No. 343

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MODEL ENGINEERS' WORKSHOP

THE MAGAZINE FOR HOBBY ENGINEERS, MAKERS AND MODELLERS SEPTEMBER 2024 ISSUE 343 WWW.MODEL-ENGINEER.CO.UK

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Rising to the challenge of producing super-accurate screw threads.



WORKSHOP DIARY

Making a tailstock for a dividing head.

ACCURATE DEPTH MEASUREMENT

A handy modification improves digital calipers.



INSIDE THIS PACKED ISSUE:

■ STEVENSON TROPHY COMPETITION – WE PROFILE THE WINNERS AND YOU CAN VOTE FOR YOUR FAVOURITE. ■ SIMPLIFY VICE ALIGNMENT FOR BENCH MILLING MACHINES. ■ THE UGEARS MARBLE RUN – A DIVERSION FOR MODEL ENGINEERS. ■ EXPERIENCES WITH A DENFORD CNC LATHE. ■ TIPS FOR STENT GRINDER USERS. ■ UNDERSTANDING RADII IN ENGINEERING. ■ THE HISTORY OF LATHES. ■ PLUS ALL YOUR REGULAR FAVOURITES!

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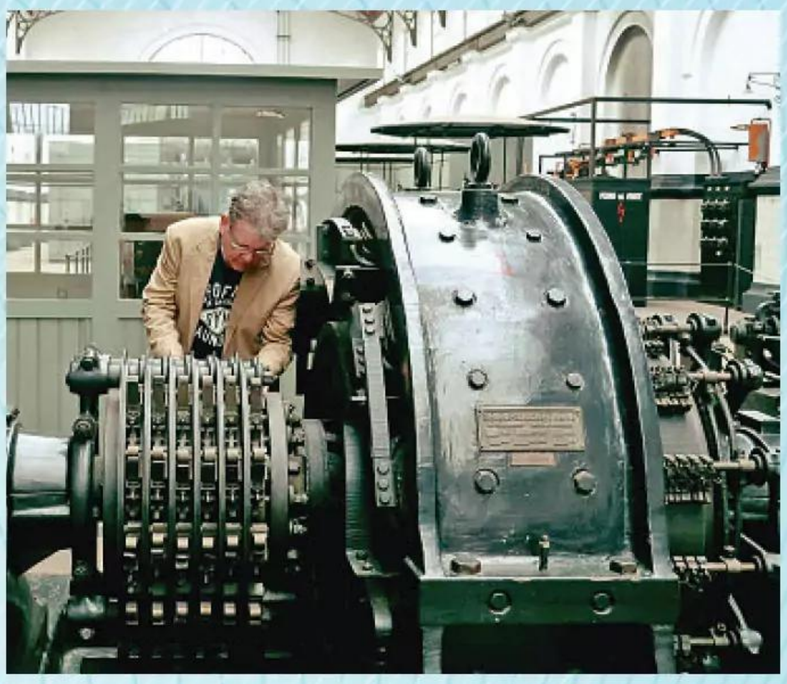
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This issue was published on 14 August 2024
The next issue will be on sale 20 September 2024



On the Editor's Bench







The Llandovery Bike Weekend

A few weeks ago I spent a day at the Llandovery Bike Weekend, a family-friendly two-day event held in support of Blood Bikes Wales. Blood Bikers are all volunteers and they play a vital role in supporting the NHS by transporting blood for transplants, donated organs and other urgent supplies between hospitals. I was there as part of the musical entertainment, but I had plenty of time to look around and thought I would share a few photographs I took.

First is the World's Fastest Wheelbarrow, which achieved over 58mph at Elvington, 'piloted' by Dylan Phillips. Next is the 'Lister/Honda' a diesel-powered motorbike. Rumour has it that power is delivered at the rate of approximately one stroke per 100 yards... You can see the skills arena behind, where we saw a lot of extreme knee-scraping as riders circulated among the cones.

There were lots of very beautiful bikes on display, but the one I have decided to single out is a beautifully restored 173cc 1968 BSA Bantam. I remember one of my friends, 'Cookie', who was considered really cool as he came to school on a very battered Bantam, wearing a 1950's style white leather helmet and RAF-surplus goggles, at least on the days when he could get it to start. I think his was an ancient 123cc model, which would have been over 25 years old even then!

Neil Wyatt



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Spindle bore: 38mm
Number of spindle speeds: Variable
Range of spindle speeds: 50~2500rpm
Weight: 65Kg

Price: £1,185



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SPECIFICATION:
Distance between centers: 750mm
Taper of spindle bore: MT4
Spindle bore: 26mm
Number of spindle speeds: Variable
Range of spindle speeds: 50~2500rpm
Weight: 140Kg

Price: £1,904



VM25L Milling & Drilling Machine Belt drive & Brushless Motor

SPECIFICATION:
Model No: AMAVM25LV (MT3) / (R8)
Max. face milling capacity: 63mm
Table size: 700×180mm
T-slot size: 12mm
Weight: 120Kg

Price: £1,431
W DRO – Price: £1,921
W DRO + PF - Price: £2,210



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SPECIFICATION:

Gas Strut
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750W BRUSHLESS Motor
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SPECIFICATION:

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Swing over cross slide 150mm
Width of bed 135mm
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Spindle bore 26mm

Price: £2,555



VM32LV Milling & Drilling Machine Belt drive & Brushless Motor

SPECIFICATION:

Model No: AMAVM32LV (MT3) / (R8)
Max. face milling capacity: 76mm
Table size: 840×210mm
T-slot size: 14mm
Weight: 240Kg

Price: £2,100
W DRO – Price: £2,537
W DRO + PF - Price: £2,948



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Contents

9 Hardness Testing
Jaques Maurel explains how Vickers Hardness is tested, with plans for making your own device of applying repeatable force to a special indenter.

16 From the Archives
In this issue we share some very useful tool and cutter grinder tips.

18 The History of the Lathe
Henk-Jan de Ruiter takes brief tour of the long history of this ubiquitous machine tool.

21 Workshop Diary
In the first instalment of a new, occasional, series, Alex du Prê explains how to make a tailstock for a dividing head.

28 Improving Depth Measurement with a Digital Caliper
Geoff Andrews details a modification you can use to increase the accuracy when using a digital caliper to measure depth.

32 Building a Marble Run Chain Hoist
While waiting for his new workshop to be ready, Mark Noel tackled a complex Ukrainian wooden construction kit.

40 Thread Milling in the Workshop
Bob Reeve completes his thread milling challenge, this article supports a talk to be given at MMEX in October.



46 Entries for the Stevenson Trophy 2024
We have had a bumper crop of entries for the Stevenson Trophy, we present the work of the finalists in their own words and pictures and explain how you can cast a vote for the winner.

53 Getting the most out of your Brushless Mill - Part 4
Jason Ballamy concludes his short series with a guide to fitting alignment buttons to a milling vice for easy and accurate relocation.

56 The Midlands Model Engineering Exhibition
Here's an update on how MEW will be taking part in this October's MMEX exhibition.

60 Beginner's Workshop
Geometer looks at radiuses – how they are specified and how to check them in your engineering projects.

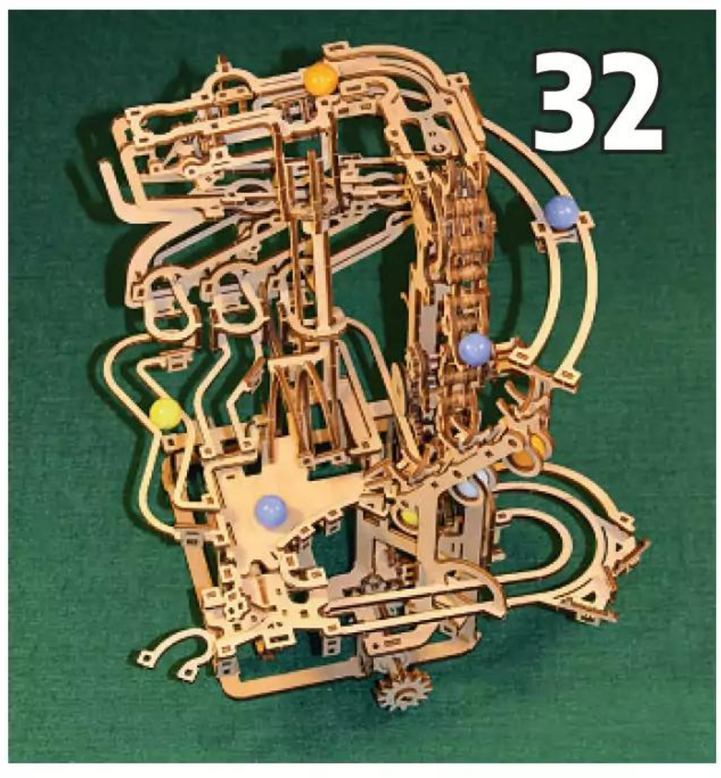
61 Getting To Love My Denford Novaturn
Mick Knights explains how he uses Quickturn CNC with his Novaturn CNC lathe..



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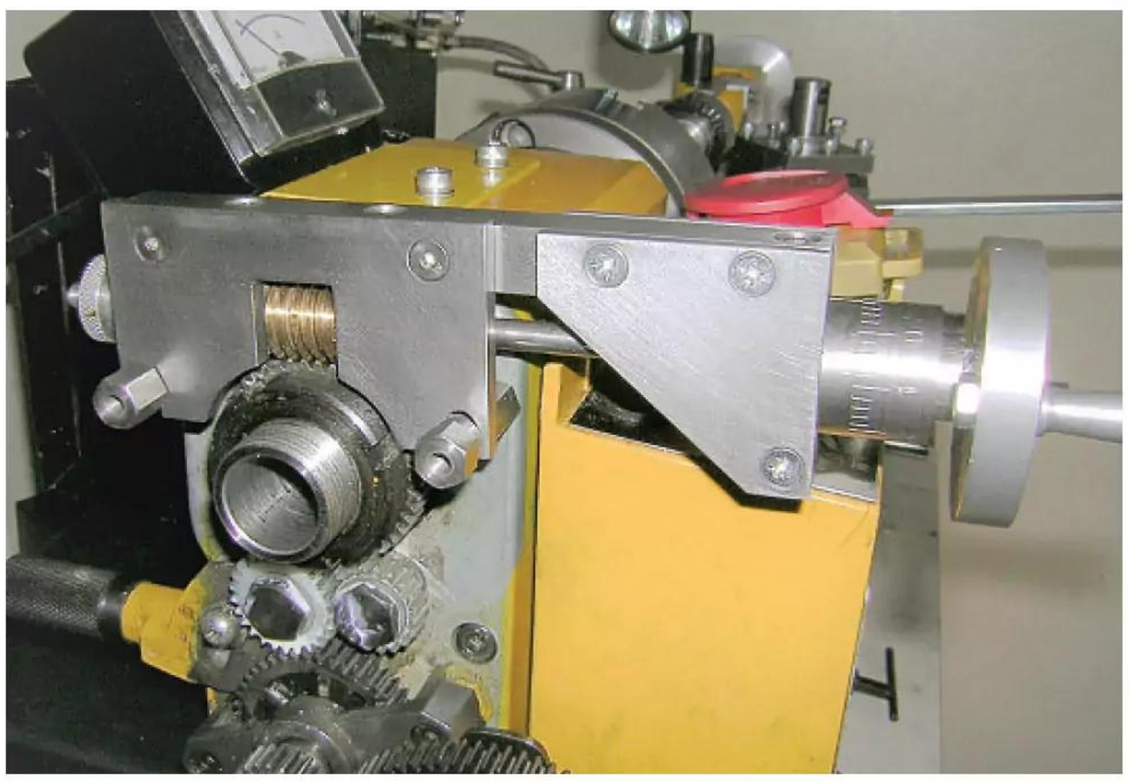
See page 24-25 for details.



Coming up...

in our next issue

In our next issue we have detailed plans for Michael Cox's precision headstock dividing device for mini-lathes.



Regulars

3 On the Editor's Bench
The Editor went to a biker festival and saw some very unusual vehicles.

36 Readers' Tips
Our winner offers a neat chute to help keep swarf away from moving parts of a mini-lathe. Send your tips to meweditor@mortons.co.uk, you could win a prize.

38 On the Wire
This month we have news from the SMEE and Chester Machine Tools, as well as an exciting new application for 3D printing.

58 Scribe A Line
Enjoy this month's postbag with feedback from readers and an update for overseas subscribers. We are always keen to hear from you – send the editor your thoughts at meweditor@mortons.co.uk.

64 Readers' Classifieds
This month's collection of readers' for sale and wanted adverts.

ON THE COVER

Our cover features Bob Reeeve's setup for milling a square-section thread on a large bar. See more details on page 40.

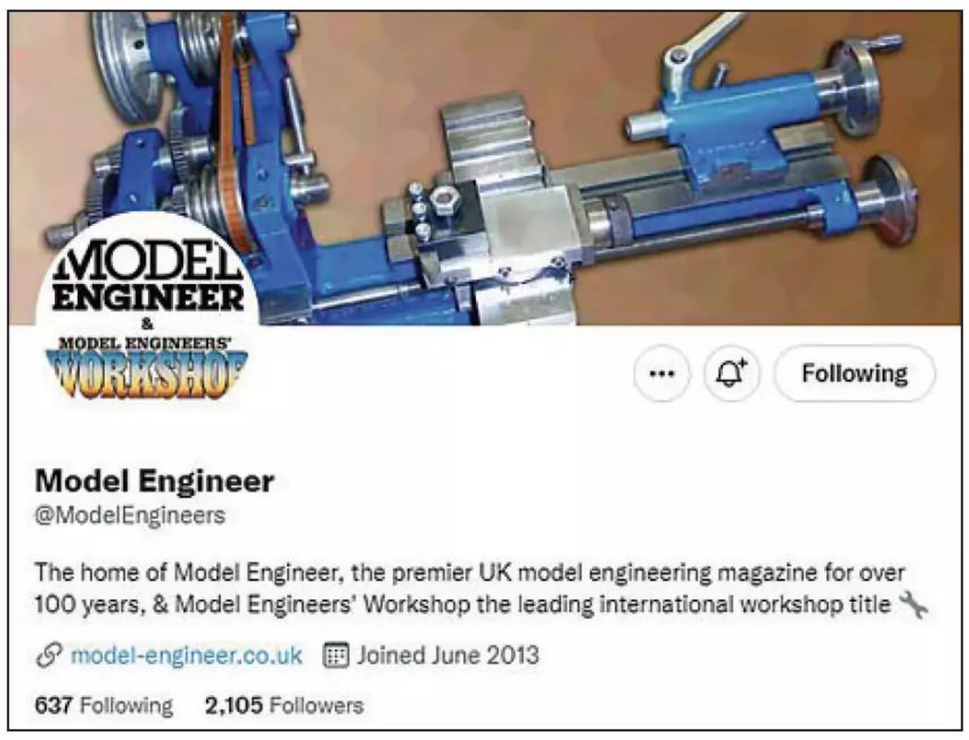


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THIS MONTH'S BONUS CONTENT

Extra Content!

See the videos for Jason Ballamy's Brushless Mill series:
https://www.model-engineer.co.uk/forums/topic/getting-the-most-from-you-brushless-mill/
Or search the forum for 'getting the most'.

Hot topics on the forum include:

Model Turbines Started by Turbine Guy
This detailed thread will be of interest to those readers fascinated by the rotors featured in Mike Tilby's micro-milling machine.

Pin sharp images achieved by early plate cameras. Started by Greensands
Comparing old and new technology. Does the Camera lie, or is it just the processing?

The Prusa method of p3D-printing holes – who knows more?
Started by Versaboss
A brief mention in Roger Froud's Paint Can Turner article has piqued readers' curiosity.

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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Technical data

Swing over bed	**310 mm**
Swing over cross slide	**190 mm**
Centre width	**900 mm**
Bed width	**180 mm**
Spindle bore	**38 mm**
Spindle tip	**MK5**
Spindle speed	**80 – 2000 rpm (adjustment in 2 ranges)**
Metric thread	**(18) 0.2 – 3.5 mm/turn**
Inch thread	**(21) 56 – 8 TPI**
Longitudinal feed	**0.085 – 0.832 mm/turn**
Transverse feed	**0.01 – 0.1 mm/turn**
Maximum upper slide travel	**65 mm**
Maximum transverse support travel	**210 mm**
Maximum longitudinal support travel	**650 mm**
Tailstock spindle travel	**100 mm**
Tailstock quill diameter	**38 mm**
Tailstock quill taper	**MK3**
Motor power	**1.5 kW / 230V**
Dimensions	**1520×675×1320 mm**
Weight	**295 kg**

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Hardness Testing

Jacques Maurel, in France, makes a device that applies a repeatable force to a special indenter for Vickers Hardness Testing.

It's worth knowing the hardness of the materials used in model engineering, mainly the steels coming from the scrapbox to have some idea of the tensile strength, and to estimate its machinability. But hardness testing can also check the result of a heat treatment (quenching, annealing, case hardening). A very crude test from a plain file or from grinding sparks can be made but is not very accurate.

I propose to you an attachment for making a "Vickers" test and another one using a "struck ball" as hardness test.



The Vickers Hardness Tester.

Vickers hardness tester

The idea came after reading the article from Rod Jenkins in issue 245 of Model Engineers Workshop about the Lammas tester (itself described in Model Engineer in 1989). The Vickers test seems the easiest one for a model engineer; a pyramid shaped diamond indenter (but a carbide one works as well) is fed into the test piece for a duration of fifteen seconds with a known force (I used 100kgf). A square imprint is obtained, the diagonal of the square "d" is then measured.

The Vickers hardness is the ratio between the force and the pyramid imprint surface area, using the calculation:

Hv = 1.8544 F/d2

F = force in kgf, **d** = square diagonal in mm, **Hv** = Vickers hardness in kgf/mm2

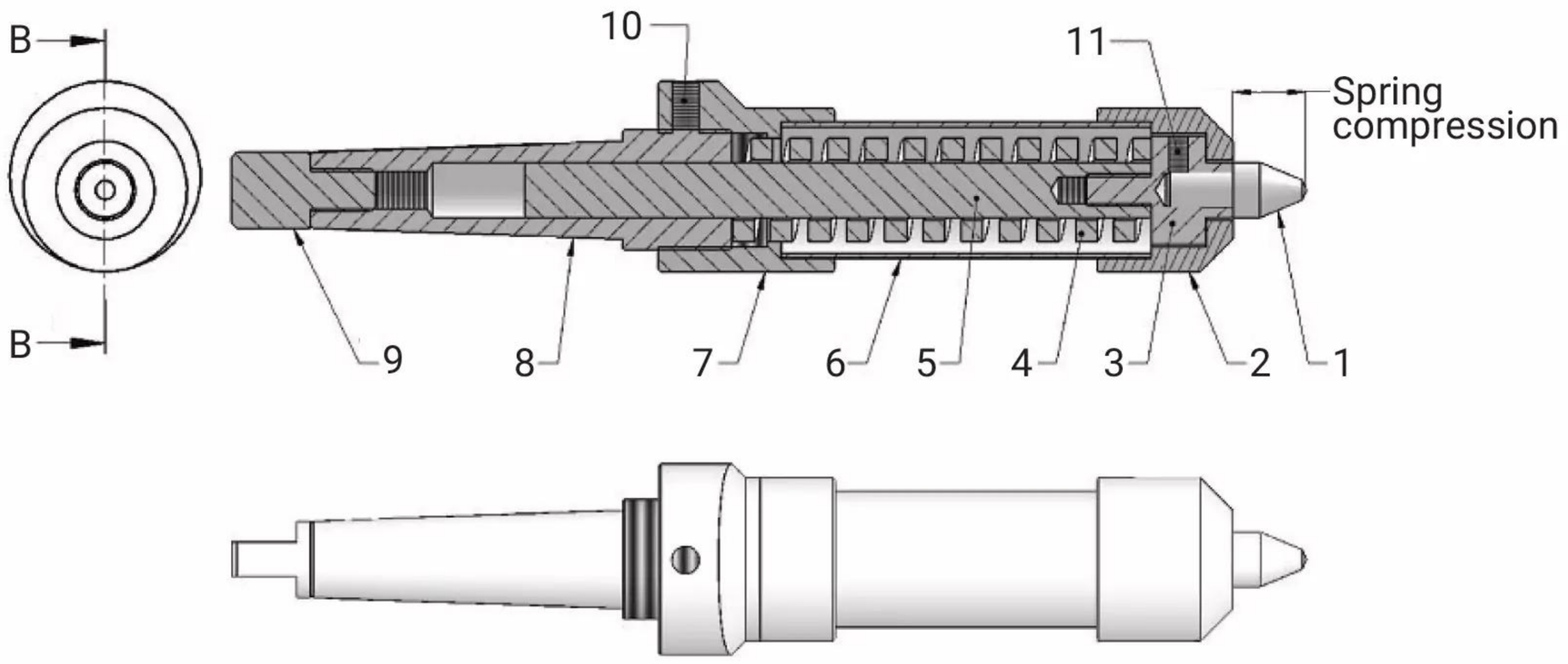
Notes

The result is the same for a different force (often 30kgf) but the bigger the imprint the easier it is to measure. The imprint is small, so the test piece surface must be smooth to ensure accuracy.

About the units. The kilogram (kg) is a mass unit, the force unit is usually the Newton (N).One kilogram-force (kgf) is the force exerted by the gravity on a 1 kg mass so 9.81 N (as the gravity acceleration is 9.81m/s2) so very near 10N or 1daN. The mass is constant while the weight (due to gravity) is not, so it would be smaller on the moon, for example.

Attachment for Vickers testing

See **photo 1** and **fig. 1** of the Vickers testing device, which applies a



Vickers Hardness Tester

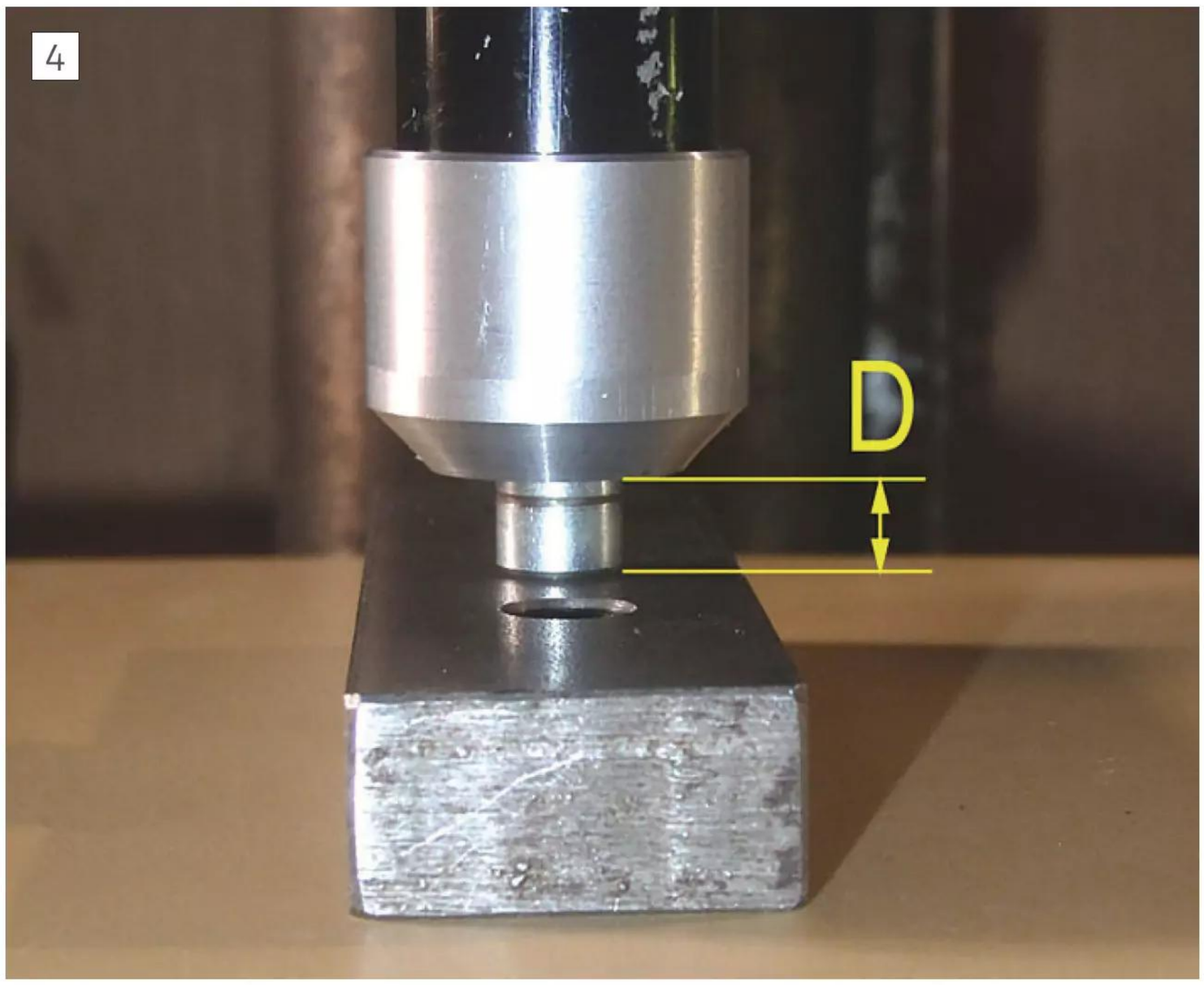
Figure 1



Bath scale on drill press for calibration.



Dis-assembled to show the spring.



Calibration with dummy indenter, at 100 kgf, 2.5mm of the dummy should protrude.

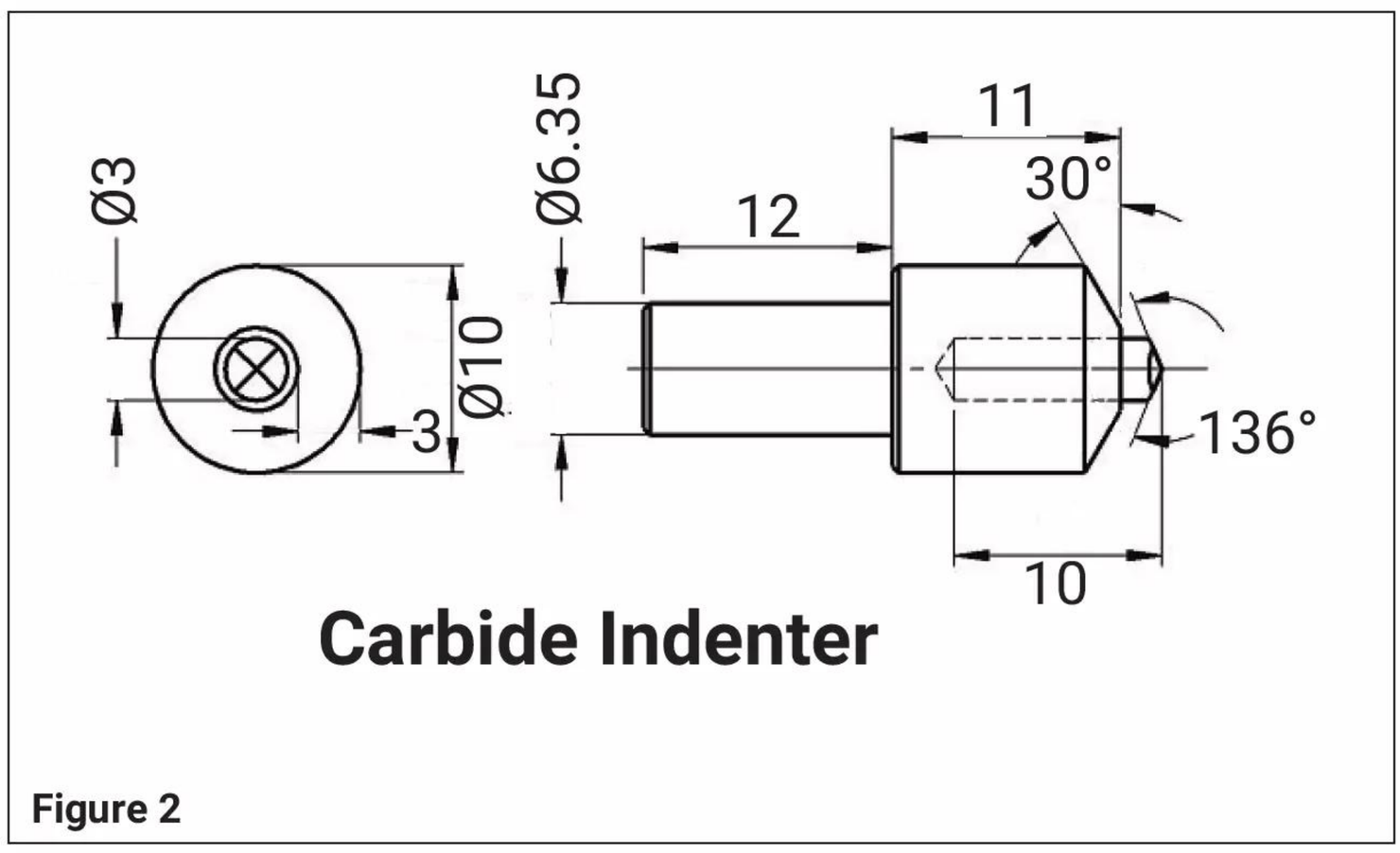


Figure 2

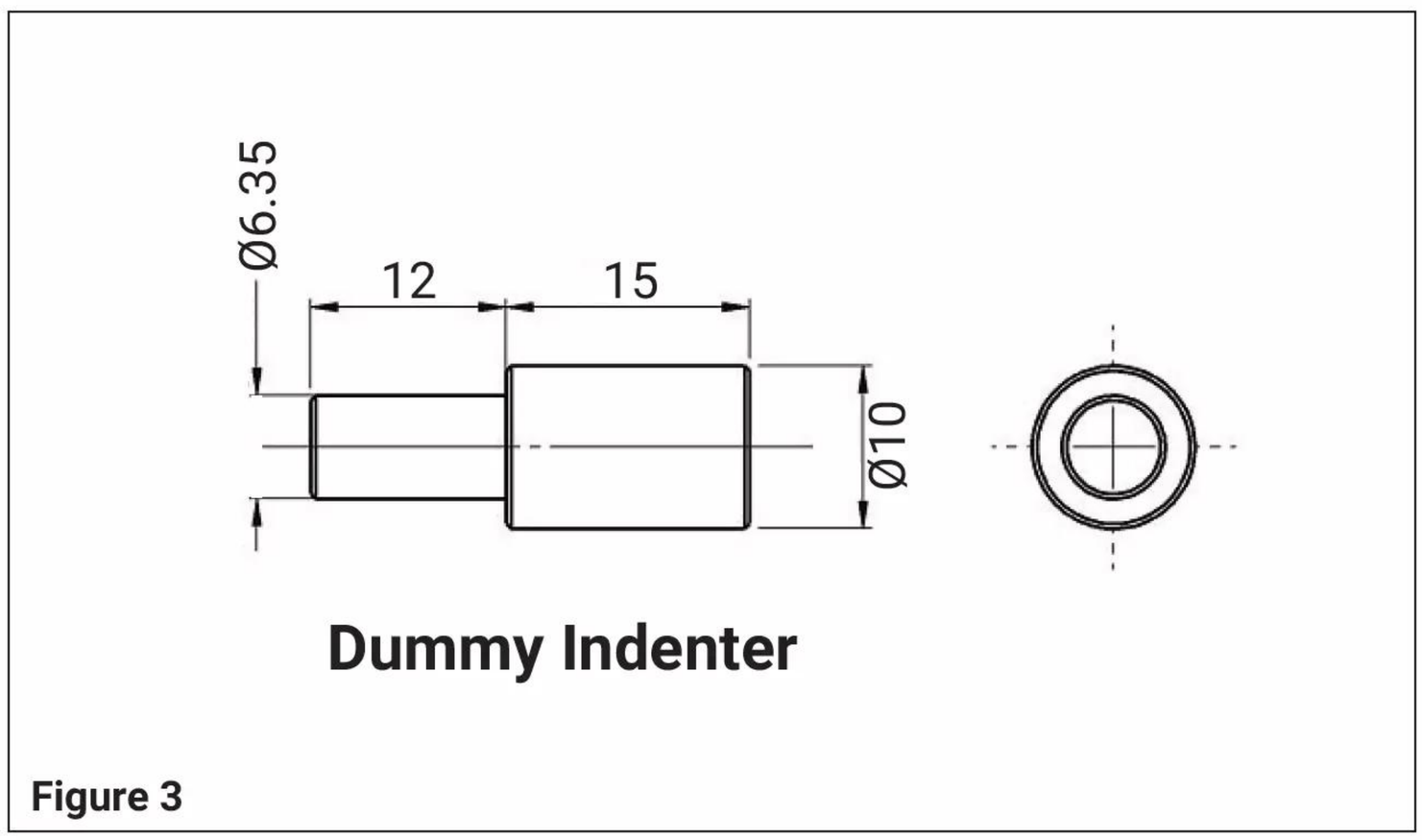


Figure 3

controlled force to a carbide indenter, a commercially obtained part shown. The idea is to use a drill press (as a press here) to lower the device until it contacts the test piece. The internal spring will then be applying the 100kgf to the indenter. This is not a problem as the force is multiplied by about eight from the capstan lever to the spindle on my drill press. This is easy to calculate, it's the ratio between the capstan lever radius and half the rack driving pinion pitch circle diameter. This radius is easy to calculate without dismantling, just measure the spindle movement for half a turn of the capstan and divide this movement by, π as the pinion pcd is rolling without slipping on the plane of the rack machined on the spindle barrel.

Measuring the force

This was first tested with a bathroom scale. It was tested for accuracy with calibrated masses up to 7kg with a good result, so it was expected to be the same until 100kg. See **photo2** showing the scale on the drill press table, the test piece set in the centre on a steel strip, the indenter set in the drill chuck, this worked well.

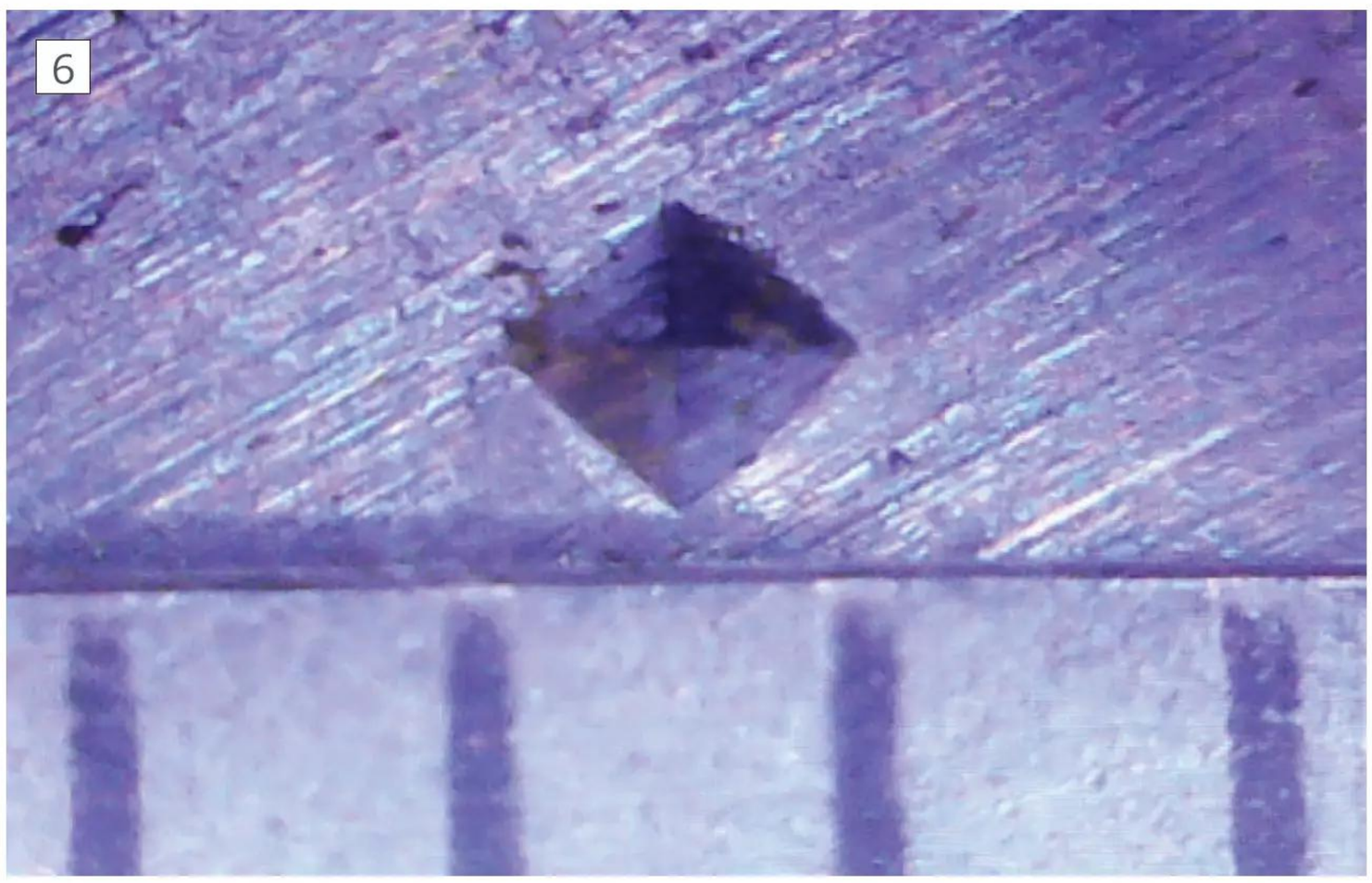
The usual bathroom scale measures the weight in kgf, this is satisfactory for our purpose (the author lives in France, UK and American readers may need to convert from stones and pounds). Commercial scales measure the mass (in kg) by balancing against a reference one (their measure should be the same on the moon).

In the attachment, the force is controlled by a spring, it's a standard stiff spring using a square wire, see **photo3**. This spring **4** is compressed by the indenter holder **3** set in a guiding spindle **5.** In turn it slides in the Morse taper 2 (MT2) bracket **8,** held in the drilling machine spindle. The compression throw of the spring is limited by the front stop **2**. This front stop is linked to the spacer **6,** itself linked to the adjusting sleeve **7**. It is therefore possible to adjust the throw by turning **7,** which is screwed on **8** and to lock the position with screw **10**. Only the machined parts are illustrated

The calibration is made in the following way, **photo 4**. A dummy indenter, **fig. 3**, longer (15mm) than



Digital microscope.



Indent viewed through the microscope. Measurement of this image gives the diagonal size.

the genuine one (which is 12.5mm long) is fitted in the indenter holder and pressed on the scale until it reads 100kg load. The distance, D in photo 4, is measured (I used a set of drills stepping by 0.1mm). From this result adjust the spring until the force is 100kg when 2.5mm of the dummy indenter protrudes. With the actual indenter in place, the force will be 100kgf when the face of the tool contacts the test piece. There is a slight error (up to 1.5% for the softest steel giving the largest imprint) due to the indenter penetration in the test piece.

Measuring the imprint

I used a low-price digital microscope (it was 50€ in 2023), see **photo 5**, the diagonal measurement was first made directly on the screen (when the view is clear) with a graduated rule, the magnification is near to 20 times (between 18.5 and 22) and not the same in the horizontal direction as in the vertical one. It also varies as time passes. To cope with these problems, the finely graduated rule was placed by the indent (see **photo 6**). If there is no room for a graduated rule on the part, first measure the graduated rule for an actual calibration.

By dividing the diagonal imprint width (measured on the screen) by the 1mm (1 graduation) width (also measured on the screen), it's possible to calculate the actual imprint diagonal width in mm, whatever the magnifying coefficient. (It is possible to buy finely graduated glass graticules that could be placed over the indent for direct and accurate measurement – Ed.)

Use of the attachment

- Set the attachment in the drill press spindle.
- Set the test piece on the drill press table.
- Slowly lower the indenter on to test piece until the front stop contacts the test piece and wait for 15 seconds.
- Release the load and bring the test piece to the microscope for measuring the diagonal imprint.
- Calculate the hardness from the formula explained above, Hv = 1.8544 F/d2

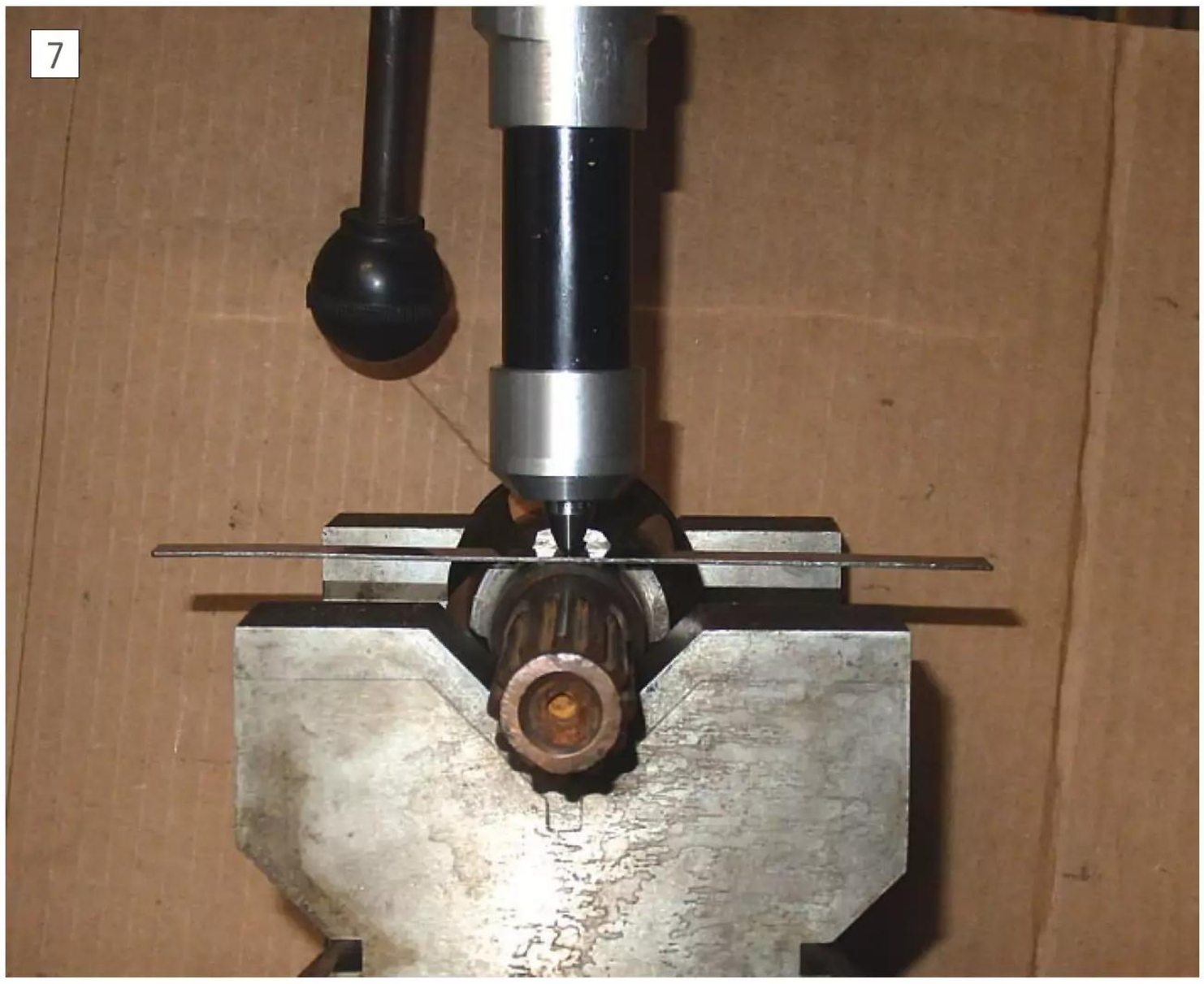
Notes

The tensile strength is usually around 0.32xHv in daN/mm2 for carbon steel and low alloy steels, but not normally specified for highly alloyed Steels. Neither is it specified for cold rolled steels due to work hardening.

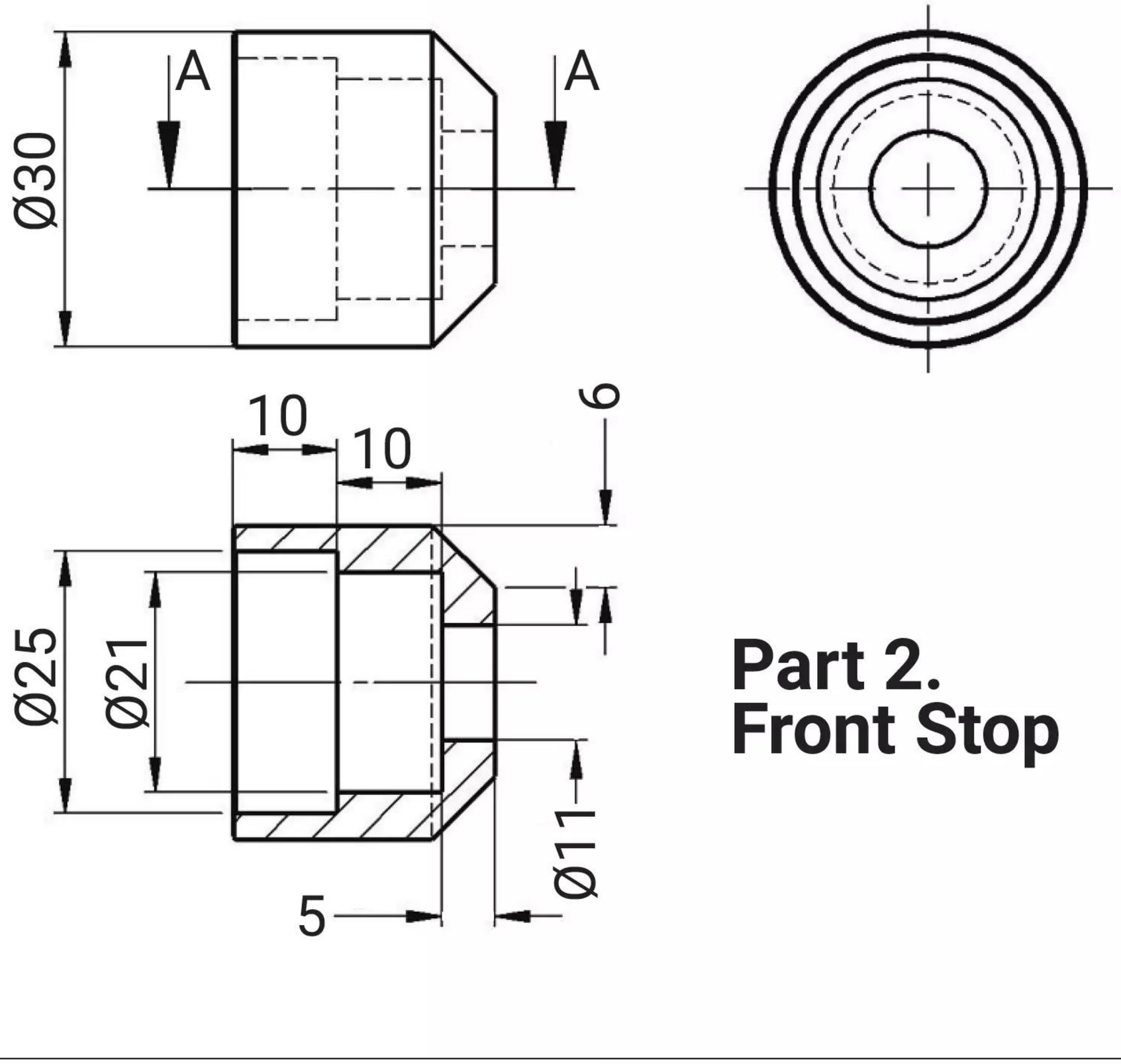
Conversion tables are available to convert the Vickers hardness (**Hv**) into the Rockwell C (**HRC**) scale for high hardness (hardened) steels.

Hv	392	446	513	596	697	830
HRC	40	45	50	55	60	65

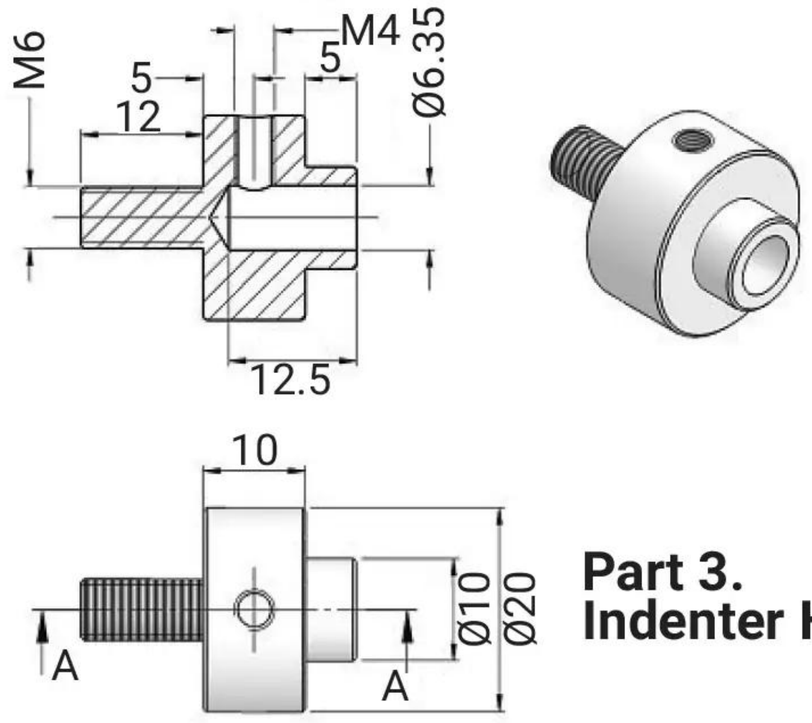
For example, roller bearings parts have a hardness around 60 HRC. For measuring on a cylinder, set the testpiece on Vees and use a strip of steel sheet to centre the indenter, see **photo 7**.



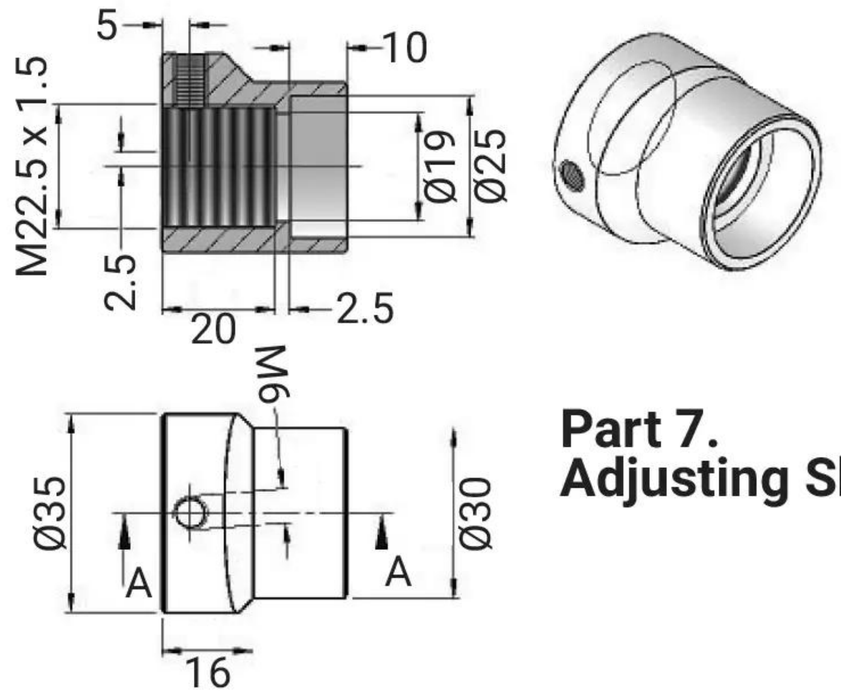
Aligning the tester with a curved surface.



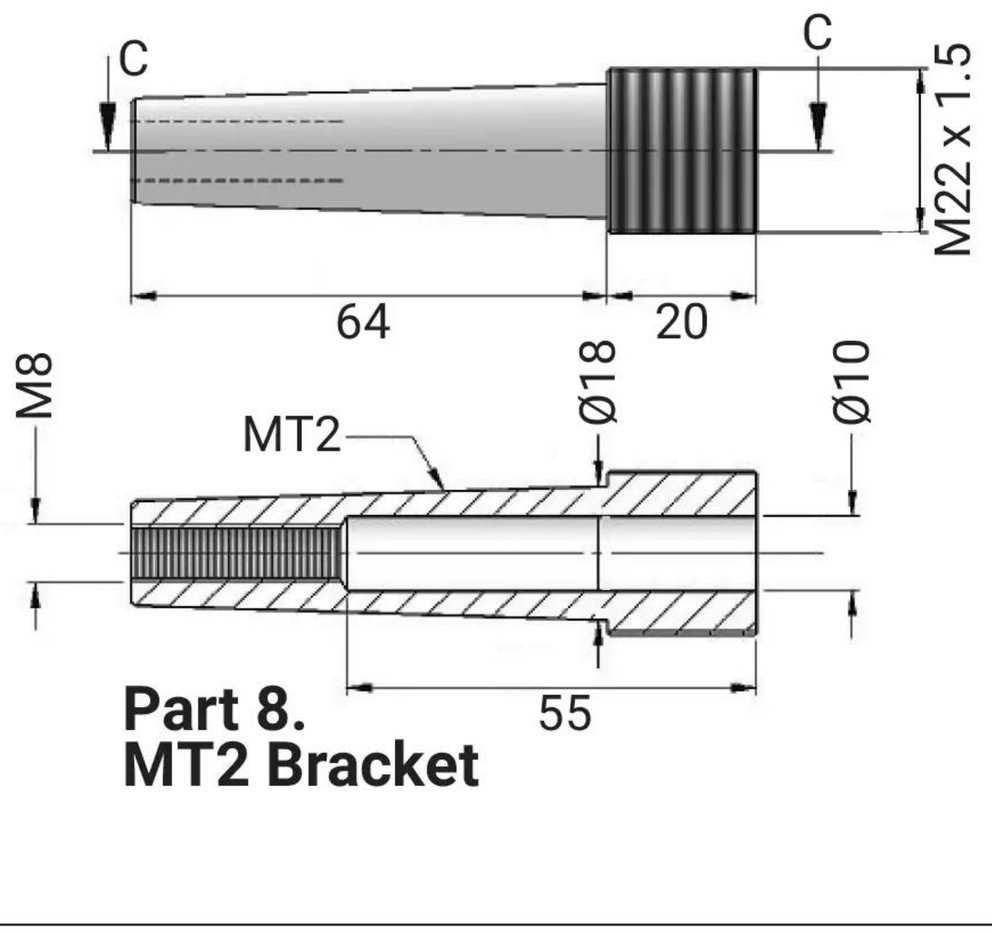
Part 2. Front Stop



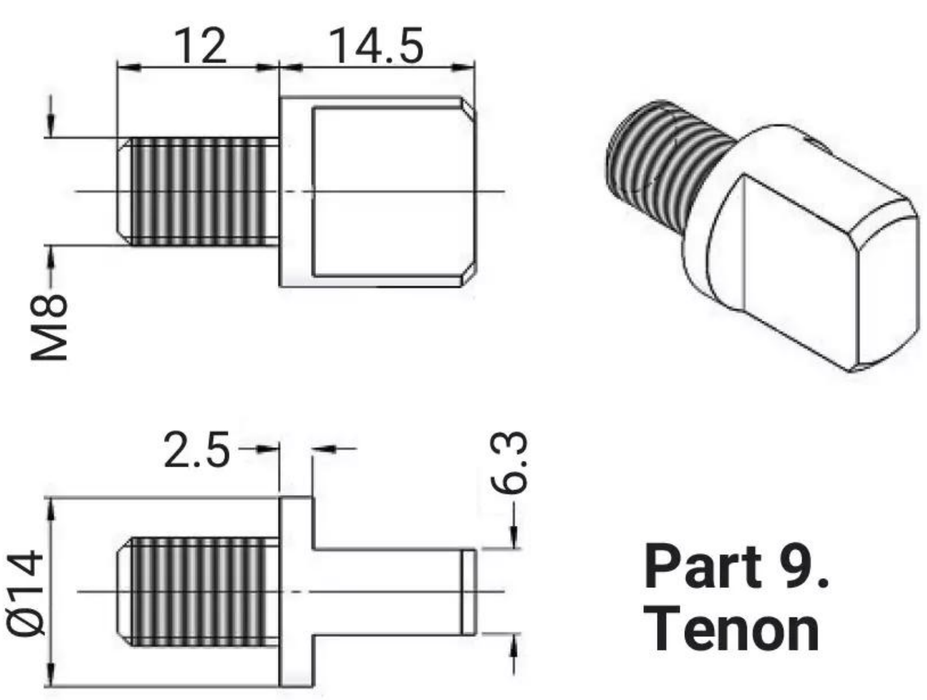
Part 3.
Indenter Holder



Part 7.
Adjusting Sleeve



Part 8.
MT2 Bracket



Part 9.
Tenon

Parts list

One of each part is required

N°	Name	Material	Remarks
1	Indenter		See text
2	Front stop	2017	
3	Indenter holder	FCMS	
4	Loading spring		See text
5	Guiding spindle	Silver steel	Diameter 10mm, 112mm long
6	Spacer	Light alloy	Internal diameter 22mm, external 25mm

7	Adjusting sleeve	2017	
8	MT2 bracket	FCMS	
9	Tenon	FCMS	
10	Sleeve locking screw Hc M6 by 8mm long	8-8 min	
11	Indenter locking screw Hc M4 by 6mm long	8-8 min	

Making the attachment :

Indenter 1

I bought a low price diamond one from Amazon (65€ in 2023) and made one from carbide , a 3mm diameter 10mm long piece of carbide stuck in a free-cutting mild steel (FCMS) bracket, ground with a diamond wheel see **fig. 2** that worked well. Off course the length is the same as the diamond one to ensure getting the same load from the spring. See **photo 8** showing the indenters used including the dummy one used for load calibration, **fig. 3**. There is a red point on the diamond indenter, this is to show one diagonal direction, this could be of some use when a large part is to be set under the microscope and if you want one diagonal to be horizontal on the screen.

Loading spring 4

This is a standard stiff spring (usually used in die punching works) external diameter is 19mm, 4mm square wire, 77mm length at rest. The stiffness is 7.7 kgf/mm (I've made a plain rig for testing) so about 13mm compression will be needed for a 100 kgf load.

Spacer 6

The actual length is 66 mm, but could be adjusted, see later.

Adjusting sleeve 7

The excentric part is just for lodging the locking screw, put a 4mm thick packing under one jaw of the 3 jaws chuck to set the eccentricity. If the contact between jaw and cylinder is a plane perpendicular to the jaw calculation gives:

Packing thickness h = 1.5 x e (e = eccentricity)

I should have used 3.75mm as packing, but this is not a critical dimension.

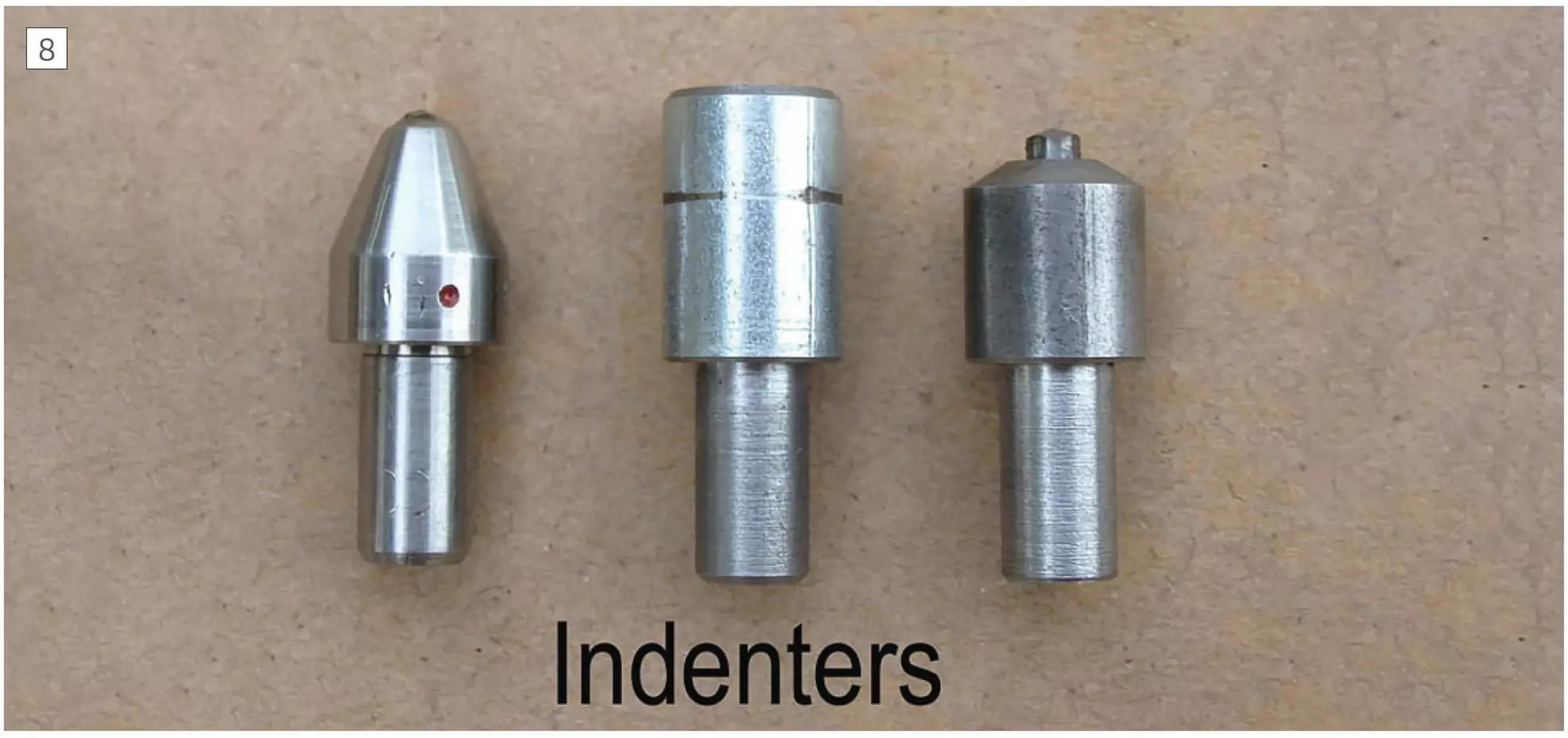
There should be no problem with machining the other parts.

Setting and adjusting :

The spacer **6** should be stuck to the parts **7** and **2**, but this way it's not easy to change the indenter, though it is possible to drill a radial hole in **2** for unscrewing **11**. A plain and easy solution is to have a press fit between these parts, a strong one between **7** and **6** and a light one between **6** and **2**. This is possible with no pain by squeezing the ends of part **6** in the 3 jaw chuck, the thin walled tubing getting a triangular shape. This worked well.

After calibration we want no load at rest on the spring, there is even a slight free axial movement for the indenter, this way the slight press fit between **6** and **2** is sufficient and the indenter easy to change. This can be achieved by adjusting the length of the spacer. My spacer **6** length is 66 mm, relative to my spring **4** length.

In a future article I will explain how to use the "struck-ball" method of hardness testing.



L-R: Commercial diamond indenter; dummy indenter, shop-made carbide indenter.

From the Archives

With over 125 years of Model Engineer magazine and nearly 35 years of Model Engineers' Workshop in our archives, there's a huge selection of fascinating and often useful ideas for the workshop to be found.

From Issue 156, Autumn 2001,we have a particularly useful instalment from Charles Woodward's series on Living with the Stent Tool and Cutter Grinder. Just a reminder, always use the card washers on both sides of a grinding wheel when clamping it.

LIVING WITH THE STENT TOOL AND CUTTER GRINDER 3

Charles Woodward shows us how to use this versatile machine



Wheel balancing

The necessity to balance the grinding wheels arose when I changed the plain wheel from 5in. dia to 150mm (6in.). The 5in. wheel was obtained from my workplace. I think it may have been cut down from a larger size as I couldn't find a similar wheel in the catalogues. I didn't anticipate any problems using the 150mm wheel which was only 6mm thick and much thinner than the 5in. wheel.

The wheel is mounted on a wheel nut flange, secured with 4 x M6 screws, and screwed onto the grinding spindle. When I put the 6in. wheel onto the machine, both DTI's vibrated excessively and the horizontal slide crept forward, not a good situation! What to do? I could change back to the original wheel; this was unthinkable, I had just spent £20 or so on a grinding wheel I could not use. A way of balancing the wheel would have to be found.

Fig. 15 shows a cross section of a grinding wheel assembly on a plain grinding machine. As can be seen the wheel is mounted on a wheel collet assembly. Prior to use, the wheel must be statically balanced; this is achieved by fitting the wheel and collet assembly onto a balancing arbor and parallel balancing ways; the weights are then moved until static balance is achieved. I decided to do something similar; I machined a step on the existing wheel flange and an aluminium disc with a matching step but 0.005in. shorter, **Fig. 16**. I drilled a circle of M6 holes in the disc and 2 x 2BA holes at the edge of the disc to clamp the disc to the flange. This disc would imitate the weights on the commercial arrangement and rotating the disc around the flange would be the same as moving weights within the balancing groove. In retrospect M6 was too large for the weights. I used one full (unmodified) screw and a lighter screw. I left the disc large enough to add smaller holes at a greater radius spaced between the M6 holes if required in future for refining the balance.

The next thing was to balance the assembly. I had a spare spindle; originally when I built the machine I put a LH and RH nut on the spindle to secure the wheels but I grew dissatisfied with this arrangement as I realised I could not grind on both sides of the cup wheel without the cup wheel unscrewing. I assembled the plain wheel assembly (wheel flange nut with plain wheel, wheel flange, and balance weight) onto the spare spindle, rigged up parallels on the surface table after checking the levels, and statically balanced the wheel satisfactorily this way.

Subsequent to balancing I had removed the cup wheel and replaced it with a taper cup wheel for point thinning. On replacing the cup wheel I once again had out of balance wheels. This time I balanced the assembly on the machine after removing the drive belt; the bearings where free enough to allow me to do this. The next time I removed the cup wheel I marked the relationship between the wheel shaft and wheel and replaced them in that orientation without any problems. As an alternative solution for balancing, issue 42 of MEW 16 contains details of a surface grinding machine wheel which has been modified by the addition of a new wheel flange assembly, which allows balancing on a pair of knife edges.

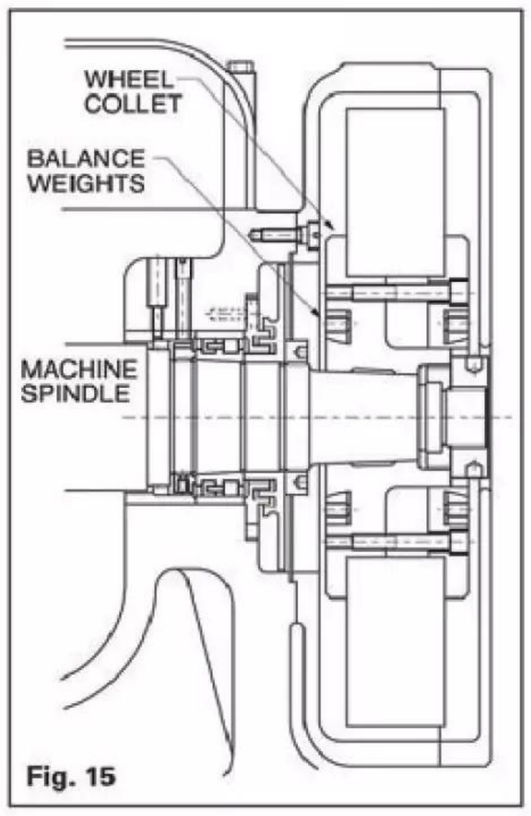


Fig. 15

Plain grinding

At the end of my previous article I mentioned using the Stent as a plain grinding machine. I have recently done a bit more work on the problems I encountered and plain grinding appears to be a practical proposition. When I built the machine one of the thoughts at the back of my mind was to use the machine as a plain grinding machine. I planned to motorise one of the tailstocks and rotate the component I was grinding between dead centres. I bought a geared motor from Maplins, enclosed it in a plastic case, and attached it to the tailstock with an aluminium bracket. I had previously machined the front of the tailstock to give a bearing for a drive pulley, **photo 29**. I made up a couple of 1:1 pulleys from Tufnoll and used a round belt for the drive. The motor is 12 volt which I drive from the Black and Decker Minicraft controller, **photo 30**. When grinding a piece of ½in. dia x 4in. long silver steel, **photo 31**, I had previously had limited success, using the 5in. wheel. The component got hot, expanded, and eventually the belt slipped and stopped rotating, the finish wasn't bad but it wasn't good either. I had made a couple

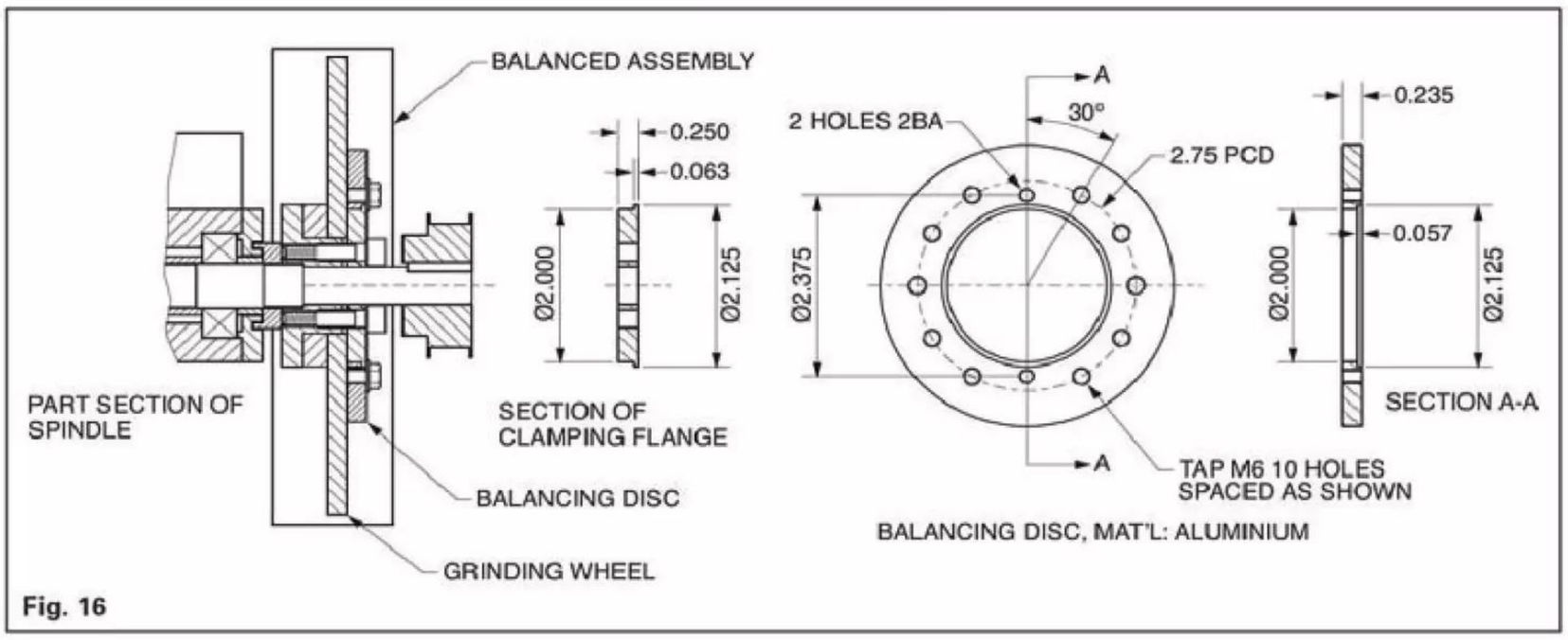


Fig. 16

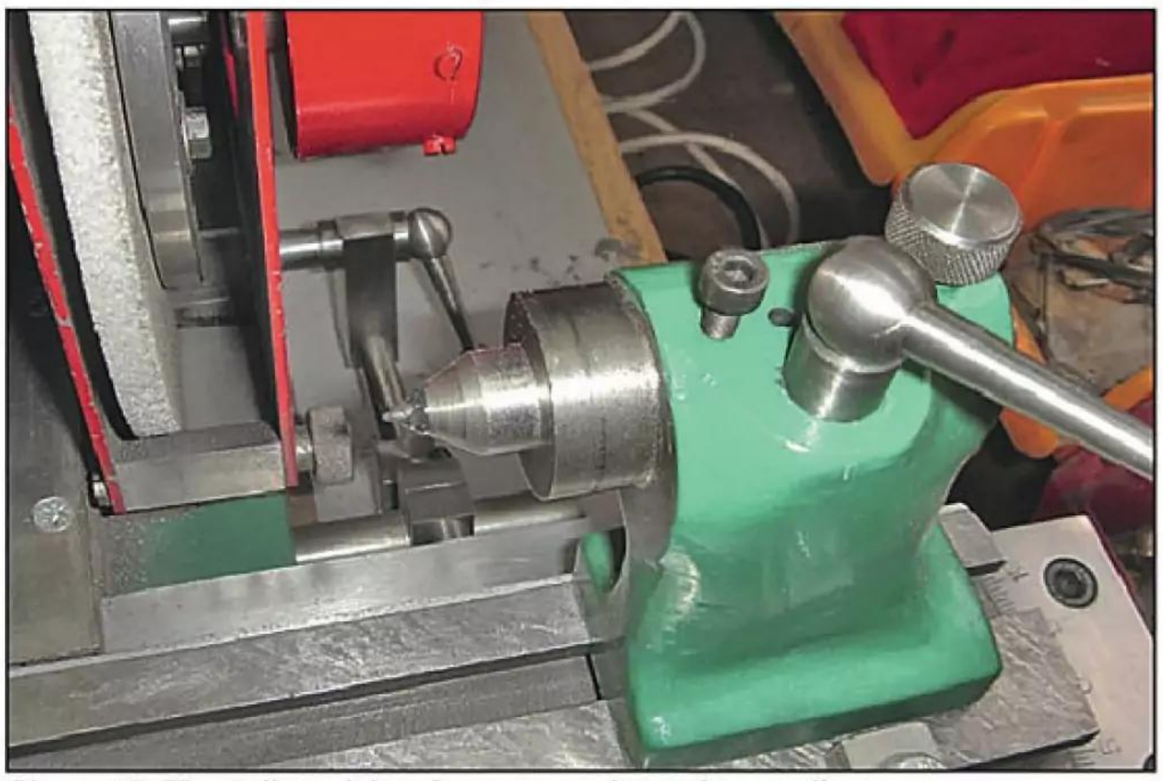


Photo 29. The tailstock has been turned to take a pulley.



Photo 30. The transformer for driving the drill.

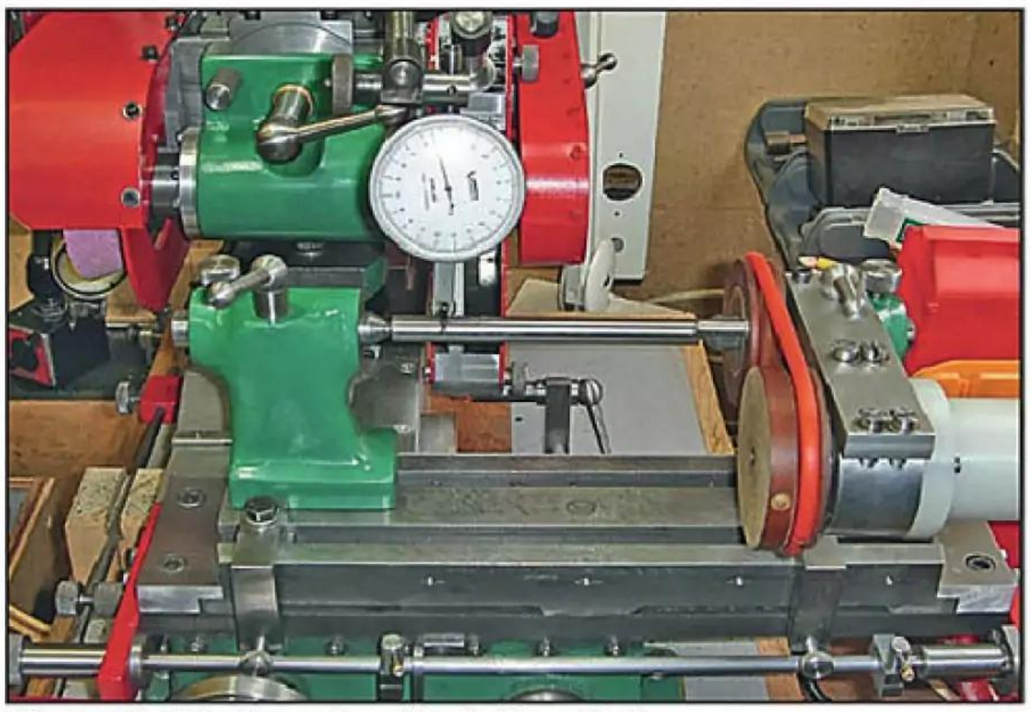


Photo 31. Grinding a length of silver steel.

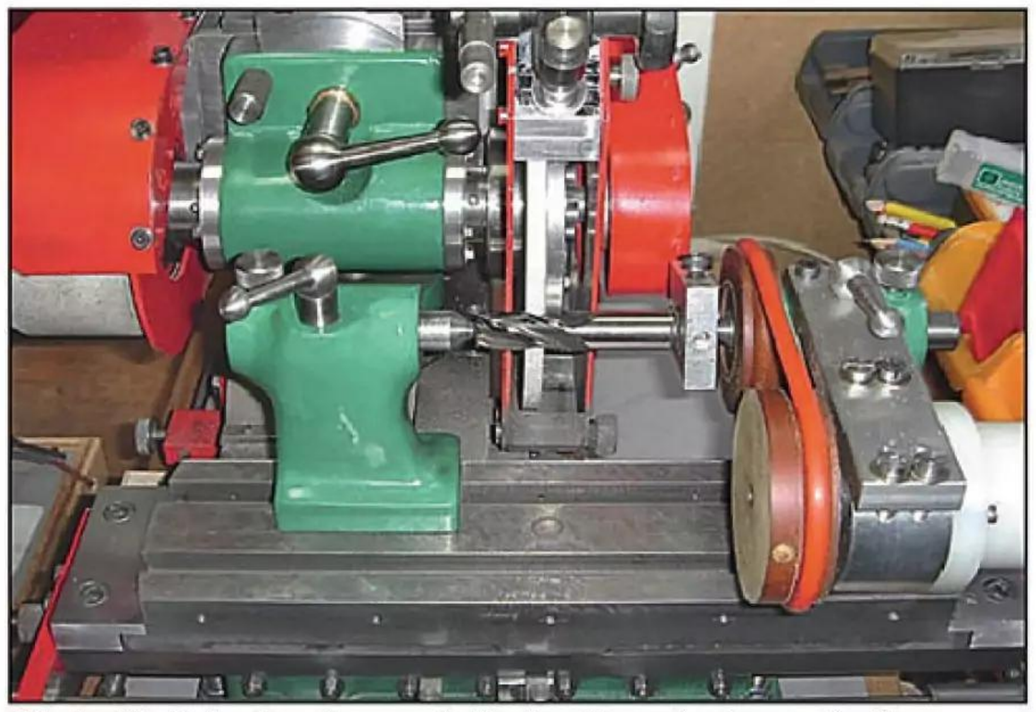


Photo 32. Spinning down a helical cutter prior to regrinding.

of brackets to attach to the table in order to easily set the taper, these can be seen at the edge of the table in the previous photo, and these seemed to work OK. When I changed to the narrower 6in. dia wheel I did not have the same problem with heat and the finish appeared to improve, this is possibly because I had not attempted to balance the 5in. wheel on my previous attempts. Marks which could still be seen on the ground surface were reduced, and when I removed the cup wheel the finish was further improved. I think the marks could be due to using a cheap single phase grinding machine to power the Stent and slight imbalance in the grinding wheel. I don't think the finish is quite up to commercial standards, but it is quite acceptable and I have used it to grind the diameter of an end mill prior to regrinding, **photo 32**. I once had a 5in. lathe of fairly light construction. I originally ran it with a single phase motor, and on taking light cuts, would experience a spiral pattern superimposed on the surface finish. I tried all ways of removing this defect, but it only disappeared when I changed to a 3 phase motor. I think I could be getting a similar effect on my grinding tests.

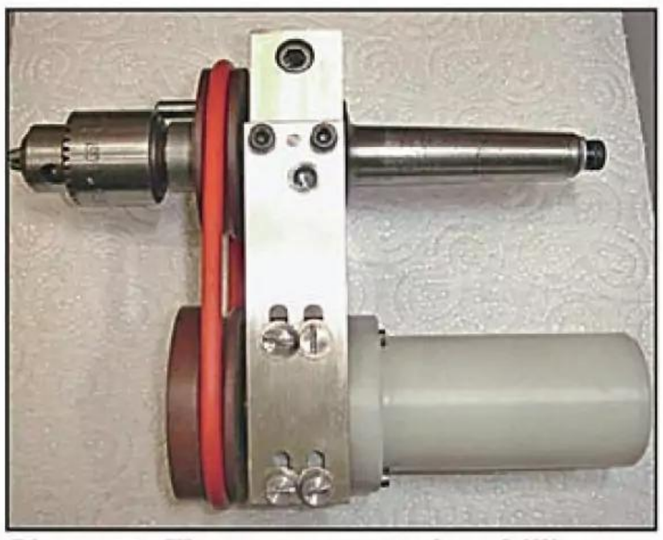


Photo 33. The counter rotating drilling attachment. This is driven by a 12 volt electric motor.

Counter rotating drilling unit.

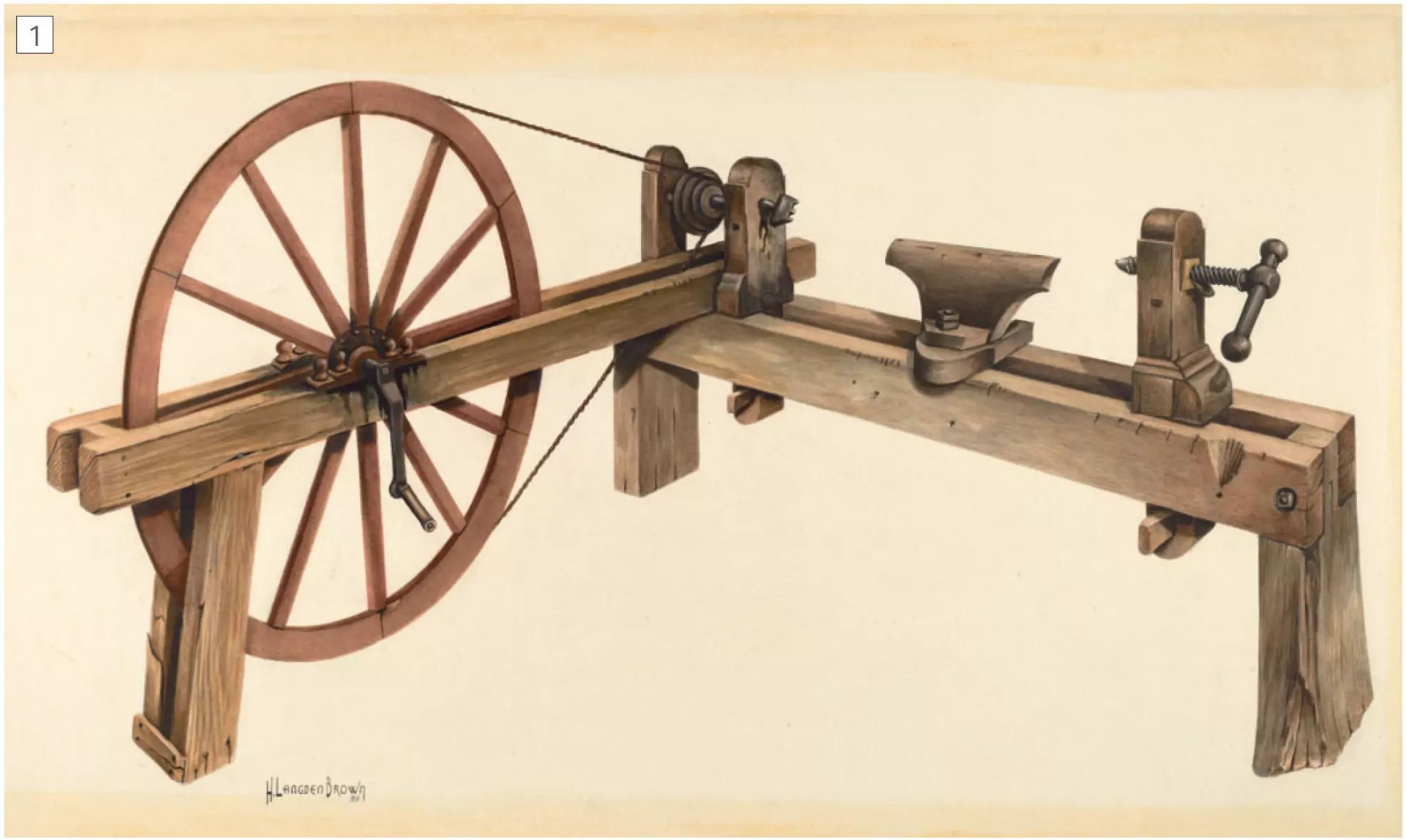
In my previous article I said if the drive unit did not work in the Stent I could use it for a counter rotating drilling unit on the lathe. As part of my hobby I do the occasional clock repair. I recently had a Westminster chiming clock with a badly worn pivot on the going train. The obvious answer to repairing the pivot was to cut it off and fit a new pivot. The pivot was .030in. dia and I wasn't sure of my ability to centre, drill and fit a new pivot on the Myford, having used small drills before I know they are very prone to wander, and I didn't fancy making a whole new wheel and pinion assembly. From my experience in industry I knew that counter rotating a drill helps to keep it in a straight line and greatly reduces the tendency to wander. Now was the time to make a counter rotating drill unit. Casting about for a suitable spindle on which to hang my drive unit I came across a old revolving centre which I had recently converted from a male centre to female centre by removing the male point and fitting a MS sleeve which I then bored in situ to create a female revolving centre.

I made an aluminium block which went over the centre body and to which I could attach the drive motor bracket, I bored out the centre of the female centre to take an arbor on which I mounted a small drill chuck. The drive pulley fitted over the body of the female centre, and there I had a driven drilling unit which would mount into the tailstock, **photo 33**. The job was completed and the clock is now ticking away in the workshop, waiting to be put back in its case.

While I have written this article about tool grinding using the Stent I recently made, I have no great expertise in this field. I worked for a long time in engineering before retiring and I am still interested in the subject. I have loads of peripheral experience on grinding and can usually tell when a cutter is incorrectly ground. The wheels I have used are 4in. (100mm) taper cup wheel grade WA60KV. I used this for general grinding. For point thinning and grinding chipbreakers on turning tools I use a plain wheel 150mm x 6mm grade WA60K5V, and 4in. x 2in. cup wheel 38A60KVS.

The History of Lathes

Henk-Jan de Ruiter takes a look at the long history of our favourite machine tool.



Painting of a Manual Woodturning Lathe by H. Langden Brown, 1939.

With today's CNC Lathes you might think that the lathe as a modern tool is probably only 100 years old or so. However, as a matter of fact, the first tools working as a primitive lathe date back from ancient times as early as the year 1300 BCE and have been found in China, Egypt and Greece. In comparison, Archimedes described the water screw, a solution for raising water in 234 BCE, although it was known earlier than this.

The early lathes were used for turning wood into bowls, dishes and for making weapons. They were operated by two persons, one would turn a workpiece with a rope in a sort of lathe frame and the other person would shape the object with a sharp tool.

Lathes were further developed by the Romans in Italy, as they needed a sturdier lathe to work on shale, a soft type of sedimentary rock from clay for bricks, tiles and pottery.

The Vikings used bowl and pole lathes to make household objects, for example wooden chair legs. During the Medieval period, woodwork such as furniture making grew into an important job and provided an income for many people, **photo 1**.

Later, several sketches have been found from Leonardo DaVinci about screw cutting lathes. In 1718, Audrey Nartov, a Russian engineer invented one of the first lathes with a mechanical cutting tool supporting carriage and a set of gears. Not much later, the first metal slide rest lathe was invented by Jacques de Vaucanson, a famous builder of automatons, in 1751.

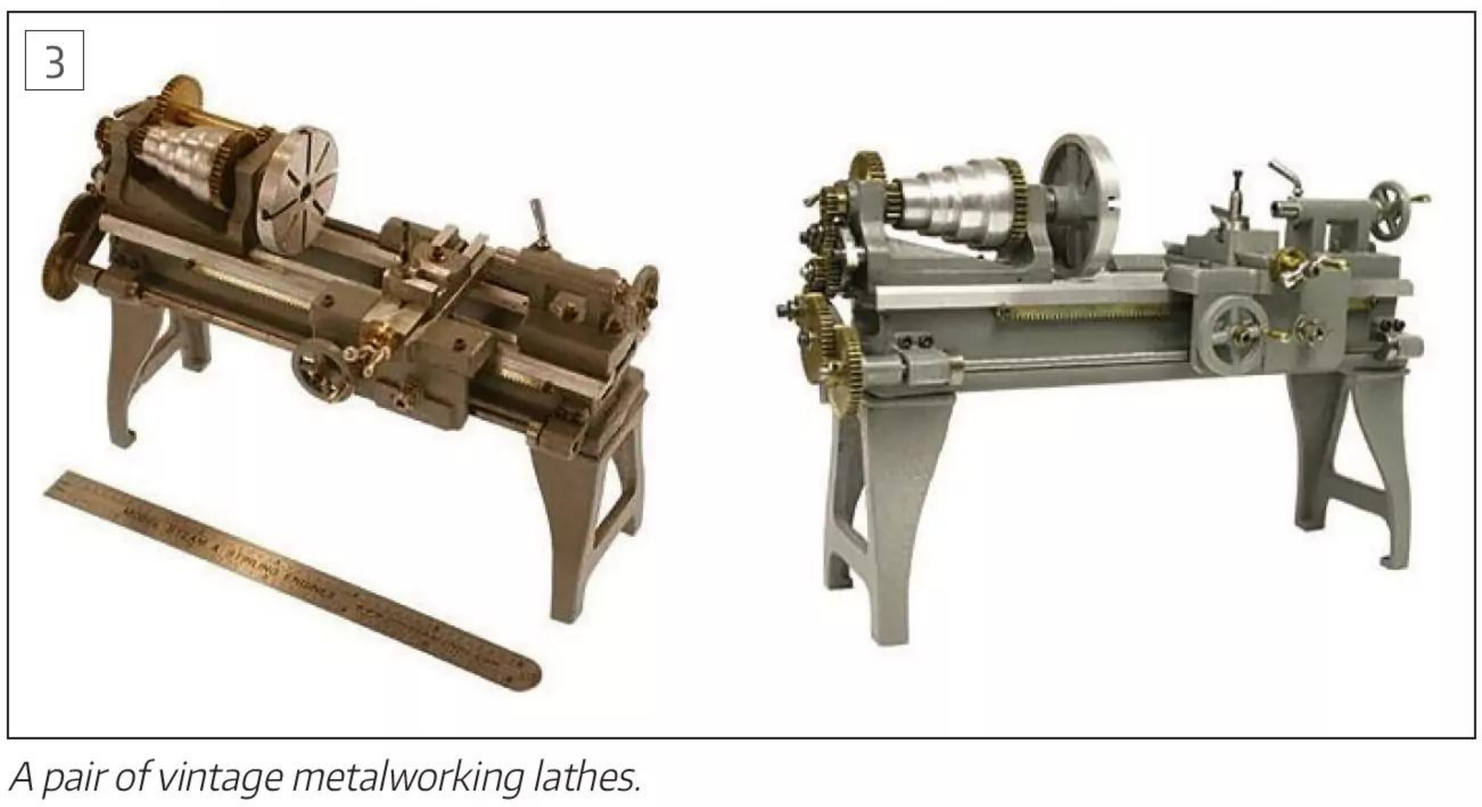
Around the same period a horizontal boring machine was installed by Jan Verbruggen in 1772 in the Royal Arsenal in Woolwich, England, **photo 2**. These were powered by a horse and used for making heavier cannons. Another Englishman, Henry Maudsley, made many improvements to this horse powered lathe and he is also regarded as the inventor of the metal lathe.

All these steps played an important role from transforming a traditional agricultural system into a more mechanized society which was started by the Industrial Revolution around 1750 in England. This was made possible also by financial funding by private individuals and through the forming of new non-governmental financial institutions looking for new investments.

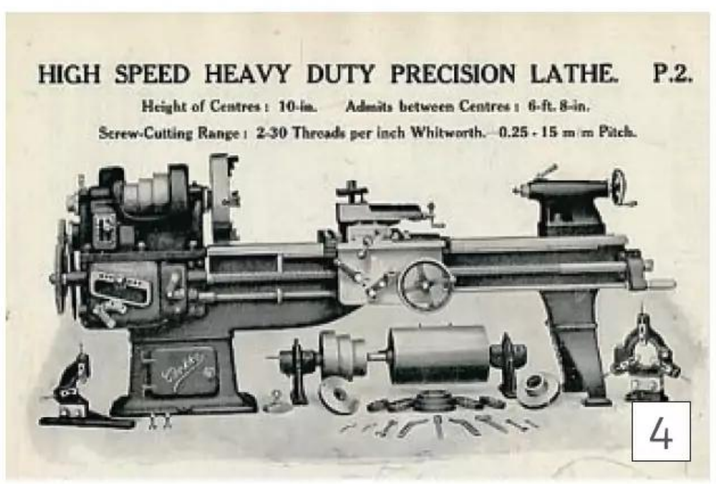
During the Industrial Revolution people were trying to find new production methods, for example, mechanized textile spinning was introduced, and people started using mechanized power, generated by water wheels or steam engines, transmitting it to a lathe via (overhead) line shafting to ease the work and to produce a higher and more efficient production in order to keep up with demand from


2

Drawing by Jan Verbruggen 1778, Horizontal boring machine Woolwich Royal Brass Foundry.


3

A pair of vintage metalworking lathes.



4

A large early 20th century lathe.

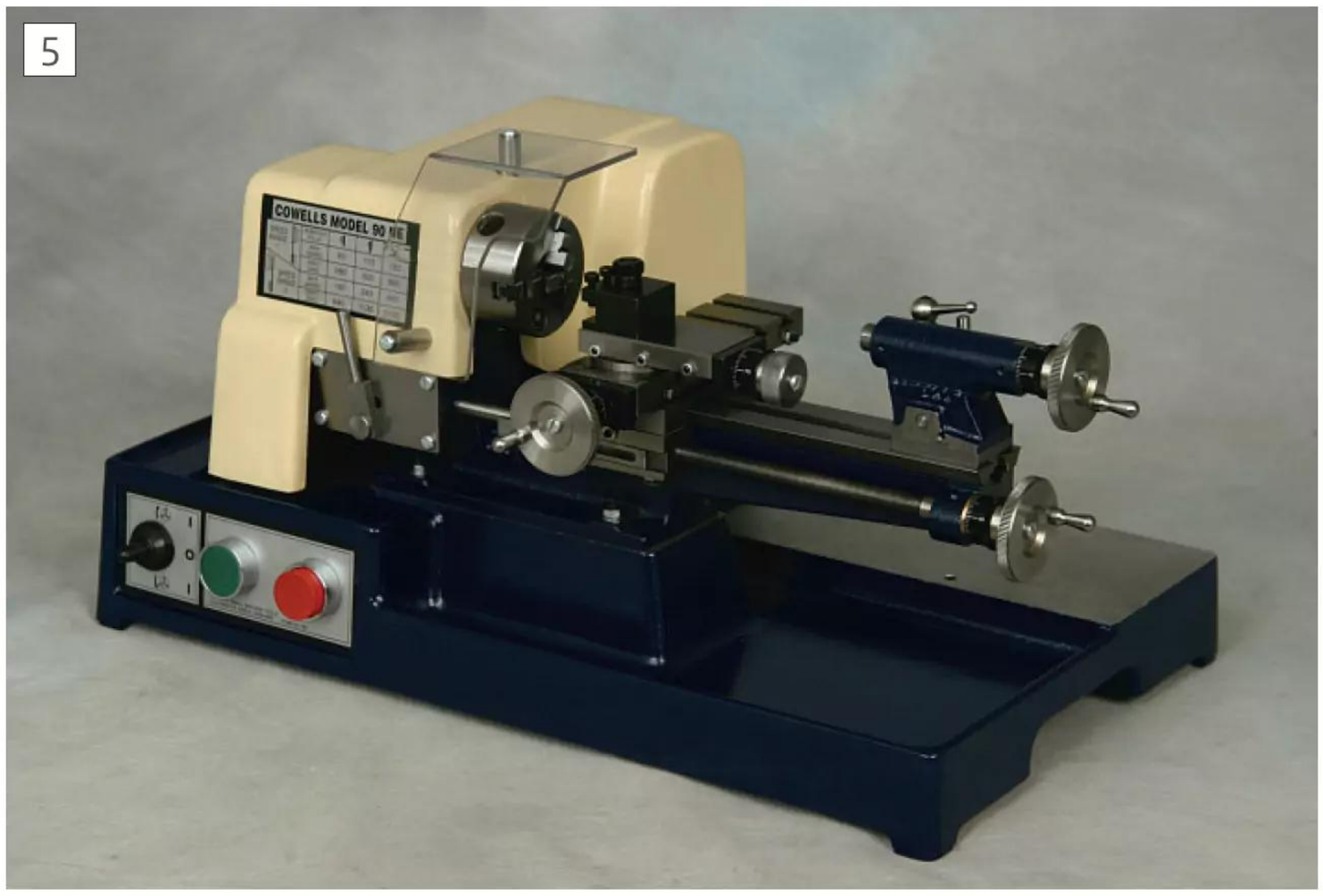
a growing world population. This all led to the development of the basics of the modern lathe as we know it today, **photos 3** and **4**.

When electric motors made their entrance in the late 19th century this line shafting was gradually replaced by them. More recently modern servo-controlled mechanisms were applied to control lathes in the 1950's, which led to todays' CNC Computer Numerical Controlled lathes.

There are many different types of lathes to be found in the modern manufacturing environment, each of them made for a specific task.

The oldest ones are woodworking lathes, but there are also duplicating or copying lathes, pattern making lathes for foundries, metalworking lathes, cue lathes for making billiard cues, glass working lathes, metal spinning lathes, rotary lathes (invented by Immanuel Nobel, the father of A. Nobel) used for working with wood veneer, ornamental turning lathes for decorative work, reduction lathes which can convert a certain workpiece into a smaller scale, watchmaker lathes and music recording lathes.

Most diverse are the metal making lathes; these can be categorized into many types. Bench mounted centre lathes are the most common for the home machinist, but there are also



Cowells ME 90 lathe.



Myford connoisseur.

toolroom lathes, turret lathes, gang tool lathes, multi-spindle lathes, CNC lathes, Swiss-style lathes, combination lathes, micro lathes, brake lathes (for the Automotive industry), wheel lathes (for the Railways), pit lathes and vertical lathes.

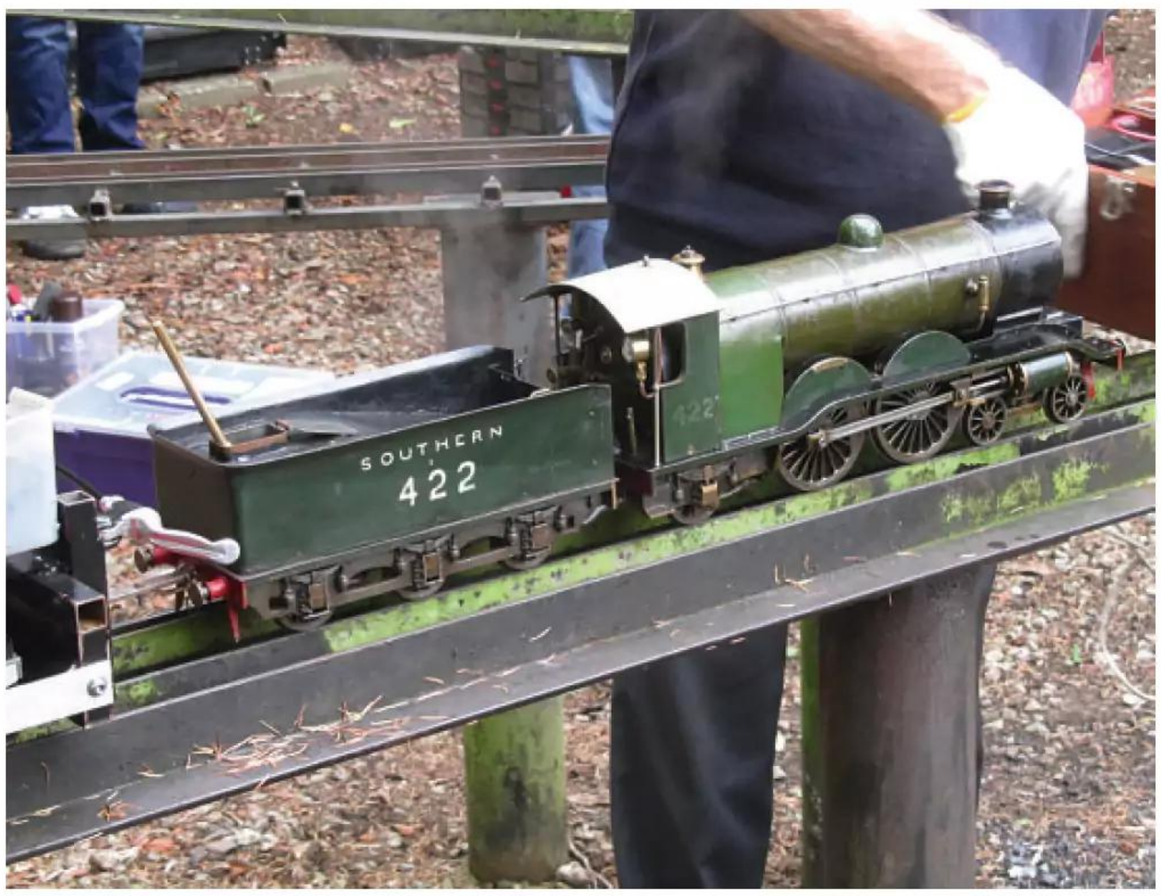
Some popular names come to mind in the world of metal lathes. Companies who have been around for quite a while are Cowells, **photo 5**, and Myford, **photo 6**, from the UK, Proxxon and Wabeco from Germany, Unimat from Austria, Bergeon and Schaublin from Switzerland and Sherline from the USA. ▮

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NEXT ISSUE



Contents subject to change.

Battle of the Boilers
The famous contest, a century ago, established the supremacy of coal fired boilers for model steam locomotives.

Kinematics
We look at the relationships between position, velocity and acceleration.

BR Standard Mogul
Doug Hewson embarks on the construction of a 5 inch gauge model of a British Railways standard 2-6-0 tender engine.

Driving trolley
Mike Joseph constructs a simple driving trolley to accompany his 5 inch gauge battery electric locomotive *Zahia*.

Publicity
Roger Backhouse reminds us that the motto *Publish or Perish* applies as much to model engineering societies as it does to scientific discovery.

The Next Issue of Model Engineer is issue 4749, August 23 2024

A Workshop Diary

Alex du Pre returns with an occasional series highlighting some interesting workshop challenges. He starts by making a small tailstock for a dividing head.



It is always the way with model engineering as a hobby that any project is frequently interrupted by the absence of a particular tool or part to complete a job, leading to the need to divert your attentions to the making of additional tools, fixtures and fittings. Often these make interesting mini-projects in their own right and should be considered as part of the fun rather than a blocker to progress. Often a machining problem can be solved by digging out a rarely-used and almost-forgotten tool made many years ago for another project. Over time, your collection of tools and accessories builds up, allowing almost any job to be tackled.

In this article and the ones that will hopefully follow, I'm going to focus on the machining journey rather than the end product, in the hope that I can offer some interesting workshop stories and share some tips and techniques that might be of use in your own endeavours. Equally, I will share things that have not gone so well.

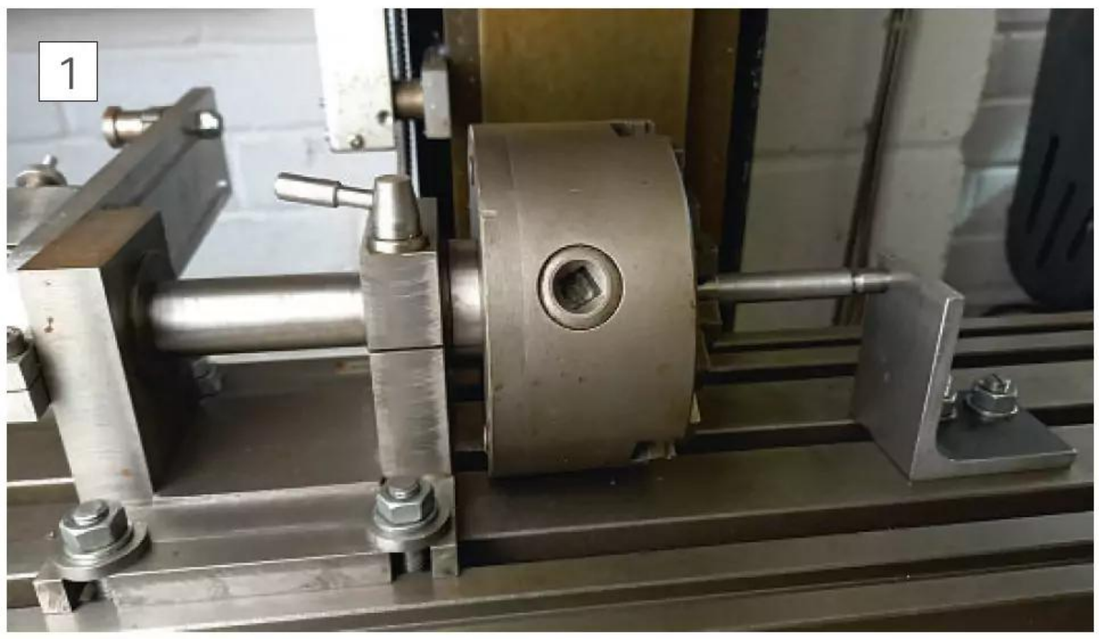
Over recent years, my workshop endeavours have included making an experimental trike and bits and pieces for model cars, in particular some small internal combustion engines and my current project, which is a model five speed gearbox, hopefully one day to be matched with a suitable engine and chassis.

I am going to start with a look at angle iron, a rather unglamourous topic you might think, but nevertheless one that will hopefully throw up some interesting points.

Angle Iron

Angle iron, or mild steel angled section to give it a less colloquial name, is a material I have used on a few occasions recently. Angle iron is readily available from local metal stockists and can be obtained in many sizes. It is cheap, easily cut, machined and welded, and so can be a great starting point for certain workshop projects. Many other shapes and sizes of steel section, such as flats, channel and I-beams can also be useful. Tubing, both circular and rectangular, extends your options further, but I am getting off-topic already.

I used a piece of angle iron the other day to make a small tailstock to pair with my dividing head (the latter was described in MEW 265 and 266) and a while back I used more angle iron sections to make a compact sheet metal ›



The tailstock in use with the dividing head on the mill table.



Cutting off a length of angle iron in the bandsaw.

bender. I'll start now by looking at the tailstock, **photo 1**, and maybe come back to the bender another time.

A Small Tailstock for the Dividing Head

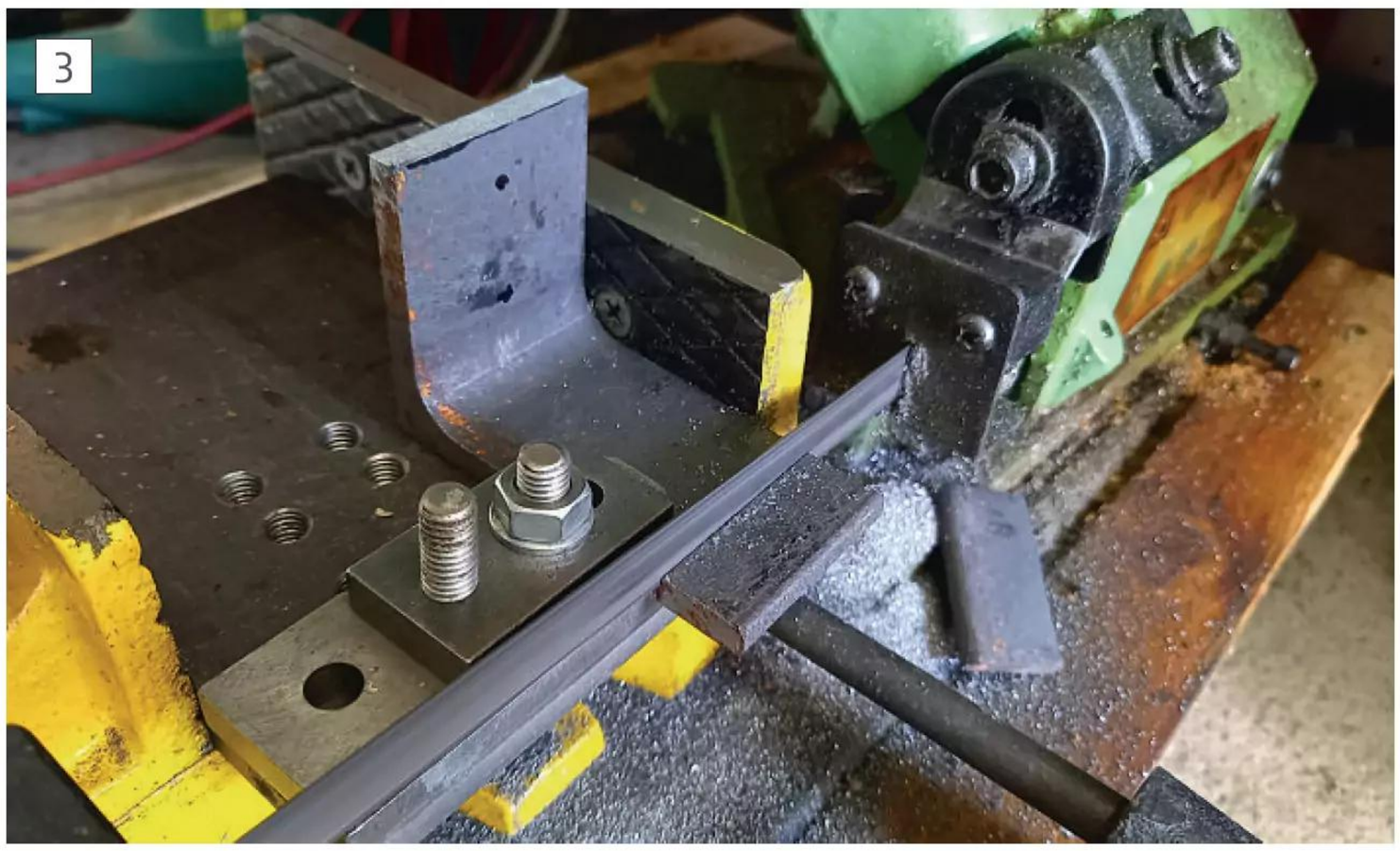
I needed a simple tailstock to support a workpiece with a long overhang in the dividing head, the workpiece in question being the blank for some small gears.

This was a fun job improvised on the spot with drawings only existing in my head. I had some angle iron left over from the sheet bender project, so decided to use that. With no critical dimensions apart from the height of the centre I could proceed quickly.

As with many machining jobs, there are many different ways to approach the task. In this case, I decided to use the lathe, with the workpiece bolted to the cross slide and the cutters held in the lathe spindle.

The first step was to cut off a suitable length of angle iron using the trusty bandsaw, **photo 2**. Next, the two flanges on the angle were cut roughly to length. Short workpieces need a special fixture to hold them in the bandsaw as the vice jaws alone do not give a suitable grip. In my case, I have a slab of steel drilled with a number of M8 holes, which forms a fixture onto which various workholding dogs and clamps can be secured. This fixture is held in the bandsaw's vice, **photo 3**.

Having created the blank, it was then machined on all external faces using a flycutter mounted to the lathe's faceplate. For this application, the workpiece only really needed to be machined flat on its bottom face, however, for the sheer fun of it, I faced it all over.



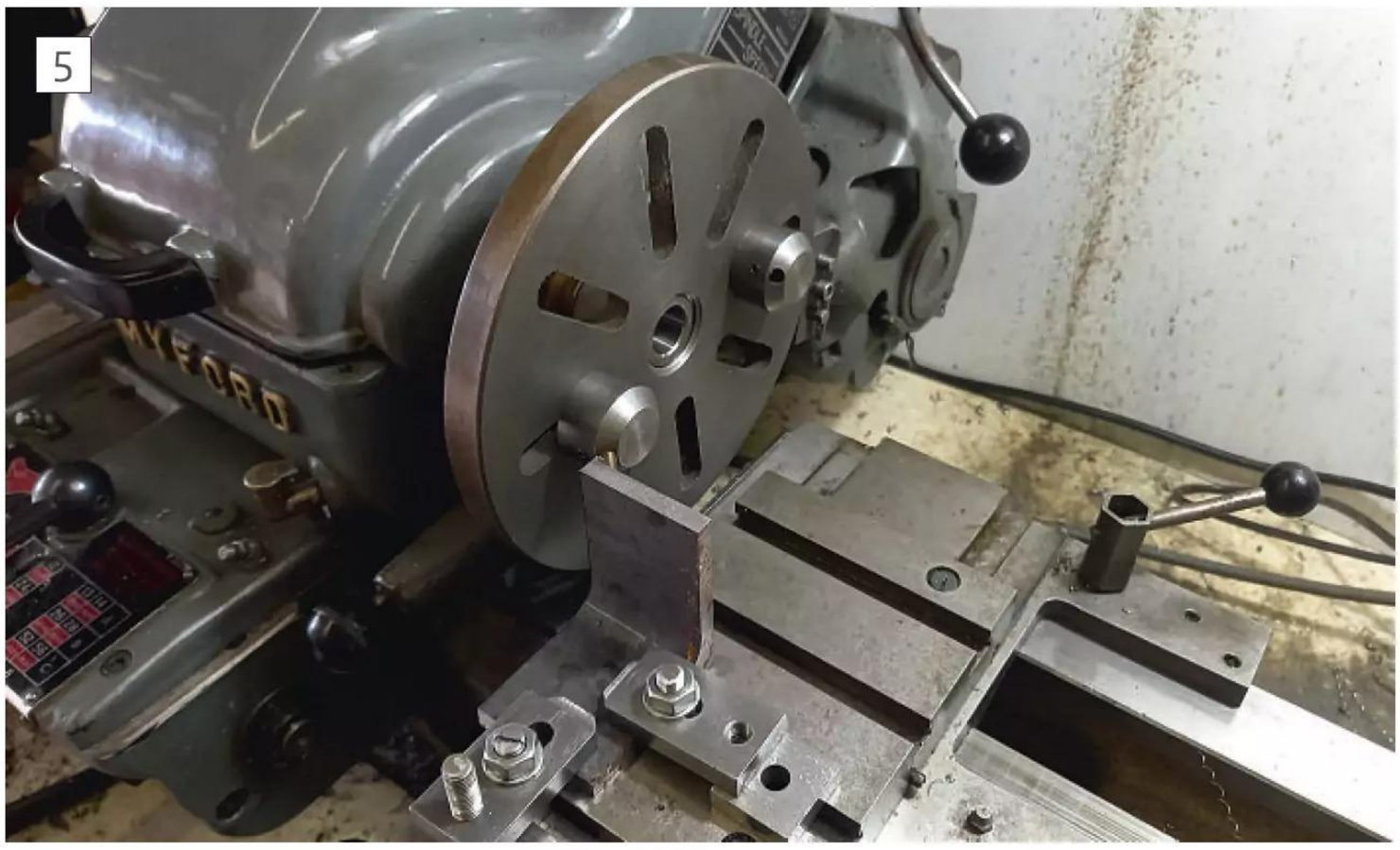
Using a fixture to hold the workpiece in the bandsaw.



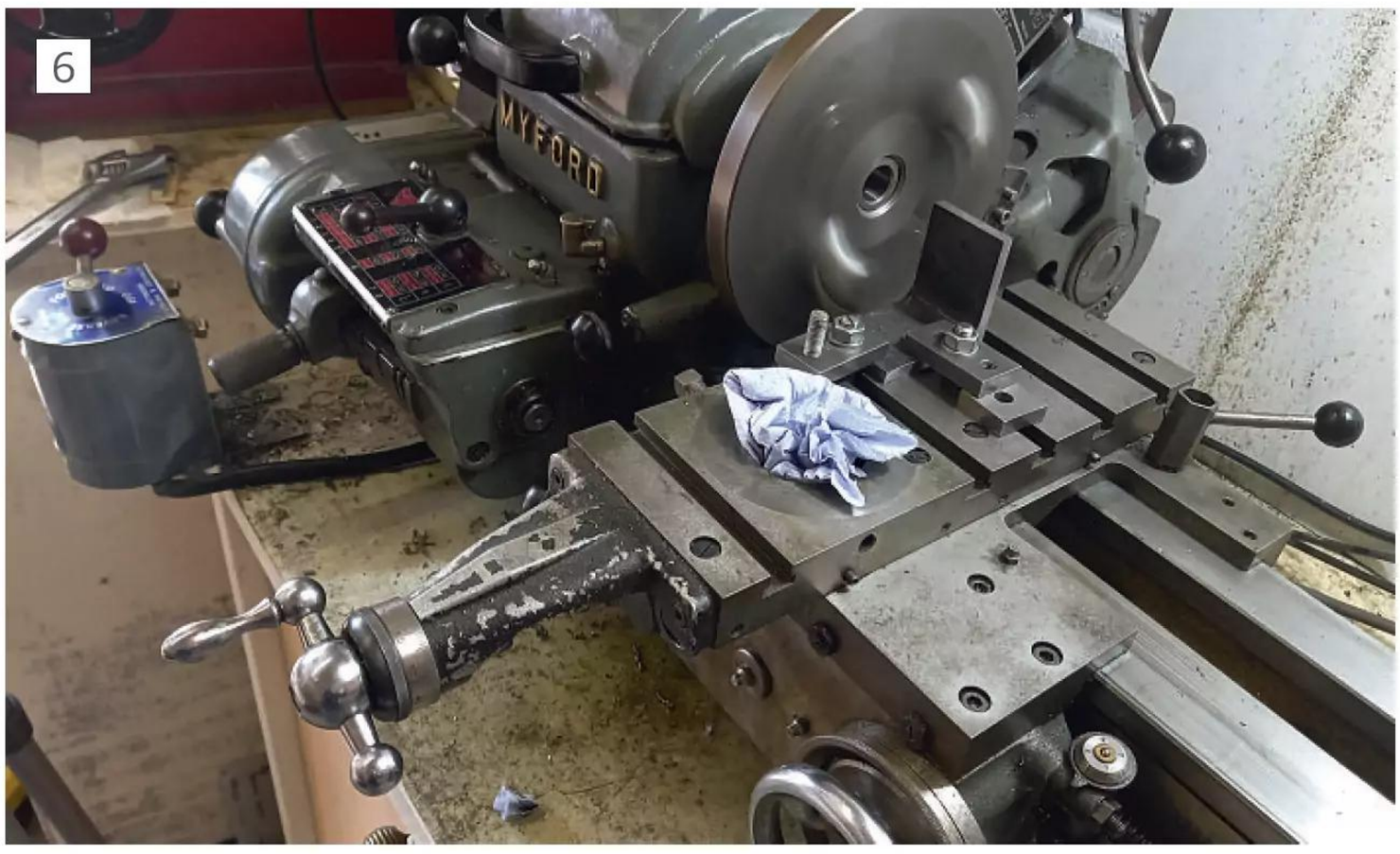
The components of the faceplate flycutter.

This job could have been done in the mill but at the time the mill was set up for another job and the lathe offered a number of advantages, not least the simplicity of holding the workpiece and the power cross feed on the Myford. My X3 mill is a simple machine without the luxury of power feeds. In this set up, the Myford is more rigid than the X3 too.

The flycutter used consists of two key parts, one that holds the high-speed steel cutter and a second that is essentially a counterweight but could be used to hold a second cutter if needed, **photo 4**.



Flycutting the workpiece using the lathe.



The power cross feed in action.

The cutter is bolted to the faceplate with the counterweight set opposite. The cutter's sweep can be adjusted by moving it along its mounting slot. A fairly slow spindle speed of 120rpm is about right for this job but not too critical if it is balanced well. This is an excellent and very satisfying method of machining large, flat surfaces, provided the cross slide is perpendicular to the lathe spindle. Light cuts and a steady feed are the way to go.

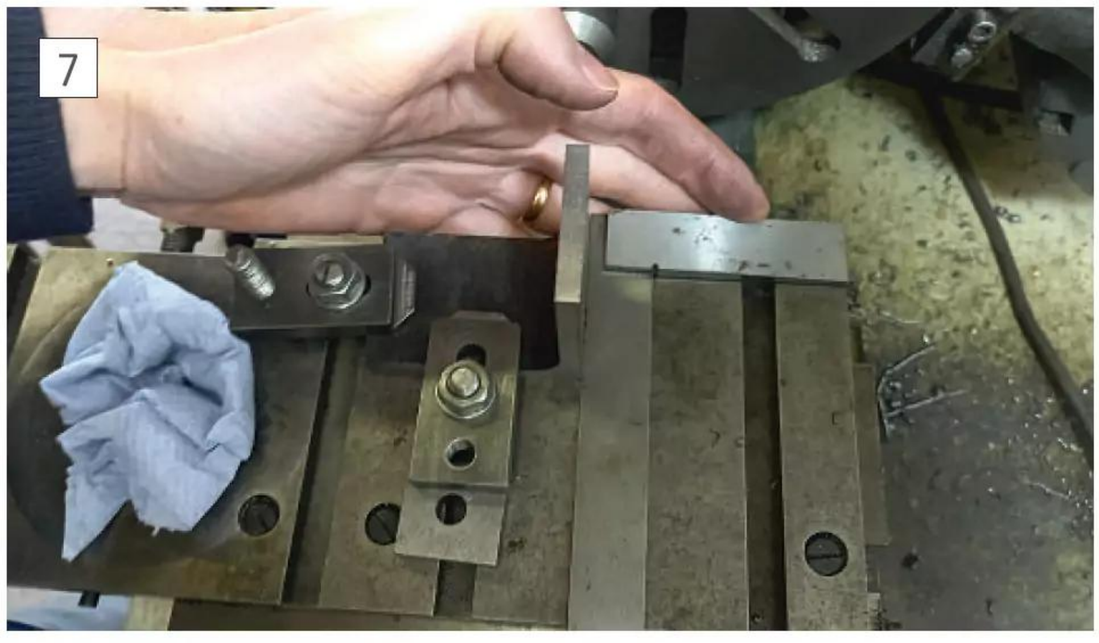
The workpiece was bolted to the cross slide using two clamps, **photo 5**. The Myford cross slide is relatively flexible and in this set up considerable bending forces are applied to the slide. I found it was necessary to tighten the clamps enough to hold the work securely but not so much that the slide seized.

With a slow power cross feed set, the first edge of the work was faced, using several passes. With each pass taking about a minute, there is the chance to take time out for a photo whilst maintaining due supervision of the work. The hole in the cross slide in which the top slide normally lives has been plugged with a bit of paper to keep swarf out, **photo 6**.

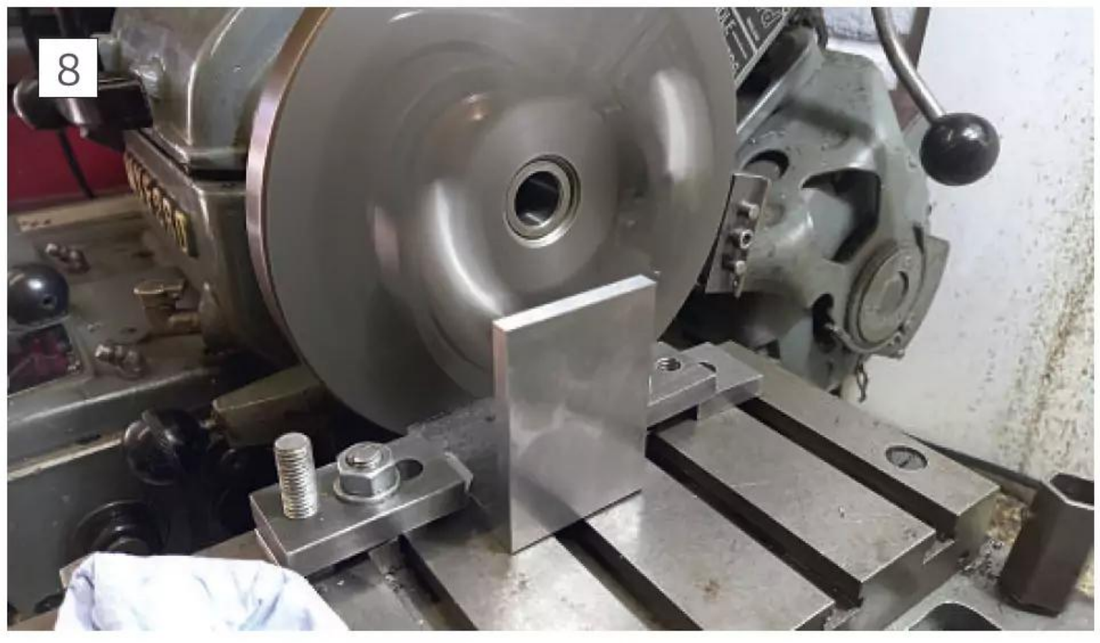
The newly machined edge now becomes the reference edge, with which all other surfaces now need to be parallel or perpendicular as appropriate. An engineer's square held against the front edge of the cross slide was used to set up the workpiece for subsequent cuts, **photo 7**.

The flycutter gives a very good surface finish to the work, provided it is sharp and has a slightly rounded tip, **photo 8**.

The two flanges of the raw angle iron are only approximately at right angles in the unmachined state, but the above method ensures that both main faces are accurately perpendicular within the limits of the accuracy of the lathe. In theory, the top surface of the cross slide and the slide's movement will be square to the lathe spindle but in reality, will be slightly out to some extent, so for critical applications it would be worth checking and taking any necessary measures to compensate. But for most model engineering purposes, the accuracy will be more than good enough and so the method described above is perfect for making angle plates, squaring blocks and so on.



Using a square to position the workpiece.



A good surface finish achieve by the flycutter.



Drilling the bolt holes using the drill press.



Cutting the clearance feature using a slot drill.



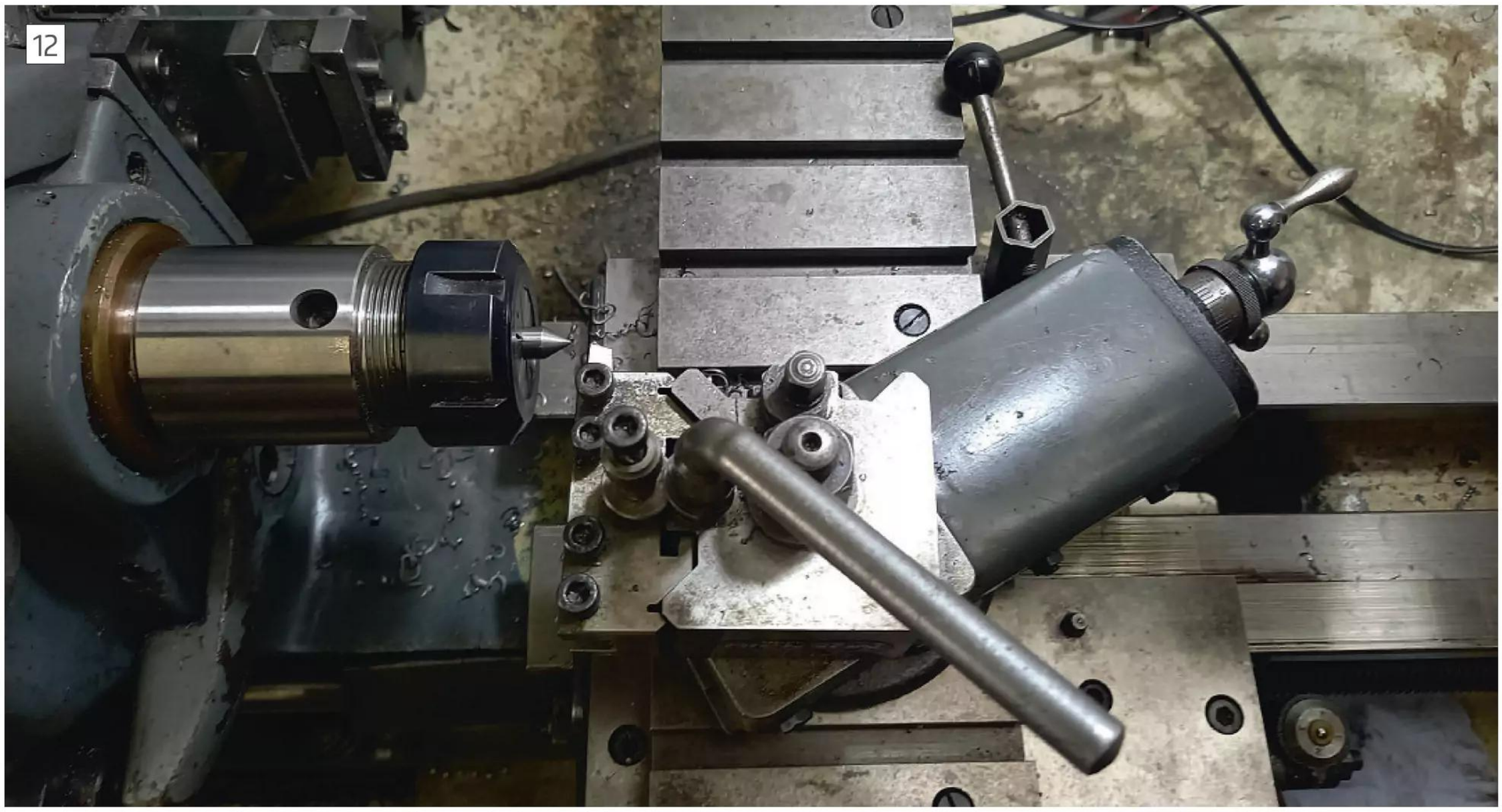
The finished centre ready for hardening.

The machined part was then taken to the drill press and two bolt holes drilled in the lower flange, **photo 9**. The holes were cleaned up with a deburring tool.

When I made it, the aforementioned dividing head was bored on the same lathe by clamping it to the cross slide and using a boring bar held between centres, so its spindle axis is exactly at the lathe's centre height. The hole for the tailstock's centre needed to match the dividing head's centre height, so was drilled through from the lathe's headstock, by fitting a drill chuck in the lathe spindle.

The final job on the angle was to machine a clearance to prevent the gear cutter from fouling the tailstock when making small gears. This time I used a fairly large slot drill held in an ER32 collet mounted to the lathe's spindle nose. Taking a series of light cuts, I was able to use the lathe's carriage power feed to complete the feature, using the cutter in a drilling mode rather than using its side teeth, **photo 10**.

To complete the tailstock, I made a hardened centre from silver steel, **photo 11**. The standard 60-degree angle was machined using the top slide, holding the part in a collet, **photo 12**. The part was then reversed and an M6 thread cut using a tailstock die holder. With the die holder's tommy bar resting on the cross slide, I use a very slow back



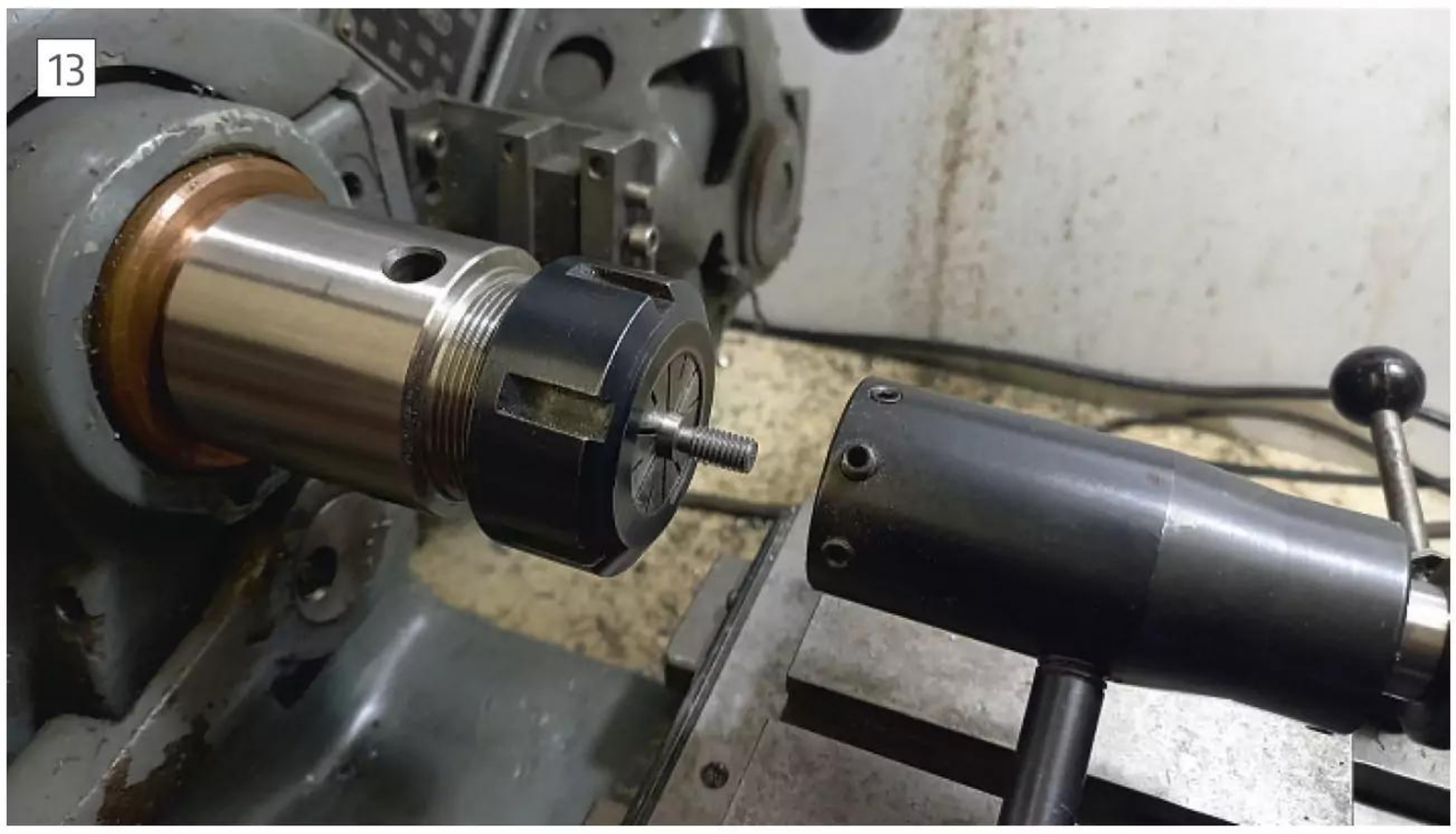
Forming the tapered portion using the angled top slide.

gear speed to cut the threads under power, keeping one hand on the lathe's clutch. I don't think I would be brave enough to do this job under power on a lathe that couldn't be run really slowly and didn't have a clutch, **photo 13**.

Finally, the centre was heated to red heat in the brazing hearth using a plumber's blowtorch then immediately plunged into cold water to quench and harden it, **photo 14**. It was then heated in the oven with dinner at 200 degrees for ten minutes or so to temper it and then quenched again. Tempering increases its toughness at the expense of some hardness, reducing the likelihood of brittle fracture in use.

The tailstock was completed in a couple of workshop sessions plus one dinner time and resulted in a useful accessory that will get me through the gears project and will re-emerge for further use on occasion in the future, as long as I remember I've got it. The angle iron came from the scrap box and meant I didn't have to mess about turning a large lump of metal into swarf or bolting together two flats to make an angle. Above all it was a fun little job that allowed me to exploit the lathe's versatility.

In a future issue, I'll show you how I used some more angle iron to make the sheet metal bender. ▮



Cutting the thread with a tailstock die holder.



Heating the centre to quench and harden it.

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Improving Depth Measurement with a Digital Caliper

Geoff Andrews explains a modification that helps increase accuracy when using a digital caliper to measure depth.

We all have the need to measure depths in our work. Usually most accurate method is by using a depth micrometer having a wide rigid base to place on the work and a depth rod to make the measurement. However, we do not all have these as they can be expensive, and the usually fairly wide base can sometimes make taking a measurement in a restricted place difficult.

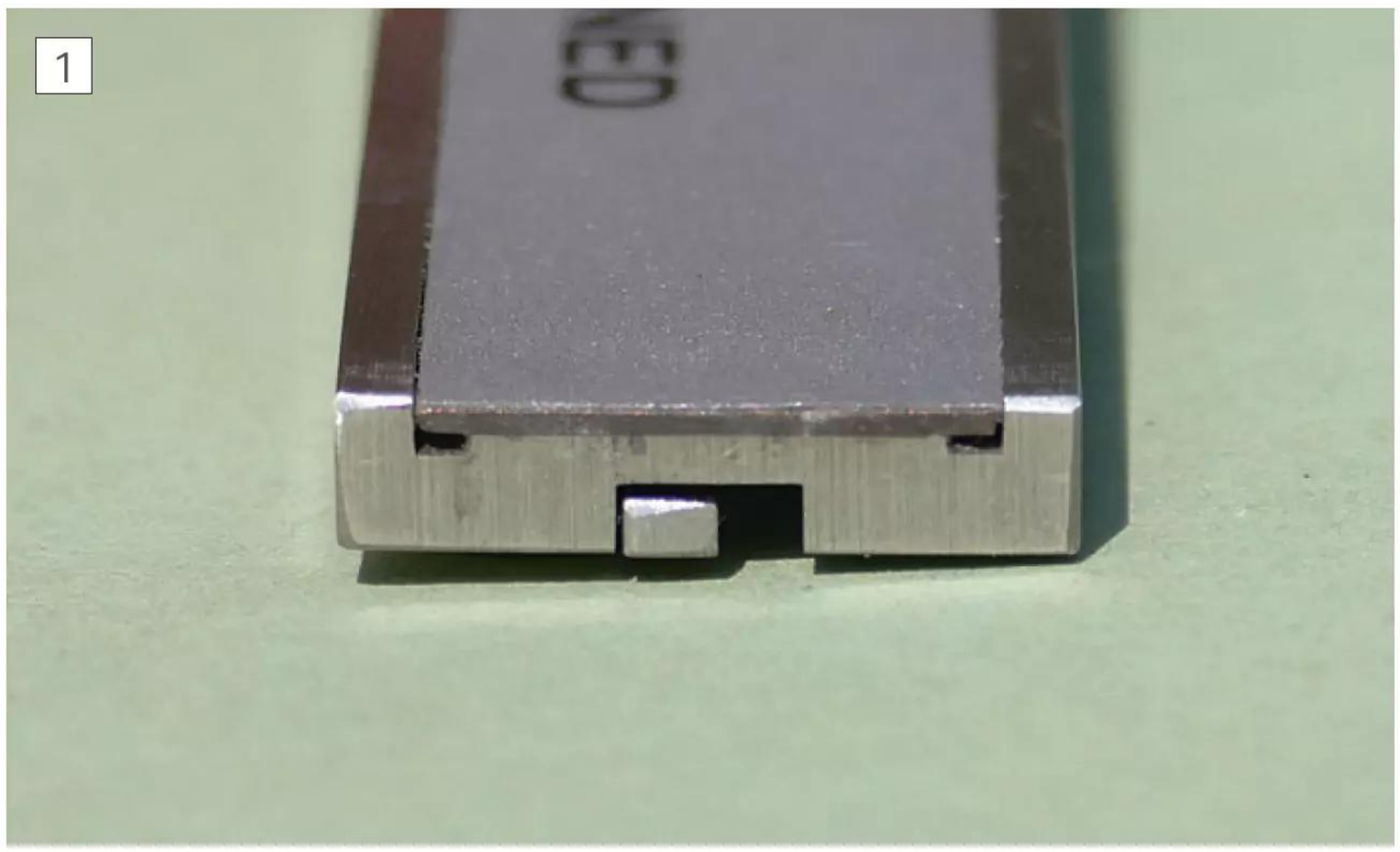
Alternatively most workshops are equipped with a digital caliper. Whilst not the most accurate measuring instruments they do have the convenience of being able to take external, internal and depth dimensions all in one unit. Personally, when turning, I often use the digital caliper for convenience to check progress but always take the final dimensions with a micrometer.

And so it is that depth measurements are taken using the digital caliper. Taking measurements this way has its own inherent problem, however, in that the base area we have for resting on the work is very small, **photo 1**. With a total base area of approximately 6 x 3.6 mm half of which is taken up by the depth gauge itself.

Whether used horizontally or especially vertically there is another problem. With the majority of the weight being in the jaws and gauge reading the calipers are inherently top heavy with the result that any slight hand movement whilst trying to hold the base against the work is magnified by the pendulum effect of this top weight.

As it happens, I have two of these devices, so I decided to alter the older of the two which is now over twenty years old but still in perfect working condition.

The solution seemed straight forward, add a larger base to the digital caliper.



Typical end of caliper.

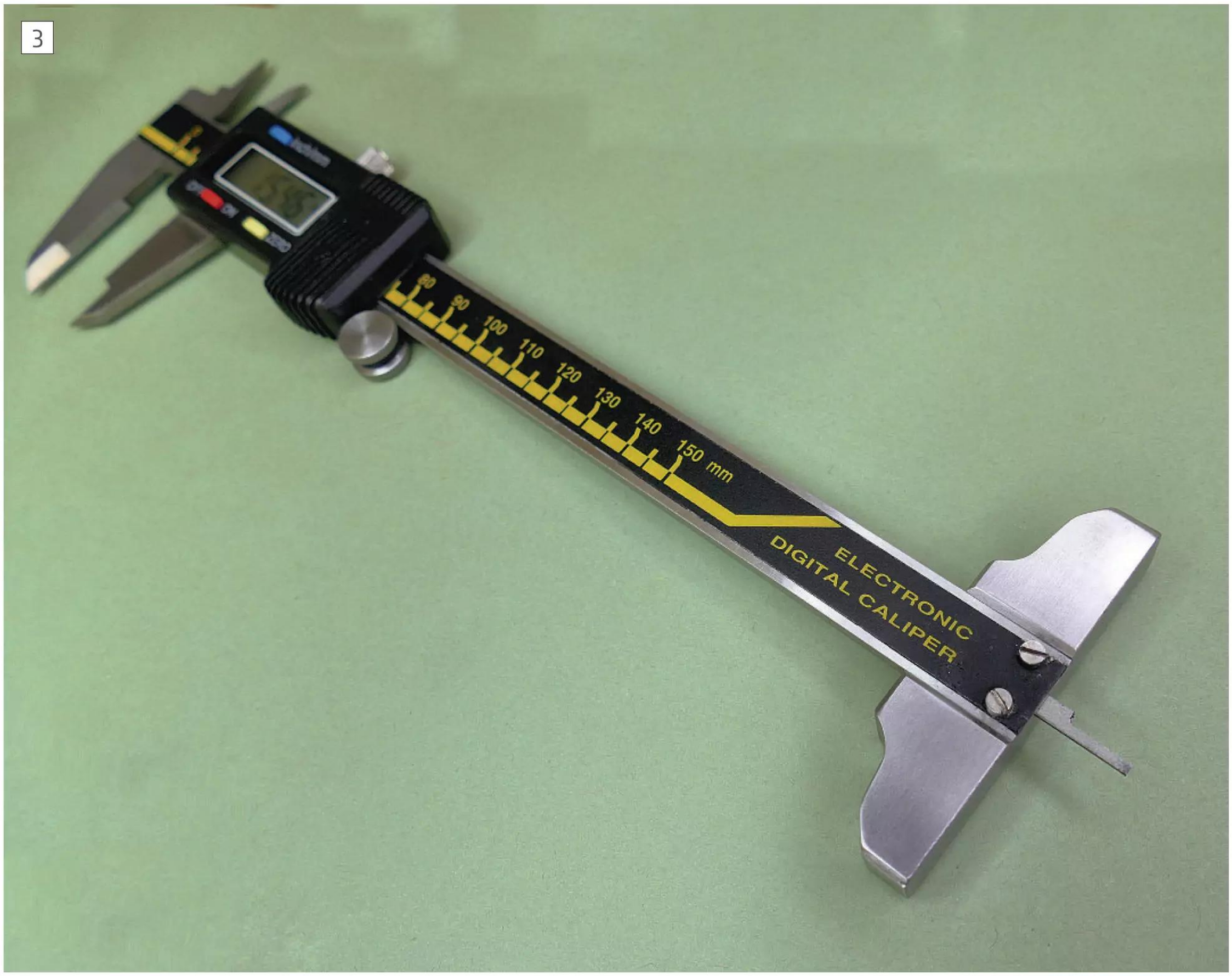


First new end base.

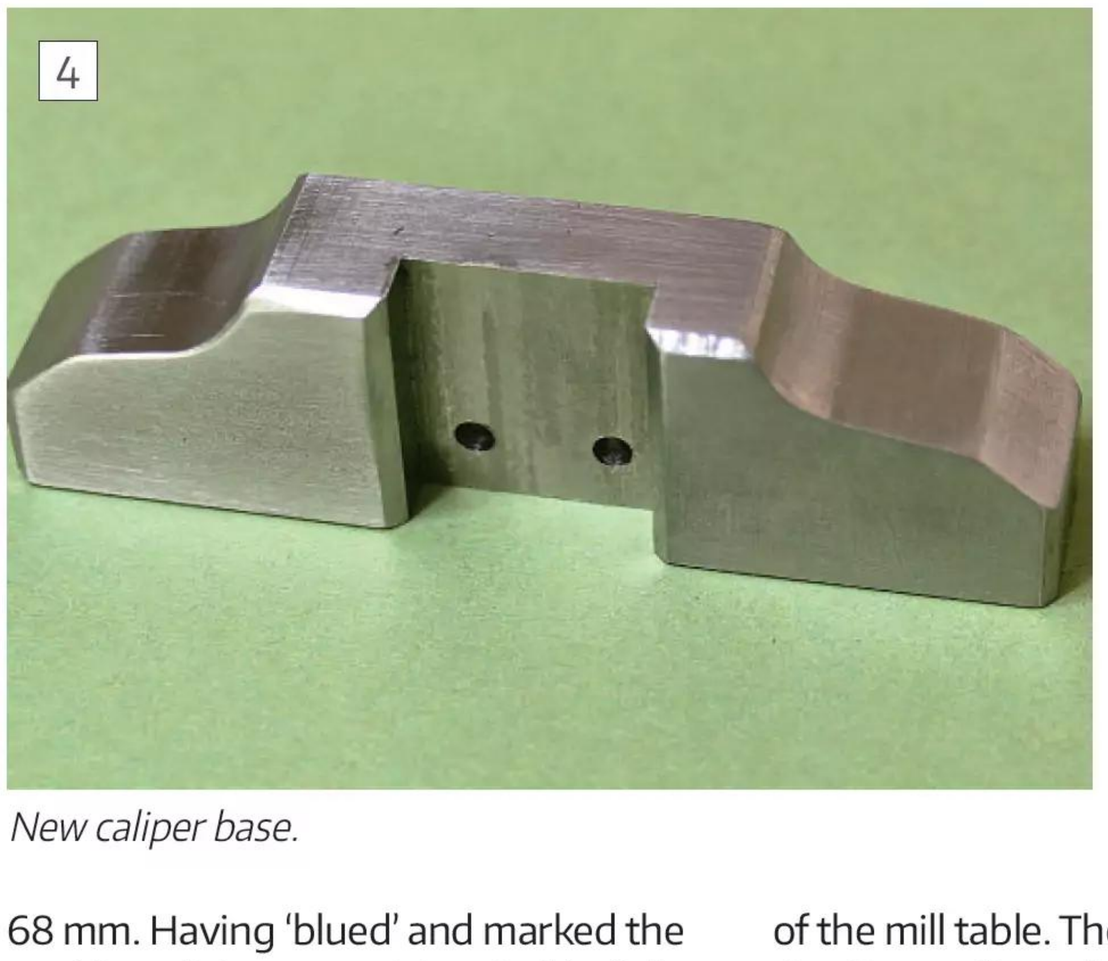
The first attempt which was made from a section of 1/4" x 5/8" x 68 mm long steel is seen in **photo 2**. It was to be fastened to the rear face of the caliper.

Once fitted, however, it quickly became apparent that this was not going to be sufficient because although it held the caliper much more stable sideways it did not prevent some 'wobble' forward and backwards. The second attempt by recessing the caliper into the base, as shown in **photo 3**, was much more successful. A detail of the new caliper base is shown in **photo 4.**

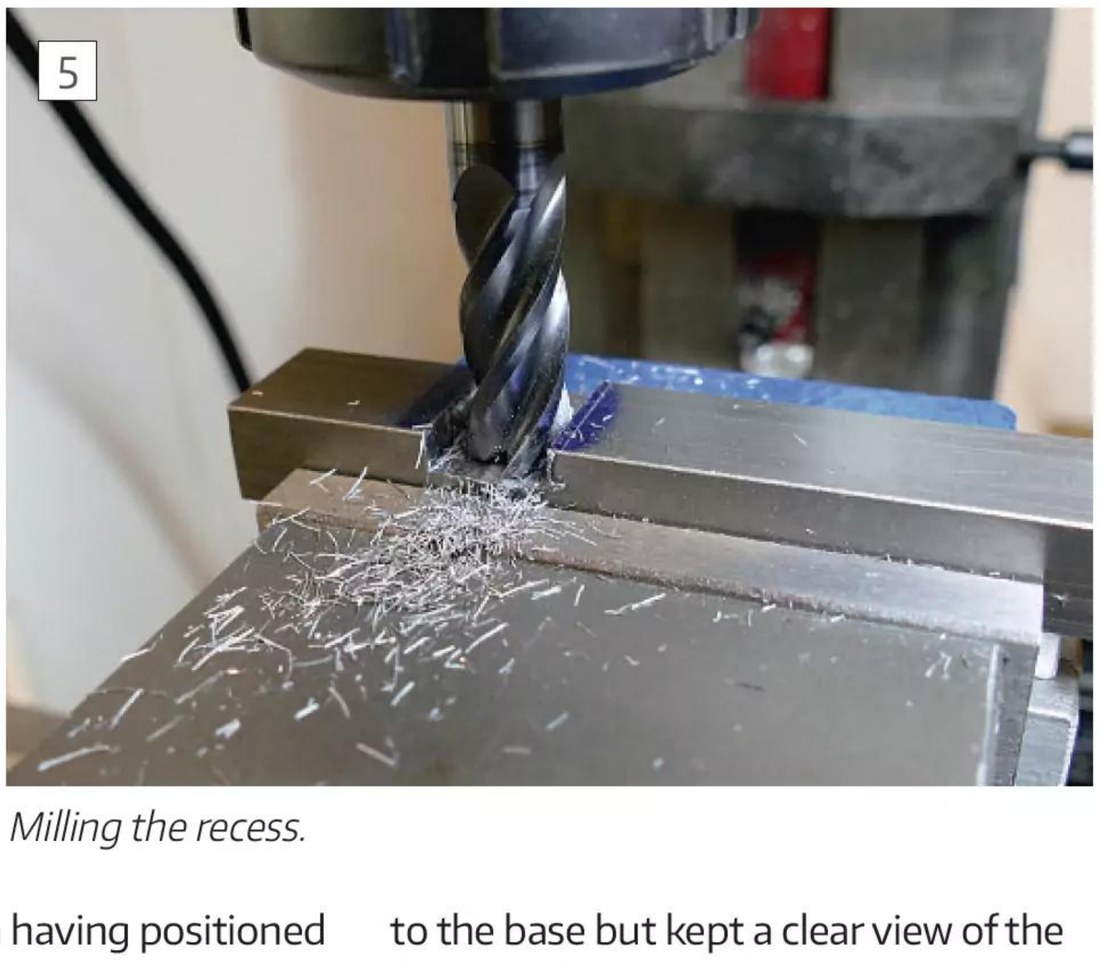
This base was made from a piece of 3/4" x 1/2" steel with a final length of



Caliper with new base fitted.



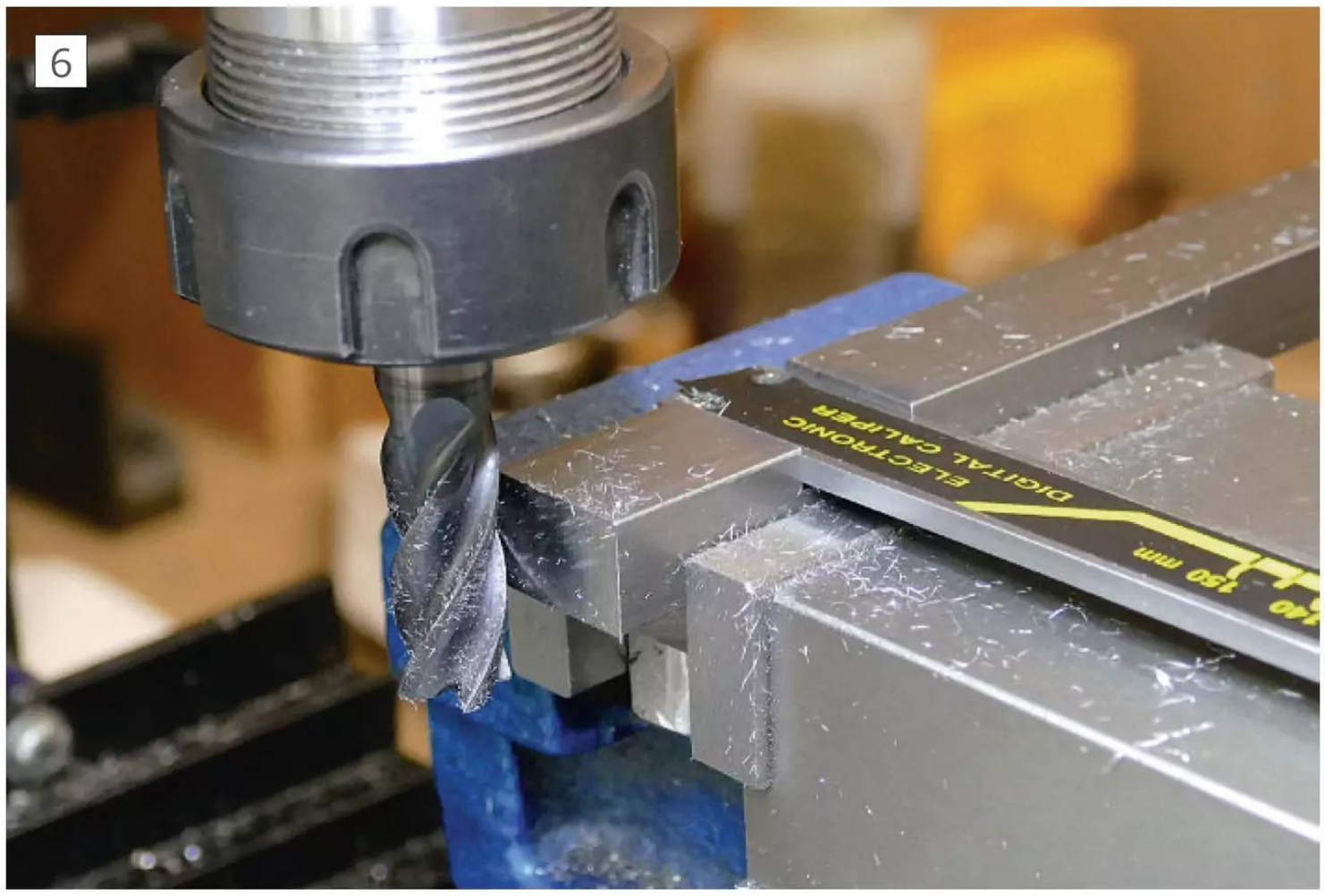
New caliper base.



Milling the recess.

68 mm. Having 'blued' and marked the position of the recess I then held a full length of steel on a pair of parallels in the vice of my milling machine. I had previously checked with a TDI to ensure the vice was still parallel to the traverse of the mill table. Then having positioned the 12 mm dia. carbide cutter at the centre line of the recess I locked the X axis used the Y axis traverse to cut the slot at 4.5 mm deep, p**hoto 5**. This depth gave a degree of forward support to the base but kept a clear view of the depth rod

The slot was then widened to the left at that depth using climb milling on the last small cut to get the best finish to the edge. I then proceeded to remove



The caliper fitting as required and end squaring.



Milling the inclined shoulder.

material from the right side until I neared the final mark.

I wanted to get the caliper to fit as closely as possible in this slot in order to keep squareness, so the final passes were very small with a number of tries until the fit was as I wanted. This was a light hand pressure with the caliper being lifted without the base falling off. **Photograph 6** shows the fitting of the caliper and the end of the base being squared off in the milling machine.

The next operation was to extend the piece out slightly and rotate the vice to an angle of 10 degrees to form the inclined shoulders using the X axis, **photo 7**.

Deciding upon the length I wanted the shoulder to be I set the table stop accordingly and proceeded to cut the shoulder to half the diameter of the cutter at that length. Having now determined the full 'half' length of this base I cut the material to allow a small amount for squaring up and repeated the process for the opposite side. The vice was then set parallel to the traverse again and a 45-degree cutter used to put a chamfer onto the straight edges. The chamfer was taken to a depth to match the caliper in the recess for ease of reading. The whole piece had rough edges removed and then polished up the final job.

All well and good but then came a problem which I had not anticipated. My intention was to use the holes already in the end of the caliper to fasten it to the new base. The original screws were not long enough, and my nearest size of suitable length (2.40 mm diameter) were just too large to fit the diameter of the original holes. I knew the caliper was stainless steel but had not anticipated that it would be hardened. A point clearly marked on my newer caliper I subsequently realised but not the older one. Three dulled 2.5 mm dia. drills later, the fourth finally made it through the two holes in the caliper.

After carefully marking the first hole in the new base, ensuring that the bottom of the caliper was level with the underside of the base I drilled though and counter-bored the rear face for the nut to be recessed. Repeating the process with the second screw.

Now to test. I was pleased to find that the new base was a great improvement

8



Accurately checking the depth with caliper free standing.

9



Caliper back in its case.

in accurately measuring and providing a repeat reading of the depth. Part of the original problem had been the top-heaviness of the device. By fitting the new base this has brought the centre of gravity nearer to its centre position and thus improved the balance as can be seen in **photo 8** where the caliper can be seen completely free standing whilst measuring the depth of a machine vice jaws. It is also easily held with the thumb and forefinger against a component while a measurement is taken.

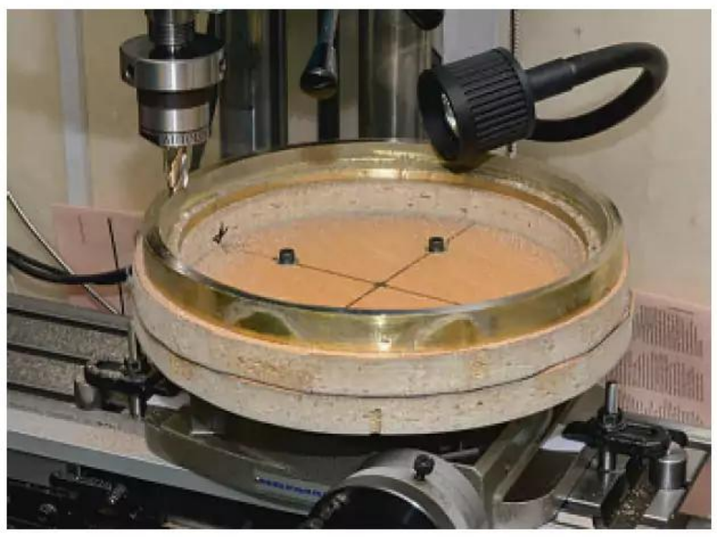
After slightly altering the cushioning in the case the new base fitted well, **photo 9**. I also made a slot to keep the original first attempt. - I might find another use for it. ▮

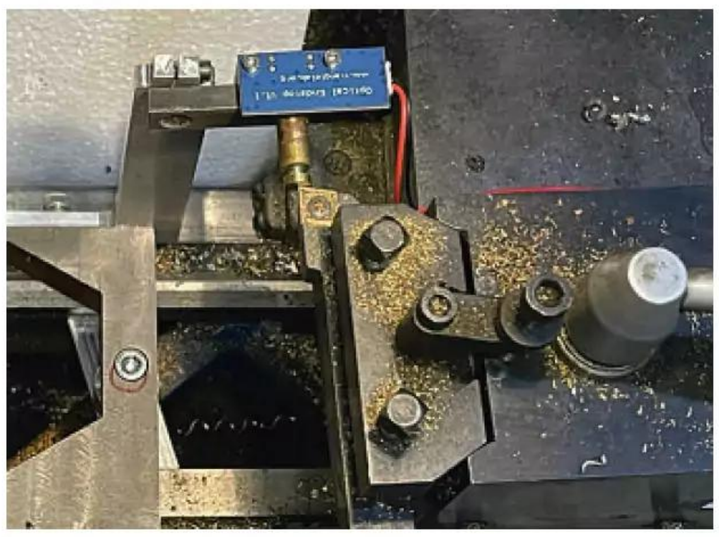
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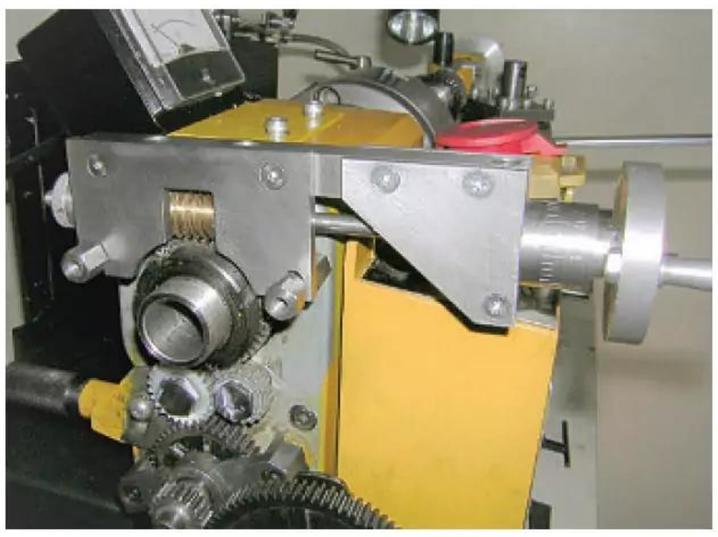
Coming up in issue 344, October 2024

On sale 20 September 2024

Contents subject to change







Adrian Garner explains how to mill large diameters, using clock bezels as an example.

Simon Davies makes a tool-tip detector for accurately setting digital readout equipped lathes.

Michael Cox shares his design for a precise indexer for mini-lathes.

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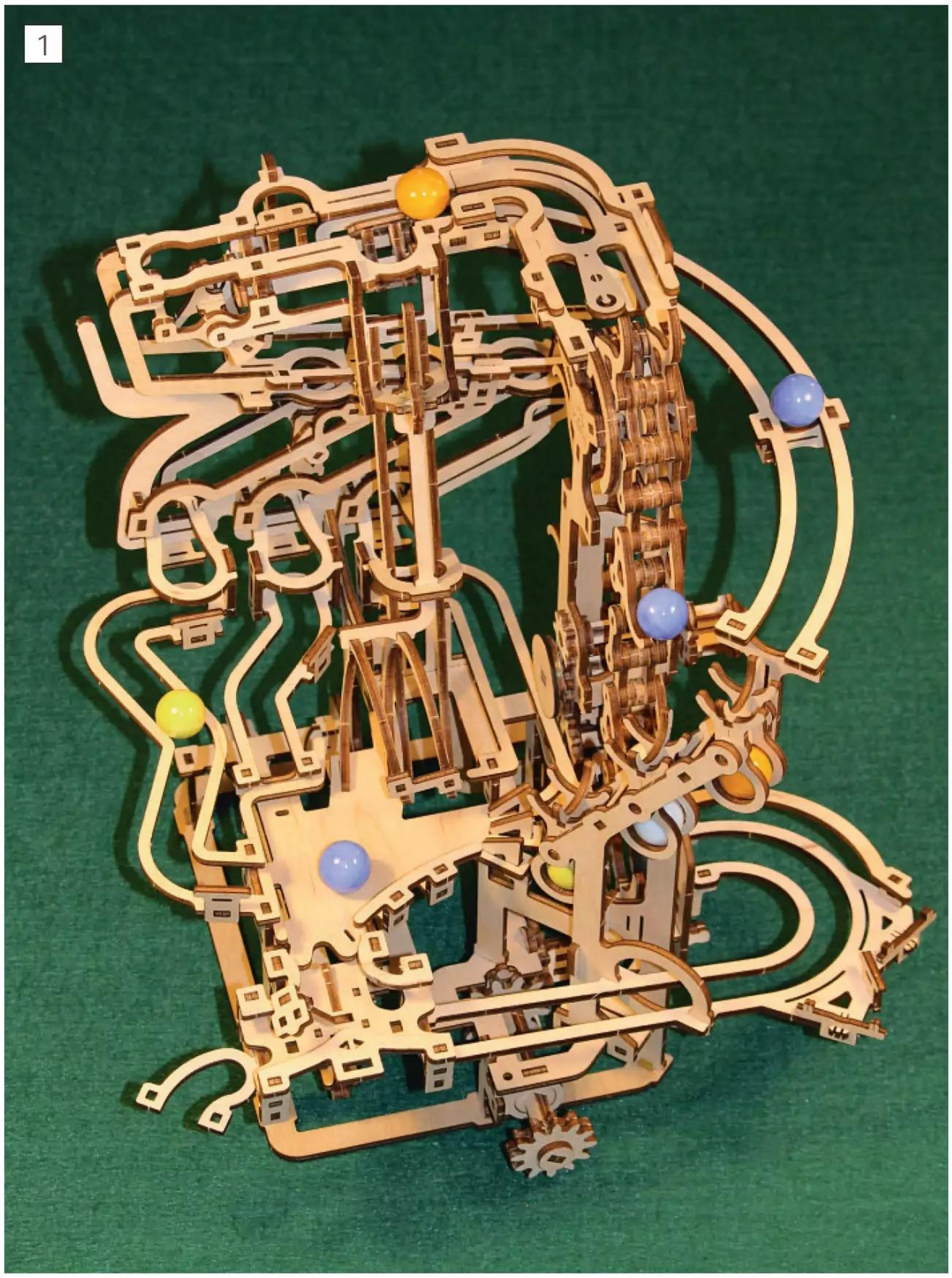
Building a Marble Run Chain Hoist

While waiting for his new workshop to be ready, Mark Noel found a way to keep his brain cells buzzing.

Anyone visiting Christmas markets in Europe will have marvelled at the number of wooden toys on sale that were once the traditional favourites of children in Great Britain. These include pull-along trains, dogs and cars, rattles and puppets, plus assorted puzzles and lettered blocks made to amuse and educate all ages, and not just children.

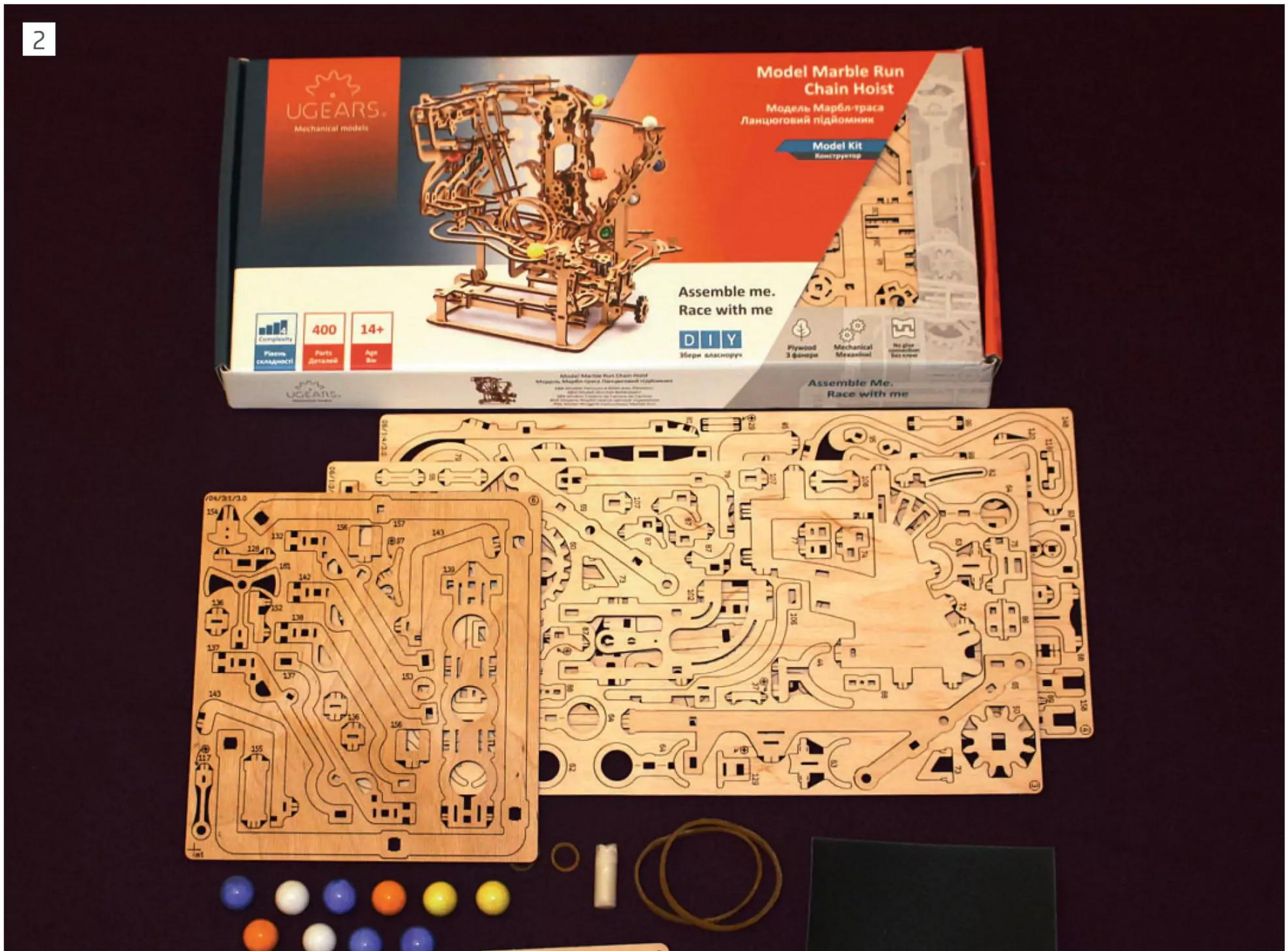
These craft skills are very much alive on foreign shores and appear to have reached a pinnacle of creativity in the hands of Ugears, a young team of engineers and designers based in Kyiv, Ukraine. Launched in 2014 the company has grown rapidly to now offer an extensive portfolio of extraordinary mechanisms each of which is assembled from a kit based on laser cut ply. After moving house my workshop gear remains in store awaiting improvements to the garage that will become my new man cave. In the meantime, to prevent cerebral decay, I have been tackling a number of mechanical kits of which the Ugears Marble Run Chain Hoist has been the ultimate test, **photo 1**. Another reason for purchasing this kit was to support a highly talented group in beleaguered Ukraine.

Such is the international demand for Ugears products that I found the Ukraine factory to be out of stock of the Chain Hoist. Fortunately their Netherlands outlet was able to supply the kit which arrived quickly and free from import charges. The attractive box contains all that is needed for assembly, comprising 6 sheets of 3mm plywood with 400 numbered, laser cut parts, a sheet of sandpaper, a wax stick, rubber bands and ten coloured marbles, **photo 2**. No glue is required since components are joined via tabs

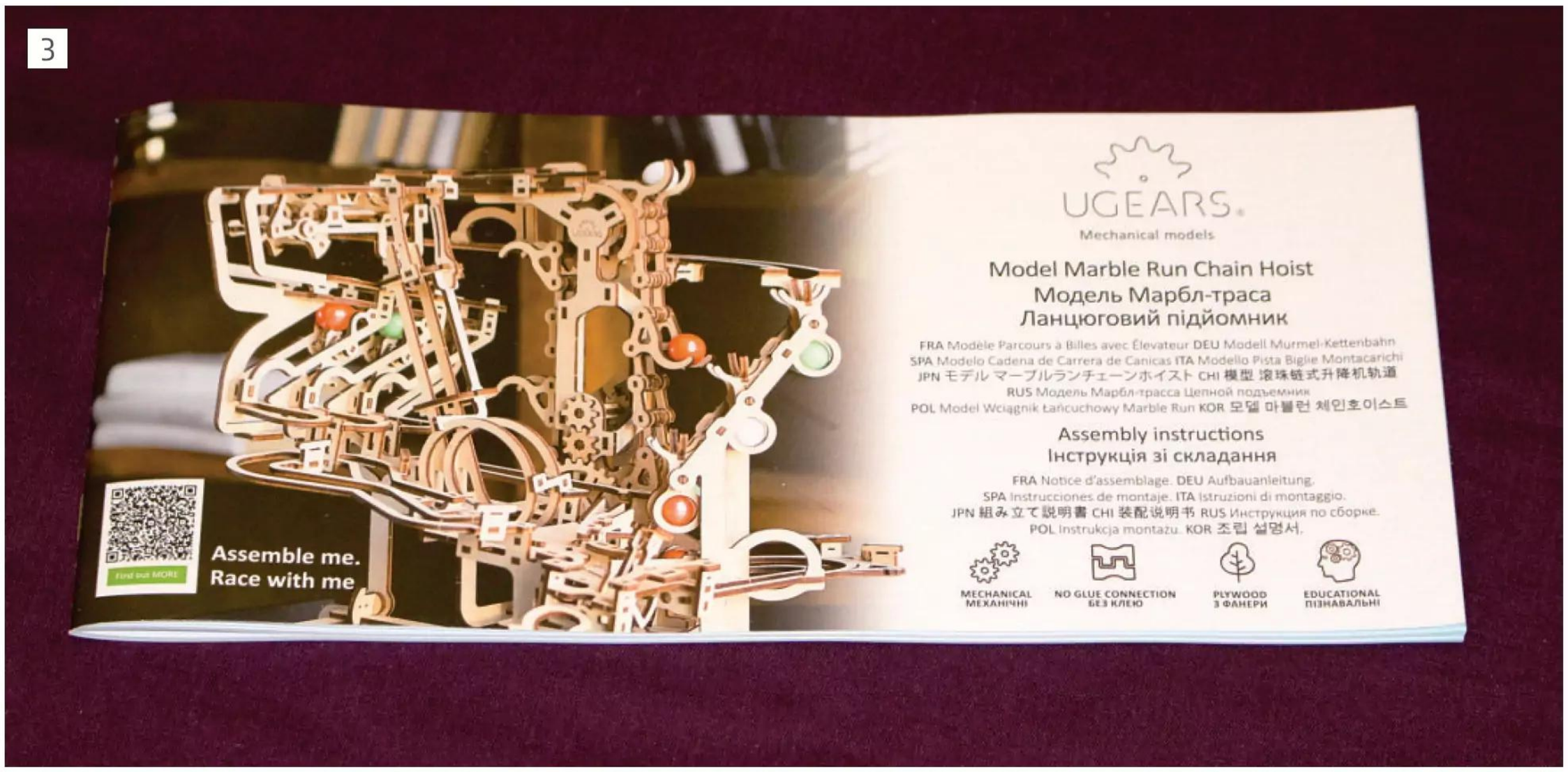


My Ugears Marble Run Chain Hoist completed after 29 hours of mental and physical dexterity!

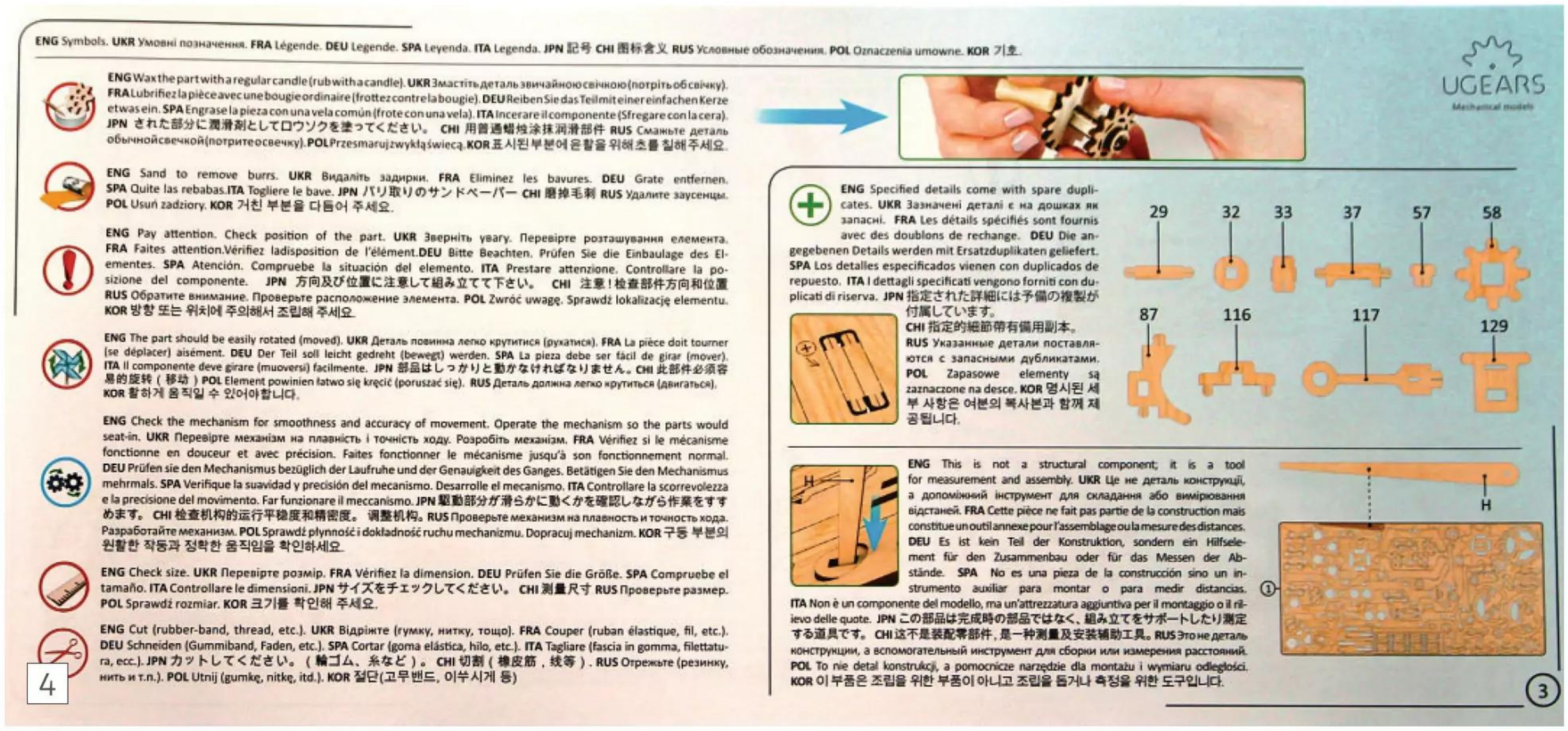
that click into the holes of an opposing part. Ugears boast that CAD modelling is used to ensure precision in the overall design and construction, and this quickly became evident as the contraption came together. Much thought has also been given to drafting a very detailed, fifty-five page construction manual, **photo 3,** that even includes a key to icons that denote where special care may



The kit contains everything needed to complete the Marble Run, although the additional tools shown in photo 5 proved useful.



The superb instruction manual for the kit, printed in eleven languages.



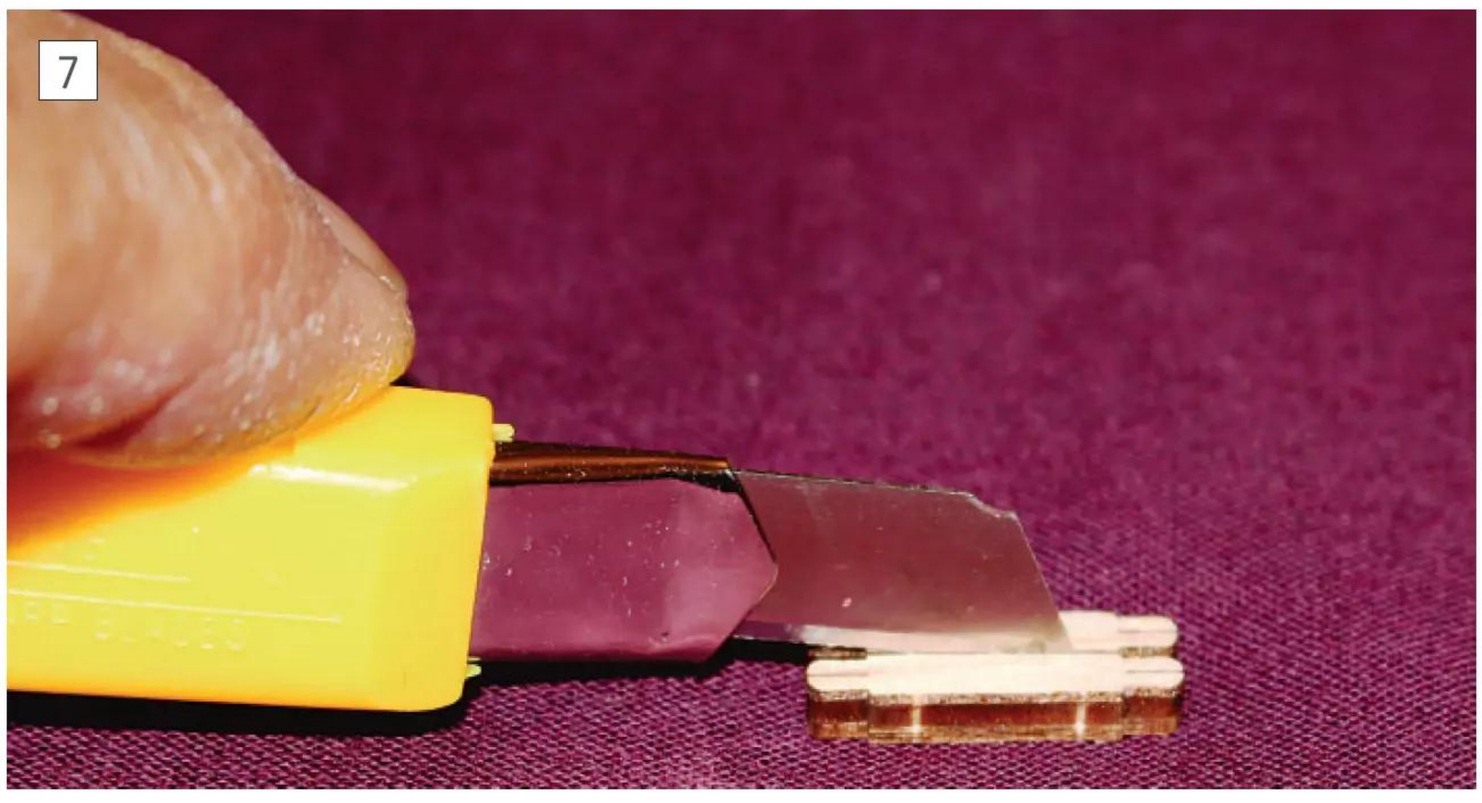
Page 3 of the manual describes each of the special symbols that appear where advice is needed on lubrication, etc. This page also shows how parts are pinpointed on ply sheets by referring to an inset picture (bottom right.



Additional tools that made construction much easier. I found that the stiff 'emery board' was more effective for dressing parts instead of the floppy sandpaper sheet supplied in the kit.



Using a slim drift and aluminium block below to press home a joint located in a tight space.

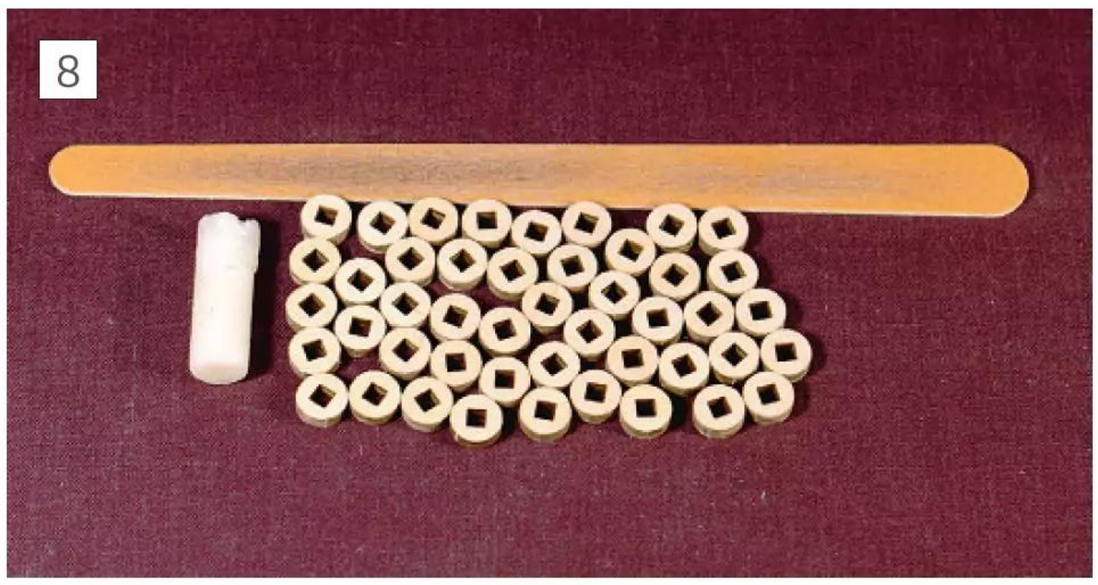


Each laser cut part is held in the parent sheet by narrow tabs which can be difficult to remove without breakage. With the ply sheet backlit these tabs can be pinpointed then cut with a craft knife enabling safe extraction of the more fragile parts.

be required, **photo 4**. This manual is printed in eleven languages that include Ukrainian and Japanese. However, to challenge myself further I decided to follow the instructions written in English.

During the build I found that several other tools and materials became handy during the assembly, **photo 5**. These include:

- A light hammer and a variety of drifts to help press connections between parts where access is tight as seen in **photo 6**.
- Needle nose pliers to pinch joints together in cases where finger pressure is insufficient.
- A jeweller's screwdriver to help pry parts from the boards.



Construction of the chain requires sanding and waxing the sides of 48 spacers - a tedious task but essential to ensure smooth running of the mechanism.



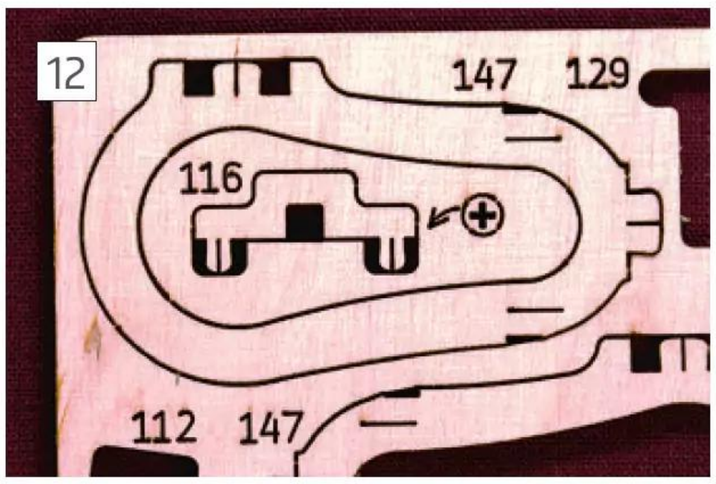
*The ball-hooks and spindles of the chain. The spacers shown in **photo 8** slip over these spindles to widen them to engage properly with the sprockets.*



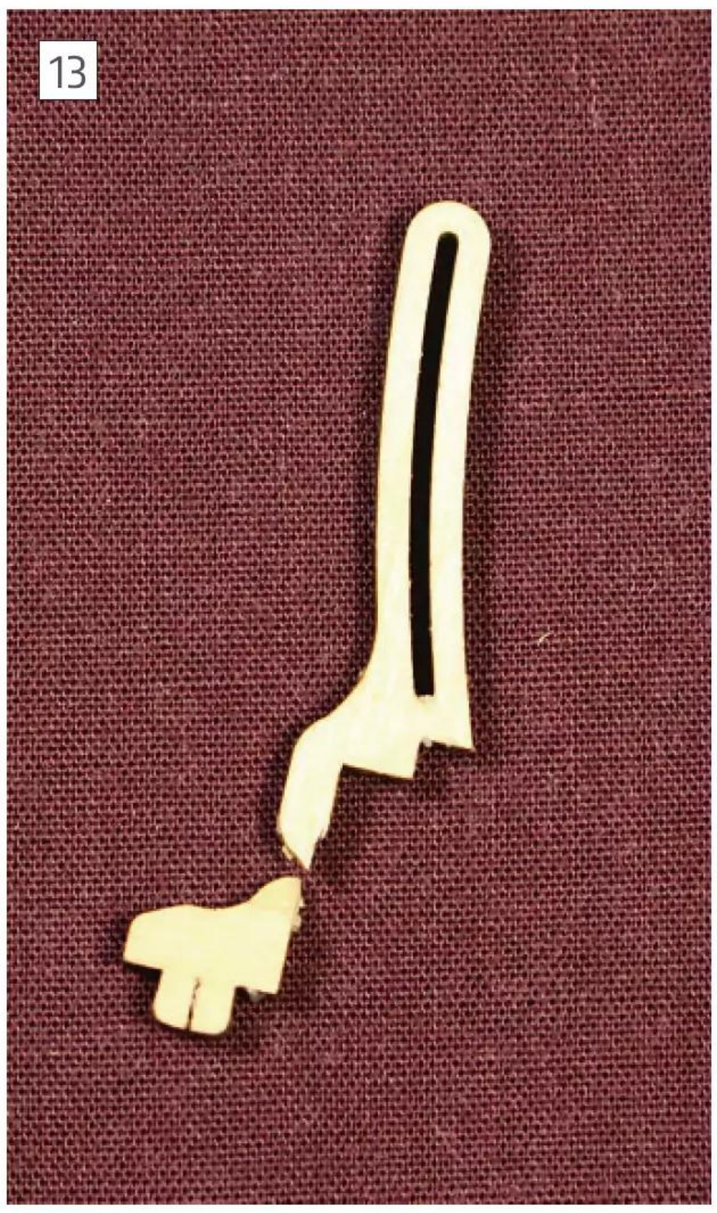
Driving home one of the spindles for the chain. Despite taking great care you can see that the one on the left has broken. Thankfully the kit contains spares of this fragile component.



The assembled chain. The six pairs of U-shaped hooks on the side of the chain work to lift the marbles up the machine.



An example of one of the spare parts in the kit, in this case for part 116 nested inside part 147 and marked with a + symbol. Notice how parts are numbered externally. Removing them too soon will therefore lead to confusion.



Part 82 is positioned to direct balls down a track and is the most fragile in the kit. It was easily broken during assembly and had to be glued in place with 5 minute epoxy.

- A craft knife to cut tabs holding the smaller parts on the ply sheets. This reduces the risk of breakage as they are pressed out or separated, **photo 7**.
- Several 'emery boards' of the type used to shape fingernails. These are more convenient to use than the flexible sheet of sandpaper provided. Obtain these from your favourite beautician.

The kit includes a thin stick of candle wax for lubricating bearings and gear teeth. To this I added several cake candles since the supplied item became a crumbled mess towards the end of the build. **Photograph 8** shows one of my emery boards which, combined with Ugears' wax stick, was used to lubricate the forty-eight spacers that form part of the chain built according to pages 10 and 11 in the instructions. Tedious indeed! Incidentally, I experimented with Nikwax tent waterproofer as a possible alternative to rubbing candle wax on prescribed ply surfaces. However this wax emulsion (once dried. had little effect and may run the risk of swelling the wood, actually increasing friction. However, others may want to experiment further with this magical elixir.

Photographs 9, 10 and **11** show interesting stages in the build where the chain parts and the ball-chain itself come together. At this point we have only reached page 10 in the construction manual! It was during this process that, despite taking great care, I broke the first of three parts critical to the mechanism, namely one of the spindles passing through a chain link, **photo 10**. Fortunately this is one of several more fragile parts for which duplicates are provided, each marked by a **+** symbol on the boards. An example is shown in **photo 12** for part 116 nested within part 147. Once the build concluded I had logged a total of 3 parts I had managed to break, the most unfortunate being part 82 for which no spare was provided and where the designed wall thickness was probably too narrow, **photo 13**. This was soon glued into place with 5 minute epoxy.

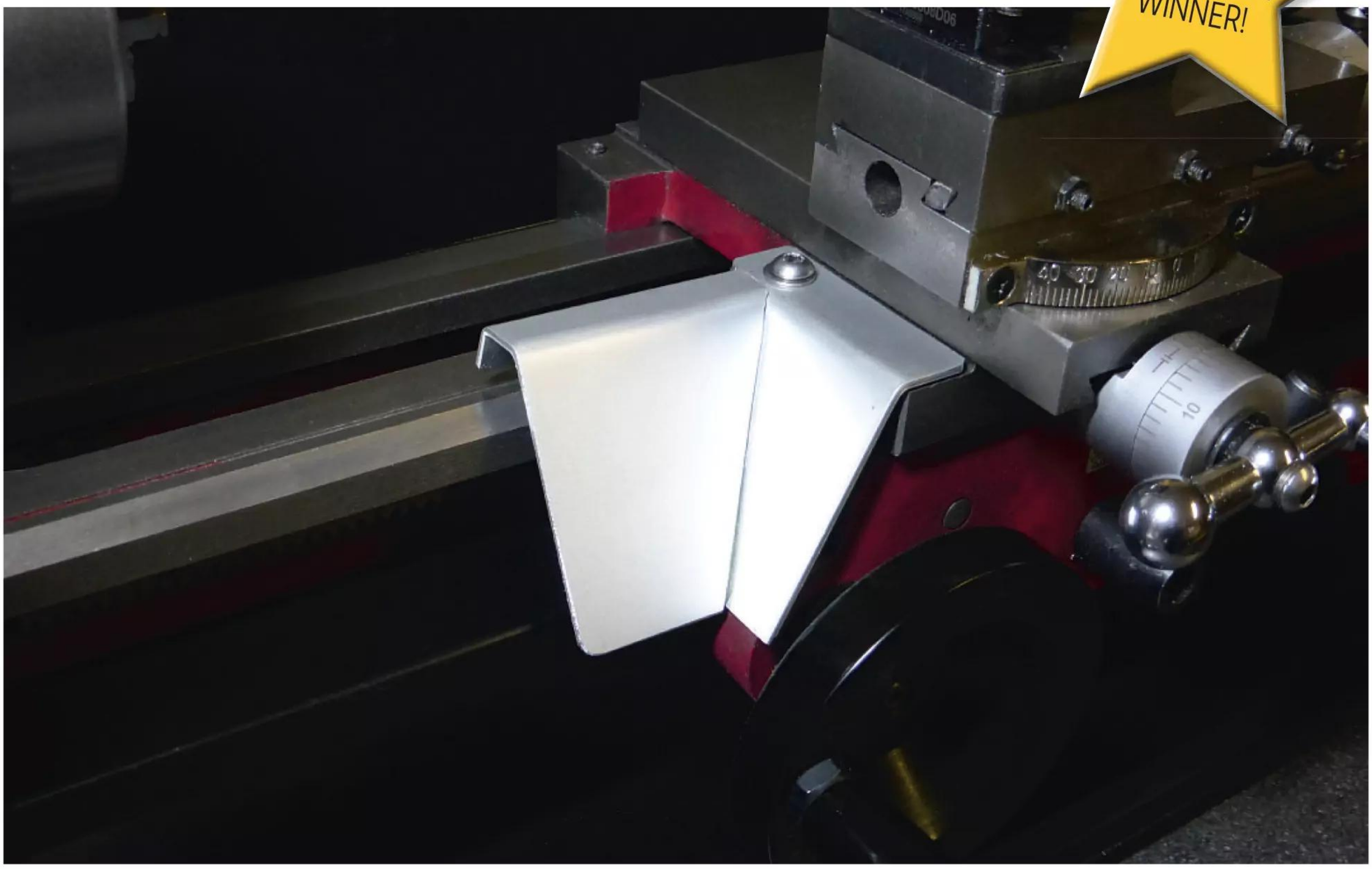
• To be continued

Readers' Tips

CHESTER MACHINE TOOLS

A Swarf Chute

TIP OF THE MONTH WINNER!



This month's winner is Peter Webb from Woodbridge, with his solution to keeping swarf out of the moving parts of his mini-lathe.

A major issue with mini lathes is swarf getting into the apron gears, especially when using the automatic feed. Gear covers are available from USA but they tend to require fixing holes to be drilled and tapped into the apron. This simple chute is fixed to the saddle using one of the existing M6 tapped holes provided for fitting a travelling steady.

The chute is made from two pieces of aluminium sheet with a tab hidden behind allowing them to be joined with Araldite (screws could be used instead). The chute in the photograph is fitted to a SC3 mini lathe and was made from 2mm sheet but 1.5mm sheet would bend more readily while providing adequate rigidity.

A version of chute could be made for use when a travelling steady is in use. It could attach using neodymium magnets or possibly under the head of the travelling steady fixing bolt.

It cannot be said that the chute will guarantee swarf never gets into the gears, but it should make it very much less likely. Perhaps a chute could have a brush or rubber blade underneath to deal with swarf resting on the lead screw cover.

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

Please note that the first prize of Chester Vouchers is only available to UK readers. You can make multiple entries, but we reserve the right not to award repeat prizes to the same person in order to encourage new entrants. All prizes are at the discretion of the Editor.

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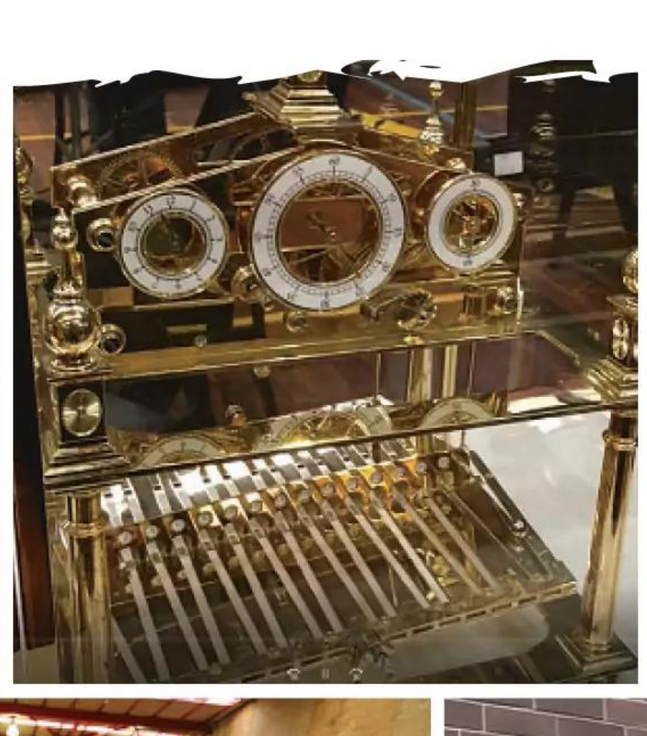
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See model steam and petrol engines running, home-built clocks ticking, robotics whirring, electronics zapping then view creative dioramas and textile displays – the Melbourne Society of Model and Experimental Engineer's "Let's Make It" Exhibition will inspire everyone to make stuff.

For further information contact Bruce Rodda via email **brucerodda@yahoo.com**















Derek Brown presented with Honorary Membership of the SMEE



On Saturday 27th July at the York City and District Society of Model Engineers Alan Hopwood on behalf of the Society of Model and Experimental Engineers (SMEE) was pleased to award Derek A.G. Brown with an Honorary Membership Certificate in recognition of his long service to the Society.

Alan referred to Derek's wide knowledge of engineering matters and his demonstrations of drill sharpening at shows using the Quorn Tool and Cutter Grinder by the 6-facet method. Derek had developed this technique for the Quorn and in particular has invented a setting jig which makes this procedure very much quicker and effective.

A hearty round of applause marked the moment from the York Society where he is much appreciated.

Chester Open Week 2024

Chester Machine Tools are pleased to announce the next Open Week at their Hawarden showroom this September 23rd–27th.

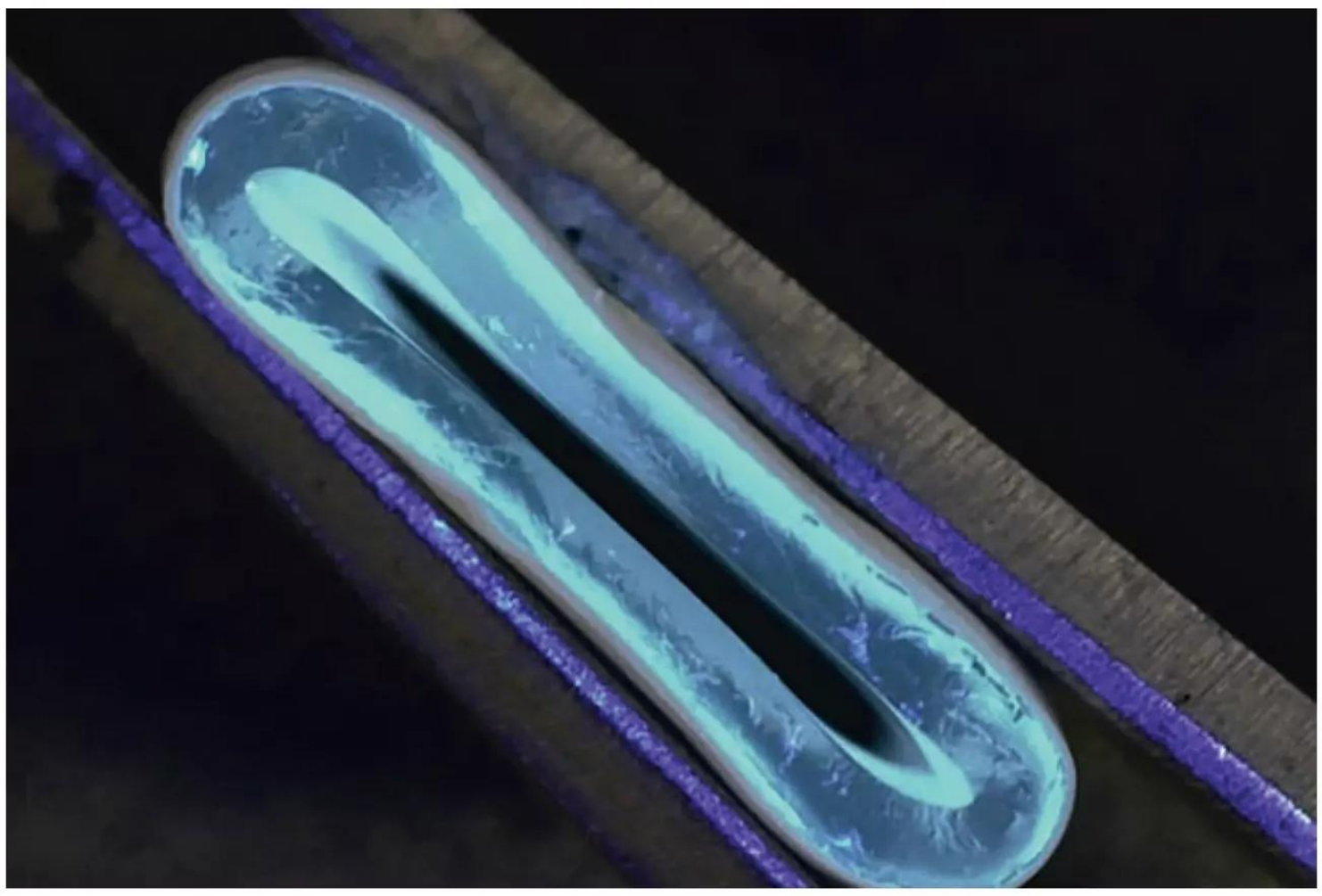
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3D Printed Blood Vessels Could Save Lives



3D-printed blood vessels, which closely mimic the properties of human veins, could transform the treatment of cardiovascular diseases. Strong, flexible, gel-like tubes – created using a novel 3D printing technology – could improve outcomes for heart bypass patients by replacing the human and synthetic veins currently used in surgery to re-route blood flow, experts say.

The development of synthetic vessels could help limit scarring, pain and infection risk associated with the removal of human veins in bypass operations of which some 20,000 are carried out in England each year. The products could also help alleviate the failure of small synthetic grafts, which can be hard to integrate into the body.

In a two-stage process, a team of researchers led by the University of Edinburgh's School of Engineering used a rotating spindle integrated into a 3D printer to print tubular grafts made from a water-based gel.

They subsequently reinforced the printed graft in a process known as electrospinning, which uses high voltage to draw out very thin nanofibers, coating the artificial blood vessel in biodegradable polyester molecules.

Tests showed the resulting products to be as strong as natural blood vessels.

The 3D graft can be made in thicknesses from 1 to 40 mm in diameter, for a range of applications, and its flexibility means that it could easily be integrated into the human body, the team says.

The next stage of the study will involve researching the use of the blood vessels in

Dr Faraz Fazal, of the University of Edinburgh's School of Engineering and lead author, said: "Our hybrid technique opens up new and exciting possibilities for the fabrication of tubular constructs in tissue engineering."

Dr Norbert Radacsi, of the University of Edinburgh's School of Engineering and principal investigator, said: "The results from our research address a long-standing challenge in the field of vascular tissue engineering – to produce a conduit that has similar biomechanical properties to that of human veins. With continued support and collaboration, the vision of improved treatment options for patients with cardiovascular disease could become a reality.

Thread Milling In The Workshop



Bob Reeve concludes his investigation into the practicality of thread milling using CNC and various types of cutter.

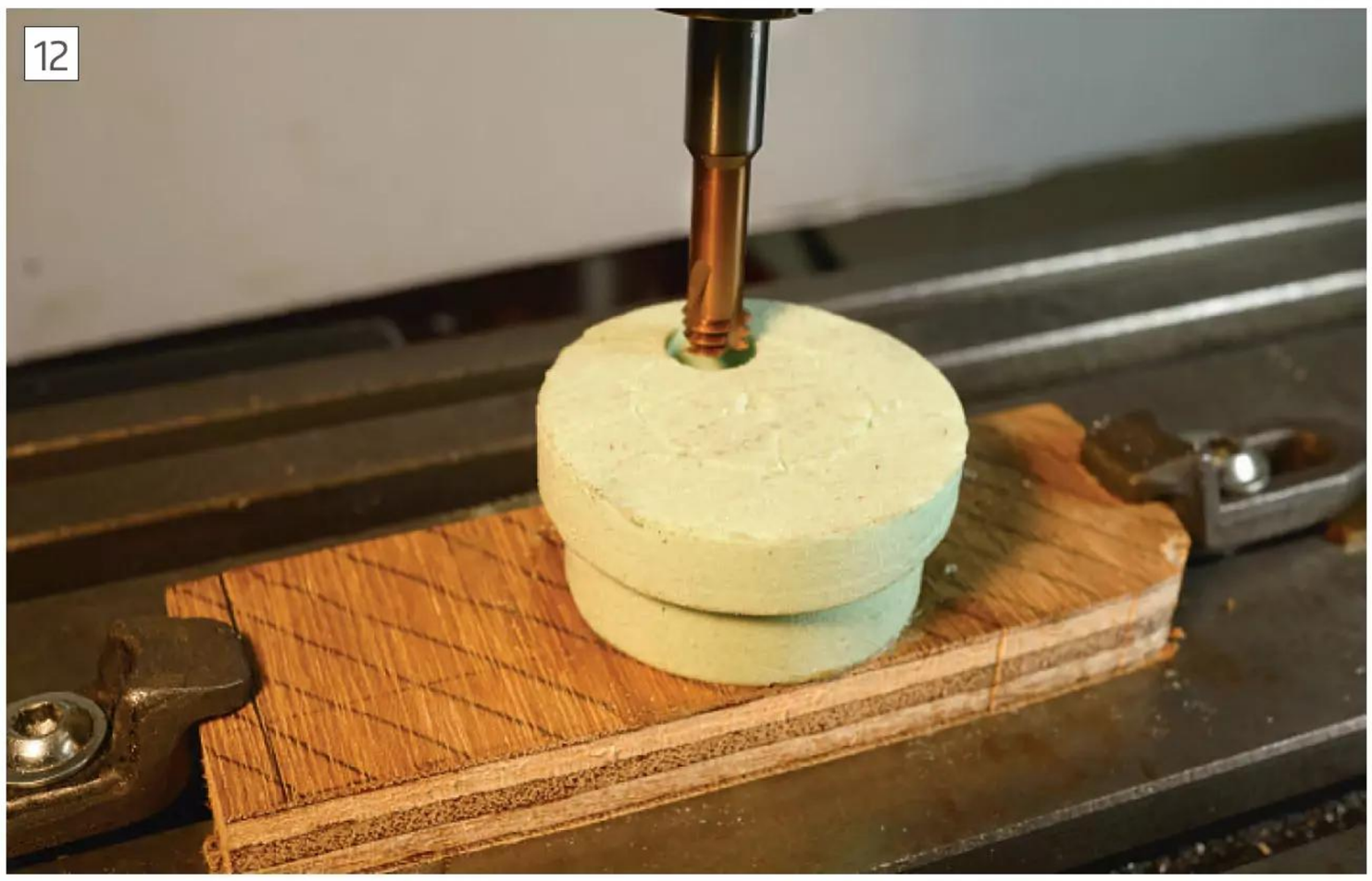
Tools are available with a single thread form which will produce a short range of threads but with only a partial profile. These are intended to reduce the tooling costs where use is infrequent and/or a number of pitches need to be covered.

The tool shown is tungsten carbide and has higher metal removal rate providing it can be run at the high speeds intended. The maximum speed on my X3 is 3300 rpm so performance would be limited for the smaller sizes. However for Model Engineers time is less important than for commercial applications and the cutters are perfectly satisfactory. I understand that in commercial use these cutters would be used to cut to full depth in one pass. I was not that brave!

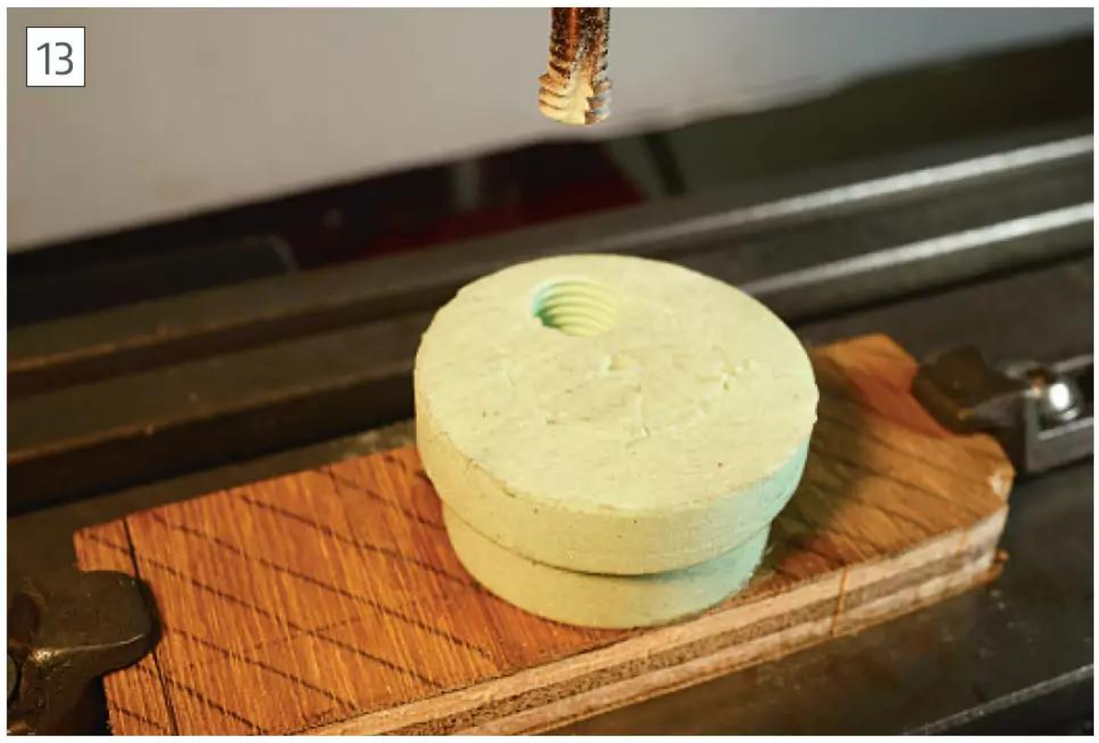
Photograph 12 shows a further cautionary detail. I used a closed cell ridged foam mounted on a plywood base in order to protect against mishaps. **Photograph 13** shows the threaded hole completed.

A trial in a scrap of aluminium followed with the result shown in **photo 14** complete with a commercial M10 set screw fitted into it. Even with my cautious three-cut approach the ½" deep thread took less than three minutes.

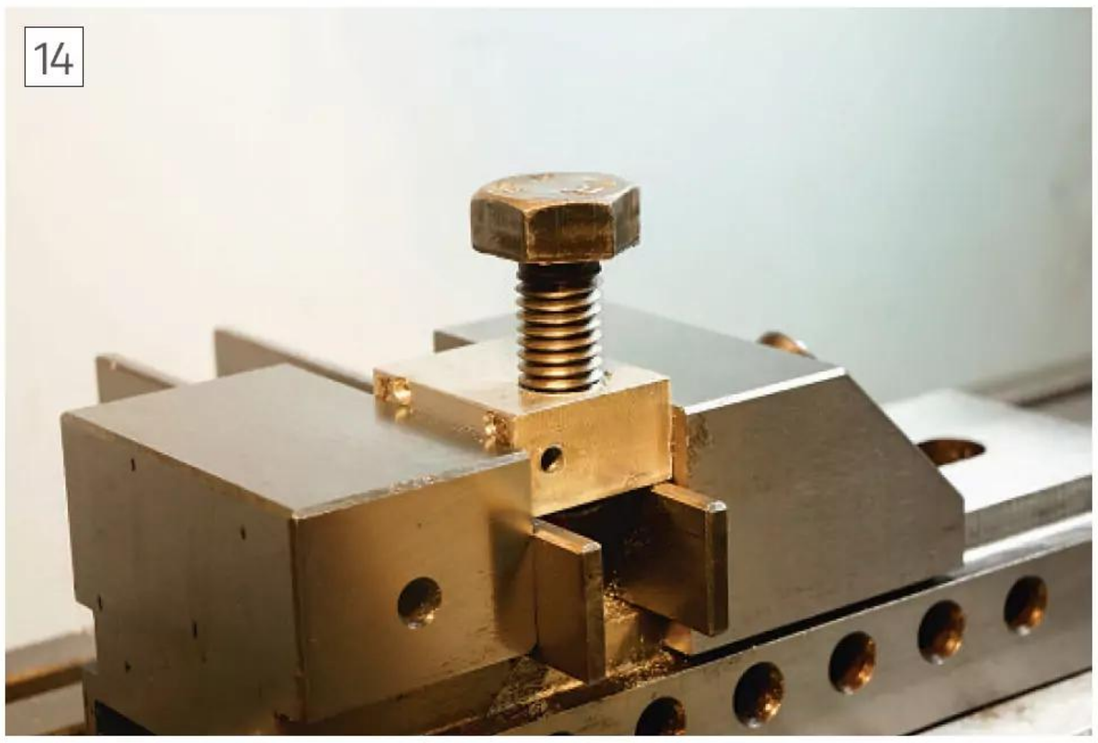
One point raised at the SMEE demonstration of this was that the cutter was visibly changing feed rate as it proceeded round its circular path. Something that was not noticeable with the larger external cutters. Probably a result of the interpolation necessary for both X and Y axes. Each axis in turn would need to accelerate from zero to the maximum specified feed rate then back to zero, twice per revolution. Mach 3 does provide some control over this, but it was not explored further.



Closed cell foam for first internal trial



Successful internal thread cut.in foam



Successful internal thread in aluminium

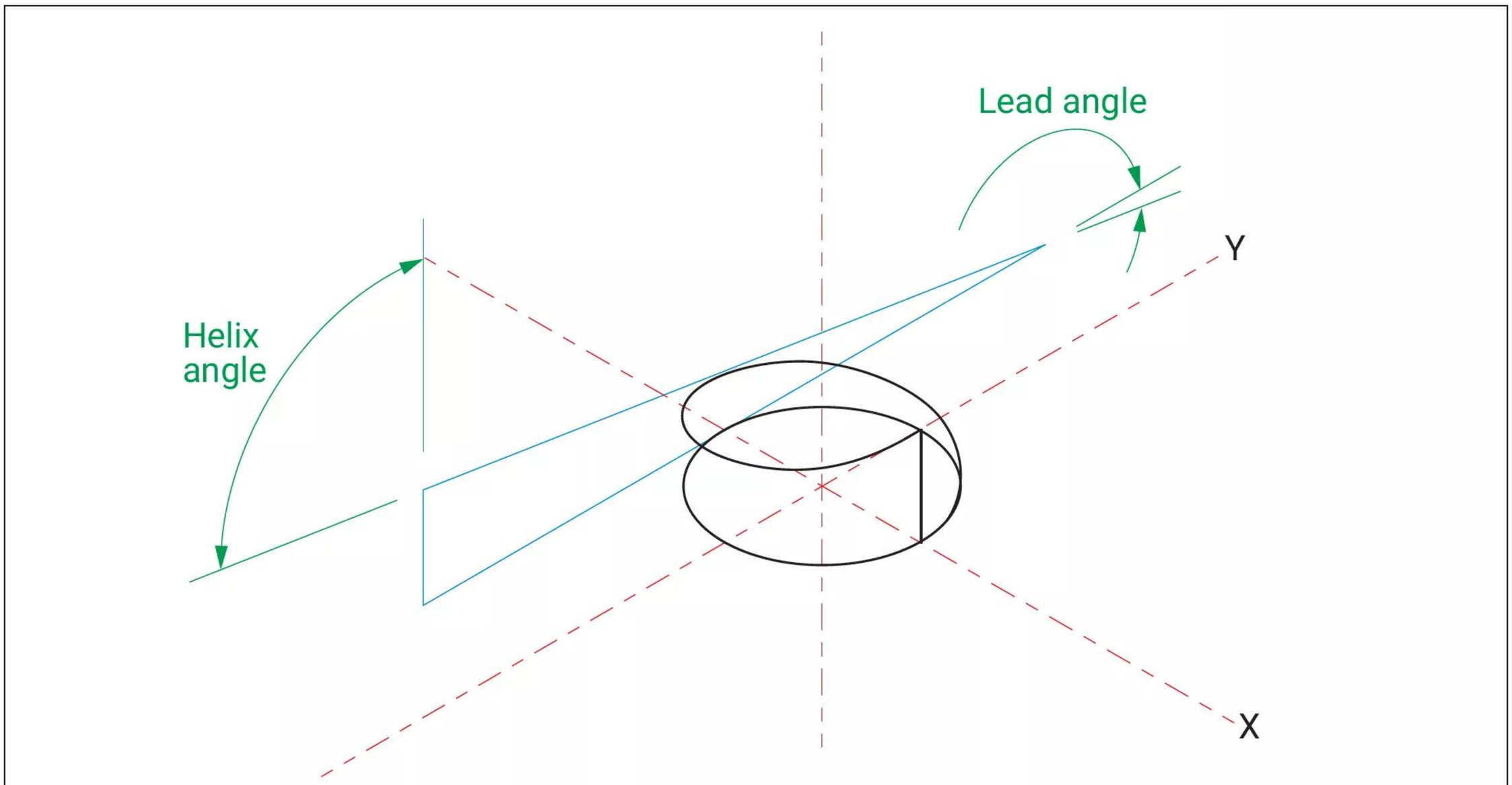


Figure 2

Meanwhile, Brian Neal (who's challenge this was) had made some progress of his own. This was initiated by a local ME Club member's request for help in replacing a threaded adaptor from an old garden strimmer so that a new strimmer head could be fitted. The thread in question happened to be a left-hand M10 x 1.25.In addition, as if that wasn't difficult enough, there was no easily accessible male thread to act as a gauge. Taps were available, but were too expensive for a one-off job like this, and anyway, where was the challenge in using taps and dies?

The first task was to create a male pattern for use as a gauge. Brian used Fusion 360 to create a 3D CAD model followed by the F360 CAM module to create the toolpath. This all went as it should, including diameter, pitch and the required "left –handedness".

That led to the inevitable search of the tooling websites for suitable cutters. Brian came across some cutters which I had missed, namely the cutters mainly intended for production use which had multiple threads. These could complete full form threading to the required depth on one circular cut. However, such complexity comes at a cost and restricts the application compared with some other options.

The internal cutters I used also produce a full form thread but only one thread at a time. They are however restricted to one pitch and thread depth. But were somewhat less expensive.

Brian also found a third type of cutter with a single thread capable of cutting a limited range of pitches and depths, but without the ability to round the thread crests. These would generally leave the threads flat topped as would a lathe turned thread. Two cutters were purchased, one 0.5 to 1.0 mm and a second 1.0 to 1.5 mm. pitch.

He used a factory CNC conversion of a Wabeco 1400 mill, equipped with ballscrews, Hiwin profile rails and a counter balanced head. A specification ideally suited to the multiple acceleration/deceleration cycles of thread milling noted earlier.

The depth of cut was increased in steps of 0.2mm utilising multiple toolpaths generated in Fusion 360 CAM, partially to avoid tool breakage but also to ensure a good fit for the thread. The workpiece was in steel, and a spindle speed of 1500 rpm was used at a feed rate of 200 mm/min.

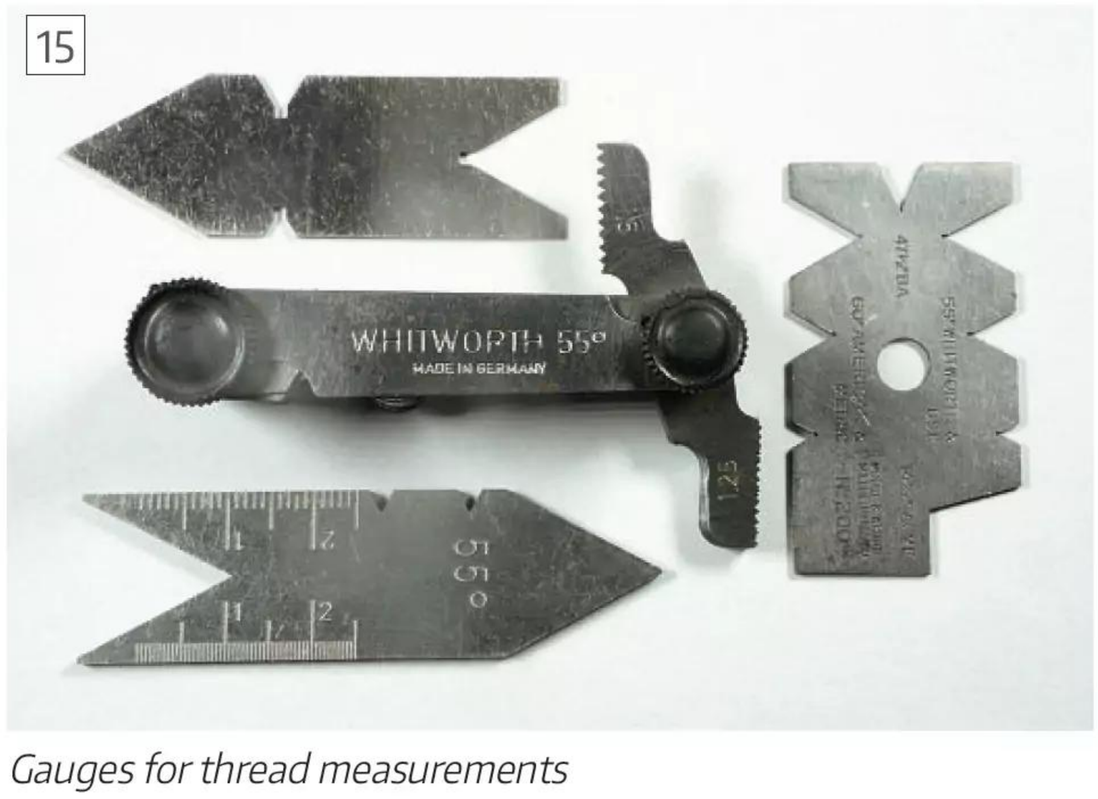
Brian reports being delighted at how un-dramatic the process turned out. Both he and I were somewhat apprehensive about an expensive cutter running relatively fast trying to enter a hole with only fractions of a millimetre clearance to cut a thread. It then had to find its way out without crashing into anything. However, it all went well, and the strimmer repair was successful, with the grass round the ME Club tracks noticeably shorter than it was.

At this point it was necessary to address the helix angle issue. The topic had been discussed at two consecutive SMEE Digital Group meetings and (with some consulting of reference works) a consensus was beginning to emerge. But it also emerged that there were some variations in thread milling that might be more critically reliant on helix angles.

As a starting point there was the concept of the thread as a curved wedge. This was partly responsible for me realising I had been incorrectly using the terms "Lead Angle" and "Helix Angle" as if they were interchangeable, **fig. 2.**

As can be seen the convention is that the helix angle is measured relative to a normal to the vertical thread axis. The helix angle is measured relative to the thread axis.

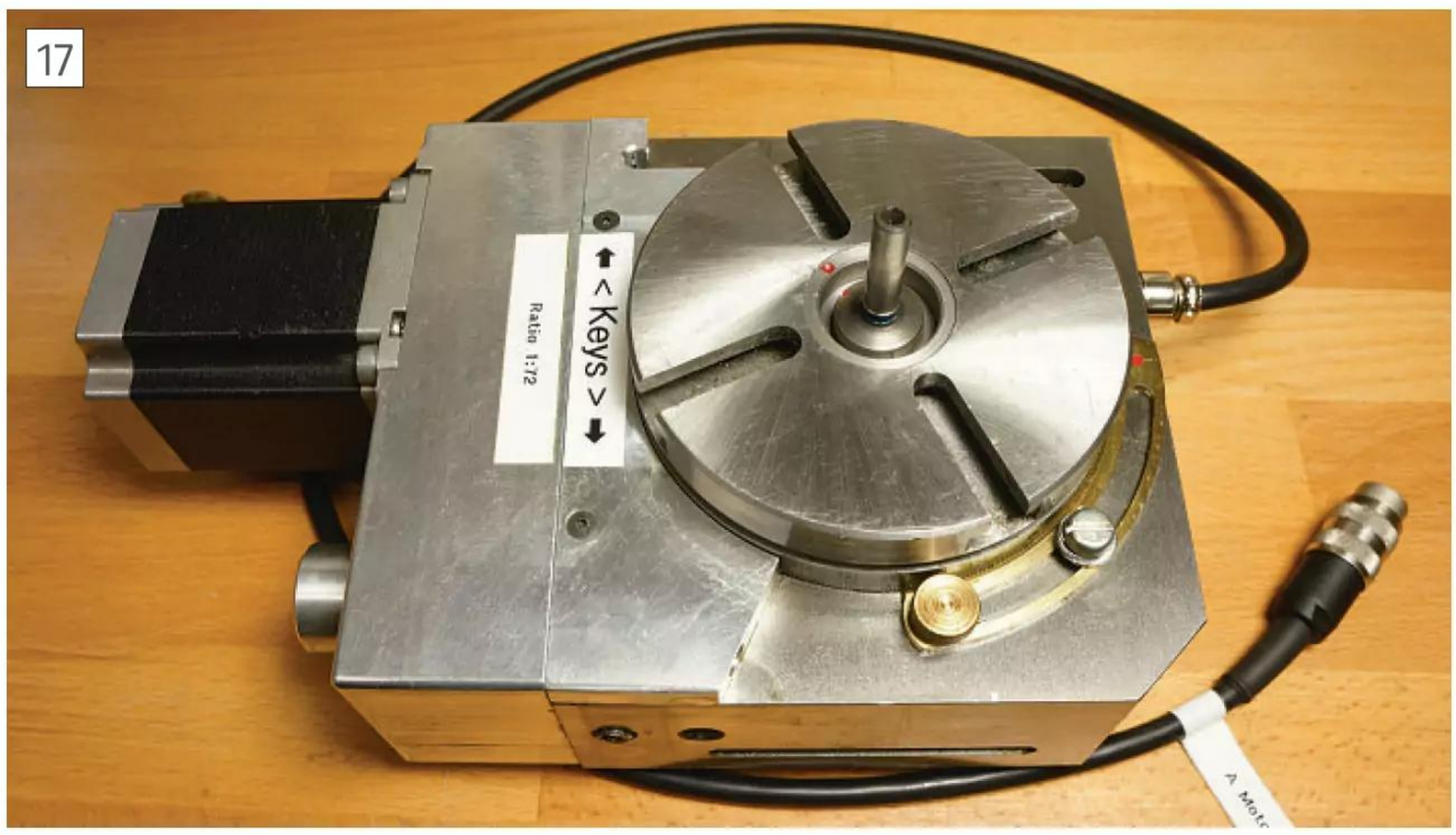
The lead angle is therefore the complement of the helix angle. Lead angle is used in preference as it better represents the behaviour of single and multi-start threads. A significant feature ›



Gauges for thread measurements



Measuring a carbide threading tip



CNC converted Sieg Rotary table

of the use of these terms was the way we measure threads, especially those produced on a lathe.

Photograph 15 shows a selection of measuring tools all of which are used parallel to the thread axis, making no allowance for lead angle.

It might have been expected that tungsten carbide inserts for thread cutting might be made to more exacting standards with the small correction for lead angle. By using the magic of PhotoShop on a carbide threading tip I was able to produce **photo 16** which looks very much as if there is no correction. I have attempted to show what effect a correction for lead angle would have in **fig. 3.**

A 60° lathe tool mounted with the top AB horizontal will produce a v groove of width AC which is clearly narrower than AB.

This arises because the thread definitions, including pitch, are referenced to the horizontal axis.

There are however, circumstances where pitch is measured normal to the groove eg diffraction gratings where the units are lines per inch (or per mm) which therefore has a slightly different interpretation to threads per inch. A diffraction grating for visible light might have typically 100 to 200 lines per mm.

As a final comment on thread measurement, I checked what Machineries Handbook had to say on the issue of thread measurement by the three-wire method; normally considered to be the most accurate method. It states "the formulas ... do not compensate for the effect of lead angle apon measurement ... but they are siufficiently accurate for checking single-thread screws unless exceptional accuracy is required"

However, there are additional guidelines for thread milling. Specifically:

1. Compensation is not needed if lead angle small <3.5° for external and < 2.5° for internal threads.
2. Interference possible for steeper lead angles, particularly internal, especially with square or trapezoidal threads.
3. Interference may produce a distorted thread form. Minor interference is only important for high precision work.
4. Small diameter and single thread cutters likely to have less interference.
5. Large diameter threads likely to have less interference.
6. If there is little interference, planetary milling (as used so far) likely to be acceptable. Milling with lead angle correction is more complex.

The next phase of investigation for thread milling was in the use of a fourth axis on the CNC mill. In this case the 4th axis was a rotary table, **photo 17,** which could be used with the axis vertical or horizontal; it was the former that was used here.

The first test was an M10 x 1.5 external thread in aluminium, **photo 18**. This was a video clip taken with everything at speed, complete with chips, and limited to two threads to reduce the video file size, but it does show the very neat finish of the thread. As can be seen, **photo 19**, a commercial M10 nut fitted a longer version of the thread (six threads) as it should without further adjustment.

There was some SMEE discussion as to whether this was thread milling or turning with a powered tool. The jury is still out! It was also pointed out that the previous set up without the rotary table produced a perfectly acceptable thread without the added complexity. Three possible advantages came to mind.

- There is no repeated acceleration and deceleration so machine wear is reduced.

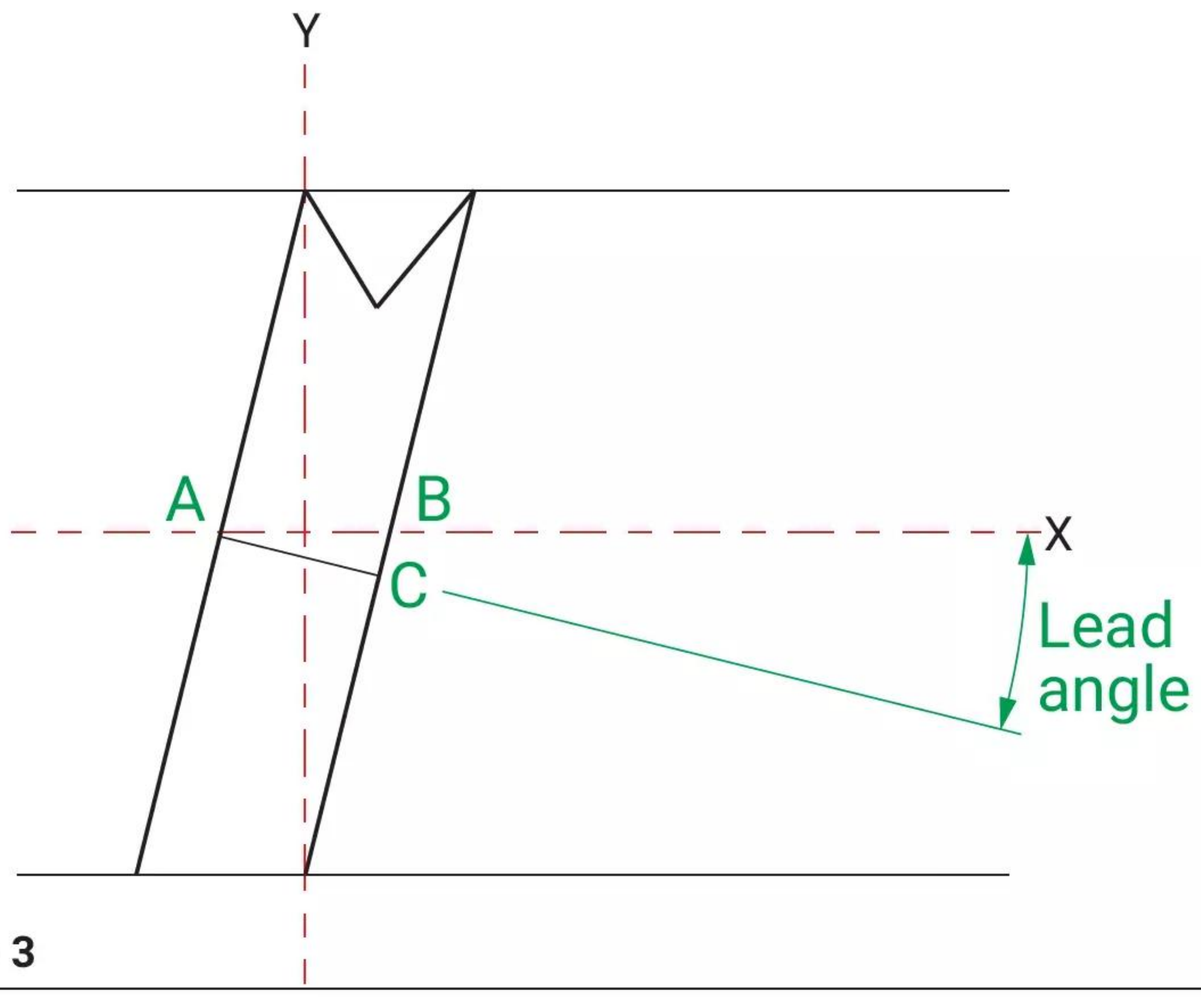


Figure 3



Carbide tool in action with rotary table



Successful M10 X 1.5 result

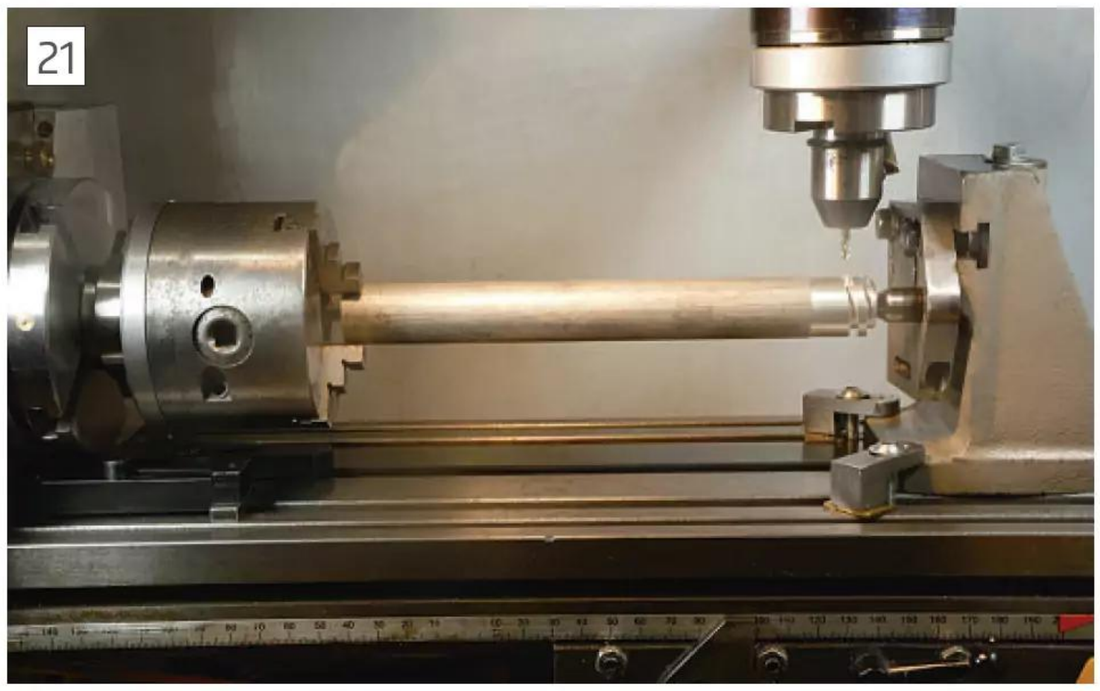
- The program is easier to write - my program is just 42 lines with annotation.
- It is easier to correct for lead angle with this set up on a vertical mill with a swivel head.

One curious feature emerged when I wrote the original program version for six threads. As each thread was added, 360° was added to the total movement; so for six threads the cumulative count is 6 x 360 = 2160°. Normally one of the delights of a CNC machine is the control labelled "Go To Zero". One push of the button rewinds all the axes to where they started. However, for the case in question, the reduction gear in the rotary table is 72:1. So if this were a manual rotary table, 6 X 72 = 432 turns of the handle would be needed to wind the table back to zero. On the CNC rotary table the stepper motor does the rewind, but a G0 command is probably slightly slower than a manual wind and some patience is needed. After a couple of sessions watching this, I decided it was much quicker to press the zero button on the A axis, then press "Go To Zero". With that in mind I rewrote the program for just two threads and made no attempt to "rewind" within the program, relying on the use of the manual zero at the end. The two-thread program is as follows;

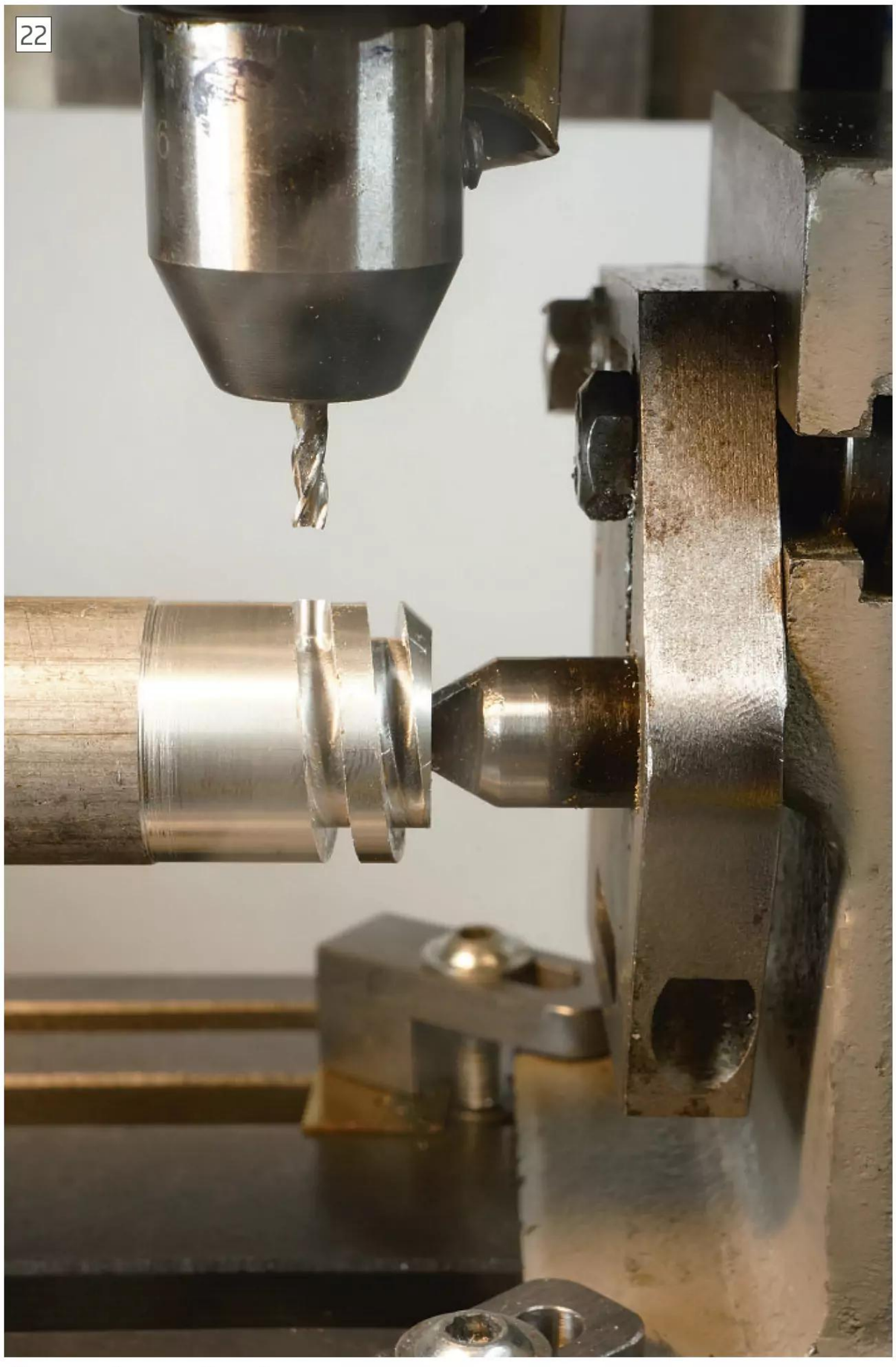
```
% Rotary Table External Thread Cut
G15 G17 G21 G40 G49 G50 G69 G80 G90
%G15 CARTESIAN CO-ORDS
%G17 XY PLANE
%G21 MILLIMETRES
%G40 CANCEL CUTTER RADIUS COMP
%G49 CANCEL TOOL LENGTH OFFSET
%G50 RESET ALL SCALE FACTORS TO
UNITY
%G69 CANCEL CO-ORD SYSTEM
ROTATION
%G80 CANCEL MOTION MODE
%G90 ABSOLUTE DISTANCE MODE
#10= 1.0 (thread depth)
#11=-1.5 (pitch)
#12= 2 (no. threads)
#13=10.02 (workpeice dia.)
#14= 7.54 (tool dia)
% Manually zero Axis 4
% Set workpeice vertical,centre at x0 Y0
% Set top of workpeice at Z0
% Use full form carbide cutter
G0 Z10
G0 X0 Y0 A0
F100
M3
```



How not to do it!



A square thread set up



Close up of square thread.

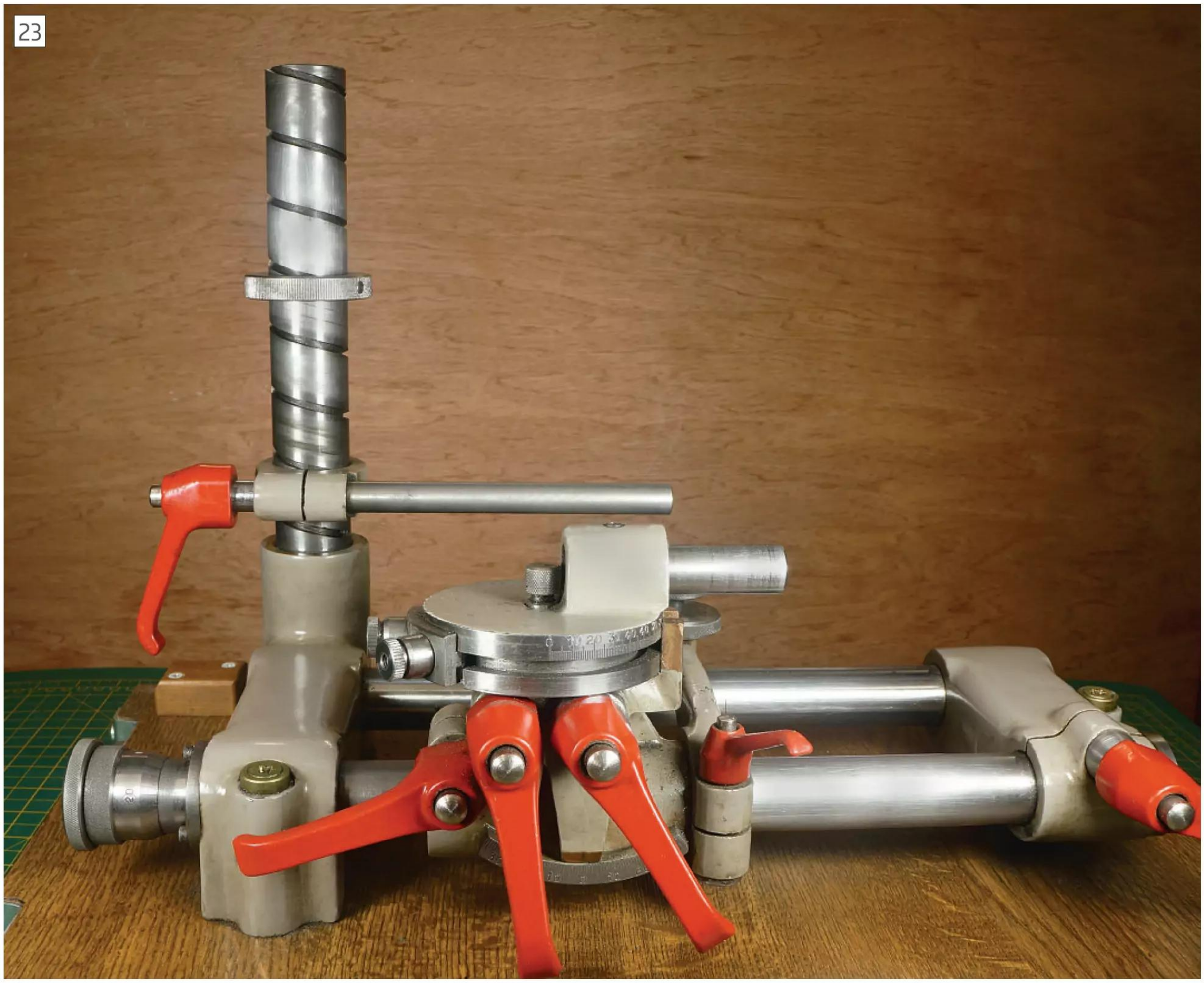
G0 X [[[-0.5]*[#13+#14]]-3] (tool 3mm clear)
G1 Z0
G1 X [[-0.5]*[#13+#14]] (tool touching)
G1 X[[[-0.5]*[#13+#14]]+[0.33*#10]] (Cut1)
G1 A-720 Z[#11*#12]
G0 X [[[-0.5]*[#13+#14]]-3] (tool 3mm clear)
G0 Z0
G1 X [[[-0.5]*[#13+#14]]+[0.66*#10]] (Cut 2)
G1 A-1440 Z[#11*#12]
G0 X [[[-0.5]*[#13+#14]]-3] (tool 3mm clear)
G0 Z0
G1 X [[[-0.5]*[#13+#14]]+[#10]] (Cut 3)~
G1 A-2160 Z[#11*#12]
G0 X [[[-0.5]*[#13+#14]]-3] (tool 3mm clear)
G0 Z0
M05
M30.

At this point I took the opportunity to explore what would be the result of ignoring the guidelines for the circumstances where lead angle could be ignored.
I selected:

Small dia. thread (1/2") –	Bad
Square threadform –	Bad
Coarse pitch (1/4") –	Bad
Medium dia. Cutter –	Not good
No side clearance –	Very bad

The result is shown in **photo 20** – best described as truly awful! There had been considerable interference which had increased the width of the groove from the intended 1/8" to about 0.144" and there was a substantial burr on the lips of the groove.

Had my machine been fitted with a tilt head I suspect that I might have corrected most of this easily. Just tilt the head by the lead angle and re-align



Quorn wheelhead height adjustment

the business end of the cutter on the workpiece.

Fortunately, there was yet another way of utilising the rotary table to produce a square thread which was even closer to turning with a powered tool.

For this, the rotary table was fitted with a three-jaw chuck and the table mounted with the axis horizontal. There was also a tailstock centre in use so as to be able to demonstrate the increased length that could be accommodated, **photo 21**. The thread is square with a 6mm pitch which was milled with a 3mm dia. slot drill.

This set up is unlikely to be used for threads other than square or trapezoidal, but it does have the advantage of not suffering from the interference that occurred in the previous example. It is also relatively easy to program. However, I have yet to find a way of machining the nuts.

A close up of the result is shown in **photo 22**. One familiar application might be the grinding head height adjustment for the Quorn tool and cutter grinder.

Photograph 23 shows my Quorn, built in the mid 70's The thread was cut on a venerable Pallas milling machine with a flat belt drive, but the set up was very similar to Photo 21. That was at a time before CNC had become popular with model engineers. Fortunately the Pallas had a feature not often found on mills; the swivel table was arranged so that the automatic (X axis) feed would swivel with the table. Even so, there was a lot of calculation before the correct change gears were arranged to drive the differential dividing head at the correct ratio. I then broke two 1/8" end mills before I realised the feed rate was too high and even turning the table traverse manually was too fast. I had failed to realise the actual feedrate was the vector sum of the table traverse speed and the rotational speed of the workpeice. The gears connecting the table feed to the dividing head effectively increased the federate above that normally provided by operating the table traverse handwheel. The solution was to fit a long extension to the dividing head index arm and use that to provide a very slow manual federate. The result was probably the longest groove I have ever milled and it took a while. I think I prefer CNC.

References

Ref 1; Carols, Cappuccinos & Lofted Solids. MEW 235, 236 & 238 (2015-16)
Ref 2; Bob's Better Bevels. MEW 316-319 & 322

ENTRIES FOR THE STEVENSON TROPHY 2024

We have had an excellent 'crop' of entries for this year's Stevenson Trophy – the workshop equipment competition where readers get to choose the winner yourselves.

In fact, we had so many entries, that we have had to strictly apply the 500-word limit and limit the number of photographs (entries with fewer words got an extra photo!).

Readers and Model Engineer Forum members can vote up until the 30 September using the link here: tinyurl.com/32tdwh6p. You can also access the poll using the QR Code on this page. The result will appear in the November issue of MEW, and we hope to award the trophy at this year's Midlands Model Engineering Exhibition in October.

Lathe Saddle Stop – Alan Girvan

I have been wanting a lathe saddle stop for quite a while and there have been quite a lot of excellent examples in Model Engineers' Workshop. However the problem I had with them was that they all bolted to the rear of the lathe. My lathe is fairly tight to the wall which makes it difficult to access and I am sure there are lots of other hobbyists who just don't have the space to have their lathe sitting out from the wall for access either. So I decided I would try and cobble together something I could bolt onto the front of the lathe without drilling or making alterations to the bed of the lathe.

After a lot of pondering and thought I came up with this. It is a five-station saddle stop, I tried to make it a six station but it turned out to be a failure, so I decided to start again with a five stop and this time I got it to work. I have been using this for about four years now and it has done everything I wanted it to do. I am sure there are lots of people out there who will improve on the design and probably turn it into a six stop. I have found it very easy to use. Whenever you have finished with it you can take the centre out and leave the frame in situ so when you need it again you just have to push it in.





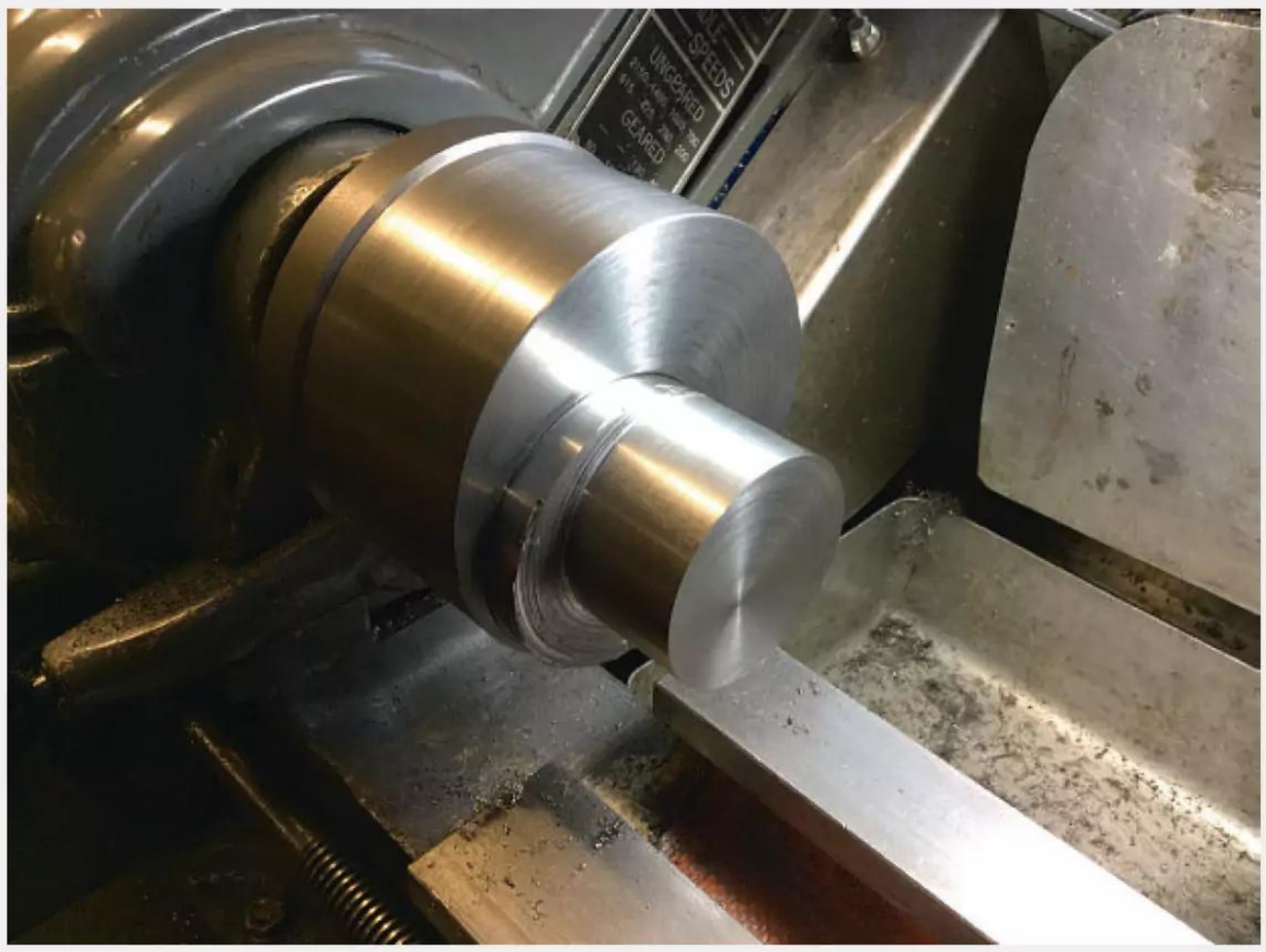


Eccentric Chuck – Bernard Towers

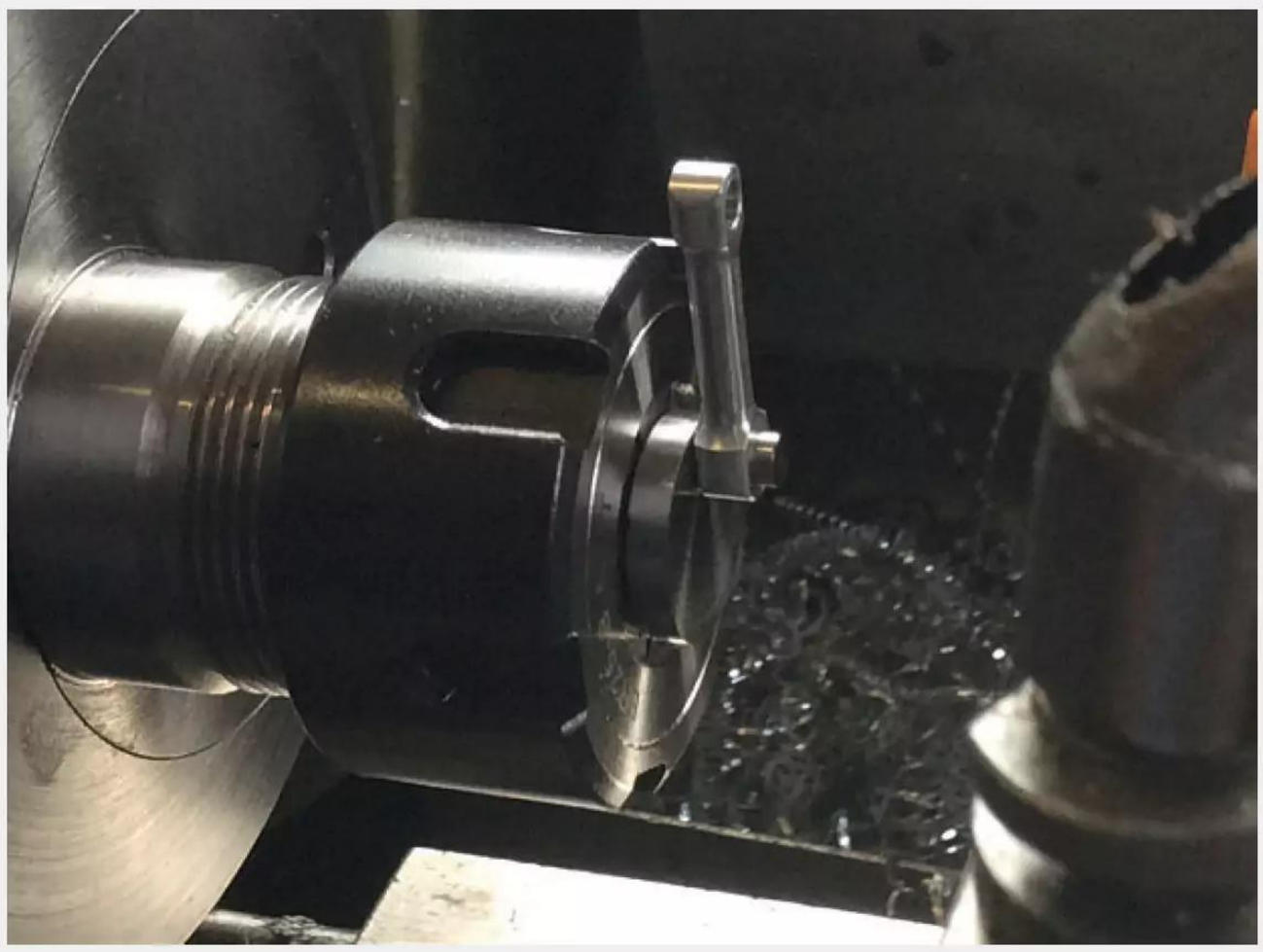
As I Spend some of my workshop time making small ic engines the thought of having a nice bit of tooling for doing the crankpins as I prefer to have them integral rather than pressed in place. After a bit of investigation it seems eccentric chucks are the thing of dreams for the home workshop so pencil and cigarette packet drawing started. The one I have made is 4"od but is still a heavy piece of kit and even though a lot of metal is removed from the main body you then fill it with the adjustable part so essentially its solid with an ER 25 collet nose out front. I'm sure that this weight adds to the ability to get a good finish on your parts.

This can obviously be made with a backplate of your own choosing, mine just happens to be Myford. The adjustable part is locked/unlocked by a George Thomas type used on his pillar tool design. This hole has to be machined first and a piece of brass bolted in place. It is not difficult to make but produces a lot of swarf as a 2 1/2" hole has to be bored through the 4" x 2" blank which is eccentric by 1 1/4".

With your 2 1/2" x 3 1/2"long blank fitted into the bored hole the ER or whatever style nose you like can be machined on the front, it does involve a fair bit of interrupted cutting.The tapers and threads you use is up to you but keep the tolerances as tight as you can, mine has a commercial ER25 bb nut and I used that as the thread gauge. It is possible to have a crankshaft up to 4" long in the chuck something which is difficult with a 4 jaw and small bore lathe and if using a Keats jig would leave a lot of overhang. It is set by using a Dial gauge with a piece of smooth flat steel screwed to the plunger at right angles allowing the chuck with dowel installed to read the stroke of the chuck. I have a hole drilled in the adjustable part to allow a pin spanner to be used to help with the adjustment.







Bevel Gear Test Rig – Bob Reeve

Work started late in 2018 to improve the quality of bevel gears produced in model engineers' workshops. These were parallel bevels, rather than the fully formed versions produced commercially. The starting point was a pair of 1:1 Mod 0.5 bevels made without the errors already identified by others. This rapidly led to the realisation that some means of comparing the performance of the bevels was required. At which time the Covid pandemic appeared with its associated restrictions. What follows can be considered a child of the Lockdown!

The development work was documented in a series of MEW articles, starting with four parts of "Bob's Better Bevels" (MEW 316). A very crude test rig was devised which identified the features needed to get more meaningful results, including better bearings, accurate shaft alignment and easy adjustment of meshing.

In parallel with this was considerable theoretical work (and maths) to identify where approximations inherent in the current methodology could be improved. The second-generation test rig had all the extra features identified above, plus the unintended additional capability of sustained high-speed running for noise and vibration evaluation.

The theoretical evaluation of the geometry indicated that tooth separation was excessive and some angles were not ideal. Bevels cut with a revised geometry were better, but really needed CNC machining to achieve the more complex geometry reliably (MEW 319). It also necessitated an accurate means of adjusting the mesh. The criteria being that gears should mesh without binding, with minimal backlash but must not bottom out at the root of the tooth.

The third iteration of the test rig included micrometer meshing adjustments (40 tpi), providing optimised meshing by "feel". The rig was also fitted with a short rubber coated torque reaction bar to locate in the T-slots of my CNC mill which provided the variable speed drive for the rig (MEW 319). By this time the bevels had progressed from 1:1 to 4:1 (MEW 312). Such bevels were more demanding in terms of the precision required to manufacture them. The dial gauge assessing concentricity was calibrated in microns and setting cone angles on the lathe utilised a sine bar to get the correct angle.

The revised rig worked well, but only after one of the shafts was replaced due to run out. The tests were now exceeding 10,000 rpm on the o/p shaft, while the handle was used for low-speed evaluation using engineers' blue. The latter showing up some unexpected faults still present, and the former showed noise levels dominated by resonances in the assembly.

Finally, a pair of 4:1 bevels was produced which I considered satisfactory. No binding and minimal backlash; not quite instrument quality, but much improved. The SMEE stand at MMEX 2022 exhibited the test rig, together with an automotive differential using some of the gears produced (MEW 331).

Could it be further developed? It should be possible to include a measuring datum so that optimal meshing could be transferred with pre-determined shim sizes.





Tailstock Tap Holder – Brett Meacle

This entry is only a simple accessory to make, the whole job could be completed in one piece with only the Collets and Closing nut purchased to finish the job. As outlined in the original article "Sliding Tailstock Holder" MEW 288, I wanted to demonstrate that even without screw cutting facilities, or a lacking of experience or confidence to machine the threads or bore accurate tapers, the job can still be done by a newcomer until they have gained the skills to move onto more complex operations with confidence. All that is required is the production of a few accurate holes by reaming or boring to size, determining the actual size of the hole using plug gauges then machining a matching shaft to fit with a suitable clearance or interference tolerance.

Purchased Items include the ER Collets and Closing Nut, ER Motor shaft chuck to modify and a Modified 2MT Arbor.

A number of years ago I made GHT's Threading tools, the sliding die holder was made, the ease and convenience of having preset dies proved well worth the time & effort.

Interest dwindled before I moved onto the sliding tap holder and I continued to use the time honored method of holding the tap in the tailstock and sliding it along the bed, winding the chuck with a mandrel handle. This works well with larger taps but you lose some feel with small ones, which can lead to oversized threads.

The original drawings showed the taps being held in a series of adaptors drilled to match the shanks of different size taps and secured with grub screws. The only drawback is that taps seem to come in a large variety of shank sizes and to complete the tapping attachment would require a similar number of different sized bushes.





I came across a series of ERG 16 tapping collets, which not only hold the shank of the tap but also the square section. They are a bit of overkill for the task, and I'm sure normal ER collets would hold the taps securely. I was able to use the smaller ERM style closing nut for a more compact, neater looking arrangement.

Deciding on the ER16 size, the tap holder was enlarged slightly and a tommy bar hole was drilled into the knurled section. This hole with a tommy bar inserted allows holding the tap holder when tightening the collet, also gives something to grip when tapping larger sizes, as holding the knurled surface will become uncomfortable after a certain point.

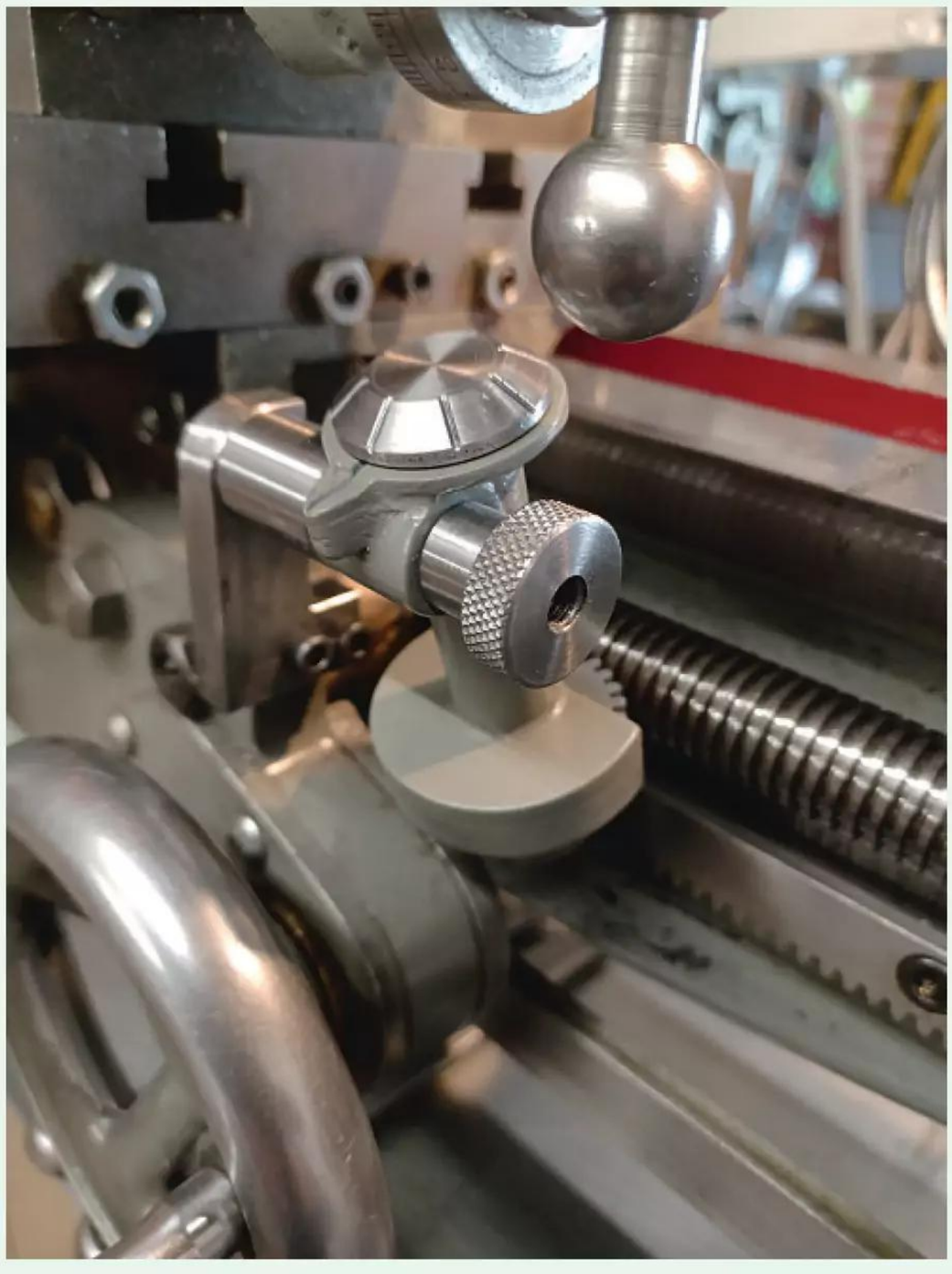
To machine the shank of the collet holder, a collet was clamped onto a turned spigot held in the lathe chuck. The two parts were assembled using a shrink fit but could also be completed using one of the widely available liquid adhesives.

The completed sliding tap holder has improved the quality and fit of small threads and could also double as a sensitive drilling attachment for small drills.

Myford Screw Cutting Indicator – David George

I had been looking at making a screw cutting indicator the same as the one on my lathe, as a new original seemed a bit pricy. I drew up the parts in Alibre Atom 3D and looked at casting the body, but a friend said he could 3D print it and it could be used as a pattern. After printing other than a couple of areas where the cross-support diameter contacts the main body which needed filling, it seemed perfect to use as is. There is also a gear which was supposed to be used on a Boxford would be suitable to match the leadscrew on my lathe. The only difference is it is twice the size, so I had to modify the bottom part of the body model to suit the larger gear. The gear has a recess to take a bush to allow for a grub screw to hold the gear to the shaft when tapped and I decided to make the top indicator with shaft from steel, but it could be made by printing as well. For my use I have made a shaft, bracket and knurled nut to support the indicator from steel but again these are available for printing. The gear has a grub screw in the lower boss, and I decided to fit a bush into the gear to make the thread more substantial so that it is possible to set the indicator line prior to use. The plastic used to print the body and gear was a bit orange and I decided to paint it to match my lathe and it now looks just the part. After assembling it worked well and after painting just the ticket and a bit cheaper.

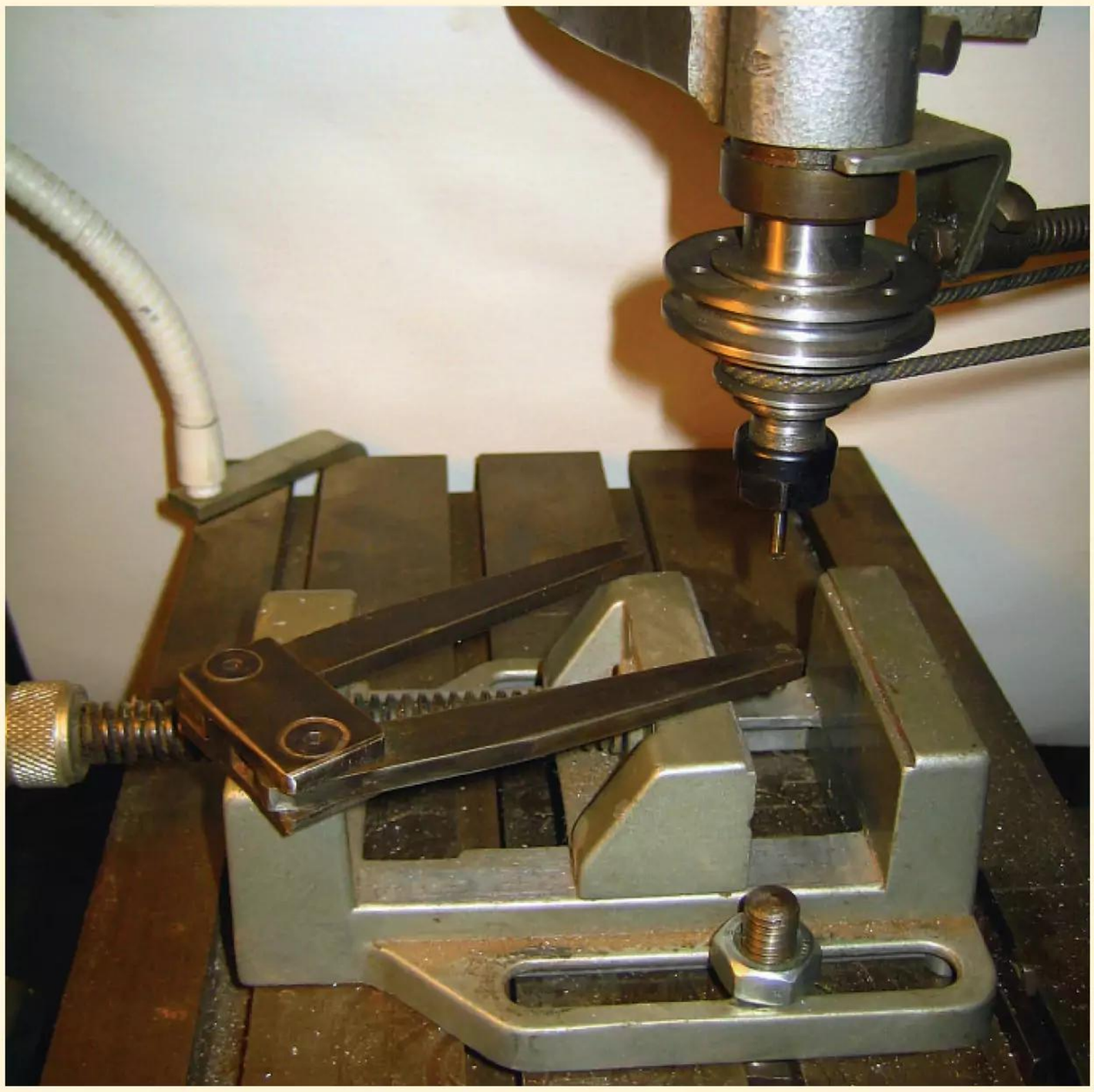






Taylor Hobson Engraver Spindle – John Cuckson





Unlike most of my projects, this was not so much a matter of choice but of necessity. I bought a Taylor Hobson D Engraving Machine at auction but shortly after I began using it, I realised it was noisier than it should be and, more importantly, it gave a terrible finish both when engraving and when light milling. It was clear the spindle was at fault and after some trouble dismantling it, I found out why. The original design is very elegant relying on hardened, uncaged balls running directly on the very hard spindle which developed spalling followed by false brinelling. At some stage I will endeavour to regrind the spindle (it seems to be through-hardened) as well as the outer races which were similarly damaged. But to get the machine up and running, I decided to make a completely new spindle and to fit the nose with E11 collets rather than the proprietary taper fitting that Taylor Hobson used. The E11 collet enables standard 1/8-inch diameter cutters to be used plus all the other sizes covered by this range of collets.

The new spindle design is based on thin section ball bearing races with a 24mm X 12 mm X 6mm race at the nose (which carries the pulley and takes most of the cutting forces) and a 15mm X 10mm X 4mm race at the top. Preload is provided by two stacks of three wavy washers each 0.3 mm thick pushing via a sleeve on to the outer race of the upper bearing. The spindle was made of unhardened 080M40 (ex EN8). Getting the right size wavy washers proved impossible so their outer and inner diameters had to be adjusted to fit the space in the barrel while keeping the spindle diameter as large as possible. The resulting spring rate then had to be recalibrated and spacer thicknesses adjusted to achieve the desired preload of 50 Newtons having carefully measured all the relevant shoulder lengths. The drive from the pulley to the spindle copied the original where a flat key on the inside of the pulley drives a flat on the spindle.

The design challenge was to come up with a design that allowed all the pieces to match precisely the outer diameter and length of the original Taylor Hobson spindle. Plus, of course, the pulley had to match the original to maintain the machine's speed range of up to 18,000 rpm. An additional feature was a ring of pin holes in the upper part of the pulley to enable a small specially made pin spanner to hold the spindle while the collet is tightened and loosened.

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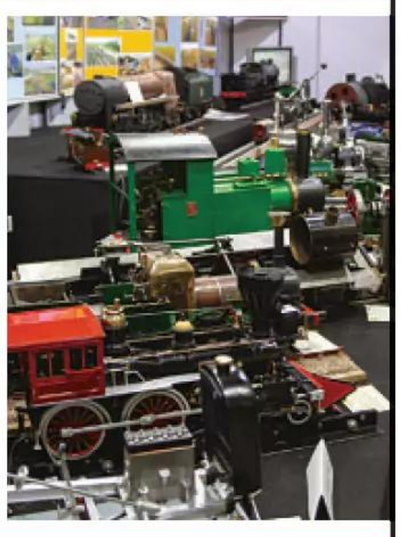
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Getting the most out of your Brushless Mill. Part 5



Jason Ballamy concludes this short series by explaining how to modify a milling vice for easy and accurate relocation.



Measuring the width of the upper tee slot.



Measuring the width of the supplied keys.

One topic that crops up fairly regularly on the forum is clocking the fixed jaw of a vice true to the X-Axis with many finding it a lengthy process and then once they do eventually get the vice clocked true, they are reluctant to remove it to make full use of the milling machine. One option to speed up this process so that you can get the most time actually using the mill is to fit keys to the base of the vice which locate against the edge of a tee slot and make fitting the vice quick and repeatable to within acceptable limits for most work.

For this example I will be using an 80mm versatile vice from ARC Euro Trade which comes complete with a swiveling base, universal keys and the slot already milled in the base of the vice and holes tapped to attach the keys. The swivel base is best removed and stored for the odd occasions when it may be needed which will give more head room and also save humping such a weight on and off the Mill's table.

The first thing to do is check what width the upper narrow section of your tee slots is, a small mill is likely to be 10mm, a large one 14 or 16mm or in the case of the SIEG SX2.7 that I will be using 12mm. Older machines will have similar imperial width slots, **photo 1**. Next check the width of the supplied keys in the case of this size of vice they are 14mm, **photo 2** which conveniently gives us



Using Dti to set bar true to X-Axis.

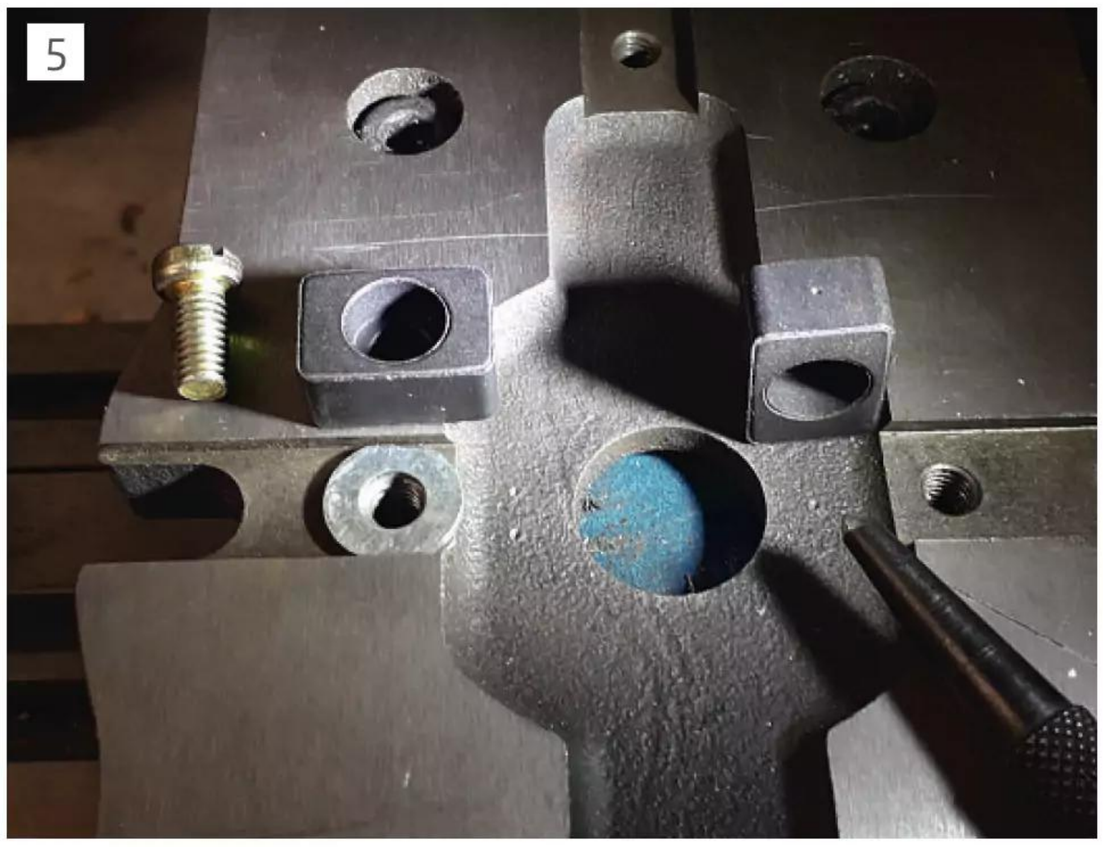


Marking keys and vice.

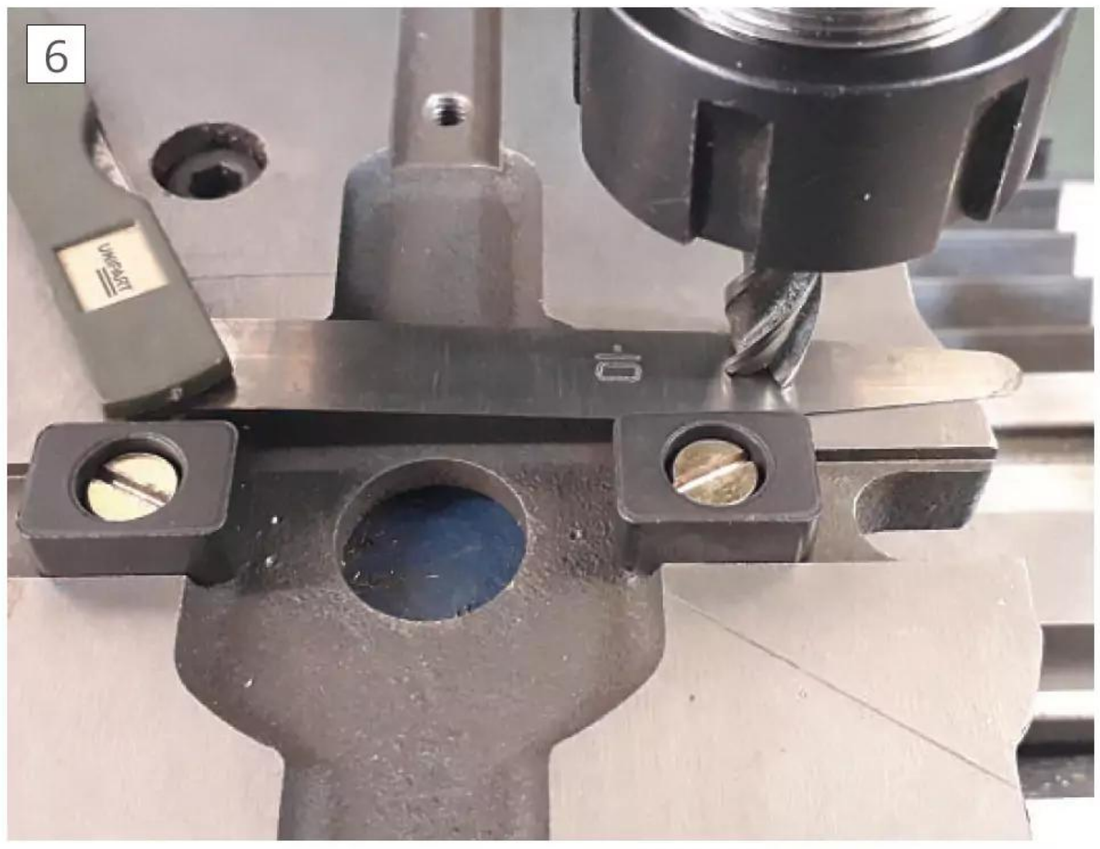
some material to come off allowing their fit into the tee slots to be fine-tuned. Don't worry if your keys are less than the width of your slots, they can still just have a small amount skimmed off them to bring them into line.

The fitting process starts by clamping a reasonably sized and straight square or rectangular bar to the mill table and clocking it as true a possible along the X-Axis. **Photograph 3** shows a 25mm square bar being positioned using a lever type DTI fixed to the underside of the head by its magnetic base.

Having made sure that the vice is clean from swarf, particularly behind the fixed jaw if you have removed it at some time the vice can now be placed upside down over the bar and the jaws firmly tightened. Use an edge finder on either slide of the slot to find its centre and zero the Y-Axis hand wheel or DRO if you have one. Mark the keys and the vice so that they can go back into the



Spacing keys with washer.



Setting cutting tool height 0.1mm above vice



Cutting of keys completed.

same positions if you have the need to remove them at some time. I used single and double punch marks on the end of the keys and matching marks on the recessed underside of the vice, **photo 4**.

Before screwing the keys to the underside of the vice add a washer so that the key sit's a bit proud of its final position, this will enable the sides to be machined without risking nicking the bottom face of the vice with your milling cutter. **Photo 5**. With the keys now firmly screwed in place on the washers bring a milling cutter down to just above the vice, in **photo 6** I am using a 0.1mm feeler gauge to ensure the cutter is clear.

It is now just a case of taking equal amounts off either side of the keys until they are just below the width of the tee slot that was measured earlier, something like 0.05 to 0.1mm undersize will do which is 11.90mm to 11.95mm for a 12mm tee slot, **photo 7.**

Remove the keys and with a fine file remove any burrs then reassemble into the slot but this time without the spacing washers and that is the job done. In use the vice is put into position and gently pushed back so the keys rest against the far edge of the keyway while the clamping screws or nuts are tightened. With luck you should have a vice that can quickly be positioned with an accuracy of 0.01mm over its jaw length which equated to approximately 0.007degrees which is good enough for most jobs. If there is something special than needs more accuracy it should not take long to clock the vice in as you will be starting not far from where you want to be. The video shows the results from just pushing the vice with its machined in-situ keys back against the central tee slot.

No slot or keys?

If your vice is not equipped with the locating slot, then mount it upside down as has been shown and locate the middle of the hold down lugs and use that as the Y position to mill a slot say 12mm wide and 2mm deep. Use a 10mm diameter tool doing a central pass first then open up equally on each side using the material you will make the keys from to gauge the final width. Tap the hole M4. The keys can be 12mm wide x 10mm high and around 16-20mm long, drilled M4 clearance and counter bored to clear the head of an M4 cap head screw.

Thiis ends my short series on getting the most out of the SIEG SX2.7. You can access videos about this modification and other instalments on the forum at www.model-engineer.co.uk, or use the QR code.

THE MIDLANDS MODEL ENGINEERING EXHIBITION

Thursday 17th to Sunday 20th October 2024 at Warwickshire Event Centre

Model Engineers Workshop at MMEX

At this year's exhibition, the **John Stevenson Trophy** will be awarded in association with Model Engineers' Workshop and the www.model-engineer.co.uk website. This competition is awarded for excellence in practical and useful workshop equipment. You have a say in who wins this prestigious trophy, see pages 46-51 to view the entries and then vote for your favourite.



The Model Engineers' Workshop Talks Programme

Following the successful and well attended talks at last year's exhibition, Model Engineers Workshop is pleased to host the talks at MMEX this October. The full timetable appeared in the previous issue, and it will be prominently displayed around the show.

MEW editor, Neil Wyatt, will be demonstrating 3D printing with the **Society of Model and Experimental Engineering.** The **SMEE** will be presenting other practical workshops and demonstrations as well as a range of their famous models on display and a chance to meet the members and learn about their training courses, programme of meetings and membership.

Other Highlights of MMEX

There will be **over 30 clubs and societies** present displaying hundreds of exhibits covering a wide range of modelling skills. This year we welcome **5 new clubs** to the exhibition including; Association of Helicopter Aerosports, Harlington Locomotive Society, Northampton Society of Model Engineers, Nottingham Society of Model and Experimental and The Young Engineers.

There will also be **nearly 40 of the leading model engineering specialist trade suppliers**, all waiting to meet you and provide everything you need for your modelling activities.

The **competition and display classes** are now getting lots of entries in the 16 display or competition classes. These range from locomotives, station engines, aircraft, marine and machine tools to name a few! Whether you are a beginner or experienced model engineer your work is welcome!

Fully completed models are welcome to the competition and any part-built models can be put in the display categories so visitors can see the work in progress!

Entry is free and prizes for 1st, 2nd and 3rd will be awarded by the judging panel. Judging will take place on Thursday 17th October with the awards ceremony on Sunday 20th October. Entering a model into the competition or display also gives you 2 days' free entry to the exhibition!

Don't miss your opportunity to be part of the show. Closing date for entries is Monday 23rd September. The competition is open to entrants of all ages with a specific Young Engineers Award for entrants under 20 years old. An entry form can be downloaded from the website.

Opening Times are Thursday – Saturday 10am – 4.30pm. Sunday 10am - 4pm.
Tickets cost Adult £13.00, Senior Citizen £12.00, Child (5-14 inclusive) £5.00
A full list of confirmed exhibitors to date is available at www.midlandsmodelengineering.co.uk as well as the competition entry form and advance tickets.

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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.**

International Delivery

Dear Neil, usually I get my MEW copy in the first week of the month. Three weeks of July have gone, and I didn't get a copy. Is there a problem?

Peter Chevalier, The Netherlands.

Hi Peter, I understand your replacement copy has arrived. I'm afraid there have been some problems with our international distributor of late. Mortons are monitoring the situation closely and we hope the problem will be sorted soon. In the meantime our apologies to any overseas readers who have to wait an extra week or two for their beloved MEW – Neil.



Turntable Weight

Hi Neil, here is a pic of my turntable weight. I have to order some blacking chemical to complete it

Geoff Warner, by email

MEW Keeps You Young!

Hello Neil, Will you please include the attached advert in a forthcoming edition of MEW. I very much enjoy the magazine, and still occasionally learn something new, despite my 91 years young! The balance suits me fine, as even the CNC and electronic articles are interesting, although I am unlikely to pursue either to any extent. Keep up the good work

Roy Smalley, Sheffield.

Feathered Friends

Good Afternoon Neil, attached is an article about "Home Foundry Work" I hope it is of use. I have not had access to the shed of late as swallows have taken up occupancy. I have put covers over most of the tools but oh the mess they make!

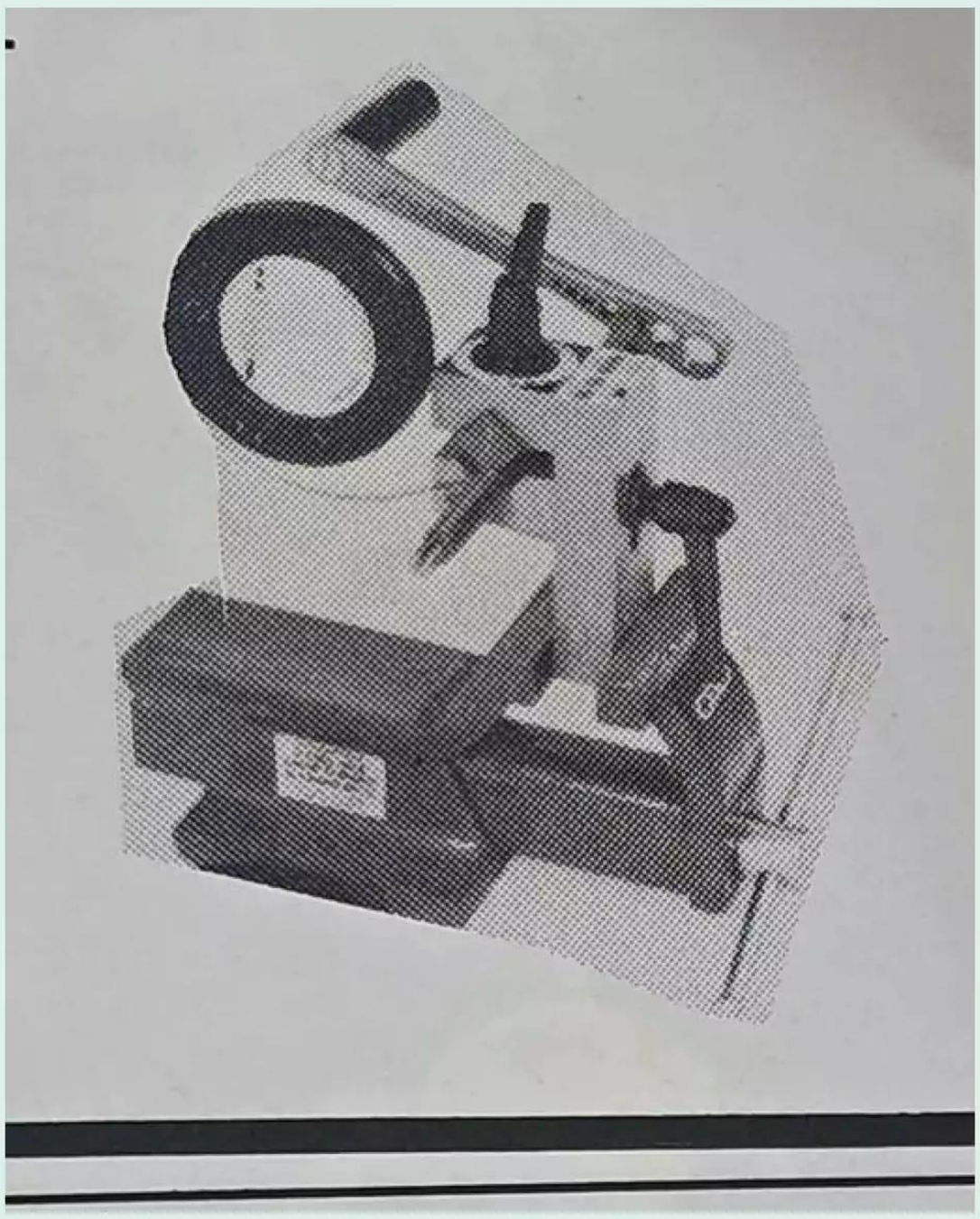
Paul Tiney, by email

Thanks Paul, I'm sure readers will enjoy the article in due course. I hope the Swallows let you back in the workshop soon!

Spring Winder

Hi Neil, My brother is looking a supplier of a similar spring winder tool as in the attached photos do you know who produces a similar tool/ device? Nothing found locally.

Richard Cains, in Australia.





Back Issues

Good morning Neil, I purchased the July issue of Model Engineer's Workshop Magazine, and have read the article "The Potty Engineering Cutter Grinder" part 2 - by Stewart Hart - but have not managed to find the issue containing part 1. Can you tell me please how I may obtain a copy?

Mike Waldron, by email.

Hi Mike, Back issues of MEW are available from this link: www.classicmagazines.co.uk/issue/MEW - Neil.

Online Indexes

Here's a reminder that David Frith's latest Index for Model Engineers' Workshop can be downloaded on from the Forum at www.model-engineer.co.uk – just sect Forums and then the Model Engineers' Workshop topic. Alternatively scan the adjacent QR code.

If you prefer the paper indexes, don't worry, David will be producing these in the future, carrying on Barry Chamberlain's sterling work.

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 By Geometer

Radii — functions and checking

For the reason that it is so easily specified, a radius is generally chosen in mechanical design as the junction between converging lines or surfaces as an alternative to a sharp corner-or a more complicated curve as may be employed in special circumstances. Specification of a radius is always as ***A,*** where it is only necessary to substitute a dimension for ***R.***

A radius, however, is more than a simple academic contrivance, a feature of basic geometry, for the curve it, specifies is often essential for efficient functioning of the machine or component. Generally, it is indispensable for changing the direction of flow of gases or fluids in passages, for conduction of heat from surfaces and for strength in areas of stress in components.

Thus. as at ***B,*** a right-angle curve in a pipe introduces little more resistance than a continuous straight flow; whereas if the bend is a sharp comer, the edges set up minor contrary flows or eddies.

Where the flow is of heat from a part as from a cylinder to its cooling fins-the rate of flow is generally best where the fins, as at C, join the barrel with a root radius and are tapered out to their tips. This is apart from the necessity for radiused and tapered fins for moulding and casting the cylinder.

The flow being of stress, as when a component is strained under load, strength is always improved by employing a radius rather than a sharp corner where there is a sudden change of shape or section. Consequently, shafts terminating at flanges, as at 0, and joining to webs in the case of crankshafts, as at E, always carry radii.

Rough radii are fairly easily formed, as on the square end of a piece of metal such as a clip, when a file is used to round it. Working more precisely, dividers can be used to scribe the radii, leaving lines to file. A single clip will thus gain in appearance? and should there be several they will be reasonably alike. Filing can be more accurate still, if a steel disc (diameter twice the required radius and preferably hardened) is clamped to the metal or held with it in the vice.

Small radii as left in machining processes are provided by suitably rounding the turning tools-as on shafts ***D*** and ***E.*** Then it is necessary for the tools to be ground to the required radii for reproduction on the shafts.

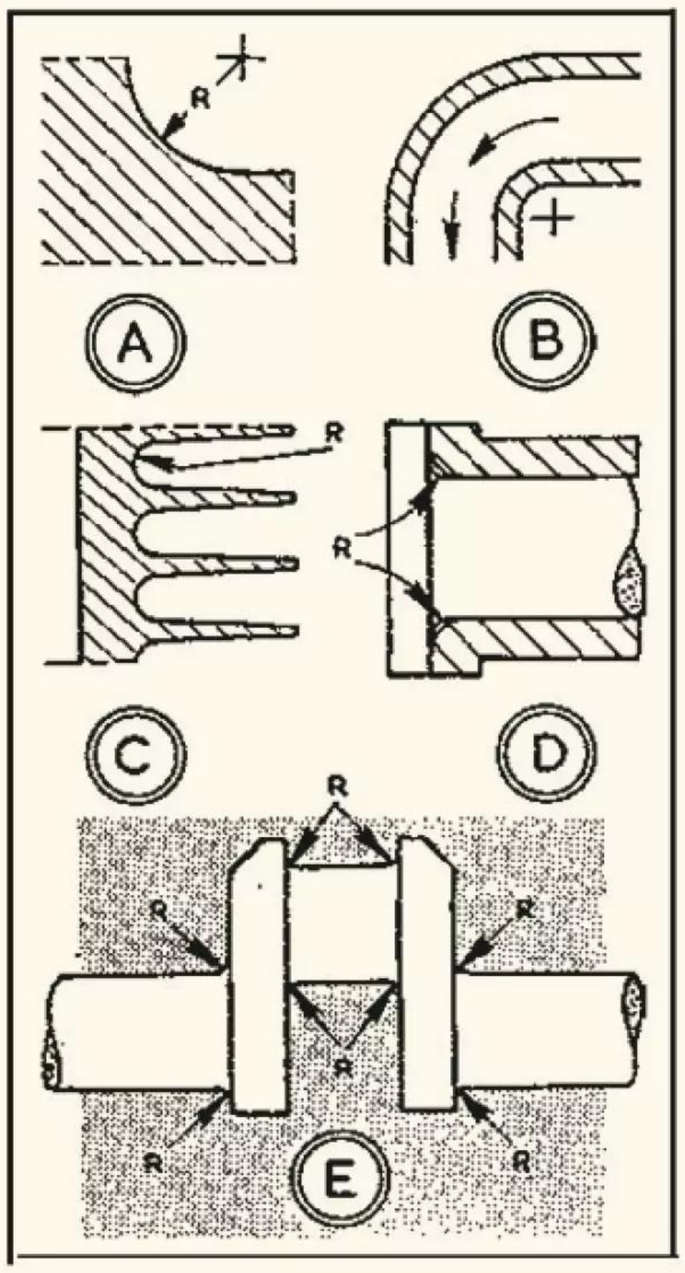
Checking of such small radii is done with gauges as at F-a holder containing a range of sizes from about 1/32in. to 1/4in. The appropriate one is presented for comparison to the tool or to the work when, if necessary, holding up to a light will better reveal the fit. An incorrect turning tool may then be rectified by using a hand abrasive stone.

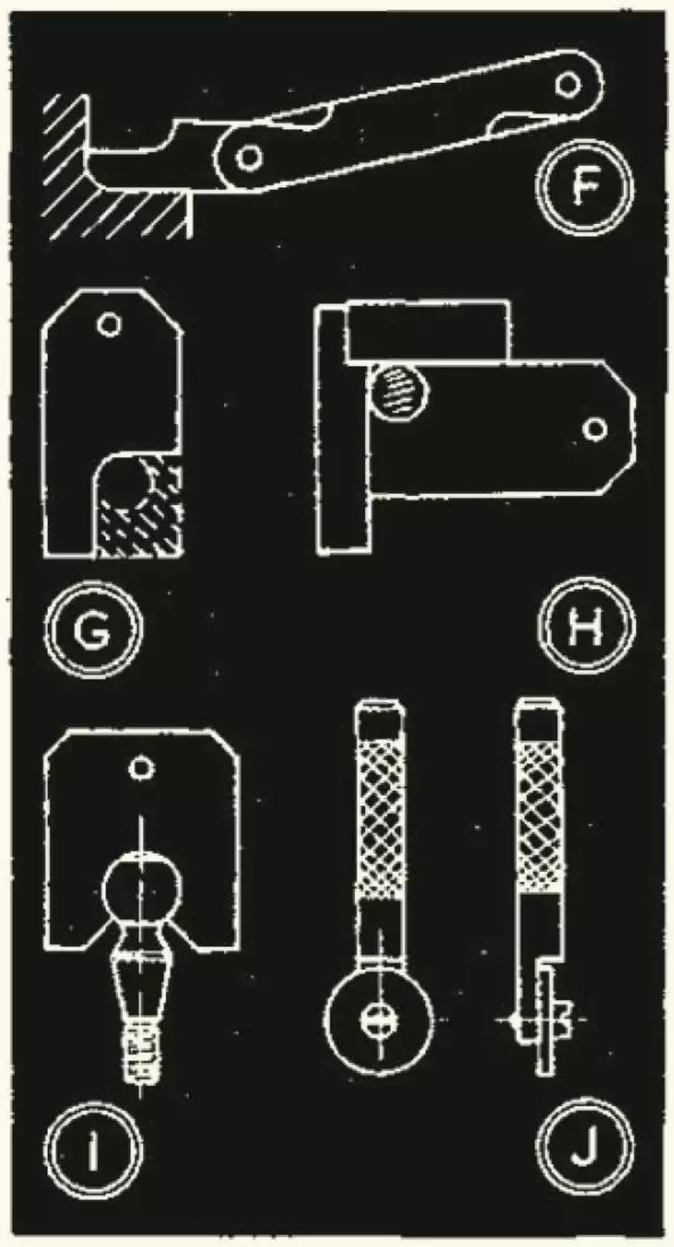
Particular care is necessary when, as at ***D,*** a shaft has a radius fitting in a bearing. Either the end of the bearing must carry a larger radius or be chamfered or counter-bored clear of the shaft, otherwise there will be to some extent the condition of " riding " on the radius. In fitting in such a case, the shaft radius would be checked with the gauge at *F,* and a larger one selected for the bearing as it is scraped to clear.

Radius gauges similar to but larger than the standard type, *F,* can be produced by drilling and filing from plate material (1/16 in. to 1/8 in. thick). For the internal radius a hole can be drilled or drilled and reamed, and the surplus material sawn and carefully filed away, G. For the external radius, *H,* a hardened disc can be used as a filing guide. If the material is square the disc can be aligned, holding a straight-edge along each edge in turn or using a small square,

For checking ball components, a hole in a plate gauge need only be relieved clear of the shanks, I; and in production gauges of this type there may be two holes, one " Go," the other " Not Go."

Attaching a handle with a central screw facilitates use of the radius gauge at J, a disc parted'or sawn from steel bar previously machined to size.





Learning to love my Denford NovaTurn, Part 2

Mick Knights describes using his Denford Novaturn CNC lathe.

Before we go much further, I feel I need to explain a little bit about the right-angled cartesian system on which the control operates, as I will be talking about plus and minus quadrants as the set up progresses. **Figure 1** is a plan view of a two-axis machine with bar stock positioned in a chuck. The absolute X and Z zero position is on the centre line of the spindle and the face of the bar. An ATC would be positioned on the X+ side of the centre line and so all external tooling would be inverted in order for them to cut on the X+ side of the bar. The manual tool change is the same as a conventional lathe and operates in the X- quadrant and so all external cutting operations will be carried out on that side of the bar. All tool movements up to the Z zero position will be Z+ any cutter movement beyond Z zero will be Z-. The CNC control takes all unsigned values as being + so if a cutter is operating in the – quadrants the value must be signed. For example Z-21.63 or X-7.85 The + symbol does not need to be applied to cutter movements in the + quadrants.

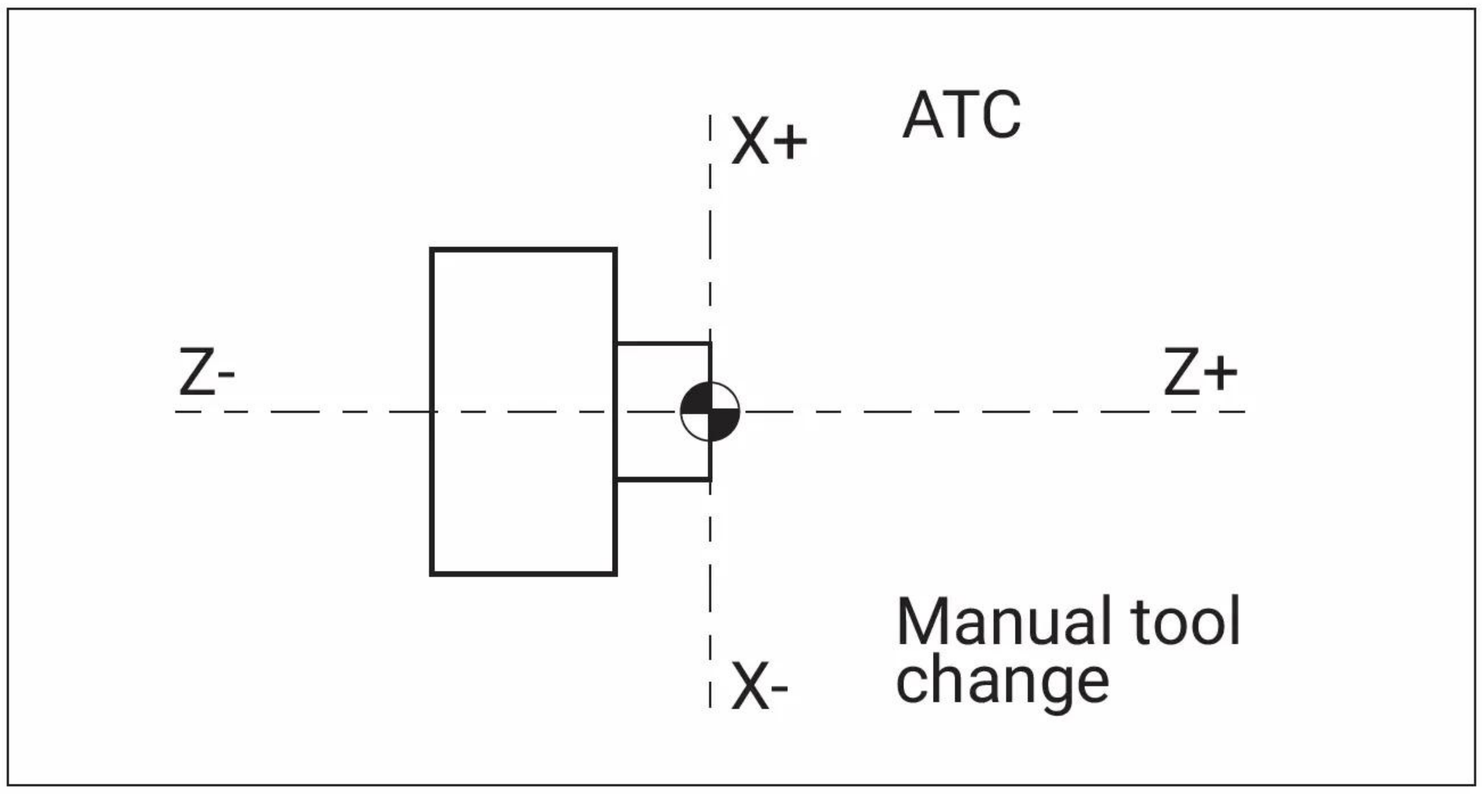


Figure 1. *+ and – quadrants.*

Now for the first job. This is a simple component comprising of a concave radius, a turned diameter, drilled hole and finally parting. This component will be a ball joint retaining cup for the push rods on the rotary engine I'm currently building. As you can appreciate the post processor needs to know a lot of information in order to create the finished part program, what actually follows here is unique to the 2D Design and VRTurn software, but all controls will need to have a fair deal of information entered in order to execute the machining cycle, although the format will probably differ from control to control.

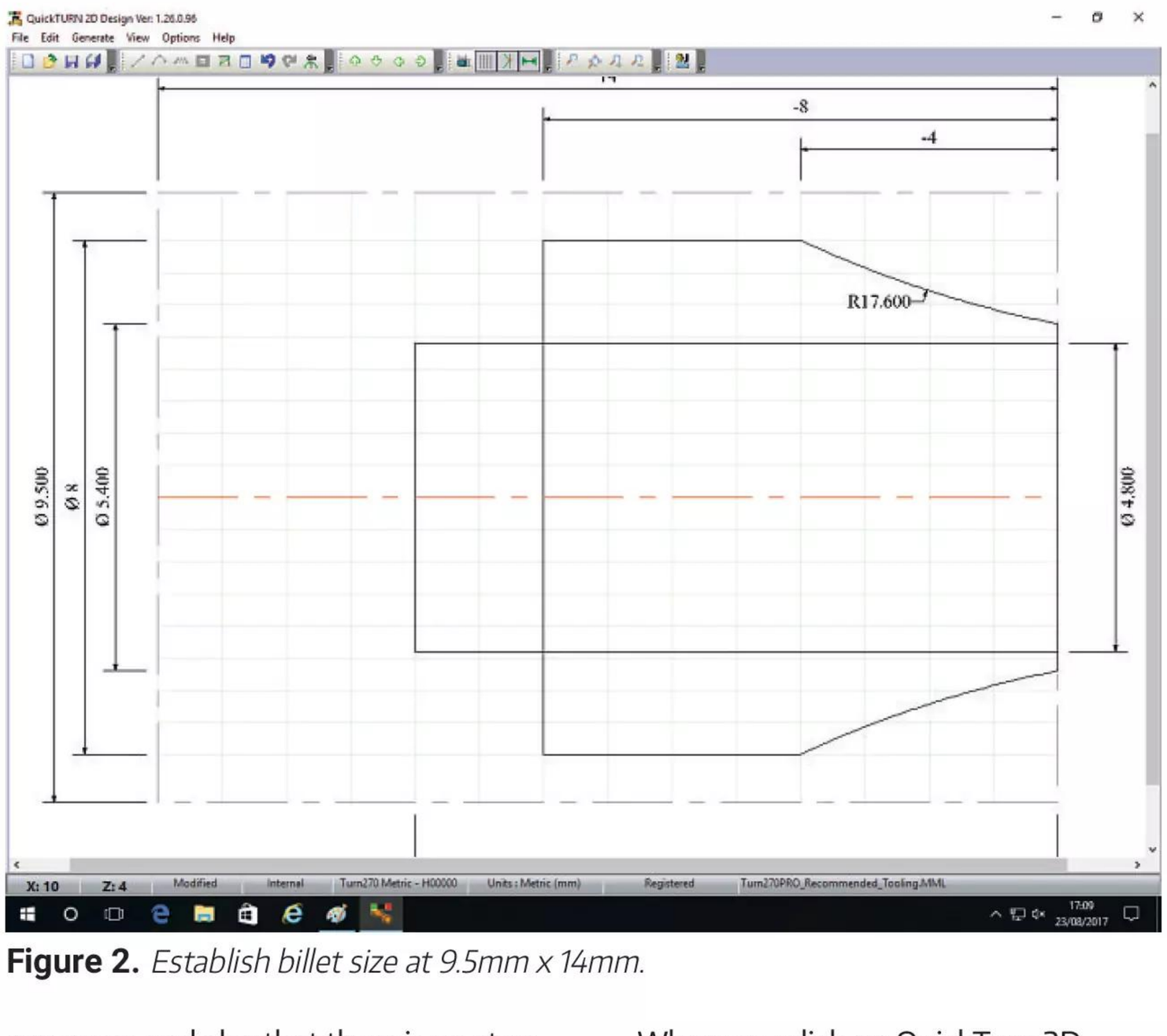


Figure 2. *Establish billet size at 9.5mm x 14mm.*

The first stage is to produce the CAD/CAM generated part program. I mentioned in part one that this was my first experience of CAD/CAM generated programs and also that there is no step-by-step tutorial that I could find and so I got to grips with it by clicking on various tabs to see what happens. However the QuickTurn 2D design software package couldn't really be quicker to understand or more straight forward to use.

When you click on QuickTurn 2D design the first screen to appear asks for the billet diameter and length, the length will be the amount protruding from the chuck, so obviously this must take into consideration any parting allowance, **fig. 2**.

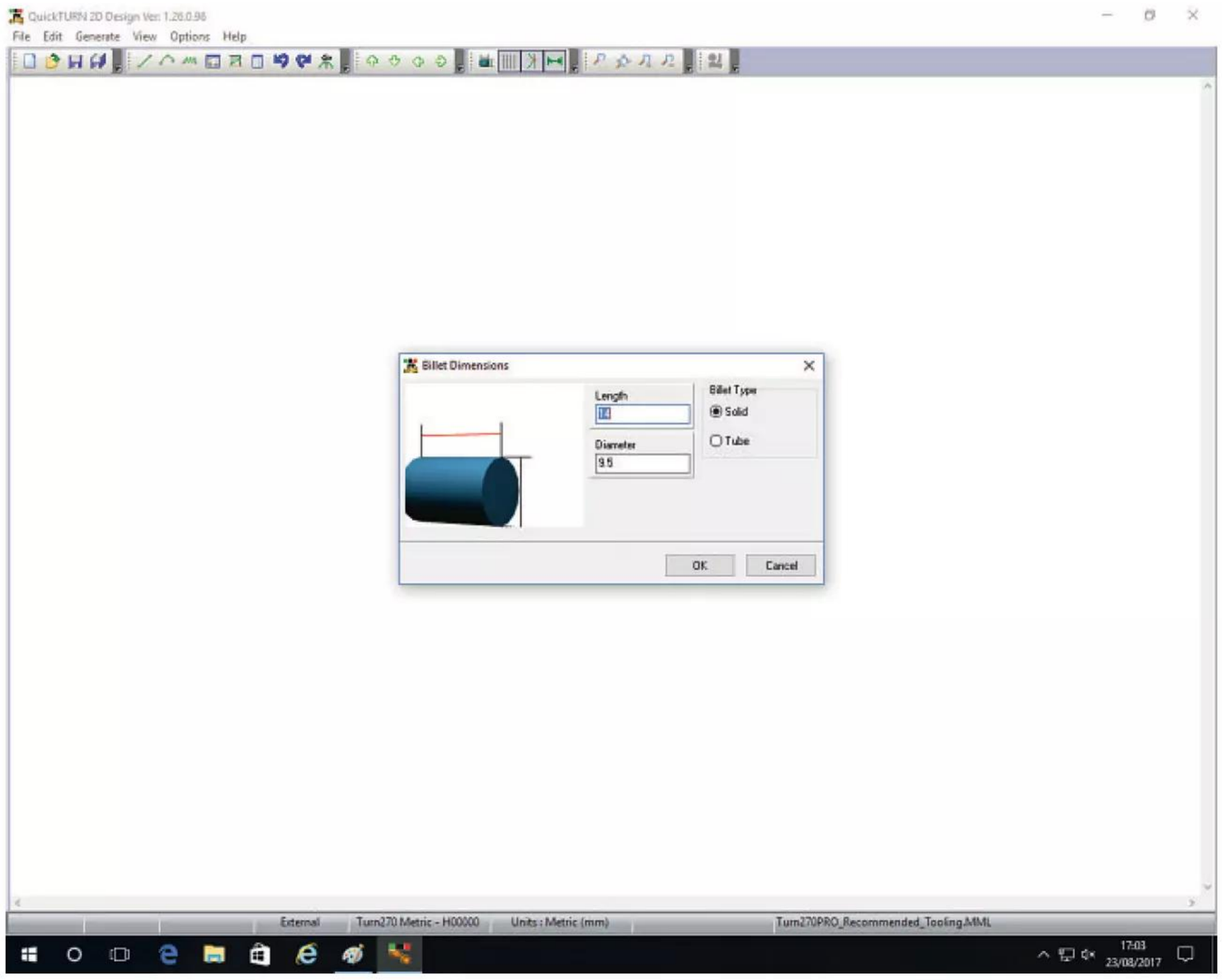


Figure 3. *The completed CAD drawing.*

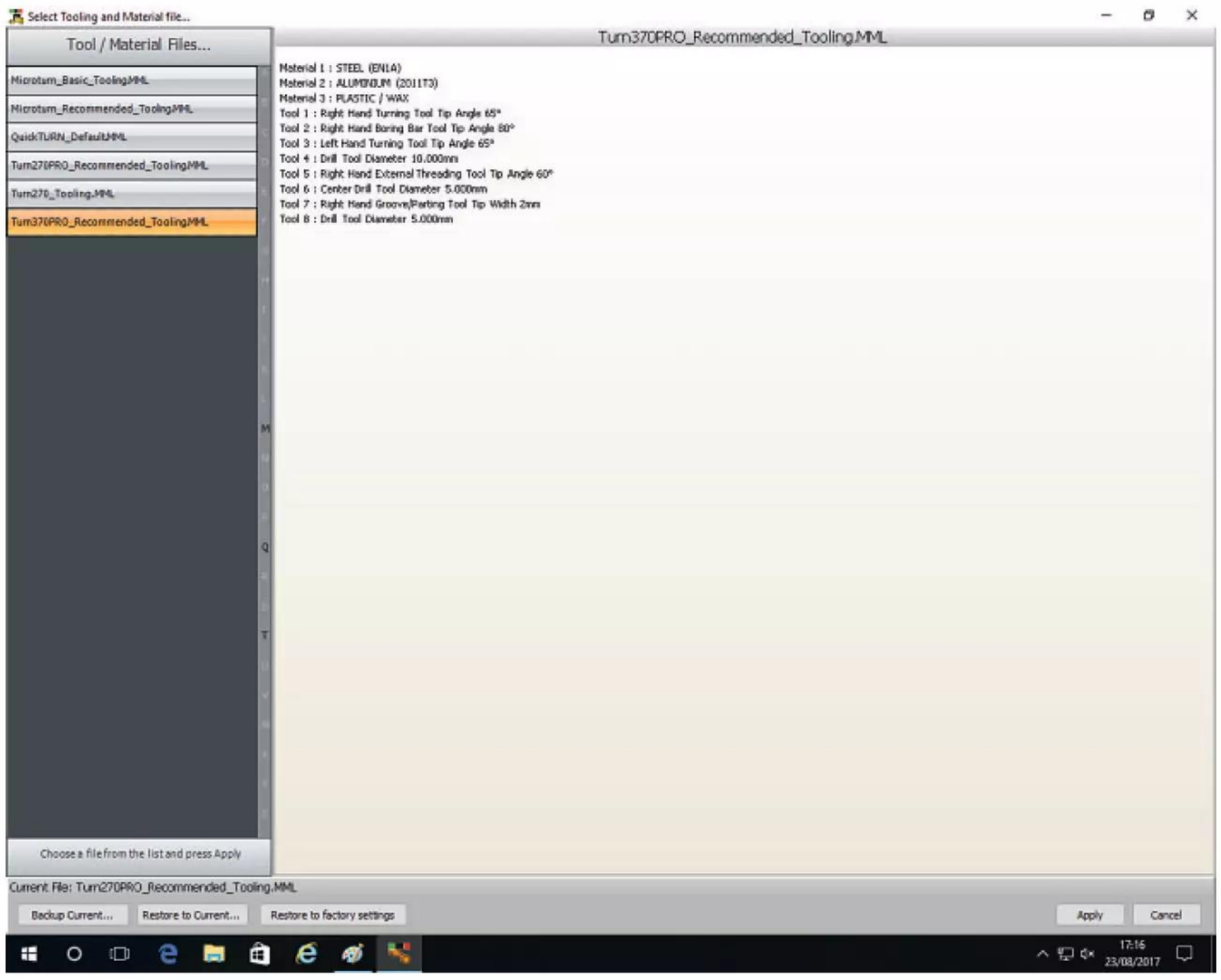


Figure 4. *Tooling selection.*

Once the overall dimensions of the material are established click OK, which opens the second screen. This screen is where the actual component is drawn and there are two methods of achieving it. The first is to drag the cursor along the screen grids until the desired line, or curve has been generated, the position of the cursor in the X and Z axis will appear on the screen, however the incremental positions in both axis are 1.0mm which is a bit too large for any practical purpose, so the best method is to generate the desired form by manually entering the exact X and Z coordinates positions one position at a time. To create a final parting off operation the last line generated should end at the centre line. When the outside profile has been generated any internal features can be created by switching from external to internal mode. **Figure 3** shows the completed CAD drawing.

Before continuing to the CAM post processor the tooling required has to be established and as the software is assuming there is an eight position ATC in use there will be four external and four internal tools available. To open this screen click on options and select Materials and Tooling where a list of all the default tooling available for different machines will appear and the selection best suited to your machine and application can be selected, in this case its Turn370PRO, **fig. 4**. Once the selection has been made the tooling can be further refined by again clicking options and this time selecting Machine Tooling, where the previous selection will be displayed. The tools required have to be established and then made active by green ticking the operate tool position box. In this case T01, T02, T06 and T07. As the machine doesn't have an ATC the external tooling, T01 and T07 must be green ticked as inverted, I'll explain further on, **fig. 5**. Some aspects of the selected tooling need to be further refined, this is achieved by clicking on the required tool which will open another window where changes can be made to reflect the tools in the actual machine tool library and any drill diameters that will be used. Here the drill diameter has been established as 4.8mm, while the centre drill diameter has been changed to one that is below the selected drill diameter. This doesn't mean that a centre spotting drill of that diameter has to be used when machining the component, this is to allow the post processor to generate the G code part program, as it won't allow the body of the centre spotting drill to be larger than the selected twist drill. While we're on the subject of centre drills, they should never be used on a CNC machine as the pilot diameter is prone to snapping off, usually a few millimetres into the work piece and the cone, still under feed, will push the pilot further into the component to ensure that it's virtually impossible to remove, that's why a centre spotting drill should always be used. As the spotting drill only produces a shallow cone for the

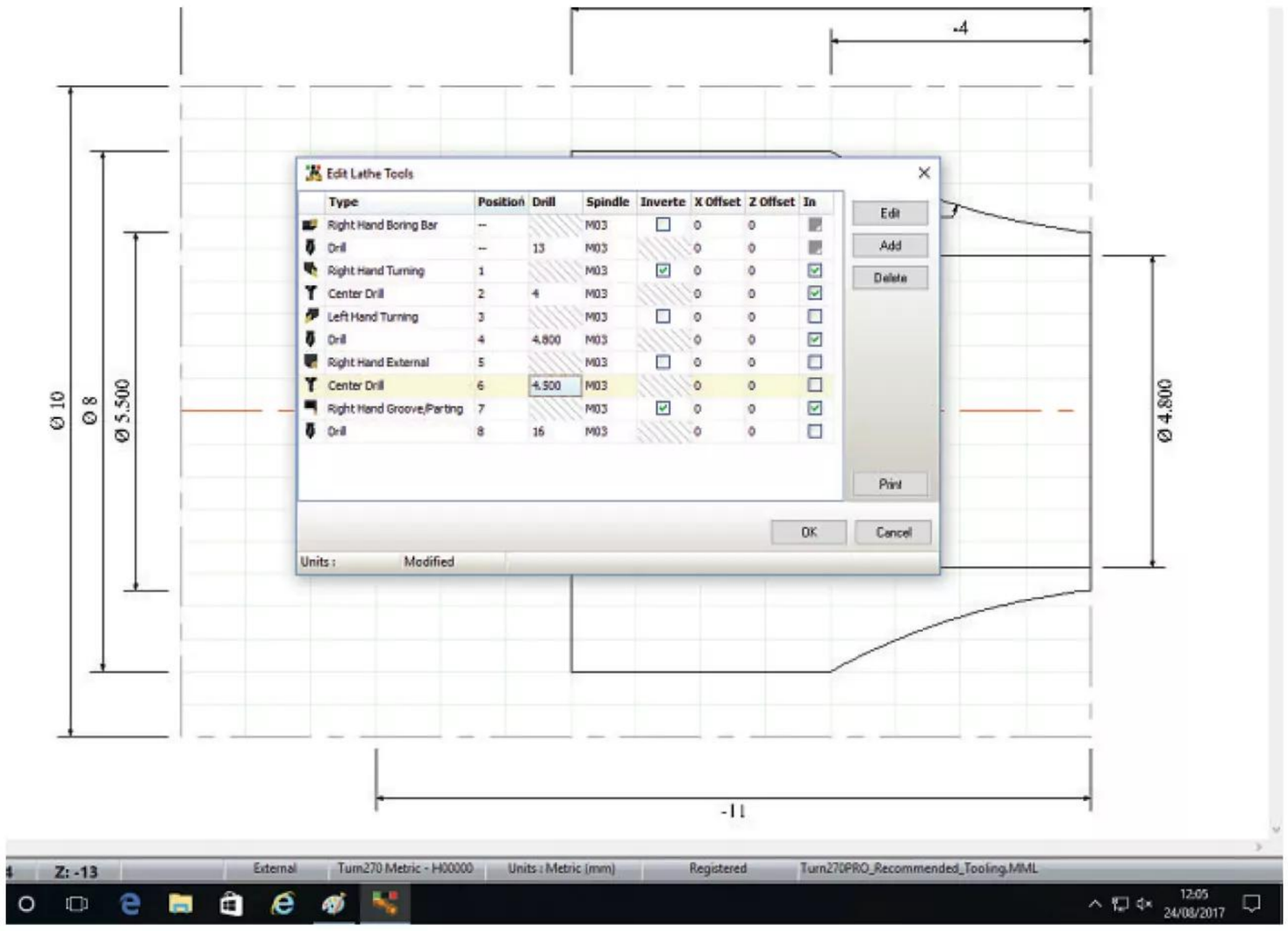


Figure 5. *Selecting the active tooling.*

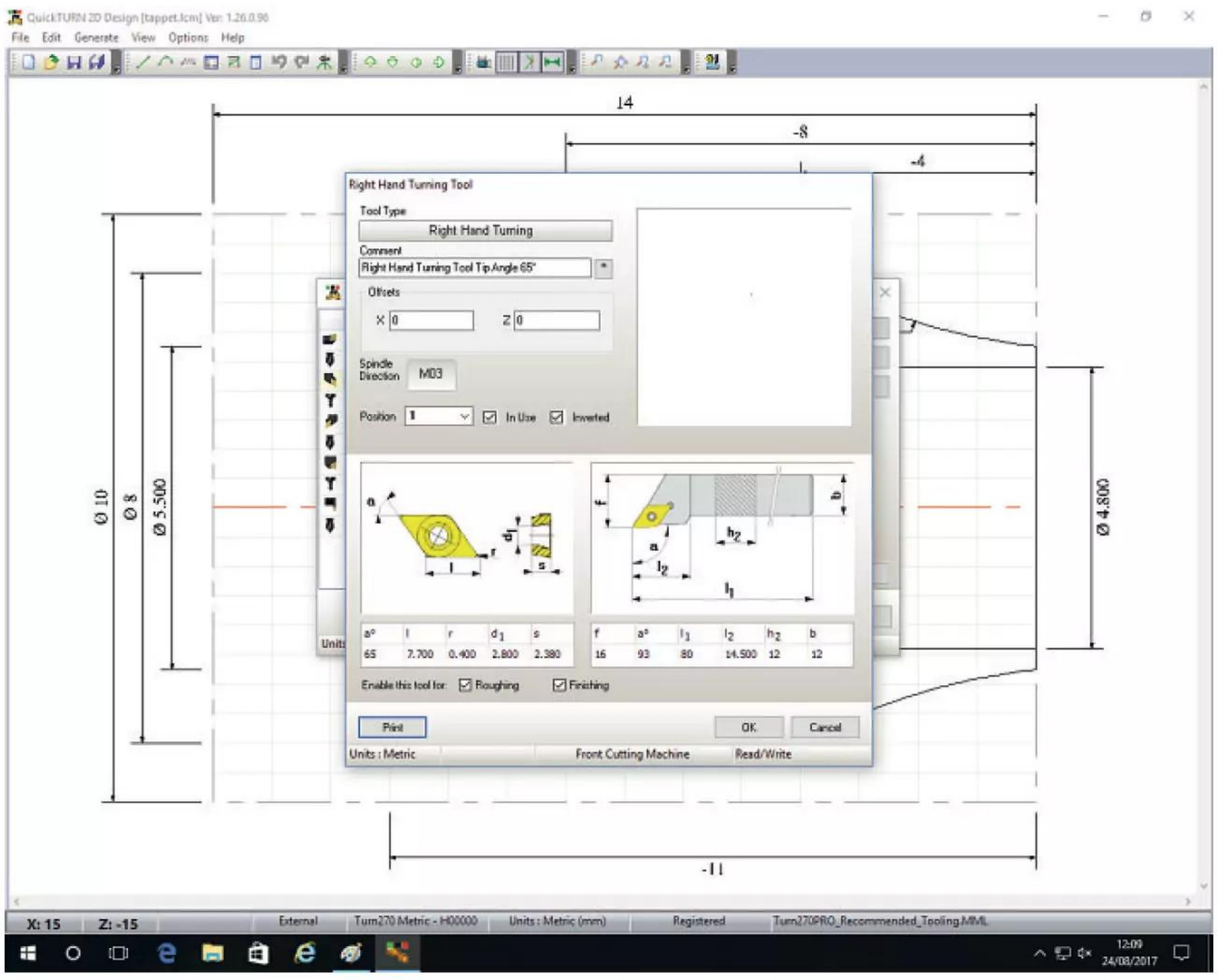


Figure 6. *Refining the details of T01.*

drill to locate, the overall length of the centre drill in the T02 tooling window should be changed to about 3mm. If this isn't done then the program will send the spotting drill as deep as the centre drill's pilot and cone, which would probably make the resulting cone bigger than the drill it's locating. But back to the editing of the tool details and we'll take T01 as the example seeing as it's the reference tool for all the others. It's important to enter all the cutting tip clearance angles requested along with the tool tip radius, as all these factors have a bearing on the finial program and how it produces the component, the cutting tip radius is an important value to enter when generating arcs and radii, as this may affect the finished form. With the simple work piece that's being processed here it's not critical to enter the back and side clearance angles, but when the tools are cutting complicated forms and back cutting tools are also being used, the cutting tip must not come into contact with a previously turned contour or shoulder and so all clearance angles must be entered so the post processor can take them into account when generating the tool paths. Looking at **fig. 6** we can see that T01 has been allocated as the roughing and finishing turning tool, we can also see that the tool is in use and has been inverted. Without a user's manual for the CAD/CAM software I'll have to take an educated guess here, but the CAM side of the software won't create a tool path for a component unless the tool has been ticked as inverted, I'll offer my suggestion as to why I think this is, but of course I'd welcome any input if I'm wrong. When turning on a manual lathe any tools that are set upside down in a rear tool post would be referred to as being inverted, but as the external tools set in an ATC are inverted anyway and cut in the positive quadrant the post processor takes it as read and the program is generated to reflect this, it's only when the tools are mounted in a manual tool change and will cut in the negative quadrant that the post processor needs to know that the tools are mounted in a different orientation to the ATC and to take that into account when generating the part program, so the invert tooling box is green ticked as active.

With such a small component and with so little material being removed T01 being both the roughing and finishing tool presents no problem, but of course when large amounts of material have to be removed, then a roughing tool (T03) must be requested alongside T01. If you click on the actual tool a drop-down menu appears and displays all the different tooling options available for that particular tool position, but when I've tried to change the designated tool the new selection hasn't registered, some more random clicking may be required here when I need to change the tools to different positions than the ones allocated.

One more screen to go, again its options and click on 'Materials tooling' This screen allows you to choose the material, in this case it's free cutting mild steel EN1A. The right-hand columns are ›

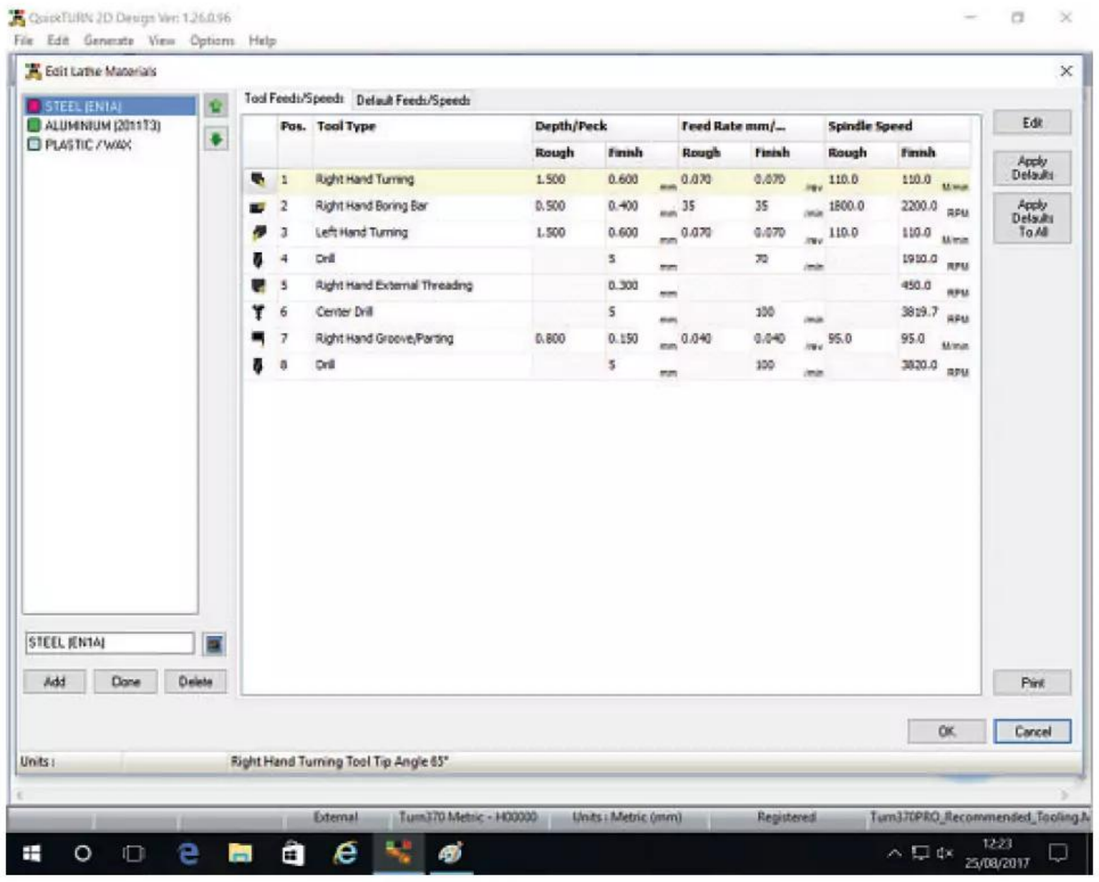


Figure 7. *Materials and Tooling machining parameters.*

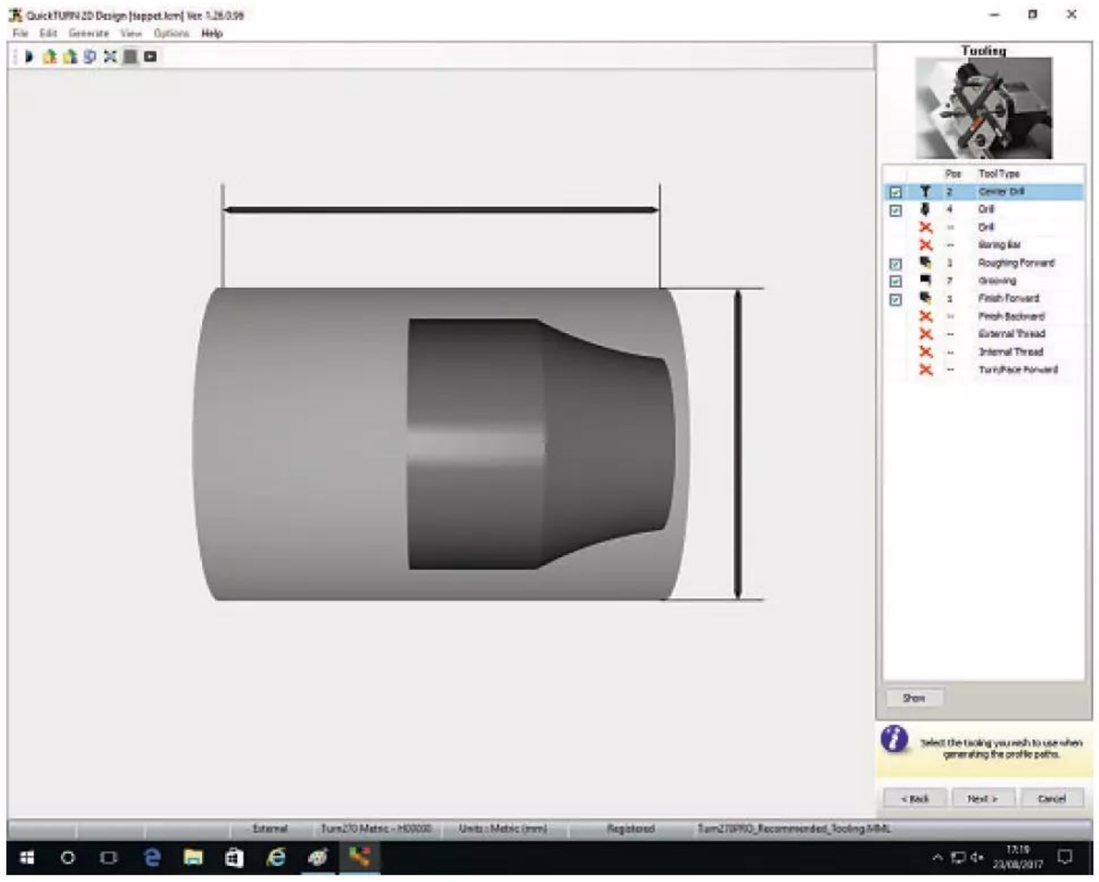


Figure 8. *Prior to post processing.*

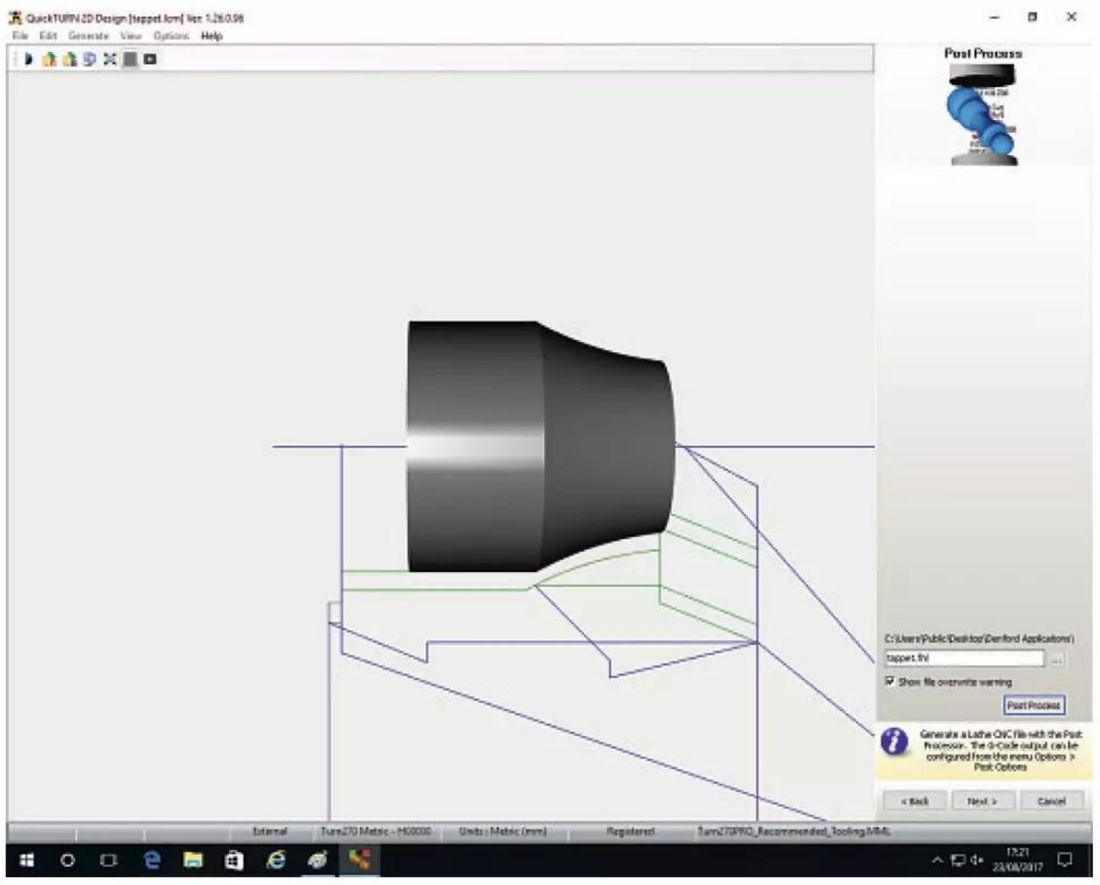


Figure 9. *Component post processed.*

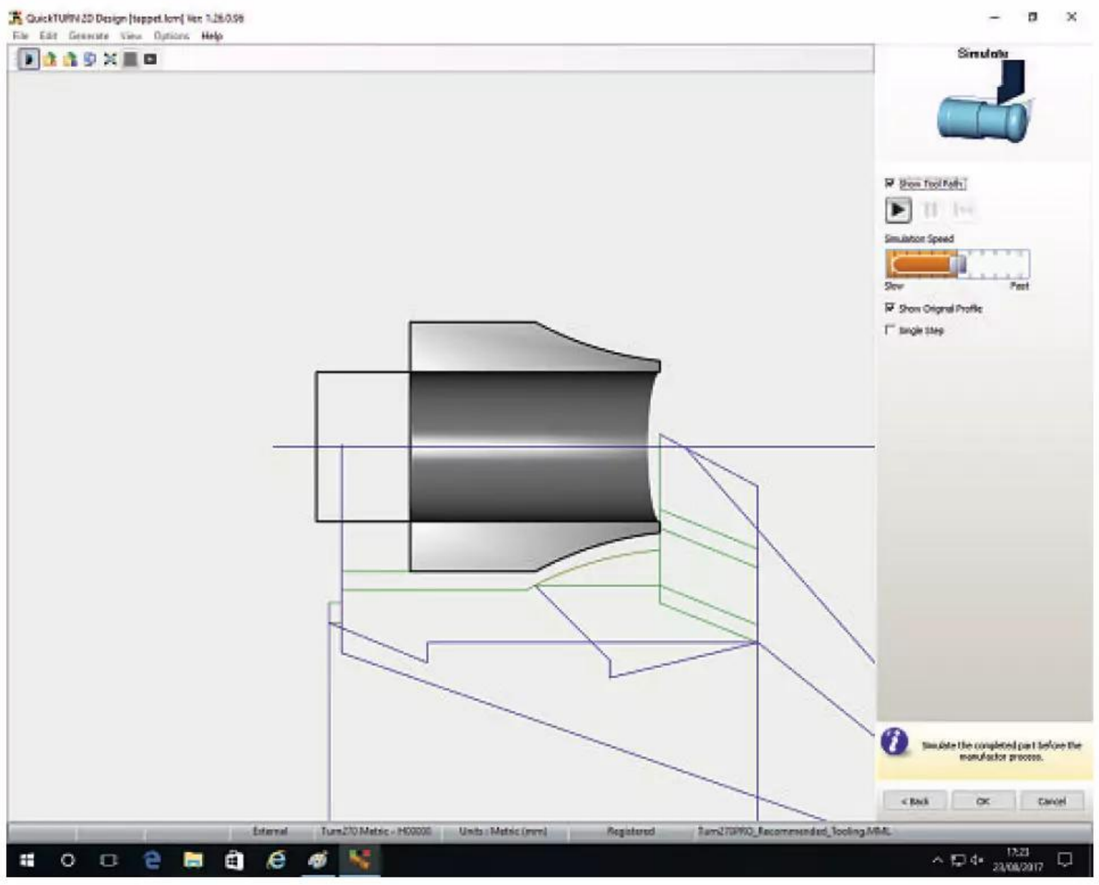


Figure 10. *The component after a simulated machining cycle.*

the machining parameters for each tool selected, here you can edit the depth of cut for roughing and finishing cycles, the spindle speeds and cutting tool feeds. If you're not at the stage to try editing the completed program, then this is where any adjustments have to be applied, **fig. 7**. I would suggest cutting the feed rate by a half, as the default values shown are a little on the rapid side, especially the parting feed. Once confident with the machine's operation the feed rates can easily be increased, or decreased to a value that suits your own machining requirements by editing the program. I will of course show how to make simple edits to the generated program when we get to the machining.

Time to move on to the post processor which will crunch the data and produce the G code part program, so this time click 'generate' on the tool bar. The first screen to appear will have a solid image of the component that's just been produced by the CAD part of the software, **fig. 8**. The light colour surround is obviously the stock to be removed. On the right-hand side the four tools that were selected to produce the component are displayed. If all the detail and data look to be okay, it's time to send it to post processing, this takes a matter of seconds for the tool paths to appear, **fig. 9**.

The final window will allow machining simulation, where the speed of the play back can be adjusted in order to study in detail all the cutter and drill movements either in rapid, or in real time, **fig. 10**. As you can see all the cutter paths are in the negative quadrant and so the program was successfully generated for a machine with manual tool change. The completed part program is now ready to be loaded to the VRTurn control for machining. I think you'll agree it's a relatively uncomplicated process from start to finish and once you've done it a few times it becomes even easier and takes very little time to complete, which of course allows machinists without any knowledge of G code to produce even the most complicated components, which is the way of the world these days, but I would thoroughly recommend that any reader tempted to go down this CNC road familiarises themselves with the basic G codes and the construction of part programs, as the simple editing of speeds and feeds, as well as adding optional stops during the machine process is a definite advantage.

● To be continued

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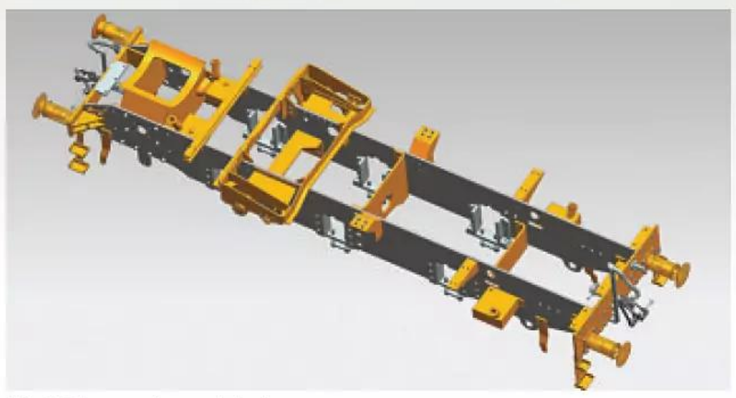
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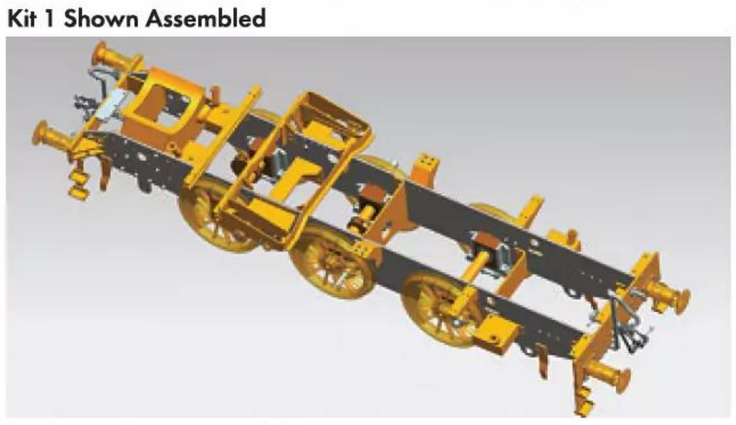
GWR 15xx CLASS FOR 5" GAUGE

£6,495 + £195 p&p

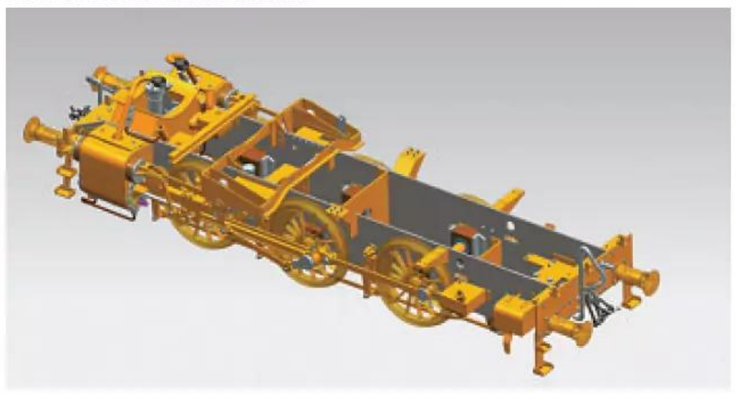




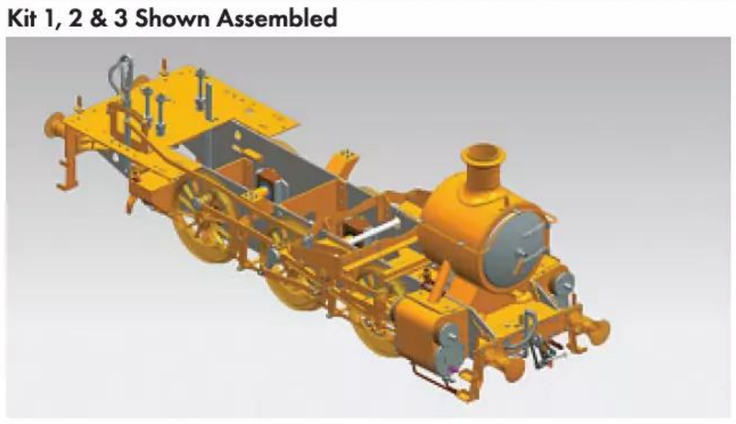
Kit 1 Shown Assembled



Kit 1 & 2 Shown Assembled



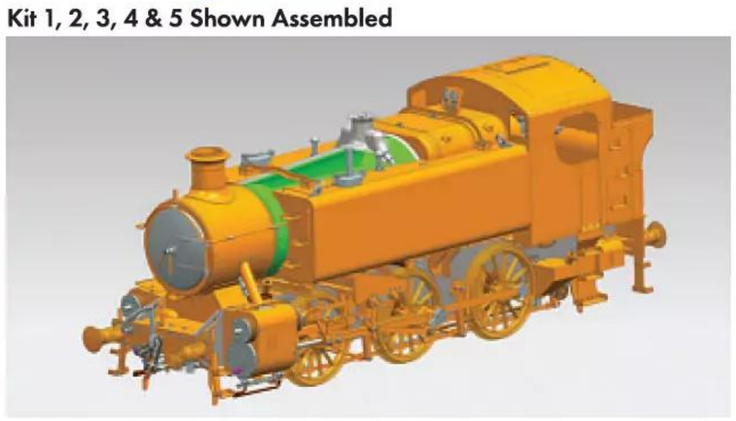
Kit 1, 2 & 3 Shown Assembled



Kit 1, 2, 3 & 4 Shown Assembled



Kit 1, 2, 3, 4 & 5 Shown Assembled



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The GWR 15xx Class

All ten locomotives of the class were constructed in 1949 at Swindon and entered service on the Western Region of British Railways. They were employed on heavy shunting duties at London Paddington. Numbers 1501/2/9 were later sold to the National Coal Board for use in collieries. The 15xx was turned out in different liveries including lined black and NCB maroon.

The 15xx Model

We have chosen the 15xx Class as our first fully machined, bolt-together, kit model. It is a substantial tank engine with two outside cylinders and Walschaerts valve gear. You will receive the model in a single delivery with every component required to build a complete model. The kit is divided into 6 sub-kits. See illustrations here showing the build stages. It is suitable for the novice builder who will benefit from illustrated assembly instructions and an instructional video. The kit is delivered fully painted in the livery of your choice. The model is also available ready-to-run. Boilers are silver soldered and UKCA marked. All components benefit from a 5 year warranty.

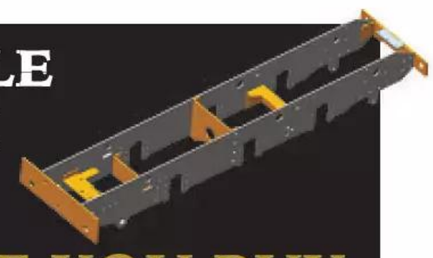
Summary Specification

- 5" Gauge, coal-fired, live steam
- 2 outside cylinders
- Outside Walschaerts valve gear
- Stainless steel motion
- Silver soldered copper boiler
- Boiler feed by axle pump, injector and hand-pump
- Multi-element superheater
- Drain cocks
- Safety valve
- Etched brass body
- Choice of liveries
- Mechanical lubricator
- Reverser

Approximate Dimensions

- Length 35" • Width 10"
- Height 14" • Weight 51kg

FREE SAMPLE KIT WORTH £100!*



TRY BEFORE YOU BUY

Experience the 15xx build for yourself with this free kit comprising main frames, stretchers and buffer beams. It is completely free when you request the brochure. **It's yours to keep, with no obligation to buy the model**. This free kit reduces the cost of the model to £6,395 should you decide to purchase it.

Delivery and Payment

Save £195.00. Free p&p for any order received within 28 days.

The order book is now open and we are happy to accept your order reservation for a deposit of just £995.

We will request an interim payment in £2,450 in September as the manufacture progresses, a further stage payment of £2,450 in October and a final payment of £500 in November/December 2024 on batch completion.

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15xx model in BR Black livery

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