter for subsequent use to speed up the changing process.

My first idea was to retain the tool with the packing pieces in a small bag or keep them together with an elastic band. A better idea, in that it could probably be

BORING TOOL HOLDER

The subject of boring and making boring tool holders has been discussed in this magazine before. As far as boring tool holders are concerned, what suits one person will not necessarily suit another. This article by Harold Hall describes a tool holder that solves the problem of securing the bar and of height adjustment if one has a fixed height tool post



brought to the machine as stored, would be to use adhesive tape to hold the pack together, including the tool.

It was with this latter idea in mind that I considered a more engineering approach,

but with the same basic idea. I chose to make a channel out of steel with grub screws on one side to hold the tool in place, with shims between tool and channel to set the tool at the correct height.



Three finished holders, each ready for use with its boring tool fitted.



The shims seen in this view ensure that the tool is immediately ready for use at the correct height when mounted on the top slide.

The screws require only light tightening as, when in use, the tool will be held by pressure on the tool from the top slide clamp, down through packing and channel to the top surface of the top slide. The top of the tool must be above the top of the channel.

A number of these channels can be made, making one for each frequently used tool. The depth of the slot 'A' can be varied to suit different tools, allowing for, say, only 10-30 thousandths of an inch of packing required.

These simple holders greatly reduce the time taken in tool setting and will quickly repay the small effort in making them and, what's more, a simple height-setting gauge could be made to enable tools to be set initially away from the machine.

A 'PROFESSIONAL' SLOTTING TOOL

In the first issue of *Model Engineers' Workshop* we gave plans for making a small lightweight slotting tool for use in the toolpost. This new design, by Peter Robinson of Peterborough, was originally intended for professional use, and indeed is in regular use in his engineering business. Working from the cross slide it avoids wear on the lathe bed by racking whilst being capable of really heavy duty slotting and splining work. One casting is required and this is available from College Engineering Supplies

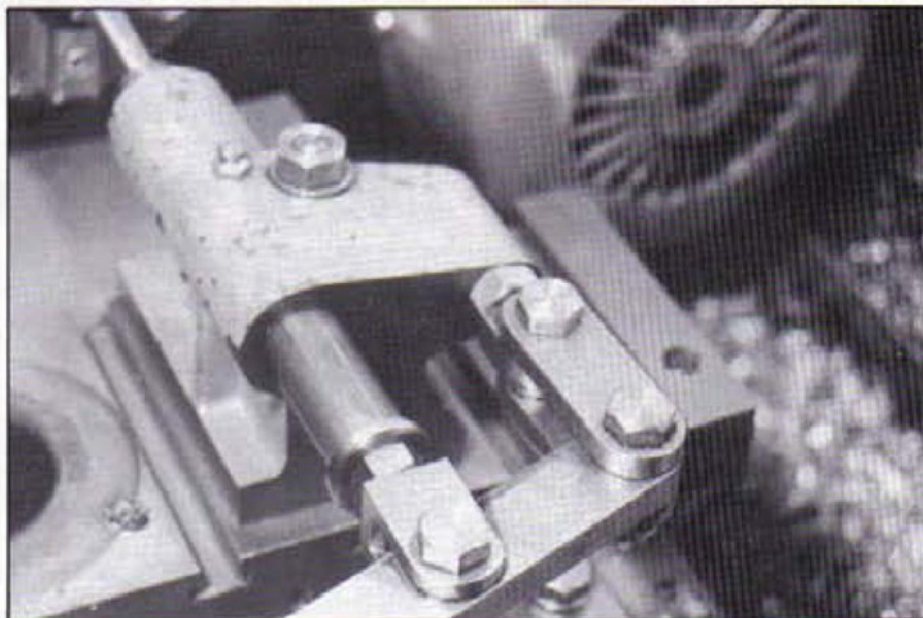
This keyway cutter, or slotting tool, is intended for any work that involves a slotting action. It will cut keyways and slots in general and, in conjunction with a dividing device, can be used for splining work. The one illustrated has been in use for a number of years and so is well tried and tested.

The body

One casting is involved, this being the body. This is really the only part too that involves any slight complication in machining, and in fact one can hardly describe the work as a 'complication'. Only three operations are required on the casting, with some small faces to be cleaned up as well. The first must be to machine the bottom to provide a reasonable datum surface. If a milling machine is available, and it is anticipated that most readers looking to make this type of tool will have one, then it is simply a case of holding the casting in the vice to do the machining.

If a vice big enough to accept it is not available, it can be clamped against an angle plate. The bearing side should be against the plate, with suitable packing between the side and the plate to get it square. Before machining, the set-up should be tested with a surface gauge to ensure that the casting is correctly situated. Make sure all clamps are tightened up, and it may be found necessary to put a couple of parallels underneath it. Once the bottom has been machined, it will be possible to machine the other surfaces as shown on the drawings.

Mount the casting on the cross slide of the lathe and drill and bore the bearing, using a boring bar between centres. It will be seen that the drawings specify two heights to cover the Myford 7 and 10 lathe



Mounted on the lathe cross slide, the finished tool in action; this close-up (above) shows the arrangement of the operating mechanism.

At right, a close-up view of the cutting tool.



At left, an overall view of the tool in position on the author's lathe.

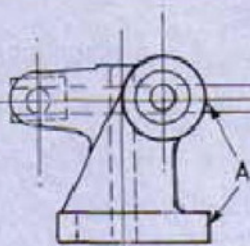
range. Boring it between centres will automatically ensure the correct height and measurements will not be required. It also means that the casting can be used for other machines of a similar centre height, because as long as it can be mounted on the cross slide and bored, then it will fit any lathe.

When the casting has been bored, move the cross slide over and drill the hole for the anchor; again, being mounted on the saddle ensures the work is exactly at centre height. If a tailstock tapping device is available, then it can be tapped at the same time.

There are two fixing points - one is a hole through the main body, the other a curved slot, the radius of the curve being taken from the centre of the hole in the body. This means that the hole position

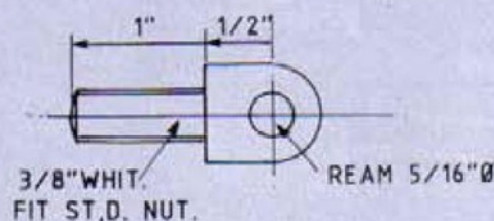
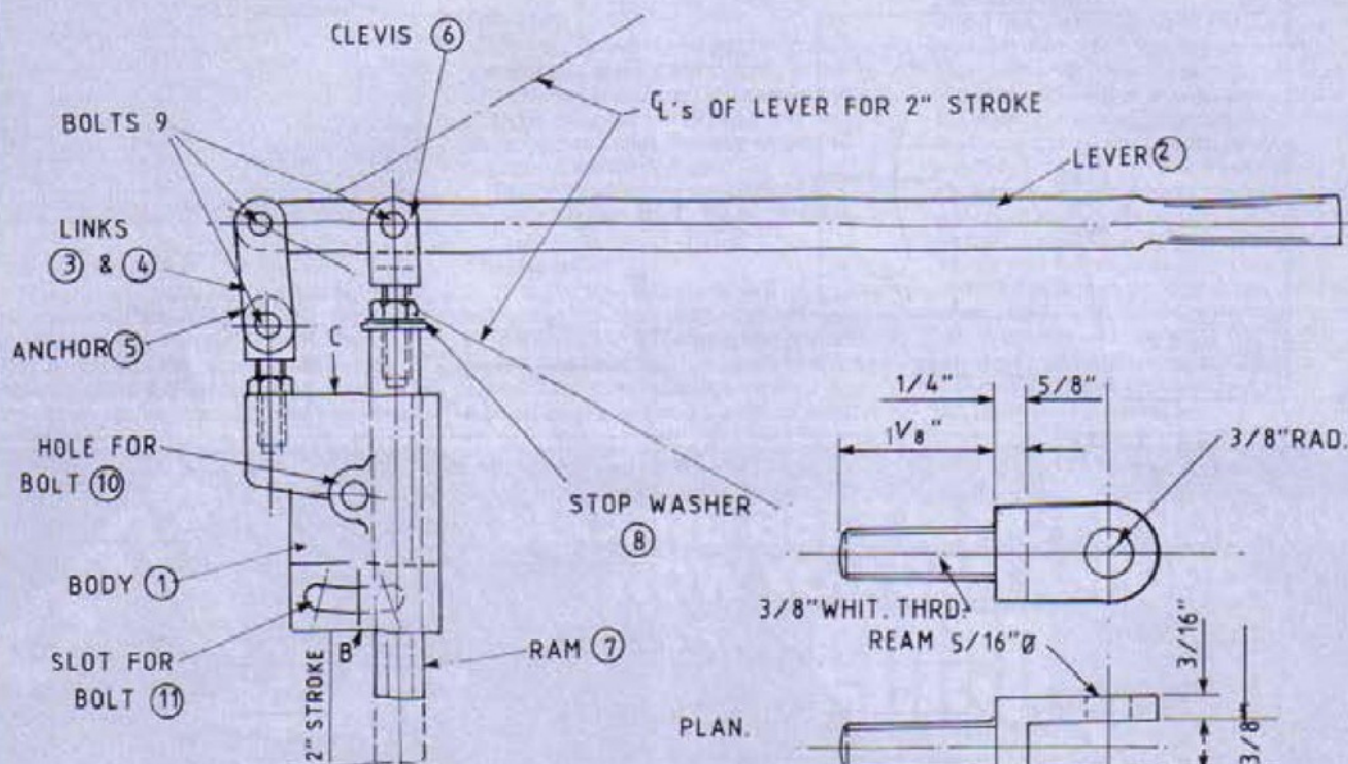
must be marked on the bottom of the casting and the curve taken from there. The obvious way is by using a rotary table and milling the slot. Not everyone has a rotary table and this means the curved slot will have to be chain drilled and filed. This in itself is not too difficult albeit a little time consuming. The problem may come however in drilling through the body. For the sake of accuracy, it should be drilled from the bottom, but a great deal of care must be taken to position it so that it comes out in exactly the right place.

An alternative would be to drill the hole through from the top of the casting. Plug it at the bottom with a short length of mild steel that has been marked with a centre and then pick up the slot from that. It certainly is the way in which errors are least likely to occur.

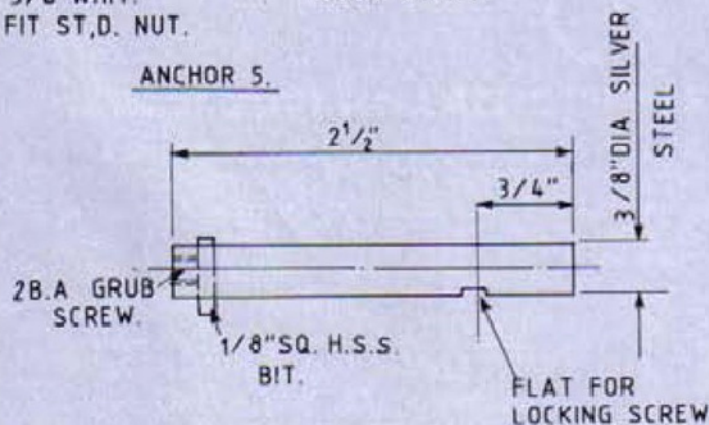


NOTES ON MACHINING ON MYFORD 7 or 10.

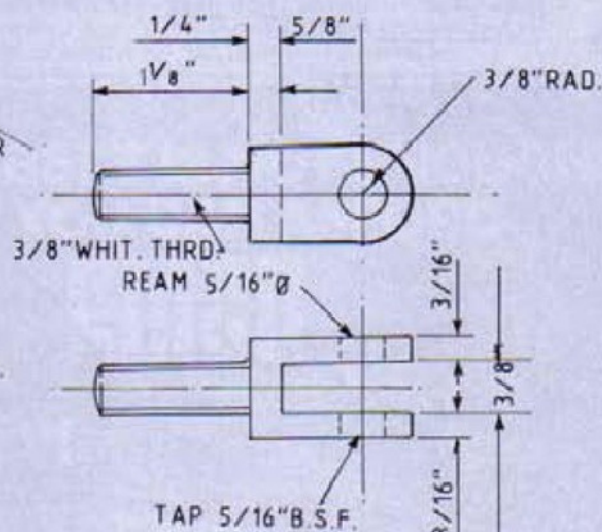
CLEAN UP WITH FILE FRONT FACE OF BASE & PAD MARKED 'A' CLAMP ON CROSS SLIDE ONTO THESE FACES & FLYCUT BOTTOM FACE. MARK OUT & DRILL & FILE HOLES FOR BOLTS 10 & 11. CLAMP ONTO CROSS SLIDE USING BOLTS 10 & 11 & FLYCUT THE FRONT EDGE OF BASE. THIS FACE IS THE SETTING FACE FOR POSITIONING THE BODY FOR SUBSEQUENT MACHINING & ALSO FOR USING THE ATTACHMENT. (THE PAD ON THE BARREL OF THE BODY MAY NOW BE FILED OFF FOR APPEARANCE IF REQUIRED) MOUNT THE CASTING ON THE CROSS-SLIDE AGAIN WITH FACE 'B' TO THE HEADSTOCK OF THE LATHE USING THE FACE 'A' TO ENSURE SQUARENESS. FLYCUT FACE 'B' & DRILL & BORE THE BODY TO A CLOSE SLIDING FIT ON THE RAM. TURN THE BODY THROUGH 180° & MACHINE THE FACE 'C' & DRILL & TAP THE HOLE FOR THE ANCHOR.



ANCHOR 5.

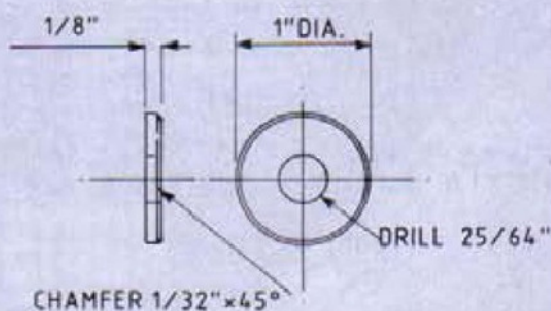


TYPICAL TOOL BAR

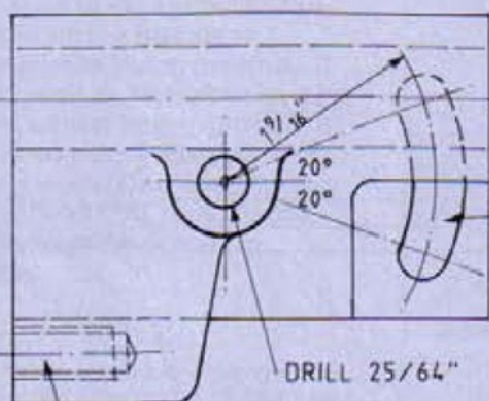
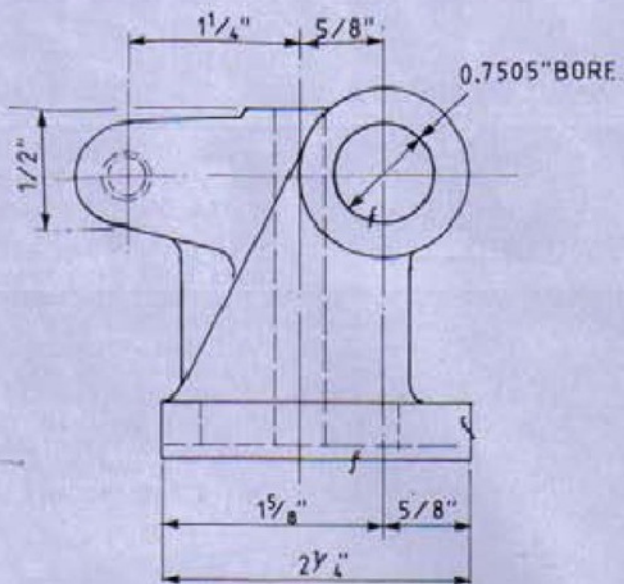
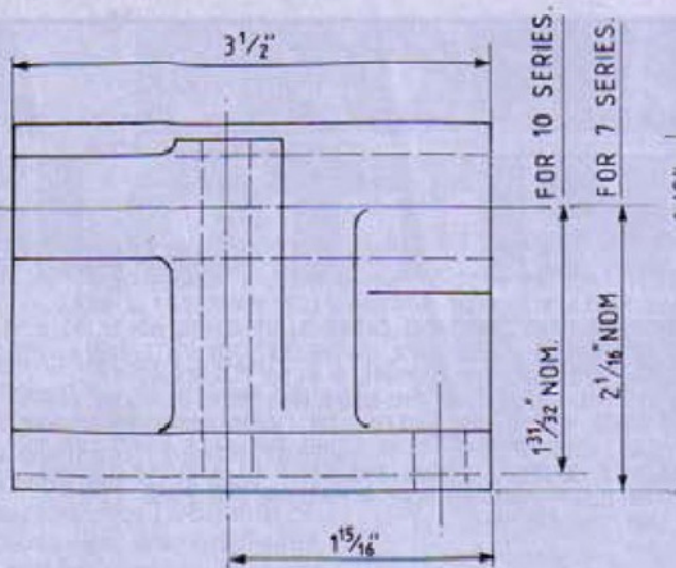


MATL 3/4" SQ. B.M.S.

CLEVIS 6.



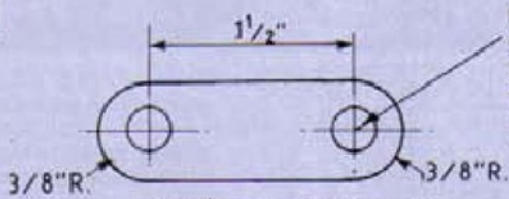
STOP WASHER 8



BODY 1.

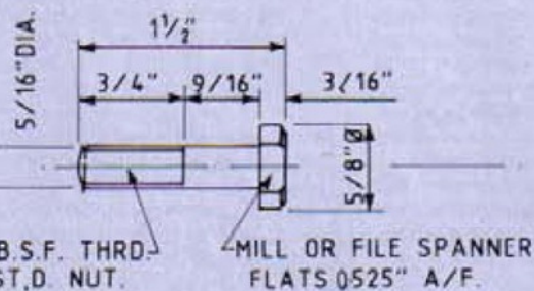
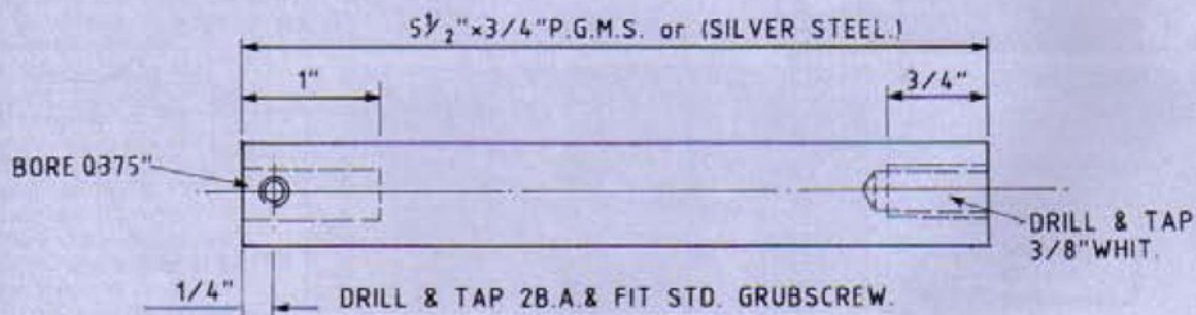
SLOT FOR BOLT.

DRILL & TAP
3/4" WHIT x 3/4" Dp.

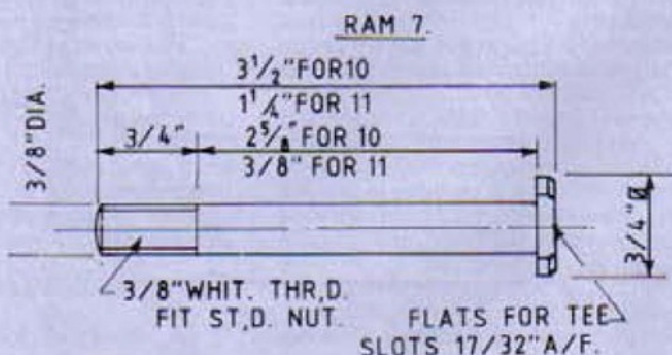


MAT^L 3/4" x 1/4" B.M.S

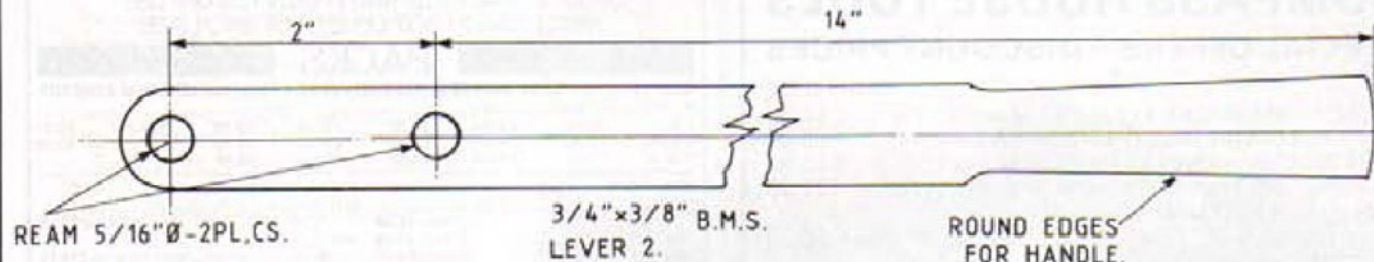
LINKS 3 & 4.



BOLT 9.



BOLTS 10 & 11.



MATERIAL LIST			
Item	No. Reqd	Material	Description
1	1	CI	Body
2	1	BMS	Lever
3	1	BMS	Link
4	1	BMS	Link
5	1	BMS	Anchor
6	1	BMS	Clevis
7	1	PGMS	Ram
8	1	MS	Stop Washer
9	3	MS	Bolts
10	1	MS	Bolt
11	1	MS	Bolt

The anchor

The anchor can be made out of square stock. Turn and thread it first, then drill the $\frac{1}{8}$ in. diameter hole to reaming size. Tap a block of metal to the same thread as the anchor and put this in the milling machine vice. Screw the anchor with a locknut on it

into the block and when in a suitable position tighten the locknut hard. It is now possible to mill the slot. When this is done, finish the cross hole with a reamer.

The clevis

The clevis can be made in exactly the same way as the anchor.

The ram

This is a straightforward boring job at one end and drilling and tapping at the other. No great accuracy is required and so it can be mounted in the three-jaw chuck and supported with a steady whilst the operations are carried out.

The bolts are again straightforward enough, the flats can be filed or milled.

The handle

This, like the other parts, is a fairly easy machining job. Start with a bar with good square ends. Put a centre in one end and set the other in a four-jaw chuck to run true. Support the work with either a hard or a rotating centre and turn the round section

for the handle. Remove the work from the lathe and drill and ream the two holes for the bolts. Round off the end away from the handle, either by filing or with a rotary table, if available.

Using the tool

To use the tool, mount it on the cross slide and adjust the length of stroke; check that it has been set squarely to the lathe axis. Set the cutting tool at centre height. Start with a very fine cut and slowly work the cross slide out after each cut until the full depth is reached. Tools can be ground from high speed steel, or these days possibly tungsten carbide, it now being available in small diameter stock. The tool will cut at an angle by simply swivelling it on the curved slot. It will be necessary to ensure that the angle at which it is set is correct, this is easy enough on an outside taper as a parallel set along the edge of the ram in contact with the taper will do the job. Inside tapers pose something of a problem and it will probably be best to set these with a protractor.

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Like 'Bluey', I too felt the need for a belt sander and for quite a while various half formulated ideas for building one floated around in my head without anything definite materialising. At one stage, about two years ago, I actually rushed out and bought a sanding belt and a start was made on some rollers.

Enthusiasm waned, however, and the idea (along with the belt) lay fallow until the advent of Bluey's article in the Winter 1990/91 issue.

Upon reading this excellent article, an immediate start was made. There were some changes, of course. The only suitable piece of R.H.S. (Rolled Hollow Section) that I had to hand measured 2½in. X 1½in. X ¼in. thick. Some quick calculations revealed that this material would just accommodate the 2in. wide belt, but this meant that the roller diameter had to be held to 1½in. and length of the body increased slightly to compensate. The bearing housings were made from 2in. X 2in. pieces of mild steel ½in. thick. The rest of the body followed closely along Bluey's lines. The only other significant change was in the belt tensioners. I machined these in one piece from half inch across flats hexagon steel.

The drive system was, in common with a lot of good ideas, discovered by accident. Although I have several ex-appliance motors lurking in the workshop, none recommended itself for the job in hand. Making and fitting of the rear frame was deferred until I could settle on a suitable motor. At this point I decided to set up the body and run a test to check the tracking of the belt and so forth.

Gripping the body of the sander in the vice, I secured the pulley spigot of the drive shaft in the chuck of my ½in. portable drill (a 500w Bosch), and applied the power. A few minutes fiddling had the belt tracking nicely



The complete sander, as yet unpainted.

A SIMPLE BELT SANDER

From correspondence received, it would seem that many readers have made or are making the sander described by 'Bluey' in the Winter 1990/91 issue. Most tools can be made from available materials and altered to suit the constructor; in this article Terry Lane from Australia gives brief details of how he made such a machine using rolled hollow section material

and I stood back to have a well-earned gloat.

The sight of the still-attached drill hanging off the drive gave rise to inspiration. Why not use the drill as a drive unit? Why not indeed! The Bosch, although hardworked in its youth, sees little service now, most of my workshop drilling is carried out using either the bench drill or a little cordless Black & Decker with a ½in. chuck that is worth its weight in diamonds.

A few quick tests indicated that the Bosch would deliver plenty of power and, an added bonus, would give the choice of two speeds: 1,000 and 3,500 rpm. A simple bracket to carry the drill was soon made from a piece of 2in. X ½in. flat mild steel, with the drill clamp made from an oddment of industrial nylon. This was screwed to the underside of the bearing housings using four M4 screws. An equally simple 'table' was folded up from ½in. mild steel and screwed to the sides of the body, straddling the belt.

No provision has been made for mounting the sander. I have found that gripping it in the vice is quite satisfactory as it can be mounted horizontally, vertically or at any convenient angle in between. The drill can be attached or taken off in a matter of seconds and the whole thing packs away neatly in a drawer.

There is a down side (isn't there always). Both the drill bracket and the table have to be removed in order to change belts. However, as this only involves the removal of eight easily reached screws, it shouldn't cause anyone too much pain.



Sander can be used horizontally, vertically or at any convenient angle in between (top left). Top right, close-up of tensioner detail. Above left, underside view; note the simplicity of the bracket. Above right, the modified drive and table are evident in this shot. Unit uses a standard Bosch 500 portable drill.

TURNING A MORSE

Unless suitable equipment is available, getting the exact set-over of a top slide for taper turning is largely a matter of trial and error. In this article a novel idea by Harold Hall could solve many of the problems associated with taper turning

Having required, on a number of occasions, to turn a Morse taper when making items of workshop equipment and found the task of trial and error to set the top slide rather laborious I decided to consider the possibility of other ways of arriving at a satisfactory result.

Problems involved

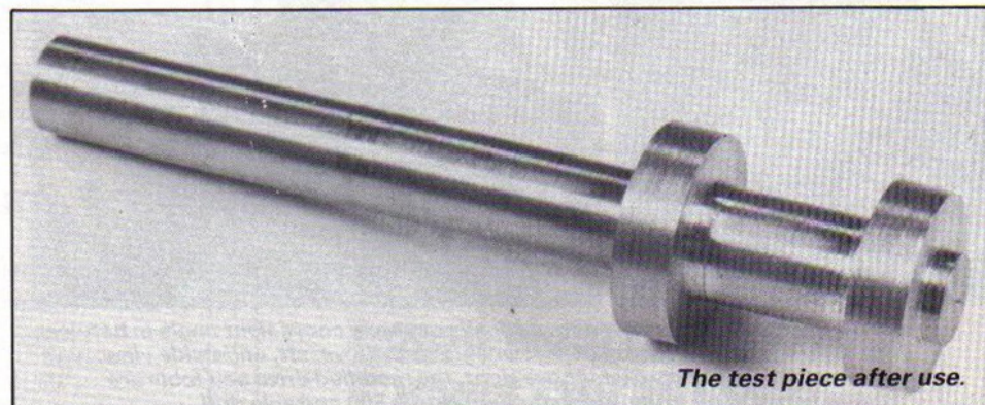
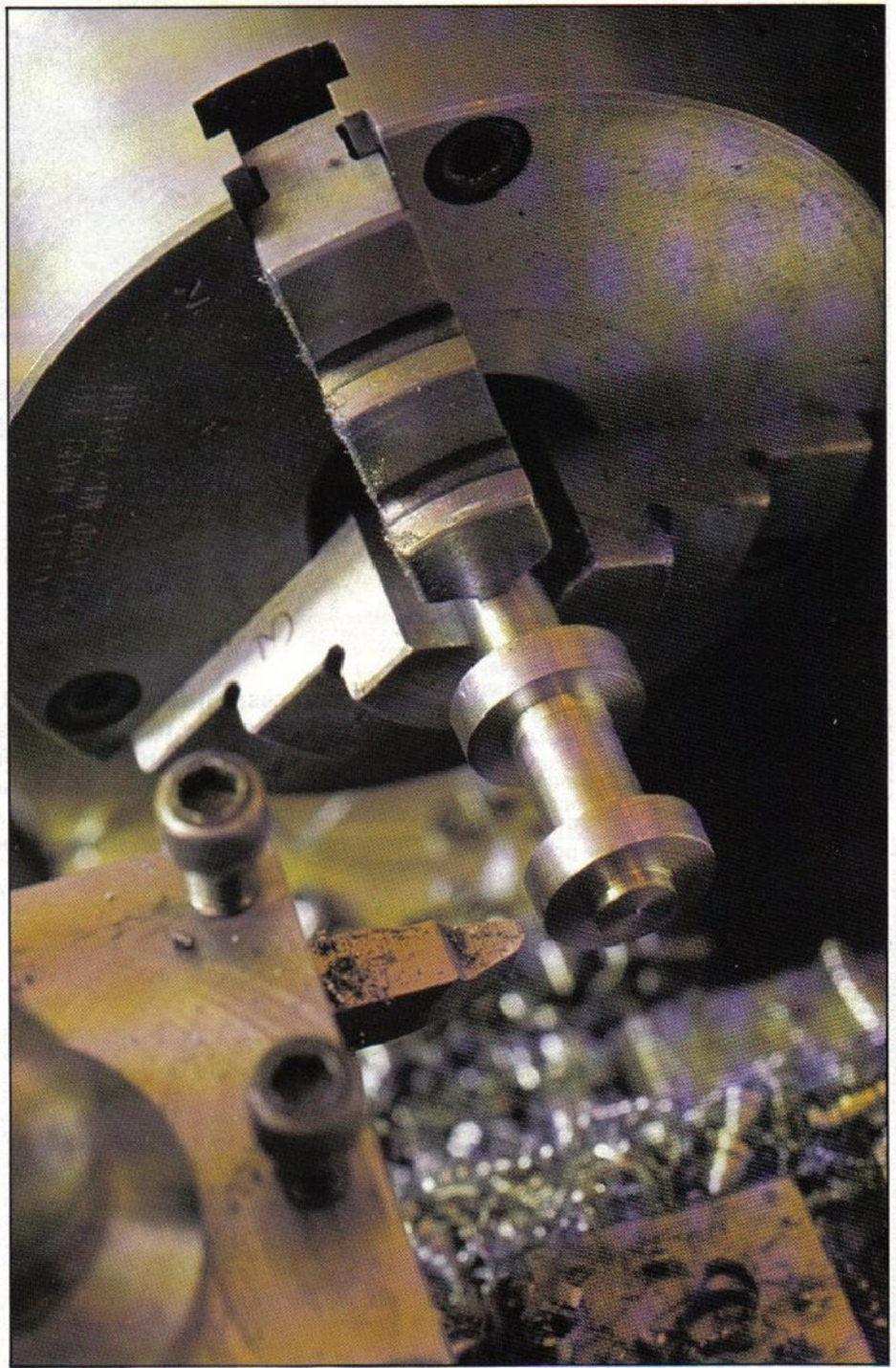
The problem for the small workshop is the lack of facilities for measuring angles to a very high degree of accuracy or, alternatively, diameters at precise points along the length of the taper. It was with the last factor in mind that I was prompted to consider the method now suggested.

The basis of the idea is the ability to measure the difference in two diameters at a precise distance apart and from these dimensions, determine the taper. The first requirement is to make a turned part as per **Figure 1**. Making the part from $\frac{1}{2}$ in. dia. would be suitable, but as will be seen as the method is explained, the only important dimension is that shown as 'A'.

In view of the difficulty of measuring dimension 'A', those shown as 'B' and 'C' can be measured with a micrometer and dimension 'A' arrived at by subtracting 'C' from 'B'. The top slide can now be set to the approximate angle and the two diameters turned with a continuous movement of the top slide only as in **Figure 2**. Diameters 'X' and 'Y' can now be measured and the difference calculated. The top slide can be adjusted and further cuts taken, until the difference as indicated in the table is achieved.

A variation of this method would be to turn the two diameters (using the saddle and not the top slide) as in **Figure 3** with the required difference. This can be used initially to set the top slide by sight and then by taking small cuts, making adjustments to top slide as required, aiming to achieve an equal flat on each test diameter as shown in **Figure 4**.

With a flat of 10 thousandths of an inch or less, an error of a few thousandths of an



Colour picture shows the turning of the two ridges on the mandrel. These will later be used as gauges as explained in the text.

The test piece after use.

TAPER

inch should be detectable and may be sufficiently accurate (see later paragraph about accuracy). Otherwise, the part can continue to be turned and checked as per **Figure 2** and method already described above.

Dimension 'A' has deliberately been chosen at what would appear an unnecessarily complex value rather than say, 1.000 in. or 0.750 in. This has been done to ensure the difference in diameters works out to an exact number of thousandths of an inch (0.040 in.) as, due to the shallow taper, an error in the difference is much more significant than an error in the distance 'A'. It is worth noting that, typically, an error of 0.0001 in. in the difference dimension would give a similar angular error to a 2 thou. error in dimension 'A'.

As it will be difficult to achieve dimension 'A' and the difference dimension without any error and whilst I have not done any comparative tests, my considered opinion is that it would be better for any error present to be such that the larger end was oversize relative to the smaller end, ensuring that the outer end has the tightest fit.

If a 2 in. or 3 in. micrometer is available, then the testpiece could be made with the difference and dimension 'A' both multiplied by two or three thus making any errors less significant.

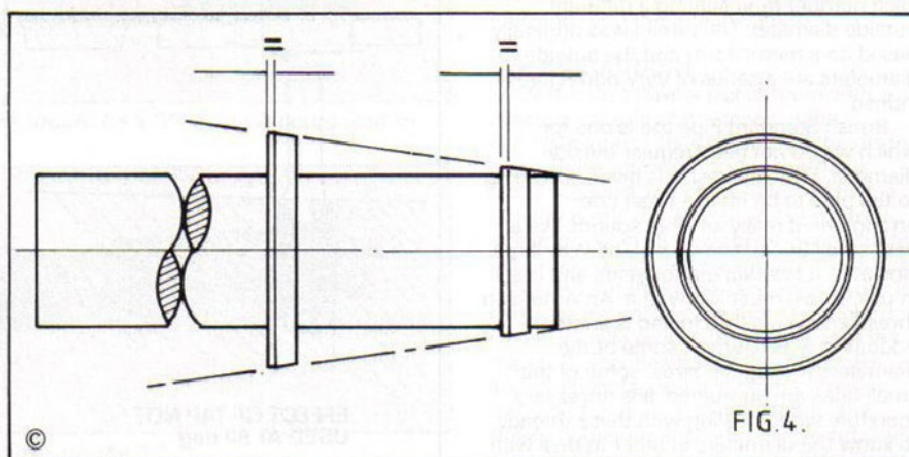
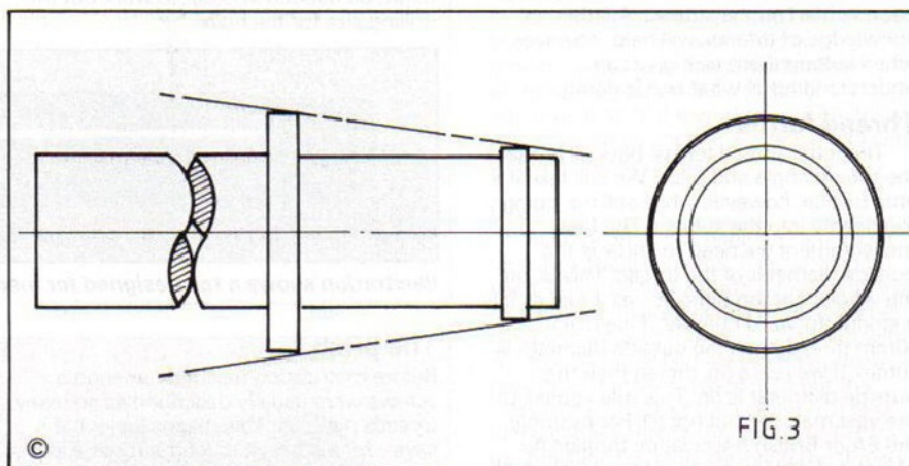
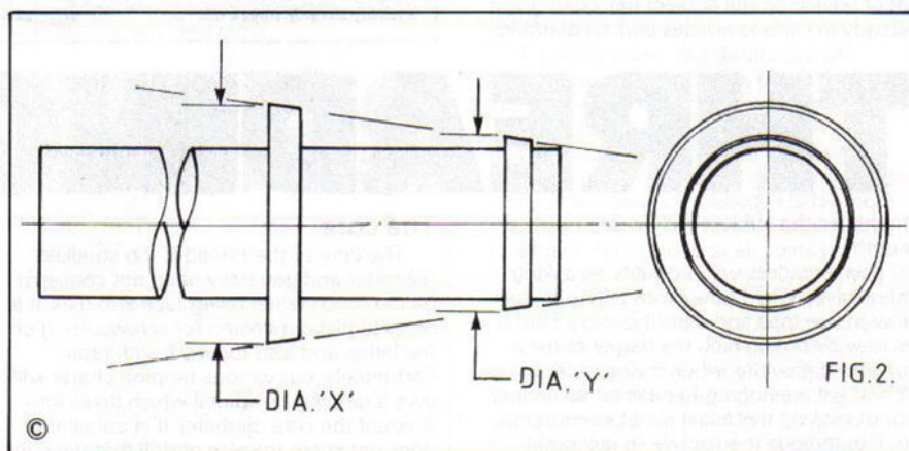
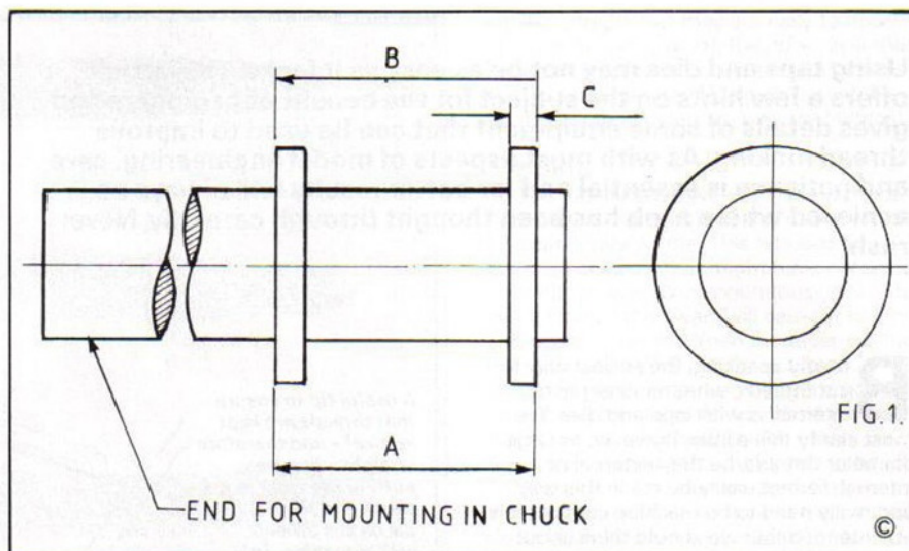
One other point to note is that the taper is dependent on tool height. It is therefore preferable to use the same tool and height setting for producing both the initial testpiece and final taper. In this respect, a well sharpened bullnose tool will produce an excellent surface finish.

MORSE N°.	TAPER PER FOOT ON DIA.	DIM 'A' FOR 0.04" DIA. DIFFERENCE.
1	0.59858"	0.8019"
2	0.59941"	0.8008"
3	0.60235"	0.7969"
4	0.62326"	0.7701"
5	0.63151"	0.7601"
6	0.62565"	0.7672"

QUICK TIP

I'm sure every model engineer has driven a nail into a piece of wood and split it! An old dodge, which I always use, is to hold the nail on its head on a hard surface and hit the point with the hammer. When driven into the wood it will not cause a split, as it cuts the fibres instead of spreading them apart. Don't be tempted to touch the point on the grindstone, it doesn't work! Either oval or wire nails can be treated in this way. By the way, if the hammer slips off, rub the pin or face on a piece of abrasive cloth, concrete or a brick.

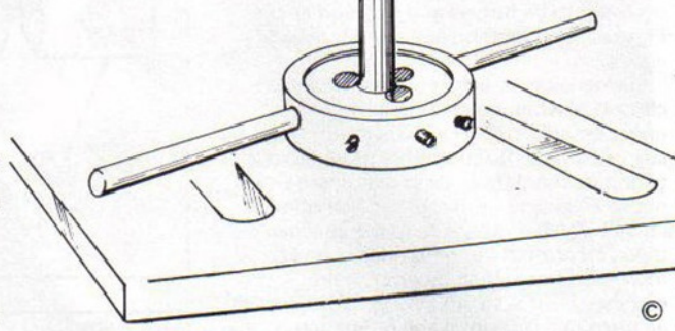
Don Unwin



Using taps and dies may not be as easy as it looks. This article offers a few hints on the subject for the benefit of beginners and gives details of some equipment that can be used to improve thread making. As with most aspects of model engineering, care and patience is essential and far better results will always be achieved where a job has been thought through carefully. Never rush!

Broadly speaking, the easiest way to cut threads, whether external or internal, is with taps and dies. We must clarify this a little, however, as large diameter threads, be they external or internal, cannot easily be cut in this way and really need to be machine cut first. It is not intended that we should think about screw cutting by machine in this article. A lot of advice on the subject has been given already in various articles and no doubt in

A useful tip to ensure that threads are kept vertical – and therefore straight – involves putting the work in the chuck and resting the die on the drilling machine table. This way, all should be at exactly ninety degrees.



THREADING FOR

the future the subject will be dealt with at length.

Some readers will probably be asking themselves why bother with telling people how to use taps and dies, it is easy. That is as may be but, in fact, the beginner may run into difficulties when trying to do so. Whilst we are hoping to pass on some tips about *making* threads it is not intended to go into threads themselves in any great detail. There are so many that books have been written on the subject. A little knowledge of threads will help, however, when cutting them as it gives an understanding of what one is doing.

Thread forms

The term 'thread forms' basically means the thread angle and pitch. We will take it a little further, however, while still not going too deeply into the subject. The first measurement we need to know is the outside diameter of the thread. This is, on the whole, not too difficult – as a rule as it is a straightforward number. If we use a 10mm thread, then the outside diameter is 10mm. If we use a $\frac{3}{8}$ in. thread then the outside diameter is $\frac{3}{8}$ in. This rule applies to the vast majority, but not all. For example, the BA or British Association threads (to give it its full name) is numbered from 0-25, each number representing a different outside diameter. The thread was originally based on a metric form and the outside diameters are a series of very odd figures indeed.

British Standard Pipe too is one for which we do not get a regular outside diameter. The thread size is given according to the pipe to be fitted – most odd arrangement really as what sounds like a very small thread can, in fact, be very large. However, it has worked for years and is still in use, so we must live with it. An American thread known as the Unified is another oddball in which, whilst some of the diameters are regular sizes, some of the small ones are numbered. It is necessary therefore when dealing with these threads to know the diameters in order to deal with them properly.

The core

The core of the thread is the smallest diameter and generally need not concern us too much when using taps and dies. It is an essential dimension for screwcutting on the lathe, and also for work with taps. Fortunately, our various tapping charts will give a tapping-sized drill which takes into account the core diameter. It is only if one does not know the size of drill that the core might be needed in order to work out the drilling size for the hole.

many complete turns of the thread. When it came to metric threads it was hardly possible to say how many threads per millimetre as many would not have had even one thread to that length. The distance covered by the length of a complete turn of the thread is used instead and is called the pitch. The term has, in many cases, drifted into use for Imperial and American threads as well and so sometimes we will find the threads per inch (T.P.I.) called the 'pitch.'



Illustration shows a tap designed for machine use.

The pitch

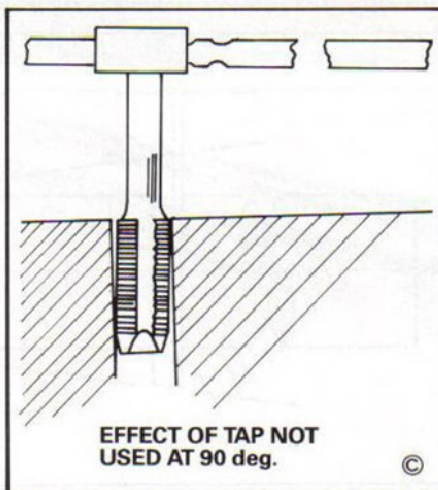
Before metrication reached our shores screws were usually described as so many threads per inch. This means just what it says – for each inch of length there are so

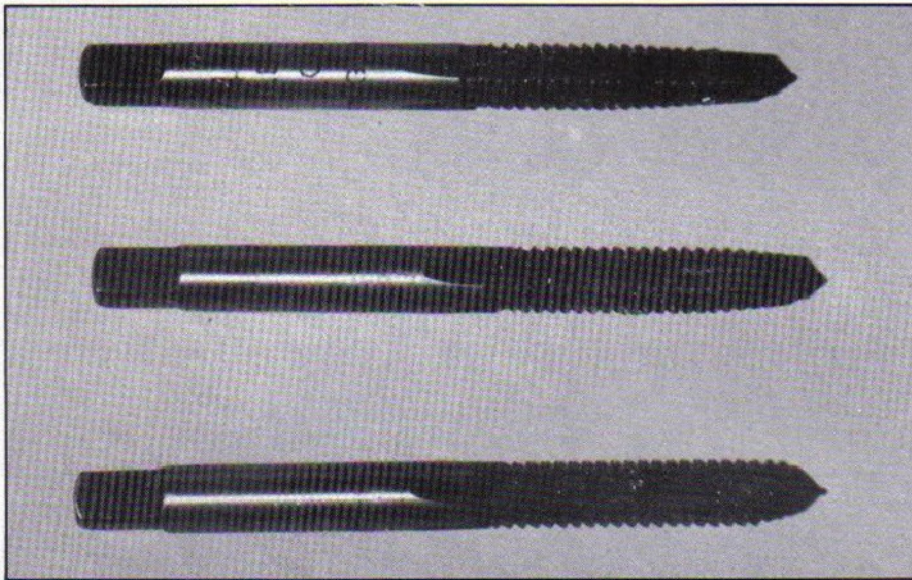
Thread angle

Threads are generally angled in order to make them fit easily on the nut. Sometimes we find square threads and other odd shapes but these are not usually used for fastenings, more for drive mechanisms. Threads used for fastening will almost invariably have an angle which will vary according to the type of thread and again, as far as the use of taps and dies is concerned, is of little interest. It is essential knowledge of course when cutting a thread by machine.

Taps

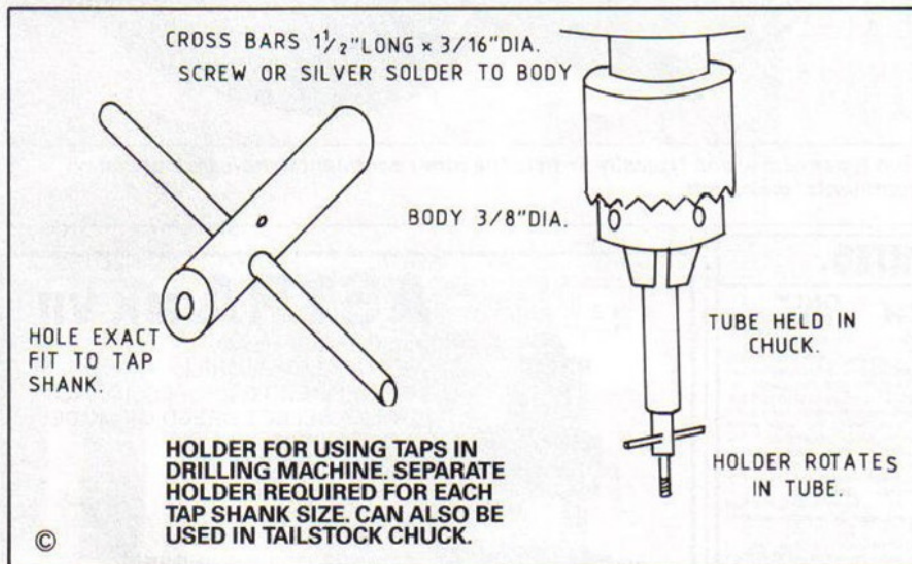
To tap a hole it must first be drilled to the correct size. Various charts will give this. It is then tapped using the tap in a tap wrench. In order to get a good start, a taper tap is used first of all. This, as the name implies, is a tap with a taper on it which makes entry to the hole easy. The tap should be lubricated with a good tapping compound and used with a tap wrench. There are several versions of these which





Three types of tap; taper (top), second (centre) and plug tap (bottom).

BEGINNERS



This tap wrench has worn round where there should be a 'V'; using it could lead to tap breakages.



A typical tap wrench; the square on the tap fits into the 'V'.

can be bought, but they are easy to make at home and well worth the effort as it then becomes possible to have a range of sizes to suit different taps. This puts less strain on the tap than using an oversized wrench.

Tapping

The tap should never be twisted more than half a turn at a time, and it should then be pulled back a little. This releases any build-up of swarf that might have occurred. If the tap is wound in continuously there is every chance the swarf will cause it to bind and possibly break. When the taper tap has been used to its full depth, a plug or bottoming tap can be used to get a good even thread through the length of the hole. There are, in fact, three grades of tap, viz. taper, second and bottoming, and to be correct all three should be used. This involves time and expense and the two will do most work quite well. The plug tap must be used in the same way as the taper.

Problems

So far so good, but things can go wrong. One big problem is to keep the tap at ninety degrees to the hole. It may sound ridiculous but a tap can enter the hole at quite an acute angle, which means the screw will follow at that angle if indeed the thread ever gets completed. It is far more likely that the tap will break first. Angling must then be avoided at all costs but this is not as easy as it may sound. One way is to keep checking the tap with a square but it is quite obvious that a normal try square will not fit easily up alongside a 2mm or say an 8 BA tap. Here small pieces of bar stock with known ninety degree angles should be used for checking. Larger taps may possibly be checked against a try square.

Ideally, taps should be used in a device known as a 'staking tool'. This is guaranteed to keep the threads square but to many it is just an extra piece of equipment to fill the workshop. The drilling machine can be used as a staking tool with a little bit of adaptation.

Dies

Much of what has been written about taps also applies to dies. They should be used in the same way, and again care must be taken to ensure that they run at a true ninety degrees to the work. Checking with squares as described for taps is perfectly possible. Another method is to put the work in the chuck of the drilling machine and lay the dieholder on the table. Rotate the machine by hand, relieving the thread every half turn or so and thus letting the machine keep the thread square.

Die adjustment

British dies have a slot in them with a recess each side of it; screws in the dieholder grip in these to secure the die in place. If the screw which fits the slot is tightened hard first of all, followed by the other two, the die will cut at its maximum size and will, in all probability, not get to the full thread depth. If the centre screw is not tightened but the other two are screwed in hard, the die will cut the thread undersize (it will actually reduce the diameter of the material). The idea has both advantages and disadvantages. Leaving the screw in the centre undone for the first cut, and slowly tightening it on successive cuts, will allow the thread to be made to the correct

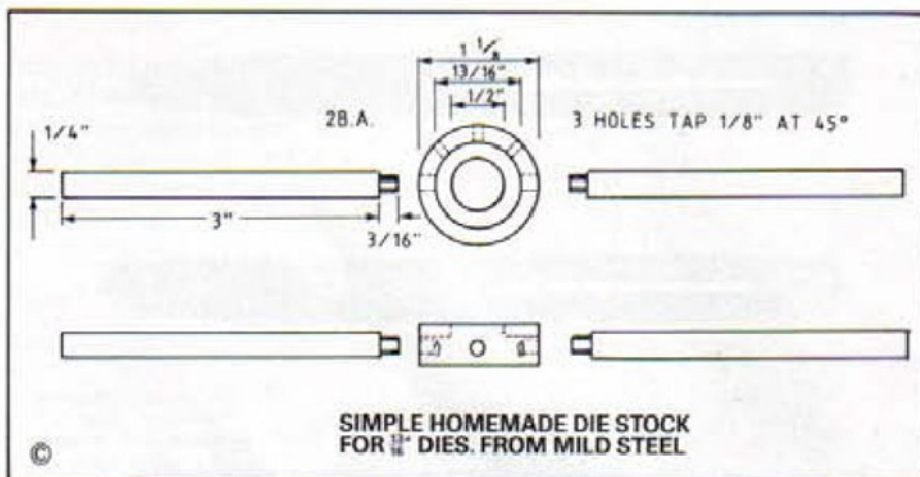
depth in easy stages. Getting the thread exactly right can, however, be a little difficult and requires a great deal of care. Dies made on the continent and many from the USA do not have the slot and are designed to make the thread as a single cut. This again has both advantages and disadvantages: the thread will certainly be the correct size, but it may also be difficult to cut a thread on larger-diameter material.

Purchasing taps and dies

When possible, only the best quality taps and dies should be used. Good quality ones are quite expensive and it may be that the number of threads to be made will not justify the purchase of an expensive tool or tools. Carbon steel threading tools (which is what the cheaper ones are) do not have a very long life and therefore any taps or dies that are going to be used frequently are worth the extra money to purchase in high speed steel.

Worn taps and dies will tear the metal rather than cut good clean threads and their use should be avoided. Taps can be sharpened with very thin grinding wheels but it is not a job for the beginner. It is essential therefore that they be well looked after to prevent blunting unnecessarily. Do not keep them in tins or boxes where they can rub against each other and wear the edges off. If you must keep them in this way, wrap them in paper or cloth to prevent damage.

Remember, care with threading will always pay off. Use plenty of cutting compound and look after the tools. And keep those threads straight!

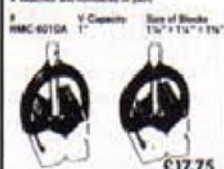


Two types of die, one typically British, the other continental; note lack of slot on continental die on left.

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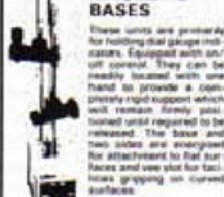
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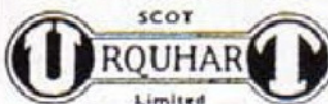
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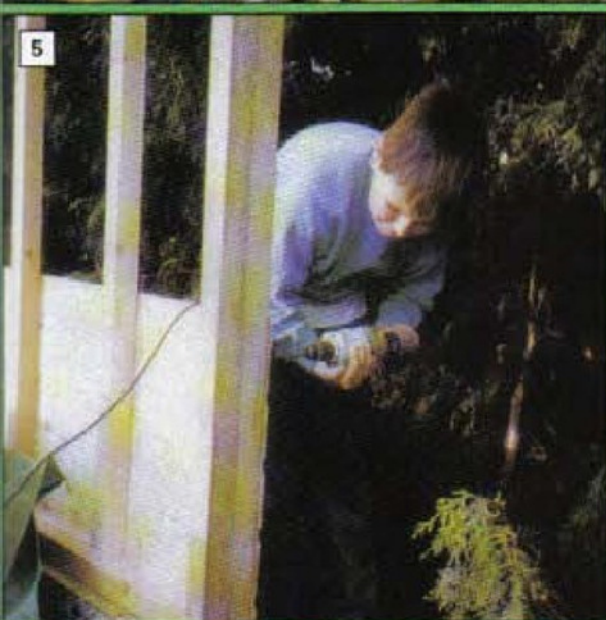
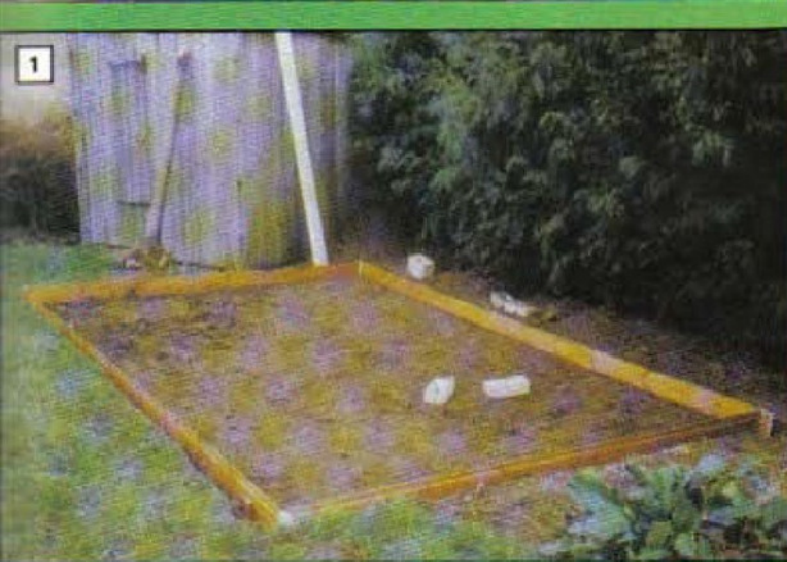
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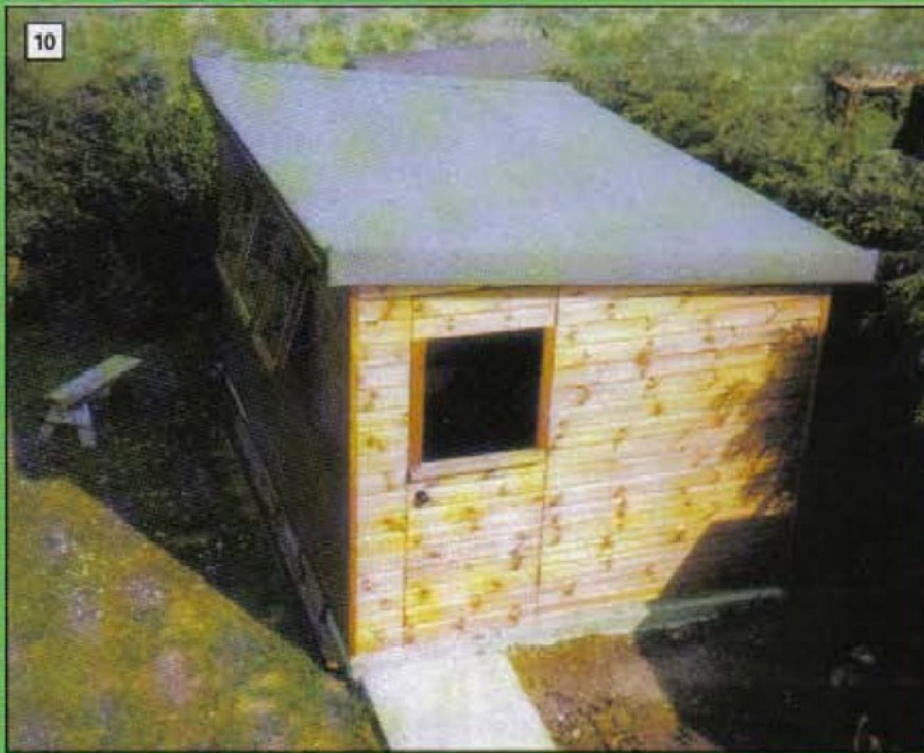


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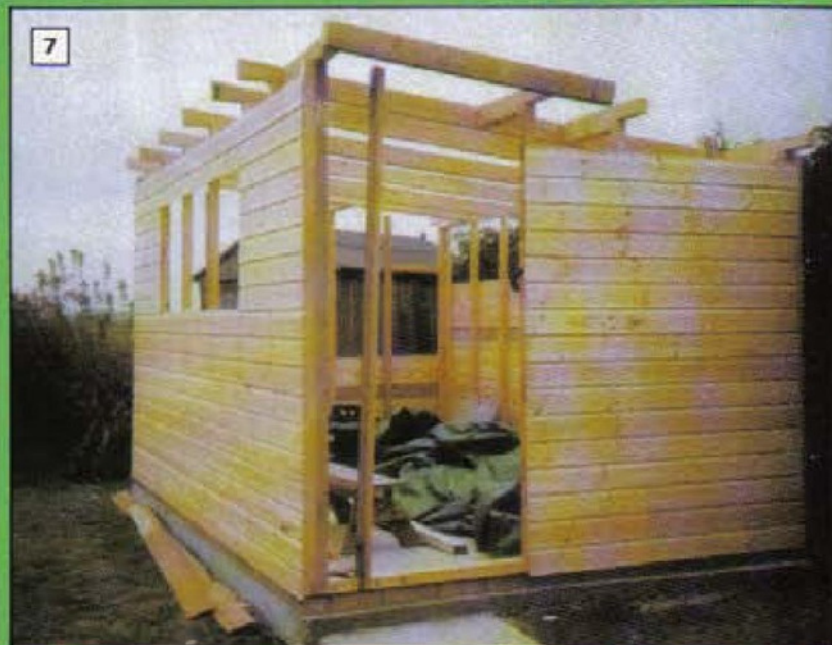


From correspondence we received it would seem that visits to workshops are quite popular features. This article offers something a little different as it is a photographic record by Tony Meek of the complete construction of his new workshop

WORKSHOP WANDER



1. With site for the new workshop decided upon, the area was excavated to a depth of about ten inches and boards put round the edge to hold the base material. The soil was rammed down hard.
2. Hardcore was put into the area, and at this point it was decided to make a decent path as well so the ground was excavated for that too. Concrete was poured in and levelled, and then a sheet of plastic laid over it, to prevent damp from rising. Fine concrete mix was poured on top and levelled. The path received the same treatment except for the plastic sheeting.
3. The frame was made up in sections. Joints were cut on the milling machine to ensure accuracy and everything was screwed and glued together. The frames were then bolted together.
4. With the frame assembled, the roof trusses were added.
5. The outer skin was to be tongued and grooved timber. This was screwed in place one board at a time, care being taken to line everything up accurately.
6. A view of the workshop internally while the cladding was being added.
7. An external view showing the neat assembly of the outer cladding to this point.
8. A view from above showing clearly the roof trusses.
9. The outer timbers, when completed, were treated to prevent rot inside and out. The workshop was kept dry at this stage with a plastic sheet.



For many years Tony Meek, a builder of high-quality models, had his workshop in the garage. Garages, of course are fine; there is invariably quite a bit of room and the dirt created does not matter too much. But there are also disadvantages. Firstly, they are generally dark places with little natural light and, secondly, they are usually inclined to be damp, particularly if shared with the family car. In Tony's case, the workshop was not shared with the car which had to stand outside all the year because of the workshop!

Deciding that there was a need to improve the situation he decided that he would build a workshop in the garden and set about looking at prefabricated wooden buildings. Unable to find a suitable structure, and having given the matter a great deal of thought, he decided that it was as well to start from scratch. That way he could have the strength of construction he wanted, the window and door positions as required and would also save money.

The photographs show the project as it was carried through. Individual features that were particularly wanted were: The door at one side of an end, which allows more wall space at that end than the more usual design of a door in the centre; Windows at the correct height for the

bench and in the exact position required; Full insulation, and good electrical wiring.

Inside the workshop gives an air of space in spite of its modest size; it is warm and cosy and comfortable to work in. All equipment is easily to hand, and of particular interest are the sloping shelves which enable tools, etc., to be easily got at without the clutter associated with the normal shelf. The inclusion of an old but good-quality stereo system allows relaxing music to be played whilst working on the latest project!

QUICK TIP

Hacksawing by hand can be hard work. It can be made easier by applying cutting oil to the blade and by making, say, ten strokes with the saw at an angle of twenty degrees and then ten at thirty degrees. Both angles are approximate, of course. This has the effect that the saw is constantly cutting on a smaller area than when it is maintained in the same position throughout.

10. The roof was laid on as separate plywood panels and then coated with three layers of felt, glued down. Raised end sections to assist the flow of water from the roof were made by putting battens along the edges and felting over.

11. The windows and door were the last parts to be fitted. These were made off-site and fitted as a unit.

12. Electric wiring was the next task and the frame was used as the support for this, all wires being taken to a consumer unit with an earth leakage trip. The internal recesses were then fitted with one inch thick polystyrene sheeting for insulation and warmth. The sheeting can be seen here at the height of a single sheet.

13. The internal insulation is completed. This will then be overlaid with insulation board painted white to reflect the light.

14. With the workshop complete, storage units are laid out. Tony prefers to use sloping shelves wherever possible as these make it easier to see what is on the shelf and also prevent dirt settling. Because of the insulation board internal walls, used to give warmth, tools are hung on hooks on a plywood panel.

15. Screwdrivers, etc., are put on a sloping shelf with suitable holes drilled to accept them. Again there is no trap for dirt and it is easy to see the tools. The small bowls are used to hold parts for the work under construction, their shape making it easier to retrieve the parts. Permanent storage is in plastic boxes and tobacco tins as photograph number 14.

16. The milling machine is set at an angle to the corner to allow more room. Plenty of storage space is provided under the bench and a shelf immediately under the roof ensures maximum use of space.

17. Yet another sloping shelf; this one is fitted over and to the right of the lathe. Holes take care of various accessories. The tin on the right contains cutting oil which is applied with pipettes which are kept in holes in the tin. The lathe itself is shown on the front cover of this issue.

18. The home-made drilling machine is kept on a separate bench. Swarf from the machine is the very devil in a workshop and tends to wind itself round everything. Keeping the machine separate makes the swarf easier to deal with.



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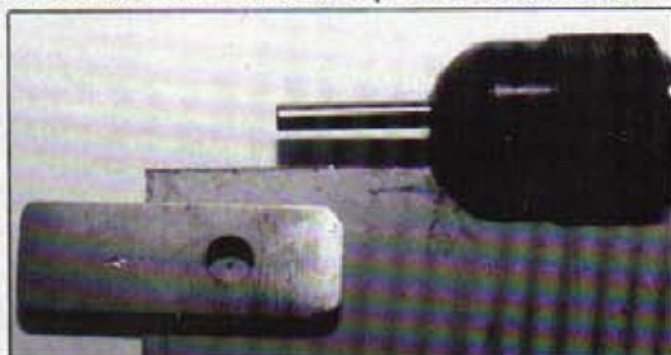
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KNURLING

There are two main reasons for carrying out knurling operations. The first is to enable one to get a good grip on the tool or other artefact that the process is carried out on, the second is to enhance the appearance of such an object. There is no doubt that the process works well, and with proper equipment is very easy.

Good and bad knurls

A great deal of discussion takes place from time to time as to what is a good knurl. Certainly, in the practical side of technical examinations, examiners study the knurling carried out by students at great length. What is it they are looking for? That is something of an interesting question as, to a large extent, it is a case of beauty being in the eye of the beholder. It is very hard to say exactly what a good knurl is. It should be deep enough in the metal so that the outer edges are not flat. The pattern should be clear and precise.

Equally, it is possible to produce knurls that are rather too deep. If the pattern is raised to the point where the edges are sharp, then whilst the knurl may look very good, when used it will cause pain or injury to the hand that is in contact with it. We must look for a good compromise but, as far as the model engineer's workshop is concerned, if the operator is satisfied personally with his or her efforts and feels no better could have been achieved, then that is a good knurl!

Here's a departure from our more normal practice, in this case with a combination of several articles by various authors which it is hoped will give readers a chance to make a knurling tool of their choice. Each type of tool has its own particular advantage, there probably being no such thing as the perfect tool...

The knurling process

The process involves pushing hardened wheels into the work and raising the metal to the pattern. Because of this it has been known for apprentices, who should have made work a press fit, to knurl the part that is too small a diameter and so raise the metal by sufficient to obtain the fit. Not a practice to be recommended but it certainly does happen. This pushing the knurling wheel in requires a considerable amount of pressure which can be detrimental to the bearings of the lathe. Not so bad on a big industrial machine, but on the lighter machines used in the model engineer's workshop, the process could ruin the machine. It is therefore as well to use tools that do not apply too much pressure on the bearings and one such tool was described in the first issue of *MEW*.

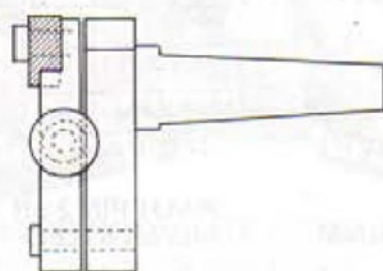
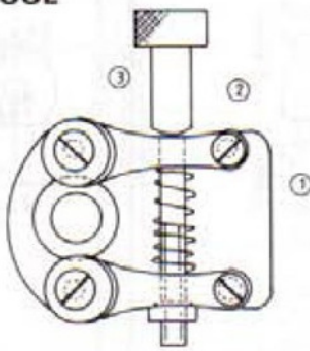
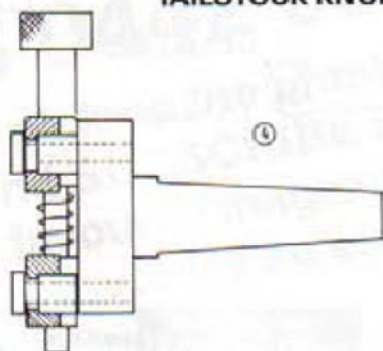
With a few exceptions, the best types of

tool work on a caliper basis, tightening on to the work rather than being rammed home and, on the whole, it is this type that we are dealing with in this issue. They require at least two wheels and to operate them the wheels should be tightened on the work which, if possible, should initially be rotated by hand. Again, this is getting away from the normal commercial practice, but it gives the operator the chance to see what is going on. Once he or she is certain that the wheels are both rotating freely and are centrally placed on the work the adjusting screw can be tightened and the machine started up at a slow speed. The wheels can be traversed along the work very slowly in order to get the length of knurl required. Do not attempt to get the knurl full depth at the first go, unless a very light pair of wheels is in use. (Heavy knurling requires more pressure than does light knurling). After the work has been traversed, tighten the adjuster and make a

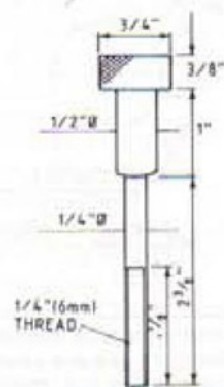


A pair of knurling wheels of diagonal pattern; used as a pair, they will produce a diamond marking.

TAILSTOCK KNURLING TOOL



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Far left: a somewhat unusual diamond pattern knurling wheel.

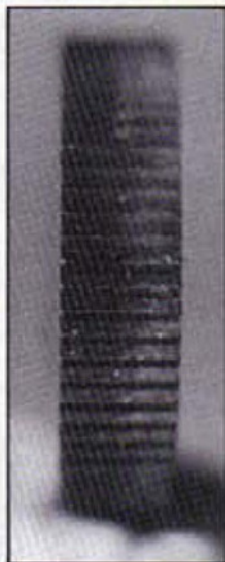


Left centre: an example of good quality knurling; note the clear cut diamonds.

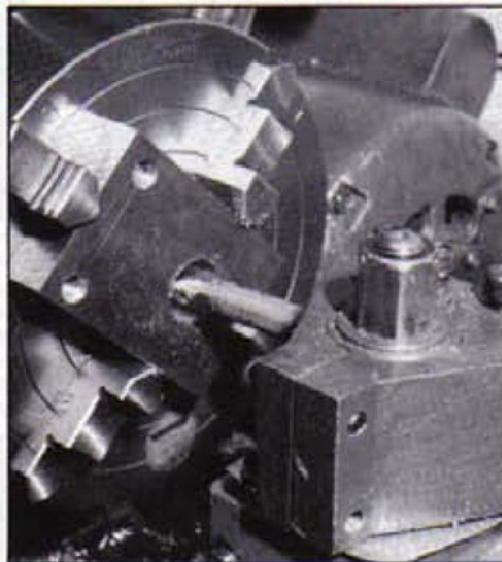


Near left: an example of knurling that went wrong; a double pattern can be seen where the tool did not relocate in the grooves.

Near right: a knurling wheel for producing straight pattern knurls.



Far right: construction begins on Stan Bray's tailstock knurling tool discussed below and at right. Here the hole for the taper is being bored in the body.



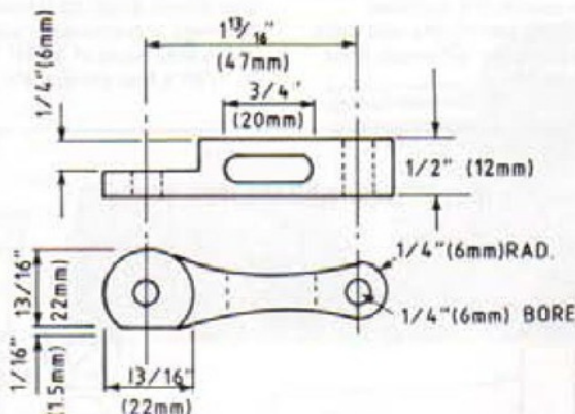
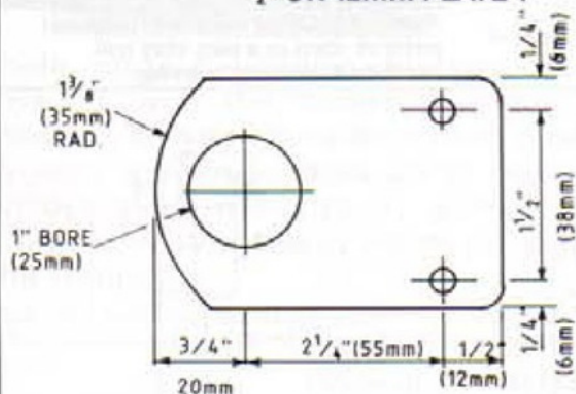
very reliable for lengthening the knurled section as witness marks are liable to be left. The only thing to do is to tighten a little at a time and run backwards and forwards on the work slowly. With a great deal of care it may be possible to carry out the lengthening process.

A nice finish can be obtained with a knurl if the metal is just relieved at each end. This smartens up the edges, which can be rather ragged if the pattern alone is left. This principle can also be followed if it is found that a knurl needs lengthening and it is not possible to lose the witness marks. Small grooves to break the pattern into sections can look very smart and will not prevent a good grip being obtained either.

Knurling from the tailstock

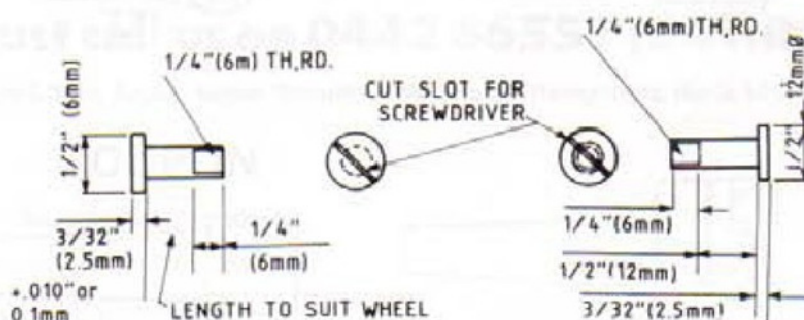
One problem with knurling is the fact that usually the tool is set in the toolpost. This means removing cutting tools, or losing their setting in most cases. To avoid this and to prevent strain it is possible to knurl from the tailstock and the design shown here enables this to be done. As always there are some disadvantages. It is not, for example, possible to obtain any great length of knurl because of the holding taper, unless there is a considerable overhang. The tool about to be described falls into this category and can only be used for short lengths. The drawings and photographs differ. The reason for this is that the tool was made to fit a lathe turret rather than the tailstock. The drawings allow slightly larger work to be dealt with. As always, readers can adjust measurements to suit themselves. Another

BODY 1 off MILD STEEL 1/2" OR 12mm PLATE 1



second pass and so on until the required depth is reached. The use of a good cutting oil helps, and remember that pressure means heat. This is a pressure operation and so considerable heat will be generated.

If after the wheels are removed it is found that the pattern is not deep enough, they can be reset, although this should be avoided if at all possible as the best knurls come from work where the wheels have remained in contact all the time. Diamond patterns are made using two wheels which are right and left-handed. Straight knurling can be done with one wheel, as indeed can diamond work. However, even with straight knurling, it is as well to use a caliper type tool with a pair of wheels. To reset the knurl, apply the wheels with very light pressure to the work and they will fall back into the original pattern. Whilst this will work for making a pattern deeper, it is not



WHEEL PIN, 2 off SILVER STEEL HARDEN & TEMPER (STRAW)

PIVOT PIN 2 off SILVER STEEL

inevitable difficulty with this type of tool is the fact that the arms swing in an arc and so only line up on the work over a short range of diameters. Even so, it is an ideal tool where one wishes to make a number of components and the toolpost is required to hold turning tools, it not being desirable to remove the setting in order to knurl the work.

The taper

The taper speaks for itself. Obviously it must fit the lathe, but the section that fits the tool can be varied according to the work required and perhaps the diameter of metal available. Those who are not happy at turning tapers can buy blank arbors which can be used. Short tapers are not at all difficult. If the lathe does not have a taper, then a parallel shank could be made to fit a drill chuck.



The body

This is made from a piece of mild steel bar stock, and is quite hefty in order to give good support. It should be marked out to take the arms and for the hole which the taper will fit in. The two small holes can be drilled and tapped first, and then the piece mounted in the four-jaw chuck and bored to size for the taper. Afterwards it is rounded off for the sake of appearance.

The arms

These are made from mild steel bar and can be marked out individually. They should be drilled first and then the two slots cut. When this has been done these too can be shaped.

The pins

Four pins are required, two of which are for holding the bars to the body. These can be of mild steel and they should lock up in the threads in the body in such a way that the arms will pivot without any end play. The other two pins, for the knurling wheels must be made of silver steel. They must be hardened and should be tempered to blue—they must not under any circumstances be left soft.

Adjuster

This is also of mild steel. The arm itself

Two views of the tailstock knurling tool designed and made for MEW by Stan Bray. Actually, this one was designed for lathe turret use; the drawings show a tailstock alternative.

will hardly need any explanation but the rounded ends are important as they allow the movement of the arms as the adjuster is altered. Finally, a spring is fitted to push the arms apart as the screw is unwound.

It has already been pointed out that knurling tools come in a considerable variety and so that this article includes two other good designs by Don Urwin, one being a hand knurler of particularly useful design. We are also including a design by Allan Mackintosh. A man with long experience, Allan has given a great deal of thought to the matter. In spite of the fact that under normal circumstances a tool of the non-caliper type applies a lot of pressure to the lathe bearings, Allan's design is of this type but manufactured in such a way to prevent too much pressure being applied.

Stan Bray



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A 'UNIVERSAL' KNURLING TOOL

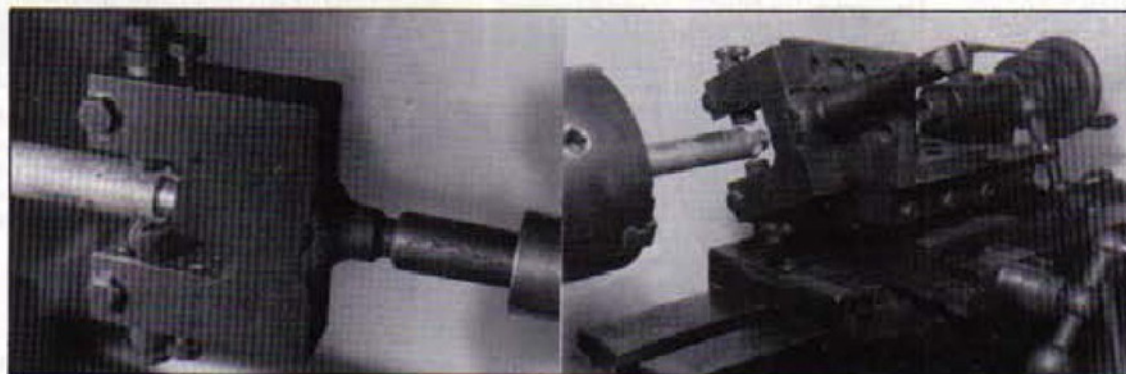
During the last war when I was a young man in charge of the machine shop of a scientific instrument-making factory we had to produce

thousands of knurled knobs of many types and sizes on capstan and turret lathes. What is more, the resident Ministry of Supply inspector was a stickler for good quality knurls, both diamond and straight, which he used to examine with an eyeglass!

We could not tolerate producing scrap so had to find a reliable method whereby the unskilled operators we had could make

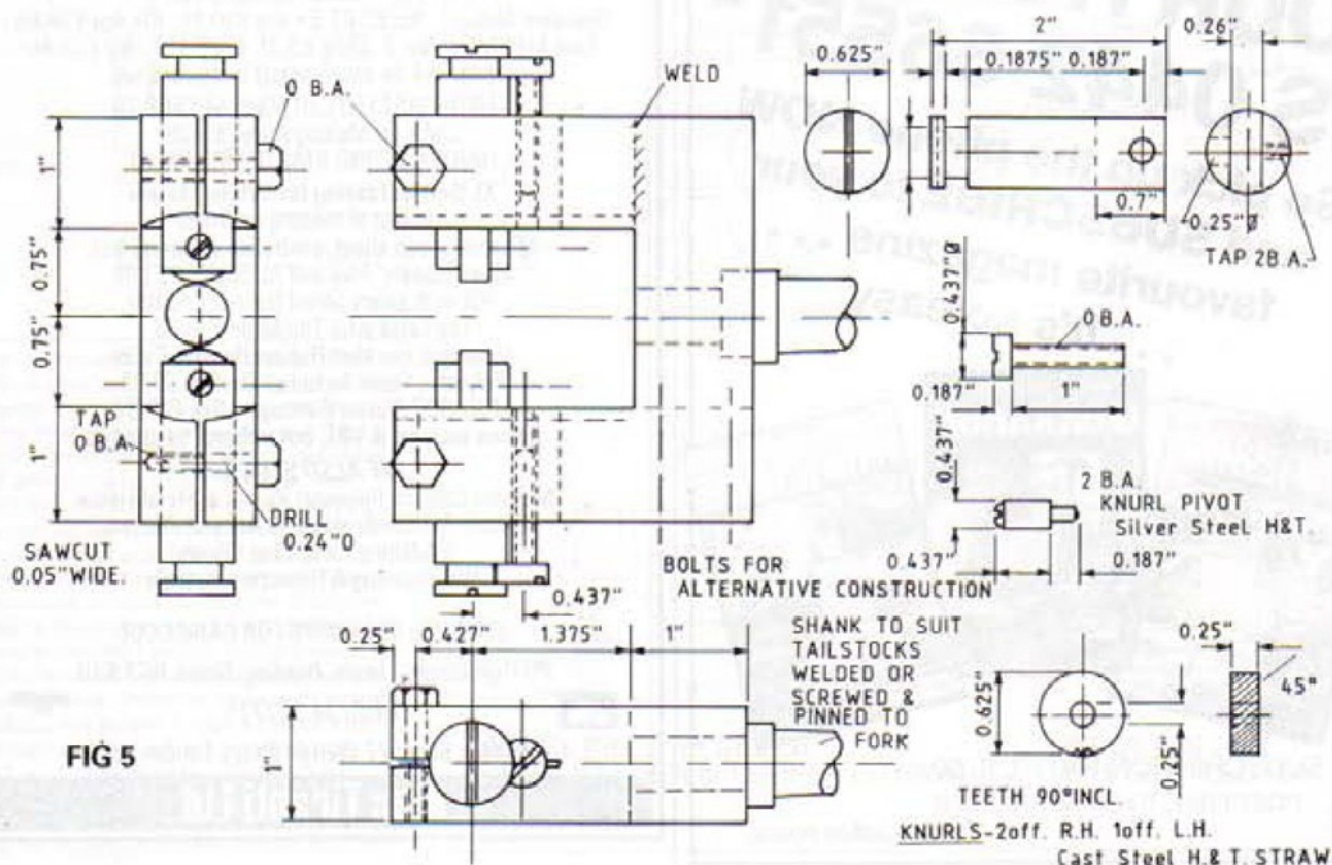
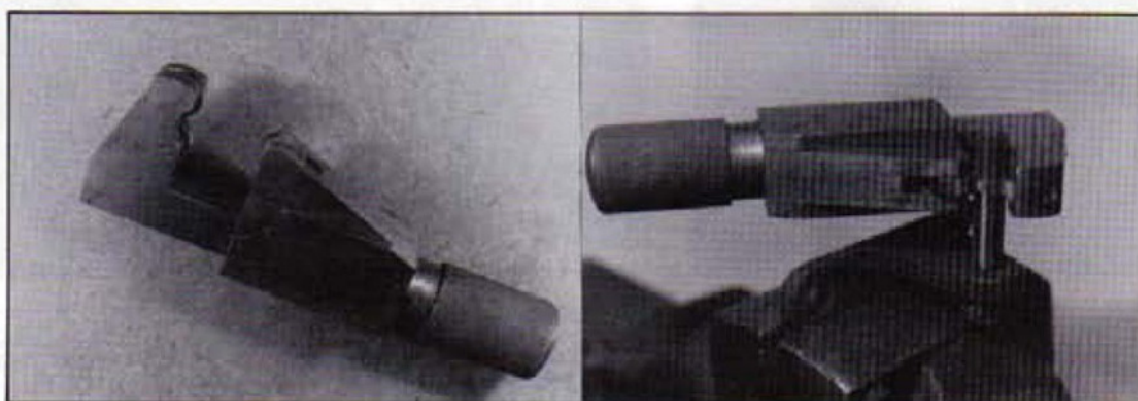
good knurls without any fuss. My guide at the time was a book which I had obtained from Alfred Herbert Ltd. called *Turret Lathe Work* and in it were described two devices suitable for capstan or turret lathe use.

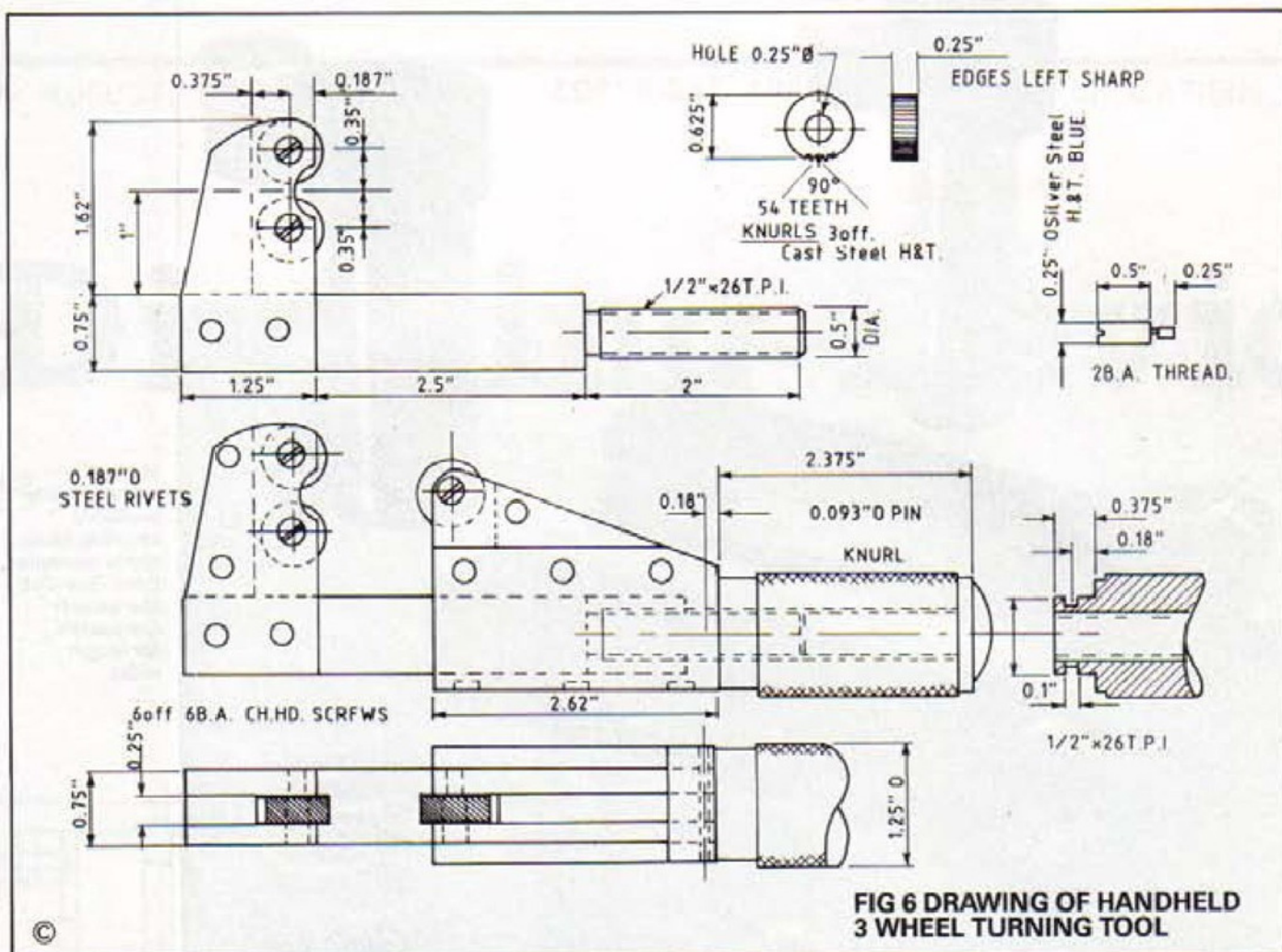
We were unable to obtain any quickly, so I had one of the 'Universal' type made in the toolroom (I also looked after that department so it was easy to organise!). The big advantage of the tool is that the



Far left: 'Universal' knurling tool Fig. 1. Shown here mounted in the tailstock. Left: Fig. 2, same tool this time mounted on the top slide.

Right: Fig. 3. Three wheel left-hand knurl. Far right: Fig. 4. Knurling a component which cannot be rotated.

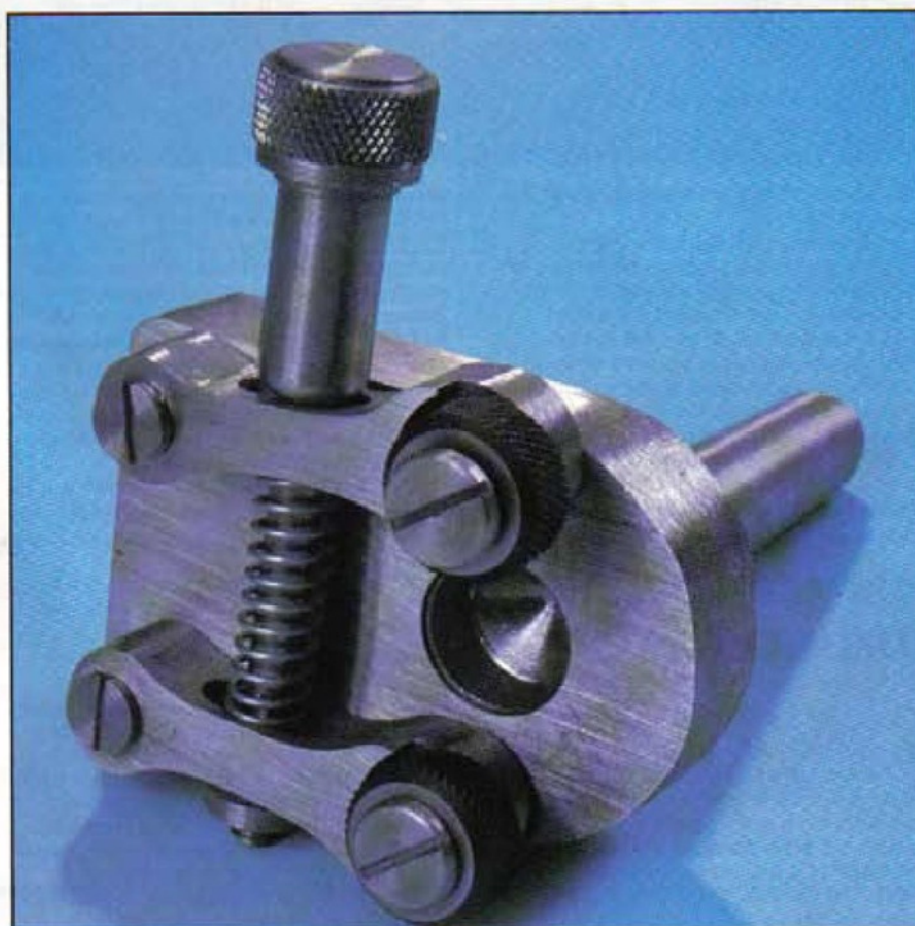




wheels are straightcut and by adjusting the angles of the two wheels, knurls of any diamond angle or straight can be produced with ease. This device produced consistently good quality knurls, running the machine at about half the normal turning speed for the material and keeping the work well lubricated.

These tools were so successful that we made several more, producing many thousands of knurls during the war years and in the following peacetime production.

Later on in the war period I made some batches of small tools in my father's home workshop, selling them and giving the money to the company food parcel fund for employees on active service. One of the tools I made was an automatic centre punch like the Starrett pattern, making a batch of about a dozen. The body, cap and punch end, each a mild steel component, all require knurling, so I made a similar tool, the Herbert 'Universal' design with a No. 1 Morse taper shank to fit the tailstock of Dad's 'Reimac' lathe. As the wheels are straightcut they were easily made of tool steel on the lathe using a milling spindle and a change wheel as a means of dividing. Incidentally, the corners of the wheels are left sharp not chamfered. Figure 1 shows the tool. Unfortunately, when I came to make the punch body, the fork of my knurl frame was not long enough so I had to mount it sideways and bolt it to an angleplate clamped to the topslide. In this



Stan's neat little tailstock/turret knurling tool.



Various commercially available knurling tools, these examples from True-Cut; the wheels are coated for longer wear.

way any length can be knurled. **Figure 2** shows the set-up.

In the course of their daily work scientific instrument makers often have to make their own special knurled surfaces. The most popular amongst the skilled chaps was a handheld tool rather like a three-wheel pipecutter but with skewcut knurling wheels instead of sharp cutting wheels. The tool was, I believe, made by Mauser or Lorch in Germany before the war. The ease with which they produced good knurls impressed me so much that I made my own, shown in **Figure 3**. The

usual way to start is to swing the tool backwards and forwards whilst gradually tightening it onto the work, with the lathe stationary, until a full knurl is reached. The machine is then started and the tool pushed sideways by hand. Speed about half that for normal turning. I do not usually apply any lubricant other than oiling the wheels in their forks. One of the advantages of this tool is that knurling can be produced on a component which cannot be rotated in the lathe as **Figure 4** shows.

I still use both tools but as the three-wheel device needs no setting up, it is

much quicker for one-off jobs. The 'Universal' type is better when making several parts of the same diameter.

I very rarely get poor knurls from either device but perhaps I'm just lucky!

For the benefit of readers who may like to make similar tools, I include in **Figures 5 and 6** drawings of each type. The fork of the 'Universal' knurl can be welded as in my case or bolted together.

The hand knurl is built up of $\frac{1}{4}$ in. and $\frac{1}{2}$ in. bar mild steel sandwiched together and riveted.

D. J. Unwin

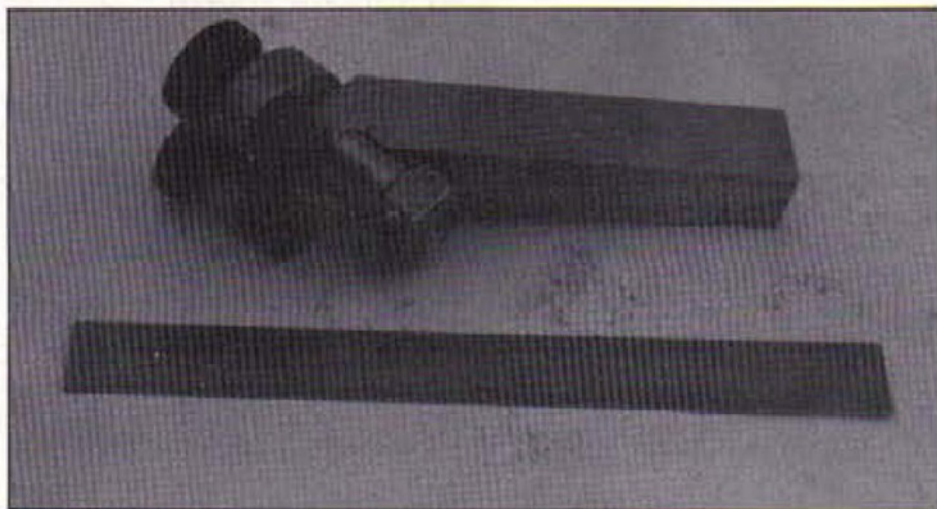
AN IMPROVED KNURLING TOOL

In the early '60s I was employed as a tool inspector by a very large (and high-tech) engineering firm which could make anything, literally, in the engineering line provided that it was expensive enough - the result was that about the only institution that could afford us was the Government!

One day, a 'first piece' was brought to me for inspection and I was struck by the beautiful knurl on the piece; I was sufficiently interested to go to the lathe operator and ask him how it had been done. He showed me a knurling tool made by the 'Quick' Engineering Co. It is a rather complex tool and at the present time it costs in the £200 to £250 range and is thus beyond the budget of most amateur machinists. The tool cuts rather than rolls the knurl into the metal and so exerts much less strain on the lathe than a normal knurling tool and, in addition, it produces much clearer knurls.

The ordinary knurling tool is advanced straight into the work from the topslide and is then traversed from side to side until the full knurl is produced; this works well in a heavy lathe and with a copious supply of coolant to carry away the swarf, but exerts a heavy strain on a light lathe such as is usually found in an amateur workshop. The caliper type of knurling tool is floating and so does not exert strain on the lathe but again there is the problem of carrying away the swarf as this is likely to be rolled into the knurl produced, spoiling the finish.

The 'Quick' tool cuts the knurls with the corner of the knurl wheel and so the



Reader Allan Mackintosh's improved knurling tool, described below.

problem of carrying away the swarf is much easier and, in fact, if a blower is used while cutting the knurl, this is quite sufficient to clear swarf and coolant is not necessary at all.

Later, I was in charge of a small instrument shop and (as I did not have to pay for it!) I ordered a 'Quick' tool for the shop. The tool, as is usual for diamond knurls, employed two knurl wheels and closer inspection showed that the tool had a micrometer arrangement to set the knurls at different spacing for different diameters of work. For the first week I religiously used this arrangement but then it occurred to me to question the necessity for altering the space; I set the tool to a medium spacing

and used it like this for the next two or three years - the combination and extra expense of the tool was quite unnecessary!

For a number of years I have had a Marico caliper type knurling tool in my home shop and, within its limitations, it has proved very satisfactory but there remains the difficulty of clearing away the swarf as a strong jet of coolant is too messy for me. It occurred to me that it would be possible to make a simplified form of the 'Quick' tool.

At first I thought that I could use a rocking motion to equalize the knurl wheels such as is found in the ordinary knurling tool, but I found that the pressure exerted by the cutting action of the knurls was

insufficient so I then redesigned the tool so that I could lock the knurls in a fixed position - I use the tool in a block toolpost so once properly adjusted, the tool goes back into the same position.

The drawings, I hope, make the parts of the tool clear; one point should be noted; the assembly drawing is from the bottom of the tool but the direction arrow for the feed should make its position in the lathe clear (it might feed satisfactorily in the other direction but I have not tried it - if I get something to work in a certain manner, I tend to stick to it!). The following notes may be of use:

(1) The shank is from $\frac{5}{8}$ in. $\times$ $\frac{3}{4}$ in. mild steel. Might be better from $\frac{5}{8}$ in. square mild steel as this would give room for a locking dowel pin in the assembly.

(2) The knurl plate is from $1\frac{1}{2}$ in. diameter mild steel (which happened to be on hand), but $1\frac{1}{2}$ in. diameter is more likely to be in the maker's workshop and this would do just as well provided that the dimensions from the centre are held and the $\frac{5}{16}$ in. dimension also held to give clearance to the knurls (the knurls used, by the way, are $\frac{5}{16}$ in. diameter). The $\frac{3}{8}$ in. holes should be a close rotational fit.

(3) The knurl spindles should be a close rotational fit and should be hardened and tempered and the nuts and locknuts should also be hardened and tempered.

(4) The knurl washers should be hardened and tempered and are needed to give clearance for the knurls.

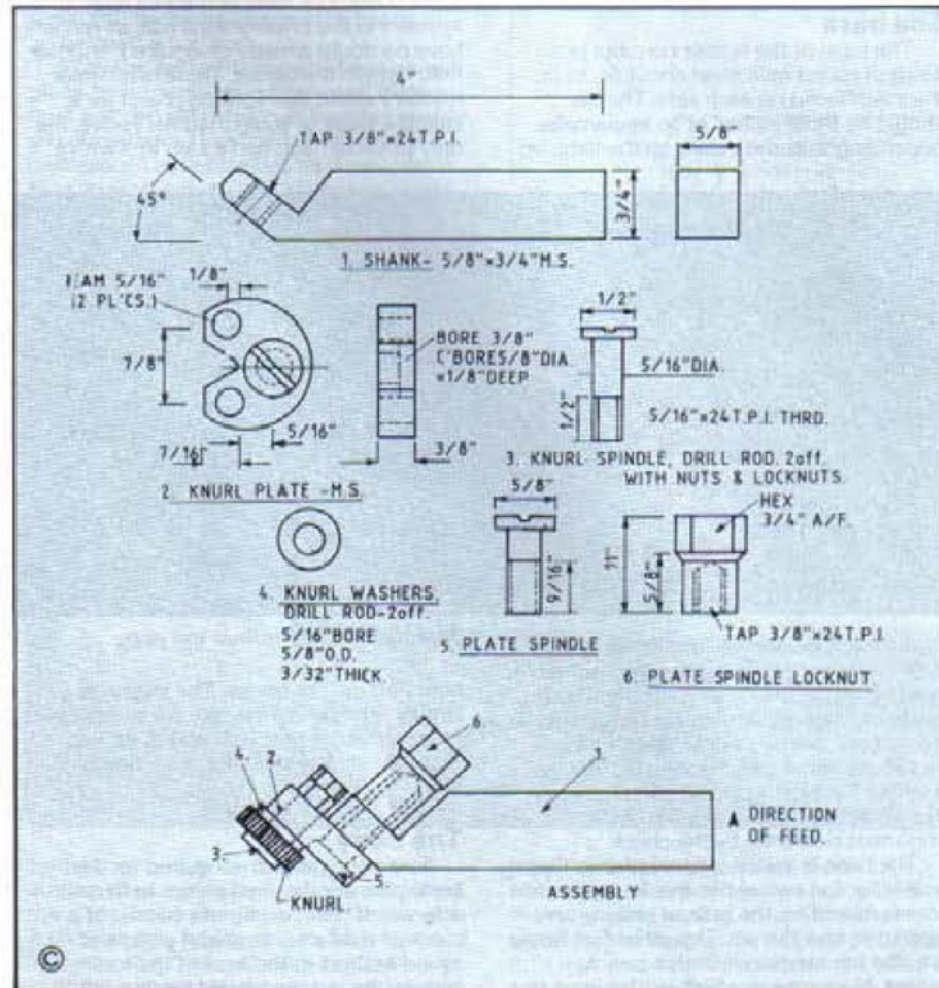
(5) The plate spindle must give very positive locking action to the plate, hence the rather massive locknut (No. 6). I would have liked to put in a dowel pin to lock it, but this was an afterthought and, as made, there is no room for it.

General

I thought that I could get away with the normal rocking action of a pressure knurling tool to equalize the knurls - I was wrong and it did not work. The present assembly is tricky to set initially; I use it in a block toolholder which brings the intersection of the knurls approximately on centre. To set the tool, I brought the knurls into contact with the workpiece and locked them there - I found that the slight give in the assembly upset the equalizing of the knurls, so I set it a little above centre. After some trial and error I got it right and it now cuts evenly and gives very much better knurls than a normal knurling tool. Once set properly in a block toolholder, it goes back in exactly the same position.

The tool is operated using the power feed and the operation done in one pass with a jet of air from my compressor to ensure swarf clearance. My original thinking was to use the approximate pitch of the knurls (these are 1mm) so I set the lathe to 26 threads per inch (too lazy to set up my metric change gears) but this did not work and made a mess. I then set the lathe to fine feed and it worked to perfection - the knurls feed themselves into the grooves automatically although they are exerting a cutting action (don't ask my why, because I have not thought this out). Another mistake in my thinking was that since the knurls do their work in one pass, they should be fed in the depth they are cutting (i.e. $1\text{mm} \times 0.707\text{sq}$); not so - they should be fed in about double this depth and work well like this.

Allan Mackintosh

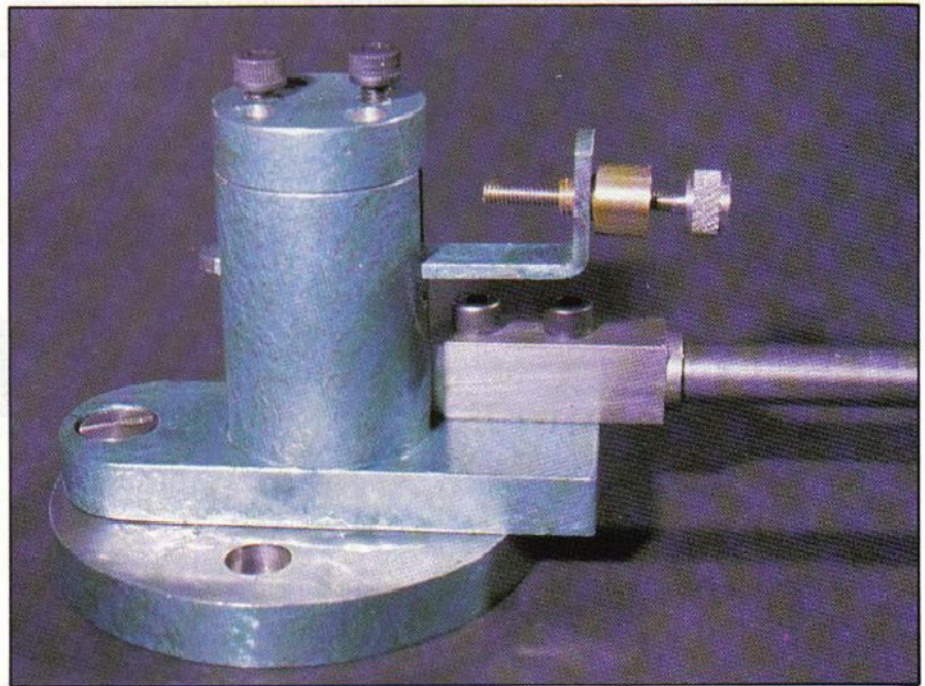


Frequently there is a need to turn radii when making workshop equipment and this little tool will deal with the problem. It can easily be made from scrap materials

There are many ways of making radii when using a lathe. The easiest way by far, where a small radius is required, is to make a form tool and just run that into the work. For larger areas we need other methods and it is usual to use a turning tool in a special form of holder.

It is possible to make radius tools that will make both inside and outside radii. These however need some form of slide arrangement, and whilst no doubt at a later stage such an item will be described in the magazine, at the moment it is proposed to concentrate on a very simple holder that is easy to make even by a complete novice.

Right, the completed tool; simple to make from stock material.



A BALL TURNING



The base of the tool; ignore the central hole — it just happened to be in the scrap material used!

Requirements

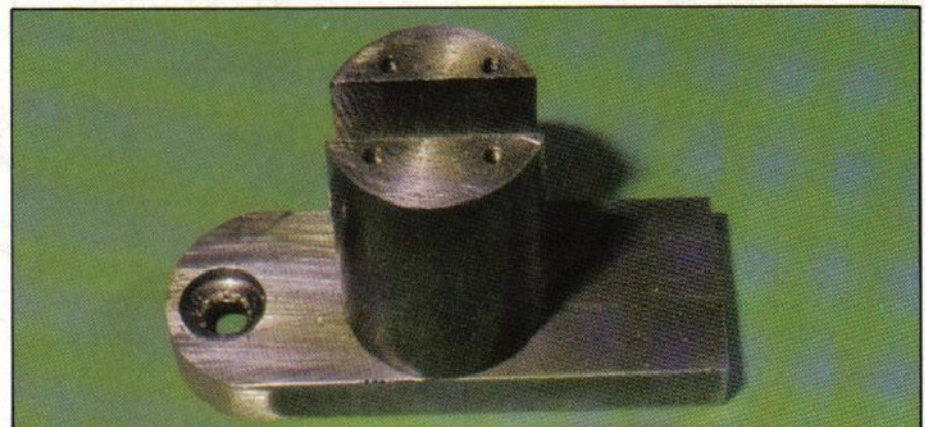
Any simple tool will have to be hand operated and, providing care is taken, this is no great problem. As with all turning operations, the tool must be set at centre height for the best results. As it is to be rotated about an axis, the cutting edge or point too will need to be correctly set to line up with the centre of that axis. This means that the tool used will have to be carefully ground, and it may be desirable to allow the holder to have some sideways adjustment for lining up purposes. There is also a problem with the tool being likely to catch the chuck as it is moved round and so the tool will need as much clearance here as possible. As no slide is to be included, the adjustment of the tool point or cutting edge will have to be made by moving the tool in and out of the holder. This has two effects. Firstly, there will inevitably be some lack of rigidity in the tool. Secondly, fine adjustment will be difficult. The latter we

can take care of to some degree, the former is not so easy and once again it must be stressed that cuts will have to be small to make up this loss.

The base

The base of the holder consists of a piece of round mild steel about $\frac{3}{8}$ in. to $\frac{1}{2}$ in. thick and faced on each side. The bar should be three inches or so in diameter, depending to some extent on the lathe on

hold the device on the cross slide. These sink below the surface of the base and allow the holder to rotate easily. Obviously, all burrs must be well cleaned off on all three holes. The base of the tool that appears in the photographs has, as readers have no doubt already discovered, another hole right in the centre. There is no great mystery about this: looking round for a suitable piece of scrap material to use, the only piece to hand had a step in it with a



Completed body minus the cap.

which it will be used. Readers may wonder why round section is used, surely square or rectangular would do as well? Rightly so. Metal of these sections would work but the round base has two advantages. Firstly, it provides a good bearing surface with the minimum overhang of the holder at any one time. Secondly, it helps provide that all-important clearance by the chuck.

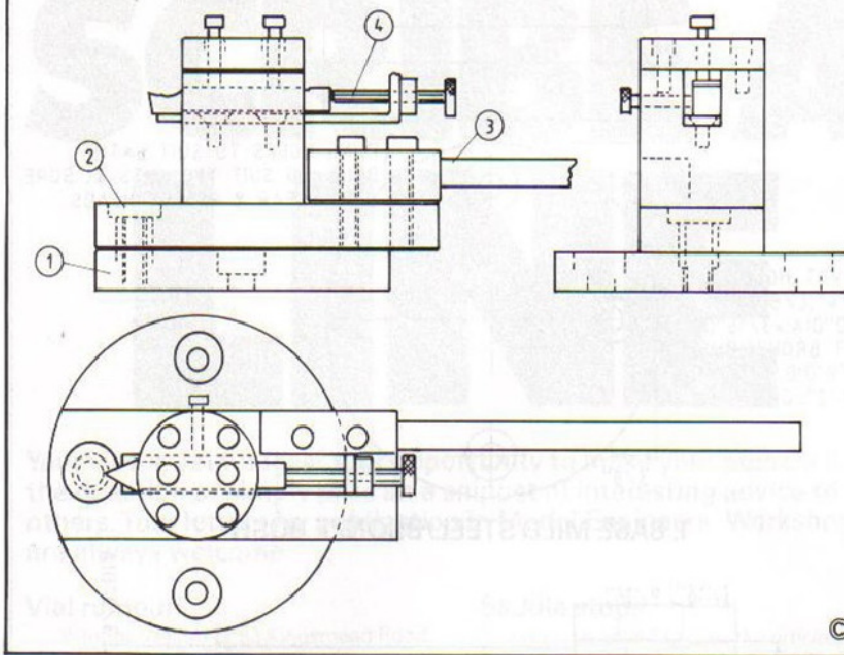
The base is drilled in three places. One hole is for the swivel pin, this is counterbored for the bronze bearing and tapped to take the pin. The other two holes are also counterbored, in this case to accept Allen screws which will be used to

hold the device on the cross slide. These sink below the surface of the base and allow the holder to rotate easily. Obviously, all burrs must be well cleaned off on all three holes. The base of the tool that appears in the photographs has, as readers have no doubt already discovered, another hole right in the centre. There is no great mystery about this: looking round for a suitable piece of scrap material to use, the only piece to hand had a step in it with a

The body

Two main parts are required for the body plus another two pieces to fit on afterwards. The main parts consist of a piece of mild steel strip and a piece of round section. In the case of the tool shown, these are screwed together but

RADIUS TURNING TOOL



QUICK TIP

When filing mild steel, files quickly become clogged. They also pick up slivers of the material which mark the work in such a way that it is difficult to get a good finish. Before starting, clean the file and rub neat cutting oil over it. This improves the work and prevents clogging.

the pilot screw and on the bottom face to accept the part of the bearing that will stand proud of the base.

Tool adjuster

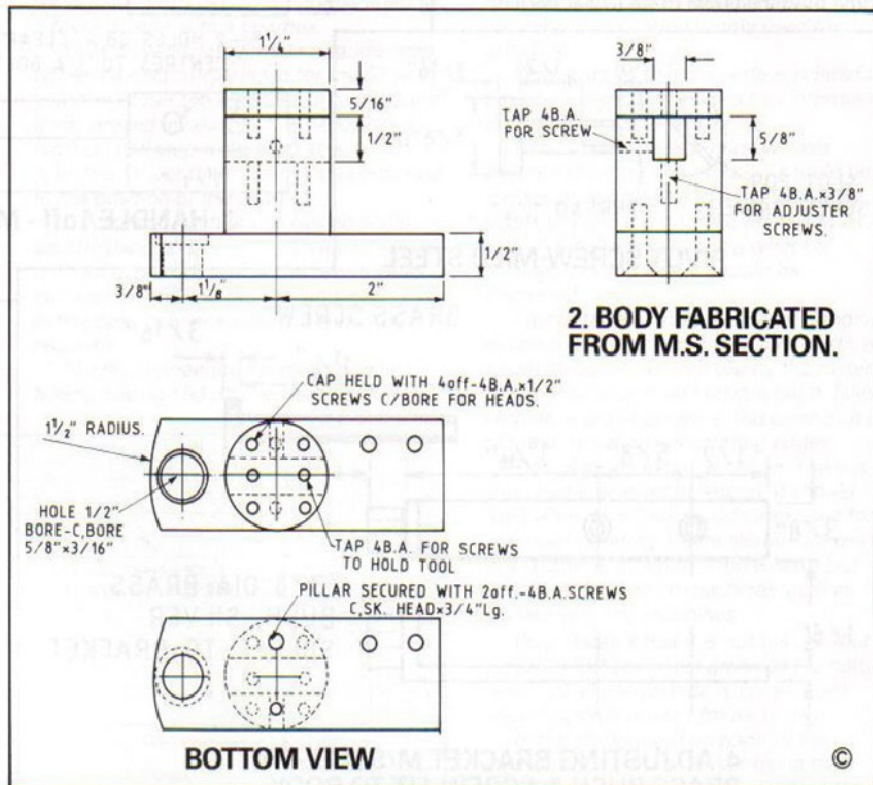
The tool adjuster is a strip of mild steel. Drill it tapping size for the screws which will hold it to the body and then pass these holes through to the body in the same way that the holes were passed through from the cap. Tap the holes in the body slot, and open out those in the adjuster to clearance size and countersink them. Drill and tap a hole in the end and then bend that end up to ninety degrees. The bush that takes the

TOOL

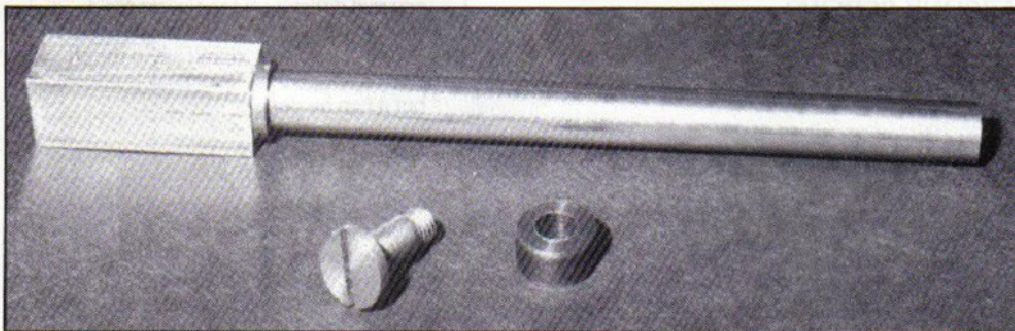
they could be brazed if one so wished. Originally it was thought that three screws would be needed to screw the parts together but two have proved quite satisfactory. Cap screws were used and again counterbores allowed the heads to go below the surface.

With the two parts together, get a small piece of the same round bar used for the post and drill six holes in it. Four are shown as counterbored but this is not entirely necessary. These four will be used to hold the cap on the post, the other two to hold the tool in position. To pass the four screw holes through to the holder, drill the cap first of all tapping size for the screws chosen for the work. Stick the cap to the body or holder with cyanoacrylic adhesive, and spot through. A sharp tap will remove the cap, and the holes can be drilled into the body and tapped. Those in the cap can be opened out to clearance size.

The slot for the tool can now be milled. Note that it needs to be deep enough for the adjuster to be screwed in, and do not



2. BODY FABRICATED FROM M.S. SECTION.



The pivot screw and bearing photographed with the handle; shape of latter is up to the individual but it must not be so long that it imparts too great a leverage.

forget to allow for the height of the tool-cutting edge that is likely to be used. When the slot is cut, just make a mark in line with it on the bar to which the holder is screwed. In theory this mark, which is exactly in line with the tool centre, should be used as the

point for the pivot. However, if we move it across just a fraction, we can gain a little more valuable turning space near the chuck. When the position is sorted out, the hole is drilled clearance size for the pivot and counterbored on the top face to recess

adjuster screw is threaded in and then brazed or silver soldered into position.

The adjusting screw is made from mild steel and the knob knurled for convenience of making adjustments. These are done by releasing the tool and winding the adjuster.

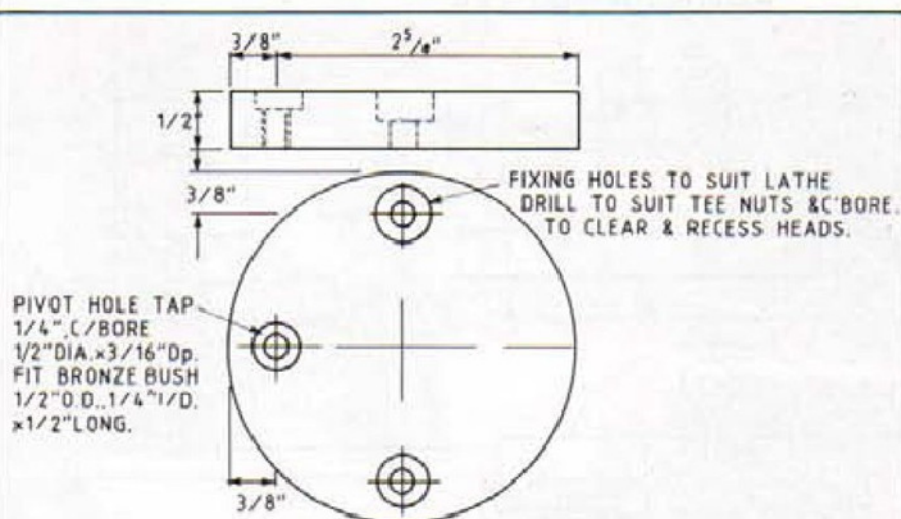
If it is a case of increasing the circumference, then the tool must be pushed up against the adjuster screw each time. Somewhat primitive but better than the more usual arrangement of simply undoing the holding screws and moving the tool in and out by hand with no form of register.

The handle

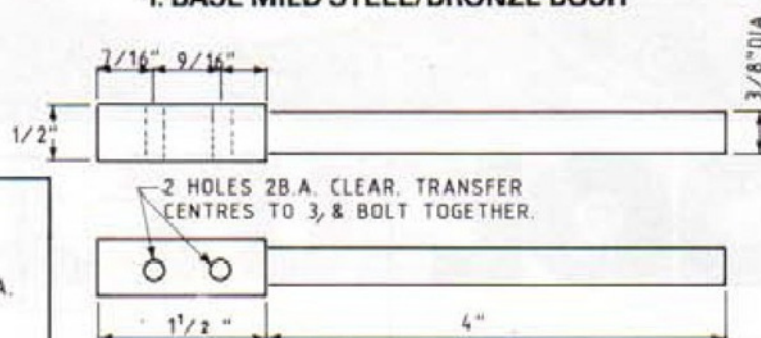
The handle shape, etc, is really a matter of personal choice. It must not be too long as we do not want to apply too much leverage. It will be seen that it is situated on one side of the tool; this helps a little with clearances when the tool swings towards a chuck, and should ensure that fingers do not get damaged. Some readers may wish to set the handle at an angle to raise it, others will be happy to leave it at a lower position. As the tool is only going to be used occasionally it probably matters little which way it is done.

Using the tool

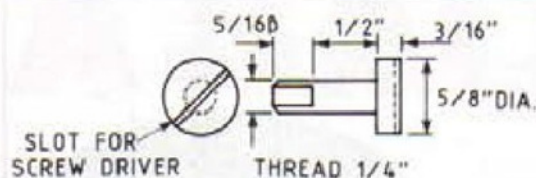
It is well to rough out the shape and size of the ball to be turned using the cross slide before using the ball turning tool. In fact, some machinists can make a near perfect



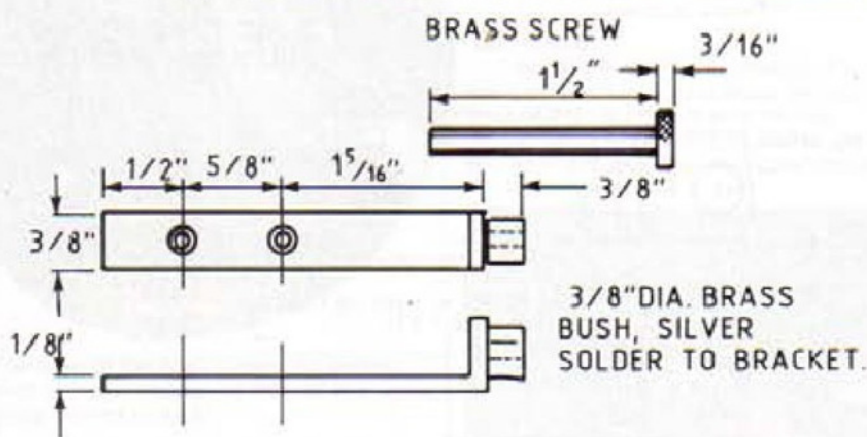
1. BASE MILD STEEL/BRONZE BUSH



3. HANDLE 1off - MILD STEEL



PIVOT SCREW-MILD STEEL



4. ADJUSTING BRACKET M/STEEL-FIT BRASS BUSH & SCREW. FIT TO BODY WITH COUNTERSUNK SCREWS.

ball shape by simple arithmetic and adjustment of the cross slide. Once some semblance of a ball has been reached, then start using the holder. The actual tool should be more or less knife shaped and, because the post is offset from the pivot, must be ground slightly on the side. Set the cutting edge just clear of the material and carefully swing the tool slowly round to find the spot where it is closest to the metal. Start at that point with the actual cutting and go carefully, do not force things. The tool can be adjusted to allow for it to cut a greater area each time.

It will not be possible to go right round the material of course and, as a rule, one will not require the ball shape to leave the parent bar. It should however be possible to complete the ball up to this point without any real difficulty. If for any reason a complete ball is required, the material will have to be parted off and set in the chuck for finishing - a far from easy proposition but it can be done.

Refinements

At the beginning it was suggested that some sideways adjustments for the tool could help in getting it on centre. This can be achieved by simply drilling and tapping four holes (two on each side of the slot) in the body. Small grub screws can be used to move the tool sideways and line the cutting edge up with the centre. This means the slot will need to be cut a little wider than the proposed tool. This adjustment certainly has much to recommend it, and can be an aid to better machining. The grub screws also help to make the tool a little more rigid.

QUICK TIP

When drilling a hole which partially breaks out into a cross hole, for example, problems occur as the drill is pulled off axis, or even breaks. This can be avoided by replacing the normal drill just before breaking through by one of the same size sharpened with flat cutting edges as in the photograph. Proceed with drilling carefully until full diameter has been reached again then replace the original drill. To get the end square with the drill axis, stand it on a plate and check with a set square. It is useful to build up a collection of various sizes sharpened with flat ends so that one is to hand when needed.

Don Unwin



SCRIBE A LINE

Your views, your pages! Your opportunity to make your point, ask the question or simply pass on a snippet of interesting advice to others. Your letters for publication in *Model Engineers' Workshop* are always welcome

Vial rumour!

Anthony Walton of 62 Kingsmead Road, SW2 3JG would be pleased if a reader or readers could assist him regarding his mechanics improved level. Perhaps anyone with information would care to contact him direct.

Are you open to receive letters from subscribers? If so I have one for you:—

Can any reader help? I have a Starrett No 98 series Mechanics Improved Level length 18 inches. I need to make the vial non-magnetic. How does one dismantle the two ends of the vial? They are, of course, eyed stoppers, and made of magnetic steel. Are they screwed in, or brazed, or just a force fit? As the contents of the level are glass, one cannot afford to make mistakes or embark on a dismantling process which would distort the brass tube.

Saddle stops

I was interested to read the article on micrometer stops in the Winter 1990/91 issue stating this device cannot be fitted to a Myford lathe with a gearbox.

Over 20 years ago I made a saddle stop, without a micrometer head for my S7 with gearbox as per the enclosed drawings, and it has proved invaluable. It is necessary to have several stop rods, each about $1\frac{1}{2}$ inches longer than the previous one, due to the position of the gearbox.

It occurs to me that this device could also be used on any of the Myford 7 series without a gearbox where the owner does not wish to drill and tap the lathe bed, and in this case only one stop rod would be required.

Model engineering for me is purely a hobby, having had no engineering training,

but I hope this will be of interest to your readers.

R. G. Shepard
Isle of Wight

Abrasive comments!

Sincere thanks to Richard Brown of Botley for the following information which he sent to us after reading our article on abrasives in the April/May '91 issue.

The article on page 18 of that issue on abrasives contains good information about the use of abrasive wheels, but I would like to comment on the following:

Para. 2 refers to an adhesive holding the particles together. Normally this is referred to as a bond, as it fulfills more purposes than just an adhesive.

Para. 3 refers to three types of abrasive. In fact, in engineering, we normally use only two, aluminium oxide and silicon carbide. (Diamond wheels can be used for sharpening tungsten carbide tools, but these are very expensive.) Aluminium oxide can be used in its raw state, regular aluminium oxide, which is normally brown but sometimes coloured blue or, in its pure form, white and sometimes coloured pink. Reference is made to heating before crushing. The heating is only used for purifying.

Para. 4 states that the code is printed on paper washers. Sometimes this information is printed on the wheel itself.

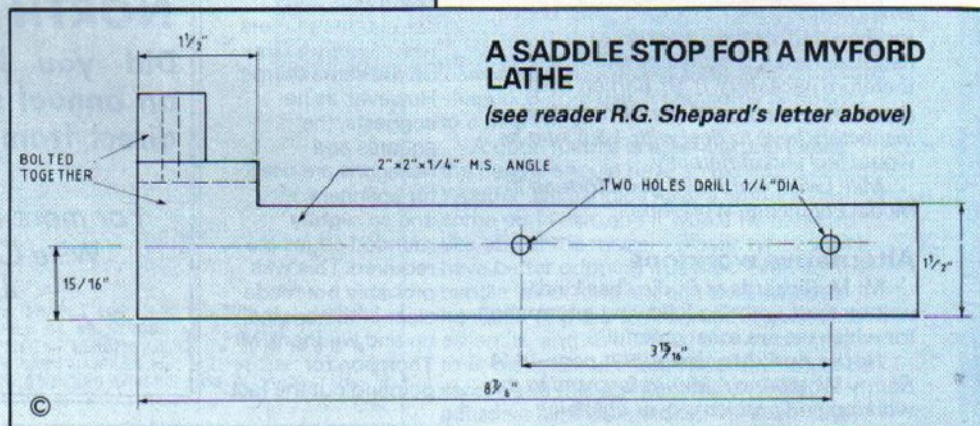
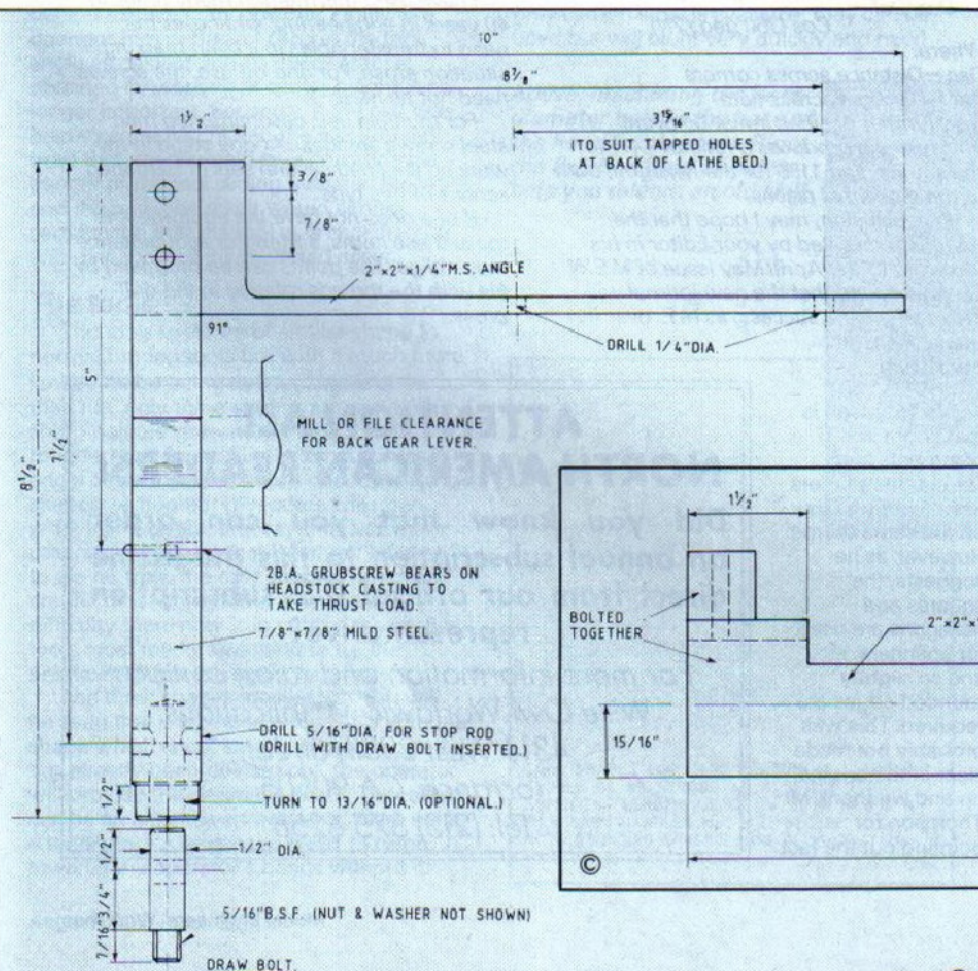
Para. 5 refers to mounting wheels. Before mounting, the machine should be electrically isolated and wheels visually inspected and the ring test only used as a part of the examination. If a wheel is damaged in any way, it should be discarded.

Para. 6 talks of the principle of grinding. In fact the particles of aluminium oxide, a tough abrasive, are torn out by the material being ground as they become blunt. Silicon carbide, a brittle abrasive, fractures as it is blunted exposing new cutting edges.

Para. 8 refers to white silicon. There is no such material as white silicon, it should read white aluminium oxide and used for precision grinding. White aluminium oxide is available in straight-sided wheels but usually only used on machines such as surface grinding machines.

Para. 9 states that it is not the grit that is green. In fact the grit is green as the natural colour of silicon carbide is green. Black silicon carbide is used for roughing.

In the photograph on page 19 the caption should read "At the top is the manufacturer's code and below that the date of manufacture. On the left is the M.O.S., the maximum operating speed, which must not be exceeded. At the bottom



A SADDLE STOP FOR A MYFORD LATHE
(see reader R.G. Shepard's letter above)

is the size of the wheel and below that the standard code for the wheel."

Interpretation of the code on the wheel illustrated is:

B—Brown A—Aluminium oxide
(C would be Silicon carbide)
36—Grit size, roughly 36 per inch. (normal grits for our purpose would be 36 to 80)
P—Grade, A is soft, Z is hard, so P is a hard wheel.
5—Structure, 1 is close grained, 10 is open grained, 5 is mid-range.
V—Bond, vitrified. (R—Rubber, E—Shellac, B—Resinoid.)

To select a suitable wheel the following rules apply:

Abrasive: Aluminium oxide is a tough abrasive used for cutting tough materials such as steel. Silicon carbide is a brittle abrasive used for cutting brittle materials such as tungsten carbide and masonry.
Grit size: Low numbers are used for coarse or rough cutting, high numbers for fine or finishing work.

Grade: A soft wheel is used for cutting hard materials such as tungsten carbide and hardened steel, a hard wheel is used for cutting soft materials such as mild steel and masonry.

Structure: Open wheel is used to carry coolant and remove swarf. Closed wheel is used for fine finishing work.

Bond: Vitrified bond is used for general tool sharpening etc. Rubber bond is used for very thin wheels for slotting. Shellac bond is a cool cutting wheel used for cutting-off silver steel etc.

Resinoid bond is used in reinforced wheels used for grinding and cutting-off with portable machines.

Safety: Abrasive wheels must be mounted on machines designed for them, with paper washers and recessed flanges not less than 1/3 the diameter of the wheel. They should be properly guarded and work rests adjusted as close as possible to the wheel. Resinoid wheels on portable machines are mounted between the small undercut flanges provided without paper washers.

Full information about safe mounting of abrasive wheels can be obtained from the HSE Guidance Note PM22 Training advice on the mounting of abrasive wheels, ISBN 0 11 883568 8, available from HMSO or booksellers, price £2.00. Abrasive wheel manufacturers publish booklets giving information on mounting and selection of suitable wheels.

Finally, I take exception to the remarks Mr. G. Bartlett makes in his letter about the HSE and the Regulations. I am not an Inspector, but over the years have had many dealings with them and working with the many Regulations. As so many employers are not prepared to take action for the safety of their employees, Regulations, enforceable by law, are therefore necessary. If Mr. Bartlett had experience of some of the carnage that Inspectors have to deal with, I am sure he would feel very differently.

May I wish continued good fortune to Model Engineers' Workshop.

Alternative worktops

Mr M. Richards of Dudley has kindly written to us with the following information for which we are most grateful.

Re the April/May issue 1991 page 46 'A Sturdy Workbench'. Your references to the worktop and problems over obtaining

suitable materials, plywood being expensive and rare in strong enough thicknesses. Have you tried M.D.F. (Medium Density Fibre Board)? It is used by the building trade for flooring and construction of stairs (risers and treads). I have a piece 100mm (4in.) thick which was originally part of a shop counter. Thinner section can be obtained easily at the various D.I.Y. Superstores. It is tough stuff, and is lasting well on my bench which is also used for repairing old rusty motorcycles!

Flats by formula

From Mr R.F. Thomson of Paignton, we have a received a letter containing the following comments.

One small item in the April/May issue, did cause me some puzzlement. I refer to the 'Quick Tip', appearing on page 29, which deals with the formation of square and hexagonal cross sections, from circular bar. Whilst the figure of 1.15 for hexagonal sections appears just about right, in fact about 0.4% low, the corresponding ratio of 1.37 for square sections appears to be much more in error, since this is well known to be 1.414, ie the square root of two. In fact, this turns out to be approximately 3% low. On reflection however, I came to the conclusion that the strict geometric basis of calculation has been modified, to produce sections with very small arcs at each corner, thereby providing a measure of clearance at those corners.

However, you might agree, that this could mislead, if some unsuspecting reader were to use these smaller ratios, (particularly for a square), in circumstances where the strict geometric formula should apply. Whenever I wish to produce polygonal sections, with an even number of sides, from round bar, I work to the following formula, if necessary easing the corners afterwards, with a fine file:

$$\text{Dac/Daf} = \frac{1}{\cos(360 \text{ deg./} 2N)}$$

Where:

Dac—Distance across corners

Daf—Distance across flats

N—Number of sides (must be even)

This formula produces a ratio of 1.414 for the square, and 1.155 for the hexagon, both to three decimal places.

In conclusion, may I hope that the optimism revealed by your Editor in his foreword to the April/May issue of M.E.W. continues, and that the new journal will prove as great a success, as M.E. over its many years of publication.

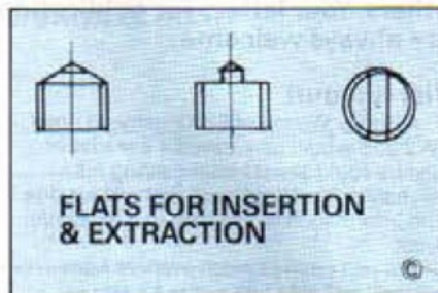
Mr Thomson is quite right in his comments and some other readers have written to us on the same theme. However, as he suggests, the squares and hexagons are used for spanners, etc., and so slightly rounded edges are required. This was probably not made clear in the original tip and we thank Mr Thomson for pointing out the fact.

A locating punch

From Mr Luxon-Jones of Gloucester comes the following useful advice which he sends for the benefit of readers after seeing the article on fitting a backplate.

Having read the article on fitting a chuck backplate, in the April/May '91 issue of M.E.W., I wonder if your readers might find the following a useful alternative to your published method?

1. Take a screw or screws of the same thread as the chuck mounting holes.
2. Cut lengths of thread short enough to screw flush into holes.
3. Place drill chuck and taper socket into lathe mandrel, grip screw thread in chuck and turn a shallow sharp point on it. Repeat on remaining pieces of thread.
4. File a flat on each side of point.



5. Insert screws point out in holes in chuck, with points equally proud of face.
6. Enter backplate spigot into chuck till contact is made with points. Tap backplate with soft mallet or hammer shaft.
7. Remove backplate, which will bear three neat indentations. Centre punch these indentations suitably firmly and one has three accurately located points for drilling. Marking-out fluid, lipstick or similar on the backplate will highlight the marks.

I have used this method many times in 40 years in engineering, whenever the need to transfer holes in a blind marking situation arose. For one-off use, the screws need not be hard.

For multiple use, casehardened mild steel screws are ideal. At one stage in my working life I had several sets of hardened screws of this type.

If one does not have the equipment to make these items, a friend or acquaintance may oblige. The points can be produced by file with the threads rotating in the drill press.

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The art of hand turning is one that is nearly forgotten; however it is a useful skill well worth the effort of learning. The essential need is for a suitable adjustable rest such as the one described here

HAND TURNING

These days the art of hand turning is largely forgotten. Many years ago it was frequently practised with a high degree of skill and with excellent results. Is there, we must ask ourselves, any place for it in the modern home workshop? The answer is yes; for certain operations it can be a most useful method. Small intricate shapes which are difficult if not impossible to complete with the lathe slides, for example, can benefit from the method. There is a tendency these days for such work to be carried out by the operator using files. Using a file in a rotating lathe is highly dangerous, and is to be discouraged. It is also difficult to achieve really good results in this fashion.

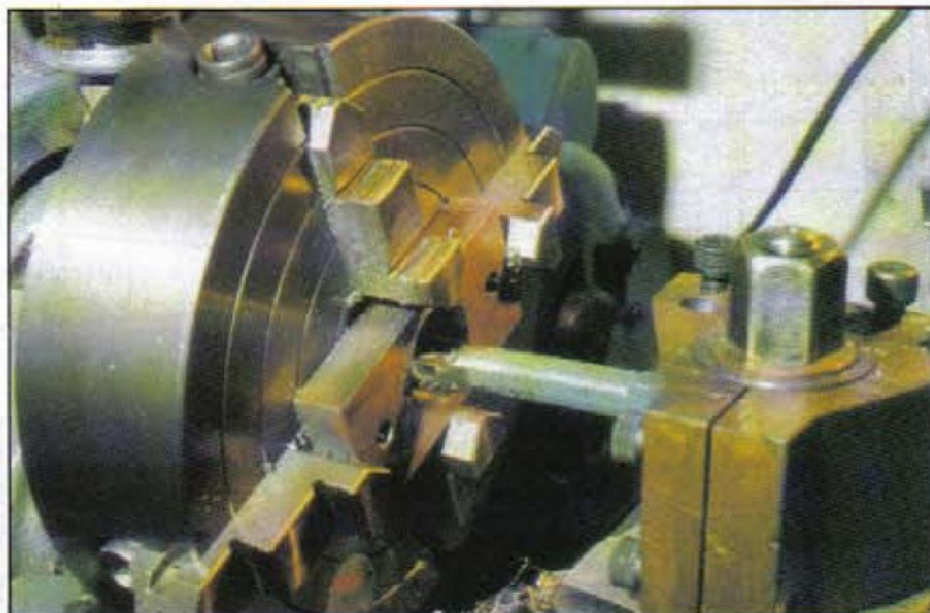
Methods

Hand turning is carried out using long tools resting on a block. The block, not unnaturally, is called a 'hand turning rest' and is usually made adjustable as to the distance from the work and the height at which it will be set. The tools are not only long but have extended handles to allow the operator to get a good grip. They are simply pushed into the work and swivelled sideways as required to obtain the desired shapes. The tool is held at an angle of about forty five degrees to the work and is used above the centreline, the toolrest itself being set to a height approximately at the centre height of the lathe. The reasons behind this are fairly obvious. Firstly, the operator him or herself can set the tool angle as desired and so the clearance obtained by working at centre height is no longer important. Secondly, if the rest was below centre height and the tool worked from that, there would be a considerable danger of the tool sliding between the work and the rest. The result would almost certainly be that the tool was snatched up and damage and injury would occur.

The tools

The tools used are of similar shape to normal turning tools but with a much more limited range being needed. More often than not, only three shapes are required: a sharp pointed graver type tool, a well-rounded tool for making internal curves and a slightly less-rounded one for varying shapes. (A number of readers will now write in, no doubt, and say they use many others!). We accept that the three referred to are far from the only shapes, but they are the most common and with the difficulty there now is in getting the correct tools most readers wanting to try the practice will have to settle for a few...

The three shapes are illustrated. It will be seen that a top relief is included with the shape which is not strictly necessary, as it has already been pointed out, the operator will provide the clearance angle. The relief can be an aid in swarf breaking, there being a tendency for lengths of swarf to climb towards the operator's hands without it.



Buying hand turning tools new these days is almost impossible. Tools are sold for woodturning and if these can be obtained made in high-speed steel then they could be reground for use on metal. If only carbon steel is available, they can be used but will blunt very quickly and need

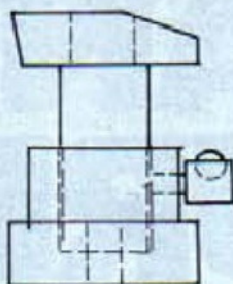
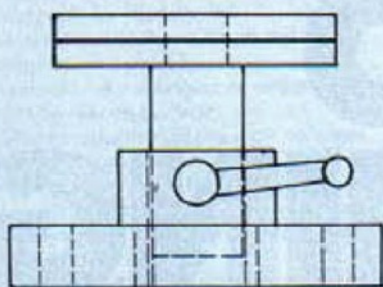
frequent sharpening. Second-hand purchases are possible if one is in the right place at the right time. The alternative is to make one's own tools. They can be made from redundant files in the way that scrapers are. The file should be ground smooth along one edge at least, and then

Above, machining the large diameter hole in the base of the hand turning rest. Right, the finished item all set to help you relearn an old skill.

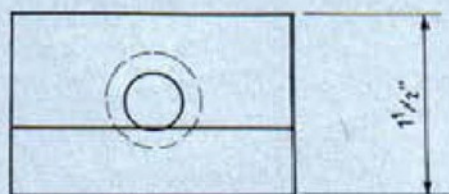
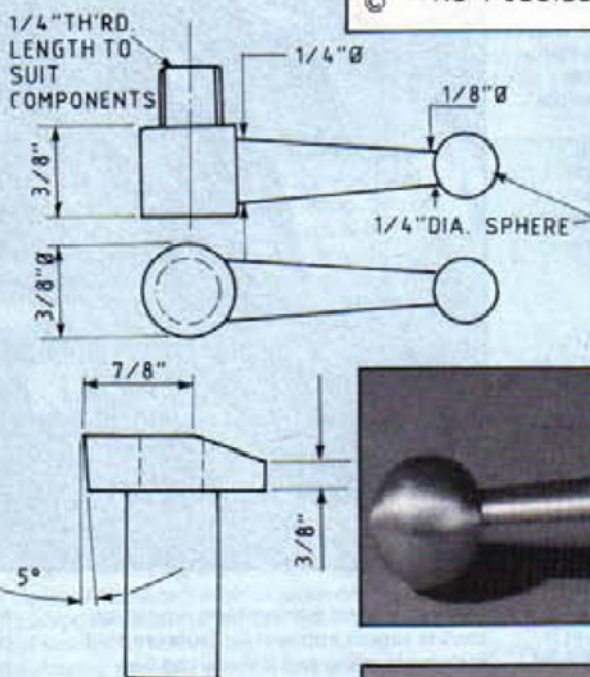
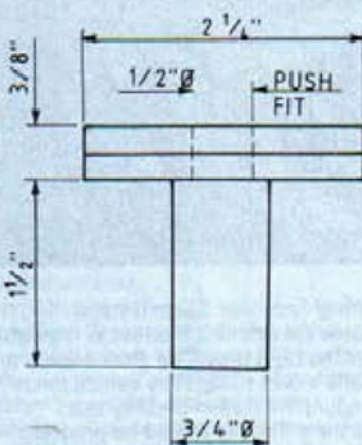


shaped. Before use, it should be tempered to a blue colour.

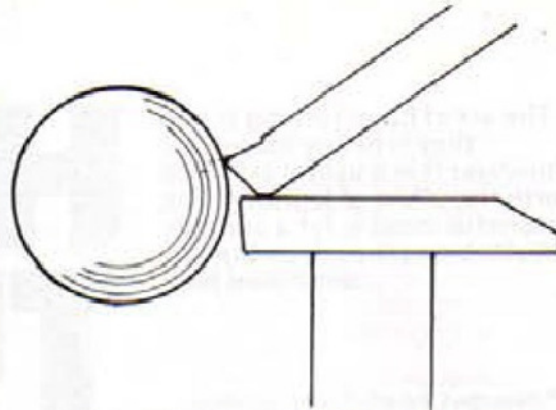
A good handle is essential and ideally the handle should have an extended length. Wooden file handles have a tendency to come off in use, and it would be better to use one of the modern plastic types which have better gripping qualities. Even so, the handle is not long enough to allow both hands to grip the tool, something which is essential, and so a sleeve should be made to fit the lower section. The sleeve must be secure and this can be done with an adhesive such as Araldite. The illustration



HAND TURNING REST



REST 1off-MILD STEEL



TOOL REST AT CENTRE HEIGHT
& POSITIONED AS CLOSE TO WORK
AS POSSIBLE WITHOUT RUBBING

Below, the locking handle prepared for silver soldering. Typists' correction fluid is used to prevent the solder running where not required. Bottom, an upside-down view of the rest; note relieved edge.



shows the method used to grip the tool when in use; although this method is far from obligatory, it is a good safe one and whilst some readers will find other ways, it is worth considering for a start.

Working practice

The lathe should be run at a slower than usual speed and the tool pushed into the work but not too hard. It can be swivelled to make the shape. It is essential that the work is supported with a centre in the tailstock to prevent as much movement as possible. Most hand turning will, no doubt, be done on brass or plastic, and no cutting agent will be needed. When working on mild steel, a cutting oil is advisable, although tallow is a very good alternative and is a little less messy to use. It is fairly

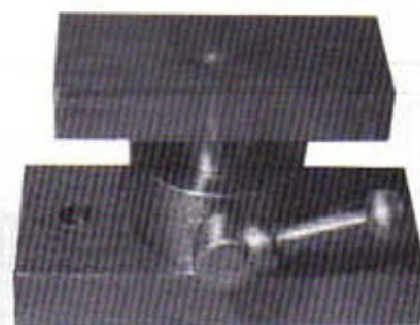
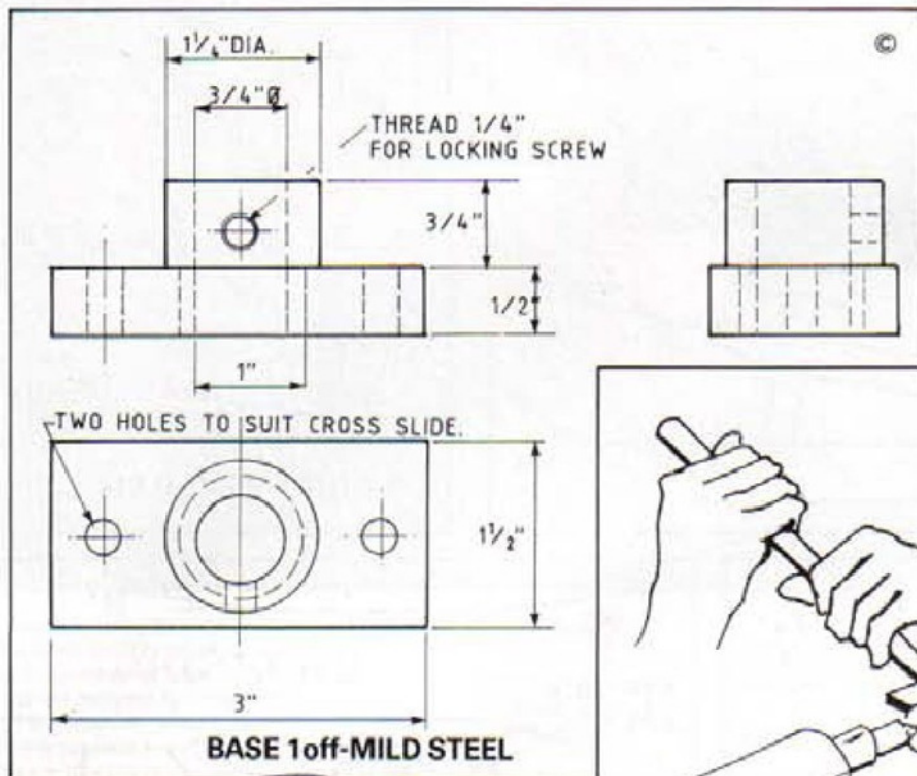
obvious that cuts should be kept as light as possible. One point that may interest readers is the fact that the early craftsmen would frequently use handtools for parting material off. Parting off was an operation always fraught with danger and better control could be obtained by hand, particularly with large diameter materials.

A hand turning rest is described for the benefit of readers. It will be seen that one side of the rest is at an angle of about thirty degrees. At first glance, there seems to be no logical reason for this. It was used for polishing. The angled section was put facing the work, and a buffing stick, which was (and indeed still is) a piece of wood with emery paper stuck on it, was passed under the work for polishing purposes. This allowed a considerable amount of pressure

to be applied and allowed the abrasive to cut into the metal. The operation is still used today by many clockmakers. Under no circumstances should the method be tried using a file, whether wrapped in emery cloth or not.

The toolrest

Hand turning toolrests can be purchased to fit most lathes, but they are very easy and quick to make and can be made from scrap material more or less to suit one's own needs. Ideally they should rest on the lathe bed in order to give maximum rigidity but the one described is designed, in fact, to bolt on the cross slide. With modern lathes, cross slides are remarkably rigid and if, when the handrest is used, the slide is



Finished rest showing adjusting angle.



Two views of the base; note the tapped hole for the locking screw.

tool. This involves heating it and then soaking it in oil. A fairly high temperature would be required and it was thought that if it was held in with a retaining compound this would probably give way when heated. The alternative would be to braze the parts together. Getting a good push fit in this size of material is not difficult and readers are urged at least to have a try. It is a good exercise

in accurate turning and if it goes wrong then brazing or an adhesive can be resorted to afterwards. The holes for the securing bolts must, of course, be made to suit the lathe on which the rest is to be used. The hole for the clamping screw can be drilled and tapped either before or after assembling the two parts. Those with a mind, and the material, to do so could machine the whole base from the solid. There is no need for the upright section to be round and so it could be made on a milling machine, shaper or a lathe as desired.

The rest

The top section or rest is also, in the case of the one shown in the photographs, made in two parts. Here again there is something to be said for making it a single

item. The round section is an easy sliding fit in the base with no discernible rock. Its construction is so simple that no description is needed on how to do it. After it was finished, its top was casehardened. Once again, this rules out the use of an adhesive for holding the parts together, the one in the photographs was made in two pieces and the parts were a push fit.

Locking screw

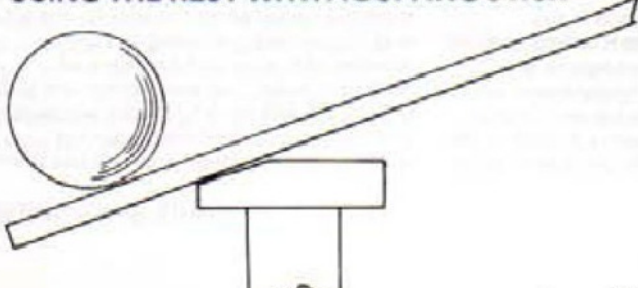
The locking screw should be of brass in order to avoid raising burrs on the column and making it difficult to set the rest to the required height. There is no reason why a large knurled headed screw should not be used. The construction shown looks a little neater and saves on precious large-diameter brass.

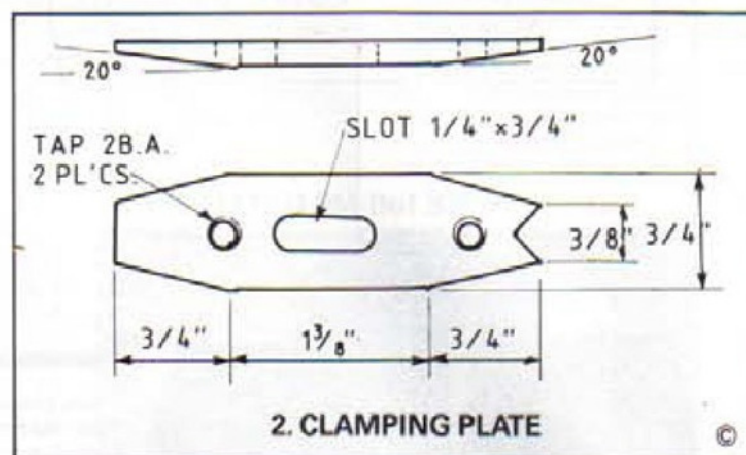
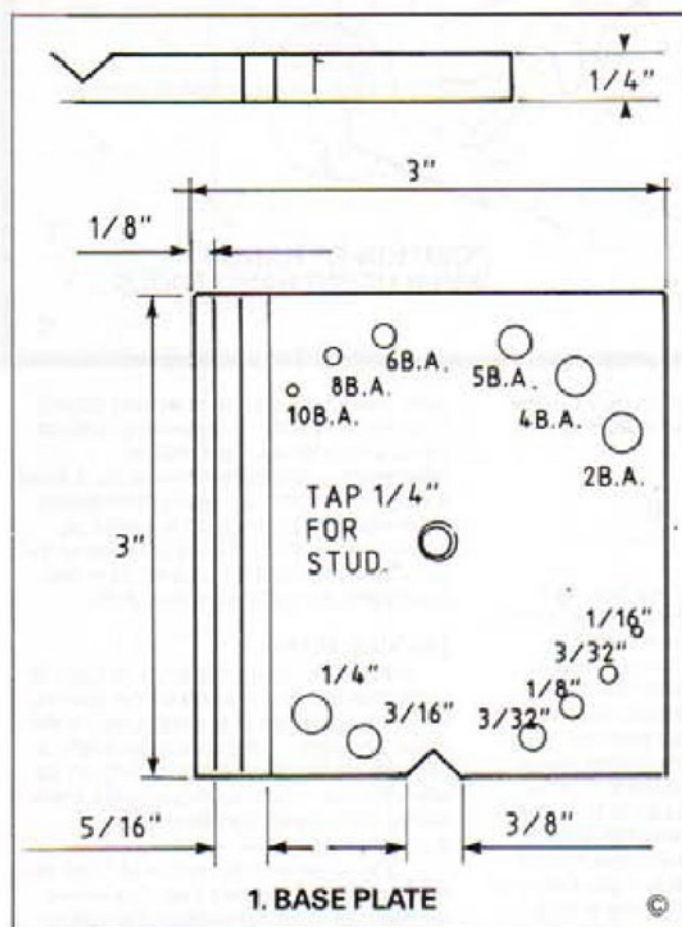
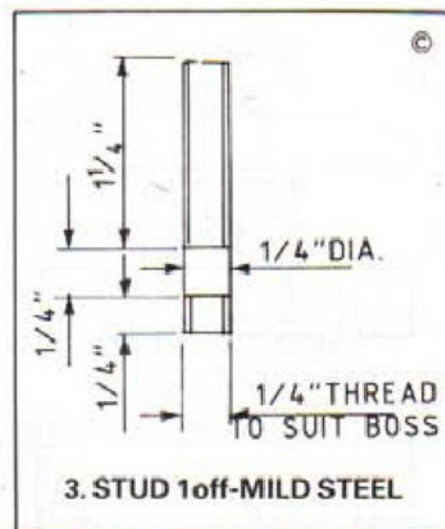
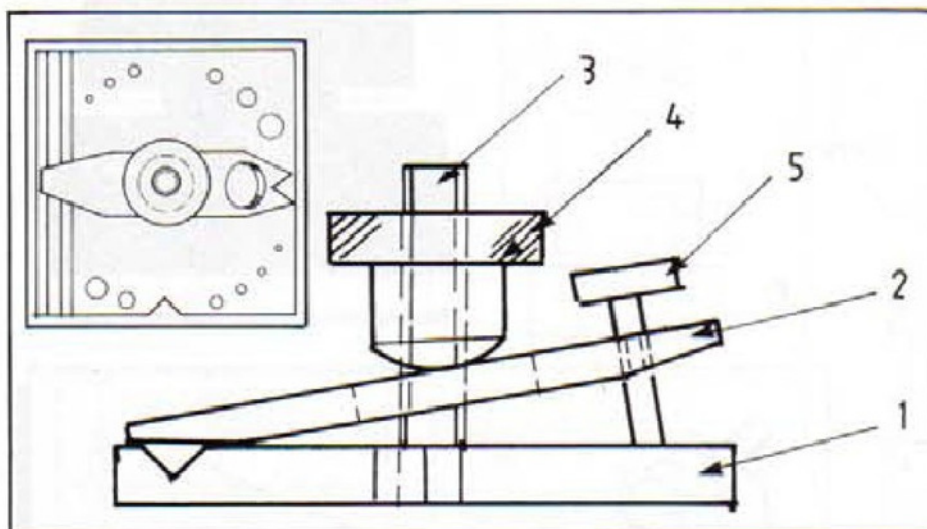
The screw section was made first, and the handle as a separate part. The screw section was hand tightened in the rest so that it held the rest in position. A mark was made in a position that was thought suitable for the handle. Leave a little to allow for compression of the screw which will invariably happen when doing this. The screw was removed and drilled and the two parts silver soldered together.

One problem with silver soldering this sort of work is that the solder tends to run everywhere. The part was therefore liberally coated with typist's correcting fluid before soldering to keep it in the right place. The end result is quite pleasing.

There we are, a hand turning rest which can be made in less time than it took to write this! Even if there is no intention of actually doing hand turning, the rest will be found useful for marking-out on work in the chuck and a variety of other little jobs. The fact that it works from the cross slide means that it can be bolted into position in a matter of seconds.

USING THE REST WITH A BUFFING STICK





A FINGER PLATE

Called a 'finger plate', this is, in fact, a simple clamping device which is useful for holding small and awkward work. It is easy to make from scrap material and at least one should be to hand in every workshop!

The most common use of finger plates probably involves clockmakers, where the plates are used in order to work on very tiny parts. They are, as it happens, very useful in many workshop situations and, whilst the particular one described here has many functions, other versions can be made to suit other purposes. Basically, a finger plate is a clamp for holding tiny pieces of work. Whilst

usually they are used in the vice or on the drilling machine, they can also be used on the milling machine or the vertical slide.

In order to make them more versatile, rather than being a plain clamp the plate will contain holes, vees, etc., which are intended to accept work of various sizes and shapes. The plates are usually made of scrap material and it is worthwhile considering making several different versions over a period.

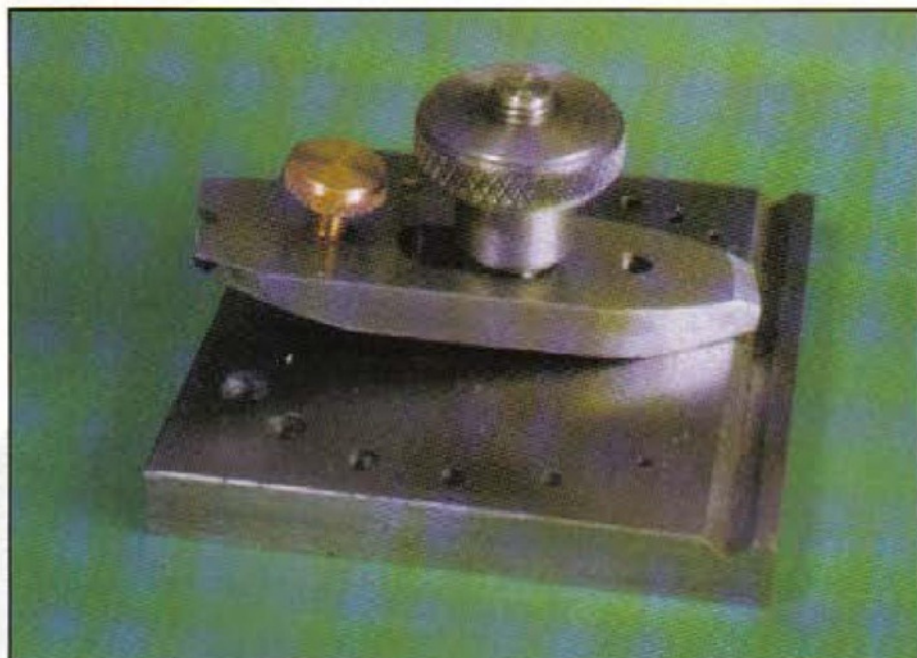
The base

This is a piece of plate and in the drawings and photographs it will be seen that it is square. There is no reason why this should be so, a rectangular shape will do just as well. The only advantage that a square base has is that it can be used on all edges, whereas a long thin one can only, as

a rule, be used at either end.

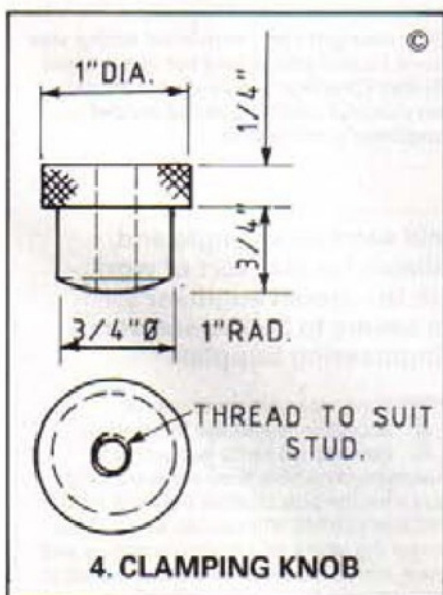
There is a central hole which is tapped to take the pillar. This is shown as $\frac{1}{4}$ in. B.S.F. thread but it could have been $\frac{1}{8}$ in. or the metric equivalent. All that is needed is a pillar stout enough to allow the clamp to be hand-tightened to a point where work will not slip.

At one end a vee cuts into the plate to allow work to be set over it for drilling holes, etc. Once again, the size shown is just a suggestion and it can be larger or smaller as one wishes. An arc was scribed from the centre when the hole for the pillar was marked out and along this are a number of tapped and a number of clearance holes. The sizes shown are 10-8-6-5-4-2 BA and $\frac{1}{4}$ in. B.S.F. These are sizes in common use by the constructor but readers who use other sizes can use them.



The only thing to watch is that the holes are kept reasonably small, there being little point in making large ones as such work can be gripped by other means. In the case of the three smallest sizes, counterbores were made in the underneath. This saved some tapping and, with such small screws, left plenty of material for working purposes.

The other holes along the other end of the arc are clearance holes in Imperial sizes. Again those most common to the builder were chosen and other sizes can easily be substituted. These holes are useful for working on pins, etc.



A long vee along one side allows round work to be held securely for drilling. This was made by the simple method of tipping the base on its side in the milling vice and machining along it. The vee does not need to be at all deep. To set it at exactly forty five degrees, a block which had been previously made was used. A variety of these at different angles are kept in the workshop; they are made from strip steel about 1/8 in. thick. The angle is marked on and machined. The blocks are then simply rested on the vice and the work adjusted up against the chosen one to get the required angle. A great deal of time can be saved in this way.

The clamp

The clamp is a piece of mild steel bar. A slot is milled in the middle and two holes are tapped each end of this to accept the height adjusting screw. The majority of finger plates which are made seem to have just one such hole which means only one end of the clamp can be used. By making two it was possible to fork one end of the clamp so that tiny drilling operations can be carried out between the fork; the other end is left plain for general clamping operations. The ends of the underside of the clamp are angled off and slightly radiused to allow the clamp to be brought right down on the work. The ends are also tapered inwards a little - not entirely necessary, but it can be handy when small work is involved and it certainly does no harm. Care should be taken to ensure the lower ends are flat, otherwise the clamp is likely to tilt when tightened up, although the play in the central slot will take care of any slight discrepancies.

The Pillar

The pillar is a piece of mild steel threaded at each end. The same thread was used, but different ones could be used if one so wished. One end screws into the base and is tightened up hard to prevent it moving. The other end protrudes through the clamp sufficiently for tightening purposes. For a quick release, a very light spring could be inserted between the clamp and the base, round the pillar. This would lift the clamp as it was slackened off, but it is only a minor refinement.

The clamping nut

Made from mild steel, this is a simple turning and tapping exercise. It can be knurled if one has facilities or otherwise could be left plain. No doubt, most readers will knurl it as there is sufficient information on knurling in this issue alone for there to be no excuse not to do so! Note that the bottom of the nut is rounded off to allow it to seat better on the clamp.

Adjusting screws

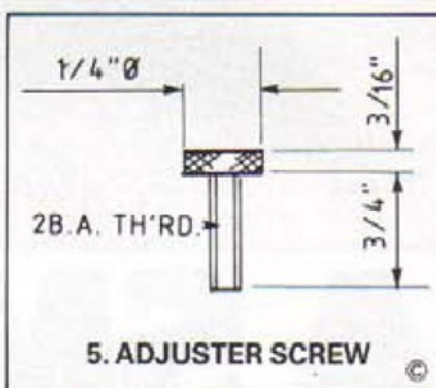
This was made of brass to prevent marking the base. If it is made of steel, in no time at all the base will be scored all over. Once again, it is a simple turning,

threading and knurling operation, and should need no description

Using the finger plate

Little probably needs to be said about the use of the plate. Work is simply fitted in the most convenient way and clamped to secure it. Try not to get too steep an angle when clamping, if possible. When drilling round stock using the long vee, do not worry about the drill passing right through. Any holes made in this way will probably be put to good use later on. Remember to remove any burrs that may be raised. The tapped holes are useful, amongst other things, for filing squares, etc., on screws, or for holding threaded material to slot it when making grub screws.

The plate can be used on a machine, in which case it must be clamped firmly in position. Some readers might like to consider putting some form of holding device for securing it in the vice which can take the form of a bar screwed underneath

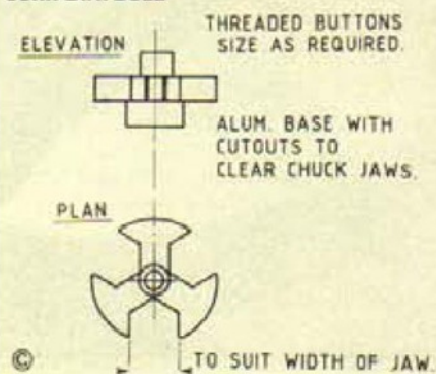


- in which case, make it removable so that it can be taken off in order to use the finger plate elsewhere. Another alternative is a piece of round stock, threaded and screwed to the bottom. This is then slipped into a square section piece of steel with a hole bored along its length, and split lengthwise. As the vice tightens up, the bar is held secure. If one wishes to turn the work round, simply slacken the vice and twist it; as the vice is tightened, the finger plate will become secure again.

QUICK TIP

This little gadget enables 'thin items' to be held squarely in the three jaw when it cannot be aligned by the vee grooves and when overtightening of the chuck could cause damage. The work is thus prevented from being pushed back with the action of the drill or tool and by suitable sizing of the components can be arranged to present an exposed face for facing. I call it 'JAWGE'.

John D.H. Boaz





A SMALL TILTING VICE

Two views of the completed tilting vice seen closed above and set at an angle below. Castings are available for this very useful addition to the model engineer's workshop.

It is frequently necessary to drill or mill work at an angle and, although there are suitable vices available for this sort of work, usually they are rather bulky for use in the model engineer's workshop. This easily made little vice seems to be the answer; castings are available from College Engineering Supplies



Tilting vices are most useful accessories and the far eastern imports are remarkably cheap. However, invariably they are extremely bulky for the size of work they will hold, and it is virtually impossible to get them under the chuck of a drilling machine and leave any reasonable clearance. Added to that they are frequently unstable, making precision drilling a chancy affair.

Searching for a small tilting vice, it was decided that constructing one's own was the only possible answer. Plans were originally drawn up for the complete construction of the whole set-up. Browsing on the College Engineering Supplies stand at the Model Engineer Exhibition, a set of castings for a small vice, more or less the exact size of the design in mind, was spotted and it was decided to use this instead of the fabricated version. At the same time a slab of cast iron 15mm thick was obtained with which to make the base.

Making the vice

Machining of the vice castings proved to be exceptionally easy. The body was first

mounted base down on the milling table and the top of the fixed jaw and the other end machined to the same height to give suitable datums to work from. The casting was turned over and secured by bolts through the slot while the base was machined.

It could then be clamped on the base and the slot and recess machined. This allowed it to be turned the right way up again and clamped at the ends. The jaw and end faces were machined as was the sliding face. The recess for the steel jaws, that were to be fixed, were also machined at this stage.

The moving jaw

Again this was quite straightforward machining. It did call for the use of the normal milling vice, but would be possible by using the small work-holding clamps designed by Bob Fletcher and described on page 28 of the winter issue of *Model Engineers' Workshop*. First a datum was made of the top of the jaw and the tongue machined using this, followed by the back and front faces including the recess for the jaw. The ends followed, being left a little oversize so that they could later be trimmed to match the body.

Fixing the moving jaw

The moving jaw is secured in the standard fashion for this type of vice. A

plate rides in the recess in the base and screws pass through this into the jaw. The plate is of mild steel and can be marked out, drilled and the holes transferred by passing a drill right through into the jaw with the set-up mounted and clamped in position on the vice. The holes in the jaw can be tapped and those in the plate countersunk to accept the screws.

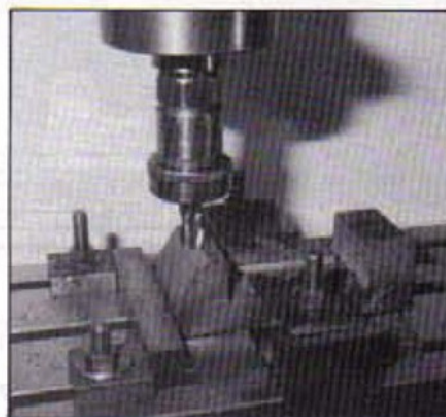
The drive screw

Here again we have a pretty straightforward machining job. The thread, however, must be parallel so threading should be carried out using a tailstock dieholder, preferably as a chaser after screwcutting first.

The thread for the screw in the rear of the body must be carefully marked out and then drilled, using a pilot drill. The moving jaw can be clamped in position and the drill passed right through into it. The hole in the body can be opened out and tapped. The hole in the moving jaw is also opened out to take the screw end. The hole was passed right through and counterbored, the drive screw to be held in position with another passed through from the jaw face.

The jaws

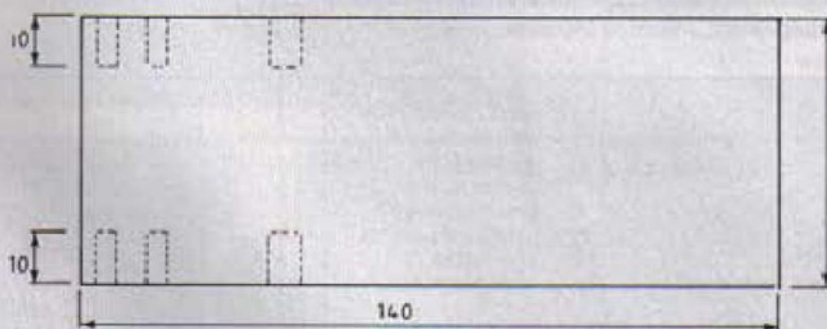
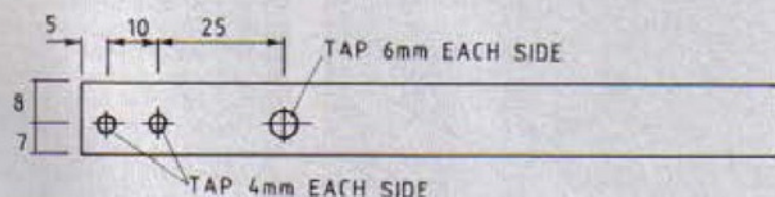
It has already been explained that these are of mild steel. They are fixed to the vice with countersunk screws. The plate used on the moving jaw is straightforward



The first step is to get a datum by machining the fixed jaw and end to the same dimensions.

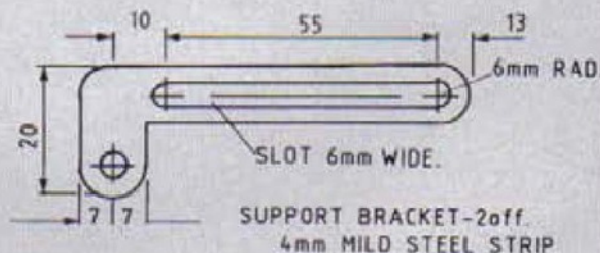
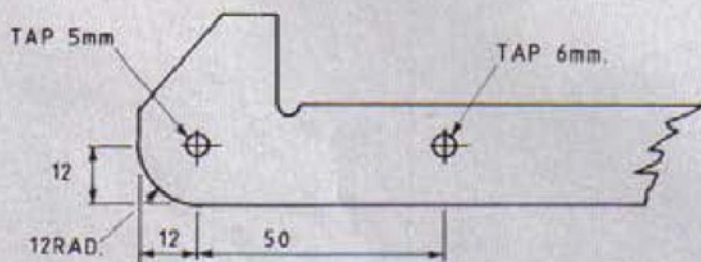
enough. Simply drill the plate to tapping size, stick it with cyanoacrylic adhesive to the moving jaw and spot through the holes into the casting. Remove the plate, open out and countersink, then tap the casting and the job is done.

The plate for the fixed jaw is a different kettle of fish as the casting is at an angle where the screws must pass through. Mark the hole positions on the castings and centre punch lightly, making sure the casting is upright, start off with a small

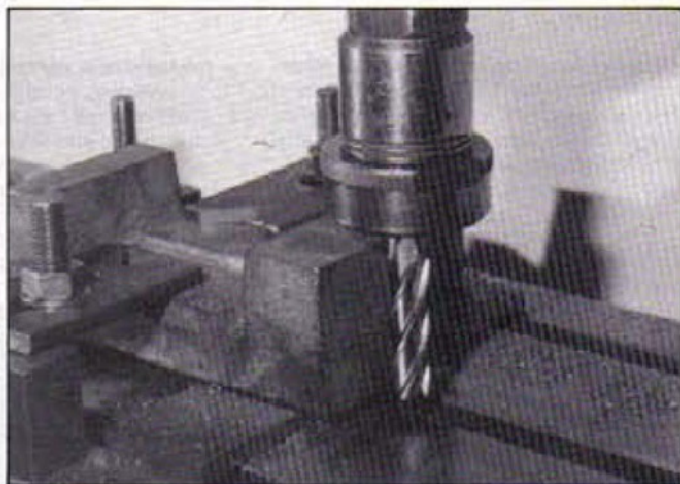
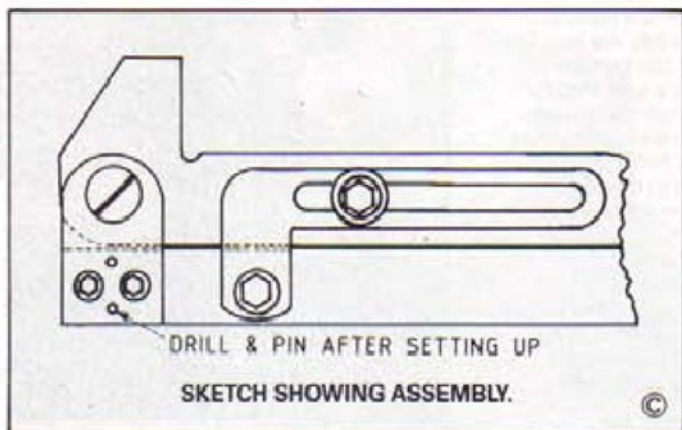


ADJUST WIDTH TO
ALLOW GOOD FIT TO BODY

BASE-CAST IRON OR MILD STEEL



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Without moving the setting, a long series end mill was used to machine the end.

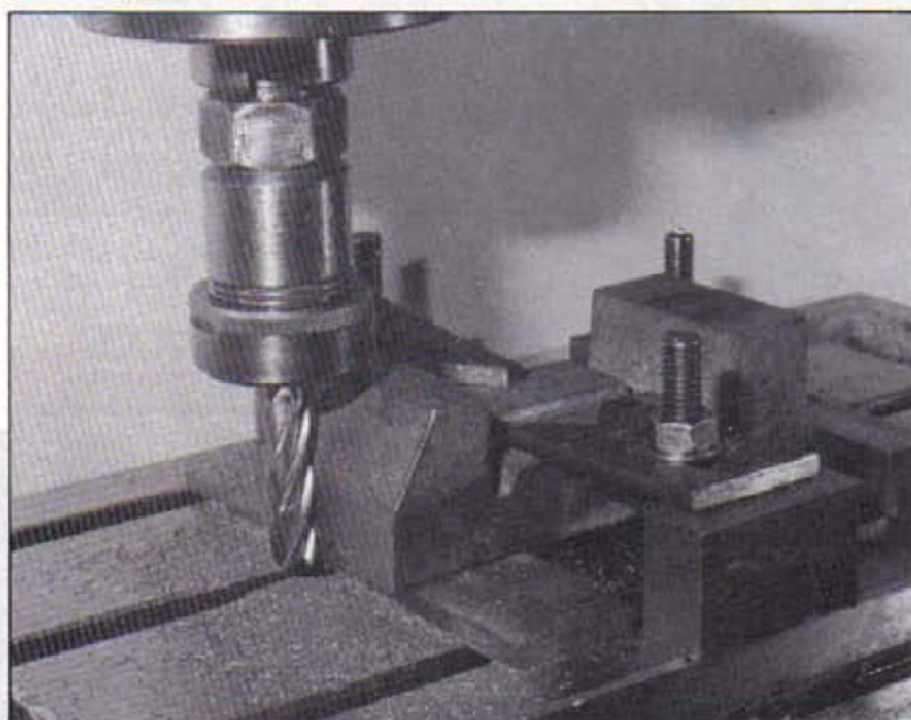
centre drill then use a 'D' bit or slot drill to extend the hole to about $\frac{1}{16}$ in. or 3mm depth. It should then be possible to drill right through using the tapping sized drill.

Stick the plate to the casting and, supporting it on the edge of the drilling table, pass the drill through to make a recess deep enough to use as a centre. Remove the plate and drill through. It can be fixed to the casting either by passing the bolts through the casting and screwing them into the plate, or by tapping the casting and passing the bolts through the plate after countersinking the holes. The latter method is probably best if Allen screws are to be used, but if they are to be slotted ones, getting a screwdriver in to tighten up could pose problems.

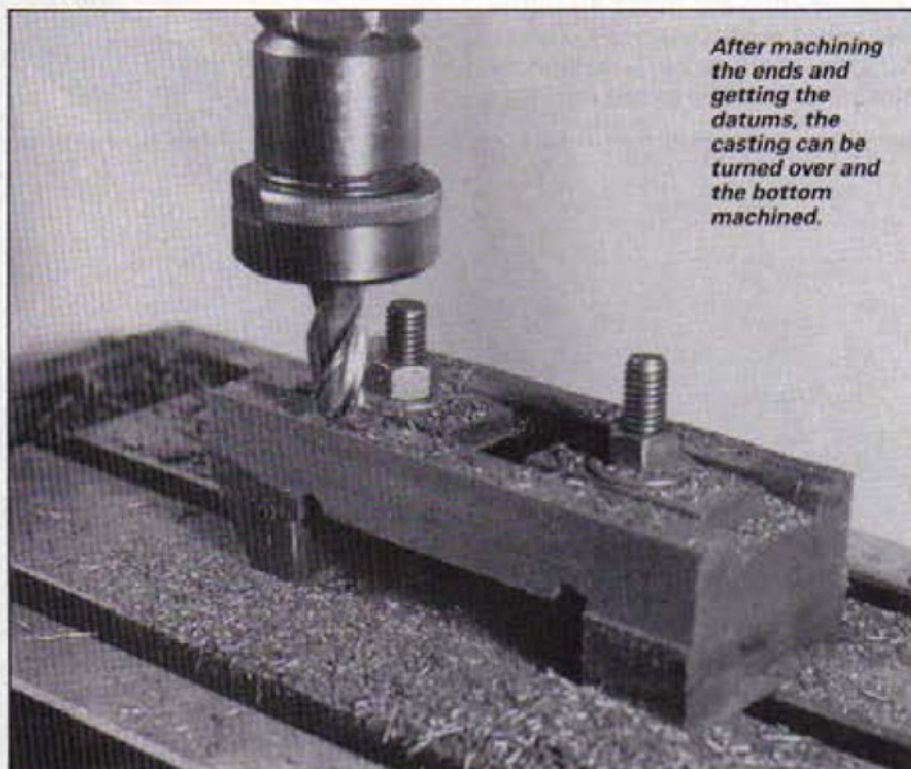
Finally, machine the plates whilst fixed to the vice so that they are both the same then remove them and caseharden.

The base

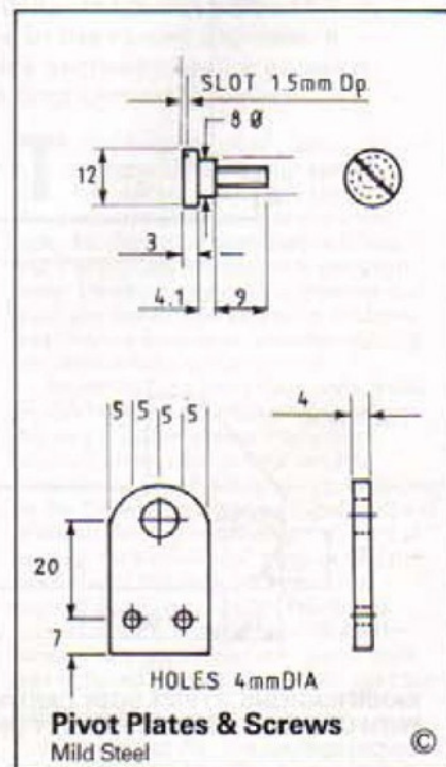
This too was quite straightforward; using the small clamps to secure it to the table, a datum was formed. It was turned

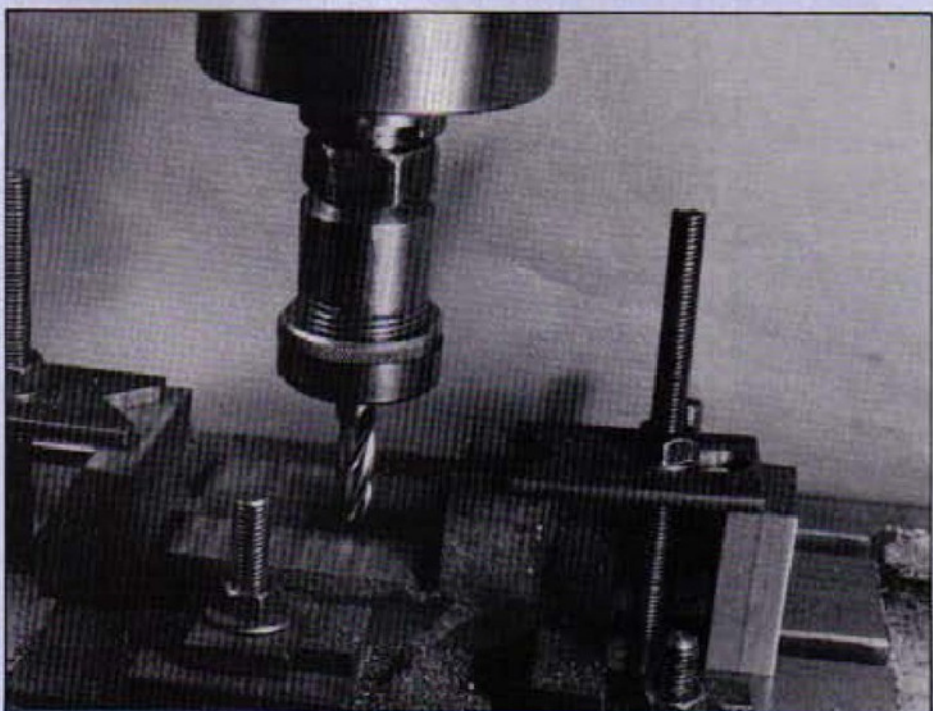
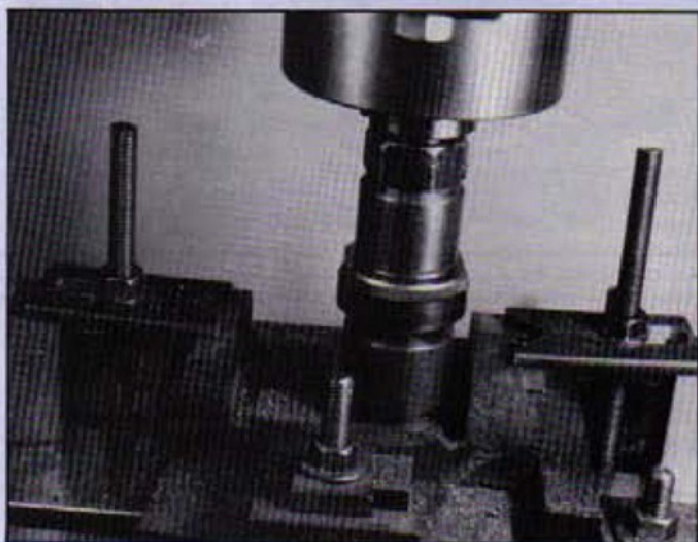
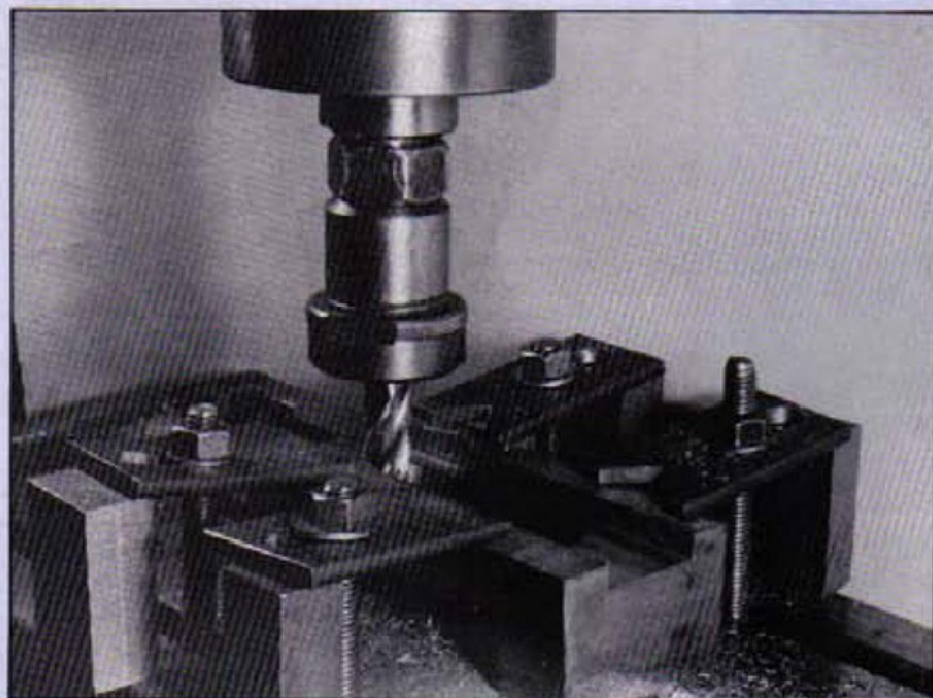


Above: still with the same clamping arrangement, machine the outside edge of the fixed jaw.



After machining the ends and getting the datums, the casting can be turned over and the bottom machined.





Above: the clamps are moved and the underneath recess and slot machined. Left: the casting is positioned on its base and the slide surface machined to size with a fly-cutter to produce a good finish. Below: an end mill is used to complete the fixed jaw and the end.



The swivel brackets; accurate marking out is essential to ensure smooth tilting action.

over and the other side also machined to get it smooth, the work on both sides being done with a flycutter to ensure a good finish. To machine the edges, the casting was clamped against an angle plate, once again working on the principle of machining alternate sides.

Tilting mechanism

Four small pieces of mild steel are called for here. The pivot pieces have three holes and it is simply a case of transferring these holes to the castings, with the vice clamped flat on the base. Use the centre, made with the drill when it is passed into the body, to scribe a line so that casting can be rounded off in order to allow it to tilt.

The slotted pieces can also be fitted by transferring the holes through. It must be remembered that the accuracy of the tilt will, to some extent, depend on the accuracy of these pieces when fitted. It is therefore essential that marking-out is done carefully as is positioning. One way of ensuring the pivot is exactly right is to clamp both pieces to one side and to drill the pivot hole through both at once. In this way it must line up. As long as the pivot pieces are set accurately on the base, it will run perfectly true.

When things go wrong

No matter how careful one is, there is always the danger that things will not go according to plan, the biggest problem here being the danger of the two pivot pieces being put off line. Accuracy can be checked with a scribing block, or vernier height gauge with the vice set at several different angles. If all is well, then at all points both sides will be at exactly the same height. If all is not well, there will be a tilt which will vary with the angle.

If this should happen, open out the two holes in the pivot plate which fixes it to the base. Tighten the screws up very hard and keep adjusting the plate until the vice is right. Do not go mad on the opening up; it may be wise to open one hole at a time and to increase the diameter on each wrong testing. Once the correct position has been obtained, centre punch and drill through in two places, passing the holes into the casting. Fit small pins in the holes to prevent any further movement of the plate. The pins need only be about $\frac{1}{16}$ in. or 2mm diameter. Pins should also be inserted in the other side, as the unevenness of the movement is otherwise likely to cause the plate to shift.

If readers have a rotary table, degrees can be marked on the casting to allow for easier setting-up but this is not a necessity as the angle of tilt is easily checked with a protractor. Another refinement could be to machine slots in the base to match the milling or drilling table. Readers will find this a most useful device which is cheap to construct and, if a little care is taken, can be highly accurate.

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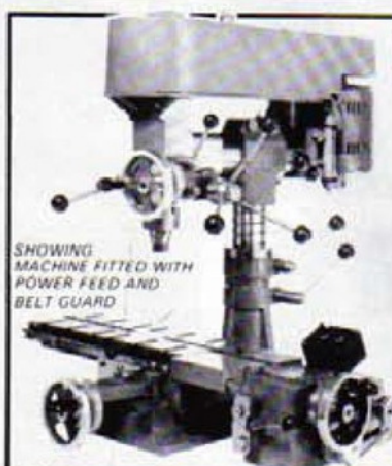
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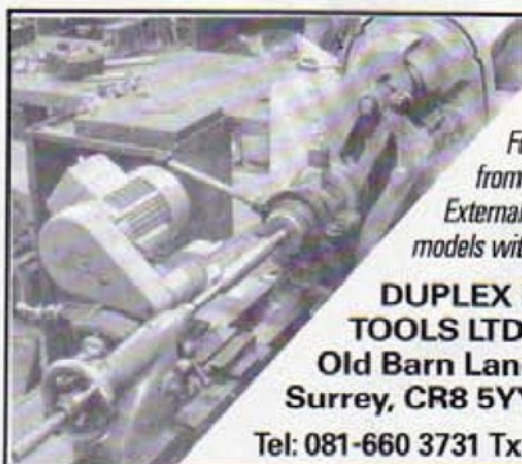
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When requiring to mill a special shape, a simple form fly-cutter is the easiest and quickest tool to use on free-cutting materials such as brass or light alloy. (The expression 'form' is used to cover cutters, be they for use on a lathe, milling or shaping machine, they are shaped to a particular form to suit the job required). Even on these materials, flycutters will produce better results if given some form of relief. When the



Figure 1; a mandrel, two blanks and a fly-cutter.

MAKE YOUR OWN MILLING CUTTERS & GEARS

material to be worked is steel, cast iron or similar, a multi-tooth form relieved cutter will have a much more satisfactory performance.

From time to time I make cutters of this type, usually for cutting gears, and I use a method which is simple and produces cutting teeth with reasonably accurate form relief.

Making a multi-tooth cutter

The first step is to produce the blank. The choice of material is usually decided by what is handy but any steel capable of being hardened (not case hardened) can be used. I have used cast tool steel, gauge plate, slices parted off round bar and even an old file that had been softened first. The diameter of the outside should be as small as possible, consistent with the size of cutter arbor to be used. The small diameter will allow the use of a comparatively high rotational speed without making the actual cutting speed too high and so cause premature blunting of the cutting edge. The thickness of the cutter is determined by the width of the form required, although it is advisable not to go thinner than around $\frac{3}{16}$ in. as there may be a problem with distortion when hardening. My usual size of cutter is $1\frac{1}{2}$ in. outside diameter and $\frac{1}{2}$ in. bore, but I have in the past gone as small as 1 in. outside diameter and $\frac{1}{4}$ in. bore.

Most of the gear cutters are about $\frac{1}{2}$ in.

Special shaped milling cutters are expensive to buy, even when it is possible to get them. In the first of a two-part feature, Don Unwin explains how to make one's own; the system used can be adapted for making things such as tee slot cutters and dovetails, as well as radiused tools

thick and this gives sufficient stiffness for the smaller tooth sizes. I have had to use one $\frac{1}{2}$ in. thick for a 1.5 mm module involute cutter which I had made to cut a new timing gear for a veteran car.

Having decided on material and size, produce a disk with the bore and two side faces finished to size, but leave the outside diameter oversize. Take care to turn the two faces parallel.

The mandrel

A stepped mandrel is the next thing required in order to machine the outside edge. The mandrel should have a clamping screw or bolt with a large diameter washer in order to lock the cutter blank securely. To enable it to be replaced accurately in the chuck, mark it where number one jaw will fit. An alternative is to machine it from hexagon bar and mark the flat, which makes it even easier to return accurately to the chuck. The mandrel can be kept for the future and can be used whenever another cutter is required. **Figure 1** shows a mandrel and two blanks as well as a fly-cutter, and should give readers some idea of what I am getting at. Once the mandrel

has been prepared, the cutter blank can be fitted and the circumference machined to ensure it is circular.

Before taking it off the lathe, set a surface gauge to the centre line and mark four radial lines at ninety degrees on the face of the blank. The position of the lines can be obtained either by using some sort of dividing device or by careful use of a square. The operation is illustrated in **Fig. 2**.

Marking the teeth

Remove the mandrel from the three-jaw chuck and either hold it in an independent four jaw or pack one jaw of the three-jaw self-centring chuck so the blank is about $\frac{1}{2}$ in. off centre giving a total throw of half an inch. Ensure it is still parallel to the lathe axis so that, although the blank rotates eccentrically, it does not wobble sideways. Make a mark or note of the scribed line position and put a piece of packing under one jaw, the idea being to enable the work to be rotated and to get each of the scribed lines in exactly the same position. This is illustrated in **Figure 3**.

With the surface gauge set at centre

Figure 2; marking four ninety-degree radial lines.

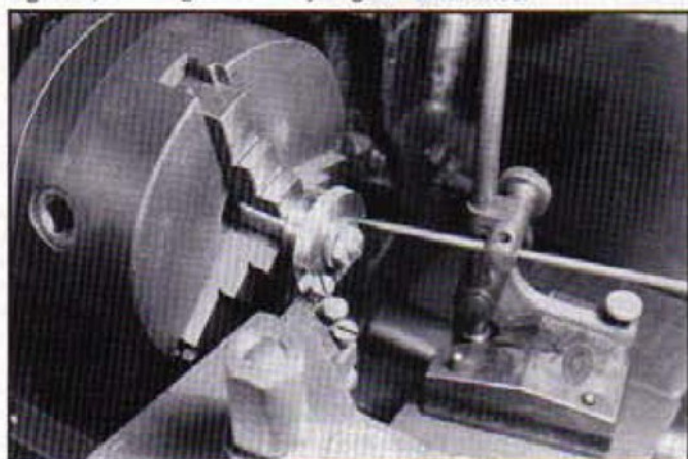
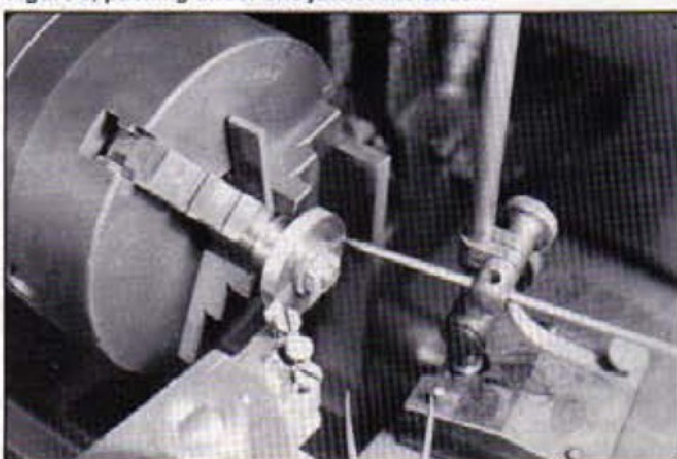


Figure 3; packing under one jaw of the chuck.



height and the packing remaining in place under the chuck jaw, slacken the mandrel nut and rotate the blank until one of the four marks is lined up with the scriber point, as is also shown in **Figure 3**. When it is right, tighten up the nut to prevent any further movement of the blank.

Remove the surface gauge and the packing, and machine the outside of the blank until the machined segment or area in contact with the tool is approximately a quarter of the blank circumference; note the reading on the cross feed index dial. Repeat the operation a further three times, setting up each time with the same piece of packing under the same jaw, and rotating the work in the chuck to the next scribed line. Take care to use exactly the same index reading on each operation. When completed, the blank will have four equal curved segments.

Shaping the cutter

The above operations are now repeated but this time using a form tool of the profile required for the finished cutter. The end result will be a blank with the four curved segments shaped to the form required. **Figure 4** shows the operation. The blank in this case is for a gear cutter and the tool used to get the shape will be described later in the article.

Making the teeth

With a little care the teeth can be cut by hand using a small saw and a file; alternatively they can be milled. If they are to be done by hand, then the blank will need marking out as shown in **Figure 5**. Take care to remove all burrs. Milling the teeth is quite easy to do, either on the milling machine or using milling equipment on a lathe. The end result will be a neatly finished cutter.

The mandrel used for turning the blank is held in the machine vice and a piece of steel is clamped in such a manner as to locate on the back of the tooth as shown in **Figure 6**. A $\frac{1}{16}$ in. slitting saw is set up so that one face is along a maximum diameter line marking the tooth-cutting face. The cut is made and the blank is reset for each tooth in turn. The material between each cut is removed by making a series of cuts and

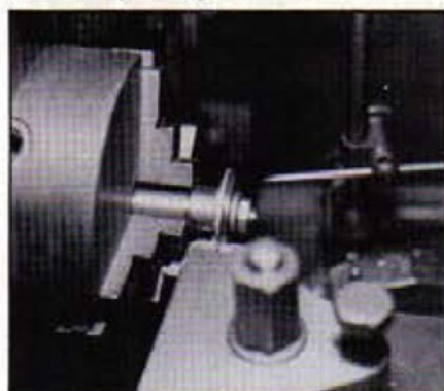


Figure 4; the blank with four curved segments.

rotating the blank slightly between each one. **Figures 7 and 8** show the sequence of operations.

Heat treatment

The cutter can be hardened and tempered in the usual way, preferably quenching in oil to avoid distortion. Tempering is probably best done by heating the cutter in a tin lid with a layer of

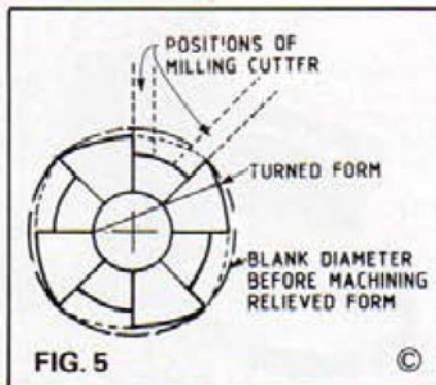


FIG. 5

Finally, hone the cutting edges with a small stone or a lap and it is then ready for use.

Form relieved flycutters

The offset idea can also be used to produce a relief edge on a flycutter. In this case, the cutter blank is held in the bar-and-mounted eccentrically in the lathe. As it rotates against the tool in the toolpost, the relief angle is reproduced. **Figure 9** shows this operation, and **Figure 10** is a diagram to assist readers in their understanding of it.

In 1981 Mr W.H. Payne wrote an article for *Model Engineer* in which he described a slightly more precise method of producing multi-toothed cutters, the main advantage

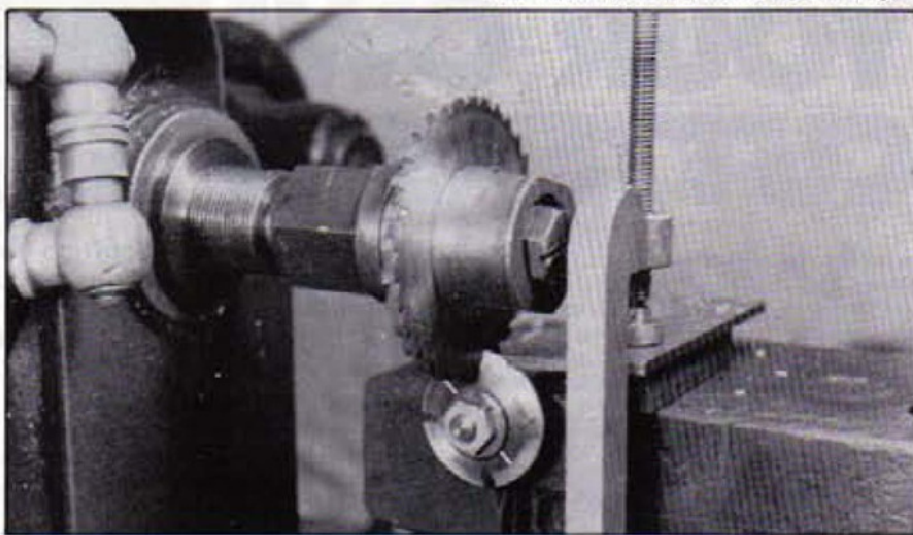


Figure 6; a piece of steel is clamped in contact with the back of a tooth.

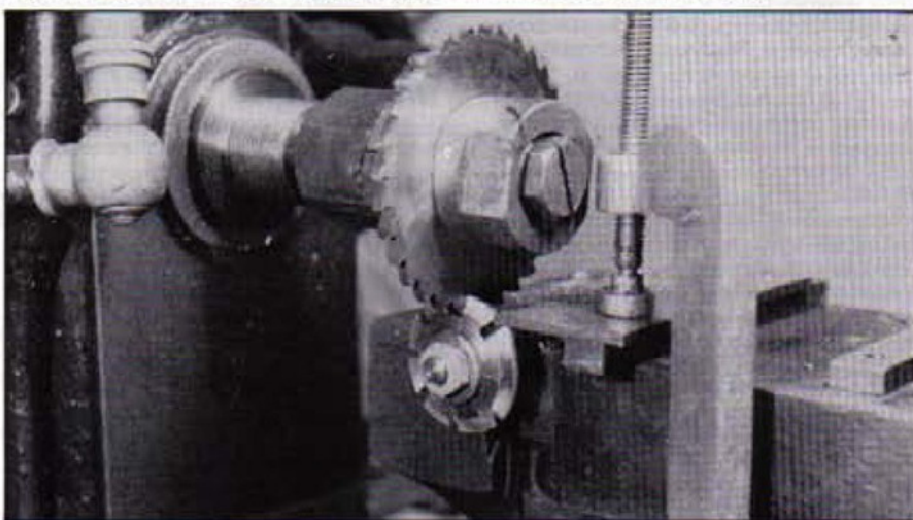


Figure 7; material is removed between each cut.

fine sand, in order to get even heating throughout the whole of the metal. Light straw is the ideal colour for the temper. The quenching medium for both hardening and tempering will almost certainly be dictated by the type of steel used for the manufacture of the cutter.

Sharpening

The cutter should be cleaned and the cutting edges sharpened. If some form of cutter grinder is available, then there is no problem. Failing this, with care, it can be done on the outside of a normal grinding wheel, setting the rest so the cutter is at right angles to the stone. Only a very light touch is necessary and exactly the same amount must be taken off each cutter.



Figure 8; a series of cuts is required to remove the material.

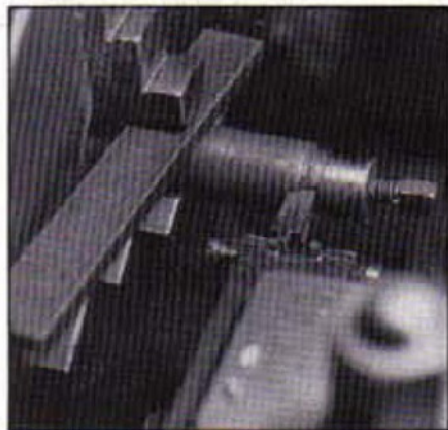


Figure 9; reproducing the relief angle.

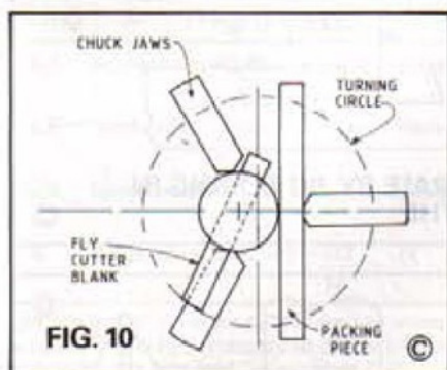


FIG. 10



Author's form tool.

being that it gave a predictable relief angle which was chosen as fourteen degrees. He used a larger offset radius and the form turning tool was mounted a specified distance below centre height. The description gave details for producing a five-tooth cutter of a specific diameter. I would have tried his method but the cutter dimensions were far too small for my purposes, so I resolved his geometry in terms of the radius of the cutter blank 'R'. My values are shown in **Figure 11** for a five-tooth cutter and in **Figure 12** for a four-tooth type. The method worked perfectly satisfactorily but I found no practical advantage, so usually (but not always) I use the original system.

I have made over fifty cutters, some of which are shown in **Figure 13**, and I have been professionally responsible for the method being used by apprentices to produce many more in research workshops. Why not try both for yourselves and see which suits you best?

Cutters for clock gears

It is much more satisfying when building a model or a clock involving gearing to cut the gears oneself. Whilst

commercial gearing is generally produced by a generation process, quite satisfactory results can be obtained by cutting each tooth separately with a form cutter used on the lathe or a milling machine and using some form of dividing device to space the teeth. The latter does not need to be at all

complicated and many means of dividing have already been described.

The cutter used must be of the correct form to produce a tooth of the right shape; such cutters are available commercially but are rather expensive. However, they are not difficult to produce on the lathe using

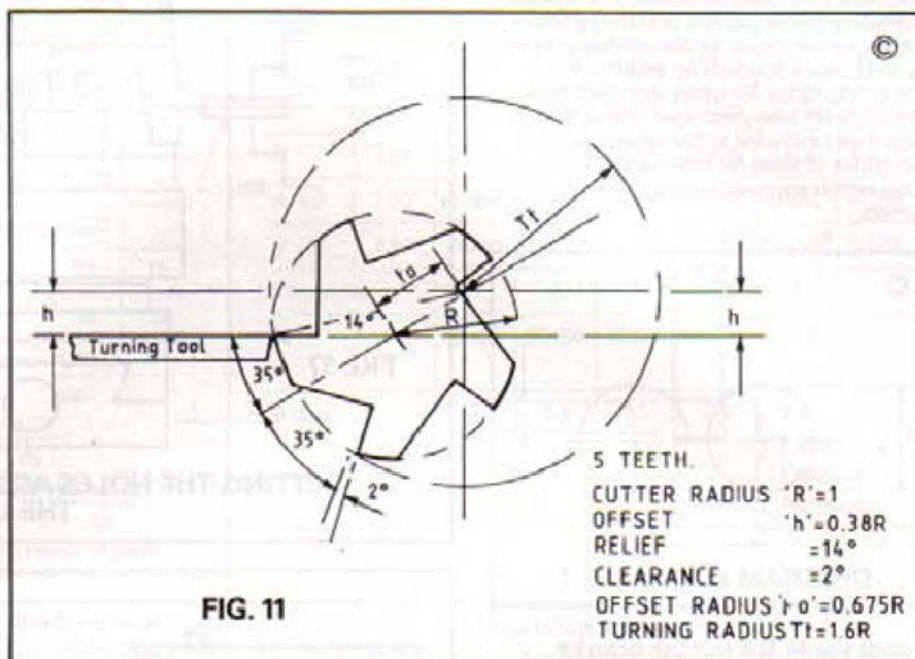


FIG. 11



Figure 13; just a few of the fifty or so cutters made by the author.

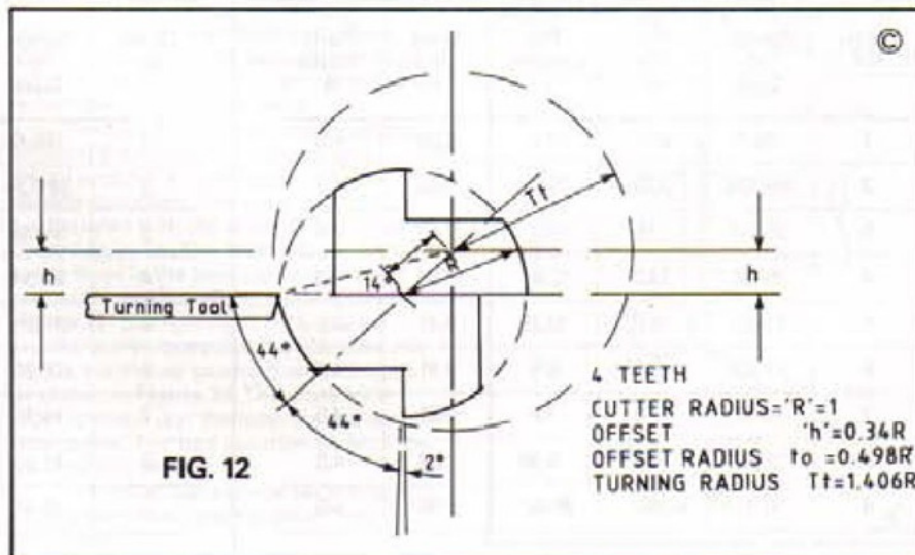
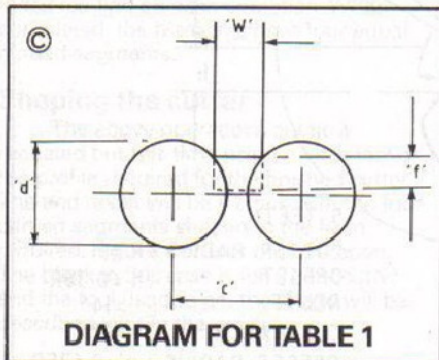


FIG. 12

simple form tools, it is also more satisfying to carry out the work personally.

The involute form

The basis for producing a cutter is the single curve approximation to the involute gear shape, the calculations for which were originally published by Brown and Sharpe Company of the U.S.A. It was also given in a book called *Gears for Small Mechanisms* by W.O. Davis in which an additional correcting factor for gears with less than twenty teeth was described. These figures have been included in the values given in the tables of sizes for making the form tools which are used to shape the gear cutters.



Form tools for cutter blanks

Figure 14 shows details of the form tool. It consists of a piece of mild steel bar with two accurately spaced holes into which are clamped two turned, hardened pins which form the cutting edges. Figure 15 shows the method of use.

The diameter of the pin, the in-centre distance, the amount of in-feed and the blank width are all obtainable from Table one. This is normally twenty degrees, but if a pinion with very few teeth is required, then a thirty degree pressure angle gives a stronger tooth without undercutting at the root.

The tables are given for 1 D.P. and to

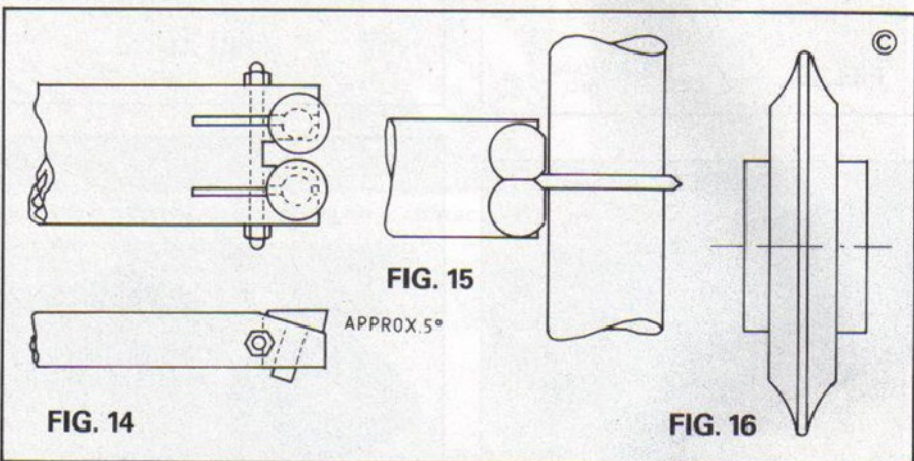
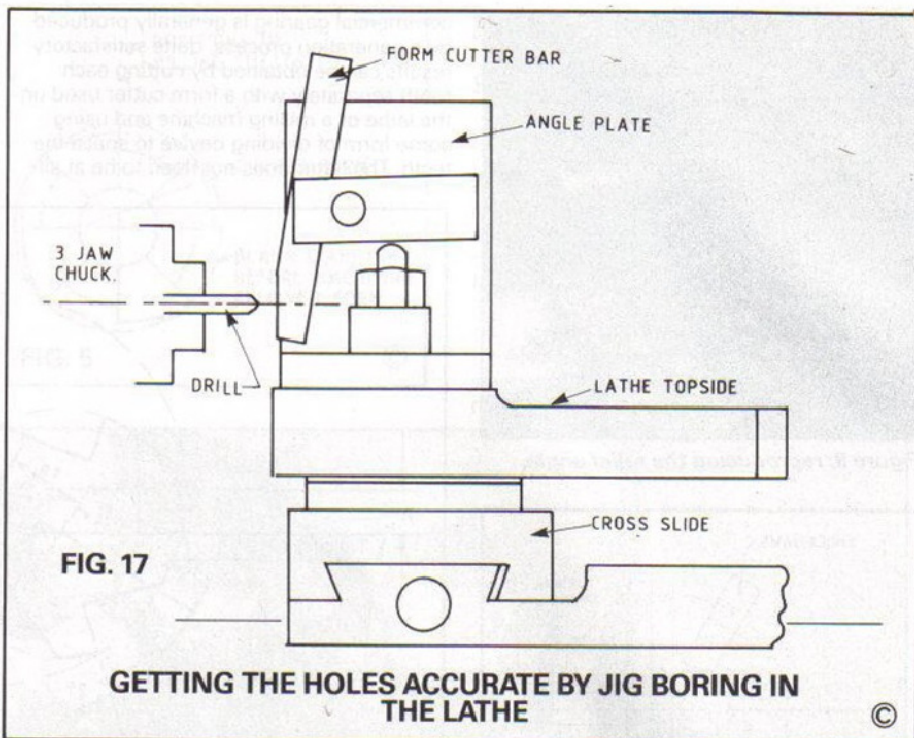


TABLE 1

INVOLUTE CUTTER PROPORTIONS
For 1 DP or 1 Module
30 deg. PRESSURE ANGLE ($\cos \theta = 0.866$)

Cutter No.	Range of Teeth	Pin Dia. d	Pin Centres c	Feed In f	Blank Width w
1	135-R	67.5	59.5	3.20	4.0
2	55-134	27.5	25.0	2.85	4.0
3	35-54	17.5	16.3	2.67	4.0
4	26-34	13.0	12.4	2.54	4.0
5	21-25	10.5	10.25	2.41	4.0
6	17-20	8.5	8.5	2.31	4.0
7	14-16	7.0	7.2	2.18	4.0
8	12-13	6.0	6.36	2.06	4.0
9	10-11	5.0	5.6	1.98	4.0

TABLE 1a

INVOLUTE CUTTER PROPORTIONS
For 1 DP or 1 Module
20 deg. PRESSURE ANGLE ($\cos \theta = 0.93$)

Cutter No.	Range of Teeth	Pin Dia. d	Pin Centres c	Feed In f	Blank Width w
1	135-R	46.17	44.80	3.934	4.0
2	55-134	18.81	19.07	3.415	4.0
3	35-54	11.97	12.64	3.098	4.0
4	26-34	8.89	9.75	2.875	4.0
5	21-25	7.18	8.147	2.710	4.0
6	17-20	5.81	6.864	2.543	4.0
7	14-16	4.788	5.905	2.387	4.0
8	12-13	4.100	5.267	2.251	4.0
9	10-11	3.42	4.632	2.108	4.0

TABLE 2
OGIVAL CLOCK TOOTH PROPORTIONS
For 1 DP or 1 Module
PINION 1/3 OGIVE

DP	1	34	40	42	44	48	52	
a	0.74	0.022	0.019	0.018	0.017	0.016	0.014	
b	1.75	0.052	0.044	0.042	0.040	0.037	0.034	
s	1.99	0.059	0.050	0.048	0.045	0.042	0.038	
r	0.77	0.023	0.019	0.018	0.017	0.016	0.015	
a + b	2.49	0.074	0.063	0.060	0.057	0.033	0.048	
e	1.15	0.034	0.028	0.027	0.026	0.0239	0.022	
N	6	7	8	9	10	11	12	13
0 deg.	30	25.5	22	20	18	16	15	13.8
a,A	Addendum = $\frac{0.74}{dp}$		b,B		Dedendum = $\frac{1.75}{dp}$			
e,E	Tooth width = $\frac{1.15}{dp}$		r,R		Radius = $\frac{0.77}{dp}$			
s,S	Space width = $\frac{1.99}{dp}$		d		dia. of blank = $\frac{N + 1.48}{dp}$			
θ	Angle of radial sides = $\frac{180}{N}$		N		Number of teeth			

get the actual dimensions required to make a cutter, it is only necessary to divide all the values by the required D.P. number. D.P. means diameter pitch, i.e. a twenty degree pressure angle:

Cutter number 3, 35 to 54 teeth D.P.

Then 'd' diameter of pins 0.239 in.
'c' centre of pins 0.253 in.
'f' feed-in 0.062 in.
'w' width of blank 0.080 in.

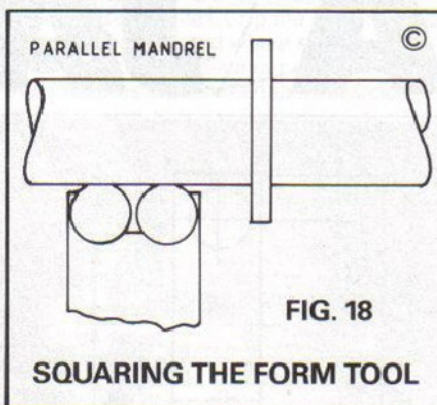
Cutter forms should always be calculated for the lowest number of teeth of the range covered by the cutter, i.e. a 55 - 134 cutter, Number 2, is calculated for 55 teeth. This gives the most curved flanks, and least risk of tooth interference.

In those cases where the pin diameter 'd' exceeds the centre distance 'c', a flat will need to be ground or filed to make them fit. It may also be necessary to grind off the front to clear the mandrel in certain circumstances. In the case of small pitches, width 'w' may become rather small to provide a sufficiently stiff cutter blank. This can be avoided by stepping the blank as shown in Figure 16. In fact, I usually keep a small stock of turned but uniform blanks and produce the edge thickness in this way.

The shank of the tool can be any convenient piece of mild steel, but obviously must be long enough to clamp in the toolpost and should be about $\frac{5}{8}$ or $\frac{3}{4}$ in. thick and wide enough to accommodate the two holes for the pins, without bending under the strain. The centre distance between the two holes must be as accurate as possible and to enable the tool to be set accurately should be perfectly square to the sides. To achieve this, they can be jig-bored by clamping the bar on an angle plate fixed to the toolpost, Figure 17. The index of the cross slide can be used to measure the distance, and the holes centre drilled, drilled and reamed by holding the tools in the lathe chuck and using the top slide as a feed. The diameter of the holes is not all that important but the pins which will be inserted in them must be of sufficient diameter so as not to break under

the strain when in use.

The cross hole for the clamping bolt can be around 4 or 2 BA depending on the



size of the tool. The clamping slots can be sawn by hand or milled. Make the pins from cast or silver steel, and the shanks should be a good fit. Take care to get diameter 'd' accurate. Harden and temper to a light straw, and polish the large diameter. Clamp them both in the tool shank and lightly grind across the tops to get them level. Finish with an oilstone and remember to remove all burrs.

The tool is now ready to be used to produce the milling form cutter, and I would suggest a multi-tooth cutter as already described. The cutter blank must be prepared with the width of the edge correct as in 'w'. The form tool we have just made is set in the toolpost ensuring it is absolutely square with the axis of the lathe, Figure 18. Each pin must be located precisely with respect to the blank so that they are both just touching on each edge, as shown in Figure 19. The cross slide index is noted and the lathe started up on a slow speed. The tool can then be fed in by the required amount 'f'.

The cutter can now be segmented as already described and hardened and tempered.

TABLE 3
OGIVAL CLOCK TOOTH PROPORTIONS
For 1 DP or 1 Module
GEAR

DP	1	34	40	42	44	48	52
A	1.35	0.040	0.034	0.032	0.031	0.028	0.026
B	1.55	0.045	0.039	0.037	0.035	0.032	0.030
S	1.57	0.046	0.039	0.038	0.036	0.033	0.030
R	1.57	0.046	0.039	0.038	0.036	0.033	0.030
A + B	2.90	0.085	0.073	0.069	0.066	0.060	0.056
E	1.57	0.046	0.039	0.037	0.0356	0.0326	0.030
Cutter No.		5	4	3	2	1	
N		21/25	26/34	35/54	55/134	135/	Rack
θ deg.		9	6.9	5.1	3.3	1.3	Parallel for Practical Purposes

Metrication

It is worth noting that the tables can be used for making metric module cutters; I have made several such cutters for repair jobs. All that is necessary is to remember that the gear module is the reciprocal of D.P. i.e. the metric module is defined as $PCD \div N$, PCD being in millimetres.

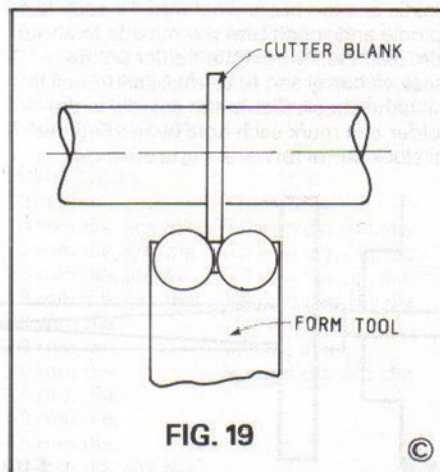
By multiplying the values of the table by the metric module needed, the result will be the required dimension in millimetres, i.e.:

0.5 module
Cutter number 3, 35 - 54 teeth
'd' diameter of pin 5.985mm
'c' centre of pin 6.32mm
'f' feed-in 1.549mm
'w' width 2.0mm

If you prefer working to Imperial methods throughout, convert the required metric module to the Imperial D.P. by dividing 25.4 by the D.P.

$25.4 \div 0.5 = 50.8$ then carry on by dividing these values as before. Remember the result will now be in Imperial figures.

To be concluded



Some time ago I had a long slender spindle of square cross section steel with a small diameter hardened journal at one end which needed easing down in diameter with an oilstone and burnishing. The spindle had a gearwheel at the end furthest from the journal and only a small length which could be held in the lathe chuck, whilst the square end prevented the use of a conventional steady at the journal end. Furthermore, the fact that the end was hardened prevented a centre being drilled in it and the shape was unsuitable for supporting with a hollow centre.

I thought the job would be a good excuse to make an engineer's version of a watchmaker's Jacot tool, a simple device I had been intending to make but never got round to. It is really a form of steady and the easiest way to describe it is by the sketch **Figure 1**, supporting the troublesome spindle **Figure 2** and **Figure 3**.

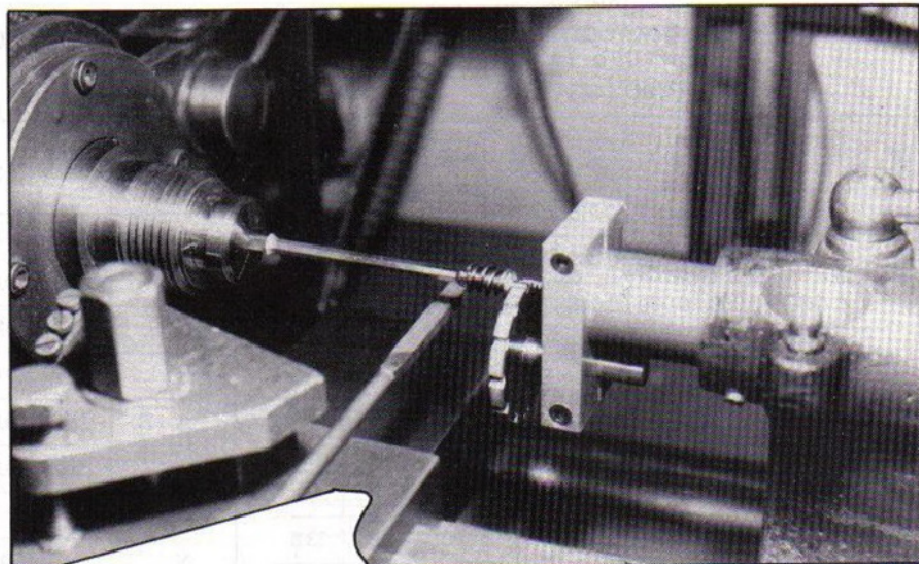
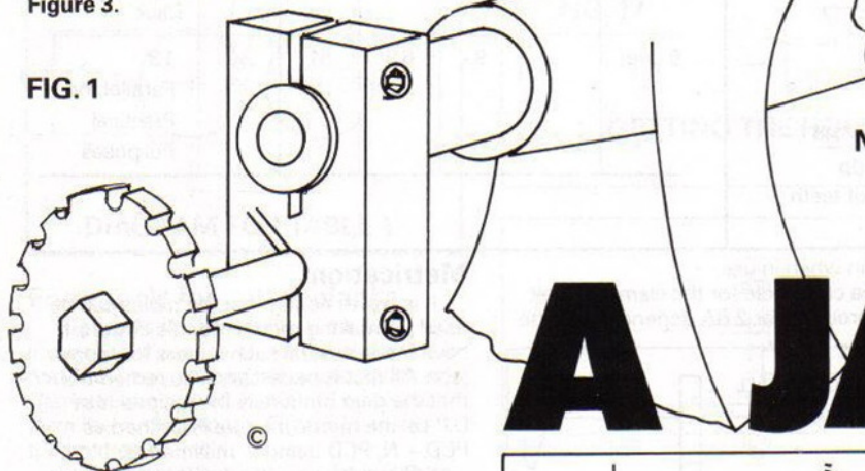


FIG. 3

Readers familiar with clock-making equipment will know of the Jacot Tool – others may never have heard of it. Nevertheless, it's a useful device whether for clock-making or general machining purposes and here Don Unwin tells readers how to set about making one

FIG. 1



The holder

Start by making the holder first **Figure 4**, bored to fit the outside diameter of your tailstock barrel. I used light alloy but you can use anything convenient. You can make a taper shank if you prefer but fitting on the outside of the barrel is best as it enables a long spindle to be passed down the bore.

I made two steady discs **Figure 5**, one with the smaller range of diameters and a thicker one with a range of larger diameters. Make two supporting spindles **Figure 6**, of $\frac{3}{8}$ in. diameter mild steel with a 2 BA stub on one end, a simple turning job.

The steady discs

The steady discs are best made of hard wearing plastic such as Tufnol, but acetal plastic or even brass would do. Fit each to a spindle and rough turn the outside to about $2\frac{1}{2}$ in. diameter. Mount the holder on the tailstock barrel and fit a small centre drill in the lathe chuck. Clamp the spindle in the holder and mark each hole by feeding the tailstock barrel forward, **Figure 7**. Exact

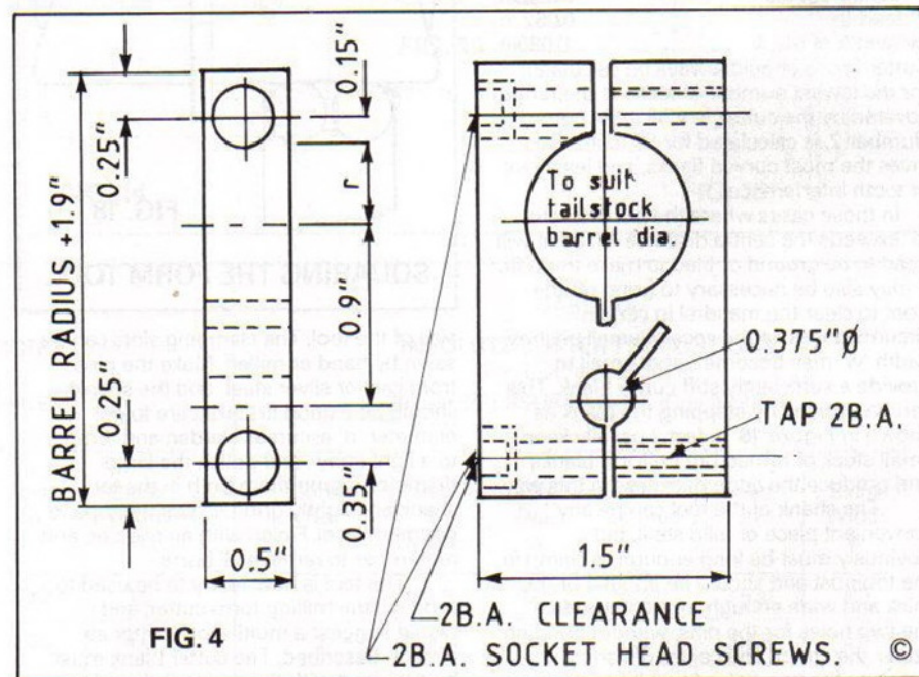


FIG. 4

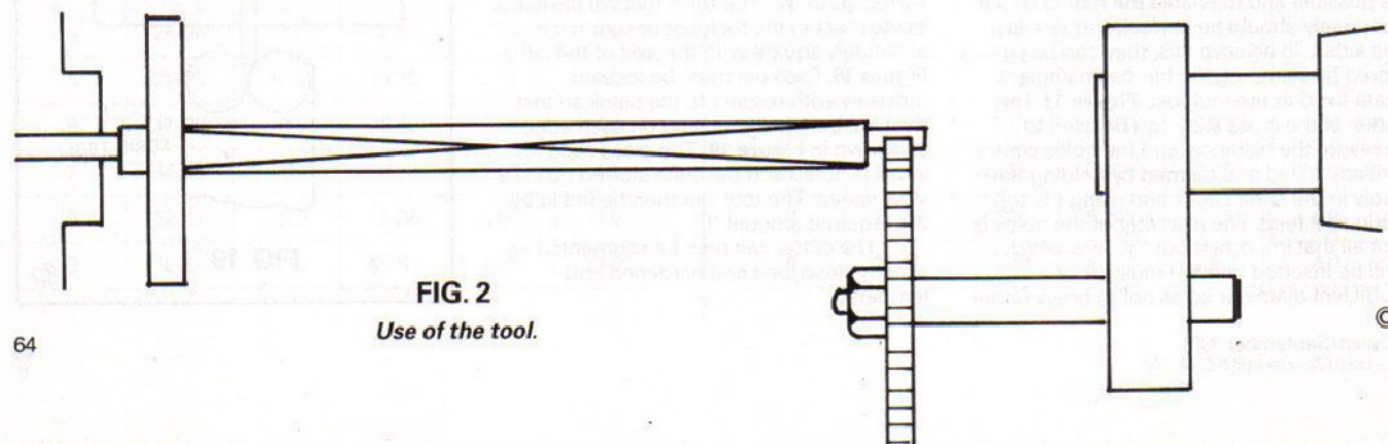


FIG. 2

Use of the tool.

dividing is unimportant, I guessed mine but you can mark off each hole if you prefer.

The small holes can be closer together than the large ones. When all are centre drilled take the discs off of the spindles and carefully drill each hole, starting with a size smaller then opening out to correct size. Make sure that the holes are drilled square with the disc face. I have listed the sizes I used but choose your own to suit your own type of work. I suggest you drill the widest range possible, as further holes cannot be

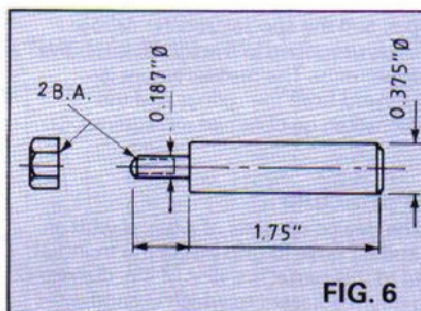


FIG. 6

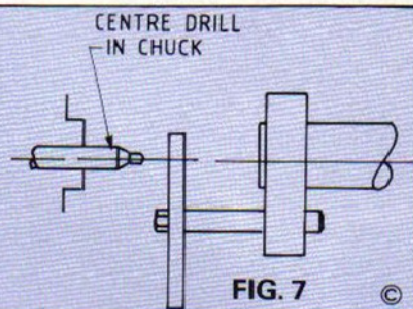


FIG. 7

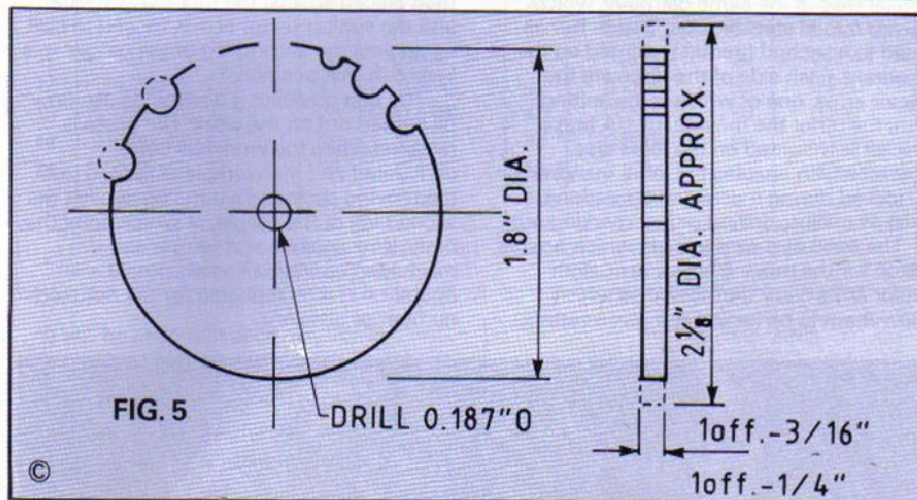


FIG. 5

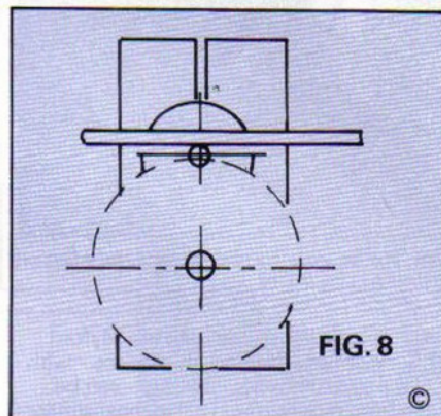


FIG. 8

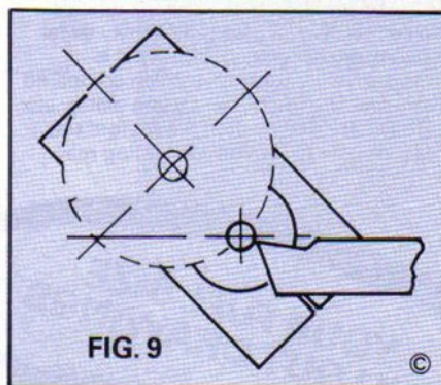
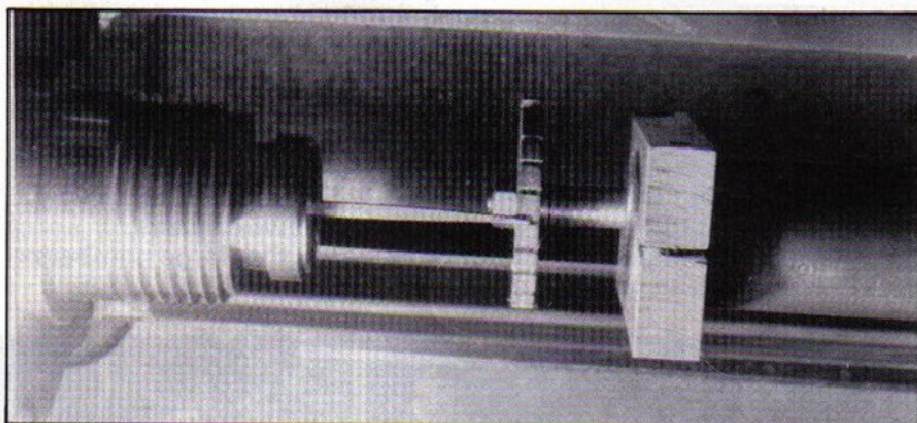
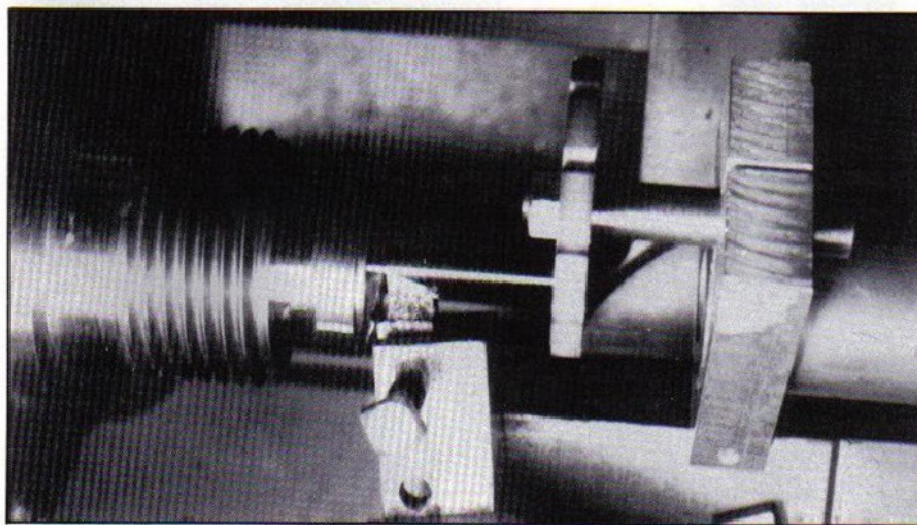


FIG. 9

drilled later when the disc is finished off.

When all the holes have been drilled and slightly countersunk each side, replace the work on the spindles. Grip the spindles true in the lathe chuck and with a sharp tool, reduce the outside diameter of the discs so that the holes are reduced to semicircles.

TOOL



Above, top; Figure 10. Above, Figure 11.

Leave a few thou oversize rather than undersize.

Using the Jacot block

For filing, stoning or burnishing a journal, the Jacot block is mounted below the work as in Figures 8 and 3, whilst turning, such as facing the shoulder back, the block is mounted at 45 deg. above and behind the work as in Figure 9. Figure 10 shows it in use supporting a taper drift whilst cutting the teeth and Figure 11 shows it underneath to provide support while filing the flats.

Incidentally, I made two holders, one for each of my lathes. In this case it is important that the centre distances between the barrel hole and the spindle are exactly the same. As with many simple tools I've made in recent years, I wish I had made it years ago!

Hole sizes

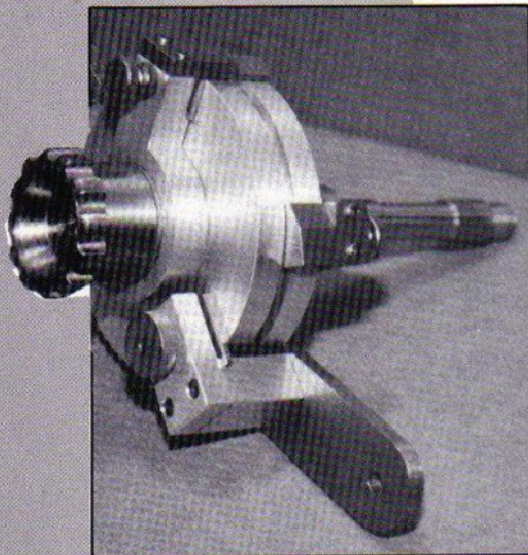
Thin disc

1.0 mm dia. $\frac{1}{16}$ in. dia.
1.2 mm dia. $\frac{3}{32}$ in. dia.
1.5 mm dia. $\frac{1}{8}$ in. dia.
1.8 mm dia. $\frac{5}{32}$ in. dia.
2.2 mm dia. $\frac{3}{16}$ in. dia.
2.8 mm dia. $\frac{1}{4}$ in. dia.
3.0 mm dia. $\frac{5}{16}$ in. dia.
3.6 mm dia. $\frac{3}{8}$ in. dia.
4.0 mm dia. $\frac{1}{2}$ in. dia.
4.5 mm dia. $\frac{7}{8}$ in. dia.
4.7 mm dia. $\frac{3}{4}$ in. dia.

Thick disc

5.0 mm dia. $\frac{3}{16}$ in. dia.
5.5 mm dia. $\frac{1}{4}$ in. dia.
6.0 mm dia. $\frac{5}{16}$ in. dia.
6.5 mm dia. $\frac{3}{8}$ in. dia.
7.0 mm dia. $\frac{7}{16}$ in. dia.
7.5 mm dia. $\frac{1}{2}$ in. dia.
8.0 mm dia. $\frac{5}{8}$ in. dia.





The finished dividing device, ready for fitting to the lathe.

Although designed with the Myford ML7 lathe in mind, this device – with a few minor adjustments – can be made to fit most lathes. Unlike most similar ideas, it does not use the change wheels and so this gives it greater flexibility as far as lathes are concerned. Equally, it is comparatively inexpensive when compared with a dividing attachment using plates, etc.

To fit lathes other than the Myford the measurement of the mandrel fitting may

caliper, and the special transfer caliper which is described in the text is set to this measurement. The measurement is transferred from the caliper and the divisions can be obtained as required.

The principle

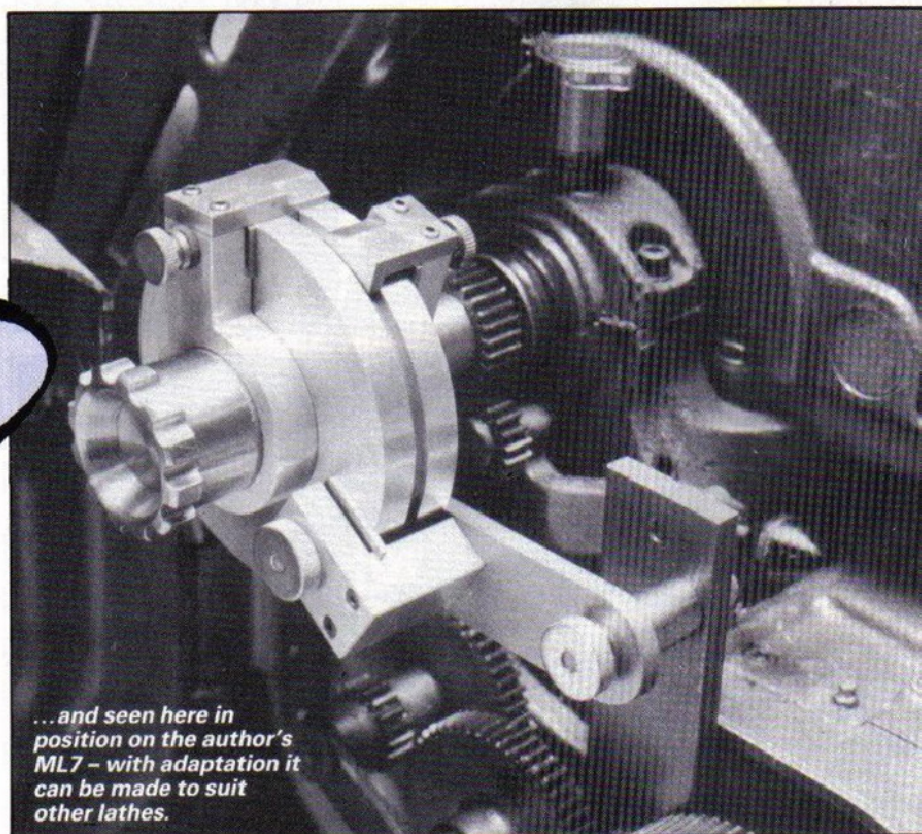
The device consists of a barrel with an expanding nose to grip inside the mandrel. Fixed to this barrel is a disc of 4in. diameter aluminium adjacent to which is another similar disc of the same diameter, which carries a mild steel bracket. This in turn is fitted to a second bracket mounted on the quadrant. Each side of the discs are the sector arms, one of which is the setting arm, the other the moving arm. A brake bracket is mounted on the fixed disc bracket which enables the lathe mandrel to be locked during machining operations, such as milling, drilling or just marking out.

The fixed disc carries a pin which acts as a stop for the moving sector arm. Both sector arms carry thumbscrews which allow them to be locked at a given setting.

Usage

To use, the attachment is mounted on the lathe, the brake is released as is the moving sector arm. The workpiece is mounted on the faceplate or in a chuck and the first machining position is set. The brake is applied and the moving sector arm is turned anticlockwise to the stop position and locked. The dimension for the chosen number of divisions is taken from the chart and set on the micrometer or vernier; from this it is set on the transfer caliper, which is then placed against the moving arm cap, and the setting sector arm is moved to butt up against the second leg of the caliper. It is locked in that position.

The first machining operations can now be carried out on the work. The brake is released when the work has been completed and the workpiece rotated until the moving sector arm butts up against the second leg of the caliper, at which point the brake is re-applied, and the second machining operation carried out. The operation is then repeated for the required number of divisions.



...and seen here in position on the author's ML7 – with adaptation it can be made to suit other lathes.

need to be varied, but that is all. The device enables dividing to be carried out rapidly, and requires only one setting to be made for any number of divisions. It will work for all divisions up to sixty but some of the lower divisions may be a little difficult, as a micrometer reading is required for accurate dividing and some readers may not possess large enough micrometers for these lower numbers. However, there is no reason why a vernier, accurately set, should not be used for the lower readings, and in these days of dial and digital vernier gauges it is simple to achieve the required degree of accuracy.

Method of dividing

The device works on the principle of obtaining the chord of a circle for the number of divisions required.

The figure, which can be obtained from the table, is set on a micrometer or vernier

The need for division in the model engineer's workshop is ever-present. The cheap way is to use the lathe change wheels, the expensive way is to use a full dividing head. In this article, Al Longworth offers a neat device which is more accurate than change wheels but avoids the expense of a full dividing head. Although some experience will be necessary to make it, it is not all that difficult. It can be constructed from stock materials but it is hoped that sets of castings and materials will be made available by Model Engineering Services, Pipworth Farm, Pipworth Lane, Eckington, Sheffield S31 9EY. It should be noted that large numbers of divisions may lead to slight cumulative errors

A SIMPLE TO USE

No. of Divs	CHORDAL VALUES FOR DIVISIONS TWO TO SIXTY (on 4" diameter circle)									
2	6.283" ($\frac{1}{2}$ circ.)	17	0.735"	32	0.392"	47	0.267"			
3	3.464"	18	0.695"	33	0.380"	48	0.262"			
4	2.828"	19	0.658"	34	0.369"	49	0.256"			
5	2.351"	20	0.626"	35	0.358"	50	0.251"			
6	2.000"	21	0.596"	36	0.349"	51	0.246"			
7	1.735"	22	0.569"	37	0.339"	52	0.242"			
8	1.531"	23	0.545"	38	0.330"	53	0.237"			
9	1.368"	24	0.522"	39	0.322"	54	0.233"			
10	1.236"	25	0.501"	40	0.314"	55	0.228"			
11	1.127"	26	0.482"	41	0.306"	56	0.224"			
12	1.035"	27	0.464"	42	0.299"	57	0.220"			
13	0.957"	28	0.448"	43	0.292"	58	0.216"			
14	0.890"	29	0.432"	44	0.285"	59	0.213"			
15	0.832"	30	0.418"	45	0.279"	60	0.209"			
16	0.780"	31	0.405"	46	0.273"					

AS THESE ARE OUTSIDE THE RANGE OF THE 0 - 1" & 1" - 2" MICROMETERS, OBTAIN 6, 8 & 10 DIVISIONS THEN IGNORE EVERY ALTERNATE DIVISION.



QUICK TIP

Sometimes it is not practical to hold work in the chuck or collet, a typical instance being when the outside has to be completely machined and witness marks are not desirable. Lightweight material such as wood, plastic, thin sheets, etc., can be secured with double-sided sticky tape. The photograph shows a piece of plastic being machined whilst stuck to the jaws of a three-jaw chuck in this way.

It will be seen that each position is obtained by releasing the moving sector arm, turning this anticlockwise to the stop and relocking, then releasing the brake and turning the work until the sector arms meet and then reapplying the brake.

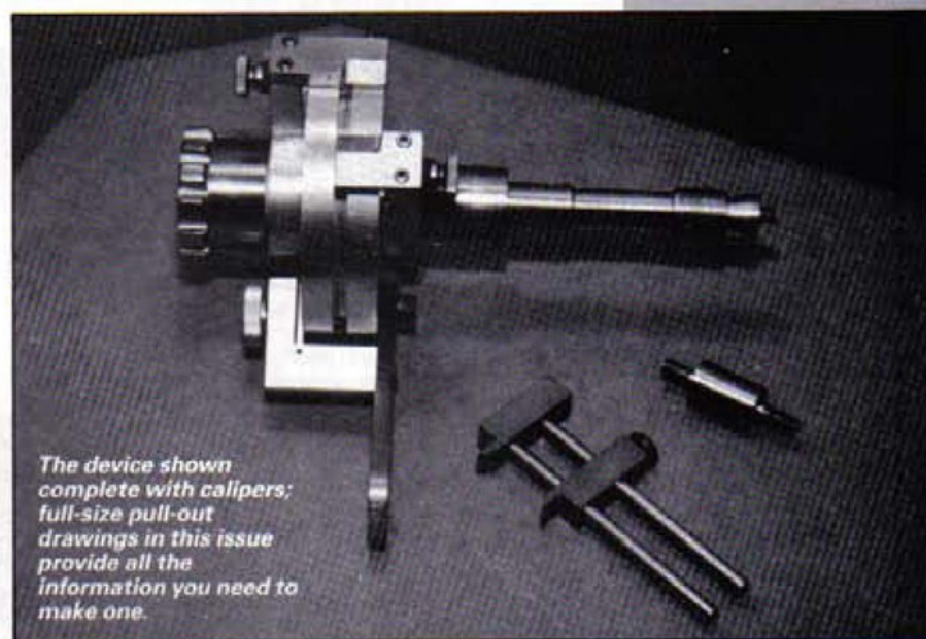
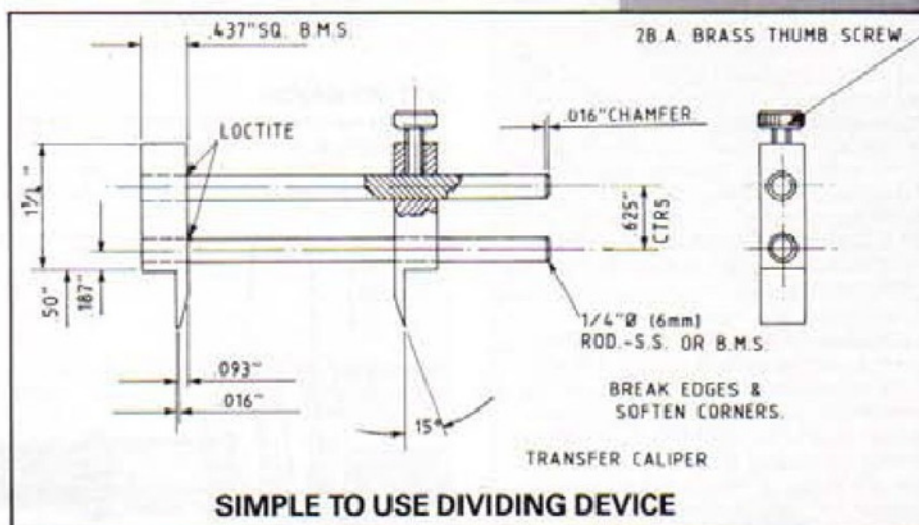
Checking for accuracy

An accuracy check can be quickly carried out before machining operations begin by marking the work for the first operation and checking that the indexing arrives back at this mark after the required number of divisions have been indexed. A quick way of making such a check without marking the metal is to cut a cardboard disc and secure this to the faceplate or chuck with double-sided tape. A scriber set in the toolpost can be used for marking this and ensuring the accuracy of the check.

Manufacture

There is not a great deal to be said about making the device, as it is all straightforward turning, drilling, milling, etc. Strangely enough, although accuracy is of importance, the actual work does not have to be as accurate as one would expect from a device designed in itself to be highly accurate! Care must be taken that the caliper heads are a good sliding fit on the bars, as sloppiness could cause measurements to go wrong. Likewise, the jaws should be square to the bore and should also be flat. Casehardening of the jaws might give an improvement in the life of the caliper, but as no great pressure is applied, it is certainly not a necessity.

The dividing attachment can be fabricated from stock material or made from castings which it is hoped will be available. Whilst, as always, appearance of the finished product is important, it is not essential to the working of the device and ordinary good, straightforward machined finishes will suffice to make it work correctly.



DIVIDING DEVICE

GRANDPA ENTERS THE COMPUTER AGE!

Many years ago, whilst still a boy at school, I purchased a few back numbers of *Model Engineer* from a local newsagent. Among them was the issue for 9th November 1950, which illustrated upon its front cover the most complicated piece of geared mechanism that my, as yet untrained, eyes had ever beheld. The caption inside informed me that this object was a compound geometric chuck constructed by Mr Norman Tweddle who was, I believe, at that time President of the Society of Ornamental Turners. However, my whetted appetite and aroused curiosity were to be frustrated by the fact that no article explaining the purpose or function of this mysterious apparatus appeared in the pages of the magazine. In fact, as far as I am able to ascertain, no article concerning this, or any other geometric chuck, was to appear in the *Model Engineer* for a further twenty eight years. However, I stand to be corrected on this point as I am not a regular reader.

And so it came to pass that I finished my schooling and began serving an apprenticeship in engineering. But when I asked about the curious mechanism with which I had fallen in love and desired to know more, the foreman sadly shook his head in dazed bewilderment. "Son, chucks come in all sorts of guises and sizes. We have three-jaw self-centering, four-jaw independent, soft jaw, collet, bell, ring, drill, pin and magnetic! But geometric - never 'eard of 'em!"

However, as in all affairs of the heart, persistence and diligence finally paid off and my interest kindled and rekindled over the years, eventually enabled me to construct a fairly accurate picture of my 'first love's' character and behaviour. Although I had better state here and now that, apart from instruments that I have made for myself, I have never once held one of these objects in my hands; nor have I ever indulged in the art of ornamental turning, and have neither the time nor the inclination to do so. But to return to *Model Engineer* - not being a regular reader of the magazine I was delighted when a colleague who had learned of my interest in geometric chucks, recently handed me two back numbers of *Model Engineer* for 1st September and 6th October 1978. These contained an excellent article on the subject by a gentleman describing himself as 'Tubal Cain'. My *Dictionary of Phrase and Fable* informs me thus: **Tubal Cain**, a descendant of Cain. "The instructor of every artificer in brass and iron." *Genesis* 4:22. Nice to know that we lesser mortals are in such capable hands, isn't it? Had I known about him before, I might have looked up geometric chucks in the Old Testament! As another legendary figure in model engineering LBSC would have said, "Nuff sed". However, I had now completed the circle in full. Pity Tubal Cain's article had

The article on making a geometric chuck in the June/July '91 issue proved to be very popular. Things are now taken a step further by Mr Smith from Bristol, who offers us a computer program for the chuck, as well as sharing some of his considerable knowledge of their history

not been around when my curiosity was first aroused - but that's another story.

First principles

It was not originally my intention to deal at great length with mechanical geometric chucks, as Tubal Cain has covered the ground fairly comprehensively and now Mr

diamond styli the patterns may be used to enhance the surface of glass objects.

In order to generate these patterns, geometric chucks rely almost exclusively on the use of epicycloidal gearing, i.e. sun and planet gearing. When the chuck embodies only one sun and one planet gear (regardless of how much other gearing may be employed within the chuck, in order to give a particular value to the overall gear ratio) the chuck is described as a 'single part' chuck. However, two, three and, I believe, six part chucks have been constructed. This is achieved by taking the output drive from the first planet wheel and, through suitable gearing, using it to rotate the foundation plate upon which the second planet wheel is carried, whilst the second sun or stator wheel is held 'stationary' with respect to the foundation plate of the first part ... and so on (see

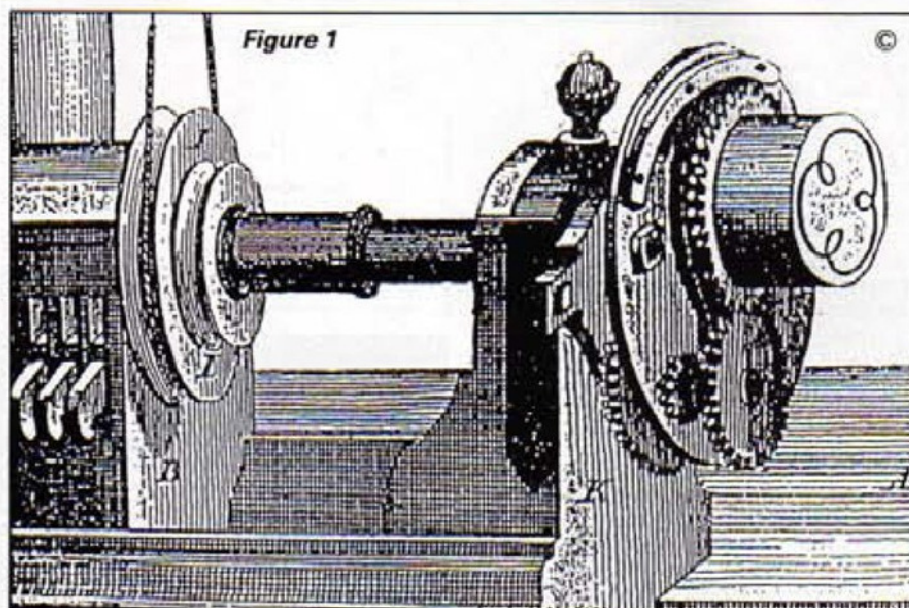


Figure 1

Allard has given us a description of his. However, in order to make my own article complete in itself, I think it may be wise to give an account of first principles, and the general historical record. Geometric chucks are attachments to the lathe and have the purpose of generating patterns. These patterns are in two dimensions only and serve little purpose other than to amuse and, in some cases, astonish the onlooker. The only practical value which such contrivances have is their employment in the ornamentation or decoration of previously turned work. Of the millions of patterns which a two-part chuck may be capable of producing, it is usually the simpler figures that are most suitable for this purpose. Typical surfaces which might be decorated with such devices include the lids of ebony, rosewood, boxwood or ivory trinket cases, watch cases (in the softer, more precious metals) and by the use of

Figure 8). Geometric chucks may look very complicated indeed but they all work on the same simple principle: namely, two rotations and an eccentricity per part. The manner in which the eccentricity is derived will be dealt with in the next section.

History

Before getting involved with the computer simulation of these instruments, I thought that readers might care to consider some of the early illustrations of geometric chucks. These illustrations are rarely reproduced and this is unfortunate, for the simplicity of the early instruments should give those who wish to make mechanical geometric chucks a sound understanding of the principles. As far as I am able to ascertain, the earliest illustrations appear in the *Manuel du Tourneur* of L.E. Bergeron, published in 1816. *The Machine Epicycloide*

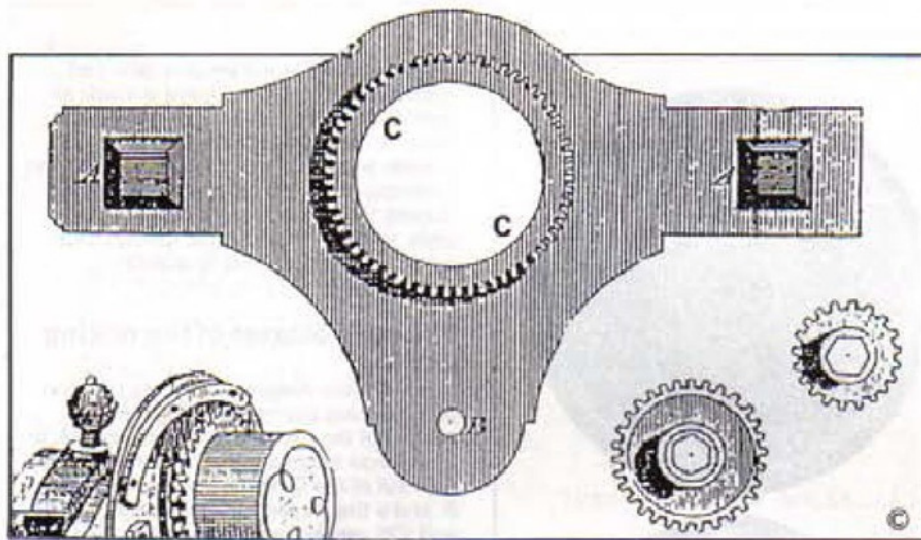


Figure 2

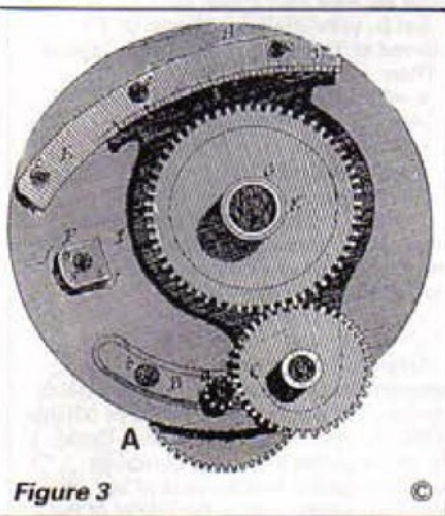


Figure 3

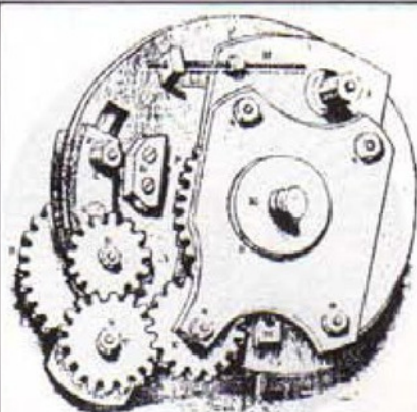
here illustrated in **Figure 1** is clearly what we would now describe as a single part geometric chuck.

The backplate in **Figure 2** bears the sun or stator wheel 'C'. This is bolted to the lathe headstock by what appear to be square-headed bolts marked 'A'. The foundation plate 'H' in **Figure 3** then screws on to the lathe mandrel nose which is free to pass through (and rotate within) the stationary sun gear 'C'. When the foundation plate is completely screwed on to the mandrel, the teeth of the planet wheel 'A' engage with the teeth of the sun

gear 'C', such that, when the mandrel is rotated, carrying the foundation plate 'H' around with it, wheel 'A' is set in motion. Further consideration of **Figure 3** reveals that the shaft carrying wheel 'A' has at its other end the pinion *a* and the bearing for this shaft is bored in a block 'B' fitting into a curved mortise and locked by the screw *b*.

The drive from *a* is now transmitted via an idler wheel 'C' to the front terminal wheel 'G'. Now notice that wheels 'C' and 'G' are carried upon an independent plate 'I' (shaded darker than the surrounding foundation plate, and hereafter referred to as the flange). This is free to pivot about the centre of idler wheel 'C' and can be locked in any position along the eccentricity scale 'E' by the locking screws *c*. When these screws are released and the flange 'I' moved until it reaches the stop 'F', the eccentricity between the front terminal wheel 'G' and the centre of the foundation plate 'H' is zero. Now, if a faceplate, carrying a workpiece, were screwed on to the hub 'K' and the chuck set in motion (at this setting of the flange) the device would merely act as a differential gear system, the faceplate rotating at a different speed to the lathe mandrel, the difference in speed depending, of course, on the overall gear ratio of the system. But if the screws *c* are released again and the flange 'I' given some eccentricity with respect to the centre of the foundation plate 'H', then two rotative motions will result.

The front terminal wheel 'G' rotates independently on the flange but at the same time is carried around by the



Wilcox's Circloidal Chuck



Figure 4

foundation plate 'H'. Thus we arrive at our single part chuck having two rotations and an eccentricity. If we now permit a tool or stylus to make contact with the workpiece carried on the faceplate, a pattern will be drawn upon the workpiece similar to those illustrated in **Figures 4** and **6**, the exact nature of the pattern being determined by

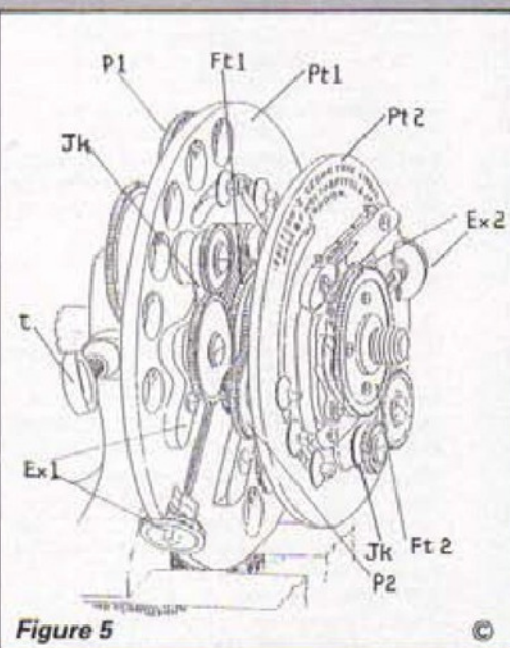


Figure 5

QUICK TIP

A good timesaver in the workshop is to make a simple drill stand to take the clearing and tapping size drills for the threads you use most and put it next to the drilling machine. I have one with 0, 2, 4, 6, 8 and 10 BA clearing and tapping size drills and a set of BA countersinks for each head size plus a general-purpose one. Another block has two sets of BA cheese head counterbores, one set with clearing size pins and the other with tapping size pins.

Don Unwin

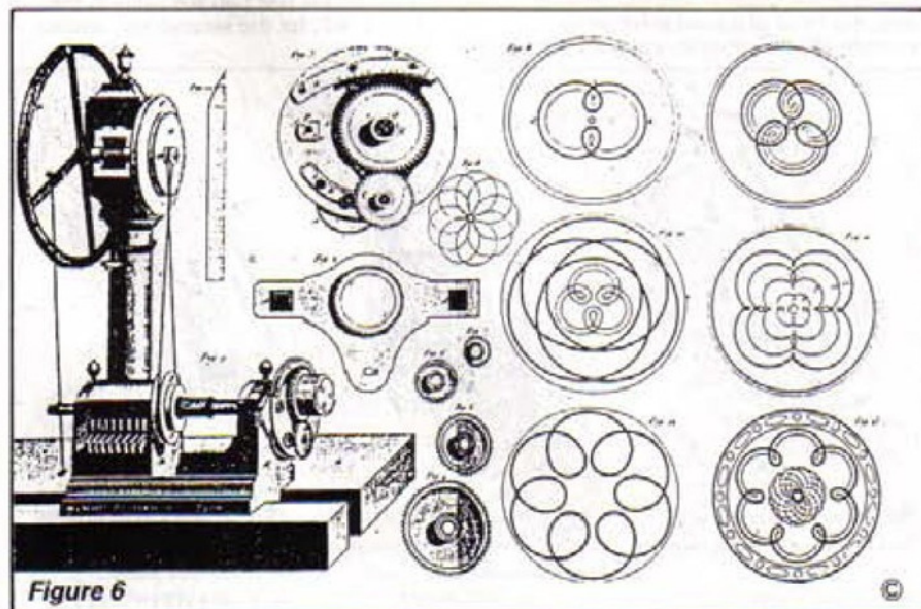


Figure 6

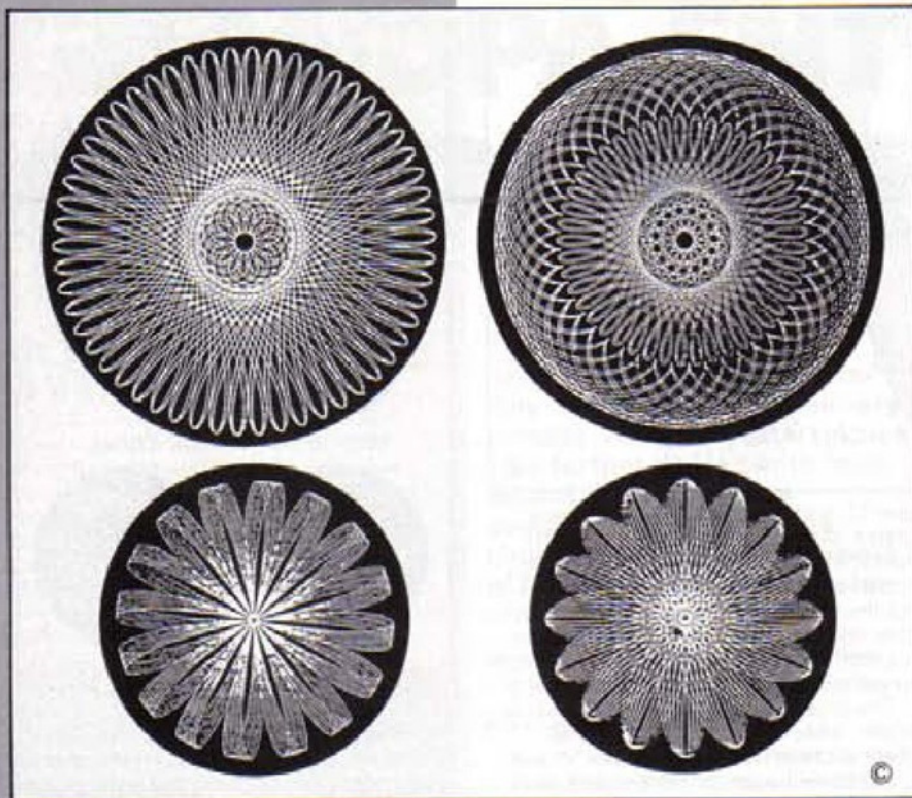


Figure 7

the overall gear ratio of the system and the amount of eccentricity applied by the offset of the flange. The change wheels for making alterations to the gear ratio are clearly illustrated in Figures 2 and 6.

Wilcox's circoidal chuck, Figure 4, is virtually identical to the Machine Epicycloide except for the addition of a reversing wheel and a screw adjuster for the fine control of the eccentricity setting. Wilcox has also 'housed' the front terminal wheel by adding a front plate (mounted on standards) to the flange, an important, though simple, modification leading to increased rigidity.

Figure 5 is a rare illustration of the famous (to those familiar with ornamental lathes) two-part Ibbetson/Holtzapfel. Here, in both of the parts, a dovetail slide is used to control the eccentricity (Ex) of the front terminal wheel (Ft), an important departure and one leading to the added complication of using 'jack-knife links' to maintain the mesh of the wheels when the slides are operated. Both the slides (Ex) and the links (jk) are clearly visible in the illustration. The thumbscrew (t), which can be seen protruding at the rear of the first part, is one of the two locking screws which Holtzapfel's used to secure the backplate (carrying the stator wheel) to the lathe headstock.

It should now be abundantly clear that this two-part chuck is really two, virtually identical, units albeit the second part is a little smaller than the first. However, each has its own planet wheel (p), eccentricity control (Ex) and front terminal wheel (Ft). The second part can, if required, simply be unscrewed from the first, leaving a threaded arbor protruding from the first stage front terminal wheel (identical to that seen protruding from the front terminal wheel of the second part). A faceplate or workpiece may then be screwed on to this arbor and the unit used as a simple or one-part chuck. Figure 8 illustrates the manner

in which this principle may, if necessary, be further extended. The drawing shows an 'exploded view' of a three-part chuck. Each part, in this instance, is constructed on the Wilcox system, for simplicity. The eccentricity of the front terminal wheel is controlled from a simple flange rotating about the centre of the intermediate wheel (I₁) (I₂) (I₃) and locked by a knurled thumbscrew. Each has its planet wheel (P₁) (P₂) (P₃), eccentricity scale (r₁) (r₂) (r₃), front terminal wheel (Ft₁) (Ft₂) (Ft₃) and each has a stator wheel (S₂) (S₃) (S₄) which would, when the parts were coupled, mesh with the planet wheel of the next stage. And so, finally, we arrive at a three-part chuck having two rotations and an eccentricity per part. However, the mathematical summing of these rotations and eccentricities is a slightly more complicated matter, as will be seen in a later section.

Bare bones

If a circle rolls (without sliding) on the outside of the circumference of another circle, the locus of a fixed point on its circumference is called an *epicycloid*; if it

rolls on the inside the locus is called an *hypocycloid*. If the fixed point is inside or outside the circumference of the rolling circle, in the case of the circle rolling outside another circle, the locus is called an *epitrochoid*. If the fixed point is inside or outside the circumference of the rolling circle, in the case of a circle rolling inside another circle the locus is called a *hypotrochoid*.

The co-ordinates of the tracing point

Let 'P' (see diagram 1) be the position of the tracing point when the point of contact of the circles has moved from 'A' to 'H'. 'P' was originally at 'A'. Let a and b be the radii of the fixed and rolling circles, and θ and ϕ the angles turned through by 'OH' and 'CH' respectively; then the arc 'AH' is $a\theta$ and the arc 'PH' is $b\phi$. Since the arcs are equal $a\theta = b\phi$ also $\phi = a\theta/b$.

Let (x, y) be the co-ordinates of 'P' referred to 'O' as origin and 'OA' as axis of x . Then

$$\begin{aligned} x &= OK - PM - OC \cos \theta - PC \cos CPM \\ &= (a+b) \cos \theta - b \cos(\theta + \phi) \\ &= (a+b) \cos \theta - b \cos \frac{a+b}{b} \theta \\ y &= KC - MC - OC \sin \theta - PC \sin CPM \\ &= (a+b) \sin \theta - b \sin \frac{a+b}{b} \theta \end{aligned}$$

If the rolling circle is inside the fixed circle, the co-ordinates of the tracing point are obtained by changing the sign of b . Hence, for the hypocycloid:

$$\begin{aligned} x &= (a-b) \cos \theta + b \cos \frac{a+b}{b} \theta \\ y &= (a+b) \sin \theta - b \sin \frac{a+b}{b} \theta \end{aligned}$$

Nearly all the curves generated by geometric chucks are, in fact, epitrochoids (the locus of a point either inside or outside of the circumference of the rolling circle). We can simulate this in the computer equations by the attachments of an imaginary vector arm at the centre of the rolling circle, extending beyond its circumference. If this vector arm is designated L and the radii of the circles designated ' R ' and ' r ', then the equations become:

$$\begin{aligned} x &= (R+r) \cos \theta - (r+L) \cos \left(\frac{R+r}{r} \theta \right) \\ y &= (R+r) \sin \theta - (r+L) \sin \left(\frac{R+r}{r} \theta \right) \end{aligned}$$

Nomenclature

Geometric chucks are usually set up with respect to the following nomenclature:

- the overall train value or diminishing effect of the wheels in use on any particular part from the front terminal wheel through to the stator wheel is 'V'. Thus, for the first part the value of the train is 'V1', for the second 'V2', and so on.

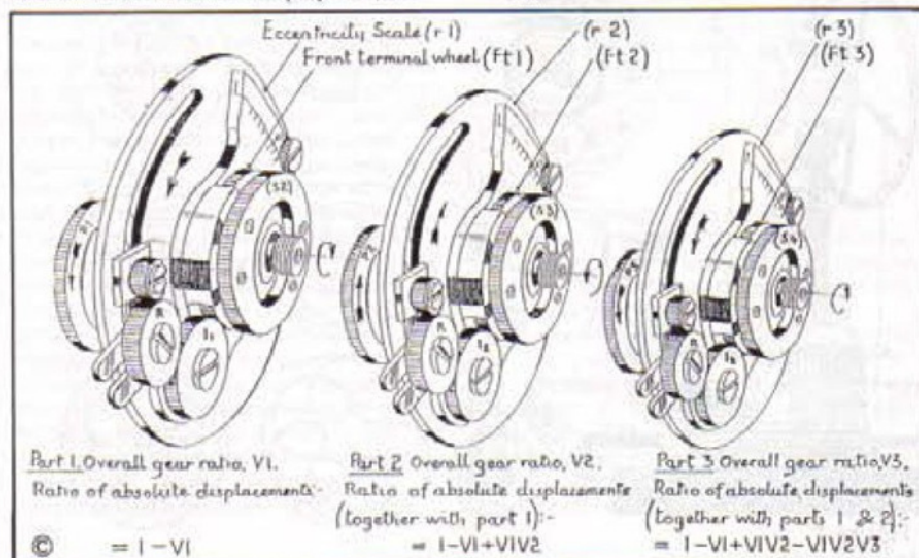


Figure 8

Figure 9

INDEX TO THE GEOMETRIC CHUCK:

A TREATISE UPON

THE DESCRIPTION, IN THE LATHE,
OF
SIMPLE AND COMPOUND EPITROCHOIDAL OR
"GEOMETRIC" CURVES.

BY

THOMAS SEBASTIAN DAZLEY, M.A.,

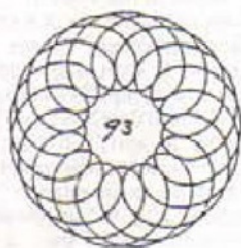
AUTHOR OF

"NOTES ON THE EPICLICAL CUTTING FRAME."

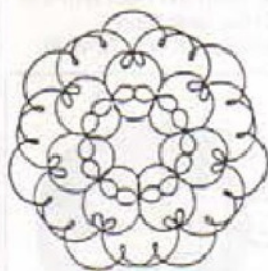
LONDON:

LITHOGRAPHED, PRINTED, AND PUBLISHED FOR THE AUTHOR, BY
WATERLOW AND SONS, GREAT WINCHESTER STREET, E.C.
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HOLTERBYLL & CO., 46, CILKING CROSS.

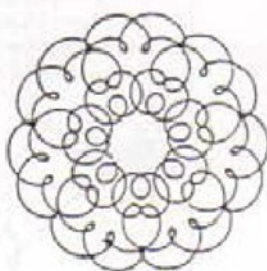
1871.



94



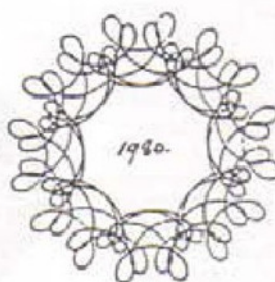
1972.



1973.



98.



1980.



1981.



1974.



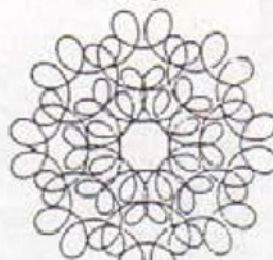
1975.



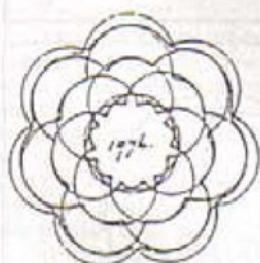
99.



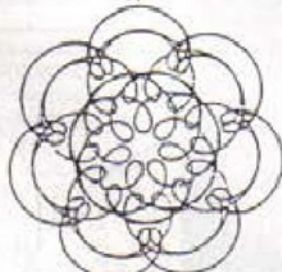
1982.



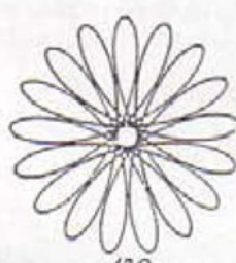
1983.



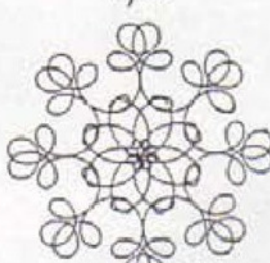
1976.



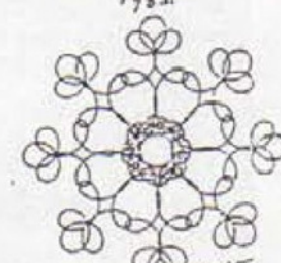
1977.



129.



1984.



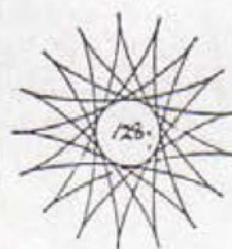
1985.



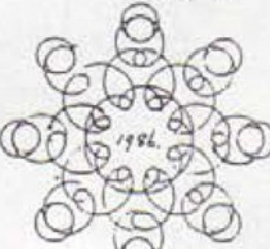
1978.



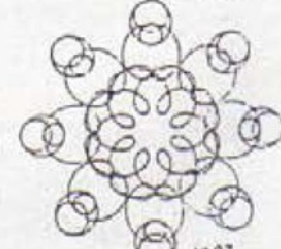
1979.



125.



1986.



1987.



In order to add a second part to the mathematical model it is now necessary to consider the section of the equation in which this sign occurs. The expression in brackets $(1 - V_1)$ or $(1 + V_1)$ relates to the ratio of absolute displacement between an increment of rotation (θ) of the mandrel (and consequently the first part's planet wheel carrier) and an increment of rotation of the output arbor, from the front terminal wheel and through the gear train represented by the value of ' V_1 '. Now, in

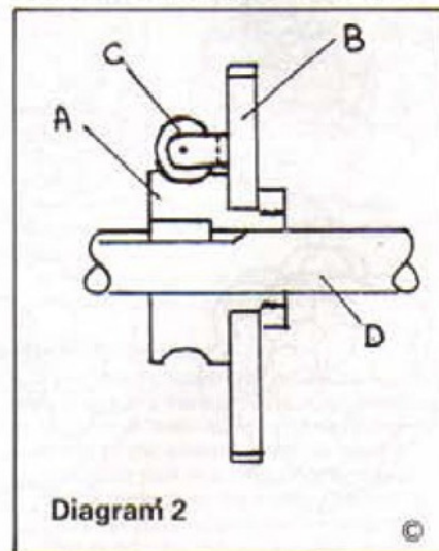


Diagram 2

- With respect to computer modelling, the phase angle is important with reference to the drawing of companion figures, which we will deal with later. In the case of the mechanical chuck, there is another aspect

of phasing which ought to be considered. If the lathe is stopped and any adjustments made to the eccentric slide (in order to superimpose one figure upon another, for example) a partial rotation of the wheels in the train would occur. This partial rotation would result in the axes of the lobes or cusps of the new figure being out of phase with those of the original. Compensating devices were subsequently introduced in order that such errors could be obviated.

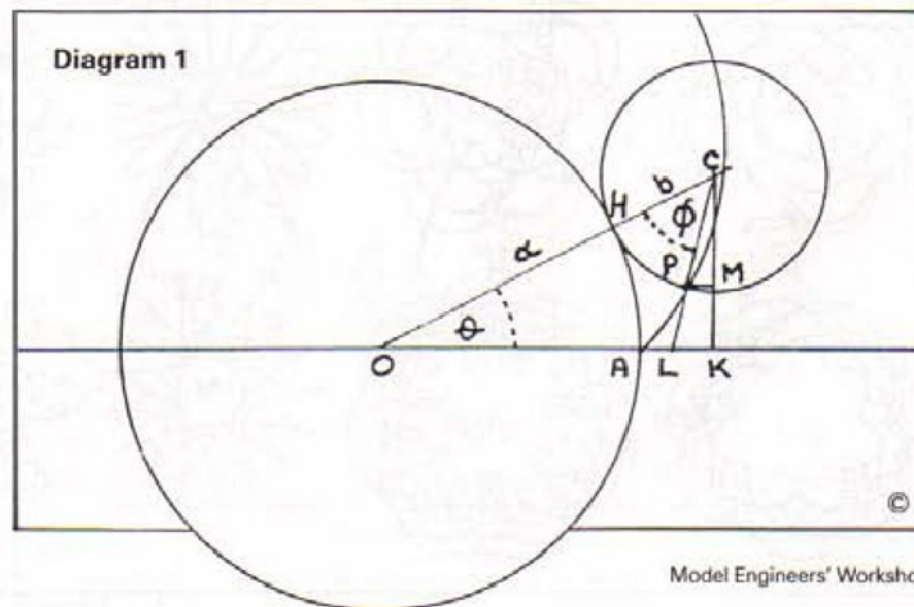


Diagram 1

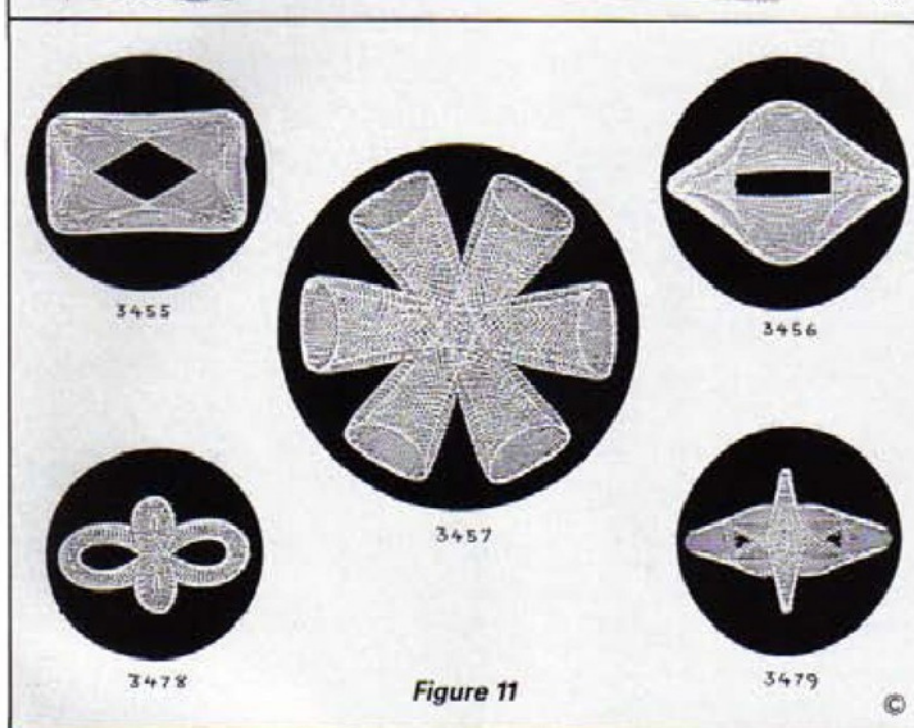
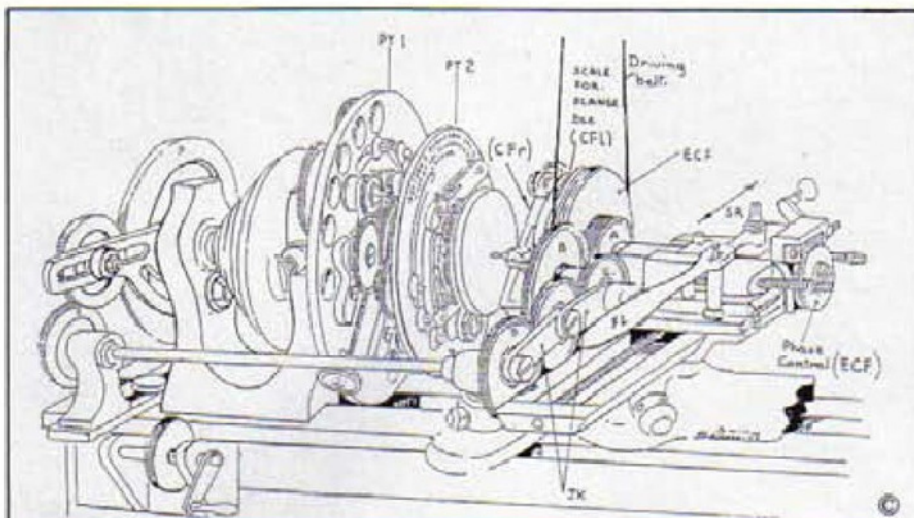


Figure 11

the case of the first part this is fairly easy to obtain (as we have already seen) because the stator wheel of the first part is stationary, being rigidly attached to the headstock of the lathe. In subsequent parts, however, the stator wheel is only 'fixed' with respect to the rotating planet carrier of the previous part.

There is a special procedure used in the summing of epicyclic gear trains which need not be considered here.* Suffice it to say that the ratios of absolute displacement for the second and third parts are:

$(1 - V_1 + V_1 \times V_2)$ 2nd
and $(1 - V_1 + V_1 \times V_2 - V_1 \times V_2 \times V_3)$ 3rd
By now a pattern has emerged enabling the 4th part to be written thus:

$(1 - V_1 + V_1 \times V_2 - V_1 \times V_2 \times V_3 + V_1 \times V_2 \times V_3 \times V_4)$ 4th
and so on, if it is necessary to add further parts.

The computer originally used in these experiments was the BBC model B and later on an Acorn Electron was substituted. The programming - carried out in extended Basic - worked equally well on either. Accordingly, those having access to either of these computers can type the programs straight in. Virtually any modern micro should suffice, although some minor

modifications to the programming may be found necessary. The format of the programs should be fairly easily understood by working through them line by line and referring to the manual for explanation of the keywords, if necessary. In the case of program IBB1 the Basic formula for the epitrochoid X co-ordinate occurs at line 380 and for the Y co-ordinate at line 420. Similarly at lines 370 and 410 for IBB2. Readers may care to model 4, 5 or 'umpteenth' part chucks, and if so, if they follow the reasoning referred to earlier (relating to absolute displacements) they should not have too much difficulty. Be particularly careful with the bracketing of the equations and be mindful of the fact that the equations will expand alarmingly as more parts are added. I have included program 'QVD' (for a three part chuck) to demonstrate this. Readers can experiment - inserting their own parameters. Remember when entering the 'theta step' parameter to any of the programs, that this is the term in the equation which will determine the speed at which the program runs. The smaller it is, the better the resolution of the curves, but the program will take longer to complete the drawing of a figure.

In the case of the compound chuck (program IBB2) readers will probably be intrigued by the order in which the various parts of the pattern are produced by the tracing point. I would defy anyone to predict this, prior to running the program and watching a particular pattern generated on the screen (try 1984 - 1985).

The parameter tables

In 1875 Thomas Sebastian Bazley M.A. wrote a learned treatise dealing with the operation of the Holtzapffel two part geometric chuck. The title page of this work is illustrated in Figure 9, surrounded by a few examples of the Victorian ornament to which Bazley, apparently, devoted half of his life. The parameter tables have been drawn up strictly in accordance with the eccentricities and gear ratios given by Bazley, in order to test the accuracy of the

```

L.
5 REM SINGLE PART GEOMETRIC CHUCK
10 *TV0.1
20 MODE 0
30:
40 INPUT "THETA STEP (DEG)";INC
50 INC = RAD (INC)
60:
70 INPUT "E×1":r1
80 INPUT "SR":r2
90:
100 INPUT "PHI 1 (DEG)"; PHI1
110 PHI1= RAD (PHI1)
120:
130 INPUT "V1":V1
140:
150 S = r1+r2
160 Factor = 500/S
170:
180 VDU 29,648;512:
190 PROCAXIS
200 :
210 THETA = 0
220 PROCX
230 PROCY
240 X1 =X

```

IBB1

PROGRAM CONTINUED OVERLEAF

computer modelling.

Figures 93 to 129 are all 'simple' figures, that is to say, they can be drawn with the aid of a single part chuck. Hence, use program IBB1 to illustrate these figures on the computer, entering the parameters from Table IBB1. Figures 93, 94, 123 and 124 are examples of figures in which the loops (and in one case cusps) turn in. Conversely, Figures 98, 99, 128 and 129 are examples of figures in which the loops turn out. Accordingly, an examination of Table IBB1 will indicate that in the latter case V1 has changed from positive to negative (recall the previous section).

The Figures 1972 - 1987 are compound figures and these necessitate the use of a two part chuck. Hence, use program IBB2 to demonstrate these figures on your computer - entering the parameters from Table IBB2. Figures 1972 - 1979 are examples of compound figures in which the loops turn in. The parameter table shows V1 positive whilst V2 is negative. It will be noticed that the figures are paired - 1972 1973; 1974 1975; 1976 1977; 1978 1979. These are companion figures (mentioned earlier) and an examination of the table shows that the only change which occurs (in order to switch from one pattern to the other) is the phase angle Phi1 (once again recall the previous section).

Figures 1980 - 1987 are examples of compound figures in which the loops turn out. The parameter table shows both 'V1' and 'V2' negative. Once again the figures are paired as companion figures - 1980 1981; 1982 1983; 1984 1985; 1986 1987. Again the table shows the only change from one to the other, in each pair, is a change of the phase angle Phi1 from 0 deg. to 180 deg. (N.B. The difference which occurs in the SR column would only change the overall size of the figure.)

Of further historical interest

Figure 10 illustrates a number of accessories to the ornamental lathe from the pages of Holtzapffel's *Turning and Mechanical Manipulation*, Vol. 5. The construction of any one of these delightful and ingenious little contrivances would provide an excellent project for any model engineering enthusiast who wished to try his hand at something slightly different.

Figure 10g is, of course, the lathe slide rest equipped with a lever-operated tool receptacle, into which any of the square shanked accessories may be fitted. These were, in their day, powered from an overhead drive which could, no doubt, be incorporated in order to adapt the Myford for the purpose of ornamental turning.

Figure 10a is the eccentric cutting frame, 'b' the drilling frame, 'c' the collet chuck for the drilling frame, 'd' the universal cutting frame, 'e' the elliptical cutting frame and 'f' the epicycloidal cutting frame. Figure 10h shows the manner in which the cross slide could, if desired, be driven from the headstock through a train of wheels - the so-called spiralling drive. Some of the beautiful figures which can be generated using the elliptical cutting frame and the headstock of the lathe as a counting or indexing device are illustrated in Figure 7.

A supplement

Further examination of the epicycloidal cutting frame, illustrated in Figure 10f, will reveal that this is in effect a one part geometric chuck adapted to be held in the

```

250 Y1 = Y
260 MOVE X1,Y1
270 REPEAT
280 THETA = THETA + INC
290 PROCX
300 PROCY
310 DRAW X,Y
320 UNTIL X>X1-.01 AND X<X1+.01 AND Y>Y1-.01 AND Y<Y1+.01
330 INPUT "TO DRAW ANOTHER PATTERN TYPE 1 OTHERWISE TYPE 0":P
340 IF P=1 THEN 40 ELSE 350
350 STOP
360 :
370 DEFPROCX
380 X=Factor*(r1*COS(THETA)+r2*COS((1+V1)*THETA+PHI1))
390 ENDPROC
400 :
410 DEFPROCY
420 Y=Factor*(r1*SIN(THETA)+r2*SIN((1+V1)*THETA+PHI1))
430 ENDPROC
440 :
450 DEFPROCAXIS
460 MOVE -500,0: DRAW 500,0: MOVE 0,500: DRAW 0,-500
470 ENDPROC

```

>230
>C.

IBB2

```

10 REM TWO PART GEOMETRIC CHUCK
20 *TV0.1
30 MODE 0
40 INPUT "THETA STEP (DEG)": INC
50 INC = RAD (INC)
60 INPUT "Ex1": r1
70 INPUT "Ex2": r2
80 INPUT "SR": r3
90 :
100 INPUT "PHI 1 (DEG)": PHI1
110 PHI1 = RAD (PHI1)
120 INPUT "PHI 2 (DEG)": PHI2
130 PHI2 = RAD (PHI2)
140 :
150 INPUT "V1": V1
160 INPUT "V2": V2
170 :
180 S = r1+r2+r3
190 :
200 Factor = 500/S
210 VDU 29,648;512:
220 PROCAXIS
230 :
240 THETA = 0
250 PROCX
260 PROCY
270 MOVE X,Y
280 REPEAT
290 THETA = THETA + INC
300 PROCX
310 PROCY
320 DRAW X,Y
330 UNTIL FALSE
340 STOP
350 :
360 DEFPROCX
370 X=Factor*(r1*COS(THETA)+r2*COS((1+V1)*THETA+PHI1)+r3*COS((1+V1-(V1*V2))*THETA+PHI2))
380 ENDPROC
390 :
400 DEFPROCY
410 Y=Factor*(r1*SIN(THETA)+r2*SIN((1+V1)*THETA+PHI1)+r3*SIN((1+V1-(V1*V2))*THETA+PHI2))
420 ENDPROC
430 :
440 DEFPROCAXIS
450 MOVE -500,0: DRAW 500,0: MOVE 0,500: DRAW 0,-500
460 ENDPROC

```



```

>L.
10 REM 2 PART IBBETSON + ECF
20 *TV0.1
30 MODE 0
40 INPUT "THETA STEP (DEG)": INC
50 INC = RAD (INC)
60:
70 PRINT "GC PARAMETERS"
80:
90 INPUT "EX1": r1
100 INPUT "EX2": r2
110 INPUT "SR": r3
120:
130 INPUT "PHI 1 (DEG)": PHI1
140 PHI1 = RAD (PHI1)
150 INPUT "PHI 2 (DEG)": PHI2
160 PHI2 = RAD (PHI2)
170:
180 INPUT "V1": V1
190 INPUT "V2": V2
200:
210 PRINT "ECF PARAMETERS"
220 INPUT "CF1": r4
230 INPUT "CFr": r5
240:
250 INPUT "ECF Driving Ratio (SP)": DR
260 INPUT "V For ECF": Vc
270:
280 INPUT "PHI 3 (DEG)": PHI3
290 PHI3 = RAD (PHI3)
300:
310 S = r1+r2+r3+r4+r5
320:
330 Factor = 500/S
340 VDU 29.648:512:
350 PROCAXIS
360:
370 THETA = 0
380 ALPHA = 0
390 PROCX
400 PROCY
410 MOVE X,Y
420 REPEAT
430 THETA = THETA + INC
440 ALPHA = THETA*DR
450 PHI3 = PHI3 + (INC*Vc)
460 PROCX
470 PROCY
480 DRAW X,Y
490 UNTIL FALSE
500 STOP
510:
520 DEFPROCX
530 A = Factor*(r1*COS(THETA)+r2*COS((1+V1)*THETA
+PHI1)+r3*COS((1+V1-(V1*V2)) THETA+PHI2))
540 B = Factor*(r4*COS(ALPHA)+r5*COS((1+Vc)*ALPHA
+PHI3))
550 X = A-B
560 ENDPROC
570:
580 DEFPROCY
590 C = Factor*(r1*SIN(THETA)+r2*SIN((1+V1)*THETA
+PHI1)+r3*SIN((1+V1-(V1*V2)) THETA+PHI2))
600 D = Factor*(r4*SIN(ALPHA)+r5*SIN((1+Vc)*ALPHA
+PHI3))
610 Y = C-D
620 ENDPROC
630:
640 DEFPROCAXIS
650 MOVE -500,0: DRAW 500,0: MOVE 0,500: DRAW 0,-500
660 ENDPROC

```

tool receptacle of the slide rest.

Figure 11 illustrates the manner in which this instrument was sometimes used. This is known as a four part turning set up. Here the epicycloidal cutting frame, hereafter referred to as the 'ECF', is located in the tool receptacle of the slide rest. The drive to the 'ECF' is from an overhead pulley and thence via a diminishing train of wheels 'A, B, C, D, E, F' (spiral drive) to the headstock mandrel (the normal drive of which is disconnected). The central idler wheel of this train is carried on jack-knife links (jk) in order to permit movement of the slide rest (SR) along the cross slide. The 'ECF' driving pulley has a broad-faced gear 'A' mounted at the rear and keyed to the pulley. This allows a small amount of movement of the tool receptacle, to facilitate bringing the tool into contact with the faceplate carrying the workpiece. The faceplate is in turn mounted on a two part geometric chuck driven from the mandrel. In this way two, separate, epicycloidal systems are geared together, facing each other with both tool and workpiece moving in distinctly independent geometric figures!

As one might imagine, some very complex geometric patterns were demonstrated in this manner. Unfortunately, whilst the former programs are mathematically perfect and will faithfully reproduce the figures generated by their mechanical counterparts, I have not, as yet, been able to devise a similarly mathematically perfect program for this set up. However, the program given as ECF2, whilst not suitable for the general case, will reproduce the figures illustrated in **Figure 11**, 3455, 3456, 3457, 3478, 3479, all of which are from Bazley's Index. I leave readers to experiment further and, hopefully, find the perfect formula for the program.

Who knows? Finding the solution to Smith's last program may become one of the great endeavours of the model engineering fraternity! N.B. A problem which arose in the compilation of the programs was that of stopping the program when the pattern was completed. A number of methods were attempted (one of which has been left intact in 1BB1, lines 320-350). However, these were not entirely successful, the easiest way being to use the escape key. (The problem is far more complex than it might appear at first sight.)

Conclusion

During the late 1880s, or thereabouts, an Holtzapffel ornamental lathe, complete with its full range of tools and accessories, cost somewhere in the region of £3000, a truly colossal sum in those days. These machines were produced as expensive playthings for the very rich and will never be made again. It is important, therefore, that a record of their functions and capabilities be maintained. The geometric chuck was one of the more interesting accessories to such machines, and it is hoped that this little article may eventually find a place in the final compilation of such a record.

Acknowledgements

I am indebted, for his assistance, to my old friend Jack Bones, Senior Lecturer in Mechanics of Machines at the Department of Mechanical Engineering, University of Bristol, and also to Mrs. Miggy Singh for


```

>L.
10 *TV0,1
20 MODE 0
30 INPUT "THETA STEP (DEG)"; INC
40 INC = RAD (INC)
50 INPUT "Ex1"; r1
60 INPUT "Ex2"; r2
70 INPUT "Ex3"; r3
80 INPUT "SR"; r4
90 :
100 INPUT "PHI 1 (DEG)"; PHI1
110 PHI1 = RAD (PHI1)
120 INPUT "PHI 2 (DEG)"; PHI2
130 PHI2 = RAD (PHI2)
140 INPUT "PHI 3 (DEG)"; PHI3
150 PHI3 = RAD (PHI3)
160 :
170 INPUT "V1"; V1
180 INPUT "V2"; V2
190 INPUT "V3"; V3
200 :
210 S = r1+r2+r3+r4
220 :
230 Factor = 500/S
240 VDU 29,648;512:
250 PROCAXIS
260 :
270 MOVE 0,0

```

OVD

```

280 THETA = 0
290 REPEAT
300 PROCX
310 PROCY
320 DRAW X,Y
330 THETA = THETA + INC
340 UNTIL FALSE
350 STOP
360 :
370 DEFPROCX
380 X = Factor*(r1*COS(THETA)+r2*COS
((1-V1)*(THETA)+PHI1)+r3*COS((1-V1+
(V1*V2))*THETA+PHI2)+r4*COS((1-V1+(V1*V2)
-(V1*V2*V3))*THETA+PHI3))
390 ENDPROC
400 :
410 DEFPROCY
420 Y = Factor*(r1*SIN(THETA)+r2*SIN
((1-V1)*(THETA)+PHI1)+r3*SIN((1-V1+
(V1*V2))*THETA+PHI2)+r4*SIN((1-V1+(V1*V2)
-(V1*V2*V3))*THETA+PHI3))
430 ENDPROC
440 :
450 DEFPROCAXIS
460 MOVE -500,0: DRAW 500,0: MOVE
0,500: DRAW 0,-500
470 ENDPROC

```

her help and encouragement during the project.

Bibliography

*A section on the summing of epicyclic gear trains is to be found in *An introduction to Mechanics of Machines* by J.L.M. Morrison and B. Crossland, Longman (pp. 178-179). Those who wish to 'drink deeper

at the well' of ornamental turning will find all they require in *Turning and Mechanical Manipulation*, Vol. 5, by J.J. Holtzapfel.

Bazeley's *Index to the Geometric Chuck* is a rare book but might be obtained on Inter-Library Loan.

A recent publication on the subject is *Ornamental Turning* by T.D. Walshaw (otherwise *Tubal Cain*), published by Argus

Books, price £15.95 plus £1.60 p&hp. Available from Argus Books, Argus House, Boundary Way, Hemel Hempstead HP2 7ST. Photocopy reprints of the *Model Engineer* articles referred to by the Author are available from Readers' Services (Photocopies) at the above address - postal service only.



PARAMETER TABLES

IBB1

θ INC	Ex1	SR	Phi1	V1	Fig.	θ INC	Ex1	SR	Phi1	V1	Fig.
5	4	2	0	5.666	93	5	4	14	0	-4.66	98
5	32	28	0	5.666	94	5	32	28	0	-4.66	99
5	476	124	0	2.8333	123	5	388	212	0	-2.833	128
5	43	17	0	2.8333	124	5	33	27	0	-2.833	129

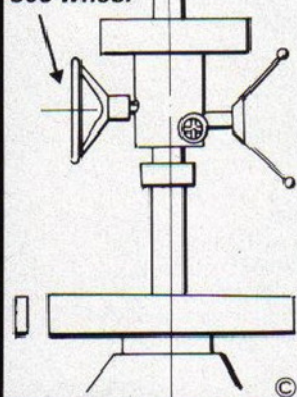
ECF2

θ INC	Ex1	Ex2	SR	Phi1	Phi2	V1	V2	CFI	CFr	SP/DR	Vc	Phi3	Fig.
2	7	2	0	0	0	-2	2	12	.22	-80	-2	180	3455
2	7	2	0	0	0	-2	2	12	.22	-80	-2	0	3456
3	6	6	0	0	0	-2	2	12	.27	60	-2	180	3457
1	17	34	34	0	0	-2	2	0	.09	48	2	0	3478
1	17	34	34	0	0	-2	2	12	.12	60	-2	0	3479

IBB2

θ INC	Ex1	Ex2	SR	Phi1	Phi2	V1	V2	Fig.
1.0	4	2	.07	0	0	3.5	-6	1972
1.0	4	2	.07	180	0	3.5	-6	1973
1.0	3	3	.05	180	0	3.5	-6	1974
1.0	3	3	.05	0	0	3.5	-6	1975
1.0	2	4	.05	0	0	3.5	-6	1976
1.0	2	4	.12	180	0	3.5	-6	1977
1.0	1	5	.07	180	0	3.5	-6	1978
1.0	1	5	.14	0	0	3.5	-6	1979

Old Fiat 500 wheel



QUICK TIP

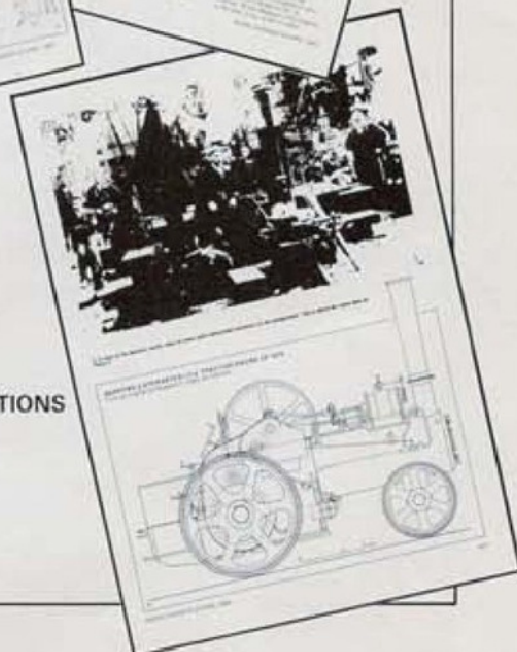
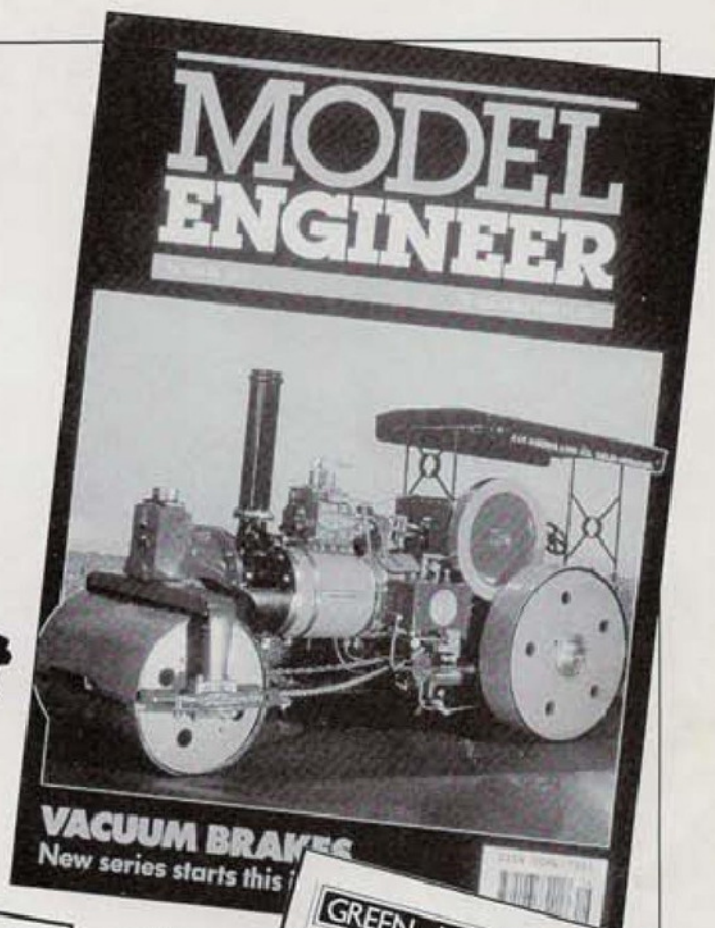
I have a mill drill of Far Eastern manufacture similar to the one shown at the Jack Sealey premises in *MEW* Autumn 1990 issue. Mine was purchased in the USA. I found raising and lowering the head difficult from the front of the machine because the crank handle which was fitted moved to awkward positions as it was rotated. I replaced it with a small car steering wheel (mine was from a Fiat 500) suitably bored and secured with screws. I have since used the machine for eight years and have had no further problems.

Frank Birchall

θ INC	Ex1	Ex2	SR	Phi1	Phi2	V1	V2	Fig.
1.5	5	1	.1	180	0	-1.6	-6	1980
1.5	5	1	.1	0	0	-1.6	-6	1981
1.5	4	2	.04	0	0	-1.6	-6	1982
1.5	4	2	.01	180	0	-1.6	-6	1983
1.5	3	3	.08	180	0	-1.6	-6	1984
1.5	3	3	.08	0	0	-1.6	-6	1985
1.5	2	4	.09	0	0	-1.6	-6	1986
1.5	2	4	.09	180	0	-1.6	-6	1987

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