

No.282

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JULY 2019

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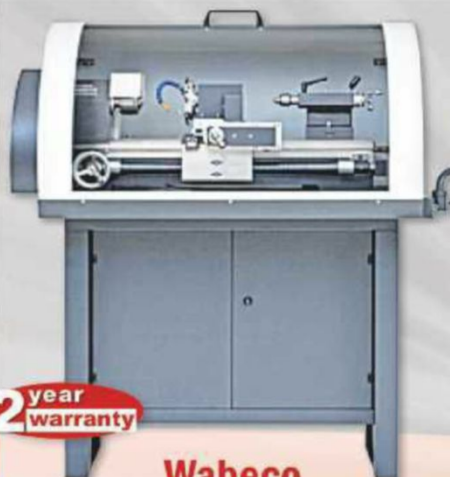
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On the Editor's Bench

Stevenson Trophy

Congratulations to all the entrants in the John Stevenson competition. The voting, by ME Forum Members, wasn't quite as even this year as last year, but all entries generated interest and had their 'champions'. The winner, with a lead of just one vote, was Mike Cox with his low-profile clamps.

A very close second was John Hinkley's indexer. The rest of the entries were pretty bunched together, but Rik Shaw pulled clear by a neck with his build of Harold Hall's grinding rest.

Once again, congratulations to all the entrants, thanks to everyone who voted and helped make this a success. Mike Cox wasn't able to get to Doncaster for a presentation, but I hope to meet up with him soon to award the trophy. On which topic...

Doncaster Exhibition

This issue includes a modest selection of pictures tooling on display at the National Model Engineering and Modelling Exhibition. I was at the exhibition on Friday and Sunday and it was good to meet many MEW readers, some familiar faces and some new ones but it was great to meet you all.

I've sneaked in a photo of another of P. Dunham's tools here, a tool height setting gauge. I ran out of space to give a photo and detailed description of one in this month's 'Lathework for Beginners' article, but I think this picture says it all, especially how a two-bar design can be used to set tools from above or below.

While on the topic of practical tools, I should announce that the John Stevenson Trophy was won by our regular contributor, Mike Cox.

I would also like to mention that this issue includes news that Warco are withdrawing from attending shows for the foreseeable future. Only Chester and Myford had lathes at Doncaster and these were modest displays. I know that in the past exhibitions were an important place for people to come and see machine tools 'in the flesh', so to speak, but I think the way we shop for such things has changed.

I hope this change does not have an adverse effect on people attending exhibitions; certainly, there are still plenty of trade stands selling new and secondhand tooling as well as a bewildering selection of models, castings and materials.

Perhaps in a way it's a good thing as it has had the effect of securing the place of the remarkable models on display as the centrepiece of the exhibitions. Some of the competition and loan models at Doncaster were, quite frankly, breath-taking. Similarly, diverse and quality displays can be expected at other exhibitions and I do urge any and all readers to make their way to at least one each year. Being able to see the work of your peers up close is always an inspiration and there's also the pleasure of meeting others with a shared interest in your hobby.





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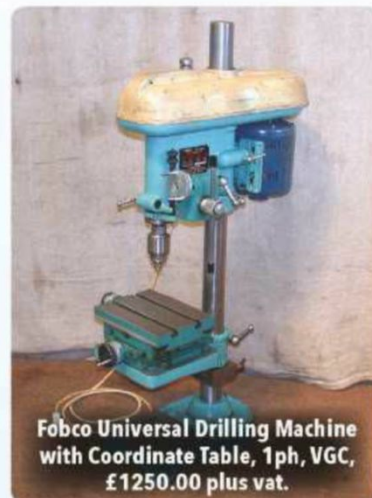
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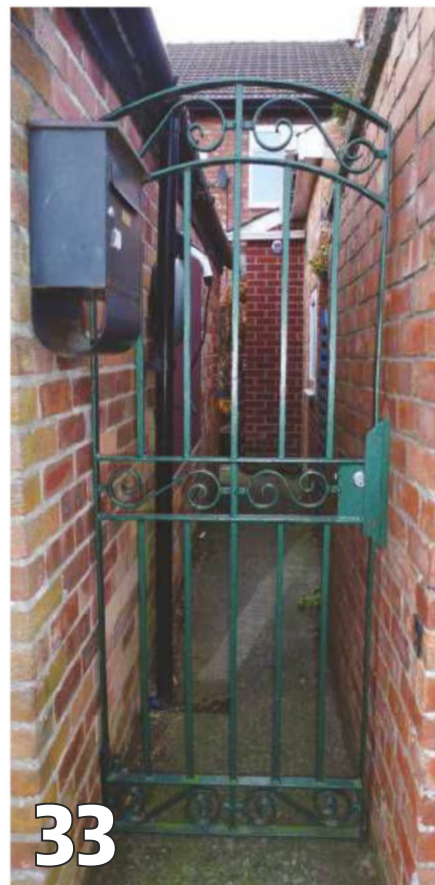
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Coming up...

in our next issue

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This month's cover shows Derek Brown demonstrating the grinding of four-facet drills at the recent Doncaster Show. See page 13 for more pictures from the show.



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www.model-engineer.co.uk/stevenson



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

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An Eleven-Inch Rotary Table

Richard Wightman makes a bumper accessory for his mill.



My 4" rotary table with 4-jaw independent chuck fitted

It's been a while since I wrote anything for this Magazine or Model engineer. Workshop time has been somewhat limited over the last few years but now that I am semi-retired with a little more time, I can put pen to paper, or should that be keyboard to screen? Anyway, I am back in the habit of taking photos and thought that this latest creation might be of some interest to my fellow readers.

Over the years the need to machine parts with a large radius has cropped up quite a few times. I have always managed one way or another, but it has always been a makeshift situation which is far from ideal. My 4" rotary table, **photo 1**, with an independent 4 jaw chuck fitted gets a lot of use but does have its obvious limitations. Now decent rotary tables ain't cheap so much so that a few years ago I set to and built myself a 7" rotary table, **photo 2**. This has been a very useful bit of kit especially for jobs like cutting a large hole in the smoke box plate, **photo 3**, for my current loco build, Conway a 3½" gauge 0-4-0 by Martin

Evans. I have found a sacrificial table of MDF is a cheap and easy way to mount parts to be machined. But still jobs come up that even the 7" table can't cope with. I need something bigger. For example, I

have to make the expansion links, **fig. 1**, for said loco but they have a radius of 4 9/16" (9 1/8" diameter) which clearly exceeds even my 7" rotary table. I could have cobbled something together to machine them



My home made 7" rotary table

but by the time I had finished bodging something together I was sure I could come up with a better idea. Not wishing to go down the route of building a large rotary table along the lines of the 7" one (which would probably take a couple of months with my current available workshop time) I put the old grey matter into inventing mode and came up with this idea. A hand operated 11" rotary table.

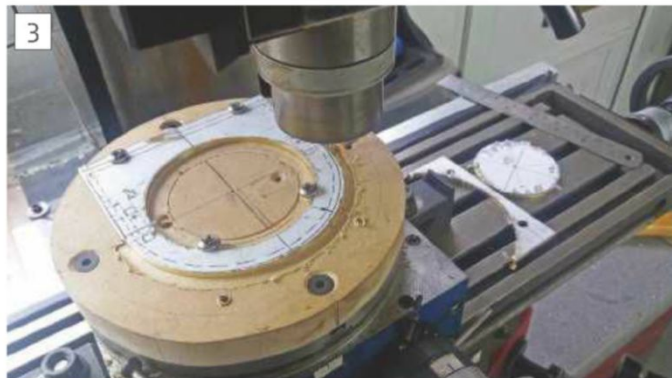
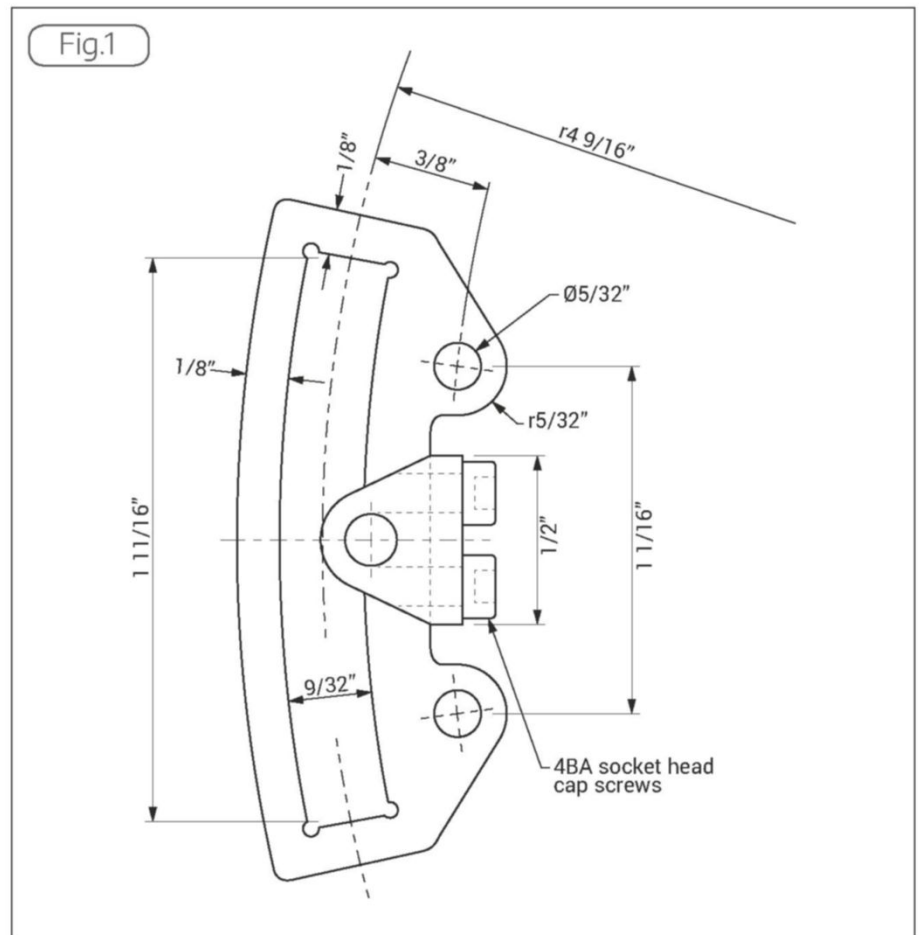
Basically, it is car brake disc, 11" in diameter. This one had been kicking about the bench at work for some time and was surplus to requirements so was duly brought home to my bench. A quick glance online shows they are available for under £20.00 including the postage, they are quite heavy, so take a trip down to your local parts supplier or local garage where they should be cheaper.

Anyway, lets get on with the construction. I started on mine at around 10 AM and had it up and running and machining parts by 3 PM.

I am not going to supply plans or measurements as more often than not I work with what I have in my 'that'll come in handy one day box'. Also, it doesn't bother me using and mixing imperial and metric material. The table was also designed to fit my X3 milling machine which uses M10 studs in 12mm slots. Smaller machines like the X1 and X2 use M6 studs in 8mm slots so build to whatever your machine will take. The basic parts consist of

1. A brake disc
2. A bit of 10mm thick steel plate
3. A piece of 6mm steel plate
4. Some 1/4" thick brass plate
5. An offcut of angle iron
6. A length of steel bar
7. A block of aluminium
8. A bit of 20mm thick MDF
9. Various nuts, bolts, screws and washers

Brake discs are exceptionally well machined, obviously they have to be, or all sorts of braking problems will occur. If there is the slightest run out problems



Cutting out the smoke box front plate



The chamfer in the centre of the brake disc



Turn and centre drill a scrap of aluminium



Centring in the mill



Removing the chamfer with a boring head



Rough cutting the 6mm steel disc



Turning the 6mm steel disc to size



Countersink the steel disc

such as judder, uneven braking and pedal bounce are a few of the problems that will be experienced. I doubt such accuracy could be achieved in the home workshop. Starting with the brake disc the central hole has quite a deep chamfer (not all brake discs are like this) which if

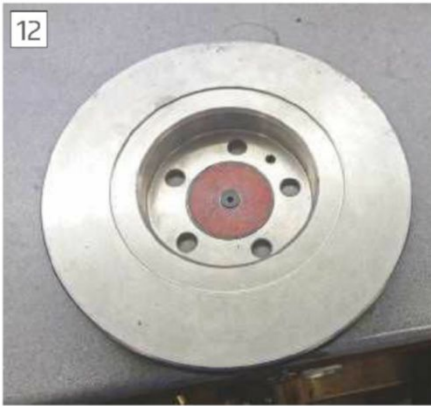
you get the same sort needs to be removed, **photo 4**. The disc is way too big to fit in my Myford lathe, so I turned up a scrap of aluminium to a tight fit in the disc and centre drilled it, **photo 5**. This enabled me to centre it in my milling machine under the quill, **photo 6**. Then machine away

the chamfer with a boring head, **photo 7**. It's not critical as to what size the hole is as the 6mm steel plate will be machined to suit. Apart from a few tapped holes that's all the machining the disc needs.

The 6mm steel plate has an 8mm hole drilled in the centre and then has the corners



Drill and tap and slot the base plate



A trial assembly



Cut the brass plate roughly to size



Finish the brass plate to size

knocked off in the band saw. For jobs like this I use a scrap of wood and a good size wood screw, **photo 8**. Mount the 6mm steel disc on a mandrel with an 8mm bolt and a large thick washer and turn to size. Aim to get a really good close fit in the disc,

photo 9. Countersink the central hole until an M8 countersunk socket head cap screw sits just below the surface, **photo 10**. The brake disc is 6mm thick at the hole, so I skimmed a few thou of the 6mm steel disc so that it sits just a gnat's (gnat's

is a well known engineering technical term for a few thou) below the surface. That's it for this part.

The 10mm thick steel base plate is next. Drill and tap 8mm in the centre. Machine two slots, one each end for mounting to the milling machine table, in my case I used a 1/2" cutter to cut the slots, **photo 11**.

Time for a trial assembly. Bolt the 6mm steel disc to the 10mm base plate with an M8 countersunk socket head screw and drop the brake disc on, **photo 12**. Bolt the base plate to the milling machine table and apply a liberal coating of oil. If all is well the disc should turn freely.

There's a bit of video here www.youtube.com/watch?v=zCeSvCy-9Pk of yours truly trying the fit.

To hold it all together I used a bit of 1/4" brass plate which is firstly cut roughly to shape on the band saw, **photo 13**. Then finished to size by filing and on the disc sander, **photo 14**. Aim to get a good fit inside the brake disc, **photo 15**. I just managed to get it in the lathe chuck to centre drill it, **photo 16**.

●To be continued



Brass disc inside the brake disc



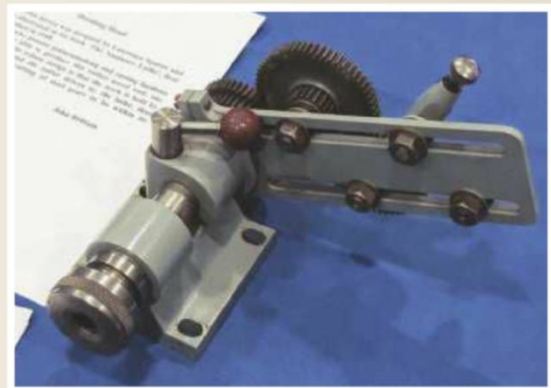
Centre drilling the brass plate

Tools at Doncaster

A look at tooling on display at the national Modelling and Engineering Exhibition in May 2019



◀ The show was well attended, as this view across the exhibition hall from the SMEE stand on Friday morning shows. Lawrence Sparey's research microscope, featured in Model Engineer many years ago, is beside Derek Brown who was demonstrating drill grinding.



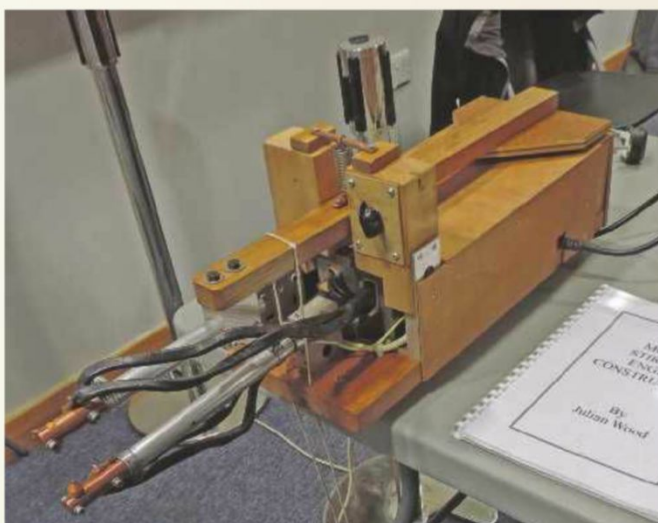
▲ Another Lawrence Sparey design, but this time built by John Brittan is this compact but versatile dividing head which uses a compound train of changewheels.



▲ Three very practical riveting tools by V. Crossman. The two on the right are made from scratch but that on the left is modified from a good quality pair of what I call 'water pump pliers'.



▲ The best in show award went to Mike Sayer's Bentley Blower engine, which I am sure will be featured in Model Engineer magazine. I hope MEW readers will be equally interested in the assortment of jigs and special tooling made to help with building the engine.



▲ This purposeful spot welder based around a microwave transformer was on the Stirling Engine Society stand. It bears a family resemblance to Dyson Watkin's design as featured in MEW 229.



▲ P. Dunham exhibited a number of well made workshop tools, this is his pillar tool with comprehensive accessories and a neat miniature pipe bender.

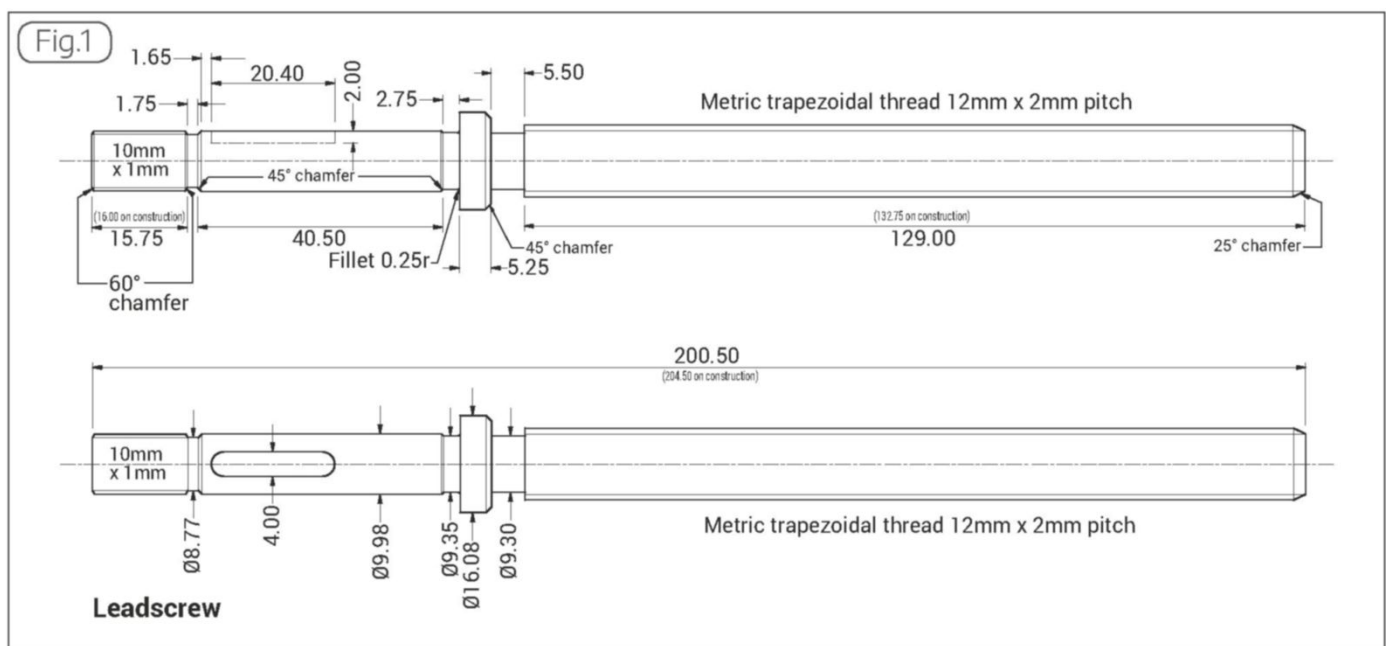
A Second Cross-Slide Leadscrew (Part 2).



Peter Shaw returns to the story of his cross-slide odyssey



Leadscrew.



This article is the second of a series of articles exploring the techniques used when making a copy of an existing item such as the cross-slide and associated components. There is no intention to provide a blow-by-blow account of these items, merely to use them to demonstrate the thinking and procedures involved in such a project. However, in this particular article, I shall be looking at the leadscrew which is such a complex item that detailed information will be given. The leadscrew is shown in **photo 1** and **fig. 1**.

Initial considerations

As shown on the drawing, there are a number of unusual values such as 16.08mm for the diameter of the flange and 9.98mm for the

diameter of the plain section. Some of these may be put down to poor measurement technique whilst others may be due to tolerancing by the original designer. It seems to me that, for example, the flange diameter of 16.08mm probably should have been 16.00mm, there being no obvious reason for the extra 0.08mm. The diameter of the plain section at 9.98mm may well be correct for the original device, but for the copy, as the matching hole will be made by reaming, and a 10mm reamer has a tolerance of -0 to +0.012mm then perhaps the diameter should be best described as a nominal 10mm.

Another consideration is that I decided to make the trapezoidal thread slightly longer, to gain a few millimetres of extra travel.

What this means is that when

constructing a new lead screw, making the flange diameter 16mm means that the complete leadscrew may be made from an as-bought 16mm diameter bar of BMS with a resultant saving in material being removed. However the 8.77mm diameter at the right-hand end of the 10 x 1mm thread and the 9.30mm at the left-hand end of the trapezoidal thread are used as thread runout grooves, and as such should be adhered to as closely as possible; the 9.98mm plain section I decided to make as near to 10.00mm as I could achieve; whilst the other dimensions are not that critical and hence it will not matter if they are not exact.

Constructional Notes

The leadscrew requires that two threads

2

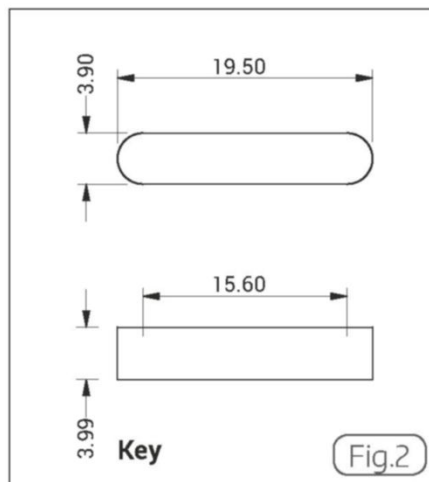


Trapezoidal cutting tool.

be cut: 12mm diameter x 2mm pitch metric trapezoidal, and 10mm diameter x 1mm pitch metric. The latter pitch, whilst not being a standard metric thread, is a standard spark plug thread for which taps and a die are available, and hence were purchased and used. For the trapezoidal thread I decided to make my own screwcutting tool from an old file, **photo 2**.

Many readers will own a screwcutting gauge: mine is by Moore & Wright, and although it covers a variety of thread forms and angles, it does not cover the metric trapezoidal thread. I therefore decided to make my own from a piece of 1mm thick steel by marking two converging 75 degree lines from one of the sides thus giving an included angle of 30 degrees. The area between the two lines was carefully filed away, and a short saw cut made at the junction of the two lines in which the point of the tool could sit, **photo 3**. Note that to aid setting of the tool in the lathe, each pair of opposite sides were made parallel to each other and perpendicular to the other pair. I could now carefully grind my tool until the top of the tool exactly fitted between the jaws of the cutout. For this particular size and pitch the end of the tool should be ground to 0.598mm, that is, the width of the root of the male thread. Measuring this is difficult with only basic tools, so what I did was to set the micrometer to 0.60mm, then compared the tool tip to the gap between the anvils. Possibly not the most accurate way of setting the tool tip, but the best I could do. I then did a trial cut on a piece of scrap bar of the correct diameter; and promptly broke the tool!

Following a regrind, I attempted another trial cut by feeding the tool in very gently,



starting at 0.2mm infeed, then 0.1mm, and finally 0.05mm as the cut deepened. Another author suggested that the sides of the cut should be shaved by the tool by moving it very slightly to one side of the cut, followed by moving across to the other side, all by using the top-slide. This resulted in yet another tool breakage, so that idea was abandoned in favour of straight in and out.

Ultimately, I successfully cut the full thread and kept deepening the cut until the existing leadscrew nut could be run the full length of the screw.

Order of work

Start with a length of 16mm diameter bar slightly longer than required to allow for the ends to be faced to the correct length. Place the bar inside a 4-jaw independent chuck with about 10mm showing, and using a dial test indicator (dti) set the bar for minimum runout, face the end and drill a centre.

Reverse the bar and repeat, but this time reduce the bar to the correct overall length whilst facing the end.

Now pull out the bar from the chuck until about 150mm is projecting from the chuck and using the dti set for minimum runout adjacent to the chuck jaws. Note that it may be advantageous to use the tailstock with a dead centre to provide some gentle support for the outlying end of the bar whilst adjusting the runout. On completion, lubricate the dead centre and apply the tailstock to securely hold the bar in place. The bar is now ready for turning and threading.

First reduce a length of 138.25mm (as measured from the end of the bar) to 12mm diameter using a knife tool. Change the knife tool for a narrow square ended tool (I use my parting off tool) and create the 5.50mm wide x 9.30mm diameter thread runout groove. Now replace the narrow tool with the trapezoidal threading tool, using the screwcutting gauge to ensure correct orientation of the tool, engage the appropriate changewheels, and start cutting the thread.

The minimum speed of my lathe is 125rpm which is far too fast for cutting short threads hence for short threads I normally use a mandrel handle, however, as using a mandrel handle on this length of thread is very tiring, therefore I used power drive. Unfortunately, this then introduced another problem in that the inertia of the lathe drive system means that the lathe takes an appreciable time to come to a halt once power is cut. Thus, it is necessary to cut power at a point where the tool will just run into the thread runout groove. Easier said than done! So much so that I found



Home-made screwcutting gauge.

it necessary to be prepared to smartly withdraw the cutting tool if it looked as if it was going to overrun the runout groove. Fortunately, most cutting runs stopped short whereupon I used the mandrel handle to finish the run.

Returning the tool to the beginning of the thread was under power and the same problem arose at the tailstock end.

There is another problem. The usual method is to cut the thread, clean it up as described below, and then try the nut. But the only nut I have is inside the saddle, and to get it out requires the removal of the cross-slide. But the cross-slide is in use cutting the thread. A truly chicken and egg situation. Actually, it is not as bad as it sounds because it is possible to remove and replace the cross-slide without losing that all-important registration between the mandrel, changewheels and longitudinal leadscrew, so the method becomes cut the thread until the cutting tool just starts to scratch the runout groove, clean up the thread, remove the cross-slide, extract the leadscrew nut, back off the tailstock and try the nut. If it doesn't fit, then put it all back together, take another very fine cut and repeat as above.

Unfortunately, there are two other problems. I find that often the tool does not cut to full depth as indicated by the cross-slide dial. This is due to spring, that is the work bending ever so slightly away from the tool or slack in the compound slide components, or both. Now for rapid stock removal this relatively unimportant, but when getting towards the finish, I find that

I need to take a number of cuts all at the same cross-slide setting. In fact, when I do this, I repeat the cuts until the tool stops removing material.

The second problem is that my experience of lathe screwcutting is that the action of cutting the thread always throws up burrs and these can be a confounded nuisance to say the least. Ideally, one should clean the thread with something like a chaser, but if, like me, you have not got one, then the alternative is to gently use a file against the thread to remove the burrs, followed by applying the thread cutting tool again just to clean the flanks of the thread as the file may have turned some of the burr over into the thread. Messy I know, but there is not much I can do about it.

Once the trapezoidal thread has been completed, the embryo leadscrew can be turned around and the other end completed. To protect the already threaded portion, I use a copper sleeve made from a piece of surplus/scrap copper pipe. As before, the leadscrew will need setting for minimum runout adjacent to the chuck jaws, and although it may be possible to do the work without tailstock support, I would strongly recommend it.

As before, the first step will be to reduce the 16mm down to say 10.5mm, then, using the narrow bladed tool, turn the two grooves paying particular attention to the face of the flange as this becomes part of the bearing for the leadscrew. The section for the 10mm x 1mm pitch thread should then be reduced to 9.87mm-9.88mm to allow for the inevitable extrusion effect

when screwcutting, whilst the plain section should be reduced to as near as possible 10.00mm paying particular attention to the finish as this forms part of the leadscrew bearing system.

The 10mm x 1.00mm section can be either cut full depth in one pass by a die, or as I prefer as it lessens the effort required, partially screwcut in the lathe before finishing off with the die.

The final operation will be to cut the keyslot slot using a 4mm slot drill. This can be done either with a milling machine or with a lathe vertical slide attachment. For items as small in diameter as this, I prefer to use the vertical slide because I have difficulty getting the milling machine head close enough to the work, requiring substantial packing to raise the work with the consequent risk of something slipping.

Mistakes

Eagle eyed readers will have noticed the strange marks on the circumference of the flange. What happened here was that at the end of one thread cutting run, having backed the tool out prior to returning it to the start of the thread, I inadvertently switched the lathe into normal forward mode. Now whilst the tool was well clear of the thread, it was not clear of the flange and it promptly cut a thread along the top of the flange before coming to a halt. I filled the resulting groove with epoxy putty, but I now think that soft solder may have been better. As it happens, the top of the flange plays no part in normal operations, nevertheless it does look ugly. ■

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Summary Specification



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- Piston Valves
- Walschaerts valve gear
- Silver soldered copper boiler
- Drain cocks
- Mechanical lubricator
- Superheater
- Reverser
- Stainless steel motion
- Boiler fed by axle pump, injector, hand pump
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One Man *and* His Lathe



Richard Wilson and his Denford 280 Synchro lathe



The Denford 280 Synchro lathe as bought.

Introduction

I was introduced to model engineering at school in the 1960s, like many others, and built my first model there, a Stuart Turner No. 9 horizontal steam engine. I've had a home workshop ever since, sometimes well equipped, sometimes not, depending on circumstances. My output hasn't been great, several stationary steam engines, a Juliet 0-4-0 loco, a Wallis and Stevens 'Simplicity' roller to the Plastow design, a Tasker tractor in 4" scale, a horizontal gas engine to an old Stuart design, but with castings from my own patterns, a Dore Westbury milling machine, and finally a hand operated planing machine of my own design, again using castings from my own patterns.

For some years my lathe was a 5" Raglan Little John dating from 1954, which gave excellent service, but about five years ago, I decided that I wanted to upgrade to something a little more modern, and slightly larger if possible. The Raglan had a variable speed system based on two opposing expanding pulleys, so that speed could be changed on the move. A little tricky to set up initially, but once set, gave very little trouble. I really liked this arrangement, and my preference was for the replacement to have a similar system. I wasn't a great fan of electronic variable speed control, using a DC motor, following unhappy experiences with a Chinese mini lathe, when I managed to burn out 3 motors

due to extended use of low speed causing the motor to overheat. I looked at several new offerings from regular advertisers in this magazine and ruled them out either because of the electronic speed control, or the amount of fiddly belt changing involved. Having studied the excellent www.lathes.co.uk website, I considered the fabled Myford 280, which ruled itself out, partially because none ever seem to come up for sale, and also because, judging by the prices asked for the smaller Myford 254, I couldn't have afforded one anyway. A more modern Raglan 5" would have fitted the bill, but I couldn't find a decent one at the time, and the same went for a Boxford 280.

Description

I was scanning through the advertisement of a well-known dealer when I came across a Denford 280 lathe, **photo 1**. For those not familiar with the make (and I admit I wasn't at the time) there is an excellent description and company history in www.lathes.co.uk. Basically, Horace Denford started making Boxford lathes after the war, aiming at the school and training market, and then, in the early 1950s, sold out to the Harrison group. Having done this, he then started making similar Denford lathes of 4½" and 5" centre height, using the 'Viceroy' brand name, also aimed at the school and training market. There seemed to be sufficient demand for both companies to prosper, although one can imagine that Harrisons were not amused! The ultimate development, in the late 1970s, for Denford in conventional centre lathes, before turning to CNC machines which they still make, was the Viceroy 280 Synchro, so called because the swing was 280 mm, 11" approximately. This had speed control by variable pulleys, just like Raglan, using a lever on the headstock, (some had a more complex system using an electric motor to operate the variable speed pulleys) and came with all its

Horace Denford started making Boxford lathes after the war, aiming at the school and training market...



Accessories with the lathe as bought.

original standard equipment, 5" Burnerd 3 jaw chuck, 6" Burnerd 4 jaw chuck, 8" faceplate, catch plate, travelling steady and fixed steady, **photo 2**. I knew from previous experience with the Raglan, that a lot of time and money can be spent tracking down and buying these items, especially the steadies. It had been fitted with a non-standard tee slotted cross slide, which was a plus point for me, as I do like to be able to bolt work onto the cross slide for boring operations. The original cross slide was also included. It was a metric machine, but with dual imperial/metric dials, and a gearbox capable of 72 metric pitches, covering all standard metric pitches from 0.20 to 7.00 and a lot of others, plus feeds of 0.03mm to 2.14mm per rev. It was a 3-phase machine, and at the time was fitted with

an elderly Jaguar Cub inverter, without any form of speed control, to enable use on a 240-volt single phase supply, which is all I have, **Photo 3**.

It is quite a substantial machine, weighing 330kg (720lbs), 11" swing over the bed, and 24" between centres. The tailstock barrel is bored for 3MT tooling, the headstock spindle will pass just over 1" (1 1/16" to be exact) and has a 4M T internal taper with a camlock D1-3 nose. The 3-phase motor is rated at 1.2kw and has proved more than adequate. The bed has 2 vees and 2 flats and is straight with no gap.

Condition as Bought

This machine seemed to fit the bill for me, so, having asked a lot of questions, and got satisfactory answers, I made an offer, to include VAT and delivery, which rather to my surprise, was accepted. Several days later, a large van pulled up outside my house, and disgorged a pallet carrying a very well wrapped lathe and cabinet stand (For stability, the lathe had been taken off the stand). The kind delivery driver wheeled it down the drive to the garage at the rear of the house and parked it near the door. It was destined to stay there for about a week, until the Raglan had been sold and removed from the garage. This period was spent unwrapping, and cleaning down with degreaser, it wasn't bad really, I just wanted to get it as clean as possible, and cleaning the usual indescribable sludge out of the suds tank. I also created a frame on casters to carry the cabinet stand, something I do for all my machines. This means that the lathe stands about 5" higher than normal, but I am tall, and dislike stooping over a machine. The paint was reasonable, although not pristine, but the only thing I repainted was the sheet metal splashback, which was worn down to bare metal. The lathe is an odd pale blue, so I took a small



The original Jacobs Cub inverter. I tidied up that wiring as one of the first jobs!

component down to the local paint store and got them to mix some matching satin finish paint, which has worked very well. There is a small shelf at the back of the splashback, so I took this opportunity to punch some holes in it using a small punch tool normally used for making holes in electrical enclosures, so that it could be used for storing 3MT drill chucks, revolving centre and my home-made tailstock die holder. 6 more smaller holes served for holding chuck keys. I also tidied up the wiring to and from the inverter, enclosing it rectangular plastic trunking with clip on lids. I then used my engine hoist to reunite the lathe and the cabinet stand, before gently easing the whole thing into the garage through the side door, **photo 4**.

The headstock, gearbox and apron are all oil filled, so I took this opportunity to drain them and refill with ISO32 hydraulic oil. The headstock has both plastic and steel gears in the back-gear train which ensures quiet running, but the plastic ones are susceptible to damage if previous users have made a habit of changing gear before the spindle has come to rest. Fortunately, the teeth on mine are virtually unmarked. The D1-3 camlock spindle nose means that the back gears are not subject to shock loadings when trying to get a tight-fitting chuck to unscrew.

The time had come to actually try the thing, so I plugged it in and switched it on. The controls consisted of an on/off switch, forward and reverse switch, and suds pump switch. Everything seemed to work, and I gently ran it up and down the speed range (more about the speed range later) and tried out the apron controls for sliding, surfacing and screw cutting. All good so far.

I then put a piece of 1" steel bar in the chuck and tried a cut. A little disappointing, as there was a tendency to chatter. I consulted the handbook, which



The Denford 280 Synchro lathe as installed in my workshop.



Screw cutting gearbox and its controls.

I had got from Tony Griffiths, and read the section on adjusting the taper roller bearing. Off with the headstock cover, slacken the large castellated locknut, tighten the inner castellated nut (both threaded left hand) and retighten the locknut. The handbook merely says that the bearing adjustment is correct when the bearing is hand hot after an hour of running. I seemed to have achieved this and have had no more trouble from chatter since.

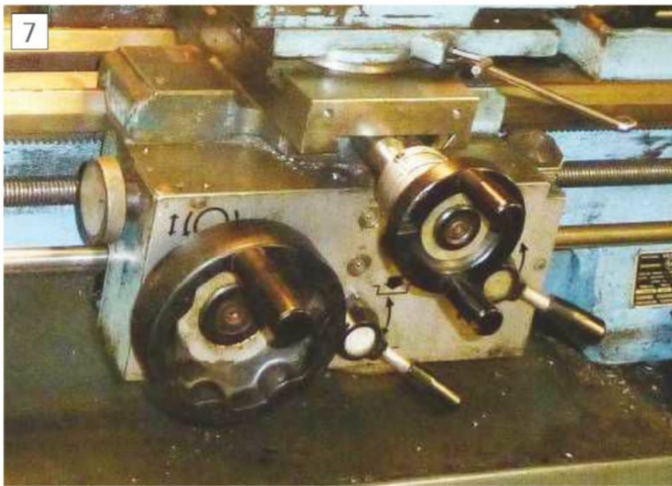
Screw cutting Gearbox

The screw cutting gearbox, **photo 5**, is quite complex compared to Norton type boxes, and to use it needs the operation

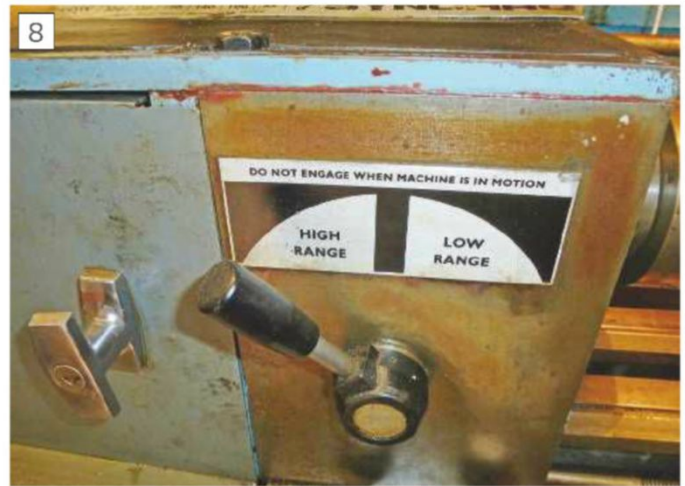
of three levers and one knob, in strict sequence, some with the lathe switched off and some with it running. I studied the handbook very carefully before I used it for the first time, but I've got the hang of it now. Simply going in there and playing with the levers/knob is a sure recipe for problems. It does 72 metric pitches, covering all standard metric pitches from 0.20 to 7.00 and a lot of others, plus longitudinal feeds of 0.03mm to 2.14mm per rev or cross feeds of 0.012 to 0.84mm per rev. Direction of travel is controlled by a tumbler gear cluster accessible by opening the sheet metal door over the screw cutting train at the end of the headstock. Once upon a time there was a micro switch on



Spare screw cutting gears stored inside gear cover.



The apron and its controls. The large knob on the left selects transverse or longitudinal feeds, the lever on the right engages the half nuts and the lever in the middle engages the selected feed.



The single lever control for the back gear

the cover which would have prevented the lathe being started when the cover was open, but this had been disabled by a previous owner. To get the full range of pitches/ speeds a set of 7 stud gears is supplied, from 16T to 35T, stamped 'A' to 'G', and in addition to manipulating the levers on the box, it is necessary to check that the correct stud gear is in place. My spare gears are stored on a spindle inside the gear cover door, retained by a large wing nut, **photo 6**. It sounds quite complicated but is in reality pretty quick to operate once you have the hang of it.

Apron and Saddle

The apron (**Photo 7**) is a delight to use. On the right-hand side is the lever controlling half nut engagement, and in the middle another lever, up to engage, down to disengage fine feeds. It is very light to use and doesn't lock up under load as so many do. These two levers are interlocked, so they can't be both engaged at the same time. On the left-hand face of the apron is a large knurled knob, twist one way to select longitudinal feed, twist the other way to select transverse (facing) feed. There is a moveable collar on the feed shaft below the leadscrew, which when it is contacted by the face of the apron, disengages a dog clutch, and stops longitudinal feed. Its only a safety device, because it takes about 1/4" of saddle movement to fully disengage it and should not be relied upon for working up to a shoulder. I believe some machines had a similar fitting to automatically disengage the half nuts when screw cutting, but mine doesn't have this. Presumably, when these machines were used in training workshops, the instructor would have set these stops before letting the trainees loose on them. The saddle lock is a square headed bolt which hides under the topslide. I found that one end of an old double ended brake adjustment spanner fitted the square perfectly, and stays permanently in place, so no groping under the topslide with a spanner when I want to lock or unlock the

...I must admit that I've never used the suds pump, because I think it would splash too much around in a small workshop.

saddle. One surprising omission, given the size and date of the machine, is that there are no felt wipers on the saddle nor is there any sign that there ever were any. Rectifying this is something I've been meaning to do (I've even got the felt to

do it with) but haven't got around to yet. There is a suds delivery pipe attached to the saddle, but I must admit that I've never used the suds pump, because I think it would splash too much around in a small workshop. I just use a household plant sprayer, filled with soluble oil at a dilution of 5:1, rather than the recommended 15:1, which I find leaves a nice oily deposit on the machine, and doesn't seem to cause corrosion or staining.

Speeds

A single lever on the front of the headstock engages or disengages the back gear, **photo 8**. A lever on the top of the headstock adjusts the variable speed pullies and can lock at one of six available locations, **photo 9**.

The original Denford sales brochure gave the speed range as 70-260 in back gear and 400-1600 in direct drive. This



Headstock speed control. The lever controls the variable speed pullies and can only be moved when the lathe is running.



Electrical controls. From the left, suds pump switch, main on/off switch, inverter controls.

didn't quite agree with the plate on top of the headstock which shows 65-320in back gear and 380-1600 in direct drive, with six speeds in each range. Purely out of curiosity, I checked with my hand-held rev counter, and got a surprise! 70-225 in back gear and 360-1150 in direct drive!

I replaced the variable speed belt, adjusted the variable speed mechanism (which looked original and was in good condition), but could do no better. Eventually, after carrying out a calculation based on a back gear ratio of 5.09-1, that with a low speed in back gear of 70 rpm, the low speed in direct drive must be 356, corresponding pretty closely with my own findings but not agreeing with either of the Denford figures, I came to the conclusion that, for whatever reasons, the Denford figures were fictional! It really hasn't caused me any problems, apart from 70 rpm being a bit high on a couple of large-diameter cast iron jobs, otherwise these speeds were just fine for me. In any event, after a couple of years the original inverter quietly died, and I've replaced it with a modern ABB inverter with variable speed, allowing me to comfortably get down to 35rpm, and up to 1600 if necessary, plus a jog facility which is great when threading with the tailstock die holder. I leave the inverter set to give standard speeds, and still use the headstock lever for speed changes, only adjusting the inverter when I need a speed outside the standard range. The control panel now has an on off switch for the suds pump, a main on-off control with emergency stop, and the inverter controls, **photo 10**.

Modifications and additions

I found the original 6" 4 jaw and 8"

It does help that I also invested in a replaceable tip parting tool when I was at an exhibition. Parting off holds no terrors anymore!

faceplate a bit small for some work, so acquired a used slim body 8" 4 jaw and a used 10" faceplate, both from the internet, and these are both comfortably in the lathe's capacity.

As delivered, the lathe had a very basic 2-way tool post. I considered a 4-way tool post but was persuaded to try a QC tool post. I was a little reluctant initially, because I'd had very poor results with a QC on the Chinese mini lathe, mostly due to the low level of rigidity in the top slide/cross slide set up. Having looked around I settled on a tool post and four toolholders from RDG. I had to make a suitable centre bolt, which was easy enough, and got the new tool post fitted, **photo 11**. I've been very pleased with it, on a machine the size of this size it is very rigid, and I have no problems parting off 50mm steel at 350rpm with a parting tool in one of



Quick Change tool post.



Cutting the 127T gear for the Imperial screw cutting attachment.

the toolholders. It does help that I also invested in a replaceable tip parting tool when I was at an exhibition. Parting off holds no terrors anymore! A rear tool post did come with the lathe and would easily fit on the back of the long slotted cross slide, but I've never found the need to use it. After my first purchase, I got some more toolholders, bringing the total up to 10, and this is plenty for my day to day needs. One is spare and used when I need to use one of the more unusual lathe tools.

Support

Although Denford have not made conventional centre lathes for many years, and hold no spares, they run an excellent support forum on the internet, mainly for their CNC machines, but there is also a section devoted to their old 'Viceroy' badged conventional machine tools. When the factory was about to dispose of their paper drawings some years ago, one of the forum members managed to rescue most of them and has scanned the majority of them which are available to view on the forum. This means that the original factory drawings for a component, showing dimensions, tolerances, material specs etc, are often available, and I've used this facility several times when making replacement parts.

Cutting Imperial Threads

As I said earlier, the gearbox is metric, and although I could manage a lot of imperial threads, by selecting the nearest of the 72 metric ranges, roughing the thread, then finishing with a die, I really wanted to be able to cut 'proper' imperial threads. Denford used to supply a translation set, including a new quadrant and gears, to enable a metric lathe to cut imperial threads. I went through the drawings on the forum, and lo! There were the

...the original factory drawings for a component, showing dimensions, tolerances, material specs etc, are often available...

drawings for the quadrant, the gears and all the fittings. I set to making a pattern for the quadrant, and while that was away at the foundry, I started gear cutting. My Centec mill and Vertex dividing head handled the 18DP gears comfortably, although for the 127T gear, I bought a division plate with 127holes in it from the late John Stevenson. I had to do some work on the dividing head to make the division plate fit as it was larger diameter than the standard Vertex plates, and I had to fit a spacer under the dividing head to raise it for the larger diameter of the 127 and 135 T gears, **photo 12**. My Centec had the facility to use a rapid rack feed on the X axis, and I used this when cutting the gears. A few seconds saved per tooth adds up when you have about 600 teeth to cut!

The translation set as supplied by Denford would enable a metric lathe to cut 21 imperial threads from 4 to 28TPI, but I made an additional 3 gears extending the range to 28 imperial threads from 4 to 56TPI, which covers the majority of standard UK and American threads, the main exception being 19TPI. It takes around 10 minutes to fit the attachment, **photo 13**, less with practice. The chart I drew up for gearbox



The completed imperial screw cutting attachment with all the gears. The red item is the foundry pattern for the quadrant.

Fig.1

DENFORD SYNCHRO 280 IMPERIAL THREAD CHART FOR METRIC LATHE

IMPERIAL THREADS AND FEEDS								L/H Lever
Dial Reading	1	1	2	2	3	4	5	LEFT
TPI	4	4.5	5	5.5	6	6.5	7	
Slide Ins./Rev.	.0764"	.0680"	.0611"	.0555"	.0509"	.0470"	.0437"	
Surface Ins./Rev.	.0300"	.0267"	.0240"	.0218"	.0200"	.0184"	.0171"	
Stud Gear	54	48	54	49	54	52	54	
TPI	8	9	10	11	12	13	14	CENTRE
Slide Ins./Rev.	.0382"	.0340"	.0306"	.0279"	.0254"	.0235"	.0218"	
Surface Ins./Rev.	.0150"	.0134"	.0120"	.0109"	.0100"	.0092"	.0086"	
Stud Gear	54	48	54	49	54	52	54	
TPI	16	18	20	22	24	26	28	RIGHT
Slide Ins./Rev.	.0191"	.0170"	.0153"	.0139"	.0127"	.0118"	.0109"	
Surface Ins./Rev.	.0075"	.0067"	.0060"	.0055"	.0050"	.0046"	.0043"	
Stud Gear	54	48	54	49	54	52	54	
TPI	32	36	40		48	52	56	RIGHT
Slide Ins./Rev.	.0096"	.0085"	.0076"		.0064"	.0059"	.0054"	
Surface Ins./Rev.	.0038"	.0034"	.0030"		.0025"	.0023"	.0021"	
Stud Gear	27	24	27		27	26	27	
Dial Reading	1	1	2	2	3	4	5	

Screw cutting chart for imperial threads. settings is **fig. 1**.

Thread Dial Indicator

One difference between an imperial leadscrew and a metric leadscrew is that the thread dial indicator (TDI) on an imperial machine covers all threads, but on a metric machine several different gears are needed for the bottom of the TDI. In the case of the Denford 280, two gears are needed to cover the full range of metric threads, a 28T and a 30T. I only had the 30T, which was on the TDI fitted to the machine. A search of the Denford forum came up with a drawing for the gears, so, having bought a spare TDI on the internet, quite cheaply, I cut a 28T gear, for it, **photo 14**, inclining the Vertex head to get the correct skew to match the leadscrew pitch. In truth, I usually keep the half nuts closed, and simply withdraw the tool at the end of a pass, and reverse back, something that's quite safe to do with a D1-3 spindle

nose. To date, all my screw cutting has been into a relief groove, so speedy withdrawal of the tool hasn't been an issue. In any event, cutting imperial threads on a metric lathe, leaving the half nuts closed is the only way. Still, it's nice to have both TDIs, just in case.

Taper Turning Attachment

My lathe didn't have a taper turning attachment, but Denford had offered one, of slightly unusual design, in that it relied on a stylus screwed into the back of the standard cross slide, bearing on the edge of a flat steel plate, which could be skewed to the desired taper angle. The cross slide and stylus was pressed against the plate by two strong springs fixed at one end to the saddle, and at the other to the cross slide, one each side. The plate could be removed, and a pair of centres substituted, which if a master workpiece



Alternative Thread Dial Indicator fitted with 28T gear cut by myself.

was fitted to them, enabled the attachment to act as a copying device.

This attachment appealed to me, and again, a search of the forum came up with most of the drawings. I failed to find the drawings for the springs and spring housings, but use of a materials list, and a sectional view on the GA of the device enabled me to get pretty close, **photo 15**. Again, pattern making was required for the main brackets, but all the rest was from readily available steel bar stock, bought mainly from College Engineering Supply, because they had the required imperial sizes, and would cut what I wanted to length. It's just about finished now, **photo 16**, all I have to do is to roll the lathe away from the wall (it is on casters, remember?), take the splashback off and line the attachment up at the right level, before drilling and tapping for the four 8mm fixing screws. There are machined pads on the back of the bed for this attachment (painted over), but no

Denford lathes don't seem as well known these days, and certainly don't command the same prices in the second-hand market as a comparable Boxford, which means that bargains can be had!



Spring housings and stylus for taper turning and copying attachment.

screw holes. The factory fitters must have done these on an as and when required basis when erecting a lathe ordered with the attachment.

Summary

I'm very pleased with my Denford 280 Synchro, and to date it has done everything I've asked of it. Whilst it can't be compared with a Colchester or Harrison, it is robust, accurate and capable of removing a lot of metal in a short space of time. My next engine project is a half size Robinson Hot Air Engine from an unmolested set of Alyn Foundry castings, which, from the paperwork with them were made in the early 1990s. Most of the castings are cast iron, my favourite material, and I don't see

that the Denford will have any difficulty machining them.

Despite their popularity in the educational and training market in the 1950s and 60s, alongside Boxford, Denford lathes don't seem as well known these days, and certainly don't command the same prices in the second-hand market as a comparable Boxford, which means that bargains can be had! Just be careful to check on the condition of those plastic gears in the headstock, and that the screw cutting gearbox works as it should, the two areas where clumsy handling in the past may have left its mark. ■



The complete taper turning and copying attachment awaiting fitting to the lathe.

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YOUR CHANCE TO TALK TO US!

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

Rust

Dear Neil, Chris Sayers-Leavy asks about liquids to get rid of rust. I worked in the printing industry for years, and we used phosphoric acid in the plate making process. we used a solution with it in. I some how found the solution got rid of rust. That led me to try phosphoric to get rid of rust. I had to dilute it with water, for it to work properly. I can not remember the ratio but something like 25 % acid / 75% water. Always add acid to water!

You must clean with water to get rid of the acid, then coat with oil, or primer. It rusts again in seconds. One good thing about Phosphoric, it is not as dangerous as other acids, Sulphuric, hydrochloric being two.

John R. Yeoman, York

Sub-Plates

Dear Neil, I read with interest the article by Keith Keen about sub-plates for workholding - a very useful idea and one that I will keep in mind. It struck me while reading the article that an alternative approach would be to drill/tap similar hole patterns in a lathe faceplate; on a gap-bed lathe this would have the advantage that larger diameters could be held for peripheral machining than would be possible with the chuck.

Of course, very few ideas are really new - I discovered that later in the issue, Geoff Harding shows a Unimat 3 faceplate drilled with hole patterns for a very similar purpose!

Tony Jeffree, Mull

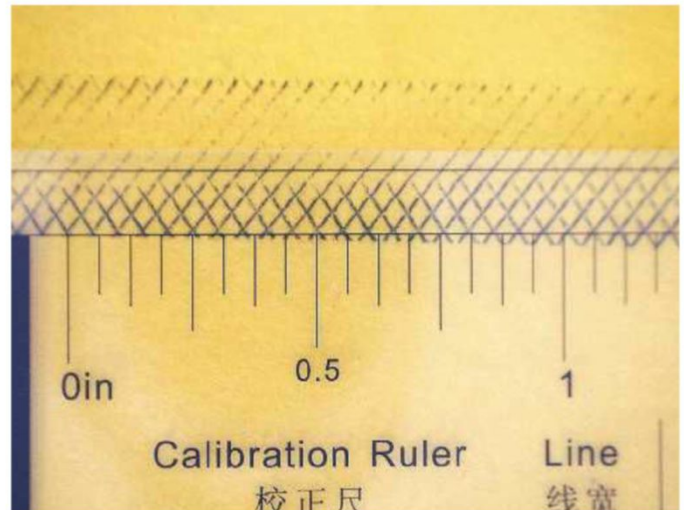
Southbend

Dear Neil, You probably already have had a response but in the last issue of MEW someone was asking about spares for a Southbend lathe - I would suggest he goes on the Home Shop Machinist HSM forum and asks the question, I feel sure he will get a response.

Southbend seem very popular over the pond and I understand there are several clones so a good chance depending on what parts he wants.

John Fawcett, Lancaster

Knurling



Dear Neil, As a self-taught model engineer I continue to learn a great deal from MEW. One discipline that eludes me however is what I have heard is the "brutal art of knurling". Every machinist I have asked about this tells me that they have only ever done it on large industrial lathes and that even then they were not comfortable with the process. Reading various trades publication suggest strategies that I have not found entirely helpful on a Myford Super 7 using scissor knurls.

To explain the mixed results I have had so far, I reasoned that if a set of knurls was say 22 TPI, then the piece being knurled must have a diameter (circumference) that supports this pitch much like a gear wheel. Exploring this option, I placed a bit of 1"MS in the chuck and supported the end with a tailstock centre. 1" bar gives a circumference of Pi, and my knurls seem to have a pitch of 19.75TPI so this works out at very close to 62 impressions around the bar. I set the scissor knurls over the centre of the bar and finger tightened the wheels against it. I then withdrew the top slide and closed the knurls together by about 15 thou. Starting the lathe in top back gear, I plunged the knurls firmly back over the centre of the bar with lots of lube. The result was very encouragingly good but after I stopped the machine and engaged a much higher speed for a few seconds, I was surprised to find the knurls self-feeding towards the chuck.

Should I be feeding in from the side of the job as some suggest or doing as I have seen some demos on YouTube and just plunging straight in? I ran the knurls over a piece of carbon paper on cardboard to produce the image included. This seems to show the pitch as 19.75 TPI (although advertised as 22 TPI) and also that the impression is advancing around the wheels. Is the advancing pattern normal?

I am hoping that one of your reader with experience and knowledge might be tempted to prepare an informative article on this subject as I am probably breaking every rule in the book and am reluctant to impose heavy loads on my machine by experimenting too much.

Graham Lill, by email

Grinding Rest



Dear Neil, I recollect seeing an article in MEW published in the last few years with drawings for constructing a lathe tool grinding rest for a bench grinder that could be built using only hand tools.

I should be most grateful if you would kindly excuse my senility and point me at the right issue.

MC Black, by email

My suspicion is that the item you have in mind is Harold Hall's grinding rest, last published in the 25 year special in 2015. A google search should easily find details of this on Harold's website. Readers may also wish to suggest their favourite grinder designs from over the years – Neil.

Healthy Cutting Oil?

Dear Neil ... and I thought I was alone! Writing in, Scribe A Line, Peter Peters from Sherbourne says how he recycles old extra virgin olive oil as a cutting oil. I've been using cooking oil for years. My choice is cheap cooking oil, the sort that is high in polyunsaturates and considered less ideal for various reasons. I have to say that, so far, the metal does not seem to care!

Stephen White, by email.

Bombe

Dear Neil, MEW No.281 shows on the cover Bletchley Park's Bombe in action.

As Dutch reader I had not heard about this museum and did not know the bombe codebreaking calculator. On page 56 more information is given, but I wonder how it was working?

Can you give me an explanation.

Henk Salij, Ridderkerk, Netherlands

I'm afraid the best I can do is refer you to the English Wikipedia article, which is rather tough going! I'm afraid the Dutch article has no technical content. – Neil

<https://en.wikipedia.org/wiki/Bombe>

Happy Reader

Dear Neil,

I have always enjoyed some part of MEW but no 281 is the first that I have read and enjoyed from front to back.

You and your contributors are to be congratulated on producing such a great read.

Adrian Seal, by email

My Interests

Hello Neil, I have joined the SMEE, and registered for the digital group. I may be wrong, but sections of our hobby appear to be reaching out strongly into electronics and CAD.

You asked about hobbies in a recent issue. My activities in music (keyboard) have led to the recent construction of a 2 metre tall Voigt tapered pipe PA speaker but this is esoteric! However I am busy with a spare time research project involving a small Stirling engine received as a Christmas present:

- Solar absorber for the hot end
- Evaporative cooler for cold end (Both using water and tiny centrifugal pumps)
- Data capture using a Velleman (Belgian) K8055N experimenters board
- Control and measurement using Abacom's Profilab Expert graphical programming tool. This avoids all code writing, and creates a cool graphical user interface.

Glyn Craig, South Africa

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

Exhibition Announcement from Warco

After long and serious consideration, Warco have decided not to attend the Midlands Model Engineering Exhibition in October this year. This difficult decision has been made based on costs and major disruption in preparing the counters and machines for presentation at the exhibition, setting up and attendance over the exhibition days and re-stocking the stores and showroom after the event. This combined effort, involving many staff in multiple departments, is at least five weeks out of an already stretched work schedule.

Warco has been attending the Midlands exhibition since its inception in Birmingham some thirty years ago, through the moves to the Royal Showground, Donnington and then to the Warwickshire Event Centre.

Warco would like express their thanks and apologies to their many regular visitors and loyal friends.

To compensate for not attending, we will have some very special

offers to coincide with the week of the show. Warco will continue to organise their Open Days throughout the year.

www.warco.co.uk



Bletchley Park Update

John Harper has been in touch to express his thanks to MEW and it's readers for the many offers of skilled help with producing spare parts for the 'Bombe'. He has been in touch with many readers whose experience ranges from working on the Bluebird Project and Thrust 2 to restoring a Dakota and Lancaster. Another reader was a member of HM Forces, intelligence during the war and has offered to assist in other ways.

I do need to make one correction, however, in May 2018 the Bombe was moved across Bletchley Park, so it has passed from the care of the Bletchley Park Trust to the National Museum of Computing, so it is now in the same home as Colossus

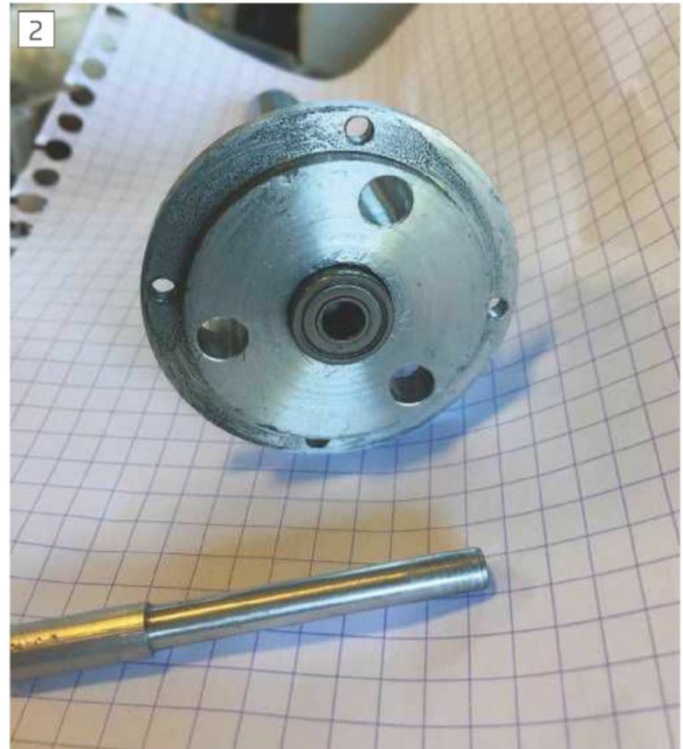


Out, Out Damned Bearing

With apologies to the Bard, Simon Davies shows his powers of perseverance



Bearing partly returned to blind hole



This shot shows some evidence of trying to remove the bearing by other means

In the recent past, I have had to remove three bearings from blind holes, none of which was easy to extract. I hope the following may be of assistance to anyone else in a similar position in the future.

I discovered this first method by pure chance and although I have not seen it published elsewhere, I cannot imagine that it is unknown, but I hope to bring it to a wider audience.

I had a need to replace a small shielded bearing, shaft size 5mm, that was firmly located in a blind hole. Although the bearing was in an unhappy condition, I was hoping to recover it for the short term until a replacement could be found. The problem of course was finding a means of removing the 12mm diameter race which was firmly fixed in a blind hole. **Photographs 1 and 2** show the object with the bearing partly replaced for these photos, I had no intention of returning the bearing properly into the hole just for this article!

After various fumbblings all of which risked damaging the shields, I decided to

apply a method that I had read about but never successfully applied. In this method, the void behind the bearing is packed with grease and a tight fitting shaft inserted into the bearing to act as a piston. This is then firmly struck, and, in theory, the bearing is then hydraulically ejected from the hole. As is all too common the case, theory and practice departed on diverging paths and a lot of grease seemed to appear everywhere whilst the bearing remained firmly in place.

The next step after removing the larger globs of grease was to remove the aluminium shaft I had used as the piston which immediately presented a new problem. The shaft would slide out until a certain point whereupon it stuck in the bearing. Major cursing followed until light dawned that this was maybe my salvation. I then gripped the aluminium shaft in a vice and proceeded to pull it out on the slide hammer principle.

This removed the bearing from the hole with no further damage. Once removed, the reasons for the shaft getting stuck



The shaft after being cleaned up. The thin walls around the centre drilling are clearly visible

were clear. I had chosen a scrap piece of aluminium which had been centre drilled leaving an almost sharp edge at the end. My frustrated striking of the shaft trying the hydraulic solution had resulted in the shaft bottoming and then peening over to effectively form a rivet head on the end of the shaft. Shaft removal took a matter of seconds after a brief introduction to Mr. Belt Sander. **Photograph 3** shows the end of the shaft after the bulge had been ground away, some remaining grease still visible.

I am aware it is not an ideal method to remove a bearing by tugging at the centre but in the absence of any other means to remove it, this method at least is better than none.

If I needed something more solid or I was looking for perhaps a more refined solution, I would machine up a small cone shaped piece of steel to drop into the end of the shaft to help peen it over – rather in the manner of the brake pipe flaring tools that used to be available for cars.

The second bearing extraction was a rather more brutal affair. We had been lent the use of a professional quality concrete mixer so that our occasional gardener could build some small walls. However, two weeks into the loan, it started to make very unhappy noises and eventually stopped functioning altogether. My examination revealed that the motor pinion was no longer engaging with the ring gear around the outside of the drum. This was because one of the two bearings supporting the drum was no longer in existence.

Photograph 4 shows the drum once it had been removed from the remainder of the mixer. After dismantling the machine, it became clear that there are two chunky bearings supporting the entire weight of the loaded drum which had probably never seen any form of lubrication in their entire lives. The outer bearing had disintegrated into an inner quasi-welded to the shaft, some non-spherical balls and the remains of the cage and shields. Moreover, the outer track had broken into two, having split along the bearing track, presumably as a



Mixer drum – the entire weight is born by 2 bearings about 70mm or so apart



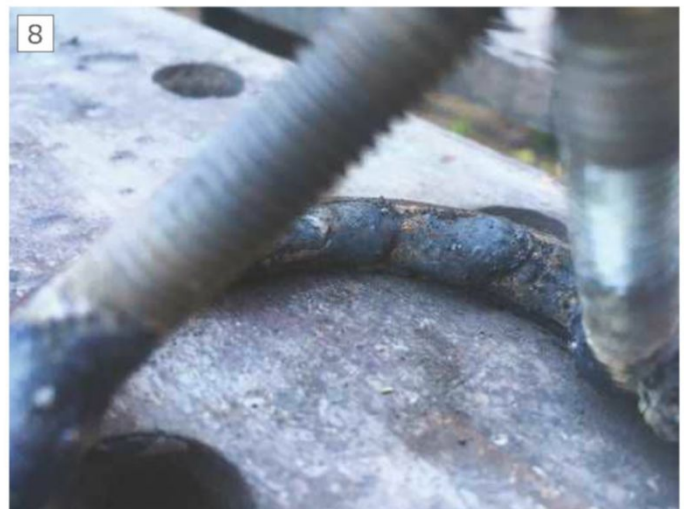
Less than simple access – the out of focus ring is the edge of the remains of the bearing outer



Crude and roughly applied but with maximum current for deep penetration



Equally noxious welding of the studding – but it held!



The bead is clearly seen here as well as the point where the track split into two

result of trying to ingest part of a shield or cage. This half outer was firmly embedded into a blind hole without even any notches for a puller, leaving no opportunities to remove it. Presumably the bearing would be removed by inserting a puller inside the 35mm shaft under normal circumstances. Photograph 4 also shows the location of the bearing some 50mm below the height of the surrounding drum.

Realising that the only way to remove the track was to provide some means to attach something to it, I got my MiG welding set out and welded a couple of pins to the remains of the track. I then proceeded to break the weld since this bearing was well attached.

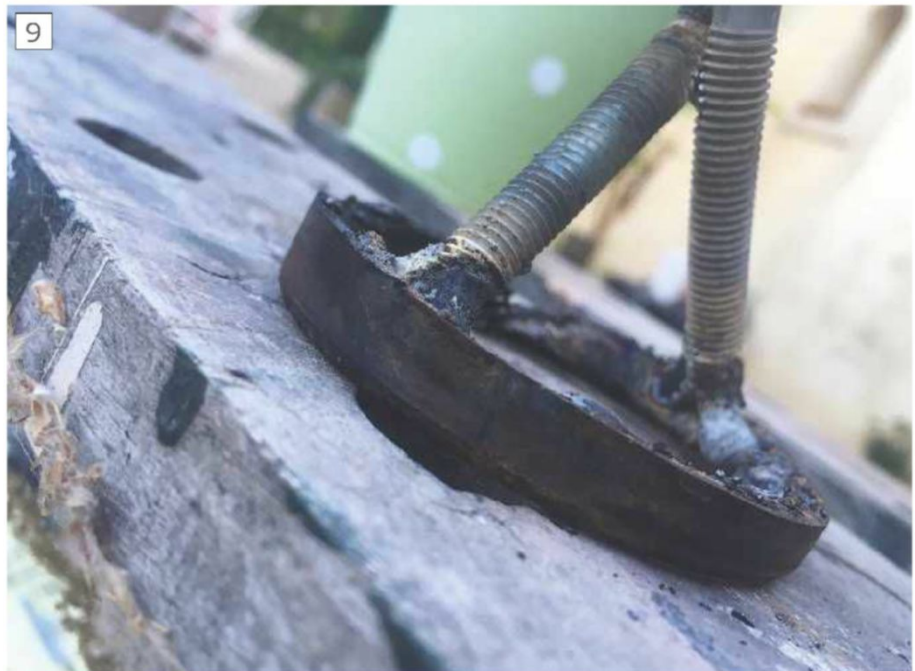
I then tried a trick I had heard about some time back from the classic car world and applied a thick and deep layer of weld around the entire visible remains of the track. **Photographs 6 to 9** show various views of the welding, I make no claims for a quality job here and I doubt it would pass any welding examination. Care was needed to ensure that I did not weld the bearing to the hole and just ensure that the bearing would never come out but a Dremel with a grinding wheel fixed a couple of those errors. Some evidence of this work can be seen in **photo 10**. The theory is that the cooling of the weld bead should shrink the entire bearing and thus loosen it. Plenty of heat and thermal shock may also help the process. After a couple of beads were laid down, I welded 2 scrap bits of studding to the track and used a slide hammer to successfully remove the whole lot.

Once the blind hole was cleaned up, a new bearing was obtained off the shelf at the local tractor dealer, somewhat to my surprise and the drum and mixer reassembled.

Generally, we look upon the effects of heat and stress being applied to one side of an object as being a bad thing, but in this case, it got me (and the bearing) out of a tight hole.

In a last case, I had to remove a 12mm shaft sized bearing from yet another blind hole. This bearing had also started to break up but was still in one piece fortunately. Lacking a puller to fit inside the shaft, I found a Rawlbolt (expanding bolt used for bolting structures to masonry) slightly smaller than the hole. This one was the variety that has an exposed thread with a nut to tighten it against the end of the expanding part. As the nut compresses the unit, it expands thanks to a simple set of ramps. Enough force can be generated to crack individual bricks in two! I then inserted the expanding part into the bearing and tightened it until the bearing was firmly gripped. A second nut was then added to provide purchase for my slide hammer. A couple of blows and out popped the bearing.

The expanding bolts come in a range of sizes and intermediate sizes could be achieved with thick shim I suspect. They form a very useful method of gripping all manner of holes provided no precision is required and are readily available at DIY stores. ■



This shows more clearly how the bearing outer broke up into two

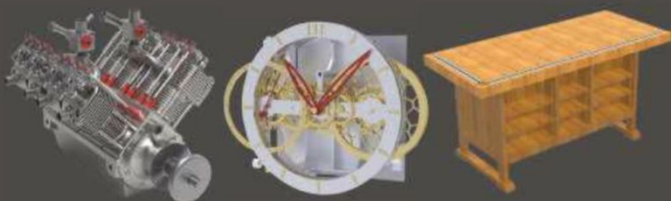


Some Dremel work is visible upper right where I was too enthusiastic and welded bearing to drum. The studding for the slide hammer can be seen as well



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A Hydraulic Press

James Perry describes how to make a workshop press around a hydraulic jack. Part 2.



This meant that when the V die was clamped up for drilling, the four fixing holes could be spotted through for accurate positioning in the die. See **photo 20**. I believe in maximum screw length retention, particularly where shock loading can be expected. The tapping holes in the die had to be drilled as deep as reasonably possible, without breaking through the other side. After they were drilled the base plate and die were separated and the two inner base plate holes were opened up to 5/16" diameter and countersunk on the underside to accept the fixing screws. With two large and cumbersome clamps holding the die and base plate together I found it was better to complete the two inner fixing holes entirely. Fixed with the inner screws, it enabled me to dispense with the clamps. Of course, only after all tapping holes were complete could I open up the remaining two fixing holes to 5/16" dia. It then just remained for the two end holes to be opened up to 3/8" to accept the guide rods.

The 1/2" dia guide rods had a 12mm long section machined down to 9mm. This meant the resulting shoulder ensured they would stand upright in the base plate. The 9mm dia section also had a weld prep chamfer machined on it. The top ends of the rods were drilled and tapped M6 to fix the end caps. They were duly welded into the base plate and the welds ground flush on the underside of the plate.

Photograph 21 shows the die and guide rods ready for the base plate.

A small digression here. I'm a magpie where supplies of good materials are available. Never throw a printer away without scavenging for materials, in



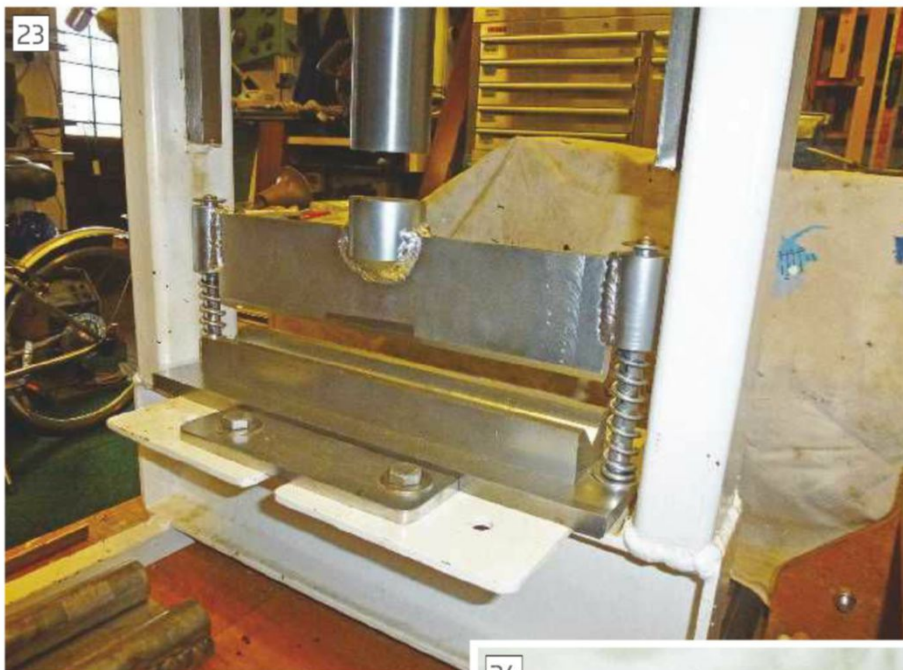
particular the beautifully polished and machinable rod they contain. Whilst they are made virtually all over the world, they keep to their USA origins. Everything seems to remain imperial (well USA imperial anyway), hence my use here of imperial rod.

The Blade is made from 75mm x 12mm BMS. The business edge has a 90 degree angle to match the Die. It follows Alan Hearsom's style in having a 2mm flat at the apex rather than a sharp point. On the heavier bends a sharp apex wouldn't last long. The pressure pad has a deep slot to

accommodate the Blade and to ensure a very strong weld. **Photograph 22** shows it ready for machining.

Photograph 23 shows the tooling assembled in the press. An extender has been added between the Pressure pin and the Tooling. I found that in use, the narrow 12mm thick blade caused the fold to close to less than 90 degrees when applying pressure to get the sharpest fold. It meant that for the heavier gauge metal I had to accept curved folds with an inner radius of perhaps 6-8mm rather than tight 90 degree bends. In addition,





only ever done in a forge. **Photograph 30** shows the tooling I produced to make the bends. The tool is 25mm BMS round and the die sides are 30mm dia. They are mounted on 12mm thick plate 100mm wide by 130mm long. The confining cheek plates are shown as usual bolted to the anvil plate 100mm apart.

The curves are produced by taking small bites every, say, 30 mm along the metal. Whilst this suggests a series of little flats between the bites, in practise the result is indistinguishable from a true curve. The distance between bites depends upon the size of the curve being produced.

The two "horns" of the tool suggested to me originally that using both at the same time would enable me to produce matching pairs of spirals. In the event, I discovered that I would need two pairs of hands. An electric pump and foot pedals would have been the answer, but the scope of the job would have ballooned out of all proportion.

the 2mm wide flat on the face of the blade imprinted itself on the inside of the fold. If anything, both of these effects had their advantages and looked good on finished jobs.

However, it did raise the question. What about the times when I particularly wanted square corners? Since this was almost always when folding thinner plate, the use of a blade without a flat on the pressure point was quite workable. It also meant that the Die would need a narrower V slot to accept model sized folds.

This was achieved by adding adaptors to the existing Blade and Die. The addition to the blade is shown in **photo 24** and that to the Die in **photo 25**. They were both cut out of 25mm square bar. Each was cut initially to about 400mm long and allowed a sacrificial 50mm each end. This allowed the workpieces resting upon V blocks at each end to be clamped to the milling table outside of the required working length.

Photograph 1 showed the tooling with the adaptors fitted mounted in the press. Cheek plates 100mm apart are shown, between which various tooling assemblies are mounted.

The following show a couple of light weight folding jobs. **Photographs 26** and **27** are rather obviously an ash pan for a wood burner. **Photograph 28** came about because the CO objected to the noisy clatter in high winds and decided to remedy the situation with sticky tape. My protests were pointless. However, it was a good excuse for me to play with the Folder, hence **photo 29**.

Garden Gate and Arch Curves

I have never liked the "Meccano" gates made with flimsy flats which seem to be the norm these days. My aim was to produce curves and spirals cold, which are usually



26



I made sure that all the welds were continuous, which, coupled with heavy coats of Hammerite keeps the rust out for a good while

When doing any bending with the press it was important not to over-bend. Experience showed that less is always better than too much. Restraightening was always an unwanted chore and in the early stages it often meant scrap metal.

I had a salutary lesson on the importance of proper weld penetration. During an initial trial. I was bending 30mm x 5mm. It proved to be well within the capabilities of the jack, so I kept pumping for maximum shape, pushing the tool down between the die sides. With a shot like a gun one side of the die flew off in a very dangerous manner. **Photograph 31** shows the result and the very poor weld I had on it. My welds definitely had more attention after that!

I found that initially I still ended up with a small flat at the start of each curve, so this end was hacksawed off each time. Later on, I found that placing a section of 20 x 5mm flat against one of the Die rounds, I was able to form a full curve from the outset.

Photograph 32 shows some of the curled flats and **photo 33** a gate they formed part of.

I've made a number of garden arches out of half inch rebar by pulling the metal around in the vice. After shoulder damage I can no longer do it this way. The press now takes all the hard work out of it. Incidentally, the ridged pattern on Rebar provides a brilliant surface for climbing plants. **Photograph 34** shows typical results. The large radii were achieved by continually checking the result against a template. I found after a bit of practise that a bite every 50mm or so produced satisfying results. I made sure that all welds were continuous, which, coupled with heavy coats of Hammerite keeps the rust out for a good while.

Broaching Keyways

Again, in the past, I've had to cut keyways the hard way usually by sawing and filing. I thought the press would provide an ideal opportunity to produce machine quality keyways.

My method however was not a success. Nevertheless, it's worth a brief explanation

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to show the pitfalls and point the way forward.

My intention was to make the broach out of the appropriate size of HSS lathe tool steel. The tool would be backed by a bush to match the bore. see **photo 35**. The flat on the bush was sufficient position the tool for its first cut of about 0.3mm deep. Each pass would be a small cut of about 0.3 mm deep. Subsequent passes, of similar depth, would be achieved by placing shims behind the tool to progressively move the tool forward and deepen the slot, see. On the first tool I tried to have a cutting edge on all 3 sides, see **photo 36**. This proved too fragile and shattered. **Photograph 37** shows the simplified profile I ended up with. Although this appeared to work well, it showed further problems. Even with very shallow cuts, swarf built up on the cutting edge and at the end of the cut burst out of the slot destroying the shape, **photo 38**.







After each pass the tool tended to jam in the slot and it was necessary to dismantle the setup to prise it out. This meant the tedium of resetting the tool again accurately each time until the full depth was achieved.

Since that wasted effort, I've noticed that "push" broaches are available on the market, including even the appropriate backing bushes and shims (I thought these were my original idea – it seems that there is nothing new under the sun!).

This is definitely unfinished business.

Broaching Square holes

Before the press, cutting square holes was tedious. It was done the hard way, either filing or using a vice to press HSS cutting tools through a root pilot hole to equip boring bars. The press gives a much more positive and better control. To start it off and keep it parallel with the required axis, I found it useful to drill oversize (the diagonal dimension of the square required) for a small distance. It did mean I was limited in sizes to whatever HSS steel was available. A lead angle was ground on the business end of the HSS to encourage it to bite. This particular piece was one used the hard way (before the press was built) but the principle remains the same. On thin plate it works well. On boring bars I was equipping, the HSS size was 1/8 inch. To avoid the swarf buildup the initial drilled hole was 11/64 inch (my best guess). Since the load is on the corners, loss of contact in the middle of the flats was not important (that was my excuse and I was stuck with it – it worked).

Cutting square holes in plate needs a die of larger dimensions beneath the work piece. In industry the die would be hardened and tempered as well. Initially I talked to a company to see whether it would be worthwhile buying tooling. It's



almost a Black Art, dependant upon the work piece material and its thickness. They are designed for each job. Clearly too rich for me. For the few times I was going to do it, I had to accept a mild steel die that was ruined each time. My results were less than perfect but suited me at the time. I'll do better next time.

Injection Moulding

This, I've no experience of, but the article in MEW 213 on this topic intrigued me. It's worth a try. Whether the spring return will drag the piston out of the molten plastic is a possible impediment. It might be necessary to fit all four return springs rather than the two shown. One of these days perhaps !

Afterthought

My guesstimate of 10 tons for the jack size was I think a little light. When folding thicker material up to 300mm wide it tended to struggle a little. The 15 ton jack available would fit the frame I made.

A hydraulic press is a "must" for Broaching keyways. Although I knowingly sized my press to suit the material available, if I'd seen the "Push Broaches" available I almost certainly would have increased the press height to accommodate them.

The press has now been in use for a year or so and has proved its worth many times. ■



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PART 12 - TOOLHOLDING

This ongoing series will build into a complete guide to using an engineering lathe. This month Neil Wyatt looks at toolholding and setting in more detail.

To achieve anything with a lathe it is necessary to fit a suitable tool and present it to the work. For the vast majority of turning work this means fitting a tool of some sort to the topline, and virtually all lathes come supplied with some form of toolholder to facilitate this. The requirements of a toolpost are:

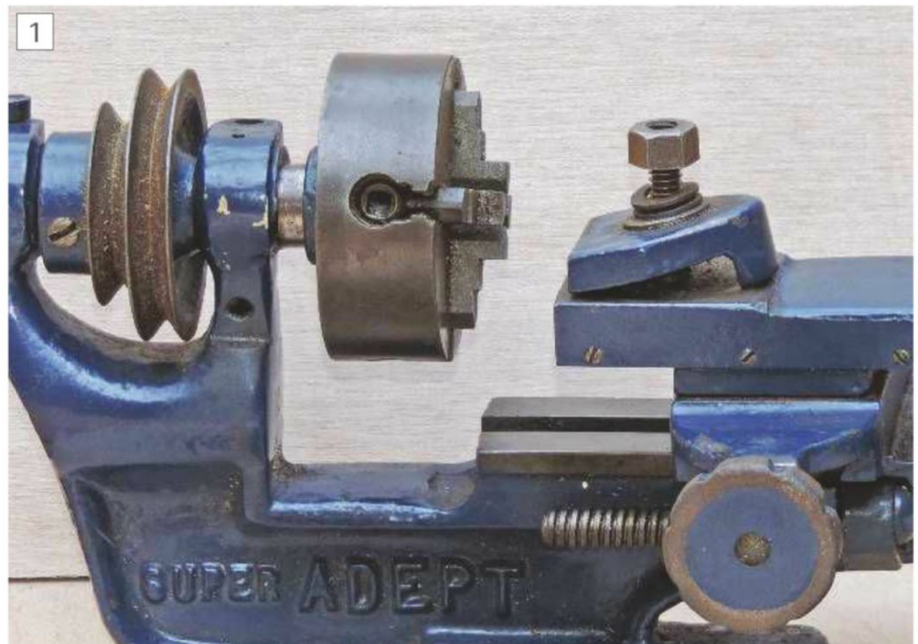
Rigidity – the more securely tools are held then the less vibration, improving finish and enabling deeper cuts and faster metal removal.

Adjustment – at the very least it is important to be able to adjust the angle of the tool to allow different operations such as turning and facing and ensuring parting tools are represented exactly perpendicular to the work. Toolposts can be height adjustable to remove the need to use packing strips under tools.

Ease of use – some older toolpost designs are very fiddly to use, requiring the tool to be accurately reset at every change. At the other extreme, quick change toolposts allow tools to be swapped over in seconds with no need to check their adjustment.

Traditional Toolposts

The traditional tool holder for British lathes is shown in **photo 1**, a simple L-shaped clamp that is tightened down onto the tool by a nut on the toolpost. The tool height is set using packing. This style of toolpost,

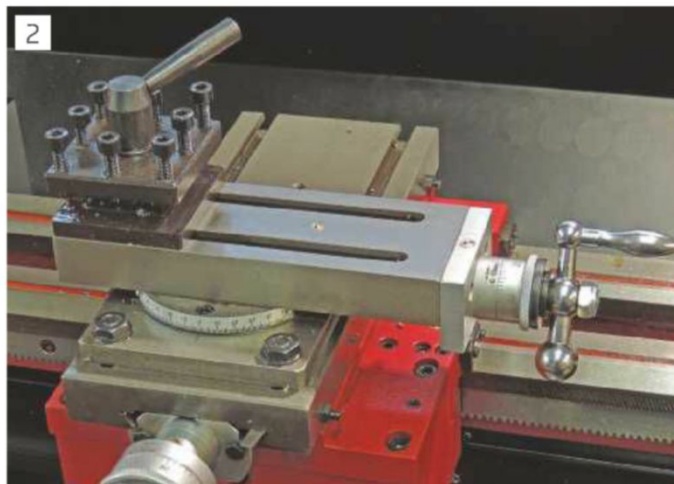


The traditional-style toolholder of a Super Adept lathe

although flexible and rigid, is fiddly to set up and offers no help with aligning tools and it has long been rare aside from still being standard on a few 'heritage' designs whose owners almost always replace them.

The American counterpart is the 'lantern' tool post. This is a more complex hollow toolpost with a 'boat' shaped insert that

is used to angle the tool to set the height of its cutting edge. The downside being that changing the tool height also changes its geometry. It leaves the tool with more overhang than the British style and also limits the lathe to tools that can fit through the toolpost slot.



The large four-way toolpost of an SC4 lathe



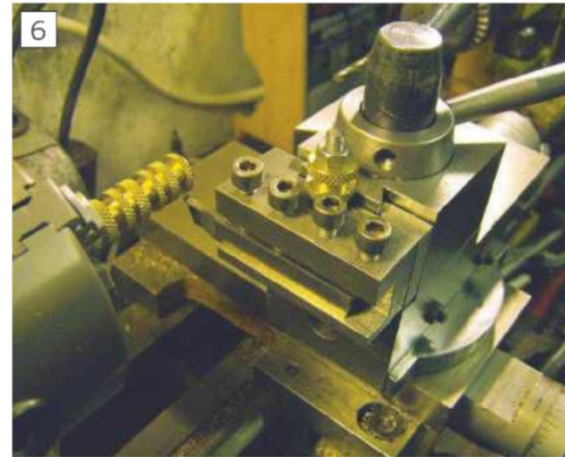
Using packing strips to set a tool at centre height



The simple toolpost of a CO lathe



One of Richard Smith's 'Prototype' holders



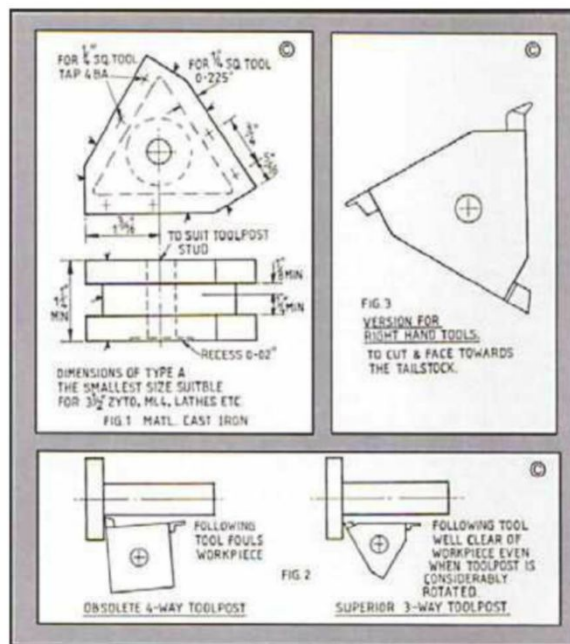
My shop-made QCTP

Standard 4-way toolpost

The basic toolholder supplied with most lathes is the four way toolpost shown in **photo 2**. Tools are placed in the slots and secured in place, usually with two or three of the clamping screws. These toolposts have the major advantage of being very rigid. In principle it is possible to fit four tools, but in practice this can prove impractical, depending on the choice of tool, and often they end up being used with just one or two tools fitted most of the time.

Height setting is achieved using packing – one source of suitable material is a drink can, cut into strips, although I prefer to use a single, slightly thicker piece of aluminium sheet **photo 3**. If you use tipped tools you will probably find that the same packing will suffice for all the tools of a particular shank size, but for HSS tools or others, such as parting tools, that may have different tip heights it makes sense to keep the packing with the tool.

Radial adjustment of tools can be adjusted by rotating the toolpost – useful if you need to present a tool at an unusual angle. Often, they have a simple ratchet allowing the toolpost to be repeatedly turned to the four different stations so setting



the tool accurately allows this feature to speed up tool changing. Most such posts have an accurately square centre pillar, if the ratcheting is also accurate you can align many tools simply by pushing them against the centre pillar before securing them in place.

Some small lathes have a simplified

toolpost that just takes one or two tools, but is otherwise similar to a four way post, **photo 4**. Four-way toolposts with height adjusting 'boats' are also available.

Lammas Toolpost

A design that was popular with hobbyists until relatively recently was the David Lammas' design for a three-way toolpost, first published in Model Engineer in 1985, **fig. 1**. This design allows three tools to be held with less interference with each other and the work than a four way toolpost. The design also appeared in MEW issue 27, January/February 1995. Castings for these are still available on line, but they can be milled from solid bar or even fabricated from a 'sandwich' of three pieces at the expense of a little rigidity.

Richard Smith 'Prototype' System

It's worth mentioning this system that has featured in several articles in MEW over recent years. It uses oversize toolholders for carbide inserts that clamp to a central pillar, **photo 5**, allowing easy angular adjustment; a screw allows repeatable height setting.

Quick Change Toolposts

For industry, where time spent changing



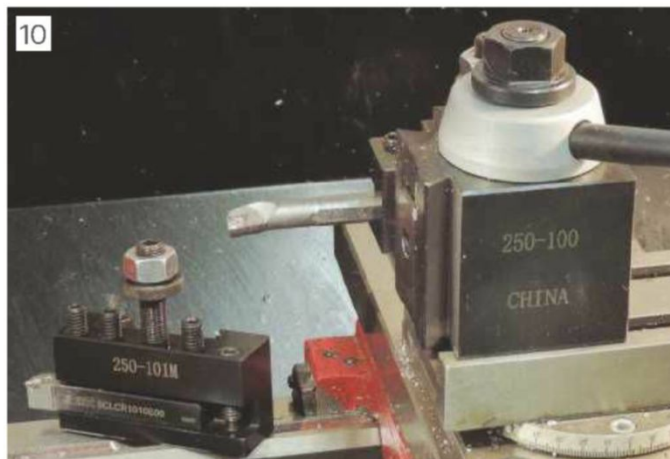
The SC4 dedicated quick-change toolpost



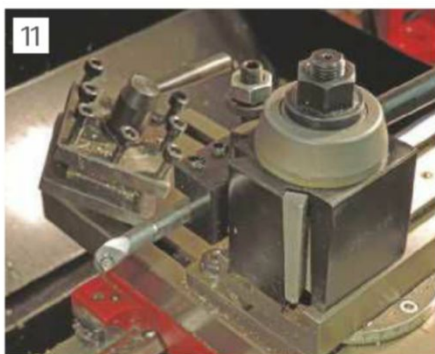
Special purpose QCTP toolholders, a knurling/toolholding combined holder and 000 and 100 parting tool holders



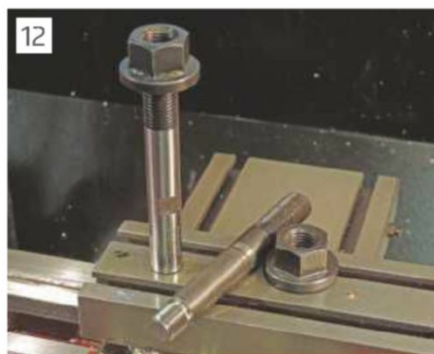
Model 000 toolpost fitted to a mini lathe (the lathe has a 100mm chuck fitted, which makes the QCTP look smaller than it really is).



Model 100 toolpost with piston clamping fitted to SC4 lathe



Model 111 wedge-lock toolpost, with the original 4-way behind



New pillar to fit 1XX toolposts to an SC4 lathe, lying down is the original Model 1XX pillar modified to have an M12 thread.



Model 100 slim toolholder with reduced base thickness

and setting tools is literally lost money, it is not surprising that various systems of quick-change toolpost have been developed. These allow tooling to be set up once and swapped in and out in moments. Increasingly hobbyists are using QCTPs in their workshops because not only are they convenient and efficient, they can make doing runs of repetitive work vastly less boring and more pleasant. Don't we all prefer to spend our time cutting metal than swapping tools?

Several years ago, I made my own QCTP for my mini lathe, photo 6, together with a dozen or so holders for a range of uses (MEW 197, December 2012 and 198, January 2013). Since then my only regret has been that I didn't make enough toolholders!

I was given the opportunity to try some different types of QCTP on the C4 lathe. There is a toolpost designed specifically for the SC4 that uses an 'inverse wedge' draw-in system, photo 7. This looks rather different from the well-known Dickson toolpost system but has a similar working principle but with a simplified geometry. The SC4 system only has one type of toolholder available, but this is suitable for both round and square-shank tooling.

It comes with a replacement pillar suitable for the SC4 lathe. This tool post requires an allen key for locking and only has a single position for holders, so you have to rotate it for some operations. It works well, and its low height gives good view of the work. I had to experiment with different thickness

washers to get the (original SC4) toolpost clamp handle to point in the right direction.

I also was able to try out the 'Model XXX' toolposts. These are available in three sizes, 000, 100/111 and 200/222. These are much taller toolposts with two positions for ordinary dovetail toolholders and a ball ended lever providing either wedge or piston locking.

My first impression of these toolposts is that they have a better level of finish and feel very smooth in operation, however, they are much bulkier. They also have a wider range of toolholders available including boring tool and knurling holders, photo 8. See my comment later about the 100 version and SC4.

The Model 000 toolpost is small wedge-locking toolpost, suitable for lathes of about 3 1/2" centre height such as mini-lathes, photo 9, and Myford 7-series lathes. It will fit on a C4 lathe, but its toolholders are too small for some tooling appropriate to the larger lathe and its position back from the edge of the top slide means tools have to be overhung. Its dimensions are very similar to my shop-made QCTP for my mini-lathe, although the dovetails are approximately 3mm wider. In all likelihood I will modify my shop-made toolholders to work with the 000 toolpost and keep it on my mini lathe.

The Model 100 Toolpost is a piston-lock toolpost for 4"- 5" centre height lathes, like the SC4, photo 10 The Model 111 Toolpost is a wedge-locking version with the same overall dimensions that also takes Model

100 toolholders. Again, these are very well finished. Whether you prefer the piston-type or the wedge type toolpost is very much a choice of personal preference. Having tried both they are equally secure and pleasant to use. I have a marginal preference for the wedge type as when loosened the dovetail becomes 'smaller' making it marginally easier to drop a different holder in place.

As supplied the original Model 100/111 toolposts required two modifications to work with the SC4, photo 11. The first of these was to turn down the end of the supplied fixing pillar and screwcutting the end M12 to match the SC4 top slide. The second problem was that the supplied toolholders have bottom lip 11mm thick, thicker than the base of the SC4's standard toolpost so I could not use 10mm shank tools. I solved this situation by bandsawing a 3mm slice off the bottom of the toolholders



Inserted tip boring bar with flats

Tool Height Gauge

There has been much discussion about the need to set tools exactly on the lathe's centre height.

I'll start by assuming that the most basic way of checking tool height is to compare the cutting edge to a centre in the spindle or the 'pip' on a faced off workpiece, it's not difficult to do this to better than 0.25mm or 0.010", but this seems quite a large error when we are typically working to an accuracy of ten times this.

Let's look at turning a 10mm diameter, if the tip is 5mm from the axis of the lathe but set 0.25mm high or low it will cut oversize. How large is the error in diameter? We have a tiny right-angled triangle so Pythagoras tells us the diameter we get is 0.0062mm, about six microns. Even a tool set an apparently huge 1mm too low will only give an error of 0.10mm or half a thou.

Clearly for work 10mm in diameter or larger, achieving exact tool height is not greatly important, but what about smaller work? Even at 4mm diameter the error caused by a tool 0.25mm off the correct height is only 0.015mm.

These errors are also relative, so if you set the dial to zero after taking a cut at 10mm diameter, then work down to 4mm the error becomes 0.009mm – acceptable for most everyday work.

Below about 4mm in diameter the relative errors grow rapidly, so clearly for fine work more care is required in setting the tool height.

Errors in tool height also affect their cutting geometry. A tool set slightly too high will appear to have increased top rake, at the expense of reduced clearance below the cutting edge. A

sharp tool may cut freely if set slightly high, but there is always an increased risk the tool will rub, particularly when cutting larger diameters. Another risk is that a high tool will bend slightly further into the work when loaded, increasing the risk of vibration and grabbing.

If a tool is set low its top rake is reduced. This is unlikely to cause major problems with larger diameter work, but it may cause smaller work to ride over the top of the tool.

Again, these errors are exaggerated when you are turning smaller work.

In practice set the tool height as accurately as possible while being aware that it is less critical when turning larger diameters. It is generally better for the tool to be slightly low rather than slightly high. Centre height is most important for parting tools – too high and they will be more prone to grab, too low and they might be pulled under the work when approaching the centre.

I will confess – in twenty years of turning I have always set my tools by facing across the work and adjusting them to minimise any centre pip. Many people prefer to use a tool height gauge of some sort. Making such a gauge is straightforward, all you need is a stable base that will stand on the lathe bed with a horizontal arm that can be used as a comparator to set tool height. Some people like a gauge that sits on top of the tool, others one that sits beside the tool so they can 'feel' when it is level with the top of the gauge.



Boring bar set, note holder



V-grooved toolholder



QCTP boring bar holder with sleeve

and this is the arrangement I have used for much of this series.

In the light of this, Arc Euro Trade have had both special toolposts, **photo 12**, and 'Model 100 Slim' toolholders with a 7mm thick bottom lip, **photo 13**, manufactured specially to suit the SC4 lathe; I understand that these are now in stock. For SC4 owners I recommend the 100 or 111 toolpost with the 'slim' holders, rather than the set with a variety of holders as these will require modification (plus the boring bar holder is really for bars too large to suit the SC4)

The Model 200 Toolpost is a massive construction suitable for 6" centre height and larger lathes. I haven't tried one of these (it would be far too big for the SC4) but Mike Haughton review one for his Chester Craftsman 6" lathe in MEW 176, May 2011.

It is important to bear in mind that these centre heights I have given above are approximate – the adjustment on toolposts gives a degree of latitude of choice, and also the size of the post is linked to its robustness. While the 100 toolpost is clearly oversize and wastes a lot of working capacity) on a mini-lathe, some SC4 users

might want to use the 000 if they mostly do delicate work.

A good guide is that the footprint of a new toolpost should be approximately the same as the lathe's supplied toolpost to maximise both rigidity and the available capacity while minimising overhang.

Bear in mind there are two issues I met with the SC4 when choosing a new toolpost to a lathe. The first is to make sure that you will be able to set your tools at centre height, secondly see if a custom fixing pillar to suit your lathe is available. If not, you can always sleeve an undersize pillar or simply turn a replacement as a nice exercise in screwcutting. I would suggest using a medium carbon steel like EN8 or EN16T.

Round Tools

Boring bars often have round shanks and it is not unusual to encounter HSS tools that have been ground from round bar, especially if you make your own tools from things like that never-ending supply of broken centre drills. Unless these have flats top and bottom, **photo 14**, you will need to use a holder of some sort. These

normally take the form of a length of square bar, bored out to suit the tool and split along one side, **photo 16**. These should always be used with the split vertical, because the holder uses cotter pins to apply force from the side of the holder.

Most quick-change toolposts have toolholders available that incorporate a v-groove that makes holding round-shanked tools easy, **photo 16**. For very robust tooling there are quick-change toolholders bored out to various sizes and sometime supplied with a sleeve to reduce the bore, again make sure the slit is at 90 degrees to the clamping force, **photo 17**. ■

Arc Euro Trade

The various accessories featured in this series including a wide range of toolposts for mini lathes and the featured Arc SC4-500 lathe are available from Arc Euro Trade.

Readers' Tips



Simple Myford Lever Stop



This month our lucky winner of £30 in Chester gift vouchers is Mervyn Karwot who has an idea to solve a little niggle with Myford S7 lathes.

I have always found the tailstock handle on my old Myford Super 7 to be a problem as it can fall backwards when it is released. Perhaps the design has been changed now but a simple cable tie can provide the solution if this is a problem. I used a cable tie with a strap width of 7.5mm and a head width of 12mm.

This fits perfectly around the eccentric shaft and the head provides the right amount of friction against the tailstock body. You can rotate it around the shaft to a suitable position, it is not seen from the front and it is done in seconds.

If the head of the cable tie is rotated around the shaft, it comes against the adjusting screw which acts as a stop to keep the handle from going back any further. From the top, you can hardly see the modification.

Mervyn Karwot



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

Please note that the first prize of Chester Vouchers is only available to UK readers. You can make multiple entries, but we reserve the right not to award repeat prizes to the same person in order to encourage new entrants. All prizes are at the discretion of the Editor.

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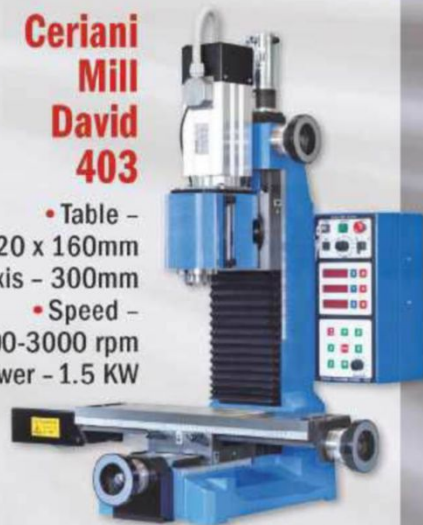
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A Secondary Hand Wheel



Stephen Bondfield replaces a standard handle with one that is more comfortable to use.



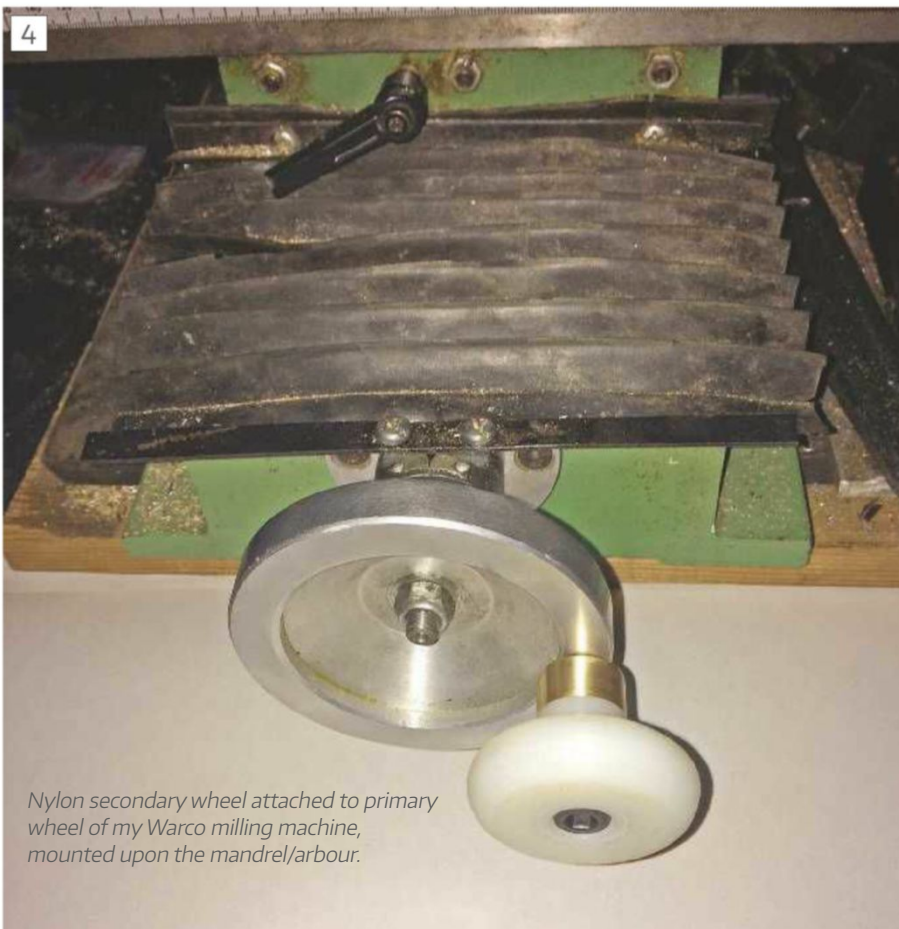
Handwheel



Original projecting handle

Readers of this article might find inspiration to improve their machine tools by making this very simple accessory that is commonly found on the steering wheels of fork lift trucks and invalid vehicles, that enables easy, rapid turning. This item provides a

definite enhancement to the purpose of moving worktables or cross slides of milling machines and centre lathes. Being a secondary, smaller, freely rotating hand wheel, it can be easily fitted to the circumference of a primary wheel by replacing the existing projecting handle,



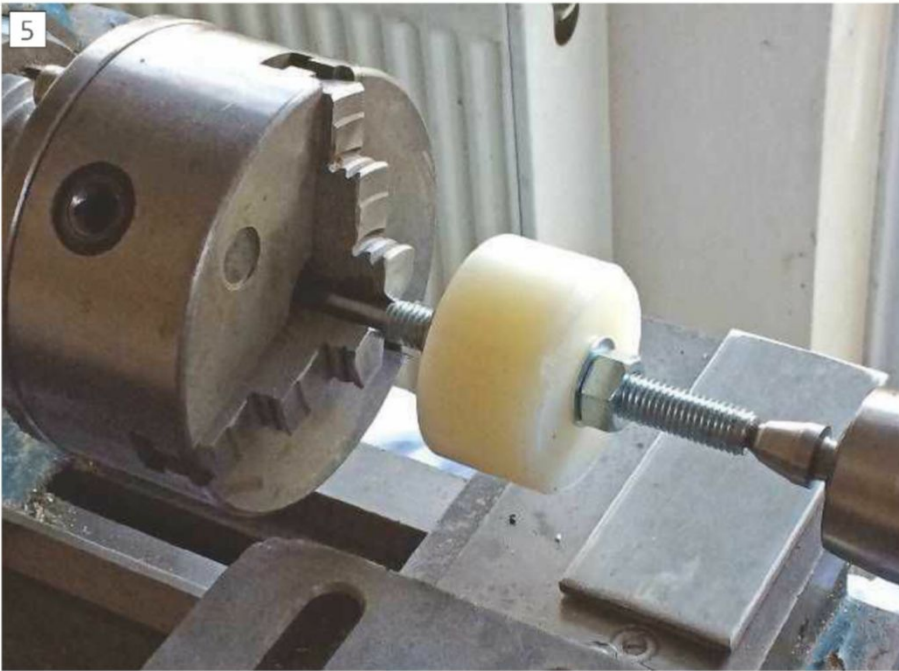
Nylon secondary wheel attached to primary wheel of my Warco milling machine, mounted upon the mandrel/arbour.



Handwheel plus handle version.

photo 1, 2 and 3.

By manually gripping this wheel and applying force against the primary wheel in the same direction of rotation, a more efficient method of causing accelerated movement is provided to those surfaces that are driven by lead or feed screws. By making and fitting a secondary wheel to my Warco milling machine, the task and effort to move the work table for any considerable length was removed and I



Bar ready for machining to profile.

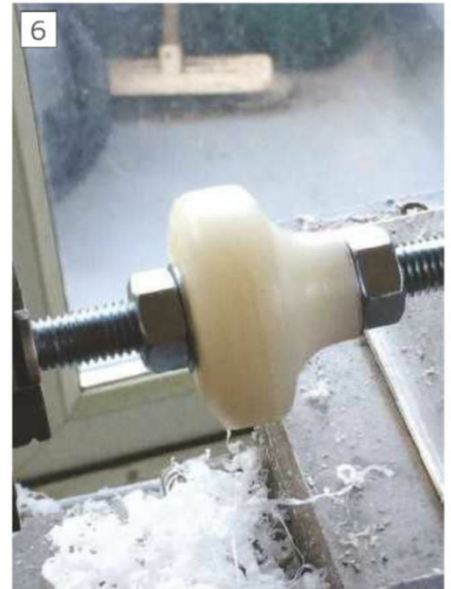
found that it was possible to propel the worktable faster and more comfortably than before, without losing the ability to make fine calibrated movements because the primary hand wheel is independently moveable, **photo 4**.

Making such an accessory is a very simple project and the wheel can be made from a variety of materials; hard wood, metal, nylon and so on. The basic objective form and profile is a matter of personal choice. Something that feels comfortable to use in the hand and which rotates freely, are the main prerequisites of the design. Obviously, the item must be strong and durable enough to enable rotation to be applied by prolonged manual force.

For these reasons I chose to use a piece of 50mm diameter, dense nylon bar 30 mm long, which I machined on a centre lathe. After facing off both ends, a 12mm hole was drilled through the centre for the entire length, and one end was counter

Something that feels comfortable to use in the hand and which rotates freely, are the main prerequisites of the design.

bored to accept the head of an 8mm socket headed machine screw. The nylon form was then mounted upon a 12mm threaded mandrel, tightly nutted down at both ends, one end of which was secured in the jaws of the three jaw chuck and the other end supported by a rotating centre in the tailstock, for the purpose of machining a profile that was to be



Machined profile, almost complete.



Completed profile, prior to fitting of central bush.

approximately one half of the diameter of the primary wheel that it would be fitted to, **photo 5**.

Using a radius tool in the tool post, I



Brass bush.



Counterbore with bush fitted.



Finished with bush and M8 screw.



Unthreaded space on 8mm attachment screw.



Secondary wheel in situ.



My hallway and machines.

Probably the most critical fitting of the entire assembly is the threaded length of the 8mm socket headed machine screw.

produced a shallow elliptical profile to the form and left a flat, 19mm wide surface on the periphery, which fitted comfortably in my right hand, **photo 6**.

The original 50 mm diameter, was further reduced down to 22 mm diameter at the other end to that which had been counter bored for the 8mm hexagon socket headed machine screw, **photo 7**.

Using a piece of 20mm diameter brass bar which had been drilled 8.2mm for its entire 20mm length, I machined a bush to dimensions for it to be a light force fit into the 12mm central hole of the nylon form of the handle. The clearance hole of the bush enabled free concentric rotation of the handle when fitted to the primary wheel. The choice of brass in the making of this component was simply from convenience, as there had been a piece of scrap lying in the tray beneath my lathe. An "Oilite" bearing or a piece of phosphor bronze would have sufficed had they been close to hand. Whichever the choice, the function is to allow free rotation without consequent wear to the malleable nylon form, **photos 8, 9 and 10**.

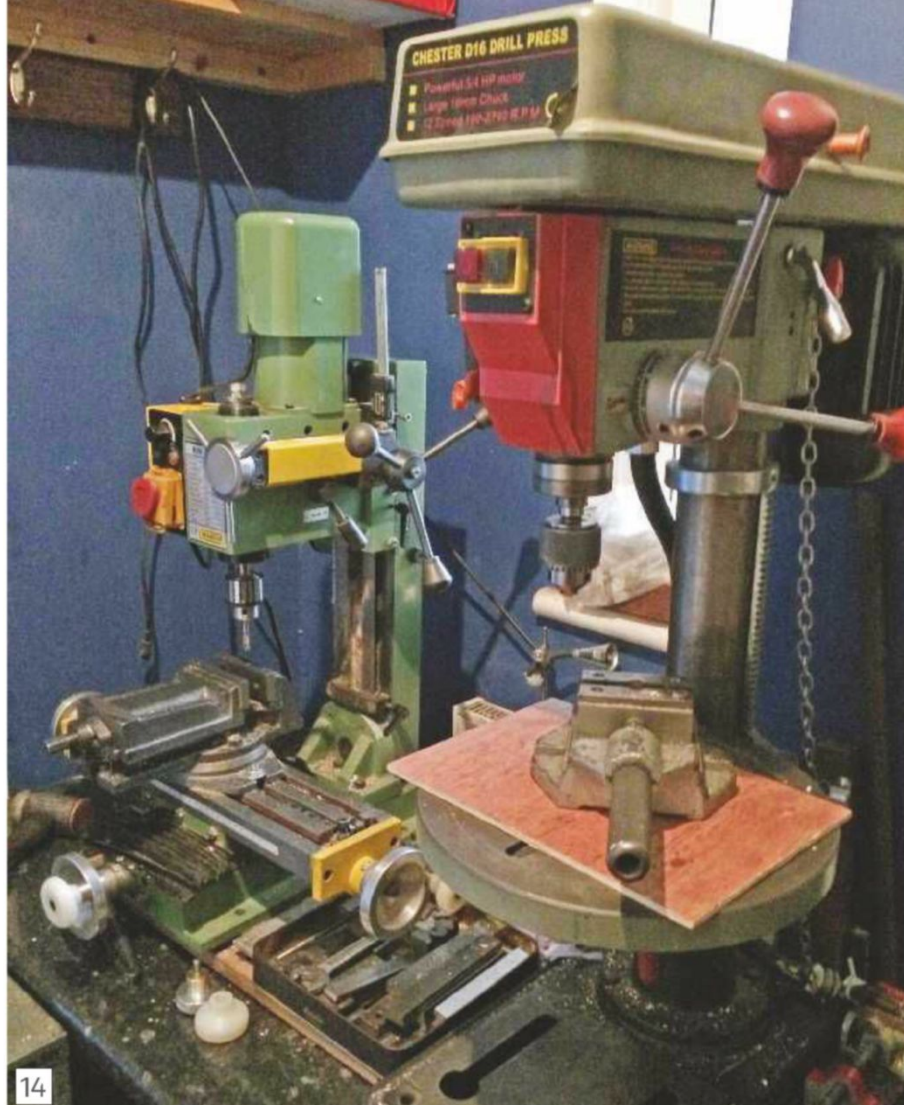
Probably the most critical fitting of the entire assembly is the threaded length of the 8mm socket headed machine screw.

Efficient function of the secondary wheel is dependent on there being a very small unthreaded space between the end of the bush and the surface of the primary

Efficient function of the secondary wheel is dependent on there being a very small unthreaded space between the end of the bush and the surface of the primary wheel...

wheel so as to allow its free rotation on the axle that is the machine screw, **photos 11 and 12.**

My milling machine is mounted on a fairly low level chest of draws next to my front door, in my hallway. After fitting this design of secondary wheel to both x and y axes, the task of moving the worktable transversely and lengthways is much easier and I am not as contorted as before, when trying to move about in such a confined space as my hallway, **photos 13 and 14.** ■



Another view of the hallway.

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Coming up in issue 283

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August's issue, number 283, will once more be packed to the gills with more great workshop articles:



Brian Wood makes a drill over 2m long!



Peter Barker on mounting chucks on taper arbours



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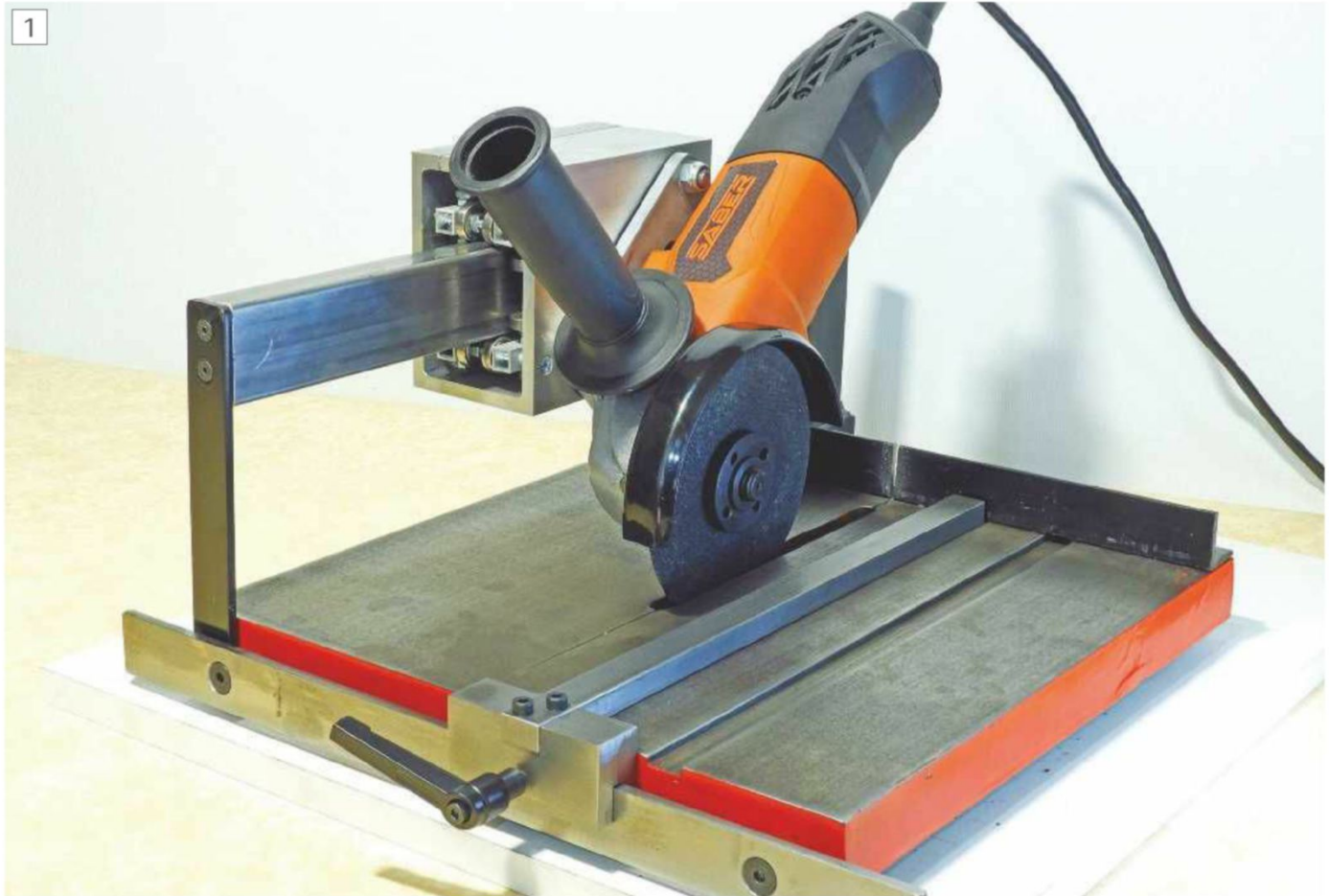
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Sliding Chop Saw

David Haythornthwaite



The finished metal cutting sliding saw

Background

I have many machines and tools in my workshop and a large proportion of them are "shop made". Whilst I have a metal-cutting horizontal bandsaw, I often find that it will not cope with some of the metal cutting jobs that are required. Particularly I have found myself cutting plate steel with a hand-held angle grinder, which was far from an ideal method.

Back to the Drawing Board Again

This project began to take shape when I found a small, cast iron, circular saw table-top being thrown on the tip. I have a table saw in my workshop (garage) which is much bigger than the item being discarded, so the garbage one was not much use to me for that purpose. However, the sliding, metal cutting chop saw, **photo 1**, began to take shape in my mind.

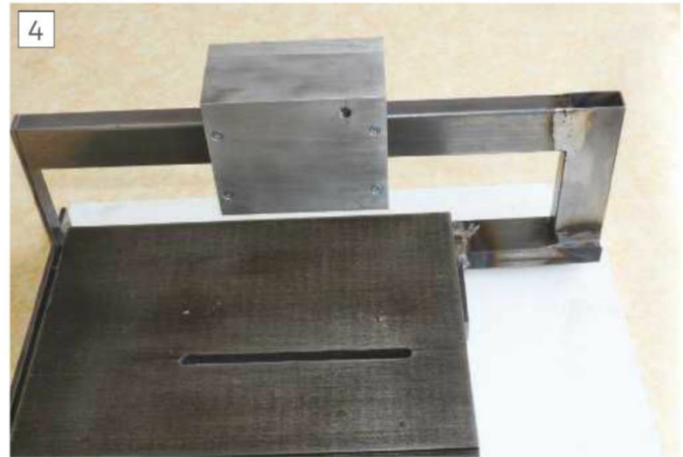
There are many items for sale, described as "chop saw stands for angle-grinders" on auction websites, but I wanted to be able



Original cast iron table 305 x 290mm



Saber' angle grinder with mounting cradle



Slide rail arrangement

to cut reasonable sizes of sheet metal and plate, not just bar stock, so it was essential for me to be able to slide the angle grinder accurately in a straight line.

The recycled saw table-top shown in **photo 2** was 305 x 290mm, and obviously it would be unlikely that other readers would find a similar item to be recycled. However, this article is not intended to be a blow by blow account of how to make an identical item but to give readers ideas as to how a similar item could be constructed. My table had a substantial cast iron surround on it, so that a slot could be ground across the top without destroying the integrity and strength of the base. In the absence of a base such as mine, a suitable base could be constructed out of angle iron and a sheet metal top, either by welding or riveting. Alternatively, the base could be made from thick ply and a steel channel rebated into it across the length of the cut line. However, this is to be constructed, it is important that there is a place for the grinder blade to cut right through the surface of the base, without setting a wooden base on fire.

The Choice of Angle Grinder

Most builders would probably utilize an existing angle grinder from their workshop, but I saw a new angle grinder in a local budget store for the unbelievable price of £18.00. It seemed to be ideal for my purposes. The name of the grinder is "Saber" and this is shown in **photo 3**.

If you are using an existing angle grinder, then you will have to design your own mounting system, but the Saber grinder has the advantage of having three positions where one could attach the handle, one on the top and one on each side. This meant that I could use two mounting points to attach a mounting bracket and use the third to attach the supplied handle which came with the grinder.

I had some aluminium channel 100mm x 50mm x 5mm thick which I had acquired when I removed a domestic elevator from my parent's house. I cut a 110mm length of this and removed one side to make an aluminium angle 100x50mm. You will see that, in photo 3, I have milled away a



Front edge of the slide rail

"window" from the 100mm side, to allow the angle cradle to fit snugly to the top of the grinder and to allow access to the on/off switch. I was pleased to find that the top of the grinder was flat, and parallel to the blade where the mounting point was situated, thus ensuring a rigid mount. The grinder handle uses an M8 thread, so the cradle was attached with two M8 countersunk bolts. The rear corner of the cradle was drilled and tapped M8 ensuring that the tapped hole was absolutely square to the aluminium surface of the bracket. A 120mm length of 8mm silver steel rod (drill rod to our American friends) was threaded in the lathe and screwed tightly into the tapped hole. An M8 Nyloc security nut was fixed to the underside to act as a locknut and there was just room to accommodate this underneath the bracket. This rod is to act as a swivel shaft to allow the grinder to swivel on the sliding rail to give the "chop saw" action to the movement of the blade.

Great thought was given to the final relative positions of the blade centre, the swivel rod and the height of the sliding rail. This paid off by eventually finding the action of the device both comfortable and practical in use. I am not including any drawings as

this tool was designed around "what was available" but, to help a prospective builder, the radial distance between the swivel shaft and the grinder spindle, is, in my case, 140mm. Please ignore the hexagonal section on the end of the swivel shaft, it just happened to be there!

The Slide Rail

The next task in the design was to decide how to slide the angle grinder back and forth and at the same time being able to adjust the height of the grinding wheel above the table. I did consider using two parallel tubes on which to slide the grinder, but I was concerned about grinding dust clogging up the sliding surfaces. I also debated whether the sliding rail should be able to hinge up and down as in a chop saw, or whether to make the sliding rail fixed, parallel to the base, and create a swivel action on the grinder as it slides on the rail to control the depth of cut. Any reader building this will have to decide what method to use according to which materials are available and the engineering facilities to hand.

For what it is worth, I considered using heavyweight ball bearing drawer slides and



Constructing the sliding carriage



Finished sliding carriage assembly

even considered using telescopic front forks from an old mountain bike, for the sliding action.

In the end, I decided to use one fixed, horizontal sliding rail exactly parallel to the baseplate. This was created from some rectangular steel tube approximately 19mm x 38mm and 1.5mm thick. This was actually an imperial measurement tube that was 0.75" x 1.5" and was left over from making a bed frame.

The actual slide rail is shown in **photo 4** and the following features are important. The swivel point for the chop saw/angle grinder is the hole in the side of the box that slides along it. As the centre of the grinder blade will be forward of this point, it is necessary for the sliding rail to overhang the rear of the baseplate if the grinder is to be able to cut steel to the back edge of the baseplate. On my machine, the useable section of the slide rail overhangs the baseplate by 80mm and the overall length of the slide rail frame is 425mm. The height of the top of the slide rail is 120mm above the baseplate and the pivot point, shown as an 8mm hole in photo 4 is 140mm above the baseplate. You will also note that my MIG welding needs a lot of practice!

I wanted to be able to easily remove



Sliding carriage enclosure

the sliding carriage from the slide rail, if required, so I constructed the front of the frame by fitting an aluminium block into the front of the rectangular tube as shown in **photo 5** and fitting a detachable support.

The final slide rail is very rigid and indeed the whole machine may be carried by using it as a handle.

Naturally, it is important to ensure that the slide rail is true to the baseplate when finally fixed. The size of the sliding carriage enclosure is 100 x 67mm and is 120mm long. It was constructed from more of the aluminium channel that was used to make the angle grinder cradle. The dimensions of my sliding mechanism were dictated by the size of my rectangular tube.

The Sliding Carriage

The sliding carriage was constructed from a length of 10mm square aluminium tubing obtained from the local DIY chain, and four pieces were cut, each 120mm long. Sixteen budget metal-shielded, deep groove, ball bearings 4x16x8mm were purchased and axles were made from 5mm silver steel, turned down on the lathe to 4mm at the ends to fit the 4mm bearings and threaded for the fixing nuts. **Photograph 6** shows one side of the carriage assembled, together with one turned axle and a second axle assembled with its two ball bearings.

Assembling and adjusting the working



Tilting mechanism fixed to the enclosure



Protractor plate to set the grinder in a fixed angular position



Cutting 1/4" plate with the grinder

part of the sliding carriage is a little fiddly but is quite straightforward. The assembly is shown in **photo 7** and it should be obvious from that, how the assembly works. Things to watch are the position of the vertical and horizontal axles. Obviously, they must be in different lateral positions to enable the axles to cross, but it must also be born in mind that, as the bearing diameter is larger than the width of the 10mm square aluminium tube, you have to be careful that the actual bearings do not touch each other as well as ensuring that the axles do not interfere with each other. To adjust the contact of the top and bottom bearings with the slide rail, the distance apart is adjusted by altering the length of the side axles. Conversely to adjust the contact of the side bearings with the slide rail, the distance apart is adjusted by altering the length of the top and bottom axles.

Once I had tested the effectiveness of the sliding carriage, it was necessary to enclose the carriage in a rectangular housing, not only to protect the sliding carriage from grinding dust, but also to give a suitable flat surface from which to pivot the angle grinder and mounting cradle. The sliding carriage enclosure is pictured as an exploded view in **photo 8** and in this picture, the top and bottom axles have been replaced by (longer) M4 x 60mm countersunk setscrews, which pass through the housing left side (away from the camera) and support the housing from the sliding carriage, which in turn, is supported by the slide rail. I hope that this is clear! Once tested for free running, absolute rigidity and lack of play, the right-hand side of the housing was attached to the left-hand side by four M3x25mm countersunk setscrews tapped through into the left-hand side of the housing.

The Tilting Chop-Saw Mechanism

The angle grinder cradle with its 8mm silver steel pivot bar as previously pictured in photo 3 is shown in **photo 9** attached to the sliding housing. The 8mm pivot bar passes through both sides of the housing thus giving two widely spaced bearings for the pivot bar. On my machine, a 10mm, flanged, wrapped steel, plain backed bush

bearing has been pressed into each side of the housing, and as those bearings are coated with PTFE, it creates a nice smooth rotating action on the pivot bar. To, hopefully, make this clear, the bushed bearings are 10mm outside diameter, pressed into reamed 10mm holes in the housing. The bearings are 8mm bore being a nice fit on the 8mm silver- steel pivot bar.

The Fixed Position Plate (protractor)

The angle grinder can be left freely swivelling, and indeed it is usually used, freely sliding along the horizontal slide rail and able to freely swivel in order to adjust the depth of cut of the grinding blade. Occasionally however, it may be advantageous to be able to cut metal to an accurate depth, in order to form a groove on the top of a metal block. I considered making the grinder swivel adjustable to defined heights, but of course we are using a cutting disk which will wear away and be a slightly different diameter each time we use it. It is therefore inadvisable to create fixed stops to control the angle of the grinder.

I therefore created a "protractor" which

screwed onto the opposite end of the swivel bar to the cradle that holds the actual grinder. Both the swivel cradle for the grinder and the protractor are locked in fixed, relative positions on the pivot shaft by M8 "Nyloc" nuts, so that both swivel plates swivel in sync with each other.

The fixed position protractor is shown in **photo 10** and was made from 1/4" steel plate. Although the sliding chop-saw was unfinished at this point, it was for exactly this kind of task that I was making the tool. I therefore used the partly finished machine to cut the protractor plate as shown in **photo 11**. It proved to work exceedingly well. You will see in the photo, the reason why the machine was designed with the lower part of the cutting disc rotating away from the operator. If the reverse was the case, the operator would be showered with sparks. The curved section of the protractor was also cut with the grinder by nibbling away at the edge of the curve and finishing off the curve on the belt sander. The curved slot in the protractor was milled out by fixing the protractor onto the rotary table, and - to give an idea of scale, the radius of the curved slot is 60mm from the pivot



The protractor plate and grinder in raised position to allow on/off switch operation



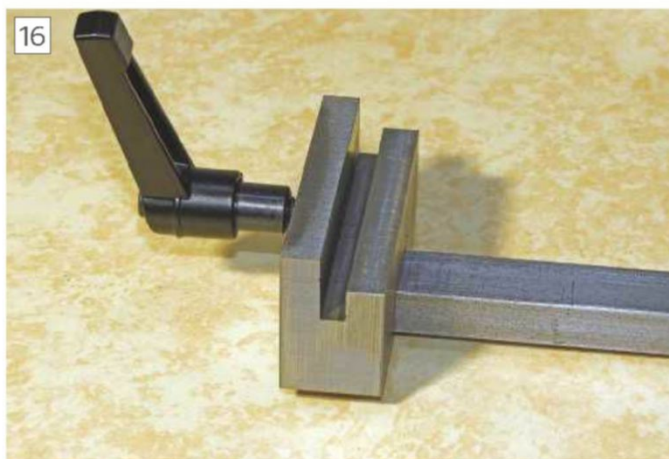
Protractor locking mechanism



Sliding mitre fence



Optional longitudinal fence



Fence clamping mechanism

point to the centre of the slot. The slot was cut with a 1/4" slot drill.

Photograph 12 shows the basic setup of the protractor on the machine. This photo shows the chop-saw locked in the raised position, where the on/off switch on my machine can be accessed. The advantage of the protractor plate being locked in the raised position, creates extra safety when starting the motor.

It is perfectly practical to dispense with the protractor, but it has various advantages, and on my machine, locking it at the bottom position, allows the rear fence to lock between the swivel plate and the angle grinder, thus preventing the grinder from traversing the horizontal slide rail when transporting the machine.

Readers will note from photo 12 that the rear fence is simply a length of 25mm angle iron bolted to the baseplate. As the cutting disc is in front of the swivel point of the angle grinder, it is imperative that the rear end of the slide rail is set back from the baseboard for the grinder to be able to cut right through the rear fence.

The knob to lock the protractor was a simple turning job on the lathe and knurled to a diamond form. However, the centre was tapped M6 and a long M6 cap head setscrew was countersunk into the knob in order that a hexagon (Allen) key may be used by those with arthritic hands, **photo 13**. It proved to be unnecessary in my case,

but is a good alternative to using security levers, and I prefer the appearance. The side of the sliding housing was drilled and tapped M6, and an M6 Nyloc nut was epoxied to the inside of the housing to reinforce the aluminium thread in the housing. A captive washer was also epoxied between the protractor and the housing to give appropriate clearance.

The Arguments for or Against a Mitre Fence

My rescued saw table already had a slot for a sliding mitre fence, so I used this to take a Picador mitre fence, which I already had for my belt sander. This is shown in **photo 14**. However, there is no need for the mitre guide to be able to slide. A static mitre fence is just as effective, because the actual cutting face can slide forward and backward. I find that I usually make an angled cut with the sliding mitre fence pressed back against the static back fence. A static mitre fence would be much easier to make than a sliding fence.

The Advantages of a Longitudinal Fence

I find that a longitudinal fence i.e. a normal circular saw type of fence is a useful addition to the metal sliding chop-saw. This is illustrated in **photo 16**, with the fence situated to the right of the saw blade. This would probably be the normal use of

the fence, but the fence could be just as easily used on the left side of the blade. **Photograph 14** shows the fence being used in this way. It is helpful to use the fence to the left, when cutting more than one part to exactly the same length.

The fence "T" bar sits on the top of a straight edge which is bolted parallel to the front of the baseplate. The T-bar has a groove milled into it so that it is a tight sliding fit onto the front straight edge. Of course, extreme care must be taken to see that, when in situ, the fence must be absolutely parallel to the travel of the cutting blade.

General Comments

I find the machine a pleasure to use. If the cutting feel is to be comfortable and smooth, I believe that it is necessary for both the sliding and the swivel mechanisms to be perfectly free of play, and this is the reason that I chose to use ball bearings for the slide and PTFE coated bushes for the swivel.

I use 1mm wide cutting discs, which cost less than £1 each at my local tool shop and they seem to last a long time. I am still using my first one!

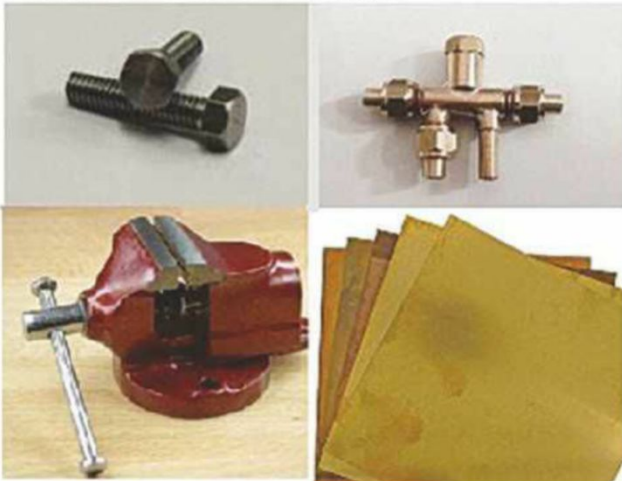
Anyone making a similar item will be using parts that they have around or can be cheaply available, so my instructions are intended as a list of ideas as to how to create your own device. I hope that readers find this to be useful. ■



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Designing a Lifting Beam

R. Finch designed a lifting beam to be installed in his garage and gives a detailed method for anyone to design and fit their own lifting beam.

Introduction

After I moved house, I lost my old workshop which was in a wooden shed but the new house had a double garage which would house my new workshop. The flat roof consisted of wooden joists, spanning the full width of the double garage, covered with corrugated steel sheeting. As the roof was steel, condensation was a problem, and the garage was always damp during cold weather. It needed insulating, but I did think about fitting a lifting beam at a later date. In order to do this, I measured the deflection of one of the beams with a known load (me) hanging from it in the centre of the beam, before insulating the roof space and lining it with sheets of plywood. Once insulated and split into two halves – one for the car and one for the workshop – I left the lifting beam as a 'future development'. Subsequently I decided to buy a milling machine which would be delivered on a pallet brought into the garage on a hand truck and left for me to unload it. This provided the spur I needed to design and install the lifting beam, **photo 1**. Whilst there are many equations in this article, it is not particularly difficult to follow the design by substituting your own values in the equations. If you are put off by the mathematics, then just have a slow read through and you should be able to follow what is going on.

Disclaimer!

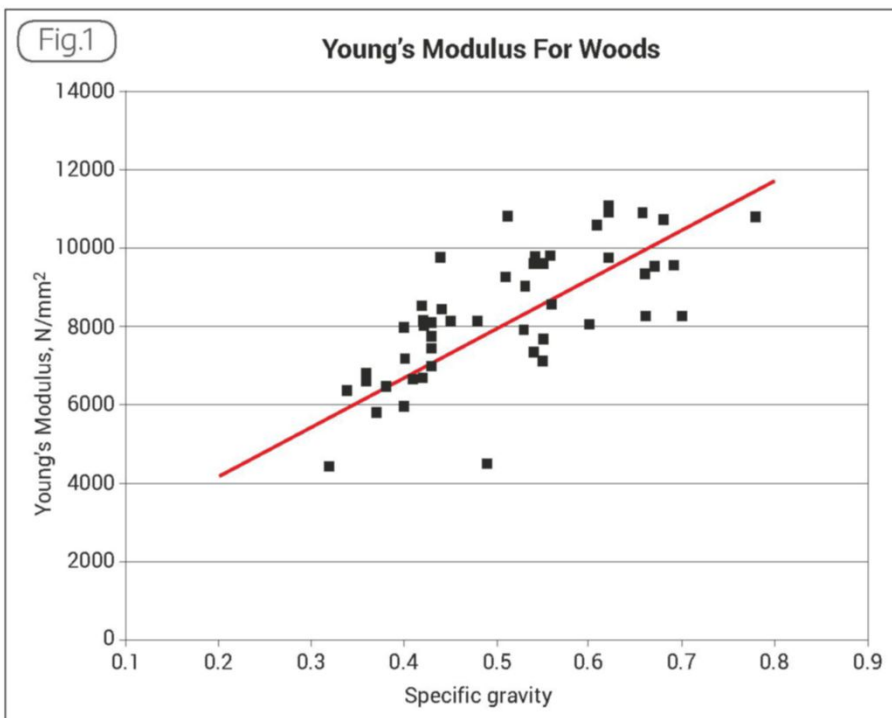
All the information in this article is given in good faith, but reliance placed upon the contents of this magazine is at the reader's own risk. You must use your own judgement as to whether you are competent to undertake any design work, if not, then consult a qualified structural engineer.

Roofing joist properties

Prior to insulating and lining the garage roof, I inspected each beam that could be used to support the lifting beam looking for knots, splits and cracks in the beams. All the beams seemed to be in good



The installed beam



condition without any significant flaws, so I insulated and lined the roof and continued building the workshop. When the time to purchase of a milling machine came, I set out to design the lifting beam, knowing that the wooden roof beams did not have any imperfections which would restrict the use of the beams despite their now being hidden from view.

As the roofing beams were wood, they would not have 'standard' properties listed in text books, as do steel beams, which could be used for calculations. I did look up values of Young's Modulus (also known as the Modulus of Elasticity) in a handbook, **ref. 1**, which gave values of Young's Modulus for softwood of between 4400 N/sq.mm and 13000 N/sq.mm, depending on the species of wood and its specific gravity, as shown in **fig. 1**. Unfortunately, all the data are based on American native softwoods, so some degree of interpretation would be required for timber used in the UK, as this may be British timber or European, depending on the purchaser of the original wood. Also, the correlation between specific gravity and Young's Modulus is too poor to permit

reliable estimation for any wood of known specific gravity. The variation of more than three to one seemed a rather wide range to allow a reasonably accurate value to be used, bearing in mind that I did not know for sure which wood had been used for the beams when the garage roof was constructed. Modern buildings tend to use wood which has been graded, so some idea of the strength can be read from the printing on the finished timber. (As a matter of interest, the European Standards for grading timber are in a tremendous state of flux – what will happen after Brexit is open to question!). As my roof beams were old (40 years) they had no markings on them. Fortunately, as I had previously measured the deflection under a known load, I could calculate Young's Modulus for the beams in my roof.

A simply supported beam is shown in **fig. 2**. This is a general case, but I used the case where $a = b$ which is a single central point load. The equation relating Young's Modulus to deflection for a simply supported beam with a single central point load is given by **ref. 2**:

Equation 1:

$$y = \frac{-F \times L^3}{48 \times E \times I}$$

where y is the deflection in mm; F is the static load in Newtons; L is the length of the beam, mm; E is Young's Modulus, N/sq.mm; and I is the fourth moment of area of the beam, in mm^4 . Don't panic at the mm to the power of 4 – all will be revealed later. This equation is a worst case one. Where the load imposed is not centrally placed, the deflection will be less than calculated for a centrally imposed load and as the equation for an offset load is quite complicated, anyone who wants to calculate the deflection produced by an offset load could always consult the original reference. For a rectangular beam set vertically on edge, the dimensions of its cross-section are as shown in **fig. 3**, and I is calculated (ref. 2) from:

Equation 2:

$$I = \frac{wd^3}{12}$$

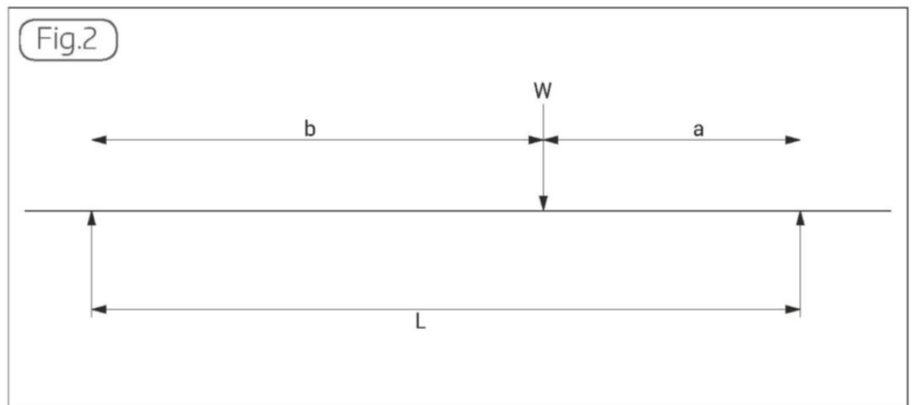
For my roof beam, I weigh in at around 81 kg, so that equates to $81 \times 9.81 = 800 \text{ N}$ producing a deflection of about 25 mm. It can be seen that w and d are both in mm, so that is where the mm raised to the power of 4 comes from. For my garage roof, the wooden beam had actual dimensions of 175mm depth by 45 mm width (a nominal 7 by 2 inch beam), so

$$I = \frac{45 \times 175^3}{12} = 20.1 \times 10^6 \text{ mm}^4$$

Equation 1 can be re-arranged to be able to calculate E (Young's Modulus) which is needed to calculate the allowable load on the beam. Re-arranging equation 1 gives:

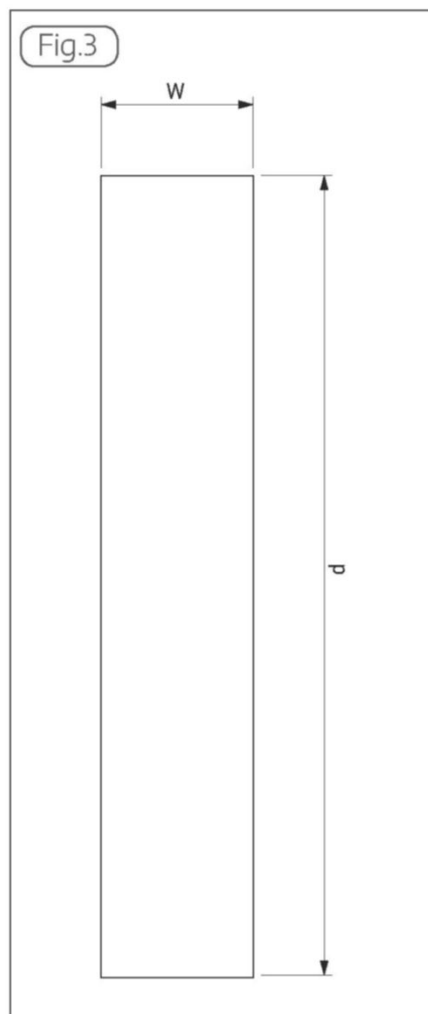
$$E = \frac{-F \times L^3}{48 \times y \times I}$$

so substituting my values of $y = 25 \text{ mm}$; $F = 800 \text{ N}$; $L = 5000 \text{ mm}$ and $I = 20.1 \times 10^6 \text{ sq.mm}$, gives:



$$E = \frac{800 \times 5000^3}{48 \times 25 \times 20.1 \times 10^6} = 4146 \text{ N}^2$$

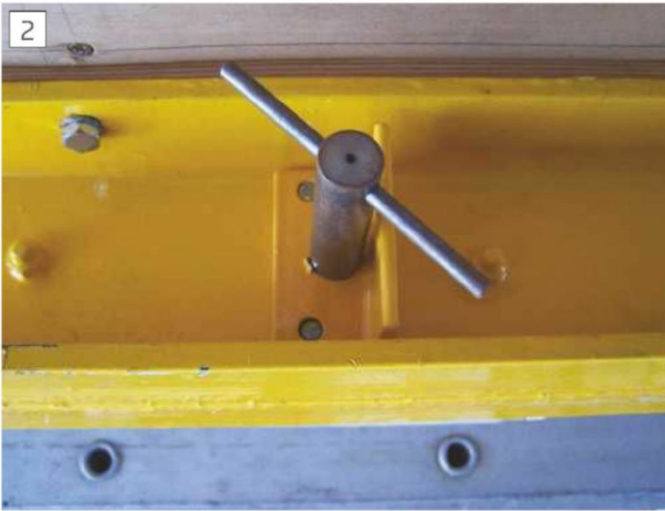
This is just under half the mean value of 8317 N/sq.mm and just less than the minimum value from the data quoted in ref. 1, so this left a question. To use my calculated value or the literature values? It can be seen that the most difficult figure to determine in the deflection test was the actual deflection – the load (me) could be determined from the bathroom scales, and the other dimensions could be measured quite easily using a steel tape measure. The deflection under load was more difficult – trying to measure a gap between the beam and the top of a vertical pole held close to the beam was quite prone to errors, but if I had over-estimated the deflection (quite likely), then the value of Young's Modulus would be too low and the values would be safe. I decided that, since my value was less than the published data, I would use my data.



Assumptions

The two equations above are based on certain assumptions. These are that the beam is homogeneous and has the same Young's Modulus in tension as compression; the beam is straight or at least that the maximum out-of-straightness is less than 10% of the beam's depth; the cross section is uniform; all loads are perpendicular to the axis of the beam and lie in the same plane; the beam is long in proportion to its depth; the beam is not excessively wide; and the maximum stress does not exceed the elastic limit.

Looking at these in detail, wood is certainly not homogeneous, but as the Young's modulus quoted in ref 1 is measured along the length of the beam, it does apply to a roof joist so this assumption is not entirely invalid. The roof beams in the garage roof actually are almost perfectly straight – in fact, only one beam (not used for the lifting beam) was visibly distinctly warped, but the total distance out-of-straight was only about 25 mm in the length of 5 metres, so this assumption is valid. The assumption that the beams are of uniform cross-



The end stop to limit trolley travel



The trolley at the stop – between two of the mounting screws (circled)

section is valid as the beams are machine sawn from the tree, so they are of constant cross-section, within 1%. With regard to the assumption that all loads are perpendicular to the beam and lie in the same plane, the beams actually slope at 1 in 100, so this assumption can be taken as being acceptable as the error is very small. The beams are long with respect to their depth, being 5 metres long and only 175 mm deep, a ratio of just over 28:1. According to ref 1, for timber beams, this ratio should be at least 24:1 and for steel beams at least 8:1 for Equation (1) to be valid. This assumption is therefore valid for the original test beam spanning the full width of the double garage. The assumption that the beam is not excessively wide is also valid, as the width of the wooden beam is only just over 1/4 of the depth. Finally, the assumption that the elastic limit is not exceeded is also valid, providing that the stress is kept at a low value. This assumption is valid as will be shown later. Note that loading a beam with a length to depth ratio of less than 24:1 and measuring the deflection to determine Young's Modulus for the beam will result in an erroneously high value, giving the impression that the beam is stronger than it is in reality. As a simplistic explanation, a beam that were only as long as it were deep would clearly fail by crushing rather than by bending, as it would be too rigid to bend. The error in using a beam of more than 24:1 is negligible.

Design Loading

I decided that the lifting beam would be designed to split the load between at least two adjacent roof beams, by using a removable stop on the beam, **photo 2**, to limit the trolley movement so that it was always supported by at least two beams (**photo 3** – the screws securing the beam to the roof beams are circled). Since the trolley would always spread the load over at least two roof beams, the load could be equally divided between just two of the roof beams. The roof beam spacing is 400 mm, so each roof beam would only have to take the equivalent of 400 mm of the steel joist acting as the runway beam. As the ceiling in the garage was only 7 ft high and I am over 6 feet tall, I decided that using a 175 mm x 100 mm steel joist as the runway beam would leave very little clearance above my head, particularly if a trolley were used. Therefore, I decided to use a pair of 100 mm x 50 mm channels back-to-back to make the equivalent of a 100 mm x 100 mm universal column. Universal columns this size are made, but are difficult to obtain – the only stockholder I could find who had any in stock would only sell me a full length column of 12 metres – far too long, too heavy and too expensive for my purposes. The 100 x 50 channels weighed in at 10 kg/m, so a 400 mm length of two channels together would equate to 8 kg. I bolted the two channels back to back with M8 grade 8.8 bolts spaced at 170 mm centres.

I had already decided that the maximum load that should be lifted would be 250 kg. There is, of course, the lifting tackle itself to be considered. The trolley weighed in at 7 kg, and the chain block weighed in at 20 kg. Thus, if the load were to be split over

two wooden beams, then the load on one beam would be $250/2 = 125$ kg for the load, 27 kg for the lifting tackle and 8 kg for the steel beam itself. Therefore, the design should be for a single point load of $125 + 27 + 8 = 160$ kg. This equates to a load of $160 \times 9.81 = 1569.6$ Newtons, say 1570 N for simplicity, acting at the centre of each roof beam.

Deflection calculation

Based on the calculated value of Young's Modulus, I decided that if I halved the span of the beam by building a supporting central wall in the garage, the span would be only half the original span, so the deflection would only be 1/8th of the original deflection. Equation (1) can be used to determine the deflection under the design load.

$$y = \frac{-1570 \times 2500^3}{48 \times 4146 \times 20.1 \times 10^6} = 6.13 \text{ mm}$$

which is quite acceptable, since the value of Young's Modulus I used is below that of published data thus making the calculated deflection a worst case. In practice, the deflection was not noticeable when lifting the milling machine at 110 kg.

Maximum stress

The maximum allowable stress in bending for timber is a complex subject in its own right and depends on the expected life span; the quality of the timber itself bearing in mind the effect of knots, shakes and splits; and the ambient conditions to which it is exposed. Taking some data from ref 1, the values for the design stress in bending for a 10 year life varies from 9.3 N/sq.mm up to 19.7 N/sq.mm for the highest quality. As these figures are based on American species of timber, I decided to opt for the safe design and go for the lowest value and take a maximum design stress as 9 N/sq.mm.

The stress in the timber under load can be calculated from the maximum bending moment using an equation given in ref 2. For a straight beam under a single central load the maximum bending moment is given by:

Equation 3:

$$M = \frac{F \times L}{4}$$

so substituting in the values for the beam gives:

$$M = \frac{1570 \times 2500}{4} = 981250 \text{ N.mm}$$

and the maximum stress is given by the equation:



The timber uprights for the wall

Equation 4

$$s = \frac{M \times e}{I}$$

where e is half the beam depth, so substituting gives:

$$s = \frac{981250 \times 87.5}{20.1 \times 10.6} = 4.07 \text{ Nmm}^{-2}$$

As the lowest design stress level in bending is 9.3 N/sq.mm, the stress in the roof beam is less than half this value, so is acceptable and the beam design is satisfactory. As the stress is less than half the maximum allowable stress, it can be taken that the loading does not take the beam out of the elastic range, satisfying the previous assumption. However, there is the possibility that the beams might buckle sideways under load, but there are ways around this. Firstly, in my case, the beams were constrained to be vertical at both ends by being embedded into the top two rows of the bricks of the garage wall, so would be held more rigidly than if they merely sat on the top of the wall. Secondly, there is a decking fastened to the top of the beams consisting of stringers which support the steel sheets and there is the plywood sheeting fastened to the underside of the beams. Both these will have some restraining effect on the twisting and buckling of the beams and since the beams are loaded well below their maximum permissible stress, buckling is unlikely when the lifting beam is in use.

Centre wall support

Having decided that using half the width of the garage as a maximum length for the beam, the support in the centre of the beam has to be designed. I decided that since I was to split the garage into two rooms, the centre wall could be used to support the centre of the whole roof beam. As the load on the beam has been calculated to be 1570 Newtons, the centre wall has to take half of this, which is 785 N. As the lifting beam spreads the load over at least two of the roof beams, the load on a single upright would be one quarter of the total load of 1570 N. I built the wall as a series of uprights secured to a batten on the ceiling and one on the floor, **photo 4**, and then clad both sides with 9 mm plywood including a damp proof membrane and some glass fibre insulation. Each upright was located directly under a corresponding roof beam. Note the printed grading marks on the uprights in photo 4. The damp proof membrane and plywood covering being installed is shown in **photo 5**.

Having decided that the part load was to be supported by the wall upright in photo 4, the ability of the wooden upright to take the load needed investigating. Taking the worst case that the upright itself takes the full load (i.e. the plywood surface is non-load bearing) and assuming that the ends are freely rotating (they are actually fixed into slots routed into the horizontal battens) being the worst case, there are two cases to consider. Firstly, there is the crushing load which would compress the wood to failure. Reference 1 provides a series of data, again for native American softwoods, with values of between 16 N/sq.mm and 49 N/sq.mm. As the upright had actual dimensions of 42 mm x 69 mm (a nominal 3 inch by 2 inch), and the imposed load is half that of the end of each beam i.e. $785/2 = 392.5$ N, say 400 N, the actual crushing stress will be $400/(42 \times 69) = 0.138$ N/sq.mm, less than 1% of the minimum value, so crushing as a failure mechanism can be discounted.

The next consideration is lateral instability of the column, which results in buckling of the upright column. The Wood Handbook (ref. 1) suggests that Euler's formula is suitable for slender vertical columns, which are columns where the column buckles before the compressive stress exceeds the proportional limit. This is the worst case for loading. Euler's formula is quoted as:

$$\frac{F}{A} = \frac{\pi E}{\left(\frac{C}{r}\right)^2}$$

where C is the height of the column and r is the radius of gyration. For a rectangular beam r is equal to the least dimension of the cross-section divided by the square root of 12, i.e. $r = d/\sqrt{12}$.

Substituting in the values for the column, d is 42 mm, so $r = 42/\sqrt{12} = 12.12$ mm; the cross-sectional area of the column is $42 \times 69 = 2898$ sq.mm; and the length is 2100 mm; so the maximum permissible end load for the column is:

$$F = \frac{2898 \times \pi \times 4146}{\left(\frac{2100}{12.12}\right)^2} = 1257 \text{ N}$$

which exceeds the design imposed load of 400 N per upright by a factor of three. Consequently, the upright is adequate for the task. In fact, the upright will be able to take a greater load since the column alone would tend to buckle along the line of the wall as the column is thinner in that direction. As the plywood wall has been screwed to the upright, it will be more constrained in that direction, so would in all probability buckle in a direction at right angles to the wall if seriously overloaded. However, the effect of the plywood cladding on increasing the buckling potential of the wall cannot be reliably predicted – only where the ply is glued onto the upright could any practical increase in load be calculated.

Securing the lifting beam

The lifting beam now needs to be secured to the roof beams.

I decided that, since I had already insulated the roof and put a plywood ceiling in place, it would be a last resort to use steel angles to attach the lifting beam to the sides of the roof beams using bolts through the roofing beams, as it would require removal of the ceiling and its re-installation with all the difficulties of fitting the plywood ceiling around the angles. The simplest option was to use woodscrews or coach screws (lag screws in the US) to fasten it to the ceiling, **photo 6**. This is better than it sounds. I investigated the pull-out force required for screws screwed into softwood at right angles to the grain. Again, data was available from ref. 1 but this required the specific gravity of the wood to be known. As I could not very well take a beam out and weigh it to determine the specific gravity, I measured the specific gravity of a separate similar softwood joist that I used as a decorating plank. The specific gravity worked out at 0.42.

The steel channels fastened back-to-back forming the steel lifting beam would be far stiffer than the wooden beams, so the steel lifting beam would distribute the load to at least two wooden beams, so each wooden beam would take a maximum of 50% of the static load at any point on the runway beam. Since the two channels would be back-to-back and fastened to each wooden beam by two screws, any one screw would take 25% of the point load of 1570 N, say 400 Newtons per screw. The pull-out force according to ref 1 is given by the equation:

Equation 5

$$p = 108.25 \times G^{\frac{3}{2}} D^{\frac{3}{4}} H$$

where p is the pull-out load, N; G is the specific gravity of the wood; D is the shank diameter of the screw; and H is the length of penetration of the threaded part of the screw. I decided to use standard M8 x 70 mm coach screws to secure the beam. It is recommended that for softwood, the screw is threaded into a pilot hole which is 70% of the core diameter of the screw. The screw had a core diameter of 5.6 mm, so the pilot holes would be $5.6 \times 0.7 = 3.9$ mm. The screw would penetrate into the beam a distance of 50 mm, so substituting into equation 5 gives:

$$p = 108.25 \times 0.42^{1.5} \times 8^{0.75} \times 50 = 7008 \text{ N}$$

which provides a factor of safety of $7008/400 = 17.5$ times against pull-out. However, the screw strength must also be considered. In general, the lowest grade of steel bolts is grade 4.6 which have a minimum ultimate tensile strength (UTS) of 400 N/sq.mm and a yield of 60% of UTS. Such bolts can be loaded generally to a maximum of 40% of the UTS or 2/3rds of the yield strength. As the coach screws were not marked, the allowable load is likely to be equivalent to a grade 4.6 bolt. A screw with a root diameter of 5.6 mm has a cross-sectional area of $\pi 4 \times 5.62 = 24.6 \text{ mm}^2$ so can withstand a load of $24.6 \times 0.4 \times 400 = 3936 \text{ N}$ which is less than the pull-out load, so the screw will fail in tension before being pulled out. As the maximum load is 400 N, the safety factor against screw failure is $3936/400 = 9.84$ which is satisfactory. As a comparison, if the unmarked screw were to be made of basic EN1A steel (230M07), then the UTS would be 460 N/sq.mm which is more than that of the grade 4.6 bolt. Also, Tubal Cain (ref. 3) states that coach screws are made of mild steel with a UTS of 430 N/sq.mm. Hence the use of unmarked coach screws can be deemed acceptable.

However, as always, there are caveats with the use of coach screws in wood (ref. 1). Firstly, it is recommended that the screw is located at least 1.5 times the screw shank diameter from the edge of the wood. In this case, the screw is 8 mm diameter, so the minimum beam width would be $3 \times 8 = 24$ mm and the beam is 45 mm wide which is acceptable. Secondly, two adjacent screws should not be installed closer than 4 diameters apart. With 8 mm screws, the minimum spacing should be $8 \times 4 = 32$ mm and since the steel lifting beam is 100 mm wide, the screws can be inserted into holes drilled with their centres 10 mm in from the edge of the steel web, they would be 10 diameters apart thus satisfying the second condition. Therefore, the beam can be attached to the roof beams by M8 coach screws.

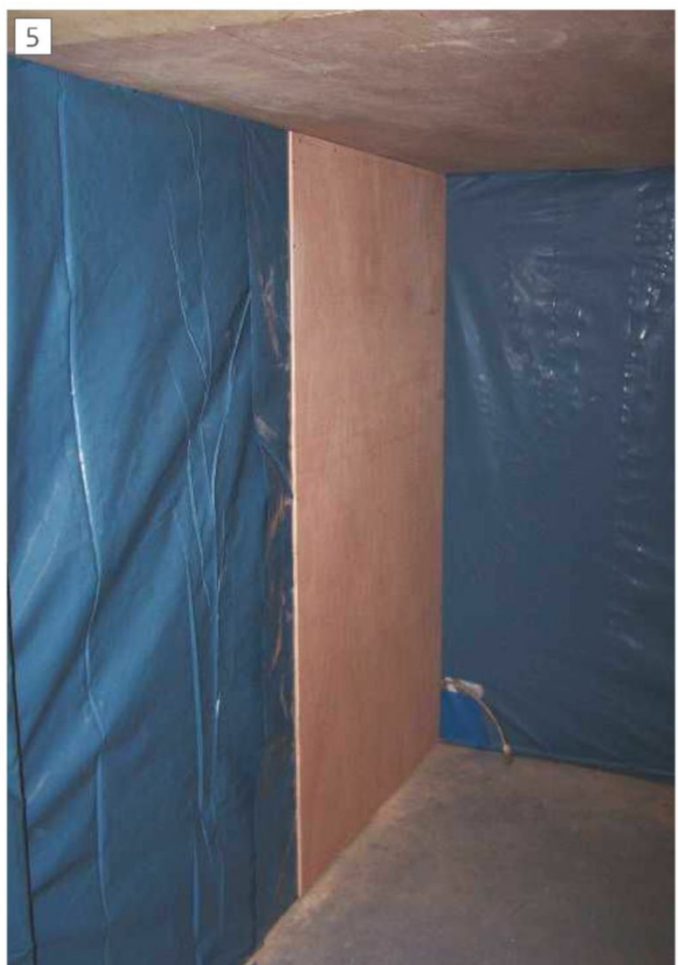
Installing the beam

The lifting beam, being steel, is heavy amounting to 36 kg and being 1800 mm long, so it is quite unwieldy. Ideally, it should be lifted into place using a lifting beam (!), but I had to devise a single-handed operation to do this. Firstly, as can be seen in photo 1, I used a length of 10 mm thick wood to fit between the top of the beam and the underside of the ceiling with a groove cut to allow for the plastic joining strip used to join the edges of the plywood ceiling together. I drilled this as a template for the pilot holes into the roof beams and used this to transfer the hole spacings to the steel lifting beam. The lifting beam was then drilled to match. The template was screwed to the ceiling allowing the lifting beam to be positioned correctly so that the holes in the lifting beam coincided with the pilot holes drilled for the coach screws.

As I had to work alone, I arranged two pairs of step ladders to face each other, spaced just less than the beam length apart. This allowed me to put the steel beam onto the first step at one end and lift the other end onto the first step of the other step ladder. Then each end was lifted in turn onto successively higher steps until it was on the safety rail at the top. This was then sufficiently close to the ceiling to allow one end to be lifted up and two coach screws driven in sufficiently far to take the weight of one end of the beam. The other end was treated in the same way, and once in place, all the remaining coach screws were screwed in and tightened just enough to secure the beam firmly in place.

A Safety Note

If you install a beam such as this, remember to keep a copy of your calculations and mark the safe working load of the beam on a suitable label fastened to the beam, along with the date of installation. That way, you will not forget what the safe load is. It is a good idea to remember that a layer of lying snow on the roof will increase the load on the roof beams, so it would be inadvisable



The damp-proof membrane and plywood lining

to use the lifting beam when fallen snow is present on the roof. Similarly, pools of water on the roof due to poor drainage will also increase the static load on the roof beams. Also, if you ever sell the house (inevitably, either you or your executors will sell the house) the purchaser will know exactly what the beam safe working load is. The new purchaser may not need to use the beam, but at least you will know that no harm will come to anyone through ignorance of the load capacity. In my case, I added a notice to the dividing wall to the effect that it was an integral part of the lifting beam support, so should not be removed unless the lifting beam were removed first.

Conclusions

A method of designing a safe attachment method for a lifting beam to substantially horizontal wooden roof beams is described.

A practical experimental method is given to establish the Young's Modulus of timber beams.

A design method is given for calculating the allowable load on a timber beam, the deflection and the maximum stress.

A design method is given for determining the allowable load for a vertical timber column to prevent failure by buckling or lateral instability.

The safe loads for coach screws into wooden beams are given along with the minimum spacing required. ■

Nomenclature:

- A column area, sq.mm
- C height of column, mm
- D Shank diameter of screw, mm
- d depth of beam; least dimension of cross-section; mm
- E Young's modulus N/sq.mm
- F Static load, N
- G Specific gravity
- H Length of penetration of the threaded part of the screw shank, mm
- I Moment of inertia, mm⁴
- L Length of beam, mm
- M bending moment, Nmm
- p Pull-out load, N



The M8 x 70mm hexagon headed coach screws

- Q Allowable load, N
- r least radius of gyration, equals $d/\sqrt{12}$
- w width of beam, mm
- y Deflection, mm
- σ_s allowable compressive stress; maximum stress in bending

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- **South Cheshire**
John Arrowsmith visits the South Cheshire MES and hears about their plans for a track extension.
- **Beam Engine**
David Haythornthwaite tackles the rather tricky job of machining the connecting rod.
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Taming the 'Universal' Tool and Cutter Grinder

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

I always planned to make some form of tool grinder. There are three types available for the model engineer to construct, Quorn, Stent and Woden but will take a lot of time to. All will do a good job and while all have their deficiencies, owners will champion them. The Quorn is the cheapest at about \$400 which now only seems to be available from the USA. For the Stent, a set of castings casting will now cost in the order of £500. The Woden, a modification of the one designed and used by the late great George Thomas, costing about £450 if you include all the accessories. Finally, there is the Chinese "Universal tool and cutter grinder". A Google search will show many examples of these, and two examples are sold by RDG and Chronos, (there will be others). These range in price from £500 to £900, but there shouldn't be any tool making involved with one of these (or so I thought). At an auto jumble, I discovered a very cheap version of this machine with an initial asking price under £300 and after a lot of bartering, a deal was struck, **photo 1**.

The machine proved to be very capable for lathe tools, but "Universal" as purchased it is certainly not. They are originally designed for the grinding of single point engraving tools. Many



The grinder showing some of the new gear.

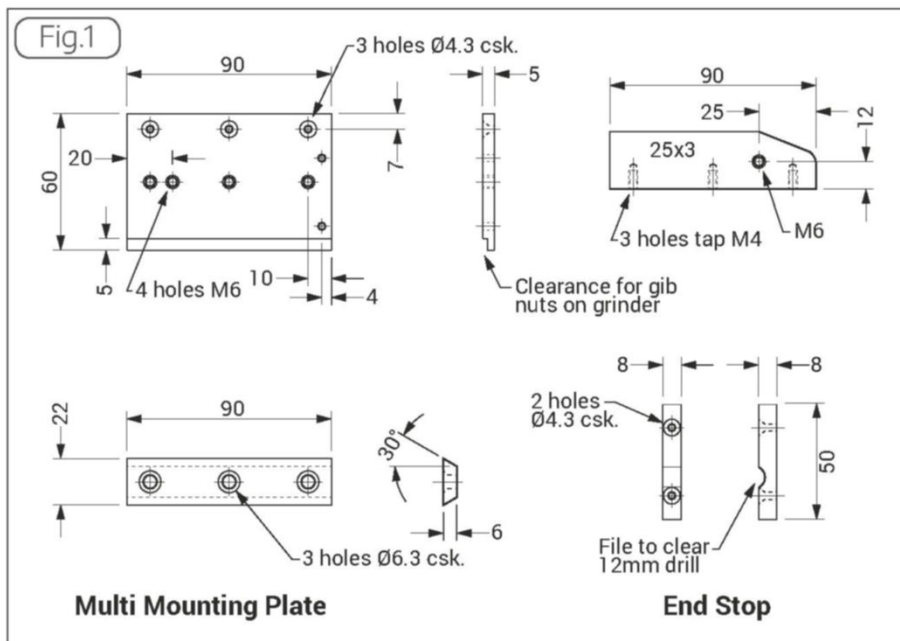
forums state that this type of machine is useless for multipoint cutters such as end mills, slitting saws and four-facet drill grinding so should be avoided. I intend

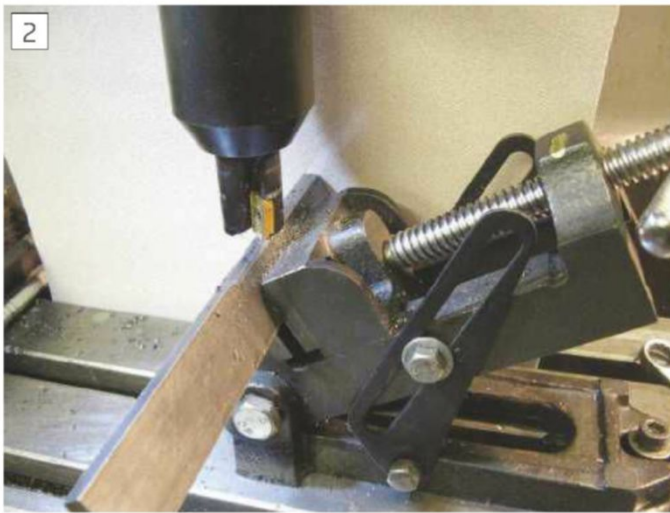
to show you that this is not the case, and a series of very simple additions and modification to the machine will enable all of these cutters to be sharpened with ease. Another advantage is that most of the tool setting can be done off the machine with the employment of simple setting jigs.

On getting the machine home, the reason for the low price became obvious. A number of the parts had very poor standards of fit, but after a bit of work which I won't bore you with, these problems were soon solved. This transformed the machine, but it still wasn't "universal". Incidentally, the machines seen at exhibitions by the firms indicated above have a quality which significant order of magnitude better than mine, and I have viewed them with sadness because in comparison, mine was rather cheap and poor (not now), so don't be put off by my problems.

The machine as supplied has a good range of work heads:

- 1) Universal head with built in indexing and a resettable degree scale
- 2) End mill grinding attachment with a top mounted tool rest and a long





Milling the first side of the dovetail bar



Checking the fit of the ER 20 collet

sliding portion for the cutter to move. For a long time, this was not used, I thought it was useless and the tool rest was in completely the wrong place, but now it's great!

- 3) A holder for square lathe tools this again was not used much as the tools had to be removed and replaced at times.

One frustration was the gib strip always dropped out onto the floor when changing the work heads, so a long loose fitted retention pin was fitted. Drill through the casting and the gib then ream 1/8" or 3mm between the gib screws and into one of the work heads. Ream the hole, then remove the gib and glue a pin at least 25mm long into it with Loctite or similar retainer, then enlarge the hole in the casting to provide ample clearance on the pin. Anybody having a machine of this type is no beginner, so I'm not giving a blow by blow account of manufacture, just the critical points.

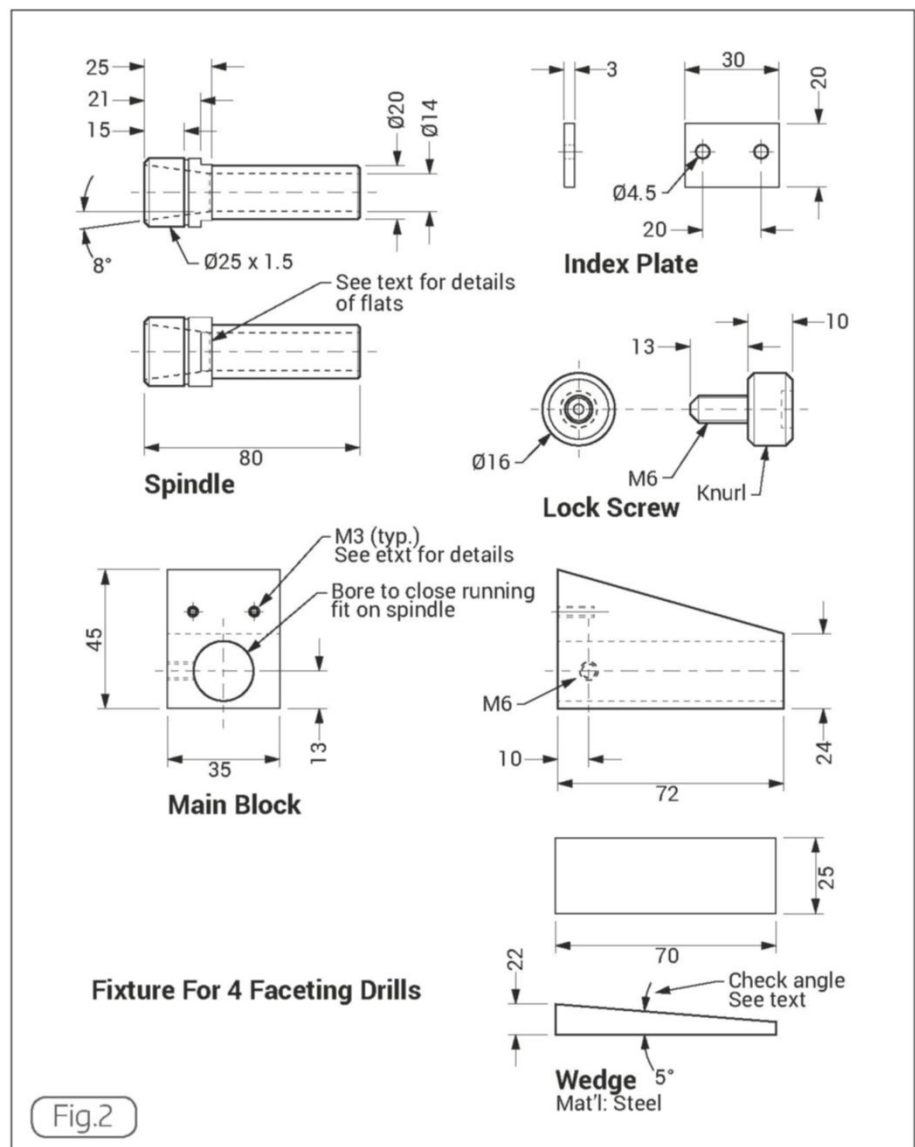
For lathe tool grinding, I mainly use 8mm square tools. They are perfectly adequate for reducing 25mm stock to nothing in two cuts on my Myford and are even used for all but very heavy roughing on my Colchester Student. To enable these to be ground, I have a 3/4" diameter holder with a square hole in the centre. This was made from a piece of 25mm diameter stock about 160mm long slotted 8.2mm wide (for tool bit clearance) along its length in the mill to a depth of 16.5mm. Saw in half and braze together ensuring correct alignment. Mount and centre an 8mm square bar in the four-jaw, centre the end for tailstock support. Tap two M5 holes at right angles, true to the central hole in the embryo holder which is secured to the mandrel with the grub at the headstock end along with a smear of nut lock to stop rattling at the tailstock end. Later, these holes will provide the clamping for the tool bit while being ground. Now it's an easy matter to turn the outside diameter to 0.748", to fit the R8 collet, skim the end, reverse and face the other end. Smaller tool bits can be

used with two appropriately sized packings, e.g. 1mm x 8mm for 6mm tool bits.

Multi use mounting plate

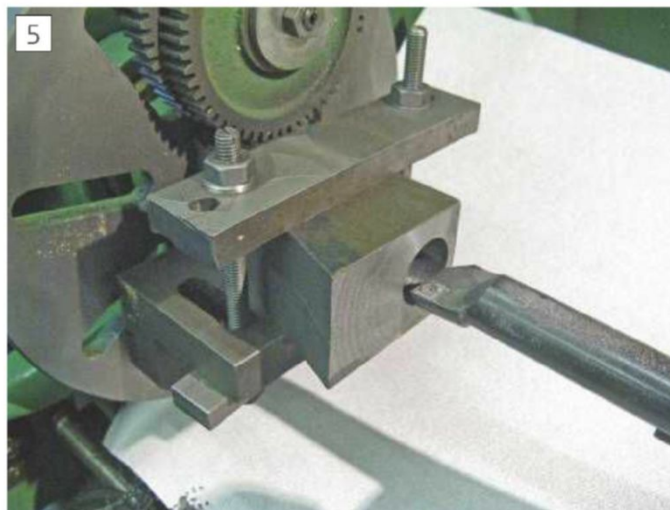
The centre of my system is a new plate to hold the new components, **fig. 1**. The plate is cut from 6mm plate, initially oversized.

Start with the dovetail bar. We don't need tremendous accuracy of manufacture here, there's plenty of leeway with the gib, and any slack will be taken up by the clamp screw. We are not using the dovetail as a slide; it is just for location and does not move in use. Carefully measure the dovetail





Screw cutting diameter 25 X 1.5mm



Boring the mounting block to 0.75"



The setup for fixing the indexing plate, drill both pieces tapping size then open up clearance, 4mm deep to the drill lip without unclamping.



Components for drill and slitting saws.

angle, mine was nonstandard. Machine the bar to be parallel and of the correct width for your machine. Set up an angle vice and end mill one of the angles, or angle the mill head, **photo 2**. Ensure you leave a short witness of uncut material about 1mm wide on the pointed edge of the dovetail; we will need this as a machining reference later. Invert and rough out the other side. Take it out of the vice, but under no circumstances should the vertical feed of the mill be changed. Use two bars of silver steel and measure the width of one of the original work heads and repeat this for the bar while clamped to something flat, which will tell you exactly how much to remove to get a fit. Be careful to remove the material from the non witness second side. Screw to the top plate with countersunk cap screws in the bar, check it fits in the machine and modify as required.

Now we finish the multi plate parallel with the dovetail bar. Set the dovetail bar flat on a parallel in the mill vice and mill round the edges of the top plate. Prepare and fit the edge fence with three small

countersunk cap screws. The pillar at the front is for mounting the slitting saw detent assembly, but I tend to leave it on as it makes a good handle. Fix the end stop on the back edge, the gap is there to enable screwdrivers or even chisels to be clamped in place for grinding.

Four facet drill grinding.

I won't go into the benefits of using four facet drills, this has been covered many times before, but I can honestly say their functionality is quite amazing.

The task is easily achieved with the use of ER20 collets in a dedicated holder. The collets will enable the holding of drills from about 3mm up to 13. Anything bigger has pilot holes and for me, a four facet point is not really needed. For smaller drills I use Derek Brown's diamond sharpening system. Any four facet grinding can only be achieved when one can constantly check the state of the grinding, so it will need to be easily removed, inspected and replaced back in exactly the same position.

Start with the collet chuck itself, **fig. 2**.

Use a piece of bar 85mm long of diameter to finish at 25mm. Mount in the four-jaw, face and centre the end for tailstock support and turn the diameter to 3/4" with a fine finish. I did mine to 20mm, but the imperial size will be more useful as it can be held in the standard R8 collet and will be useful in the mill so aim for 0.749" for running clearance. Reverse in the four-jaw chuck with shim protection and push it in as far as it will go and set it very true with the DTI (mine was ok in the ER 32 chuck). Drill the clearance hole to about 14mm, then skim the outside and turn boss to 25mm diameter. Make this too long for now to give plenty of space for juggling the angle when boring for the collet.

Set the top slide over to 8 degrees and bore a socket just deep enough to enter the socket about 10mm. This will allow you to test the angle and adjust as required. A simple wiggle test will soon let you know if the angle is too steep or shallow, this sort of angle setting can be frustrating! Final testing is done by putting micrometer blue in the socket, then pushing the collet in and giving

it a slight twist. Don't let it rock. Any adjustment in the contact will be obvious. As an alternative, if you have an existing ER chuck for the lathe, the top slide can be pre-set at the angle using the dti in existing socket before commencing work on the screw thread. This is what I did, and the result was right first time, **photo 3**. When the angle is correct, face the end until the end is 25mm from the shoulder of the $\frac{3}{4}$ " shank then re-bore the socket and so that the collet projects 11.5 - 12mm from the face of the embryo holder. Doing it this way gives you plenty of margin for error.

Screw cut the thread to 1.5mm pitch,

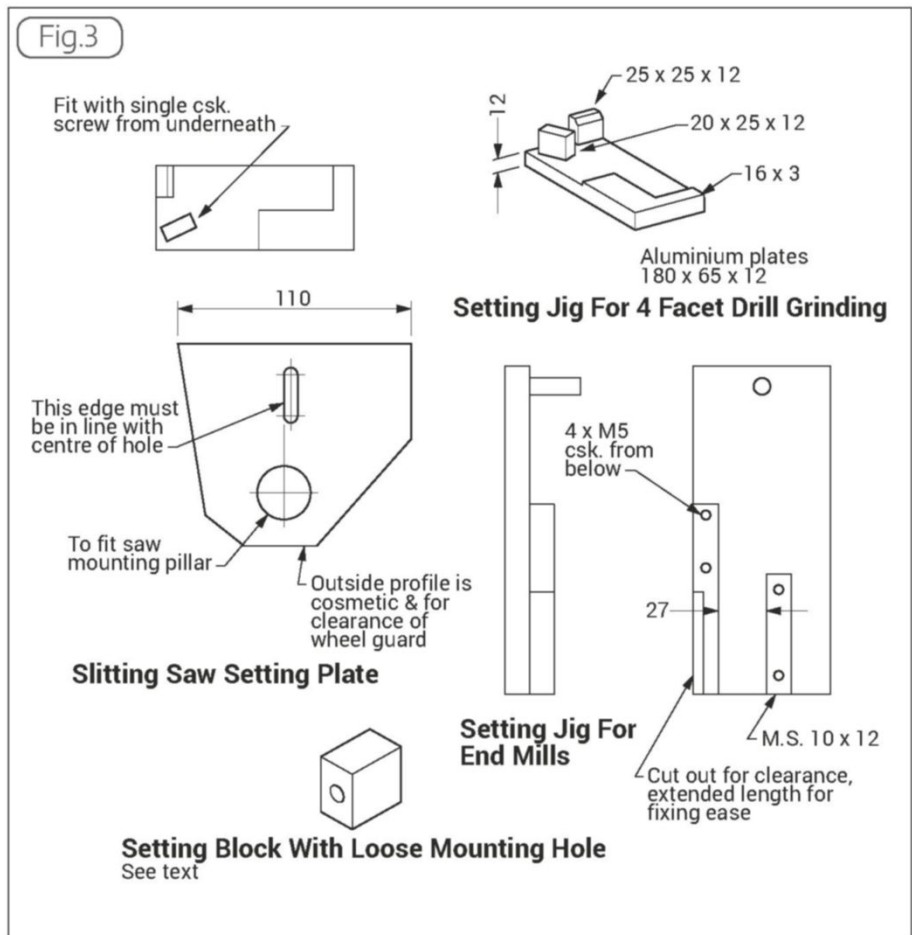
photo 4. If you have an imperial Myford lathe, change the gear on the tumbler reverse cluster to a 34 tooth, and set the gearbox to cut 24 tpi. This will cut a thread with pitch error of 1 micron. The collet nut itself is not worth making, it's complicated machining and a relatively low cost item, so buy one, then use it to gauge the thread.

The indexing flats must be exactly equidistant from the spindle axis. Set the spindle in the dividing head chuck and clock it very true. Form the two flats, but the depth must not cut into the $\frac{3}{4}$ " body or the indexing won't work.

Making the collet block

I used cast iron for this as I had it already a block I ground true at College 45 years ago just waiting for a use. Finish the front face flat by milling or fly cutting then this face is the datum against the fixed jaw of the mill vice to finish the bottom.

Mark the position of the bore on the big end, mount on an angle plate on the faceplate and set the punch mark running true using a wobbler. This is not as easy as it sounds, we need clearance for the boring tool at the faceplate end and the block must be perfectly square, so firstly lightly clamp it to the angle plate off the machine checking with a V block or 123 block to get this right.

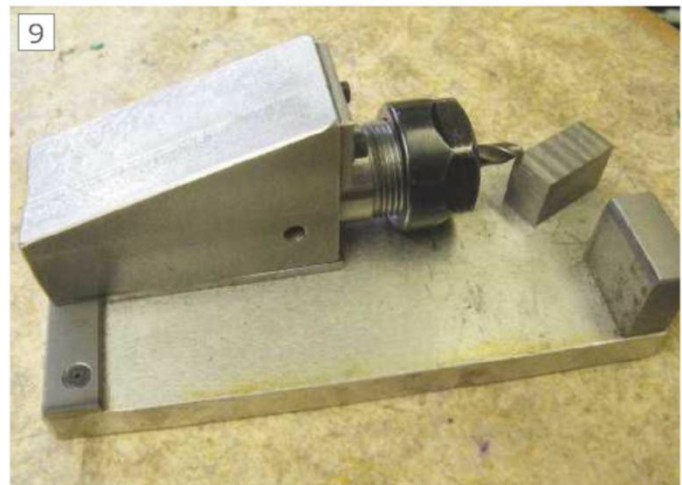


Don't rely on an engineer's square here. Now the centring positional adjustments are made to the angle plate not to the block. Face the end flat then produce the bore for a precision running fit on the shaft aim for a clearance of plus 0.001" relative to the exact shaft diameter, **photo 5**. The angled face can now be set approximately horizontal clamped to an angle plate, the bottom face being set to 15 degrees which will give the difference between the angle

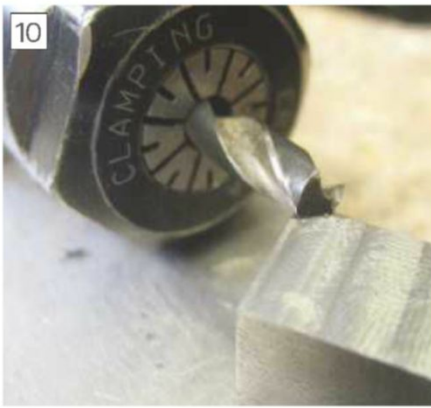
of the primary and secondary clearance on the drill. Use a $\frac{3}{4}$ " bar in the hole to aid setting up. To finish, drill and tap the M6 clamp screw (not often used). Produce the indexing plate, oversized at first. This is tightly clamped to the spindle for drilling the fixing screws. **Photograph 6** clearly shows the setup. Check when the plate is fixed that there is almost zero clearance on either spindle flat. If there is any problem, it will need very careful adjustment with



Setting plates.



Mount the drill in the collet and finger tighten the nut to just grip it, then tuck the back of the block against the setting plate step and angle the lot down pushing the drill just into contact with the length block. Move it to the left and press the drill lip firmly down onto the height setting block and tighten the collet nut. Very occasionally, the drill will rotate during this process, so it is wise to check it afterwards

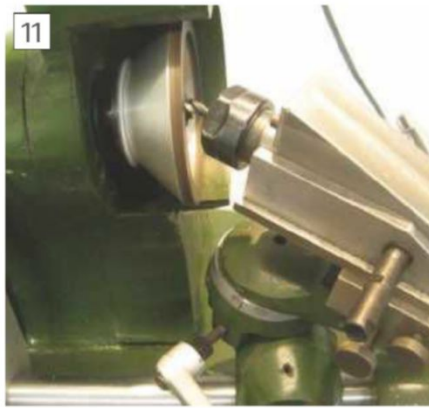


Close up of setting the drill, showing how the raised part of the jig ensures clearance for the collet nut.

a very fine pillar file. Finally finish the indexing plate to size. All components for drill grinding and slitting saws are seen in **photo 7**.

Setting plate

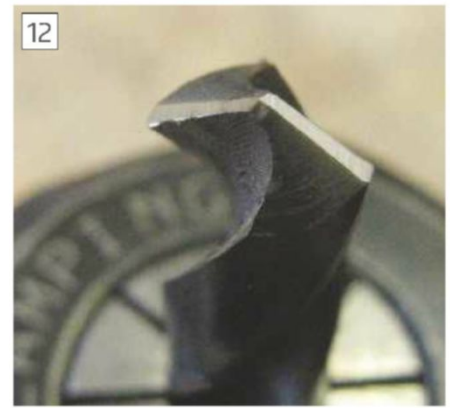
The lip of the drill being ground must be parallel with the bottom face of the collet block, an easy task with the setting plate, **fig. 3**. It's made from 10mm aluminium with a piece of 3mm steel fixed on the top to allow clearance for the ER20 screw cap. We now fit a bar 10mm in the collet and measure the gap between it and the plate, add 5mm and that's the exact centre height. Machine the block of steel to this exact height being careful to maintain sharp edges. I fixed mine with a single countersunk screw from underneath so that it can be angled to the most convenient position. The second block is used to set the projection of the drill, useful when you are grinding a number of drills so avoiding too much adjustment needed to get the drill up to the grinding wheel. The photographs and captions will now show the grinding



Load the universal plate onto the grinder rotating plate and set it at a horizontal rotation of 59 degrees and a vertical one of 10-12 degrees angled upwards. Now adjust the position, switch on and grind the first primary clearance. Note the setting on the feed dial on the main bar, back off, index the drill and repeat for the other lip to the same feed setting. Check with a powerful eye loupe that any damage has been removed from both lips.

process. The setting plates are shown in **photo 8** while **9** and **10** show the setting procedure. Set the rotating head to 59 degrees and angle it upwards by 10 degrees for primary clearance. Grind the first facet, back off and repeat for the second edge, **photos 11** and **12**.

To produce the clearance angle, without using the wedge, angle the tilting bracket a further 15 degrees to 25 total and grind away using a lot of cut until one edge begins to get close to the centre of the drill, then it pays to take your time as if this facet is just a little too long one has to return and re do the primary clearance. We are aiming to get all four facets to meet at an exact point. If the drill is badly damaged, it pays to start freehand grinding on the bench



The incomplete primary clearance, the damage still needs removing here. You will now understand the reason for the separate removable block for examination!

grinder, as the cutter grinder does not like you taking big cuts, and in some cases it is necessary to reset the lips level in the jig if a lot of material has to be removed.

Why an angled collet block?

The original concept was to just invert the block and the secondary angle would be presented to the wheel with only the lateral in feed needing to be changed. However due to the peculiar 3D geometry of operation on this machine, there are so many different things at different angles which resulted in the secondary clearance was always being tapered. It completely removed the primary clearance at the periphery of the drill before all the facets met in the centre. I was to say the least very dejected as simply flipping the block over was a primary design consideration at the planning stage. After a few months I looked closely at a drill and the penny dropped. Out came the angle setting blocks, and I found that if the bottom end of the block was pushed out by 5 degrees

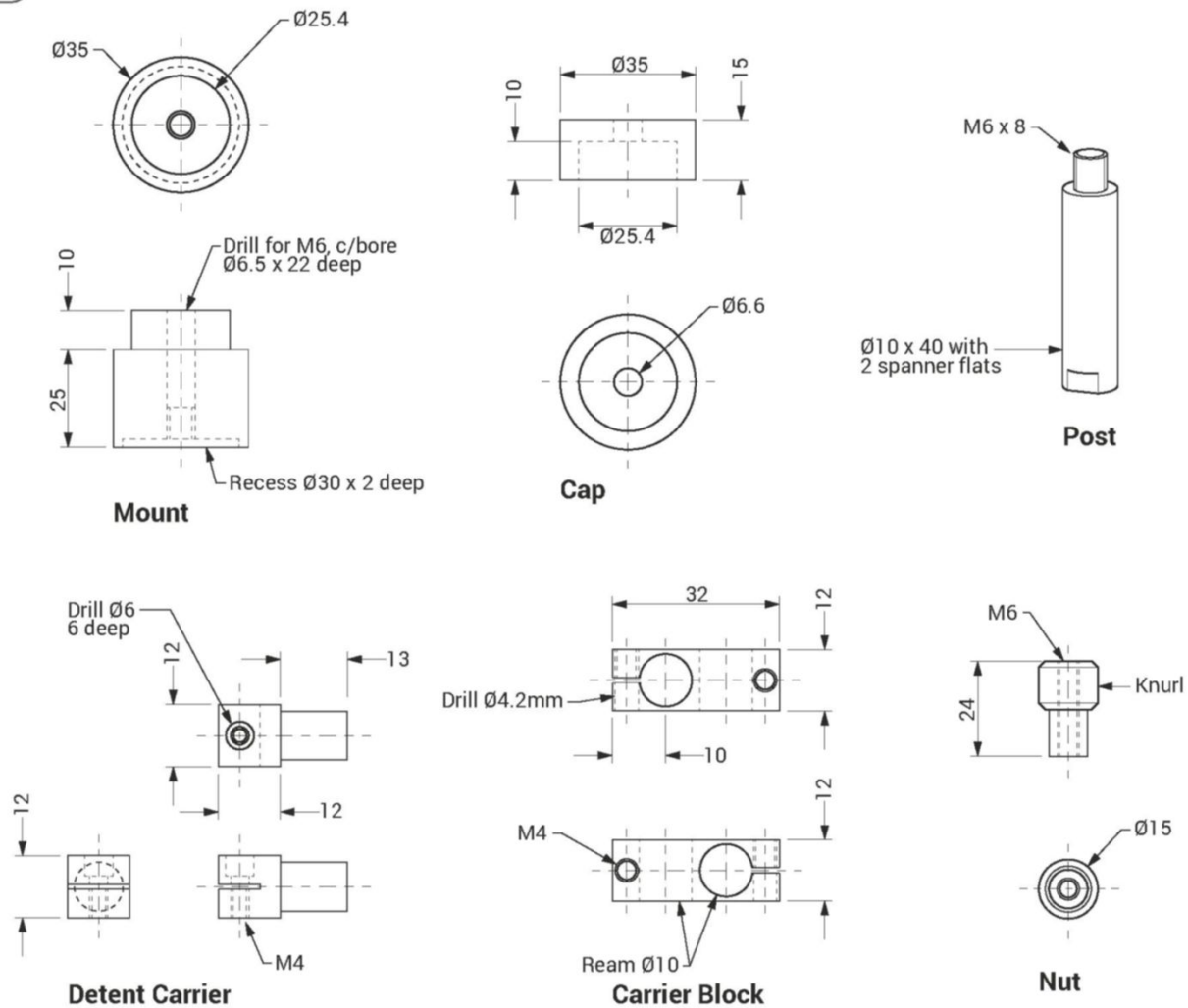


Using the wedge, here the block sits on its angled face.



The finished drill, all facets meeting in the centre.

Fig.4



Components For Slitting Saws

then the secondary clearance had been taught a lesson and was in the correct place. So a long piece of 25×6 bar was set at the correct angle in the mill vice to make a tapered wedge, then it was cut to length from the stock material.

Photograph 13 shows it in place. The result is now very satisfactory, **photo 14**, so the need to reset the tilting bracket angle is removed. You may need to modify the wedge angle on your machine, I would suggest the use of drills stood vertically at the end of the top plate fence then it will be a simple calculation to determine the angle the wedge needs to be cut to. I can assure you the use of the wedge is a great time saver especially when a group of drills are being worked on.

Equipment for grinding slitting saws

The parts in **fig. 4** are all simple components and require little description except the setting plate. Start with the mounting pillar. This has a central M6

tapped hole, the shoulder position should be higher than the fence, and the spigot should be a close running fit on the bore of the slitting saws. Loctite a stub of M6 in the bottom and tap a matching hole in the base plate. For the detent arm, I used redundant fittings which came with one of my DRO kits. The detent itself is the end of a hacksaw blade with the teeth ground off and uses the already drilled hole in it for mounting.

The setting plate is used to set the saw square to the wheel and getting the detent into the correct position prior to setting the clearance angle with the rotating head. It is a job for the mill, so clamp the 1.5mm steel sheet (don't profile it yet) on plywood on the table, with what will become the wide end of the plate on the left. The final Y axis table movement must be towards you. Drill and bore the central hole to match the mounting pillar using a boring head. Fit an 8mm slot drill and move the spindle 4mm towards you putting the edge of the slot radial

to the bore. The radial slot can now be cut to form the setting window, taking it close to the central hole to give a better view of the setting in use, (mine is a bit too far away). Machine the left edge now to ensure it is at right angles to the window. In the photograph you will see another slot in my plate, I had thought this would be needed for a sliding clamp to temporarily fix the plate to the saw, but it wasn't needed. Cut the angles which will clear the wheel guards and check on the grinder. Clearly mark on both sides of the plate which is the radial window edge.

●To be continued

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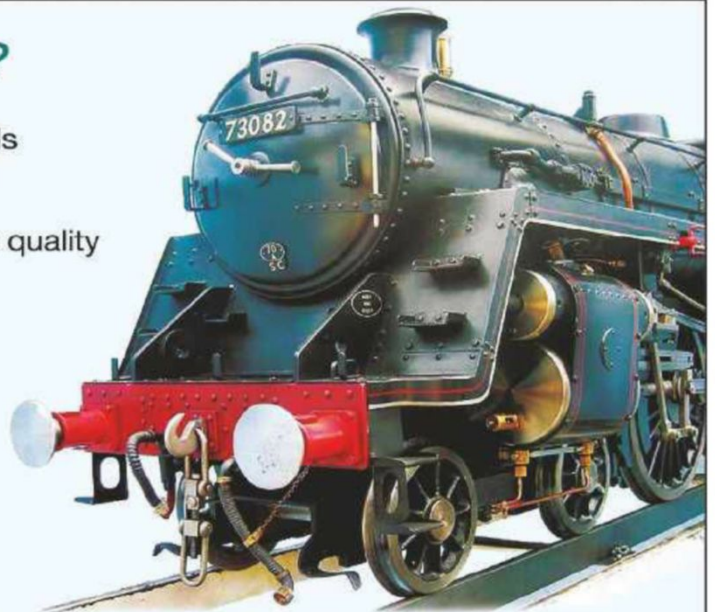
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BR Standard Class 5MT 4-6-0

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UK RRP £3200.00 for the kits and £4200.00 for the RTR



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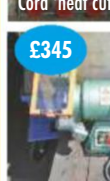


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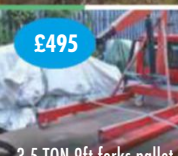
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