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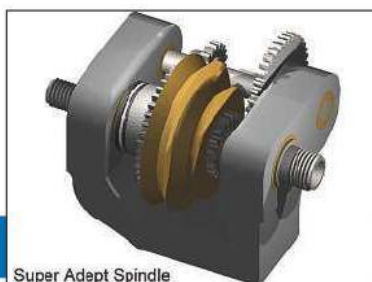
On the Editor's Bench

Did You Make It Yourself?

Besides model engineering (in the widest sense), one of my other hobbies is electronics, especially the cantankerous little microcontroller chips found inside things like 3D-printers and CNC machines. Given that, you might expect my workshop to be fully automated, but in fact the metal working and the 'electricity' pretty much keep to their own sides of the workshop. Exceptions are the DROs on my mill and the speed controller for my electric shunter.

As some wide-ranging debate on the forums at www.model-engineer.co.uk has shown, feelings run high on the place of new technology in the workshop, and computers and new technology aren't everyone's cup of tea. The debate is exemplified by the 'did you make it yourself?' question. To some using, say, laser cut frames or CNC parts is no different from buying a casting or a ready-made pressure gauge. Others disagree. Equally, the rise of reliable kits for locos and tanks, for example, means that those with the enthusiasm but not the time or workshop can now 'make' their own models.

What really matters is that, however you choose to pursue your hobby, you enjoy it. The fact is there are a huge diversity of ways to make creative input, as one forum member observed – even LBSC used to make locomotives for people to their own designs.



Super Adapt Spindle

Good Honest Metal Bashing

If all this 3D computing is too much for you, relax! Although my workshop activity this month has been a bit limited, due to holiday as much as work, I have done a few practical things. I turned up a spindle between centres, with raised collars at each end, both accurately sized by taking finishing cuts at the same setting, and checked with a micrometer. I can now mount this bar between centres at any time and, using a dial gauge fixed to the headstock, adjust the tailstock so it is accurately in line with the spindle. Anyone who has a lathe with a set-over tailstock should consider making one of these simple gauges – none of the measurements are critical, as long as it is turned between centres and both collars match.

One Man and His Lathe

My thanks to everyone who responded to my call for 'expressions of interest' in a series giving lathe owners' perspectives on their machines. As you might imagine I did get rather a lot from owners of some lathes, especially the Myford ML7 – *quelle surprise!* Naturally this means I will have to disappoint a few people by not taking up their offers, indeed I hope to have contacted everyone by the time you are reading this. On the plus side, the offers received made it clear that such a series would be far more than a simple list of the features of various lathes. I am sure that this can be a worthwhile and varied series that should make interesting reading for anyone thinking about buying a new (or second-hand) lathe. My hope is that the series can start in the New Year.

FIRST STEPS IN 3D CAD

I've started 'blogging' the 'Super Adapt' project I mentioned last time on the forum. My challenge is to make a new headstock with bronze bearings, including a taper bearing at the front, and a 4:1 'back gear'. My pile of sketch designs was already getting thick, then while editing Murray Eddington's 'Mind to Metal' for this issue, I was inspired to make the effort and get to grips with Turbocad 21 Deluxe. The first part I designed was the new spindle, and while the initial learning curve was almost vertical, I was surprised to be able to make a fully rendered and accurate drawing within a few hours. After some more effort, I was able to produce what looks like it should be a functioning back gear, although it is considerably more robust than the original. I understand that the way to make real progress is not to take the approach of making 2D drawings, but to start thinking from a 3D viewpoint. I must admit most of my parts started as 2D profiles that were extruded or 'spun' into 3D, but the main headstock started as a solid block, from which I 'carved' the outline and 'machined' the holes. I was also surprised how easy it was to export parts as STL files – suitable for 3D printing. This opens the door to casting the headstock using a printed pattern, although I have already got a lump of continuous cast iron ready for this purpose.

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Coming up...

in the November issue



A CHAMPION RESTORATION

Paul Weighell restores a sensitive drill that's at least sixty years old.

PLUS John Harris eschews a cheap and cheerful bandsaw and makes a REDAY power hacksaw from a set of castings, David Piddington devises an interesting setup to machine an awkward casting for a friend, Peter Shaw makes a filing rest and lots more to interest every hobby engineer.

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ON THE COVER



Murray Eddington worked a carbide toolbit hard and fast to machine a ball nut. Despite the light show, the tool was not damaged.



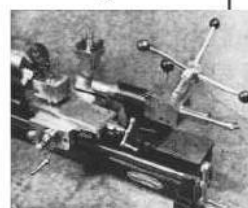
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Martin Cleeve's Rack Tailstock Designs

In 1956 the *Model Engineer* published a design for a Myford rack tailstock modification, 'the Rack Tailstock' by Martin Cleeve. In 1960 it published a revised version for the EW lathe. Read the full articles online.



The Model Engineers Workshop Free Plan Collection

Over the first few years following its launch in 1990, *MEW* regularly included a free pull-out plan. These plans covered a diverse range of tools, from a filing rest to a simple lathe – now these plans are being made available again through our website!

FREE PLAN: A Simple to Use Dividing Device

The latest free plan to be added to the collection - this dividing device takes an unconventional approach. Designed by Al Longworth, it appeared in *MEW* issue 6, August/September 1991.

Lathe Bearings

Back in 1947, the year the Myford ML& was released, there was still great suspicion about using taper roller bearings in lathes among hobby engineers. Read this highly informative letter by E. H. Doughty, British Timken's Chief Technical Engineer defending their products and giving some excellent diagrams of how they can best be used.

Some of the other live topics on the forum include:

- Backyard Casting
- Machining – sitting or standing?
- Adding a Brake to a Colchester Lathe

Join the conversation and look out for the new 'help and assistance' topic!!

Spindle Driving Handle

Alan Hearsum has a new take on an essential accessory for any small lathe.



A spindle driving handle is a workshop accessory tool used to manually drive a lathe headstock spindle and in turn rotate the chuck which holds the work-piece in a lathe. It is normally used for tapping, threading, when dies are used in an adapter in the tailstock and for rotating work held in a 4 jaw chuck clocking the job using a dial test indicator. It can also be used for manually screw cutting when the lathe is not under power particularly for cast iron and the softer non-ferrous metals. In this latter case change wheels need to be engaged as in conventional screw cutting where the lathe is under power.

The described spindle driving handle in this article uses a ratchet handle. The advantage of a ratchet driven driving handle is that it allows the operator to do several quarter circle turns in quick succession without physically over stretching when stood in the right position in front of the spindle chuck on the lathe. Myford (www.myford.co.uk) continue to sell spindle driving handles for their lathes and provide a download on how to use them.

Features

The main principle of a spindle driving handle is it gets its drive feature by gripping the bore of the lathe spindle. This is achieved in a similar way to using a Rawl bolt in the task of fixing a bracket to a masonry wall where the rawl bolt draws a tapered nut into the split body and in turn grips the sides of the hole in the masonry.

This particular driving handle, in this project, uses a ratchet spanner so that there is better flexibility and control when standing facing the work piece mounted in



1

The completed handle.

the lathe chuck. There is no need to complete a full circle of the driving handle when using a ratchet driving handle, the ratchet does not require the handle to be rotated 360 degrees. **Photograph 1** shows the completed handle, and **photo 2** in place on the lathe, in this case a Myford ML7 lathe. A similar design can be used for other centre lathes with a different size of spindle bore, length of spindle and different distance from the inside of the change wheel guard in relation to the position of the headstock spindle.

General arrangement

Figure 1 shows an exploded view of the driving handle assembly. The cranked ratchet arm uses a traditional Rolson cranked ratchet tool (13mm and 10mm nut sizes) normally used for tightening and undoing hexagon nuts. The chrome plated plain revolving handle was purchased on eBay and the length of the M10 thread increased by machining in the lathe. The part which grips the inside of the lathe spindle bore is machined from a piece of $\frac{1}{8}$ inch diameter BMS to finish $6\frac{1}{4}$ inches overall length. A piece of M8 screwed rod has a hexagon cone shaped nut at one end and the other is attached to the ratchet tool with an M8 nut clamped with washers either side of the 13mm end of the tool.

Assembly

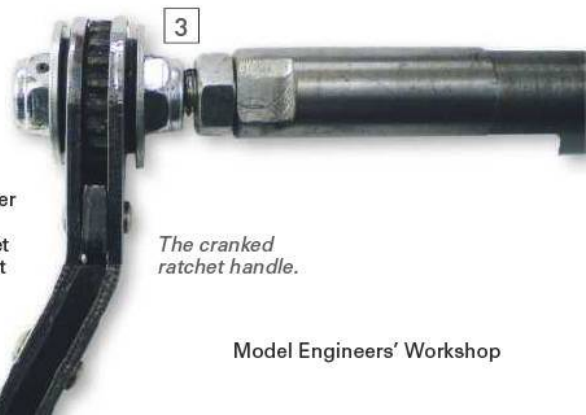
Figure 2 shows the component dimensions required for a driving handle for a Myford ML7 lathe. **Photograph 3** is a picture of the cranked ratchet handle showing the 13mm end. An M8 nut is first placed on the screwed rod (**fig 2, item A**) which tightens the part which goes up inside and grips the bore of the lathe spindle. This fits next to the two filed surfaces for a spanner to hold the part in the bore until it grips the bore. A fibre self-locking nut is then placed on the screwed rod leaving a gap of $\frac{1}{8}$ inch of thread. A large M8 washer is then placed on the screwed rod butting up against the cranked ratchet handle. Then a further M8 normal nut



The handle fitted to an ML7 lathe.

is placed on the screwed rod. The cranked ratchet handle fits over this nut providing interference to drive the spindle when fully assembled. A further washer is added to the assembly and another lock nut added, tightening the two lock nuts. Finally a $\frac{1}{16}$ inch steel roll pin is knocked into a $\frac{1}{16}$ inch drilled hole through the composite nut and screwed rod.

Photograph 4 shows a conically shaped nut (**fig 2, item C**) machined from hexagonal BMS bar 0.4375 inch across flats. This hexagonal bar measures approximately $\frac{1}{2}$ inch across the points of the hexagon which will pass up a 0.594 bore of a Myford ML7 lathe spindle bore without interference. The total angle of the conical nut is 120 degrees. In the final assembly a $\frac{1}{16}$ inch steel roll pin stops the nut turning.



3

The cranked ratchet handle.

Fig. 1

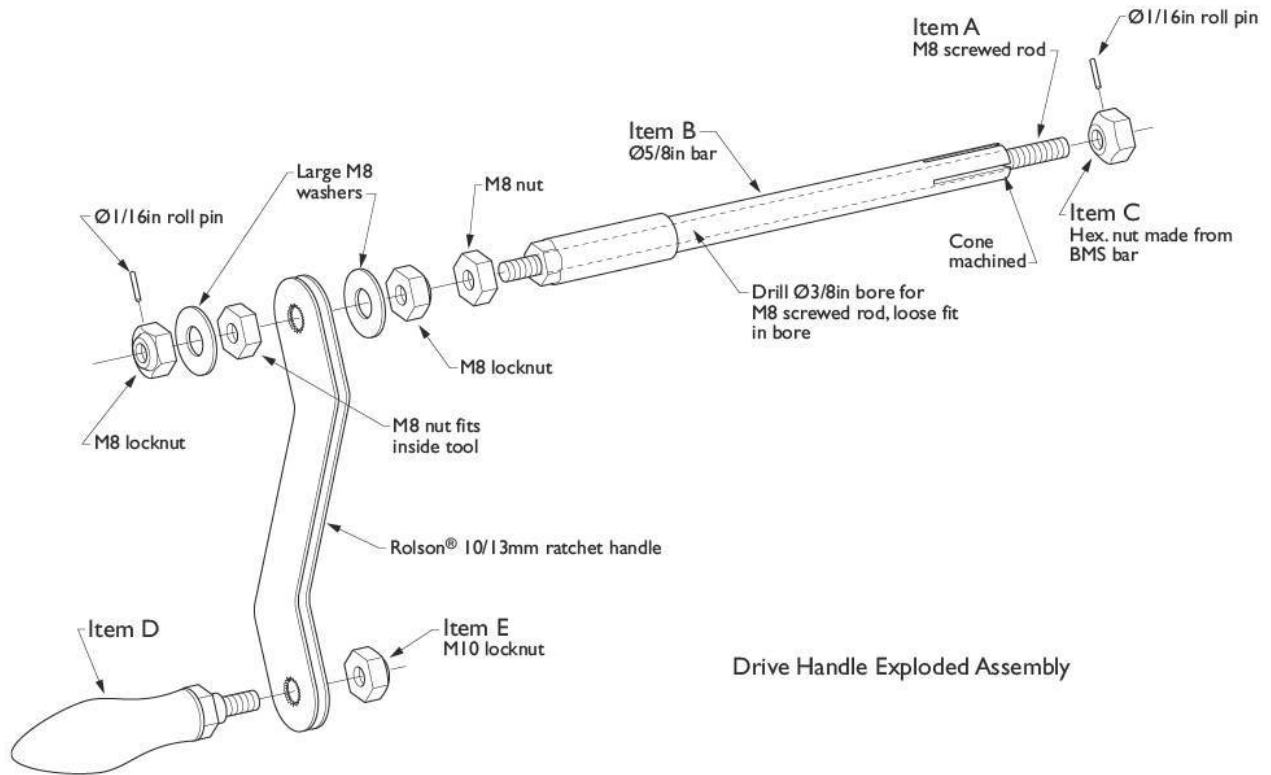
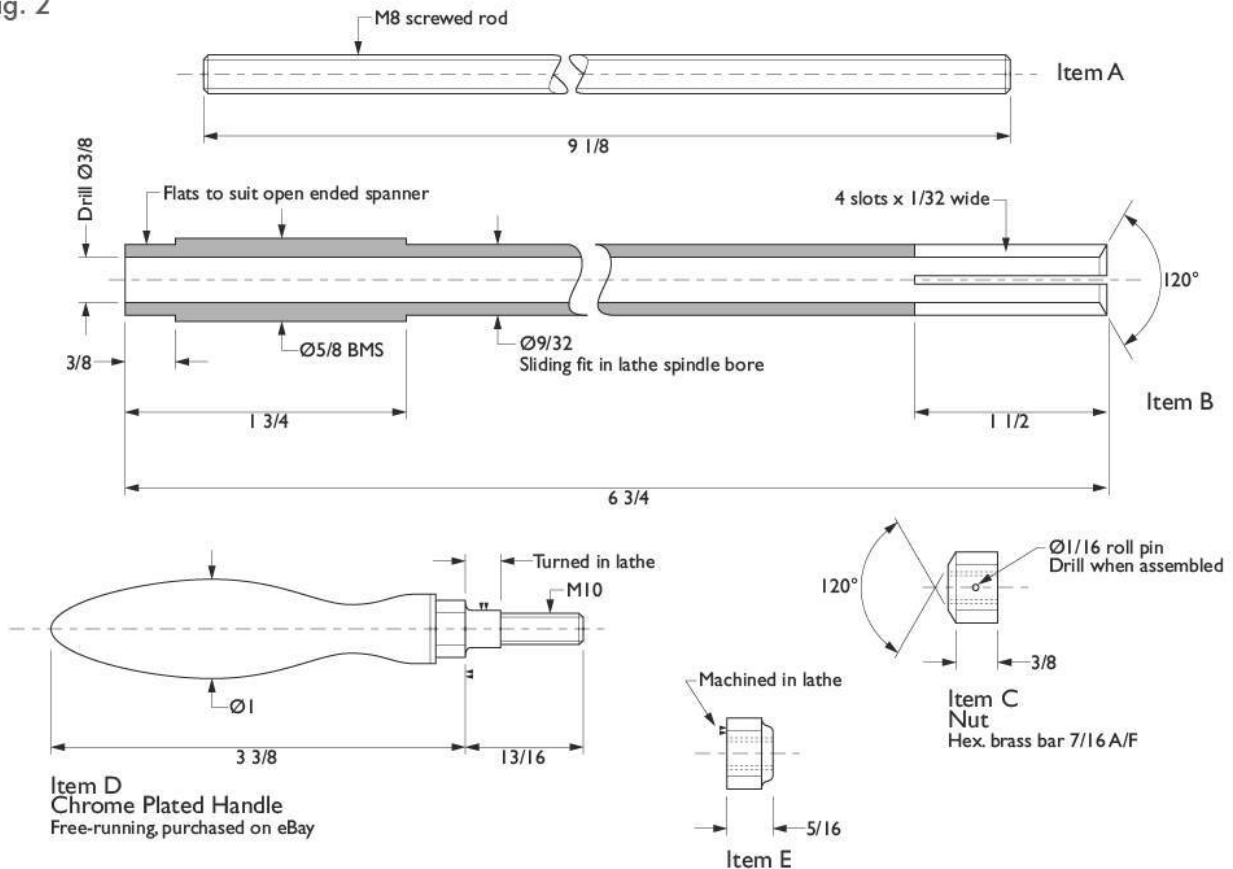


Fig. 2





The conical nut.



The chrome revolving handle.

Photograph 2 includes the component which grips the lathe spindle bore (fig 2, item B). It is $\frac{3}{8}$ diameter BMS $6\frac{1}{4}$ inches long machined in the lathe between centres, 5 inches long, leaving $1\frac{1}{4}$ inches un-machined. The machined fit size is 0.593 inches diameter, a sliding fit in the bore of the lathe spindle. A fixed steady is used in the lathe, located on the machined surface, to steady the part whilst a $\frac{3}{8}$ inch drilled hole is produced. A long drill is needed held in a chuck in the tailstock of the lathe. A centre drill is used to find the centre of the component. This step is always wise to centralise drilling. Where possible cutting coolant should be directed towards the drill to aid cutting. Before removing the component from the lathe, a 120 degree conical end should be machined inside the $\frac{3}{8}$ inch drilled hole (fig 2, item B). This angle should match the angle on the engaging nut (fig 2, item C). A $\frac{3}{8}$ wide flat is filed on the component to suit or fit a suitable size open ended spanner. Four $\frac{1}{2}$ inch saw cuts $1\frac{1}{2}$ inches long create the flexibility required for the tube (fig 2, item B) to grip the bore of the lathe spindle. These cuts would be best made using a slitting saw driven in the lathe or milling machine when available.

Handle

Photograph 5 shows a plain revolving chrome handle (fig 2, item D) fitted to the Rolson cranked ratchet handle. It has a M10 thread which is a snug fit in the handle. The length of the threaded part needs to be machined to 0.8125 inches. This can be achieved by placing two nuts on the thread, locking them together, and using these to hold in a chuck in the lathe. A knife tool/parting tool is then used to remove the metal by gently plunge cutting. There is no need to preserve or maintain a thread after machining as there only needs enough thread to hold the nut which has been machined to reduce the amount of thread it needs in relation with the thread on the chrome plated handle (fig 2, item E). In the final assembly a M10 fibre lock nut is tightened onto the crank handle. This nut (fig 2, item E) needs to be machined to reduce its thickness.

Application

When using the completed drive handle it is pushed into the spindle bore of the lathe. An open ended spanner is placed on the flats of figs 1 & 2 (item B) to hold

in place and another open ended spanner turned clockwise on the nut nearest to the spanner on the flats. This clockwise rotating movement will draw the conical shaped nut into the conical shaped component and thus gripping the bore of the lathe. This action expands item B allowing the slits in the tube to open. Tighten the nut until there is complete interference and the handle drives the lathe spindle without slippage. If slippage of the driving handle occurs there is a need to further tighten the nut; however not over doing it.

Conclusion

Finally, do not operate the lathe under power with the handle in position. Always remove the handle which only takes less than a minute to do. There is always a temptation to take a short cut and we all know that is how near misses occur and eventually accidents happen. Because the handle has a ratchet there will be those that feel the ratchet could be engaged to allow the handle to remain in the lathe - please don't as it may still spin at speed, it takes so little time to remove the driving handle. ■

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From Mind to Metal

New technology has allowed Murray Eddington to develop new ways of working.



Apart from (or possibly because of) some test drives with Autocad 11 and 13 back in the 1990s, I've tended to regard CAD tools as a major hurdle and have simply avoided them for anything more than manipulating and viewing drawings and models. Recently, after many years of designing parts using 'pencil CAD' (good old pencil and paper) and fully manual machining, I've recently started to use 3D CAD to create parts and assemblies, before cutting metal. Looking back, I feel a little embarrassed that it took me so long to take the plunge but now that I have done so over the last 8 months or so, I can say it's been a very productive and fulfilling process. Previously, I couldn't have imagined how it could possibly be quicker to design something by starting in CAD than simply getting in the workshop and starting to machine from sketches, particularly if you are only planning on making one example.

Spindle nose adaptor

My first exercise in 3D CAD came last year when I set about designing a D1-3 spindle nose adaptor. This is a fixture that can be bolted down to a machine table and will accept any of the common range of D1-3 fittings. It mimics the nose of the lathe spindle, hence the name. As I now have a variety of 3-jaw, 4-jaw and collet chucks plus large faceplate, driver plate etc for my Colchester Bantam, all of which share this system, a spindle nose adaptor would allow me a lot more options for working on my milling machine.

The Camlock system uses a combination of a taper and a flat face to locate the chuck concentric and perpendicular to the lathe axis. The D1-3 size also uses 3 eccentric cams to pull the chuck against the said face and taper. They act against 3 pins that stick out of the back of the chuck. The Camlock series dimensions are defined in the international standard ISO 702-2. I was able to locate a copy and thus work to the specification rather than having to rely on my own measurements.

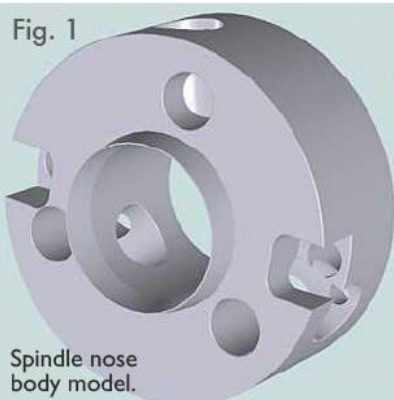
I started out by machining up a spindle nose with the taper and face that fitted the chuck nicely but lacked any means of holding it on or driving it. As I would be mounting the adaptor with bolts into the table in use, I drilled and recessed 2 holes at this stage, figuring that I'd find them useful for holding the adaptor during the machining operations. In terms of accommodating the various features within the body, it would have been more convenient to have had 3 fixing bolts rather than 2 but my rotary table has 4 slots, which decided it. It was around about this time that

I started to consider what a tricky challenge it would be to position all of the various radial and axial bores within the adaptor body along with the 2 bolt holes. It would require some devilish 3D calculations to place them all without clashing.

Geomagic design

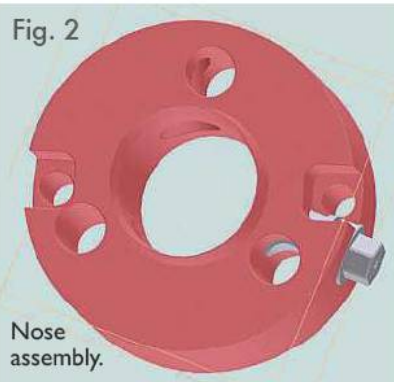
It was at this point that I installed a 30 day trial demo of Geomagic Design (this used to be called Alibre but has been renamed). I found I was able to create 3D models for the existing body and the key elements of the D1-3 system quite rapidly, including the 3 cams, the 3 radial (cam) bores and 3 axial (pin) bores. This work was done in the 'part design' environment. I started out by modelling a simple cylindrical body, adding the critical features of the D1-3 nose (taper and face, cam bores and locking pin bores) and a central bore. Then I created the radial and axial bores (fig. 1). It's important to think ahead with this kind of work, which meant in this case creating each of the triple bore sets and the bolt hole sets as separate circular patterns so that each group could be moved around independently as a set. I needed to ensure that the bores for the cams precisely intersected the cutout on the chuck pins. One of the questions I had to resolve was how best to position the various bores (including the 2 fixing bolts) within the body so that they didn't clash and in a way that it would be fully compatible with standard chucks. I can say with certainty that I personally wouldn't have been able to do this at the drawing board, whereas it was fairly straightforward within the CAD environment.

Fig. 1



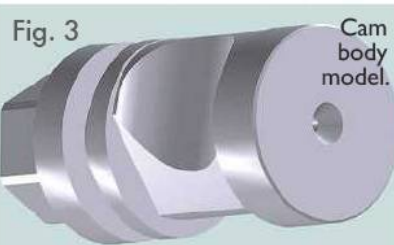
Spindle nose body model.

Fig. 2



Nose assembly.

Fig. 3



Cam body model.

Once these basic building blocks have been created, the 'assembly design' environment allows you to assemble several parts together and apply mating constraints so that they fit together correctly. For instance, when assembling a cam into a bore, a 'coaxial' relationship will align the cam axis to the bore axis. To further define the position, you need to position the cam along the axis at the correct distance. In a real life design you will have recognised the need for a pin to locate into a groove to constrain the cam. Assuming that the CAD parts you have designed also incorporate such a feature, you can align one face of the groove with one edge of the pin. This still leaves the angular position of the cam unconstrained. However, by leaving it unconstrained you



Spindle Nose Adaptor in use.

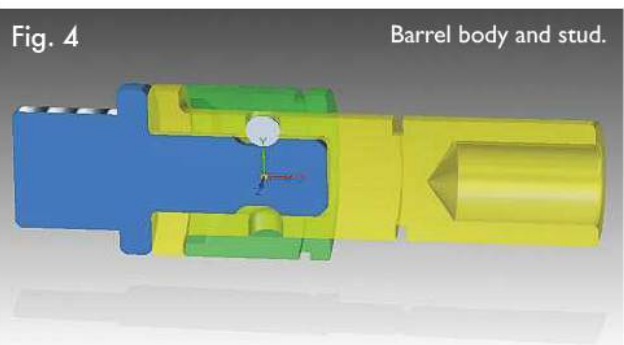


Fig. 4

Barrel body and stud.

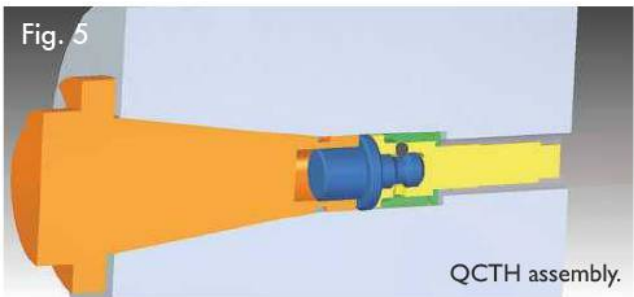


Fig. 5

QCTH assembly.

can turn the cam with the mouse and see how it behaves. If you wanted to get really fancy, you could even add the cam pin to the assembly and watch it move in and out as you turn the cam.

I was able to finesse the positions of the features (mainly the fixing bolts) so that I ended up with a reasonable result. With the hindsight now provided I could see that a larger diameter body would have been advisable but I wasn't about to copper up again for another lump of steel. I was unable to avoid one of the bolt head recesses breaking through into one of the cam bores but I figured I'd be able to modify the design of one of the cams and thus make the whole thing workable. I also placed the cam retainer pins on the rear face of the adaptor for simplicity, rather than on the side (you couldn't do this on a lathe nose or you wouldn't be able to access the retainer pins) (fig. 2). I didn't fancy trying to machine the square chuck key holes in the cams, so I also changed them to external hex heads that I could easily mill on the rotary table and tighten with a spanner or socket. Finally, I altered the length of the socket to suit the actual diameter and bore of my roughed out body (fig. 3). This gives an idea of how easy it is to modify complex assemblies in 3D CAD in a way that would be very difficult using traditional pen and paper or even 2D CAD.

The final challenge was the machining of the 3 cams to my own design. Having created an assembly of working parts in Geomagic, I was pretty confident that it would do what I required, assuming I could be trusted to machine the parts up correctly. This is where the third element of modern 3D CAD applications come in. You can take the parts and assemblies you have created and automatically generate full drawings from them, complete with dimensions, section views, detailed views, parts lists etc. The parts, assemblies and drawings are all associative, so that a change made in one automatically results in the others being updated. You find that

the dimensions you define to develop the parts in the design phase do not necessarily provide the machining dimensions you need to actually produce the parts, so you need to add those yourself but that is a trivial job. I'm pleased to say that I managed to make these parts up accurately and without any gross mishaps. It's been a useful accessory on several occasions e.g. for milling and drilling parts on the rotary table using the collet chuck, 4-jaw chuck, faceplate etc. (photo 1).

you can only save the parts in Geomagic format or export to .STL (suitable for 3D printers). You can still create parts, assemblies and drawings (it's exactly the same application but with some features disabled). As I was looking for greater file exchange capability, I did the QCTH design this time in Solid Edge (from Siemens). This is a mid-range 3D parametric CAD package like Geomagic and Solidworks, with a very similar set of capabilities.

I looked around to see if anyone had developed a QCTH for the NMTB30 system

The final challenge was the machining of the 3 cams to my own design. Having created an assembly of working parts in Geomagic, I was pretty confident that it would do what I required, assuming I could be trusted to machine the parts up correctly.

Quick change toolholder for the milling machine

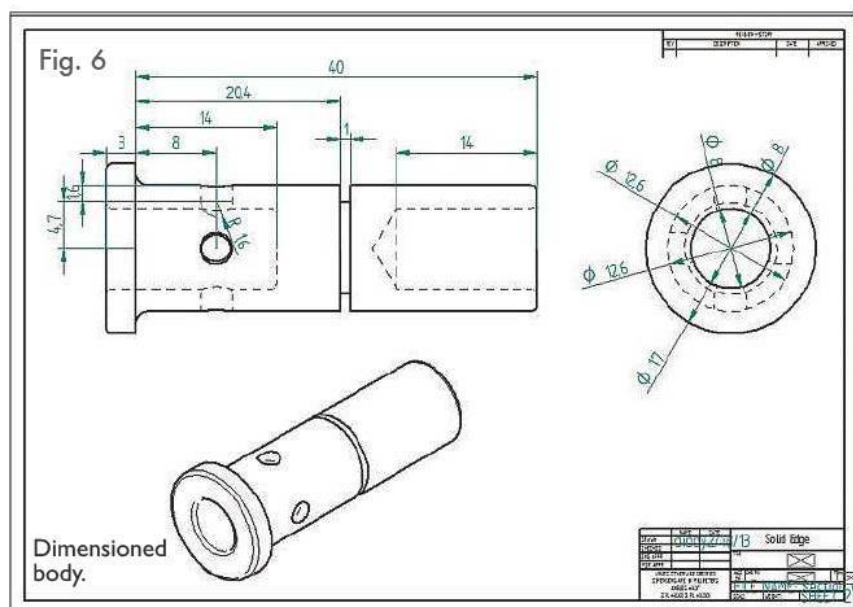
Emboldened by this experience, I designed a quick change toolholder (QCTH) for my Bridgeport clone milling machine. For me to do accurate work in a milling machine on a reasonable timescale requires a DRO and frequent picking up of feature positions using an edge finder. The QCTH allows me to swap NMTB30 tooling over rapidly without having to lock the spindle, loosen the drawbar, knock out the tool, replace it with another, tighten it up etc. Instead of taking a minute or so to swap over, I can now do it in literally just a few seconds.

Solid edge

By now, the 30 day trial of Geomagic had expired. The hobby version of Geomagic comes at a reasonably affordable price (Cubify Design, for under 200 quid) but

and couldn't find anything. The space available for the gubbins is pretty limited, so one of the first tasks was to make up an accurate model of the spindle nose, along with a toolholder and a drawbar. There are QCTH systems for the ISO30 system but apart from the basic taper itself, the spindle nose design is quite different. Generally, the ISO30 QCTH systems either push the taper in from the outside or pull it from within using a drawbar by means of a pull stud at the narrow end. I opted for a drawbar actuated ball and ramp design in the end, being about the only solution I could sensibly fit in the available space (fig. 4). These are widely used in quick release hose couplings and in some older pull stud designs.

I did a fair amount of evolution of the parts in CAD before I was happy that it was a workable design that I could actually make and would stand up to the



requirements (fig. 5). Again, I was able to print out detailed drawings for each part with dimensioned features, suitable for machining them up (fig. 6). I've been using the QCTH quite intensively for quite a few months now and I'm very pleased with the way it works (fig. 8). Apart from fitting a heavier spring (for peace of mind), I've not needed to change anything and so far, nothing's broken or come adrift.

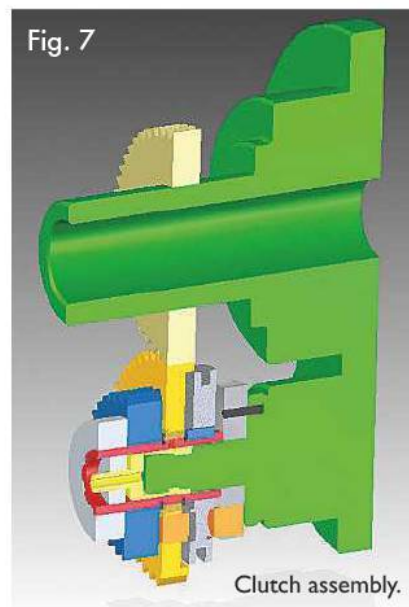
Screwcutting clutch for the Colchester Bantam

Next up, I designed a version of Graham Meeks' screwcutting clutch that was modified to suit the Colchester Bantam. Pretty much everything had to be scaled and positioned uniquely to fit the existing gear train, so the same approach was taken. I modelled the back end of the headstock, then started to create a series of parts to fit the space and functional requirements (fig. 7). I can't pretend that I just came up with ideas in the CAD environment. It just doesn't happen for me and I doubt there are really any

engineers who actually work that way. Before going near a CAD program, you have to have at least a basic concept in mind, which in my case requires several sheets of hand drawn sketches.

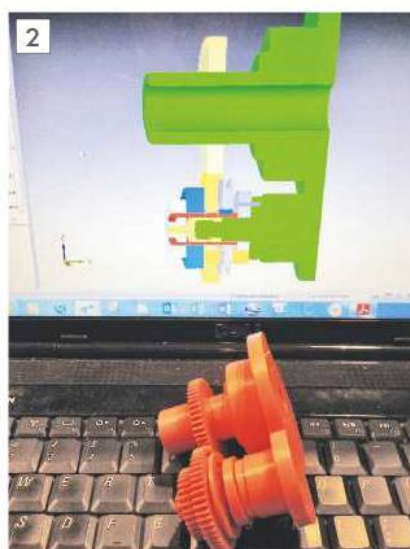
Ultimaker2 3D printer

Around this time, we acquired an Ultimaker2 3D printer at work and started to use it for rapid prototyping tasks. The screwcutting clutch was an ideal candidate for the printer. Once I was reasonably happy with the CAD design on the screen and it was about 90% completed, I was able to print out the parts on a 3D printer, both the whole assembly at 50% scale (much quicker to print out) and some individual parts at 100% scale (to offer up to the machine) (**photo 2**). Being able to print out the parts and fit them together before you go off and make them in metal is very helpful when the assembly is fairly complex. It's not essential but it reduces the risk of getting something badly wrong and allows you to make minor (but often helpful) changes.



Clutch assembly.

I then made a few detail changes and set about procuring and machining up the parts from the detailed drawings created in Solid Edge. As long as the full assembly and its parts are finalized in CAD (and assuming you've designed something that it's actually possible to machine!), the parts manufacturing process is a relatively straightforward matter of following the drawing (**photo 3**). In practice, I find that I see further improvements that can be implemented as I start to make the parts up, not least due to the availability of tools and materials in my workshop. In this case, I will update the part model and assembly to reflect what I've done. If there is a knock-on effect with mating parts etc, I will reprint the drawings for those parts, which will have been automatically updated by the CAD. With 'pencil CAD' or stuff that is made up as you go along, you need to do this coordination manually which can be messy. At the time of writing this, I've got all the major components for the mechanism machined up and assembled. These fit



3D-printed assembly.



Making parts from a drawing.



Clutch mechanism.

together very nicely and perform the required functions (photo 4). The final parts required for completion are the trip rods for automatic disengagement.

Stepper motor drives for CNC milling machine conversion

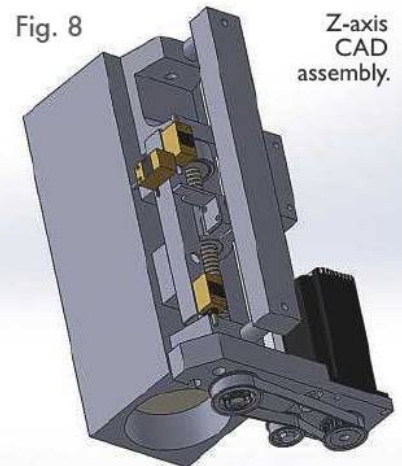
Currently I am making up stepper motor drives for my Bridgeport clone milling machine, in order to convert it to CNC. Although this is a fairly well worn path in the CNC world, my implementation is fairly unusual, as I have managed to keep the design relatively compact while requiring minimal modifications to the machine itself (eg just two M6 threaded holes for the Z-axis mechanism). If you are familiar with the Bridgeport J-head, you will know that it is a very complex shape due to the various assemblies and controls that are contained within it. This makes visualizing and dimensioning mating parts quite challenging. In practice, I think you have 2 options if you want to achieve a reasonable rate of progress – either make parts up by eye or trial and error as you go along or develop the parts and assembly in CAD, then spit out the drawings and machine up the parts (fig. 8). As you might expect,

customize, download the CAD models of the finished part and even order online - if you have the wallet to support that!

The Z-axis ball screw and ball nut both required a fair bit of machining, yet they are made of some form of hardened steel. These aren't parts that you'd want to attempt to anneal, machine and reharden and I don't possess any form of grinding tools apart from a few angle grinders. However, it is perfectly feasible to use carbide inserts and tooling to turn and mill them directly. The skill is to use a high surface speed, power feed (to keep a constant and controlled feed rate) and a modest depth of cut with no coolant. Presumably the heat generated anneals the steel as it cuts. The tools survive but the swarf glows and burns as it comes off the tool, so you have to stand back (photo 6)!

Solidworks vs Solid Edge vs Geomagic/Alibre

The X, Y and Z-axis assemblies were designed in Solidworks, which has a very similar feature set to Geomagic and Solid Edge. As before, I found that printing out some of the key components enabled me to verify that I had the correct dimensions



advantage of Geomagic Cubify Design (the hobby version of Alibre) is its price. Unless you are very rich or lucky enough like me to have access to the full version of one of these tools through your work, out of these particular 3 candidates you may be best to go for Geomagic for hobby use. One of the downsides of Cubify Design is that they seem to want to charge you for tutorials etc while most other companies want to help you to get up to speed as quickly and easily as possible, free of charge. There are several other candidates out there for 3D CAD and none of them are right or wrong, it's just a matter of personal preference, finance and circumstances.

One example of a design calculation that would be pretty difficult to get right manually is belt centring. Originally I had planned to drive my X and Y-axis ballscrews directly using closed-loop stepper motors. It is difficult to find any rational basis for the motor torque ratings specified for many of the CNC conversions that are described on the internet, other than 'it works ok for me'. The closest I could find were the white papers published by Tormach for the PCNC series machines. I did some design calculations myself that supported my belief that direct stepper drive would be a perfectly viable solution for my system. However, at the

Many of the parts I ordered in, such as the toothed timing belt pulleys and the ball nut and ball screw needed to be machined to suit my installation - there simply isn't the freedom to make assemblies like this using entirely off the shelf parts.

I took the second option and again I found that printing the parts out and trial fitting them allowed me to confirm that I had measured up the features correctly and do some finessing of the detailed parts designs before cutting metal (photo 5).

There were inevitable late changes to some of the constraints, such as the dimensions of the Z-axis ball screw and nut which I ordered from the Ali Express website. When it finally arrived, I found that the ball nut length was actually 38mm rather than the 42mm shown on the supplier's original drawing. All was not lost, as I was able to reduce the size of some of the associated parts and end up with an extra 4mm of quill travel.

Many of the parts I ordered in, such as the toothed timing belt pulleys and the ball nut and ball screw needed to be machined to suit my installation - there simply isn't the freedom to make assemblies like this using entirely off the shelf parts. In many cases, the suppliers provide 3D CAD models that you can download and use or modify. There is a large European database at Traceparts which you can use to find free 3D CAD models, even if you don't use it to actually source your parts. I had to make models for most of my parts but I was able to save a lot of time by starting with some of these more generic parts and making my own variants from them. Another starting point might be Misumi, who provide a wide range of configurable parts that you can

and to finesse some of the details before starting to cut metal. Although the menu structure and some of the feature names are different, once you get to grips with any of these applications, they have very similar capability (they have to, in order to be competitive).

The advantage of Solidworks is that it seems to be by far the most commonplace mid-range 3D CAD tool nowadays. The



Z-axis parts.



Machining hardened ballnut.

last minute, I was able to source some 'proper' AC servo motors and drives from DMM Technology in Vancouver which possess a better torque-speed characteristic than can be found from a stepper motor, so I redesigned the X and Y-axis drives. Servo motors have a lower torque capability and a higher speed range than a stepper motor, so I had to redesign the drive to incorporate a step-down toothed belt drive.

The normal way to implement a toothed belt drive in this application seems to be to mount the motor in slotted holes so the belt can be tensioned by moving the motor against the belt - this struck me as easy but messy. If the pulley centres could be positioned accurately to begin with and a small tensioner pulley provided to take up any wear, the motor could be mounted in a fixed position. Solidworks allows you to generate a belt or chain that mates with your pulleys. You can specify a fixed belt length and use that to drive the position of the tensioner within its slot once you have the centres close to where they need to be (fig. 9). Once I had received the pulleys and belts and machined the Y-axis housing, I was pleased and relieved to find that they were an exact fit. I was less than impressed with my first attempt at the Z-axis belt drive which I dimensioned using an online pulley centre calculator. Solidworks enabled me to get the right answer.

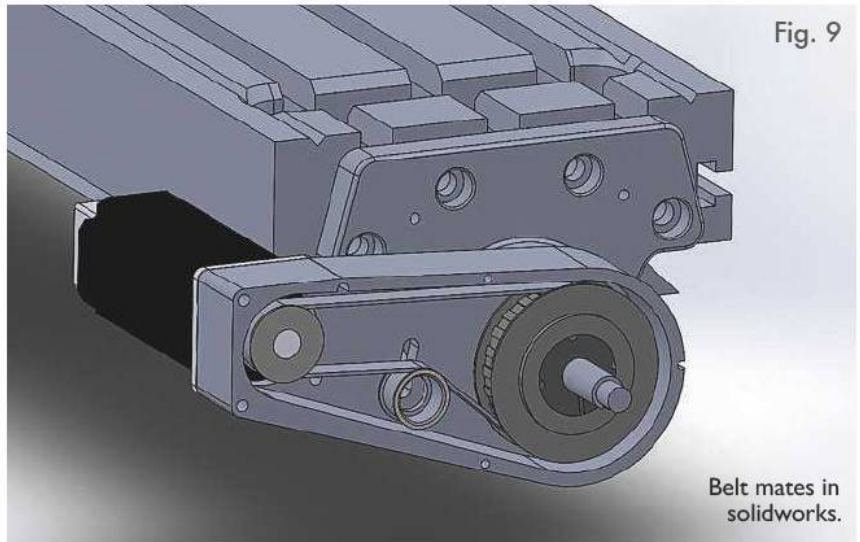


Fig. 9

Belt mates in solidworks.

Conclusions

I'd recommend trying out a modern 3D CAD application if you have the budget and interest to do so. There are many things that can be done in CAD that can't sensibly be done manually or at the very least can be done much more quickly and easily in CAD, with the ability to make live changes that update the associated drawings and assemblies instantly. And

if you want to get carried away, you can motorise your mechanisms and simulate operation quite easily. Ultimately, the work you do to create the CAD model is carried through to the toolpath that machines the part. As I said at the beginning, I am not an experienced user of CAD or CNC but in that capacity I can testify how easy it has been to get up and running without a great deal of pain and effort. ■

An alternative to the Vee Block/Vice

Harold Hall's
HINTS



Harold Hall offers a simple alternative for holding round workpieces on the mill.

I am not suggesting that the setup being described in this brief article is the preferred one in all cases, but is worth considering as it has advantages in some. Most workshop owners would first consider the vice as a means of securing a round item for machining and in many cases it is the obvious first choice, especially if the vice is already on the machine table.

One reason for using the method, shown in the photo, is if the workpiece diameter is too large for the available vice as whilst the photograph shows a relatively small diameter workpiece, in theory there is no limit to the diameter that can be accommodated.

Another reason is if through holes are to be drilled. In this case, the parallel would have to be removed just prior to the drill breaking through with the possibility that the workpiece would then drop in the vice when the drill pressure is again applied. Of course, if the diameter is large two parallels could be used not unlike the method in the photograph.

Another use for the method is that it can easily accommodate parts with two diameters much easier and more securely than if using a vice.

However, if the method is chosen, for whatever reason, it is quick to set up. Place the first fence on the machine table setting it using a square off the table's front edge. Place a piece of bar, width about 60 to 80% the diameter to be supported between the first bar and the one now being placed. Secure the second one with a nut and stud and then the workpiece with an overhead clamp. I think the photograph makes that all clear.

For longer workpieces, longer, or two fences per side, can be used with two overhead clamps. Of course, sufficient of the workpiece must be available for the required task to be completed, be it a drilled hole, a keyway or a flat.

If the workpiece has two diameters a second pair of fences will be required, maybe of a different thickness. For this, position the first pair as above and fit the



workpiece and then place the second pair using the workpiece to position them.

If more than one part is to be made then an end stop could be incorporated enabling subsequent parts to be placed identically. This is something that can be a problem using the vice but is very simple in this case.

Do keep the method in mind, you never know when it will be found useful. ■

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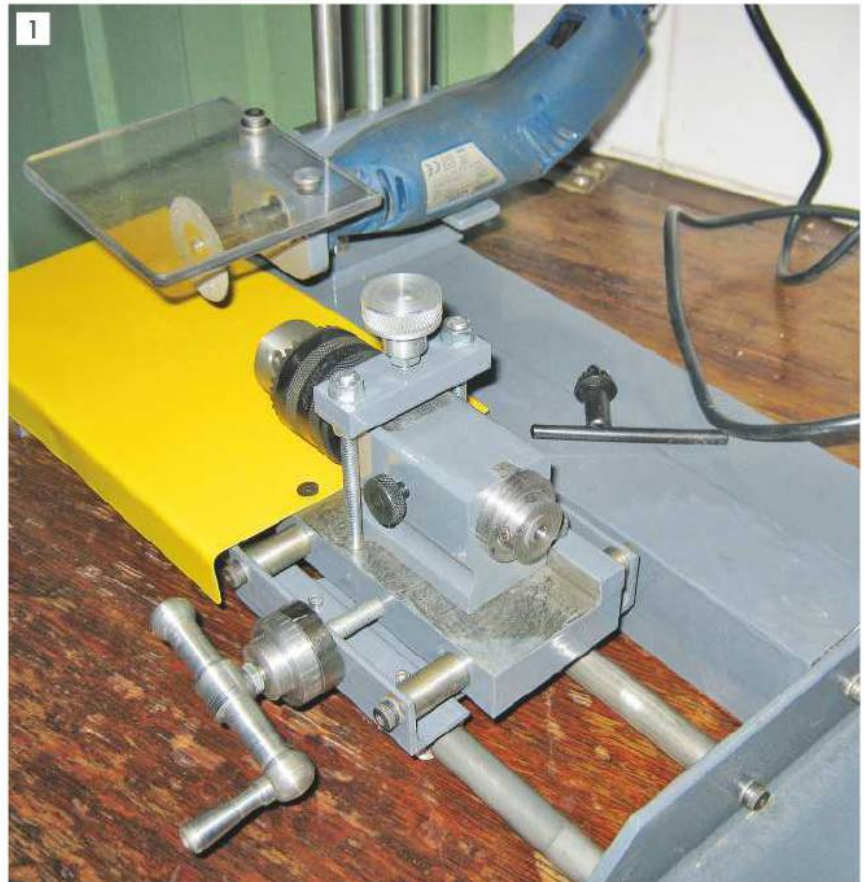
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The concept

I wanted to sharpen some small taps. I could have used an oilstone or a diamond stone, but this is a slow method when you have several taps to do in one go. The only option I could see was to make what is, to all intents purposes, a small tool grinder (**photo 1**).

The small grinding wheel used with die grinders would be ideal. So this got me around to thinking of a rotary tool (I have a Draper Multi-Tool) mounted on a stand. A method of moving the grinder up and down, with a carriage below to move the tap in and out and another to move the tap under the grinding wheel to grind the tap, would be the answer.



The finished tool.

A Tap Sharpening Tool

Will Doggett has found a solution to extend the life of his taps.



The process of design

I didn't start with drawing as such, just sketches on odd bits of paper as I went along from one part to the next. I think we call it 'designing on the hoof'. The photos were taken at the same time as I was making the tool. The sketches were drawn after the parts were finished. This was easier as some of the parts were remade as the project progressed. I started at the top and worked my way down the design, so to speak. The sizes described in the text and shown the sketches are the right and finished size.

The material was all from bits that I had in the workshop and made up from stock items that are readily available. I have used bolts or screws to keep it simple - no welding or silver soldering - so those new to the hobby (who I like to call apprentices) can, if they wish, make it with a lathe and a drilling machine. I must admit that I did use a band saw for cutting some of the materials to size, and a milling machine to get one part to the right size as it was to big for the project. I also used a welder to

join some parts as I didn't have the right size of material, but a visit to your local steel stockholder should enable you to get around this.

The process of manufacture

The first consideration was how to mount the draper grinder. Removing the large plastic collar on the collet end revealed what turned out to be 18 x 1.5 mm pitch thread. This was going to be the mounting point with a bracket at the back for support.

My initial thought was to make a mounting plate with a thread in it to hold the grinder, but the chances of the grinder finishing in the right position were slim with this method. I wanted the on/off switch on the top for easy access, and speed control on the bottom when it was finished.

Protective nut

The first part to be made was a protective nut. This was made from aluminium and is to protect the thread on the end of the

grinder when it is clamped in the steel holder.

This is drilled and tapped M18 and 21mm overall diameter and 10mm long with a slot in the side, so that it can be screwed on to the grinder and then clamped in the end of the holder, fixing the grinder in place. The protective nut is shown in **photo 2**. **Photograph 3** shows the nut fitted to the grinder.



The bush nut.



The protective nut fitted.



The parts of the support.



End support boring.



Tapping the clamp thread.



Cutting the clamp slot.



Tapping the end plate.

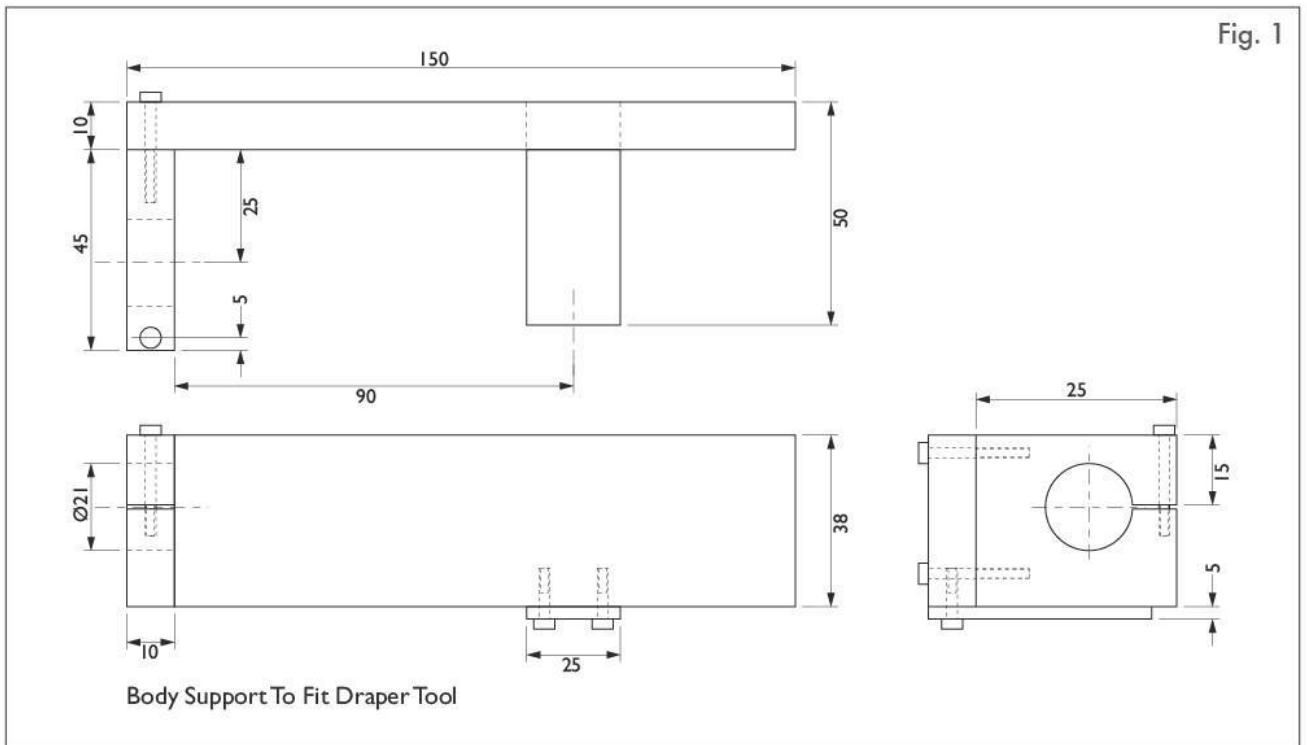


Fig. 1

The support bracket

The support bracket (fig. 1) requires a clamp to lock the grinder and a bracket arm to help support the grinders weight. The position for the clamping hole in the end plate was calculated by setting the grinder level on a steel plate and then measuring the height to the chuck centre, and then putting an angle plate at the back of the grinder and measuring from this to the centre.

The parts for the support bracket are shown in photo 4. They consist of three pieces one 38x10x45mm, one 38x10x150mm and one 25 x5 x 50mm, all

steel. The 38x10x45mm plate makes the end piece that will hold the protective nut so this was made first.

The position for the hole for the protective nut was marked out 15mm down from the top and 25mm in from the fixing face. It was then centre popped and the part was put in the four-jaw chuck and centred with a wiggler. It was then centre drilled and opened up with a 16mm drill. After drilling it was bored out to 21mm to fit the protective nut (photo 5).

The clamping screw hole was next, for an M5 socket head cap screw. The hole

was marked out an equal distance from the side and front and drilled for tapping in the bottom part and clearance in the top part. Tapping is shown in photo 6. A slot was then cut with a hacksaw to give the clamping action (photo 7).

The next thing was to fit the front part to the side. This was done with two M5 socket head screws. The side part was marked out to miss the hole that had been bored in the end plate and drilled. These holes were then transferred to the end part, and this was drilled and tapped for the screws. Tapping the end plate is shown in photo 8.

On completion of the assembly I tested the fit of the grinder in it as shown in **photos 11 and 12**. Everything was in the right place, the clamp worked and the grinder sat on the bracket as it was intended to. An M6 thread was then put at about half way along the length to fix it to the raise and lower block.

The next task was to work out a way to adjust the height of the grinding wheel so that the wheel can be feed onto the tap with accuracy. It also accommodates different sizes of tap as I had planned to use a fixed height chuck to hold the taps when grinding them, and some sort of height adjustment was necessary.

A column idea was a bit of a problem, as I wanted stability and one column would swing when moved up or down. I could have used a keyway down the shaft, but I felt this was making it over complicated for what I wanted. After a lot of thought I decided to use two posts to hold the carriage for the grinder and support bracket.

The raise and lower block

The raising and lowering block (**fig. 2**) was cut from some 20x60mm stock to a length of 80mm, then it was reduced to 20x30x80mm. Cutting to width on the band saw with Mike Houghton's Jig is shown in **photo 13**.

After sawing the block it was filed to size and deburred. I could have put the block in the four jaw chuck on the lathe to bring it to size, but the saw is quite accurate so the was no need for this. It was then ready for marking out for the holes.



A long, narrow metal beam with two vertical supports, labeled 10. The beam is made of a light-colored metal, possibly aluminum, and has a slightly weathered appearance. It is supported by two dark, rectangular metal brackets. The background is a plain, light-colored surface.

The block was marked out for the 1/2 inch column holes (1/2 inch bar was the only material that I had at the time, 12mm would be a metric alternative) and at the same time the centre hole which is for the rise and lower screw (**photo 14**). To mark out I used a digital height gauge (this is modified Vernier calliper that I made some time ago. The calliper used a battery in about two days, this is why I modified it. I only use the height gauge for a short time so there's no problem with batteries now).

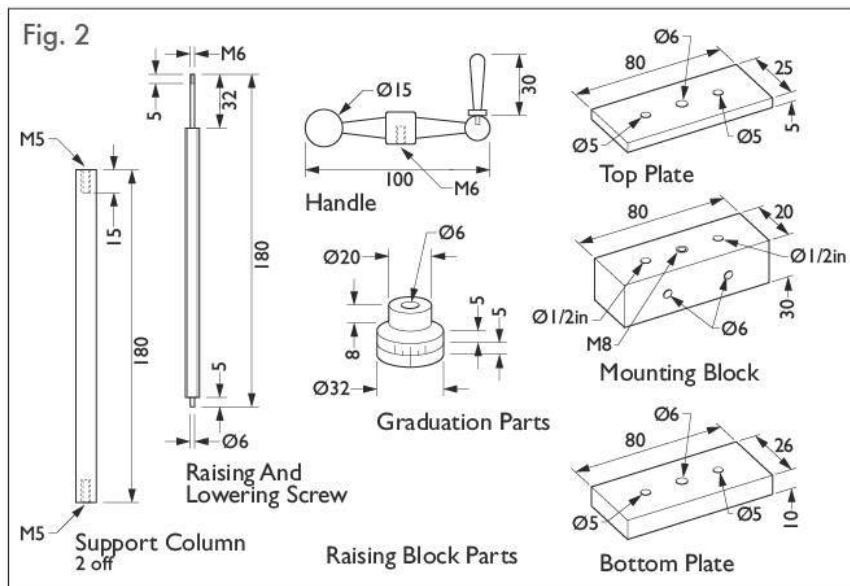
The top and bottom plates were also marked out at the same time and at same settings as the block. This way I cut down on any inaccuracy in the holes.

The block was held in a small machine vice clamped to the table of the drill and holes were then drilled and reamed $\frac{1}{2}$ inch. The holes that fit on the support rails were just reamed and are not going

to have bushes fitted in them, as I don't feel that is necessary.

The centre hole was drilled and tapped M8. This is for the lift and lower screw. There are two other holes drilled in the side of the block. These are for attaching the support bracket and are 6mm diameter.

The top column plate is made from some 6x25mm bar finished 80mm long. The bottom plate is 10x40x80mm. The unfinished plates are shown in **photo 15**. After the photographs were taken the centre hole in the top plate was drilled 6mm so the lift screw's plain shaft could



Marking out the raising block.

pass through. A blind 6mm hole was drilled on the bottom plate for the bottom of the screw shaft.

The column screw

The lift and lower screw was going to be M6 because of the 1mm pitch, but it was a bit flimsy. As M8 is 1.25 pitch and looks better for size I chose M8 as the extra .25 pitch doesn't make much difference when in use. The top part of the 8mm was reduced to 6mm for 32mm, and the top 10 mm has an M6 thread to fit the handle and a plain section for the graduation ring and top plate. At the bottom there is another section of 6mm diameter, 8mm long this is to fit in the hole in the bottom plate as a guide for the screw to stop it wandering about. This also has a 6mm washer fitted to it on assemble.

Handle & graduation scale

The handle was made next, from a piece of 22mm diameter steel. This has a 22mm centre section and two balls on each end the smaller ball is 17mm the other is 21mm. The centre has a M6 tapped hole in it to fix to the screw shaft. **Photograph 16** shows the larger ball being turned. A small handle was also turned with a M6 thread on it to fix it in a hole in the small end, **photo 17** shows the parts of the handle ready for assembly with Loctite. The dimensions for the handle are a bit arbitrary as I made it with what material I had and machined it to look right and balanced.

At the same time the graduation scale parts were roughly turned to size with a shoulder to fit together shown in **photo 18**. These would be re-machined and have the lines for the position scale put on later. The lower part has a counter bore of 19x3mm in it and is fixed to the top plate with M3 screws. It is 32mm diameter and 5mm thick.

The top part, the graduation dial, is also 32mm diameter and is 13mm high with a 19x2mm projection to fit the bottom parts counter bore. The 8mm up stand is for a 2BA screw to fix it to the screw shaft, so that the graduation dial rotates with the handle when it is turned to lower or raise the tool.



Top a & bottom plates.



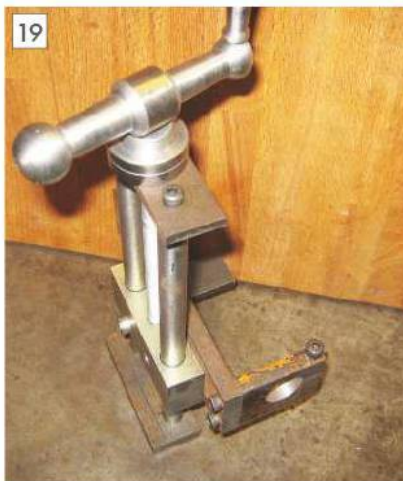
Turning the ball end.



Graduation parts.



The handle parts.



The support in position.

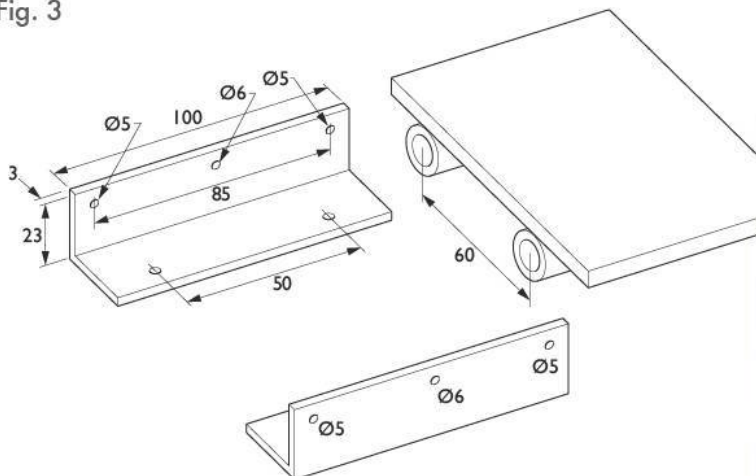
The assembled parts are shown in **photo 19**, this is before the scale lines were done. I didn't put a locking system on the column as it was not required.

The X carriage

The X carriage (**fig. 3**) is used to move the tooling along under the grinding wheel on the line of the flute of the tap from left to right as looking from the front. It was fabricated from a piece of flat and some round steel. The top was 93x75 x6mm, but as I didn't have any material that size, I made it from a piece of used 2-inch angle. I cut it to length, sawed it in half, tack welded the two parts back together to make a flat plate and then it was finished to size.

The tubes for it the carriage to move on were made from 22mm steel and cut 70mm long, then drilled and reamed 15mm to match the rails. They were then fixed to the bottom of the plate at 60mm centres with 3mm countersunk socket head screws. **Photograph 20** shows the top of the carriage and **photo 21** shows the underside and my rather crudely welded joint.

Fig. 3



X Carriage With Y Carriage Support Angle



The X carriage.



The underside of the X carriage.

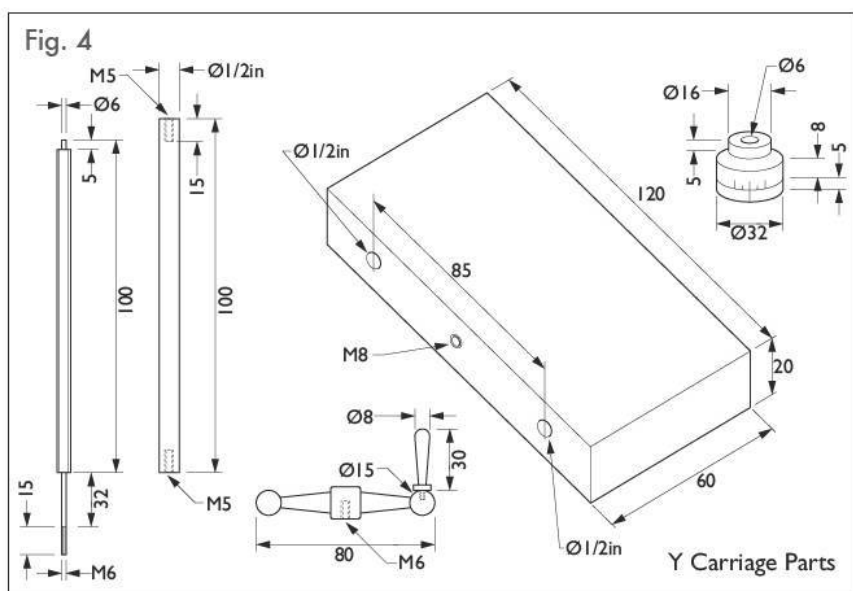
The X carriage support rails

The rails for the carriage to run on are 15mm round steel cut to 350mm finished length and supported with two angles at each end. These are in turn attached to the ends of the main base. The rails are drilled and tapped M5 in both ends to fit the holes drilled in the end supports of the base (see later).

Photograph 24 shows the main base with the holes for the rails. The rails for the carriage can be seen fitted and with the carriage in place in photo 25.



The Y carriage parts.



The Y carriage

The Y carriage (fig. 4) which moves the tooling in and out, looking from the front, was made in the same way as the X carriage with an angle support at each end and a top with rails to move on. This carriage has a graduated lead screw to move the tap that is being sharpened against the grinding wheel with accuracy.

The carriage rails were fixed to two 100mm pieces of 25x25mm angle screwed to the X carriage top (photo 22).

The table is piece of 20x60x120mm long steel, drilled and reamed to fit the rails. These are 1/2 inch diameter by 100mm and fixed to the angle with M5 socket head screws.

The carriage lead screw is made from M8 threaded rod 145mm long, with a 38mm section of 6mm and 15mm of M6 thread

on one end. The other end has a section of 6mm just 5mm long. The longer section is again for graduation dials and is which is the same as the Z-axis dial and handle. The dimensions for this are shown in fig. 4. There is only one slight difference - a lockout to secure the handle to the shaft on the Y-axis.

The graduation dials on the Y-axis are made the same way as on the Z-axis dials. The Y carriage graduation dial is held on the shaft with a 2 BA socket head grub screw, and the fixed part is held to the frame with a counter sunk socket head screw. The two carriages X and Y are shown in photo 23 assembled for test fit to check they are smooth in their operation.

To be continued...



The carriages.



The base.



Base with carriages.



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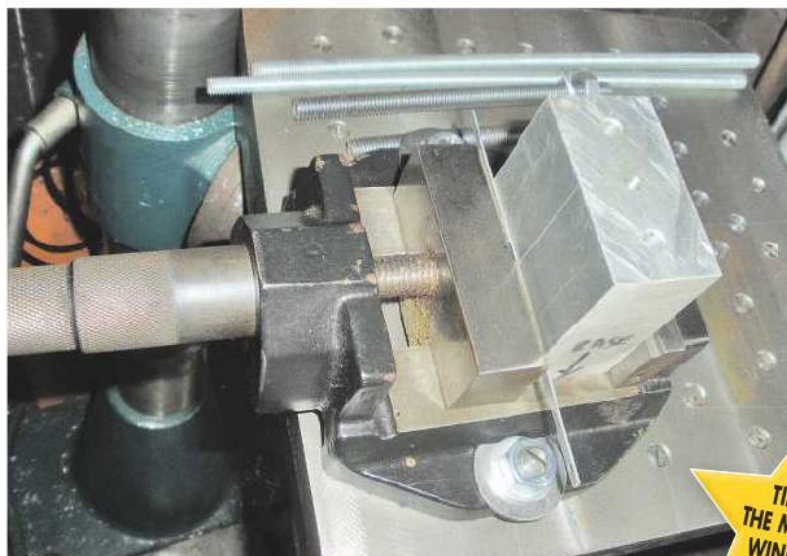
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This month's runner-up is **Peter Farmer**, who receives a book from the Workshop Practice Series.

I don't know if this will be of interest to your readers but I have found this tip useful over the years. When scrapping screw type electrical connectors ie mains 13a plugs, ceiling rose, or anything with the small 3mm brass screws save them to use on locking bolts. Just drill the end of the bolt, I found they were a tad over 3mm. No need to tap a thread as it allows brass screw to turn on end of bolt. This saves the bolt damaging the part which is being locked onto.



This month's winner offers two tips for the prize of one from **Colin Murdoch** in Leeds:

First tip is from toolroom practice of long ago - one of David Nye's windsceen wiper's steel strips can be used in a machine vice placed just at the top of the loose jaw. This ensures that the item that is being held has its Datum Face square up to the fixed jaw irrespective of how true the other faces are. Some wipers have stainless steel strips, these are better than the galvanised ones.

Second tip is an add-on cast iron slab filled with tapped holes and screwed to the drill table. Nothing new in that one might say, but if you have several vices, rotary tables etc., each with its own particular layout for the clamping bolts, the tapped holes can be laid out to that every item can have its own arrangement for spacing and size of stud.

More than that - you may need more than one position for each of the items according to the work to be done. All the holes were drilled right through the table where possible and tapped in situ. Each hole has its own stud sized so that the drill table can rotate freely - any one can be replaced by a longer stud for clamping a work piece without a vice.

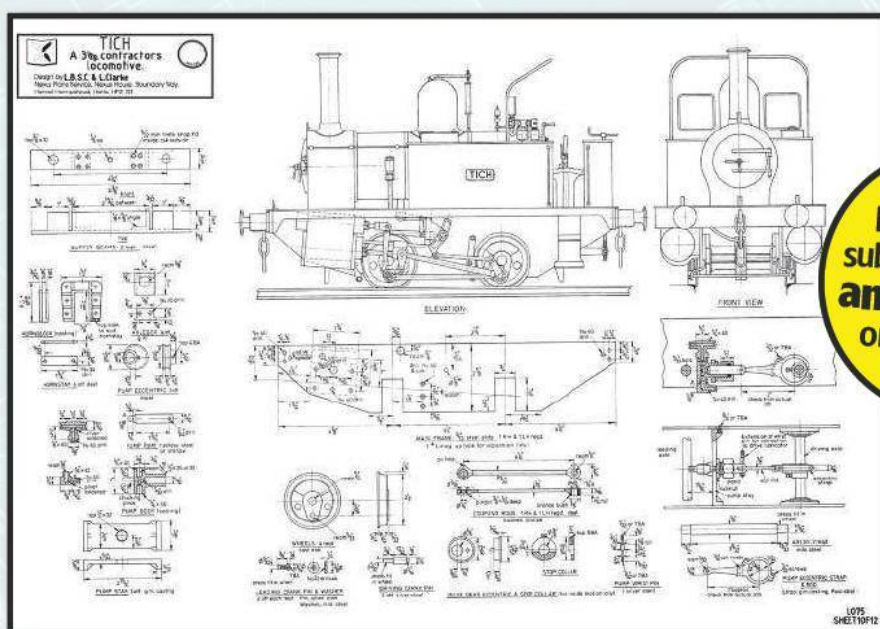


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Half Nut Repair for Drummond M Type Lathe



In 1924 when Drummond brothers of Guildford announced the improvements to their M type lathe one of them was the inclusion of a retracting half nut which allowed the user to easily engage and disengage a power feed via the lead screw. This improvement was a consequence of numerous requests from customers to provide a rack and pinion motion to operate the saddle. A half nut for the lead screw was therefore essential to replace the existing full nut.

Geoff Walker undertakes the repair of a lead screw half nut on a Myford or Drummond M type lathe.



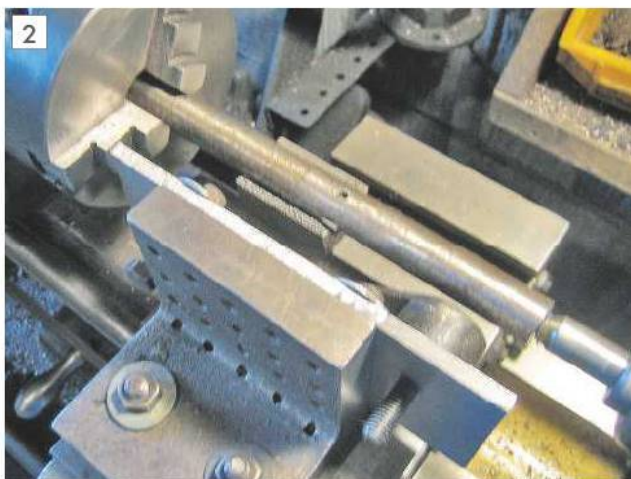
Half nut aligned on the centre line of the lathe.

The half nut, in the form of a cast swinging arm, pivots on a short arc into and out of engagement with the lead screw. Initially made from cast iron and later cast in bronze it is unusual and unlike more conventional half nuts which lift and engage square to the lead screw. The lathe with the new half nut continued in production in this form until around 1951. Thousands were made, in later years by Myford, and many are still around today. In my workshop I have two of them in regular use, a Drummond and a Myford.

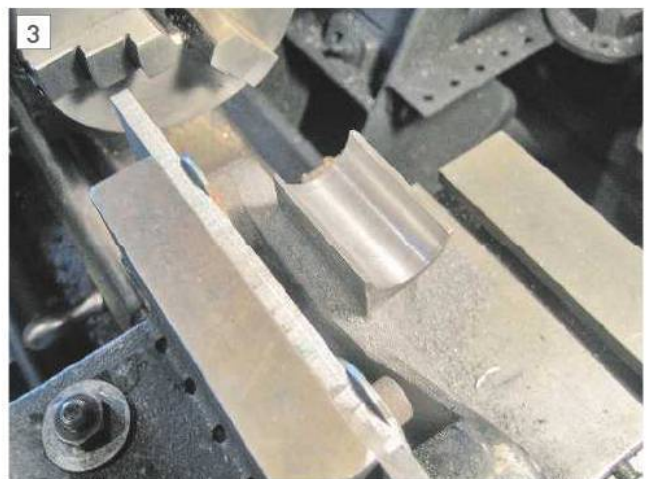
The half nut is an important component part of the machine and needs to be in at least good condition if machining operations under a power feed are to be carried out to a reasonably high standard. After being in constant use over a long time the nut is subject to wear and eventually a failure. As a result either a newer replacement, a repair or a new fabrication will be needed. The latter of these 3 options is the main focus of this

article, but first let's consider briefly the first two options:

1) A new nut is not an option, so a user must seek a replacement one with much less wear. Two problems here, there are not many around and many owners who have a spare are reluctant to sell them, simply because they so rare. They will, understandably, hang on to them. Even when they do come up for sale a good



Boring the half nut to size.



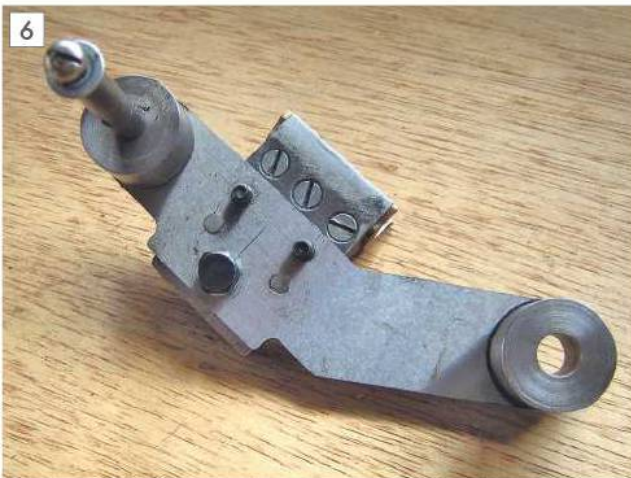
Boring complete to $\frac{1}{8}$ inch diameter.



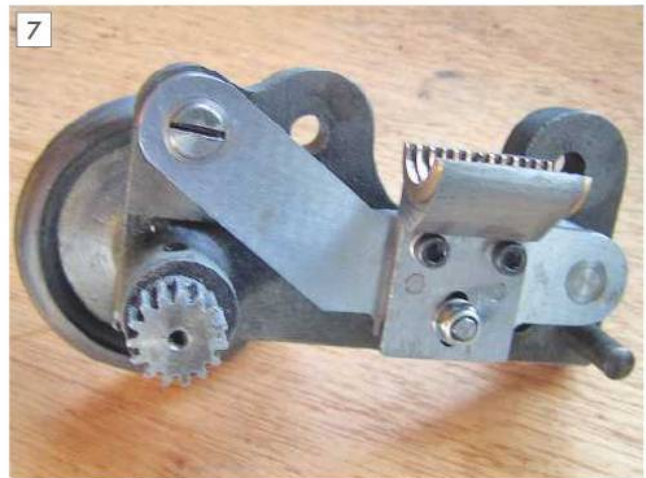
Bobbin secured in place with loctite.



Completed half nut, rear view.



Completed half nut, front view.



Half nut attached to the apron.

one will command a premium price. Now assuming you do get one don't think that the replacement problem is solved. It may be but not necessarily. My personal experience would suggest that luck will play a part in finding a half nut that will fit and engage satisfactorily on your machine. I have found that there are subtle dimensional differences between M types and not just between the 2 manufacturers. Most notably is the distance from the inside face of the apron to the centre line of the lead screw. This face on the apron acts as a datum as it is a point of contact for the half nut on the lathe. The said distance in my experience can vary by as much as 5 to 10 thou, which is a lot. Now of course it could and may well be less but should you acquire a half nut which has been used on an M type with a significant dimensional difference to yours then the centre line of the nut will not align with the centre line of the lead screw and will consequently bind when engaging or disengaging the nut. Of course you can make adjustments and/or leave a little slack in the pivot and you will probably, eventually, achieve an acceptable fit. This type of solution is for me unsatisfactory. I wanted something more precise.

2) A repair is a good option. I have seen numerous repair attempts some very good and all with respective merits. By far

and away the best one I have seen is one devised by Mr. Richard Bird. This was ably described by Steve Papworth in a series of articles in M.E. magazine in 1994. I used this method to repair the C.I. nut on my '29 Drummond M. This method requires the machining away of the worn thread. To achieve this the nut is attached to a fixture on the lathe cross slide with the centre line of the nut aligned with the centre line of the lathe. A boring bar is then used to machine the threads away. A pre-prepared bronze half nut bobbin with a 3/4 inch L.H. square thread is then inserted into the machined space and secured using either soft solder or loctite. For this method to be successful the material around the square thread needs to be substantial enough for the machining to be carried out and still support the new half bobbin. The cast material around the worn thread on my 1929 M type half nut was substantial and therefore the nut was entirely suitable for this type of repair. **Photographs 1 to 4** briefly illustrate the method involved. Photograph 1 shows the half nut secured to an angle plate with the centre line of the half nut aligned on the centre line of the lathe using a short length of an old lead screw. Photograph 2 is the half nut being bored to size to receive the bronze half bobbin. Photograph 3 is the completed boring to 3/4 diameter, the waist diameter of the bobbin. The half bobbin held in place with Loctite is shown in photo

4. For a detailed description of Mr. Bird's ingenious method and the making of the bobbin you can refer to Steve Papworth's articles from 1994 in M.E. magazine.

On my Myford M type lathe the bronze half nut was also showing serious signs of wear. I had fears that it would fail whilst using the lathe. The cast area around the thread was thin and certainly not suitable for a Papworth/Bird style repair. I chose the option of a new fabricated arm as I wanted a half nut that was precisely fitted to my machine, bespoke in every respect. I felt it would be easier to control the accuracy of a new fabricated nut rather than devising an alternative repair method for the existing one.

Photographs 5, 6 and 7 show the complete fabricated solution, a very simple design but nevertheless requiring accuracy in each stage of construction. Photograph 7 shows the half nut arm fixed in place on the lathe apron.

Making the new fabricated half nut arm and half bobbin

I do not wish to be pedantic in my description therefore not all the making procedures will be covered for each part, just the main points. The full arm assembly has 6 main component parts, all of which can be seen in photos 5, 6, and

Fig. 1

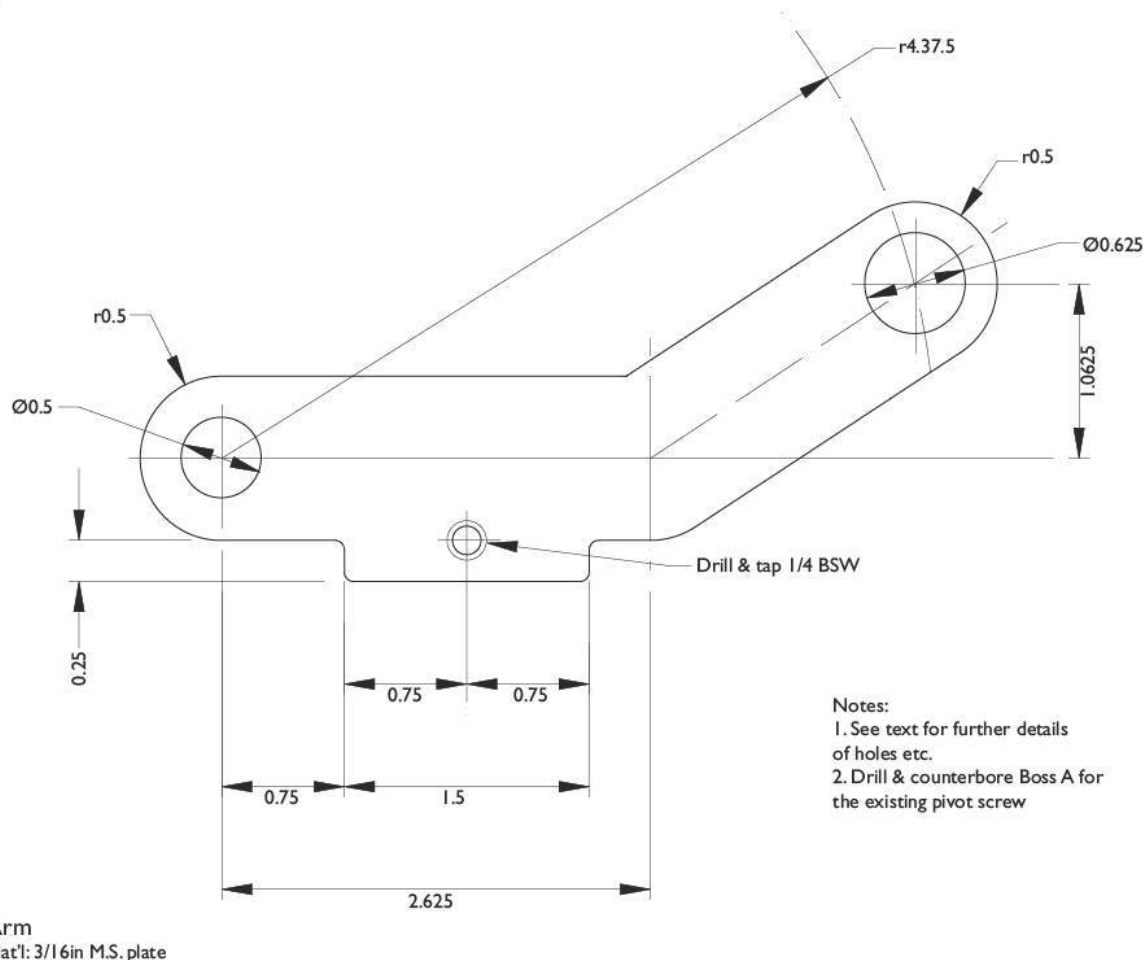


Fig. 2

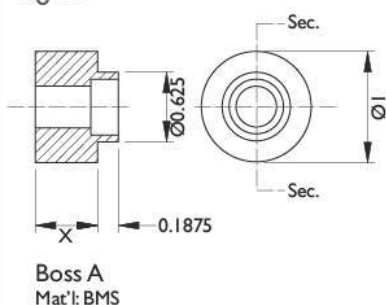
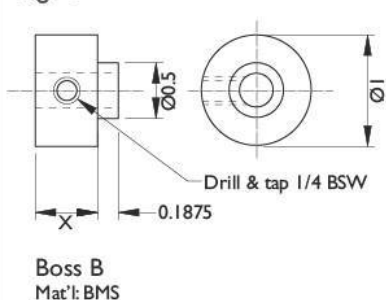


Fig. 3



7. Figures 1 to 6 show detail sizes for each of the individual parts. Measurements throughout are mainly imperial, however, some hole sizes are given in metric.

Taking measurements from your lathe

There are only two measurements you need to take from your lathe, one of which is to check the outside diameter of the lead screw which should be $\frac{3}{4}$ inch. The other measurement is the distance from the inside face of the apron to the

outer edge of the lead screw. To measure this I used an expanding bore gauge and a micrometer (photo 8). Using this measurement you can determine the distance to the centre line of the lead screw. Also if you deduct half the width of the bobbin ($\frac{1}{32}$ inch) plus the thickness of the arm ($\frac{3}{16}$ inch) that will give you distance x on the two bosses (figs 2 & 3).

Making the arm

The arm is made from $\frac{3}{16}$ inch thick B.M.S. plate. The outer edges can be marked out then cut and filed to the dimensions shown. I have added a $\frac{1}{4} \times 1\frac{1}{4}$ inch projection on the underside to provide a larger bearing surface for the bracket, more room for fixings and dowels and an increased finger space when setting the position of the bracket.

The only really important dimension is the distance between the pivot hole and the handle stud hole. Care needs to be taken to ensure accurate spacing of these holes which is nominally $\frac{4}{16}$ inch. As the two holes are quite large I chose to drill and bore each hole to size, clamping the arm to the lathe faceplate. This method will also ensure that both holes are square to the face of the arm.

Prior to the setting and positioning of the bracket the only other hole that needs drilling at this stage is a single hole in the

Fig. 4

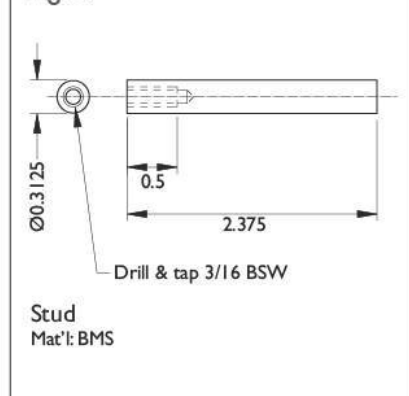
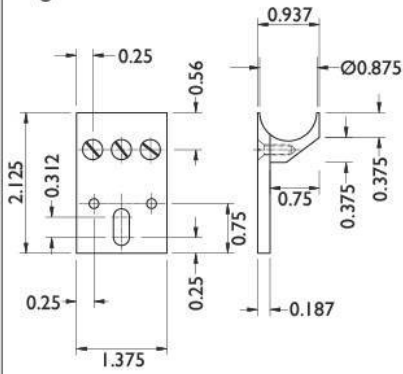


Fig. 5

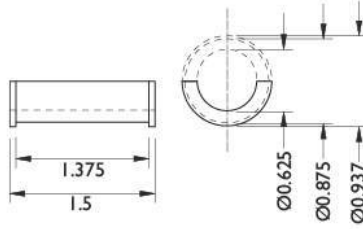


Half Nut Bracket

Mat'l: BMS

For details of hole sizes, additional holes & fixings please refer to text

Fig. 6



Half Nut Bobbin

Mat'l: Phosphor bronze

Blank sizes only

lower part of the arm. This should be drilled and tapped $\frac{1}{4}$ B.S.W. or similar. The other 4 holes for screws and dowels are drilled later, after assembly and setting of the bracket and half bobbin.

The two arm bosses

The two bosses are made from 1 inch diameter B.M.S. bar. Simple turning operations are needed which need very little explanation. The register diameters for each hole in the arm should be made a little oversize to provide a light interference fit. If after assembly and testing the distance x needs any minor adjustment then the boss (s) can be easily removed from the arm. On final assembly a smear of loctite can be applied to secure the bosses in place.

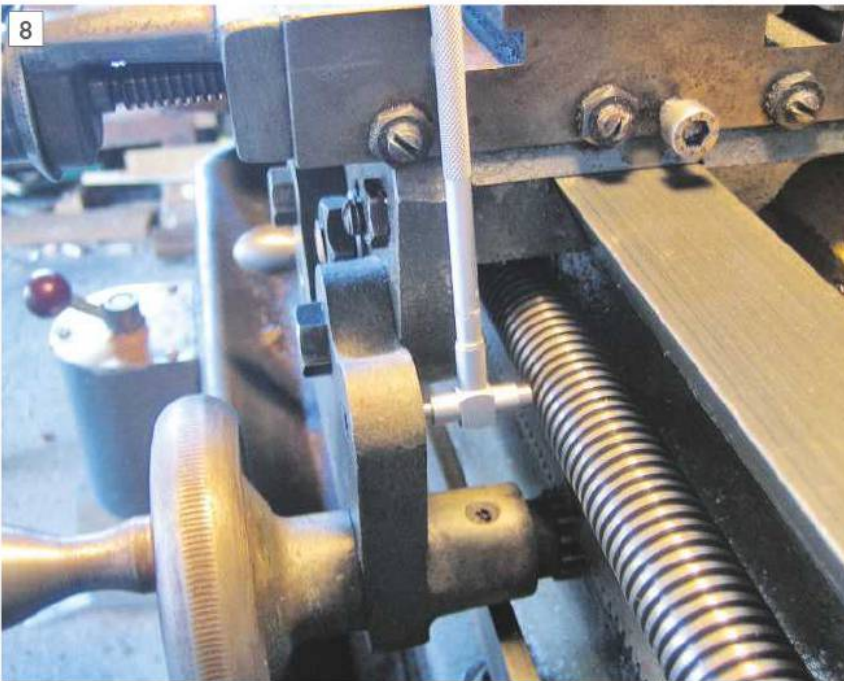
Distance x is of course important as it effectively sets the half nut bracket and bobbin on the centre line of the lead screw.

Making the half nut bracket

Photographs 9 and 10 show a M.S. block $1\frac{3}{4} \times 1\frac{3}{4} \times \frac{3}{4}$ inch attached with 6 small countersunk head screws ($\frac{5}{16}$ inch or similar) to a length of $\frac{3}{16}$ inch M.S. plate $4\frac{1}{4} \times 1\frac{3}{4}$ inch. The overall depth of the two is $\frac{1}{16}$ inch. At the centre height ($\frac{1}{32}$ inch) drill and tap a small hole $\frac{3}{16}$ B.S.W. or similar. Using this hole as a fixing point set a $\frac{1}{2}$ inch diameter toolmaker's button exactly on centre height. I used a prepared distance piece $\frac{1}{2}$ inch diameter. The toolmaker's button can be made from a piece of $\frac{1}{2}$ inch diameter silver steel approximately $\frac{3}{8}$ inch long with a hole $\frac{5}{16}$ inch diameter.

With the assembly resting on a surface plate the button is set on top of the distance piece and then secured in place with a $\frac{3}{16}$ inch screw and washer. The lateral position of the button is less important and may be set equidistant with a steel rule.

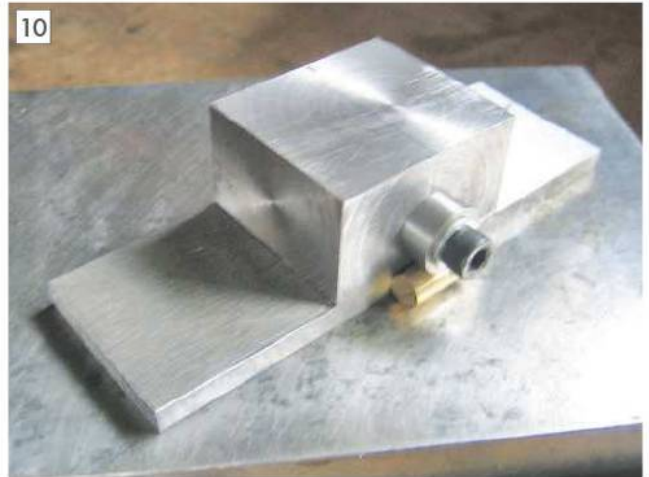
I had thoughts about making two fabricated arms, one for each of my two M types. This explains the way I constructed the bracket for machining. As can be seen two brackets are machined at one setting. The subsequent repair of the cast iron arm left me with a spare bracket. Of course if you only need one bracket then you only need to extend the $\frac{3}{16}$ inch plate on one side of the block. The whole assembly



Gauging the gap between apron and lead screw.



Half nut bracket assembly and toolmakers button.



Assembly with the toolmakers button set.

now needs setting up in a 4 jaw chuck (photo 11). The button is roughly centred and then adjusted and clocked until running true using a D.T.I.

After removing the button drill and then bore to a diameter of $\frac{7}{8}$ inch. As the material after boring will be precious thin at two opposite jaw points it is prudent to use a pair of clamp plates, relieved in the centre to transfer the pressure from the lathe jaws to the outer edges of the block. After the boring is completed chamfer the corners of the block as shown in fig 5 and then split the assembly into two halves.

Making the half nut bobbin

I'll not go into the finer details of screw cutting the bobbin. That is fundamentally text book material and therefore reference to any number of good Model Engineer books will provide all the technical information needed to cut a left hand internal square thread. In this case $\frac{3}{4}$ inch diameter and 8 T.P.I. I will however make a few general points.

A short length of an old lead screw would be very useful to have as this can be used as gauge to ensure that the thread is sized correctly and in particular not undercut. A little overcut would be fine but undercut would be a disaster. If you add the chucking length to the bobbin length it is a quite substantial piece of phosphor bronze. Take your time, get it right first time, phosphor bronze is not cheap. Fig 6 shows the blank sizes of the full turned and half bobbin but not the details of the square thread.

A junior hacksaw is ideal to split the bobbin into two halves and a sheet of medium emery paper on a flat plate can be used to level the cut surface. The crests of the threads will need some minor fettling and smoothing, the latter with a piece of fine wet or dry paper wrapped around a short length of $\frac{5}{8}$ inch diameter bar. To secure the half bobbin in the bracket, Loctite would be a good choice.

Setting up on the lathe

Photograph 12 shows the half nut bracket and bobbin attached to the arm with a single $\frac{1}{4}$ inch screw, washers and nyloc nut. The screw is locked tight in the $\frac{1}{4}$ B.S.W. threaded hole and effectively acts



Centring the toolmakers button in the 4 jaw chuck.

as a stud. It can be seen that the bracket has a slotted hole and two 4.5 mm. pilot holes for a $\frac{3}{16}$ inch reamer. The slotted hole is of course to adjust the vertical height of the bracket. For now the nyloc nut needs to be just tight enough to allow the bracket to slide freely up or down.

Remove from the lathe the rack and the clutch knockout bar. Remove the apron from the lathe and attach this assembly, adding the existing engagement knob and spring to the new stud. Refit the apron on the lathe and raise the knob to the upper engaged position. Now slide the bracket upwards until the half bobbin engages with the lead screw. When satisfied the engagement is correct tighten the nut with a small spanner. It is important to ensure that the upper plain lead screw thrust pad is set correctly, in just light contact with the lead screw. Failure to do so could result in the lead screw deflecting upwards if too much pressure is applied when positioning the half nut.

When the setting is complete and secure remove the arm from the lathe and using the existing holes in the Bracket as a guide drill right through. Now ream the two

holes $\frac{3}{16}$ inch and fit two silver steel dowels. Two further fixing screws can now be added for additional security.

Some hand fitting will almost certainly be necessary as space is very tight at the back of the apron. This will involve filing the underside of the bracket to give adequate clearance between bobbin and lead screw when the half nut is disengaged. Clearance will also be tight between the bracket and the upper thrust pad and also the front of the lathe bed. Some filing to give clearance may again be necessary.

That more or less sums up all the procedures. Photograph 13 is a front view of the apron with half nut in place. I found that it was certainly worth the trouble making as I now have a half nut which engages smoothly and positively with the lead screw. Disengaging is also a lot easier as the nut no longer binds when releasing with the lead screw rotating. If you are well organised and equipped the new arm is little more than a weekend project. For the short length of lead screw I may be able to help. If you don't know me already then I am happy to be contacted through the editor. ■



Bracket and bobbin fixed to the arm for setting on the lathe.



Completed half nut attached to the apron.

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Fitting a Three-Axis Digital Read Out System to an X3 Milling Machine



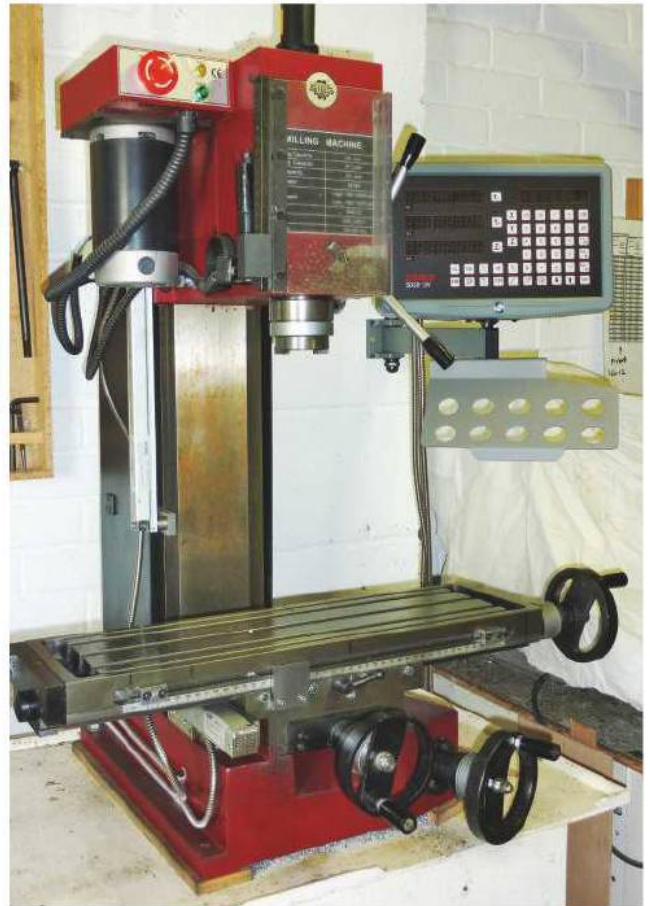
Part 2

Alex du Pré fits digital readouts to all three axes of his X3 mill, and discovers some extra travel along the way.

The need for some precise and repetitive milling on some model IC engines led to the purchase of a three-axis digital read out (DRO) system for my X3 milling machine. This article describes how the DRO was installed on the mill.

Increasing the X axis travel

Before ordering my scales, I carefully measured the X axis travel on my X3 and concluded that I needed a 370mm scale. When I came to fit the scales, I realised that I had failed to remove one of the table stops and the actual travel was in fact 410mm. Whilst gently cursing my carelessness, I considered my options which were essentially to order a longer scale or to fit a stop to limit the X axis travel, neither of which greatly appealed. On examining the machine more closely, it occurred to me that the X axis travel was being unnecessarily constrained by the X axis leadscrew bearing housing bolted to the left hand end of the table, which butted up against the end of the ways (photo 13). A small modification would remove the obstruction and allow some 60mm of additional travel which I felt was worth having, whilst helping to justify the purchase of a longer scale. I felt that 60mm of extra travel would still leave the slide adequately supported at the limit of its travel. In fact, the length of the slide supported in this position is still greater than when the table is moved to the opposite extreme of its travel. I like to set up a machine vice on one end of the table and an angle plate or rotary table on the other to reduce set up changes, so this extra travel has considerable value.



The X3 milling machine with DRO system installed.



The leadscrew bearing housing, showing how it fouls the end of the slide and limits X axis travel.



The bearing housing removed from the machine.



Modifying the bearing housing.



The modified housing fitted to the mill.



The milling machine with table and saddle removed.



The saddle being set up on the Warco lathe/mill ready for machining. Further clamps were added after aligning the saddle with the DTI.



The rebates milled into the saddle to provide clearance and a stop for the modified bearing housing.



The limit of the X axis travel before...

... and after modification. The black lines show the addition travel achieved. The mill spindle is in line with the locking handle, so now reaches the ends of the T-slots.



The bearing housing is fitted to the end of the table with two cap screws and aligned with two pins. Tapped holes are provided which can be used to remove the housing with the aid of two jacking bolts (photo 14). To increase the X axis travel, it was necessary to modify both the bearing housing and the saddle. The bearing housing was machined using my back up machine, a Warco lathe/mill (photo 15). The metal removed from the bearing housing was carefully measured to give clearance over the gib strip and to allow a positive stop to be achieved against the saddle. This cut into the jacking holes, so I provided two

new ones closer to the alignment pins and actually in a better position than the originals in my opinion. The modified housing is shown in photo 16.

The mill table was then removed from the saddle (photo 17), and the saddle was removed from the mill and set up on the lathe/mill (photo 18). Two rebates were milled onto the saddle (photo 19), shaped to allow the modified housing to move a further 60mm and then positively stop against the end of the rebates. The result of the modification can

be seen in photos 20 and 21. This completed the modification, other than taking the opportunity to clean and re-grease the slides, with copper grease as in the originally supplied condition.



The 470mm scale with installation guide, cover and mounting brackets.

Fitting the X Axis Scale

With the modification complete, the total X axis travel was now some 440mm, so I ordered another, longer, scale with 470mm travel, this being the shortest scale giving the required travel (**photo 22**).

To fit the scale, the mill table and saddle were bodily removed from the milling machine in order to give access to drill the necessary holes in the saddle. First, the new extents of travel were marked on the mill table and the position of the centre of the travel located. The positions were marked with a black marker pen, **photos 23 to 25**. The reason for doing this is to ensure that the scale and the slider are mounted centrally around the table's travel.

The scale was mounted to the rear edge of the table, which is free of obstructions apart from the coolant drain plug. The necessary holes were drilled and tapped and then the cover backing was bolted to



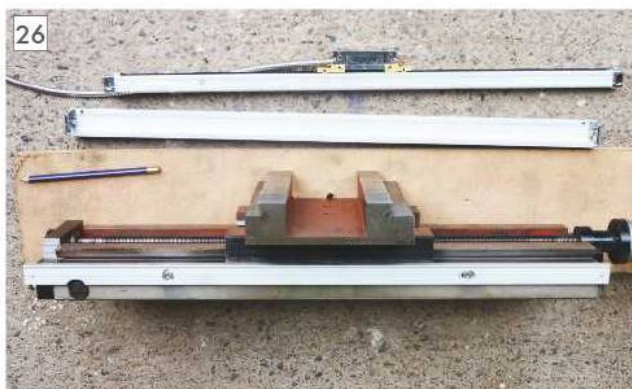
The mill table at one end of its travel...



...and at the other end.



The centre of the X axis travel marked on the mill table. It is easier to fit the X axis scale with the table removed from the machine.



The cover backing fitted to the table.



The mounting bracket for the slider.



The scale and cover in position on the mill table.

the mill table (photo 26). The backing was filed to clear the drain plug.

One of the supplied brackets was modified to provide the mounting for the slider. The brackets provided are rather odd as none of the holes seem to align with any the holes in the scales. Nevertheless, it was easy enough to mill the bracket to fit the space available and to drill holes in the required positions. The rear of the saddle was drilled to accept the fixing bolts (photo 27). It was then straightforward to fit the scale and the cover, although the cover also had to be filed to clear the drain plug (photo 28). With the mill table returned to the machine, the scale was checked for alignment along its top and rear face and adjusted to complete the X axis installation (photo 29).

To be continued...

COMING UP...

Next time, Alex du Pré concludes by installing the display console and reflects on the benefits of the system.



Checking the scale's alignment with the X axis.

STEEL HEAT TREATMENT COLOUR CHART

Sooner or later we all find ourselves needing to harden and temper steel, perhaps to make a tough wear-resistant part, or a specialist cutter. One of the challenges of doing this is accurately judging the 'tempering colour' which determines the final hardness. The traditional way of doing this is to take advantage of the colours produced by the thin oxide film that forms on hot steel at temperatures between 200 and 300C. Often the colour, rather than a temperature, is quoted. This then leaves us with the challenge of judging a colour, which is a subjective process. One way to learn the colours is to heat the end of a steel rod until the range of colours form along its length, but the accompanying chart should also be useful. Finally, remember that these colours need oxygen to form, so don't heat the metal with a direct flame.

Colour	Temp C	Colour
	300	Dark Blue
	295	Full Blue
	290	Deep Purple
	280	Purple
	275	Light-Purple
	270	Brown-Purple
	265	Brown-Red
	255	Yellow-Brown
	250	Dark Straw
	230	Pale Straw
	210	Pale Yellow

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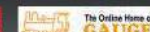
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Tool-Holding Adapters for Cnc Tooling Part 2



Peter King in New Zealand needed a way to achieve repeatability and greater convenience.

I had owned my KX3 CNC milling machine for some months and the number of '3 Morse tool-holders was starting to proliferate – I had been warned this would happen but it had not really registered.

I calculated how many adapters I would use – nearly fainted – and bought 5 metres of 30mm free-cutting steel bar. The bar is much cheaper if bought in a whole length and cut at home, the stockholder kindly cut the bar in half to get it in my car without charge! If you have very deep pockets the supplier may cut all the little billets for you on a CNC band-saw. Always ask if the stockholder has a lot of off-cuts in the size you want – they are always relieved to get rid of them, and don't charge for original cutting and may make a small discount on the purchase.

The first operation I would suggest is that sufficient of the short billets required be sawn to length from bar, but remember to allow a little extra for facing to length.

Then mount each in turn in the lathe chuck with about 35mm protruding (**photo 3**) and lightly face the outer end to clean up. Then machine the tail portion of the adapter to finished diameter and length and put a small bevel at the outer end. Use the 3 Morse tool holder you are going to use, to hold these as a gauge (**photos 4 & 5**). David Fenner suggested to me that a reasonable undercut be made into the flange face at that end of the Tail to accommodate tool holders that are a bit deficient in the bevel on the tool entry. It is very worth while doing this to ensure the adapter fits flush up to the holder, mine needed it. Then centre drill the end followed by drilling 4mm tapping size to depth for the adjusting screw and put a



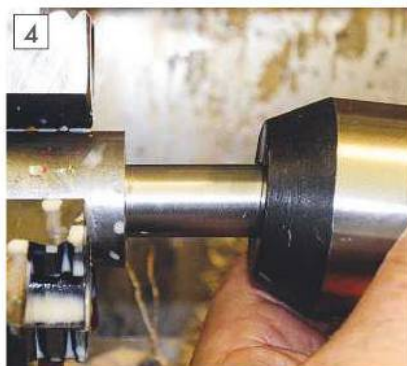
One of the adapters.

thread crest clearing countersink into the pre-drilled hole – i.e. big enough to leave a clear bevel all round *after* the hole is tapped (**photo 6**). Don't tap the blind hole yet!

The next stage is to mount all the tail ends one by one into a Morse shank ER Collet holder mounted in the lathe mandrel (or use whatever other Collet system you have). Another tack would be to mount whatever size of 3 Morse Tool Holder (**photo 7**) you are going to use in the lathe mandrel as I did, secure the adapter tail in it and machine to your



Machining the tail of an adapter.



Using the MT3 holder as a go gauge.



The adapter tail is a close fit.



Drilling for the tapped hole.



Adapter in the holder for turning.



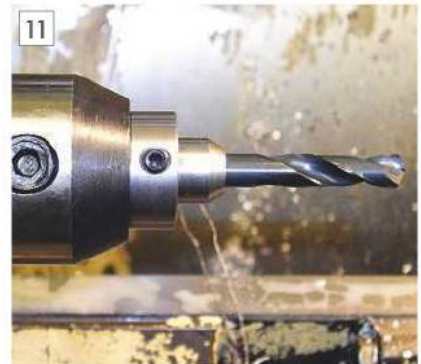
Check the drawbar is fitted!



An adapter fitted in the MT3 holder.



Drill the holder undersize...



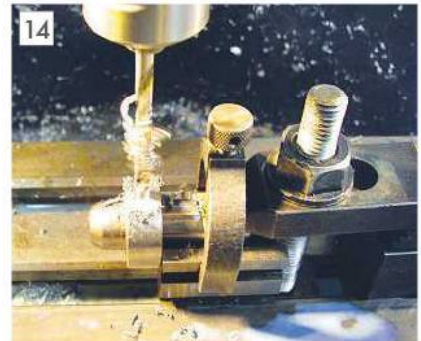
...then bore to a close fit on the tooling.



Reverse the adapter and tap the end hole.



Aligning the v-block with the spindle.



Drilling the grub screw hole.

hearts delight. Do use a drawbar! See **photo 8**. You may want to use a 4-jaw independent lathe chuck, if so get out your DTI and some soft shims to protect the tail of the adapter. Then with the un-machined end of the billet and enough of the tail projecting from the chuck for the DTI to reach, adjust to get the tail part running true (Remember you cannot use the raw bar for setting as it isn't true). With the blank adapter thus held to reasonable accuracy in the Chuck and maybe higher accuracy in a Collet/Tool Holder, but sticking out a little - 4 to 10mm - to allow machining the outside of the flange, (**photo 9**) skim the projecting end to the diameter of the flange. Now reduce the nose to diameter and length and face the end. The tapered bit is up to you, but don't go overboard (mine is about 3mm on the radius x 6mm on axis). Carefully centre the end and drill undersize of the intended size by about 0.5mm to the depth where you meet the 4mm tapping-size drilling (**photo 10**). Now either very carefully bore, step drill or machine ream (depending on convenience) the hole to the finished size, testing with intended tool. If boring is used then keep testing with the shank of the tool you are going to use in the adapter until it just slides in (**photo 11**). Break all edges - including that of the sized hole - mark its size on the tail with a marker pen and put to one side. When all the batch have been taken to this stage, refit your chuck and mount each adapter by the flange with the tail outwards and then run a 4mm gun nose or machine tap down the now through hole (**photo 12**).

The next stage requires some care, as the task is to drill and tap the hole for the grub screw. An easy way of doing this is to put a 90 degree spotting drill into the pillar drill or mill drill and bring it down to trap a small v-block and lock the spindle (**photo 13**). This centres the v-block on the drill

axis. Clamp the straight edge of a steel set-square to the table and against the end of the v-block. to the table. Now you can retract the spindle then clamp the v-block so it is sufficiently clear of the spindle axis that an adapter can be clamped to the block (**photo 14**). If this done right, the flange face will rest against the end of the v-block with the position where the grub screw will go lying under the drill axis. Try and get it near central on the edge of the flange. Use a Spotting drill - or try a split point drill - to start a centre for the tapping size drill which should follow. Use a larger drill than the tapping size for spotting and you will leave a neat bevel after drilling tapping size. I show an M6 thread but it is not important, use any suitable size of Allen grub screw you have, but do try for dog point type (fig 1). I know it's a pain, but to get things square (1) spot drill (2) change to tapping drill (3) drill tapping size (4) change to a taper second tap. Hand turn and feed using a centre in the chuck and a spring biased centre in the chuck and resting in the butt end of the tap holder until a couple of full threads are cut (**photo 15**). You can then remove the tap and the adapter and hand finish the thread until a reasonable depth is tapped and then change to a bottoming tap. Be careful not to go too far and blemish the tool mounting bore. One way to prevent this is to put the tool the adapter is intended for into the bore and remove it only for the last turn of the tap. There will almost certainly be a burr in the tool mounting hole where the thread emerges, if you reamed the tool hole a standard size then just hand feed the machine reamer through again - if bored then use the next smaller size of drill to the hole (Imperial fractional/number/letter or Metric) and carefully hand feed it down the hole to remove the burr. I have seen a cunning old fitter use a ball end rotary burr in a hand held holder to remove such burrs

by spinning the tool down the hole in the end of the thread with his fingers. For an adapter for very small drills, take the grub screw tapping size drill down to the upper side of the tool hole. Then run a centre cutting end mill slightly bigger than the dog on the grub screw down to the central axis of the tool hole - and no further - to give the grub screw dog a hold on the tool.

The last stage is to end mill a flat along the tail shank to accommodate the grub screw in the main tool-holder, the experienced will need no further advice - beginners read on. Take one milling vice and a small v-block (probably with a thin parallel or two). Clamp the vice to the bed of your vertical mill or mill/drill with the jaws aligned along the x-axis. Now open vice wide and place the v-block at a right angle to the jaws of the vice - not parallel - and place the adapter tail into the vee and while holding the lot down, close the vice. I did it a bit differently (**photo 16**). If there isn't about a quarter of the diameter of the tail above the vice jaw



Tapping for the grub screw.



The adapter clamped in a v-block ready for machining.



Milling an angled flat.

then put a thin parallel spacer under the v-block. Fit an end mill into the mandrel and carefully mill a flat along the tail, take light cuts 0.25 to 0.38mm until you have a flat about 6mm wide along the tail (photo 17). You may find it convenient to mark, stamp or scratch the tool size on part of the flat – the perfectionists (with an eye to The Model Engineer Expo) among us will probably engrave it!

Before mounting drills or other plain shank tools into the adapters, carefully mark the shank of the tool with a black marker pen approximately where the grub screw will lie when the tool is set. Widen the mark to a little longer to allow for longitudinal adjustment, now grind a flat. This flat does not have to be very fancy and it only needs to be about 0.5 to 1mm deep depending on tool size. This is what stops the tool spinning in its seat and holds any settings – if in doubt have a look at the much bigger flat on an FC3 cutter. There is some advantage in cutting the flat deeper at the cutting end on both adapter and tool so that the grub screws engage the taper flat and discourages the tail/shanks from walking out (photo 17). The taper also biases it against the adjusting screw. This will require a slight adjustment to the tail milling operation by putting a small shim of 0.6mm or so thickness under the v-block at the cutting of the adapter, photo 16. This can just be seen in the photo as the Vee block is not level. When putting a flat by hand on the tool with a bench grinder it is just necessary to make the ground flat just a bit deeper at the cutting end. When setting the tools, do not do a Mr Atlas job



The tapered flat.

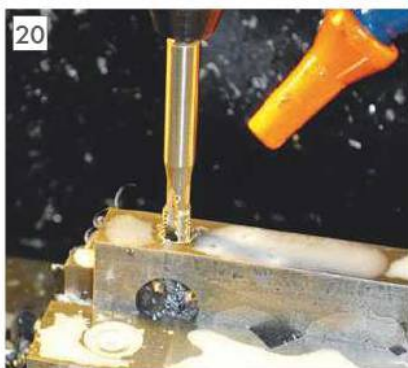


Checking the fit of the mounting collar.

on the grub screws as you could break the smaller drills – they just need to be nipped up normally.

Now we come to the setting jig, materials are realistically what you can find in the bits box. I suggest that the following guide sizes are suitable:

- 1) Stop arm about 13.0 x 25.0 x 75mm mild steel.
- 2) Main block about 25.0 square x 125.0mm mild steel.
- 3) Mounting rod for setting bar about 13.0 x 190.0mm silver steel or mild steel – ground stock if you can find it.
- 4) Stop arm locking thumbscrew from 16.0mm to 25mm diameter bar, preferably brass.
- 5) Adapter locking thumbscrew is the same as 4 above.
- 6) The two collars on the mounting rod are suitably sized mild steel.



Tapping the stop arm.

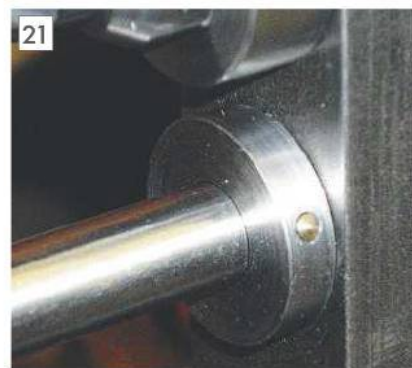
We will start with the mounting rod. Put the raw rod in the lathe chuck and round or bevel one end ensuring that there is no burr left on the edge. Reverse in the chuck and cut a short $\frac{3}{16}$ inch or 8mm length of a 0.50 inch or 13mm fine thread you have a die for (photo 18) I used 32 x 0.50 inch ME.

Now take a piece of 25.0mm round bar and centre the end, then drill undersize followed carefully down the axis for about 25mm by a tapping size hole to match the thread on the end of the mounting rod. Countersink the hole sufficient to clear the threads and tap about 13.0mm deep and check that the mounting rod fits and screws in at least 6mm (photo 19). Part off 6mm for the outer adjusting collar and break the sharp edges, then drill and tap for a small brass locking grub screw through the radius of the collar. I just used Loctite thread lock. To countersink the parted off face, put the rod in the chuck with about $\frac{3}{16}$ inch or 4mm of the thread exposed. Screw the collar on with the previously countersunk face inwards and lightly countersink the outer end of the thread to just clear of the threads. Bore the remainder of the bar to a tight fit on the mounting rod and part off at least 6mm to 13mm and break edges. Now you have a choice to either drill and tap the same as the previous collar for a grub screw or leave it alone for a later effort.

Next the stop arm. For a flashier job, skim the two widest faces if you wish (I didn't). Mark the position of the holes for the mounting rod and the thumbscrew on the same centre line round the corner. Clamp in vice and drill and ream the hole for the mounting bar, check the bar fits and break the edges. Then countersink, drill and tap for the thumbscrew, now break all the sharp edges and put to one side (photo 20).

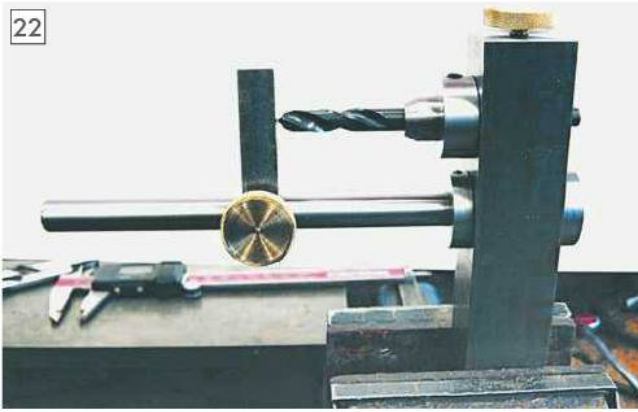
Now we come to the main block. Same routine, skim the faces and mark out for the sundry holes. Clamp in vice and drill and ream (preferably machine ream) the holes for the adapter and mounting rod – check they fit nicely and turn smoothly with no shake. Now set up and countersink and drill the hole for the thumbscrew (holes if you are fitting two screws) – clean up any burrs inside the bores and break all edges.

Assemble the tight collar to the mounting bar and slide (tap it) down far enough to allow the bar to go through the main block. Put the threaded collar on until the bar is just under flush with the outer face of the collar and then move the tight collar up against the main block. Now



The taper pin fitted to the stop collar.

22



The setting jig in use.

23



An adapter fitted with a tool.

comes a difficult bit, if you did not put a grub screw hole in earlier. Sort out a taper pin/a taper pin reamer (of the right size!) and suitable drills. Now set up and drill through both the collar and the mounting rod then carefully – with lots of cutting oil – ream until the pin push fits a bit more of bigger side protruding (photo 21). Fit the pin and tap it home with a small hammer and a pin punch, cut off the bit of the small end that sticks out and then grease the bar. Adjust the threaded collar until the mounting rod just rotates easily with no end shake and do up the grub screw or put a spot of wick in Loctite on the end of the thread.

Assemble the stop arm to the mounting bar and fit the thumbscrews to both it and the main block, and that's about it. The finished jig with an adapter fitted and the

stop bar against the tip of the tool is shown mounted in my small bench vice (photo 22). The adapter on its own with a tool fitted and adjusted is illustrated (photo 23).

That's about it, a nice big turning and boring job with enough interest to keep your attention. Cut and machine a few more blank adapters than the number of tools on your list to cover the ones you have forgotten. To guide you my initial list was:

- Spotting drills – 5.
- Tapping size stub drills – 12.
- Clearance size stub drills – 10.
- Reaming size stub drills – 8.
- Plain shank centre cutting end or slot mills metric & imperial size – 12.
- FC3 metric & imperial size mills – 20.
- Small ball nose mills – 3.
- Small bull nose mills – 3.

And possibly a couple of small $\frac{1}{4}$ inch or 6mm shank taper cutting mills – 75 holders!

Yours should be in the sizes you use most and will keep you out of the wife's ambit for a while! If you think that is more than you would use, consider that the library for the Tech's machine is well over 700 tools – some are large facing cutters. If my memory is correct Mach3 caters for 255 defined and zeroed tools in the tool table!

Not having a library of preset zeroed tools will quickly become a pain as setting up tools fresh every time a CNC job is undertaken will take about 5 minutes minimum for each tool. You will be doing the same to the same tools often enough to get fed up with it! Do keep a list to hand of what tools are set up and the number they go by. ■

A Travel Stop for a Warco 220 lathe

Peter Shaw fits a handy adjustable stop for the leadscrew of his lathe.



One of the problems with the Warco 220 lathe (Mashstroy C210T) is that the width of the saddle is such that it is very easy for the jaws of the 160mm 4 jaw chuck to catch on the saddle if they are extended outside of the chuck body. Whilst this very simple device was primarily aimed at assisting in the prevention of this problem, it will also be found useful as a general purpose leadscrew travel stop for manual turning only. Unfortunately, due to the nature of the 220's automatic feed arrangements, it cannot be used to automatically stop saddle feed. Use with automatic feed will require care to ensure that a powered collision does not occur.

The idea for this device arose as I had been in the habit of using lengths of wood resting on top of the leadscrew guard to act as temporary stops when I realized that the two screws holding the guard in place on the headstock could be used to hold a permanent bracket into which could be fitted a length of studding thus giving an adjustable stop.

A piece of suitable scrap metal about 10mm thick was obtained from the scrap box and fitted to the lathe by empirical methods, i.e. cut, file, drill & mill until it fitted. Hence there are no measurements or



Travel Stop.

drawings other than to say that the part where the two fixing screws are located is about 4mm thick whilst the part where the screwed rod screws into the bracket is left at about 10mm thick with the excess thickness towards the headstock. I used 6mm screwed rod for the actual adjustable stop because I had some and because I wasn't sure how much clearance I would have along the front of the headstock. In fact, I could have used 8mm screwed rod which I think may be more rigid and hence more suitable.

I replaced the two existing leadscrew guard fixing screws by longer countersunk screws. This was to allow for the extra thickness of the bracket. I used countersunk screws because I had them, but would in any case recommend them as this will avoid any further loss of leadscrew travel – I have



Components.

on occasion had the saddle hard up against the headstock casing and had to use the top-slide to gain that last little bit of longitudinal travel. On my lathe, I also found it necessary to remove sufficient metal from the bracket to allow the saddle wiper to slide over the top.

It will be necessary to have a selection of lengths of screwed rod available; initially I used a single 150mm long length which worked admirably when using the 4 jaw chuck. Unfortunately, when I changed to using direct collets, I had to remove the screwed rod as it was not possible to screw the rod far enough to the left to allow the saddle to approach the work. I suggest that five lengths differing by about 25mm covering the range of 50mm to 150mm might be suitable. ■

Sharpening Gear Cutters with a Worden Grinder



A blunt cutter halfway through a job gave Roderick Jenkins a challenge.

Over the years I've made a few gears in my workshop using home-made Brown & Sharp type milling cutters in silver steel, made according to the instructions provided by Ivan Law in 'Gears and Gear Cutting' and using my Eureka backing off device. I've always been very careful to run these gear cutters at a slow speed so that there is no risk of overheating the cutter and spoiling its temper. However, I recently treated myself to a set of High Speed Steel cutters from Hong Kong. These have turned out to be of good quality. I was using one of the cutters to mill a helical gear when halfway through the first gear it stopped cutting.



The blunt gear cutter.

Examination of the cutter showed that it had become blunt (photo 1). Knowing I now had HSS cutters I had become somewhat cavalier in my attitude to the cutting speed and used a simpler set up to drive my milling spindle. A quick calculation showed that I was running the cutter at more than 10 times the recommended rate for high speed steel! No wonder it had become blunt. I hadn't really ever expected to sharpen one of these cutters, I don't make that many gears. Could I do something with the Worden?

Form relieved cutters like this are designed to be sharpened across the diameter, so if I could hold the cutter and

use a tooth rest to index the tool there was a chance that I could save this gear cutter. Looking at the standard Worden tool holder, the gap between the two hold down screws was just big enough to clear the radius of the gear cutter and leave space for a tooth rest on the other hold down screw. I made tool holder for the cutter that had a central hole that was a snug fit on the M5 hold down screw and had a boss that was a good fit on the 16mm hole in the gear cutter and slightly less than its thickness. A thick washer was then made to go on top of the gear cutter to hold it in place when the hold down screw was tightened up. The tooth rest

was turned and then had a notch milled in it to engage the tooth (photo 2).

To sharpen the cutter I set the Worden table horizontal and the tool slide at zero degrees on the angle scale. I used a steel rule across the grindstone to set the tooth rest in line with the cutting face of the grindstone. The gear cutter was then clamped in place with a tooth engaged with the rest (photo 3) I selected what looked like the worst tooth to grind first and used the micrometer screw to advance the toolholder until I was happy that the tooth was now back to its original profile. I made a note of the setting on the toolholder so that all the teeth would be sharpened to the same



Cutter holder and tooth rest.



Cutter mounted on Worden toolholder.



Sharpening the gear cutter face.



Sharpened tooth face and ground interference on back of tooth.

extent. Moving from tooth to tooth was simply a case of loosening the hold down screw and lifting up the gear cutter and replacing it at the next tooth.

The fact that the Worden only has a cup wheel, rather than a dish wheel, means that I do have a slight problem. Although the grinding wheel sharpens the cutting face it also grinds the back of the tooth (photo 4). This has no effect on the

functionality of the gear cutter but it does mean that I will be limited to only sharpening it 4 or 5 more times. I don't think that is going to be an issue – I will be more careful in future to control my cutting speeds. To minimise this interference problem I only used a depth of cut sufficient to sharpen the actual tooth cutting profile rather than the whole depth of the gash as was done

when the cutter was new. And this has an advantage since I am indexing on the unsharpened part of the tooth. The sharpening will be consistent rather than changing half way round when the indexing would suddenly shift to a sharpened tooth face.

The result is that I now have a usable gear cutter that was able to finish the job (photo 5). Another feather in the Worden cap. ■

In our Next Issue

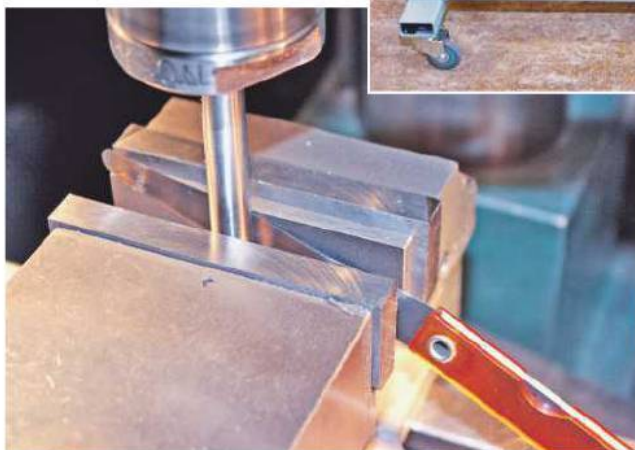
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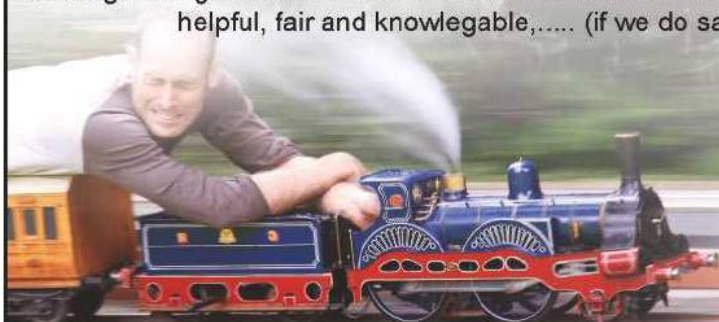
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A beginners' guide to Home Metalworking

Part 10



David Clark gives some advice to beginners on using the milling machine.



The finished tee-nuts and clamps.



Machining the sides of the tee-nuts.

As well as working in engineering, David Clark has set up and operated several home workshops. This regular series offers much sage advice for the beginner.

Last time, I cut off some bar to start making some clamps to hold the vice down and for other clamping duties on the mill. Cutting bar up with a hand hacksaw was too much like hard work, so I looked on Gumtree and found a smallish Warco bandsaw about 60 miles away. A few hours later the bandsaw was in place in the workshop ready for use. The bandsaw was one of the smaller versions, the maximum diameter it will cut of is, I think, 4 ½ inches. This will be large enough for anything I require to be cut off.

I also purchased a bit of 20 x 10mm BMS to make the clamps from and some 8mm all-thread bar to make the studs. I had plenty of material to make the tee-nuts. I chose M8 because it is strong enough to do the job but not too large to fit the tee-nuts without leaving enough metal surrounding the 8mm tapped hole. The set of tee-nuts, studs and clamps are shown in photo 1.

I purchased enough material to make six clamps which should be sufficient for most jobs in the workshop, I will make

four tee-nuts as well. I will also cut several studs of various lengths, 50mm, 75mm, and 100mm should be fine for the majority of work.

The studding

Just hacksaw the studding into suitable lengths and lightly deburr the end on a linisher, the grinder or in the lathe. This operation will be easier if you put two nuts on the bar before hacksawing to length. Then when you have deburred the stud, wind the nuts off at both ends of the studding and this will remove any remaining burrs on the thread. Use your own judgment for the lengths of studding you will require. Try to keep a spare length of all-thread bar in the workshop for making any different required lengths of studding as needed.

The washers

You will need to use large washers on the clamps to protect the slot and even out the clamping pressure. Either turn up some thick washers or buy some repair washers from your local DIY store. Repair washers are large diameter washers but what their actual use is I have no idea. For use as 8mm washers, I purchased some 6mm repair washers and opened the centre hole to 8.5mm. 8mm repair washers would have been too large for the clamps.

To drill the hole in the washers, I used the lathe. It is not easy to get a thin washer running true so I made a stepped mandrel to fit the tailstock chuck. The stepped mandrel consists of a pilot diameter that will fit the existing hole in the washer and

a larger diameter that will hold the washer true. Simply put the washer in the stepped mandrel, wind into the three jaw chuck and tighten. Remove the stepped mandrel and drill the hole to size. Deburr both sides of the hole by hand with a countersunk held in a drill chuck.

The tee-nuts

You will need several tee-nuts to fit the milling machine table. First, make a sketch of the sizes required. For the Warco WM 14 the sizes are: length about 20mm, overall width, 18.5mm, width of the tenon, 9.5mm, the bottom height, 7.5mm and the overall height 17mm.

Start by cutting the bar to length, I used 20mm long bits of bar. I did not bother to machine the ends to length, I just lightly deburred the blocks.

Machine the overall width if the bar stock is wider than required. Put the tee-nut blank sideways in the vice with the bottom of the tee-nut against the fixed jaw. Rough out each side of the tenon, do one side first, and then turn over and do the other side. I took 5 passes of 1mm from each side before final finishing (photo 2). Rather than come down 5mm one after the other, I put one tee-nut into the vice and took 1mm of all four tee-nuts before taking the next cut off all four tee-nuts. I find this far quicker than keep lowering and raising the cutter. This will give the basic tee-nut shape.

Final sizing

Measure the bottom height of the tee-nut and move the cutter towards the fixed jaw so that the correct size will be cut on



Using a parallel against the vice as an end stop.



Using a wobbler to find the centre of a hole.



Drilling the tee-nuts.



The tap with flats on it.



The tap showing the difference between the original and extended flat.



Tapping the hole.



Use the Z readout to see how deep you are going.

the next pass. Measure the width of the Tee part and deduct from the finished Tee width. Divide this dimension by two and raise the mill's table or otherwise lower the cutter by this amount. Now take a finishing cut on one side of the tee-nut and then the other side. The tee-nut should now fit the Tee slot except that it may be higher than the surface of the table depending on the size of material you stated with. If necessary, take a light skim over the top of the tee-nut so that it is below the table's surface (photo 3).

Drilling and tapping the tee-nut

Now you need to drill and tap the tee-nut to take the studding. The tapped hole should be in the centre of the tee-nut. Use an end stop on the vice to ensure the tee-nuts are all clamped in the same position. I used a parallel against the end of the vice sliding the work up to the parallel (photo 4). I used a centre finder to find the centre of the tee-nut in the X direction and moved over 10mm plus half the width of the wobbler in the Y direction (photo 5).

Centre drill all of the tee-nuts in turn. Just push them up to the vice stop, centre and remove from the vice. Make sure that you put all the centre drilled tee-nuts on the bench or machine table in the same orientation as they went into the vice because we did not bother to machine them all to exactly the same length.

Next, drill all the tee-nuts undersize, say 6mm. Then follow through with a 6.8mm drill for tapping M8 (photo 6). We will tap the tee-nuts by hand but in the milling machine. If the tap has a female centre in



Milling the ends of the clamps in a vee-block.



Drilling the end holes.

the end, you can put a male centre into the mill and use this centre to line up the tap with the hole. If you have a male centre on the tap, put a bit of bar with a 60 degree centre (or a standard lathe centre) into the mill spindle and use this as a tapping guide. I used a 6mm sidelock holder as this has a countersunk 6mm hole which was ideal for an M8 tap. If the tap has a male centre, the chances are that you cannot use the female centre and the tap wrench at the same time. In this case extend two of the flats on the tap shank by grinding so that you can fit the tap wrench on as well as use the female centre (photos 7 and 8).

To tap the holes, use some cutting oil, keeping the male or female centre on the end of the tap with one hand, turn the tap wrench half a turn with the other hand. Back the tap out and keep tapping forward half a turn at a time and then back out (photo 9). Once the tap has had several turns and is running true, you can stop using the support centre. Do not tap all the way through the hole. Stop when the point just reaches the other side of the tee-nut. You can use the Z axis readout to see how far the tap has gone through (photo 10). This should leave a small portion at the bottom of the hole untapped. This plain bit is to stop the stud going right through the hole. If the hole is tapped right through, the stud could go down lower when the nut is tightened up and split the Tee slot out by pressure from underneath. Lightly deburr the finished tee-nuts all over.

Making the clamps

Making clamps is a simple job in the home workshop. The sizes suggested are suitable for a small mill like the Warco WM 14 as used in this series. The methods described are suitable for batch production of matching components. Most machining time in the workshop is spent setting up the work on the machine. The actual machining time is usually very short.

Start by cutting the clamps to a length of 65mm + a cleaning up allowance of about 1mm (0.5mm at each end). Use the bandsaw's built in vice stop to ensure all the clamp blanks are the same length. There are several methods you can use to clean up the ends to length. I purchased 20 x 10mm bar because when you place two bits of material together it makes a 20 x 20mm square block.

The first method is to put two of the clamp blanks together in a four jaw self-centring or independent chuck. Then you can face the ends, turn round in the chuck and face the other ends. Accuracy of length is not too important, just clean both faces up and lightly deburr the sharp edges.

Method two is to hold the clamp in the machine vice with the end overhanging the vice jaws and clean the end up with the side of an end mill, turn the component round in the vice and do the second end.

The third method, which is my favourite way of machining short lengths of round and square bar to length, is to put the bar into a vee-block (photo 11). The vee-block will hold the bar upright and square for machining. I used a bit of angle to make sure the blanks clamped properly as I could not get two vee-blocks into the vice. Just skim over the ends with a flycutter or end mill to give a good finish. Ideally, the cutter should be pushing the work towards the fixed jaw. If the cutter is pushing the work (and the vee-blocks) towards the open end of the vice there is a chance the work and vee-blocks could tilt away from the cutter due to the cutting pressure.

Now we have the ends of the clamps machined, we can start to cut the slot in the body of the clamp. I nearly always use the same sequence for cutting a long slot through a bit of bar. If you try to cut a slot straight into the bar, the cutter will normally cut too large a hole and then when you run the cutter along the slot, you will get a keyhole effect.

A better method is to drill a slightly undersize hole at each end of the slot (photo 12) and then open the hole out with a size end mill or slot drill. You don't need to centre drill the holes, just use a stub drill and follow through with a size end mill or slot drill. This will give you two accurate holes and an accurate length of slot. (I know the slot length in a clamp is relatively unimportant but this method is ideal when the slot length is important as well.) If making a large slot, you could always finish the end holes with a boring bar.

At this stage, I changed from cutting the slot to machining an angle on the ends of the clamps (photo 13). I did this so I could use the hole to angle the clamp. I put a drill shank through the clamp and put it on the top of the vice jaw. I dropped the far end onto a parallel in the vice to give the angle.



Milling the angles on the end of the clamps.



Taking the end holes to size.



Finally machining the width of the slot.

Now you have an embryo clamp with two holes in it and the ends chamfered. Change to a size slot drill and machine the ends to size (photo 14). When the ends are machined, change to an undersized end mill and finish each side of the slot so the slot is to size (make the slot about 9.5mm wide to allow for the 8mm diameter studding. Do this by machining one side (photo 15) and then turning the clamp over to machine the other side. This ensures the slot is in the centre of the bar. You now have a clamp with a decent slot in it.

Top hat nuts

To make top hat nuts drill and tap some round bar M8 to match the studding. Tighten an 8mm bolt into the end of the nut blank at the large diameter end and face it in the lathe. Put the nut blank and hexagon bolt onto a parallel, one of the hexagon flats should rest on a parallel. Lightly mill the reduced diameter of the bar and turn over 180 degrees in the vice and mill at the same setting. Measure the AF (across faces dimension) of the two milled faces. Subtract the AF of an 8mm nut and raise the table or lower the cutter

half of this dimension. Mill all 6 flats at this setting. You should now have a shouldered top hat nut.

You have now machined a set of clamps, studs, washers, tee-nuts and top hat nuts that will do most of the clamping requirements in the home workshop. You will probably need other sizes of tee-nuts, perhaps for an angle plate or rotary table but you have the basics to start machining in your workshop.

To be continued...

Stub Mandrel's Short End Increasing Mini-Lathe Cross-Slide Travel



Stub Mandrel squeezes the last little bit of travel out of a mini-lathe saddle.

Most lathe owners assume that the cross-travel of their lathe's cross-slide will be sufficient to face across the full diameter of the lathe's swing. In practice, this is rarely the case, and in all honesty, it is something we rarely need to do. There are exceptions, of course, such as truing up a faceplate, but more importantly the more travel we have the greater flexibility we have in tool placement, making it easier to turn large diameters and bores or other awkward tasks.

Mini-lathe owners might imagine that the limiting factors on the cross-slide travel of their machine are adequate engagement of the leadscrew in the feednut and overlap of the dovetails. This is true when feeding the slide 'away from the operator', but winding the saddle 'out' it will stop somewhat sooner than one might expect. It is, however, possible to increase the 'towards the operator' travel significantly. In fact, you can increase the usable travel



to over 3 inch with two minor modifications. The first step is to file the end of the feed nut to a radius of about $\frac{3}{8}$ inch, so that it can feed right up into the end of the slot in the saddle (photo 1). You will now find the slide butts up against the index, still limiting its travel. Milling a shallow recess in the saddle to clear the



index is the next step (photo 2). Chamfering the bottom edge of the nut may be needed to ensure you get the last thou of full travel. Together this is quite a bonus, as it gives about half an inch of extra travel, and enables you to face work a full 6 inch diameter, as against about 5 inches as standard. ■

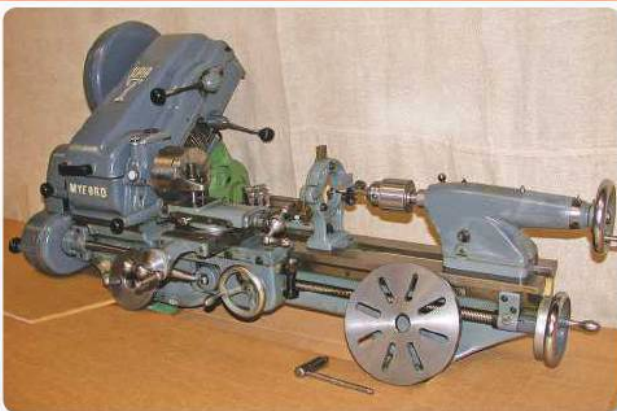
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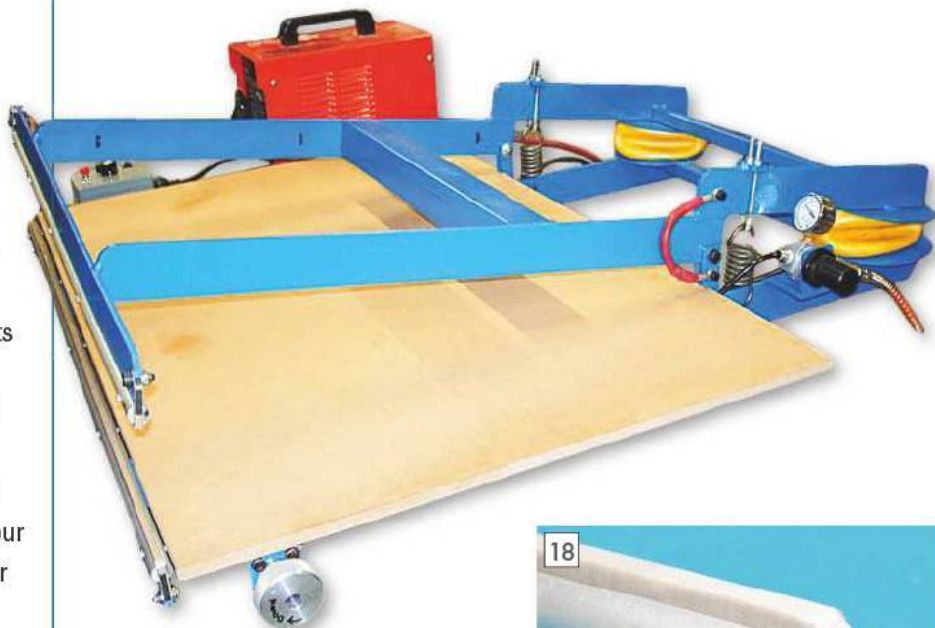


Plastic Sheet Welding Machine Part 2

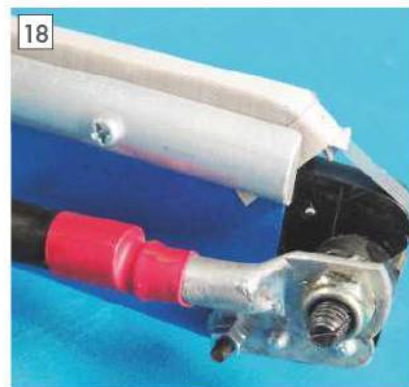


As part of an ongoing development we use inflated plastic bladders to lift parts of the equipment. I have been using a bag sealer, described further on, but it really didn't have either the versatility or the grunt, to weld serious bladders and I spent an amount of time chasing leaks. I also glued sheets together to make bladders as I will describe further on. We had a local company welding these on a high frequency welder, but due to the delay, travel and labour costs we decided we needed our own machine. The cost of the commercial units was outside our budget and I only have 240v single phase power.

Tony Rossiter in Adelaide developed this effective machine to meet a commercial need.



The cables need to carry 20 or 30 amps so suitable cable can be purchased from an electrical supplier. I used car jumper leads after a mechanic 'tutted' saying my car computer could get



Cable lug on expansion block.

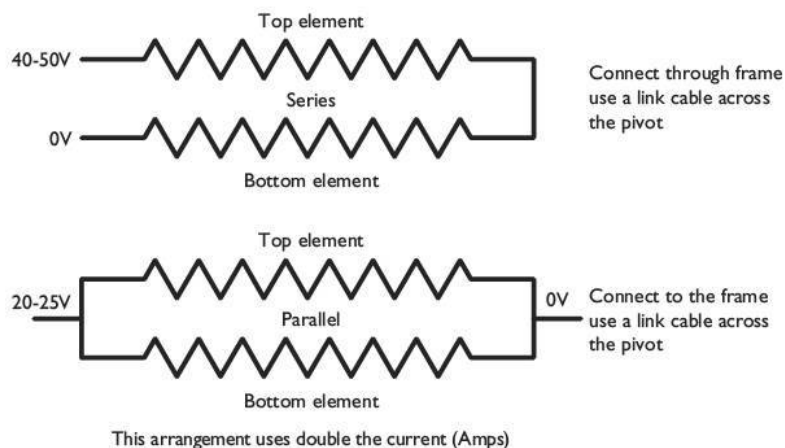
zapped if I didn't use spike protected leads and these became spare. The lugs can be soldered on and some 'shrink on' tube completes the job (**photo 18**) and either:

- The elements are connected in series with one power lead going to each element and the circuit is completed through the frame.
- Or the elements are connected in parallel with one power lead going to the frame and the other to the end of one element and from the same connection a lead is linked to the end of the other element, **diagram 3**.

The Timer

The timer is housed in a plastic box along with the relay and the 12 v transformer (an ex-plug pack power adaptor). A 240 v

Fig. 3



AC relay with a 12v coil switches the 240 v input to the welder or any other device (handy to have). From the box is a 240 v lead to plug directly into a power point and mounted on the box a 240 v socket, which the welder plugs into (UK style sockets probably require a larger box). The neutral and earth wires on the in-coming lead, connect directly to the output socket and the active wire goes to one switched terminal of the relay. An active connection is made from the output switched terminal of the relay to the 240v power outlet. The 12v DC transformer is used to power the 555 and the relay coil, an active wire is branched from the relay and a neutral wire from the output socket to it.

A linear variable resistor changes the timing from 0-60 seconds in two stages 0-10 and 0-60 via a switch which switches between two capacitors. A flashing LED signals the ON condition. The 555 switches the relay via a NPN transistor as the relay coil drew too much current to power direct, a 555 can supply up to 100mA so a solid state relay may not need the transistor.

All the components for the 555 were soldered to strip board along with the wires that connect to the variable resistor, change-over switch, flashing LED and trigger button. The 0 and 12v DC supply come from the transformer. Details are shown in diagrams 4 & 5 and photo 19.

For heating Elements, either AC (Alternating Current) or DC (Direct Current) is suitable. If you wish to use 12v batteries to power your welder you will need a 40A DC relay, make sure it will handle the DC current, as not all AC relays will. The 555 can be powered by one battery, but will need a diode to kill the inductive spike when the relay opens. The arrangement would be much simpler and a trickle charger could top-up the batteries.

To be continued...



Timer components on stripboard.

COMING UP...

Tony assembles the machine, and give some advice on using the welder.

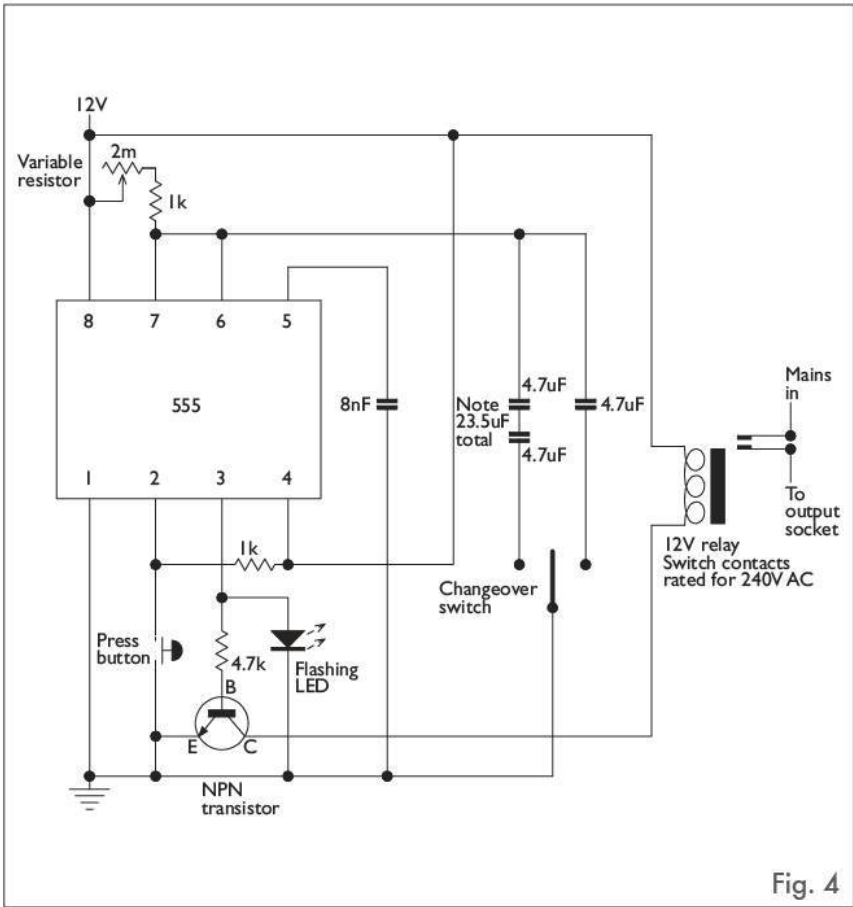


Fig. 4

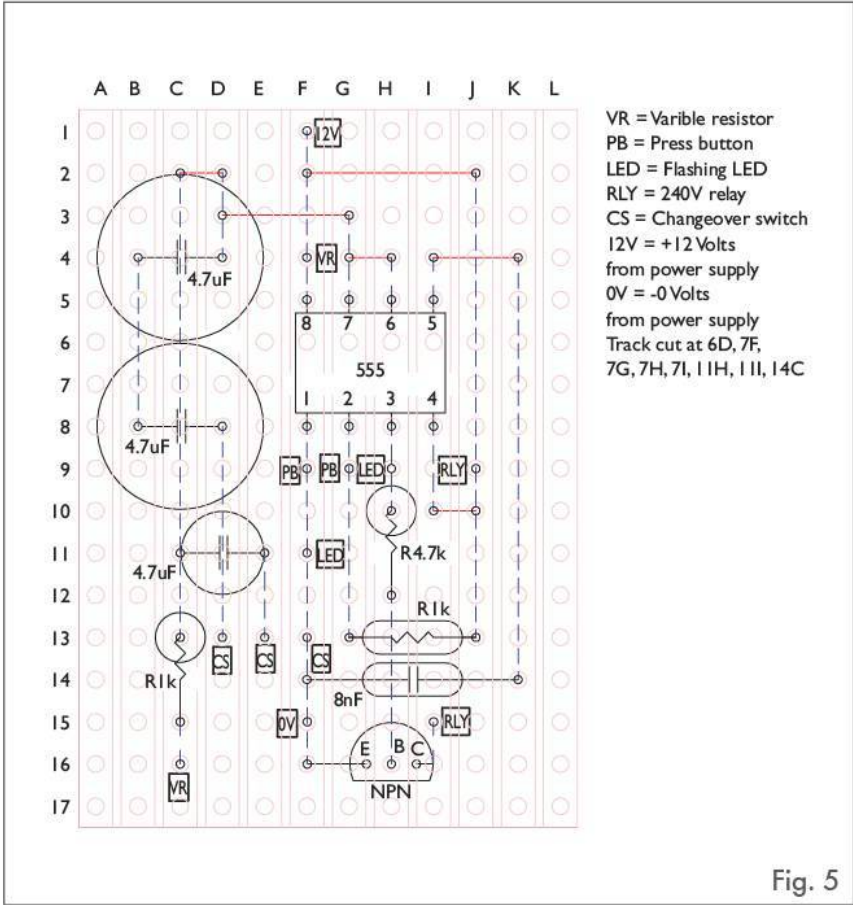


Fig. 5

On the Wire **NEWS** from the World of Hobby Engineering

Events at The Warwickshire Exhibition Centre

The Midlands Model Engineering Exhibition will be taking place from 16 -19 October at the Warwickshire Exhibition Centre. The National Traction Engine Trust will be a new attendee this year, and as well as model traction engines a full-size Foden steam tractor is promised. Other displays will commemorate the 80th anniversary of the Flying Scotsman exceeding 100mph and the 120th anniversary of the Manchester Ship Canal featuring models and memorabilia. As always there will be a good mix of model engineering suppliers and clubs and societies in attendance. Advance tickets for the exhibition are available to book online at www.midlandsmodeleengineering.co.uk

For a show with a different flavour, the International Model Boat Show returns to the Warwickshire Exhibition Centre from 7-9 November, promising over 600 models across nearly thirty club and society displays, plus over 20 specialist suppliers. Again a number of anniversaries will be marked by displays at the show: The Bluebird Club will mark 50 years from Donald Campbell breaking both land and water speed records in Australia. 150 years of the RNLI and, again, the opening of the Manchester Ship Canal will also be the subject of displays. A poignant sailing tribute is also planned to mark two minutes silence on Remembrance Day. The website for the show is www.modelboatshow.co.uk

Latest Machine Mart Catalogue out now

I'm sure many readers will have already seen the latest Machine Mart catalogue. At 500 pages and 7,500 products this is the biggest ever edition, and once again, I was struck by the way that new designs are resulting in improvements to well-established tools. For example, what could be simpler than a spanner? Well there are new designs with more comfortable handles and more positions they can grip a nut – which also promise to be less liable to round off stubborn nuts.

I'm considering buying a MIG welder soon, so I had a long chat with a chap from their technical department. Not only did he help me understand the pros and cons of gas and no-gas MIG welders, he also suggested machine suitable for the type of work I am likely to do – and my need to operate from a 13-amp socket! The technical department don't do sales, so if you do want advice on anything in the catalogue, it's well worth giving them a call.

You can order a catalogue by visiting machinemart.co.uk or phoning 0844 880 1265.



The New Dremel Micro

Dremel have just announced a new multi-tool, which they claim will be the most compact Li-ion powered design yet. It's certainly true that, to date, most battery powered rotary tools of this kind have been a bit 'chunky', but judging from the pictures and promised 250g weight this new tool does look very promising. Dremel highlight its slim design and ease of use. As well as variable speed, it has speed and battery level indicators and an LED light to illuminate the work area.

To emphasise its high-tech credentials, Dremel is supporting its Micro launch with a Win a Trip into Space promotion offering one lucky winner the opportunity to fly in a Lynx Mark II, one of only two spaceships currently allowing consumer space flights, to a height of over 100 km from the Earth!

As someone who would like to 'lose the lead' without the usual bulk of batteries I'm hoping to see the Dremel Micro in action soon, so watch this 'space' for more news. Priced at £110 including VAT, the Dremel Micro should be available when you get this magazine. For now, satisfy your curiosity at <http://www.dremelmicro.com> where you can also enter the space trip competition. Good luck!



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YOUR CHANCE TO TALK TO US!

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BLACKER HAMMER

Dear Neil, Regarding the letter from Danny Rearden on the Blacker Power Hammer B-type. This $\frac{1}{2}$ scale model was built by myself in 2004, first shown at the Harrogate ME exhibition in 2005, and again in 2014.

The Blacker Hammer is a copy of the full size hammer that our local blacksmith of Pickering, Mr W.H. McNeil, had in his workshop. It was bought in 1951 at the Festival of Britain show.

In 2003-4 when I decided to make a model I had to do some research and find full scale drawings to work from. The drawings were obtained from agricultural engineers Neville Barnes Ltd. of Upton, Gainsborough, who were very helpful.

Also, in 2012 I saw a foot-treadle hammer in my local museum, Pickering, and made a $\frac{1}{2}$ scale model of this, it is believed to be an early model Blacker.

C.P. Bramley
Pickering

MOVING PICTURES

Hello Neil, I am a follower of your magazine in New Zealand. Every year I read about your ME Exhibitions in the magazine and wonder what it would be like to be there. This of course will never happen. I wonder if it is possible someone could wander around with a video camera and post the result on your website?

I have many projects on the go all the time with very little actual time to do them. Reading your magazine fills in the gaps. Good work.

Brian Hooper

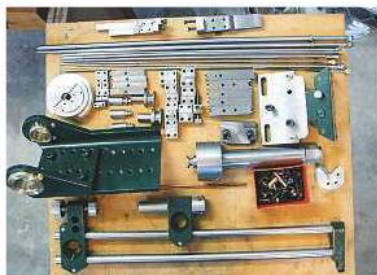
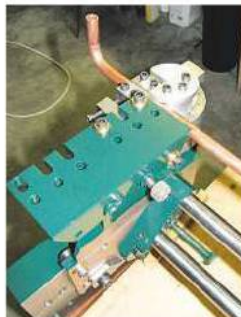
SPINDLE DESIGN

Dear Neil, As I've been minded to make a 3 MT rotating tailstock chuck for some time, I was interested to read Darren Conway's article in MEW 219. However, I'm not sure if his being a fellow Chartered Professional Engineer is intended to endorse what is a rather complex solution to what should be a simple piece of workshop equipment.

BUILT FROM MEW PLANS

Dear Neil, Here are some photos of a tube bender I built from Ian Hunt's plans that were in the *Model Engineers' Workshop* issues 94 and 95. Once you set it up you get a near perfect bend.

Regards
Noel Muirhead
Timaru, New Zealand



It's normal practice that tapered bearings are fitted so that they can be adjusted to remove play and minimise friction. To achieve this, the bearing should have a tight push fit on the shaft and an accurate slide fit in the housing. If Darren's design is to be followed, it might be better to use the bearing the other way round and provide threaded lockable adjustment on the outside of the housing. However, looking to see what well respected tool manufacturers have to offer, it appears that the use of taper bearings is considered over complex and they prefer a simple triple row of ball bearings - a solution better suited to home workshop applications.

As far as use is concerned, I'd add to Darren's list by including the improved support of slender work pieces in general and, in particular, long slender crankshafts for multi-cylinder engines where it's desirable to remove the axial compression and tendency for distortion that occurs when using conventional centres without continuity supports. Also

useful when turning large diameter tubes.

Whilst runout accuracy is an important aspect of the design, the cumulative accuracy of the whole tailstock assembly does require careful consideration as the use of a more rigid support at this end will invite additional misalignment vibration into the work than the simpler point support. In this regard, it's worth bearing in mind that standard ER collets aren't considered precision items and might add to any alignment problems found in the tailstock itself.

On a different tack, I'd like to say how much I enjoyed Graham Astbury's article on drip oilers, particularly pertinent as I had just purchased one and was able to much improve its performance after taking on board Graham's useful advice.

I hope you're enjoying your new role as Editor as much as I'm enjoying the new look and feel that you're introducing into the magazine - long may it continue.

Kind regards, Stuart Walker

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

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4-Facet Drill Grinding on a Stent Hybrid^{Part 2}

Stefan Green experimented with using a Picador drill sharpening jig to produce 4-facet geometry on his Stent-based machine. This month he reports his findings.

I do not have the luxury of spending a lot of time in the workshop (even though I am retired, my diary says I have spent less than 100 hours in there during the last year; voluntary commitments unfortunately take priority) and therefore I am wary of embarking on time-consuming elegant solutions when there might be a simpler way – an initial 'knife and fork' approach can be so flexible and helps me to home-in on an eventual design.

Accommodating drills outside the Picador's normal capacity

What about 1MT drills which are too short or too long, and all 2MT drills?

With the short 1MT drills, of which mine are all small diameters, I effectively lift the V to provide clearance for the taper shank by inserting 2 identical thickness packing pieces. It doesn't usually matter that they don't create an equal sided V –



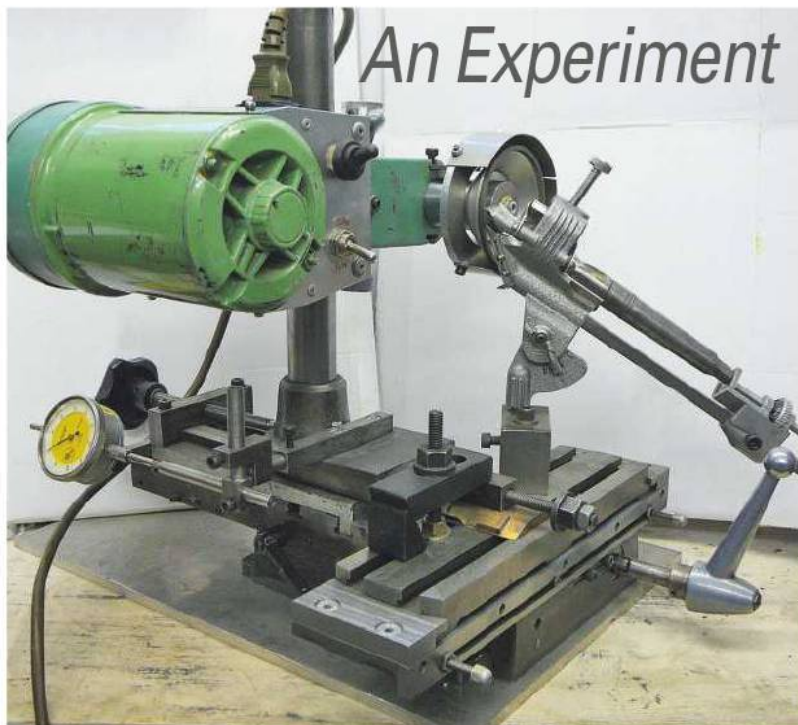
The short 5mm 1MT drill packed with 2 lots of .200 inch Pitters to allow the taper shank to clear the V bed.

the trough is still central. For convenience so far I have used spare Pitters (slip gauges) that I happen to have accumulated (see photo 6) – I have used 1 off .200 inch at the back and 2 off .100 inch Pitters which are just visible at the front. If I ever need a size I don't have, I will either find some suitable flat strip, or simply mill a strip to a convenient size and cut it in two.

For the long 1MT drills, and all 2MT drills of a diameter which fit the V, I was going to make an extension to the Picador 5/16 BMS square 'bed' by making a variation of a carpenter's half-joint, but at 180 degrees instead of 90 degrees. I judged that the long overlap would provide adequate fastening points (e.g. 2 or 4BA countersunk screws) and sufficiently repeatable accuracy without the need for dowels.

In the end I bought a 12 length of 5/16 inch square BMS at a Midlands ME exhibition, used a hot air

An Experiment



The complete installation showing the Picador jig mounted securely in a trued-up rectangular block which can be set at the appropriate angle relative to the reciprocating table. The extra long jig 'bed' has replaced the standard one.

gun to loosen the interference fit of the 'as supplied' assembly and simply fitted a longer piece. If necessary the original can be reinstated.

With this increased capacity I can handle all my drills up to the Picador 3/4 inch/19mm capacity limit, although I must admit that the V could do with being longer for a more reliable location on the larger drills where the helix length is greater than that of the V. What I initially did was to position the drill by feel, and then lightly clamp the tang to the 5/16 inch bed adjacent to the tailstock with a small toolmaker's clamp before I tightened the V clamp. This stopped the tang end of the drill moving.

Having decided to write this article, however, I felt honour-bound to revisit this problem. Although 1/16 inch gauge plate might be better, I cut two 3 x 1/2 inch strips of .057 inch (17 gauge) hard stainless from an offcut, and inserted these to in effect lengthen the Picador V. The result is a big improvement. The tail clamp is no longer needed and the long helix drills locate with no rock (photo 4).

The other main problem I have encountered is that the height of the Picador assembly in conjunction with the

narrow dovetail slide of the Stent causes the set-up to flex (up to .010 inch on a DTI) under pressure from the diamond wheel, especially when grinding the big facets of the large drills. This results in the facets not being truly flat. But, as you will see from the results, this does not seem to have a serious impact. I might be able to improve things by using a conventional wheel, or a better diamond one.

If my experiments turn out not to be representative of what I may need to use 4-facets in the future, then I will review my strategy decisions at that time. If I end up including a longer term solution in phase 2 of my Stent refurbishment, then it will be an all-purpose design based on the developments I have used with the Picador, together with lessons learned between now and then, and also with careful consideration of the various designs which have appeared in *MEW* in the last year or so.

In the meantime, if I have to regrind my 2MT 1.1 inch diameter 'swarf-maker' which is well beyond the capacity of the Picador, then I'll devise something using my indexing T&CG workholder. Although the overhang will be significant, I am sure the assembly will be rigid enough as the drill is relatively stubby and the indexing workholder is very substantial (it weighs 5kg). And it is not as though I need it to be super-accurate – I am unlikely to try to use it without already having used smaller drills first, so the important thing is to get equal length lips. I might even be able to get away with grinding only the primary facets.

Trial results

In order to complete this article I have conducted a few drilling tests in 1 inch square mild steel bar using my trial drills.

Has there been any problem arising from the 2 degrees inclination error? I cannot see from the results that there is a serious problem with having done this. Yes, the facets may be ever so slightly wedge-shaped, and I may have attributed some of the few difficulties I encountered to drill manufacturing tolerances where an expert may eventually convince me that this 2 degrees is the cause. The biggest problem may well be that I have to grind off more material than I should need to when I first do a 4-facet grind on a particular drill. But with drill point geometry being so complicated anyway, I am not convinced that adjusting the block spigot location bore by 2 degrees will necessarily be the correct amount. And my compound angle expertise is not good enough to work out the theoretically correct adjustment. The bottom line is that, as you will see below, the drills cut pretty well – and after all, that's what matters.

If a problem does emerge then I will address it, probably initially by making another block with an inclined bore with a locking screw at 90 degrees to this bore and doing some identical trials. But if any of you decide to have a go by using your own jig, you may find that yours has a different angle – certainly the Draper (Model No. 1180) has an inclination of about 8 degrees which I am sure is too big to ignore.

After the 4-facet regrind all 3 drills produce holes which are tight on size (using clean engine oil as coolant via an oilcan) – about +.001 to +.002 inch on

diameter; even the large drill with its uneven web achieved +.002 inch. On position, the smaller 2 were well within .005 inch, and the large drill was within .007 inch. I say 'well within' because my only way of checking was to use my Dore-Westbury mill as a pseudo 'co-ordinate inspection machine' to check positional accuracy as well as using it to drill the holes. Unfortunately there is a little more play in the D-W head than with the Société Genevoise (SIP) jig borer I used in a similar way 45 years ago on my project! However, with careful clocking of the holes and appropriate clocking to estimate the slight head wear (about .001 to .002 inch when the quill is unclamped), I would be very disappointed if my positional best estimate of .002 to .004 inch was not good for the 5mm and the ½ inch drills.

With drills as large as the 23/32 inch, I do not really expect to be using them without having first made a pilot of some sort. However it was gratifying that the 23/32 inch drill could make such an accurately sized and positioned hole in one pass with such a modestly powered machine. And also being the ¾ inch reaming size, I was very pleased that subsequent machine reaming improved the positional accuracy to around .001 inch with a diameter of no more than +.0005 inch oversize.



Overall I am satisfied that I have got an adequately good approximation to a true 4-facet grinding capability if and when I feel I need it, and with very little effort – I just need to be careful. And I am also pleased that from my limited experience so far, it appears that drill point configuration does not have to be completely accurate; the fact that there is (almost) a point – and yes, it does need to be as central as possible – makes all the difference compared with conventionally ground drills.

One other word of warning, however, regarding plain shank drill manufacturing accuracy. I have already touched on web position accuracy, but I have also noticed that a set of metric drills I bought recently display noticeable bending. Whenever I use one for the first time I check it for straightness and do my best to judiciously tap it as true as possible. Clearly if time is to be expended regrinding any of these at some point in time, it might make sense to replace those sizes needing the 4-facet treatment with a better quality of drill first.

Is 4-facet worth the effort?

Now for the philosophical question – in a home workshop is it worthwhile converting to 4-facet at all? Or maybe

the question should be – under what circumstances is it desirable or necessary to have a 4-facet ground drill?

I have no intention of regrinding my entire stock of drills for the following reasons: Firstly, the amount of time needed – the time per drill increases significantly as the drills get larger due to there being so much more metal to remove on the secondary facet, even if the angle were reduced. Secondly, the main advantage of 4-facet is being able to drill accurately without a pilot/centre. Therefore larger drills are less likely to be called upon to do this.

I think I will be prioritising my 4-facet grinds along the following lines: Salvaging accurately any severely damaged/broken/ chipped drills of any size between ½ and ¾ inch, and converting any sizes where I need to drill repetitively and therefore can save significant time by dispensing with a centre drill e.g. ⅜, ¼, ⅝, ⅜ inch and their metric equivalents.

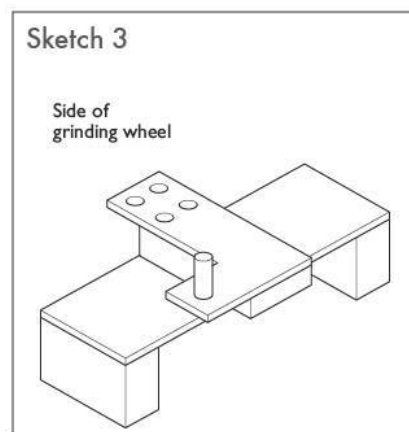
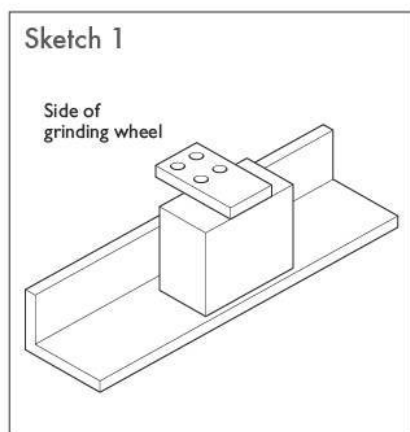
I will also be converting those where it is difficult to use a centre drill on the round-column Dore-Westbury due to the length difference between, say, a centre drill in a collet and a typical mid-size straight shank drill in the ¼ to ¾ inch diameter range where I have no suitable collet, or when using MT drills. These situations often necessitate a column height change and consequent difficulty in achieving an accurate reset, and therefore 4-facet would be a distinct advantage by eliminating the need for using the centre drill.

Finally, I will be using 4-facet for situations where a centre drill will not fit/ reach, for example, the bottom of narrow and/or deep slots.

All other drills of any diameter will be reground as and when necessary and using the most appropriate method based on my needs and accumulated experience.

Another possible alternative when centre drills are too short and MT drills are being used is to raise the D-W column high and then use different combinations of drill sleeve extensions – over the years I have collected quite a lot from 4 to 10. Of course every joint increases the possible error, particularly since no.1 Morse tapers are so easily bent.

And as an aside to situations where standard centre drills just won't reach, I have been on the look-out for some extra long centre drills ever since I acquired my D-W, but I have not yet come across any at the normal exhibition suppliers. There are CNC spotting drills which might suffice, but I have not bought any yet. I have, though, picked up a couple of home-made 3 to 4 inch long centre-drill holders – one made from ½ inch diameter BMS and the other from ⅝ inch diameter, both of which I am finding useful, although their accuracy is no better than a 4-facet drill, and maybe slightly worse. Perhaps if I made a holder from a stronger or ground material their accuracy might be better. Also resharpener those I have with a 4-facet geometry would be very useful – I will add it to my jobs list to have a go at the large one – I can't see that much, if any, extra tooling would be needed, and certainly not a spiralling head – that should only be needed, as suggested in the Quorn 'Bible', for the countersink part of a centre drill.



Sketches of suggested simple beds for using the Picador with a bench grinder for 4-facet grinding.

Suggestions for quick and dirty 4-facet grinding with a bench grinder

Now the other big question is – can my Q&D approach be made to work successfully with only a bench grinder? Most of you will have spotted that my Q&D solution to the Stent y-axis feedscrew absence has been to adopt a clock-based feed measurement mechanism, plus 2 simple Q&D ‘push’ mechanisms to feed and retract the column and wheelhead assembly (one of my next steps is to make the ‘pusher’ a ‘push-pull’ so that I can de-clutter the table). Simple, but they work.

Given that most of us have surplus equipment as well as a scrap bin, and also bearing in mind the tools and designs which are available, for example –

- Some of Harold Hall’s designs in his Tool and Cutter Sharpening book WPS 38,
- The kit commonly used in the wood-working profession for chisel sharpening
- The relatively crude design of some professional T&C grinder attachments (as I have already implied, it is the ability to set accurately which is important – the grinding part is relatively simple)

I have 2 untested basic suggestions for how this can be achieved, with variations, explained in **Table 1** and **Sketches 1-3**. At all times I am keeping the Picador principles in mind i.e. being able to create backing-off, the ability to wipe the drill edge across the wheel as smoothly as possible over a short distance, the ability to apply tiny amounts of in-feed between each ‘wipe’, and to be able to accurately repeat it for the other edge to obtain equal length lips.

The bench grinder is assumed to be on a board or similar flat surface such that a simple wooden plinth can be inserted to raise it if necessary, that the side of the wheel is accessible and sufficiently flat, that a ‘bed’ and simple saddle can be accurately located relative to the wheel side at an appropriate distance from it, and that the sideways pressure exerted will be no greater than that when using the Picador jig in its ‘as-designed’ mode.

In conclusion

Overall this has been a worthwhile experiment for me and, having decided that I would commit something to paper,

Table 1

1. Stand alone x-y unit.
Utilise a surplus/available x-y table or cross-vice by mounting one axis parallel to the side of the wheel. Remove the feed screw from the x or the y axis (whichever you have decided to make parallel to the wheel) and replace with a lever mechanism to facilitate rapid side-to-side motion (note - if it is the y-axis feed screw which is removed the lever mechanism may need to accommodate the small in/out movement of the x-axis, depending on where the fulcrum is mounted)

2. Combine one of the 2A options with one of the 2B options listed below

2A. A simple in-feed and guide mechanism combined with a means of mounting the Picador drill jig.	2A.1 Make a plate with simple ‘L’ section rails to mate with protrusions on a mounting block, and control the in-feed of the block with a simple ‘pusher’ screw feed. The Picador mount/block interface needs to have the ability to be set at different appropriate angles.	2A.2 Calibrate the Picador tailstock adjuster and mount the jig in a block with suitable angle adjustment.	2A.3 Use a ML7 top-slide with pivot location, together with a fixed mounting block. Rotate the top-slide to achieve the desired grinding angle.	2A.4 Modify elements of the designs in WPS38 e.g pages 90/91 in conjunction with an appropriate mounting block for the jig.
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2B. A simple bed fixed parallel to the side of the bench grinder wheel

2B.1 A simple slide rest made from, say, aluminium or steel angle or slit channel (ideally no fillet nor draught angles) plus a simple block of a size such that it can be securely gripped to maintain contact with the guide while reciprocating it. (see sketch 1) (I will use slit Alum channel as the bed to sharpen my lawn mower cylinder)	2B.2 A simple round bed and saddle with a levelling screw plus a simple handle/knob to aid reciprocating (see sketch 2)	2B.3 A simple square edged rectangular bed with a saddle similar in principle to the ML7 saddle/bed interface but without gib strips (use shims), plus a handle/knob to aid reciprocating. (see sketch 3)
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my thinking has become even more focussed. I hope that the conclusions I have reached make sense,

I would therefore like to think that this short article encourages those of you with a suitable tool and cutter grinder to have a go at this alternative use for the Picador and its related ‘cousins’ (but remember the inclination problem

outlined earlier), although I am sure that many of you will come up with valid improvements to the quick and dirty processes I have outlined. If you only have a bench grinder I would be interested in knowing whether my suggestions are valid – or otherwise. No doubt Scribe a Line will eventually reveal all! ■



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A Live Tailstock Spindle

Part 3



Darren Conway tackles a useful accessory as an exercise in precision work.

These experimental results demonstrated that the preload would be highly sensitive to axial location of the bearings and that the correct preload would be difficult to set with any degree of accuracy. The very high stiffness prevented axial displacement being used to estimate preload as planned. The results also showed that high preload would not improve overall stiffness. Applying excessive preload would only accelerate bearing wear and early failure. These experiments revealed major disadvantages with the planned approach of using a pair of steel spacers. A key problem was the difficulty in precisely determining the correct lengths of the spacers when the bearings were installed and under load. It was not sufficient to make the spacers of equal lengths. It is a very cramped working space and impractical to measure with the range of metrological instruments found in my workshop. The inability to accurately determine the difference in spacer lengths needed to apply the required preload effectively killed the option of using a pair of steel spacers.

An added disadvantage of using two steel spacers would have been the impossibility of making future adjustments for bearing wear. The alternative of using just the outer spacer with no inner spacer was considered. The preload would then be set by adjustment of the socket head screw on the arbor end. Without an inner spacer to aid alignment, bearing tilt on the arbor was a potential problem with this arrangement. The main risk with this approach was that any overshoot resulting in excessive preload could not be easily undone. Preload can be increased, but not easily reduced. Backing off the cap screw would not be sufficient to allow the bearing to move on the arbor and reduce preload. A sliding fit between the bearings and the arbor would have reduced overall stiffness. It was decided that an inner spacer was required to

As a Chartered Professional Engineer, I get little opportunity to get my hands dirty in the workplace. In order to satisfy my desire to actually make stuff, I have built up a home workshop centred around a Denford Viceroy TDS 1/1. GB lathe. Work and family commitments severely limit the opportunities to get quality workshop time but I do enjoy the challenge of designing something that I then get to make. I specifically aim to explore and extend the limits of my own skills and the capabilities of the tools to hand. To that end, I designed and made the live MT3 tailstock spindle to stretch my amateur workshop engineering skills and add another lathe accessory to my collection.



The completed live MT3 adapter.

prevent preload overshoot and to ensure alignment of the bearing on the arbor.

Another approach to setting pre-load is the drag test. Rotational resistance tends to increase with preload. I was unable to find any data on the relationship between drag torque and preload. Measuring this relationship on the adapter would have required the construction of an experimental rig to vary the applied preload and measure the drag torque. That was something I chose not to do.

The next option explored was to use a rigid steel outer spacer combined with a semi-rigid inner spacer. Ideally the inner spacer would initially set the correct axial location of the bearings, and then slightly reduce in width over time to allow adjustment in the future. This required a material that was rigid enough to resist compression when the bearing preload is first set, and then creep under compression to allow future adjustments to the axial

separation of the bearings. Unfilled PTFE is a material that exhibits viscoelastic properties. Unlike other plastics such as Nylon, PTFE molecules cannot be cross-linked and have no memory. PTFE will creep under stress which is normally considered to be a deficiency but not in this case. In this application stress creep will cause the inner spacer to slowly reduce width in a self-limiting way. As the width is reduced, so is the stress and resulting creep. When the bearing preload is next adjusted, the PTFE spacer will allow limited adjustment while reducing the risk of preload overshoot. PTFE is highly resistant to corrosion but exhibits a temperature expansion coefficient of 135m/(mK), about ten times greater than steel. The inner spacer will never exert enough force to overcome the support provided by the clamping washer, so dimensional instability won't affect bearing preload during use. The PTFE spacer acts more like a spring with a high rate (Newton/metre). The use of a semi-rigid spacer is not a 'standard' solution, but it was considered to be the most suitable option for this application.



The inner and outer bearing races were compared to determine the correct spacer widths.



Both faces of the PTFE inner bearing spacer were machined in one operation to ensure parallel faces.

Bearing Spacers

The lengths of the spacers was determined by measuring the height of the inner and outer bearing shells with a height gauge on a surface plate as seen in photo 16. The outer spacer required the faces to be perfectly parallel and without burrs. The spacer was made from solid bar held in a chuck and tailstock centre. All machining was completed without changing the work holding setup. The bar was faced and grooved at close to the length of the spacer. The inner and outer

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All of the parts prior to assembly.

rim edges were chamfered. A facing cut was made at each end of the spacer. The bar was then drilled and bored to free the spacer. This method ensured both ends of the spacers were perfectly flat and parallel. The same method was applied to the PTFE spacer, **photo 17**. The required length of the PTFE spacer was determined by comparing the height of the bearing inner and outer races on a surface plate. The PTFE spacer was annealed for 1 hour at 150deg C prior to the final cuts to help stabilise the PTFE. The PTFE was made about 0.2mm longer than the nominal difference to ensure that the PTFE spacer would push against the bearing and prevent or correct any tilt misalignment.

Assembly

As part of the final assembly, great care was taken to clean the components of swarf and other contamination. I placed a magnet in the cleaning solvent to trap suspended metal particles. The items were washed in solvent changed three times just prior to assembly. I wore polythene gloves to prevent skin particle and sweat being left on the parts. Once the parts had been cleaned, they were assembled in a clean environment, **photo 18**. These weren't the only parts made as part of this project. A range of bushes, a dummy bearing and a pin spanner seen in **photo 19** were also made.

Care was also taken to use uncontaminated lubricant to avoid one of the most common causes of bearing failure. The bearings were packed with standard No.2 grade grease, taking care not to apply an excessive amount, another common cause of bearing failure. Too much grease would increase friction and generate heat. Typically bearings should be packed with 20%-30% grease and 80%-70% air space. In this case, there is plenty of space outside of the bearings for surplus grease to escape to.

The V-seal was fitted to the arbor. After the bearing retainer was put in place, the first inner bearing race was then pressed onto the grease-smeared arbor. A stack consisting of an outer bearing race, the spacers and the second outer bearing race were then fitted onto the arbor before pressing on the second inner bearing race.

Prior to assembly, the arbor was cooled in the freezer and the inner bearing races heated to about 70°C to minimise the force required to fit the bearings. The bearings were initially fitted with about 0.5mm of axial backlash. The bearing retainer and M6 cap head screw were then fitted. Liquid thread-lock was applied to the socket head screw thread to keep it in place. The entire arbor assembly was chilled, then easily pushed into the bearing housing before tightening the outer bearing retainer. The partially assembled adapter was then fitted to the tailstock in order to measure the axial backlash and set the preload.

The method to set the preload was to measure the axial backlash between the arbor and the bearing housing, then adjust the cap screw on the arbor to reduce the backlash to zero. A 6mm cap screw has a 1mm thread pitch so the inner bearing races will be drawn closer at a rate of 0.003mm/degree. As with making precision step cuts when turning metal, I applied changes in 10-degree steps to ensure that the last step arrives at zero backlash. The difference between zero preload and too much is a fraction of a turn. There is no practical method of measuring the preload applied by this method but it has achieved a rigid and smooth running outcome.

Tool Storage and Preservation

In order to keep this tool in good condition it needed a protective case. I use PVC plumbing pipe with a couple of push-on caps. The examples in **photo 20** make low cost but very robust storage cases. For some tools, I include wooden or foam inserts to avoid too much movement inside the case. Coating the tool with heavy oil inhibits corrosion. Tools stored in this way remain in perfect condition. In years to come, the tool cases will identify the maker, purpose and manufacture date of the enclosed tools.

Conclusion

The design process included detailed investigation and analysis of various options for bearing and seal arrangements. The results of experiments caused changes

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Miscellaneous parts made during the manufacture of the adapter.

to the spacer materials selection in order to achieve a practical method of setting bearing preload. The application of precision machining techniques combined with accurate measuring instruments achieved dimensional accuracy to tolerances measured in microns. The outcome is a lathe accessory designed and produced to professional standards with amateur home workshop facilities. The design presented here can be readily modified to suit other lathes. The live tailstock spindle is a really useful but rarely used tool that expands on the capabilities and benefits of the normal range of simple tailstock centres. ■

20



Enclosures made from PVC plumbing pipe and fittings provide excellent protection.

REFERENCE

4. SKF v-ring seals www.skf.com/group/products/seals/industrial-seals/power-transmission-seals/v-ring-seals-pt/index.html

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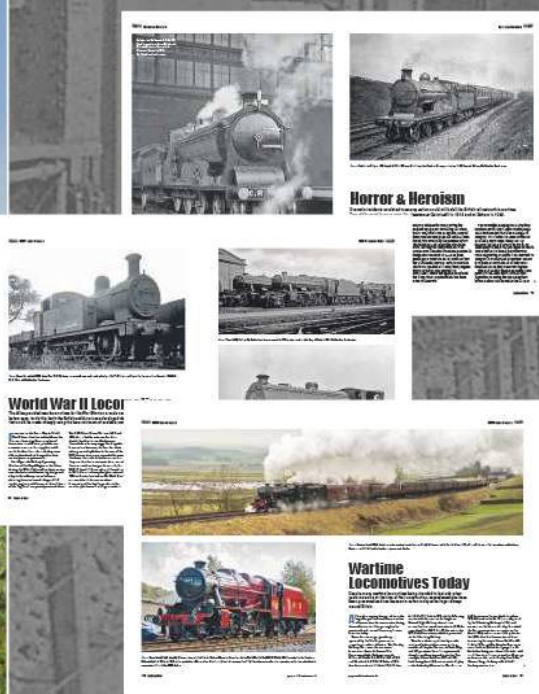


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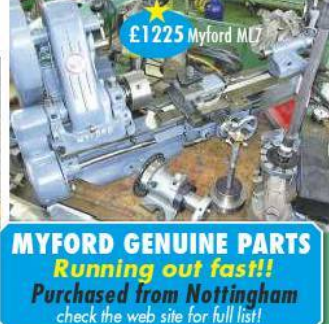


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Duplex D27 toolpost grinder

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Emir beech bench Reduction NOW only £245 to Clear

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Myford ML7

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Myford VMF mill

£3750



Union G16 16" Ped grinder + extractor

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Harrison vertical mill

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CVA 1A precision lathe + collets

£950



Startrite 275 saw + brake sliding table

£1450



Harrison M250 + inverter & remote switch 240 volts

£3750



Colchester Student 1500 + gap

£1750



RJH finisher 240 volts

£275



The Quick Step Mill

£625



Tripos (German) on/off switch

£425



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£725



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£5 each



Meddings M10 precision drill inverter

£495



Schepach Basato 4-saw

£725



Startrite Mercury

£225



WD-40

£20 each



Bright mild & lead bearing steel x 24"

£5 each



Viceroy buffer

£245



Flamefast DS320 brazing hearth/torge

£425



Startrite 18-S-5 bandsaw

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Tooling for sale!

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Dickson tooling available!

various 30INT tooling



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Colchester Triumph 2000 steady

£725



RJH finisher + extractor 240 volts

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- 100-3000 rpm vari-speed
- Weight - 150 Kgs



- Optional splash-back and safety guard

Ceriani 203 Lathe

- Centre height - 100mm
- Swing over gap - 260mm
- Motor - 1 HP
- Centre distance - 500mm
- Spindle bore - 20 or 30mm
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