No. 331

FERGUSON'S PARADOX DEMONSTRATOR

Using the Filengrène program to design modified gears

MODEL ENGINEERS' WORKSHOP

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Peter Barker moves his Myford onto a new bench.

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The next issue will be on sale 15 September 2023.

On the Editor's Bench

Back in the Workshop

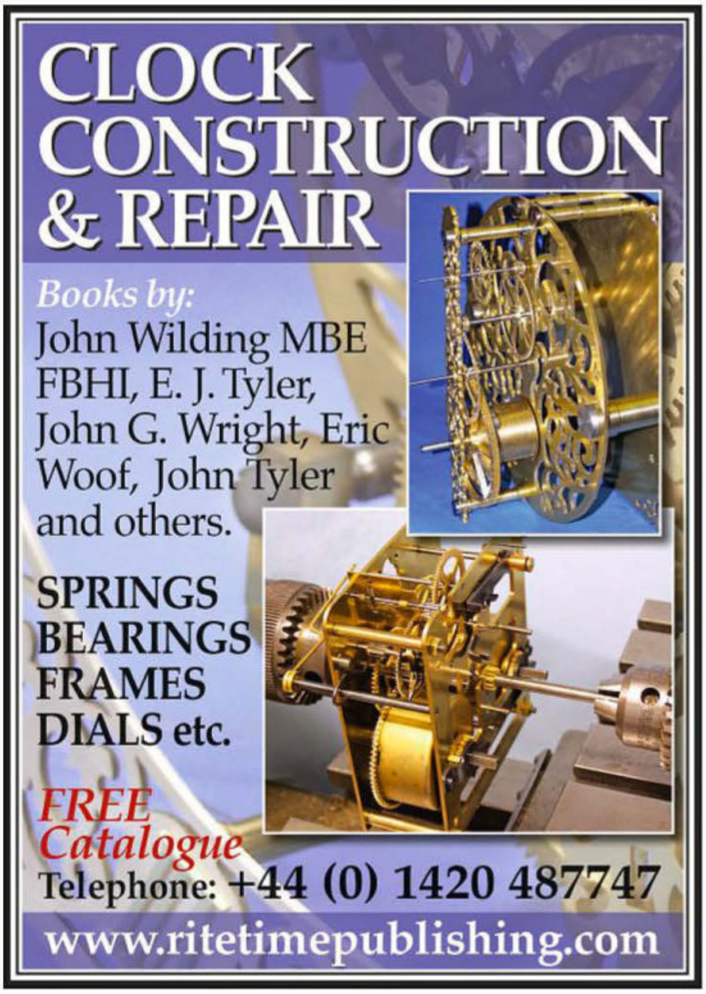
It seems like forever, but at last my workshop is fully functional (although it seems to be untidy already). Of course as soon as my lathes were properly set up, a friend called round with a 'little job'. In this case modifying the clamp washer of a chop saw for a skim off the spigot, so that it can fit 25mm bore saws instead of 1" ones; apparently the cost difference was nearly four times as much for the imperial ones!

Admittedly most of my recent workshop activity has involved 3D printing, however judging by the amount of workshop projects I see that use 3D printing along with other more traditional tools, it has become mainstream now.

I recently decided to 'upgrade' some old microphones by converting them to XLR sockets for balanced leads. Of course the irony is that even reasonable ones are ridiculously cheap these days, but I had three and two of them are usable quality, so I thought why not? A search for various types of XLR male connectors suitable for fitting at the end of a cylinder was not productive, but I found double ended male connectors that looked like they could do the job. After cutting the shells in half on the bandsaw and tidying it up, I was able to make suitable holes in the ends of the microphones, 'milling" a stepped recess with my trusty Dremel. The half-shells were glued in place with a high-viscosity superglue, and then it was just a case of rewiring them.

Incidentally, many microphones means many cables that can be hard to keep track of. A handy gadget I bought recently is a 'bluetooth label printer'. It is charged from USB and holds reels of thermal print labels, which it recognises using an RFID tag! As well as simple labels, I got a reel of ones specially for cables with a thinner tag to wrap around the cable, then a larger section that folds back to secure the tag. You design the labels on a free app on your phone, which can even generate QR codes. An ideal solution for keeping track of which plug is which machine in the workshop!

Neil Wyatt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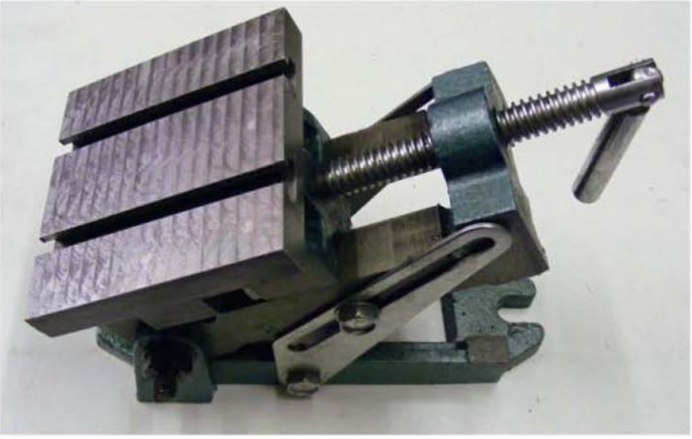
Coming up...

in our next issue

Michael Cox converts an angle vice into a tilting work table.



Regulars

ON THE COVER

Our cover shows Austin Hughe's adjustable bench grinder rest, that uses the cross slide from a Unimat lathe, see pages 14-18.

HOME FEATURES WORKSHOP EVENTS FORUMS ALBUMS

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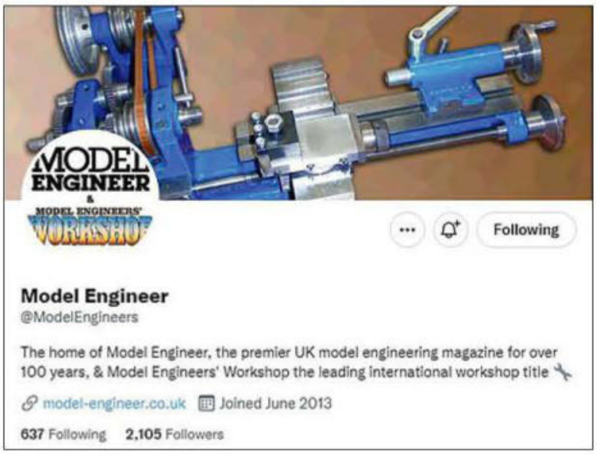

THIS MONTH'S BONUS CONTENT

Log On to The Website for Extra Content:

All the links in Jacques Maurel's article on gear design are to be found at:
www.model-engineer.co.uk/filengrene

Other hot topics on the forum include:

Why do modern car engines have different types of bolt type heads like Torx etc? IA good question, by Simon Robinson 4.

Damaged Screws & QCTP help!!! Extracting reluctant screws by Margaret Trelawny

Multiple Bearings in Spindle Thoughts on spindle design by Steve Crow.

High Speed Milling Tips, Tricks, Speeds and Bits by Iain Downs.

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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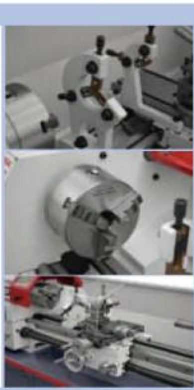

Cormak TYTAN 750 Universal Manual Lathe

The Cormak TYTAN 750 Vario lathe is a rigid, durable, accurate lathe for metalworking, equipped with a lead screw and a base as standard, multiple useful features, such as 250/750 mm turning, smooth spindle speed adjustment adjustable with a potentiometer, LCD displayed spindle speed, threading capability, bed and guides inductively hardened and ground, change gears, lead screw in a cover - in accordance with the newest safety and EC regulations.

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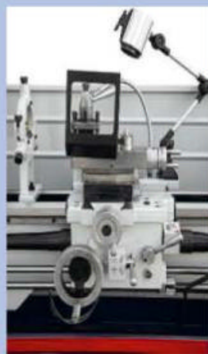
- the removable bridge enables the working of elements with an increased diameter
- retractable chip drawer and tool drawers for better and efficient work



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Manufacturer	Cormak	Manufacturer	Cormak
Model	**Tytan 750 Universal Lathe**	Model	**TORNADO 360 Universal Lathe**
Swing over bed	250mm	maximum turning diameter	360mm
Swing over cross slide	150mm	maximum turning diameter over the bed	220mm
Centre width	750mm	maximum turning diameter in the selected bridge	490mm
Bed width	135mm	maximum rolling length in the choice of the bridge	168mm
Spindle bore	26mm	turning length in fixed fishes	970mm
Spindle tip	MT4	bed width	187mm
Spindle speed (smooth adjustment)	50–2250 rpm	spindle end	D1-4
Metric thread	(18) 0.2–3.5 mm/rev	spindle bore	52mm
Inch thread	(21) 8–56 threads/inch	spindle rotation range	90-2000rpm
Longitudinal feed	0.07 -0.4mm/rev	spindle speed number	8 ranges
Tool holder	4-Way	range of longitudinal feed	0.055 - 1.291 mm / rev
Tool holder Dimensions	12 x 12mm	range of transverse feed	0.014-0.345 mm / rev
Maximum cross support travel	70 mm	the maximum dimension of the tool	16mm x 16mm
Maximum transverse support travel	110 mm	metric thread	0.4-7 mm
Maximum longitudinal support travel	650 mm	inch thread	4-60 TPI
Tailstock Quill Diameter	30 mm	pipe bush diameter	32mm
Tailstock spindle travel	60 mm	sleeve end of the horse	MT3
Tailstock quill taper	MT2	engine power	1.5Kw
Motor power	1.1kW / 230V	pump power	0.1Kw
Dimensions (with base)	1350×560×1250 mm	weight	570kg
Weight	205 kg	dimensions	1890x720x1500 mm

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A Rotary Table From Automotive Flywheels

Ken Lonie makes a large rotary table using an unusual source of material.

I am a retired engineer from the Sunshine Coast in Queensland, Australia. However, my experience has always been in management and design in the mining industry and I have only acquired a lathe and mill since retirement and enjoy metalwork and restoration of old cars.

After purchasing my Bridgeport mill, I also purchased a Vertex indexing head which I have used for cutting splines and gears etc. However, at one stage I used it to mill a semicircle on the mill. Disaster! I now know that the Vertex indexing head is really only for indexing and meant to be locked when actually machining. When rotating it while milling, I stripped the threads that the worm engages with. They are only really slots cut into the cast iron drum. Fortunately, I was able to pack the rotating drum up so that the worm meshed with an undamaged portion of the drum gear.

I realised a separate robust rotating table for milling any circular path, was needed. Any units I looked at on the internet were expensive, so I contemplated making my own. As I am into old cars and old flywheels and ring gears are readily available, I wondered if I could rotate one flywheel on top of another, possibly with a row of ball bearings separating them, and then rotate the top flywheel with a worm made to mesh in with the ring gear on the top flywheel. I could also fit the indexing plates from my Vertex to use it as an indexing head.

I obtained two old flywheels from 1950 English Rileys and one ring gear in reasonable condition. The most complex part of the project turned out to be calculation of the worm angles and pitch etc.

The Worm gear

The ring gear has an outside diameter of 13.25 inches and 104 teeth.

From Ivan Law's excellent book on Gears and Gear Cutting, diametral pitch is DP = (N+2)/OD, where OD is the outside diameter.

Hence the DP of the ring gear teeth is 8. I intend to make a worm that will be angled up at its helix angle to mesh with the ring gear.

Now the circular pitch is given by:

CP = PI/DP = 0.3927 inches.

The helix angle of the worm is given by:

Tan(Helix Angle) = CP/(PI*PCD)

Where PCD is pitch circle diameter of the worm.

For DP = 8, OD of the worm is given by:

W = PCD of the worm + 0.250 inches

(Assuming the same thread depth as for a spur gear) as shown on page 88 of Ivan Law's book.

Therefore:

Tan(Helix Angle) = CP/(PI*(W-0.250))

However, the circular pitch of the worm is less than that of the ring gear because of the helix angle of the worm. The circular pitch of the worm is equal to the circular pitch of the ring gear, divided by Cos(Helix Angle).

The adjusted Helix Angle is therefore given by:

Tan(Helix Angle) = 0.3927/(PI*(W-0.250)*Cos(Helix Angle))

This reduces to:

Sin(Helix Angle) = 0.3927/(PI*(W-0.250))

My lathe has a leadscrew of 8 tpi and therefore with the standard changewheel ratio of 1:1, (and with the quickchange gearbox set at 8tpi), the lead screw advances one eighth or 0.125 inches for every revolution of the mandrel.

From Ivan Law's book page 92, the required changewheel ratio for the lathe to cut the appropriate worm thread, is given by:

R = 0.125/(adjusted Circular Pitch)

R = 0.125*Cos(Helix Angle)/0.3927

These two equations can be solved to provide:

R = (0.125/0.3927)*Square Root((1+x)*(1-x))

Where:

x = 0.3927/(PI*(W-0.250))

We can now calculate R for various values of W until we end up with a practical value for the worm OD and an achievable changewheel ratio for the lathe.

We can then use:

Sin(Helix Angle) = 0.3927/(PI*(W-0.250)) to calculate the helix angle of the worm.

Practically, we need to end up with a worm OD of around one inch.

I ended up selecting a changewheel ratio of R = 0.312 and a worm OD of W = 0.881 inches. This results in a Helix Angle of 11.43 degrees so the worm will be tilted at 11.43 degrees to the plane of the flywheel.

The circular pitch of the worm is given by:

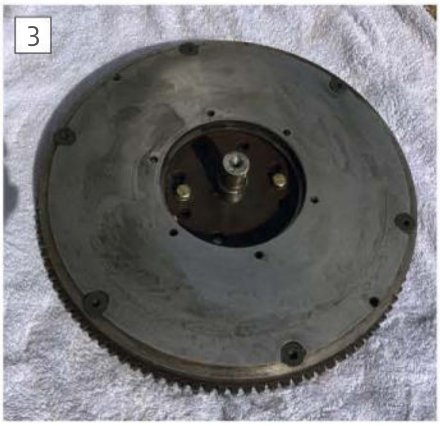
CP(adjusted) = 0.3927/Cos(Helix Angle) = 0.4006

This equates to a worm threads per inch of 1/CP(adjusted) = 2.496 tpi, Say 2.5 tpi.

Now using factoring as per Ivan Law's book page 90, 0.312 = (26*30)/(50*50) where the first two gears are the driven gears and the two 50 tooth gears are the drivers. This is also equal to (26*48)/(80*50). However, these gear combinations will not fit on the lathe with the existing banjo. I ended up using (26*96)/(80*50) and selecting 4 tpi on the quick-change gearbox. This results in the same overall ratio but enables a 96 tooth gear to be used instead of the 48 tooth and allows proper meshing of the changewheels within the adjustment of the banjo. The 50 tooth gear is the driving input gear which meshes with the 96 tooth gear which is jointly mounted on the banjo shaft with the 80 tooth gear. This in turn meshes with the 26 tooth gear on the driven output shaft.

To achieve this combination, two new changewheels had to be made, the 96 tooth and the 50 tooth. I already had a

Plate welded to centre shaft.



Shaft mounted to the table.

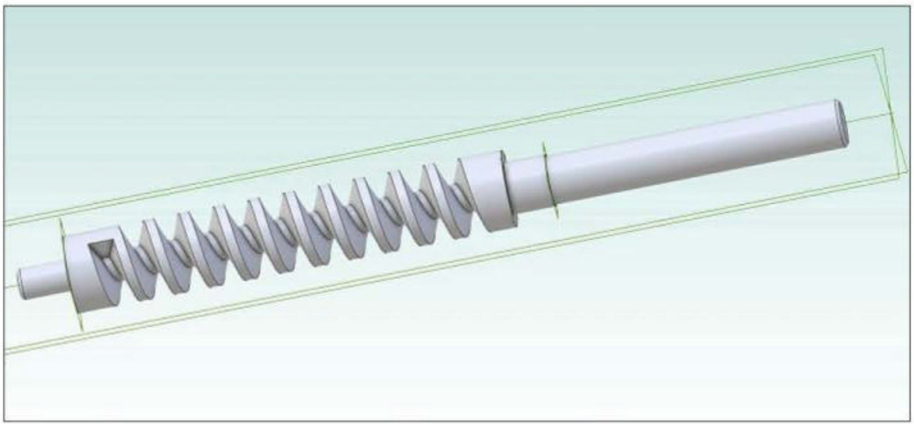


Figure 1

26 tooth and an 80 tooth changewheel.

After setting up a test piece in the lathe and lightly skimming the surface, the screw thread of 2.5 tpi was indeed achieved. So now the worm could be cut with an OD of 0.881 inches and 2.5 tpi with a thread depth of 0.270 inches. (thread depth = 2.157/DP = 0.270 from Ivan Law's book page 88). His book also shows on page 88, that the tool for cutting the worm needs to have straight sides angled at the pressure angle (20 degrees in this case) and should have a tool tip width of 0.091 inches for a 20 degree pressure angle.

The worm was then cut as shown, and mesh with the ring gear, at the helix angle, was checked.

Figure 1 shows the worm drawn in Alibre with seating for a small deep groove ball bearing on the bottom end and a larger one on the upper end.

Base and Rotating Table

The flywheel for the base was machined flat on the upper surface and a bronze bush bored out to 22 mm was pushed into the base as the locating bush for the upper rotating flywheel. See **Photo 1**, viewed from the underside.

An extension was also welded onto each side of the base to provide mounting points for the rotary table and to locate the worm housing. The worm housing hold down bolts were recessed into the base so that they did not foul when securing the rotary table.

There was a recess in the centre of the upper rotating flywheel, which needed to be filled in to provide a flat base for mounting components on the table. The 22 mm diameter centre shaft was machined up and some 6 mm plate welded onto the end, as shown in **photo**

Upper surface of table.

Mesh of worm and wheel.

Worm housing.

2. This was then machined into a circular disk and faced off in the lathe. The disk and shaft were mounted in the table and bolted in place with two bolts, as shown in **photo 3**.

Photograph 4 shows the rotating table from the top with the fill in disk fitted and a number of holes drilled and tapped in the table surface for the fitting of hold down clamps.

The end of the shaft was drilled and tapped to take a retaining screw which secures the top table to the base using a washer, once assembled.

Worm Housing

The next part of the exercise was to manufacture the worm housing and its end plate. The barrel was machined to 49 mm diameter and 190 mm long from 50 mm bar I had scrounged from an old trailer axle. It was bored out to suit the outside diameter of the bearings at each end of the worm shaft, with the top bearing being a larger outside diameter than the worm diameter, to allow for assembly. The top bearing was a press fit onto the worm shaft and the top bearing is located on a step in the bore of the housing so that the worm is located in the correct position in the housing.

The completed worm and its mating with the ring gear, prior to installation of both in the table is shown later in **photo 5**.

The top bearing is retained in the housing by the bearing end cap which is of such a length that it provides no axial float on the top bearing. The bottom bearing is free to float axially in its bore. Three countersunk screws in the end cap secure the end cap to the housing. **Photograph 6** shows the housing. The ›

Worm housing components

Completed rotary table.

base for the housing was welded to the housing at 11.43 degrees to the housing axis and the base machined flat after welding, as shown in photo 6. A slot was then cut in the housing by mounting the housing base on the mill and milling the slot at 11.43 degrees to the housing access. This slot allows the ring gear to mesh with the worm. Some filing was required at each end of the slot to allow free passage of the ring gear.

Assembly

The housing was then offered up to the assembled table and moved in and out of mesh until acceptable back lash was achieved. The assembly was then clamped and the locating holes drilled through into the housing, and tapped before bolting into position. Some shimming was required.

Photograph 7 shows the worm housing components prior to assembly and **photo 8** shows the completed assembly.

Figure 2 shows an Alibre exploded view of the rotary table and **fig 3**, an Alibre drawing of the completed assembly.

In practise, the table is a pleasure to use. It is probably heavier than I had anticipated and there is some backlash, which I think is due to me overcutting the worm (or due to some wear on the

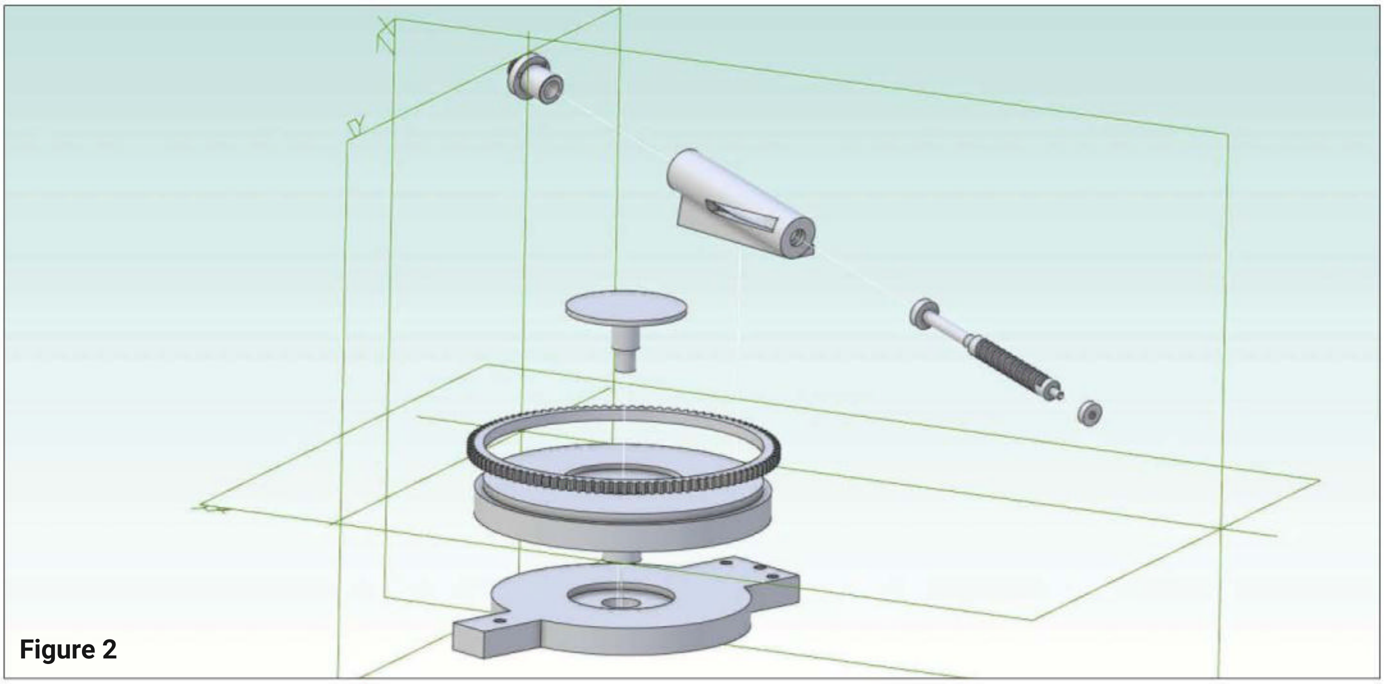


Figure 2

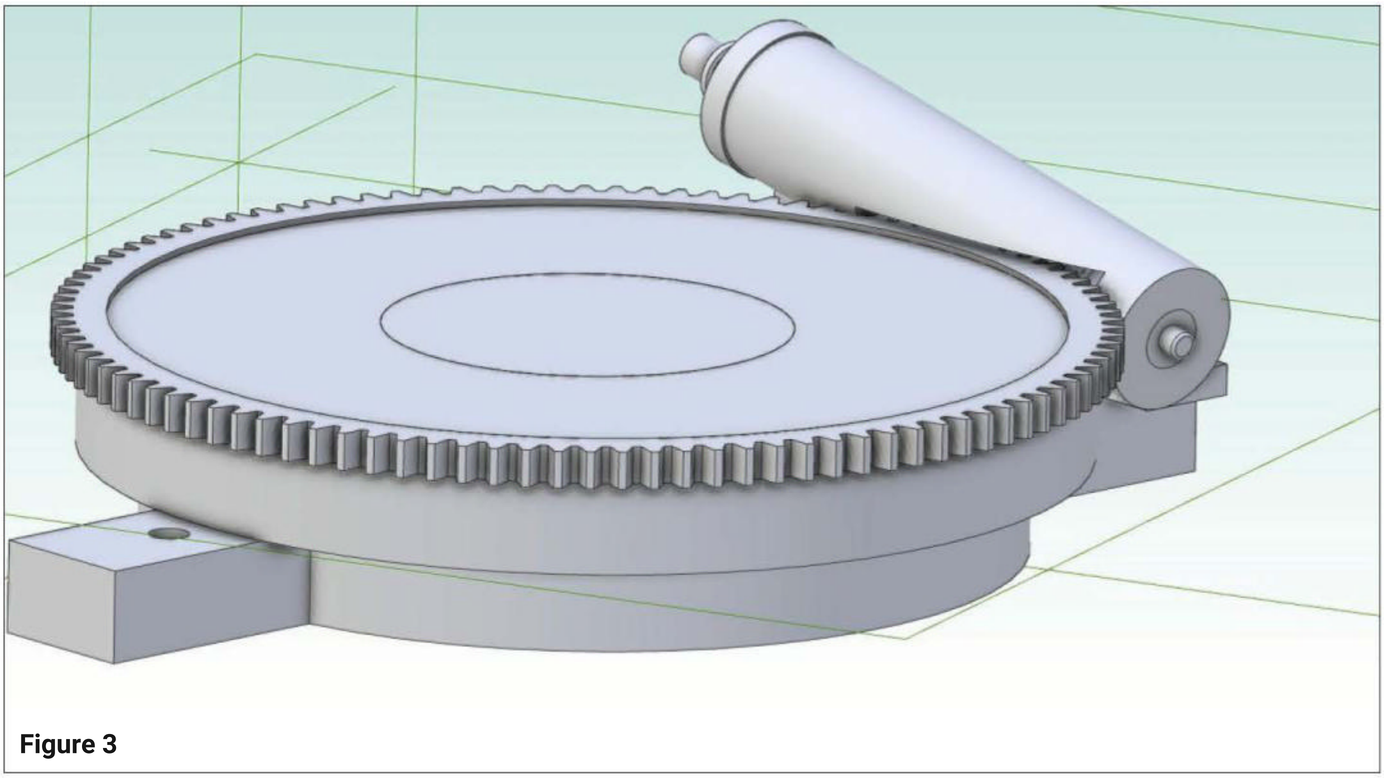


Figure 3

Figure 4

ring gear). When I have time, I might cut another worm but slightly oversize to see if I can reduce the backlash. Smearing of some grease on the rotating faces during assembly is all that is required for relatively easy operation. The ball bearing idea between the faces was not necessary.

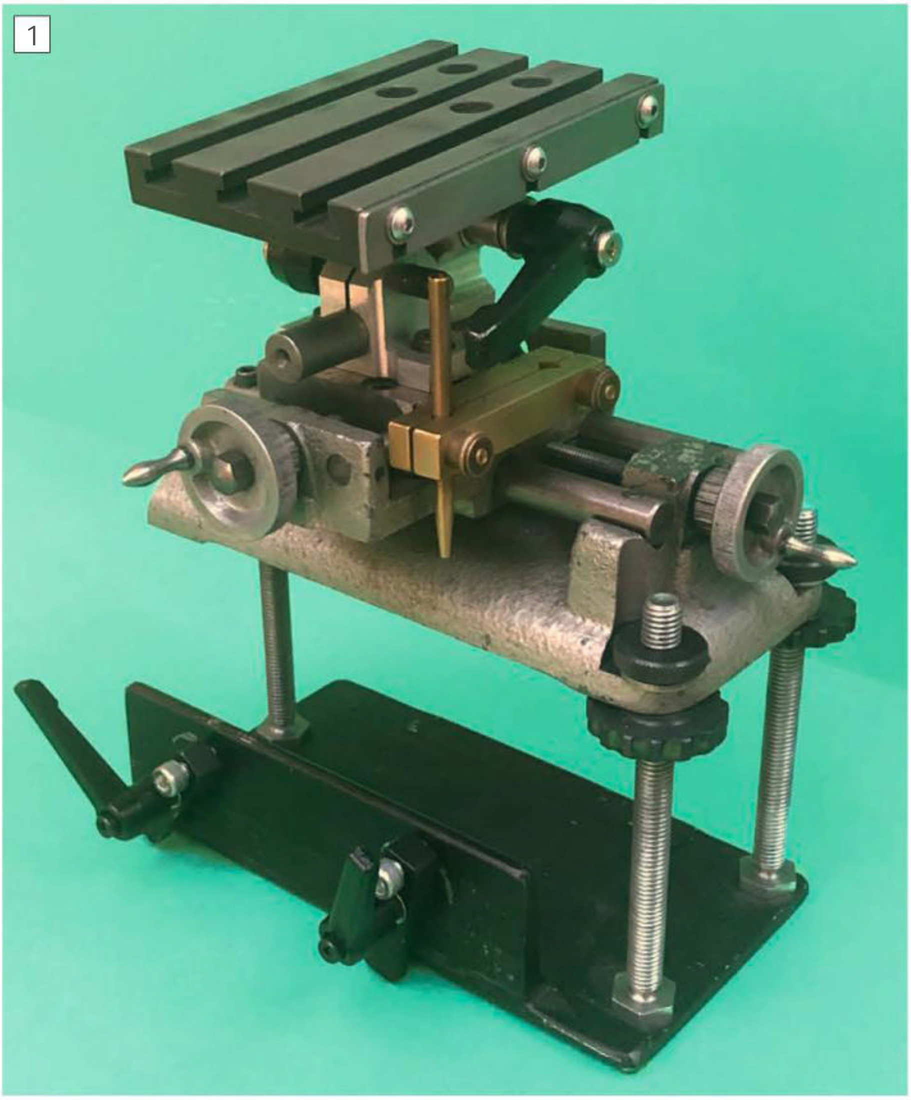
In the meantime, my next project is to make a sign for the outside of my shed. **Figure 4** shows the proposed sign layout.

Angle Setting for Bench Grinder

Austin Hughes explains how to easily achieve accurate angles, particularly for grinding lathe tools.

My bench grinder rest utilises the cross-slide from an early Unimat lathe, described in **MEW 231**. In addition to the fine screw feeds towards and across the wheel provided by the slide, it also has two perpendicular tilt axes, height adjustment, and it can be positioned in front of, or perpendicular to, the wheel, **photo 1**.

Like most home projects, it has continued to evolve. Major improvements include the use of indexable handles instead of fixed ones, and the fabrication of a new base to allow the table to be lowered further to accommodate bulky tools held in newly-acquired ER collets. The three M10 threaded pillars that support the table have been replaced with longer ones, and the original knurled aluminium adjusting nuts have been replaced with steel versions whose extra inertia allows them to be spun better, to speed up changes in table height. I was afraid that the three pillars might prove insufficiently rigid, but they are fine.


1

Improved Grinding Rest

Despite the rest having every conceivable adjustment, I never found it easy to set the grinding angle. Often, I would wonder whether the table had to be level; whether it or the edge of the tool should be on the centreline of the wheel; and how the curvature of the wheel came into it.

What finally spurred me on to sort out my problems was when I decided to attempt to sharpen end mills. In his excellent book 'Tool and Cutter Sharpening', Harold Hall describes sharpening the flutes as 'almost certainly the most demanding sharpening task to surface in the average home workshop', so it's hardly surprising that I am still working on that challenge. But before that, it was the much simpler task of sharpening end mill teeth that really prompted me to seek a straightforward method for setting the cutting angle. The result of my labours is shown in **photo 2**; it consists of some modest additions to the end shield of the grinding wheel, and despite its simplicity, it works very well.

Grinding angles

I had always believed that grinding should take place on or near the horizontal centreline of the wheel: after all, that is where the rest is provided on off-hand grinders, and texts dealing with adjustable grinding rests tend to imply that the table (or rather the tool being ground) should initially be along the centreline. Most books

Aligning the rest's table using Ruler and Sector Plate. (This photo also shows the perpendicular lengths of angle iron to which the base of the rest may be clamped so as to face either the edge or the face of the wheel.)

recommend a set of templates (one for each clearance angle, made from sheet material) to aid setting the angle, but I preferred to get by with the help of an old school protractor, albeit with only moderate success.

From time to time I had sharpened large awkwardly-shaped tools with the rest well above the centre line on the unguarded section of the wheel, with the table angled steeply downwards. This confirmed that there is nothing magical about grinding on the horizontal centreline: after all, how could the wheel know where on its exposed periphery the cutting was taking place?

It was uncertainties like these that prompted me to investigate what really matters. My findings are not new, but they formed the basis for an easy method of angle setting which I hope that others might find useful.

To keep things simple, the discussion will be limited to the job of creating a front clearance or relief angle on a rectangular tool, or the primary or secondary clearance of end mill teeth, as these both require the same approach. The angle of twenty degrees chosen for illustrative purposes is larger than usually required, but it makes the sketches easier to follow.

Figure 1 illustrates these methods. The first approach is shown by the upper row of sketches. The rest is shaded light grey and the tool bit is darker. We assume that we start, fig. 1(a), from a position where the table is horizontal, and its height is such that

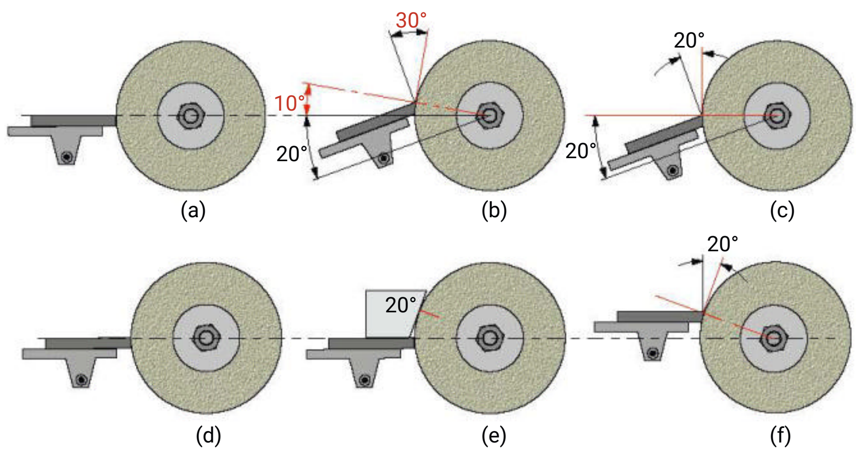


Figure 1. Angle setting methods

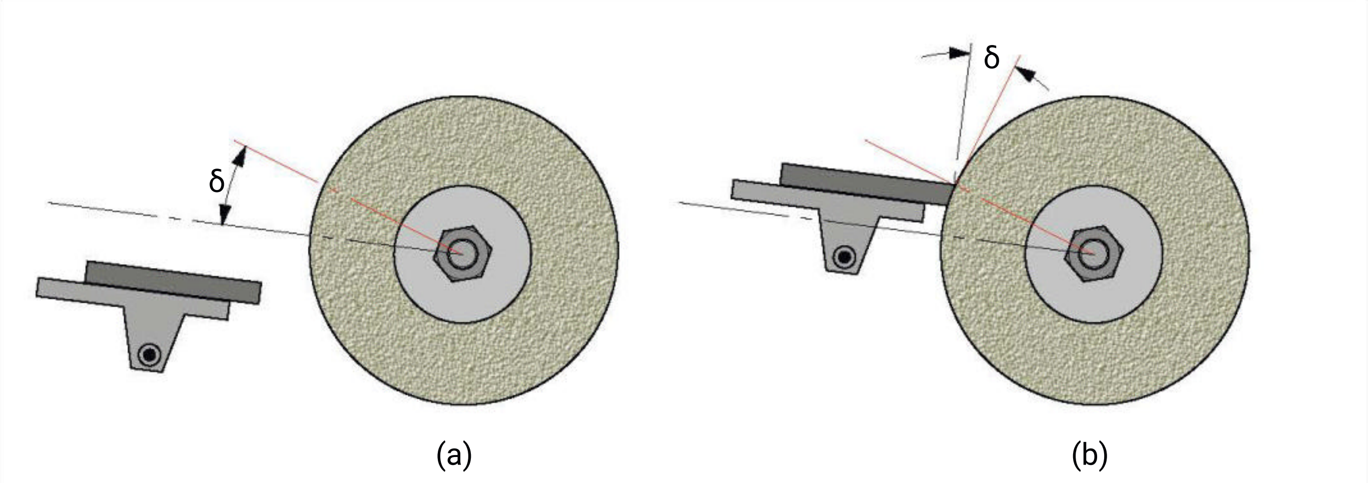


Figure 2. Two-line method for setting clearance angle

the tip of the tool is on the centreline of the wheel. This is a convenient reference point from which to begin our discussion, though not of any practical use as it gives no clearance at the tip.

It's perhaps worth mentioning here that it is the angle at the tip of the tool that determines how well it cuts, which is why we are focusing on the top edge of the lathe tool: the line of cut is tangential to the wheel at the contact point.

We are aiming for an angle of twenty degrees, so naturally we tilt the table upwards by that angle and move the table towards the wheel until contact is made, as shown in fig. 1(b).

Unfortunately, we can see from fig. 1(b) that because the tilting has raised the tip above the centreline, an additional component of angle is introduced: the larger the radius of the wheel, the less significant this effect becomes. With the particular proportions shown here the added height results in an increase of ten degrees, so we get a clearance angle of thirty degrees, not the twenty that we expected.

The extra ten degrees represents a 50% error in the final angle and is unlikely to be acceptable. But before we discuss what must be done, it should be acknowledged that in order to illustrate the principle, this example has deliberately chosen a larger than normal clearance angle: with a more likely angle of say five degrees, the 'error' will be much less.

By lowering the table and moving it to the left until the tip of the tool is again on the centreline of the wheel fig. 1(c), the correct angle is obtained.

The second approach is shown in the lower row of sketches, in which fig. 1(d) is the same as fig. 1(a). A twenty degree 'angle guide' as recommend in text books is placed on the table, and a mark (red in fig. 1(e)) is made on the wheel at the point where the guide is tangential to the wheel. Judging the true point at which the guide is tangential to the wheel is not always easy. The table is then raised and moved horizontally to bring the tip of the tool to the red mark, as shown in fig. 1(f).

When we compare figs 1(c) and 1(f), we see that if fig. 1(c) is rotated clockwise by twenty degrees, it becomes identical to fig. 1(f). And if either picture were to be rotated by any arbitrary angle, it would still represent an arrangement for grinding the clearance angle that we want. There is clearly nothing special about the horizontal, nor the position from which we start, so just what does matter, and is there an easier way of getting to it?

The essential requirements can best be seen by picturing two radial lines drawn from the centre of the wheel, and spaced apart by the desired clearance angle, δ. The absolute angular position of both lines is unimportant, but they must be separated by the angle δ.

To set the desired clearance angle (δ), the table must be parallel to one of the lines (the black one in **fig. 2**); this can be achieved either by adjusting the tilt of the table to be parallel to the line, or drawing the line so that it is parallel to the table, see fig. 2(a). Note that the initial position of the table is unimportant, so long as it is parallel to the black line.

The table must then be moved to bring the tip of the tool to the point where the second (red) line intersects the periphery of the wheel: grinding in this position will produce the correct clearance angle.

The essential conditions for achieving a specific angle are remarkably simple if we use the two radial lines approach. There is nothing special about the angle of the table (and it is not even necessary for it to be able to tilt), and the method is independent of the diameter of the wheel. The table must however be capable of vertical and horizontal adjustment.

At this stage, it would not surprise me if experienced MEW readers were thinking 'so what - that's obvious to me', and to them all I can say is that it certainly wasn't to me, but I'm glad to have joined the enlightened brethren!

Equally, there will be those that think it's all very well 'picturing two radial lines drawn from the centre of the wheel', but the lines are purely hypothetical, so how are we to make use of this in practice?

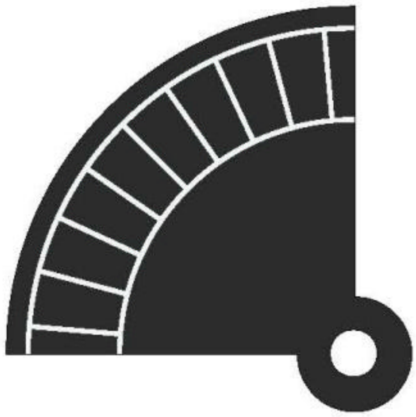


Figure 3. Sector plate

Theory into Practice – Arrangement of Setting Guides

At first I thought of putting lines on the wheel, but that would be of limited use because the lines need to project out as far as the rest in order to line up the table (or, more importantly, the tool). Instead, a set of lines are engraved on a sector plate, **fig. 3**), which in turn is mounted on a stub shaft fixed to the end cover of the grinding wheel, and co-axial with the wheel, **photo 2**.

The stub shaft is actually an M10 screw, and the plate is secured with a spring washer and nut tightened just sufficiently to allow the plate to be rotated with firm hand pressure, such that it remains wherever it is positioned.

The sector plate is made from 4mm acrylic, and the arrangement of nine lines defining eight sectors of 10° was arrived at after various trials on pieces of card. The lines were engraved with a spot drill, and filled with white paint.

The centre line bisects the plate, which spans 90° in total. My eyesight is still good enough to interpolate to a degree or so between adjacent lines at 10° intervals, Appendix). I found that more lines became too busy, and fewer made interpolation harder.

Next on the shaft come the guideline 'ruler(s)', made from transparent acrylic with an engraved centreline. They are secured with large, knurled nuts, and when setting is completed, they can be loosened to hang vertically out of harm's way. The rather clumsy looking addition on the right-hand side of the wheel guard (photo 2) is for setting the ruler horizontal: it was added when I realised that more often than not I chose to start with the table horizontal.

The table can set at any arbitrary angle, but assuming that the table is

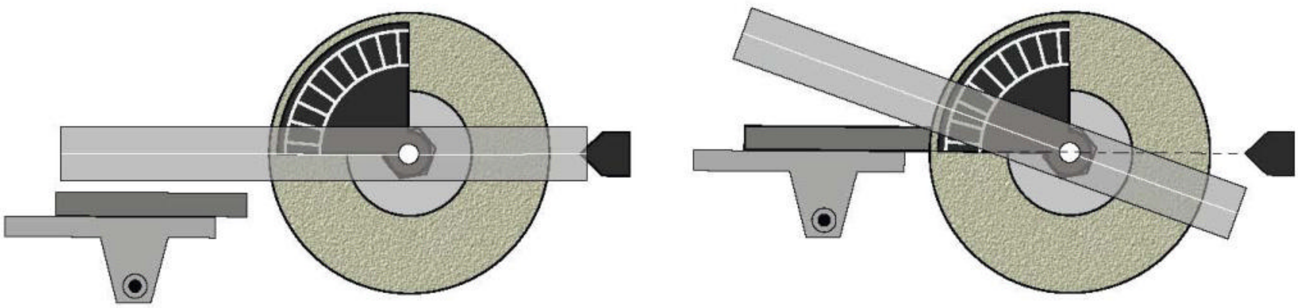


Figure 4. Stages in setting clearance angle

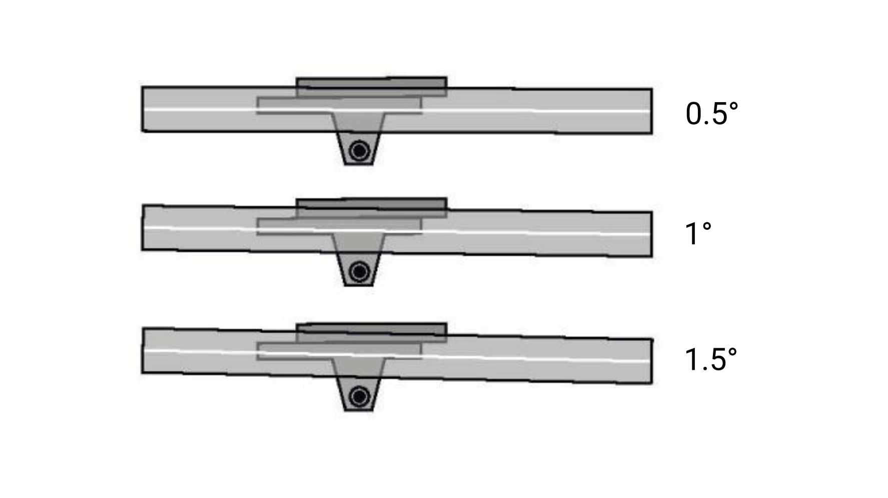


Figure 5. Degrees of misalignment

initially to be set to the horizontal, the procedure is as follows, see **fig. 4**.

1) Set the ruler horizontal with the aid of the guide on the right, and rotate the sector plate so that its bottom edge is horizontal, as shown in fig. 4(a).

2) Adjust the tilt of the table (or more importantly the tool bit) so that it is parallel to the ruler, fig. 4(a).

3) Rotate the ruler by the required clearance angle (in this case twenty degrees, as per the previous example), interpolating between the graduations on the sector plate, as shown in fig. 4(b).

4) Move the table vertically and horizontally until the tip of the tool touches the edge of the wheel at the point indicated by the ruler, fig. 4(b).

In most cases I find that only one ruler is needed, but occasionally a second one is useful, especially if the table is not horizontal.

Needless to say all this has to be done by eye and given the spacing between the wheel and rulers it is important to view the setup along the axis of the wheel in order to avoid errors due to parallax.

Sharpening end mill teeth is now a much quicker process. I use Harold Hall's method with a swivel base on the table designed to restrict grinding to the corner of the wheel, and I prefer to set up with the table slightly sloping downwards so that there is no tendency for the fixture holding the tools to slip off the table. Sharpening the side flutes – well, that's work still in progress...

Appendix

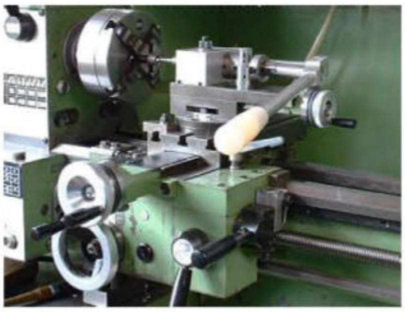
For those who might be interested, the three sketches in **fig. 5** show what it looks like when aligning the table and ruler by eye. It is not difficult to get within about a degree or so, which is sufficient for most purposes, and I'm sure that few would disagree with the view that a sharp tool with a slightly wrong angle is much better than a blunt one with a perfect angle. ∎

In our Next Issue

Coming up in issue 332, October 2023

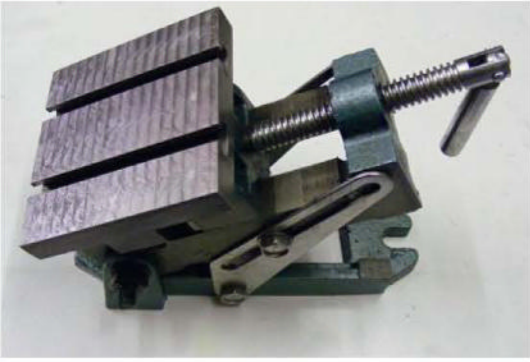
On sale 15 September 2023

Contents subject to change



Graham Meek 'squares the circle'.

Chris Hallaway shares his design for a compact dividing head.



Michael Cox converts a basic angle vice into a tilting mill table.

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

Rounding Things Off

Howard Lewis reviews his experiences of using the 'Repton' radius turning attachment.

Some time ago, a friend died and left me a small legacy. It seemed appropriate to spend the money on something connected with Model Engineering, so a Repton radius turning attachment was purchased, since it was bound to be needed at some future time. From time to time, it has.

The Repton radius turning attachment is shown in **photo 1.** The normally straight handle has been bent upwards to clear the locking handle on the front toolpost.

If a radius turning tool is to produce a truly spherical surface, whether convex or concave, it needs to be set so that it rotates about the centre line of the workpiece. I could not properly understand and get on with the instructions provided, to centre the tool on the workpiece. Sometimes, setting the tool by trial and error methods in both the vertical and horizontal planes can take longer than the actual turning, once the correct locations have been found.

As usual, one job spawns another, and so a centering attachment was needed to simplify making that setting. Consequently, a centring attachment was designed and made up, to use the centering aid normally used in a drill chuck on the Mill. Although this example relates to a Repton tool, maybe the design can be modified to suit other radius turning attachments.

The 'Repton' radius turning attachment

The centring attachment on the Repton.

Centring Tool

This replaces the tool holder in the main body of the device, and carries a commercially available centre indicating tool to centre the tool, on the workpiece, as can be seen in **photo 2.** The device is simply made, consisting of pieces of, in this case, aluminium, fixed together to replace the actual cutting tool and its holder, so that the radius turning attachment can be centred on the workpiece, and then the cross slide locked in position

The only parts requiring any sort of precision are the foot which replaces the holder for the cutting tool while the attachment is being centred on the workpiece. The foot needs to be a close fit in the groove through the base of the attachment, ensuring that when assembled, all the parts are at right angles to each other.

The hole in the bracket which carries the centre indicator is reamed to be on the centreline of the bracket, and a close fit on the stem of the centre indicator. In this instance, for purely cosmetic

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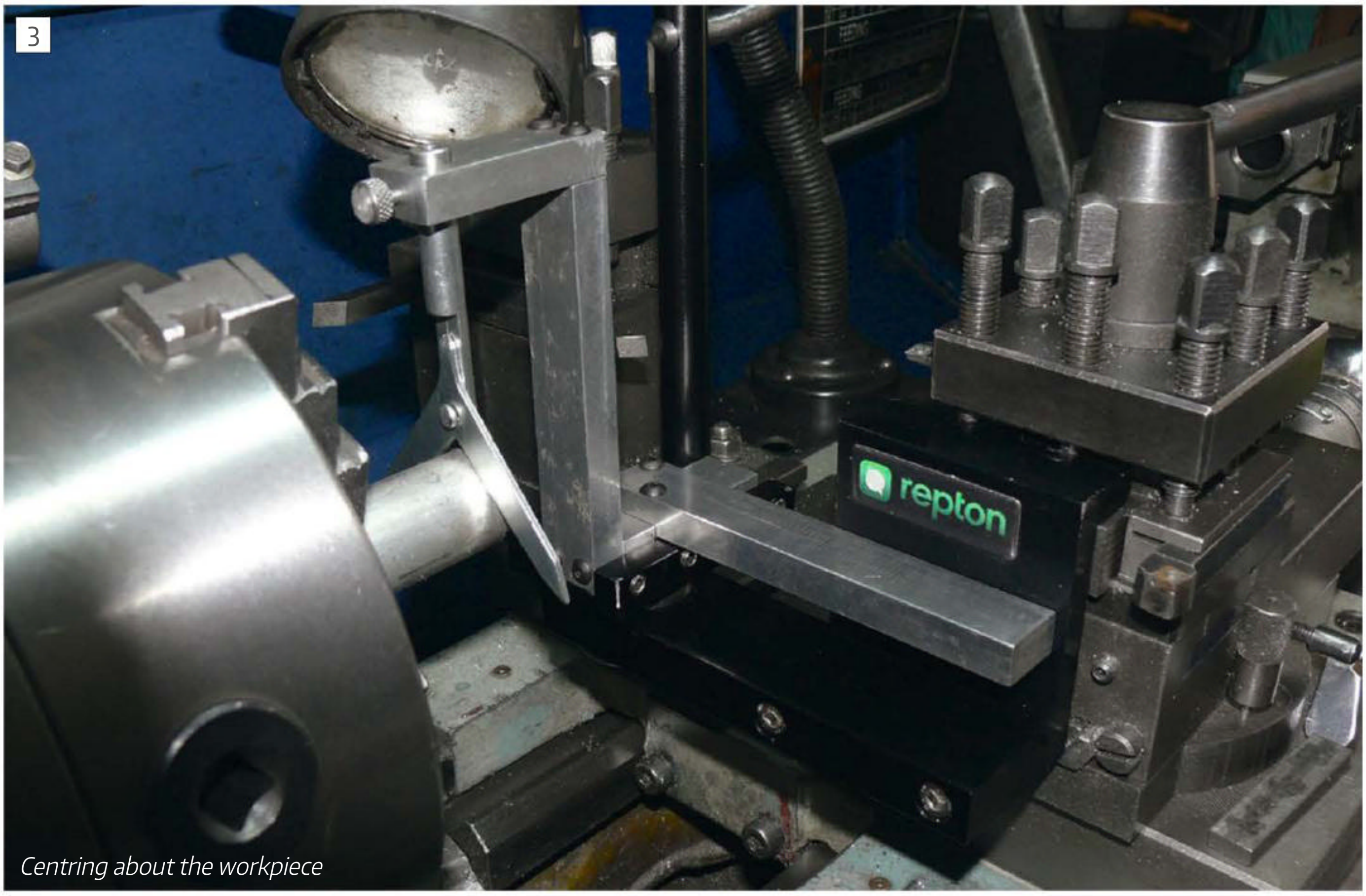
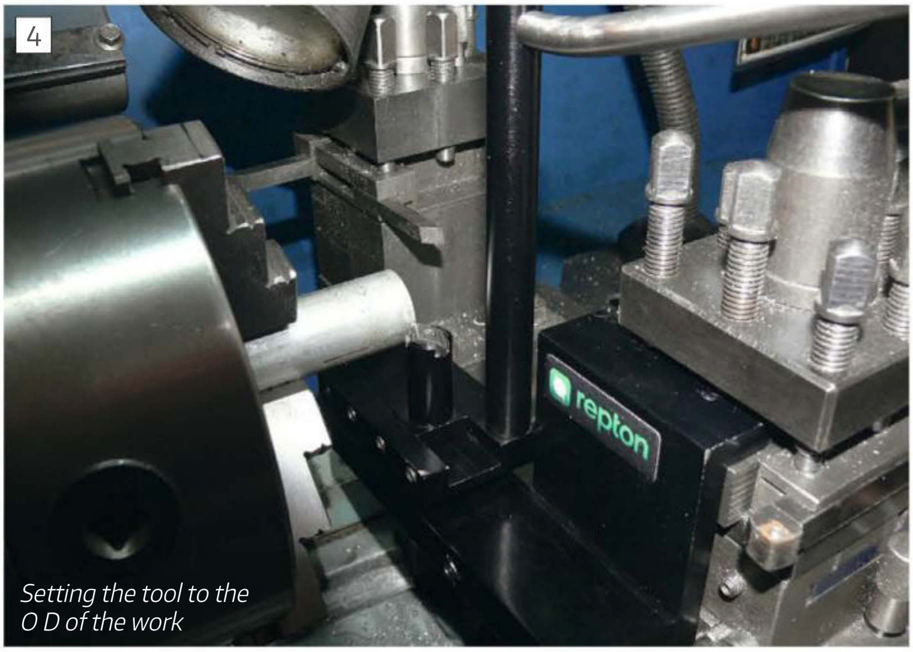


Centring about the workpiece



Setting the tool to the O D of the work

reasons, the parts are secured together with M4 button head screws, but there is no reason why ordinary capscrews cannot be used.

The horizontal bar is deliberately made long, so that it can rest against the body of the attachment to ensure that the tool holder carrier is at right angles to the axis of the lathe.

The cross slide and saddle are moved to bring the centre indicator over the material in the chuck. The cross slide is then adjusted, with the horizontal bar held against the body of the attachment, until the indicator shows that the radius turning attachment is on the centreline of the workpiece. The attachment being centred on the workpiece is shown in **photo 3.** The cross slide is then locked in place, and must remain undisturbed while the tool is used.

Description

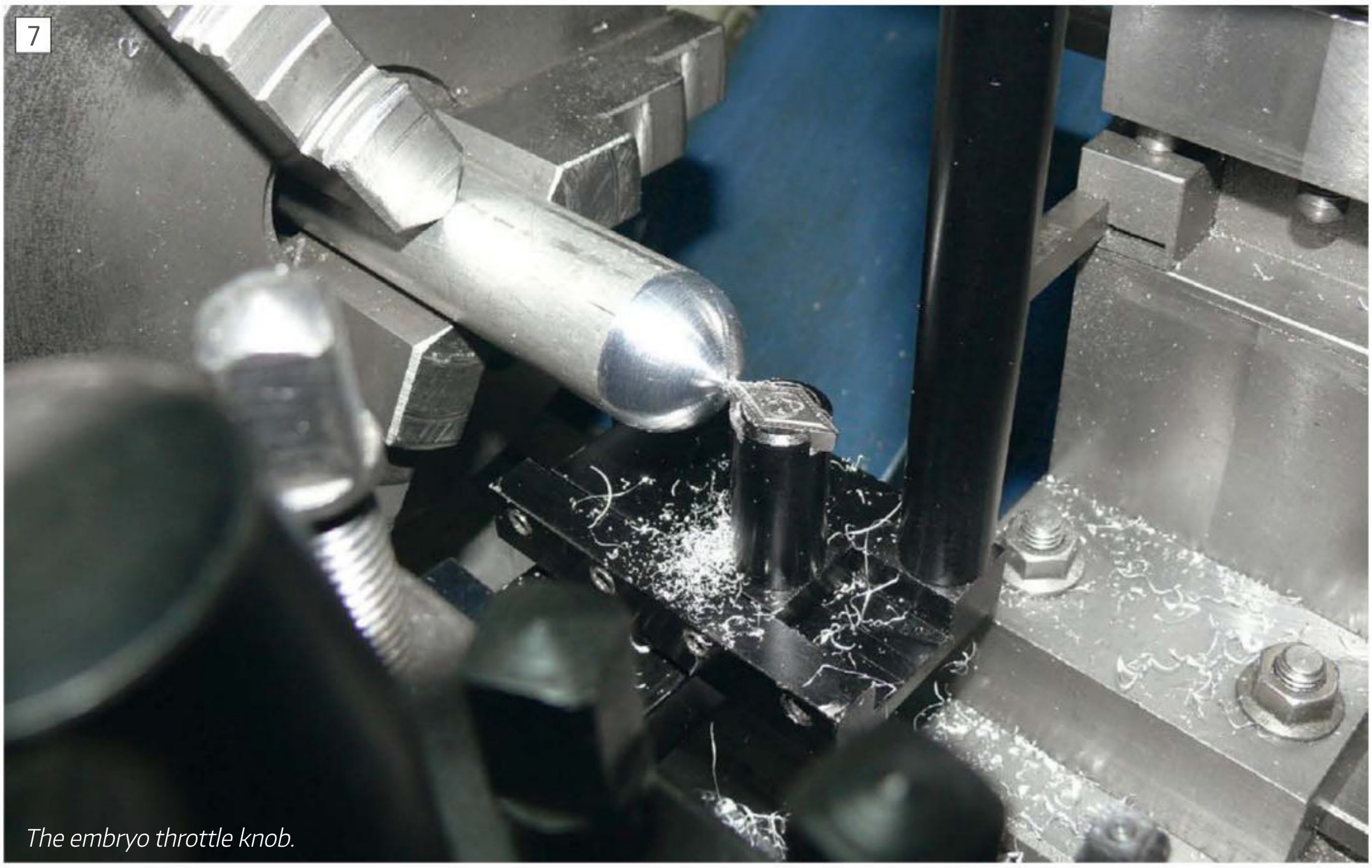
To prepare to turn a radius, the centering device is removed from the body, and replaced by the tool holder, very lightly clamped into place and the saddle moved to allow the tool to be set against the OD of the workpiece. The saddle is moved away from the chuck so that the tip of the tool just touches the corner of the workpiece when the handle is used to rotate the tool about its pivot. The top slide should be set as if for turning parallel to the lathe axis.

The handle is used to rotate the tool to begin turning the radius. The cut is applied, using the Top Slide to advance the tool, until the desired radius or sphere is produced.

The difficult bit, usually, is gaining access to the grubscrews that clamp the tool holder firmly into the slot in the main body, to tighten them, because of everything being so close to the chuck. Once this has been done, the radius turning tool is ready for use – **photo 4.**


5 The replacement knob in place on the biscuit tin.


6 "The Rolling Stone" in miniature.


7 The embryo throttle knob.

In use

Shortly after arrival of the Repton, the plastic knob on the biscuit tin broke. So, how better to try out my new toy than to make a replacement for the broken plastic knob? The end result, the new knob for the biscuit tin is shown in **photo 5.**

Another job was to turn a small aluminium ball intended to be the obvious part of a small display item to act as a "crowd puller" when the society had a stand at local model shows. It was inspired by "The Rolling Stone", a water feature in a street in Luxemburg. This is a large granite ball supported, and rotated, by water pressure.

The mark on the aluminium ball, **photo 6,** was actually an error but serves to show that the ball is supported by a low pressure (5 psi) air supply, and is rotating. The support started life as an aluminium candle stick, but became raw material waiting to "come in handy", and so this became its destiny.

The latest job was to make a replacement for the plastic knob which had broken off a motorised lawnmower, leaving a rather jagged piece of metal as the throttle lever. So a replacement knob was required, and the Repton seemed an obvious means of producing one. The end of turning the spherical radius for the new throttle knob is shown in **photo 7.**

Before parting off to length, two tappings were made, ready for grubscrews. Once parted off, the metal was very carefully clamped in the vice on the mill and slotted to fit over the throttle lever

The lawnmower can now be operated without fear of a sore or cut hand.

In the end, the Attachment, although infrequently used, has again, proved its worth. ∎

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 of 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.

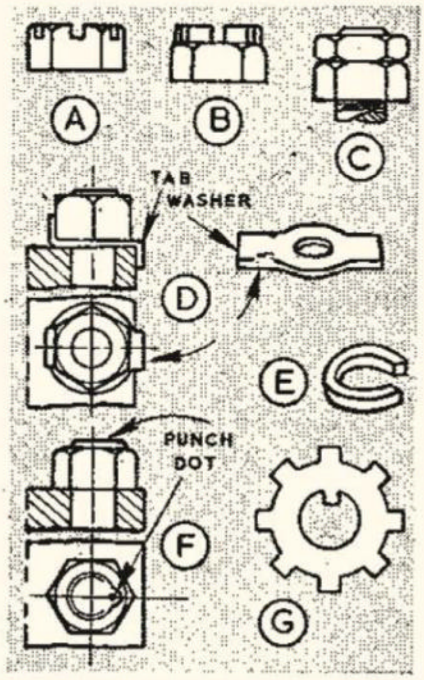
Beginner's Workshop

Preventing nuts unscrewing

GEOMETER explains some of the better-known processes for preventing nuts becoming loose on their bolts and studs

THE PROBLEM OF preventing nuts and threads slackening from vibration or other movement has been solved in various ways according to the requirements of assemblies, and, as usual, there are. the " do's " and " don'ts." Where rotation is in a particular direction, threads can be right or left-hand so there is a tendency for them to tighten. Spindles of cycle pedals, wheel hub nuts. of cars and on occasion the actual wheel nuts of lorries are examples of this method-and there are numerous' other applications. Naturally care must be taken in dismantling to turn in the required direction.

Split pins are perhaps the most common locking devices for nuts, whether on studs or bolts, and require the nuts to be either slotted or castle types, *A* and *B*. The slotted nut *A* needs less room where space is lacking,_ but is not so strong as the castle nut *B* with its circular portion on top incorporating the slots. Consequently, slotted nuts must not be substituted for castle cuts in important fittings.



Split pins should fit the holes reasonably tightly, their heads be tapped into slots, then the legs opened round the ends of the bolts. Where there is continuous vibration (car big-end bearings), loose split pins will eventually wear so the legs break off and the pins fall out.

The lock-nut

Another common device is the lock-nut C on U-bolts of car springs. Usually, the thin nut is on the end or outside, though in this position some engineers declare it takes the load on the bolt, owing to slight slackness in the threads of the thicker standard nut.

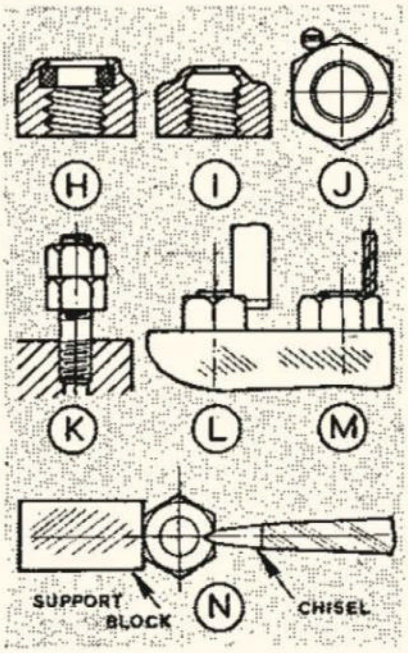
Plain washers do not prevent unscrewing, but they are used in preference to others where firm pressure is required and it is desired to avoid scoring a metal surface by the underside of nuts. There are two types of tab washer, however, to provide security-the single type D and the the multiple type fitting on two or more bolts or studs, with a tab at each position to turn up on the nut.

In final tightening of nuts, care is required on multiple tab washers not to twist them, and on single tabs not to turn them into a wrong attitude for locking.

Spring washer types

In general use, three types of spring washer provide security: single coil *E*, double coil (similar) and the serrated type with bore or outside cut. Spring washers should not be used where loads are heavy, or the undersurface can be scored from dismantling. Under pressure, a single coil washer will often break or splay; a double coil, splay, and a serrated type break. Coarse, sharp single coil washers can be much improved by slightly straightening-in the vice, using pliers.

Unless assembly is permanent, studs or bolts should not be burred. However, the centre punch dot *F* is often used on aircraft sub-assemblies. For removal, the displaced portion is chiselled or filed off.



The multiple-tab washer G is used with keyed or splined shafts (car hub nuts). For unscrewing, the outside tabs must be fully released or the inner one will be sheared.

Nuts fitted with a fibre insert H provide security against unscrewing for two or three removals-after which they are not so secure. They should not be used where heat can dry or burn the fibre.

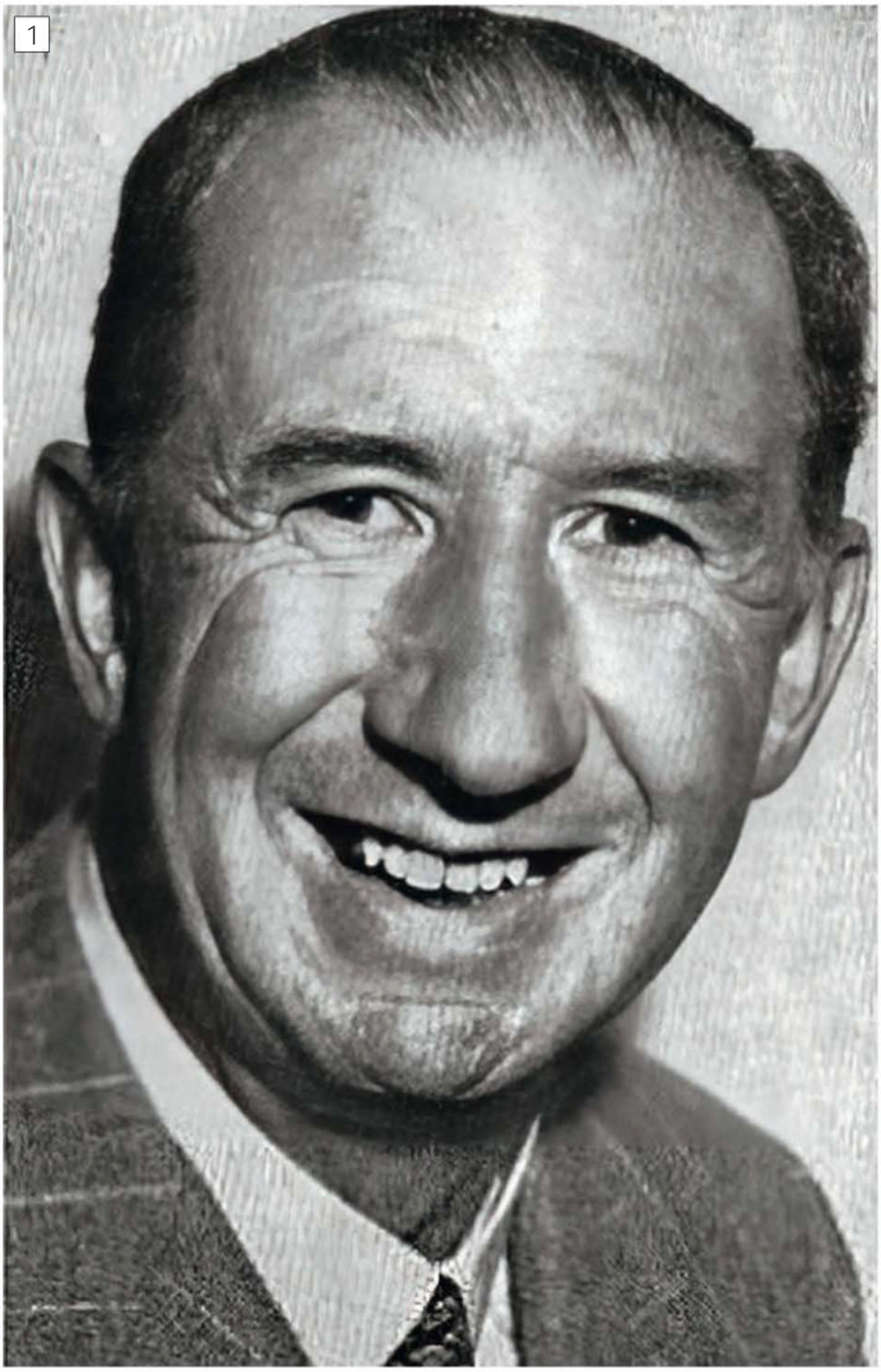
All steel nuts Z have an undersize piece at the end which grips the thread on the bolt or stud. These are a modem alternative for castle nuts on car big-end bolts. They avoid the difficulty of the split pin holes not being in line when. the nuts are fully tight-to overcome which,' castle nuts have to be removed and filed on the bottom. In many fittings, a normal nut can be held by a small screw against a flat J-motorcycle crankpins.

Studs can be fitted and removed by means of two nuts locked firmly together K-turning on the top one for fitting, on the bottom one for removing. Immovable nuts may be split *L* with a sharp chisel down one of -the flats, or a small drill down one of the comers M-then a chisel used for splitting. Alternatively, a chisel and support block can be used as N. ❑

Tales from the Workshop

Nevil Shute Norway

Many readers will be more familiar with Neville Shute Norway, **photo 1,** by his pen-name of Nevil Shute, under which he was a novelist. He wrote many highly successful books, some of which were turned into movies, and example being *On the Beach,* an apocalyptic story of the aftermath of a third world war. His writing brought him wealth to the extent that he abandoned the UK and moved to Melbourne to escape what he felt was an oppressive tax burden. But there was far more to his life than just his novels, he was an accomplished engineer – and a model engineer.

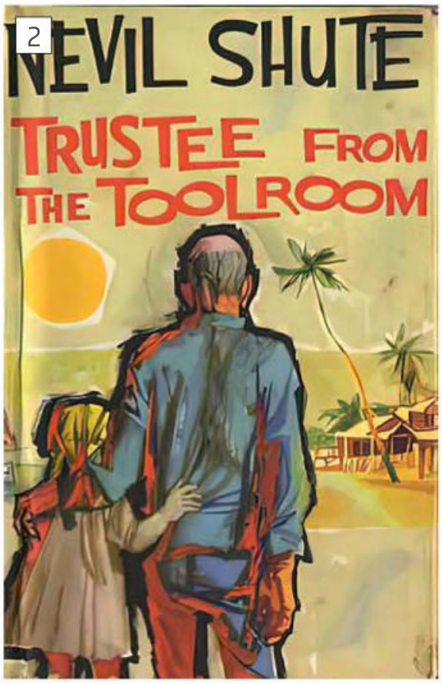


Neville Shute Norway.

Borne in 1899, in the First World War he served in the Suffolk Regiment, having been unable to join the Royal Flying Corps – he felt this was because of a stammer. After the war, Norway began his career with De Haviland, but soon moved to Vickers, where he became deputy chief engineer on the R100 Airship project under Barnes Wallis (the inventor of the 'bouncing bomb'). Wallis left and Norway became chief engineer. R100 was a civilian project for a passenger carrying airship developed alongside the more notorious R101 which was designed by a government team. Aside from a short test flight, the R101's maiden voyage had India as a destination, but it crashed in northern France. In contrast R100 made a successful journey to Canada but was scrapped in reaction to the R101 disaster. In his biography and other writing, Norway was damning in his criticism of the civil servants and managers involved in the R101 project. He concluded "government officials are totally ineffective in engineering development".

He then went on to co-found the company Airspeed Limited, who built the Oxford bomber trainer and the Horsa gliders used in the D-Day invasion. By the time of the Second World War he was becoming a successful novelist but worked in the Directorate of Miscellaneous Weapons Development. This top-secret establishment worked on developing unorthodox weapons, some more successful than others (search for 'The Great Panjandrum' online) One of his inventions was cast iron headed missile known as the 'rocket spear' which performed well and largely replace torpedoes for anti-submarine aircraft.

After the war he flew to Australia in his Percival Proctor, which was when he made the decision to emigrate. In Australia he continued his successful career as a writer.



The Trustee from the Toolroom.

As mentioned, Nevil Shute Norway was not only an engineer and a writer, but he was also an accomplished model engineer. In fact he often mentioned the hobby in his books. Following his death in 1960, ME editorial reported that there was a ship modeller in *The Rainbow and the Rose*, and the serial version of *Trustee from the Toolroom*, **photo 2**,explains how protagonist Keith Stewart 'had most of the basement for his own domain. Here he made models and wrote about them weekly for the *Miniature Mechanic*.

At the time it was clear the 'Miniature Mechanic' could only be a reference to Model Engineer. Several months later a more involved link was made to Edgar T. Westbury, a prolific writer in Model Engineer on almost all topics, aside from live steam. He was particularly interested in tools and techniques, and though he produced many advanced internal combustion engines – no doubt he would have enjoyed Model Engineers' Workshop. In 1960 the editor of Model Engineer, Vulcan, wrote:

"Mr E. T. Westbury like most of us at Noel Street (the former offices of Model Engineer), believed that Keith Stewart, hero of Nevil Shute's *Trustee from the Toolroom*, was a characterisation of himself.

"E.T.W. knew Mr Shute Well, which was probably one of the reasons that persuaded the novelist to use him as the basis for Keith"

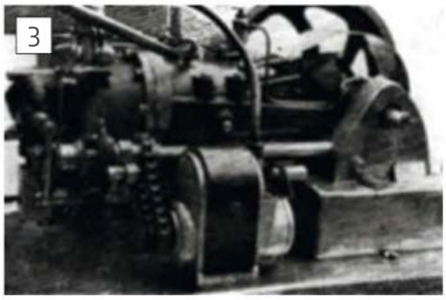
Westbury himself wrote a few months later:

"I knew Nevil Shute Norway for several years and had a very high opinion of his talents, not only as a pioneer, in aircraft engineering, but also as an enthusiastic model engineer. He shared with me a profound admiration of the work of craftsmen in every branch of skilled work, and deplored the fact that they were too often merely taken for granted, and rarely received either the remuneration or credit they deserved.

"On the occasion of his last visit to the ME Exhibition I was able to have a long discussion with him on various details of his model activities, and in the course of it he expressed his ambition to build one of my *Seal* engines "if I am clever enough!" I understand that this enterprise was begun but never finished.

Although in the worldly sense, his success was most notably in the literary field, nearly all of his books contained evidence of his knowledge of, and interest in, engineering and I have no doubt that his heart was always in the world of models; he was a regular reader of *Model Engineer."*

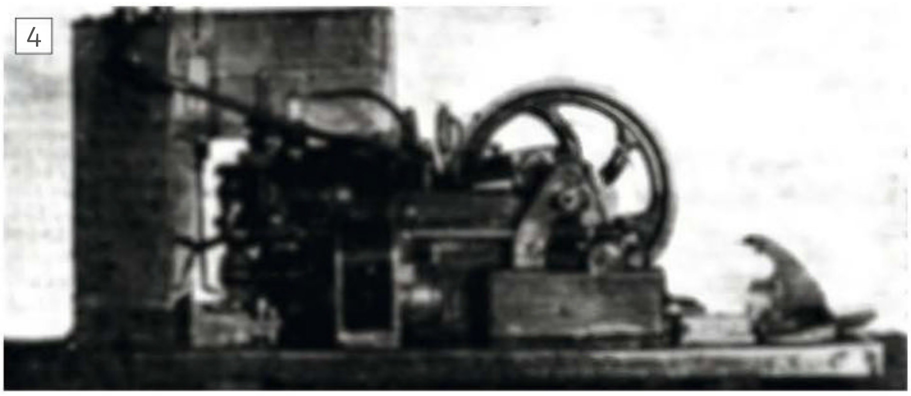
Norway has featured in many issues of Model Engineer over the years, I have focused on the contemporary articles and those published soon after his passing. Perhaps the most interesting is *Models and Fiction* by Donald Stevenson, min Model Engineer volume 100 No. 2488. Stevenson visited Norway at his home on the south coast and viewed his study, forty-foot schooner and 'luxurious pig stay made out of an elaborate air-raid shelter. From our perspective the real interest in the article is his model engineering activity, a whole building with several rooms. The 'dirty



The Stuart Turner petrol engine.

room' housed a forge, an electric grinder and a woodworking vice, among other related items. The largest room was the 'metal shop' which had electrically run shafting powering a lathe and drills, with extra pulleys for driving models. It also contained a hand shaper, assembly bench and a metalworking bench, with extensive tool storage in wall-mounted cupboards. The tools were free of rust, despite the coastal local, something attributed to the substantial building being light, well-ventilated and warmed. Norway was as obsessive in logging the time spent on his hobby projects as his professional ones, and the author found that the engine depicted in **photos 3** and **4**, taken by Mrs Norway, took 550 hours of effort. The engine was a modified Stuart Turner 1/8 horsepower internal combustion engine made with No. 800 castings. One modification was adding an oil pump rather than using oilers. Stevenson described it as very fine workmanship and that it started from cold without trouble.

Readers of his books will note that Norway held artisans and craftspeople in high regard, feeling they were undervalued by society. Reflecting this, he was an active supporter and member of local model engineering societies and clubs, and no doubt enjoyed the company of fellow hobbyists. ∎



Another view of the engine.

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.**

CNC Router Feedback – 1

In the last issue John MacPhee asked about the pros and cons of important machinery direct from China.

Dear Neil, I bought one direct from China many years ago, the company do not exist now, or rather they have probably rebranded. A couple of points I would like to make, the first may be obvious. My unit was around £600 and I got hit with £100 import tax. Second, be prepared to replace the electronics / control unit. If / when it fails it is impossible to repair as the numbers were ground off the main components.

Bob, by email

CNC Router Feedback – 2

Dear Neil,

I am nearing the end of a Cad/Cam router build. The router Kit was supplied by Ooznest – WorkBee and the software by Vectric – Aspire. There are free downloads for the software and many training videos for the WorkBee. Both companies have an excellent technical department. But a good understanding of computers is essential, I learnt it the hard way and I am still learning.

Neil, you are absolutely right you have no recourse if something goes wrong and it will!!

Bryan More, by email

Wifi Range

The writer of the article on resin printers suffered from wifi range limitations to his workshop. August 23 issue, MEW 330.

My house rambles with the router at one end. Wifi not working in some rooms.

I use AV600 Powerline adaptors or similar. These are mains plugs with an ethernet port and come in pairs. One is plugged into a mains socket near to the router and linked to it with an ethernet cable. In the workshop the other plug again plugged into a mains socket and linked to your PC with an ethernet cable.

The technology uses the house ring main cable and spurs to pass signals from plug to plug. Wifi is not being used. I use two pairs to link a HD TV and a PC.

Ian Richmond, by email.

Young Engineers' Recognised

Dear Neil, Thank you for including the item in your magazine. It is good to publicise new young incomers, and the Societies in general.

There is, apparently, a good write up in the FMES newsletter, and this has been passed onto the local newspaper.

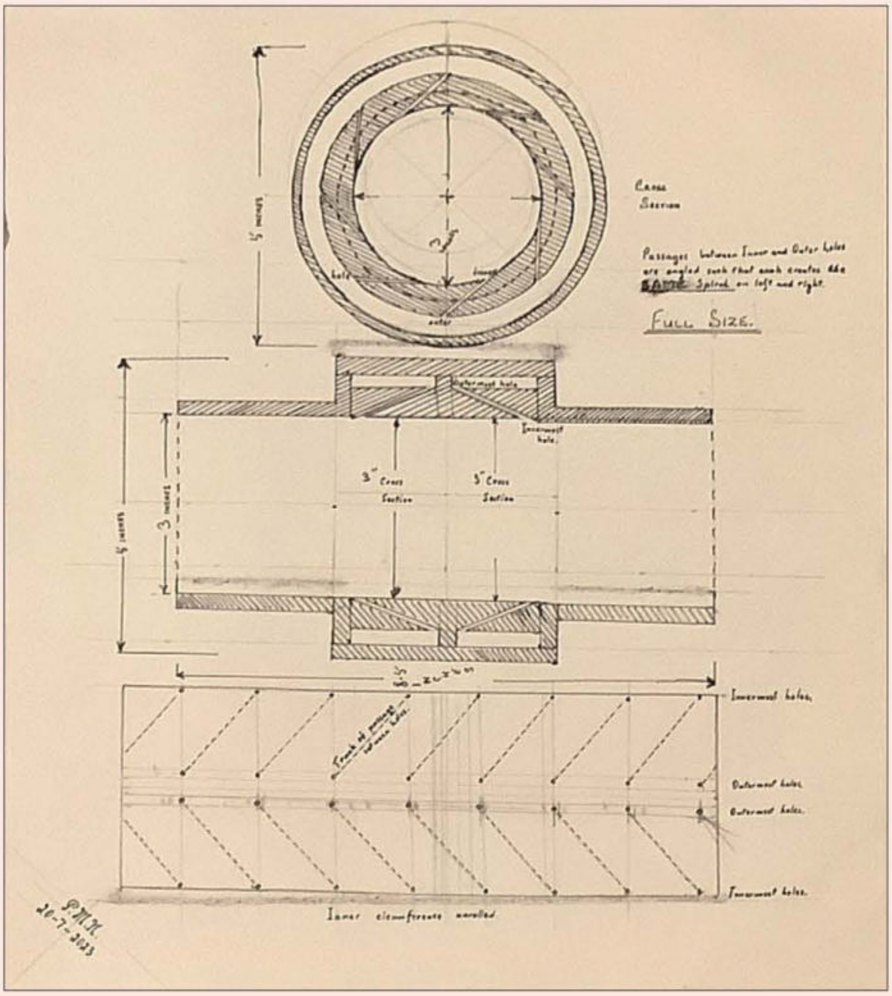
It is important that Societies publicise themselves, to attract new, hopefully, younger members to compensate for the losses after Covid and lockdown .

Howard Lewis, Peterborough

Potential 3D Test Piece

Dear Neil, I wonder whether the under noted might prove sufficient of a challenge. As shown full size, it is within the physical constraints of the Halot-Mage Pro 3D printer and together with its internal voids and interconnecting holes could probably only be created 'as-is', using such a machine. Currently I would only say that it may prove to be some form of motor, but I will not know until a prototype has been tested.

Peter Napp, by email.



Hi Peter, I'm guessing this is some form of engine cylinder? Bear in mind that the result will be made of resin and won't take high temperatures. Some minor changes to the external shape might better suit the printing process and maximise strength and accuracy.

What I suggest is that I draw it up in CAD and print off a 50% size version at the show. That would let you assess surface quality and dimensional accuracy, and consider if you wanted to take the idea further.

Let me know a bit more about it - how would it be mounted and what sort of piston would be fitted. It's easy to add mounting lugs or flanges in CAD, and it would be interesting to see what sort of piston seal we could achieve - I might be able to scale it to suit o-rings I have handy as I doubt a printed sliding fit will be close enough to seal, Neil

Dore Westbury Query

Dear Neil, I am trying to find an edition of model engineers workshop with information on the Dore Westbury mk 2 mill as it is not in any copies I have at the moment and would like your help if at all possible, many thanks

Geoff, by email

Hi Geoff, Recent issues featuring the DW are: 274, 289,281,315. The index linked here should help you: https://www.model-engineer.co.uk/forums/postings.asp?th=186202

If you have a digital subscription nearly all issues are in the digital archive. Hope that helps, Neil.

Component Tester

Dear Neil, I got my component tester from JYETech and it is brilliant. Avoid copycat versions as I have heard of problems.

Incidentally JYETech also make a hand-held oscilloscope (yes hand held) and this too is great

One point, follow the build instructions to the letter no deviations and the kits are easy to make.

Vic Whittaker, Leyland

Boring from the Lathe Tailstock

Keith Keen finds an alternative way to carry out hole boring in the lathe.

A local builder who knows that I have a lathe, asked me to make him a new plain bearing bush for a rather old power tool that he had. The tool had become unusable because the bearing was completely worn out. In order to bore the replacement bush to be a nice sliding fit with the shaft of the tool, using my lathe, I wondered if I could use my milling machine boring head in the lathe tailstock, instead of boring from the cross slide. My boring head has a 2MT morse taper, the same taper as in my lathe tailstock barrel. I did this and it worked very well, although I was aware that simply tapping the boring head into the tailstock barrel with a rubber hammer was not really a good way to secure the borer - normally, when used in the milling machine, the boring head would be secured with an M10 threaded drawbar in the hollow milling machine spindle. But no such provision is available on a lathe tailstock, so for future use I devised another way to secure the boring head to the tailstock barrel, using the clamping collar shown in **photo 1**.

The securing collar that I made is shown in **photo 2**. It is basically a thick disc with a concentric centreline hole and recess for easy sliding fits over the lathe tailstock barrel and the boring head that I have. My lathe is a Myford 254 plus and the tailstock barrel OD (outer diameter) is 28.3mm. My boring head (Arc Euro Trade 060-290-00400 + 060-290-00600) has an OD of 50mm. The collar has a 1.6mm wide slot and two M6 capscrews for tightening around the tailstock barrel and the boring head. **Figure 1** shows the details and dimensions of the collar that I made for my particular lathe and boring head dimensions. To make the collar I had a choice of using either aluminium alloy or Ertacetal C (which is an engineering plastic similar to Delrin). I initially went for the metal collar, but as this is quite a big chunk of metal, I included some extra Φ8 and Φ5 holes in the design, as can be seen in fig.1 and photo 2, to make the collar less rigid for tightening up with the M6 capscrews.

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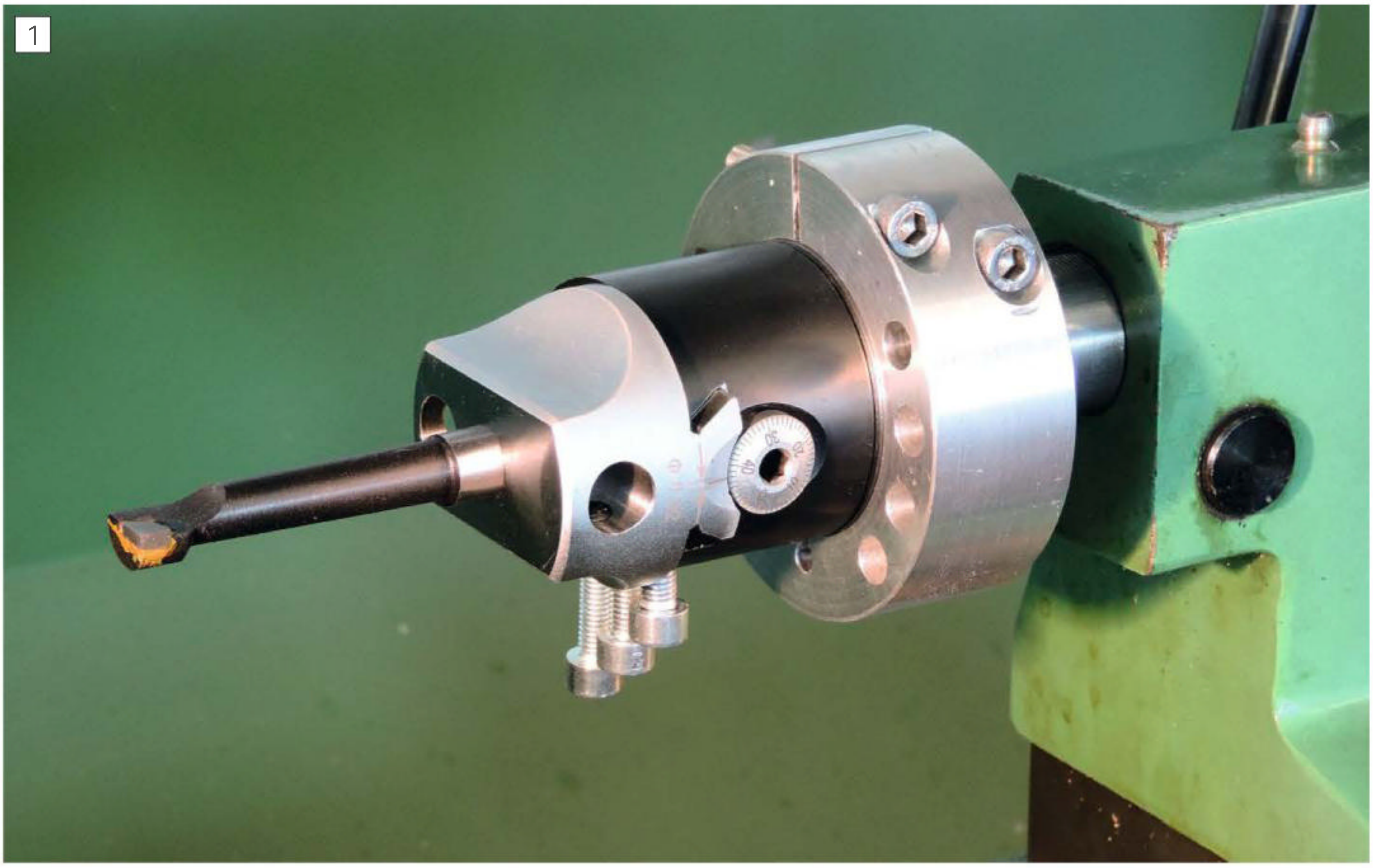


Boring head in the lathe tailstock with clamping collar.

The aluminium collar.

Parts for making the collar.

To secure the boring head onto the tailstock barrel, the head assembly is first tapped in place in the tailstock barrel and then the two M6 capscrews are tightened.

How it was made.

This is just an outline of how I made the collar using the machine tools I have, without going into too many details. My vertical mill/drill has a DRO but my lathe has not.

I started with a piece of 3.5 inch diameter aluminium alloy round bar roughly cut to a thickness of about 32mm. This was faced off both sides in the lathe to a width of 28mm, and still in the lathe, a 9.8mm hole was drilled through the centre, this size being a snug fit for an M10 set screw in a simple work-holding mandrel.

Next I made the three items shown in **photo 3** - the simple stub mandrel in 1 inch diameter steel round rod with an

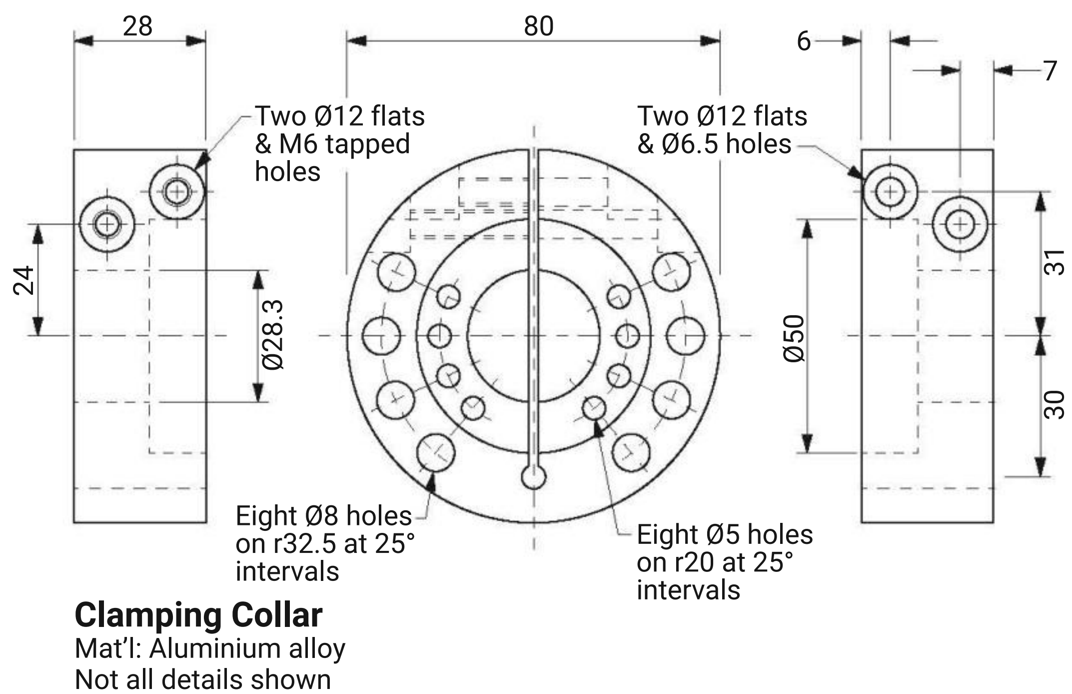
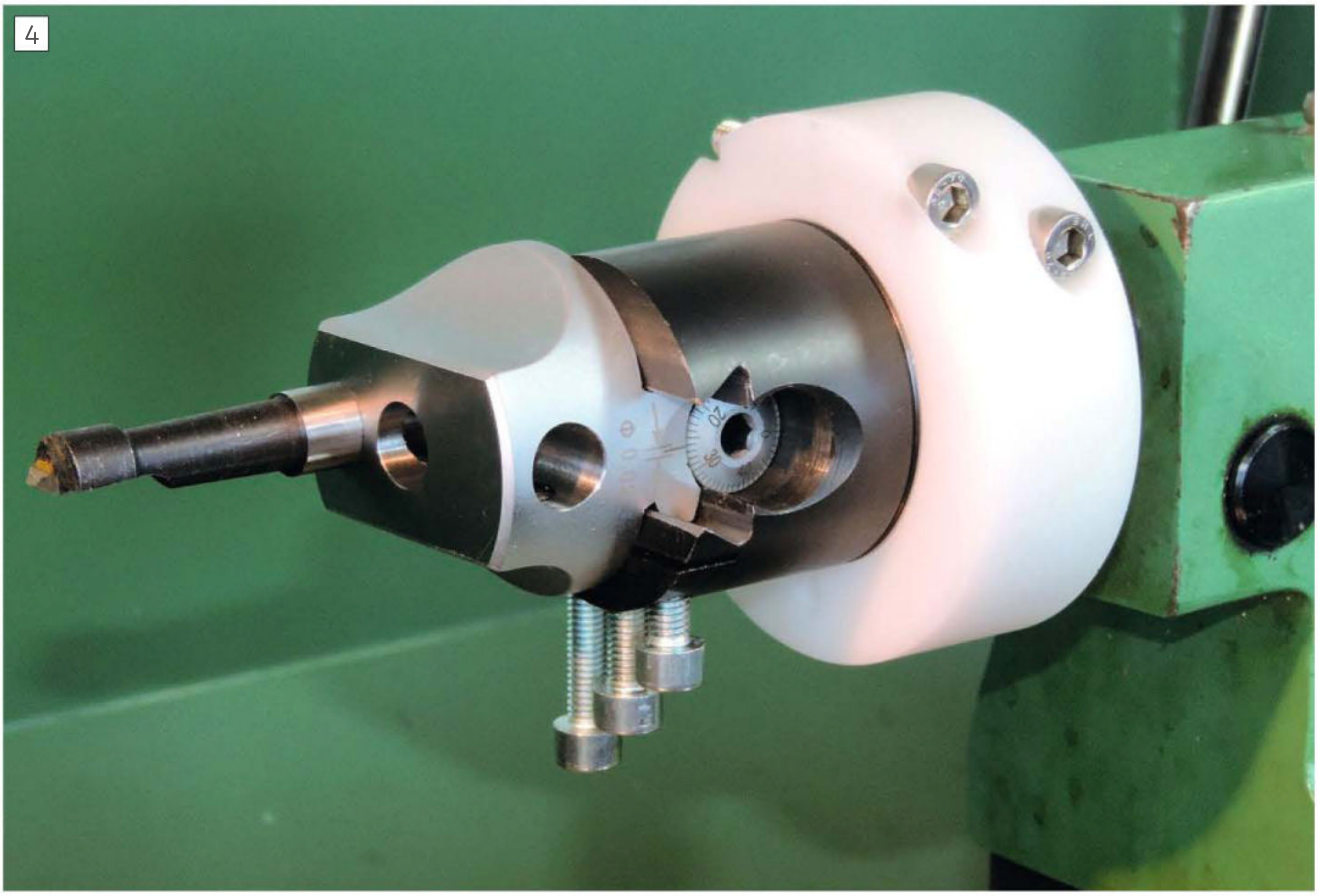


Figure 1. Clamping collar details.



Boring head in tailstock with the Ertacetal C collar.

M10 setscrew, a hole position locator made from half inch diameter brass round rod and turned at one end to 9.8mm diameter, and a simple scriber made from quarter inch diameter silver steel round rod and turned to have a conical pointed end.

Using the stub mandrel the workpiece was turned in the lathe to an OD of 80. It was then moved to the mill and clamped flat with a plywood support on the table, and the centre position (0,0) was set on the DRO using the brass rod locator. A 5mm hole was then drilled at position (0,-30mm), and the silver steel scriber was used to score a mark in the Y axis direction to show where the slot would go.

The workpiece then went back to the lathe and drilling and boring was carried out to make the through hole and the concentric recess to give sliding fits for the tailstock barrel and the boring head.

Going back to the mill, the workpiece was mounted in a milling vice, and the slot was cut using a 100mm diameter 1.6mm thick slitting saw. The slitting saw was not quite large enough to cut the entire slot, so this was finished off with a hacksaw and needle files.

With the workpiece mounted in other positions in the milling vice, four 'flats' were machined into the curved sides of the workpiece, using a 12mm slot drill, and then the cross holes were drilled and tapped as shown in fig.1.

Finally, the 8 Φ8 and 8 Φ5 face holes were drilled with the workpiece clamped flat on the milling table above a plywood support piece.

Using the tailstock borer.

The boring head that I have has three grubscrews (with a steel ball underneath each) which are used to tighten the moveable cross arm at its setting, before boring. For convenience I replaced the grubscrews with capscrews (of different lengths) which were easier to get at when being used on the tailstock.

As an exercise to try out the tailstock boring arrangement with the collar, I made another collar, this time with my other material choice option, the ertacetal plastic, and (of course) boring from the tailstock rather than the cross slide. As the plastic material is more flexible than aluminium, the 8mm and 5mm face holes were not needed and were therefore not drilled.

The plastic collar was found to work equally well in securing the boring head to the tailstock. **Photograph 4** shows the assembly with the plastic collar. It also shows another feature of using the boring head in the tailstock. The boring head that I have has two position holes for inserting boring tools, one central and the other offset. When boring relatively small holes with a tool in the central position, the tool can be used the 'right way up' as shown in photo1, for boring on the near side of the hole being bored. But for much larger holes, boring can be carried out with the tool 'upside down' and in the offset boring head location, for boring on the far side of the hole being bored. This configuration is shown in photo 4.

Theasby's Wrinkles

From the pen of Geoff Theasby, we have two interesting ideas for keeping things organised workshop.

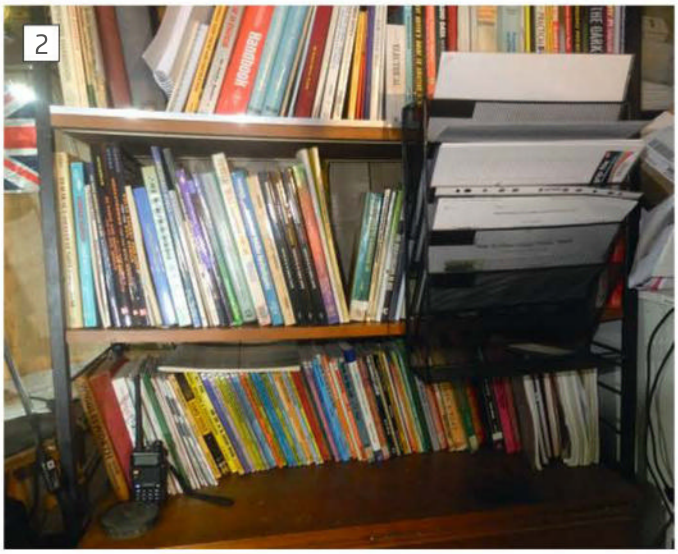
The magazine rack.

A sliding magazine/file rack

The rack is shown in **photos 1,2** and **3.** I have always got half a dozen projects on the go, and I keep all the relevant notes and updates in separate plastic folder. For some time it has been increasingly difficult to find storage space for them. I bought a magazine rack, but I still couldn't find space for it.

Then I realised stacking books two deep on a bookshelf is not practical, but if a moveable rack were available...

It obscures part of my working library, but I never need access to all the books all the time. A sliding rack answers the problem. It can be moved to obscure a section of shelving not currently required, and if it really proves to cause difficulties, it can quickly be lifted off altogether. Ina my case, no machining was required, just two plastic pulleys, two M4 screws and four locking nuts, with washers. The running rail is a length of 1 cm x 1 cm aluminium angle screwed to the edge of a shelf.



Rack at right.

And the rack at left showing the range of movement.

The screwdriver holder.

A Pistol (Grip Screwdriver) Holster

My pistol-grip electric screwdriver is always in use but takes up a lot of space on the bench. I had thought that a sort of 'holster' might help, but eventually, I conceived the following; a hole in a piece of wood, big enough to poke the nose of the screwdriver through, and screwed to the underside of a drawer. The screwdriver is retained easily, and yet is still to hand, **photos 4 and 5**.

Footnote

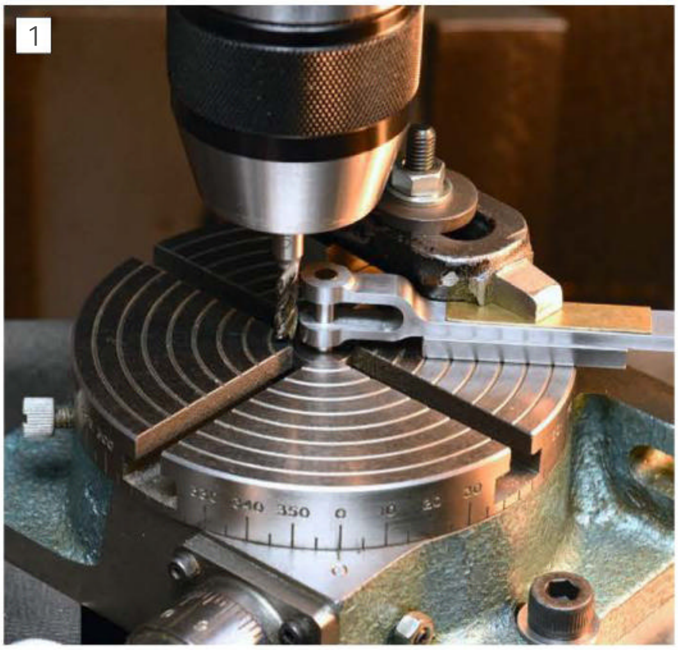
Not an original idea, but very practical, a magnetic tool holder, mounted on the wall to my left. No longer is a jumble of tools, some not used for the project of the moment, congesting the bench, but they are easily available nevertheless. Duratool at B&Q are representative suppliers. ■

Screwdriver in storage.

Artful Dodge #11 –

Positioning work on the rotary table

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.



Rounding off an expansion link.

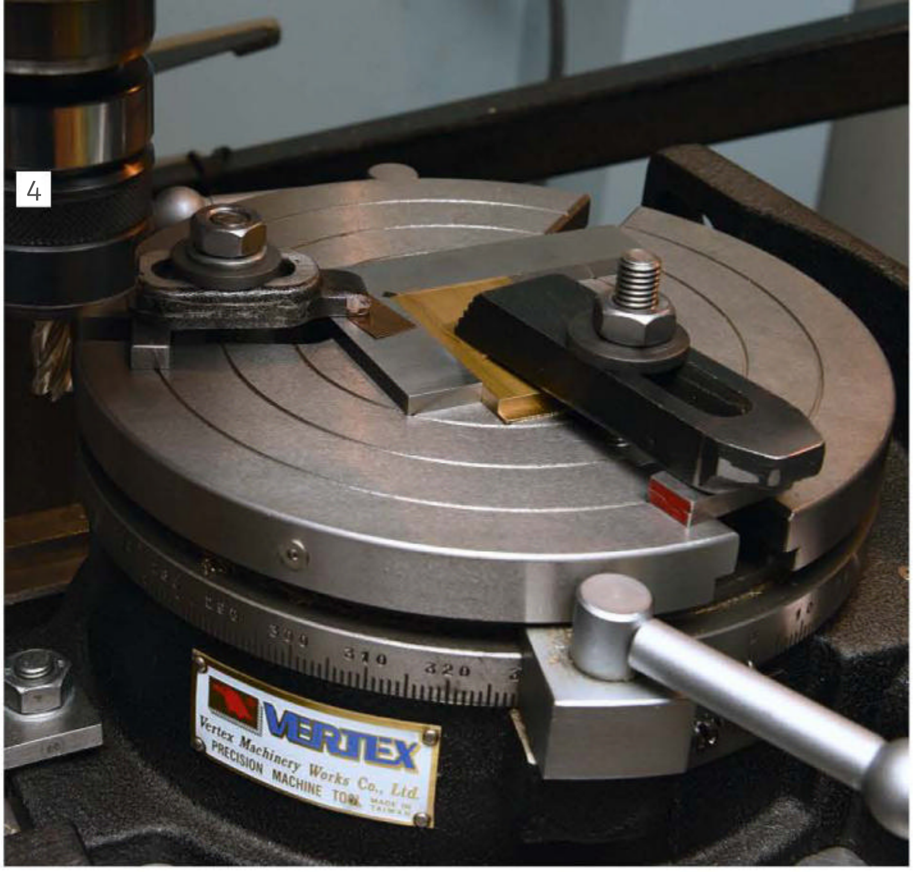
Precision square clamped to table.

The rotary table is a most useful accessory for the vertical mill. Larger tables (6" or 8" in diameter) generally feature a No. 2 or No. 3 Morse Taper centre. Smaller tables (3" or 4") often just have a cylindrical central bore. Big is not necessarily better; smaller tables are better suited to the clamping of small components such as eccentric rods or lifting links, **photo 1**. Larger tables are ideal for milling coupling rod ends; they can also tackle the milling of an expansion link clamped to a plate bolted to the rotary table.

It's a good idea to check the accuracy of your table, by which I mean does the table rotate truly about the centre, or is there some eccentricity? I used a 6" rotary table, badged for Myford, for several years before I thought to check this; I found that there was some 0.015"

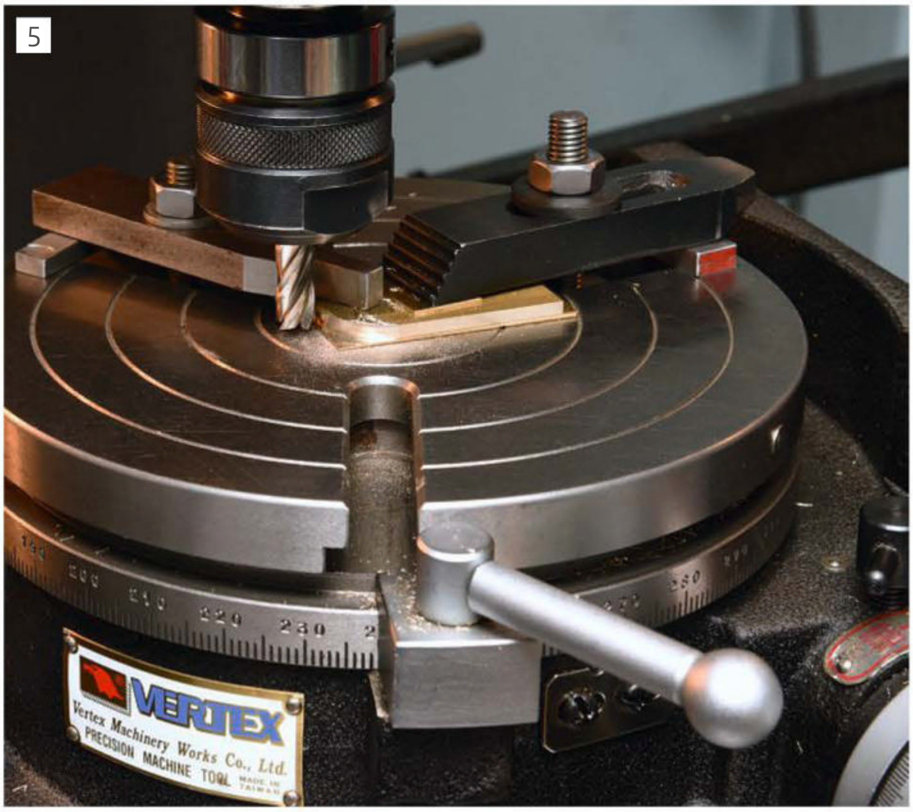
Morse taper accessories and inserts.

4



Workpiece replaced, not sacrificial spacer.

5



Milling to the radius.

of eccentricity – far too much to enable good work to be done. (I'm sure that it is most unusual for a Myford rotary table to exhibit this problem.)

You'll need a Morse Taper adaptor so that lathe chucks can be mounted. This will enable you to mill a square or hexagon onto a cylindrical work-piece held in the chuck. I have never felt the need for dividing plates, finding that the basic rotary table provides sufficient angular precision for my needs, as long as I remember to always eliminate backlash by rotating the table in one direction only.

Much rotary table work involves clamping a work-piece down onto the surface of the table and the question is always, "How do I position the workpiece accurately?"

The first step is to make an accessory for the table which fits the ground Morse Taper and features a 0.5" bored hole into which a variety of turned inserts can be fitted. A blank MT arbor provides the basis for the accessory. A tapped hole in the bottom of the 0.5" bore provides the means to extract the accessory without the need to take the table off the mill. **Photograph 2** shows MT2 and MT3 accessories and a variety of inserts. Any workpiece which features a reamed hole at the centre of the radius to be milled can now be positioned accurately on the table.

But how do we position a work-piece when there is no hole in the centre of the radius? One solution is to drill a hole, use it to position the workpiece on the rotary table, mill the radius and then fill the hole with a rivet. A better approach is:

1. Position the rotary table on the table of the mill so that the centre of the rotary table is aligned with the machine spindle in the Y-axis; a ½" dowel held in a drill chuck facilitates this task. Clamp the Y-axis.
2. Turn an insert of diameter twice the radius you need to mill on the workpiece, with a 0.5" spigot to fit the hole in the centre of the accessory. Place it on the rotary table. If the radius to be milled is smaller than ¼", then you need to make a bush with an outer diameter of ½" and with a reamed hole of the required diameter in the centre into which a dowel can be fitted.
3. Set the table to a convenient angle (0°, 90°, 180°, 270°).
4. Clamp a precision steel square (without base) to the table so that it is tight against the disc and aligned with the X and Y axes of the mill, **photo 3**.
5. Remove the insert/dowel and replace it with the workpiece plus a sacrificial spacer to protect the surface of the table **photo 4**.
6. Clamp the workpiece down and remove the square. You are now ready to mill an accurate radius.
7. Mill the workpiece, moving the table of the mill only along the X-axis until the desired radius is reached, **photo 5**.

A small V-block can be used in place of the plain square. ▮

Down the Drain

Laurie Leonard tackled what should have been a minor domestic repair but found himself re-learning a valuable lesson about stainless steels.

I like my cup of well-earned coffee made in a cafetiere and have to take my share of the domestic chores associated with it. I had dismantled the cafetiere**, photo 1,** to give the parts a good clean and poured the washing up water down the sink drain. When I came to reassemble the cafetiere I found that the bottom nut that holds the filter onto the plunger was missing. No major panic: empty the cupboard under the sink, unscrew the trap on the drain and retrieve the nut. Panic: it was not there. It must have got carried outside with the flow of water. I was not going to put my hand down the outside drain in the vain hope of it being there. Having a lathe in my workshop the problem would soon be resolved. I even had some suitable stainless steel in stock.

1

The dismantled cafetiere filter assembly

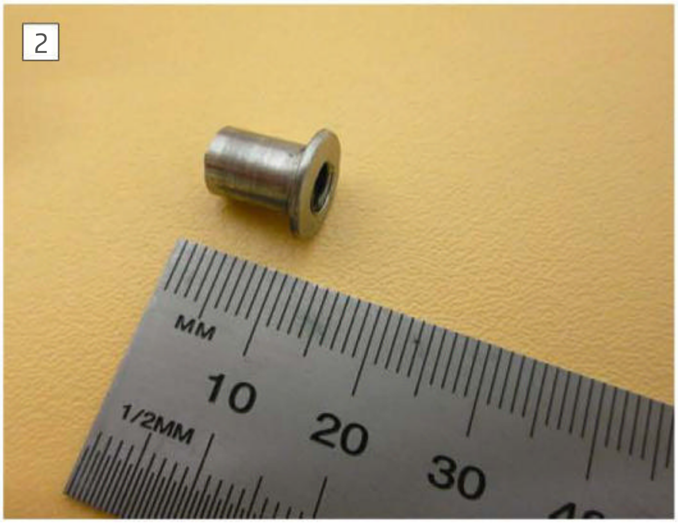
The manufacture

The length of stock was gripped in the 3-jaw chuck (concentricity not an issue) with sufficient protruding to make the nut which is shown in **photo 2** to give an idea of size. **Photograph 3** shows it screwed onto the plunger indicating how the outer diameter is constrained by the end of the plunger. Machine the outer diameter for a suitable length and then drill tapping size for the length of the nut plus the width of the saw blade to cut it off. Do not want to waste material (I am also not a fan of parting tools). Just need to start tapping whilst in the lathe to prevent a drunken thread and then cut the nut off the stock and finish the tapping operation with the nut held in the vice. Job done.

The moral

Not exactly. As expected, the job started to turn in the chuck as the tap bottomed. The nut was removed from the stock and the cut end faced. The job was then gripped in the vice to finish the tapping. Attempting to complete the tapping resulted in it slipping in the vice jaws, stainless is funny stuff and tends to pick up. Tighten the vice up a bit, and then a bit more and a bit more.

I should have given more thought to the manufacturing operations. Initial thoughts were that it is only a nut but the thin wall, constrained by its design, meant that it was hard to grip. Gripping it in the vice to finish the tapping flexed the wall which made it harder to tap so it slipped. Tightening the vice further made



The completed nut giving an idea of size

The nut screwed onto the end of the plunger showing the outer diameter constraint.

The reassembled filter assembly with the new nut.

the matter worse and visibly distorted the nut. I eventually managed to reshape the nut and finished the tapping.

More thought before machining should have identified these problems. Not being so miserly with the stock and providing a longer tapping hole, at the expense of waste, would probably have resulted in it not having slipped in the chuck and the complete tapping operation may have been possible whilst held in the lathe chuck. Achieving this would have prevented the problems from gripping the stock in the vice. Holding the nut in a collet, eg one of the ER series, may also have provided a far better machining operation by giving the nut all round support.

I am pleased to say that the cafetiere is now fully functional again and the new nut functions as it should, **photo 4**.

"Filengrène" – Software for Gear Design Part 1

To help you with gear design, with neither calculations nor charts, Jacques Maurel proposes you use this free software designed for industrial use.

Filengrène was designed by a teacher (Mr André Meyer) specialising in gear machining. There is a video description of the software, **ref 1** at the end of the article.

The aim of the software is to design any type of gear (with all the possible refinements) and to machine them with plain milling cutters on a five axis CNC. You pay only if you want your machine to be able to use the software results with your machine.

The interest is that any type of gear can be machined with plain cutters, so low tooling cost, but of course the cutting time is longer than the one of dedicated gear cutting machines. This is convenient for one off jobs or small batches for gears having a big module.

The interest for model engineers is in two ways:

For those using the hobbing process, it's easy to get all the figures needed with no calculation for machining cylindrical gear spur or helical ones.

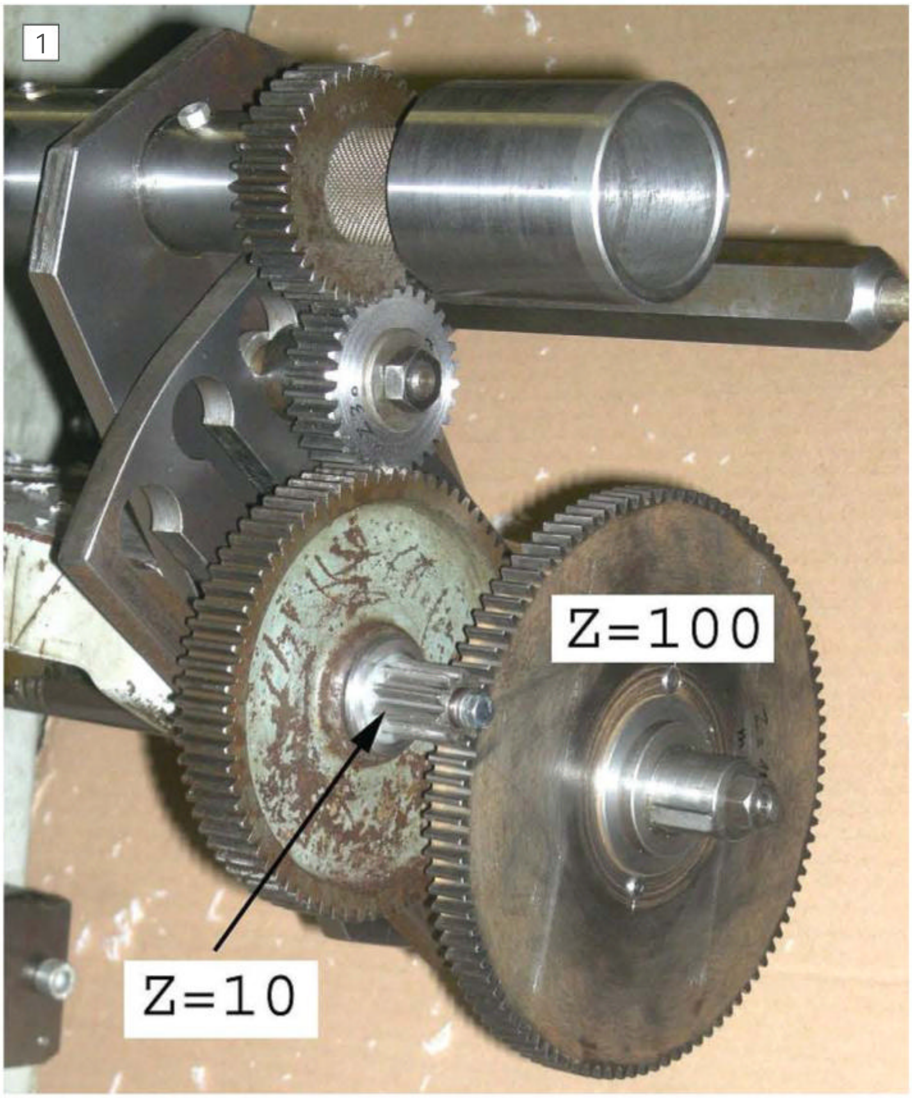
For those having a 3D printer, it's possible to use the software results ("stl" files) to print complex gears such as spiral conical ones. I've seen a differential made this way **ref 2.**

The software can be found here: https://moodle.insa-rouen.fr/course/view.php?id=700

There is an English version of the software, but the tutorial videos are in French. It's possible to get French subtitles from YouTube, and to have them translated in English. The translation is not perfect, but sufficient to understand if you know the gears subject; **Ref 3** for these videos.

Download the software, unzip and install it (launch it). The following examples will be used as tutorials.

The following examples show what can be achieved using Filengrène:



Ten and one-hundred teeth gears.

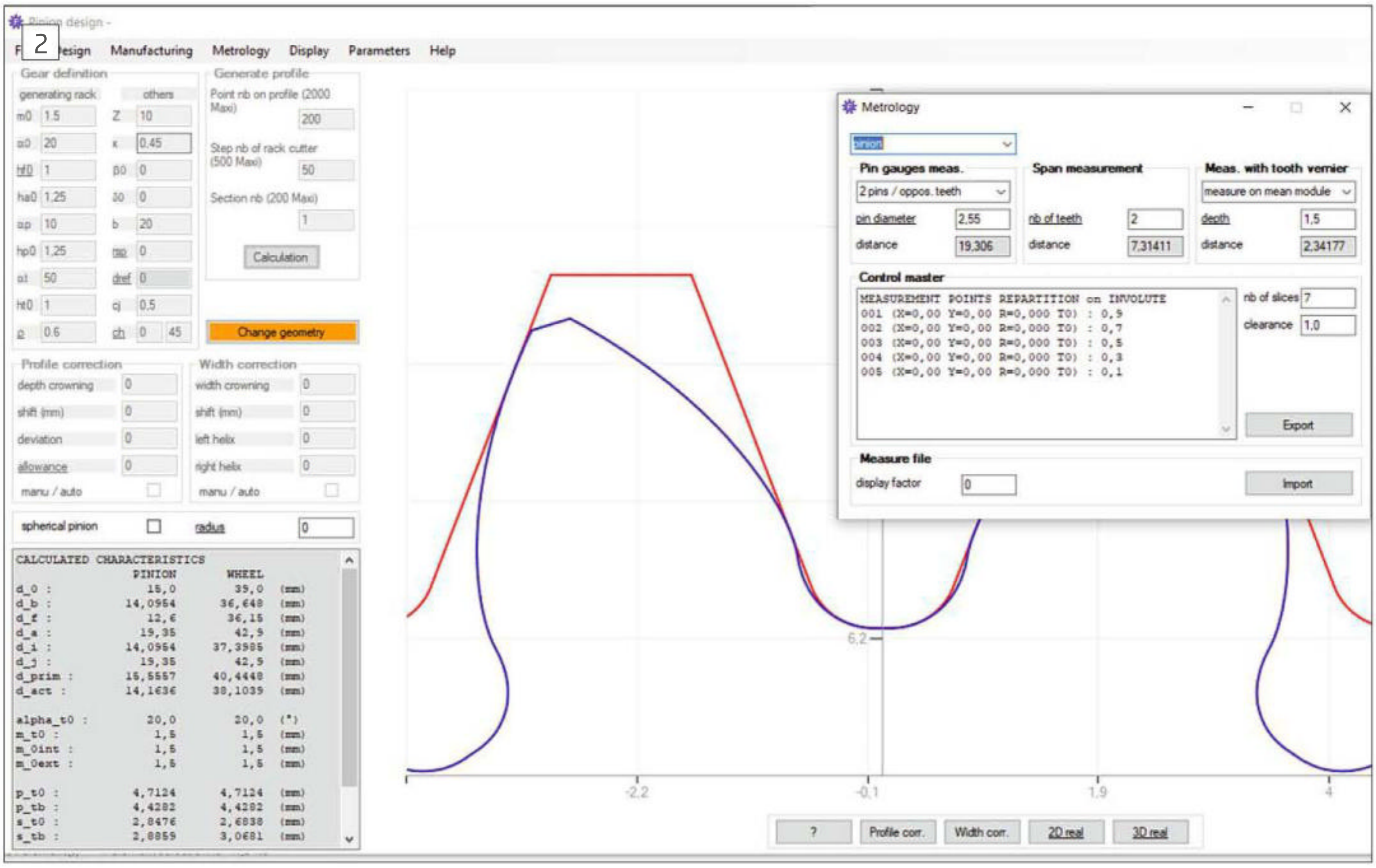
Removing undercut:

Making a 10 teeth gear meshing with a 100 teeth standard gear, to be used in a quadrant for helical machining on a milling machine, **photo 1**.

The main problem here is to remove the undercut. The ratio of a 10-tooth gear to one with no undercut (17 teeth) is calculated as x = (17-10)/17 = 0.411. I've chosen to use 0.45. Look at the screen shot **photo 2**.

In the Filengrène top left menu, choose "design" and then "pinion"; fill the table "gear definition": m_0 = 1.5 ; Z = 10 ; α_0 = 20° ; x = 0.6 ; hf0 = 1(1m) ; ha0 = 1.25(1.25m) ; ρ = 0.6 (0.4m) ;

b = 20 (pinion thickness); hp0 = ha0 ; ht0 = hf0 (refinements, see later) the other figures are for conical and/or helical pinions, later). Left click then "calculation"



Designing in Filengrène.

in the "generate profile" table.

Most of the results can be seen in the left table. Only one piece of information is necessary for us, the head diameter **da = 19.35** for machining the gear blank.

Left click then "metrology" in the top left menu, to get the "span measurement" **Wk = 7.314,** a dimension necessary for the gear control. (An explanation of these measurements and modifications to gears will appear as the third part of this short series – Ed.)

A left click on "?" in the bottom menu shows you the cutting rack definition see **fig. 1**. The values ht_0 and αt are used for tooth head rounding. This is named "topping" and made on gears being case hardened. The values hp_0 and αp are used to make a "protuberance" for gears that are to be finished by grinding (to avoid any ridge near the tooth foot). These refinements are of no use for us.

A left click on "3D" in the bottom menu shows you the 3D view of the gear.

Go to "help" in the top left menu to know all the display possibility using the mouse.

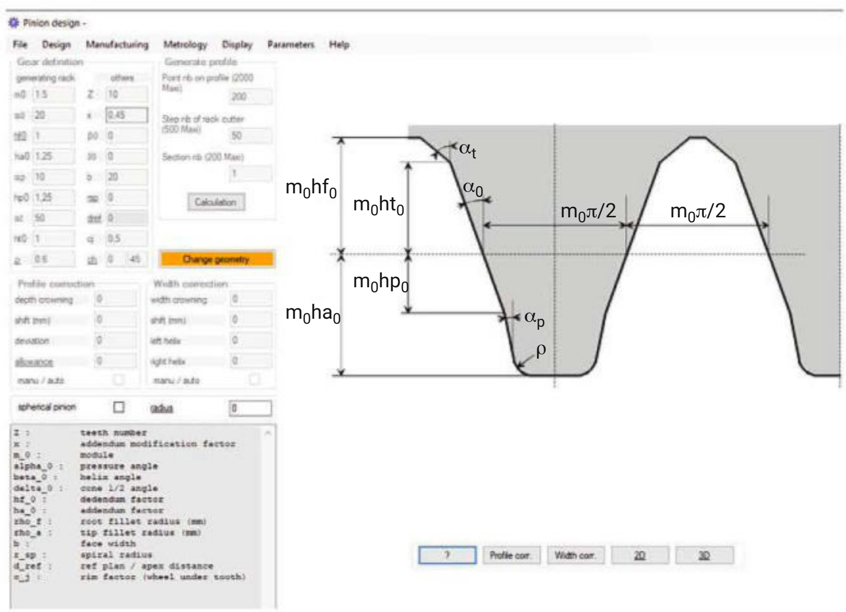


Figure 1

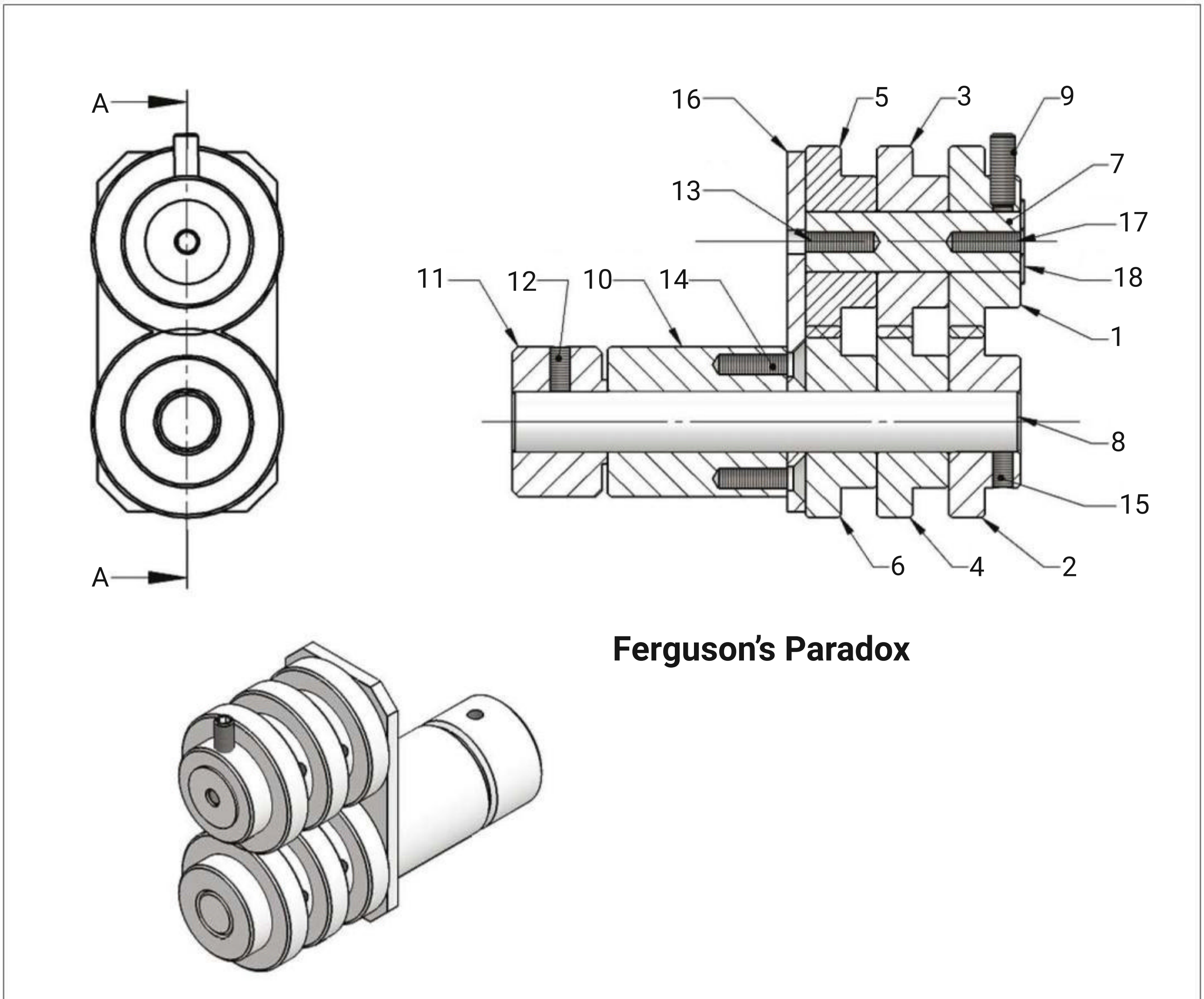
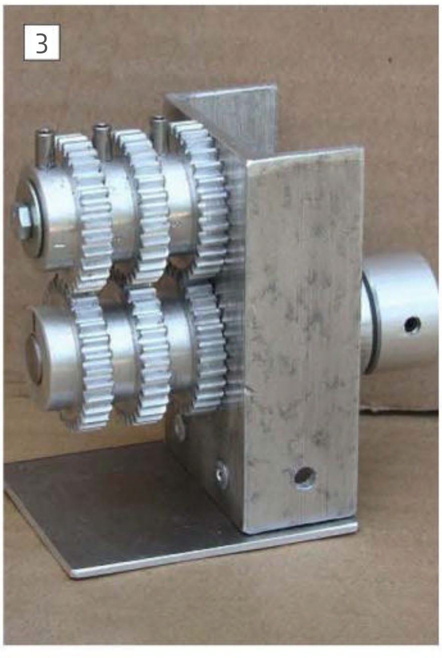
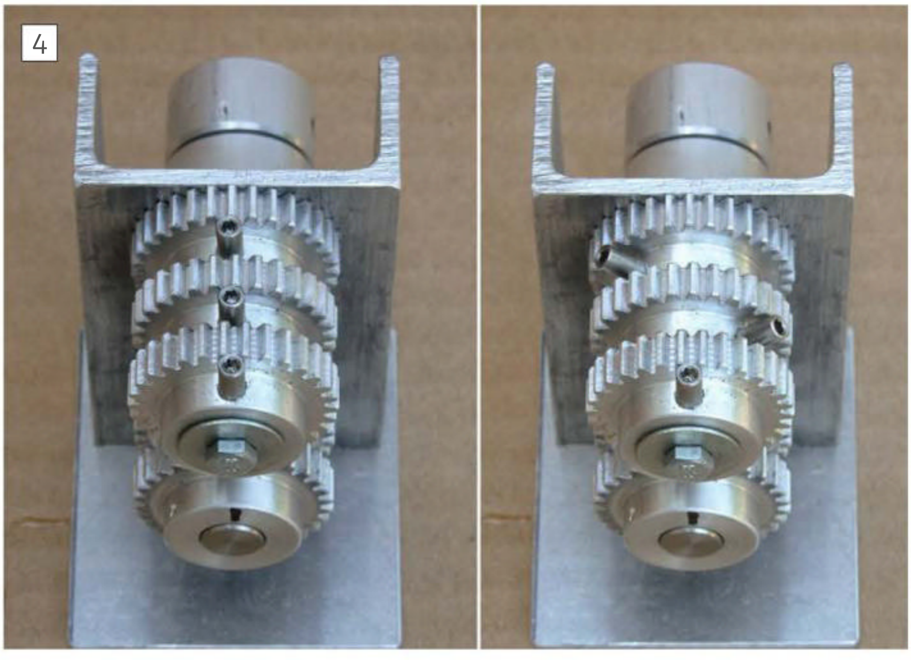


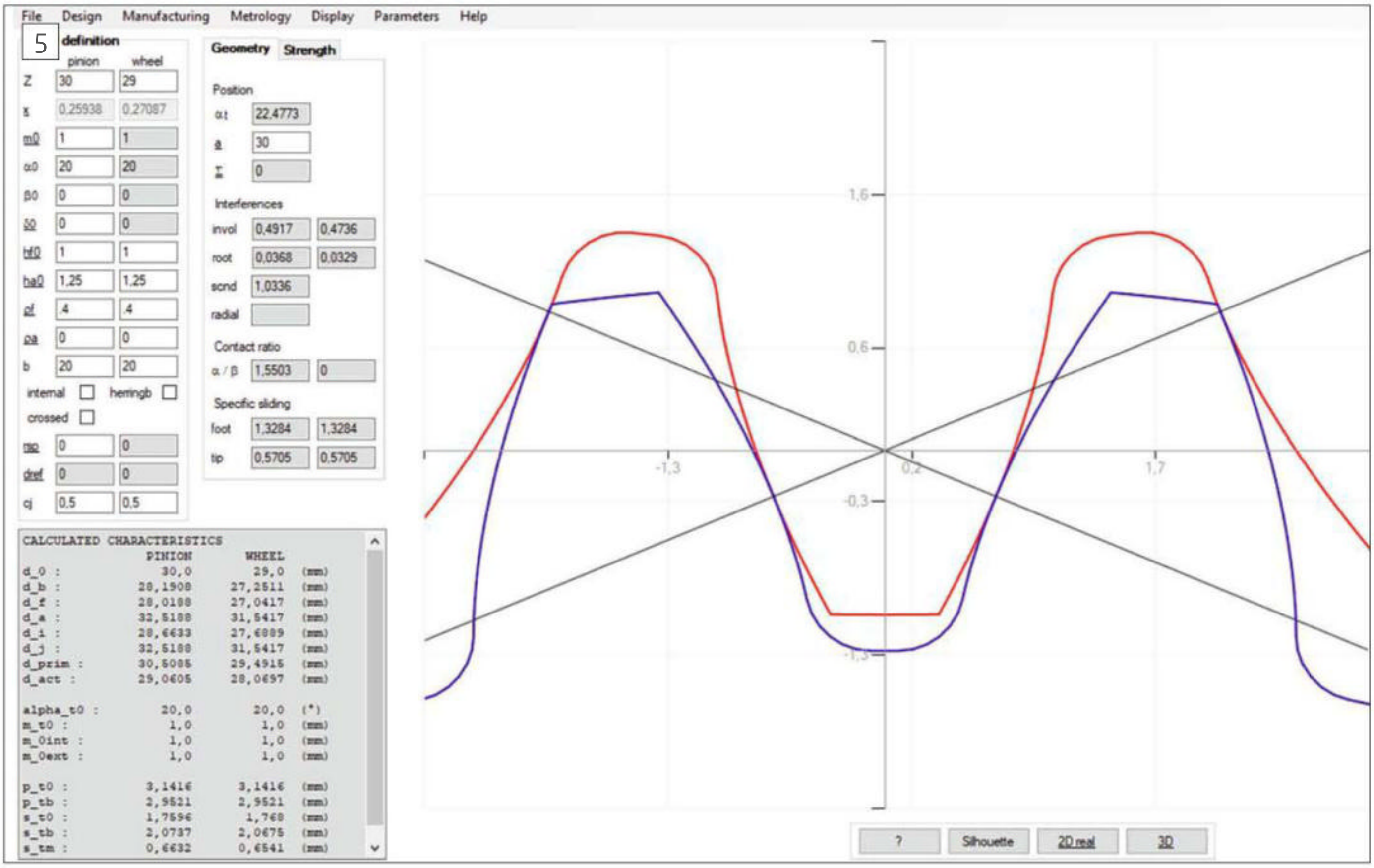
Figure 2



The Ferguson's Paradox device.



The device before and after four rotations. One gear pair 'runs slow' another is 'fast'.



Designing the Ferguson gears.

Adjustment of the centre distance:

I will explain how to make **"Ferguson's paradox"**, (**fig. 2** and **photo 3**). Wheels 1, 3 & 5 are free on axle 7. Wheels 2, 4, and 6 are locked on axle 8. Wheels 1, 2, 4 and 6 have the same number of teeth (30). The wheel 3 has 29 teeth and the wheel 5 has 31 teeth. Indexes are set on wheels 1, 3, 5 to check their angular position These indexes are parallel before start.

When you turn axle 8 by one turn the index of wheel 1 retrieves its starting position, while the indexes of the wheels 3 and 5 are moving in opposite directions, **photo 4 right** shows the indexes position after 4 turns of the input shaft. This is surprising as the wheels seem to be identical at first sight ence the paradox. Have a look at the video, **Ref 4** at the end of the article.

Wheels 1 and 3 are standard ones, but all the others have a shifted profile to cope with the centre distance which must be the same for the 3 gear sets.

Look at the screen shot **photo 5** showing the gearset Z4/Z3 (the common centre distance is known from the standard gearset Z1/Z2 so 30mm):

In the top left menu, choose "design" and then "gear"; fill the table "gear definition" as already seen, but keep the x boxes to "0". Go then to the aside table named "geometry", double left click the "a" box (centre distance, actually 29.5) and write 30, the "x" boxes will be filled with the right values in the "gear definition" table.

The blank diameters can be read in the left down table; da4 = 32.51 and da3 = 31.54.

From the top menu "metrology" you can get Wk4 = 10.93 and Wk3 = 10.92 for the gear control.

All the part dimensions are given in the parts list if you want to machine your own gears. Be careful when setting the wheels, set the indexes parallel and then tighten the grub screws fixing wheels 2, 4, 6.

Details of all the parts will be given in the next issue.

References

All these links are available at www.model-engineer.co.uk/filengrene

Ref 1: Printed differential: https://www.usinages.com/threads/filengrene-cfao-pour-les-engrenages.129655/page-5

Ref 2: Video filengrene description: https://youtu.be/sIbzPBEFFzg

Ref 3: Filengrene tutorials:

Video gear concept 1: https://youtu.be/d-VDn_Azlvk

video gear concept 2 : https://youtu.be/LapzpOw9uXY

video 2D display : https://youtu.be/sc7s_yv4rE4

Video 3D display : https://youtu.be/kAk-kbN-qFc

video throated worm wheels concept : https://youtu.be/EWnm16BUyq4

video about tooth profile modif and crowning : https://youtu.be/Og4PUE2scUE

video about protuberance : https://youtu.be/PyLdse5ypug

video about gears machining 1 : https://youtu.be/u8Og6jBajdc

video about gears machining 2 : https://youtu.be/HTlv7VQlW0g

Ref 4 : Ferguson's paradox video : https://www.youtube.com/watch?v=wPXMDo1oLlw

Model Engineers' Workshop and Model Engineer at the Midlands Model Engineering Exhibition

More news about the Society of Model an Experimental Engineers at the forthcoming exhibition at Warwickshire Event Centre Thursday 12th to Sunday 15th October 2023

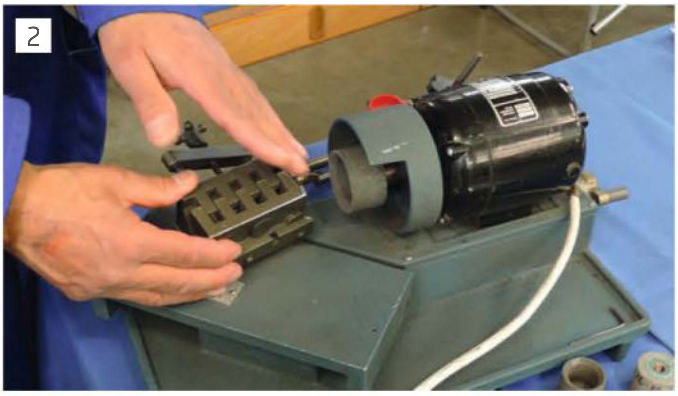
As regular readers will be aware, Model Engineers' Workshop and its sister publication Model Engineer are teaming up with the Society of Model and Experimental Engineers to celebrate our joint 125th birthday in 2023. To mark the occasion we will be attending the Midlands Model Engineering Exhibition, organised by Meridienne Exhibitions.

SMEE at MMEX

Celebrating its shared 125th Anniversary with Model Engineer, the Society of Model & Experimental Engineers (SMEE) is preparing a larger stand for the Midlands Model Engineering Exhibition. Meridienne, the exhibition organisers have kindly allocated a 40' x 8' stand to allow the society to mount a much larger

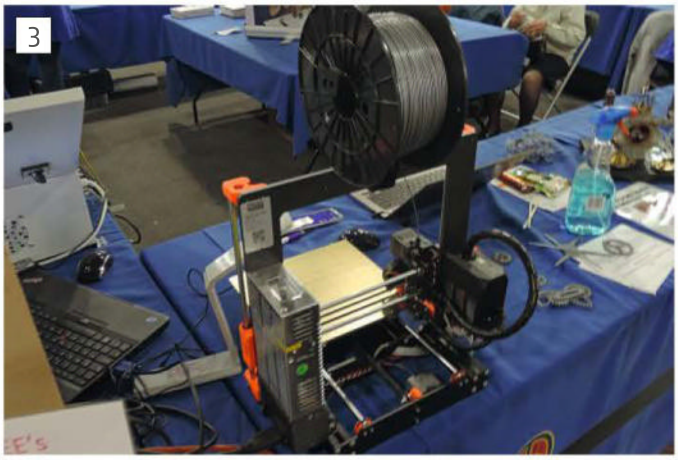
1

Maurice Fagg and Mark Noel with Mark's Multigrind, as featured in MEW issue 242 in 2015.



2

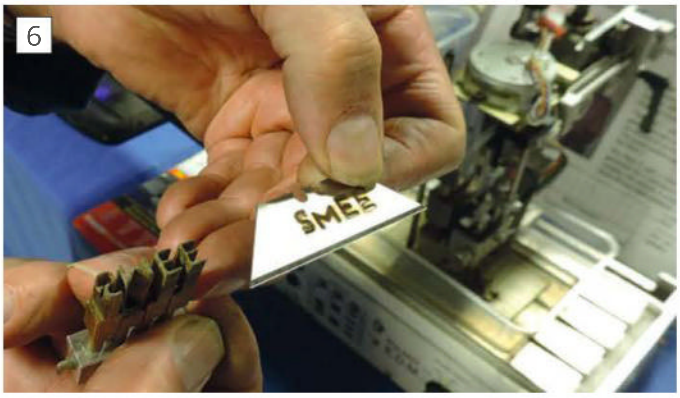
Drill sharpening in 2015. The interlocking opposed vees automatically centre the drill at the right height.



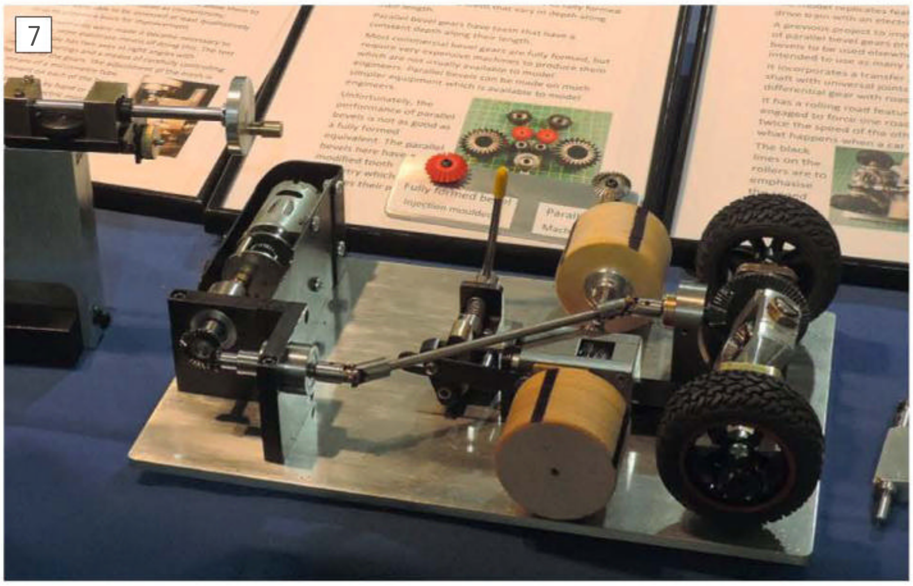
A 3D printer in 2018.

Prototype spark eroder in 2014.

Neal Read demonstrates hand scraping in 2015.



An interesting demonstration of the spark eroder in 2016.



The SMEE stand at MMEX in 2022.

Bob Reeves differential gear demonstration in 2022.

display covering its history, from its foundation by Percival Marshall, through to activities today. Ralph Thompson, who has organised SMEE presence at the Midlands Show for some years, said "Trying to compress 125 years of history whilst also representing current members work and our range of activities is quite a challenge. We plan to include many fine models from our collection including some rarely seen examples of work by Cherry Hill, James Crebbin, and Bill Carter". The stand will also include a range of interesting work from current members, including Peter Wardropper's superb "River Darenth". Other parts of the stand will include demonstrations of lathe work and Neil Wyatt's 3D resin printer, and information about training courses, the talks programme which go out on Zoom (as well as being 'live') and the facilities at the Society's HQ, Marshall House.

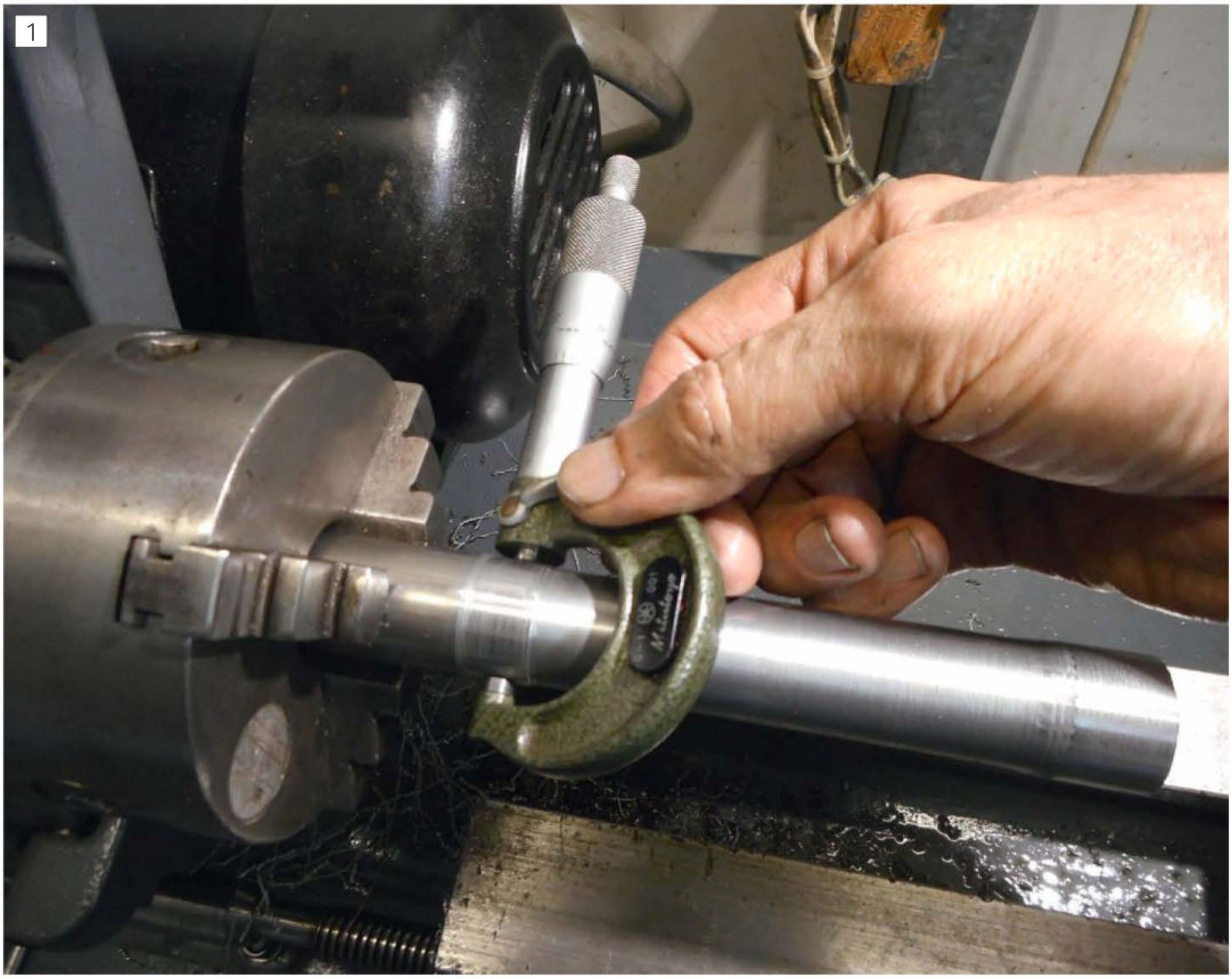
The accompanying photos show various aspects of the SMEE display stand at various exhibitions in the past.

Set Up Your Lathe to Turn True

Pete Barker makes a firm foundation for his Myford and installs the lathe without using an expensive precision level.

Much ado is made of setting lathes level to persuade them to turn true with no taper along the job. But the term "level" is a misnomer and refers simply to using an expensive precision level to make sure both ends of the bed are aligned in the same flat plane, within tenths of a thou per foot, regardless of whether truly level overall or not. It is indeed possible, and quite easy, to set a lathe up to turn parallel, **photo 1,** without using a precision level at all.

First you need a firm base to work from. After the rebuild and wide-guide conversion of our Myford ML7, the time came to move it from the overhaul bench to its permanent home. But, oh dear, that bench was a flexible piece of 1/4" steel plate with a leg welded on to each corner by a previous owner, **photo 2.** Strong enough for a general work bench but very saggy under the weight of a lathe.



Measuring a six-inch test piece to set a lathe to turn parallel without using a level. Note the centre section is relieved to speed up test cuts of the two larger bands at the ends.

Four stout legs, but the unsupported flat plate benchtop was not suitable for the weight of a lathe.

Reinforcements required

The first step was to haul the bench out into the daylight and weld a 1-1/2" steel angle framework under the benchtop. A ladder design was used, with a lengthwise runner front and back with multiple cross-members joining them, **photo 3.** Two of these cross-members were set to coincide with the lathe's mounting bolts to provide maximum support from lathe bed directly to the framework. The steel angle was clamped to the benchtop and tack welded evenly to get the plate as flat as possible before final welding in a series of longer stitch welds. Braces were also welded between the legs to stiffen up the whole assembly, **photo 4.**

After a lick of paint, the bench was moved into position and suitable

Welding steel angle support rails under the bench top.

The completed bench with extra steady rail around the legs.

Sheet metal shim placed under one wonky foot of the bench to take up the gap before bolting down with the concrete anchor bolt.

Standard machinists level used to set bench top to slope slightly backwards for oil drainage in the drip tray.

anchor bolt holes drilled into the concrete floor. Before bolting down, a shim was placed under the one foot found to have a gap under it, **photo 5.** This essential step ensures the bench is sitting unstressed and not pulled out of shape. I shimmed mine so that a standard machinist's level, **photo 6,** which is about half as accurate as a full precision level, showed the bench was slightly low at the back, so that oil and coolant in the drip tray would flow that way. Just a personal preference. And one day I might put a drain hole and catch tank back there.

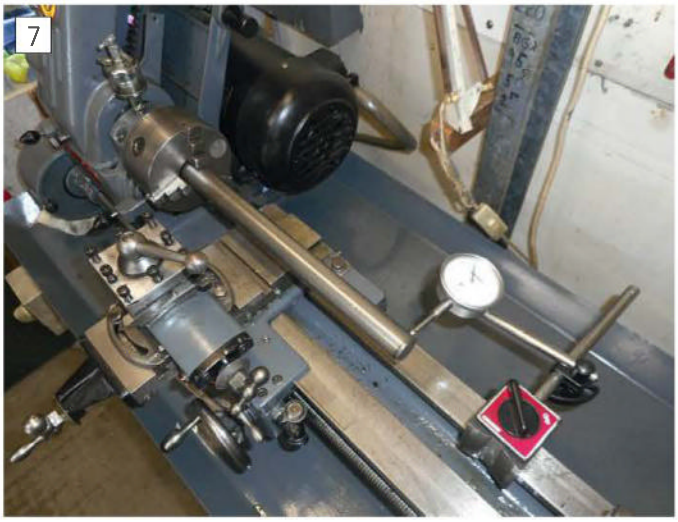
After fitting the homemade drip tray and raising blocks to the bench top, we slid the lathe off the old bench on to the new using some blocks of wood. Removing the motor, cross slide, chuck and tailstock first made it very manageable. After reassembly, the machine was ready to be "levelled" and set to turn true over the length of a test piece.

Please mind the gap

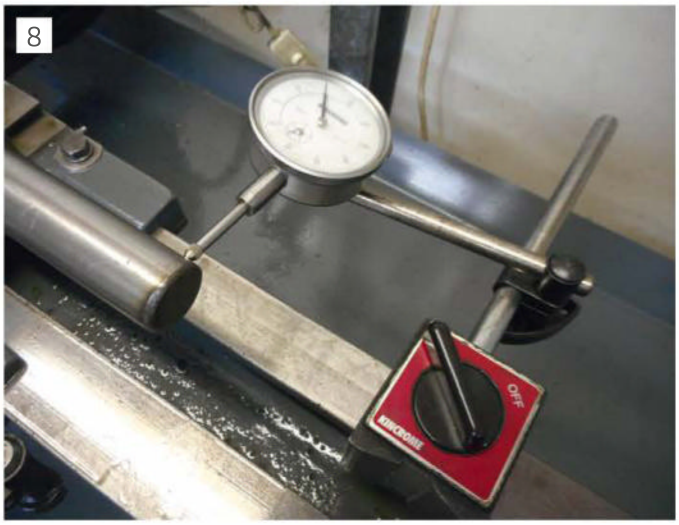
This next step was the same as when bolting down the bench: find any foot on the lathe bed with a gap under it and fit a shim to fill it. Shim was a simple square of brass shim sheet the right thickness with a slot cut in it to slide around the mounting bolt. If your lathe has the adjustable screw type raising blocks, adjust the nuts on all four up to meet the base of the lathe so it sits firmly with no gaps or rocking. In our case, a five thou shim was needed under one tailstock foot to get all four feet sitting firmly grounded. Nothing to be concerned about. Structural steelwork like a bench is lucky to be that close to flat. Ten, fifteen, twenty thou or more would not be surprising.

Next, we followed the suggestion in the Myford ML7 User's Manual for setting up the lathe in the absence of a precision level. A piece of 1" diameter round bar was gripped in the chuck, protruding about 12". A dial indicator was set to bear on the far end of the bar, with the plunger set to indicate any movement in the horizontal plane and the dial then set to zero, **photo 7**. The object was to tighten down all four mounting bolts without moving the needle. Any variation indicates the bed is being twisted by the torque on the mounting bolt and a suitable shim needs placing under that foot, **photo 8**. In my case, after adding the one shim, I tightened down the two bolts at the headstock end first, **photo 9**, then the two tailstock end bolts evenly. No movement of the needle showed my shimming was all good. This meant the lathe bed was now sitting in its "natural" unstressed state. Assuming that it has not developed a twist of its own over the years, the bed should be sitting straight like this. Assuming.

Just out of interest, at this stage I put the standard machinists spirit level across both ends of the bed and checked it, **photo 10**. It confirmed, roughly, that the lathe was consistent from end to end, but angled slightly to the rear along with the bench, so oil and coolant would run to the rear of the drip tray. So far so good. But we must



Dial indicator bears on end of steel bar while tightening down mounting bolts to ensure no distortion of the bed in the process.



Any movement of the needle while tightening down the bolts shows a shim is needed under that foot of the lathe bed.

Tighten down mounting bolts evenly.

Standard machinists level roughly shows both ends of the lathe bed are out of level, but by the same amount, so all is good.

remember this is not a true precision level, and that it is sitting on the bed ways with a small amount of wear from 60 years of use, which could throw a more sensitive level out of kilter.

Moment of truth

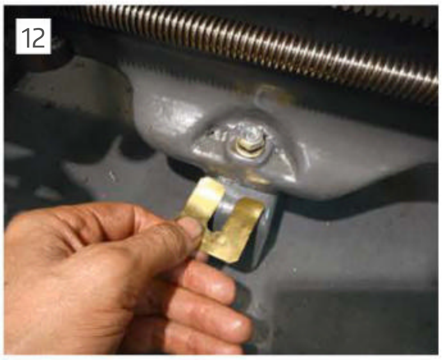
Then came the acid test: turning a test piece. This is the only way to really tell how your lathe is performing under load while taking a cut. Even lathes set up to perfection with a precision level can need this final adjustment to cater for slight movement and flex under load. That's another good reason to forget the precision level and go straight to the real-world turning test. The test is very simple. A piece of 1" diameter bar is gripped in the chuck with 4" to 6" protruding. The shorter option is probably good enough for general work. We opted for 6" just to see if it could be done. The chuck should be known to have good jaws, either freshly reground like mine or use the four-jaw which tends to have less wear and grips better by nature.

Note that no tailstock is used for this test. We are aligning the bed itself with the headstock spindle here and are assuming the headstock has not been moved from its original factory setting. Tailstock alignment is a separate process, covered earlier in issue 290 before the lathe was moved to its new bench.

The test is to simply take a light cut along the length, say one or two thou deep, with a very sharp high-speed-steel tool bit. The centre section can be relieved with a deeper roughing cut first to speed things up if you like. The two remaining narrow bands are then cut at the same cross slide setting and measured up, **photo 1**. Both should ideally measure the same, or within less than half a thou at most. Mine measured up to have just over one thou taper over the 6" cut. So a two thou shim – the thinnest we had -- was added under the front mounting bolt pad on the tailstock end. Another cut was made along the test piece and the measured taper was down to less than half a thou. The two thou shim was replaced with a three thou item. Final cut along the test piece showed a taper over 6" to be in the region of one or two tenths of a thou, more than good enough for this home hobby workshop.

The rule for shimming is if the test piece measures larger at the free (right-hand, end, add shim to (or raise the threaded adjuster, to raise the front foot at the tailstock end. If the test piece measures smaller at the free end, shim or adjust to raise the rear foot at the tailstock end. Shims are cut with tin snips or even scissors, with an open slot to go around the bolt, **photo 11**. Tap any burred edge down flat with a hammer on a steel surface. Shims can be slid in under the foot with the bolts loosened off and then retightened, **photo 12**. You can see that the amount of shimming needed is minimal. Steady, steady is the name of the game. Tip: Always cut the corners off such shims as shown in the picture. Corners left sharp can cut unwary fingers to the bone, which is very painful.

Shims cut from brass stock with scissors or tin snips.

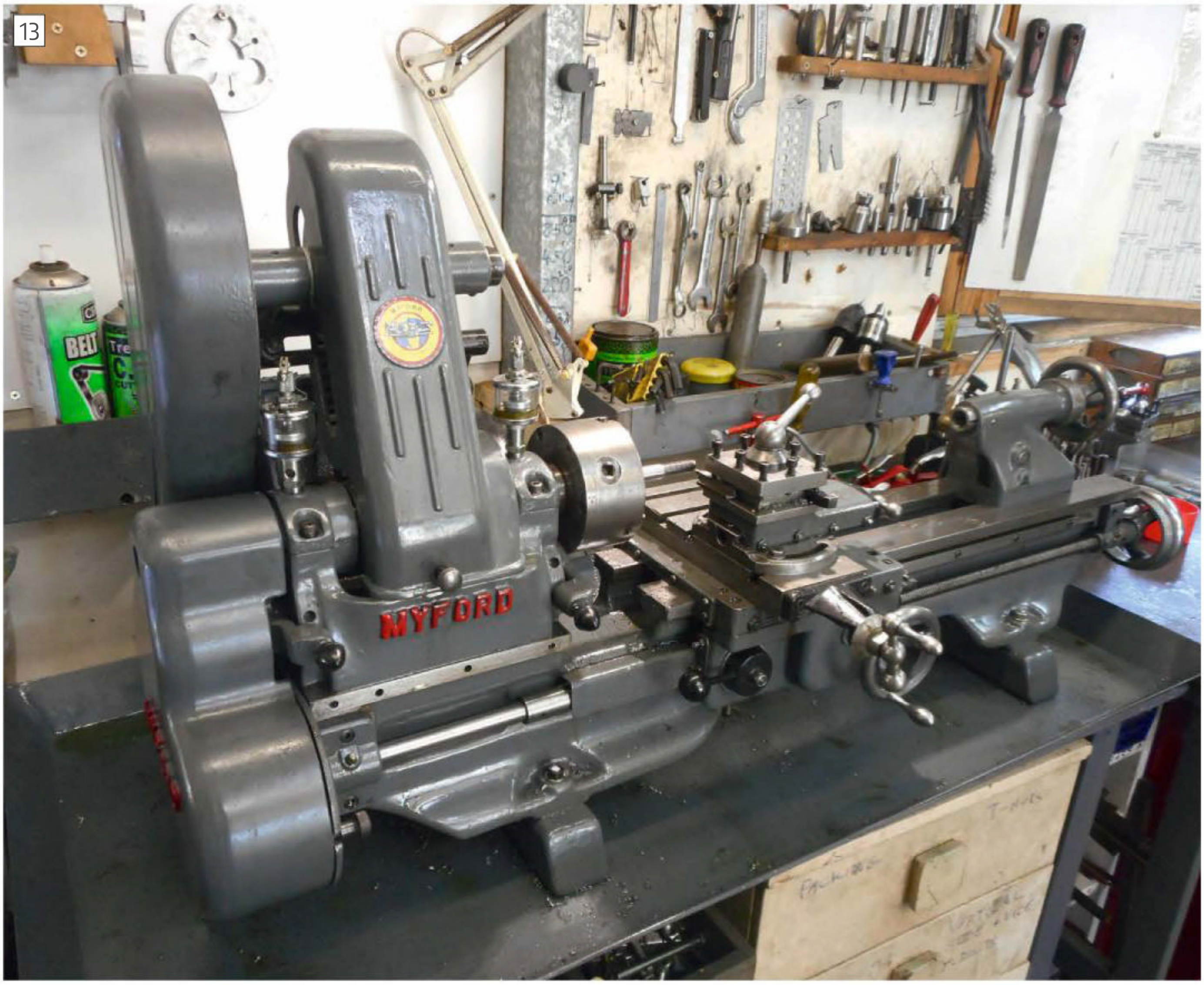


Shim slid in around mounting bolt.

Conclusion

The lathe has since been pressed into service on a number of jobs, **photo 13,** and has been found to continue to turn parallel over the length of typical jobs with no taper apparent. All done with no expensive engineer's precision level, on a lathe sitting slightly off level for the sake of oil drainage and set up in almost less time than it has taken to write about it.

The taper turning test has proved to be an effective way, in conjunction with the dial indicator method of bolting down, of setting a lathe to turn parallel under real-world conditions with no need for an expensive precision level.



Lathe turning jobs true. And oil running to rear of drip tray.

From the Model Engineer Archive

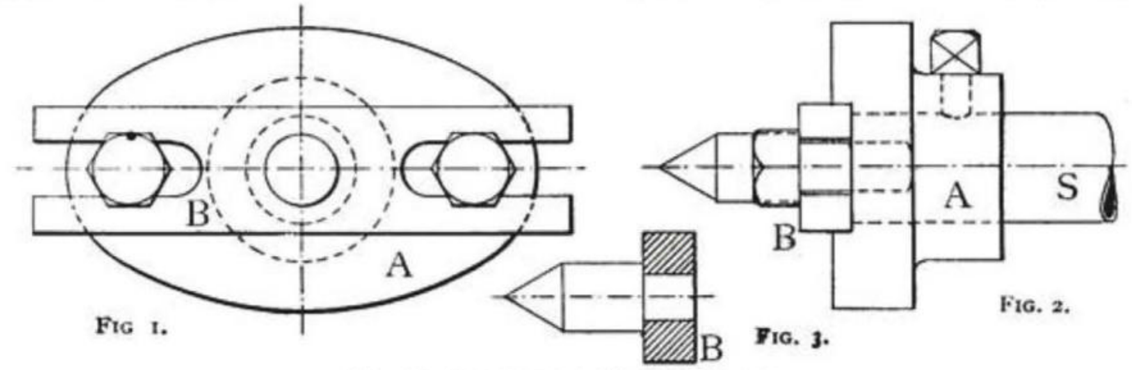
Workshop Notes and Notions.

[Readers are invited to contribute short practical items for this column, based on their own workshop experience. Accepted contributions will be paid for on publication, if desired, according to merit. All matter intended for this column should be marked "WORKSHOP" on the envelope.]

A Taper Turning Attachment for the Lathe.

By C. HAWKINS.

The accompanying sketches represent a handy and easily made appliance for providing lathes (which are not provided with an offset tailstock) with a taper turning arrangement. It is readily adjusted, and can be set to produce the required taper in a few minutes.



AN ATTACHMENT FOR TAPER TURNING.

The casting A is made from a gland pattern, and is bored to fit the tailstock spindle S, and is fastened by a setscrew as shown. In the casting a groove is planed or filed about ½ in. deep into which a forging B is made a sliding fit. It will be seen that this piece has slotted ends for adjustment, and is fastened in position by two setscrews. The steel centre is either screwed into B, or may be made a driving fit into B as shown (Fig. 3), the back to be filed flush.

Care should be taken to make the groove central, *i.e.*, half above and half below the line of centres, so that the new centre will be the proper height.

Metal Turning Notes.

By W. G. B.

When square-centreing steel forgings, &c., for turning, the sharp bits formed in and around the hole, which are rather awkward to remove by wiping, will fall off if the end of the work be dipped in "soda-water," the same as used for a turning lubricant. Also, the annoying jarring which often accompanies the turning of work of fairly large diameter, when a heavy cut is taken, can generally be abated by placing a pad of waste between the carrier and the driving pin.

A Hint to Users of Leclanche Batteries.

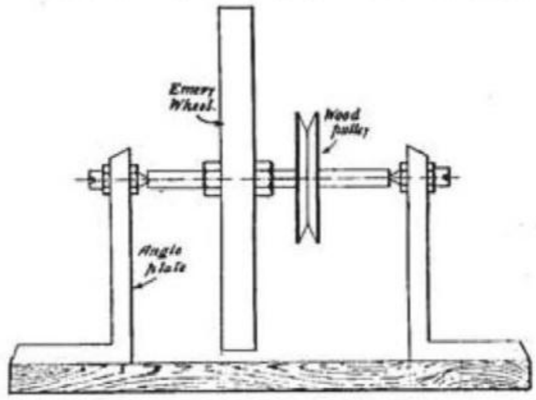
By G. W. MORTIMER.

There may be many, like myself, who are large users of Leclanché batteries. To keep on recharging the batteries is an expensive item for any with slender pockets, so this hint may not be wasted. I have used salt and rain-water for a considerable time now and find it quite as good as sal ammoniac. The best way to recharge them is as follows:—Measure out the quantity of rain-water that you require, and then dissolve as much salt as possible in it. Pour in the batteries, and then close the circuit for about a quarter-of-an-hour, afterwards leaving the cells for at least twelve hours, when they will be ready to use again. If the current is not *quite* sufficient it can be augmented by putting an extra zinc rod in one or two of the batteries. When the batteries begin to weaken, add a little more salt and give them a rest, when they will regain their former strength.

A Substitute for an Emery Wheel.

By H. G. T.

Emery wheels are an expensive item in the amateur's workshop; really effective substitutes may be made as follows:—Turn in the lathe wood wheels ⅛ in. smaller in diameter than the emery wheel required, but full width. Cut a strip of ⅛ in. leather the width of the wheel, which is then glued and the leather fastened on with wood pegs made of match sticks. When the glue is set, glass-paper the leather to give smooth surface, then glue the leather all round and dip in emery powder; when set, repeat. The sides of the wheel may be treated in a similar manner if so desired; the emery may be renewed at any time.



A SUBSTITUTE FOR AN EMERY WHEEL.

Bore a hole through centre of wheel, cut a thread on spindle, and fix wheel on with a nut each side; centre punch ends of spindle. The wheel may now be run between lathe centres by driver chuck, or two angle plates may be forged as in illustration, centre-points and a wooden pulley turned and fitted, and the wheel driven by a strap from the treadle-gear.

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 are 'Workshop Notes' articles from earlier Model Engineers. The first, from Volume 9, No 128 – October 9 1903, features an offsetable tailstock for taper turning and an alternative to an emery wheel. The second is from Volume L (50) No. 1184 – January 3 1924. I can recommend the modified D-bit for flat bottomed holes and countersinking tip, but the bell chuck could present a hazard with all the protruding screws – if you copy this, use a suitable guard.

SMEE & MODEL ENGINEER
Celebrating 125 years
A Joint History of Model Engineering

24 The Model Engineer and Electrician. January 3, 1924.

Workshop Notes and Notions.

Short practical notes of workshop interest are invited for this column. Contributions must be based on the sender's own experience and should be marked "WORKSHOP NOTES" on the envelope. Accepted items are paid for within a few days. Unaccepted notes will be returned if a stamped addressed envelope be enclosed.]

A Bell-Chuck from Scrap.

Like most engineers I am very fond of making tools from odds and ends picked out of the scrap-box. The bell-chuck here illustrated and described was made from old bronze motor-cycle bearings.

The first stages of construction are shown in the sketches. Fig. 1 shows simply a plain bush

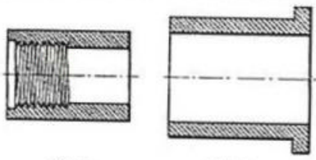
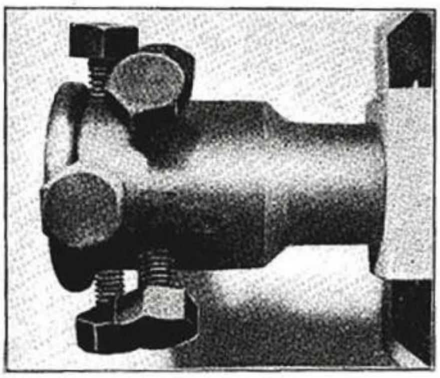


Fig. 1. Fig. 2.

screwed to fit the lathe nose. It is necessary to counterbore this to bed well on the mandrel-collar.

When fitted to satisfaction turn down to fit the bore of Fig. 2, which is also a bush, but in this case has a flange. When the flange is finally rounded off as shown in the photo it adds considerably to the appearance of chuck.

After turning the first bush to size, the



The Completed Bell Chuck.

second, or bell proper, is sweated on and pinned with brass pins driven through both. Drive pins a little below the surface and solder the ends over. It is then put on the nose and turned up in *situ*. It only remains to drill and tap eight holes for the set-screws. These are ¼-in. Whitworth.—J. A. LLOYD, M.B.A.A.

Square-ending a Drilled Hole.

It occasionally happens that, for some reason or another, a blind hole is required to have a flat bottom instead of the hollow cone as left by the ordinary drill. A method which can be successfully adopted where only one or two holes require such correction is to take a piece of silver steel of diameter equal to that of the hole, and file away half the thickness at the end, leaving a somewhat hooked lip as shown in Fig. 1. The half-diameter remaining must now be slightly backed off, taking care that the edge is kept straight, and at a *very slight* deviation from the true perpendicular to the axis. On hardening and tempering this to a straw, it can be fed gently into the hole, when it will remove the cone portion, and leave the bottom of the hole nearly flat, really a little higher in the

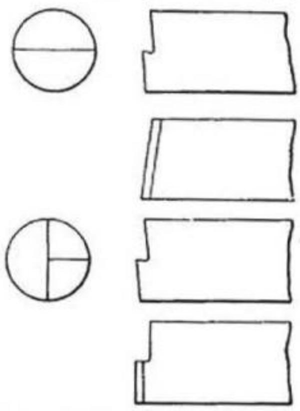


Fig. 1.

Fig. 2.

Making a Tool for Bottoming a Drilled Hole.

centre. For some purposes, such as valve seats, this is all to the good, and in most cases it is too slight to be of importance. If, however, a dead-flat bottom is desired, all that is necessary is to finish the drill end *quite* square across, and then remove half the cutting edge altogether to allow for cutting clearance (Fig. 2).—NATHAN SHARPE (Member, S.M. & E.E.).

Countersinking.

When countersinking holes in the drilling machine considerable difficulty is usually caused by the drill chattering and running out, entirely spoiling the appearance of the work.

The following dodge entirely obviates this :—

A piece of old rag is folded over two or three times, and laid over the hole. The drill is then fed down carefully, and as soon as it is felt cutting through the rag, it is withdrawn, a fresh part of the rag placed over the hole, and the process repeated several times.

Myford Super 7 Lathe - Neil Wyatt

On the Wire

NEWS from the World of Engineering

Chester UK announce their next Open Week.

Chester Machine Tools are pleased to announce their forthcoming Open Week this September 18th-22nd at their Hawarden showroom.

It's the perfect opportunity to check out their latest range of metalworking machines including lathes, mills, and drills. Alongside some great offers throughout the week.

Why not come along and visit Chester at Hawarden Industrial Park, Clwyd Close, CH5 3PZ this September 18th-22nd. For more details contact sales@chesterhobbystore.com

The Airbrush Company Courses

The Airbrush Company has been holding courses since 2006. They are often told that there are very few companies who are offering airbrush courses, so we have students travelling from all over the UK, and even further afield!

The courses are for those who are struggling with their new airbrush, those who want to progress their current skills, or those who simply want to try airbrushing before they commit to investing in equipment. They are ideal for anyone who wants to get started in airbrushing, or who has problems getting started with their They.

We offer airbrush training taught by expert tutors on nearly every application, from beginners to advanced. These include custom painting, art & graphics, model painting and even cake decorating! Students have the chance to get hands on and try out various airbrushes, learn how to master a huge range of techniques, plus buy products at a student discount.

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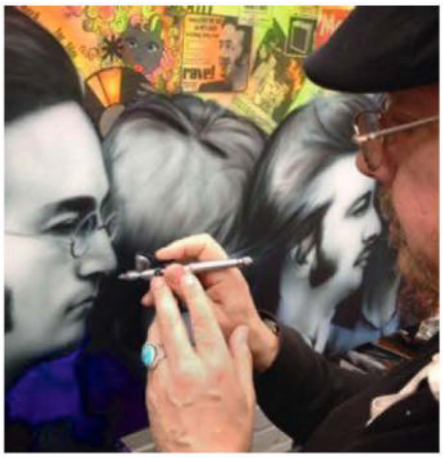


Setting up for Milling a Compound Angle

R. Finch explores the mathematics behind setting up complex angles for milling or sharpening.

I have been making a drill sharpening jig which has a slide used to position the drill at a suitable radius for grinding the point. The drawing for the slide has a pair of angles making a compound angle. The drawing is shown in **fig. 1**. The two principle angles are 31°, which is the complement of the 59° point angle of a standard Jobber's twist drill. In my simplistic way, I mounted the slide on an angle vice tilted at 31° and then rotated it by 31° to set the two 31° angles. This is shown in **photo 1**. As an aside, my low cost angle vice did not have any machined datum on the base casting at all, so first I set the vice upside-down in the normal milling vice and machine two datum faces parallel

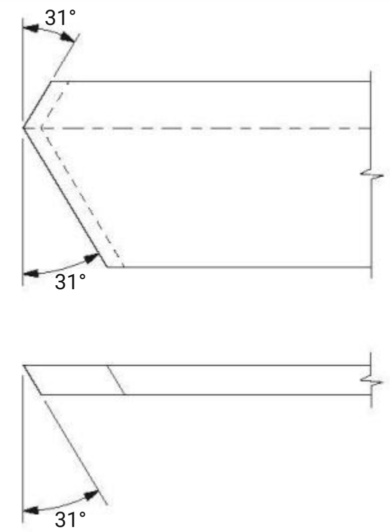
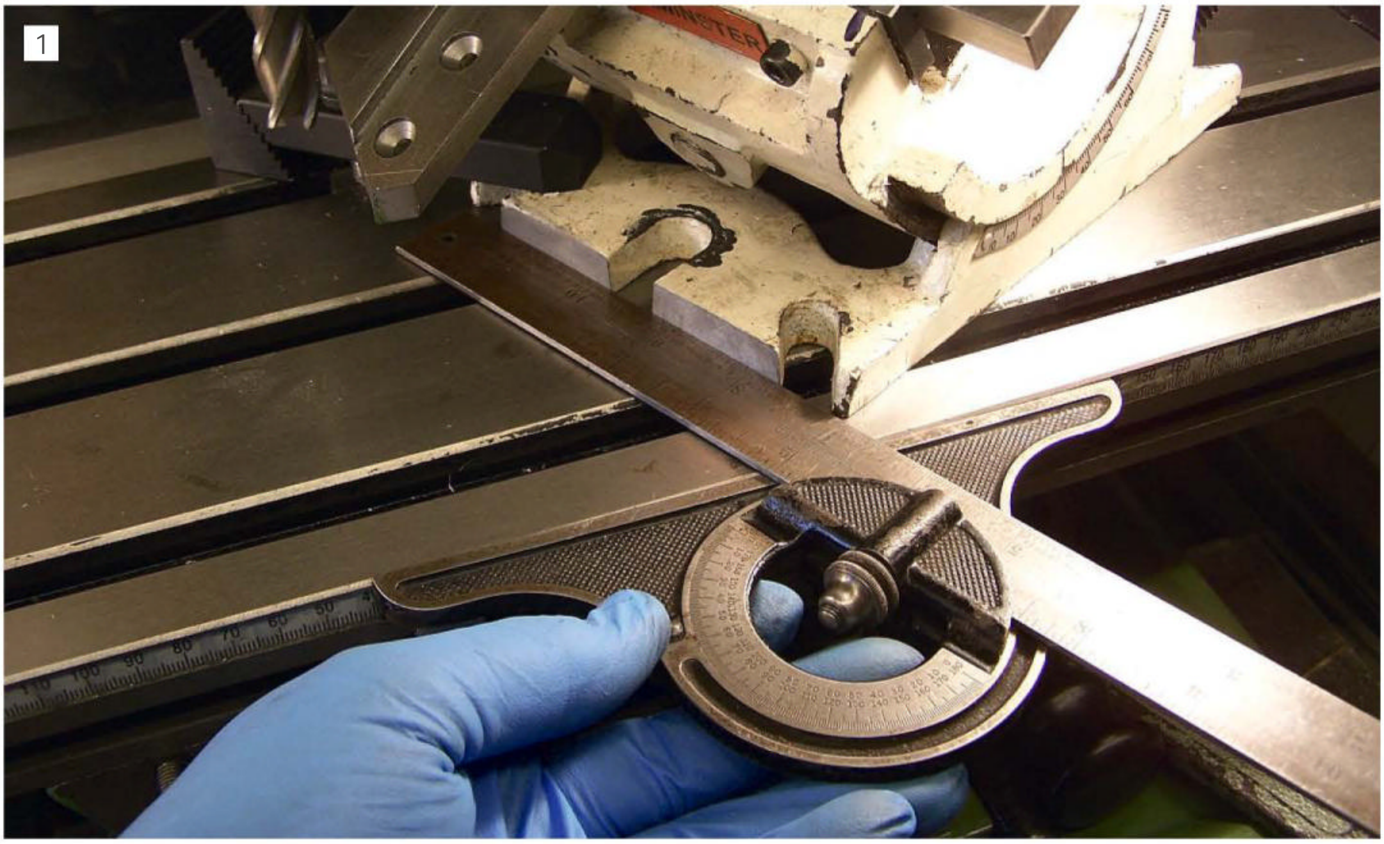
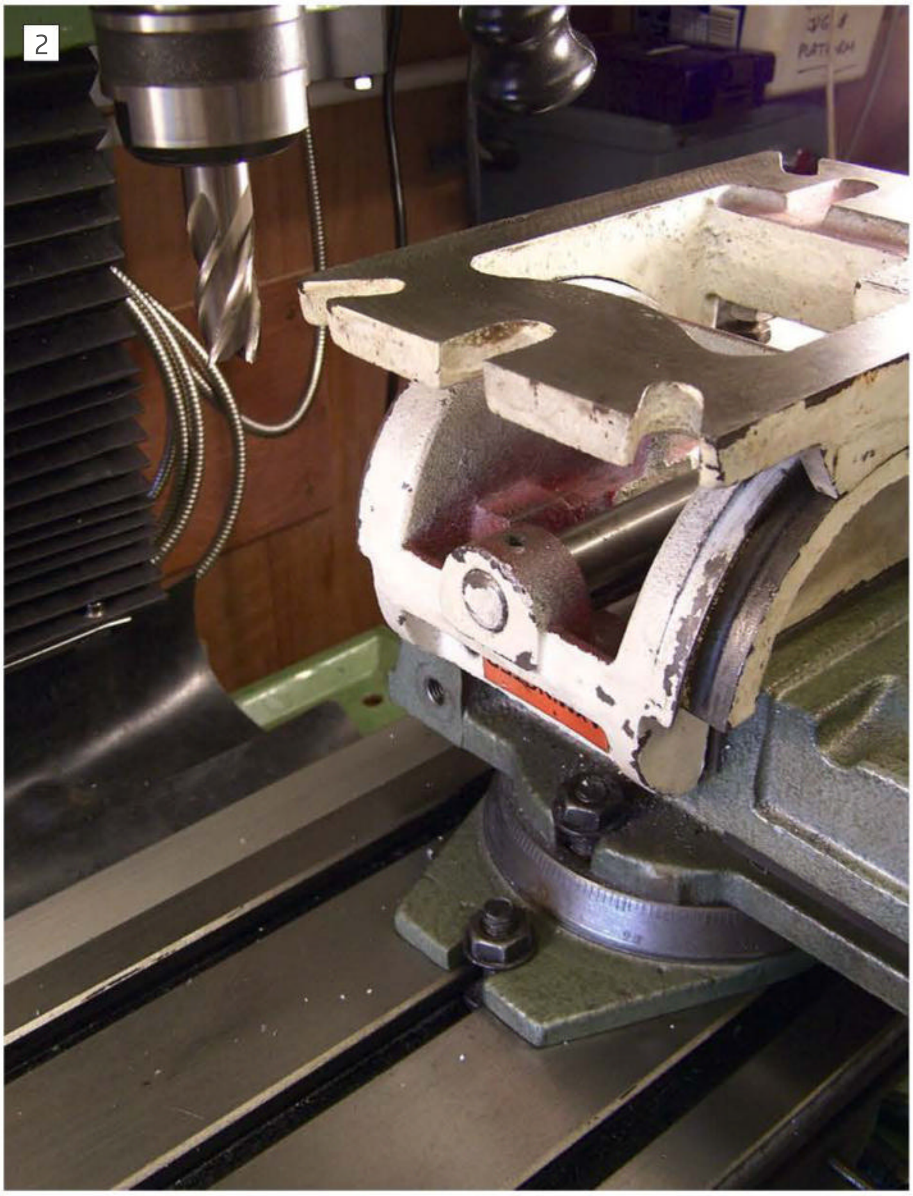


Figure 1. The two 31° angles as drawn.



The angle vice tilted and rotated.



Ready to machine one of the datum faces on the base of the angle vice.

to the jaws on the base of the tilting vice as shown in **photo 2**.

Just before I started the cut, I realised that the scribed line at 31° on the slide looked as if it were not parallel to the table on the milling machine and so I would not machine the compound angle correctly. Working on the principle that if it doesn't look right, then it probably isn't right, I decided to work out what the correct angles should be for setting the vice. Hands up all those who would have set the angles at 31° like I did – it is an easy mistake to make. A real case of measure twice, cut once! (The angles would have come out at around 35° instead of 31° after calculating the correct angles.) This left me with a problem – how do I make sure that the angles that I set for the tilt and rotation of the vice give me the correct 31° angles as in the drawing? I decided to retreat from the Workshop to have a think. I concluded that I should draw out exactly what I had and then try to solve the problem analytically using geometry.

Those with a 3-D CAD package could easily draw it and determine the correct angles. As I only have a 2-D drawing package, I had to draw an isometric sketch of the set-up shown in **fig. 2**. To understand this, the line AB is the vertical line of the edge of the slide when horizontal on the milling machine table and represents the line of the end-mill cutter.

Tilting the vice by the angle T moves the line to AC. By rotating the vice by angle R, it moves the line of the slide to AD. The length of the line BC is given by AB × tan (T) where T is the angle of tilt of the vice.

From this, the line BD is given by BC / cos (R) where R is the angle of rotation of the vice. The compound angle which must be 31° is determined as $\tan^{-1}$(BD / AB)

For those a little rusty on their geometry, $\tan^{-1}(X)$ is means "the angle whose tangent is X".

Since BD = BC / cos (R)
and BC = AB × tan (T), the compound angle is given by
tan (31°) = AB tan (T) / AB cos (R).

As AB can be cancelled from the top and bottom of the equation, the result is tan (31°) = tan (T) / cos (R) which is the required equation to solve.

This immediately presents a problem in that there is only one equation but two unknowns – T and R – so it cannot be solved directly. However, there are two ways of dealing with this problem. The first is to fix one variable, such as T and then calculate R. This has the problem that fixing T may well make the resultant angle R impossible or the equation indeterminate. The second method is to make the two angles equal, such that T = R, which then reduces the equation to tan (31°) = tan (T) / cos (T).

Using a pocket calculator determines that tan (31°) = 0.60086, so the equation becomes: $0.60086 = \frac{sinT}{cosT}$. However this needs re-arranging so that the unknown angle T is on the left-hand side and fortunately, help is at hand.

There are two trigonometrical identities which are $tanT = \frac{sinT}{cosT}$ and $cos^2T + sin^2T = 1$. Using the first identity of $tanT = \frac{sinT}{cosT}$ results in the equation: $0.60086 = \frac{sinT}{cos^2T}$.

Now since $cos^2T + sin^2T = 1$ it follows that $cos^2T = 1 - sin^2T$ and substituting in the equation gives $0.60086 = \frac{sinT}{1 - sin^2T}$ which can be re-arranged as:

$0.60086 \times (1 - sin^2T) = sinT$.

Multiplying out the brackets gives: $0.60086 - 0.60086\, sin^2T = sinT$. and re-arranging gives: $0.60086\, sin^2T + sinT - 0.60086 = 0$.

This is a quadratic equation which can be solved using the standard formula:

$x = \frac{-b \pm \sqrt{(b^2 - 4 \times a \times c)}}{2a}$ which may stir up the grey matter a bit if you remember this algebraical equation from school maths. In this case, $a = 0.60086$; $b = 1.0$; and $c = -0.60086$. Substituting in the equation gives the solution for *sin T* as:

$$\sin T = \frac{-1 \pm \sqrt{(1^2 - 4 \times 0.60086 \times -0.60086)}}{2 \times 0.60086}$$

which simplifies to: $\sin T = \frac{-1 \pm 1.56337}{1.20172}$.

Since the value of a sine must lie between -1 and +1, by inspection, the only possible solution is that of $\sin T = \frac{-1 \pm 1.56337}{1.20172} = 0.46884$ hence the angle required is $\sin^{-1} 0.46884 = 27.956°$ By both tilting and turning the vice by 28° the correct 31° on both the required angles will be achieved.

Having set the slide up at the calculated angles of 28° and then machined the compound angle, the end result was that both 31° angles were machined correctly, and a satisfactory result was obtained. ▮

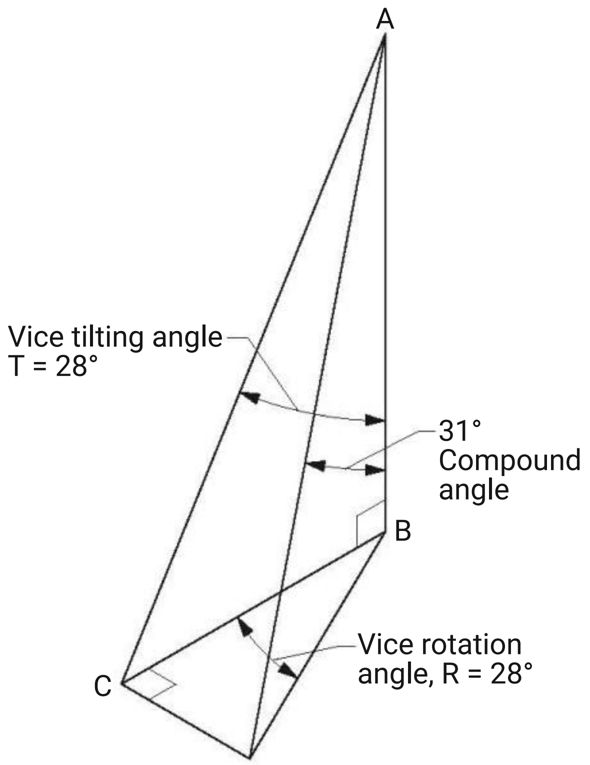


Figure 2. The geometry of the compound angle resolved into two axes.

Readers' Tips

A Briquette Splitter for Live Steamers

TIP OF THE MONTH WINNER!

1

This month's winner is Derek Spedding who found supplied fuel was too chunky for his steam wagon. Another nice example of traditional skills matched with 3D printing as well.

At a rally recently in place of the usual coal allowance we were issued with briquettes, a variety called Newburn, which I found to light easily, burn cleanly, and give plenty of heat. The only problem was that the briquettes were too big for my 4 ½'' Foden Wagon. For

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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.

the duration of the show I coped with that by smashing the briquettes up with a club hammer, but that was a messy business with a good deal of waste, and a better method was required.

My solution, quickly knocked up from material to hand, is shown in the attached photos. This was designed to sit on an old builder's bucket, **photo 1**, with the jaws made from 20mm angle iron 80mm long, **photo 2.** They are hinged so that the jaws are around 30mm apart when parallel, which seems to be a good size, **photo 3**. The guillotine is tacked onto a piece of 40mm square tube, and 3D-printed caps hold everything in place on the bucket, **photo 4**. A bit of old curtain pole makes a comfortable handle. As you can see the contraption splits the briquettes in two very cleanly, with negligible dust or other waste, **photo 5**.

After some use of the splitter I found I needed to beef up the end caps, **photo 6**. I've also clamped the whole thing together with some allthread, nuts, bolts, and washers.

I hope this may be of help to others – the use of alternative fuels is only going to increase from now on.

Bob's Better Bevels – Postscript, part 2

Bob Reeve dives into the big box of better bevels that resulted from his experiments. Continued from last issue.

Each of the cylindrical bearing housings held two ball races. Each housing would then be clamped in a steel plate. The two steel plates being mounted at right angles to each other. The mesh of the bevels was intended to be adjusted by sliding the cassette in its clamp.

Photograph 15 shows a single steel plate already bored to take the two cassettes, but not yet separated into the two separate plates that would be needed. The slitting saw mounted on the vertical spindle of the mill has cut horizontal slots that were intended to provide the clamping arrangement.

With the clamping arms drilled and tapped M4, the plates were separated, and the edges cleaned up. A pair of spacers was machined to locate the motor mounting plate. The plates were all fixed together with more M4 screws. The bearings and motor were then re-positioned and fixed to the baseplate as in **photo 16**.

After some adjustments to the mesh of the bevel gears it all ran satisfactorily at twice the speed of the motor.

The next stage was to design a means of showing how the differential gears behave if one wheel was rotating faster than the other. In full size this occurs when the vehicle negotiates a bend.

The intention was to use a rolling road type of arrangement whereby one wheel was geared to the other so that the pair would rotate at different speeds.

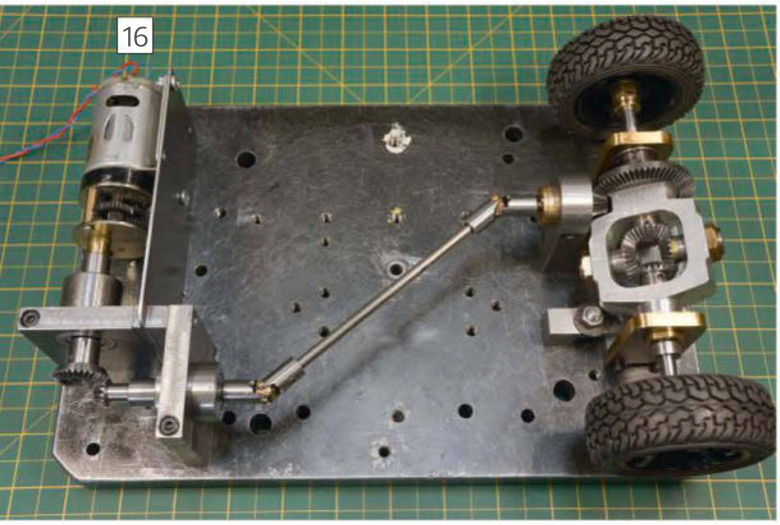
Photograph 17 shows a pair of wooden rollers, cut with a holesaw and left un-sanded to provide the necessary friction for them to be driven by the wheels on the differential.

The rollers were mounted on a temporary axle to show the aluminium drive flanges.

These drive flanges were turned and bored to size then set up on a rotary table to drill the countersunk screw holes. There are quicker and easier ways to do this, but by way of an experiment I chose to use the rotary table that forms the 4th axis from my CNC X3 mill, together with the control unit built to allow the unit to be used independently from the mill, **refs 1** and **2**.

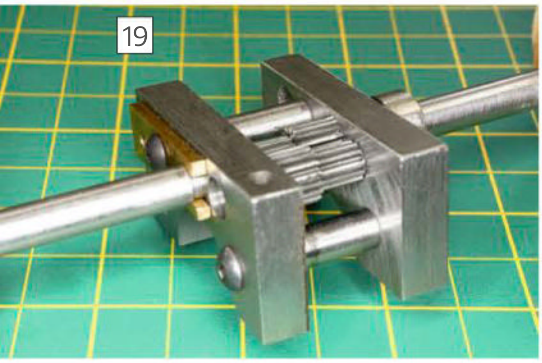
Making cassette bearing holders.

Photograph 18 shows the drive



Working angle drive with speed step up.

Wooden rollers.



Speed reduction gearbox.

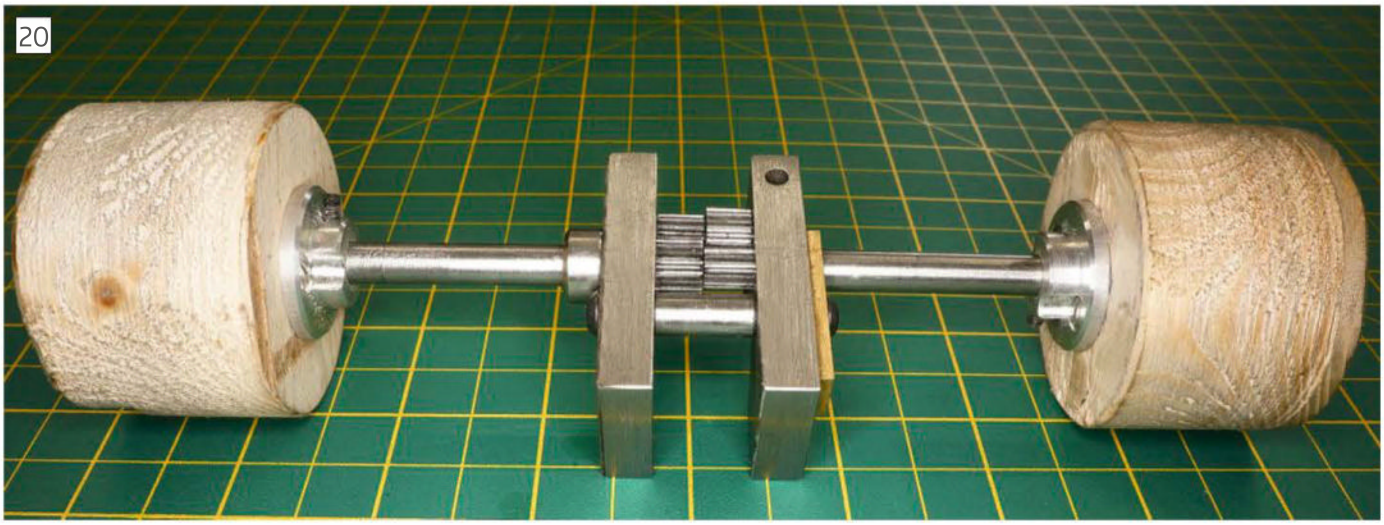
Centring drive flange on mill.

flange being centred under the vertical spindle of my Thiel, with the control unit sitting on the table to the right. Note the rotary table is raised above the table of the machine on parallels. This allowed the Morse taper collet in the centre of the table to be clamped and unclamped with the ratchet spanner in the foreground, without moving the rotary table.

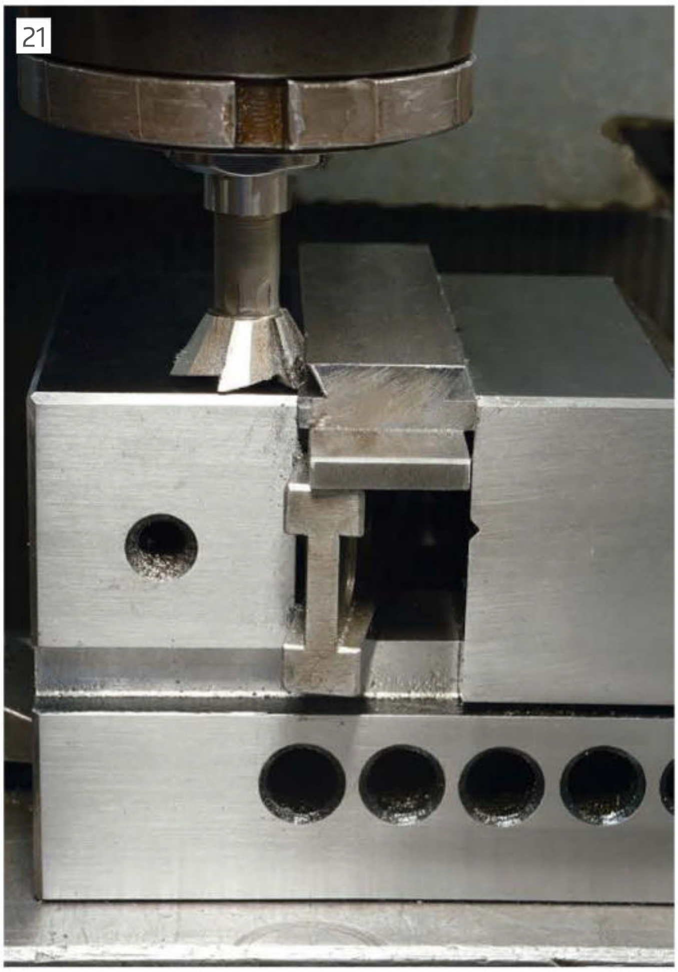
The set up worked just as it should, but next time I'll use the Theil's DRO – the step rate from the controller was much too slow.

To demonstrate the differential capability of the gears required that the two road wheels could both rotate, but at different speeds. Preferably with the speeds sufficiently different to be evident by a simple visual observation. I chose a speed ratio of 2:1 so the rolling road required a gearbox with that ratio between the two rollers. The input and output shafts would need to be in-line and rotating in the same direction. Which implied a three shaft arrangement with a two stage overall ratio of 2:1. To minimise the size the two stages would each need to be 1:√2.

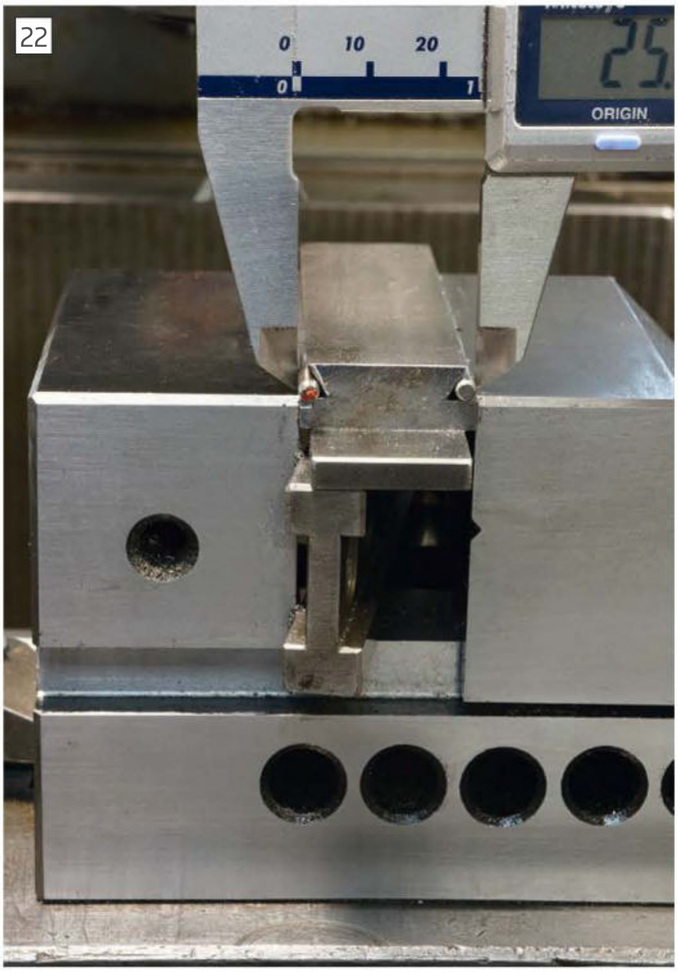
Again to minimise the size, I chose 0.5 Mod. gears with a minimum number of teeth. In this case 12 and 17 teeth giving a ratio of 1: 1.417 – close enough! Conveniently that also determined the input shaft diameter since (no. teeth +2)*module = (12+2)*0.5 = 7.0 mm dia.. The resulting gearbox is shown in **photo 19**.



Rollers attached.



Cutting dovetail.

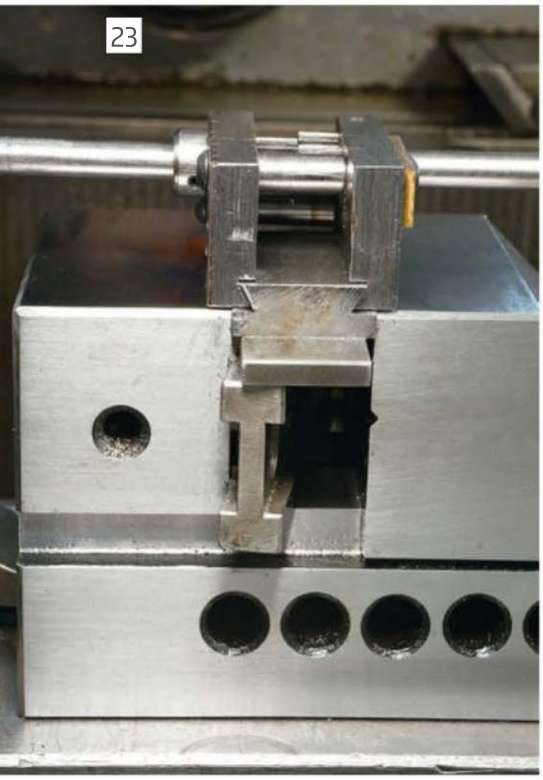


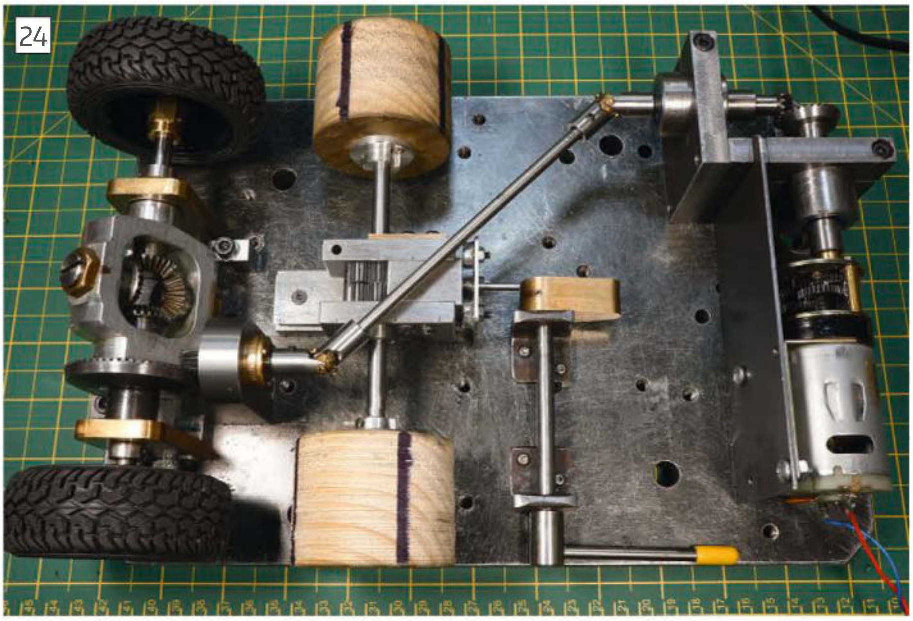
Measuring dovetail, a useful technique.

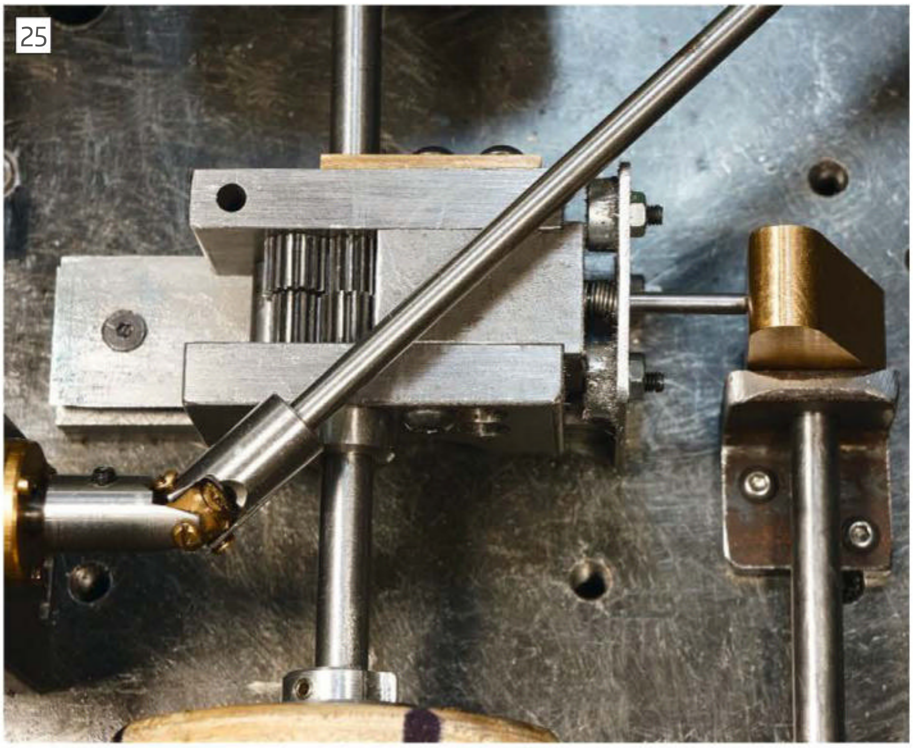
Note that this was not intended to be the final size – in the usual Model Engineering tradition, I used the materials that were lying around. The gearbox was attached to the rollers as shown in **photo 20**.

With a 2:1 ratio and the wheels driving the rollers, then one wheel was rotating at twice the speed of the other. A vehicle with wheels having the same differential speeds would have been travelling in a circle such that the faster wheel circumnavigated a circle twice the diameter of the slower wheel. These two circles would have had a common centre, the same distance from the vehicle as the distance between the wheels and on the side of the slower wheel.

The next step was to attach the gearbox and wheels to the baseplate and provide some means of bringing the wheels into contact with the rolling road. I chose a dovetail slide to do this, mainly because it was compact and required only one additional component (plus screws) providing there was sufficient room to cut the mating dovetail in the base of the


Testing fit.


'Rolling road' fitted to test rig.


Catch and release cam.

gearbox; which fortunately, there was. The downside was that dovetails require careful attention to tolerances if they are to work as intended. In this case the sliding movement was to be achieved by means of a spring, so the dovetail slide needed to be relatively free-moving. Unlike the dovetail slides on a machine tool. **Photograph 21** shows the initial cutting of the dovetail.

The second cut completes the dovetail form, but there was then the tricky business of measuring the result to ensure the mating part fits. **Photograph 22** shows my approach, using small silver steel rollers to establish a width at a known point.

It required a bit of trigonometry to calculate the relevant dimension on the mating part, but readers who have successfully negotiated the earlier parts of this series should have no difficulty with that.

Photograph 23 shows the mating part fitted- after some work with a hand scraper to get it to move freely. An end plate and guide rod were added to the dovetail slide in order to locate the spring. **Photograph 24** shows the mechanism assembled onto the prototype bedplate.

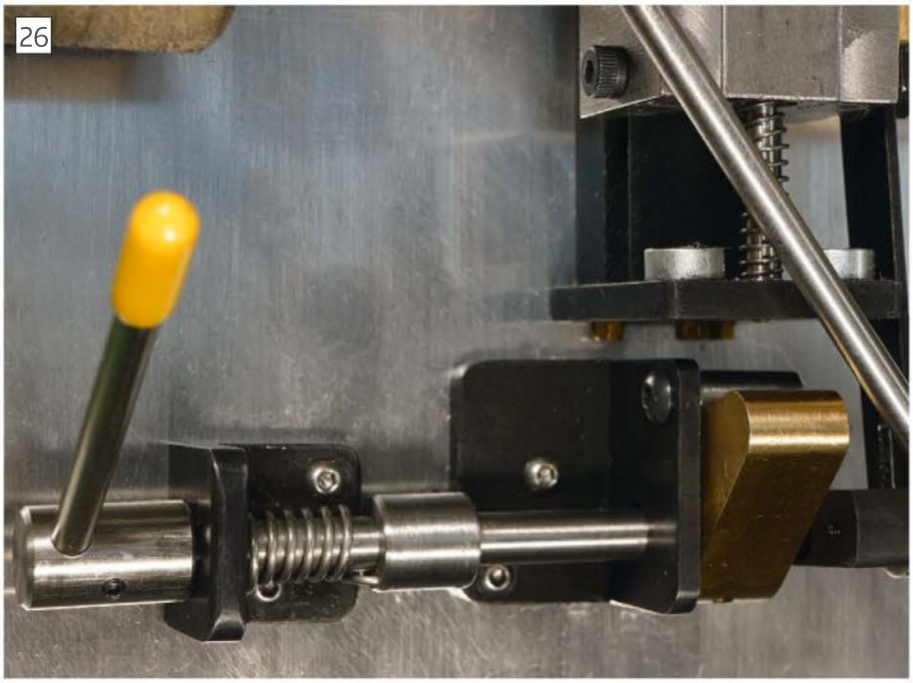
A magnetic latch restrains the slide until the lever with the yellow handle is actuated. The brass cam forces the sliding carriage away from the magnets until the spring takes over and pushes it towards the wheels. Note the black lines drawn on the rollers which are there to emphasise the speed difference between the rollers when running under power.

Photograph 25 shows the magnetic catch and release cam in detail. This worked as it should, but it was soon obvious that I should have made provision for the operating lever to latch the rolling road on the magnets.

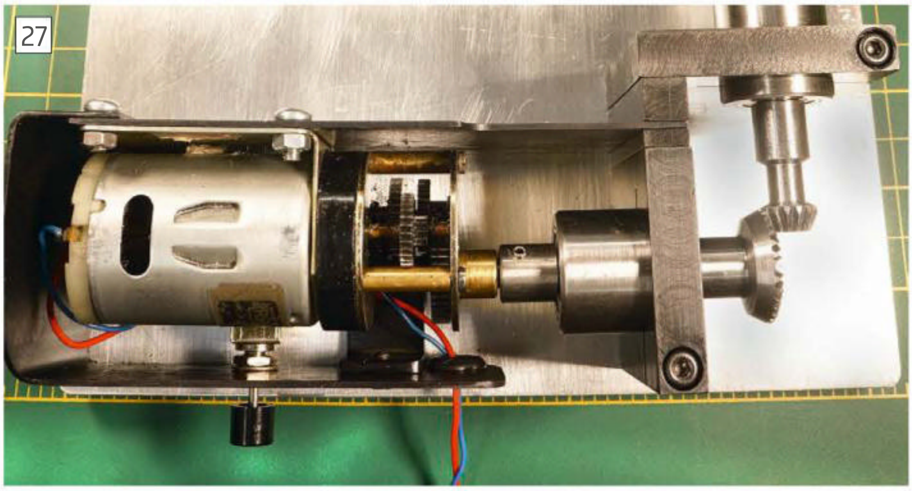
At about this stage I accepted an invitation to display the Differential Demonstrator at the Warwick show. So, the scruffy baseplate had to go and a few other things needed tidying up.

The baseplate was not only scruffy but was also heavy. The all up weight being over 11 kg. It was replaced by much more presentable and portable ¼" aluminium plate.

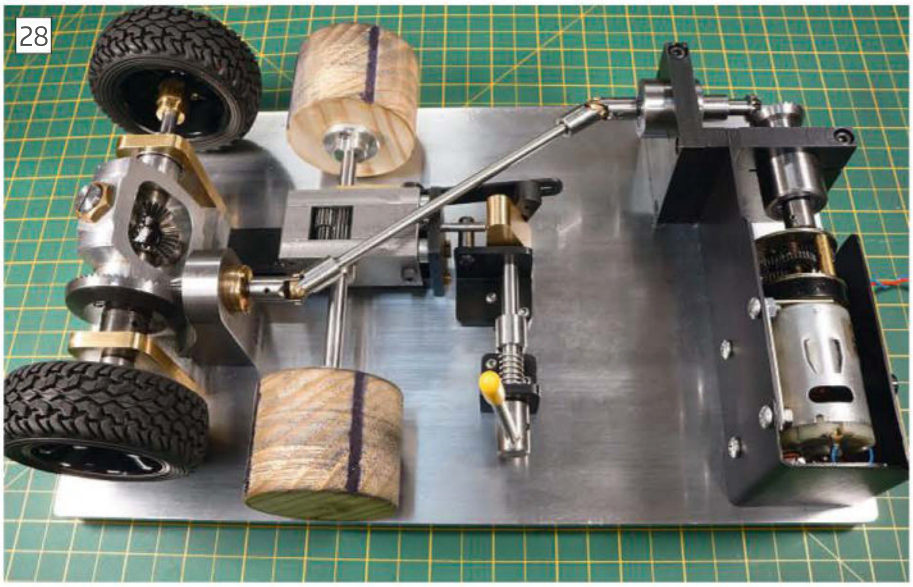
Next up for improvement were the parts in mild steel. I chose chemical ›



Chemically blackened parts.



Motor and switch details.



The finished demonstrator

blacking for some of the parts, but not all. Some were left with their natural finish to contrast with the blacked components. The latching mechanism reset was also added at this stage. **Photograph 26** shows some of the chemically blacked parts including an additional crank web and link bar added to the end of the operating shaft. This was intended to move the gear mechanism on the dovetail slide until it was close enough for the magnets to latch it in place. A torsion spring was added at the opposite end of the operating shaft to return the operating lever (yellow handle) to the upright position.

Unexpectedly, the mechanism in this form did not need the brass cam. If the slot in the link bar was slightly shorter than intended, it could be used to dislodge the gear mechanism from the magnets and allow it to return to its original position with the rollers pressing on the road wheels. Thus rendering the brass cam redundant. However, on balance, including the cam mechanism was considered a more interesting option and the cam was retained.

There was also a need to add an on-off switch. A momentary push-on switch was selected as this would not allow the demonstrator to be left running unattended. The switch can be seen protruding from below the motor in **photograph 27**.

The sheet steel surround to the motor was also chemically blacked, but not without difficulty. The steel in question was left over from an incinerator project. Unbeknown to me this was definitely not mild steel and refused to be chemically blacked. A few moments thought suggested a high nickel and/or chromium content. A short dip in an acid etch solved the problem and it blacked as it should.

Photograph 28 shows the demonstrator ready for the party. In addition, the bevel box now contained significantly fewer bevels.

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1 MEW No. 249. Dec 2016. C Wilson. An Arduino Controlled Indexer.

2 MEW No. 261. Nov 2017. R Reeve An indexer control map

3 Northcote Parkinson, The Economist 1955

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