No.253

THE MAGAZINE FOR MAKERS AND HOBBY ENGINEERS

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APRIL 2017

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COVER FEATURE

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On the Editor's Bench

Tap on my Shoulder

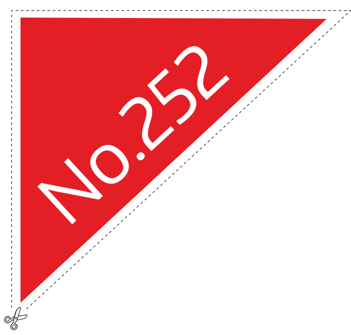
I received an interesting letter, intended for Scribe a Line from Stuart Mcall, he wrote:

I keep coming across taps & dies etc., carrying the name 'The LAL Company (purporting to be made in England) but can find absolutely no reference to this Company on the Internet other than those associated with the sales of "used" tools. One reference thought it might be Langham, Archer & Lane of Sheffield, but this again is a "ghost-name" as regards any Internet reference. I have become intrigued as to whether this was just a Trademark for another manufacturer. Any information would be appreciated but I fear those with knowledge may already have departed this life!

This was of particular interest to me as I have a very nice set of even-number BA taps and dies that used to belong to my grandfather. It is indeed a LAL set, but LAL stands for Lehmann, Archer, Lane Ltd. of Fairlop in Essex. Nearly all of the (carbon steel) taps and dies are original, sadly the 2BA die has snapped. They still get some use despite their age, although I have another, full BA set that includes the odd numbers. The set is 'No. 37' and has taper and plug (no second) taps, five 13/16'' dies, a small but beautiful No. 182/0 tap wrench as well as a very nicely made diestock.

Errata

I'd like to apologise to readers confused or inconvenienced by the incorrect numbering on the cover of the last issue. Yes, the one with the 'blue cover' really was issue 252 despite the prominent '251' in the corner. We also know that many readers rely on these corner flashes to help them find the right copy in their archives, so here's a 'cut-out-and-keep' triangle with the correct number on it for you to stick on the front of the last issue.



An unrelated error was the inclusion in Issue 251 of a Greenwood Tools advert. The ad copy had a flash on for the Doncaster show with last year's dates. Unfortunately, the advert should not have appeared and did so by mistake. This year's Doncaster Show (the National Model Engineering and Modelling Exhibition is on the 12-14 May.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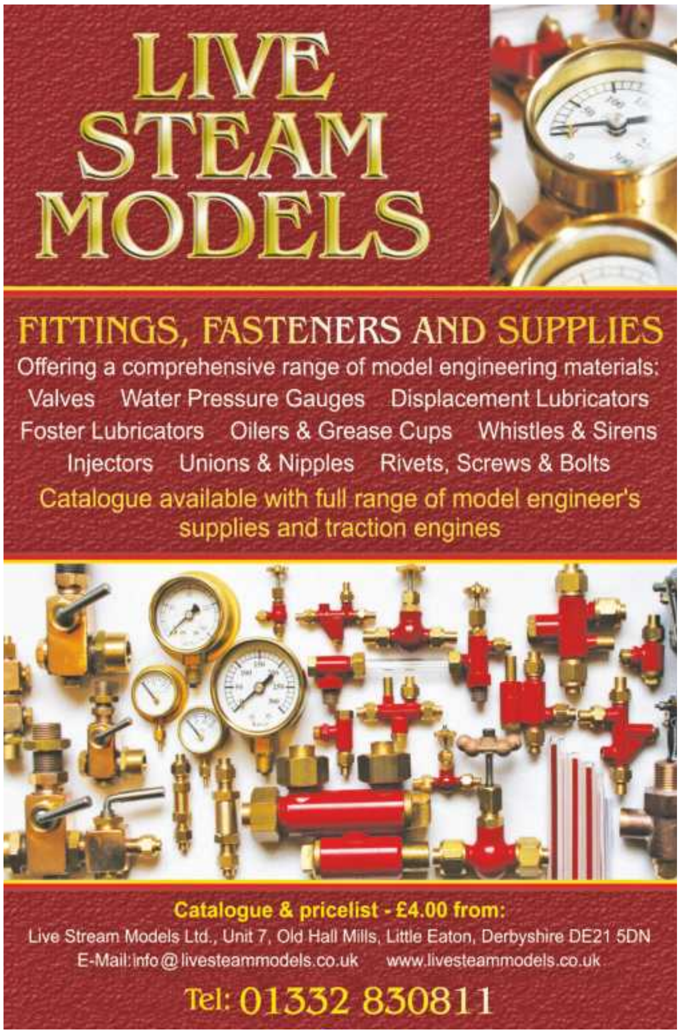
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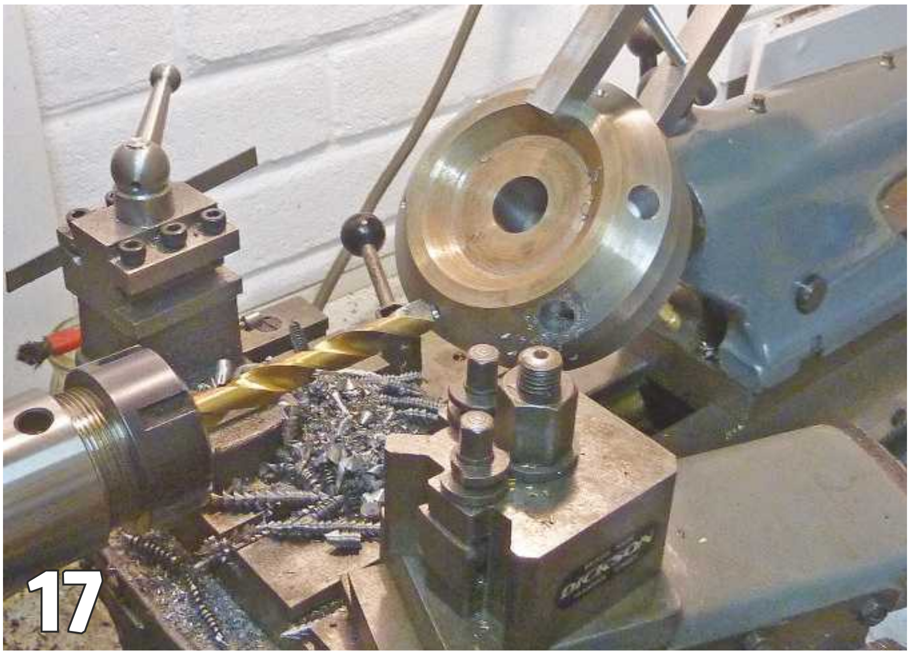
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Coming up...

in the May issue

Once you have enjoyed this issue, look out for MEW 254 for more exciting workshop adventures

Regulars

ON THE COVER

This month's cover features Alan Jackson and his fine Colchester Chipmaster lathe (p.28). Alan is well-known as the designer of the prizewinning Stepperhead CNC lathe which was featured in MEW in detail.

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THIS MONTH'S BONUS CONTENT

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

Ken Willson's Improved Headstock Bearings for a Myford Super 7
Head for the Article Reprints section of www.model-engineer.co.uk to find out how Ken fitted taper roller bearings to his Myford.

Plus: Digital Caliper Review
If you missed our recent digital caliper review, it's now on the website too!

It's been yet another bumper month for new forum members – if you are a 'lurker' why not join in the discussion!

Burnerd Miniature Quick-set Toolpost type TP
- Great ingenuity or flawed design? You decide!

Arduino Rotary Table
- Continuing discussion of Carl Wilson's design, including developing a keypad interface.

Thread Pitch Error
- Is there a rule of thumb for how accurate you need to be?

PLUS: Model and tool builds, problem solving and engineering chat!

CLASSIFIEDS EXTRA SUBSCRIBE ARCHIVE SUPPLIERS

Making Lathe Tools out of Old Files

Peter Shaw does some practical experimenting in his workshop.

Successful Tools.

Many years ago, shortly after I became involved in this hobby, I read something about re-using old, worn-out files to make lathe tools. This I found intriguing, and did indeed attempt to make such a tool. It was a total failure! Nevertheless, I kept the idea in mind, and when some years later I had need of a replacement parting-off tool, I resurrected the idea with eventual success, but only after attempting an impossibly long blade.

Over the next few years, I picked up other hints & tips, some of which did not work for me, whilst others did indeed work but with a few provisos, and I now have five tools made from old files plus a quantity of spare sections for use later if required. This article is a discussion of what I found worked, and just as importantly, did not work.

Successful tools

At the extreme left of **photo 1** is a parting-off tool made from a 4in x ½ inch x 1/8 inch file which works very well indeed provided the cut is flooded with cutting fluid and the tool is used firmly, i.e. no "tickling" of the work, otherwise chatter results. The actual blade itself has a tip width of 1.84mm and is about 10mm long. The holder for this tool is similar to that shown on page 21 of L. C. Mason's book, Using the Small Lathe, albeit with a channel the same width as the height of the file. The tool is thus held

Miscellaneous bits of file and a leadscrew!

rigidly whilst cutting.

Next is a narrow bladed tool made from a 5/16 inch square file. The file was "smashed" (see later) in an attempt to obtain a number of usable lengths, but I ended up with just the one piece. The initial tool was ground as a trepanning tool for use on aluminium and featured a tip width of 0.93 mm and a blade length of about 6mm and as such worked very well indeed. It also worked well when creating some narrow grooves in free-cutting mild steel to such an extent that I was able to gently traverse the tool sideways along the bottom of the groove in order to obtain a smooth surface. Unfortunately, at some point I exerted too much sideways pressure and broke the tool necessitating a regrind. The blade length remains the same at about 6mm but the tip width is now 1.46 mm. There is evidence of slight chatter which suggests that I possibly need to reduce the tip width to perhaps 1.0 mm or less.

The third tool from the left is a metric trapezoidal thread cutting tool. The source material was a 12 inch long flat file approximately 7 mm/ 9/32 inch thick which was cut (see below) into 6 x 80 mm lengths. This tool is used vertically (it measures 11.4 mm high) and works well provided care is taken. For my purposes, the included angle was 30 degrees which makes for a rather narrow tool which should have a tip width of 0.6784 mm, or, in practical terms, almost 0.68 mm. I did have breakages caused by too much infeed and too much transverse pressure. (One document I have recommends shaving each side of the thread alternately by 0.025 mm if the male thread does not fit the nut. I found it better to slowly increase the depth, thereby slowly shaving both sides equally and to reduce the infeed from 0.25mm to 0.1 mm or even 0.05 mm).

The three remaining tools all came from a large 9 mm/ 3/8 inch thick file broken by the "smashing" method. I suspect I may also have used my large angle grinder to reduce the broken pieces to a manageable size. As will be seen, there are two cranked tools, left and right, one of which has not been finished because I have not, as yet, needed such a tool. The third tool is the result of much experimental grinding and despite its rather unconventional appearance, now works very well as a finishing knife tool which will also take reasonably deep surfacing cuts. It also works well as a facing tool. All three tools are used flat, a requirement for the cranked tools, but adopted for the knife tool as well.

The leadscrew shown in photo 2 shows the trapezoidal thread, grooves, and a smooth section (which will become the bearing for the leadscrew) all of which have been produced using the above tools. The thread at the right hand side was created by a silver steel single point tool and finished by a die so doesn't count. The flange was created by using the narrow bladed tool but suffered from an accidental wrong direction selection on the lathe resulting in the trapezoidal tool making an unscheduled cut!

Soften, Smash, Cut. Or not, as the case may be!

One of the early tips I picked up was that it was possible to soften files, shape them as required, and then reharden. The recommended method of softening was to place the file in an open fire last thing at night when the file would be heated slowly to soften it and then would gradually cool as the fire died down. Yes it worked, and the files were most definitely soft, indeed I could cut them with a hacksaw. But, and I don't know why, the surface of the file appeared to have delaminated such that it was no longer usable as a lathe cutting tool. **Photograph 2**, middle item, shows one of the files treated this way and shows a short hacksaw cut at the right hand end.

Another tip was that one way of reducing a file to short usable lengths was to wrap it in a piece of cloth, fasten in the vice and hit the protruding section with a hammer to break, or "smash", the file into small pieces. For this to work requires that the files be brittle, which indeed they are. This was reasonably easy with the 5/16 inch file, but difficult with a larger file, requiring a very hard blow with a 2½ pound club hammer. Unfortunately, there is no control of where the breaks occur, or even the shape of the broken pieces, thus much grinding was required just to obtain reasonably rectangular pieces. All in all, this procedure cannot be recommended.

The final tip was to use a small angle grinder fitted with a cut-off disc for steel. Mine is 1.6mm thick and so a reasonably narrow cut can be made. I found this a satisfactory method to use and even used it to shape the right hand cranked tool in photo 1. The problem, of course, is that cutting and grinding tools such as these create heat which will soften the hardened steel. My solution was to hold the file between the plastic lugs supplied with my Workmate, cut for perhaps three or four seconds and then flood the cut with cold water from a watering can spout, the whole job being done outside. My reasoning behind this is that it takes time for the heat to travel from the cut, therefore as long as the eventual cutting edge of the new tool is well away from this initial cut, then by flooding it in this manner, I should be able to prevent any softening of the new tool cutting point. There is a danger that this might introduce small cracks, but as it is all experimental, then that possibility is something I will live with. The top part of photo 2 shows that I managed to obtain 6 x 80 mm lengths of suitable steel from one file. It also shows that my attempt to cut the file down the middle was somewhat amiss hence I ended up with six pieces 80mm long but with widths varying between 11.5 mm and 15 mm.

Grinding to shape.

Two problems arise here. The first is that my grinder becomes very hot with use. It always has, indeed its predecessor was returned under warranty for this very reason, yet this one, after 28 years is still working satisfactorily despite its apparent overheating. Nevertheless, once the casing becomes almost too hot to touch, I stop operations and allow the grinder to cool. Which does not make for rapid tool making.

The second problem was that of overheating the tool. In the end, I would grind for three or four seconds, or maybe less, I didn't bother timing it, and then immediately dunk the tool in room temperature water. Using my fingers as a rough and ready thermometer, I would say that the ground surface was no more than warm. Regardless of that, the tools do appear to work so it would seem that I have kept any temperature rise to a reasonable level.

As part of the tool forming process, I also blunted any of the original file teeth by quickly running them over the coarse grinding wheel.

Mounting & Using the Tools

None of these tools come anywhere near centre height for my lathe, so I use packing as necessary under the tool. Also, where original file surface is uppermost, and hence will have the toolpost clamping screws bearing on it, I use a length of shim steel to protect the bottom of the clamp screws.

Files are carbon steel and designed for hand use which by its nature is slow. Using the tools at a high speed in the lathe will damage or even remove by wear, the cutting edge. I found that on 12 mm free-cutting steel, the knife tool worked best at 250rpm with a modicum of cutting fluid. The narrow bladed tool and the trapezoidal tool were used at 125 rpm, the minimum for my lathe with some or no cutting fluid. The reason for no cutting fluid was because at times I wanted to see what was happening and the use of fluid tended to obscure visibility.

It is also worth noting that files are brittle, hence the cutting tips can be easily broken or damaged with accidental misuse, but as long as care is taken, they do work and can perform useful work.

Conclusion

Is it feasible to produce lathe tools from old files? Well, with some provisos, yes it is. Is it a good method of producing lathe tools? No, I don't think so unless one is desperate, or wanting to do it just for interest. The problem is that it takes a long time to create a tool, and the resultant tool has to be treated with care as outlined above. As it happens, some time ago I bought an old 16mm square file for £1.50 from a car boot sale with the intention of making one or more seriously heavy duty tools. According to my lathe handbook, my toolpost can handle 16mm tools, therefore other than cutting off a suitable length and blunting the teeth, I should not need to perform any major grinding other than that necessary for forming the cutting point. I feel a further experiment coming on!

Given a choice between using old files, proper high carbon steel, e.g. silver steel or HSS, then there is no contest. HSS will probably take as long to grind to shape, but will be stronger and faster cutting. Silver steel will be easier to shape for complex needs, but then will require hardening and tempering. Nevertheless, this has been an interesting experiment and I have now five or six blanks which can be used for future one-off requirements as and when they arise. Plus, I now know a lot more about re-using and re-purposing files. And that, for me, is what it is all about self-education by experimentation.

References.

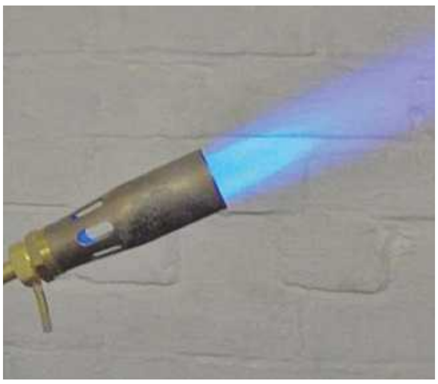
L. C. Mason: *Using the Small Lathe.* ■

In our Next Issue

Coming up in issue 254
On Sale 21st April 2017

In the next issue of Model Engineers' Workshop there's more to help you get the most out of your hobby:

Myford Bed Regrind – **Laurie Leonard** reports on what's involved



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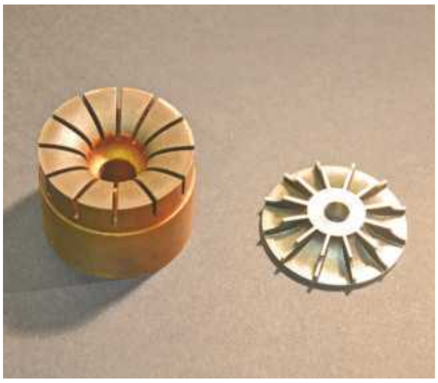


Ben Tubbing looks at what Spark Erosion has to offer the hobby engineer.

DON'T MISS THIS GREAT ISSUE - SEE PAGE 60 FOR OUR LATEST SUBSCRIPTION OFFER

Useful Techniques for the Hobby Workshop

Darren Conway demonstrates some model engineer's workshop nous by way of making a Poly-Vee Pulley

1

The completed pulley ready to fit

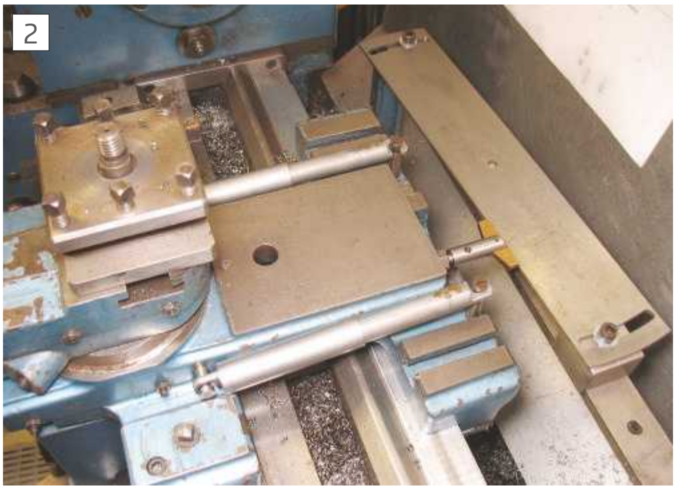
I am modifying my Nardini MS350 lathe to fit an electronic variable speed drive. The unmodified lathe was 3 phase, 400VAC but I only have single phase, 220VAC in my workshop. I needed to fit a new 220VAC motor to match the VSD output. This required new pulleys for the poly-vee belt I will be using. The lathe was originally fitted with three belts running on triple-sheave pulleys. The original belts were old, perished and heavily contaminated with coolant. Not only are these expensive to replace, but belt technology has improved since the lathe was built. In addition, the original motor pulley wouldn't fit the new motor. New pulleys for single poly-vee belt provides a low cost, high performance drive solution. **Photograph 1** shows the new driven pulley ready to be fitted to the lathe.

This article isn't about making a pulley for an obscure and rare lathe. This article describes a selection of simple and advanced methods that can be applied by model engineers to other applications. This project required the making of a pulley to fit a tapered and keyed driven shaft. The pulley also needed to be machined for the industrial type poly-vee belt fitted in place of the original belts. While this application might be unique, the methods applied are universal.

There were two phases to this project. Matching the bore to the existing driven shaft on the lathe, and making the vees that the belt would run in. Completing these phases is described below. I started with the problem of matching the pulley to the driven shaft.

Matching to the Shaft

The replacement pulley needed to exactly



2

The factory taper attachment uses springs to pull the cross slide onto the straight edge

3

Measuring the difference between the steps on the bar

The top slide is moved to zero the gauge

The gauge zeroed on the other step with the top slide moved

match the driven shaft taper angle. The taper also defined the axial location of the pulley on the shaft so the diameter of the tapered bore in the pulley was important. I didn't have drawings that specified the tapered shaft dimensions but I did know that achieving a good fit required machining the bore to a precise angle and diameter. To solve this problem, I had to apply methods that accurately matched the dimensions of the bore of a new pulley to an existing tapered shaft.

The shaft diameter was measured at two points along the length of the shaft. The difference between the two diameters divided by the distance between the diameters gives the taper. For the driven shaft, the measured ratio was 1:20. When measured relative to the shaft centre line (the included angle), the ratio was 1:40. This didn't appear to match any known standard taper. The shaft taper is less than 50mm in length and I used calipers and a ruler to take the measurements so I knew that the measurement wasn't very accurate.

Taper Forming Method

I had the choice of using the top slide or the taper attachment to turn the taper. The taper attachment is easy and convenient to use. The factory taper attachment uses springs to pull the cross slide against a template (a straight edge for a taper) as shown in **photo 2**.

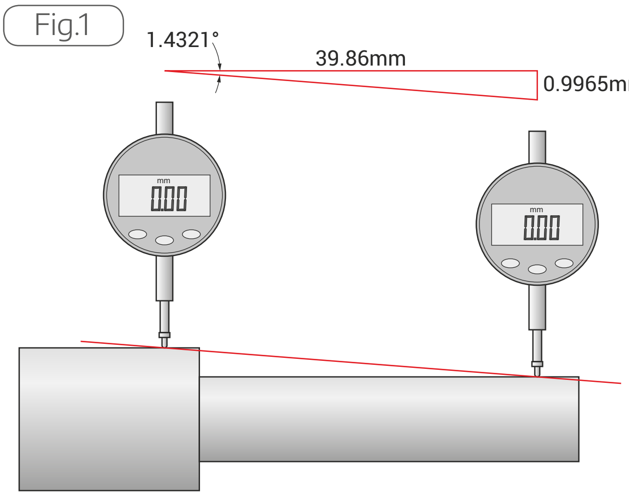
The taper attachment is rigid and well made but it is not as rigid as the top slide. Rigidity is vital when working to close tolerances. For short tapers, the top slide offers better rigidity and more control for cutting accurate bores. The taper was short enough to be well within the range of movement of the top slide. Accuracy was essential for this work so I elected to use the top slide for making the taper.

Making a Prototype

Having measured the taper and made the decision to use the top slide to cut the tapered bore, the next step was to setup the lathe. The pulley blank was a large biscuit of cast iron. It intentionally had a small allowance for machining to minimize metal removal. A mistake during machining of the bore would create a heavy piece of scrap metal. I therefore decided to make a prototype bore. This was a short piece of 35mm diameter bar that I drilled and bored to match to the tapered shaft. The sole purpose of the prototype was to accurately setup the lathe and complete a dress rehearsal of making the bore. The prototype was sacrificial in that it was thrown away once it had served its purpose.

I began making the prototype by drilling a 23mm diameter hole through the bar, slightly smaller than the small diameter of

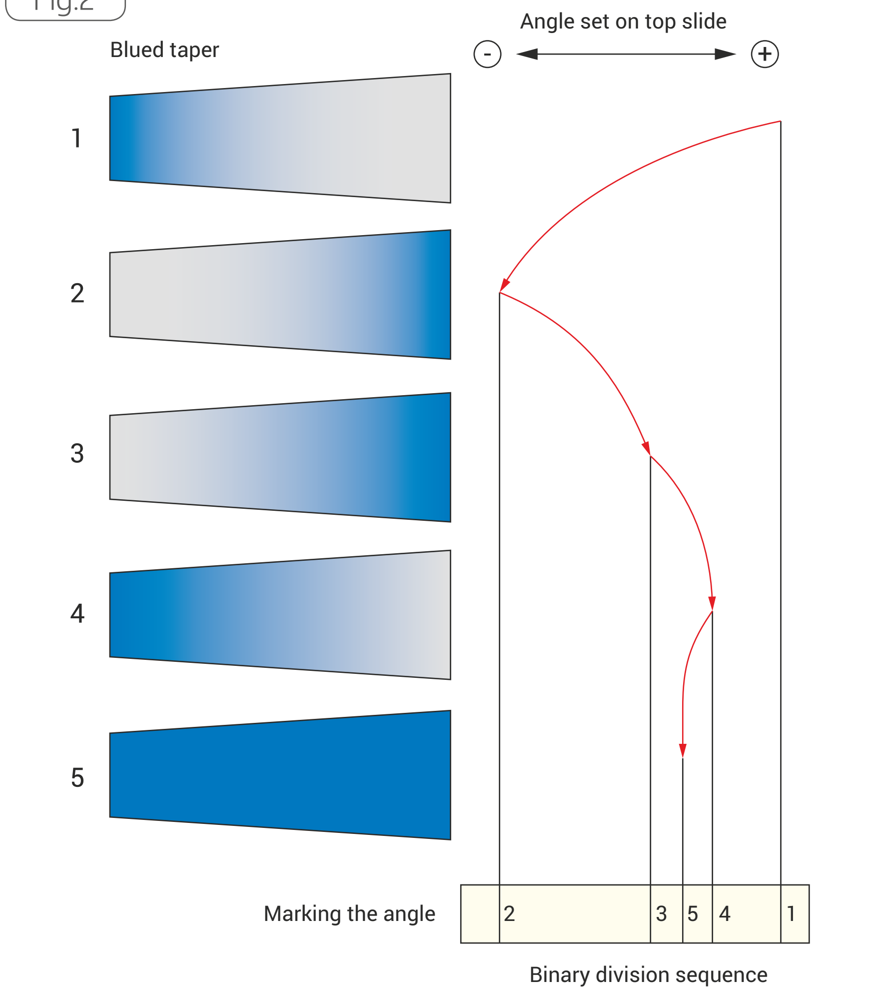
Fig.1



the tapered shaft. I then needed to set the taper on the top slide. This is where the key disadvantage of using the top slide to cut accurate tapers becomes apparent. The degree graduations on the top slide are far too coarse to use to accurately set an angle. Previous experience had shown that making fine adjustments to the angle is difficult. A small nudge has unpredictable results. I needed to improve both the angular accuracy and resolution for this job. Accuracy was required to set a specific angle and resolution was required to make fine adjustments.

Key steel clamped to the top slide allowed fine adjustments to angle

Fig.2



Setting the Top Slide Angle

To accurately set the absolute angle of the top slide, I used the lathe and trigonometry. I machined two diameters at the end of a short bar. The taper on the shaft had a 2mm difference between the big and small end. On the bar, I machined the diameters with about a 1mm difference in radius. I used a micrometer to accurately measure the difference between the diameters as shown in **photo 3**.

I now had a reference precisely aligned to the spindle axis that I could use to set the angle of the top slide. On the tapered shaft, the two measured diameters were separated by 40mm. If the angle on the top slide is set to exactly 1.4321 degrees, then moving the top slide 40mm would change the radius of the tool path by 1mm. I could confirm this by using a DTI against the two diameters machined on a bar. The concept is illustrated in **fig. 1** which shows the principle of the method. As drawn, the steps on the bar would need to be unreasonably long. Much shorter steps can be used if the saddle is moved to align the DTI with each step. The shorter steps will also improve the accuracy by eliminating a long potentially flexible overhang. The steps only need to be wide enough to accommodate the tip of a DTI. It is important that the surface finish of each diameter is good to achieve accurate measurements. Note that the DTI is only required to indicate the same reading (zero in this case), so either a DTI or dial gauge are suitable.

Setting the angle is shown in **photos 4** and **5**. Comparison of the photos will reveal differences in the location of the

Table 1

Error Source	Error (mm)	Formula	Error (Deg)	Error squared
D diameter	0.001	/D) -asin((d-	-0.0060	3.6E-05
d diameter	0.001	/D) -asin((d-	-0.0016	2.5E-06
Taper Length	0.008	/D) -asin(d/	0.0003	1.1E-07
DTI error	0.0001	l/D-asin((d-	-0.0002	2.5E-08
Mean square error (Deg)				0.006

top slide, carriage and the DTI. The key differences are that the top slide has been moved 40mm and the DTI probe is on a different diameter on the bar. The carriage has been moved to locate the DTI probe on the correct diameter. The cross slide is not adjusted. In both cases the DTI reads exactly zero which proves that the angle set on the top slide is precisely 1.4321 degrees.

With this method. it doesn't matter what the diameters are, it is the difference that is important. It doesn't matter how much the diameters differ, it is only important to know what that difference is. For this project, a difference in radius of about 1mm was convenient but I could have picked any random value.

Angular Errors

It is possible to estimate the accuracy of this method by calculating the effect of errors. The effect of each error is calculated by subtracting the measurement with error from the error free measurement. This method uses linear measurements to determine an angle. Part of this calculation needs to convert linear to angular measurements and errors. The overall angular error is calculated by squaring each contributing error, summing them, then taking the square root of the total.

The overall error of this method is shown in **Table 1** where:
e : the measurement error
D : the large radius of the taper
d : the small radius of the taper

Table 1 Calculation of the expected angle error

The uncertainty errors of the DTI and micrometer were taken from their respective calibration certificates. The lathe errors were estimated based on previous testing. Note that when reading graduations, it is usually assumed that the expected error is 1/3 of the graduation. With magnification and some practice, it is possible to reduce the error to 1/5 of the graduation.

The linear component of each error is transformed to the equivalent angular error. The result of these calculations is the expected error of the included angle. Calculations in the table show that the expected error would be 0.006 degrees. To put this into context, if the shaft taper was 100 metres in length, the expected taper error would be 11mm. So with a lathe, a micrometer, a DTI, and the right method, it is practical to achieve very accurate tapers.

This is not the only method of determining the angle of the top slide. I have seen descriptions that include the use of a sine bar and gauge blocks. These tools are purpose made to set precise angles but they depend on having an established reference surface that is aligned to the lathe spindle axis. That is not a standard feature on typical lathes, and there is usually no simple way of comparing the reference to the spindle axis. Both gauge blocks and sine bars are sufficiently specialized and expensive to ensure their inclusion is uncommon in most home workshops.

The method I applied doesn't suffer from these disadvantages. The tool generates the reference surface and is therefore guaranteed to be aligned to the lathe spindle axis. There is no requirement to establish a separate reference. The applied method only needs a micrometer and dial gauge which should be found in even the most modestly equipped workshop. From a practical perspective it is simple to apply and especially suited to shallow tapers.

Fine Angular Adjustment

Setting an accurate angle on the top slide requires an adjustment method with fine resolution. I knew that although the stepped diameter method of setting an angle is very precise, the measurements of the tapered shaft were not. I used a set of digital calipers to measure the diameters and a ruler to measure separation distance between the measurement points. There is no need for calculations to realize the expected errors were significant.

The top slide was now setup to cut a precise angle for the bore. I clamped the prototype into the 3-jaw chuck and machined the tapered bore. I removed the prototype from the lathe and smeared a thin even coating of engineers blue on the bore of the prototype. When fitted it to the tapered shaft on the lathe, the blue was only transferred onto one end of the shaft. As expected although the prototype was bored to a precise angle, it wasn't the correct angle. The error was perhaps only a few tenths of a degree but it wasn't a good fit. I needed to be able to make fine changes to the angle of the top slide.

I achieved high resolution adjustment simply by clamping a piece of wood across the lathe bed, and then clamping a long piece of key steel to the side of the top slide as shown in **photo 6**. The key steel rested on the piece of wood. This simple clamp-on accessory allowed fine adjustments to be made to the angle of the top slide. I drew a line on the wood to mark the position of the key steel before loosening the top slide clamping screws. I rotated the top slide by moving the key steel bar and measured the distance from the line to calculate the change of angle.

Fitting the Taper

The method to arrive at the correct taper in the bore was to use binary division. Rather than apply small corrections to the angle and step towards the taper angle, I initially applied quite a large correction with the intention of stepping over the unknown taper angle and made a cut on the bore of the prototype. A trial fitting with blue confirmed the correction overshoot. I then halved the initial correction, made another cut and did another trial fitting. Depending on which end of the tapered shaft was blued in contact with the prototype bore determined the direction of the next correction.

By repeating this process, the error was halved with each trial fitting. After 5 iterations, the error was reduced by a factor of 25 = 32. If a 6th iteration was needed, the error would have been reduced by a factor of 64. The method is illustrated in fig. 2 which shows how the systematic halving of corrections homes in to the unknown taper angle. I have never seen this technique applied to metal fitting but it is widely used in other fields. It is an efficient and simple method to match the taper of the bore and shaft.

The final fit is shown in **photo 7** where the engineers blue has been transferred from the prototype bore onto the entire length of the tapered shaft. For the benefit of the camera, I applied a fairly liberal coating of blue. Normally, a thin smear of blue should only leave a slight tint at the contact surfaces. The even layer of blue indicates a good fit between the shaft and the prototype. The top slide was now setup for cutting the tapered bore.

To be continued

7

An even rub of blue transferred from the prototype bore proves a good fit

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Make a Lathe Tailstock Turret

To accompany this month's pull-out plan, Alex du Pre explains how to make this useful accessory for any lathe of three to four-inch centre height.

Introduction

This article describes an easily-made lathe tailstock turret, **photos 1** and **2** and **fig 1** (please see the pull-out plan for figures), suitable for use on many different lathes. I will briefly describe the purpose of this useful accessory and discuss the features of this particular design before detailing the construction. The article concludes with notes on setting up and using the tool.

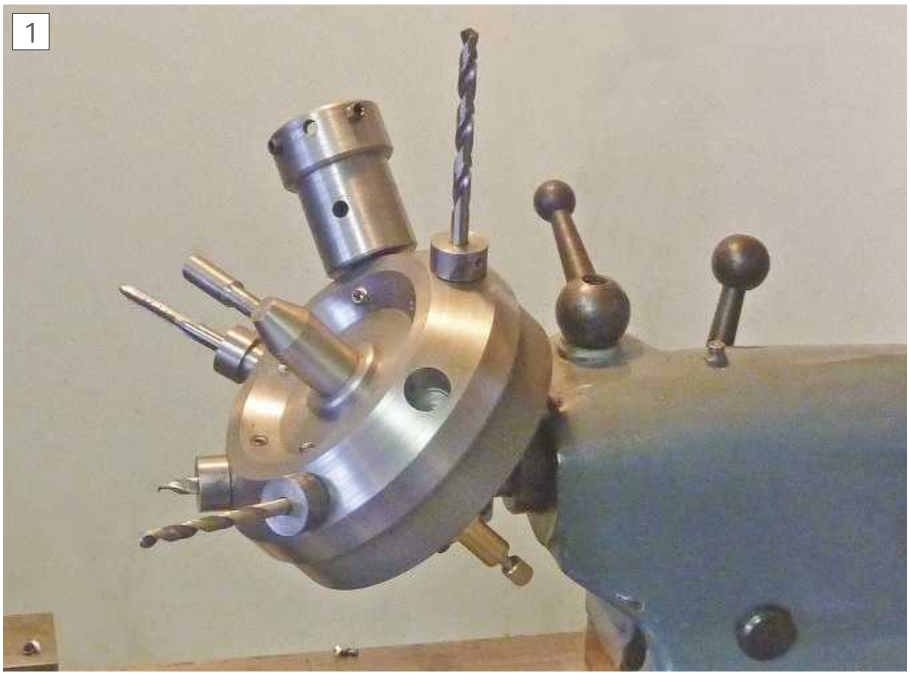
Making the tool is a satisfying machining exercise well within the capabilities of a modestly-equipped home workshop. A lathe will be required and although a milling machine is desirable, all milling operations could be done on the lathe with little difficulty.

What is a Tailstock Turret?

The need for a production run of identical parts is often encountered in the workshop, for example a batch of nuts and bolts or steam fittings. If the lathe is not set up especially for this, it can involve repeated and time-consuming tool changes. Productivity can be greatly enhanced by equipping the lathe with some accessories and those most frequently encountered are the quick-change tool post, carriage multi-stop, mandrel back stop and tailstock turret, which is described here. The power of the tailstock turret to improve productivity is unlocked to its fullest extent when used in conjunction with some of these other accessories, as demanded by the job in hand. In combination, these accessories effectively convert the lathe into a capstan lathe.

The tailstock turret is an accessory fitted to the lathe's tailstock in place of a single drill chuck. It has a number of tool stations, six in this case, allowing different tools to be held and rapidly presented to the workpiece in turn. This is far quicker and dramatically less tedious than repeated tool changing with a single chuck and indeed far more satisfying. Typical tools are drills, centre drill, taps and dies, although other cutters can also be used.

1



General view of the turret fitted to the lathe tailstock.

2

Underside view of the turret

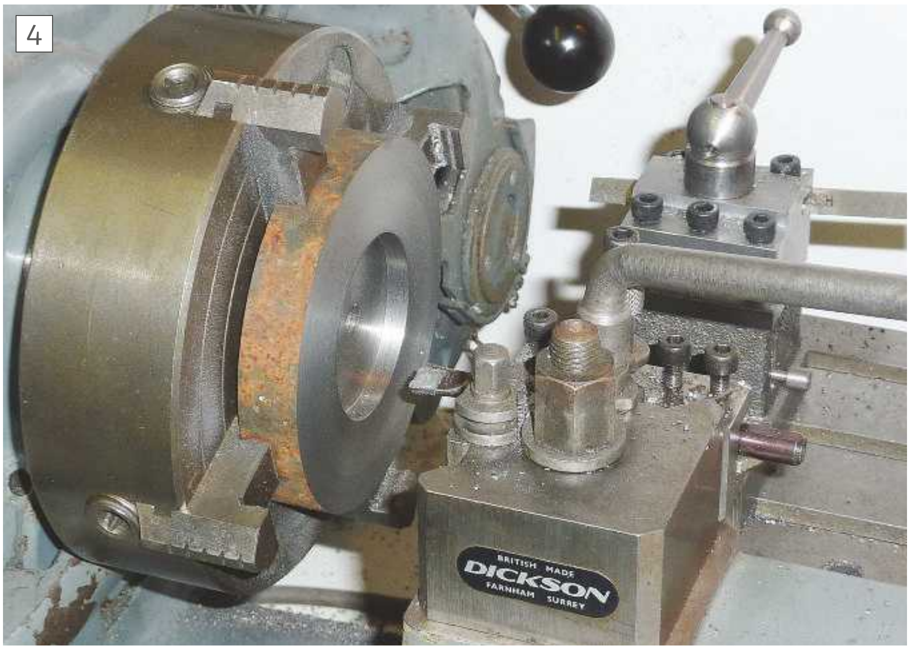
3

Turret dismantled to show all the parts required.

Description of this Tailstock Turret

This tailstock turret is suitable for use on lathes between about three and six inches centre height, although there is no reason why the design couldn't be scaled up or down to suit bigger or smaller lathes or tooling. It is mounted onto an MT2 arbour which fits either directly, or via an adapter, into the lathe's tailstock bore, depending on the lathe in question.

My turret is used with no problems on a Myford Super 7, which has an MT2 tailstock quill. I would just caution you to check the fit of the design on your lathe before starting construction, for example between the tailstock body and the back of the turret. Extending the tailstock quill should avoid any problems with clearances but slight adjustments to the design may be required to avoid any fouling. MT3 quills will have a larger diameter which may foul the back of the turret. Better to anticipate this from the start rather than discover you have a problem later.



Boring the recess in the body.

Setting up the four-jaw chuck with jaws reversed. Aluminium pads have been fitted to protect the finish on the work.

Drilling the hole in the turret before boring.

The turret has two main parts; the body, which is fixed, and the turret, which indexes into six fixed positions with the aid of a spring-loaded detent. A locking handle is provided to prevent the turret from rotating during each machining operation. The locking handle is a particular feature of my design and does not appear to be common to the majority of other turrets I have seen, where the rotating turret is held in place solely by the detent. In use, I have found the lock to be necessary as the detent alone does not have the rigidity required to resist machining forces and also suffers from a small amount of play. The lock increases rigidity and is essential where lathe-type tools are being used, which would apply a significant sideways force to the turret. It is surprising how much flex there can be during some machining operations. The turret needs a lock! The turret has six holes bored into it, into which the required tools are fitted by means of an adaptor.

The various parts are shown in **photo 3**.

Materials

To ease construction and reduce costs, the tool is made entirely from bar stock and stock screws and a spring with no castings required. The body is cast iron (but is not a casting, as such!) and the turret is free-machining steel such as EN1a. The remaining parts are from steel bar stock with the exception of some of the detent parts which are best made from brass. A ready-made MT2 blank end arbour is recommended, but you can make this from steel bar stock yourself if you are confident in turning tapers accurately.

Construction Notes

Body

This part, **fig 2,** is turned from cast iron. A lathe tool with little or no top rake is best suited to turning iron and a better finish will be obtained if the tool's nose is rounded slightly. A reasonably slow lathe speed of around 120rpm will be about right for this part.

Start with a slice of cast iron round bar slightly larger than the finished size of the part. Hold in a three- or four-jaw chuck and face one side. Turn the blank around in the chuck, ensuring it is seated properly against the flat faces of the chuck jaws, and take a light facing cut. Measure the thickness of the blank and take one or more further cuts across the face to a depth, in total, equal to the difference between the current thickness and the required final thickness. The best way to do this is to lock the carriage and take the final finishing cuts using the topslide, first setting it parallel to the lathe's X axis. Use the topslide handwheel dial to set the correct depth of cut. This will bring the body to the required thickness.

Without removing the body from the chuck, put a centre drill in the tailstock chuck and centre drill the blank. Then drill the central hole in the body to the correct tapping size. Finally, tap the hole using a tailstock tap holder.

At the same setting, bore the recess in the body using a short boring bar, photo 4.

Finish-turning operations on the turret.

The diameter is not critical as the spigot on the turret will later be turned to fit, but it is important to get a good finish on the sides of the bore. Lightly chamfer the corner with a suitable lathe tool or take the edge off with a file. The body can now be removed from the chuck.

To complete the turning operations on the body, make a stub mandrel in the lathe with a thread to match that just made on the body. The three-jaw chuck can be used to hold the stub mandrel. Because of the large diameter of the body, the diameter of the stub mandrel should also be reasonably large otherwise it is likely to slip in the chuck due to the cutting forces and concentricity will immediately be lost. Without removing the stub mandrel from the chuck, screw the body onto it hand tight. Using a fairly slow lathe speed, turn the edge of the base to the required diameter. The outer diameter is not critical, but aim for a good finish. The corner on the side facing the turret should be left sharp, or at most very lightly chamfered, as this will help to avoid the ingress of dirt between the turret and the base. The opposite corner can be more heavily chamfered to suit your taste.

Mark out the positions of the two holes for the bolts that secure the base to the arbour. Drill to clearance size and countersink generously on the same side as the recess, but avoid damaging the sides of the recess.

Finally, mark out, drill and ream the hole for the detent. The plunger, which forms part of the detent, will fit directly into this reamed hole, so accuracy is important to minimise play in the mechanism. The tapped holes for the screws which attach the detent housing to the body can be drilled and tapped now if their positions are marked out very carefully, but it may be better to wait until the detent housing has been made so that the positions of these holes can be spotted through from the detent housing.

Turret – Turning Operations

The part is shown in **fig 3**. Start with a slice of free-machining steel slightly larger all over than the finished dimensions of the part.

Mount the blank in the lathe chuck. Depending on the size of your chucks, it may be possible to use a three-jaw chuck with reverse jaws at this point, but since a four-jaw independent chuck will be used later anyway, you may as well fit the four-jaw now.

Assuming you are using the four-jaw, reverse the jaws, **photo 5**, and centre the blank by eye. It is not necessary for it to be accurately centred at this point, but it should be at least approximately right as it is a large chunk of metal and needs to be balanced.

Face the blank and rough out the spigot and the outer diameter as far as you can without crashing the lathe tool into the chuck jaws. Centre drill then drill through the bore slightly undersize, **photo 6**. Then, use a boring bar to finish the bore to a size sufficient to give good clearance over the axle that supports the locking lever. Clearance is needed as the turret is centred by the spigot, not the axle. The hole is bored rather than drilled so that it is square with the face and concentric with the spigot, allowing it subsequently to be used for clocking the turret central in the four-jaw when machining the outer face. Drilling would be insufficiently accurate in this regard although the finished size of the hole is not important.

Without disturbing the part in the chuck, finish-turn the faces and spigot to final size aiming for the best possible surface finish. The spigot should be a close, shake-free but running fit in the recess in the body. A good fit is important as a loose fit will affect the repeatability of tool positioning. The specified dimensions ensure that the larger diameter face on the back of the turret bears directly against the face of the body. There should be clearance between the smaller diameter face and the bottom of the recess in the body.

Finish turn the outer diameter to size (the dimension is not critical) and chamfer the corners using a 45° cutting tool, **photo 7**. To machine the outer diameter, you will need a left-hand knife tool, or similar, mounted parallel to the lathe spindle axis. The tool will need to fit between the small gap between the chuck jaws and the workpiece. Be very careful to avoid running the cutting tool into the chuck jaws.

The reason for using free-machining steel for the turret is that it is easy to achieve a very good surface finish using the lathe cutting tools and it is suitable for components such as this where no specific mechanical properties are required of the steel.

Now reverse the turret in the chuck, using packing strips to protect the finish-


The turret reversed in the chuck ready for machining the remaining surfaces.

machined diameter. Small U-shaped clips bent from aluminium sheet can be fitted to the chuck jaws to make good protective packing. Using a dial test indicator with the probe in the bore of the turret, centre the turret in the chuck, ensuring that the face is bearing snugly on the chuck jaw surfaces. It has to be said that accurate concentricity of the outer surfaces with those already machined is not absolutely critical, but it will enhance the sense of satisfaction from a job well done. Make sure that the chuck jaws are firmly tightened, **photo 8**.

Rough out the profile of the outer face, setting over the top slide to achieve the 45° angles, then finish turn, ensuring the correct thickness is achieved. Again, the dimensions are not critical, but try to get them close. Remove sharp edges with a fine file. Filing the edges of a rotating part in the lathe is, I suspect, not considered good practice, although I equally suspect that it is common practice. If you do this, please consider the hazards arising from the proximity of the chuck jaws and so on and take due safety precautions.

This completes the turning operations on the turret, which can be set aside whilst work on the taper and angle piece is completed, **photo 9**.

Turning operations on the turret completed.

Taper

See **fig 4**. Take a stock MT2 blank end arbour, one with a female screw thread at the smaller end rather than a tang, and mount it in the lathe's spindle bore using a suitable draw bar, cleaning both the bore and the taper first. Do not be too gorilla-like when tightening the draw bar otherwise excessive force will be required to remove the arbour, risking damage to the lathe. Use an alternative size of taper to suit your lathe's tailstock as required, checking compatibility with the design dimensions first. You can make your own arbour, but the commercial items are so cheap and accurate that it is hardly worth it other than as a machining challenge and for personal satisfaction.

Turn the spigot at the outer end of the arbour to the correct outer diameter to allow the screw thread to be cut. Just under 10mm diameter is ideal for the M10 thread specified, but adjust if you want to use an alternative thread. Recess the base of the spigot to give an area for the thread to run out and face the shoulder. This shoulder should bear snugly against the angle piece when the two parts are assembled later; the recess allows this to happen. Chamfer both ends of the threaded portion generously, then cut the thread using a tailstock die holder. This completes the taper.

Angle Piece

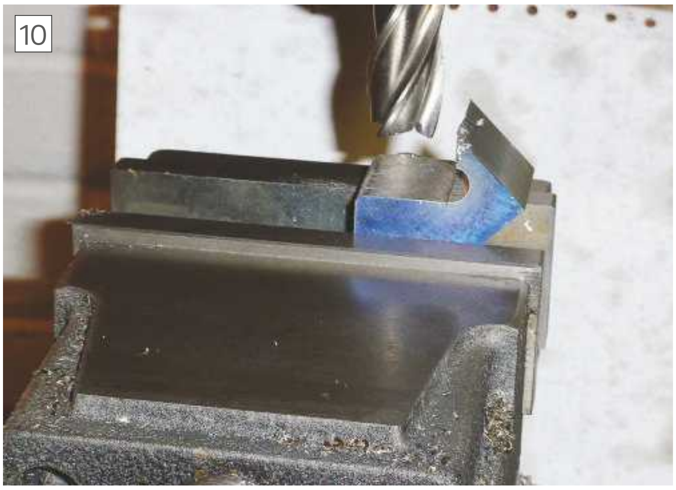
This part, **fig 5**, joins the taper to the body. Start with a suitable length of square section steel, slightly oversize all over. Mill the blank to size on all faces or, alternatively, turn it to size using facing cuts in the lathe, holding the part in a four-jaw chuck.

Mark out the outline of the profiled edge, carefully centre-punching the position of two holes which will form the radiused internal corners. Holding the part in a vice in the mill or drilling machine, drill these two holes to size. Return the part to the milling machine and hold it in a machine vice. Set it at 45° then mill the first angled face up to the marked out line. Repeat for the second angled face, **photo 10**. Finally, machine away the two 'ears'. Be careful to mill just up to the surface of the drilled hole and no further. In fact, being slightly undersize is better as it will show up much less than cutting too deep, **photo 11**.

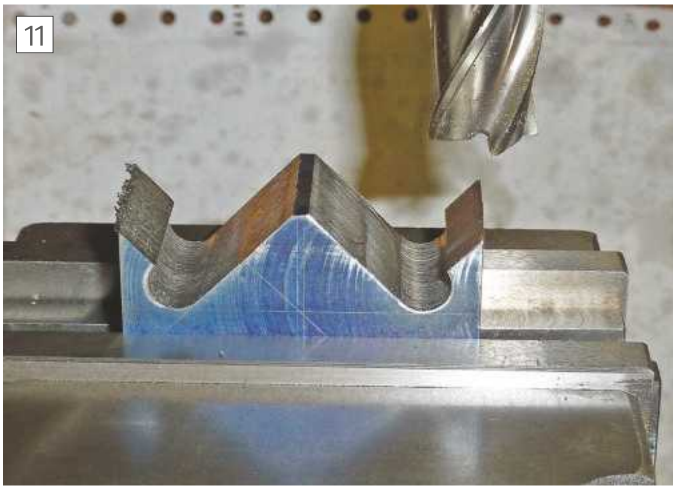
Lightly chamfer all edges with a file to finish, photo 12. You may also wish to put more effort into removing the machining marks than I did, depending on whether you are aiming for an exhibition quality piece. I must admit that my home-made machine accessories tend to be a means to an end so I probably don't put as much effort into cosmetic aspects as I should.

Mark out the position of the M10 hole into which the taper will screw and hold the part accurately at 45° in the drill vice. Drill the hole to tapping size and tap the hole, starting the tap perpendicular to the angled face by holding it in the drill chuck held in the drilling machine and rotating the drill spindle by hand, isolating the machine from the mains first and not under power under any circumstances. Finish tapping the hole by hand using a tap wrench.

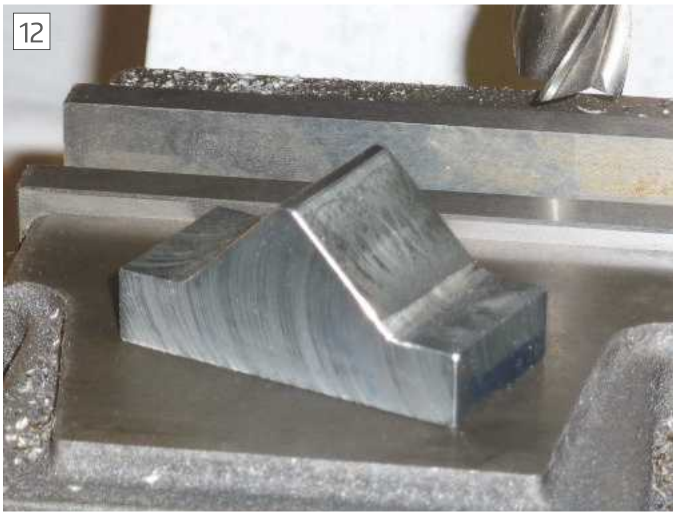
Mark out, drill and tap the two bolt holes using a similar process, working carefully to ensure accurate alignment with the corresponding holes in the base. This completes the angle piece.



Milling operations on the angle piece.



Machining away the waste material on the angle piece.



The basic shape of the angle piece complete.

The detent fitted to the body

Detent

To make the detent body, place a piece of brass round bar in the three-jaw chuck and turn the flange and outside diameter using a right-hand lathe tool, with the flange on the left hand end of the work. Drill through to the smaller diameter. Knock back the sharp edges with a fine file and then part off to length. Reverse the part and chuck lightly, to avoid damaging the finished surface, ideally now holding it in a collet. Drill the bore to the larger diameter, but don't drill right through; leave a lip on the outer end of the part for the spring to bear against. Ideally, finish this hole to depth with a D bit or a slot drill to give a square end to the hole. Carefully mark out and then drill the two bolt holes, holding the part vertically in a suitable vice, ideally one with a vertical V-shaped groove in the fixed jaw. Make them slightly oversize if you are not confident that the holes will align with those already made in the body. The detent will be secured to the body using two M3 cap screws. **Photo 13** shows the detent fitted to the body.

The detent plunger is made from ground silver steel which should be a close sliding fit in the reamed holes in the body and the plunger body. Place a length of silver steel bar in a collet chuck in the lathe if you have one, or the three-jaw, and turn the taper on the end. Kill the sharp edges with a file and then part off to length. Reverse the plunger in the chuck and drill and tap the end, adding a light chamfer to the outer end.

The rod is made from a short length of round bar. Place it in the chuck and cut the thread at both ends using a tailstock die holder.

Finally, make the knob from brass. Chuck a suitable piece of brass bar in the three-jaw, face the end and turn to size. Partially part off (i.e. turn a groove) and knurl the knob, then chamfer both ends. Drill a blind hole and tap the thread from the tailstock, then part off fully.

The rod can be permanently secured into the knob using thread lock or left removable, with the addition of screw threads, as you prefer.

The detent components

To complete the detent, find a suitable spring approximately as specified in the drawing. The detent components are shown in **photo 14** and **fig 6**.

Locking Handle Axle

This is a simple turning and threading job, fig 7. Place a length of steel bar in the three-jaw chuck. Face the end and turn the reduced diameter for the threaded portion at one end. Recess the root of the threaded portion with a parting tool, ideally one with slightly rounded corners, to allow the thread to run out. Chamfer each end of the threaded portion generously. Cut the thread using a tailstock die holder. Turn the outside diameter of the plain portion to size, noting that this should give a clearance fit in the bore of the turret. Chamfer the corner very slightly, just enough to kill the sharp edge. Part off to length, not forgetting that there will be a thread machined on the other end.

Reverse the part in the chuck, or ideally hold in a collet to protect the finished surface, and make the thread on the opposite end as before.

Note that the length of the plain portion should be such that the outer shoulder sits slightly below the face of the turret on assembly. If it is too long, the locking handle will not bear on the turret face and so will not lock the turret.

Locking Handle

This consists of three parts, the body and the lever arm, which can be assembled permanently with Loctite or similar on completion, and a thick washer. The body and lever arm can be made to screw together, but this would seem to offer more work for little practical benefit. The completed locking handle is shown in **photo 15** and **fig 8**.

Start with the body. Chuck a suitable length of steel bar and face the end. Finish turn the outside diameter for a length just greater than the length of the body. Set the top slide to the required angle and cut the tapered portion. Chamfer the outer end and part off slightly over length.

Reverse the part in the chuck protecting the finished surface by wrapping in thin card or similar. Face the end, bringing the part to the required length (it is not critical) and chamfer the corner lightly. Drill a blind hole in the end and tap the thread from the tailstock.

Next, remove the part from the chuck and drill the hole for the lever arm. The set up for this operation is not entirely

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15

The locking handle

16

Drilling the tool station holes from the headstock.

straightforward as the hole is drilled at an angle to the axis of the part, but square to the surface of the taper, and in line with the centre-line of the part. The quickest way is to grip it in the milling machine vice, setting the angle by eye, but this is a little crass and risks damaging the finished surface.

There are many better ways. If you have an angle vice, hold the part by its ends and set the vice to the angle necessary to bring the top surface of the taper horizontal. Then centre the mill or drill spindle over the part and drill the blind hole in increments to final size, noting that a free sliding fit on the lever arm will be necessary if it is to be assembled with Loctite.

If your mill's head can be angled, then you can hold the part by its ends in a normal vice, with its jaws parallel to the mill's Y axis and setting the mill head to the required angle. A little ingenuity will no doubt result in a suitable approach for your equipment.

The lever arm is a simple turning job that requires no further description. Just make sure the smaller diameter is a good fit in the body so that the Loctite works efficiently.

To assemble, lightly coat the inner end of the locking arm with a retaining grade of Loctite and twist into the body. Leave to set and then wipe away any excess Loctite around the join.

To make the washer, face the end of a suitable piece of steel bar and turn to the required diameter. Chamfer, drill through and part off.

Turret – Drilling Operations

We now return to the turret to drill the various holes for the tool stations and detent.

Start by drilling the six equally-spaced holes for the detent in the turret. These need to be aligned precisely with the detent hole already drilled in the body, although the exact angular spacing between the six holes is not so important. There is no particular reason, other than aesthetics, for them to be equally spaced or indeed for there to be exactly six holes. Dividing equipment is not necessary for this operation. There is probably space to fit one or two more tool stations in if you so desire, although it will be a rare operation that requires more than six.

Mark six equally spaced lines around the circumference of the turret with a fine permanent marker or similar. This can be done by measuring the diameter of the turret with vernier callipers and then calculating the circumference using the formula:

Circumference = 2 x π x radius
where
π = 3.142
radius = diameter divided by two

Cut a strip of paper exactly equal in length to the circumference and mark six equally spaced lines along its length. Wrap the paper around the edge of the turret and transfer the positions of the lines onto the turret using a fine permanent marker. Do not scribe the marks as they will be permanent, unlike the 'permanent' marker lines, which can later be removed with solvent.

Using the same pen, mark a single line on the body, so that it can be lined up with the marks on the turret. The positions of the marks relative to the tool stations or any particular point on the body is immaterial as will be evident from the following.

Fit the turret to the body and align one of the marks on the turret with the mark on the body. Maintaining the alignment, clamp the two parts, body uppermost, onto the mill table. Fit a new and good quality 8mm drill into the drill chuck and manoeuvre the mill table until the drill will smoothly enter the reamed detent hole in the body without binding. Lock the mill table slides in this position. Using a slow drill speed, spot through the detent hole into the turret, drilling just deeply enough into the turret to mark the position. Remove the 8mm drill and replace with a 6mm drill. Drill into the body to depth and gradually open out the hole with progressively larger drill bits, e.g. 7mm, 7.5mm 7.9mm and finally, 8mm again, using plenty of cutting fluid. This should produce a sufficiently accurate hole without damaging the reamed hole in the body. Drilling straight through with the 8mm drill first time is likely to give an oversize hole and damage the reamed hole. Loosen

17

Drilling the holes for the tool station locking screws.

the machine clamps and rotate the turret relative to the body to bring the second position into alignment. Tighten the clamps again and spot through and drill the hole as before. Repeat for the remaining four holes, being careful not to allow swarf to get caught between the body and the turret. Unfortunately I failed to take any photos of this operation so I hope my description is sufficient.

Clean off the turret and body and reassemble, fitting the detent to the body. All being well, the detent should smoothly enter all of the holes in the turret without binding.

Next, after checking the tailstock is aligned with the headstock, fit the taper to the body via the angle piece and put the assembly into the lathe tailstock, ready to drill the tool station holes, **photo 16**. It is not shown in the photo, but it would be much better to use the locking handle rather than the engineer's clamp shown. I had not made mine by this stage. It should be noted that there is no facility, or need, to align the tailstock turret with any particular angular position on the tailstock. It should be angled to be roughly upright for the sake of convenience, but actually, the angle has no bearing at all on the position of the active tool (i.e. the one of six tools on the turret brought into use) since it remains coincident with the lathe's spindle axis. The ability to rotate the tailstock turret in the tailstock can sometimes be useful to avoid clearance problems in a particular set up.

However, it is vital that the tailstock spindle is accurately aligned with the headstock spindle as any offset will be irreversibly reproduced in the position of the toolstations. This should be checked and adjusted as necessary by running a dial test indicator along a lathe test bar held between centres. The lathe also needs to be level, that is, the bed not twisted along its length.

Next, drill and bore the six tool station holes in the turret. To prepare to drill the first one, make sure the tailstock turret is securely pushed into the taper bore of the tailstock, engage the plunger in any of the six detent holes and take up any slack by gently rotating the turret against the detent, always in the same direction (and subsequently when you use the turret). Tighten the locking handle to securely clamp the turret to the body and prevent the detent from bearing the cutting forces, which will be considerable.

Fit a centre drill to an accurate three jaw chuck or a drill chuck, or, better still, a collet chuck, attached to the lathe's spindle. Slide the tailstock into position and lock securely to the lathe bed. Centre drill the position of the first tool station deeply, feeding the work using the tailstock handwheel. Using progressively larger drills, drill the hole until it is just smaller than the required diameter, by about 0.2mm but with the parallel sides of the hole to the required depth. Do not drill so deeply that you break through the rear face of the turret.

18

Tapping the holes for the tool station locking screws. The drill spindle is rotated by hand having isolated the machine from the mains.

By indexing and re-locking the turret, complete all the holes to this stage, leaving them undersize in preparation for the finishing cuts.

Finish the holes to size using a slot drill, but don't try to square off the conical ends to the drilled holes as this will put excessive cutting forces on the slot drill and result in an oversize or non-circular hole. When I made the prototype, I used a boring head for this operation, but the asymmetric cutting forces caused considerable flex due to the large overhang of the turret and it was not entirely satisfactory. I therefore recommend the slot drill approach.

The final job on the turret is to drill and tap the six holes for the tool holder locking screws. This job was completed on the prototype using a lathe with an integral milling head, **photo 17**. Without this facility, the set up on the mill or drill table will be somewhat more challenging. I suggest gripping the turret by the angle piece in a machine vice, setting the angle carefully and using a machine jack or other packing to support the overhang. However, this may not give clearance for the detent, in which case try clamping the part to an angle plate instead, again holding it by the angle piece and supporting the overhang.

Whatever set up is used, a centre drill is first fitted to the drill chuck and the drill spindle positioned for the first hole. Centre drill, drill to tapping size, then tap. It is best to start the tap using the drill spindle, **photo 19**, rotated by hand, then to finish by hand with a tap wrench. It will be necessary to de-burr where the tapped hole breaks through into the tool holder hole. Repeat for the remaining five holes, indexing using the detent. It will not be possible to use the locking handle for this operation as it will foul the drill chuck, so one or more engineers' clamps should be used instead when drilling the holes, as shown in photo 17.

Tool Holders

A large number of individual tool holders will be required to cater for every eventuality as they are specific to the tool in question. Centre drills, drills and taps will most commonly be used, along with other more specialist tools discussed below, **photo 19** and **fig 9**.

I need not describe making the tool holders in detail as the machining is straightforward. Just be sure that the bore is concentric with the outer diameter.

It is worth making a large batch of tool holders (twenty or more) as they are easy to make and it is worth having a good supply of spares with undrilled bores ready for future jobs. The tool holders themselves are a simple turning job and can be sized to take tools up to about 10mm in diameter, **photo 20**.

The tool holders consist of a 12mm diameter portion, which must be a shake-free fit in the matching holes in the turret, and a larger-diameter collar which provides sufficient material to take a grub screw to secure the tool in the holder. The collar is not necessary for small tools. A hole is drilled and reamed or bored through the centre. For short tools, this hole need not be full depth, but for larger tools, it can go right through. A radial tapped hole is provided in the collar for the grub screw. A flat is milled on the 12mm section, in line with the grub screw in the turret, in order to secure the tool holder to the turret whilst preventing rotation under cutting forces.

Finally, it is necessary to grind a small flat on the shanks of the drills and taps used, lined up with the position of the grub screw in the collar.

To give you an idea of the number of tool holders you will need, the following is suggested as a check list:

- Centre drills of all sizes used.
- Tap of all sizes used.

A selection of tool holders with tools fitted

Spare tool holders

- Tapping drills to match all taps used.
- Drills.

I commonly use taps of 3, 4, 5 and 6mm, so this required eight tool holders plus two for corresponding centre drills as a starting point, with a similar number for the drills.

As well as lots of tool holders, a couple of small drill chucks fitted with a 12mm diameter shank will be useful for emergencies, but the greater overhang is likely to cause problems with accuracy and will certainly foul other parts of the lathe, so I would not use this approach as a matter of course.

Die Holder and Other Tools

Although drills and taps will most commonly be used in the turret, other tools may sometimes be needed. One such tool is the tailstock die holder, **photo 21** and **fig 10**, although admittedly, there are few occasions when one would be needed in conjunction with drills and taps. A likely scenario is centre drill, dead centre and die holder, when working on batches of slender, threaded components. The need for other tools is less frequent and the design and construction of such is left to your ingenuity.

Construction of the die holder will be straightforward if you have progressed this far. Individual die holders will be needed for different sizes of die, although all dies in a set typically have the same outer diameter and thickness. The outer diameters are not critical but the bore must be machined to a good sliding fit on the bar which supports it. The suggested sequence of operations is as follows:

Place a piece of suitable bar stock in the three-jaw chuck with sufficient length protruding to make the sliding part. Face the end, then machine the outer diameters and part off. The shoulder should be to the left at this point. Reverse the part in the chuck, wrapping it in thin card or similar to protect the machined surface. The shoulder just machined should butt up against the face of the chuck jaws for security. Face the end then centre drill and drill right through slightly smaller than the finished bore. Bore the end to a diameter and depth to accommodate the die to be used. The die should be an easy but not loose fit so that it is held concentric with the die holder.

Without removing the part from the chuck, the smaller diameter bore is now finished. Bore through until the hole is about 0.1mm smaller than finished size, then finish the hole with a reamer held in the tailstock, or bore to size if you can get a good finish from the boring tool.

Chamfer all corners lightly to complete the turning operations then drill and tap the holes for the tommy bar and grub screws. The tommy bar is simply a short length of steel bar stock that will fit in the holes just drilled. It has a suitable knob at its outer end for comfort.

The spigot, which is inserted into one of the holes in the turret and which supports the die holder, is a simple turning job, although the diameters need to be accurately made so that it fits without shake into the turret and die holder holes. A small flat is milled on its inner end as for the tool holders.

Using the Tailstock Turret

The tailstock turret comes into its own for batch production of parts that require a succession of tailstock-mounted tools to be presented to the work. It is considerably quicker to index the tailstock for each operation than to change the tooling in a single chuck, and causes less wear and tear to the chuck.

Many small components have various combinations of internal and external threads, stepped bores and so on, all of which require different cutting tools to machine them.

The die holder components

To use the tool for a specific batch of parts, first establish which cutting tools will be needed and prepare tool holders for these tools. Fit the tools to the turret in the order in which they will be used, so that the turret is indexed once for each operation. I find it preferable to rotate the turret anti-clockwise to present each tool in turn to the work as this seems more convenient and intuitive.

Where possible, you don't want to have to slide the tailstock along the bed when indexing between tools as this takes time and causes wear to the lathe, so the tailstock quill should be positioned so that it is almost fully withdrawn for the longest tool, allowing the shorter tools (e.g. centre drill) to reach the work by extending the quill. It is worth considering shortening the drill shanks to allow this.

For the machining operations, position and lock the tailstock. Rotate the turret to position the first tool, engage the detent, take up the play in the same direction used in the manufacture and tighten the locking handle. Apply the tool to the work using the tailstock handle. Repeat for subsequent operations. If depth of cut is important, use the graduated dial on the tailstock handle or some other means to measure this.

Conclusion

The tailstock turret is a satisfying and straightforward machining exercise that will give you a handsome and extremely useful lathe accessory. It does not take long to make and the time invested is likely to be paid back by greatly speeding up your work in future.

As mentioned at the start, the tailstock turret comes into its own when used with other simple lathe accessories in a production run. This will be the subject of a future article.

In the mean time, please feel free to forward any comments to me via my website, Ref. 1, or via the ME forum.

Reference

1. www.amdengineer.com

Readers' Tips

CHESTER MACHINE TOOLS

Tip-Top Tapping Tip!

TIP OF THE MONTH WINNER!

This month Stephen Bondfield claims his advice for more successful tapping is not always obvious, he wins this month's Chester Vouchers!

Try this if you are having problems tapping by hand with fine, small diameter taps that are either blunt or are making worrying noises and squeaks as resistance increases and they become tighter to the feel.

Take the workpiece with the tap already partly inserted into the object and mounted in the tap wrench, to a source of warm or hot running water. Apply washing up detergent in liquid form to the hole and tap in the workpiece and hold the object beneath the running hot water, at the same time as continuing with the action of tapping. Re apply washing up liquid when needed. You will find that the stream of water clears small particles of swarf from the hole and the tap within it and the washing up liquid (suds!) provides lubricity, thereby enhancing the ease of the action of tapping.

I found this method to be quite helpful when tapping stainless steels for any size of hole but particularly those which are less than 4mm diameter.

The photograph is of a stainless steel workpiece with three 2.5 mm tapped holes, held under the hot tap of the bathroom sink.

Digital Height Gauge

Runner up Stuart Cole converted a cheap caliper into a cost-effective height gauge. He wins a prize from the MEW lucky dip!

After reading the excellent article comparing Digital Calipers, I have found a good application for a "low cost" Caliper.

A few minutes with a Dremel soon removed the unwanted arms and suitably mounted square on an old stand, I now have a very usable Digital Height Gauge ideal for marking out etc. An off cut of Plate Glass (edges bevelled) has made a acceptable Surface Plate.

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.

One Man and his Lathe

Alan Jackson claims to have the oldest Colchester Chipmaster in captivity

It may be an extravagant claim, it is number 1006, the sixth Chipmaster, **photo 1**, made in 1956 according to the label on the tailstock end of the bed, **photo 2**. A few years after this was made I was a first-year apprentice draughtsman at the Marconi Wireless Telegraph Company in Chelmsford, Essex. For the first year, I went to Colchester technical college full time to be taught City and Guilds Machine shop engineering: doing a three year course in one year and ordinary national certificate. I did not then appreciate how lucky I was. We used to spend all Friday in the machine shop where, among the many machine tools were two brand new Chipmasters. There was a scramble amongst about ten students to get on them first. Then they were new, shiny, and ran like the smoothest machine in the shop.

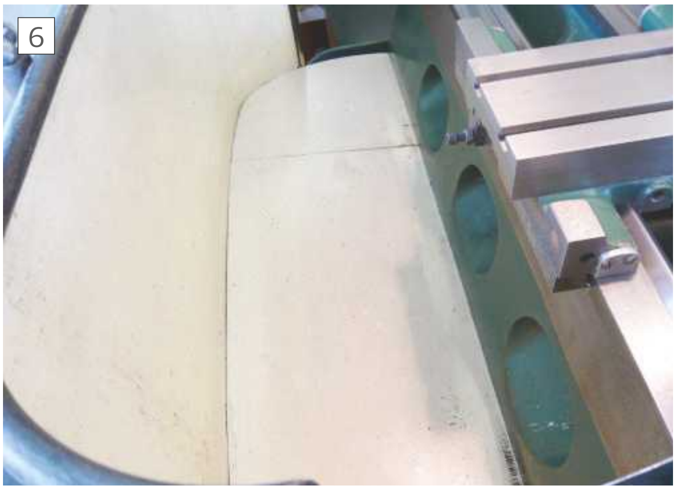
We even had a tour around the Colchester lathe factory in Colchester; I particularly remember the foundry, black sand everywhere and very hot. When I retired, I looked at a few Chipmasters, but the real problem was how to get it delivered. I found only one local company who could deal with a machine weighing about a ton. They gave me a price, which was more than I thought I was going to pay for a reasonable lathe, to collect and deliver such a machine. When I questioned the price, he said it was simply the cost for a driver and truck for a day's work. It did not matter at all to him what the machine would cost. He then said what machine did I want as he had a contract to clear some machines from Teddington University. When I said a Colchester Chipmaster; he thought they might have one of those so to call him back in a couple of weeks. So I called him and arranged to see it at his yard. It looked pretty shabby with only a three-jaw chuck. However, I agreed his asking price if he would deliver it about 5 miles away and (a big and) manhandle it to my shed which was over about 50 feet of uneven lawn. With a grimace, he agreed. Well four big chaps arrived in a Hiace truck and using their considerable strength manhandled it to the concrete surface of my shed. I thanked them and gave what I thought was a good tip for this. So there it was, shabby and to my dismay, when I checked it over with a test bar etc. with a fairly worn bed. I even made several graphs of the wear at one inch intervals along the bed in the vertical and horizontal using a clock gauge along a test bar. The rest of the machine was in relatively good order. I think it may have had a relatively light use,

1956 Name Plate

All cleaned up

Temporary cross slide stop

Cross slide screw and nut



Swarf Tray

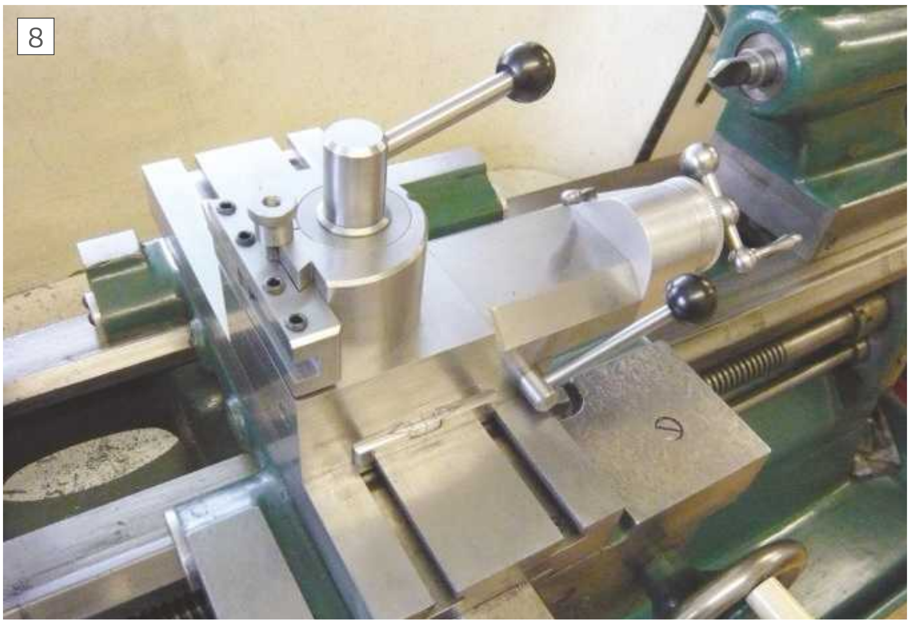
Grinding spacers fitted between jaws

doing simple repeated tasks with little use of the feed or screwcutting facilities etc. Well here it was and it was not easily going to go anywhere else worn bed or not. The wear on the inverted vee (about 0.005" max,) was mainly at the areas close to the chuck.

The tailstock sliding and guiding surfaces were in much better condition even untouched closer to the chuck end. So I hatched a plan to simply remove the areas, which were higher than the lowest point to make the saddle guide surfaces flat and straight again. I dismantled the tailstock and used the lower base as a guide to mount a clock gauge on. This slide base was moving on much less worn areas than the saddle moved on, so this was my "reference straight edge". Not perfect but after some correction, better than anything else I had. I sharpened up my scraper and got absolutely nowhere, just skidding across the "hardened surfaces". Not all early Chipmasters had hardened beds it was then a customer option with no indication if it was hardened or not. Now what? I made some home-made files by gluing cut up sections of a linishing belt to various pieces of wood. These were my files to finally make or completely destroy the lathe bed. It seemed terribly cruel to vandalise virtually unworn pristine surfaces with a sanding pad, but bit by bit the clock gauge was reading less and less. As I progressed I used finer grit grades. I settled for readings that while not to Schlesinger standards were pretty good even though I say it myself. I did not do anything with the leadscrew or feed shaft to suit this slightly lower saddle, it seemed quite good as it was.

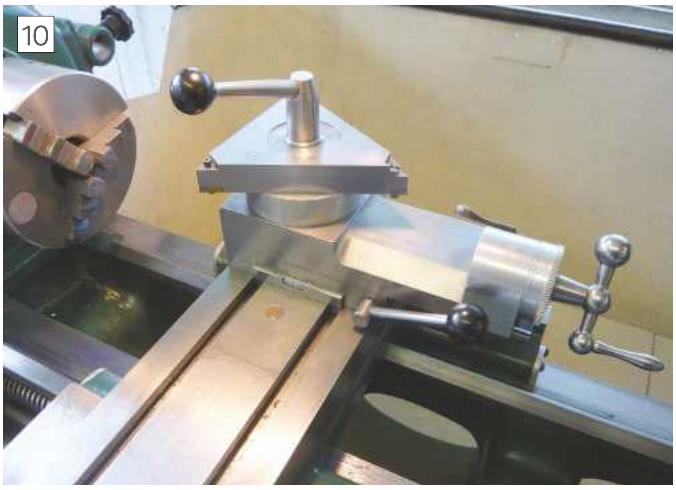
The tailstock also had what I think is normal wear at the front of the base plate. The barrel pointed downwards about 0.008". I shimmed it up to be parallel with the bed in the vertical plane. It was OK in the horizontal plane. The result was that the barrel axis was now about 0.006" too low. The barrel has a No 3 Morse taper, now nearly all my tailstock fittings from my previous lathe are No 2 Morse.

I made a No 3 Morse male sleeve with a



New Topslide

Locking Lever below dial



Inverted triangular toolholder

Polyvee belt conversion

Replaced toothed belt

No 2 Morse bore which is eccentric to the outer Morse taper by about 0.015". This was fitted and pulled into position by a long hollow screw in the barrel bore. Before it was pulled tightly into the barrel it was rotated to match the height of the mandrel. Horizontal adjustment was made in the normal manner using the set over adjustment on the tailstock base. The result is a preferred No 2 Morse and on centre and parallel in both axes. I also adapted the tailstock to take the capstan feed I had made for my previous Denham lathe. This now permits nearly five inches of travel.

A good clean up and paint, I matched the original dark green paint, and careful reassembly seemed to wash away those shabby years. The mandrel bearings seemed to be as good as new which was a relief; it would have been a big problem otherwise. I never intended to keep the massive 5hp motor or the variable speed control fitted as standard. These were replaced with a Telecamique inverter and a new 1.5hp three phase motor. I cut a hole in the lower stand where the original speed control was located to fit the inverter. The existing rear mounted switch box internals were modified so that it could switch the inverter for forward, off and reverse. A variable resistor is housed inside the on/off knob so that rotating the knob increases or decreases the speed. This made for a neat clean operation with the wiring inside the existing, hollow on/off/reverse lever, **photo 3**.

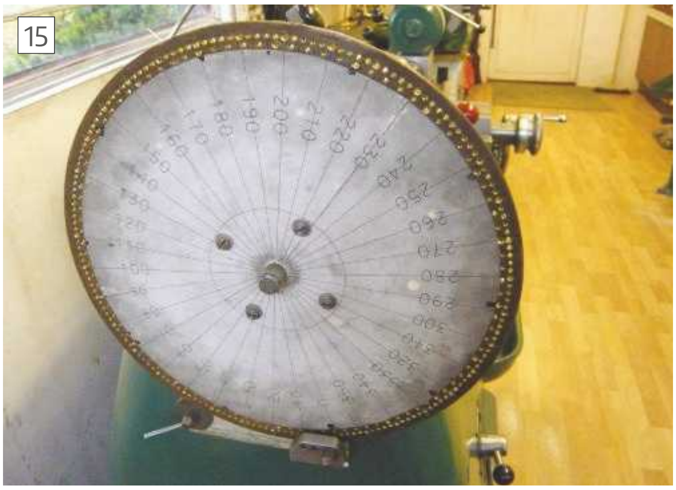
The cross slide was modified by adding tee slots for greater versatility and to mount my lever locking topslide in place of the original topslide. The advantage of this is that it can be moved and locked anywhere at any angle on the cross slide. The cross slide feedscrew was worn in the middle part. It is a two-start thread of 0.200" lead or 5 TPI twice. I set this up in the lathe, which now had no feed screw. I fixed a stop at the end of the cross slide, **photo 4**, and manually pushed the slide up to the stop on re-cutting the feedscrew and manually withdrew it to return the cutting tool to make another cut. With the lathe set at 5 TPI, I found that I could make one cut with the screwcutting dial at number one then a second cut at number three. This is when the screw cutting dial has rotated 180 degrees from number one. The purpose of this was to make the second cut along the other screw thread on a two-start thread. Using the topslide set parallel to the lathe axis to advance and retract the cut. I cut off just enough so that the worn part was the same as the rest of the screw. Albeit with a thinner thread part and a wider groove between the screw flanks. The reasonably worn nut was cut up as shown in **photo 5** to make it adjustable. I was most pleased with the result; it is about 2 to 3 thou backlash over the entire travel of the cross slide. The end result of my butchery to the lathe bed was that when I was making the vertical column for the Stepperhead lathe I was able to turn a 450mm long, 75mm dia Mild steel bar for the full length to within about 0.0005" and nobody was more pleased and relieved than me.

The standard splash guard on a Chipmaster is a deep affair reaching down nearly to the floor. This is where a suds pump is normally located but was missing in my case. This was not a problem for me, as brush application suffices. If you dropped a tool or part it became a real pain to retrieve it from deep down among the swarf. At the point where the lathe bed sits on its substantial base support is a gap about 5mm wide. I cut a sheet of 6mm plywood to fit the space between the bed and the splash guard with about 15mm angle aluminium fitted to the splash guard to support the other side using self tapping screws. The edge of the plywood was tapered to fit into the gap and rest on the angle support.

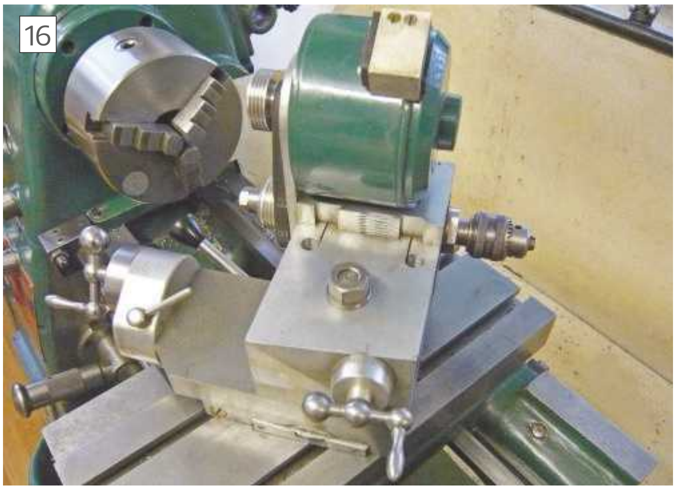
The result works very well as anything dropped down can be reached and swarf is easily accessed for cleaning, **photo 6**. I cleaned up the existing three jaw chuck and reground the jaws using a Dremel. Along time ago I cut a ring of steel into three equal

Close to the tailstock

Fourway, plus boring & parting tools



Mandrel dividing disc



Milling-Drilling head

parallel ended segments. These can be positioned between the chamfered faces of the jaws, tightening the jaws with these in place pushes the jaws in a similar manner to the normal operating mode and allows clear access for grinding the jaw contact faces, **photo 7**. EBay supplied a four-jaw chuck and a Jacobs Rubber flex chuck but I had to make the chuck holder to fit the lathe.

I have since made a new Lever Locking Topslide, **photo 8**, This features an oval gib of my own design. It enables the whole upper slide to be solidly locked to its base unit for the full slide length.

A locking lever is positioned just below the feed dial to do this, **photo 9**. It has a screwcutting withdrawal lever for external/internal screwcutting, the intermediate spindle runs on ball bearings and the feedscrew nut is machined, not moulded from acetal, and this can be adjusted for backlash on the feedscrew.

It has a choice of toolholders, the triangular one for tipped inserts can be inverted and then mounted on the far side of the item being turned like a rear parting tool, **photo 10**. This is very useful if there is a lot of metal to be removed on a long part, it avoids nearly all the swarf being thrown forwards and seems to assist in getting a good surface finish.

Being able to place the topslide on the far side of the piece being turned is also very useful for screwcutting up to a shoulder or a blind bore. The topslide is set at an angle to suit the thread, say 60 degrees to the lathe centreline. Then the cutting tool is positioned just slightly away from the shoulder with the saddle up against a bed stop. To cut a righthand thread the lathe is run in reverse and when the leadscrew is engaged the cutting tool will move away from the chuck to cut the screwthread. This enables the cut to be applied while the lathe is rotating to form a thread depth undercut and avoids scary moments trying to disengage the leadscrew before the tool hits a shoulder as in the normal method.

One main feature of a Chipmaster is the toothed belt drive to the mandrel. As good as it is, it still makes a whine due, I guess, to air being forced out of the tooth recesses during rotation. I worked out that I could just about fit a polyvee belt in place instead. Two aluminium sleeves grooved for a wide polyvee belt are pressed onto the existing toothed pulleys. I was going to Loctite them on but it was not necessary. I was lucky my calculations were good, as the belt tension is just right, lucky because there is no space for a jockey pulley anyway, **photo 11**. This new polyvee drive is great; the lathe is like a new machine, so much quieter than before. To be fair, polyvee belts did not exist in 1956 so the toothed belt was the latest technology then, **photo 12**.

To finally finish it off I made a set of bed wipers for the saddle. The holes were already drilled and tapped but the original ones were not fitted, I suppose this had to be specified when it was first ordered.

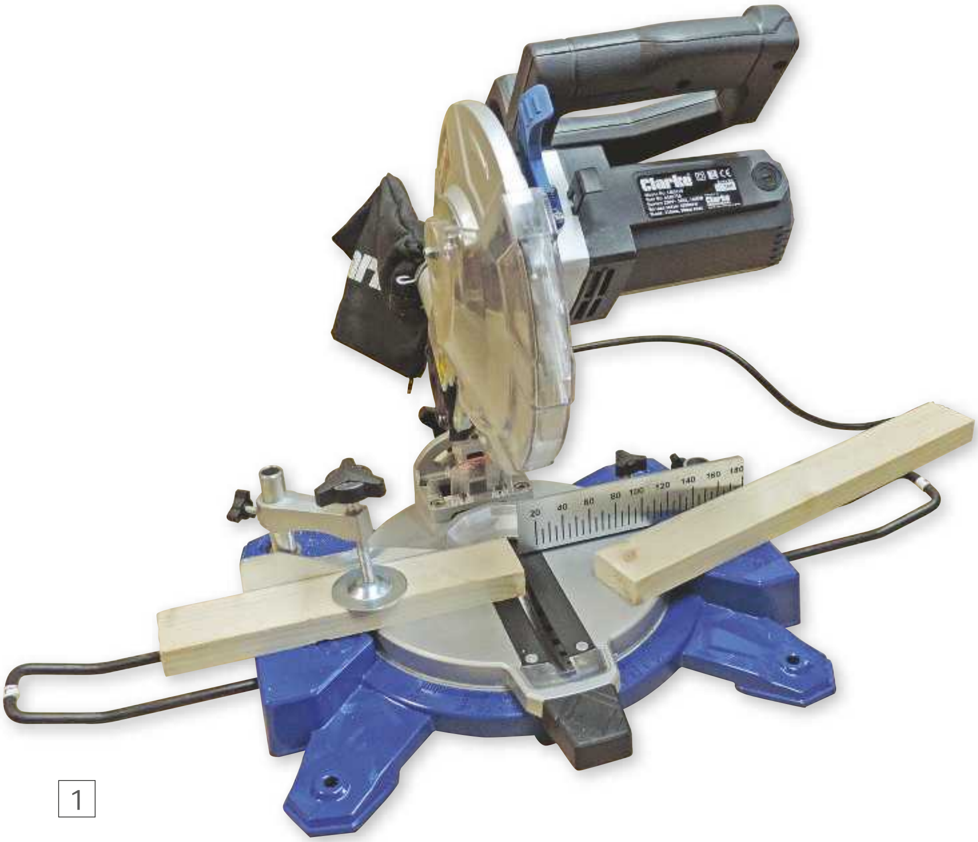
Another nice feature of a Chipmaster is the power feed disengagement up to a bed stop, very useful for boring etc. All in all, it is a great machine, **photos 13 & 14**, probably a bit under powered, should have got a 2 hp motor instead of 1.5 hp but it is not a problem for most of the things I do and back gear can always be engaged for large diameters etc.

Over time I have added many attachments, a topslide milling/drilling spindle, **photo 15**. A large brass disc scale from an old rusty meat scale has 200 and 180 holes around the periphery. This can be mounted on the outside end of the mandrel for indexing, photo 16. I have also made a rotary table that can be mounted on the cross slide in the vertical or horizontal. A Harrison vertical slide has also been adapted to fit the cross slide.

It is 60 years old now and is still going strong; it still runs as smoothly as the ones I used at college as an apprentice. It has weathered time very well, I only wish I could say the same thing about its owner! ■

On the Wire NEWS from the World of Hobby Engineering

Clarke CSM210 from Machine Mart



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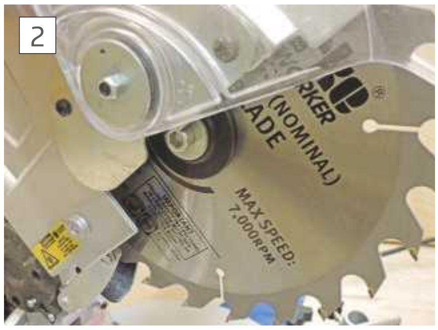

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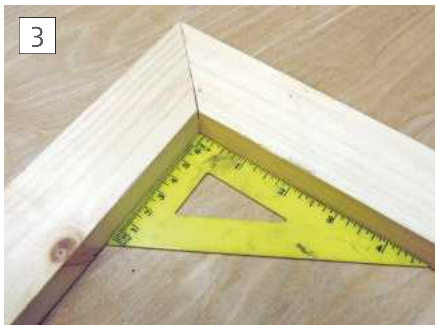

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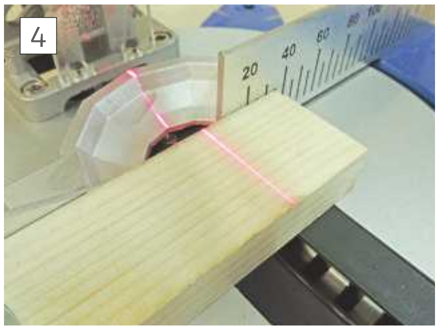

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Okay, this is a woodworking tool, so what is it doing in MEW? Well, aside from this being the April issue, a good mitre cross cut saw is really useful in any the workshop as they are ideal for fabricating wooden framing and structures, including benches, stands and shelving. Most of the benches in my workshop are built up on frames from CLS studding which is relatively well finished and free from significant knots – it's also inexpensive as it is used in huge quantities by the building trade. The Clarke CMS210, **photo 1**, is a 210mm (8") Mitre Saw able to cut up to 120 x 60mm in hard and soft woods so it is well suited to working studding and much bigger material.

The saw came fitted with a 24-tooth TCT tipped blade, **photo 2** which gave very clean, crisp cuts and I found it easy to use with both small and larger timber. The mitre guide can be adjusted although it was accurately set, **photo 3**. Although it was fairly loud in use, but it was not overly noisy and it was comfortable and easy to use. I was impressed by several features of the saw, as well as the expected safety interlocks, it has an integral dust bag which collects nearly all the sawdust without the need connect the workshop vacuum. There is also a built-in laser (battery powered on a separate switch), the beam, **photo 4**, is narrower than the blade and was well aligned with the left had side of the cut.

Whilst it doesn't have the capacity of larger blade sliding head mitre saws, the CMS210 is a great solution for anyone who struggles to cut accurate square ends and mitres by hand and wants something to speed up DIY and workshop jobs. It is available from Machine Mart for £71.98 including VAT both in store and from www.machinemart.co.uk.

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

Mike's Workshop

Cutting angles on a bandsaw Michael Cox

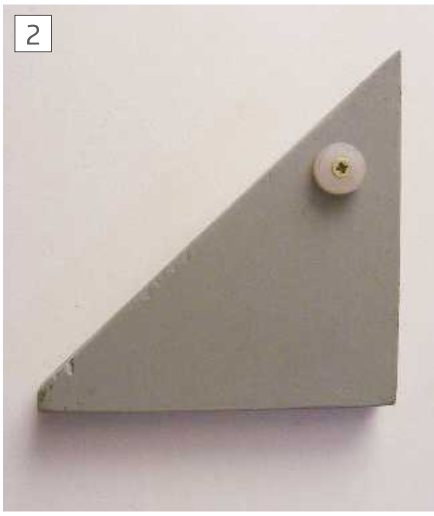
Making frames for small machines often involves cutting angles in solid bar, box section or angle. The most common angles required are 90 and 45 degrees. I cut most metal using the popular 6 x 4 bandsaw but it is frustrating to keep having to adjust the angle of the vice jaw for 45 degrees and then back to 90 degrees. I also dislike having to disturb the fixed jaw, because I like to keep it accurately at right angle to the saw blade.

To get around this problem a wooden block cut at a 45-degree angle was made, **photo 1**. This just slips into the vice and automatically sets the 45-degree angle, taking advantage of the swivelling abilities of the moving jaw. To stop the block slipping as the vice is tightened, a small disc is attached to the back of the block, **photo 2**. This fits into the slot that the moving jaw slides in, **photo 3**.

Using this system means that changing from 90 to 45 degrees and vice versa takes but a few seconds and the accurate right angle position of the fixed jaw is retained.

The same system can be used for other regularly used angles. I have another block cut for a 30-degree angle.

The 45-degree angle block

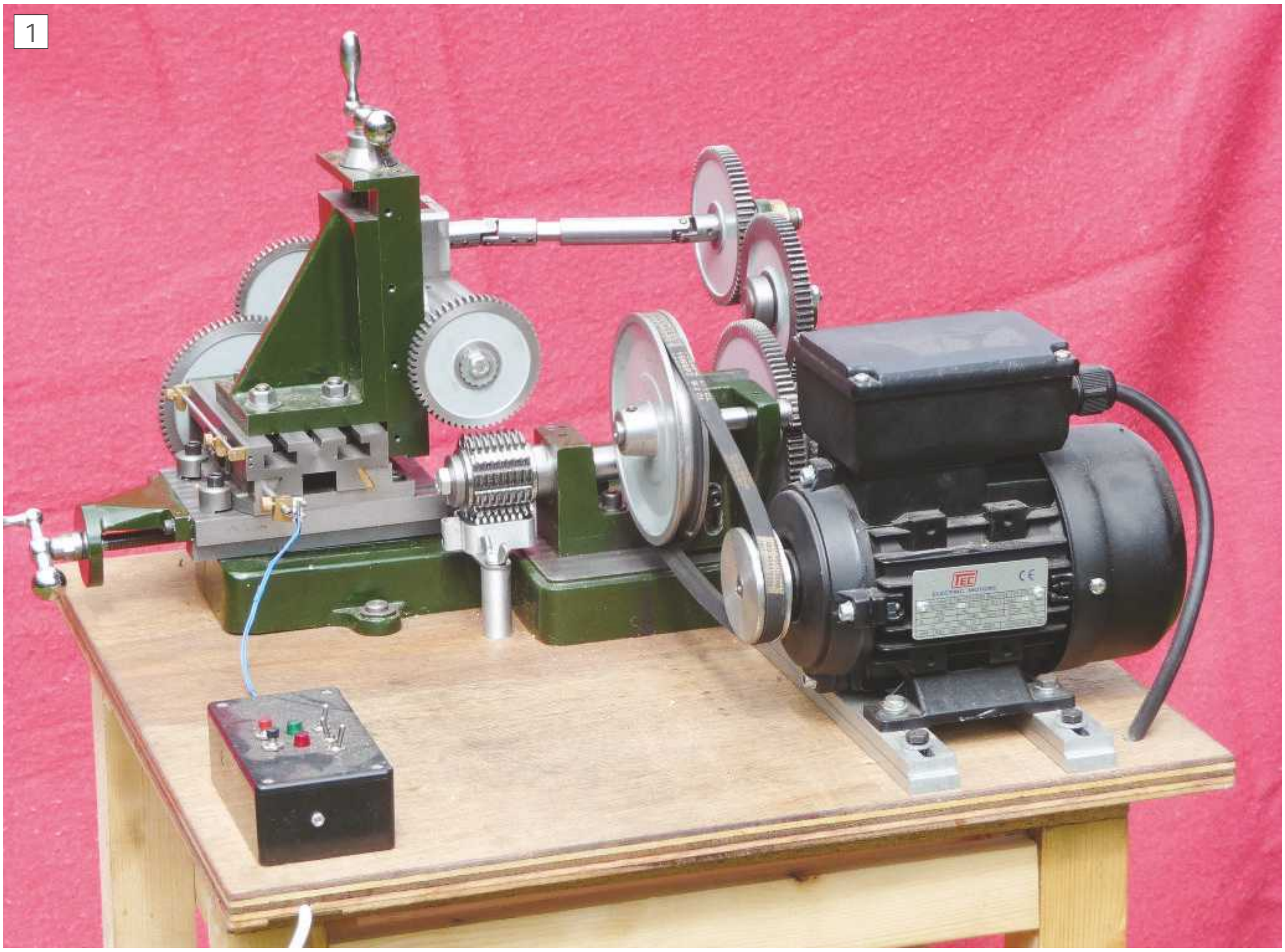


The anti-slip disc on the back of the block

How the anti-slip disc lines up with the slot.

Extending the capabilities of the Jacobs Gear Hobber.

Differential indexing, worm gears and more. By Chris Robinson



The Jacobs hobber in standard form set up cut a spur gear

Introduction

The Jacobs Gear Hobbing Machine has been around for at least 40 years and is still available as a set of castings and drawings from College Engineering Supply1 as a home workshop project. Designed originally by Tom Jacobs and featuring in a series of Model Engineer articles in 1976, it was intended more to demonstrate the process and principles of gear hobbing than as a production machine. I built my mine in 2009 and with the plans available the machine is intended to make spur gears only. **Photograph 1** (Yes, the universal joints on the cardan shaft are incorrectly aligned. I was careless in the assembly for the photo.) shows it set up in its standard form to hob a spur gear. However, I was fascinated with the idea of making helical gears as well as spur gears.

While I could see how to modify the machine to make helical gears, I found it difficult to find definitive information on how the index ratio is subtly altered due to the component of feed at 90 degrees to the motion of the hob teeth. I finally found what I was looking for in a manual for a Barber Colman industrial hobbing machine and developed an Excel spreadsheet to determine compatible index and feed gear

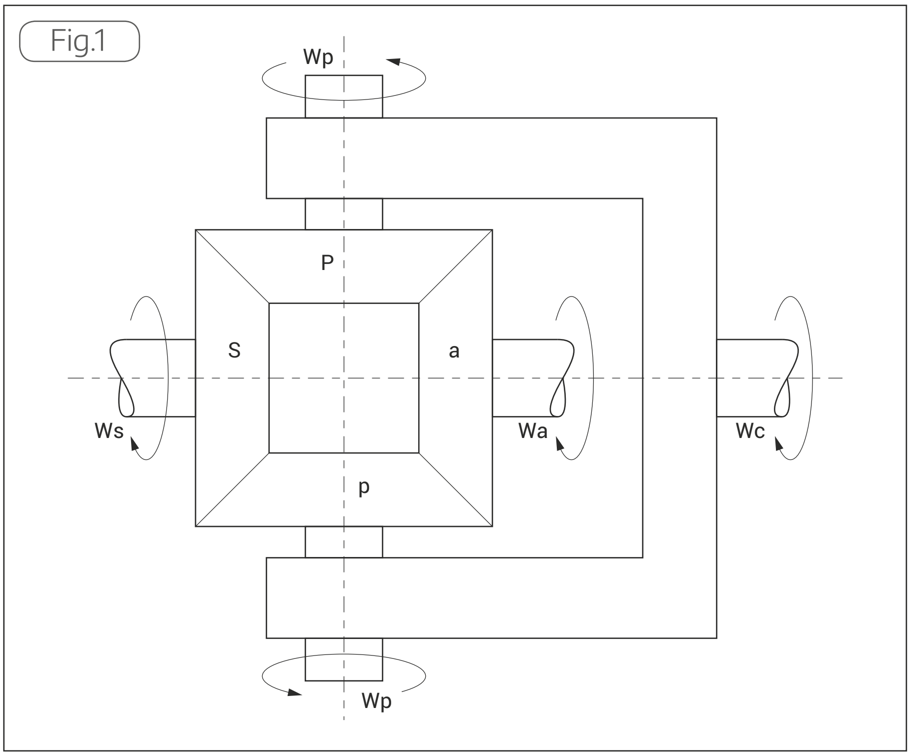


Fig.1

trains using the mathematical device of continuous fractions. As a result, I was able to successfully make a number of helical gears with helix angles up to 45 degrees. This is described in a Model Engineers' Workshop article published in 2010-11[2]. Index correction was achieved by using a second set of 4 gears in the index train making, with the 4-gear feed train and the two-gear drive train, a total of 14 gears. Not the most elegant solution and requiring many gears, but effective.

Having done that I thought about what else this little machine could do. After seeing photographs of a Jacobs hobber fitted with a differential in the index train at the Harrogate show, I could find no information on how it was connected or what it was for. After much head scratching I discovered that it could deliver index ratios to make gears whose tooth counts are prime numbers without already having the prime number gears in the first place, and it works fine. Other modifications enabled the making of worm wheels with hobs using automated plunge feed, the making of worm wheels using ACME taps as hobs using automated tangential feed and the making helical gears with high helix angles in the range 60° to approaching 90°. This article describes the modifications and the processes to achieve these capabilities

Having learned that industrial hobbing machines only use a four-gear index cluster, I realised that I should be able determine the necessary gears using the same technique, continuous fractions. The Excel spreadsheet was accordingly rewritten to do this and details are described at the end of this article.

A differential for the index gear train

As mentioned above, in order to hob a gear having a prime number of teeth, it would normally be necessary to already posses a gear having that number of teeth (or a multiple of it). There is an alternative, that of a differential gear which will allow the cutting of not only prime number gears but other numbers of teeth for which the gears are not available for a standard index train.

The differential gear

Figure 1 shows the basic form of differential gear with bevels of equal teeth, similar to that fitted to the rear axle of a car. If we consider this as an epicyclic gear with a sun gear (s), two planet gears (p) held in a carrier (c) and an annulus gear (a) which because of the mitre bevel design is another similar bevel gear and if the rotational speeds of these parts are ωs ωp ωc and ωa respectively then :

$\omega a = \omega s + 2\omega p$ equation (1) $\omega c = \omega s + \omega p$ equation (2)

From (2) $\omega p = \omega c - \omega s$ Substituting this in (1) : $\omega a = \omega s + 2(\omega c - \omega s)$

So: $\omega a + \omega s = 2\omega c$ This is the general equation for a differential

Figure 2 shows a differential installation suitable for the hobbing machine. The input shaft to which the hob is fixed drives the "sun" bevel gear (s). The gear with T2 teeth is fixed to the "annulus" bevel (a) but otherwise is free to rotate on the input shaft, and the gear with T1 teeth is the carrier (c) and carries the two "planet" bevels (p). Gears T3 and T4 are both keyed to the output shaft which drives the index worm which in turn drives the gear blank. The two idler gears can be of any convenient size. The relationships between the rotational speeds of the various parts are:

$\omega a + \omega s = 2\omega c$ equ (3) $\omega c \times T_1/T_3 = \omega o$ equ (4) $\omega a \times T_2/T_4 = \omega o$ equ (5)

From (3) $\omega c = (\omega a + \omega s)/2$ Substituting this in (4) : $(\omega a + \omega s)/2 \times T_1/T_3 = \omega o$ equ (6)

From (5) $\omega a = \omega o \times T_4/T_2$ Substituting this in (6) : $\omega o \times T_4/T_2 + \omega s = 2\omega o \times T_3/T_1$

So: $\omega s = \omega o\,(2T_3/T_1 - T_4/T_2)$ or $\omega s/\omega o = (2T_3/T_1 - T_4/T_2)$

Using standard index gears, to cut a gear of X teeth $\omega s/\omega o = X/W$ where W = Machine constant. This is equal to the number teeth on worm wheel assuming a single start worm.

So to cut a gear of X teeth using the

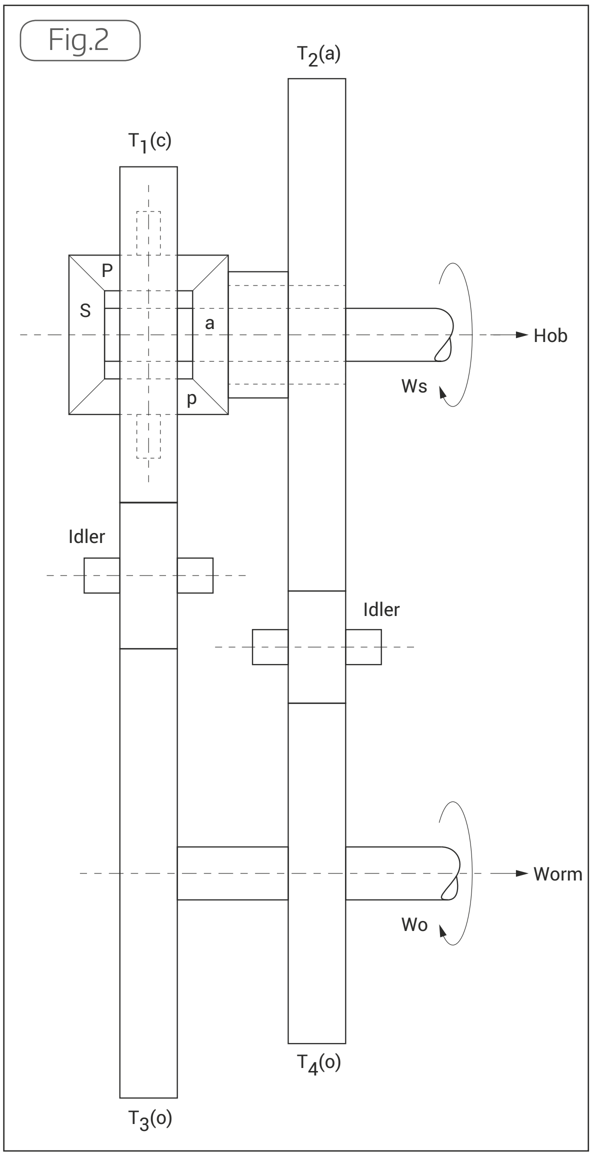
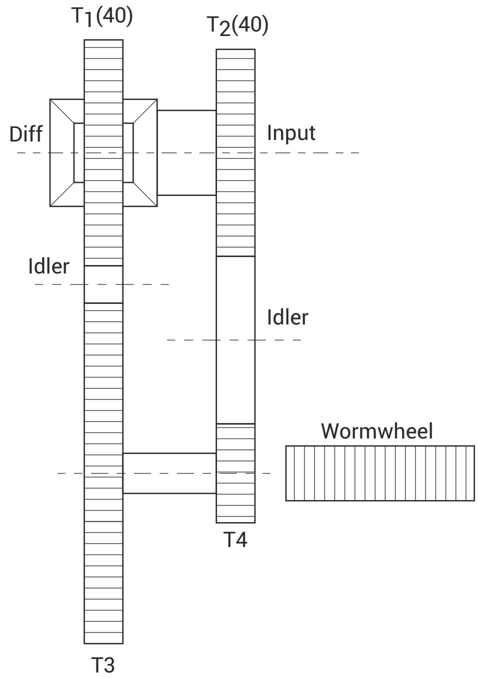


Fig.2

Fig.3

X = 2T3 - T4

	T1	T2		T1	T2
	40	40		40	40
X	T3	T4	X	T3	T4
31	35	39	93	60	27
37	36	35	97	65	33
41	40	39	99	60	21
43	39	35	101	70	39
47	36	25	103	65	27
51	36	21	106	70	34
53	40	27	107	65	23
57	40	23	108	65	22
59	40	21	109	65	21
61	40	19	111	70	29
63	42	21	113	70	27
67	50	33	114	70	26
71	60	49	116	75	34
73	50	27	118	75	32
78	50	22	121	75	29
79	50	21	122	75	28
83	55	27	123	75	27
85	55	25	124	80	36
87	60	33	126	80	34
89	55	21	113	70	27
91	55	19	127	80	33



Differential Gear Set Up For Hobbing Prime Number Gears And Others

differential X/W = $(2T_3/T_1 - T_4/T_2)$

If we make both T_1 and T_2 equal to W, in our case 40, this reduces to X = $(2T_3 - T_4)$

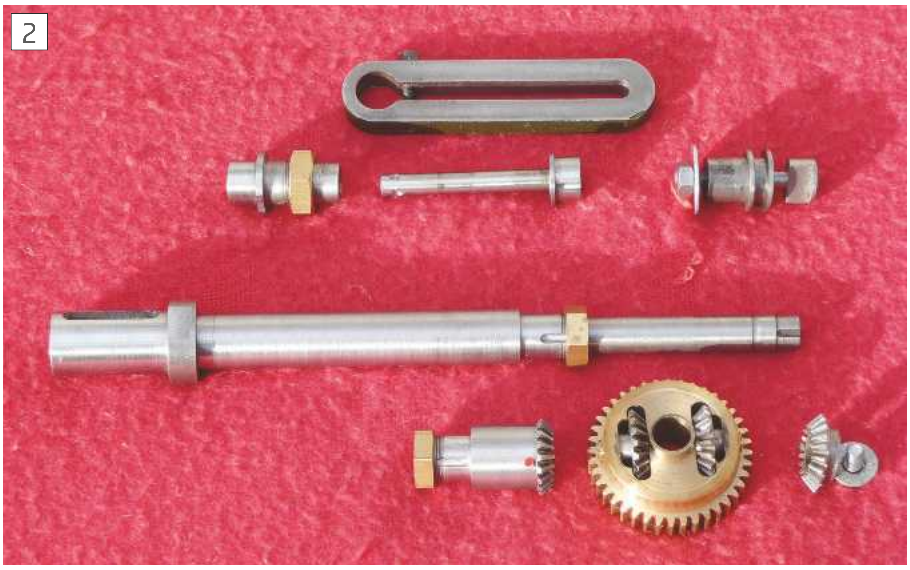
Figure 3 shows arrangements for cutting gears of prime numbers of teeth and others for which a conventional index train may be difficult up to 127. With a range of gears from 20T to 100T indexing up to 180T is available. By gearing down the drive from T1 to T3 gears with a 2:1 reduction instead of an idler this can be extended to 380T, and with a 3:1 reduction to 580T should these large tooth numbers ever be required. The differential offers a great deal of flexibility.

Modifications required

The additional parts required are shown in **photo 2**. These are a lengthened main shaft to accommodate the differential assembly, the differential body incorporating a 40T gear forming the carrier (c) which mounts the two "planet bevels", a "sun" bevel which is keyed to the end of the lengthened shaft, and an "annulus" bevel which is integral with a sleeve to mount gear T_2. This is usually a 40T gear but useful solutions can be obtained with any gear which is multiple of 8.

The bevel gears are "parallel depth" bevel gears which can be made on a mill with a dividing head using an involute "one tooth at a time" gear cutter. This is described in Ivan Law's book, Gears and Gear Cutting3 pages 104 - 111.

In addition, the following are also required. A modified stub shaft which can accommodate two banjo arms, a shaft to accommodate two driven gears, an additional banjo arm but with a smaller bore so it can be mounted on the end of the stub shaft next to the brass nut which secures it to the "L" bracket, plus another set of parts to mount the second idler gear.



Additional parts required for the differential

Hobbing a gear using the differential

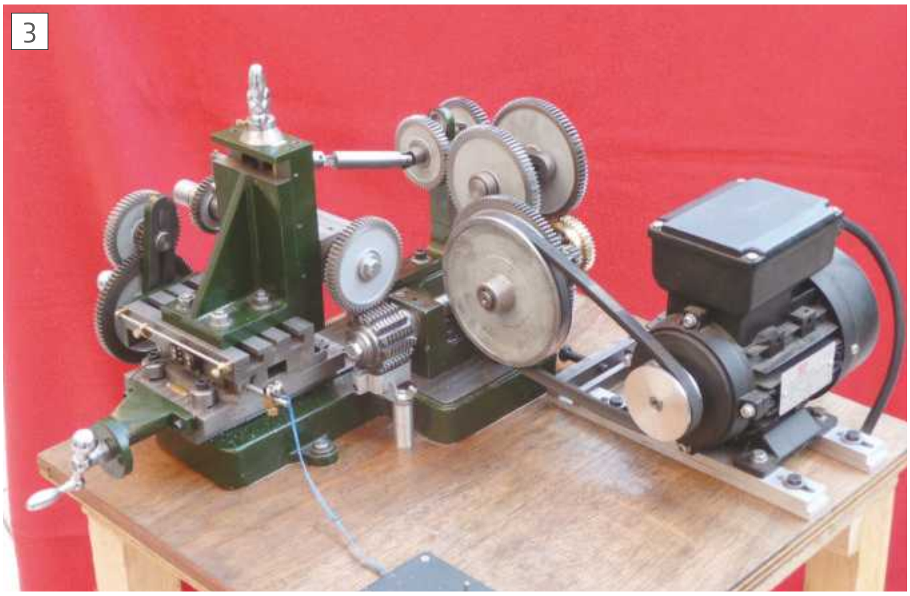
Photographs 3, 4 and **5** show the set up for hobbing a 59-tooth spur gear using the differential. 54T and 49T gears are mounted in the T_3 and T_4 positions respectively. Note that these two gears are different from the T_3 and T_4 gears (40T and 21T) shown in fig. 3 for hobbing a 59T gear. Both will work fine. The idler gears can be any convenient size provided they bridge the gaps. In all other respects the procedure is the same as using conventional index gears. The use of the differential is not restricted to hobbing prime number gears. By playing about with the equation **X = $(2T_3 - T_4)$**, most gears can be hobbed using this method of indexing.

Hobbing worm wheels

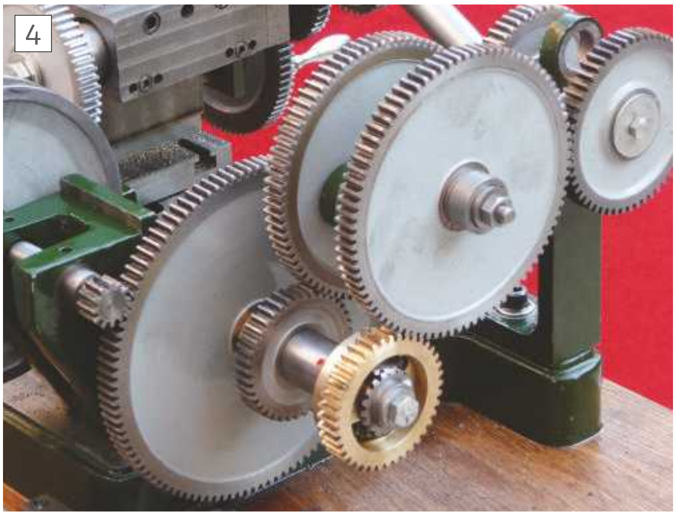
The hobbing of worm wheels with gear hobs on the Jacobs machine is quite feasible with the addition of a powered vertical feed. It could, of course, be done by manual feed but this can be somewhat tedious. The set up for this is shown in **photo 6**. Drive for the vertical feed is taken from an additional 20DP right handed single start worm keyed to the workpiece arbor driving a 20T worm gear.

The additional parts required are shown in **photos 7** and **9**. These comprise a modified thrust plate for the vertical slide that can support a banjo arm, an extension drive assembly mounting the 20T wormwheel and bringing this drive to the level of the thrust plate, and a modified leadscrew capable of mounting gears. In addition, a worm, **photo 9**, is required to mount on the workpiece arbor. The parts for attaching the gears to the leadscrew and for the banjo arm and mountings for the intermediate gears can be taken from the cross-feed assembly as the cross slide will always be fixed when hobbing worm wheels. The two long hexagon nuts are required to mount the handwheel for the cross slide in the absence of the gear mounting parts, these can be seen in photo 6.

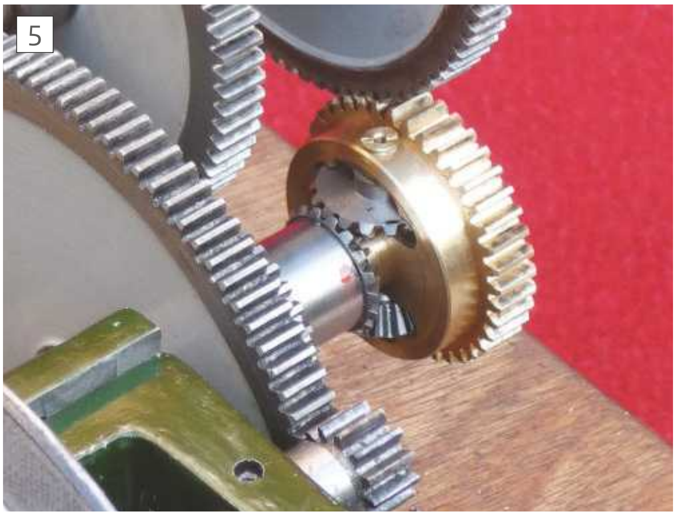
Since we have removed the calibrated scale from the vertical slide, some alternative means of determining the depth of cut is required. This is achieved by the dial gauge mounted on the sliding frame shown in photo 8. It attaches to the moving part of the vertical slide using the tapped holes for the gib adjusting screws. The dial gauge plunger contacts the cross slide. The slides of the mounting frame can be adjusted to give a zero reading at the start of the cut. The range of the gauge is 5mm,



Set up for hobbing a prime number spur gear with the differential



Details of differential and transmission gearing



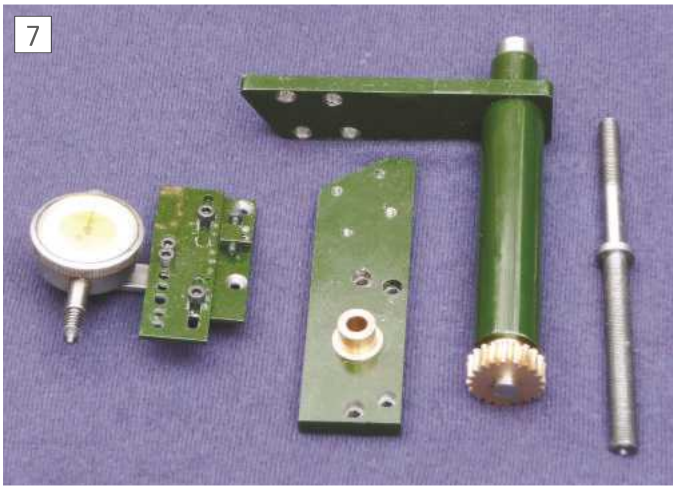
Differential details

more than ample for any gear required.

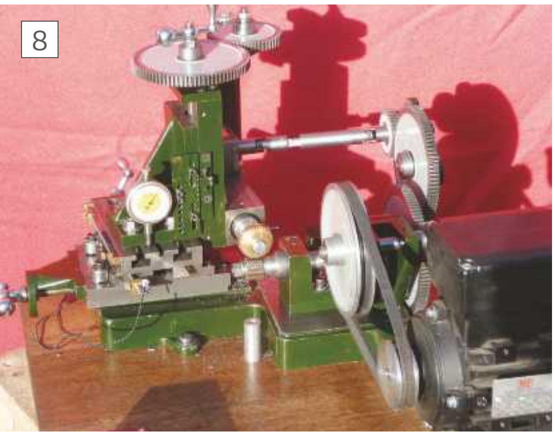
Hobs for making worm wheels

To reduce frictional losses and wear by minimising sliding speed, the worm of a worm and wheel pair should have as small a diameter as possible within the geometric constraints of the pitch and shaft mounting. In industry, therefore, wormwheel hobs reflect the size of the worms used which typically have an OD/pitch ratio of around 5. Gear cutting hobs generally have OD/pitch ratios of 7 and above. However, worm and wheel pairs based on regular gear cutting hobs will work perfectly satisfactorily though their efficiency will be lower. The main index worm drive of the Jacobs machine is a case in point. This uses a 20DP single start LH worm of 1" OD. College Engineering Supply provide the worm wheel, and this is no

Set up for hobbing a wormwheel with plunge feed

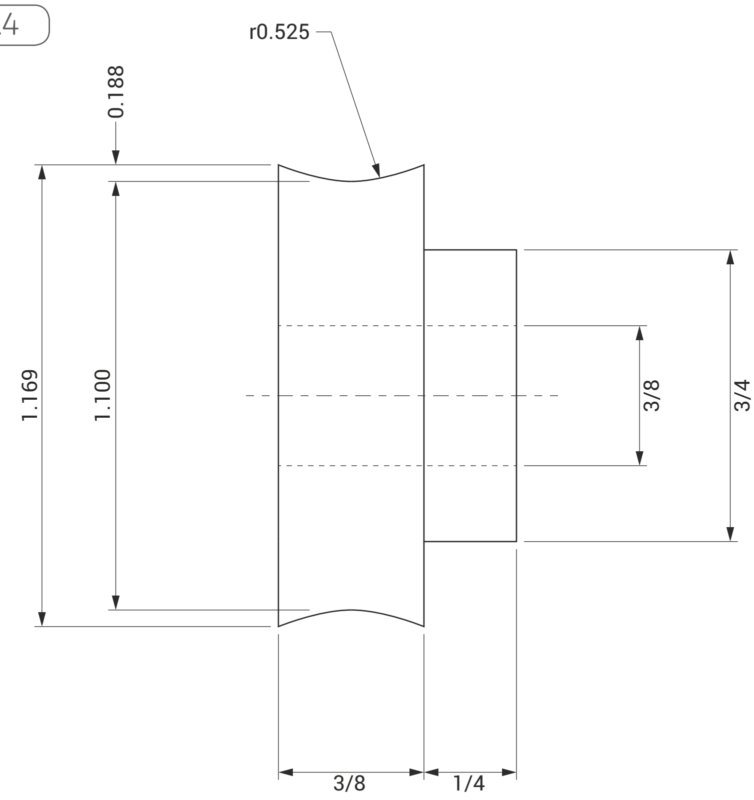


Additional parts required for plunge feed.



Hobbing a 39 tooth, Mod 0.8 wormwheel with a RH hob to mesh with a LH worm

Fig.4



20T DP20 Wormwheel

doubt because a 1" OD Left Handed gear cutting hob was available to make it. The OD/pitch ratio of this worm is 7. In practice, it is acceptable to use standard gear hobs and the worm wheels described in this section have been made using them. One limitation is that most gear hobs have teeth based on a single start thread. This means that the lead is equal to the pitch of the hob which equates to the circular pitch of the tooth size in question. Using a single start hob means that the wheels can only mate with single start worms. In industry worms having up to 4 or more start threads are used to give lower ratios. Take for example a worm meshing with a 24 tooth wormwheel. Using standard single tooth gear hobs will produce a ratio of 24:1, whereas 2, 3 and 4 start worms will produce ratios of 12:1, 8:1, and 6:1 respectively. However 90° crossed axis gears having these ratios can be made on the machine by making 45° helix angle gears of the same hand as described in my 2010 MEW article2, so it is of little limitation for the model engineer.

Producing worm wheels

To make a worm and wheel pair the first step is to select the hob to be used and the ratio required. In the case of the worm and wheel used for the vertical feed drive shown in photo 9, a 20DP hob of 1.25" OD was chosen primarily because the worm has to be mounted on a 5/8" diameter shaft, and a 20:1 ratio was chosen requiring a 20-tooth worm wheel. A right-hand worm is required to give the correct direction of rotation. The next step is to design the worm wheel blank as per **Fig 4**.

The blank OD at the centre of the mesh = (20 + 2)/DP = 22/20 = 1.1" The outside radius of the wrap around is equal to half the inside diameter of the worm mesh = (Hob OD – 4/DP)/2 = (1.25 – 4/20)/2 = 0.525"

20 DP RH worm, 20 tooth wormwheel and temporary 20T helical gear

With a wheel width of 0.375" the OD at the edge is : 1.1 + 2 x (0.525 – √(0.5252 – 0.18752)) = 1.169"

Brass or bronze is a good choice of material for the worm wheel if the worm is made of steel. Brass was used and the wrap around radius turned with a form tool ground to a radius of 0.525" or at least near to this.

The hob machine set up is as per photo 8 but with the cross slide set normal to the hob axis, i.e. 0 degrees on the scale. A ratio of 3:1 was used between the vertical shaft and the vertical slide feed screw giving a plunge feed rate of 1/60 mm per revolution of the workpiece. The blank should then be set so the centre of mesh is directly over the centre line of the hob and the vertical slide screwed down so the hob is just touching the work and the dial gauge set to zero. The machine can then be started with the vertical slide feed gears in mesh and left running until the depth of cut is 2.74 mm.

Making the mating worm is a straight screw cutting exercise except the pitch of the screw is irregular and equal to π /20 = 0.1571 in. Ivan Law's book3, chapter 6 will be of some help here. **Photo 9** also shows the completed worm and wheel.

Now the more thoughtful may ask how was this worm wheel made when needed for the vertical feed drive train required for its own making? A chicken and egg situation. The answer is that a 20T helical gear having a helix angle equal to the lead angle of the hob, 2° 30' was made in aluminium (also shown in photo 9) and used in making the 20T brass worm wheel. This is a once only use so aluminium was suitable.

To be continued

A Dual Action Feed for a Lathe Tailstock

Geoff Walker describes an improvement for his Drummond M that can be adapted to many similar lathes.

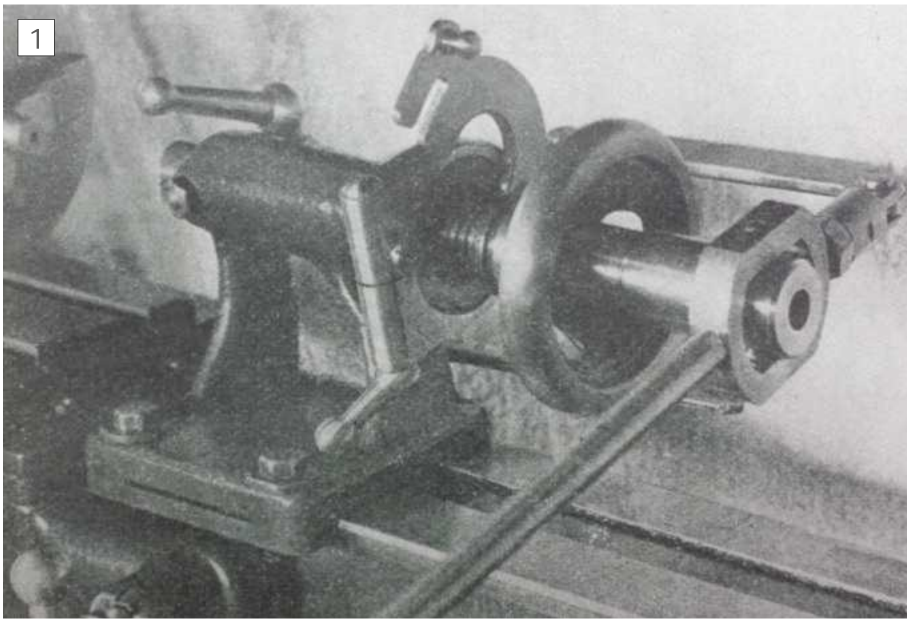
I am often researching old books and magazines for attachments and accessories which will enhance the performance and increase the versatility of my old pre-war Drummond lathe.

One such popular addition is a lever action tailstock attachment, which for me is generally preferable to the hand wheel feed. I say generally as there occasions when I would prefer to use a hand wheel feed. Unfortunately when a lever action attachment is fitted it usually takes some time to switch over and reinstate the hand wheel feed.

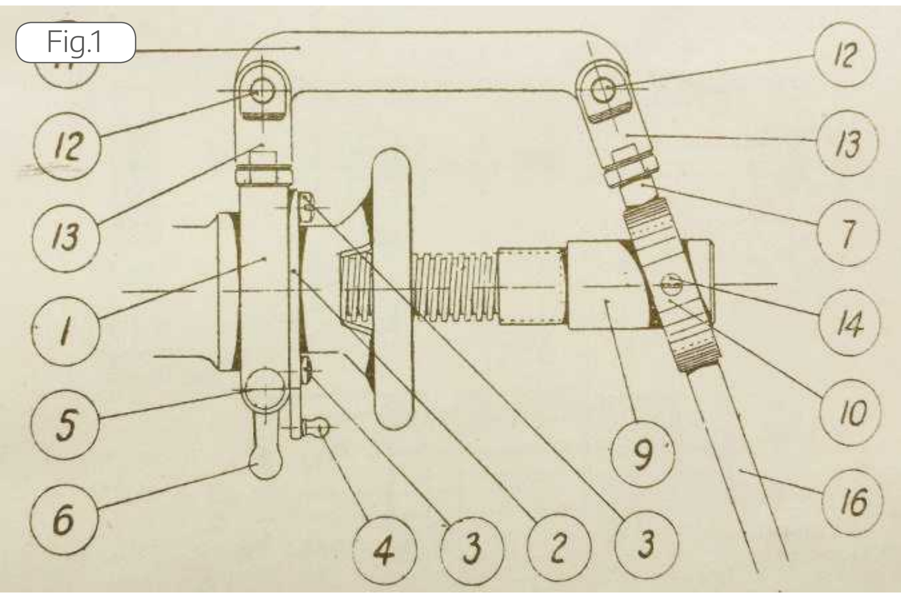
When after some research I discovered a tailstock attachment design which combines both the lever and hand wheel feed I was naturally very interested.

The researched attachment can be seen on a Winfield lathe in **photo 1** and in a general arrangement drawing, **fig 1.** They are the work of the notable technical writer Mr Ian Bradley. His design featured as an article in a war time issue of Model Engineer Magazine, published in August 1941. I acquired a copy of this article, from issue 2103, which includes additional photos, drawings and instructions.

This article is essentially a brief analysis and review of Mr. Bradleys original work and how I adapted his design for use on my lathe. I have followed most of the detail in his design and only made some minor changes to the fulcrum forks (13), the link (11) and some fixings. No drawings are offered other than Mr Bradley's. My intention is to present enough information through text and photographs to help a home machinist also adapt the idea for use on their lathe.



The original 1941 attachment on a pre-war Winfield lathe

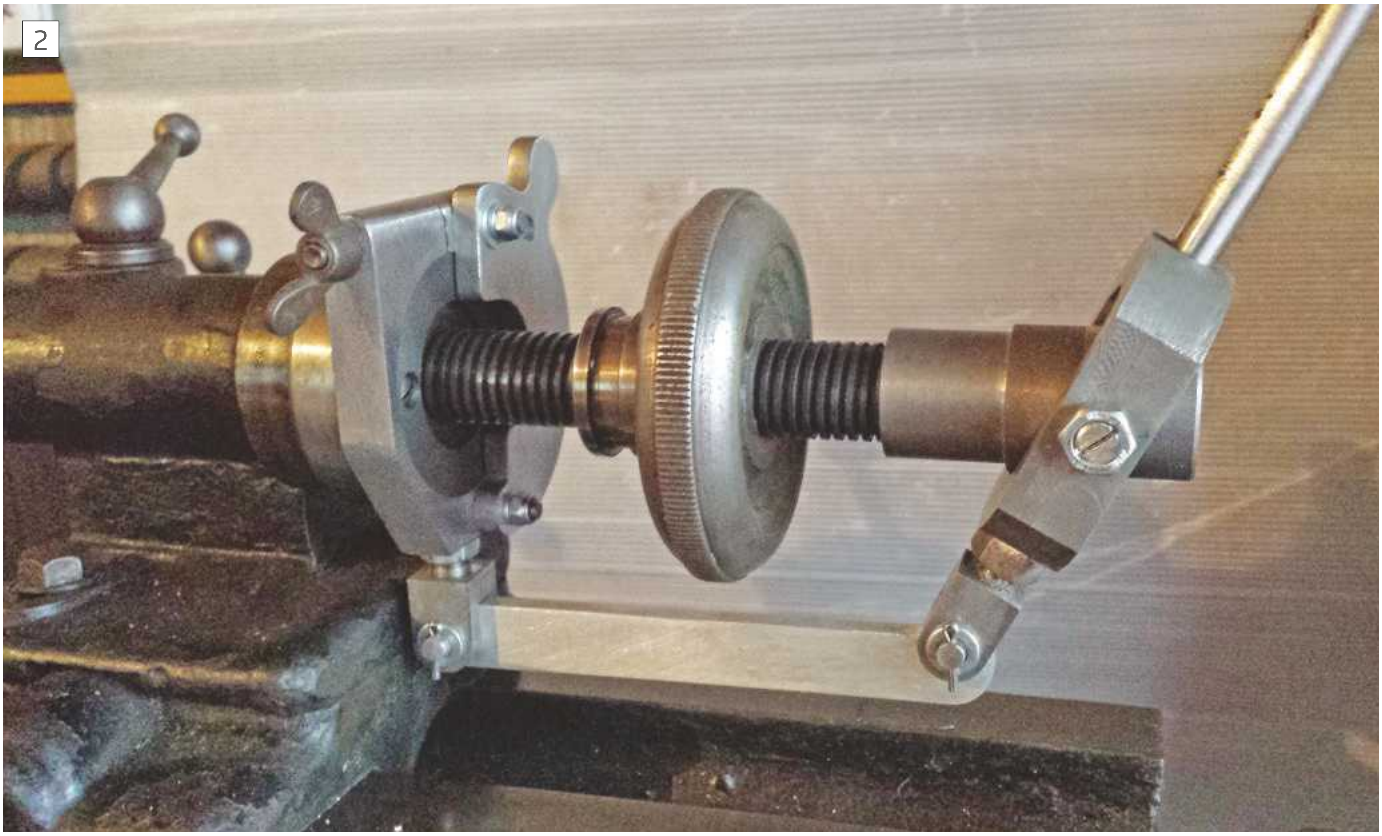


The original general arrangement drawing.

The original idea, now 75 years old, is a simple but novel design and one which could be used on any lathe which has a machined boss on the rear of the tailstock and an annular groove in the hand wheel. A longer than normal barrel is desirable but not essential. Photograph 1 and the drawing show the attachment set for use with the lever in a horizontal position. There is a collar (1) clamped on the rear boss and fastened to this is a latch (2) which can pivot in and out of engagement with the annular groove in the hand wheel. In the photo the latch is shown out of engagement and the hand wheel withdrawn so the barrel is free to move when the lever (16) is pushed forward. By returning the hand wheel and lowering the latch into the annular groove the hand wheel operation becomes effective. The collar has a locking screw (5) and handle (6) which allows the whole assembly to be rotated enabling instant and convenient adjustment of the operating lever position.

So what are the benefits of a dual action feed? A comprehensive analysis would take some time to explain, from my experience here are some examples.

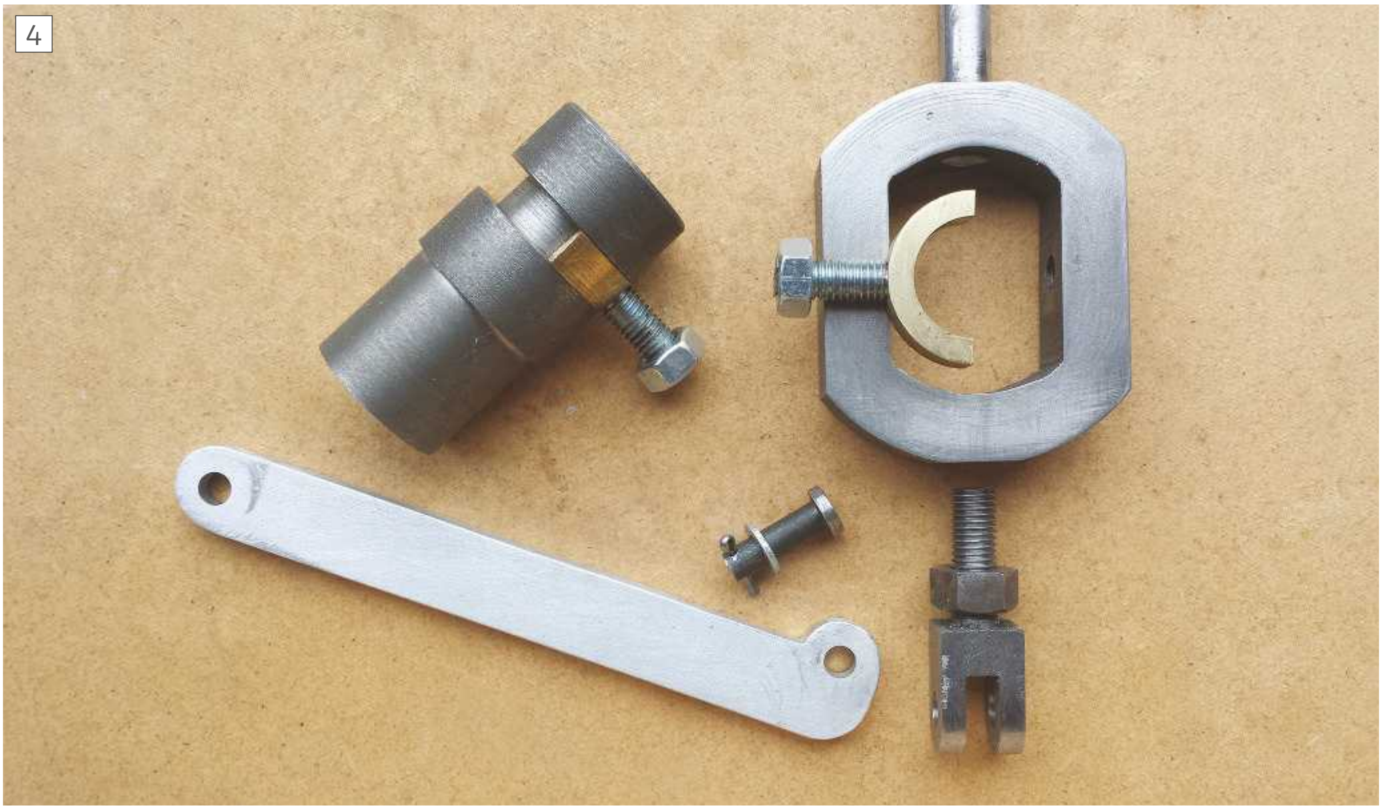
1. The hand wheel feed is better for



A 2016 attachment on a 1929 Drummond lathe

larger drills used at slower speeds. In this instance the wedge action of the screw will deliver more force and thus require less effort than the lever feed.
2. The hand wheel is also better for maintaining and holding a steady feed rate, for example when using a cross drill vee pad in the tailstock.
3. The lever feed is better for smaller drills and of course the drill can be withdrawn quickly to clear swarf from the flutes. Really small drills are probably best served by an attachment which locates in the tailstock taper similar to the Hemingway sensitive drilling attachment designed by Chris Heapy.
4. When tapping holes with the work held in the lathe chuck and the tap in the tailstock chuck the lever feed can be used to apply pressure on the tap whilst the chuck is turned by hand. Once the

The bridle and component parts.



The collar, latch and component parts.

tap starts to cut no further pressure is required as the tap will self-feed as the thread engages.

The lever arrangement in Mr Bradley's design is by no means unique and has been a popular choice on many lathes and attachments including Chris Heapy's. Examples of some lathes are the Lorch, Boley and Pultra. The simple linkage arrangement which uses a bridle (10) to feed the barrel of the tailstock is an efficient design. The barrel has an extension (9) which has an internal square thread to match the barrel thread and an annular groove on the outside. The bridle straddles the groove and through hinge pins (14) distributes the load from the lever evenly on either side of the barrel. Other popular lever arrangements, similar to the type used on the Myford Series 7 lathes, transmit the load from one side of the barrel via a pin which is set at a right angle in the barrel casting. The bridle is probably better because as well as dividing the load it also brings it closer to the centre line of the barrel. The efficiency is further enhanced by using a pair of segments, as seen in **photo 2**. These locate in the annular groove and instead of a point loading in the groove from the hinge pins the thrust is taken through the segments which further distributes the load around the circumference of the barrel. The segments also facilitate the rotation of the whole assembly without disturbing the barrel extension.

All the component parts of the bridle from my tailstock can be seen in photo 2 and the collar and latch components in **photo 3**. The complete attachment shown with the lever set vertical is in **photo 4**. It can be seen that the hand wheel can used as depth stop but there is no provision to lock it in place.

There is no difficult work in making the component parts. A vertical spindle milling machine will make light work of much of the metal removal but there is no avoiding some possibly tedious bench work. The collar, the latch and the link are made from mild steel, the barrel extension and bridle are cast iron and the segments are bronze.

The collar has two studs, one for the latch pivot and one through the elongated hole. They both have a washer/nyloc nut pinched up lightly so the latch will hold in an open or closed position.

It's important that the holes in the bridle and segments are drilled square and diametrically opposite or the smoothness of operation will be impaired. To do this I used a vertical slide/angle plate arrangement. The work was clamped on the angle plate and then drilled from the headstock. With a test piece in the drill chuck the cross and vertical slide dials were used to set the drilling position accurately. The hinge pins were turned from mild steel studding, have a screwdriver slot for adjustment and are secured with a lock nut.

I would recommend that all pivots are made precisely and are a neat sliding fit in each pivot hole. This will give the whole attachment a really positive feel as the lightest touch on the end of the lever will result in an immediate lateral movement of the barrel. The length of the link is important and will need to be a bespoke size on your lathe.

Unlike Mr Bradley's design my barrel extension has no square thread and is just plain bored to a neat sliding fit on the barrel. I have found this arrangement entirely satisfactory. I thought that I would have to slit the extension like a collet and make a loose clamp to secure it on the barrel but it really hasn't been necessary. Once the link is connected with the fork pins the extension is held securely in place.

A long tailstock barrel certainly helps as there will be plenty of space to accommodate the hand wheel and the barrel extension. If you have a short barrel then the barrel extension will need an internal connection locating inside the end of the barrel. As for the external connection it just needs to be turned to neat sliding fit and it will be fine.

I'm glad that I discovered Mr. Bradley's 75 year old design as it looks good on my 87 year old Drummond. I've had it set up on the lathe for a long while and 80% of the time I use the lever feed, which is as stated really efficient and a joy to use. The hand wheel feed is fine, with enough hand room to comfortably turn the hand wheel and apply the effort required. Also when using the hand wheel feed it is easy to flip over the latch to withdraw the drill and clear swarf from the flutes.

It took a long while to make but the whole assembly has a solid, robust feel which will give reliable service for many years to come. It should certainly be good for the lathes centenary in 2029. ■

Long Travel Threading Guide for the Lathe

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

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.

The column and the base were then re-assembled and clamped down to the cross-slide. Using the 18 mm end-mill, located in the tail-stock, the cross-slide was then moved to align the milling cutter with the hole, **photo 13**, and then one of the cross-slide gib adjusting screws tightened up to prevent the cross-slid from moving.

A boring head, inserted into the Morse socket in the lathe spindle, was set-up to bore out the hole. Progressive passes, with small cuts, were taken until the hole is opened up to a very close sliding fit on the 20.0 mm gauge, **photo 14**. When the hole reached size at the front, it was found that the gauge would not pass through. Repeated runs of the boring head through the work, at the same setting, together with copious amounts of oil, produced a smooth and parallel finish.

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Trial Fitting the T-Nut

Die Holder & Guide Tube

Three die holders were made covering 13/16", 1" and 1.5/16" outside diameter dies. All dies are larger than the 20 mm guide tube so collars were needed to secure the die to the guide tube. Rather than having different size die holder mounts, dictated by die diameter and a corresponding collar to fit to the guide tube, I decided to make the mounting hole on the dies the same

13

Aligning Guide Hole Ready for Boring

14

Testing Bore Size Using a Plug Gauge

size and make one collar.

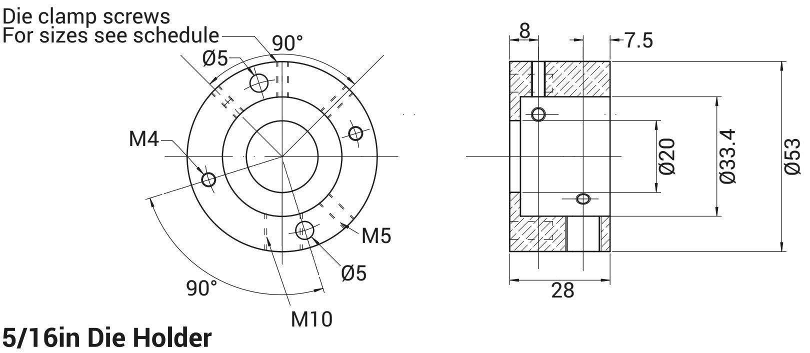
As the largest die is 1.5/16" (33.34 mm), this was selected as the mounting socket bore size for all the die holders.

In producing the die holders, collar and guide tube, thought was given to the manufacturing sequence. The guide tube has to be a sliding fit in the column, the collar needs to close fit to the guide tube and the die holders a sliding fit to the collar. So, the logical sequence is to make the guide tube first, as this can be used to gauge the collar bore, followed by the collar, which is used to gauge the die holder bores.

Guide Tube, fig. 2

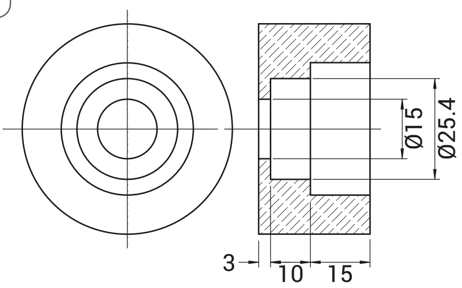
The guide tube is turned to an exact 20.0 mm, using the hole in the cross-slide mount column as a gauge. This was turned from a piece of 25 mm (1") bar, chucked in the 4-jaw, drilled and reamed to 16 mm diameter before being parted off to length. The ends of the tube were then lightly chamfered.

Fig.3



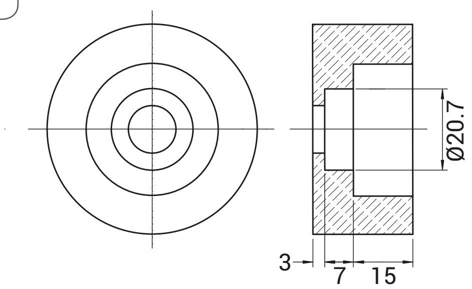
1 5/16in Die Holder

Fig.4



1in Die Holder
Take general dimensions from 1 5/16in die holder

Fig.5



13/16in Die Holder
Take general dimensions from 1 5/16in die holder

Guide Tube Collar, fig. 2

The collar was cut from a piece of bar stock and turned down to 33.34 mm. The bore was then drilled and bored out to 20 mm, to a close fit on the guide tube. The part was then turned over and faced off and the edges lightly chamfered. The collar was fixed to the end of the guide tube using a retaining compound.

Die Holder Body, figs 3,4 & 5

Gauges were turned for the two smaller die sizes (13/16" (20.64 mm) & 1" (25.4 mm)), again stepped to give a couple of under size dimensions.

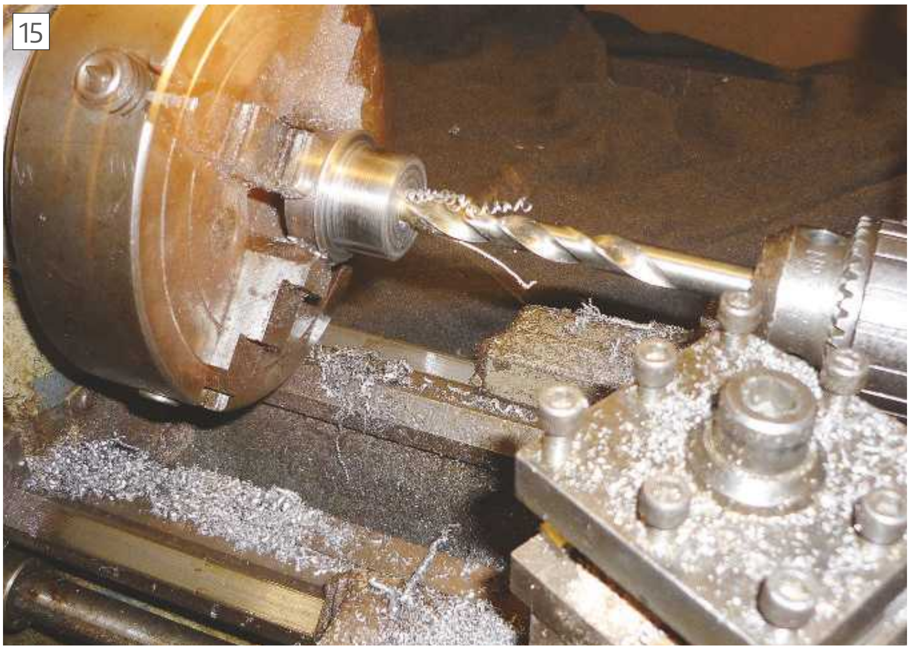
The three blanks for the die holder bodies were cut from approximately 63 mm (2.1/2") diameter bar. As the bar was rather rough and I decided to cut it about 20 mm longer than required, face off and machine a register (about 15 mm long) one end to form a good surface to grip the part in the 4-jaw.

The machined ends of the blank was then chucked, faced off and 30 mm turned down to 53 mm diameter. The part was then centre drilled and bored to create the smallest of the two holes, **photo 15**. The recess for the guide tube collar was then further drilled out and bored 15 mm deep, **photo 16**, gauged by the guide tube collar. In the case of the larger die, the bore was to a full depth of die thickness plus the thickness of the collar, totalling 25 mm. The recess for the die was then bored to depth, measured using a vernier calliper, **photo 17**. The hole was brought to size using the previously made gauges for measurement with final checking using the corresponding die, **photo 18**.

The holder, and the chuck jaws, were then turned over and the end faced off to reduce the total length to 28 mm for the two larger holders and 23.5 mm for the smaller holder. It is important that the piece is mounted true as this end face has to be perfectly perpendicular to the bore of the die socket.

The next job was to mark out the holes for the die clamping and adjustment screws.

15



Drilling Die Holder

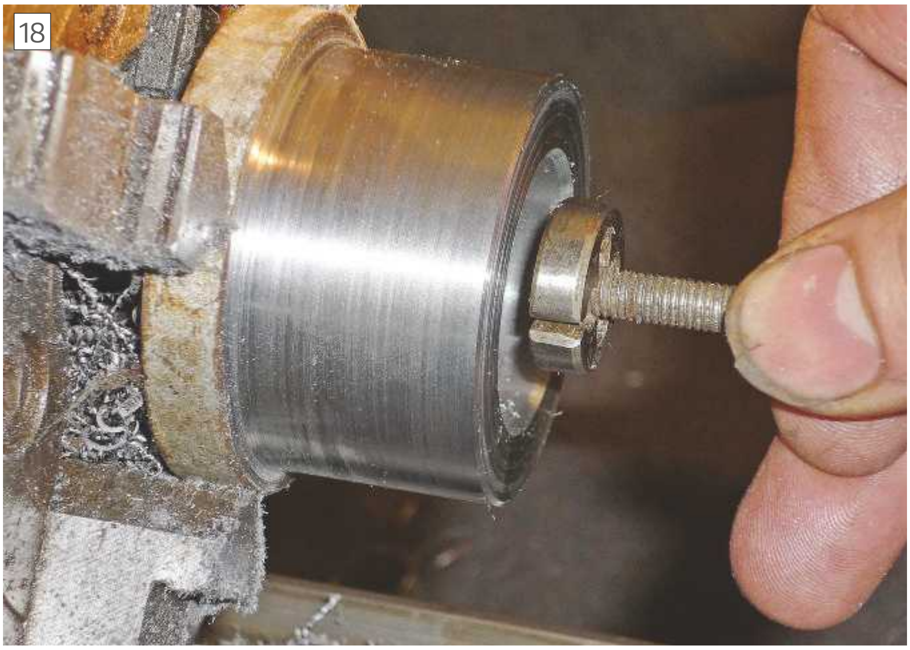
Boring to Fit Guide Tube

Checking Die Recess Depth

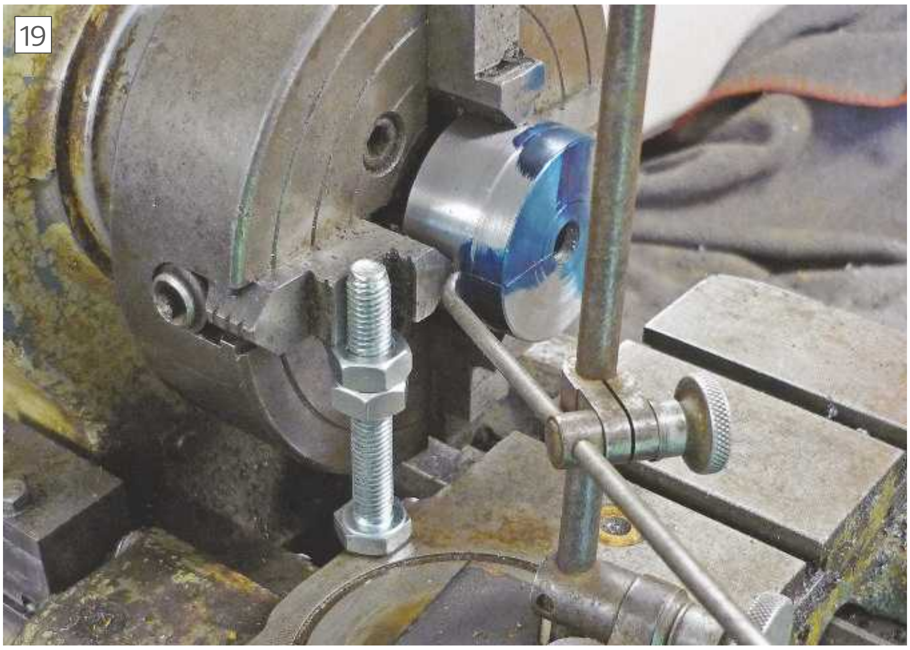
As I needed two holes at 90° (the clamp screws) and the adjusting screw between the two, on this occasion I considered it easier to mark it out on the lathe, using the 4-jaw chuck as an indexing head.

The die holder was blued up in approximately the expected position of the lines and then placed open end into the chuck, with about 20 mm protruding, and trued up. A M12 bolt with a couple of nuts was set to rest one chuck jaw horizontally, photo 19, and, using a scribing block set to lathe centre height mounted on the cross-slide table, a horizontal line was scribed across half the face and along the exposed side edge. The chuck was then rotated on quarter turn, the jaw re-seated on the bolt and the second line, at 90°, marked. The die holder was then removed from the chuck and, using dividers, another line was marked out splitting the two previous lines to give the three drilling positions at 45° increments.

The holes need to be in the middle of the die recess to register with the clamping locations on the die. The position could be calculated from the drawing, but if there are any errors in machining I thought it was best to measure the distance from the bottom of the die recess to the edge of the open end of the holder, using a depth micrometer. From this measurement was deducted half the thickness of the die and this measurement noted down; one measurement for each die holder.



Final Check Using Die



Marking Out the Die Screw Positions

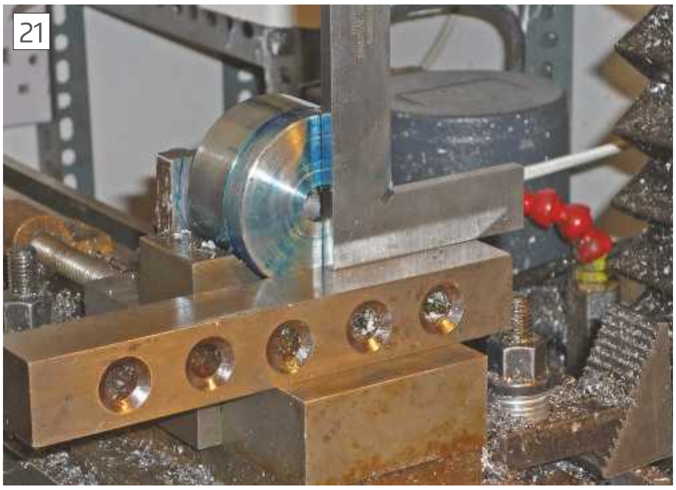
A V-block was then clamped in the vertical milling machine vice with a vertical plate behind it, **photo 20**. The table y-axis was then adjusted to bring the V-block's slot centrally under the drilling spindle using a round bar, having a diameter equal to the slot width, in the drill chuck, **photo 21**.

The die holder was then placed on the V-block and adjusted so that the fist of the reference lines sat vertically, as gauged using a square, **photo 22**. My vice's fixed jaw is rather too narrow to sit the square on comfortably, so a parallel was placed on top to increase the contact area. Once vertical, the holder was held in place using a toolmaker's clamp and its edge located using an edge finder. Then, the x-axis dial was zeroed and the table moved along by half the diameter of the edge finder plus the dimension determined above. The first hole was then drilled (centre drill first) and tapped, **photo 23**. The process was repeated for the second and third holes, without the need to move the table. In all cases, a taper tap mounted in the drill chuck was used to start the thread, forming about 2 – 3 threads. After this I prefer to release the tap from chuck and finish by hand, either with the work still mounted on the mill or independently in a bench vice. For the two large holders, I used M5 tapped holes, while M4 was used for the smaller die holder.

Hex-socket grub screws were inserted in each of the holes. Points were added to the die adjusting screw by locking two nuts onto the head end, mounting in the 3-jaw and turning down a 30° inclined taper.

The clamping screw, which clamps the die holder onto the guide tube collar, is

Set-up for Drilling Die Screw Holes

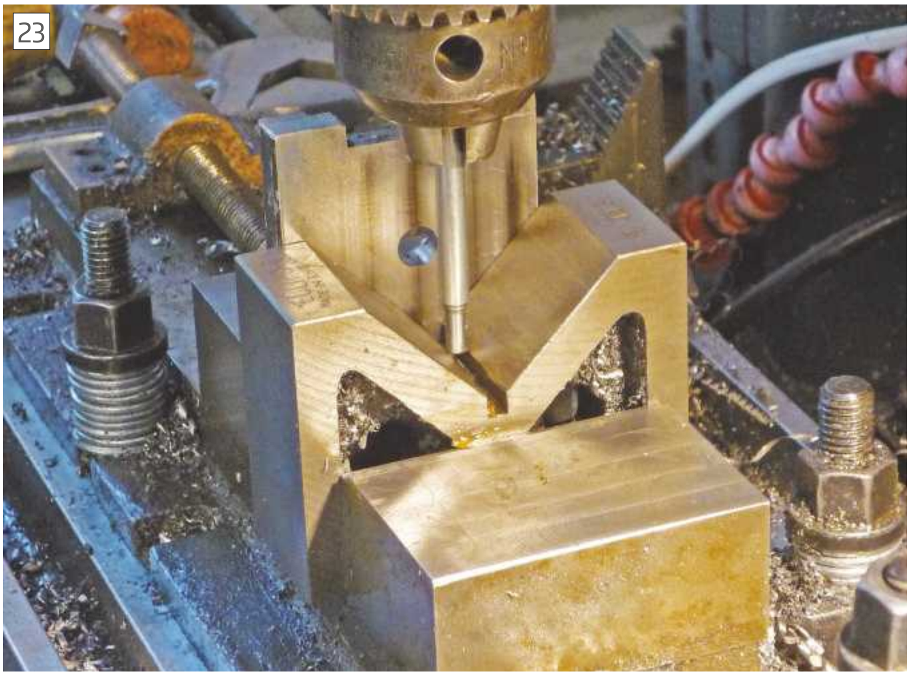


Setting V-Block Centrally

Aligning Die Screw Positions for Drilling

located on the opposite side to the die adjusting screw. As there were some differences in the depth of the recess for the collar between the three I decided to drill the holes using the guide tube collar as a reference. A V-block was clamped in the milling machine vice, **photo 24**, and adjusted so the slot was centred under the spindle. The guide tube plus collar were then clamped to the V-block and the outer face edge centred under the machine's spindle. The table was then moved forward 7.5 mm to give the drilling position for the clamping screw. The first die holder was fitted on the collar and held in place using a toolmaker's clamp.

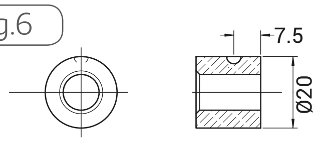
Using a centre drill, a pilot hole was drilled followed by a 4.2 mm drill (M5 tapping) and drilled to a depth of 13 mm, using the quill dial, to cut 10 mm through the die holder and a further 3 mm into the guide tube collar. The drill was swapped for a M5 tap and a couple of threads were cut, after which the die holder was removed and the thread finished by hand. The exercise was applied to the other two holders,



Tapping Die Screw Holes

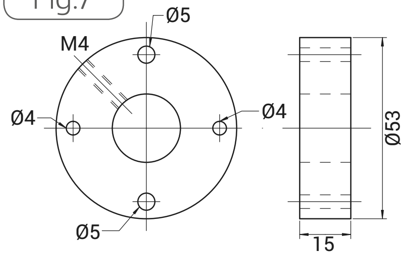
Drilling Die Holder Securing Screw Hole

Fig.6



Guide Bush
Bore dimension to
suit thread being cut

Fig.7



Guide Bush Holder

although the drill only needed to break through the die holder in these cases. After the third holder was drilled, the die holder was removed from the collar tube and a 5 mm drill used to open up the diameter of the 3 mm deep hole in the tube collar.

The position of the handle hole is not critical and this was placed near to the collar locking screw. The die holder was held in a V-block with a backing plate, as described for drilling the die holding screws, and an 8.5 mm hole drilled 7.5 mm from the rear edge, followed by tapping M10.

Work Guide, figs 6 & 7

The work guide is a small bush, located in a removable holder, and positioned in front of the die to provide alignment of work and die. This is held in by a guide holder.

The guide bush holder was made from a piece of approximately 16 mm thick strip, 65 mm wide and cut to about 60 mm. The centre was located and drilled 10 mm, put on a M10 bolt and locked down with a nut for turning down to size on the lathe. As I was making three holders, one for each die holder, four blanks were mounted together and all turned down to 53 mm diameter, **photo 25**. One of the guides would be used as a drilling template for the guide bushes.

The holders were mounted in the lathe's 4-jaw, clocked true and bored to a close 20 mm, using the gauge employed previously for the hole in the main column, and then faced off. This face was marked as a reference as the bore is square to the bore. Finally, the edges are chamfered and the part turned over and faced off, again finished by chamfering.

The guide holder is held to the die holder using a combination of screws and pins orientated at 90°. After bluing the face opposite the reference face, the guide is placed on a v-block and the total height measured using a height gauge, **photo 26**.

To be continued

Turning Guide Bush Holder Blanks

Locating Top Edge of Guide Bush Holder

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Brazing Steel 1

Dear Neil, regarding Neil Macnaughton's query about brazing mild steel sections in issue 251, I am just wondering if the problem is with the flux.

Some time ago I had trouble silver soldering built up crankshafts using Easyflo. I too thought my propane torch didn't produce enough heat, but the problem disappeared magically when I tried Tenacity flux instead.

Easyflo doesn't like being keep hot for long and by the time the job was hot it had lost its mojo. Tenacity has more stamina and stays active while the job gets up to temperature.

Sorry if this is a bit obvious to experts, but it took me more than one ruined job before I found out the hard way!

Chris Thorn, by email

Brazing Steel 2

Dear Neil, in the March edition of MEW, Neil Macnaughton asks for help on propane brazing. My suggestion would be to look at an alternative to propane. For some 50 years I was an enthusiastic oxy-acetylene user, with my main emphasis on bronze welding. However, about 20 years ago I was introduced to TIG welding, and when more recently, I discovered that bronze welding was also possible with a specialised TIG rod, my oxy acetylene set just fell out of use.

Chatting to a welding equipment company at a recent MACH exhibition at the NEC, I was assured that they could not only supply TIG bronze rods, but a MIG wire to a similar specification. I might add that before finding the TIG rods, I had tried gas welding bronze rods without success – as I recall, they spat all over the place when introduced to a TIG 'flame'.

The specification of my rods is CW-1800 Bronze Filler wire Copper/Tin alloy, and the TIG process does not require any flux. They do produce a rather coppery looking weld but I have had no problems although I have only used them on steel sections up about 8mm thick. They produce a strong weld and I have experienced no failures or cracking. I suspect that a more detailed investigation of availability would produce other rods, possibly including one for brazing.

John Calnan, Buckinghamshire

In our next issue we will start a short series by David Banham that looks into silver soldering in detail – Neil

To Ground or Not To Ground?

The paragraph on page 3 of issue 251/2 on "VFD Issues" compels me to comment.

The text in the original article by Laurie Leonard is perfectly accurate. The "correction" under VFD issues is incorrect as is obvious when looking at the physics involved.

Braided shield acts as a pretty good Faraday cage. A Faraday cage works whether it is connected anywhere or not and no electrical radiation can escape a Faraday cage. If though the shield is left floating it can slowly get statically charged up and therefore it is better to ground the shield somewhere. It is difficult to determine which end should be grounded but in most cases either end will do.

If the shield is grounded at both ends this will create a large conductive loop (a single turn coil) which is a good coupler of magnetic fields. This will result in currents in the loop which will cause voltage drops in the shield which will result in interference.

I am an electronic engineer with experience and particular interest in the subject of preventing interference in systems and at circuit level.

I would like to commend you on the direction in which you have taken the magazine which has led me to again subscribe to MEW.

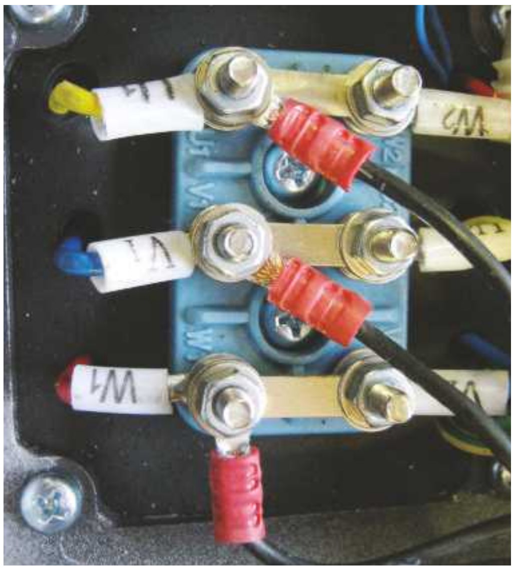
Eckart Hartmann, by email

Previously I received critical emails from two other electronic engineers (in response to Laurie's article) who gave opposite advice, with equally compelling explanations.

To make things more confusing, some VFD manufacturers (IMO for example) recommend grounding both ends, but others (e.g. Siemens) recommend only grounding one end.

If neither the manufacturers nor our electronic engineer readers can't agree – who am I to decide which is right or wrong?

As this is an interference, not a safety, issue (as long as motor and inverter are properly earthed separately from the screen) I can only suggest readers follow the instructions supplied with their device and if they have an interference problem consider connecting or disconnecting one end of the shield (only) to see if this makes a difference – Neil



Motor Connections

Dear Neil, In my article on Variable Frequency Drives published in issue 251 of MEW I note that Photo 14 shows the motor connected in Star configuration and was taken before I realised that the output voltage of drive unit was such that the motor used needed to be connected in Delta configuration. Three links were supplied with the motor and these were connected as in the enclosed photo in Delta configuration. Perhaps this comment is worth passing on to MEW readers.

Laurie Leonard, by email

Electrical Feedback

I tried to read the contribution An Arduino in my toolbox, but I wonder whether this is what your readers like. Very complicated and I think only a few can follow this. Don't forget, in my opinion, that most of your readers are somewhat older. Or am I wrong?

In most of the Dutch model engineer associations the members are not that young and less youngers come in. So who is interested in this kind of contribution?

Maybe I am totally wrong, but should like to hear the thoughts of others.

Henk Salij, Member of the Dutch Model Engineering Association in the city of Rotterdam.

Thank you Henk, the recent Arduino articles have sparked more positive discussion on our forum at www.model-engineer.co.uk than any other recent articles! I do realise that these technical topics may not interest some readers, but our readership covers a wider age range than you may think. I do try to make sure every issue has a wide range of topics so that most of it will be of interest to most readers - Neil

Rotary Table Woes

Dear Neil, thank you for placing my request in Scribe a line.

Would you please pass my thanks to Timothy Sims for his advice concerning drying out my OMT rotary table? His detailed reply is appreciated and his advice will be kept in mind – though I too feel that, as he suggests, 40/50 Kg of "thing" on a granite worktop would not be compatible with domestic harmony.

The table has now added to the ambience of the sitting room for some 10 weeks and has almost become part of the furnishings. However; despite the warmth, and leaving the internal scale illuminating lamp switched on (it is only 6W though) there has been no change whatsoever in the legibility of the scale. I believe now, that the problem is due to fine particles of dirt (whether metal fragments or WHY) adhered to the scale by an oil film. The time has come for it to be returned to the bench and the Allen keys brought to hand – determined measures are called for.

Malcolm Leafe

Video Star

Dear Neil, I know you are aware of me adding videos to YouTube showing my grinding rests being used for various sharpening tasks. However, as you gave them such a prominent position in the 25 Year Special (thanks) I thought it would be good to give the videos a mention in an issue of the magazine. Of course, many readers will be aware of them due to me publicising them on various forums, but no doubt there will be a few who have an interest in the rests but do not visit them. For those, can I suggest they visit my website www.homews.co.uk where the will find links to each one and much besides.

Harold Hall, by email

NEXT ISSUE

- **A 4 inch scale Sentinel:** Alan Barnes meets the builder, Ian Day
- **Percher-Ron:** a workshop 'assistant'
- **Charles Franklin Kettering:** an extended letter from Ron Fitzgerald
- **Candlesticks:** for at least 'four candles'...
- **Articulated Locomotives:** different machines

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Laser Centring Tool

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Fig.1

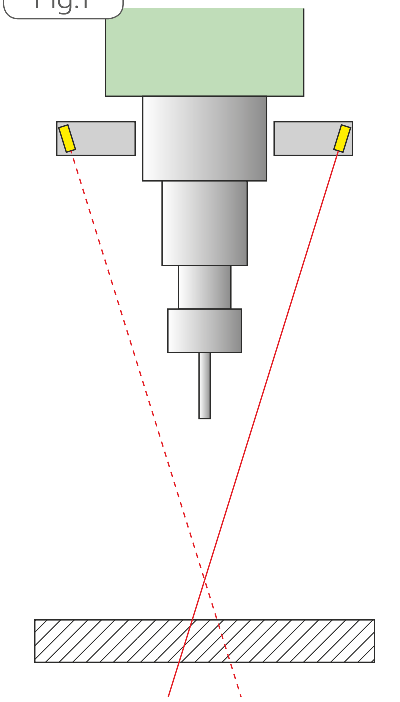
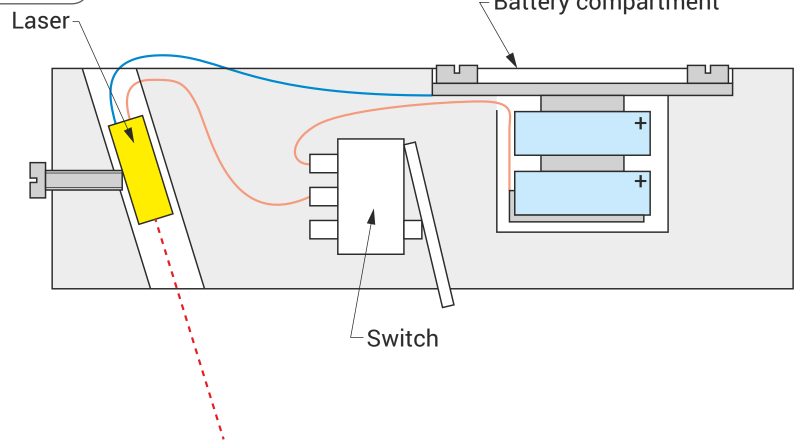


Fig.2



Like many home engineers I bought a laser centring tool at one of the engineering shows. This had a 10mm shaft and fitted into a mill collet. It produced a fine red light beam vertically downward onto the job when held in the collet. Provided you had the mill running it would give a somewhat circular indication of the mill axis centre but rarely a distinct fine dot. I tried aligning it for a better centre dot but it seemed to have a mind of its own. Consequently, it was not getting used much.

I subsequently came upon Mike's Workshop site mikesworkshop.weebly.com and he showed an alternative idea for a centring tool whereby the laser diode was offset on an arm. This produced an hour glass shaped dual cone of light which converged to a dot at the centre position as the quill was moved up and down. It allowed centring to not just centre punch dots but also by widening the circle with up and down movements of the quill, you could accurately centre on flat and circular jobs. Mike gave reference to a You Tube site by Dan Gelbart which illustrated this potential youtube.com/watch?v=otSjut1iGGk. See **fig. 1**.

Mike's design was made and lead to a nasty bruise as the rotating arm attacked me when I got too close. It was also frustrating in that it still needed to be put into a collet for rotation and use. The device shown in Dan Gelbart's video appeared to slip over the chuck and so did not need to be held like a tool in a collet. It also meant the device was much higher up the quill and less likely to add to my bruises. Dan Gelbart was enthusiastic about the device but did not indicate a source. A web search did not turn up anything so I resolved to produce something similar for my VM-B mill.

A 25mm slice was cut from the end of a 100mm diameter rod of HDPE (Acetal or Delrin would be similar). This was chucked

1

The underside of the device

on the lathe using external jaws and both faces turned square. HDPE is not the best of material for machining as it soft and 'soapy'. The slice I had cut did not run true so I marked jaw #1 position for reference. This meant I could take it in and out of the chuck and reposition after checking for fit on my VM-B quill boss. On completion I had a 'halo' disc ready to mount the diode, battery and a switch – and a large pile of plastic swarf.

The 3V laser diode was sourced on EBay together with a small lever arm micro switch. The switch was to allow the laser to be switched 'ON' only when it was in place and gripped on the quill boss. This was thought to be a good eyesight protection mechanism and would also be a battery saver. I tend to forget to turn battery devices off, and this had a potential eyesight hazard if left lying around.

Mike on his site suggested a 75-degree angle for the diode mounting. This was duly drilled into the disc as close as possible to the edge. A partially milled slot was milled on the inside diameter face to take the micro switch. The connecting wires were soldered to it and then it was potted in place with twin pack. A 12mm blind hole was slot milled to take two LR44 button cells. The battery hole also had a small slot down its side to allow the battery wire to be passed out. Slots were milled on the top surface of the ring to allow the wiring to be potted into the disc.

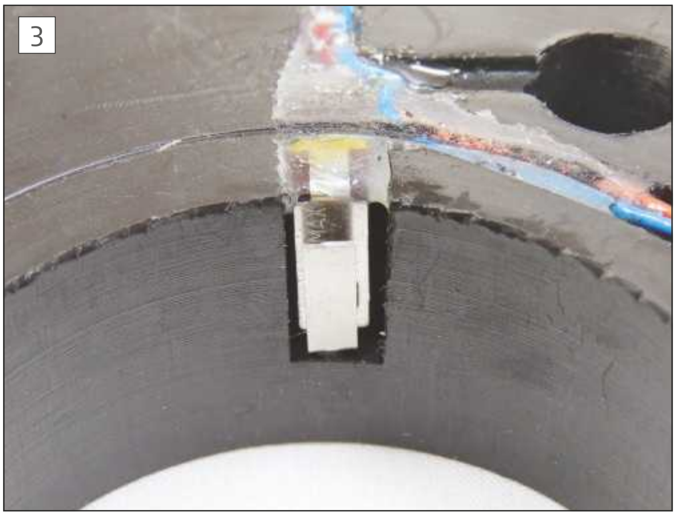
The battery contacts consisted of two parts. The positive battery contact at the bottom of the hole was made from a 12mm disc of nickel silver (but could be any conducting material). I left a small tag off one side for the wiring connection which would pass up the slot in the sidewall. The negative battery contact at the top of the hole was a piece of printed circuit board. This was profiled to fit into a milled recess in the top surface of the ring and held with two M2 fastening screws to allow battery changes.

The negative connecting wire was soldered to the underside of the pcb surface. If the 12mm hole is drilled too deep, then you can either build up the surface of the pcb with solder or solder a small spring in place to make up the shortfall. The wiring arrangement is shown in **fig. 2**. Double sided copper clad PCB is one of my favourite materials for making insulated contacts and for quick fabrications. It has an inherent strength and my experiences and uses are probably worthy of a separate article.

Some means of fastening the ring in place on the quill boss was needed and after experimenting with magnets and O rings, I defaulted back to making a simple 6mm Acetal screw with what I thought would be a nice HDPE knurled knob. Have you ever tried to knurl HDPE?

In principle, the job was complete but

And the top.



Details of the switch.

The laser 'power bulge'

The laser centre fitted to the mill

The laser centre in operation

I should have done the physical mathematics first. While the disc fitted well and the micro switch mechanism worked etc the diameter of the disc was clearly defining the maximum distance of the diode from the central axis. With such a limited diameter disc the laser beam was blocked when the collet nut was in place. I also found that my diode mounting hole was not accurately aiming in line with mill quill central axis (try saying that after a few beers). This meant that when the quill was wound up and down over the job, the beam circle would never achieve a dot, it came close then expand out again. It was going to be difficult to adjust this with the design as it was.

Reluctant to start from scratch and make more plastic swarf, I decided to add a 'power bulge' off the side of the existing ring which would now contain the diode. This had two benefits. It increased the diode mounting distance from the axis and so avoided the interference of the collet nut with the beam. It also meant that the diode mounting could be finely tuned to adjust the beam direction to allow alignment with the quill axis. A grub screw was also fitted to grip the diode once aligned in its mounting hole. This additional mounting block was made from Acetal.

See **photos 1-4** for general views. Ignore the various unused holes which are from my first attempts.

The assembly was re-wired and the wiring potted in the milled channels with twin pack.

This power bulge modification to the ring fulfilled all the objectives and I now had a very useful alignment aid that could be quickly slipped on and off the mill quill boss. I can now align to a point on a job or find the centre of a work piece while leaving a tool in place in the collet. See **photos 5** and **6** for the device when fitted to the VM-B

I have not gone into detail on dimensions as clearly the design is dependent on the quill boss dimensions and available materials. No originality is claimed for the concept and this article has been written more to stimulate and popularise this simple idea.

Note - there is an eyesight hazard associated with the use of laser diodes so please use all sensible precautions and do not stare directly into the beam. In particular, do not use a high-power laser diode, the lowest power (and safest) units are ideal for this use. ■

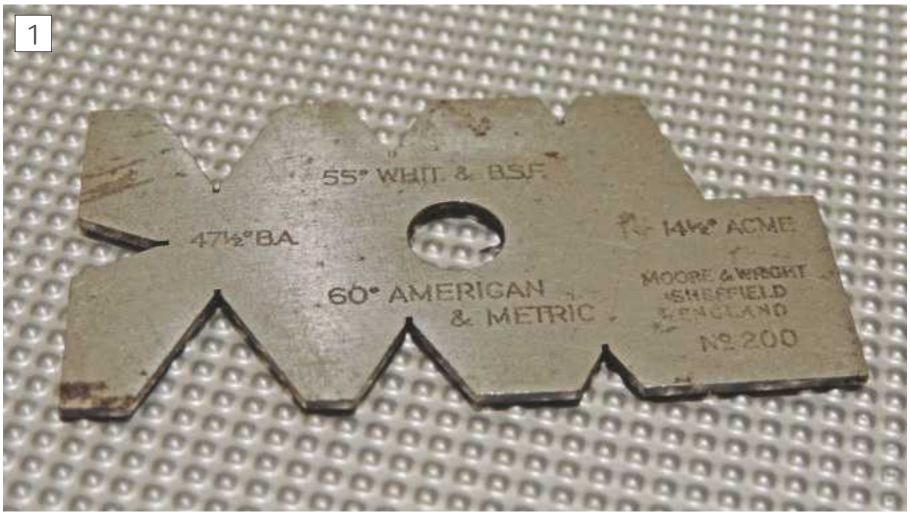
Screw Cutting Gauges – A Comparative Review

The Editor takes a look at a couple of small pieces of metal.

On the forum at www.model-engineer.co.uk I received an unusual request. A discussion about tight-fitting chucks drifted on to the topic of screwcutting gauges. The cost of importing one from the USA was prohibitive, but forum members found a range of different types from UK suppliers. There was a wide range of price and it was noted that Moore and Wright screwcutting gauges were rather more expensive. I was asked to undertake a comparative review. No problem, as I'm sure you would expect, the Editor of MEW has both M&W and economy versions in his well-equipped toolroom. So here are my findings.

For those who may be unfamiliar with screwcutting gauges, they are rectangular metal templates, with various notches cut out to help with grinding and aligning tools for screwcutting. The v-notches are sized to suit 60° metric threads, 55° imperial threads and 47.5° BA threads. A special notch allows tools for 14.5° Acme threads to be checked as well. Alignment is done by placing one side of the gauge against the work, and offering the tool tip up to a notch on the opposite side.

The M&W gauge, **photo 1**, is thinner and is slightly smaller in its length and width than the economy, **photo 2**, but the measurement notches appear to be the same sizes on both gauges. It's hard to be definitive about what material they are made of. The M&W is discoloured in patches, which may be a bit of surface tarnish, suggesting a carbon steel Whilst the economy version looks like stainless steel. A discrete scratch test showed the M&W is significantly softer than the economy version.



The Moore and Wright screwcutting gauge, note the tiny slots at the tip of each notch.

The M&W's markings appear to be etched or laser engraved, while the economy gauge has very clear stamped markings. The M&W markings are fainter and harder to read at a distance. The M&W one has the maker's name and No.200 which the other does not.

The edges of the M&W gauge don't feel as 'sharp' but they are both well finished. it may just be that the M&W gauge is older and has worn through contact with other tools.

The import is noticeably heavier and this makes it a little more pleasant/positive to handle. The slight extra thickness may help alignment when offering up to a sharp tool.

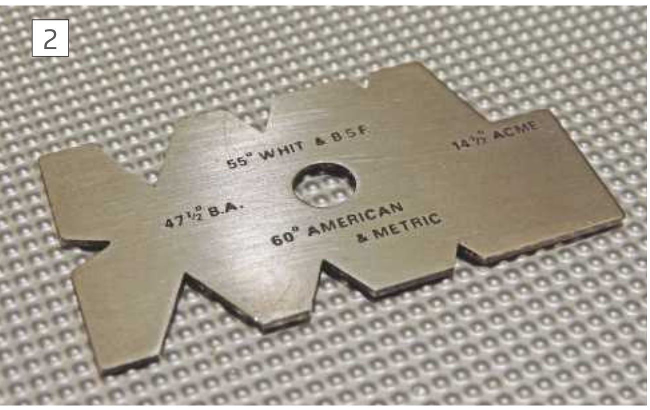
The both have a hole in the middle of exactly the same size. The arrangement of notches is identical, but as mentioned above the imported one is larger and the notches are therefore slightly further apart.

I can't see or feel any difference in the accuracy of the notches comparing the two gauges one against the other.

There is one difference that does put the M&W tool ahead. It has small slits at the bottom of the v-notches and the acme notch has a 'square' corner. The imported gauge has a slight radius in all internal corners.

In many ways the economy gauge appears superior – its markings are easier to read, it has a bit more thickness, has a bit more weight, appears to be of stainless or less easily tarnished steel and it is noticeably harder. In contrast the M&W is smaller (with the same size notches) which makes it a little handier to use. But the main difference is the little notches in the vees. This means that out of these two, only the M&W gauge can be used reliably on a pointed tool that hasn't had the end slightly stoned, which is exactly what you need when you are grinding a tool to match the template. This means the M&W wins by a clear head.

Naturally other 'economy' gauges may have notches or at least more cleanly cut corners, but I would say that if you want to grind your own screwcutting tools, rather than just set them, look for the little slots at the bottom of the V notches. ■



The Economy gauge has clearer markings and is made of a harder steel.

A Tale of Anti-Vibration Mountings

R. Finch describes the trials and tribulations of fitting anti-vibration mounts to his lathe.

My first lathe and workshop were located in a garage attached to our house which had a solid floor. The lathe was a very old, solidly built one which was driven by a flat belt and fast-and-loose pulleys on an overhead counter-shaft to provide a 'clutch' to avoid constantly stopping and starting the motor. The vibration from the motor and the lathe could be heard inside the house and the Domestic Authority insisted that some means of stopping the noise was found as it disturbed the children in the evening. In her opinion, the easiest way was to not use the lathe at all but naturally this did not really appeal to me. I had to find a solution.

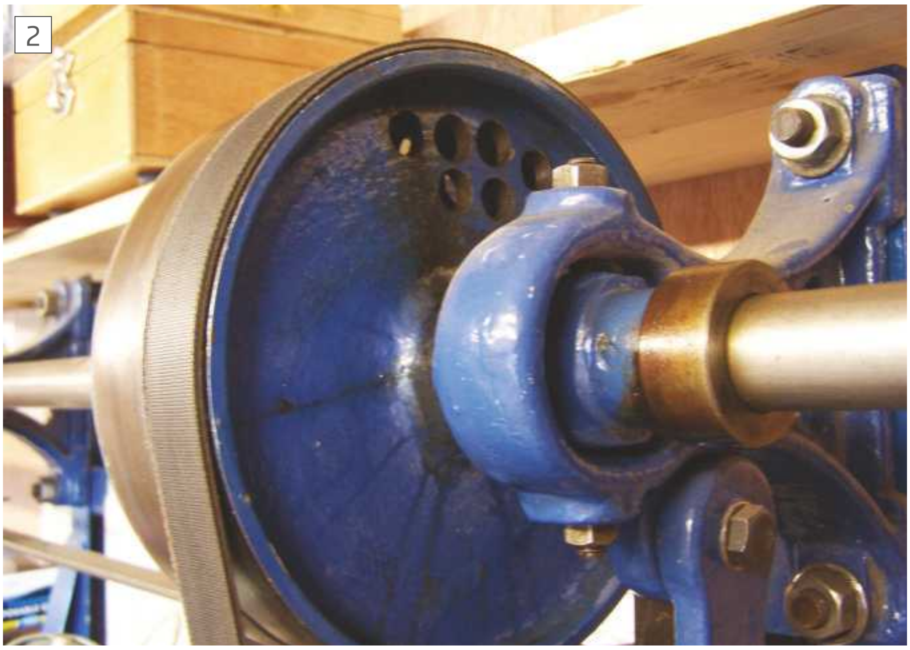
The apparent solution

At the time, I was working as a project engineer installing a chilled water system and the refrigeration units were large – both were some 2 metres long, 1.5 metres high and about 0.6 metres wide. As these had reciprocating compressors built in, there was a need to isolate these from the floor to minimise sound transmission to the plant offices next door, so rubber strips were provided by the mechanical installation contractors. The rubber strips were about 50 mm wide and 8 mm thick and came in long lengths. Each refrigerator unit was mounted in a steel box frame which was placed on the floor with a strip of rubber underneath the frame, forming a large rectangle under the edge of each unit. There were, of course, offcuts and several of these were 'acquired' from the on-site skip. These are shown in **photo 1**.

1

The rubber anti-vibration strips

2



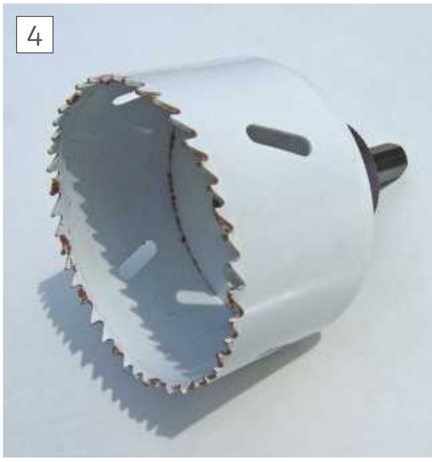
The balancing holes in the pulley

The refrigeration units were quite heavy and the area of rubber mounting was small, so I checked the compressive stress induced by the units on the rubber, and then determined whether the lathe load was too great for them. As it happened, the total weight of the lathe and its stand produced a slightly lower stress level than the refrigeration units, so I jacked the lathe up and slipped four sections under the steel angle frame of my lathe stand to acoustically isolate the lathe from the house. I was sure that there would be adequate sound insulation because the loadings were similar and they worked with the large reciprocating compressors.

Resonance

The lathe motor with the drive belt off running on its own at 1450 rpm was beautifully quiet and ran vibration free so it could no longer be heard in the house. However, there arose a new problem that whilst the motor was running on the 'loose' pulley, the cabinet stand started rocking backwards and forwards about twice a

The offcuts of material



The hole saw used to cut the pads

second – indicating that the 'loose' pulley was out of balance. On leaving the pulley loose and without the belt, it did indeed always return to the same orientation after being rotated, showing a distinct heavy position. Even more interesting was that as the lathe was driven using the 'fast' pulley, the cabinet stand rocked from front to back for a few seconds before steadying and then rocking again. This had me very puzzled, until I noticed that whilst driving the lathe using the 'fast' pulley, the 'loose' pulley idled and rotated on the counter-shaft just a bit slower than the 'fast' pulley. Stopping the lathe motor whilst still driving the 'fast' pulley left the 'loose' pulley rotating and slowing down. The lathe mandrel stopped quickly but the cabinet stand continued rocking whilst the loose pulley was still rotating. This suggested that not only was the 'loose' pulley out of balance, but the 'fast' pulley was out of balance as well. When the rocking stopped whilst the lathe was running, it was because the two pulleys were effectively balancing each other. When the lathe was rocking, the two were making the out-of-balance couple worse. Since the counter-shaft rotated at about 420 rpm or 7 revs per second, it would seem that this was the third harmonic of the frequency of rocking which was about 2 1/3rd Hz.

I had not realised that the 6-cylinder reciprocating compressors were very well balanced and ran at 1450 rpm, giving a vibrational excitation frequency of about 24 Hz for the fundamental frequency and a third harmonic of 72 Hz. both of which were far in excess of the resonant frequency of the refrigeration units on their rubber mountings. I had now discovered that the rubber pad did not have much inherent damping properties but where the excitation frequency was far removed from the resonant frequency of the system, this lack of damping did not matter. However, in my case, with the excitation frequency being effectively the third harmonic of the resonant frequency, some resonance was bound to occur and better balance and more effective damping were required.

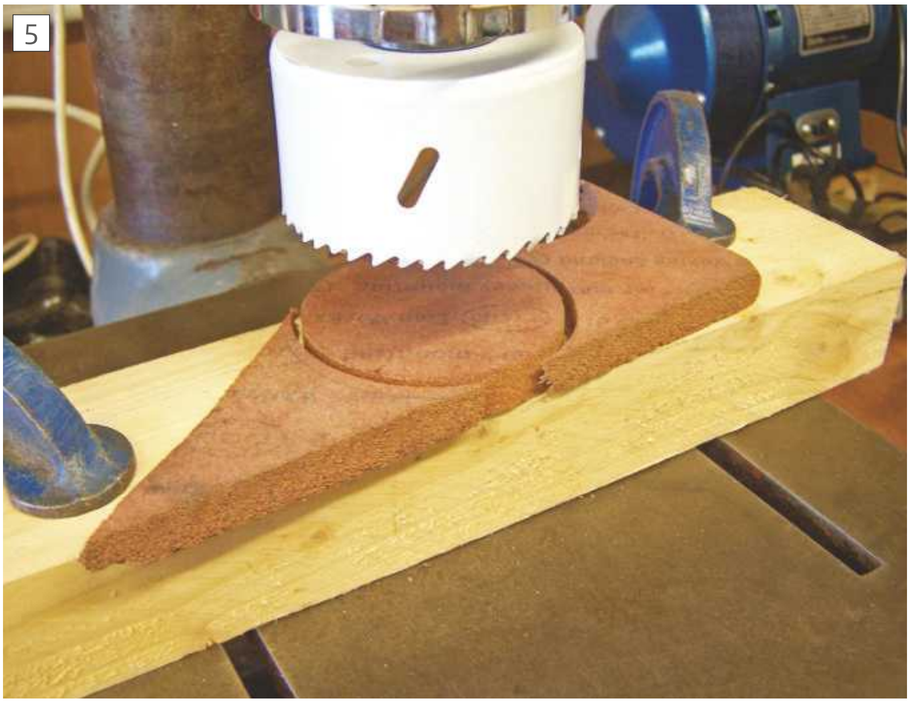
A question of balance

Not having access to any dynamic balancing equipment, I statically balanced the 'loose' pulley by drilling 12mm holes in the web of the pulley on the heavy side on a trial and error basis until the pulley was reasonably balanced statically, **photo 2**. I did the same for the fast pulley, with the holes visible through those drilled in the loose pulley. On re-assembling the counter-shaft, there was a great improvement, but again, there was still some rocking depending on the which speed was selected for the mandrel. This indicated that the mandrel pulley was also out of balance.

I dismantled the lathe mandrel and on inspection the casting forming the mandrel pulley was cast slightly eccentrically, and also had a single thick web cast into the hollow part. This web had been drilled for an oil hole from the flat pulley surface to the mandrel to allow lubrication of the pulley when running on the mandrel in back gear. I decided that the best course of action was to try to remedy the imbalance by removing the web and replacing the oil feed with a short length of copper tube fitted into the oil holes. On reassembling the mandrel, there was a great improvement, but the lathe, rather like me, still felt rather unsteady on its feet due to the softness and lack of damping of the natural rubber mounts.

Salvation

As it happened, I did not need to continue with the wobbly lathe as I had to move the



The set-up for cutting the circular pads without a pilot hole

A pad cut out very cleanly

lathe from the garage to a new shed – a growing family required a larger car which meant that the workshop had to go from the garage. Capital expenditure sanction for construction of a new shed down at the bottom of the garden was sought, and granted, from the Domestic Authority. With the lathe in the shed, it did not matter whether there were vibrations or not – as it was down the garden the noise did not affect the Domestic Authority, so I simply mounted the lathe cabinet stand on the wooden floor on which it stood firmly.

More scrap arises

Some years later, I was involved in safety work on a new pharmaceuticals intermediate plant in the North East. I knew the project engineer very well, so a tour round the plant was arranged. There was a centrifuge being installed and was mounted on sheets of anti-vibration material, made from finely graded cork particles held together with a nitrile rubber binder. This had quite positive vibration damping properties and was ideal for the task. It also had a high loading capability, and did not 'creep' or extrude under load. As the centrifuge was being installed on the day of the visit, I was able to request that any offcuts of the anti-vibration pads were kept for me as I thought that, rather than go into a skip, they 'might come in handy' one day. A few days later, a package of offcuts arrived in the internal mail and were duly placed in my 'Engineering Stores'. Samples of the offcuts of material are shown in **photo 3**.

A different problem

Having had my workshop in the wooden shed for about 20 years, I retired and a house move was made, of course resulting in the inevitable relocation of the workshop. This time, I had a double garage with a concrete floor, detached from the house, so vibration would not be a problem. However, the concrete floor of the garage had been given a 'float' finish so that whilst it was smooth it was not entirely flat having slight undulations across the entire floor. This meant that the steel cabinet of the lathe did not sit on the floor without rocking. I decided therefore that whilst I could pack it up on wooden strips, a much better solution would be to use the anti-vibration pad material scrounged many years before. Although it is manufactured in various thicknesses, I was stuck with 12 mm thick material since that was the thickness I had been given. If it would support a large centrifuge, it would do for my lathe. With the price for a whole sheet 1200 mm square being around £400, I was happy with my pieces, although there are Engineers Merchants who will supply cut lengths off the sheet in various widths if only a small quantity is needed.

The ideal solution

I decided to make the machinery mounts as a steel foot with the pad inside. The maximum loading suggested by the manufacturers is 35,000 kg/m^2, so I thought that a load of only about half this would be ideal as it would allow for any additional equipment stored in the cabinet stand. The pads were cut out using a standard hole saw, but without the pilot drill (**photo 4**). As the material is somewhat flexible, I had to find a way of holding it securely whilst drilling. I did this by attaching the material using double-sided sticky tape to a block of softwood clamped to the drilling machine table. I very slowly fed the hole saw into the offcut using bottom speed of about 500 rpm on the drill (**photo 5**), withdrawing it frequently to release the dust which I removed at source using the workshop vacuum cleaner. After using the hole saw, the pad was removed from the wood quite easily and can be seen in **photo 6**.

I made each foot from 230M07 mild-steel round bar and made a recess two-thirds of the pad thickness in depth to take the pad, machined using a boring tool. This proved quite challenging to produce a flat surface without a through pilot hole. I drilled the largest hole I could down to the required depth, and then flat-bottomed the hole using an endmill. I followed this by simply taking very light cuts and slowly bringing the boring tool out using the cross-slide to the correct diameter, as in **photo 7**. The top was drilled and tapped to take a stud to allow for adjustment of the foot to level the lathe. As the lathe is of 1935 vintage, I used imperial screwed rod to be compatible with the rest of the lathe. Using screwed rod allowed the lathe to be levelled by adjusting the nuts on the stud. Attaching the pad into the recess was accomplished by the use of double-sided sticky tape, although an impact adhesive could have been used. All that is necessary is that the pad is retained well enough so that when the mount is placed in position, the pad does not fall out. One of the final finished mounts is shown in place in **photo 8**. I was so pleased with the feet that I decided to make a second set, **photo 9**, when I bought a new milling machine.

Conclusions

Overall, I have found that natural rubber anti-vibration mounts are not really suitable for a lathe or other workshop equipment due to their inherent lack of damping, despite their good acoustic isolating properties. Pads made from graded cork particles bonded with a synthetic rubber binder make good anti-vibration mounts with a firm support yet adequate sound insulating properties. ■

The flat recess for the pad

A finished mount in position

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