No.151

JUNE 2009

MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

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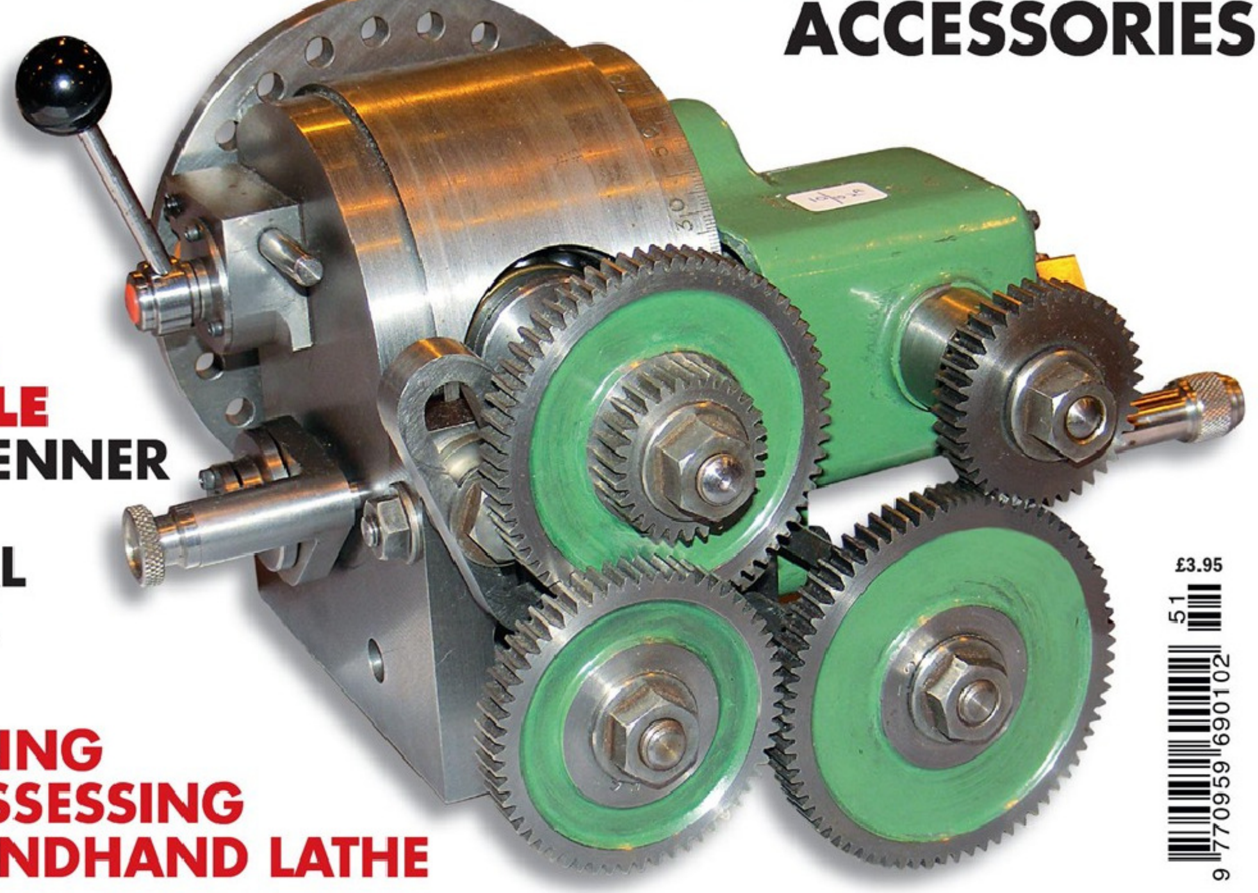
HAROLD HALL LOOKS AT DIAL TEST INDICATOR ACCESSORIES

STEPPERHEAD
AN EXPERIMENTAL LATHE



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DAVE FENNER MAKES A METAL ROLLER

CHOOSING AND ASSESSING A SECONDHAND LATHE

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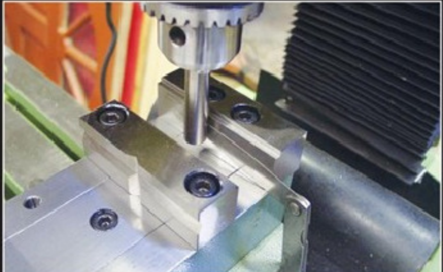
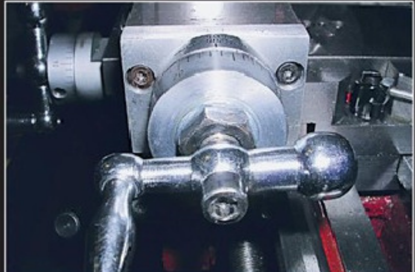
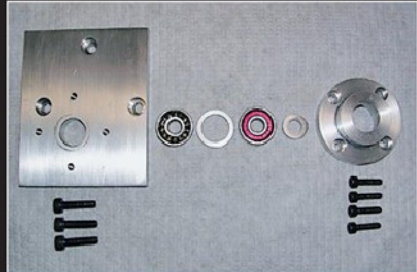


FINDING A MACHINE DATUM



MINI LATHE TOPSLIDE IMPROVEMENT



X1 MILL IMPROVEMENTS

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BACK ISSUES & BINDERS
Tel: +44 (0)844 848 8822
Email: customer.services@myhobbystore.com

EDITORIAL
Editor: David Clark
Tel: +44 (0)1847 821136
Email: david.clark@myhobbystore.com

PRODUCTION
Designer: Yvette Masson
Illustrator: Grahame Chambers
Pre-Press: Brian Vickers
Ad Production: Robin Gray

ADVERTISING
Senior Sales Executive: Duncan Armstrong
Email: duncan.armstrong@myhobbystore.com
Tel: 0844 848 5238

MARKETING & SUBSCRIPTIONS
Marketing Executive: Heather Morrison

MANAGEMENT
Head of Design and Production: Nikki Coffey
Special Projects Publisher: Nikki Parker
Subscriptions Director: Rebecca Blighton
Chief Executive: Owen Davies
Chairman: Peter Harkness

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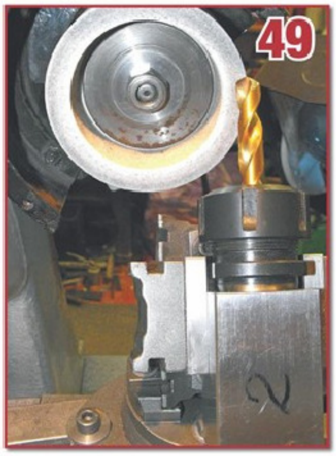

ON THE COVER

Ivan Law made this excellent compound dividing head. It has been seen at various exhibitions over the past couple of years.

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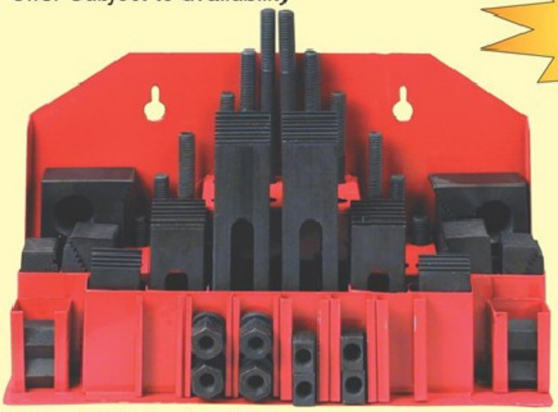

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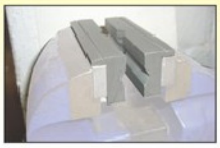

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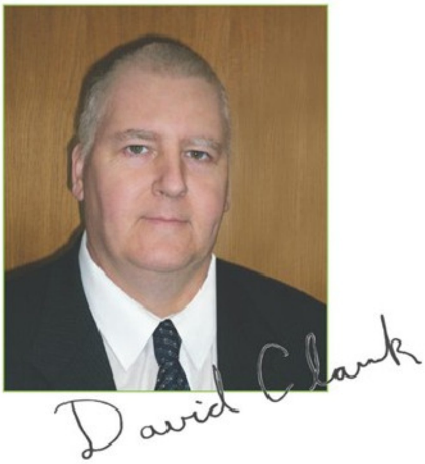
ON THE EDITOR'S BENCH



Model engineering societies

During my recent travels, I visited three model engineering societies, Bournemouth, Nottingham and East Somerset.

Bournemouth was local to Poole where I was staying and I had visited before when I lived in Poole although I was never a member. They have a small clubhouse that does the job, a reasonable length of track and also a 16mm narrow gauge raised level 32mm gauge line.

I visited Nottingham on the Wednesday prior to visiting the Myford open day on the Thursday. The original intention was to visit Andy Clark at Polly Models but we had some time left over afterwards. So Pete Thomas took me to the Nottingham track and club room. What a revelation. The track was superb but probably not of much interest to the majority of MEW readers'.

What are of interest though were the workshop facilities. There was a large Colchester lathe, Bridgeport turret milling machines, an Adcock and Shipley horizontal mill, a Jones and Shipman 540 surface grinder, A large spark eroder and a very large metal cutting bandsaw as well as other machines. These machines were all available for the use of Nottingham society members. (Bring your own cutting tools.)

The East Somerset society at the Bath and West Showground had similar facilities although perhaps not quite as much.

When I visited Dave Fenner prior to travelling down to the Model Engineer Exhibition last September, he took me to the Perth society club house and track. Although we could not access the workshop Dave mentioned how well equipped it was.

This makes me wonder how many more clubs and societies have such superb workshop facilities? For all of us struggling away doing large jobs on small machines, could we make life easier by joining a local (or perhaps not so local) club?

Although the clubs are probably all model engineering orientated, I doubt anyone would say to a fellow member you can't machine that here as it is not a model. You pay your subs and use the facilities as you see fit as long as you are not causing anyone a problem.

So, would anyone like to get cheap access to large, expensive machinery? Join your local club; I am sure they will be pleased to hear from you.

Surveys

I have received large amounts of surveys back for both Model Engineer and Model Engineers' Workshop. I have not had chance to read many of them yet but will be sorting out the prizes in the next month or so. I am just waiting for the last batch of surveys to be sent to me so everyone gets a fair go in the draw.

Model engineer exhibition

Arrangements for the Model Engineer Exhibition are coming along fine. Many of your favourite traders have already booked and this year, it looks like being bigger and better than it has been in recent years. Now we have a stable company we can concentrate on putting on a world class exhibition like we used to. Many people have said they prefer the move back to Sandown Park as they did not like Ascot.

A few people have asked if Sinsheim will be back this year. This will not happen in the foreseeable future because of the cost of transporting the track to the UK and then setting it up.

We do intend to attract the best of the best in the way of models and will be making a big effort to attract many club stands. This year, there may well be a boating pool for the boats and perhaps hovercraft modellers to run on (or should that be in).

The Model Engineer Exhibition judges are looking at possible new rules and classes to allow for kit built models such as Polly locomotives and also for the builder who uses laser cut components in his (or her) models. With modern technologies, this is beginning to encroach more and more into the fine exhibition entries seen at the Model Engineer Exhibition. I don't envy the judges task in deciding the new rules but wish them good luck in their endeavours to move the Exhibition into the 21st century.

The Myford open day

This was my first visit to the Myford Spring Show. I was not sure what to expect, I knew Myford sold second hand as well as new machines and equipment. I did not realise the amount of stock Myford have in their reconditioned lathe section. There were probably 20 or more lathes on view including 2, maybe 3 of the Myford 254's. All the lathes were immaculately turned out and would be a pleasure to use in the workshop. Alright, I am biased, I like Myford lathes. I have a Myford ML7R with a full range of equipment. This is very similar to the Super 7 but has the ML7 cross slide and top slide. Although 10 or more years old, my lathe has probably not done more than about 40 hours of work.

I spent a few bob at Myford's, more than I intended but there were so many items at bargain prices I could not resist. Fortunately, Myford accessories retain their value well so I don't really regret the cost of my purchases. Perhaps one day, I will upgrade to a large bore Myford with a gearbox? We shall see.

This open day was really well attended; there was even a coach party from Woburn on the Thursday. If you get a chance to go to the open day in the autumn, I would take it. I doubt you would regret it.

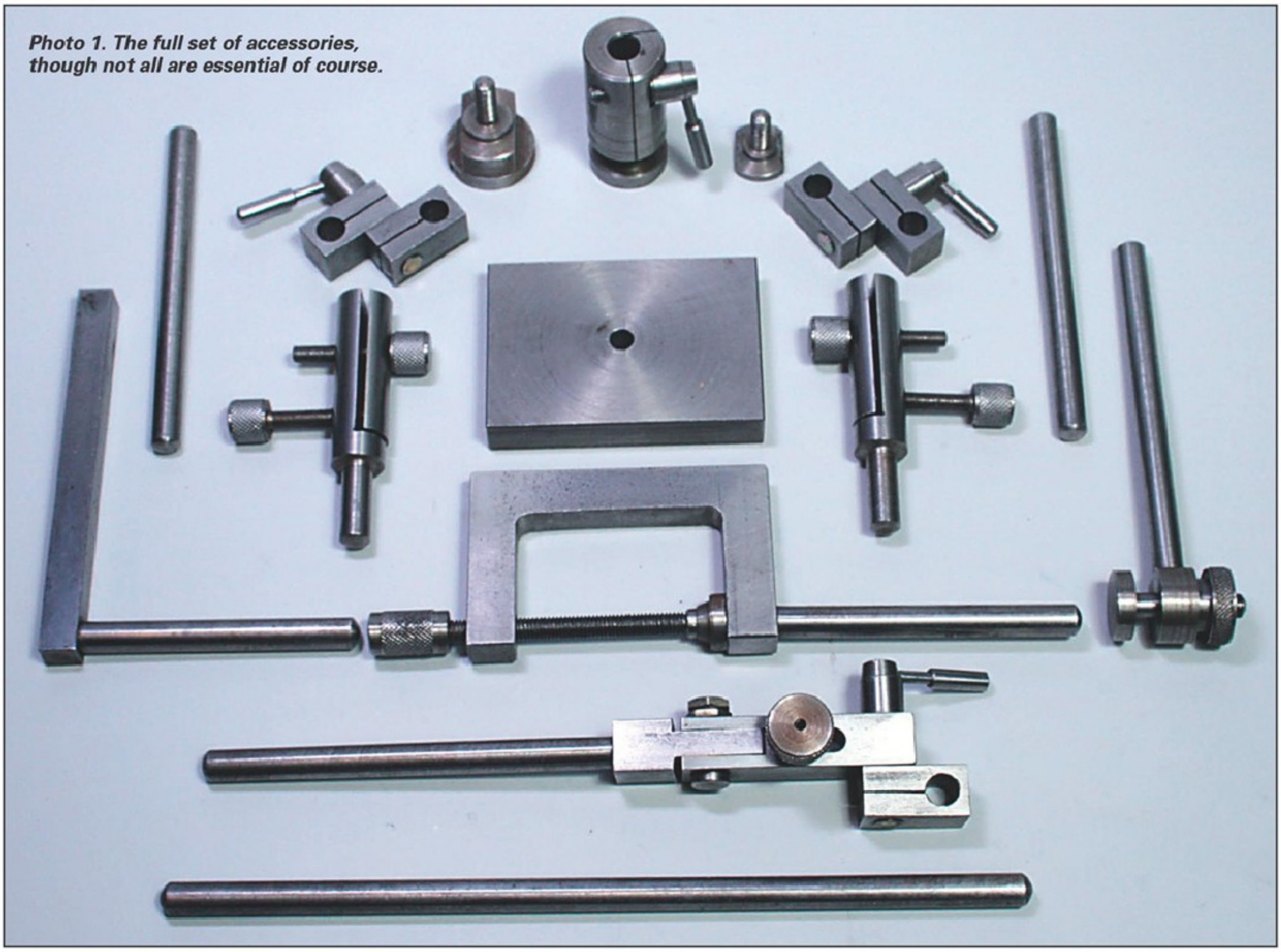


Photo 1. The full set of accessories, though not all are essential of course.

DIAL INDICATOR/DIAL TEST INDICATOR ACCESORIES 1

Photo 2. Mounting a DTI on the milling machine can be problematical. This method, which shows a vice being positioned, makes the process very straight forward.

Harold Hall makes some useful accessories

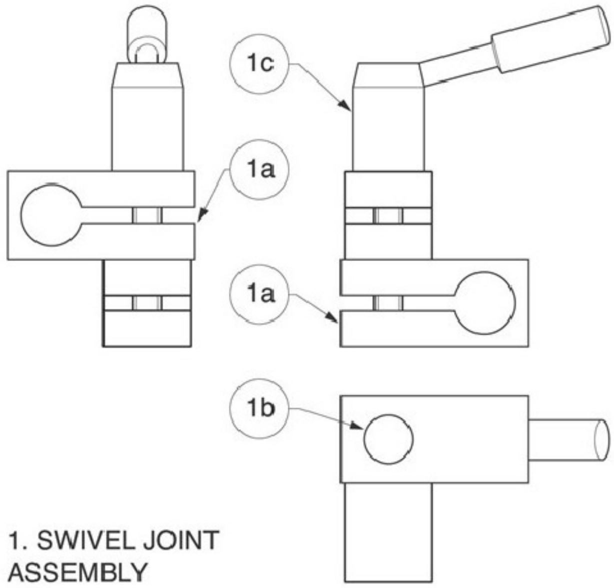
Three things have prompted me to start writing for Model Engineers' Workshop again. 1, Some unexpected free time. 2, The editors request for some small constructional projects and 3, Some encouraging E-mail's received via my web site (**ref. 1**). If you are puzzled by this statement, I decided late in 2007 to take a break, maybe permanently, from writing, and have provided nothing since early 2008. The articles that you have been seeing since were already with the editor.

To satisfy the editors wish for some projects taking just an hour or two of workshop time, I have returned to the idea of my articles published in MEW issues 14/15 (December 1992) which consists of a series of mini projects, the items being seen in **photo 1**. Readers who have these issues will I hope accept this being aired again and if the items were not made at that time perhaps they will be prompted to make at least some of them this time round. I have though rewritten the text, taken new photographs and converted the drawings to metric dimensions.

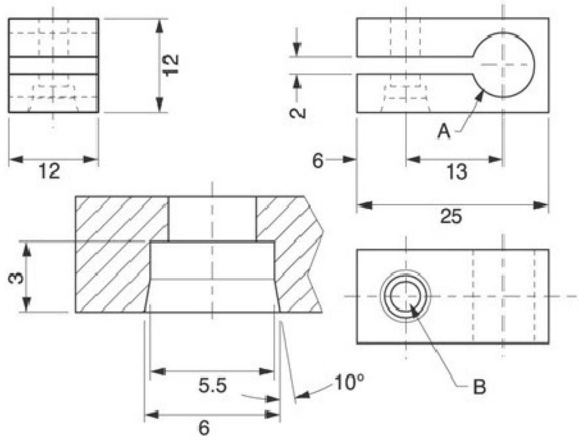
For me, positioning a DTI (dial test indicator), or dial indicator, on a machine to carry out some testing can be quite difficult, especially so with the milling machine. In this case, the item being tested will invariably be on the machine table and then one has the problem of finding some fixed member on which to anchor the indicator. Even if an anchor point is relatively easy to find, hanging the indicator off this so that it reaches the workpiece, or workholding device, can be quite difficult. This is where the central, and simplest feature of this article really makes life easy, these are the swivel joints and associated bars. **Photo 2** shows an example of their use in this way.

Swivel joints (part 1)

These can be purchased commercially, that in **photo 3** (left) being typical but can be surprisingly expensive and if intending to equip the workshop with at least six then making one's own as described here is worth considering especially as they will provide an interesting project for a couple of hours. They are also more adaptable



1. SWIVEL JOINT ASSEMBLY

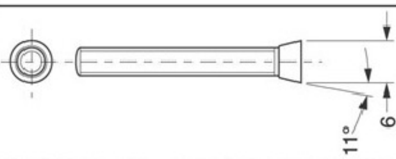


HOLES:
A. 8mm TO SUIT BARS
OTHER DIAMETERS AS REQUIRED
B. 4.2mm

MATERIAL: 12mm SQ. STEEL 070M20
QTY: MAKE 12 OFF HOLE B 8mm DIAMETER

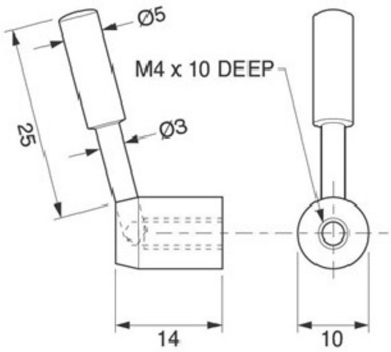
1a. HALF JOINT

Photo 3. Commercial (left) and shop made (right) swivel joints. The bit in the centre is for producing the tapered hole in each half joint, see drawing.



MATERIAL: M4 x 30 HEX HEAD SCREW
QTY: AS REQUIRED

1b. SCREW



SHAPE GENERALLY AS SHOWN
USE ADHESIVE TO FIX ARM

MATERIAL:
10 DIA. STEEL 230M07
5 DIA. STEEL 230M07

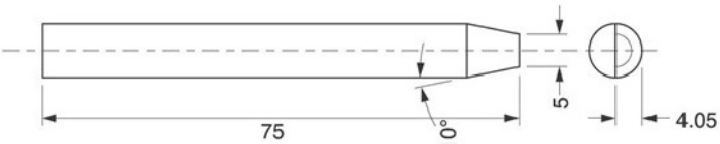
QTY: AS REQUIRED

1c. NUT

than the purchased item. The photograph also shows the shop made item (right) and the bit mentioned in the next paragraph.

Manufacture is very simple and little needs adding regarding this. A number of half joints (1a) can be aligned for slitting by mounting them onto one of the bars and then the assembly clamped on the milling machine table. If you do not want to damage your piece of bar with the slitting saw being used, slit just short of the bore and finish using a junior hack saw. Make a small bit, **Sk. 1** from a piece of silver steel or similar to produce the tapered hole, first drilling to the minimum diameter and then using the bit to produce the taper. The taper ensures that the clamp screw (1b) does not rotate when the assembly is being clamped. If you need some guidance with hardening and tempering silver steel then the latest article I can find in the magazine on the subject is one by Bob Loader and published in issue **115**, page **20**.

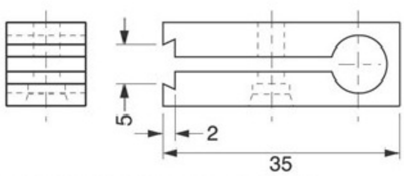
Most of the half joints will be made to suit the diameter of the bars, 8mm in this



MATERIAL: 8mm DIAMETER SILVER STEEL

HARDEN CUTTING EDGES

SK.1 TAPER BIT



OTHERWISE AS HALF JOINT 1a

1d. DTI HALF JOINT

Photo 4. One half of a Swivel Joint is being used to hold a dial indicator by holding the indicator's barrel. A half joint with a larger bore will be required.

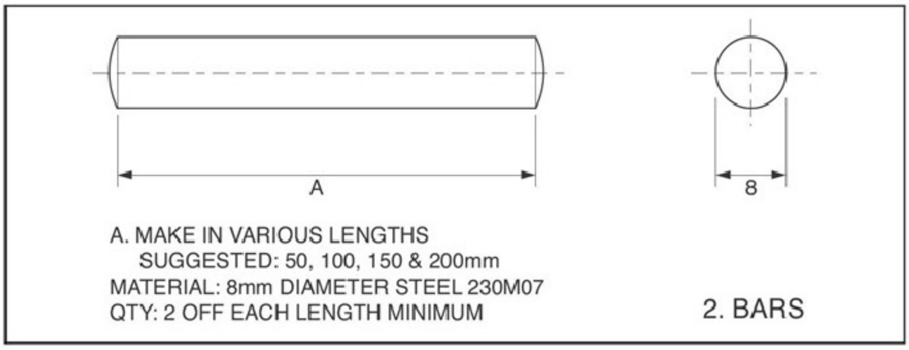
case, but others may be required to suit other diameters, typically to house the fixing barrel of a dial indicator, see **photo 4**. The half joints can easily be dismantled allowing bores to be mixed and matched to the items being held.

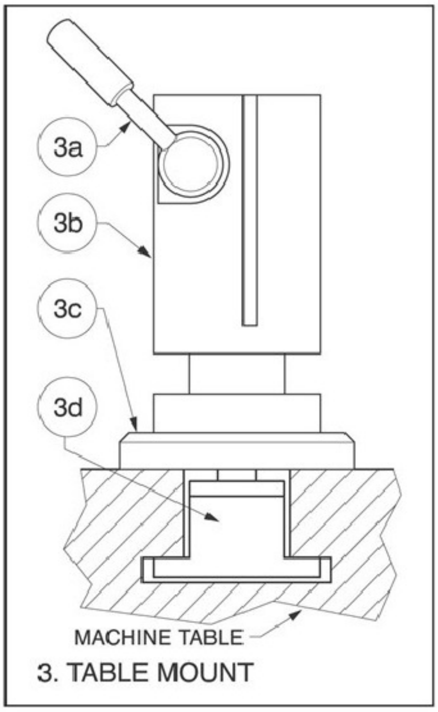
The clamp screw is made from a hexagon head set screw with the head modified as per the drawing. To do this, place a small piece of steel in the three jaw chuck and face the end and tap M4. Run a nut onto the screw to be modified and thread the screw into a tapped jig in the chuck, using the nut to lock it so that the screw head is just clear of the nut permitting the head to be fully machined. You may ask why use a nut, but after machining there will be nothing easy to grip so as to remove the screw from the jig in the chuck

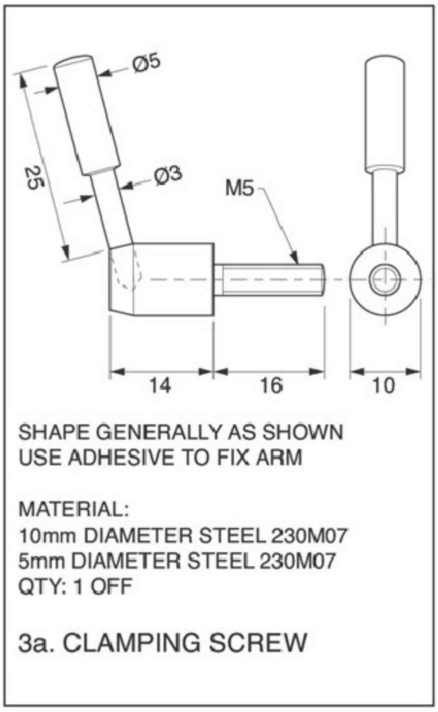
Make the clamp nuts (1c) as per the drawing, fixing the arm in the nut itself using a two-part resin adhesive or similar.

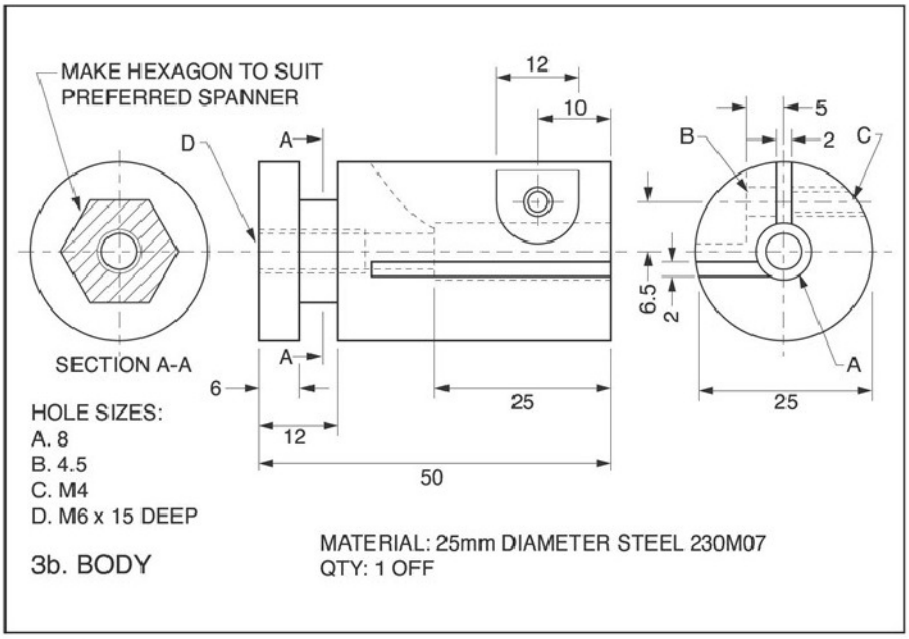
DTI's, as opposed to a dial indicator, are often held using a small dovetail area on its main body and a special half joint (1d) will have to be made to serve this purpose. However, a small round post is often provided on the indicator as an alternative mounting arrangement and again a special half joint will be required, this time one with a smaller bore.

If a half joint is to be made to clamp onto the dovetail, a very small dovetail cutter would be required, but as this is unlikely to be available, and in any case precision is not required, then the shape can be done by hand using a small triangular file after milling a 5mm wide recess across the end of the half joint.









Bars (part 2)

All that needs saying regarding these is, do make a range of lengths and at least two of each length. To make a presentable job of these use a form tool to radius the ends. Incidentally, with a little care a radius tool of this type can quite easily be used to produce a smaller radii than that to which it is ground by making multiple cuts at slightly reducing diameters.

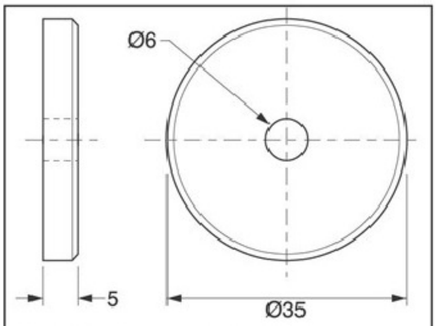
Additional items

The above two items are essential but others that follow can be made, or not, depending on the workshop owners intended uses for the system.

Table Mount (part 3)

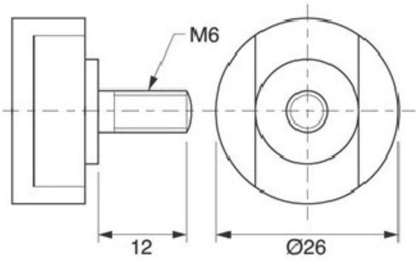
This simple item provides a very rigid mount for whatever use it is being put to. I say whatever, as it will be seen through the article that it has many and varied uses, typically, **photo 5** shows it being used on the lathe cross slide to mount an indicator. In this case the mount could stay there whilst convenient and a second mount made for use elsewhere.

The mount (3b) is equipped with a hexagon to take a spanner for tightening it onto the table. However, the workshop owner in the early stages of equipping his



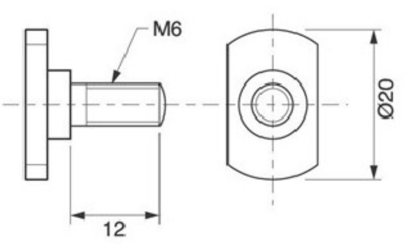
MATERIAL: 35mm DIAMETER
STEEL 230M07
QTY: 1 OFF

3c. SUPPORT WASHER



MATERIAL: 25mm DIAMETER
STEEL 230M07
QTY: 1 OFF

3d. LARGE TEE BOLT



MATERIAL: 20mm DIAMETER
STEEL 230M07
QTY: 1 OFF

3e. SMALL TEE BOLT

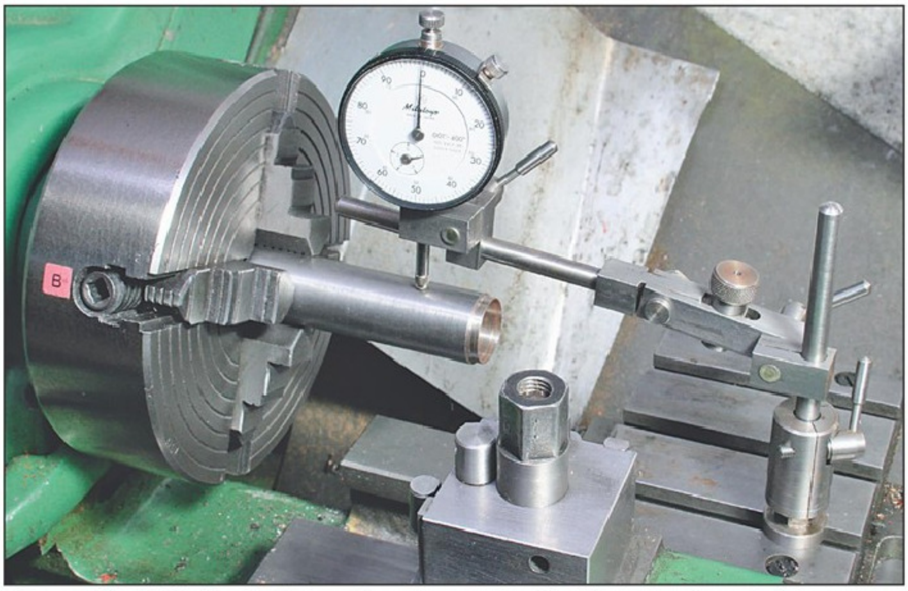
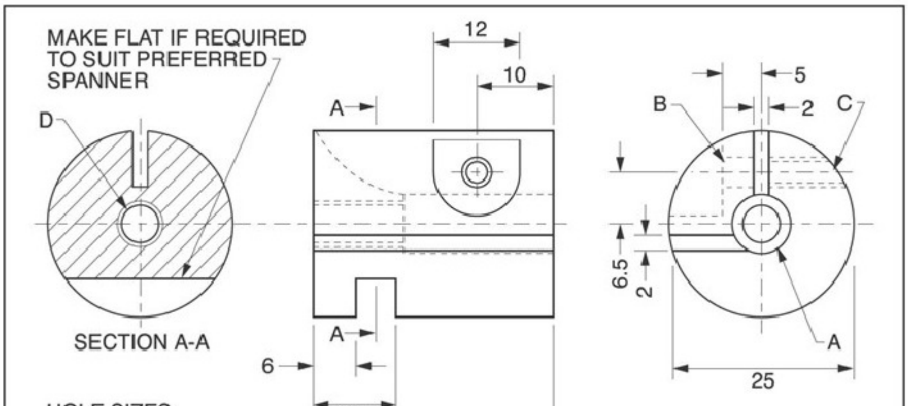


Photo 5. The Table Mount (3) provides a very secure base for mounting a DTI or other device, a light weight guard for example.

or her workshop may not have a dividing head so some other means of indexing it must be found. First, turn a length of 25mm diameter to 50mm long and drill and tap one end M6. Fit an M6 hexagon head screw into the threaded hole and with a rule resting on one face of the hexagon set this level by eye, more accurate than this is by no means essential, and mill the first flat. Repeat the process for the remaining five faces. It will be necessary though for the body to rest on a parallel and for some form of end stop provided so that each flat can be milled without the need for repositioning each time.



HOLE SIZES:
A. 8
B. 4.5
C. M4
D. THREAD TO SUIT FIXING METHOD

MAKE CLAMP SCREW FOR THIS AS PER PART 3a

MATERIAL: 25mm DIAMETER STEEL 230M07
QTY: 1 OFF

4. FIXED MOUNT

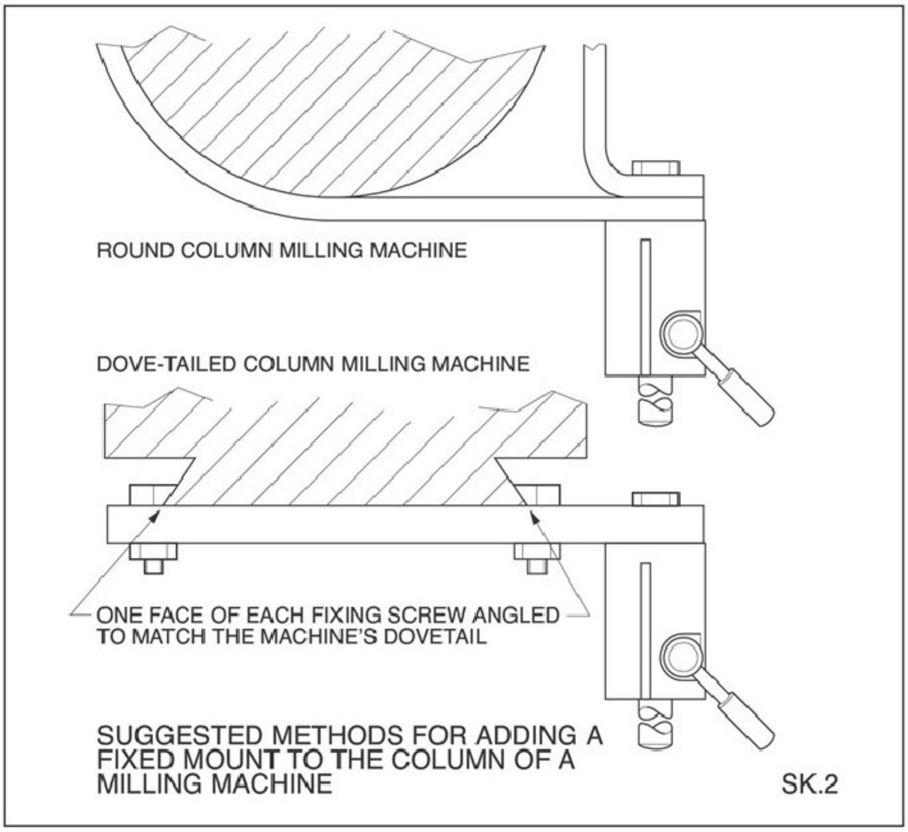
The large washer (3c) is for use when mounting the assembly on the milling machine with its larger T slots. The reader may of course have to change the dimensions given for the T bolts to suit the machines on which the assembly is to be used.

In the case of drilling the hole for the clamping screw see my article on drilling jigs (issue 140 page 12) for an easy way of accurately locating its position.

Fixed Mount (part 4)

This part is very similar to the table mount and can be made in much the same way but as it has only to be fitted the once I have used just a single flat for the spanner rather than a hexagon. **Photo 2** showed this in use and **photo 6** is a close up of how it is mounted on my machine, though in some cases this item will need changes to suit the machine on which it is being mounted. With this requirement in mind I consider it unfortunate that milling machine makers do not at least provide some mounting surface for anchoring a dial indicator (but perhaps some do), as for me using an indicator in this way is an absolutely essential feature of using a milling machine.

Photo 6. A close up of the Fixed Mount on the milling machine head. This is held by replacing the nut that secures the down feed stop.



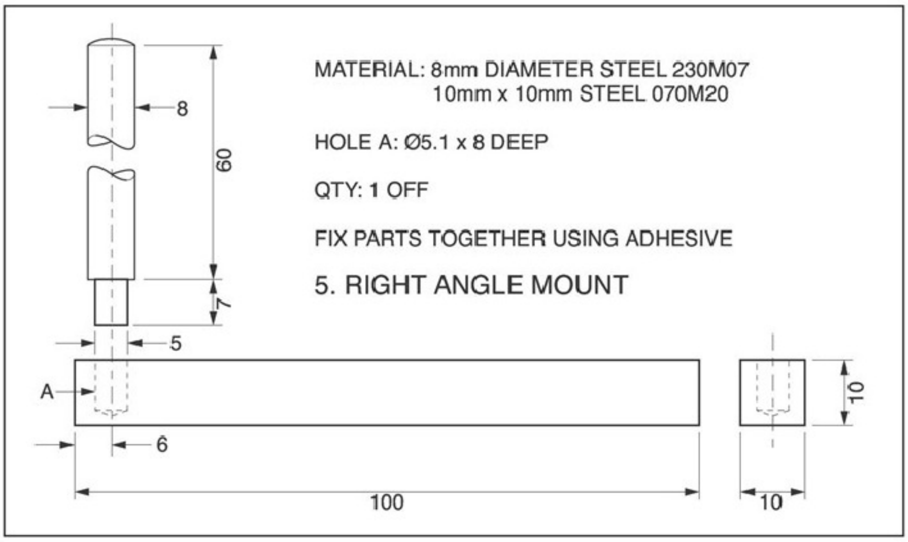
If no easy method of fixing a mount off the machine's head is available then some method off its column would seem the only other option. As there will be a multitude of methods I can only give two basic suggestions which will need to be adapted to suit the machine in question, **Sk. 2** illustrates my proposals.

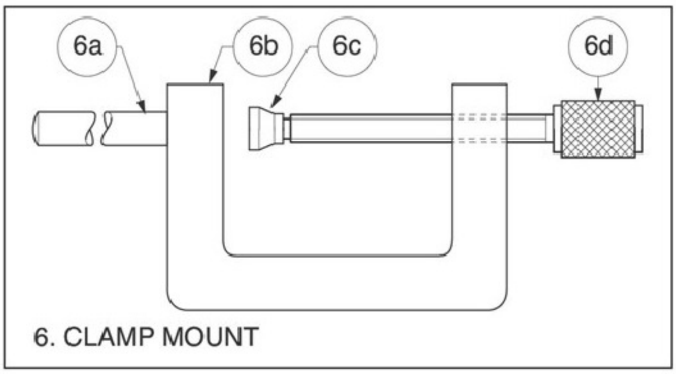
Lathe mounting methods (parts 5 & 6)

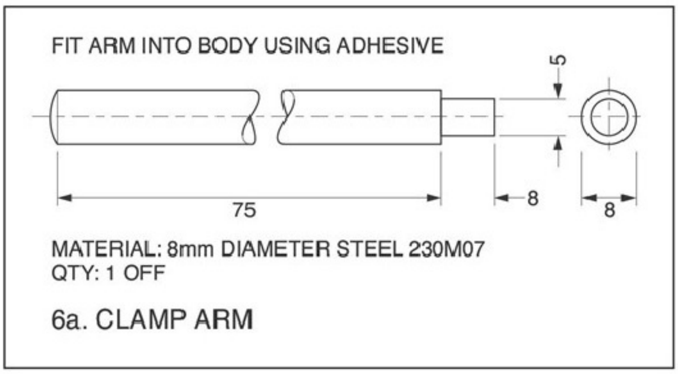
A method of mounting an indicator on the lathe that has been fairly common over the years is that shown in **photo 7** and if you have a spare holder in your quick change system then the arrangement could be left permanently set up **photo 8. Photo 9** shows another common method with neither needing any explanation as to their manufacture, other than to say place a piece of rectangular bar in the vice and clamp the pad (6c) onto this using the clamp screw (6d) Then, with a hammer and pin punch, make the head captive as seen in **photo 10**. The small Vee block (6e) is retained loose so as to provide the alternative of tightening the clamp either onto a flat surface or a round item as in **photo 9**, the block can just be seen in the photograph. To be continued...

Photo 7. A simple Angle Mount is one way of mounting a DTI on the lathe.

Photo 8. If you have a spare quick change holder then the set up in photo 7 can easily be retained for immediate use.

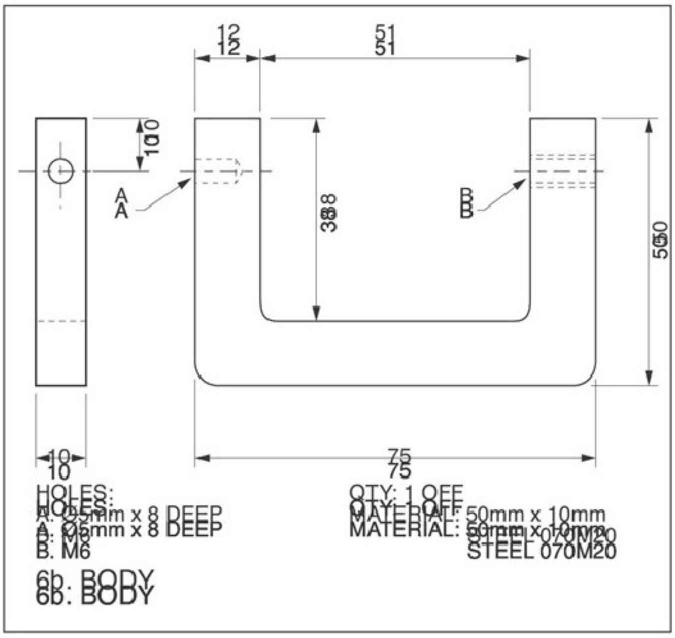


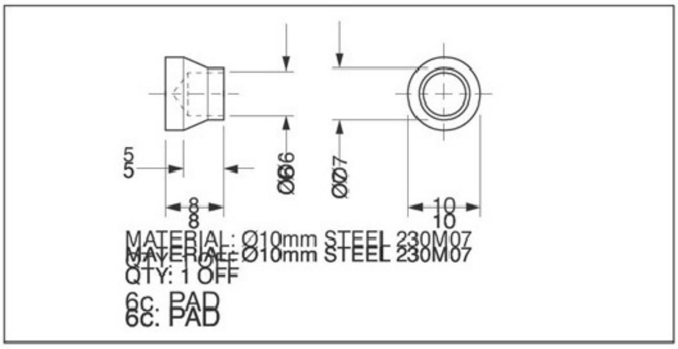


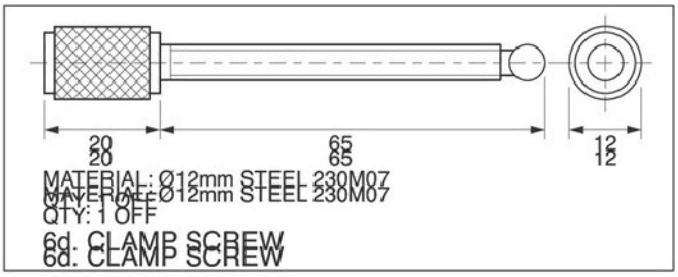


Reference

1. My website www.homews.co.uk







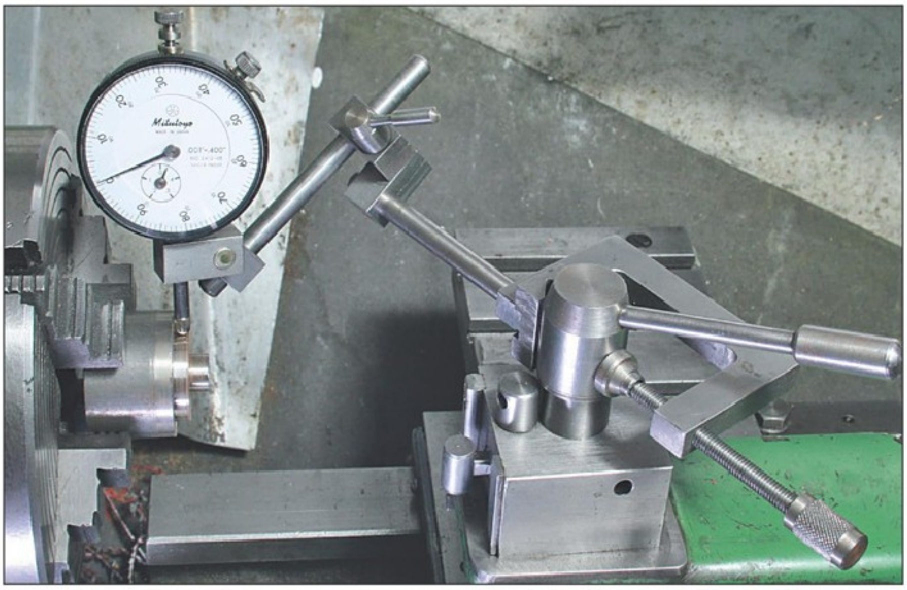
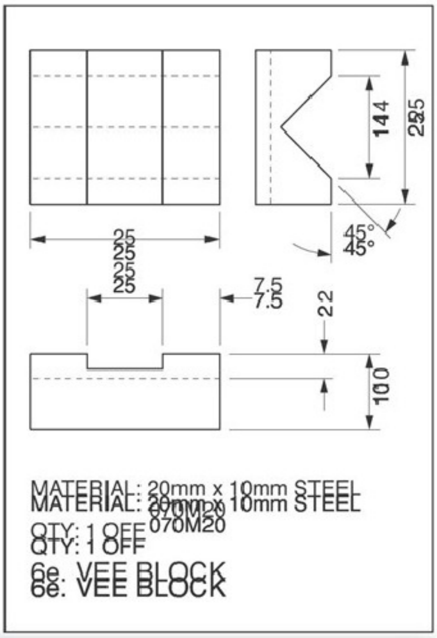


Photo 9. The Clamp Mount seen being used on the lathe. Note how the small removable vee block makes it possible to use it on a round surface.



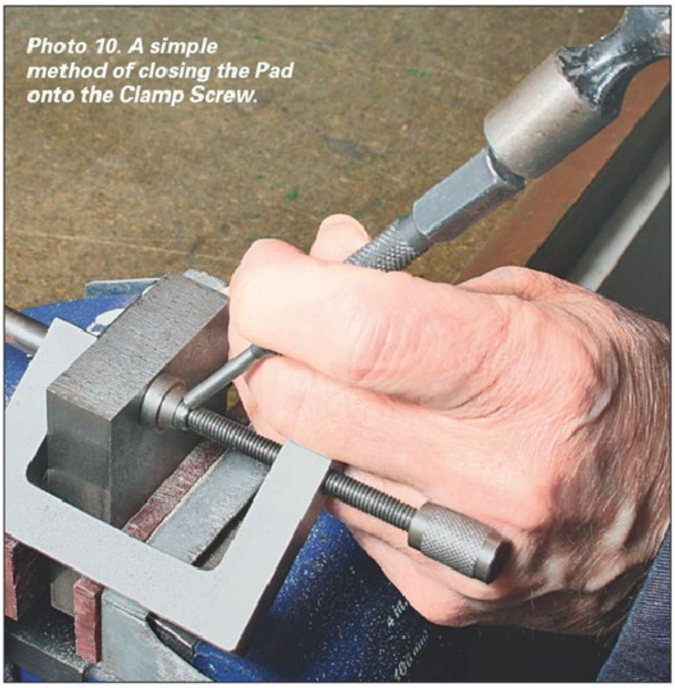


Photo 10. A simple method of closing the Pad onto the Clamp Screw.

Cover photos

I would like readers to supply some interesting tooling and workshop related photos for use on the front cover. Perhaps you have an unusual machine readers might find interesting or have constructed a useful tool that would look good on the cover? You will need a reasonably high resolution digital camera. We do pay for cover photos. If interested, contact me at the usual editorial email address for guidelines. (See page 3.)

Scribe A line

I do get some letters, mainly by email for Scribe A Line but could do with a few more. If you have anything that your fellow readers may find interesting, drop us a line. You might win a Workshop Practice series book.

Free Adverts

I don't get enough Free Adverts to run this feature in every issue. This service is free to non traders so dispose of that surplus machine cluttering up your workshop. I normally run wanted adverts in both Model Engineer and Model Engineers' Workshop but try to keep for sale adverts to one or the other magazines. I know the Free Adverts work because on occasion I have printed the wrong phone number and have had readers ringing me to find out the correct number.

Articles

I still have quite a few articles in hand but would like some more small projects that can be done in a few hours. Also, I don't have any more CNC projects when Stepperhead concludes. Can you help with an article or a series?

THE *STEPPERHEAD* MULTI-MODE MACHINE

Alan Jackson describes his superb CNC lathe

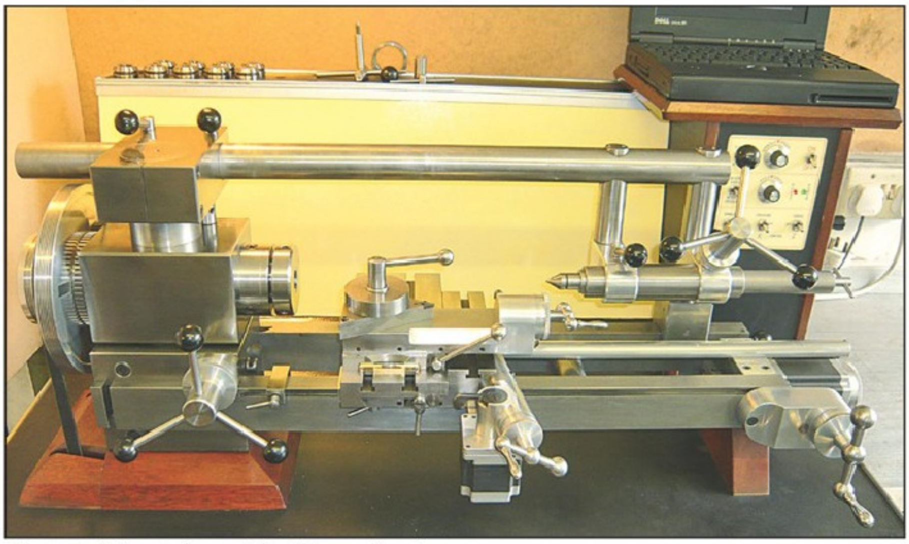


Photo 1. A front view of the Stepperhead.

'*Stepperhead'* that's the best name I could come up with. (***Stepper*** motor driving the lathe ***head***stock). **Photo 1** shows the front view of the finished machine and **photo 2** shows the tailstock end. It is my attempt to design and build a machine to do a versatile range of operations and incorporate modern technology. David Urwick's brilliant 'Metalmaster' designed in the 1950s was my starting point. I decided to try to construct one. The drawings are freely available from Yahoo group 'Metalmaster'.

The first problem was a lack of castings available, but even if I had a set of castings some of the components were too large for my workshop capabilities. I have a Colchester Chipmaster lathe and a Tom Senior M1 mill plus a small home made surface grinder made from the lower half of a Dore Westbury mill, the top half has been fitted to the Senior mill. I did not have a large enough milling machine for the main bed and the auxiliary bed of the Metalmaster.

So I started a redesign to suit my capacity. My first attempt copied the same configuration as the Metalmaster whereby the vertical column, overarm and tailstock are stationary and attached to the bench via a sturdy base plate. The base plate is bolted to the main column and supports the whole machine. The lathe bed and carriage is raised and lowered relative to the fixed head and tailstock.

I began making the base plate from a piece of steel channel and soon realised that this part has to perform a tough task supporting the whole machine cantilevered over the bench. It also

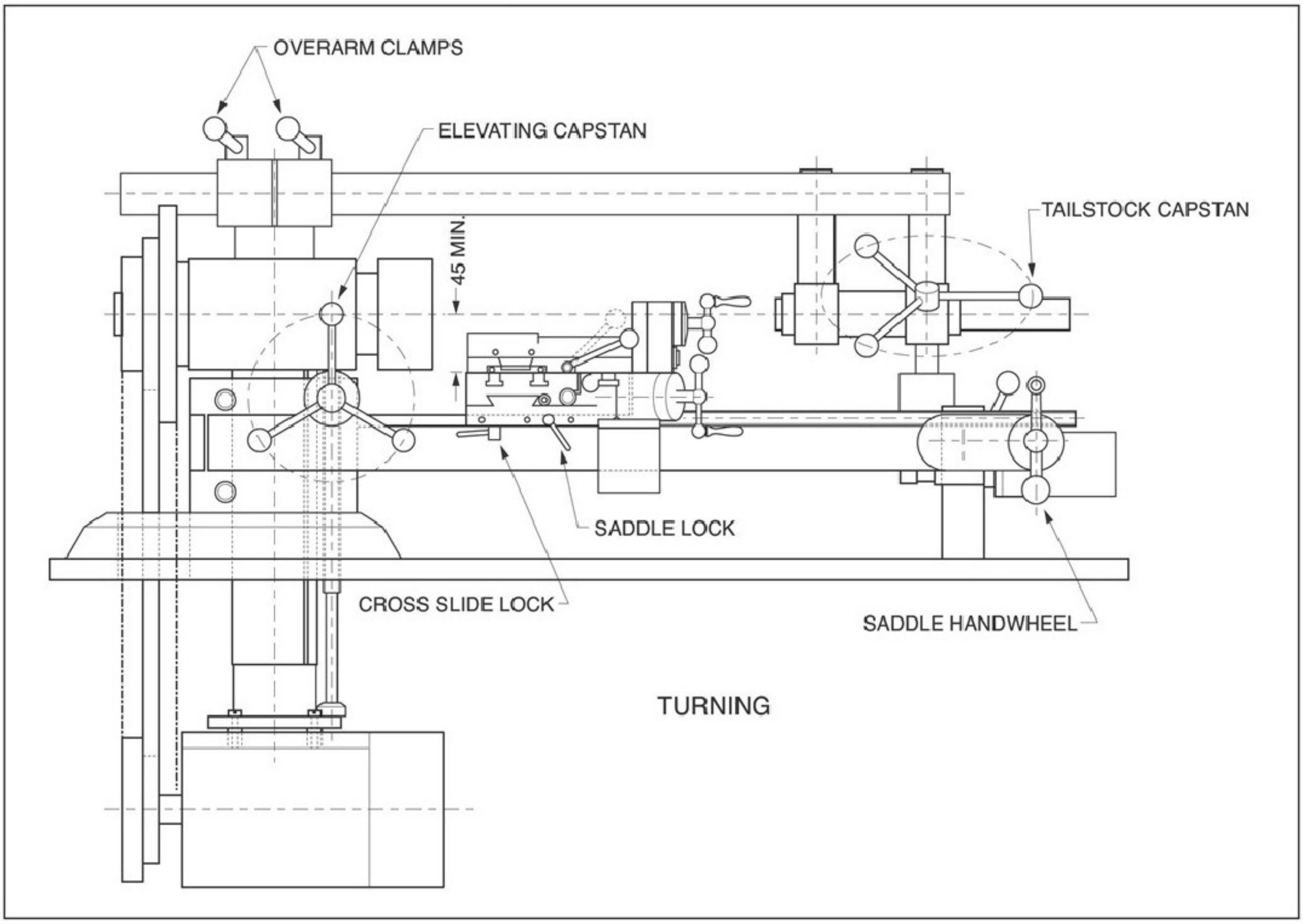


Photo 2. The tailstock, saddle drive and control panel.

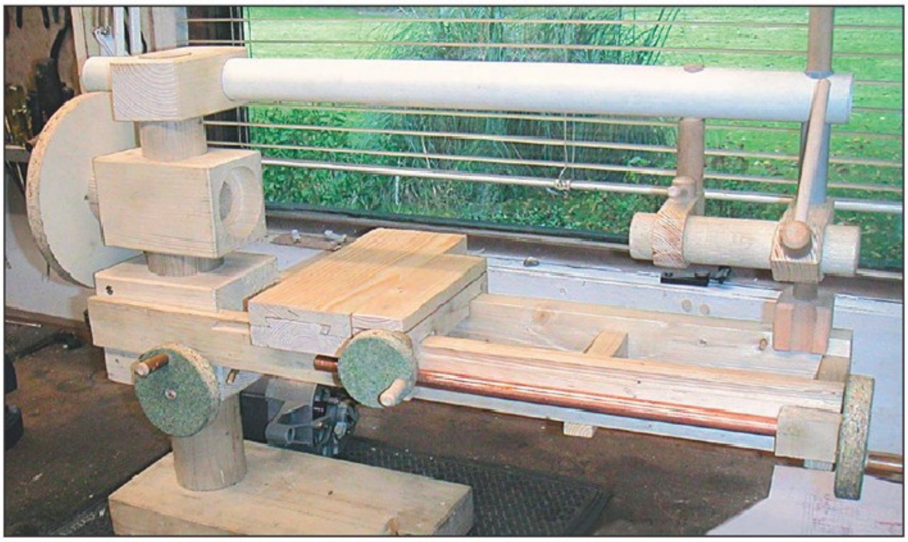


Photo 3. The wooden mock up. This saved a lot of wasted time.

demands a substantial bench to absorb the cantilever bending forces.

To better understand these concerns I made a simplified, full size, model of my proposed design in wood, **photo 3**. I did wonder if this was worth the effort but it certainly was justified. It showed that the demands on a normal bench mounting would be excessive when the design is translated into steel. It was also very noticeable that the operating height (when mounted at a normal bench height) was too high and it became worse when the bed was raised. Of course a special lower mounting bench could be made to suit but it still did not feel right. A major rethink was required. Comparing the combined weights of the moving and fixed parts of this design showed that the fixed parts weighed slightly less than the moving parts. This suggested reversing the fixed and moving parts.

The advantages are:

1) The base plate can be eliminated and the bench mounting requirements are substantially reduced.
2) The lathe bed remains at a fixed height and can be supported at the tailstock end. Avoiding the long unsupported cantilever of the bed, plus the bench can add support to the bed as with conventional lathes.

The *Stepperhead's* largest pulley is 200mm dia. The overarm is positioned so that it can slide past this pulley and this allows the tailstock to be integral with the overarm, saving weight and improving rigidity compared with a separate sliding tailstock.

A secondary vertical column is incorporated into the tailstock, which can be locked at the tailstock and the lathe bed. The combined primary and secondary vertical columns and horizontal overarm can therefore all be locked together to the lathe bed. This forms a completed rectangular frame and stiffens the whole assembly of headstock, tailstock and lathe bed as each component is contributing to the overall rigidity and alignment.

A guide block clamped rigidly at the top of the main vertical column provides a sliding/clamping guide for the horizontal overarm. The main column is guided in the lathe bed block using a radial triangular gib, as in the original Metalmaster. The triangular gib fits closely into matching Vee grooves in the bed block and main column to align the lathe mandrel with the lathe bed. The gib extends the full depth of the bed block and has two lower adjusting screws as well as the locking lever at the top. When the head and tailstock are raised or lowered the triangular gib lock and tailstock column lock obviously must be released. It is also beneficial to release the tailstock bed clamp as this improves sliding with the secondary column

The saddle and cross slide can be operated in any of three modes:

1) Manually via the calibrated handwheels
2) Semi automatically via stepper motors. Each axis can be individually driven by its stepper motor. The speed and direction can be set and switched on or off at the control panel. The cutting feed can be varied and the direction changed at will.
3) CNC control via the laptop computer. In this mode the computer program controls each axis either individually or in combination with each other.

The lathe mandrel can be driven in two modes:

1) Via the under drive main 3 phase 430w inverter controlled motor. There are three sets of Poly Vee pulleys, which together with inverter speed control can give a speed range from 15 RPM to 3200 RPM in both forward and reverse directions.
2) Via a stepper motor dedicated to indexing the lathe mandrel (*Stepperhead*), **photo 4**.

The head and tailstock can be raised and lowered permitting the following operations:

1) Up to 200mm max dia x 450mm between centres can be swung over the cross slide, **photo 5**. The horizontal overarm and tailstock can be removed permitting 410mm max dia to be rotated over the bed.

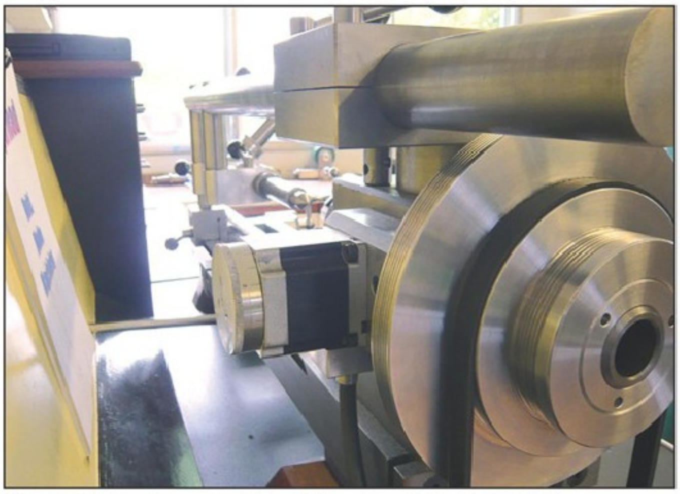


Photo 4. The steppermotor at the side of the headstock. Note the 3 step Poly Vee belt drive pulley.

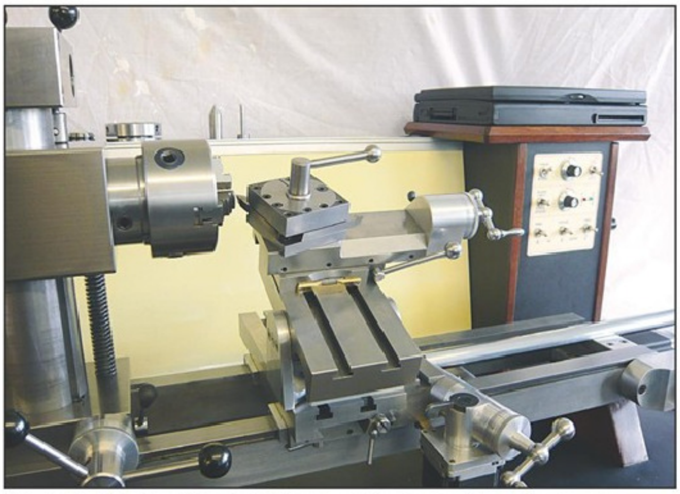


Photo 5. The headstock fully raised for large diameter turning.

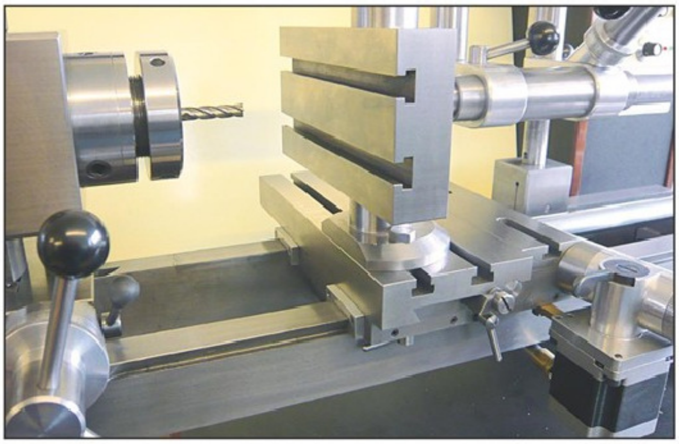


Photo 6. Mounting table on vertical column on cross slide.

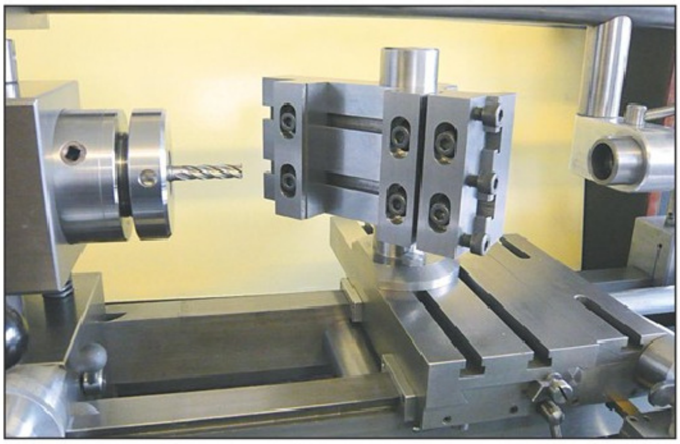


Photo 7. Angled mounting table with vice.

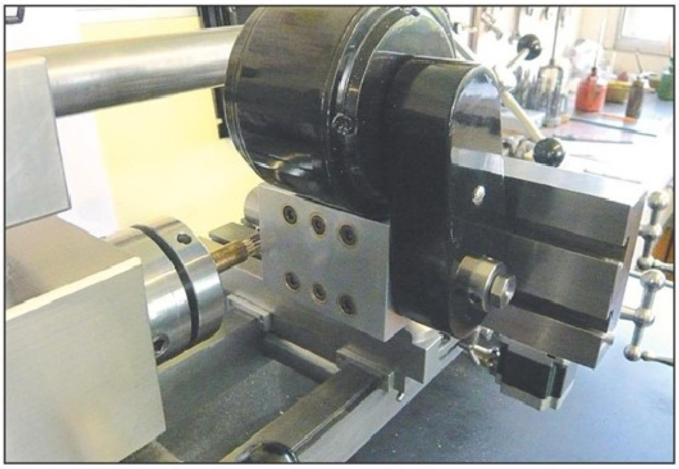


Photo 8. Milling head on mounting table for gear cutting (cutter above gear).

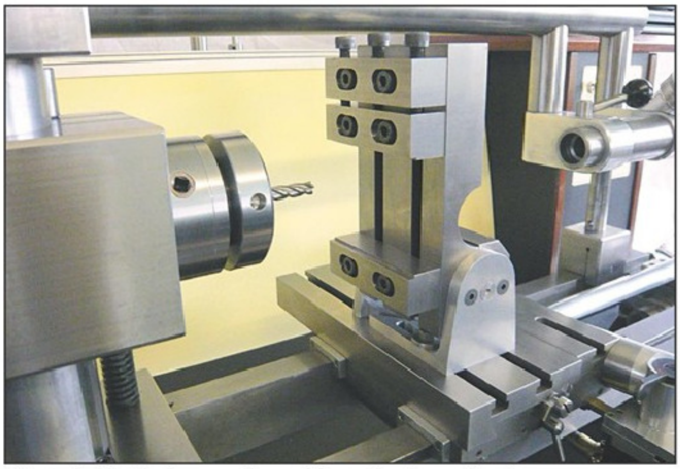


Photo 9. Vertical mounting table on horizontal column.

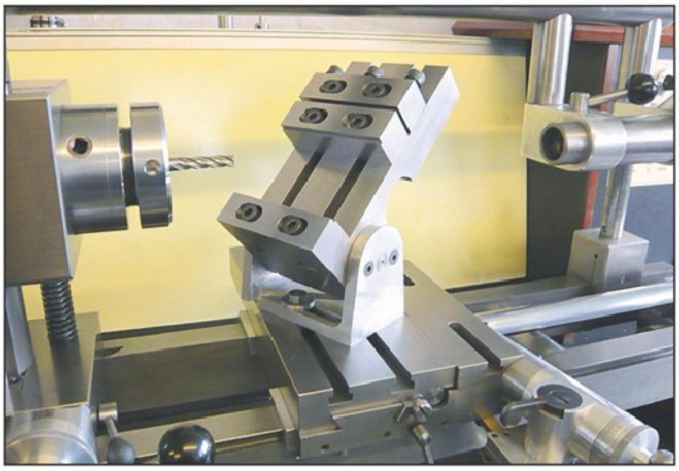


Photo 10. Mounting table and horizontal column both set at angles.

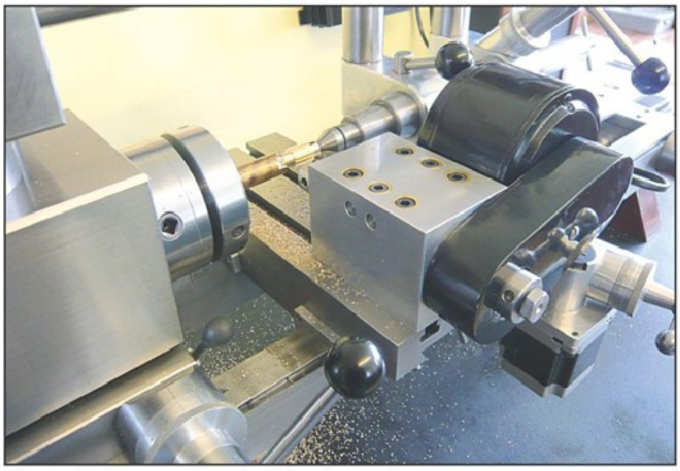


Photo 11. Gear cutting (milling head directly on cross slide & cutter below gear).

2) It can be operated as a horizontal milling machine. Cutters can be mounted in the lathe mandrel and supported, if desired, by the tailstock. The cut depth is set by the vertical adjustment of the column, **photos 6 to 10**.
3) The milling head can be mounted directly on the cross slide or via its own topslide for gear cutting, drilling, milling, and grinding, **photos 11, 12 and 13**.
4) The mounting table can be attached to the overarm and the milling head can be directly mounted either vertically or horizontally. The top slide mounted milling head can also be mounted on this table at any angle. This converts the lathe into a small vertical milling machine, **photos 14, 15 and 16**.
5) The boring and facing head can be fitted to the lathe mandrel, which will create a horizontal boring machine, **photo 17**.

The triangular gib can be removed from the vertical column.

The column is fully raised. A screw at the top of the gib strip is unscrewed to provide a lifting handle. This permits the lathe mandrel, overarm and tailstock to be rotated up to 5 degrees either side of the lathe bed axis. In this mode long taper turning is possible. Tapers can also be generated using CNC control of axes X and Z so there is a choice overlap here, **photo 18**.

If the lathe mandrel is driven by its stepper motor the mandrel can be rotated more than 5 degrees because the restriction of the motor drive belt through its bench aperture is avoided. The wooden section at the bench aperture can be lifted off to permit the belt to be fitted or removed, **photo 19**.

To sum up this is the range of machining operations that are possible:

1) Manual lathe operations with variable feeds to saddle and cross slide.
2) Screwcutting via CNC (a CNC/manual mix can also be used).
3) Taper turning and contour turning using CNC control of axes X and Z.
4) Taper turning by rotating the head overarm and tailstock relative to the bed.

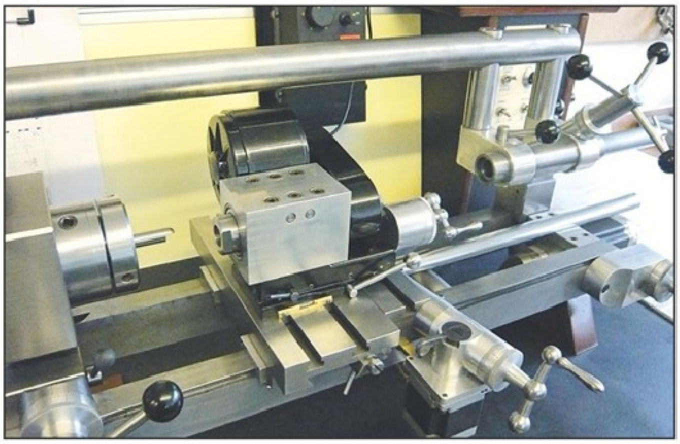


Photo 12. Milling head on its top slide on the cross slide.

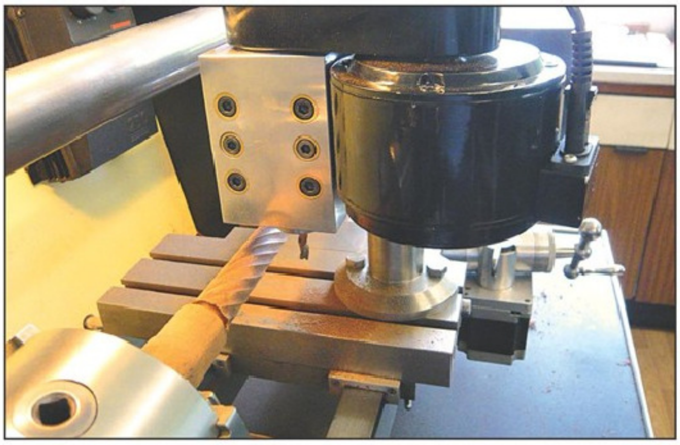


Photo 13. Milling head on mounting table for tapered spiral milling.

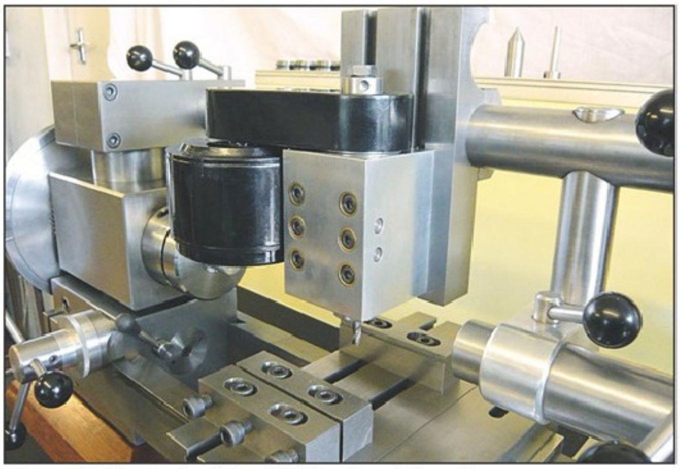


Photo 14. Vertical milling (Milling head directly on mounting table).

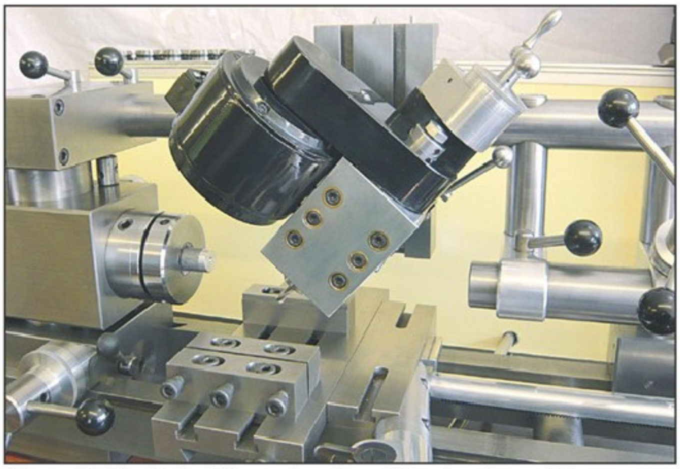


Photo 15. Vertical milling using the milling head top slide on the mounting table.

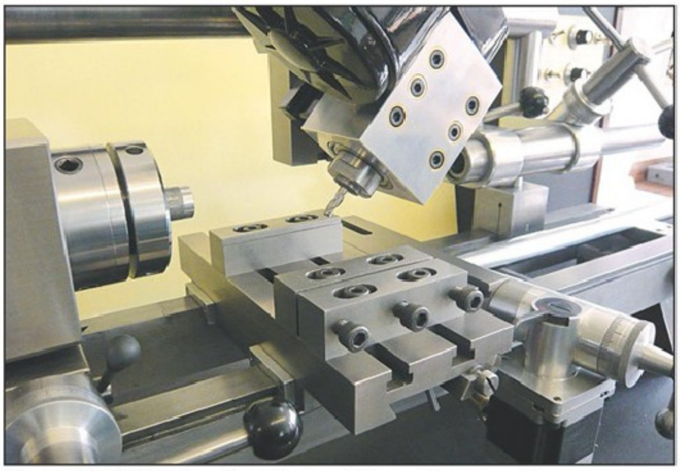


Photo 16. Milling head on its topslide on the mounting table - vice on cross slide.

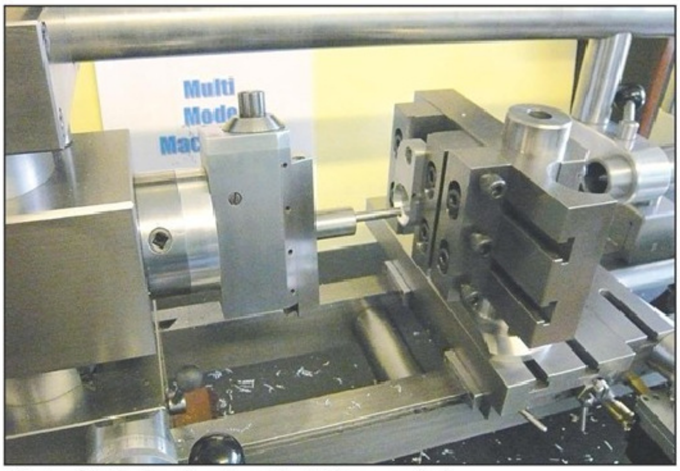


Photo 17. Boring head on the lathe mandrel. (Taper boring using Z axis at 0.001in./rev.)

5) Horizontal milling
6) Vertical milling
7) Horizontal boring
8) By using the stepper motor driven headstock in conjunction with the milling head a multitude of milling, gear cutting and drilling operations are possible.
9) The Stepperhead axis A can also be driven simultaneously with axes X and Z. This can be used to create spiral milling and ornamental patterns etc.
10) A grinding wheel on the milling head enables cylindrical & cutter grinding of end mills & drills etc. Of course grit protection for the slides is advisable.

To be continued...

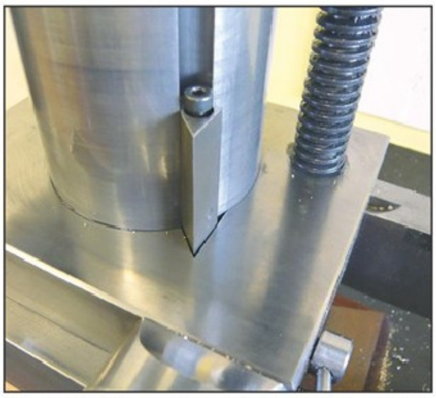


Photo 18. Triangular gib being lifted out. The top screw is unscrewed to serve as handle.

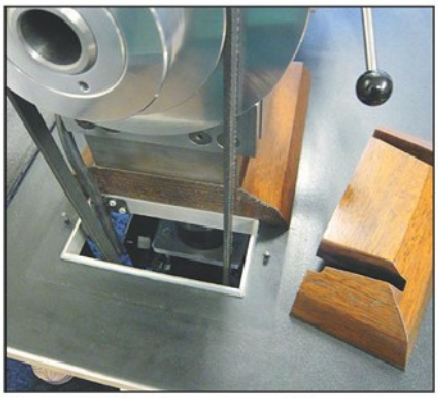


Photo 19. Bench aperture with cover removed.

CHOOSING AND ASSESSING A LATHE

Dave Fenner looks at buying your first lathe

Photo 1. Mini-Lathe typifies the straight bed design.

Buying a lathe is frequently a first step into the hobby of model engineering, or a considered move forwards on the metalwork side of some other hobby with a significant element of home construction. It is very likely that the person contemplating the purchase will already have a number of hand tools, and perhaps a bench mounted pillar drill. Machine tools tend to cost significant sums of money, so it is worth taking a bit of care over the transaction. Over the years, I have been asked on various occasions for advice on buying a lathe, and this can be difficult, particularly if the prospective purchaser has not really determined a few basic factors. To give such advice invites similar pitfalls to advising the newly qualified driver on choice of first car. This article will nevertheless attempt to persuade the prospective purchaser to ask pertinent questions (of himself as well as the seller) and to inform the decision making process towards choosing that all important first machine.

Here, I am focussing on smaller, lower priced lathes, and the discussion and illustration of some aspects will be influenced by equipment I have owned and used, and items which are available in house to be photographed.

In recent years, combination machines have become available from suppliers such as Warco, Chester and Machine Mart, which give the attributes of a lathe combined with a mill. In a way these are somewhat similar to the earlier established practice of adding a milling attachment to a Myford. My impression is that they give the advantages of a large centre height, milling versatility and a smaller foot print. However, I have no personal experience of working with one of these, so do not feel sufficiently informed to include them in the discussion.

Size matters

Size is important from several points of view. First, what kind of parts do you want to make? Second, how much space is available to accommodate it? Does access to, or position within the workshop impose limitations on the dimensions or weight?

Taking the first of these points, it is often said that you can make small parts on a big machine but you cannot make large parts on a small machine. This is true to a certain extent. However, trying to make watch spindles on a large industrial lathe would introduce difficulties due to the loss of "feel", and probably a limitation on spindle speed. My own experience, before kitting out for commercial production, was to start with a second hand Myford ML7. In those days, Chinese imports were something of a novelty, and the choice of machinery suitable for the tyro amateur was very much more limited. I felt that the Toyo and Unimat were out of my budget. This first ML7 was used for initial projects such as a Stuart 10V and the Jones 605 two stroke. Although the machine had seen better days, it was still capable of accurate work.

When I became involved in building a seven and a quarter inch gauge Royal Scot, while the Myford would still cope, I guessed that there would be an advantage in having a bigger machine to remove metal more quickly, and acquired a Colchester Bantam.

This stayed with me for around fifteen years, until it was replaced by a Chipmaster from the same stable, which offered a mixture of advantages and disadvantages, but importantly accepted the same accessories and tooling as the Bantam. Both of these machines had been used extensively in industry, and were certainly not in their first flush of youth. Again, though, with care, good work was possible.

So my first piece of advice is to try and have a clear view of what you are planning to make. Lathe size is usually quoted as say Xmm centre height and Ymm between centres. These numbers give the height of the spindle centre above the bed, and the maximum length of work that can be mounted between centres. It should also be noted that in modern parlance, suppliers often quote "swing" rather than centre height, and this figure is often diametric not radial. Thus 90mm centre height might equate to 180mm swing, being the maximum diameter of work.

A further complication to be aware of concerns bed styles. A straight bed, **photo 1** continues from tailstock to headstock, whereas a gap bed, **photo 2** has a gap (or in larger lathes, a removable section) close to the chuck admitting work of larger diameter but short axial length. So if you are keen to be able to skim brake discs or turn large traction engine wheels, this feature could be important.

If you plan to work on long parts, then you will either want a suitable dimension between centres (some machines are offered as long bed variants) or perhaps a sufficiently large spindle bore to take the bar size through the headstock.

Moving on to weight and space, the Mini-Lathe shown in **photo 1** weighs around 45 Kg and has been mounted on a redundant dressing table, fitted with castors. The machine footprint is about 39 in. x 13 in. or roughly a metre by 330mm. Its low weight and small size mean that it can be easily moved around if need be.

Allowing space to open the change wheel guard, the footprint of the Myford Super Seven, **photo 2** is a little larger at about 56in. x 24in. (1420mm x 610mm) and the weight of the machine with motor is now in the region of 90Kg. If mounted on the manufacturers stand, then a further 55Kg. is added. Going a stage further, the Chipmaster is an older generation tool room lathe, **photo 3** which turns the scales at over 500 Kg. Here, the foundation plan requires around 79in. by 39in. (2metres by 1 metre) to allow for guard opening. Thus within this limited range of centre heights, (approx 90mm to 143mm) and looking at machines aimed first at the amateur and then at the industrial user, the weight has spanned a factor of ten. Whereas the Mini-Lathe might be tucked into the corner of a spare room, a bit of floor reinforcement might be needed for a Chipmaster or a more modern counterpart such as a Harrison M250.

How much ?

Trying to indicate what to spend is like the old question "How long is a piece of string?" It will be determined by factors such as the bank balance, how seriously you are taking the hobby, and the view of senior domestic management. It is, though, worth bearing in mind that even if your initial choice is wrong, provided you have purchased sensibly, the machine will have a fairly predictable resale value. This is particularly true of Myford products which now have a history spanning over fifty years. The market for secondhand Chinese lathes is more difficult to judge. In spite of their popularity in recent years, relatively few adverts appear for them. Does this mean that owners simply do not want to part with them?

Some model engineers are able and prepared to spend sums approaching £10,000 on a single machine. Amongst the aeromodelling fraternity their counterparts are happy to risk having a similar value of engine, airframe and electronics committed to the sky. For most of us, financial constraints limit our expenditure to more modest levels. On that basis, let us take two example scenarios. A) a budget of under £500, and B) of under £1000.

New or Second hand

In the case of budget "A", you might find a second hand ML7 or Boxford, or choose a new Mini-Lathe, Unimat or similar, and be able to afford some choice tooling and accessories. Other alternatives might include ex industry machines of larger size. For small scale work several machines worthy of note are those from Taig/Peatol, Unimat, Cowells, Proxxon and Toyo. There are a number of other machines, no longer in production, which may be encountered such as Drummond, Zyto etc, which may be available at relatively low cost.

For "B" you might perhaps raise your sights to a second hand Super Seven or Boxford, ideally with quick change box or look to one of the larger imported new machines such as the Chester DB8VS, **photo 4** or offerings from Warco, again with some accessories.

Of the new machines, at the Mini Lathe level, there may be different supply arrangements, for example, Arc Euro Trade offer this machine either "In the box" or for a higher price, "fully prepared". In my experience, the preparation process was something that could be undertaken by anyone with some basic mechanical skills, who is prepared to invest the time. Also at the budget level, the machine will probably lack some of the "bells and whistles" which come as standard on more expensive equipment. Many of these however, can be home produced to give the desired upgrade. The DB8VS machine (priced in 2008 at about £700) was supplied fully prepared, adjusted and ready for work. It was described in Issue 144 of MEW.

With any new machine, one thing that you can rely on is that the various slides, bearings and other wearing parts will all be in brand new condition. Another factor which has come into play in recent years is the adoption of variable speed spindle drives. Thus the C3 Mini Lathe and its smaller brothers the C0 and C1 machines have this feature, as does the larger Chester example. Older, second hand machinery is less likely to have this advantage unless it has been fitted as an extra by a previous owner. Both the Chipmaster and Super Seven illustrated earlier have been fitted with inverter drives. The Newton Tesla package for the Myford gives the ultimate in convenient fitting, while the Eurotherm inverter fitted to the Colchester cost less but needed more in terms of electrical and mechanical expertise to set up and commission.

Most new machines will have the spindle running on either ball or roller bearings. Opinions differ as to the relative smoothness, stiffness and accuracy of plain versus ball/roller bearings. For our purposes I do not believe that there is an issue here. One point that should be mentioned however is that of cleanliness. Plain bearings require more oil than a ball bearing. If, however, you plan to use cutting oil, the point becomes irrelevant as the amount of coolant/ cutting oil will be considerably more again.

Mention was made above of the "Quick Change" box also known as a Norton box, **photo 5**. This comes into its own if much screwcutting is to be undertaken using different pitches. New machines generally don't have this unless you get up into industrial (or new Myford) territory. If screwcutting is to be just the occasional exercise, or you will use mainly one thread pitch, then using a traditional change wheel arrangement will not cause great inconvenience. In the case of Myford lathes the box can be added as an extra, but finding one at an attractive price may not be easy.

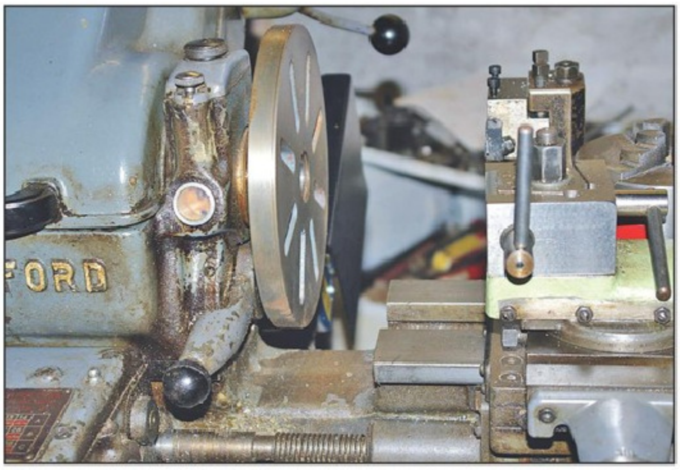


Photo 2. Gap bed allows larger diameter to be turned.

Photo 3. Colchester Chipmaster dates from the fifties and weighs in at some 500Kg.

Photo 4. View of the Chester DB8VS.

Photo 5. Quick change gearbox on Myford.

A second hand machine may have "enjoyed" the attentions of one or more previous owners. Taking a motor car analogy, you have the company rep who spends much of his time on the motorway, and who has the car regularly serviced, you have the boy racer who does less miles but regularly exceeds 7000 rpm and does just basic servicing, and then you have the octogenarian who does less than 3000 miles a year, never exceeds 50mph, and has minimal servicing. Each of these will give rise to different modes of degradation, and the same may be said for lathes.

You will occasionally find small machines which were purchased for use on just one job in a factory environment. It may be that the bed is then worn badly over a short length, or possibly the saddle was locked so that the bed is virtually unworn, but the cross slide or tailstock has endured a beating. When, in the late 80's, I purchased a Herbert 2D capstan lathe, the dealer informed me that the machine had come from the local college. From a conversation with an engineering lecturer, I then found that the machine had been used only twenty minutes each year for one particular exam. It was in effectively new condition but still had to be partly dismantled as the cross slide grease had hardened, causing extreme stiffness. As a general rule, ex school or college machines will be in good condition as regards wear, but may show damage due to carelessness etc.

Dealer or private sale

As with the vehicle analogy, each has its place. As a first machine, it is unlikely that you will buy unseen. With a new machine, a dealer will probably have an equivalent example in the showroom or on an exhibition stand that can be test run. With secondhand, it should be possible to see it run under power. In either case some form of warranty will be the norm.

Buying privately will cut out the dealer margin, but also lose any warranty, - caveat emptor.

I am reminded here, of a conversation with a gentleman who phoned from abroad, to seek my advice on lathe choice. This would not be a first machine, as he explained that he had previously owned a Myford, and was now considering either a factory reconditioned Super Seven, or a very much cheaper but larger Chinese machine. He also noted that his son was advising against spending several thousand pounds (of potential inheritance) on what looked like an expensive toy. My first comment was along the lines "It's your money, so you decide how to spend it". My subsequent observations included some which related to "feel and perception" rather akin to having owned a Bentley and now choosing between either another of the same, or a Jaguar, as well as discussing the more quantifiable performance factors. Whilst I was not able to come down firmly in either direction, I think the discussion did cover a number of points which helped.

Some weeks later I received another call from the same gentleman who, by this time had made his decision, ordered and received his factory reconditioned Myford lathe; this time he was phoning to share his delight.

Photo 6. Its not a cross slide, it's actually part of an X-Y table, but these Tee slots show what damage can be inflicted by careless clamping and over tightening.

Spare parts

Something to keep at least at the back of your mind is the availability and cost of spare parts. For the new small Chinese lathes, replacing things such as damaged plastic changewheels is pretty painless. Equivalent new (and even second hand) parts for an industrial machine can be a rather different kettle of fish. New spares for Myford Sevens are readily available from the factory, and these along with Boxford parts may also be found advertised on Ebay (beware of cheap imitation parts) and the excellent www.homeworkshop.org website.

The need for spares can arise in unexpected ways and have unintended consequences. One friend of mine owned an old Rivett toolroom lathe which became damaged during a house move. The parts were not obtainable, and so the insurance claim was based on having the broken components remade to order. The result was that the Rivett was scrapped and a replacement machine purchased.

Assessing second hand

Returning to the vehicle analogy, a car might fail its MOT test, however, its owner would have been quite happy to drive it around earlier in the day. In a similar way even a machine in poor condition may be capable of good work, but it may need more care. When first looking at a car, the procedure will often follow the pattern, walk round, kick the tyres, wobble the wheels, visually inspect outside and inside, try the controls for feel, listen to the engine and take a test run. A similar sort of approach will serve for machinery, and fortunately most machines incorporate features which allow adjustment to take up some of the forms of wear, so with a bit of TLC, even what may appear to be a real dog, can be given a new lease of life.

A static machine with no power available will limit what you can check, although more is possible if you can take and use a DTI (dial test indicator) on a magnetic stand, plus a length of silver steel of say 16mm diameter. First impressions count, so is it reasonably tidy, are there lumps missing, **photo 6** from cross slide Tee slots? Try out the various wheels and handles checking for stiffness or sloppiness.

Most small machines will be equipped for a single phase power supply, and if this is the case, then a tip from our editor is to take along an earth leakage trip breaker (as used for safer connection of lawnmowers, hedge cutters etc). Supplying power via one of these will highlight some types of fault which may not be apparent when fed through traditional fuses, but may cause the breakers in a more modern consumer unit to trip.

A further consideration, usually for larger machines, arises if it is set up for three phase power. In this case, you have to decide how you will operate the lathe in your domestic situation. Exceptionally, you may already have three phase, if not, then it is unlikely to be economic to have the supply altered for one machine. In general there will be three avenues available.

1) For a small machine such as a Myford which has seen industrial service, the motor and switch may be swapped for a single phase unit (perhaps of slightly higher power) and the wiring altered to give reversing if desired.
2) It will usually be possible to retain the three phase motor, alter its internal connections for 240volts and supply it via an inverter (otherwise known as a VSD - variable speed drive or VFD - variable frequency drive). This will give the benefits of variable speed, soft start, jog, etc. Note that in general, the output from an inverter is at 240 volts between phases, (not 240 volts phase to ground).
3) A larger machine may have a number of added electrical complexities, such as a safety cut out on the change gear guard, emergency stop from a foot bar, and contactors for motor and coolant pump control. Here, assuming also a rather more powerful motor, fitting an inverter may not be so simple, and hence consideration should be given to employing a single to three phase converter. These are available from several specialist suppliers who advertise regularly in MEW. One article which dealt in depth with this subject was "Three

phase Power Solutions" written by David Sharman in Issue 101 of MEW. Because of the different types available, the application should be discussed with the supplier from the outset.

Headstock

Give it a spin and listen to the bearings and feel for tightness. Even at low speeds, problems in a worn ball or roller race may be audible. Apply pressure to each shaft axially and radially, looking for slackness. Set the DTI over the three jaw chuck, **photo 8** and in it, grip the silver steel. Apply up and down pressure to the rod; any movement of the DTI indicates slackness in the headstock bearings. The clock may then be used to check for end float. Different methods exist for adjustment. On lathes with angular contact or taper roller bearings, adjusting out the end float will also sort out radial slack. On a Myford Super Seven, the front main bearing is plain but tapered, so adjusting the position of the two rear angular contact ball races, **photo 9** takes up clearance in the plain bearing. Myford ML7's have front and rear plain cylindrical bearings which may be individually adjusted by means of shims.

Mount the DTI on the saddle at centre height acting horizontally on the rod. Move the saddle to shift the DTI to near the outer end of the rod. Zero the clock and rotate the spindle slowly. Chuck inaccuracy will probably be evident as eccentricity. Stop the spindle at the mid point reading, then move the saddle towards the chuck. If the clock reading varies by more than a thou or two, then it suggests that the headstock is not aligned correctly with the bed. Some lathes have provision for adjustment here, but in many cases the alignment is effectively fixed.

Remove the chuck and inspect the spindle nose and Morse taper for damage. Check the back gear train, if fitted, for damaged/missing teeth and wear to its shaft/ bearings.

Bed

Start with a visual check looking for saw marks, (often caused by careless parting off with a hacksaw), general impact marks and evidence of wear. If you can see evidence of the original machining marks, then that is clearly a good sign. In most cases, the bed will tend to wear preferentially near the chuck where most of the action occurs, and it may be possible to make comparative micrometer readings. In the case of a Myford style bed, wear may occur on the top surface, and/or the sides or undersides. Slight wear you live with, really bad calls for a bed regrind. What you can live with will depend on what you want to make and to what degree of precision. Wear to the bed will occur in conjunction with wear to the relevant moving surfaces e.g. saddle and tailstock, for which comments follow.

Tailstock

Have a look at the state of the taper socket in the barrel. Industrial machines tend to engage both the taper and the tang, hence rotation of a tool in the socket is unusual. Many hobby machines do not engage the tang, and so it is more likely that rotation occurs, with the possibility of wear or damage. Light damage to a non hardened socket can be cleaned out with a Morse taper reamer.

The fit of the barrel in the casting, should also be checked, although, the effect of a loose fit can be minimised by gentle application of the lock. It is quite possible that the tailstock will be out of alignment, but this is easily adjusted. Some wear should be expected between the tailstock and the bed. The Myford tailstock base incorporates provision to adjust a gib strip between the shears. To assess this aspect on a Vee - flat bed machine really needs careful measurement. On one such machine that passed through my hands, the tailstock base had worn so that the tailstock centre was below machine centreline, and the barrel pointed downhill towards the headstock. Accuracy was restored to a tighter tolerance by carefully selected and positioned shims.

Saddle

Over time, wear may occur on the various surfaces where the saddle contacts the bed. Wear on the vertical sides may show up as movement of the saddle, when pressure is applied to the saddle across the bed, first one way and then the other. Again the DTI may be used to check. The saddle should also traverse the length of the bed freely. If the gib strip has been adjusted to take out slack where the bed is worn, then the saddle will tighten up when moved towards the unworn section at the tailstock end. A DIY technique to correct this was described by John McIntosh in Issue 109 of MEW. In the case of the Myford 7's, the saddle is prevented from lifting by metal strips running against the underside of the front and rear shears. These are adjusted by means of laminated shims. Again, if adjusted for a worn dimension, then movement will be stiff at the unworn part.

Wear on a "Vee - flat" style bed may be more difficult to gauge. Under downward pressure, the saddle will always assume a specific attitude, rather than being able to float slightly across the bed.

To get an idea of wear to the screw cutting half nuts, engage them on the leadscrew. If the saddle is now racked left and right using the handwheel, movement may indicate wear in the half nuts and/or end float of the lead screw.

Cross slide

This moves on a dovetail slide, and the first quick check is to wind the slide all the way in and then out. It should travel smoothly without stiffness. Stiffness in one area may indicate wear elsewhere. If it feels loose, then adjusting up the gib strip is easy. Rotate the handle backwards to zero then gently forwards noting the reading at which the cross slide starts to move. This will give a measure of the backlash in the screw. This may be due to a combination of factors: wear on the leadscrew nut (easily replaced) wear on the lead screw (less likely) and poor adjustment of the handle assembly to the cross slide end plate (readily adjusted).

Topslide

The mechanism here is very similar to the saddle, and the same approach may be adopted.

General observations on backlash and wear

Backlash in the main, the cross slide and top slide lead screws is to be expected, but is unlikely to cause a problem except when milling in the lathe. During normal turning, the loads are in one direction, and so the leadscrews are loaded one way and backlash does not come into the equation. If when milling is contemplated, the job

Photo 8. Movement caused by pushing up/down on the bar would be picked up by the DTI. This lathe has been retro fitted with taper roller races for extra rigidity.

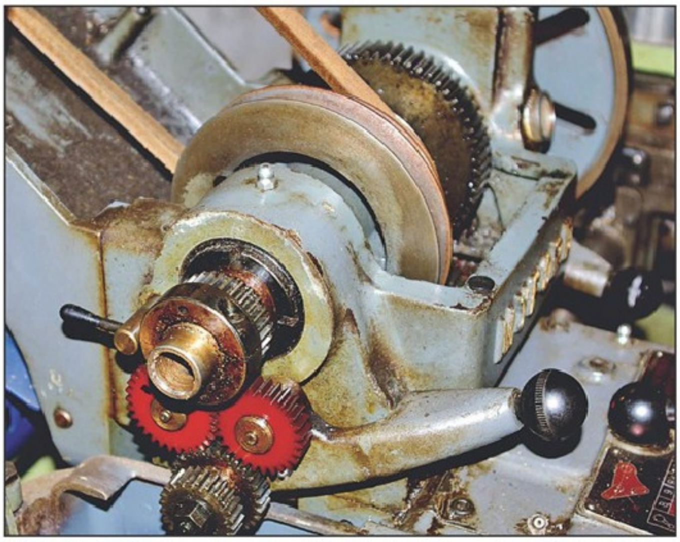


Photo 9. Visible here is one of the slotted ring nuts which adjust the Myford headstock spindle bearings.

is planned so that the work is fed against the cutting force, then the same applies. If however, a "Climb milling" situation is allowed to occur, then the cutter may be drawn in by the amount of the backlash, giving an undesirable "snatch".

In a similar way, the effect of wear between the saddle and bed etc. will often become more apparent when loads and motion are reversed. On most machines, the saddle is driven by either the handwheel operating on the rack, or by the leadscrew. In each case, with few exceptions, the line of action of the force applied lies to the front of the bed. Thus when boring a cylinder, while the saddle is fed forwards, it takes up one position, and when drawn back, if there is a bit of slack in the fit to the bed, it can twist slightly viewed from above, so that the boring tool would cut deeper if not moved inwards to clear. This "problem" may sometimes be turned to advantage, if the extra depth is small and its amount known. Taking that final cut backwards at the same setting may remove just those few tenths you were after.

Changegears

Are they all present, correct and with undamaged teeth.

Chucks

Some machines may have been supplied with perhaps just one three jaw chuck. Having a four jaw, **photo 10** and a face plate, **photo 11** gives more versatility to handle non round work. Does each chuck have a full complement of jaws, internal and external? Inspect the jaws for broken teeth. **Photo 12** shows a set of jaws for a small chuck where one tooth has been broken on one jaw. This type of damage occurs when the chuck is used for oversize work (engaging just the inner teeth) and then tightened sufficiently to cause the fracture. The chuck is still quite useable for smaller bar sizes, but if the jaws are removed, then the order of replacement is changed to ensure correct radial positioning. Such damage to a four jaw chuck may also be repaired in the home workshop using the technique described by Peter McKelvey in MEW Issue 89. For three jaw chucks, the cost of a set of jaws can be comparable to that for a new chuck. One route sometimes worth investigating, is that of fitting soft jaws, which tend to be considerably cheaper. If a selection of chucks is on offer, then a collet chuck would be a bonus.

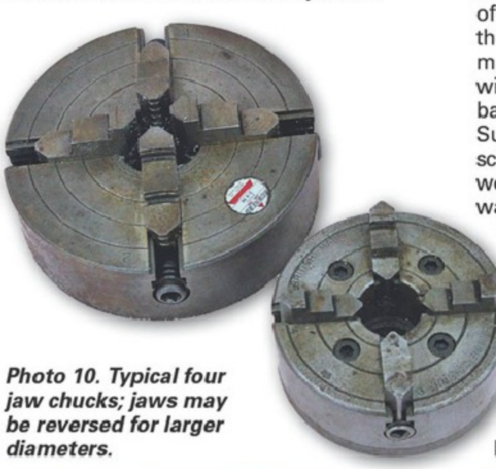


Photo 10. Typical four jaw chucks; jaws may be reversed for larger diameters.

Under power

If the machine you are considering can be run under power, then you have the opportunity to confirm that the motor and switchgear function, and make further judgements. Check for noise and vibration at various speeds, and that the back gear, if fitted, operates correctly.

Try out the different speeds (particularly if a geared head) and the feed system(s). If you are able to turn a trial job, then you can turn then measure a constant diameter and check the behaviour when taking a heavy cut.

Additional points in assessing a bargain

Look carefully at what is included in the offer. A private seller may be disposing of an entire workshop, and hence all of the accessories relating to the machine may be up for grabs, whereas a dealer will naturally wish to include just the basic accessories. As an example, my Super Seven, was acquired from a private school. The staff involved in the sale were well informed as to value, so it was not one of these knock down prices that you hear about, where taxpayers' money is concerned. Nevertheless, the numerous accessories made the overall package extremely attractive.

For the benefit of the beginner, some of the "extras" you may be offered are listed here, together with notes on application together with my comments on their usefulness based on personal experience.

Four jaw independent chuck, **photo 10**. This is used mainly to grip work which is often square or rectangular in section, also to offset round bar e.g. for eccentrics. I would class the four jaw as almost indispensable as it may also be used in place of a three jaw, and if the three jaw is not spot on, then the four jaw can be set to more accurate concentricity. Because of this, some people would advocate buying a four jaw ahead of a three.

Collet chuck - mostly used for small rods and thin walled tubes, more accurate than a three jaw. I managed without one for a number of years so would put this in the "desirable" rather than "must have" category. Of course now having several versions, I would not wish to be without them.

Tailstock tooling - you will need as a minimum, a tailstock chuck to hold centre drills and drills, and a tailstock centre together with one for the headstock. A "live centre" kit gives added versatility, **Photo 13**.

Saddle stop - For the Mini lathe, a cheap single position stop is available, **photo 14** while the factory item from Myford, is a multi position unit, **photo 15**. I would class a stop of some form as an essential. As an alternative to buying, several designs for home construction have appeared in this magazine over the years, and in an emergency, it may be possible to press toolmakers or "G" clamps into service.

Graduated leadscrew handwheel, this gives precision control of the saddle position, particularly useful if you plan to do milling work in the lathe. Myford have a bolt on kit, while for the Mini Lathe and many others, you need to make your own, **photo 16**.

Steadies - two types will be encountered, fixed and travelling, **photo 17** each being used to support round work as an alternative to a tailstock centre. If your bar size won't go through the headstock, then a steady can provide the answer.

Thread dial indicator - this makes imperial screw cutting much easier, **photo 18** however, if you have a reversible Vari-speed drive, then you may find it just as quick to reverse between cuts.

Vertical slide - if you intend milling in the lathe, then one of these, preferably the swivelling type is a must.

Taper turning attachment - I have never owned one for the Myford, but have made one for the Mini lathe. I would see it as

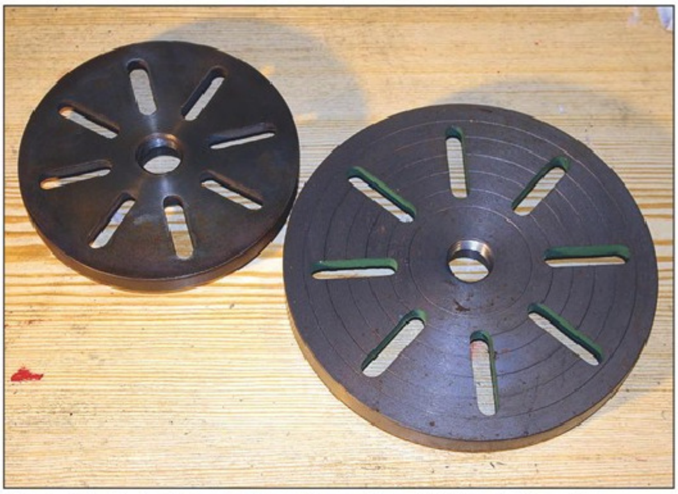


Photo 11. Myford now offer a larger 9in. (228mm) diameter faceplate (right) in addition to the earlier pattern.

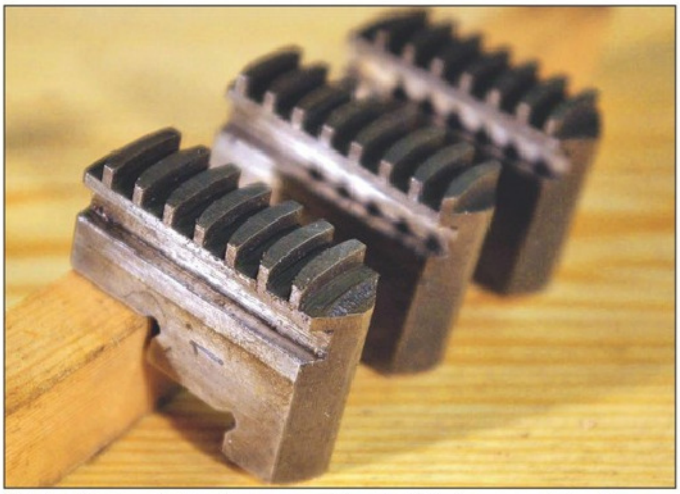


Photo 12. Jaw in the foreground has lost its innermost tooth.

Photo 13. The drill chuck and centre (bottom row) are regarded as essential; the live centre kit (upper section) can be useful for particular types of job.

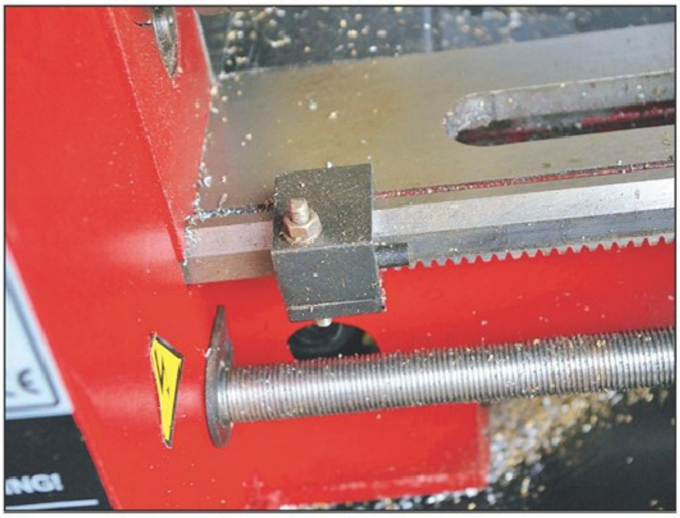


Photo 14. Single position stop as fitted to Mini- Lathe

Photo 15. Myford multi position stop fits to rear of bed and is a more complex attachment.

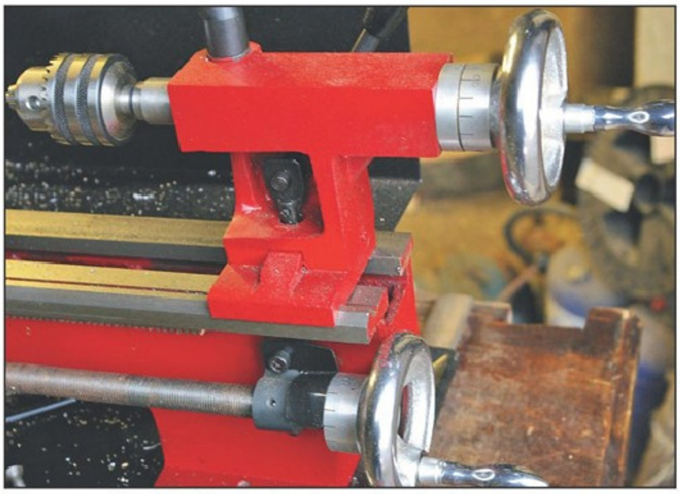


Photo 16. This Mini-Lathe has been fitted with a leadscrew handwheel, also an indexable collar on the tailstock wheel.

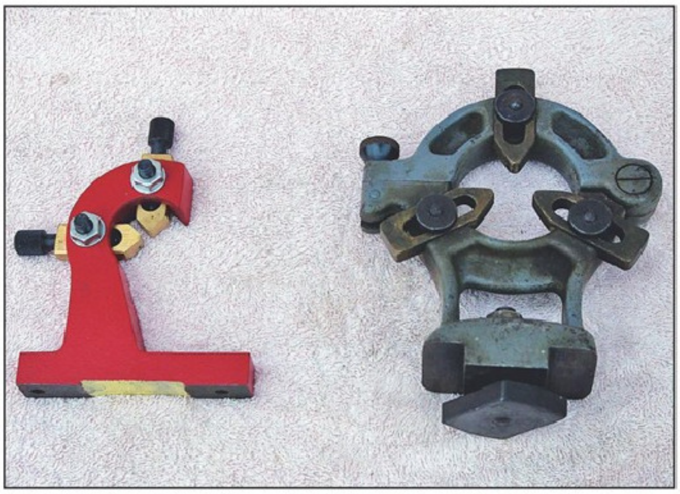


Photo 17. Travelling steady for Mini-Lathe (left) and fixed steady for Myford (right).

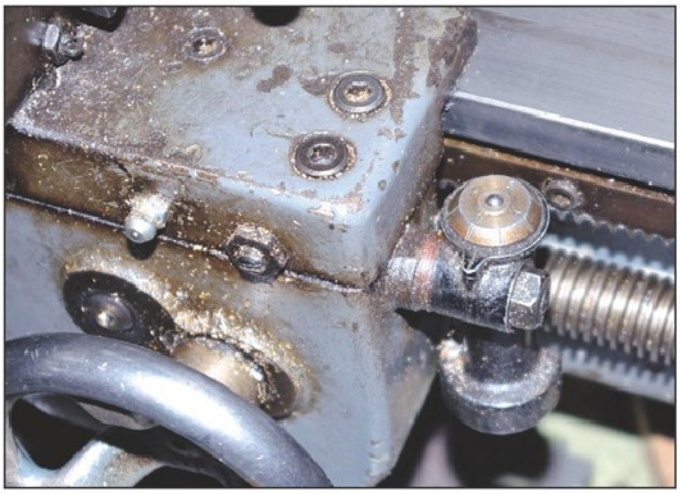


Photo 18. Threading dial indicator can be added to Myford.

something you could happily leave until you see a real need.

Sundry items which will be found useful include carriers (Lathe dogs), small angle plates and vices. ■

Suggested further reading

An excellent source of information is the website run by Tony Griffiths (www.lathes.co.uk) from whom many technical manuals are available. Machines are also advertised there. One article which introduced a fresh approach to restoring worn slideway surfaces was that written by John Feeney and published in Issue 98 of MEW. This introduced the topic of building up by using specialist epoxy resins, and while this may be frowned upon by traditionalists, it has, nonetheless, been for a number of years, a technique employed by reputable machine tool makers and rebuilders.

In addition to the recently published Workshop Practice book by the writer, concentrating on the Mini-Lathe, available from www.myhobbystore.com, a number of other works have appeared over the years, some oriented towards a particular machine, some more general in nature. Those on the following list give useful information on particular machines.

Myford ML7 Lathe Manual	Ian Bradley
The Compact Lathe	Stan Bray
The Taig Lathe	Tony Jeffree
Unimat 111 Lathe Accessories	Bob Loader

To Die, Now! (Better than 'Yesterdie'?) 5

David Piddington continues his look at dieholders.

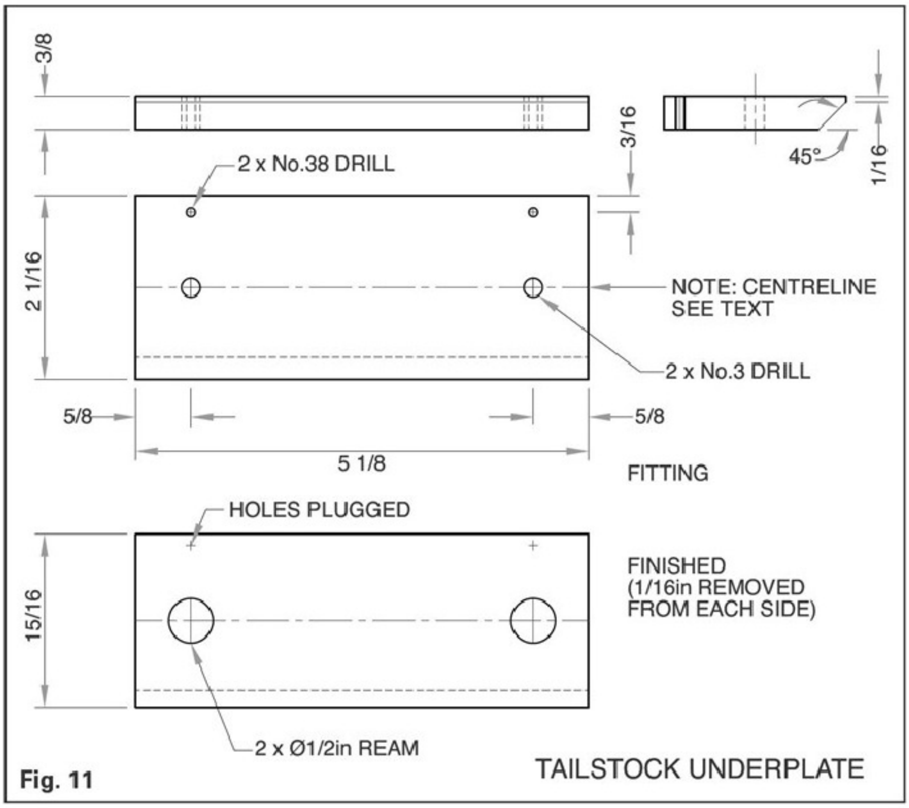


Fig. 11

The under plate

The under plate, **Fig. 11** measured from my machine is required at 2 3/32in. wide by 5⅛in. long, deliberately slightly longer than the tailstock's base, and of 2¼in. thick mild steel. This is best machined from 2¼in. material if you can get it, or 8mm x 55mm if that is the nearest alternative you can obtain. Check the width from your own machine leaving a few thou' side clearance. I had completed mine to size and found that the lower left corner, looking towards the headstock, fouled the top of the leadscrew handwheel preventing insertion pressed up against the under side of the bed shears, necessitating a 45deg. chamfer. Due to the magnificent gift of a compound swivel vice from a friend giving up his workshop due to illness, I was able to chamfer as shown in **photo 47** and was actually the first time I used this vice.

Attention may now be given to the tailstock base with its adjustment block where as shown in **photo 48** it may be seen being temporarily fitted into the bed shears with a screwdriver and socket key. It is shown in the reverse position for this image, though it will fit either way, as the bed shears are ground parallel. It must be a smooth, sliding fit.

At this point it must be stressed that this adaptation requires the tailstock to be rigid and non-adjustable for offset centres from the headstock. We will later bore out the front to take an adaptor bush for the dieholders. The underside of the tailstock casting has been cored out leaving a wall thickness of about ¼in. This is insufficient for secure screws so I reasoned that if the cross hole for the former clamp handle spindle were plugged, this is ⅝in. diameter then the plug could be secured permanently and a stronger bolt inserted through the hole formerly occupied by the clamp spindle. **Photo 49** shows the inverted base being aligned to a 25/64in. diameter drill being careful to centralise it as the actual hole size on mine measured 0.415in. diameter and the nearest available drill I can ascertain is a letter "Z" and I don't have one. The drill will be replaced with a ⅝in. end mill, slot drill or a counterbore if you have one completing a shallow cavity as seen in **photo 50**.

Tailstock securing bush

Next machine up a bush as shown in **Fig. 12** to be a close push fit inside the hole and a ⅝in. diameter MS plug 2¾in. long for the cross hole. If you don't have one, make up a centre punch from ¼in. diameter silver steel about 2½in. long and after inserting the sharp end into the bush's hole, make a heavy dot on the side of the plug. Now, the raised edge around this dot will prevent removal of the plug, but after a little dressing with a smooth file, it can be removed to the drilling machine where it may be cross-drilled and tapped ¼in. BSF. Alternatively use metric of 6mm x 1mm pitch. A socket head cap screw 2in. long is now required, though few of our regular suppliers stock this length. However all is not lost for there are many nut and bolt retailers who will usually sell over the counter to private individuals. This single screw has made for a really solid piece of equipment. Unfortunately, as time proved, this was not as secure as I had hoped and, while finishing the unit prior

Photo 47. Chamfering the underplate.

Photo 48. Checking the fit of the tailstock base to the bed shears.

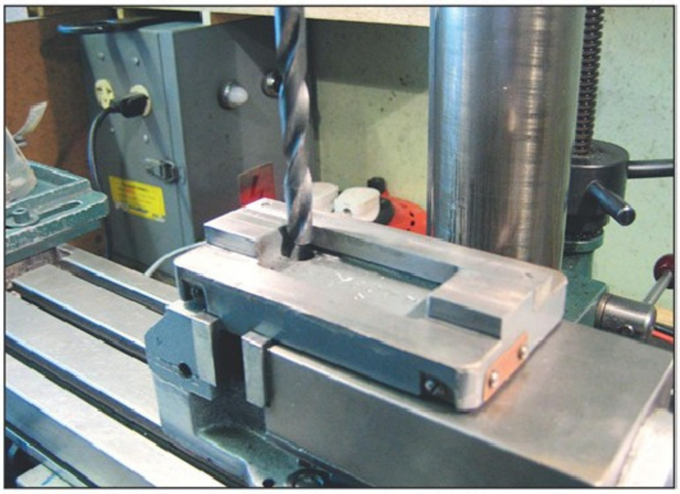


Photo 49. Aligning the drill with the clamp hole.

Photo 50. Counterboring the base underside for the securing bolt.

to final painting, I inadvertently tapped the upper part sideways. Luckily the original centering scale was still attached and I had already noted its position to the fiducial line on the tailstock body and could reset it. The obvious way would be to put the adapter in the three-jaw chuck and re-align the smaller end to the bored tailstock but the saddle is in the way. To overcome this problem I drilled into the top of one of the external bosses on the casting and hammered in a 3⁄32in. spring (roll) pin, see **photo 51**, which as can be seen, is being readied for undercoating.

After coating the upper surface with a marking colour, the under plate may now be carefully positioned centrally inside the bed supported on a piece of wood or other packing. The plate is slightly longer than the tailstock, deliberately so, and the extra length will be at the lathe's headstock end. Scribe two parallel lines from the bed shears and then after removing it to the

Photo 51. The spring roll pin about to be hammered into its hole.

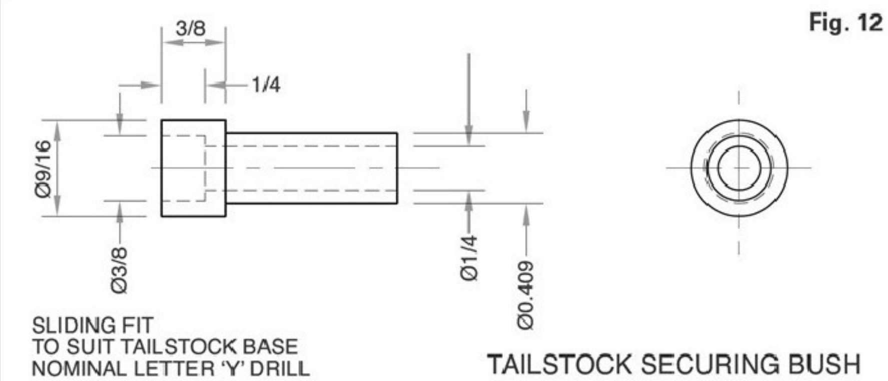


Fig. 12

TAILSTOCK SECURING BUSH

marking out bench, scribe a centre line between these two marked lines along the plate. Measure in 5⁄8in. from both ends and make a centre dot. Drill both holes with a No. 3 drill (or 13⁄64in.) and remove the burrs both sides. These holes must now be transferred to the underside of the tailstock which latter item should first be clamped to an angle plate as shown in **photo 52**. This is the "two hands" method of this sort of awkward job. I already had a selection of 3⁄8in. drawbars and had a suitable one with 3⁄8in. BSF threads at both ends and 8½in. long. I have others too with different threads at the ends. If you do not have such a bar, then make a temporary one of this length. The "two hands" method requires two spanners to fit the nuts and a suitable area of bench or machine table, or whatever you have available. As shown in this view, I have a ring spanner resting on the edge of my surface plate held there solely by gravity. At the other end, not shown, are two nuts locked together so that with my right hand I could tighten the assembly holding the loose nut before putting the ring spanner in place. Then, having achieved a non-slip assembly, I used a small spirit level first on the top edge of the angle plate, and then to adjust the disposition of the inverted tailstock parallel to the surface plate and then finally tightening the drawbar. If your bench is not horizontal simply note where the level's bubble is and set the tailstock to that same indication.

Next, study **photo 53** where it will be seen that a piece of steel plate has been wedged against the front inner bed shear and my digital calliper has been posed showing how to measure the depth of the

Photo 52. The two hands method of clamping the tailstock to the angle plate.

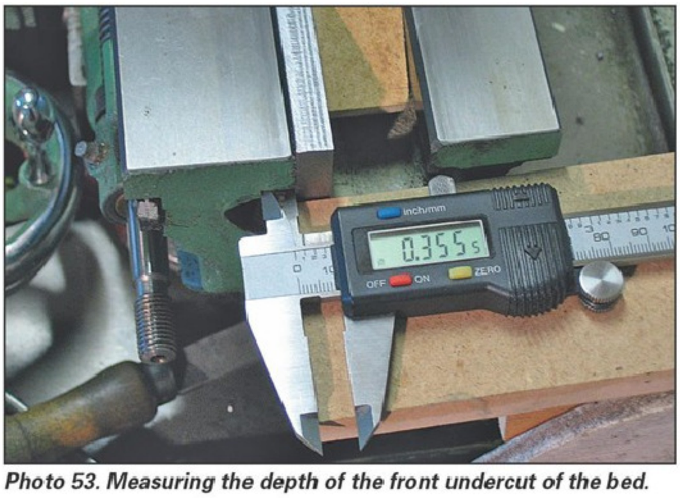


Photo 53. Measuring the depth of the front undercut of the bed.

Photo 54. Measuring the depth of the rear undercut.

undercut. **Photo 54** shows a similar procedure for the rear shear. Obviously, as I did, you will not need the temporary shelf to support the calliper. My own machine's bed shear undercuts were: front 0.357in. and rear 0.371in. thus the centre of the under plate will be 0.014in. towards the front shear. I had made my under plate a close fit under the shears and its width is 2.097in.. Note that on these posed images, the readings differ from my text.

Under plate gauge

Using a depth gauge, or the step end of the digital calliper measure the depth of the tailstock's tenon, which fits between the bed shears. Mine measures 0.321in. -slightly greater than a nominal 5/16in. Take a length of 3/8in. mild steel of the same length as the tailstock and machine one side to match the tailstock's tenon. On an adjacent side, mill away to match the width of the wider shear undercut, which on mine, was 0.371in. See **Fig. 13**.

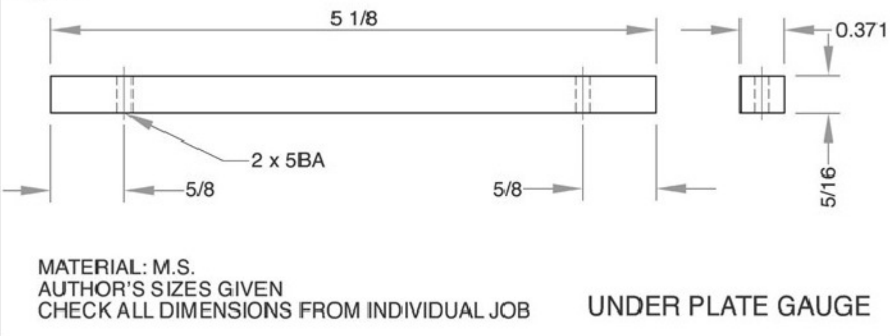
Next drill two No. 38 holes on the rear edge of the under plate at 3/16in. from the edge and fit to it the newly machined rectangular under plate gauge ensuring that you fasten to the thinner dimension. I used 5BA screws for which the above size is the tapping drill for 87% thread engagement. It is essential that both rear edges are exactly in line. The holes in the under plate may be plugged later.

Now with a wedge of, say, 6mm MDF clamp the bolted together under plate and gauge on to the inverted tailstock on its angle plate and take the whole assembly to your drill table and spot through the two securing holes with the No. 3 drill. **Photos 55 and 56** show views of this procedure and the under plate gauge can be clearly seen positioning the under plate parallel with the tailstock tenon. After removal of the under plate, tap the holes about 3/4in. deep.

Remove the temporary under plate gauge and open out the holes in the under plate with a 1/4in. drill - no larger at this time. Then with a couple of temporary bolts, try the assembly for fit. I was gratified that mine was satisfactory.

By using a number drill's shank I found that a No. 14 was the distance between the bottom of the tailstock's tenon and the top of the under plate, this being 0.182in. - almost 3/16in. Add to that the plate's thickness of 3/8in. and there is room left on my 1991 machine of 11/16in. clearance for the spring, its cap and the tensioning bolt. We must therefore work to less than that in the hope that other machines do not vary appreciably.

Fig. 13



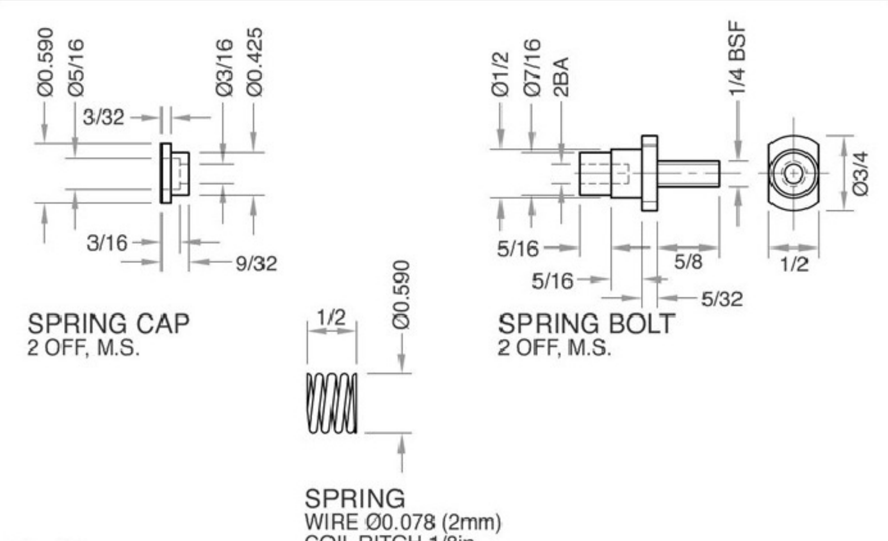


Fig. 14

Spring components

The springs are shown in **Fig. 14**. I have no specification for these and used the only possibly suitable one I had in stock, which looked about right if cut in half. It was 1 1/16in. long with 0.078in. (2mm) wire diameter and 0.590in. outside diameter with a 0.430in. bore. I cut through the spring with a micro-drill and a diamond-impregnated point, **photo 57**. (I assume it is diamond as it certainly cut through the wire doing only minor damage to adjacent coils.) The cutting process unfortunately leaves a far-from-flat-end

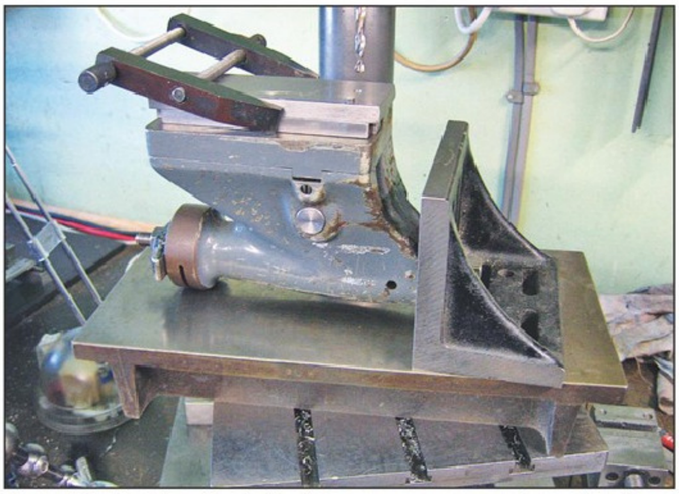


Photo 55. Spotting the holes for screws to secure the underplate.

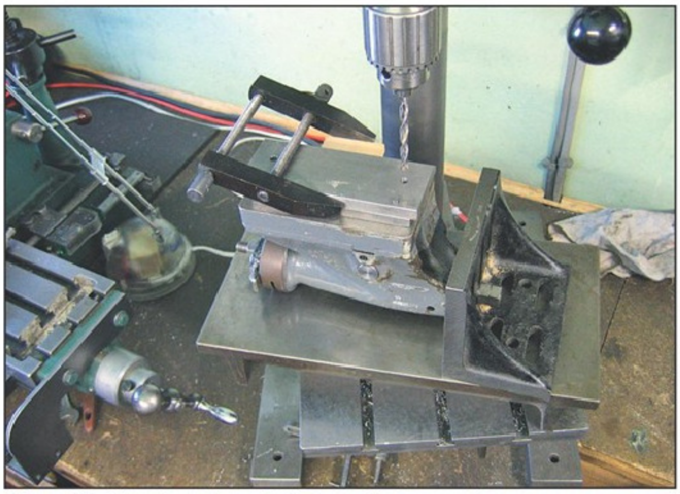


Photo 56. Another view of the spotting operation.

Photo 57. Separating the halves of the spring with a diamond burr.

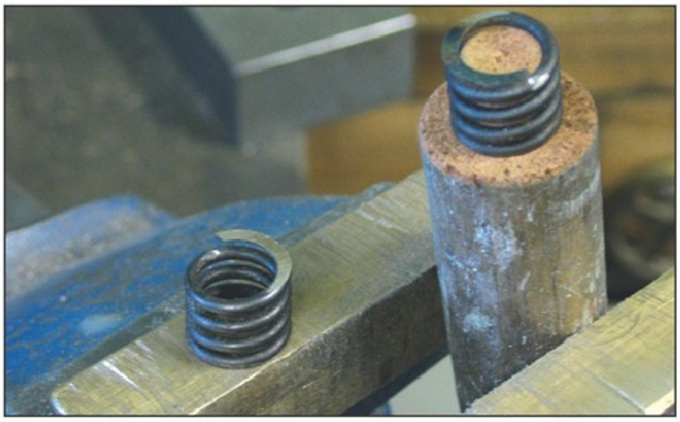


Photo 58. A method of holding a spring to grind its end square.

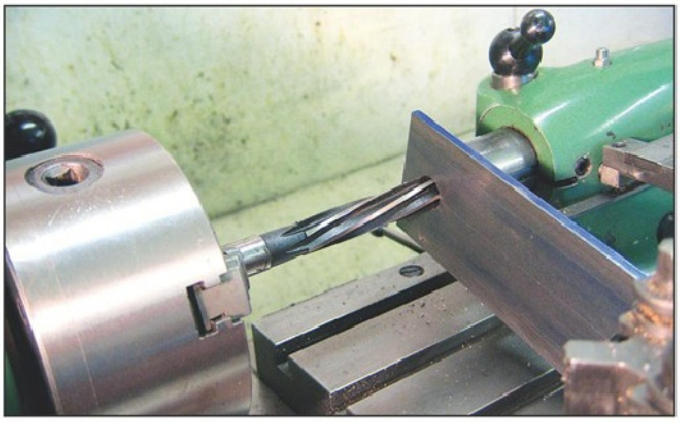


Photo 59. Reaming the underplate holes in the lathe.

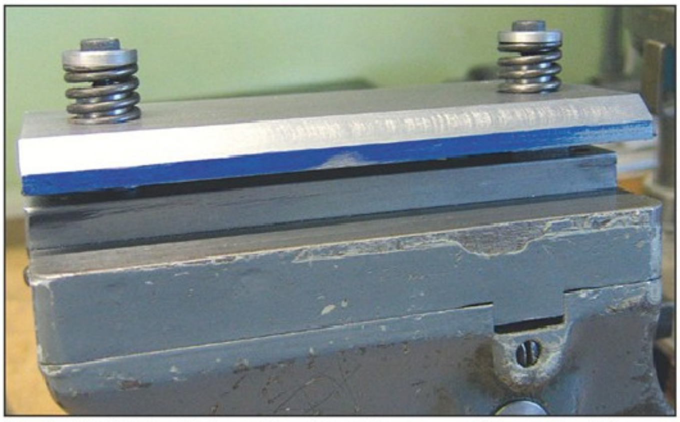


Photo 60. Method of marking the rub areas on the underplate.

to the spring but for this purpose I do not think it will matter overmuch. The raised ends can be placed, very carefully, against the side of your bench grinder to true it lightly. Turn a plug of wood to fit the bore tightly to do this so you can hold them without danger of damage or burning to your fingers and, at the same time ensuring they are both the same length. **Photo 58** shows what I achieved with this method.

Subsequent operations showed that this spring was strong enough holding the tailstock down against stresses from a revolving single point cutter for boring the front of the tailstock for the die holder adapter. However, it was far too strong for making long slender threads such as 8BA and 10BA where the drag resistance of the tailstock on the bed is greater than the fine threads will withstand. Therefore a much lighter spring will be needed that will just, and only just, keep the under plate in contact with the bed for most threads. No spring is required at all for the very fine threads, the weight of the tailstock being sufficient.

I had already realised that if a sliding fit were aimed at, any lift away from the true vertical would bind on the spring bolts and so although I have quoted a ½in. reamed size for the plate the bolts are a clearance size on this diameter. **Photo 59** shows my reaming process for the hole as my ⅜in. capacity bench drill's chuck was unable to accept the reamer's shank. The pre-drilling up to 31/64 was done on the slowest speed of my drill, the drill shanks having been long ago reduced to ⅜in. diameter. It will be noted that the tailstock barrel front face supports the plate by means of my right hand - it was on the camera at the time this posed image was taken - gently pushing it. I ran the lathe spindle on the fastest speed in backgear, 77rpm on the Myford S7, and applied cutting oil to the reamer.

The under plate bolts and spring caps, also on **Fig. 14** need no special instruction as they are plain turning, drilling, threading and tapping. Now, are you not pleased that your ¼in. BSF die is in its preset holder and cuts an accurate thread to match your tap? Counterbore the cap with an end mill. Use 2BA x ½in. long socket cap screws and check with the bed that these will clear the inside bed-way top. I found my unit would slide firmly as I had expected, so after putting some blue marking (NOT marking out blue) on each side edge, it was found that these were rubbing hard under the bed shears as in **photo 60**, which will have to be removed. It may also be realised that swarf will inevitably find its way into the gap between under plate and bed rib, so I propose a drastic solution of removing 1/16in. from both sides of the under plate. It was only the initial close fit that enabled the plate to be positioned under the tailstock body centrally disposed to the bed. That we are now removing the positioning edge is no longer important. If you use a spring like mine, adjust so that a minimum pressure is put on to the spring with the cap screw.

As only two springs are required I am unsure where to recommend a purchase. The only spring that might be suitable from a model engineering suppliers are those for the 3½in. gauge passenger bogies by Messrs Reeves 2000 but these are listed in packs of eight. Any alternative spring will require a different spring cap, and an amendment to the upper part of the spring bolt provided it is not larger than ½in. diameter. To be continued...

WARNING

When cleaning up the under plate, do not break the leading edge but leave it sharp. If you look at the equivalent edges of the saddle, or your tailstock where it slides along the top of the bed, you will note a similar condition. This is to prevent swarf access. If by chance you have already done this, then return the plate to your mill and take a small cut across the end until the 'sharp' condition is met.

Even then the sharp edge is not foolproof for I remember a brand new machine being returned to the works. While setting it up in its new owner's shop it has been near a 'dry' grinding machine. A small quantity of grinding dust had blown across and settled on the bed. All unknowing, the operator engaged the quick power traverse and the dust penetrated under the saddle and it seized. It was found impossible to free it hence its return to the makers. When the saddle's apron and all connecting shafts had been removed the overhead 10-ton crane attempted to jerk the saddle off the bed. This only succeeded in lifting several tons of machinery off the floor. It was eventually removed with screw jacks from beneath but the sight of the gouged bed will remain in my memory forever. It was as if long, badly broken fingernails had scraped across a slab of butter down to a depth of about ⅛in. The underside of the saddle was in no better condition.

Photo 1. Clocking along a workpiece.

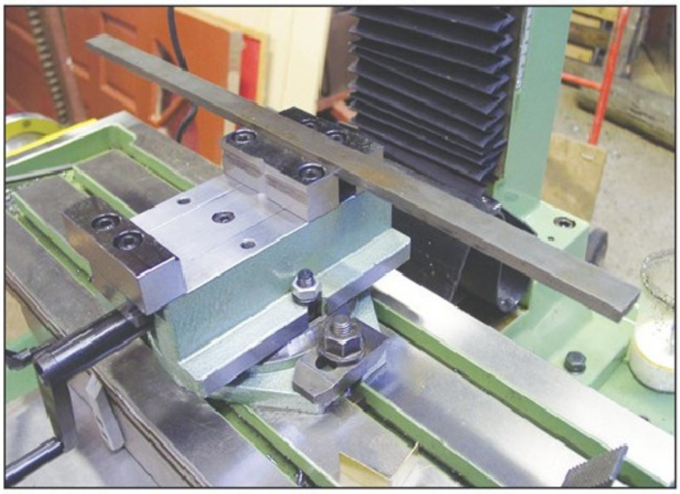


Photo 2. For approximate setting, a long straight bar may be sighted against the Tee slots.

FINDING THE DATUM

Dave Fenner looks at locating holes and edges

Background

For many milling operations, a logical sequence of operations will commence with an initial squaring up with a fly cutter or end mill to establish one or more datum surfaces from which the positions of other features may be determined. In most circumstances, the datum positions will be taken from existing edge surfaces, or perhaps scribed lines. However, on some occasions work may be referenced to the centre of an existing hole, and it was the process of addressing this less usual aspect that started the train of thought on this subject.

Setting up parallel to the table

Many set ups will require that one edge of the work is either parallel or at right angles to the machine table. If the work is to be held in a vice, then the vice must be accurately aligned with the machine.

The classical method of ensuring parallel or perpendicular setting is to use a clock gauge held in the stationary mill spindle on a vertical mill. **Photo 1** shows this procedure, where the table has been moved in the Y direction so that the work contacts the stylus, then in the X direction to the extremities of the work. Any variation in the clock reading indicates an out of parallel position. The usual technique for setting a vice is to lightly tighten one bolt so that it forms a pivot point, and have the other somewhat slacker. The work or the vice can then be nudged with a nylon mallet, with slight rotation being encouraged around the first bolt. To set up the vice more quickly, but less accurately, I keep a handy length of mild steel flat bar, **photo 2** which can be gripped in the vice and sighted against the Tee slots. On some mills where the column features a flat front face, it may be possible to employ a purpose made U shaped bracket which is clamped in the vice. The table is then backed towards the column, until the two equal length legs contact the column.

If the work is to be clamped directly to the table, then for best accuracy, again, the clock should be used. My quick and dirty solution here is to have a couple of setting pins, made from 16mm bright bar which were turned down in a collet chuck to closely fit the Tee slots. These can be seen in **photo 3** and on the machine in **photo 4**. With two of these in place, the straight edge of the work can be simply backed against them and clamped in place. A close approximation may also be obtained by using a locked depth gauge at each end of the work, **photo 5** to set a specified distance from the table edge. This of course assumes that the Tee slots are in alignment with the X axis (in the case of a new machine, an inspection report may indicate the tolerance and actual measurement of error). An older second hand machine should be accurate, but it may be worth checking by locating a clock in the spindle and zeroing against carefully fitted pins, or running along one slot.

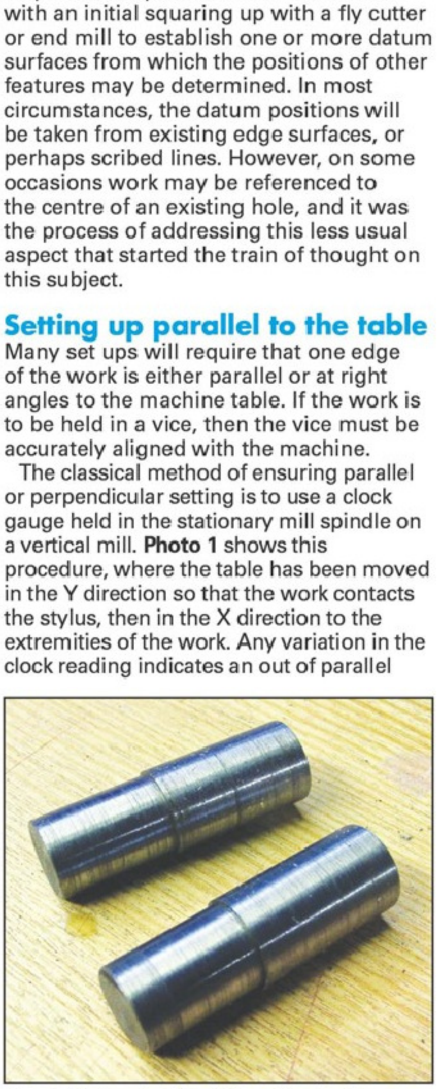


Photo 3. A pair of setting pins for the VMC mill.

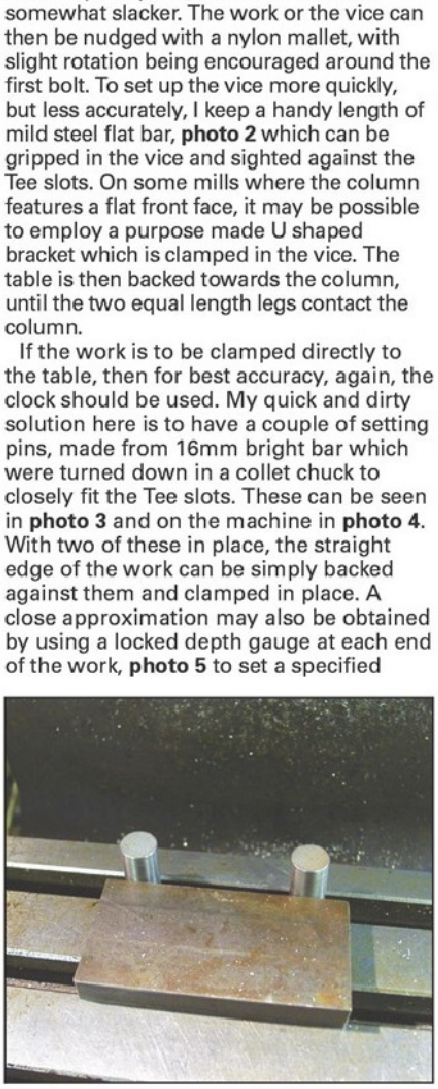


Photo 4. Work can be pushed back against the pins prior to clamping.

Setting up across the table

If the edge is to be set at 90 degrees to the table, then again the clock method used on the Y axis, will deliver the most accurate result, however for speed, using a good quality square will normally be good enough, **photo 6**.

Alignment device

A simple alignment device, which is geometrically a bit like a carpenter's bench hook, can be made quite quickly from a length of flat bar and two short pieces of silver steel bar. Drawings are not given, as the size chosen will be determined by the material available and the size of the machine. My flat which happened to be of section two inches by half inch (approx 50mm by 12mm) had lain around for many years and acquired more than just a patina of rust. It was cut to a length of about 12 inches (305mm) although for smaller work, this might be reduced to say 7inches (180mm). The broad faces were given a lick on the linisher and then the narrow ones cleaned up by draw filing. The flat bar was set spaced up from the mill table, (to allow the drills to poke through without damaging the table) taking care that it was in alignment with the longitudinal X axis. Again, the best method for setting alignment is to use a clock gauge and traverse the full length, but I used the approximate depth gauge method, and found it to be about a thou out. If the bar is found to be out of straight, do not despair, just get it pretty close and proceed to clamp it down. With the Y axis locked, two holes are then drilled. I have positioned these closer to one edge, spaced them ten inches (254mm) apart and chosen a diameter of 3/8in. (9.5mm). This spacing would allow *a secondary function as a 10 inch sine bar for angle setting. To obtain accurate holes, the process was to start with a centre or spot drill, drill through at $^{23}/_{64}$in. then open out to $^{3}/_{8}$in. I had planned the work in two distinct stages, but if you place your spacers carefully, or consider them as sacrificial, then one set up will suffice as follows. If you choose the more involved procedure, then move on to "Assembly".*

Single set up method

Without slackening off the work clamps, fit a slot drill or end mill to the chuck, and proceed to take a light cut along one side of the bar, ensuring that the Y axis is locked for the duration of the cut. Without disturbing the work, this procedure may then be repeated for the opposite edge. This method offers the theoretical benefit of being more foolproof and error free. Because the work has not been disturbed, all the features should be parallel within a tight tolerance, governed by the machine's own inherent accuracy.

Assembly

If the holes are accurately to diameter, you may simply Loctite in two silver steel pegs of appropriate size. If however they are slightly oversize, then turn down say $^{1}/_{2}$in. dia. to fit. In this latter case, ideally the pins should be turned using a collet chuck, thus ensuring concentricity.

Multiple set up method

*To correct any slight out of straightness or parallelism, further operations can be undertaken. The assembly was now clamped to an angle plate, and its height from the table set by equal spacers under each pin. If you have a set of slip gauges then these are ideal, however a good alternative is a couple of short pieces cut from flat bar - **photo 7** shows my set up using pairs of parallels made many years ago. Other techniques here are equally valid, such as lengths of bar faced to length. Just check with a micrometer that the sizes are equal, before starting. The top edge of the alignment bar can now be shaved with an endmill or flycutter to be accurately straight and parallel with the positions of the two pins. The procedure can then be repeated for the second side. In use the pins may be located against the edge of the table as in **photo 8**, or against a Tee slot edge.*

Having now set the work in alignment with one or other of the machine axes, it is then necessary to bring the spindle to a known position with reference to the datum edges. One point worth mentioning here concerns backlash in the table leadscrews, which will almost certainly be present unless your machine is fitted with high quality ball screws or is near new. The trick is to always approach a setting from the same direction, that way, the backlash effect is nullified. Sometimes this will mean going beyond a desired position and then coming back in the chosen direction.

This need to know where the spindle is located with reference to some feature of the work (or fixture) is a basic requirement for almost any reasonably accurate work, but is also particularly true in the case of CNC machines, where the machine needs to know where the spindle is in relation to the table and the work, before commencing the cycle.

Probably the most common situation is that where we are working from one or two datum surfaces. Several methods are available employing equipment ranging from the no cost home brewed accessories to fairly expensive microscopes.

Working from an edge

For many situations, it is convenient to work first from the static vice jaw, since once the spindle has been referenced to it, then the corresponding side of any work clamped in the vice automatically has a known position. Any of the various methods to be described may be used on the vice, except **method 1**, the "Rizla". This dates back to the times when no self respecting machinist would be without his self rolled cigarettes and his packet of Rizla paper. These papers typically measure just over a thou (0.025mm) in thickness. Where it was necessary to mill say a shoulder in rectangular work, a small piece of the paper was attached to the side of the work by wetting with coolant, then the cutter brought carefully across to it. When the cutter picked off the paper, the cutting edges were assumed to be one thou off the work. If needed, the position of the spindle centreline could be determined by compensating for the radius of the cutter. The reason for not using this method on the vice is the danger of running the cutter

Photo 5. With care, good accuracy can be achieved using a depth gauge. The error measured here was 0.002in.

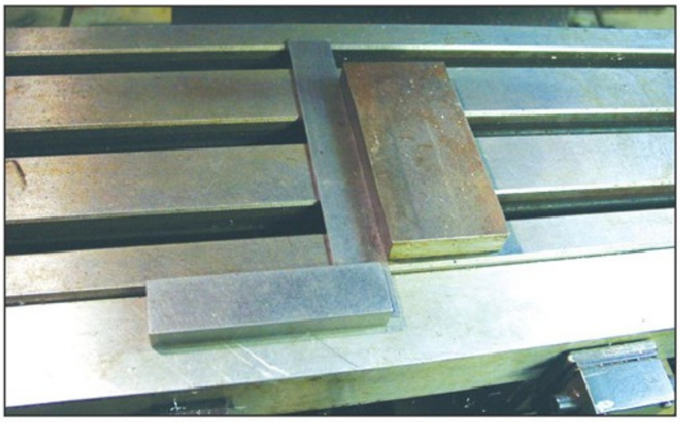


Photo 6. For working across the table prior to clamping, the workpiece may be held against a try square located against the table edge. Not as accurate as using a clock but acceptable for most work.

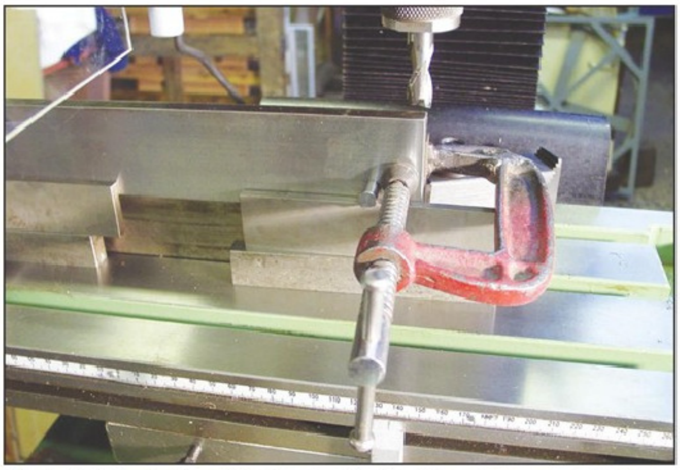


Photo 7. Edge is trued to the pins by locating pins on parallels.

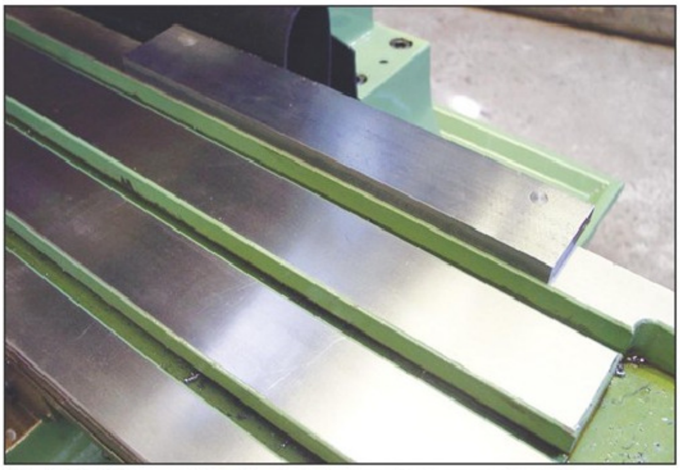


Photo 8. Alignment device located against rear edge of table. Work may then be set against it and clamped.

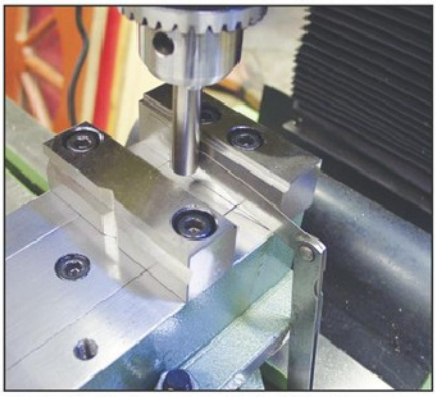


Photo 9. Feeler gauge is lightly nipped between bar and vice.

Photo 10. Home made edge finder.

Photo 11. Lower section of edge finder has moved about 1mm to the left giving positional indication.

Photo 12. Detail of one track, tension spring, and 5BA screw.

Making an edge finder

The raw materials for my home brewed effort were all found in various scrap boxes and comprised a length of half inch diameter bright bar, two 16x12x12 mm dia. inner tracks for use with needle roller bearings, a tension spring, and a 5BA screw. This last item was used to give a convenient connection to the spring.

*From the bar, two parts were turned, the arbor and a cap for the lower section. The arbor featured a shoulder at one end to locate one track (Loctited in place), a counterbore at the other to locate a retention pin for the spring, and a stepped through hole to accommodate the spring. Using the two tracks ensured that the material was hardened and ground giving accurate diameters and square end faces. However, I see no reason why other prospective builders should not make these parts from silver steel. Some of the component parts may be seen in **photo 12**. The tracks used have an OD of 16mm which means that to bring the spindle centre in line with the edge, requires an offset of 8mm. On a metric machine such as the Warco WM 18, this is particularly convenient as it equates to four complete turns of the handwheel. In the case of an Imperial machine such as my Myford VMC mill, a diameter of 0.400in. would require an offset of 0.200in. requiring one complete turn. Of course, if a DRO system is fitted, then offsetting to datum would be carried out using it. As with the earlier item, no drawings have been given as the contents of scrap boxes will no doubt vary.*

into the hardened vice jaw which would cause damage to both.

Method two I will dub the "rod and feeler", and it is probably the method I use most frequently. It can also be adapted to quick set ups for cross drilling small shafts. In its most basic form, a length of round rod (silver steel is an ideal choice) is gripped in the drill chuck, and moved across towards the face of the work or vice. When it just nips a feeler gauge, **photo 9** the spindle centreline is offset from the face by "half the rod diameter plus the thickness of the feeler gauge". One can of course make do with one "master rod", but by preparing a selection of rods of different diameters, it becomes a quick exercise to set the offset to cross drill work to a fair degree of precision. Thus if the 0.002in. feeler is the standard, then a rod of 0.371in. diameter gives instant setting for cross drilling a shaft of 0.375in diameter. For metric applications, one might employ a 0.1mm feeler, in which case a rod of 9.8mm would give an accurate setting to cross drill a 10mm shaft.

Method three takes us into the realms of more specialist (and usually purchased) equipment, namely the edge finder, a piece of equipment that I had read about, seen used by others, but had not employed myself. The original intention was to borrow one for the purpose of this article, but thoughts then turned to wondering how easy it might be to make one. The answer proved remarkably simple.

Edge finders come in a variety of forms; single ended, double ended, single or double diameter etc. I chose to make the simplest possible example shown in **photo 10**.

It is made in two sections, the upper, which is fitted to the spindle chuck, and the lower, which does the position sensing. The two sections are drawn together by a tension spring.

In use, the spindle is run at about 500 rpm, and it is likely that the lower section will start to run slightly eccentrically. The spindle height is set so that about half of the lower section overlaps the edge to be found. The table is then moved slowly to bring the finder into contact with the edge. As the edge is approached, it will bear intermittently on the finder, gradually moving the lower section into a concentric position. Finally, when a true touch is achieved, the frictional drag will occur throughout the whole spindle revolution, and the lower section will move sideways about **1** to 1.5mm. This can be seen in **photo 11**. Very high accuracy and repeatability (e.g. 0.0002in. or 0.005mm) is claimed for commercial edge finders, and certainly, using the Schumate DRO as a reference, the home made version proved to be better than a thou (0.025mm) on both counts.

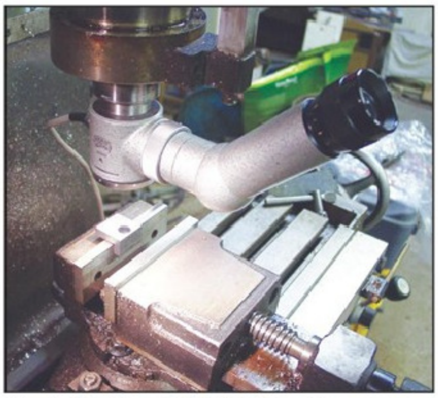


Photo 13. Hensoldt Wetzlar microsope fitted to VMC mill .

Method four takes us once more into the realms of more specialist equipment, namely the centering microscope. Colin Golding described his design in MEW Issue 98, and in Issue 106, Dick Stephen covered the construction of the Hemingway kit which includes those hard to source optical components.

Due to good luck, some years ago, I did manage to acquire a centering microscope, **photo 13**. As purchased, something rattled inside, no image was visible, and the arbor taper was something of a mystery. After dismantling, the rattle was traced to a detached mirror, and a new R8 arbor was turned with a correct internal location for the mirror. Careful readjustment was then needed to bring the centre point to the middle of the graticule. The original kit included a battery for illumination (long gone but easily substituted) and a device for accurately locating edges, **photo 14**. This becomes useful if the edge has been given

Photo 14. Detail of the edge accessory. The mirror features a fine line which is in line with the lower vertical face.

Photo 15. Here the rod blank was held by two Allen screws in the fixture clamped in the vice. Setting the datum position was achieved by means of two pointed accessories, lined up using a magnifying glass.

a chamfer, making it more difficult to determine the position of the vertical surface.

A microscope can also be ideal for locating the centre of existing holes or measuring distances between features such as holes, edges etc.

A modern development of method four utilises a webcam fixed to the spindle and linked to a workshop PC. Software is available to make such a set up an extremely useful alternative to the traditional microscope. Tony Jeffree and Dick Stephen described one system in MEW Issue 112, which provided the motivation for a second by Mike Trethewey which appeared in Issues 121 and 122 and addressed the question of illumination.

Using either a microscope or a webcam in conjunction with a two axis DRO system opens up the possibility of performing quite complex inspection of parts in a similar manner to an industrial CMM (coordinate measuring machine).

Method five involves the use of a laser. To the best of my knowledge this was first advocated by Peter Rawlinson (MEW Issue 79) as a device to aid mill head tramming. Comment from Richard Bartlett (Issue 80 and others prompted further development by Peter to give centre finding capability as described in Issue 81. Since then purpose made laser devices have become available at relatively low cost.

Working from a hole or scribed lines

There are those situations where the location we wish to adopt for reference is not a nice straight edge but could be a hole, either drilled, possibly reamed, or alternatively threaded as a bolt location. This can arise in situations such as a connecting rod where the periphery is created using the big and small end locations as datum positions. I came upon just this problem in a CNC application, where the rod blank was located on a fixture by two M6 Allen screws. In **photo 15** may be seen the profiled rod blank, and the pointed gadgets fitted to the spindle and the fixture to set the datum. Because the CNC software is to an older standard, it was considered desirable to be able to bring the spindle directly above the centreline of the location bolt, rather than to some other known offset location. A magnifying glass was used to set the points in line, and measurement of the machined blank indicated an error of 0.0025in. (0.06mm)

With a manual mill you are able to test the position of a hole by placing a rod of equivalent diameter in the chuck, then gently feeding the quill down and adjusting the table position so that the rod enters the hole freely. The accuracy achievable will depend largely on how closely the rod fits the hole. A second technique I have used on occasions employs a longer, more flexible, pointed rod again fed down manually into the hole. If the final approach is examined with a magnifying glass, then the deflection may be seen and compensation made.

In the case of scribed lines, I often simply fit a centre or spotting drill, line up the chisel edge with one axis then drop it down on the work, observe the mark made and correct accordingly, **photo 16**. The spindle is then rotated 90degrees and the procedure repeated.

Microscope or webcam methods are likely to work well here. Lines are quite straightforward, and small holes can be centred within the graticule. Larger holes are likely to involve more work to locate the centre.

In the case of a sizeable bore, then it can be back to the clock, **photo 17** or even the coaxial centering gauge type device as described by Peter Rawlinson in MEW Issue 118. This allows the clock to be more easily read from the front of the machine. These accessories are of course available commercially, but at a significant price. The set up illustrated in **photo 17** utilises the smallest Warco magnetic base locked on to the drill chuck outer ring. It should be noted that for stable readings, the chuck jaws should be tightened.

Cross Drilling Shafts

To arrive at the centerline position to cross drill a shaft, variations of several of the techniques noted above may be employed, notably the rod and feeler and the edge finder. If only reasonable accuracy is needed, then the rough and ready approach using a six inch rule or strip of flat metal strip may be used. With the work gripped in a vice, and a centre drill fitted to the chuck, the spindle is rotated to align the chisel edge of the drill with the axis of the work. The quill is then lowered to nip the strip or rule between drill and work. **Photo 18** shows the strip held at an angle indicating an error. The table position is then adjusted so the strip is held level as in **photo 19** where the spindle is now correctly positioned for cross drilling. Just how accurate this can be will depend principally on the diameter of the shaft (smaller shaft - higher precision) and how well you can judge the angular error. If we assume that the angle can be held within one degree error, then the drill position will be within 0.0175 times the shaft diameter of the true centreline location. This for a one inch (25.4mm) shaft, max error is 0.0175 inches or 0.44mm, while for something like a small railway axle of 0.125in. (3.175mm) diameter, the maximum error should be 0.0022in (0.055mm). ■

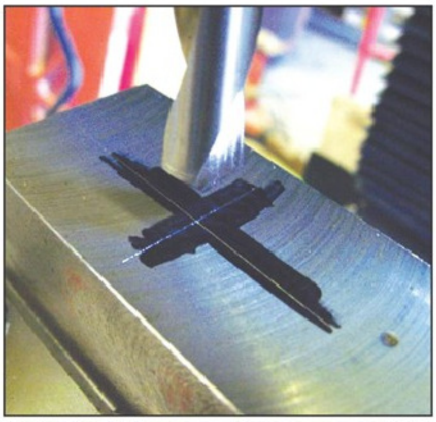


Photo 16. Using a spotting or centre drill, the spindle is rotated so that the chisel edge is aligned with one scribed line. The position can be checked with magnifying glass or by dabbing down on to the work. The spindle is then turned 90 degrees and the process repeated.

Photo 17. The chuck has been tightened to lock the outer ring, then the mag base attached. The clock can then be used to set the hole in the work concentric with the spindle.

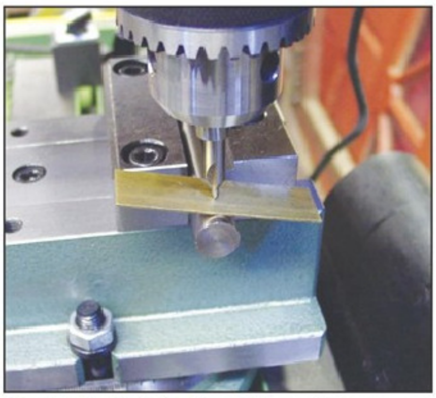


Photo 18. Strip is nipped by quill pressure; the angle indicates a positional error.

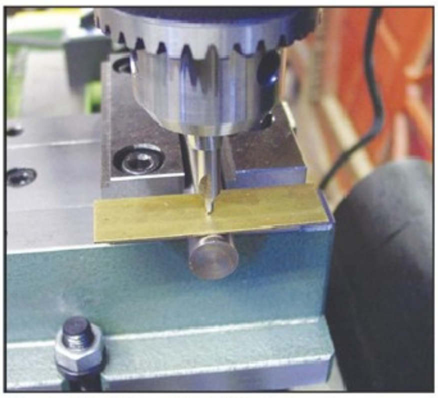


Photo 19. When the strip is level, the drill is on centre.

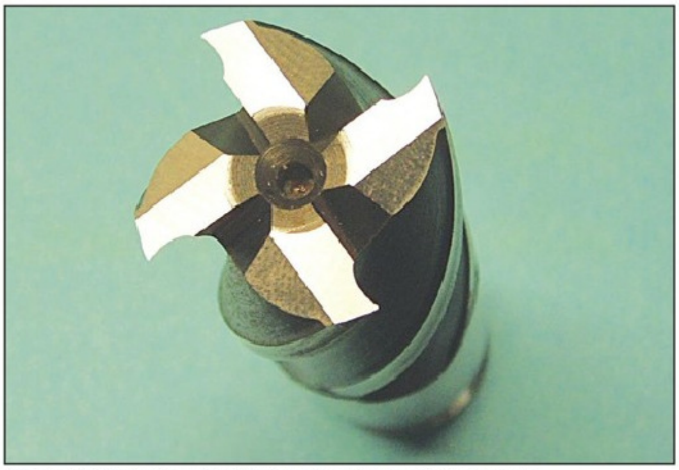


Photo 1. Typical end mill showing four cutting edges.

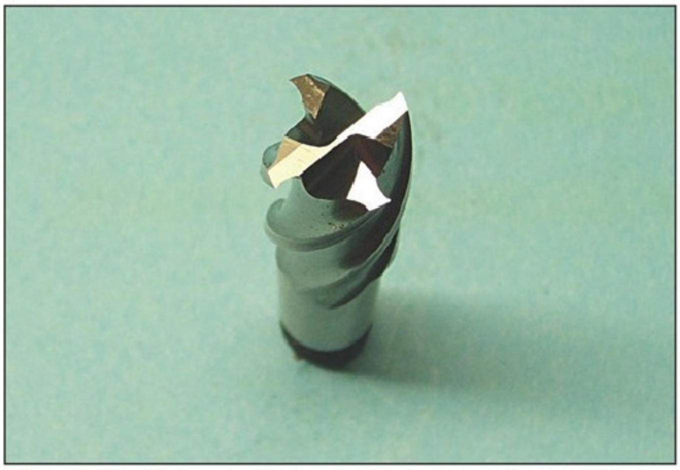


Photo 2. Modified end mill showing two overlapping cutting edges.

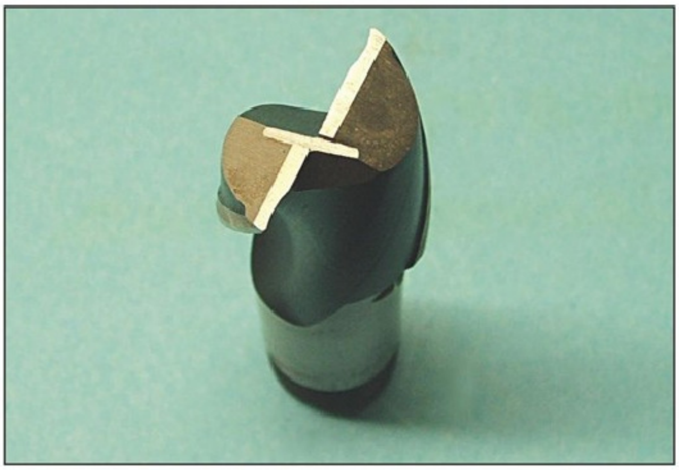


Photo 3. Slot drill showing two overlapping cutting edges.

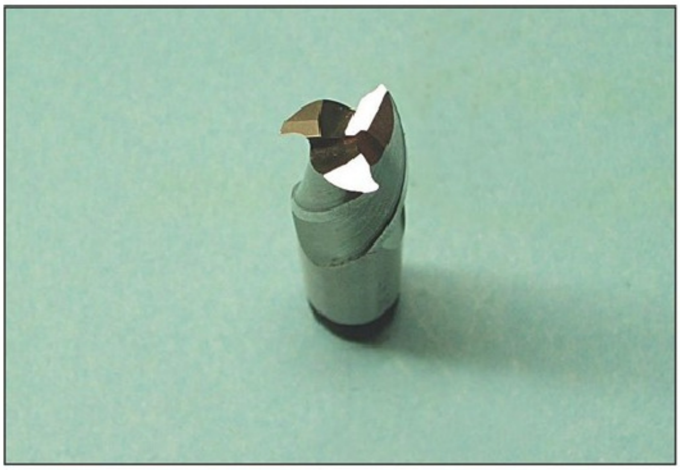


Photo 4. "Uni" mill showing three cutting edges, two overlapping.

AN INTRODUCTION TO MILLING 4

Donald Brymer looks at milling slots, grooves and keyseats.

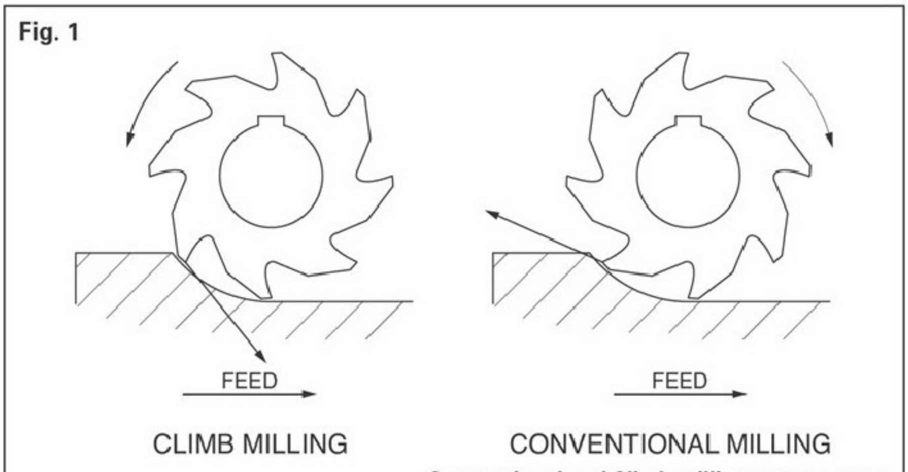
When a slot/groove or keyseat is to be milled, which cutter is most suitable for the task? Is it an end mill (four plus, non overlapping cutting edges depending on diameter) **photo 1**? Is a variation of the traditional end mill with two of the four cutting edges overlapping as in **photo 2** best? Maybe a slot drill with two overlapping cutting edges, **photo 3**. Perhaps a "uni" mill, generally with three cutting edges two of which overlap, **photo 4** or a side and face cutter, **photo 5**? The following text can help to answer this question.

End mills and slot drills

End mills with no overlapping cutting edges cannot be plunged into the work surface and must enter the work from beyond an edge or face. If an accurate width slot is required the end mill is not the best choice for a single pass cut as the multi tooth cutting action of an end mill tends to make the cutter wander very slightly resulting in an oversized slot/groove being machined. This does not mean that an end mill cannot be used for accurate slotting/grooving. It does mean that a smaller diameter cutter than the width of the slot/groove should be used and multiple passes are required at full groove depth to increase the width of the groove to the desired width. To machine an accurate slot/groove using this method, consider the following points.

- Centralise the undersized cutter on the centreline of the slot/groove.
- Leave 0.5 mm on the depth for finishing if required and take a cut to the required length.
- Withdraw the cutter from the slot, stop the machine spindle.
- Measure the width of the machined slot/groove, this size will be bigger than the diameter of the cutter.
- Subtract the measured width from the required size and divide the result by two. This is the amount to accurately move the cross slide of the milling machine. Which way the cross slide is moved will depend on which end of the table the slot is on and the rotational direction of the cutter (left or right hand flute helix angle).
- If the slot/groove is on the right end of the table and the spindle direction is clockwise from above, the cross slide would be moved toward the machine column. This will ensure that the cutter will be conventional milling, (detailed later in the article.)
- Complete the cut to length and then withdraw and stop the cutter.
- Measure the width of the slot/groove and again subtract this size from the required

Photo 5. Typical straight toothed side and face cutter.



Conventional and Climb milling cutter setups.

width. The result is the amount of material to be removed to bring the cut to size. Use the paper edge pick up method mentioned in a previous article to pick the opposite side of the slot/groove.

- For this setup, the cutter will need to be rotating and bought to the left hand end of the slot before any cross feed adjustment is made. Make the required adjustment feed toward the cutter to conventional mill.
- When a measurable distance has been cut, lower the table, stop the cutter and measure the cut.
- Make adjustments as required and continue the cut. Check any adjustments.
- Repeat the above steps to machine the slot/groove to depth.

When using a slot drill to machine a slot/groove the above procedure can be used. However, if the feed rate is correct then the cut of a slot drill will generally be on size. If a keyseat is being cut, the multiple pass method is recommended as the width of any keyseat is critical.

Slot drills by virtue of the overlapping cutting edges can be plunged directly into the work, thereby allowing "blind" slots to be machined at any position along the length of a workpiece.

The great majority of new end mills and slot drills are 30deg. right hand helical fluted, available in short, standard and long series with screwed and parallel shanks and are available in high speed steel (HSS), coated HSS, and solid carbide. Solid carbide cutters are particularly useful in home machining situations as coolant can be eliminated. However, the manufacturer's recommendations for speeds and feed rates must be used as these cutters will rapidly loose their cutting edges if used with a low cutting speed and a slow feed rate. Very high surface finishes are easily obtained with solid carbide end mills and slot drills. A suggestion is to make sure that your milling machine is capable of the spindle speeds required for solid carbide cutters before any are purchased.

Side and face cutters

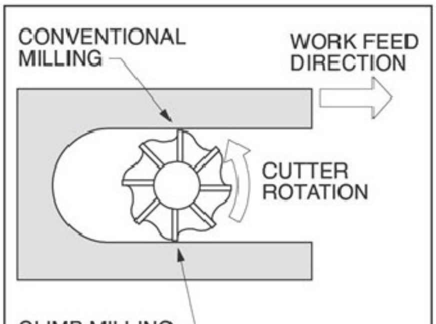
When using a side and face cutter to machine a slot/groove the cutter is best used in the horizontal position. It is capable of much heavier cuts and higher feed rates than end mills and slot drills. Straight tooth cutters do have a tendency to chatter if the set up is lacking rigidity. Chattering can be overcome by using a stagger tooth side and face cutter (alternate teeth have opposing helix angles).

Side and face cutters produce more accurate cuts and better surface finishes than end mills and can be used to produce accurate slots in one pass. This will however depend on the accuracy required for the job at hand and two smaller width cuts may be required to produce the required slot width for a size for size or interference fit. A problem that exists when using side and face cutters that does not exist with end mills or slot drills when machining blind slots is the cutter run out length that will be dependant on the radius of the cutter and the depth of cut.

Conventional milling versus climb milling

This is an important topic that should be understood before any milling takes place, particularly when milling with small diameter milling cutters as incorrect cutting can easily breaks these small cutters.

When conventional milling the rotation of the cutter is opposed to the direction of the feed and the resultant cutting action will take up the table feed screw/nut backlash before any cutting takes place. When climb milling, the rotation of the cutter is in the same direction as the feed thereby pulling the work into the cutter depending upon the amount of backlash between the feed screw and nut, **Fig. 1**. This problem can be overcome if the machine is fitted with a backlash eliminator that removes all backlash from the feed mechanism. Climb milling should be avoided for most milling operations if the mill does not have an eliminator, very fine cuts being the exception.



Cutter positioned to conventional mill on side of wide slot.

Advantages of conventional milling

- Backlash not problematic.
- Cutter teeth operating on clean metal.

Advantages of climb milling

- Cutting starts with maximum chip thickness that reduces to nothing.
- Better surface finish.
- Cutting action forces work onto the table.
- Suitable for thin workpieces.

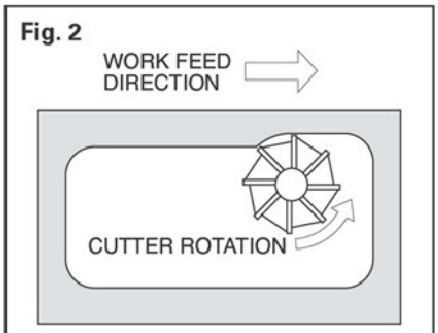
Disadvantages of conventional milling

- Teeth rub on the work surface until sufficient pressure builds to affect the cut.
- Work requires sufficient clamping to inhibit work lifting off table.
- Lower quality surface finishes.

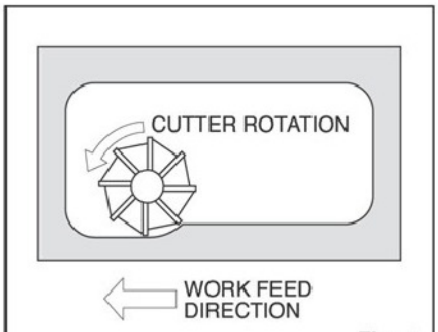
Disadvantages of climb milling

- Can be very detrimental to both cutter and work without backlash eliminator.
- Cutting edges in contact with mill scale and cast surfaces.

So, how does this apply to end milling and slot drilling applications? When an end mill/slot drill enters a workpiece both conventional milling and climb milling takes place. As both cutting actions are simultaneous the effects of both are cancelled, **Fig. 2**. Feeding from either direction is safe. When a cutter is smaller in diameter than the slot width being machined the cutter must be positioned to give conventional milling on both sides of the slot **Figs. 3 and 4**. When using this method to machine slots, care should be taken as the increased loading at the end of each cut can cause the cutter to undercut the ends of the slot. Whatever method you decide to use, correct cutting speeds and feed rate are important. ■



Milling cutter cutting with conventional and climb cutting.



Cutter repositioned to conventional mill on opposite side of slot. Note change in feed direction.

A METAL MANGLE

Dave Fenner makes a precision combination rolling tool.

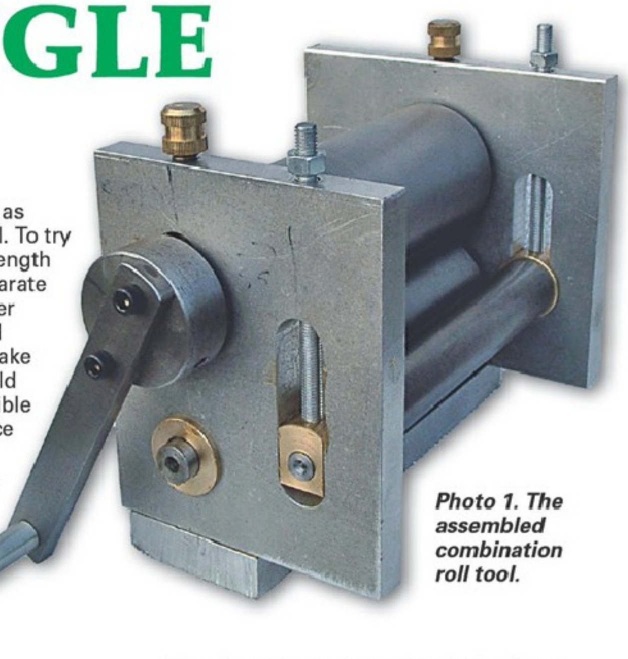


Photo 1. The assembled combination roll tool.

Background

When rolls are mentioned, the first thoughts are towards the traditional pyramid or slip rolls, which come in a vast array of sizes applicable at the small end to model making, and at the heavy end to industries such as shipbuilding. Here the function is to produce a controlled bend in a piece of sheet or plate. Contrasting with this, however, back in MEW Issue 123. Gary Wooding introduced us to the jeweller's rolling mill, where the purpose is similar to a full size rolling mill, to gradually reduce the thickness of work, either sheet or wire. As Gary mentioned in his article, a further application uses rolls to impress a pattern on soft metal, using something like wire mesh or an engraved plate to impress a pattern on the work.

Pukka jeweller's mills are relatively narrow and thus as can be seen from Gary's photograph in his article, you are able to screw down the top roll on both sides simultaneously by means of a geared drive from a single handle. My thinking led me to consider a gadget which would do the "mill" job, but also be equipped with a third roll to permit bending. When rolls are connected by gears, two main approaches are used. With just two gears, the PCD of the gears must approximately match the roll diameter, and the tooth size must be sufficiently large to allow for the change in centre distance as the rolls are adjusted for material thickness. If four gears are employed, then more leeway is available for sizing, and the arrangement is very much less sensitive to meshing problems as the top roll is moved.

Design and philosophy

The design process involved repeated trawls through the scrap box, interspersed with pauses to scribble sketches on the back of envelopes, and at one stage, a quick go at the CAD program to set out the gear centres. Gary had mentioned 65mm diameter rolls, so my starting point was a couple of likely looking lengths of black steel bar, about 65mm diameter and about 180mm long. The material was EN24T so this was not going to machine as easily as free cutting mild steel. To try and make the best use of the length available, I decided to add separate spigot shafts at each end, rather than machine away the limited length. If buying material to make something similar, then it would almost certainly be more sensible to make each roll as a one piece item.

In model engineering circles, some of the most readily available sources of low cost gears relate to the Myford change wheels from alternative suppliers. At the Harrogate exhibition, I chanced upon one supplier offering 42 tooth gears for the princely sum of five pounds each. I bought four. These would transmit drive between the two main rollers. One caveat should be noted here. These cheap gears are probably of far eastern origin, and it is probably a case of "you get what you pay for". They will certainly do the job, but after mounting them, I found that the accuracy of the bore left a bit to be desired. When spun on the spindle, a few thou of swash was visible at the periphery. This effect could be eliminated by setting up each gear to skim the bore with a boring tool, and then adjusting the location sizes accordingly.

Ideally, the bearings would be phos/bronze, but I had none around in anything like a suitable diameter. What I did have was a box containing a number of overmakes in brass. These surplus components were essentially 32mm OD, bored 11mm, by about 25mm thick. Other approaches to the bearing question might involve Oilite or Glacier bushes.

The two side plates were cut from a recycled production jig jettisoned by a major manufacturing company. The whole jig was originally composed of two aluminium plates about 16in. by 18in. each by ⅝in. thick, and separated by one inch diameter spacers some four inches long. One plate was riddled with slots and holes; however, the other had merely the five holes for attaching the spacers. I tried several methods of cutting the plate into more manageable chunks with a notable lack of success. (Hand sawing one length of about 18inches and a second of about six in this thickness was viewed as very much a last resort, and one to be avoided at all costs. A couple of in house approaches were attempted. The plasma cutter was persuaded to fire up, but although it will just about handle this thickness in steel, aluminium proved to be a non starter. A trial was also undertaken using an angle grinder, but again to no avail. One tool not tried, was the woodworking table saw, and this may have been an erroneous omission. If others have tried using such equipment on aluminium, perhaps they might be prevailed upon to report on their experiences for the wider readership. (Since writing these notes, I have purchased a pair of carbide tipped saw blades from Aldi, and the instructions mention using the fine toothed one on aluminium, so this may indeed be a viable option.)

Outside, an enquiry to the local auto breakers yard indicated that oxyacetylene cutting does not work well on aluminium. "It melts but doesn't cut" was the retort.

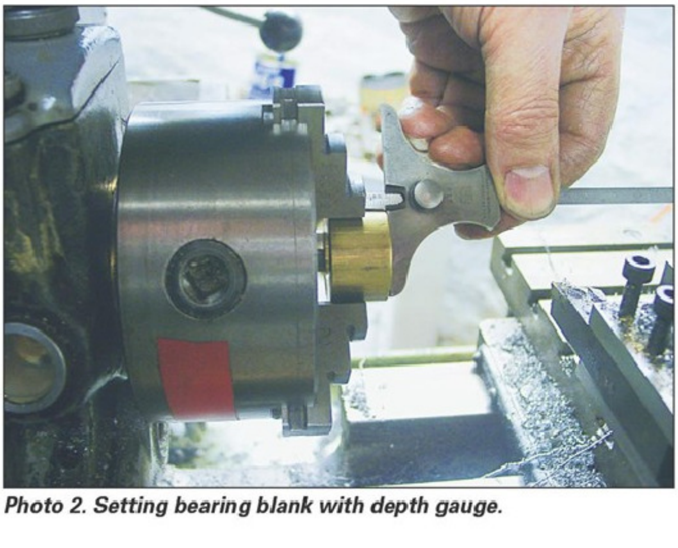


Photo 2. Setting bearing blank with depth gauge.

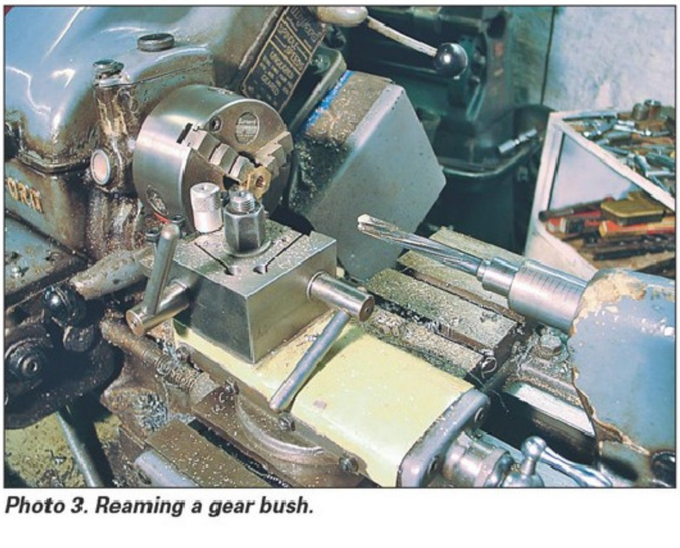


Photo 3. Reaming a gear bush.

The straightforward solution was to find someone with the right tool for the job. The right tool would be a powerful vertical bandsaw, and the someone turned out to be G. Johnston Engineers Ltd. in Dundee, where Mr Johnston senior cut the two pieces in about as many minutes.

As can be seen from the **photo 1**, at the time of writing, both the main rolls are of plain diameter. Two jobs remain. First a series of 90 degree Vee grooves will be added to accommodate a range of squares from say one mm to about six mm. and secondly, the three rolls will be taken to a heat treatment specialist for hardening.

THE MANUFACTURE

Bearings

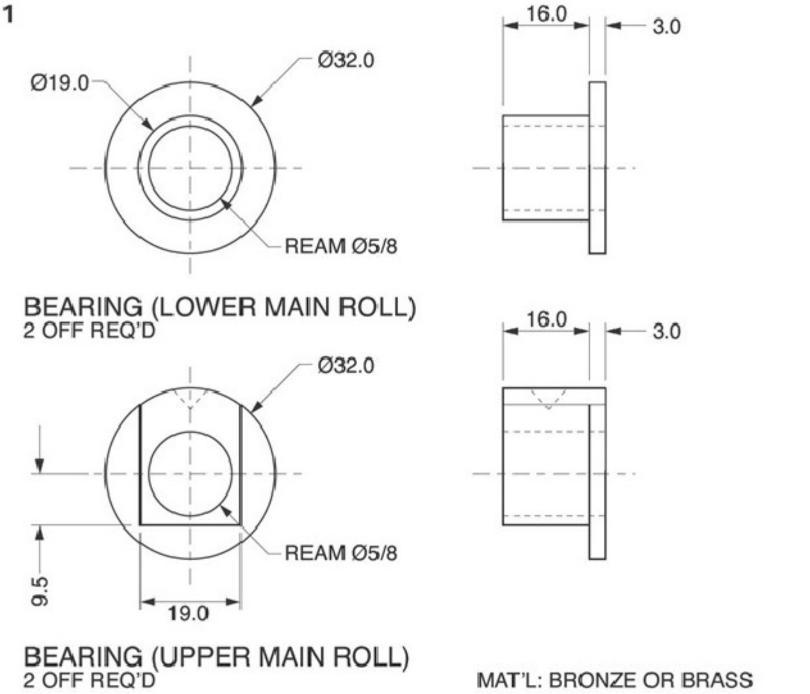
I chose to part make the main bearings first as I often find it easier to match shafts to bearings than vice versa. These are shown in **Fig. 1**. As each finished roll will become quite a weighty item, it may be found easier here to work this way round. The four main bearings were first chucked in the three-jaw chuck and faced back to 19mm thick, then drilled 15.5mm before reaming 0.625in. (This happens to be the bore size of the gears). To speed up setting, I used a depth gauge to get consistent protrusion from the chuck, along with a saddle stop, to chop the same amount off each. Use of the depth gauge is shown in **photo 2**.

Bushes for the gears were turned from a handy length of brass hex, leaving a 2mm flange. The bores were drilled and reamed 10mm as in **photo 3**.

Rolls

Accurate rolls are the key to this gadget, and if buying material in, I would suggest obtaining lengths of free machining EN1A which might later be case hardened. Accurate in this context relates not so much to the actual diameter, but more to the concentricity of roll O.D. versus those of the location bearings. If close tolerancing is not achieved here, then the gap between the rolls will vary during each rotation. It is also worth ensuring that your tailstock is adjusted to allow the lathe to turn parallel over the length of the roll. Mine turned out to be about 0.002in. out over the seven inches. I felt that any attempt to dial out this error would probably make things worse not better. **Editor's note:** Perhaps if you turned one roll one way, left side to left on lathe and the other roll around the other way, right side to left on lathe, the taper would cancel out?

Fig. 1



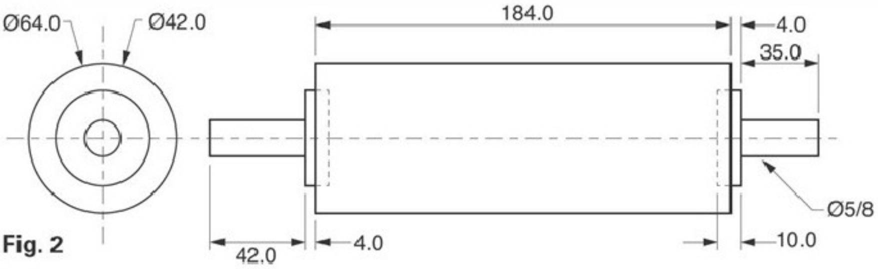


Fig. 2

TOP PRESSURE ROLL (DRAWN AS COMPOSITE CONSTRUCTION)
ENDS ARE RETAINED BY THREE M6 SOCKET HEAD CAP SCREWS ON 30 PCD
1/8in KEYWAYS REQ'D AT BOTH ENDS OF TOP ROLL & GEAR END OF BOTTOM ROLL
BOTTOM ROLL IS SIMILAR BUT 42 SHAFT LENGTH IS REDUCED TO 25

By electing to use the existing pieces of EN24T, and wishing to make full use of the available length, I gave myself the added problems of making and fitting four extension shafts. **Fig. 2** shows my composite construction arrangement. By comparison the third roll - a one piece item - was very much more straightforward.

I started by setting up each roll blank in the four jaw, centering up, facing the outer end, then boring the end to a depth of about 6mm and a diameter of 44mm. The second end was then dealt with in the same way, both pieces being faced to the same overall length. One of these is shown in **photo 4**.

Material for the four extension shafts was then cut, and each faced and centred, then turned leaving a flange thickness of over 10mm (**photo 5**) and a generous

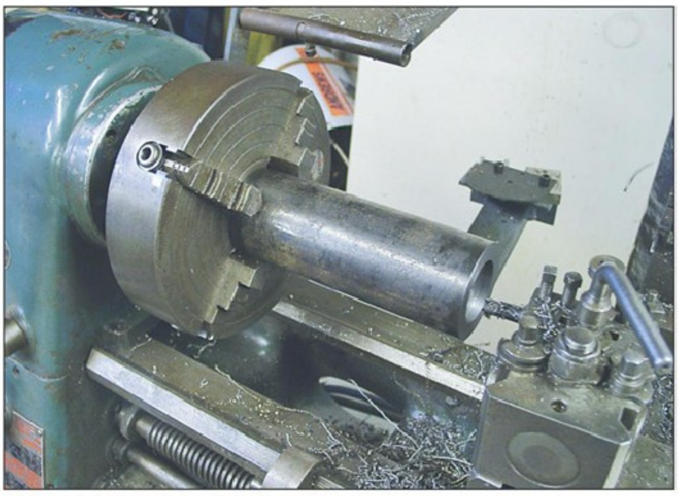


Photo 4. Counterboring the roll.

Photo 5. Rough turning extension shaft.

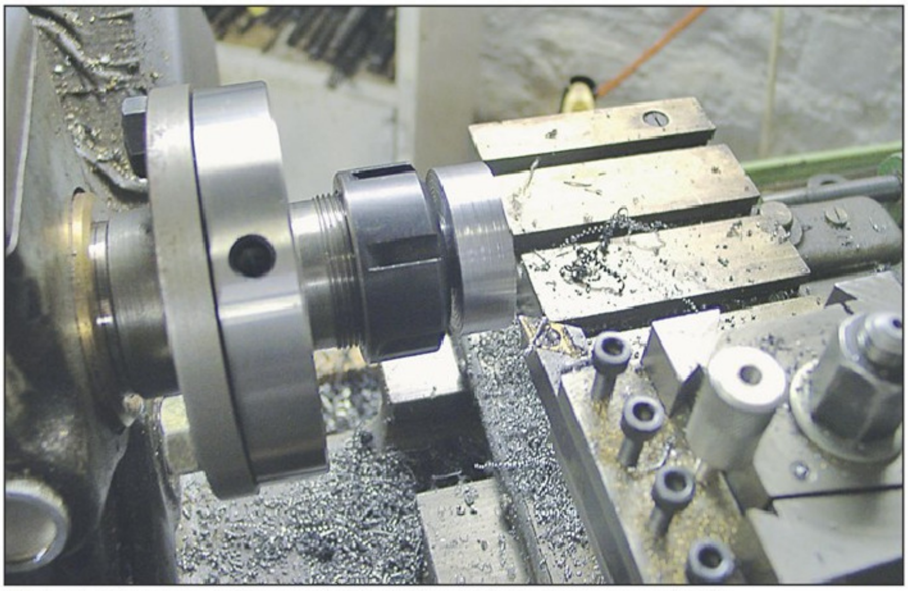


Photo 6. Extension shaft mounted in ER32 collet chuck for concentricity.

allowance on the shaft diameter. They were then transferred to the ER32 collet chuck in the Super 7, **photo 6**. This again gave high accuracy for concentricity and would minimise errors in flange squareness. In each case the flange was made a tight fit in its roll end recess, and each shaft was matched and identified with a specific roll end. Attachment of shaft to roll would be by means of three M6 Allen screws, so the positions for these were spotted, drilled and counterbored using the mill and rotary table. **Photos 7 and 8** show an arrangement for setting the required 6mm counterbore; the cutter is dropped down to contact a 20thou (half a mil) feeler, then the quill is locked, and the quill stop bought down to contact the shank of a 6.5mm drill. It was not possible to drop directly to the work as the holes had already been partially cleared. Each shaft was then fitted to its roll, and the positions spotted through before drilling and tapping, **photo 9**. At this stage, each shaft was given an additional mark to fix its angular position for assembly. The reason for this is that due to the work holding method for cutting the counterbores, it is possible that these are not in perfect alignment. As the rolls are finish machined as an assembly, this inaccuracy becomes irrelevant. However, when they are dismantled later for heat treatment, then it will be essential that the parts go back together in exactly the same angular positions to ensure that errors do not creep in.

Purists will wish to set up the assembled rolls between centres for finish machining of the shafts and then the roll outer diameter. I cheated a little as the Chipmaster has an industrial collet chuck of proven accuracy, so used this to grip the work while machining the opposite end supported by the tailstock, to fit its bearing, **photo 10**. For this type of operation, I find it useful to set up two separate saddle stops, one in the conventional manner to control the extent of cut, the second placed "back to front", **photo 11** so that the saddle may be moved back smartly without danger of upsetting the tailstock centre. The final turning operation here was the outside surface of the roll. A new carbide tip was fitted, and a very acceptable "as turned" finish, **photo 12** resulted, somewhat to my surprise as I had thought that the alloy steel might prove more tricky.

Three of the shafts will require ⅛in. keyways and to cut these, each roll was simply clamped down to the mill table, using a strip of card to protect the roll

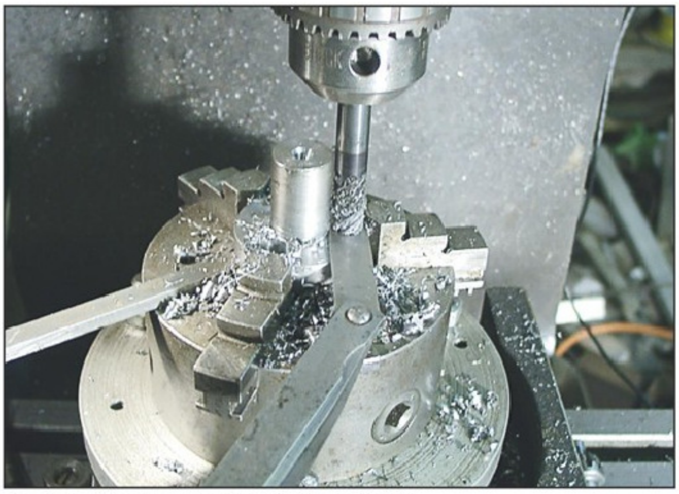


Photo 7. Dropping to twenty thou feeler.

Photo 8. 6.5mm drill under quill stop.

Photo 9. Hand tapping end of roll.

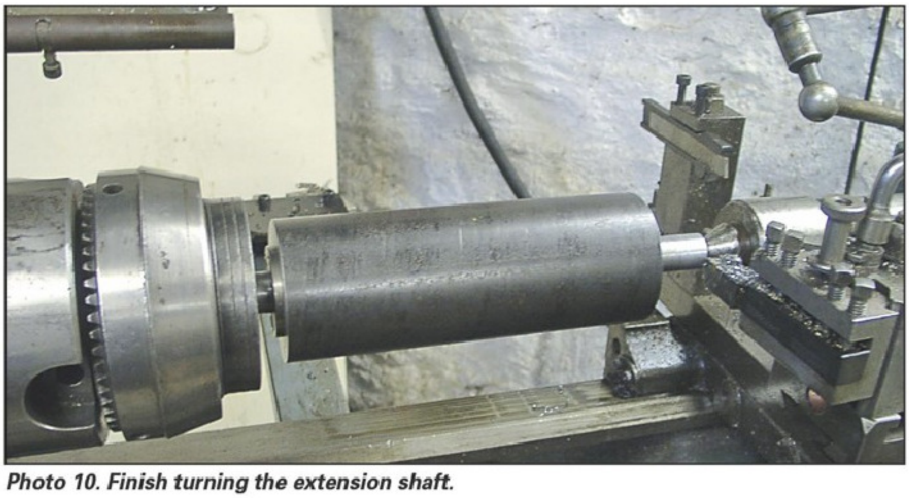


Photo 10. Finish turning the extension shaft.

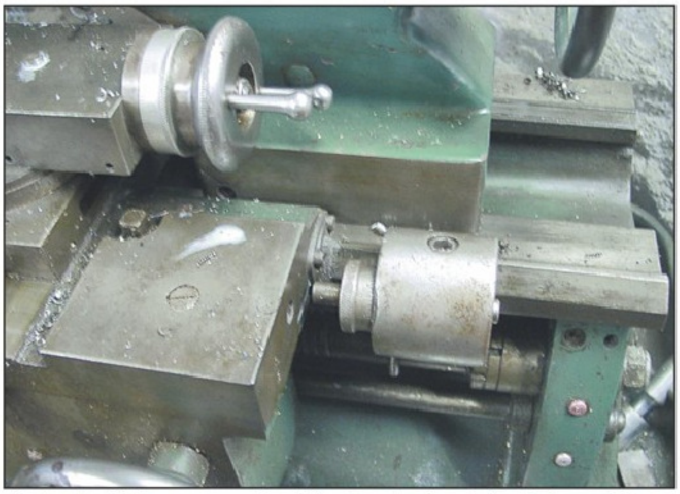


Photo 11. Using a second saddle stop to the right of the saddle.

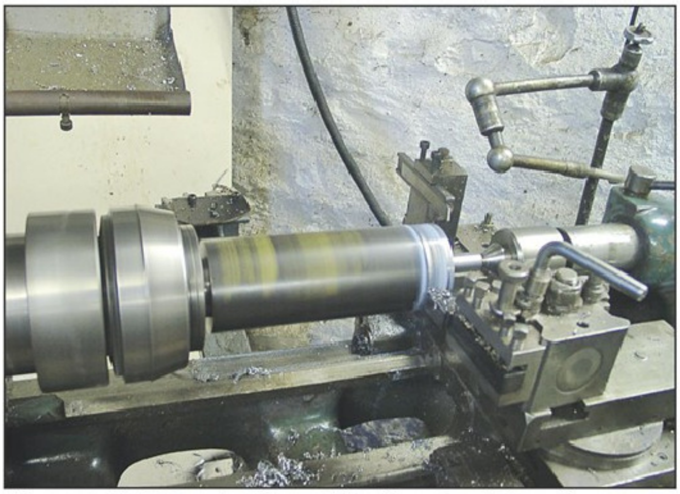


Photo 12. Finish turning the outside diameter of the roll.

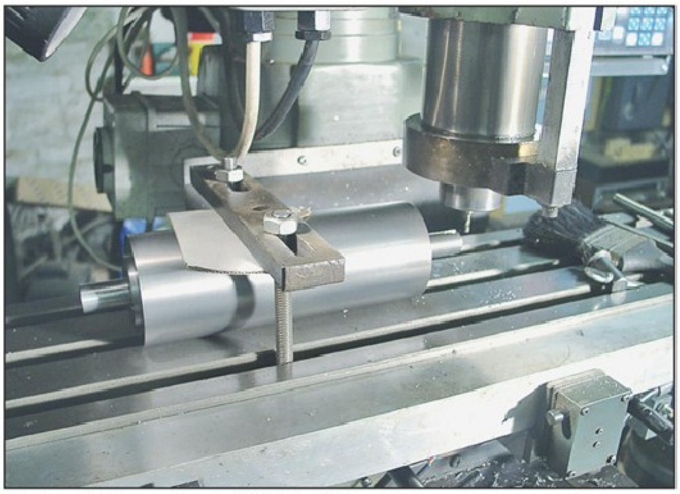


Photo 13. Key milled with ⅛in. FC3 cutter.

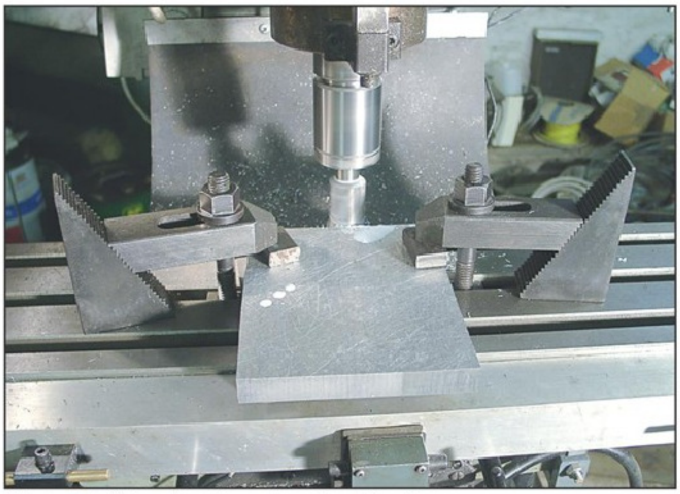


Photo 14. Trimming the edge of a side plate.

surface, **photo 13**; the cutter used was a regular throwaway FC3.

The third roll, **Fig. 3** was a much simpler affair being a length of 28mm bar, cut, faced to length and cut down to the 11mm location diameter at each end. Again, using the large collet chuck made this a doddle. To do this on a smaller machine would probably entail using the fixed steady to face and centre each end, then using either the steady or the tailstock centre for support whilst cutting the bearing diameter.

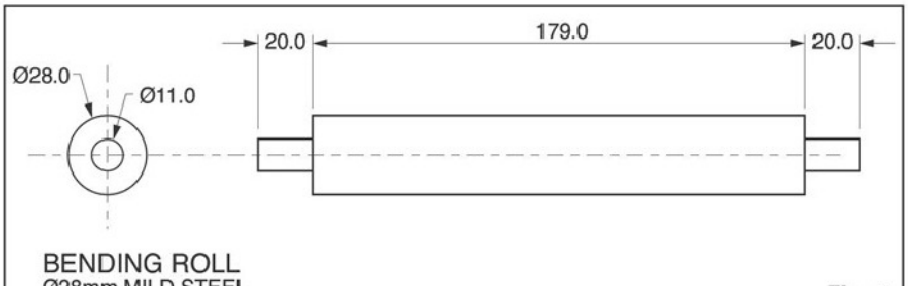


Fig. 3

Side plates

Figs. 4 and 5 show the general dimensions of these two parts. Having obtained outside assistance to cut these roughly to size, the next job was to mill them to accurate rectangular shapes. Squaring off was done in the mill set up as in **photo 14**. Specific outside sizes are not so important, but it is helpful to make sure that both are machined to the same height. This was achieved by clamping both together, **photo 15** against an angle plate with their machined edges in contact with the table and taking a cut across the top. It may be worth giving a mention here of the set of four milling cutters offered by Tracy Tools (cutting diameters ⅝, ¾, ⅞, and 1 inch, priced at the time of writing at £28-00) which are unusual in having ⅝in. diameter shanks which fit the smaller sized Autolock chucks, a size compatible with many model making milling machines. The one inch cutter proved ideal for sweeping

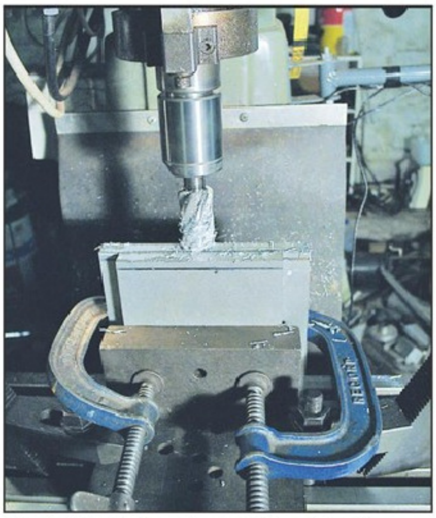
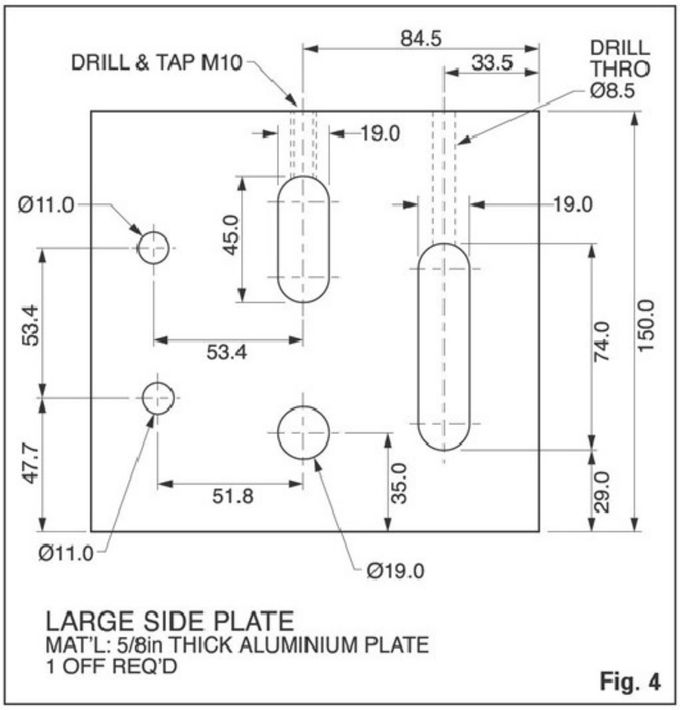


Photo 15. Plates clamped together to ensure equal height.

Photo 16. Drilling and tapping the upper edge of side plate.



LARGE SIDE PLATE
MAT'L: 5/8in THICK ALUMINIUM PLATE
1 OFF REQ'D

Fig. 4

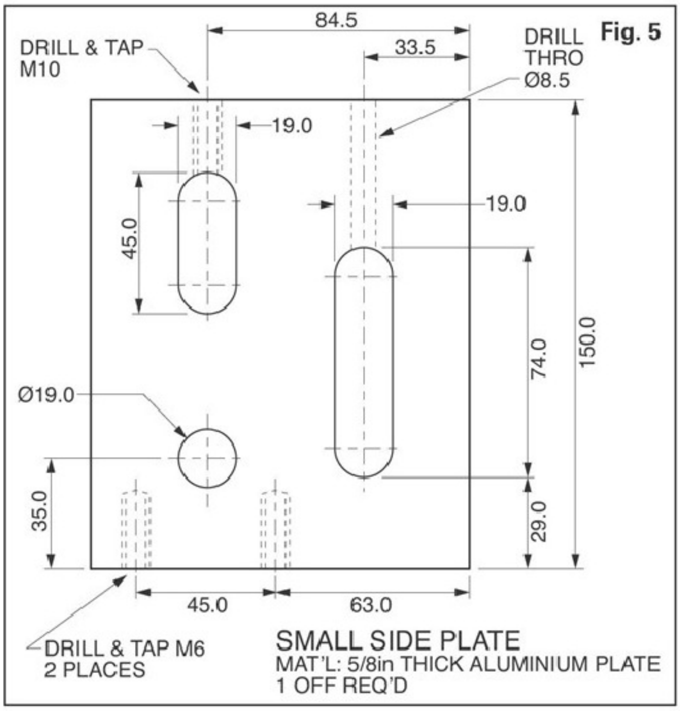
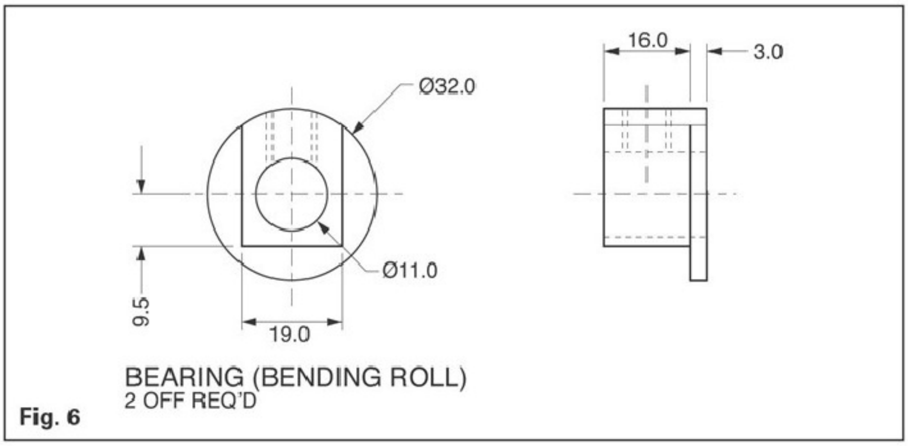


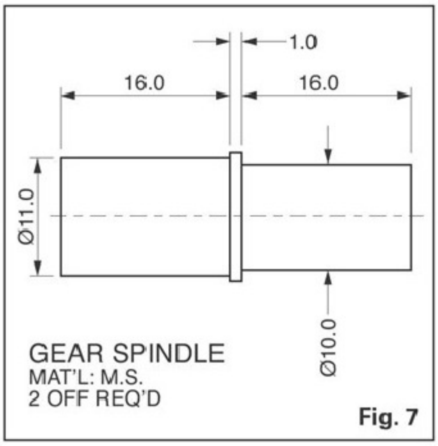
Fig. 5

SMALL SIDE PLATE
MAT'L: 5/8in THICK ALUMINIUM PLATE
1 OFF REQ'D



BEARING (BENDING ROLL)
2 OFF REQ'D

Fig. 6



GEAR SPINDLE
MAT'L: M.S.
2 OFF REQ'D

Fig. 7

across the edges of the plates, and the ¾in. came into its own for boring the bearing locations and cutting the slots.

My chosen sequence was first to spot the various positions using a 10mm spotting drill, then to drill through at this diameter, followed by 13mm. This then allowed the ¾in. end mill to be plunged in now that the centre section was already cleared. For the slots, a series of plunge cuts was followed by offsetting some five thous in each direction prior to taking two cuts along the length of the slot to give a

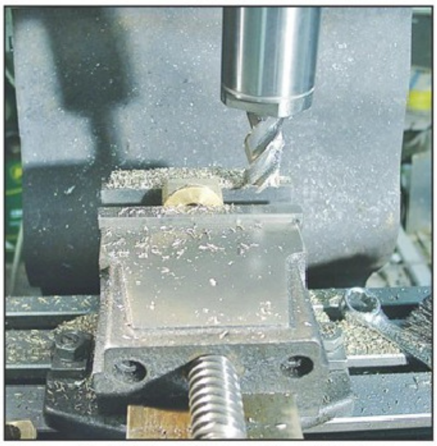


Photo 17. Milling the bearing side face.

theoretical width of 0.760in. Positions for the gear spindles were simply drilled through, first 10 and then 11mm, which gave a repeatable and close fit for the latter size.

Work on the edges entailed drilling and tapping the M6 positions to take the bolts through from the base bar, and then drilling and tapping M10 from above for the main roll adjuster screws, and drilling the holes to clear the M8 threaded rods which would draw the bending roll up into position, **photo 16**. Here the tap has been started in the machine to ensure verticality and then released from the chuck. After drilling, the work was moved to the bench to complete the tapping by hand.

Back to the bearings

The bearings had been left at a preliminary stage, reamed to 0.625in.An expanding mandrel was now made to this size, and the two bearings for the lower roll turned to an O.D. to fit neatly in the 0.750in locations in the side plates. Aiming for an easy sliding fit, the bearings for the upper main roll were milled, **photo 17** taking material off each side to ensure centrality in the 0.760in. slot, and leaving a 3mm flange. Material was then removed from the underside to allow greater movement in the slot. (Some subsequent work was also undertaken with a file, adding radii to the edges to extend this further). The upper surfaces of these two bearings were each drilled with a spotting drill to create a sort of 90 degree countersink location for the end of the roll adjuster rod.

The two bearings for the bending roll, **Fig. 6** are called upon to pull upwards. I am guessing that the loads on this roll will be considerably lower than on the main rolls and therefore I have settled on the pre-existing diameter of 11mm. This allowed re use of two more of the free brass blanks. At this bore diameter, sufficient material was left on the upper side to accommodate the M8 thread for the two pull rods. To create this feature, first apply a spotting or centre drill to establish the position. Next check the depth of material available, then after fitting the tapping drill, set the quill stop so that the drill will stop say fifty thou short of breakthrough. This will avoid damage and rework on the bore. Tapping was done in two stages, a start with a spiral point tap in the machine, then finishing off with a plug tap by hand to ensure the maximum thread length.

Threaded parts

The two adjuster screws for the main top roll are simply lengths of M10 screwed rod, cut to approximately 56mm length, with one end turned to 90 degrees to

Photo 18. The two adjuster screws.

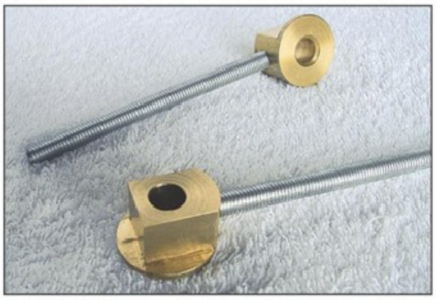


Photo 19. Pull rods assembled to bearings.

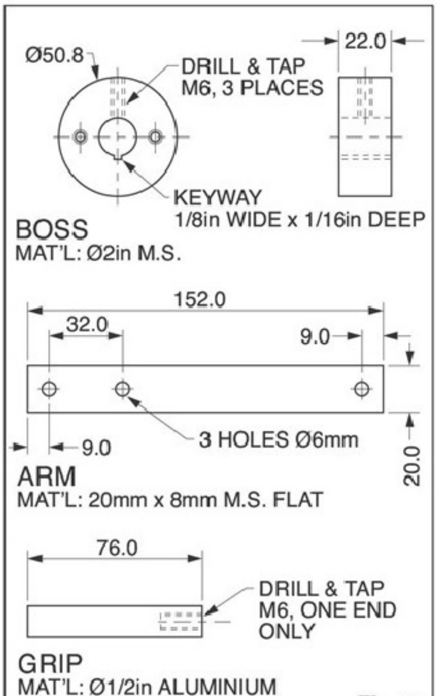


Fig. 8

match the recess in the bearing. To the top of each is added a brass knob, and here again, it was the scrap box to the rescue. The knobs shown in **photo 18** actually started life as threaded inserts for inclusion in a plastic moulding. It may be that a larger diameter will prove beneficial, but for the moment these suffice. Once assembled and screwed down, a light saw cut was added to the top of each knob in line with the side plate. This would allow even adjustment of each side of the roll.

In a similar vein, the two pull rods shown screwed into their associated bearings in **photo 19** are nothing more than two 115mm lengths of M8 screwed rod. Probably not for the purists, but doesn't it just make life easier.

Base

This was cut to length from a piece of 2.5in. by ¾in. aluminium flat bar. In my case this was very much sized on the job, and thus a drawing is not considered necessary. The main rolls were measured over the shaft flanges, half a millimetre

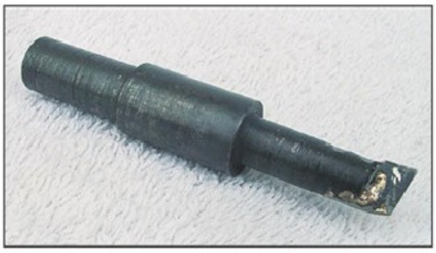


Photo 20. Cutting tool for internal keyway.

added for clearance then an inch and a quarter for the two plates, plus a few thou for safety. Bolt hole positions were also determined, these being drilled and counterbored for M6 socket head capscrews.

Gear spindles

These were straightforward turning jobs, for which the material was 12mm diameter bright free cutting mild steel bar. Details are shown in **Fig. 7**.

Handle assembly

This is composed of three parts, shown on **Fig. 8** as the boss, the arm and the grip. The grip is almost exactly as it came out of the scrap box, a length of ½in. diameter aluminium already drilled and tapped at both ends. The only added work was to increase the chamfer at the outer end. The arm is just a length of 20 x 8mm mild steel flat cut to length then drilled for the three attachment screws. The boss was cut from a length of 2in. steel bar, faced, drilled and reamed to ⅝in. to match the roll shaft. Two holes are drilled and tapped M6 for the capscrews and a third radially to take a grubscrew. A keyway was also thought to be desirable here and the set up and tooling is shown in **photos 20 to 23**. The bodged exhaust clamp serves to lock the mill spindle against rotation. The cutting tool is simply fitted to the drill chuck after checking the angular setting with a straight edge. My cutter is some 80 thou wide so to cut a keyway 125 thou in

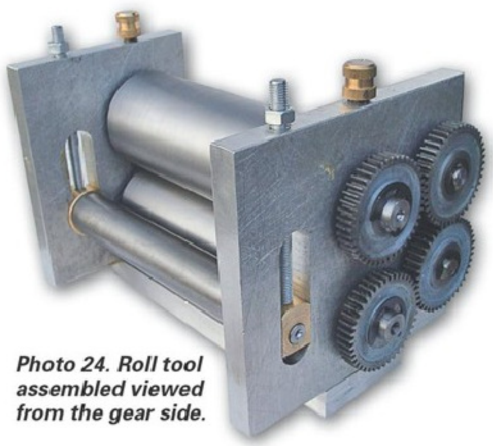


Photo 24. Roll tool assembled viewed from the gear side.

width requires one central cut followed by another displaced each side by about 22 thou. The width achieved can be checked with a drill shank.

My experience indicates that with this set up, the tool can be fed in about three thou at each cut. Thus for something around the sixty-odd thou depth needed for the key in question, just twenty or so strokes are required for each of the three settings. All fairly easily done in not much more than three minutes

Assembly

One of the impulse purchases at a recent boot sale was a box of E clips. A desire to put some of these to good use has influenced my approach to holding this thing together. Smaller E clips are used to keep the gears on their spindles, and larger ones to stop them falling off the ends of the rolls. Loctite has been employed to retain the bearings in the gears and the two fixed bearings in the side plates. To avoid damage to the shaft, a brass pad is placed below the grub screw in the boss. The assembled rolls are shown viewed from the gear side in **photo 24**. I was tempted to say completed, but the Vee grooves are an outstanding job. Heat treatment will also be delayed until there are other items to justify a minimum order. ■

Photo 21. Keyway tool and spindle lock fitted.

Photo 22. Detail view of spindle lock in position.

Photo 23. Spindle lock components.

ADDING A BALL RACE TO A MINI LATHE TOP SLIDE

David White improves his Mini Lathe

Introduction
The Mini Lathe in all its incarnations is a tweaker's dream. The recent series of articles and book on the subject by Dave Fenner describes many improvements. Some modifications, such as a carriage lock and tapered gibs are almost mandatory for any purchaser of a mini lathe. They add rigidity to the turning setup and make good surface finishes easier to achieve, even in steels. If you've read any of my recent articles concerning the X1 mill you'll know that I'm a great believer in replacing leadscrew sleeve bearings by ball races wherever possible. It makes the associated handwheel much easier and smoother to turn. More importantly it allows the gibs on the slide to be tightened up to a much greater extent, adding to the rigidity of the system. With ball bearings the advice of snugging up the gib setscrews and backing off an eighth of a turn before locking them in position is redundant - just snug them up and lock them. All the more surprising then is that adding a ball bearing to the mini lathe top slide is one of the less common mini lathe modifications, particularly as it's so cheap and easy to do and it only takes a mornings work.

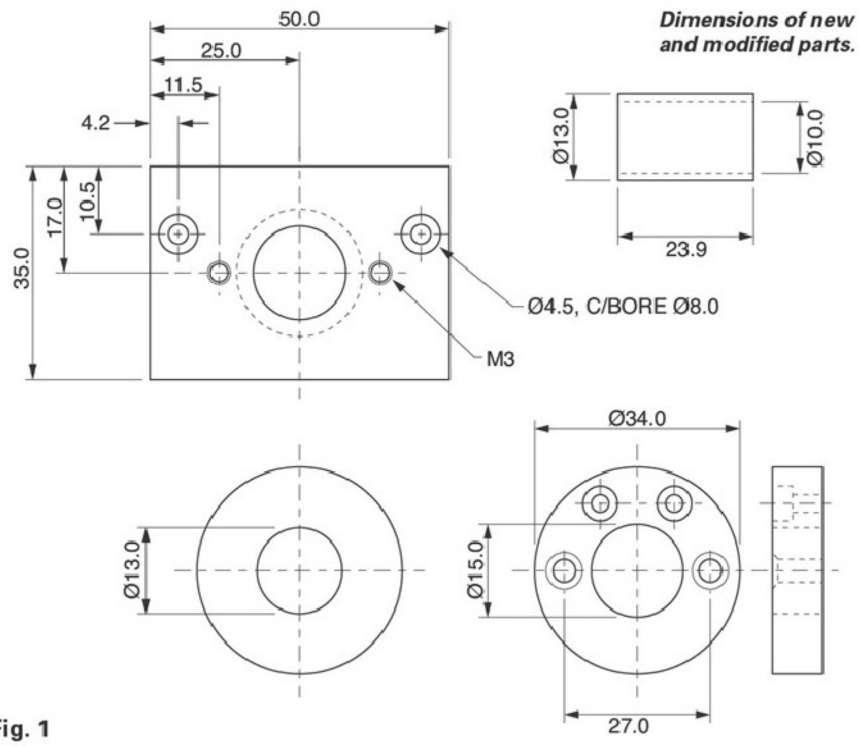


Fig. 1

Implementation
The top slides of the mini lathes from various makers are in general very similar but do differ somewhat in the details, such as the diameter of the handwheel end of the leadscrew, the method of retaining the indexable dial, and the thickness of the upper top slide casting. The description and dimensions given here apply to the Real Bull series of mini lathes such as Warco but are readily adapted to the Sieg machines from Arc Euro Trade and Chester although a different ball race may be required. This modification only works for mini lathes fitted with a simple handwheel on the top slide, and cannot be adapted to work with versions of the mini lathe fitted with DRO's.

The first decision concerns details of the bearing housing - can the ball bearing be fitted inside the existing sleeve bearing? Probably not because the mounting holes

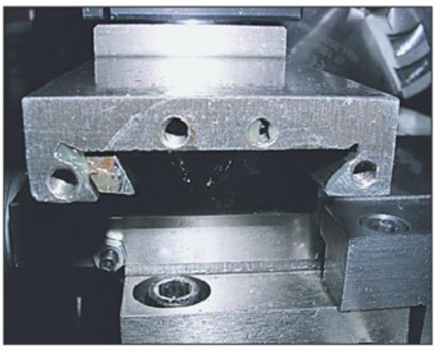


Photo 1. End on view of topslide.

for the existing bearing, the two closely spaced threaded holes at the top of **photo1**, get in the way of the ball bearing assembly. It's possible to make a slightly longer version of the existing bearing housing but it's a lot of work and the laser engraving isn't easy to reproduce. Instead the new bearing housing is made from a 50 x 35mm piece of aluminium plate and fitted to the top slide using the pair of threaded holes adjacent to the dovetails drilled 3.3mm and tapped M4, **photo 1**. These hole positions were used because they allowed the most "meat" and space for the socket head capscrew counterbores on the bearing plate. The hole positions were measured and marked on the end of the topslide casting using digital callipers. The jaws of digital callipers are extremely hard and do double duty as a scriber! The positions of these holes were noted and transferred to the bearing plate. The distance from the top of the bearing plate to the centre of the bearing pocket was determined using digital callipers as follows. Measure the distance between the inside and outside diameter of the original cylindrical sleeve bearing housing (d1) then measure the distance from the top of the bearing housing to the top surface of the top slide casting (d2). The required distance is then d1-d2+5 because the inside diameter of the bearing housing is 10mm. The dimensions appropriate to the lathe used for this project are shown in **Fig. 1**.

Available bearings
The ball bearing used was a miniature bearing, type 69002RS, dimensions 10x22x6mm available from Arc Euro

Photo 2. Partially completed bearing plate.

Trade. The bearing plate was chucked up in the four-jaw chuck on the mini lathe and the bearing pocket was bored out to 21.95mm diameter and 5.9mm depth. The diameter is a little undersize because the bearing will later be pressed into the plate using a vice. Similarly the depth is a little short so that the outer race of the ball bearing will be clamped between the top slide casting and the bearing plate. The 4.5mm mounting holes, counterbored 8mm diameter by 4mm deep can now be drilled in the positions determined previously. The mounting plate at this stage is shown in **photo 2**. Don't press the ball bearing into the bearing plate as I obviously have done; wait until the last pair of holes have been drilled.

The old sleeve bearing housing is to be fixed to the new bearing plate so that it clears the bush, which will be made to lock the ball bearing to the leadscrew. The original mounting holes could have been

Photo 3. Finished bearing plate.

reused but there is only a 4mm thickness of aluminium before the ball bearing is reached. Accordingly two new 3mm holes were drilled on the diameter each 3.5mm in from the edge. The holes were then countersunk to accept an M3 Philips head screw. At this point, lightly press the ball bearing partway into the new bearing plate making sure it's square and can still be removed. Push the leadscrew into the back of the ball bearing and slip the old bearing housing onto the leadscrew from the other side of the new bearing plate. The old bearing housing can now be positioned so that a line through the diametric 3mm holes is parallel to the top of the new bearing plate. Use a 3mm transfer punch to mark the positions of the corresponding holes in the new bearing plate. Drill the holes in the bearing plate 2.5mm and tap M3. The ball bearing can be pressed into the bearing plate at this point. The finished bearing plate is shown in **photo 3**.

The hole in the original cylindrical sleeve bearing housing is now bored out from 10mm to 15mm and a series of facing cuts taken in the lathe until the width is reduced to 8mm. All of the operations on the bearing housing are as shown in **Fig. 1**. Make sure cuts are taken from the correct face as the laser engraving needs to be retained!

The bush which locks the ball bearing to the leadscrew needs to be very carefully made so that the indexable dial mounted on it rotates true against the face of the old bearing housing. There should be a very small gap between the old bearing housing and the indexable dial and no touching as the handwheel is rotated. The bushing is made from steel as the indexable dial is locked against it by means of a socket head grub screw - aluminium would eventually get chewed up. For Real Bull mini lathes a simple bushing suffices, but for those machines where the indexable dial is held in position by a friction spring, a retaining groove will need to be machined into the finished bushing. The bushing is made from 3/4in. diameter mild steel. Begin by boring out a nominal 10mm hole 26mm deep with a small 6mm boring bar. The hole needs to be bored out just sufficient for the handle end of the leadscrew to be a perfect sliding fit, there should be no slop whatsoever or you'll end up with a wobbly indexable dial. Drilling the hole simply will not do, but drilling and reaming to 10mm might be adequate. Now turn down a 25mm long section to 13mm and part off to leave a 24mm long bushing. The 13mm diameter outer surface of the bushing should have been turned and lapped to give the best surface finish possible. Details of the bushing are given in **Fig. 1** along with dimensions for all of the other parts.

The 10mm hole through the indexable dial needs to be bored out to a nominal 13mm diameter so that it is a perfect sliding fit on the bushing. Again no looseness or slop is permissible or the indexable dial won't rotate true. The fits with the bushing aren't so hard to achieve as they sound; all that's needed is patience, care, and lots of trial fits. If bodger second class (I've been promoted) can do it so can you. The finished line-up of parts is shown in **photo 4**.

Second lathe?

It may not have escaped your attention that turning operations have been described when the topslide of the lathe is in pieces! Hmmm. If you have a second lathe, or access to one, then no problem. I only have one lathe and no access to a second one, so how was it done? Fortunately I had a spare leadscrew for trial and error fitting to the bush as it was being made, although this is not strictly necessary. More important is a quick and dirty bush made from a 25mm length of half inch outside diameter steel tube. The walls of the tube were 20swg so the inside diameter was close enough to 10mm that the bush was usable. Using the original washer and screwing one of the original nuts and the handle onto the arrangement shown in **photo 5** gives a usable, if ungraduated, topslide. Notice that the old bearing housing has been mounted on the new bearing plate in **photo 5** although this is not necessary for crude topslide operation. Notice too that the bushing shown in **photo 5** is the finished version, not the stopgap made from steel tube. The makeshift topslide can be assembled at judicious points during manufacture of the components to make completion possible.

Spare parts are available

You might be worried that irrevocable modification of key parts of your lathe may land you with a pile of scrap metal if you mess up. No need to worry. The spare parts situation in the UK is second to none; far better than in the US for example. Although they don't advertise the fact much, I can't think why, many of the importers of Chinese machine tools for the hobby and model market carry pretty comprehensive stocks of spare parts, which they make freely available.

Digression over, lets get back to the task at hand. Now that all of the components are finished, a trial assembly will allow the length of the bush to be finalised. The gaps between the indexable dial and the modified sleeve bearing housing, and between the indexable dial and the washer should be as small as possible consistent with unhindered rotation of the dial. Take a series of very small facing cuts across the bush until this situation is reached. **Photos 6 and 7** show two views of the finished topslide.

Even when the gibs are snugged up, motion of the topslide is smooth and free with absolutely no detectable play in the dovetail mating surfaces. Grab hold of the topslide and try to pull it in any direction; there will be absolutely no detectable motion. Before I added the tapered gibs, carriage lock, and topslide ball bearing even my best attempts to turn steel were visible as a very fine screw thread; now it's easy to produce a very fine surface finish on mild steel. ■

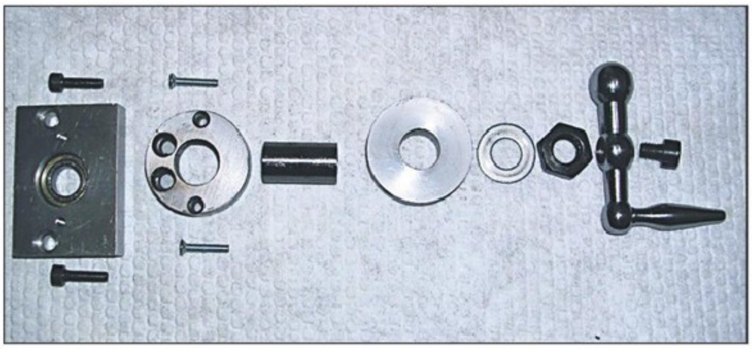


Photo 4. Parts line up for the topslide ball bearing.

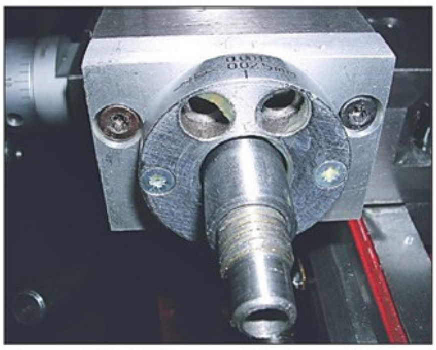


Photo 5. Partially assembled topslide ball bearing.

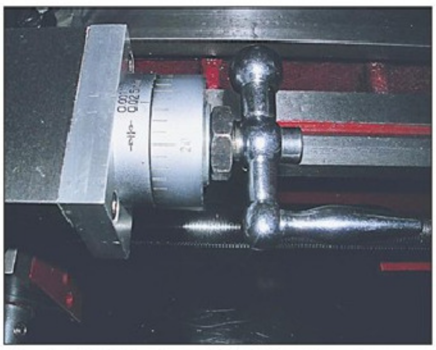


Photo 6. Side view of finished bearing.

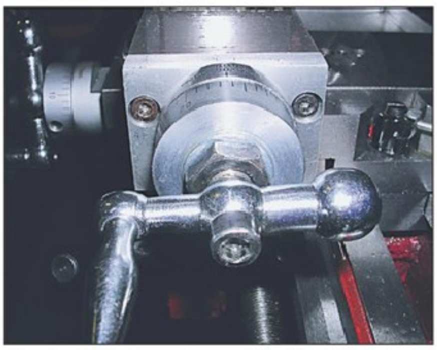


Photo 7. End on view of finished bearing.

Z-AXIS MODIFICATIONS TO THE SUPER X1L MILL

David White improves his mill

Z-axis bearing

The modifications described here were made to an X1 micro mill but like all of the others previously described they will benefit many of the various types of X1 milling machines. The Z-axis bearing is the hardest working on the X1 series and relieving the pressure on it makes a big difference to the ease of use, particularly in manual mode. For CNC operation the choice is between a cheap reduction of the Z-axis friction or a larger, more expensive stepper motor. The Z-axis sleeve bearing block (part no. 96, "screw support") is made of high quality cast iron (as far as I can tell) and its top surface bears the entire 20 kg load of the headstock and motor assembly. This surface mates with a high carbon steel insert embedded in the z-axis handwheel. Because of this loading the bearing block is obviously subject to wear and may need replacing after a long period of heavy use.

Implementation

A simple thrust bearing interposed between the bearing block and handwheel would all but eliminate the wear and make the handwheel easier to operate. This should be possible using an 8x16x5 mm miniature thrust ball bearing from Arc Euro Trade part no F8-16 if a 5mm deep portion of the 8mm hole though the bearing block is bored out to 16mm. The thrust bearing can then sit in the small recess. **Photo 1** gives the general idea.

This modification is cheap, simple to implement, and very effective, but still leaves the residual friction of the sleeve bearing proper. An arrangement using a pair of cheap skate bearings is preferable. The skate bearings are designed to handle radial loads but are well known to handle quite substantial axial loads as well, so they will work well for this application. Bearings with a 22mm diameter have to sit above the top of the column because there is only 10mm between the centre of the leadscrew and the back of the column. This means that the minimum spindle to table distance is increased by 20mm unless you go to the trouble of making a new leadscrew, a topic I will return to in a future article. As always the internet was checked to see what others had done before starting this project. Most of the implementations used monolithic aluminium ball bearing blocks very similar to those previously described for the X and Y-axes. A step was milled into the block just below the bottom of the ball bearings so that the block sat on top of the column and the original sleeve bearing block mounting holes could be used. The general arrangement should be obvious from the mock up in **photo 2**.

The problem with this approach is that it has to be exactly right first time; there is little scope for adjustment, or the leadscrew will bind.

This article uses a variation of the ball bearing system described by Christoph Selig at www.einfach-cnc.de Herr Selig's method is much simpler to implement and allows for plenty of adjustment. Incidentally his website is well worth a look because it has details of X1, X3, and BF20/WMD20L CNC conversions together with lots of pictures and full sets of drawings; amongst many other good

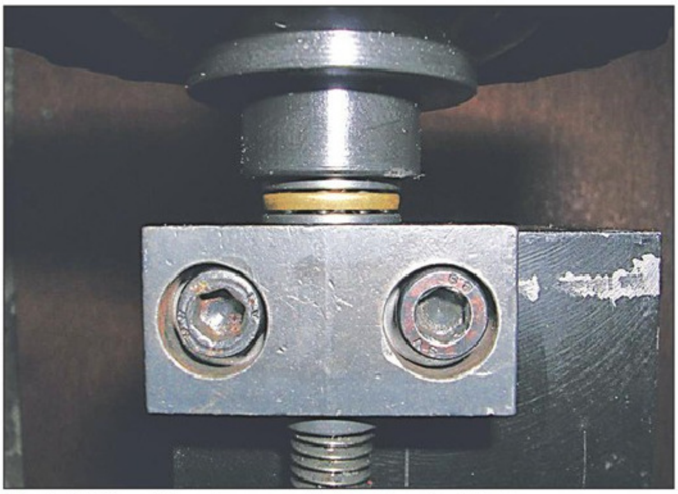


Photo 1. Thrust bearing mounted on bearing block.

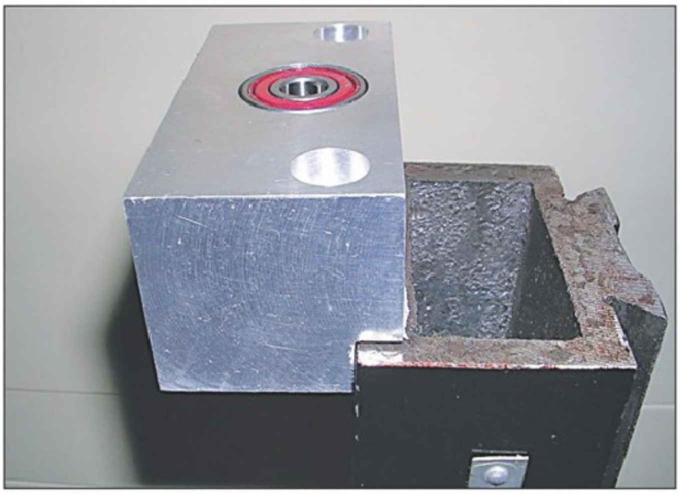


Photo 2. Common implementation of z axis ball bearing.

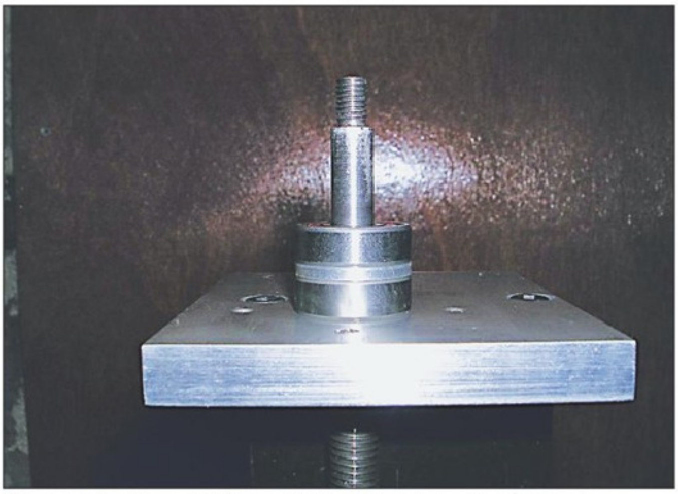


Photo 3. Implementation with thrust plate and cylindrical bearing housing.

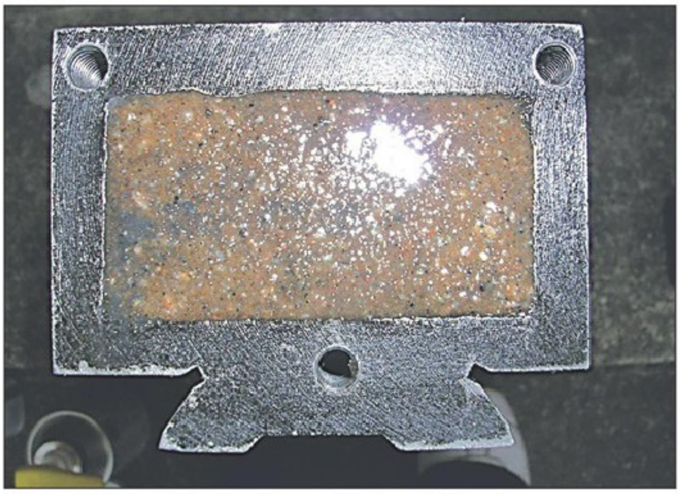


Photo 4. Holes drilled and tapped in top of X1 column. Note epoxy granite fill.

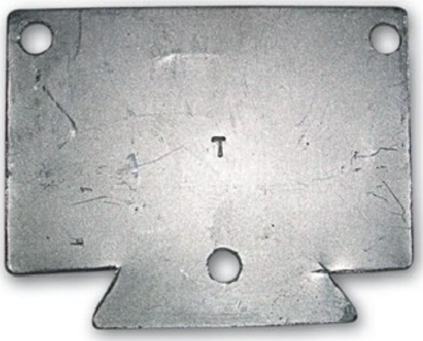


Photo 5. Template used to transfer hole positions to thrust plate.

things. The website is invaluable if you speak German and only marginally less useful if you're limited to looking at the pictures and drawings. The ball bearing system consists of two parts; a thrust plate which sits on top of the X1 column, and a cylindrical bearing housing which sits on top of the thrust plate. **Photo 3** illustrates the general idea, although the bearing housing is not shown.

Obviously, with this arrangement the original bearing block mounting holes cannot be used. Instead three 4.2 mm diameter holes are drilled 20mm deep into the top of the X1 column and tapped M5 as shown in **photo 4**.

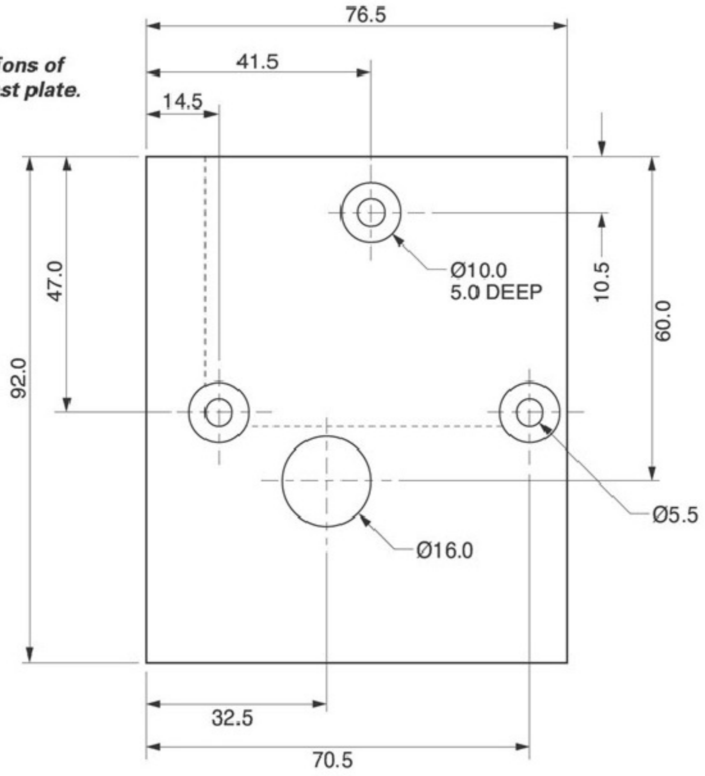
Unless a floor standing pillar drill and suitable clamps are used these holes will need to be made with an electric hand drill. This means that positional accuracy is going to be somewhat suspect. In order to guarantee that the holes in the column and thrust plate line up accurately a template of some kind is advisable. Hand drill the holes in the column first, blue the top of the column, and press a small sheet of aluminium down onto the blued surface. Carefully remove the aluminium, accurately centre punch the hole positions, and scribe the outline of the top of the column on the aluminium sheet. Carefully cut the aluminium sheet to the scribed lines and drill holes at the punched positions with a 1mm drill. A typical template is shown in **photo 5**.

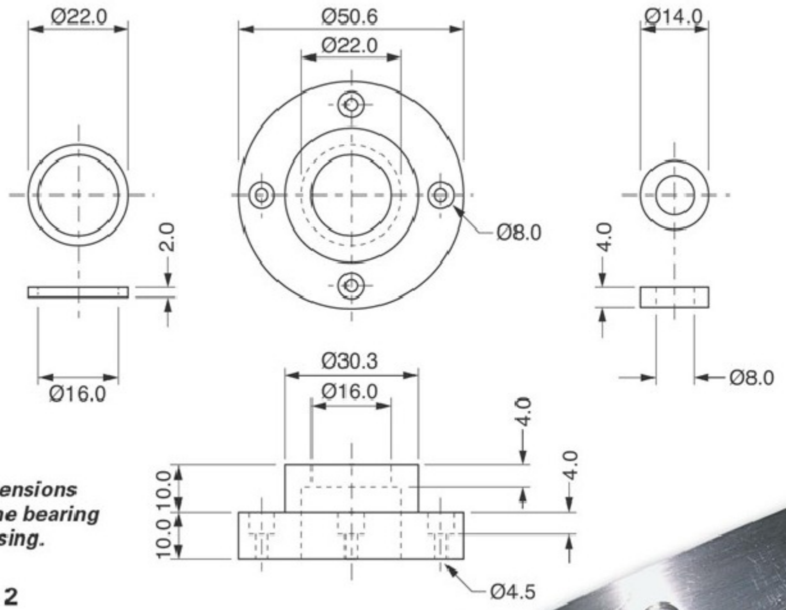
Transfer the holes

Use this to mark the hole positions on the thrust plate. The point of a punch centres accurately in the 1mm holes and a tap with a hammer transfers the hole positions. The dimensions of the thrust plate are given in **Fig.1** but should only be used for guidance as the positions of the mounting holes may vary by a small amount, as we have seen, and so may the position of the leadscrew in relation to the back of the column for different X1 mills. This means the leadscrew position will need to be carefully measured up before starting. The thrust plate is made from 10mm thick aluminium. The 16mm hole is designed to clear the inner race of the bottom ball bearing in the housing. The thrust plate may prove a little large to fit in the four-jaw chucks of most mini lathes, so unless you have a larger lathe, boring the 16mm hole will have to be done on the mill. I find boring large holes on a mill extremely tiresome and avoid it if at all possible. I used a bimetal hole saw in my drill press to make the hole. Even this was not without problems as the hole saw stopped cutting at a depth of about 5mm because it could no longer expel the swarf.

Fig. 1

Dimensions of the thrust plate.





Dimensions of the bearing housing.

Fig. 2

I had to turn the thrust plate over in order to drill the remainder of the hole. The three thrust plate mounting holes were then drilled 5.5mm before being counterbored 10mm diameter by 5mm deep to take socket head capscrews. The top and bottom of the thrust plate are shown in **photos 6 and 7**.

Notice that the mounting holes for the bearing housing have not been drilled at this point. Attention can now be turned to the bearing housing, the construction of which involves straightforward turning and boring operations according to **Fig. 2**.

Roller skates

The bearings used were miniature bearings, type no. 608ZZ, dimensions 8x22x7mm available from Arc Euro Trade. These are essentially roller

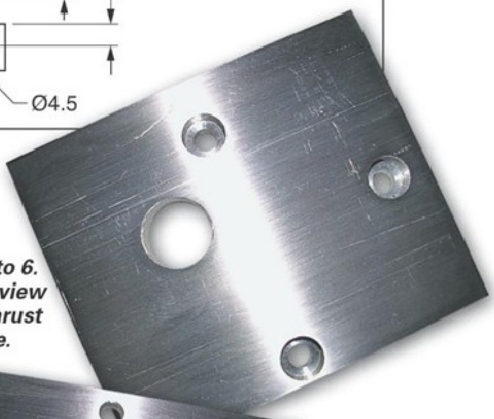


Photo 6. Top view of thrust plate.

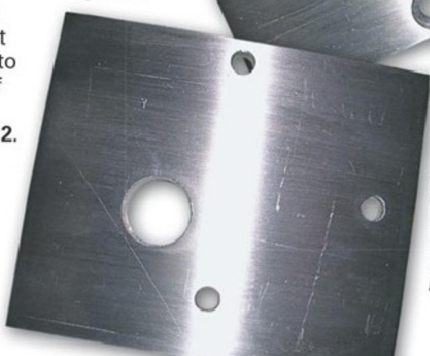


Photo 7. Bottom view of thrust plate.

Photo 8. Top view of bearing housing.

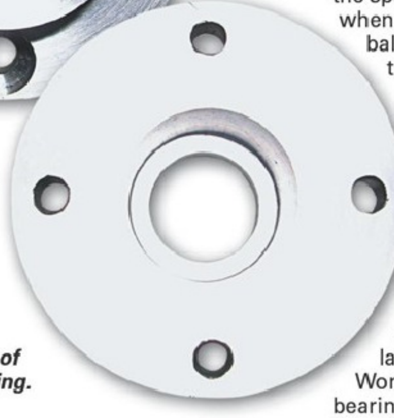


Photo 9. Bottom view of bearing housing.

skate bearings and are very cheap because they are manufactured in very high volume. Face both ends of a 25mm length of 50.8mm (2 in.) diameter aluminium stock on the lathe, then drill a suitable pilot hole and bore out a 16mm hole right through the workpiece. Enlarge a 16mm length of the bore out to a nominal 22mm diameter. The diameter of this bore should be such that the ball bearings are a tight push fit, so a bit of careful trial and error is in order when you get close to the required diameter. As an aside here I should mention that an investment in a good boring bar is well worth the price. I currently use the Glanze indexable boring bars available from Chronos (www.chronos.ltd.uk) and these go through aluminium like a knife through butter on my mini lathe. The fact that you can take large cuts takes the boring out of boring! Flip the workpiece over in the chuck and take a series of facing cuts until the total length is 20mm. Now turn a 10mm length of the aluminium down from 50.8 to 30mm diameter. The bearing housing can now be removed from the lathe and the four mounting holes drilled 4.5mm and counterbored 8mm diameter by 4mm deep on the mill or drill press. Top and bottom views of the bearing housing are shown in **photos 8 and 9**.

The bearings need to be separated by a couple of mm so that they can be preloaded. This is the function of the spacer shown in **photo 10**.

Recall that the 22mm bore in the bearing housing is 16mm deep and each ball bearing is 7mm thick. The 22mm diameter spacer, **Fig. 1** therefore needs to be a nominal 2mm thick with an inside diameter sufficient to clear the inner races of the ball bearings, say 16mm. In practice the spacer needs to be 2.1mm thick so that when the bearing housing, complete with ball bearings and spacer, is bolted to the thrust plate the bearings are clamped in place. The spacer is turned from a piece of 25.4mm (1 inch) aluminium stock and then parted off. Parting off can be a bit of a trial on a mini lathe but with the Glanze clamp type indexable parting off tool, again available from Chronos, its an absolute doddle. I'm no expert but I can get the aluminium to come off in one continuous tight roll with the lathe singing sweetly all the time. Wonderful! The gap between the bearing housing and thrust plate should be sufficiently small that it does not act as a repository for debris. Top and bottom views of the fully loaded bearing housing are shown in **photos 11 and 12** whilst **photo 13** shows the bearing housing in place on the thrust plate.

Trial assembly

Now that all of the components are complete they can be trial assembled on the mill column so that the bearing block can be used as a template for drilling its mounting holes in the thrust plate. Push the milling head up to within 50mm of its maximum height and lock it in position. Wind the leadscrew down so that the washer at the end of the threaded section is level with the thrust plate; slide the bearings and spacer onto the leadscrew, and the bearing housing on top of them. Fix the bearing housing in place with a toolmakers clamp and wind the leadscrew up and down by hand, as best you can, to make sure that the bearings are properly seated and centred. This can be done because the motor, controller, etc will have been removed from the headstock at this point and what remains doesn't weigh very much. When satisfied with the position of the bearing housing use a transfer punch to mark the positions of the mounting holes on the thrust plate. Drill these holes 3.3mm and tap M4. The completed set of components should now appear as shown in **photo 14**. The top of the bearing housing isn't really a bit wonky, it's just the camera angle!

You'll notice that there is an extra spacer to the right of the ball bearing. This sits on the top ball bearing and spaces the handwheel off the top of the bearing housing. It has a diameter of 14mm and a thickness of 4.1mm with a through hole of 8mm as shown in **Fig. 1**. The bearing housing screws are M4x20 cap head types and the thrust plate screws are M5x20. The whole assembly can now be fitted to the column of the micro mill, reusing the original shaft key, washer, lock screw, and handwheel as shown in **photo 15**.

Much less effort is now required to wind the headstock up and down, particularly if you've lapped the column and made new brass gibs. After the Z-axis ball bearings have been fitted, the gib adjusting screws can be tightened right up, no need to back them off, without locking the head to the dovetails. At this point, if you've been following the series of articles, all three micro mill axes have been fitted with preloaded ball bearings, which make manual use of the machine very much easier. It also paves the way for a pretty straightforward CNC conversion.

Damping the column

Chatter is an ever present problem with hobby sized machine tools because we always want to make bigger cuts than the machine is happy with. Chatter is simply the machine protesting, and it places increasing limits on what you can do as the machine becomes smaller and smaller. Making the body of the machine from cast iron helps in this respect because it's much better than steel at damping vibrations. However, epoxy granite is an order of magnitude better than cast iron at damping vibrations. This material is increasingly used by industrial machine

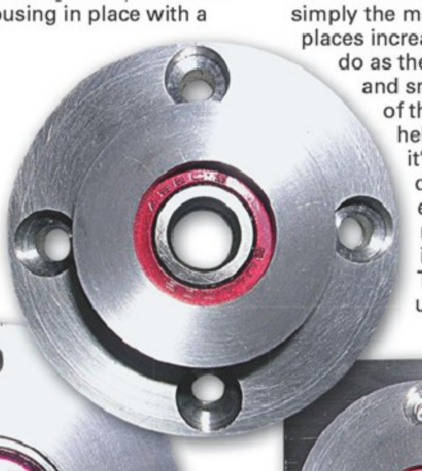


Photo 11. Top view of loaded bearing housing.

Photo 10. Bearing housing with bearings and spacer.

Photo 12. Bottom view of loaded bearing housing.

Photo 13. Loaded bearing housing on thrust plate.

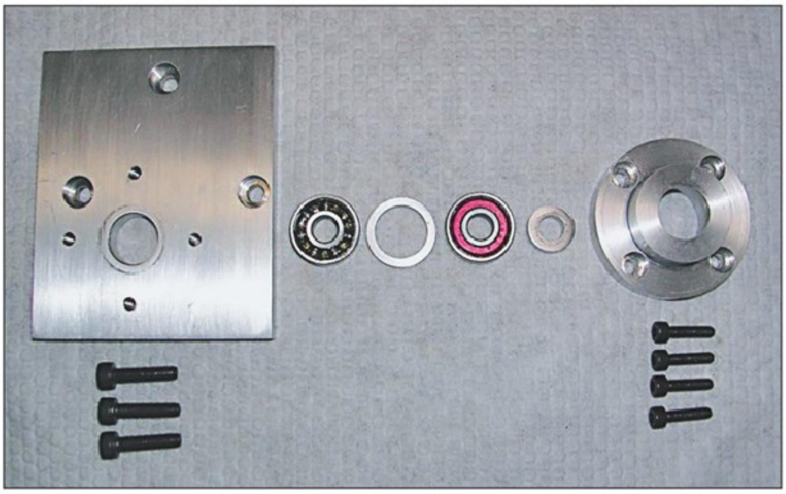


Photo 14. Complete component lineup for z axis ball bearing.

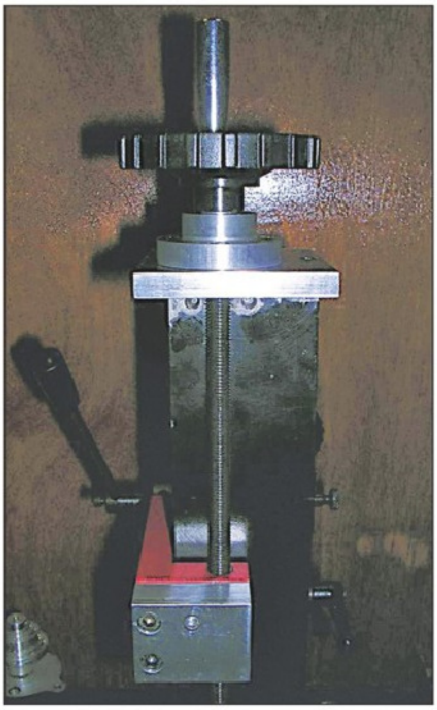


Photo 15. Ball bearing mounted on mill column.

tool manufacturers not only to fill the voids in cast iron assemblies but to form the entire framework (bed, column, headstock, etc.) of the machine. Epoxy granite is also popular for making and upgrading amateur machines; witness the huge thread devoted to this topic on www.cnczone.com

The column of the micro mill is by description small and it's also hollow. This means that it will have quite a number of resonant modes of vibration which can amplify any chatter induced by machining operations. Filling the column with damping material will reduce the amplitude of these resonant modes and thereby reduce chatter. So damping the column of the micro mill should improve its performance but won't alleviate the need for a bigger machine if ambitious metal removal is your goal. I got the inspiration for trying the epoxy granite after reading about it at www.cnccookbook.com

The first thing to do is make a trial batch of epoxy granite to see how it turns out. A mixture of sizes of material is required so that all of the gaps between particles are efficiently filled and only a small amount of epoxy is required to bind the ensemble together. The aggregates used are shown in **photo 16**. These are granite chips of 14mm, 10mm, and 6mm diameter, granite dust, builder's sand, and glass bubbles.

The granite chips and sand were obtained from a local builder's merchant, www.jwgrant.co.uk, who kindly made up a goody bag of a couple of kilos each of the various granite chips and sand. Any material used needs to be baked in an oven first, to drive off the moisture. Baking at 180°C for 45min works fine. The epoxy resins and hardener came from from East Coast Fibreglass supplies, www.ecfibreglasssupplies.co.uk, as shown in **photo 17**.

The yellow dispensing pumps are sold separately from the resin and hardener but are well worth getting as they meter out the correct proportions of both, so you only have to count pump fulls rather than using graduated mixing containers. The glass bubbles are also available from the same supplier. A 1.2kg resin/hardener pack plus pumps cost around £35. If you only want to fill the X1 column then a 600g junior pack at £12 will be enough but you'll have to measure out the resin and hardener yourself.

In order to try making some epoxy granite, mix together one tablespoon of each of the aggregates described above in a plastic bucket. Be careful with the glass bubbles as they form an almost gaseous dust which is a respiratory irritant. Do the mixing outside. Meter in one pump full of resin and one pump full of hardener and mix everything thoroughly together into a homogenous mixture. The mixture needs to contain enough epoxy to hold the mass together when you poke it but not so much that there is a liquid excess - about the consistency of stiff ice cream. Tip the mixture into a 200ml plastic cup and you should obtain something like that shown in **photos 18 and 19**.

Photo 16. Aggregates used in epoxy granite.

Photo 17. Epoxy resin and hardener used to make the epoxy granite.

Photo 18. Side view of epoxy granite trial.

Photo 19. Top view of epoxy granite trial.

If you look closely at **photo 18** you can see some small bubbles in the epoxy. This is undesirable so when the X1 column is filled the mixture must be well tamped down as each spoonful of mixture is tipped into the column. The epoxy granite was left to cure overnight and then knocked out of the cup with a couple of sharp raps on a hard surface. The cup shattered and after picking off the bits you can see the result in **photo 20**.

Set in stone

The epoxy granite is very homogenous and has moulded very well to the cup - you can even read the writing on its bottom! The chip on the left of **photo 20** happened when the cup was dropped whilst attempting to release the epoxy granite from the cup.

This trial was a worthwhile exercise and disclosed two useful facts. The first is that there isn't much time left after mixing the epoxy and hardener into the granite chips - about 15mins before it becomes unworkable. The second is that ignoring one of the manufacturers recommendations seemed to work better. The epoxy and resin should be mixed first and then the aggregates added. The problem is that the reaction of epoxy and hardener is very exothermic; enough to melt a plastic cup unless something is added quickly to cool it down. The heat will also cause the epoxy to set faster. If the resin and hardener are mixed on top of the aggregate mixture, before folding it in, then the heat is conducted away very rapidly and the mixture only gets mildly warm. It might be better to use the resin/hardener pack with the slower 206, rather than 205, hardener because this will give you 30mins rather than 15mins working time.

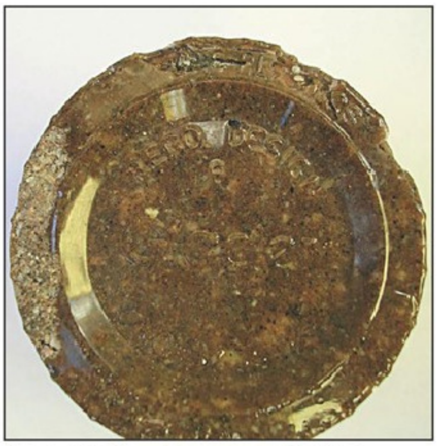


Photo 20. Cured epoxy granite trial after removal from mould.

Before the X1 column is filled the bottom will need to be plugged. A small piece of plywood carved to shape is ideal. The column can then be screwed to a piece of scrap wood to hold the plywood in place as shown in **photo 21**. The tapped holes for the Z-axis sleeve bearing can be protected by coating the matching socket head capscrews with grease and screwing them in fully. The epoxy granite will not adhere to the greased screws.

In order to fill the X1 column, mix together a seven eighths full 200ml cup of each of the six aggregates in a plastic bucket followed by four pump fulls of resin and four pump fulls of hardener. Stir well with a metal rod until all the epoxy is taken up. Then add another four pumps each of resin and hardener and stir until there is a homogenous mixture. You may have to add another pump full or two of resin and hardener to get the consistency right. Use a couple of metal tablespoons to ladle the epoxy granite mixture into the X1 column and tamp down with a metal or wooden rod (about 25mm diameter is good) after every three or four spoonfuls have been added. Work quickly and when the column is full level off the top with the flat of a knife which has been lightly smeared with oil. The column can then be left for a day or two to cure. **Photo 4** shows what the top of the column looks like after the epoxy granite has cured.

Photo 21. X1 column prepared for epoxy granite fill.

Before the column was filled with epoxy granite it would ring, not like a bell, but ring none the less when suspended by a piece of twine and struck with a spanner. After filling you need rope to suspend it and get only a dull "donk" when you tap it with a spanner. The column is now definitely extremely well damped and this should translate through into less chatter when machining heavily for the X1 that is although I haven't had time to quantify the improvement yet. Filling the voids in the bed of the mini lathe with epoxy granite could also be a worthwhile exercise. ■

Bearing part numbers

When commercial bearings are used in articles in Model Engineers' Workshop, The first thing I do when editing is to phone Arc Euro Trade. As well as supplying tools, they also stock and supply a wide range of bearings. As a lot of readers' will phone Arc Euro Trade when making a project described in Model Engineers' Workshop, it makes sense that we publish the correct International bearing code.

There are two reasons for this, if we publish a random internal code used by an individual supplier, Arc Euro Trade (and other suppliers) have to stop what they are doing and search for the correct bearing code that the reader wants.

Secondly, wherever the reader lives, anywhere in the world, he can go to his local bearing stockist and quote the correct code from Model Engineers' Workshop and be assured of getting the correct bearing for the project in hand.

You don't have to order bearings from Arc Euro Trade. Because we supply a standard bearing code, you may buy them from anywhere you like.

A Clarkson Tool and Cutter Grinder 4

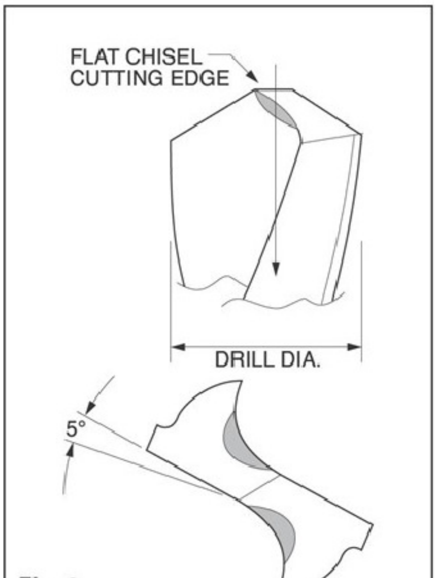


Fig. 2

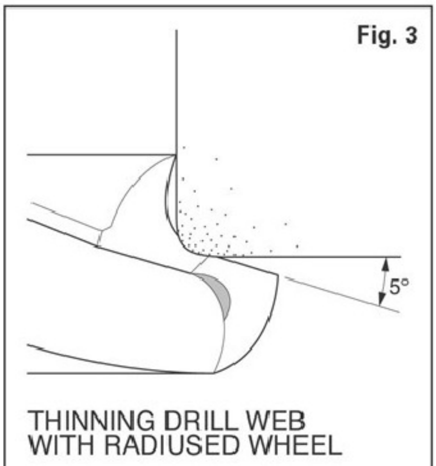


Fig. 3

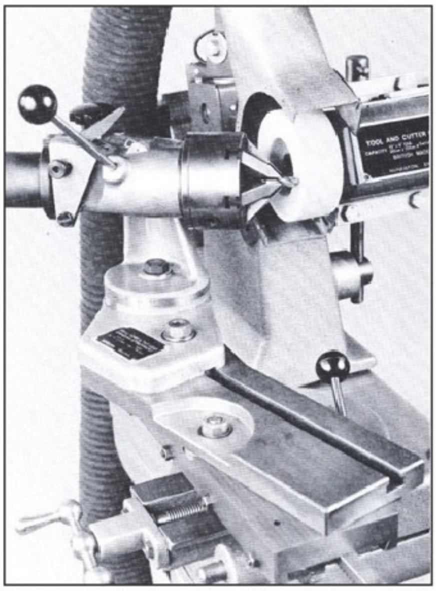


Photo 34. The Clarkson/March drill point and tap lead grinding attachment.

Mike Haughton finishes looking at drill sharpening and introduces the Clarkson method of sharpening the end teeth of milling cutters etc using the Clarkson system of sleeves used in the Universal Head and his own adaption's using collets.

Unfortunately I don't own a Clarkson Drill point grinding attachment; they occasionally appear for sale at ridiculous prices. However, I do have a copy of the March operator's booklet and the following drawings are taken from that. See **Figs. 2 and 3**. **Photo 34** shows the Clarkson/March drill point and tap lead grinding attachment mounted on a Mk1 machine. You will notice that Clarkson/March use a rather expensive precision six jaw self-centering chuck to hold the drill by its flutes. To copy the Clarkson attachment would be a large task and I opted for a 3 way vice holding a 5C collet block that is inexpensive and more than accurate enough for our purposes.

I have used ER32 collets in the range 0.5mm to 20mm mounted in an ER32 to 5C collet adaptor, which in turn is mounted in a 5C collet block. The various parts are shown in **photo 35**. Much of the drill sharpening that follows uses this arrangement. The ER32 to 5C adaptor conveniently has a shoulder with 2 flats that can be seated against the ground bottom edge of the three way vice.

My method uses the set-up shown in **photo 36** and can thin the web or produce something like the commercial modified split point. I have set the drill at an angle of 55deg. and raised the wheel head. The angle of 55deg. elevation is outside the engraved scale on the vice. These scales are in any case hard to read and I have "cheated" by using a digital angle gauge from Machine DRO. **Ref. 26**. This device,

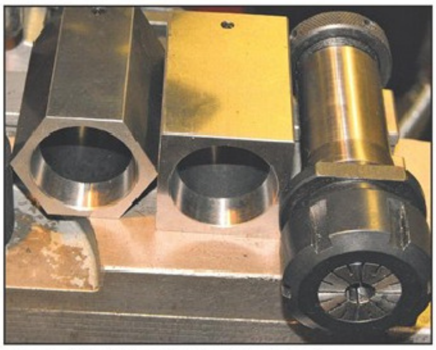


Photo 35. 5C collet holder blocks used for holding cutters.

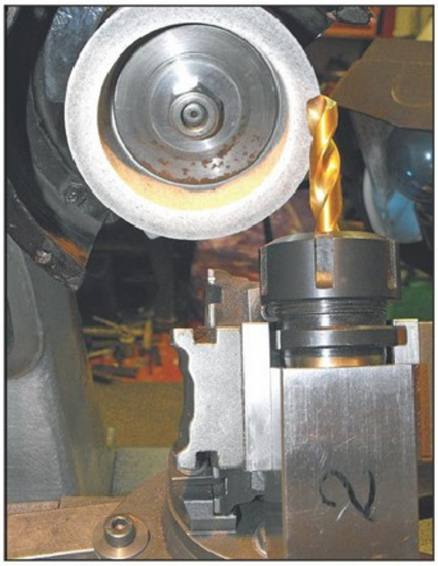


Photo 36. The setup for thinning the web.

Table 5	**Operation - Web Thinning/Point Thinning**
ABRASIVE WHEEL	WA80 -JV1 Straight Cup, dress small radius on edge.
WHEELHEAD	Adjust height so drill bit is approximately at centre height
Table	Set at 90deg. to wheel head spindle
Top swivel plate	Set to 0deg.
3 way vice	Mount at 90deg. to wheel face. Mount drill in ER32 collet and 5C adaptor. Mount adaptor in the 5C square fixture. Mark 2 opposite faces of the block. Place fixture in the vice and slide backwards to rest adaptor flange against the bottom edge of the vice. Use digital angle gauge to set vice at 55°. Adjust drill bit projection so the wheel misses the vice. Adjust drill rotation in ER collet by eye for thinning you require.
Feed	Lock the rack and pinion. Use cross slide feed. Feed in cautiously; adjust the rack to get correct cut into web. Lock the rack. Note the slide reading and withdraw. Turn the collet block over and reseat against flange. Slowly advance the slide feed to the noted position.
Notes	Resist the temptation to take too big a cut with the cross slide feed. <0.1mm (0.004in.) maximum

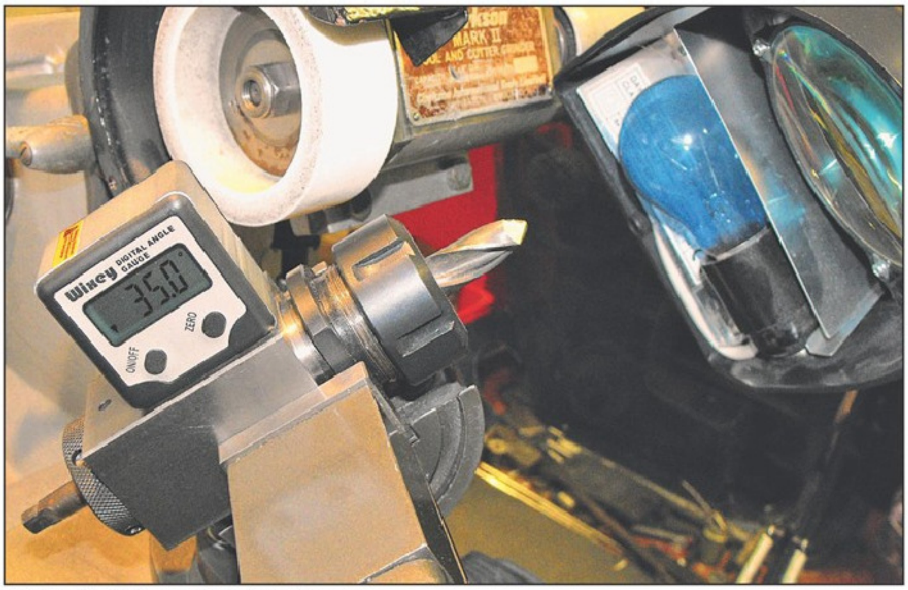


Photo 37. Using a digital angle gauge.

Photo 38. A 135deg. drill sharpened on the reliance type jig.

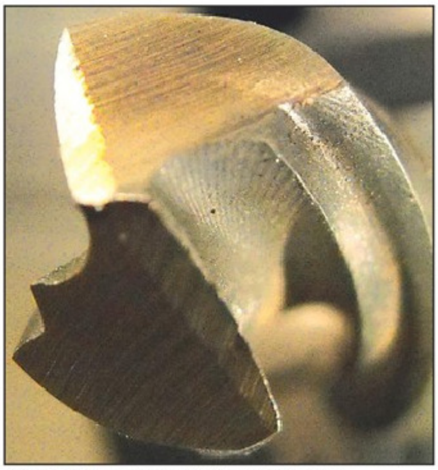


Photo 39. A drill sharpened using the four facet method.

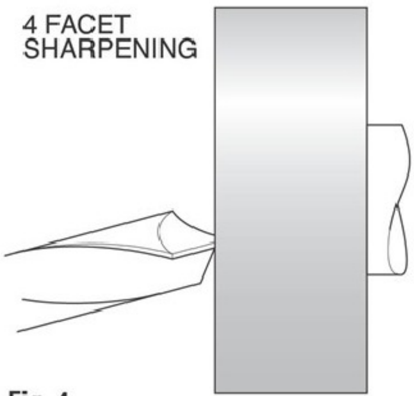
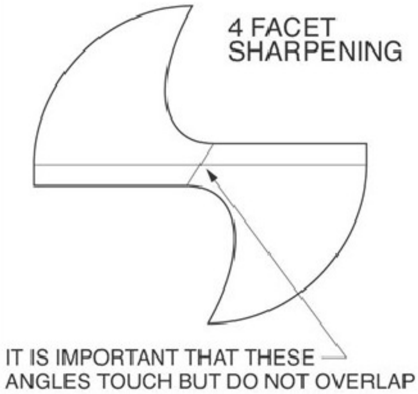


Fig. 4

GRINDING THE FIRST FACETS

Fig. 5



which has a magnetic base, is shown in **photo 37** and will appear in several set ups that follow. There are several points to note. Any length of drill that can be held in an ER32 collet can be sharpened. The block can be removed to observe progress and replaced. The light and lens shown is there for just that purpose. **Table 5** describes this web thinning operation as shown in **photo 36**.

The results from this system are good and the system is flexible enough to achieve the Clarkson style web thinning and/ or point thinning or both. My operating description will have to be adjusted to get the result you want. There is no need to tightly close the ER32 collet, just hand tightening is sufficient as the grinding forces are low. **Photo 38** shows a 135deg. drill sharpened on the reliance type jig with thinning of the web and point. The performance of this drill is better and has a lower drilling force, but it does not self center any better.

11) Four Facet Drill sharpening

In his book on the Quorn Prof. Chaddock describes four facet drill sharpening, but not the conical point relief. **Figs. 4 and 5** show the concept of grinding four flat facets and the effect on the drill point. The chisel edge becomes an apex of two edges instead of a single flat edge, which improves drill centering. The point is effectively thinner than it was. The primary clearance used by Prof Chaddock was 10 to 12deg. and the secondary clearance 25 to 30deg.

Clarkson provide a four facet sharpening method for their drill point sharpening attachment. They use the angles 6 to 10deg. for the primary and 35deg. for the secondary. The choice is yours. I have been able to sharpen by the four facet method using the collet adaptor and block described above. To prevent grinding on a wide surface of the wheel, Clarkson swivel the bottom casting 1 to 2deg. to transfer

Table 6	**Operation - 4 Facet Drill sharpening.**
ABRASIVE WHEEL	WA80 -JV1 Straight Cup
WHEELHEAD	Adjust height so drill bit is approximately at centre height for each facet.
Table	Set at 90deg. to wheel head spindle then move 1 to 2deg. anticlockwise.
Top swivel plate	Set to 0deg.
3 way vice	Mount at 59deg. to wheel face. (118deg. drill point). Mount drill in ER32 collet and 5C adaptor. Mount adaptor in the 5C square fixture. Mark 2 opposite faces of the block. Place fixture in the vice and slide backwards to rest adaptor flange against the bottom edge of the vice. Use digital angle gauge to set vice at 10deg. Adjust drill bit projection so the wheel misses the vice. Adjust drill lip orientation to horizontal. For the secondary clearance set the vice to 30deg. inclination and raise the wheel, repeat as before.
Feed	Feed with the rack and pinion. Advance the cross slide until a cut is obtained. Turn the collet block over and reseat against flange. Feed with the rack and pinion and observe the new edges. If a lot has to be removed to create a new primary edge you may have to rotate the drill in the collet to make the new edge horizontal.
Notes	Resist the temptation to take too big a cut with the cross slide feed. <0.1mm (0.004in.) maximum. If the primary and secondary facets are not parallel a small adjustment of the drill in the collet may be required. Smaller drills require smaller feeds.

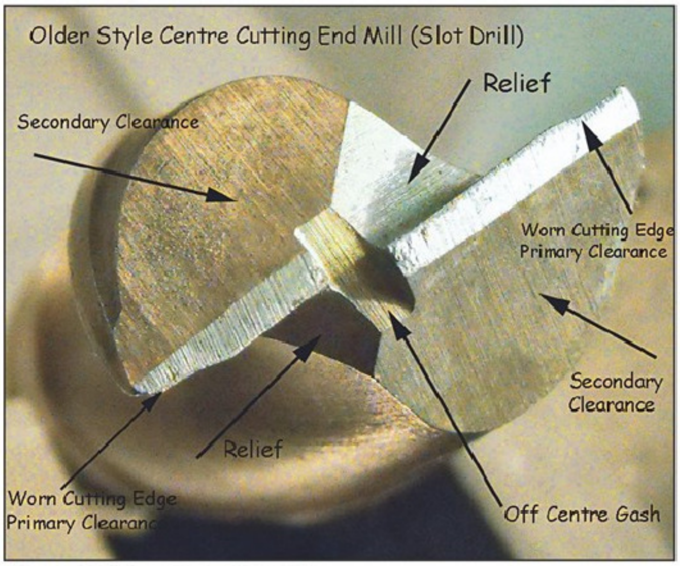


Photo 40. A two flute slot drill.

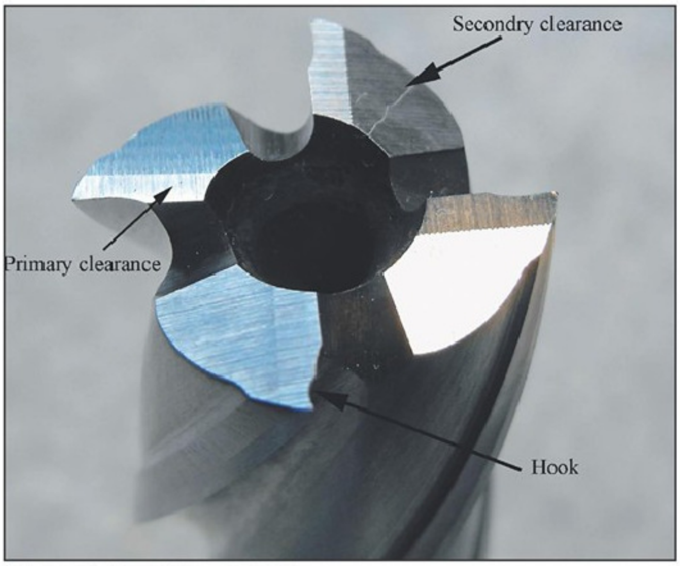
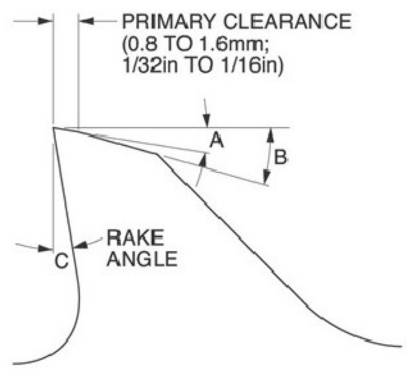


Photo 41. Four flute end mill.

Fig. 6



MOST CUTTERS HAVE PRIMARY (A) AND SECONDARY (B) CLEARANCES

the grinding action to the edge of the wheel. When I come to describe lathe tool sharpening in a later episode this is the approach to adopt; it reduces rubbing which just generates heat.

Photo 39 shows an old 35/64in. 1MT drill with an unusual web design that I sharpened to a 100deg. point by the four facet method. Although the lip shape isn't perfect, more practice is required, it self centres very well and drills smoothly from the tailstock into low carbon steel. The tapered first facet is probably because the web wasn't designed to be sharpened at this point angle. The final sharpening cuts by the four facet method have to be very cautious with frequent close examination of what's going on. You can get curved cutting edges if the drill point is ground at an angle the manufacturer didn't intend. I don't think the four facet method makes a lot of difference for drills below about 6mm; otherwise it's worth the effort for precision hole drilling.

12) Six Facet Drill Sharpening

See **Ref 27.** for Derek Brown's description of this modification. The angles used are 10, 25 and 45deg. I need to do some more experimentation to assess if this modification is worth the extra effort. The end result isn't unlike some of the commercial modified split drills.

13) Basics of milling cutter design.

You should closely examine any cutter you propose to re-sharpen with some sort of magnification before you decide on a course of action. It's a good idea to have a new cutter of the same design to compare with the used one.

The clearance and rake angles vary with the manufacturer and the material to be worked, **Fig 6. Photo 40** shows a used older style HSS 2 flute slot drill (centre cutting end mill). You should be able to see the two sharpened facets (clearances) to each cutting edge plus the off centre gash. The 2 primary cutting facets are unequal in length to provide centre cutting and the secondary clearances have been relieved to provide better chip clearance and to provide a rake angle. The primary facets are worn, with most of the wear concentrated at the end of each cutting tip. This cutter has almost certainly been (badly) re-sharpened before and is fairly typical of the sort of used cutters you will come across. **Photo 41** is a slightly used 8% cobalt HSS 4 flute end mill. You can easily see the primary and secondary clearances on each tooth plus a hook shape to the outer edge of the cutting edges. This is produced by the flute shape and could be there for easier cutting of long chipping softer metals. You will come across other styles of end mills that do not have secondary clearances, so be careful. **Photo 42** shows a Hall Powerbor® cutter, as used with magnetic base "broaching" machines. These cutters are usually used on structural steel and have no secondary clearance but a very obvious hook shape to the teeth. These cutters are used to bore large holes, the solid centre being ejected once the cutter has passed through the workpiece.

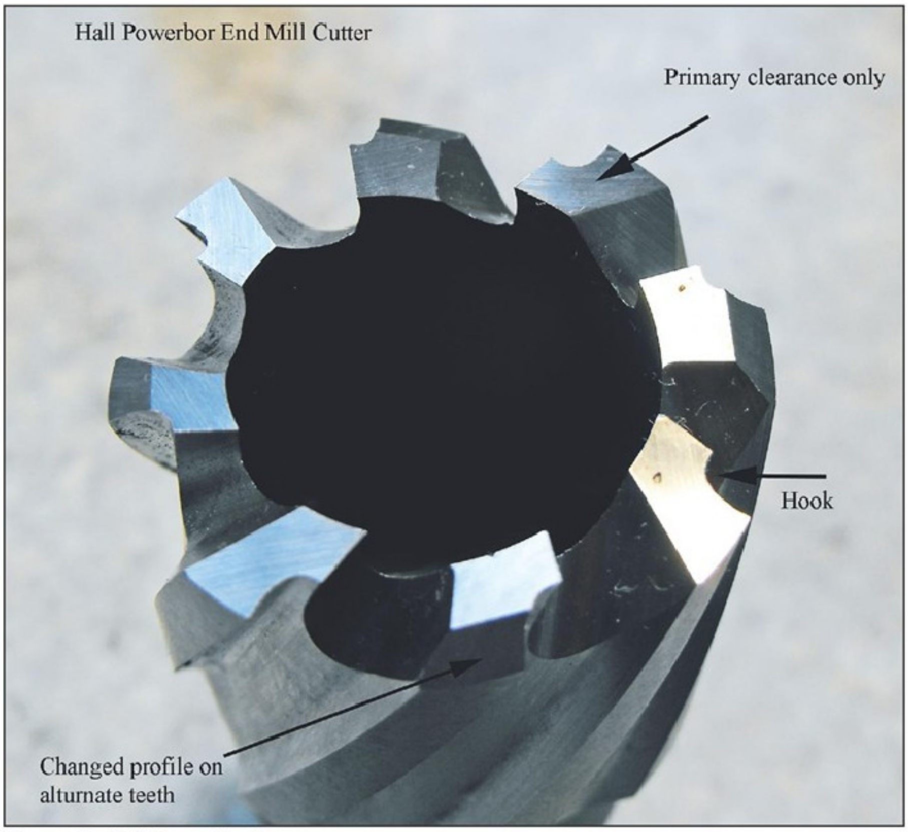


Photo 42. Hall Powerbor® cutter.

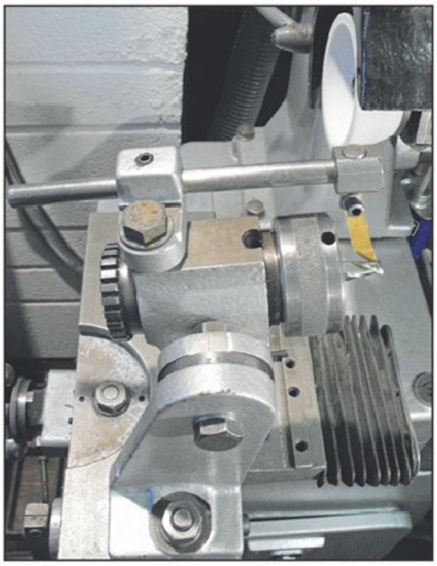


Photo 43. The Universal head mounted on the table.

Photo 44. Genuine Clarkson sleeves and bushes.

Photo 45. Commercial sleeves and adaptors.

14) Sharpening the end teeth
Assuming for the moment that we have no damage to the flutes and only the end teeth need to be re-sharpened. The Clarkson standard equipment consists of a Universal Head and some form of tooth rest to index the cutter teeth. **Photo 43** shows the Universal head mounted on the table with the general tooth rest mounted on top. In my MK2 machine the Universal head has been bored out to accept a non-standard collet holder, for which I have a set of 5 imperial collets which I have been unable to identify. They have a very small clamping range. The original Clarkson sharpening system utilised adaptor bushes for each cutter shank diameter and parallel concentric sleeves that slid into the Universal head. Indexing of the cutter was by a tooth rest. **Photo 44** shows a group of genuine Clarkson sleeves and bushes. If you could look closely at them, they are each etched with the Clarkson Logo and a part number. Bushes were available to suit all the standard imperial and metric milling cutter shank sizes plus Morse taper sockets and a regrind mandrel for saws and side and face cutters, shown centre back. My problem was these sleeves were un-usable because my universal head had been bored out to 1.625in. and the standard Clarkson sleeves are 1.250in. The Stent, being based on the Clarkson uses sleeves based on 1.000in. dia. The Clarkson sleeves are deceptively simple and were obviously turned, hardened then ground to very precise sliding fits in each other. I have turned a number of sleeves to accept R8, ER32, 5C and a reducing sleeve to use the Clarkson sleeves and bushes shown above. The starting material was a metre of 2.25in. 20 carbon steel from a local shop said to be En3 Ref 28. An interesting exercise in parallel turning and a lot of swarf! The internal bores were finished with a brake cylinder hone. The desired fit is a smooth slide with no shake.

Photo 45 shows some of the sleeves and commercial 5C and ER32 to 5C adaptors. ER32 will take collets up to 20mm, the larger sizes having a closing range of 1mm and those below 3mm, 0.5mm. 5C collets go to at least $1\frac{3}{16}$in. dia. but beware the collet body will only pass about 25mm. The reason for making an R8 adaptor is to mount tooling I use on my vertical mill, particularly arbors for slitting saws. Both 5C and ER32 can grip milling cutters over their flutes and this is necessary because the distance between the wheel and the universal head is fairly small. Hence sharpening long cutters that will pass through the collets are not a problem.

Sharpening the end teeth of milling cutters is one of the easiest of operations, provided you take the time to set the machine up correctly before you start grinding. **Table 7** summarises the operations, but a bit of additional information is in order. The Clarkson swing table has no angular calibration, a total pain I find, so I commence by setting a large angle plate on the top swivel plate set at zero degrees and use this to set the wheel parallel to the table. Having mounted the universal head on the machine with a piece of ground rod in the collet I use a square to check that the rod is perpendicular to the wheel, **photo 46.**

Although the universal head has no adjustment at the base, there is sufficient play in the table slot and base tongue to make a careful clamping of the base necessary. Having got the head aligned you then rotate the top swivel plate by about 1deg. to leave the cutter front teeth concave, so they only cut on the periphery. If you stand a sharpened cutter on its end on a machined surface you should be able to see daylight through the centre of the teeth. It should also be standing vertically on the outermost point of each tooth, unless it only has 2 teeth!

Clarkson quotes primary clearances of 8deg. for end mill cutters below 20mm and 6deg. above that size. Secondary clearances for cutters above 20mm are given as 15deg. but I have seen bigger numbers elsewhere.

Clarkson advises operators to make their own tooth rests from bits of hacksaw blades, **Fig 7.** I prefer springy brass for end mills so the cutter tooth can be advanced past the tooth then moved backwards to find the new position against the rest.

Once you are set up and getting good results a lot of milling cutters can be sharpened in quite a short time. Try out

Table 7	**Operation - Milling cutter end teeth sharpening**
ABRASIVE WHEEL	WA60 -JV1 Flaring Cup (shape11) 100mmdia x 40mm deep. No wheel extension. Dress the wheel cutting face.
WHEELHEAD	Adjust height so milling bit is approximately at centre height of wheel.
Table	Set at 90° to wheel head spindle
Universal Head	Mount at 90° to wheel face. Elevate head to obtain primary or secondary clearance angle. (use of digital angle gauge preferred) Install collet or sleeve and cutter to be sharpened. Install tooth rest support and select a suitably shaped tooth rest. Adjust first milling cutter tooth edge to be horizontal.
Top swivel plate	Set to 1°to give teeth slight concavity.
Feed	Cautiously advance the cross slide so a slight cut is produced when the rack and pinion moves the cutter across one tooth. Grind only one tooth at a time. Rotate the cutter to the next tooth and repeat. Remove the sleeve and cutter to observe progress. Replace and repeat.
Notes	Resist the temptation to take too big a cut with the cross slide feed. <0.025mm (0.001") is an absolute maximum for a 10mm cutter. Smaller cutters need smaller cuts. Go around all the cutter teeth until no further material is removed. Least is best to extend the life of the cutter.

Table 8	**Operation - Milling cutter- end mill, re-cutting end teeth**
ABRASIVE WHEEL	WA80 -M6V Saucer Shape 13 or 12 Dish 100mmdia x 10mm deep. Fit wheel extension. Dress the wheel cutting edge to profile.
WHEELHEAD	With the wheel stationary adjust the wheel height to enter the existing
Table	Set at 90° to wheel head spindle
Top swivel plate	Rotate to approx 90°. Adjust with static wheel to produce positive rake to tooth.
Universal Head	Mount to left of the table. Install cutter in a collet. Elevate head and rotate collet to obtain a close fit to the existing gash in cutter. Adjust rotation of cutter to give a good engagement in the existing slot. Install tooth rest support and select a suitably shaped tooth rest. Adjust to index against the positioned tooth.
Feed	Bring the wheel slowly downward into the cut and note the depth. Rotate to the next tooth and repeat.
Notes	Resist the temptation to take too big a cut. Feed the wheel down slowly. If need be, advance the cross slide by a small amount <0.025mm (0.001") to produce a clean positive rake to the cutter teeth. Go around all the cutter teeth until no further material is removed. Least is best to extend the life of the cutter.

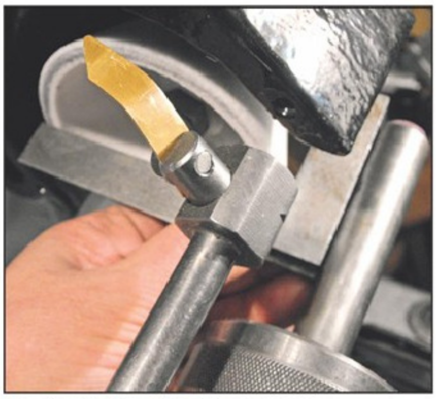


Photo 46. Checking for square.

the ones you have sharpened; most tool makers in industry never used the tools they sharpened for others (but they got plenty of flack if they weren't any good). The moral has to be, resharpen tools early and frequently for the best performance on the machine. Even if you don't get the primary relief quite parallel with the cutting edge, so long as the edge is sharpened it will cut well.

15) Recutting end teeth on end mills.
A time will come when repeated re-sharpening has removed so much cutting tooth that the cutter will have to be recut between the teeth. The idea is to cut the front of the tooth to a positive rake of about 10deg. The best wheel profile to use is found by offering different wheels into the existing slot when the wheel is stationary, **photo 47**.

This testing also gives a good indication of the angle that the cutter must approach the wheel. I usually find that a 15deg. taper wheel gives the best results, the white wheel in the photo probably needs to be dressed to a better shape. It's worth keeping a wheel for just this operation. Notice the brass indexing finger.

The sharpening sequence is described in **table 8.**

The next stage should be to re-sharpen the cutter end teeth, described above. I usually sharpen the secondary relief first then follow with the primary. If you grind a "lot" away the cutter may have to be rotated slightly to allow for the helix angle of the flutes.

16) Recutting end teeth on centre cutting end mills
Older style 2 flute slot drills **photo 48** require two recutting operations. I usually cut the longer of the 2 teeth first trying to leave the cutting edge radial, using a flat wheel. The cut is made by lowering the wheel into the existing cut to deepen it.

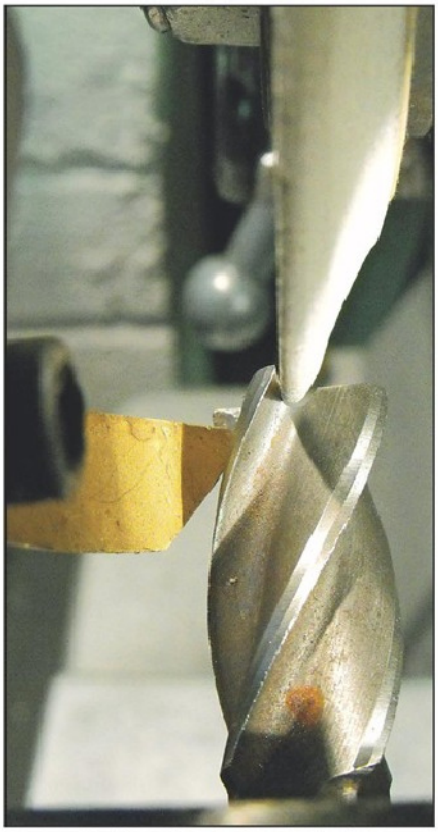


Photo 47. Checking for best wheel fit.

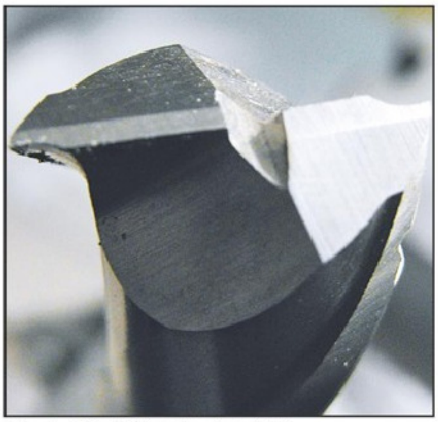
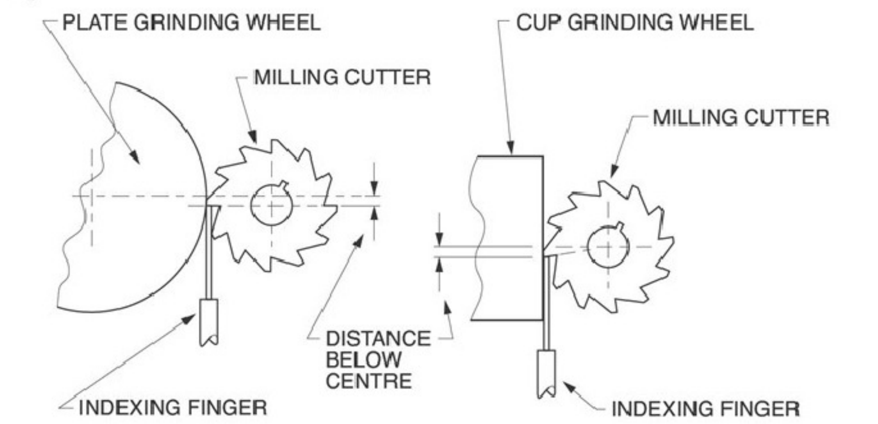


Photo 48. Old style slot drill.

This takes some practice, especially as you have to maintain the positive rake of the cutting edge. Repeat for the shorter cutting edge, which is supposed to lag slightly behind the centre. Again difficult to set up, but worth ruining a few old cutters to work out how to do it. Finally the central gash is made with a very narrow cut off wheel or a thin dressed dish. The secondary and primary clearances are then sharpened as described above. There are a number of centre cutting end mills available with 3 flutes, one cutting edge being longer than the other 2. These cutters will probably require a dish to recut the leading edges of the teeth.

Fig. 7



References

Ref. 26 www.machine-dro.co.uk/
Ref. 27 D.A.G Brown, Model Engineer p36 7January 1993; p152 4 February 1994; p194 16 August 1996; 20 September 1996; 20 December 1996.
Ref. 28 http://www.oldengine.org/members/diesel/Tables/steel.htm

To be continued...

SCRIBE A LINE

Pillar tool

I have two queries about David Haythornthwaite's pillar tool in issue149.

1) Why is there a cotter pin and handle in the upper arm where it is holding the tool shaft? I don't see any use for this accessory there although it is clearly needed in the other three places. Is it just to make both of these arm assemblies the same?
2) It seems to me that the method of making the curves on the end of the cross bars is far too difficult to get the near perfect curved end to the cross bar that is needed for good operation. Both length and orientation of the curve need to be just about zero tolerance for satisfactory operation of the finished tool in view of the lengths and therefore the error magnification of the pillar and the tool holder.

There seems to be a much simpler way using the tools and methods already illustrated in the article.

A) Machine the castings as given with the cross arm shoulder facings identical as in photo 4.
B) Machine the cross bars to identical dimensions as stated, particularly the distance between the shoulders as in page 28 but making the inserted portion deliberately too long by a few mms so that it just protrudes into the long bore.
C) Assemble the arms and epoxy in place photo 9.
D) Mount each assembly as in photo 12 and bore out the main bores. This immediately makes the inserted shafts exactly the right length to take the cylinder inserts with no awkward and potentially inaccurate dimensioning.

I must compliment David on an excellent design which is easier to make and far more flexible in use than other similar pillar tool holders which have appeared over the years. Even to have to buy a face plate especially for this is not an expensive item these days.

Ted Wale, Canada.

Rods, Poles and Perches

Star Letter

Eckart Hartmann (MEW150) may not be aware of it, but previous generations of schoolboys, now much older and still steeped in imperial measurements, had to learn about rods, poles, chains, perches, and a few other oddities long after these units had disappeared from daily use. Fathoms and knots are still with us and no-one complains about those. Although he says there is no end in sight, there is in fact no end at all. When our descendants are all equipped with Metric lathes, taps, drills, screws et al, there will still be the vast stock of drawings that will never be redrawn or redimensioned, and everyone will have the same problem in reverse. Anyone reading old copies of Model Engineer will find inches in tenths, twelfths, twenty-fourths and forty-eighths, plus the "full" and "bare" dimensions beloved by LBSC. We ourselves have moved on since then. Even the die-hard imperialists would concede that fractional dimensioning is better replaced by decimal when you get down to small units, and then whatever superiority is claimed for metric just disappears. Unless the USA decides to follow us into being trendy for its own sake, another century or so of living with a mixture seems likely.

George Swallow by email.

Compressor

Richard Wightman's cheery assurance "I'm in the motor trade so I have some knowledge and experience with compressors" instantly rang alarm bells of the "Trust me, I'm a salesman" variety. As I read more of his article (MEW No. 150 page 38) these bells were fully justified.

I presume his motor trade experience does not extend to ownership or management of a garage with an air compressor: if it did, that experience would tell him that the law requires his garage compressor's air receiver to be insured and that the insurance company won't oblige until their engineer surveyor has inspected and, if deemed necessary, pressure tested it. Whilst I presume insurance is not obligatory for an air receiver in a private workshop with no public access and no employees, Mr. Wightman's knowledge and experience of air compressors should tell him that "the tank (sic!) ...made from an old fire extinguisher..." will, when pressurised with air, possess substantial energy with the potential to cause harm to anybody within range should it fail. Thus to advocate the use of "an old fire extinguisher" as an air receiver without any warning that it should first be inspected for corrosion and other defects by a competent person and, ideally, pressure tested (with water, certainly not air) is irresponsible. Although the test pressure and working pressure are marked on the extinguisher, this does not mean that it can be safely pressurised for evermore. The 2 litre extinguisher shown may cause limited harm, but readers are not warned of increasing danger if a larger extinguisher is used.

If Mr. Wightman were familiar with air receivers, he would know that a drain valve is required - there is no drain in his design, so his receiver will trap water until it is full.

Mr. Wightman's "old fridge pump" (for 'pump' read compressor: we can be excused engineering terminology pedantry in an engineering magazine) may not last too long as an air compressor. The erstwhile hermetically sealed domestic refrigerator compressor shown in the photographs has lasted for so long because lubricating oil has been sealed within it - eventually this will be lost in the open system in which the compressor is to be used.

Finally, there is no mention of disposal of the refrigerant before disconnecting the compressor from its refrigerator. Older refrigerators used CFCs (e.g. one of the Freons) as a refrigerant. CFCs damage the environment and must be removed professionally, not released into the atmosphere.

Ian Moignard, Jersey.

Interfering with radio amateurs

Regarding Mike Haughton's article in April's MEW, I would only commend him on the fitting of a motor suppression system to his Clarkson tool and Cutter Grinder, then he openly states that he uses a Powerline Ethernet Network system to run his computer networking system!

I can only think that this is due to a lack of thought or understanding of the system that he is using and the harm that it is able to do.

These systems, also known as PLT or Power Line Transmission systems while not being banned are the total scourge of Radio Amateurs and others using the HF bands.

What they, PLT are, is a system for wide band interference as the system uses the whole of the High Frequency Radio spectrum to transmit Data and anyone using a receiver in the locality is completely wiped out.

Radio amateurs and many other HF Radio users are actively attempting to have these systems made illegal due to the potential for interference. If you can imagine, these systems are connected to mains cabling systems and this potentially makes every lamp post or over-head cable, not to mention the house wiring, a radiating Aerial at HF.

Rod Mitchelson by email.

WRITE TO US!

We would love to hear your comments & questions and also feeback about MEW

Write to the Editor, David Clark, Model Engineers' Workshop, MyHobbyStore Ltd., Berwick House, 8-10 Knoll Rise, Orpington, Kent BR6 0EL. Alternatively email: david.clark@myhobbystore.com

THE STAR LETTER OF THE MONTH WINS A WORKSHOP PRACTICE BOOK

YOUR CHANCE TO TALK TO US!
Drop us a line and share your advice, questions and opinions with other readers.

Dehumidifiers

I'm delighted to confirm your comments (MEW No.150 page 54) about dehumidifiers in workshops.

For at least twenty years I've had a domestic dehumidifier running in my workshop, controlled by a built-in humidistat to maintain 65% to 70% humidity which I monitor on a separate hygrometer - two actually, as hygrometers used not to be considered accurate. Stand-alone humidistats are available from R.S. at £41 and £49. Whilst a timer would be cheaper, a humidistat is obviously more appropriate. For the dehumidifier to be effective, doors and windows must be kept closed.

I try to avoid heating the workshop, but when warm clothes are insufficient I use a radiant heater to make me feel warm without raising the entire workshop's temperature excessively as a fan heater would, thereby possibly increasing the likelihood of condensation on cool surfaces of workshop machinery. Obviously any gas or oil-fired heater that heats the workshop air with a flame must be avoided as it will produce condensation and draw in more outside air.

I have no sign of rust, but I do coat machine tables and slideways with appropriate lubricant.

Ian Moignard, Jersey.

Hard work

In MEW issue 149 David Piddington bemoans having to tap 396 holes by hand. There is a solution for this 'one turn forward, half a turn back' drudgery. For this type of task commercially spiral fluted taps are used, they can be bought individually from industrial suppliers. These are normally fitted to a tapping head that automatically reverses the tap out, but even using this type of tap by hand will speed the process as no backwards turns are needed. Due to the spiral flutes, tightly curled ribbons of swarf emerge from the flutes as the tap is wound in.

While my tooling supplier throws up his hands in horror at the suggestion, I also use these taps in a reversible battery drill. With tapping compound, a low speed and the drill clutch set on the lowest setting that still allows the tap to rotate (as it is preferable to let the clutch slip rather than break a tap if something does jam) it taps holes beautifully. I'm sure that the really keen could make up a counterweighted cradle with a parallelogram linkage (perhaps an old drawing machine arm) that would keep the drill axis perpendicular to a work surface at all times. Devices like these are used industrially too, although normally using air driven tapping devices.

Michael Green from down under.

The editor replies: It was common practice in several of the firms where I worked to use an electric screwdriver or reversible drill for tapping holes. We used spiral point or spiral flute depending on if the job had a through hole or was blind. We started off with a light clutch setting and increased it a bit until it would tap to depth and slip. Don't try this with an expensive casting or a component with many hours of work in it.

Survey and reamers

I have dutifully returned the completed MEW survey, although I have objected strongly to supplying personal detail that included date of birth. Not coyness on my part, but I'm fed up to the back teeth with "security", "marketing".

In summary, I have taken MEW for approximately 10 years and am happy with the current magazine. My two minor caveats will be picked together with all the other comments. The difficulty I had with the form was simply the space available to suggest future topics. I think my two topics could be covered with an article each.

In my time reading MEW, I cannot remember any mention of insurance for contents in or visitors to the workshop. Also, what are the legal requirements for boilers; test certificates, who issues them, how long are they valid for. You could argue this is a topic for Model Engineer, but I am sure that many MEW readers will have small test boilers. I can think of a possible future situation where as a birthday treat one of my small neighbours would come with his father (both wearing safety goggles obviously) to see a Stuart 10V running or a CNC machine working. I only hope that such an idea does not stir up a hornet's nest of diatribes for and against Health & Safety, similar to that following the MEW front cover of Dave Fenner's daughter.

Similarly, I cannot remember any specific articles on reaming. There is nothing in Tubal Cain's "Drill, Taps and Dies". Sparey mentions floating a reamer on a centre held in a lathe tailstock. I've heard shock horror stories of reamers seizing in brass/bronze. Could one of the experienced engineers write an article covering:-

- Machine reamers/hand reamers.
- D-bits.
- Methods of holding and presenting the reamer to the job.
- Speeds.
- Lubrication.
- Methods to bring the hole diameter to within 3-5 thou ready for reaming.
- A rule of thumb for incrementing and stepping up through the drill sizes.
- When is boring a better alternative to reaming.

George Walker, Reading.

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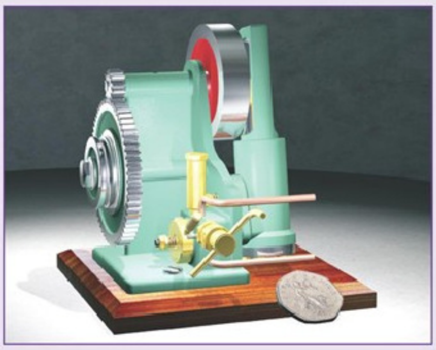

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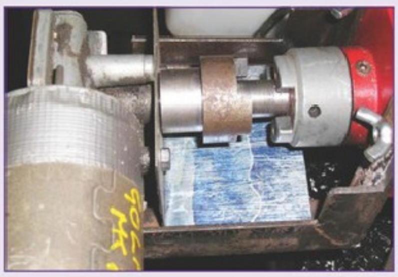

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RESTORE
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Shield Technology has released a new rust removal product, 'Restore Rust Removal Gel'.

I expect we all remember products like Jenolite for removing rust? Dunk the item and leave it a while and the rust is converted to a black oxide.

Well now there is an easy to use alternative, Restore Rust Removal Gel.

This product is a simple, clean way to remove rust from ferrous components. Rather than just report the availability, I thought I would give the 250ml sample bottle a test run.

I have some castings for a Redwing gas engine sat on the workshop floor under the hacksaw. They where slightly rusty when purchased secondhand. I thought the base casting would be an ideal test piece, **photo 2**.

This casting had slight surface rust so reading the instructions for use it said rub gel in with a scourer. Right I thought lets rub the casting with a scourer and see what happens; after all, scourers are supposed to remove rust and corrosion. A quick rub over later and it was obvious a lot of effort would have to be expended to bring the metal back to a rust free condition.

Right, on to the gel. The bottle was inverted onto the corner of the scourer and a thin layer of gel about 25mm in dia was left. I rubbed the gel onto the casting for two minutes without using any real scrubbing method and then wiped the gel off with a kitchen towel. The result can be seen in **photo 3**. I did not go all over the casting. That is a job for the future when I am ready to start the machining.

The casting appeared clean in the bit that was worked on and there appeared to be no remaining rust where I had rubbed the gel on. **Photo 4** has had part of the original casting Photoshopped on over the finished face so you can see the difference.

Arc Euro Trade says 'Typical uses include vehicle bodywork, motorcycle tanks and mudguards, machine tool tables and beds, larger woodworking tools etc.

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Photo 1

This is a great product and I will certainly be using it in the future. Those of you with unstarted castings gathering rust or a part finished model under the bench can now use this product to clean off the rust and get started again. A 250ml bottle will go a long way but if you have a lot of derusting to do, the gel is also available in 500ml bottles.

Restore Rust Removal Gel is highly recommended, it does what it says on the bottle and it does it well.

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Photo 2

Photo 3

Photo 4

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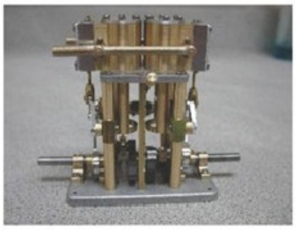

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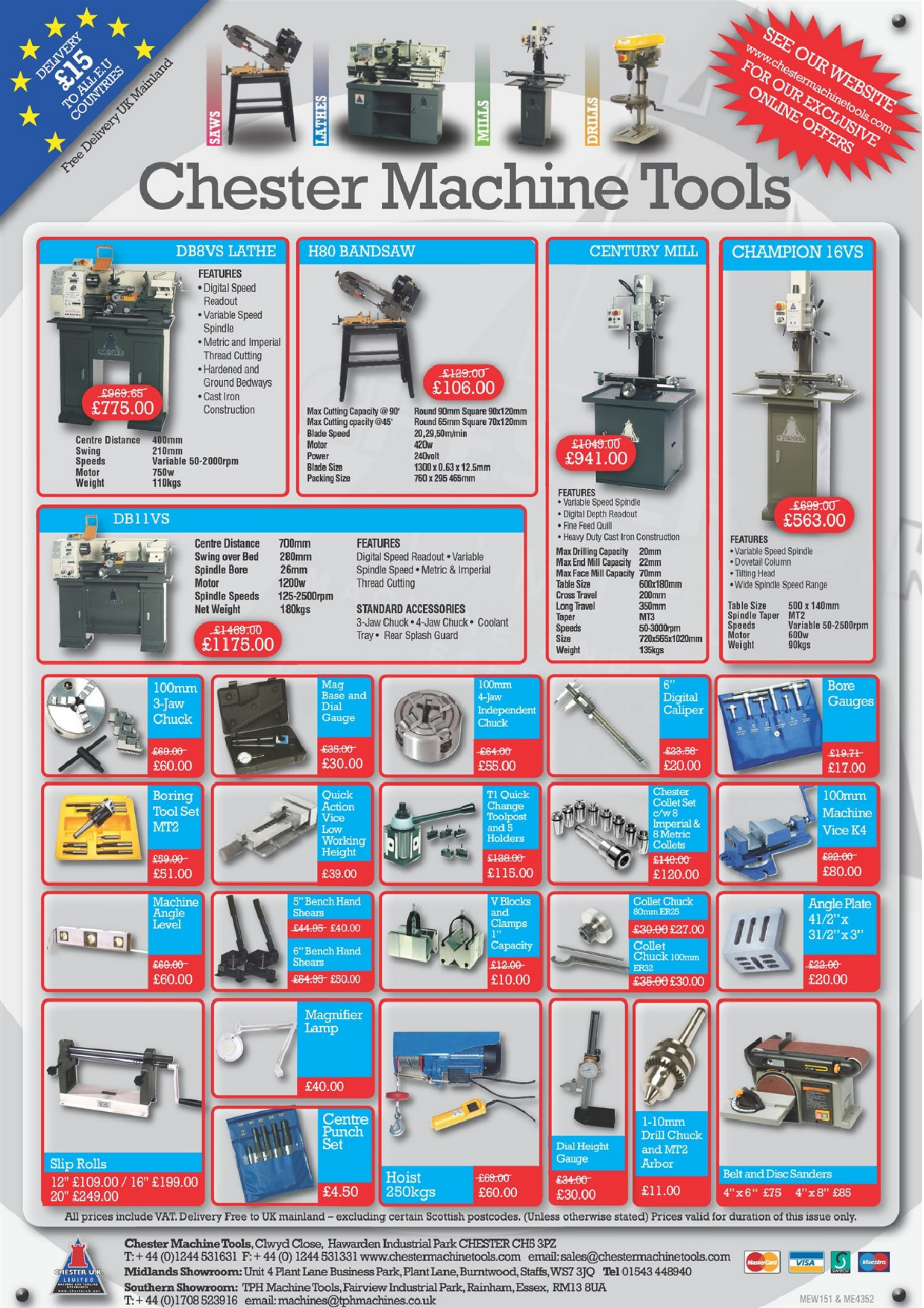
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