

No. 326



FLY BY WIRE

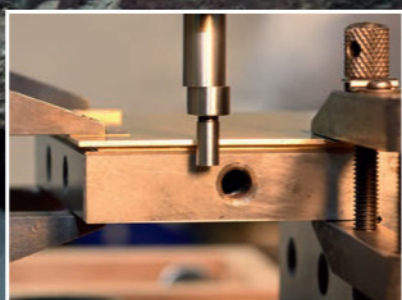
– Easy manual control for CNC machines.

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THE MAGAZINE FOR HOBBY ENGINEERS, MAKERS AND MODELLERS APRIL 2023 ISSUE 326 WWW.MODEL-ENGINEER.CO.UK

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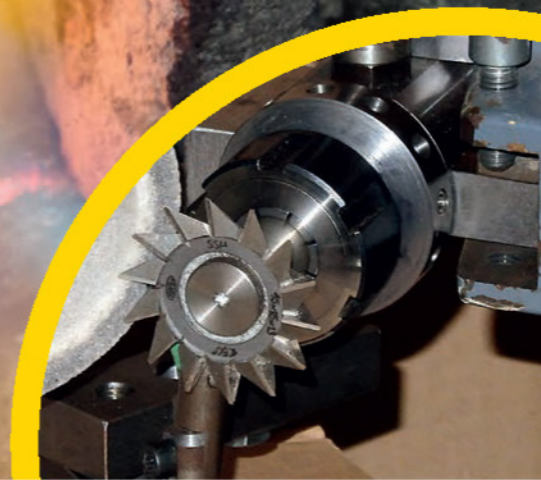
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INSIDE THIS PACKED ISSUE:

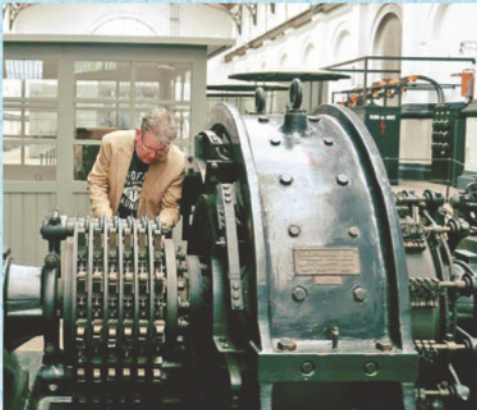
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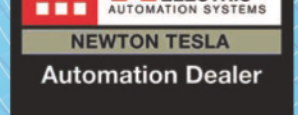
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The next will be on sale on July 22, 2022.

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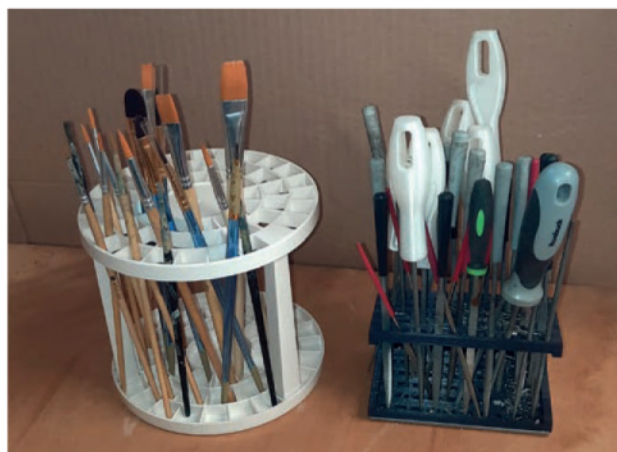


On the Editor's Bench

A bit of Repurposing

I paid a visit to 'The Works' recently. For readers not familiar with this establishment, it's a chain that started off specialising in remaindered books but has branched out into various areas including basic craft supplies. I was mainly looking to pick up some cheap paintbrushes, but I saw a few things that might be useful in your workshop. The basic paintbrush stand in the photo is a great little organiser, but my first thought was that it would also make a handy stand for my collection of small files. It comes flat packed and the construction would allow of the three uprights being shortened by an inch or two to better suit files. My 3D printed version is shown next to it, but I've come to feel the holes are too small and too closely spaced for comfortable use. The question is... do I go back for another paintbrush stand, or do I 3D print one whose holes and sockets are closer in size to the paintbrush type?

Not in the picture is a paint mixing dish about six inches across with several circular depressions. This will be ideal for holding groups of small (and tiny) screws and fixings with the shape making them much easier to pick out than a typical steep-sided tray.



They also sell a range of craft sets aimed mostly at younger people, often heavily discounted. Some of the more expensive of these are for making the like of letter-keyrings and coasters in clear polyester resin, complete with moulds and decorative items to encapsulate. I was tempted to buy one, and probably will on my

next visit, as having some small quantities of casting resin potentially has many uses, from making glass-clear windows for models, lenses for model lamps or even a 'lens' blank for an optical centre finder.

A Really Useful Adhesive

In my DIY adventures I've made good use of multipurpose polyurethane adhesive. It's very strong, flexible and waterproof with gap filling properties (it foams slightly when activated by water). I have even managed to fix the two parts of an aquarium pump impeller together with it – so far, it's lasted longer than a new part does! I've been using it in a 'sealant gun' format, thankfully unlike most sealants that end up setting in the tube, the screw-on end cap for the nozzle is capable of keeping it fresh for several months. Look out for these adhesives, there are many brands, as the size of a tube means it is very economical it's worth getting a quality one.

Neil Wyatt

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| <ul style="list-style-type: none"> • Stainless steel motion • Boiler feed by axle pump, injector, hand pump • Etched brass body with rivet detail | <ul style="list-style-type: none"> • GWR Pattern Safety valves • Choice of liveries • Painted and ready-to-run • Reverser • Coal-fired live steam | <ul style="list-style-type: none"> • 5" gauge • 4 Cylinder • Piston Valves • Walschaerts valve gear • Drain cocks • Mechanical Lubricator | <ul style="list-style-type: none"> • Silver soldered copper boiler • Multi-element Superheater <p>Approx Dimensions:</p> <ul style="list-style-type: none"> • (L) 73"x (W) 10"x (H) 13" • Weight: 97kg |
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Chris Gabel combines a range of approaches to make a neat and convenient controller for his CNC mill that can be programmed for other types of machine.

15 Artful Dodges

John Smith on getting better accuracy for milling and drilling operations.

17 Myford Spindle Bearing Replacement

In this guide for Myford 254 owners, Robert Trethewey takes you step by step through the process of a headstock bearing change.

24 From the Archives

We travel straight back to 1938 to discover a dovetail measuring technique that's as useful today as then in our series celebrating 125 years of Model Engineer.

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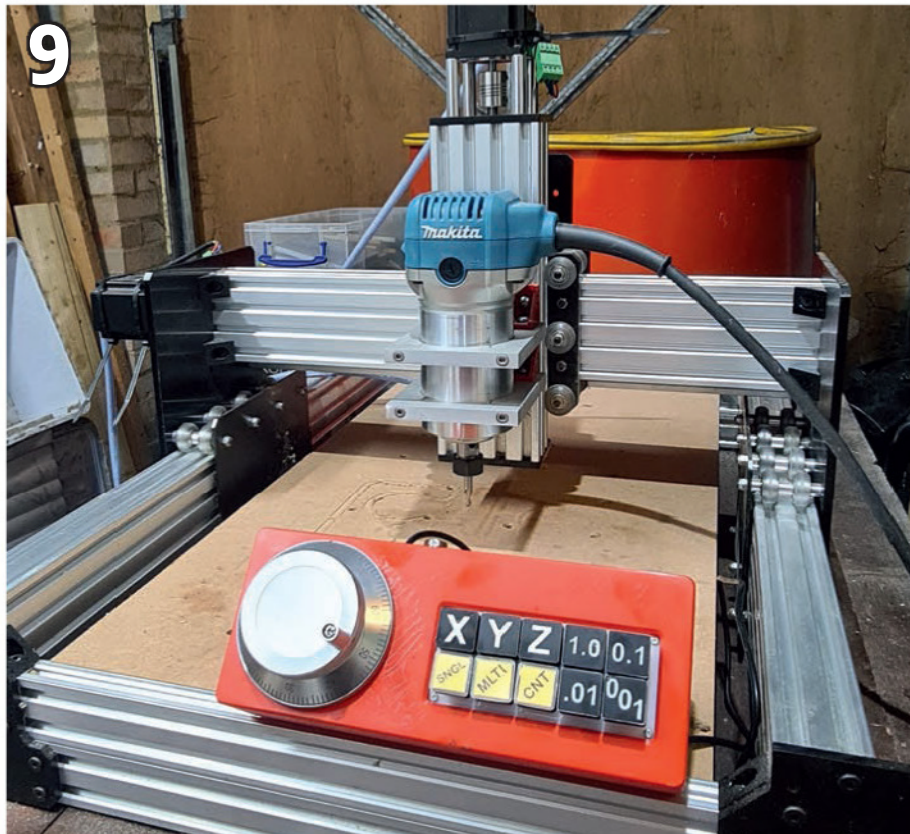
This month the series concludes with a look at the more creative aspects of workshop photography, using lighting, colour and texture.

34 A Foray into Casting

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42 Notes for Newbies

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53 Upgrading a Mill with a High Speed Spindle

Simon Davies found his shop made spindle couldn't take the extreme speeds he wanted to use; he explains how to go about fitting an off-the shelf device.

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Jacques Maurel makes some accessories to further extend the versatility of his sharpening attachment.

61 Beginner's Workshop

This month Geometer looks at testing and facing valves.



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Coming up...

in our next issue

Julian Palmer solves lubrication issues with an auto oiler for his Myford ML7.



Regulars

3 On the Editor's Bench

The editor finds some handy bits and bobs in a craft shop.

26 Scribe A Line

More of your letters and comment with a handy tip for better surface finish and a nice lever tailstock project. We are always keen to hear from you – again send an email to meweditor@mortons.co.uk.

50 On the Wire

The science behind quieter propellers and an ancient British clock.

52 Readers' Tips

Our winner this month has a neat and tidy update on a popular modification. Send your tips to meweditor@mortons.co.uk.

66 Readers' Classifieds

This month's selection of readers' sale and wanted ads, carefully transcribed by Heidi who can decrypt the most obscure handwriting!

ON THE COVER

The dramatically lit cover of this issue shows a PLA pattern being burnt out of a plaster mould ready for investment casting. See page 33 for the story behind this photo.

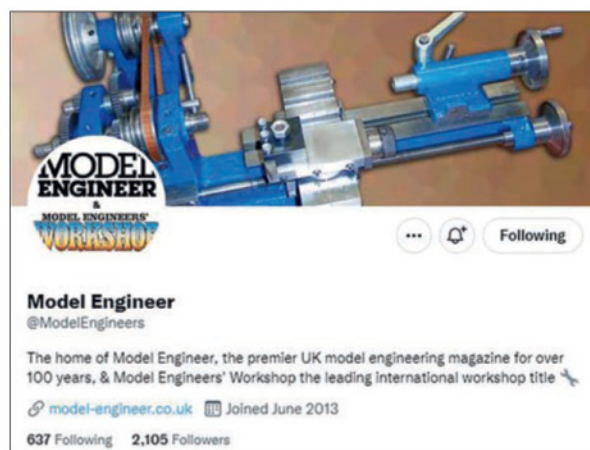


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THIS MONTH'S BONUS CONTENT

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Visit our website to see advice on how to deal with the day when we need to leave out workshops behind.

www.model-engineer.co.uk/disposal

Other hot topics on the forum include:

Electric steam engines, the future! Is this a feasible way of powering a steam engine model? – By Cyril Bonnett

New dehumidifier required. Any recommendations? By Bo'sun

Damaged allen screws removal Any tips? By Larry Phelan 1

James Coombes but not as you know him A fine engine build by JasonB

Come and have a Chat!

As well as plenty of engineering and hobby related discussion, we are happy for forum members to use it to share advice and support. Come and join us – it's free to all readers!

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Swing over cross slide	220mm
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Spindle taper	MK5
Spindle speeds	12
Range of spindle speeds	65, 90, 120, 160, 220, 300, 380, 500, 640, 850, 1100, 1650 rpm
Maximum side stroke of the tool holder	160mm
Maximum longitudinal stroke of the tool holder	100mm
Types of metric thread	17 types
Metric thread range	0.5–4 mm
Types of inch thread	24 types
Inch thread range	9-40 TPI
Longitudinal feed range	0.1–1.396 mm/turn
Transverse feed range	0.025–0.34 mm/turn
Tailstock quill diameter	40mm
Tailstock quill bore	70mm
Tailstock quill taper	MK3
Motor	1.1 kW, 230V
Dimensions	1400×770×550 mm
Net weight	320 kg



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Technical Data	HK25L VARIO Milling Machine
Drilling	25 mm
Cylindrical-frontal milling	16 mm
Frontal milling	63 mm
Spindle taper	MK3
Spindle feed	50 mm
Head tilt	+/-90°
Number of spindle speeds	adjustable
Spindle speed range	50–2250 rpm
Table surface	700×180 mm
Maximum longitudinal table travel	490 mm
Maximum transverse table travel	180 mm
Maximum vertical travel	280 mm
T-slots number	3
T-slots dimensions	T12/ 12 mm
Motor	S1: 0.75 / S2: 1.1 kW
Weight	115 kg

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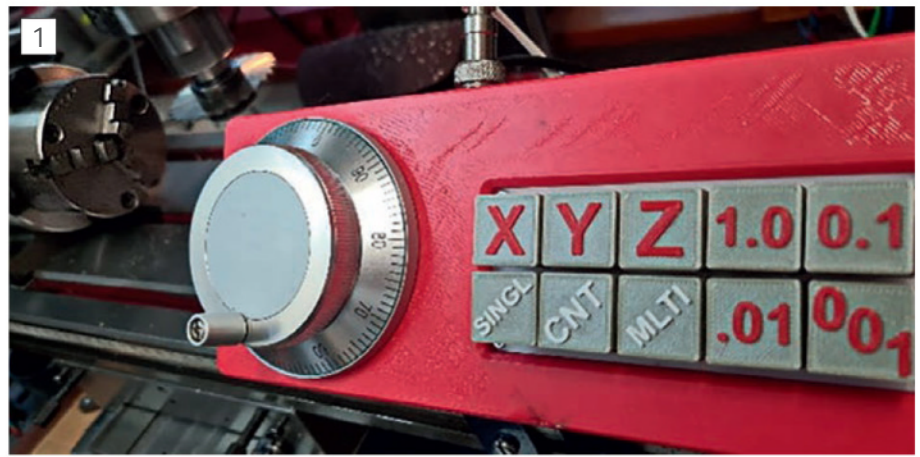
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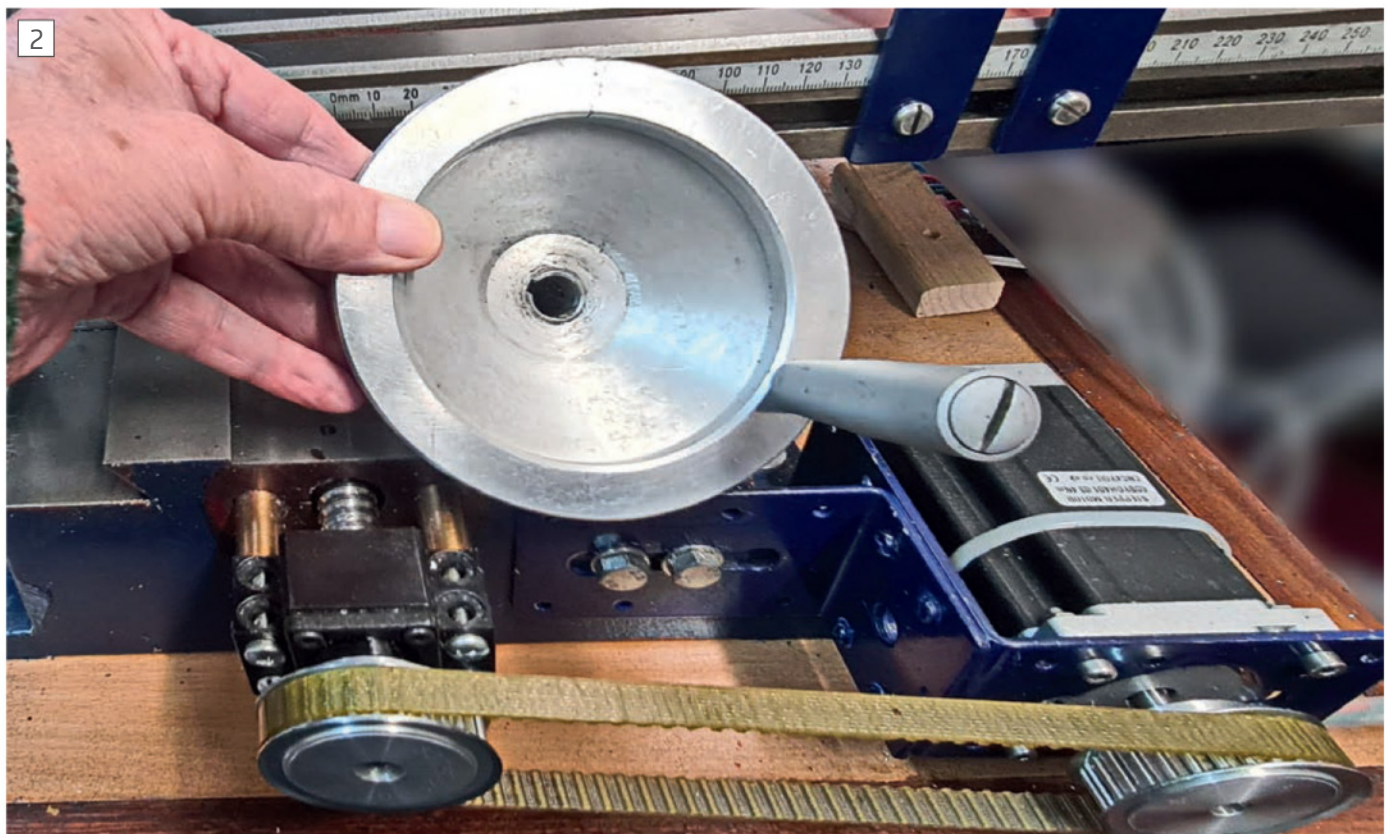
Fly by Wire – A Manual CNC controller

This project by Chris Gabel combined a lot of skills, although the work itself is quite simple, some of those being CNC control, a continuing valuing of manual machine tool work, 3D printing, and research into how to easily enable the programmable keypad.

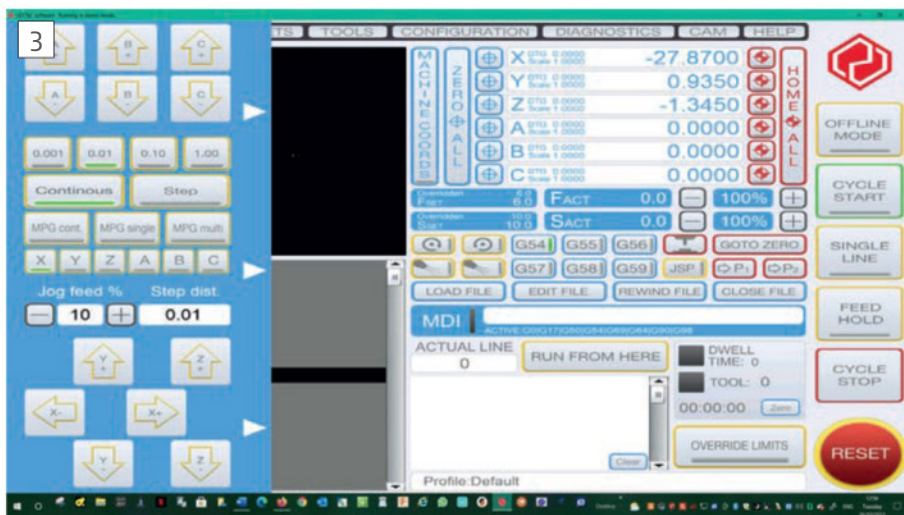
Converting my manual milling machine to CNC is one of the most satisfying and useful projects I have undertaken. With it I have been able to create precise components that I would have struggled to make with a manual mill. Additionally I have learned computer design skills which work across a variety of projects, including 3D printing, and CNC router work with a 24 x 24 inch workspace. There is just one problem... I no longer have a manual mill. All the handwheels have been replaced with stepper motors, **photo 2**. Stepper motors are turned by my laptop



Fly by Wire Controller.



My handwheel-free mill.



UCCNC control screen.

and its software. If I want to drill a hole to depth, or face the end of a piece of stock, or make any kind of simple cut I have to draft this in a design program such as Fusion 360 or Vectric. This is transformed to machine G code which is then fed to my handwheel-free mill.

One option is called "Conversational Programming" These are mini program wizards which reduce tasks to the simplest method possible. Want to drill a hole? Fill in the x and y coordinates and the depth and press "go". Simplified routines for milling a rectangular area or a pitch diameter circle of holes also exist. I would still like my handwheels back.

My normal CNC workflow goes like this: Design the part in a CAD design program. I use Vectric V carve for 2D or 2 1/2 D, and Fusion 360 for 3D items. Then have the CAD program

create G Code. Transfer the code to the laptop and its motion controlling software. There are several Machine Motion Control Programs. I use UCCNC. Although not the most popular it is the most simple to buy and install and is inexpensive. Mach 3 and Mach 4 are considered the standard, but Mach 3 is no longer supported, and Mach 4 is complex and I didn't like the licensing arrangements, **photo 3**. The UCCNC mill software is controlled using a mouse or the laptop keyboard. In addition there are Pendant Controllers which have a Manual Pulse Generator wheel and switches to select which axis to control and to set functions, **photo 4**. These are quite expensive and need to be come in the same flavour as your CNC software. I improved on this and came up with my Fly by Wire Controller, **photo 5**. Because UCCNC control software I am



UCCNC Pendant.

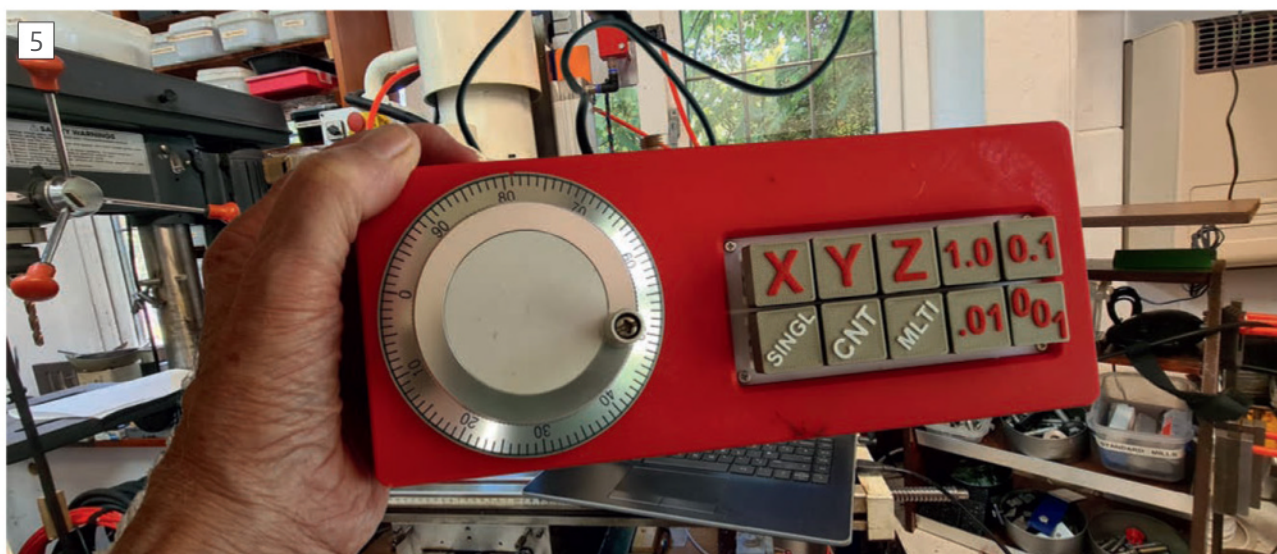
using supports only one Manual Pulse Generator input, I designed my Fly by Wire Controller to use just one MPG handwheel, along with large buttons which could easily and quickly select the desired axis. With only two major components and some standard connectors you are in business.

Component one is a ten-key programmable keypad, **photo 6**.

Component two is the Manual Pulse Generator, **photo 7**. These come in two sizes of 60mm or 80mm. The MPG generates a pulse with each click of rotation. I used an MPG with four connections, 5 volt power requirement, and it generated 100 pulses per revolution. The specification for this is: *100 pulses per revolution 80mm 5volt 4 connection MPG*.

Connections to the CNC control computer system are made using four Pin 12mm GX12 aviation style plugs and sockets, **photo 8**.

I chose a ten key programmable



My multi-axis controller.

keypad. They do come in 2, 3, 4, 6 and 8-key varieties as well. Each key can be set to function as a specific keyboard press or as a hotkey shortcut key. Almost all CNC control software has a method of setting hotkeys. UCCNC uses hotkeys,

Mach 4 uses keyboard mapping. In order to use my mill manually, I need to have control of the following:

1. select which axis I want to move
2. select how I want the work to travel
3. generate pulses with a Manual Pulse

Generator Handwheel to make everything move.

I looked at the UCCNC control screen, photo 3, and the variables requiring selection were easy to sort out. All of the cnc jogging actions shown on the left blue panel of the control screen can be set as hot keys. The ten actions I chose for my mini keypad were: Key 1 - Select Axis X; Key 2 - Select Axis Y; Key 3 - Select Axis Z.

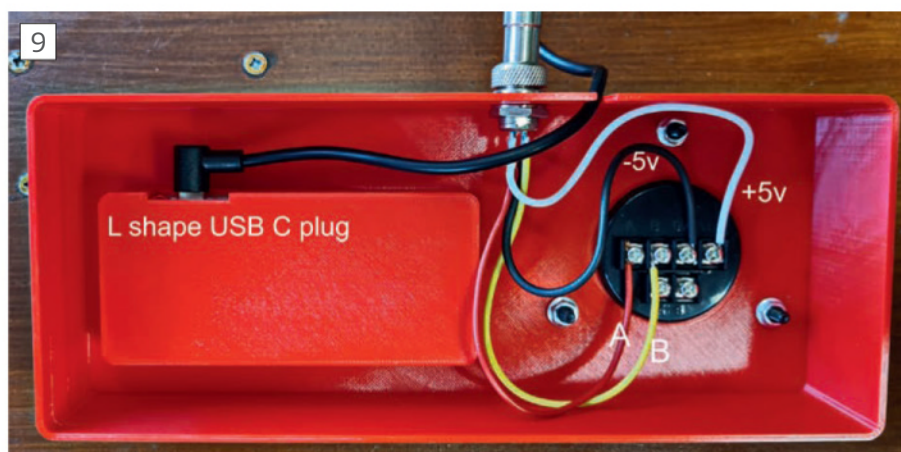
Next, I assigned the distance moved per pulse of the MPG Handwheel: Key 4 - 1mm; Key 5 - 0.1mm; Key 6 - 0.01mm; Key 7 - 0.001mm.

The last three keys were used to assign the mode of how the UCCNC handled signals from the MPG Handwheel: Key 8 - Single mode; Key 9 - Continuous mode; Key 10 - multiple mode.

The MPG Handwheel generates mill movement in either a negative or positive direction depending on the direction of handwheel rotation. Wiring and connection of the MPG is basic and simple. There are only four wires from the MPG handwheel. These are +5 and -5 volts, and A and B connections out. A and B go to the breakout board inputs. On mine these inputs were configured in UCCNC as "MPG inputs", using the UCCNC software configuration screen. The manual gives connection specifics listed under "MPG", **photo 9**. Once the keypad is configured with the SAYO software, it simply plugs into the host PC USB socket. The only note here is that I ordered an "L" shaped Type C USB cord to plug into the keypad as the printed box design would not accommodate



Sayo 10 key keypad.



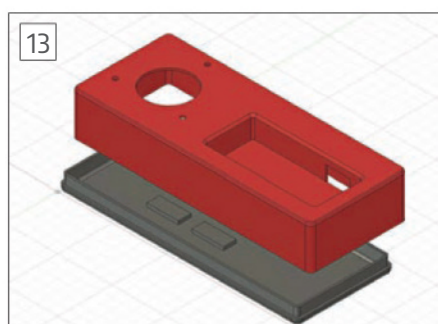
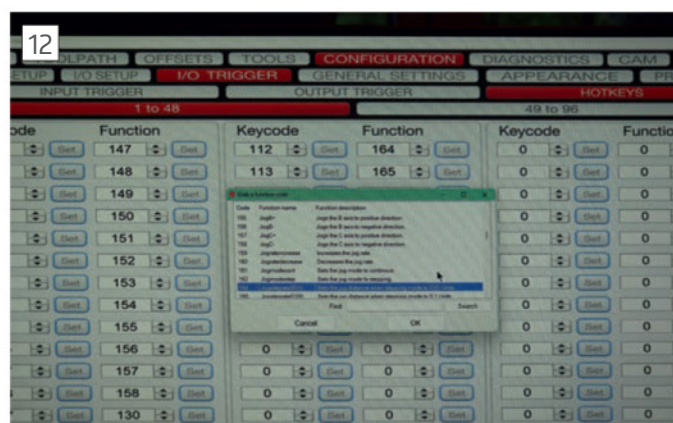
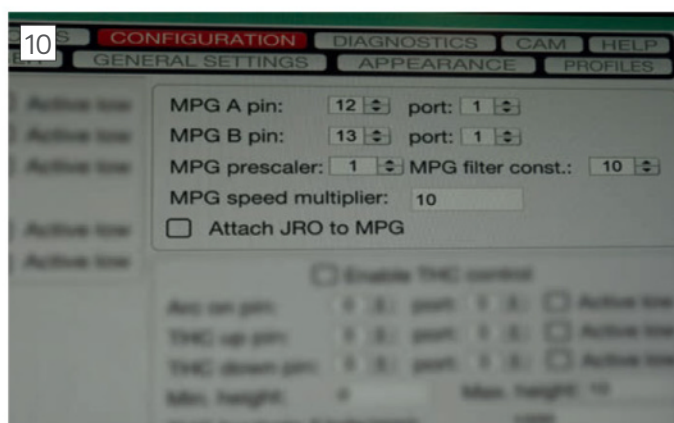
Internal connections.



Manual pulse generator.



GX12 connector.



a straight USB C plug. The UCCNC software picks up those pulse signals and are configured in the “Inputs” screen of the software, **photo 10**.

The Keypad

There are several varieties on offer with different numbers of keys. The hot key keypad is popular with computer gamers wanting fast action hot keys for PC games. The keypads are programmed via a software download and connect to your computer via a USB-c connector. The only difficulty is that, depending on who you buy it from, the keypad often comes with no instructions. A bit of web research sends you to the manufacturer's website (all in Chinese) but if you persevere the correct language does appear. The programming is very easy and quite sophisticated, where any keyboard

action can be assigned to the keys on your keypad. After programming, the keypad will connect to your cnc software simply by plugging it into the Laptop USB socket. It functions as a form of remote keyboard.

Assigning actions to the mini keypad

The keypads all seem to be manufactured by SAYO. The method to find the website and program the keys goes as follows:

In your browser type in <https://osu.sayobot.cn/download/>
Press the green rectangle. This immediately downloads zipped software.

Check your downloads folder for “settings xx.zip” and extract it. Choose the file appropriate for your operating system. Mine is Windows. Double click on “Sayo_CLI.Windows.exe”.

A Windows security window pops up regarding “protect your PC”. Push the “more info” button, then move the bottom slider on the pop-up, and select “run anyway.” Note that I have

no information, good or bad about the safety of this site, but could find no reports of evil intent. If a notice comes up saying there is a newer version, click on it and repeat the above method.

Programming your keyboard

Plug in the mini keyboard to your computer with its USB-C connector. Start the Sayobot software from your downloads. It will look for the type of mini-keyboard you have plugged into the network connected computer. In this case it opens a ten space grid which replicates the layout of your mini programmable keyboard, **photo 11**. I programmed the first three keys with letters X, Y, and Z. The remaining keys were all assigned Function keys F1 -thru F7. You click "save" and are finished. The final step is to assign Hot Key values and desired actions. This is done on the UCCNC software side, **photo 12**. Clicking on: Configuration > IO Trigger> HotKeys > 1 to 48.

For example, X, Y, and Z have key codes 88, 89, and 90 respectively. Having selected those keycodes, you can then assign the function by pressing "set"



Printed keys.

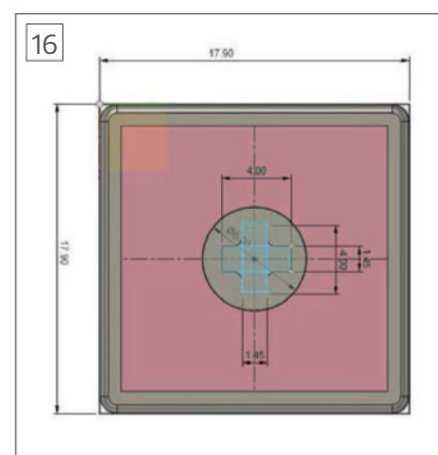
on the flyout menu. For Key 88, you set function 220, which is "MPG X Axis Select." Key 89 gets function 221 which is "MPG Y Axis Select", and so forth. Mini Keypad F1 is Key number 112 and is assigned Function 164 which is "Jog Step Rate .01". The options available in the Set Function field are considerable.

Making the case and keys

This project, **photo 13**, extended my 3D printing and modelling skills. The box is straight forward. This was modelled in Fusion 360. It was a delight to have the MPG, keypad and connectors all fit perfectly. The back holds four 4 x 25 mm niobium magnets. These will hold the controller on any steel surface or bracket. I found epoxy gave a better bond than did cyanoacrylate. An alternative to the magnets would be to use industrial grade Velcro to hold the controller in place, **photos 14 and 15**.

The keypad key design was quite important. While a black sharpie could mark the original keys with a graphic mark, I wanted keys that were as large

as possible to be easily visible even with peripheral vision. I also wanted them to be as physically large as possible so that axis selection in particular could be made with ease and without mistake. They needed to be buttons which fit a standard Cherry MX layout, **photo 16**. The bottom detail of the keycap where it plugs onto the keyswitch is small but does lend itself to 3D printing. The key caps push on or off easily. I wanted to have large numbers or letters in contrasting colour. Standard PLA filament was used for all keys. Red letters on silver-grey keys worked well. Many 3D printing filament colours are translucent and end up looking quite muddy. 6mm letters are about the smallest my 0.4 nozzle printed well. My original idea was to make the new keys in an almost cubic button shape with the letters or words incised in the top surface of the key. This would give a recessed letter to a depth equivalent to two printing layers. I use 0.2mm layers, so the letters would be incised by 0.4mm I then printed the letters in a second colour. This was really fussy. This



Bottom dimensions.



Layers for printing.

method printed with the key top facing down. However, what worked best was to extrude the letter or words upward from the key top surface by .5mm. This method had the key top facing upwards for printing. I then selected the top .5mm in the slicer program and told the printer to let me print this top 0.5mm in another colour, **photo 17**. Prusa Slicer allows you to change colour on specific layers, even if you have a one single colour at a time printer.

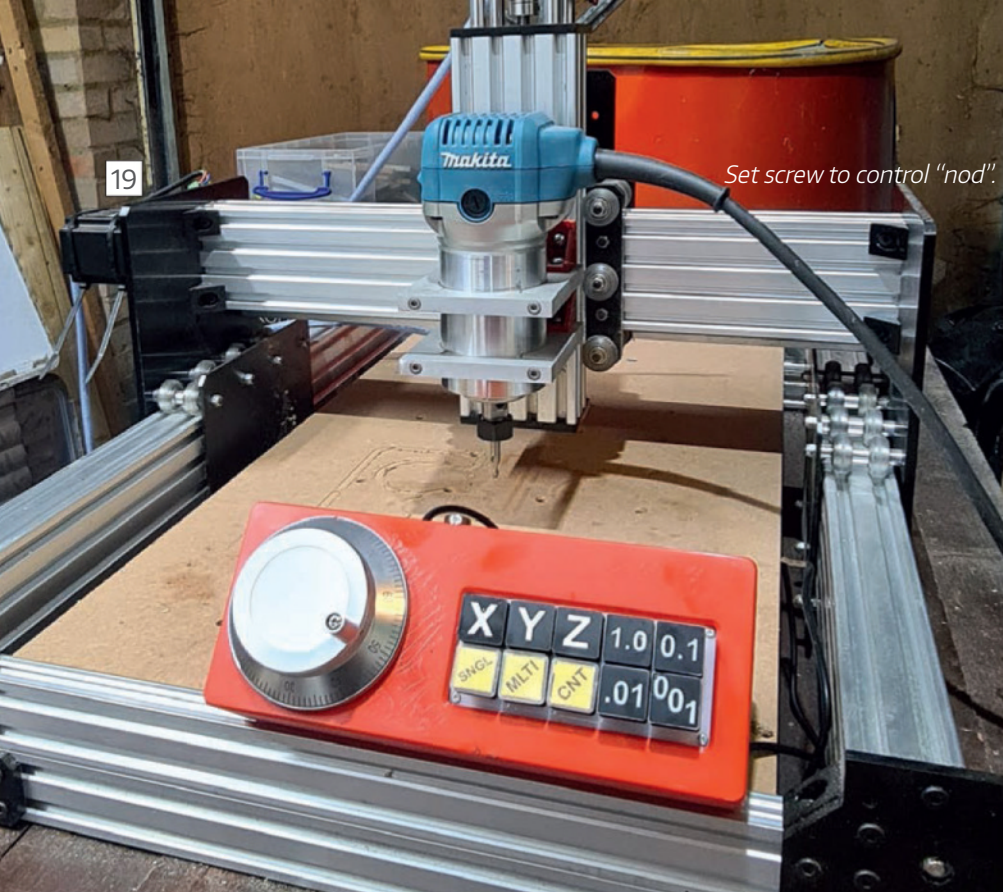
Using the system

Connection is simple. The mini keypad lead goes into the laptop USB socket, and a 4 pin mini-DIN plug and socket connects to the controller system. The MPG/keypad box uses its magnets to stop it sliding around on the mill table. An example where manual control is preferred is using a slitting saw to cut the slot in screws, **photo 18**. The depth of cut is easily moved by Using the X axis button and the MPG wheel. Exact depth can be seen on the DRO of the CNC software on the laptop. Moving the length of the cut is by moving the Y axis under control of the MPG. Ease of use is very close to that of using handwheels. The controller position and slitting saw proximity is for illustration purpose only! It is worthwhile noting that the programmable keyboard could



Screw slotting control.

19



Set screw to control "nod".

clear clip tops. These were adapted from Thingiverse file <https://www.thingiverse.com/thing:3791028/files>. The transparent top caps need to be printed 100% solid with no infill, to ensure transparency. The only change to the model was to stretch the lower body to keep the height more in line with the incised keys. This was done in the print slicer, **photos 20 and 21**.

Alternative approaches

My original idea came from watching a 'This Old Tony' YouTube video called 'Maho CNC Conversion: THE MOVIE!!' Tony built a 3 axis MPG controller. His control system was based on Pokeys control hardware and Mach 4. This Pokeys controller supports 3 MPG inputs which could move X, Y, and Z axis. Whereas my UCCNC software only supports one MPG. However, my design of using a single MPG along with dedicated selection keys is highly fluid and sensitive in use.

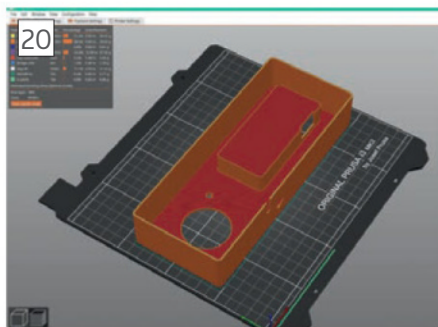
There are Arduino processors as well, which enable you to create a programmable keyboard from Arduino basic components. I could not get my UCCNC software to read the signals properly, but it might be worth exploring for other workshop computer-controlled projects. To explore this, search for "Macro Keyboard with an Arduino Pro Micro (32u4)". This Arduino processor will emulate programmable key presses.

This is not really meant to be a 3D printing project, and because of its simplicity, a variety of non-printed wood, metal or plastic enclosures would work well. Re-legendable MX keycaps abound on ebay, already made. You buy a readymade key, click off the clear top and insert your own label.

The manual pulse generator can be sourced easily online and prices vary from £10 to £50. The specification for this is 5 volt, 4 Terminal. 100 pulses per revolution. Most common sizes are 60mm or 80mm in diameter. The keypad can be found by searching for "10 key programmable keypads". Prices vary from as low as £13 to £39.

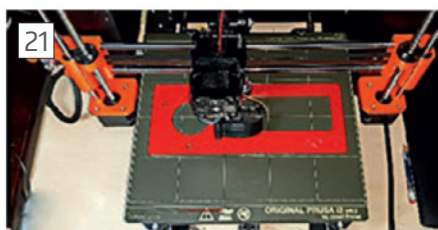
This makes a great weekend project which is immediately usable. I have been pleasantly surprised how much additional use I have gained on my CNC mill, just by having an easily accessible manual controller. ■

20



Plates in position at rear of table.

21



Plates in position at rear of table.

of precision. I am considering using that button for another purpose. Having a "Zero All" button which would reset the DRO on the laptop could be much more useful than a .001mm feed button.

The rectilinear controller box shape works great, and I would maintain its present design. It is printed with the flat surface down on the platen. The only change I would make is to include a click-snap mounting method of holding the bottom to the top body. This could easily be included in the model design.

I originally planned to make keys in a dark colour, with a letter or number incised inwards but alas, it worked better to extrude the letter up, not down. This worked great and looked better too.

My print files have been uploaded to <https://www.printables.com/> This is the Prusa file library which is usable by all without charge. There are four files for the controller box itself. Two for the top and two for the bottom. There are 2 files for each printable key. The files are .f3d readable in Fusion 360 and .3mf readable by your print slicer. To find the files enter "MPG" in the search field or "CNC Multi Axis MPG Controller and Keys for UCCNC".

If you choose to use re-legendable keys, you can print (or buy) keys which have removable transparent covers which snap on to lower bodies. Paper labels are inserted under the

find varied uses for control whenever a pc or other laptop is being used in the workshop, **photo 19**.

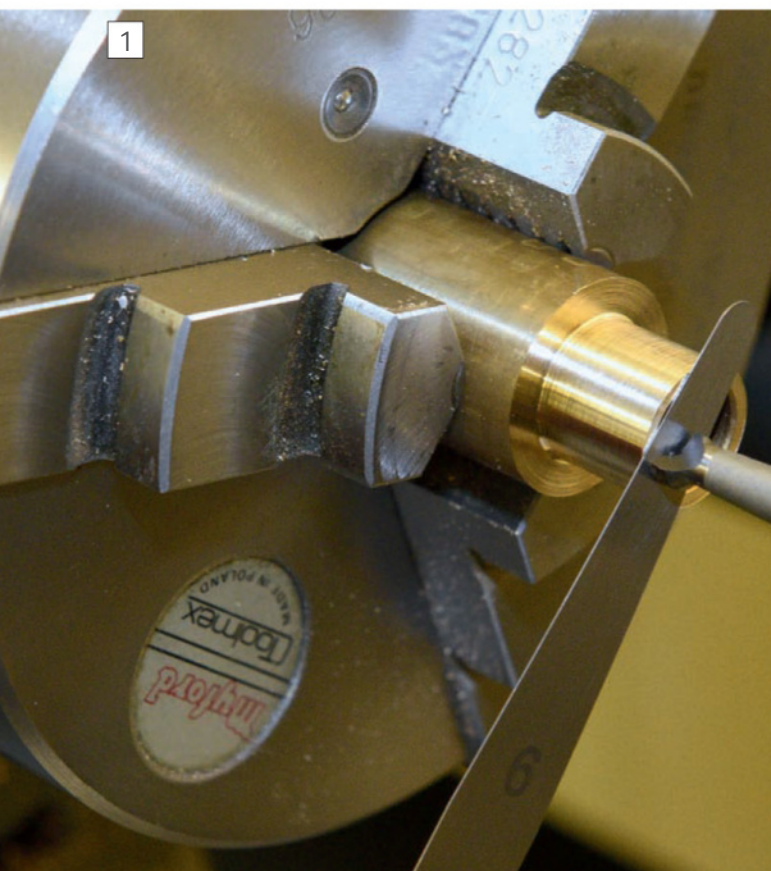
Good ergonomics are important for this project. The tactile feedback of the MPG handwheel is excellent and is an unexpected bonus. It might work better to have X, Y, and Z as a separate three-key mini keypad, but although available they are expensive and hard to source. I am not sure that having a .001mm feed button is of any benefit for my system though, as the resolution of my cnc system is not up to that level

Artful Dodge #6 —

Tool setting, and marking out with precision using a vertical mill



Essential reading for beginners and valuable to old hands, this series by the late John Smith shares some of his wealth of skill and experience from over half a century in hobby engineering.



Using a feeler gauge to set a boring tool.



Spotting rivet holes.

If you need to bore a hole in the lathe to a precise depth (say 0.500") in relation to the machined end of the workpiece in the chuck, take an arbitrary feeler gauge of (say) 0.006" thickness, set the leadscrew hand-wheel to precisely 119 (assuming a leadscrew pitch of 0.125"), advance the boring tool using the top slide to just touch the feeler gauge held between tool tip and workpiece, **photo 1**, then lock the top slide. You then know that four

revolutions of the hand-wheel will give the bore a depth of precisely 0.500". I would normally bore the hole to within a few thou of the desired diameter by boring to a depth of 0.495", leaving 0.005" for a finishing cut. It's very similar if you use a metric lathe.

On the mill it is very similar. Set the Z-axis hand-wheel to 97 (if the Z-axis leadscrew has a pitch of 0.100" and you are using a 0.003" feeler gauge), bring the tool down using the quill movement

mechanism to touch the feeler gauge held between tool and workpiece, then clamp the quill. You now know that when the Z-axis hand-wheel reads zero, the end mill will be just grazing the surface of the workpiece.

The vertical mill, particularly one with a DRO for X and Y axes, can be used to accurately spot all the rivet and screw holes in a workpiece made from sheet material – such as a tank or tender side, or a bunker rear, **photo 2**. This process

is often called "jig-boring". The first benefit is accuracy, the second that your workpiece does not end up with a lot of visible scribed lines made by your height gauge. A metric centre drill with a point diameter of 1mm is ideal for this purpose as the drill is just below 3/64" diameter and so can be used to spot holes for 3/64" rivets.

The first thing to master is the use of an edge finder. The most common edge finder has a machined end (often of 0.200" diameter for an Imperial machine) which is attached to the body of the edge finder by means of a spring such that end and body can be co-axial or not. To set the X axis, push the end of the edge finder so that it is offset from the body and move the X-axis hand-wheel to advance the edge finder to the machined reference edge of the workpiece, with the mill running at a slowish speed (say 400 rpm). As the table is advanced, the end of the edge finder becomes more and more co-axial with the body until the edge is reached, at which point the end steps out,

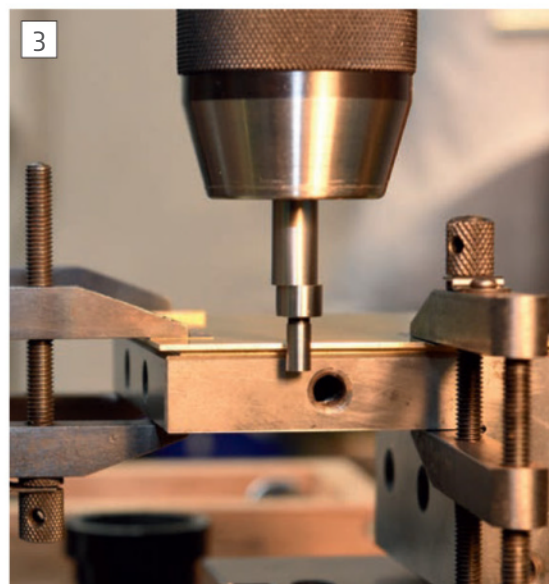
photo 3. The X axis DRO can now be

set to zero. It's a good plan to move the edge finder away from the edge of the workpiece, flick the end to push it out of being co-axial with the body, and then move the table very slowly in again to see if the end steps out exactly at zero on the DRO.

This technique is repeated for the Y axis. With the edge finder removed, the table can be advanced exactly 0.100 inches towards the workpiece in both axes. When this point is reached both axes can be zeroed again on the DRO. This is the "origin" – the point at which X and Y axes cross.

Using a table of hole coordinates, it is then a simple task to position the table to the coordinates of each hole with respect to the origin (using the DRO) and spot each hole using the quill lever. There are just two things to remember:

1. To set the quill stop so that the drill cannot put unwanted countersinks into the workpiece,
2. To put a sacrificial sheet of material under the workpiece to protect the surface against which the workpiece is clamped.



Using an edge finder

I have used a vertical mill without a DRO successfully to spot holes (by using the hand-wheel scales), but it is a much more error-prone process requiring a great deal of concentration! And don't forget to always approach each hole position from the same direction, to avoid backlash error. ■

MODEL ENGINEER

NEXT ISSUE

DRO

Graham Astbury describes how he fitted a digital read-out to his Warco WM16 milling machine.

Optimal Oscillator

David Fulton optimises the performance of a two-cylinder oscillating engine.

Fire Queen

Luker builds a five-inch gauge model of Fire Queen, sister locomotive to Jenny Lind, which avoided the scrap yard and ended up languishing for nearly a century in a shed at the Dinorwic Quarry.



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Myford Spindle Bearing Replacement

Robert Trethewey changes the worn spindle bearings on his Myford 254V+ Series Lathe.



Rear cluster guard.



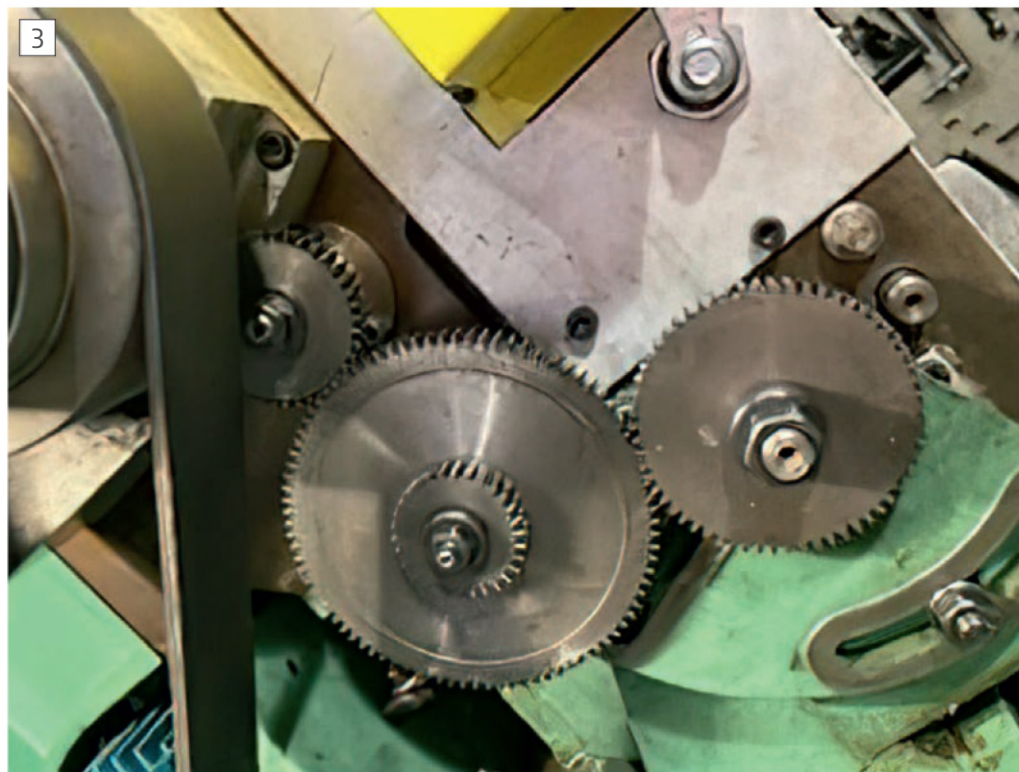
Guard fixings.

The lathe I had purchased several years ago and now nearing its twenty fourth birthday was due a service overhaul. I'd recently been experiencing some medium speed chatter and I decided that whilst doing the service, oil change and inspection. I'd look at the main spindle bearings to see if they were the cause of my machine's chatter.

The Myford manual supplied to me through Lathes.co.uk was good in most regards but gives no description of the hurdles you have to overcome to do this procedure. In the hope that this article will assist other owners of one of these impressive series of small lathes, I have compiled this article.

The first item removed was the machine's rear gear cluster guard, **photos 1 and 2**. This gives full access to the primary gears which drive the machine's leadscrew shown in **photo 3**.

These gear sets are easily removed and stowed in the rear guard. The machine's

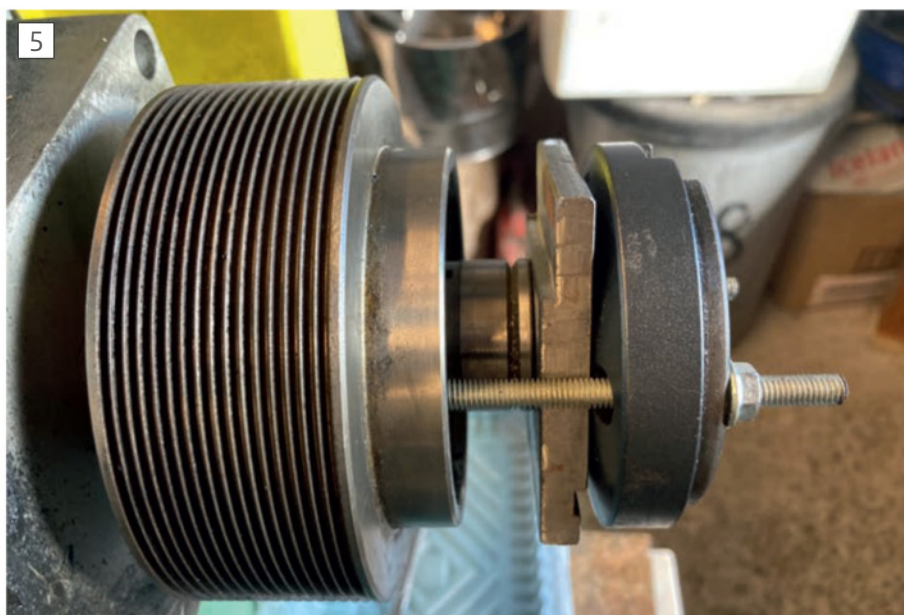


Primary gears.





Pulling the drive pulley.



Puller arrangement.

drive belt was removed, and this allowed access to the main spindle housing reduction gear housing. To remove this housing the spindle rear cluster drive pulley assembly has to be removed – it's held on tightly through the inner race of a needle roller bearing item 75.

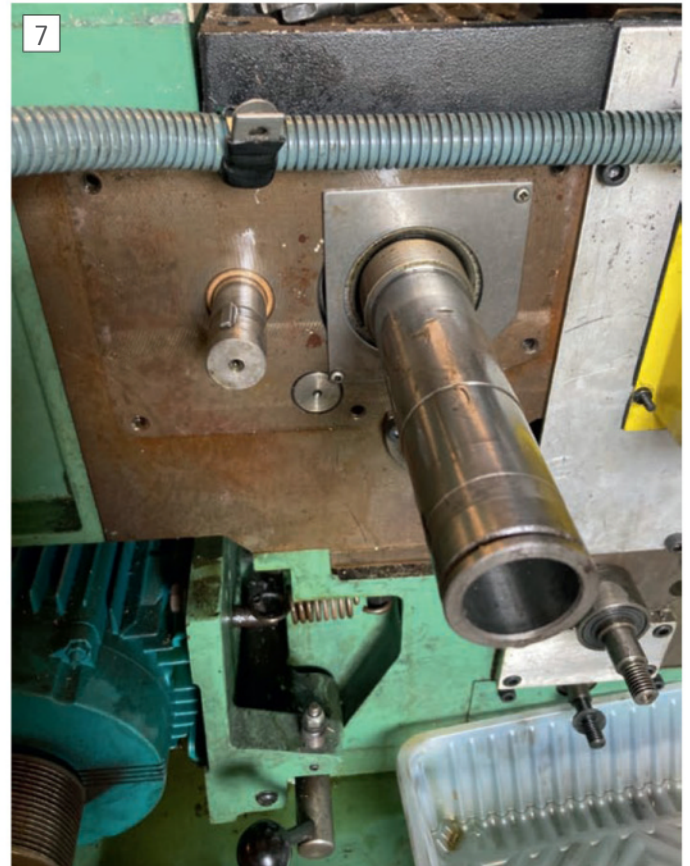
Due to the tightness of this bearing's inner race on the machine's spindle I had to utilise the external drive dog less it's two sprung loaded square drive washers as a method of extracting the assembly off the shaft. Two 100mm lengths of 6mm screwed rod and nuts were used as can be seen in the photos below – this method was used gradually to pull the whole drive pulley off the main spindle a small amount at a time by alternative half turns on each nut, **photos 4 and 5**.

Now the reduction gear's external housing can be easily removed, there are five bolts four long and one short one. This will drain the oil in this external housing as it does not have a drain plug of its own. Be careful to avoid breaking the gasket between the machine's frame and the gear housing. You can now drain off the oil inside the spindle gear housing by removing the drain plug circled in **photo 6**, **photo 7** shows how I caught the oil.

The machine's spindle is located in the housing by two taper roller bearings both identified as Timkin. Type 18590-18520 is the rearmost bearing, and the front bearing is a Timkin 368A-362A as Timkin bearings are now produced in China it was decided to replace these with Japanese equivalents from KOYO bearings through their UK distributors Henderson Bearings. The spindle has a threaded lock ring which is exposed following the removal of the drive belt assembly. This has a socket cap screw which has to be removed. My machine uses a metric leadscrew and as such most of the set screws are metric – however there have been imperial set screws used so please be careful as to how much effort you use to undo these. Once the set screw has been undone and is loose in its thread the locking collar can be undone with an appropriate "C" collar wrench. Then remove the rear bearing cover plate which is held in place by two small screws. At this point in time the gearbox lid was removed and inside the rotary positioner was removed by undoing its three small screws, **photos 8**



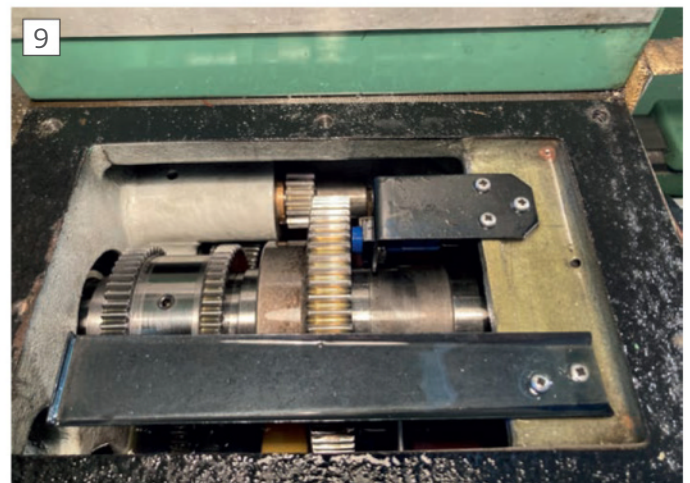
Drain plug location.



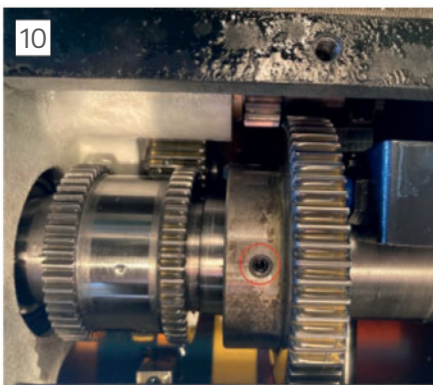
Catching oil.



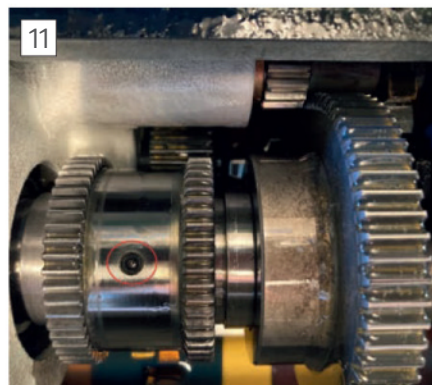
Gearbox lid screws.



Lid removed.



Location of gear locking screw.



Second gear lock screw.

and **9**. The front bearing oil channel was removed with its two small screws.

The removal will expose the two gears in the gearbox which will need to be allowed to slide off the spindle when the spindle is drawn out of the gearbox by pushing the spindle forwards towards the tailstock.

The 67 toothed gear item 67 and 52T x 52T Tumbler gears both have locking cap screws to be loosened so that they can slide off the spindle as it is pushed out forwards, **photos 10 and 11**.

12



Races ready for the freezer.

With the spindle screwed locking collar removed, the spindle front bearing cover plate item 86, mounted behind the spindle head, is released from the machine by the removal of three cap headed set screws. There is a gasket here which was not damaged in any way and

remained in place on the front face of the machine. The spindle was driven forward using a soft-headed mallet and care was taken to ensure the two internal gears did not snag when the spindle was fully extracted. Both gears were inspected for wear and tear; no damage of any kind

was identified. Both gears were washed cleaned and stored for reassembly. The replacement bearings had both their outer races removed and placed into the lowest, coldest drawer in our freezer unit, **photo 12**, for two days to slightly shrink their diameter to assist in reassembly.

13



Rear race housing.

14



Front race housing.



Inside headstock.

The old outer races were punched out of their respective housings and the housing faces washed and cleaned. The gearbox was drained and washed out and cleaned thoroughly, **photos 13, 14, 15 and 16.**

The new outer races were pressed into their respective mounting holes and wetted with new oil. In fitting the new front taper roller gear, first ensure you put the front bearing cover onto

the spindle followed by the gear itself. By placing the spindle into the housing and using the machine's tailstock a slight constant pressure was exerted onto the front face of the spindle to press the new taper roller to its final position.

Then with the insertion of the 67 toothed gear and the 52T x 52T tumbler gear onto the spindle, ensure the woodruff keys (No: 505) are correctly positioned. With the tailstock pushing up against the front face of the spindle, the rear taper roller bearing can be fitted to the spindle. There is the need to press this rear taper roller further onto the spindle and this can be achieved using the rear bearing locking collar, initially reversed so as to get the best thread connection on the spindle thread. By holding the "C" spanner still and turning the spindle through the webs on its front face the bearing is pressed into its final position. Fit the steel cover plate with its two small screws when you have removed the collar, then reverse the collar to lock the bearing into place. Fill the gearbox to just below its full level (the centre of the glass).

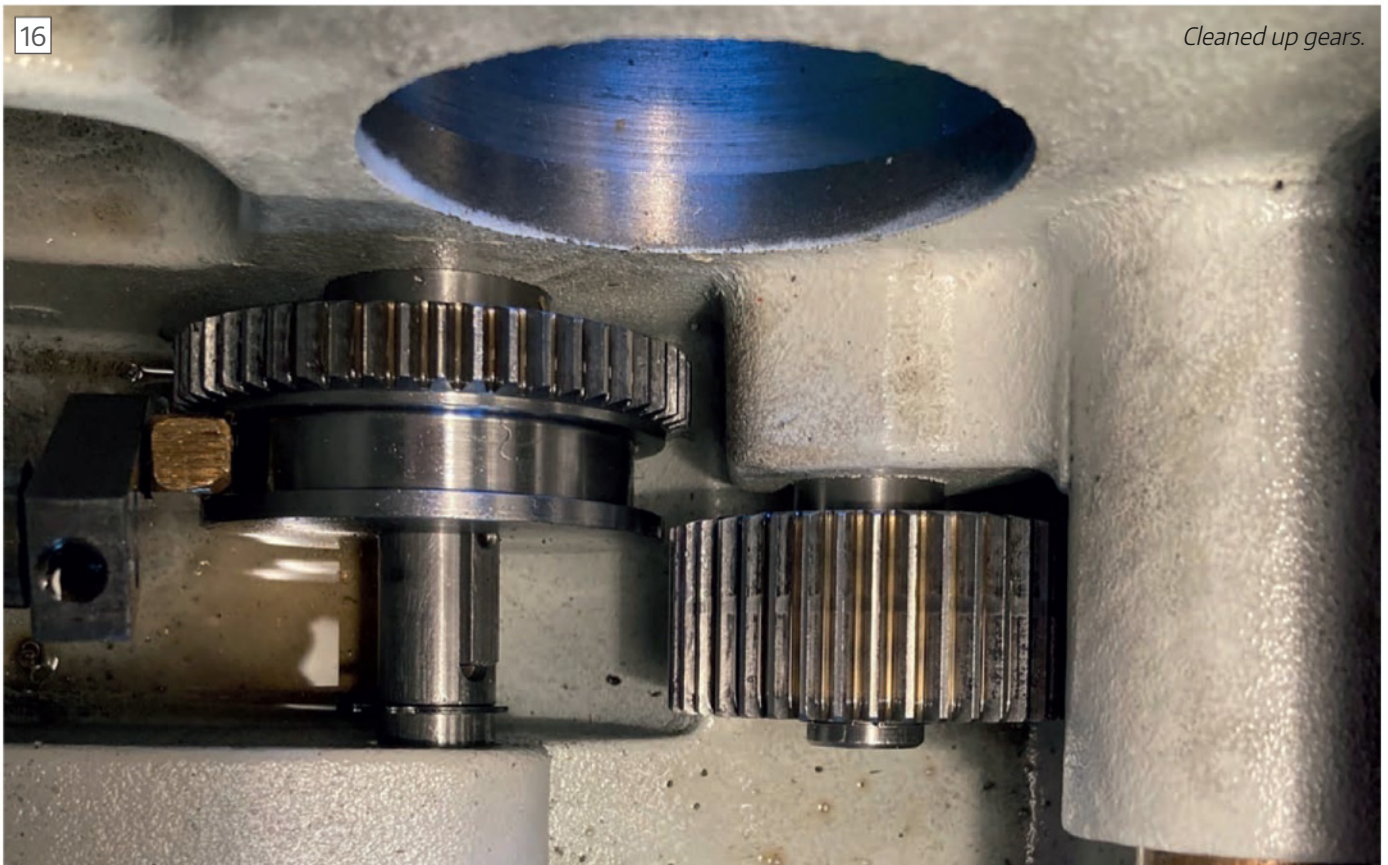
Refit the reduction gear train onto its external shaft (back gear shaft item 35) and secure the grub screw so that



Gear flush with shaft end.

the gear sits flush with the shaft end, **photo 17.**

Now the backgear housing can be fitted into place with the gasket and secure evenly the five screws that hold it into position. Undo the top oil filler plug and fill the casing with oil until you see the level in the front oil level sight gauge come up to its mid position. Wait for a few hours to ensure there are no leaks from the backgear housing gasket before reassembling the gear train as



Cleaned up gears.



Reassemble gear train.

shown in **photo 18**. The drive pulley assembly has now to be reassembled onto the spindle. In doing this there is the problem of how to press the inner race of the needle bearing item 75. To assist in the gentle persuasion of the inner race a tool was constructed from a 560mm length of 12mm screwed rod a 1/2" square drive socket (large enough to seat inside the spindle core), several 12mm nuts and a length of pipe larger than the outside diameter of the spindle, but not larger than the outside diameter of the needle roller bearing's inner race, **photos 19** and **20**. Inner race put onto the spindle then the cut tube placed behind it and with a piece of plate as a washer the nut was gradually tightened, driving the race into its final position.

The final job is to refit the rear panel and lock into position – turn the feed screw selector to mid position so that the feed screw is stationary and reduce the machine's speed to minimum and run the machine for ten minutes in forward and reverse to enable the replacement bearings to seat themselves properly. The gearbox oil will be replaced after 100 hours of operations I used an EP 80W-90 Gear oil from Smith Allan and ordered 5 litres to ensure I'd had enough to do at least two oil changes. ■



Socket a good match for inner race.



Puller construction.

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The image displays four modelling magazines. **Model Boats** (Vol. 72 No. 864, November 2022) features a boat on the cover and a 'WIN!' banner for a 1:12 African Queen kit prize draw. **Model Engineer** (Vol. 230 No. 4706, 16-19 December 2022) features a steam locomotive and articles on 'First Locomotive?' and 'Pipe Insulation'. **RCME & Electronics** (No. 11, November 2022) features a radio-controlled jet aircraft and a 'FREE PRO-PLANS' offer. **Popular Popham** (No. 11, November 2022) features a radio-controlled jet aircraft and a 'FREE INSIDE RAIL BOOKAZINE' offer.

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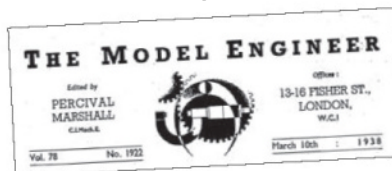
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From the Model Engineer Archive

To celebrate 125 years of Model Engineer magazine and the Society of Model and Experimental Engineers, each issue in 2023 features fascinating historic content from Model Engineer relevant to workshops, tools or techniques.

These pages from Model Engineer Volume 78, No. 1922 feature a 'lathe clutch' from March 1938.



TOOL-ROOM TOPICS



Gauging Dovetail Slides

By R. HUTCHESON

A CORRESPONDENT has been called upon to make some gauges for checking small dovetail slides, and he is desirous of knowing the best type of gauge for the job.

There are two commonly used methods of gauging dovetails: one entails the employment of a profile gauge, while the other calls for the use of two cylinders which are nested in the angles, and the size of the dovetail is judged from the distance apart of the cylinders; the principles underlying the two systems of gauging will be discussed.

A male dovetail is indicated at Fig. 1, and there are two important dimensions to be checked, viz., the angle α of each side, and the distance the two sloping sides are apart. The first dimension is definite, but what is the distance between the two slanting sides?

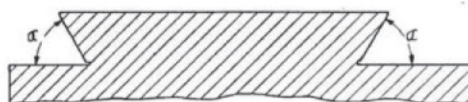


Fig. 1. A section through a male dovetail slide.

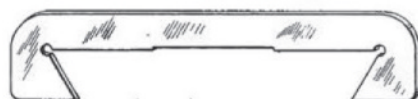


Fig. 2. A profile gauge for a male slide.

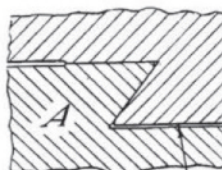
When large numbers of slides of the same width and angle of dovetail are to be produced, some form of profile gauge can be made, the simplest gauge of this type being that shown in Fig. 2. This gauge is made of gauge steel, i.e., a bright flat strip steel capable of being hardened, the thickness depending upon the length, and being sufficient to ensure that the gauge is rigid.

If one examines a pair of machine parts which are dovetailed together, to slide one upon the other, it will be noticed that no attempt is made to get the slides to fit at both the top and the bottom, but a decided clearance is left between one or other pair of faces, as is indicated in Fig. 3; the arrangement shown at A, where the upper faces are in contact, being used almost invariably, rather than that at B, where the under faces are in contact. A clearance is also left in the extreme corners.

The clearance between the faces must be allowed for on profile gauges, so that the gauges, when applied to the work, will bear only on the slopes of the dovetails and the other rubbing faces, the gauges not making contact with the faces between which there will normally be a clearance.

Gauging with profile gauges in this manner can be elaborated upon when the slides are to be machined to limits, and limit gauges of this type will be described shortly.

Gauging dovetails with the aid of cylinders is common. A female slide is shown in Fig. 4, and a small cylinder or disc, a , is nested in each corner. The distance apart of the inclined sides is obtained



by measuring the distance l between the two cylinders. The male slide is tested in a similar manner by arranging the cylinders on the slide, in the manner shown in Fig. 5, and determining the distance L over them.

This test alone is not sufficient, as can be judged from Fig. 6. Two slides are shown, one having dovetails of about 75 degrees, and the other having dovetails of about 30 degrees. The cylinders that are nested into the corners are all of the same diameter, and the cylinders in each pair are exactly the same distance apart; it is evident that even though the distances

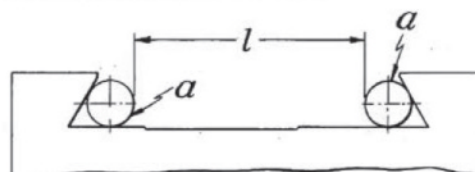


Fig. 4. The distance apart of the sloping sides of a female slide can be determined by gauging between a pair of cylinders a , a .

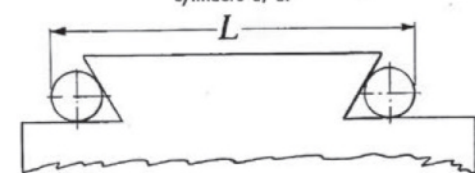


Fig. 5. "Cylinder" gauging applied to a male dovetail slide.

Checking the distance between centres of a pair of rollers in the above manner must be accompanied by an independent checking of the angles.

The angles themselves can be checked by means of profile gauges, and the gauges are best made so that they measure the angle between the flat rubbing face of the slide and the inclined side. Taking the two slides shown at A in Fig. 3, they can be tested by gauges in the manner depicted by Fig. 7. When

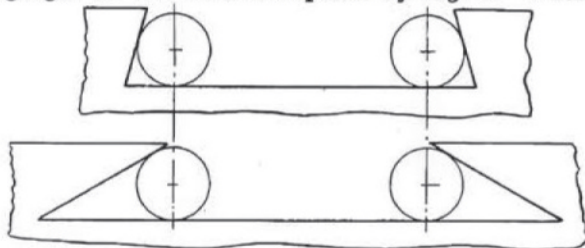


Fig. 6. Gauging the centre to centre distance of the cylinders is not a sufficient check on the angles.

slides are being machined the first cuts taken should be directed towards obtaining a correct inclination, which can be tested by the gauges of Fig. 7, after which the precise distance apart of the inclined faces can be gauged with the aid of the cylinders.

When a dovetail is to be machined, the angle α and depth h are given, and also the full angular width of the slide either at the large or small end of the dovetail, as is indicated by the dimensions

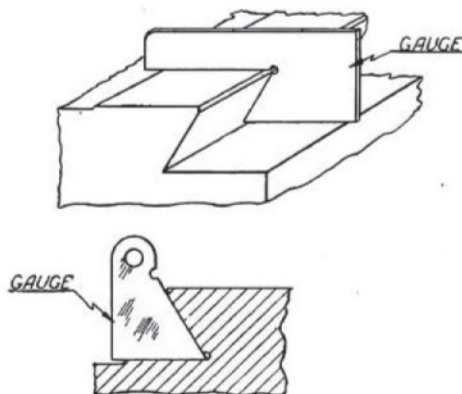


Fig. 7. Profile gauges for testing the slope of the sides.

W and w , respectively, in Fig. 8. By "angular" width is meant the width if the angles were continued to sharp corners in the manner of Fig. 8.

Considering, firstly, the male slide, the distance L over the cylinders is given by the formula:—

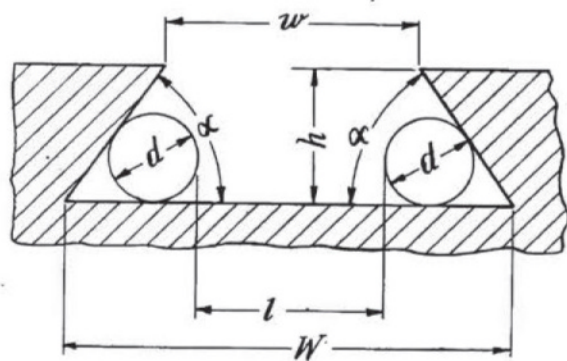
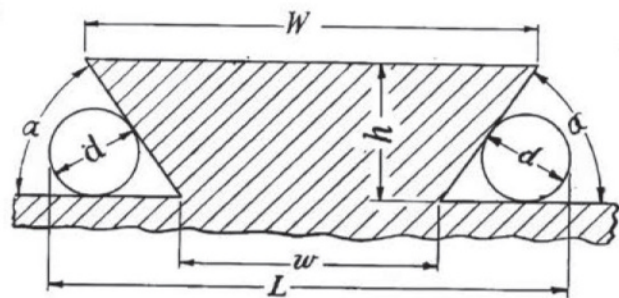
$$L = d \left(1 + \cot \frac{\alpha}{2} \right) + w$$

If the greater width W were given, instead of the smaller width w , then the smaller width could be readily determined by trigonometry.

For a female slide (Fig. 9) the distance l between the cylinders can be determined from the formula:

$$l = W - d \left(1 + \cot \frac{\alpha}{2} \right)$$

The distance L over the rollers of a male slide can be readily measured by means of a micrometer, or a vernier caliper. If the work is being machined to limits, a stepped gap gauge, made of plate, can be employed to check the overall dimension.



Figs. 8 and 9. The dimensions to be considered in gauging dovetail slides.

In the case of the female slide, the distance l can be checked by means of the internal jaws of a vernier caliper, or by means of an internal micrometer.

The Largest Diesel-Electric Locomotive in the World

Capable of hauling a loaded 14-car train at a speed of 117 miles per hour, and scheduled to make the trip from Chicago to Los Angeles in 39½ hours, the Union Pacific's newest streamlined locomotive, "City of Los Angeles," with motors, generators, and auxiliary equipment furnished by the General Electric Company of New York, will soon be in regular passenger service.

The three-unit 5,400 h.p. diesel-electric locomotive that furnishes the motive power for the train is the largest locomotive of this type yet built. It is powered by six 900 h.p. engines, and has six electric generators, which furnish the power to drive the twelve high-speed traction motors on the six three-axle trucks. The traction motors are similar to those in successful use on other high-speed diesel-electric trains.

Directly behind the third unit of the locomotive is the auxiliary power car which contains two diesel engines, each of which drives a General Electric 300-kW alternating-current generator. The two alternators are connected in parallel to supply 600-kW of 60-cycle current to the train line. This current will be used to heat, light, and air condition the train.

Scribe a line

YOUR CHANCE TO TALK TO US!

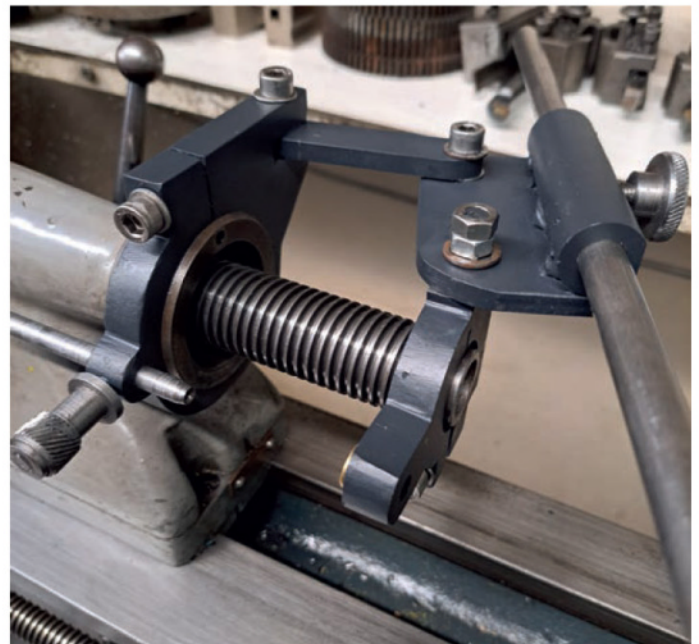
Readers! We want to hear from you! Drop us a line sharing your advice, questions or opinions. Why not send us a picture of your latest workshop creation, or that strange tool you found in a boot sale? Email your contributions to meweditor@mortons.co.uk.

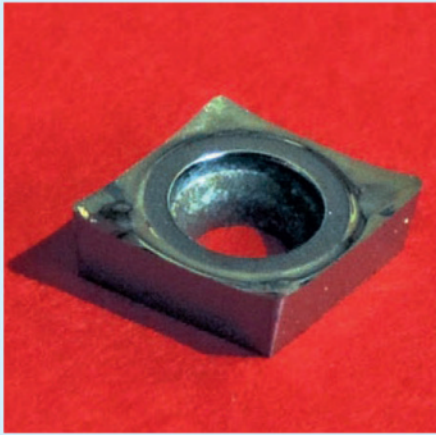
Lever Arm Tailstock 1

Dear Neil, I had always fancied a lever arm tailstock for my aged M17 but the price when available was prohibitive (being a tight old fart didn't help). It never entered my head to make one until I saw Pete Barker's excellent interpretation of a lever arm tailstock that could have come from the Myford factory. I was immediately disappointed when looking at the drawings and realised that Pete's was made from $\frac{3}{4}$ " Bar stock of which I didn't have any. I forgot about the article until issue 324 arrived and prompted me to look at the drawings again. I realise that it was never going to look like the one Pete made but with a few changes it could be made simpler from some $\frac{1}{4}$ " and $\frac{1}{2}$ " plate that I did have. I now have a lever arm tailstock that is a joy to use.

It pays to look at drawings and see if it inspires you to change, alter, modify things to suit your needs or what materials you have available.

Terry Lowry, by email.





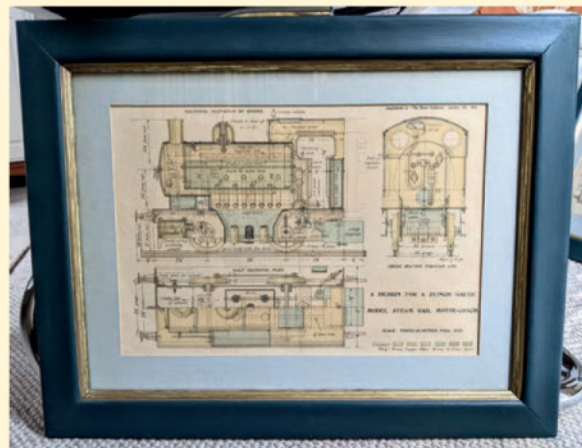
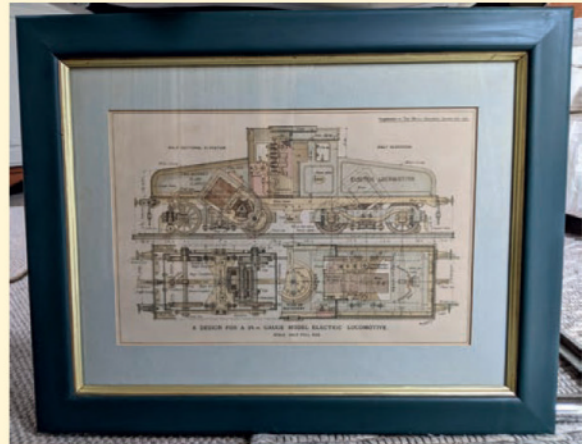
Achieving a Nice Surface Finish

Dear Neil, just a quick tip with respect to the Artful Dodge #3 article in MEW issue 324. I have never been able to achieve what I regard as a "nice surface finish" in mild steel using moulded carbide inserts such as the CCMT type mentioned in the article with my Myford ML7 lathe. Part of the issue is probably the relatively poor rigidity of the ML7 top slide plus a Dickson style tool post. Well sharpened HSS tools do a far better job. All is not lost for carbide inserts with small lathes. I have found that the ground and polished carbide inserts sold for machining non-ferrous metals give an excellent finish in mild steel. My method now is to use a CCMT insert for the heavy roughing down to within few thou of the desired size then a CCGT insert for the final finishing to size.

Keith Fisk, Wellington NZ

Framed Pullouts

Dear Neil, many years ago I inherited a huge number of the Model Engineer from a friend which after many months of pleasant flicking through passed them on at a local auction for about twenty quid I think. Not before I retrieved two mint "new year supplements" which were tucked inside in mint condition. These were and still are strongly coloured, so I had them framed and looked after ever since. So, we have Jan 5th 1905 Design for 3x1/4" Model Electric loco and Jan 7th 1909 Design for 2x1/2" gauge model rail steam engine.



Stanley Bennett, by email.

We discussed the best way forward and an advert for Stanley's two framed prints can be found in the Readers' Classifieds section at the back of this issue. – Neil.

Loco in distress!

Dear Neil, I have just received my copy of no. 325 for which I thank you, but upon first perusal see upon page 33 the flier for the next issue of Model Engineer. Unfortunately this depicts a locomotive bearing the headboard "1960 / 2020 A world First - Lincolnshire Coast light railway" and upon each side at the front a flying Union Flag, both of which are upside down which is an internationally recognised 'sign of distress'. This situation however does not appear upon the driver's face!

Peter M. Napp, by email

Lever Arm Tailstock 2

Dear Neil, has anyone modified a Myford Super 7 to use Pete Barkers Lever tailstock attachment?

John Chappell, Caloundra Qld, Australia

I'm sure this has been done. Has anyone got details? – Neil.

Workshop Photography Part 5

The first four articles in this series have chiefly looked at the technical side of workshop photography. This final part looks at the more creative aspects, like lighting and colour, that can make the difference between a simple record of an object or process and a more engaging image.



3D printed candlestick looking rather anaemic under ambient light.



This is much spookier!

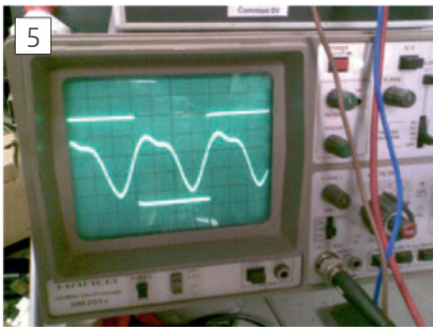
In the last issue we looked at lighting, with the accent being chiefly on achieving even results without strong highlights and deep shadows. However for more powerful images one of the most powerful tools to hand is creative lighting. I'll accept that **photos 1 and 2** aren't a typical engineering subject (the candlestick is 3D printed!) but they do show the difference that lighting can make. Having the light source or sources inside the frame can make for a very successful image, think how many great sunset photos you see. In this case the choice was made to allow the candles to provide all the illumination, but for most workshop images you will want to have some additional illumination as well.

The main challenge here is that our eyes can handle a huge range of contrast, much more than a typical camera, so some effort is needed to balance areas lit by different light sources. So-called 'HDR' processing as discussed in the first instalment can help with this, but the more balanced the lighting to start with, the better the result you get.

Photograph 3 is a good example, in this case the practical aim is to show how a Dremel multi tool fitted with an LED can illuminate the workpiece, in this case a small casting that is being fettled. By balancing the background lighting with that from the tool itself a more realistic situation is pictured than using the integral light alone (I doubt you would want to fettle in the dark!) The choice of a fairly close crop on just the fingers, rather than the whole hands, makes for a more powerful composition. Incidentally, this photo was taken without assistance, so a tripod was used to hold the camera and the self-timer set to give enough



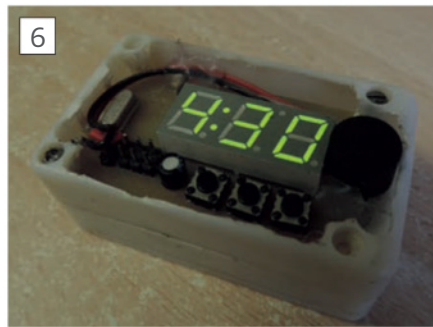
This shot combines ambient and in-image illumination to good effect.



An interesting waveform tests a trigger circuit.

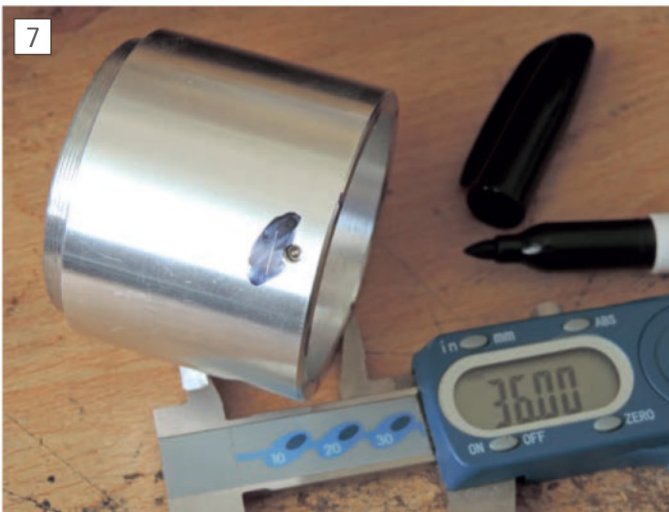
delay to get the work into position. The large live-view screen on the camera assisted framing.

The portable oscilloscope in **photo 4** is a less composed shot but is an example of the challenge of balancing background illumination when



A small cycle timer based on an AVR chip.

photographing an illuminated screen. In this case it wasn't too hard, but to photograph a traditional oscilloscope, **photo 5**, under bright fluorescent lighting I had to set the display brightness rather higher than normal – you can tell by the rather broad traces.



The micrometer display is quite clear in this image.



Illuminated screens can be a challenge.

Obviously, I turned it down again afterwards as I didn't want to burn out the phosphor. In many cases, however, you may need to adjust the ambient light rather than the subject, perhaps by adding or reducing the number of light sources, using a reflector or moving closer to or further from a light source.

In many cases it isn't too difficult to balance relatively bright light sources, such as LEDs, **photo 6**, or LCD displays, **photo 7**, with normal lighting. **Photograph 8** on the other hand was a triple challenge. It's a superficially simple image of a non-contact infra-red thermometer, but as well as getting everything lined up, there was the need to find a spot that allowed the thermometer to be adequately lit while still keeping both the LCD display and the laser spot visible. It wasn't a total success as the temperature (27° C) is hard to read (it may not reproduce in



A non-contact thermometer.

print. I did try taking it with the display illuminated... but then proper exposure of the display meant the laser dot was barely visible.

In the last issue we had a few examples of using more directional or focused lighting to make an image more dramatic or to draw the eye to a specific point. **Photograph 9** is a nice example of what could have been a very ordinary image being lifted up by lighting that highlights just the dial gauge and the setup it is being used to adjust.

Colour

Great use of colour can make an image more exciting and vibrant. Unfortunately hobby engineering tends to be dominated by grey lumps of metal held on grey machines, **photo 10**. It's not an exaggeration that the workshop side of the hobby is not very colourful at all. That said, if you can find a way to include few colourful images alongside an article or in a display it will help catch the eye and break up a less striking sequence of images.

Naturally, with a practical hobby, you want to avoid things being too contrived but there are some obvious options.

Coloured metals, particularly brasses or bronzes and heat treated (especially blued) steel often look good, but different metals together always look interesting, **photo 11**. Decorated metal objects may have sufficient interest of their own even if the colour is relatively subtle, **photo 12**.



Moody lighting on a mini lathe.



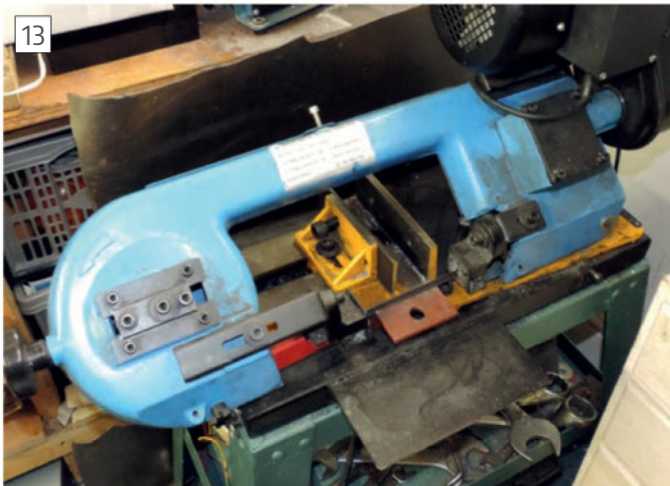
Lots of subdued colour here!



A touch of brass adds interest to this assembly.



An etched lunar dial for a jovilabe.



A modified bandsaw.



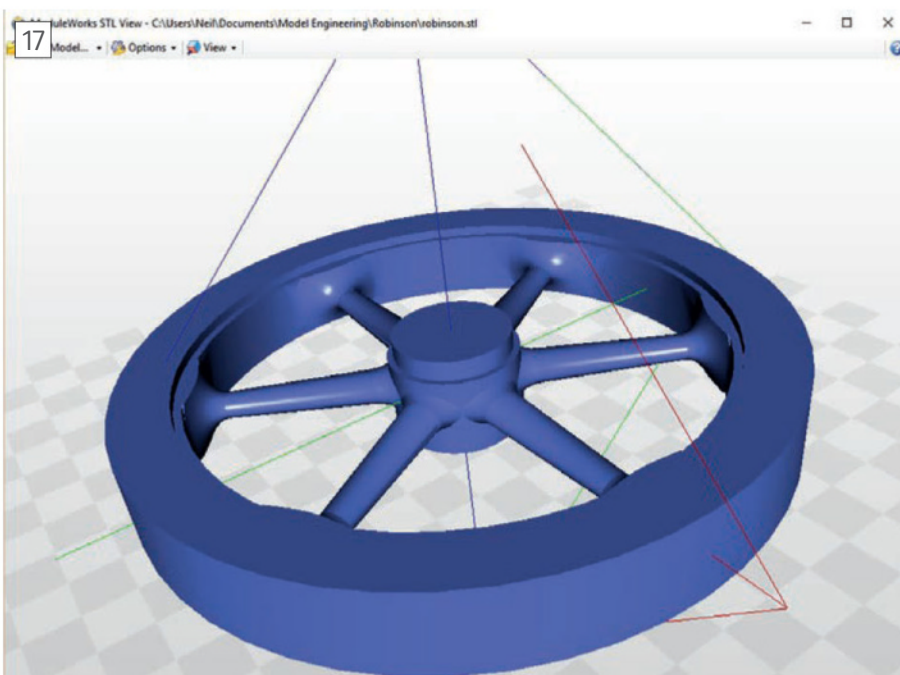
Plain MT sleeves cheered up by a strong background colour.



A Tamiya Panther tank on a complementary background.



3D printed and painted, not a casting!



A 3D rendering of a flywheel pattern.

Where tools (or models) include strong colours, try and make sure these are part of the image. The bandsaw in **photo 13** may make a better image zoomed out rather than cropped just to a smaller area of interest (in this case the small work support table).

When photographing a plain looking object a coloured background can really help. We have already looked at this in some detail, **photo 14**, so just a reminder that backgrounds should not overpower the foreground objects, subtle textures or plain colours are best. Coloured backgrounds can also help set off relatively colourful items, especially if you use a contrasting colour as in **photo 15** or a complementary colour, **photo 16**.

It is not exactly photography, but if you produce 'rendered images' in a CAD drawing program, consider using relatively strong colours to make them appear more attractive, **photo 17**.

Textures

Textures are patterns and shapes in an image, strong textures add interest



to an image and can even give it a three-dimensional feel. **Photograph 18** is a great example of how different patterns and finishes helping convey the sense of a battered and abused old engine. Also looking back to photo 15, see how the textured felt makes a more pleasant background than the card in photo 14

Etched and engraved parts often have strong textures that can look quite striking in an image, **photo 19**.

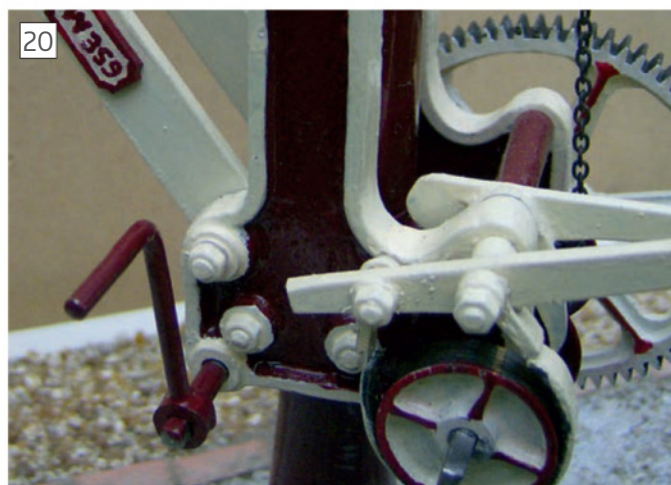
Close ups of models and assemblies can offer a lot of texture and depth, **photo 20** has quite a lot going on, with a machined gear, etched plate and several fabricated parts. This gives a great range of shapes and forms but all part of a meaningful whole.

Normally we want to hide machining marks, but sometimes they can be used to make a point and provide an interesting image, such as the close up of a milled finish in **photo 21**. Closeups can provide really interesting textures such as the display screen in **photo 22**.

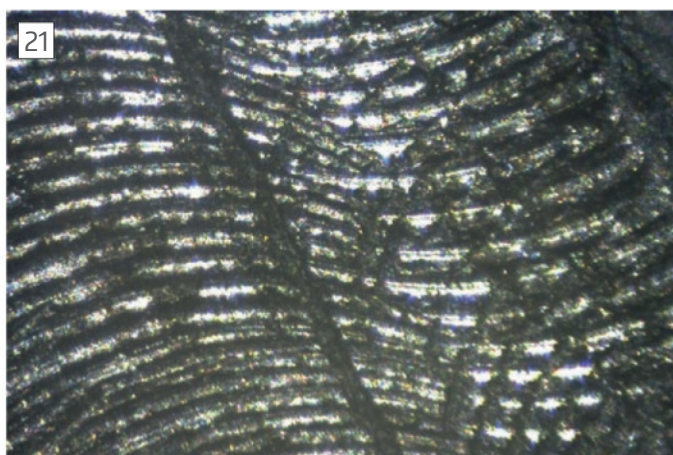
A much-abused Suffolk lawnmower engine.



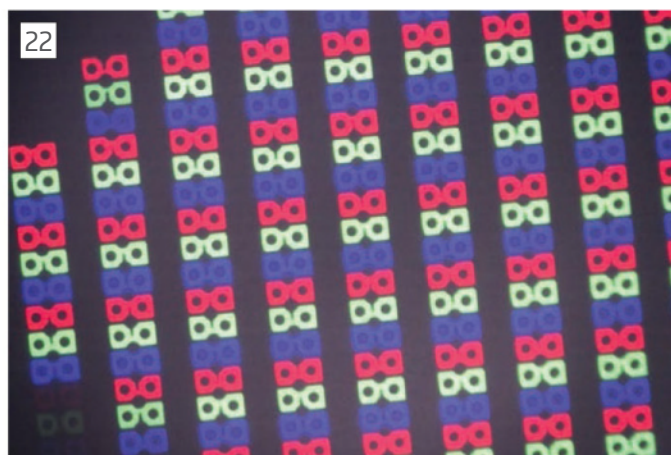
Deeply etched nameplate for a lawn roller.



Interesting shapes on a model crane.



Milled brass, under a USB microscope.



Close up of an early OLED phone display.



John Stevenson sharpening endmills at Harrogate.

Telling a Story

When illustrating an article, it is very tempting or even necessary to document every stage of the process with a separate image. Particularly meaningful are images that show someone doing something, particularly using a machine, such as **photo 23** which shows the late John Stevenson using an end mill sharpening module. Another simple way

to tell a story is to show parts at different stages of manufacture in the same image, **photo 24**.

Sometimes it is possible to capture a lot of information in a single picture, although it may need some explanation. **Photograph 25** illustrates a whole series of points around investment (often called lost-wax casting), as well as being another

example of mixed lighting. It shows a simple improvised hearth, at the right is the plaster investment being heated to melt out a 3D printed armature to create the mould space. The need for a quite aggressive approach with a fierce flame to totally clear the mould is obvious. There is plenty of insulation in evidence, so the mould doesn't cool too much when the heat is transferred to the melting pot, at left. The steel pot has an obvious handle (so it can be held by a hefty pair of combination pliers) and contains a number of brass items. These are smothered in borax, this acts as a flux that will melt into a liquid cover, helping prevent oxygen getting to the melt and causing fumes of zinc oxide which could pose a health hazard. Less obviously, the whole setup is outdoors to minimise the risk of breathing fumes. It may not be possible to get quite so much into every image as this, but this one would certainly work well as the main image for an article on investment casting.

Conclusion

It has sometimes been a challenge not to cram in even more examples of the good (and bad) in workshop photography, and there are many areas still left unexplored, such as ways of including people in images and photographing large subjects, such as vehicles. But hopefully this short series has helped you think about your workshop photography and, if you are a contributor to MEW, your local club magazine or sharing images on the web, it will help you get better results in future. Happy snapping! ■



Stages in machining loco wheels from solid.

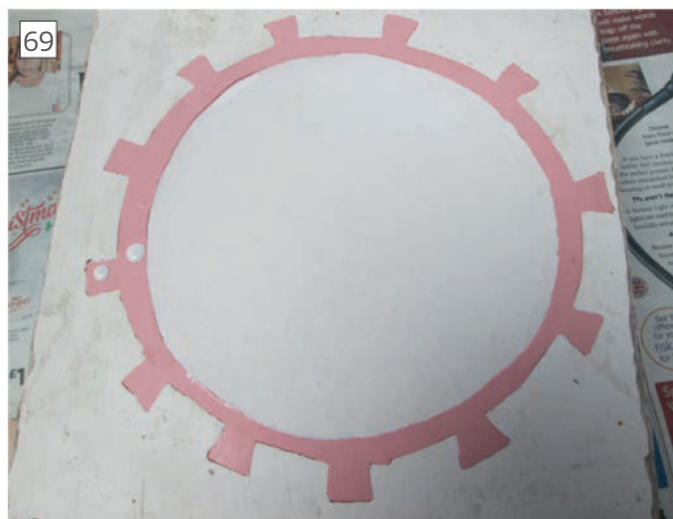


Burning out an investment mould.

A foray into casting



Laurie Leonard shares his experiences of casting in the home workshop.



Using the Silicone Mould

A plaster casting was taken from the mould by filling it with plaster of Paris.

photo 68 shows the set up using a spirit level and lolly sticks to level the mould as

my bench has warped. The filled mould is shown in **photo 69** and a painted casting in **photo 70**.

A similar process was used to produce a thistle plaque shown cast in plaster in

photo 71. A high temperature silicone rubber was used to make a mould so that a cast could be made in pewter. In **photo 72** the mould is being dusted with talc to permit easier removal of the

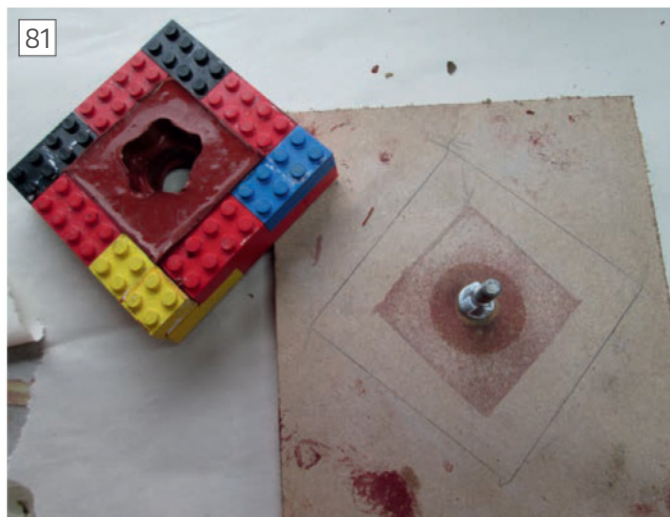
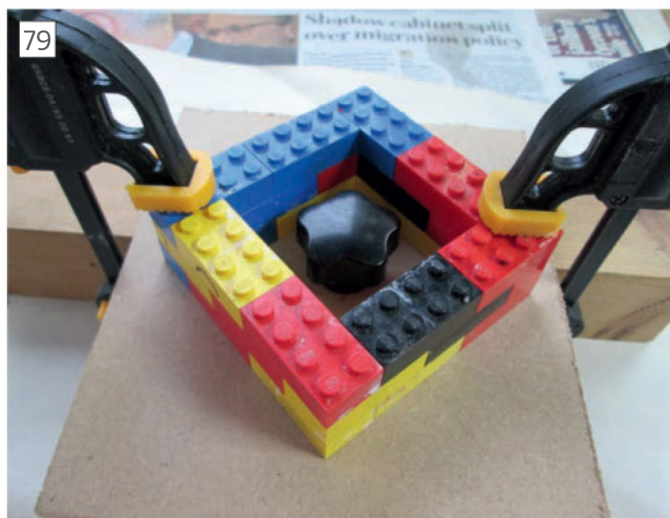
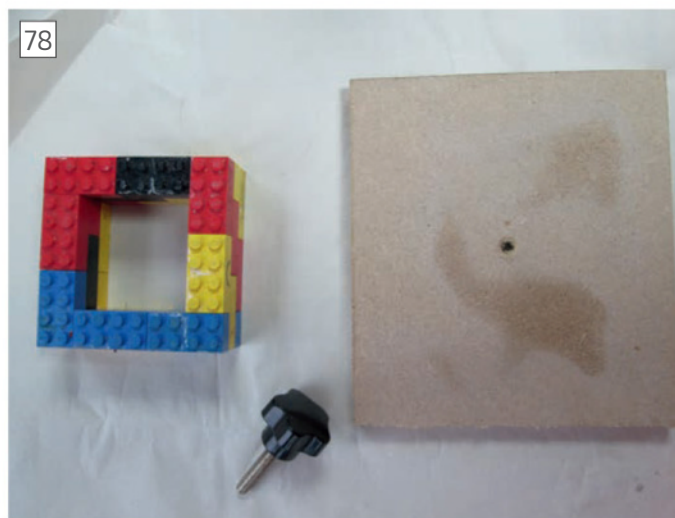


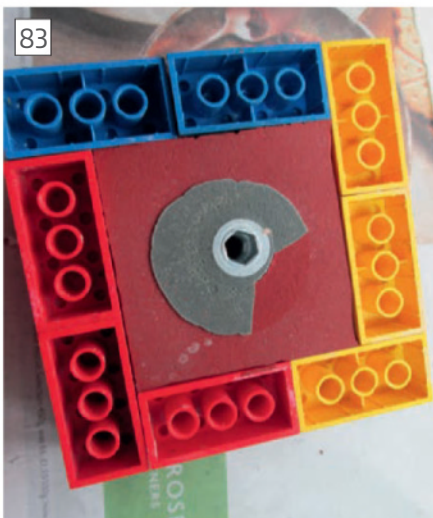
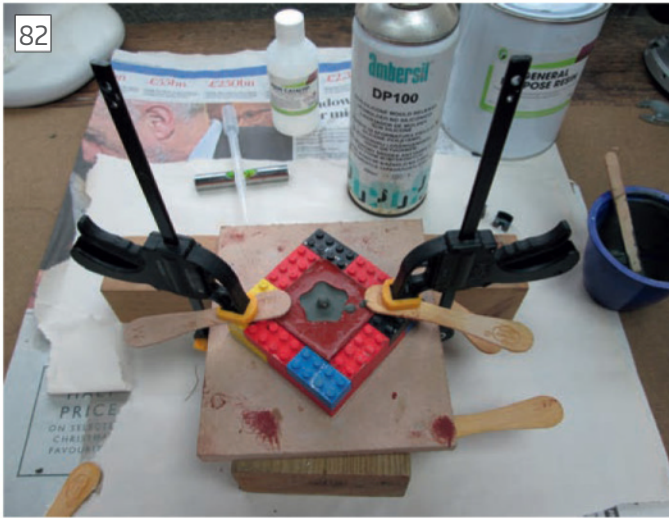
finished casting. Due to the cost and weight involved the base of the plaque was not cast and metal only added to fill the thistle shape, **photo 73**. It proved to be more viscous/higher surface tension than I expected hence the rather hit and miss pour but when released from the mould, **photo 74** I was still rather pleased with the result. **photos 75** and **76** show a polyester resin casting made from the mould. A brass powder rich mix of catalysed resin is painted on the surface of the mould and left to cure and then the rest of the mould is filled with a mixture of resin and slate dust keeping the cost down. The reverse of the plaque shows the incorporation of a wooden fillet to assist with hanging. A sculpture



made in a similar manner is shown in **photo 77**.

As stated above moulds can be made completely out of silicone rubber. I required some threaded knobs and made some using an existing knob as a pattern for an all silicone rubber mould. The procedure is similar to the above but the plaster jacket is not required and the rubber is poured directly onto the pattern. The rubber still needs to be contained and model building bricks provide a good way of building up a moulding box as shown in **photo 78** where it is seen with the knob to be used as a pattern and a baseboard predrilled to take the knob screw. A suitable "O" ring was placed on the knob screw to seal the knob to the board and the knob was held in place with a nut under the board. **Photograph 79** shows the mould ready to pour the rubber. Some leakage into the brick joints occurs especially if the brick are old and well used but this does not cause a problem





slate dust (filler to reduce the amount of resin needed) and poured into the mould until flush with the top, **photo 82**. When the resin had hardened the new knob was released and the flash as seen in **photo 83** was removed.

The latter was caused by the rubber not being held hard down onto the board. I considered making a clamping plate but chose to keep the access for resin pouring as free as possible.

Photograph 84 shows a completed knob. The small lump on the underside of the top was caused by an air bubble being trapped when the mould rubber was poured leaving a cavity in the mould rubber. Most jobs end up with some clean up. **Photograph 85** shows the mixing bowls and the solidified remains that were easily cleaned out of them. Due to the open mould technique employed some finishing of the knobs was required, **photo 86** but a minimum was done as these knobs were not for show. The relative sizes of the insert and knobs can be seen in **photo 87** but I think that the technique and the insert,

and can be cleaned off when the box is disassembled. A suitable release agent applied to the pattern, base board and box will assist in releasing the mould. A quick approach was chosen using only a one-part mould so the rubber was only poured to the top of the pattern, **photo 80**. After the silicone rubber had cured the mould was trimmed, the silicone rubber cuts easily with a sharp knife,

before moving onto the resin pouring stage. Female threaded knobs were required so a threaded boss as used in knockdown furniture construction was employed as a readymade boss for the knob. A short bolt of the same thread was coated in release agent, passed through the base and then tightened into the threaded boss, **photo 81**. Note the pencil lines showing the outline of the mould box but I had to keep turning it to get the knob in the centre; I had not marked a lead side! Polyester resin was then mixed with hardener and



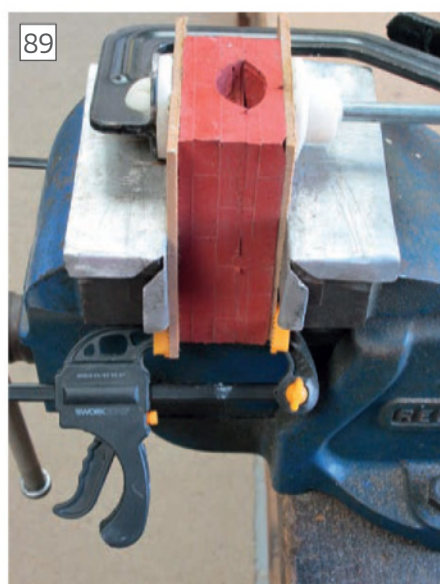
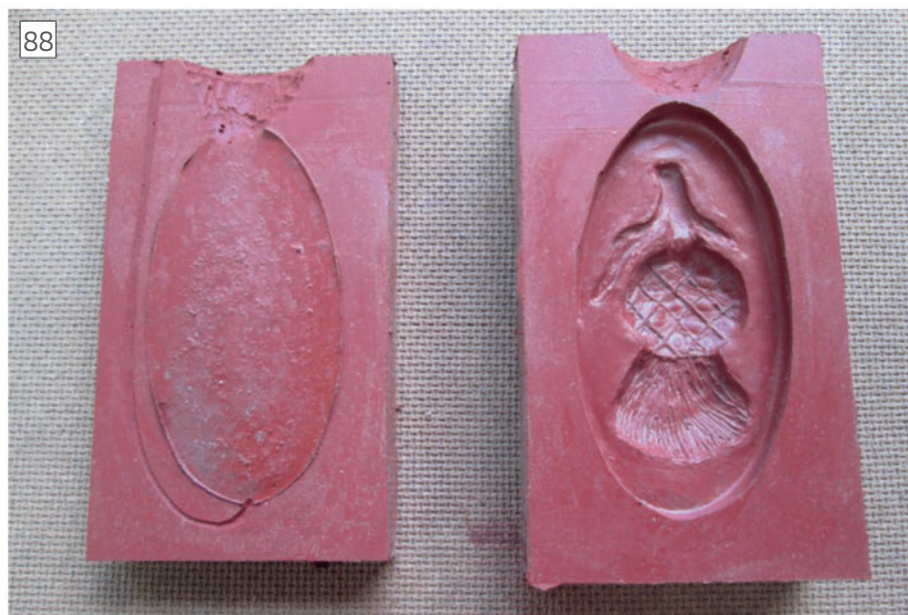
M6, could successfully be used on much larger knobs.

Another example of a silicone rubber only mould is shown in **photo 88**. The pattern for the small thistle was once

again sculpted from clay but a two-part mould was made. Ideally locating pins/dimples should have been made to ensure registration when the mould was assembled for pouring, **photo 89**,

but the parts were aligned by touch before the mould was clamped for pouring. Both an as cast and finished sides obtained are shown in **photo 90**. This dark silicone rubber is the high temperature rubber suitable for low melt alloys.

The fine detail available by using silicone rubber to create the mould can be utilised for many projects. I was interested in the texture of a piece of bark and wanted to make a casting of it. I made a mould by building a dam of clay around the edge of the piece of bark



which I had sealed with acrylic varnish and then applied a release agent. The mould was then filled with a pliable grade of silicone rubber and left to cure. The rubber then became a mould to make a positive plaster cast. The three stages are shown in **photo 91**.

Lost polystyrene

The first time I tried this was to make a sculpture as part of the final project on my Art School course. I wanted to make a small pair of boots and the texture obtained by using the "bubbles" type of

polystyrene seem ideal for the job. I had read **ref. 3**, that castings could be made by immersing the polystyrene pattern in a suitable container and covering it with dry sand having made suitable arrangements to pour the molten metal onto the pattern to melt/burn it off. I used lead from car wheel balance weights, those were the days, as it melted at low temperature, was to hand and the finished work was "an example". The result is shown in **photo 92** suitably tarnished after some 20 odd years. The base of the casting, **photo 93** was used as the pouring funnel.

I also tried to make a tool holding jig as shown in **photo 94**. The two flanges were cut out of sheet polystyrene using a shop made hot wire cutter, **ref. 4**, together with the bridge piece. The pieces were assembled using PVA adhesive. Having drilled the hole in the bridge piece I was aware that all was

not well and a little pressure cause the casting to fail, **photo 95**, there being insufficient metal due to the honeycomb result of the pattern. I tried again and this time the jig failed at the adhesive joint, the metal not flowing across the PVA.

A more successful project was the production of clamp brackets, **photo 96**. These were used to secure the solar panel mount mentioned earlier to the grab rails on my narrow boat.

Latex

Latex is used to make flexible moulds but problems can be found with deep undercuts on the pattern/model. The process is similar to using silicone rubber so I will not go into great detail. The thickness of latex is built up in layers that are painted on and allowed to cure before the next layer is applied. **Photograph 97 to 101** show a sequence of steps involved in





creating a plaster cast from a clay model. **Photograph 102** shows what is known as a cold cast bronze casting, from the mould. This is made as described above with a bronze power rich layer of resin

which is backed, when cured, with a cheap filler loaded resin. The surface of the casting is polished with wire wool which exposes the bronze and further polishing can be carried out with metal

polish but, as in the example, this will tarnish unless it is lacquered.

I have also used latex to make a mould of tree bark to make castings. A casting and mould, not the one from which the illustrated casting was made, are shown in **photo 103**.

Conclusion

In this case I think that this just means the end! Perhaps some techniques may not seem directly relevant to the title of our magazine but I have to admit that I have yet to build a model. It was to be a loco but then I realised that that needed track so have done some research on a traction engine. After a back operation lifting weight bothers me although I want to build one capable of pulling passengers which is likely to be heavy, so I am still at the thinking stage.

As a MEW subscriber from very early on in the life of the magazine I have gleaned a wealth of information and ideas from the articles and learnt a lot that I have applied to the things I have made (or mended). I hope that the above will at least spark a few ideas.

Suppliers I have used

Alec Tiranti. Tel 01635 587430.

Web www.tiranti.co.uk

Industrial Plasters. Tel 01380 850616.

Web www.industrialplasters.com

John Winter & Co. Ltd. Tel 01422 364213.

Web www.johnwinter.co.uk

References and other works of possible interest

3 MEW 181. Michael Cox, "Aluminium Casting in the Home Workshop"

4 MEW 184. Michael Cox, "A Hot wire Cutter for Expanded Polystyrene"

5 Model Engineer issues circa autumn 1994. Articles on last wax casting.

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Notes For Newbies – Part 2



Howard Lewis is a long-standing model engineer, he shares more of the lessons he has learned the final part of this two part series.

Tailstock

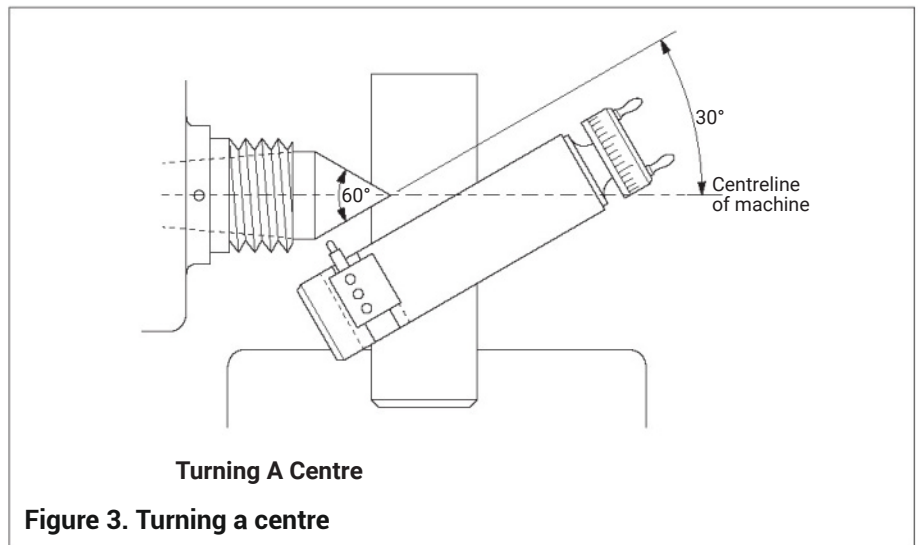
For most work the tailstock needs to be aligned so its centre is aligned horizontally and vertically with that of the headstock. If the tailstock is offset, drills and reamers, and any other tool carried in the tailstock will not cut accurately. Small tools, especially centre drills, may be broken, and in particular reamers will cut oversize. Being held off centre it will cut more on one side than the other, and act like a boring bar to give an oversize hole.

Ideally, before checking the alignment of the tailstock, it should be ensured that the bed of the lathe is free of twist. If the lathe bed is twisted, it is likely that long cuts will be tapered. The means of checking for, and correcting, any twist is set out in books such as Ian Bradley's "The Amateur's Workshop", and his "Myford Series 7 Manual". This is sometimes referred to as "Rollie's Dads Method".

Where the lathe bed is of the cantilever pedestal type, as in machines such as the Myford ML1,2, 3 or 4, twist is less likely. For lathes where there are separate mountings at headstock and tailstock, levelling to remove twist is more likely to be required.

The tailstock usually has a morse taper within the hollow barrel. this can be used to carry a centre or items such as a drill chuck or die holders. some twist drills and reamers have morse taper rather than plain shanks and can be mounted in the tailstock. It is essential that the tapers with Headstock and tailstock, and any tooling inserted into them must be clean and undamaged if accuracy is desired.

The Centre most often used in the Tailstock is hardened. When turning between centres, the centre in the Headstock is soft. If there is any damage, or it is suspected that then centre is not accurate, it should be mounted in



the undamaged Morse Taper in the Headstock (Using an adaptor sleeve if necessary) and lightly skimmed to clean up. For this the Top Slide needs to be set over to half the angle of the centre, namely, thirty degrees, **fig. 3**

When using a centre to support or align work, the centre and centre drilling must be greased. Failure to do this may cause the centre to seize to the work and ruin both items.

Turning between centres with an offset tailstock will result in a taper being turned. (Sometimes this is done deliberately, but most of the time correct alignment is required).

Once the centres are known to be in good condition, they can be used to align the tailstock. The centres are used to carry a bar known to be accurately machined round and to be parallel. Alignment bars can be purchased for this purpose, or with a 4 jaw chuck one can be made from a length of silver steel, or precision ground bar, of as large a diameter as possible, (for stiffness). The length should be the greatest that can be held between centres. For a 2 MT

headstock, the largest diameter that will pass through is 1/2" or at most 13 mm.

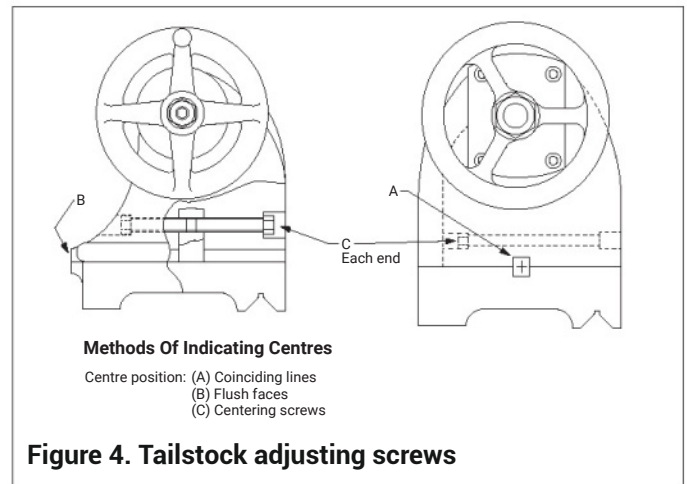
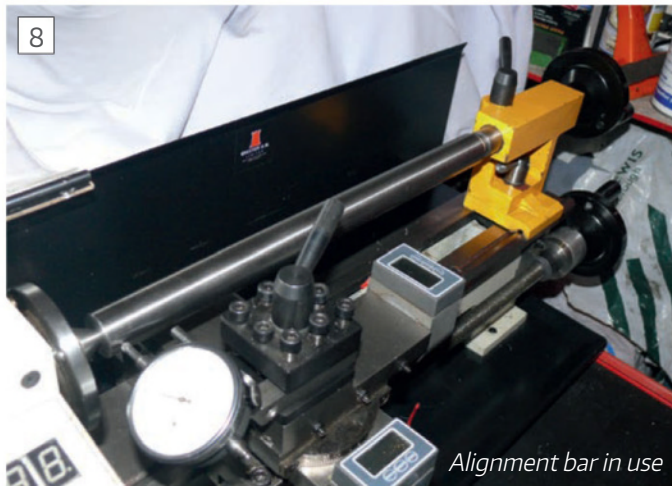
Making An Alignment Bar

To make an alignment bar a length of silver steel, or precision ground round should be mounted in a 4 jaw chuck and passed through the headstock so that only a minimum protrudes from the chuck. The chuck is then adjusted so that the bar runs as concentrically as possible, before being centre drilled.

The bar is then reversed in the chuck and accurately centred again, before being centre drilled. The bar is then ready to be used to find what, if any, misalignment exists. It is not necessary to run the lathe for this operation, indeed the chuck should not be rotated at all.

The bar is set and lightly gripped between centres, with the tailstock clamped to the bed, and the Barrel should be clamped. A dial test indicator, preferably a plunger type, is arranged horizontally, and (probably carried on a magnetic base) set to centre height.

A magnetic base has the advantage that when on a ferrous surface and



switched “on” it does not move about, unlike a scribing block. If no magnetic base is available, a holder should be made up so that the DTI can be clamped in the toolpost, to bring it to centre height.

There are two types of DTI, a plunger type, shown here on a magnetic base, **photo 6** and a “finger” type, often called a “Verdict” after one of the manufacturers of such an indicator.

photo 7.

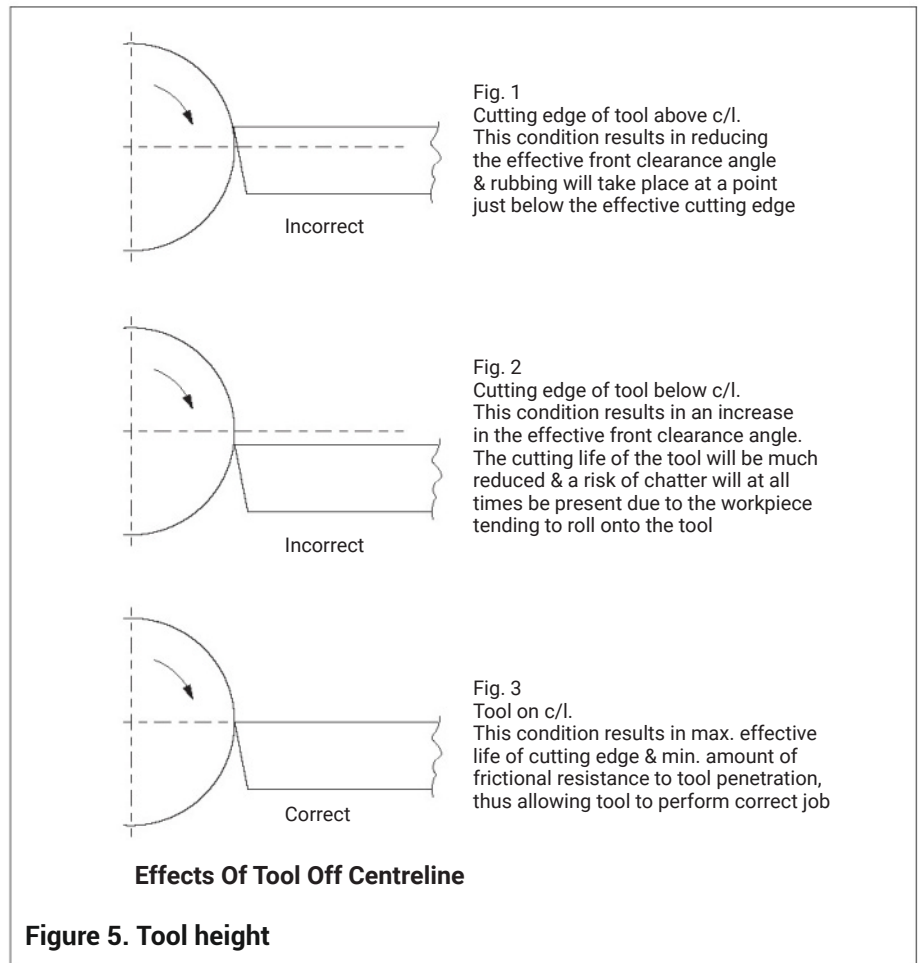
The finger type “clock” is usually more finely graduated than the plunger type.

Photograph 8 shows a shopmade, as opposed to purchased, alignment bar in use. Very often, a purchased alignment bar will include a Morse taper of a size that suits a lathe and can be used for further alignment checks (such as for twist in the bed).

A word of caution though; it is better not to get too carried away over alignments, eccentricities, etc. Hobby lathes, often, are either ex-industry lathes which have worked hard and worn, ex technical college lathes which have done little work, but been abused by careless and unknowing students, or new hobby lathes built down to a price. In either case it is unrealistic to expect the machine to produce the same level of precision as a new industry machine costing at least fifty times more! Very often spending care and time can improve an indifferent machine to the point where it is quite capable of really good work.

Aligning The Tailstock

With the plunger “clock” near to the headstock, it is set to zero. The saddle is then moved to bring the “clock” to the tailstock end of the bar. If the tailstock is correctly aligned, the reading will still



be zero. If it is not, the tailstock needs to be aligned.

Near to the base of the tailstock there will be two screws, one on the front facing you and another on the back. These are adjusted, one against the other, to reduce the dti reading to one half of the value found. **Figure 4** shows this process; as an aside, this shows a tailstock for a lathe with a prismatic bed.

The saddle is returned to the headstock end and reset to zero, before

returning to the tailstock end again. If there is any reading other than zero, the tailstock adjustment should be repeated. When both ends show zero, the tailstock is aligned.

Cutting Tools

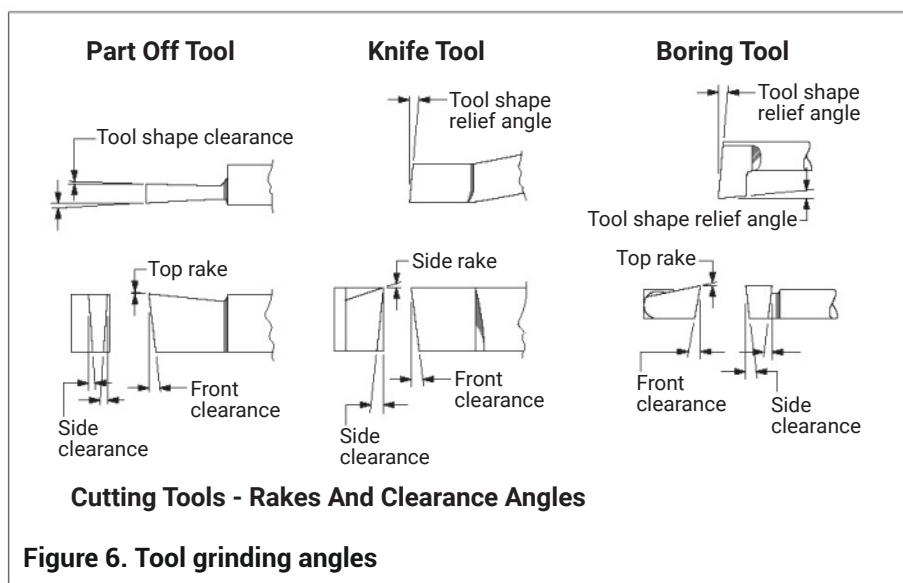
To cut, the tool must be correctly ground, and set with the cutting edge on the centre height of the lathe. A tool that is set above or below the centre height will not cut correctly, if at all, **fig. 5.**



Hss toolbits



Carbide tools



Tools are often referred to as being right or left hand. Viewed from above, from the operator position, a right-hand tool points, and cuts, towards the headstock. A left-hand tool points, and cuts, towards the tailstock.

The two types of material most commonly used for cutting tools are high speed steel and carbide. HSS is available either as tools, pre-ground to shape, or as toolbits of various sizes, **photo 9**.

Carbide is available as a piece brazed onto a steel shank, or as replaceable tips held to a steel shank by a small screw or a clamp, **photo 10**. Note that the brazed Carbide tool at the bottom is a left hand tool.

Carbide is capable of cutting harder, or hardened steel much better than HSS. It was developed to remove metal faster in an industrial setting, and so benefits from the higher speeds available on

more modern machinery, but ideally needs a rigid machine to get the best performance. Older lathes with oil drip fed plain bearings tend to be suited to the lower speeds, and the tool steels commonplace when they were first designed and made.

Carbide tips, strangely are typically not as sharp as HSS tools, but those intended for machining aluminium are sharper and perform well on steel. They are not suited for sharpening on an ordinary bench grinder with a grey carborundum wheel but need a diamond wheel for this purpose. They do not withstand hard knocks, which chip them.

HSS can be ground on an ordinary bench grinder, and can be ground to special shapes, if desired.

All tools need have clearance around the actual cutting edge, at the front and at the side. The top rake will help the

tool to cut. The angles, which prevent the tool from rubbing, should vary to optimise the cutting action for the tool and work material being used. In practice, a small variation in angle can be tolerated without detriment in many cases, **fig. 6**.

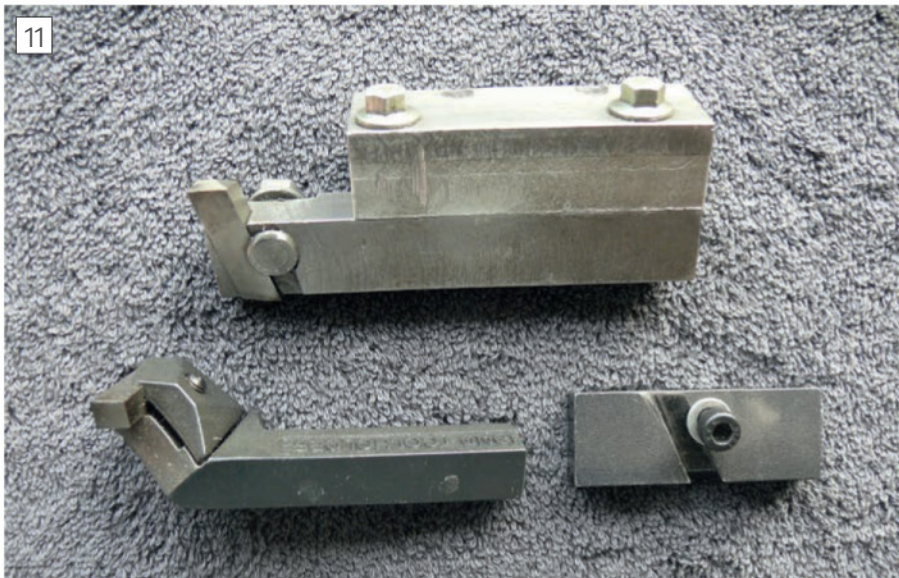
The tool generally used for normal turning is referred to as a "knife" tool. Cutting tools must be mounted so that the cutting edge is on the centre height of the lathe. In many toolposts, shims are placed under the shank of the tool to bring the cutting edge up to the centre height. Steel is available as "shimstock", or old feeler gauges can be used. Many biscuit tins are made from tin plated steel which is about 0.010"

(0.25 mm) thick and can be cut with tin snips. On a quick change toolpost, each holder has a screw to do adjust the tool height.

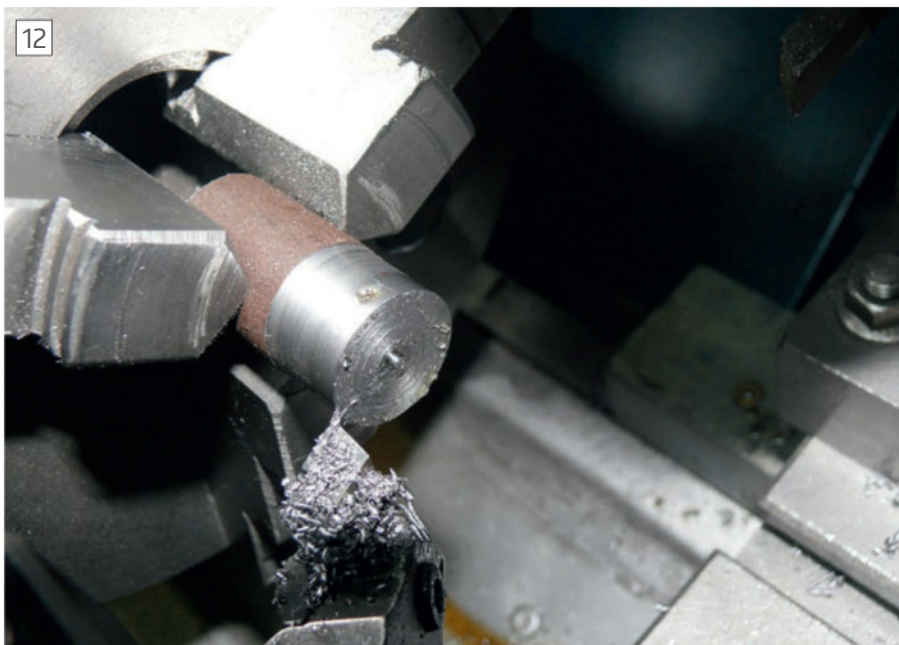
Because it has to be small to enter a bore, a boring tool has to be slender, and the holder is, therefore, weaker. This means that cutting forces will deflect the shank of the tool. The depth of cut when boring should much be less than that when outside turning or facing. To finish a bore to fine limits, several "spring" cuts may be necessary.

To avoid tool marks, when any tool is withdrawn, the work should not be rotating. To prevent a tool withdrawal mark after the finishing cut, the lathe should be stopped and the tool moved away from the work before the saddle or top slide is moved.

Surface finish is dependent upon the correct cutting speeds and feed rates being used for the material and the



Shop made centre height gauge



Effect of off centre tool

tool being used to machine it. Harder materials generally require lower cutting speeds. Excessive speed will both spoil finish and shorten tool life. Too high a feed rate will reduce surface finish, and shorten tool life. Depth of cut and feed rate can be increased when roughing out, although the shape of the tool may need to be modified to obtain longer life. Finishing cuts should be small with a low feed rate. The surface finish can be improved if a small radius is stoned onto the edge of the tool.

For the best finish, the depth of cut should be minimal, and the feed rate as low as possible, ideally less than the radius on the edge of the tool.

How hard a machine can be driven depends on machine power, condition, rigidity, tooling and material being worked. Not to mention operator skill!

Feed rate means the distance that the tool is traversed for each rotation of the work. Moving the tool rapidly across the work will produce a rough finish, akin to a spiral or screw thread. Feed rate can be controlled by suitable arrangement of gearing between the mandrel and the saddle. The higher the reduction ratio between mandrel and saddle the finer the feed rate will be.

It is possible to set too fine a feed rate, so that the tool cuts intermittently. This will happen if the pressure between the

tool and work is too little to cut, so the tool does not cut until more pressure has built up to force the tool into the work. Having cut, the tool will then not cut, until the force has built up again. All this time the work is rotating, and the tool being moved into it. A blunt tool will amplify this effect, with deterioration of surface finish.

Carbide tips will produce very fine finishes at high speeds and feeds because the local heating at the cutting edge softens the steel. The blue or brown, sometimes red hot, swarf coming off shows the heat being generated, but the machine needs to be sufficiently rigid and capable of withstanding the speeds and loads involved. Many hobbyists use both carbide and HSS tools for various purposes. A carbide tip can be used for roughing, followed by a HSS tool for finishing. It is very much a matter of horses for course, based on the machine and material being used.

Many hobbyists use what is a tangential turning tool. This is a toolbit, usually HSS, but some use carbide) held in a holder which sets the tool at the correct angle. Sharpening the toolbit only entails grinding one face, using a jig. Such tools are available (such as the "Diamond" turning tool because of the shape of the face of the toolbit). Such tools can be made in the shop, and work well for both turning and facing.

The tangential turning tool needs the toolbit to be adjusted within the holder to set the edge at centre height.

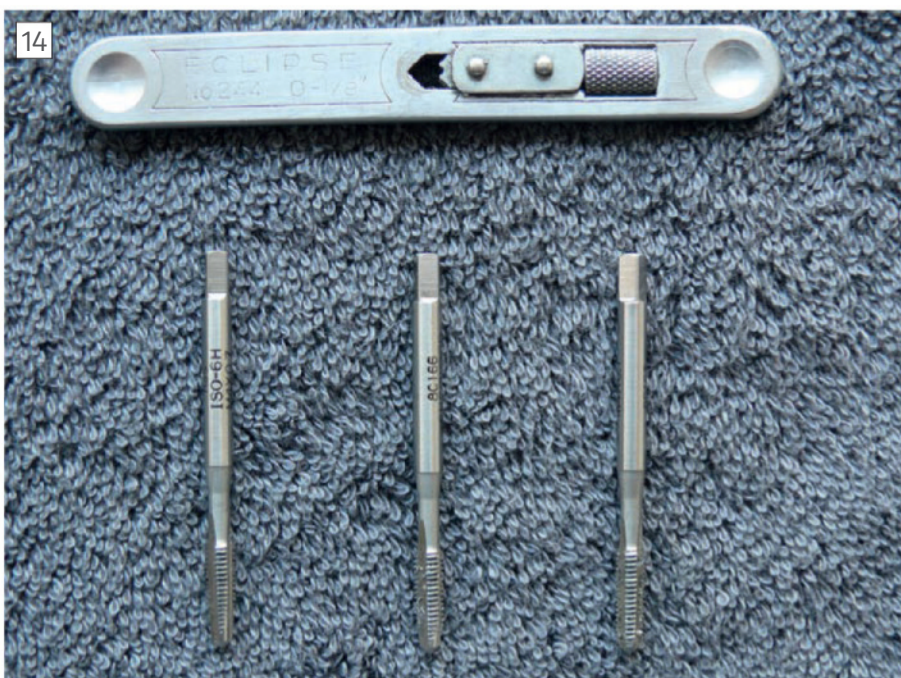
Photograph 11 Shows a home-made tangential turning tool and a commercial one, but in left hand form, together with the sharpening jig. If it is not at centre height, the tool does not cut well, and leaves a "pip" when facing the end of a workpiece, **photo 12**.

Chatter

Chatter, which creates an unpleasant sound and leaves a patterned surface on the work, can be caused by a number of problems. The speed may be too high, the feed rate may be too great, the tool holding arrangements may lack rigidity, the machine may be worn and require attention to the headstock bearings, or the gib strips, or the cutting face may be too wide. A chamfering tool may cut well, initially, but begin to chatter as the width of the chamfer increases, demonstrating



Centre height gauge



Taps and tap wrench

this effect. The tool may be blunt, or off-centre height. One or more may contribute to the problem.

It could be that the tool geometry is not correct for that particular material, or metal may have built up on the cutting edge, particularly when turning aluminium. Using a cutting lubricant may solve or diminish the problem.

A centre height gauge is a great time saver for setting the toolbit. Making such a setting tool is a good learning exercise in becoming familiar with

the lathe. Methods of setting up can vary, depending upon the equipment available, and the level of accuracy required, from simple to complicated.

Photograph 13 shows a shop made centre height gauge on the cross slide with a shop made, small, tangential turning tool mounted in the four way toolpost of a mini lathe.

Threads

At some time there will be a need to cut threads. Quite often smaller threads,

upto $\frac{1}{2}$ " or 13 mm will be produced using taps or dies. A tap cuts an internal thread in a predrilled hole. The tap produces a thread inside a hole which has been drilled to an appropriate size. Charts, such as a Zeus charts, are available detailing the size to be drilled for particular thread type, and size. Dies produce external threads and are adjusted to give the correct fit to the matching bolt or stud.

How much smaller the hole is than the nominal size depends on the characteristics of the thread (Pitch and form) Imperial sizes the pitch is usually quoted as tpi (Threads per Inch) metric threads are usually quoted in terms of pitch. Thus, a M4 x 0.7 mm pitch thread would require a hole 3.3 mm in diameter.

Taps often come in sets of three; a first cut, a second cut and a bottoming Tap. Taps are driven by a tap wrench which grips the square end of the tap. The difference between them is the amount and length of taper over the first few threads. A bottoming Tap can cut a thread to the bottom of a blind hole. Taps will break if subjected to bending, so it is advisable to guide or provide support whilst the thread is being cut.

Photograph 14 shows a set of M4 Taps, with the First Cut on the left, Second Cut in the middle and the Bottoming Tap on the right, with a Tap Wrench above. Note the differing amount of taper.

External threads can be cut with a die. The work is often turned a little under the nominal diameter. This is so that the thread is truncated, to avoid the crests interfering with the root of the other thread. Dies are usually split, so that they can be adjusted, like the M4 one shown, by the screws visible in the die holder shown in **photo 15**. Rather than cut the thread to full depth in one pass, the die can be opened with the centre screw for the first cut. For subsequent cuts the centre screw can be relaxed, and the outer screws used to close the die. The adjustment of the screws is quite delicate. When tightening the screws to close the die care must be taken not to overtighten the outer screws for fear of cracking the die.

In the lathe, a sliding tailstock die holder, **photo 16**, can be used to carry the die. In this an arbor is mounted in the tailstock and the die holder slides along this. The holders will often be capable of holding four different sizes of die. In this



Die holder

way, the newly cut thread is subjected to minimal force to draw the die along. If the die and holder was solidly mounted in the tailstock it would have to drag the tailstock along the bed of the lathe. In particular, for fine threads (which are shallow) there will be the danger of stripping the thread as it is cut.

As an example, a 40 tpi Model Engineer thread is only 0.016" (0.4 mm) deep so will not be strong enough to drag along the weight of the Tailstock, as the cut starts, and will strip.

By arranging change gears in the right way, (or using the Norton gearbox, if the lathe is so equipped) a lathe can be used to cut threads which are larger than immediately available taps or dies, or when it is not economical to buy an expensive tap or die for a "one off" job, never to be used again.

Quite often time will be spent in making tools to make other things. Making simple tools is a very useful (and economical) way of becoming familiar with machine and its operation. If you make a mistake, it is better, and cheaper, to do so on a piece of steel bar than an expensive casting from a kit!

A centre height gauge gives practice in turning, drilling and tapping and the end product is a useful time saver when mounting tools into the Toolpost, and quite specific for your machine.



Sliding tailstock die holder

A mandrel handle for turning the lathe by hand is another useful accessory (particularly on a low powered lathe) for taking the heavy cuts involved in screwcutting, or taking threads up to a shoulder. Running a thread cutting tool, or a tap into a shoulder under power often does damage to both!

Note the shop made graduated leadscrew handwheel, tailstock clamp, and clock holder mounted in the four

way toolpost, just visible, in photo 8 of the previous instalment.

Some make clocks, others locomotives, steam, battery electric, or internal combustion engine powered, road engines, or tools or improvements to a machine. Some restore classic motorcycles or cars, or even old machine tools. Each to their own! The objective of the hobby is to obtain enjoyment, and we all learn along the way. ■

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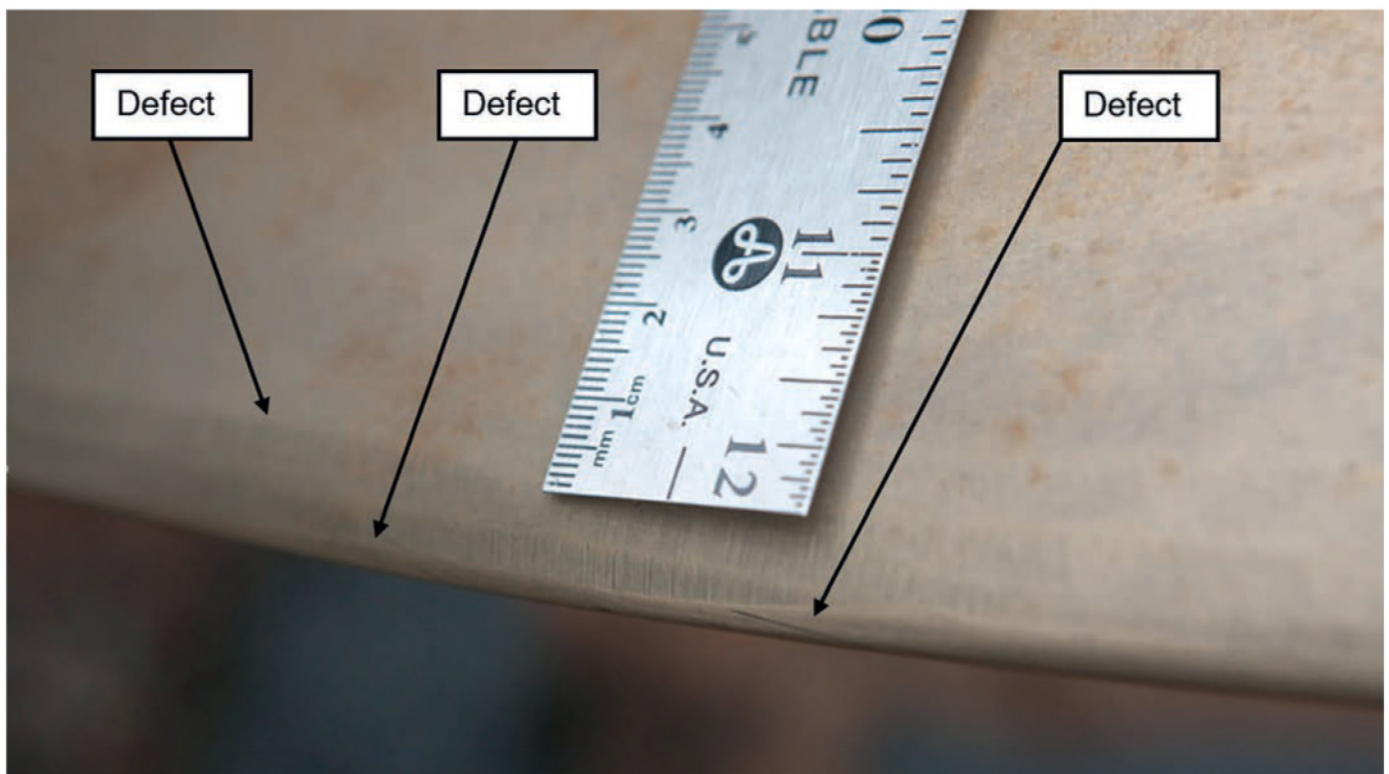
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Small Propeller Defects Can Result in Increased Underwater Radiated Noise



The slightest deviation in the machining, polishing, and finishing of ships' propeller blades could result in underwater radiated noise and cavitation, even if defects are within the maximum tolerance allowed. A Canada Transport-funded study found the slightest change in propeller geometry resulted in "significant" cavitation, and much earlier than previously thought.

The behaviour of a section of propeller blade with leading edge defects of $94\mu\text{m}$, $250\mu\text{m}$ and $500\mu\text{m}$ were studied using Computational Fluid Dynamics (CFD) at the DRDC-Atlantic Research Centre, and Memorial University of Newfoundland, in a three-year project.

Project lead, Dominis Engineering President Bodo Gospodnetic, said: "Experimental results show that current widely accepted propeller manufacturing tolerances as stated in the ISO standard need to be thoroughly evaluated."

The current tolerance for a defect to the leading edge of a propeller blade is $500\mu\text{m}$ (0.5mm).

Ship propellers are manufactured with the majority of propellers made from castings rough machined on CNC (Computer Numerically Controlled) mills and then finished using robotic and manual grinding. However, robotic and manual grinding of propeller surfaces introduces inaccuracies and deviations from the approved design, which can lead to cavitation, erosion, noise,

vibration and loss of propeller efficiency.

Researchers found that a ship with a propeller defect of 0.5mm would have to sail at 45% of the speed of a defect-free propeller to avoid cavitation noise. The smaller the defect, the less speed reduction is required to remain quiet.

"The 0.5mm defect tested is one of the tightest ISO 484-1 propeller manufacturing tolerances yet it has been demonstrated that it affects cavitation inception significantly and detrimentally. The rules need tightening up. We know that 80% of underwater radiated noise comes from the propeller, but if ships are legislated to be quiet in sensitive habitats then they will have to limit their speed to below the cavitation inception speed," said Gospodnetic.

Earliest Example of The English Domestic Clock Heads to Auction



One of the earliest examples of an English domestic clock is to be auctioned by Dreweatts. The clock, which was made when James I was on the throne and William Shakespeare was writing his first folio, was produced by the celebrated clockmaker William Bowyer (circa 1590-1653), described as: "Probably the finest maker of lantern clocks in London up to the Civil War".

The 'lantern' clock, which is a type of antique weight-driven clock shaped like a typical lantern of the period, was first produced in England around 1600 and continued to be popular until the late 18th century. The earliest examples from the early 1600s, such as this, are highly sought-after and admired as being from the 'first period', which was the term given to any that were made prior to the civil war. The clock is one of a group of only six surviving examples from Bowyer's earliest phase of clockmaking, making it extremely rare.

Highly decorative and well-finished, the clock's dial is finely engraved with a large chrysanthemum bloom over twin entwined stalks, set with a flowering foliage to the centre. It is signed by Bowyer and carries an estimate of £15,000-£20,000.

Clarke Bench Buffer/Polisher

This range from Clarke is ideal for buffing and polishing metal and composite surfaces to a bright lustrous finish. These units feature a robust cast iron base with rubber feet that reduce vibration. This range can also be bolted to a workbench to make it even easier to use.

The range consists of three models, CBB150, CBB200, and CBB250, the number is the approximate wheel diameter in mm. For added safety and ease of use, all three models feature a handy front-mounted on/off switch whilst it is also easy to fit and remove the polishing mops, allowing for



efficient working.

Both the CBB150 and CBB200 comes with 1x Stitched and 1x Open Style Polishing Mop to help get you started, whilst the CBB250 comes with 2 x Stitched.

These Clarke buffers are available from Machine Mart who also sell a range of Bench Grinders, and a Whetstone Sharpener, all of which can be viewed at www.machinemart.co.uk.

Readers' Tips



A Neater Tailstock Index

TIP OF
THE MONTH
WINNER!



This month's winner is Mike Hurley whose neat improvements to an old idea make it worth sharing.

Although my lathe tailstock has a zeroing dial calibrated in .05mm increments, I sometimes feel it a bit fiddly when just needing to roughly drill a hole to 'several mm' deep, and I can never find my 6" rule when needed!

So I resurrected an old unused manual vernier caliper, fitted it to a block of alloy bored to fit the barrel, clamping with a socket screw.

Superglued a simple brass indicator to the tailstock top and it works a treat, easily adjusted. Nothing particularly original or novel but does the job for me.



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 600 words and a picture or drawing. Don't forget to include your address! Every month we'll choose a winner for the Tip of the Month will win **£30 in gift vouchers from Chester Machine Tools. Visit www.chestherhobbystore.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.

Upgrading a Mill with a High Speed Spindle Part 1

When his shop made spindle reached the limit of its capabilities, Simon Davies decided to replace it with an off the shelf design, but this still demanded some accurate mounting arrangements.



My original water cooled HSS, wires and pipes dripping all over the place

I converted my BF20 mill to CNC some thirteen-plus years ago and I have upgraded it over the intervening years. In 2013 I designed and built a high speed spindle for it to allow the use of small carbide cutters which was serialised in Model Engineer during September and October 2013. This used modern brushless motors from the model boat and aircraft world combined with double row bearings and an ER11 collet system to permit milling speeds up to 12000rpm. A water-cooling system ensured that the unit remained within the temperature limits of the motors and magnets, although it added to the paraphernalia surrounding the unit. A key design criterion at the time was to align the HSS spindle with the main mill spindle axis, thus permitting the use of both the main motor and the HSS

without realignment. **Photograph 1** demonstrates the compact nature of this unit in use.

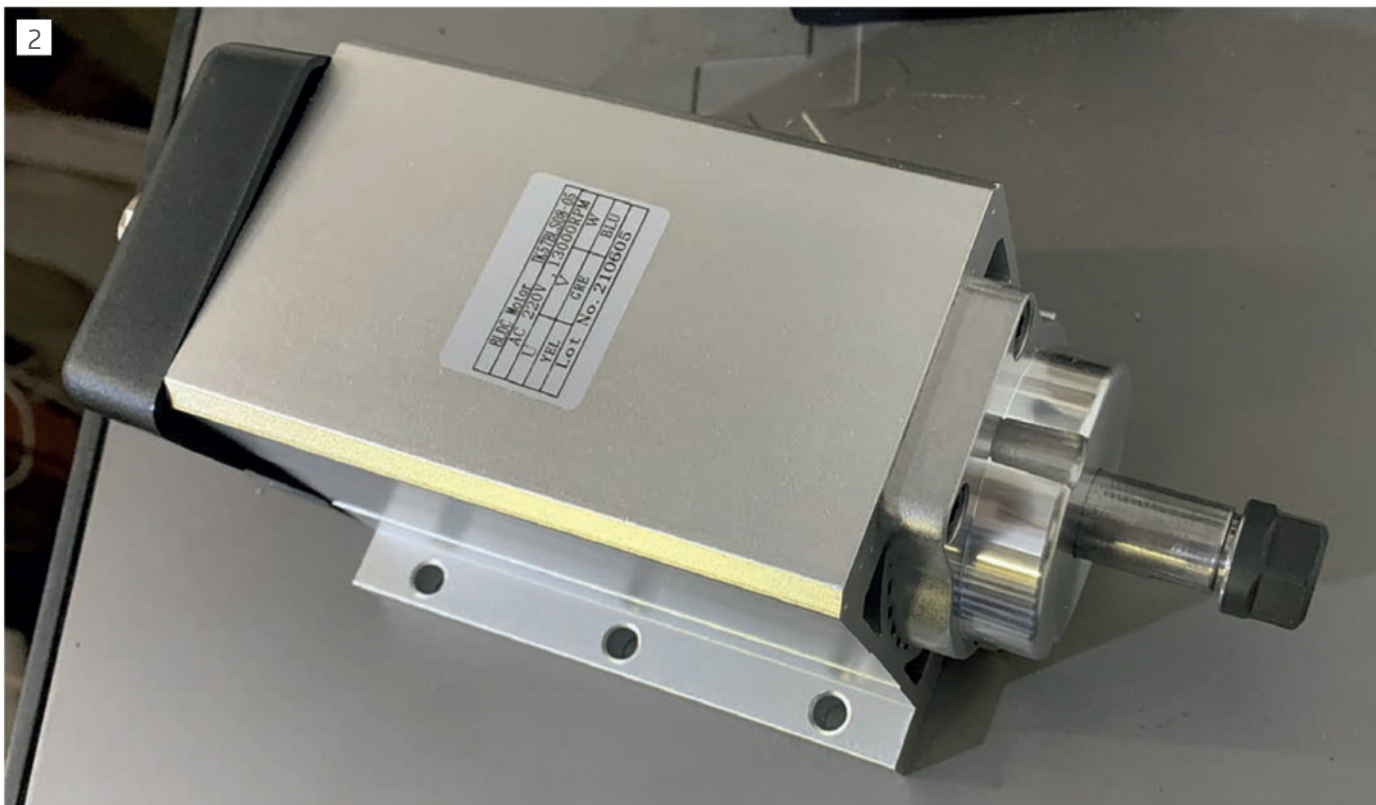
Over the years, several modifications have been applied to improve the motor drivers and eventually to replace the motor itself. This resulted in a more powerful unit being installed that had the capacity to run up to 20,000rpm, more advantageous for the sub 1mm carbide cutters I have used. However, the bearings, already well used, took some dislike to the elevated speeds (although actually specified to over 20k rpm) and the steadily increasing howl from the bearings encouraged me to look at the next step. Unfortunately, replacing the main double row bearing was “non-trivial” due to the original design of the unit, and left me wondering whether there were other

alternatives available. Eventually I found commercially available HSS units with drivers out of China which looked as if they could be used as replacements for my home-built unit, albeit with some degree of integration required.

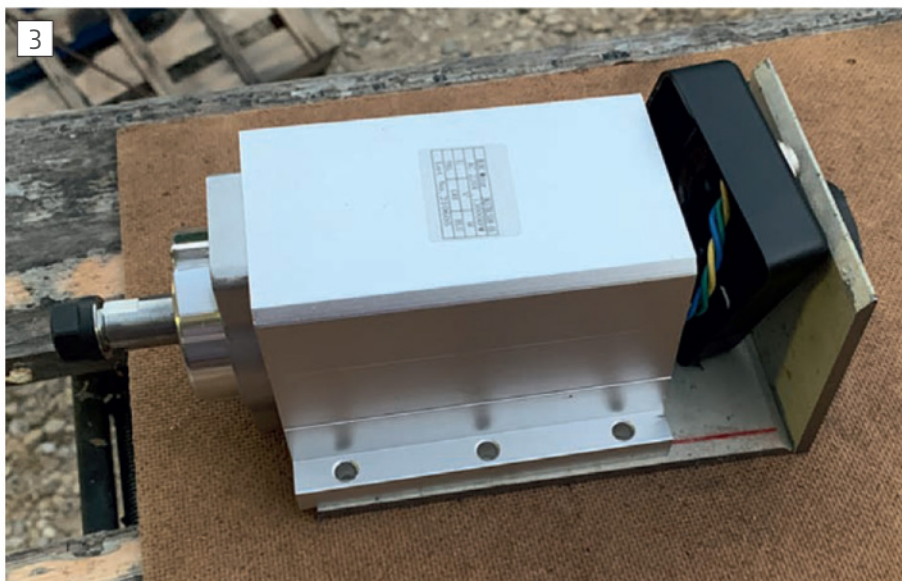
The following description is how I achieved this and includes drawings and other information to achieve a similar result on this or any other comparable mill.

Design Criteria

Several requirements were laid out before any effort was expended. My main requirement was to repeat the same setup from my home made HSS in that the spindle should be in the same axis as the main MT2 motor spindle. A rapid result was desired since I needed to carry out some work on brass



The new spindle as it arrived. The fixing bolt holes can be clearly seen.



Pieces of plate laid out to shown the angle concept

descending down to 0.8mm end mills and engraving cutters with 0.3mm tips, neither of which would be very happy with the standard 2,850 rpm maximum speed from the standard motor. Given the size of the cutters, overall alignment was considered to be critical and needed to be designed in as part of the manufacturing process.

The external spindle needed to have the minimum possible length so that it did not intrude too far into the Z

axis working area and hence limiting the height of the workpiece. Minimum spindle speed was chosen to be 10k rpm, ideally rather more if possible and needed to have speed control that could be integrated into my existing CNC controller.

Proposed Solution

Searching through various suppliers revealed a split into roughly three categories of add-on spindles:

- Sub 500W units that came without any dedicated controller and having speed control adjusted by voltage variation of the power supply. In general, these were circular cross section and designed to be mounted by glorified pipe clips. Most speed ratings seemed to be limited to a maximum of 10,000 rpm.
- 600W – 1.3kW units using brushless motor technology and coming complete with a separate controller allowing integration. Apart from a few at the upper end of the power spectrum, the vast majority of these units were air cooled. Some had a similar construction to the first category, but others came with rectangular section extrusions incorporating mounting holes.
- Upwards of 1.3kW units – these were discarded since I didn't need the power output and they were too bulky to comfortably fit the available space.

The choice boiled down to the first two categories and I eventually chose one of the rectangular section units rated at 600W, 12k rpm spindle speed and air cooled. As **photo 2** shows, this has six mounting bolts in two flanges running in line with the spindle axis, so the next challenge was to design a structure to



The existing mill spindle showing the reference outer face and the end face of the quill

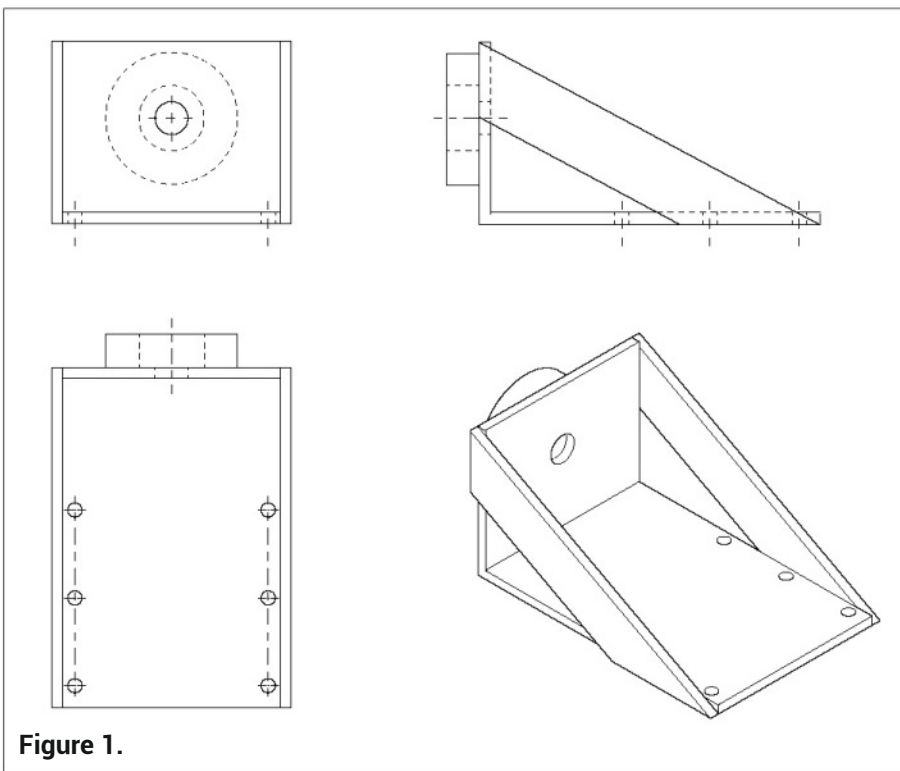


Figure 1.

attach the unit in line with the main spindle. This is best summarised as a glorified angle plate with the shorter face attached to the existing spindle assembly and the inner face of the longer side forming the mounting for the new spindle. **Photograph 3** shows the spindle and the angle bracket components in 'concept' form.

Alignment

I had three alignment requirements:

- That the new spindle should have no angular misalignment in the X direction
- That the new spindle should have no angular misalignment in the Y direction
- That there should be no misalignment from the zero position of the Z axis referenced to the main machine spindle.

The (exaggerated) drawings hopefully illustrate these requirements that ended up driving the construction sequence.

The first two requirements were solved by ensuring that a strict order was followed for machining to ensure that the relevant faces were at right angles or parallel to each other where necessary.

The last of these requirements was addressed using the existing mill assembly. My mill has a MT2 spindle with a draw-bolt running up the inside of the spindle for retaining the MT2 tooling. The spindle is ground externally with two spanner flats added but it offered enough ground shaft to use as the reference for alignment as shown in **photo 4**. The actual diameter is that well known dimension, 29.7mm, which required several re-measurements before I was convinced that it was truly the case. I decided against using the MT2 shaft because the new spindle plus bracket was going to be a substantial weight and it seemed unfair to apply that to a relatively flimsy MT2 shaft. Instead, I decided to use the outside of the shaft as the reference axis and to use the existing draw-bar to pull the new bracket assembly up to the face of the mill quill, thus applying the weight directly to the rather more substantial quill.

Design

My design for a mounting bracket is shown in **fig. 1**. The design ideology is that the construction is fit for purpose,



Ex-computer rack stabilising foot about to donate some plate

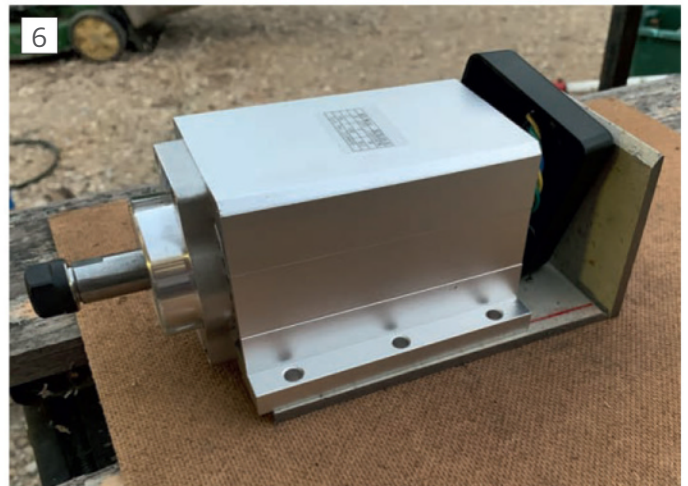
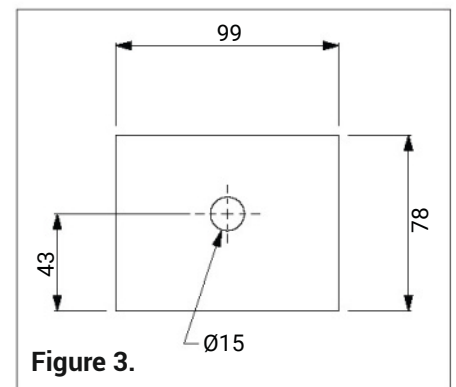
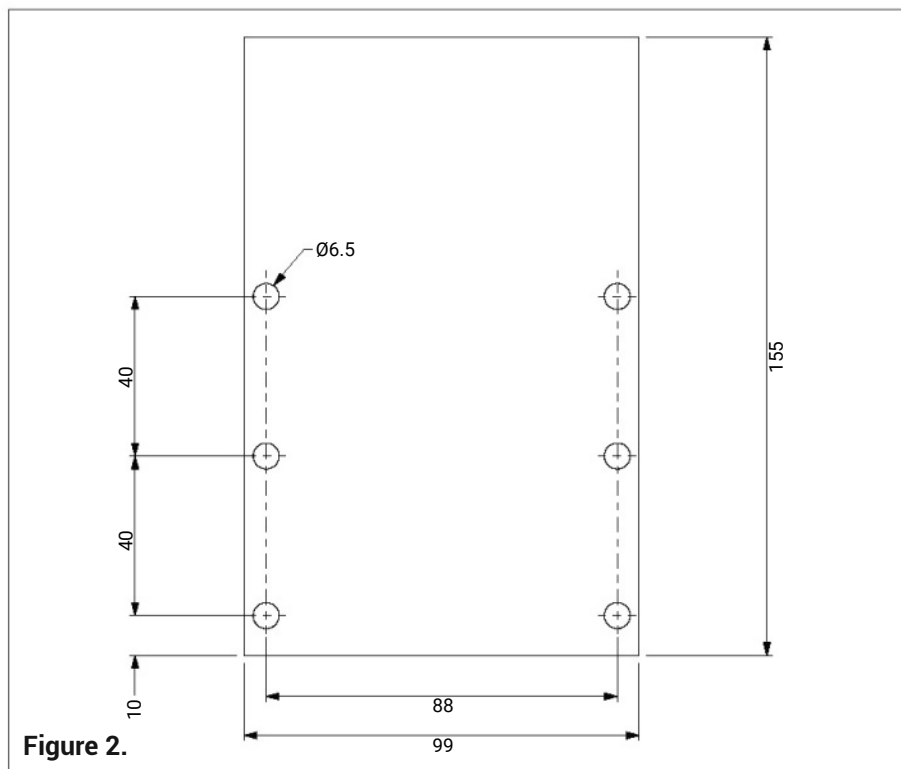


Plate cut and ready to be welded

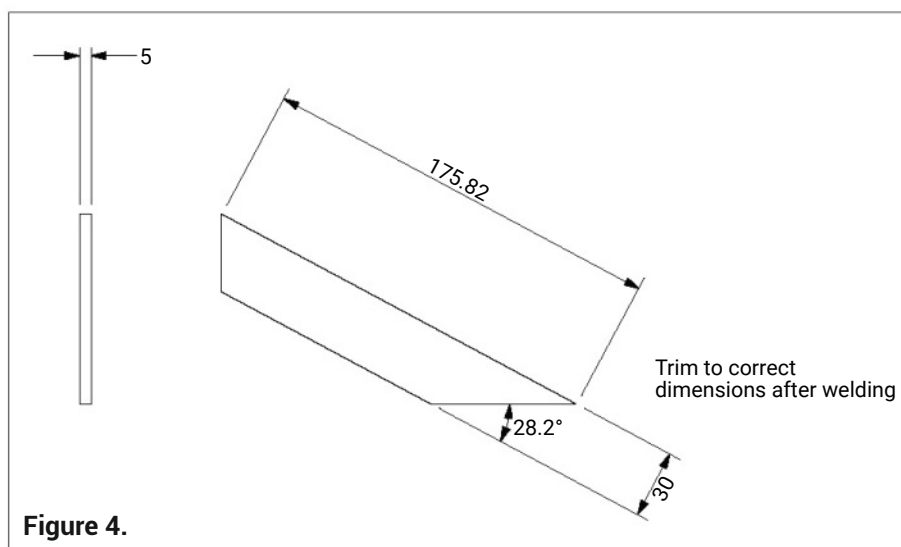


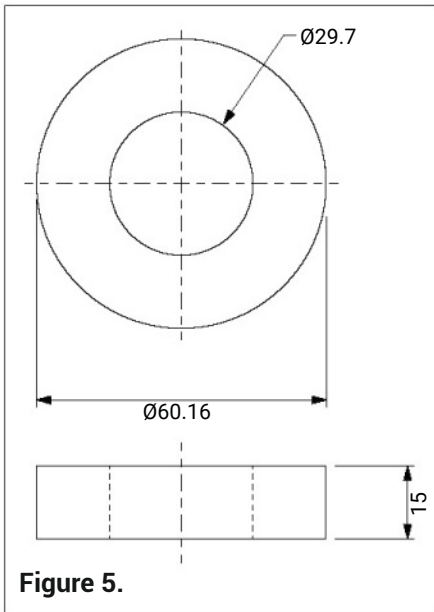
does not have unnecessary decoration or finishing and arrives at the finished object as swiftly as possible, without discarding required accuracy. Very much my understanding of the late John Stevenson's ethos!

Construction Sequence

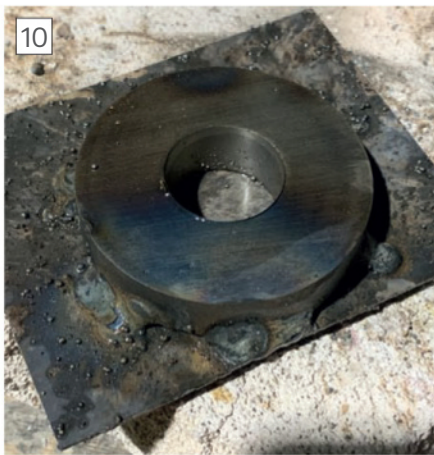
Looking for a swift conclusion to this exercise, I decided on a welded construction for the angle with welded stiffening where necessary. The final accuracy would be determined by the subsequent machining operations. Similarly, the ring that located the bracket axially would be welded into place and finish machined for accuracy.

The material source was some 5mm steel plate which started life as anti-topple plates intended for 19" computer racks **photo 5**. These were scavenged as surplus to requirements some 20 years ago and have been providing chunky bits of plate ever since. The sole disadvantage is that they have been coated with what I presume is an epoxy-based paint which resisted mechanical (means (angle grinder brushes and sanding disks), chemicals and even a





Cutting the annular ring the easy way



The results of MiG welding the annular ring to the end plate

blowtorch. Two pieces form the angle plate **photo 6, fig. 2** and **3**, and the bracing parts, **fig. 4**, were cut from

the same material. The location ring, **fig. 5**, was a piece of nondescript steel, 60mm in diameter with a hefty bevel machined to help welding **photo 7**. Any similar plate would be suitable, ensuring sufficient stiffness to the final structure.

Looking at the general assembly drawings the important relationships are those between the outer face and ring at the top of the bracket and the inner vertical face. Additionally, the six mounting holes will play their part as well. None of the other faces are important once construction has

finished. The following sequence was created to ensure that these relationships were met.

Welding

An annular ring was prepared from a suitable piece of steel and bored to about 5mm than the final required dimension of 29.7mm to fit the MT2 spindle outer dimension, **photos 8** and **9**. An approximate position for this was determined using the new spindle and it was welded into place on the top plate, **photo 10**. This assembly was





11
Returned to the lathe to make the ring face parallel to the face of the end plate



12
Initial setup for welding the end and main plates together using a magnetic clamp



13
Tack welding the first of the two side braces. The tack welds on the main to end plates can be seen as well

returned to the lathe in the 4 jaw and the top face machined to be parallel with the plate to reduce subsequent

machining with the result shown in **photo 11**.

The two pieces of plate were held



14
Final results of the welding. Not at all the prettiest welding and not improved by forgetting to use my can of anti-spatter at times. Penetration achieved however and I doubt it will fall apart in use!

using magnetic clamps at a measured 90° and tack welded on the inner face, **photo 12**. Once cooled, the angle was re-measured and corrected with the aid of a big hammer and vice as far as possible. The two side braces were then added and tacked into place and the relationship between the main plates re-measured to ensure nothing had moved **photo 13**. The braces were then fully welded followed by the inner face of the main plates, **photo 14** and **15**.



Side braces trimmed to size, ready for machining



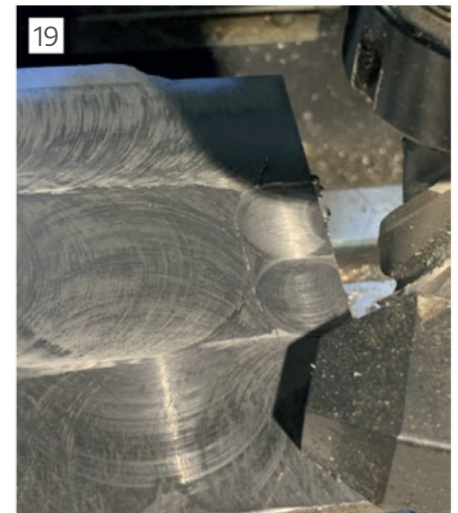
Clamping onto the annular ring, parallel and shims underneath the edge to get the reference face level with a pair of Stevenson's blocks at the other end which happened to be about the right height. Angle gauge was used for the measurement especially given the less than flat surface to work onto



Clamping at this end stretching the supply of my spacer blocks to the limit. The 'epoxy' or whatever coating can be clearly seen along with my careless hacksawing

Machining the reference plane on the back of the long edge

I decided that a reference plane was a necessary starting point both for measurement as well as ensuring a truly flat surface to lay onto the mill bed and other holding devices. The newly welded angle plate was inverted and held down onto the mill table, using one edge of the short plate and a set of spacers at the other end. Clamps were applied to the outer of the annular ring and the very end of the reference plane, **photos 16 and 17**. The plate was shimmed to a near horizontal position and then machined flat using a single point cutter in my boring head in lieu of a big fly cutter, **photo 18**. The unmachined area under the holding clamp was subsequently machined below the height of the rest of the plane, **photo 19**.



Milling out the area under the clamp below the reference surface



Fly cutting removes even the epoxy coating! One final cut to go to get rid of the hollow centre left



Milled surface ready for the new spindle. Note the milled reference surface on the side brace weld. Also note the continued presence of the epoxy coating on the end plate, even very close to the welded areas!



Milling the top edge reference plane, parallel with the main reference plane

Machining the inner face

The plate was inverted to lie on the reference plane, in line with the X axis using a set square on the unwelded outer edge of the bracket. The new spindle has two raised areas under the

bolt holes so the machining on this face only needed to match this area. The plate was skimmed with a large end mill to provide a final machined surface for the spindle. This machining was allowed to continue right up to the inner edges

of the welded braces as future reference surfaces, **photo 20**.

A reference edge was also machined into the top edge of the angle for future use, **photo 21**.

● To be continued

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**Coming up in issue 327
May 2023**

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Matt Shaw's Boxford headstock tool started as a depth stop but now has several uses.



Julian Palmer put an end to pools of wasted oil under his ML7 with an electrical auto oiler.



Roy Oxley wanted a new industrial standard drill for his workshop and went with a Clarke 12 Speed machine.

DON'T MISS THIS GREAT ISSUE-SEE PAGE 54-55 FOR OUR LATEST SUBSCRIPTION OFFER

BEGINNERS WORKSHOP

These articles by Geometer (Ian Bradley) were written about half a century ago. While they contain much good advice, they also contain references to things that may be out of date or describe practices or materials that we would not use today either because much better ways are available or for safety reasons. These articles are offered for their historic interest and because they may inspire more modern approaches as well as reminding us how our hobby was practiced in the past.

Beginner's Workshop

By GEOMETER

TESTING and FACING VALVES

DEPENDING ON EQUIPMENT available and, to some extent, on the condition of the valves themselves, there are various ways by which they can be tested and faced during decarbonising or overhaul of an engine-aspects of reconditioning not dealt with in previous articles.

The problem, of course, can be dodged completely by fitting new valves and, where the old are obviously bad or doubtful, this is the best way. Alternatively-a method which works well where valve stems and guides are in good condition-a spare set of valves can be kept, faced up between-whiles by a firm, to be ready to grind in on the next occasion.

Wear and wobble tests

Necessary or expedient as such methods may be, however, they cannot cover all cases, particularly those in which, for some reason or other, emphasis must be on individual resourcefulness.

Drawn from its guide, the appear-

ance of a valve stem reveals where it has rubbed. With a micrometer the extent of wear can be checked by reference to diameters where contact has not occurred. Diagram A X-XI, Y-YI shows a difference of 0.004 in. to 0.005 in. which is acceptable. Ordinarily, wear is reasonably general or round one side, though when a rocker is the means of operation, or a spring has been wrongly fitted-imparting side thrust-the wear may be as A, diagonal. When fairly considerable it can be felt with a finger or nail, or seen by using a caliper.

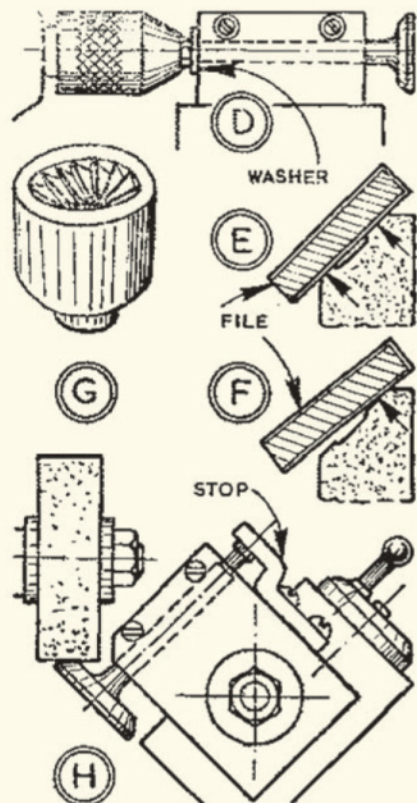
With the valve in its guide, a test for wear should be made with the face clear of the seating at approximately mid-lift, where play will be most noticeable. On a side-valve engine, the cam can be situated for the valve to be raised by the tappet and the head moved sideways, B.

Rotating the valve in its guide reveals wobble arising from bending close to the head, or eccentricity from incorrect machining-though it is necessary to distinguish this from the play occurring from slackness in the guide. If an indicator is available it can be fixed with its plunger touching the side of the valve head to show extent of wear and wobble. Laid in V-blocks C the stem of a valve is checked for bending, and with the head against a stop (a heavy block), the face is checked-both tests employing an indicator if available.

Methods of facing

On a valve facing machine, the stem is held in collets and the face rotated against that of a grinding wheel. On a lathe, the stem is gripped in the chuck and a single-point tool used on the angled top-slide. With a lathe, support is given by the tailstock centre-if that in the valve head is true. If not, a centred flat metal disc should be used on the tailstock centre, pressed to the valve head with a rubber disc interposed. This gives support and prevents vibration.

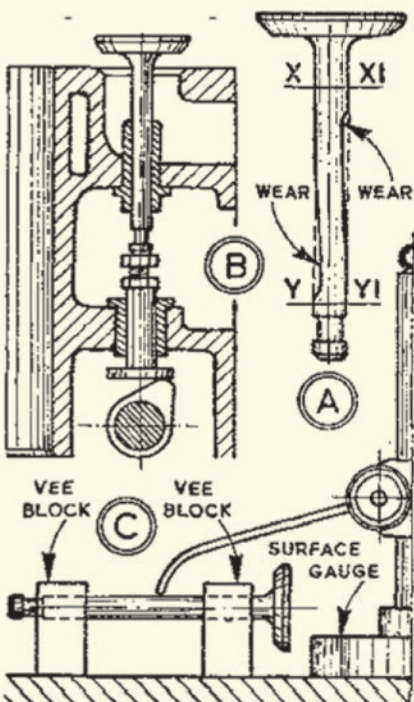
Using a lathe, or jig and medium speed drilling machine, preferably electric (with assistance), a valve face in reasonably good condition can be trued by filing, employing medium-cut and fine files, with firm slow



strokes, finally polishing the face with fine emery cloth on the file.

A block of light alloy or hardwood, drilled for the stem, split and provided with clamping screws, permits mounting in the vice D, a washer interposed for location. The file should be applied with flat contact E, not on one edge F. Bright marks reveal how contact is made and metal removed. A cutter G enables facing by hand. A guide locates the valve stem which is gripped in soft jaws in the vice, then the tool rotated. One tool covers a range of valve heads and interchangeable guides take stems of different diameter.

Fitting a stop to the jig D and mounting on the angled top-slide of a lathe, valves can be trued running a grinding wheel on a mandrel in the chuck, using the highest possible speed, putting on cut from the top-slide, and turning the valve with a screwdriver or pin tool H.



Sharpening Cutting Tools – Part 1



Having used his attachment to sharpen taps and dies, Jacques Maurel makes some further accessories for sharpening other types of tools.



It's possible to sharpen the conical part of **centring drills**, but this is of little interest due to the small wear and low cost of these tools nowadays. A suitable accessory for this task for the "Quorn" T&C grinder was described by Professor Chaddock.

Sharpening the conical part of counter sink drills.

This works very well provided the cutting edges don't go to the centre, the relief angle is small in this case (only 1° at the outside of the tool), **photo1**. The routine is the same as for sharpening taps.

Sharpening (or making) single lip engraving cutters

See **photo 2**. A special cam, **fig. 1**, is used as "rotation stop" for a simple rotation of the cutter against the grinding wheel plane. The dividing collar is in contact with the body for no axial movement.

Example: making a 90° engraving cutter, the clearance is usually 25° , **fig. 2**. The flat must be exactly at centre height, see **fig. 3**. This tool works also very well as spotting drill.

- 1 – Set the grinding wheel plane to the clearance angle.
- 2 – Set the special cam and one index on the dividing collar.
- 3 – Set the spindle in a horizontal plane and to the right taper angle.
- 4 – Tighten the collet, the tool flat must be horizontal when the

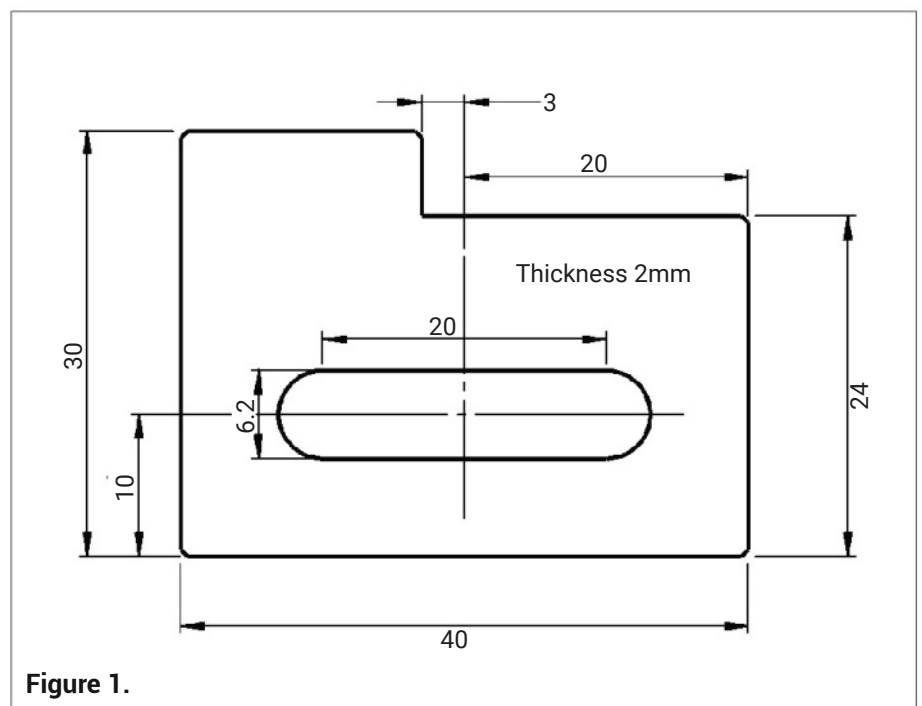
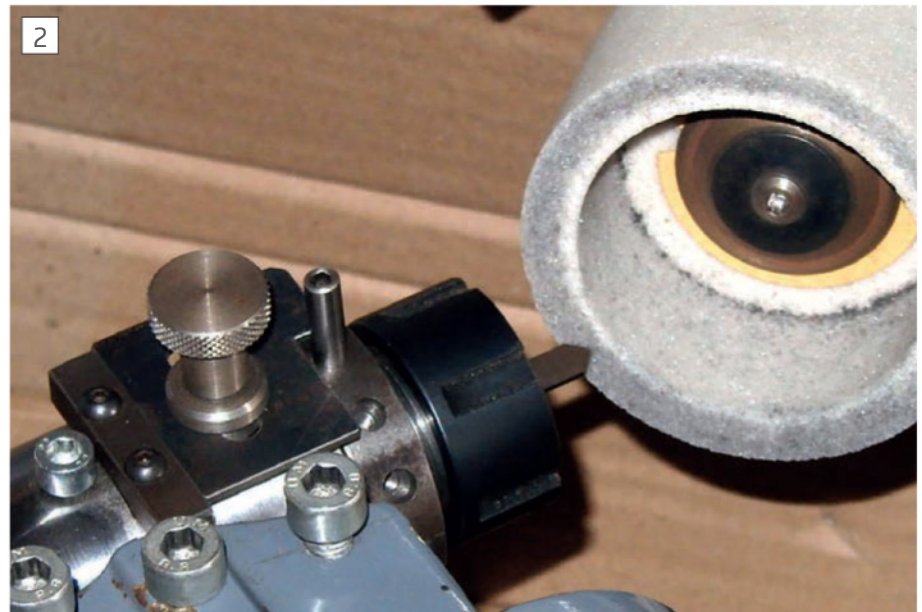
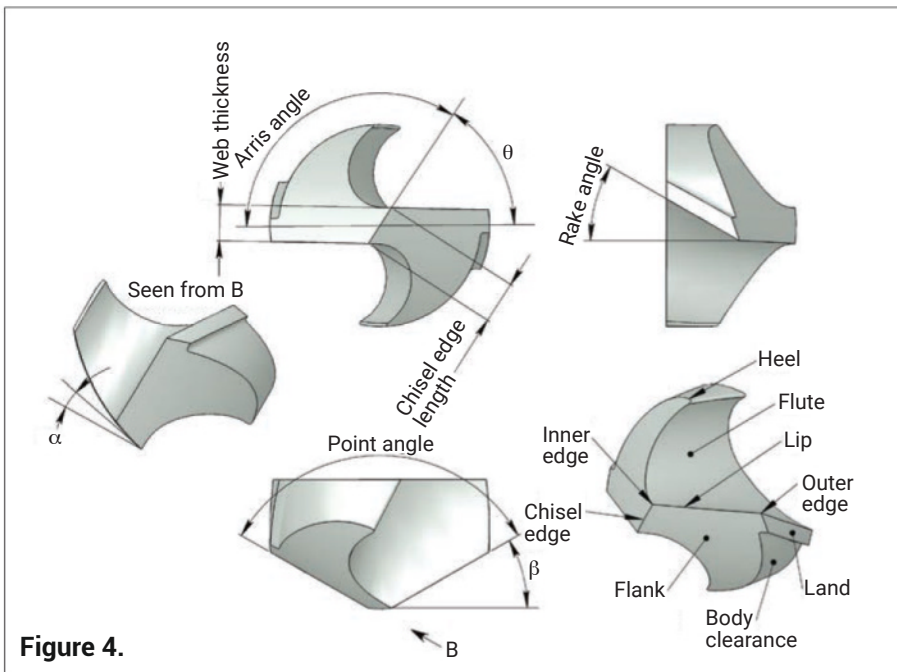
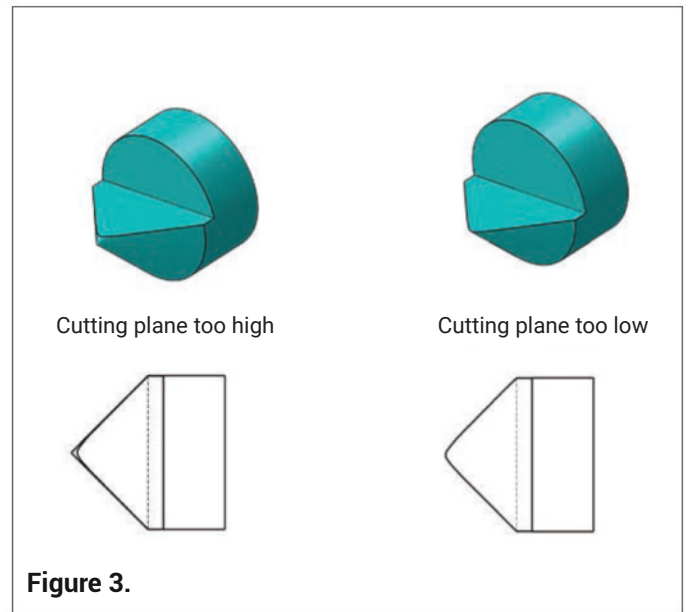
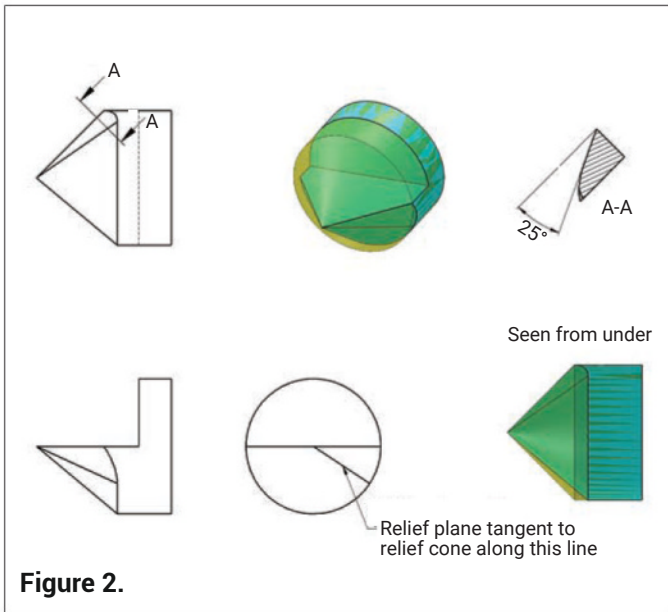


Figure 1.

index is stopped on the cam. A fine adjustment is possible by moving the cam sideways and locking with the knurled nut.

- 5 – Move the transverse movement to contact the grinding wheel plane, feed 0.02mm and turn the spindle for about one-half turn, turn back



to the stop, repeat this routine until sharpening is complete.

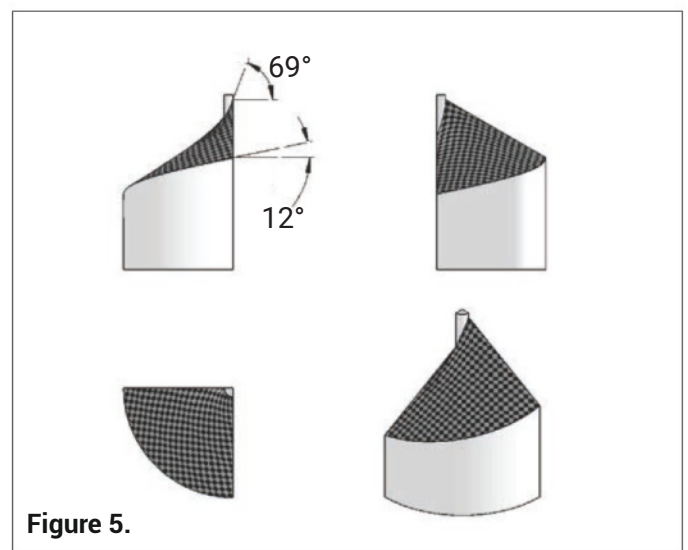
Sharpening drills

See **fig. 4** for drill point definition. It could be thought that a helical surface is ideal for drill sharpening, but it's not. Why?

Because this leads to a very long chisel edge, see **photo 3**, the helical movement was defined for 12° clearance at the outside diameter of the drill. The problem is when to stop the helical movement? It is about 50° here.

A true helical surface would give a near 90° clearance angle for a point near the axis! See **fig. 5**. On this drawing it can be seen that the helix angle is 12° for 25mm radius but 69° for a 4mm radius.

The actual ground surface is not of a true helical shape, it's the "envelope" of



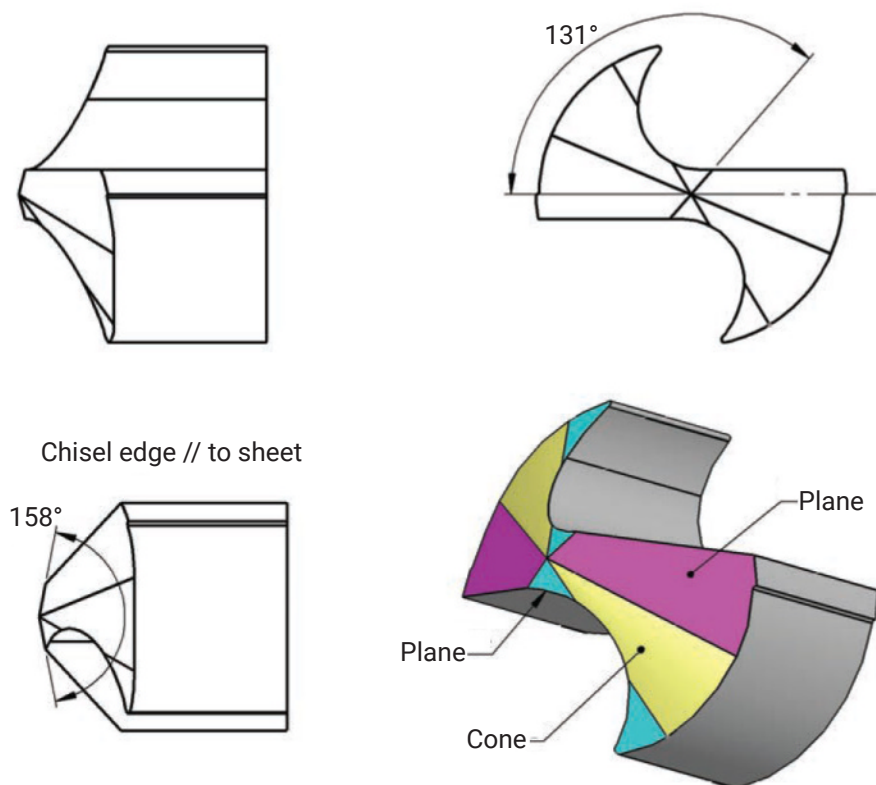
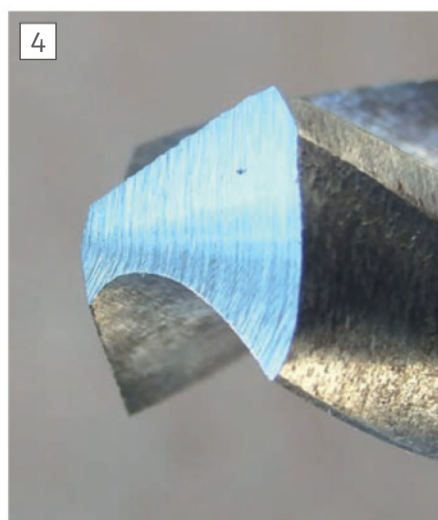


Figure 6.



the grinding wheel working surface (plane or cylinder or cone) during the helical grinding movement. And the problem occurs on the part of the drill beyond the drill axis due to the web thickness.

As we don't want a long chisel edge, we must use only a small drill rotation for sharpening, say 30° giving about 125° aris angle, but this is sufficient for removing the drill heel. Another inconvenience is that you'll have to adjust the cam for each drill diameter if you want to keep the same clearance angle.

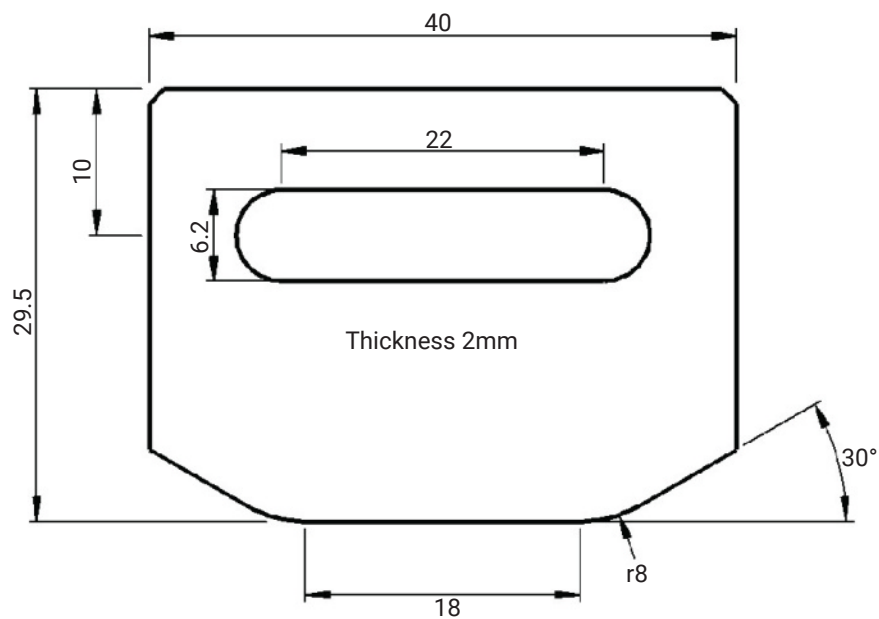


Figure 7.

In fact there is no need for a helical clearance, just use a plain rotation, like for the one lip milling cutter, **photo 4**, and **fig. 6** that shows the cad model: the purple part shows the 12° clearance plane, the yellow part shows the conical part for 36° drill rotation and the blue part the remaining plane. A special cam, **fig. 7**, giving only 36° angular throw, is used with 2 indexes set on the dividing collar. As you can see, there is a point end like for a four-facet sharpening, giving a "self-centring" property.

The great advantage of this method is that the tool indexing is automatically made while turning the attachment spindle.

Routine for drill sharpening

Please see **photo 5**.

- 1 Set the grinding wheel plane to the clearance angle (most often 12°).
- 2 Set the special cam (fig. 7) for drill sharpening (giving 36° angle throw) and 2 indexes on the dividing collar.
- 3 Set the spindle in a horizontal plane and to the right angle (most often for 120° point angle).
- 4 Tighten the collet, the drill cutting edges must be in a horizontal plane when one stem is contacting the

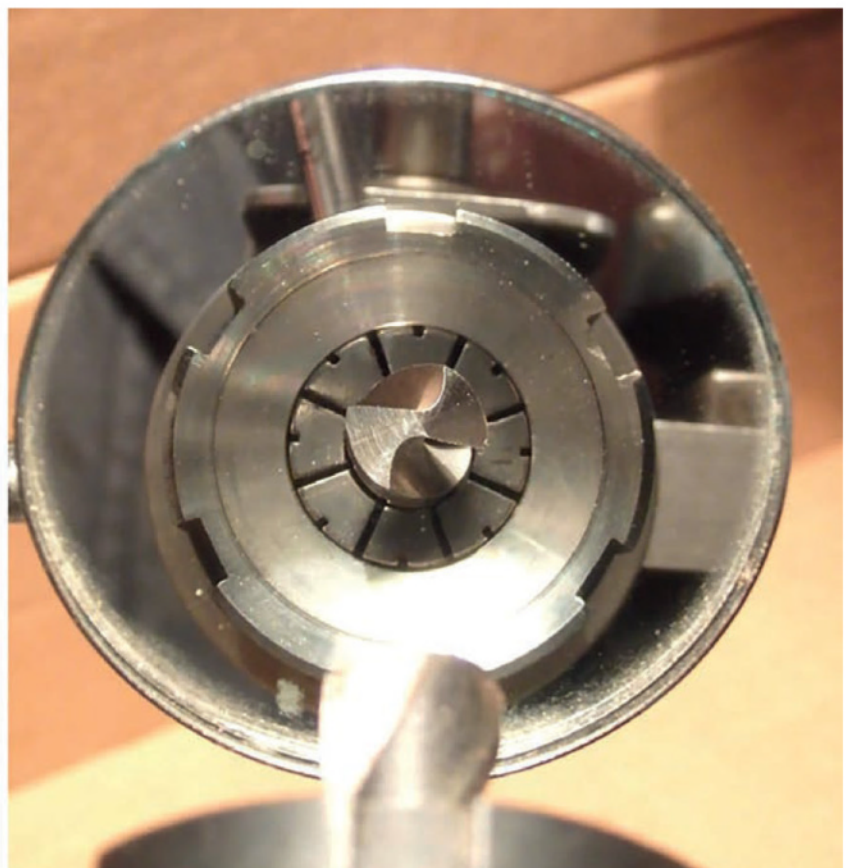


beginning part of the cam, a mirror is of great help (see **photo 6**) as you are behind the drill, it's also worth locking the spindle to ease this adjustment). Here also a fine adjustment is possible by moving the cam sideways and locking with

the nut.

- 5 Move the transverse movement to contact the grinding wheel plane, feed 0.02mm and give one turn to the spindle, repeat this routine until full sharpening.

● To be continued



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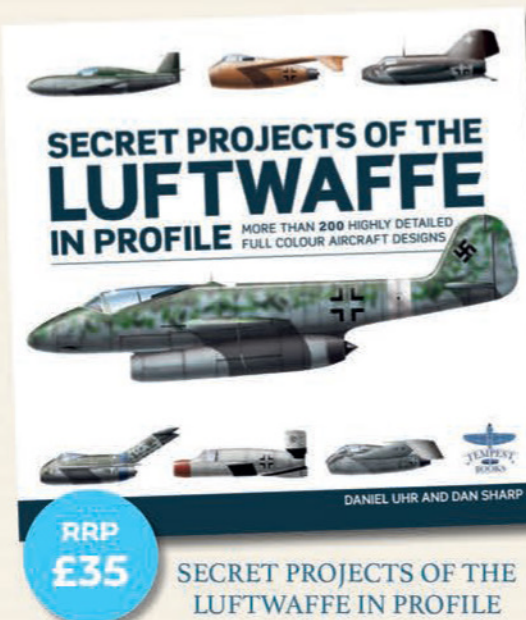
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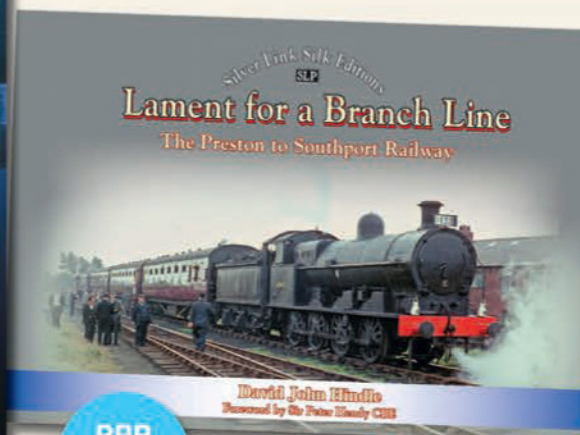
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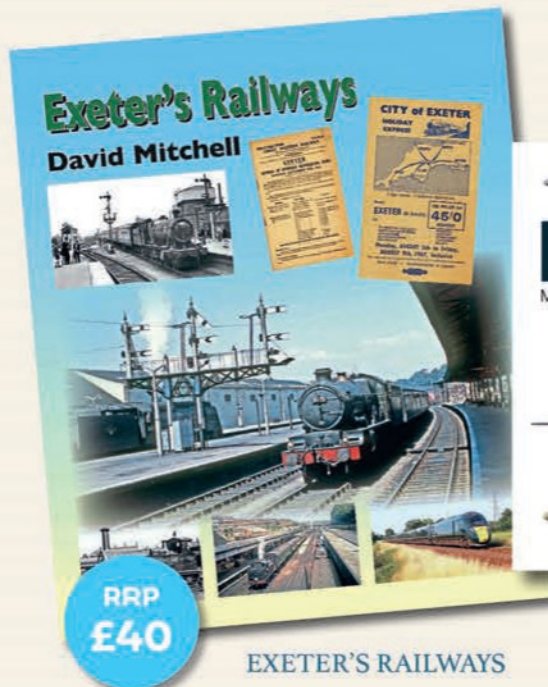
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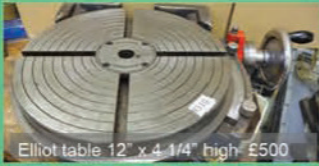
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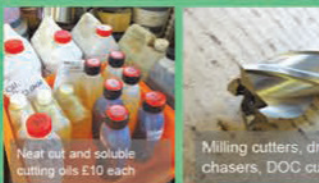
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AVAILABLE



Centec 2B milling machine + quill head and power feed table, nice!



Neat cut and soluble cutting oils £10 each

Milling cutters, drill bits, chasers, DOC cutters etc.



Colchester Bantam 2000 lathe (long bed) metric leadscrew, Dickson post £4950



Stanier precision vice 55mm jaw New / New Zealand £195



Myford SPEED 10 lathe + Transwave inverter, cabinet stand & tooling £2000



X-Y 12" x 6" table £525



Toggle press £145



Myford Super 7B lathe in lovely condition with power cross feed and tooling 240 volts
Free delivery UK mainland £4950



Harrison / Colchester change wheels



Transwave 4HP & 5.5HP Rotary converter £750 / £850



Meddings L1 MK.V drilling machine £2250



Emco 5 7/8" centre height lathe toolpost grinder £600



Creuson Morrisflex 240V 8" polisher buffer £825



Clarke 917 vacuum former £495



Myford 3/4HP 240V resilient mount motor configured to match a Dewhurst reversing switch already wired + instructions £226



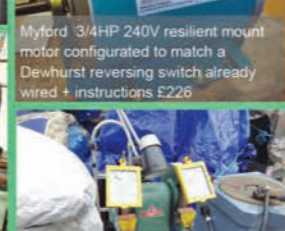
Trugrip collets metric £35 Imperial £30, Marico 2820 £15 each



Chester Cub 630 6" x 30" centres chucks, steadies hardly used £2950



Colchester Triumph 7 1/2" x 30" gap bed centre lathe, 2" spindle bore, 3 jaw chuck, 4 way tool post from university £2750



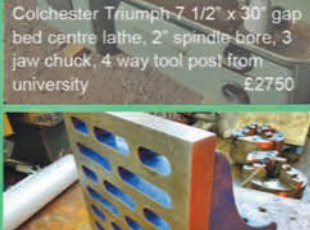
RJH Bison 10" pedestal grinder complete with light £450



Tripus 240v switch £90



Myford bridge & rifle felts £7.50 each



ANGLE PLATES, BOX CUBES, VICES, LATHE ACCESSORIES!



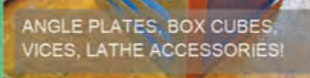
Myford gearbox unused £1000



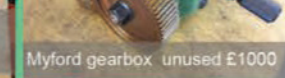
Chester mill, R8, powered table both ways like new! £4500



Crown Windley Brothers 6ft x 4ft cast iron surface table £1425



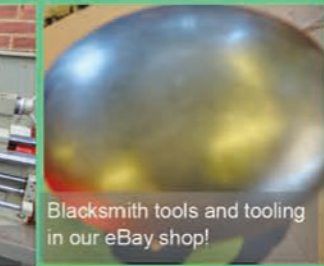
70KVA Perkins engine diesel Generator, silent run £3750



Books and manuals in our eBay shop from £6.00



Harrison M300 lathe £3950



Blacksmith tools and tooling in our eBay shop!

Please phone 0208 300 9070 to check availability.
Distance no problem - Definitely worth a visit - prices exclusive of VAT
Just a small selection of our current stock photographed!

Worldwide Shipping

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