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On the Editor's Bench

Last month I was visiting my brother, and he showed me a bee swarm that had made itself comfortable in a bush at the end of his garden. My experience of honeybees is that they are pretty docile if you don't do anything to upset them, and he'd not had any problems with hanging out the washing near them. I was able to get close enough to snap a picture of the swarm on my phone. It brought back long-forgotten memories of Windy Miller smoking and catching a swarm in a particularly exciting episode of *Camberwick Green*. It seems the original transmission date was 1966, although as an avid fan I'm sure I saw it a few times!

We had some debate about calling in a beekeeper before it became a problem, but a in due course the swarm moved on, leaving behind a beautiful wax comb. Joe sent me the second picture of this incredible piece of 'natural engineering'.

Another example I like is the internal bracing seen in the long bones of birds, a pattern of diagonal struts bringing to mind the 'geodetic' construction of the Wellington Bomber.

Just recently I saw a remarkable news article on tool use by capuchin monkeys in Brazil. Not only do these clever little chaps use stones for breaking open tough seeds and nuts, they have actually left a 3,000-year record of used and abandoned stones. Unlike our own ancestors, they simply select suitable stones – but the fascinating thing is that over those three millennia the shape and size of stones changes. It is presumed that this reflects changes in what foods are available to them.

It's fascinating to consider such examples of how the forms and constructions of animals are tuned to deal with the demands put on them, and perhaps it helps us appreciate just how special our own abilities are.



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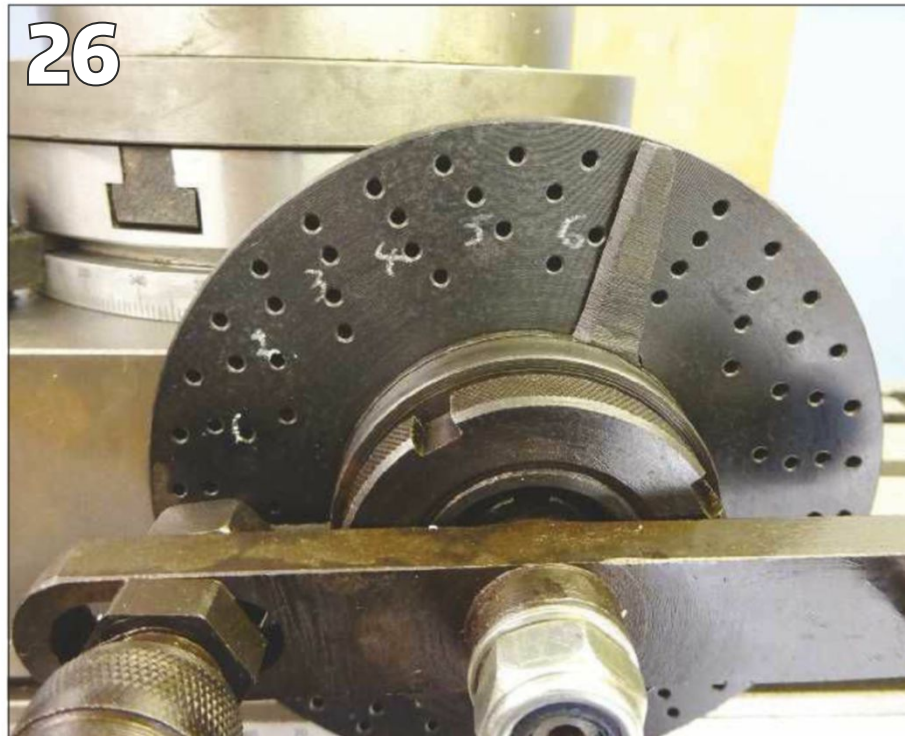
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ON THE COVER >>>

This month's cover shows Brian Wood with an enormous extended drill for making a long hole through the stone tower of his local church. For the full story see page 33



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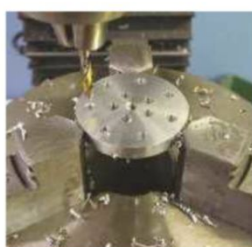


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Any questions? If you have any questions about our recent Alibre Atom3D or current Lathework for Beginners or Milling for Beginners series, or you would like to suggest ideas or topics for future instalments, head over to **www.model-engineer.co.uk** where there are Forum Topics specially to support these series.

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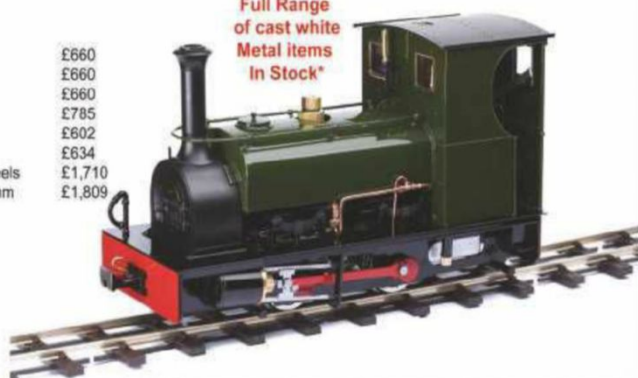
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A Lathe Saddle Multi-stop

Roger Vane presents a refined design for lathe saddle stop worthy of any machine.

About 20 years ago I designed and made a multi-position saddle stop for my Myford Super 7. At the time most of the design ideas consisted of rough sketches with a couple of hand-drawn drawings.

When a fellow Club member (Paul Clark) was looking to acquire a saddle stop he came along to view mine and decided to build one for his Myford Super 7. That said, I agreed to provide some detailed CAD drawings, and while the device was in pieces, I took a number of photos of the component parts.

Having drawn the device in detail, and taken some photos, it made sense to write it up as an article which may inspire others to make something similar as a useful addition to their lathes.

Although this design is for a multi-stop, it is also in frequent use as a simple single stop for turning and boring to a given dimension, say up to a shoulder or the bottom of a bore.



The assembled unit on the bench

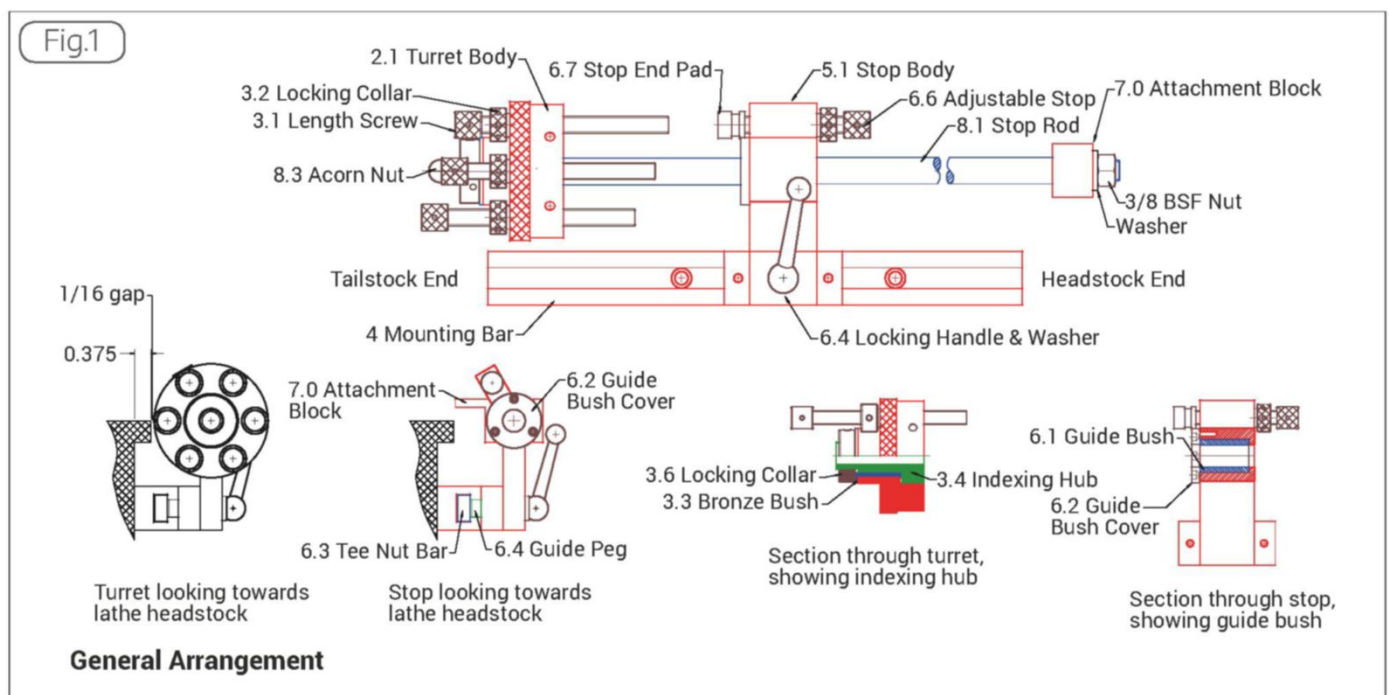
Introduction

This six-position saddle stop is mounted at the rear of the lathe out of the way but is easily accessible. It uses existing tapped holes in the machine intended for mounting a taper turning attachment or saddle stop, and also a coolant pipe, so there is no drilling or tapping of the machine required.

Although the design is specifically for the Myford Super 7, the principals could be applied to other machines. It is substantial

and capable of being scaled up or down if required.

Some of the photographs may show a slight deviation from the drawings as the opportunity has been taken to make small improvements to the design based on around twenty years experience of using the system. These will be explained in the relevant section of the text. Most of the 'action' photographs are posed using parts made twenty years ago, although there are



a few taken by Paul whilst making his own saddle stop.

The dimensions shown relate to my own machine and hopefully to other Super 7's made at around the same time as mine (c.1971). I cannot vouch for consistency with earlier or later machines, particularly those with power cross-feed where I believe that a different bed design was used. Having said that, any changes required to the saddle stop are likely to be limited to the position of the mounting bar in relation to rear overhang of the bed. There is limited clearance here between the bed and the turret, with the minimum distance between the turret assembly and the bed being around 1/16". The check is that if the overhang of the bed from the rear mounting face is 0.375" then all should be well.

As always, please check your own machine and take any differences into account. Importantly, where there is



The assembled unit on the lathe



Attachment to the lathe saddle (using an existing tapped hole) (Paul Clark)



Turret body and parts (bronze bush has already been assembled into the body)

an * next to a dimension this needs to be checked against your machine or components made and will be covered in the text.

I have positioned the device at the tailstock end of the bed. This avoids any conflict with the taper turning attachment and also allows for full carriage travel towards the tailstock end of the bed. It does mean, however that there is a degree of 'overhang' when the saddle is at the very right-hand end of the bed.

A couple of very simple pieces of tooling are shown towards the end of this article, although their use will be described when needed.

A note regarding fasteners and threads specified. These are predominately imperial, but metric where there is no readily available alternative fastener, such as the M4 button head screws holding the guide pegs into the stop body. There is no reason why metric threads could not be used throughout, with 5/16" BSF being replaced by M8, 2BA being replaced by M5, etc. The choice is entirely yours. In fact, I tapped the

holes for the length screws in the turret body as M8, fully intending to make the screws from commercial M8 studding. When I purchased and then tried the studding, I found it to be an unacceptably loose fit, so I then had to thread the length screws using a die.

Please note that all drawings have been produced using third angle projection.

General arrangement (fig. 1)

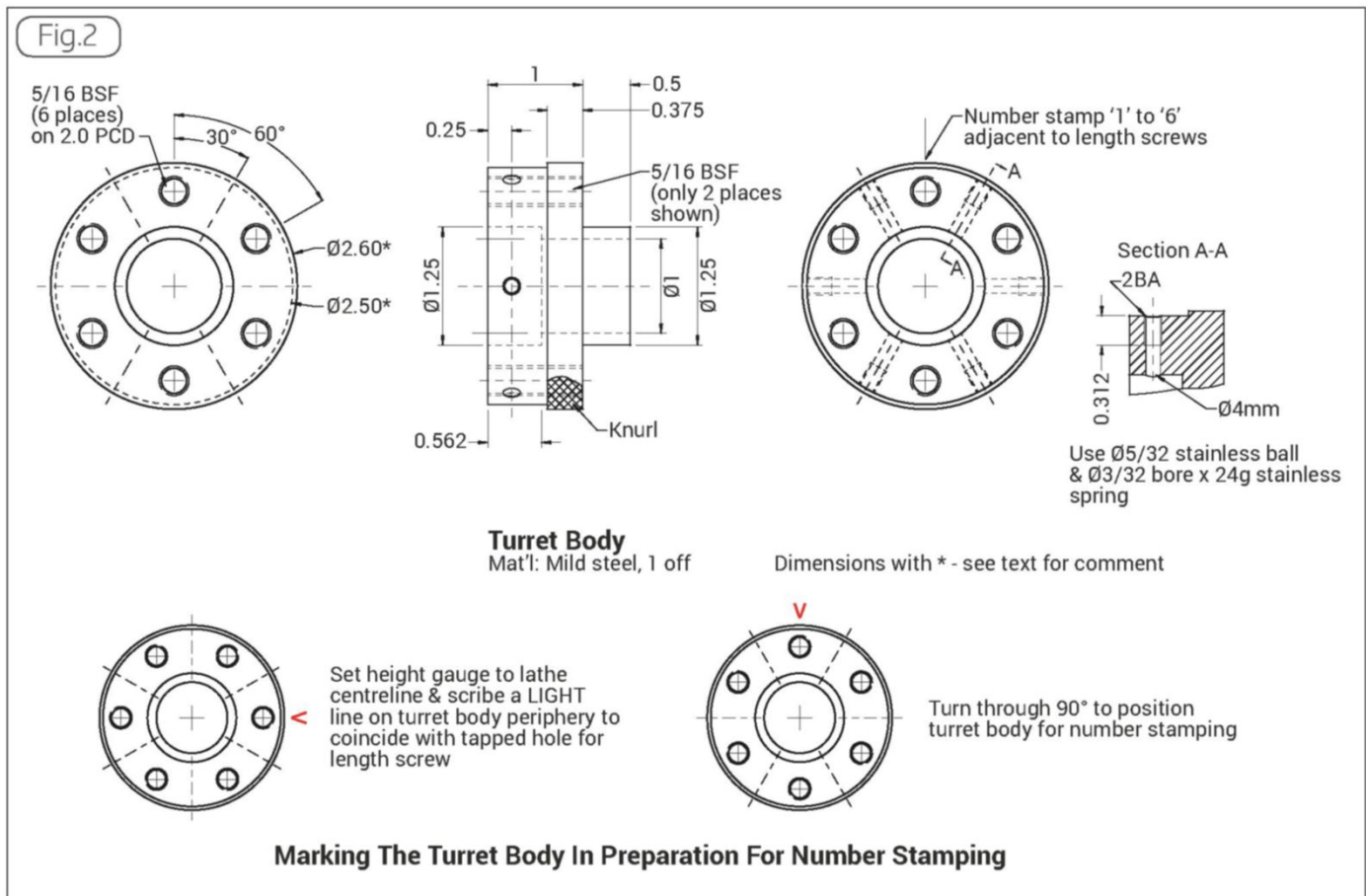
So, how does it work? The layout is shown in the general arrangement drawing **fig. 1**, and the assembled unit is shown as **photo 1**, where it is set-up on the bench as it would be seen if looking at the back of the lathe. **Photograph 2** shows the turret as fitted in relation to the bed.

There is an attachment block (7.0) which is held onto the saddle by means of single 1/4" BSF screw fitted into a tapped hole provided by Myford for mounting a coolant pipe. The attachment block has a horizontal hole in it for the stop rod (8.1) to be fitted, **photo 3**, and it is this stop rod that passes through the stop body (5.1). An indexing

turret assembly (3.0) is then fitted to the other end of the stop rod to provide the six stop positions. The stop rod may need to be shortened if you work at the tailstock end of the bed, rather than towards the headstock end, however in twenty years of use I personally have not had a job that has required me to work that far away from the spindle.

I'll now have a few words about the turret and stop units. The turret itself has been designed to provide very positive indexing of the six positions, giving reliable alignment between the length screws (3.1) on the turret and the end of the adjustable stop attached to the stop unit (6.6 and 6.7). Indexing of the turret is by means of spring loaded balls which seat into a series of holes in the indexing hub (3.4). These holes in the indexing hub are spaced at 60 degrees to each other. The indexing hub is keyed to the stop rod.

The stop block is clamped to a tee-slotted mounting bar (4.0) which means that it can be moved in relation to the lathe bed. It has a floating guide bush (6.1) to



overcome any small errors in alignment that may be present.

An adjustable stop fitted to the stop block allows for minute adjustments to the position of the saddle without having to adjust the individual length screws once they have been set, thus retaining their relationship to each other.

The stop block is fitted with a tee-nut bar (6.3) which clamps the stop unit to the mounting bar and also a pair of guide pegs (6.4) which serve a dual purpose. Although their main function is to provide guidance for the stop block in the mounting bar, they also serve to locate the tee-nut bar and stop it from rotating, making it easy

to replace the stop unit should you have removed it for any reason.

The drawing also shows the position of the stop system in relation to the lathe bed. If you intend to build this, please check clearances on your own machine and make any adjustments to the design that may be required.

Turret - body (fig. 2)

Before we start work on the turret, it is worth seeing what the assembly consists of. I have included a photograph here of the finish machined turret and some of the small parts, **photo 4**, where the bronze bush has already been fitted into the turret

body. In the final assembly there will be an additional five length screws and locking collars, as well as the two peg keys.

Now let's get to work, starting with the turret body and the small parts which go to make up the turret assembly.

2.1 Turret body

Initially this is a nice easy turning job. Holding the mild steel blank in a 3-jaw chuck, firstly face off and then turn the rear boss to 1.25" diameter by 0.5" long, but don't drill and bore the central hole yet.

The blank can now be turned around in the chuck and faced off to the overall length of 1.5". At this stage the outside diameter can be turned to size and the

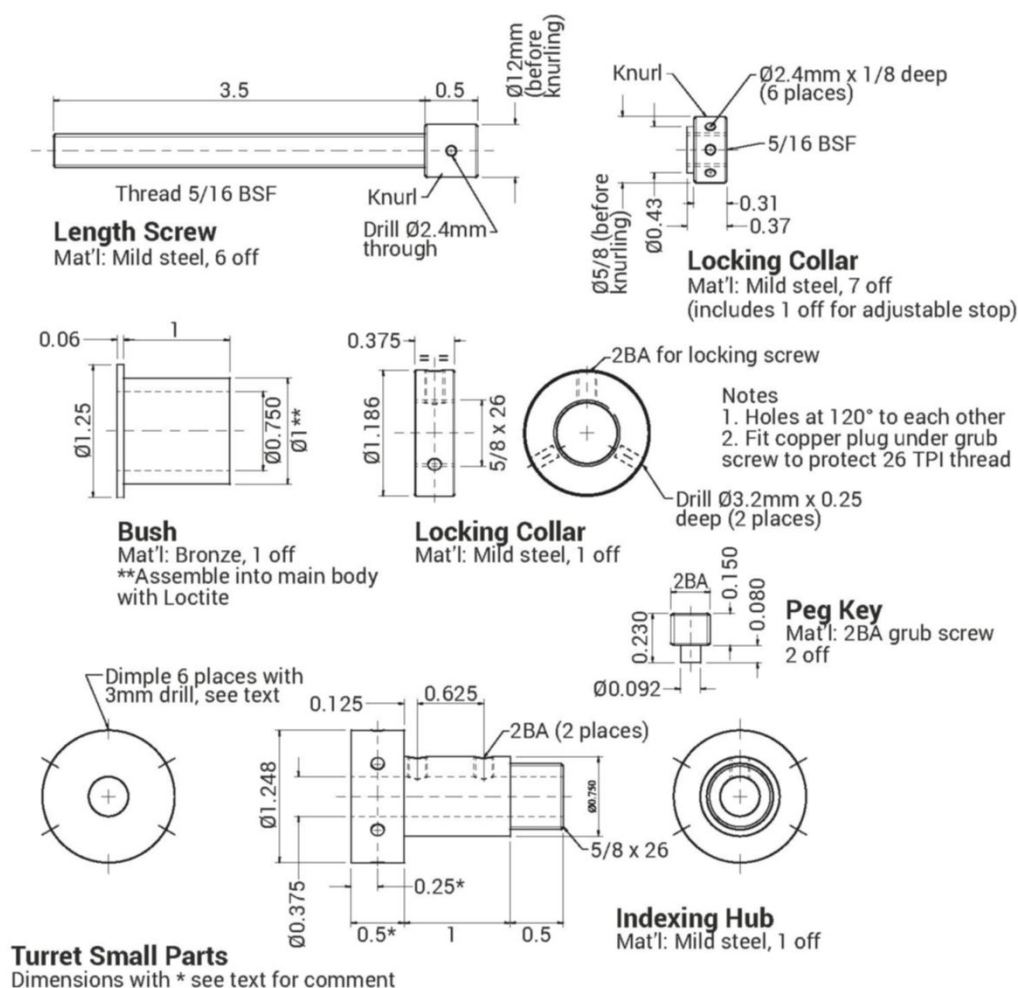


Drilling the turret body for length screws (posed)



Drilling the turret body at the index positions (posed)

Fig.3



knurling done. Before knurling though, it's worth centre drilling the face and supporting the work with a tailstock centre as knurling is quite a tough operation.

Incidentally, Paul didn't have any material of large enough diameter, so planned on using some 2.5" diameter that he had in stock. This would mean that the knurled section would be slightly larger than 2.5" in diameter due to the surface being raised, which is alright. I would advise, however, not to reduce the smaller outside diameter to 2.4" as the 'wall thickness' between the tapped hole (for the length screws) and the OD would be rather less than I would wish for. A reasonable compromise would be to reduce this diameter to 2.45" which would give a greater 'wall thickness' whilst retaining a diameter difference between the knurled and plain sections.

The next operation is to bore out the centre of the turret body to the dimensions shown on the drawing. The basic turning operations are now complete, and the body can be removed from the chuck.

Now for the interesting bit. There are six 5/16" BSF threaded holes for the length screws to be placed at 60 degrees to each other, and six drilled and tapped holes for the detent springs, also to be placed at 60

degrees to each other. The holes for the length screws and those for the detents are placed at 30 degrees to each other.

How you tackle these holes will depend very much on the equipment to have available. I decided to describe using my George Thomas Versatile Dividing Head (VDH) as that was the equipment that I would have had available at the time. Initially I set the job up using a 3-jaw chuck, and for the length screw holes the set-up would be fine. But, when it came to the holes for the detents it was a different matter, as the chuck jaws were 'open' to such an extent that they fouled the cross-slide. Even for Plan B, in which I fitted the body to a mandrel, and this was then fitted into the VDH using a collet, **photo 5**. This photo, and the next three are posed to show the set-up that I would have used.

Please note that for these photos I have used the indexing hub and the stop rod as the mandrel, as I didn't see the point in making a special mandrel just for a posed photo (too lazy?). I would not recommend this set-up in practice as you would run the risk of drilling the dimple in indexing hub too large and too deep meaning that the balls could drop into the indexing hub and then the indexing function will not

work and the mechanism could jam up completely and be impossible to dismantle. It would be better to make a special mandrel.

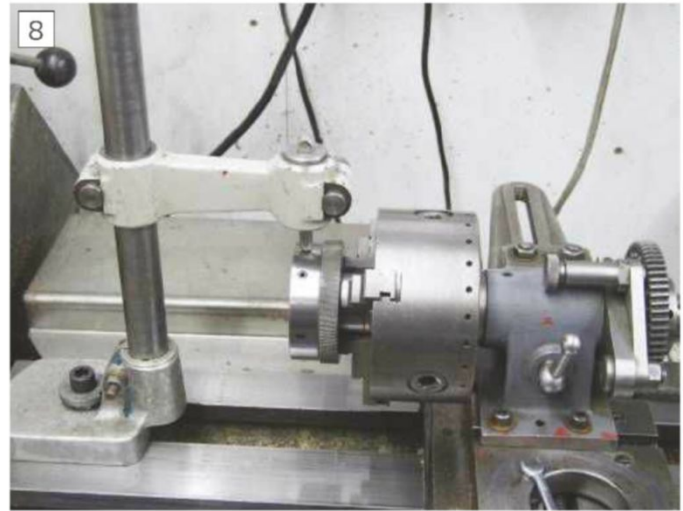
Drill tapping size for the length screws, and then tap 5/16" BSF preferably using the lathe chuck to guide the tap to ensure that all holes are square to the face of the turret body. If you have a variable speed drive then you can probably do this under power using the 'jog' function, otherwise it will need to be done by hand, not forgetting to turn the power supply off.

Before setting up to drill and tap the holes for the detent springs and balls, it is worth marking the periphery of the turret body with a lightly scribed line to help in setting up for number stamping. Only lightly scribe the line as it has to be polished out once the number stamping has been done. As there are several ways of aligning the turret body for number stamping, it might be best to scribe the line in all six positions so that you cover all options.

Now that the 5/16" BSF holes have been drilled and tapped do not remove the work from the VDH, but turn it through 90 degrees on the cross-slide and drill and tap as drawn for the detent positions (another posed picture - **photo 6**).



Setting the turret body in the VDH ready for number stamping (posed)



Number stamping the length screw (indexing) positions (posed)

Although I have specified six locations for the detent balls and springs, I have found that using three is sufficient for very positive indexing. However, I would still advise drilling and tapping at all six positions just in case you feel that an even more positive action suits you.

You will notice that this set-up only uses one tee-slot on the cross slide so care needs to be taken to avoid the VDH moving. I can't recall having any problems with such an arrangement, but if you have concerns simply use the tailstock to 'push' the workpiece against the drill.

During this operation please ensure that your springs and balls fit into the holes without any resistance.

That done, now is an opportunity to stamp all six positions with a number or any other identification mark that suits you. I used 1/8" number stamps, placed clockwise looking from the tailstock towards the headstock, so effectively if using 'No 1' position, you will rotate the turret away from you to use 'No 2' position, and so on.

The first thing to do is ensure that the numbers are stamped to coincide with the length screws. There are several ways of doing this depending on the equipment you have available. I have used the VDH and 3-jaw in conjunction with the pillar tool to stamp the numbers, although it is also possible to use an angle plate mounted on the cross-slide in conjunction with the pillar tool mounted on the lathe bed. Of course, you could always stamp the numbers freehand, but I'm not brave enough to attempt that.

If using the set-up that I'm suggesting here, the first thing that we must do is to ensure that the tapped holes for the length screws are correctly orientated in the chuck, so the method shown in **photo 7** should help. Simply fit a couple of screws into the threaded holes, and then use a square to set the vertical.

Before going too far with this operation it may be worth using a simple drawbar through the VDH mandrel to secure the turret body in the lathe chuck, after all if you're planning to use large number stamps

and a 2lb hammer the turret body could become dislodged.

To stamp the numbers, align the turret body with the pillar tool and stamp away, **photo 8**. The number stamping operation will raise the surrounding metal, so when all six have been done to your satisfaction, dress this back and polish out those lightly scribed lines.

Turret - small parts (fig. 3)

Making these items is a straightforward turning job. Ideally they should be made at the same time as item 6.6 which is the stop screw as it is identical apart from the thread length (which is 2.25" long rather than 3.5" long).

Turn down and thread 5/16" BSF, aiming for a nice smooth thread without any sloppiness. and then knurl the head. After parting off, the cut end can be faced off and a couple of small chamfers at the ends of the knurled section will make the screws more pleasant to use. All that needs to be

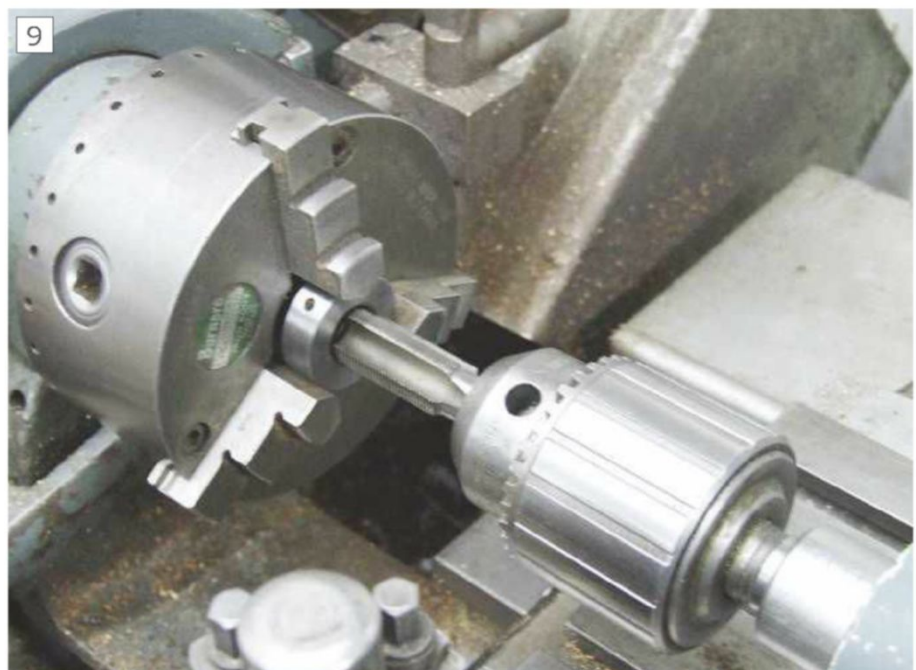
done now is to drill the cross-holes 2.4mm which will provide a nice easy fit for a 3/32" tommy bar.

3.2 Locking collar

The locking collars are basically knurled nuts with 6 tommy bar holes around the periphery and are straightforward to make. The total requirement for these is seven, as we will need one for use as part of the stop assembly, so it is worth making them all now.

If I were making these again, I would first produce a number of threaded, knurled discs from 5/8" diameter bar stock - free cutting steel is perfectly adequate here. Place a length of material in the 3-jaw chuck, face and turn the shoulder on the outer end. The bar can now be threaded 5/16" BSF and the outer surface knurled, breaking the edges with a small chamfer. Following this I would part-off from the parent material, adding sufficient length for facing to clean-up.

Now prepare a mandrel which has been



Threading the locking collar



Measuring the turret body and indexing boss as an assembly



Spotting the index positions in the indexing hub (posed)

threaded 5/16" BSF for a distance of around 3/8". The blanks can be screwed onto this mandrel and the recently parted face cleaned up to give an overall thickness of 3/8". Once all have been cleaned-up the mandrel can be transferred to an indexing head and the 6 holes around the periphery added. These holes are 2.4mm in diameter for a depth of 1/8" to avoid breaking into the threaded bore.

3.3 Bronze bush

The bronze bush is a straightforward turning exercise. Aim to make the reduced section of the outside diameter (1") an easy fit in the turret body so that it can be secured with a Loctite retainer.

In fact, now would be a good time to fit the bronze bush in preparation for machining the indexing hub (3.3) below. Simply apply the Loctite retainer and place the bush in the turret body with the flange facing to the rear as seen in photo 4. and the general arrangement fig. 1 - 'Section through the turret'.

3.4 Locking collar - indexing hub

The chances are that you will have to screw cut the 26tpi thread on the indexing hub, so it would be sensible to make the locking collar next so that it can be used as a gauge. It is probably easiest to cut a disc slightly longer than required and facing both 'ends' to machine it back to 3/8" thick. Also, while in the chuck drill a hole through the disc (say 1/2" diameter) so that it can be mounted on a simple mandrel (don't use your best mandrel for this as you will almost certainly drill a hole into it).

Fit the disc onto the mandrel and turn the diameter down to 1 3/16" and then break the edges with a small chamfer. It is easiest to produce the holes around the periphery before final boring to make thread, so transfer the mandrel to the indexing head and drill and tap the 2BA hole for the locking screw - this is where you will probably drill into the mandrel. Now index 120 degrees and drill 3.2mm x 1/4" deep for a 1/8" tommy bar, then index another 120 degrees and repeat.



Drilling tapping size for the peg keys (posed)

The disc can now be removed for the mandrel and refitted into the 3-jaw chuck, when the central hole can be opened up and tapped 5/8" x 26tpi (see **photo 9**). While doing this take a very light skim over the face to remove any 'wobble' and then the bore will be exactly square to the face - mark this face as the one which will be closest to the bronze bush. In this way there will be complete contact between the two components.

Finally, the means of locking the collar onto the indexing hub should be provided as this collar controls backlash in the turret assembly. Here, I would recommend that a small slug of copper should be placed under the grub screw to avoid damaging the threads on the indexing hub.

3.5 Indexing hub

This item is made from mild steel, and initially it is a nice easy turning job. It is best to ensure that the 1.248" and 0.750" diameters are a good running fit in the

turret body and bronze bush respectively. Then turn the indexing hub and cut the thread, using the locking collar as a gauge.

At this stage the 0.500" dimension marked * should initially be made slightly longer than shown on the drawing so that it protrudes from the turret body. This will allow you to determine where the indexing holes in the hub should be drilled. There will almost certainly be some deviation in the dimensions shown on the drawing - the bush may protrude into the main body of the turret more or less than the 1/16" allowed for, or the turret body may be slightly thinner or thicker than intended - we will need to compensate for this when drilling for the detents. We need indexing to be smooth but positive, so it is important that the holes in the turret body and the indexing hub align accurately.

Anyway, we can complete the turning of the indexing hub and screw-cut the thread for the locking collar. Now fit the indexing hub into the turret body and measure the



The holder for machining the peg keys and the special centre punch



Machining a peg key in the special holder

protrusion.

So, we now need to measure the protrusion (if any) of the indexing hub from the body as shown in **photo 10**. (We can either face the indexing hub back to be flush with the turret body or take the deviation into account). As you will see from the photograph my indexing hub is slightly proud of the turret body.

It is now time to drill for the detent positions and for the peg keys. Measure the protrusion (if any) and add to the 0.250" dimension specified. Set on a mandrel and dimple in 6 places (at 60 degree increments) with a 3mm drill on the centre line of the indexing hub. This size will allow for positive engagement of the balls while not locking-up as the ball is not at risk of disappearing into the hole. **Photograph 11** shows the general idea.

Once these six holes have been spotted, don't remove the mandrel from the indexing head or deviate from centre line, but reposition to drill and tap the holes for the two peg keys. It is best to tap these holes using the milling machine spindle to ensure that they are truly in line with the centre line of the hub as the peg keys will fit into the keyway to be milled on the stop rod. **Photograph 12** shows the tapping drill being used prior to tapping.

3.6 Peg key

These look quite tricky to make, but they are easy if you use a special holder. The holder is drawn in **fig. 9** and shown in **photo 13**. It's also shown in use holding the grub screws for machining the 0.092" diameter tip which engages with the stop rod. (8.1) - see **photo 14**. I made these items from 2BA x 3/8" long grub screws.

The first operation is to reduce the depth of the key socket by around 0.08", which is no problem in a light duty item such as this. The screw is held with the socket outermost. Unless this is done the socket is effectively too deep and when trying to machine the tip you will encounter the inner end of the socket and the newly machined tip will fall off.

Now measure the length of the remaining



The peg keys with the indexing hub

screw and calculate how much the screw needs to be reduced in length to achieve the finished overall length of 0.230". This figure will be around .065". That done, fit the grub screw with the plain end outwards by passing an Allan key through the central and 'do-up' until tight. Face to length by removing the calculated figure, and then

turn to achieve the reduced diameter of 0.092" for a length of 0.80". Job done.

Photograph 15 shows the completed indexing hub, together with the two peg keys awaiting assembly. During the final assembly process the depth of the peg keys will need to be set in relation to the keyway in the stop rod, so that will have to wait until the stop rod is available. To assemble, fit the peg keys and then back-off slightly - the keys can be secured with thread-lock if desired. It may also be necessary to dress the tops of the keys slightly if they finish proud of the surface. **Photograph 16** shows the keys fitted into the indexing hub, complete with the stop rod.

Assembling the turret

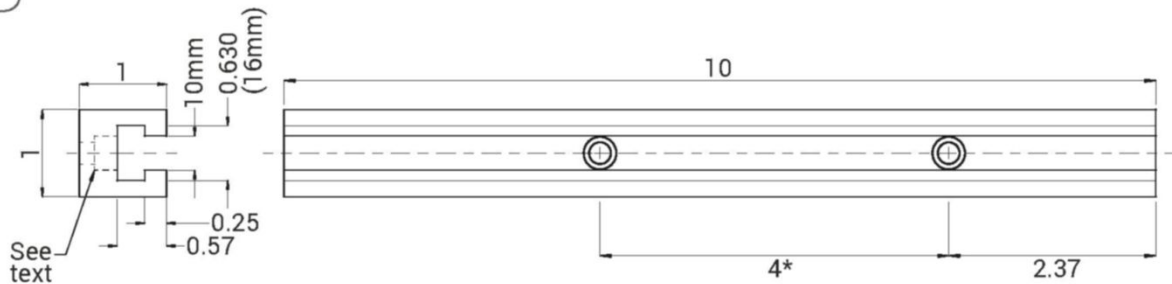
The good news is that the turret can finally be assembled as shown in **photo 17**. Adjust so that turret turns freely without any backlash by adjusting the locking collar, which should itself then be locked with the grub screw. Add the detent balls and springs and test for positive 'indexing'. I would suggest that you start off by using three positions, adjusting, adding or subtracting to suit the 'feel' which suits you.

All that needs adding now are the length screws with locking collars and the turret assembly itself is complete.



The peg keys have now been fitted to the indexing hub - shown with the stop rod

Fig.4



Mounting Bar

Mat'l: Mild steel, 1 off

*Check on job - see text for comment

17



The turret assembly complete and ready for fitting

All that needs adding now are the length screws with locking collars and the turret assembly itself is complete.

Mounting bar (fig. 4)

You might notice that my mounting bar, **photo 18**, appears to be shorter than that in the drawing, and of course it is. I made my mounting bar 8" long, and it has proved to be perfectly adequate over the years. However, I'm aware that I use a quick-change toolholder system which has a greater overhang towards the headstock than a conventional 4-way toolpost, or indeed the standard Myford offering of a single toolpost. We are also using collets far more than ever before and these may have less overhang than a conventional chuck. All of this means that the stop block may need to be moved further towards the headstock. I've therefore drawn the mounting bar at 10" long to avoid possible problems.

4.1 Mounting bar

The tee-slotted mounting bar is fitted to the back of the lathe and uses the machined face and attachment holes which Myford intended for fitting their taper turning and multi-stop attachments. The end of

the mounting bar coincides with the end of the bed. As the machined face does not go all the way to the end of the lathe bed, the mounting holes are offset, and this is evident from the photos and drawings.

The mounting bar provides a positive location for the stop body by means of two guide pegs fitted to the stop body, whilst a tee-nut bar supplies the clamping force. I would advise co-ordinate drilling the holes in the mounting bar, as if the axis of the bar is not parallel to the lathe bed then the floating bush in the stop body could be working overtime. Please check the spacing of the holes in your machine bed, just in case it is different to mine. I always drill holes like this as I would for dowels - tight to size. The screw thread used by Myford was 1/4"BSW, and if you measure the screw diameter, you'll find that it will be undersize. Use a 3/8" slot drill to finish the hole for the 'cap', ensuring that you go deep enough to clear the bottom of the tee. It will probably be necessary to skim the head of the capscrew to obtain an easy fit.

The main problem that you will encounter is how to hold the mounting bar securely for the milling and drilling operations. I'm sure that I would have held the material

18



The completed mounting bar (8" version)

in a standard 4" milling vice, but then the mounting bar that I made is only 8" long, and not the 10" that I'm now suggesting. If I were to be doing the job now, I would use a matched pair of machine vices, which are ideal for holding long jobs. However, I am aware that very few people will have such luxury available.

One possibility is the method used by Paul. Due to a limited X-axis travel he had to tackle the milling operations in two bites, although most of us would be able to do the job without moving it on the table. So, this is how Paul tackled the job (in his own words)...

"The modus operandi was to align the job over the T slot and clamp as shown. Parallelism was assured by the buttons and offsetting parallel. Four holes in all were made suitable for 5mm cap head Allen screws clear of the bottom of the T. These screws screwed into four scrap bits of tapped plate in the bottom of the table slot. This held everything perfectly securely and allowed for moving the job along so the cut could be made in two 5" passes as the machine travel is shorter than the job. It all went pretty well."

●To be continued



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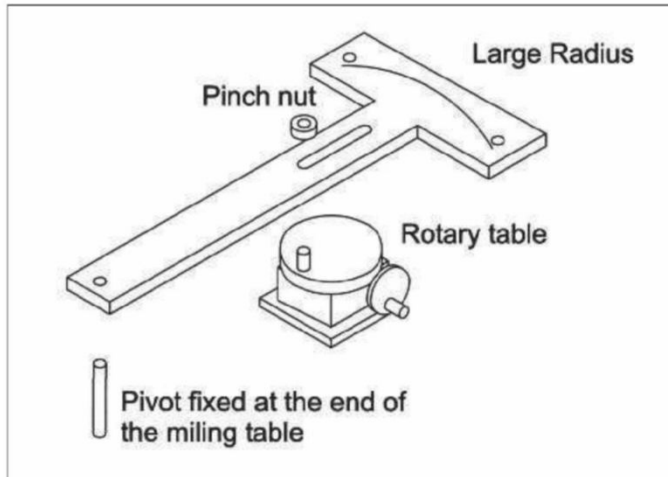
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Scribe a line

YOUR CHANCE TO TALK TO US!

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



Milling a large radius

Dear Neil, I read with great interest Richard Wightman's "An eleven inch Rotary table" and will am sure follow his example using a car brake disc.

I am contemplating a similar project where an expansion link is required for a 12" to the foot small stationary steam engine. A much enlarged version of Richard's set up will not be possible as my milling machine throat depth is too small.

I have sketched up a method that might work. A rotary table is used to move a jig plate in a semi circular arc. A pivot is locked into the tee slot at the end of the milling machine table. A fixed pin is attached to the tee slot of the rotary which drives through a slot in the jig plate. In addition, a pinch nut is added to this pin to keep the jig plate lifting during milling. Additional support will be needed under the jig plate at the work end. Suitable bolt holes will be drilled and tapped to the workspace end of the jig plate to suit the job.

Geoff Harding by email

Another Electronic Leadscrew

Dear Neil, I can't imagine that you are not aware of this, but just in case (!) I'd like to draw your attention to this You Tube series. To my mind it is being very well presented. Maybe you could give it a mention in the magazine? I have no link or any other interest with the author and James does not know that I am approaching you about this.

<https://youtu.be/7QaQrqn4yel>

It may be that a commercial kit will become available - there has been to my recollection no indication that this will happen despite my lobbying for one.

Bob Hawtin, Hartsholme

Bearing removal recipe

Dear Neil, Regarding the article on removing bearings from blind holes (MEW, July, page 29), the conventional use of grease tends to be messy, as the author described. I was intrigued when a friend told me that he uses papier maché made from paper kitchen towels and water - it's less prone to escape through the bearing than grease. I'm wary that there's often nothing new under the sun (confirmed by Tony Jefree on page 26 of the same issue) so, before presenting this solution to Scribe a line as a novel idea, I resorted to Googling: "bearing removal with paper". Omitting the inverted commas produces numerous articles and videos of that recipe and a variation using damp bread.

As Tony said: "Few ideas are really new." I shan't be applying for a patent.

Ian Moignard, Jersey

Beam Design

Hi Neil, I'd like to congratulate Mr. Finch and yourself for publishing such a comprehensive treatment. It's an area I studied many, many, moons ago and the first time I have seen an author and a magazine editor with the 'bottle' to publish an article on it.

I carried out a similar exercise for an existing rolled steel joist in my garage some years ago. In my case the weakest points were the two rather 'flimsy' brick piers holding up the steel beam. Something I thought that could be readily fixed with a couple of suitable builders acrows.

The methodology Mr Finch so carefully outlined is of course applicable to many other areas where 'beams' of one sort or another are proposed. Most workshop machinery involves cutting tools suspended by beams - although they are not always so easily recognised.

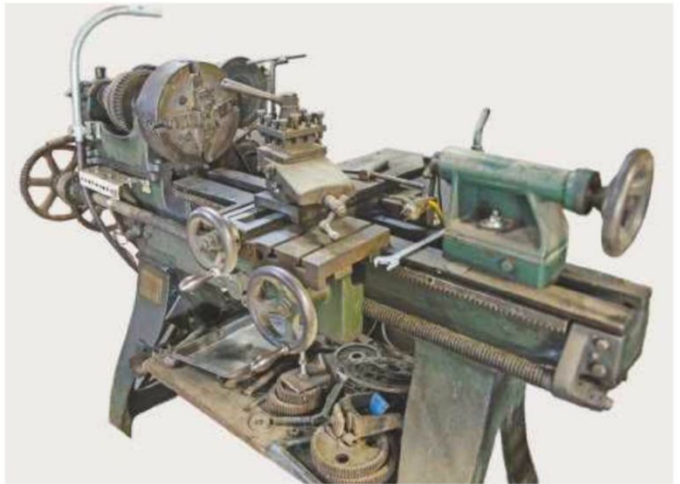
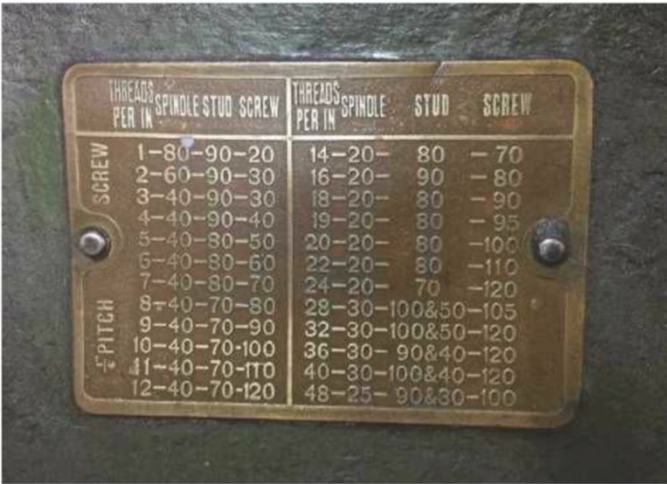
I suspect that it comes as quite a surprise to many people that halving a beam length reduces the displacement under a given load by a factor of eight - something to bear in mind with boring bars and lathe tool holders.

I think this article has great educational value, far beyond the already wide gamut of our interesting hobby. Hopefully it will be picked up by technical colleges and universities and it would be nice if Mr. Finch and My Time Media would consider waving any copyright restrictions on its use.

Once again, well done the pair of you.

Bob Hawtin, by email.

Thanks for the appreciation, Bob. I believe that academic institutions are allowed to make copies of single magazine articles for educational purposes under existing copyright law - Neil.



Lathe Identification

Dear Neil, The attached photos are of a lathe my mechanic purchased a few years back. It is still serviceable, but has been abandoned in favour of a newer (safer!) machine.

There are no identifying marks, labels etc and so we cannot identify the manufacturer.

Do you think it can be identified from the photos? It could be of interest to a collector or museum.

Brian Sala, Piggoreet, Australia

Knurling

Dear Neil, In response to Mr Lill's correspondence regarding knurling ('Scribe a line', MEW issue 282) I can only suggest what works for me - a method taught to me when I first started using a lathe in 1969:

- 1) Use a low spindle speed (my lathe at home is an old Drummond and has a choice of three speeds plus back gears - I use the lowest normal speed, which is around 200 RPM).
- 2) Use plenty of cutting fluid (to wash away the tiny fragments of swarf produced) - flood coolant if possible.
- 3) Go in 'hard and fast' with the knurls to prevent a double pattern (if using a scissor type knurling tool, a couple of quick twists of the clamping screw will set the tool to full depth in a second or so).
- 4) If using a scissor type knurling tool, ensure the wheels are truly above and below the work axis - if they are not, there is a risk that the work will be 'squeezed out'. If using a 'bump' type tool, make sure the tool is set vertically so the force on the work piece is at centre height to avoid excess stresses on the tool and the work piece, and if diamond knurling the two halves of the pattern will be cut with different depths.
- 4) Keep the knurls moving - do not 'dwell' in one place.
- 5) Complete the knurl in a single pass - do not attempt to go over a

piece a second time to cure an initial cut that was too shallow.

- 6) Feed along the work piece at a rate of about 1/4 inch (5mm or so) per second.

I feed the tool by hand, but feeding under power is equally good

Regarding the issue of knurl pitch and its relationship to work piece circumference, I was not taught to 'match' the circumference of the work to the knurl pitch and I have never done so. The knurling pattern seems to adapt to any circumference without any problems.

I got involved in a discussion on an engineering forum on this point and as I had never heard of this idea of matching work size to pattern pitch I decided to investigate. I produced a brief write-up of my investigation and I attach a copy which Mr Lill may find interesting. Please will you be kind enough to forward the document to him.

Ian Newman, by email

Thanks Ian, I have passed on your document and by now you will know I have invited you to write up your findings as an article for MEW - Neil.

Taming the 'Universal' Tool and Cutter Grinder

Part 2



Graham Sadler modifies an engraving cutter grinder to be more versatile.

Sharpening procedure

Set all the work head scales to zero. Fit the slitting saw and have the setting plate on top, loosely clamp in place. Loosen the universal base plate clamp and slide it all forward until the setting plate is in contact with both sides on the grinding wheel; I find moving the spindle forward is the easiest way of achieving this. Rotate the slitting saw until a tooth lines up with the radial edge of the window. Concentrate on the point of the saw tooth especially if the gullet is angled then lock it all tight with the top clamping screw. Move the base plate away from the wheel to avoid any possible damage to it, fit and adjust the detent assembly and get it located in a convenient saw tooth gullet, **photo 15**. Now remove the setting plate, rotate the whole work head to get the required tooth clearance angle. Bring the saw close to the wheel and set the stop if needed to avoid catching the next tooth with the wheel; this will be easier when you have made the penguin stop which is to follow later. Switch on, add cut and grind the first tooth, keeping a constant pressure with your hand to ensure



Setting a slitting saw, note the position of the cutter edge in the setting window and the pressure on the detent causing it to bend.



The start of the grinding process, an obviously blunt and sad 10mm slot drill



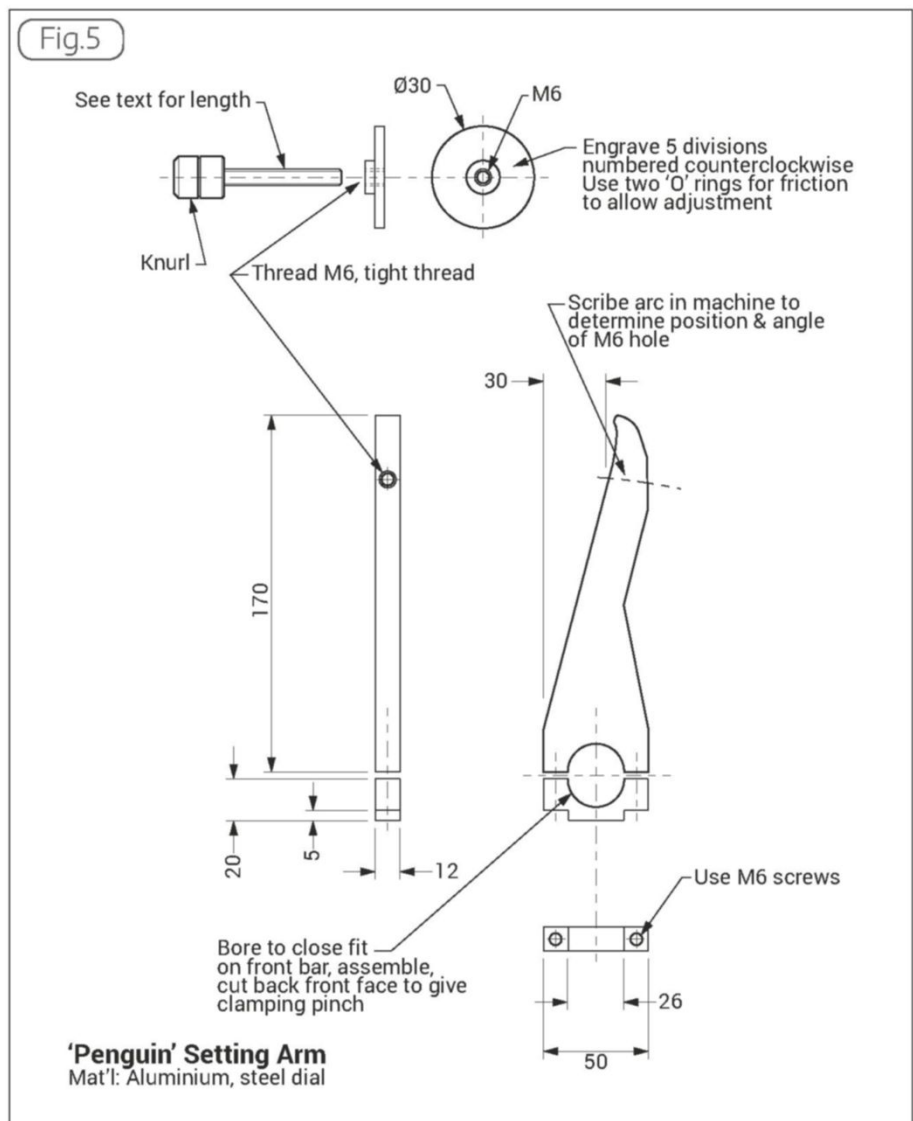
Use a mini disc to enlarge the gash if needed

contact with the detent. Swing towards you, index and do the next one until all teeth are ground. Repeat with more cuts until all teeth are sharp, it's a very simple and quick operation.

Sharpening the end of end mills and slot drills.

Often, sharpening only the end tips will do the trick of revitalising the cutter; in theory should be an easy process but again we need extra kit to enable this to be achieved. The problem is the controlling of the radial in-feed needed when swinging the whole work head and tool across the face of the grinding wheel on the front bar needs to be very carefully controlled or when one is grinding the first edge the opposite side is so easily caught ruining the cutter or giving you a lot more work. The grinder as supplied, does have an in feed control, but its use is extremely crude and insensitive and it is impossible to quantify movement. It consists of a bar about 40mm long inside the headstock of the machine fixed to the main feed, and is controlled by a loose fitting M8 screw. It is impossible to accurately control the feed and crossing over the central hole of an end mill or central gash of a slot drill is, to say the least, a bit hit and miss. I know this after completely destroying some already very sad practice cutters.

The solution is to make a sensitive feed control and remove the above mentioned screw completely. Photograph 1 showed this in position. I call it a Penguin arm due to its obvious shape, **fig. 5**. Start with a piece of 10mm aluminium plate 175 x 50mm. The end is finished true in the mill, and a small piece is fitted to the end with M6 cap screws. It is then a simple faceplate or mill job to bore the arm to a precision fit on the front bar. On completion, separate the components and remove from the front edge only 1mm from the abutment face to provide a pinch for the clamping screw action. The length of the arm and screw position is set to bring it to the centre of the work head spindle by mounting a scribe in the collet with every scale set at zero.



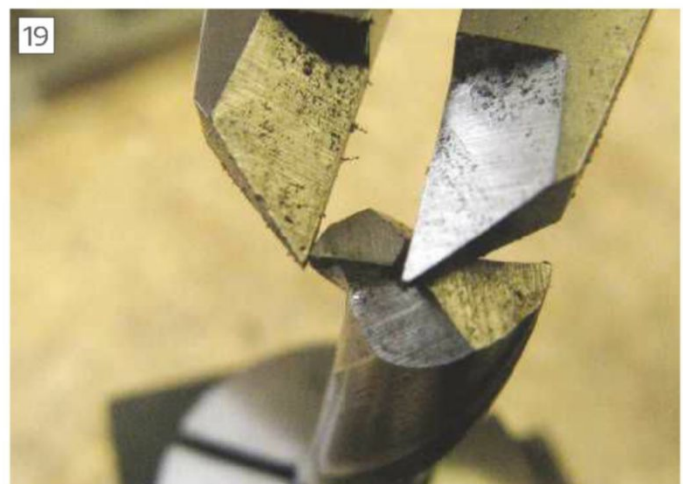
Scribe an arc on the end of the Penguin arm to give the length position at the top end. Convert the arc to a straight line with a ruler and set this line vertical in the drill vice so that the arm can be drilled 5mm for tapping M6. This thread has a pitch of 1mm so it is easy to control the in-feed. Now the shape

of the rest of the arm can be produced. I made a card template first to see the result and modified this until satisfied and the arm was cut and suitably finished with file and abrasive.

The design point here is that the adjustment point is on the same radius as



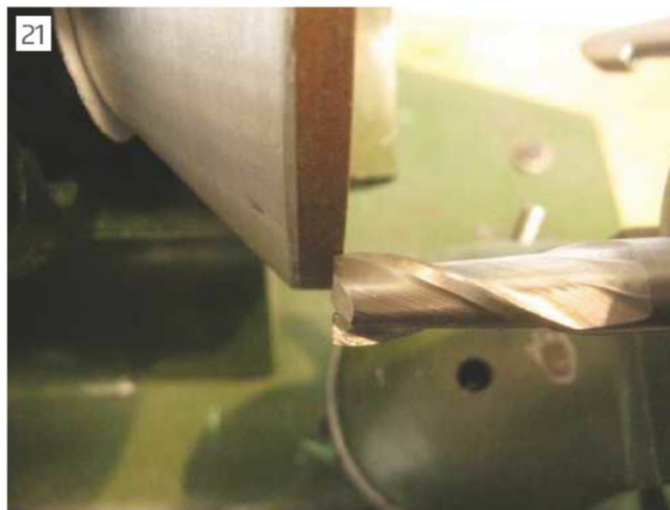
With digital callipers, measure the length of the long lip to the centre of the gash and make a note of this. Zero the callipers. Gosh they didn't look that dirty!



Measure the other lip, and what you now have is the difference in the lip lengths. Let's say for ease that this is 4mm and 2mm (1.95 in reality!)



Using the setting block to set the cutting lip level. On some end mills the cutting lips are not radial so then just get the gap between the edge and block parallel. Lock the spindle, tighten the collet and finally zero the degree scale on the work head for "indexing".



Mount the work-head, the cutter facing the cup wheel, and add the appropriate clearance, usually 6 degrees by rotating the head downwards. With the machine switched off bring the cutter say 3mm to the left of the face of the wheel and adjust it so that the long lip side of the cutter just contacts the wheel and lock the front bar in position.



Slacken the penguin stop on the front bar and swing it into contact with the machine frame. Rotate the setting dial until it just starts to move the arm. Add the required 4 turns plus 0.2mm to fully enter the gash to match the 4mm long lip length. Lock the penguin arm to the main bar which itself is unlocked. Move the cutter to the right then back off the penguin screw to zero rotating the main bar, thus adding precisely the required 4mm advancement of the cutter onto the grinding wheel and the gash will be centred on the very corner of the wheel and the short lip is protected. (The final stages are in the text).

the work head, so that one turns of the adjusting screw i.e. 1mm feed when clamped to the main bar will thus move the work head by almost exactly the same amount. Now we have a controllable movement. The knurled screw in fig. 5 should be made with a tight thread. The length of the thread will need to be adjusted according to the final width of your penguin arm plus 2mm more than the radius of the largest cutter you intend to sharpen, plus the thickness of the dial. Dome and polish the end.

The dial, which is tapped M6, has 5 graduations, so that each gives 0.2mm feed. I did the division with the aid of a digital angle gauge sat on the chuck jaw. Use a sharp V-tool set vertically and incise it about 0.1mm deep. Set the angle gauge on the



The crude inaccurate and redundant original feed control, drill then split with a chisel.

chuck jaw and zero it exactly where it is. Now it's easy to rotate the chuck until the gauge reads 72 degrees and the next line is engraved. Stamp the numbers 0 to 5 going anticlockwise then it's back in the lathe to part off; I used a thin disc and soft jaws. Fit the dial, with the end in contact with the grinder and screw the adjuster in until you just feel the arm move.

We need an aid to setting the cutter in the correct position. With the setting pin supplied with the machine is very difficult to see what's going on, but with the work-head off the machine it still isn't easy. Another setting jig is required, it is very similar to the one we have already made.



Cutting the toggle switch hole in the front of the machine. Much easier than expected.

This time Fig. 3 and photo 8 show the strips fixed onto the base plate. These are needed to clear the dovetail slides so that the work head is mounted on the operational part of the dovetail the notch in the front bar is to clear the micro adjuster.

Now we need the setting block for the cutter lip position, done in exactly the same way as for the four-facet grinding jig. I drilled a hole in the back a small clearance on a pin fitted into the plate so that it didn't get lost.

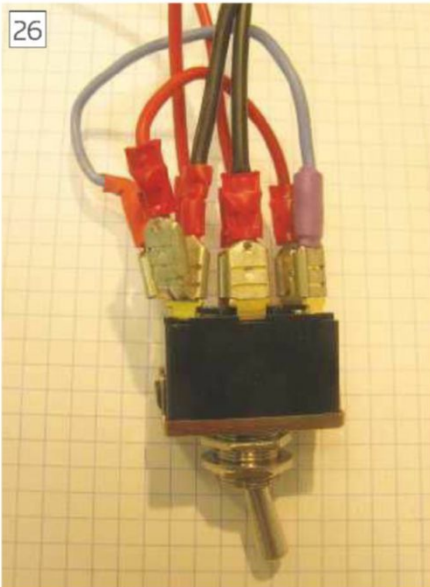
Grinding the ends of milling cutters.

I will cover slot drills here as they are the most difficult due to one edge being longer than the other. **Photographs 16 to 23** show this better than text, it uses the standard R8 work head.

When the long edge has been ground, ground ensure the penguin screw is against the machine frame, lock the front bar, slacken its indexing screw then reposition the penguin arm into contact with the machine head and lock it. This maintains the setting for the long edge. We will need to limit the in-feed swing of the work-head for the short lip by the difference between the lip lengths i.e. 2mm. Unlock the front bar; add two turns of the penguin screw which will push the work head outwards. The short edge can now be ground after



The modified motor connections take care and ask if uncertain!

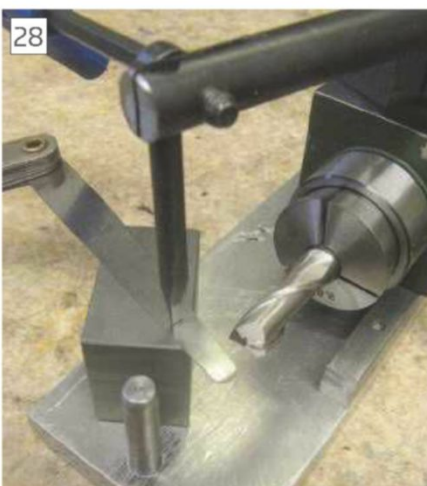
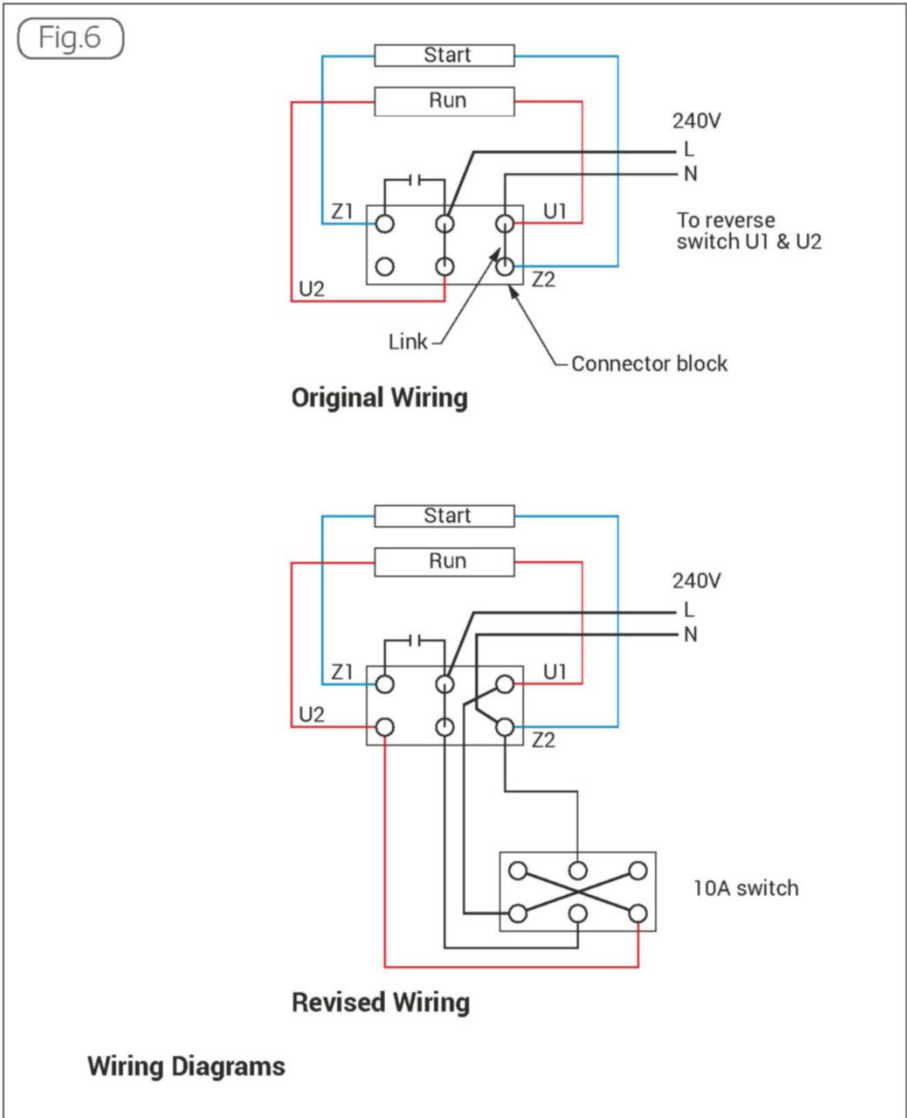


The 10 amp toggle switch with the spade fittings

indexing it round without any danger of hitting the long edge. Repeat as often as required to get a sharp tool. If the first lip needs more work all that has to be done is set the penguin arm screw to zero and proceed. I advise switching the grinder off when doing any changes, not for safety, but it is so easy to catch one of the lips on the grinding wheel and give one a lot more work to do again! Like the slitting saw sharpening, it's straightforward once you have done one or two cutters. The improvement of the cutter in action is



Set all angle scales on the machine to zero. After loosely setting the cutter in the collet, the rest is put into position on the machine to ensure it will not foul the grinding wheel or wheel guard. Spiral the cutter forwards to check all is ok and tighten the collet. Now set the tool rest and fiddle it into a clear position just clear of the front of the cutter. There should be minimal clearance between it and the grinding wheel. Set the back stop on the head spindle to limit the length of the cut.



Remove the head and loosen the T-nut fixing only, the one attaching the rest assembly to the work head. The tool holder head is then put on the jig. Swinging the rest to one side to clear the cutter above the setting block, slackens the end screw holding the tool rest pin itself and lift it a little. Do not let the finger mounting bar rotate, keep this locked. Now use feeler gauges to set the clearance angle by lifting the loosened pin and pressing it tight onto the block and locking the finger pin in place.



Now swing the whole rest assembly into the correct position and lock in place with the T-nut fixing

a complete revelation to be honest! The setting dimensions usually involve decimal millimetres, but the Penguin dial graduations cater easily for this, and as the central gash is wide enough there is room for slackness here. I find that it is easy to get 3 or 4 end sharpening sessions before the geometry of the cutter becomes compromised and then it becomes necessary to deal with the secondary clearance.

Grinding the spiral edge of the cutter is a lot more difficult at first and requires further modification to the machine.

When grinding the periphery of the cutter, we will be using the face of the wheel with the grinding rest mounted above the cutter. Grinding on the edge of the wheel is impossible as we don't have any means of elevating the grinding wheel relative to the cutter centre line, the normal method of obtaining the clearance angle. The cutter is



Grinding is achieved by rotating the cutter counter clockwise against the finger rest starting this in the root flute and pulling towards you at the same time.

angled upwards and there is little clearance for the grinding rest, see **photo 27** later.

This is the only position where the mounting for the rest which is above the work holder can be positioned, but there is a problem. The cutter will be forced away from the rest by the downward rotation of the wheel and consequential rotation of the cutter without an extreme bit of luck and care will be forced downwards thus reducing clearance to zero and rendering the cutter useless. The only solution is to have the wheel rotating upwards and forcing the cutter onto the rest and not away from it. As we will see later this makes for very easy setting of the height of the rest to obtain the correct clearance angles

I fitted a toggle switch into where the old now unused bar stop was positioned using a 10 amp spade switch, but this was not as easy as it seems. With the machine on its back, the base is removed, and the redundant old lever fixed to the front bar (which controlled the now unused adjuster) can be seen. This must be removed, to give space both physical and for electrical safety purposes. It is achieved by drilling a few shallow holes into it then splitting the casting with a chisel, photo 23. Four holes at the corner of a square were drilled through from the front of the machine. The waste was cut out starting in the existing M8 hole

with the jig saw, a surprisingly easy task with a good quality metal blade, **photo 24**. A thin plate of yellow plastic chosen to match the main switch is drilled for the switch and fired to the machine with 4Ba screws.

In order to reverse the motor, all that is required is to switch over the mains feed to the running windings, but this must be done safely. On the 6 pin terminal block on the motor there was already one spare connection, and a little rearrangement of the others gave a second spare. These provided the connections to the reversing switch. One of the links had to be removed, **photo 25, fig. 6**.

Unfortunately, the before image of the connections was lost. The connections shown relate to my machine, yours may be different, although the principal remains the same, take care and double check before switching on.



End of the cut. After doing the first edge, switch off, note the feed setting on the main bar then back off, rotate the cutter, to the next edge, switch on, add cut and so on. Because of the geometry of the machine, the grinding will be extended further than the original but will not have flute which is not a problem.

Use spade crimp fitted connectors which are reliable and give you the chance of changing the connections if the motor rotation does not match the switch position. If you don't have a decent pair of crimping pliers, remove the plastic shield on the spade fitting, solder the wire in using heat shrink tube to provide the insulation protection. I wanted a down movement of the switch for down (anticlockwise) rotation, which is the normal position, and switched up for clockwise up rotation. The switch is provided with a missile type switch cover which automatically sets the switch to standard down rotation when the cover is down. You will need two female spade connectors which have an additional male blade position, see **photo 26**.

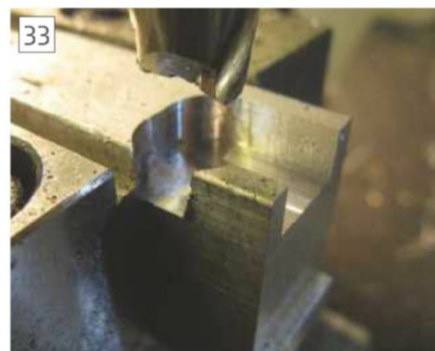
Calculating the clearance angle

The tool rest needs to be set above the cutter centreline by an exact amount dependant on both the required clearance angle and the diameter of the cutter the table shows what is needed but the maths for calculation is given in **table 1** which shows the grinding finger rest setting for different cutter diameters.

Clearance = Sin (angle) X cutter radius



Close up of the finger position



The now sharp cutter seen earlier the slot was completed with a single cut while the end two, at full depth, which would not have been possible before as seen in photo 17!

Table 1

Cutter Diameter	Setting for 6 degree
	Clearance in thousandths of an inch
6	13
9	20
12	26
16	33
20	39
22	46

Photographs 27 to 32 with their captions show the grinding procedure. While cutters less than 6mm can be sharpened with difficulty, they should be regarded as throw away. This is where the Quorn with its spiralling hobs has the real advantage, but let's face it, Professor Chaddock designed the machine for this very purpose - making very small cutters.

Finally, **photo 34** shows what the cutter from photo 17 can do. ■

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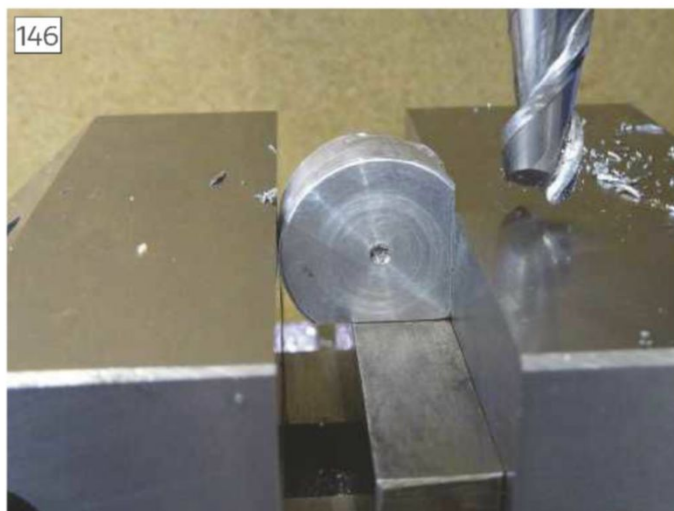
Milling for Beginners



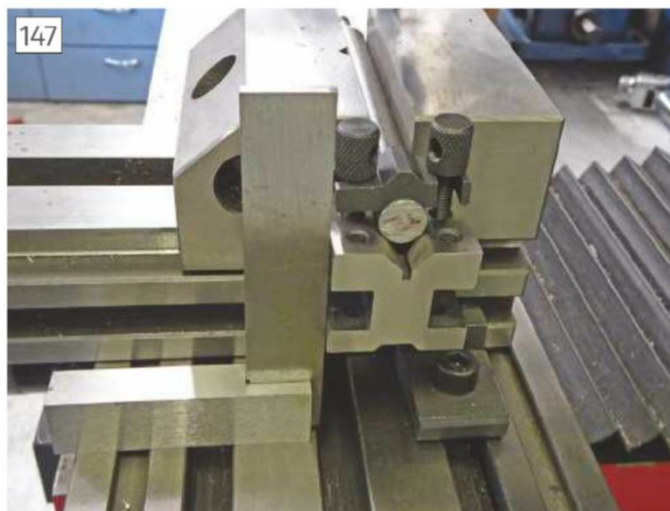
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PART 12 - INDEXING AND DIVIDING

This month Jason Ballamy discusses different options for indexing and dividing



Using vice jaw to index 90degrees



Vee block used to index 4 positions

Basic Indexing

Indexing is the process of rotating the work against a fixed reference point or surface to give the required number of faces or points. In its simplest form the fixed jaw of the milling vice can be used to form square items by placing the previously machined horizontal surface against the vertical jaw, **photo 146**.

This really only works if it is practical to get the machined face in contact with

the jaw which is not always possible for example when creating a square on the end of a long piece of stock in which case other means of indexing need to be used. If the work is sufficiently long enough to protrude out of the opposite end of the vice to where you are cutting it then a vee block can be clamped onto the end and a try-square used to set the vee block as it and the work are reset at 90 degree intervals. If you don't have a vee block, then a piece of

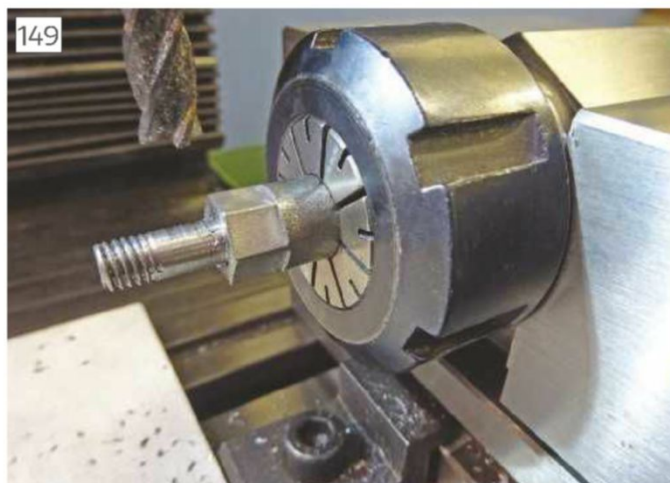
square stock could be drilled through to suit the rod and temporarily bonded on photos **147 & 148**.

Indexing with Collet Blocks

A step up from these basic methods if you already have a set of collets is to use a collet block, these come in both square and hexagonal giving the option for hex head screws and bolts. ER Collet blocks are probably the most common ones in use by



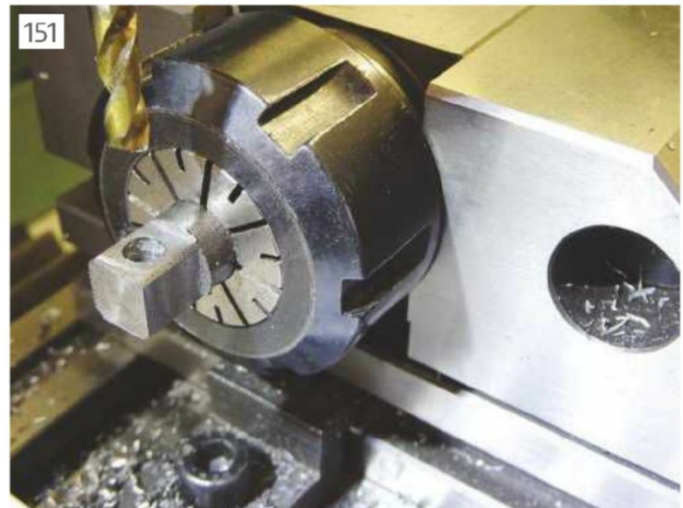
Close-up of square used to index the vee block



ER Block showing back of nut against vice jaws



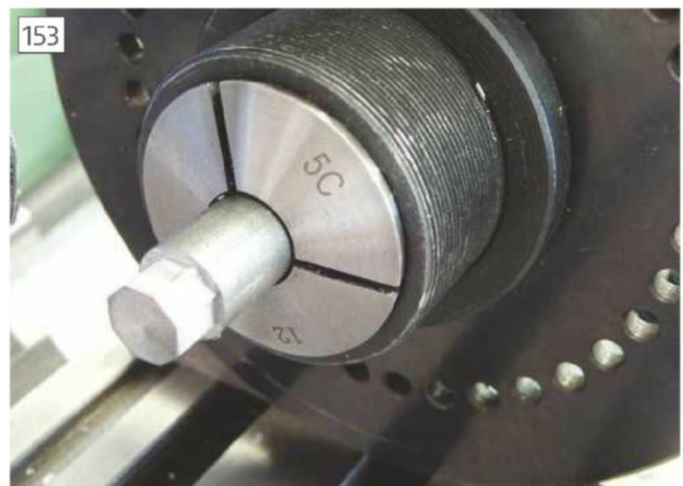
5C block in use showing positioning stop



Drilling hole square to faces of square



Milling a slot central and at right angles to hole



Octagon milled with spin indexer

beginners who will already have ER collets to fit the chuck for their mill. In use it is best to have the back of the nut against the side of the vice jaw which acts as a length stop. It is then simply a case of taking cut, stopping the machine and repositioning the ER block with the next face against the fixed jaw or bottom face of the vice, then taking another cut and so on, **photo 149**. Do take care to ensure that the block is sitting fully down in the vice as there can be a tendency for them to tilt if the piece of work is protruding a long way out the back, it should also go without saying that swarf should be cleaned out of the chuck at each resetting so that does not throw the work out of position.

Collet blocks are also available to take 5C collets which are more often used for work holding on the lathe. These are used in much the same way as the ER blocks except as they do not have a projecting nut a vice stop needs to be used if you want a set length of cut. **Photograph 150** shows a square being formed on work in a 5C block and a stop screwed to the side of the vice jaw. This is the best form of stop as it makes it easier to slide the block out of the vice for repositioning which does not need the tool moved as far between cuts to get clearance as it does to lift an ER block up and out of

the vice or if a rear stop was used on the 5C block.

Indexing is not just limited to machining external features, it can be used to ensure such things as holes, slots, etc. are at the correct angle relative to each other. **Photograph 151** shows the end of some round stock that has first been squared up as described earlier, then the work has been centred in the Y-axis and a hole drilled which will ensure it is at right angles to two opposite faces. In **photo 152** the block has been stood vertically with its next face against the vice jaw and a slot has been milled which will now be at right angles to the hole. Provided the Y-axis was locked between these two operations the slot will also be central to the work so no need for centre finding twice.

The same setup as shown in photo 152 with the block stood vertically can also be used to drill four and six hole patterns on a PCD if a suitable stop is used to locate the block against so it remains in the same X-axis position each time it is reset.

Indexers

As well as giving a greater choice of increments than 4 or 6 sided blocks an indexer makes the job a lot faster as it can quickly be spun around to the next

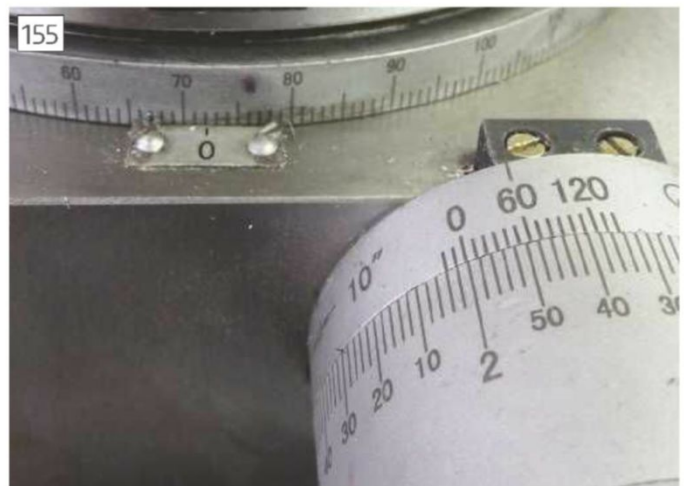
position which saves a lot of time over the stop-reset-start of blocks and if doing something like a batch of hex bolts makes the process a pleasant one.

Probably the most common one used for hobby work is the "spin indexer" which is designed to take 5C collets but a 5C to ER32 can be bought for them but the best option is to get the "Stevenson" version from our sponsors ARC Euro Trade as this comes complete with a special sleeve and closing nut that allow ER32 collets to be used as well as the usual 5C with the added bonus of reduced overhang.

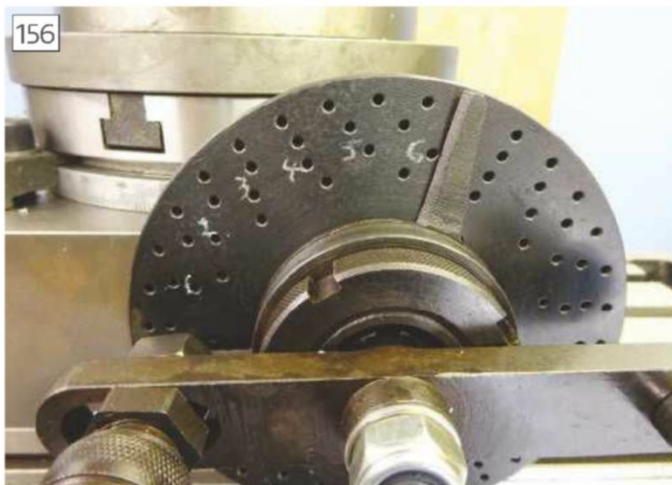
They work by having a detent which engages in a series of holes in an indexing plate and the one supplied generally has 36 holes. To use the spindle lock is first loosened and the pin retracted then the spindle and the division plate which is fixed to it is rotated to the desired position, pin pushed into the hole and spindle lock tightened. For simple indexing of numbers that will divide into the plate holes such as 2, 3, 4, 6, 9, 12, and 18 the pin is kept in the zero hole. If you need a number that will not divide into 36 then the additional holes can be used for any whole degree divisions such as 36, 45 and 72 degrees should you want 10, 8 or 5 divisions. **Photograph 153** shows an octagon that was indexed with the pin in



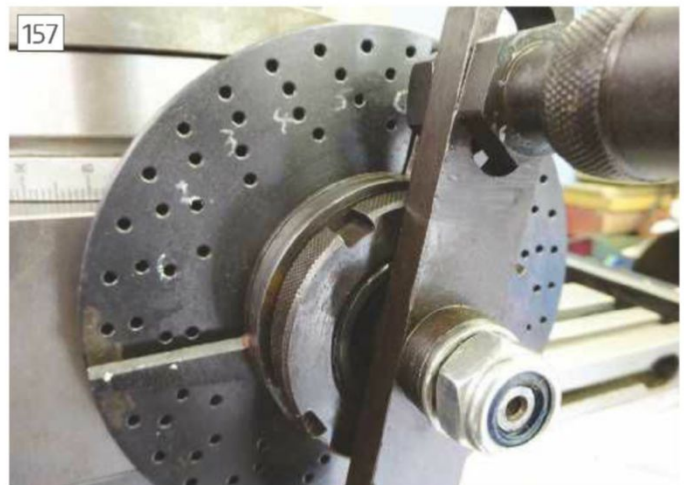
Pin and hole locations in spin indexer at position zero



Easy to ready whole angles to get 72 degrees



Arms set to give required number of CLEAR holes between them



Handle after turning 10 full times plus the 6 holes

zero at the 0, 9, 18 and 27 holes giving 0, 90, 180 and 270 degrees and the pin in 5 hole giving angles of 45, 135, 225 and 315 degrees for the other four faces. **Photograph 154** shows the arrangement of pin holes in the plate and casting.

Those starting out with older second-hand machines may find in with the tooling they get an indexer that uses lathe change wheels rather than a drilled plate. These can be used in much the same way as the spin indexer but if the number you want is not a multiple that suits the tooth count a different gear will need to be found that has a suitable number of teeth. On a similar note if you have the need to index a lot of parts with an unusual number of facets or holes then a purpose made plate can be made with just the number of holes required for direct indexing. If you have a DRO then they are easily made using the PCD function if not then co-ordinates can be quickly worked out using CAD or Zeus tables if they have the right number in there.

If you are going to be doing a lot of indexing, then they are also available where the work can quickly be indexed around to the next chosen position by just the pull of a lever but those are probably more suited to commercial batch work than the home workshop.

Dividing

This is a subject in it's own right so I will only cover a few basics, it is essentially the use of gears to reduce the angular divisions obtainable to less than 1 degree until a point is reached where an exact division or a multiple of that division will give the required angle between one point and the next.

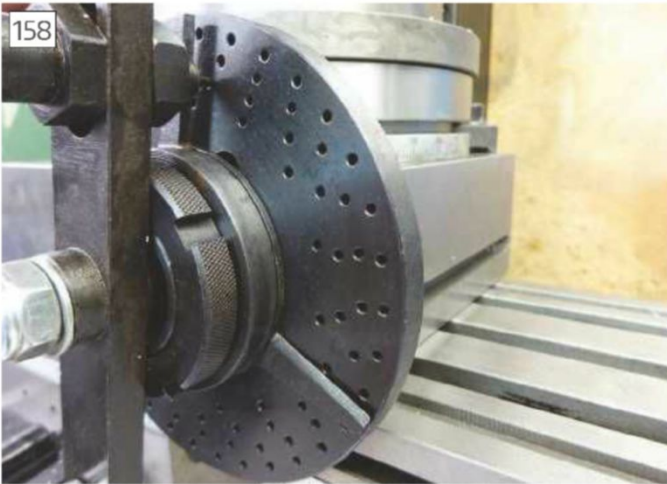
Simple dividing can be done with either a rotary table or an indexing head with the rotary table being the more versatile tooling as it can also be used for curved cuts. The spindle is driven by a handle through a worm and wheel which depending on what you have may have a ratio of 40, 72 or 90:1.

Taking the middle 72:1 ratio as an example on a rotary table for work that is not critical the scale on the table and hand wheel can be used for any number that can easily be read off the scales. Each turn of the wheel will move the table 5degrees (360/72) so if we wanted to drill say five holes equally on a PCD the handle would need to be turned 14 times (14x5 = 70) and an additional 2 degrees on the handle scale to get the required 72 degrees between each hole, **photo 155**. This is quite easy to read off the scales and keep track of but once you start getting into numbers that are less than a quarter of a degree or 15minutes its is easy to make a mistake or

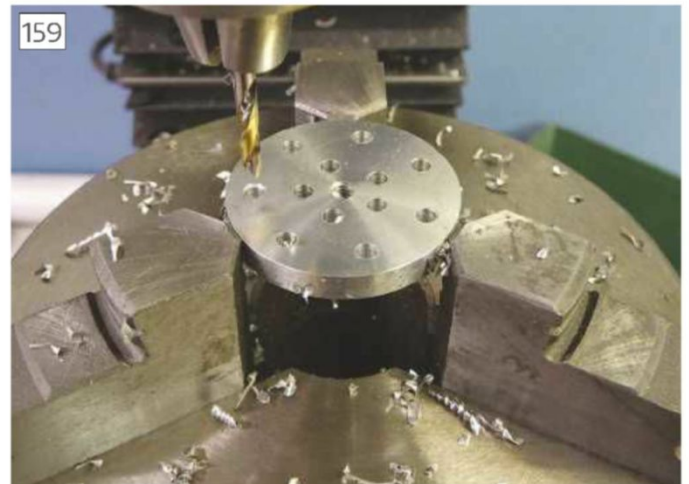
end up with errors if rounding up or down.

If we use a seven hole spacing as an example then the angle the spindle needs to move each time is 51.428571 degrees ($51^{\circ}25'43''$ and a bit) which is very hard to read off the vernier scale as you will be eyeballing the seconds between the 10 second division lines and the odd bit will need rounding up or down. For a job like this division plated can be added to the table or dividing head and the handle changed for one with a detent. It is then a matter of finding what number of holes in the plate are needed in combination with the reduction ratio to give an angular movement that your desired spacing is divisible by.

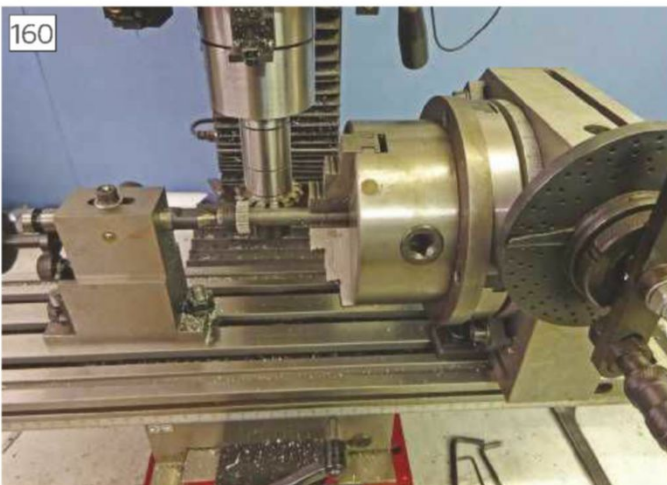
With luck your table or head came with a chart that shows what hole plate to use and how many turns of the handle are needed, if not you should be able to find an online calculator easy enough where the ratio and available hole plates are entered and it will give you the required hole and rotation information. For the seven-hole spacing on this 72:1 ratio rotary table the chart says to use the 21 hole plate with 10 full turns and 6 holes. Which when broken down gives:
 10 turns of 5degrees (360/72) = 50degrees
 6 holes of 0.2380952degrees ((360/72) / 21) = 1.4285712degrees
 Total 51.4285712degrees
 Desired 360/7 = 51.428571degrees



Arms moved ready to start the next sequence



7 holes drilled and ending up inline with the first hole



Typical set-up for cutting small gears



Close up showing cutter clear of work and chuck

Which allowing for the fact the dividing will be exact and my calculator has rounded things up very slightly will give an exactly equal spacing.

Putting that into practice after removing the hand wheel the correct plate with the 21 hole pattern is mounted onto the rotary table and then the dividing handle fitted to the worm and the detent positioned along the handle so that it lines up with the correct ring of holes, in this case the second ring from the middle.

Wind the table around to where you want the first hole or cut positioned and let the pin of the detent drop into the nearest hole. Loosen the two arms and bring one up to touch the pin on the opposite side to the way the pin to rotate the handle. Then move the other arm so that you have the required number of holes between the two arms, don't make the mistake of counting the hole with the pin in it as one of the six, you actually need seven holes - one for the pin and six empty holes, lock the two arms together when you have then set correctly, **photo 156**.

You can then make your first cut. When this is done pull the detent out of the hole and turn the handle carefully counting ten full turns from where it was and then put it back in the hole adjacent to the second arm which will be the additional six holes, **photo 157**.

Follow this by rotating the pair of arms in the same direction that the handle was turned until the first arm touches the pin. You can then make your second cut, **photo 158**, and carry on like this. For your first few attempts it would be wise to put a fine pen or point in the mill and use that to mark each position to check you have things correct and return to the same starting point as nobody wants half a hole or gear tooth, **photo 159**.

I have done a short video which shows the above procedure, there's a link at end of this article.

Compound and Electronic Dividing

Looking at the charts that come with dividing heads and rotary tables you will see that not all divisions are possible with the supplied dividing plates, in these cases it may be possible to work out the required number of holes and make a custom plate but another way around it if you have a dividing head is to use what is known as compound dividing. This involves using a hole plate to drive the worm via a train of gears instead of directly which increases the possible combinations to give the number of divisions wanted.

In more recent times the use of electronics to send a signal to a stepper motor that is used to drive the worm has

become more common and due to the small increments that the motor can be rotated gives a similar effect to compound dividing but with the bonus of letting the controller do all the maths and it does not over or under wind the handle or loose count part way through.

To finish off this part of the series I have included a couple of photos of a typical setup using a rotary table to cut gears. When cutting small gears, the chuck can get in the way of the cutter so the blank is best mounted on an arbor so it can be held where the gear cutter can pass right across unimpeded. If just cut like this the work would flex away from the cutter so it is usual to use a tailstock that can be bought as an accessory for most rotary tables to support the far end of the arbor, photos **160 & 161**. ■

The items featured in this series are available from Arc Euro Trade, **www.arceurotrade.co.uk**, who also sell the X series of mills. See the accompanying thread on Model Engineer Forum **www.model-engineer.co.uk/mfb** for more discussions about this series. Video Link **www.model-engineer.co.uk/mfb1**

A Simple Storage Solution for Quick Change Tool Holders

Roger Froud describes a straightforward but very useful way to keep your toolholders organised.



The toolholder rack, almost fully loaded.

Having acquired and made a number of quick change tool holders over the years, I thought it was about time I made a better way of storing them rather than putting them on the shelf. The following simple design was devised to achieve that.

I wanted something that would keep them out of the way but still have them conveniently to hand. I also wanted to have them in a position where any coolant would drain from them, back into the tray, **photo 1**.

The idea is simplicity itself, relying on the cutout in the tool

holder to hold them in place.

The individual holders, **fig. 1**, are held on a long length of M10 threaded rod, with spacers, **fig. 2**, to keep them apart, **photo 2**. The whole thing is clamped end to end with a pair of nuts, **photo 3**. The brackets on the end can be made to suit whatever lathe back you have, or perhaps go underneath a convenient shelf.

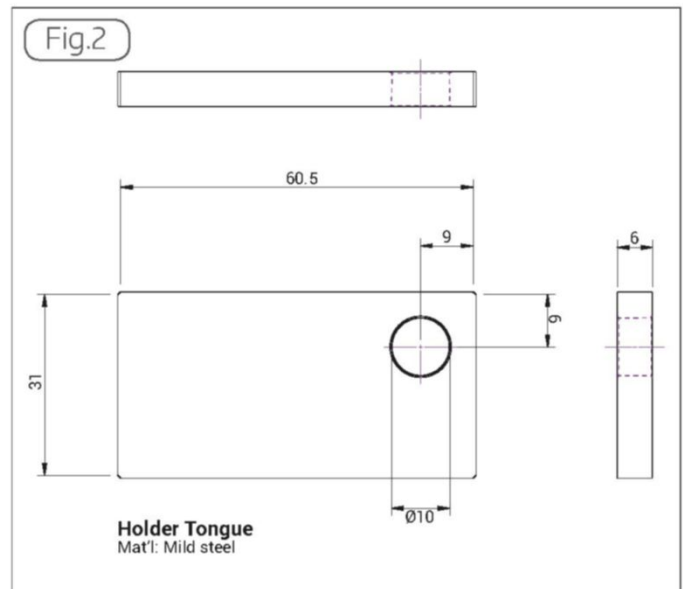
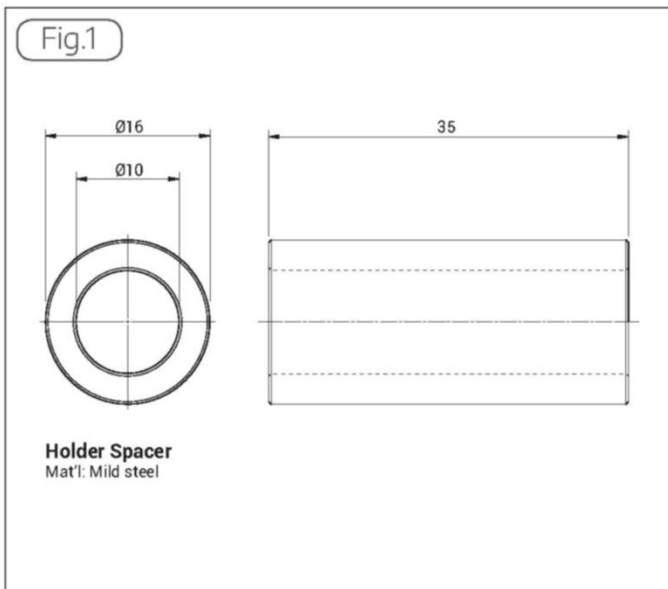
The idea can easily be scaled or adapted to suit different sizes of tool holders, these ones are typically fitted to Harrison or Colchester lathes. ■



The unloaded rack



A close-up to show how the rack is constructed.



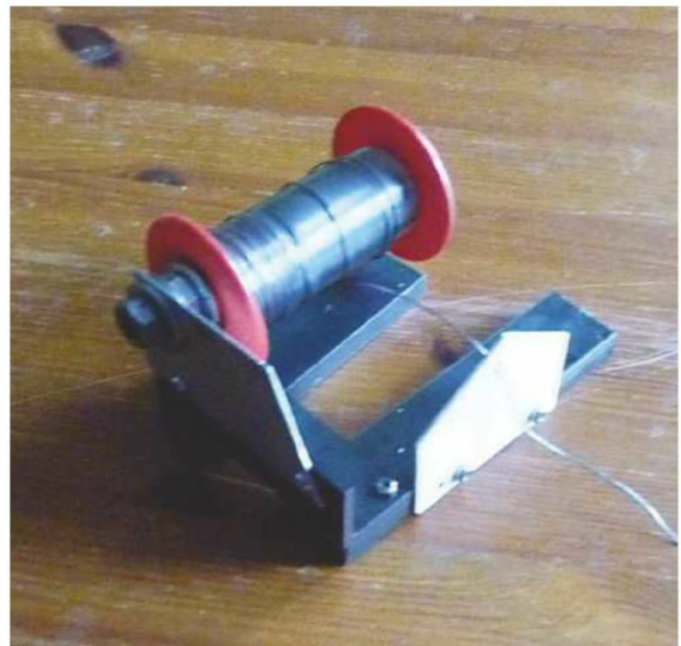
Solder Stand

Theasby's Wrinkles

Readers of Model Engineer will be familiar with Geoff Theasby's Club News column. His combination of bad jokes and randomised photograph captions has given him the reputation of being both politically incorrect and pictorially inaccurate. Geoff he also is a deep well of workshop ideas, so we will be featuring some of his 'wrinkles' from time to time, here's the first from our very own luminaire luminary:

Simple Solder Stand

One from the junkshop! Solder dispenser, using offcuts of steel angle and bar, aluminium sheet and Plastikard. It's weight kept it strong and stable, even in Storm Theresa... (That would be the meteorological one – Ed.) The solder reel doesn't wander about the bench whilst I'm building a circuit board and it supports the solder if making a joint in mid-air. Plastikard (Through which the solder feeds) is available in several thicknesses, this is 1.5 mm, can be cut with scissors and has no sharp edges to damage the solder. Embossed brickwork etc. finishes are available, if you feel like building a Southern Railway "Tavern Car" model, or even a rustic solder dispenser.... The solder feeds from below, keeping the height down (It's 65 mm high overall) the reel is a 500 gram size and hung on an M8 bolt. It could be fitted with non-slip feet if required. The steel bar was 25 x 10 mm, and it took me 15 minutes to hacksaw through it. (Memo to self, must get power hacksaw going again!) No dimensioned drawings, it depends on what's in your scrap box. ■

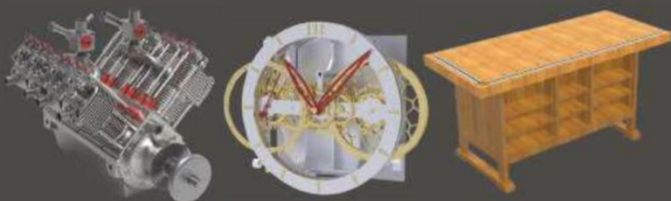


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Supersize Me!

Brian Wood extends a masonry drill to 2 metres in length



A typical SDS drill

I get interesting commissions from time to time and this was something completely different. My self employed electrician neighbour Andrew asked for my help with special tooling to help him install lighting at a local church.

The request for the work had been made by the Diocesan Advisory Committee for the church to conceal the armoured cabling supplying a set of vandal resistant outdoor lights and contain it in a trench in the churchyard by running it out neatly through a wall.

No problem you might think, but not in this case. The wall was in the bell tower, a Grade II listed structure, built about 700 years ago and estimated to be six feet thick in dense sandstone!

Background

As well as this being a very different sort of workshop challenge, the job had now acquired a flavour of pioneering work along the lines of the method used to drill the long holes for pre-stressing bars in the supports built under York Minster in the late 1960s to underpin the central tower.

The estimate of thickness proved to be pretty accurate, at the death the wall was 1.7 metres thick [5' 7"]

Andrew is an IMechE engineer and had already figured out a way ahead for the job; we discussed his thoughts and agreed on some modifications to the basic principles.

Accordingly, I was presented with a new Bosch 25mm diameter SDS drill bit of 1 metre working length and another shorter drill with the same SDS chuck fitting end. It was the biggest they had at the very well

equipped professional tool hire and sales organisation locally. On asking for their thoughts they said the job couldn't be done without expensive guidance equipment to get a hole to meet in the middle.

Bearing in mind that we are talking here about a 25mm hole and not tunnel boring, Andrew's ideas seemed perfectly reasonable to me; the recommended dual drilling approach was clearly a nonstarter anyway using hand held drilling methods. He is also a stubborn Yorkshireman and such a challenge was like waving a red rag at him, he was not going to be defeated by such negative thinking!

With the job finally done and dusted I now know rather better and will add more information further on.

For those unfamiliar with the term, SDS is

an abbreviation for Special Drilling System which very effectively combines rotation with rapid axial hammer action. A typical drill bit is illustrated in **photo 1**.

The induction brazed tungsten carbide tip is ground to a centred pyramidal shape and not sharp edged like a traditional drill; it works by battering the material into small chippings that are swept away as they form by the rotary action.

The tooling

The tool was made up from the 1 metre long SDS drill with its drive end inserted into a close fitting socket into a 1 metre length of 16mm diameter En1 black steel bar I had ordered in for the job.

At the other end of the bar, a similar socket was made to contain the drive end



The joint preparation

cut off from the smaller drill.

I had grave doubts about the heating effects of gas welding (all I have available) on the state of heat treatment in the drills so I made up a brazed test piece from another SDS drill in another section of bar of the same size to evaluate those effects on the drive fitting.

There was a little softening of hardness which I thought might be beneficial in this case. As a crude test, I hammered the test piece about in the vice to see if side strength had been affected, but that too also seemed satisfactory within the limitations of the test. Certainly, there was no sign of a brittle nature, which is at variance with what took place later on the job.

These joints are shown here side by side before brazing in **photo 2**. Note the filed out extension to the helical dust clearance slots on the drill body. I imagined they would be essential to prevent a choke when the drill was buried out of sight and reach within the depths of the wall. That would as a minimum be an embarrassing disaster. For the brazing I used Sifbronze to make all the joints in the tool; braze was fed in through the side holes in the joints to get well into the sockets.

Photograph 3 is a rather fine posed fashion picture of me in my overalls delivering the fruits of my labour. It does at least give a good idea of the size of the thing.

The drilling experience

The plan of attack by the team was to use another 1 metre long drill of 25mm diameter to make an initial hole and when that was at full depth, swap over to my modified drill to extend it onwards, using the hole as a guide to steer it.

Progress was very encouraging at first until about four feet into the wall when the drive fitting in the drill chuck broke off with all the signs of brittle failure.

Urgent work took place in my workshop to try and salvage the job and finish in what was left of the day which led to us crudely milling three flats around the drive end. Because of the length involved it needed a pretty hairy set up on my horizontal mill that involved hand bracing at the remote end.



Delivery

Crude as this was, it did at least give the circumferential locations for an angle grinder to deepen and lengthen them to allow gripping by a three jaw SDS drive drill chuck.

This approach failed miserably on the job as hammer action cannot be used successfully in that way since all the hammer action is dissipated within the chuck itself. Forward progress was now measurable in microns, if at all.

A new attempt was made on Day 2, having now brazed in the cut off drive end from a well used 16mm diameter drill, this time using a length of the full diameter of the drill. It was joined to the bar with a sleeve and is shown here in **photo 4**.

Without knowing any better, I hoped this would improve the control of heat decay back into the coupling. The original attempt had used the old dodge of a raw potato stuck on the end of the coupling, a

method I had been doubtful about in this case anyway.

Despite all the care and attention this new attempt failed within two minutes of use before brittle failure again took place at the same spot as before on the coupling.

By now the electrical team was beginning to think that the Good Lord had taken exception to this assault on His church, either that or they had a closet heathen in their midst!

Better success with a new approach

Fortunately, I was able to take advantage of a supply delay in the lighting units that were coming from Germany so there was time to try again in somewhat less of a rush. This time a 1 metre long 12mm diameter drill had been bought to be used as a pilot from the existing hole, we would then drill back from the outside after breakthrough and bring the final hole up to 25mm diameter throughout.

By now I was getting rather concerned about the reductions in the length of the black bar from cutting off the failures, it would take too long to get a fresh length in time for the job so I tried to remove the 25mm drill from the end of the bar.

Even with the braze dribbling out of the fitting it would not let go and what I thought was rotation was actually necking of the small end within the hole. The bar also bent during this battle.

I could have saved the gas and cut it off instead which is what I had to do but with an extension to remove the bend in the bar.

This time even more care with the joint preparation measurements was taken with to preserve both the length of the working end and, hopefully, leave enough of the drive end to contain the condition of temper.

With fingers crossed as well, it was cut through at about a quarter of its length.

I had to trust that gave enough length back from the 12mm drilling tip to the coupling to prevent fouling before breakthrough by the coupling within the wall that would get close to the mouth of the smaller diameter hole. There was a very definite element of "muck or nettles" creeping in by this stage!



The new joint on attempt 2



A new joint on attempt 3



Breakthrough

The whole assembly was laid up for alignment in angle iron as in the arrangements used in the other constructions and the new joints were brazed together. **Photograph 5** shows the re-purposed joint from the 16mm attempt with the 12mm drill fitted instead, it is certainly not a prize winning piece of work but from the experience gained in trying to break a joint it was clearly plenty strong enough.

Day 3 dawned and as it was a Saturday the boss himself took charge to try and salvage some lost time. I was pretty well keyed up as well as this approach with the smaller diameter drill was really the last shot in the locker without starting over and running into criticism for the added delay.

You can imagine my feelings then when he phoned to say "Well-----" paused dramatically for what seemed a long time, before announcing that breakthrough had happened in under half an hour. It was all over!

Photograph 6 shows the breakthrough which came out directly into a shallow trench outside the church wall. The lights themselves would not look out of place on a warship, they are massively made and really heavy.

Photograph 7 shows them looking just as solid and unmoving as the Easter Island statues and about as pretty! The church authorities however love them.

With buried cables as well and fresh plant growth to hide the runs the installation should stand up well to defeating the metal thieves in our part of the country.

Postscript

Photograph 8 shows the first of the failed joints in close up with clear signs of a rapid brittle fracture. The second failure, at exactly the same point, was not so easy to diagnose as there had also been rotary polishing on the broken faces. It had happened just as suddenly, straight



"Bomb proof" lights

through the coupling without any deviation and displayed all the other hallmarks of brittle failure.

I did file hardness tests on both of these broken sections and yet more on my earlier brazed test piece as well as on a new SDS drill without finding significant differences between them. Clearly hardness, or any lack of it, was not a factor here. So what other possibilities existed?

The speed of failure in only two minutes working of drill 2 was clearly an extreme reaction to severe stress and I can only consider that some form of complex harmonic standing wave effect was taking place.

The tooling as a whole would be expected to contain multiple resonant frequencies when in use which could have combined and focussed on that point in the set up as perhaps an obscure effect of damping within the hole acting on the combined length of the tool.

The two failures were in identical positions and the only thing that had changed in the tooling geometry between them was a rather small difference at the drive coupling end.

It is compelling to make the comparison here with wine glasses being made to shatter from induced sound waves resonating within them.

I find it significant that the only major change to the tooling geometry was with the rebuild using the smaller diameter drill which gave the final success; it would most certainly have had big effects on sound paths within the tool as a whole.

The new combination raced through the remaining 19 inches of stone without any trouble at all.

All this is conjecture on my part of course but I don't like unexplained failures that are uncannily similar to each other; it is even less satisfactory to just write them off as "just one of those things".

What has though been a positive

outcome has been the knowledge I have gained of the really surprising strength of a virtually empty brazed joint, there was no yielding in it at all at red heat. Given another such job in the future I will be much better prepared for it and tackle it in a different way.

I was given website directions from a completely unrelated but interested party to direct me to the Silverline range of SDS drills who market, amongst others, 24mm diameter drills at 1.5 metres working length and at what looked to me like suspiciously low prices..

One of these would still have been 200mm short of penetration in this case but it might do for a less demanding job. On learning this and exploring the Bosch professional website to see what other drills they might have, I found it was very badly let down by the quite useless search facility.

I gave up trying to wade through the thousands of products displayed.

I do know from a brief glimpse of one page that they do much longer drills but couldn't note the details in time before contact was lost entirely.

I then tried the Heller website but couldn't get beyond the message telling me the site couldn't be reached and to please check spelling or try blah, blah – life is short enough and clearly my server had also had enough as well!

Sadly, the eating of humble pie later at the tool hire place was rather uneventful and it took the shine a little off the triumph; perhaps the choking was too well concealed to be evident! ■



A clear view of the fracture face

Mounting a drill chuck on a tapered arbour

Pete Barker strikingly demonstrates the power of tapers carefully assembled with basic tools



Chuck and arbour arrive in two pieces, ready to be assembled.



Assembly tools are a copper faced hammer and diamond file.

A new drill chuck and Morse taper arbour purchased recently arrived on my doorstep in two pieces, **photo 1**. But not to worry. Assembly is a simple matter using the most basic of tools, **photo 2**, and the job has since proved both accurate and surprisingly sturdy.

Two different tapers make up the typical drill chuck arbour. The longer end is a Morse taper that must fit into your lathe tailstock or drill press spindle. In the case of The Flagellator, my 1937 Drummond M-type lathe, this is a smallish No. 1 Morse taper. Later Myfords and Far Eastern mini-lathes will take the larger No.2 Morse taper here. The arbour's other, shorter, taper is usually a Jacobs taper, designated in this case a JT2. Or it might be a more modern DIN standard taper designated as a B12 or such. In any case, it must be the same taper as the hole in the chuck body. Often this is marked on the body, and usually on the packaging it comes in.

Initial clean up

As both chuck and arbour were low-cost hobby market items, careful inspection revealed some burrs left at the ends of both male (arbour), and female (chuck), tapers. These burrs need to be removed before assembly or they will stop the tapers from gripping each other. The arbour was supplied hardened so small diamond files were used, a flat one for the arbour, **photo 3**, and round for the chuck, **photo 4**.

Cleanliness is next to godliness if you

want a heavenly bond between tapers. They depend on the wedging action of the tapered surfaces to stick together and transfer the rotational load when drilling. Any trapped particles will keep the surfaces separate and deter gripping, so acetone was used to wash away any filings and grease or dirt on the male and female tapers. It is best not to use alcohol or degreaser as these can leave salts or oils

on the tapers which impede grip. Harley-Davidson race team engineers for many years washed their tapered crank pins with distilled water before assembly for this reason. With 80 to 100 horsepower going through a single crank pin, grip was critical. Whichever fluid you use, final clean is a wipe down with a lint-free kitchen wipe or cloth. Once cleaned, do not leave fingerprints on the mating surfaces.



Great care must be taken to remove burrs from the taper ends.

Getting it together

Assembly is simple but requires care. Once the two parts are scrupulously cleaned the arbour is "wrung" into preliminary position by hand. This consists of simply putting the tapered arbour in the tapered hole and pushing them together with a twisting motion. This seats the taper in its hole and helps the arbour go in straight in the final step.

Now we are ready for the application of controlled brute force to join the two pieces together permanently. Avoid using excess force such as a hydraulic press, large vice or four-pound sledgehammer. These can drive the tapered arbour in too far and warp the chuck body, even jamming it. All that is needed is one or two good blows from a medium-weight copper-faced hammer to the end of the arbour. Before striking such a blow, retract the chuck jaws out of harm's way and set the end of the chuck on a solid flat surface. I used a one-foot square of 5/8" steel plate set on the end of my bench that is reinforced around the vice. A piece of paper was laid on it to help prevent the chuck from skidding if my hammer blows were not perfectly vertical, **photo 5**.

One firm blow from the hammer should be enough to seat the taper. Being a belt-and-braces kind of fellow, I gave mine a second blow just to make sure. When striking, avoid a pecking motion and follow through firmly so the taper does not try to bounce back out of its hole.

A gripping test

The first test after assembly was for accuracy. Mounting the arbour and chuck in the headstock spindle of The Flagellator, a piece of round silver steel bar was gripped in the jaws. A dial indicator measured a runout of just one thousandth of an inch, **photo 6**, a good result indeed for a drill chuck, especially a low-cost unit like this one.



Test piece runout is measured at .001", a good result.

Next came the acid test: grip under load. A piece of scrap bar was drilled with a 1/2" drill bit with the shank turned down to fit the 3/8" chuck. There was no sign of movement of the chuck or arbour, proving there is nothing wrong with our assembly. A final test, done mostly for amusement, was to enlarge the hole with a 1" drill bit fed in under heavy load, **photo 7**. There was still no sign of slipping either of the chuck on the arbour or the arbour in the tailstock. A year of use has seen no change in this grip under more usual workshop conditions.

Conclusion

Careful deburring and cleaning of tapers followed by careful assembly with firm, but not excessive, force creates a surprisingly strong grip, more than sufficient for the home workshop. ■



A round file works best to deburr the end of the chuck taper.



Arbour and chuck are wrung together and placed on solid surface before the arbour is driven home.



Taper does not budge under load when drilling a one-inch hole with heavy feed.

Readers' Tips



A simple solution for cleaning threaded holes



This month our lucky winner of £30 in Chester gift vouchers is Neils Borgen who has a simple solution to cleaning up threaded holes.

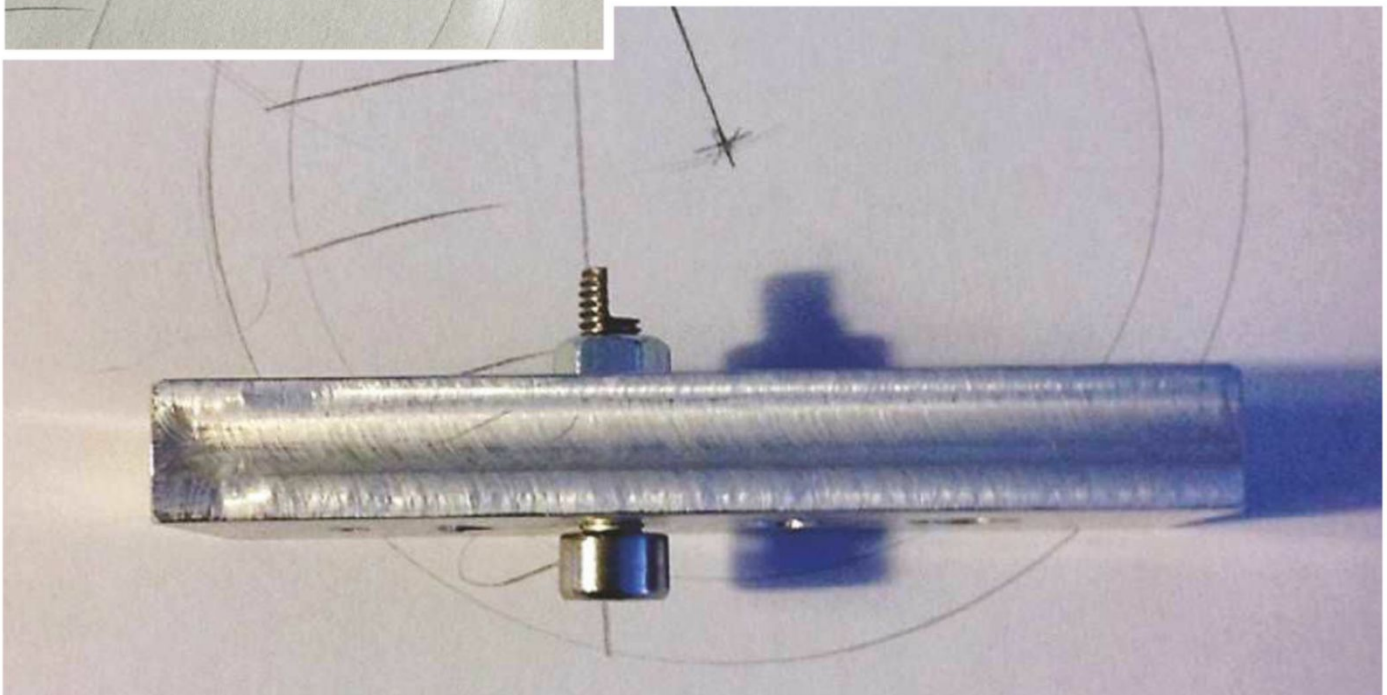
An article about a simple thread cleaner made me think of an even simpler one.

Please take a look at the photo showing some samples.

The cleaner is manufactured by screwing a bolt into a threaded piece of rectangular aluminium.

A nut is added and tightened to make sure the bolt won't rotate when milled. The aluminium is placed in a vice and the bolt is milled using a vertical mill and a 6mm diameter end mill. More than half of the diameter of the bolt is milled away to obtain an optimal cutting angle on the thread cleaner.

Niels Borgen



We have £30 in gift vouchers courtesy of engineering suppliers Chester Machine Tools for each month's 'Top Tip'. Email your workshop tips to neil.wyatt@mytimemedia.com marking them 'Readers Tips', and you could be a winner. Try to keep your tip to no more than 400 words and a picture or drawing. Don't forget to include your address! Every month I'll chose a selection for publication and the one chosen as Tip of the Month will win £30 in gift vouchers from Chester Machine Tools. Visit www.chesterhobbystore.com to plan how to spend yours!

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An Eleven-Inch Rotary Table

Part 2

Richard Wightman makes a bumper accessory for his mill.



Mark out and drill four 6mm holes



Using a transfer punch to mark the steel plate



Drill and tap the steel disc



Four short springs

Mark out for 4 bolt holes and drill 6mm, **photo 17**. Drop the brass disc into the brake disc and using a transfer punch mark the 4 holes onto the steel disc, **photo 18**. Remove the steel disc, drill 5mm and tap M6. If you look closely at the photo you will see that the nearest hole has been stamped with a number 1. The corresponding hole on the brass disc is likewise stamped with the number 1 to ensure the parts are fitted in the correct position, **photo 19**. The parts are held

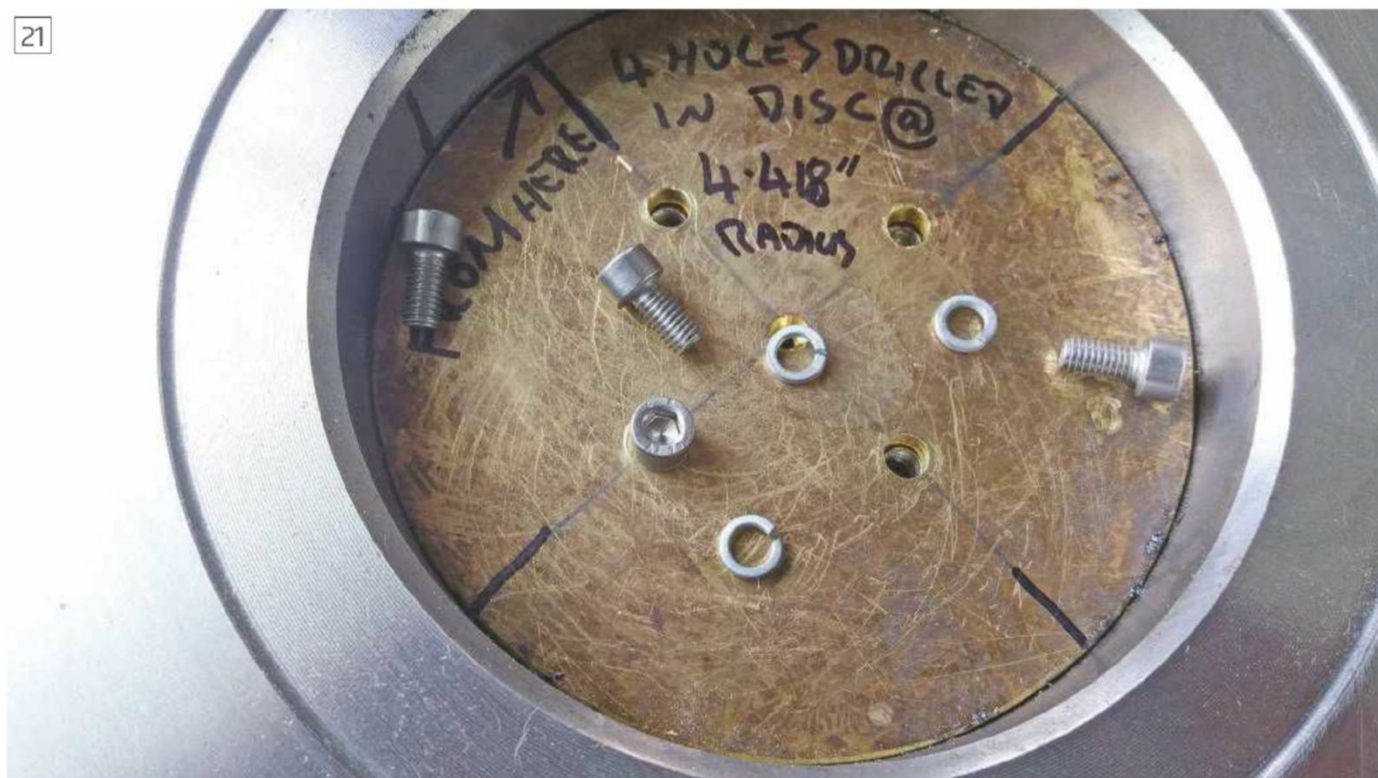
together with four cap screws. I originally assembled it with four short lengths of spring to apply pressure but leave the table free enough to turn, **photo 20**. I later changed the springs for spring washers as a small amount of lift could be detected and they worked much better, **photo 21**.

The rotary table can now be assembled with plenty of oil, **photo 22**. Centre the rotary table under the milling machine quill with a centre in the brass disc, **photo 23**. Then tighten the nuts that hold the base

plate to the milling machine table, **photo 24**. An indelible pen is used to write some information on the inside, **photo 25**. Move the milling machine table over and drill and tap four M6 holes, **photo 26**.

Mark out an 11" circle on the piece of 20mm thick MDF, **photo 27**, and cut out with a jigsaw. Finish the edge on the disc sander. Drill four 6mm holes to match the four holes tapped in the disc and countersink. Fix the MDF to the brake disc with four countersunk socket head screws. ➤

21



Spring washers

22



Assemble with plenty of oil

23



Centre the table under the quill

24



Tighten the base plate mounting bolts

25



Information written in indelible pen

For the job in hand I have made an adjustable stop. On the underside of the disc drill and tap two holes for M6. Drill two corresponding holes in a short length of steel bar and bolt on, **photo 28**.

A length of angle iron has two M10 holes drilled on one face to match the 'T' slots of the milling machine table. The other face has a slot milled to match the height of the

stop bar, **photo 29**. Two nuts and bolts are fitted into the slot to provide adjustable stops, **photo 30**. A modification for larger work pieces will be a single post fitted into one 'T' slot and two steel bars fitted to the disc something like **fig. 2**.

The operating handle is a steel bar ground at one end to fit into the vents in the disc, also shown in **Photo 30**. As

a bit of a guide I printed out a protractor and glued it onto the MDF, also shown in the photo. The next time I will also print ever decreasing circles which will aid when mounting the work piece. Because the table is larger than A4 paper size I had to print out on two sheets of paper and make a joint across the centre. While the rotary table is centred under the quill bring it down to



Drill and tap four M6 holes in the face of the disc



Mark out an eleven circle on the MDF



Drill and tap for the stop bar



Machining a slot in the stop



Adjustable stops and operating handle

press a centre hole in the MDF.

To lock the table a post of aluminium is fitted into a T-slot, cross drilled and tapped M8. An M8 cap head is modified with a T-bar and a soft aluminium pad fitted, **photo 31**.

That's about it for the construction. In practice it works exceptionally well.

The job in hand was to machine a pair of

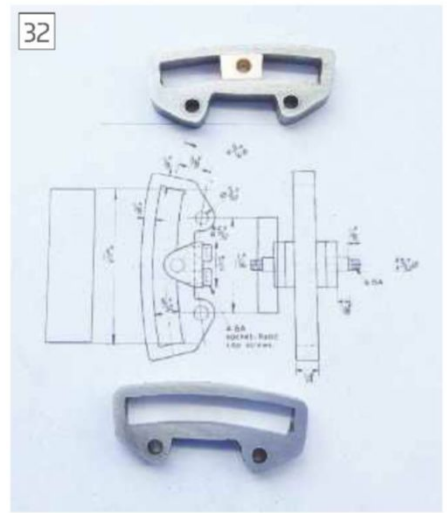
expansion links, **photo 32**. To save time marking out I print out exact size drawings of the part required and glue them to the material, in this case $\frac{1}{4} \times 1 \frac{1}{4}$ " gauge plate. The rotary table is centred under the quill. The Y axis is moved over $4 \frac{9}{16}$ ". Place the blank on the table and bring the quill down so that the point of the centre presses down onto the blank at the required

position. Screw the blank to the table. Raise the quill a little and turn the table back and forth and set the stops. Drill the blank at each end then machine away with an end mill, **photo 33**. It's surprisingly easy to turn.

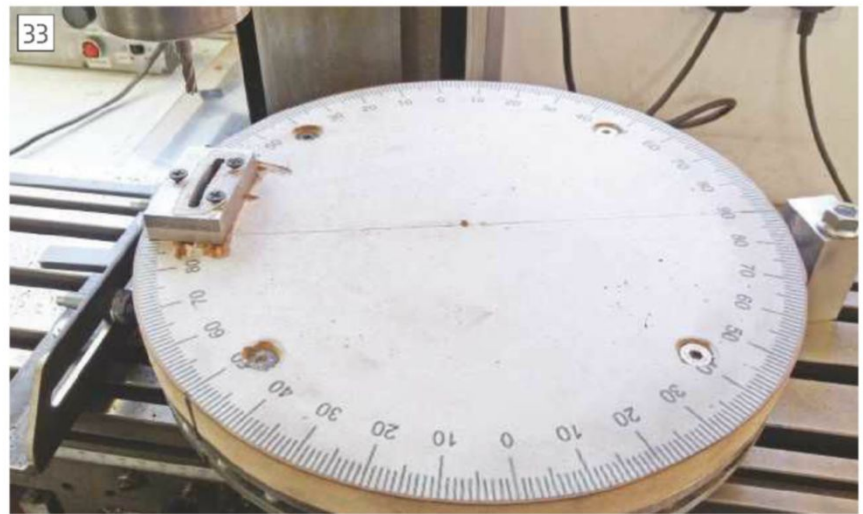
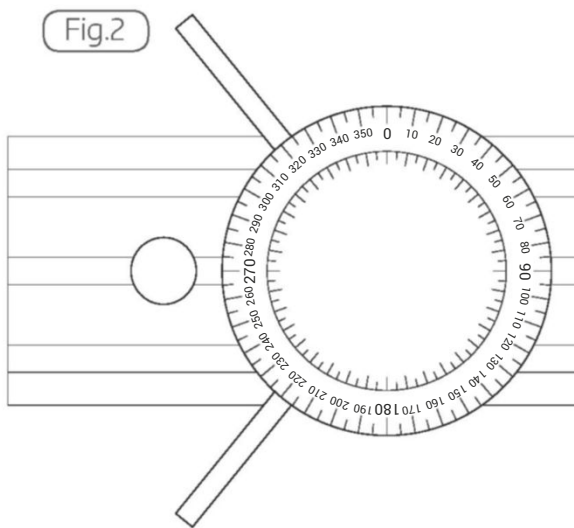
As a comparison I have placed all 3 rotary table on the mill, **photo 34**. Its always satisfying to make a bit of kit that works and in this case it works very well. ■



Table lock



A pair of machined expansion links



Machining the expansion links



All three tables

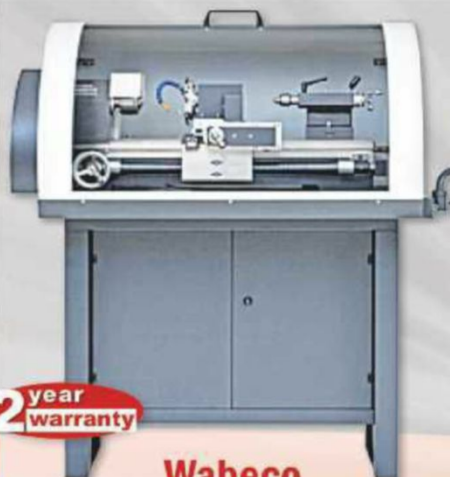
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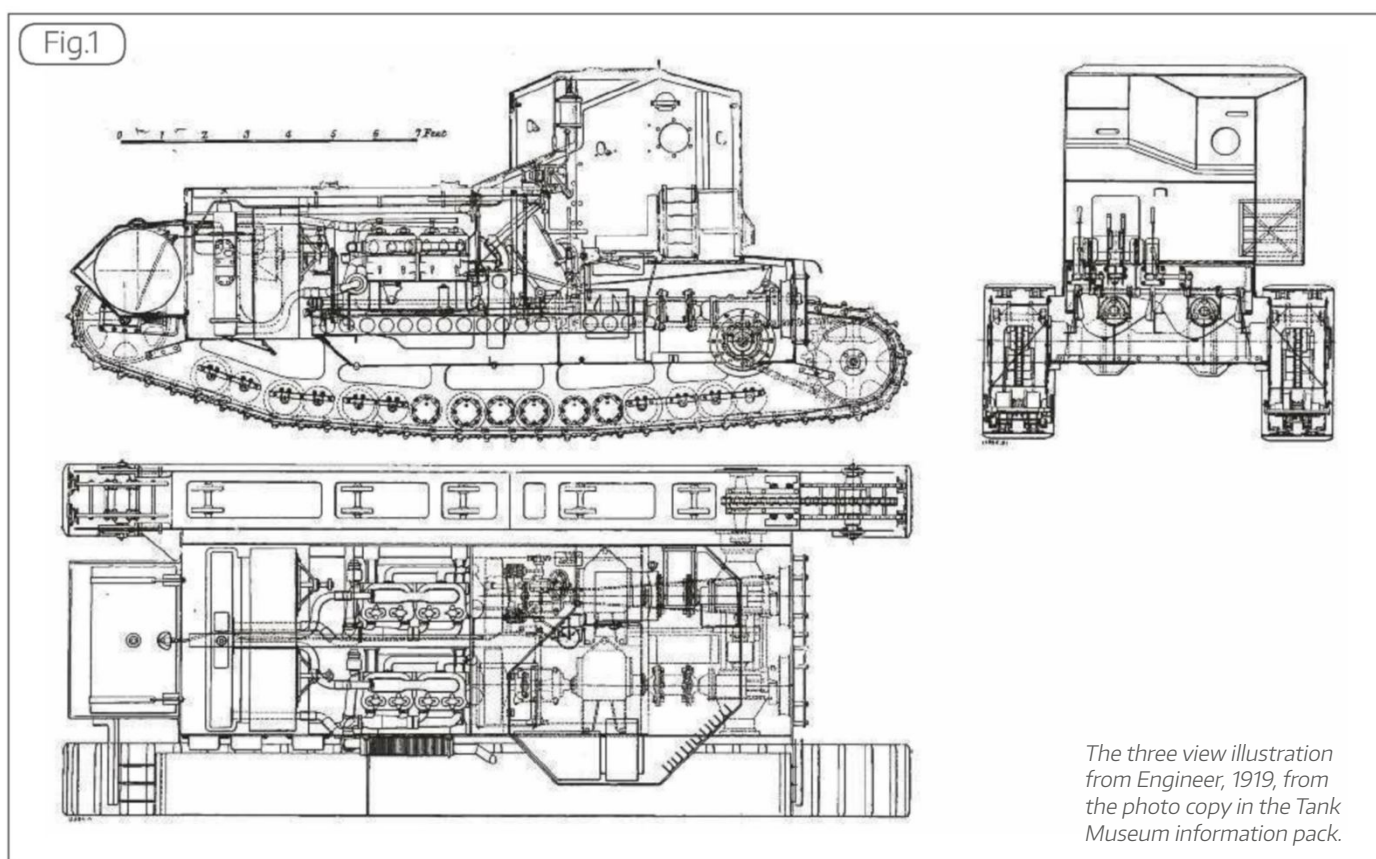
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How Alibre Complements My Workshop Tools

Stephen King explains how he uses CAD to support his modelling.



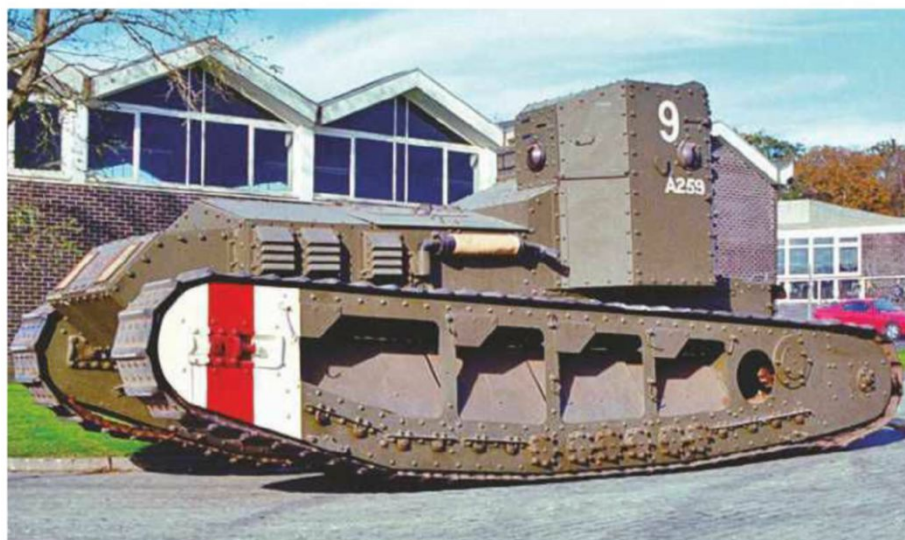
My father was an instructor at Bovington; I started work at Bovington; I started work at Fighting Vehicle Research and Development Establishment, Chertsey and was posted back to Bovington as a student on the Long Armour Course that dealt with tank design. Small wonder that when I came to retire, I should choose a project that entailed making something and tanks.

The choice proved quite simple based on my lack of machining skills. It should have flat panels fabricated with bolts or rivets but no welding/brazing (fire risk in a terraced house) and need a minimum of machinery to produce shapes. The choice was obvious: a WW1 Tank – not the giant Mk IV but the Medium Mark A, Whippet, **photo 1**, with 4 stroke petrol engine and radio control.

The first requirements of any project are the dimensions and shape of the object to be modelled. The Tank Museum was able to produce a helpful information pack and, of course, housed the actual vehicle at Bovington. The pack contained one 3

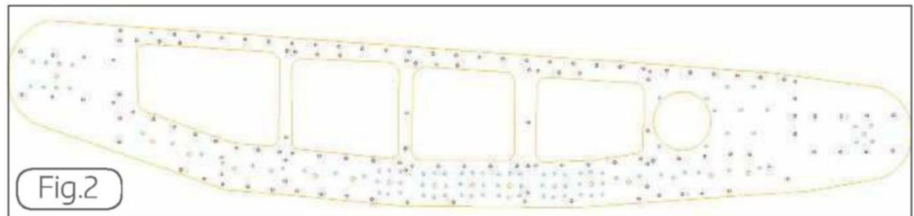
view illustration printed in *Engineer*, dated 1919, some postcard sized blueprints of the outline and a drawing of a track plate plus

some ¾ view photos. This would be meat and drink to seasoned, scratch building model engineers but I really was starting

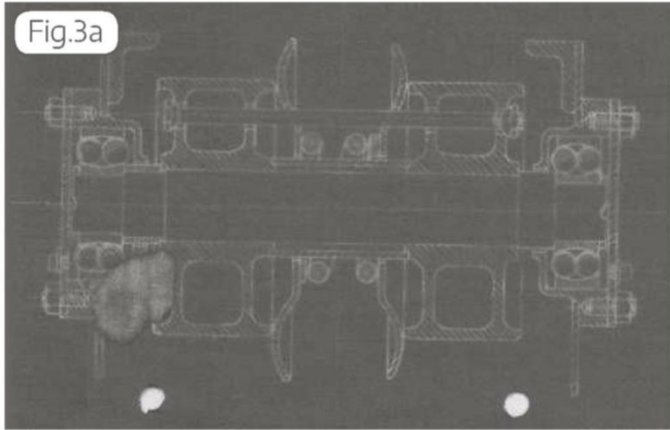


The newly restored Whippet at Bovington. Tank Museum.

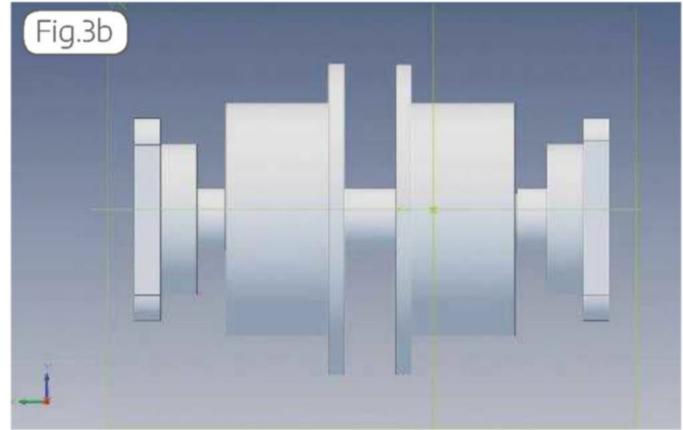
I will concentrate on describing the process of producing the working drawings as this took several years before being able to acquire and house the machinery. Some work from the back of an envelope while others use pencil, paper and T-square or even a 2D CAD package. We did very little engineering drawing at Birmingham



Exported Drawing of the Outer Track Frame for Laser Cutting.



Heavy Road Roller Assembly from the Blueprint. Tank Museum.



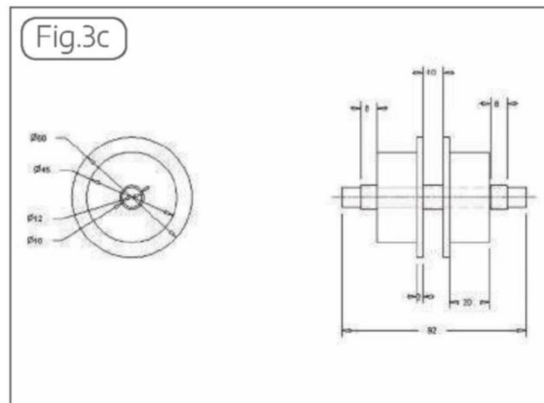
The Heavy Road Roller Axle Assembly remodelled in Alibre.

University and I proved to be no artist. There were 2D CAD packages available for home use but at that time they were very unfriendly. They also wanted measurements for each line that I did not have. Some had 3D facilities but these mainly consisted of declaring spheres, cubes etc. and combining them.

Parametric design was available in 3D CAD as represented by AutoCAD or Solid Works but not affordable for the home user. About this time, I discovered the old Alibre. It was the only affordable package for home use that followed parametric design allowing me to concentrate on the shape and relative spacing of the object and add measurements later.

The means of obtaining the basic dimensions proved to be “interesting”, in the Chinese sense, either measure the Bovington exhibit, scale photos or the Engineer three view illustration. Physical measurement would be tedious and lead to accumulating of errors. Photos are seldom fully side on and suffer from perspective even if they are. That left the three view illustration from Engineer.

The three view Engineer illustration was a work of art, very detailed but not an



*The Drawing of the Heavy Road Rollers
produced automatically by Alibre*

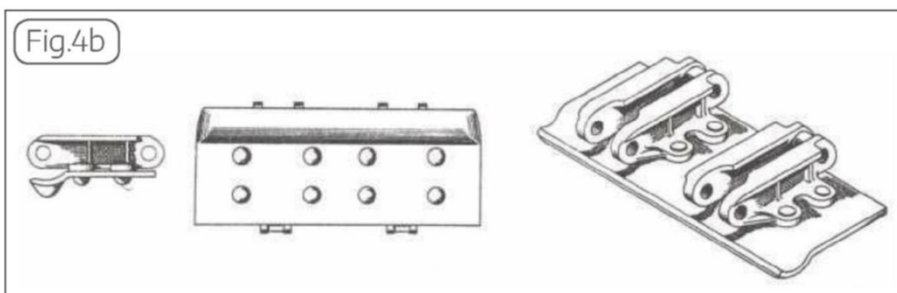
engineering drawing following modern conventions, **fig. 1**. It is effectively an assembly drawing that is very precise in shape and detail but understanding the section planes proved to be a minefield. Overall, I had only two precise dimensions (the horizontal distance between idler and sprocket centres and total height) from the blueprint cards. The track plate drawing gave two views that were helped by an illustration in old report held by Tank Museum. The overall effect was inscrutable and trips to Bovington revealed that all

detail of the tracks and running gear was hidden behind the side armour panels.

The first problem was the shape of the track frame side panels. They had subtle changes in direction and partial circles at each end. This did not favour building the shape from scratch in the Alibre Part module or in 2D CAD. The Alibre concept is to create the 3D model and internally export this to the Drawing module to produce the normal three view engineering drawing. However, a scan could be imported into the 2D CAD, traced, tidied and exported as a DXF. David Jupp, the technical expert at Mintronics, said that I could go in the back way by importing the DXF into the Drawing module. It could be tested by Alibre for inconsistencies then cut & pasted into the Alibre Part module workspace.

Those with the sharper eyes will see that the elevation view from Engineer shows a section through the upper track run to the engine bay. Those lines were estimated and added in the 2D CAD. The result was a closed figure outline showing the track frame side panel shape together with all the rivet, axle and mud chute holes. It only needed the magic dimension 1046 mm declared for the horizontal distance between Idler and Sprocket axle centres and it was done. The files for inner and outer track frames, **fig. 2**, were exported as DXF and the disc sent to a laser cutting firm. They produced a precision result far better than anything I could have marked out and machined.

Next up was the running gear: Tracks, road wheels, Sprockets, idlers, axles and bearing mounts. Here the data came from the Tank Museum's miniature blueprints, **fig. 3a**. However, these diagrams were really assembly drawings albeit with



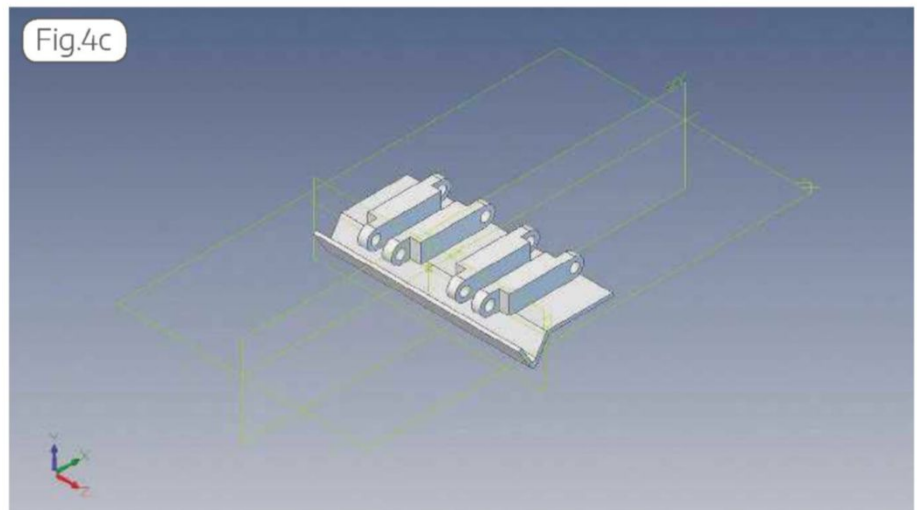
Individual Track Link. Tank Museum.

some useful measurements, but the blueprinting had suffered with age and smudging and there was at least one conflict in the measurements between drawings. The individual parts were recreated in Alibre, **fig. 3b**, using the measurements from the blueprints. They were then fitted into the virtual track frames to check against the photos and adapt for modelling purposes. A problem was found in the idler adjuster bracket. Unusually two different views were available for this part but some of the dimensions shown differed. While the running gear parts for the heavy and medium tanks were identical, the photos suggest that this bracket may differ slightly hence the conflict was indicated. Modelling the part in Alibre showed where minor adjustments would solve the problem and the relevant dimensions were easily changed.

Once the 3D model parts were complete, it was easy to transfer the data internally, straight to the Drawing module. Opening the Drawing module showed the standard view layout 2D working drawings, **fig. 3c**. These can be dimensioned automatically but was done manually for convenience of placing.

The original tracks may be pictured as two engineering or welded chains with bent link extensions on both sides, with a track foot plate riveted across 2 side by side links, **fig. 4a**. Shows the basic drawing of the Track Link and Roller Assy from the Tank Museum information pack. It took some interpretation! **Figure 4b** was discovered in another Tank Museum report and provided more useful information on the shape. The final design used was simplified as shown in the version produced in Alibre, **fig. 4c**. **Figure 4d** Shows a reproduction track link assembly produced sometime after WW2. Again, sharp eyed readers will see that the links are back to front when compared with **fig. 4b** thus highlighting the difficulty in interpreting the original drawing in **fig. 4a**.

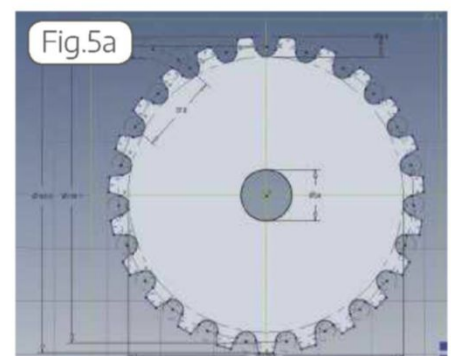
Initially the sprocket design appeared straight forward. The blueprint and Engineer illustration showed that it had 23 teeth and the "chain" pitch was 38 mm at 1/5th scale but it spanned 2 teeth. The originals were probably standard sizes in 1916, alas no longer. There is a well known bodge where you drill roller size holes



Individual Track Link reproduced in Alibre.

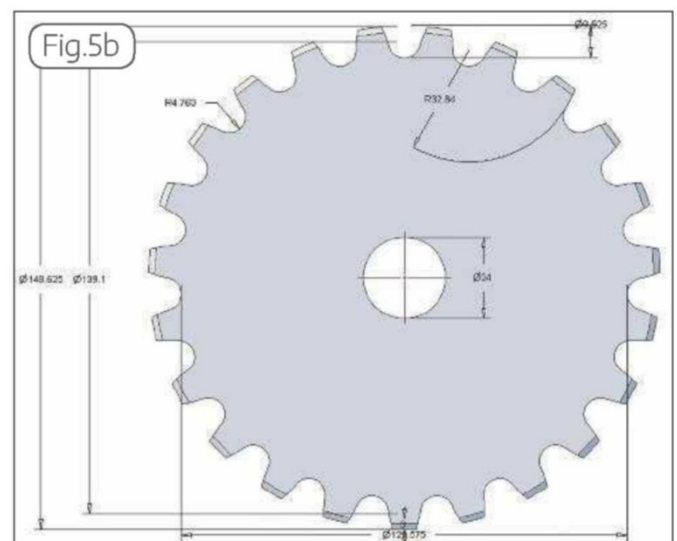


Reproduction Link at Bovington.



Sprocket Construction Sketch from Alibre.

round the sprocket PCD, cut down to just above the PCD and approximate the shoulders by filing. The idea was modelled in Alibre and the tooth shoulder radius found by scribing an arc from the roller centre two teeth away. The 3D virtual sprocket was converted to a 2D drawing in Alibre, **fig. 5**, and sent to my cousin, Stephen Day, in New Zealand who was able to have

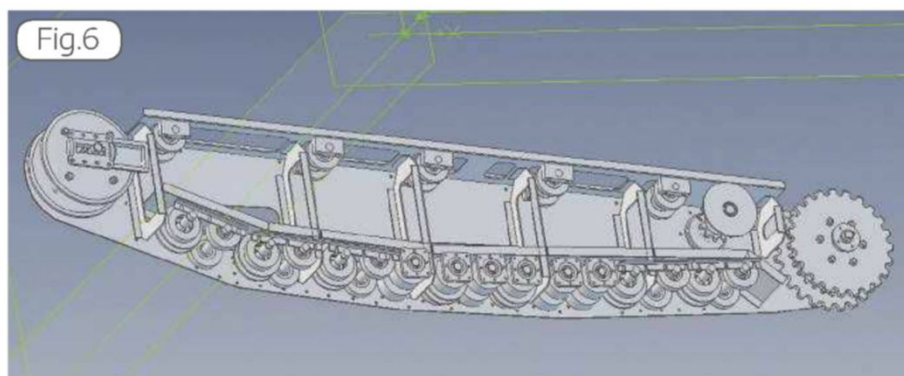


The Drawing sent to New Zealand.

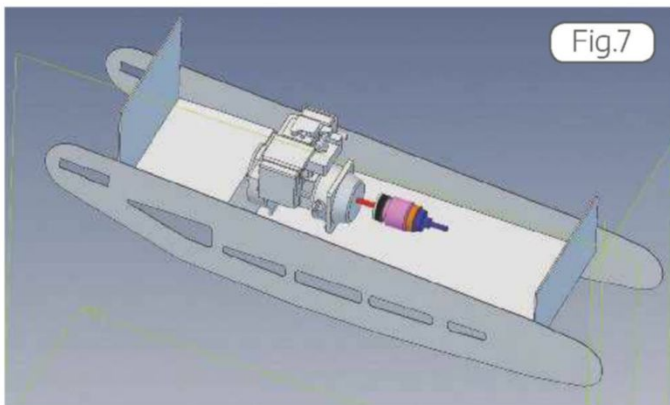
them laser cut for free.

The final layout for the Track Frame and Running Gear is shown at **fig. 6**. Note that the outer Frame Panel has been removed.

The engine and transmission have yet to be thought out in detail for production, but some virtual modelling has already been done. There were concerns about size of engine (a 31 cc Honda GX31 strimmer) fitting into hull interior space. The engine was laboriously measured, and all protuberances noted then fed into Alibre as a series of parts to give an acceptably accurate assembly. This assembly was then



Alibre Mock-Up of the Track Frame and Running Gear with the outer Frame Panel removed.



A Mock-up of the Engine Bay to check space availability.

inserted into a quick virtual mockup of the engine bay, **fig. 7**. The concerns proved false as the engine was dwarfed by the space, leaving lots of room for cooling provisions in due time. Note that the engine shown in fig. 7 is a custom made 22 cc originally intended for the Whippet model.

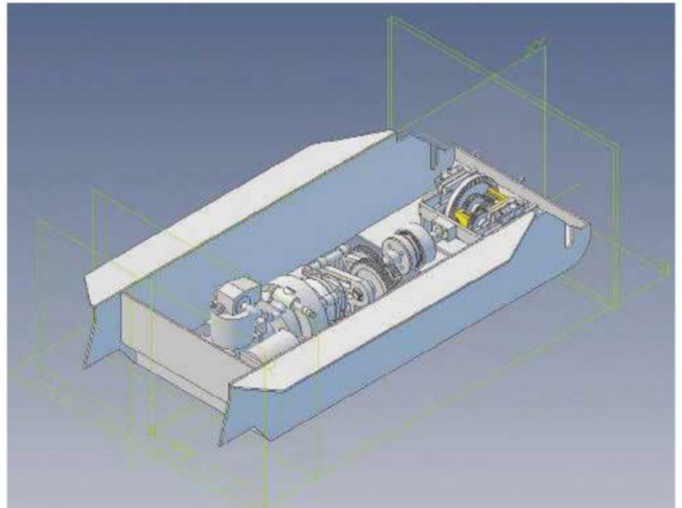
The transmission (inside the hull) will consist of a reduction box giving high, low and reverse gears and a steering box (fig. 7, shown in magenta and blue.). These gear systems will be based on Sturmey Archer 3 speed bicycle hub gears based on a cut down Wilson design by fellow tank modellers Mike Tull in Fareham and Iliya Cerjak in Amsterdam (both of internet fame). At present the two boxes are still simple virtual models in Alibre.

As an example of forward planning, using Alibre, see **fig. 8**. This shows the general layout of the internal power train for a 1/5th scale WW2 M3 Stuart Tank.

The Whippet crew compartment and superstructure have purposely been left until last as it is largely a cosmetic cover for the working parts. In the original it consists of flat plates riveted or bolted to a semi continuous angle iron backing frame. This lack of a full frame will probably require yet another set of jigs to aid assembly before riveting/bolting. The whole structure will have to

be modelled in Alibre if only to get the exact shape of the individual plates. However, a more convenient and stronger solution might be to treat it as a sheet metal part and simply fold in the appropriate places. My version of Alibre has the sheet metal module that will take the virtual model and produce a template that can be stuck onto a single, flat metal sheet and folded along the proverbial dotted lines. This module might not be in Alibre Atom.

I am no artist and am severely challenged by engineering drawing either with a pencil or 2D CAD software. The Engineer illustration and blueprint cards give shape and relative position information but few if any dimensions. Alibre has enabled me to cope with these limitations and produce an answer that is not too shabby for an amateur. The usual disclaimer applies reference Alibre other than as a customer of their UK partner Mintronics who helped me at every request. ■



Alibre Mock-Up of the Engine Compartment for a 1/5th scale WW2 M3 Stuart Tank.

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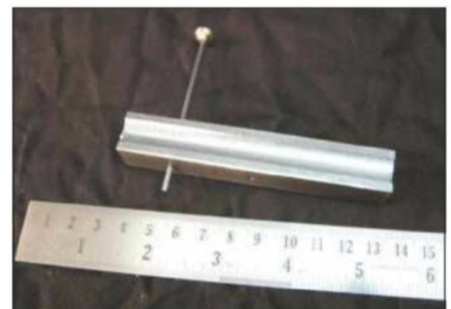
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Triboelectric Powder Coating for the Home Workshop

Chris Gabel looks at a practical alternative to paint.

Rich vibrant colours more robust than paint, **photo 1**. No chipping or peeling. Perfect finishes for many of our model engineering projects. No solvent release, thick coatings and fast processing times of less than 30 minutes are common.

Plastic coating powder colours are linked to the RAL colour standard and the range can exceed that of spray cans, **photo 2**. Colours come in matt, gloss and satin as well as transparent. There are finishes which mimic chrome. Bright undercoats can be covered with translucent overcoats to produce more funky colours sometimes associated with motorcycle and car customising styles. The powder used in the following work was triboelectric polyester powder from Electrostatic Magic, **photo 3**.

Building a Triboelectric Powder Gun

The challenge was to make my own powder coating gun and to be able to coat workshop projects in a manner that is as convenient as liquid paint, but with the additional advantages of powder coating. I hoped to build a powder spray gun that was safe and easy to use without using high voltages or expensive kit, **photo 4**.

There is excellent information on the web which enabled me to understand the physics of electrostatic powder coating. Some of the early patents described how different forms of powder spray guns worked. There is material on YouTube as well describing DIY powder coating techniques.

Corona Guns and Triboelectric Guns

All powder coating works by statically charging the coating powder which will then stick to any grounded object. Two systems are in use. The corona system uses high voltages to charge the powder while Triboelectric guns use a friction effect to



Workshop powder coated work.



RAL colour range.



Half Kg bags and powder gun jars.

induce the charge on the powder. Both guns are available for DIY use. I chose to develop my own version of a triboelectric gun, due to its simplicity and ease of use.

The Corona Gun:

Although corona and triboelectric powder guns look similar, they differ in how they work. The first, and the one usually found in commercial applications, is the corona powder coating gun. This works by exposing the powder stream to a high voltage, usually 30,000 to 100,000 volts as it passes through the gun. The high voltage

creates a cloud of excited electrons at the tip of the gun. This blue glow is a corona and is an electrical discharge brought on by the ionization of the air at the tip of the spray gun electrode. This corona is an intense cloud of negative ions. The powder picks up a charge as it passes through that cloud, **fig. 1**.

Eastwood produces a corona gun for home use. Self-building a corona gun is probably not too difficult, but the alternative triboelectric powder gun described next is so much better with no Health and Safety High Voltage dangers.

How Triboelectric Guns Work:

It is quite easy to grasp that in a corona gun, powder becomes charged when zapped with 30,000 volts. The triboelectric gun however works just by rubbing together two dissimilar materials. Surface friction does it all.

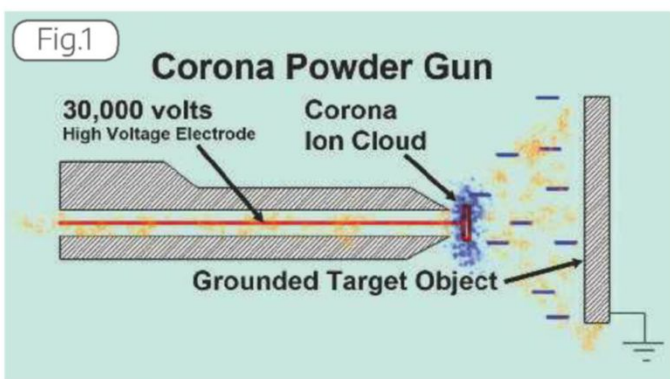
The "Triboelectric Series" figure shows the relative charging characteristics of some common materials, **fig 3**.

The red items tend to gather a positive charge, the blue items gather a negative charge. Note that polyester is well above

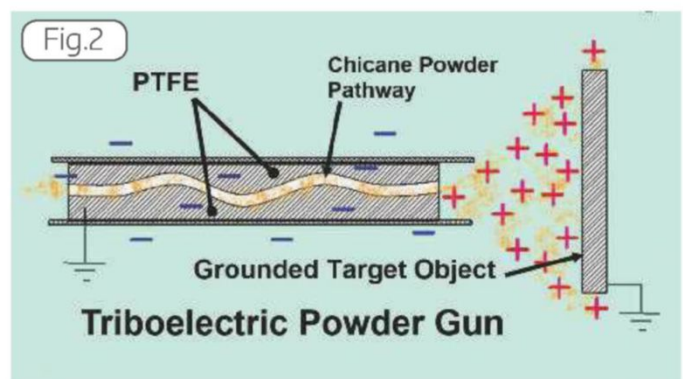
Teflon (PTFE) meaning that the polyester powder will become positively charged when forced into frictional contact with PTFE. There are no high voltages in a triboelectric gun. All of the electrostatic charge is created by friction of different molecules rubbing against each other. Using the example of rubbing a toy balloon on your hair, you can create a triboelectric charge on your hair and on the balloon. A charge is imparted in the balloon by the frictional contact with your hair. As the balloon rubs your hair the balloon grabs electrons from the hair leaving the tips of the hair with a positive charge. The hair is attracted to the balloon, as dissimilar charges attract. At the same time strands of your hair fan and spread out, as each fibre is positively charged and like charges repel each other. For the construction of



A siphon feed powder gun.



Schematic of a Corona powder gun.



Schematic of a Triboelectric powder gun

this triboelectric gun, we simply have to force the polyester powder material into frictional contact with Teflon (PTFE). The polyester particles will be stripped of their electrons, therefore gaining a positive charge, the moving powder cloud continues on. It is attracted to and sticks to the grounded workpiece, **fig. 2**.

Reduction of the Faraday Effect:

There are other advantages gained with the triboelectric powder gun. The corona gun can impart unwanted charges in cracks, pockets and crevices and inside corners of the target piece. These charges repel the powder and cause thin or bare areas in the final coating. In addition surface charging can cause an unwelcome orange peel surface. The triboelectric gun does neither of these. Corners coat well and there is a reduction of orange peel effect.

The Powder Coating Process:

The process itself is not complex, but the quality of the resulting finish is dependent upon good craftsmanship at each step. The first step is to prepare the object to be coated. This is probably the most important step. Just as in soldering, using adhesive, or painting, the object should be surgically clean and oil free. Sandblasting is the preferred method, followed by a wiping down with acetone. Mechanical cleaning with files and abrasives works too but consistency is

more difficult to attain.

Sandblasting also leaves a light "tooth", which aids in surface adhesion. Nitrile gloves are suggested in order to prevent fingerprints, **photos 5 & 6**.

Items such as cast iron are naturally porous and therefore oily and should be de-gassed. This is done by baking the object for 20 minutes at 220 degrees C. If this step is missed, the oily inclusions can release vapor during curing which will degrade the coating.

The Second step is to hang or securely support the object on the coating rack and to attach the ground cable, **photos 7 & 8**.

All about Grounding:

You can see from the figures that being able to ground both the gun and the target object is of prime importance and is what makes powder coating work. There are two ways to create a good ground. The method used by almost all of the DIY coating



Sand-blasting is the ideal preparation.



Wiping down with acetone removes all traces of oil.

systems, including corona and triboelectric, is to use domestic ground connections found in the home electrical circuit. A 3-pin plug is used and has the live and neutral pins removed, leaving only the ground. This ground is wired to both the gun and the work piece using crocodile clips to the workpiece and crimp bullet connections to the gun, **photo 9**.

If you are adopting this method, it is necessary to do a safety check on your outlets. For £10 or so it is possible to purchase a plug-in socket tester which will confirm that your domestic ground is actually functioning as it should. For all my ground connections I have used 16 gauge, 1.5mm cable. This may seem excessive, but I have had no ground problems.

Water and gas pipes do not make good



Plug and cables for domestic ground connection.



Heavy items can be well supported on the rack.



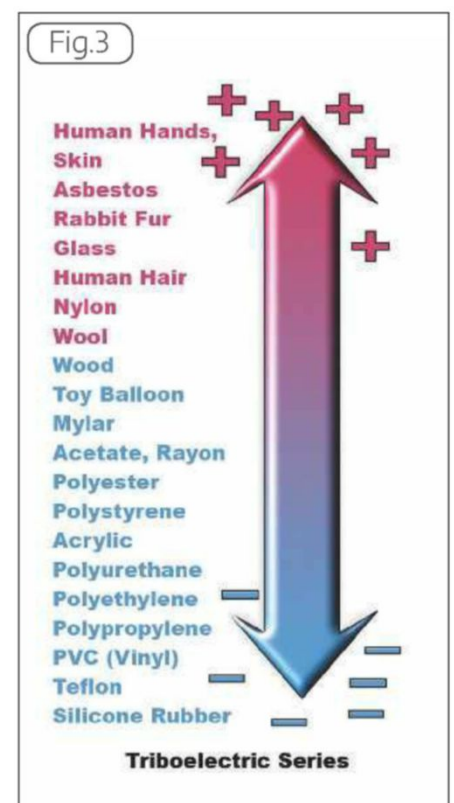
Some items are best suspended from the rack

grounds. There are too many sections of plastic pipe in modern systems to enable good ground connections.

The second method is to buy a 2 metre copper grounding rod which is literally hammered into the ground. This can then serve as a dedicated grounding point for all of your powder coating efforts. An outdoor location with damp soil will provide the best ground. This is the preferred method and provides an excellent ground. I used 16 gauge stranded wire for a robust ground system and found that this ground rod produced notably better results, **photo 10**.

If it is a dry hot summer, or if you live in the desert, a bucket of water poured on the earth around the rod will improve grounding too.

The concept of "ground" can be confusing. This is because the same word





Earth grounding rod and cable connection.

and similar symbol is used in electronic circuits. The other common use is when referring to "earth grounding" that we find in domestic or infrastructure electrical distribution systems. Electronic ground and earth ground have become interchangeable in a confusing manner.

It would be incorrect to think of earth ground as an electrically negative point. It is simply a void, which will soak up either a negative or positive charge in order to create a neutral state. In tribo spray coating we are dealing with static charges. In the tribo system the powder is stripped of its electrons, leaving it positively charged. These positive ions are attracted to the grounded target object. Grounding in this instance means earth grounding. Earth ground can be considered an electrical void of charge, and this is why both Positive powder ions from a tribo gun or Negative powder ions from a corona gun are both attracted to earth ground. The charge rules do still apply: Positive is attracted to negative, and negative to positive. Like charges repel each other, but both positive and negative charged particles will be attracted to the void of earth ground as the electrical potential attempts to equal out to zero.

Masking

There are some places you do not want powder, such as threaded holes or precision bores. These areas can be masked off with a high temperature Kapton masking tape, **photo 11**.

Silicone tapered plugs can be inserted in holes too. Plug sets are available online but are pricey. Good tapered plugs can



Kapton tape is used to mask threads.



Internal bores are covered with Kapton tape trimmed flush.

be made by letting silicone sealant cure inside the cartridge nozzle. A plug is visible in **photo 12**.

Kapton tape is not all that flexible and can end up where it is not wanted during curing. Some users suggest that it be removed at first fusion, but before full curing takes place. A scalpel works best for trimming.

Rack and Oven

There are two remaining components required for a powder coating system. They are the rack and oven which enable you to efficiently carry out the process, **photo 13**.

Looking on the web, a search for "Mini oven" or "Compact Oven" shows a variety on offer from about £20. They have only a 9 or 10 Litre volume, so coating and curing large parts is difficult. But they do a good job for small parts.

The circular element of our budget line domestic fan oven burned out a couple of years ago. With powder coating on the "future projects for the workshop" list, I kept it. YouTube showed that the element replacement could be done in under 5 minutes. A new element was only £8 on Amazon. This oven has a volume of 200



A wall cabinet carcass and domestic oven complete the setup.



Powder application.

litres and will accept most medium to large workshop constructions.

The oven racks are an important part of the coating process as it is necessary to physically suspend the part in mid-air while the powder is applied. After coating the part needs to be transferred to the oven for curing, so determine the size of your spray booth by referring to the size of your oven rack.

The most efficient way to build a small part spray booth is to use a kitchen wall cabinet carcass. 600mm is a standard size. Wooden rails were added to allow easy placement of the rack in and out. A

vent can be placed at the back with dust filter media attached to the back. A fan can create an airflow through the vent. This will help control the powder overspray. Provision for a gun holder and for keeping the ground line and air line under control can prevent tangles and jarring of the freshly coated work, as it is transferred to the oven.

Powder Application

The goal is to have the powder exit the gun in a party-balloon sized cloud, but not under too much pressure. Too high a pressure and the powder cloud is huge and

can dislodge any powder already applied to the target object. If pressure is correct, powder should look like light smoke. In **photo 14**, the pressure was too high and powder built up everywhere.

●To be continued

ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE

● Men In Sheds

James Wells looks back at the aftermath of World War II and marvels at the ingenuity of the 'men in sheds' during the post war years.

● Drax Power Station

Roger Backhouse spends an Engineer's Day Out at the mighty Drax power station in Yorkshire.

● C38 Locomotives

Les Phillips describes the construction of a couple of Australian 5 inch gauge Pacific locomotives.

● VMC Mill

Peter Russell adds variable speed control to his Warco VMC milling machine.

● Four Inch Burrell

Alan Barnes tells the story of Derek Finch and how he was inspired to build his own 4 inch scale Burrell agricultural traction engine.

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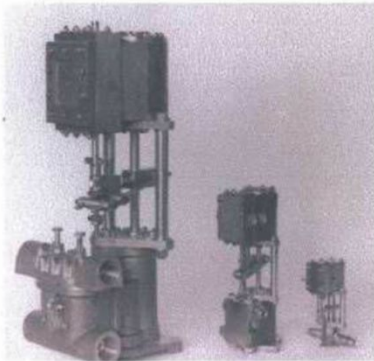
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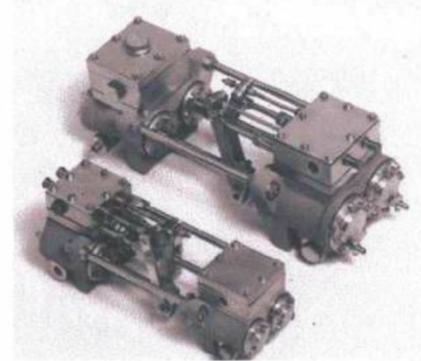
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Dewhurst Drum Switch Repair

Glyn Davies offers some advice on fixing these switch units that were fitted to many postwar lathes.

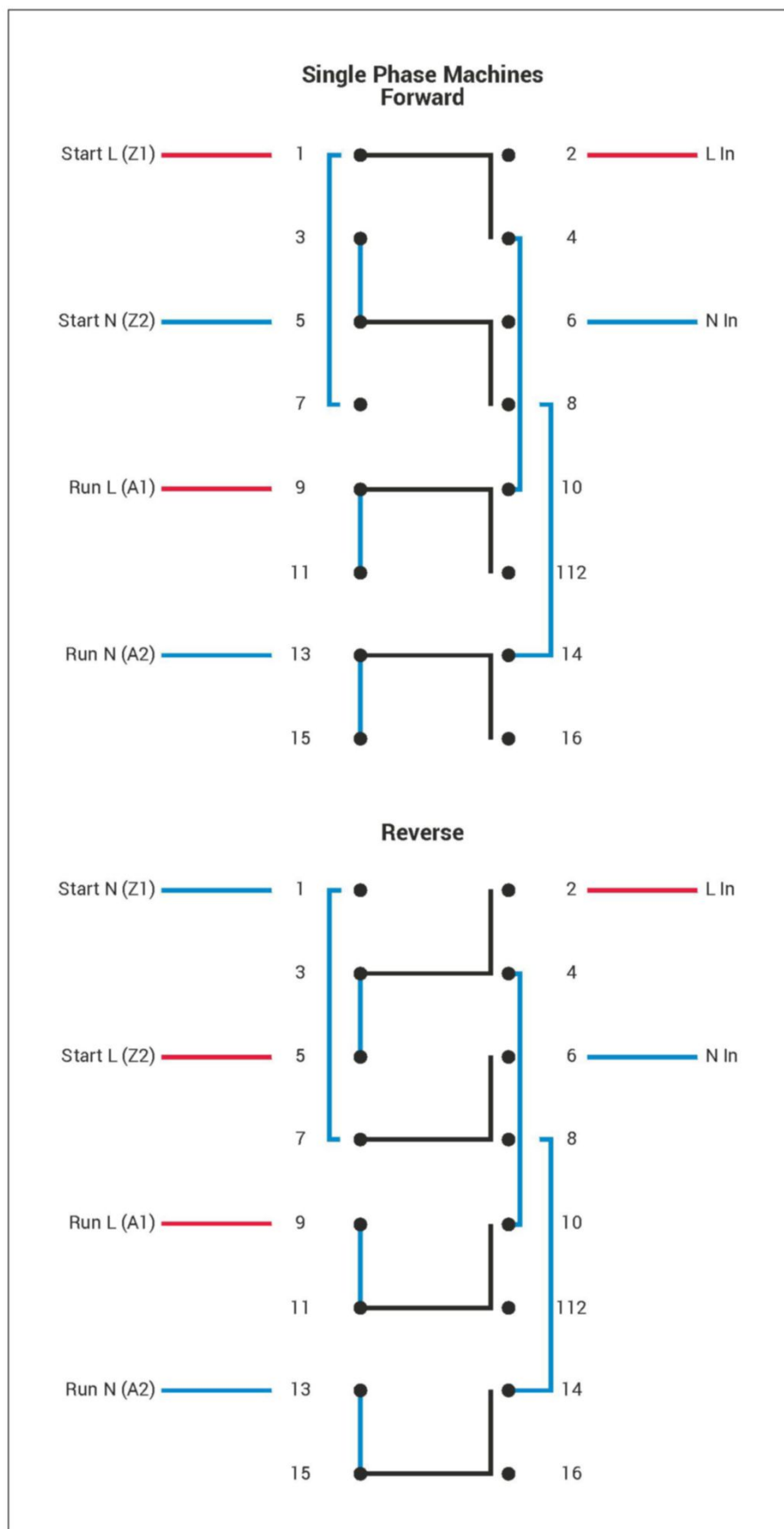
The contacts of the Dewhurst Type A Reversing Drum Switch, **photo 1**, that was fitted to my 1960s Myford Super 7 lathe burnt out, and as new replacements are no longer available, I cast around for a solution. The lathe is fitted with an MEM No Volt Release contactor, so I only used the drum switch to set the motor to run in either forward or reverse and its failure was somewhat surprising.

Anyway, frazzled as it was, I needed a new reversing switch. A trawl of the Farnell catalogue revealed a Moeller T0-4-8213/EZ three position switch at about £27 as an affordable possibility, so I bought one.

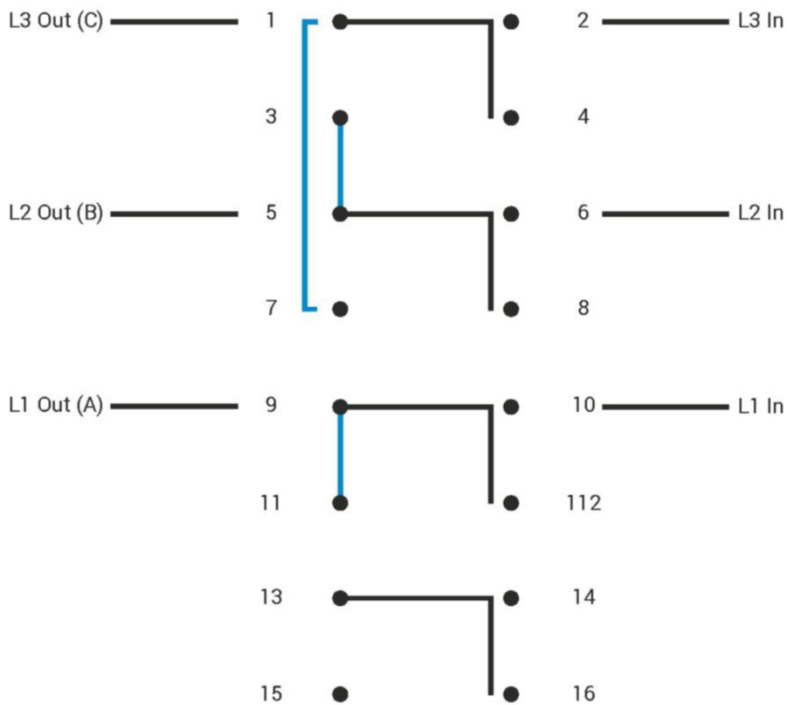
Single phase induction motors have two windings – a start and a run. Both are connected to the mains supply to start the motor, but a centrifugal switch in the motor then cuts power to the start winding when the motor runs up



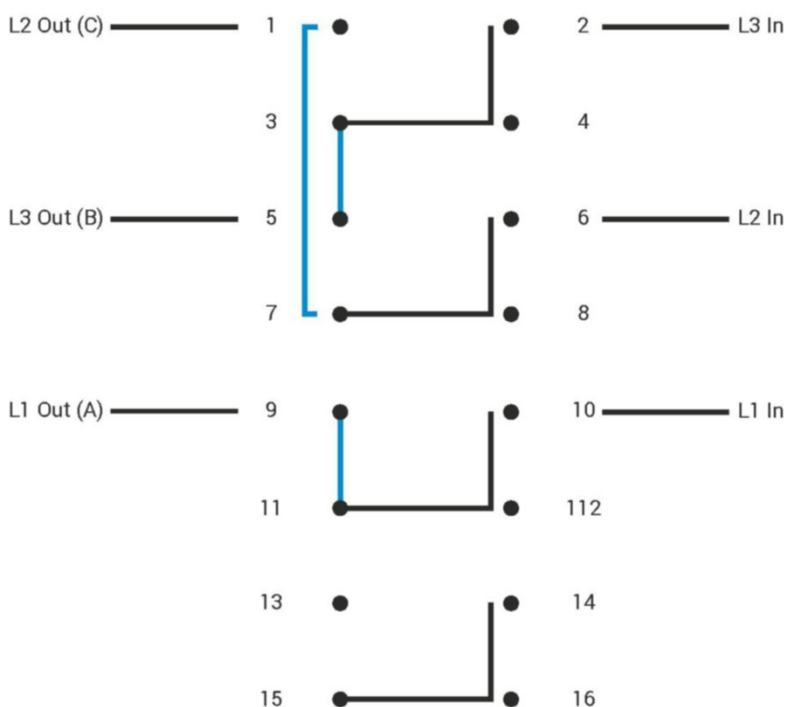
Dewhurst Switch



Three Phase Machines Forward



Reverse



to its operating speed. To reverse the direction of the motor, the live and neutral connections of (conventionally) the start winding need to be swapped. The Moeller contact arrangement differs from the Dewhurst switch and it took some head scratching to figure out how I could make it work for my single phase motor. I have an uneasy feeling that the solution I came up with is more complicated than it needs to be, but it works so I'm happy.

As always, make sure everything is isolated before starting work and if you do not feel competent to work with mains switching, find someone who is to assist you.

For my single phase lathe, this is how I wired it. There are sixteen terminals on the switch body, four pairs of which were already linked by Moeller. I added additional links to the following terminal numbers: 1-7, 3-5, 9-11, 13-15, 4-10 and 8-14. The switch wiring is then supply live to 2, supply neutral to 6, motor start winding Z1 to 1, motor start winding Z2 to 5, motor run winding A1 to 9 and motor run winding A2 to 13. If I had found that the motor ran backwards when the switch was set to forwards, I would have swapped over the connections to terminals 1 and 5.

Removing the switch front plate allowed the switch to be mounted into the old Dewhurst switch casing and with all the wiring connected, the front cover fitted without problem, as shown in **photo 2**.

To make understanding the wiring solution that I used easier, I made a schematic drawing, shown below. The drawing also shows how the Moeller switch could be used to repair a Dewhurst switch fitted to a three phase lathe. This is simpler in that the only additional links needed are 1-7, 3-5 and 9-11. ■



New switch fitted inside old casing

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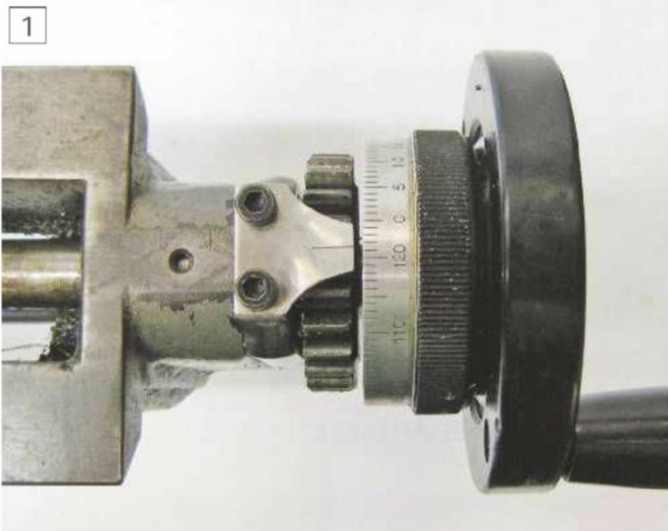
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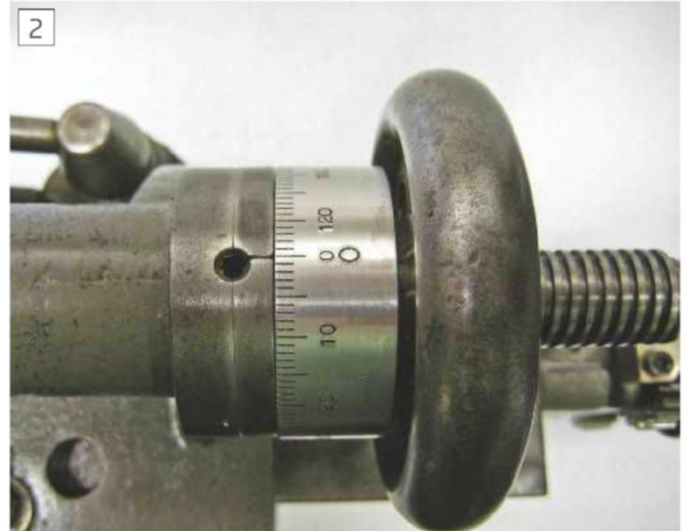
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True metric pitches using an 8 tpi leadscrew or the story of a wonderful gear



Resettable lead screw dial.



Resettable tailstock dial.

Eric Clark describes how he cut accurate metric threads on a small imperial lathe

This is the story of how I have convinced my 1902 Drummond flat bed treadle lathe to cut true metric threads using a "wonderful" gear. I do not claim any originality for the method described as I am sure others have done similar things before but to paraphrase Newton we all "stand on giant's shoulders"....

Whilst doing some research for this article I bought a copy of "Screwcutting in the Lathe" by the late Martin Cleeve which is quite the best and most comprehensive book on the subject that I have ever encountered. And you have guessed it – there is one short paragraph on "my" method.

The Drummond lathe has an 8 TPI lead screw which is very common on small lathes used by model engineers so the principle described can easily be adapted to a wide variety of machines.

At Amberley Chalk Pits museum, I once saw a very similar Drummond lathe on display which has a small information sign casting doubts on the ability of anyone to carry out screw cutting on such a machine.

Let me assure everyone that a treadle powered Drummond flatbed lathe is an excellent screw cutting machine for the model engineer due to its very good back-gear arrangement, ease of reversing, and the fact that speed can easily be adjusted to suit the job in hand, giving control over the process in total with no fear of crash-ups. It also provides good leg exercise!

When I first obtained this lathe, it had no graduations on any of the movements so I began a quest for suitable micrometer dials with suitable graduations going in the correct direction. After a long search I found a lovely one suitable for the cross slide (100 graduations) but never located one with 125 for the lead screw. I decided to make one and pondered the method to be used to graduate it. Dividing is also very easy on this lathe as it has no tumbler reverse so suitable gears can be mounted directly on the end of the mandrel.

The snag was that I did not have a 125 toothed change wheel. It is possible to obtain 125 divisions using a compound train with string and weights to maintain tension, but this was considered too indirect for ease of working.

Enter the "wonderful" gear.

At a Model Engineer exhibition a few years ago one of the major machine suppliers had a bucket of odd change wheels priced at a very reasonable £2 each. Being a born

magpie, I searched this wonderful bucket and found a gear which had a double track of teeth 125 and 127. This was obviously a modern 1.0 mod gear and therefore much finer than the old 14 DP gears used on the Drummond but all I wanted it for at this stage was as an indexing wheel, so the tooth pitch did not matter. I bushed the bore of this wheel to 5/8" diameter and drilled an appropriate hole for the Drummond driving peg.

After successfully making and fitting the resettable lead screw dial, **photo 1**, and a similar resettable dial for the tailstock, **photo 2**, my thoughts turned to the 127 tooth part of this useful gear wheel and could it be used to produce true pitch metric threads?

Cutting "near miss" metric threads.

It is possible to cut slightly inaccurate metric threads on an imperial lathe using a standard set of change wheels i.e. progressing in steps of 5 teeth or together with a 21 tooth wheel (Myford's answer) or a 63 tooth wheel or several other combinations of translator gears detailed in Martin Cleeve's book.

The errors produced are quite small and may not be too significant for short threads for attaching nuts say up to one diameter long. However, the errors quickly accumulate so this method is not always so suitable for longer threaded items.

The leadscrew on ordinary workshop

lathes is not an especially precision item and usually wears to a certain extent adding to any inherent inaccuracy. This is often given as a reason not to worry about slight pitch inaccuracies when cutting metric threads on an imperial lathe as such errors will be “absorbed within the leadscrew wear”.

I am uncomfortable with this reasoning as:

1. The errors are very likely to add together to produce greater than expected inaccuracy
2. As model engineers we should try to get things as accurate as possible

The only way to cut accurate metric pitches using an imperial lead screw is to use a 127 tooth “translator” gear.

One inch is set internationally as exactly 25.4 mm. (Take no notice of older books that give slightly different conversion factors).

The 127 tooth gear derives from the factorisation of 254 into 2×127

As 127 is a prime number this is the lowest number of teeth that can be used on a translator gear.

This brings a number of practical problems (described below) so Drummond and other manufacturers introduced gears of 63 teeth which enabled the user to get ratios that gave more accurate near misses.

Table 1 shows my screw cutting chart using standard Drummond gears and quantifies the pitch errors which are quite small and frankly quite good enough for all practical purposes.

A college lecturer was very fond of using the phrase “for all practical purposes” The lack of precision in this phrase puzzled one of the students who asked the lecturer to explain what it meant. After thinking for a few moments, he said

Suppose all the young ladies lined up



Gear train set up for metric screw cutting.

Table 1

Change wheels for cutting METRIC pitches on a Drummond 3 1/2" flat bed lathe

PITCH mm Required	MANDREL	DRIVEN	DRIVER	DRIVEN	DRIVER	LEAD SCREW 8 TPI	ACTUAL PITCH mm	ERROR%
0.5	30	60	45	55	25	65	0.49956	-0.0874
0.6	20	40	30	65	45	55	0.59948	-0.0874
0.70	25	45	*	*	25	63	0.69996	-0.0063
0.75	40	38	35	60	25	65	0.74983	-0.0225
0.80	20	55	*	*	45	65	0.7993	-0.0874
1.00	20	40	30	60	63	50	1.00013	0.0125
1.25	25	40	30	60	63	50	1.25016	0.0125
1.50	30	40	30	60	63	50	1.50019	0.0125
1.75	35	40	30	60	63	50	1.75022	0.0125
2.00	20	40	*	*	63	50	2.00025	0.0125
2.25	45	40	30	60	63	50	2.25029	0.0125
2.50	25	40	*	*	63	50	2.50031	0.0125
3.00	30	40	*	*	63	50	3.00038	0.0125
3.50	35	40	*	*	63	50	3.50044	0.0125

Notes

1. Table is for lathes with 8 tpi leadscrews only.
2. Idler gears may be required to give correct rotation for right hand threads on some lathes
3. Errors may be acceptable for general fasteners see Table 2 for exact metric pitches.
4. Calculations;

$$\text{TPI} = 8 \times \text{drives/drivers}$$

$$\text{Metric pitch} = 25.4 / \text{TPI}$$



The “wonderful” gear and its mate.

on one side of an empty room and the young gentlemen did the same on the opposite side facing them. Then at my signal they all moved forward enough to exactly halve the distance between them. No matter how many times this was repeated theoretically they would never meet, but after only a few moves they would be close enough together “for all practical purposes”.

If you do use a near-miss set-up it is best to leave the thread fairly full and

then finish it with a die as this gives some improvement over short lengths of thread.

Problems with 127 tooth wheels

The first problem is finding one for your lathe!

They may be available for current lathes if you are very lucky, but it will be difficult with older and obsolete machines.

The second problem is the diameter

Table 2

Using Drummond 14 DP gears together with a compatible pair of 1.0 module gears

Drummond 14 DP gears				1.0 mod translator gears				
PITCH mm	TPI See note 4 below	MANDREL	DRIVEN	DRIVER	DRIVEN	DRIVER	LEAD SCREW 8 TPI	ERROR %
0.70	36.285	35	* IDLER	#	60	48	127	0
0.80	31.750	30	* IDLER	#	45	48	127	0
1.00	25.400	25	* IDLER	#	30	48	127	0
1.25	20.320	50	* IDLER	#	48	48	127	0
1.50	16.933	50	* IDLER	#	40	48	127	0
1.75	14.514	40	20	35	48	48	127	0
2.00	12.700	50	* IDLER	#	30	48	127	0
2.25	11.289	48	32	45	36	48	127	0
2.50	10.160	50	30	45	36	48	127	0
3.00	8.466	50	25	45	36	48	127	0
3.50	7.257	35	36	60	20	48	127	0

Notes

1. Mod 1.0 Translator gears: 48 and 127 must always be meshed together
2. Mod 1.0 48 translator gear must be ganged with a 14 DP gear
3. Calculations:

$$TPI = 8 \times \frac{\text{Driven}}{\text{Drivers}}$$

$$TPI = 25.4 / \text{metric pitch}$$
4. TPI shown in above table shows 3 places of decimals only for compactness. Full values were used in the calculations.

of a 127 tooth wheel matching the pitch of the others in the set-up and will be, comparatively, rather large. If obtainable, a 127 tooth 14DP gear would be 9.21" (234mm) diameter. Often it is difficult or impossible in practice to accommodate it into the calculated gear combinations due to the great difference in diameters.

"My" method.

Remember my 1.0 module 125 & 127 tooth double wonderful gear?

I thought that if I could find a suitable mating gear with a sensible number of teeth I could come up with a system of integrating this pair of gears in with the normal 14DP Drummond gears to give a totally practical set-up for producing true metric pitches.

The only proviso is that the two 1.0 module gears must always be meshed together with the smaller one keyed to a standard Drummond gear with the 127 gear attached to the lead screw. See **photos 3, 4 & 5**.

Being a magpie, I had obtained a number of 1.0 module gears from a scrapped-off special purpose machine rescued from the skip of a local company.

In this collection was a 48 tooth gear. Other mod 1.0 pitched gears could also be used but the 48 tooth one was the best of the "rescued" ones for my purpose.

A session with the pocket calculator and some trial set-ups showed that the 48 tooth gear (divisible by 8 compatible with the lead screw pitch) gave a good practical match.

Both gears were bored or bushed to

give a 5/8" bore and side connecting holes were drilled to match the Drummond gears. (Drummond gears do not have keyways).

I decided to use the 127 tooth gear on the leadscrew for all set-ups.

Table 2 shows the change wheel arrangements using gears that I had available.

Postscript

Some years ago I reluctantly sold the

flatbed Drummond lathe due to lack of workshop space. It was a very nice lathe to use being very smooth and almost totally silent in operation. I retained the wonderful 125 /127 gear for future use as the purchaser of the lathe had no interest in cutting metric threads. I never considered motorising the 100 + year old Drummond lathe with its flimsy headstock bearing arrangements designed for human power only.

I enjoyed every minute of owning the old Drummond lathe and used it to make several model engines including James Coombes. Stuart V4 variant, V10, H10 and S50. I also made many items of workshop equipment, made spare parts for some obsolete shoe repairer's stitching machines belonging to my brother in law.

When our Grandson, Archie, was very small I made him a toy milk float from a Hobbies plan. Construction was very straightforward but there was a requirement for some crates of milk bottles 24 in each crate. I made the dummy bottles from 3/8" dowel rod on the trusty Drummond using a suitable form tool. This was a rather boring job but after I had made two dozen or so, my wife Susan took over production when I convinced her that the Drummond was a very good "exercise machine".

Photograph 6 shows the finished milk float complete with milk bottles.

I was very sorry to part with this wonderful old lathe but happily it went to a very good home. ■

REFERENCES

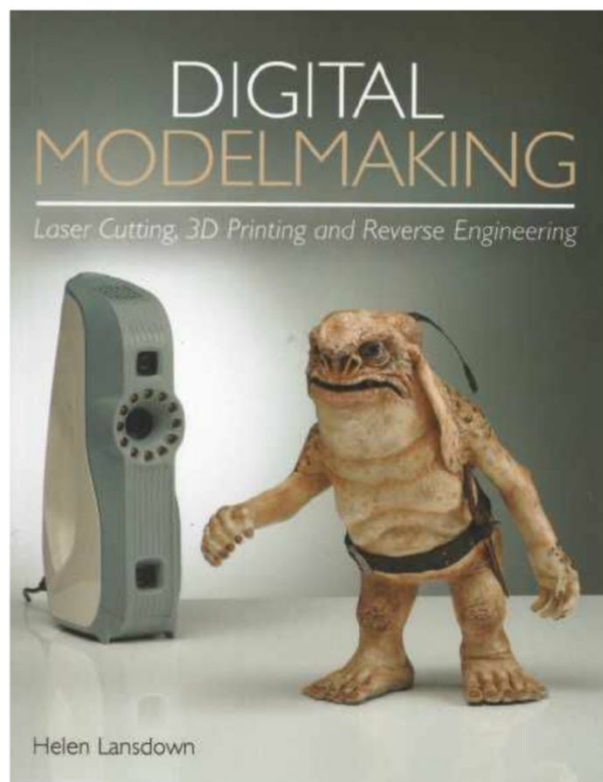
1. Chester Machine Tools for the 125 /127 toothed gear (for 910 lathe)
2. HPC Unit 14, Foxwood Industrial Park, Chesterfield. S41 9RN Tel 01246 268080 for 1.0 Mod gears. Other suppliers available.



Archie's milk float with milk bottles.

On the Wire

NEWS from the World of Hobby Engineering



Digital Modelmaking – Laser Cutting 3D Printing and Reverse Engineering

This new book from the Crowood Press is by Helen Lansdown, a professional model maker and design who now works as a lecturer in model design at Hertfordshire University. As such it is intended as a textbook introducing undergraduates to the latest modelmaking techniques. Each chapter offers 'stand alone' coverage of a topic, each one covering an aspect of the subject in depth at the expense of a little repetition.

The book starts by covering basic modelmaking skills, but then concentrates on five areas of particular interest to MEW readers. First are laser cutting, 3D printing and CNC machining. Next is the increasingly relevant field of 'reverse engineering' – which here means scanning an original object in order to make a replica. The book concludes with a review of software, particularly 3D CAD and some useful appendices.

Although most of the examples in the book are non-functional models, it also covers areas such as automata and prosthetics. Don't be misled by the cover – there is a lot here to interest anyone who wants a primer in these technologies which are becoming ever more accessible to hobbyists.

Digital Modelmaking is a medium-format full colour softback with 192 pages. It costs £20 and is available from www.crowood.com.

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There are many types of mops, felt wheels, nylon abrasive wheels and a rubber bonded abrasive wheel available for this machine; everything you need for all kinds of metalworking. Well made and simple to use, it is perfect for many metal-based crafts and hobbies.

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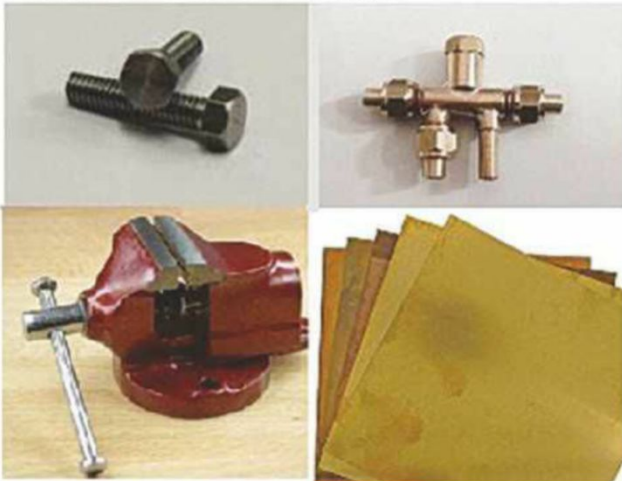




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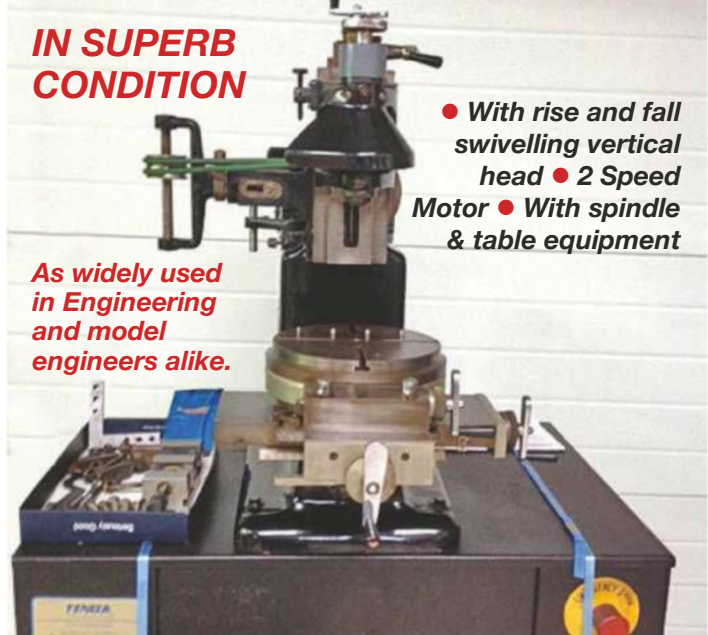


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Making Some Gimmel Rings



Gary Wooding rises to a fascinating challenge



In late 2016 I received an email from somebody in Thailand – could I make a pair of puzzle rings as wedding rings. I replied that I could but would really need to meet them first. They turned up in early December and it became apparent that they didn't want puzzle rings – they wanted gimmel rings (also spelt as gimmel or gemmal).

What's a gimmel ring? I hear you ask, and, for that matter, what's a puzzle ring?

A puzzle ring consists of a number of hoops (usually four) linked together in such a way that they can be manipulated to form a single woven ring. They are notoriously difficult to assemble if you don't know how. **Photograph 1** shows such a ring assembled and disassembled. This example is unusual as it is set with garnets.

A gimmel ring is a ring with two or three separate hoops or links that fit together to form one complete ring. The name gimmel comes from Latin gemellus, meaning twin. In Elizabethan England they were known as

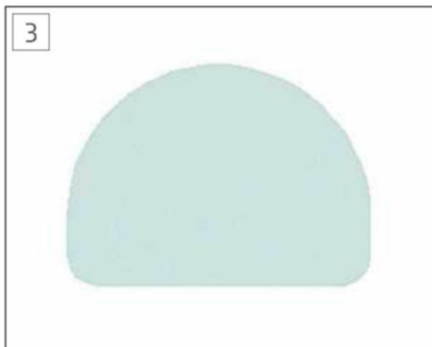


Joint Rings. In the 16th and 17th centuries, such rings were fashionable in England, Germany, and other countries, where they were often used as betrothal rings. The engaged couple would each wear one hoop and link them to use as a single ring on the wedding day. With triple link rings, a third person could witness the couple's vows and hold the third part of the ring until the marriage, when the hoops were linked to

make a single wedding ring.

Photograph 2 shows an example of an ancient gimmel ring of 2 hoops.

Although I'd made lots of puzzle rings, I'd never made a gimmel ring before, but I agreed to do some experimenting and, if the results were satisfactory, would make them a pair out of the latest precious metal – Palladium*. The man's ring was to be 4mm wide, and the woman's 3.5mm. The

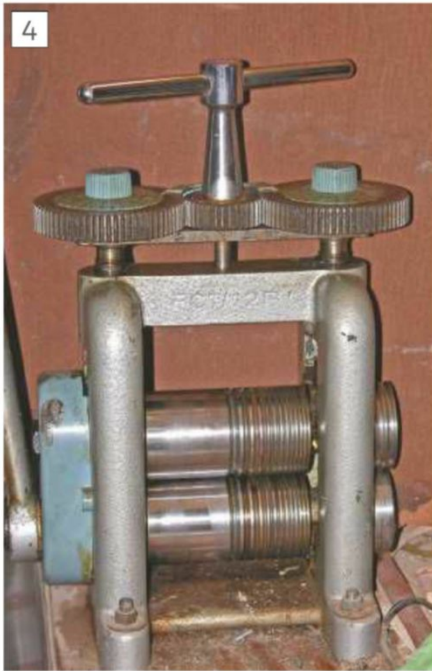


**Palladium is the latest Precious Metal, and joined Silver, Gold, and Platinum in 2010.*

Palladium has much in common with Platinum – it is very white, does not require plating and does not tarnish.

It is less dense and less expensive than Platinum and the consequences of mistakenly confusing it could be costly.

Only precious metals can be Hallmarked. From June 2009 a voluntary Hallmark could be applied, but from January 1st 2010 it became compulsory. It is illegal to sell a Palladium article made after that date unless it contains an official Hallmark.



A gimmel ring is a ring with two or three separate hoops or links that fit together to form one complete ring.

couple then returned to Thailand with the intention of returning to the UK for their wedding in June.

I decided to experiment with copper, and the initial results were sufficiently encouraging that I emailed to say I could make them, and could they get their fingers measured for size? They agreed the price and I got to work.

This is the story of how they were made.

The cross section of the finished rings was to be as shown in **photo 3**.

Notice that it's a little deeper than half-round, with slightly rounded corners. The actual ratio is 4:3 and I thought it would be no problem to create this with my rolling mill.

Photograph 4 shows my rolling mill, the main rollers of which are 65mm in diameter, with a flat section for rolling sheet metal, and a set of V-grooves for rolling square section rod or wire, see **photo 5**.

The axles of the rollers extend through the right-hand pillar and accept pairs of short auxiliary rolls with grooves of various sizes – **photo 6** shows a pair for forming 4mm half-round wire.

My plan for making the 4mm ring was to start with a strip of 4×2mm wire. I didn't have any 4×2mm wire, but I did have some



5×5mm. Calculations showed that 39mm of 5×5mm, when rolled down to 3.175×3.175mm in the square rolls, could then be rolled down to 2mm in the flat rolls to become 4mm wide and 120mm long. I could then fold it in half to make a 4×4mm cross section, and then twist the central section by 360°, as shown in **photo 7**.

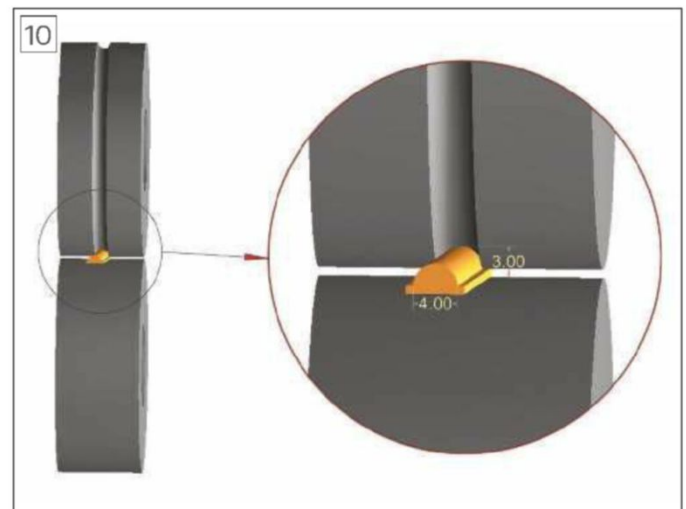
This piece was then passed through the V-rolls to create the square shape shown in **photo 8**.

The next step was to pass it through the 4mm half-round auxiliary rollers to create the desired basic cross section. This is where it all went wrong!

The required cross section is 4mm wide by 3mm thick, but the half-round rolls give 4×2mm when closed – see **photo 9**.

No problem, I thought – just open them to leave a gap of 1mm. This "solution" created two new problems.





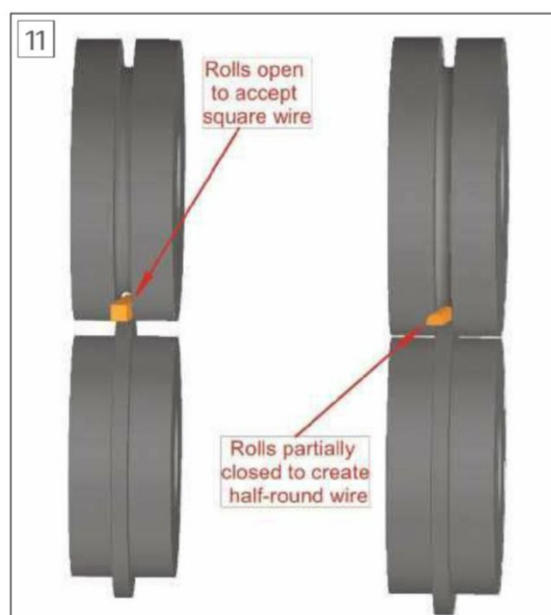
1. The pressure exerted by the rolls to convert the square section to half-round is transmitted throughout the section of metal being squeezed. The incompressible metal behaves rather like a very viscous liquid, and instead of remaining 4mm wide, it oozes out of the unsupported sides resulting in the cross section shown in photo 10. If I'd been working with copper, or some other inexpensive metal, this would have been easily remedied by simply filing away the unwanted extrusions. But precious metal is far too expensive to waste in this way.

2. As a result of there being no lateral support in the gap between the rolls, the pressure on the twisted part causes it to partially untwist, resulting in rather distorted hoops in the final ring. This is totally unacceptable.

The only solution I could think of was to make a new pair of rolls with supporting sides, as shown in **photo 11**.

Since I had two rings to make;

one 4mm wide and the other 3.5mm wide, I needed two pairs of special rolls. The prospect of machining 7mm deep, half-round grooves into steel bars was not that appealing, so I decided to make them in the



form of separate narrow inner rolls that use the same pair of steel cheeks. **Photograph 12** shows the two pairs of inner rolls and the steel cheeks. One pair of inner rolls is sandwiched between the outer cheeks by means of high-tensile screws that screw into threaded holes in the left-hand cheeks.

Since the main rolls are 65mm in diameter, both pairs of inner rolls had to be 65mm too. That meant that one pair of cheeks had to be 75mm and the other only 55mm. The next job was to make them.

The diameter of the roller axles is 28mm, and the width of the original roller extensions is 20mm, which means that the width of each cheek must be 8mm. I had two bars of mild steel (MS), one 75mm and one 65mm in diameter. I first bored a 22mm deep, 28mm hole in the 75mm bar, and another one, 50mm deep, in the 65mm bar. I then faced both bars at both ends and mounted the 75mm one vertically on the mill table, and drilled three equally spaced, 22mm deep 5.3mm holes, on a 39mm PCD around the centre.

The bar was then returned to the

lathe, where an 8.5mm slice was parted off. The end was again faced before another 8.5mm slice was taken.

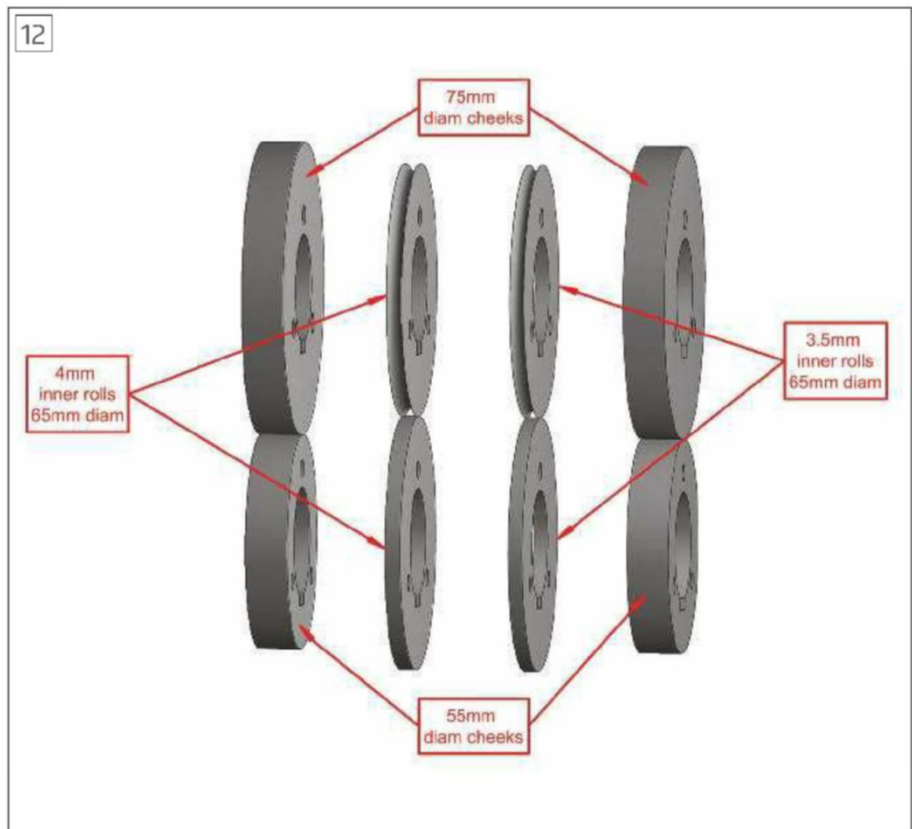
The next task was to face the cut sides of each slice and reduce the thickness to 8mm. But how to hold them?

I needed an expanding mandrel but, since I didn't have one, I had to compromise. I rummaged around in the scrap box and found a 100mm length of 1.25" bar and a 1/2" BSW screw.

I faced the end of the bar and cut an 8mm×28mm shoulder, then drilled a 10.75mm axial hole and used a 1/2" BSW taper tap to create a threaded portion just deep enough to accept a few full diameter threads. I then made two longitudinal saw cuts to create the mandrel shown in **photo 13**.

The slice could then be placed against the shoulder such that when the screw met the shallow threaded section, further tightening opened the saw cuts to grip the slice firmly enough to allow the cut side to be machined as in **photo 14**. After this, the 5.3mm holes in one cheek were tapped M6, and those in the other were opened to M6 clearance (6.1mm).

This procedure was then repeated for the 55mm cheeks, which were made from a portion of the 65mm bar turned down to 55mm.





All the inner rolls were made from the 65mm bar which was drilled as per the cheeks, but with 6.1mm clearance holes. After returning it to the lathe, the end with the 28mm bore was then machined to create a shallow 50mm recess, approximately 0.4mm deep before parting off a 4.5mm slice. This was repeated for the matching 4mm roll. Both slices were then mounted on the expanding mandrel with the recesses together, to allow another 50mm shallow recess to be machined on the parted-off face. This recess was sufficiently deep (approx. 1.5mm) to remain a recess after a later operation reduced the slice thickness

to 4mm. The slices were then reversed to process the other one. See **photo 15**.

It was then necessary to machine each slice to 4mm, but the expanding mandrel was not sufficiently accurate for this, so another mandrel was needed.

This was made from a short length of 2" bar, faced at both ends with a short 28mm shoulder at one end. The bar was then mounted vertically in the mill and three equally spaced 4.5mm holes were drilled on a PCD of 39mm. The holes were then tapped M5, see **photo 16**.

Each slice in turn was then mounted on the mandrel and screwed securely, rough machined side outwards, to the shoulder by means of three M5 screws – see **photo 17**.

The purpose of the recesses is twofold.

1. The slice can be bolted in direct contact with the turned surface of the shoulder.

2. Because the M5 retaining screws are within the recess, the slice can be accurately trimmed to precise thickness without having to worry about the retaining screws.

The next job was to machine the semi-circular groove on the edge of one of the rolls. The prospect of grinding a semi-circular parting-off type tool, exactly 4mm wide, was not attractive, especially since I needed a 3.5mm one as well. So, I decided to obtain two HSS drill rods (4 and 3.5mm

diameter) grind one end rather like a tangential turning tool and make a suitable holder. It worked really well – see **photos 18 & 19**.

The final part of making the rolls was to cut an 8mm keyway. Since neither roll would experience torque very much and be turned very slowly, there was no real requirement for a proper rectangular keyway, so I decided to cut a small slot with an 8mm end-mill. To ensure consistency I made and used the simple jig shown in **photos 20 & 21**.

With all the parts made it was time to test the theory. I assembled both new rolls, **photo 22**, rolled a piece of copper to 4mm square in the V-rolls, and put it through the new rolls. It seemed to roll nicely, but - horror of horrors - I couldn't remove it from the "die" roll. It was well and truly stuck. I could see one end of it, which looked exactly right, but it just wouldn't budge.

The considerable pressure needed to mould the copper to the required shape had jammed it onto the sides of the deep groove.

Serendipity smiled. I just removed the roll from the mill and undid the screws holding it together. The copper then came out easily, and it was just the right shape. Had I made the rolls by machining them from one big lump I would have been well

Had I made the rolls by machining them from one big lump I would have been well and truly stuffed.



and truly stuffed.

The toolmaking was over, I now had to make the rings. I rolled the Palladium nicely, bent the result into a circle and soldered the ends of each hoop together. When both rings were ready, they were sent to the Assay office to receive their hallmarks. When they returned I tidied them up and

polished them as shown in **photos 23 & 24**.

There is one last twist to this story.

The couple arrived to pick up their rings in the last week of May. Her ring fitted perfectly, but his ring was three sizes too big! They had given me the wrong sizes: the jeweller who'd measured their fingers had got it wrong. It was a big job

to reduce his ring by 3 sizes and there was no time to do it by their wedding day that weekend. They took the rings and returned them the following week when I was able to adjust the size.

Everything worked fine in the end, and they were very pleased with the final result. ■



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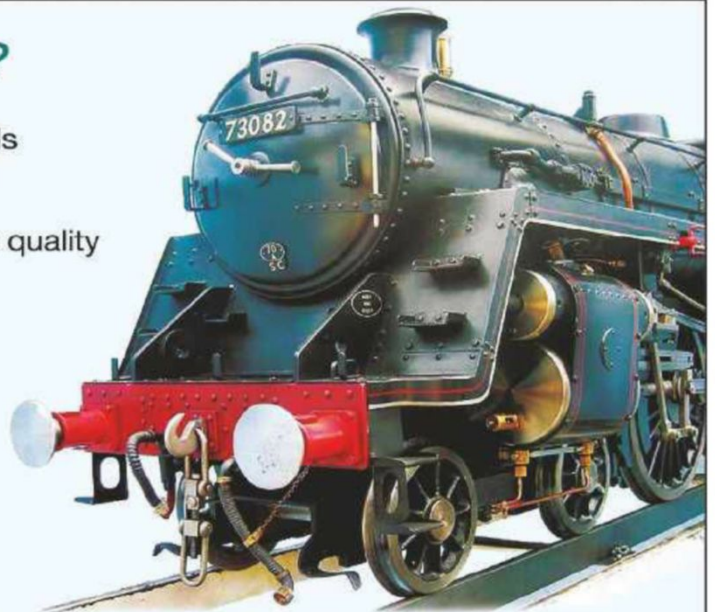
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Harrison L5 L5A L6 travelling steadies special £40 each
Colchester student travelling steadies side and bottom mount special £40 each
Colchester Bantam 2000 fixed steady £375
Colchester Student 1800 / Master 2500, Triumph, Mastiff fixed steadies

Coming In:

Myford VMB mill
Rhodes shaper
Scheppach Basato 3 & Record BS300E bandsaws
3 metre bar rack £145
Record No2 & No3 bench vices £20 & £30 each More details on Web Site



£495

3.5 TON 9ft forks pallet truck £495



RJh buffer

240V
£425



£20 each



£3950

Denford Turn 270 Pro CNC



New

£30 each

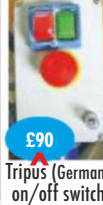
various!

Angle plates + surface plates



Special 5 for £20

Myford ML7 / Super 7 Rifle / Bridge bed felts



£90

Tripus (German) on/off switch



£525

Union 10" pedestal grinder



£845

Tom Senior Mill



£3250

Colchester Colt 6.5" x 40" centres



£1475

Wadkin BL150 wood lathe



£845

Clarkson tool and cutter grinder



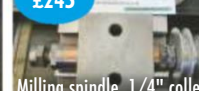
£1475

Union buffer + built in extractor



£245

Blacksmith tooling



£245

Milling spindle, 1/4" collet (Myford spacing bolt holes)



£625

Q & S Terrier 8" hacksaw



£4950

Myford Super 7B lathe hardened bed



£1250

Sedgewick TA315 12" sawbench



£195

Back in!

Stanier 55mm precision swivel machine vice from NEW ZEALAND 'Finest Engineering'



£2950

Harrison M300 lathe + gap

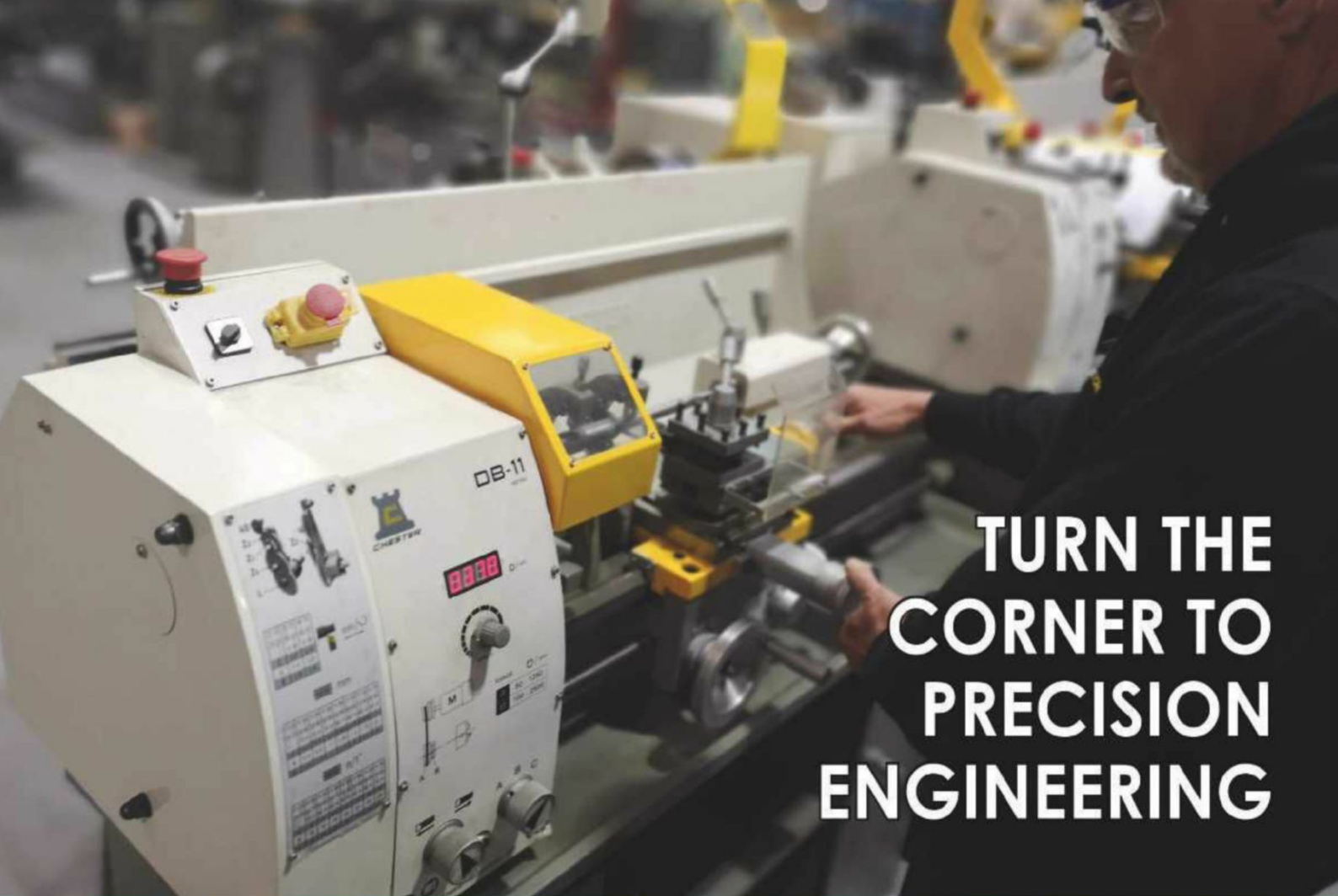
Please PHONE 0208 300 9070 to check availability or to obtain our list
DISTANCE NO PROBLEM! • DEFINITELY WORTH A VISIT • ALL PRICES EXCLUSIVE OF VAT

Just a small selection of our current stock photographed!

We are currently seeking late 'Myford Super 7B' & 'Super 7 large bore' model lathes!

SHIPPING WORLDWIDE





TURN THE CORNER TO PRECISION ENGINEERING



CHESTER
Hobby Store



Swing Over Bed	280mm
Swing Over Cross Slide	145mm
Distance Between Centres	700mm
Width of Bed	135mm
Spindle Bore	26mm
Spindle Taper	MT4
Speed Range	125 - 2500rpm
Longitudinal Feed Range	0.07 - 0.2mm/r
Metric Threads	0.2 - 3.5mm
Imperial Threads	8 - 56 TPI
Cross Slide Travel	115mm
Top Slide Travel	50mm
Tailstock Quill Travel	70mm
Tailstock Taper	MT2
Motor	1.2kW (1.6hp)
Weight	180kg
Dimensions	1390x700x630mm

£1,450.00 inc. vat

also includes 12mm lathe tools, live centre, drill chuck and arbor and 8" digital caliper

Features

- Spindle speed readout
- T slotted cross slide
- Offset tailstock
- Variable speed
- Metric and imperial thread cutting
- Longitudinal power feed
- Change gears
- Dial thread indicator

For more information contact our **Sales Team**, call us on **01244 531631**, email us at **sales@chesterhobbystore.com** or visit **www.chesterhobbystore.com**

Prices may be subject to change without notice, all prices exclude delivery