No.273

PLANS, TOOLS, TIPS AND TECHNIQUES

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INSIDE

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- Making a Facing Head
- Large Capacity Milling Vice
- Ron Wright's Milling Aids

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COVER STORY

Fabricating a George Thomas Versatile Dividing Head

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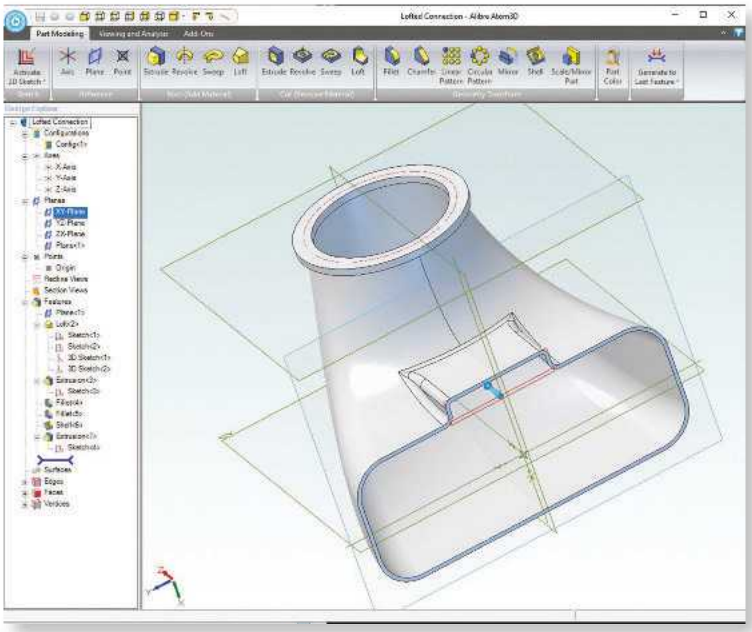
On the Editor's Bench



alibre ATOM3D

Coming Soon – Introducing 3D Computer Aided Design

One of the things I have been trying to get to happen for readers of Model Engineers Workshop is a practical introduction to 3D CAD (Computer Aided Design). I use CAD to help me solve all sorts of design issues as well as producing plans (such as my boring head which appeared in MEW some while ago) and, of course, designing parts for 3D printing. The tricky part is that for a series to be successful, readers need to be able to access the software – and for long enough to really try it out rather than a short trial.

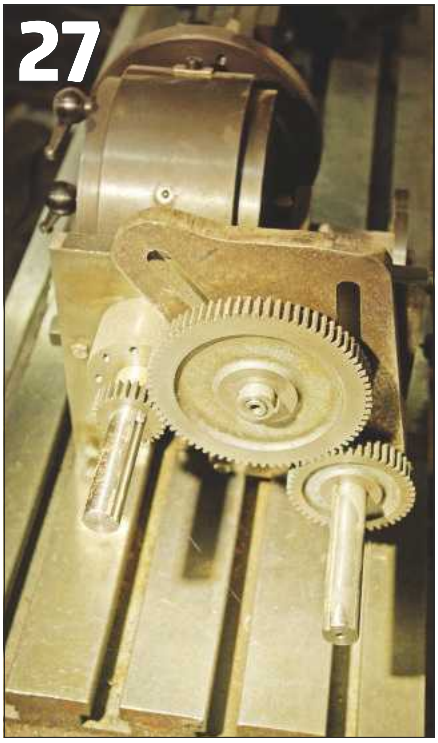
I'm delighted to introduce an incredible offer for all Model Engineers' Workshop readers – an extended free trial of the incredibly capable Alibre Atom3D computer aided design software. Atom3D is a hobbyist version of the widely respected Alibre CAD drawing package. Unlike may other hobbyist packages it has several advantages:

It isn't cloud based so all your files sit on your own computer, so you have full control over your creations and aren't dependent on a good internet connection. Although it is a 'reduced' version of the professional package, it hasn't been hobbled by taking out important features for designing or limiting the number of parts you can assemble – instead features needed for a production environment have been removed. Most importantly, unlike most hobby packages it's fully parametric so if you decide to change a part, right from the beginning of your design you can adjust it and the changes 'ripple through' to the finished item without you having to modify any dependent parts yourself.

Alibre Atom3D is ideal for all engineering drawing and modelling applications, from producing 2D plans to preparing parts for CNC production and 3D printing. It even allows you to test the movement of your mechanisms on screen in 3D! Atom3D requires a reasonably modern PC running Windows 7 or later.

The normal Alibre Atom3D trial is for 30 days, but Alibre have kindly agreed a special six-month free trial period for all readers of MEW! Full details of how to download and activate your trial of Alibre Atom3D will be in our next issue – together with the first instalment of a four-part tutorial which will also be backed up with exclusive content and a discussion topic on our forum at www.model-engineer.co.uk.

Contents

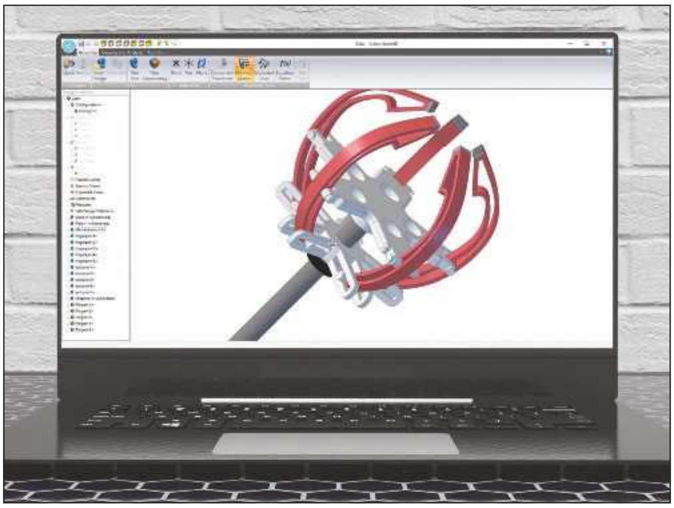


See page 52 for details.

Coming up...

in our next issue

Coming up in our next issue, MEW 274 a tutorial series to get you started in 3D Computer Aided Design. Written specially for MEW Rob Footit's series will start right from the basics and be accompanied by example files and a discussion space on our website. Best of all, you will be able to enjoy a special SIX-MONTH free trial of the outstanding Alibre Atom3D software.



Regulars

ON THE COVER

This month's cover shows Pete Barker's fabricated body for his fabricated Versatile Dividing Head to the George Thomas design. To find out how you can do the same, see the full article starting on page 40.

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THIS MONTH'S BONUS CONTENT

Log on to the website for extra content

This month you can download an introductory article on the Arduino, together with instructions for making your own 'Shrimp' Arduino expansion board, previously published in Maker World Magazine.

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

Where are you? Come and join one of the busiest and friendliest model engineering forums on the web at **www.model-engineer.co.uk?**

Another workshop insulation question

- A great overview of options for insulating your workshop in this discussion

Motor Cycle General Discussion

- Love bikes? From vintage classics to speed records, join one of the most popular 'chat' threads!!

5 inch 0-4-0 Shunter

- It need not take years to make a working locomotive. Take a look at what Ron Laden has achieved in a few months.

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

CLASSIFIEDS EXTRA SUBSCRIBE ARCHIVE SUPPLIERS

A Facing Head

Brett Meacle makes a useful accessory from a lathe topslide

I purchased a small shaper a few years ago now, and as usual with shapers, it was missing its vice.

The shaper is an Australian copy of the Atlas 7" and as the chances of finding an original vice were very slim, I decided to make a copy of the Atlas Vice, a rotary table and an indexing head while I was at it.

I searched the web and found what information I could to draw up the components. Patterns were made, and castings duly obtained and seasoned for a good few years, I'm not the fastest worker in the west. **Photograph 1** shows the 3 main castings for the vice.

As shapers seem to be flavor of the month lately, I thought I would start to machine the castings. Turning the square base section in the lathe was standard work in a 4 jaw but as the main body of the vice was too big to swing in the lathe, I started looking at the milling machine to machine the mounting face.

Most of the other work on the vice was going to be done on the mill, including a hole for a centre pin.

I have already made a small boring head to the George Thomas design and it does the job of boring very well. I could have just flattened the surface with a face mill doing a couple of passes. I thought it would be more accurate if it was faced so started to think about making a larger boring and facing head. But it was a project for the future and making a facing head from scratch was going to slow down this project.

1

Shaper Vice Castings.

I then remembered I had a readymade dovetail slide assembly in the form of the original topslide from my 920 lathe as a result of upgrading the cross slide/topslide to beefier components. I thought the basic slide would make a good facing head for light duty work. **Photograph 2** shows the topslide as originally fitted to the lathe.

All that was required was a block to hold the cutting tool, a shank to mount it in the mill and a feed mechanism to automate it. None of the modifications are irreversible and the topslide can be returned to its original state and refitted to the lathe again if it is your only option.

Slide components

To improve the smoothness of the topslide/facing head, an additional gib adjusting screw was fitted as well as a couple of other mods as suggested by GH Thomas, **photo 3**.

The gib strip is doweled to prevent it moving, making adjustments more consistent and a locking screw also added. The gib strip itself was a little too sloppy so while I was doing the other mods, I decided to make a new one. **Photograph 4** Shows machining the edges of the new gib to match the slide dovetails. One side is done, the job flipped over and the other side machined. The gib is held against the slide dovetail with a piece of round bar and packing pieces, clamped by screws in the adjuster holes. To ensure you don't damage the slide doing the final cut, the gib is raised up slightly above the surface using a strip of sheet metal under the embryo gib. These tweaks make for an easier to adjust and smoother slide and are a benefit on any sliding assemblies.

2

Basic topslide.

Drilling addition screw and dowel holes in slide.

Machining new Gib Strip.

Shank

I decided to use a straight shank held by an R8 20mm collet. The shank is just simple turning and boring of a close fitting hole in the nose for the locating spigot. **Photograph 5** shows transferring the three holes from the original mounting plate onto the shank. The only other thing required is to counterbore the holes for the Cap screws.

Tool block

This was made from a piece of cast iron, shaped into a rectangle for a start using inserted carbide face mills, making it easier to hold the block in the mill vice. I drilled and reamed the 12 mm hole for the toolbit and two more 10mm holes for the clamping bolt. An M6 Tapped hole is also required to clamp the toolbit into the block. The outside can be shaped to suit your tastes and to reduce the weight.

When working on components on the mill, drill press or vice it is good practice to pack the work up off the surface. Wood or mdf makes a good protector. If you have packed up the work and are worried about the drill snatching as it breaks through, a piece of metal can protect the surface of the vice or table. With experience you can hear and feel the cutting action of the drill change just as it's getting close to breaking through, **photo 6**. Most amateurs seem to value their equipment much more than those in some other areas, making the effort not to drill holes in vices or drill press tables.

Leadscrew bracket

To make the new feed unit I decided to make a new bracket and increase the length of the leadscrew to allow a little more travel, with the new components the travel was increased to 56mm.

As you are working from existing holes in the slide, it's important to measure the holes accurately so everything bolts up in the correct location. I find the easiest way is to insert a screw or bolt into the hole and measure from a known datum and depending what you are measuring, either subtract or add half the screw diameter to get the correct dimension. Some 15 mm thick cast iron was selected to make the leadscrew bracket. Once upon a time I would have marked out and centre popped the holes, but I usually now just use the mill to coordinate drill the holes.

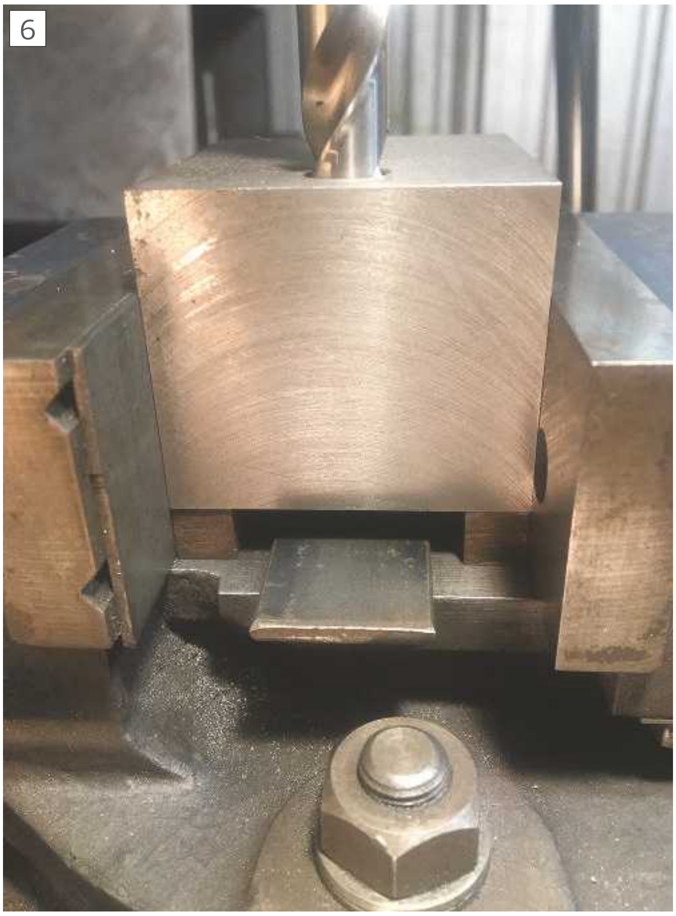
Use an edge finder to accurately find the Datum edges and starting point. To use an edge finder slowly advance the rotating probe towards an edge when it reaches the centre axis of the edge finder it flicks sideways, **photo 7**. You must then advance the spindle half the diameter of the edge finder probe to be on the datum point and zero the hand wheel dial.

Use the hand wheel dials to move to each hole and drill the position with a spotting drill or a centre drill if you prefer, depending on the job it is sometimes better to complete all machining operations at that hole before moving to the next one.

The hole for the leadscrew is reamed 12mm and counterbored 20mm to a depth of 5mm. **Photograph 8** shows using a 20mm end mill to produce the recess. The mounting holes are countersunk to allow the socket head cap screws to be recessed although this could be omitted and just use bolts or Button head screws.

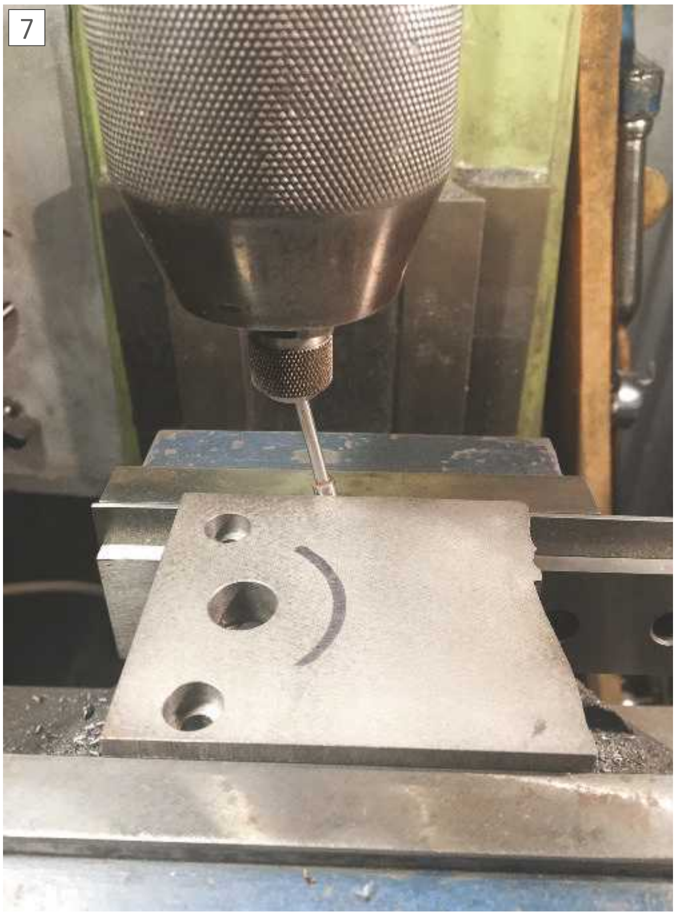
The hole is first drilled to suit the pilot of the counterbore. The hole is then recessed to depth and if necessary the screw hole increased in size to allow some movement. The counterbore I use is called a Super Counterbore, **photo 9**, and is

Transferring holes to the shank.



6

Packing workpiece in vice.



7

Using a GH Thomas style edge finder.

available to purchase in standard sizes in HSS but I have also made a number in silver steel with different counterbore and pilot sizes to suit different jobs. I find the standard cutter sizes are very large on both the pilot and counterbore for each screw size. Once the holes are done the end bracket just needs finishing the outside dimensions and deburring.

Leadscrew

The leadscrew on this style of topslide is a normal M6 thread. If you were converting this on a permanent basis you could increase it to M8 or even a true acme leadscrew.

Material for the leadscrew shank was mounted in the lathe and turned down to fit the reamed holes in the end bracket and ratchet wheel. The large 20mm diameter is machined to fit the recess in the bracket. Part off the finished piece and reverse in the lathe. The hole for the leadscrew is tapped M6 and the flange faced off so it was a snug fit in the recess of the leadscrew bracket. This will help reduce any end float in the leadscrew.

The new leadscrew is a length of threaded studding, cut to length, chamfered and secured into the shank using Loctite.

Index assembly

I decided to fabricate the index wheel in two parts and silver solder them together. Some 25mm material was fitted to the lathe. The hole for the leadscrew reamed 12mm. A 20mm spigot was turned to mate up with the wheel.

8

Machining recess for feedscrew.

The wheel was made from a 75mm square of 6mm hot rolled flat. The centre hole and the 10 division holes were marked out using dividers and centre popped. The 12mm index holes were drilled and the wheel transferred to the lathe 4 jaw.

Photograph 10 shows a 20mm hole being bored with sufficient clearance for the silver solder to penetrate the joint. The 2 pieces were prepped with flux and silver soldered together and cleaned up to remove any flux residue.

The outside diameter and the teeth were then formed on a belt linisher or could be filed to shape as nothing is high precision. The final job was the drill and


9

Super Counterbore recessing end plate.


10

Boring the index Plate.


11

Completed new Components.

tap the 5mm screw hole to attach the ratchet wheel to the leadscrew shank. Assemble the leadscrew into the bracket then fit the ratchet wheel and spot through the tapped hole to locate on the shaft. Drill the shaft to accept the end of a 5mm grub screw to lock the two components together.

Assembly and use

Once everything is made, deburr and clean all the parts up. **Photo 11** shows the new components made for the facing head.

Fit the topslide components together without the leadscrew and adjust the gib screws to obtain a smooth but firm sliding movement for the length of the travel.

Screw the leadscrew into the facing head, fit the end bracket and then fit the index wheel to the feedscrew. Lubricate and check for a smooth operation.

The only other component required is the trip mechanism to advance the cutter with each rotation and as each mill will have different mounting requirements, your design skills will be needed to come up with a solution. Exact dimensions for all of the components are only a guide as there are lots of different designs out there and you can modify the parts to suit your requirements.

Photograph 12 shows the facing head machining the bottom of the shaper vice body.

With a day for making the new components, this facing head completed the job with ease and allowed the vice project to continue on without hitting a major speed bump. A graduated dial could be incorporated into the index assembly and it could also be used as a large diameter boring head as well. Even without a graduated dial you could rig up a dial indicator to advance the cut an accurate amount. It is totally reversible if you are using your working topslide or you could go the whole hog and keep it as a dedicated tool. ■


12

Machining the shaper Vice body.

My Biggest Vice

Howard Lewis makes a confession.


The fixed jaw

Most of the time work can be held in the ordinary milling vice, such as the 100mm Vertex, but every so often a job comes along which is far too big for any available vice. Using clamps, can sometimes mean that the clamps lie on the intended path for the tool.

Imagine the size and weight of a conventional vice capable of holding work 12 inches (300mm) long!

A long time ago, whilst visiting Pro Machine Tools at Barnack, on one of their machines there was what seemed to be just what the doctor ordered. Having returned home some thought was given as to how a similar device could be made for my Mill/Drill. What follows is the end result. It may not see a lot of use, but when needed, it is invaluable. I call it an Infinite Vice, since it accommodates an almost infinite number of sizes.

Construction

This simple device consists of three basic assemblies. A fixed jaw, a moving jaw and a forcing "jaw".

Photograph 1 shows the fixed jaw. This is just a square or rectangular piece of steel with the ends machined square to the faces. The length is exactly that of the width of the table. The material needs to be sized to withstand, without flexing, the forces that are going to be applied. To each end is fixed a rectangular plate, (ideally gauge plate) located by two roll pins and secured by a capscrew. (M6 in my case) Two holes are drilled through what is to be the top face, to match the centres of the T slots in the table, and counterbored to take two capscrews.


The moving jaw


The 'forcing' jaw

I used M8 for this on all three parts.

Photograph 2 shows the moving jaw. This is almost identical to the fixed jaw, except for a centre drilling, placed on the intersection of the vertical and horizontal centre lines, on one face. This is used to seat the ball in the end of the forcing screw.

The end cheeks locate the jaws so that there is no unwanted movement across the table, and the width of the cheeks holds the jaws square across the table

Photograph 3 shows the forcing jaw. This is made from the same material as the fixed and moving jaws, and drilled and counterbored in the same way, but lacks the locating cheeks on the ends. On the intersection of the vertical and horizontal centre lines, it is drilled and tapped ½ UNF.

The forcing screw is a ½ UNF setscrew, selected for two reasons.

1) ½ UNF is 20 tpi, thereby capable of producing a larger clamping force, for minimal rotation and applied torque, than a coarse thread.

2) There was one immediately available!

The end was chamfered, and drilled to just clear a ball bearing, to a depth a little over half the diameter of the chosen ball. The ball was placed in the drilling, and the edges peened over, to retain the ball.

All that now remained to do, was to make up six T nuts to fit the T slots in the table, each with a M8 tapping.

After deburring and cleaning all the parts, the Infinite vice was ready for use.

T nuts are positioned in the slots in the table close to where the jaws are to be placed. The fixed jaw is clamped in position, and when the workpiece has been positioned, the moving jaw is brought up to it, but left very lightly clamped. The forcing jaw is then positioned and clamped firmly into place, before using the forcing screw to clamp the moving jaw against the work, which is lightly tapped down with a soft mallet, before the cap screws for the moving jaw are fully tightened.

The vice in use

Photograph 4 shows it being used to hold a piece of aluminium, approximately 100 x 250mm to be cleaned up on the edges.

The workpiece is supported on parallels, so that the 12mm end mill clears the table, and more parallels are placed between the jaws and the workpiece, again to provide clearance for the cutter.

Once the edges had been cleaned up the vice had to be reconfigured to hold the narrow sides of the material. The "long" end of the work needs to overhang the front of the machine to ensure that the material does not foul the column and prevent the table being positioned for machining the ends.

The vice was then reconfigured again. It was then used to hold the aluminium so that the remaining larger surfaces could be cleaned up, using a larger diameter milling cutter.

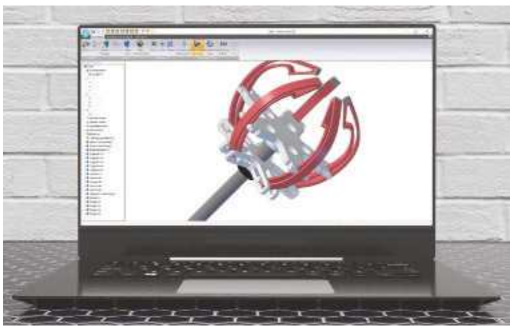
The eagle eyed will have noticed that each jaw is numbered and carries the serial number of the machine with which it is intended to be used. ■

In our Next Issue

Coming up in issue 274

On Sale 2nd November 2018

Content may be subject to change



alibre ATOM3D

The November issue, number 274, of Model Engineer's Workshop will bring you the opportunity to take a free six-month trial of Alibre Atom3D. This fully featured and powerful CAD package is ideal for all engineering and modelling tasks including the design of 3D parts and assemblies, producing engineering drawings and interfacing with CNC and 3D printing. You can even test out the movements of your designs before you commit them to metal!

To back up this exciting opportunity, we will be starting a four-part tutorial series that will take you from the absolute basics of using Alibre Atom3D and get you well on the road of designing your own objects.

Please note you can't access the six-month trial yet – full details will be supplied in the next issue of MEW!

Plus – The Index for issues 261 to 272, a Dore Westbury Mill and making Drummond Toolholders

DON'T MISS THIS GREAT ISSUE - SEE PAGE 52 FOR OUR LATEST SUBSCRIPTION OFFER

Converting a WARCO WM280V-F Lathe to 3 Phase Operation

Barry Chamberlain takes a look at fitting a variable frequency drive to a lathe, focusing on the practicalities involved. Part 3

New design Power Supply PCB

Splash Back Panel areas marked for material removal

Merfyn making first cuts with his plasma cutter

Part way through 2nd cutting operation – first panel removed

The factory installed Warco Speed Display and Input Sensor Unit require 5v and 9v supplies. Rather than build a separate 12v power supply solely for the fan a new Power PCB was designed to provide all 3 power rails using the same PCB footprint as the now redundant Filter PCB, **photo 21**. The original insulated plate was used to mount the Power PCB to the component shelf.

The mains wiring was disconnected from the rear cover panel and discarded. It was replaced by a suitable length of 2.5mm screened 3 core cable fitted with a 13Amp plug. The live wire was soldered to the existing 12Amp fuse holder mounted inside the rear cover panel. The wires were then connected to a floating terminal block, the screening woven wire being sleeved and connected with the earth lead. The brown and blue flying leads previously connected to the Contact Breaker were connected to the mains terminal block, and the earth lead from the headstock connected to the mains terminal block.

Splash Back Panel

Offering the splash back panel back into position confirmed that a degree of rework was required where the rear of the motor was concerned. Note that the marked 'curved' cut out area, **photo 22**, extends 30mm from the edge of the panel. Rather than produce a complex drawing the three photographs should be sufficient to follow required cuts, **photos 23** & **24**. To minimise distortion of the relatively thin sheet metal a friend kindly offered to assist and used his plasma cutter to remove the excess material which saved a lot of time and effort. When the cutting was complete the edges were smoothed up with a small hand-held grinder. The panel was temporarily refitted, and a card template produced to give adequate clearance

Refitted, sealed and painted Splash Back panel

over the rear area of the motor. When a satisfactory form was achieved the pattern was transferred to a 1mm thick steel sheet, cut out and formed to shape, then tack welded to the splash back panel and painted, **photo 25** and **fig. 7**. The remaining gaps were sealed using filler and the area repainted. When re-fitted, there was approximately 15mm clearance between the rear of the motor and the modified splash back panel - more than sufficient to allow the motor rear cooling paddle (not a fan) to disperse the warm air produced when operating the motor.

Invertek Optidrive

With power applied it is necessary to set up the controller. At first sight the manual is somewhat overwhelming but after an evening's study it becomes relatively straight forward. With power applied, parameters are selected/entered by use of the front panel keypad. The main three buttons of interest are the Navigation and the Up and Down buttons. The remaining buttons are used for START and RESET/STOP when operating directly via the panel.

Pressing the NAVIGATION button for more

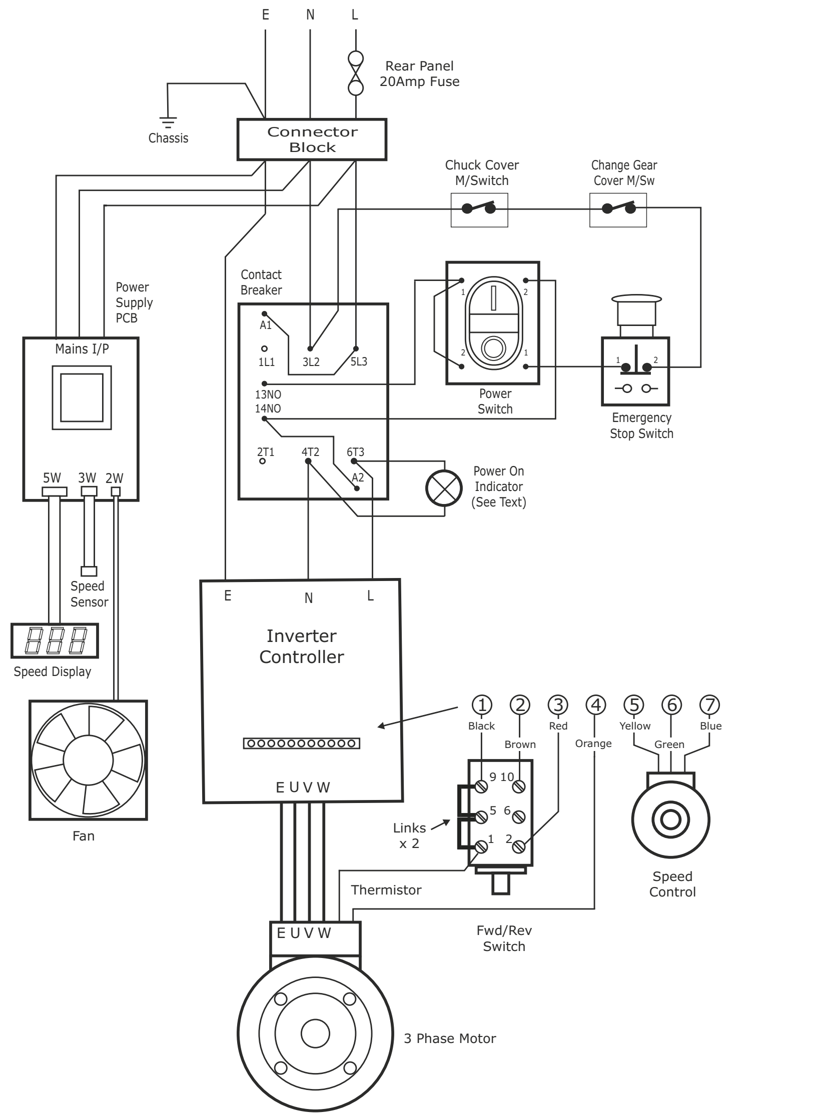


Fig. 1 SCHEMATIC WIRING

Invertek Parameter Table

Par	Description	Minimum	Maximum	Default	Units	Set
PO-1	Max Frequency/Speed Limit	PO-2	500	50.0	Hz/RPM	85.0
PO-2	Min Frequency/Speed Limit	0.0	PO-1	0.0	Hz/RPM	0
PO-3	Acceleration Ramp Time	0.0	600.0	5.0	Seconds	5.0
PO-4	Deceleration Ramp Time	0.0	600.0	5.0	Seconds	5.0
PO-5	Stopping Mode	0	2	0	-	0
PO-6	Emergency Optimizer	0	1	0	-	0
PO-7	Motor Rated Voltage	0	250/500	230/400	V	230
PO-8	Motor Rated Current	Drive Rating Dependant			A	5.8
PO-9	Motor Rated Frequency	25	500	50	Hz	50
PO-10	Motor Rated Speed	0	30000	0	RPM	0
PO-11	Voltage Boost	0.0	20.0	3.0	%	4.2
PO-12	Primary Command Source	0	6	0	-	0
PO-13	Trip Log History	N/A				
PO-14	Extended Access Code	0	9999	0	-	101
PO-15	Digital I/P Function Select	0	12	0	-	6
PO-37	Access Code Definition	0	9999	101	-	101

›

Chuck Safety Cover restrained clear of the chuck

than 1 second causes the display to change to PO-1 indicating parameter 01. The displayed value is modified by use of the UP and DOWN buttons until the desired value is indicated followed by pressing the NAVIGATION button once more to store the value. Pressing and holding the NAVIGATION button for more than 1 second returns control to real-time mode, although the controller will revert to real-time mode after 20 seconds if no further selections are made.

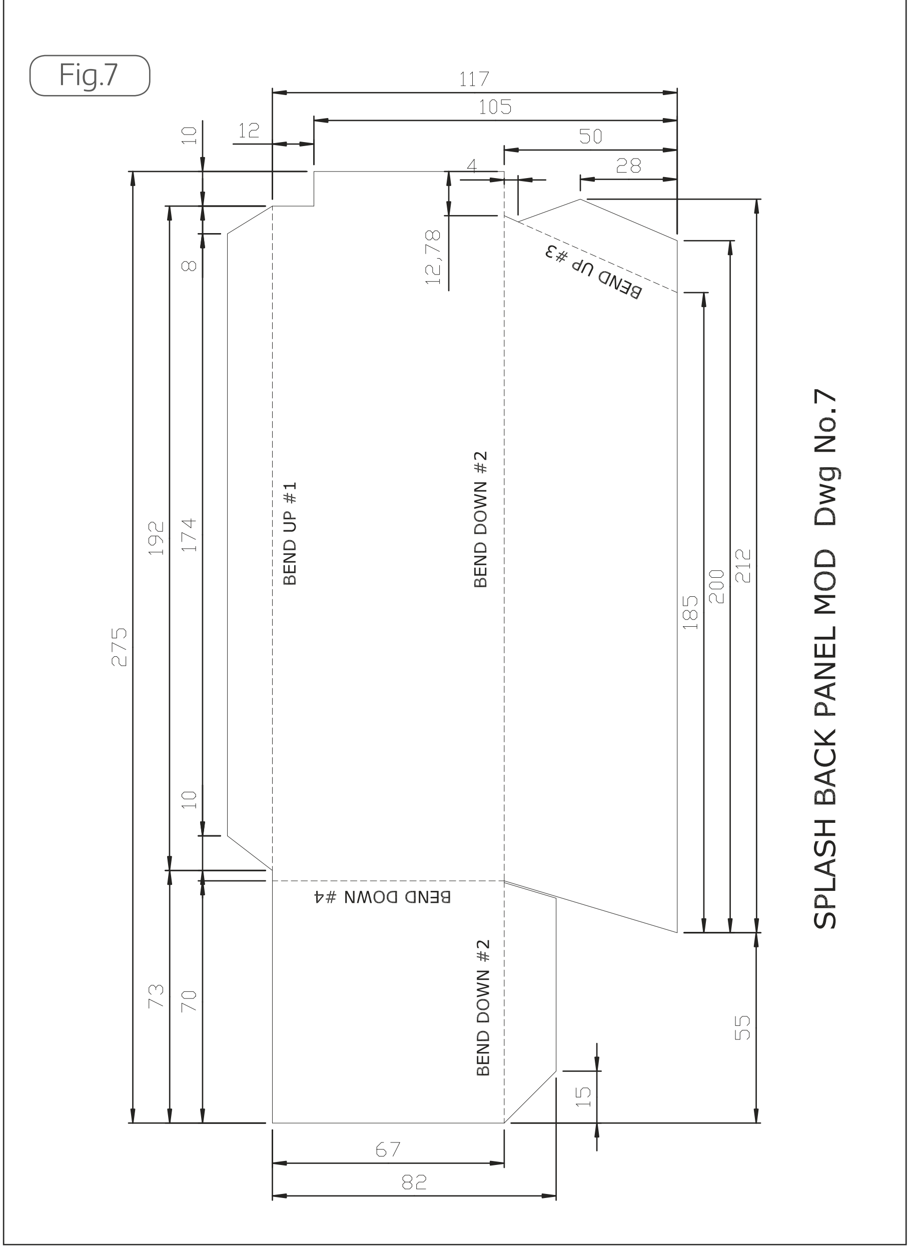
The Invertek controller has 50 available pre-set parameters (many have further sub-set options) making the unit extremely versatile. The parameters used in this particular application are set out in the table below.

Note: Parameter PO-14 must be set to the same value that is stored in PO-37 in order to access parameter codes above PO-14, the default value being 101.

The PTC thermistor leads are connected to Terminals 1 & 4 on the controller. In order to monitor this resistance (and hence the internal temperature of the motor) the value of parameter PO-15 was set to 6. This setting is dependent upon parameter PO-12 being set to 0.

Although it is possible to enter a maximum frequency up to 500Hz, parameter (PO-1), a practical maximum might be no more than 100Hz, i.e. double rated label motor speed. In this case it has been set at 85Hz.

Tool Tray with chuck keys stored in holders



The controller offers 3 display options, namely Motor Shaft Speed, Frequency or Current.

The displayed Motor Shaft Speed is an approximation of motor rpm derived from the maximum frequency set by the user and the rated speed entered from the figure stated on the motor rating label. This is only useful when running motors with a direct shaft drive.

Similarly the frequency display is not particularly useful. The display was, therefore, selected to display current which has some relevance in terms of work being done. Fortunately, the Warco lathe features an rpm indicator displaying true chuck speed.

Chuck Safety Cover

It was apparent that the original Chuck Safety Cover would no longer function as before being now 100mm above its original location. To resolve this problem an extension arm was designed, see fig. 8. Because the rear of the lathe is pretty close to a workshop wall pillar the radius of operation meant that the cover would no longer pass beyond the vertical so a "keeper" was fashioned out of a 20mm x 200mm strip of steel which, with a small notched aluminium bar, allows the guard cover to be retained clear of the chuck when required, **photo 26**.

Tool Tray

A 9mm thick plywood tool tray was designed to fit above the headstock and gear change cover, **fig. 9**. It is bolted to the control panel with 8mm stainless button head bolts through existing holes. This covered the panel holes, isolating the electrical components and provides a neat alternative to having tools floating around on the headstock. Because chuck keys tend to wander, a small holder was constructed out of two short lengths of brass bar and a brass keeper plate. In **photo 27** the main chuck key plus two smaller keys can be seen. The smaller keys were made to assist with setting an independent 4-jaw chuck and are safely stored on the side wall for the occasional times when they are required.

Testing

In order to see just how much power was available the lathe was set up for parting off a 25m diameter mild steel bar. Using an inverted 3.2mm (1/8") wide parting off blade the lathe was set to run in reverse and the tool set to automatically advance using power cross feed to create consistent


Up and running again

and repeatable conditions. The lathe speed was continually reduced until the machine faltered. At this point the speed was gradually increased until a clean cut was obtained at a constant chuck speed. Surprisingly, when set to between 27 and 32 rpm the machine operated well and the parting off operation was completed with no signs of labouring. Most impressive.

Conclusion
Apart from running a lathe with a "bullet proof" controller which provides a high chuck torque and guards against any overload or underload condition, the main change is that previously the direction of rotation was selected first, then the motor controlled with the On/Off switch, **photo 28**.

With the revised circuit, from the moment that mains power is applied the 90mm fan runs continually. The Invertek controller is powered up when the On/Off switch is switched on, indicated by the green LED. Motor start up is dependent upon the direction selected with the Forward/Reverse switch. Because this switch is only handling a small signal voltage, switch failure over time is not anticipated to be a cause for concern even when a high speed has been set. This sequence takes a bit of getting used to but soon becomes the norm.

Engineering Club Membership
My local engineering club, Banbury and District Model Engineering Society, meet once a month when speakers are booked to give illustrated talks, or for less formal member's evenings when projects and techniques are discussed. Such was the case with this particular project - the help, encouragement, and assistance that was offered was found to be invaluable as the weeks went by.

In particular, I would like to acknowledge input by Steve who suggested making a plywood prototype backplate and motor mount to check the viability of the task before committing to cutting metal. Not only advice but practical help came too, as lacking welding or plasma cutting equipment a vote of thanks is due to Merfyn who offered to assist when required. Bill was also a great help in the workshop each week, particularly when two hands weren't sufficient! Mustn't forget to mention Richard who grabbed the tool tray plans and plywood, and reappeared three days later with a completed tool tray! Finally, Steve kindly stepped in again when asked to proof read this article.

Hopefully the above will encourage readers to join a local club where they may also enjoy the company of like-minded individuals and benefit from a wealth of knowledge and help to enhance their workshop experience. ■

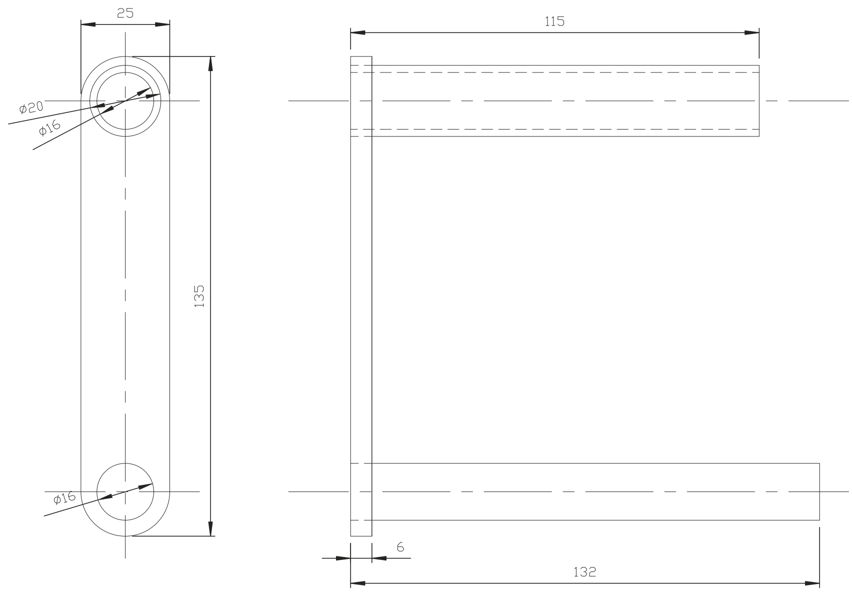


Fig.8 Cover Guard Extender Dwg No.8

Supplier Details
Three Phase Motor 1.5kW, 2 pole, B34, 80 Frame – **www.swmotorsandfans.co.uk**
Invertek Optidrive ODE-2, 1.5kW Single Phase IP20IN 3 Phase Out - **www.motorcontrolwarehouse.co.uk**
Contactum SB252015 IP65 Metal Enclosure - **www.contactum.co.uk**
Laser Cut Motor Plate - **www.lasermaster.co.uk** – (copies of Motor Plate drawing available on request)
LED – 230v LED CML 19350231 Rapid Electronics Part No. 59-6765
28mm OD Corrugated Flexible Cable Conduit Tubing
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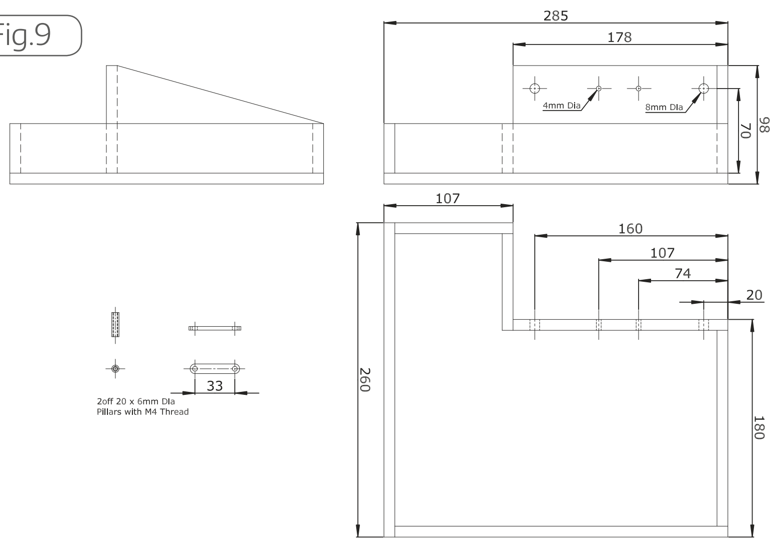
1.5mm/14AWG Motor cable 3 core plus earth screened cable.
8 Core Multicore Cable 7/0.22 Small Power Cable
PCB – The author would be willing to make assembled PCBs available if sufficient interest is expressed.

Fig.9


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The modified spanner

Four Gadgets

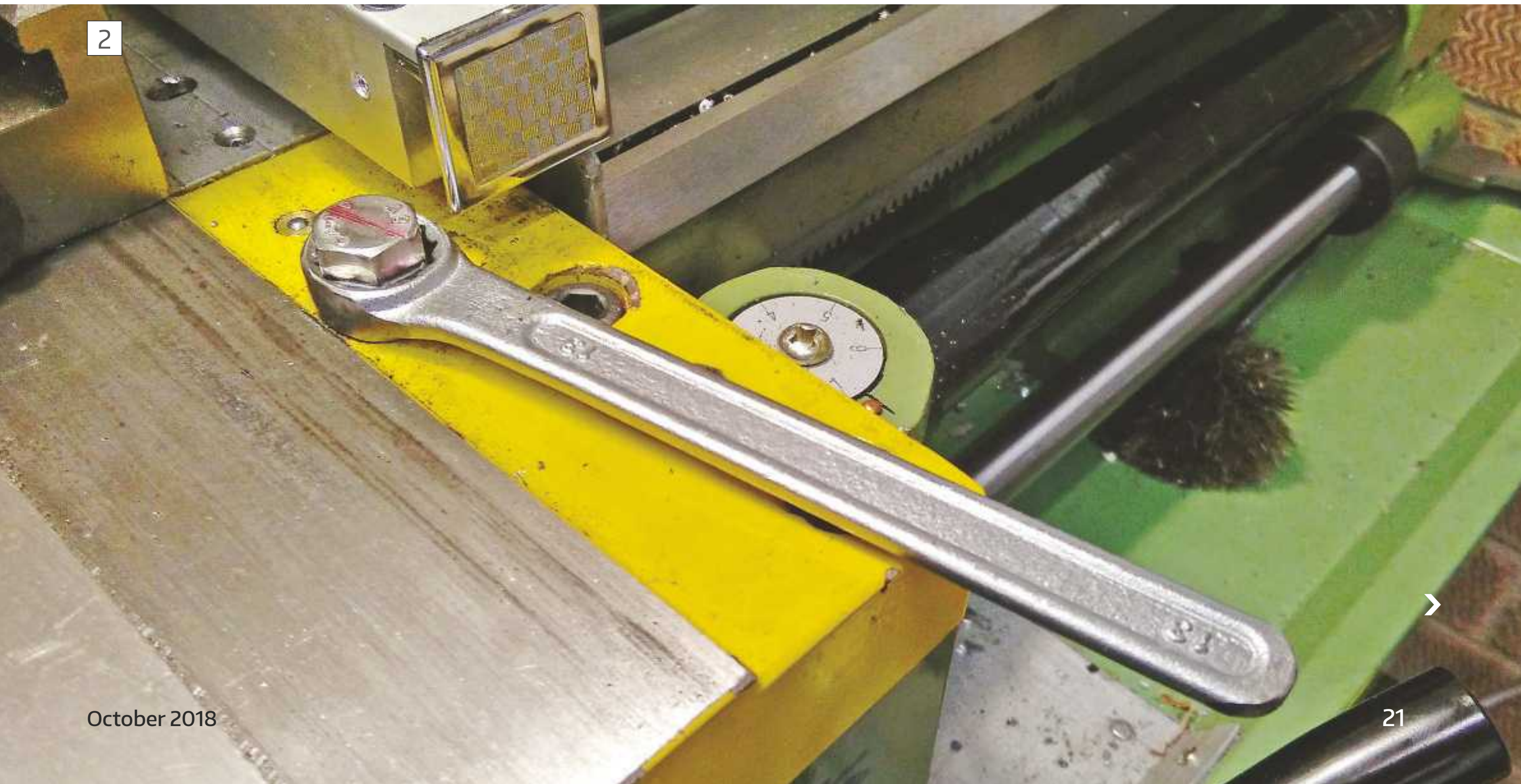
Nigel W. J. Taylor describes four simple workshop tools, each unrelated to the others but all useful

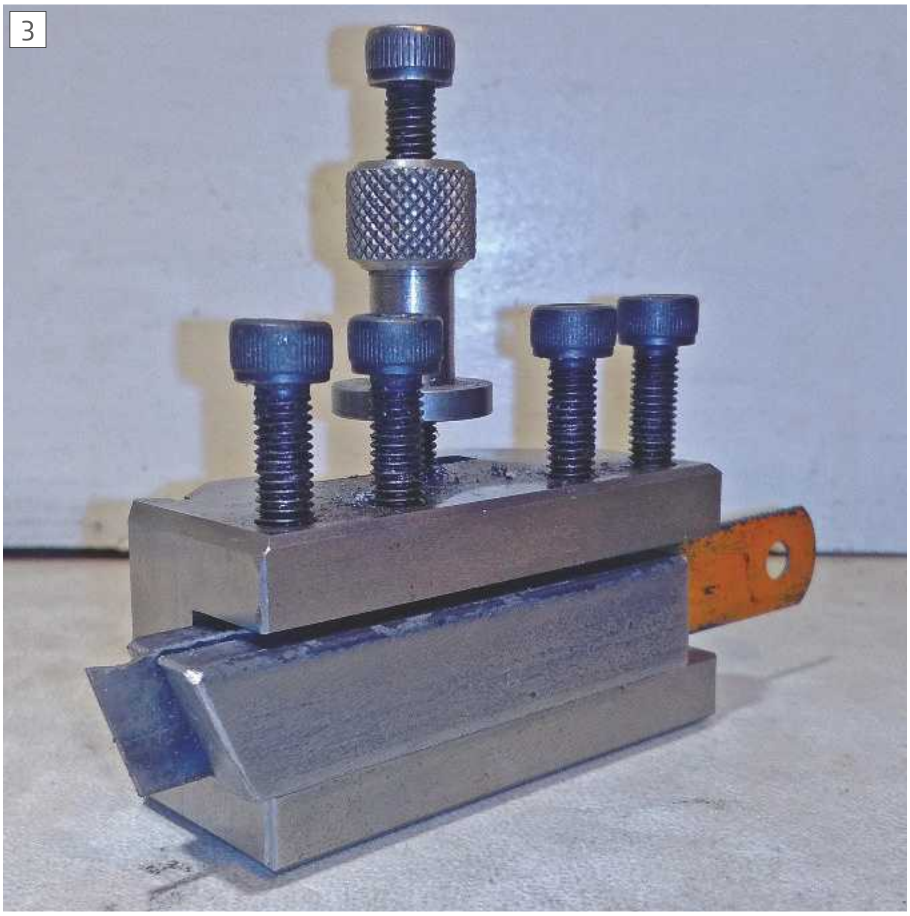
Improved Saddle Lock

The saddle lock on my Warco 290V lathe required the use of an Allen key (other brands are available!) This would be ok was it not for the fact that the top slide was frequently in a position that prevented the key fitting in. I replaced the bolt with a hexagon headed one, onto which I threaded a nut tight under the head to make it deeper.

Breaking into my piggy-bank, I made a trip to Poundland (other similar shops are available) and bought a set of three spanners, including the 13mm one I required. A little time spent using my grinder made the ring end smaller in diameter to give clearance for the cross slide and removed the open end, **photo 1**. A worthwhile, low-cost and quick improvement, **photo 2**.

The new saddle lock lever in use



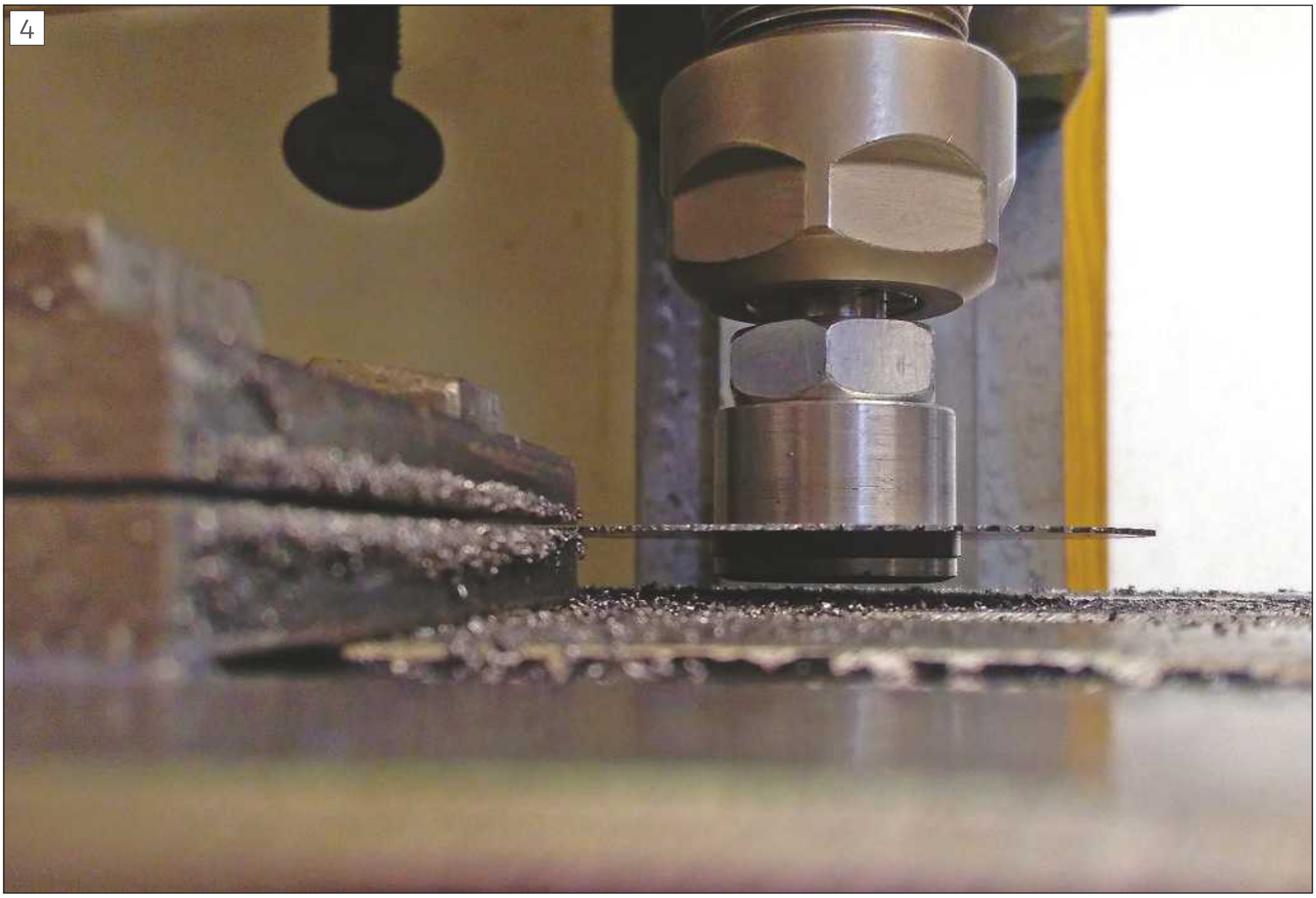

Hacksaw Blade Parting-off Tool Holder

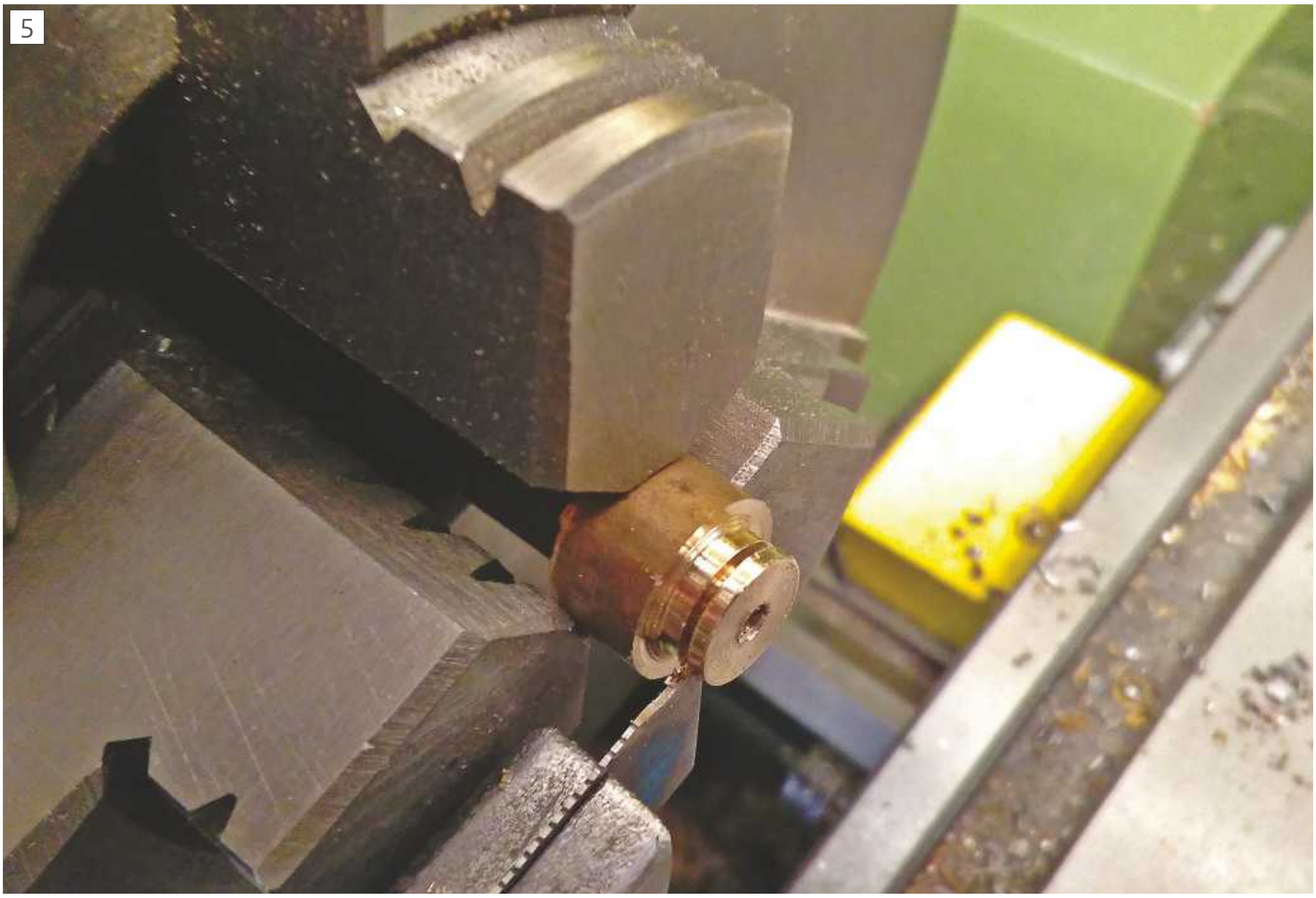
Hacksaw Blade Parting-off Tool Holder

Neither the holder design (I think I saw it on YouTube) nor the use of a hacksaw blade to part-off is original, but I've not seen the two ideas put together, **photo 3**. The holder is a piece of 12mm square steel. A slot is cut in it, just less than the depth of the hacksaw blade and the same width as the blade. In my case, I used a slitting saw to make an initial cut, **photo 4**. I then used a hacksaw, having taken the set off the teeth with the careful use of a hammer(!), to widen the slot to make a tight fit for the parting blade. The blade is slipped into its holder, and then I put it into my quick release tool holder, with the grub screws tightening down onto the top of the hacksaw blade, holding it tightly down. **Photograph 5** shows the tool in use, making a thin M3 nut (threaded washer?) to repair the handle on a friend's leather music case.

Low Profile Slitting Saw Arbour

When I got a set of slitting saws and an arbour, I found the arbour made positioning the workpiece awkward. I also thought it looked clumsy, so I designed and made a low-profile version, **photo 6**. It has three parts, the body, the collar and the nut, **photo 7**. My slitting saws are 5/8 inch internal diameter, so that is the size of the bottom portion. The flange is 7/8 inch diameter and 3/32 inch thick. The collar


Making the initial cut with a slitting saw



Parting off a special brass washer

The low-profile slitting saw holder

On the Wire NEWS from the World of Hobby Engineering

Expo Tools Catalogue

The new Expo 2019 Catalogue is due for release towards the end of September. The release of the Catalogue was delayed due to the additions of a few new exciting ranges of products, we have been assured that it will be worth the wait! The most exciting addition this year is the MIG Ammo range! Details of stockists with the 180 MIG Ammo paint stand can be found inside. Free copies of the 2019 Expo Catalogue will be despatched to customers who have ordered before from Expo Tools, if you are a new customer and wish to get a free copy please visit **www.expotools.com** or visit your local stockist and pick up a free copy!

International Model Boat Show featuring Tamiya Truckin

It's the final countdown to the launch of the 2018 International Model Boat Show which will take place from Friday 9th to Sunday 11th November at the Warwickshire Event Centre.

Over 3,000 visitors are expected to attend the show and enjoy over 600 models on the club and society displays. Over 20 of the leading specialist suppliers will also be present.

As always, the large indoor boating pool will be in full use as all the club members sail their models for the visitor's enjoyment. Some clubs demonstrate as a group such as the RNLI with commentary which visitors find is really interactive and enjoyable. The Surface Warship Association will again lead a poignant sailing tribute at the poolside during the two minutes silence on Remembrance Day.

For younger visitors there will be 'children's sailing' on the pool for their own experience of remote control boating.

As the ONLY 3 day marine modelling exhibition dedicated to all aspects of marine modelling this is an event not to be missed – book tickets now to take advantage of the specially discounted rates at **www.modelboatshow.co.uk**.

A New Book – only from SMEE

Twist Drills – Geometry and Performance: If you have ever wondered why twist drills have the shapes they do and how to set up a drill grinder to achieve the best shape for a particular purpose, then a new book "Twist Drills – Geometry and Performance" by Jörg Hugel should be on your bookshelf. Jörg is a distinguished emeritus Professor of Electrical Engineering Design at ETH Zurich, and a well-known SMEE member.

The book has 80 pages, in a handsome hardback format. It contains a detailed analysis of the design features required for proper performance of both conventional cone-type drills and those with four-facet geometry. This is followed by a description of methods for accurate measurement of the tip profile of a drill, either directly or from photographic data. There is also a discussion of the advantages and limitations of the main types of grinding machines and jigs. The book is accompanied by a CD of Excel spreadsheets which allow you to calculate the profile of the drill tip produced by any chosen combination of the various setting angles in the grinding equipment for either type of drill.

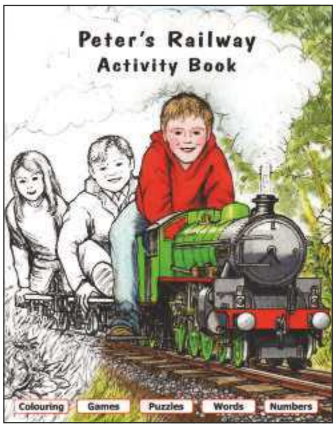
Copies are available directly from SMEE. Only 100 have been printed, so supply is limited. The price is £15 in the UK, including first-class postage. For destinations in Europe the cost increases by £3 and for the rest of the world by £5.50, to cover postage charges.

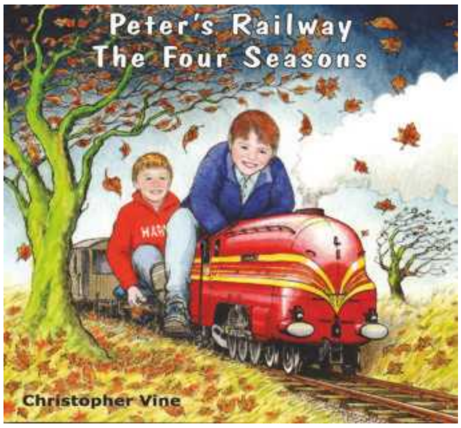
Copies can be ordered via SMEE by emailing **meetings@sm-ee.co.uk**, or contact Norman Billingham at Marshall House, 28 Wanless Road, London, SE24 0HW.

10 Years of Peter's Railway

Peter's Railway is celebrating ten years since the first book was published. With 19 books in the series, they have now sold over a quarter of a million copies. Author Chris Vine, a chartered engineer, has been busy not only writing the books but also creating interactive Young Engineer's Centres, holding school workshops and featuring on the recent TV documentary The Unstoppable Flying Scotsman.

The latest two books in the series include the *Peter's Railway Activity Book* with 32 pages of games, puzzles and colouring pages. In a large format it should keep the interested youngster happy for an hour on Christmas Day! The other new book is *Peter's Railway The Four Seasons* where our young hero learns to play the violin – well no, actually he and his friends have an assortment fo seasonal adventures, including making a sleeper painting machine.





Further information on the Peter's Railway series of books can we found at **petersrailway.com** and more details of Chris' and the books' ten-year journey click on 'Our Story'.

New Chief for London Transport Museum

London Transport Museum has announced the appointment of Elizabeth McKay to the new role of Chief Operating Officer. McKay will work alongside the Museum's Director, Sam Mullins, to deliver an ambitious five-year plan which aims to increase visitor numbers, diversify audience engagement and create exciting new commercial opportunities.

McKay said, "I'm delighted to join London Transport Museum (LTM) as the new Chief Operating Officer. LTM has always been an innovative and forward-looking museum that punches above its weight. I've been impressed by the ambitious plans and an excellent senior leadership team and look forward to contributing to its future success."

London Transport Museum was granted charitable status in 2007 and receives funding through visitor admission income, trading activity, sponsorship, trusts, foundations, public funding and individual giving. In 2017/18 over 400,000 people visited the Museum in Covent Garden.

Cosyfeet backs Street Men's Shed

Cosyfeet is backing Street Men's Shed with a £750 cash injection to purchase a metal working lathe and as well as other tools and materials.

The funding has been made available from Cosyfeet's £750 Community Project Award for Somerset, which is given annually to a local, non-profit initiative, geared towards enriching the lives of older people.

Street Men's Shed provides a meeting place for men to meet, communicate and create using the tools and equipment provided. There are currently 54 members, most of whom are men aged over 65, although membership is open to all.

Members use the Men's Shed facilities for a diverse range of projects including making furniture and fencing as well as restoring objects such as grandfather clocks, vintage radios and fishing rods. They also benefit from socialising with other members, bringing a shared sense of community and purpose.

Street Men's Shed is facing uncertainty over whether it will remain at its current premises in The Tanyard due to an imminent change of leaseholder. Members are hoping to be given permission to stay once the lease changes hands at the end of November.

"Although we are not yet certain whether we will remain at The Tanyard, we have a great deal of local support and a strong future ahead of us," says Club Secretary, Brian Bastable. "This award will enable us to invest in much-needed equipment for the benefit of our members."

Cosyfeet makes extra roomy footwear for people with swollen feet and has an active policy of giving back to the communities it serves. Launched in 2014, the Cosyfeet Community Project Award for Somerset offers a one-off donation of £750 to a local registered charity or not-for-profit organisation working on a project that supports and enriches the lives of older people.

For more information on the Cosyfeet Community Project Award for Somerset visit **www.cosyfeet.com/communityprojectaward**

For more information on Street Men's Shed see **www.streetmensshed.btck.co.uk** or visit unit 10, The Tanyard, Leigh Road on Tuesday mornings or Thursday afternoons.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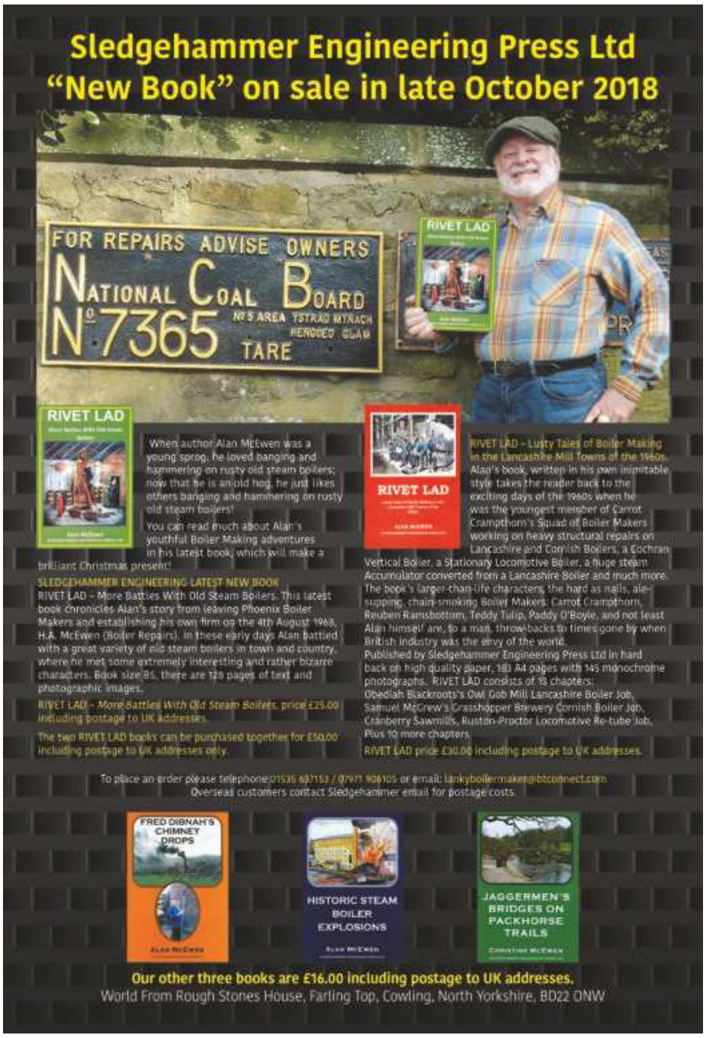
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RIVET LAD – More Battles With Old Steam Boilers, price £25.00 including postage to UK addresses.
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Differential Dividing

John Olsen makes an attachment to allow dividing awkward primes.

Much has been written over the years in Model Engineer about dividing, especially on simple modifications to lathes to permit dividing common numbers with minimal equipment. To the best of my knowledge nothing has ever been written here about differential dividing. This would be because few would have had the necessary equipment. However, times have changed, and more of us now have milling machines and dividing heads so the adaptation I have made to permit a Vertex BS0 dividing head to perform differential dividing may be of interest, particularly since the resulting adaptation could also be used to cut helices.

For those who have not encountered the idea before, differential dividing is a method that allows us to divide by a much wider range of numbers than can normally be accomplished with a worm dividing head and a set of plates. The idea is that we take a conventional worm dividing head, but instead of the dividing plate being fixed to the body of the head, it is able to rotate and is connected by a train of gears to the main spindle of the machine. As we move the index detent around the dividing plate, the dividing plate itself is also moving. This changes the size of the divisions on the final output shaft. By a suitable choice of gearing we can achieve a very wide range of divisions. This will be limited by the gears we have, but it turns out that any gears we need and do not have are themselves likely to be ones that we can make. We are no longer limited by having to find a dividing plate with a suitable set of common factors. As will be seen in the examples below, we can divide a circle into prime number divisions without having any dividing plate or gears with that particular prime number as a factor. For my own version of the device, I am using a standard set of Myford change wheels. These are readily available, and not too hard to make if other teeth numbers are needed. Any errors in the gears used, and in the dividing plates themselves, are divided by the ratio of the worm in the head, so you need not feel any qualms about using home cut gears for this device. If your home-made gears are good enough to run smoothly when used as change wheels on the lathe, they will do for this device as well.

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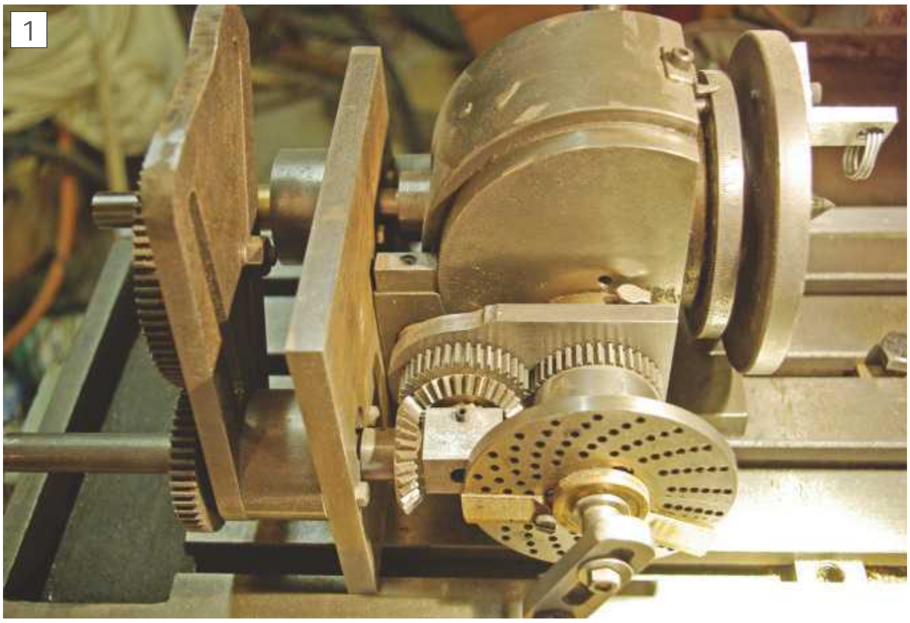


The attachment fitted to a BS0 dividing head.

Before diving into the construction, let us first review the common methods of dividing and then the special features of differential dividing. The most basic method of dividing is direct dividing. This uses a dividing plate, which in some cases may be the bull gear of a lathe or even the jaws of a chuck, which is directly attached to the job. A detent engages with the teeth of the gear or the holes in the plate, enabling the job to be rotated and stopped in positions corresponding to the divisions required. In this way we can divide by the number of teeth in the gear, or by any integral divisor of that number. Where the lathe has been provided with a 60-tooth bull gear we can divide by some quite useful numbers, as shown in **table 1**.

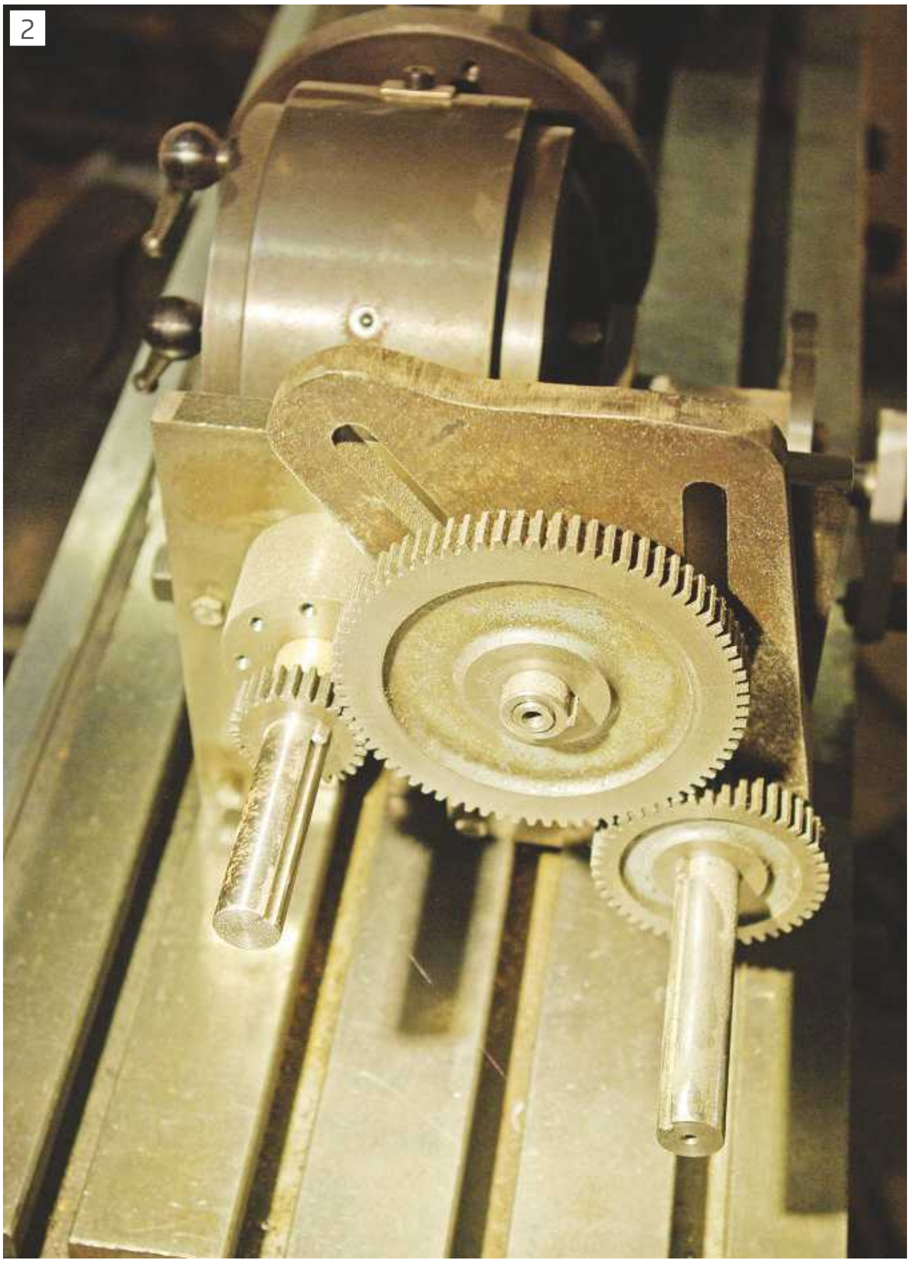
Should the lathe not have a suitable bull gear, we can attach one to the spindle, and this will allow us to divide by other numbers, provided we happen to have a range of suitable gears. For run of the mill problems like spacing studs nicely around a cover this method is very good, since we rarely want large prime numbers for this. Compound trains can also be used for harder dividing problems.

An improvement over direct dividing is to use a worm reduction gear between the dividing plate and the job. In effect this multiplies the number of holes in the plate by the ratio of the worm, making it possible to divide by a much wider range of numbers. It also divides any angular error in the dividing plate by the same ratio. The cost of these gains is the need for an accurate worm and wheel, since any errors here will be reproduced exactly on the job.

With a worm dividing head of this type it is reasonably easy to understand what is going on. The job must be positioned correctly for each division, by rotating through a certain angle from the last position. The worm ratio is usually 40:1 so the input shaft must rotate through 40 times the angle required on the output shaft. This requires selecting a division

Table 1 Direct Dividing from a 60 tooth bull wheel

Number of divisions	60	30	20	15	12	10	6	5	4	3	2
Teeth to skip	1	2	3	4	5	6	10	12	15	20	30



The quadrant goes on the backing plate and then the chosen gear train is mounted. This one is for 71 divisions.

plate with a suitable number of holes and then moving the division pin to the correct hole for each movement. For a simple case, where the division plate has the exact number of holes required, then each move will involve moving the pin to a hole 40 spaces away from the hole just used. Mostly a table is provided, but if the table is missing then for each circle of holes multiply the number of holes by the worm ratio and divide by the number of divisions required. Provided the result is an integer (whole number) then that is the number of divisions to step each time. If the result is not an integer, then that circle will not divide by the required number of divisions. A typical dividing head, like the Vertex BS0, will be able to do all of the numbers from 1 to some maximum, then some numbers above that. The plates for the BS0 cover every prime number in the range from 1 to 50. Primes larger than 50 are not possible with the standard plates. Note that I am not saying that 50 is prime. The largest number it can possibly do is the number of divisions on the largest plate multiplied by 40, which in the case of the Vertex is 40 times 49, or 1,960. This is of course somewhat more than is likely to be practically required. A semi-universal head like the Vertex BS0 will in fact cover almost all normal requirements.

Where an unusual number is required, there are a number of ways of accomplishing the work with a worm dividing head. The basic idea is to make a dividing plate as accurately as possible, then use it as the master plate to perform the actual job. The angular errors in the dividing plate will be divided by the worm ratio. A worm ratio of forty means that a reasonably competently made dividing plate will provide work as accurate as you are likely to need. If you are uneasy about the accuracy, use your home-made plate to divide a better one, which will be much more accurate. One simple approach to making such a plate is to draw it up in a CAD program, then print it, preferably on a laser printer but an ink jet will suffice. Use double sided tape to stick it onto a blank, then spot through all the holes and drill them. An older approach was to use the calibrations and the Vernier scale on a rotary table to make the master. The space age approach is of course CNC machining, or at least a stepper motor control on a rotary table. Then of course there is the differential dividing method, which we will now explore.

The method involves setting up a gear train from the output shaft to drive the division plate by a small amount, **photo 1**. We then divide in a similar way to normal, except that each time we move to a new hole, the hole itself has moved to a different position. As a result, we don't get the number of divisions that we would if we used that plate in the normal way. This can be a little confusing to get your head around if you think about the input side. We move the pin from one hole to another, which would give us so many degrees of movement at the output. OK, but that movement will be fed back by the gear train to the division plate, so the hole we are aiming for has moved so we move a little further to get there. But that movement itself then causes more movement of the division plate... like Achilles in Zeno's paradox, we will never actually reach the tortoise with this approach.

A better way to look at this is to consider everything from the perspective of the output side. In dividing our peculiar number of divisions, whatever it is, the output shaft must start in one position and then rotate through one complete turn, dividing the angular space into "n" divisions. To create an artificially simple example, suppose we have only one division plate, which has forty divisions, and suppose our worm is 1:1. That would only permit us to divide numbers which are exact divisors of 40, eg 2, 4, 5, 8, 10, 20 and 40. For some reason we need to divide a circle into 41 divisions. We will use the 40 hole plate as if we were dividing into 40, but will use the gear train to adjust the motion. Now, our output shaft will still have to turn through a total of 360 degrees, but we will need a total of 41 stopping places instead of 40. That means the angle the output shaft must turn through is 360/41 degrees instead of 360/40 for each division. Since we made our worm 1:1, the same applies to the input. So, using our 40 hole plate, we must rotate the division plate by a small amount in the opposite direction. How much? Well, the output shaft has done 1 whole rotation when we get back to the starting point. Hence in our situation, the input shaft must also have done one whole rotation. But we must have

Table 2 Ratios approximating Pi

22	179	201	223	245	267	289	311	333	355	52163
7	57	64	71	78	85	92	99	106	113	16604

passed over 41 spaces instead of 40 on the division plate, so the division plate must have done 1/40 of a rotation in the opposite direction. So we need a gear train that has a ratio of 40:1 and reverses the rotation.

Now, making things a little more realistic, we will try another example but with a 40:1 worm as is common. We could now do forty divisions by using the same hole (on any plate) forty times. To get 41 divisions, we will do the same thing, but gear the division plate to rotate in the opposite direction. Now, the input shaft will have to rotate through forty turns but will have to drop into the same hole of the division plate 41 times in the process. For this to happen, the division plate will have to rotate 1 full turn in the opposite direction to the input shaft. Thus the gearing will be 1 to 1, which should not be too hard to organise. Each time we move the pin to a new hole, we will turn the input shaft just under one full turn, and the hole will move a little in the opposite direction to meet us.

If we follow a similar argument for getting 39 divisions from a forty division plate, we will find that we must again use a 1:1 gear ratio, but this time we must rotate the division plate in the same direction as the input shaft. So we can note that when we want to reduce the number of divisions from that provided by the plate, the division plate will be geared to rotate in the same direction as the input shaft. When we want to increase the number, the division plate will rotate in the opposite direction.

Forty is an artificially easy number, because it matches the worm ratio. The 39 and 41 divisions are also possible from the standard plates anyway. Suppose we have a plate that can do 72 divisions but we want 71. From our earlier examples, we can see that it will need the division plate to be rotated in the same direction as the input shaft. But by how much? The output shaft must still do a full turn, and the input shaft must also still do 40 turns. But instead of doing this in 72 steps we must do this in 71 steps. Typically for 72 divisions we will use an 18 division plate and take steps of 10 divisions each time, but when we have done this 71 times the dividing pin must be back to the starting location. (I.e. the input shaft must have done exactly 40 full turns) Relative to the dividing plate it will still be 10 divisions short of the starting hole, so to be back to the starting location the dividing plate itself must have moved 10 divisions in the same direction. So for 1 full turn of the output shaft the division plate must move 10/18 of a turn in the same direction as the input shaft. Looking though our Myford change wheels, we find that we have a 25 and a 45. These will give the same ratio, since 10/18 = 25/45, so we put the 25 on the main shaft and the 45 on the shaft driving the dividing plate. Any convenient set of idlers may be used between, provided the direction is correct. Compound trains could of course also be used if necessary, **photo 2**.

Note that this will require us to have a suitable pair of gears to give this ratio, but at least these are more reasonable looking numbers than trying to find a 71 hole plate or gear. In fact, this is a merit of the method. Three things determine the gears we need:

- The ratio of the worm
- The division wheel chosen
- The difference between the wanted number of divisions and the available number.

This means that if we do not happen to have the exact wheels needed, they are at least something we could make without already having them. But generally we will have something in a normal set of change wheels that will do.

I now find myself looking at what I have written and wondering if it is sufficiently clear. The danger is that by writing more I will simply make the verbiage more dense and confusing, so I will set out the process of choosing a ratio in a step by step fashion. This assumes you have a table for normal dividing for your dividing head, but not for differential dividing. I will use 71 as an example.

1 Examine the tables to determine if the number required can be divided in the conventional manner. As we will find, 71 cannot.
2 If not, choose a number that can be divided that is a small amount larger or smaller than the number you require. In our example, 72 is a number that we can easily divide.
3 Set up the dividing plate and the arms as if you are going to divide by that number, using the normal table. For 72 we would normally use an 18 hole plate and we would move the detent around by 10 divisions each time.
4 Note the difference between the number of divisions you want and the number you have set up for. For instance, 72-71 =1 (Sign is important.)
5 Divide the number of divisions for each step (as set up in 3) by the number of divisions on the plate being used. For instance, for 72 we have 10 divided by 18. (You can leave this expressed as a simple fraction.)
6 Multiply the number from step 5 by the number from step 4. So for 71 we get 1 times 10/18.
7 This result is the amount the division plate must rotate by when the main shaft rotates by one full turn. A negative number means that the division plate goes in the opposite direction to the input shaft, while a positive number means that it goes in the same direction.
8 So the actual ratio needed is 1: 10/18. That is the velocity ratio of the gears, the

3


Proof of the pudding, a gear with 71 teeth.

Table 3 Division Table for 40:1 worm and 5 step change wheels

Notes for table.
Set-up A has one idler between the driver and the driven.
Set-up B has two idlers between the driver and the driven.
No compound trains are needed.
The driver is the gear on the main shaft, the driven is the gear on the bevel shaft.
Direction –1 means the dividing plate will rotate in the opposite direction to the dividing arms.
means it will go in the same direction.

Divisions needed	Set up as if for	Division plate	Divisions per step	Overall gear ratio	Set-up	Driver	Driven	Gear C	Gear D	Direction
51	52	39	30	30 to 39	A	50	65	Any		1
53	52	39	30	30 to 39	B	50	65	Any	Any	-1
57	60	33	22	2 to 1	A	50	25	Any		1
59	60	33	22	2 to 3	A	50	75	Any		1
61	60	33	22	2 to 3	B	50	75	Any	Any	-1
63	64	16	10	5 to 8	A	25	40	Any		1
67	70	49	28	12 to 7	A	60	35	Any		1
69	70	49	28	4 to 7	A	40	70	Any		1
71	72	18	10	10 to 18	A	25	45	Any		1
73	72	18	10	10 to 18	B	25	45	Any	Any	-1
77	80	20	10	3 to 2	A	60	40	Any		1
79	80	20	10	1 to 2	A	25	50	Any		1
81	80	20	10	1 to 2	B	25	50	Any	Any	-1
83	85	17	8	16 to 17	A	80	85	Any		1
87	85	17	8	16 to 17	B	80	85	Any	Any	-1
89	90	18	8	8 to 18	A	20	45	Any		1
91	90	18	8	-8 to 18	B	20	45	Any	Any	-1
93	100	20	8	14 to 5	A	70	25	Any		1
96	100	20	8	8 to 5	A	80	50	Any		1
97	100	20	8	5 to 2	A	60	50	Any		1
99	100	20	8	2 to 5	A	20	50	Any		1
101	100	20	8	2 to 5	B	20	50	Any	Any	-1
102	100	20	8	4 to 5	B	40	50	Any	Any	-1
103	100	20	8	5 to 2	B	60	50	Any	Any	-1
106	100	20	8	12 to 5	B	60	25	Any	Any	-1
107	100	20	8	14 to 5	B	70	25	Any	Any	-1
109	100	20	8	18 to 5	B	90	25	Any	Any	-1
111	120	33	11	3 to 1	A	90	30	Any		1
112	120	33	11	8 to 3	A	80	30	Any		1
113	120	33	11	7 to 3	A	70	30	Any		1
114	120	33	11	6 to 3	A	60	30	Any		1
117	120	33	11	1 to 1	A	50	50	Any		1
118	120	33	11	2 to 3	A	40	60	Any		1
119	120	33	11	3 to 1	A	30	90	Any		1
121	120	33	11	3 to 1	B	30	90	Any	Any	-1
122	120	33	11	2 to 3	B	40	60	Any	Any	-1

123	120	33	11	1 to 1	B	50	50	Any	Any	-1
125	120	33	11	5 to 3	B	50	30	Any	Any	-1
126	120	33	11	2 to 1	B	60	30	Any	Any	-1
127	120	33	11	7 to 3	B	70	30	Any	Any	-1
129	120	33	11	3 to 1	B	90	30	Any	Any	-1
131	140	49	14	18 to 7	A	90	35	Any		1
133	140	49	14	2 to 1	A	70	35	Any		1
134	140	49	14	12 to 7	A	60	35	Any		1
137	140	49	14	6 to 7	A	60	70	Any		1
138	140	49	14	4 to 7	A	40	70	Any		1
139	140	49	14	2 to 7	A	20	70	Any		1
141	140	49	14	2 to 7	B	20	70	Any	Any	-1
142	140	49	14	4 to 7	B	40	70	Any	Any	-1
143	140	49	14	6 to 7	B	60	70	Any	Any	-1
146	140	49	14	12 to 7	B	60	35	Any	Any	-1
149	140	49	14	18 to 7	B	90	35	Any	Any	-1

ratio of the number of teeth on each gear is the inverse of this or 1:18/10. This can be multiplied and divided by suitable factors to find a pair of gears that we actually have. With a bit of thought we find that we can use 25 to 45, which are both part of the standard Myford set. If we were using change wheels that stepped by four, we could use 20 and 36.

9 Depending on the spacing of the two shafts and the direction needed, we may need one or two idler gears. The number of teeth on these does not matter.

10 If this is the first time you have done this, divide around the whole job just making marks with a scribing block. Count the marks when you reach the start. If the number is wrong, or if the first mark does not line up with the scriber after going around, then you have got something wrong. This is actually good practice with any form of dividing.

Now, we are not likely to want really unusual numbers of divisions all that often but having made an adapter like the one to be described, we can potentially use it for other applications. Some examples follow.

1 Gear the output shaft of the dividing head to the milling table feed. This will allow cutting a helix, the pitch of which may be varied by changing the gear ratio. A 1:1 ratio will give a helix pitch equal to the table lead screw. This lends itself to milling screw threads. This will require a quadrant to fit onto the end of the milling table. It also requires getting the cutter to match the helix angle properly.

2 Gear the division plate to the table lead screw. This will also allow cutting helices, but of a much longer pitch. Here a 1:1 ratio together with the 40:1 ratio of a typical dividing head will give a pitch forty times as long as the table lead screw. In addition, the dividing plate and selector pin are in the path, making it easy to cut a multi-start helix. This can be used for cutting helical gears, provided the change wheels available can provide the correct helix angle.

3 Gear the division plate to the lead screw and use the division plate to perform linear dividing. This is potentially useful where a length must be divided into equal divisions that are not easy to measure using hand wheels or a digital scale. For instance, cutting racks will often require odd division numbers since PI is included in the pitch calculation. This can be done with an offset table. Using a table of offsets like this is difficult with just a calibrated hand wheel. A set of digital scales makes it easier, but even so errors are possible. The geared arrangement will reduce the possibility of errors. The downside is that such arrangements will generally need a division by pi, and any gear train will only provide an approximation to Pi. Fortunately, the approximation can quite readily be as good as we are likely to need. For general work, the standard Pi approximation 22/7 will give an error of under half a thou per inch. If a higher standard is needed then there are other approximations such as 355/113, which will provide a very low error while still being able to be constructed with reasonably practical gears. When I say practical, you may need to use the differential dividing facility to make yourself a set. Rather than making a rather large 355 tooth gear, a 71-tooth gear should be made, **photo 3**, and the 5:1 ratio can be incorporated in the rest of the train. (355/5=71). Other possible ratios are shown in **table 2**, although the last would

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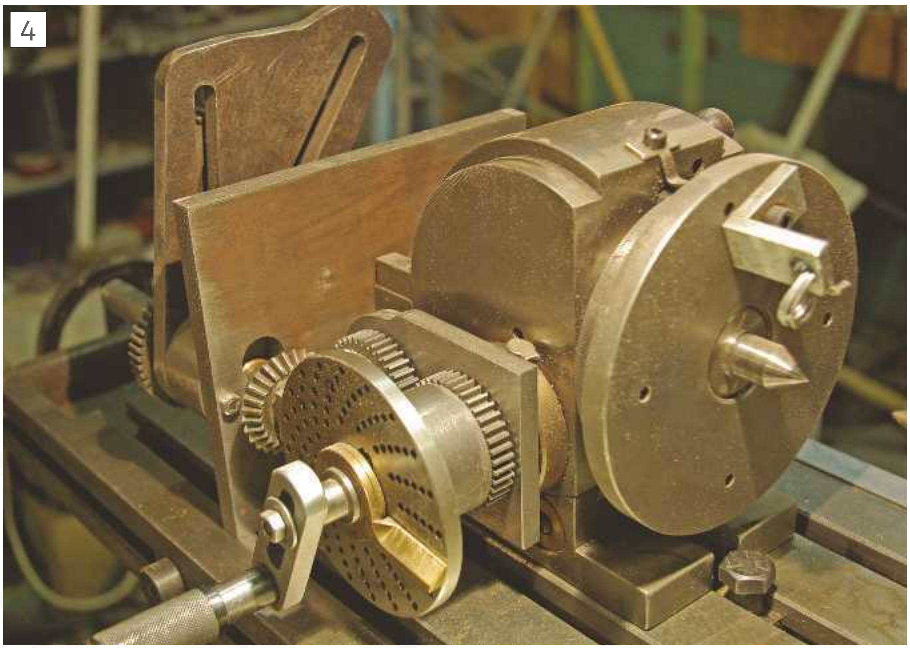
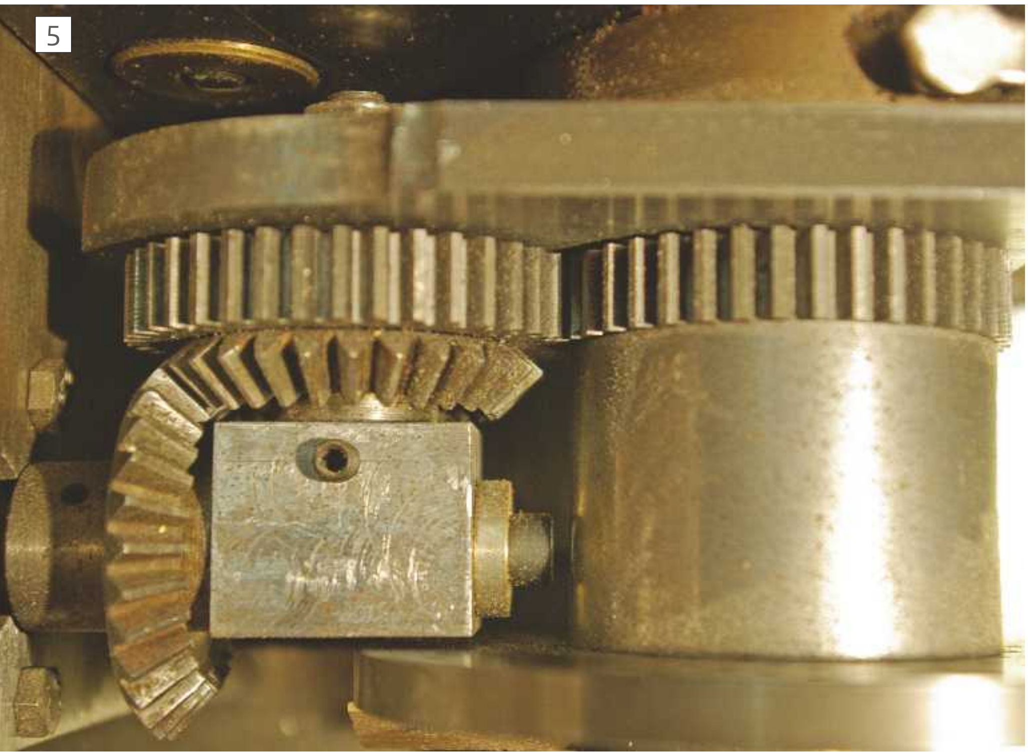


Checking the gears for mesh. They should all turn freely at this stage.



The bevel gears and their block fit in behind the dividing plate.

be rather impracticable.

Note also that the gearing to the table lead screw may be via the 40:1 worm of the dividing head, if this suits. This is more likely to be the case for small divisions than for large.

I have not so far implemented any of these possibilities. Gearing to the milling machine lead screw will require another quadrant and shaft assembly and this will vary according to your mill.

A dividing head with the differential capability built in is called a universal dividing head. Vertex do make a universal dividing head, the BS2, but this is a much larger device than the BS0 and so not suited to many of the mills that we model engineers tend to own. The instructions for my Vertex include the tables for the larger head. These are of limited use to us since the Vertex change wheels step by four instead of five. Their use of a skew gear compared to our bevel also means that their trains need to rotate the second shaft in the opposite direction to ours. This completely changes the type of set-up you want to use. Also our shafts are probably too far apart to permit using their trains anyway so I have provided table 3 for some of the division figures that require the use of differential dividing, tailored to the use of Myford change wheels and the device described. This table takes you to 149 divisions. If you want more divisions than this, you will have to work it out for yourself. Bear in mind though, that generally more than one gear train can provide the correct result. It is the overall ratio and direction that are important. You can also calculate a different train by starting with a different choice of division plate. For instance, if adjusting from 72 to give 71 did not give suitable gears, we could try adjusting from another number, perhaps 75. Generally, the closer the better, to reduce the effect of backlash in the gears. Compound trains can be used if needed, and idlers may also be used to correct the direction. Also remember that I have not actually tried most of these trains, so check for the correct division ratio before cutting metal. I did use a spreadsheet to check my calculations. It is a little hard to use a spreadsheet to do the initial calculation, since it involves making a judgement as to which is the best basic division set-up to start from, but a spreadsheet can easily calculate for you what division ratio you will get with a given train. So provided that came out to what I had been calculating for, the train should work. I would still suggest rechecking since errors can easily creep in. It is of course traditional to blame the printer!

You will see that **table 3** includes a couple of possibly unexpected numbers. It turns out that it is not possible to divide by 96 or 125 with the standard set of plates. Not all of the numbers that need differential dividing are primes by any means. Another familiar number that will be seen there is 127. So now you can make yourself a 127-tooth change wheel for cutting accurate metric threads. I am not very convinced myself about the utility of this. I have had such a change wheel for over ten years and have never actually used it. The very slight increase in accuracy that it can give has not so far justified cutting a slot in the lathe stand to permit mounting the wheel. You will find that such a wheel in the standard Myford 20DP tooth is a rather large device. It does look impressive hanging on the wall though, and it did not cost anything. It came with a set of change wheels from a scrapped lathe of unknown brand.

The Differential Indexing Attachment

On to the construction of the device, **photo 4**. An important design criterion was that no major changes to the Vertex dividing head should be required. It should also remain possible to return the Vertex to normal operation without too much trouble. In the event the only modifications to the Vertex were four holes drilled and tapped M5 in the end of the main base. The concept should be equally applicable to other similar dividing heads, but of course dimensions may need modifying to suit. The Vertex is a copy of the Brown and Sharp and there are others of very similar appearance, so this design may be able to be adapted to other brands. Most of the machining required is fairly straightforward turning and milling, and presumably if you wish to make this you have at least a dividing head, and therefore probably a milling machine. So I will not go into too much detail of particular set-ups. I will give a brief outline of the parts and their purpose, and which bits are important. You will see from the photographs that my own example was not built with any intention of competing in exhibitions.

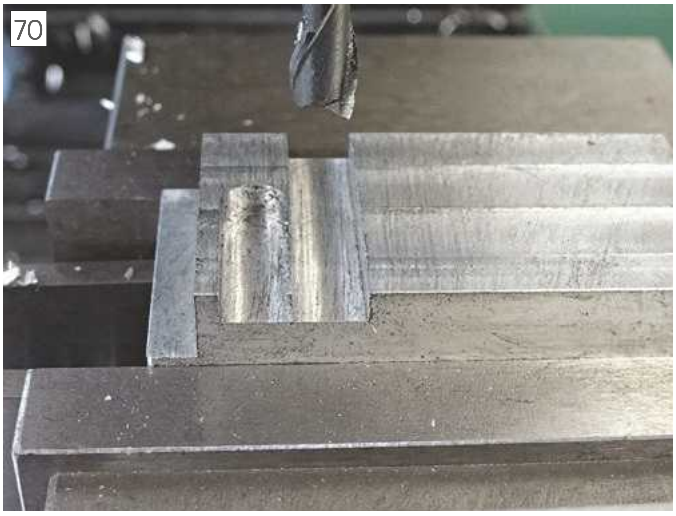
One difficulty for the drawings is that the Vertex is largely metric, apart from the spindle nose and the Brown & Sharp taper in mine. I gather some have the number 2 Morse taper. On the other hand, the Myford change wheels and the shafts they fit on are Imperial measurement. To add to the fun for builders, you will require a good pair of bevel gears, **photo 5**, which must be a 1 to 1 ratio. The actual number of teeth is not too critical. Mine came from my collection of "could come in handy sometime" stuff, so you will probably not be able to exactly duplicate them. They should have an outside diameter of up to 2 inches or 50mm. The teeth should be fairly fine. Mine have 36 teeth, but finer teeth would reduce the backlash. Backlash is not too much of a problem in practice, but should as always be taken up in the same direction. After doing my first try at the drawings based on my own unit, I contemplated for a minute or two on the folly of providing drawings to suit gears that you will not be able to obtain. As a result, I have redrawn things to suit a pair of gears listed in the Davall catalogue. These are straight bevel gears, 1.5 module with 30 teeth. I would have liked more teeth but these were the best match I could find on the Internet. The catalogue number is MB15-30S. I have not had any dealings with Davall at all, so the usual disclaimer applies. Other suppliers may have similar gears. If you do obtain the Davall gears, one of them will need modifying.

●To be continued

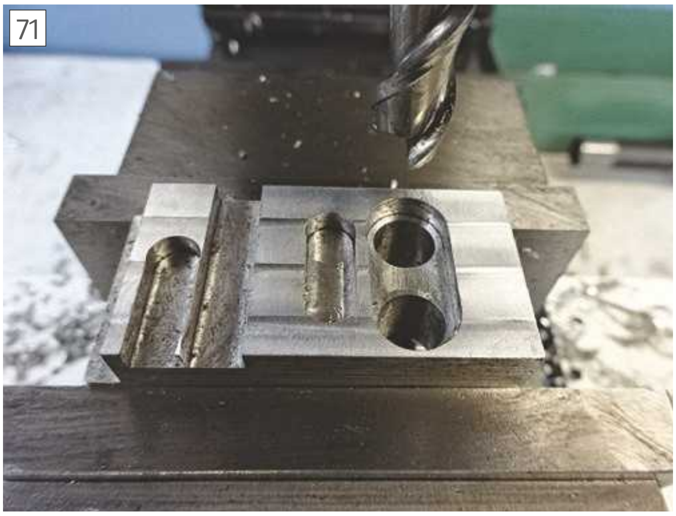
Milling for Beginners

PART 7 – USING A 2-FLUTE CUTTER (SLOT DRILL) AND SQUARING UP A ROUGH BLOCK

This month Jason Ballamy looks at the various uses of a 2-flute Slot Drill and describes how to square up a rough sawn block of metal.



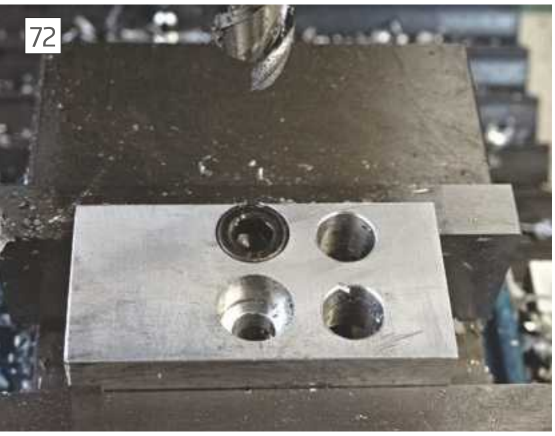
Open Ended and Through Slots



Wide and narrow Closed Slots

Using a Slot Drill (2 flute cutter) For Open Ended Slots

As its common name suggests the 2 fluted "slot drill" is the ideal cutter for producing slots, the main reason for this is that only one cutting edge is ever in contact with the work piece so that if the force of the cut were to deflect the cutter to one side it would still not cut an oversize slot as can happen when using cutters with more flutes.



Counter bored Holes

To cut a slot that is open on one end but does not pass right through to the other as shown on the left of **photo 70** touch the cutter onto the top surface of the work, engage fine down feed and zero the quill DRO in much the same way that was described in part 6. The cutter can then be lifted slightly and the work moved to one side before putting on the cut. For the 6mm diameter cutter used here on aluminium 1.5 to 2.0mm depth can be taken in each pass running at about 1500rpm. It is then just a case of feeding the work along until you get to where the slot is to end, then move the work back in the opposite directing so the cutter is clear before putting on another cut and repeating until the required depth is reached.

If the slot passes all the way through (right, photo 70) then there is no need to return to the start position to put on the next cut, just do that at the opposite side and cut in the return direction as well.

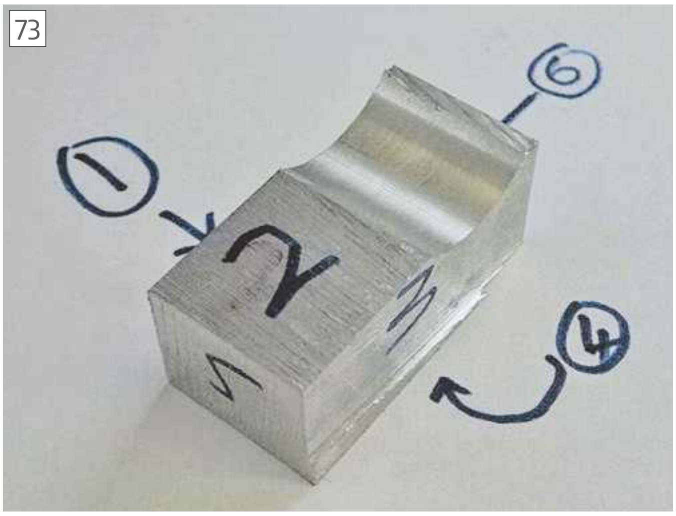
If you don't have a cutter for the size of groove needed then use the next size down and first cut along the middle to remove most of the waste followed by some full depth passes along each side to open the slot up to the desired width.

Using a Slot Drill (2 flute cutter) To Cut Stopped Slots

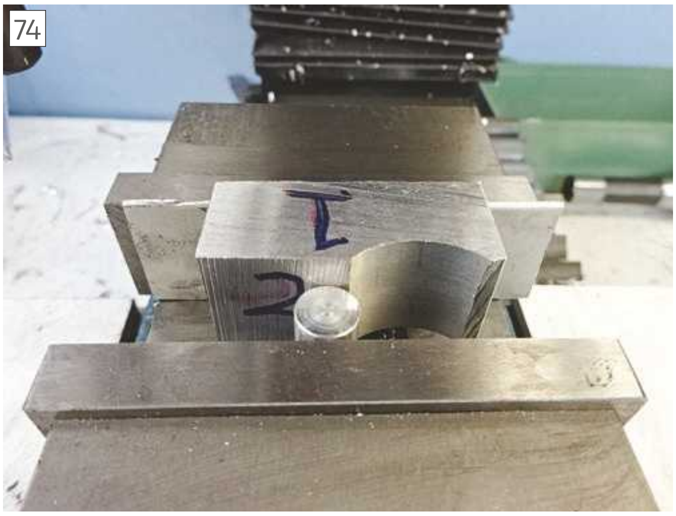
If you need to cut a slot where both ends fall within the bounds of the work piece, then use can be made of the slot drills ability to plunge vertically into the work much like a drill due to it having one of the cutting edges on the end that passes through the centre of the cutter.

For smaller cutter of say 6.0mm diameter or less start again start by toughing off, engaging fine feed and zeroing the DRO then lift clear and start the cutter rotating. Use the fine feed to lower the slot drill into the work, it won't cut as fast as a drill and some cutters are better at plunging than others so just feed slowly until you reach the depth for the first cut at which point the work can be fed along until you get to the other end of the slot, plunge down again and cut along the slot again and so on. **photo 71**.

For larger slots it is usually better to drill an undersize hole at either end of the slot so that the cutter does not have such

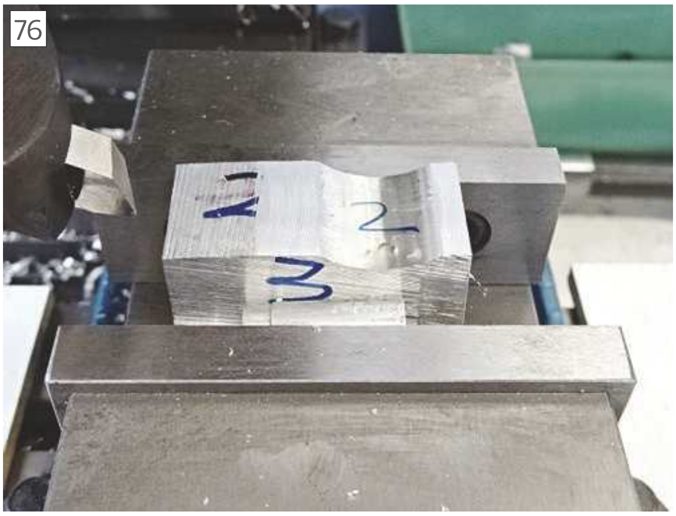


Rough cut stock marked up in order of cuts 1-6



Set up for machining face number 1 with front and rear packing

Face 1 after machining and De-burring with File



First Cut off Face number 2 with packing at front only

a hard time when plunged, this method can also be used on smaller cutters if you find they don't plunge too well. The larger 10mm slot to the left of photo 71 was done this way using an 8.0mm diameter hole at each end.

Using a Slot Drill (2 Flute Cutter) to Drill Holes.

Slot drills can also be used on materials that tend to grab a conventional twist drill when opening the hole up to a larger diameter or to counter bore a hole for say the head of a cap head screw. Drill the smaller hole first with a normal drill then mount the required size slot drill and use that either just with the quill lever feed or using the fine feed if the material is particularly prone to grabbing as the fine feed will help resist the tendency of the cutter to be drawn into the work. Also use the fine feed if counter boring as the DRO can be used to get the required depth, **photo 72**.

These cutters can also be used to provide a start for a twist drill when the hole enters the work at an angle. Just set up the work at the required angle and gently feed the slot drill in until it is cutting full diameter. You can then either carry on a bit further so there is a hole to locate your drill bit in or stop and then spot drill the flat that the slot drill created before following up with your chosen drill bit.

Material specific 2-flute cutters

On the easier to cut materials such as Aluminium, brass, bronze and plastics the larger clearance space between the two cutting edges can be made good use of to help clear the larger volumes of swarf that it is possible to produce so in these cases the 2-flute cutter can be used where a 4-flute would normally be used on harder materials such as steel and iron. If you are likely to be working these softer materials quite often then it is worth investing in specific non-ferrous milling cutters which as well as being 2-flute for clearance have a steeper helix angle that will also help to lift the swarf out of the cut at a faster rate. These cutters are usually uncoated as that also helps to prevent aluminium from sticking to the cutting edges. The 10mm cutter in **photos 72** and **81** is one of such design.

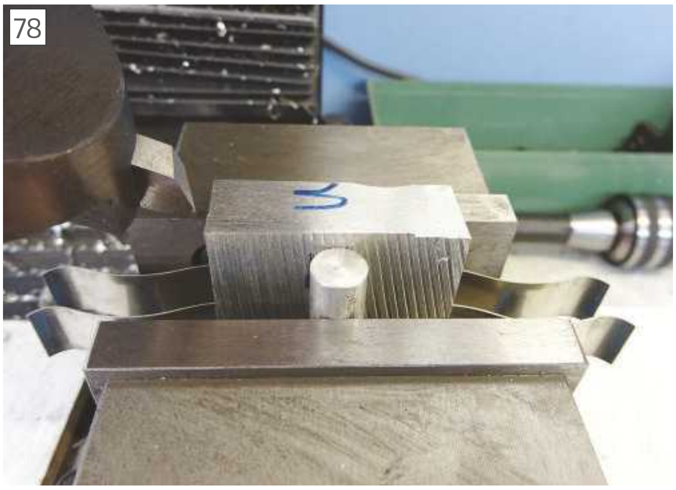
Squaring Up an Uneven Block

Sometimes the piece of material being worked on won't already have flat sides that are at right angles to each other be that because it has been sawn from a larger piece or could even be a casting. The following sequence of photos and descriptions show how to go about making an odd shape into a regular one. I have shown it being done with the aid of a fly cutter as these will cover a reasonably large area in one pass and are easy to sharpen in the home workshop so work out quite economical to use, however the same could be achieved with several passes of a large 4-flute milling cutter.

After removing any obvious burrs start by studying the work piece and then number the sides 1, 2, 3 and 4 with the flattest side being number 4 if there is no obvious flatter side then try to ensure that side 4 is concave rather than convex. The

These cutters can also be used to provide a start for a twist drill when the hole enters the work at an angle

Checking face 1 is square to face 2



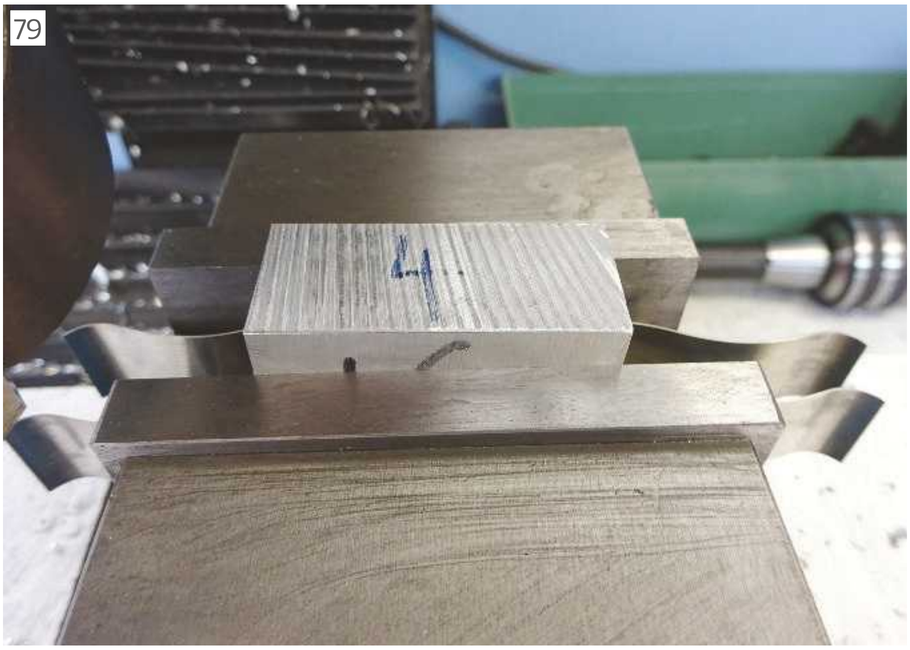
Set up for face 3 with face 1 on parallels, 2 against fixed jaw and packer on still rough face 4

two ends are numbered 5 and 6 in **photo 73**.

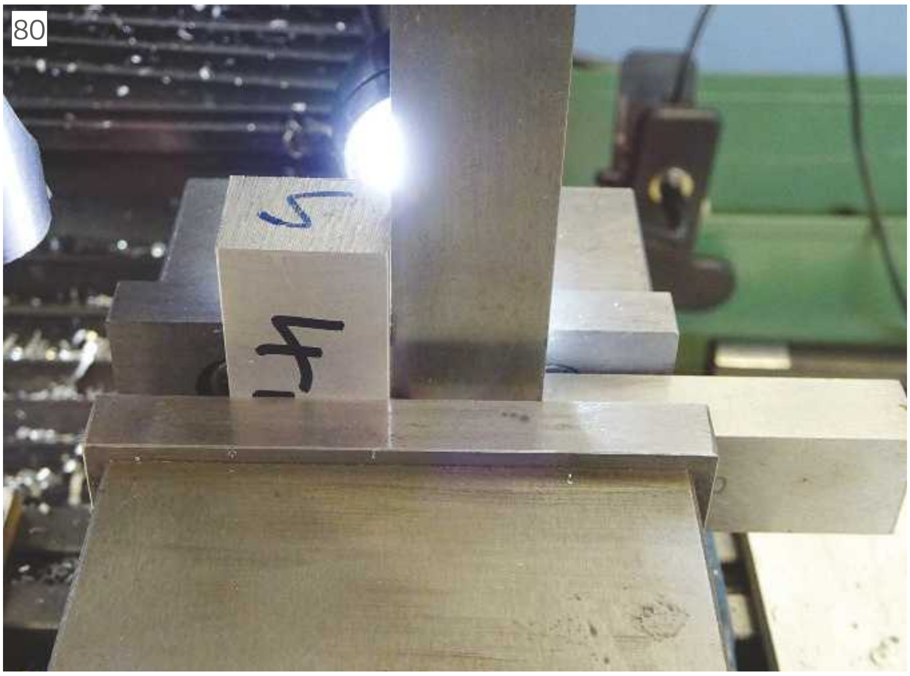
Ensure that your vice is clocked in true to the X-axis as described in part 6 and then place a thin piece of aluminium against the rear fixed jaw, this will protect the jaw from any point loading due to the uneven surface of the work and also give a better grip as it will deform slightly with pressure. The work piece can now be put into the vice with face number 4 to the rear and face number 1 upwards followed by a short length of aluminium rod which will ensure the work is held flat against the rear jaw & packer rather than being pulled away as could happen if the moving jaw was left to find its own position against the uneven work.As you tighten the vice set the top (No1) face horizontal by eye. **photo 74**.

With the work now held securely proceed to take cuts across face number 1 until the whole surface has been cleaned up by the cutter at which point it can be removed from the vice and de-burred with a fine file to ensure the piece can be held for the next stages with the machined face flat against the vice or parallels without being canted by a burred edge. **photo 75**.

For the next cut the work is held in the same way except the packing piece against the fixed jaw can be left out so that face number 1 bears against that jaw and face number 2 is upwards ready to be cut. **photo 76**. For the purpose of these photos



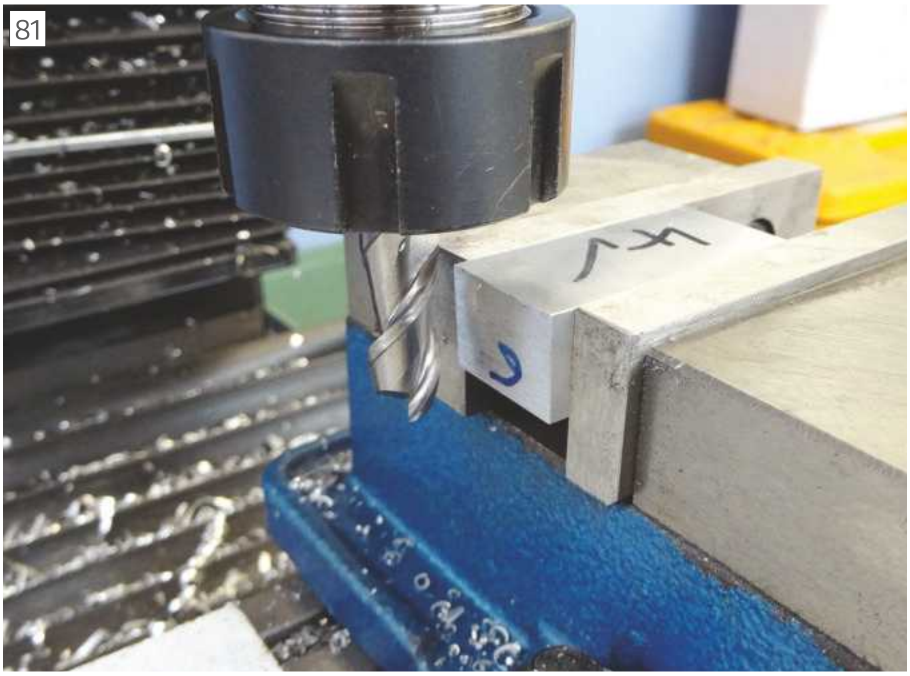
Ready to machine face number 4, no jaw packing and face 2 on parallels



Setting work vertical to machine end 5

If you are likely to be working these softer materials quite often then it is worth investing in specific non-ferrous milling cutters...

> If your chunk of metal is too large to fit in your vice then a similar setup can be replicated by substituting an angle plate for the vice's fixed jaw and the mill table in place of it's base.



Alternative method used to machine end 6

I won't machine away the circular notch but just take a couple more passes until the rest of the face has all been machined.

Again, de-burr the work when it is removed from the chuck, a tri-square can then be used to check that faces 1 & 2 are at right angles to each other before machining face number 3 **photo 77**. This time when the work is put back in the vice it can be set against the bottom of the vice as well as the fixed jaw or as in this case raised up on parallels if smaller than the height of your vice jaws. Having the previously machined face number 1 resting on the parallels will ensure the cut on face number 3 is parallel to that face and at right angles to face number 2 which is placed against the fixed jaw. **photo 78**. The work can be measured during these cuts until it is to the required thickness, if you are aiming for a square profile then zero the quill DRO on the final cut so the next face can be finished to the same height.

The work is rotated once more to machine face number 4 but this time as the moving jaw will be against a flat machined face (number 1)the small piece of bar is not needed, face number 2 should rest on the vice bottom or parallels which leaves face number 3 against the fixed jaw. **photo 79**.

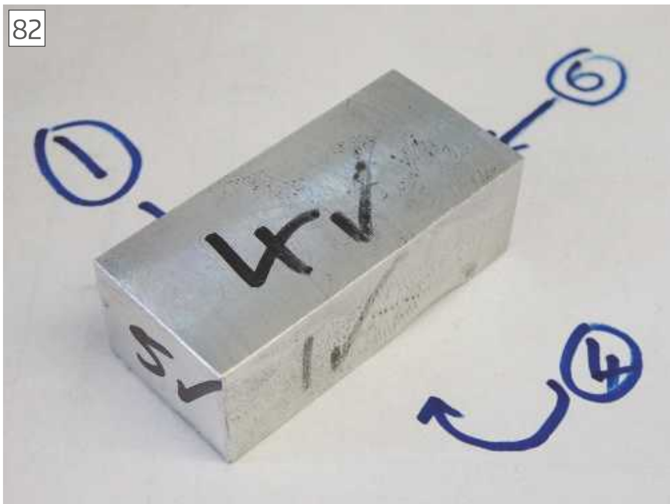
With the four long edges now all machined the two ends can be tackled next. Provided the work does not stand a long way above the vice jaws that can be used to hold the work vertically. Use the tri-square against the vice base and one side of the work to set it vertical, a light source or sheet of white paper behind will help to see how well the work abuts the square's blade. Alternatively a DTI can be held in the spindle or with a magnetic base to the mill head and run up and down the side of the work to ensure it is vertical. Once happy that the work is lined up the end can be cut until the surface has been cleaned up right across. **photo 80**.

The other method if the work is not too thick is to have the end sticking out one side of the vice and using a reasonably large diameter cutter so that there is less risk of it flexing away from the work take full depth passes across the end. As the vice jaw was previously set true to the X-axis this cut in the Y direction will be at right angles to it. **photo 81**.

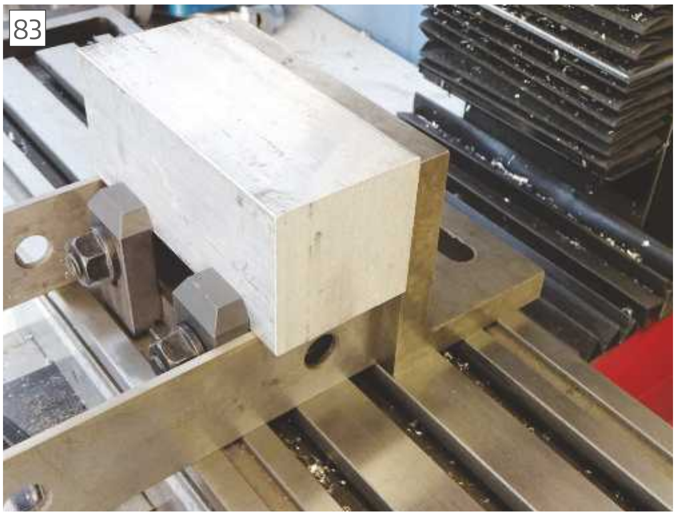
After all this that rough piece of metal should look like the one shown in **photo 82** with all faces machined at right angles to the next and parallel to the opposite face.

If your chunk of metal is too large to fit in your vice then a similar setup can be replicated by substituting an angle plate for the vice's fixed jaw and the mill table in place of it's base. The work will have to be clamped to this and more than likely packed up with parallels so that the cutter will clear the top edge of the angle plate. **photo 83**. ■

The items featured in this series are available from Arc Euro Trade, **http://www.arceurotrade.co.uk**, who also sell the X series of mills. See the accompanying thread on Model Engineer Forum **https://www.model-engineer.co.uk/forums/postings.asp?th=131318&p=1** for more discussions about this series.



All faces machined true

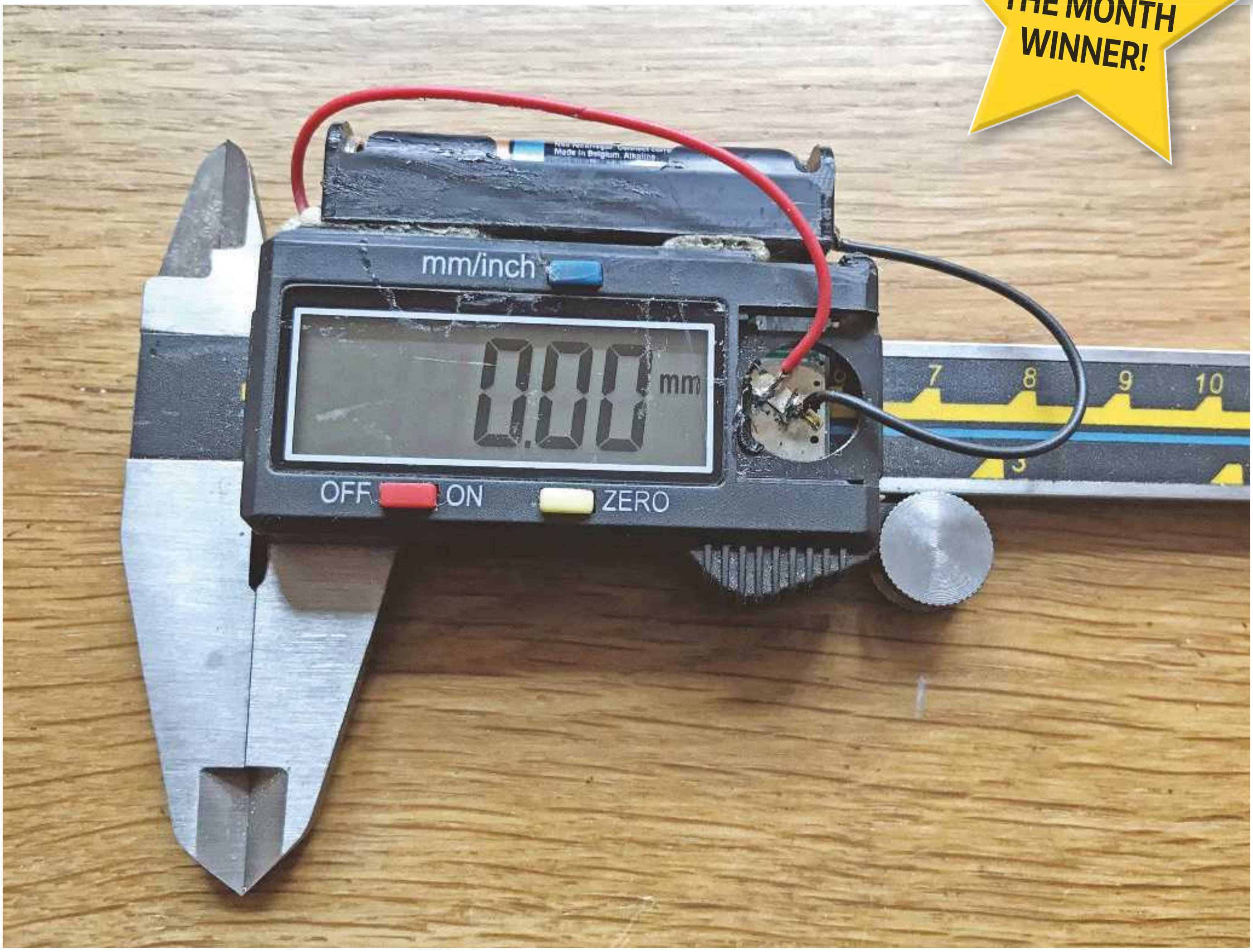


Similar set up for large work using an Angle Plate.

Readers' Tips

More Power!

TIP OF THE MONTH WINNER!



This month our lucky winner of £30 in Chester gift vouchers is Richard Gibson, who has come up with a neat twist to the popular idea of using a cheap digital caliper as a lathe DRO.

I decided to convert my lathe to a simple DRO machine using a pair of the cheap but accurate digital verniers available. However, the only downside was the lifetime and cost and faff of changing the button batteries.

I have overcome this by piggybacking a AAA battery holder on top of the vernier and soldering a pair of fine wires to the positive and negative contacts in the battery compartment. This means a vastly extended battery life and a cheaper solution especially if you use rechargeable batteries. The battery holder I obtained from CPC Farnells Product code BT 03698.

I found a couple of dabs of Gorilla glue effective in fixing the battery compartment to the vernier.

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. You can make multiple entries, but we reserve the right not to award repeat prizes to the same person in order to encourage new entrants. All prizes are at the discretion of the Editor.

1

The completed Versatile Dividing Head with fabricated body is virtually indistinguishable from the original cast version.

A Fabricated Versatile Dividing Head

Pete Barker in Far North Queensland digs in the scrap box and welds up a substitute 'casting' for G.H. Thomas' classic Versatile Dividing Head

Having recently added a Myford vertical milling slide to "The Flagellator", my 1937 Drummond M Type lathe, I found I now needed a small dividing head for gear cutting. Buying one would not fit in with the 1930s Depression era ethos of my heritage machine shop, so the decision was taken to make my own. The simple way, using pieces of flat plate to form the body in the modern style would look out of place on the ancient Flagellator. But G.H. Thomas' curvaceous Versatile Dividing Head looked just the part. Except, the cost of postage from the UK to remote northern Australia on top of the already costly castings was more than my Depression era budget could accommodate.

Instead, I decided to fabricate my own "casting" from pieces of steel welded together. The result, **photo 1**, maintains the original classical lines of GHT's design and has already proven very successful in operation, including the drilling of 814 holes in its own three indexing plates, **photo 2**. It has also been pressed into service for the cutting of its own secondary helical worm gear but that's a story for another issue.

2

The almost completed unit in use on the lathe drilling its own index plates.

Puzzle: Drawings and the scrap box

The first step was to scan GHT's original drawings from his book Workshop Techniques and print them at actual size. This allowed me to scrounge around in the scrap box and find various pieces of steel that could be welded together to make up the body. The heart of the job was a piece of 1 5/8" diameter bright mild steel (BMS), 2 3/4" long, drilled and bored at this stage to ¾" diameter. It will later be bored out to final size to hold the main spindle.

The next piece in the puzzle was the lump sticking out to one side of this main barrel to clamp the tailstock mounting spindle. At first blush the obvious solution seemed to be to mill or turn a flat on the side of the

3

A slice of 1 5/8" bar held in the tailstock is used to position the marked out scallop ready for boring to the correct radius.

4

The offset job rotates around the boring bar as the scallop is machined. Ensure there is enough clearance before starting lathe.

›

By taking light cuts, the boring bar iss brought out to meet the marked out radius line for the scallop. Piece of paper provides extra grip.

The two main barrels are held in the vice, tacked in two places each side, then welded together.

main barrel and weld on a piece of 1 1/4" flat plate. But flat plate that thick is unobtainable in the sticks where I live, and prohibitively expense to have shipped in small quantities. So, a cunning plan was hatched to use a handy piece of 1 5/16" diameter BMS bar 2 1/8" long and machine a scallop out of one side to match the curve of the main barrel, then weld the two together. A flat surface would then be milled on top and bottom of the second piece to make it look like the original casting.

The top and bottom of the smaller tailstock clamp barrel are milled flat and blended to the main body with files and rotary grinder.

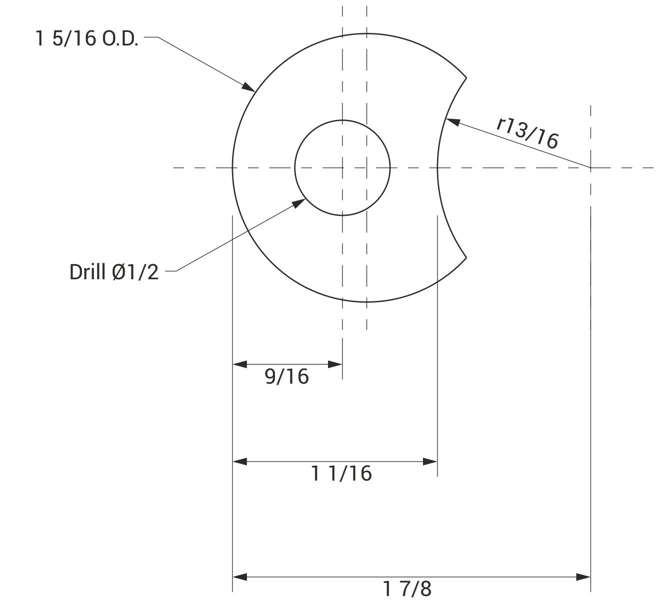
Scallop: Boring part of a hole

A bit of head scratching resulted in marking out this second piece for an offset half inch hole to be drilled in the position where the final 5/8" hole would later be bored and then marking out the scallop. See **fig. 1** for dimensions. The piece was gripped in the vice alongside a piece of wood that allowed the centre point of the scallop radius to be marked out and used to swing a pair of dividers draw to the 13/16" radius. Or a piece of 1 5/8" bar could be used as a template to scribe the radius without as much fuss. The job was then mounted in The Flagellator's four jaw chuck, so the offset half inch hole could be drilled, using the tailstock centre to get the prick punch mark on the layout into position. Remember, what we are making at this stage is a substitute rough casting so no point in wasting time with wigglers etc. for a more precision location.

Setting up to machine out the scallop was a little trickier. The job was mounted to The Flagellator's faceplate using one long bolt through the already drilled hole, with a piece of paper between the job and faceplate to provide both grip and a few thou safety barrier between the tool and the faceplate at the end of each cut. The right offset on the job was set using a slice of the 1 5/8" bar held on a mandrel (nut and bolt!) in the tailstock chuck. The job was manoeuvred until the marked-out line matched the edge of the slice of bar, **photo 3**. A boring bar was then used to "bore" out the scallop in the job as it rotated around the invisible centre of the radius of the scallop. Great care must be taken when setting this up to ensure the job does not foul the boring bar, **photo 4**. If it does, a smaller boring bar must be used. Swing the job over by hand before starting the motor, to make sure there is sufficient clearance when taking cuts.

I mounted a counterweight on the faceplate, so the boring could be done at 200rpm without The Flagellator dancing across the workshop floor. Small cuts of about 0.020" were taken until the tool reached the marked line and the job was done, **photo 5**. You can see I lost my bottle at the last minute and did not machine all the way through to the paper, instead leaving a few thou of metal that was later filed off. Also, I highly recommend painting that counterweight and bolt bright red, as

Fig.1



Fabricated VDH Tailstock Spindle Barrel

8

The main spindle lock barrel has the scallop turned in the lathe, then is positioned ready for clamping and welding.

9

The welds on the stand webs are ground smooth before welding on the base plate. This allows much easier access for the grinder.

I have done since catching my knuckles on it while focussing my attention on the job in the centre.

Sum of the parts: Welding

The two pieces of round bar were laid on the full-size drawing to prove the theoretical mark up and the scallop machining before welding together. All was good, so the two pieces were clamped together in the vice, the scallop providing perfect alignment of the pair. My welding equipment consists of an ancient arc welder, dubbed "The Penetrator", purchased at a garage sale for $50 and a 5kg box of 3.2mm rods that came with it. So the old welder was cranked up to its full 140 amps to get maximum penetration on these thick pieces of metal. Because welds contract as they cool and pull the adjoining pieces of steel out of alignment, four tack welds, two on each side, were applied to keep things straight before the final welding began, **photo 6**. After all four sides had been welded and cleaned, a second layer of weld, laid on with a weaving motion, was added to fill in any gaps and add strength.

Welds were then cleaned up with an angle grinder and Dremel tool before mounting the job on the vertical slide to mill the flats top and bottom of the tailstock shaft barrel. I ignored my original mark up lines and the amount machined off was determined by eye to look best where the two pieces blended together and had been welded. It ended up slightly thicker than on the original casting drawings, but I was happy with that. Resulting piece was starting to look like a dividing head body, **photo 7**.

There was one more tricky piece to machine and add: the spindle lock barrel that runs at right angles to the main barrels along the bottom. Eventually it will be bored and reamed to take two brass locking buttons that protrude into the main spindle bore, so needs to be located reasonably accurately. This piece was made by using a piece of 7/8" diameter BMS bar 2 1/8" long, with a scallop machined out of it to wrap around the main barrel, using similar technique as described for the tailstock spindle clamp barrel. This piece was then set up and welded to the main body in the same way as already described, **photo 8**.

10

With the base plate welded in place and ready for final clean up, the job is now looking like a versatile dividing head body.

Last stand: Plate fabrication

Thus endeth the tricky machining part of the story. What remains is to fabricate the webs that form the stand for the main barrel unit, and then the base plate. The base was easy, a piece of 3/8" plate cut to 4" by 2 3/4" using my friction disc chop saw. The shapes of the three webs that extend up from the base to the barrel unit were taken straight from the full-sized copy of the plans. The small central web is critical. It determines the centre height of the main spindle barrel, so this will need to be sized appropriately for your lathe. G.H. Thomas's dimensions suit the Myford ML7. The Drummond M type is just a tad different centre height. The slight angle on each end of this web is critical for getting the two main webs set in the right position for the right look true to the original casting.

The two main webs were made from 1/4" plate, each piece sized at 1 3/4" by 2" and marked up with a complete circular hole in the position to allow the locking pad barrel to protrude through. The two plates were tack welded together and the hole bored through in The Flagellator in one go. They were then separated, and the top half of each hole cut off to provide the final semi circular relief to clear the main spindle lock barrel. The central web was welded on first, again starting with tack welds, using a magnetic angle plate for location. The two main webs were then filed and ground to shape to fit against the main barrel, requiring some chamfering across the top to blend nicely into the shape of things. Each was clamped into position then tacked and welded. The Penetrator was dialled back to about 110 amps with smaller 2.5mm rods for this thinner metal. Before the final assembly was welded to the base plate, the existing welds were ground smooth with a carbide burr in a Dremel tool, **photo 9**.

Hot topic: Annealing

The result was a pretty reasonable approximation of a rough casting (with the emphasis on rough! I never claimed to be a welder), **photo 10**. But before I started machining it, I wanted to stress relieve the whole thing to ensure that over time as the welds settle, the body will not be pulled out of shape. It was decided to anneal the whole unit, which would also alleviate any hard spots in the welding that might make final machining difficult. A stack of fire bricks was built and a large propane torch hooked up to the barbecue gas bottle. After about an hour of patient heating, and not so patient mumbling, the dividing head body was glowing a nice cherry red and a magnet would not stick to it, so it was buried in a bucket of powdered lime for insulation overnight to cool slowly and anneal. Lime is nasty stuff, so use gloves and safety glasses for this, as well as for the heating stage.

The heat blackened lime scale made the fabricated VDH body look virtually indistinguishable from a casting, a very pleasing result. The raw "casting" was cleaned up on the wire wheel and then returned to The Flagellator for finish machining, **photo 11**. G.H. Thomas's book mentioned above contains full instructions for machining, much better than I could ever do, so I shan't go into the details here. If you decide to build the VDH you will most certainly need the book. After a lick of paint, the fabricated VDH body could easily pass as the "real" thing, **photo 12**.

Conclusion: Form plus function

The end product has been a beautiful classically styled piece of kit, **photo 13**, that has already proved very useful in the workshop. Fabricating the body, and the secondary worm wheel bracket, not only saved me the purchase price and shipping of the proper castings but also provided a very interesting project, both in solving the machining challenges without a milling machine and in the fabrication/welding aspect. Of course, the trade off is that it takes quite a bit of time to do the extra work.

A future article will cover how to substitute a straight cut Myford change gear for the main worm wheel on the Versatile Dividing Head and how to use the VDH to make its own secondary "straight cut helical" worm wheel substitute for the micro adjustment. ■

11

Body is finish machined following G.H. Thomas's original methods, just the same as a casting.

12

With some finishing and painting, the fabricated body looks just like a bought 'un.

13

The completed dividing head is both a beauty to behold and a useful piece of kit in the workshop.

References

Workshop Techniques by Geo. H. Thomas. TEE Publishing. UK. 1998

Materials list

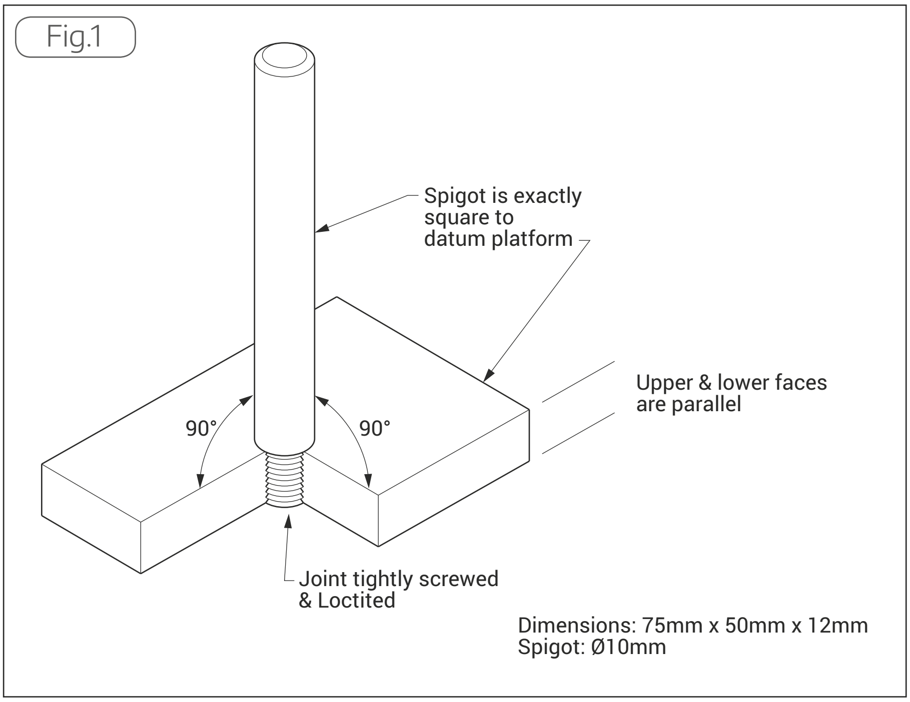
1 5/8" Diam. x 2 3/4" M.S. 1 off.
1 5/16" Diam. x 2 1/8" M.S. 1 off.
7/8" Diam. x 2 1/8" M.S. 1 off.
4" x 2 3/4" x 3/8" M.S. 1 off
2" x 1 3/4" x 1/4" M.S. 2 off
1 15/16" x 9/16" x 1/4" M.S. 1 off

Some Aids to Milling Machine Geometry

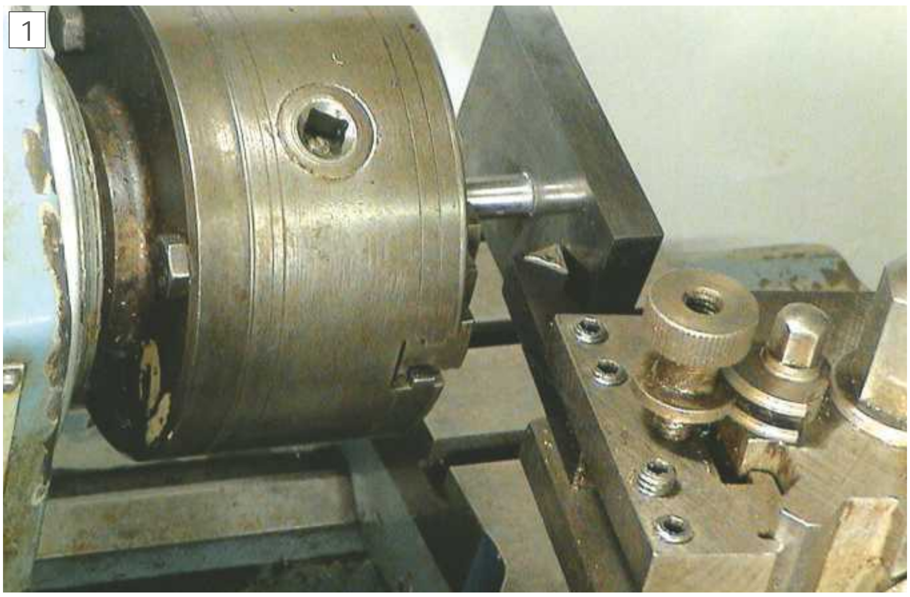
Ron Wright describes two handy accessories to speed up setting and improve accuracy on the mill.

Vertical milling machines of the round column type can be very versatile in their operations because the cutter can be positioned in numerous locations simply by; altering the angularity of the milling head, swinging it around the column and moving it vertically with respect to the table. But useful as these functions are their advantages diminish if the tool cannot be accurately locked in any desired location, so with this in mind the setting aids described ·below have been constructed.

Firstly, to locate the cutter axis exactly square to the table the little device shown in **fig. 1** can be used. I have described this I as a "datum platform" and it consists simply of a small rectangular slab of mild steel with a short spigot screwed, and loctited, firmly into a threaded hole in its centre. The dimensions given are not critical, but it is essential that the two faces of the slab (platform) are parallel to each other and square to the spigot.



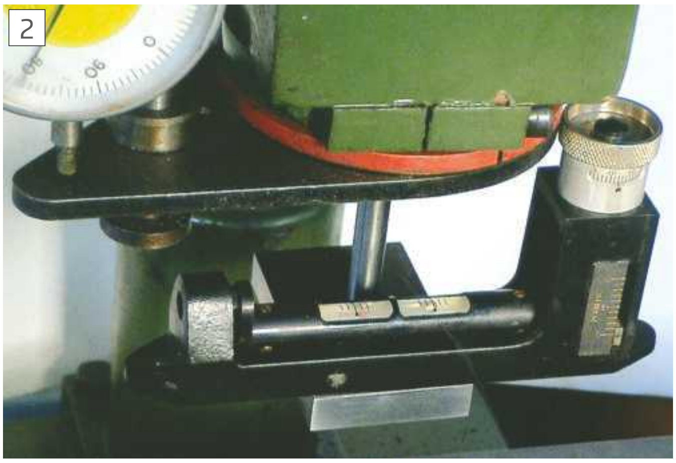
This can be achieved by chucking the spigot in the lathe and taking light cuts across both faces; **photo 1** shows the inner face being skimmed. In use the spigot is held in the milling spindle in a collet which will probably give better central accuracy than a chuck, and ensure that the platform is exactly square to the spindle centre line.



Skimming the datum platform

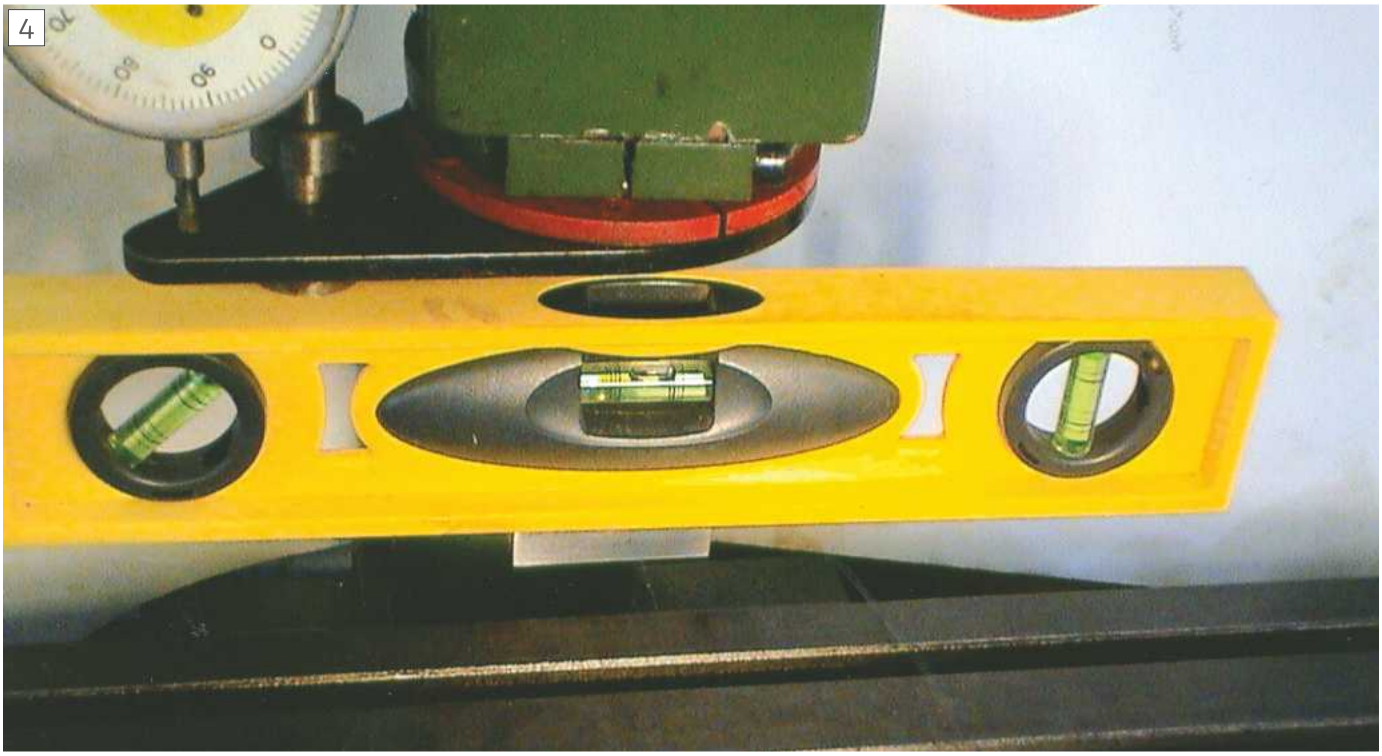
Following this a clinometer is placed on the table and set to zero and then transferred to the datum platform where there should be no change of reading if the spindle is precisely square to the table surface. If not the angular position of the head can be adjusted until the clinometer shows the same indication as that of the table.

This procedure can be repeated with readings taken across the table and if any discrepancy is found it will be due to the column being out of vertical, and as this will normally be bolted down to the bed

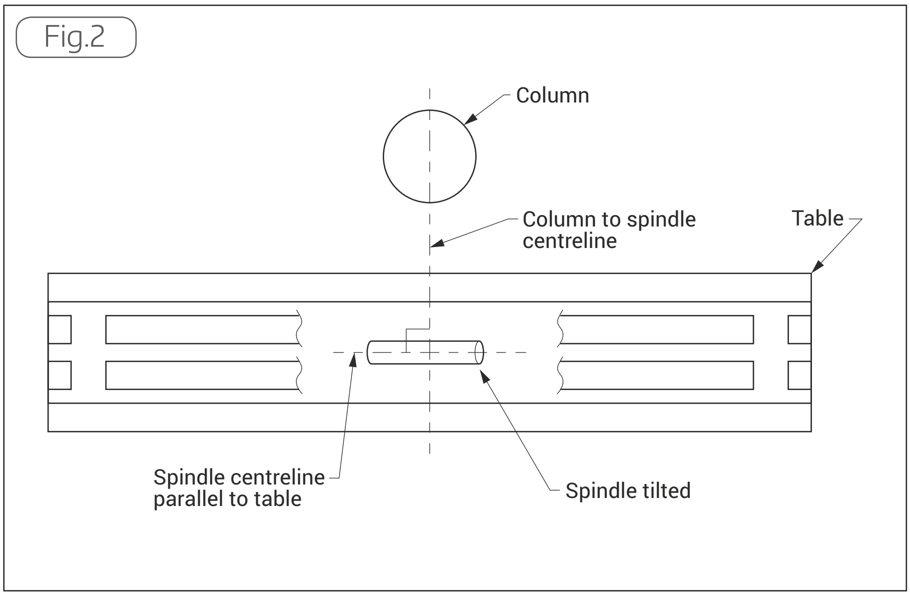


Using a clinometer to set the plate level

Plate and cheap spirit level



Using the spirit level to align the plate and mill

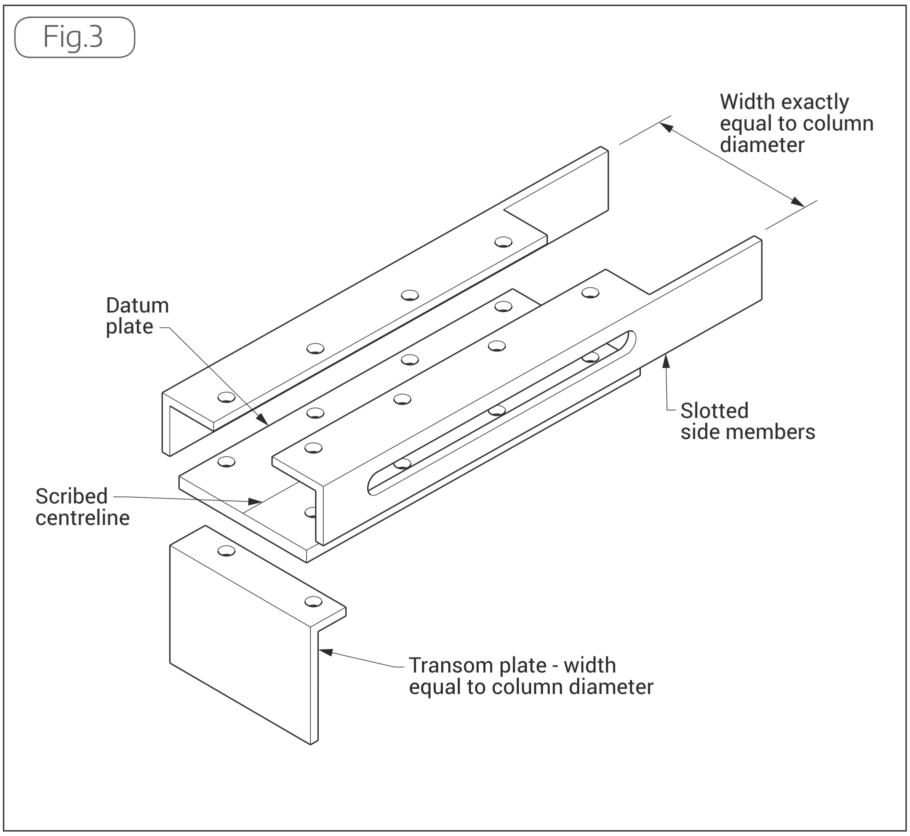


correction can be made by fitting shims between the column base and the bed. Some years ago, I did in fact have to correct my machine in this way (Chester Champion) and everything has been satisfactory since.

Photograph 2 shows the procedure being carried out using the clinometer but just out of curiosity I tried using a cheap

> For all straightforward flat surface milling operations spindle to table squareness is important...

Using the platform with an angle gauge



plastic spirit level, **photos 3** & **4**, and to my surprise it was just as good!

Note: for all straightforward flat surface milling operations spindle to table squareness is important, because if the cutter is tilted even slightly from the vertical it will cut deeper on one side than the opposite side which will result in a faint groove being machined instead of a flat surface.

Photographs 5 & **6** show an additional use for the platform in setting the spindle over to a precise angle, using either an angle set or a sine bar and slip gauges; in both cases the angle is 200 just for illustration but obviously by using the sine bar any desired angle can be set. And lastly as **photo 7** shows, this simple device can also be used in the lathe for angular setting of the top slide.

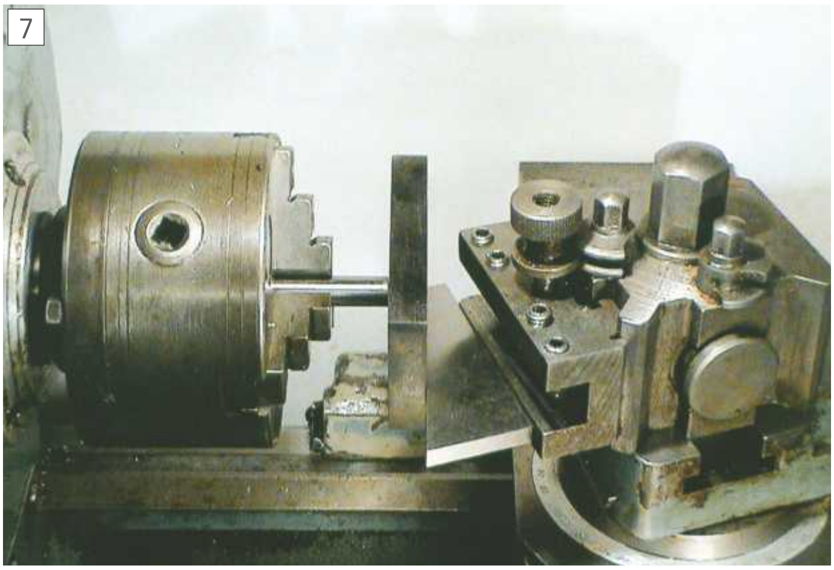
Another need for good precision arises when machining with the head set at an angle for milling across the table on the Z axis, or for angular drilling along the table axis. In both of these cases it is essential that the spindle axis is exactly parallel to the table centre line, **fig. 2**, and in order to achieve this the device shown in **fig. 3** can be used, which is simply a centre line indicator.

Construction is quite straightforward and consists of two lengths of mild steel angle iron with a flat plate (the datum surface) bolted between them, such that at one end the horizontal parts are cut away leaving the two side arms protruding. It is important that the distance between these two is exactly equal to the column diameter. Also of course they must be precisely parallel to each other, so the transom plate at the outer end must also match the column diameter and be square to the two side members; **photo 8** shows this.

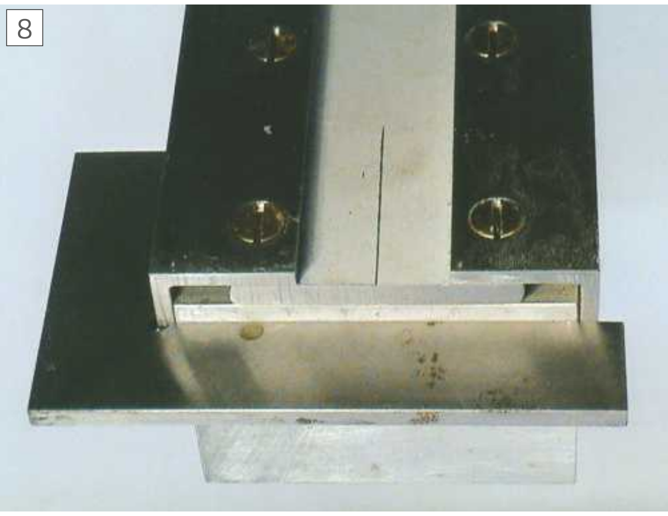
Slots are cut along each of the side

> But useful as these functions are their advantages diminish if the tool cannot be accurately locked in any desired location.

Using it with a sine bar



Using the platform to align the top slide of a lathe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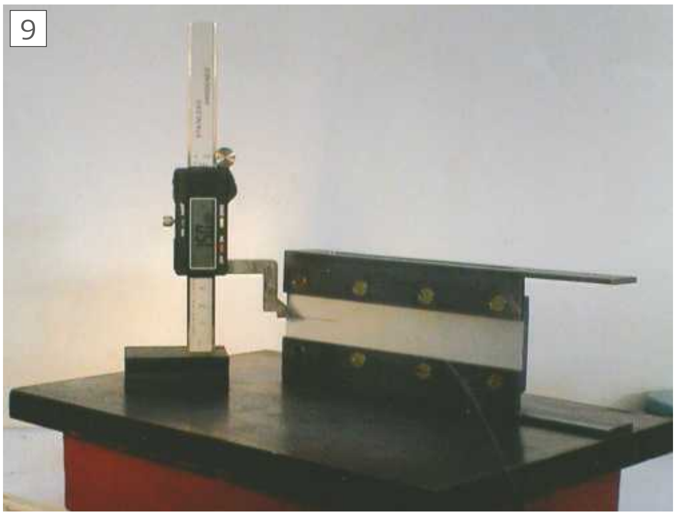
The centre line indicator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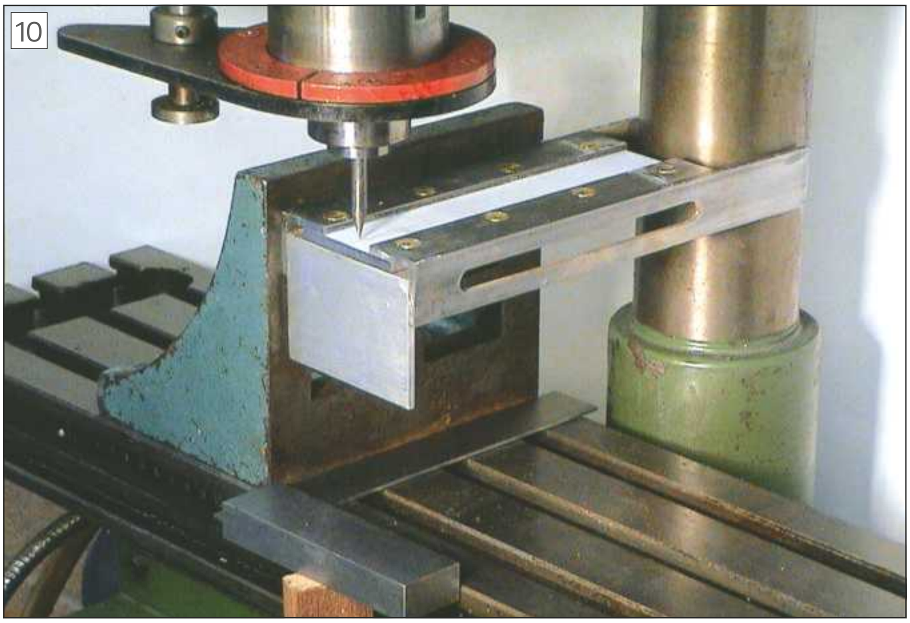
Scribing an accurate centre line

faces and a centre line is scribed along the upper face of the datum plate (photo 8). Ideally this should be done by using a height gauge on a surface plate, **photo 9**, but with care an adjustable square would probably do just as well. The trick of finding the exact centre is to mark parallel lines from each side which will allow the centre position to be determined; then the height gauge or the square can be set to this dimension and an exact centre line marked. Note; this is much easier to do than it is to describe!

Photograph 10 shows the device in use whereby one side is bolted to an angle plate which is set square across the table and positioned so that the protruding side members fit closely around the column; this will place the scribed centre line exactly co-incident with the column centre. An accurately pointed spigot is then fitted tightly into a collet in the machine spindle such that if the milling head is swung around the column to line up the pointer with the scribed line, then the centre line between the spindle and the column will be exactly square across the table; as shown in fig. 2. This also means that the spindle centre line, when tilted, will be exactly parallel with the table centre line.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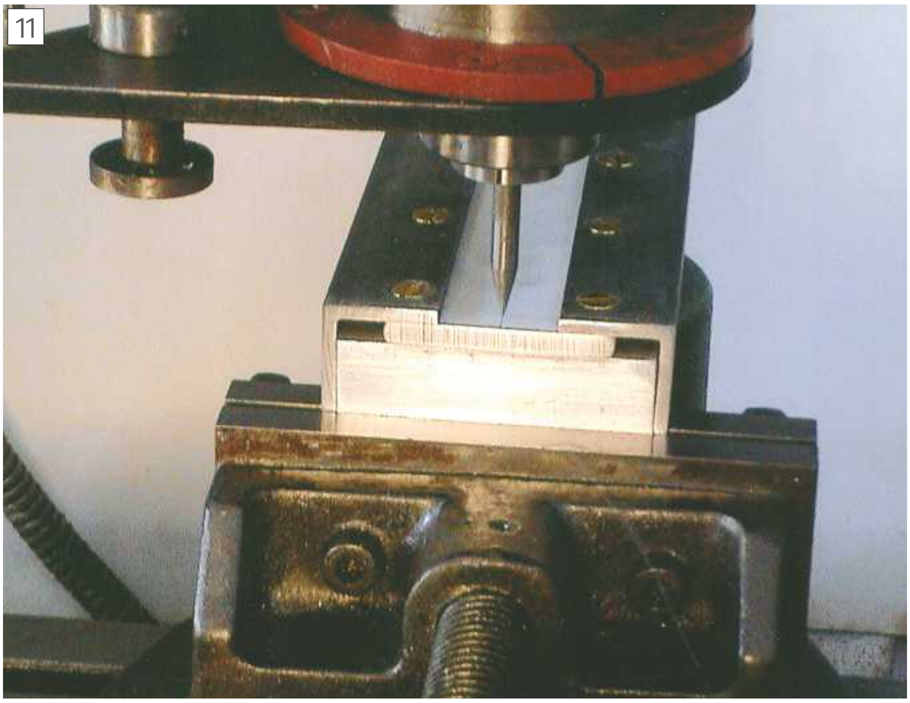
The indicator fits around the column

Consequently, any machining operations performed using the Z axis leadscrew will result in a flat and geometrically correct surface being cut on the workpiece; and any holes drilled will be square to that surface.

And finally, **photo 11** shows the indicator being used to check vice jaws for parallelism with the table. Assuming that the transom plate has been fitted exactly square to the scribed centre line, it can be simply clamped in the vice and the table shifted along the z axis. If the jaw is parallel to the table the spindle pointer will remain on the line; if not the vice position can be adjusted until it does and the clamp nuts tightened. ■


11

Using the indicator to check vice jaws

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Scribe a line

Dear Neil, with regard to 'exciting' parting off of awkward materials such as aluminium and stainless steels, whereas end working is fairly well provided for with swarf control, peck drilling, dog clutches etc, surfacing cuts not so much. Bear in mind that I do my parting off with industrial throw away tooling in my own workshop and they do as their told or else, so, be aware that these blades will accommodate both their nominal size say 4mm, next size up 5mm & round nose tips in the same blade handy for area clearance in wide & deep grooves. Now to return to parting matters, whereas CNC lathes have a swarf control subroutine for these materials involving feed in, back off to break swarf carry on ad infinitum, these are not to be found on your average bench top lathe. All is not lost however as you can emulate (still a word) this technique manually, feed in, back out a mil, carry on etc. etc., usual health and safety considerations apply, keeping swarf well away from where you are standing, having some form of work catcher would be nice, my days of picking off components by hand or bicycle spoke ended about 50 years ago. As an experiment you might try in an idle moment when parting off a billet, doing it with a round nose tool, you will discover why straight or angled tips or HSS blades are not as clever as you think. So, hope this has at least given some food for thought & cured your insomnia.

Bob Hutchinson, via the forum

PS: I didn't recognise you in the picture of you presenting Mr, Ashton with his trophy, thought it was some other tall bloke with a beard.

MEW in the USA

Dear Neil, even though I am not really an engineer, I have always been a keen maker of whatever it was I needed.

I started reading Model Engineers Workshop about three years ago, having previously dismissed it as something only for steam train enthusiasts; since then I have bought nearly all of them.

I have just returned from Minnesota USA, where I was on holiday seeing family. The area we were staying in, is rural farming country; so there was a lot of old machinery just sitting out there.

We had a day at the state fair, where there was some nicely restore old engines; of which I have attached a couple of pictures.

However, the real reason for writing; was caused by my desire to have reading material for the trip home. The local places we had been, didn't have anything of interest for me (which I found surprising); so the relatives said they knew where to take me.

We ended up at a Barnes and Noble book store, I am sure we once had them here; but don't know any locally.

They had the best selection I have seen in years and I soon found a couple of custom car mags (that being my main interest)

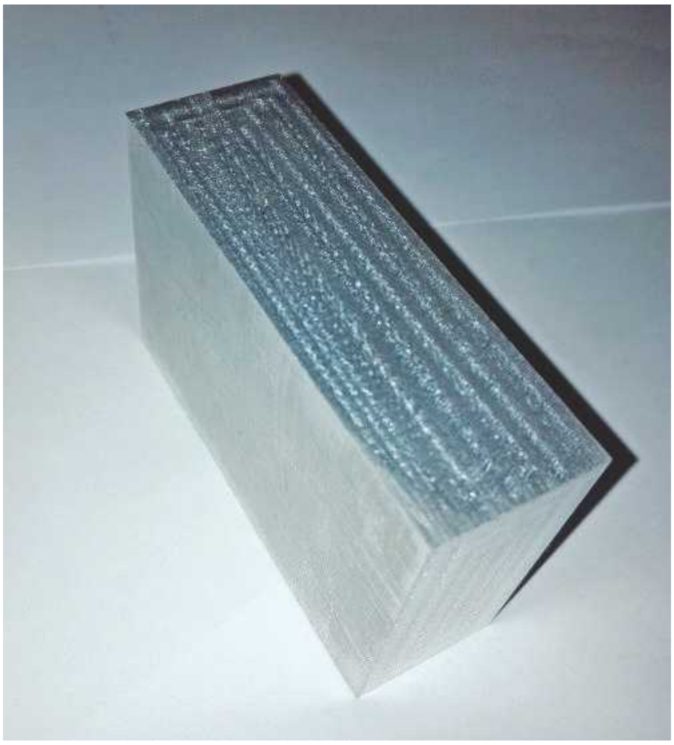
But I also found a title called The Home Shop Machinist, which seems to be a similar content and style to yours.

There was also what looked like a sister mag, called Machinist Workshop; but this looked like it was aimed more at professionals.

Then just as I was moving along, I spotted a familiar looking cover and lo and behold it was the current issue of Model Engineers Workshop; however, I declined to purchase it. The price tag made it a little over priced compared to waiting till I got home.

These sort of shops are bad for someone like me, my insatiable drive to read means I could easily have spent £50-60 on magazines; let alone books.

Eddie Dicker, by email



I Made a 1-2-3 Block

Dear Neil, Having read almost every page of every issue of MEW, I did not see very many references to 1 2 3 blocks. I therefore decided that maybe it would be good if I made my own. Researching the web produced a myriad of examples as well as the exorbitant prices attached to them.

I found a piece of high quality Aluminium (yes I know it normally is gauge plate or similar) and proceeded to machine my block. The photograph shows my finished block.

I know they are normally made in pairs and drilled full of holes, but I prefer it as I have made it.

Why the excitement?

Well in the process I found out again how accurate my Taiwanese horizontal band saw really is as well as my Taiwanese mill/drill. Both the mentioned machines are more than 20 years old and the saw especially has worked very hard.

The block I made clocked true to within 0,01 mm all round tested on a granite surface plate.

The message I have to fellow engineers is to look after your equipment and your equipment will look after you.

PS I have received another year subscription to my favourite magazine for my 70th birthday on 2nd September.

MEW greetings, Maans vd Merwe

Bench Oven Query

Dear Neil, I have recently built the workshop oven described in MEW 267, and it works pretty well from the point of view of achieving stable internal temperatures for annealing and tempering etc. However, I was surprised at the very high external case temperatures reached, so I am wondering if I have made a mistake with construction or materials, or whether this is to be expected.

With the oven set to 300C the temperature on top of the oven next to the heater mounting bracket screws is 150 C, and the outside of the front door is over 50 C. With a set temperature of 600 C the case top is 300 C and the front door is 150 C.

Mike Crossfield, by email

Chris Gabel replies:
Hello Mike, Thank you for your query. I too found quite a bit of heat leakage, mostly around the element termination but around the thermocouple as well. I 'm quite sure it is a question of how one fits the insulating blanket without gaps, but also without breaking or compacting the fibres which would reduce the insulating properties. I experimented with different materials for the insulation too. One of my preferred materials is the aluminium oxide lightweight refractory brick as used in kilns for firing ceramics. The material carves easily and is an excellent insulator. It was difficult to fit around the heating element. Getting it to fit seamlessly inside a small curved cylinder was difficult as well, so I opted for the insulating blanket. I found during development that yes there was heat leakage, but the design and controller did enable a consistent and stable heating environment.

Chris Gabel, by email
Mike Crossfield adds that he has since made an outer heat shield from perforated stainless steel over the most critical area (see photo).

Mystery Tool Rides Again

Hello Neil, I can shed some more light on this, it's part of a small parts or plate vice. I prepared one a little earlier. Well 52 years actually. As a raw apprentice in HM dockyard Chatham the first 8 months were spent using nothing but hand tools.

Mostly quite useless bits that fitted together in a multitude of ways (hopefully) to test skills with a file and hacksaw.

In the case of the plate vice you clamp the rectangular legs in a normal vice and adjust the level of the plate part so that just enough of the jaw is above to clamp the small part. Hope that makes sense.

This job is remembered with some chagrin as in typical MOD fashion the rectangular legs were made from round bar which we marked out and then cold chiselled and filed to shape. A very good exercise in using a cold chisel correctly as a proper cutting tool, but a very painful experience for a sixteen year old not used to hitting things with a hammer.Ouch I can still feel my left thumb protesting. As I remember it the turned pins were made by the slightly older lads once they got through to the turning section. On our model the springs are inside the legs.

Many thanks for a great Magazine.

Gordon Dodd, by email

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Tools from Files – A Follow-up

Peter Shaw revisits his article published in MEW 253

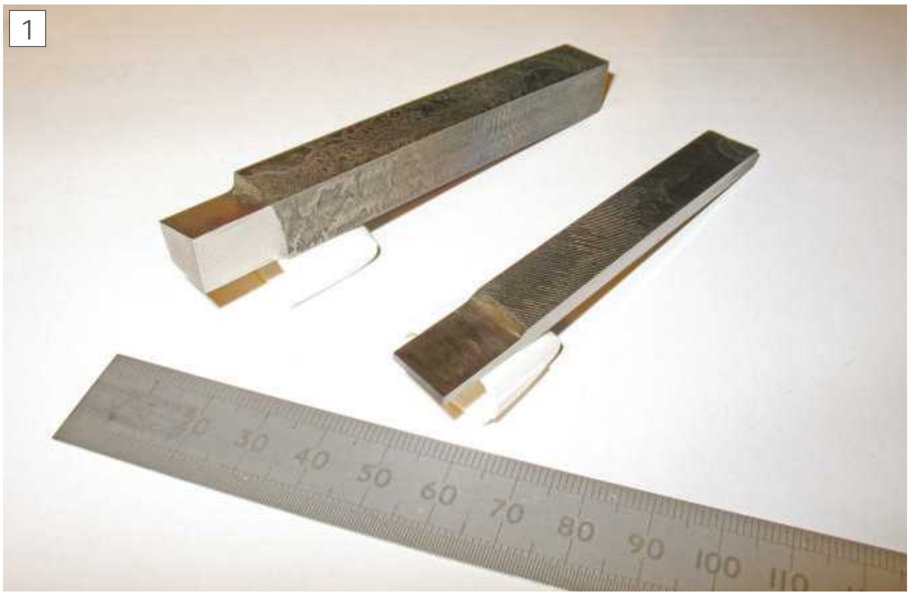
In 2015, following some experiments on re-using old files to make lathe tools, I wrote an article which appeared in MEW in April 2017.Since then, I have experimented further both in using these tools and in creating new tools. This article thus builds on the earlier article.

16mm Square File

As reported in the original article, I had deliberately bought an old 16mm square file from a car boot sale with the intention of using it to create some heavy-duty tools. Furthermore, I had expected to be able to use these tools directly in my 4-way toolpost as according to the lathe handbook, the 4-way toolpost could take 16mm square tools. Unfortunately, what the handbook omitted to say, and that I had not realised, was that the lathe centre height was 2 or 3 mm below the top of the tool slot hence any 16mm tool would have to be ground down to get the cutting point to the correct position.

Another problem was that I had expected to be able to create four 100 mm long tools out of this file. What I actually found was that firstly the file was not long enough for this, and secondly, I had forgotten to take the taper into account, the taper starting about 230mm away from the tang and decreasing to about 8mm at the tip of the file. Plus, the tip was actually broken. The eventual result was that I had enough square material for two tools 16mm square x 110 mm long, neither of which have been used as yet, and enough part tapered material for a 12mm square x 100 mm long tool. Still, three tools for £1.50 cannot be that bad!

Faced with the necessity to create an untapered tool, I decided that rather than attempt to grind away the surplus, I would treat it as if it was silver steel, i.e. anneal the metal by heating and allowing to cool slowly, followed by attempting to mill it square. If all went well, I could then shape the cutting edge on the grinder, re-harden, temper, and then finally sharpen properly.



The two tools mentioned in the text. Note the grain swelling on the knife tool caused by overheating, the rough surface from the milling tool, and the tempering colours.

A diversion!

Now, at this point I have to say that I have never been taught how to anneal or harden high carbon steel – all my knowledge has been gained from reading books and then experimenting. In particular, I have found the relevant colour, e.g. cherry red, rather difficult to determine, something I am not alone in as Tubal Cain in his book *Hardening, Tempering & Heat Treatment* (WSP 1) writes of the "problem of interpretation: what sort of straw, for example!" Also, L.C. Mason in his book *Using the Small Lathe* says that he finds that cherry red is sometimes not quite hot enough, a better indication of colour being that of cooked carrots. What this means is that on the few occasions when I have made hardened tools, I have deliberately erred on the high side and have consequently overheated the tools, indeed when I put a photograph of my homemade countersink on the MEW website, I was promptly told that I had well and truly overcooked it. Despite that I have successfully made three small tools and made a further two tools which have developed hairline cracks yet still work. The last tool that I worked on, I did it with Tubal Cain's book open at the relevant colour pages and was surprised to find that previously I had probably been in the region of at least 100 degrees C above the required temperature. I also suspect that the hairline cracks may have been due to not tempering quickly enough after the re-hardening.

16mm Square File (continued!)

Annealing the metal was done in the time-honoured method of heating it inside a firebrick oven until it was hot enough (see above), holding it at this temperature for about 25 minutes and then allowing to slowly cool inside the oven. Strictly speaking, I should have held it at the high temperature for 38 minutes (i.e. 1 hour per inch or 25mm), but I wasn't too bothered if it wasn't annealed all the way through because I was only interested in the outside two or three millimetres, and in any event, I was going to re-harden it eventually.

Once annealed, I found that I was able to easily mill the piece square. As **photo 1** shows, the milling was quite poor: this was because I used a broken endmill, which I had roughly re-ground and use purely as a quick and dirty heavy-duty stock removal tool. With hindsight, what I should have done was to have used a file after the removal of the excess material. That would have given me a smoother surface.

I then used the coarse and fine grinding wheels to create the required shape for a knife tool followed by hardening and tempering to light straw. Once again the tool was heated to well above the required temperature, held there for about 25 minutes and then quickly cooled in water. At this point I should have immediately cleaned the metal to allow visual inspection of the tempering colours and then tempered it to light straw. Unfortunately, I left tempering to much later, and this is, I think, why my tool developed a small horizontal crack. Nevertheless, it works, and works well, but for how long is anyone's guess.

Flat File Conversion

In the April 2017 article, I showed a parting off tool made from an old 4 by ½ by 1/8 inch (100 x 12 x 3mm) flat file which actually works very well. This particular file had been subjected to a number of failed experiments which resulted in the original 4 inches (100mm) being reduced to about 2 inches (50 mm), and whilst it is held securely in the holder, there is very little leeway for any future re-shaping. As it happened, I had an old flat file which was probably originally about 3/16 inch or 5mm thick. I have converted this file to a 100 x 11.8 x 4.3 mm tool with an appropriate blade for parting off. There is thus plenty of length to allow for regrinding and resharpening, see photo 1.

As before, the file was annealed, then its edges milled to the correct size to fit the slot in the holder, followed by polishing of the upper edge to aid swarf removal. To prevent the teeth of the original file from damaging the holder, I decided to remove them, initially by milling, but ran into difficulties holding the tool firmly enough so ended up either lightly grinding or filing them – I can't remember which. Finally, the tool was hardened and tempered as above. Note that this time, I followed Tubal Cain's advice and did not have any problems with hairline cracks.

Angles and Sharpening

As I think is well known, the actual angles used on a lathe knife tool are not at all critical, and it seems that as long as the tool is sharp, a few degrees either way will not prevent the creation of a usable tool. Studying the various documents, I have available, I came to the conclusion that the angles shown in **fig. 1** were a suitable initial compromise, although with hindsight, I think the side rake angle of 15 degrees may be beneficially increased to 20 degrees. This is because I have found that there is a tendency for small particles of swarf to weld themselves to the tip of the tool, thus destroying the cutting point and leading to a rough finish. In addition, even when this does not occur, wear can be seen on the top surface of the cutting corner, shown as an ellipse in the drawing. It seems to me therefore, that increasing the side rake angle may help by allowing the swarf to escape more easily. As a result, I have deliberately increased this angle to 25 degrees on one of the knife tools and found that there does seem to be a slight improvement, but given the amount of grinding required, I am not that certain how beneficial it is. And yes, I am aware of the difference between 20 degrees and 25 degrees.

Although not shown on the drawing, I also rounded the vertical edge on the cutting corner in order to enable the tool to work as a finishing tool. Tubal Cain recommends 1/64 inch (0.4 mm) radius, but I simply used a diamond hone to add a small but noticeable rounded corner.

Using the tools

As an amateur, I am not bothered about work rates, hence tend to turn at low speeds with light cuts. With these tools I use a normal maximum of 250 rpm, occasionally 355 rpm, and even more rarely, 500 rpm, and generally a maximum cut of 0.5 mm off the diameter. A lot of my turning is short distance hence I use hand feed taken at whatever speed seems appropriate to produce a good finish. For true finishing cuts, contrary to established wisdom, I feed as slow as possible, and whilst I understand why a faster and deeper cut is better, slow and shallow cuts work for me. Having said that, I have found that on a tough steel, it does seem that the faster feed rate and the deeper cut do seem to work better, albeit with the appearance of a very fine thread. Perhaps this is an indication that the tool tip rounding is insufficient.

For facing cuts, I use minimum depth of cut and sufficient feed to obtain a smooth surface with a whatever seems to be an appropriate rotational speed.

I have tried a heavy cut, fed at a high rate. The tool did work, but not only was the tip build-up excessive causing a very ragged finish, but clouds of smoke was generated from the cutting fluid, presumably an indication that both the tool and the work were hot. I do not like the smoke, and I do wonder about its effect on health. Perhaps someone in the know may care to comment on this. For what it is worth, I use Neatcut as supplied by Warco, this should not be taken as any criticism of either.

I tried the parting off tool on what appears to be a manganese steel as shown by Tubal Cain's spark test. It did not like it, even with cutting fluid, and this led eventually to breakage of the tool. With ordinary mild steel, again as shown by the spark test, it was satisfactory.

Wear and tear

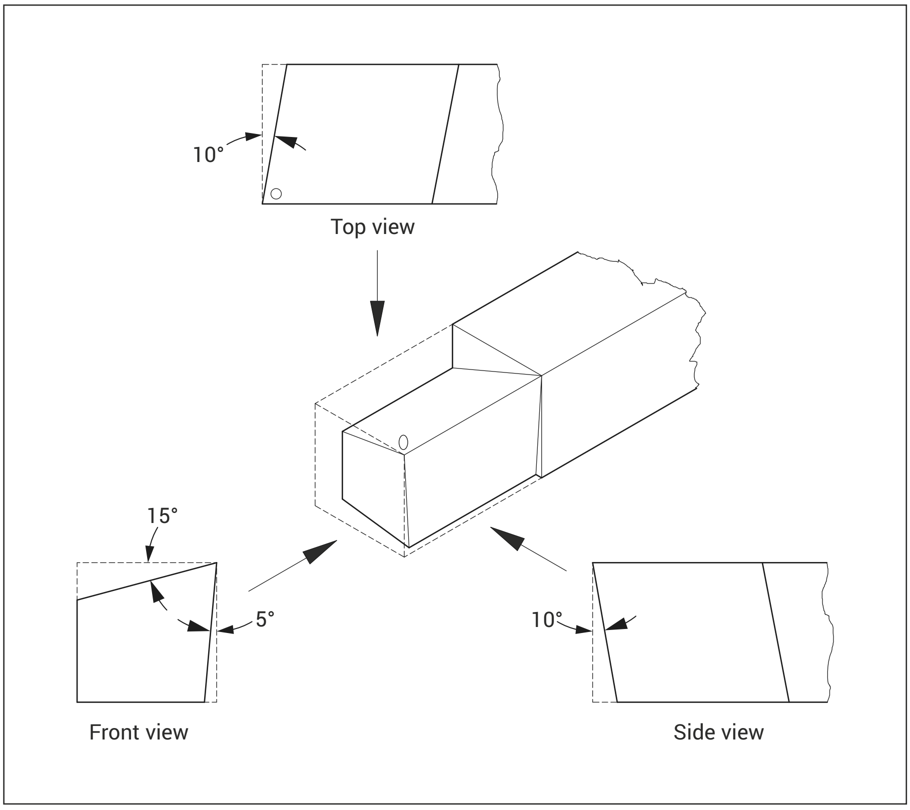
As mentioned above, the knife tools suffered from tip build-up. For light work, the build-up is not excessive and is easily removed by a few strokes with a diamond hone. I also found that the tools wear rather quickly, necessitating a re-grind and re-sharpen. This is not difficult as only the front face requires working on and provided the wear is not excessive, easily done. Possibly another reason for increasing the side rake.

Conclusions

In general, in comparison with HSS, the tools work well especially on mild steel, but do seem to wear quickly, although re-grinding and re-sharpening is easy. Having made the tools, I now use them in preference to HSS, silver steel, or carbide for all my basic external turning needs. And best of all, I am re-using material which would otherwise be scrapped, and that gladdens my tight Yorkshire heart and wallet! ■

References.

L. C. Mason: *Using the Small Lathe.*
Tubal Cain: *Hardening, Tempering & Heat Treatment.* Workshop Practice Series No. 1
Peter Shaw: *Making Lathe Tools out of Old Files.* MEW253, April 2017, Page 9.



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My Little Chuck Adventure.

Brian Howett modifies a chuck backplate

It began when I entered a competition – soon forgot all about it – until I had a letter informing me I had won £50-00 – enclosing vouchers - just before Christmas.

Nice surprise, but it had to be spent at Chester Machine Tools. Not a problem, they had an Open Day coming up.

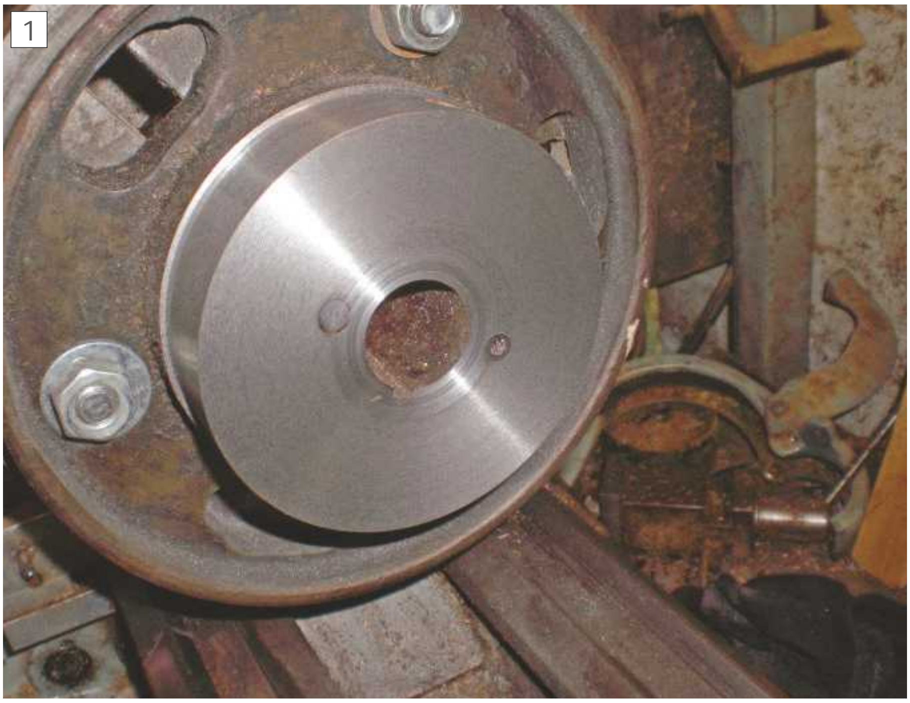
So I set off for Chester. I am not in the market for a new lathe – or milling machine, so I reviewed the selection of "small tools" and accessories. I seem to have a fairly comprehensive collection of tools and tooling – so nothing took my eye, but with £50 to spend – there had to be a choice.

One thing I fancied was a 4-jaw self-centring chuck, so the choice was made – (plus another £50). Then the fun started! I seemed to remember lathe backplates being on offer at sensible prices – then found most were too small for my needs.

I then remembered an old cast iron lathe backplate I had – used as a weight when gluing wood. It was a little too large, but better than too small. I don't hoard junk – just things "that will come in handy one day". As it was too large to hold in my chuck – I had to bolt it to my lathe faceplate. So far so good, the plan was to bore it out to take a 1 ½" x 8 BSF thread to fit my South Bend spindle.

A cleaning cut revealed it had already been bored out and a 1 ½" steel insert put in, photo 1. Slight snag?

1



I discovered an existing insert.

I don't hoard junk - just things "that will come in handy one day".

I bored it out to 3", and turned an oddment of cast iron down, done between centres on a tapered mandrel, **photo 2**, heating the faceplate and shrink fit pressing it in, **photo 3** & **4**. I have a flypress – rarely used – but this was a day when it was to prove its worth.

As this was to be quite critical I invested

2

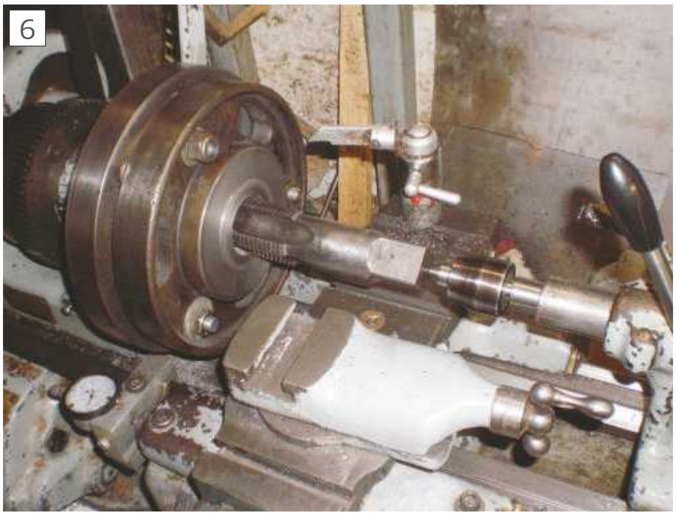
Turning a plug between centres.

3

The insert pressed in.

Cleaning up the rear of the backplate.

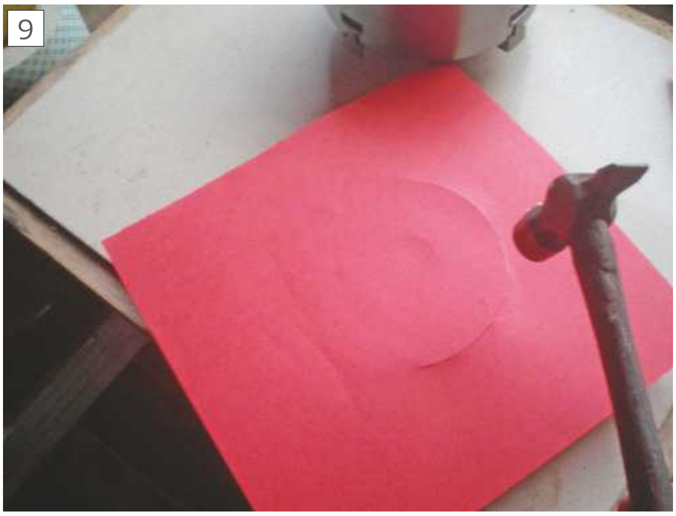
The thread prior to clean up.



Running the 1 ½" tap through.

Skimming the mounting face.

Holes filled with epoxy steel.



Using the 'gasket making' technique to create a template.

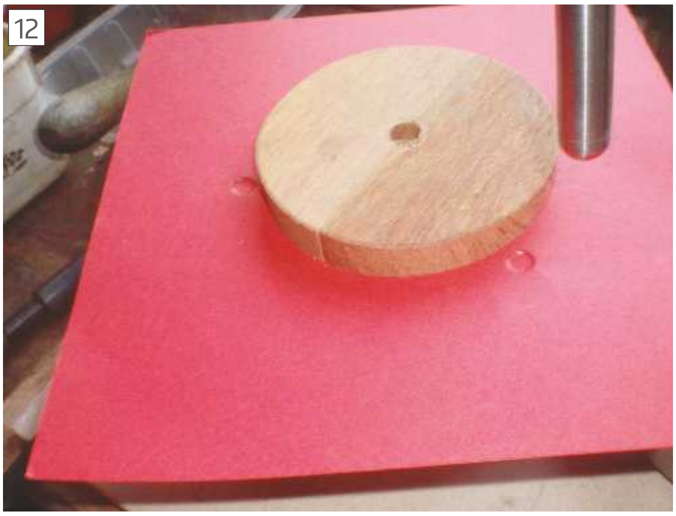
in a Whit/BSF form boring bar, then set up and cut the internal thread, **photo 5**, having re-set the casting proud of my faceplate with some suitable tool steel blanks. I calculated how deep I needed to cut – plus a little bit – then realised it had to be a very good fit. A tap run through would ensure perfection!

Many phone calls and visits to local engineering contacts drew a blank – everyone is on UNC or Metric these days, and a tap of the size I wanted was asking too much. New prices were horrific – even online, but I spotted one among some "new-old-stock" offers. I duly sent off an order – a 1 ½" BSF tap - and ONE half inch BSF tap arrived. Just a slight misunderstanding! This was soon put right, however, and that vital cleanout pass was made, **photo 6**.

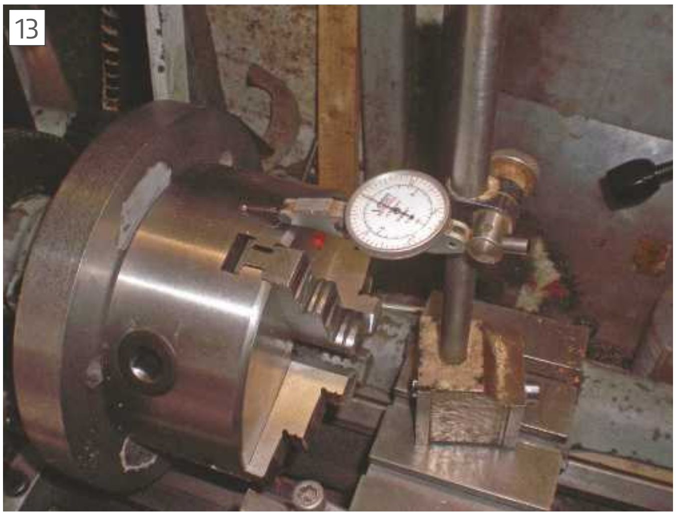
Then followed a series of juggling operations, firstly mounting it proudly on my South Bend, and skimming the chuck mounting face, **photo 7**, and then the register. For some reason it has some rough half-round holes, which gave an irregular cut. These I filled with epoxy steel – which

A clean cut.

The hardwood bung.



Marking out the hole locations.



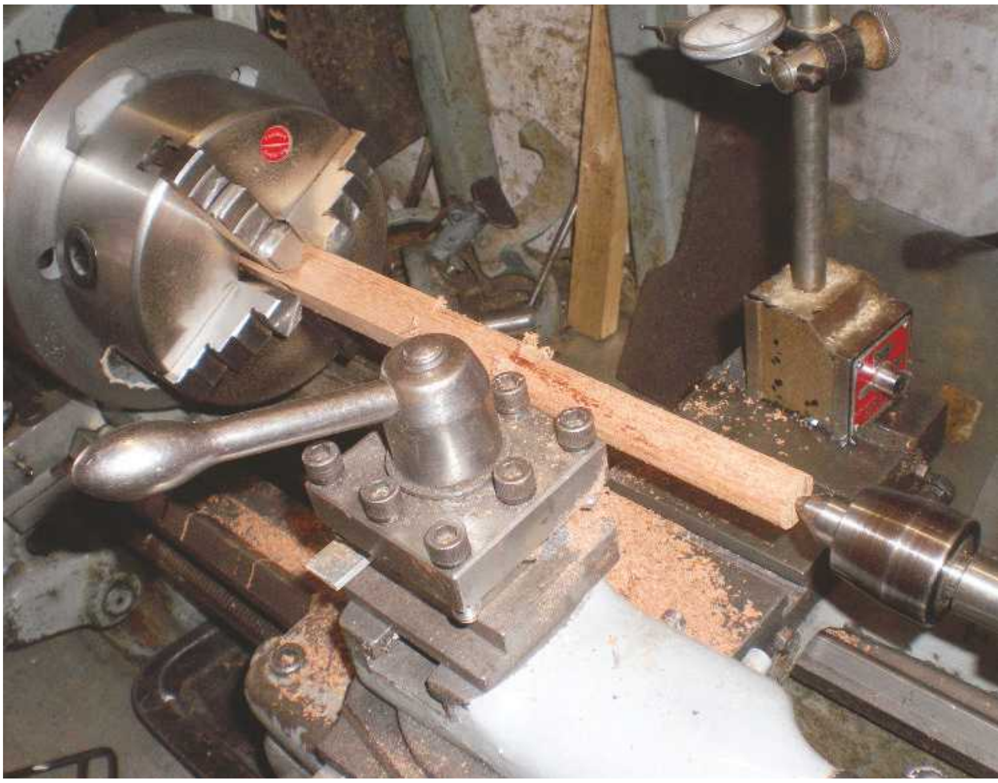
Perfect alignment!

didn't ease the irregular cut, but it was purely to be for cosmetic effect, **photo 8**.

Then – realising the chuck mounting holes would be blind holes – a means of transferring the mounting hole locations was needed. My Dad was a WWI Dispatch Rider, and one thing passed on to me was making gaskets, (who makes them nowadays?) A piece of stout card was attached with double sided tape – gentle brushing blows with a small hammer – and the raised register land cut through, photos 9 & 10. Again, taps with a ball-ended bar (I didn't have a spare suitable small ball pein hammer) and I then had a means of transferring the hole locations to the new backplate. A hardwood bung was turned to fit the chuck register, **photo 11**. The mounting hole locations were carefully marked – and drilled, **photo 12**.

Finally, cleaning up the resin inserts – a coat of primer – and coat of grey enamel – and finally mounting and bolting up the chuck.

My DTI showed zero-zero, **photo 13** & **14**. Success! – and "Thanks to our friends at Chester!" ■



The chuck in use.

I treated Myself – Digital Height Gauge

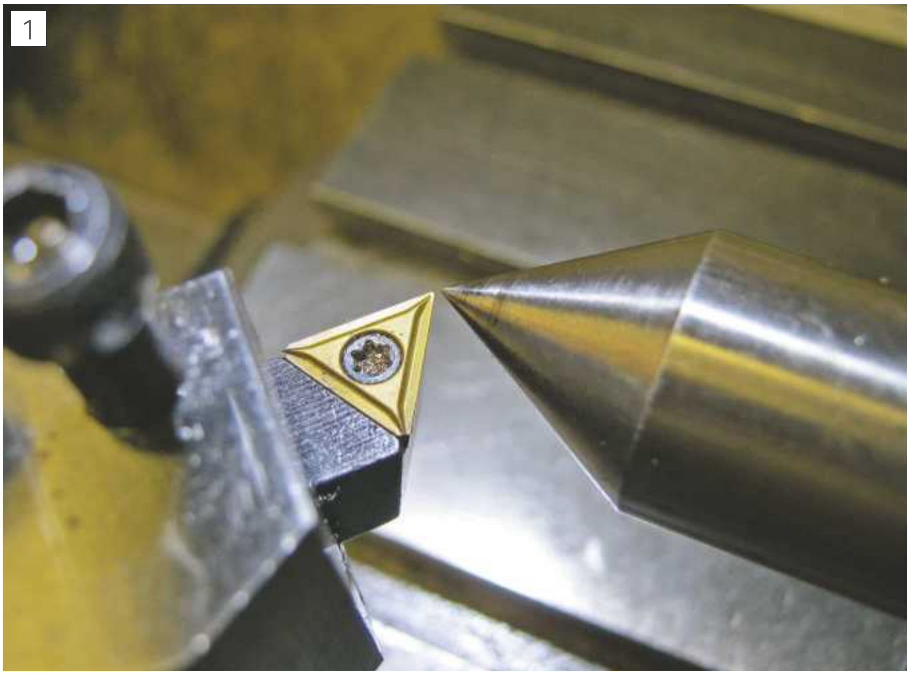
Laurie Leonard indulges in some (engineering) retail therapy

In the hobby workshop, as in many areas of life, the available budget plays a significant role in determining what items, if any, are to be purchased. The usual questions: "Can I afford this? Can I really justify buying this? Will I get the use out of it if I do buy it?" amongst others go through the mind when drooling over a tool catalogue or an advert in MEW.

I am here to argue that once in while it is necessary to throw caution to the wind and splash out on a new Widget, digital, analogue or just plain manual but in this case digital and treat yourself! Having had my eye on a digital height gauge I splashed out and bought one and have been well pleased with the use I have been able to put it to. Below I give some examples to perhaps tempt readers to such a purchase and commit to paper some of my mental justifications (after the fact?) for the purchase.

Lathe Tool Height Setting

The cutting tip of a lathe tool must be at centre height and there are many ways of checking/setting it. At school we were instructed to set the tool, mounted in the rocking boat type of tool holder, by advancing a centre in the tailstock to the tool and gauging the tip of the tool to the point of the centre by eye and locking the tool – my eyes were much better then, **photo 1**!



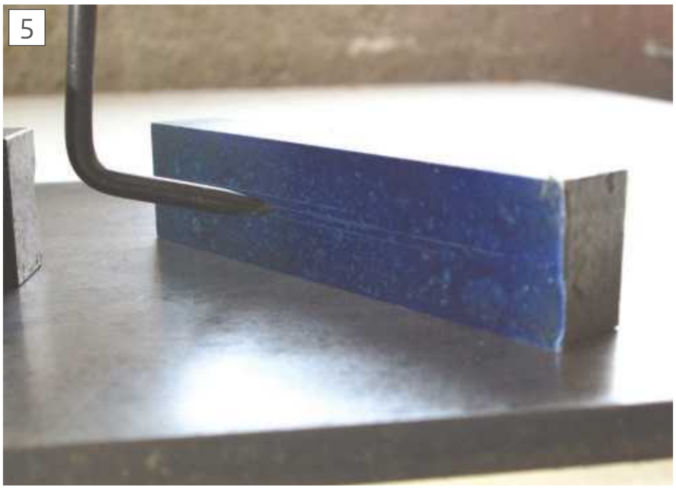
Setting lathe tool height utilising the tailstock centre point

Proprietary centre height gauge

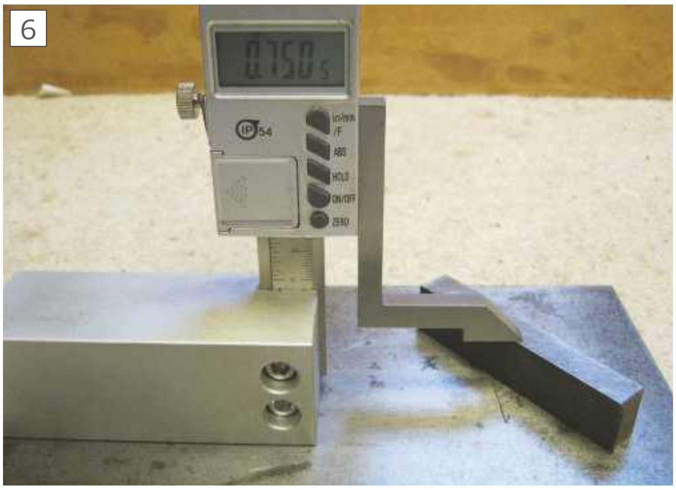
The usual questions: "Can I afford this? Can I really justify buying this? Will I get the use out of it if I do buy it?

Using a piece of silver steel and a Digital Height Gauge to calculate centre height

Using the calculated centre height to set the tool height



Using a marking gauge to scribe a centreline



Measuring the thickness of a block prior to scribing a centre line along it

I have been quite impressed with the proprietary tool setters such as in **photo 2** where the rod of the gauge is held in the lathe chuck and the gauge rests on the tip of the tool. However, this needs the lathe to be level (as it should be) for it to work accurately. An accurate method independent of any lathe bed incline makes use the digital height gauge but what do you set it to? A method used to calculate a value for the centre height involves chucking a piece of silver steel (assumed to be accurately ground) of known diameter and measuring the height above the bed ways as in **photo 3**. By subtracting half the diameter of the silver steel the centre height can be calculated and used in conjunction with the gauge to set the tool height.

On my Myford 7 (with a nominal centre height of 3 ½ inches) with the tailstock centre method and my eyesight I got a tool set height (measured after the event with the digital height gauge) of 3.506 inches. The proprietary setting gauge (also

Scribing a centre line on a block using the Digital Height Gauge

8


Measuring the overall height of "v" bloc mounted cylindrical work

9

Marking the centre line on cylindrical work

measured after the event with the gauge) gave a tool set height of3.496 inches. A value for the set height of 3.497 inches was obtained using the calculated height method utilising the quarter inch rod of the proprietary gauge as the "silver steel". The latter method and the proprietary gauge method are prone to an error if the jaws of the chuck used are not true: mine are not by a couple of thou. Deviation from nominal centre height may occur for a number of reasons including regrind work on the lathe depending on what is done.

Having ascertained the setting height, the lathe tool is then set to just kiss the underside of the gauge, **photo 4**.

Scribing a Centre Line on a Block

There is often the need to scribe a line along the centre of a block or strip of metal. A marking gauge can be used utilising a trial and error method to get the centre line (I was also taught this at school), usually involving at least two steps, a guess marked from both edges and then splitting the difference by eye to arrive at the centre,

10


Setting a work piece mounted on a vertical slide to lathe centre height.

11

Setting depth of cut on a router table

photo 5. The height gauge can be used by zeroing it on a flat plate/surface plate (I use a piece of gauge plate) and then lowering the height gauge onto the top of the block to measure the height of the block in question, **photo 6**. By halving this measurement and setting the gauge to the result the centre line can be scribed utilising the scoring edge of the gauge, **photo 7**.

Scribing a centre line on cylindrical work piece and setting up for milling in the lathe

The centre line on a cylindrical piece of work can marked using a similar method. The work piece can be supported on"v" block(s) the centre height calculated from the height of the piece, **photo 8**, measured with the height gauge and the previously measured diameter of the work piece. Setting the gauge to the calculated value (height of work piece less half its diameter)

Whilst working to a thou may be considered normal practice in metalwork, working to close tolerances can also be important in woodworking applications.

will enable the centre line to be scribed, **photo 9**. The state of my "v" block, made when I was an apprentice on a course at Derby Tech, shows the far from ideal conditions in my shed despite the blocks being kept oiled and in a sealed box. Trying to clean them up a bit recently revealed my "works number" stamped on the block in the clamping groove.

Should the work now need to be set up for machining, eg a slot milled using the lathe, then the DHG can again be used in the set up. In a job I recently did it was necessary to mill a slot for a key and the lathe was to be used as the job was for the mill drive and the mill was out of action. The piece, mounted on a "v" block on a vertical slide, was placed on a piece of gauge plate and with the gauge set to the lathe centre height the slide was adjusted until the centre line corresponded to the setting.

It is also possible, and with eye sight like mine more accurate, to set the gauge to the lathe centre height plus half the diameter of the job and then adjust the vertical slide until the top of the job just kisses the underside of the gauge, **photo 10**.

Plating coming off and swarf stuck to the magnets on the base of the Digital Height Gauge

Router bit height setting

Whilst working to a thou may be considered normal practice in metalwork, working to close tolerances can also be important in woodworking applications. A recent project required grooves to be machined in some strips of wood to accommodate a sliding lid. Perhaps not overly critical on clearance but if a job it worth doing ... A router table and cutter was used to cut the slots and the depth of the groove was accurately machined by setting the height of the router bit above the table using the height gauge, **photo 11**.

A Word of Caution

My particular digital height gauge is equipped with magnets in the base to hold it on a magnetic surface. I have encountered two problems with these. First, they attract swarf which can play havoc with readings and secondly the plating is coming off in places which in turn can prevent the gauge sitting down on the reference surface, **photo 12**. ■

NEXT ISSUE — MODEL ENGINEER

- **GWR Water Crane**
  Roger Davis builds a one third scale water crane for the Bath and West Railway.
- **BR2 Front Nose**
  Mick Knights describes how he made the front nose and propeller mounting for his Bentley BR2 aero engine.
- **Garden Railway**
  Martin Evans makes a point.
- **LNWR 'D' Tank**
  Chris Rayward describes the construction of his LNWR heavy shunting tank locomotive.
- **We Visit Cheltenham**
  Graham Gardner spends a day with the Cheltenham model engineers.

Content may be subject to change.

ON SALE 12 OCTOBER 2018

Mike's Workshop

A Lever Feed Tailstock for The Mini-Lathe

Mike Cox fleshes out the details of a useful Mini-Lathe mode first introduced on the forum by John Stevenson.

When I first purchased my mini-lathe one of the first projects I attempted required drilling 4mm holes 50mm deep into round mild steel bar. Drilling the first 10mm was easy but as the hole gets deeper then the drill must be withdrawn frequently to clear the swarf that accumulate in the flutes. Failure to do this slows the whole process down, the drill heats up and becomes blunt and there is the possibility of the drill jamming and breaking. On the other hand, withdrawing the drill every few seconds is also slow and tedious. Whilst doing this operation I pondered on how this operation could be performed more efficiently and I started to imagine a feed arrangement a bit like a drill press on its side whereby the drill could be advanced into and withdrawn from the bar by moving a lever.

A while later I research this concept on line and discovered that this was not a new concept and that lever feed tailstocks already existed. I eventually found a design for a lever feed tailstock and I built it but the stroke was quite short and it was not very satisfactory except for very small holes. An alternative design was later published in MEW which I also built but this was not very satisfactory either.

Fig.1

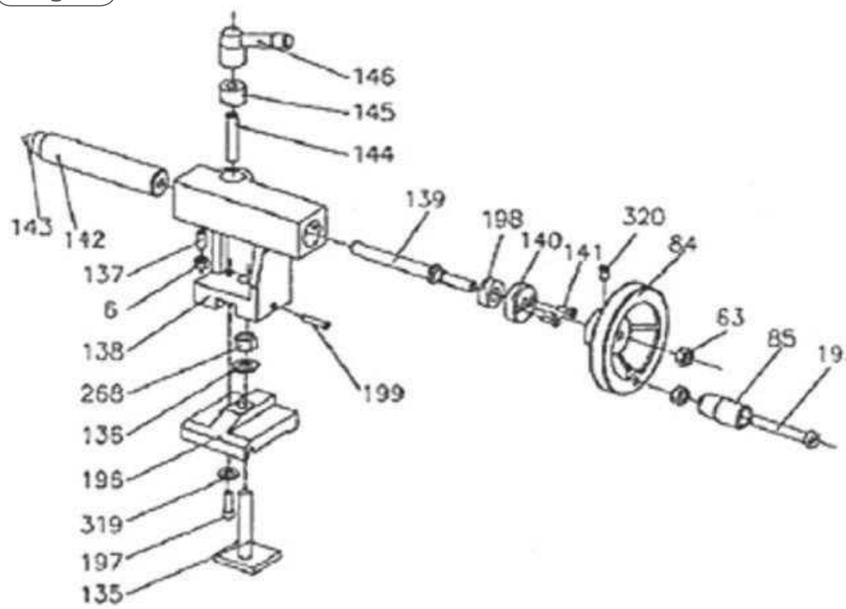


Fig 1. The Seig Tailstock
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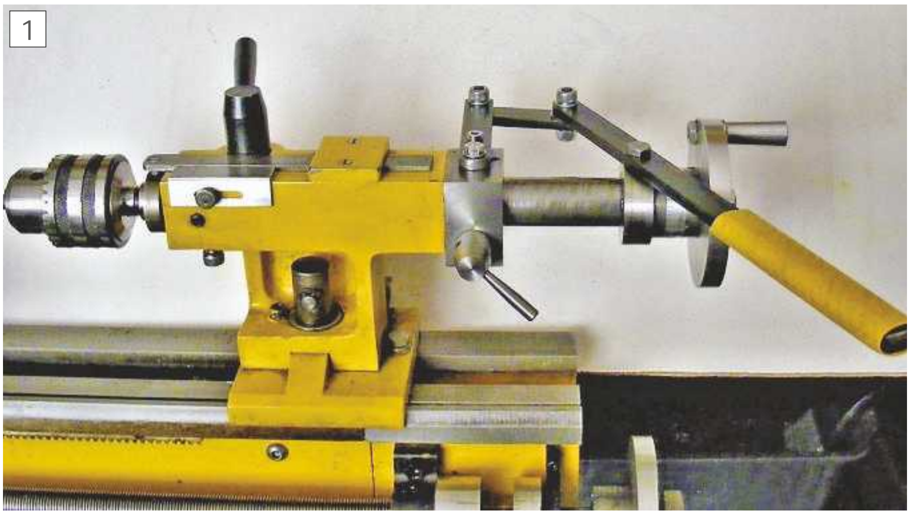
1



The lever feed tailstock

Back in 2014 there was a discussion on the ME website about lever feed tailstocks and John Stevenson was advocating the system used on Clausing lathes. He went on to show that this system could be adapted for use on the mini-lathe, see www.model-engineer.co.uk/leverfeed. What I liked about this system was that it required minimum alteration to the existing mini-lathe tailstock whilst retaining all the benefits of screw feed as well as having lever feed capability.

Sadly, John Stevenson passed to the great workshop in the sky in October 2017. Over the years John has provided me with many useful ideas as well as entertained me with his unique contributions to various fora to which he and I belonged. In this article I will describe my version of the lever feed tailstock that I made according to the principle expounded by John. I dedicate this article to his memory.

The standard Sieg tailstock.

An exploded diagram of the standard Sieg tailstock is shown in **fig. 1**. The Morse taper sleeve, 142, slides in the tailstock barrel, 6. To prevent the sleeve rotating it is grooved along the bottom and screw, 137, locates in this. The end of the sleeve is threaded to accept the feed screw, 139. This is 10mm diameter with a left hand 1.5mm pitch thread.

The end of the tailstock barrel is closed with the plug,198 and the end cap,140. These are both secured to the tailstock barrel by two screws, 141. The screw, 139, has a flange that bears on the end plug and the shaft protruding through the end cap is fixed to the hand wheel, 84, by grub screw 320 and nut, 63. The position of the hand wheel is adjusted so that there is just sufficient clearance between the collar and the end plug and between the hand wheel and the end cap so that it can rotate easily but with minimum axial play.

A cross section through the standard tailstock is shown in **fig. 2**. It can be seen that as the hand wheel and feed screw are rotated then the Morse taper sleeve is moved in or out of the tailstock barrel.

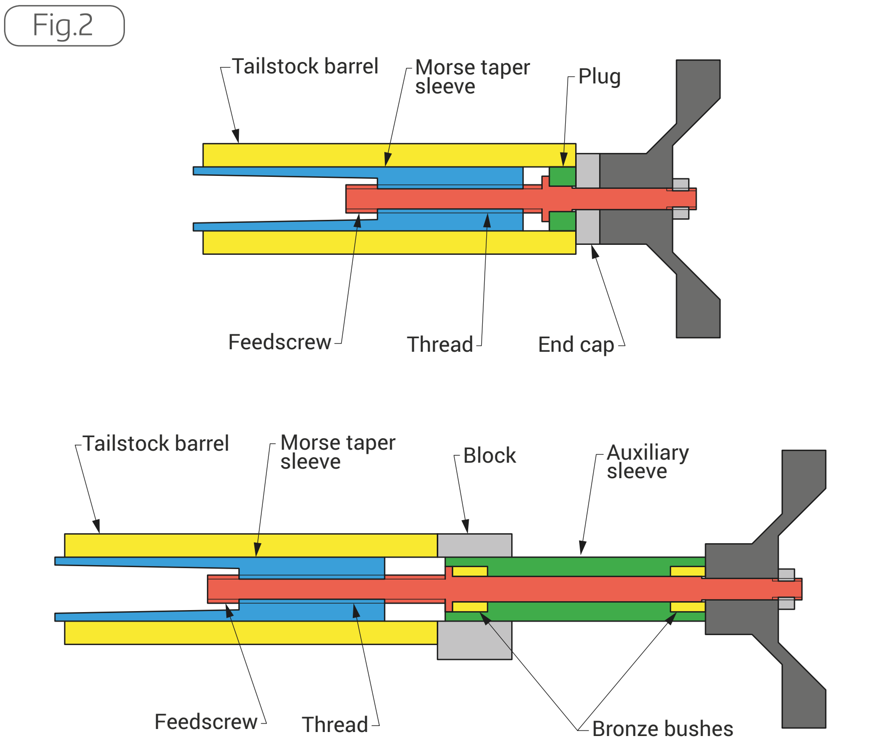


Fig 2. The Original And Lever Feed Tailstock

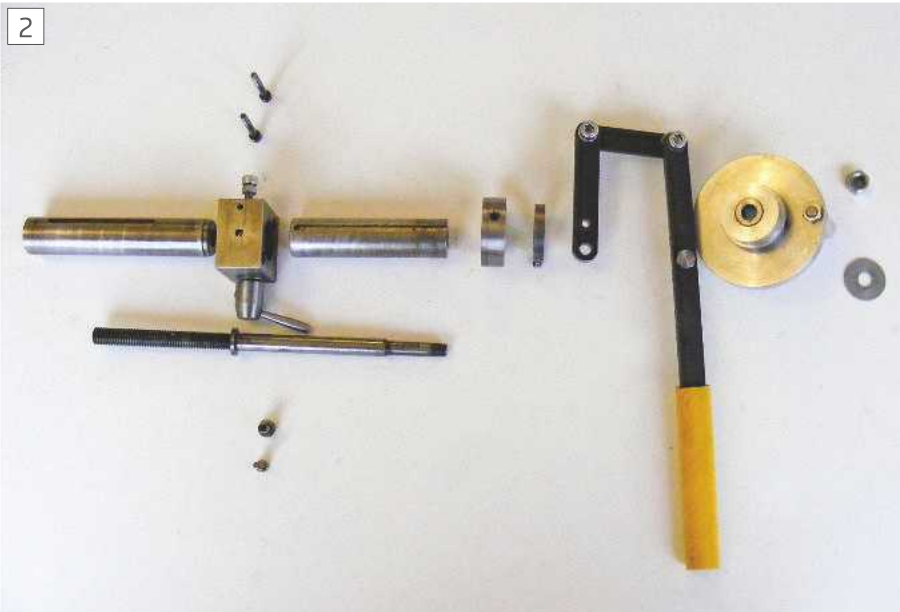
The modified tailstock principle.

The cross-section diagram fig. 2 also shows a schematic for the new tailstock. A block has been added to the end of the tailstock barrel and in this slides an auxiliary sleeve. This auxiliary sleeve replaces the plug. It can slide in and out of the barrel thus enabling a lever feed action with the addition of a suitable lever system. Alternatively, the auxiliary sleeve can be locked into the block so that it cannot move. With the auxiliary sleeve locked then the feed screw can be used to advance the Morse taper sleeve in the normal way.

The finished lever feed tailstock is shown in **photo 1**. The block on the right side of the tailstock barrel is clearly visible as is the auxiliary sleeve. The clamping screw is at the bottom of the block. If this is tightened, then the auxiliary sleeve is locked in the block and normal screw feed can take place. If the clamp is released, then the auxiliary sleeve slides easily in the block and the lever feed function can be used.

Photograph 2 shows the lever feed removed from the tailstock and partially dismantled. On the extreme left is the Morse taper sleeve. This part is the one supplied with the tailstock. To the right of this is the block with the locking arrangement protruding from the front and a screw, that locates with the groove on the auxiliary sleeve to prevent it turning, protruding from the back. Next right is the auxiliary sleeve. Note the groove that runs almost the entire length. Underneath the block is the feed screw. To the right of the auxiliary sleeve is a collar that fixes to the auxiliary sleeve by means of a grub screw. It thus acts as a stop preventing the auxiliary sleeve from going too far into the tailstock barrel. It is also the attachment point for the lever handle. Next right is another collar which matches the diameter of the graduated collar on the tailstock hand wheel. The collar has a fiducial line to provide an index for reading the graduations. The lever system is shown next and this attaches to the top of the block on one side and to the collar on the other side. On the extreme right is the tailstock hand wheel complete with graduated collar.

2



The components of the lever feed tailstock.

The auxiliary sleeve.

The auxiliary sleeve, **fig. 3**, was made first because it can then be used to test the fit of other parts. It was made from a length of 22mm diameter cold drawn round steel bar. On receipt this was check for roundness and straightness and the bar was true to within 0.05mm in roundness and straightness. An 88mm length was cut off and chucked in the three-jaw chuck on the lathe. The fixed steady was set up near the chuck and the fingers adjusted to touch the bar. The steady was then moved along the bed and repositioned near the end of the bar. The end was then faced, chamfered, centre drilled and drilled out 5mm for a depth of 45mm. The piece was then removed from the chuck and reinserted with the unfaced end outwards. It is important that the fixed steady is not mover and the fingers not altered during the removal and reinsertion. The outer end was then faced, chamfered, centre drilled and drilled out 5mm for a depth of 45mm. The hole was then enlarged by drilling all the way through firstly with an 8mm drill and secondly with a 10.5mm drill. The end was then drilled out with a 13mm drill to a depth of 11mm. A small boring bar was set up on the lathe tool post and this was used to enlarge the 13mm hole to 16mm.

Without disturbing the steady rest, the piece was removed from the chuck. The length was measured, and it was then reinserted into the chuck the other way round. The end of the piece was then faced, and sufficient material removed to bring the length of the piece to 86.5mm. The end was chamfered and drilled out to a depth of 9mm with a 13mm drill. This opening was then enlarged to 16mm using the boring bar.

The next step was to cut a groove, 4mm wide and 1.5mm deep from one end of the piece almost to the other, as shown in fig. 3. This was done in the mill. The fixed jaw of the mill vice was adjusted parallel to the x axis using a dial indicator. The piece was then clamped in the vice and the groove cut using a 4mm slot drill. **Photograph 3** shows the finished piece.

Two bronze bushes, **fig. 4**, were made to fit both both ends of the auxiliary sleeve. These were machined from 19mm bronze bar. This was turned down to be a snug fit in the end of the sleeve for 21mm. It was then drilled out 5mm to a depth of 25mm and then drilled out again to 9.8mm. The outside of the bar was lightly knurled and then two pieces were parted off 9mm in length.

The bushes were pressed into both ends of the auxiliary sleeve. One should be recessed 2mm below the end of the sleeve and the other should be just slightly proud of the end. **photo 4** shows end of the sleeve with the recessed bush.

Once the bushes were in place they were reamed out to 10mm with a hand reamer.

Fig.3

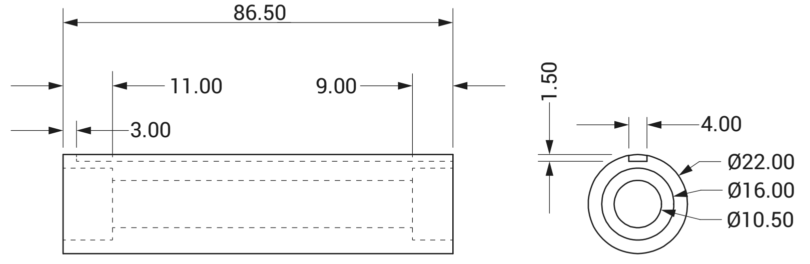


Fig 3. The Auxiliary Sleeve

3

The auxiliary sleeve

4

The auxiliary sleeve showing the recessed bush

Fig.4

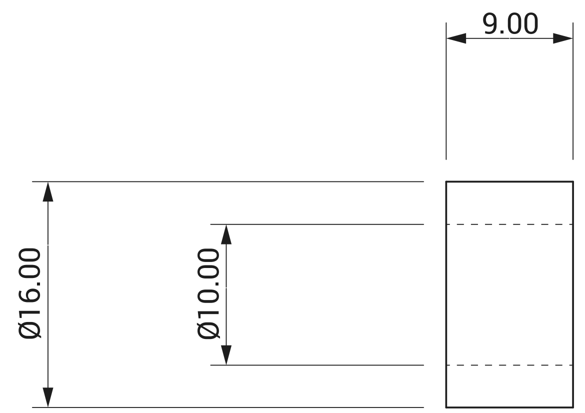


Fig 4. The Bronze Bushes

The block and clamping screw.

The block and clamping screw must be made together. The first step is to make the clamping screw, **fig. 5**. This was a simple turning job on 8mm round bright mild steel. The end was turned down to 5mm for a length of 10mm and threaded with an M5 die.

The piece was then parted off 28mm from the shoulder. The end was cleaned up and lightly chamfered.

The block, **fig. 6**, is quite complex with holes to be drilled on every face. The hole positions were marked out and centre punched. The 8mm hole in the left-hand face was drilled to a depth of 33mm and the small hole in the bottom face was drilled and tapped M4. The inside of the hole was cleaned up with an 8mm reamer.

The clamping screw was inserted into the 8mm hole and positioned so that the shoulder was about 2mm below the surface of the left-hand face. An M4 brass screw was then used to fix it in position. This assembly was then set up in the four-jaw chuck ready for drilling and boring the large 22mm hole. After centring the punch mark for the 22mm hole it was drilled out to 13mm using successively larger drills. It was bored out to 22mm using a boring bar mounted on the tool post. As 22mm was approached then the bore was frequently tested using the auxiliary sleeve to ensure a good sliding fit without excessive side play. The M4 brass screw was removed and the clamping screw was withdrawn. During the boring process a scallop of material was removed from the clamping screw, **photo 5**.

The rest of the marked holes were drilled out. The 4.5mm holes on the front face were counter bored 7.5mm for M4 cap screws so that the heads were just below the surface. The others hole were tapped as per fig. 6. The finished block is shown in **photo 6**.

The locking nut and lever were made next, fig. 7. This was made so that the locking lever could be located in one of six equally spaced locations with respect to the nut. The nut was a 12mm length of 10mm round bar. This was drilled through 4.3mm and then tapped M5. A short M5 hex head screw was screwed into the nut.

Fig.5

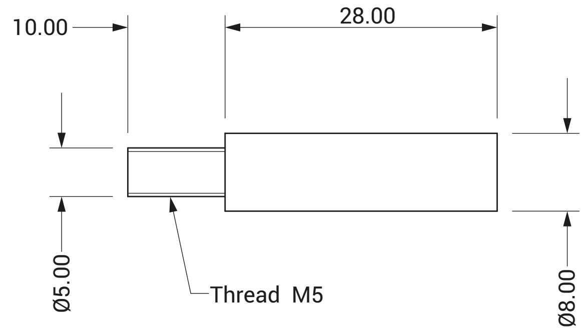
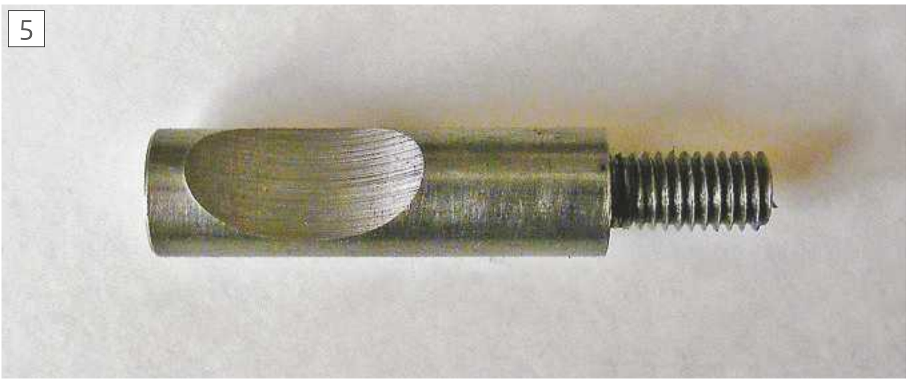


Fig 5. The Clamping Screw



The clamping screw. Note the scallop of material removed when boring the block.

Fig.6

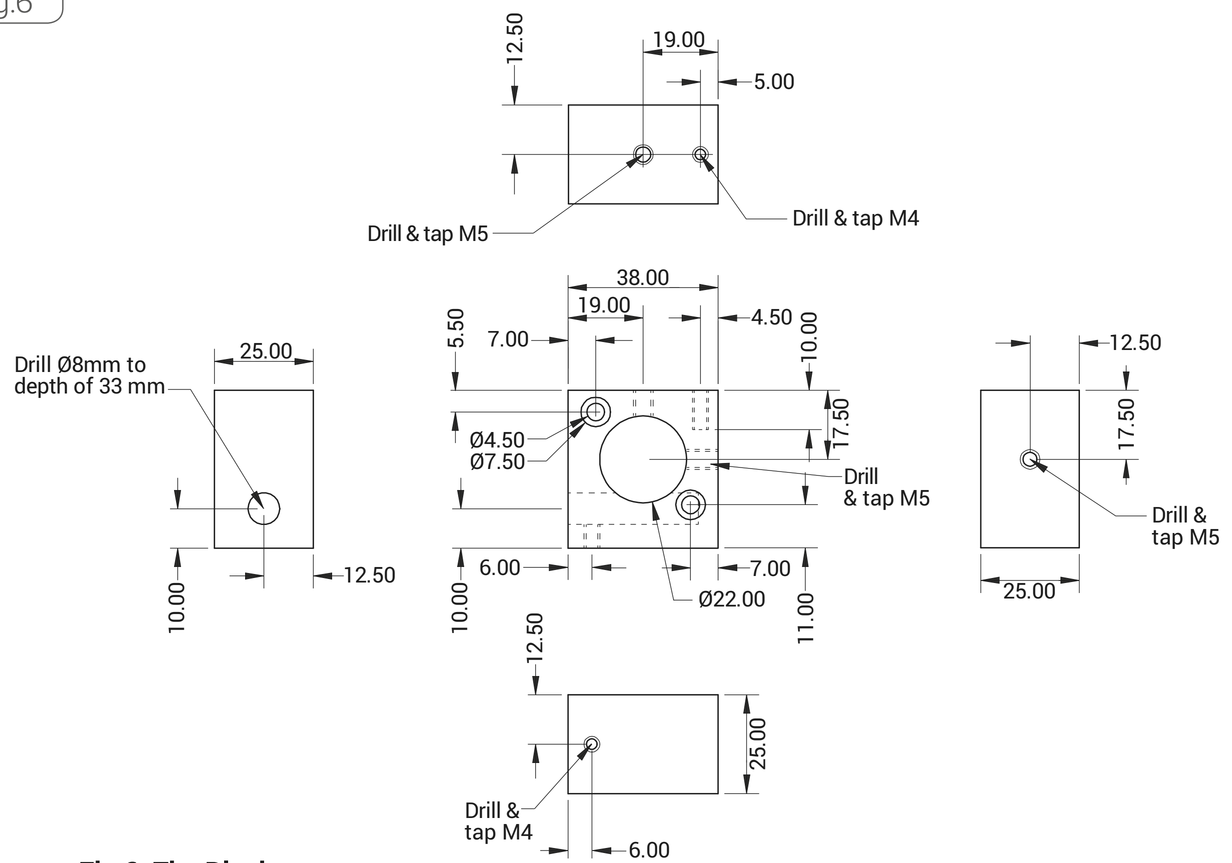


Fig 6. The Block

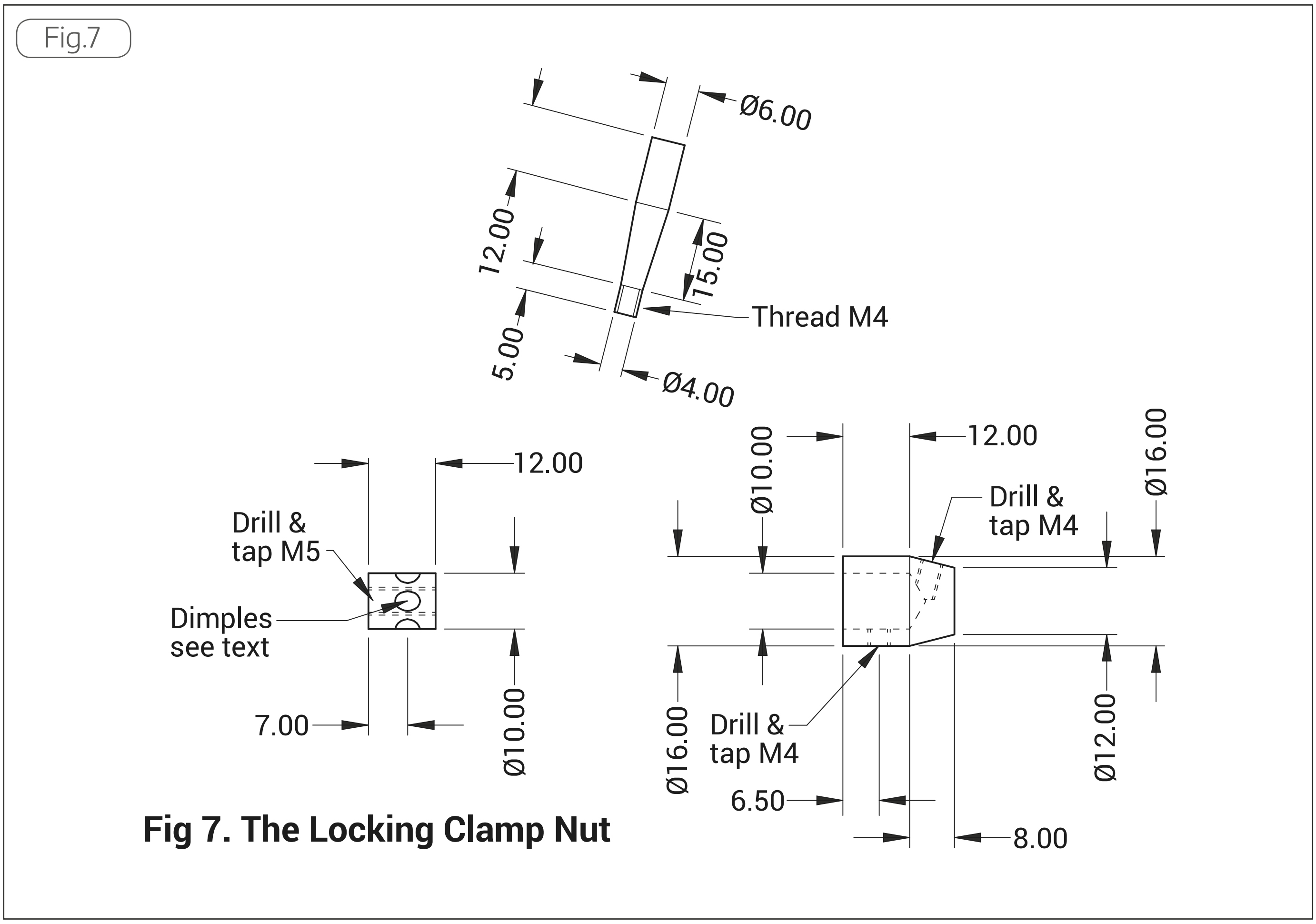


Fig 7. The Locking Clamp Nut

The nut and screw were clamped in the vice with one of the hex screw flats parallel with the top of the vice jaws. The first dimple was marked using a centre drill and then enlarged using a 4.5mm drill. Drilling was only done to the depth of the conical end of the drill. The piece was rotated to bring another hex screw flat parallel to the top of the vice and the process was repeated. This was done six times to give six equally spaced dimples around the nut. The knob was turned from 16mm diameter steel and the lever from 6mm diameter steel as shown in **fig. 7**. **Photograph 7** shows the finished components. The knob locks to the nut using a 3mm M4 grub screw.

●To be continued

6

The block.

7

The clamp nut and lever.

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