

No.241

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MAY 2016

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EDITORIAL

Editor: Neil Wyatt

Tel: +44 (0)1689 869 912

Email: neil.wyatt@mytimemedia.com

PRODUCTION

Designer: Yvette Green

Illustrator: Grahame Chambers

Retouching: Brian Vickers

Ad Production: Robin Gray

ADVERTISING

Senior Account Manager: Duncan Armstrong

Email: duncan.armstrong@mytimemedia.com

Tel: 01634 238893

MARKETING & SUBSCRIPTIONS

Subscription Manager:

Kate Hall

MANAGEMENT

Publisher: Julie Miller

Group Advertising Manager: Rhona Bolger

Email: rhona.bolger@mytimemedia.com

Chief Executive: Owen Davies

Chairman: Peter Harkness

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On the Editor's Bench

A Bigger Build

It's my plan to publish a few longer constructional series over the coming months – but there are a few things I will be bearing in mind. First, I will not have more than one extended build series running at a time, secondly I will make sure that even where the tool is a specialist one, the series will include plenty of ideas or components that will find wider application in the workshop.

This issue sees the start of a short series by John Pace on making a milling head for producing leadscrews. This may seem a specialised bit of equipment, but in practice the device will be equally at home cutting gears or any other job that needs a special form cutter, and also John gives plenty of valuable advice on the subject of milling threads.

I'm still keen to hear from readers with their ideas for tool builds whether short and simple (like Mike Cox's little rotary broach!) or more complex.

REMAP

Readers interested by this month's article on adapting a camera for single, left-handed use may wish to give some thought to helping out REMAP. REMAP is a fantastic charity that bring model and hobby engineers together with people looking for innovative, and sometimes unique, solutions to the problems they face. Sometimes these are everyday issues, such as achieving greater mobility, or helping disabled athletes achieve better performances on the sports field. Equally

THE MODEL ENGINEER EXHIBITION AT BROOKLANDS



This issue contains an entry form for MEX 2016 which is on 16-18 of September. I would really like to encourage readers to enter some of the tooling they have made, or at least consider entering a 'loan entry' if you don't fancy being in the competition. I enjoy seeing the ingenuity and skill in working tools as much as the complexity of working scale models. In any case, please come along and say hello – and bring the family because your ticket also gives entry into Brooklands Museum and the London Bus Museum so there really is something for everyone.

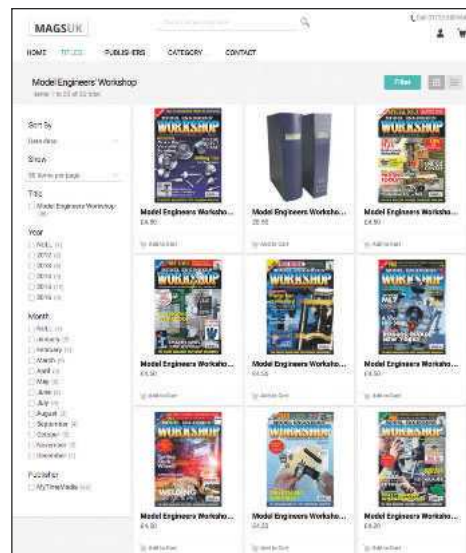
important are solutions that help people take up or resume a hobby or interest.

If you would like to know more about REMAP visit www.remap.org.uk, or see the REMAP-page later in this issue.

Australian readers may wish to contact TADACT (Technical Assistance for the Disabled) via www.technicalaidact.org.au

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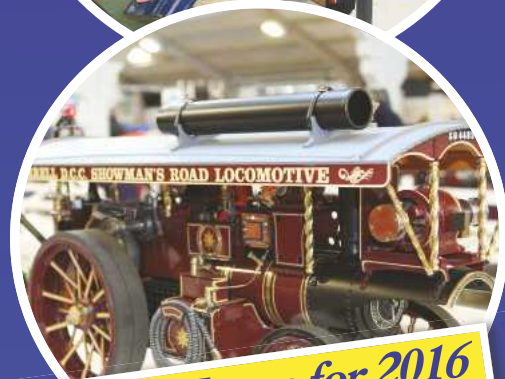
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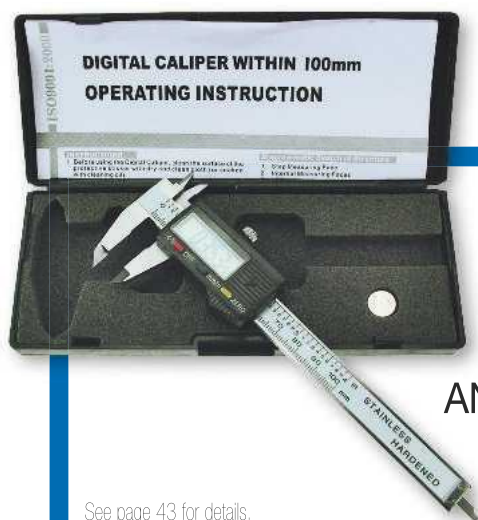
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Coming up...

in the June issue

IF YOU ENJOY THIS ISSUE, LOOK OUT FOR THE JUNE EDITION, PACKED FULL OF MORE TOOLS AND TECHNIQUES:



Tony Hills explains his approach to digital dividing, David Shrimpton fits power feed to his mill and Mark Noel's MultiGrind – is this the ultimate workshop accessory?

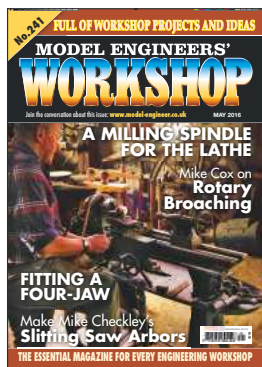
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ON THE COVER



The Way We Were. Stewart Hart took this photograph of Mike Smith demonstrating his treadle lathe at a club gala. Mike has since donated the lathe to the Hanson Museum.



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Joerg Hugel's Drill Grinding Tables

SMEET expert on drill grinding, Joerg Hugel has analysed the performance and use of several different drill grinding methods. He has kindly allowed us to put his full text and tables on the website.

Other hot topics on the forum include:

- > **Buying a 3D-printer, but which one?**
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Fitting a 4 Jaw Chuck



Fitting a larger chuck to lathe often requires the fitting of a backplate, Barry Chamberlain takes us through the procedure.



The supplied chuck and the backplate before fitting.



The rear of the chuck and the plain face of the backplate, as supplied.



Studs fitted to the backplate.



The matching zero marks.



Cloth to catch dust, fixed clear of the rotating parts.

Having recently improved the versatility of my Warco MW280V-F Lathe by adding a 5C Collet Chuck to compliment the supplied 3 and 4 Jaw Chucks I realised that I would also benefit from fitting a 125mm 4 Jaw Self Centering Chuck, and this article details the procedures involved.

Photograph 1 shows the 125mm 4 Jaw Self Centering Chuck, set of outside jaws and chuck key as received from Warco. To the right is the separately supplied Warco back plate and associated fittings. **Photograph 2** shows the rear of the chuck and the chuck mounting side of the chuck back plate.

The first task is to fit the back plate mounting studs and, to ensure maximum clearance between the rear of the lathe driving plate and the lathe body when fitted, the slightly longer threaded side of each stud should be fitted into the back plate (**photo 3**). The back plate is now fitted to the lathe drive plate and the 3 nuts tightened up. It is good practice to fit chucks in a consistent manner and so I stamped a zero on the back plate adjacent to the zero mark on the lathe driving plate mark which is just visible in **photo 4**.

With the saddle set as far to the left as it would go it was 'locked off' prior to the back plate facing cuts being made. As can be seen the cross slide was approaching the limit of travel but there was enough to get the job done. Because cast iron is notoriously abrasive it is very important to protect the lathe slide ways and a covering should be positioned to contain most of the generated chips/dust. The protective covering must be safely positioned well below and well clear of the back plate as shown in **photo 5**. In this case I used an old cloth as I was anticipating a large amount of debris, and judged that provided there was no danger of it snagging on the driving studs and becoming a safety hazard it would be acceptable. As always with cast iron the first cut tends to be the most difficult until the outer crust is breached after which life becomes much easier.

Start with a facing cut across the entire front face at around 180 - 200rpm which is quite sufficient to produce a good result.



Setting up to drill chuck mounting holes.



Drilling the new holes using co-ordinates.

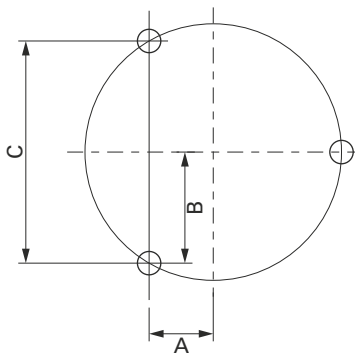


Using a 'lantern chuck' to hold screws for shortening.



Ready to check the fit.

Fig. 1



A = 0.25000
B = 0.43301
C = 0.86603

Co-ordinates for locating three equally spaced holes

This first cut needs to be of at least 0.5mm deep as anything less will result in rubbing and blunting of the cutting tool. Once the facing cut has been made attention should turn to turning down to produce a good fit between the back plate and the rear of the chuck body.

Measure the inside diameter of the chuck body and the depth of the recess. The aim here is to have the chuck a snug fit onto the back plate, ideally such that the chuck will fit when tapped onto the back plate with a soft nosed nylon hammer. In practice an interference fit may take some time to achieve, but this is what must be aimed for. It is important to ensure that the corners are square to ensure a snug, flush fit between the chuck and back plate, and that the back plate does not bottom out in the chuck recess - I allowed for a clearance of 0.5mm. Finally, use a boring bar to skim the inner hole as this is used to find the fixing hole centres in the next operation. Remove the cloth covering the lathe slide ways carefully and dispose of it along with the swarf into a bin. Remove the back plate and thoroughly clean both it and the area around the lathe driving plate to remove all traces of cast iron dust. I use a vacuum cleaner to clean swarf away from my machines but in this case I also sprayed the surfaces lightly with Duck Oil before using a clean cloth to remove the remainder of the dust/debris.

The next stage is to drill the chuck mounting holes. These holes should be offset by 60 degrees from the mounting stud holes, the studs being removed for this operation. In **photo 6** the back plate can be seen reversed and set off from the mill table by parallels to allow the drill to break out without damaging the mill table working surface.

The chuck body data sheet shows that the mounting holes are set at a pcd of 108mm. Referring to the page in the Zeus reference Charts and Tables covering 'Co-ordinates for locating equally spaced holes in jig boring' details the co-ordinates for 3 equally spaced holes, reproduced in **fig 1**.

Multiplying the above values by the pcd (108mm in this case) results in Dimension A = $108 \times 0.2500 = 27.00\text{mm}$ and Dimension B = $108 \times 0.43301 = 46.76508\text{mm}$. After rounding A = 27.00mm and B = 46.77mm.

Having clamped the back plate to the mill table as described above it is now necessary to locate the centre and this is easily accomplished with a centre-finder. Once the centre has been located the digital readout was zeroed. The table was then offset to X = -27.00, Y = -46.77 and the rearmost hole was centre drilled followed by a 7.9mm drill.

The table was moved to new co-ordinates X = -27.00, Y = +46.77 and drilled. Finally, the table was moved to

co-ordinates X = +54.00, Y = 0.00 and drilled as shown in photo 7. Note that the Z co-ordinate is set to zero with the tip of the drill just in contact with the back plate in order to monitor the progress of the drill in relation to the mill table.

The back plate was then released, turned over and clamped directly to the mill table. This time the alignment of the holes on the mill table is insignificant as the centre of each hole has to be found individually using the hole centre finder (**photo 7**). Not possessing a counter-bore tool for an M8 cap-head screw I selected a 14mm slot drill in order to set the head of the cap heads below the surface of the back plate. Having found the centres, each hole was counter bored to a depth of 8.5mm.

Thoroughly clean the back plate, the fixing clamp assemblies and the mill table of all cast iron residue on releasing the work from the table.

For stability, the jaws of the chuck were opened and placed directly onto a wooden work surface. The back plate holes were checked for alignment and the cap head screws dropped in and set finger tight before tapping the back plate down firmly onto the chuck body. The supplied M8 cap head screws were too long and had to be shortened by some 4mm to ensure full engagement before 'bottoming out'. For this operation I made use of my lantern chuck, as shown in **photo 8**. The cap heads were inserted, tightened up, and the edge of a steel ruler passed over the screw heads to ensure none were proud of the back plate.

The back plate and lathe driving plate mating surfaces were then wiped with a clean cloth to remove any remaining debris. With a protective wooden 'tray' on the lathe bed (**photo 9**) the chuck was offered up and bolted into position on the lathe driving plate, having aligned the stamped zero marks.

Run-out checks - the Inspection Chart sheet accompanying my chuck listed 5 checks, the first of which checks the concentricity of the chuck body which should have a maximum deviation of 0.03mm. In my case this was 0.025mm indicated.

The second test, checking the accuracy of grip on a test bar, calls specifically for a Master Pinion, the third test for any pinion. The maximum deviation for either pinion being identical at 0.04mm. For this



Testing runout.

test I used a length of 12mm diameter ground bar. At the specified distance of 50mm I recorded a maximum run-out of 0.04mm (**photo 10**) which is just within specification.

The final two checks call for the use of test rings, the first of which is held on the periphery of the extended jaws and the second with a ring held within the jaws. Measurements with a DTI being taken on the outside (first check) and inside (second check) of the respective ring faces. I have no access to test rings so ignored these checks, being content with the measurements I was able to make. Suitable accurate rings could be produced from the inner and outer rings of a very large ball-race should you have any within your workshop.

The Inspection Chart sheet states that for this particular range of chucks (up to 160mm capacity) the chuck body itself should have a maximum deviation of 0.04mm, and mine came in at 0.03mm.

The new back plate, having a larger diameter than the chuck body, would have a better appearance if it was reduced to match the chuck body. Because the travel of my saddle is restricted by the spring like shield covering the top driving shaft the options for turning the back plate down are somewhat limited. I managed to find sufficient travel on the compound to complete this task with a left hand boring bar set inverted as shown in **photo 11**.



Reducing the backplate diameter to match the chuck.

The saddle was 'locked off' whilst the boring bar was used and the lathe set to run in reverse to suit the inverted tool. The final result can be seen in **photo 12**, complete with freshly stamped 0 mark adjacent to the 0 on the drive back plate.

Note the use of paper towelling rather than a cloth to gather all cast iron debris/dust below the work area. Again, when introducing anything below a rotating chuck it is extremely important to ensure a good clearance between all rotating parts and to double check before commencing that there is no opportunity for the paper towelling to become entangled with any part of the chuck assembly. Turning the chuck by hand before applying power was the method employed to confirm that the paper towelling was well clear. Were it not for the extremely abrasive qualities of cast iron residue a protective covering would not normally be tolerated so near to a revolving chuck.

Safety - coupled with caution - is the key word when performing potentially hazardous procedures. The paper towelling was removed and the whole work area cleaned thoroughly once the task was completed.

Full house. **Photograph 13** shows the other chucks safely stored and out of the way on three chuck holders made as described in *MEW* Issue 224 and yes, the broom handle is getting embarrassingly short now! ■



The finished result.



Chucks stored on holders from MEW 224.

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Adapting a Camera for a disabled photographer

Ian Johnson uses his workshop skills to convert a camera for left-handed use.



Imagine only having the use of your left hand to use a camera. Imagine the difficulty of the simple operation of pressing the shutter button on a camera made for right-handed people. This is my starting point for this project – to enable my disabled partner to take photos again with the aid of a specially made adapter.

Inspiration for the adapter

Some years ago, my partner suffered from a serious illness, which left her with limited mobility and unable to use her dominant right hand. As a keen hobby photographer she was devastated not to be able to take photographs of nature and the surrounding area that she loved. She has a small Olympus compact and has tried using it upside down, using her thumb to operate the shutter, not the best method at all! And she had all but given up hope of continuing her hobby. After some research looking for a suitable camera, I was shocked to find that manufacturers produce cameras for right handed people only! Try using a camera with only your left hand and you will very quickly see what the problems are! This project seeks to address this problem.



Roughing out the base from Acetal block with 12mm slot mill.

An action plan is needed!

So what to do? I considered the modern activity cameras, but these were also for right handed users. Maybe a selfie stick, or wire connection, but this would require batteries and wires, and I'm not confident with wiring and electronics.

The answer was, use her existing Olympus, and make something mechanical! I'm more comfortable with mechanical things!

Now came the hard part! I had to think of some way of converting a two handed operation into a one handed operation. This would involve re-locating the position of the shutter release button, and the twist action zoom function, both of which are on top of the camera. Both actions needed to be easily accessed by the fingers and thumb of the left hand.

I am a time served fitter turner in the chemical industry, with experience with many machines, including all manner and makes of lathes, horizontal and vertical mills, NC and CNC machines. Fitting work included work on steam turbines and chemical plant and everything in between. I had a career change into health and safety, then teaching, and now I have a carer role. I like to keep up my old skills, although I have a small workshop, everything I learnt as an apprentice still counts.



My workshop equipment includes: Warco mini lathe, micro mill, bench drill, 5 inch grinder, 4 inch vice, files hand tools galore, and lots of patience!

Please have a look at my website: www.thesmallworkshop.co.uk for my other projects.

Thank you for taking the time to read this article.

Ian

A cradle or base for the camera, and a decent sized hand grip will be needed, both to be firmly attached via the 1/4 inch x 20 tripod mounting screw. A separate one piece block will house a trigger, an operating push rod and rocker to actuate the shutter button. And a knurled rotating wheel will be used to operate a forked rod to imitate the left/right twist zoom function.

I will be taking dimensions directly from the camera, and making it all up as I go along! So apart from little sketches, detail dimensions are sparse or non-existent for this one off project.

Material choice

Okay, so far so good, now I have some sort of vague plan, so, what material to make it all out of? Well, I haven't got a vast choice of material, but I did have some useful pieces of black Acetal bar and rod from another project. Acetal is an engineering plastic, very tough and easy to machine, ideal for this project. It's also a good choice of material because I will be using a mini-lathe and micro-mill. They are very capable machines but there will be a lot of roughing out. Aluminium was considered but would have made the job a lot harder to machine and it is cold to the touch, this adapter has to be user friendly and nice to hold.

The base

A piece of acetal 40 x 28 x 120mm was used to make the base of the adaption. Using a 12mm slot milling cutter, the base was roughed out to fit the camera. I left one side thicker to give something solid to attach the trigger housing block (**photo 1**). The little micro mill was happily chomping away at the acetal and after a



Relief radius cut into base for the lens rotating bezel.



Method of locating tripod screw onto base.



Prototype zoom fork operating rod.



Top view showing fork action on zoom control and shutter button push rod.

Although I was making it all up as I went along, by now I could see my vague plan was starting to take shape and something which might actually work was appearing on the bench among the growing scrap pile!



Top plate with rocking lever for shutter button and brass pin.

few test fittings and fettling, the camera fitted snugly in the base. Later in the project, I machined a recess and a male and female slot in the base and hand grip, just to ensure rigidity, but in hindsight this was probably not needed.

The camera has a large lens cover with a rotating bezel which, when rotated, operates the on screen menu functions. To accommodate the bezel a relief radius was fly cut into the front of the base and also on the shutter trigger block (photo 2).

I couldn't figure out how to align the tripod screw mount into the base, so, after a cup of tea and a think, a short 1/4 inch x 20 brass screw was machined to a point, two small flats were filed on it so I could screw it into the camera, this now acted like a transfer punch onto a strip of masking tape, for the 1/4 inch clearance hole (photo 3).

I was thinking it might take at least two attempts to get the base right, mainly because it is an odd shape with cut outs for access to menu buttons, but to my surprise I got it right on the first attempt! Result!

Zoom and shutter controls

This part of the job really made me think! I made a rough prototype actuating forked rod for the zoom twist control, to prove it would work (photo 4). I then made a much improved fork with a better profile. A 6mm square was milled on the bottom of the fork for the zoom operating wheel.

Photograph 5 shows the block with the improved forked rod aligned with the zoom lever. It also shows a 3mm dia aluminium push rod for the shutter release button, this rod is operated by a trigger, pushing it against a little rocker which is housed in a small block on top of the camera (photo 6).

Next job was the rotating thumb wheel which needed to have a good grip. More head scratching and cups of tea were needed! I held the wheel in the dividing head, 24 vertical slots were milled on the diameter, giving the wheel a very coarse spline type of grip. A 6mm square hole was slotted in it (as shown in photo 7) this is to accept the square machined on the bottom of the zoom fork rod. A

slotting tool was made for this job, ground from a spare 8mm drill and worked a treat.

On the third attempt a smaller acetal block was finally milled to size to hold the trigger, and the top block, and a long hole was drilled through the block for the fork. The trigger was milled and filed to shape (no photo of it being machined sorry) although it can be seen in the final assembly (photo 14). A clearance slot was machined to accept the zoom wheel.

Although I was making it all up as I went along, by now I could see my vague plan was starting to take shape and something which might actually work was appearing on the bench among the growing scrap pile!

Handgrip

The hand grip needed to be chunky and easy to hold. A piece of 30mm dia x 100mm Acetal bar was used and a 6mm radius form tool produced five comfortable finger grips. This will be



Using slotting tool to form square hole in the zoom wheel.



Boring out the bulk of the hand grip. Lots of overhang but no vibration.



6BA cheese head brass screws.



View of the radius cutter profile off set.

secured through the base and into the tripod screw. Most of the bulk has been drilled and bored out to keep the weight down. **Photograph 8** shows the precarious work holding and the tipped long boring bar needed for this job, there wasn't much to hold on to, but a good finish was achieved with very little vibration over a combined 200 mm, pretty good for a small lathe!

were also needed. The only thing I didn't make, was the trigger spring.

A quick test assembly of everything to align the parts, and then mark the locations for the 6BA screws, drilled, counter bored and tapped. I'm not sure of the strength and holding power of 6BA screw threads in Acetal, so I made the screws quite long (20mm) to ensure there was enough threads to give a good firm hold in the plastic (**photo 9**).

Assembly and fitting

Almost everything is made from Acetal, apart from four cheese head 6BA brass screws with a 0.016 inch wide screwdriver slot milled in the heads. Two 6BA brass pivot pins and a steel spring for the trigger

Finishing off

Before I presented it to my partner it needed to look good! So every surface was fly cut to give a uniform smooth finish and to reduce the bulk. A good finish can

Verdict from the user?
She says it is life changing!
She can now return to a much loved hobby which she has not been able to take part in for many years.



Using the homemade radius cutter.

be achieved with Acetal using a honed HSS tool, I always give the cutting edge a quick rub over with a fine diamond hone. The adapter weighs a mere 119 grams, and when fitted to the camera it all weighs a reasonable 340 grams.

Just to complicate things even more, after fly cutting every edge was crisp and sharp, so I decided that a small radius was needed on all edges... and, of course, I didn't have a radius cutter! So I made one from a short length of 8mm diameter bar of tool steel. I machined an eccentric shoulder on one end, like a cam, and with a 1.5mm radius cutter cut the shape of the radius (**photo 10**). This is now the shape of the external radius cutter. The rod was now milled down to half its diameter, with the off-set cutting edge this gave the tool a natural cutting edge clearance. Heated up to cherry red and annealed to straw colour it is plenty hard enough for most jobs. In use it acts like a mini fly cutter (**photo 11**) and it works quite well too, I was very pleased with the results!

On the top block I milled a small groove for the function dial indicator with a slitting saw, then filled the groove in with white marking ink (**photo 12**).

Using the device

Time for assembly and testing. It fits nicely in the hand, and it works! The zoom function is easily accessed via the rotating wheel, and the shutter button trigger is easily operated by the middle finger. Even the half press function for focussing works as it should do. And a firm grip can be maintained at all times with the finger grooves. All other functions and buttons can be accessed easily, but the important functions are the shutter and zoom (photos 13 and 14).

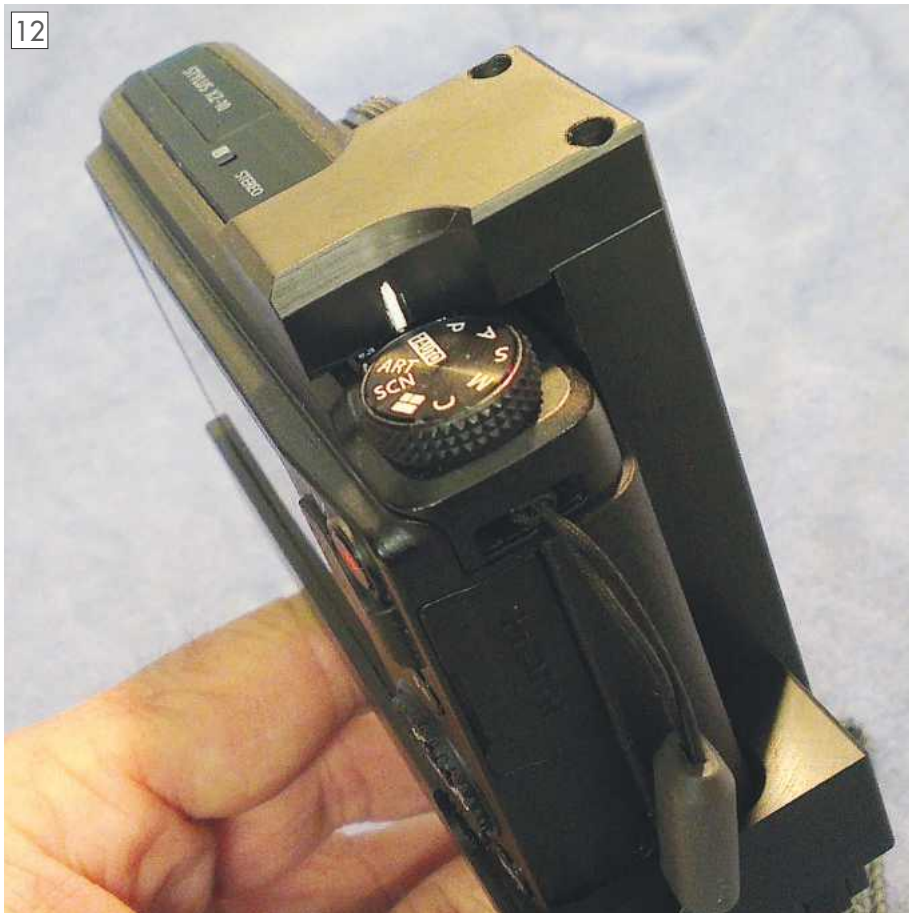
Conclusion

Verdict from the user? She says it is life changing! She can now return to a much loved hobby which she has not been able to take part in for many years, she's very pleased with it.

Minor issues include the need to unscrew the device off the camera to gain access to the battery and memory card. And it can't be screwed to a tripod. Nothing that will cause a major problem.

It was a pleasure to design and make this camera adaption, it took many cups of tea and deep thought to come up with the method of converting the push button and twist actions, but I initially had a vague idea how this would look and work, and stuck with it, and now that it is made I can think of a dozen different ways to make another one.

I don't know how many of our readers or their friends with dexterity issues would appreciate a device like this, but it was very rewarding to feel that at least one person appreciates the work that goes into a project like this. ■



View of the top plate with white dial position marker.



This is how the adapter fits in the hand.



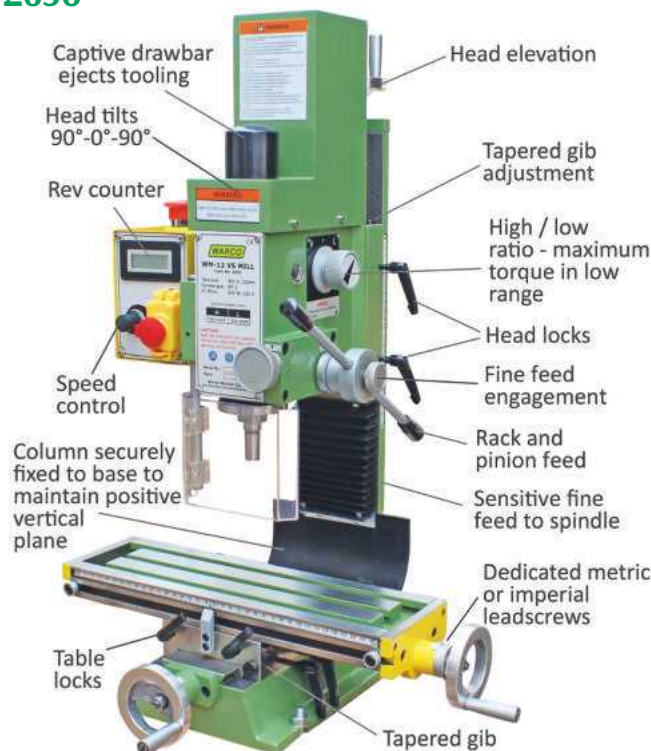
The finished adapter.

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A Slitting Saw Arbor



Mike Checkley describes a handy workshop accessory.

A slitting saw provides a valuable addition to both lathe and mill tooling. During the build of my Stuart 7A, parts that benefited from the use of a slitting saw included the crank shaft, conrod, main bearings and valve glands (**photos 1a, 1b & 1c**). The risk of losing an almost finished part due to the slip of a saw blade or wonky cut is one that is not worth taking and can be significantly reduced by using a well made slitting saw.

Slitting saws used for the Stuart 7A manufacture were 50 and 63mm diameter by 0.5mm thick. Saws of this size tend not to have a keyway so rotation of the blade in the arbor is prevented by friction from the clamp washer and arbor face. This can be seen as a benefit, especially to those new to using a slitting saw, as I was, finding the correct feeds and speeds through trial and error. In the unfortunate case that the blade jams the blade can slip in the holder saving the part, the blade and in extreme cases the machine tool motor and controller. The diameter of the arbor provides support for the blade, too little support risks the blade wandering off line, flexing or even breaking. Too large a supporting diameter reduces the useful depth the saw can be used.

This article and drawings refer to the machining of an arbor for the larger Ø63mm slitting saw. I had previously used silver steel for the smaller arbor but my stock did not extend to 25mm diameter so the larger arbor was made from mild steel. Mild steel is readily available as either grade EN1A or EN3B. EN1A is the free machining variety and gives a much better finish than EN3B, which is more suitable to jobs which require welding. When I have purchased mild steel from engineering shows it has been a lottery which grade I got so I have since purchased a couple of metre lengths of EN1A from my local metal supplier to have in stock.

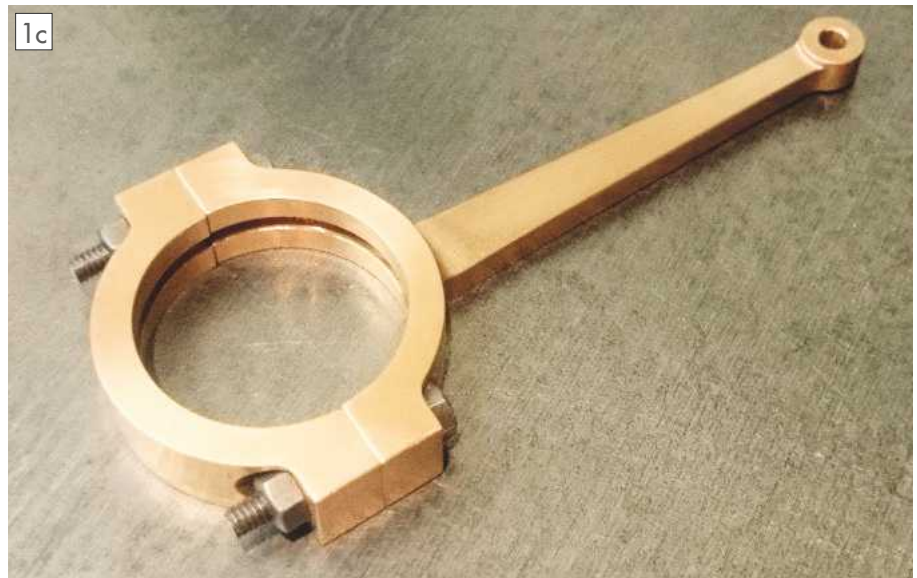
Chuck a piece of 25mm diameter bar in the lathe, face off and centre drill (**photo**



Cutting out an extra piece from a crankshaft.



Splitting an eccentric strap.



The finished eccentric strap for a Stuart 7a.

2). Centre drilling the shank provides support for turning the shank to size and also aids in aligning the arbor back in the lathe if it needs adjusting or truing up in later life. Bring the bar out of the chuck enough to machine the length of the shank, whilst supporting the free end using a revolving centre turn the shank down to size. There is no need to use good

tooling whilst rough turning the shank so I used a knife tool with a spindle speed of 100rpm. My lathe gearing is set to give the lowest feed rate on the lead screw of 0.09mm/rev, which I retained throughout the machining of the arbor components. Rough the diameter down to about 0.5mm above the final diameter (**photo 3**) and then change to a sharp round tipped tool.



Stock faced and centred.



Roughing out.





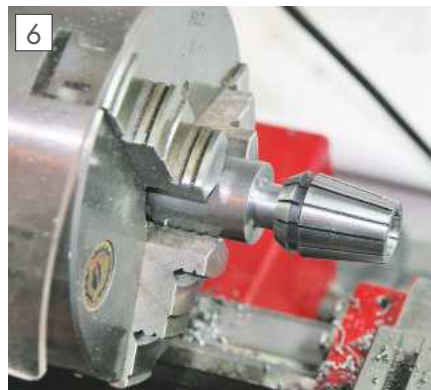
Checking diameter.

Whilst running the spindle at 200rpm turn the shank down to final size. Using a tool with a radius gives both a good finish and provides a nice corner radius where the shank meets the main arbor diameter, to reduce stress concentrations. The finished diameter of the shank should be a nice fit in the larger diameter end of the collets range. I choose a 14mm diameter collet for this arbor as this is the largest collet I have in a set of ESX25 collets so I aimed for 0.01 to 0.02mm below this for the shank diameter (**photo 4**). Finish the shank with a chamfer (**photo 5**) and trial fit the collet before the arbor is removed from the chuck (**photo 6**).

Flip the arbor in the chuck and turn the locating ring down to size plus some extra. This extra material is removed to final size with the arbor mounted in a collet chuck for greater precision (**photo**



Finished shank.



Testing fit in collet.



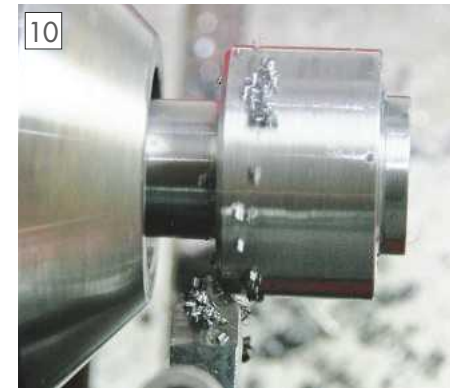
Reversed blank mounted in collet.



Chamfering end.



Trial fitting.



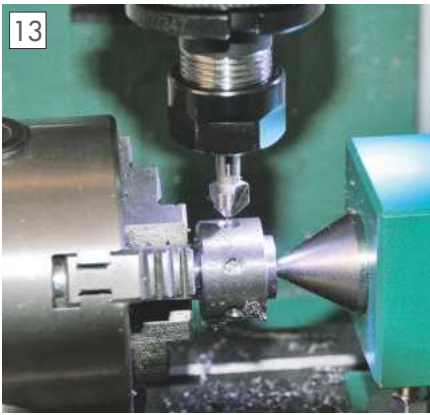
Chamfering rear edge.



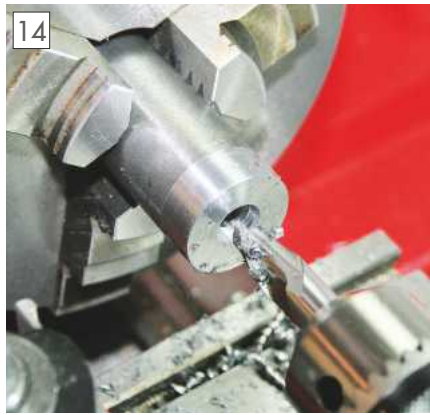
Tapping for securing screw.



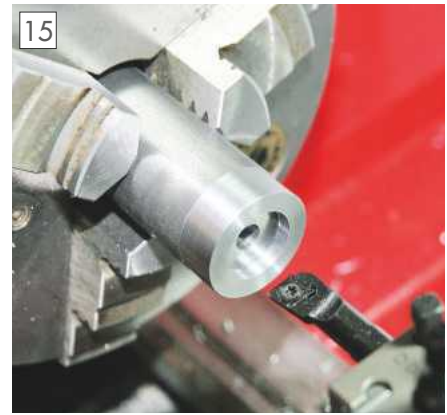
Holes for clamping bar.



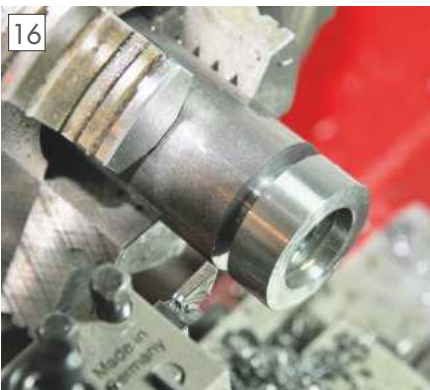
Countersinking holes.



Using a slot drill to start a cavity in the end of the clamp washer.



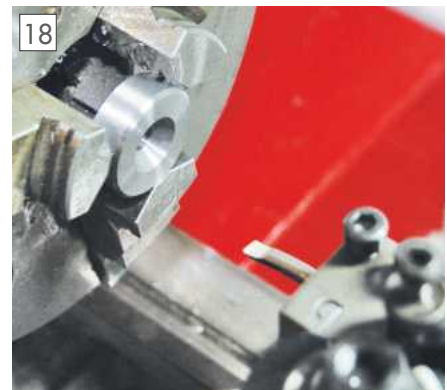
Bored out cavity.



Parting clamp washer.



Chamfering before completing parting.



Using small boring tool to countersink the top of the washer.

7). Machine a chamfer (**photo 8**) before performing any trial fits of the saw blade (**photo 9**) as any burrs will give false results. For small chamfers, rather than offsetting the top slide on a regular basis I have ground a chamfering tool, which has become a very useful and frequently used addition to my lathe tooling! I use this tool with a spindle speed of ~100rpm and it is good for about a 2mm size chamfer before it begins to chatter. Chamfer the shank end of the arbor using the same chamfering tool (**photo 10**). Drill and tap the arbor to accept the clamp screw (**photo 11**).

Remove the arbor from the lathe and mount in the dividing head on the milling machine. Drill and counter sink six holes equally spaced (**photo 12**). These holes are to accept a bar for reacting the torque when tightening the clamp screw. Slightly countersinking the hole provides a lead in to the hole for the bar (**photo 13**). This concludes the machining of the arbor and it is now time to machine the clamp washer.

The clamp washer is the same diameter as the arbor and should be as low profile as possible to reduce any interference issues when slitting components that do not protrude far from vice jaws or fixtures.

Chuck the same diameter bar as used for the arbor in the lathe, face off and drill through 6.6mm. A hole of this diameter is not large enough to accept a typical boring bar so I used an old 10mm slot drill to counter bore (**photo 14**) and give enough access to bore the hole out to match the locating ring of the arbor (**photo 15**).

Begin to part off the clamp washer from the bar (**photo 16**) but before completely removing the washer it is convenient to chamfer the corner at this stage (**photo**



Two finished arbors.

17). Recommence parting off to completely remove the washer from the bar. As the washer is only 8mm deep, gripping the washer in the chuck is doable but leaves little clearance for a chamfer tool. Tidy up the face of the washer from the parting off operation and countersink the hole. I have a small boring tool for gentle operations like this

(**photo 18**). This concludes the machining of the washer and the manufacture of the slitting saw arbor. This is a simple tool than can be made accurately and in only half a day. Different sized arbors can be made for different diameter slitting saws (**photo 19**) or different shanks for different mounting methods. ■

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

Antex Hot Air Rework Tool and Soldering Station Combo

This new six-piece Soldering Station from Antex features a Hot Air Rework tool, two nozzles, a station, a 50-Watt soldering iron, that goes from room temperature to 450°C in 55 seconds, with a safety stand (**photo 1**). The station itself is housed in a robust metal enclosure, the LED digital display indicates both iron and rework gun temperatures.

As a convinced Antex user, my two favourite features of their irons are the easy to change tips and the very slim handles, and the 24-volt iron supplied with this station is very slim and comfortable in the hand. It is great to use, heating up very quickly and only losing around a degree or so in temperature on medium sized joints. I found that it was happy at 340° centigrade, rather than the 350° I would normally use.

The part of this station that most interested me, however, is the hot air rework tool. Increasingly these days 'interesting' components are only available in surface mount (SMT) packages. Normally surface mount parts are soldered in an oven. This creates new problems for servicing, so any 'duff' joints or parts are removed and reattached by using the hot air from a rework gun to melt the solder. Of course, this means the gun can be used to attach parts to an empty board. The gun is temperature controlled and also has a variable speed fan – no risk of blowing away small parts!

I have managed to hand-solder parts at pitches around 1mm with a very fine tipped iron and 'pressing' each leg down onto a tinned pad. While it works, attaching 64 pin package this way can drive you insane. I won't talk about using the grill to fit chips with pads underneath them...

It so happens that a current project of mine needed a 32-pin SMT USB to serial chip fitting (**photo 2**). You can see how tiny the pads are (**photo 3**).

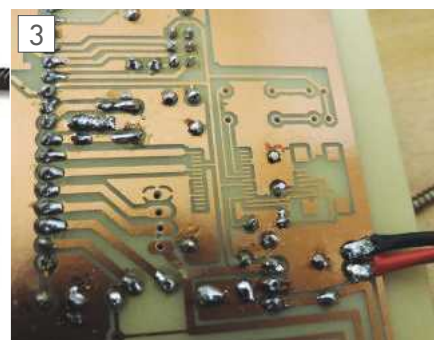
With a rework gun it is usual to apply tiny spots of solder paste to each pad, perhaps using a plastic mask. With care, however, it is possible to tin the SMT pads by stroking them with a freshly tinned iron. The package can then be aligned over

28 pins on a chip about half an inch long.

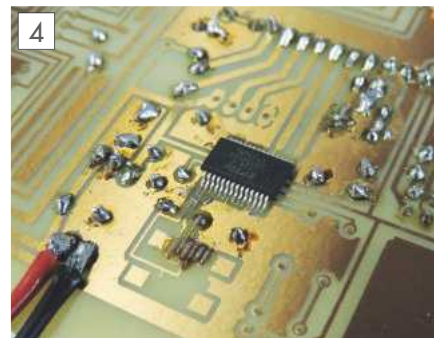
the pads (**photo 4**). I found that just using the hot air gun didn't result in a successful joint. I then used a wire to add a tiny smear of non-corrosive flux along each row of legs and re-applied the blower (**photo 5**). As soon as things heated up a glint of bright, molten solder became apparent on each 'foot'. Although I had not perfectly aligned the chip, probing with a multimeter 'proved' all the joints were okay and there were no bridges between adjacent parts (**photo 6**).

Using the rework gun was so much easier than using an iron, I have no hesitation in recommending it as an ideal solution for anyone who regularly uses surface mount chips in their projects.

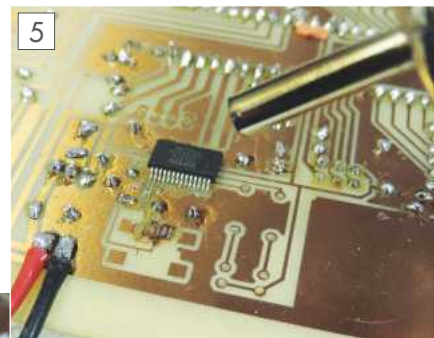
The station's retail price is £249.98, it is available direct from Antex at www.antex.co.uk or telephone +44 (0)1822 613565.



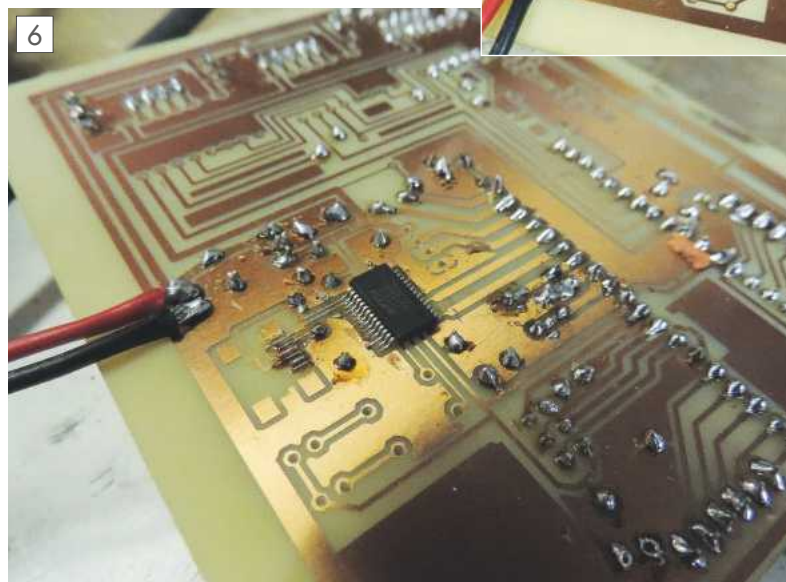
Compare the SMT pads with the standard pads at 0.1 inch spacing.



Chip placed on the tinned pads.



The blower in action.



The finished result.

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Rotary Broaching

Further Developments



Michael Cox has come up with a simplification of his original device.

Rotary broaching is a way of machining holes with non-circular profiles such as hexagonal holes. The commercial equipment for rotary broaching is expensive as are the tools. This puts the technique beyond the resources of most model engineers because it is difficult to justify an expenditure of more than £100 for something that is used only occasionally.

A while back, *MEW* published an article in which I described a simple way for rotary broaching in the lathe (**ref 1**). The unit (**photo 1**) described in this article was designed to facilitate not only the broaching operation but also it provided a simple jig to enable hexagonal broaching cutters to be made.

A typical cutter made using the jig is shown in **photo 2**. This cutter was made from silver steel and is 70 mm long and the shank in 10 mm in diameter. The particular cutter shown has been turned down at one end and then six flats have been milled on the end to provide a 5mm AF hexagon end. The flats are milled at a 2 degree angle to the axis of the shaft.

Photograph 3 shows the hexagonal end of the cutter. Notice that the end has a small conical depression in the end. This was made using a standard HSS twist drill with a 118 degree point before the flats were milled.

Photograph 4 shows the other end of the cutter. This is drilled out with a 60-degree centre drill so that a 6mm steel ball just sits in the conical depression.

Making this type of cutter is straight forward using the jig described in *MEW* 185, but they could also be made using a rotary table or a dividing head on the milling machine. After machining the cutter it is hardened and tempered.



The other end of the cutter showing the conical hole.



The rotary broach tool described in MEW 185.



A 5mm hexagonal cutter.



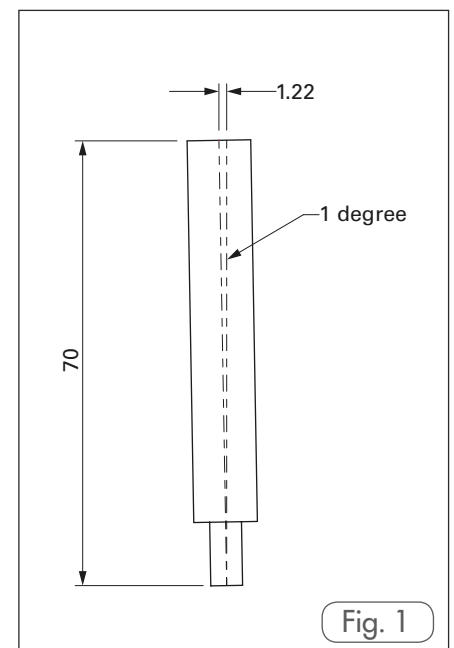
The hexagonal end of the cutter.

As originally described in *MEW* 185 the toolholder/jig was mounted on the toolpost of the lathe during rotary broaching. Recently I needed to make some hexagonal holes in some aluminium plate that was too large to mount in the lathe chuck or on the faceplate. After a little thought I realised that that all that was needed was a way to make the tool precess (i.e. wobble) with a 1 degree conical motion and then I could make the holes on the mill.

The wobble bar

Figure 1 shows the geometry required to produce a 1 degree conical wobble on the cutter. It can be seen that if the cutter is located in a hole in the workpiece then the other end of the tool must move in a circle of radius $70 \tan(1) = 1.22$ mm.

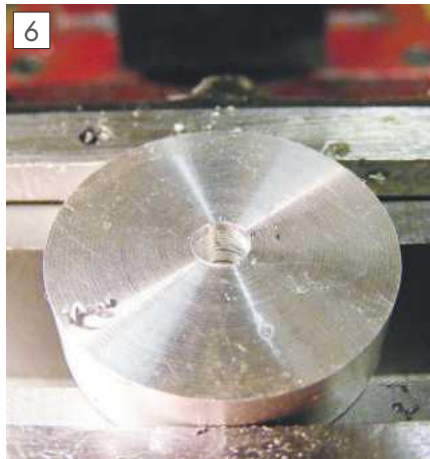
To make the wobble bar a piece of 10 mm round mild steel bar was taken and the end faced in the lathe. The piece was then lightly centre drilled using a BS1 centre drill in order to locate the centre of the bar. The hole was only circa 1 mm deep. The piece was then mounted vertically in the milling vice. With a BS1 drill in the chuck the piece was positioned so that the centre depression was directly under the drill. Using the graduated collar on the milling table the workpiece was displaced 1.22mm from the centre and a



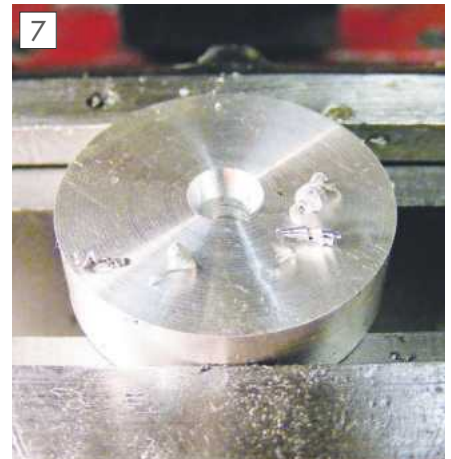
new hole was drilled in the end of the bar. The BS1 centre drill was replaced with a BS4 centre drill and the hole enlarged until a 6mm steel ball just sits in the conical hole. **Photograph 5** shows the end of the wobble bar with the offset hole.



The wobble bar.



The hole in the workpiece.



The chamfered hole.

Rotary broaching in the mill

In order to illustrate rotary broaching in the mill I will describe the operations to make a 5mm AF hole in a workpiece using the cutter described earlier (see photos 1, 2, and 3).

Firstly a 5mm hole is drilled through the workpiece (**photo 6**). The hole is countersunk using a 60 degree centre drill so that the diameter of the countersink is just larger than the across the points measurement of the tool (**photo 7**). The hexagonal cutter is then located in the countersink and a 6mm steel ball located in the end of the cutter with plenty of molybdenum disulphide grease. The wobble bar is then chucked in the mill and lowered until the offset hole locates on the steel ball (**photo 8**). The mill is started at circa 400 rpm and pressure applied to the wobble bar using the mill fine feed. The cutter will slowly sink into the workpiece. **Photograph 9** shows the completed rotary broached hole.



The mill set up.



The completed hexagonal hole.

Conclusion

Rotary broaching is often regarded as a rather specialised technique and the cost of commercial equipment puts it beyond the resources of most amateur engineers. Both this article and the previous article in *MEW 178* demonstrate that it is possible to carry out rotary broaching successfully using the very simplest equipment. ■

Rotary broaching in the lathe revisited

It is also possible to use the wobble bar in the lathe. To do this the wobble bar with the offset hole is simply mounted in the tailstock chuck. The workpiece is prepared by drilling a hole. The hole is countersunk using a centre drill. The cutter is placed in the countersink, the ball located between the wobble bar and the cutter,

and pressure applied using the tailstock as shown in **photo 10**. The lathe is run at circa 400 rpm and the tool will slowly sink into the hole under the pressure from the tailstock. A 5mm socket formed in a 10 mm steel bar using this method is shown in **photo 11**.

The advantage of using this technique over the original method proposed in *MEW 185* is that the full force of the tailstock is available for the broaching operation.



The lathe set up for rotary broaching.



A hexagonal hole made on the lathe.

REFERENCES

1. Rotary Broaching – The Easy Way, Michael Cox, Model Engineers Workshop 185, Jan 2012.

Readers' Tips

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TIP OF
THE MONTH
WINNER!

Our winning tip from Robert Dawes is a handy way to neatly shorten screws.

Simpler Screw Shortening

It doesn't take long to discover when you first start shortening bolts or screws that a hacksaw cut messes up the thread where the bolt or screw has to be cut and without further treatment on grinding wheel, linisher or with a file it is impossible to screw on a nut or screw the screw into a tapped hole. However, if the saw cut is made with a piercing saw the threads around the cut seem to be undamaged and the screw will enter the tapped hole or whatever without difficulty. I normally shorten any bolt or screw below $\frac{1}{4}$ inch with a piercing saw and keep a supply of coarse pitch blades for the purpose. Smaller screws may need a finer pitch blade. The code that applies to the pitch of piercing saw blades is a bit unusual and I can never remember how it works. However, a minute or two spent on the internet will reveal all. I always have to look it up before ordering!

Perhaps someone will find this helpful.



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 we will choose 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.chestershobbystore.com** to plan how to spend yours!

Please note that the first prize of Chester Vouchers is only available to UK readers. Other prizes are at the discretion of the Editor.

Our runner up is Ted Fletcher who wins a set of ten Shaviv deburring blades with a Mango II handle.

Tap and Die Storage

I used to keep my taps and dies in small tobacco tins and found it a bit of a bind locating the correct pair. I was given a chunky length of new wood, about a metre and half long, by 100mm high and about 220 wide. I thought it would be a shame to cut it up for fire wood. I thought I would plane it up then cut it into three pieces, and bevel the sides as shown in the photo,

I gave each of them a coat of varnish. I drilled holes along the bevelled edges in which to place my taps, taper one side, plug the other, along the top I cut recesses for the dies. I gave each hole a good squirt of oil before inserting the tap or die and after twenty or more years have not seen a sign of rust.



No more than one prize with a value of £30 will be given each month. By entering you agree your entry can be freely published and republished MyTimeMedia on paper or electronically and may be edited before appearing. Unpublished tips may be carried forward to future months. You will be acknowledged as the author of the tip. There is no guarantee that any entry will be published and if no publishable tips are received a prize will not be awarded. The decision of the editor is final.

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18 Months with a Tormach

PART 2



Bob Rodgeron recounts his early experience with an American made CNC mill.

I first became aware of Tormach Machine tools after having some magazine articles published on the manufacture of various parts for vintage and Veteran Motorcycles. The editor of the magazine (*Home Shop Machinist*) sent several copies of the magazines and on the back pages were some advertisements for Tormach Mills.

I was impressed, the machines looked to be very robust and well presented. I took a look at Tormach's website and was also struck by the quantity and quality of tooling at what were reasonable prices.

I had had nothing to do with CNC machining prior to this, other than admiring the quality and repeatability these machines could turn out. However, a little flame had been lit and before long I could see me using a machine like this for prototyping and a few small production runs as part of my business and also hobby use. Above all I could see it as a great challenge in retirement that would stop my brain from seizing up as I got even older.



The mill uncrated.

By now it was over a year since I had received the mill and I struggled on, slowly getting a bit better at drawing things in 3D and producing part programs.

There are quite a few videos on you tube available via Sprut Cam America that help with various aspects of the preparation of part programs. However, a lot of these are for older versions of Sprut Cam and you have to struggle to find what you are looking for. Sometimes the lay out is a little different between the different versions.

The manual for Sprut Cam can be downloaded. It extends to several hundreds of pages and helps a lot, however, it is a translation from the Russian Language and in places it is poorly done. I think this may change since Tormach have a close relationship with Sprut Cam and Jake Stauber of Tormach took over the Sprut Cam training side of things. Hopefully more video will be produced that is directly linked to Tormach machines.

I found that I was constantly having positional problems with the tool in relation with the work piece and found it particularly stressful when initially starting a job, having to cheat the system to get the start point right. Despite this I soldiered on and produced one or two commercial parts, none of which were

cost effective because I broke cutters getting there (**photos 14 and 15**).

I then bought a program called Gearotic because I want to be able to make the odd gear and sprockets. I found this worked really well, was simple to understand and I had instant success with the 4th axis and made test samples of a gear, a toothed belt pulley and a couple of sprockets (**photos 16 and 17**).

Not everything was a success. One gear cut eccentrically due to the fixture not being clamped properly in the three jaw and another got chewed up because of incorrectly adjusted backlash in the rotary table, annoyingly it happened while cutting the last tooth. Ironically just a couple of days after this happened we were taught all about setting the rotary table backlash correctly at a Tormach workshop.

Path Pilot

About the time that I was producing my first parts Tormach announced the introduction of Path Pilot. A Linux based controller software to replace the cumbersome Mach 3, everybody raved about it but I had learnt everything based upon Mach 3, so why change? I struggled on with improvement but still had problems with offsets and coordinate systems both on the machine and in



This was successful but took a lot of time to get the program right.

The long piece in the centre was successfully made on the CNC Mill. It is part of a steering damper for a 1929 Terrot motorcycle.



The large gear was cut with a round nosed end mill because that was the only small cutter available, hence the wrong root profile.



Sprockets made on the Tormach and drawn up using Gearotic.

Sprut Cam. Meanwhile I decided to buy the upgrade board and software that was required for Path Pilot with a view to running Path Pilot in the future.

The Final Straw

I think the final straw came when my wife and I were away for a weekend in our motor home; I took my lap top with me to do some drawing and part programming in the evenings, I was struggling with Sprut Cam again and I eventually let out one expletive too many. It was at this point that I explained that I didn't have anybody to help me with the software, frustration was getting the better of me and I needed to do something about it. As far as I know there are no training courses available in the UK other than full time courses run at colleges or specialist software providers own training establishments. I am not aware of any evening classes local to me either, internet searches found nothing suitable.

I knew that Tormach ran a workshop specifically for new owners or prospective new owners of their milling machines but that was on the other side of the pond and would be expensive. However, my long suffering wife had no objections to me attending the course so I booked on the soonest one I could, which was some two months ahead in October. Meanwhile a windfall tax rebate helped with the cost of fares and lodgings in the USA for a week.

Perhaps I should warn anybody who does go on the course - take plenty of money, you are sure to be lured by the goodies on display. I ended up buying more than I intended such as thread mills, diamond drag engraver, slitting saw holders and a Superfly fly cutter.

Tormach Workshop

The workshop runs from a Tuesday to Friday, the first day and a half covers Sprut Cam and is covered by Jacob (Jake) Stauber and the remainder of the week is covered by Jason Pulvermacher & Jake.

I flew out from the UK on a Monday, arriving at my hotel in DeForest just after 10 at night. I was tired to say the least and on reflection would have been better off flying out on a Sunday thus leaving me more time to recover from the flights. I flew from Manchester via Atlanta to Dane County Airport (Madison) and had a boring 4¾ hour wait in Atlanta for my connecting flight. I booked a hire car for my time on the course having driven many times in the USA I have no problem with the quaint way Americans drive on the right hand side of the road.

Tormach's headquarters is in Waunakee Wisconsin, not far from the shores of Lake Michigan, set in lovely slight rolling

countryside. The headquarters is a new modern factory building on a small trading estate and was about 6 miles from where I was staying. Most of my time in the USA has been in the desert South West States where everything seems big and spaced far apart. This area is almost the opposite, the farms here seem much smaller and the buildings are nearly all of wooden clad structure and of striking design.

First Day

I arrived early at Tormach's headquarters to find that I was the first attendee there, when I entered the building I could hear a mill running and saw that in one of the rooms Jason was machining some soft Vice jaws to make a fixture for the work pieces we were about to make that week. I was immediately impressed with the way Jason was using Path Pilot's conversational programming to produce the fixture. I



A wide variety of Tormach products on display.



The machine and accessories room.



Tormach automatic surface grinder.



Some work produced on the PCNC Mills.
They show the contouring capabilities of the mills well.



Some of the attendees in the workshop.



The Swing Indicator holder that is made during the workshop.

introduced myself and was made welcome by Jason and watched him work.

While the rest of the attendees turned up I was able to take a good look around the training/display shop. The full range of Tormach products (**photo 18**) and accessories were on display, except for their brand new small mill (more of which later). **Photograph 19** shows the machines, the mill in foreground is equipped with a high speed water cooled spindle (Max RPM 30,000 I believe) To the left of this machine are two Tormach automatic surface grinders (**photo 20**). Various machined samples are displayed on the shelves to the right of the mill (**photo 21**). It is an Aladdin's Cave to

anybody who has a home workshop, I knew that my wallet would be a little thinner by the end of the week.

There were nine people attending the workshop. The Workshops are deliberately kept to a maximum of ten, a group of more than 5 people wouldn't easily be able to see what was happening at a machine and also it would make it more difficult for the instructors to give one on one instruction when required.

Once everybody turned up (**photo 22**) introductions were made and a quick check revealed that about 4 people owned their own machines, one or two were working for companies/schools, that either had machines or were about to install

machines and the rest were people who were contemplating buying or had placed orders to buy a machine.

The first 1½ days cover Sprut Cam. The main reason I attended was to get a little better at using the software and to learn about tool offsets etc. so I was keen to get started.

During the workshop you get to make a rather nice swing indicator holder that fits the Tormach TTS system spindle (**photo 23**). It comprises components that are made on the various mills as well as a couple of minor modifications to some vvc commercial screws etc. These parts at first glance don't appear to convey that full use of the machines capabilities will



Jason Showing one of the attendees how to load the ATC and enter its dimensions in the tools library.



The mill set up as a lathe with the TTS holder in the spindle and the cutting tool set in the machine vice.

be utilized, however, that is not the case. Things such as machining multiple parts, flipping the part, fourth axis milling, profiling, pocketing, thread milling, thread tapping, engraving and chamfering are carried out while producing these apparently simple components.

Jake showed us the correct order of making a program in Sprut Cam, what type of machining method to choose and how to arrive at a finished program.

One thing that did surprise me was that it isn't necessary to choose the PCNC 1100 option in the machine's choice of Sprut Cam, it was recommended to choose either a 3Axis milling machine or 4 Axis mill from the menu. Why did I spend all those hours setting up and using the PCNC 1100 option and drawing the? I don't know but I did.

The first parts to be programmed are the rail caps for the swing indicator. These are basically two pieces of aluminium an inch long with two vee-grooves spaced about $\frac{3}{4}$ inch apart. They also have a hole through the middle and a counterbore. The corners have radii and all edges are chamfered at 45 degrees. This apparently simple piece is not as simple as it first appears because you need two of them and it is this piece that is used to show you how to produce more than one identical component in a program as well as how to flip the part. This one piece takes up the whole day + half of the second and I must admit that by the end of the first day, even though I had enjoyed it, I was ready to return to my hotel and get some sleep.

Day 2

Day two of the workshop is split; half of the class, those that are not wanting to pursue Sprut Cam further, go into the machine shop and start with the two Rail

caps while the rest of the class continue with further Sprut Cam instruction finishing the program for the rail caps and ending with a Q & A session with Jake.

After lunch (which is provided by Tormach) the people that had been working with Sprut Cam went into the workshop where both Jake and Jason continued to show you how to reference the mill and set tool lengths, tool tables & tool offsets (**photo 24**). This I found invaluable because it was an area that had caused problems for me. The various methods of measuring offsets and setting zero were shown. I was particularly impressed with the Haimer height and edge setting tool, so much so that I bought one while attending the Workshop.

Perhaps I should warn anybody who does go on the course - take plenty of money, you are sure to be lured by the goodies on display. I ended up buying more than I intended such as thread mills, diamond drag engraver, slitting saw holders and a *Superfly* fly cutter.

The TTS holder was also made on the second day (**photos 25 and 26**). This is a round part with the Tormach logo engraved onto its cylindrical surface, this piece is made by putting a piece of bar stock into a fixture machined into the machine vice soft jaws. In this position the mandrel that fits the Tormach TTS collet and the undercut for the register face are machined. Once this is done the piece is put into the TTS Collet on one of the mills and, using a cutting tool mounted in the machine vice the outside diameter is machined. Thus demonstrating how you can use the milling spindle as a lathe for light work.

Fourth axis work is then demonstrated when the work is mounted in a collet chuck in the rotary table set with its axis



The finished TTS Holder.

horizontal. The engraving is carried out in this position using a $\frac{1}{8}$ inch Round nosed end mill. When this piece of work was done the engraving was painted using an acrylic paint marker and left to dry. That more or less ended the second day, a lot was covered and I hoped I could remember how it was done when I got back into the workshop at home.

Day 3

Day 3 started by splitting the class into two groups; while one group finished their TTS adaptors the other group made the DTI Holder (**photos 27 and 28**). This piece is the most complex of the parts. It is quite small, has two blind holes in it, two small tapped holes, one larger tapped hole, a through hole, a dovetail and a slit. This is machined entirely using the fourth axis for all of the operations except the final operation which is carried out using a fly cutter with the work set in a soft jaw vice fixture (**photo 29**).



The DTI Holder (On right hand end) and the Block (Larger item below the rails).



Dovetail to take a DTI.



The block mounted in the soft jaw fixture having the large hole threaded using a thread mill.

With each of the parts the set up is demonstrated so that you do get to see how the work is set up, tools are put into the tools library and offsets applied. Whenever possible you get a chance to do some of this yourself.

The two smaller holes were tapped using a tension compression tapping head and the larger of the holes was threaded using a thread mill. The slitting saw set up was also demonstrated along with chamfering using a drill mill.

By now the other group had finished their TTS adaptors and a start was made on the last part. Again this part, the block, was machined in a fixture milled out of the vice soft jaws and comprised two blind holes, a threaded hole, some profile work and chamfering. The set up was demonstrated but not many people got to machine it before the day was through.

It was also during day 3 that Jason & Jake were able to get a new PCNC 440 mill out of the workshops and into the display area. It is a much smaller machine than the 770 or 1100 but despite this you can see from **photo 30** and **photo 31** without its enclosure, that it is very heavily constructed and from what I have seen of the literature and various video clips is every bit as capable as it's bigger brethren. With it's table size of 18 x 6.3 inch, more modestly sized work envelope and a spindle motor of ¾ HP at 300 to 10,00 rpm, I think this mill is aimed at the hobby end of the market for people who are looking at the smaller sized mills for such things as jewellery, clock and watchmaking, model aircraft engines and small scale model locomotives. Options available now are a Deluxe cabinet stand, flood coolant, A fourth axis, power draw bar and ATC option will be available soon.

It's recommended footprint is 42 x 36 inches which is not too big a space when compared to the minimum of 67 x 43 inches required for the PCNC 100.



This knurled nut was modified using the mill.



Attendees about to machine a component.



Jake with the PCNC 40.

Day 4

The final day continued with the machining of the block and some more work with the mill set up as a lathe to machine some of the knurled nuts that are used in the indicator (**photo 32**). The mill is used as a lathe to cut a parallel portion on the shank, machine the knurled portion to length and turn a taper on the end of the parallel shank.

Photograph 33 shows group of attendees about to machine a component. In the foreground on the table is a Tombstone that has multiple work pieces set up on it. To the rear of the table is the height gauge and granite block that are used to measure tool length below the spindle face.

The pace of the last day was a little slower than the previous three and everyone finished machining their components by lunch time. Assembly was then completed using the Arbour Press to press the two short rails into the block. Once everyone had done this Jason and Jake were available for questions, of which most people had a few to ask. The day finished early on the Friday afternoon to allow people who had to travel time to make their flights etc.

I should mention that each day one of Tormach's Specialists gave a talk on various subjects. Daniel Rogge covered setting up your machine; Jeff Hamre covered fourth axis rotary tables and how to adjust them for backlash. Andy Grevstad covered Cutting tool technology, describing cutter inserts and the insert tooling available through



The new PCNC 440 shown without an enclosure.

Tormach. Also discussed was what various coatings do to cutters and drills etc. On the final day Brennan Williams covered machine maintenance.

Was the Workshop Worth Attending?

In a word, yes. I learnt a lot and it helped me resolve the problems I was having with offsets; I would recommend anybody who is about to buy any of the Tormach mills to factor the cost of the workshop in when making their purchase. It will certainly get you up and running quicker than you would by going it alone.

The people running the workshop are specialists in their particular field and are obviously fully conversant with Tormach Mills and their associated accessories and software. All of them are easy to approach and will answer your questions with enthusiasm.

Since Attending the Course

I had a day to myself in Wisconsin at the end of the Workshop so I took the opportunity to pay a visit to Oshkosh, home of the EAA Museum and the world Famous Oshkosh Fly In. It is only about 60-70 miles from Madison so it doesn't take long to get there.

It is just over a week since I arrived home and on arrival I was eager to get back into the workshop to try out Path Pilot.

Fortunately, I was not so badly affected by jet lag this time and was back to normal after one nights sleep so I got straight into



The Tee Nuts and Motor Cycle inlet tube made using conversational programming.

the workshop and set about installing the new board in the controller. I spent ages looking for a printer port type socket inside the controller, not realizing it was actually on the board itself. Once I got the board installed and the computer case back together I switched on and attempted to get Path Pilot to run but I had no success so I called Tormach support. I had taken pictures of the various screens I was presented with when I tried to get it to run and I sent these to Tormach support. Within a few minutes I got an email telling me what to do to get it to run properly. This involved changing some of the Bios settings in the controller, something I wouldn't normally do, however, the instructions were clear and easy to follow and once I booted back up I had Path Pilot on the screen.

With Path Pilot on screen I was at last able to play, first off instead of running the first part as described in the manual for the PCNC 100 with Path Pilot I adapted it to make some cup holders for my grand children using the circular pocket and engraving functions. I ended up making 8 of these and they cleaned me out of 3 1/2 inch HE 30 Aluminium Bar. Once they were out of the way I made some Tee-Nuts to suit the Tormach but utilizing the studs and nuts from a smaller clamping set. I was amazed at how easy it

was to program the machine, simple jobs such as taking a surface cut off some stock are as easy as they would be in a manually controlled mill, simple pocketing, simple profiling, engraving, drilling and threading, both internal & External can be programmed at the machine and are easy to do with an intuitive screen display to guide you through.

Threading I found remarkably easy, both the internal threads generated in the Tee Nuts and the external thread on the inlet tube for a single cylinder motorcycle turned out far better than any I have done on the lathe or with a tap or die (**photo 34**).

In Conclusion

Having bought the mill with the intention of stopping me from becoming brain dead in retirement from the oil industry and to try and earn some money by machining components for people, I think I have done the right thing. I have spent many hours with my head buried in the manuals for SprutCam as well as hours at the computer drawing things in 3-D, my brain has been more active than it has for a long time and will stay that way. The learning curve has been very steep and I'm still not at the top of the hill by a long way.

The upheaval created in my workshop by the arrival of the Tormach mill was hard to

bear and to some degree I am still suffering as a result because everything is now in a different place and I keep having problems finding things.

Not Everything went to plan during installation and initial use of the machine, on a few occasions I had to contact Tormach's Technical Support. The support team were excellent and were able to resolve any problems I had quickly and efficiently and I have confidence that any future problems will be handled the same way.

My confidence took a battering every time I broke a cutting tool or got the work or tool offsets wrong but I went straight back at it and kept on trying. Since attending the workshop my issues with Work and Tool offsets seem to have vanished and I am left wondering how I had problems with them in the first place.

Despite the frustrations I have thoroughly enjoyed my time with the Mill and learning how to use it.

To any older readers of *Model Engineer* or *Model Engineers Workshop* who think they can't go into CNC machining because they don't know enough about it I would say give it a try, learn how to switch on a computer, flex the grey matter, it's still Engineering even though you aren't twiddling the knobs and controls of a manual machine. ■

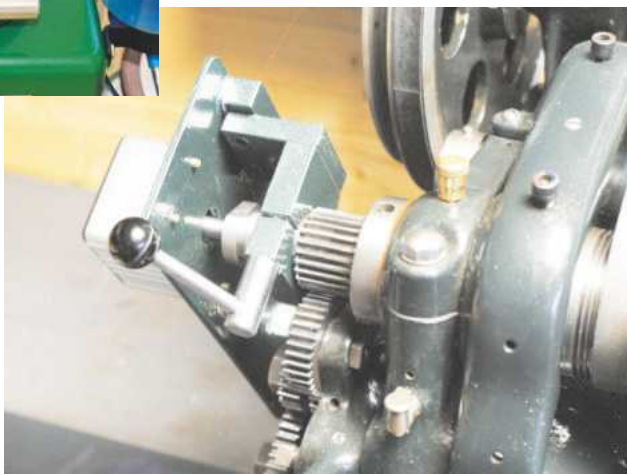
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The Amadeal AMAT25LV Milling Machine



David White looks at one of the larger, but still 'benchtop', mills on the market.

Long time readers of *MEW* may remember that I reviewed the AMA25LV milling machine in Issue 145 back in December 2008. I was one of the earliest purchasers of this machine and was very impressed with what I bought. Subsequent to its availability in the UK in this product has become one of the most popular small milling machines on the planet in a number of guises (e.g. WMD25LV, BF20, G0704); particularly since its appearance in the USA as the Grizzly G0704. My machine has performed flawlessly for the last seven years and I haven't had to replace a single part. When I saw that Amadeal was selling what looked like an updated/rated version of the AMA25LV I was mildly interested; but common sense told me that I had a perfectly good milling machine and needed a replacement like a hole in the head. You all know what happened next! Fortunately, I was able to sell my AMA25LV for a very good price so the new AMAT25LV didn't cost me too much.



The AMAT25LV unpacked.

The AMA25LV is made by Weiss machinery and the AMAT25LV by Titan machinery, both in China. Interestingly there is no mention of the AMAT25LV (aka TM25V and pM25V) on the Titan website. The AMAT25LV has been available in Australia as the TM25V, and in the USA as the pM25V, for the past couple of years; but only very recently in the UK. The machine seems to be well regarded and most of the information available online concerns conversion to CNC.

The new machine arrived the day after I ordered it, in the usual plywood packing case. Only it turned out to be not so usual as the case was very robustly constructed indeed. Getting it open involved a couple of large crowbars and much profanity. Once the top was removed it uncovered a substantial reinforcing strip of wood which I had to cut off with a hacksaw because the staples retaining it were so long and thick – a crowbar was no use at all. Anyway I eventually removed all of the plywood panels leaving the machine on the palletted base, as you can see in **photo 1**.

Also inside the packing case were a user manual, a drip tray (most unusual), and a box of tools/accessories. As most of you will know the user manuals for Chinese

machine tools always leave something to be desired. Often they refer to earlier models of the machine that you bought, but invariably there is an exploded parts diagram which bears a useful resemblance to the machine at hand. The manual here applied to a completely different machine and contained no exploded parts diagram! Drip trays are usually an optional extra for milling machines, but strangely enough not for lathes. I didn't use this drip tray because I already had a much larger and deeper one that I had previously used for my

AMA25LV. However, the drip tray was useful as a template for drilling the holes to mount the AMAT25LV on my workbench. The box of tools/accessories was a big improvement on those I had got with Chinese machine tools in the past. The plastic tools box was pretty solid, with latches that worked, and a top tray for small parts with a separately closable lid shown in **photo 2**.

The tools, etc. are shown in **photo 3**, and you also get a pair of disposable screwdrivers plus a plastic oil bottle (not shown). The large wrench fits flats



The AMAT25LV toolbox.



Tools that come in the toolbox.



Base to column fixing on the AMA25LV.

machined onto the spindle and can be used to hold it still for cutter removal etc.

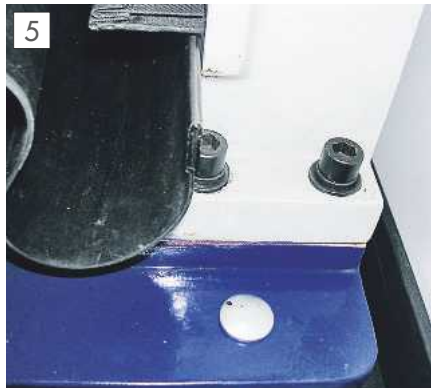
Now onto the machine itself. As I describe the machine I will highlight the differences between it and the AMA25LV as I guess prospective purchasers face a dilemma as to which is the best buy for them. The most noticeable difference between the AMA25LV and the AMAT25LV is the method of mounting the column. The bottom of the AMA25LV column is recessed and the step so formed rests on the back of the base and is secured to it by four horizontal cap head bolts. You can see this at the top right of **photo 4**.

The AMAT25LV column has a flat base which is fixed to the machine base by four vertical bolts (see **photos 5** and **6**). This makes it much easier, and safer, to remove the column as it is still stable even after you have removed the retaining bolts (assuming you have removed the spindle head first), although you should still take care. The AMA25LV column will topple over if the retaining bolts are removed.

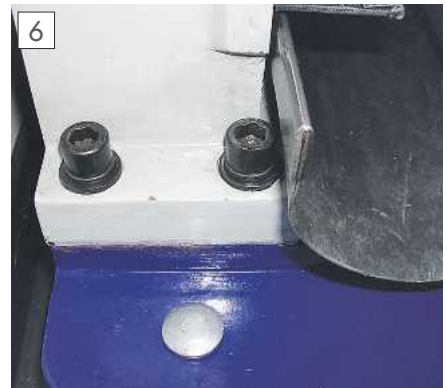
The control box of the AMAT25LV is mounted on an arm attached to the spindle head and has controls for forward/reverse, start/stop, and speed. There is an emergency stop button and an illuminated LCD speed display. There is an amber light between the start and stop buttons which I assume is a motor fault light – but I have no way of confirming this as yet. When the start button is pressed there is a 0.5 to 1s pause before the motor starts. The pause



The four bolts securing the spindle head to the z-axis saddle.



AMAT25LV base to column fixing RHS.



AMAT25LV base to column fixing LHS.



View of Brushless DC motor.



View of the belt drive.

can be circumvented by moving the speed control immediately after pressing start. Don't ask me why!

The other features where the AMA25LV and the AMAT25LV differ are not so obvious and some research and/or teardown is required to appreciate them. The AMAT25LV weighs in at about 140kg, which is some 25kg heavier than the AMA25LV, so it should be somewhat more rigid. If you browse through the forum posts on the internet concerning the AMA250LV (WMD25LV, BF20, G0704) you will see that the two commonest modifications people make to these mills is conversion to belt drive with a more powerful motor, and the so called 'three bolt mod'.

Both of these features come as standard with the AMAT25LV. You can see the 1kW brushless DC motor and belt drive in **photo 7** and a close up of the belt drive in **photo 8**. The upshot of this is that the mill is both very quiet in operation and capable of removing metal much more rapidly than the AMA25LV.

Photograph 9 shows the method of fixing the spindle head to the z-axis saddle. There is a central cap head bolt, about which the spindle head can rotate, and three additional bolts ('three bolt mod') which fit into a circular track on the z-axis saddle. When all of the nuts and bolt are tightened up the spindle head is very securely fixed to the saddle. The AMA25LV only has the central cap head bolt and the one nearest to the observer in photo 9. This means that the head has a very slight tendency to nod forward when not under pressure and then back up again when the mill is working hard.

The leadscrews of the AMAT25LV are larger in diameter than those of the AMA25LV and 3mm pitch as opposed to 2mm. Both leadscrews have square section threads. The leadscrew nuts of the AMAT25LV are brass and have adjustable (with difficulty) backlash compensation, whilst the AMA25LV has steel nuts with an easier to get at method of backlash compensation. The handwheel dials have the same resolution on both machines because the AMAT25LV handwheels are larger. The AMAT25LV has 10mm greater y-axis travel than the AMA25LV because the leadscrew nut is mounted further back (towards the column) on the x/y-axes saddle.

In order to move the machine from garage to workshop I needed to traverse one step, a flight of stairs, and transport it across a new oak floor. Needless to say, a world of pain awaits if the new floor is compromised in any way. Fortunately milling machines are usually easy to break up into a small number of pieces for transport. In this case the head and column are easily removable, and the table can be separated from the base if necessary.

In order to remove the head, you first need to unscrew the three handles from



Laying the head on its side.



Useful small trolley.

I did have to wait for a burly son to visit before we could lift the base and table assembly onto the workbench.

the feed lever and remove the two little hex head grub screws from the small hole behind the feed lever and close to the saddle. Now carefully loosen the bolt and nuts shown in photo 9 just enough to rotate the head through 90 degrees as shown in **photo 10**.

I had previously made two blocks of wood with holes cut in them to accommodate the diameter and depth of the feed lever hub. put these on the table of the milling machine and gently lower the head onto them using the z-axis handwheel. Now the head can be removed from the saddle by removing the bolt and nuts shown in photo 9 and pulling it off. The column can be removed by undoing the four cap head bolts that secure it to the base of the mill. Be warned that you can't get enough torque to remove these bolts with an allen key alone. They are done up extremely tightly and an extension bar of some kind will need to be slipped onto the allen key to get enough leverage – I used a piece of steel tube.

The head weighs about 35kg, the column 30kg, and the base plus table 75kg. The head and column were manageable, but an awkward 75kg is a bit of a stretch for two (past their sell by date) people. While I was



Mill mounted on workbench.



Extra supports for the centre of the workbench.

pondering this I got dragged off to B&Q for some boring household stuff and found the little trolley shown in **photo 11**, good for 150kg, on offer for £20. The handle folds down flat when not in use – ideal!

The little trolley was easy to lift down the stairs, even when laden with 75kg, and my wife and I managed the entire move I about 10mins. However, I did have to wait for a burly son to visit before we could lift the base and table assembly onto the workbench. The mill in its new home is shown in **photo 12**. The workbench is rated for 250kg, and I guess that the mill plus stored tooling probably weighs



Hockey puck machine foot.

200kg. Being a bit conservative I made the extra supports shown in **photo 13** to fit under the centre of the workbench.

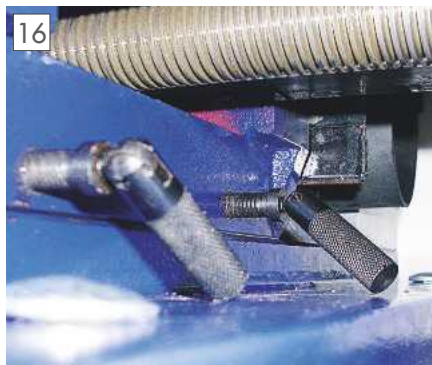
The 25mm diameter aluminium rod is drilled and tapped at one end to fix it to the short length of aluminium channel with a countersunk M6 screw; and drilled at the other end to be a close sliding fit for the long M8 bolt fixed to the machine foot. The feet are made from ice hockey pucks as shown in a bit more detail in **photo 14**. The ice hockey pucks are easy, if messy, to machine. The bottom of the puck is recessed to accommodate the head of the M8 bolt and a small washer.



Electric screwdriver drawbar wrench.

The AMAT25LV has a captive drawbar with which to jack the MT3 tooling out of the spindle. I use an MT3, ER40 collet system most of the time and the drawbar screws into the tapped end of the MT3 taper. In order to secure the collet chuck, one tightens up the square section, top end of the drawbar with a spanner whilst holding on to the collet chuck; the chuck is jacked out by unscrewing the drawbar. I soon got fed up with all the manual screwing and unscrewing and made the little Gizmo shown in **photo 15**. It consists of an electric screwdriver, and a bit with a hex shaft at one end and a square socket at the other. As memory serves the key for tightening up the Myford turret toolpost fits the AMAT25LV (and AMA25LV) drawbar, and I simply cut off the crossbar, drilled an appropriately sized hole in the cut end, and forced in an old hex screwdriver bit. Made life much easier.

Now that the machine was up on the bench it was easier to inspect and play around with it. As you can see in photo 12 the x-axis can be locked by means of two indexable handles and this works fine. The y-axis is locked by means of the two custom made handles shown in **photo 16**. These are used in place of indexable handles because space is tight. However, they are not very satisfactory because they tend to hang down and jam into the base of the mill when the y-axis is moved. As



Original y-axis locking handles.



Indexable locking handles for the y-axis.



Original 'bullets' for locking handles.



New 'bullets' for locking handles.



Insert/removal tool for new 'bullets'.

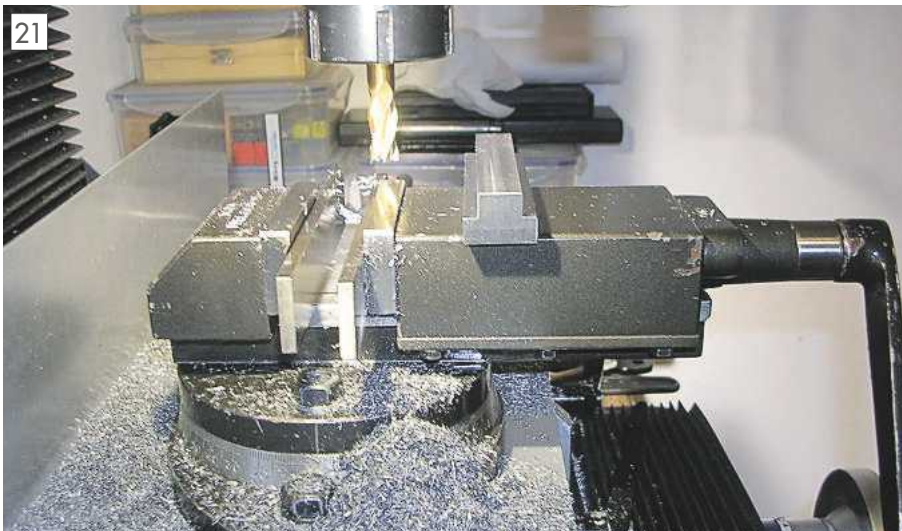
the locking screws need only a fraction of a turn to lock the axis; indexable handles are easily fitted in place of the custom handles, as shown in **photo 17**.

In the AMA25LV the screws of the locking handles do not bear directly on the tapered gibs, but rather onto small brass 'bullets' which in turn press onto the gibs. The 'bullet' has a conical working end which results in line contact with the gib. In contrast the bullets in the AMAT25LV are made of steel and part of one end is milled away so that it bears on the tapered gib with a small surface, as shown in **photo 18**. This struck me as an odd

arrangement – why not mill the whole of one end at 60 degrees so that there is a larger surface area bearing on the gib? Maybe there is a reason, but it evades me. Accordingly, I made the bullets shown in **photo 19** to replace the originals.

I used brass because I had some to hand, but steel would serve equally well. The original steel bullets are easily removed by wiggling a powerful, rare earth magnet over the threaded holes for the indexable handles. After I replaced the bullets I noticed that the axes could be firmly locked with a much smaller rotation of the indexable handles than previously. Incidentally, I drilled small 1.5mm blind holes into the flat the ends of the brass bullets I made, so that they could be removed by jamming a cocktail stick or thin metal rod into the hole. You can see this in **photo 20**. I put a micrometer clock in the spindle collet chuck and lowered the clock probe into contact with the table using the fine feed. I then ran the x- and y-axes back and forth to the limits of their travel. The clock pointer trembled a little indicating that the table was perpendicular to the spindle, in both directions, to within 0.01mm. Good!

At this point I thought I'd found all of the little quirks of the AMAT25LV and was keen to do some machining. I mounted a swarf guard and milling vice onto the mill table, and got to work making some t-nuts for the Axminster CT1 compound table I'd bought for my pillar drill. The partially finished result, together with the large amount of metal removed, is shown in **photo 21**.



Nearly completed set of t-nuts for CT1 table.



Electric screwdriver vice crank.

I'd read on a metalworking forum that one of the 'clones' of the AMAT25LV could easily handle a 2.5mm depth of cut (DOC), even in steel. I thought that was probably a bit of an exaggeration, and anyway I always mill conservatively, so I settled on a 1mm DOC with a 4 flute 12mm HSS cutter. The cutter went through the steel like a knife through butter and almost as quietly! So maybe 2.5mm wasn't an exaggeration but I didn't try it anyway! I tried both conventional and climb milling with equal success, but I think it would be sorely tempting fate to climb mill with a DOC of greater than 1mm. Even 1mm requires a degree of care because the leadscrew/nuts are not backlash free. Being able to use a robust DOC will save me a lot of time compared to the smaller cuts one is able to take with the AMA25LV. It was encouraging to note that the motor, motor controller heatsink, and spindle bearings didn't noticeably heat up after this protracted bout of milling steel. Incidentally, running the milling vice jaws out to accommodate large workpieces, and then back in again for smaller pieces, requires a lot of time consuming handle cranking. I found that a ¼ inch hex screwdriver to 14mm socket adaptor could be used in conjunction with an electric screwdriver to run the vice jaws in and out before final tightening with the handle. The arrangement is shown in **photo 22**. Another time saver! (in fact a 14mm octagonal socket fits, but a 14mm hex socket is too small – hence the evidence of grinding in the photograph!)

I noticed while I was milling the t-nuts that moving the table from right to left was noticeably easier than moving it in the opposite direction, so I checked the preload on the bearings. Let me digress here a little to describe the bearing arrangements for the x- and y-axis leadscrews of the AMA25LV. The y-axis has a pair of thrust bearings, one on each side of the bearing housing, as shown in **photo 23**. The bearing preload is adjusted by tightening or loosening the leadscrew handwheel retaining nut. Because the y-axis leadscrew is so short, the end remote from the handwheel can be

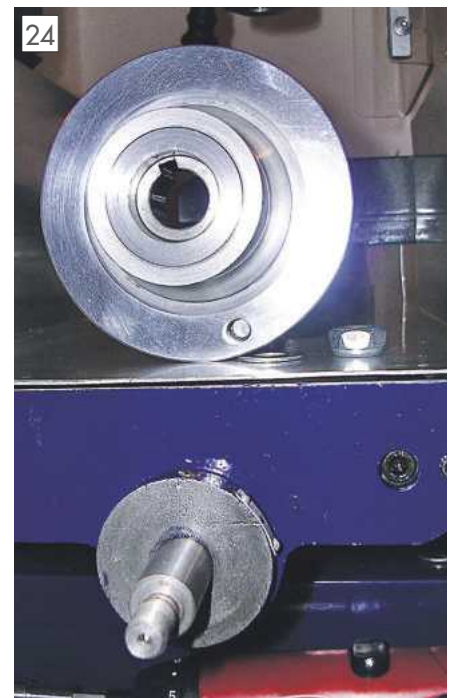


Thrust bearing pair and housing for AMA25LV.

unsupported. The right hand side of the x-axis leadscrew has a similar dual thrust bearing arrangement to the y-axis leadscrew, whilst the left hand side has a single thrust bearing on the outermost side of the bearing housing, perfectly satisfactory for the long x-axis leadscrew – supported at both ends and with thrust bearings to reduce friction. So back to the AMAT25LV. What I discovered was that whilst the right hand side of the x-axis leadscrew had the same dual thrust bearing arrangement as the AMA25LV, the left hand side had no thrust bearing at all! See **photo 24**. The contact area between the left handwheel and the left hand leadscrew support/endplate is considerable and this will result in significant friction when moving the table from left to right. I checked on the internet to see if this situation was common to all of the AMAT25LV clones and was amazed to find that it was! The AMAT25LV y-axis bearing set up was, thankfully, identical to that of the AMA25LV.

This lack of a thrust bearing is a major disappointment and a situation that I must remedy quickly. Adding a new thrust bearing (17 x 30 x 9mm) requires boring out either the handwheel or the endplate to provide a 30mm diameter by 8.5mm deep cavity for holding the bearing. The boring may be done on a lathe (preferable, easiest), if you have access to one, or by using a boring head on the AMAT25LV itself. Boring on the mill is a much slower process than using a lathe because the cuts are necessarily smaller. The handwheel can be bored out using a 7x10 mini-lathe but at least an 8 inch swing over bed is necessary if you choose to bore the endplate. I will almost certainly bore out the endplate. Notice that if you bore out the handwheel it might be necessary to shorten the locating key a little so that it does not foul the bearing when everything is reassembled. It's probably easier on the wrist to loosen off the left handwheel and move the y-axis exclusively with the right handwheel until a thrust bearing is fitted.

In summing up I would note that the strengths of the AMAT25LV include its low noise, its column mounting method, its rigidity, the 'three bolt mod', the powerful



AMAT25LV LH x-axis handwheel removed to show lack of thrust bearing.

1kW motor, the belt drive, and the brass leadscrew nuts. The weaknesses are the lack of any meaningful manual and the 'missing' thrust bearing on the LHS of the x-axis. The lack of a bearing on such a heavy table will rapidly cause wear on the contact surfaces between the handwheel and endplate. Amadeal must really make it clear to the manufacturer that this is an unacceptable situation.

Now for the crunch question; is the AMAT25LV worth the £215 extra over the AMA25LV asking price? In my opinion the answer is yes; the positives far outweigh the negatives, and the latter are fixable. If the manual and 'missing' thrust bearing are fixed the AMAT25LV (and clones) could potentially become as, or more, popular than the AMA25LV and its clones. If you don't need the extra 'beef' of the AMAT25LV, or budget doesn't allow, then the slightly less capable AMA25LV remains an excellent buy. ■

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Beavering Away

I wanted to comment on the front cover and article in the last edition of the magazine 239. I also have a Beaver Model A mill like Ken Hall's Grimston and it is an absolutely wonderful mill and incredibly versatile. There are so few around so it was a really great surprise to see one in the mag. I did the almost identical changes he wrote up and added Chinese scale DROs which have been really useful and surprisingly accurate for the price. I wonder if I could ask if there are any other model engineer users out there of this machine? I think it is absolutely the perfect size for the model engineer - smaller than the BeaverTurret mill (like a Bridgeport) but usefully larger than the S3 mills from China. The build quality and rigidity is also superb.

Richard Gordon. West Sussex



Sound Chaser

Dear Neil, I was interested to read Peter Nicholson's article on threading using odd Coventry Die Head chasers. Presumably for normal single start threading, it doesn't matter particularly if you don't grind away all the threads except one, the rest will just trail along in the track of the first. With careful setting of the tool to the appropriate angle this could be a way to produce taper pipe threads I suppose.

I'm a bit confused with the last paragraph regarding multi start threads. I think I understand the first example, in order to cut a 2 start thread, with a 1mm pitch thread form, it is necessary to set the lathe to produce a 2mm pitch thread, so the second thread is started after $\frac{1}{2}$ turn of the spindle. Surely, though, if a 3 start thread is needed, of 12TPI thread form, it will be necessary to set the lathe for 4TPI, so the second and third threads start after $\frac{1}{3}$ and $\frac{2}{3}$ of a turn respectively, not 36TPI as stated in the article.

Richard Wilson, by email



Small Projects

Dear Neil, Congratulations on the format of 239 MEW. I am a beginner in model engineering after retiring from the construction industry and for the past couple of years I've been making all kinds of small things. I purchased a WM14 milling machine and super mini lathe from Warco and have made for the workshop, a Surface gauge and clamps and punches, carriage stop for lathe plus small vices, and all the other small things we all make in are workshops. I would appreciate more small projects for the mini lathes.

Walter Allen, by email

Sage Advice

Dear Neil, I've just received the last issue of MEW. Thank you very much for publishing my article. I have been a subscriber since issue No.73 but own all the issues from the first, less No.79 that was not distributed in my country for some unknown reason?

Here is some good advice from an old machinist: If you are machining a complex part, begin by the third one as you'll certainly fail making the first two.

J. Maurel, France

Don't Look too closely

Dear Neil, A little while ago I had an itch for a microscope that wouldn't go away. I recently spotted on eBay an instrument of real quality that was a little old (1960s) & was lucky enough to purchase it for just a few pounds. It turns out that I couldn't have chosen better for it transpired that it is an inverted metallurgical model, designed especially for inspecting metal surfaces etc. Never having used one before it took a bit of tidying up and the provision of a new lighting system (a £1 LED torch from Tesco!) but what I saw with magnifications of 100 to 400 astounded me. Surface finishes that I regarded as excellent to the naked eye looked quite shocking with gouges and scratches. It made me think very seriously about how to improve them and I haven't come up with a solution yet! Perhaps it's not a good idea for everyone to view their work in this fashion AS IT COULD LEAD TO SOME OF US GIVING UP!

John Crammond



Flick of the Switch

Dear Neil, I was re-reading *MEW* 239 and noted Mike Stratton's problem in finding a high amperage reversing switch (Milling Machine Electric Powered Drawbar).

It would be possible to use a particular type of mains voltage 'grid' switch to provide this direct current reversing function for some applications. The one needed is an 'intermediate' switch used to install additional two way switching points on lighting circuits. One version is mounted using a 'grid' facing plate and a 'grid' yoke switching plate.

Unlike the normal two-way one pole 'two way' switch the 'intermediate' switch is two-way two pole and has the internal connections to reverse the input to output connections. No additional wiring is necessary. They are also quite reasonably priced.

Please note that the switch does not provide an on/off function, a separate switch is required for that. These intermediate switches are available with 10 and 20 amp ratings. Note also that switching direct current is more onerous than switching alternating current (with dc there is no current reversal to extinguish any arc across the contacts) and so some derating should be applied, so for low voltage high current applications Mike's solution may well be better. You cannot, of course, reverse the direction of alternating current so this solution is only applicable to direct current applications.

Bob Hawtin, Suffolk

More on Tool Holders

With only minor modifications the neat tool tip holders described by Jacques Maurel can form the basis of an effective 'fairly quick tool change' system when combined with a simple slot in a block type tool-post whether single, double or four-way. The inherent upwards tilt angle of the tool means that cutting tip height is defined by how far forward it projects from the holder. So, if some means of repeatably locating the holders at the same projection in the tool-post, tool-in-holder assemblies can be interchanged retaining the tool tip height and projection from the post just like a proper (expensive) Quick Change system.



The most simple location method is step close to the front of the tool-holder engaging against the base of the tool-post. Alternatively make all the tool-holders the same length and butt them up against a stop fitted inside or across the end of the tool-post slot. If the stop were made to screw in place an alternative position or two could be provided for when more tool projection is desirable to clear features on the job in progress. Off machine setting makes life much easier, especially when sharpening or touching up tools mid job. Best done with a simple jig comprising a replica of the tool-post slot and locating device with a tip height setting indicator fixed a suitable distance in front. Although a simple stop would work fine as only the projection distance needs to be set a scribed line indicating the tip height is probably sensible as a sanity check.

Slotted block tool-holders are easily made by screwing and gluing standard stock plate and bar sections together. Chewing out from solid in the usual way needs a fairly hefty mill if the job is to be done in reasonable time. Two slot versions are narrower than the common four-way and better suited to smaller machine where space is limited. In retrospect I've pretty much never used more than two slots on a four-way so two parallel slots on opposite sides of the block would have done just fine. A standardised two slot block system would work well with Peter Nicolson's threading tools and Peter Shaw's parting tool too.

Realistically some sort of indexing/locating key or device is desirable. Especially when rotating a two slot block to keep two tools in operation on the same job. For example paired roughing and finishing or turning and facing tools. Given a locating device its perfectly practical to make extra tool-posts so as to have enough toolsets ready to go do a complete job. Changing a tool-post complete with tool-holders is probably quicker than swapping out tools even if the hold down device is an ordinary stud and nut. There are various ways to make changeover faster by using only a partial turn to release rather than unscrewing a normal nut. An interrupted thread or some sort of rotary cam action device are probably the obvious ones for a commercial device. However both appear to have certain design subtleties making the difference between working ... sort of / usually okay / really well ... which is probably not the sort of thing you want to tangle with in the home shop. An inherently reliable, more easily made, system is to hold the tool-post it down onto the top-slide via a freely rotating, but vertically restrained, pillar cross drilled near the top passing through a hollow castellated head bolt screwing into the block. A suitably stout tommy bar can be running through both cross drilling and nut castellations generates the actual holding down forces. Clearly once the basic position of the hollow bolt has been set only a fraction of a turn is needed to loosen the tommy bar enough for it to be withdrawn allowing the tool-post to be lifted off and a replacement fitted whereupon a similar fraction of a turn in the opposite direction will lock things solidly again. One of the 14TPI pipe threads would probably do just fine for the hollow nut giving around $\frac{1}{4}$ or $\frac{1}{2}$ rd of a turn between release and lock.

If going to the trouble of making multiple blocks carving one from solid to take a direct mounting version of Peter Shaw's parting tool or one of the commercial blades, HSS or carbide tip according to taste, would probably provide a welcome increase in rigidity compared to simply mounting a holder in the slotted tool-post. The other side of this solid tool-block could usefully mount a bar type boring tool holder using eccentric bushes to set tip height as per the George Thomas design published many years ago in *Model Engineer* and reproduced in his book *Model Engineers Workshop Manual*.

Clive Foster, Sussex

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Parting is Such Sweet Sorrow



Stub Mandrel tries out some new carbide tooling from Arc Euro Trade



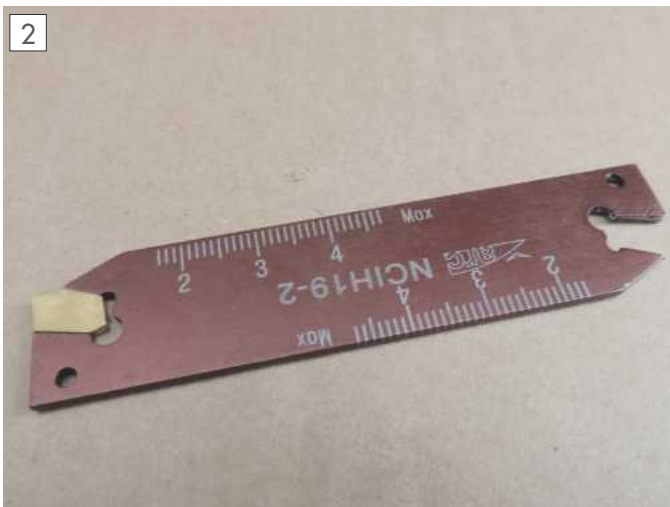
Nothing exercises MEW readers more than parting off. Think about it, your parting tool is probably 1.5mm wide at a minimum and more likely closer to 3mm wide. If you have a small bench lathe, how often do you take a conventional cut 3mm deep? Parting is one of the most demanding tasks for any lathe, as it involves taking a broad cut with an overhung tool, often at the bottom of a deep groove that impedes the removal of chips.

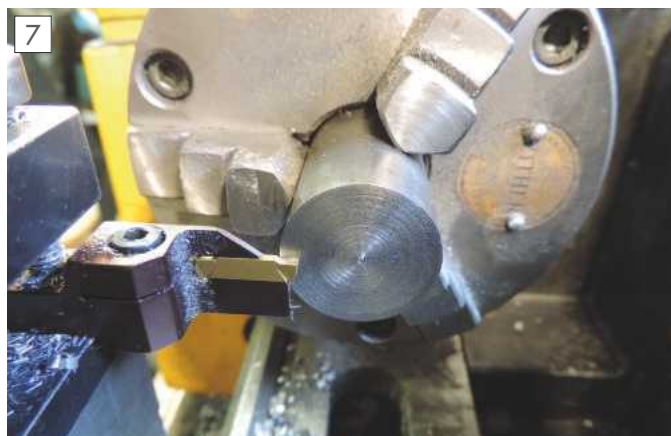
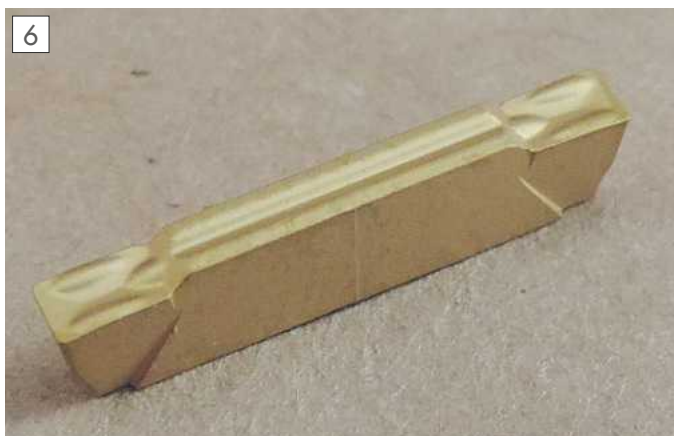
LBSC famously described 'parting steel with a sound like frying bacon', but George Thomas who made parting off into showmanship. He combined a well-adjusted lathe, a rear toolpost, the right tool and the right speed. With his specially ground tools he reached a point where he

could part off 1½ inch mild steel at 615 rpm! By his own admission this was a piece of showmanship reserved for exhibitions, and more usually he found a suitable speed (for mild steel) of 200 rpm at one-inch diameter.

Well, I've just been testing out a carbide-tipped parting tool, and it had no trouble parting one inch steel at 600 rpm – in fact this seemed to be the speed it was happiest with.

George Thomas' ideal tool had a v-groove on top, to encourage the formation of curled, narrow swarf, amongst other features. Two essential pieces of George Thomas' advice, however, are to match the size of the tool to the job and to keep the end of the tool square to the job. Small tools are not rigid





enough to tackle large diameters and the angled tool end to avoid making an end pip produces sideways forces that can bend the tool off line and jam the job.

Getting the right speed for any parting job depends on many variables (the material, its diameter, the tool, the state of the lathe and the phase of the moon). There has to be an element of trial and error. Finally, don't be afraid of the job. A jam up and a broken tool-tip can make you understandably cautious. George Thomas was adamant that a confident and positive approach was essential, and that over-cautious pecking at the work will never bring good results. Don't just watch either – let your ears and your fingertips tell you what is happening.

Things have moved on since GHT's day, when high-speed steel was by far the dominant choice for parting tools, though the lucky might have a stellite tipped blade. Today inserted-tip carbide tools can be made in almost any tool-shape you can imagine, and a vast amount of research has been done to come up with optimised designed for different jobs. Carbide parting tools are generally deeply scooped out and shaped to cause the swarf to curl and break into short pieces which are easily ejected from the cut (**photo 1**).

I have been looking at some of this style of tool from Arc Euro Trade. The NCH19-2 is a double ended holder, designed to be held in a block similar to one you would use for an ordinary HSS parting blade (**photo 2**). The material is spring steel and the insert is simply tapped into the holder with a soft-faced mallet. The example I saw had been used (and abused) by Ketan at ARC who got carried away trying to part some suspect cast iron. It wasn't hard to swap out his broken tip, as the tool comes with a little pry-bar for extracting the inserts (**photo 3**).

The other two tools have conventional shanks for fitting in a toolpost. They have clamps secured using an allen screw in the body, rather than relying on a 'tapped in' fit. The QA0812R02 uses the same inserts as the double ended holder (**photo 4**) it is ideal for medium to large lathes – it is rather too long to use with a mini-lathe or similar small machine.

The smaller MGEHR0812E02 tools is much better suited to mini-lathes (**photo 5**). This holder uses a double-ended insert (**photo 6**). It is pretty much dead on (or a little below) centre height when fitted to my machine (**photo 7**). As an aside these holders have awful names, but as they are laser engraved into the sides of the

holders (together with a neat ARC logo) you should never struggle to order the correct insert!

So what are these tools like to use? I could only trial the smaller shanked tool, so I had a few runs using a one-inch bar of EN1a mild steel (not leaded). The first thing I noticed was that the tools are not a sharp as HSS ones, which I usually bring to a razor-edge on a diamond wheel. This means the tool can make a horrible sound before it starts to cut properly – and it needs good positive feed to start cutting. No point being lily-livered!

Typically, carbide tools should be run much faster than HSS, as this softens the metal and actually makes cutting easier. I found this insert did cut at lower speeds of 300-400 rpm, but the belt drive on my lathe had a tendency to slip if I fed too fast, and the insert 'howled' if I fed too slow. Rather than fiddle with this balancing act, I tried higher speeds. At 1100 rpm the tool cuts like a dream, with little coiled chips flying, but it is hard to feed in fast enough by hand and if you are too slow the noise is quite disconcerting. I am sure the tool would work brilliantly at these high speeds under power feed.

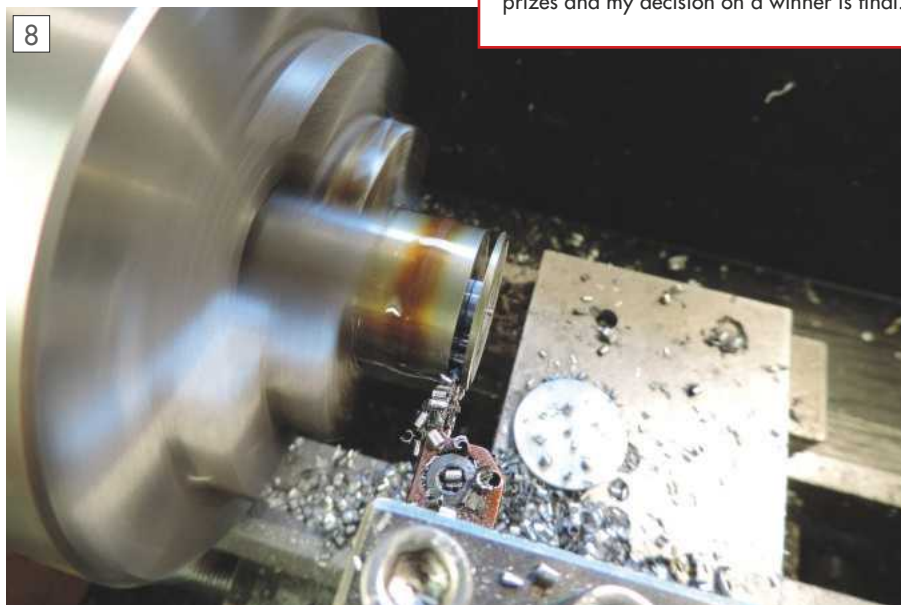
Luckily, I was able to fine the 'goldilocks zone' for my lathe – that is not too fast, not too slow. It turned out to be GHT's 600rpm, feeding manually, at about a quarter of a turn of the handle per second, which equates to a 1-thou chip thickness (**photo 8**). A little brush applied neat

cutting fluid made hand feeding easier and eliminated any tendency to make horrible noises. In contrast Ketan reported that he got best results at 350 rpm and cutting fluid made no difference. This suggests that you will need to experiment to find the best speed for your own machine, but my advice would be 'don't go too slow'.

In conclusion, these tools are nicely finished and presented and use readily available and affordable inserts, and they appear to be capable of working harder than HSS. Just like ordinary inserted tip carbide tools, however, they do take getting used to if you are more familiar with HSS. ■

WIN A Carbide-Tipped Parting Tool

MEW has one of the Arc Euro Trade QA0812R02 tool holders, suitable for medium-sized lathes, to give away to one lucky reader. For your chance, send the editor a picture of your workshop in an email to neil.wyatt@mytimemedia.com headed 'Arc Parting Tool Give-Away'. We will publish a selection of the pictures in a future issue and whichever picture most tickles Stub's fancy gets the parting tool. Closing date is 30 April, no alternative prizes and my decision on a winner is final.



Modifications to a drill press



Laurie Leonard shows how to reduce working clearance in the quill.

I recently purchased a new drill press which was larger than the one it replaced and was chosen for its drilling capacity, table design and the geared handle arrangement built in to raise and lower the table. Whilst the machine met all these criteria I have not been happy with the play manifest at the drill bit especially when the quill was near full stroke.



Checking play with a clock gauge.

An amount of working clearance can be expected in most mechanisms. The actual amount will depend on such factors as the expected working environment and the tolerances to which the mechanism has to perform. The latter is closely allied with the permitted cost of the mechanism. This play was checked with a clock gauge (**photo 1**) and was found to be worse in the x direction than the y direction but was particularly noticeable when drilling into a centre spotted mark as the bit, even a centre drill, tried to climb out of the spot mark.

Having corresponded with the supplier it was found that the machine was within specification and so I therefore decided to investigate ways of reducing the play.

Initial Adjustment/Modification

The machine, as supplied, has an adjustable depth stop which comprises a heavy yoke carried by the quill which in turn carries the chuck guard. The yoke provides the support for a screwed rod scale and with an adjustable lock nut arrangement which limits the travel. The

latter registers on a stop which is integral with a cover over the quill drive pinion shaft end nut (**photo 2**). Removing the depth stop gives access to this cover and removing the cover gives access to an adjuster screw provided by the manufacturer to take up play. This Allen screw, complete with lock nut, can be seen lower right in **photo 3**.

Time was spent adjusting this screw but without achieving any significant reduction in the play. In photo 3 a hole can be seen directly above this screw and through it the 'v' groove in the quill that



Depth stop register.



Quill play adjusting screw.

the pointed end of the screw locates in which additionally prevents rotation of the quill within the head. Looking for a way of reducing the play it was argued that with a large clearance for the quill within the head, even with the screw relatively tight, may permit the quill could pivot on the screw point resulting in drill wander. The second hole was drilled and tapped (taking precautions to prevent drilling the quill and the ingress of swarf) and an additional screw fitted to try and prevent this. It did reduce the play at the drill bit when tightened up hard but the quill would not retract properly. A modified screw fitted with a steel ball instead of a point was tried to reduce friction but no avail. It was concluded that another solution was required.

Sheathing the quill in shim material was considered but dismissed on practical considerations and minimal space for the shim.

External Stabiliser

A lot of the foregoing is applicable to many makes of machine. The following work is specific to my machine but it is likely that it can be applied in some form to many other makes. Dimensions are specific to a machine and, as is often the case, the dimensions of the parts made were to some extent governed by the material available. Accordingly no specific drawings are given but the reader can adapt the idea to personal requirements.

It was concluded that an additional fixture was needed to reduce the play. Whilst this would inevitably lead to a modification to the machine this was to be kept to a minimum. The completed modification is shown in **photo 4** and from above (nearly complete) in **photo 13**. The solid yoke used by the depth stop was utilised to support a stabilising column which slides in a close tolerance housing securely fixed to the main head casting by a bracket. The small number of parts used for the stabiliser are shown in **photo 5** and are not hard to make but some comments on their production follow.

The column housing was machined on the lathe using a four-jaw chuck from a bright mild steel off cut. The hole for the guide rod was drilled and reamed from the tailstock and the work was then turned through ninety degrees to drill and tap the hole (**photo 6**) required to secure the housing to the machine head bracket, the latter being made from a piece of angle. This operation threw up a burr in the bore, (**photo 7**) which was removed utilising the reamer.

Throughout the work care was taken to ensure holes etc. were perpendicular as in drilling the hole in the support bracket, **Photograph 8**, where the bracket is supported on parallels. The stabiliser column was made from a piece of bright mild steel. Ideally this should have been ground silver steel but at the time of construction none was to hand and the work was being done to prove or otherwise the suitability of the stabiliser idea. The column rod was slightly reduced at one end to produce a shoulder then drilled and tapped for a draw bolt. The column is carried on a piece of mild steel strip and secured utilising a hole with an interference fit of a few thou, a draw bolt



Stabiliser component parts, less card packing.

Completed stabiliser.



Tapping the stabiliser housing in the lathe.



Burr thrown in the stabiliser housing by tapping.



Utilising parallels to drill square.



9 Drawing the column onto the support strip.

being used to pull the column onto the support strip up against the machined shoulder (**photo 9**). A suitable adhesive could also have been used.

In photo 4 it can be seen that the bracket supporting the column housing is secured against the head casting utilising two screws fitted into drilled and tapped holes. The quill was removed to make sure that it was possible to drill in this position and to ensure that when the drill penetrated the head it would not foul on anything. Ideally the bracket should mate onto a machined surface on the head casting but this was thought to be impractical to provide particularly as the success of the project was not known. Instead, two layers of card were used for it to 'bed' onto the casting. Clean screw holes in the card were made using a wad punch (**photos 10, 11 and 12**). A set of punches may seem to be a luxury but when the need for one arises they make short work of this kind of job. In this application it is important that the holes in the card are cut cleanly so that the bracket beds hard over the surface of the casting and not onto the burr thrown up by cutting the hole. I have found that using a piece of faced chipboard as an anvil for the punch gives rise to a clean cut.

The final task was to set up the stabiliser and mark the pre-drilled holes in the column support strip through to the yoke to enable tapped holes to be provided for fixing. A toolmakers clamp was used to hold the support in place and the support



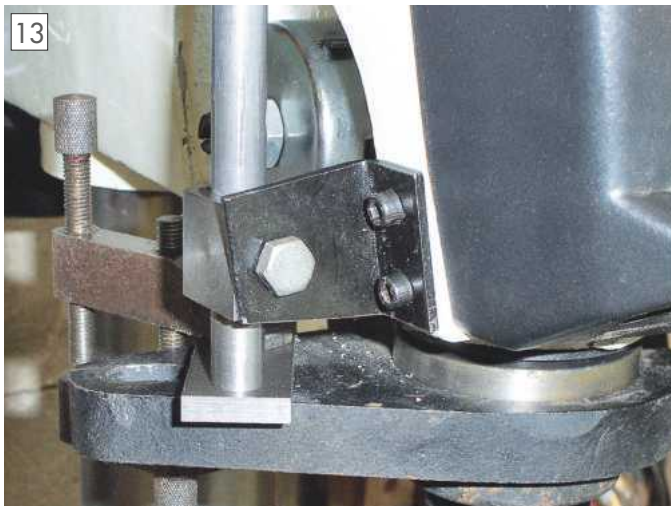
12 Use of wad punch to produce clean holes in card.

strip was adjusted to ensure free travel of the quill before the clamps was hardened up (**photo 13**). The drill bit initially used in the stabiliser support strip was the tapping size for the screws that were to be used to secure the bracket to the yoke. The yoke was removed from the drilling machine with the support strip still held in place by the clamp and the holes were drilled through into the yoke with the tapping size bit and then tapped (**photo 14**). The holes in the support strip were then opened to screw clearance size. The substantial nature of the yoke can be seen

in **photo 14**. It is held securely to the quill by a pinch bolt not shown.

Conclusion

Whilst the stabiliser has greatly reduced the play it has not totally eliminated it but the reduction gained is deemed to be worth the effort. A silver steel column and longer column housing may have reduced this further. The resulting stabiliser is not glamorous and could be tidied up to reduce the 'prototype' look but it is functional. ■



13 Utilising a toolmakers clamp to hold parts in place prior to drilling.



14 Tapping the screw holes in the yoke: the substantial nature of the yoke.



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A Tailstock Centre Set

PART 2



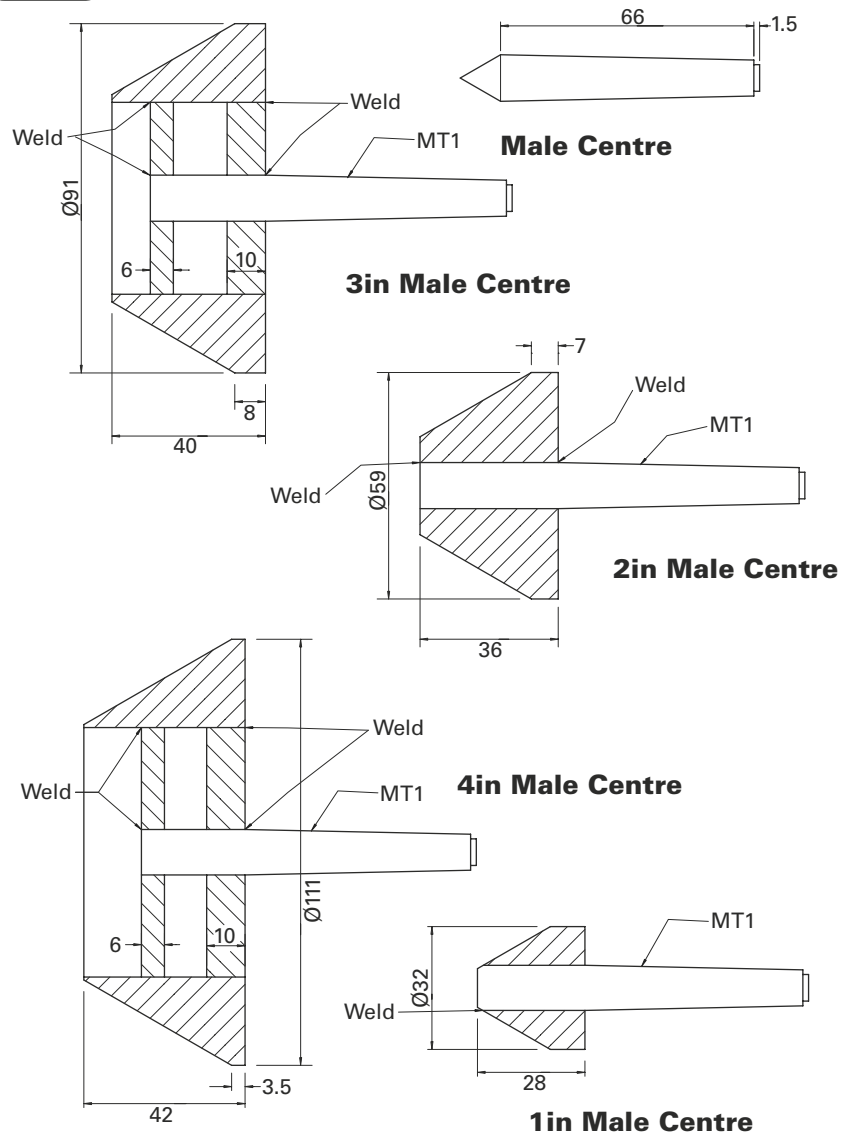
Peter Tucker's rotating tailstock centre and variety of different shaped adaptors can support a wide range of jobs from the tailstock.

Having been in the construction industry most of my working life and being somewhat of a hoarder I now have a stock of metal of questionable provenance. After retirement I purchased a lathe/mill combination which I am learning to use, turning the scrap into 'useful' items.

This article is about my construction of a rotating tailstock centre; the main criterion is that it is made from materials on hand, and that the male and female centres will, hopefully, fit any size tube up to 4 inch galvanised water pipe.

As my material stock has been collected over years (and most is of unknown quality, and I am not from an engineering background) I do not expect anyone to exactly copy my methods or approach, however, hopefully they will be of interest or use to readers. I work in both imperial and metric measurements, as most people tend to be more metric than imperial I will keep mainly to this, however, when things come as imperial I will give them in this system.

Fig. 6



Male and female centres

These are the business ends of the centre (photo 13, figs 6 and 7) I decided to, if possible, make the centres to fit up to a standard inch, galvanised iron pipe size, so I found a stub of $1\frac{1}{4}$ inch bar and an offcut of $1\frac{1}{2}$ inch black steel bar these would form the male and female centres for 0-1 inch internal diameter pipe. There were two small badly rusted rollers from some derelict machine formed the centres to take 1 to 2 inch ID pipe. The next piece of steel was, I am sure, a shaft coupling, this made a male centre for 2-3 inch pipe.

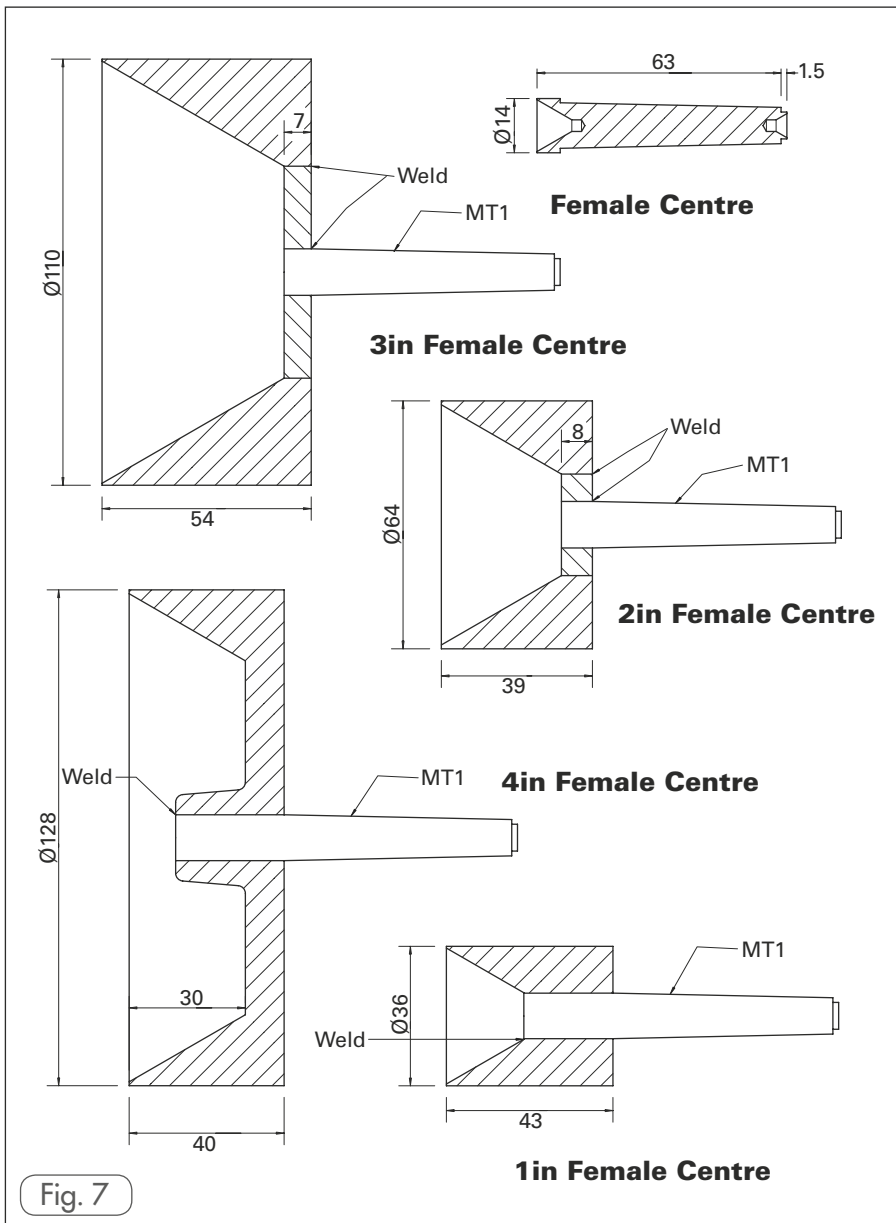
Another shaft with an internal keyway $\frac{5}{16}$ inch deep was cut in two, the shorter, piece made a male centre for 3-4 inch pipe, the other made the female 2-3 inch centre. I filled the keyway with weld before cutting the coupling. Finally, for the 3-4 inch female centre, I had been given an off cut from a large shaft 130mm diameter with a keyway, the keyway did not go to the shaft end but was partially over the length I wanted to use so I filled that part with weld for cosmetic purposes. This I found was a mistake as the shaft was high carbon steel and the heat from the weld and subsequent



The finished nosepieces.



Boring bar made to fit the small female nosepieces.



chill from the mass of surrounding steel formed a hard patch which my band saw could not cut! Most of this shaft was cut with the band saw but a friction blade in the power hand saw cut the hard patch. With the exception of the 1¼ inch stub and the 130mm disk these blanks were held in

the three jaw chuck and turned to size and shape (60 degree taper). The 130mm disk, being too big for my three jaw chuck, was turned in the four jaw.

To form the smallest female centre a tapered boring tool (**photos 14 and 15**) had to be made and to turn the larger ones



Bar from photo 14 in action.

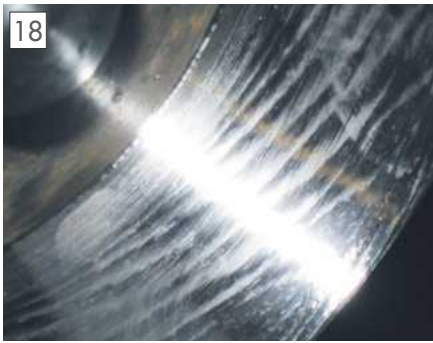


Cylindrical tool post for the larger female nosepieces.

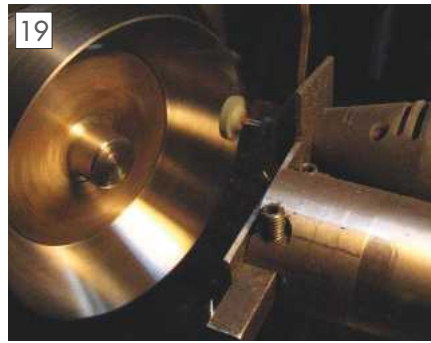


Tool post from photo 16 in action.

an extended cylindrical tool post (**photos 16 and 17**) needed to be made. I make my boring bars using ordinary or high tensile steel to which I silfos a tungsten carbide tooth scavenged from derelict circular saw blades. The pieces which had been shaft couplings needed disks fitting to connect



Chatter striations on the largest female nosepiece.



Rotary tool with grinding disk used to remove striations in photo 18.



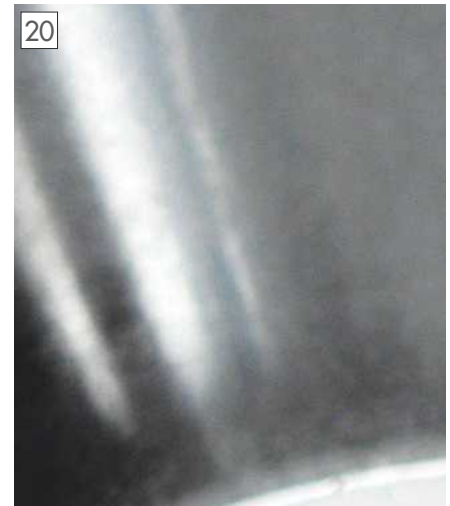
Male nosepiece held between a female nosepiece and tail stock while finishing.

to the 1MT. The male centres had two disks - a 10mm at the base and a 6mm nearer the apex the female could only have the 10mm at the base. Because the centres with the 10mm base only have very little interaction with the Morse taper to hold it in alignment for welding, I made a welding jig. All centres and tapers were now welded. The MT3/MT1 adaptor now came into use to hold the centres in the lathe spindle where they were cleaned up and made concentric with their Morse tapers. The smallest male centre was fully formed at this stage. The largest female centre gave some trouble, I could not achieve a smooth surface with any cutting tool (**photo 18**) I think the 1MT did not give enough rigidity to this large a disk. My solution was to mount a small rotary tool on the tool post and grind the surface (**photo 19**). The resultant finish is shown in **photo 20**.

With the front and sides cleaned up the backs of the female centres were no trouble to finish held in the lathe chucks, the male centres could not be held thus. My solution was to mount the corresponding female centre in the adapter in the lathe spindle and fix the male centre in the female centre with double sided tape, backed up with a tail stock dead centre to the end of the male centre's Morse taper (**photo 21**).

Other parts and assembly

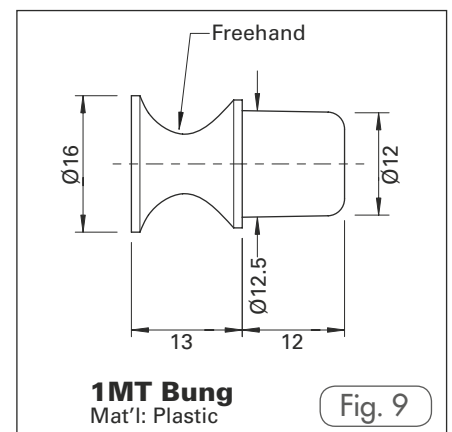
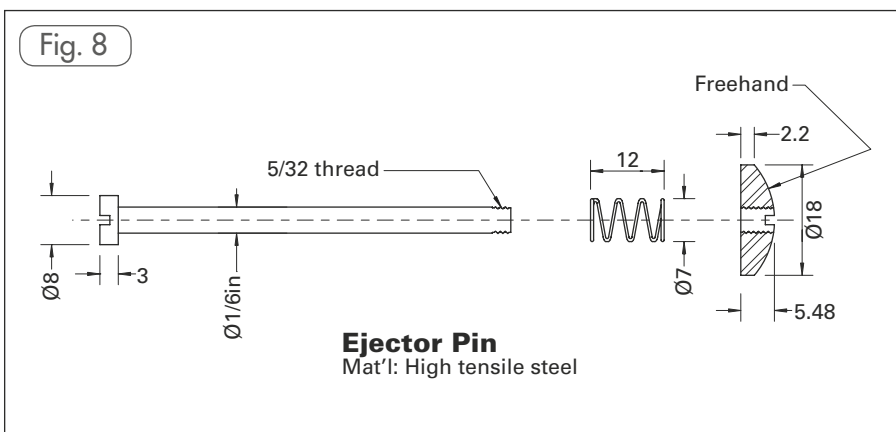
An ejector pin (**fig 8**) was needed, I wanted this to be from high strength steel. What was chosen was the central strand from a cable used in making pre-stressed concrete structures, this steel is very tough being extremely high tensile so I doubted my ability to cut the thread needed on one end. The end to be threaded was

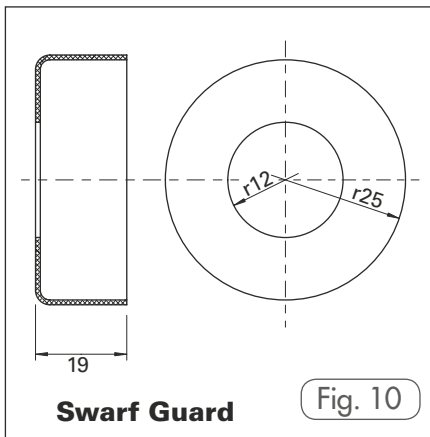


Surface finish left by rotary tool.

heated red hot and allowed to cool. This rod is an awkward size at $\frac{1}{8}$ inch diameter necessitating opening the 4mm in the inner body to 4.5mm, I turned the softened end to $\frac{5}{32}$ inch and with a single point tool attempted to cut a fine thread (operating the lathe by hand with a spindle handle,, however on the second pass the work broke the tool so I needed an alternative method. I mounted the rotary tool in the tool post with a 0.4mm thick cutting wheel and cut a helical groove, when I considered the groove deep enough a die was run over to form the thread. The rod was then cut to length and a disk of steel welded on the unthreaded end and this was cleaned up to size in the lathe. A steel bar was mounted in the lathe, drilled, and tapped to fit the ejector rod thread and a disk parted off. The threaded disk and the disk welded to the ejector rod were slotted to accept screw drivers. A spring was found to fit between the welded head of the ejector rod and the inner body, this is to hold the outer disk of the ejector pin against the outer body when not in use, hopefully it will keep out swarf. While measuring for the pin, and generally poking about in the 1MT socket I considered how difficult it could be to clear it of stray swarf, so I made a plug (**fig 9**) from plastic rod to be fitted when the centre was not in use.

The final part was a swarf guard (**fig 10**) to cover the front of the inner and outer bodies. A stub of two-inch steel bar was chucked in the lathe, turned to 50mm, and polished; from an off cut of 1mm thick sheet aluminium a $3\frac{1}{2}$ inch disk was cut





and annealed. This disk was trapped between the 50mm steel and a small steel disk supported by the tailstock dead centre, an attempt was then made to spin the outer extremities of the disk on to the cylinder, removing the partially formed part to re-anneal on two occasions, however after the third annealing on continued forming the work cracked and was discarded. A second disk was cut and the process was repeated with the same results. A third disk was cut (the last of the scrap), this time only a small amount of forming was attempted between annealing; after perhaps as many as a dozen annealings the part was formed, it was then trimmed and polished on the former. Assembly should be straightforward; all parts **photo 22**, are cleaned and lightly oiled, the taper roller bearing was inserted into the main body and the inner body fitted, the thrust washer and rear bearing were inserted (ensuring that the washer is the right way around) and the rear nut fitted. Putting one of the medium sized pipe centres in the rotating body's Morse taper will facilitate tightening the rear nut. A spring was slipped over the ejector pin which was then inserted through the inner body's Morse taper, with a screw driver in the ejector pin slot the ejector disk was screwed on the pin end. The swarf guard was pressed on the main body to finish.

Storage

All these components needed a home so a drawer was constructed to fit the lathe cabinet (**photo 23**). The sides, front, and back are 5¼ inch by ¾ inch timber, a groove was run down the middle of the board to take a 12mm piece of particle board. The particle board was drilled 13mm to take the 1MT shanks of the larger centres, a slot was cut for the rotating body, and three spring clips were fitted two for the small centres and one for the rear nut spanner.

In Use

In use the centre seems to perform well, however, after machining a cast iron bar I removed the swarf guard and found fine iron particles were getting past it and threatening the bearings. After cleaning my solution to this problem was to cut an annulus of felt to fit on the inside face of the swarf guard and fix it with double sided tape, then replace the swarf guard so the felt just touches the inner body. ■



Rotating centre before assembly.



Drawer with centre and nosepieces.

PURCHASED PARTS

Taper roller bearing SKF 32004 size ID 20, OD42, width 15mm.
Ball bearing 6700-2RS size ID 10, OD 15, width 4mm.
Note: These bearings are available from Arc Euro Trade reference 32004 and S61700-2RS.

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16-18 September 2016
Brooklands Museum, Weybridge, Surrey

OFFICE USE ONLY

CLASS	ENTRY NO.

Please return completed form by Friday 5th August 2016 to:

Mr Mike Law, 12 Maple Drive, Elkesley, Retford, Notts DN22 8AX

Email: post@michaellaw.co.uk

Entries may be returned by either post or email but in order to reduce costs, the organisers would prefer to correspond by email.

ENTRY FORM COMPETITION & LOAN MODELS

PERSONAL DETAILS (Please print)

Surname _____ Forename(s) _____ Age _____

Address _____

Post Code _____ Email _____

Home Tel No _____ Daytime Tel No _____

Model Club or Association _____

How many years have you been a modeller? _____

MODEL DETAILS – PLEASE TICK BOX IF MODEL IS FOR LOAN ☐

Entry Class (competition entries only) _____

Model Title (to be used for catalogue and display card) _____

Model Description (to be used for catalogue and display card) _____

Model Scale _____ Length _____ Width _____ Height _____ Weight _____

Type of construction _____

Parts not made by you and commercial items _____

Please supply a photograph of the finished model for insurance purposes. (Please note: It may not be possible to provide insurance for models entered later than 5th August 2016.)

Are you supplying Judges Notes? Yes ☐ No ☐

Value of Model (MyTimeMedia Ltd will not insure the model unless a realistic value is entered) £ _____

I have read the rules and conditions of entry and confirm the information is correct to my knowledge and I accept the conditions of entry.

Signature _____

Information about entries included on or with this form may appear in MyTimeMedia Ltd publications and on our websites.
 Other than entrant's name, no personal information will be published.

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**PHOTOCOPIES OF THIS
FORM ARE ACCEPTABLE**

To help you get the best from The Model Engineer Exhibition

These notes are written purely for guidance. Full information is contained in the Competitors' Information booklet which is sent to every entrant as part of the information package. If you have an item and are unsure as to the Class into which it should be entered, leave that section blank and we will take care of it. The Judges have the right to move any competition exhibit into another class if they feel that by doing so its chances of gaining higher marks or a more appropriate award are improved.

If the item is offered as a Loan exhibit please indicate this by writing Loan on the form in the box identifying the Class. Loan models are not judged but carry all other privileges associated with competition entries.

Part built models are particularly welcome in the Loan Section; visitors like to see work in progress, and entry does not preclude the item being entered in competition when completed.

The classes listed below are those associated with mainstream model engineering.

Club exhibits

Where a club is exhibiting, each model should be entered on a separate entry form and clearly identified as a club exhibit by entering Loan/Club in the class section box. This ensures that we have a full record of all models on display during the show and facilitates matters of administration and insurance.

Additional forms

If you do not wish to deface your copy of the magazine we are happy to receive photocopies of the entry form, one for each model. We will be pleased to send out extra forms if required, so if you know of a modeller who is not a reader of one of our magazines but who you think may wish to participate, please advise them to contact our Exhibitions Office, or simply photocopy the entry form for them. The success of the show depends largely on the number of models on display. Your work could well be the stimulus which inspires someone else to start in the hobby. There can be no doubt that this event is our showcase on the world of modelling in all its aspects. Every modelling discipline needs more and more participants, and it is by displaying not only the crème-de-la-crème, but also examples of work of a more achievable standard, that people are encouraged to join into the wonderful world of modelling, in whatever aspect. We look forward to seeing a sample of your work at the show!

Engineering Section

- A1 Hot air engines.
- A2 General engineering models (including stationary and marine engines).
- A3 Internal combustion engines.
- A4 Mechanical propelled road vehicles (including tractors).
- A5 Tools and workshop appliances.
- A6 Horological, scientific and optical apparatus.
- A7 General engineering exhibits – not covered by the above

Railway Section

- B1 Working steam locomotives 1" scale and over.
- B2 Working steam locomotives under 1" scale.
- B3 Locomotives of any scale, experimental, freelance or based on any published design and not necessarily replicas of full size prototypes, intended for track duties.
- B4 Scratchbuilt model locomotives of any scale, not covered by classes B1, B2, B3, including working models of non-steam, electrically or clockwork powered steam prototypes.
- B5 Scratchbuilt model locomotives gauge 1 (10mm scale) and under.
- B6 Kitbuilt model locomotives gauge 1 (10mm scale) and under.
- B7 Scratchbuilt rolling stock, gauge 1 (10mm scale) and under.
- B8 Kitbuilt rolling stock, gauge 1 (10mm scale) and under.
- B9 Passenger or goods rolling stock, above 1" scale.
- B10 Passenger or goods rolling stock, under 1" scale.
- B11 Railway buildings and lineside accessories to any recognised model railway scale.
- B12 Tramway vehicles.
- B-K1 Working steam locomotives built from a kit.
- B-K2 Working locomotives other than steam powered. (Any model locomotive in class B-K1 and 2, built from a commercial kit, entered into these classes will not be judged in the medal classes but can receive commended certificates and an award from a trade supplier).

Marine Models

- C1 Working scale models of powered vessels (from any period). Scale 1:1 to 1:48
- C2 Working scale models of powered vessels (from any period). Scale 1:49 to 1:384
- C3 Non-working scale models (from any period). Scale 1:1 to 1:48
- C4 Non-working scale models (from any period). Scale 1:49 to 1:384
- C5 Sailing ships and oared vessels of any period – working.
- C6 Sailing ships and oared vessels of any period – nonworking.
- C7 Non-scale powered functional models including hydroplanes.
- C8 Miniatures. Length of hull not to exceed 15in for 1:32 scale, 12in for 1:25 scale, 10in for 1:16 scale; 9in for 1:8 scale. No limit for smaller scales.
- C9 For any model boat built from a commercial kit. Before acceptance in this class the kit must have been readily available for at least 3 months prior to the opening date of the exhibition and at least 20 kits must have been sold either by mail order or through the retail trade.

Scale Aircraft Section

- D1 Scale radio control flying models
- D2 Scale flying control-line and free flight
- D3 Scale non-flying models, including kit and scratch-built
- D4 Scale flying radio controlled helicopters

Model Horse Drawn Vehicle Section

- G1 Carriages & other sprung vehicles. (Omnibuses, trade vans etc.) Wagons, carts and farm implements. Caravans.

Junior Section

- J1 For any type of model, mechanical or engineering work, by an under 14 year old.
- J2 For any type of model, mechanical or engineering work, by an under 16 year old.
- J3 For any type of model, mechanical or engineering work, by an under 18 year old.

All entries will be judged for standard of craftsmanship, regardless of the modelling discipline, i.e. a boat will not be competing against a military figure. Providing a model attains sufficient marks it will be awarded a gold, silver or bronze medal.

Model Vehicle Section

- K1 Non-working cars, including small commercial vehicles (e.g. Ford Transit) all scales down to 1/42.
- K2 Non-working trucks, articulated tractor and trailer units, plus other large commercial vehicles based on truck-type chassis, all scales down to 1/42.
- K3 Non-working motor bikes, including push bikes, all scales down to 1/42.
- K4 Non-working emergency vehicles, fire, police and ambulance, all scales down to 1/42.
- K5 Non-working vehicles including small commercial vehicles (e.g. Ford Transit,) scale from 1/43 or smaller.
- K6 Any available body shells including Concours, in any scale or material, to be judged on appearance only.
- K7 Functional model cars/vehicles which must be able to move under their own power of any type. Can be either free-running, tethered, radio controlled or slot car, but must represent a reasonable full size replica.

DUKE OF EDINBURGH CHALLENGE TROPHY Rules and Particulars

- 1. The Duke of Edinburgh Challenge Trophy is awarded to the winner of the Championship Award at the Model Engineer Exhibition.
- 2. The trophy remains at all times the property of MyTimeMedia Ltd.

- 3. The name of the winner and the date of the year in which the award is made will be engraved on the trophy, which may remain, at the discretion of MyTimeMedia Ltd., in his/her possession until required for renovation and display at the following Model Engineer Exhibition.
- 4. Any piece of model engineering work will be eligible for this Championship Award after it has been awarded, at The Model Engineer Exhibition, a Gold or Silver medal by MyTimeMedia Ltd
- 5. A model may be entered more than one year but if the model wins it will be permanently retired.
- 6. Entry shall be free. Competitors must state on the entry form:
 - (a) That exhibits are their own bona-fide work.
 - (b) Any parts or kits which were purchased or were not the outcome of their own work.
 - (c) That the model has not been structurally altered since winning the qualifying award.
- 7. MyTimeMedia Ltd. may at their sole discretion vary the conditions of entry without notice.

COMPETITION RULES

- 1. Each entry shall be made separately on the official form and every question must be answered.
 - 2. Competition Application Forms must be received by the stated closing date. LATE ENTRIES WILL ONLY BE ACCEPTED AT THE DISCRETION OF THE ORGANISERS.
 - 3. Competitors must state on their form the following:
 - (a) Insured value of their model.
 - (b) The exhibit is their own work and property.
 - (c) Parts or kits purchased.
 - (d) Parts not the outcome of their own work.
 - (e) The origin of the design, in the case of a model that has been made by more than one person.
- NOTE: Entry in the competition can only be made by one of the parties and only their work will be eligible for judging.
- 4. Models will be insured for the period during which they are in the custody of MyTimeMedia Ltd.
 - 5. A junior shall mean a person under 18 years of age on December 31st in the year of entry.
 - 6. Past Gold and Silver medal award winners at any of the exhibitions promoted by MyTimeMedia Ltd. are eligible to re-enter their model for the 'Duke of Edinburgh Challenge Trophy'.
 - 7. Past winners at any of the exhibitions promoted by MyTimeMedia Ltd. will not be eligible for re-entry into the competition unless the exhibit has been substantially altered in any way.
 - 8. MyTimeMedia Ltd reserve the right to:
 - (a) Transfer an entry to a more appropriate class.
 - (b) Describe and photograph any models entered for competition or display and to make use of any such photographs and descriptions in any way they may think fit.
 - (c) Refuse any entry or model on arrival at the exhibition and shall not be required to furnish a reason for doing so.
 - 9. Entry into the competition sections is not permitted by:
 - (a) Professional model makers.
 - (b) Anyone who has a financial interest in the direct supply of materials and designs to the public.
- NOTE: If unsure, please contact the Competition organisers prior to the show.
- 10. The judges' decision is final. All awards are at the discretion of the judges and no correspondence regarding the awards will be entered into.
 - 11. Exhibitors must present their model receipt for all models collected at the end of the exhibition and sign as retrieved.
 - 12. The signed release for each model must be presented to security staff when leaving the exhibition complex with display model(s) after the close of the exhibition.

IMPORTANT NOTE: PLEASE MAKE COPIES, INCLUDING PHOTOGRAPHS, OF ALL INFORMATION RELATING TO YOUR MODEL, AS MYTIMEMEDIA LTD WILL NOT ACCEPT LIABILITY FOR ANY LOSS.

CLOSING DATE: 5 AUGUST 2016

Milling Leadscrews in the Lathe



John Pace gives full build instructions for his self-contained milling spindle, together with advice on its use.

Although, in the past, I have cut several replacement leadscrews for machines during conversions and have not encountered any problems, a recent experience has made me look at an alternative method of production.

During the build of a new machine which has been a project lasting a number of years, I needed to make two fairly short half inch left hand 10 tpi leadscrews at the same time also while set up a right hand screw, also 10 tpi and about 20 inches long. When cutting the left hand screw all was proceeding well until nearly at the final cut when the tool dug in the travelling steady flexed alarmingly and the job was ruined (**photo 2**).

The travelling steady jaws showed some signs of damage from cutting the thread, the thread had some burrs thrown up and the bronze pads had deep score marks. You can even see in the photo remnants of the bronze pads picked up on the threads. It was clear from this photo that all was not well long before the tool finally dug in. As the tool was leading the travelling steady the burrs that had formed clearly had played a part in this eventually leading to the dig in.

This seem to be a common problem that others have experienced, Harold Hall mentions a minor problem in his article *Using a Lathe Steady*, MEW 174 page 14 (A minor problem of the method is that the first cut will throw up quite sharp burrs which will damage the steady's jaws on subsequent traverses). I am not quite sure if he was cutting an acme thread or as he indicates a square thread as the photo does not show this clearly, and later on in the article suggests the use of a wide fine file to remove the burrs after every pass. This article was not specifically about cutting acme threads but a comprehensive look at using lathe steadies which he covered very well.



Set-up for Milling leadscrews.



Damaged screwcut leadscrew.



Milled Warco leadscrew.

MES fixed steady modified for use as travelling steady.

Solving the problem

I did not know the history of the piece of metal as it had come from my scrap box but had turned to an easy finish and appeared to be free cutting. The only difference from previous Acme threads that I had cut is that this was a left hand thread. The travelling steady on my Warco lathe has similar features to steadies seen on most machines, the sections of the steady are not particularly large and it is not possible to deflect by hand pressure. The forces generated when supporting small diameters I expect can be quite large if and when the tool digs in. I have never really understood why that only two supporting pads are fitted on travelling steadies as in some instances it would be useful to have the support all around the work.

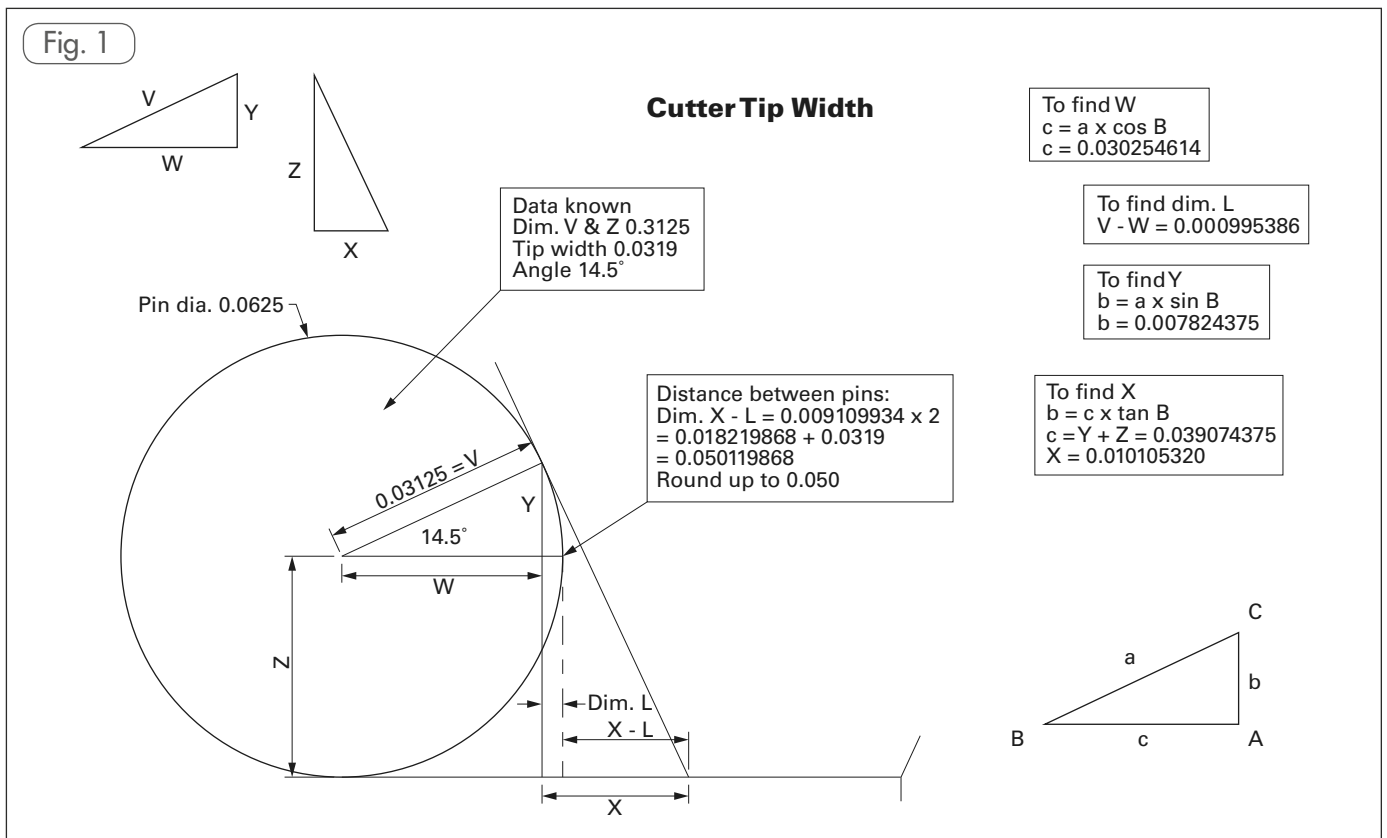
The first place to start any improvement should be here. I initially made some modifications to the existing steady by fixing a steel plate to the steady frame, but

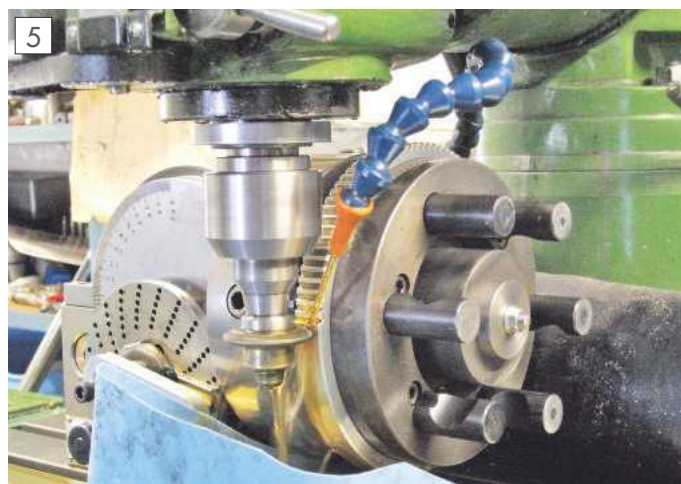
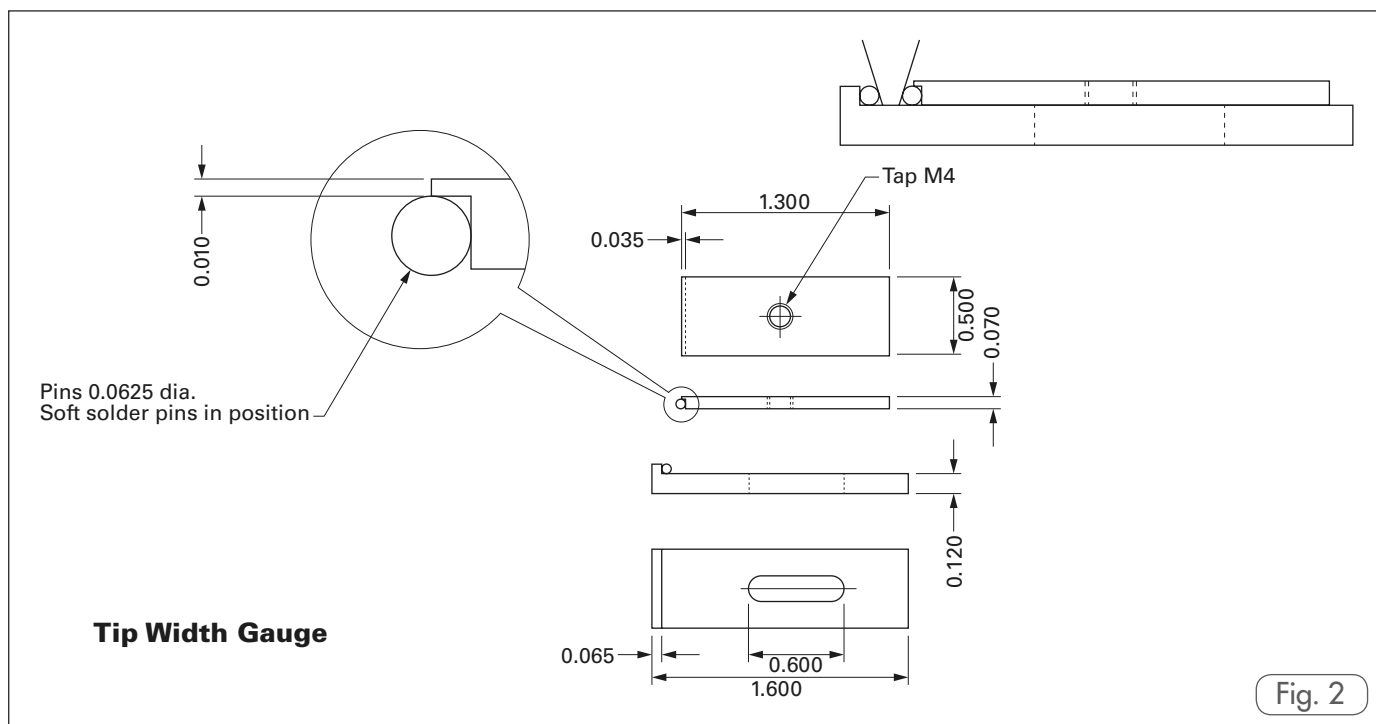
this caused problems with being able to see the job in hand and was abandoned.

On my Myford I have a fixed steady from Model engineering services it is made from a kit of parts and has four support legs and can hold up to 5 inches in diameter. Fortunately, because it is made as a kit to not only fit the Myford the base mounting detaches. Some simple brackets were made to fit this to the existing holes on the saddle of the original travelling steady. In addition to this an additional fixing to the cutter support block prevents any fore and aft rocking movement. **Photograph 3** shows the steady in position. The arrow indicates a locking bracket that ties the cutter mounting block and the steady together, this prevents the steady from any tendency to flex fore and aft and in doing so would pull the rod downwards. This is secured after the cut is set and is released to adjust the slide. I could have just used this steady and continued to produce the

leadscrews by conventional screwcutting, but just recently I have made some 1.25 module worms for the same project by milling and the finish was better than I could have done by screwcutting and also much faster to do as some were done in a single pass, the depth of cut of this worm is 0.111 inch, nearly twice the depth of a 0.100-inch acme thread. **Photograph 4** of an old leadscrew off my mill shows quite clearly that it was milled, the sweep out of the cutter at the end of the thread can be seen here. Although the sweep out looks very clean as if it is ground you may be able to see at the root of the thread the surface is faceted a clear indication that the thread was milled.

To be able to do this does mean making some parts to be able to hold and drive a suitable cutter in the lathe instead of a screwcutting tool. I decided to investigate the possibilities of doing this. The lathe would be used as for normal screwcutting





Cutting a 100 tooth 1/5 xl pulley.



Shadowgraph measuring unit.

using the leadscrew geared to the spindle. The drive to the spindle would have to be much slower than was possible using the lathe's own motor even in the lowest gear and with the inverter at its lowest setting. The drive to the cutting tool would need to be independent for ease of use. The cutting tool would be the same form as a conventional screwcutting tool and would be similar to a single row involute gear cutter and would be formed on the Eureka device that I already have. The form is easy to generate as it is straight sided and the tip width is easy to measure using an existing section of leadscrew, or a simple gauge that I used during an *MEW* article on making toothed belt cutters reproduced here in **fig. 1** the angles and calculations adjusted to suit this article, the calculations are left full and only rounded off at the end.

The gauge is shown in **fig. 2**. You may also use an Acme tap of the same pitch as this is the same profile as the leadscrew thread. More accurate observation of the profile and dimensions of the cutter form can be made using a simple to make unit based on a USB microscope bought from

Maplins. This was featured in an article *Poor man's shadowgraph* in *MEW* 189 to 191, May to July 2012. **Photograph 5** shows this unit with a cutter still mounted on the Eureka device for measuring, this is very useful as the cutter setting remains undisturbed for measuring and can be re-fitted to the lathe for machining.

Photograph 6 shows the image from the shadowgraph, the item being measured is taken from comparison from the size of a known object or using the dial indicator and leadscrew dial.

Later on I will show the production of the cutter although this was covered during that article and is exactly the same except for the form of the cutter I have used a slightly different tooling arrangement which gives an improved finish to the cutter.

I cut all of the gears and worm wheel using an electronic gear hobbing system mentioned later on in the article, I cut all of my own gears and toothed belt pulleys and have always done so, as I find that it is easier to start off with a concentric arbor and work outwards from that point. I feel that it is worth the effort to make

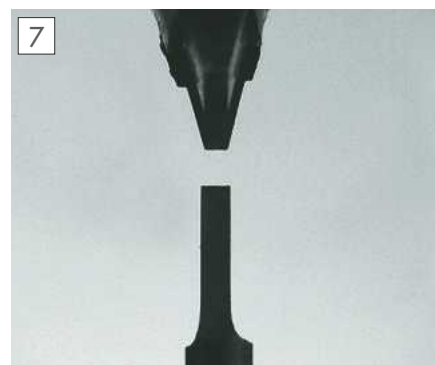


Image of cutter tip.

the tooling as in the long run it will save you time and money and has the advantage of being able to make what is required instead of using what is available.

The spindle for the cutter is of a simple construction and consists of a mounting block with plain bronze bushes, a hardened shaft to mount the cutter, the shaft is driven using a small wormwheel and worm driven from a small induction motor at

about 1500 rpm through two hardened spur gears 25 tooth driving a 23 tooth gear. This slight gear up in speed revolves the cutter at about 100 rpm, at this speed it is cutting at about 40 feet per minute - the cutter is made from silver steel so the cut speed must be kept fairly low to avoid dulling the edge. This is a slight increase in cutter speed from that suggested in Ivan Law's book Gears and gear cutting as he recommends 62 rpm for 1½ inch silver steel cutters, as I am using a full flow of neat cutting oil this should keep the cutting edge cool, in any event this should be used to wash away the chips as double cutting swarf is not likely to improve the finish. The cutter will be revolving so that the cutting action is downward to assist the chips to fall away from the work. The lathe spindle is revolving in its normal direction as it does when turning so the action is climb milling this does have the advantage that the chip is formed and falls away from inside and as such no burr's are formed on the outside of the finished job.

The cutter mounting is located on centre height and has adjustment for setting over at the helix angle and some adjustment to allow for variation in the cutter width which would affect the centre height setting if the cutters are not the same width. This eases the problem of having to make the cutters all the same width and centred. The drive to the lathe spindle is from a small geared DC motor through a further reduction gear and a toothed belt. The chuck rotates at about 1 to 1½ rpm, at this cutter speed about .002 inch is removed per tooth. This seems slow but once the machine is in



Boring the spindle mounting block.

motion it can be left to get on with it, a micro switch turns off the chuck drive motor at the end of the cut, as the cutter will cut to full depth in one pass it is possible that this may be quicker than normal screwcutting. However, a better finish may result by a roughing cut followed by a smaller finishing cut.

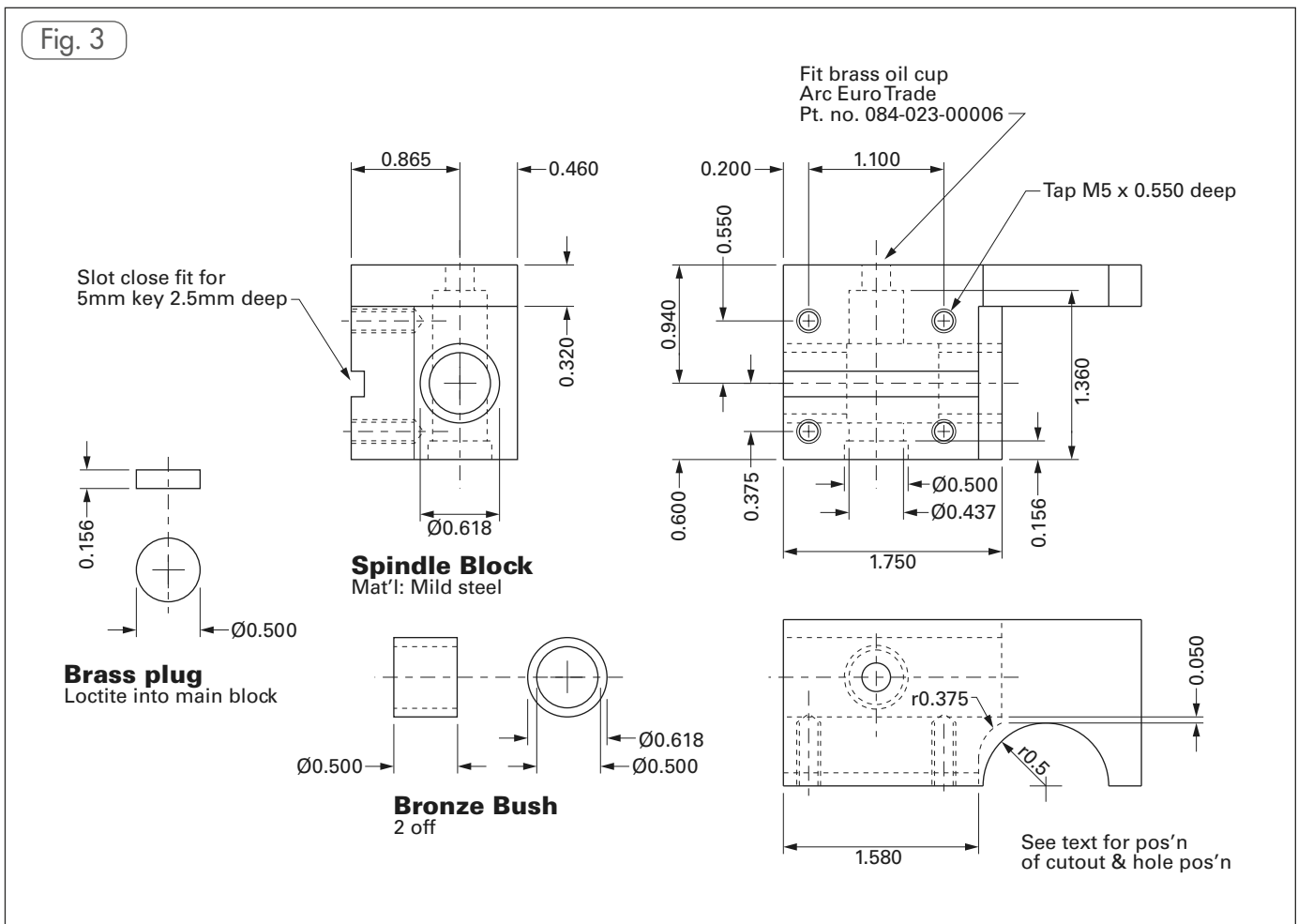
Photograph 7 shows a 100 tooth pulley being cut on the D1 5 four jaw chuck mounting for my machine. I have not included the drawings for this as this is very much dependent on the machine. Later on photograph 42 will show the complete drive unit fitted to the lathe. The photo shows the principle and from this

alone it should be possible to replicate something similar. This pulley is a shrink fit on the chuck mounting plate and will remain on the mounting as it is protected from damage and causes no hindrance to the operation of the lathe.

The spindle mounting block

The block is shown in **fig. 3**, some of the machining of the block must be done at a later time to align the worm and wheel in situ.

Photograph 8 shows the block being held in a Keats angle plate and the hole being bored for the bronze bushes. Two of





Milling the key slot.



Tapping the mounting holes spindle block.



Boring out the oil chamber.



Milling out the slots mounting plate.

these units are being made, in the foreground of the photo is one bored block. In **photo 9** the bushes have been fitted, the block is in the mill, the centreline of the shaft bore is picked up using a wobbler and a keyslot cut 5mm wide 2.5mm deep. The figures are all in imperial units but the descriptions for some of the operations are in metric, as the key steel is metric it would seem pointless to convert these measurements to imperial as are bolt sizes. At the same setting the four holes are drilled and tapped (**photo 10**). The block is bored through from the bottom to provide an oil chamber, counterbored to receive a brass plug (**photo 11**) fitted in place with Loctite. The top is threaded 6mm for a brass oil cup from Arc Euro trade part no 084-023-00006 (**ref. 1**). Excellent value at 2 for £1. 50.

Before the shaft is made using a piece of ½ inch silver steel rotated in the bushes with plenty of oil to run them in and remove the machining marks. When the shaft is made it will be a closer fit and remain so. Mill away the clearance for the worm as shown on the drawing.

Spindle block mounting plate

The mounting plate is made from ½ inch thick steel. **Photograph 12** shows the blank piece of plate held in the vice, one end is machined to provide a reference for resetting later on. Initially the slot is

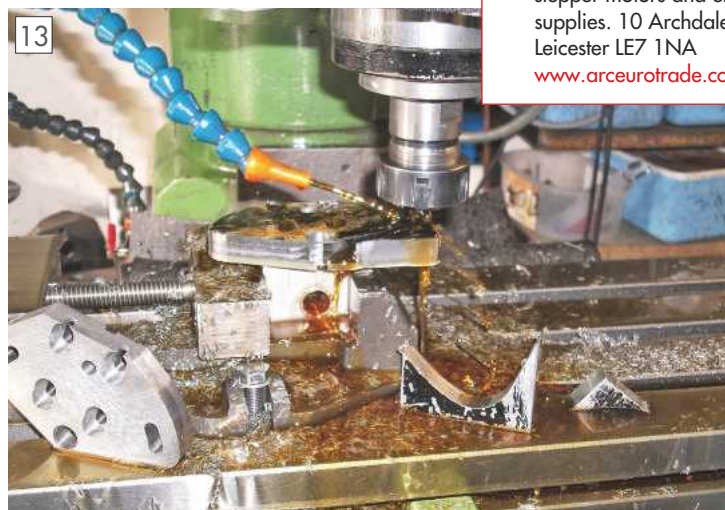
cut to fit the 5mm key steel the slot is 2.6mm deep and the ⅞ hole is bored on the same centreline as the slot. The four holes are drilled to match the holes in the block and milled to form slots as **fig. 4**. The plate is turned over and the slots counterbored and slotted to clear the cap bolt heads. In **photo 13** the plate is bolted to the block held in the vice the reference end is aligned with the Y axis and the outer profile and 2 radial slots machined. The outer profile is of no importance but is easier to do using a CNC machine. The

lower edge as drawn will clear a Myford cross-slide when the pin bore is at centre height at any reasonable angle. The pivot location pin and cutter alignment rod are shown on the same fig. and can be fitted later on the pivot pin is loctited into the hole in the mounting plate.

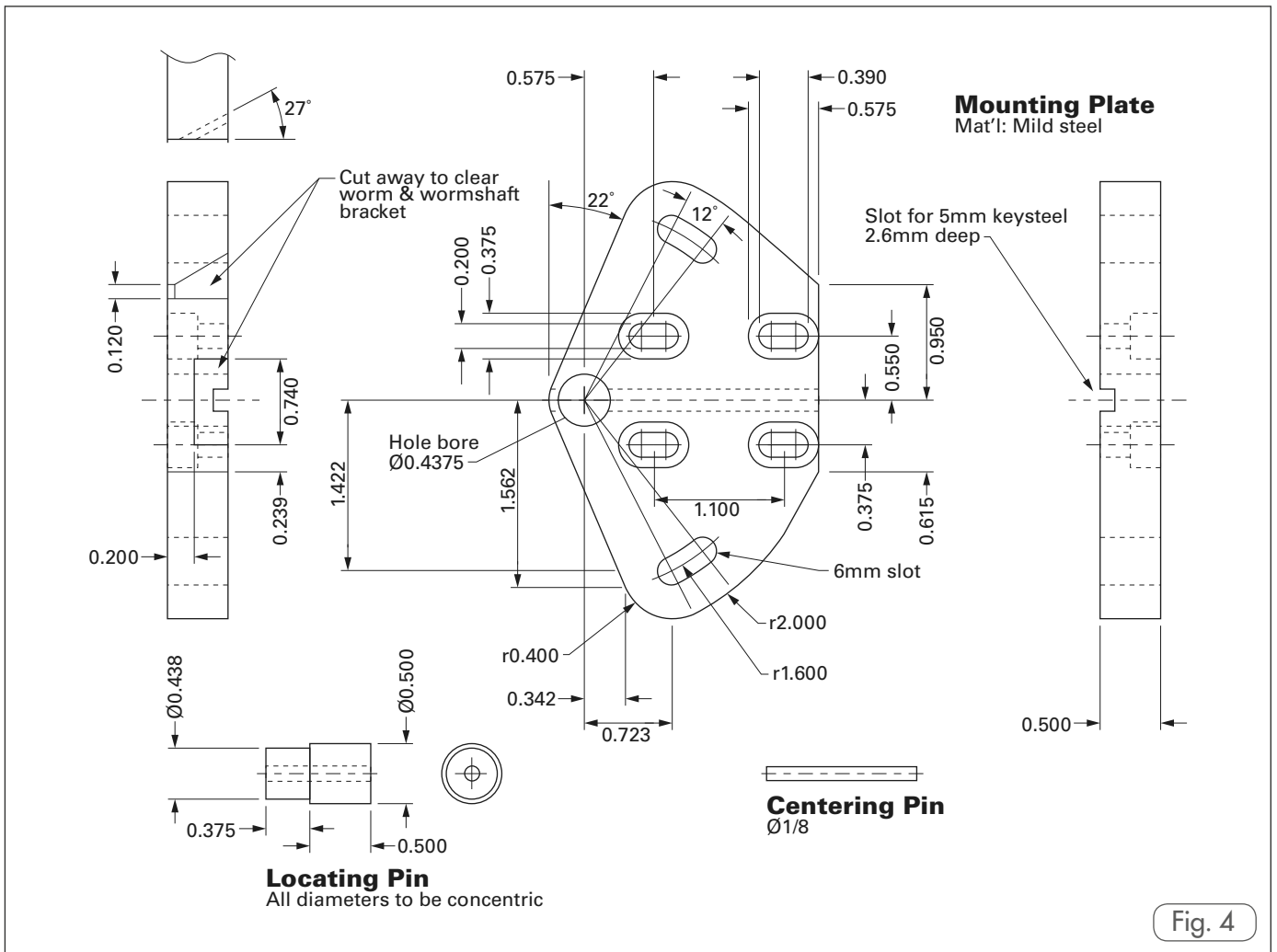
To be continued...

REFERENCE

1. Arc Euro Trade. Gear cutting hobs, stepper motors and engineering supplies. 10 Archdale Street Syston Leicester LE7 1NA
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Machining the mounting plate profile.



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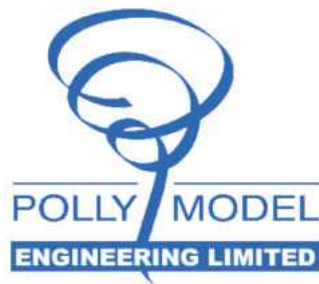
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Tales from the Bodger's Lodge

Bed Wipers



John Stevenson finds an unusual application for 3D printing.

As some of you may know, on the *Model Engineer* Forum (**ref 1**) I often post under a thread called 'Update from Bodger's Lodge' where I post about various things that quite literally get thrown through the door in the bodging jobbing shop I run. Parallel to this, I am also running a thread called 'Lathe Design not Keeping Up', where I'm updating a Colchester Bantam with various extras like DRO and the like.

This article was going to go on there as part of the upgrade, but I thought it would get more exposure if it was done as a stand-alone article because it addresses a problem in a unique way.



The front and rear wiper clamps and the remaining rear wiper.

The Bantam and the Chipmaster share the same saddle and their bed wipers are not strips of felt like on many other machines, but form-fitting wipers made of a type of soft plastic that extend out and actually wipe the bed in a manner similar to a car wiper blade (**photo 1**). Also shown are the simple plain rear wipers and the tin shields for front and rear. The small loose black piece is all that is left of the front wipers we are hoping to replicate.

There are two types, the one shown in photo 1 that fits to the rear and wipes on the flat bedway and the front ones, not shown, that wipe on the front vee. The reason the front ones are not shown, is that they have deteriorated with age and have broken up.

These are still available from the 600 group as a set of 4 with the tin retainers at about £125; yes, ouch!

So to try and keep it original and have the same wiper effect I looked at various methods to replicate these. One method I looked at was to 3D print them as you can get a rubber / soft plastic type filament. This is still a viable option as I have a 3D printer but I would need to draw the wiper in 3D-CAD and as yet, I feel I'm not skilled enough and it would also require me to buy an expensive full reel of an appropriate filament.

The next option is the one I have chosen and is based on a link that Neil put in the magazine a few issues ago, about a product called Sugru which is a mouldable rubber material. If you Google it and go on their web site, you find all sort of uses for it, but in my opinion there are few useful applications, except for arty ones. However, this product seems to be very close to what's needed here.

The only thing missing is a way of shaping it and holding that shape for the 24 hours needed to allow it to air cure.

The missing front vee wiper blocks are an ideal test for this, as they are complex enough to prove the concept. So what's needed is a female mould and I have made it two parts so that it can be stripped easily so as not to distort the partially cured wiper when removing it from the mould.

Starting off with an aluminium block, machine a 90-degree vee in on the milling machine to mimic the bed. Simple enough job in that the block is held in the vice at 45 degrees and the vee can then be cut with an ordinary end mill or slot drill to cut both sides and achieve the 90 degrees. Then remount on its end and cut a pocket in to roughly the same shape as the front of the wiper. In this case the tin shields are



The block with vee and pocket.

curved but I will trim the wiper when cured instead of spending too much time making a curved pocket.

Photograph 2 shows the block with the vee in and the pocket. The block is then rotated through 45 degrees and two slots machined into the sides of the vee to form the two extended lips.

Photograph 3 shows a small piece of alloy angle with a piece of flat screwed onto it to close the pocket up and when assembled as in **photo 4** this completes the mould.

The Sugru comes in a small sealed vacuum packed sachet and it all has to be used up in one application, it cannot be stored once it's been opened. Fortunately, there is just enough in one sachet to do one wiper. Both parts of the mould were sprayed with silicone release spray, assembled and the Sugru firmly pressed in, then levelled off and left for a day to set. This material is not fast setting and you therefore have plenty of time to work with it (**photo 5**).

After a day, the mould was undone and the wiper carefully removed and put to one side to allow further curing for the parts that didn't get into full contact with the air (**photos 6 and 7**).

After the second day you can then trim the outside shape to match the shield,

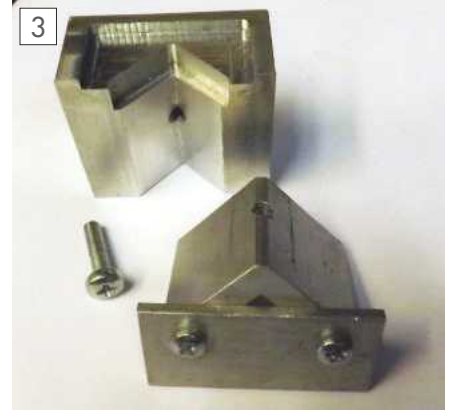
punch two holes in with a wad punch and the wiper can be finally fitted as in **photo 8**.

It took about 2 ½ hours to make the mould for the front wiper. I didn't make a rear mould as those wipers were OK and the rear one is a far simpler affair. The Sugru cost me about £4.00 per sachet from eBay so all in it's a cheap way to replicate an original wiper system.

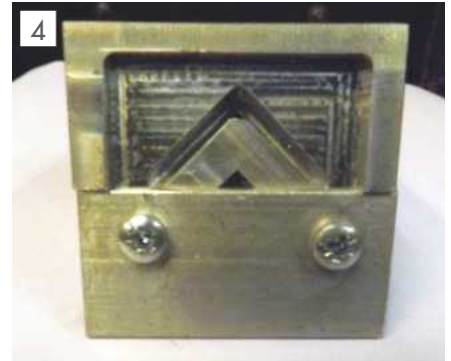
Sugru also comes in various colours so you may match it to your lathe. ■



The mould filled with Sugru.



Finished parts of the mould.



Assembled mould.

REFERENCE

1. <http://www.model-engineer.co.uk/forums/postings.asp?th=96032>



The mould opened.



The wiper was left for a day to allow the cure to complete.



Finished wiper fitted to the lathe.

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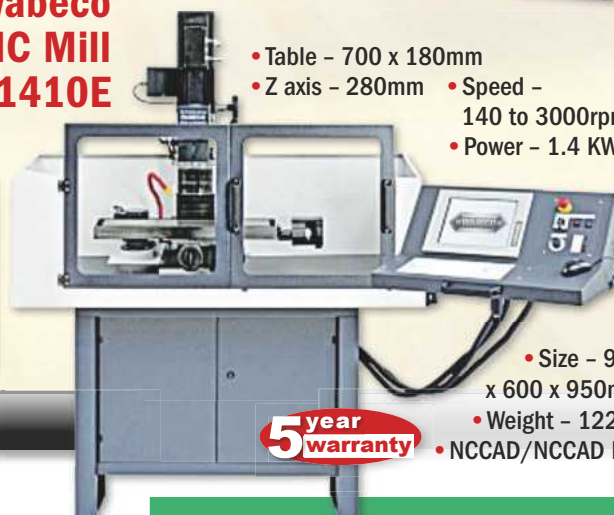
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Exhaust Cones



Marcus Bowman describes an interesting exercise in sheet metal work.

The expansion chamber for a car exhaust is a relatively simple device which has been around for a very long time. Even vintage cars have them (**photo 1**). The chambers are usually cylindrical, but the ends are often conical and taper down to match the relatively small diameter exhaust pipe. Commercial custom exhaust manufacturers often buy those conical sections, and they might typically hold stocks of the two or three most common sizes. That's fine if the customer is not fussy about the actual size, but making an exact replica is a different matter. On a custom car where the owner might want to show off the expansion chamber it is seldom because it is a specific size (unless it is very large or very fancy), but vintage cars are different, and many owners want something which is as close to the original size and specification as possible.

And so it was with my friend's 1924 Bullnose Morris. The plan was to have a custom exhaust company make a replacement expansion chamber in stainless steel, then disguise it by adding cones at each end.

The company is well used to making cylindrical bodies from standard tube or rolled from a flat sheet, and the sealing flanges can be formed in a press using standard dies. That leaves the two cones, which rather depend on a bit of knowledge of sheet metal. Having exhausted the obvious routes to manufacture, that part of the job landed at my door. Fortunately, rolling a cone is quite a straightforward task, using simple techniques. Rolling



The exhaust expansion chamber on a 1924 Bullnose Morris.

1.5mm stainless sheet was beyond my equipment, but developing the shape and rolling a test piece seemed interesting.

In this case, though, the challenge is posed by the small diameter and the short distance between the large and small ends, so some tests were required.

Developing the shape

The first challenge is to create the flat shape which can be rolled to make a cone of the correct size. That's termed the 'development' of the shape, and it can be

done in at least three ways, each of which requires a specification for the cone.

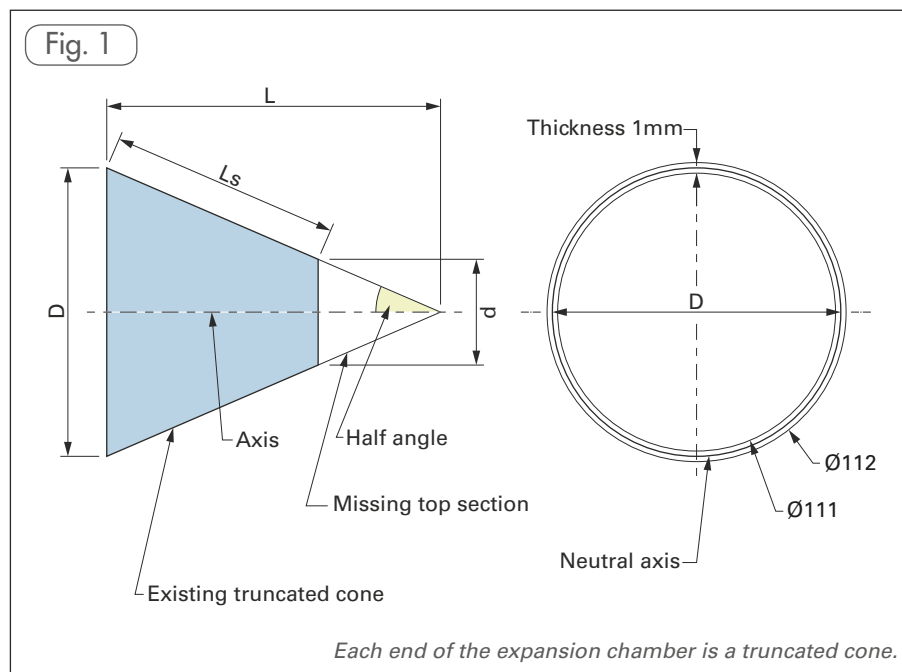
First; the sizes taken from the existing exhaust were as shown in **fig 1**:

$D = 111\text{mm}$, $d = 35\text{mm}$, and $L_s = 107\text{mm}$

The sheet forming the cones will have a thickness, and that creates a potential difficulty. When a sheet is bent, as the cones will be when they are being made, the sheet distorts across its cross-section, otherwise it would be impossible to create the bend. The metal on the inside of the curve will be compressed and the metal on the outside of the curve will be stretched. Somewhere towards the middle of the cross-section of the sheet there will be no change – no stretching or compression. That is termed the "neutral axis". For ease of calculation, we will represent the sheet as having no thickness, so that we can use simple geometry. Because of that, the sizes taken from the real exhaust were adjusted so that they were taken from the neutral axis. Assuming the thickness to be 1mm, fig 1 shows that the large diameter, which measured 112mm across the outside of the exhaust should be 1mm less when measured from the neutral axis. In the same way, d was 36, so it is stated as 35mm. The length L_s is unaffected by the curve, and is simply left as measured.

Initially, we need to calculate the half-angle of the cone (fig 1), and the length parallel to the central axis of the cone (which we will call L). Taken together with the existing sizes, those dimensions will complete the specification of the cone.

Because the cone is truncated (has the top cut off) we don't know L , but it can be calculated if we know the half-angle, so we will take that first.



On **fig 2**, the red line is parallel to the central axis, so the half-angle can be found from the triangle shown in blue. We already know the sloping side is 107, and the short vertical side is $(D-d)/2$ or $(111-35)/2 = 38$.

The half-angle A can be found by using trigonometry.

$\sin A = 38 / 107 = 0.35514$, so A is the angle whose $\sin$ is 0.35514. That is termed the arc $\sin$ (or $\sin^{-1}$). $A = \arcsin 0.35514 = 20.8^\circ$

L_t can be found from Pythagoras' Theorem or using trigonometry: $\tan 20.8 = 38/L_t$ or $L_t = 38/\tan 20.8 = 38/0.3799 = 100.0264\text{mm}$

Figure 3 shows the cone extended to the apex, and the brown triangle is the missing bit of the cone, with two dimensions known.

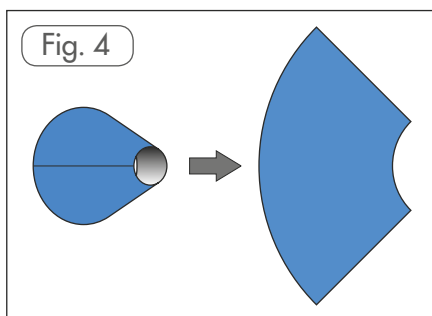
$17.5/L_m = \tan 20.8$, so $L_m = 17.5 / \tan 20.8 = 17.5/0.3799 = 46.065\text{mm}$

The total length of the cone $L = L_t + L_m = 100.0264 + 46.065 = 146.0914$ or 146.1mm

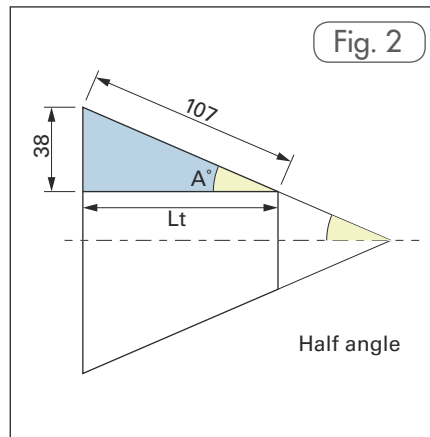
There are now three options for creating the development of the truncated cone: use software; calculate the dimensions of the development and draw the result; or use technical drawing techniques to draw the shape, with any sizes being measured from the drawing before transferring them to the metal sheet.

Using software

Sheet metal shapes can be drawn in a suitable CAD package, but sheet metal tends to be a specialist aspect of CAD available in the higher-end (i.e. most expensive) packages like SolidWorks, Inventor or RhinoCAD. In essence the method would be to draw the 3D shape by creating the two circles at the ends of the truncated cone, placing them L_t apart (which is why we needed to find L_t) and using the Loft tool to wrap a sheet around the circumference of the circles (**fig 4**). Draw a line and use the Rip tool to make a cut, then use the Create Flat Pattern tool to unwrap the cone and lay the developed surface of the cone flat. Produce a dimensioned drawing, using the automatic dimensioning tools. The whole job takes a relatively short time, so this is an easy way to solve the problem; it's just not as



Using the Loft tool in CAD allows a sheet metal cone to be drawn. The flat developed shape can then be created using the Rip tool and the Create Flat Pattern command.



The half-angle of the cone can be found by calculation.

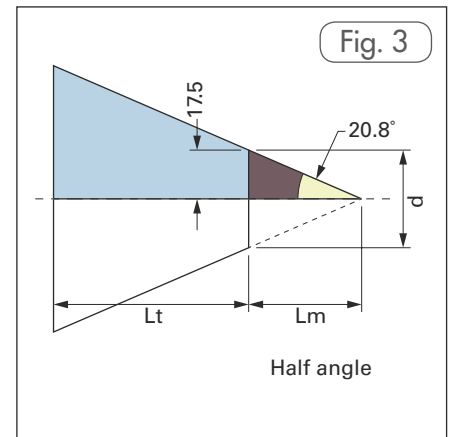
fast as working out the dimensions using a calculator. This method requires the final development to be drawn onto sheet steel.

Technical drawing

Drawing the development of a cone is a standard exercise in conventional technical drawing. Knowing the dimensions of the cone (L and the half-angle), the method is to choose radial lines on the surface of the cone, swing them around until the drawing shows their true length, then plot them in the appropriate position on the development. It's a straightforward mechanical process which is capable of producing an accurate drawing, but it does need a large piece of paper and a decent drawing board and instruments. This is certainly a viable method, but it requires a little time and some care; and it's not as easy as calculating the dimensions then drawing the development directly onto sheet steel.

Calculating the dimensions

This is the quickest way to deal with a shape like a cone, and it's the method I used for this job. Once key dimensions have been calculated, drawing the development is easy.



Knowing the half-angle, L_m and the total length of the cone can be calculated.

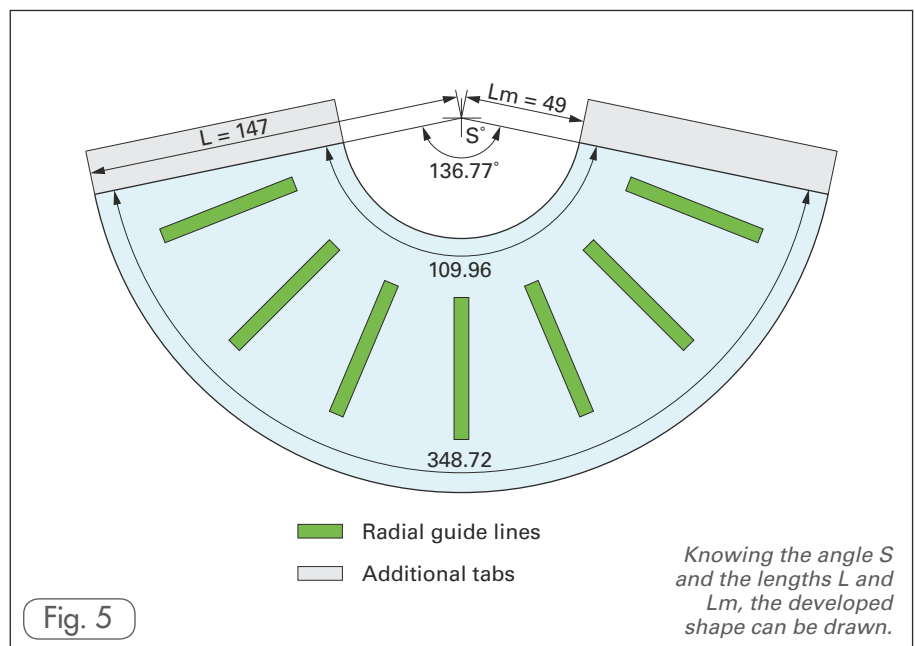
Unwrapping a full cone produces a sector of a circle, and a truncated cone has the top section missing (**fig 5**). If we can calculate the angle S at the top of the sector, we will be able to draw the development.

Taking, for no particular reason, the missing small end of the cone, L_m is a radius (r) = 46.065 measured from the tip of the cone, so the full circumference will be $2 \times \pi \times r = 2 \times 3.14 \times 46.065 = 289.435\text{mm}$.

But the small circle at the front of the cone has $d = 35$ and $r = 17.5$ so it has circumference $2 \times \pi \times 17.5 = 109.9\text{mm}$. That's a lot less than the circumference of a full circle 46.065mm from the tip of the cone, so we can use proportion to work out how much of a full revolution is needed for a length of 109.9mm. Referring to fig 5, the angle $S = 360 \times 109.96/289.435 = 136.77^\circ$.

As a check, the same calculation based on the larger circle should give the same result:

Circumference of the circle with radius 146.1mm measured from the tip of the cone = $2 \times \pi \times 146.1 = 917.97$.
Circumference of the circle at the large end of the cone = $2 \times \pi \times 55.5 = 348.72$.



Knowing the angle S and the lengths L and L_m , the developed shape can be drawn.



Aircraft-style snips leave serrations along a cut edge.



A series of radial cuts will help reduce distortion when removing the smaller area.



An overhead view of the rolls and the sheet positioned ready for rolling.



Partially rolled cone.

$S = 360 \times 348.72/917.97 = 136.76^\circ$ with any difference being simply a rounding error.

The development can now be drawn (fig. 5) using a scribe and callipers by first creating a centre point then scribing arcs with radii 46 and 146mm. It's unrealistic to expect we can work to closer than 0.5mm or 0.5 degree accuracy with handwork, so rounded lengths and angles will do just fine. Then scribe two radial lines (shown in red) 137 degrees apart. At this stage, take a marker pen and draw a few extra radial lines which will act as guides when the shape is being rolled (shown in green on fig 5).

Cut, roll, weld and dress

From this point on, wear sturdy gloves; bare hands are simply not an option. Take time after each cut to lightly deburr the cut edge. There is nothing quite as severe as a cut from the sharp edge of a sheet.

At a subsequent stage, the developed shape will be rolled to form a cone, but the rolls will do a better job if there is a small lead-in section at the beginning of the developed surface, and a lead-out section at the end, so add a narrow rectangular tab of perhaps 25mm at each end (fig 5), then cut the shape out. There are two curves, and the best method is determined largely by the tighter of the two. Electric shears will not be entirely happy cutting the smaller internal curve, but a nibbler is a viable option despite leaving the inevitable tiny scallops and razor-sharp edge. You will need a very steady hand,

though. Cutting manually requires snips which will swing easily around the curve. Gilbow-style shears may tend to slip as they cut the tighter curve, but slightly curved "aircraft" shears will use their serrated jaws to grip the sheet and follow the curve more closely. The downside is that they will leave small serrations near the edge, where they have gripped the sheet (**photo 2**). Given that the cone will be welded at each end, that is not a disadvantage on this job, so those were my tool of choice. **Photograph 3** shows a series of initial radial cuts made almost to the circumference of the inner circle, to reduce distortion when removing the smaller curved area.

The geared rolls I used were made many years ago to the G. H. Thomas design (**photo 4**) and they are useful for rolling diameters down to 25mm. The gap between two rollers positioned one above the other can be adjusted to pinch the sheet, gripping it and pulling it through as the handle is turned. The top roller can be removed so that a shape which has been rolled closed can be slipped sideways off the roll; hence the term 'slip rolls'. The rear roll is set parallel to the front pinch rolls and can be raised to force the sheet upwards, but cannot be tilted to any great degree. On some rolls, designed for producing conical work, the rear roller is either tapered or can be set at an angle. My rolls can't; but that doesn't prevent them from creating cones.

The method is to feed the flat shape through the rolls using enough pressure on the pinch rolls to grip the sheet. The rear

roll is raised to produce a shallow bend in the sheet. The layout of the rolls means there is a gap between the pinch line along the front rollers and the line of contact with the rear roller, so when the edge of the sheet has not quite reached the rear roller no bending will take place. That's why the tabs were added to the development. They reach the rear roller while the edge of the developed shape is in between the two pinch rollers, allowing bending to take place from that point and ensuring equal bending across the whole of the developed shape. Those tabs will be removed later, once they have served their purpose. If the sheet is rolled backwards and forwards it will curve gently upwards, but without any additional intervention it will try to roll itself into a rather oddly-shaped cylinder. Instead, the sheet needs to be moved sideways as it is rolled, so that the rolls always grip the sheet along a radial line from the non-existent tip of the cone to the base. The additional radial lines marked on the sheet earlier will come in handy now. It is important to guide the shape accurately, especially in the early stages of forming the curve, and the process involves a kind of skidding action because of the different lengths of the two curved edges. Photograph 4 is an overhead shot showing how I gripped the sheet to pull it anti-clockwise as the rolls take it towards the front of the picture. The rear roll is adjusted upwards in stages, to make the emerging curve increasingly tight.

Photograph 5 shows the cone part-way through the process. The material is 1mm steel and, to be honest, it was a struggle to

get to this stage because the force required to steer the sheet as the rolls pull it through is quite considerable. The theory is that rolling continues, increasing the height of the rear roller until the two additional sections have slipped past one another and the lines indicating the edges of the cone are aligned, then the top roller is removed and the cone is slipped off. Once free, the tabs can be removed carefully to leave the cone closing nicely at the joint line. However; the double thickness of the overlapping section cannot pass through the rollers, so although those additional sections help the bending in the early stages, they now hinder the process. The net effect is that continued rolling of the other parts of the cone curves and stretches those parts while the areas leading up to the overlapping sections are less stretched, and there is a real danger that the cone becomes rather lop-sided. I have rolled some large cones in heavier material than this, although not with these small rolls, but this is by far the most difficult of them all. Continued effort completed the task, and the cone was removed. This thickness and stiffness of material was clearly the very upper limit for these rolls and a cone with these dimensions. To check the method and the developed shape, two further cones were rolled. The first was of 0.7mm aluminium and was an effortless joy. The second was of 0.7mm steel and was almost as easy, and certainly much easier than in 1mm steel.

Once the cone had been rolled, the additional tabs were removed from each cone, using snips. The edges were dressed lightly by putting a bar through the cone then tapping gently with a boxwood mallet (**photo 6**). It is important not to strike the edges hard with a metal hammer, as that will tend to stretch the edges and spoil the fit. Two blows are used during dressing. The first is a direct mallet-metal-bar blow to stretch the sheet slightly and flatten the curve a touch. The second is a glancing blow off to one side of the line of contact, which tightens the curve. Draw a set of concentric circles on a sheet of paper, beginning with a circle of the intended diameter for the large end of the cone, and working out in 3mm steps, and use those as a guide to the shape of the base of the cone.



A wooden mallet and a steel bar or tube can be used to dress and adjust the curvature of the cone.

The material is 1mm steel and, to be honest, it was a struggle to get to this stage because the force required to steer the sheet as the rolls pull it through is quite considerable.

Weld the cone closed using your preferred method. TIG is a little more controllable than MIG on this kind of job, and both cause a little less distortion than gas welding. Electric arc is unlikely to give good results at the outer edges. I chose gas welding, simply because that was closest to hand, and gives good control of the weld pool. The cones were clamped closed against using a section of steel pipe placed inside each end of the cone (just visible in **photo 7**). The clamps had virtually point contact, but held the ends of the cone in place. It is very important that the seams fit well at this stage, and that the ends of the seams are level at top and bottom.

The welds were dressed inside, using a die grinder, and outside, using an angle grinder and files. It is too early to attempt to produce a final finish at this stage, because there is likely to be some distortion, and the openings may resemble a teardrop, so it's back to careful work with mallet and bars. On a job like this, protruding welds might look more like the original exhaust, but, with the bit between my teeth, I pressed on to a better finish. I planished the weld and adjacent area by supporting the weld on a tube and using a metal hammer to strike the weld with many rapid but light blows, using a wrist action and not the power of shoulder or biceps. The aim is



The ends of the seams can be clamped onto pieces of curved steel in preparation for welding.



Two truncated cones rolled from 0.7mm and 1mm sheet (on the left and right respectively) and a third (centre) truncated cone with a smaller half-angle.

not to distort the metal with heavy blows, but to tap it into final shape and to give a good finish to the surface, so the hammer should bounce lightly off the weld. An air planisher would be effective, here, if the inside of the cone was supported on a suitably narrow lower anvil, and the very large number of blows will also tend to relieve stresses in the area.

The finished cones were cleaned up using a Zirconium disc in a small angle grinder. **Photograph 8** shows the results on the right and left of the photo. The centre cone was rolled some time before, from 0.7mm steel, and is interesting for two reasons. First, it has smaller top and bottom diameters, but a smaller half-angle so it is slightly taller and thinner, and rolling it to shape was relatively easy. Second, it was rolled without using additional sections at lead-in and lead-out. Instead, the beginning and end sections were initially curved by laying the edges a little beyond the top roller and curving them with the mallet. Once rolling reached the stage at which the cone had closed, rolling continued in one direction by encouraging the cone through the rollers as though it had already been welded closed. That gave the cone a more uniform shape, which was encouraged by guiding the cone through while pressing the ends together.

Photograph 9 shows two commercially-made cones, the left hand cone having been cut from an old silencer, and the rusty right hand cone is an unused item. Note that both have a short straight section at the top, just where the exhaust pipe will



Two commercially-made cones, each showing the small parallel section at the small end which helps when welding the cone to an exhaust pipe.

meet the cone. This helps when welding cone to pipe, and it is a good idea to make this act as a sleeve which slips tightly over the exhaust pipe. That gives the joint strength as well as enabling easy welding. To make that section, use a thick pipe or bar of the appropriate diameter with the ends well rounded to form a punch, and a die made from a thick piece of wood, plywood or MDF with a hole which is an

easy fit for the exhaust pipe plus 2 x the thickness of the metal used for the cone. Heat the top edge of the cone, hold it in the hole, and tap the pipe through. A helper is useful for this operation.

Job done. Time to take the spare steel cone then polish it mightily and hang it from the workshop ceiling where it will sparkle in the light. You could always make one with a light fitting at the narrow end. ■

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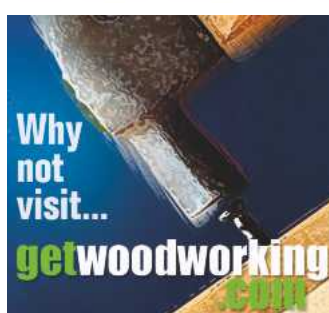
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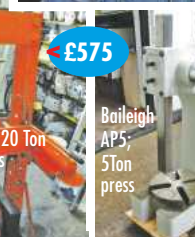
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