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THE PRACTICAL HOBBY MAGAZINE

AUGUST 2009

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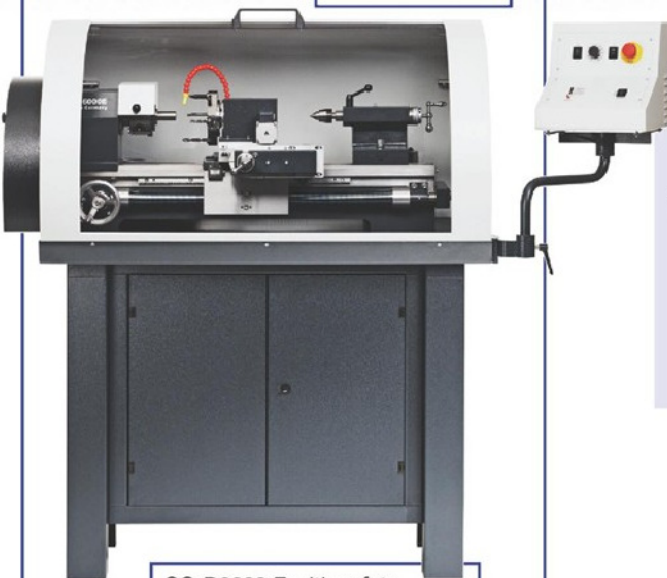
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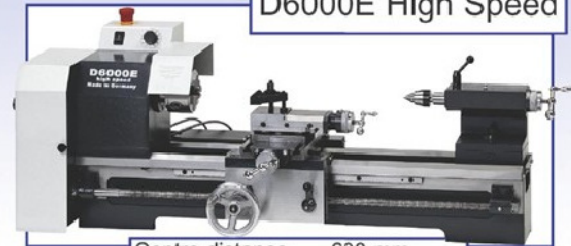
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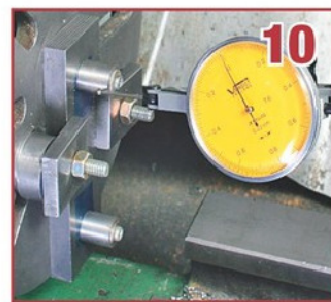
Mike Haughton concludes his look at this versatile cutter grinder.

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TRADE COUNTER

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SCRIBE A LINE



ON THE COVER

This motorcycle seen at a vintage rally at John O'Groats is an Indian model 741B motorcycle from 1941. It is a 500cc Vee twin with 3 speed gears as supplied by the USA to the British armed forces during WW2. Photo by David Clark



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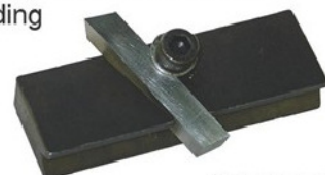
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Whilst the picture quality of Rudy Kouhoup's wonderful instructional films may not always be to Hollywood standards, the quality of instruction really is exceptional; with these films your instructor is there in the room with you. Here is a selection some of the most popular titles:

Fundamentals of Machine Lathe Operation • NEW version • 95 mins • DVD • £29.31

New, revised and extended version of THE video for the beginner to the lathe - there really is no better way to start learning how to run a lathe. However, it is basic, so if you have some experience in lathe operation, don't buy this video, buy the next but one.

Fundamentals of Milling Machine Operation • 120 mins • DVD • £29.31

Covers virtually all aspects of using a vertical, bench type, milling machine in detail - great if you have just bought a mill! Includes drawings and instructions for making a fly-cutter.

Advanced Aspects of Machine Lathe Operation • 120 mins • DVD • £29.31

In this video Rudy continues the tuition process, demonstrating rather more advanced details than contained in the video above, specifically how to achieve a very high degree of accuracy while boring, turning, facing, threading, milling or grinding on your lathe.

Advanced Aspects of Milling Machine Operation • 120 mins • DVD • £29.31

Shows you methods by which your mill can be highly accurate in every function. He also describes techniques that will expand the usefulness of your mill and dramatically improve your skill levels.

Grinding Lathe Tools • 125 mins • DVD • £29.31

Here Rudy looks at all aspects of grinding lathe tools to perfection. Really very good, and also includes plans for building a simple, but effective, grinding table. In the main covers tools used in European type (ie horizontal) tool holders.

6 Projects for the Shaper • 165 mins • DVD • £29.31

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Using Layout Tools • 100 mins • DVD • £29.31

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Building a Small Steam Engine • 220 mins • Double disc set • £34.27

Full plans, and instructions on your screen, for building a simple, small horizontal 'mill' type engine. An ideal beginner's project - Rudy makes his on a Sherline lathe and mill, so this is an engine that can be made on a Unimat, Taig or similar lathe.

Building a Stirling Hot Air Engine • 220 mins • Double disc set • £34.27

Again, full plans and building instructions on your screen for building a horizontal Stirling engine. For the beginner this is an excellent 'follow-up' to Rudy's small steam engine as, by its design, a hot air engine offers more in the way of challenges, not to mention hours of fun both building the engine, and running it!

PIONEER a Non-compression Internal Combustion Engine • 230 mins • Double disc set • £34.27

Pioneer is a dynamic 2-stroke cycle, open frame engine with poppet valves. The cams, valves, con rod and all moving parts are visible - no gears! And, as with the steam and hot air engines, no castings are required. Spark plug ignition. 12 sheets of plans, and building instructions up there on your screen.

I was so impressed with this engine that as soon as I finished watching the second DVD, I went on to Ebay to order some aluminium to start construction. I rang the local timber yard up to get some Ash to make the wood framework to mount the engine on. As you have probably realised, I quite like the look of this little engine! David Clark - Editor 'Model Engineers' Workshop' Issue No. 149 April 2009

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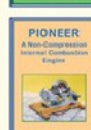
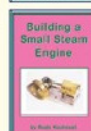
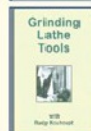
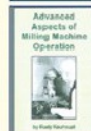
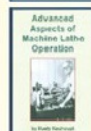
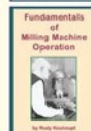
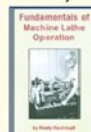
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David Clark

Lazy

I have always been lazy from the point of view that I will find the easiest way to do something. Often the easiest way is not to do it at all if it does not have to be done.

I enjoy going out into the workshop - once I get there. Actually getting up and going out and switching the machine on is the hardest bit. It has taken me about two years to fit a digital readout and an inverter to my Tom Senior mill. It now works and is a pleasure to use. It is well equipped with vice, rotary table and dividing head, in fact everything I need to turn out work quickly and easily.

I actually went out and made a baseplate for an oscillating engine that is going to be featured in a future Best of Model Engineer Special.

Newish Myford

After taking delivery of a turquoise Myford at the end of May, I have decided to get that up and running much quicker than the mill. I purchased some cheap oilcans from eBay and labelled them up for spindle oil, gearbox oil (the new Myford has a gearbox) and slideway oil. I also filled the Myford pump oil gun with spindle oil for the rear headstock nipple and the saddle nipples etc. A good oil around and the lathe was ready to go.

I transferred the front and rear quick change tool post from the older Myford to the newer one. These are genuine Myford ones and are made to a much higher accuracy than the cheap ones available on eBay. You can tell the difference, the good ones have 'M' stamped on them. I do have a cheap set from eBay and they will go onto the older Myford when I dig them out of the storage shed.

Grinding up turning tools

Up to now, most of the turning I have done has been with a straightforward 90 deg. Mitsubishi tipped tool and also a Mitsubishi tipped boring bar. Both tools took the same tips so only one packet was necessary. It was still expensive on tips so an alternative was needed and I obtained some 8mm square high speed steel blanks. I have also purchased a decent bench grinder to grind up the high speed steel tools. This was mounted on a Tesco wooden chopping board that had rubber feet on the underside (the feet are chair buffers from Homebase). I can now carry the grinder outside in good weather and grind tools outside.

I don't like grinders inside a small home workshop; the dust gets everywhere. The

ON THE EDITOR'S BENCH

first time I tried grinding in the workshop many years ago, the Myford got covered in flying grit. I had to clean it down very carefully and have never used a grinder in the home workshop again. I was lucky because I used to work in industry and could grind tools in dinner and tea breaks (or while waiting for the CNC to finish its run). Then all I had to do was finish them off with a diamond lap. Diamond laps are so cheap nowadays that it really does pay to have a selection in the workshop. I use them for fine deburring as well as tool honing.

I ground up the front parting tool for brass and the rear one for steel. The rear one is much more substantial. To set centre height for the parting tools, I simply faced a bit of brass bar adjusting the height as necessary. I also ground up a long piece of HSS at both ends to a 90 degree angle at 45 degrees to this shape <--->. Now I can lightly chamfer bores and diameters with ease simply by turning the tool holder 90 degrees. I have ground up a right hand turning tool to turn from right to left in place of the tipped tool. It works fine on brass. I turned both the bearing block and the cylinder mounting block for the simple oscillating engine with no problems. I will have to grind up one for steel with top rake for when I come to turn the crankshaft.

Once the little oscillating engine is working, I intend to start one of the kits lying in storage in the workshop. I have purchased many kits over the years, too many really but will hopefully build some eventually. I think the Stuart 10 H will be first. I half made one of these years ago but it ended up on eBay. Perhaps this time I will finish it. I know I enjoyed making the parts that I started.

Perhaps part of the problem is my production background. In my mind, I have already made the Williamson engine mentioned last month. I go through the drawings (or in this case Tubal Cain's book) several times and work through machining all the parts. The engine is finished in my mind. Perhaps I might be better off just buying the drawings and looking at these and then machining the components in my mind. It will certainly work out cheaper.

I think actually that I am polychronic. This means I prefer to work on multiple activities at the same time. Examples of polychronic behaviors include talking on the phone while doing other things and browsing the internet while in a meeting. People who prefer to do one thing at a time are known as monochronic.

Are you polychronic (preferring to do more than one thing at a time) or monochronic? Certainly most of the models produced and shown at Model Engineering Exhibitions must have been made by monochronic modellers. Which type are you, polychronic or monochronic? Is this why you never finish something before starting the next thing?

I must make the effort to change my mindset and finish a model. Life is too short to do everything but if I start now, I can accomplish something. ■



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WORKING WITH THE FACEPLATE 1

Harold Hall looks at setting up work on the faceplate.

For most workshop owners, using the faceplate to hold a workpiece is a last resort method and understandably so. Occasionally I fear, a project is even shelved rather than use this method, I know, I've done it. On the lathe, holding the workpiece can be divided into four areas, using a chuck, a mandrel, between centres or the faceplate, with the faceplate brought into service when other methods cannot satisfactorily hold the part. In some cases this will just be because, whilst it could be held in a chuck, there is not a chuck large enough. In many cases though it will be because the part is just the wrong shape for the other methods.

Deciding on whether to use a chuck or the faceplate is an infrequent decision as in most cases a chuck will be the obvious

choice. It is this infrequent use that creates a lack of experience resulting in it being an operation faced with a certain amount of trepidation by anyone other than the seasoned turner. I am therefore in this article attempting to give the reader who is relatively new to faceplate use some basic information. Also, throughout the article, I am attempting to satisfy the editor's request for simple constructional projects of an hour or two by including some relevant mini projects. What then are the problems when using the faceplate?

Faceplate, to use or not to use

Choosing whether or not to use the faceplate is an easy one in most cases, since if the workpiece cannot be held in a chuck then the faceplate is the only option. Of course, at this point you may have to

decide that the faceplate is also a non starter and some other method must be sought to machine the part. If this cannot be found then one must ask oneself is the project outside the scope of the workshop facilities. I will add here that using the faceplate will be more common in the workshop that does not possess a milling machine as the lathe will be pressed into use for surfacing some items that would otherwise be machined on the mill.

Having decided to use the faceplate, three processes have to be gone through before turning can take place, being positioning, fixing and balancing, none of which, in most cases are easy, or quick when compared to the simplicity of using a chuck.

The reader will of course realise that the faceplate will be called upon to support a multitude of shapes. Because of this, the article will be more about the methods and these will be mostly illustrated using relatively simple components as it is quite impossible to consider every possible shape.

Positioning

When using the three jaw positioning is automatic and with the four jaw it can easily be set by the adjustment that the jaws provide. Such a luxury is rarely available with the faceplate and locating the workpiece is very much a case of trial and error. To add to the problem the vertical surface means that the item being positioned has first to be clamped to hold it approximately in place. With the item lightly clamped it can be encouraged into position, typically by being tapped with a soft hammer. The clamps though being only very lightly tightened can easily loose their grip with this action and the part falls from the faceplate. It is far from an easy operation!

In view of the problems with a vertical faceplate, fixing the workpiece away from the lathe with it in the horizontal position may seem like a good idea. This though is a non starter as there is no means of determining that the part is correctly positioned, later in the article though a method of overcoming this limitation will be described.

The most common methods of determining the positional accuracy of the workpiece are by means of a centre finder, or a DTI (dial test indicator) testing some part of, or an item added to, the workpiece.

Using the centre finder

In the case of the centre finder it will be located into a centre punch mark or a centre drilled impression and the faceplate rotated by hand when any off centre error will be evident by the finder swinging in a circle. The position of the workpiece will be adjusted until the finder remains static as the faceplate is rotated and if precision is not necessary then this can be judged visually, otherwise, movement of the finder will be checked using a DTI as seen in **photo 1**.

If the reader is not familiar with this simple device it can be seen in the

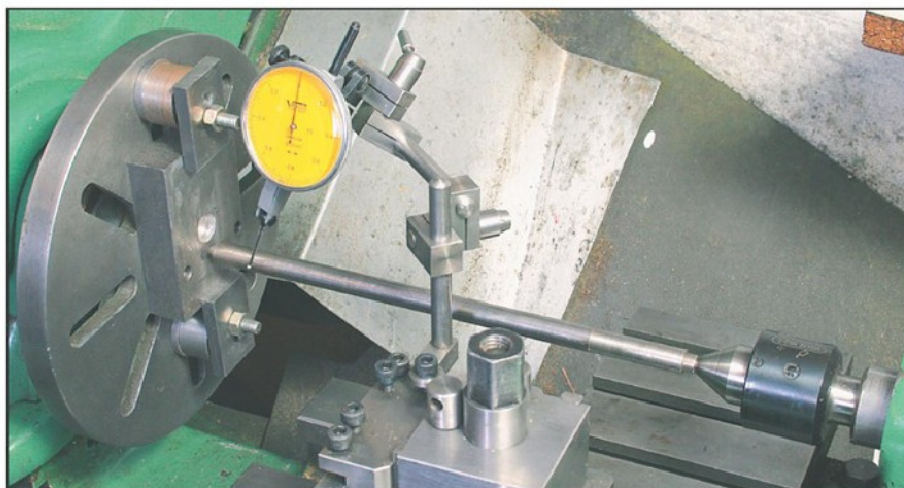
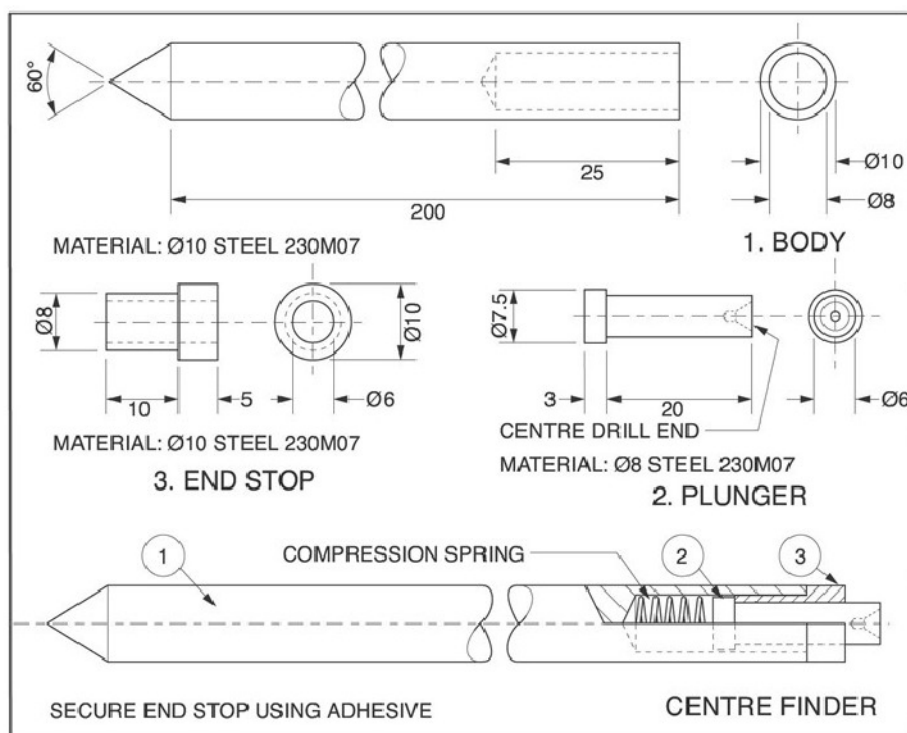


Photo 1. Using a centre finder and a DTI to position a workpiece.



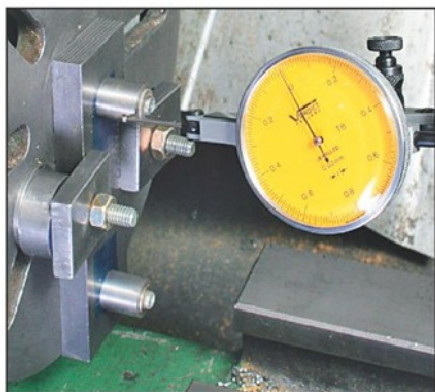


Photo 2. With two Toolmaker's buttons on the workpiece one is set true using a DTI.

photograph that it is supported between the workpiece and the tailstock centre and it is at this end that the finder has a sprung loaded drilled centre. With this compressed a little by feeding the tailstock it ensures that the working end of the finder remains firmly in contact with the workpiece as the faceplate is rotated. Similarly, it will also find a use to position parts in the four jaw chuck. If you do not possess a centre finder then this will make a simple project for an hour or so and drawings are included for this.

Using toolmakers buttons

Sometimes, the workpiece will already have a machined bore or spigot and a DTI will be used for checking that these are running true. In other cases, one or more bores will have to be made and positioned, very precisely in some cases, relative to some other aspect of the item being machined or to each other. This requirement is where toolmaker's buttons come into use.

If these are new to you then these devices are small drilled posts and made to a very precise diameter. How then are they used? Taking first the need to accurately position a single hole in a workpiece relative to some other aspect of this. The workpiece is carefully marked out and drilled and tapped where the bore is eventually to be made, normal accuracy for this process is all that is needed.

The toolmaker's button is then fitted using a screw into the tapped hole and its position adjusted so as to accurately set the location of the hole to be bored. This adjustment is possible as the hole in the button has a very generous clearance over the diameter of the screw being used. Then, with the workpiece now on the faceplate, its position can be set using a DTI so that the button runs true. It is then removed and the required bore made.

Another application is to set hole centres, say for a pair of gears. If 10mm diameter buttons are being used and the centre distance required is 87.5mm the side plates which carry the spindle bearings would be marked out at this dimension and the holes drilled and tapped; again accuracy is not critical. The two buttons would then be fitted and set across their outer diameters to 97.5mm (centre distance plus the diameter of one button). One button would be set to run true, **photo 2** then removed and the first bore made, **photo 3**. The workpiece would then be moved and the operation repeated for the second button thus ensuring that the required centre distance has been achieved.



Photo 3. The first button has been removed and the workpiece bored.

Toolmaker's buttons have precise diameters, probably within 0.002mm, but this level of accuracy is rarely required in the home workshop and they can be another candidate for a mini project, especially as it is not that easy to find a supplier. Normally, commercial items would be hardened and ground but for the limited use in the home workshop mild steel buttons should suffice provided they are treated with care.

The essential thing about their manufacture is that they should all be the same diameter within close limits, say $\pm 0.005\text{mm}$, and their base square to the outer diameter. This latter point can easily be achieved by machining both the outer diameter and end face without removing the part from the chuck. The drawing gives some suggested dimensions and I would suggest that you work to these unless you expect to work with bores closely spaced in which case they may need to be made to a smaller diameter, or make a second set. Commercially, buttons are made in sets of four with one longer than the others permitting close hole centres to be set up.

To make the outside diameters that accurate, set the top slide to nominally 6 degrees when 0.01mm feed of the top slide will feed the tool 0.001mm radially. If you are into even higher levels of precision 0.6 degrees will give an axial to radial ratio of 100:1, **Ref. 1**. When attempting to take such minute amounts off the diameter the tool will have to be honed to a very precise edge and a round nose tool is the best choice in this case as it is not required to machine up to a shoulder.

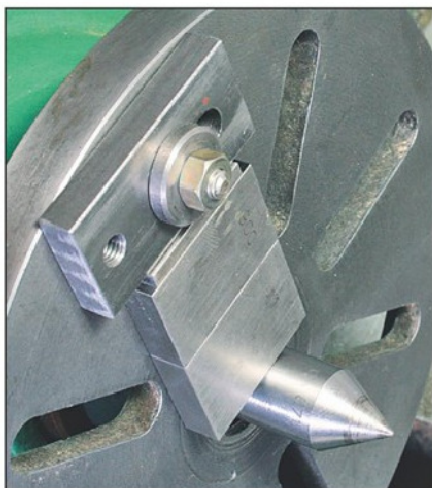
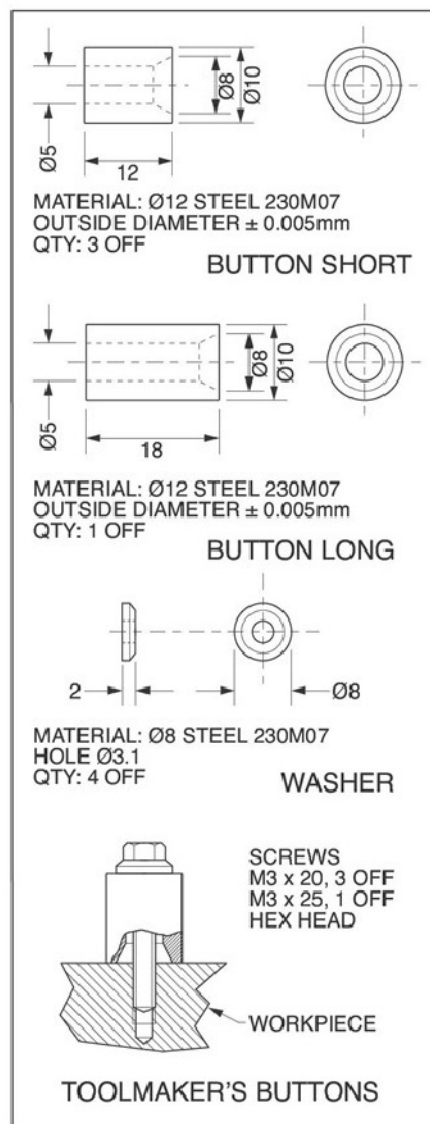


Photo 4. Setting a fence for boring a bearing block.



Using a fence

Quite often a bore or other feature will need to be accurately positioned in relation to a particular edge of the workpiece that, if straight, can be located against a fence placed onto the faceplate. This is particularly beneficial if a number of identical parts are being made. An easy way to position a fence in this way is to place the lathe's centre into its mandrel and space the fence from this using slip

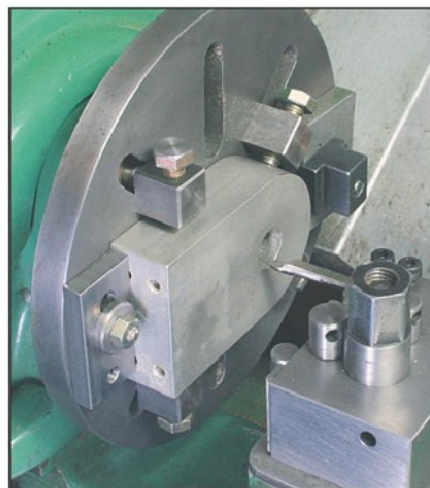


Photo 5. The bearing block being machined.

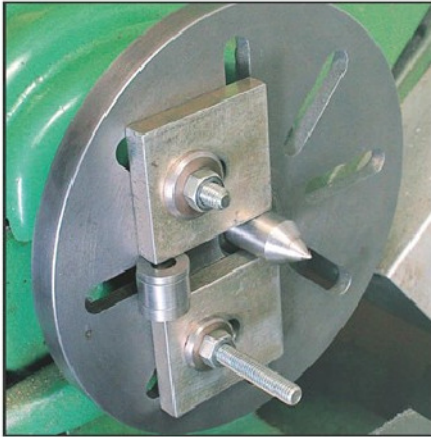


Photo 6. Setting parallel fences to support a round workpiece.

gauges or a vernier calliper, **photo 4**. The space will of course be equal to the height of the bore minus half the diameter of the centre being used. **Photo 5** shows where one of a pair of bearing blocks is being bored from the fence to locate them.

A rather more interesting version of this is seen in **photo 6** where two fences are being positioned. This is a method I often use when having to support a round component on the milling machine rather than using a V block. The spacing is not critical, only that the two faces are exactly parallel to do this. The spacers being used at the end were equal to the diameter of the lathe's centre. **Photo 7** shows a close up of the round workpiece positioned on the fences. It is particularly useful on the faceplate as it is much more compact than using a V block whilst the set up also ensured that the bore being made was exactly central across the diameter of the part, **photo 8**. If the reader is curious as to the purpose of the part this was for a mini boring head, **Ref. 2**. Reference to the article will give greater insight into using the faceplate for this boring head and is a mini article on the subject of using the faceplate in its own right.

Fixing

Fixing the workpiece is without doubt the most critical aspect of using the faceplate with size, shape, safety and security having a major impact on the problem.

Size is probably the least of the problems with this only surfacing with larger components. However, a large size component is not always a problem as **photo 9** shows.

Shape can though be a major problem especially if also a large size but unfortunately I have disposed of my 2000 plus workshop photographs due to it being almost impossible to index them and I have no examples to illustrate this. However, readers with issue 21 could look at photo number 14 on page 49 for an excellent example.

Safety is perhaps the least considered aspect of using a faceplate and this is a major oversight. The most important consideration is the very irregular shape of the final assembly which when run at speed is a considerable safety hazard. Whilst an irregular shape cannot be avoided some simple measures can minimise the dangers, for example, fixing studs and screws which if too long will project out from the assembly

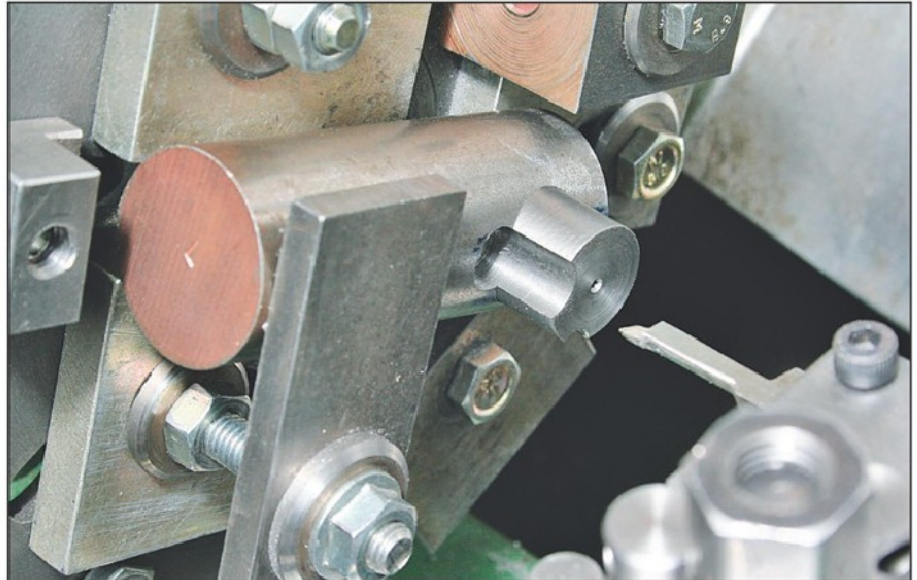


Photo 7. Close up of the round workpiece supported by the parallel bars.

unnecessarily should be avoided. Do try to use appropriate lengths, even cutting them down in length to limit the danger.

Where screws or studs are only marginally too long, lose the extra length by allowing the stud/screw to project from the rear of the faceplate. Of course, there is a limit to how much can project at the rear before it fouls with the lathe's headstock. This highlights the need to always rotate the assembly by hand before running the lathe under power. Such a test is not just restricted to the rear

of the faceplate. Similarly making sure that larger items do not contact the bed or the inside of the gap with a gap bed lathe is equally essential.

Not easy to fully check without powering the lathe is the clearance between the topslide and the faceplate assembly when a bore is being made. Where the clearance looks as though it is a border line case do stop the lathe periodically to check if the clearance is remaining OK. Also consider the effect of the top slide being moved radially as the bore size increases.

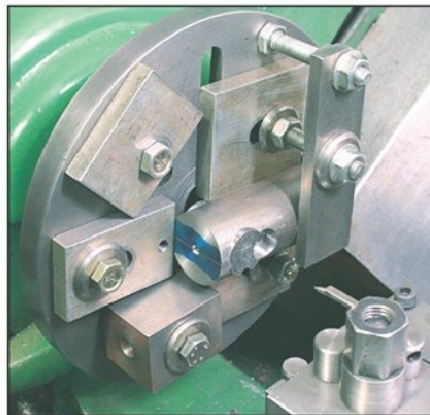


Photo 8. The component being bored. The set-up ensures the bore is central across the diameter.



Photo 9. Not all large components are difficult to fix as this photograph of a flywheel being machined shows.



Photo 10. The faceplate clamp components. The small raised portion of the packing piece has been marked with marking blue to highlight its position.

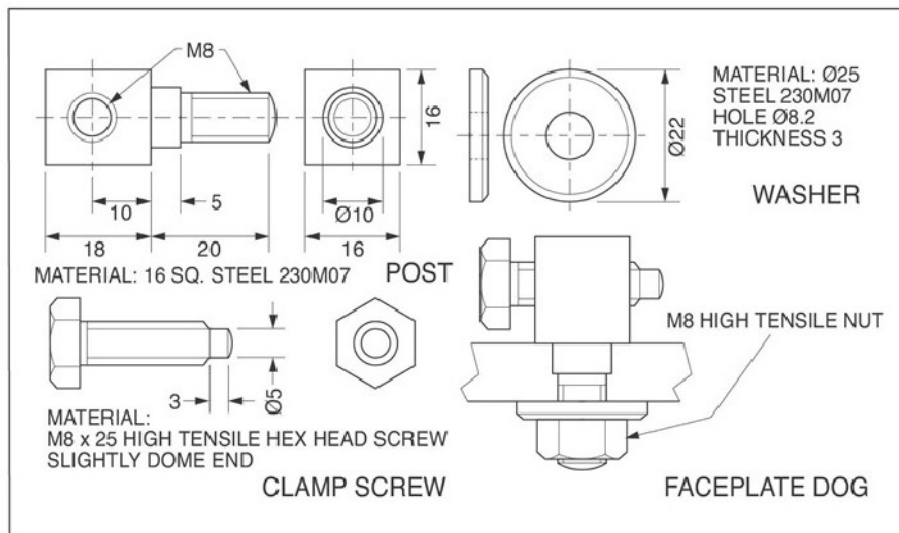
Having stated that stud lengths should be reduced to the minimum, oversize clamps will also increase the hazard. There will be a temptation to use the same clamps as used on a smaller milling machine and of course in some cases this will be perfectly satisfactory. However, the limited size of the lathe's faceplate can leave very little room for adding the required clamps, and making some smaller clamps specifically for use in this situation is all but essential.

In most cases, a clamp assembly will also include a piece of packing under the non workpiece end to ensure that the clamp contacts the workpiece in a satisfactory manner. This being with the packing just higher than the workpiece ensuring it is gripped by the tip of the clamp. The height being quite critical there is a temptation to make up the packing with a number of pieces and whilst just OK on the machine table this is taboo on the faceplate in terms of safety and practicality. Try holding a pack of packing pieces, the workpiece, the clamp and a spanner to tighten the assembly, it's just not on. The process is difficult enough without making it even more so.

Another major consideration regarding the packing is that it should itself be secured, that is, not relying on the clamp to hold it in place. The reason for this should be obvious as should the clamp become loose whilst the lathe is running the packing will be thrown with what could be devastating results, particularly if the lathe is running at high speed. Such a situation is not unknown especially where the machining operation is intermittent.

This leads me to introduce a clamping system that I designed and was published in an early issue of the magazine, Ref. 3. I am loath though to go into detail regarding these as I have mentioned them quite a number of times since but they do overcome many of the problems with clamping parts onto the faceplate. Of all the things that I have developed this one must be at the top of the list for making a very difficult situation relatively problem free. The main feature is that as the packing is threaded and is first secured by the clamp screw. This can then be used with a nut to clamp the workpiece using a clamp bar. Secondary packing pieces are made with clearance holes so that the height of the packing can easily be adjusted.

The main benefits of the system are compactness, secure packing and ease of use, the latter point due to the clamp

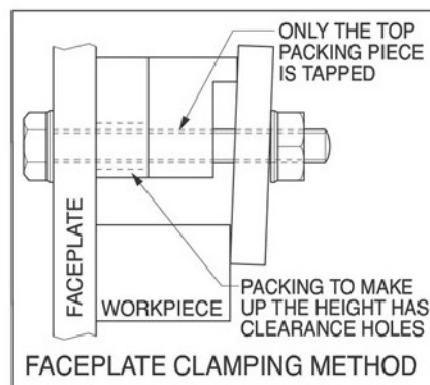


screw being made secure before needing to clamp the actual workpiece. The parts are seen in **photo 10** and the drawing shows the basic assembly. They can be seen in a number of the photographs throughout the article. These would also make another and very worthwhile mini project but realise that some readers may not have copies of the magazine that far back. In this case, if the reader goes to my web site Ref. 4 and leave a request for details I will send a copy, or maybe add the details as a page on the website. For the reader who does not have access to the Internet send a request in a stamped envelope to the editor who will I am sure then forward it to me.

Faceplate dogs

Whilst using the simple bar clamp is probably the first choice and the one most often used, there are other methods. The simplest of these are the small faceplate dogs. Drawings for these are included in the article and making these would provide a simple project to occupy an hour or two. These are ideal for squat workpieces and have the advantage of being easily able to make small changes to the workpiece position. **Photo 5** showed an excellent example of their use.

However, I do use the term squat with good reason, as a part that projects appreciably from the dogs could easily be pulled from them with the machining processes, especially if intermittent



Having dealt in this issue with using the simple bar clamp and faceplate dogs for securing the workpiece, in the next issue we will cover other methods and go into detail of further aspects of working with the faceplate including balancing the assembly.

To be continued.

References

1. For method of setting the top slide to 0.6 degrees see MEW issue 72 page 28 or Workshop Practice series book number 34, "Lathework a Complete Course" page 56.
2. A Miniature Boring Head. MEW issue 126 page 12.
3. Faceplate clamps, MEW issue 20 page 24, very worthwhile update issue 25 page 67.
4. My web site www.homeworks.co.uk/

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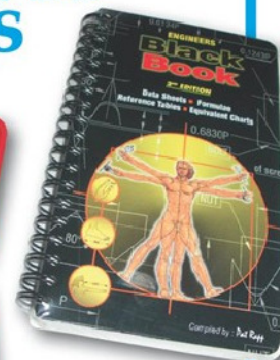
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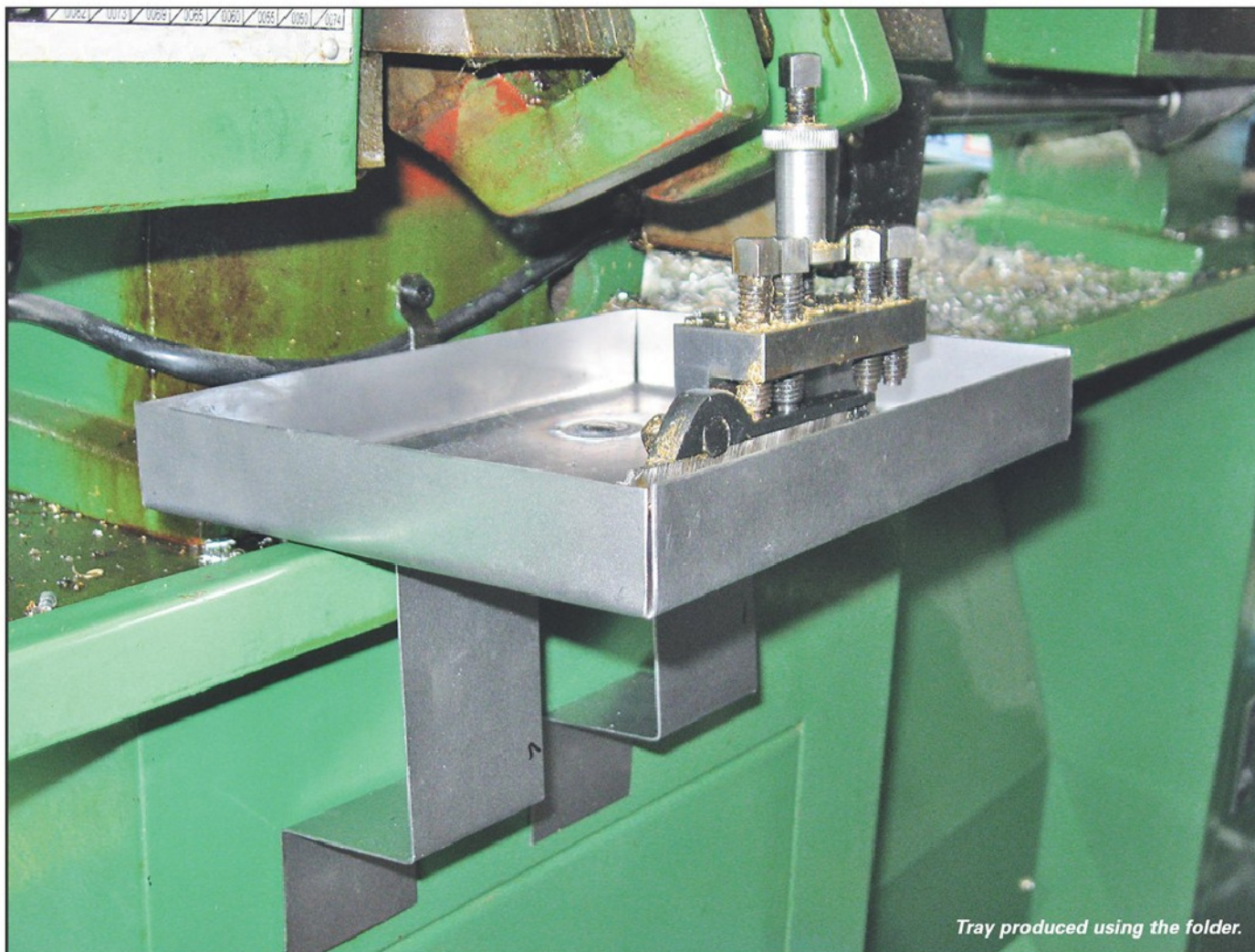
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READERS' SURVEY PRIZEWINNERS





SHEET METAL FOLDER

Jayne Reeve makes a simple sheet metal machine.

This is a slightly more complicated project this time which as well as welding equipment will also require access to a lathe. The folder was designed to be constructed from the 25 x 25 x 2.5mm angle iron left over from the welding trolley project and so is small in size and consequently folding capacity. 1mm thick mild steel is about the maximum it can handle. As the closest I've previously come to a metal folder is a picture on the internet, I had a little think and this is what I came up with. I can't comment on how this design compares with other variations but it does fold bits of metal. The final design has moveable pivot points; their height can be adjusted to accommodate different material thicknesses and bending radii. The design is pretty basic and could be scaled up if required, but I'd recommend building a small one first and having a play with it. The experience will highlight any weaknesses in the design and construction methods used and allow you to decide on any refinements/adjustments that can be implemented to produce a folder better suited to your own particular needs.

Materials

Folder Body:

- All 25mm mild steel equal angle, 2.5mm thick.
- 1 off 300mm
- 3 off 250mm
- 2 off 50mm

Pivots:

- 4 off 25mm x 17mm x 2.5mm mild steel (can be cut from the steel angle or flat stock)
- 16mm dia. mild steel bar (of a grade suitable for welding)
- 12mm dia. bar, either silver steel or mild steel
- 6mm dia. bar, again either silver or mild steel

Construction

The main body consists of one 250mm length and the 300mm length of steel angle. 'Black' mild steel as used here will require a little surface dressing on the outer faces. Running a file over the

surfaces until they feel smooth will suffice but they won't look nice and shiny. If you have access to a milling machine a light cut could be taken from the faces and if you're feeling flush 'bright' steel angle is available but is considerably more expensive. While you have the file out, file a small radius on the outer corner, again until it feels smooth to the touch, Fig. 1. Cut slots in the ends as shown in Fig. 1 and photo 1. These can either be cut by hand using a hacksaw and a file or you could set it up on a milling machine and machine the slots in place. There is no great requirement for accuracy as these slots merely provide clearance.

Originally I had envisaged that the handles (for ease of construction) would be fitted at 90 degrees to the main body, hence photo 1 shows these with square ends. During construction I decided to change this to a 45 degree mounting. Photo 2 shows the handles with the ends machined to facilitate this. Again these can be cut by hand using hacksaw/file/angle grinder etc.

The pivots consist of four 25mm x 17mm x 2.5mm flats and four 'tubes' machined from 16mm dia. bar. The flats were made from the steel angle by cutting 17mm lengths and then hacksawing a 'leg' off. The 'stump' can then be filed, ground or



Photo 1. Folder component parts.

machined flush. Alternatively you could make these from flat stock. Again dimensions are not critical. The tubes were made on a lathe from 16mm bar drilled through 12mm and parted to length. If you have a reamer of the appropriate size you could drill and ream these but an acceptable bender can be made without recourse to reaming so don't go out and buy one specially for this job (unless you need an excuse to buy more tools!). Ideally the fit between the tube and the 12mm dia. pivot pin needs to



Photo 2. Handles, showing end detail.

be an easy sliding fit, not too tight and not too wobbly! I used 12mm silver steel for this as I had some to hand and it is of course of a consistent and accurate diameter. For this application 12mm bright mild steel would probably be an acceptable substitute as its diameter is usually consistent within a few hundredths of a mm. You could of course turn suitable diameter pivots pins from bar stock. Drill through 6mm. Again you could drill undersize and ream to 6mm if you have the tools available. The last parts, the two 6mm dia. pointed pins are to aid setting up and construction. Length and point angle are not critical but a nice sliding fit is desirable. As before these could be made from 6mm silver steel, 6mm BDMS or turned to suit. **Photo 1** shows all the component parts.

Now we start with the welding, pivot components first. On the small plates mark the hole positions and drill through,

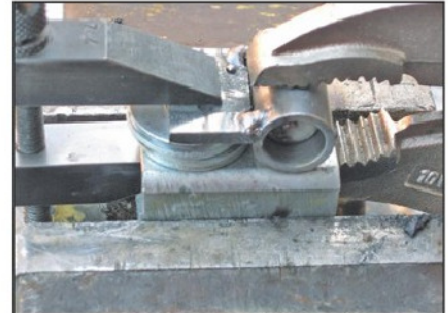


Photo 3. Welding the pivots.

choosing a drill diameter to match that of your centre punch (3mm in my case) as the finished pivots will be used to transfer the hole positions to the main body at a later stage. **Fig. 1** shows the packing piece required to correctly position the plate and tube for welding. **Photo 3** shows how this was achieved using washers to provide the correct height and mole grips and a

Fig. 1 Folder Component Parts

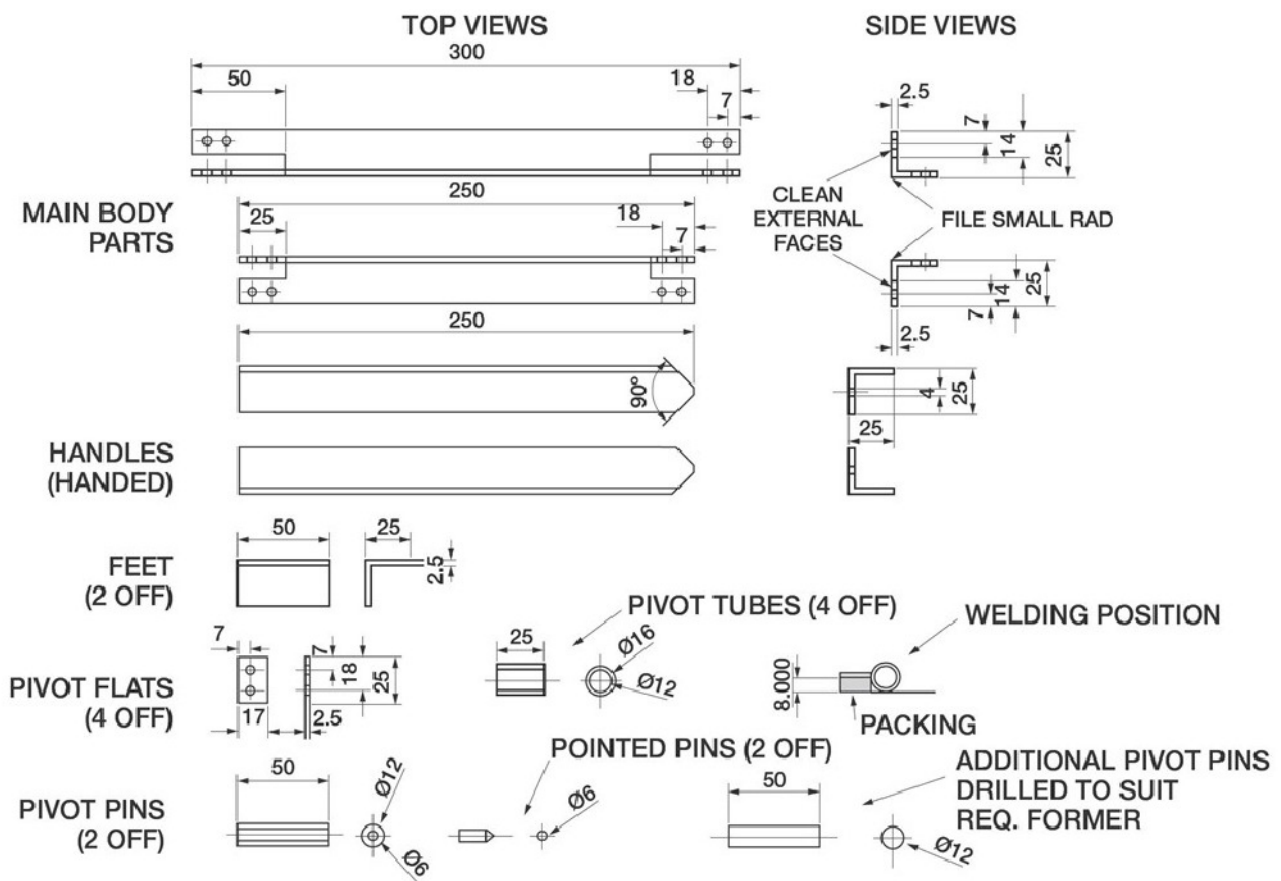




Photo 4. Pivots after welding.



Photo 5. Aligning pivots on folder main body.



Photo 6. Pivots mounted to main body.



Photo 7. Aligning feet for welding.



Photo 8. Aligning feet for welding again!



Photo 9. Mounting handles to main body

toolmakers clamp to hold everything in position whilst it is welded in place. Wait until it has cooled before turning over and welding the other side. This will require a packing piece of 5.5mm if 2.5mm thick plate is used, adjust to suit if different thickness material is used. **Photo 4** shows two completed pivots. The welds have been dressed with a gentle application of angle grinder and flap disc to a concave shape. Once all four have been completed, tidy up the 12mm bore so that the pivot

pins fit easily and assemble the two pivots. Hold the two main body members in a vice so that their top surfaces are flush and their pivot clearance slots are suitably aligned. Now clamp the pivots in place as shown in **photo 5**. Use the 6mm pointed pin to aid alignment. The centre of the pivot should line up with the junction between the two main members as in **photo 5**. The pivots are offset so make sure they are the correct way up. Once everything is lined up use a centre punch

to mark the required hole positions on the main members, also mark up which pivot is bolted to which member (you can just see the numbers in **photo 6**) so that they can be reassembled in the same position. Remove the clamps and drill the holes in the main members, and open up the holes in the pivots to just allow M5 set screws to pass through.

The pivots can now be bolted in place using suitable hardware, **photo 6** and the 6mm pointed pin to check alignment.



Photo 10. Test pieces produced using the folder



Photo 11. The folder in action producing a sharp bend

Check that the folder pivots freely. A bit of fettling may be required to the edges of the pivots to allow this. Unbolt the pivots again ready for the fitting of handles and feet.

The feet are made from 50mm lengths of angle as shown in **photo 7**. The corner has been relieved to make sure that they don't interfere with the pivots. A tickle with the angle grinder soon achieves this. **Photos 7 and 8** show the 300mm main member and the feet clamped in place (using suitable packing) ready for welding. The handles are welded to the 250mm member, **photo 9** shows one of the handles positioned at the correct angle for welding using a magnetic clamp. Try to get a couple of good welds on the inner faces of the handle (although access is a little difficult), and then run a nice weld bead in the Vee formed by the handle and the folder body.

Folder operation

Clamp the folder to the edge of a bench using the feet. The folder can produce radiused or sharp corners depending on the former used. **Photos 10 and 11** show a 6mm dia. bar used to produce a radiused corner and an offcut of steel angle used to produce a sharper edge. Note the mole grips used to hold everything in place for the sharp edge bends. For radii, the former holds the material in place and additional clamping is often not required. The 6mm former is a length of silver steel fitted into the 6mm holes drilled into the pivot pins. Different radii can be produced by making pivot pins with the required bore and using a length of bar of the correct diameter as the former. For each bend, the pivot height needs to be set according to bend radius and material thickness, see **Fig. 2**. So for a 3mm radius (6mm former) in 1mm thick material, 4mm spacers need to be fitted between the pivots and the former body. I've cheated and used combinations of washers to get the pivot point at the correct height. A more permanent solution would be to machine a range of spacers for commonly used combinations of former and material thickness. The 6mm bore pivot and pointed pin combination can again be used to check alignment when bolting up the pivots after spacers have been fitted if required. **Photo 10** shows a couple of 1mm thick test pieces produced using

Fig. 2 Folder General Assembly

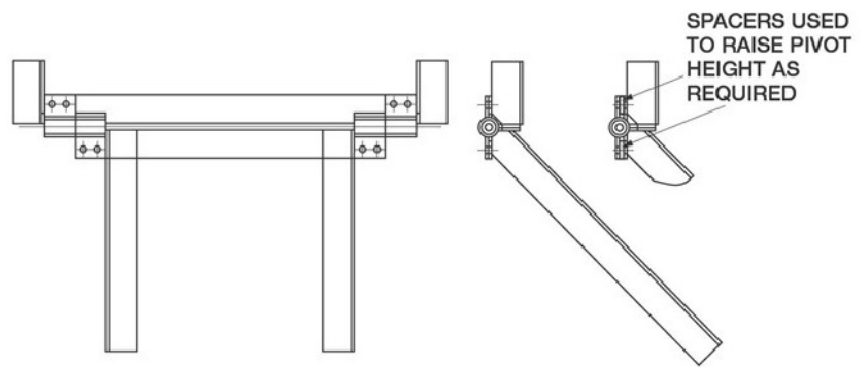


Photo 12. The completed folder.

the former. The eagle eyed amongst you will have noticed that the cap head screws used in earlier photos have been replaced. There are two reasons for this, one the cap heads I had weren't long enough to accommodate the spacers required and two, on the moving half

of the folder the pivot fixing holes have been modified to accept countersunk head screws which allow for a greater angle of bend. **Photo 11** shows the folder in use.

Photo 12 shows the simple construction of the finished folder. ■

Last month's engine model and the components built in part two. Quite realistic images can be created with good lighting and suitable object materials.

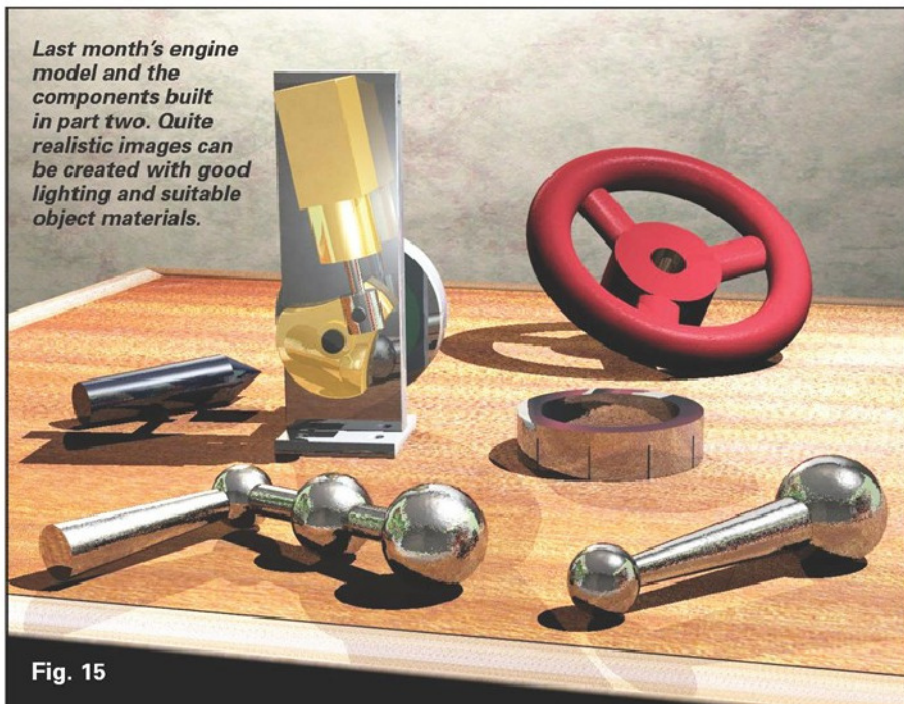


Fig. 15

FIRST STEPS IN DESIGN 2



Linton Wedlock looks at creating realistic images, further modelling with polyhedrons, and using object axes

Three main factors determine the look of rendered 3D images: the rendering settings themselves, scene lighting, and the materials assigned to the model's objects. Although these important topics won't be covered in great depth in this series, this second part introduces them, enabling you to make your models look more realistic.

Rendering

Last month, two trueSpace functions were used to produce images of scenes and objects: [Render Scene] and [Render Current Object]. A useful third tool, [Render a portion of the screen], Fig F (Figs A-H are in part one), is used by clicking the icon, then clicking and dragging the mouse over one or more rectangular areas on the screen. In addition to these three tools, which render images to the screen, you can also save images with [Render Scene to File], Fig F. Section 7.3 of the help file has more details on all these tools.

TrueSpace has a large number of rendering options which you can use to alter the appearance of images. Some possibilities include producing hidden line drawings, smoothing object edges (anti-aliasing), or using fog, snow and lens flare effects. These options are all selected from the **Render Toolbar**. This is collapsed into a small square in the top-right corner of the workspace, Fig A, but will be

displayed if you move the mouse pointer over the square. If you want to find out more about the rendering options, the help files, section 7.3, describes them in depth, so I won't cover them further except to mention the **Background Shader Effects**.

The background of a rendered image is the area not occupied by the 3D model. In the last four images shown at the end of part one, the background is a dark blue-grey colour. As an alternative to plain colours, you can also choose graduated colours, cloud effects, or incorporate graphic images and photographs. These are the relevant icons from the pop-up in the Render Toolbar:

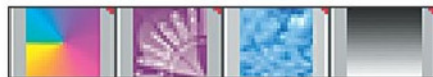


Fig. 16

Changing the background is a simple procedure and can make a big difference to a rendered image's appearance. For example, to change the background colour, do the following: Right-click [Background Effects Shader - Color]. The left-hand panel below will appear:



Fig. 17

This is a standard colour selection panel which is used many times in trueSpace. Click the mouse in the hexagon to choose a colour (white is in the centre), and adjust the slider to alter the brightness. If you right-click this panel, a further panel, shown on the right above, is displayed which allows you to specify a colour precisely by clicking the sliders or by typing in new values. Try altering the colour with the panels and click [Render Scene] to see the change in the background. The [Background Effects Shader - Graduated] and [Background Effects Shader - Clouds] functions work in a similar way to the background colour tool except that two colours are chosen; Right-click either of these tool icons, then in the displayed panel, click each colour button to get the colour selection panel.

The [Background Effects Shader - Image] tool can have an even bigger impact on a rendered image. Click the tool's icon, then right-click it to get the Background Image Panel. Click the blank button in the panel, and in the Background Image Browser Panel, double-click any of the thumbnails, then use [Render Scene] to see the result. Have fun trying several of the supplied images! If you have your own graphic images or photographs on your computer, try using these as backgrounds by loading them with the Browser Panel. Photographic backgrounds are an easy way of adding realism to rendered images. In 3D work, graphic images and photographs are commonly referred to as **Textures**.

Here is last month's engine model with examples of each of the four background effects:

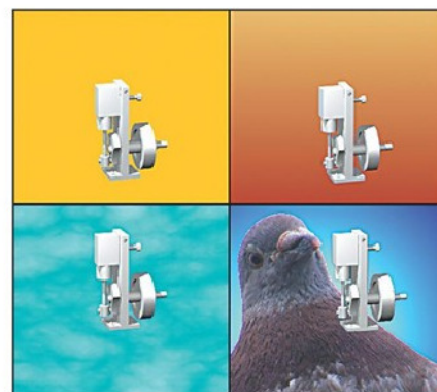


Fig. 18

Lighting

Good lighting makes a big difference to rendered images. 3D model lighting has a lot in common with lighting in photography, and similarly it's a skill that takes time to acquire. For engineering use, though, artistic scene lighting is usually not so important, and in many cases a simple light setup will be satisfactory. I will describe just one such setup, but you may care to explore lighting in more depth by looking at the Help File, section 7.2.

Start with a clear workspace by clicking [Create New Scene], Fig H. You will get a message asking if you want to save the current scene. If you want to save the scene, click 'Yes' and use the 'Save Scene' Panel. (You can if you like click 'Cancel' and save the scene with the method shown in the 'Libraries' section last month). First, for the new scene, turn off the Magic ring function using the 'TS6Files' and 'Preferences' menus, as

described last month. The 'Automatic' option was also selected last month, but this time keep the 'Scalable' option to see a different method of creating polyhedrons. For this demonstration, only a simple model will be used to observe the effect of the light setup, so click [Cube]. The cursor will have a small yellow cube to show that the Scalable feature is active. Click the left mouse button anywhere in the workspace and drag the mouse to adjust the X and Y sizes of the cuboid (rectangular block) that is created. Without releasing the left button, click the right button and you can change the cuboid's Z size. You can continue resizing the object as long as at least one button is held down. Click and drag the mouse to create a few more shapes. With the Scalable feature selected, the cube tool (and other polyhedron tools) will remain active until another trueSpace tool is selected. This is different from the Automatic option, where only one cube is created for each click of the [Cube] tool. Alter the viewpoint to see the cuboids from different angles, and you will see that the shapes have all been created with their base on the grid.

The first step in this lighting demonstration will be to eliminate the existing lights from the scene. First, click [Direct 3D Solid Render Display], Fig F, if this display mode is not already selected. If the Object Info Panel is not visible, right-click [Object Tool]. Click the arrow button next to the Name field in the panel, and you should see a list of the scene's objects consisting of several cubes and lights. Select each light name in turn and press the Delete key to remove the light from the scene. As you do this, note that the cuboids get progressively darker. When all the lights have been erased, click [Render Scene] and you will see that the objects are black because there is no (virtual) light to illuminate them. The background, however, has not changed because this is not an object and is unaffected by the scene lighting.



Fig. 19

Now to create a simple coloured light setup. Click the [Local Light] tool; this is the second icon from the bottom in the lights pop-up in the Model Toolbar, Fig B. Add a Local light to the scene by clicking the mouse anywhere in the workspace. Additional lights could be created in the scene with further mouse clicks (because the Scalable feature is active). For this demonstration, only one light will be used and then copied twice to make a total of three lights, so click [Object Tool] to exit the [Local Light] function. The new light is now the Currently Selected Object, but note that lights, unlike other objects, do not have an Object Navigation Control

around them. Position the light by typing these values in the Object Info Panel: [XL8.0/YL0.0/ZL2.0].

When a light is selected, a Lights Panel will be displayed. This is similar to the colour setting panel examined earlier, but has extra icons for specifying (among other things) if the light will cast shadows or not, and how the light intensity will diminish with distance. The light parameters can be set precisely by right-clicking the panel. In the new panel displayed, change the intensity value to 1.2. Now create a second light with [Copy] and change these values:

[XL3.0/YL-1.0/ZL8.0],
Hue:30, Saturation:0.65.
[Copy] again, and:
[XL-4.0/YL6.0/ZL3.0],
Hue:198, Saturation:0.964.

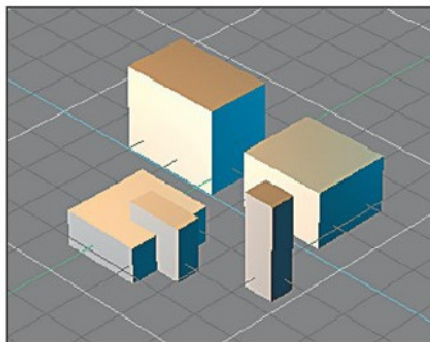


Fig. 20

I will use this light setup often in this series because it enhances the 3D appearance of objects; It also makes the printed images a little more colourful! If you want to save this light setup, first click the [Light Library] icon, the third icon down in the Library Toolbar, Fig A. A panel with many light setup thumbnails will appear. Right-click the panel and select 'Insert'. The scene's light setup will be stored in the library with the name 'Untitled'. Right-click this thumbnail, then select 'Rename' (under 'Item', not 'Library'), and type a name such as 'FSteps1' (Enter). With the light setup now saved, you may like to tryout some of trueSpace's many supplied light arrangements. Simply pick one of the thumbnails from the Light Library Panel, then click [Render Scene] to see the effect. To return to the saved coloured light setup, click its thumbnail in the panel.

Besides Local Lights, TrueSpace has eight other light types. Some of these require a certain amount of technical knowledge to use fully, but you can still do a lot with three of the simpler types - Local Lights, Infinite Lights, and Spot Lights. The difference between these three light sources is that Local Lights are like light bulbs, shining light equally in all directions, Infinite Lights illuminate all parts of a scene at a fixed angle (like the light from the Sun), and Spot Lights project a focussed beam of light, illuminating a small area. All the trueSpace light types are explained more fully in the Help File, section 7.2.2.

In the light setup described above, the three lights were positioned by typing X, Y and Z values in the Info Panel, but as lights rarely need precise locations, it is usually quicker to move them with the mouse. Left-click and drag on a Local Light to move it in the X and Y directions, right-

click to alter the Z position. Spot Lights can be both moved and rotated, depending on which part of the light is dragged. Infinite lights can only be rotated with the mouse (its position in the scene is unimportant), but you can still type X, Y and Z Info Panel values to move it away from scene objects.

Object materials

All objects so far have been created with the default trueSpace material - a pale grey, non-reflective surface. Materials are a set of attributes (colour, roughness, transparency etc.) that define how objects will look when rendered. New materials can be created by choosing their properties, and a future article will show how this can be done. For now, you can experiment with trueSpace's included sample materials, and the next demonstration will show an example of assigning materials to a scene's objects.

If you like, save the current scene, then load last month's engine model with these steps: Click [Scene Library] in the Library Toolbar. Right-click the panel and select 'Load'. Pick 'First Steps' (or whatever name you chose) and 'Ok', then click the engine model thumbnail (select 'No' in the Scene Changed message panel).

Now click [Material Library], fourth icon down in the Library Toolbar, right click the panel, then 'Load', and chose 'Metals3' and 'Ok'. To assign one of the metal samples to an engine component, simply click a material thumbnail and drag the mouse to the chosen object, then release the mouse button. Experiment by applying the different metal samples to the engine and then click [Render Scene] to see the effect. You can also try rearranging the lights (zoom out of the scene to see them all), or adding new lights. I have used Brass, White Gold, Silver and Vanadium material samples in this image:

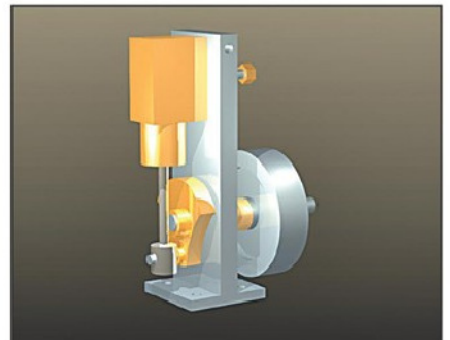


Fig. 21

The techniques looked at this month, while not yet comprehensive enough to produce photorealistic images, will still give a reasonable impression of how engineering models will look when actually built. A later article in the series will have some further methods and hints for increasing the realism of images, but for the rest of the article, I will return to 3D model building.

Modelling with polyhedrons

The engine model was built entirely with two types of polyhedron - the cube and the cylinder. These simple shapes, generally comparable to objects produced by milling and turning operations, can be used to construct substantial parts of many engineering models. With trueSpace's

other shapes - the sphere, cone and torus, you can indeed do extensive 3D modelling with polyhedrons alone. As this is such a fundamental skill, I will give a few more examples of using polyhedrons to create a variety of simple components.

Ball crank

Save the engine model scene, and click [**Create new scene**], Fig H. Using the 'TS6Files' and 'Preferences' menus, change the 'Scalable' option back to 'Automatic' (Magic Ring should still be unchecked). Right-click [**Sphere**], Fig B, to get its property panel. You can see that the sphere (like the cylinder) has settings for **Latitude** and **Longitude**. Before continuing with the Ball Crank, you may like to click [**Sphere**] several times, experimenting with different latitude and longitude values. Small numbers produce some interesting shapes, but which probably have limited engineering use. Large values will give smoother surfaced spheres. It is best to use latitude and longitude values which are multiples of four if you want to manipulate true spheres (and longitude values of cylinders, cones and tori too). If this condition is not met, the differing X, Y and Z sizes may generate small modelling errors. While experimenting with spheres, their structures are best seen with [**Wireframe Display**], Fig F, active.

Erase any spheres. Set **Latitude** to 12 and **Longitude** to 24, and click [**Sphere**]. Change the following parameters in the Object Info panel:

[XS1.5/YS1.5/ZS1.5]

(X, Y and Z sizes set to 1.5 centimetres).

Press [**Copy**] and change:

[YL2.5/XS1.8/YS1.8/ZS1.8]

[**Copy**] again, and

[YL2.5/XS1.2/YS1.2/ZS1.2]

If the Cylinder property panel is not visible, right-click [**Cylinder**]. Set

Longitude to 16, click [**Cylinder**], and [XR90/XS0.6/YS0.6/ZS5.0]

Next, another cylinder is added to make a handle. This time, though, the cylinder is created with tapered sides, turning it into a truncated cone shape. This is achieved by changing the Top Radius setting in the cylinder property panel. Set the **Top Radius** to 0.5, then [**Cylinder**], and change: [YL2.5/ZL3.0/XR180/XS1.0/YS1.0/ZS4.0]

Finally, the five shapes are all combined together. Select the central sphere, and [**Object Union**], Fig B, it with the other four shapes (the location of the first object selected in a union or subtraction operation will become the location of the resulting object). Click [**Object Tool**] to exit the union function, then click [**Render Current Object**] or [**Render Scene**] to give:

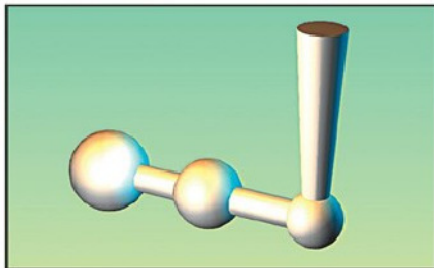


Fig. 22

Individual objects can be saved in trueSpace, allowing them to be reused in other models, and you may like to save the Ball Crank before continuing with the next

example model. First, type in a name in the Object Info Panel ('Ball Crank' perhaps) and press Enter. Click [**Object Library**], sixth icon down in the Library Toolbar, Fig A, then right-click the panel and select 'New'. Right-click the new empty panel, select 'Rename', and type 'FS Objects', or other name. Check that the Ball Crank object is selected, then right-click the Object Library panel, then 'Insert'. The object is now stored in the library, and has the same name as that typed in the Object Info panel, but with a number (0 in this case) appended. To reuse a stored object, simply drag it from the Object Library panel to any position in the workspace, many times if you want (or click it to create one in its original position).

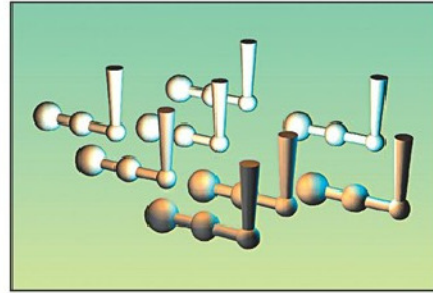


Fig. 23

Ball Lever

Erase any objects, and click [**Sphere**] with **Latitude** 12 and **Longitude** 24 (I will use the abbreviations **LAT** and **LNG** from now on). [**Copy**] the sphere and change:

[YL5.0/XS1.2/YS1.2/ZS1.2].

In the Cylinder panel, set **LNG:16** and **Top Radius** to 0.5, click [**Cylinder**], and [YL2.5/XR90/XS1.0/YS1.0/ZS4.0].

Select the first sphere and [**Object Union**] it with the other objects. Rotate the whole shape with [XR20]. Next, to create a flat face on the base of the lever, click [**Cube**], and set [ZL0.6]. Select the lever, and then use [**Object Subtraction**] on the cube. With [**Render Current Object**] you should have:

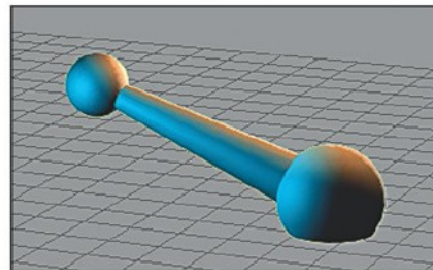


Fig. 24

Type an appropriate name in the Info Panel, and Save ('Insert') the lever in the Object Library Panel (this component will be used again in a later modelling example).

Handwheel

The **Torus** polyhedron, having the same shape as a ring-doughnut, is not often used in engineering, but here is one example.

Right-click on [**Torus**], Fig B. In the Torus property panel, in addition to Latitude and Longitude values, there is also an **Inner Radius** setting. This parameter is not always the most convenient way of specifying the proportions of a torus, and a small calculation is often needed to find the Inner Radius value. In the next modelling example - a Handwheel - this was done as follows: I chose an outer

torus diameter of 80 mm and a thickness of 12 mm. The inside diameter is therefore $80 - (2 \times 12)$, or 56 mm. The Inner Radius value is found by dividing the inside diameter by the outside diameter. In this case, $56/80$, or 0.70. Type this value in the Torus property panel, and set **LAT:24**, **LNG:60**. Click [**Torus**] and change:

[ZL0.0/YR90/XS8.0/YS8.0/ZS1.2]

(A quick way of changing the three sizes is to multiply the original values times 4, by typing *4 Enter after each of them).

For the Handwheel Boss, select [**Cylinder**] with **LNG:40** and **Top Radius** reset to 1, and:

[XL1.2/ZL0.0/YR90/XS3.0/YS3.0/ZS2.0]

[**Copy**] this cylinder, and [XS1.0/YS1.0]. Subtract this second cylinder from the boss to create a bore.

Next, three radial arms are created with flattened cylinder shapes. Click [**Cylinder**] with **LNG:16**, and

[XL0.3/ZL2.2/YR15/XS0.6/YS1.2]

[**Copy**] this shape and change:

[YL1.905/ZL1.1/XR120]

[**Copy**] again, and

[YL1.905/XR120]

Select the Boss, and [**Object Union**] it with the arms and torus.

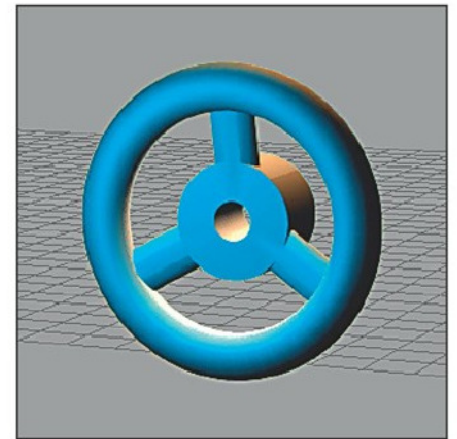


Fig. 25

Lathe Centre

This simple component introduces the use of the **Cone** polyhedron.

Save the Handwheel object and then clear the workspace. Display the Cone property panel by right-clicking [**Cone**], Fig B. This shape, like cylinders and spheres, has latitude and longitude parameters. To create the Lathe Centre's tip, set **LNG:24**, click [**Cone**], and change:

[ZL0.52//XS1.2/YS1.2/ZS1.04]

(The base diameter is 12 mm, and the height is the radius x $\tan 60^\circ$).

For the Centre's shank, set **LNG:24** in the cylinder property panel. The **Top Radius** value is calculated as follows: This is a 1MT centre, which has a taper of 0.05 per unit length. I've chosen a shank length of 36 mm, and the difference between the end diameters is 36×0.05 , or 1.8 mm. For a large end diameter of 12 mm (the same as the cone base), the small end diameter is $12 - 1.8$, or 10.2 mm. The Top Radius value is the small diameter divided by the large diameter, $10.2/12$, or 0.85. Type this value in the Cylinder property panel, click [**Cylinder**], and

[ZL1.8/XR180/XS1.2/YS1.2/ZS3.6]

To complete the centre, select the tip, and [**Object Union**] it with the shank. Rotate the object with [XR90], and click [**Render Current Object**] to give:

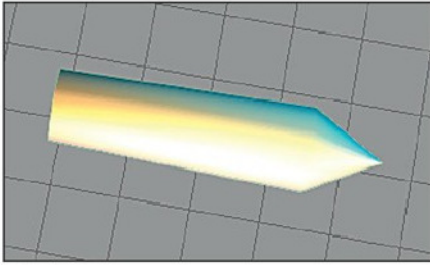


Fig. 26

Object Axes

In all the example 3D models shown so far, every starting polyhedron has been manipulated using its default reference point which is at the shape's centre. In many cases, however, a lot of arithmetical calculations can be saved, and the modelling generally simplified, by adjusting the position of the reference point before modifying an object itself.

The reference point is defined by the position of the object's own set of axes, and these **Object Axes** are completely separate and independent from the World Axes. Unlike the World Axes, Object Axes can be made visible and altered just like any other object. Try the following: Erase any objects in the workspace, and click **[Cube]**. Notice in the Object Info panel that the X, Y and Z location values are 0, 0 and 1 respectively. This is the cube's default reference point, and is at its geometric centre. With **[Wireframe Display]** selected, click the **[Axes]** tool, **Fig B**. Zoom in close to the cube, and you will see a group of three perpendicular lines with the letters x, y, and z. These are the cube's Object Axes, defining its reference point (I've changed the cube and axes colour to make them stand out in the next picture).

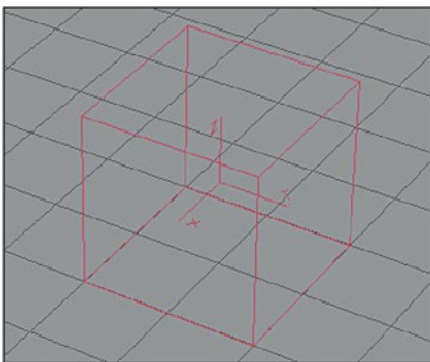


Fig. 27

When the Object Axes are visible, the values in the Object Info panel are those of the axes itself, and changing the values will alter the axes, not the object. The axes can also be moved and rotated with the mouse. Select **[Object Move]**, **Fig D**, and click and drag the mouse pointer in the workspace to alter the axes position (left mouse button: XY movement, right button: Z movement, both buttons: XYZ movement). Notice that the World X, Y and Z values are updated in the Object Info panel as the Object Axes are moved around. Next, try rotating the axes with the mouse by first clicking **[Object Rotate]**, **Fig D**. You can also use **[Object Scale]**, but as this only affects the size of the axes, it has no modelling function. It can, though, make the inconspicuous axes larger and more noticeable, particularly in solid render display mode (the axes, as well as other objects, can be scaled equally in all

directions by dragging with both mouse buttons down). When you have finished altering the axes, you can return to object modifying mode by clicking **[Axes]** again.

Sometimes it is convenient to have the object axes visible while the object itself is being manipulated. This can be done by selecting an object, clicking **[Axes]**, and then selecting the object again with the mouse. Alternatively, you can click **[Axes]**, and press the up arrow key on the keyboard. To subsequently hide the axes in object editing mode, click **[Axes]** twice.

Although I have described how Object Axes can be manipulated, you may be wondering what value this has in 3D modelling, so this second part will end with a few examples of modelling with the aid of the axes.

Modelling a lathe tool

This first example - a right-hand knife tool, is a good illustration of how adjusting an object's axes can make 3D modelling easier by eliminating arithmetic calculations. It will also demonstrate how component building can often be speeded up by using the mouse and grid snapping instead of typing values in the Object Info panel. To explain these techniques, I shall have to give a long description which may give the misleading impression that a considerable effort is required to create the lathe tool. However, with practice in using these methods, it should take only a minute or two to create an object like this.

First, here a summary of the tool's construction steps: a cube is made into a bar shape, and then another cube is subtracted from the bar, in three different positions, to form the cutting faces at the end of the lathe tool. To begin, clear any objects in the workspace, click **[Reset View]**, **Fig H**, and then **[Cube]**. This will be the subtracting object. Select **[Wireframe Display]**, then **[Object Move]**, **Fig D**, and turn on grid snapping by clicking **[Toggle Grid mode]**. Right-click the **[Toggle Grid mode]** icon to get the Grid property panel. Change the X, Y and Z values to 1, which will restrict object movement to one grid square steps. Click **[Axes]**, and drag upwards in the workspace with the right mouse button held down until the axes move to the top face of the cube, and the Z location value in the Object Info panel is 2.0 (larger mouse movements are often needed when the grid mode is active). Next, drag towards the left of the screen with the left button down until the axes move to the top left corner of the cube.

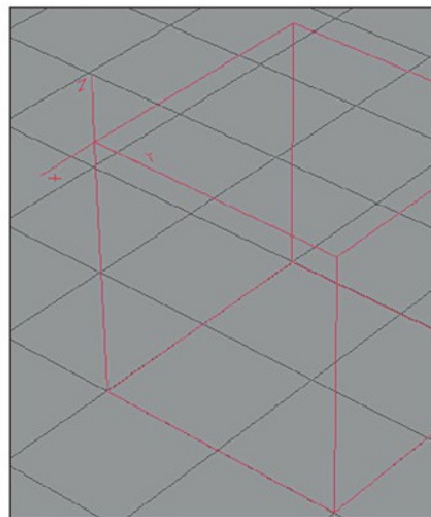


Fig. 28

In the Object panel, you should have: **[XL1.0/YL-1.0/ZL2.0]**

Click **[Axes]** to return to object editing mode. The lathe tool building steps are now simplified a little by moving the cube so that its new reference point coincides with the World centre. Typing **[XL0/YL0/ZL0]** will do this, but an easier way of doing the same thing is to use the **[Normalize Location]** function, so click this tool's icon, **Fig B**.

To create the lathe tool bar, click **[Copy]**, and select **[Object Rotate]**. The Grid property panel will change to show the current rotational snapping values in degrees (they should all be 45). Drag the mouse to the left with the right button down, and the cube will rotate in 45° steps around the Z axis. Move it four steps until **[ZR180]**. Notice that the copied cube has retained the new reference point of the original cube (click **[Axes]** to see it, then **[Axes]** again to return to object editing), and that the rotation has been around the Object Axes position. Modify the cube with: **[XS1.0/YS8.0/ZS1.0]**.

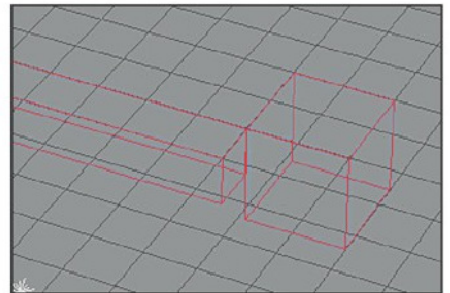


Fig. 29

Instead of typing the bar's dimensions in the Info panel, the **[Object Scale]** tool could have been used with the mouse and grid snapping to resize the bar (try it if you like). I have not done this because, with object scaling, the grid snapping steps are proportional size changes (you could experiment with this later to see what I mean). This is rarely useful; it just so happens that in this instance the lathe bar's particular dimensions would have made mouse scaling possible with the grid mode active.

Next, select the original cube, then **[Object Move]** it (with grid snapping still on) to **[YL-1.0]**. Click **[Object Rotate]**, and type 5 for all three values in the Grid panel. Any rotational changes made with the mouse will now be in five degree steps. To create the **side clearance angle** on the lathe tool, the subtracting cube should now be rotated around the Y axis only. However, dragging with the left mouse button with the **[Object Rotate]** function active will produce rotations around both X and Y axes. You can, though, stop any rotation around the X axis by clicking **[Toggle Navigation using X axis]**, **Fig F**. Do this now, and rotate the cube by one step size to make **[YR5.0]**. (The Y axis rotation could also have been done by using the 'Rotate by Y axis' handle on the Object Navigation Control).

Right-click **[Object Subtraction]**, and select **Keep Drill**. Select the lathe tool bar, and subtract the cube. Now to create the **top rake**. Select the cube, and drag the mouse upwards until **[XR-180/YR20/ZR-180]**

To reach this position, note that there is a jump in X and Z values in the Info panel

when the Y rotation reaches 90°. This may be confusing at first, even though the mouse controlled rotation is perfectly natural. Select the lathe tool and subtract the cube. With **[Render Current Object]**, you should have:

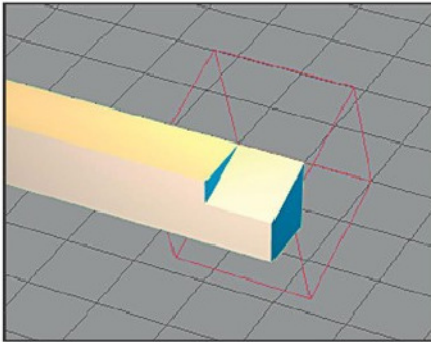


Fig. 30

Select the cube, and revolve it back until all rotation values are zero. Next, reposition it with **[Object Move]** to **[YR0.0]**. Once again, select **[Object Rotate]**, and revolve the cube around the Z Axis (right mouse button down) until **[ZR95]**. This position of the subtracting cube will produce a 5° **plan relief angle**. A 5° **front clearance angle** can be created at the same time by doing the following: Click **[Axes]**, then click the **[Normalize Rotation]** tool icon, **Fig B**. This last function rotates the Object Axes to make them parallel with the World Axes. Click **[Axes]** again. To make the front clearance angle, the cube now must be rotated around the X axis only, so re-enable X axis rotation by picking **[Toggle Navigation using X axis]**, and stop any Y rotation with **[Toggle Navigation using Y axis]**. Use the left mouse button to rotate the cube by one step to **[XR5.0]**, select the lathe tool, and subtract the cube. Finally, delete the subtraction cube. Here is a close-up of the lathe tool:

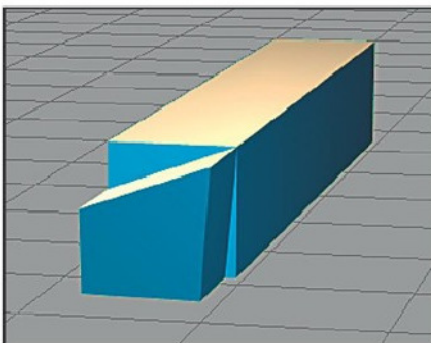


Fig. 31

Whenever an object has to be rotated in two axes, as in the example above, the procedure should be to rotate it around one axis, normalise the axes rotation, then rotate the object around the second axis. If the normalise function was not used, the angular rotations produced would be different. With small angle rotations (as used in the lathe tool), the discrepancies are small, but they would become significant at greater rotation values. This may not be that easy to follow at first, and you may find it worthwhile rotating a cube around two axes, first with and then without **[Normalize Rotation]** of the axes, to see the difference.

The technique of repositioning an object's axes before manipulating the object itself

can save a lot of effort while creating 3D models. You may like to think about how the lathe tool could have been formed if the default object axes position at the centre of the subtracting cube had been used; in this case, aligning the cube with the tool would be much more difficult.

You may have found that following the steps needed to make the lathe tool was heavy going. There is certainly a lot of information to grasp in one go in this example. With experience, though, these techniques should become second nature, and will speed up your 3D modelling. For practise, you may like to build other RH knife tools with different angles, and then perhaps to create some other types of lathe tool.

A graduated collar

Here is another example of altering an object's axes position to make 3D modelling simpler.

To make the collar, use **[Cylinder]** with **LNG:40** (and **Top Radius:1**). Set: **[XS3.0/Y33.0/ZS1.0]**.

Click **[Copy]**, and **[XS4.0/Y4.0]**. Subtract the first cylinder from the second (uncheck **Keep Drill**).

Next, a small block shape will be subtracted many times from the collar to make the graduations. For the block, click **[Cube]**, then **[Axes]**, and move the axes (with the mouse and grid snapping mode on) to **[XL1.0/ZL0.0]**. Click **[Axes]** again, and type

[XL1.9/XS1.0/Y0.05/ZS1.2].

This will make a 0.5mm wide block that overlaps the collar's outer face by 1 mm.

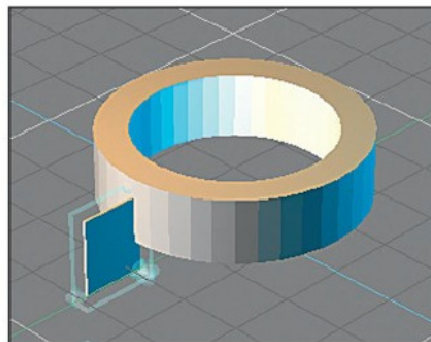


Fig. 32

Move the block's axes to the World centre (the same location as the collar's centre) with **[Axes]**, **[Normalise Location]**, **[Axes]**. For ten equally spaced graduations, click **[Object Rotate]**, and in the Grid property panel type a **Z value of 36**. Click **[Copy]**, and rotate the block one step around the Z axis (right mouse button down). Do this another eight times, rotating each copy of the block by one Z axis step. Here is a view from above:

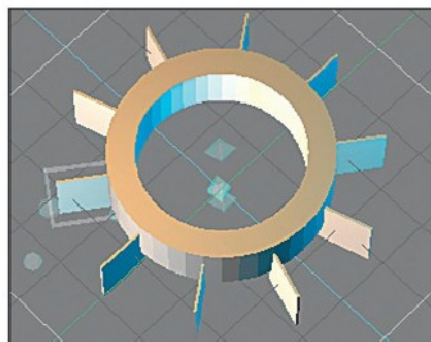


Fig. 33

Select the collar and subtract each of the ten blocks in turn. Here is the finished collar shown with **[Render Scene]** (I've made the lights cast shadows here, to make the graduations clearer).

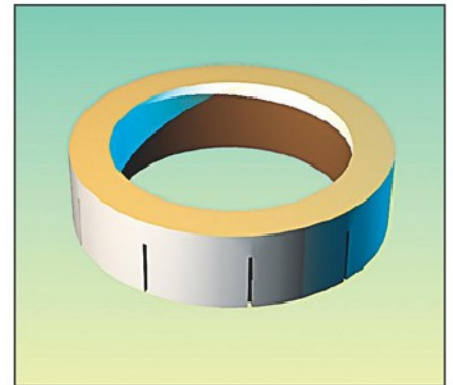


Fig. 34

A third axes example

This example simply repositions and realigns an object's axes to make object manipulation more convenient.

Clear the workspace, and reload the Ball Lever component created earlier (click this component's thumbnail in the Object Library panel). The lever's axes are currently situated at the centre of the large sphere and are also rotated 20° relative to the World X axis (a result produced by the object's construction steps). A more suitable axes position would be at the centre of the flat face at the base of the sphere, with zero rotation. To do this, first type **[ZL0.6]** to locate the bottom face at the World centre. Click **[Axes]**, and you can see the object axes placement and rotation. Now click **[Normalise Rotation]** and **[Normalise Location]**.

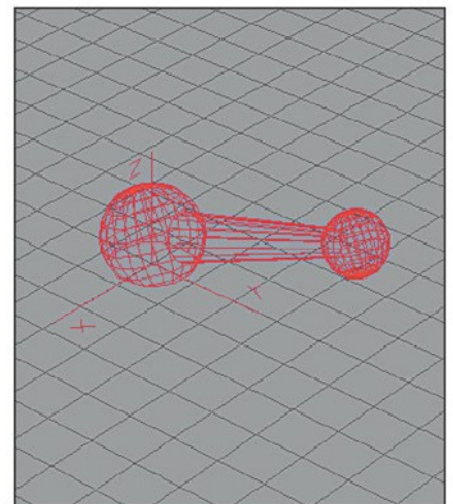


Fig. 35

Click **[Axes]** again, and turn off the grid mode. Now, if you **[Object Rotate]** the lever by dragging with the right mouse button down (Z axis rotation), the lever will behave as a real one would when turned by hand. Cancel any rotation with **[Normalise Rotation]**, and resave the edited object. ■

Next Month: Part three will show how 2D shapes can be created and edited, and will also start to look at some trueSpace functions that can turn 2D objects into 3D components.

THE WARCO WM 18 MILLING MACHINE

Dave Fenner investigates this recently released machine from Warco.

I was recently asked by our editor, whether I would be able to have a look at one of the latest Warco machines, namely the WM 18 Mill/Drill. Now seriously, who would not grab such an opportunity with both hands? For those who have not studied the Warco catalogue, this is a bench mounted machine with a 1.1Kw (1.5hp) variable speed motor, capable of fairly arduous work.

The table measures a generous 700 x 210mm with three longitudinal 12mm Tee slots each 560mm long. The travel envelope is given as X - 425mm, Y - 220mm, and Z - 370mm. However running the table from one extreme to the other, I actually measured 455mm. The Z figure implies the ability to easily accommodate table mounted accessories, with ample headroom.

In order to simplify mounting I asked that the optional stand and tray should also be supplied. On the appointed day, a carrier arrived, and, using his pallet truck, wheeled the pallet into the workshop. A box containing the stand was strapped on top of the wooden crate containing the machine, **photo 2**. After cutting the strapping, the stand was taken off and unpacked along with the drip tray, which incidentally is available as a separate item for those wishing to construct their own bench. The packing case was then sufficiently dismantled to get at the machine, **photo 3**. The next step would be to lift the machine sufficiently to mount it on the stand, and here I had to add an additional 150mm or so to allow for placing the whole assembly on a trolley for easy movement. **Photo 4** shows the stand perched on the trolley.

Lifting

Machine tools are not the easiest items to pick up and move around. Apart from being heavy, (this one is about 220Kg (484lb)) they are often top heavy and not fitted with specific lifting points. It would no doubt be possible to arrange to lift by using ropes, but I tend to avoid these if possible as it can be tricky to get things to stay vertical, and ropes have a tendency to slip and change position. Two possible pieces of lifting gear were considered, a 500Kg lightweight fork lift, and the engine lifting gantry. I chose the latter. The next question was how and where to attach the hook to the machine. The first thought was to run a sling under the head, but the length was not appropriate for the available sling. The next avenue was to make a lifting bracket which could be clamped into the vertical column above the head. **Photo 5** shows this in place, and **photo 6** shows the component parts. One bar was wrapped with masking tape to avoid bruising the machine slide. It was then a simple matter to lift and lower the mill on to the stand. During lifting, the table was moved close to the column so that the position of the centre of gravity caused the least amount of tilt. **Photo 7** shows the assembly. For anyone planning to acquire one of these or other mills, who may be unused to lifting and moving such things, my advice would be to make a lifting bracket and to borrow or hire an engine lifting crane.

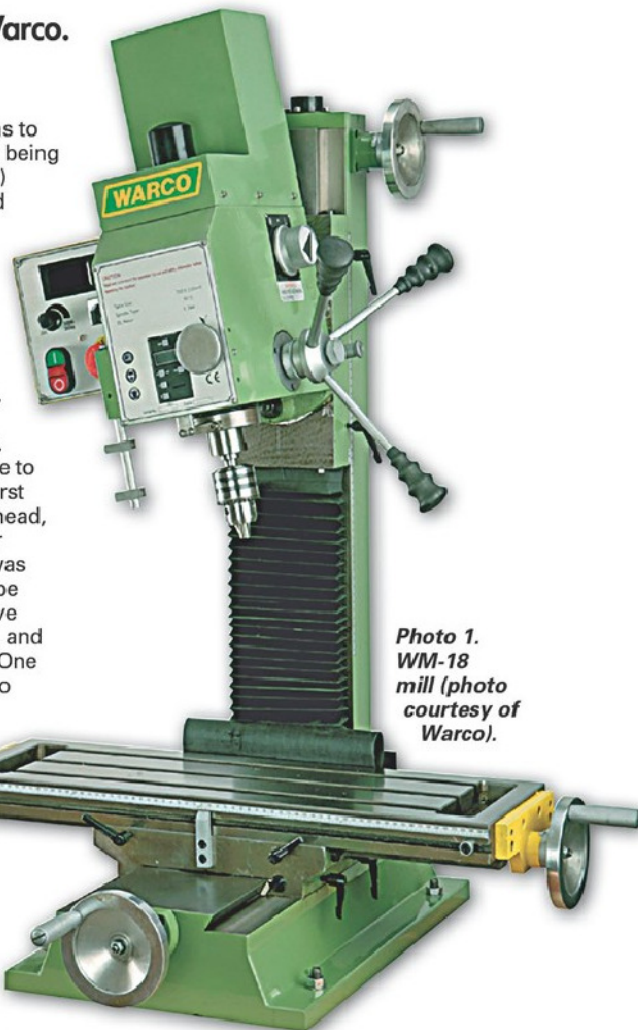


Photo 1.
WM-18
mill (photo
courtesy of
Warco).



Photo 2. Boxes containing tray and stand are secured to main case on pallet.



Photo 3. Side and top removed from packing case to reveal machine.



Photo 4. Stand and tray perched on trolley for easy movement. Also visible is the supplied toolbox.



Photo 5. Lifting bracket clamped to machine column.

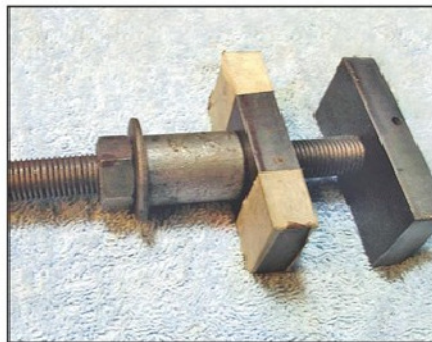


Photo 6. Detail of bracket - two plates, tube, M16 screwed rod, washer and nut.



Photo 7. Mill now located on stand.

Overview

Now that the mill was erected, it was possible to take a closer look at some of the features. One's view of machines, like cars, is influenced by previous experience of similar kit. In my case, prior to purchasing a VMC mill, I had owned a Naerok 350 mill/drill which did sterling service for about 15 years. The WM-18 shows just how far things have developed in the small mill field. Gone is the round column, with the attendant problem of maintaining head alignment when raising or lowering. Now we have a dovetail arrangement which ensures that the head can be raised and lowered without inconvenience. On the transmission side, belts and pulleys have given way to a variable speed d.c. motor driving through a two speed gearbox. This arrangement gives a speed range of about 50 to 2500 rpm, and delivers high torque at low speeds.

You can keep track of the exact spindle speed by observing the built in digital rev counter, **photo 8**. A reversing switch is included so it would be possible to undertake tapping work, using the reverse for withdrawal.

The head incorporates the 71mm travel quill, which may be fed either by the three spoke lever feed or by the fine feed wheel mounted on the front face. To eject standard tapered MT3 tooling, a taper drift may be inserted through slots in the quill.

Additional built in features are the interlocked chuck guard and the digital depth gauge, **photo 9**. This latter would seem to be a real potential time saver, as for instance when counterboring holes, it should be possible to lower the cutter to touch, hit the zero button, then quickly drill to depth. However, no mechanical depth stop is fitted, so, on some occasions, you do need to keep track of the numbers.

If one studies the catalogue carefully, there are several instances where the machine does not conform exactly to the details given. This is because the brochure went to press, based on the initial sample machine. Changes for production were made to the maximum speed (now about 2500 rpm) to improve the torque characteristic, and to the draw bar which is now not self ejecting. The actual travel varies slightly from spec, exceeding the brochure figures in X (30mm above) and quill travel (21mm above).

The other major advance is the provision of an inclinable head, which may be moved up to 90 degrees either side of vertical, allowing in effect, horizontal milling work to be undertaken. The general appearance is good, paint finish is

smooth and the aluminium handwheels with clear indexable division rings, **photo 10** give a quality feel.

When large movements are undertaken, it is very easy to lose count of the turns of the handwheel. Of course fitting a DRO system eliminates this problem, and to get around it, one modification to machines in the past, was to add say a long steel rule to the front face of the table. On the WM-18, this has been taken care of at the factory, and in addition to the X axis, **photo 11** a clear scale is also fitted to the column. Study of the parts list and exploded drawings shows that split nuts are fitted to the leadscrews to allow adjustment for wear in later life. Many of the working surfaces appear to be ground, in addition to which the X slide bore evidence of scraping. Interestingly, at several positions the parts are not just bolted, but bolted and dowelled, thus ensuring that if dismantled, the relative positions will be unchanged at reassembly.

Accuracy

The machine is supplied with an inspection report detailing a number of checks on accuracy. I decided to attempt to take a few measurements of my own (albeit with rudimentary measuring kit) and see how good the machine really is, and whether the report might be relied upon. I recalled that on my 1980's Naerok, the leadscrew pitch error was around 1.5 thou per inch. A simplistic set up to check the X axis screw can be seen in **photo 12**. A Mitutoyo digital calliper was laid on an inverted vee block, measuring over the chuck and an upstanding column, the two being positioned in alignment by adjusting the Y axis. Both the handwheel scale and the calliper were zeroed and then the table wound along in 10mm increments. The calliper reads to 0.01mm, however no measurable deviation was found over a range of some 200mm.



Photo 8. With the spindle running, the rev counter has large, clear numerals.



Photo 9. Detail of front of head showing built in DRO and to the right, the fine feed wheel for quill movement.

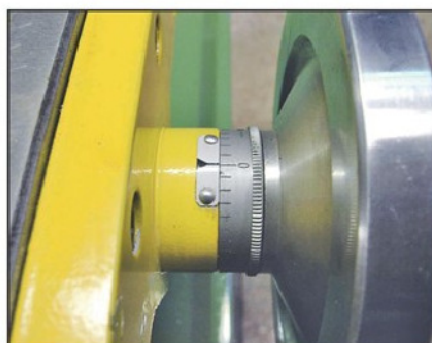


Photo 10. Aluminium handwheels have clear indexable dials.

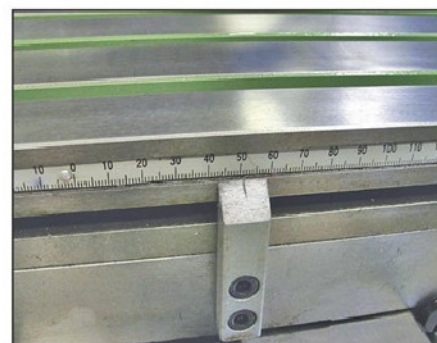


Photo 11. Scales are fitted to the front of the table and the side of the column.

One of the requirements of any mill is to be able to machine features square to one another. It is therefore paramount that the X and Y axes should be at 90 degrees within a tight tolerance. The vee block was clamped to the table, and one edge clocked parallel to it. The clock stylus was then set against the perpendicular side, and traversed using the Y axis, **photo 13**. Although the inspection report gave a deviation of 0.02mm over 150mm, I was unable to measure any error. The block was flipped over and the check repeated in case of a compensating error in the block.

My final accuracy check concerned the head alignment. As noted above, the head may be adjusted for inclination sideways, but is fixed fore and aft. The clock was fixed in the spindle and then set down on the surface of the table at two positions, directly towards and away from the operator. Here I was able to detect a very slight deviation (about a thou or 0.025mm over the width of the table) but again, this was less than the figure given in the report (0.04mm). I think that others will agree that these results are impressive for a machine aimed at an amateur market. At this point there will be those readers who assume with that scepticism which comes with advancing years, that this was a machine either carefully selected or prepared in advance of the review exercise. In fact, when I queried this point with Warco, it was confirmed that this was not the case.

In use

As a quick initial exercise, I produced a twelve inch mill setting aid which would double as a ten inch sine bar. This entailed drilling a couple of holes pitched ten inches (254mm) apart, then truing the edges to be parallel with the hole centres. It occurred to me later that the second op could have been carried out at the same setting as the first, if the spacing bars had either been positioned clear of the cutter path, or designated as sacrificial. However I had already chosen to do this by setting the work on edge and shaving with the end of a slot drill.

When drilling using the lever feed, I felt that longer handles would have been better, but the size appears to have been chosen so that the handles do not project downwards unduly below the head. In fact it proved easy to apply extra force by using two hands on two handles. Once set, the spindle speed proved remarkable stable, dropping only about 5rpm when the load was applied when drilling at around 400rpm.

A second exercise was set up using a fly cutter. Fly cutting may be a less popular method of creating flat surfaces since authors such as Harold Hall have pointed out that taking several cuts with a smaller diameter end mill can give a surface with less deviation from ideal flatness. Fly cutting can also be a fairly severe test of a machine as it requires a low spindle speed and relatively high torque, and generates cutting force once per revolution. On some other machines, the high torque has given rise to belt slip, and on others, harsh mechanical noise comes from the spindle splines as the cut commences.

I used a fly cutter made in the 70's for milling in the lathe, which has subsequently seen service on a variety of small mills. The cutter is a regular turning



Photo 12. Set up to assess leadscrew accuracy.

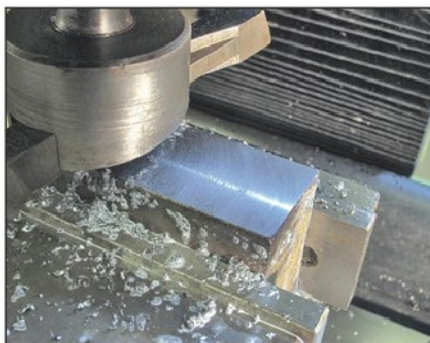


Photo 14. Flycutting in progress.

tool and was set to give a cut diameter of about three inches. Here the work was a sample block of mild steel with a top face measuring about 3 by 1.25 inches (75 by 32mm). The drive was set in low gear, and the speed set to about 100 rpm. As the cut proceeded, soluble coolant was applied by brush, and the handwheel turned to a guesstimated feed of about three thous (0.08mm) per cut. I was pleasantly surprised at the lack of mechanical spline noise, and at the very small change in speed, also the near absence of gear noise. By increasing the feed it was possible to cause slight vibration in the sheet metal tray/stand, but this was not felt on the main machine structure. **Photo 14** shows the job in progress. No doubt a more consistent finish might have been obtained had the phone not rung during the operation.

Picking up on the point touched on earlier concerning the table headroom, **photo 15** illustrates just how much flexibility arises from this. A Warco supplied Vertex BS-0 dividing head has been fitted with a four jaw chuck, mounted on the table, then swung 90 degrees to bring its axis vertical. A drill chuck had been fitted to the mill spindle, and into the chuck, a standard 13mm jobber drill. In the past, for dividing work, my first purchase was a rotary table, which occupied much less vertical height, but which would normally be mounted either horizontally or vertically. The dividing head gives the added possibility of setting to any chosen angle. If you start with a WM-18, the space available would allow you to choose a dividing head as your primary means of division.

Criticisms

The length of the down feed handles was commented on earlier, however one can either use two hands or apply feed with the fine feed wheel. The spindle taper is MT3, and certainly this allows



Photo 13. Perpendicularity of X and Y was investigated by clocking along sides of Vee block.



Photo 15. A tall set up, still room to work and the head could rise further.

substantial and readily available tooling to be employed. However, my personal preference here would be R8, which I find is generally quicker and easier to change. For a machine which is "driven" only by its owner, this is not such an issue. However in the case of a machine destined for a club workshop, it is too easy for an inexperienced member to overtighten a drawbar such that attention with a large hammer is needed to release the tooling.

One accessory, which would be a real boon, given the size of the table and travel, is a power feed. This is not currently available, but I understand that it is being pursued by Warco. Over the years, numerous designs for power traverse devices have been published in MEW, some using automotive windscreen wiper motors, or stepper motors. If any reader has devised a device to fit the WM18, then it is likely that our editor would like to hear about it.

Conclusion

The criticisms noted are pretty minor, and overall I rate this as a very competent machine. The travel envelope and power available should make it ideally suited to larger size work such as 7 1/4 in. gauge locomotives and the level of precision is at least as good as is claimed. ■

AN INTRODUCTION TO MILLING 6

Donald Brymer continues his look at dividing and the dividing head.

Differential indexing

In the previous article direct and simple indexing have been discussed. In this article differential indexing will be explained using a standard 40:1 dividing head, standard indexing plates and standard change gears.

Differential indexing permits a wide range of divisions to be indexed that cannot be obtained using simple indexing. When differential indexing, the actual dividing operation is performed as in simple indexing but the difference is that the indexing plate revolves when the indexing crank is revolved. The movement of the indexing plate may be in the same direction as the indexing crank or opposed to it. This movement is dependant on the change gear train that is set up to join the dividing head main spindle and the auxiliary shaft that is connected to the indexing plate drive and the internal gearing of the dividing head. See Fig. 1.

Principle of differential indexing

Indexing plate revolving in the same direction as the indexing crank

Unlock the dividing head indexing plate locking mechanism. Should a gear train with equally toothed driver and follower gears (overall ratio 1:1) and a suitable idler be attached to the dividing head main spindle and the auxiliary shaft and the indexing crank rotated 40 turns, the indexing plate will revolve one turn. Therefore, one turn of the indexing crank will rotate the indexing plate $\frac{1}{40}$ th of a turn from the plates original position. The indexing movement is therefore 1 pin and $\frac{1}{40}$ th of a turn to locate the indexing pin into the original hole. This indexing movement will produce 39 divisions to be indexed for 40 completed revolutions of the indexing crank. See Fig. 2.

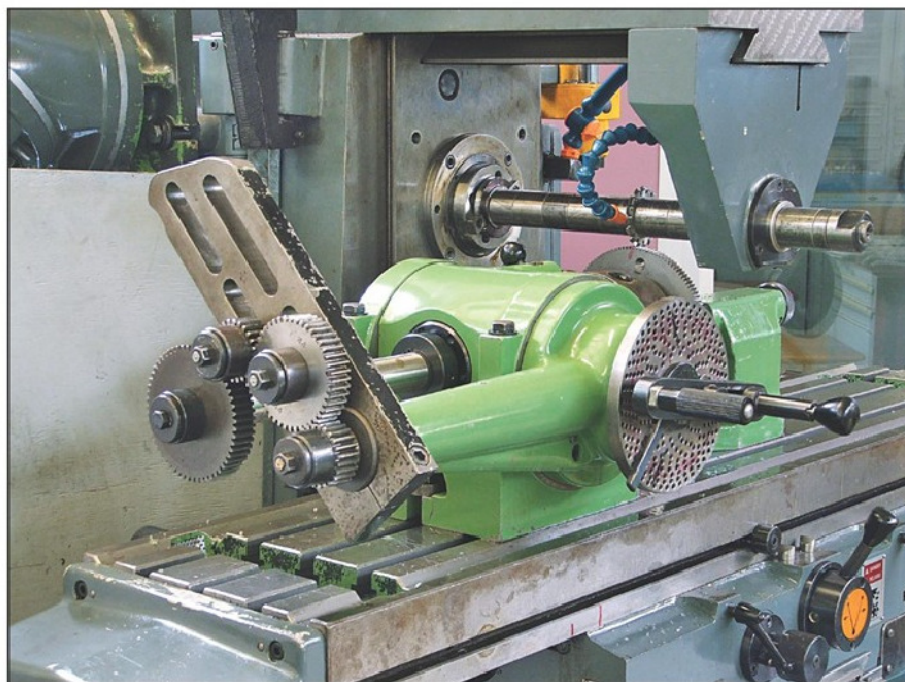


Photo 1. Setup of milling machine for 127 tooth gear cutting.

Indexing plate revolving in the opposite direction as the indexing crank

Should another idler now be introduced to the change gear train to change direction of the indexing plate the indexing crank pin will come to the original hole $\frac{1}{40}$ th of a turn less than a full turn. This action will produce 41 divisions to be indexed for 40 completed revolutions of the indexing crank. See Fig. 3.

The movement between the indexing plate and indexing crank is referred to as the differential action as it is the combined action of two combined actions.

Practical example

Required to cut a 127 tooth gear for use as a back gear for a centre lathe. Equipment available; 40:1 dividing head, standard change gears 24, 24, 28, 32, 40, 44, 48, 56, 64, 72, 86 and 100, Brown and Sharpe indexing plates 15, 16, 17, 18, 19, 20, 21, 23, 27, 29, 31, 33, 37, 39, 41, 43, 47 and 49.

Prior to setting up the milling machine and calculating the gear train consider the following;

- Determine the required movement of the indexing crank as for simple indexing.
- Calculate the change gears for the indexing movement required.
- Determine the direction in which the indexing plate should move.

Determine the movement of the indexing crank

Select a division number that is within 10% if possible of the number of divisions required. This will keep the gear ratio within reasonable limits and help to factorise the selected number into the available change gears.

Required number of divisions = 127;
Selected number of divisions = 120.

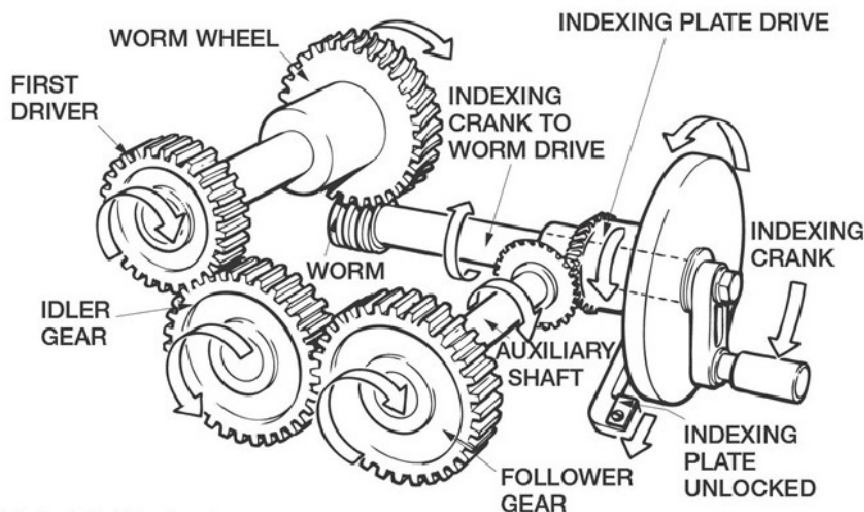
Indexing movement by simple indexing is;

$$\text{Turns} = \frac{\text{dividing head ratio}}{\text{selected number of divisions}}$$

$$T = \frac{40}{120} ; T = \frac{1}{3}$$

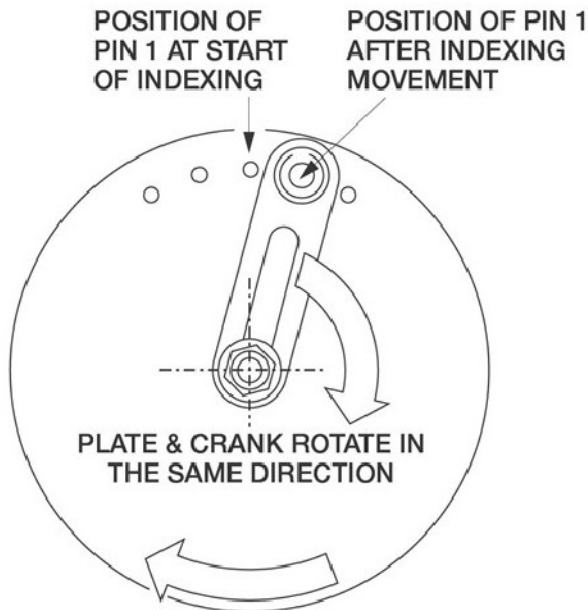
therefore use 9 spaces on a 27 hole plate or equivalent ratio. This will introduce an

Fig. 1



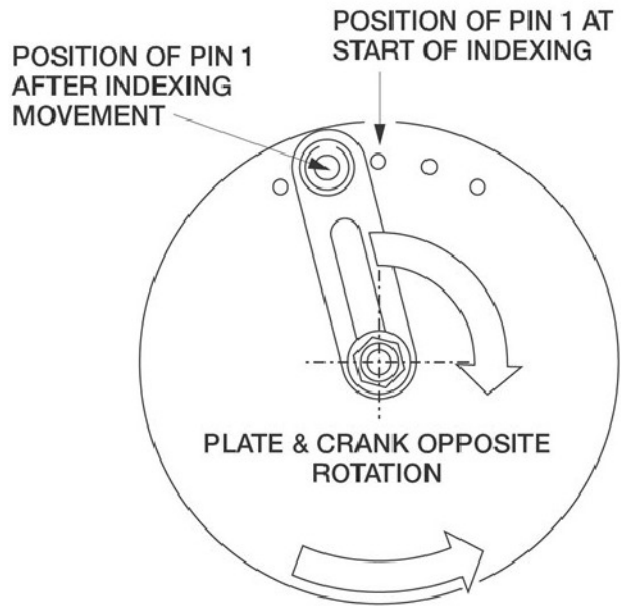
Typical dividing head gearing arrangement.

Fig. 2



Indexing plate and crank rotating in the same direction.

Fig. 3



Indexing plate and crank rotating in opposite directions.

error that is corrected by the movement of the indexing plate.

Determine the change gear for the movement

Gear train formula;

$$\frac{\text{Drivers}}{\text{Followers}} = \frac{\text{ratio}}{\text{selected number}}$$

(selected number – required number)

$$\frac{D}{F} = \frac{40}{120} (120 - 127); \frac{D}{F} = \frac{1}{3} \times \frac{(-7)}{1}; \frac{D}{F} = \frac{-7}{3}$$

factorise the gear ratio to a suitable equivalent ratio that will suit the available change gears.

$$\frac{D}{F} = \frac{-7}{3} \times \frac{8}{8}; \frac{D}{F} = \frac{-56}{24}$$

Therefore the driving gear attached to the worm wheel extension spindle has 56 teeth, while the gear attached to the auxiliary shaft will have 24 teeth.

Determine the direction of plate movement

Note that the 56 in the ratio has a negative sign, this is due to the selected number being smaller than the required number and indicates that the indexing plate must move in the opposite direction to the indexing crank. If the selected number is larger than the number required the movement of the plate and crank are in the same direction.

Photo 1 shows the machine setup to mill the 127 tooth gear. The gears being attached to the quadrant arm that clamps to the auxiliary shaft housing. **Photo 2**

shows the driver, follower and two idlers to reverse the direction of the indexing plate.

Whenever possible the indexing plate movement that opposes the indexing crank rotation is chosen as this movement eliminates any backlash that will be evident when both move in the same direction.

Checking the calculations

The accuracy of the calculations should be checked prior to mounting any of the calculated change gears by transposing the formula to make the number required the subject of the formula. This ensures that the correct gears have been selected and that the gears are in the correct positions.

$$\frac{D}{24} = \frac{-56}{120} (120 - N) \text{ becomes}$$

$$N = 120 - \left(\frac{-56}{24} \times \frac{120}{40} \right); N = 120 - (-7);$$

therefore $N = 127$ teeth.

Now that the machine has been setup, remember to test the indexing movement by test nicking the gear blank to ensure that the first and last indexing positions are in the same position.

Further points of differential indexing are;

- Make sure that the indexing plate lock is unlocked before indexing.
- Differential indexing cannot be used if the dividing head is set at an angle to the machine table.
- Differential indexing and helical milling cannot be done at the same time.
- Keep the change gear sizes as small as possible to aid the limited space on the quadrant arm.
- Lists of change gears for many prime number divisions are available in many engineering handbooks. ■

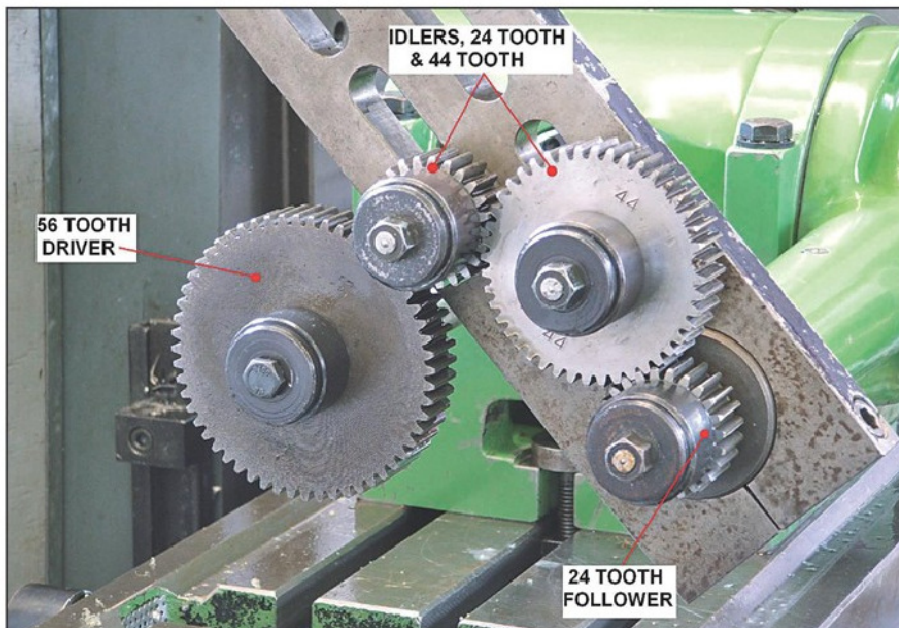


Photo 2. Details of the change gears to cut 127 tooth gear.

A DIVIDING HEAD FOR THE MINI LATHE

Dave Fenner adds a versatile accessory to the Mini-Lathe.

Background

An earlier article described a Mini Lathe headstock dividing attachment, which could be used to index work held in the spindle chuck. This in turn was employed to create the divisions on handwheels, and could be used in conjunction with the guided centre punch or powered toolpost spindle. However if we are to perform dividing functions on separately held work, using the headstock spindle as the tool driver, then a different approach is required.

My first thought was to look at the dividing head designs presented by Harold Hall. However, these lend themselves more to applications where there is a milling machine table for mounting. The concept then examined was one familiar to model engineers for the last fifty years or so, in the beautifully executed dividing head made by Myford for use with the Seven series lathes. It is also noted that Hemingway kits have resurrected a conceptually similar device designed by Westbury, and marketed by them as kit number HK2130/5.

As the Mini Lathe is considerably lighter than a Myford, the primary aim was to produce something smaller, and the secondary to employ stock materials thus avoiding the complexity of pattern making and the cost of castings. One of the first decisions to be made concerned the manner of work holding. Given that parts made on these lathes are likely to be small, the ER 20 collet nose was selected as this series would allow work of up to 13mm diameter to be gripped.

This dividing device can be made in two ways, the simple where direct division is accomplished by a plunger acting on suitable lathe change wheels, or the more complex version where a wormwheel and division plates are added. This article deals with the simple version, consideration will be given to the worm type design at a later date.

On the metric machine the supplied change wheels include 30, 35, 40, 50, 60, and 80 teeth. Thus divisions of 3, 4, 5, 6, 7, 8, 10, 12, 15, 20, 25, 30, 35, 40, 50, 60, and 80 will be directly available. The

imperial version of the lathe comes with wheels having tooth numbers which include 30, 35, 40, 45, 50, 55, 57, 60 and 65. Thus the additional factors of 9, 11, and 19 become possible.

In both of these cases, the figures above result when using a "single point" plunger which engages in the valley between two teeth. If a "split point" plunger is fitted, as advocated by Harold Hall, then it becomes possible to double up on each of the division factors. (The plunger point is designed with a tooth shaped cutout, so that when rotated 90 degrees, it locates over one tooth instead of between two.) Should owners of either metric or imperial machines require additional change wheels, then these are readily available at a modest cost from Arc Euro Trade.

The initial intention was to mount the head directly in place of the topslide. However, once tried, it was clear that there would be benefit in allowing the assembly to move towards the operator. This gave rise to the baseplate - pillar combination now proposed. Two main mounting arrangements are offered. The first locates the dividing head in place of the topslide, and sets its axis at lathe centre height. The

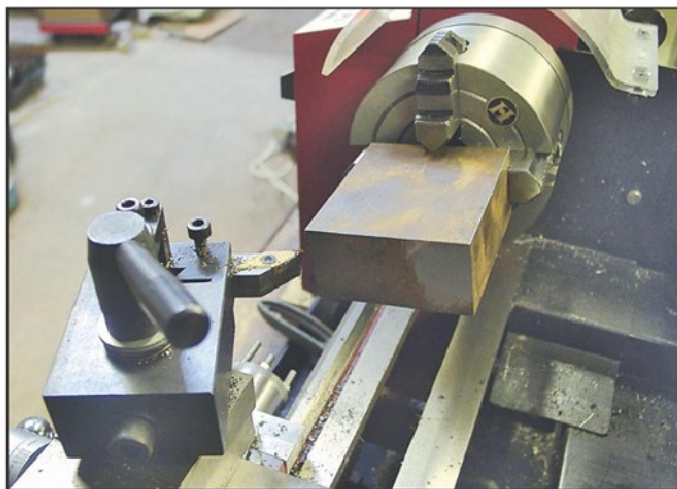


Photo 1. Body material held in four jaw chuck for facing.

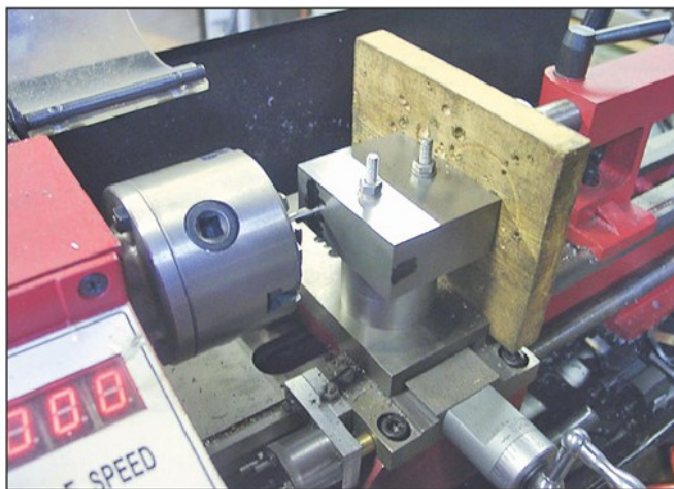


Photo 2. Work held on the saddle, pressure applied from the tailstock.



Photo 3. Drilling the body.



Photo 4. Reaming the bore for the spindle.

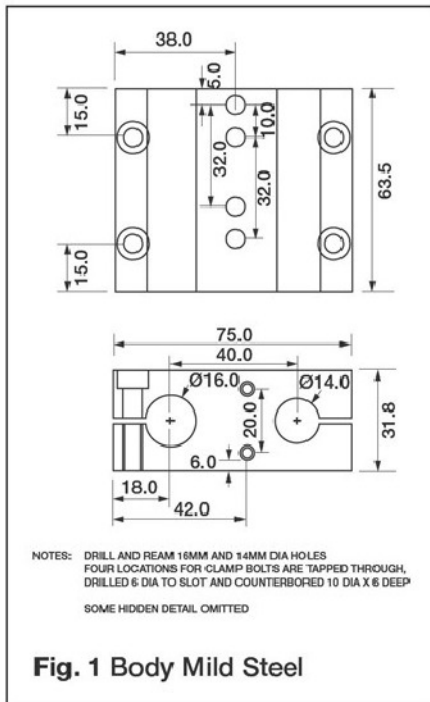


Fig. 1 Body Mild Steel

second makes use of the vertical slide with or without the milling sub table described in MEW issue 136. This would allow the axis to be raised, lowered and inclined in two planes, allowing operations such as gear cutting.

Manufacture

Because one or two of the parts are quite chunky, my recommendation would be to use larger machinery if it is available, say through your model engineering society or technical college. Nevertheless, I believe that the various components can be produced on a Mini Lathe, and have included photos of some setups to illustrate. However, while time may not be money, it is however increasingly precious and hence I have used the heavier equipment available to me to speed up proceedings. The Mini-Lathe was also kept clear of work to permit frequent checks on fitting the dividing head to the machine as work progressed.

Main Body (Fig. 1)

My initial inclination was to use a slab of aluminium, as it is easier to machine and while less rigid than steel, would be quite satisfactory here. Unfortunately the piece



Photo 5. Slitting saw used to cut slots.

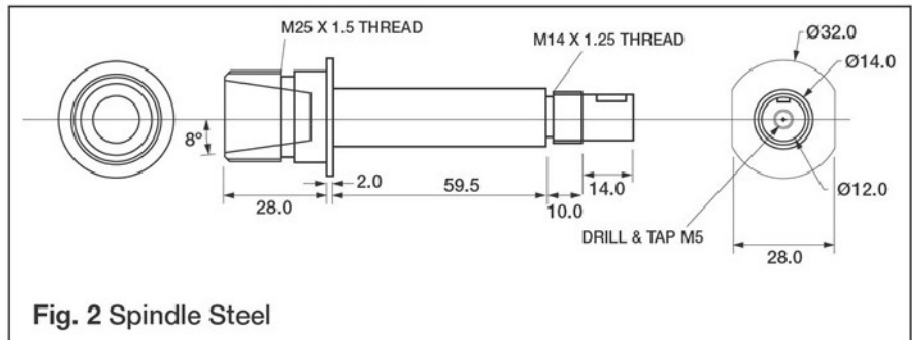


Fig. 2 Spindle Steel

available was just not large enough. The material then chosen was a length of mild steel flat bar 2.5in. by 1.25in (63.5mm x 31.75mm) cut and squared off to a length of 75mm. The most important aspects of this part are the two bores which will house the spindle and the steady arm. Care should be taken to ensure that they are parallel, at the correct spacing and held close to size. Ironically, the size question is more important for the steady arm which is made from stock material. If the bore for the spindle comes in on the large size, then simply turn the spindle location diameter to suit.

Two sets of holes have been shown for the location bolts (M6 screwed rod) The first set was drilled roughly central for appearance, then after roughly setting in position on the Mini Lathe it was decided to add a second set to allow the assembly to be moved farther from the centreline. A later addition was the baseplate which allowed considerably greater movement.

Photo 1 shows that it is possible to hold this chunk of metal in the four jaw chuck, and **photo 2** (the material has now been scrubbed up) illustrates a set up for drilling the two major holes, pressure being applied via a block of wood from the tailstock. However, I opted to deal with these operations on the mill, drilling as in **photo 3** followed by reaming, **photo 4**.

The positions for the four clamp bolts were drilled through tapping size (5mm) then counterbored 10mm diameter to a depth of 6mm to accommodate the heads of the M6 socket head capscrews.

The two slots were then cut with a slitting saw, **photo 5**. Following this, the holes were opened out to 6mm down to the slot. (It would probably be more efficient to do the opening out at the earlier setting, but then needs reasonably careful attention to the depth. By drilling

down to the slot it is easy to feel when the correct depth is achieved. Two drilled and tapped holes are required to locate the plunger support pillar. It will depend on the equipment and methods available to you, whether these are covered at this stage, or more easily spotted through after the mating part is made.

Spindle (Fig. 2)

As noted above, I had chosen to adopt the ER 20 fitting for workholding, and accordingly purchased a 10mm collet and a commercial closing nut. The nuts can be obtained quite cheaply, come with the internal extraction ring, and are hardened. It is really not worth the bother of making one.

Working with a length of 32mm free cutting steel bar, as a first stage, I machined the features for the collet housing (8 degree half angle) taking this out so that the extraction groove of the uncompressed collet stood out from the housing by about 4mm, **photo 6**. Trigonometry showed that this should be about the right allowance for the 1mm collapse on diameter. This was followed by cutting the M25 x 1.5 thread to match the purchased nut.

Purists would probably prefer to finish turn between centres. However, having established, **photo 7** that the outer diameter of the nut (tightened with a 10mm drill in the collet) showed negligible deviation on the DTI, I reckoned that if the work was centred using the Colchester collet, then the overall accuracy would be more than acceptable. **Photo 8** shows the start of work on the main length of the spindle. The nut has been gripped and accurately centred in the four jaw chuck. After dealing with the remaining turned features, the work was transferred to the mill, **photo 9** to cut the 3mm keyway.



Photo 6. Collet is tried for size, about 4mm projection to the extraction groove.

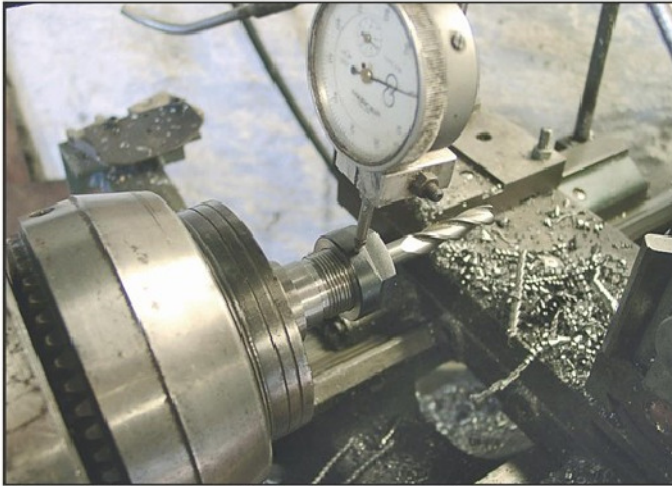


Photo 7. The nut was checked for true running....

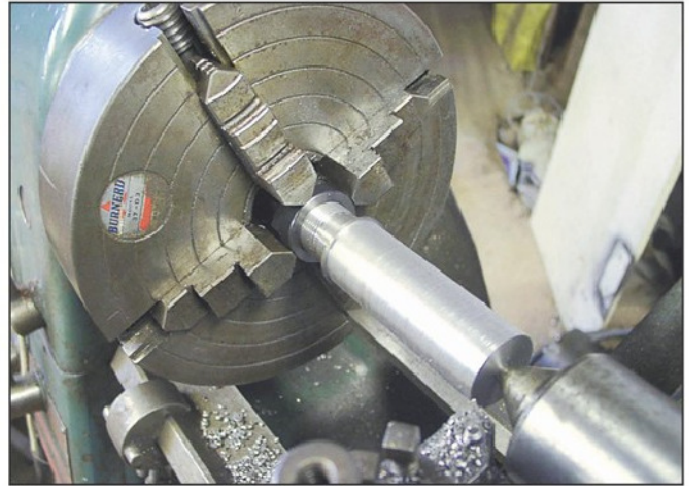


Photo 8.but was still gripped in the four jaw chuck and the work clocked.

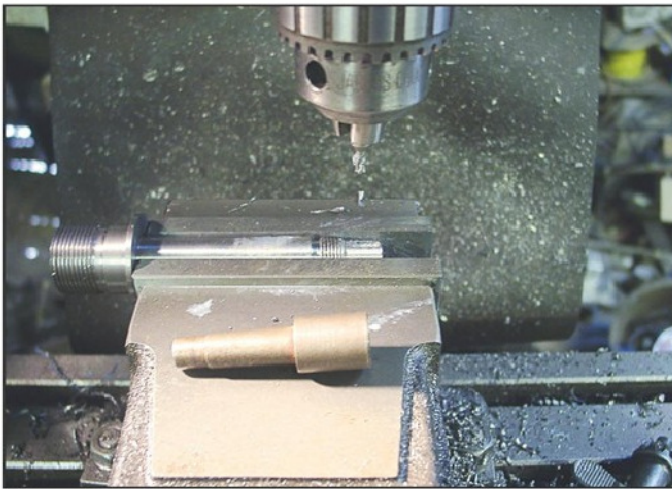


Photo 9. Cutting the 3mm keyway in the spindle.

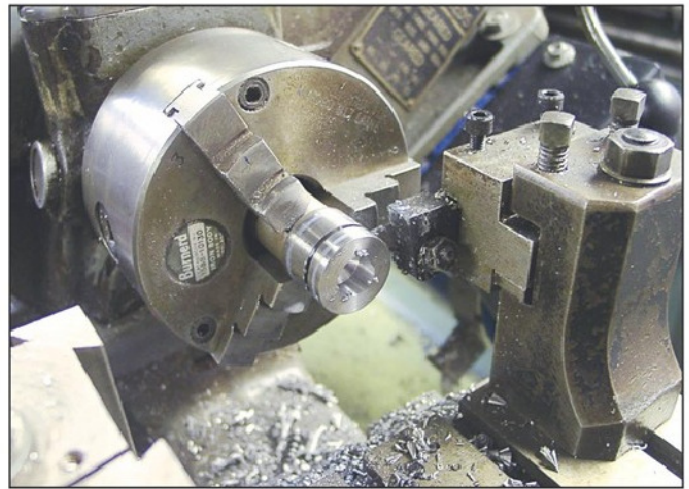


Photo 10. Parting of the embryo adjuster nut.



Photo 11. Commencing the part off operation on the spacer.

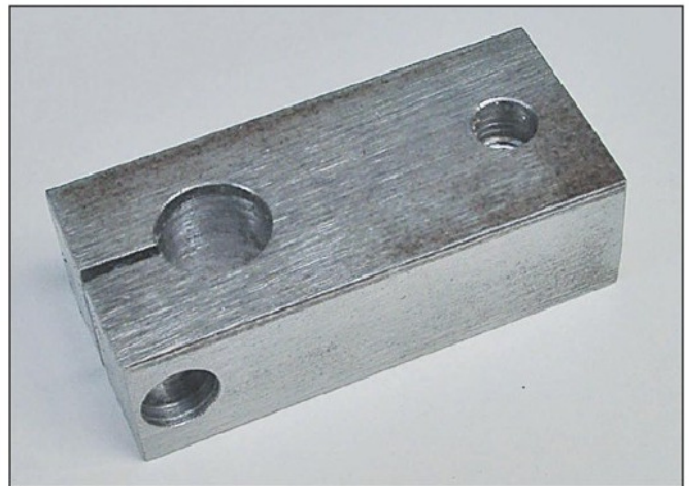


Photo 12. The finished steady bracket.

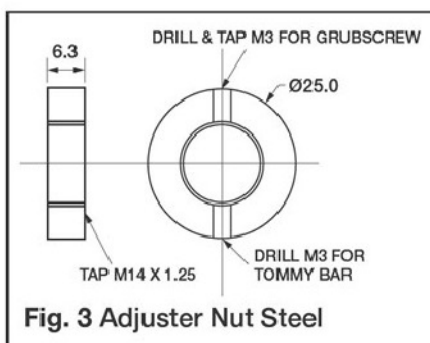


Fig. 3 Adjuster Nut Steel

Adjuster nut (Fig. 3)

A short length of steel bar (25mm diameter) was bored 12.8mm diameter then parted off, **photo 10** and faced to a thickness of about 6.3mm. It was then nipped in the chuck, squared up, gripped firmly and tapped M14 x 1.25. This gave a reasonably fine thread for adjustment purposes. The work was then taken to the mill to add the holes for the grub screw and tommy bar.

Spacer and washer (Fig. 4)

A spacer is fitted which abuts the adjuster nut, covers the end of the thread and

provides a reasonable area of face in contact with the division gear. 22mm diameter bar was used and it is a simple matter of turning, facing, drilling through, counterboring and parting off, **photo 11**. A thick washer cut from 16mm bar, is placed under the countersunk gear retaining screw, and its manufacture needs no detailed comment.

Steady bracket (Fig. 5)

Here a piece of 20mm x 30mm bright mild steel was sawn to a length of 66mm, then drilled 14mm and drilled and



Photo 13. Adjuster screw on right shown with the two screwed rods.

tapped M8. Here it is important to have these two features parallel and spaced accurately to match the bore spacing in the body. As with the body, the work is slotted, using a 1.5mm slitting saw, then drilled, tapped and counterbored for the M6 clamp screw. The completed part is shown in **photo 12**.

Adjuster screw (Fig. 6)

This part is intended to screw into the steady bracket and give a form of "tailstock" support to long slender items. Mine was made in the simplest possible manner by using a length of M8 mild steel screwed rod, turning one end to a sixty degree point, then Loctiting on a knob turned from a piece of 16mm hex brass with a matching tapped

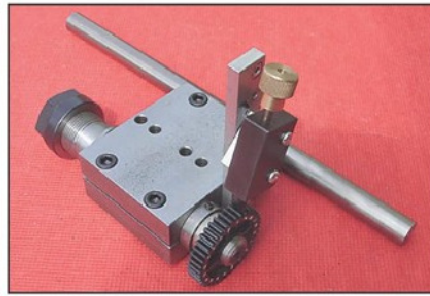


Photo 14. Head assembly fitted with forty tooth gear.

hole. The completed part is shown in photo 13 alongside two 80mm lengths of M6 screwed rod used to hold the dividing head down to the saddle.

Plunger sub-assembly (Fig. 7, 8 and 9)

The three parts here are those used for the headstock dividing attachment described in MEW issue 135. Accordingly the drawings are reproduced here, but the description is not repeated. The spring used was as follows: OD 5.5mm, wire diameter 0.6mm, free length 32mm, compressed (coil bound) length 12mm. The plunger arrangement may be seen in **photo 14** which shows the head assembly off the machine.

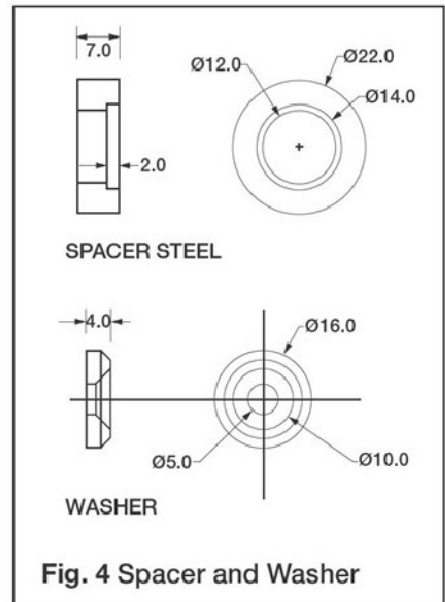


Fig. 4 Spacer and Washer

Plunger support pillar (Fig. 10)

A piece of 16mm x 8mm aluminium flat was cut to a length of 101mm. It then requires a total of eight holes. Two are drilled and countersunk to take the attachment screws, and it may be that you use these to position the mating tapped

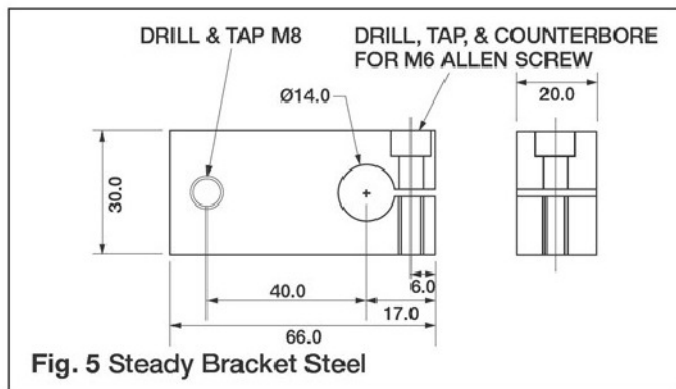


Fig. 5 Steady Bracket Steel

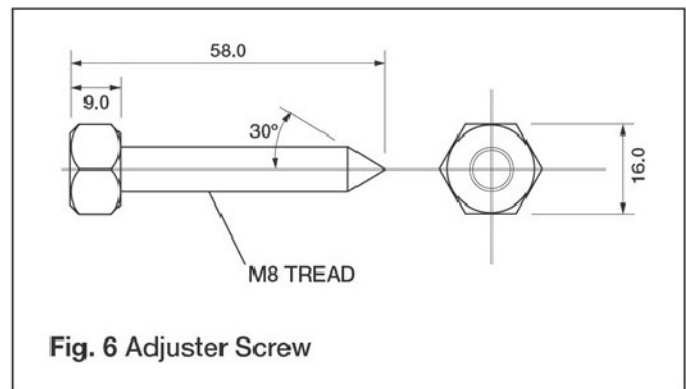


Fig. 6 Adjuster Screw

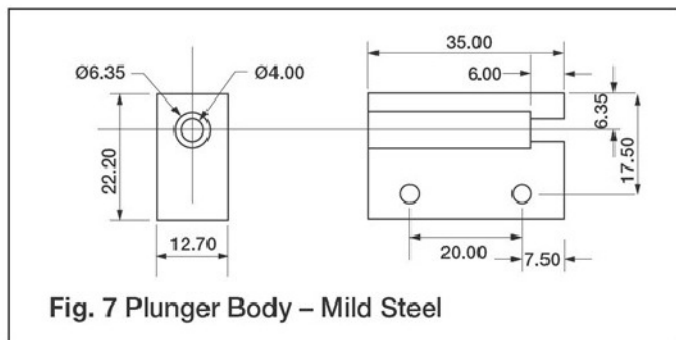


Fig. 7 Plunger Body - Mild Steel

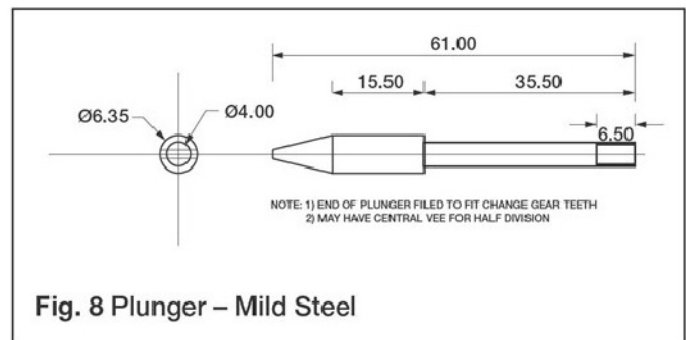


Fig. 8 Plunger - Mild Steel

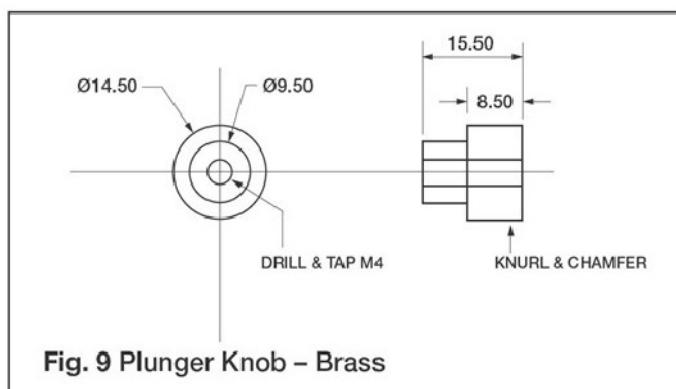


Fig. 9 Plunger Knob - Brass

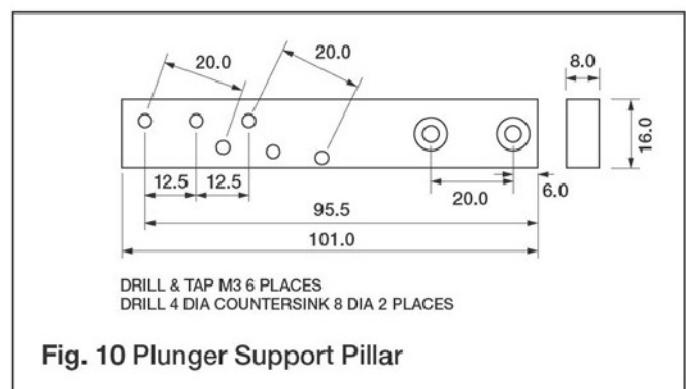


Fig. 10 Plunger Support Pillar

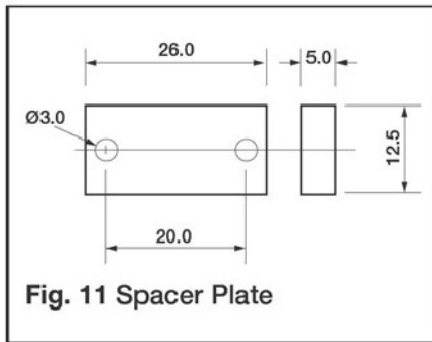


Fig. 11 Spacer Plate

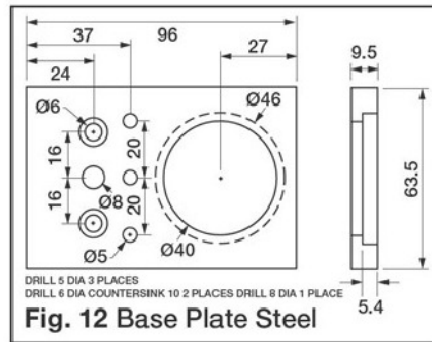


Fig. 12 Base Plate Steel

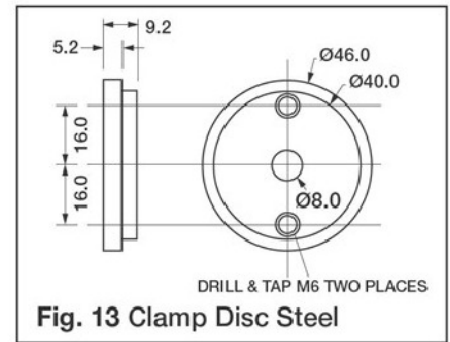


Fig. 13 Clamp Disc Steel

holes in the body. Six further holes are indicated, these being drilled and tapped M3 to give three positions for the plunger assembly so that it can engage with different sizes of gear. The positions given are those measured after construction, however the manner of their location was simply to fit different gears, place the plunger where it looked right, and mark through. The part may be seen in position in **photo 14**.

Spacer plate (Fig. 11)

This part functions simply to bring the plunger detent roughly to the centre of the gear teeth, and was made from a small piece of aluminium flat, 5mm thick. The thickness does not need to be exact, check on the job, but I expect anything between about 4mm and 6.35mm would suffice. The important points are the two holes drilled at 20mm spacing. Again if your pitching is not accurate then just open up

the holes a few thous. It may also be seen between the support pillar and the plunger body in **photo 14**.

Steady Arm

This part is not drawn, being a piece of 14mm bright bar cut and faced to my chosen length of 250mm. Others may choose to go shorter or longer depending on the applications envisaged.

Base plate (Fig. 12)

A length of bright flat steel 63.5mm x 9.5mm was cut to a length of 96mm. The two countersunk holes are designed to accommodate M6 screws which attach the assembly to the existing topline mounting in the saddle, while the three 5mm holes match those in the milling sub table. These features are all straightforward work.

It is also bored 40mm and counterbored 46mm using the four jaw chuck in the

lathe, **photo 15** to accept the clamp disc. Great accuracy is not needed, but care should be taken that the disc is then made to fit. The completed plate is shown in **photo 16**.

Clamp disc (Fig. 13)

If the clamping action is to function correctly, then some care does need to be taken here. When fitted, both of its surfaces should lie under flush with reference to the base plate. Thus the overall thickness is given as 9.2mm and the spigot depth as 4mm (compared with 9.5mm and 4.1mm on the plate) To make the part a slice of 2 inch diameter free cutting steel bar was turned down and faced. Taking the shoulder line slightly off centre gave a little extra meat for the chuck to grip. The fit and depth were checked against the plate. Whilst in the lathe, the central 8mm hole was also drilled. The part was then taken to the

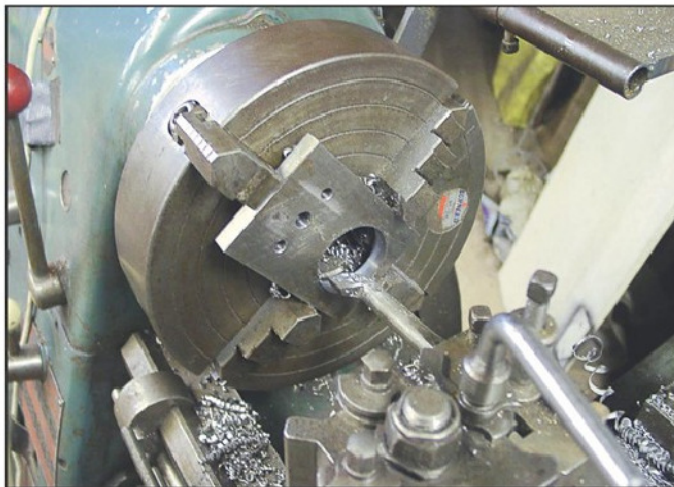


Photo 15. Boring the baseplate.

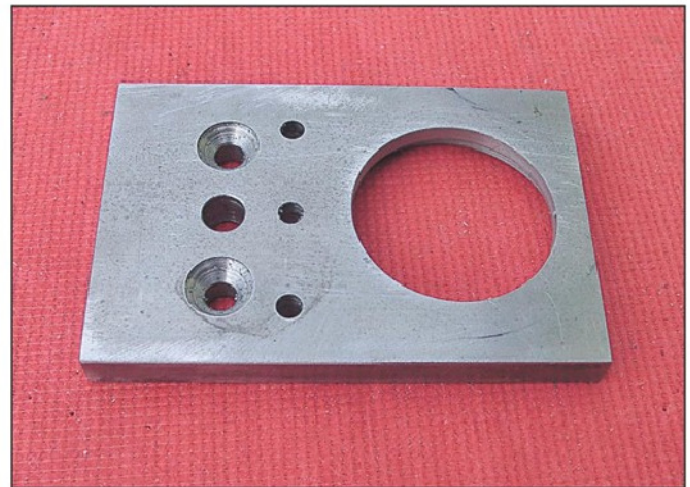


Photo 16. Completed baseplate.

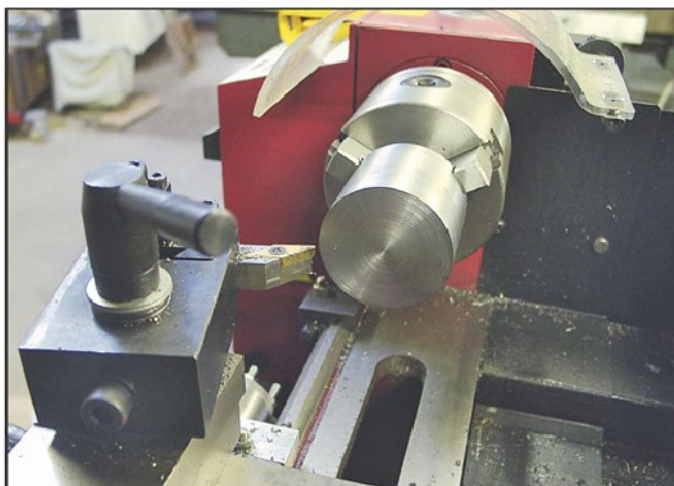


Photo 17. Facing the upstand.

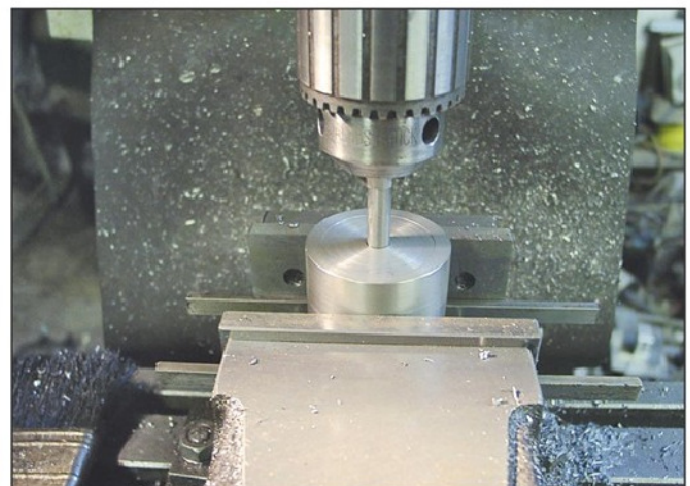


Photo 18. 8mm rod is used to find the datum.



Photo 19. Completed upstand (left) and clamp disc (right).

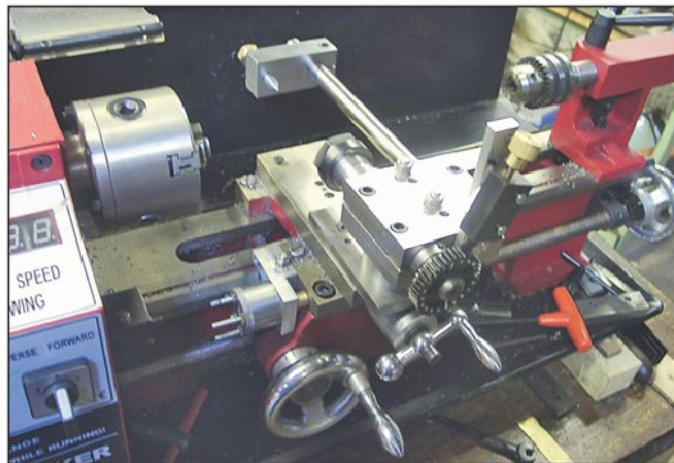


Photo 20. Here the head is bolted down to the saddle in place of the topslide. Although shown at right angles to the machine bed it may be rotated about a vertical axis. The head axis is at lathe centre height.

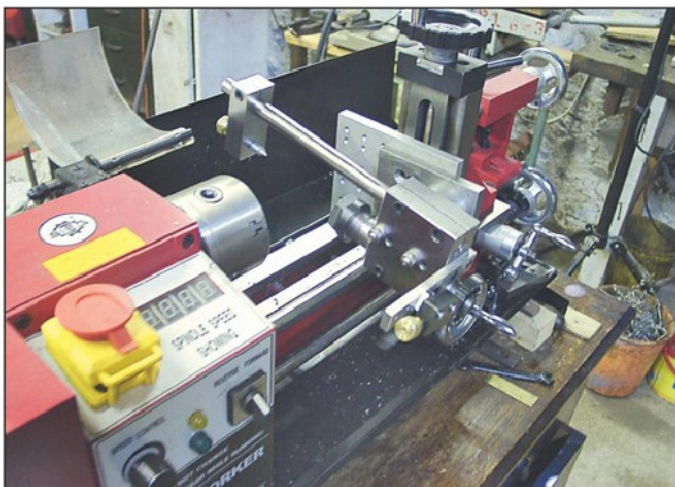


Photo 21. In this view the head is attached to the milling sub plate and in turn to the vertical slide.

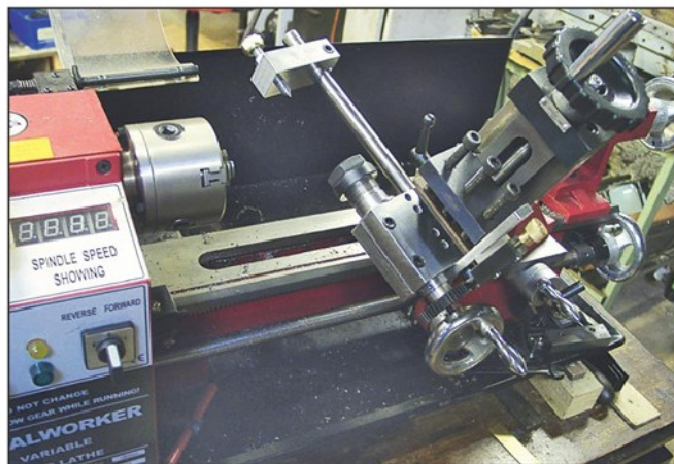


Photo 22. The head is now clamped (with protective packing) by the vice on the vertical slide. This arrangement and that in photo 21 permit rotation about both horizontal and vertical axes.

mill, where the 8mm hole was used as a datum to set the positions for the two M6 tapped holes.

Upstand (Fig. 14)

As noted previously the original intention was that this should be the sole means of support on the saddle, but a rethink introduced the baseplate. If you choose to follow my suggestion here, then the axial length of the upstand is set so that when assembled on the saddle, the axis of the dividing head is level with the lathe centre height. This can be achieved either by careful measurement of the parts and the lathe, or as in my case (because I had already made the part before the baseplate was considered) by making it slightly long, assembling on the machine,

and taking height measurements to 10mm then dealing with the other turned features before transferring to the mill using the same datum method as on the clamp disc, photo 18 to add the 6mm holes. Shallow recesses are specified at both ends to ensure that when clamped up, the parts locate squarely. Photo 19 illustrates the completed upstand and clamp disc.

You may also consider an alternative approach by making the baseplate, clamp disc and upstand first, then positioning the bores in the body, after trial assembly.

Making the part was a case of using the lathe to clean up a piece of bar, photo 17 then dealing with the other turned features before transferring to the mill using the same datum method as on the clamp disc, photo 18 to add the 6mm holes. Shallow recesses are specified at both ends to ensure that when clamped up, the parts locate squarely. Photo 19 illustrates the completed upstand and clamp disc.

Operation

The final three photos endeavour to show ways in which the dividing head may be rigged on the Mini-Lathe. In photo 20, the base plate is bolted down in place of the top slide, using two countersunk M6 Allen screws of overall length 19mm. In this arrangement, the head centreline is automatically at lathe centre height, and the head may be rotated on two vertical axes, that of the absent topslide, and the centreline of the upstand.

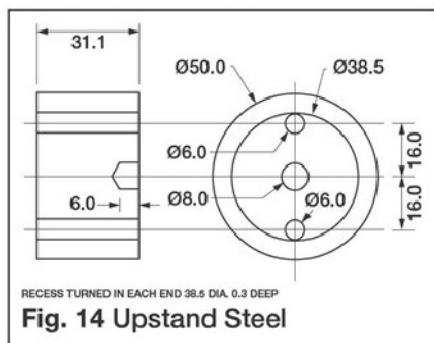
The vertical slide and milling sub table are employed in photo 21, where the head

is again held by the baseplate, this time bolted to the sub table by three M5 screws. Photo 22 shows a simpler arrangement where the body of the dividing head is located directly in the vertical slide, packing being added to protect the surface. Do though note that in this set up, the steady arm should be fitted to ensure rigid clamping. Here the head may be rotated on the horizontal and vertical axes afforded by the vertical slide, with a third (horizontal) axis (upstand) being available in photo 21.

Further work

At the outset, I envisaged this device as taking two formats, the simple, as described here using direct division from available change wheels, and the more complex using a worm gear arrangement with division plates and sector arms to achieve difficult numbers. For this exercise, a suitable worm is available at modest cost from HPC Gears.

However, it also occurs to me that for many, the Mini-Lathes will represent an initial foray into the world of model engineering, and given the variety of numbers available from standard changewheels, the ability to crack difficult division may have limited interest. Any feedback from readers to indicate the popularity or otherwise of the added development would be most welcome. ■



CHOOSING AND ASSESSING A MILLING MACHINE

Dave Fenner looks at buying a milling machine



Photo 1. Matchmaker, though CNC, shows typical industrial vertical mill construction.



Photo 2. VMC mill, Myford variety with low speed conversion and digital readout on two axes.

If you follow in the well trodden footsteps of previous generations of model engineers, a milling machine is unlikely to be your first foray into the world of machine tools. It is most probable that you have already invested in a lathe, possibly a pillar drill, and a bench grinder.

The process of choosing may well be an extension of that for the lathe, except that part of the thinking has already been done, particularly where size is concerned.

Nowadays, there is a bewildering choice of imported machines from various sources, ranging from small mill/drills to Bridgeport look alikes. If we cast our minds back to an earlier era, our choice was very much more limited. Going back to about 1978, having earlier acquired a very second hand ML7 lathe, I was offered a small horizontal mill which I think was a badged "Bonds of Euston Road". It was a very basic machine having a horizontal No. 2 Morse taper spindle, running in plain bearings and transmission which used a three speed motorcycle gear box; definitely a rudimentary piece of kit, but nevertheless useful. Other machines followed, several of which used bike gearboxes, then a Centec of which more later.

In general, a mill will be fitted with a cutter which rotates against the work which is fed into the cutter.

For operations other than drilling and sawing, this implies interrupted cutting. To mitigate the vibration that might result, milling machines, even small ones tend to be heavy beasts and when mounted on a stand are naturally top heavy, raising safety implications when moving and handling. Larger industrial machines may also exhibit this top heaviness. On one occasion, when trying to move my Matchmaker mill (approx 1.5 tons) on a

narrow pallet truck, it started to topple. Fortunately it was restrained by the close proximity of the workshop stone wall. Nevertheless, it became quite an exercise to restore it to verticality.

Catalogue information

The catalogue data for mills will often give table size, table travel X and Y, quill movement Z1, and perhaps head or knee movement Z2, with some indication of the maximum height of work that can be accommodated beneath the spindle. Note though that this dimension will be modified by the tooling fitted. The quill travel will determine the maximum depth of hole that can be drilled or bored without moving the head or the knee.

Also given will be the motor power, and the range of speeds. Of these two factors, for model making, motor power is less likely to be an issue than speed. I see that modern VMC type mills may be fitted with motors of 1.5hp. My own early (Myford) version makes do with 1/2hp, and I have not found power to be a problem. Conversely, the standard minimum speed (160 rpm) is too high for six inch slitting saws, and hence I have added a low speed belt conversion going down to 40 rpm.

Machine styles

If we look first at the development of industrial machinery, early mills tended to be either horizontal or vertical. A horizontal mill would typically be fitted with a long arbor carrying one or more cutters, and thus be able to cut one or more slots or a broad flat surface in the work, in one pass. This type of arbor would be supported at the outer end in a bearing carried by the overarm. A short arbor could also be used, so that an end

mill could be fitted pointing towards the operator, however this form of set up raises the disadvantages of loss of table travel and difficulty of viewing the work. The table would be carried on a knee, and vertical feed would be by moving the knee.

In the case of a vertical mill, the vertical spindle axis makes it very much easier to see what is going on when drilling etc. The Matchmaker, **photo 1** although a CNC machine, shows the typical construction style of a vertical mill.

In both of these cases, the relative angles of the machine are fixed at 90 degrees. The first variation on the theme occurs when (usually on a horizontal mill) the table is permitted to swing, so that the X travel may not be at right angles to the spindle axis. I have seen this feature employed for spiral gear hobbing set ups.

Next is the facility to incline the head on a vertical type. Over recent years, this has become a much more popular feature on small mills. In industry, it may well have started with Bridgeport, where the head may be inclined in two planes, sideways and fore/aft, as viewed by the operator. In the case of industrial equipment, a worm and wheel mechanism is usually added, which gives the required control to accurately position the heavy weight involved. A further Bridgeport nicety, also found on some other turret mills, is the ability to swing the entire head around on a vertical axis, also to move its ram mounting to effectively increase the effective Y travel of the machine, or indeed to move the spindle axis completely clear of the table.

Again in the case of the Bridgeport, the table is mounted on a knee, and thus two increments of vertical feed may be applied; that via the quill, and that via the knee. The smaller VMC machines also fall into this category, **photo 2**.

Older machines of smaller size tend to be less plentiful than lathes. Certainly, if one looks at Tony Griffiths excellent website www.lathes.co.uk it is clear that there have been many manufacturers of mills, but it is likely that being intended for tool room use, prices were high and production volumes consequently low. One make that does crop up from time to time is the Centec, of which several varieties may be found. If my understanding is correct, the basic machine was a horizontal mill but vertical heads were also available. I have some knowledge of two examples. The first came to me around 1979, and had a vertical head with fixed spindle (i.e. no quill feed). Vertical feed was thus by means of the knee, and control of this was by means of a long lever at the rear of the machine. Although somewhat Heath Robinson in appearance and action, it was possible to make accurate vertical feed increments by careful use of the vertical stops. Transmission was by belts and pulleys. The availability of both horizontal and vertical spindles was occasionally useful for fly cutting two surfaces at right



Photo 3. Part of the Naerok head is visible here.



Photo 4. Machining a casting on the Naerok 350.

angles. The second machine was a horizontal, passed to our club by a local works, and here the vertical movement was controlled by a calibrated worm drive. Transmission, I believe, was by gears, and a power table feed was fitted. In both cases, the spindle was equipped with a No.2 Morse taper socket. Editor's note: The Centec was available with a vertical head and quill feed.

During the 1980's small bench mounted mill/drills became available at affordable prices. In my case, the Centec gave way to a Naerok 350, **photos 3 and 4** which was equipped with a 1HP motor and an R8 spindle. Being a round column machine, it meant that if the head was raised or lowered, its angular position would be lost, with implications for the next operation. Over the years, a number of methods have been described to get around the difficulty, including some which rely on a key arrangement, and others which employ laser alignment. The paint finish on this machine may be contrasted with that on current machines, indicating the advances by far eastern manufacturers.

Several designs have come to the market in recent years, where the round column has been replaced by a sliding dovetail arrangement for the head movement. This now means that it can be raised or lowered at will without loss of registration. At the time of writing, machines such as the Warco WM18 in **photo 5**, the Arc Euro Trade X3, **photo 6** and the Chester Commodore, are typical of this style of machine.

Spindle Type

I mentioned that the Centec spindle featured a No2 Morse taper (MT2), and of course these tapers are noted for their self locking characteristics. With my own machine, I was careful to add a smear of grease to the shanks of tooling, and avoid over tightening the drawbar. In the case of the club machine, however, I recall more than one occasion where heavy blows were needed to release the arbor. Morse tapers, often No 3, are very popular amongst the modern small mills, but here I have to express a personal preference for R8. This is typically associated with



Photo 5. Warco WM 18 features dovetailed column, inclinable head and variable speed.

Bridgeport, but in terms of size is close to MT3, and is often offered as an alternative. The R8 exhibits only a slight self locking tendency and the drive is augmented by a keyway. On releasing the drawbar, only a light tap is required to eject the tooling. My gut feel is that this must be better for the bearings. **Photo 7** illustrates an R8 Clarkson style milling chuck and an R8 collet.

Other spindle types which may be encountered include the INT 30 and 40 types, **photo 8**. Tooling is located in a non self locking taper (3.5in to the foot) the drive being augmented by two pegs. In the past I have come across INT 40 tooling tapped for either 5/8 or 16mm drawbars. My agricultural style work around was to warm up and temper the extremity of each arbor, then run in a M16 tap to give a common standard. INT 40 tooling is normally associated with relatively heavyweight machinery such as the Beaver mill - a bit bigger than a Bridgeport with a five foot



Photo 6. X3 from Arc Euro Trade has a fixed head, a dovetailed column and variable speed.



Photo 7. R8 Clarkson Milling chuck above, and collet below.



Photo 8. An INT 30 adapter (left) shown with two INT 40 arbors carrying drill chuck and face mill.

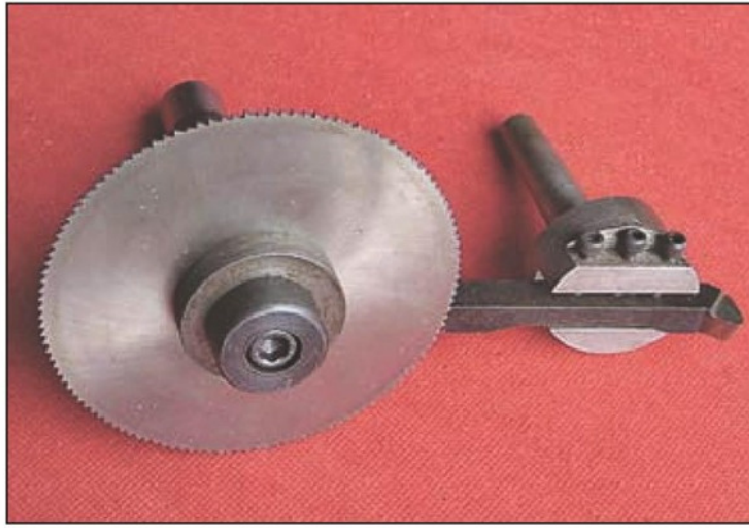


Photo 9. Six inch slitting saw and fly cutter.



Photo 10. 1/16in. FC3 cutter above, and 1/16in. solid carbide below.

table. It is also the standard used on my CNC Matchmaker mill.

I am lead to believe that the small Emco milling machines aimed at the hobby user have typically featured MT2 spindles, however I have seen a small CNC Emco machine which was fitted with what appeared to be a quick change "INT 30" taper using a pull stud lock system. This gave not only the obvious advantage of quick and convenient tool changing, but it was also apparent that due to the greater angle of the taper, the tool did not need to be drawn out as far axially before it could be moved sideways to clear the work.

Speed Range

Because the cutter radius may vary widely; from small drills and disposable FC3 end mills to larger end mills and even larger fly cutters and slitting saws, a wide speed range is a desirable feature. Technical developments in cutters are accentuating this. While for high production purposes, an industrial user may choose a fairly restricted range of cutter sizes, the typical amateur may wish to cater for more variety. You might wish to run a slitting saw or fly cutter, **photo 9** at 60 rpm or even less, while the trend particularly in CNC circles seems to be for smaller cutters running faster. Most small machines I have come across have top speeds of around 2500 to 3000 rpm, which is fine for small HSS FC3 cutters. However, a modern carbide bit of say 1.5mm diameter could be run considerably faster. **Photo 10** shows each of these for comparison. Modern industrial CNC machining centres may offer up to 30,000 rpm.

What to spend

A quick look back at classified ads suggests that in the amateur sector, there are far fewer mills offered for sale than lathes. The smaller size mills which I have owned over the years, have all been items heard about locally, and chased up quickly. Selling on the machine, which has become displaced by the trade up has on each occasion been a swift matter either using the club grapevine or local classifieds.

Going back thirty odd years, the prices paid were under £100 pounds for the rudimentary machines up to over £200 for the Centec. At around that time a new VMC style mill was bought by a fellow club member, and the price as I recall was about

£1250 (the current price of a new Warco WM-18). Today, a new VMC can be purchased for around £1500 and for comparison, my own example was acquired second hand with some extras for a little under £1000 several years ago. A budget of about half that amount should find a good second hand example of one of the popular bench mounted mill/drills.

Lighter weight machines for small scale working, are of course considerably less expensive. At the budget end, the range from Arc Euro Trade starts with their X0 Micro Mill at £75-00, moving up a size gets into an area where rather like medium sized family cars, the choice starts to broaden. An allowance of say £500 will give a number of options from our regular suppliers such as Arc, Warco and Chester. Unless you plan to undertake seriously heavy work, my view now is that a perfectly competent brand new mill for larger scale model engineering purposes need not cost more than £1500.

Pristine, restored, or basket case

Given that you probably already possess a lathe and some other basic workshop kit, very likely now backed up by a modicum of experience, you may feel more able to consider a second hand machine, even one requiring attention. It is though difficult to dismiss the design advances on some of the modern machines intended for hobby work. Electronic variable speed drive, inclinable head, and dovetailed column are features which make some of the latest machines very much more convenient to operate than some of the traditional mill/drill designs.

In the current economic climate, industrial machines have become noticeably cheaper, so that a good Bridgeport may be picked up for under £2000, whereas not long ago the price might have been nearer £3000, however ex industry equipment is likely to be set up for three phase power.

Assessing second hand

If you know something of the machine's prior history, then that will give pointers as to potential problem areas. Industrial machines may have had a hard life on production work, whereas one used in a laboratory or training establishment is likely to exhibit less wear, but in the latter case, may show surface damage due to

careless trainees. Smaller machines are more likely to have had perhaps just one "owner driver" and in hobby use, the actual number of hours run, will probably not be high.

Transmission and Spindle

If it is a single phase machine you are considering, it could be useful to take along an RCD, as supplying via one of these can indicate certain fault conditions. Start the spindle, and if it's a variable speed machine, take it from minimum to maximum speed in each of the gear ranges, listening for undue vibration from bearings, gears or electrical sources.

Take along a clock gauge with magnetic base and set it up to measure quill deflection, **photo 11**. Apply hand pressure fore and aft. On my Naerok, the quill was a slightly loose fit in the head (probably about a couple of thou) but this could be easily "dialled out" by lightly nipping the quill clamp. If however the deflection remains after locking, then perhaps the bearings are past their best.

Lock the quill and set the clock on the end face of the spindle or chuck and check the spindle end float by pushing up and down on the chuck, **photo 12**. The measurement on my thirty year old VMC was just under a thou.



Photo 11. Checking for lateral play in bearings and quill.



Photo 12. Clock positioned to check spindle end float.

Release the lock and operate the quill feed lever to check for free movement over the whole travel - also that the return spring works correctly. (These are frequently adjustable so that heavier tooling will return satisfactorily.) Engage the fine down feed, if fitted and check its operation.

On some cheap far eastern machines built some years ago, it may be worth checking that the tooling location bore in the spindle does run true. The VMC style machine mentioned above, purchased new in the early 80's by a friend, did show a slight run out in the R8 socket taper. The solution was to incline the head to the half angle, bolt a toolpost grinder to the table, then run the machine and the grinder to gently regrind the internal taper, feeding vertically along the taper via the knee.

Slideways

Slideway wear will depend on the amount of use (and abuse) together with the type of work undertaken. Start by winding the table to the extreme positions along the X axis then the Y axis. A machine used on numerous small parts may show wear biased to the centre of the slides. Conversely a large mill with a long table used over its full travel can suffer due to the effect of the overhanging weight when the table is at full travel in either direction. In extreme cases, the table will be horizontal at mid travel, but droop slightly when traversed either side. It may be possible to set up the clock and then try to rock the table to check for movement. If there is movement, then it should be possible to adjust it out by resetting the gib strips, provided of course that the wear is reasonably even over the length of the slide.

When I checked over the well worn Beaver mill I acquired some years ago, I found significant slideway wear, particularly on the Y axis. Of course Murphy's law came in to play and the wear was anything but even, part of the extremity being virtually unworn. At the outset I concentrated on adjusting for the section which had seen most use, and then found that the tapered gib had run out of adjustment. The easy solution was to add a brass shim behind the gib. This and other adjustments gave me a



Photo 13. Typical 4in. swivelling milling vice, this one from Vertex.

reasonably accurate machine, albeit with the travel now restricted to that well worn section. At the unworn section, several thous of material had to be removed, and this was done in periodic bursts of enthusiasm spread over several months. The tools used included a small angle grinder, files and scrapers. As the slideway was a rectangular section as opposed to a dovetail, it was relatively easy to keep a check on progress with a micrometer.

Turning the handles back and forth will give a feel for the amount of backlash in the leadscrews. Backlash on a mill can be more of a problem than on a lathe, as when climb milling, the cutter draws the work in, and if there is significant backlash, then this allows an uncontrolled infeed (to the extent of the backlash) with potentially damaging results. Many mills make provision for adjusting out such backlash, by means of double or split nuts. However if the leadscrew itself is unevenly worn, then the nut can only be adjusted to fit the least worn section. Mills with backlash are of course eminently useable, but work should be planned to avoid climb milling.

Three phase machines

If your workshop has a three phase supply then the world of second hand machinery is rather more your oyster. You will need to check on the current capacity of your system, but it is unlikely to present a problem. If however you are presented with an unmissable ex industry bargain, and you have only single phase, then you need to consider the options for powering up.

Start by looking over the machine and counting the motors and investigating their respective control circuits. The biggest item will be the spindle motor, with others for coolant and perhaps power traverse. The control switchgear may involve contactors, and if so, you need to

see if coils are wired to mains (415) voltage, or whether there is a low voltage control circuit.

The easy option as far as work on the machine is concerned is likely to be the acquisition of a single to three phase converter, and my suggestion would be to discuss the application with one of the suppliers of such equipment before making a purchase. Supplying via a converter should mean that you do not need to make any electrical changes to the machine.

If the machine has just a spindle motor, then rewiring to use an inverter may be an option. Inverters are now available which produce 415 volts three phase from 240volts single phase input, but most inverters run from a domestic supply, will push out 240 volts not 415 volts. It therefore becomes necessary to dig into the internal wiring of the motor and change from star to delta configuration, in order to run at the lower voltage. Driving through an inverter gives the advantages of variable speed, jog, and soft start.

The other traditional approach would be to remove the spindle motor and substitute a single phase alternative. In the case of the low powered motors for coolant and traverse, it may be possible to add large capacitors and wire for single phase. The two books by Jim Cox, "Electric Motors", and "Electric Motors in the Home Workshop" from the workshop Practice series give valuable advice and guidance on this general issue. They can be purchased from www.myhobbystore.com

Other considerations

Just as when buying a lathe, you need to consider carefully just what is included in the deal, and what you are going to need. New machines may be supplied with a drill chuck and perhaps a face mill. You will almost certainly need a robust machine vice the size of which will tend to rise with that of the machine. A decent vice of about 4in. (100mm) jaw similar to that in **photo 13** may be obtained new for about £60-00. I have not seen up to date prices for larger items, but the distinctly second hand 8in. vice which lives on the Matchmaker cost £80-00 several years ago. Much lightweight work however can be undertaken on smaller vices such as those in **photo 14**. Exclusive to Warco are the DH1, **photo 15** and DH 4 vices which give advantages in the clamping size range for a small footprint.

To clamp work to the table without a vice, a clamping system will be needed, and here we have a make or buy decision. For many years, I made do with Tee bolts made by welding flat bar on to the end of screwed rod (or even just screwing the rod



Photo 14. Myford vice (left) is a quality product useful for fine work, note weld repair beneath screw on vice to right.



Photo 15. Warco DH1 vice has gripping length similar to footprint.



Photo 16. Rudimentary Tee bolts and nuts.

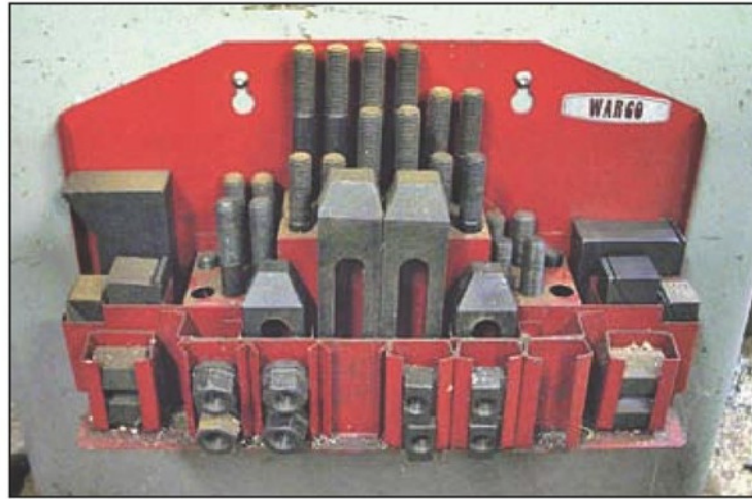


Photo 17. Attached to the front of the mill, not the best location for the clamping kit as witnessed by the swarf.



Photo 18. This Modeloy chuck has 2MT arbor and served both on mills and lathe.



Photo 19. R8 collets will take up to 3/4in. tools.

in) as in **photo 16** but the homemade items have since been augmented by two proprietary clamping sets one of which is illustrated in **photo 17**. These come in different sizes based on the stud diameter, and include "saw tooth" supports visible in **photo 4**, which add convenience to the set up process. Harold Hall has described making clamps in the pages of MEW, also in his book "Milling a complete course".

It was mentioned earlier that most milling operations involve interrupted cutting, generating cyclic forces between cutter and work. While you may get away with holding an end mill or slot drill in a drill chuck, this is not recommended practice, and anything but the lightest cuts are likely to cause the cutter to move axially in the chuck. Frequently the spiral shape of the flutes causes the cutter to walk out of the chuck, increasing the depth of cut, and potentially scrapping the work.

To hold your end mills, you have three main options. The first is to buy a Clarkson style chuck as was shown earlier in **photo 7**. These accept dedicated collets and you might standardise on a small selection of either imperial or metric to limit the initial outlay. A smaller device intended for model makers, which used to be available, was the "Modeloy" chuck. **Photo 18** shows an example of this design, which having a 2MT shank, could also be used in the Myford lathe. A variation on option one is to make a chuck and collets. Here Harold Hall gave a suitable design in his book "Lathework a complete course". Do though note that these chucks need threaded shank end mills to function correctly.

Option two is to go for an ER style collet chuck. The choice of ER series would be guided by the size of machine and the cutters to be used. Arc Euro Trade list five sizes of ER. The smallest series, ER11 take up to 7mm, while the largest ER32 will accommodate tools up to 20mm diameter. Here again, an alternative could be to make the chuck and purchase the closing ring and collets.

Finally option three is to use collets which match the internal taper of your mill spindle. These are readily obtainable for Morse taper

(No's 1, 2 & 3) and also for R8. **Photo 19** shows a selection of R8 taper collets.

Options two and three will allow the use of plain shank cutters and option three is likely to reduce the tool overhang as is evident from **photo 20**.

I hope that the foregoing notes will be of help to those contemplating moving up from working on the lathe alone, into the world of dedicated mills. The intention has been to set out some of the choices available, and to illustrate some of the pitfalls. ■

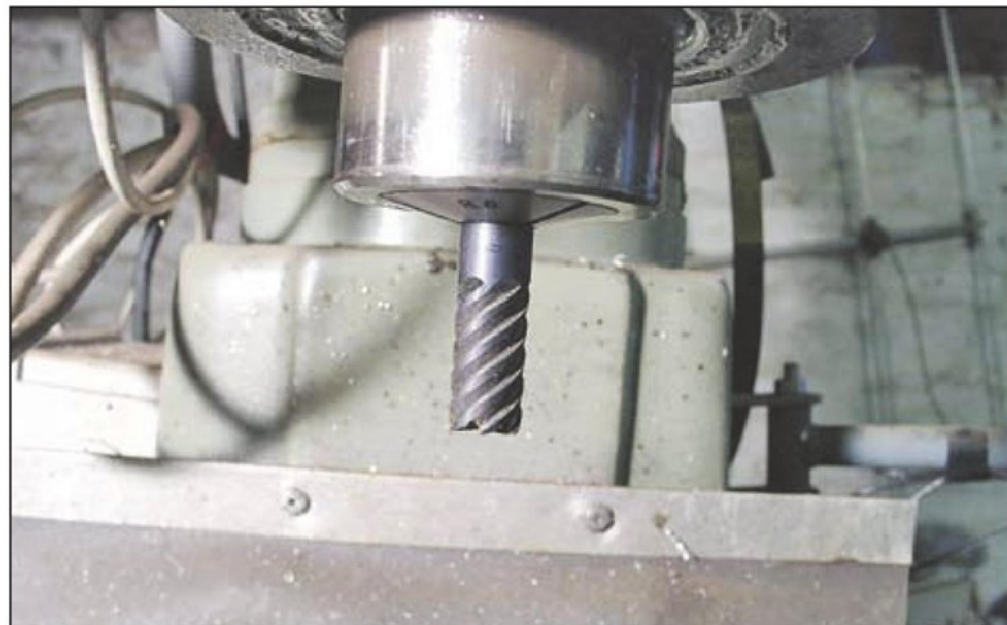


Photo 20. Solid carbide cutter held in R8 collet gives minimal tool overhang.



Photo 28. The control panel.

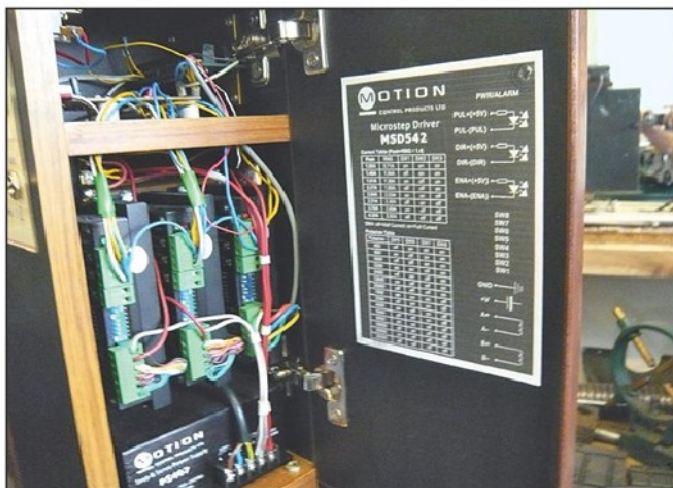


Photo 29. The neat internal wiring.

THE STEPPERHEAD MULTI-MODE MACHINE ③

Alan Jackson concludes his look at this versatile machine.

Control panel and computer mounting

The control panel and computer support box contains a Motion Control power supply and three stepper motor drivers in the lower section. Air circulation holes for cooling are provided in the back panel. It does not seem to get too hot even when run for long periods. In the upper section is a pulse generation circuit board, which can supply a variable pulse stream for manual control of the stepper motors. For the circuit info for the board I am indebted to a very good article in Model Engineers Workshop No 118 by David Haythornthwaite.

Switches on the front panel select which stepper motor is in use and its speed and direction for manual control, **photo 28**. **Photo 29** shows the neat internal wiring. The switches can also be set for computer only control of the stepper motor or motors. The main motor is also controlled at this panel via an inverter. Placing the control panel and computer at the tailstock end seems quite convenient and positions the operator away from the cutting operations. You may notice that the main pulley does not have a guard. I did consider making one but it is very convenient to be able to handle the pulley for many small tasks and I think the guard would be more often open than closed.

Computer

I have used a fairly old laptop computer that came my way, which runs on Windows 95. I do not think it would work with Windows XP so this somewhat limits the choice of CNC control systems available. I am using TurboCNC, which should only be run in DOS. TurboCNC say that the computer pulse signals are unreliable when operating through the additional load of a Windows operating system and this will result in missed steps etc. I had a struggle to get it working directly in DOS;

it boots up through a floppy disc where it is reliable and does not miss steps. I am on a learning curve for CNC and up to now it fulfils all that I need.

Stepper motors

There are two hybrid Nema size 23 motors 56mm long used for the head and cross slide and a 76mm long motor for the saddle. The stepper motor drivers are set so that each motor is just powerful enough for its axis. This provides a measure of safety because the motor will stall if overloaded. I had difficulty finding screened 4 core cable in the small quantities needed so I used TV scart cable. The 25 separate screened cables were grouped into 4 sets of 6 cables each (1 spare) for the connections between the drivers to the stepper motors.

Rear chip guard

This has been constructed from 6mm thick MDF in a triangular shape which enables cables and low voltage transformers to be housed. The cross slide cable is also routed into here via its protecting tube. The top shelf provides space to accommodate collets and chuck keys etc, **photo 30**. A slide groove is also useful for a clipboard and to mount the milling head DC motor controller when it is used. A four-way power socket is mounted on the rear face out of the way of swarf etc.

Top slide

The topslide features a lever locking arrangement enabling it to be positioned and locked at any angle anywhere on the cross slide. This has been described in Model Engineers' Workshop Nos. 119, 120 & 121. A screwcutting retract and toothed belt drive handwheel are also provided allowing a large micrometer dial

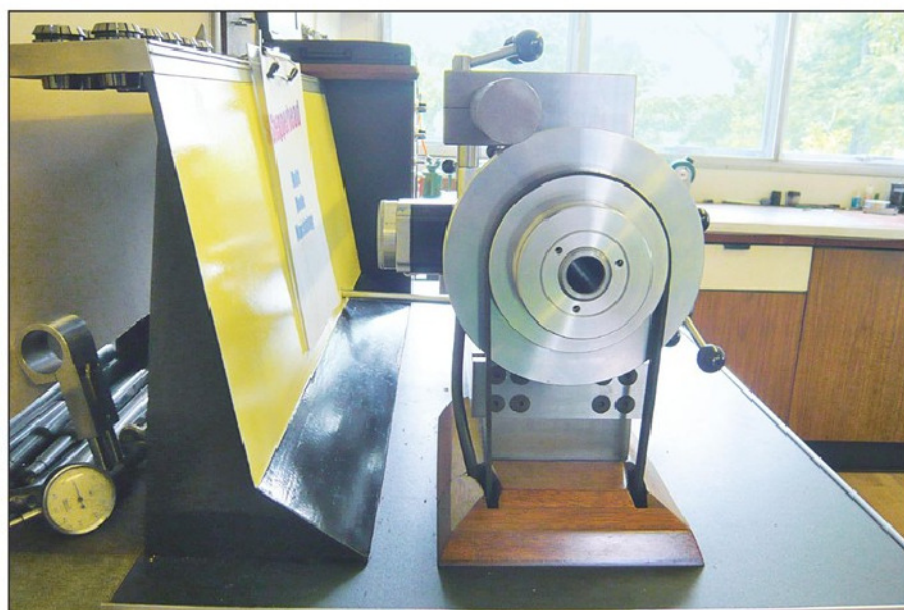


Photo 30. The rear chip guard.

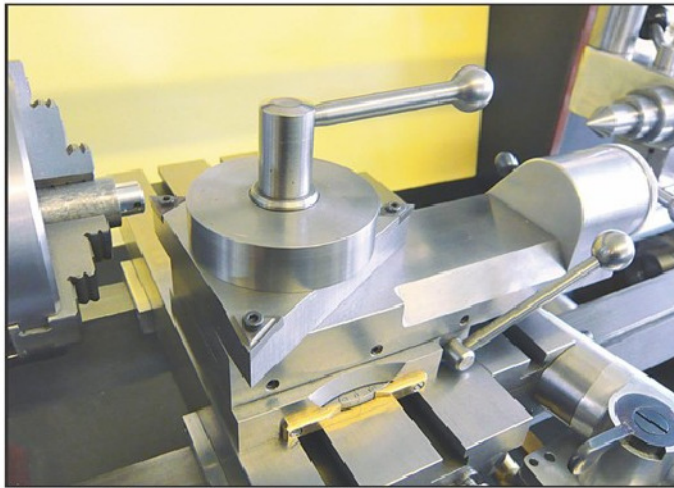


Photo 31. The big triangular tool holder....

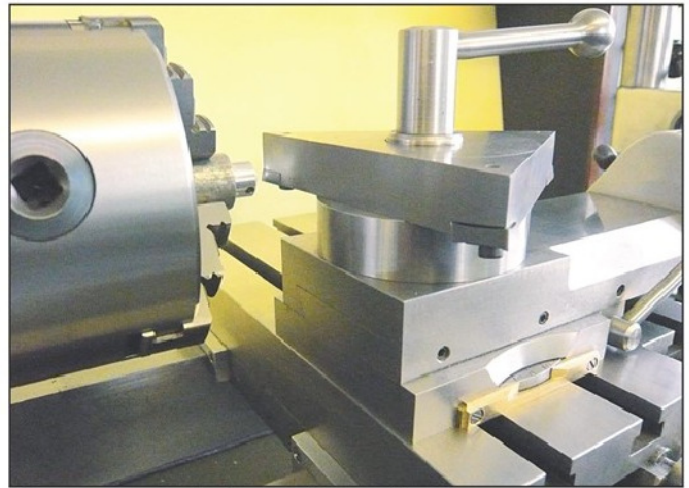


Photo 32.can also be used inverted.

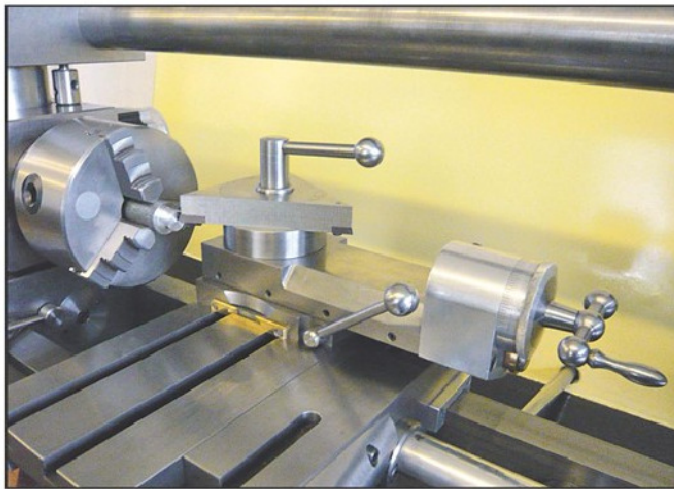


Photo 33. Running the machine in reverse.

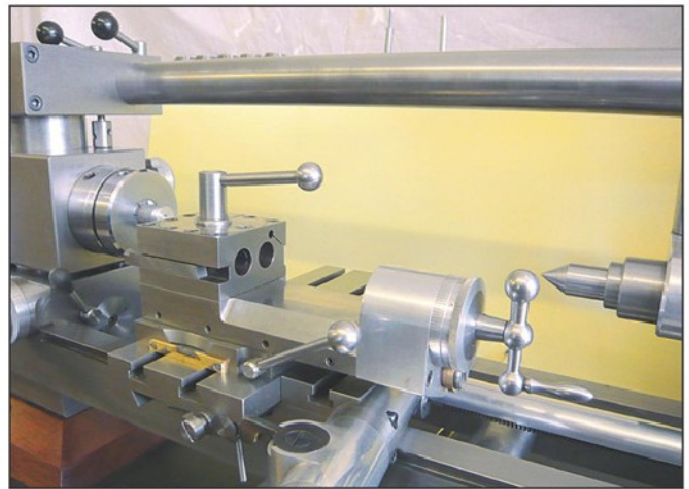


Photo 34. The square toolpost can be used the correct way up....

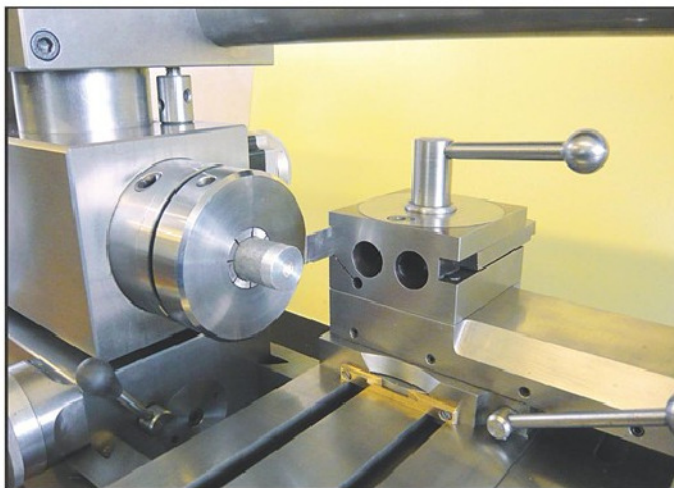


Photo 35.or used inverted.

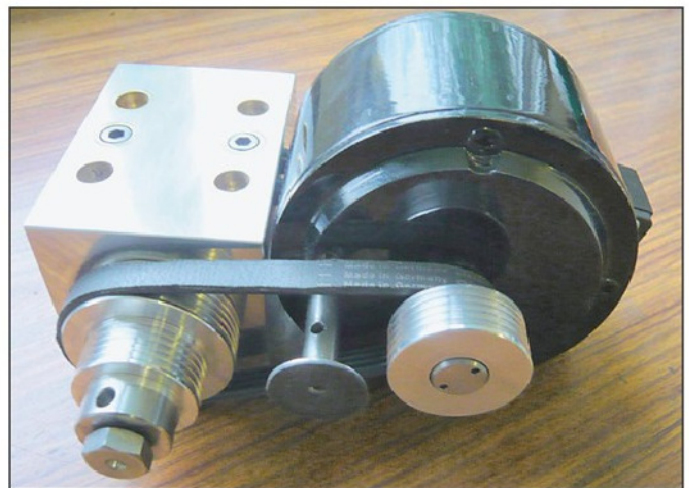


Photo 36. The milling attachment is driven using a Poly Vee belt.

with friction reset. The feedscrew nut can also be adjusted to minimised backlash. The slide has a total travel of 80mm. One advantage of the tailstock design is that it has a clear space below the tailstock barrel and allows the top slide to fit closely up to the tailstock centre. The topslide retract lever is also profiled to clear the tailstock.

Tool holders

I have made two different tool holders. Because the lathe centreline can be raised or lowered there is no need for height adjustment at the cutting tool. This permits simple rigid designs for

tool holders. Consider a Dickson style toolholder, a carbide tip is mounted on a square toolbar which is in turn mounted in a dovetail tool mounting block and this is clamped to the toolpost body mounted on the topslide. This uses many clamped interfaces each of which can make problems and also results in a cantilevered overhang of the cutting tool.

Carbide tips are directly mounted in a triangular toolholder for maximum rigidity, **photo 31**. It is also possible to invert the toolholder using the circular spacer, which has a preset thickness to mount the inverted cutting tool at centre

height. The advantages of a rear parting tool are well established so inverting the cutting tool can use these advantages for normal turning. I think this is especially important on small light lathes. The cutting tool can be positioned as a rear toolholder (the topslide will allow this) or the lathe can be run in reverse with the topslide in the conventional location. This is useful for heavy cuts and for preventing or reducing swarf being sprayed everywhere. I also believe you get a better finish this way, **photos 32 and 33**.

The square toolpost is designed for two $\frac{5}{16}$ in. square HSS cutting tools, a parting



Photo 37. This topslide is an old Myford one.



Photo 38. The mounting table can be mounted on a cross bar...

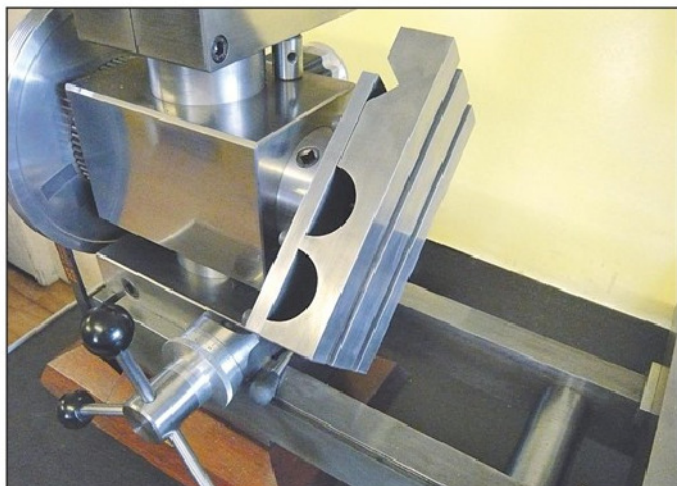


Photo 39.or on the faceplate.



Photo 40. ER32 collets can be fitted directly to the lathe mandrel.

tool and a boring tool. This toolholder can also be inverted and be used as a front or rear toolpost, **photos 34 and 35**. A D bit mounted in the chuck is useful for cutting tool centre height setting.

Milling head

The milling spindle is mounted on two large ball bearings and has a built-in drawbar, which also acts as an extractor for a No 2 Morse taper. The modified 24-volt 300-watt DC motor (similar ones are used on motorised invalid chairs) can be mounted on either side of the milling head body. A Poly Vee belt drives the spindle via low or high speed pulleys. The DC power controller can vary the speed and the power cable can be fitted either way allowing forward or reverse rotation. Four M6 through bolts mount the head assembly using tee bars directly to the cross slide or mounting table. The square body enables easy setup alignment. The milling head assembly can also be mounted directly on the milling head top slide, **photo 36**. Also see milling head photos in MEW issue 151.

Milling head top slide

This slide is a modified and very battered early Myford ML7 top slide, **photo 37**. The slotted radial bolt lugs were removed and, a lever locking arrangement fitted. The Vee slides were cleaned up and the nut made adjustable to minimise backlash. A toothed belt drive at the handwheel, with ball thrust

bearings added at the feed screw to ease the load on the belt drive. A dowelled cast iron gib strip and a slide lock screw have also been added. The machined topslide mounting point is tapped for four M6 bolts to suit the milling head.

Mounting table

Normally a vertical slide is used to expand the operations possible on a lathe. A fixed mounting table is all that is needed on the Stepperhead. It can be set at any angle and is more rigid than a vertical slide because it avoids the dovetail slide; the elevating headstock provides the vertical adjustment. The table can be mounted in many locations i.e. on the overarm or on the cross slide via the vertical or horizontal columns, **photo 38**. It can also be mounted on the lathe spindle as a faceplate by using the camlock studded plate bolted to the rear face, **photo 39**. The mounting plate is proportioned so that the faceplate assembly is balanced when assembled on the mandrel. The topslide, milling head topslide, milling head assembly and vice components can all be fitted as required.

Collet chuck

ER32 collets can be directly fitted in the lathe mandrel using the camlock chuck fitting. The collet-closing nut has $\frac{5}{16}$ in. blind holes enabling a Tommy bar to close or open the collets. Two hardened steel washers fitted inside the closing nut enable the collet to be withdrawn, as the nut is undone, **photo 40**.

Boring head

This item was made years ago and entered into the 1987 Model Engineers Exhibition where it was awarded a Silver medal and the Bowyer-Lowe trophy I am proud to say. It seemed worthwhile modifying it for the Stepperhead, which turns the machine into a horizontal boring machine. See MEW 151 for a photo of the boring head. As such boring and facing can be carried out on items mounted on the cross slide. The original Manumatic boring head was operated by a hand wheel located at the pulley end of the mandrel which, when rotated it caused the boring head cutting tool to move in or out according to the direction the handwheel was rotated. This happened whether the head was rotating or stationary.

I have since replaced this with a simple cam actuator that operates the boring head as it rotates, **photo 41**. The boring tool can be set to move in, out, or stay put at its set point by setting the control lever at the pulley end of the lathe mandrel. The cutting tool moves (when required) at a fixed rate of 0.001in. per revolution. This feature can also be used in conjunction with the Z-axis set at a chosen feed rate per revolution. For instance with a Z feed rate of 0.001in. per rev and the boring head moving in or out as desired, a 45 degree tapered hole can be bored. When the actuator is removed (or the actuator is set to the stay put mid position) the boring head reverts to manual control whereby the cut depth can only be set when the mandrel is stationary.



Photo 41. The cam operator controls the boring head.

Operation

I am still in the learning mode with *Stepperhead* but I can say that it works much better than I expected. I will go so far as to say it is fun to drive. It is after all a test bed incorporating many untried and unconventional features and my first experience with CNC, stepper motors and electronic control. I have got used to the presence of the overarm. It does not seem to restrict or hinder operation. The topslide can be moved anywhere on the cross slide. Full use of this is realised when say turning a steep taper. The topslide can be positioned so that the cutting tool is past the centre of the component being made and the lathe run in reverse. This enables easy access to the top slide handwheel whereas normally the topslide will be positioned awkwardly close to the chuck. Being able to control the mandrel speed and cutting feed during operation is also very useful. Deep cuts and fine feeds can be set for a good finish.

I have parted off a 1in. MS bar with ease using the square toolpost inverted and rear mounted using the cross slide stepper motor to power the cut.

The elevating mechanism seems to be able to do its lifting without too much effort. Subsequent dismantling showed that the rubbing surfaces of the worm and wheel were ok. The Z and X axes operate smoothly and give a good finish in manual mode and an even better finish in manual controlled stepper drive. There is not much need to change the belt position; the middle pulley size covers the speed range from 200 to 2200rpm, which is suitable for most operations, but screw cutting is best done on the biggest pulley at about 120

rpm because the additional torque keeps the speed more constant.

In some operations it seems advantageous to use a combination of CNC and manual inputs. For instance screw cutting using the computer to control the thread pitch and length and set the cut depth and withdraw manually. This is not full CNC but perhaps, a model maker's one off pragmatic version avoiding extensive programming and set up.

CNC operates in either, 'Absolute positioning' which always starts from a preset zero position or 'Incremental positioning' which moves a set distance from the existing position with no reference to any home or zero position. Certain operations require either ABS or INC mode. For most of my operations INC seem preferable. I have set up for imperial units but metric can also be chosen.

In Turbo CNC there are two operating modes. The first is preset program control whereby the control instructions (G codes) are prewritten programs that can be recalled and used or copied and modified to suit the desired operation. The second mode is called MDI (Manual Data Input) whereby a single line of control code is keyed in and the instruction is then applied. This all soon becomes quite obvious but it must be carefully carried out. The machine will only do what you instruct it to do. Tell it to do wrong and it will.

As an illustration here is a simple example of incremental MDI mode. Tan 5 degrees = 0.0875. Type in G01 Z-1.000 X0.0875 F0.001 then press enter and it will move the saddle 1in. towards the headstock and simultaneously move the cross slide 0.0875in. away from the lathe centreline at a feed rate of 0.001in./rev. and machine a taper of 10 degrees. When the cut has finished change the input to G01 Z1.000 X-0.0875 F0.001 (Positives and negatives reversed) press return and the tool will move away from the chuck following the taper. These figures can be varied at will to produce an infinite range of tapers (Morse 1, 2 etc) and feeds without having to carefully set the topslide at the angle required. I am certainly not an expert on CNC control so I will avoid trying to teach a subject I am just beginning to grasp. I just wanted to convey the advantages available to the home workshop.

I have found that using MDI mode with a manual override suits many of my requirements. What this means is, to machine the pre-described taper and be able to manually set the cut depth by using

the topslide set at 90 degrees to the lathe axis permits a degree of manual control over pure CNC operation. The computer generates the taper and the amount to be removed is controlled by the operator.

Screwcutting is another operation, which becomes easier with computer interaction.

I use the word interaction purposely, because full CNC control requires careful and extensive set up to achieve the final result from a piece of bar stock to the finished item and if you are only going to produce one item it will consume a vast amount of precious time. Well it does for me. MDI mode will allow any screw pitch for a chosen length to be cut. By using the topslide set at say 27.5 degrees (for Whitworth thread angles) the thread depth cut can be set for each pass using the topslide. I set the speed at about 120 rpm (the screen gives a readout of the mandrel speed).

The tool will then cut the screw thread to the length chosen and stop, finishing the thread with a cut depth undercut. The tool is then manually withdrawn using the withdrawal lever on the topslide. This avoids the instant disengagement of the half nuts before the tool hits a shoulder as with a normal lathe. To rewind the saddle for another cut the MDI input is modified by changing the Z-axis from minus to plus on the computer, hit return on the computer and the tool will return to the start position for a new pass. Reset the MDI Z axis back to minus, return the withdrawal lever and set the new cut depth for the next pass then hit return again. Do this as many times as required until the thread is finished. This may sound like an involved process but I am sure once observed it will seem a lot less complicated than the procedure on a manual lathe.

Left hand threads can be cut in the normal manner by starting the tool close to the headstock and moving away from the headstock with normal forward rotation or by using reverse rotation with the cutting tool on the far side of the lathe mandrel and moving the tool towards the headstock. The advantage of this is that it is not necessary to make an undercut to the thread depth to start the cut from. Also CNC threading requires a small distance at the start of each cut to get synchronised with the lathe mandrel so an extra length needs to be added for this. Any backlash in the drive is pre-compensated for in the computer setup.

Photo 42 shows what can be done. The lathe mandrel was set at 5 degrees to the bed axis. I choose 13.5 TPI because you



Photo 42. An example of taper threading.



Photo 43. Taper threading in the lathe.



Photo 44. An example of spiral and tapered work.



Photo 45. A further view of some machined components.

can, **photo 43**. This would be an awkward set up on a conventional lathe but simple with CNC and Stepperhead. In full CNC mode the Z and X axes can be programmed to make simple to complex shapes repeatedly. Positive and negative curves etc I am still in the learning mode here. Once a program has been made for a particular component it can be saved and reused again. It can also be copied and modified to make a new similar program. So a library of programmes can be built up for future use.

Milling

Milling cutters can be mounted in the lathe mandrel and the part to be machined mounted directly on the cross slide or on the mounting table via vertical or horizontal columns. There is 120mm vertical travel from the elevating headstock, 250mm travel on the cross slide and an excess of 300mm travel along the bed. Using the milling head mounted on the cross slide either directly or via the mounting table enables the lathe mandrel to be used for dividing driven by its stepper motor.

The milling head can also be attached to the table mounted on the over arm forming a vertical milling machine. One advantage of this mounting arrangement is that there is no restriction in the X direction travel. The spindle to vertical column distance (Throat) limits the X travel in normal milling machines. Vertical adjustment is provided by either, the elevating headstock or milling head vertical slide. At present only manual vertical adjustment is possible but I can see that providing a stepper motor to drive the milling head vertical slide will enable CNC three-axis control for vertical milling.

Using a diamond wheel in the milling head turns the machine into a cutter grinder.

End mill ends etc. can be sharpened using the stepper driven mandrel to index the end mill. The saddle moves up to a preset bed stop. Horizontal milling cutters can be sharpened in a similar manner. It is also possible to sharpen end mill flutes by combining the Z and A drives to follow the flutes. X is programmed to move the wheel away from the endmill at the finish of the flute and returned at the start of the next flute. The slides should be protected from grit with newspaper when doing this.

Conclusion

So now a period of operating is needed to test and explore its capabilities.

As stated earlier I have a Colchester Chipmaster lathe and a Senior milling machine both of which are in good order and modified to suit my needs. So where does the Stepperhead fit in? It cannot compete fairly with these much more massive machines.

It weighs approx 130kgs against a total of 1000kgs for the other two. But it can in a reduced capacity do nearly all that both of them can do in one machine. It can also do many tasks that neither can do. To be able to machine a component at one chuck setting avoids errors in transferring from one machine to the next and saves secondary setting up. The computer replaces the gear train and gearbox that normally drives the saddle and cross slide. The choice of feeds, screw threads, tapers etc. is infinite and instant. The stepper motor driven headstock makes dividing easy and error free.

The requirement for countershafts and clutches are eliminated. The Taper roller headstock is grease lubricated avoiding constant attention. One day I may have to downsize my workshop. Both the Senior and Chipmaster are heavy large machines and Boo Hoo! I may not be able to accommodate them, but I am sure I can fit in the Stepperhead.

There are of course alternative permutations of this design. It would be quite feasible to fit the horizontal overarm and integral tailstock to a conventional fixed head lathe. This would provide a horizontal arm to mount a milling head allowing the cross slide full movement, avoid the saddle being notched to clear the tailstock and enable more use of the lathe bed. The leadscrew configuration could also then be used. The fixed height overarm/tailstock assembly would also add stiffness to the headstock and bed.

There is an accepted convention in naming the particular axes in CNC nomenclature and I do not think I have followed this to the letter. I believe the mandrel drive should strictly be termed axis C in the lathe format. As a vertical mill the X & Z axes should change to X & Y. This will only matter if standard programs are used or transferred to other machines etc.

It has taken two years to complete this machine and about this time it is Stepperhead's birthday; it can be heard singing on Youtube. It may not be up there with Sparky's Magic Piano but it tries to do a good turn as a following act.

If you have any comments please email me at alan@jackary.plus.com

Test samples

I have made these to show off my limited CNC prowess so far.

The wooden candlestick shape has a 2.4" dia. sphere, tapered spiral column and a decorated base all made via CNC. The base underside has an inverted 15-degree tapered spiral scroll, **photos 44 and 45**.

The four holed white plastic sheet was bored using the Manumatic boring head in conjunction with a Z drive at 0.002in./rev and 0.004in./rev. The X drive was also operating on three holes to offset the taper, see also **photos 44 and 45**. ■

I have added some video files on youtube. I am a terrible camera operator so I ask you to forgive me for this.

Taper Turning <http://www.youtube.com/watch?v=Yiug1F8XCME&feature=user>
End mill Flutes http://www.youtube.com/watch?v=yMxv1jU-R_A&feature=user
End mill End <http://www.youtube.com/watch?v=FDNTeuojC78>
Gear cutting <http://www.youtube.com/watch?v=wNvgWhizX54>
Spiral milling <http://www.youtube.com/watch?v=DMmDCHkff0c&feature=user>
Happy Birthday <http://uk.youtube.com/watch?v=sCsN8Sspbq8>

Specifications

Centre height Min 80mm
Max 205mm (over bed)
Radial swing over cross slide
45 Min 170 Max
Max diameter swing over bed
410mm (Over arm removed)
Distance between centres
450mm Max
Spindle bore 25.4mm dia.
Tailstock bore No. 2 MT
Tailstock travel 125mm
Cross slide travel 250 mm
Topslide travel 80mm
Motor 430w 3-phase
1400 rpm nominal
Spindle speeds 15 to 3200 rpm
forward and reverse
Weight 130 kg approx.
Size 1000 mm long x 600mm wide x
500mm high above bench
300mm below bench for motor
Milling head motor 24V DC.
Speed range 1000 to 4000 rpm
Milling head No 2 Morse taper

A Clarkson Tool and Cutter Grinder 6

Mike Houghton concludes this series by finishing his look at diamond wheels, then looks at solid carbide tooling, "specials" and simple surface grinding on the Clarkson.

27) Resin bonded diamond wheels

I'm beginning to think that the resin layer on these wheels is colour coded. Those from RDG are a dark green and appear to behave as if they are a coarser grit than those from Arc Euro Trade which are a pinkish brown. **Photo 58** (last issue) shows a boring bar that was sharpened with a silicon carbide green wheel and then with an RDG diamond wheel. You should be able to see that the diamond wheel has almost removed the deeper and coarser scratches from the green wheel.

I have resharpened a number of brazed carbide lathe, boring and milling cutters with resin bonded wheels using the set-ups described earlier. In just about every case the end result cuts well and was worth doing. The ground surfaces appear to be polished and free of the grinding marks that a typical 80 grit white wheel will leave behind. This is probably indicative of a 150/200 grit wheel and is getting close to a "honed" surface finish. I notice the same effect when sharpening HSS tools with resin bonded diamond. In both cases the only restriction is the need for very light cuts. One remedy is to rough grind to shape on a 60# white wheel then complete the job with a resin bonded diamond wheel.

28) Solid carbide tools

Solid carbide has replaced HSS in many industrial applications, especially for working difficult materials at high speed. Solid carbide cutters have been used for engraving and printed circuit board drilling for some time and are readily available. The cost of carbide may take

your breath away, but used examples and new old stock from stores clearances do appear at times. Solid carbide is instantly recognisable because of its weight (density); something like 2x the density of steel and 15X that of water. Solid carbide tooling is sharpened on diamond or CBN wheels and the diamond wheels described above will grind it well. The clearances used for HSS seem to work for carbide. Used carbide, because it is so hard often shows different wear and damage patterns to HSS. For example **photo 60** shows an end mill that from this angle doesn't look too worn, but when viewed from the side shows extreme tip wear and chipping, **photo 61**. It's very debatable if this is worth re-grinding unless you are prepared to take the time to completely reshape the end of the cutter. With the cut off wheel you could recover the shank, which will be as hard as the rest of the cutter, unlike HSS, and reform it into a "special".

29) "Specials" and tool making

The traditional method of shaping tools from Silver Steel (drill rod) then hardening, annealing and finally sharpening can be revised if you have a tool and cutter grinder. Most of the tool shapes recommended by the old masters were very simple. D bits, single

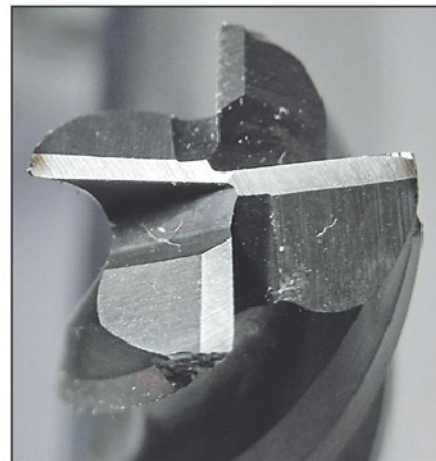


Photo 60. The end of a used carbide end mill.

edge reamers, half round drills and spear pointed drills could be made, especially in the smaller sizes, by grinding HSS rod which is available already hardened and ground accurately to size. You could even have a go at solid carbide.

30) Surface Grinding

Prof Chaddock, in his book on the Quorn describes using the Quorn grinding head in a Dore Westbury mill to surface grind some small components. I seem to remember a lot of unfortunate comments (flack) about his use of double sided tape to hold down the components on the machine table!

The Clarkson table is pretty limiting but I have ground things like washers and spacers stuck to the table with double sided carpet tape. With extreme caution it works. A better solution is shown in **photo 62** where I have mounted an inexpensive 180mm x 100mm magnetic chuck to the Clarkson table, **Ref 35**. It's deliberately



Photo 61. The side of a used carbide end mill.

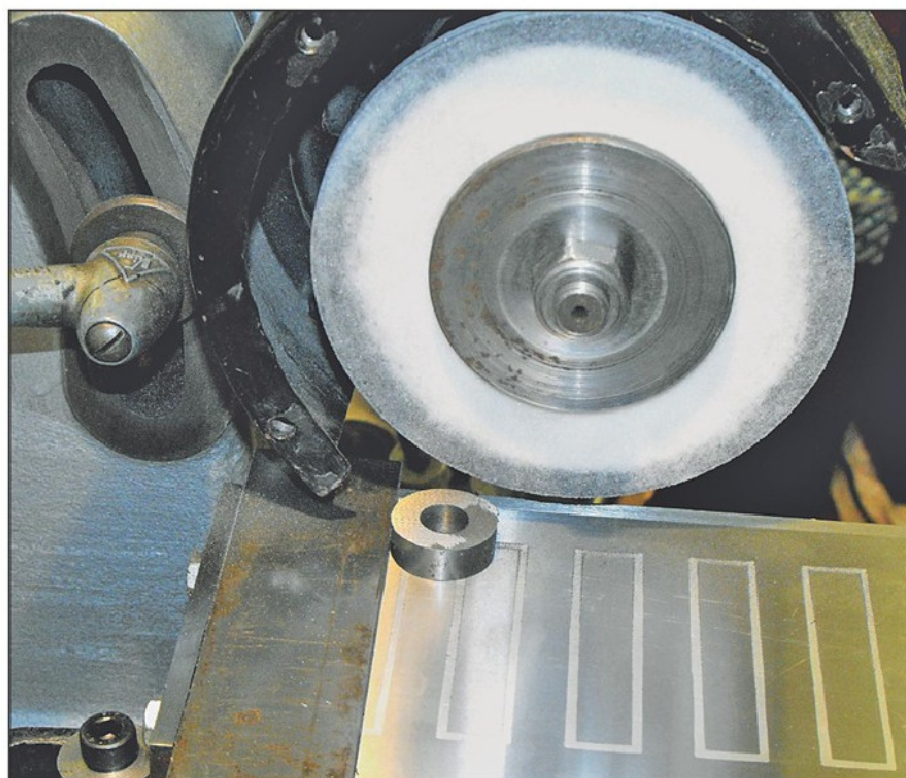


Photo 62. The magnetic chuck used for surface grinding.

mounted overhanging the table by about 35mm to increase the useable area, which is around 45mm x 100mm. The spindle extension is being used. Cheaper magnetic tables have a smaller number of poles and there are areas around the perimeter of this table where there is very little attraction for small items. Hence I have raised the end table fence and introduced a flat bit of steel to move the thick washer, spacer, being ground so it lies across 2 pole pieces. The down feed of the wheel head has to be very cautious, but it works.

Conclusions

I would recommend a Clarkson Tool and Cutter Grinder to anybody with interests in tool making or refurbishing cutting tools. There are plenty of these machines about at prices that won't break the bank, especially by private sale. The special purpose Clarkson accessories are another matter but you can improvise along the lines that I have described. I have not yet cracked the problem of grinding radii, but no doubt inspiration will provide eventually. Or maybe somebody has already cracked this one?

Buying the Clarkson has caused me to reorganise my workshop to place all the grinding, finishing, polishing and wire brushing stuff into one place, "The Grinding Department" **photo 63**. I feel happier now that all the dirty dust and grit making stuff is all in one place and the extractor is available to clean up. The bench in the photograph was constructed especially to fit the space available, there are more wheels and accessories than the Clarkson cabinet can accommodate and I had to find places for the Quorn bits and castings! Someday!



Photo 63. The grinding department.

The top of the bench isn't really that cluttered, I'm afraid this is a posed shot. I have one position on the bench with M8 tapped inserts and the grinder in use is screwed down into these. As you can probably see I have a white wheel on one grinder for sharpening woodturning gouges, a wire wheel and a polishing mop on the other and a small finisher cum sander that has proved very useful for general small scale shaping.

As far as the Clarkson goes it is teaching

me how to sharpen tooling and a bit of tool making. The next project might just be to add a motorised head for between centre grinding.

Contact me on mikehaughton@btinternet.com or email Postbag if you would like to make comments or need more information on the Clarkson. ■

References

Ref 35 <http://www.chronos.ltd.uk/> Search for magnetic chucks

IN OUR NEXT ISSUE

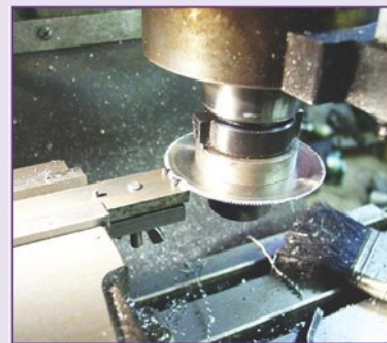
Coming up in issue 154, on sale 7 August 2009

FITTING AN INVERTER TO A HARRISON M300 LATHE



HAROLD HALL CONTINUES HIS LOOK AT FACEPLATES

DAVE FENNER LOOKS AT RIVETS AND RIVETTING



(Contents may be subject to change)

DON'T MISS THIS GREAT ISSUE – see page 8 and subscribe today

TRADE COUNTER

NEW WARCO REMOTE READOUT SCALE

Dave Fenner reviews a readout

Whilst at Harrogate, I was shown the new remote read out scale which is now available from Warco. They were recently kind enough to send one up for a closer look. As I still have their WM18 milling machine on loan, it made sense to fit the new readout to the machine.

Numerous articles have been written in the past on fitting scales to machines, so I do not propose to go into great detail. Suffice it to say that I have adopted what I believe to be the simplest possible approach consistent with achieving accurate and consistent readings. These scales are designed to be cut to length, however I was able to use the length as supplied and avoided cutting.

First I removed the two end clamps, and opened up the slots with hacksaw and file to give the result shown in **photo 1**. These were then refitted to the scale. A thin (22 gauge) brass plate was then partially made, i.e. it was cut roughly to size, and two 3mm holes drilled pitched 40mm apart. This was then located on the rear of the scale slider, using the two screws provided.

The two Allen screws securing the centre table stop were removed and this part placed in storage. The two moving table stops were then slackened off and the scale positioned with the end clamps located under them. These were then nipped up, ensuring that the scale was horizontal. A line was then marked on the brass, level with the lower tapped hole previously used for the centre stop. The space between the machine face and the brass was measured (found to be 4.5mm) and a spacer made to this length. The brass was then removed, drilled 6mm and refitted. **Photo 2** shows the new parts, viz. brass plate, spacer, and longer M6 screw.

All was then refitted to the mill, the ends being just nipped in position. The table was then traversed to each extreme to set the scale height, each clamp then being tightened. **Photo 3** shows the scale in place.

It would be worth adding a cover to keep fluid and other detritus from getting on to the scale especially if you use coolant when

machining. **Photo 4** shows the one made from aluminium angle covering a scale on the VMC mill.

The remaining work was simply to position the readout display. Whilst a plastic bracket is provided, the head comes fitted with two integral magnets, so attaching to the machine was just a case of "put in place". **Photo 5** shows the readout held by its magnets.

Also received from Warco was one of their edge finders, shown in **photo 6** along with the storage box. It is a multi-size device, having operating diameters of 4mm, 10mm and 20mm. I did wonder whether there might be some loss of effectiveness when working at the smallest diameter, but this was not the case. **Photo 7** shows that the edgefinder running at about 500 rpm has "stepped out" on contact with the edge of the vice. Here, the repeatability according to the readout scale was about plus or minus 0.01mm or about four tenths of a thou. With a metric machine such as this WM18, the 4mm diameter spigot is particularly convenient as moving back to datum is just 2mm, one complete turn of the handwheel.

Warco DH-1 Vice

I was recently fortunate to be offered the loan of one of the DH-1 vices, with the optional Vee jaws, to try out on the WM-18 mill already in the workshop for review. Now I remembered seeing the prototypes of this vice and the bigger brother the DH-4 being demonstrated at Harrogate by designer Doug House. The main idea was to offer a robust and versatile vice which would give great jaw opening capacity within a small table footprint. To achieve this, the DH-1 comes fitted with one moving and two fixed jaws, each of which can be detached and refixed in alternative positions to give a series of gripping ranges. The maximum extent is some 175mm, as can be seen in **photo 8**. This is quite something when you realise that this dimension is the same as the overall length of the vice body. One of the standard jaws is machined with Vee grooves to grip bar material, as may be seen in **photo 9**. In addition, optional Vee jaws, **photo 10** allow four point gripping of round work. As illustrated in **photo 11** the



Photo 1. Scale end clamps after modification.



Photo 2. New parts needed to fit scale.



Photo 3. Scale fitted to WM18 mill.

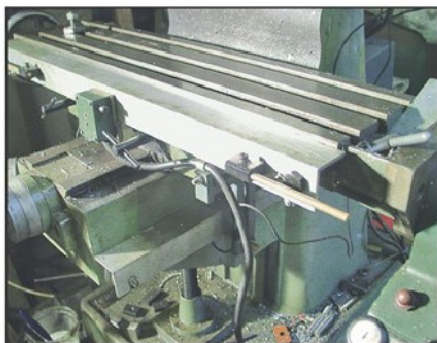


Photo 4. Typical cover to keep scale clean.



Photo 5. Remote readout is held in place by magnets.



Photo 6. Edgefinder and box.

Please note that unless otherwise stated, trade counter items have not necessarily been tested. We give news of products and services which have been brought to our attention and we consider may be of interest to our readers.

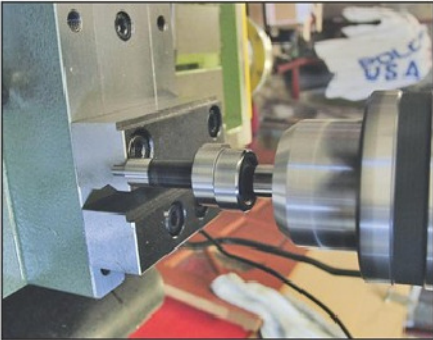


Photo 7. The rotating edfinder has "stepped out" on contact.

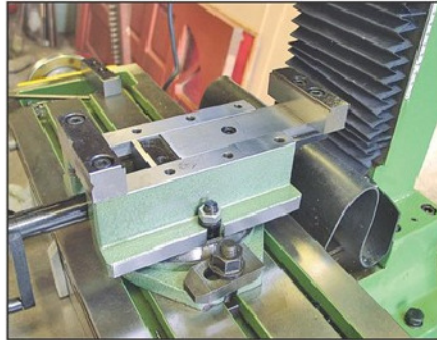


Photo 8. Jaw position set for gripping up to 175mm. Location recess for second moving jaw may also be seen.

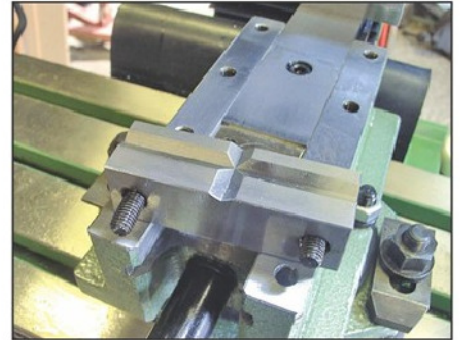


Photo 9. One jaw removed to show the vee grooves for bar material. Behind the jaw, the long slide can be seen.

steps cut in the faces of jaws, allow work to be held clear of the vice body without the need for separate parallels.

One of the bug bears of many machine vices is the tendency for the moving jaw (and hence work) to lift as the grip is applied. Articles have appeared in MEW from time to time, describing how to modify budget vices to minimise this effect. On the DH-1, the sliding member extends the full length of the base, and thus the tendency is immediately well controlled. I did try levering up on the slide and clocked a lift of just 0.001in. (0.025mm). However when work was clamped in the vice, with the clock applied, **photo 12** no lift was detected. This is presumably because the line of action of the screw is located below the slide, and actually tends to draw the jaw downwards. Thus the underlying geometry of the vice pulls the work down and does not create lift.

Both the fixed and moving jaws are held in place by substantial M8 Allen screws, the positions of the moving jaws also being determined by close fitting recesses. Thus when squaring the vice to the machine, my preferred procedure would be: first adjust the vice position by clocking along a fitted moving jaw; then set the fixed jaw in place, but only lightly nip the two Allen screws. Next,

lightly clamp the work, to align the fixed jaw, before finally tightening down its M8 screws.

The natural inclination is to fit the Vee jaws as shown in **photo 11**, and arranged thus, round work of up to 160mm can be held. If one jaw is reversed, small diameter work can be gripped at three points, and in this mode, the range goes down to around 3mm diameter.

Model and amateur engineers are famous for trying to get quarts into pint pots and get more out of their equipment than it may have originally been designed for. So, looking at the Vee jaws set in small diameter mode, it occurred to me, that an additional non advertised function might be as a lightweight bender. A strip of brass sheet was gripped between point and Vee, **photo 13**, then the jaws closed. **Photo 14** shows the result. This of course will bend to precisely 90 degrees, so it is likely that a little hand work may be needed to counter any spring back.

As befits a piece of precision equipment, the vice is supplied well lubricated, in a wooden case, **photo 15** with, surprisingly for a vice, an inspection certificate giving tolerance details. All in all, this is an impressive piece of kit, which I am not rushing to return to Warco.

Contact Warco Tel: 01428 682929 www.warco.co.uk

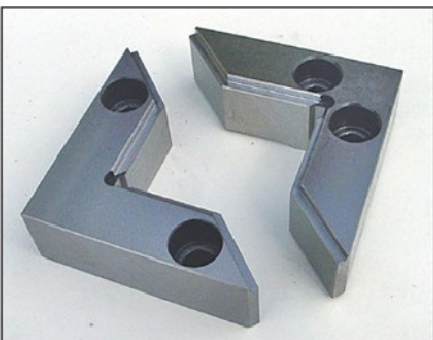


Photo 10. Optional Vee jaws for use with medium diameter work.

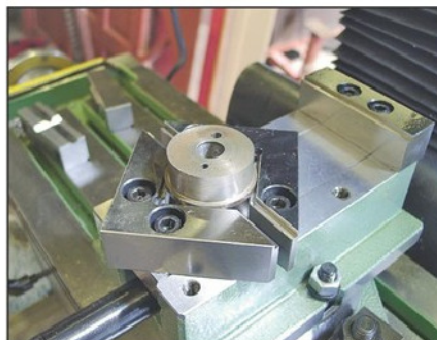


Photo 11. Work is located on the steps in the jaws avoid the need for parallels.

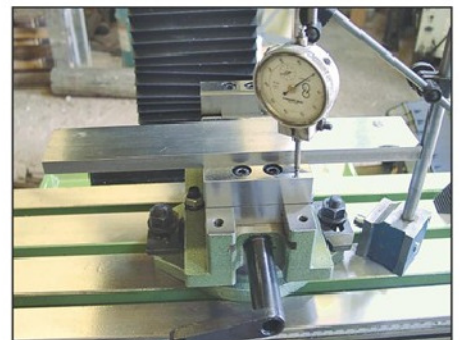


Photo 12. No lift was discernible when clamping work.

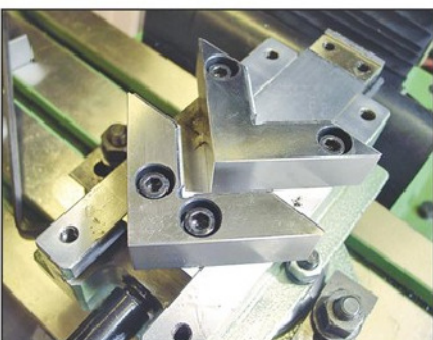


Photo 13. "Non approved" bending operation.

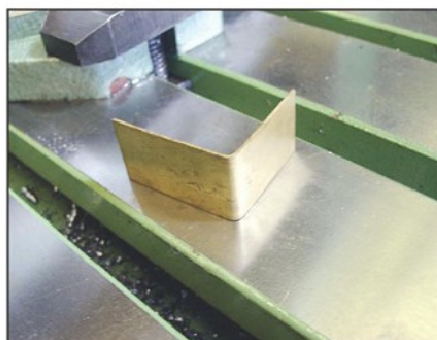


Photo 14. Crisply formed brass strip.



Photo 15. Wooden case supplied with vice.

TRADE COUNTER



Photo 16.

DREMEL

have supplied some of their drills and accessories for review.

The first of these is a Dremel 300 series drill together with a 225 hand piece on a flexible shaft. The whole set comprises the Dremel drill, the hand piece, a set of tools (cut off wheels, mounted points, rotary emery wheels and a wire brush amongst others) that clip to the end of the grey plastic carrying case, photos 16, 17 and 18.

Next is the Dremel 220 Work Station, photos 19, 20 and 21. This is a drill stand along the lines of the old Black and Decker drill stand but a lot smaller. It is ideal for smaller holes such as rivet holes. The Dremel fits into the drill stand via a threaded nose cap that screws into a threaded bush in the drill attachment. The moving head of the Work Station can be rotated so holes can be drilled on an angle. The travel of the drill looks to be about 2in. (50mm).



Photo 19.



Photo 17.



Photo 18.

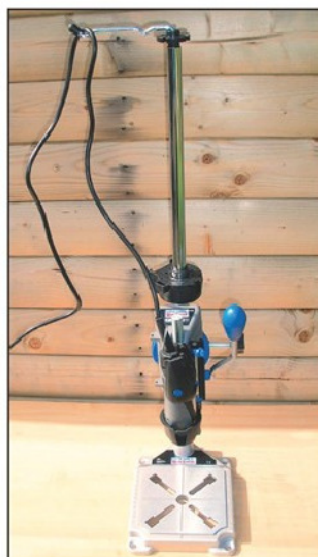


Photo 20.

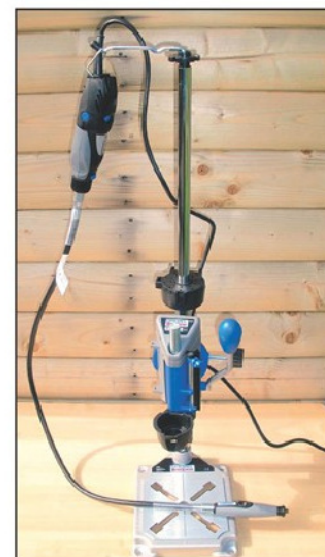


Photo 21.



Photo 22.



Photo 23.



Photo 24.

The Work Station also has a vertical pillar with an arm to take a loop on the top of the Dremel so that the flexible shaft unit can be used. Basically, the Dremel hangs on the pillar and you can go to work on an item held in your hand or even in a vice. There are lots of uses for the flexible shaft and extension tool. Cleaning up castings springs to mind as does wood carving and other model making activities. The drill will come in useful as well.

Photo 22 shows another type of Work Station, this time the model 2222 flexible shaft tool stand. This is designed to clamp onto the workbench or even the kitchen table using a thumbscrew underneath the unit. As it is made of plastic, I doubt it will mark the table. It comes with 3 steel tubes that plug into each other to make different heights of stand. I found that two tubes was an ideal height for me but you might find 1 or 3 tubes gives a more useful height. The stand also comes fitted with holes to take all your little accessory tools. The flexible shaft is also available separately if you already have a Dremel 300 series drill. I have a couple in my workshop, one set up as a drill and the other set up with the flexible shaft. Photo 24 shows the stand in use.

Finally, photo 25 shows the right angle attachment that is designed to fit onto the end of a Dremel 300 series drill. It is very useful if you have to drill a hole in a confined space.

The Dremel range is very useful in the small workshop and will probably be in daily use. Once you use a Dremel to clean up castings and drill small holes, you will wonder how you managed without one for so long.

Dremel drills and accessories are available from B&Q and some local Hobby Shops. I had a quick search online and came up with www.powertoolsuk.co.uk and searched for Dremel. I was pleasantly surprised by the low cost of both the Dremel power tools and the accessories. (I can't remember what I paid for my original Dremels but seem to remember they cost around £70 each.) As an instance, the Dremel 300 drill with extension shaft and toolkit in plastic carrying case was only £52.05 including VAT although I expect there may be a bit of postage on top of this.



Photo 25.

Contact Power Tools UK Tel: 01355 234328

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Star
Letter

Cutting Metric threads

Harold Hall's article on cutting metric threads on an imperial lathe was brilliant. I was just about to purchase a 127/100 tooth changewheel but after that I thought I wouldn't bother. Then other things intervened and I only recently got back to the business of metric threads. Digressing for a minute, one thing that intervened was the need to replace the drive belt on my lathe. I opted for an endless belt so that meant removing the spindle of course. Having done this I then decided I may as well strip the whole thing and re-paint it and this I did. The surprise was when I removed the spindle I could see no sign of wear or use, it could have been made yesterday. It was actually made in 1942!

Back to the threads, I knew I couldn't use HH's wheel arrangements as South Bend changewheels don't go in multiples of 5 teeth but in steps of 2, 4 or 8 teeth from 16 to 80. No matter, a bit of work on a spreadsheet and I had compound gear trains as HH for the common metric pitches to an acceptable degree of accuracy so to the lathe to try it out. Possibly readers with Boxford or SB are already smiling. Having only cut inch pitches I had always just followed the changewheel chart that came with the machine, no problem. But what I had seen every time I changed wheels but had completely forgotten was that the idler and combination gears that fit on the banjo were a different bore to the driver and driven gears. How observant is that!

To accommodate my compound gear trains I would have to make new smaller diameter sliding studs for the banjo, new journals and new keyed bushes for the gears, more work than I fancy for what is after all an imperfect solution. So it's back to plan A, buy a 127/100 wheel.

Anthony Reid by email

Metrication

I sympathise with Dyson, I too am a grey head, but with the changes we are experiencing in our weather patterns I frequently find the workshop either too hot or too cold.

So I reverted to the system we used in the Feasibility Dept where we not only had to cope with Imperial/Metric measurements but also standards from American petroleum companies, Deutsche Normen (German standards), British and French Standards, long before ISO took over.

Taking the Production Drawing as a gospel I change everything into my preferred system by calculator, or engineering handbook. This is then written on the drawing in red pencil above/ alongside the original dimension on the drawing sheet. No need to refer to another piece of paper, or loss of time in production. All of this is done out of the Shop, in the House, where temperatures are more even.

To keep things neat I use a Pentel continuous pencil lead which is available in several colours and diameters. Looking at railway drawings, which seem to have

Workpiece clamping

Harold Hall's article on workpiece clamping was a gem; I read it with delight and absorbing interest. I found it to be a very thorough work, so full of useful information that I don't think I shall mar another shifting workpiece, break another cutter or stall the motor, ever again. By packing on card and using the Clarkson chuck system I won't mar the table either.

I have been wary however of pulling up hard on a simple T-nut, afraid that the high modulus steel T-nut would generate such combined bending and shear force in the low modulus cast iron T-slot lips that these would shear out (examples seen with horror in machinery scrap yards).

If the lips are clamped between the T-nut and say a steel nut and washer then the iron is only in pure compression (easily withstood) and pure shear over a bigger area subject only to minor cutting and vibrational forces. A comment on this by someone of superior experience would be very welcome, if only to stop me worrying about it.

May I make a small useful addition to this topic - some years ago I bought a quantity of 5/16 BSF studding which I conveniently cut to whatever length was most appropriate to each job involving clamping workpieces to my imperial

lots of fractional sizes, it is surprising how many are repeated, so the number of calculations can be reduced by noting each size in the margin, this also can be transferred from sheet to sheet.

Please can you publish a Workshop, heating and ventilation system suitable for the larger size, mine is a 30'x8' concrete garage with a new wooden roof and double skin doors. I don't like the propane heaters, they make too much water vapour. Regards to all readers. Keep up the high standard.

Keith Harrison by email

Metrication 2

There still seem to be rumblings in "Scribe a Line" about the use or otherwise of metric measure, I thought some readers might be interested to hear of my findings when measuring a Dremel grinder for a particular application. Being of German origin, one would expect to find all the threads to be metric, but I was somewhat surprised to find that the nose hand grip moulding is threaded 3/4 inch BSF and the collet chuck threaded 9/32 inch x 40 tpi. It would seem that engineers in Europe are less taken up with the political correctness of using metric and more concerned with using the most suitable thread for the particular job in hand!

Stuart Walker by email.

Ebay Asia Engineer

I have just been caught out by ordering the wrong item in relation to the article on a low cost digital rev-counter from the February issue of MEW (No.

measure lathe - the cut was quickly made by hand hacksaw and smoothly de-burred offhand on the bench grinder. A collection of various lengths gradually accumulated in the miscellaneous box.

Along with workshop expansion including acquisition of a metric vertical mill I went metric. At no great expense a quantity of M8 studding, nuts and thick washers was obtained, the existing T-nuts run through with an M8 tap (the pitch and diameter mismatch is of no importance here). The lathe was then equipped with its own calculator to multiply or divide by 25.4! In all a doddle especially as, without giving away my exact age, my first units of measure were rods poles perches bushels hands drachms carats and even cubits. Along with school science came the cgs system but with vulgar fraction inches and number and letter drills in school metalwork, followed in electrical engineering by the MKS system, in structures by inches feet and pounds and throughout, Whitworth BA BSP CEI Unified ASA and Holzapfel screwthreads. I am now very happy with SI (aka metric), it all hangs together but I still find myself saying that I can't fathom some things.

Peter Peters by email.

147). The source of the meter was giorgio11185 trading as Asia Engineer. There are different versions of this meter, which all look identical, but differ in the voltage of the input signal. I inadvertently ordered the version with an input voltage range of 50-300V rather than the one used in the article which I assume was 0-5V.

After receiving the meter (took about two weeks from China) I could not get it to work and emailed the vendor who was very helpful and gave me instructions about modifying the meter. The modification was to change R16 on the PCB from 47k to 2k. The moral of this tale is to read the eBay listings carefully since the input voltage was mentioned, although no mention was made of different versions.

On a related matter, I am using the rev-counter on my Myford Speed 10 lathe which has a 65 tooth bull wheel rather than the much more useful 60 tooth wheel on some other lathes. I am sure it must be possible to use my 65 tooth wheel with a sensor of the type mentioned in the article and then reduce the pulse count electronically to compensate for the extra pulses. My thinking is that if every 13th pulse was removed from the pulse stream from the sensor, this would provide the same number of pulses as a 60 tooth wheel. If any electronics wizard could come up with a simple circuit to do this, I would be very grateful as might others in a similar situation.

Douglas Johnston Dundee.

YOUR CHANCE TO TALK TO US!

Drop us a line and share your advice, questions and opinions with other readers.

Ebay Asia Engineer 2

I have just competed the installation of a 'rev counter', as described by Mike Crossfield, (Issue No 147) on my Micro lathe.

However, Asia Engineer now sell Frequency meters with various input voltages, and unless you specifically ask for the 1 to 5 volt version, you may be sent the 50 to 300 volt version as happened to me. I now have the correct meter!

Some advice to readers of MEW may be in order, so that they don't fall for the same trap as I did.

My rev counter now works well, so my thanks go to Mike for his article.

Bob Russ Melbourne Australia.

Is there a good paint for aluminium?

I use aluminium a lot for making optical devices. The shiny metallic surface is often not wanted, or even, in work with lasers, downright dangerous. I have been trying to paint aluminium for years, without much success. I have tried polishing, sanding, etching with sodium hydroxide and scrupulous degreasing but no pretreatment seems to make paint stick.

Anodising is difficult for amateurs and the black dye works only for visible light: it has little effect on reflection in the infra-red. I have tried proprietary chemical blackening mixtures and have found the result has little resistance to scratching and none to salty water (a common hazard in the labs where I wish to use my aluminium creations). Matt black paints (which I often need for optical purposes) tend to flake off very readily, as do most enamel paints. There is a water-soluble 'special metals primer' for Hammerite but this seems, from numerous messages on the web, to peel off readily. Has anyone found a treatment that works? Is there some pre-treatment that would make Hammerite stick? What is powder paint and can it be applied without a huge autoclave and vent system?

Brad Amos, Cambridge.

Thank you Warco

Firstly, can I congratulate you on a fantastic magazine. I look forward to every edition of MEW. I purchased my Sieg X1 Mill 2 weeks before you started the articles on CNC conversions etc. Perfect timing.

However, the main reason for writing is, could I use your magazine to say a very big and public thank you to WARCO who I know advertise in MEW. I purchased a ZX 15 Mill from them last February. The mill was exactly what I wanted and does exactly what I want it to, and some.

The lower spindle bearing began to squeal in early May this year. Just 2

months out of warranty, I couldn't believe it. I chose a few colourful and choice expletives and decided to get to it and strip down the head and replace the bearing but this was not as easy as I had first thought. The bottom flange would not budge. I phoned WARCO and told them of my woes. The very nice lady casually said "wrap it up and we will organise someone to collect and repair it for you". The next day, a courier arrived, took it away and it arrived back repaired one and a half weeks later. No charge, no fuss no problem. Thank you WARCO. That is after sales service as it should be.

Ian Allgood, Cambridgeshire

Stepperhead lathe

I would like to thank you for your presentation of my article on the Stepperhead lathe. The photos etc have been nicely fitted to the text. I noticed one tiny typo in issue 152. On page 15 two thirds down the first column it states; "The saddle is narrow and is guided by the front bedway" whereas it should read "The saddle is narrow guided by the front bedway". I do not suppose most readers will notice this but it does give a completely different meaning.

Alan Jackson by email.

Small furnaces

I vaguely recall your asking at some time in the last year or so for suggestions of topics for coverage in articles in ME. Just recently I have been thinking about a project that could involve heat treating parts and realised that I could not recall having seen anything in ME or MEW about heat treatment furnaces. This is a topic on which I know nothing so I cannot offer to write. I imagine there will be commercially available small furnaces suitable for small

scale amateur use, and that there will be model engineers owning/using such equipment. If not then perhaps there will be jewelers who use similar furnaces/kilns. There are perhaps even relevant articles in some sister magazines, or former sister magazines, that could be reused/modified to inform the model engineers. I hope this suggestion is at least of some slight value.

Iain Miller by email.

Any takers to write the article on furnaces? Ed.

Dehumidifiers

There has been some rather strange advice about the use of dehumidifiers with suggestions that they may be best used on a timer and that they are only needed when the humidity reaches 60 - 70%. I would suggest that both are misleading. Putting the dehumidifier on a timer may appear to save money but no one should be surprised if it doesn't work and if one allows the humidity levels to reach 60% you may just as well not bother. From my experience you need to keep the workshop temperature consistent and not let the humidity rise much above 45% and this is best achieved using a humidistat which is left on permanently. Provided the workshop is adequately insulated and protected with a suitable vapour barrier you will find that the dehumidifier only runs during inclement weather and spends much of the time unemployed. It's useful to bear in mind that the higher the temperature the greater amount of water can be held in the air and that as the temperature drops the air has less capacity to hold its moisture and is only too willing to condense its moisture on to cold metal surfaces and help fuel corrosion. This tendency to condense water is not limited to metal but can also be a problem where it forms on cold masonry, and in the case of inadequate vapour barriers and insulation, can be trapped within the insulation and so develop into a serious damp problem if there is no ventilation or other means of removing the trapped moisture. Clearly, ventilation is an important factor in a workshop and if one is concerned with substantial heat loss then serious consideration should be given to a simple air to air heat exchanger. Whilst accepting that low humidity in the workshop is the best way of beating the rust, it needs to be recognised that low levels of humidity not only effectively absorb the water from any water based coolant you may be using, but may also dry you out and give you a headache!

Stuart Walker by email.

Alternative protective clothing

Here is a hint for others, how often do you feel in your workshop coat pocket for the micrometer or spanner, only to find it full of swarf having worked at the lathe?

Change your protective clothing, use a wood turner's smock top, zipped to the neck with closable collar and cuffs. Most importantly the pockets are behind you on the back, well away from the swarf. Little or none arrives in that direction.

Ken Willson by email.

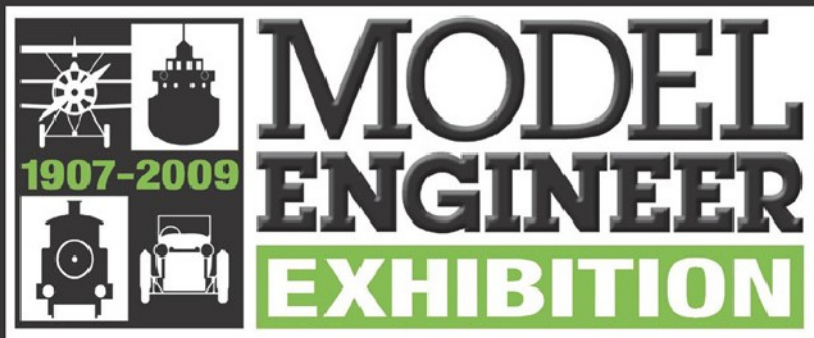


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We would love to hear your comments & questions and also feedback about MEW

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

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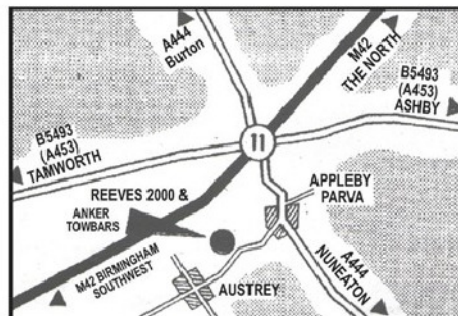
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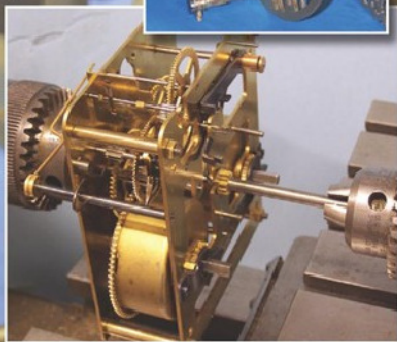
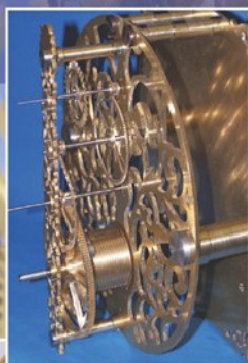
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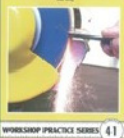
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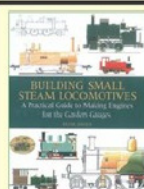


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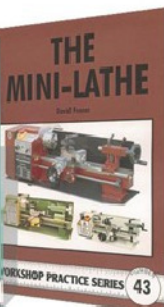
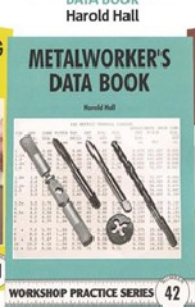
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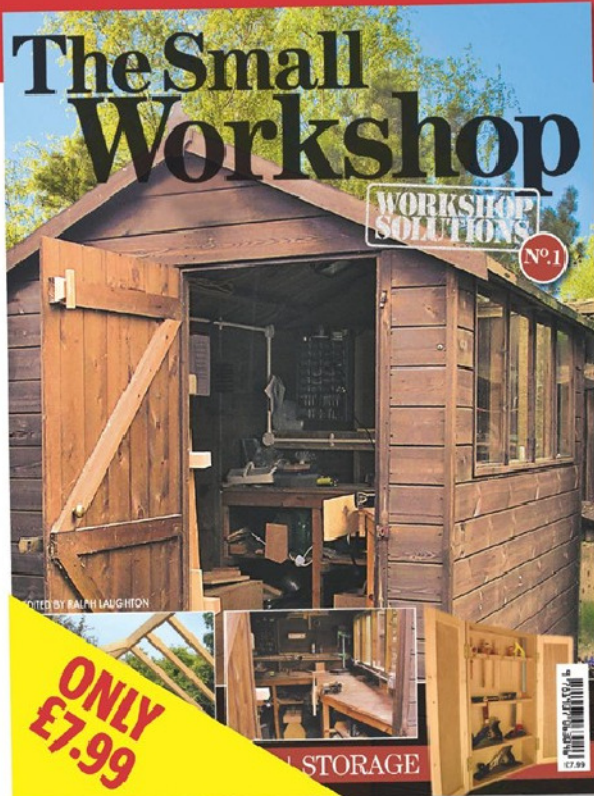
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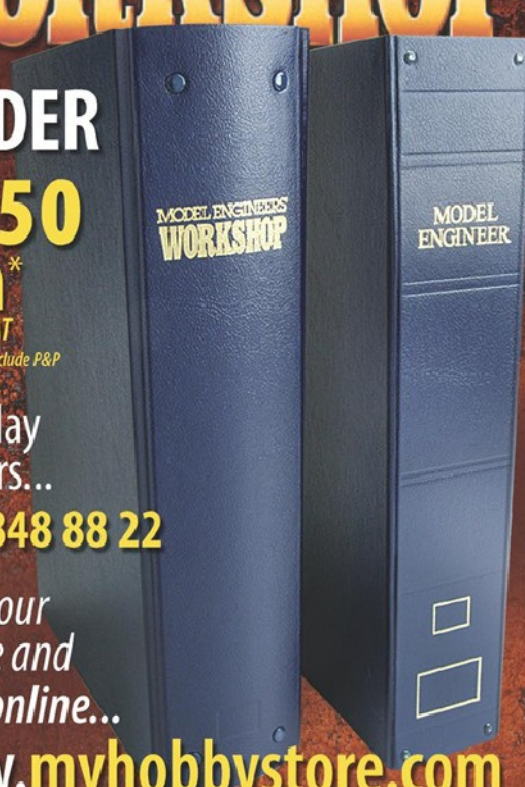
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• Bridgeport Mill, 48" table, x + y power feed, belt head, very nice	£2250	• Viceroy 10" heavy duty ped grinder	£200
• Boxford VM30 Mill, 24" x 6" table, vari speed with inverter	£1750	• Startright Saw Benches. Tilt Arbor 23" x 22" table, 8" plate, ex school. (2 Off)	Each £400
• Colchester Master 2500 gap bed lathe with Q.C.T. 3 pt steady	£3000	• Centec 2A Quill head mill. Single phase, average condition	£890
• chucks and taper turning		• Record DMB 65 vert wood band saw, as new	£150
• Tom Senior "Major" with quill feed head, outstanding condition	£1850	• Well Saw 4" cap, power hacksaw, lovely small British made machine	£300
• Myford Super 7 with coolant, industrial stand & tooling	£1000	• Tom Senior M1 vert/horiz mills, good condition. (3 Off)	£800 - £1200
• Jones & Shipman wheel balancing fixture, complete, lovely condition	£550	• Harrison L5 Lathe with tooling, single phase	£950

WE ALSO PURCHASE QUALITY MACHINES & TOOLING

DELIVERY SERVICE AVAILABLE PLEASE TELEPHONE BEFORE TRAVELLING - WEEKEND & EVENING VIEWING AND DELIVERY SERVICE

More machines always in stock. Tel: 01274 402208

Mobile 07887 535868 4 Duchy Crescent, Bradford, BD9 5NJ

HOME AND WORKSHOP MACHINERY

Genuine Used Machines & Tooling

144 Maidstone Road, Foots Cray, Sidcup, Kent DA14 5HS

Telephone: 0208 300 9070 - Evenings: 01959 532199 - Facsimile: 0208 309 6311

www.homeandworkshop.co.uk • stevehwm@btopenworld.com

Opening Times: Monday-Friday 9am-5.30pm - Saturday Morning 9am-1pm

10 minutes from M25 - Junction 3 and South Circular - A205



£745

Eagle 5W (wet) surface grinder



RJH 4" vertical belt finisher (240 volts)

£675



NEW £875

Leyton 50" x 3" set of slip ended rolls



£2950

Harrison M250 5" x 30 lathe



£950

Colchester Chipmaster lathe



£1350

Tom Senior M1 milling machine



NEW £125

Milling/Drilling ground X-Y table



JUST IN!

Boxford 1130 lathe (not finished)

- Colchester Triumph 2000 lathe £2450
- Colchester Triumph 2000 lathe £4250
- Elliot Sturdimill (coming in) £3450
- Elliot 18" shaper (coming in) £650
- Eagle surface grinder £645
- Elliot 10" shaper £375
- Myford Speed 10 long bed £1175
- Startrite 352 bandsaw £975
- Pedrazzoli Super Brown 300DV saw £625

£2450

- Marico keyway broaches just in!
- Harrison L5/L5A/140/L6 T/steadies
- Harrison D14 faceplates
- Eclipse De-magnetiser £80
- Hofmann dividing head + gears £625
- Flamefast double hearth £95
- Clarkson Autolock chucks Selection
- Colchester Triumph 2000 fixed steady £245
- Harrison M300 Ainfest attachment £345
- DS120 hearth £140
- Myford Super 7B lathe (1997) gearbox, power crossfeed, stand £3450



£425

RJH bench grinder/buffer - 240 volts



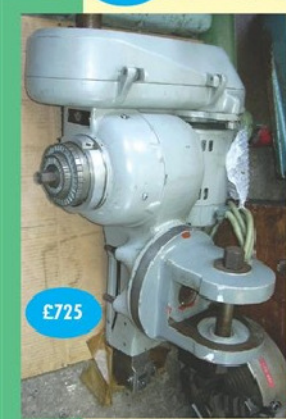
from £125

Record quick release vices



£1750

Harrison 140 lathe + gearbox & power cross feed



£725

Bridgeport slotting head



£1950

Myford Super 7 lathe



£245

Jones and Shipman (swivel base) 4" machine vice



£245

Colchester Triumph 2000 rear tool post



£1250

Boxford AUD 4 1/2" gearbox, power cross feed



£145

Colchester Triumph 2000 faceplate



£525

Deckel profile grinder + eight collets



£850

Myford ML10 lathe (greased)



£164.50

Crompton/Tyco NEW motor for ML7/Sup 7



£2250

Micron 108 drill point grinder 3-40mm



£295

Colchester Triumph 12" 4 jaw chuck



£375

Fobco pedestal drilling machine



£3750

Colchester Student 1800; 6" x 24" + gap bed, 3 & 4 jaw chucks + 240 volts



£375

PVE 200mm sine centres (extremely rare)



£125

SIP NEW (old stock) drilling machines, better quality!



NEVER USED!!

£525

Myford (never used) dividing head + four plates

Bridgeport heads also fit A&S 2E mills



£1200

Harrison L5 lathe

PLEASE PHONE 0208 300 9070 TO CHECK AVAILABILITY OR TO OBTAIN OUR LIST

DISTANCE NO PROBLEM!

DEFINITELY WORTH A VISIT

ALL PRICES EXCLUSIVE OF VAT

Just a small selection of our current stock photographed!

We have wood lathes, saw benches, bandsaws, morticers and Record vices etc - large selection!





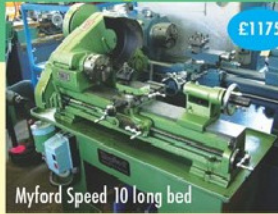
Myford Super 7B (1997)
power cross feed

£3450



Oxford Model HV460 oil cooled welder

£495



Myford Speed 10 long bed

£1175



Flamefast hearth DS120F

£140



Compound sine table
+ 10" x 5" magnetic built in chuck

£375



Marlco broach set 8-10-12-14mm

very clean



£345

RJH 6"



Adcock and
Shipley vertical
head

£625



Graduate
£950
Extractors £140
each

Graduate wood lathe + Rexon dust extractors

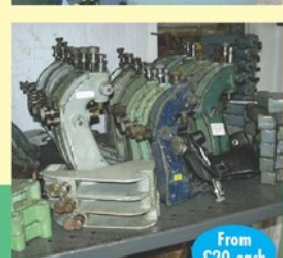


Myford Speed 10 long bed

£1175



£625



From
£20 each



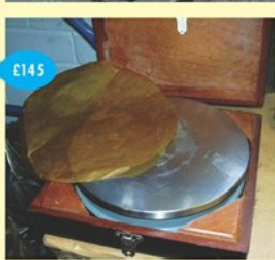
Edwards 12" pedestal guillotine

£525



Wadkin BER
spindle moulder +
feeder unit

£1400



Engineers flat PVE (cased)

£145



£40 each

Dickson toolposts to suit Colchester
Mascot (others available)



J & S grinding wheel balancer + level

£375



Keyway broaches 7/16" 18mm

£40
& £50
each



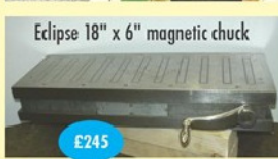
Crompton Parkinson Foot Mounted
2HP 240V / single phase 1400 revs as new.

£120



Pedazzoli
Super Brown
300DV steel saw

£625



Eclipse 18" x 6" magnetic chuck

£245



Surface plate 24" X 18"

£145



Quality measuring tools

JUST
IN!

£425



Q and S 6" power hacksaw + coolant

Just in
£345



Norton 6DB deep throat +
handle and balls

£345



Emco Unimat 3 lathe

£345



Clarkson
40INT collet
chuck + collets

£120

(we have 2MT-5MT and
30INT to 50INT in stock!!)



£345

Harrison
M300 Ainst
attachment
+ bar

As
NEW!

DELIVERY
£15
TO ALL EU
COUNTRIES
Free Delivery UK Mainland



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Chester Machine Tools

DB8VS LATHE



FEATURES

- Digital Speed Readout
- Variable Speed Spindle
- Metric and Imperial Thread Cutting
- Hardened and Ground Bedways
- Cast Iron Construction

~~£969.65~~
£775.00

Centre Distance 400mm
Swing 210mm
Speeds Variable 50-2000rpm
Motor 750w
Weight 110kgs

HV128 BANDSAW



~~£239.00~~
£219.00

Capacity Round 5"/128mm
Capacity Rectangle 4" x 6"/100 x 150mm
Speed Range 65/95/165ipm
Motor 1/3hp
Net weight 62kgs

CENTURY MILL



~~£1049.00~~
£899.00

FEATURES

- Variable Speed Spindle
- Digital Depth Readout
- Fine Feed Quill
- Heavy Duty Cast Iron Construction

Max Drilling Capacity 20mm
Max End Mill Capacity 22mm
Max Face Mill Capacity 70mm
Table Size 600x180mm
Cross Travel 200mm
Long Travel 350mm
Taper MT3
Speeds 50-3000rpm
Size 720x565x1020mm
Weight 135kgs

CHAMPION 16VS



~~£699.00~~
£629.00

FEATURES

- Variable Speed Spindle
- Dovetail Column
- Tilting Head
- Wide Spindle Speed Range

Table Size 500 x 140mm
Spindle Taper MT2
Speeds Variable 50-2500rpm
Motor 600w
Weight 90kgs

DB11VS



Centre Distance 700mm
Swing over Bed 280mm
Spindle Bore 26mm
Motor 1200w
Spindle Speeds 125-2500rpm
Net Weight 180kgs

FEATURES

- Digital Speed Readout
- Variable Spindle Speed
- Metric & Imperial Thread Cutting

~~£1469.00~~
£1199.00

STANDARD ACCESSORIES

3-Jaw Chuck • 4-Jaw Chuck • Coolant Tray • Rear Splash Guard

100mm 3-Jaw Chuck



~~£69.00~~
£60.00

Mag Base and Dial Gauge



~~£35.00~~
£30.00

100mm 4-Jaw Independent Chuck



~~£64.00~~
£55.00

DT8300D Multi Meter



~~£8.89~~ **£7.00**

4" x 6" Belt and Disc Sander



Disc Size 6"
Belt Size 4" x 36"
Table Size 216 x 146mm
Motor 370w
Net Weight 25kgs

~~£74.99~~ **£69.00**

Boring Tool Set MT2



~~£59.00~~
£51.00

Quick Action Vice Low Working Height



£39.00

T1 Quick Change Toolpost and 5 Holders



~~£128.00~~
£115.00

MY64L Multi Meter



~~£35.54~~ **£15.00**

Flexi Drive



Working Speed 0-14000rpm
Power Drive 1/10hp
Flexible Shaft 0.3-4mm
Drill Chuck
Net Weight 2.3kgs

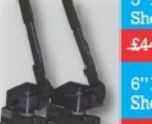
~~£109.00~~ **£89.99**

Machine Angle Level



~~£69.00~~
£60.00

5" Bench Hand Shears



~~£44.95~~ **£40.00**

6" Bench Hand Shears



~~£54.95~~ **£50.00**

8 ton Press



Capacity 8 ton
Stroke 135mm
Min operating distance 90mm
Max operating Distance 358mm
Net Weight 43kgs

~~£134.95~~ **£119.00**

1 ton Crane



Lifting Capacity 1ton
Lifting Range 0-2150mm
Working Range of Boom 960-1240mm
Net Weight 25kgs

~~£177.00~~ **£139.00**

Slip Rolls



12" £109.00 / 16" £199.00
20" £249.00

Magnifier Lamp



£40.00

Centre Punch Set



£4.50

Hoist 250kgs



~~£69.00~~
£60.00

All prices include VAT. Delivery Free to UK mainland - excluding certain Scottish postcodes. (Unless otherwise stated) Prices valid for duration of this issue only.



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ME4355 & MEW153