No.251

THE MAGAZINE FOR MAKERS AND HOBBY ENGINEERS

MODEL ENGINEERS' WORKSHOP

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MARCH 2017

Bandsaw Repair Jig

Build Gary Wooding's useful tool

INSIDE

- A Brand New Drummond M?
- Martin Berry's long travel threading guide
- Michael Green and his CVA Lathe

COVER FEATURE

Make Thor Hansen's Heavy Duty Milling Indexer

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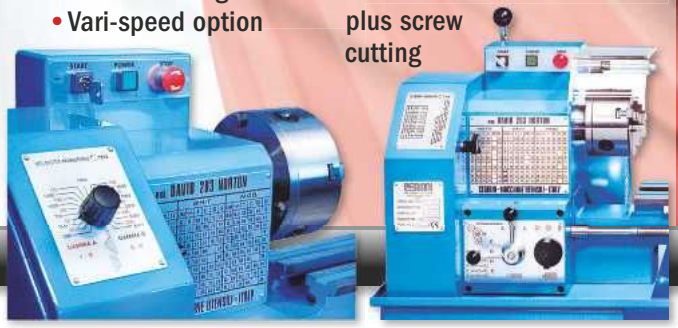

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When you have finished with this magazine please recycle it.

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On the Editor's Bench

Share Your Knowledge

As editor of MEW I enjoy meeting readers at shows and events, and sometimes getting to look inside their workshops, from modest home workshops to huge club workshops equipped like a small factory! As well as the warm welcome (tea, strong, white, no sugar, please!) that is the hallmark of our hobby, the other thing that strikes me every time is how much I learn from meeting readers. The very nature of running a workshop means you are constantly finding yourself with new problems and challenges that put your ingenuity to the test. The forum at www.model-engineer.co.uk is an excellent place to share many of these ideas, or you can send them in as a 'Reader's Tip', but I often see and hear about more involved projects that really ought to be shared more widely. I'd lay odds that in your workshop there are jigs, gadgets or home-made tools that would make an excellent article for the pages of MEW. While I have a stock of articles for future issues of MEW, I would really like to have some more constructional articles lined up for later in 2017.

Gadgets, Tips and Quick Builds

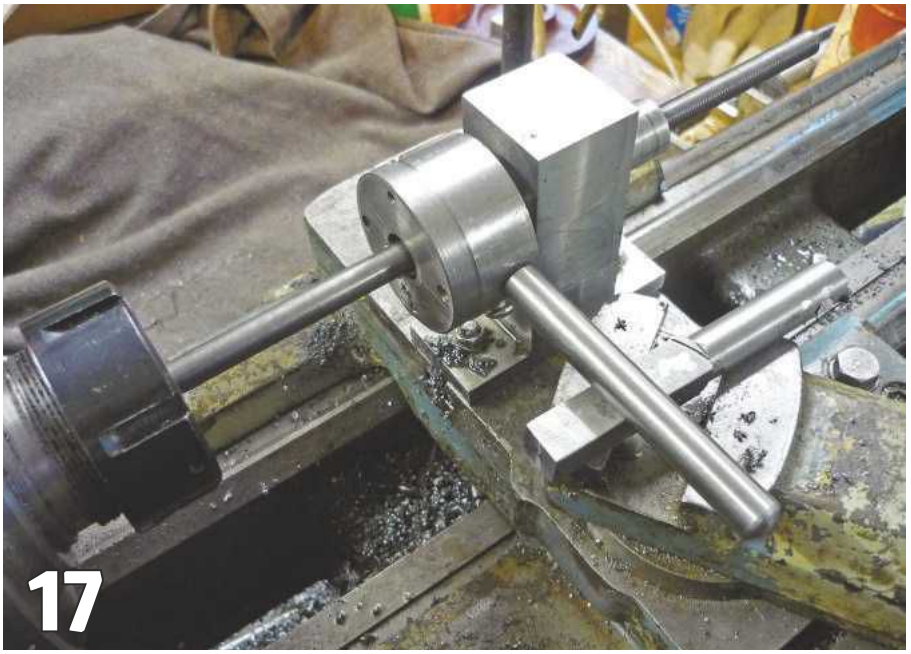
A year ago, (MEW 239, March 2016) we had a special issue where every article was a self-contained 'build' or tip that proved really popular with readers. I think we should try and repeat this in 2017, so I'd like to challenge readers to put their favourite or most successful small build down on paper. It doesn't matter if you use a sketch, a fully detailed plan or photographs to detail the build, but you need to make sure you include enough information to allow other readers to copy your idea.

So, take a look around your workshop and if you have a great idea to share, email me at neil.wyatt@mytimemedia.com with a brief outline, and I'll send you an author pack that tells you how to prepare an article for submission to MEW. Naturally, if you have a great piece of tooling that needs a longer description, I'd still be keen to hear about it.

VFD Issues

I have been contacted by a couple of electrical engineers about Laurie Leonard's VFD article in MEW 251. They both point out that the screen for the motor connection cable should be grounded at BOTH ends to be fully effective in stopping interference, and leaving one end unconnected could make it ineffective. One also advised that it would be better if the system included an emergency stop. If fitting a standard combined no-voltage release e-stop, this should always be wired before the inverter, not between motor and inverter. It is also possible to fit (or modify existing) e-stop buttons to cause the inverter to stop the motor.

Contents



See page 60 for details.

Coming up...

in the April issue

Once you have enjoyed this issue, look out for MEW 253 which will contain an 8-page free plan for Alex Dupre's tailstock turret, an excellent design suitable for most bench lathes.

Regulars

ON THE COVER

This month's cover features Thor Hansen's sturdy milling indexer, which makes use of a readily available mini-lathe spindle to ensure accuracy and simplify construction. Full details of the indexer are on page 49

HOME FEATURES WORKSHOP EVENTS FORUMS ALBUMS

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THIS MONTH'S BONUS CONTENT

You can also visit our website for extra content and join in our online forum

Make Bluey's Optical Finder and Optical Centre Punch
Some excellent and useful accessories from the very first issue of Model Engineers' Workshop are featured in this four-page full colour article. You can download the article as a PDF here: www.model-engineer.co.uk/OpticalFinder

We've welcomed lots of new members to the forum this month, and seen lots of fascinating topics for discussion:

Gearotic and Herringbone Gears
- How to arrange clearance for herringbone gears?

Square Thread for Minnie
- How to cut a square thread and make a matching tap.

Lost Wax Casting Advice
- Using 3D prints for lost-was casting.

Accurate Measurement of Steam Temperature
- Judging the effectiveness of a superheater.

Bought a Quorn, have some questions!
- Getting a second hand tool and cutter grinder into action.

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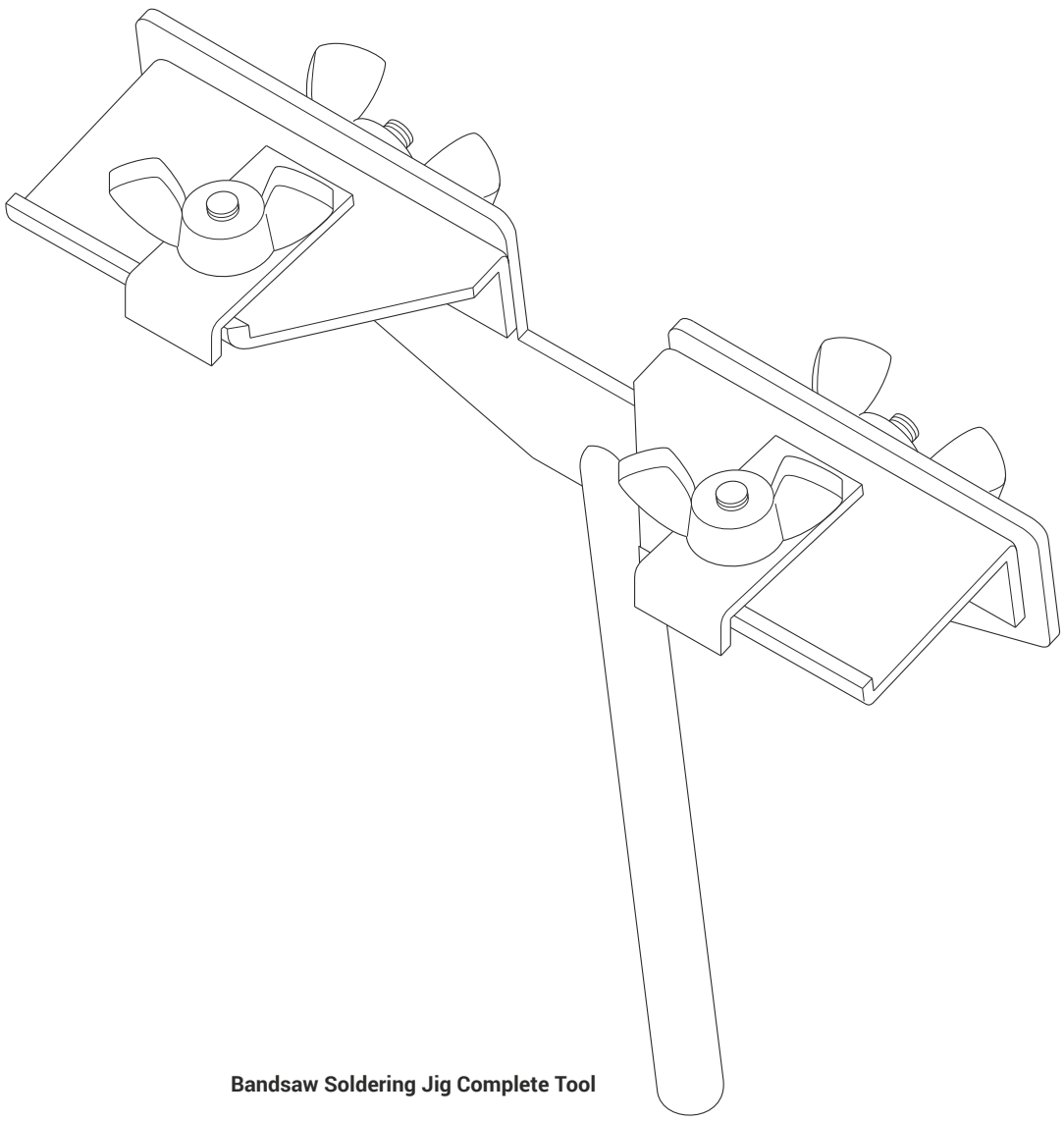
Soldering Bandsaw Blades

It's always frustrating when a still-sharp bandsaw blade 'lets go'. Gary Wooding describes a useful jig and technique for silver soldering broken blades.

Fig.1



Bandsaw Soldering Jig Complete Tool

I discovered the benefits of bandsaws several years ago, when I purchased the small Burgess unit which I use for cutting wood, plastics and aluminium. One day the only blade I had broke and I was stuck. I didn't have the means to weld it, nor did any of my friends, so I figured my only chance was to silver solder it. But how? Silver solder is not strong enough to butt join a blade, and a scarf joint seemed to present too many difficulties; I needed some way to accurately cut the scarfs, and a jig to hold the blade together securely enough to solder it. This article describes the solution.

The Jig

The jig had to satisfy several criteria; it had to:

- Accommodate blades of different widths and thickness.
- Hold the blade ends in precise alignment.
- Allow easy adjustment for holding the solder.
- Be very easy to make.
- Be very easy to use.

Several friends have borrowed it and all testified that it is effective and easy to use. The design and manufacture took less than a day, so you decide.

Making the jig

I made the jig from some 1.4mm sheet

steel that I had lying around – but you can use anything you like. Steel is probably best, but some scrap brass sheet would also do. **Figure 1** shows the complete jig, and **fig. 2** shows an exploded view of the components.

Although M3 setscrews and wing-nuts are specified, anything of similar size will do. To obviate the need to use a screwdriver or spanner when adjusting the wing-nuts, I chose to tap the holes in the supports and securely tighten the screws into them. This worked very well.

Figure 3 shows the details of each component. None of the dimensions are at all critical, but it makes life easier if the finished item is symmetrical. I cut the frame out with a jeweller's piecing saw, which made short work of the cutout, but a junior hacksaw and file will do the job too.

The slot in the handle should accept the frame (1.4mm thick in my case), which is then attached with silver solder.

I found it easiest to bend the supports before cutting the angles and drilling/tapping the holes. Since it's easier to bend long things than short ones, the small lips on the supports and clamps are best trimmed to size after bending.

Fig.2

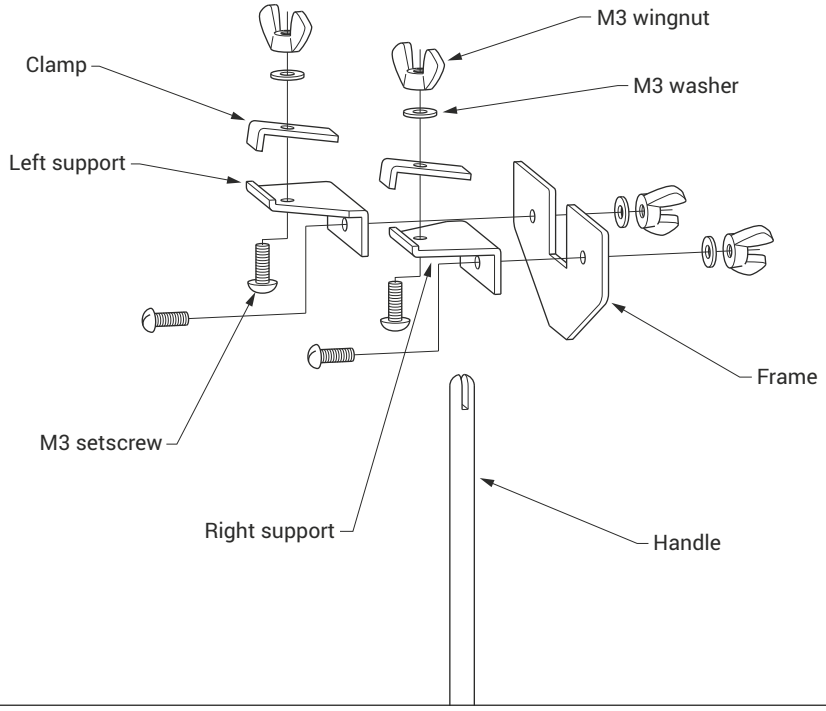
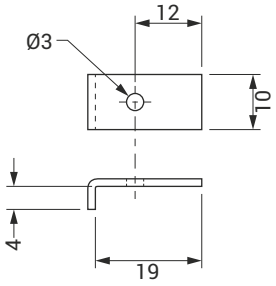
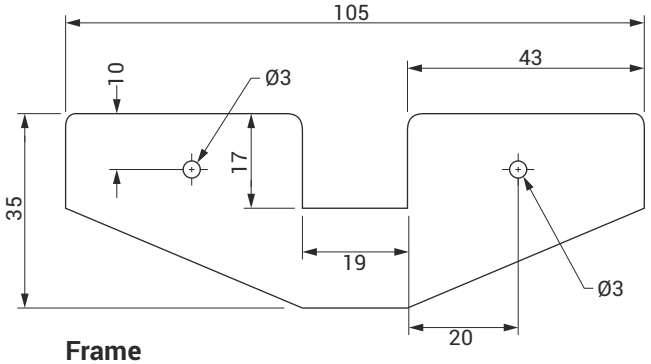


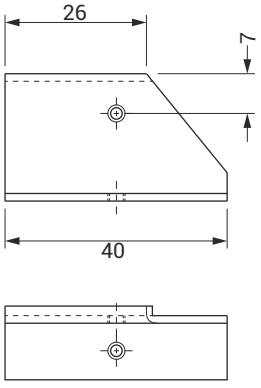
Fig.3



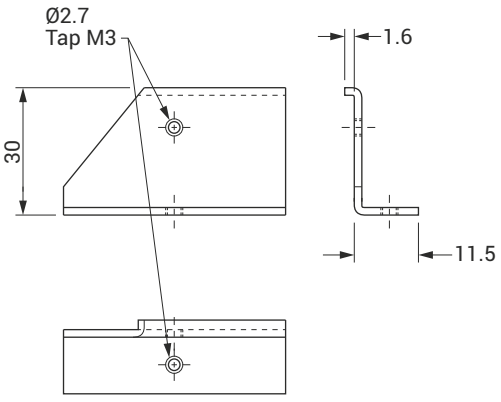
Clamp
2 off



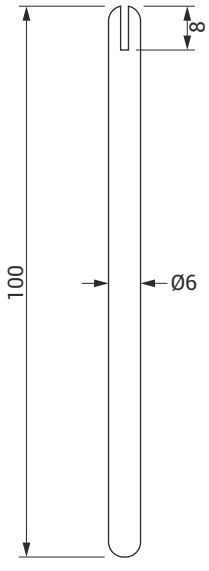
Frame
1 off



Left Hand Support
1 off



Right Hand Support
1 off



Handle
1 off

Bandsaw Soldering Jig Components

Cutting the Scarfs

This turned out to be trivial – all I needed was a piece of scrap metal, some copper wire, and a grinder. Choose a piece of metal of a suitable size and, using the copper wire, bind the ends of the blade together so that the overlap is about 6mm, as in photo 1. You can then present the sides of the blade ends at an angle to the side of the grinding wheel, **photo 2**, to shape the ends as shown in **photo 3**.

Soldering the join

Place one end of the blade into the jig, with the teeth against the frame, as shown in **photo 4**, and clamp it tightly.

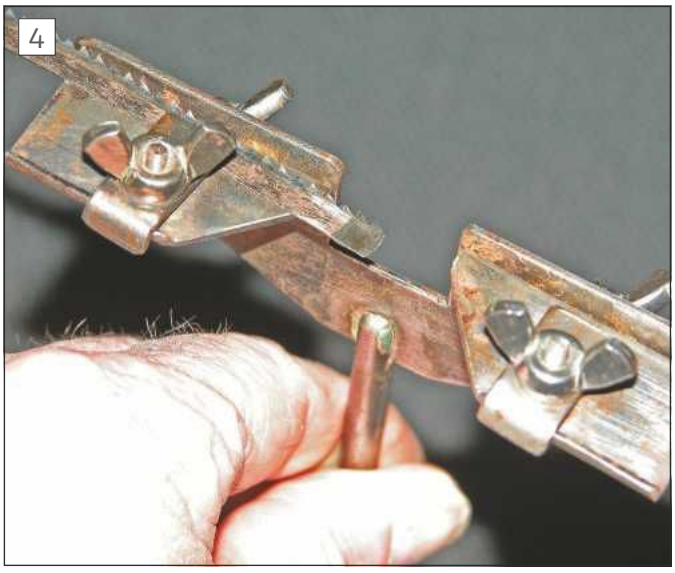
Bring the other end up, being careful not to twist the blade, and place it on top as in **photo 5**.

1

2

3

4



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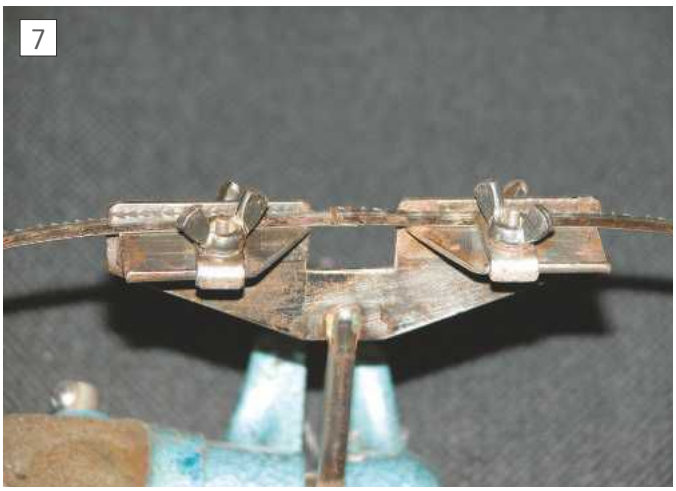
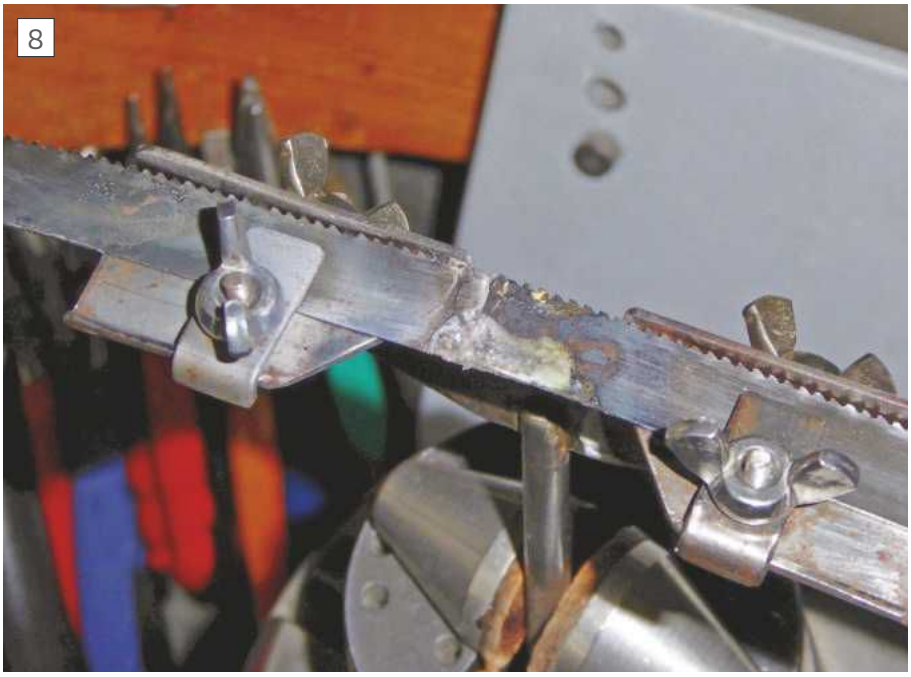
Adjust the clamps until the scarf joint fits nicely under a little tension, as shown in **photo 6**.



Insert a small piece of silver solder between the blade ends as shown in **photo 7**. (I used a little rectangular piece of sheet solder.)

Flux the joint with your usual flux and apply a flame until the solder melts – the cutout allows the flame to heat the whole joint. **Photograph 8** shows the result.

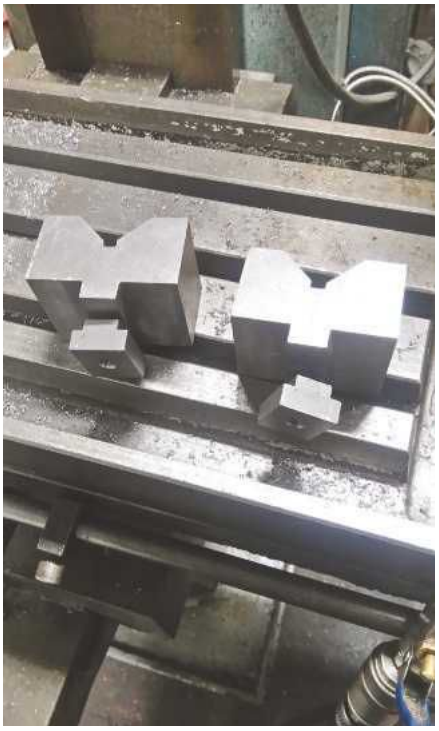


After cleaning the joint up, the blade is ready to fit into the saw – **see photo 9**.

Readers' Tips

Milling Round Bars

TIP OF THE MONTH WINNER!



Our winning tip from Andrew Lengert uses special Vee-Block to fit on the table of a milling machine, he wins this month's Chester Vouchers!

I've just started making a pair of vee blocks to fit the tee slots on my miller, with a pin through the centre to clamp onto the tee nuts, giving me repeated accuracy (as accurate as the tee slots). I don't know if anyone has thought of this idea before.

When I milled the 45 degree angle in the vee blocks I turned them around on the tee slot location

(with the exact same setting on the quill head) and skimmed them to ensure that they remained perfectly central to the dovetails.

The blocks aren't finished yet as I intend to drill & tap the sides & tops of them for clamping plates and so on. They would also be useful for milling a 45-degree angle on square bar

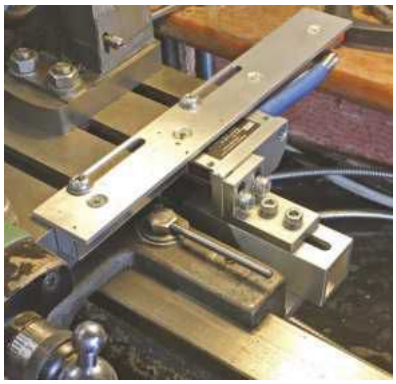
Low profile Myford carriage lock

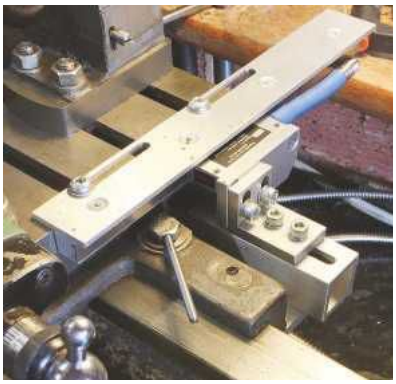
Runner up Andy Prior offers a simple enhancement for Myford 7-series lathes. He wins a prize from the MEW lucky dip!

Like many Myford owners, I had made a carriage locking handle to replace the standard spanner-operated locking bolt. However, when I recently installed a DRO system on the lathe I discovered the cross-slide mounting bracket fouled the locking handle, preventing its use.

As it only requires about 1/8th of a turn of the bolt to lock the carriage, I decided a simple solution was to modify the original locking bolt head to take a locking lever. I marked the bolt head face that was accessible when the clamp bolt was operated with a spanner, drilled and tapped the bolt head face M4 and made a simple lever that screwed into the bolt.

The photos show the locking lever in the normal and clamped positions.





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

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

Mending fences

John Crammond adds a robust upgrade to a woodworking planer

I'm sure that all of us whose efforts are mainly concerned with metal, will at some time or another have been dragged kicking and screaming into doing a bit of woodwork. It may be for making a box or cabinet to house some tooling, or a repair job inside the home, I'm afraid that it's a skill that does not come easily to me. So it was when I got fed up trying to get square edges that I decided to get one of those ubiquitous planer thicknessers to solve my problems.

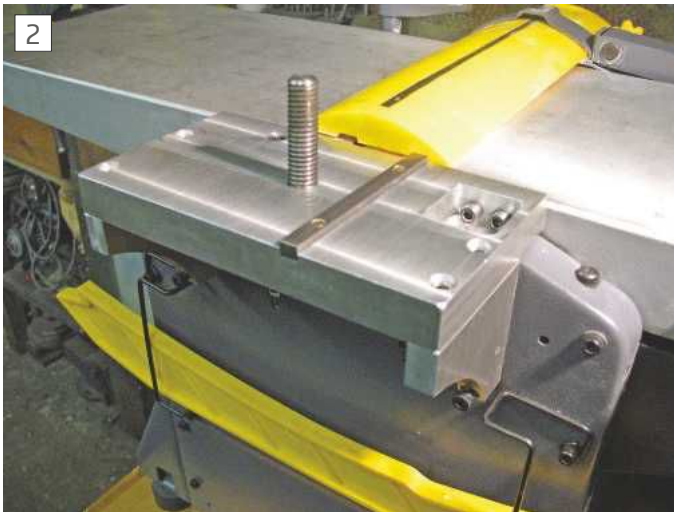
There are dozens of them, all very similar and I suspect all coming from far off places. I chose a mid range model having viewed a couple of U tube videos and was aware of the faults that I would encounter, most of which involved the fence. The machine duly arrived and I was delighted with its appearance, one problem that others have had with the infeed and outfeed tables being out of line did not exist on mine as they were perfect. However, as I expected the fence was flimsy and would bend at the slightest pressure. One other problem with the fence was that it could not be extended across the tables, a consequence of that being that the cutter blades would always wear more quickly on the fence side and would eventually produce uneven results.

I decided to solve both these problems by producing a fence of substantial proportions with an arrangement that would enable it to be positioned anywhere up to half way across the table's width, **photo 1**. My idea consists of a baseplate semi-permanently attached to the machine by existing screws and fixings, on top of which would be a sub base with hinged fence able to be moved and clamped where desired. I resolved not to drill any holes or make any alteration to the planer in any way as this would undoubtedly invalidate its guarantee.

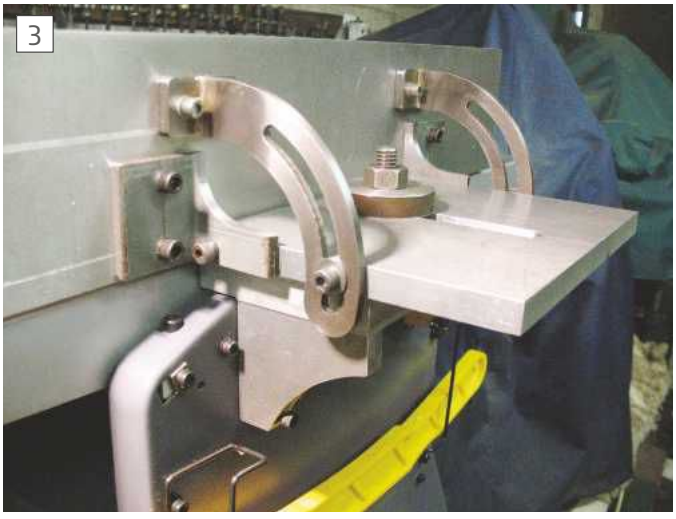
The new fence in position on the table

The fence itself and the sub base would both be made from half-inch thick alloy plate which I had to hand while the baseplate had to protrude slightly above the level of the tables, and was made out of a piece of ¾" thick alloy plate 7 x 4". Steel would have done just as well but would of course add a great deal of weight to the planer.

The machine, apart from the machined tables, is built up mainly of steel plate pressings but unfortunately none of their external surfaces were truly square to each other. Consequently, the underside of the new baseplate needed 'doctoring' to enable it to sit squarely with the table surfaces. This was eventually achieved, however in order to secure it to the existing tapped holes in the outfeed table a pocket had to be cut into the baseplate half an inch deep and of sufficient size to enable two 5mm cap head screws to be manipulated in and out. **Photograph 2** shows the general idea. The other side of the baseplate was secured by the same method used on the fence supplied, i.e. by means of a waisted screw that fitted and slotted into a keyhole.



The base plate with pocket for attachment screws



The hinge arrangements

To make the baseplate completely firm, triangular braces were fitted to each side of the plate, bearing on the rear vertical face of the planer, these were again cut out of the same alloy plate and fastened with 6mm screws. Of course, it goes without saying that the expected right angle wasn't! and each triangular plate had to be fitted independently. Patience is the name of the game and they provided the hoped-for rigidity.

With the baseplate now able to be firmly fixed, a groove is cut into it to house a tenon that will enable the sub base that has a matching slot, to slide in line across the tables. A stout ½" Whitworth stud is screwed into the baseplate while the sub base was furnished with a slot to match 4 ½" long. A two-inch steel washer ½" thick with its underside recessed and a ½" Whitworth nut will secure the two plates together very securely

With the baseplate finished and securely fitted to the planer, the sub base can be provided with hinges to enable the fence to be tilted from perpendicular through to 45 degrees to the machines tables, **photo 3**. These were cut from 2x2" bright mild steel, as usual the right angle wasn't and all outside surfaces were lightly machined. The curved and slotted links were marked out on 3/16" plate, mounted by means of the hinge pin hole at the centre of a rotary table and the slot, and outer curve cut on the milling machine, **photo 4**. The plates were then removed, band sawed close to the scribed inner line and finished off by hand. I decided to silver solder the mounting faces to the links and puzzled over how to hold them in the correct position while applying heat and solder. In the end, I machined a 3/16" slot down the centre of the mounting faces, an 8ba tapping hole was drilled in the centre of the slot and a matching hole drilled down the middle of the curved links. Countersunk 8BA screws held the parts nicely in position and soldering went without a hitch producing a much neater joint than I could have achieved by welding.


4

Milling the radius slot for the hinges

There are no short cuts to successful silver soldering. All parts must be scrupulously clean. I make up a stiffish flux paste and apply it to all areas, keeping in mind that over indulging in the use of flux means more has to be removed when scrubbing the finished joint in hot water. Once heat has been applied and the flux has flowed properly, silver solder can be touched to the joint whereupon it will quickly flash into all areas. For jobs like this I use 1/32" wire which is economical and easy to use, obtainable from several of our advertisers.

The fence itself is made from a 20" length of alloy plate 4" deep and requires little comment, the screw holes that will be used to clamp the curved links need to be placed in each side of the sub base on a radius with the hinge pivot holes otherwise they will bind and not allow the full range of adjustment intended. The hinges should be a close fit on their pivot pins and a little grease applied during assembly ensures they don't wear out. With everything screwed together, **photo 5**, the proof of the pudding is a fence that will not deflect in use, and can be easily removed for storage if necessary without losing the angle to which it had been previously set. ■


5

A rear view of the assemble fence

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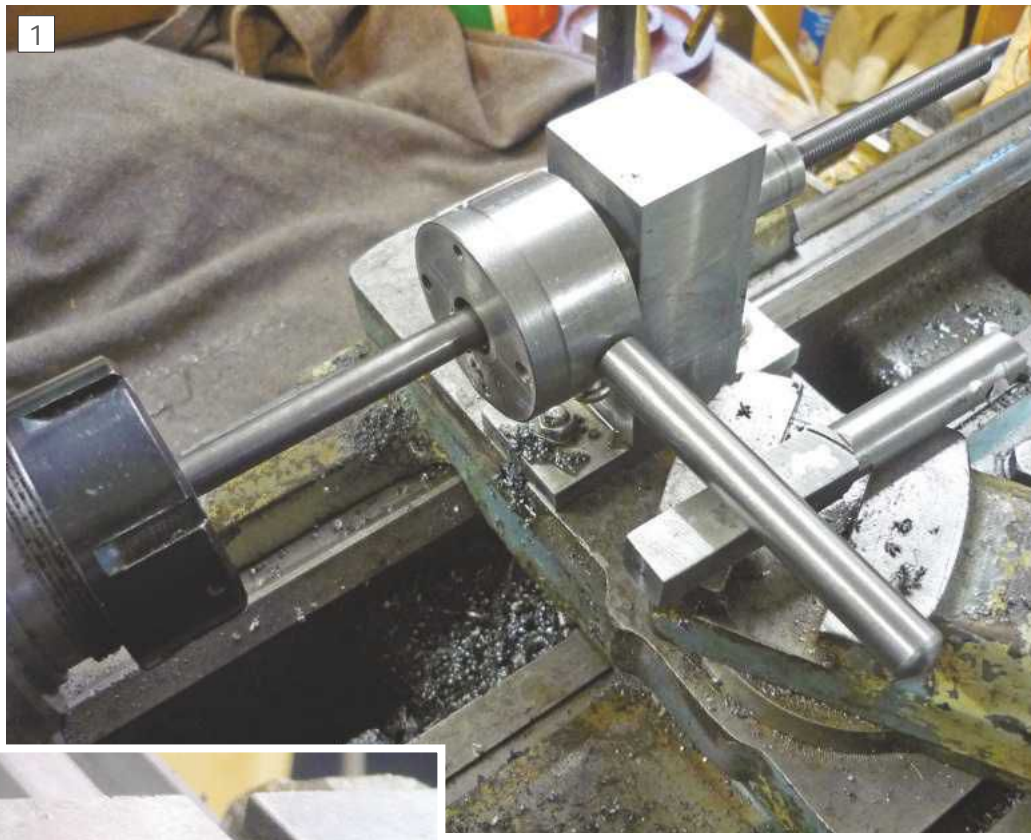
Long Travel Threading Guide for the Lathe

Martin Berry's useful accessory will let you make long threads by die cutting on the lathe.

This project, **photo 1**, came about while converting my son's small imperial lathe to have a powered cross slide. The cross-slide screw needed to be extended so that a drive pulley could be added at the rear of the slide to allow drive by a stepper motor. Despite making a threaded adaptor to connect to a plain shaft, I realised that the original shaft was sufficiently out of straight to make aligning and smooth running, through a guide bush, impossible. To overcome this problem, I decided it was better to make a new screw, the correct length for the new set-up. The thread required was 3/8" x 20 tpi (BSF) but my lathe is metric. 20 tpi is 0.787 mm pitch and the closest I could get was 0.8 mm which is a significant error, so the only option seemed to be using a die. As inexpensive 127 compound metric/imperial conversion gears are rare as hen's teeth and a die would cost less than £10 delivered, so the latter option for thread cutting was preferred.



Threading Guide

Measuring Cross-Slide Slot Width Using Slip Gauges

Although I have a tail stock die holder, the travel on this is only 40 mm; the minimum required thread being 150 mm. Threading an initial portion using the tail-stock on the lathe and carrying on with a hand-held die holder was a second option, but there is a risk of going off-track and also bending the shaft. This led me to the option of creating a lathe carriage mounted guide.

The initial principle was a guide mounted on the lathe cross slide, through which passes a die holder with built in guide bush reamed the size of the bar being threaded. The die holder can travel in the guide 50-60 mm but the longitudinal travel of the lathe carriage provides a significant extension of this distance, only limited by the distance

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between chuck and tail-stock. Long work pieces could also be supported by the tail-stock so the chances of it bending, or cutting askew, are minimised.

The guide is made from bits from the box, so the design is far from definitive and most measurements relate to my 4.5" centre height Boxford; the general dimensions are shown in **fig. 1**.

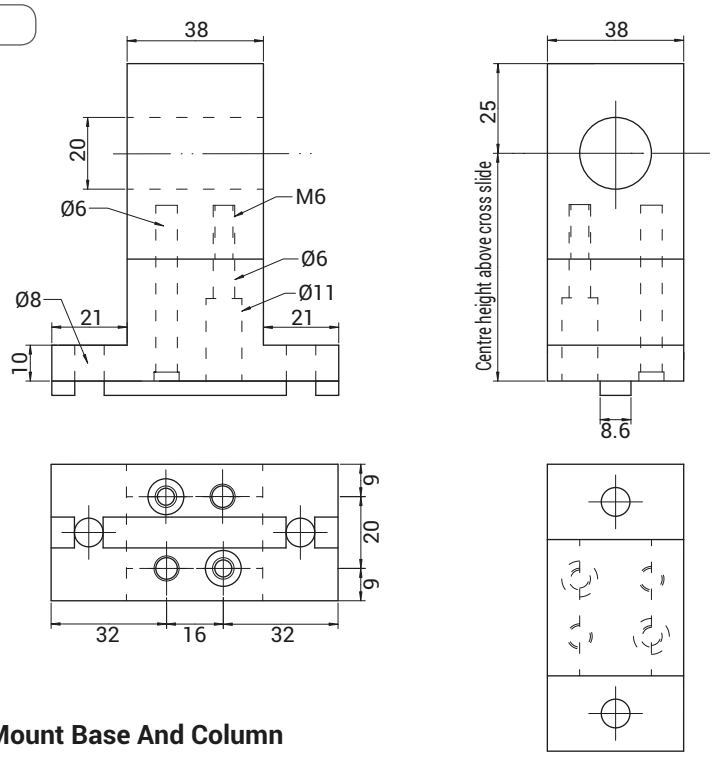
The guide is made up of two principal parts: the mount, which is clamped to the cross slide, and the die holder assembly, which is a sliding fit in the mount. Although only one sized die was needed for this project, I decided to make holders for three different sizes of dies.

Cross-slide Mount

The mount is made from two pieces of steel forming a base and a column; mainly because this best suited the material I had in stock, but it also saves having to cut away too much metal from a larger piece. The two pieces are held together by a couple of dowels and a pair of high tensile socket head screws. The column would be bored for a close sliding fit with the die holder assembly.

Both parts are made from 1.1/2 (38 mm) square bar. In my case this had a surface

Fig.1



Mount Base And Column

Milling Base Register

rust which had to be cleaned off and the cut ends squared milled to a neat finish.

Base, fig 1

The width of the lathe cross-slide slot was determined using slip-gauges, **photo 2**; this worked out as 8.6 mm (0.3395").

After setting up the milling machine vice to be square on milling machine table with a D.T.I, the bar stock was mounted and the register, to fit the cross-slide t-slot, was machined in the centre, 8.6 mm wide and about 3 mm high, **photo 3**, being equidistant from each edge. The register does not need to be exactly the same distance from each edge, but must be exactly to width to ensure it can not twist in the lathe cross-slide's slot. The observant of you will note that I've used an inserted carbide milling cutter to cut the slot. The inserts have a small radius, so will not cut a sharp 90° corner and will not therefore sit down perfectly in a slot. However, as the slot in the lathe cross-slide has a small chamfer, this turned out not to be a problem and no correction was necessary.

The ends of the bar were then cut away using a hacksaw and milled to the finished profile, **photo 4**, with sharp edges removed using a file.

The various holes (four holding the column and based together and two holding down the unit to the lathe cross-slide) were then marked out, **photo 5**, and drilled. For neatness, a slot was milled right across the register where the T-slot bolts pass through. I had considered reaming the two dowel holes but I do not have a reamer of the right size and, ultimately, the dowels could be glued in using a retainer. Luckily, my 6 mm drill was fairly new and reasonably accurate, so drilled close to finished size. The holes for the two column securing screws were then drilled through 6 mm and counter-bored 11 mm about half way down, giving plenty of clearance for the heads of the 6 mm socket head screws.

Column

The column was cut from the same bar stock as the base, cleaned up and the ends

Milling the Base

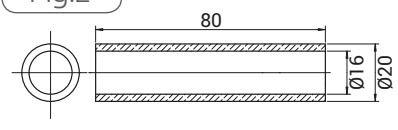
Base Holes Marked Out

Spotting Base Holes into Column

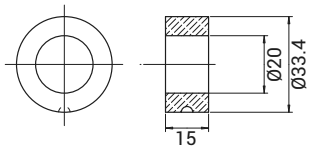
Drilling Out Spotted Hole

Marking Guide Hole Position

Fig.2



Guide Tube



Guide Tube Collar

milled square, before clamping vertically in the machine vice, using a square to set it up. The base was then sat in top and clamped in position, **photo 6**. The first dowel hole was spotted through the base into the column, the base was then removed and the hole drilled through to its final depth. The base and column were then reunited and the dowel inserted and the whole lot re-clamped. The second dowel was then spotted and after moving the base casting aside, **photo 7**, the hole drilled to depth. With both dowels fitted the two screw holes were then spotted 6mm and then drilled 5mm to depth. Both screw holes were then partially tapped M6 using the base as a guide, before finishing to depth without. After de-burring and tightening down the locking screws, the whole assembly was ready to be transferred to the lathe.

The next stage was the drilling and boring of the guide hole. The leading face of the column was coated with engineer's blue, near the top, and a vertical line scribed

Drilling the Guide Hole

Opening out Guide Hole Using an End Mill

centrally, to show the centre on the column. The assembly was then sat in a slot on the lathe cross-slide. A centre drill was placed in the 3-jaw chuck and the horizontal position of the mount was adjusted using the slide screw to align the vertical lines with the centre drill. Using the tail-stock as a pusher, the work was advanced onto the drill to mark a reference spot, **photo 8**.

The assembly was then broken down and the column chucked in the 4-jaw and set so that the drilled spot ran true, **photo 9**. The block was drilled out to 1/2", the largest drill I have, followed by drilling out using a 18 mm end mill mounted in a collet chuck inserted into the tail-stock, **photo 10**.

The guide hole boring process requires a test gauge and this was made from a piece of round bar, turned down to an accurate 20.0 mm, about 25 mm long. Then the end diameter was reduced by 0.04 mm for about 6 mm and then the first 3 mm reduced by a further 0.04 mm. This gives a couple of gauge steps towards the final dimension.

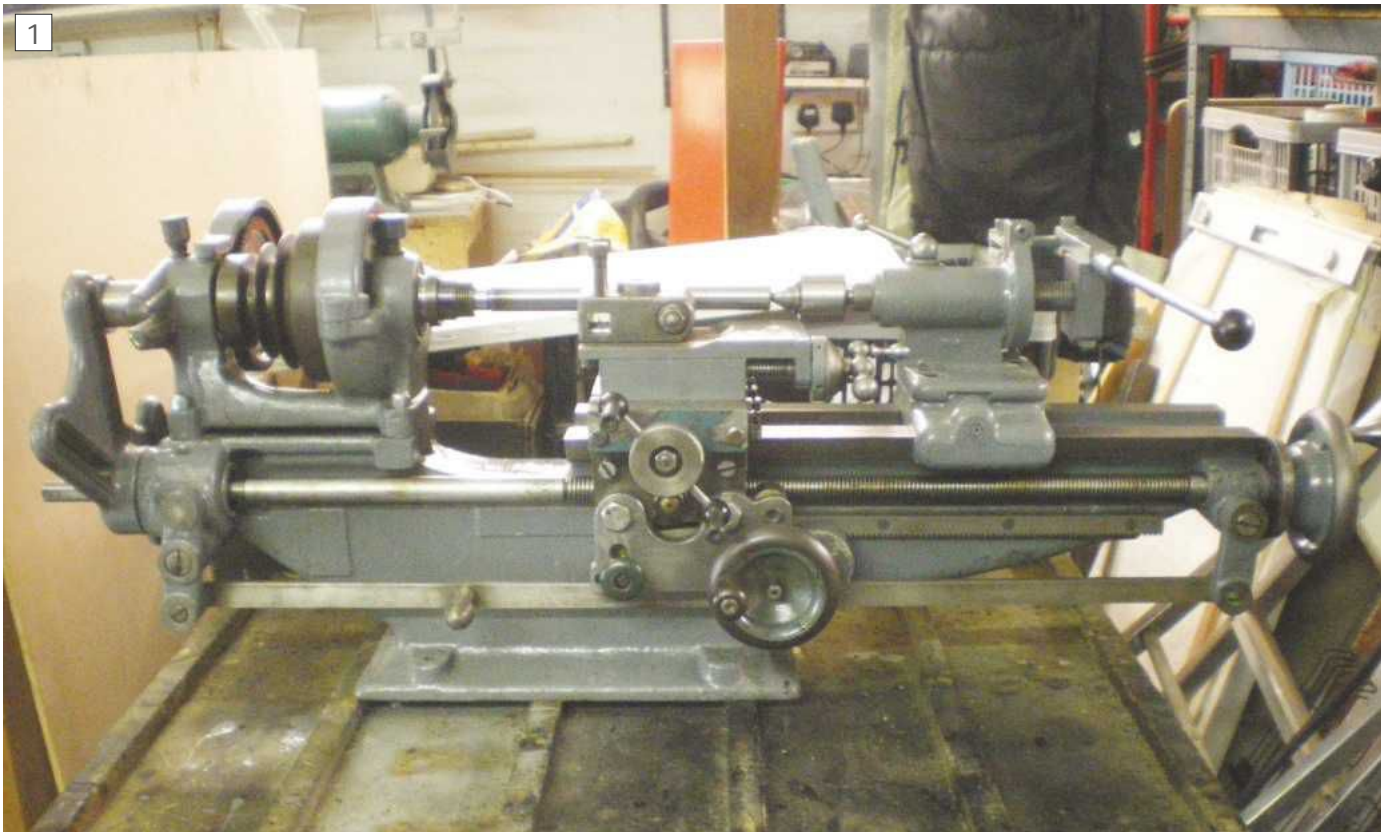
T-nuts are also required and these were made from a single piece of bar milled parallel to the base width of the T-slot and then mounted so the sides can be relieved to create an 8.6 mm wide boss, **photo 11**, to allow it to fit in the T-slot. Two holes were marked out one quarter of the bar length from each end and then drilled and tapped 8 mm. Final draw-filing removed burrs and the nuts are checked for a smooth fit in the T-slots, **photo 12**. I found the nut was slightly too tall so a small amount was milled off the top to provide some clearance between the bottom of the guide base register and the top of the nut. The nut was then cut into two.

To be continued

Milling the T-Nut

Building a Drummond M from Parts

Is it possible to recreate an historic lathe using quality used parts? Alan Hearsum found it was possible for the Drummond M.



The 'new' Drummond built from parts

The purpose of this project was to refurbish a Drummond M Lathe in order to give my existing Drummond M lathe a rest whilst it too was refurbished. The completed lathe is shown in **photo 1**. This involved building a Drummond M lathe from used parts bought from a wide range of Drummond lathe and Myford M sellers on eBay. I have found that buying individual components suits me better than purchasing a complete used Drummond lathe. Those selling individual components have selected the quality stuff to sell to avoid customer disappointment and possible returns to the seller.

Boring the headstock for taper roller bearings and oil seals

Considering the design of the lathe spindle and bearing is a critical requirement of any lathe. The Drummond spindle wears slowly over time along with its phosphor bronze bearings. As this article is based on the premise of building a lathe from quality useable parts the spindle and bearings is the one item that is difficult to find in a satisfactory condition on eBay. This rarity of quality used phosphor bronze bearings and spindle for the Drummond M lathe offers an opportunity to use taper roller bearings as a suitable modification. The alternative is to make replacement phosphor bronze bearings and spindle.

Colchester lathes have an excellent reputation and use taper roller bearings proving that if a lathe company with such standing uses these bearings they are proven method for precision work. The Colchester lathes however do use larger more robust taper roller bearings than is possible in a modified Drummond headstock. So, this project is also be a test of the suitability of taper roller bearings for a Drummond M lathe.

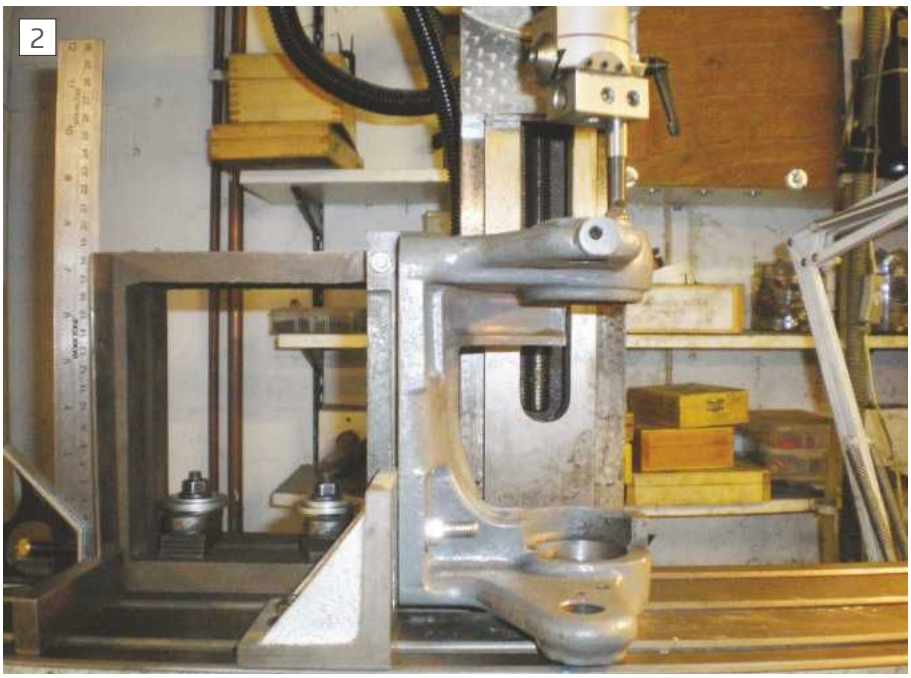
The taper roller bearing route to improvement offers an opportunity to produce a Morse taper 2 spindle and a larger bore through the spindle. It is, however, possible with careful design and machining to create a Morse taper 2 spindle maintaining the original layout and configuration of phosphor bronze bearings.

Figure 1 is a schematic drawing produced to improve the design of a spindle and provide measurements to bore the headstock for taper roller bearings and the appropriate oil seals. It is designed to

use lithium high melting point grease to lubricate the headstock bearings. Rather than machine the spindle from scratch I noticed that a Myford Super 7 spindle has a Morse taper 2 spindle and a larger hole through the spindle, so a S7 spindle was machined to meet my requirements.

When I physically compared the Drummond lathe spindle and the Myford Super 7 spindle (look ahead to photos 8 and 9) the similarity in length and diameter would allow modification. The portion next to the taper had to be reduced to 1 inch diameter as the optimum size for boring and reaming the back gear assembly and the separate pulley, shown in **Fig. 2**.

I had planned to machine the bores for the taper roller bearings of the headstock casting using my existing lathe cross-slide as a boring table setting up a boring bar between centres. However, the bores of the headstock resting on the cross-slide were above the centre line of my existing Drummond M lathe I was going to use for the boring. I had at least three options. Make some more lifting blocks for my existing lathe that would raise the height of the headstock and tailstock leaving the cross-slide at the same level. Or contract the job out to do the boring on a larger lathe, not much fun or experience in that option, or the last option to use my vertical milling machine to vertically bore the headstock.



Set up for boring headstock

Starting the boring operation

Bore at the other end

Photograph 2 shows the initial fixtures to set up the boring operation. A fully machined cast iron box was used as the main fixture to hold the headstock casting onto my vertical milling-machine table. The block measures 7¼ inches high x 6¾ inches wide x 3 inches wide with a ¾ inch webs all round. Cast slots all around the box provided an opportunity to use two tee nuts with studs and nuts to fix onto the milling machine table.

I drilled and tapped the box section webs at appropriate places on which to rigidly bolt the headstock casting for machining the bores required. The end surfaces near the existing bores on the headstock were originally machined by Drummond and provided an excellent method of ensuring any boring operation was going to be square and true end to end. These flat surfaces allowed the headstock to be pulled down onto the milling machine table. Cantilever clamps (not shown) were placed to hold the headstock fast to the milling machine table in addition to the box fixture above. A square was used with feeler gauges to ensure the headstock was vertical prior to and after clamping. An additional cast iron angle bracket was attached at the base as shown in photo 2.

The set up for boring on the milling machine was tested with a micro dial test indicator (dti) attached to the boring head tool. First this was to test that the machined surface was flat. This proved that it was flat and the surface clamped to the milling machine table was parallel with the surface where the first boring operation was to take place and in turn the existing bores should be true. If it had not been flat and square I would have needed to put shims under the surface prior to clamping to the milling machine bed.

Once the boring head had been set at 10 thousandths of an inch above the bores to minimise error, the boring operation was ready to go. Before boring finally commenced all the slide ways were tightened with the adjusting screws on the

Headstock bored for taper roller bearings

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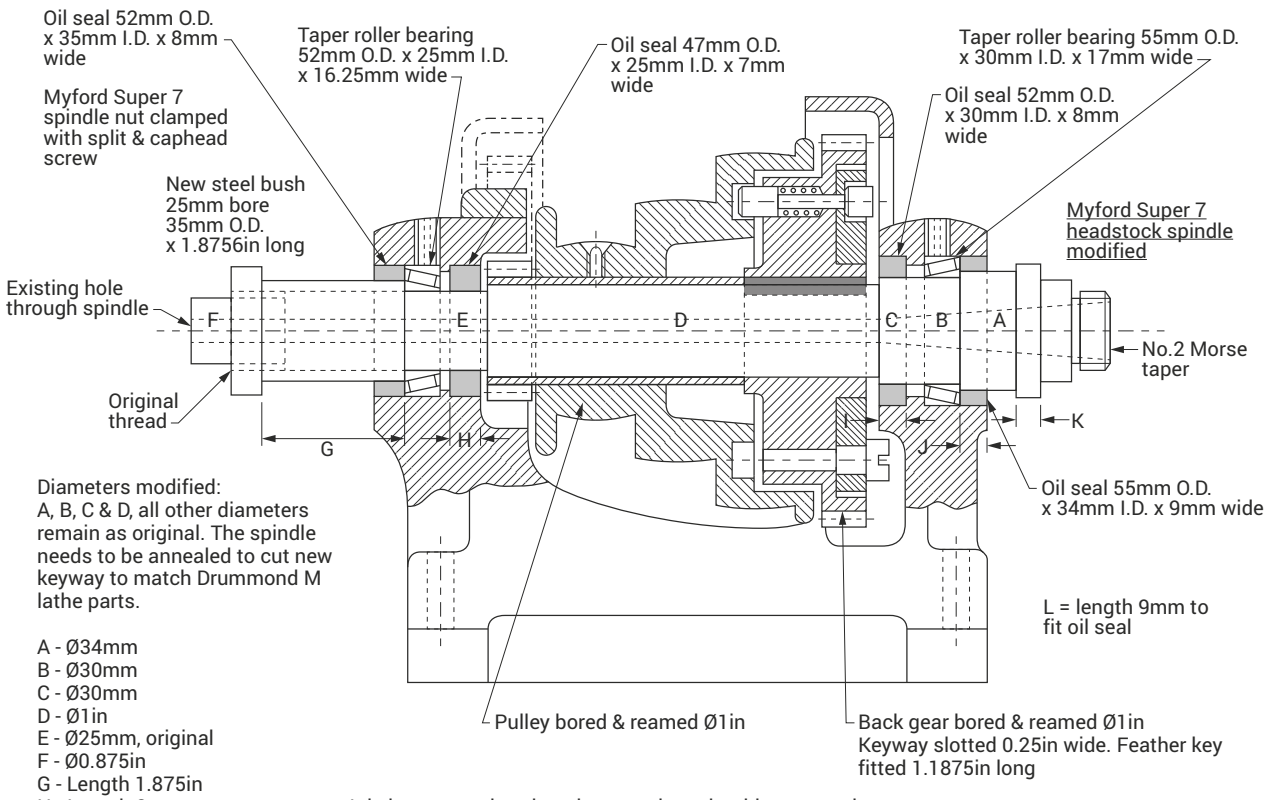


Diameters modified:
A, B, C & D, all other diameters remain as original. The spindle needs to be annealed to cut new keyway to match Drummond M lathe parts.

A - Ø34mm
B - Ø30mm
C - Ø30mm
D - Ø1in
E - Ø25mm, original
F - Ø0.875in
G - Length 1.875in
H - Length 8mm
I - Length 9mm
J - Length 10mm
K - 5/16in

It is important that there is a cast iron shoulder separating a bearing & an oil seal. Castings tend to vary in shape & length so there is a need to work out distances before boring the headstock casting.

Fig.1

Headstock fitted to the bed

Reverse of the headstock

milling machine. This included x, y and z movements. Checks were again made with a dti fixed to the boring tool. Also, the tool was carefully tightened in the boring head and the draw bar checked that the No 2 Morse shank was fully pulled up into the vertical milling machine mandrel socket. It may seem as though I went over the top with the checking prior to machining but it is a reminder of what can go wrong with such an operation if things are not tight and firm. Vibration will take place, so it will loosen the fixings if we don't take steps to prevent it.

Before starting to machine a dti was used to centralize the bores which were already machined as a taper to fit the original phosphor bronze bearings. Also a Morse taper 2 long parallel bar 0.75 diameter was used in the milling machine spindle with a micro dti at its extreme end to check that the existing taper bores were concentric at the top and bottom of the headstock casting. Whilst the bores in the headstock were tapered to fit the tapered phosphor bronze bushes the dti quickly centralized the boring operation. Confidence was gained when the headstock was eventually turned upside down and a similar method of centralizing the bores concentric with each other could be achieved.

Boring the boss on the headstock casting at the lathe chuck end commenced. A very slow feed was applied by a hand wheel on the milling machine. The diameter of the bore was 55mm x 27mm deep, **photo 3**. The cutting tool in the boring head was tungsten carbide to provide a square bottom to the bore.

Measurements were made with internal callipers and checked with an external micrometer. The real test of course is to see if the taper roller bearing will push into the bore that has been machined. A push fit is adequate as the pulling together of taper roller bearings will ensure they do not spin around in the bore. There could not be a better material to be working

Myford spindle

in than cast iron, it is an easy material to machine even though at very low spindle speeds it is apt to tear.

On completion, the first roller bearing bore the second bore which houses an oil seal 52mm bore x 9mm deep shown on fig 1 was then completed. A different shaped tool was ground as the tool was cutting with an upward feed. When I was satisfied the bearings and oil seal would easily press in I then turned the headstock around end to end and configured how to make this fixture as secure as possible to avoid vibration for the next bores, 52 mm diameter x 25mm deep, **photo 4**. The bore that is machined upwards is for an oil seal 47mm diameter x 9mm deep in the area on fig 1 marked E. Adding 1mm to the sizes of depth for oil seals is usually adequate so that the seal is flush with the surface of the casting. **Photograph 5** shows all bores finished.

Headstock is mounted on the lathe bed

The headstock now fitted to the lathe bed in **photos 6 and 7** shows two tapped holes that were originally used for oilers on the headstock were cleaned out with a ¼ BSP tap. A small groove was filed in from the BSP holes to allow grease to reach the bearings. The fitting of the headstock is simply a matter of locating the headstock casting on four studs. The underside of the headstock is machined to fit neatly on the bed. Grease Stauffer's were added with fibre washers to eliminate grease leakage.

Machining the new spindle from a Myford Super 7 spindle

Photograph 8 is the new Myford spindle. **Photograph 9** shows the Drummond M and the lower one in the photograph is the Myford Super 7 spindle finished machined with its front bearing and oil seal in place. The Myford Super 7 spindle was hardened in its earlier manufacture and made it difficult but not impossible to machine on the lathe. The taper on the Myford Super 7 spindle was firstly re-machined (turned) to a diameter of 1.625 inches to finish at 0.3125 inches wide, see Fig 2. It is not however essential to turn this diameter as you will see but it just tidies things up.

A shoulder was then formed 34 mm diameter x 0.4375 inches wide on which fits an oil seal. Another shoulder is created 30mm diameter x 1.25 inches wide that secures the front taper roller bearing and its inner oil seal. The 25mm diameter part of the spindle is left as original with its screwed thread that locks the two taper roller bearings together. The middle portion was machined (turned) down to 1.000 inches with a tolerance of size to - 0.001 inches. A ¼ inch wide keyway 0.125 inches deep x 1.3125 inches long and 0.3125 inches from the spindle shoulder was machined using my vertical milling machine. Initially the slot drill would not touch this steel until it was annealed around the area of the proposed keyway.

A feather key was fitted so it could be removed to allow the bearing and oil seal to slide further up the spindle into their resting place as shown in **photo 9**.

Original Drummond spindle and remachined Myford spindle compared

Bored out back gear

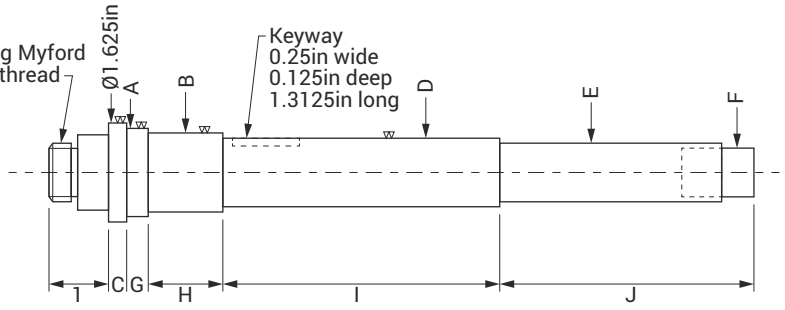
The other bored out gear

Boring the back gear and Pulley

Photographs 10 and 11 show each side of the back-gear mechanism which was originally 0.875 bore and is now bored and reamed to 1.000 inches. **Photograph 12** shows the back gear being reamed in the lathe. Setting up the back gear in a four-jaw chuck is critical so that the teeth on the back gear run true against its mating pinion. This was achieved using a dti on the diameter and face of the back gear and also on the bore being careful that the original slotted keyway did not interfere with the plunger on the dti. The pulley received similar treatment in setting up so that it ran true on diameter and in length to avoid it wobbling out of true in the lathe. The boring bar is seen in **photo 13**. This is a fairly sizable boring bar and long enough to reach through the pulley.

Method of loading up the taper roller bearings

Figure 1 shows the dimensions of the new steel bush 25 mm bore x 35 mm o/d x 1.875

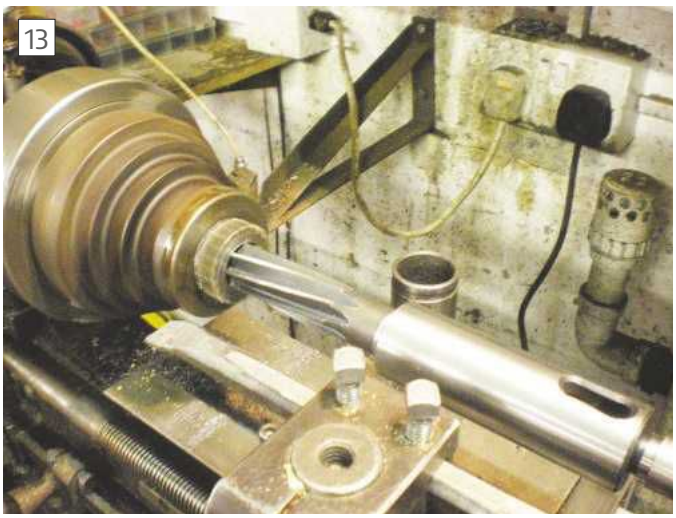


A - Ø34mm
B - Ø30mm
C - Length 0.3125in
D - Ø1in
E - Ø25mm, existing size
F - Ø0.875in, existing size
G - Length 19mm
H - Length 33mm
I - Length 4.5625in
J - Length 4.125in, existing size

Notes:
New spindle made from Myford Super 7 spindle
Machined ▽▽
New spindle for Drummond M lathe

Fig.2

Reaming back gear



Reaming for spindle

Machining new bush

Back gears and pulley in situ

inches long as seen being machined in the lathe, photo 14. The original nut which came with the Myford Super 7 spindle and is also shown in fig. 1. When suitably tightened, there was a socket head capscrew to lock the nut onto the spindle thread. Two holes were drilled, opposite each other, in the Myford nut using a drill number 10 to allow for two 2 BA bolts to connect the Myford nut to change wheels when screw cutting or fine feeding through the lathe leadscrew.

Locating change wheels on the spindle.

The symbol F in fig. 1 is the 0.875 inch diameter. Normally a Drummond M change wheel is 0.625 inches bore with holes that locate with a collar on the spindle. This collar has been replaced by the lock nut that links up to a range of change wheels on the spindle. The change wheels are 20, 30, 40, 46 and 60 teeth. The normal change wheels used on the lathe need to be bored 0.875 inches with two bolts connected the nut to the spindle. This set of gears for the spindle provide for the screw cutting of the majority of popular metric threads.

The completed headstock

Photograph 15 shows the back gears and pulley in situ on the headstock. The Yahoo Drummond Group website shows a full set of photographs of dismantling of a Drummond M headstock and its back-gears. Thought needs to be given to pushing the spindle through the bearing housings and adding things in order. Adding the oil seal first and then the taper roller bearing using fig 1 observing the handing of the taper roller bearings. Next comes the putting the back gear onto the spindle and then threading the spindle through the pulley. Before the spindle reaches the rear bearing, there is a need to add the next oil seal and pushing through to finish. The rear taper roller bearing is pushed onto the spindle from outside the rear bearing housing. The final oil seal is then fitted and the new bush pushed onto the spindle and locates the final oil seal before screwing on the Myford Super 7 adjusting nut. **Photograph 16** shows the headstock fully guarded with its cast iron guards. The Stauffer's were then loaded with grease and with several loadings there is enough grease for the moment prior to running. A front and rear view of the completed headstock is shown in **photos 17** and **18** respectively.

Testing the headstock for concentricity and trueness

Photograph 19 shows an initial test of the true running of the headstock using a magnetic dti stand fixed onto the lathe bed. This is a test for concentricity however we need to have the linear sliding motion of the saddle tested for alignment of the spindle to the lathe bed. **Photograph 20** shows a dti horizontally placed to test the accuracy of the headstock spindle with the centre line of the bed. This was adjusted by releasing the headstock holding down nuts and tapping the headstock on one corner so the dti reading was the same over the length of the test bar. A further test **photo 21** using the dti shows the accuracy of the bed related to the spindle in the vertical plane. In my case a 0.002 inch shim was placed under both securing nuts at the chuck end of the headstock casting. These shims were drilled so they are properly trapped in place. I clamped the shims between hard wood blocks prior to drilling to avoid destroying them when the drill pierces the shim.

Improving the surface of the lathe bed

There is a very good argument in

engineering circles that we should use the lathe in its present state of wear and tear to find out if it will perform and what we need it to do. That way we learn and record where to make adjustments, which gives a systematic direction to a major refurbishment.

We can learn a lot of course from studying photographs and reading what others have done in the past. My completely assembled bench lathe was shown in photo 1. Compare this with **photo 22** of the lathe circa 1921 taken from a Drummond Bothers Ltd promotional booklet. It is described as "The improved design Drummond 3½-in. Centre, Back Geared. Self-acting, Sliding Boring and Screwcutting Lathe".

Firstly, the bed needs to be tested for accuracy before assembling parts to it. I know that my lathe bed has been thoroughly checked for wear. I used a DIN approved precision straight edge lightly smeared with engineers blue to check the surfaces of the lathe shears. To accommodate the wear in one part of the bed the rest of the bed needs to be scraped to reduce it in size. Wear generally takes place near the headstock. The first task is to scrape the extreme end of the lathe under the tailstock end shears to bring them down in size to compensate for the wear at the headstock end.

The straight edge is used to control the process over the length when scraping. It is moved from side to side longitudinally to identify the high spots. These high spots are scraped until there is eventually a regular pattern of tiny patches of blue emerging after several scrapings and removal of metal. There are now electrically operated scrapers that take the strain. Not an easy task and today people often resort to surface grinding of the lathe bed shears including the shears under the headstock to get shears in line flat, straight and true. Machine surface grinding a lathe bed is the modern quick way to get a lathe bed straight and true and then do some scraping for a fine finish if appropriate.

Refurbishing the Saddle, cross-slide, top-slide and tailstock.

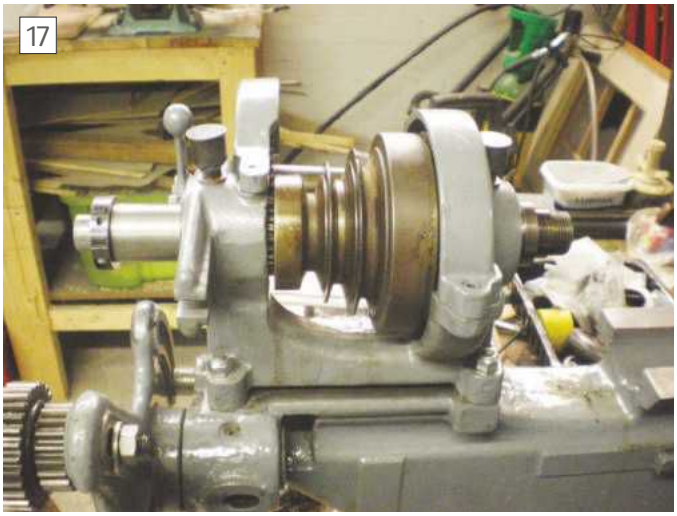
The saddle, topslide and tailstock were in good fettle when purchased from different people on eBay and other suppliers. The saddle was given some attention when improving the surfaces of the lathe bed. Using the saddle as key part of refurbishing the bed identified the need from some scraping of the slideways on the saddle in contact with the lathe bed. The slideways on the saddle in contact with the cross-slide needed some adjustment by scraping. The main thing was to ensure the screws that tighten the gib strip were adjusted so that the slideway maintains a smooth linear movement and was secure with hand pressure in an upwards direction. The assembly and fitting of the tailstock and other parts is described in detail below in the final assembly.

Final Assembly, Leadscrew, saddle, apron, crosslide, topslide and tailstock.

At the same time as fitting the leadscrew and dog clutch mechanism the saddle needs to be fitted. The clutch flat bar is last to be fitted, photo 22. The saddle with its apron half nut, rack spur gear and handwheel needs to be offered up to the bed shears. Just when the half nut is visible from starting the saddle on its journey along the lathe bed the lead screw can be pushed through the clutch housing and partially engaged over the half nut. Before moving the apron up towards the saddle there is a need to fit the plain brass bearing that snugly fits above the half nut. Then tighten the large nut in its far upward open


16

Cast iron guards fitted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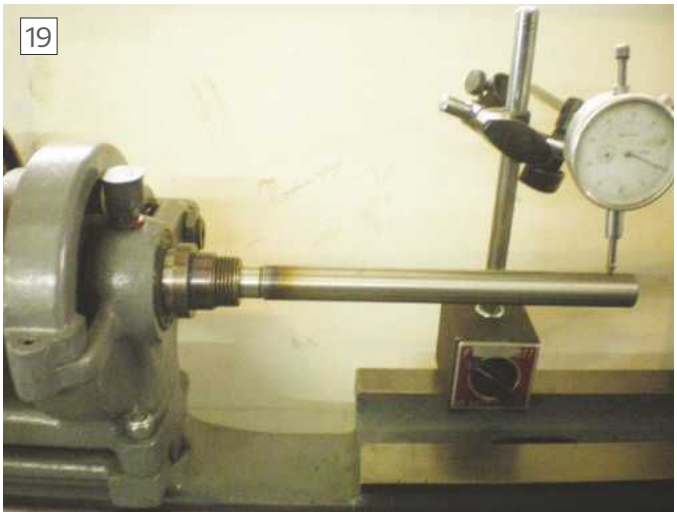
Front of finished headstock


18

Rear of finished headstock


19

Testing for true running

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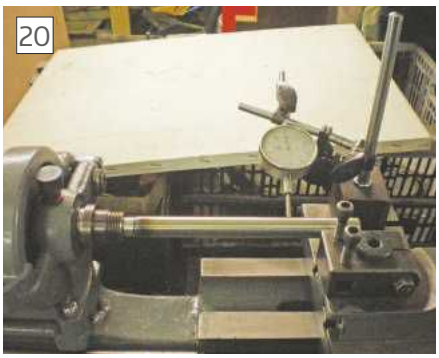
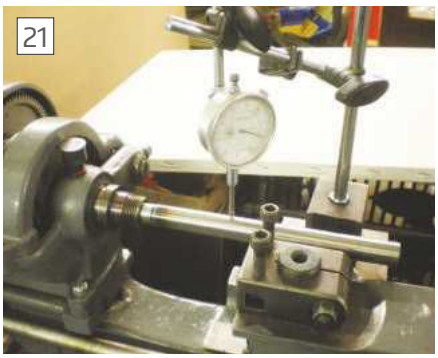


Testing horizontal alignment



Testing vertical alignment

position to provide clearance for assembly. The bearing nut is seen in photo 1 and 22 just below the cross slide handwheel.

Next is to fit the leadscrew handwheel onto the leadscrew and turn clockwise to engage the half nut in its fully open state by turning the leadscrew clockwise and it should draw the apron up towards the waiting saddle. Two large setscrews then pull the apron onto the saddle. These two nuts allow the apron to adjust in the meshing of the rack spur gear. The saddle has a keep-plate which pulls onto the oblong back shear of the lathe bed. This keep plate may need shims to adjust it to allow the saddle to move tightly yet smoothly up and down the lathe bed shears. The saddle also has two adjusting screws seen in photo 1 and 22 just below the cross-slide hand wheel. These need to be adjusted so the saddle moves smoothly forwards and backwards along the bed.

Smoothing on a very thin smudge of engineers' blue all along the front shear will show how the saddle fits when the saddle is moved. One pass of the saddle from the extreme left to the extreme right should be adequate to see the tell-tail-signs of where the saddle is touching the shear and by how much blue is removed from the shear. If the saddle stops or becomes tight at any point this is an indication that metal may need to be removed by scraping the lathe bed shears at that point so a note should be made of the distance from the tail stock end of the lathe. This tightness should be checked several times to confirm the need for progressive metal removal, mainly by scraping, to reduce the tightness. In theory, the high spots should be removed but the real test is when the spindle is turning and a cut is put on via a cutting tool in the top slide tool box and when traversed along the bed there is a smooth tight travel of the saddle. This provides further information when measuring the workpiece with a micrometer identifying error. This method provides the real live data needed on where the wear has taken place on the lathe bed.

The cross-slide also needs to be fitted in a similar way, seeing how the engineer's blue transfers from the gib strip onto the shears and visa-verse. The top slide needs the same treatment and notes made or simply scraping the slide ways for a better fit. The first experience we gain is when the cross slide and top slide tighten or slacken as they move along the dovetailed slide ways. Correction to this tightness can be simply achieved by slackening off or tightening a gib strip screw. We must also remember to lift the slideway to see if there is slackness to avoid the cutting tool grabbing the work piece.

Finally, there was a need to check the alignment of the tailstock related to the headstock. This was done with a Morse 2 test bar between centres once the earlier tests are done. Generally the problem is the tailstock has become out of line with the headstock. If at first the tailstock is traversed up to the spindle and the two points of the centres checked and the tail stock adjusted by loosening a set screw on the tailstock and moving the tail stock in the right direction with a spanner on the square headed screw.

Re-painting or touching up the paintwork

Paintwork isn't just about colour as a cosmetic effect it should have properties to keep the surfaces smooth, durable and easily cleaned providing the right kind of protection. It can be seen from photo 1 that the paintwork has been completed at stages when parts have been added to the lathe. The bed was painted first in an original Myford grey, a durable paint with a high specification for robust machine tools. The original paint for the 1947 Myford M lathe was grey and for the 1921 Drummond M lathe it is black. The paint on my existing lathe is black and it has stood the test of time with only a few chips on the paintwork.

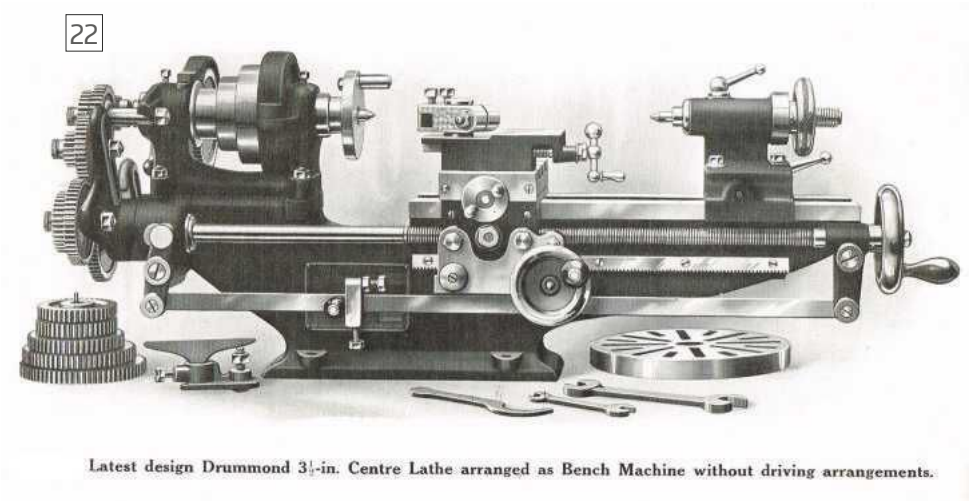
Conclusion

The Drummond M lathe became the preferred small lathe that the War office purchased for use on war ships and on land for the repair of tanks in the desert. This tells us of the high standing the Drummond M lathe was held in and throughout the 1940s and beyond.

When Myford was asked to provide lathes for the war effort they had to be the same design as the Drummond M lathe. However, the ML7 lathe which followed the Myford M lathe became the heart throb of the model engineer fraternity worldwide. Those who have used both lathes will know which is preferred based on its performance, substance; ergonomics; rigidity and not just on aesthetics. The Myford Super 7 lathe, is in a different league as a lathe.

Finally, in conclusion for those wanting to build a Drummond M lathe there are quality used parts still available to buy. The parts are interchangeable between the Myford M and the Drummond M lathe. Every week passes with used parts on sale on eBay and if we wait long enough all the Drummond lathe used parts can be purchased and an excellent lathe can be constructed, particularly if an inverter drive is added with its speed and torque control from zero to a specific upper limit. A taper roller bearing modified headstock on the Drummond M lathe does allow for the faster spindle speeds.

In my view a Drummond M lathe made up from used parts is better than buying a whole lathe that in the appropriate parlance, clapped out. If you are buying a complete or near complete lathe, though, it is always worth a visit to the seller to see its condition first hand and it may have parts that are suitable to use again in building a refurbished lathe. ■



The Drummond M from a 1921 brochure

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Richard Smith's Tooling System

Dear Neil, I read with considerable interest the really interesting article on the Carbide Insert Tool Holders designed by Richard Smith. I too am in a similar situation to Richard in that my four-way tool post is getting to be a fool thing to use and I'm tired of being continually stabbed by the thing and have decided there must be a better way.

I too was in the process at looking to replace it with Quick Change type tool holders on my Boxford Lathe. I even considered making a Lammas Type, 3 way tool holders but after seeing Richard's brilliant idea I have put my purchase and my manufacturing processing on hold for the time being.

Richard should be congratulated for coming up with such a neat idea and I hope that some forward thinking manufacturer talks to him asap in the hope that it maybe marketed as a kit or finished product for lathes like Myfords and Boxford's as I would certainly be keen to buy one. I hope he has a design mark or some other protection method on the idea too. I think its a little honey of an idea. When you look at QC tool holder's, this is such a simple but effective idea without all those dovetails to make.

I am also really looking forward to seeing the next issue and hope that a design drawing appears so that I can hobble one up to try it out as it allows for an uncluttered area behind the cutting tool.

I did have a couple of questions on Richard's system and they relate to the tool tip clearance angle.

1. Some years ago I attached a carbide tip to a tool holder I made, however it was not that successful. I later found out that some of these carbide tips need a negative tip angle for them to bite and remove metal. I modified my tool holder to give 2 degrees negative clearance and the unit worked a treat. I still use these tool holders and they are quite effective on my small Boxford lathe.

2. Also what style or type of carbide is best for Richard's system as I understand there are many different types and specifications as well the holding method that should be used. Front clearance angles etc do impact on cutting efficiency. I would look forward to some information on this aspect as well if possible. Is there a good UK supplier for these inserts as I'm not sure if there is in New Zealand. My ones all came used from industry and I understand they can be really expensive to replace.

Anyway, I thoroughly enjoy your magazine even though it takes an age to get here in New Zealand. I understand that I am of Scottish ancestry and I am exceptionally proud of my heritage. I believe very strongly in the Rolls Royce advice that quality lasts long after the price has been forgotten and surely an engineer is someone that can make something for 50p that others could do for five Pounds. That's why we engineer.

Bryce Clifford New Zealand

You will be glad to hear I have received some follow up articles from Richard which will give more details including dimensioned drawings – Neil.

Advice on Brazing Torches

Dear Neil, I wonder if I might pick readers' brains on brazing equipment. I need to braze some mild steel sections together and attempts to do so with a propane gas torch using brazing rods have not been successful. The propane flame simply does not generate the temperature needed to melt the rods and make the brazing material flow into the joints.

I have been searching the internet for suitable equipment and have come upon Rothenberger Roxy 120L Portable Brazing & Welding Kit. I wonder if you anyone has any information on this kit?

I have an 11kg propane gas cylinder and have noted on the internet that if oxygen is added to the propane gas via an oxygen gas cylinder feeding into the gas torch, that the required temperature of around 875C can be achieved. I'm not sure, however, what additional fittings and gas taps are need for combining the oxygen and the propane gases.

Possibly some of your subscribers would have useful advice. I am incidentally not keen to buy MIG welding equipment. It is too expensive for the relatively small job I have in mind.

Neil Macnaughtan, Edinburgh

Oxy-propane may be a solution, although brazing is not suited to really large sections. I'm sure you will need a purpose made torch but perhaps a reader can offer more detailed advice? Neil

Workshop Flutes – of a Different Kind

Dear Neil, I just had a 'proper' look at the front cover of tissue 250 MEW, and it looks like Stephen Wessel has dismantled a flute. Can you confirm that is the case? There certainly seems to be a lot of parts that are familiar from my own flute which I would not dare to disassemble!

Glad to see there are lots of readers and contributors with multiple skills and hobbies! Even your own keen interest in astronomy, and the parts you make to assist with that. My own interests cover way too many areas to have any chance of being competent at any of them. Hopefully I can combine a few as many contributors have done. Latest efforts involved building a remote radio control for my Nikon SLR so I could photograph the choir I was in from the organ loft whilst taking part in the performance. That at least combined music, photography and electronics, but very little workshop stuff! Now it's machining some special heat sinks for remotely switched LED lamps I have designed. They will use the mill and a slitting saw.

Last week I learned that a local retired fitter is selling up his property and moving into aged care because his wife had needed to be there since the New Year. He tells me there is no other option, and I now wonder how he will cope with leaving his rural property and having no access to his workshop. He is also a very accomplished blacksmith, and has built his own forge and hammer which he used to make amazing knives. His vast knowledge of materials and his amazing skills has me in awe, and I am sad to think all that knowledge will not be passed on because the current generations seem to regard this 'old stuff' as irrelevant.

I guess this is an inevitable part of ageing, which we all will face at some stage, but visualising this man without his workshop leaves me concerned for his welfare. There is a growing movement of men's sheds here, and I can see great benefit in these for both a social outlet, and potentially continuing with the interests of members, either as participants or mentors. Hopefully we will learn how to keep these talented men occupied and pass on their skills to future generations.

Brian Sala, Australia

The range of hobbies and interests of our readers goes much wider than model engineering! Yes, that was a flute on Stephen Wessel's bench, in fact he is the last full-time flute maker in the UK. He is concerned that the day may come when flute making skills are lost to us, and has agreed to write up some of the fascinating skills and processes involved in flute making for MEW. While I don't imagine many readers will try to make a flute, I'm sure there will be lots of interest – Neil.

Day of Atonement

Unpardonable sin on page 42 of MEW 251! It's a Triumph not a BSA. It even shows the Triumph badge on the tank. Who's going to fall on their sword Neil, you or Allen Berman? Nit picking perhaps but us hobbyists like things to be right!

Jim, by email

Allen and I have decided to let the SMEE's Press Officer take the flak! And by gum, there was an awful lot of it. Thanks to all the many folks who spotted the 'deliberate' error - just don't let my Dad find out! - Neil

Dealing with Condensation Problems

Dear Neil, In MEW, February 2017, Scribe a Line, Malcolm Leafe reports he may have moisture condensation inside his Optical Rotary Table which he would like to remove.

In the past I have removed unwanted moisture from articles such as watches and other smallish mechanisms, by using silica gel desiccant. The method just requires a suitable sized, hermetically sealed container, preferably glass so one can view progress, into which one places the article/s to be dried, together with some crystals of silica gel. Prior dismantlement is not normally required if moisture removal alone is the aim. Be patient though; it may take a few days at least, even at room temperature. I have not tried it on something as large and heavy as a 10-inch Rotary Table but were it mine, I would try this first. (Assuming if moisture has got into the ORT, water vapour can probably be drawn back out of it, given time.)

Perforate an empty baked bean tin say and fill it with silica gel. Your local friendly double glazing manufacturing company might let you have some, like mine did when I explained what I needed it for. Being hygroscopic the gel may require placing on a metal tray in a low oven for a couple of hours first, to drive off any adsorbed moisture. Check for when it has dried by holding a hand mirror over the crystals. Any condensation on the mirror means further heating is needed.

Years ago, one could obtain silica gel treated with cobalt chloride which made the gel a lovely blue colour when dry but caused it to turn pink when it was saturated. Apparently for health reasons cobalt chloride has now been replaced by safer indicators. At least one company e.g. Brownell UK, (with whom I have no connection), offer a silica gel impregnated with a colour changing organic indicator, that adsorbs 30% of its weight of water. They offer a beaded form that is less likely to break down into dust but still requires caution to limit the number of reactivation heat cycles that may eventually reduce adsorption capacity, as does contamination with dust, grease or petroleum products. Also, avoid heating the material above 120 degrees C.

With the rotary table placed on a sheet of plate glass, granite worktop etc., put container of silica gel with it and cover. A large inverted bell jar or glass aquarium would do nicely, adequately sealed down at the periphery on thick grease or with tape say. Less easy to see through but perhaps easier to find, would be a rigid polythene food container, sealed down similarly. Don't let the kitchen monitor know I suggested it though!

I Hope Malcolm finds this useful.

Timothy Sims, Sutton Coldfield, West Midlands.

Readers' Work

Bob McMenemie wasted no time in getting to work on John Ashton's Screw Modification Fixture (MEW 250.251):

I had a go at making the Universal Screw Mod Fixture in latest issue of MEW. This is my rendition of John Ashton's design which I desperately needed for reducing diameters & lengths of small screws for an 00-gauge rolling road I am about to make. ... Thanks John for your article; not only is the fixture useful for small screw holding but I found that it helps when holding bushes which need to be cut to precise lengths. I hope John doesn't mind my alterations. I didn't have any hex bar so I just used some round stock and put a knurl on it. I tapped the end 10mm as I am about to trim up some 10mm threaded rod, it also doubles up as the actual spacer for any screw length, and I used a 10mm threaded rod instead of John's spacers.

The photos show a screw fitted and how I use it to hold a nylon bush also for trimming to size. I made this with help from my 15 yr old grandson William who is showing a great interest in Model Engineering.

Please thank John Ashton for his design!

Unusual Dial Gauge

Dear Neil, I purchased this Rambold dial gauge second hand many years ago which measures to one tenth of a thou. I have always wondered why this gauge has 80 rather than 100 divisions on it. I have never seen another gauge with 80 divisions and Rambold don't make any like this now. Was it used for a particular purpose?

Fantastic magazine now with always many interesting items. Keep up the good work.

Mervyn Karwot, Central Scotland

Duplex Device

Dear Neil, I was interested to read Alan Aldridge's "Gear Cutter" articles and, in particular, MEW 248 and 249 where he describes his version of the Duplex relieving tool, as I was setting out to making one. Unfortunately, Alan's drawing lacks a general arrangement to show how the parts are assembled and is incorrect as far as the rocking arm is concerned.

Compared with the original design, which was clearly set out in ME dated 16 June 1949, this new solution seems unnecessarily complicated and offers poor advice by suggesting 2mm drilled holes should be used to position the closely spaced centres on the end of the arbour instead of a small centre drill.

I did check with a friend who had made one some time ago who assured me that he followed the original design without difficulty and was very pleased with the results, so I'd strongly recommend to anyone wishing to make a Duplex relieving tool to use the original design and guidance which includes a useful sharpening jig.

Stuart Walker, by email

I received similar comments about changes to the ratchets for the Eureka design from Ivan Law, who pointed out the original design has worked fine for many years. The truth is that nearly everyone who makes their own tooling will make changes to suit their own views, and while these changes clearly worked for Alan, the original designs are both well proven – Neil.

Spanner in the Works

Hello Neil, I am not a forum member but read it every day. Always something to learn from it. I am a retired engineering pattern maker but have not joined. I have bought Model Engineers Workshop from edition number 11 and have kept them all. Always a good read. Regarding the Wilco adjustable spanner, I bought a Bahco made version in 1990 whilst holidaying in far North Queensland at the small sugar town , Mossman. It was in the local hardware shop. When I saw the photo of yours I immediately recognised it and thought I have one of those. They are absolutely identical. Except mine must be slightly larger and has a range up to 7/16, 11mm and 1", 25mm.

I have hardly used it as I feel the sliding jaw is thin and may damage the nut if a lot of force is exerted. Still it sits in the tool box as one day it will come in handy. Being Bahco it should be decent quality and up to doing the job.

On to another subject. I feel a word of warning could be passed onto other readers. Recently I was trickle charging my motor cycle battery (gel type) and inadvertently left my nice Mitutoyo digital calliper resting on the top of the battery and forgot about it overnight. Next morning I was astounded to discover that the plastics in the calliper had melted and fused the sliding part into a seized state. Locked solid. Not happy. The battery did not get really hot to touch but obviously enough to melt the plastic. An expensive lesson there.

I always learn something from each edition of M.E.W. Have never subscribed but have standing order at my friendly local newsagent and so far have not missed an issue.

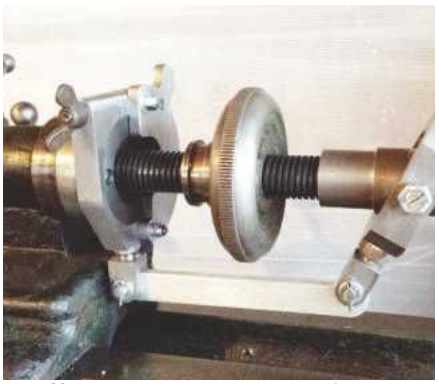
Morvan Green, South Australia.

Thanks Morvan, here's a picture of the unusual spanner for readers who don't visit the forum. You really should join, you clearly have plenty of interest to contribute – Neil

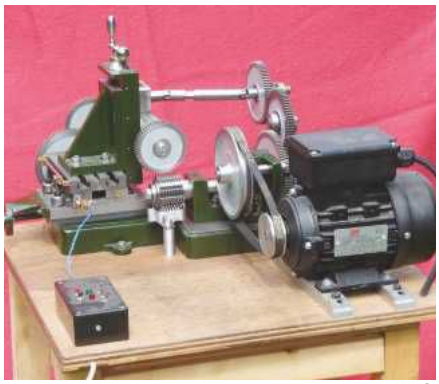
In our Next Issue

Coming up in issue 253
On Sale 24th March 2017

More excellent articles to inspire and entertain in the next packed issue of Model Engineers' Workshop:



Geoff Walker revisits Ian Bradley's Lever Feed tailstock for the Drummond/Myford M lathe.



Christopher Robinson explains the use of a Jacobs-type gear hobber

Alan Jackson on life with this Chipmaster lathe

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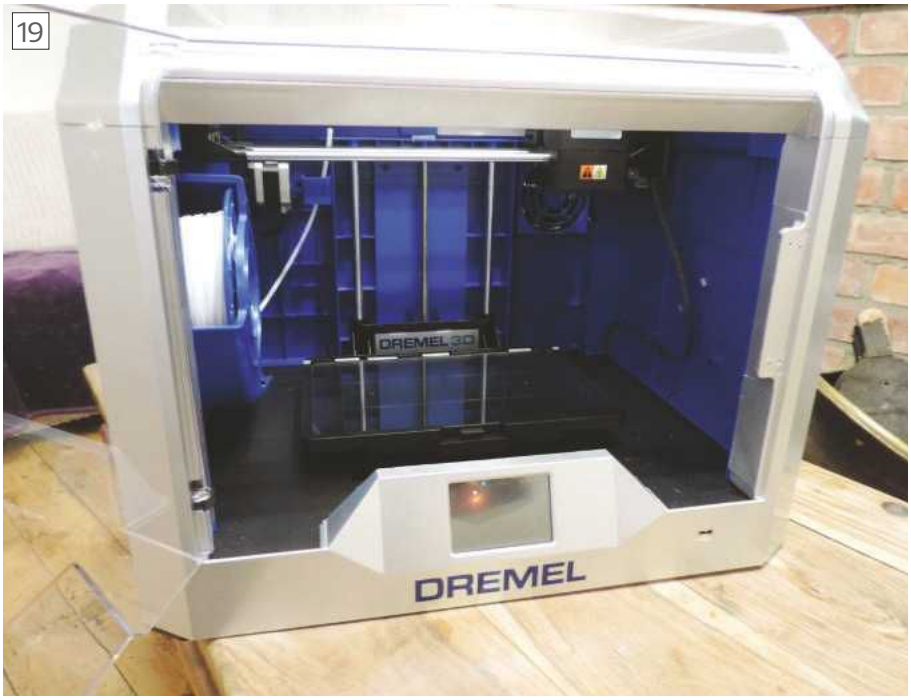
It's model engineering, Jim. But not as we know it!

– Part 2

Our MEW Editor, Neil Wyatt reviews lessons learned using the Dremel 3D40 idea Builder printer.

Last month I introduced the Dremel 3D40 Idea Builder, **photo 19**, and the workflow I used to create some test pieces. I'll conclude this time by going through some of the objects I have printed, and then giving my overall appraisal of the machine.



The 3D40 Idea Builder

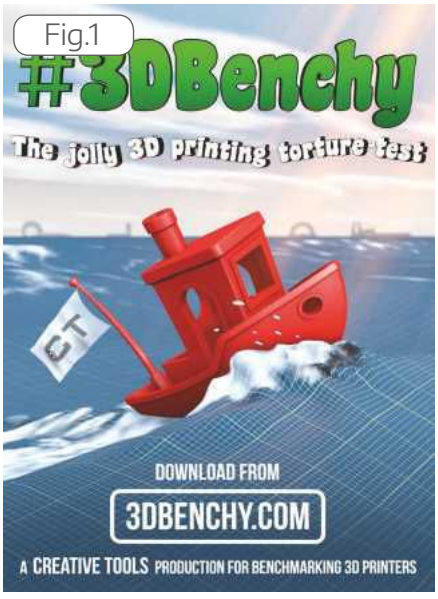
3D Benchy

'3D Benchy' is a popular test file that places heavy demands on 3D printers, **fig. 1**. The object is a toy-like small fishing boat known as 'The Jolly 3D Printing Torture Test'. It has various angles, overhangs and other features designed to be printed without supports. I downloaded the STL from 3Dbenchy.com and printed a '3DBenchy' on the detail setting to see how the 3D40 fared. The model came out very well, **photo 20**, but there were a few subtle faults, there were a few 'hanging threads' on unsupported surfaces, the very shallow (0.1mm) text on the stern was indistinct and, surprisingly, the base of the model had an area which had printed poorly, **photo 21**. Otherwise various shapes, overhangs, curves and surfaces came out well with only tiny flaws. The print was dimensionally accurate within reasonable expectations and the overall appearance was very good.

Bearing in mind that this was printed with 'out of the box' settings I think that this highlights how the Dremel 3D40 is a quality 'plug and play' solution for people who just want to get on with 3D printing, rather than spend a lot of time constructing and tuning their own machine. That said, the relatively small size and excellent documentation for 3DBenchy make it a much better test piece for setting up kit printers than the ubiquitous cube, which is actually a very straightforward task for most printers.

Build Tape

Last month I commented on how objects are secured to the build platform. The 3D40 printer uses sheets of 'build tape' which has a textured surface that PLA adheres to quite securely. I found that the supplied build tape worked very well, for a while.



3DBenchy brochure

After extended use (but less than the 50 builds quoted for black tape) items started to peel up during printing and get spoilt, or even break loose. I found I could restore the 'stick' of build tape (both the short-life blue and long-life black versions supplied with the printer) by wiping it with a little methylated spirit. The problem then was

3DBenchy test piece

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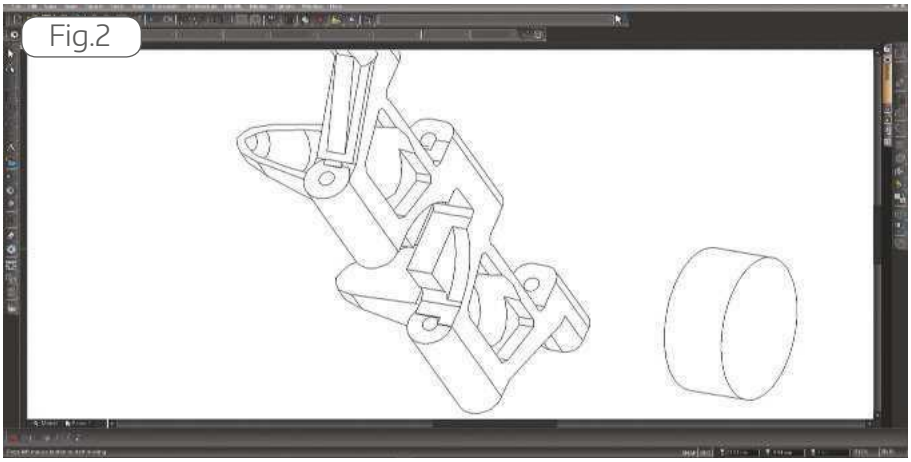
I'm still not sure why this fault appeared underneath.



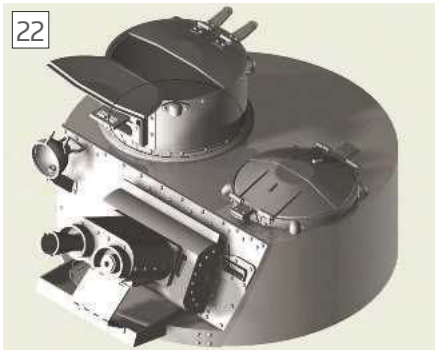
Part design in TurboCAD Deluxe

that the cleaned build tape now stuck to the objects like a limpet!

Small objects weren't too bad but for large ones the 'special removal tool cum putty knife' tended to dig into the build tape. At about £10 a sheet digging big holes in the tape is not a good idea. In the end, I found gently tapping the handle of the tool to 'chip off' the object was a solution. Some people use blue masking tape as a cheap substitute for build tape, my experiment with using it was that it works, but not as well as proper build tape.

Aside from occasional unsticking objects – solved with the meths treatment – I had just two other printing problems. One was the filament breaking on one occasion – the printer just paused and waited for me to re-feed the filament and took up where it stopped, very impressive. The other was very odd, printing two handed objects side by side the printer kept losing track of the x-axis at random points, creating stepped objects. I could never recreate this with any other objects, and printing the left and right hand objects separately also avoided the issue. My suspicion is that there was a minor error being generated in the g-code, but I was never able to track down the issue.

All the other printing problems I had were down to my poor design or processing of objects such as a base that wasn't flat, lack



Turbocad model of Vickers Light Tank turret

of support or walls too thin (I discovered walls thinner than a strand of PLA won't get printed!)

Vickers Light Tank

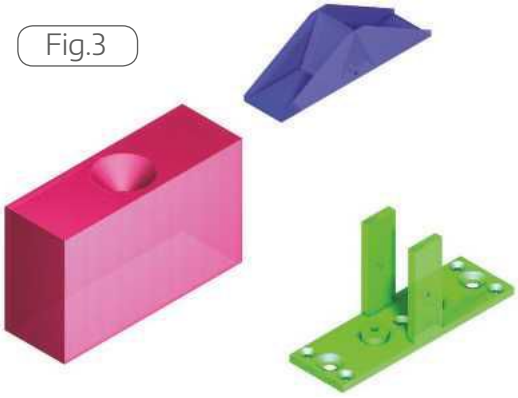
I was particularly keen to try out the potential of 3D printing for model making. Last time I featured a picture of the gun and mantlet for a Vickers Light Tank Mk. V1b. I since redesigned and re-printed this and actually printed the whole front of the turret, which I designed using Turbocad Deluxe, **photo 22**. Parts consistently print slightly oversize, and I found that allowing 0.1mm gap gave a push-fitting joint and 0.2mm was ideal for moving joints. As an example, I printed the commander's cupola and turret hatch, all at 1:6 scale and you can see the hinged lids work very well, **photo 23**. The flaps were printed to a diameter 0.5mm less than the recesses in the frames, while the hinges had 0.2mm allowance.

In last month's Ed's Bench I mentioned the track which worked very well, again designed in Turbocad – I have been thinking of using Fusion 360, but am less keen as I seem to have the knack of Turbocad now, **fig. 2**. I also printed the suspension units, wheels and tyres to see if I could use metal parts with the printed ones. Brass tube used as bushes fitted closely into the holes and was easily fixed with 'Gorilla' superglue, a gel which I found has quite an extended working time, more than the 10-30 seconds it says on the bottle. I printed the wheel hub holes undersize and reamed them to 3/8" – this was a waste of time, and for the suspension arms I just printed holes dead to size and the bushes were easily tapped in with a nylon-face hammer. I bought a long piece of spring, with both the ideal appearance and spring rate and cut it to length using a Dremel rotary tool! The end result was four fully working suspension units, **photo 24**. My hope is to exhibit a mostly 3D printed tank at the next Model Engineer Exhibition – I also hope to take some parts to the Manchester Exhibition which will take place about the time you get this issue.

Rain Gauge

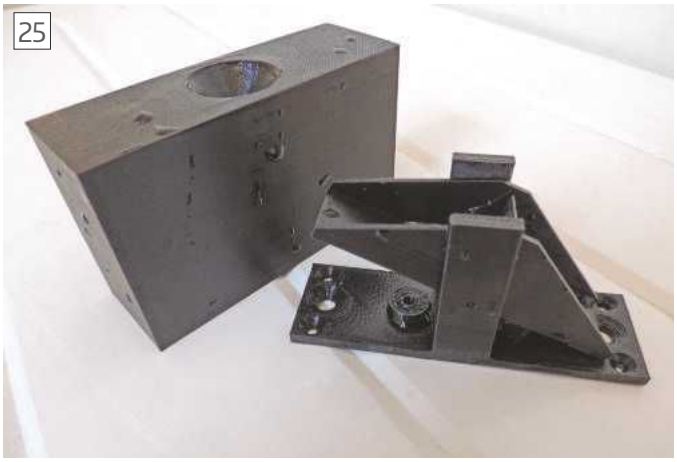
One of my on-off projects over the years is the gradual construction of an automated weather station. The main omission from

Cupola and hatch printed from the Turbocad model



Rain gauge components

3D printed light tank rear suspension unit



Components of tipping bucket rain gauge

this at the moment is an automatic rain gauge. The central part of these is a 'tipping bucket' rain counter. With the starting point of an example (non-3D printed) on the web, I created a simple design in Turbobcad Deluxe, **fig. 3**. The finished gauge works well when placed under a trickling tap, clicking evenly from side to side, **photo 25**. I now need to add an LED/photodiode pair to create a pulse each time the 'bucket' tips.

Projector Gear

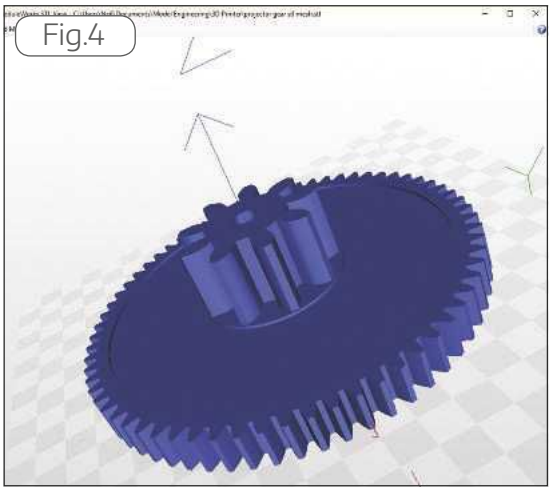
Around the time, I was testing the printer, there was an unusual request on the forum at www.model-engineer.co.uk. A forum member who works for a school was trying to repair an expensive computer projector that had stripped the gear which elevated the projector head. Unfortunately, the combination of two different module gears meant it isn't an off the shelf item, and combining two small gears securely was a bit of a challenge.

He had created an STL model of the gear, **fig. 4**, but could anyone print it out? There was scepticism expressed that a 0.5mod gear could be printed neatly enough to work, at only about 34mm across, but I offered to have a go using the 3D40 in detail mode. The first gear, **photo 26**, escaped its envelope in the post, but I was pleased to receive a grateful message saying that a second attempt had restored the projector to fully working order!

3D Puzzle

As a bit of fun, I decided to make a 3D maze puzzle. In Turbocad I created a large cube, then built three 'layers' of nine smaller cubes and various cylinders linking the smaller cubes. By 'subtracting' the smaller cubes from the large one I created a hollow structure ideally suited tom 3D printing. I then saved this as an stl file, **photo 27**, With 17mm unsupported bridges across the top of each internal cube, it was also a good challenge for the printer.

I used the 3D40's pause function to stop the print in the middle of the second 'storey' so that I could drop a 15mm ball bearing through a passage into the 'ground floor' of the maze. The printer resumed without a hitch and the maze was a complete success first time, **photo 28**. If you would like to print your own maze, you can download the file from www.stubmandrel.co.uk/model-engineering/140-3d-printable-cube-maze-puzzle.

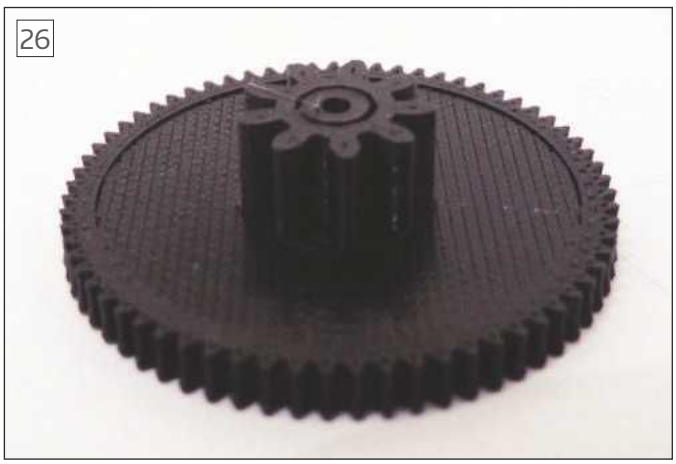


STL file for the projector gear

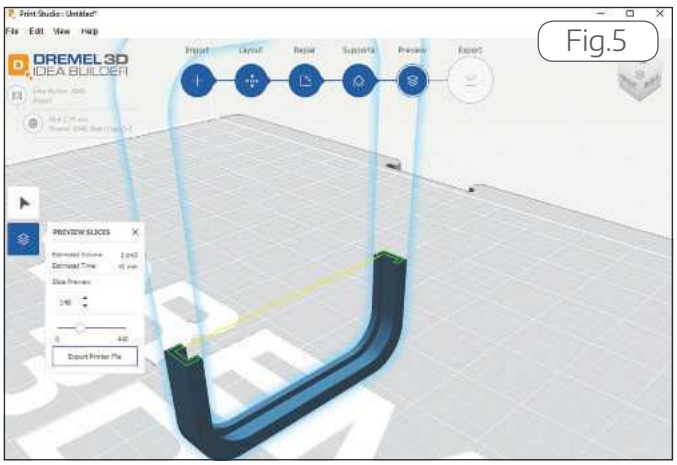
Appraising the 3D40 Idea Builder

The 3D40's key market is for education. I can imagine it meets schools' needs perfectly. Teachers with little technical knowledge can follow the quick start guide and have the machine ready for pupils to print their own objects in about an hour.

For the workshop, needs the excellent print quality, large build volume, enclosed design, rapid and accurate levelling and straightforward workflow make it a serious choice for those willing to pay around £1,000 for an off-the-shelf 3D printer, **photo 29**. Running costs may be high if you use Dremel's own brand filament, at about £19 per 0.5kg spool. The filament is not 'chipped' but only Dremel's spools will fit in the machine. Dremel also say using other brands of filament, typically available on 1kg spools, will invalidate your



The 3d printed projector gear



Print Studio screenshot.

warranty, although this hasn't stopped people coming up with 3D-printed holders for larger spools.

The 3D40 is also backed up by Dremel's warranty and technical support, as well as a large website with plenty of resources, including instructional videos.

That said, it would be wrong to suggest the 3D40 is the answer to everyone's needs for 3D printing, as it has two significant limitations for the experimenter. The first of these is that it is limited to using PLA. Poly lactic acid is a biodegradable plastic made from milk. Kept dry it is highly durable but in constantly damp conditions it can degrade – while this could be an issue for my rain gauge, we are really talking 'compost heap' conditions so this is unlikely to be a real problem. No, the issue is more that you don't have access to other types of filament such as ABS and synthetic rubbers for making flexible objects, such as tyres or rollers. For most tasks, PLA will be fine, but if you want to experiment you need a machine with a greater range of nozzle temperatures and a heated bed.

The lack of a heated bed is the second limitation. A heated bed is essential for ABS and makes it easier to print PLA without distortion, and once the bed cools removal becomes much easier. If I could keep the 3D40 (and believe me I would like to!) I would probably add a heated bed, I'm sure it would be easy to do without damaging the self-levelling system.

An add-on heated bed wouldn't work with the supplied software, you would need to manually adjust its temperature or have a separate controller. You could also invalidate your warranty. Perhaps Dremel might want to consider making a heated bed available as an integrated aftermarket item.

Wifi capability is one of the printer's plus points, but I could not connect the printer tom our home network. Tech support said this has been fixed in more recent machines, so I needed to update the firmware with a download from the Dremel website. This all went exactly as their step-by-step video said it would, but the machine still refused to detect any wifi networks so I never got to test this feature.

Unlike opensource 3D printers, you need the supplied software to generate the g3drem files that run the printer. The software doesn't really make it obvious how much control you have over the printer's features, and I would have liked a bit more information in the full manual, or a more detailed online guide. After some playing, I found that 3D Builder is much more capable than its rather chunky interface suggests, in particular it seems to be better at repairing dodgy STL files than the other supplied software, Print Studio.

Print Studio is by Autodesk, who produce the industry standard design software AutoCAD. Considering this pedigree, I was surprised that even the latest update of Print Studio was unstable under Windows 10, regularly crashing for no apparent reason and simply locking up if it could not repair an object. I also found manually placing and deleting supports to be very difficult. This is a shame as otherwise Print Studio makes the 3D40's workflow very simple, **fig. 5**, so please don't think Print Studio is unusable, it isn't and I used it to print dozens of objects.

The Bottom Line

My impression is that the 3D40 is the ideal machine for anyone who wants a no-fuss, high quality 3D printer they can just set up, send files to and enjoy the results. It probably isn't the machine for those who want to fiddle with the mechanism, add bits and pieces, change the software or experiment with different materials. It does exactly what it is meant to do, and does it very well, **photo 30**.

Suppliers of the Dremel 3D40 idea Builder are a bit thin on the ground. Axminster sell the smaller 3D20, but don't yet stock the 3D40, other suppliers are listed at https://dremel3d.co.uk/buy-3d-printer. ■

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Rendering of the inside of the 3D maze

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The actual 3D maze

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Features of the 3D40 from Dremel's website

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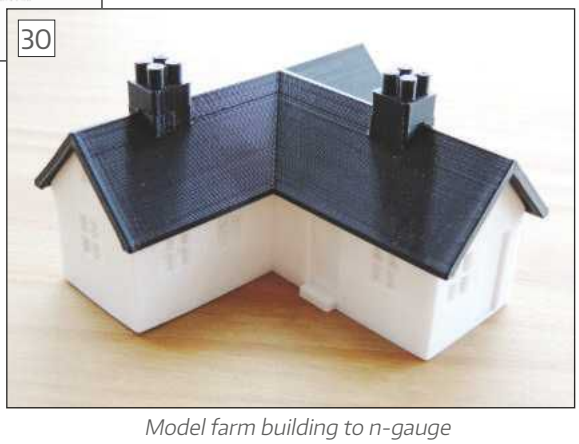

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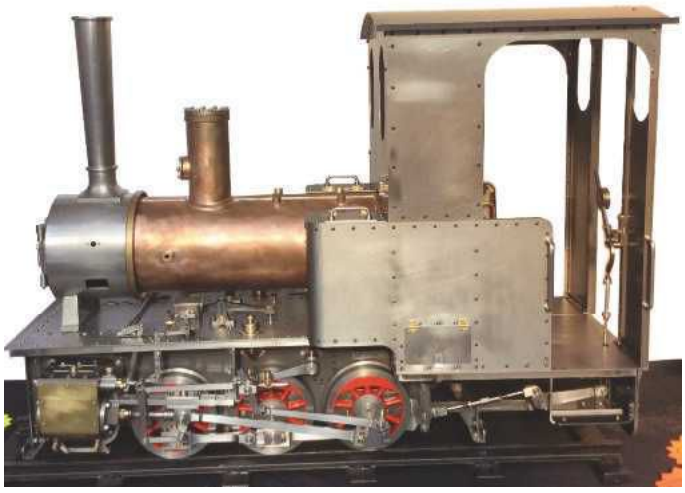
7 ¼” gauge GWR Collett Goods Doncaster 2016



7 ¼” Narrow Gauge Koppel 0-6-0 under development based on Ken Swan Design.



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Rotary Table Alignment

Howard Lewis describes his technique for aligning a rotary table under a vertical milling machine

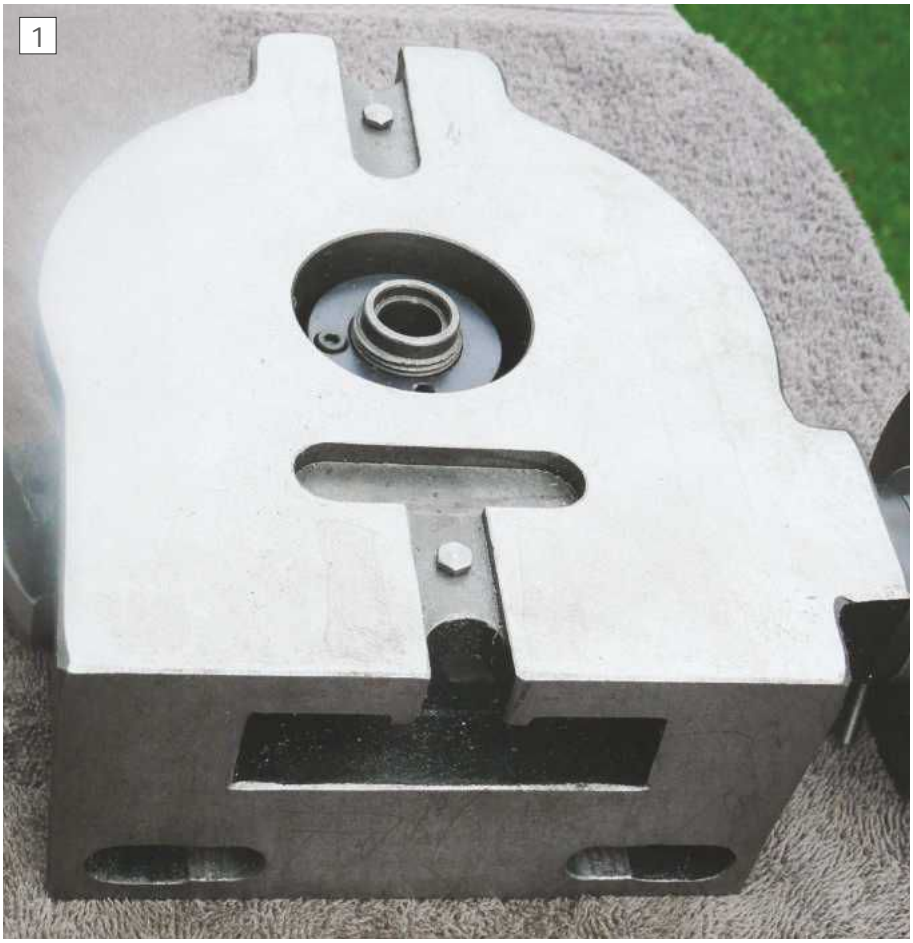
During the construction of a set of geared bending rolls, it became obvious that the blank for the gears would need to be supported whilst the gear teeth were produced. Unfortunately, there was no easy means of ensuring that axes of the rotary table and tailstock could be aligned with any accuracy, so a technique needed to be devised, and tooling made. The method devised can probably be applied to other makes and sizes of rotary table or dividing head.

The outer end of the bushes that carry the rolls also needed to be radiused, so there was a need to centralise the rotary table under the spindle when used in the horizontal mode. In this context, "horizontal" means that the face, not the axis, of the rotary table is horizontal.

Some of what follows is quite basic, and well known to some, but may be fresh to others; so will the cognoscenti please bear with me.

Basic reasoning

The Vertex HV6 rotary table, as its designation implies, can be used in the horizontal or vertical position. However, whilst the rotary table has provision for alignment with keys or dowels, when used in the horizontal position, no such means is available when used in the vertical orientation **photo 1**. Also, there may be times when alignment, using dowels or keys, is not always suitable when used in the horizontal mode.



Keyway for use in horizontal mode

Depending upon the type and size of tapers in the lathe and mill, it may be necessary to use adaptor sleeves during machining or alignment. In the vertical mode, sometimes, it suffices to align the rotary table across the table of the mill/drill

Aligning using a square

Dowels fitted in the keyway

using a square, **photo 2**.

The tailstock, however, does have a keyway cut into its base, and into this have been fitted stepped dowels, to maintain alignment in the tee slots of the mill/drill, **photo 3**.

It did not seem to me to be a feasible proposition to fix the rotary table to the mill/drill to cut a keyway, (which would be short anyway) to allow it to be dowelled onto the table very accurately, when used vertically. Consequently, some other means of alignment was needed. Notwithstanding, I did summon the courage to mount it to elongate the mounting slots slightly, to increase the range of movement across the table. For horizontal use, it can suffice to clamp the rotary table to the bed of the milling machine, before using a variety of methods of centring it under the spindle.

Alignment in the vertical mode

Since the HV6 has a 2MT bore, it seemed that this should be used as the datum axis for alignment. Initially, the method envisaged was to make up two narrow vee blocks, dowelled to the tee slots of the mill table, to be used for alignment of a long arbor, fitted to the 2MT bore of the HV6.

The vee blocks would have been machined as one unit before being split into two, for fixing to suitable dowelled bases. Then, at a model engineering show i found a 2MT stub arbor 1.500" diameter and 1.625" long, **photo 4**. This became the raw material for the method actually used.

Tailstock check.

Firstly, certainty was needed that the tailstock centre was truly on the axis of the tailstock barrel. For this, the anti rotation retaining grubscrew was removed, allowing the tailstock centre to be removed. Once out, the centre was checked for burrs, and the diameter measured. It was then put into a four-jaw chuck, on the lathe, and set to run as true as possible, (to within 0.0005" in the event).

Once centralized, the topslide was set over to 30 degrees, to trim up the centre with a tipped tool. In fact, the centre was running true and barely merited burnishing. The centre was refitted to the tailstock,

MT2 stub arbor

and the clamping adjusted to ensure the absolute minimum of clearance consistent with reasonably free movement. The anti rotation grubscrew was then refitted and adjusted, to just clear the bottom of the keyway in the centre.

The 2MT arbor

With the aid of adaptor sleeves, this was placed in the lathe, centre drilled, and progressively drilled until just under the diameter of the tailstock centre. The drilled hole was then gradually bored out, taking repeated spring cuts, until the centre was snug fit in the bore. (pulling out the centre produced an audible 'pop', and the addition of oil meant that it bounced when pushed in.

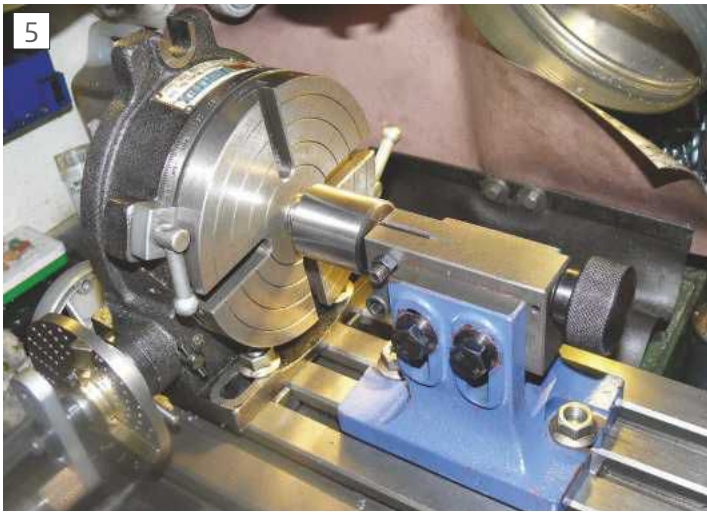
The depth of bore was chosen to provide maximum engagement of the tailstock centre into the bore, without weakening, or endangering break out of the bore, at the change of section from 1.500" diameter to the 2MT shank.

Alignment

The HV6 rotary table and the tailstock were then placed on the table of the mill/drill and their positions readjusted, so that both were over tee slots so as to allow two tee nuts, each, to retain the tailstock and the rotary table.

Knowing that the gear cutting would entail using a lot of the space available on the table, the rotary table was placed at one end of table, and very lightly clamped. The centre of the tailstock was extended, and the tailstock moved along the tee slot to enter as deeply as possible into the alignment arbor, **photo 5**.

The height clamping bolts on the tailstock were slackened, before both the rotary table and tailstock were fully clamped to the table of the mill, followed by retightening the height clamp bolts on the tailstock. In this way, the alignment of the

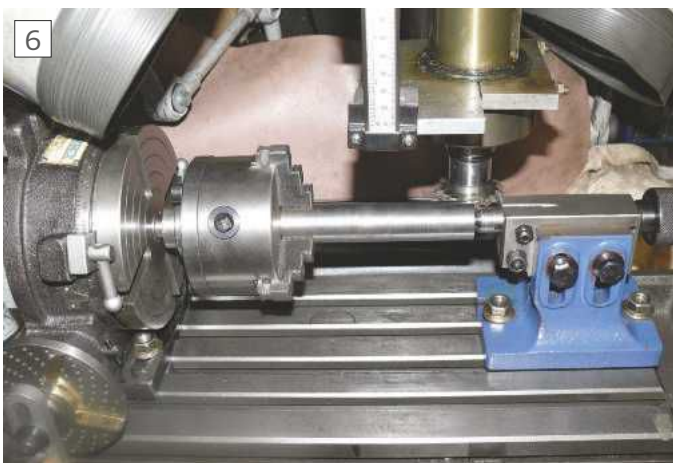


Adjusting height of the tailstock

tailstock and the HV6 were complimentary (the tailstock centre aligned the HV6, axially, whilst the HV6 would ensure that the height of the tailstock centre was on the axis of the HV6).

Once these operations had been completed, the tailstock was moved away, and the 2MT arbor removed. This allowed a 2MT arbor, carrying a 3-jaw chuck, holding the gear blank, to be fitted to the rotary table. This set up had been used in the lathe to drill and ream the gear blank, before turning the o.d., to ensure concentricity of the inner and outer diameters.

Once in place, the tailstock was then repositioned to provide support for the

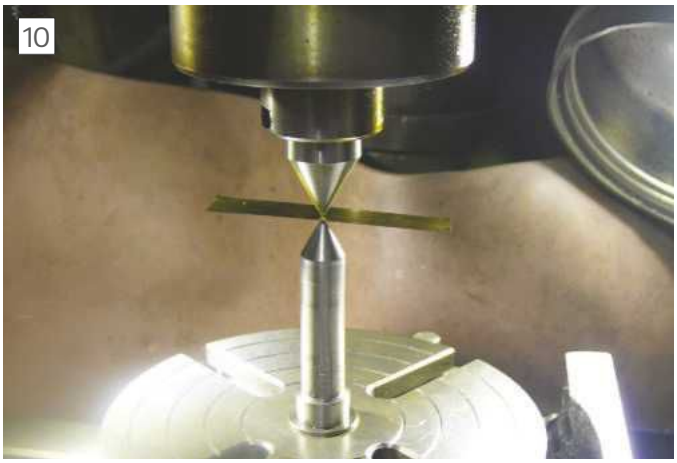


Set up for use in the 'vertical' mode

2MT arbor and plugs

Aligning using the arbor and one of the plugs

Using a centre-drilled arbor



Using the 'shim' method

Making use of the vertical alignment fixture in horizontal mode

outer end of the gear blank. **Photograph 6** shows the arrangement ready to be used in anger!

Various methods for alignment in the horizontal mode

These again use the 2MT bore of the HV6 rotary table for alignment. **Photograph 7** shows a 2MT arbor which has been bored out, with two 'plugs' that have been made to fit it.

The one on the left was made by lightly turning the diameter of the stock, followed by turning down a short section to be a snug fit in the bore in the 2MT arbor. It was then held by this location diameter in a 4-jaw chuck, and clocked on the o.d. to run true, before being centre drilled. This was fitted to the 2MT arbor, and a centre fitted to the spindle. By bringing the spindle down and adjusting the mill table in x and y axes the centre in the end of the 2MT arbor in the rotary table can be made to coincide with the centre in the spindle, as **photo 8**.

The fitting on the right was made in a similar fashion, except that instead of a centre drilling, a parallel diameter was made to suit a chosen collet. The table would then be adjusted in x and y axes, until the fitting, held by the collet in the spindle, enters easily into the bore in the 2MT arbor.

If a 2MT arbor is centre drilled, it removes the need to make the separate fittings mentioned above to centre the rotary table, as in **photo 9**.

Another possible method is to fit a 2MT centre to the rotary table, and another centre to the mill spindle. By trapping a piece of flat shim (a traditional razor blade would do very nicely!) Between the centres. Any misalignment is indicated by the shim not being horizontal. Small adjustments in the x axis will level it one plane, and similar small adjustments in the y axis will level in the other plane, photo 10. An alternative method is to reuse the fitting, used for aligning the rotary table in the vertical mode.

A Morse taper arbor is fitted into the lathe mandrel, and turned down to very slightly above the diameter of the bore in the 2MT arbor used in the rotary table, (about 0.001inch or 0.025mm). The final size is obtained by polishing with fine emery tape, wrapped around a flat board, and applied to the arbor as the lathe runs. It should go without saying that care has to be taken during this operation to prevent injury to oneself (this technique is the one recommended by the HSE for using emery on the lathe – Ed.).

The lathe is stopped frequently to use the table fitting as a gauge. For once, my work was sufficiently accurate for the gauge to bounce back when pushed onto the dry arbor. The cleaned arbor is removed from the lathe and fitted into the spindle of the mill.

The rotary table is positioned on the table of the mill, but with the mounting hardware left loose. The quill of the mill, carrying the arbor, is lowered, so that it enters into the bore of the 2MT arbor in the rotary table, **photo 11**.

With the head of the mill locked, the hardware securing the rotary table to the mill table is tightened. It should then still be possible to remove the arbor in the mill from, or to replace it in, the bore of the 2MT arbor. At this stage the locks should be applied to both axes of the mill table. The arbors may then be removed from the mill spindle and the rotary table. Do not use undue force when fitting any arbor used for aligning the rotary table.

The arbor has to be removed, without disturbing anything, before machining begins, and the horizontal mode prevents access from the rear to drive it out!

Once the work piece has been centred on the rotary table, the required radius can be obtained by offsetting the mill table along one axis, before fitting the cutting tool to the mill spindle, (not forgetting to allow for the diameter of the chosen cutter, and for backlash when reversing the direction of travel of the mill table)

If it needs to be said; to avoid 'dig ins', the direction of rotation of the rotary table should always be in the same direction, and opposing that of the cutter. If in any doubt, do not be afraid to clamp the rotary table partially, to reduce any tendency to bounce to and fro whilst cutting. ■

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Building a Digital Dividing Head

Our recent article on an Arduino controlled rotary table generated a great deal of interest, now Chris Gabel describes an even simpler approach, ideal for anyone already using the Electronic Leadscrew

Controller

Dividing in the home workshop has always been one of those sophisticated tasks most often used for gear cutting, incremented dials, creating holes on a Pitched Circle Diameter or perhaps for making a slotted sensor for a lathe or mill. The outlay needed for a universal dividing head and the hours needed to make one are considerable. However, if you have built the Electronic Leadscrew Controller from Automation Artisans, described in previous articles, a high precision dividing head can be made in a Saturday morning's work.

My rotary table is a 100mm item from RDG. It is of the lower end of the price range and is a no frills model although it is of quite robust construction. The internal gear ratio is 36:1.

There were no modifications to the table needed, with the preparatory work being disassembly and a good cleaning. In a cold workshop in the winter months you could hardly turn the handle, and I suspected a "chicken fat" lubricant might be to blame. Disassembly was achieved by removing the screw and washer from the bottom. The table was then removed by pressing or drifting out the table shaft from the bottom bearing. I cleaned and re-lubricated all surfaces with a silicone grease, and reassembled. It now turns easily in all temperatures.

The only other modification was the removal of the handle and the boring out of a centring hole in the table top. There is no MT taper in the centre of this table. But the making of a precisely fitted alignment spigot enabled the centring of the chuck and baseplate on the table.

I chose a stepper motor that was exactly the same as on the lathe. This meant that I would not have to re-configure the controller. In this case, it was a Nema 23 size, 3.1 Nm, from CNC4YOU. The construction work needed was a mounting

The Electronically controlled dividing table

plate, four pillars and a coupling. The stepper motor screws to the top of the pillars. The Baseplate screws to the rotary table through the dial mounting bearing plate, see **fig. 1**.

How it works:

This dividing head works using the Electronic Leadscrew Controller (ELS), as described in previous articles (MEW 240, MEW 246).

To briefly review these, the Electronic Leadscrew Controller's primary job is to turn the leadscrew of the lathe at a specific rate relative to the spindle rotation. This leadscrew rate can be varied precisely by the ELS, thus generating either traditional feed rates for turning, or threading pitches for cutting threads.

Additionally, the ELS Controller can do two other tasks:

- If you press the RUN button, the leadscrew turns until you release it. It also displays on the LCD screen the linear distance that the carriage has travelled. This is good to 0.01mm /0.001" precision. Thus, you can measure distance with the ELS.

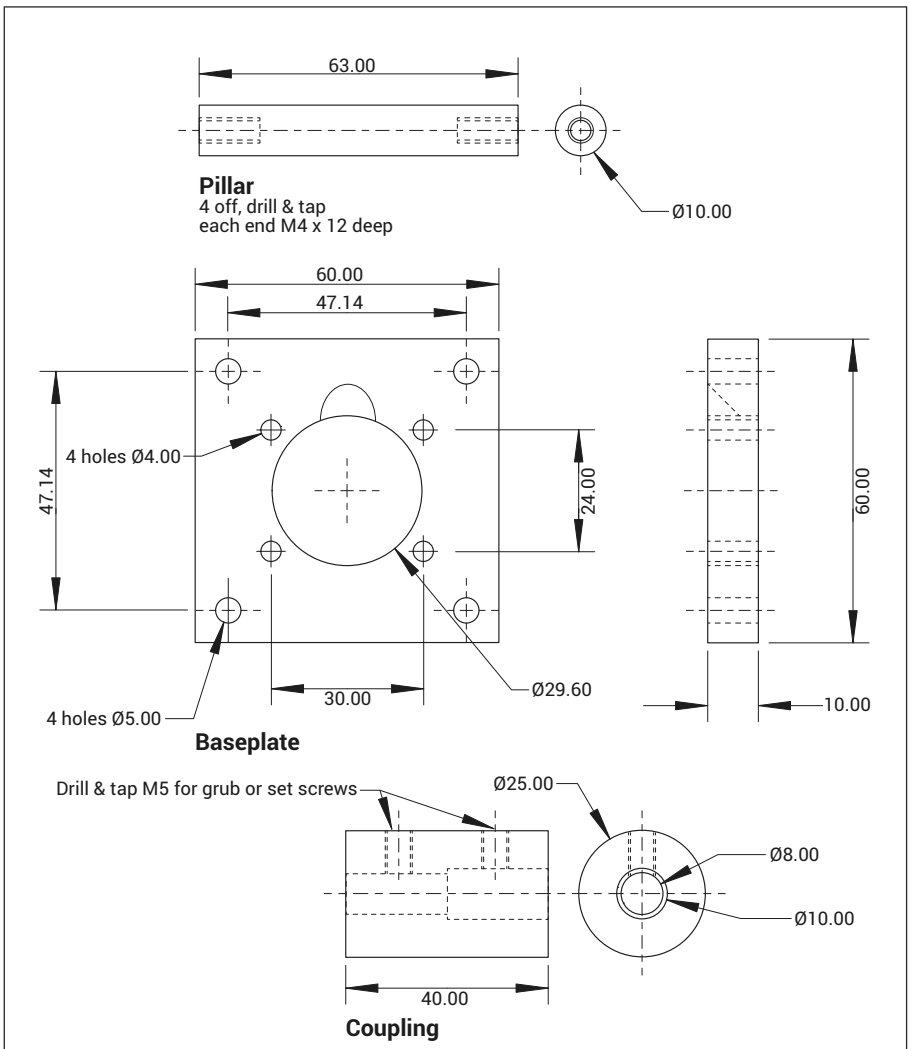
100mm rotary table

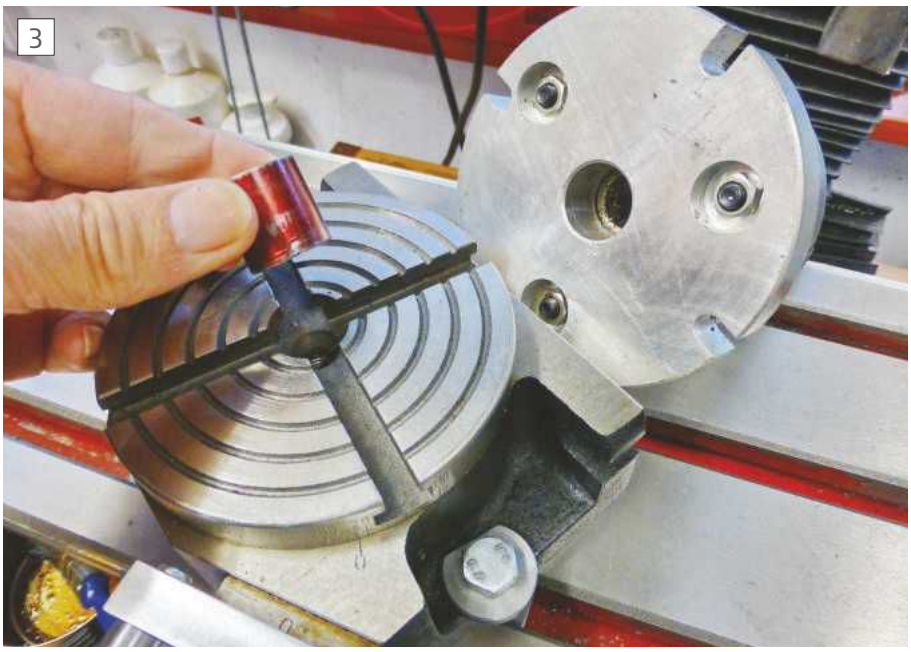
- It is also possible to set a JOG distance. You can enter a mm value, and each press of the JOG button will repeatedly move the carriage exactly that distance. Jog distances can be set to 0.001mm precision.

Up to this point we can "run" the carriage a specific distance and can repeatedly jog a set distance as well.

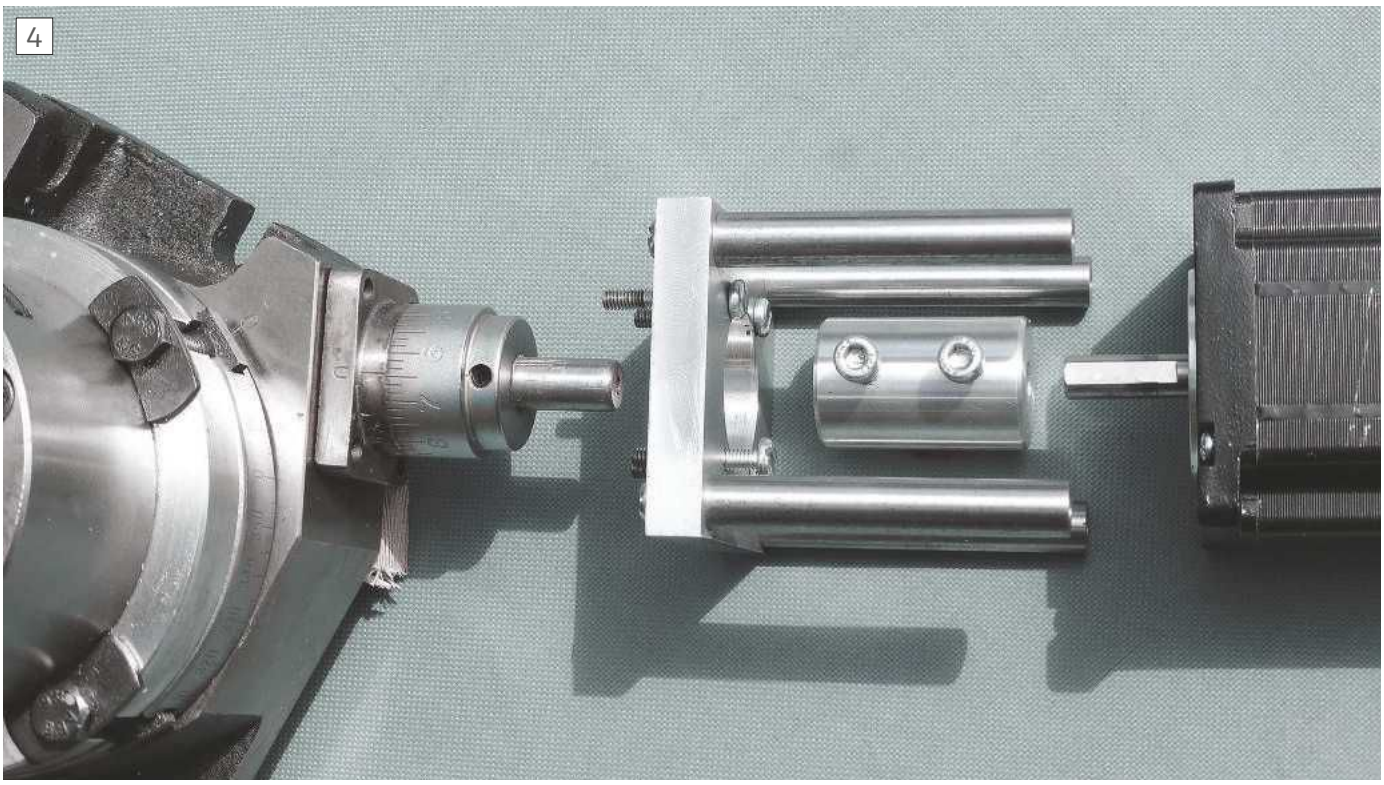
It is easy to integrate the ELS with a rotary table. You mount a stepper motor on the rotary table and join the shafts of the table handle and stepper motor with a simple coupling. Then plug it in to the controller.

Setting up is easy to do: Unplug the Lathe Z-axis stepper cable from the ELS, and plug in the Rotary Table cable instead. Set the rotary table and its vernier by hand to exactly zero. Now hold the run button down until the table turns exactly one revolution. You can use the Manual Pulse





A spigot was fitted to align the table with the baseplate



The components of the motor mounting bracket

Generator dial on the ELS set to its finest increment to home in on and find precisely the zero-end mark on the Rotary Table dial. Read the run value on the screen and make a note of it. This is the one revolution base value. My one-revolution value for this rotary table was 35.64mm.

I needed to create 6 divisions on the flywheel mounted on the rotary table. I divided my base value of 35.64mm by 6. This was 5.94mm and was entered into the jog value. Every time the jog button is pressed the table will move 1/6th of the way around. 6 presses take you all the way around. So, for 12 divisions divide the base value by 12 and put the resultant in the jog setting. Twelve jog pushes take you all the way around... and so forth.

My rotary table has a lot of backlash, so turning the table backwards for a second cut is probably a bad idea. It is important to tighten the table set screw for each cut, and then loosen it to jog to the next position.

If it is necessary to re-visit a particular cut I would suggest the table will stay in register, but you need to go all the way around in the same direction to access that cut.

I used a stepper motor of the same specification as those on the lathe. This meant that the running characteristics of the stepper on the rotary table would be familiar in use and response, and that

A milled cut enables viewing of the dial

Six divisions on a flywheel

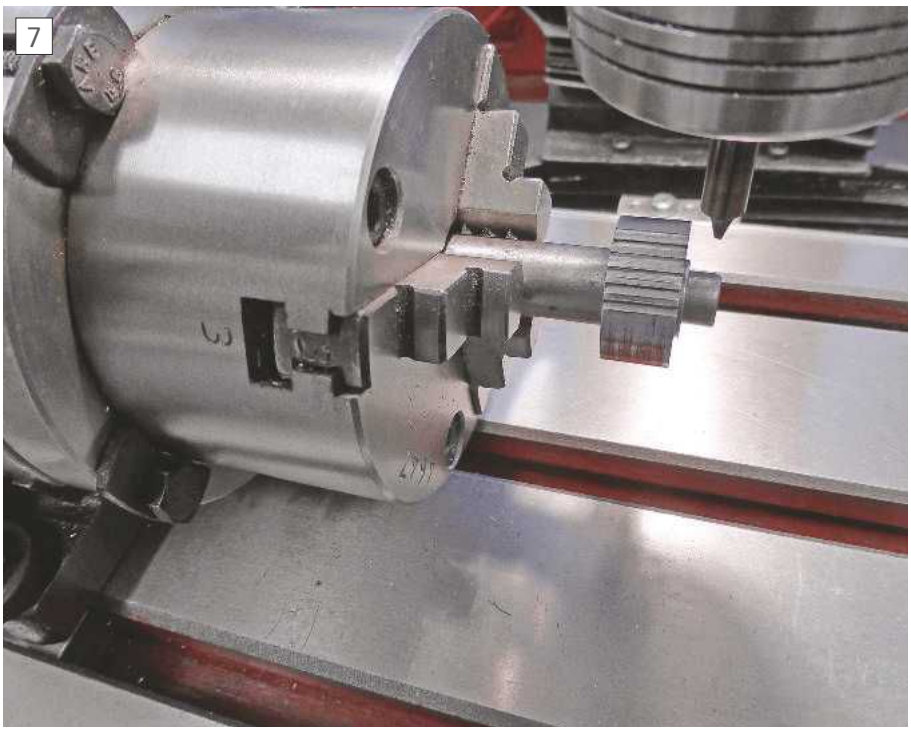
no change of basic settings on the ELS controller would be necessary.

The cables for the stepper are made from automotive 8-amp stranded wire, with four colours ensuring the wires go to the correct plug terminal. I made the cable over a metre long, and firmly twisted the wires to form a robust single cable. With the heavily twisted cable I have never had electrical interference problems. The connector used was the same type as the one connecting the Z-axis on the lathe to the ELS Controller to make them interchangeable. The connector shown is a four-pole audio connector (Neutrix NL4FX 4 pole speaker connector). It is robust and connects with a twist and click. These have been trouble free from first installation.

With the table mounted vertically on the mill, indexing of any number of divisions is trouble free, with the only limitation being the capacity of your rotary table chuck. The making of incremental dials and gears is straightforward. When mounted horizontally, marking out and the drilling of holes on a PCD is easy. For the price of an additional stepper motor, automotive cable and an audio connector, your rotary table can be converted to an easy to use, high precision dividing head.

References:

All of the major tool distributors sell a range of tables. The major differences appear to be in the gear ratios and in the rotational clamping facilities of the table. Finishes vary as well. All should be adaptable.



Cutting a small gear for a T2.5 toothed belt

The Electronic Leadscrew Controller is sold by John Dammeyer of Automation Artisans. **http://www.autoartisans.com/ELS/**.

The UK distributor is Lester Caine's Model Engineers' Digital Workshop. **http://medw.co.uk/.**

The stepper motor was purchased from **CNC4YOU. https://cnc4you.co.uk**

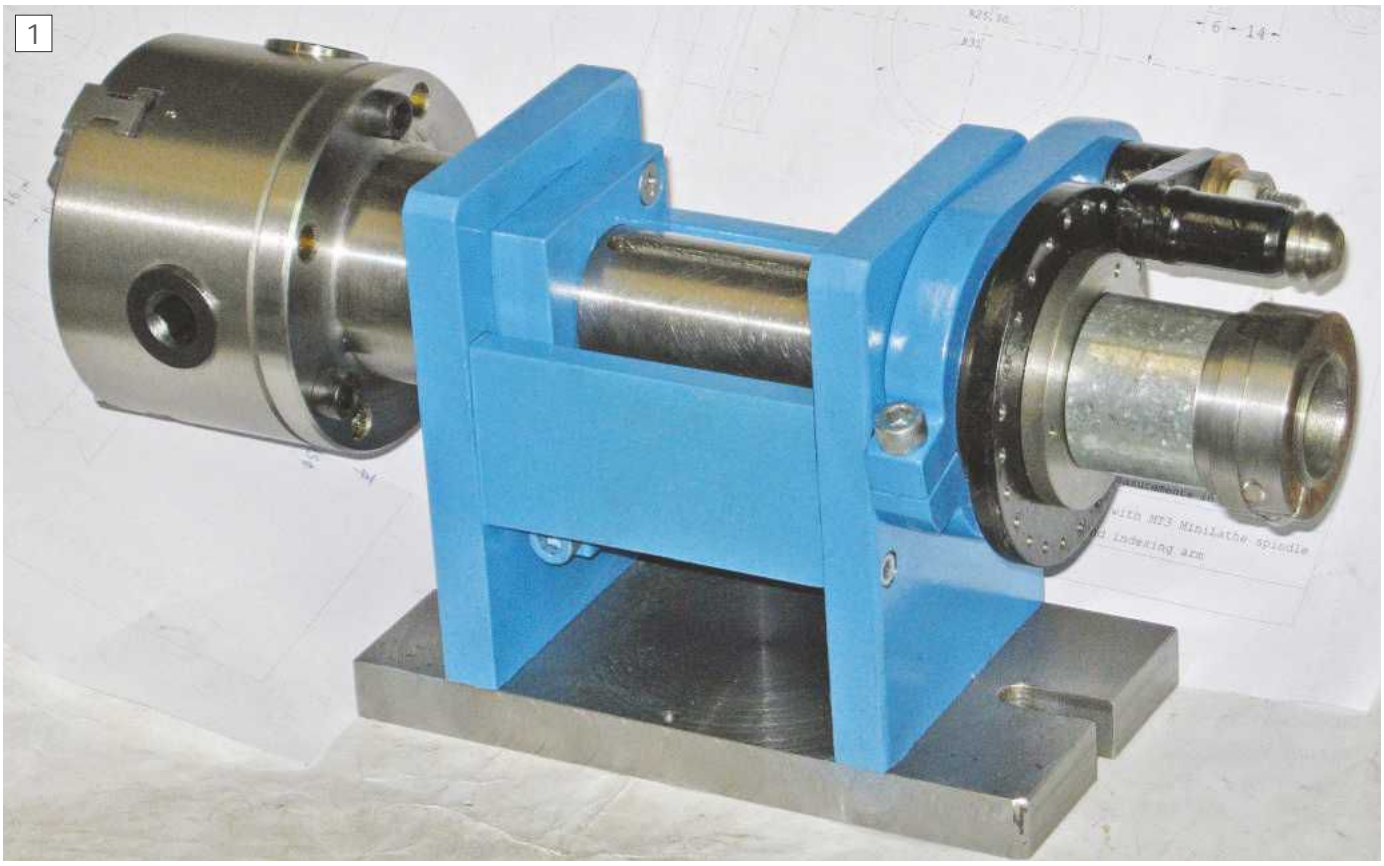
Cable connectors were from Maplin as described, and automotive stranded wire was from Halfords.

There is an E-LeadScrew support group in the Yahoo Groups site **https://groups.yahoo.com/group/e-leadscrew/** ■

Interchangeable cables and connectors

An Indexer with a Mini Lathe Spindle

Thor Hansen describes a heavy duty spindle with an MT3 bore



The finished Indexer with 80mm 3-jaw chuck

Some time ago I made a Dividing Head using a spindle from a Sieg X1 milling machine. This spindle nose had a MT 2 taper internally and I turned and threaded the outside the same as the Myford ML7 spindle nose. This dividing head has served me well, but I wanted to have the possibility to mount work in my Emco Compact 8 lathe and do some turning, then be able to transfer it to my milling machine to mill the work. The Emco lathe has a MT 3 taper in the spindle so I really wanted an Indexer with a MT 3 in the spindle. A while ago a friend of mine managed to get a good deal on two Mini Lathe spindles with 80mm 3-jaw chucks, and I bought one of them. I also made a backplate so I could use the 80mm 3-jaw on the Emco. For now, I will just make the indexer, **photo 1**, maybe I will add a worm and worm wheel later.

The Dividing Head/Indexer was inspired by what I found at Tony Jeffree's website (www.jeffree.co.uk), Harold Hall's website (www.homews.co.uk) and George Thomas' Versatile Dividing Head; I have also received valuable advice from Graham Meek.

Material

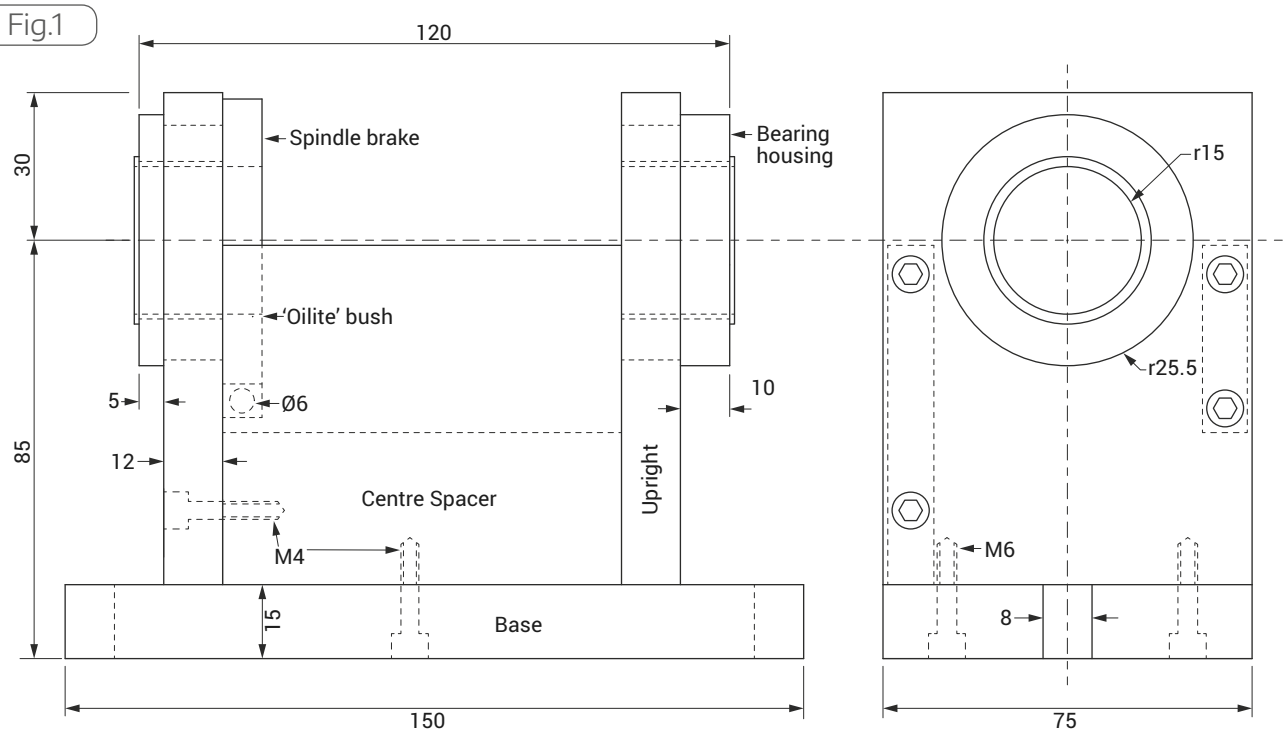
Except for the Mini lathe spindle, some Allen screws and two sintered bronze bushes ("Oilite bushes") I used mild steel from my box of scrap, except for the plunger that was turned from a 5mm silver steel rod. The base was made from 15mm thick steel, the uprights from 12mm and the spacers between the uprights from 8mm thick steel. The front bearing housing was made from a 17mm thick piece from my scrap box and the rear bearing housing was made from a suitable piece of steel, the turned to the required dimensions.

Base, uprights and spacers

The base, uprights and spacers make up a frame to carry the spindle and its bearings. The uprights, spacers and the base were squared up in the milling machine. The uprights were machined slightly wider than their final dimension. I didn't have enough material in my scrap box to make the two spacers the same size, so I made one smaller than the other. At each end of the base there will be a slot that will be used to clamp the base to the milling table. I started by drilling two 6.9mm holes and tapping them M8. The spacing between the two holes matches the distance between the T-slots on the cross slide of my HBM 290 lathe. The tapped part will be milled away when milling the slots that are just over 8mm wide. The two M8 holes were used to clamp the base to the faceplate so it could be faced. After facing one side the work was turned 180° and the other side faced. This way the top and bottom surfaces of the base will be parallel.

Photograph 2 shows the base with the 8mm slots milled and the other parts plus the piece that will become the front bearing housing. Just to test how they go together. **Figure 1** shows the frame and spindle brake.

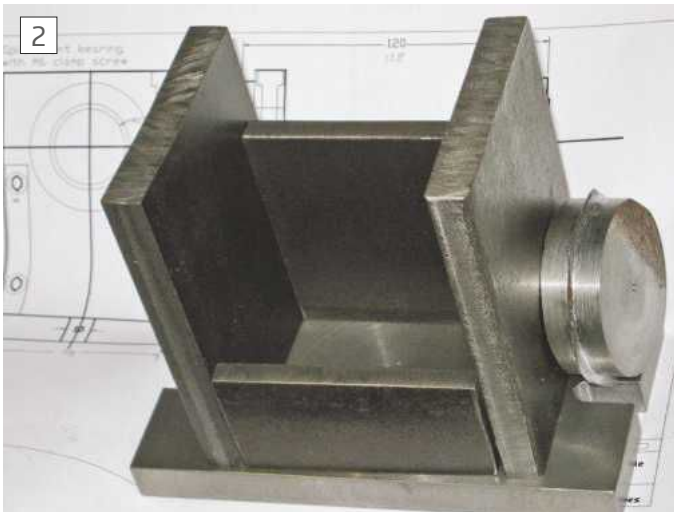
Fig.1



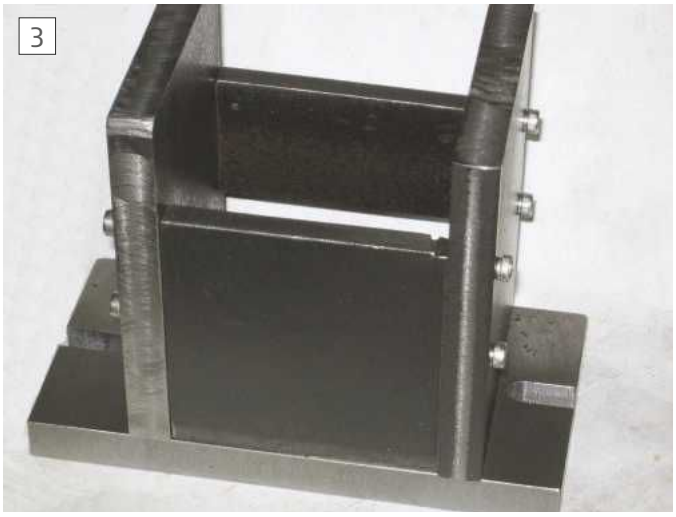
Only one spacer & 2 M4 screws clamping spacer shown in this view
No M6 screws shown

Spindle brake not shown in this view
One M4 screw not shown

Dividing Head With MT3 MiniLathe Spindle Base And Uprights
Mat'l: Steel except bronze bushes



The various pieces of the frame and front bearing housing



The frame parts mounted

Assembling

The uprights are clamped to the base using M6 Allen screws. The heads are countersunk. The positions of the uprights were marked out on the base and a hole drilled through. One upright was clamped to the base over the hole and the hole used as a kind of drilling jig to get the corre¬sponding hole in the upright in the correct position.

With the first Allen screw in place it was just a matter of using it to clamp the upright square to the long side of the base and drill and tap the other hole.

After the first upright was in place I used the same technique to drill and tap the holes for clamping the spacers to the upright. Here I used M4 Allen screws. With one upright and two spacers in place the last upright was clamped in place and the last holes drilled and tapped. **Photograph 3** shows the framework of the indexer, the M4 clearance holes in the uprights were countersunk after the photo was taken.

I now had the frame for carrying the spindle, it turned out to be very firm and I could not detect any flexing.

Milling the sides

When the uprights were squared, I made them slightly wider than the base, so after the uprights and spacers were clamped to the base the sides of the uprights had to be milled so they were the same width as the base.

I used a home-made angle-plate and an angle to mount the framework on the milling machine table and made sure everything was squared up before milling the uprights to final width, **photo 4**.

Boring the uprights

On each upright the position of the centre

Milling the uprights

Rough boring the uprights

Using a between centres boring bar for finishing the bores in the uprights

for the bearing housing was marked and each upright removed from the frame and clamped to my home-made faceplate so the hole could be bored, **photo 5**. A few 3mm thick pieces were used as spacers between the work and the faceplate. The holes were bored slightly undersize, about 1.5mm. I did not expect to get the hole centres exactly right when machining them this way, that's the reason for boring the holes undersize.

To get both hole centres to the same height I assembled the frame and mounted it on the cross slide of my HBM 290 lathe. I had designed the indexer to have the same centre height as the distance from the lathe cross slide to lathe centreline, and the two mounting slots to match the cross-slide T-slots. I used a Dial Indicator to align the side of the base with the lathe centreline. I already had a between centres boring bar and used that to bore the two holes at the same setting, **photo 6**. This way the holes end up the same height from the base and aligned with the side of the base. Even if you don't get the hole diameter exactly correct, you can adjust the diameter of the bearing housings to fit the bored holes, that's what I did. My holes ended up just under 50mm dia.

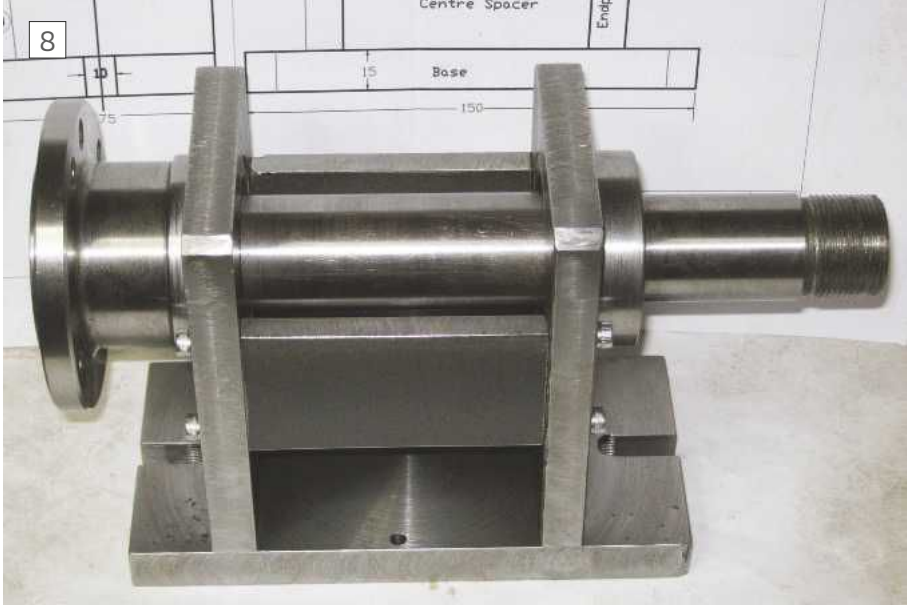
Using "French keys" to fix the rear bearing housing to the rear upright

Bearing Housings

The material for the front bearing housings were hacksawn to octagonal shape and turned to an outer diameter of 51mm. The front bearing housing was mounted in my 80mm 3-jaw using the outside jaws, then about 12mm was protruding from the chuck jaws. The outside diameter of the protruding part was turned down to a push fit in the hole in the front upright. Then a hole was drilled in the centre and opened out to 16mm – my largest twist drill – and then bored to a diameter 0.02mm to 0.03mm less than the outer diameter of the Oilite bush. The bush was then pressed into the housing using my bench vice. I used the same procedure for the rear bearing housing. The bearing housings were then pushed into the uprights after I had smeared a little epoxy on the mating surfaces.

After the epoxy had cured I drilled three 4.2mm holes on the line between the rear bearing housing and the upright. The holes were tapped M5 and three grubscrews inserted, I placed a drop of Loctite in each hole first. These "French keys" will help prevent the rear bearing housing from moving, **photo 7**. The protruding part of the rear bearing housing will carry the banjo arm, so it is important to make sure it doesn't move.

I mounted the uprights again and could now test the fit of the spindle. It rotated with a slight binding, more rotation loosened it up a bit so it no rotates with a little resistance and no slop, **photo 8**.



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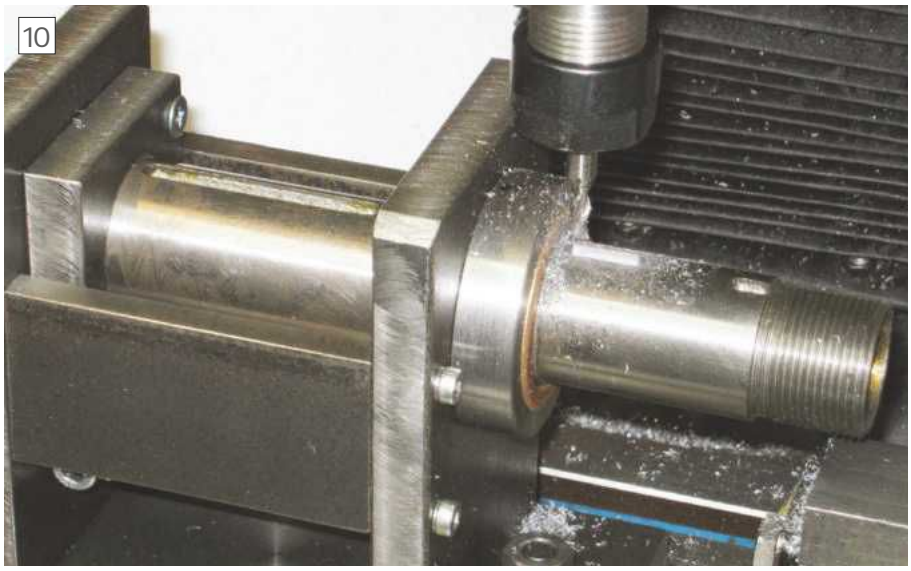
First test of how the spindle fits


9

Spindle brake mounted, and a piece of tube as a spacer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Milling a new keyway in the spindle

Brake

To stop the spindle from rotating I use a brake consisting of a rectangular piece of steel from the same material as used for the uprights, through which I bored a hole with a diameter just large enough to slip over the spindle, **fig. 4**. The lower corners were cut out and a hole drilled for a M6 clamping screw and a square nut in the opposite cut out. On the side facing the front upright I milled about 0.25mm away from bottom to about 10mm from the top. Then I used a hacksaw to make a slit. In one of the upper corners I drilled a 5mm hole and while the brake was clamped to the spindle I could use it as a drill jig to drill a 4.2mmw hole in the upright. The 4.2mm hole was tapped M5 and the hole in the brake was countersunk.

The Mini Lathe spindle is slightly longer than necessary, but I didn't want to shorten it.

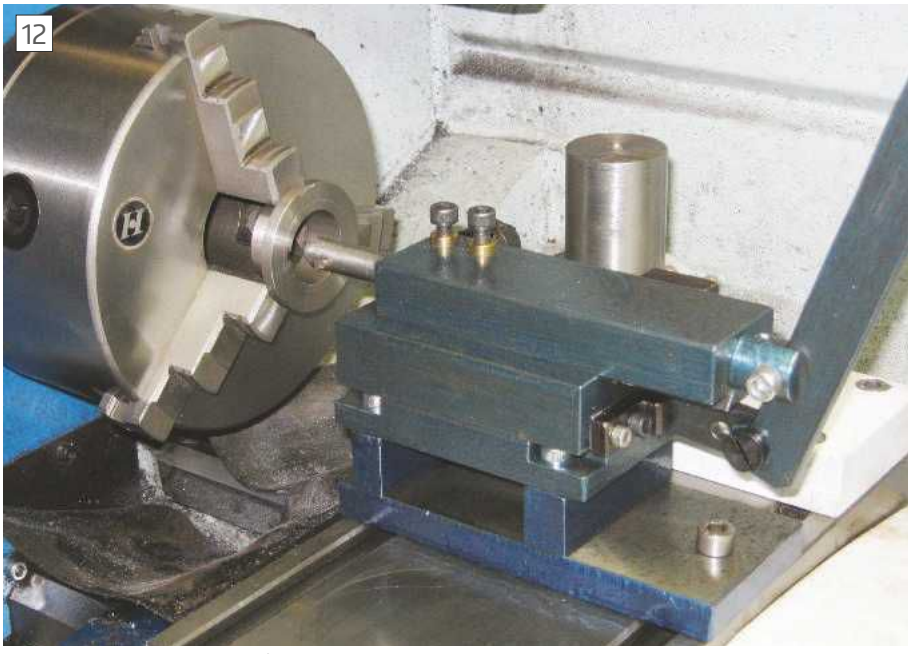
Photograph 9 shows how it looks mounted in the frame. In the photo you can also see a tubular spacer and the inner ring of a ball bearing that was used to find the necessary length of the tubular spacer. The ball bearing ring had the same width as the hub that will accept either a 24-hole plate or if needed a worm wheel.

Milling slot for key in spindle

Since the Mini Lathe spindle was used without shortening it I had to mill a new keyway close to the rear bearing. There was already a short length keyway close to the threaded end of the spindle so I decided to mill the new keyway the same width but longer, almost the same length as the width of the hub. With the brake in working condition it was a simple job to clamp the spindle in the correct position and mill the slot using a 4mm slot drill, **photo 10**.


11

Split spindle nut for adjusting axial play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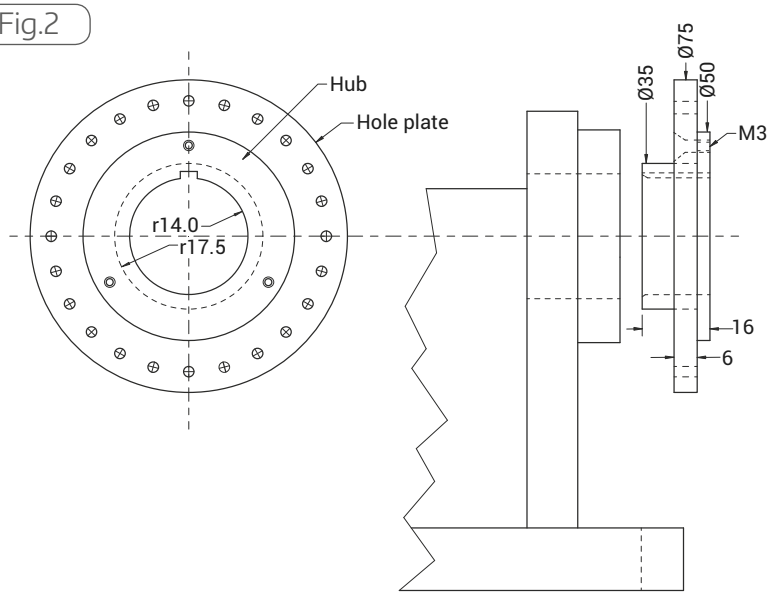
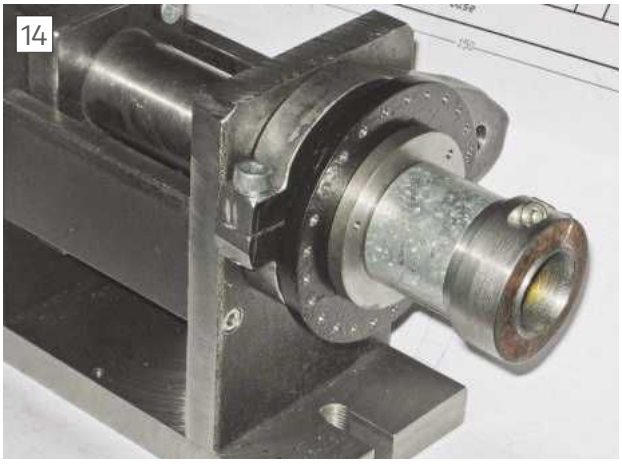
Slotting a keyway in the hub

Drilling the 24 hole indexing plate

Fig.2



24 Hole Plate And Hub
Mat'l: Steel



Banjo arm, hub with hole plate, spacer and spindle nut

Spindle nut

The rear end of the spindle was threaded M27 x 1.5, and I made a split nut so I could adjust the axial play.

I used a piece of hot rolled steel that I hacksawed to octagonal form before mounting in the 4-jaw to turn the outside and bore and thread the hole. Hot rolled steel does not warp like cold rolled steel does when you split a ring.

I milled a cut-out for the M4 clamping screw and drilled and tapped M4 before splitting the nut. It fitted well after splitting and it is easy to adjust and clamps well around the spindle, **photo 11**.

Hub

I decided to make one hub that could either take a 24-hole plate or a worm wheel. The hub has a flange that the 24-hole plate is screwed to, fig. 2. The hub was made from a piece of 50mm dia. free-cutting steel.

The flange and outer diameter and bore was turned at the same setting so the bore was concentric with the outside. The work was turned around in the chuck and faced, and I mounted my slotting tool on the lathe cross slide so I could slot the 4mm key in the hub, **photo 12**.

I also made a key to fit the keyway in the hub and in the spindle.

24 hole plate

The hole plate was made from some 6mm thick steel, **fig. 2**. The steel was rather rusty so I sanded it and gave it a coat of black paint.

The work was bored to just fit the hub, then gripped by the hole in my 80mm 3-jaw and the outside turned. It was then transferred to my rotary table so I could drill the 24 holes around the rim, first with a centre drill, then with a 2.5mm twist drill drilling through, **photo 13**.

I also drilled three 3mm holes spaced 120 deg. apart so the hole plate can be clamped to the hub.

Banjo arm

George Thomas used a banjo arm that clamped around the rear spindle housing on his Versatile Dividing Head, and I decided to use a similar arrangement to hold the index arm with plunger (for the 24-hole plate) or the worm carrier if I decide to make one.

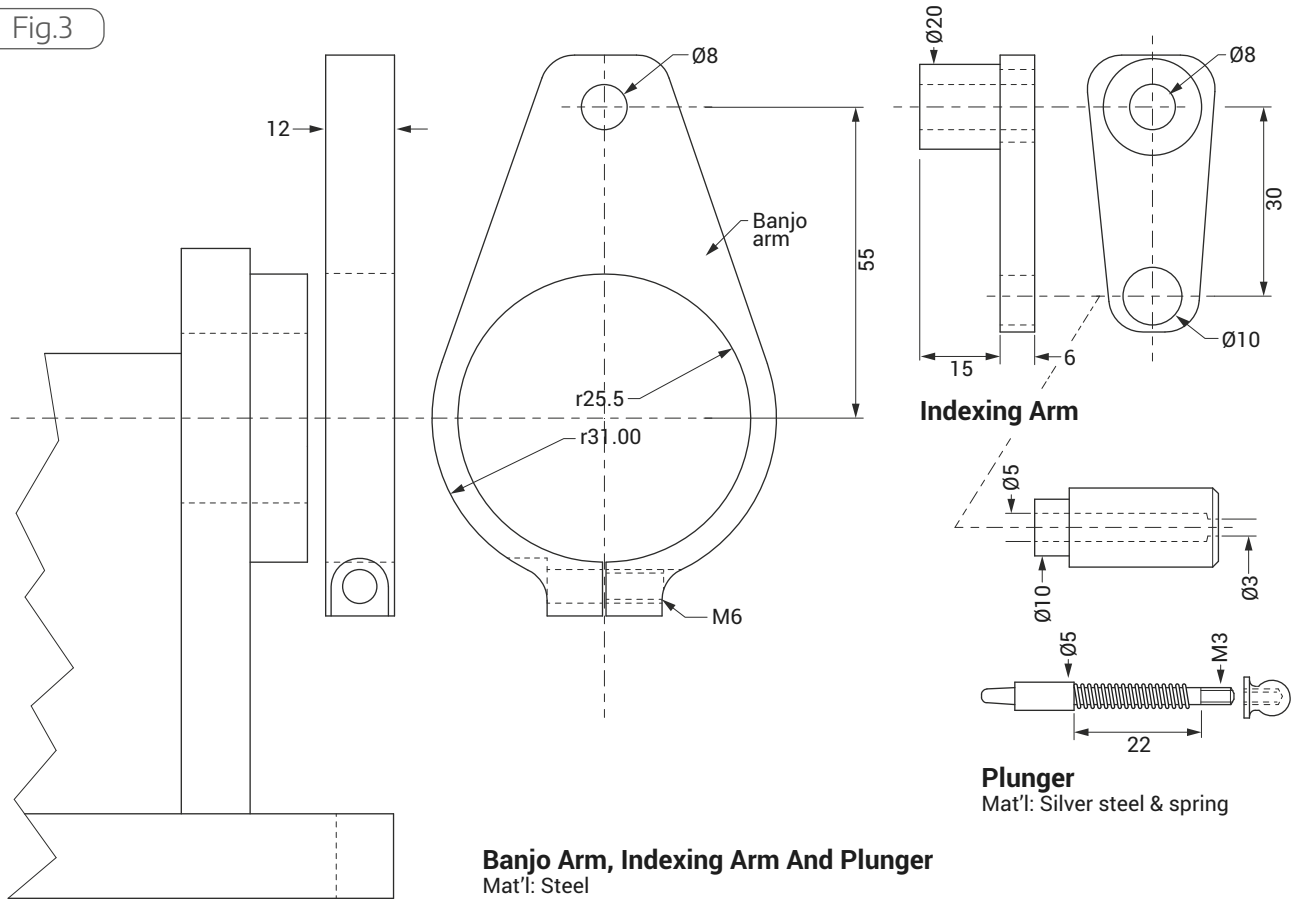
The banjo arm was cut from a piece of the same material as used for the uprights (hot rolled steel or black mild steel), the two holes were marked and I used my hacksaw to cut it roughly to shape.

The straight sides were milled with the work clamped in the milling vice.

I drilled an 8mm hole at one end and a 12mm hole at the "big" end. The 12mm hole will later be bored out to 51mm to fit the protruding part of the rear bearing housing.

Indexing arm and plunger parts

Fig.3



Banjo Arm, Indexing Arm And Plunger
Mat'l: Steel

First the 12mm hole will be used to centre the big end on my rotary table.

The work was then transferred to my rotary table. I managed to find space for three clamps while milling the rounded or curved outer parts of the end. I moved one clamp from one side to the other so I could mill the curve on the opposite side.

The work was then clamped to my home-made faceplate and the 12mm hole bored out to a sliding fit on the rear bearing housing.

After the boring operation, I drilled and tapped the end for a 6mm clamping screw, split that end using a hacksaw and it was ready to be mounted on the indexer, **photo 14**.

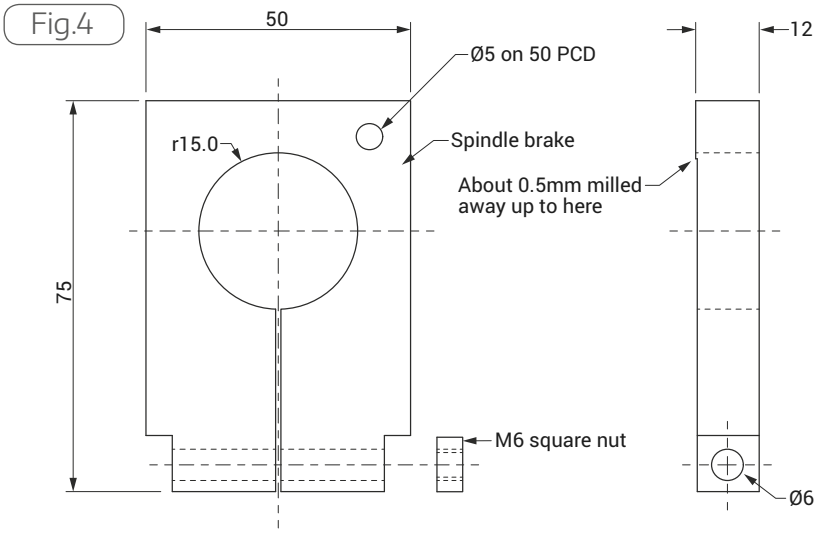
Indexing arm

The indexing arm was fabricated from three pieces. One part was a piece of the same material as used for the 24-hole plate and two pieces of rod. The three pieces were silver soldered together after machining.

I started with the 6mm thick piece and used a hacksaw to cut it roughly to shape, I milled the sides and used a file to round each end.

After silver soldering the part was pickled in a citric acid bath and then transferred to a sodium bicarbonate bath to neutralise the acid. Then I used some emery paper and gave it a coat of black paint. **Photograph 15** shows the finished part together with the plunger and spring.

Fig.4



Spindle Brake
Mat'l: Steel

Plunger

The plunger was made from a piece of 5mm dia. silver steel rod. The plunger was not hardened or tempered. I also used a piece of stainless steel for the knob at the threaded end and a spring from an old retractable ball point pen.

The 5mm silver steel was clamped in my 80mm 3-jaw with about 8mm protruding and turned down to 3mm for a length of about 7mm. The end was then screwcut in the lathe. The jaws were loosened a bit and the silver steel rod pulled out another 8mm and that section turned down to 3mm, and so on until the desired length was reached.

The final job was sanding the frame and giving it a coat of paint using some paint left over from when I made a housing for the inverter on my 290 lathe. I'm very pleased with the final result, which is a useful and robust piece of workshop equipment. ■

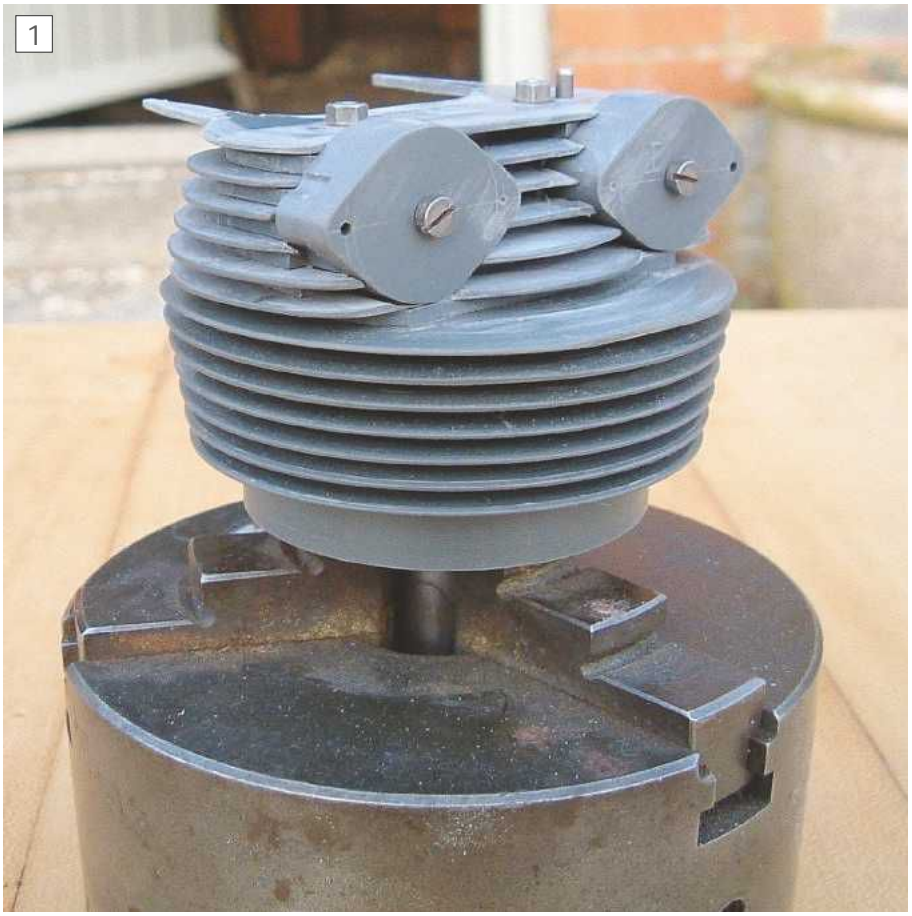
Large Model Aero Engine Casting and Pattern Making Techniques - Part 3

In his final article on this topic, Stephen Wessel looks at investment castings.

In this final part I shall describe my efforts to produce certain components for the Lynx engine by investment casting. We have already seen how complex shapes can be dealt with by fairly conventional techniques in which either a rigid pattern or a flexible rubber one can be designed to accommodate awkward undercuts or to get over the problem of draft where it is not wanted. Both these methods lead to either a sand or plaster mould at the foundry which will be formed by hand on a one-off basis.

Investment casting is quite different. Whereas a conventional pattern is reclaimed and used as many times as may be desired until it literally wears out, investment casting makes use of an ephemeral pattern usually of wax, or in the case of large work, polystyrene foam. The wax is encapsulated, or invested, in special ceramic plaster which when hardened by heat allows the wax to run out, leaving a cavity into which metal is poured. Often known as "lost wax" casting, the technique is widely employed throughout industry to make everything from door handles to turbine blades. It is especially suited to mass production of small precision parts in all sorts of metals. The big advantage from the pattern maker's point of view is that he no longer has to worry about extracting his pattern from the mould and can probably construct it in one piece. On the other hand, he has to make the wax and that's the difficult bit!

So, this article is mainly about producing suitable wax patterns that will be accurate and acceptable to the foundry. As before, I am concerned here only with the pattern making, not the actual founding, a job I consider best left to the professionals. One of the major problems I faced was the almost total lack of written material aimed at the amateur engineer working at home. Lox wax casting has been with us for thousands of years; jewellers, sculptors, dentists all use it and you can see why: wax is inherently cheap, easily carved, melted and reclaimed, while the process of burying it in the plaster, melting it out and replacing it with metal is quite straightforward. However, with the exception of dentistry (one hopes), these craft industries are not generally looking for precision in the engineer's sense. Apart from a few YouTube clips showing basic modelling of things like toy soldiers and jewellery I found nothing of a serious technical nature aimed at us.

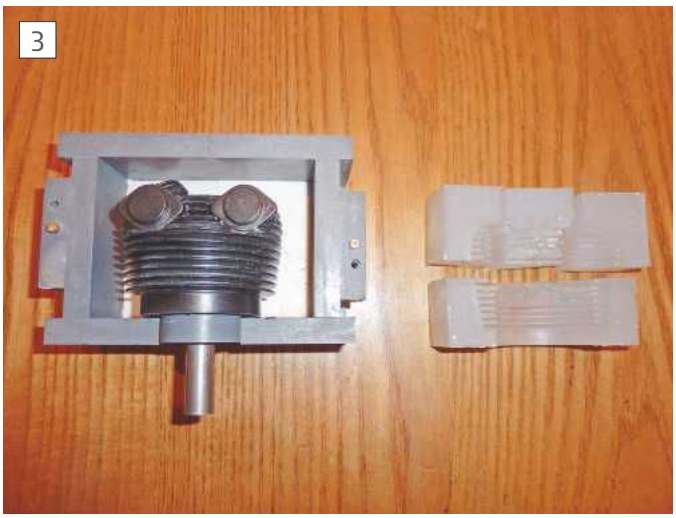


Master pattern for cylinder head under construction

I shall use the cylinder heads of this engine as an example for the rest of this article.

To make a wax you obviously need some kind of mould. In an industrial context, this would be expected to churn out thousands of identical waxes so is invariably made of metal, probably aluminium. I have seen them being manufactured using spark

Completed exterior and core patterns. Note Milliput fillets between each fin.



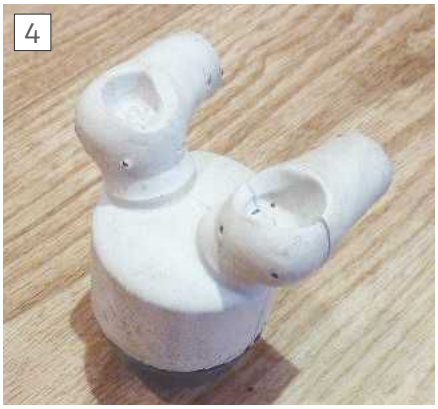
Left – ready for first rubber pour. Right – the result cut into 4 chunks. Rubber could have been saved by blocking out the box corners.

erosion techniques, for this is likely to be the only way of shaping internal contours quickly and accurately direct from the drawing. Wax can also be 3D printed and this looks to be the ideal solution for the future. But another problem facing me at the time was that I was unable to get my head around 3D drawing! I was attempting to build a scale model of an engine that had no detail drawings of any sort and would be very reliant on photographs and measurements of an original to establish the exact shape of many of the parts, especially the cylinder heads. These heads are complex both outside and in, so machining them from solid was out of the question, as was making a metal mould. The only viable route to obtaining a number of wax replicas would be to cast them in a silicone rubber mould, this being the best material for allowing both pattern and wax to be removed.

This was the very first stage of the engine project. All thoughts of the larger items like crankcase, crankshaft, pistons, etc. were way off over the horizon. I reckoned that if these heads could be conquered the rest of the engine might be not too impossible. So began a great trial with many set-backs.

Cylinder head master pattern

Photographs 1 and 2 show something of the complexity of this component.



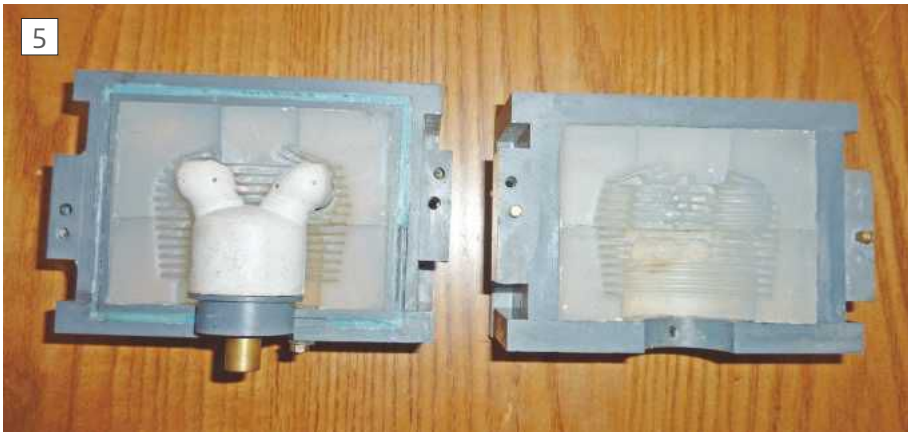
Soft rubber core cut into 3 parts. Made from Shore A 25 hardness silicone.

Notice how the upper fins pass right across between the valve chambers. The PVC master pattern was built up of thin laminations held together on two dowels that pass from bottom to top. Every fin is different and the upper six are non-circular. The lower part up to fin #7 is a straightforward turning but above that, each fin had to be individually cut out of 2mm sheet then fitted over the dowels with an interstitial spacer. The very top around the valve guides was almost too complex to draw so, with photos to hand, bits were added and subtracted until it just looked right. Lavish use of Milliput ensured nice fillets then a final spray paint to blend everything together. The internal shape was also modelled. Before starting this work, I had to establish the likely shrinkage rate of wax and add it to the metal shrinkage. While the latter is known accurately (1.3% for the alloy in question) the former tends to vary a lot from one kind of wax to the next, and pouring temperature. I bought a small quantity and carried out experiments to measure this shrinkage until I got repeatable results which turned out to be about 1.8%. I therefore blew the drawing up by 3% and crossed every available finger.

Moulding

This exterior master pattern would be used to make a rubber mould. The usual way is to support the pattern in a box then pour rubber all over it. Once set, the rubber is carefully cut into two or more chunks with a razor blade so that the pattern can be extracted; the chunks are then reinstalled in the box and will all fit perfectly together. But look again at those upper fins: the rubber would flow between them and firmly lock the pattern in place. More than that, there had to be provision for a properly supported core.

Having made the plastic pattern as one piece I was therefore committed to a two-piece mould such that the parting plane would cut through those upper fins. **Photograph 3** shows how this was done – the pattern lies horizontally in one half of the mould box and rubber poured around it up to the half way point. After it had set, the top half of the box was assembled and rubber poured in to complete the mould. Fortunately, these rubbers don't stick to previously cured rubber (or to the pattern) although a dusting of talc is a good idea and makes separation easier. On the right in this photo is one half of the mould removed and cut into sections. Although each part did come off the pattern in one piece, it was a struggle. Getting a more delicate wax out would have been impossible without



Core set into mould cavity.

damaging it. Hence the need for sections. This isn't always necessary and depends only on the shapes involved.

Coring

I now turned my attention to a suitable core. The heads are of course hollow, having in addition to the combustion space, two spherical gas passages that lead from it at 90° towards the two ports. Each passage has an internal spigot that would be bored for the valve guides. The big problem was what to make the core from. **Photograph 4** shows its shape. How could such a shape be withdrawn from a wax body? It couldn't be solid like plaster because of the need to get it cleanly out of the wax. The solution was to cast it in soft silicone and cut it into removable sections. These were carefully pinned together such that each piece could be gently pulled from the wax in different directions. The soft rubber was able to deform sufficiently but always sprung back to its original shape ready for the next casting. The system worked well and the same core was used over and over.

Another core material more likely to be used in industry is soluble wax. This can be cast in the usual way and when the time comes to remove it from the main wax body, it is dissolved out overnight in weak acid. However, it is not reclaimable, nor cheap. If you have only one mould, but wish to use it several times in succession, the long wait for the core to dissolve might tax the patience. I tried very hard to make my own hi-tech soluble cores using toffee. Easy to cast, would stand up to molten wax (just) and be easily dissolved under the tap, but I couldn't get rid of the foam which was always present. Maybe a more experienced confectioner would know what to do!

Wax injection

Having bought some investment casting wax I was now ready to make my first one and imagined, in my naiveté, just pouring it in. Molten wax however does not behave like water, being more viscous and less dense. It will not displace trapped air. If the mould has many undercuts and thin sections, this is a real problem. After various fruitless attempts to persuade it to fill the mould, like warming it, tilting it, vibrating it and cursing it in turn, I realised that pressure would be needed and maybe vacuum too. The standard industry method is to apply a pressure of around 10 - 15psi to the wax and allow air to escape through the joints in the mould box. Small wax "pots" can be obtained to do this on a small scale and I borrowed one to see if it would work. Sadly, there were still many air pockets, especially around the fins. It was at this point that the whole project was almost abandoned. Consultation with various companies produced a collective shaking of heads as if to say "if you want to go there, don't start from here".

Box ready for wax injection.

Primitive set-up for injection.

The only method remaining was to use vacuum both to get rid of all the air in the mould and pull the wax into it. Theoretically this shouldn't work: at low pressure the wax will boil and the mould will be filled with a mushy foam. But in desperation I thought it worth a try. The set-up was very simple, **photos 5, 6 and 7**: the pressure saucepan I referred to in part 1 was big enough to take the mould box, the wax was melted in a small brass box and when ready this was plugged into a hole in the cover plate. A 97% vacuum was applied and once the temperature of the wax had fallen to around 70C the wax valve was opened wide allowing a very fast fill. Almost at the same time the vacuum release valve was fully opened. The whole process took about 2 seconds. I guess the wax simply didn't have enough time to boil. It was thoroughly hoodwinked by speed! Once the right pouring temperature was established by experiment, the results were perfect. The pouring temperature I found needs to be as low as possible, just above gel point. Too hot and surface imperfections like swirl marks and signs of foaming become apparent. Warming the mould produced no benefit, contrary to what you might think. **Photographs 8 and 9** show early imperfect results.

All well and good except for one mystery. I noticed that every wax, once out of the mould, was slightly out of round at the base. Had the wax shrunk anisotropically, more in one plane than another, or had the rubber been squeezed by wax pressure? I couldn't make it out but the remedy was easy: I put each wax back into the rubber without the box, warmed it all in warm water then gave the assemblage a very gentle squeeze in a big vice. Crude but

Typical wax casting. Note air bubble at lower left.

Poor definition inside.

Finished cylinder heads.

Master pattern and 2 cores for rear cover plate.

totally effective; circularity was restored. Two partly machined castings are shown in **photo 10**.

The second major investment casting was the cover plate that attaches to the rear of the crankcase. It serves two purposes, to provide first a passage for the incoming mixture from the carburettor and second a small gear housing that contains the bevel drive to the magnetos. The patterns, cores, waxes and finished casting can be seen in **photos 11, 12 and 13**. The smaller of the two cores was again split, as before, into three pieces. The larger core pattern represents the conical induction pipe that has to turn through 90° and flare into the fan chamber. It was made by turning some PVC discs of gradually increasing diameter, cutting each into a wedge shape before gluing them together, then much work with files and sandpaper. The joints are just visible in the photo.

Some of the smaller castings required were less complex, namely valve rockers, the oil pump body and distribution fan (an Armstrong Siddeley speciality that looks like a supercharger but rotates at crank speed). All the patterns were in one piece as were the rubber moulds and all were simple enough to allow wax to be poured in with no pressure or vacuum. Very easy. **Photograph 14** shows the rockers at various stages: the master pattern in brass, the silicone mould, the wax and the finished casting in stainless steel. This mould was partially split with a razor blade along its length so that it could be opened for ejection of the wax but then close up again to its original shape. I used it to produce some 30 waxes. **Photograph 15** shows various views of the two oil pump waxes and the fan.

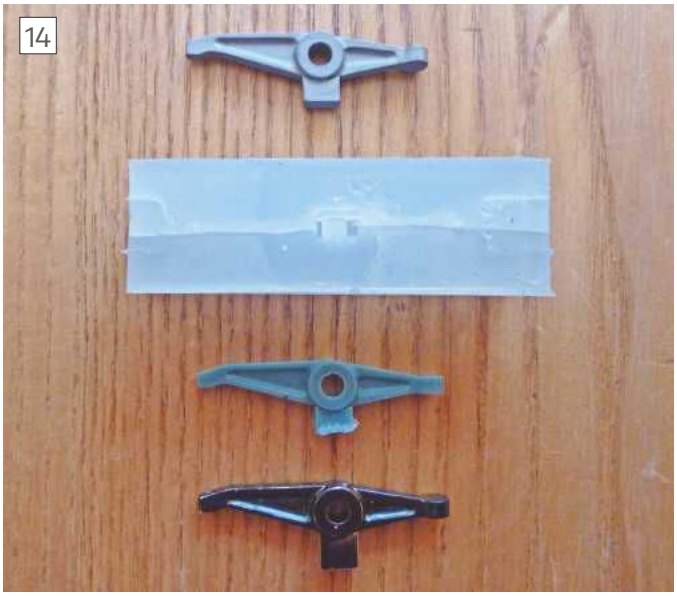
Suitable rubber and wax

The wax used for investment casting is specially formulated to have as low shrinkage as possible. It is harder than candle wax (which should not be used) and can if necessary be machined. It can be welded to itself very easily with a small soldering iron; this is useful for filling in imperfections or adding wax structures that may have been cast separately. The iron needs some sort of voltage control to keep its temperature down. Small scrapers can be made for smoothing edges or fillets. For a one-off casting it is quite feasible to make the wax pattern entirely by fabrication rather than moulding it. Small slabs could be cast, then machined and welded into whatever form may be required. However, the whole point of investment casting is quantity production, from say two or three upwards to the millions.

The silicone rubber I used had a hardness of Shore A 40. This could be described as medium hard. A balance has to be struck between the need for flexibility, in order to get the pattern and wax out of the mould, and resistance to deformation under the pressure of injected wax. Both requirements are met by designing the mould box for minimum rubber thickness. Against that, it is vital that the liquid rubber can flow properly around the pattern and has time to do it before curing begins. I mentioned this in part 2. The particular rubber chosen may depend somewhat on the complexity of the pattern; for a simple shape like my valve rockers involving little or no undercutting a relatively hard rubber

Waxes for rear cover.

Partly machined rear cover casting.



Valve rocker. Master pattern at bottom with a wax above. Split rubber mould. High tensile stainless steel casting at top.

might be used, but the cores I referred to above had to be soft enough (Shore A 25 or less) for withdrawal from the wax. Remember that "condensation cure" rubber does have a marked shrinkage whereas "addition cure" has zero.

General points about design of the master pattern

- Unlike rigid patterns for conventional casting, neither waxes nor their master patterns need have draft, although a small amount can make life easier. Silicone rubber will pick up every detail of the pattern including surface texture, even thumbprints, so it's worth spending time on the master until everything about it is as perfect as time and patience allow.
- Do bear in mind the shape of the final plaster mould and whether it is likely to withstand the forces imposed on it by molten metal. For example, a hole through the wax that is long relative to its diameter will be transposed into a thin bridge of plaster that might collapse. The plaster will have the same shape as the rubber so problems like this should show up before committal to the foundry.
- Don't forget chucking extensions where necessary for later machining.

Conclusion

I hope this article will have shown that it is perfectly possible and indeed rather exciting to prepare suitable tooling for cast components in a typical home workshop. Others may decide to invest their time more effectively in CNC machining from the solid and prefer to achieve that by more hours spent at the computer. However, an original full size casting will in my opinion look better if it is replicated as such. The main thing is to get going with the plastic master pattern; easy and cheap to make but don't forget the shrinkage allowances! You will quickly have your component on the bench and may well want to make small changes as a result of just looking at it.

The very first and most important rule to be observed with all this work is to think ahead at every stage. It is all too easy to get into a corner where you find either you can't get rubber into a mould properly or the solidified rubber cannot be extracted. Or, if working with sand, that your core box cannot be rammed or won't come apart. I mentioned the importance of degassing the liquid rubber prior to pouring. I found this vital, as otherwise the result will be full of air bubbles. During degassing the material will foam up to around 5 times its original before sinking back, so large containers are needed.

Rubber moulding is fun. Not so cheap, admittedly, but you can insert all sorts of rubber- saving blocks into your boxes with bits of wood and superglue, each one saving you a £ or two. I have also enjoyed the contact with industry that my recent projects have required, often discovering a real interest out there in our small-scale work as model engineers.

Suppliers

I have no business connection with these companies but have used their products successfully.

Wax

1. Goldstar Powders. Injection wax No. GS210
2. Exmoor Casting Supplies Ltd

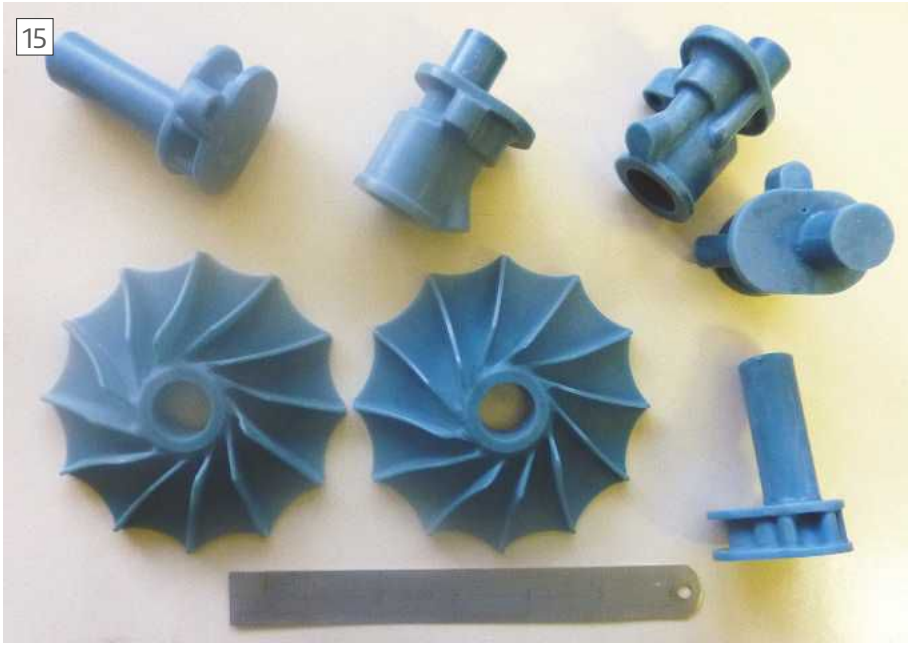
Silicone rubber

Many different suppliers. I used:

1. Alchemie RTV240 Addition cure
2. Alec Tiranti T28 Condensation cure. Also Addition Cure 33 but this is very fast curing.

Suitable spray paint that seems safe with addition cure rubber:

"No Nonsense" acrylic black lacquer, widely available. ■



Fan & oil pump body waxes.

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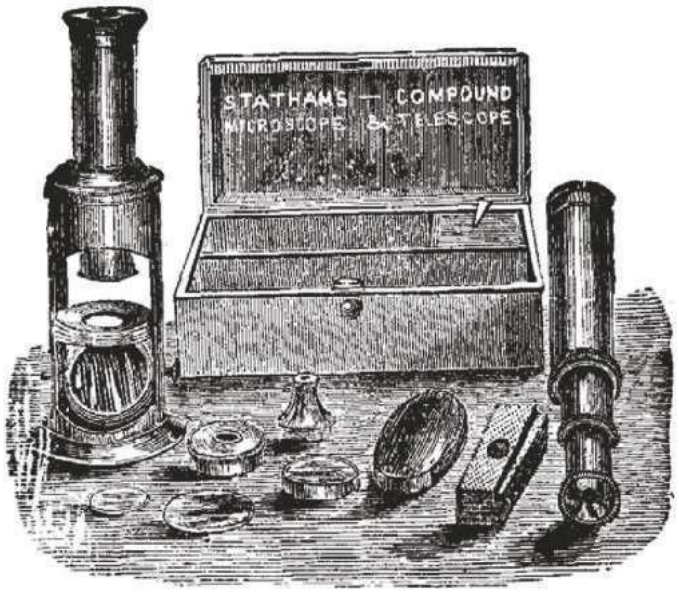

■ Selling due to bereavement. Southbend model 10k 3 speed v-belt lathe, was belt driven. 42" gap bed, cross slide with 4 way toolpost, 6" 3 jaw chuck, 10 imperial thread cutting gears, £350 ono. **T.01253 720327. Blackpool Lancs.**

■ Tyzack Lathe on a stand included a vertical slide, 3 and 4 jaw chuck, 3 drill chucks for tailstock. In good working order not sure of age. Price £115 Buyer collects. **T. 07794 036551. Cambridge.**

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■ Excel compound table 12 x 12", £95. Dental polishing hood, £8. Collet chuck LO. Taper fit. Multisize collets £140. Drill chuck 5-20mm, £20. Victoria universal Dividing Head, £200. J&S arbor press, £85. MIG welder, £30. Blacksmith's vice £12.50. **T. 01440 705594. Haverhill.**

■ Bandsaw, 7-inch capacity, single phase on wheeled stand, light use only, built in coolant system, buyer collects, £400. **T. 02392 379710. Portsmouth.**

■ Cast iron surface plate, 12 x 18", offers. Stent tool and cutter grinder accessories and drawings, offers. Myford vertical slide plain type for lathe table size 3 x 5 ¼". Offers. **T. 01425 470540. Ringwood.**

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■ Tich castings, drawings & book, £220. Sweet Pea rolling chassis, cylinder castings, drawings, £400. Boxhill chassis, professional boiler, drawings, £1,100. Adept shaper with motor, £120. Buyer collects. **T. 01622 761778. Maidstone.**

■ Maid of Kent castings, inside cylinder set, crankshaft, tender wheels, bogies wheels etc. £250. **T. 01621 779236. Maldon.**

Magazines, Books and Plans

■ We have 147 very old back issues of "The Model Engineer" dates from 1946 to 1950. They are in good condition considering their age and it seems a shame just to throw them out if somebody may be interested in them. Could meet up to deliver at service station between Birmingham and South East **T. 07962 175390. Plymouth.**

■ Model Engineers' Workshop copies 226-230 available free. **T. 01993 832927. Chipping Norton.**

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■ Post Office Type 46 Electric Master Clock, or parts for same. **T. 01553 630429. King's Lynn**

■ Air bearing to suit Clarkson tool and cutter grinder. **T. 01515 120538. Merseyside.**

■ Cowells ME lathe, also Cowells milling machine must be in as new condition and with accessories. **T. 01986 835776. Halesworth.**

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Office to Workshop – A One Time Bodge Which May Prove Handy

Ted Joliffe recycles some memories, as well as some old timber.

The stone partially in the box, although wavy it is good for woodworking tools, I have others for the metal shop

An old friend, the late Geoff Brandon contacted me to see if I would help clear his workshop as he was moving to sheltered accommodation. Among the items he passed over was his favourite oilstone, (**photo 1** shows it after repair). He told me that the case was the first thing he had made, as a lad, using timber gleaned from the local market and a bombed out house.

Recently I was setting up a woodworking shop adjacent to the workshop proper and came across the oilstone. Geoff was an ornamental turner and this had been used to rough sharpen his tools.

The box was distressed as the antique dealers describe it, but I resolved to try to get a few more years use from it. The base had been cut from an old door or window frame, the underside still bore traces of decorative moulding work. My guess was that either fish or fruit boxes had been cannibalized to form the sides or ends, which seemed to have been glued, and then tacked in place with headed panel pins. After a lot of scraping and cleaning I got back to bare wood to find that at one end the timber had split, **photo 2**. I glued it and left it to set, but it obviously needed reinforcement.

This was the end where the wood had split leaving the joint weakened

A close-up of one end showing the improvised staple

The completed box after varnishing and repair

As it had been made initially from recycled wood I resolved to repair it in the same fashion, using recycled materials. I keep a stock of good quality 15 thou thick aluminium, salvaged from spent deodorant cans. I cut out a couple of pieces to fold over the ends. Using contact adhesive I settled the ends and for appearances sake secured the bottom into the thick wood using headed pins, filched from a box of picture hooks.

Next morning I found the base well secure as was the end sections, but the sides had not stuck at all, they had sprung out overnight. First thought was scrap the thing, but sentiment prevailed, I had one last go. I gently prised the tops away from the timber using a broken junior hacksaw blade as a lever, and fed more adhesive down into the joint. Removing the hacksaw blade allowed the metal to spring back, and I secured it using a couple of clothes pegs at each joint.

After repeating this on all four corners and leaving overnight again I found that this time the glue had stuck, but I decided to try and make the joint more secure.

Normal fastenings were out, so I retired next door into the office to think. (Office, noun, a 10 x 6 ft. shed in the garden, with a worktop, comfortable chair, computers and reference books).

I kept using the stapler while filing, and realised that here was a possible answer to my problem.

Back to the workshop, using the width of my pliers as a gauge I drilled No. 56 holes through the alloy and the wood, bent up a staple from a piece of binding wire and inserted it through the holes and bent the ends over with the pliers, **photo 3**. Result, a reinforced joint and a win inspired by the office, **photo 4**. I wondered about trying paper staples, but they were too short in the arms.

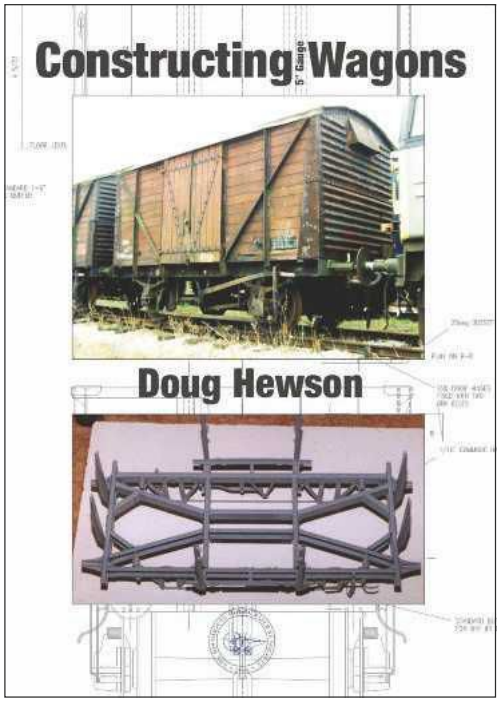
A good nip with the pliers bedded the ends of the wire into place in the wood so they did not interfere with the re-entry of the oilstone.

As a footnote, I kept the scrapings from around the oilstone and box, **photo 5**, about half a 35 mm film cassette full. LBSC often urged use of a scraping from the oilstone - now I have a pot full. ■

This was part of the scrapings recovered from the sides of the stone and the box, mixed with a tiny drop of light oil it makes a fine lapping compound

On the Wire

NEWS from the World of Hobby Engineering



Constructing 5" Gauge Wagons

The Historical Model Railway Society (HMRS) is now taking pre-orders for Constructing 5" Gauge Wagons by Doug Hewson.

Doug, is a well know 5" rolling stock modeller and also layout builder in smaller scales. Doug's philosophy is wherever possible to build models in the same way as the prototypes were built. Doug provides readers with detailed descriptions of items such as brake gear, underframe construction and the wagon door operating mechanisms, information needed by modellers whatever scale they are working in, as well as those restoring full size vehicles.

The book covers open wagons, mineral wagons, vans and brake vans, mainly those built between 1923 and the end of the traditional wagon on British Railways. It has 320 pages, over 900 prototype, model and construction photographs, 26 tables of prototype wagon information and many diagrams. Additionally, there are 36 separate A2 and A3 drawings printed on 'plastic paper' for durability.

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UK First for 3D printed Gas Turbine Blades

Engineering firm Siemens has completed its first full load engine tests of gas turbine blades completely produced using Additive Manufacturing (AM) technology. The company ran printed turbine blades with a conventional blade design at full engine conditions. This means the components were tested at 13,000 revolutions per minute and temperatures beyond 1,250 degrees Celsius. They also tested a new blade design with a completely revised and improved internal cooling geometry manufactured using the AM technology. The blades manufactured were manufactured at the Siemens UK based 3D printing facility at Materials Solutions in Worcester, and the tests were conducted at the Siemens testing facility in the industrial gas turbine factory in Lincoln.

The blades were installed in a Siemens SGT-400 industrial gas turbine with a capacity of 13 megawatts. The AM turbine blades are made out of a powder of high performing polycrystalline nickel superalloy, allowing them to endure high pressure and temperatures and the forces of the turbine's high speed operation. At full load each of these turbine blades is travelling at over 1,600 km/h, carrying 11 tons or equivalent to a fully loaded London bus, is surrounded by gas at 1,250 °C and cooled by air at over 400 °C. The advanced blade design tested in Lincoln provides improved cooling features that can increase overall efficiency of the Siemens gas turbines.

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

Write to The Editor, Neil Wyatt, Model Engineers' Workshop, MyTimeMedia Ltd., Suite 25, Eden House, Enterprise Way, Edenbridge, Kent TN8 6HF. Alternatively, email: neil.wyatt@mytimemedia.com

One Man and his Lathe

Michael Green and his 1957 CVA Toolmakers' Lathe

One of the things I tell people who are just starting out with machining as a hobby is that they are more than likely going to have at least two lathes – the first will be to learn the basics of metal turning but also to learn what they do and don't like about the machine for what they want to do. All subsequent lathes will refine that knowledge. I am no exception, as the lathe in this article came about because I discovered that something a bit larger and more rigid would suit what I was doing a lot better.

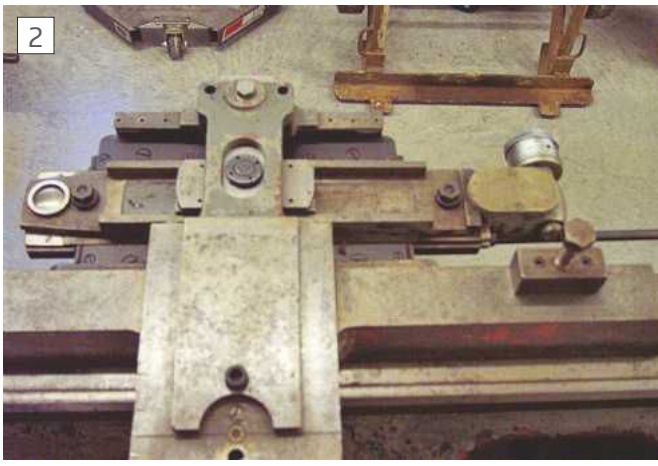
The previous lathe was a Taiwanese bench top machine, 4 ½ " centre height and 20" between centres. 1HP, screw cutting and it had a top speed of around 1000rpm - nothing awful but not much more to recommend it than that. I'm a member of TAD in Australia (similar in purpose to REMAP in the UK) and at the time I was being asked to machine some parts that were on the very edge of its capabilities, which set me thinking that something larger would make the job easier. So I started looking around, trying to work out what features and capabilities I would like. At the same time, some of the local universities were clearing out their old machines, so I became familiar with some of the more reputable brands in industrial machines and what they featured or did. Online reviews were another part of my researching. The specifications I ended up deciding on were a centre height of 6", at least 20" between centres, a top speed of at least 1500rpm and rigid enough to run carbide tooling. A nice to have was a taper turning attachment (TTA) but I was not realistically expecting to find that out there.

Here we have a large percentage of new lathes coming out of China. I didn't particularly want one of them; partly due to cost – I would be looking at a serious price tag because the specifications I had arrived at were basically an industrial lathe. The other reason was before CNC became common place there were some top notch well featured lathes being made which would probably be heavier and therefore more rigid than a more modern lathe, but probably undervalued due to their age. If you look hard you can find a range of machines, so there were Chipmasters and lathes by Weiler, Monarch,

The lathe as first seen

DS&G, SAG and all sorts of really nice (if old) hardware that was popping up. All of these required some researching to see what they offered and whether it was practical to ship them to me. One that intrigued me was the CVA brand. Reading up on the www.lathes.co.uk site, it sounded like a very nice machine but as with all of these brands, finding a reasonable condition machine at an affordable price was always a challenge.

As part of my researching I spoke with a lot of people, including owners of some of these machines to see what their thoughts were. One had a CVA, **photo 1**, which he wanted to get rid of but the distance and price initially put me off. Emailing him to get some photos I discovered that the machine had a TTA (**photo 2** – a definite inducement) but on the down side was partly disassembled and he had never run it. He'd bought it as a restoration project from someone who had partly disassembled it to restore, lost interest, then sold it on to the current owner who lacked the time to start and now wanted to clear the space. After 6 months



The highly desirable TTA up close

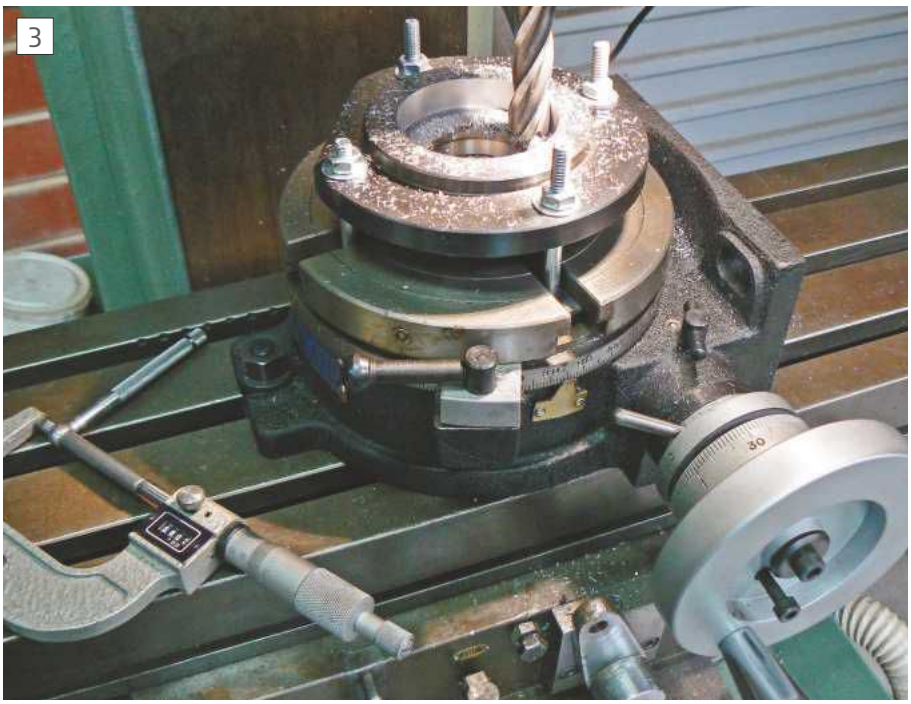
or so it had not sold, and I appeared to be the only person interested in it, so we got to negotiating and I became the owner of a 1957 CVA toolmaker's lathe in a non-running and incomplete condition.

When it arrived, I went over it and made up two lists. One was a list of things that would need to be fixed/replaced/repaired before it would run (34 items) and the other was a list of things that would not prevent function but would eventually need attention (32 items). I was fortunate

›

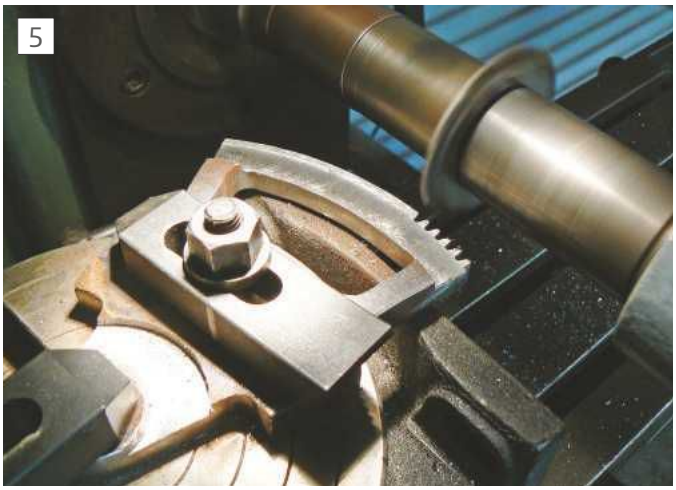
to attract the attention of John Stevenson and Tim Leech in the UK, both CVA owners, who were able to help with the odd bit of advice.

As part of that survey I stripped the lathe down and cleaned it. The amount of old swarf that came out was surprising. My tear down went to the level of checking and cleaning out the inside of gear boxes although not removing and changing bearings if I could help it. One of the things I discovered was that the main gear box that holds around 5 litres of oil needed a replacement seal, as the one fitted didn't seal any more... Most surprisingly although the seal had an imperial housing, the shaft size seemed to be metric (30mm). The replacement seals available were not a drop in fit in the housing so the housing had to be enlarged in diameter. With no lathe the normal method was not available. Fortunately, there was another way, **photo 3**. Mind you, seeing the oil level was another challenge, **photo 4**, the plastic was so old that it was almost opaque. Some glass discs and some gasket goo solved that one

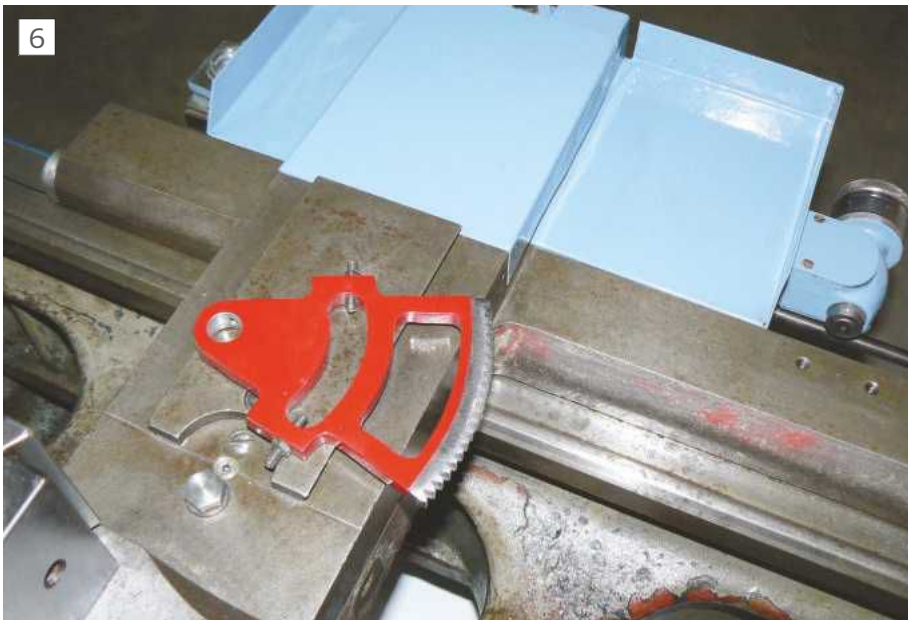


Enlarging the seal housing with rotary milling

Gearbox sight glasses – old (top) and new (btm)



Cutting the switch gear quadrant



The completed switch gear quadrant

Being a British machine of the 1950s, there were a lot of older style threads used such as BSF, BA and Whitworth, and many of these were missing. One of the past owners had used UNC threads in some places so they also had to come out. We have been metric here since 1976 so while Whitworth is still around some of the missing fasteners had to be made from scratch as they were just not available in the sizes needed.

One of the more interesting (and critical) parts I had to make was a switch-gear quadrant. The switching of the spindle was done with 415V contactors, which in turn were controlled with a rotary switch. The switch shaft had a small gear on it that meshed with a gear quadrant keyed to the switch shaft running along the length of the bed, **photos 5** and **6**.

A few of the missing items had to be bought. The lathe was minus any chucks and only had a face plate; the main tool post was also missing although oddly it

Rotary control switch

Electrical contactors on their board

Compound nuts (as found on the left; replacements on the right)

still had the rear one. I did not mind the front tool post missing as it gave me a reason to replace it with a QCTP, one of the things that would have been on the second list anyway. I've long favoured the wedge type Aloris QCTP, for the simple reason that making extra holders for the post is relatively easy. A bit of hunting around and I found a decent second-hand unit on eBay so was set.

The other major challenge was the control wiring – some dear soul in the past had removed it all, so it was a bit of work to determine what it should be, what terminals on the switch were what, **photo 7**, and put that into effect. The coil voltages on the contactors were 415V AC, **photo 8**, none of this safety first 24V stuff here! The lathe had no earth and I was not 100% certain that I'd got it right. That first power up was approached with complete confidence!

Once I could power up it was a little more straight forward as having a functional lathe I could then make up things like missing adjustment screws; remaking one of the leadscrews that had too much backlash and making up an ER collet chuck. The nuts holding the compound to the cross slide were another discovery, so another task of the now powered up lathe was to make some new ones, **photo 9**. Originally the lathe came with a 5C closer but that was long gone. There was a rack for the collets inside the door at the tailstock end of the base. Not intending to use 5C I removed this and then for good measure decided to remove the door for painting. I soon learnt that 50-year-old cast iron can be a bit sensitive to this sort of thing as it cracked, and despite taking it to the most experienced CI brazing place in town, the crack grew when they tried to repair it. The door was a write off so the one on there now is a fabricated effort to look like the original.

Being a tool room machine there were other accessories that were available to extend its utility, so on the list of things to do is a micrometer based traverse stop. Not the sort of thing that I would expect to use often but an interesting thing to make never the less. The micrometer head is on the left so possibly 'backwards' to the way one would normally be read (and from the other side). I have never seen an original one so can't say. There is apparently

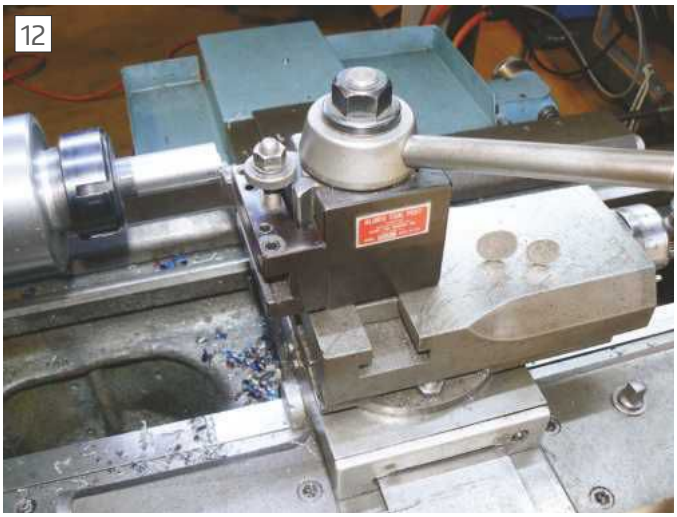
Lathe after cleaning and painting

a capstan version too, so six different lengths can be accommodated.

Some people have commented that it is a lot of effort to go to, but I think the machine justifies it, **photo 10**. The lathe including the base is cast and weighs around 1.5 tonnes. It is a 3-point mount, so moving floors are not a problem. At 4HP and a top speed of 2200rpm, it handles carbide with ease. The motor and gearbox are attached to a rubber mounted subframe, **photo 11** and that drives the spindle through a flat belt, so no vibration to speak of. In **photo 12** the small coin on the right is 1.3mm (just over 50 thou) thick and the lathe is turning at around 350rpm). The spindle has a single tooth dog clutch so that cutting threads is a dream. On the down side, it does have a relatively small bore for its size (a bit over 1"), needs change gears for metric threads and has a D1-3 camlock fitting on the spindle which is not the easiest to get chucks for.

The initial acquisition was around 7 years ago. Most of the second list items have now been attended to although there are still some out there to look at in quiet times. In the meantime, it gets used most weekends doing all sorts of things. Apart from my TAD projects and making up other pieces of tooling, there are a few unusual things that I occasionally get asked to do or decide to do.

Motor and gear box on rubber mounted sub frame



Showing how little vibration is present at the tool

Brass fittings for Grinder restoration

Photograph 13 is the wheel head of my Jones and Shipman grinder restoration. All the brass tube fittings (although not the valve) I made on the lathe, and the drip oilers that can just be seen to the right of the wheel were bought as 1 ¼" diameter units and then had the middle section removed, a new glass put in place with top & bottom housings machined from solid as there was only room for a 1" diameter version - not available with 1/8" BSP that I could find.

Photograph 14 is a steam indicator valve that I'm recreating for a friend of mine. The original is nickel plated; my copies are in bronze. Most people think of a manual lathe as only being able to

Gunmetal valves for a steam indicator

Air intake bell mouths

Screw for historic farm machine

produce cylindrical or conical surfaces but that is not always the case. Here a ball turning attachment has been used to shape the middle of the valve. The spindle was turned using the TTA and it was an enormous help in getting a matching angle for the bore.

Photograph 15 was one of those "how on earth do I do that" jobs. These are air intakes for a V8 engine that one of the guys at work is doing up and I was asked if I could clean up the castings. The profile is basically elliptical – but it was all done manually and all needed to be 'the same' so airflow was the same into each cylinder.

Photograph 16 is one of a pair of screws for a reproduction historical piece of farm equipment. The thread was ¾" Whitworth and then a fast lead LH screw was helically milled on top of it. The original was a forging so the plain shank between the thread and the head actually had to be slightly tapered.

Photograph 17 was an aluminium ring for a photographic light, made for a guy who showed up on our forum one day asking how he could make a replacement. He was a really accomplished photographer but lacked a lathe so I felt sorry for him. The ID is 100mm and the wall thickness is 1mm.

Aluminium mount for a photographic light

Weight is around 30 grams.

Photograph 18 is a Delrin worm gear being hobbed for a friend's bandsaw restoration. The original gear was Phosphor bronze but he says this one has been fitted for a couple of years now and not given trouble, so he's never bothered to change it. Part of the job was making up the cutter from silver steel, which called for some new lathe change gears as it is Module 1.

The three-ball handle in **photo 19** was

Hobbing a replacement worm gear for a bandsaw gear box

made for another lathe, around 4" long. The two semi-circular pieces next to it are a tapered split bush so it can be held in a vice or chuck for secondary operations.

Photograph 20 is a 'mass production run' of surface grinder hubs (wheel bore is 1 ¼"). When making parts like these you really have to think about making up tooling – in this case a tapered mandrel so that diameters and flanges would be concentric with the axis of rotation. ■

A replacement three ball handle

A batch of surface grinder hubs

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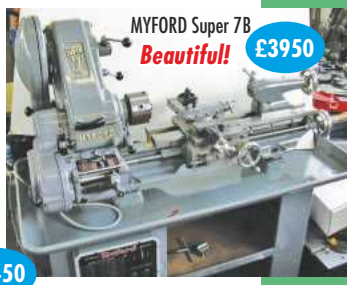

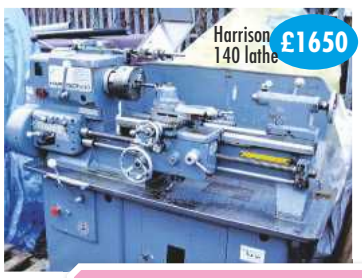

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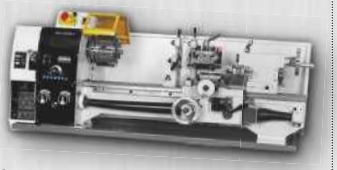

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