No. 347

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STEP IN TO CNC

The Sable 2015 benchtop CNC mill provides an easy route into CNC machining.

A RETRACTING TOPSLIDE

Graham Meek's design for a Pultra Lathe.

GUIDE BLOCK CHALLENGE

Marcus Bowman solves a machining conundrum with custom jigs.

MERRY CHRISTMAS AND A HAPPY NEW YEAR TO ALL OUR READERS!

INSIDE THIS PACKED ISSUE:

■ TOOLING AT THE MIDLANDS MODEL ENGINEERING EXHIBITION. ■ RESCUING A RUSTY SURFACE PLATE. ■ QUICK RELEASE HALF-NUTS FOR MYFORD LATHES. ■ COMPLETING THE COMBINATION LOCK. ■ CHRISTMAS MUSINGS – REVERSING TIME. ■ FUNDING YOUR MODEL ENGINEERING HOBBY. ■ BERNARD TOWERS' PRIZE-WINNING ECCENTRIC CHUCK. ■ PANEL BEATING SKILLS – HOW TO REMOVE DENTS AND BULGES.

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This issue was published on 18 December 2024
The next issue will be on sale 24 January 2025

On the Editor's Bench

Merry Christmas and a Happy New Year

The John Lewis advert. Kevin the Carrot off on an adventure and Dawn French flying around a laden dining table? A huge power surge every evening as millions of sets of garden lights are switched on at 3:30pm? Is it really that time of year again?

Yes, it appears that the ever-longer festive season is well and truly upon us. To celebrate the season I asked Microsoft's AI image generator to come up with some of suitably themed images for this issue. I'm sure that those readers with more acute eyesight will enjoy pondering the purposes and capabilities of the various machine and hand tools here and on page 58. I found them disturbingly reminiscent of Gary Larsen's "Cow Tools" – I suggest you search the internet for them if the reference is unfamiliar! While AI is capable for some remarkable things, its artistic endeavours do seem firmly planted in Impressionism, not least as far as anything mechanical is concerned. Nevertheless, it did do a sterling job of combining the ideas of 'Christmas' and 'Victorian Workshop' creating a charming scene which I am confident never happened in reality!

I hope readers enjoy the touch of seasonal whimsy in this issue. I wish you and your families the very best wishes of the season and a peaceful and productive New Year.

Neil Wyatt

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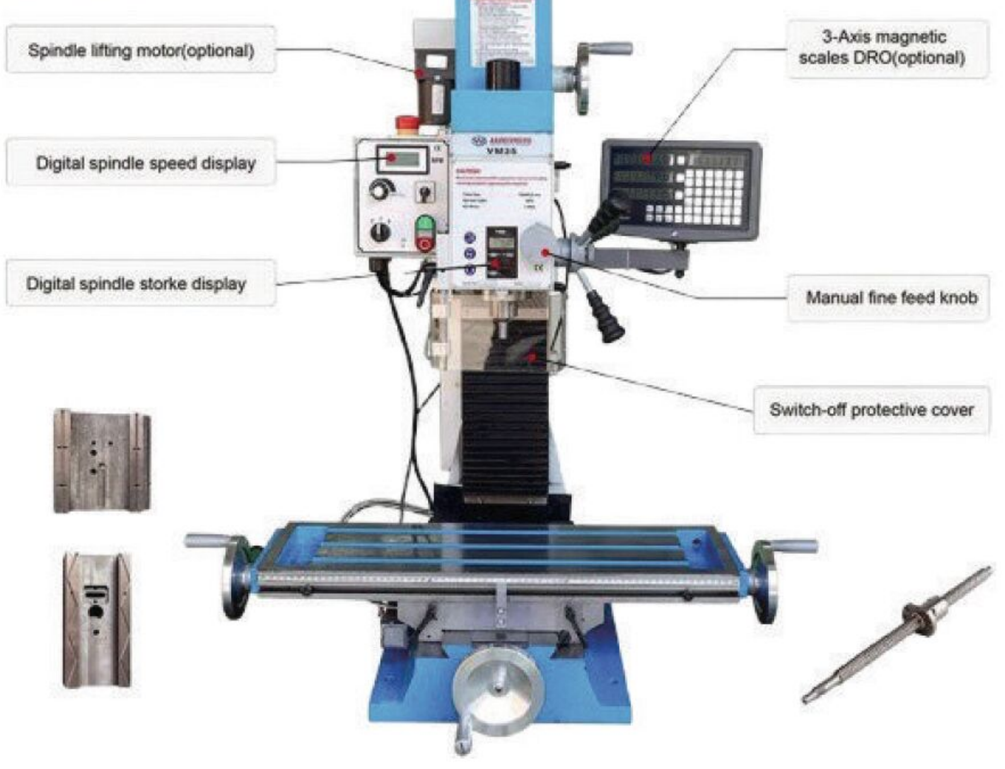

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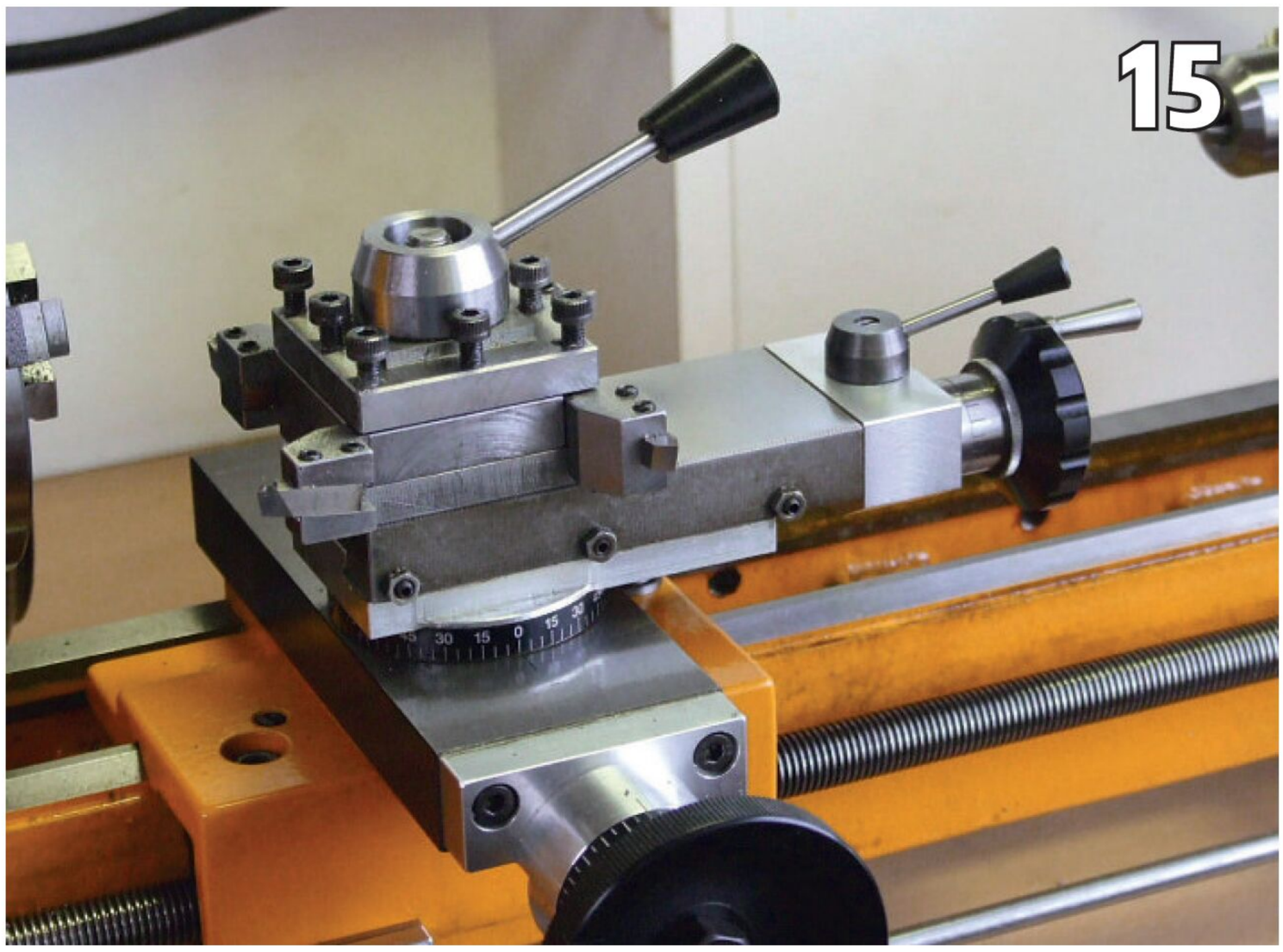

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Coming up...

in our next issue

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ON THE COVER

Our cover features Mark Noel's small Sabel 2005 benchtop CNC milling machine. Part way between a CNC router and a full milling machine it is able to work in the more easily machined metals, such as aluminium and brass. See page 17 for more details.

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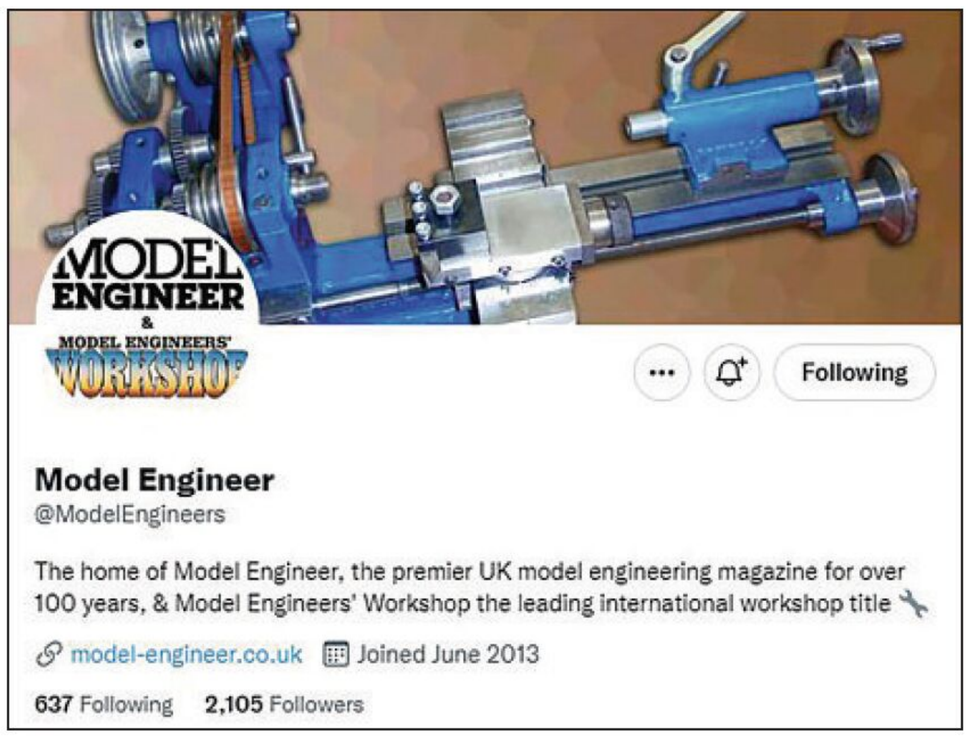

THIS MONTH'S BONUS CONTENT

Extra Content!

Visit the Model Engineer Forum to find the archived Griptru article and discuss this issue of Model Engineers' Workshop!
www.model-engineer.co.uk/768209/the-workings-of-a-griptru-chuck/

Hot topics on the forum include:

What is (Traditional) Model Engineering? Started by Martin Kyte.
I'm sure every reader will have an opinion on this topic.

A small 4-jaw chuck started by Michael Gilligan.
A treat for those who enjoy delicate work!

Muffle furnace
started by Sonic Escape.
Useful discussion of making an electric furnace.

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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A Retracting Topslide for the Emco Compact 5

Graham Meek describes a device to make screwcutting a much easier task.

To make the best use of my screwcutting attachment for the Compact 5 (to appear in MEW early in 2025), some form of repeatable tool retraction is a real boon. Years ago I designed a lever operated retracting tool holder for my Emco Maximat Super 11, (EiM June 2012 and Projects for your Workshop Vol. 1). While this worked faultlessly for external threads, cutting internal threads was still done by conventional means. However this can prove to be a long and tedious exercise just using the cross slide and topslide feedscrew handles.

A dedicated retracting tool specifically for internal threads is an alternative, but these usually come with limitations as regards the size of tool that can be held. Also the separate retracting toolholder is not the best way to go when using smaller lathes as these tend to introduce further overhanging cutting loads and possible chatter, or worse. It is far better to try and keep the cutting forces within the manufacturer's design envelope. This is one of the reasons it was decided to fit a retracting topslide to the Compact 5, see John Slater's render **fig. 1** and the **general arrangement**.

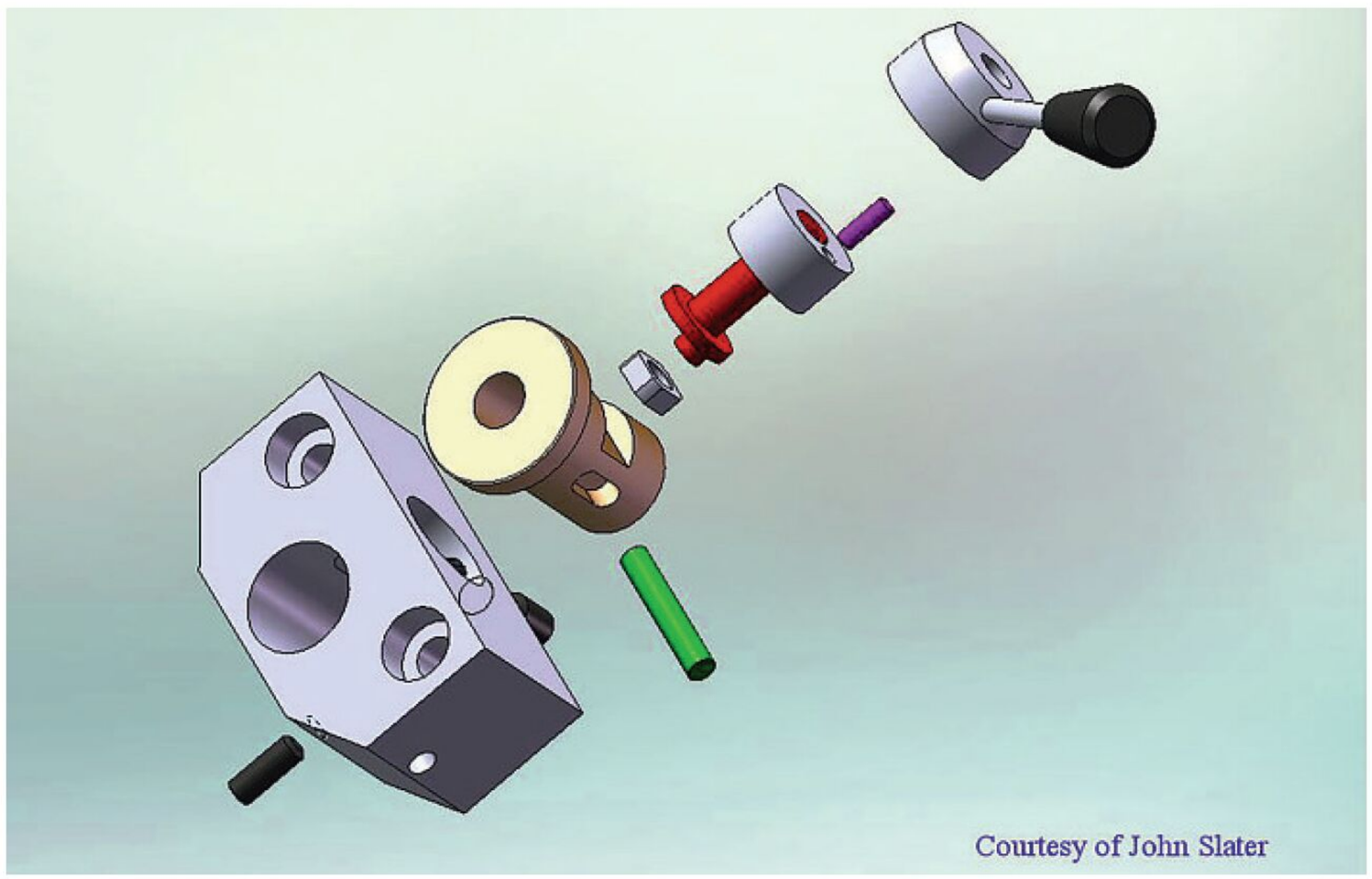
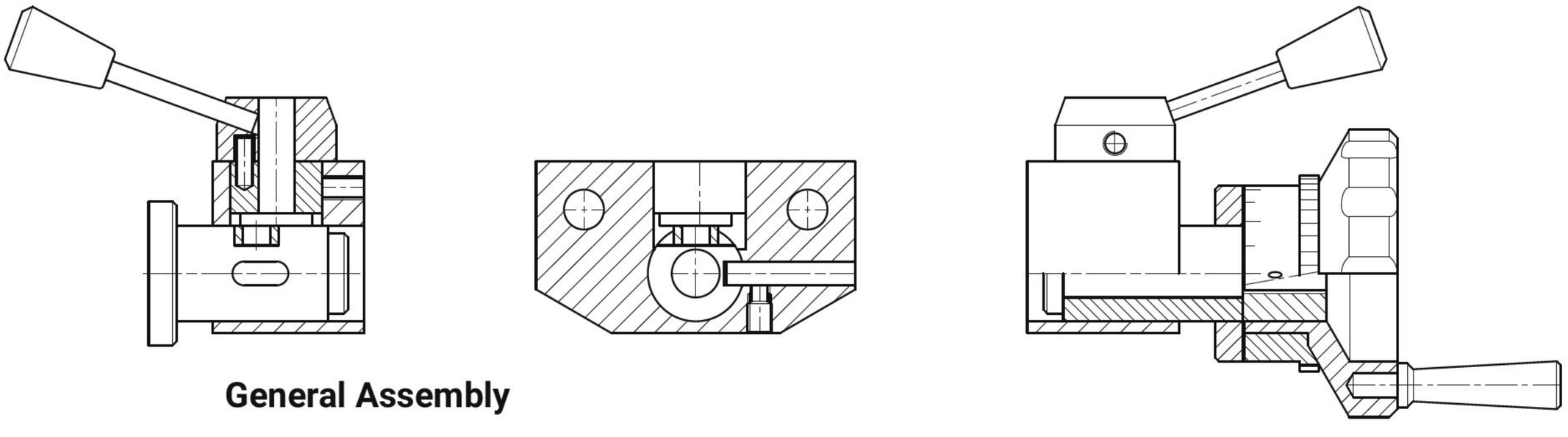
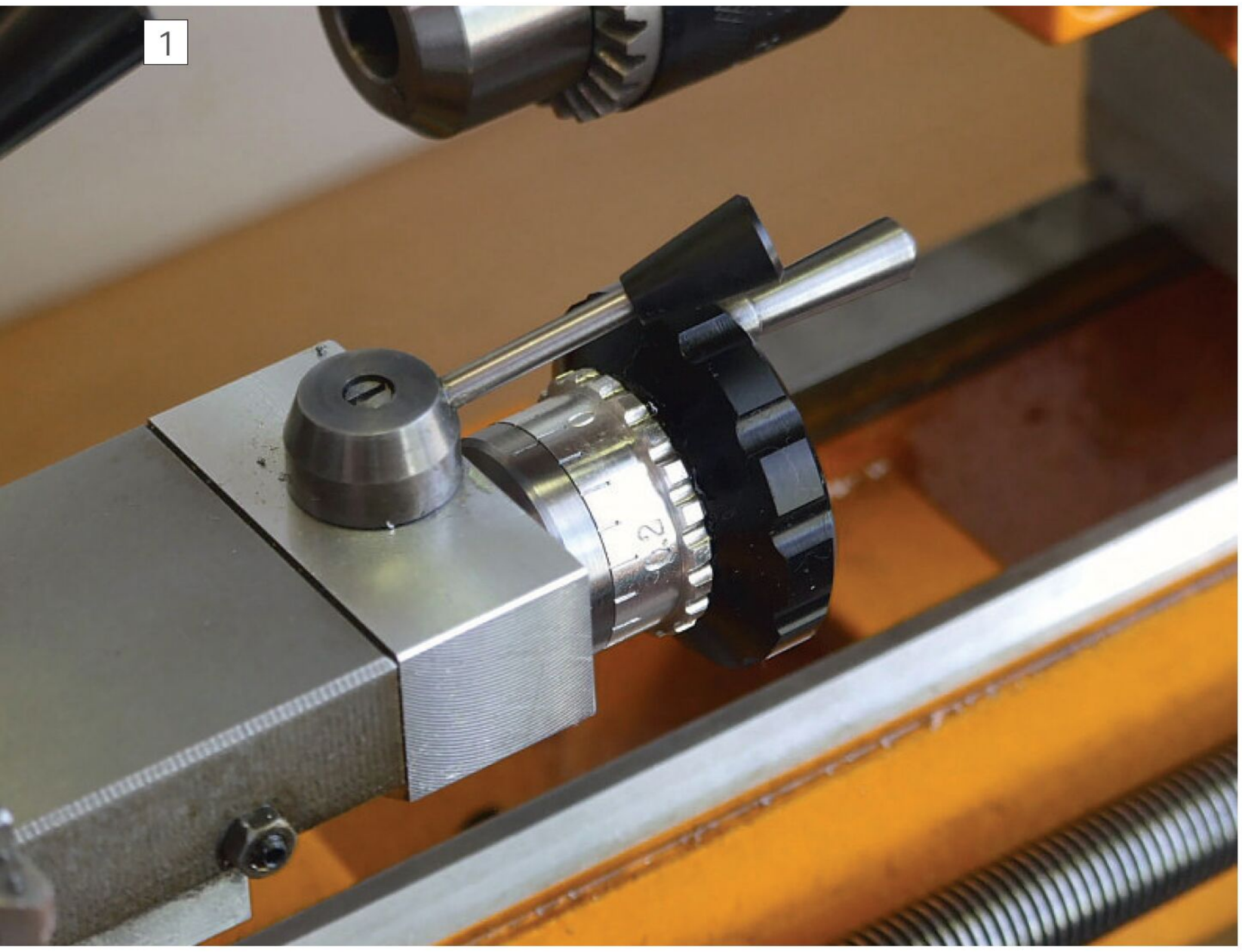


Figure 1



General Assembly



Attachment fitted, note larger dial.

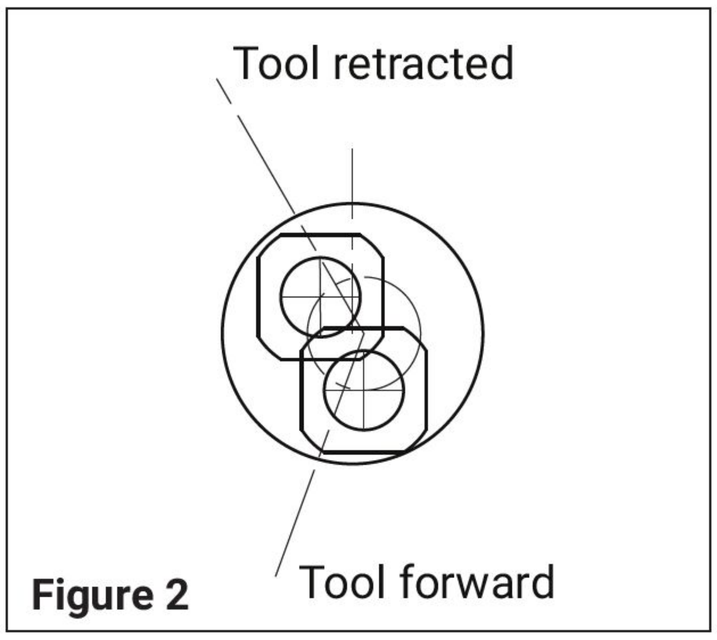


Figure 2

Fitting a retracting topslide, **photo 1**, allows the use of standard tooling which is held firmly in the standard or bespoke toolpost. **Figure 2** shows how it moves the tool. The attachment also has the capacity to do either internal or external threads merely by inserting the correct tool. Albeit internal threads require the tool be inserted upside down and facing towards the rear of the machine. One down side for the retracting topslide is that it only works

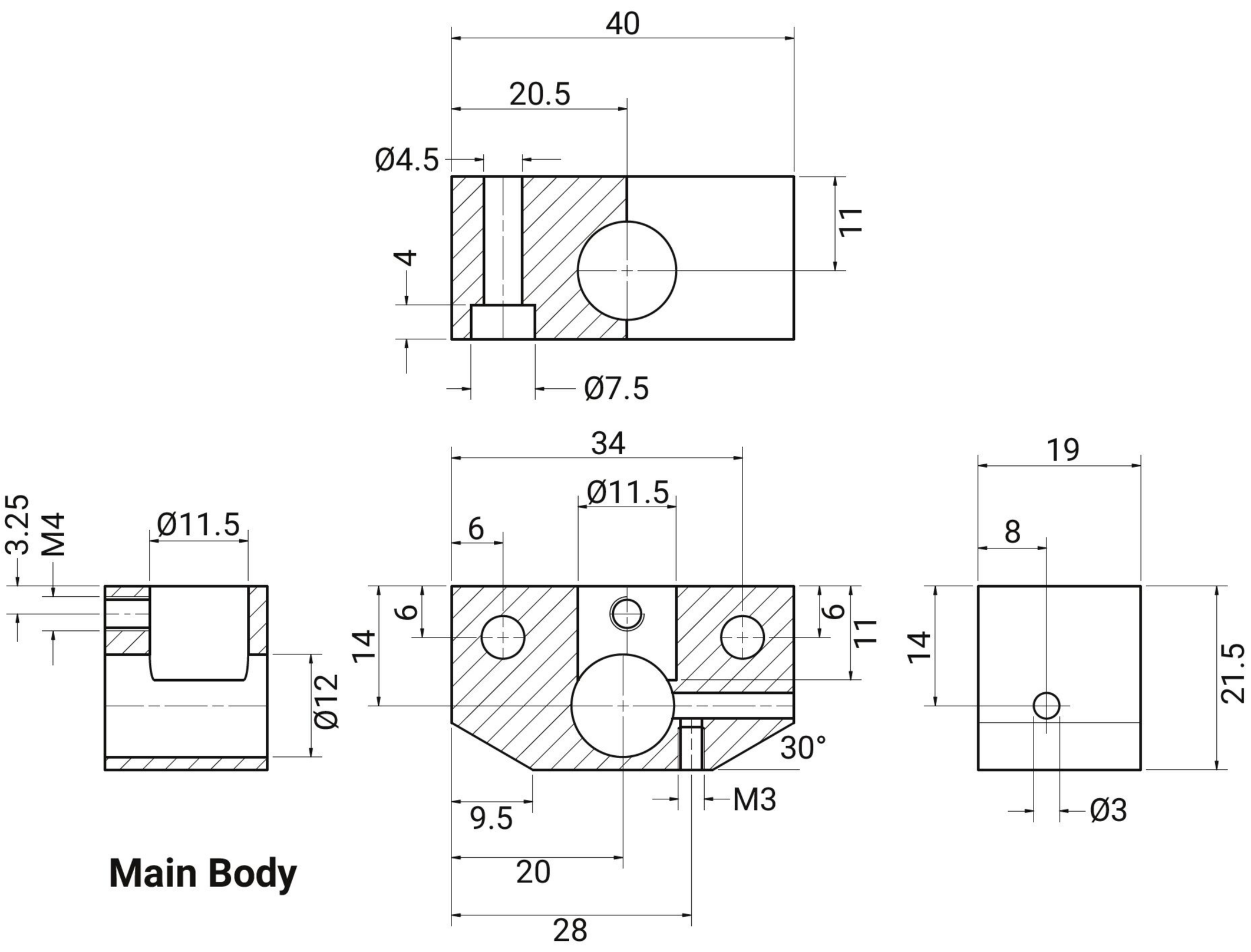
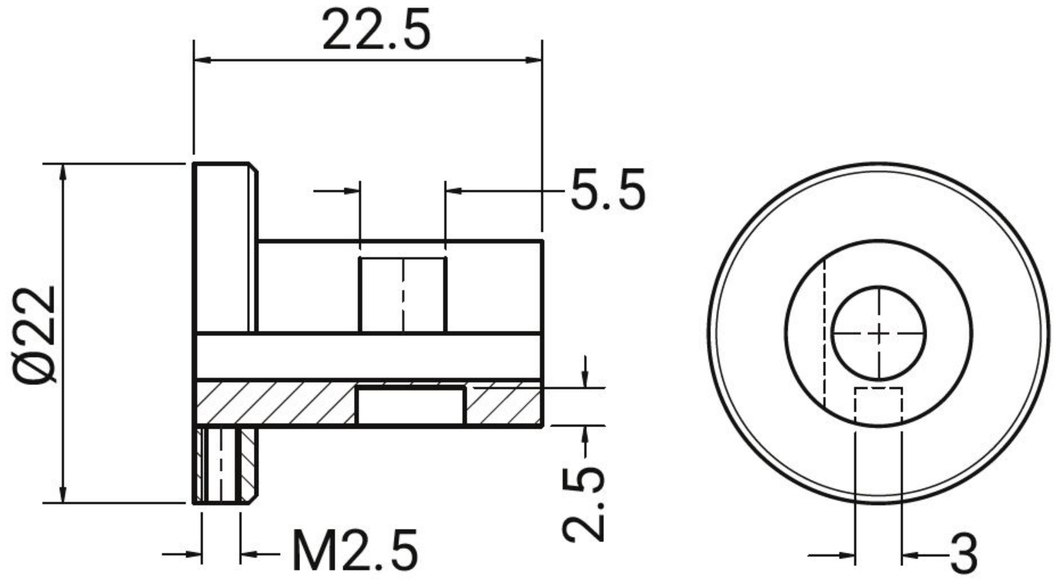
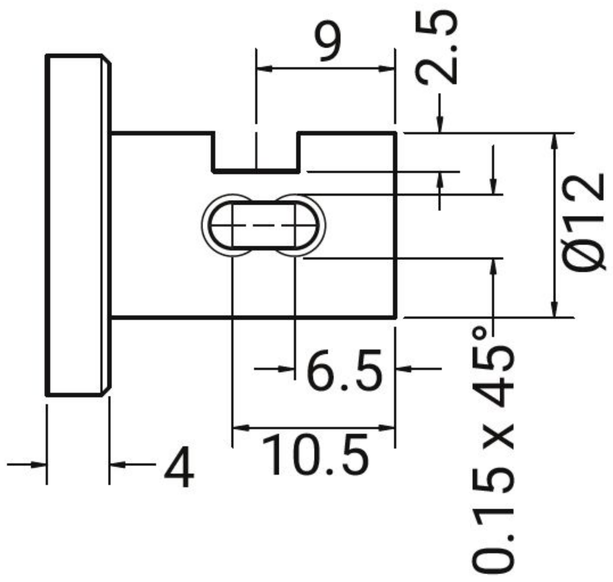


Figure 3





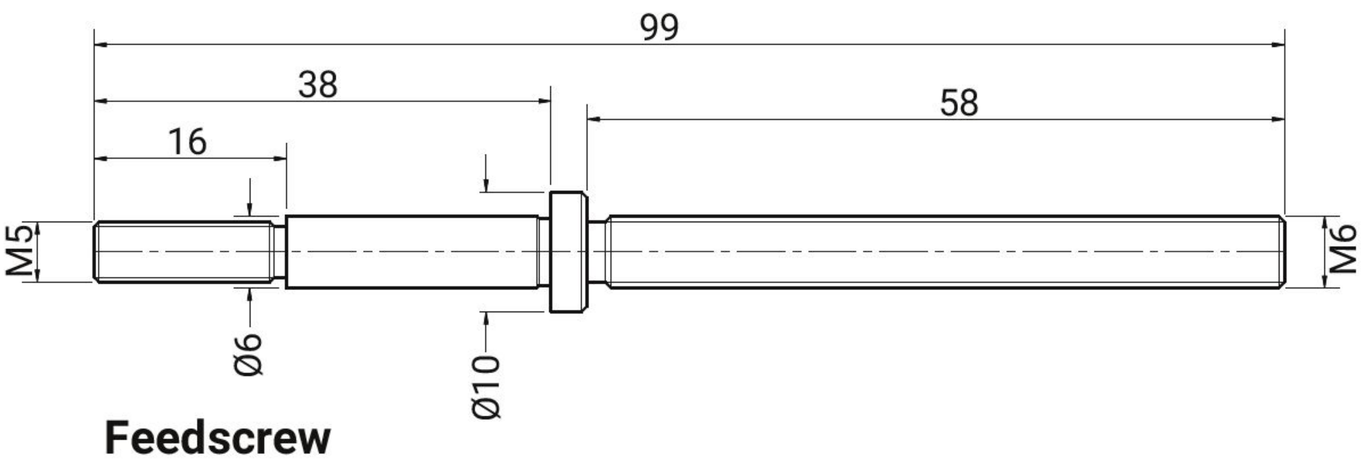
Slider And Index Ring

Figure 4

with the set-over topslide method. This I know is not everyone's cup of tea, but it is the method that I was taught as an apprentice. The usual objection is the need to calculate the in-feed due to the angle. This is not the case and there is a far simpler way to establish the thread depth.

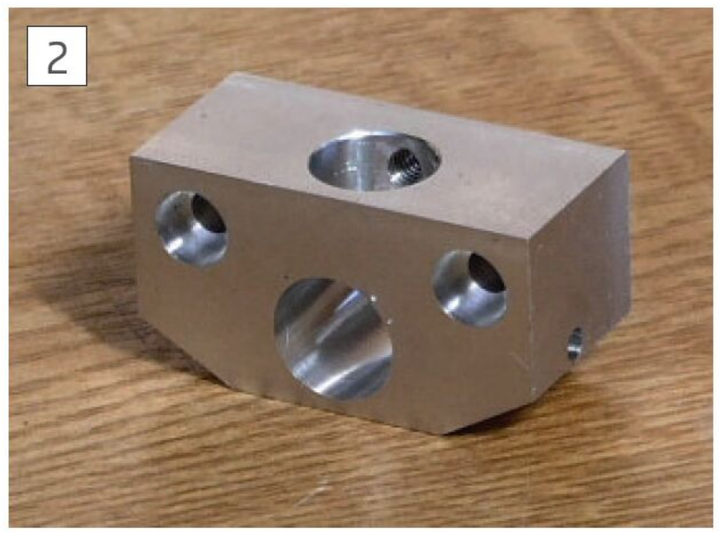
With the topslide swung around to something near half the included angle, an exact measurement is not needed. Manipulate the two handwheels on the topslide and cross slide until the tool is just touching the revolving work. Set both dials to zero, then wind back on the topslide handwheel, one or two turns depending on the thread depth. Advance the cross slide the thread depth amount and then lock the cross-slide, (don't forget to double the amount if the cross-slide dial is calibrated in material to be removed and not direct reading). This dimension is found easily in thread tables. Now advance the tool using the topslide only until the revolving work is again touched by the tool. From this point on continue screwcutting until zero is reached on the topslide dial. It is a good policy to stop short of zero and test the thread for fitting with the mating part, as the radius, or flat on the tool will play a big part on the "fit" of the thread.

Construction started as always with the main body of the unit, **fig. 3, photo 2**. This was made out of aluminium as the requirements of



Feedscrew

Figure 5



Main body.

this detail is merely to take the sliding member which houses the feedscrew. There is very little wear going to take place as the sliding element is moving at a relatively slow speed and not over any great distance.

The reader can if he or she wishes make this item out of some other material, like mild steel or cast iron, but there will be very little gained as regards longevity. Although there will be considerably more work and energy required in the manufacturing process.

The slider, **fig. 4**, was made out of phosphor bronze. This takes the rotary motion of the feedscrew and the sliding motion of the eccentric pad. A dowel working in a slot in the side of the slider acts as a stop to limit travel and stop the slider from rotating. A separate index ring is attached to provide a zero for the feedscrew graduated dial. The size of this detail will depend on whether the reader stays with the existing Emco feedscrew handwheel or the revised version with adjustable dial shown in the drawings. This latter item features a larger calibrated dial and a means to set the dial to zero.

As mentioned earlier the retraction movement of the slide is restricted by a pin in the side of the slider. The slot needs to be a good fit on the pin and attention needs to be drawn to two shallow countersinks at the ends of the slot. The chamfer does not need to extend the length of the slot just on the two ends. In use there will be some bruising of the phosphor bronze material as the slider repeatedly abuts the pin. In time this will throw up a burr at the ends of the slot. The burr in turn will damage the main body and make the retraction stiffen up. A chamfer of about 0.1 to 0.2 mm is all that is required.

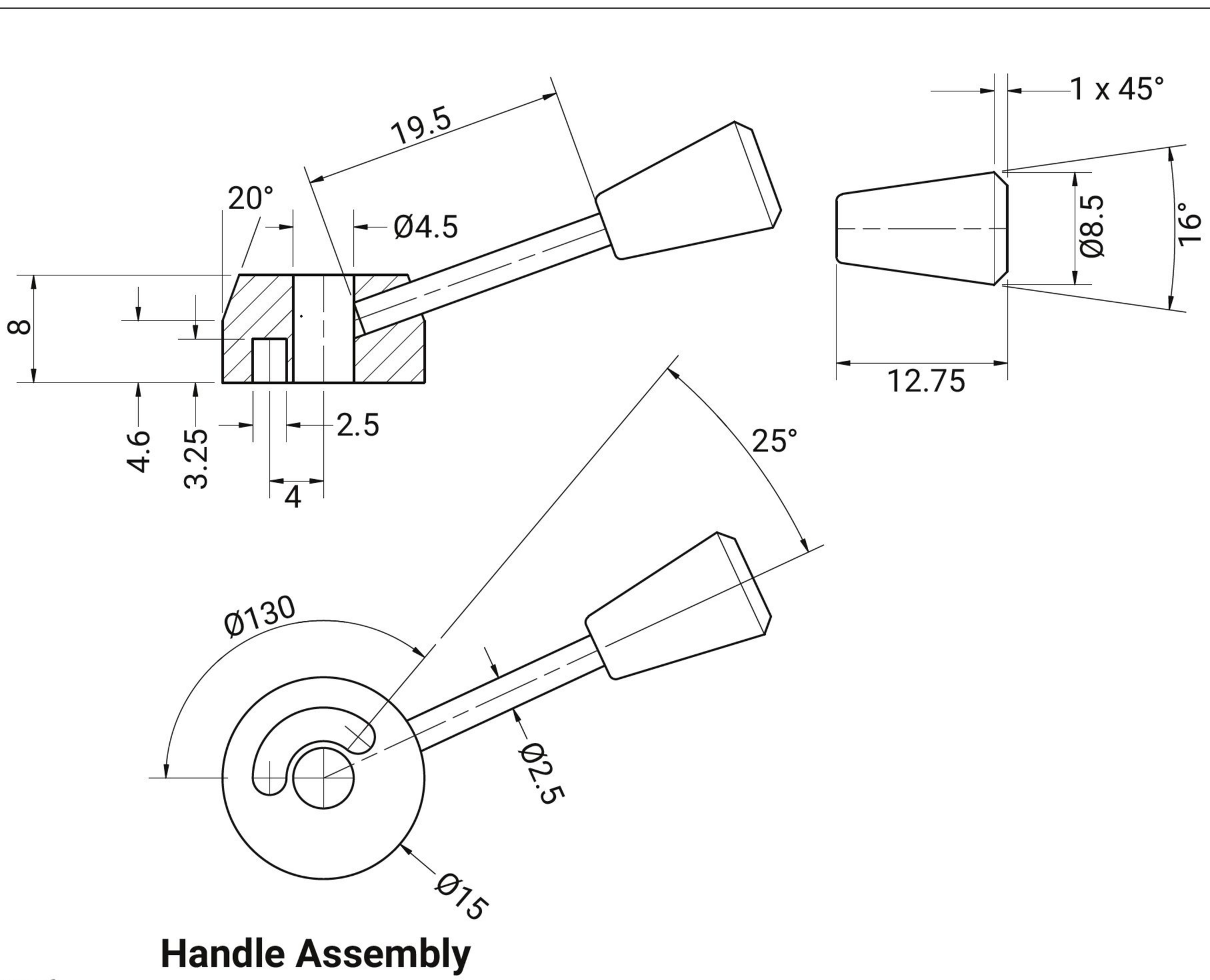
The new feedscrew, **fig. 5, photo 3**, was turned from a good quality high

Retracting topslide feedscrew.

Adjustable dial showing position of silicon spring.

tensile bolt. This material usually turns extremely well and provides a good bearing surface. Cutting oil was used during the manufacture as suds, or water-based coolant tends to make the material glaze over and difficult to cut. It goes without saying that the threads on this component need to be screwcut. Preferably between centres to ensure complete concentricity between the two threads. In screwcutting the M6 by1 mm pitch thread the opportunity was taken to make it a better fit in the topslide base.

This does entail using the lathe without the topslide in place. Instead using the Emco riser block supplied with the machine. It does, however, mean the thread cannot be screwcut using my preferred set over top-slide method. It goes without saying that the bearing



Handle Assembly

Figure 6

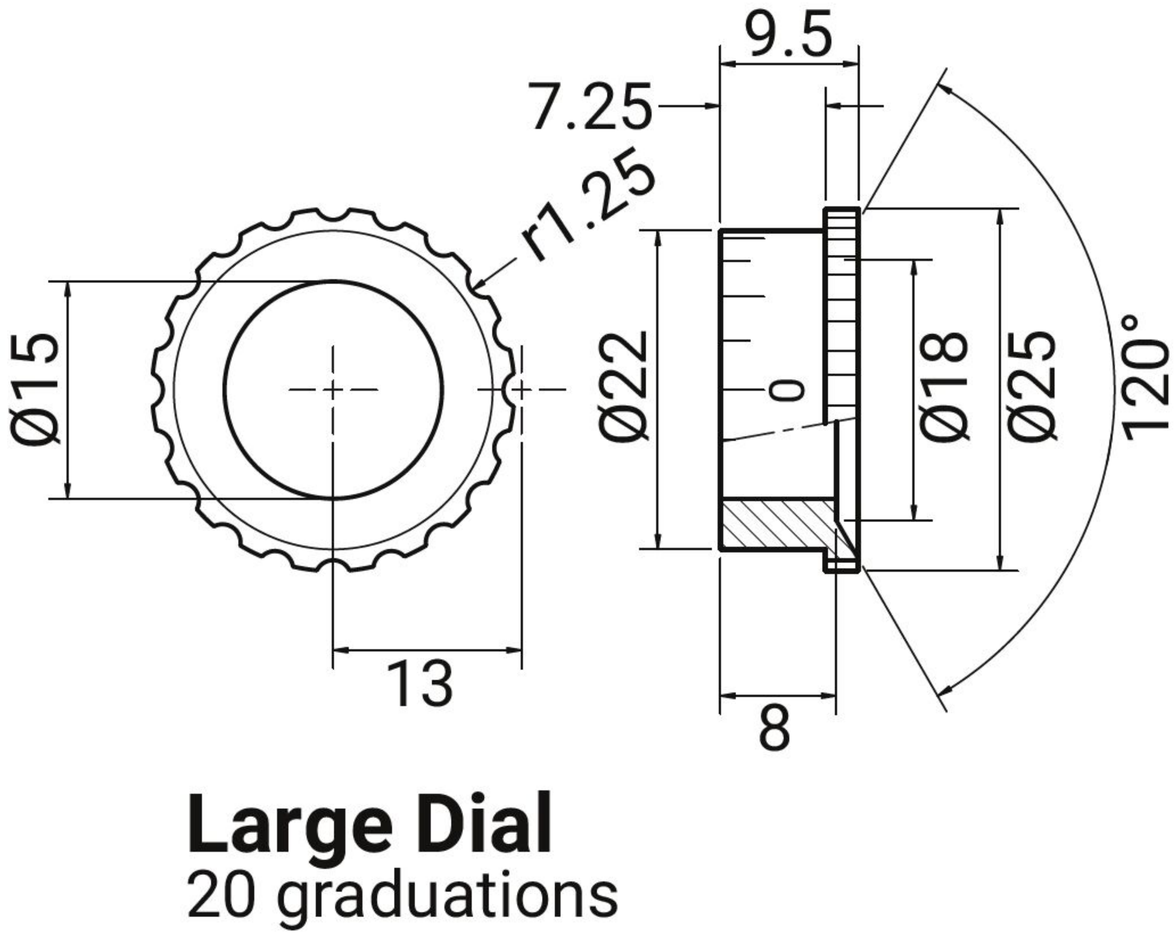


Figure 7

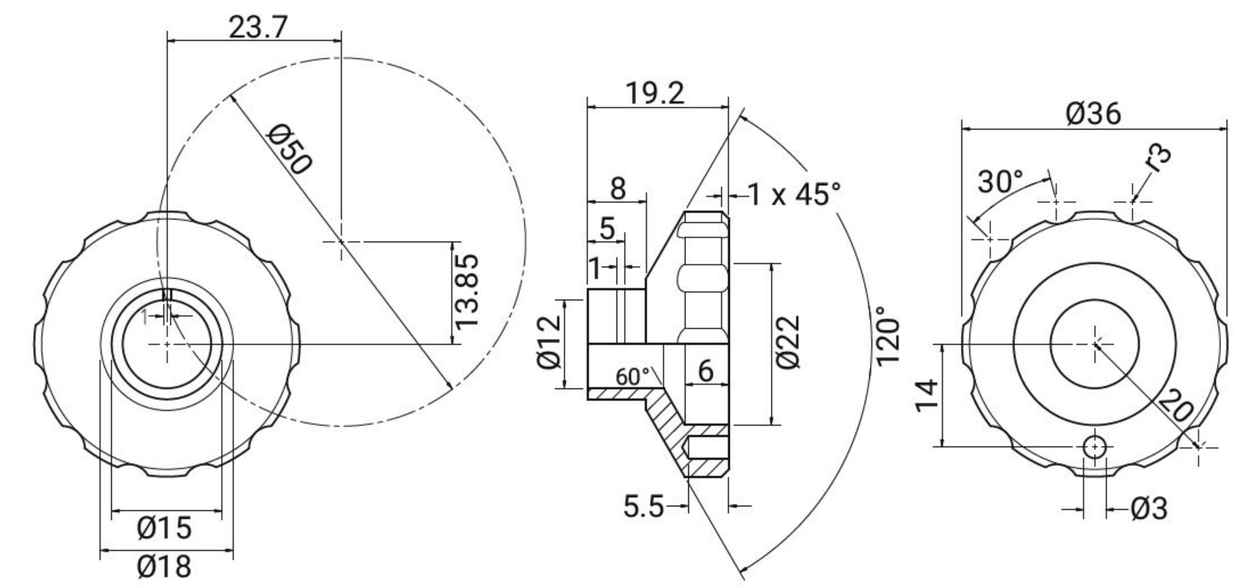


Figure 8

portion of the feedscrew also needs to be machined between centres.

A simple fixture was made to manufacture the eccentric, this makes aligning the screwdriver setting slot with the eccentric easier. This is made using an offcut of material about 16 mm diameter. This was cleaned up to a convenient size on the outside diameter and faced off. This is then parted off and the parted face, faced off. Transferring to the milling machine and using a vee block in the machine vice with the part held vertically. The milling spindle centre-line is brought coincidental with the embryo jig. Then moving in the x-axis only an amount equal to the throw of the eccentric. A hole is drilled and reamed to take the main journal of the eccentric. Repositioning the part in the machine vice without altering the y-axis. Such that the reamed hole is aligned with the x-axis and with the reamed hole at the bottom of the machine vice. A hole is drilled and tapped on the centreline of the jig to break into the reamed hole. A piece of soft copper under a grubscrew will hold the work while the eccentric journal is machined.

The setting screwdriver slot is then set visually in line with the locking screw. This does not have to be perfect as it is only to give an indication during setting up the eccentric of where the eccentric actually is. After mounting the fixture in the 3-jaw chuck it is then a simple matter to turn the eccentric journal. If the reader is at all worried that the part may rotate during machining, then a small centre in the work and some tailstock support in the form of a running centre will remove this problem.

The eccentric pad was turned to less than the across the corners dimension to avoid any fouling of the corners in the main body. The eccentric journal bearing hole was then drilled and reamed. A small chamfer is provided around the hole to ensure the part fits flush on the eccentric and to denote which face is square with the reamed hole. Using parallels and the machine vice on the milling machine. The chamfered side is loaded against the fixed jaw and half the material to be removed is machined away. After careful deburring the part is replaced in the machine vice again with the chamfered hole against the fixed jaw of the machine vice. The remainder of the material is then machine away, but it is best to take the part out and try the fit in the phosphor bronze slider. Just before the nominal size is reached. It is always better to creep upon the size than to have to start again. Once the size is reached, then hold the part across the vice, gripping on the just machined faces and with the unmachined edges resting on a parallel and the other pointing skyward. Again remove half the material from the exposed side, Followed by a repeat of step one above, as this dimension does not have to fit anything precisely. A chamfer needs to be provided on the two edges of the side opposite to the chamfered hole. These are to ensure the pad fits in the groove in the slider and rests on the bottom of the groove, and not rest on the two radii left by the cutter that made the groove.

A spare handle was available from my Emco Unimat restoration, **fig.6** and this was used as a basis for the topslide attachment. At the time I was making new adjustable aluminium dials for the Compact 5, so the opportunity was taken to fit a larger adjustable aluminium dial to the topslide, **fig 7**. This follows the same pattern as the new larger Compact 5 adjustable dials. The larger dial on the topslide also allows for more numerals to be stamped on the dial. Rather than the original Unimat 0 and 0.5 markings. The later painted numerals were not present on the original Unimat that I was restoring.

For those who are going to make the new feedscrew dial assembly, **photo 4**. The handwheel was made from Delrin, **figs 8** and **9**. The segment produced with the slitting saw is designed such as ›

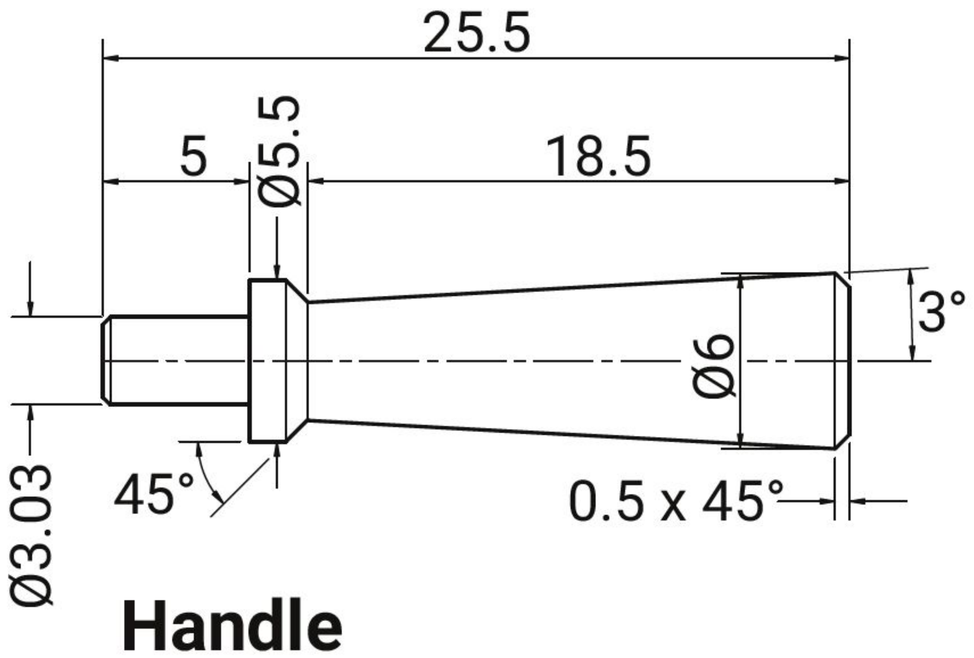


Figure 9

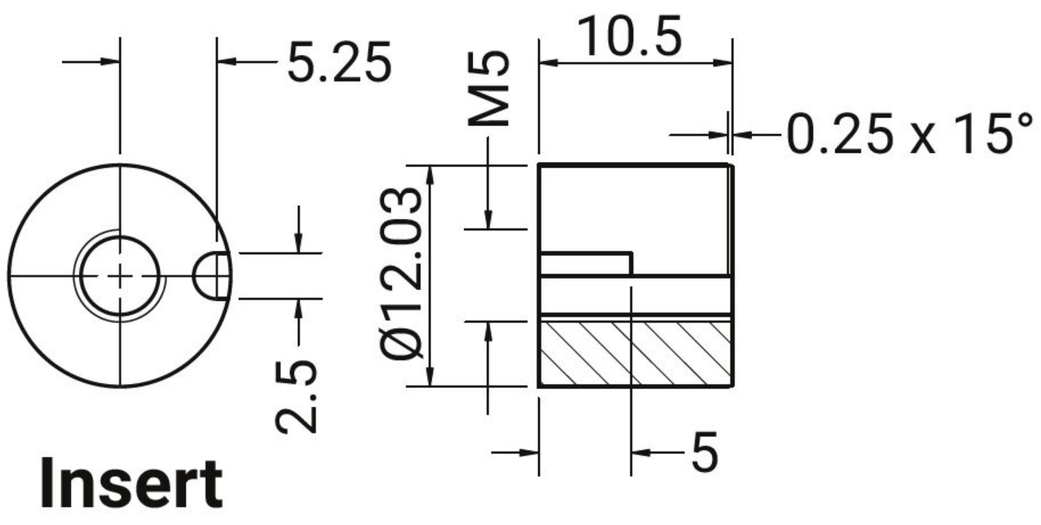


Figure 10

to give free movement of the dial when this is rotated in a clockwise direction. To give this segment some additional springiness a 2.5 mm diameter pocket is machined in the mild steel insert, **fig. 10**. This pocket is assembled near to the free end of the segment. Into the pocket is placed a piece of 2.5 mm diameter Silicone O-ring. This I found gave the desired amount of drag on the graduated dial.

After turning the eccentric bush blank, **fig 11**, this can be transferred to the milling machine. There is a 0.5 mm offset for the eccentric hole which is drilled and reamed. Using the same set-up as was used to produce the eccentric turning fixture. The dowel hole for the pin that restricts the handle movement can also be drilled and reamed at this setting. Beware this hole is also offset by 0.5 mm to the main diameter and is in-line with the eccentric hole. This item was made from mild steel as the eccentric is made of silver steel. These two metals work well together, but the reader can if desired make this item out of phosphor bronze.

With the parts all laid out, **photo 5**, the assembly is fairly straightforward with some light oil being applied to all the bearing surfaces. While some grease will be found beneficial to keep the eccentric pad on the eccentric journal. Don't forget to assemble this part with

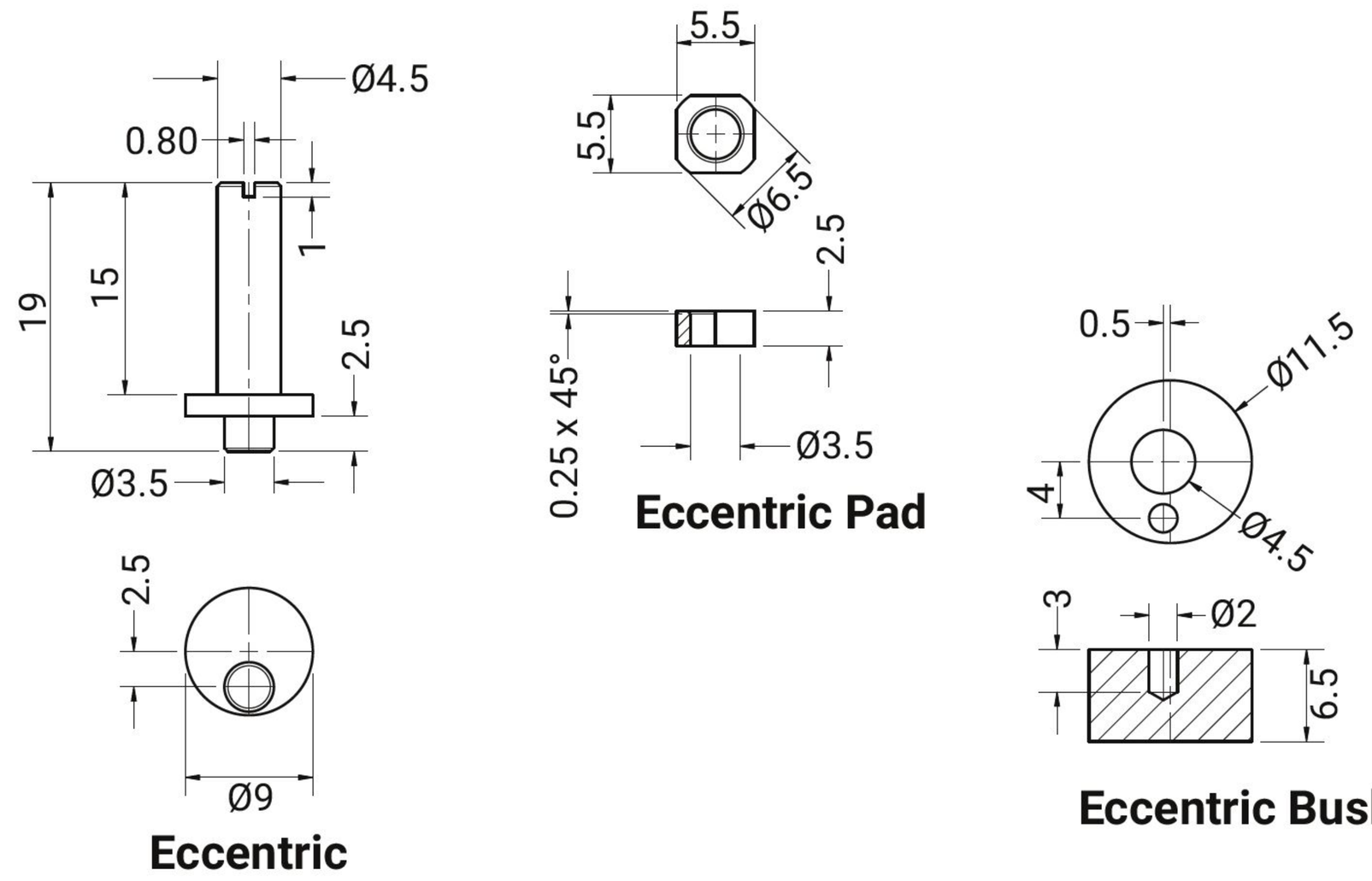
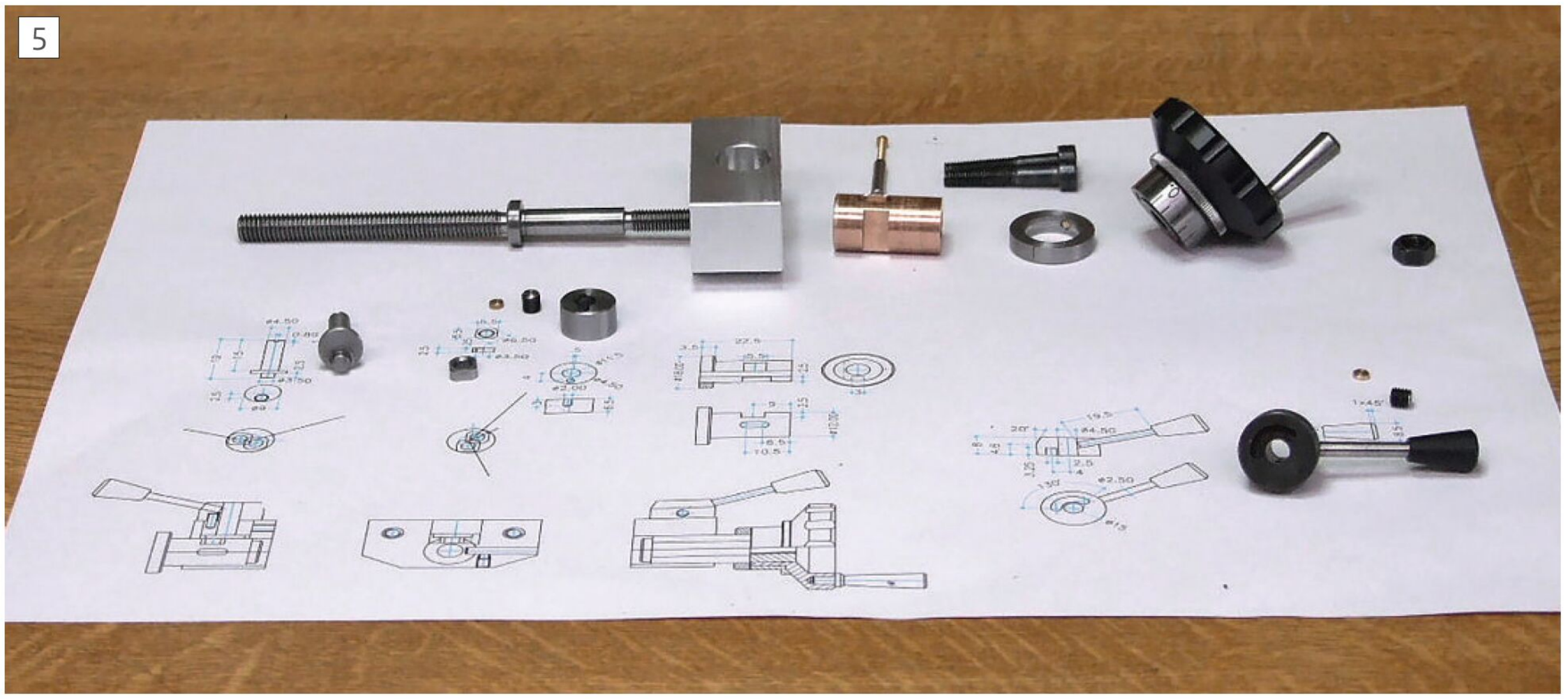
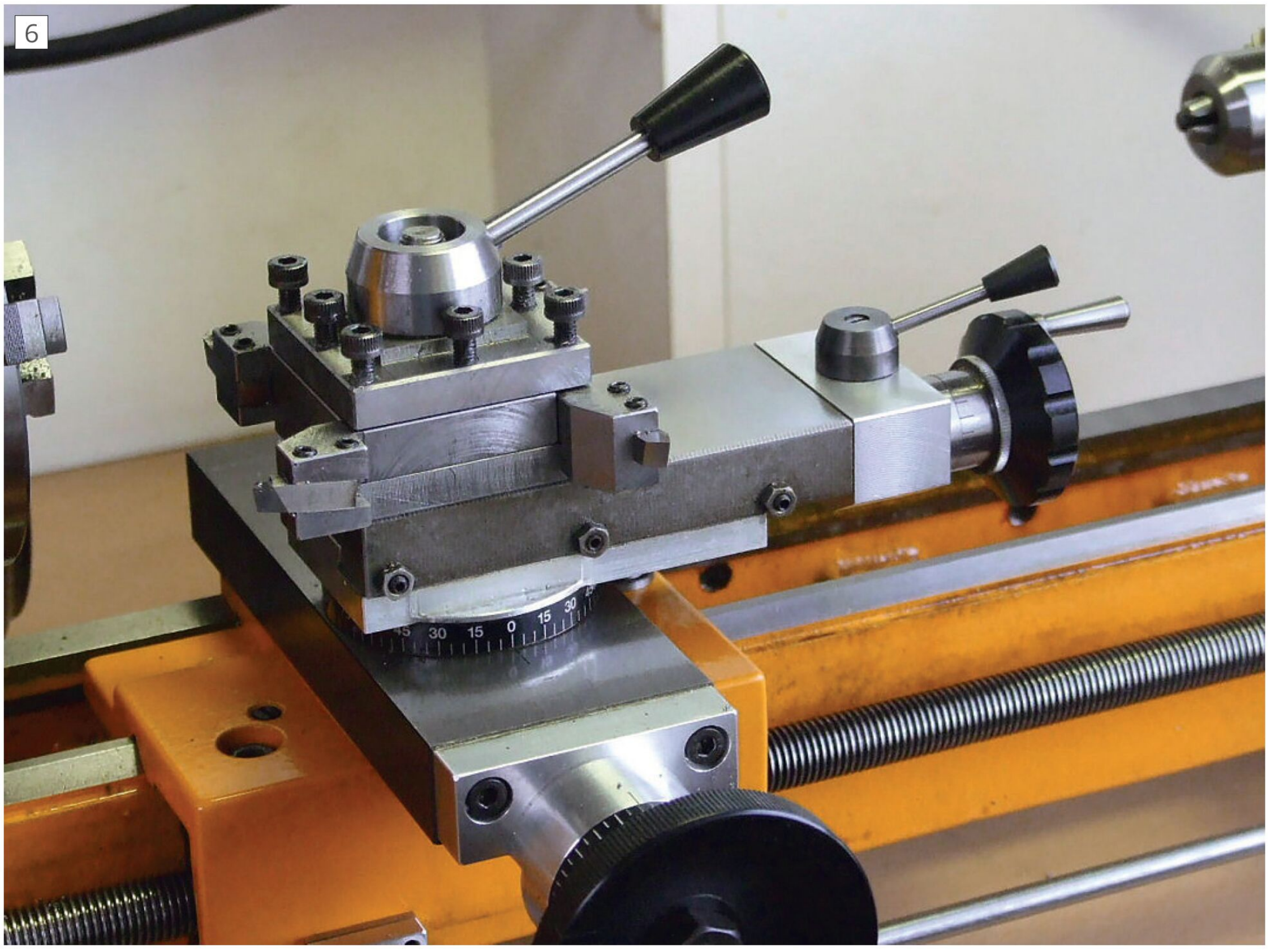


Figure 11

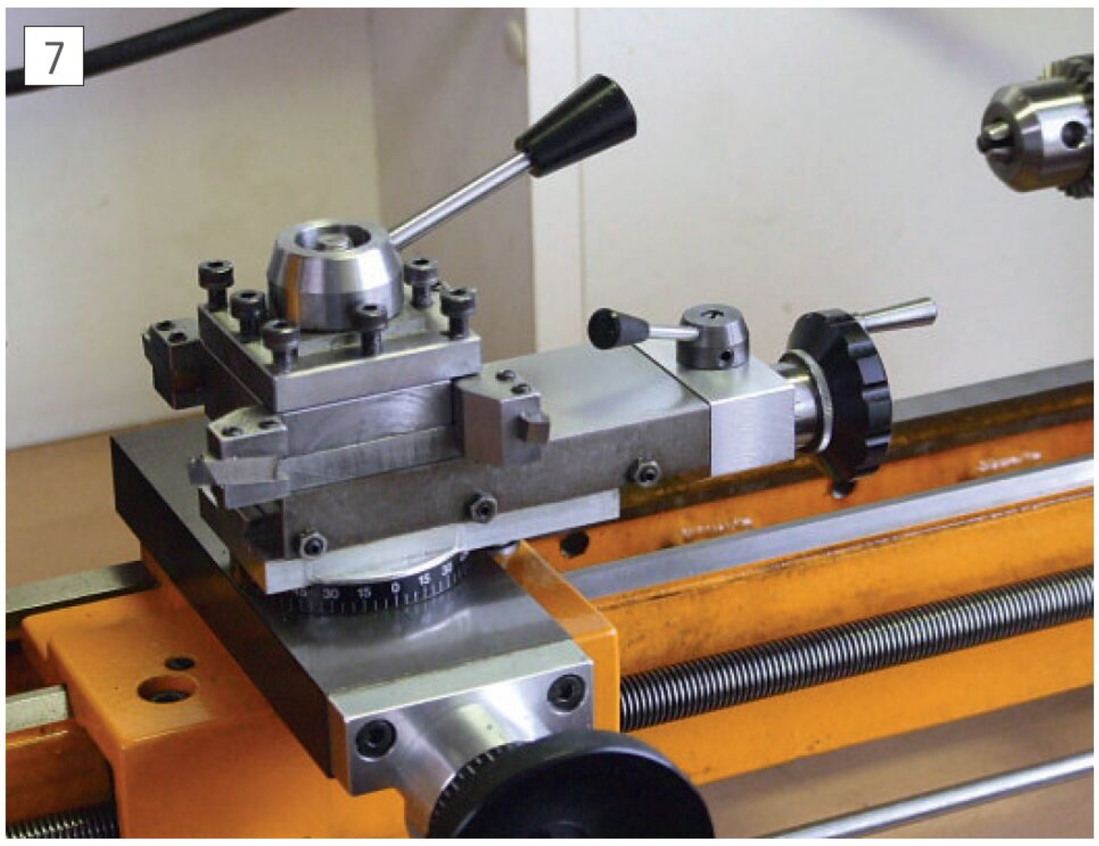


Component parts.

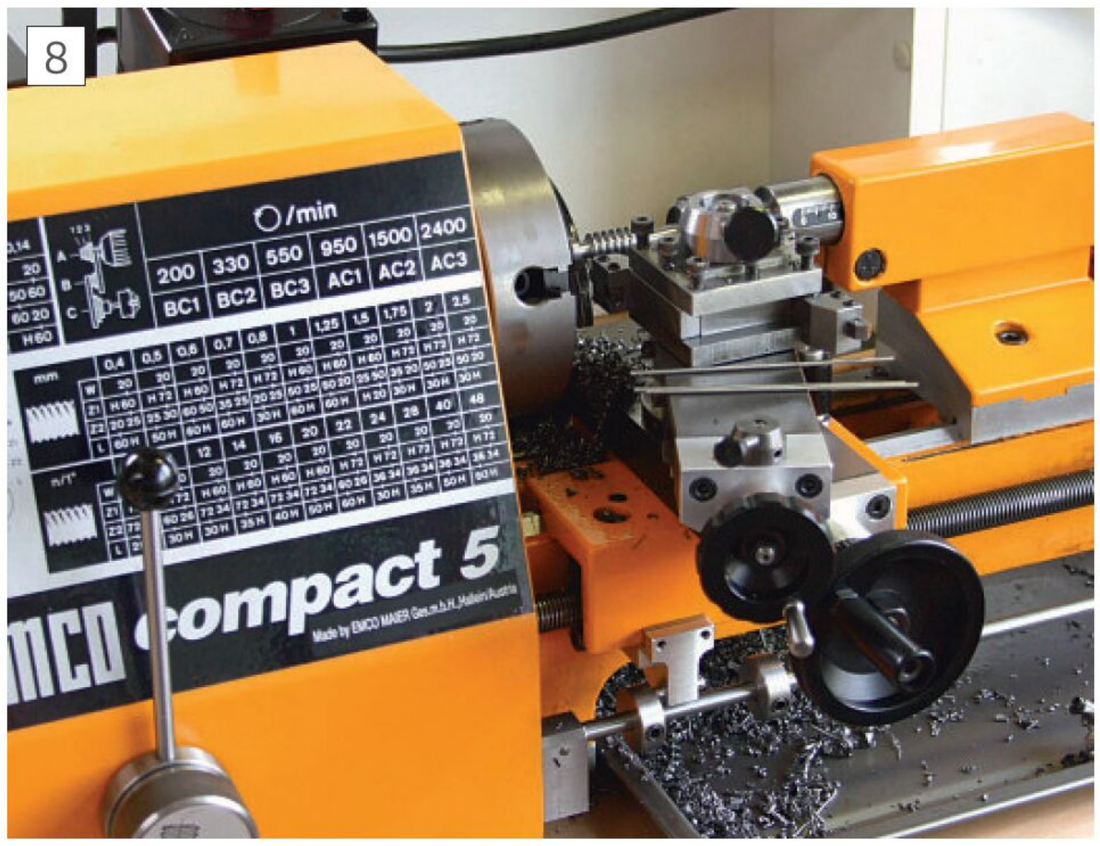
the chamfer on the pad bore nearest the web of the eccentric. The free play on the feedscrew bearing is best set off the machine. Some form of split bush to hold the thread will be found to be an advantage while performing this operation. It is possible to preset the play using a feeler gauge between the feedscrew thrust face and the end of the slider. I found 0.05 mm was about right. If this adjustment is too tight it will make turning tapers a real pain.



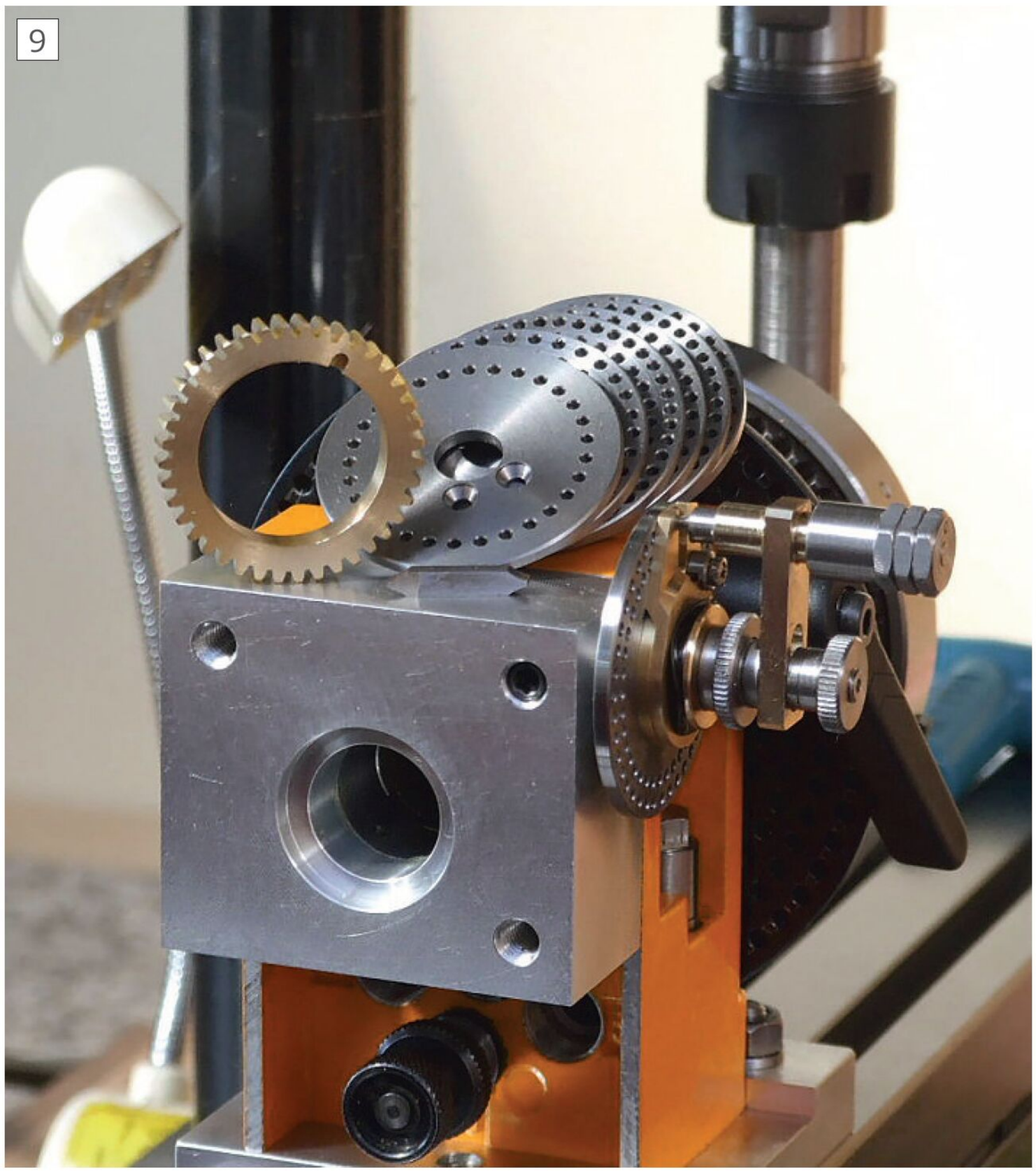
Fully forward.



Fully retracted 4 mm.



The retracting toolpost in action, 10 tpi left-hand-thread.



Dividing plates and spare worm wheel.

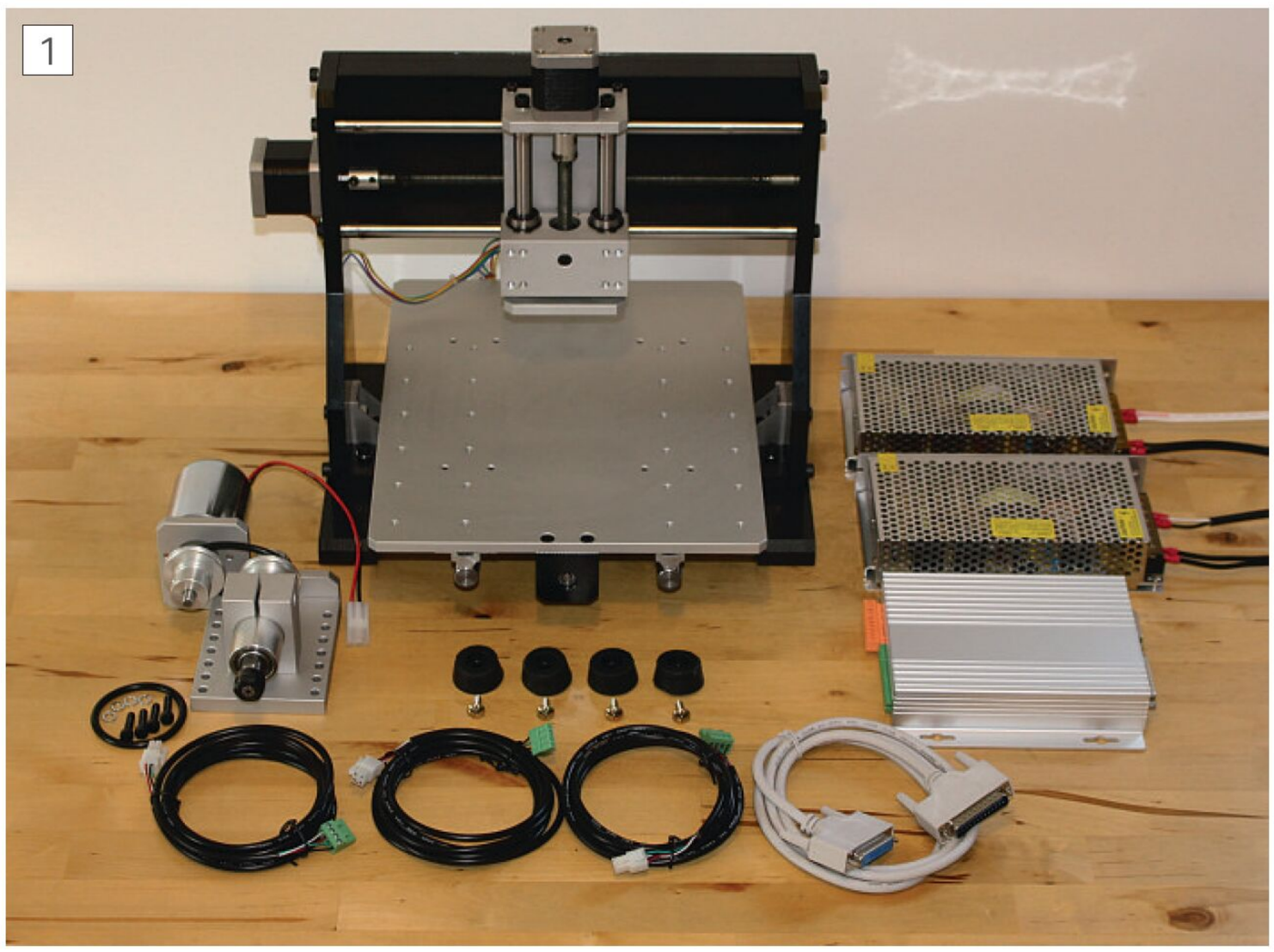
When it comes to setting the eccentric, the finished handle is mounted on the eccentric shaft loosely. The eccentric is turned using the screwdriver slot and the eccentric pin is pointing away from the main body mounting face. The ideal set-up is when the eccentric pin just passes the Null point by about 10 degrees. This is when the eccentric should be felt to lock up. The handle is used to turn the eccentric bush to optimise this position. The eccentric bush should be lightly tightened after each adjustment and a copper pad is best used under the grubscrew. Temporarily lock the handle to the eccentric using a flat point Allen grubscrew and check the setting. If it is not quite right, re-adjust as described above. When satisfied with the setting make sure the handle locking screw and eccentric bush are tight.

To assemble the unit onto the lathe first remove the old feedscrew and then screw in the new feedscrew. As regards lubrication I use Molykote GN paste, (usual disclaimer), for this feedscrew. Trying to get an oil can to work against gravity is not easy, plus I have found the paste lasts a very long time in service. Fresh paste is easily applied with a small artist's paint brush, which is reserved for such tasks. With the topslide almost abutting the base the attachment capscrews are inserted and lightly tightened. The unit when fully assembled should give 4 mm of retraction movement on the slide, **photos 6** and **7**. Try the handwheel for freedom of movement if all is fine firmly lock the attachment to the topslide. If there is any tightness try urging the attachment first one way and then the other until the best degree of freedom is found. Locking the attachment to the topslide after each iteration before trying. All that is needed now is some screwcutting to try the attachment out, **photo 8**. The first job for my RT was the 10 tpi left-hand worm for the 40:1 drive on my modified Emco dividing attachment. Perhaps with the Editors blessing we can continue with this attachment in the future **photo 9**.

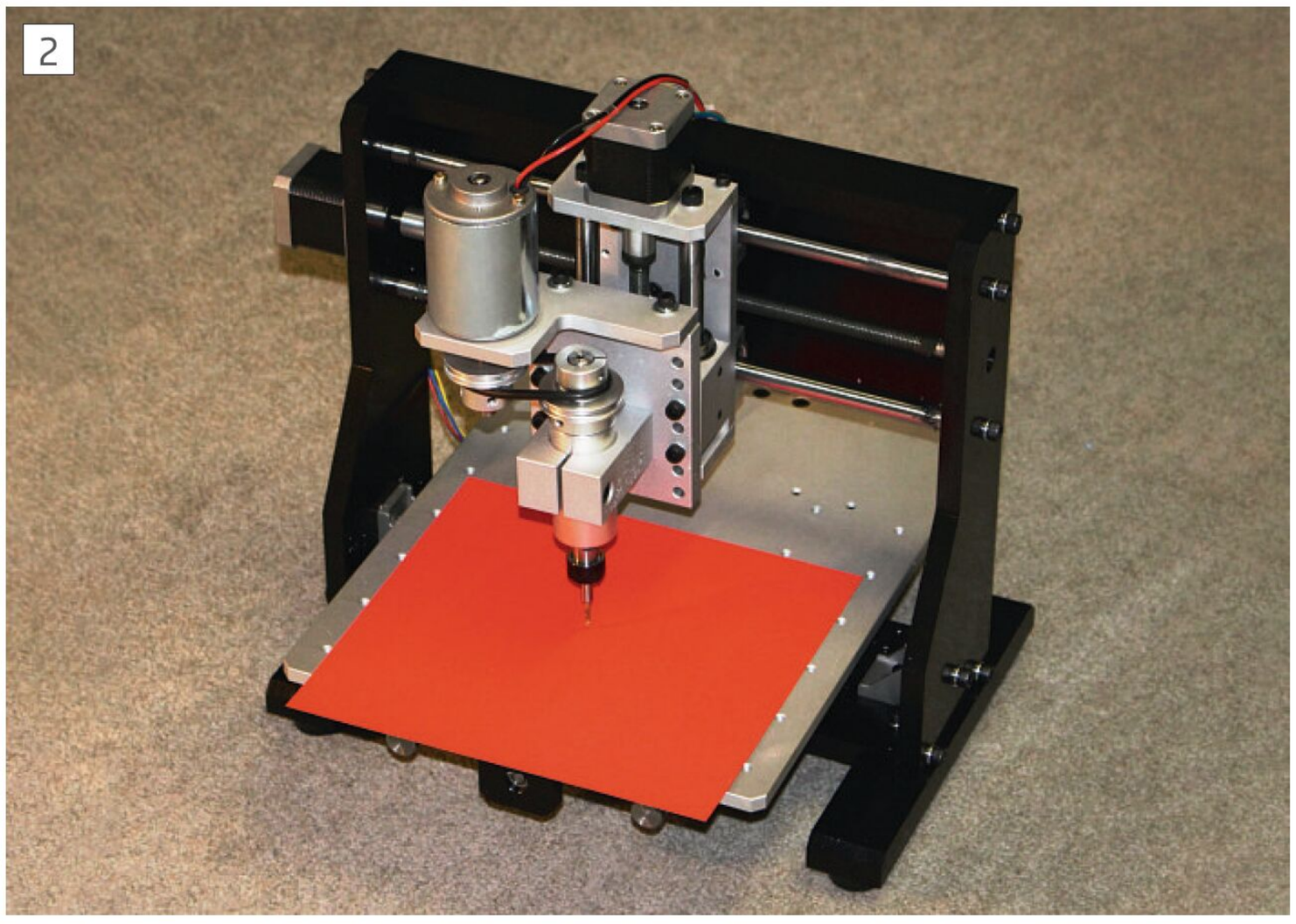
First Steps in CNC

After a long time dithering, at last Mark Noel decided to dive into CNC machining.

For some time I have been aware of the potential of Computer Numerical Control (CNC) to enhance the potential of a lathe or mill. What held me back from a purchase was the cost of yet another machine tool, and the challenge of learning another technology. Eventually I took the plunge, starting small with the purchase of a dinky CNC mill - the Sable 2015 which had received excellent reviews on the Internet. This machine is made in Taiwan and reflects their tradition of quality design and manufacture, and came complete with everything needed to get up and running as shown in **photos 1** and **2**. This article describes how I improved the little Sable, and my journey through the CNC jungle to eventually make parts that would otherwise be difficult using conventional machine tools.



Sable 2015 as delivered, complete with power supply, cables, spindle and other accessories.



Sable CNC with spindle fitted. The red card represents the machinable area of 20 x 15cm.

Comparing CNC to 3D Printing

Most readers of this magazine will already have a lathe, a mill and other tools that whittle away stock material to produce parts for a loco or other contraption. This process of *subtractive manufacturing* has been at the heart of human creativity since the first stone tools were made by our forebears over three million years ago. It was only during the Industrial Revolution that coal and water provided motive energy to add precision and speed to these processes to satisfy our increasing demand for flint arrowheads at lower cost and with consistent quality. You will have seen that they are now available in every corner shop.

It took until 1945 for it to be realised that a process of *additive manufacturing* could build a part without the waste associated with subtractive methods. Developments in computing led to the first additive machine in 1971, since when progress has been rapid to the point where 3D printers that fabricate in a wide range of polymers can fit the wallets of many MEW readers. In my case the purchase of an Ultimaker 3 has completely changed my approach to design and manufacture: as I wrote in MEW issue 313, my thoughts have essentially switched from 'What can I make' to 'What would I like to make' on the basis of the creative freedom that this remarkable technology provides,

Egg cup designed in Alibre, pierced in Meshmixer and printed in PLA, with an egg extruded by a chicken.

An example of an STL mesh surface on the starting design for the egg cup shown in photo 3.

photo 3. Meanwhile the price of CNC tools has tumbled to the point where this type of automated subtractive machine deserved a second look: hence the acquisition of the Sable. Moreover, a CNC mill would compliment my 3D printer to expand the materials that could be numerically processed in my workshop, to encompass metals, plastics and wood.

Acquiring the Software Skills

When diving into CNC or 3D printing it is easy to overlook the effort required to become proficient in the relevant design software. The cost of this software and a computer with the power to run it can actually exceed that of the CNC machine! Fortunately there are now some free 3D modelling programs and extensive libraries of 3D models that can fit one's needs, with examples listed in the Resources section. As I discovered it is essential to make the right software choice at the outset between programs that have an artistic or freeform intent, and those that are specifically intended for engineering purposes. The former are suited to carving or printing flowing shapes such as figurines in which dimensional accuracy is of lesser importance. In contrast, engineering programs focus on dimensional accuracy but with fewer tools for the creation of free-flowing shapes. To summarise:

Type 1 are true Solid Modelling programs in which parts are designed as prismatic closed solids, saved in formats that can be exchanged between other engineering programs. The model's precision is retained irrespective of scale. Examples include Fusion 360, Alibre Design, Designspark, Onshape, Sketchup, FreeCAD and OpenSCAD.

Type 2 are programs that shape parts as *surfaces* rather than solids, the emphasis being on providing tools to create freeform shapes, bounded by so-called 'NURBS' (Non-Uniform Rational B-Splines, if you must know) surfaces, suitable for carving or 3D printing aesthetic objects. Most save files in STL format where surfaces are defined as a dense triangular mesh such as that seen in **photo 4**. Examples include Moment of Inspiration, Rhinoceros and Blender.

Note that almost all Type 1 programs can also output files in STL format suitable for CNC milling or 3D printing, but usually cannot import an STL file for editing.

Comparing Workflows for CNC and 3D Printing

It is interesting to compare the workflows when moving from idea-to-part in 3D printing and CNC machining. In either case the part's shape is usually saved into an STL file using one of the program types listed above. Prior to 3D printing this file is processed with a 'slicer' program to create a sequence of extruder movements and squirts that will deposit the molten material. Some printers are optimised to work with a specific slicer, for example Ultimaker printers integrate with Cura, while Prusa printers work best with PrusaSlicer, although there are also independent alternatives such as Simplify3D, ideaMaker and OctoPrint, some of which are free. The generated list of move-and-squirt instructions are finally sent to the printer's on-board processor to lay down material and create the part.

If the part is to be CNC machined, then the workflow is more complicated. The design file is first passed to a CAM (Computer-Aided Machining) program that asks the user to define the size and shape of the stock to be machined and the type of cutter to be employed, e.g. a flat or ball-nosed tool. A choice must also be made from a range of cutting strategies that can include Cut Along X, Cut Along Y, Waterline and Contour, **fig. 1,** with the optimum strategy based on one's experience and geometry of the part to be machined. The process usually starts with a roughing cut that quickly removes the bulk of material, leaving a thin skin which is finally removed with a finishing cut, that skims off a whisker of material perhaps using a different tool. To minimise the risk of the cutter colliding with the part a safe height above the stock needs to be defined to prevent damage as the tool moves between areas to be machined. Further options often include conventional or climb milling, cut speed and ramp angle which determines the slope at which the cutter gently enters the stock.

There are a number of CAM programs focussed on the hobby community

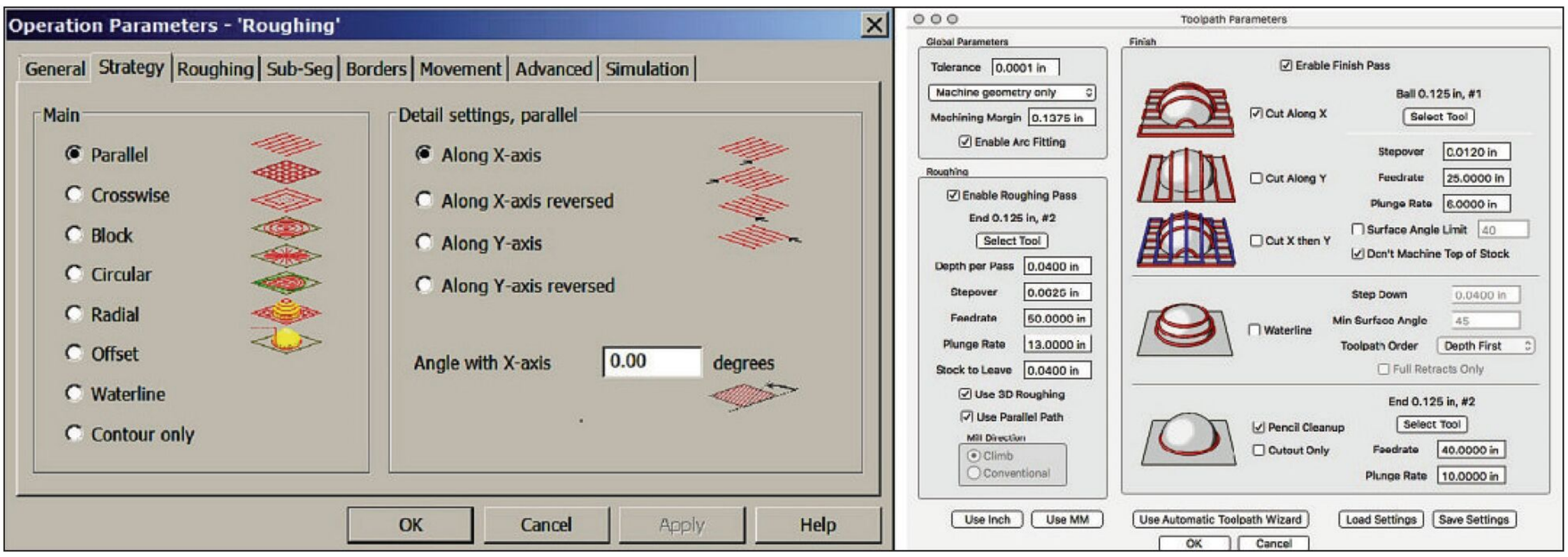


Figure 1: *Options for various cutting strategies offered by (left) DeskProto and (right) MeshCAM.*

each with varying power, complexity and challenge of learning. The choice ranges from the simple yet very effective MeshCAM through to the more involved Deskproto. All will produce a file containing a list of **G-Codes** which are the standardised instructions that command a CNC machine to undertake all the cutter movements and tool changes that will subtract a part from stock.

Motion Controllers

Industrial CNC machines have embedded controllers that accept and process these G-Codes directly. However, hobby machines require an external processor in the form of a PC running Windows or Linux that reads the sequence of G-codes, translating these into a series of cutter movements. Such a processor is called a Numerical Control or *NC Program* of which the most popular by far is Mach 3: this moves each axis of the machine via pulses sent from a parallel or USB port into an external motor drive module. Mach 4 is the latest iteration of this program providing a new interface and more advanced options.

However, exactly what happens next can be complicated since there are several methods of ensuring that the exact movement of a given axis complies with the instructions sent from the computer. Most hobby machines work on the open loop principle whereby the table carrying the stock is moved back and forth by a screw or belt driven by a stepper motor (a type of DC motor that rotates a small angle, such as 1.8°, upon each current pulse received). The NC software assumes that the table moves in strict accordance with all pulses sent, without any loss of increments, even though thousands of pulses may be transmitted to the machine over the cutting job. Provided the motor power is sufficient for the specific task then all will be well, but should the motor stall for an instant when, for example, the cutter encounters a hard knot of wood then errors in step counting accumulate and the final part will have imperfections.

One solution to this problem is to replace the basic stepper motor with a servo stepper motor which incorporates a digital shaft encoder. A microprocessor inside the unit detects errors in the shaft rotation compared to the instructions sent and, if necessary, forces the shaft to comply by increasing the motor current. Nevertheless, the electromechanical system of the CNC machine still remains *open loop* in the sense that it is assumed there are no errors in the pitch of the screw or belt driving the table, i.e. there is no monitoring of the desired movement.

These problems are overcome by configuring a closed loop system in which there is a precision distance encoder fixed to each axis, usually based on optical or magnetic technologies. The NC controller sends movement instructions to the machine and regulates the motor drive in order to match the desired travel with that detected and received from each encoder. In this way step-errors cannot accumulate, movement precision is maintained, and such machines are often faster than those based on open loop technologies. However, this advanced form of motion control is seldom seen on hobby grade machines owing to the increased cost compared to simpler open loop configurations.

By now your shiny new CNC machine might be gathering dust while your brain melts grappling with the dog's dinner that is Mach 3: a screen packed with a bewildering array of buttons. However, there are other more intuitive and up to date NC programs from firms such as PlanetCNC, EdingCNC and UCCNC which are bundled with USB-linked modules that calculate and perform tool movements without taxing the PC, **photo 5**.

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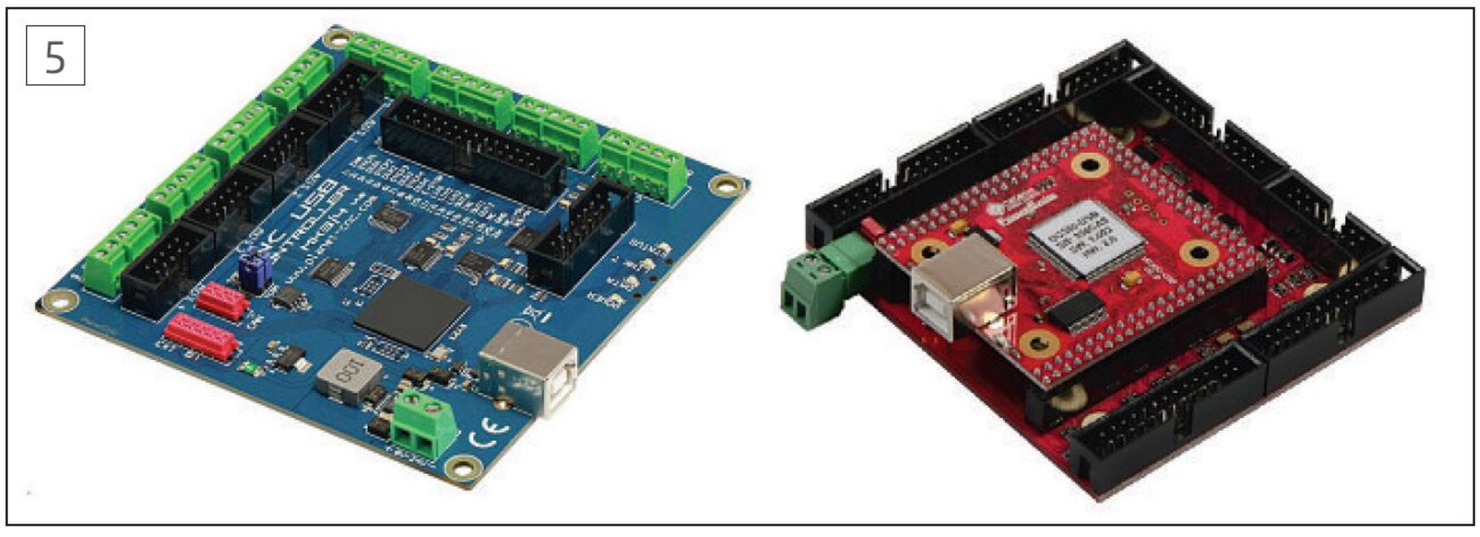

Examples of multi-axis stepper motor driver modules from (left) Planet CNC and (right) UCCNC. These serve as the interface between a Computer and CNC machine and perform the movement calculations freeing the PC from this complex task.

6

Proxxon FF500 CNC machine - a small CNC turret mill popular with small-scale model makers, especially in Germany.

7

The Wabeco FF1210 is a CNC conversion of their turret mill fitted with stepper motors to move the table and quill. Of heavier construction than the Proxxon this machine is more capable of cutting ferrous materials.

My Sable 2015: a Typical Home CNC Machine

Photographs 6, 7 and **8** show examples of small CNC machines typical of those installed in a home workshop. The Proxxon FF 500 and Wabeco FF1210 are essentially small turret mills with stepper motors driving the X, Y and Z axes. The Stepcraft M500 is more lightly constructed as a flat bed router with a large platform carrying the material, again with stepper motors driving all three axes. Conversion of inexpensive turret mills to CNC operation is a popular route for many and can produce a sturdy machine capable of cutting hard materials such as steel. Machines of the Stepcraft format carry the cutter spindle on a gantry rather than on a stiff column, are generally less rigid, and usually focus on carving wood, MDF or non-ferrous metals. Many following this configuration have also been home-built. All machines of this type are fitted

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The Stepcraft M500 is essentially a CNC router with large table that can accommodate sheets of material such as MDF or plywood for carving. Both larger and smaller versions are available from this manufacturer with different spindle options.

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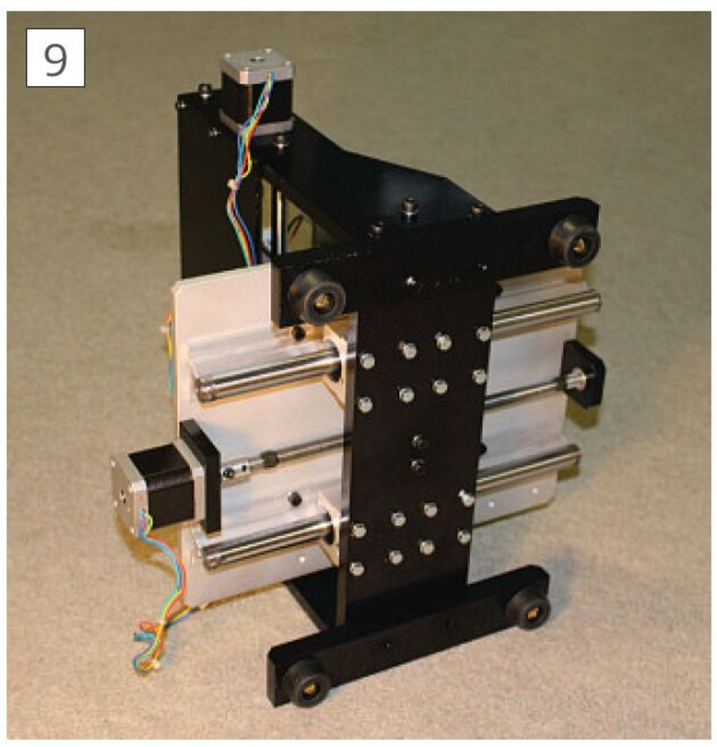

Underside view of the Sable 2015 showing the sturdy construction with a frame milled from 12mm thick aluminium plate. Ball guides and a fine-pitch screw for the Y axis can be seen underneath.

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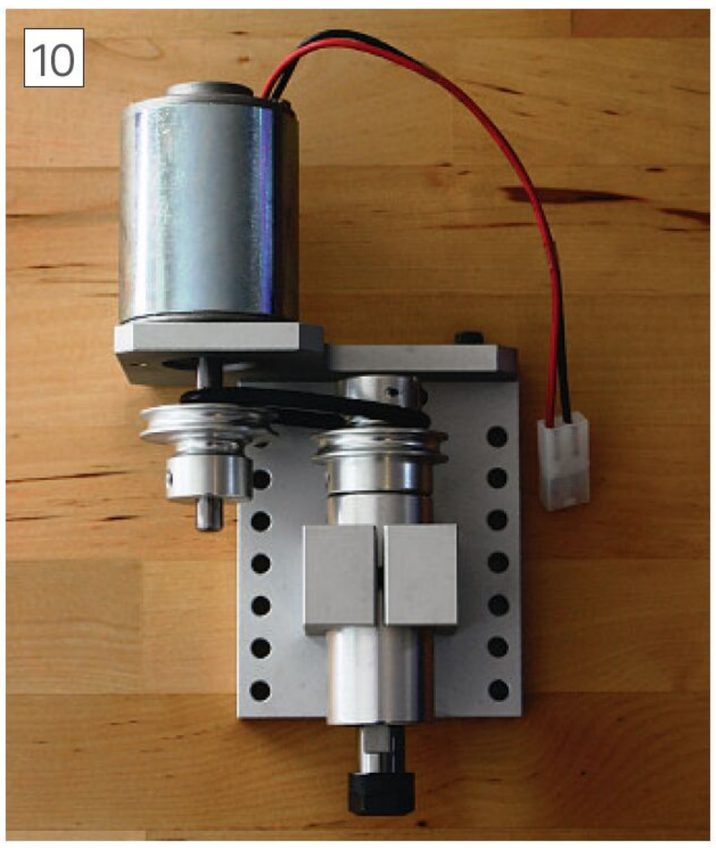
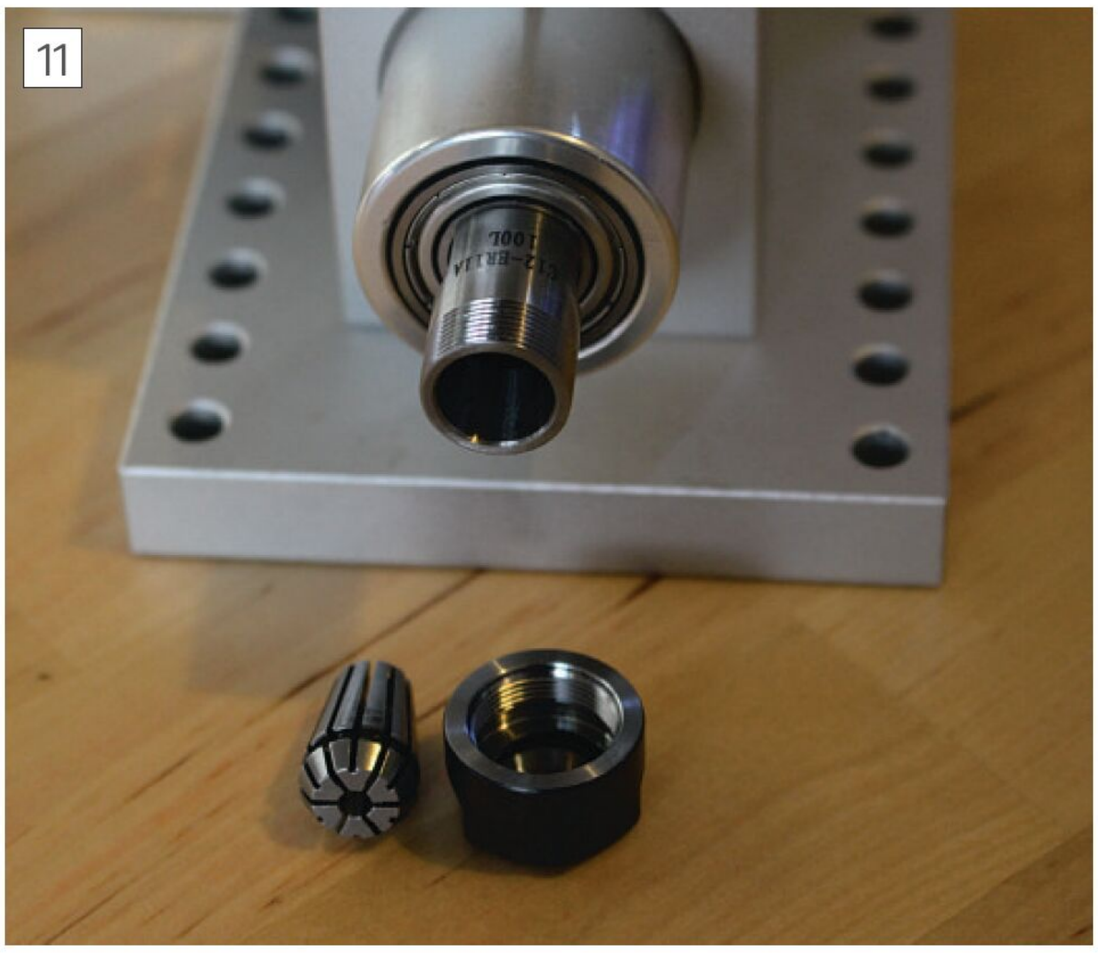
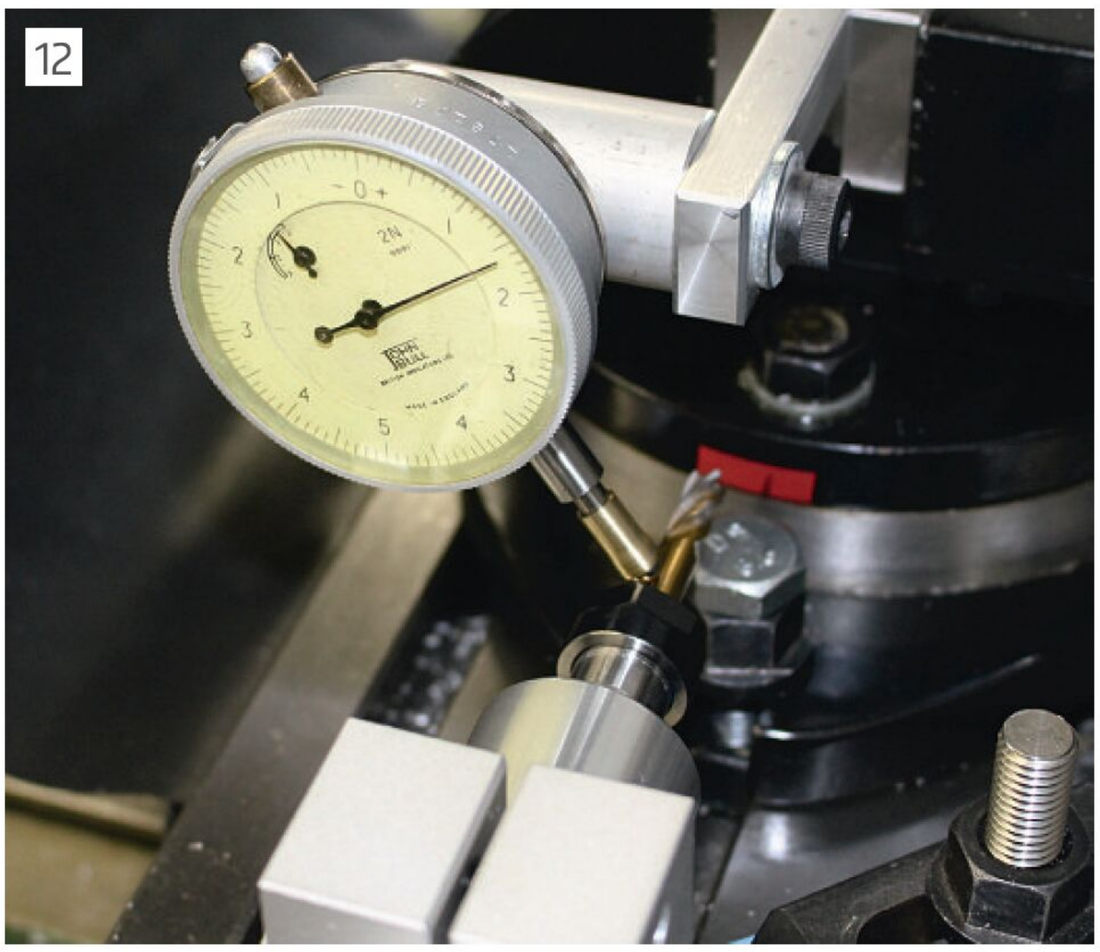


The Sable spindle and naked 12V motor. Two speed ranges are available via two pairs of pulleys.



Cutters are held in an ER11 collet chuck enabling clamping diameters from 0.5 to 7mm.



Measuring the spindle runout. This was found to be no more than 1.6 thou or 0.041mm.

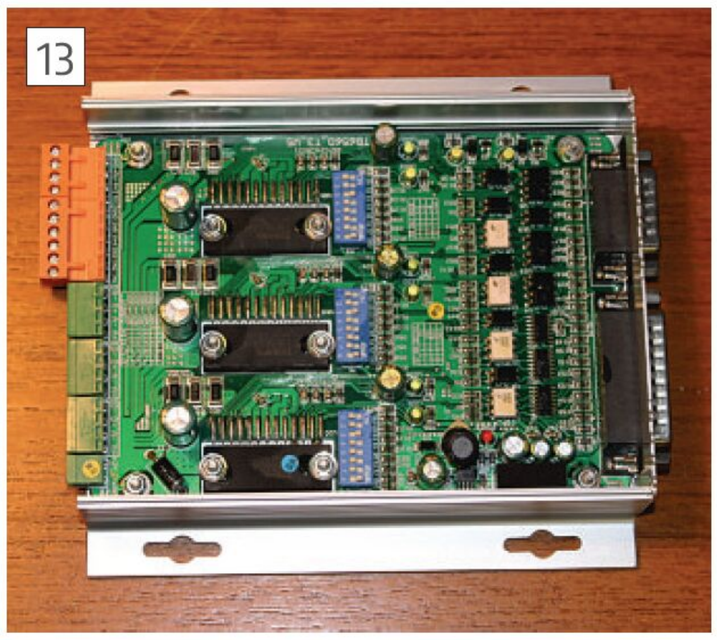
with conventional stepper motors and function on the open loop principle described earlier.

The Sable is unusual in that the structure is exceptionally rigid, with frame and gantry in 12mm thick aluminium plate and all moving parts carried on 12mm diameter precision ball guides, **photo 9**. It is therefore capable of machining hard materials such as brass and printed circuit boards. To be fair, Stepcraft also boast this capability with their sturdy German-engineered machines.

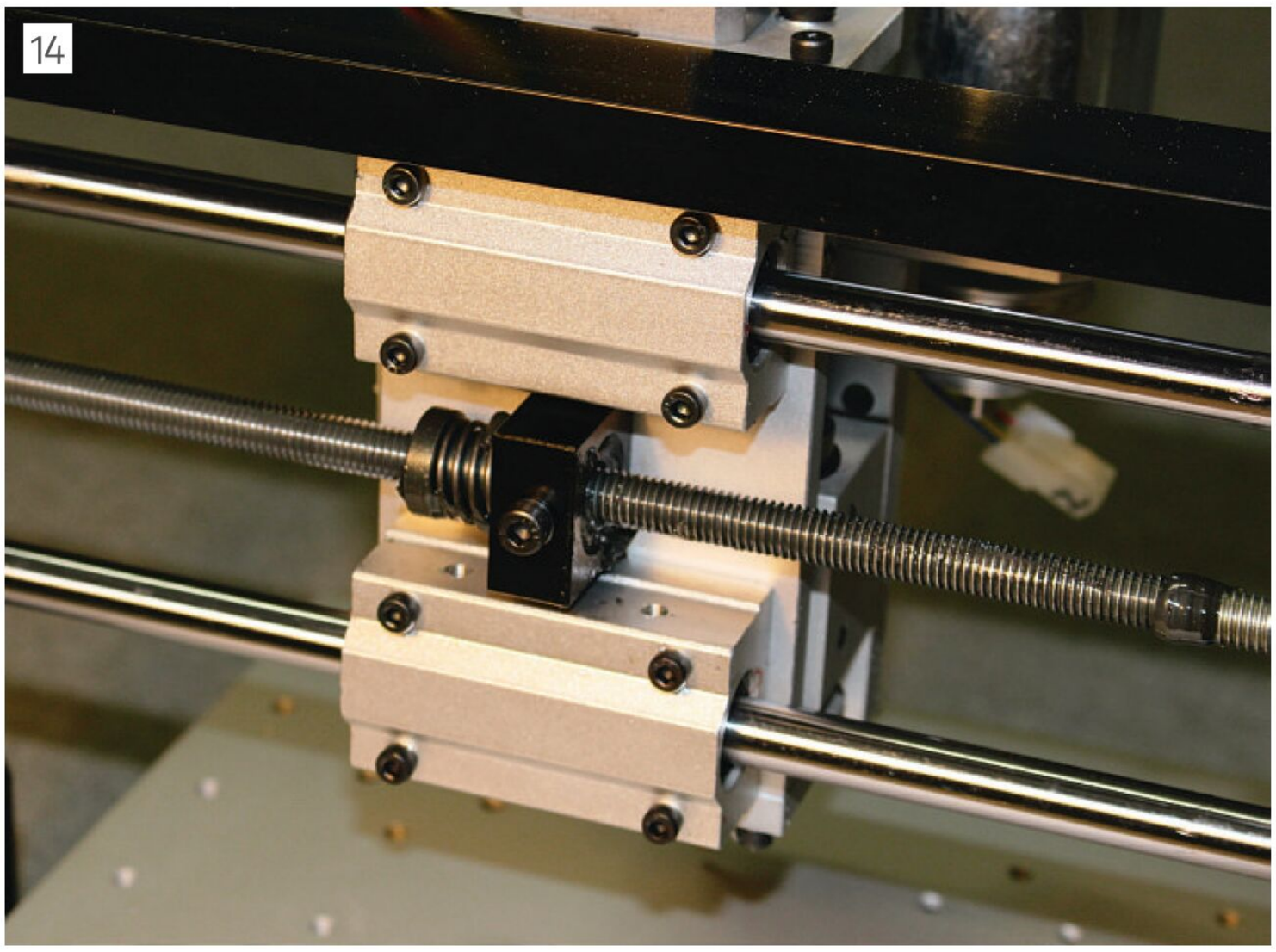
Configurations exemplified by the Stepcraft family are termed Core X-Y designs, since the table bearing the stock remains stationary while the cutter moves on all three axes. This has the benefit of requiring less bench space than, for example, the Sable in which the table moves from front to back in the Y direction. Of course this is of little consequence in such a small machine but is a factor that should be borne in mind when considering your purchase or home build of a larger machine.

My Sable was shipped with a 2-speed belt driven, ball bearing spindle with an ER11 collet chuck that was found to have only 0.0016" (0.041mm) runout, **photos 10**, **11** and **12**. DC power supplies for the spindle motor and 3-axis stepper motor driver were included together with a spare drive belt and cables (photo 1). The stepper motors are driven by three Toshiba TB6560 chips with 1/16 microstepping and optical isolators to protect electronics in both the host PC and the driver chips, **photo 13**. Free play in all three axes is virtually eliminated by anti-backlash counter nuts, **photo 14**, although the ideal solution would be to fit precision ball screws. Indeed, I note that a ball screw version of the Sable is now available.

• To be continued



The supplied stepper motor driver board. This carries three Toshiba TH6560 integrated circuits which are optically isolated from the PC to protect both sets of electronics.



Close-up of the spring-loaded counter nut on the X axis which eliminates backlash in the drive. Similar nuts are fitted to the Y and Z axes.

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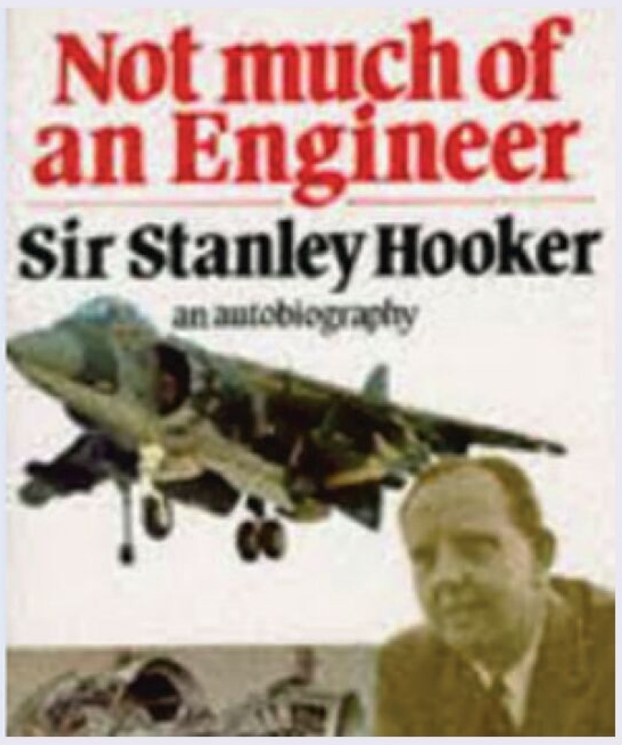
Winter Reads

Hi Neil, I think that a number of your subscribers will have already read this publication but for those who have not, it would be an interesting winter read. The book is *Not Much of an Engineer* by Sir Stanley Hooker

John Ogilvie, Christchurch NZ

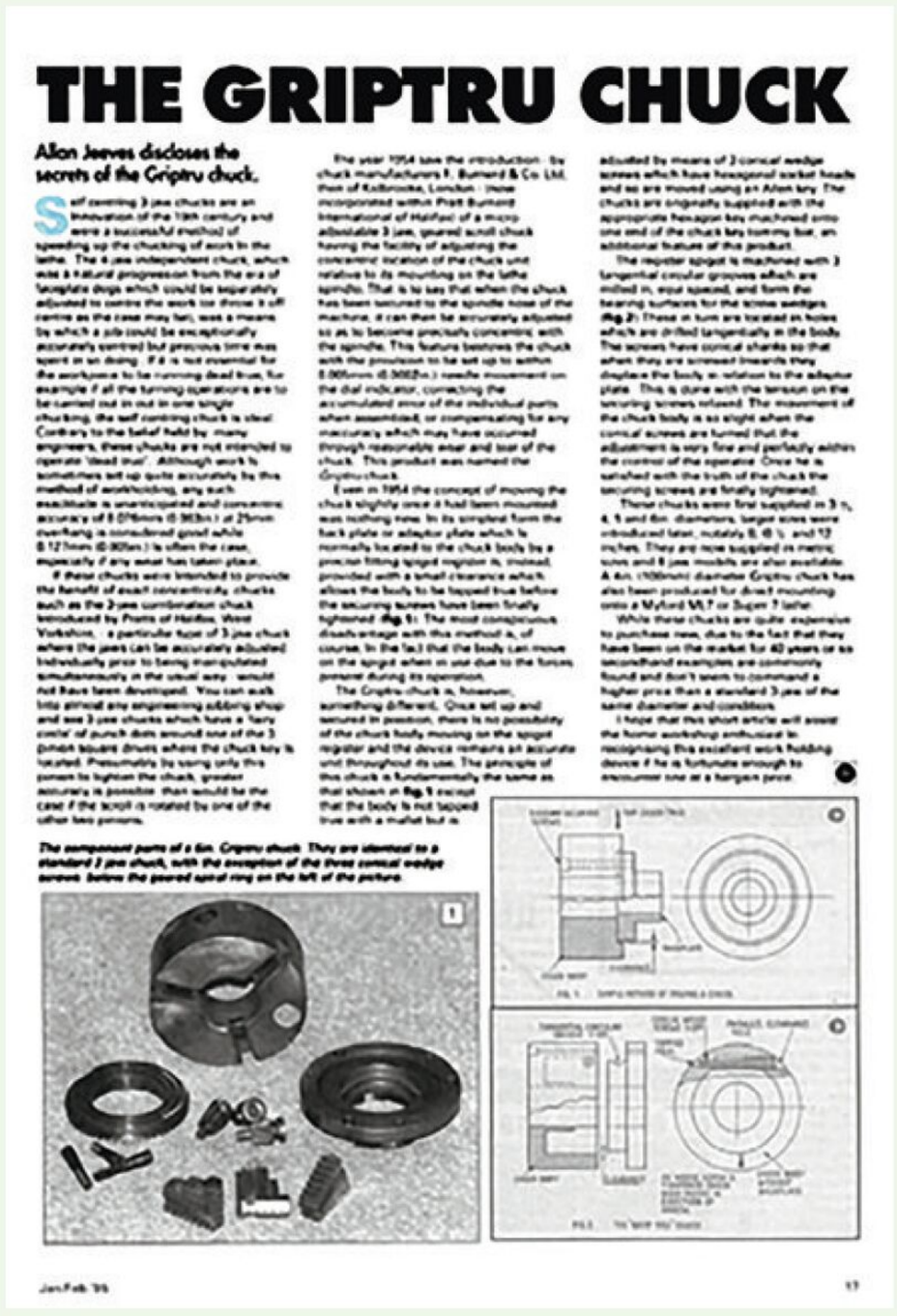


The GripTru Chuck

Dear Neil, In MEW 345 David Wragg wrote concerning difficulty reading the archive article in MEW 344. To help David out, I cleaned up the original page a little and scanned the text through OCR. Please pass on if permitted.

David Frith, by email

Many thanks David. I have sent your scan and the OCR text to David Wragg and posted it on the ME Forum at the address below. Readers, please be assured the version on the website is much easier to read than the thumbnail here! – Neil.
www.model-engineer.co.uk/768209/the-workings-of-a-griptru-chuck/



THE GRIPTRU CHUCK

Alan Jeeves discloses the secrets of the Griptru chuck.

Self centering 3 jaw chucks are an innovation of the 19th century and were a successful method of speeding up the chucking of work in the lathe. The 4 jaw independent chuck, which was a natural progression from the era of faceplate dogs which could be separately adjusted to centre the work (or throw it off centre as the case may be), was a means by which a job could be exceptionally accurately centred but precious time was spent on so doing. If it is not essential for the workpiece to be running dead true, for example if all the turning operations are to be carried out in or in one single chucking, the self centring chuck is ideal. Contrary to the belief held by many engineers, these chucks are not intended to operate 'dead true'. Although work is sometimes set up quite accurately by this method of workholding, any such machinists is unanticipated and convenient accuracy of 0.076mm (0.003in.) at 25mm overhang is considered good while 0.127mm (0.005in.) is often the case, especially if any wear has taken place.

If these chucks were intended to provide the benefit of exact concentricity, chucks such as the 2-jaw combination chuck introduced by Pratts of Halifax, West Yorkshire, a particular type of 3 jaw chuck where the jaws can be accurately adjusted individually prior to being manipulated simultaneously in the usual way, would not have been developed. You can walk into almost any engineering jobbing shop and see 3 jaw chucks which have a 'fairly constant' of punch dots around one of the 3 pinion square drives where the chuck key is located. Presumably by using only this pinion to tighten the chuck, greater accuracy is possible than would be the case if the scroll is rotated by one of the other two pinions.

The year 1954 saw the introduction by chuck manufacturers F. Burnard & Co. Ltd. then of Kidbrooke, London, (now incorporated within Pratt Burnard International of Halifax) of a micro adjustable 3 jaw, geared scroll chuck having the facility of adjusting the concentric location of the chuck unit relative to its mounting on the lathe spindle. That is to say that when the chuck has been secured to the spindle nose of the machine, it can then be accurately adjusted so as to become precisely concentric with the spindle. This feature bestows the chuck with the provision to be set up to within 0.005mm (0.0002in.) needle movement on the dial indicator, correcting the accumulated error of the individual parts when assembled, or compensating for any inaccuracy which may have occurred through reasonable wear and tear of the chuck. This product was named the Griptru chuck.

Even in 1954 the concept of moving the chuck slightly once it had been mounted was nothing new. In its simplest form the back plate or adaptor plate which is normally located to the chuck body by a precision fitting spigot register is, instead, provided with a small clearance which allows the body to be tapped true before the securing screws have been finally tightened (fig. 1). The most conspicuous disadvantage with this method is, of course, in the fact that the body can move on the spigot when in use due to the forces present during its operation.

The Griptru chuck is, however, something different. Once set up and secured in position, there is no possibility of the chuck body moving on the spigot register and the device remains an accurate unit throughout its use. The principle of this chuck is fundamentally the same as that shown in fig. 1 except that the body is not tapped true with a mallet but is adjusted by means of 3 conical wedge screws which have hexagonal socket heads and so are moved using an Allen key. The chucks are originally supplied with the appropriate hexagon key machined onto one end of the chuck key tommy bar, an additional feature of this product.

The register spigot is machined with 3 tangential circular grooves which are milled in, equi spaced, and form the bearing surfaces for the screw wedges (fig. 2). These in turn are located in holes which are drilled tangentially in the body. The screws have conical shanks so that when they are screwed inwards they displace the body in relation to the adaptor plate. This is done with the tension on the securing screws released. The movement of the chuck body is so slight when the conical screws are turned that the adjustment is very fine and perfectly within the control of the operator. Once he is satisfied with the truth of the chuck the securing screws are finally tightened.

These chucks were first supplied in 3 ½, 4, 5 and 6in. diameters, larger sizes were introduced later, notably 8, 10 ½ and 12 inches. They are now supplied in metric sizes and 8 jaw models are also available. A 4in. (100mm) diameter Griptru chuck has also been produced for direct mounting onto a Myford ML7 or Super 7 lathe.

While these chucks are quite expensive to purchase new, due to the fact that they have been on the market for 40 years or so secondhand examples are commonly found and don't seem to command a higher price than a standard 3 jaw of the same diameter and condition.

I hope that this short article will assist the home workshop enthusiast in recognising this excellent work holding device if he is fortunate enough to encounter one at a bargain price.

The component parts of a 6in. Griptru chuck. They are identical to a standard 3 jaw chuck, with the exception of the three conical wedge screws. Below the geared spiral ring on the left of the picture.

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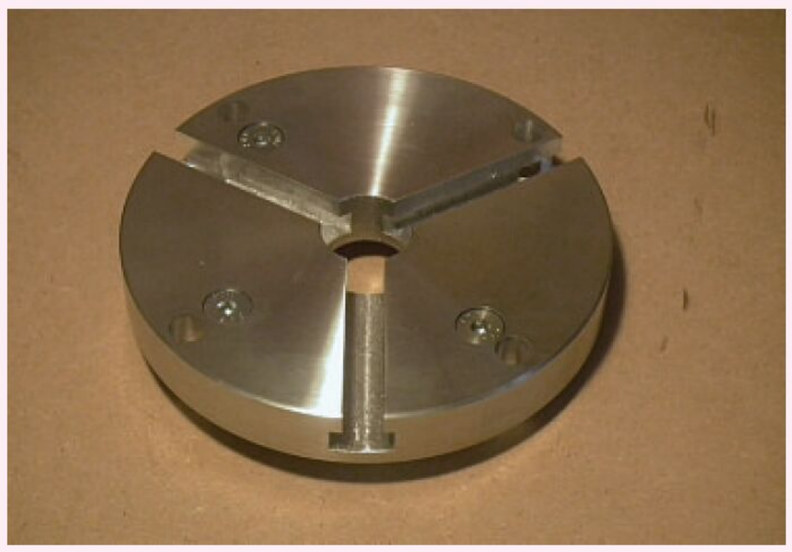
Density

Dear Neil, assuming it's never too late to correct errors I bring to your attention a serious one in "Measuring Density in the Home Workshop Kitchen" in #251. The correct formula for density is dry weight/(dry weight - wet weight). Using this the Crank case density is 2.26 (Aluminum). Cylinder head 1.61 (Magnesium). Crank case door 2.18 (Aluminum). All the reverse of the article.

DH Mayeron, Berkeley, California

Mr Mayeron and I have exchanged a few emails on this topic and we can't agree whether or not Rod Jenkins was correct! Perhaps readers with access to back issues or the MEW Archive online might care to offer a perspective? – Neil.

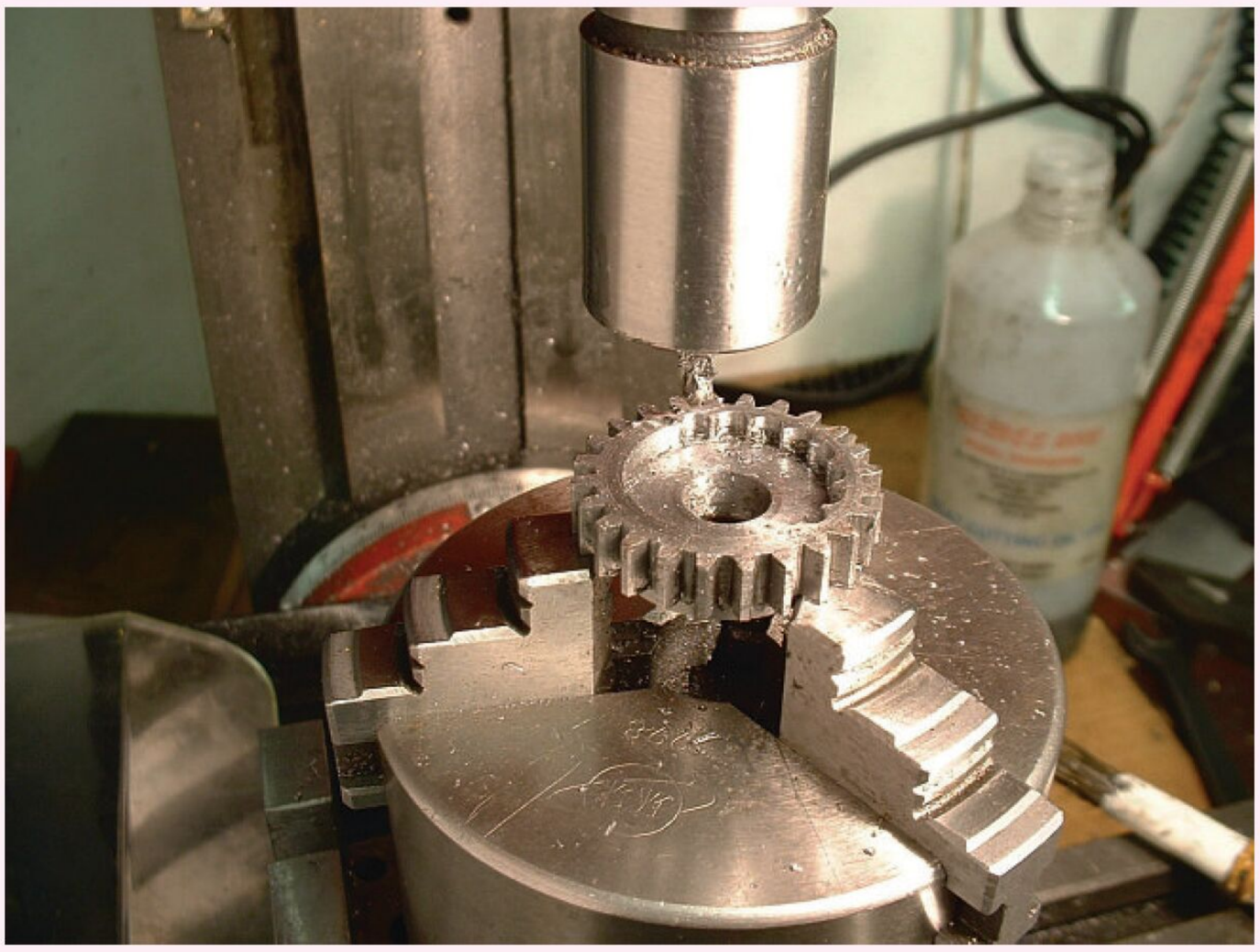
Rotary Table



Dear Neil, I was most interested to read about Geoff Andrews 100 mm rotary table improvements. I have a similar rotary table, and it has been well used. Like him I have found the need to make an additional top plate. My Plate is 170mm Diameter and has three tee slots. As the rotary table has four slots a plate with three slots improves the clamping versality.

Geoff Harding, by email

A neat job Geoff. Readers may be interested in my own solution – I made my own rotary table/dividing head with a spindle formed so that my lathe chucks and faceplate could be attached to it. The photo shows it with a chuck attached for dividing an approximate 'internal gear' for a gearbox – Neil.



Online Indexes

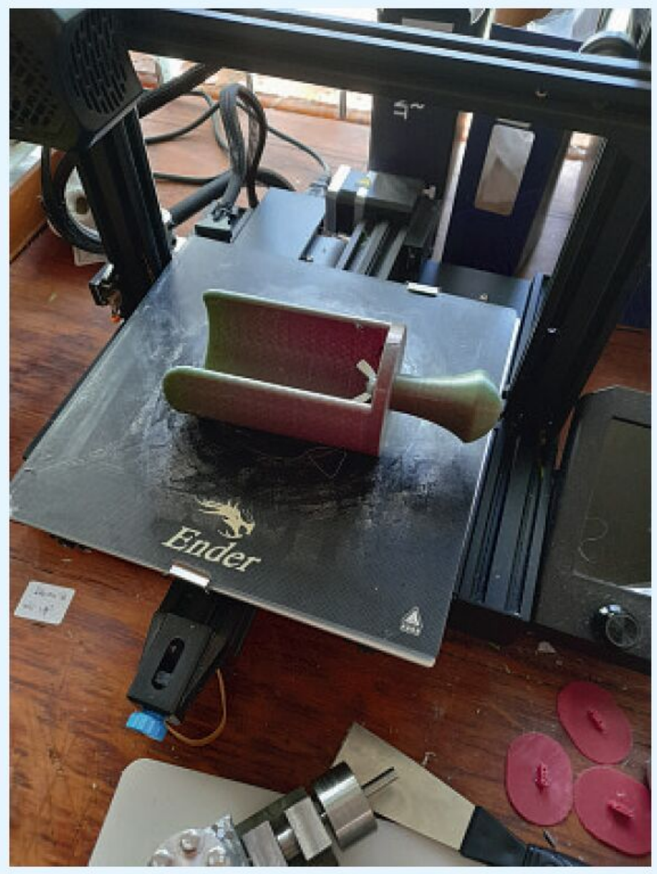
Here's a reminder that David Frith's latest Index for Model Engineers' Workshop can be downloaded on from the Forum at www.model-engineer.co.uk – just select Forums and then the Model Engineers' Workshop topic. Alternatively scan the adjacent QR code.

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

Domestic Printing

Dear Neil, the closest my wife comes to model engineering is crocheting, a skill that completely eludes me. If she had the inclination, I have no doubt that Tricia could crochet a jet turbine. She may come round though as we recently got back into making bread with home ground wheat, so I printed a guard for the grinder to stop flour going everywhere and a small scoop for the wheat. Tricia may well get into CAD herself!

Robert Walker, by email



Cleaning A Surface Plate

Roger Backhouse rescues a fifty year old surface plate.

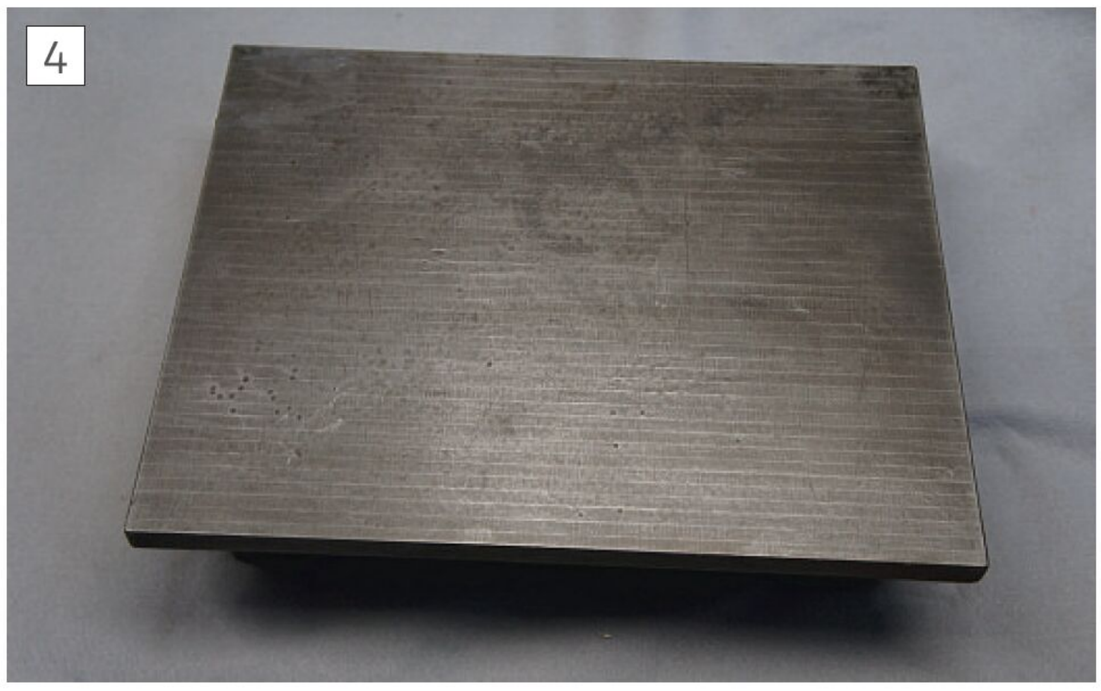
Back in the days when Barnardos still ran homes for adolescents they decided to teach their young men engineering. Despite skilled tuition with a range of tools and workshop equipment the experiment was not a success, their youths were not great learners, and everything was disposed of.

Via a friend on my allotments who'd worked for Barnardos I acquired one of their marking out plates made by Windley Bros of Chelmsford, circa 1963, **photo 1**. It seemed better than the plate glass mirror I'd been using. There may have been a cover at some time but that had long disappeared.

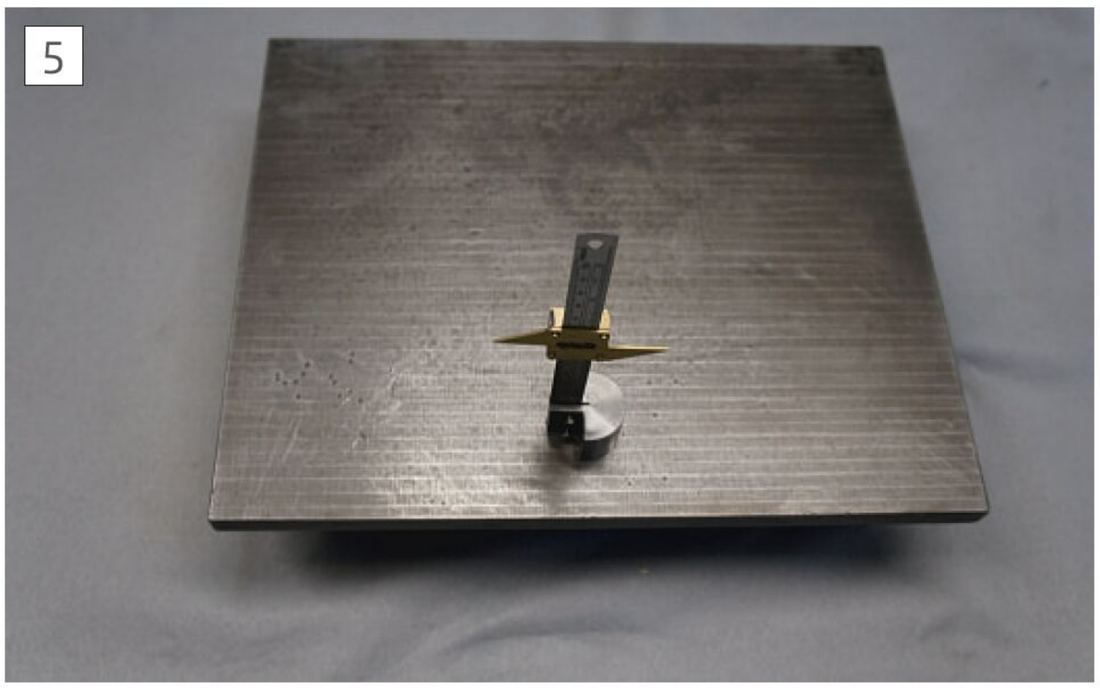
The maker's plate.

The marking out plate as received - absolutely filthy with traces of rust.

Wooden Venetian blind slats rescued from a skip formed the cofferdam sides affixed with "Hard as nails" glue.



The cleaned plate



Cleaned plate with home-made lathe tool height gauge.

The plate was dirty, with a thin film of dirt and rust, **photo 2**. I wasn't sure how to clean this without harming the plate so I asked fellow model engineers via the Society of Model and Experimental Engineers *Journal* and put a question at one of their Question Times to see what ideas might come forward.

At the Question Time, one suggestion which seemed worth a try was to soak the surface in vinegar. It promised to be effective and even better, cheap, if Aldi's product was used.

Perhaps surprisingly vinegar has a long and honourable tradition in engineering. At Shildon Wagon Works in County Durham those who removed bolts on wagons brought in for repair were nicknamed "vinegar men" as this was used to release stiff nuts and bolts in the days before WD40.

I had no container large enough for the plate but instead made a coffer dam round the edge with wooden venetian blind slats (found in a skip) stuck on with "hard as nails" adhesive squeezed from a mastic gun. Left to dry for 24 hours it made a watertight edge to be filled with vinegar, **photo 3**. This job doesn't need best white wine vinegar, so I used some Sainsbury's malt vinegar from the cleaning cupboard.

To my surprise the vinegar worked by the following day. The surface was much cleaner, **photo 4**. With the vinegar recycled back for other cleaning and the glue peeled off the edges it looked like a marking out plate again, **photo 5**.

Cover board made from plywood and strip wood

Underneath of cover board showing rubber grommets to protect the ground surface.

However, it showed other imperfections suggesting some of Barnardo's finest had not been too careful with this precision tool.

The next step suggested was to take the plate to an engineering company with a surface grinder. Finding one with a grinder big enough to take the plate proved problematic and the job would have had to wait until I had transport. It's a little heavy to take on a bus.

In the end I didn't bother with surface grinding but used a scraper to remove the slightly raised areas where someone had misused a punch. If not yet a perfect plate it is at least usable and a lot cheaper than buying one new. (Roger is being modest, it appears to be a Grade B or 'shop floor' surface plate, and it's present condition should be more than adequate for marking out purposes – Ed.)

To protect the plate I made a cover board from plywood, edged with strip wood, **photo 6**, and placed rubber grommets underneath, **photo 7**.

So don't forget the vinegar. A low-cost technique worth using to clean items even if your workshop will temporarily smell like a chip shop. ▮

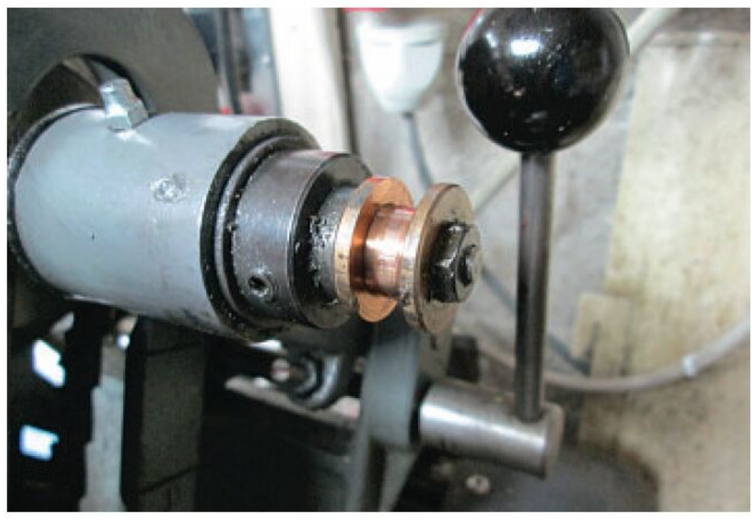
In our Next Issue

Coming up in issue 347, February 2025

On sale 24 January 2025

Contents subject to change

Make **Adrian Garner's** riveting tool, especially for model size work. Detail drawings.



Laurie Leonard solves a noisy problem with his Myford lathe's clutch.

Brett Meacle describes how to make a collet drawbar for Pultra Lathes. Full drawings.

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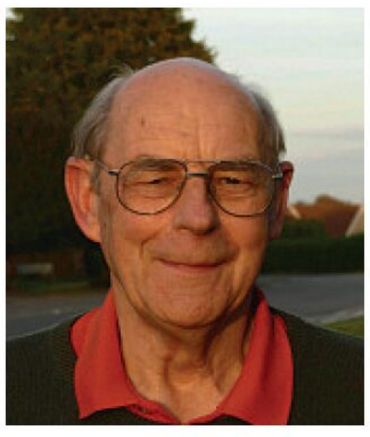
DON'T MISS THIS GREAT ISSUE-SEE PAGE 22-23 FOR OUR LATEST SUBSCRIPTION OFFER

Sharpening a Boring Tool



Howard Lewis explains how he sharpened his boring tools using a Worden grinder.

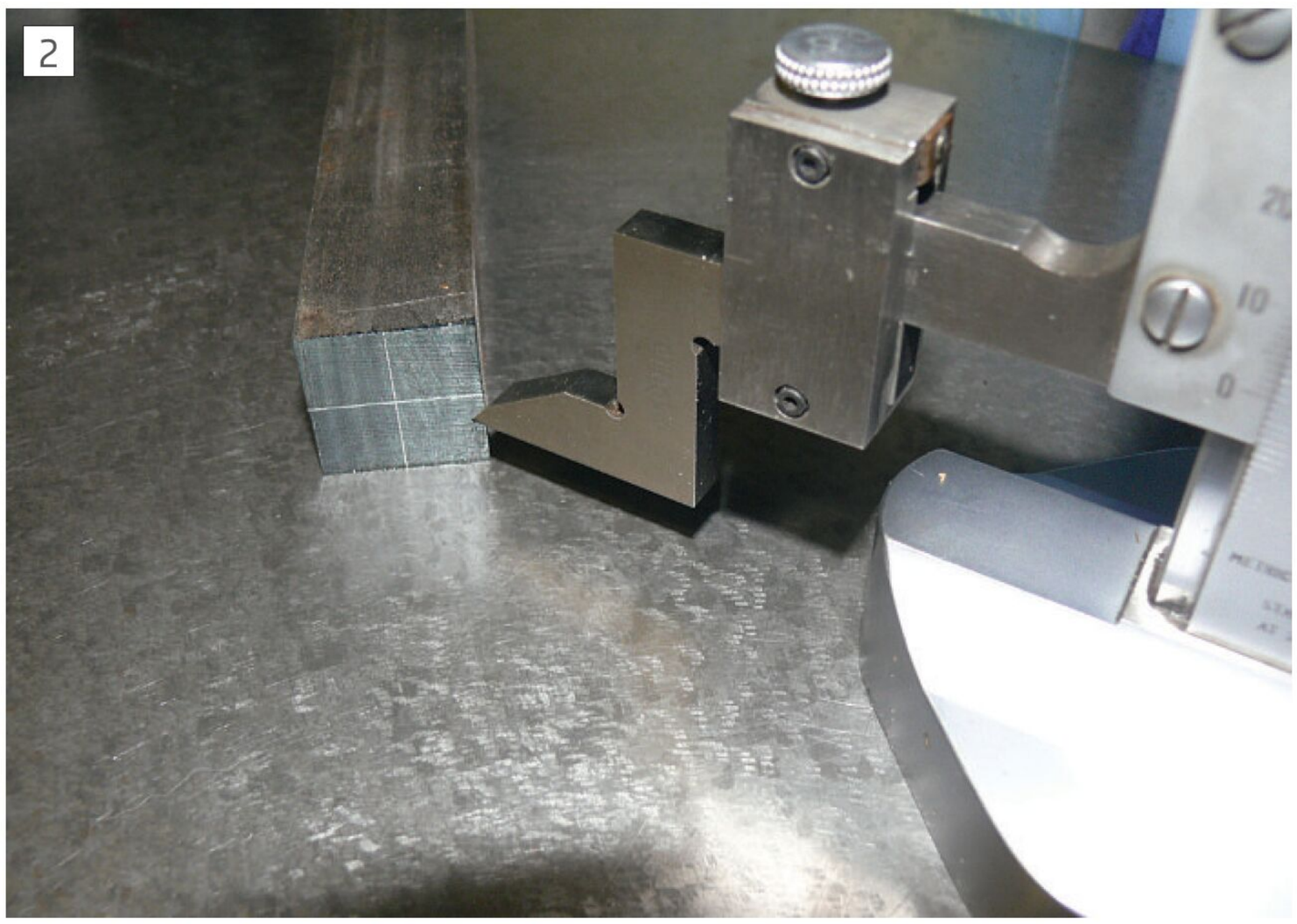
As usual, one job always seems to generate others. The original intent was to make some Christmas presents for family members, but it did not stop there. It soon became obvious that the cutters for my boring head, **photo 1**, after several years of use and abuse (particularly the latter) were in dire need of grinding. With the cutters having Brazed Carbide tips, it would be necessary to use a diamond wheel to grind them; so one was fitted to the Worden Cutter Grinder.

Since the carbide tips are extremely hard, the amount removed at each setting would be small, and it would take some time to grind both the front and side faces of all nine cutters. To grind the cutters would also require making holders so that the cutters could be held on the Worden.

One feature of the Worden is that a number of tool holders are made from 1-inch square steel, and this could be used to advantage when setting up the cutters for grinding. On this basis, the work was carried out to imperial dimensions, and using imperial fasteners, but there is no reason why metric dimensions and threads cannot be used, if this is better suited to the machine, materials, drills, taps, dies and fasteners available.

Using square steel means that when a cutter needs to be ground in one plane, it can be aligned in another and then the holder rotated through 90 degrees for the tool grinding. By setting the top face of the cutter vertical; when the holder is rotated through 90 degrees, it holds the tip so that it will become one with zero top rake, rather than negative or positive rake. Two cutter holders would be required to allow the front and side faces of the cutter to be ground.

Boring head cutters.



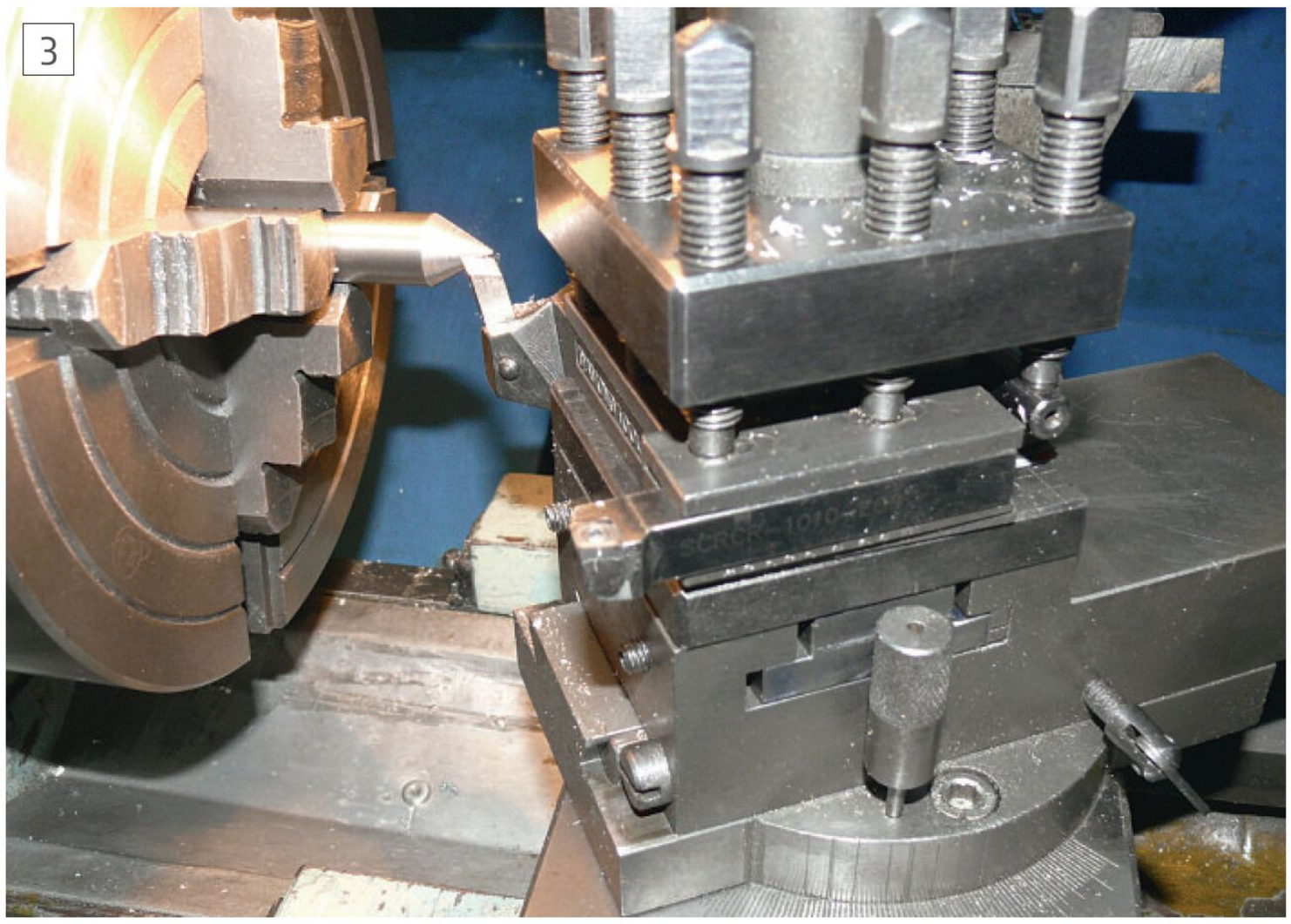
Marking out the blocks.

Clearance angles would be set by tilting the table away from the original position of being square to the face of the wheel. To make the holders, two pieces of one inch square steel were cut to approximately three inches long. The ends of the embryo holders were painted with marking out blue, and marked out to show the centre of the end face, **photo 2**.

The Next Job!

Already a second job became necessary if the workpiece was to be aligned in the four-jaw chuck using the "two centres" method. A second centre needed to be made.

A short piece of silver steel was clocked to centre it in the 4-jaw chuck, the end faced and centre drilled. It was then reversed in the chuck and recentered. Once this had been done, the top slide was offset by 30 degrees and a centre turned, using the top slide for traversing the tool, whilst the cut was applied by the cross slide, **photo 3**.



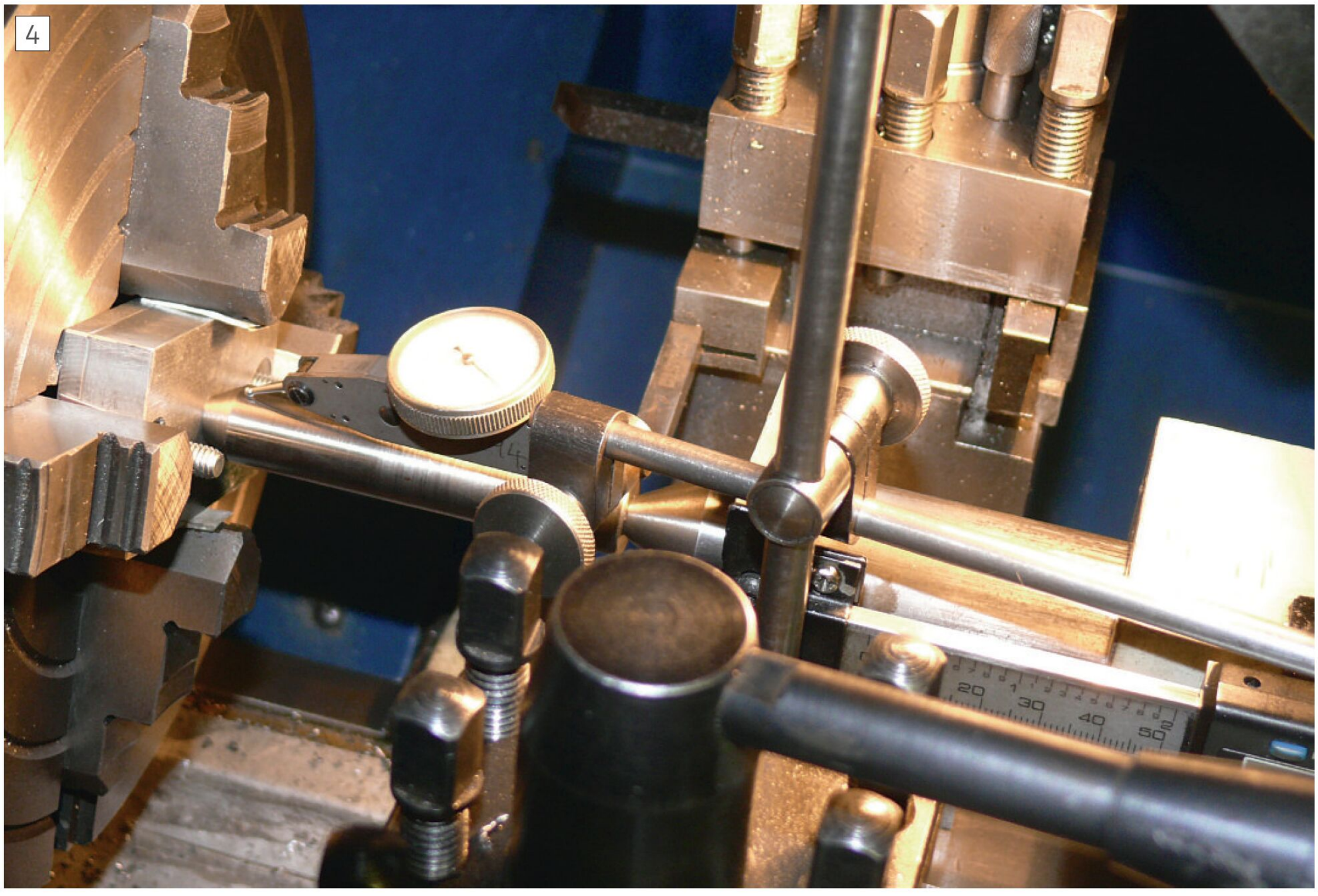
Trimming the second centre.

Tool Holders

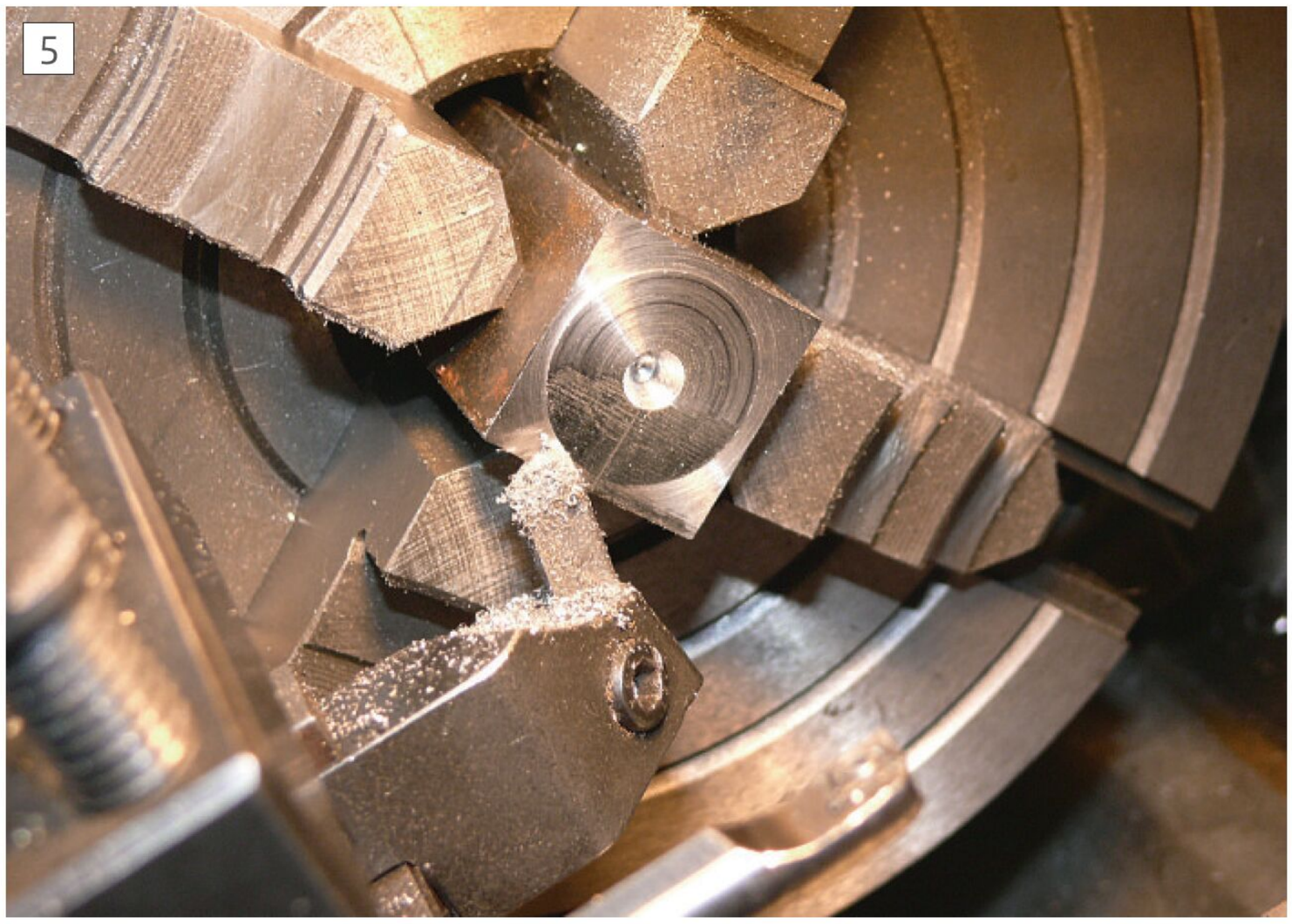
Once the steel had been centre popped on the intersection of the marking out, it could then be gripped in the 4-jaw chuck, and centred using the "two centres" method. As illustrated in **photo 4**, the second centre is fitted between another and the centre pop on the workpiece, which is adjusted until the gauge shows the second centre is running true.

Once centre drilled, the end face was faced to bring it square to the axis, **photo 5**. Later, having the end faces square to the axis will be used to align the two holders, when they are connected together.

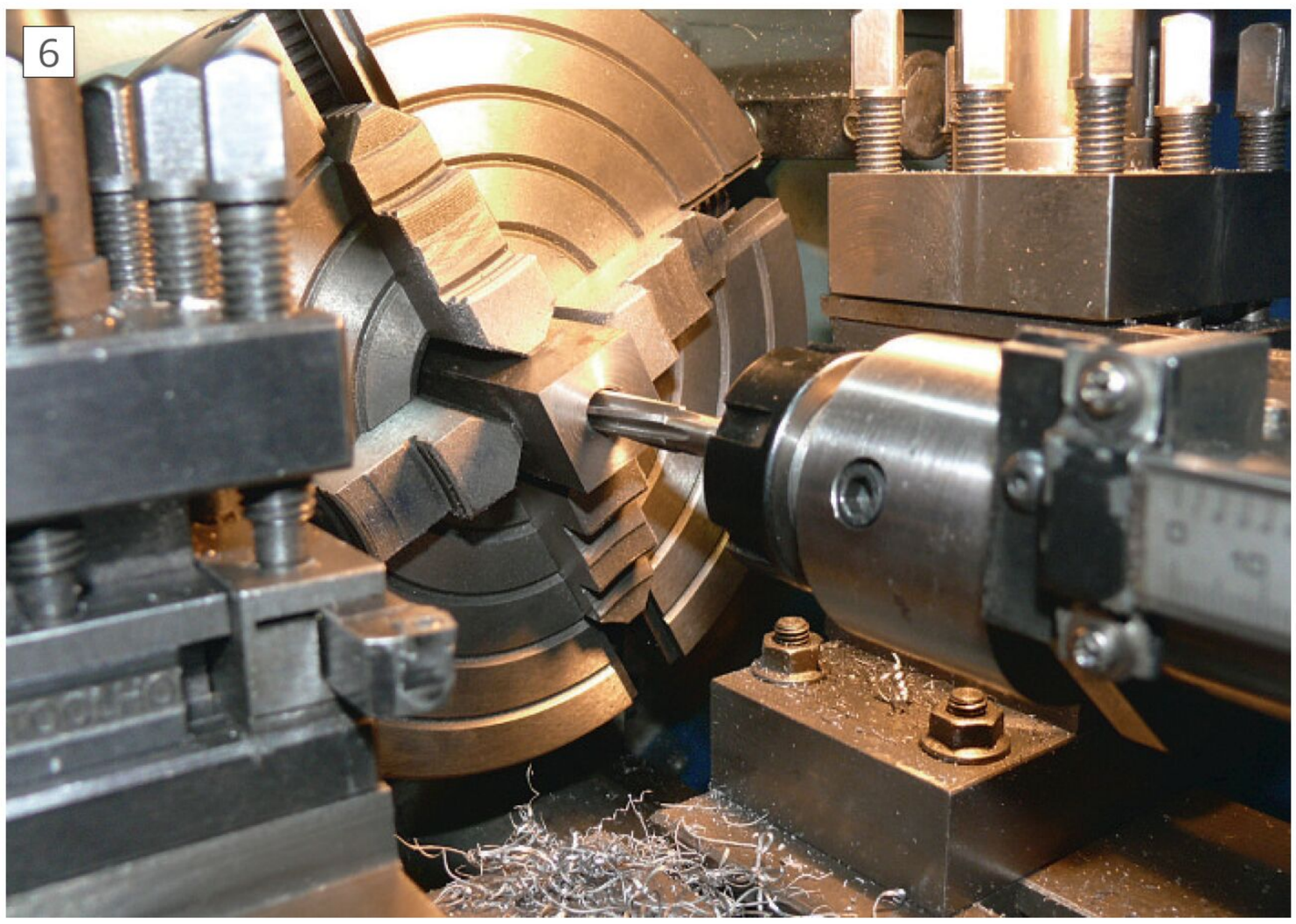
Having drilled the holder, the final operation was to ream, holding the reamer in a shop made floating reamer holder. If the reamer can float and follow the drilling, there is minimal risk of the reamer cutting off centre to produce



Centring the work in the 4-jaw chuck.



Facing the end.



Reaming using the floating reamer holder.

an oversize bore. Since the boring cutters had 3/8 inch shanks, this was the size of reamer used to semi finish the bore, **photo 6**. When reaming had been completed, the reamer was used to aid centering the holder when it was reversed in the chuck to face the opposite end.

The length of the holders can be regarded as being "open limit" since absolute precision in the length is not essential. When both holders had been faced at both ends, each one was transferred to the mill/drill and centred under the spindle.

A series of 8 – 32 UNC holes were drilled and tapped along the centreline, at 3/8" centres, **photo 7**. The availability of a number of 8 – 32 UNC grubscrews, and the necessary taps was the reason for this choice, any similar size could be used.

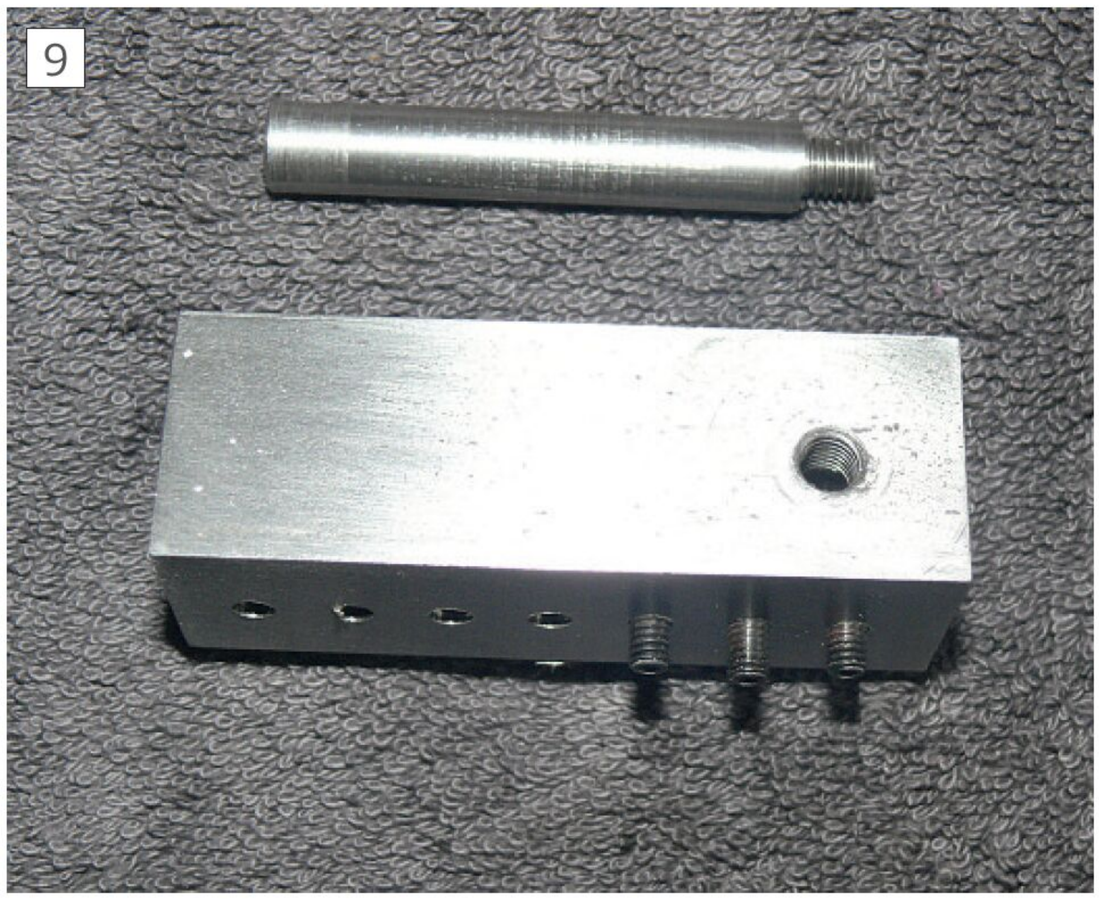
The block (now referred to as holder 2) was then rotated through 90 degrees and a hole drilled and tapped ¼ BSF, half an inch from one end face. Later, to make the holder more versatile, and to avoid the need to reset the table to produce the clearance angle, a duplicate tapping was made at the other end, **photo 8**. These tappings were to take a spigot, 3/8 inch diameter and 2 inches long, with a ¼ BSF thread on the end, short enough not to protrude into the bore.

The final operation on the holders was to run the reamer through the bores again, to remove any burrs produced during the tapping operations, or any minimal protrusion of the ¼ BSF thread on the spigot.

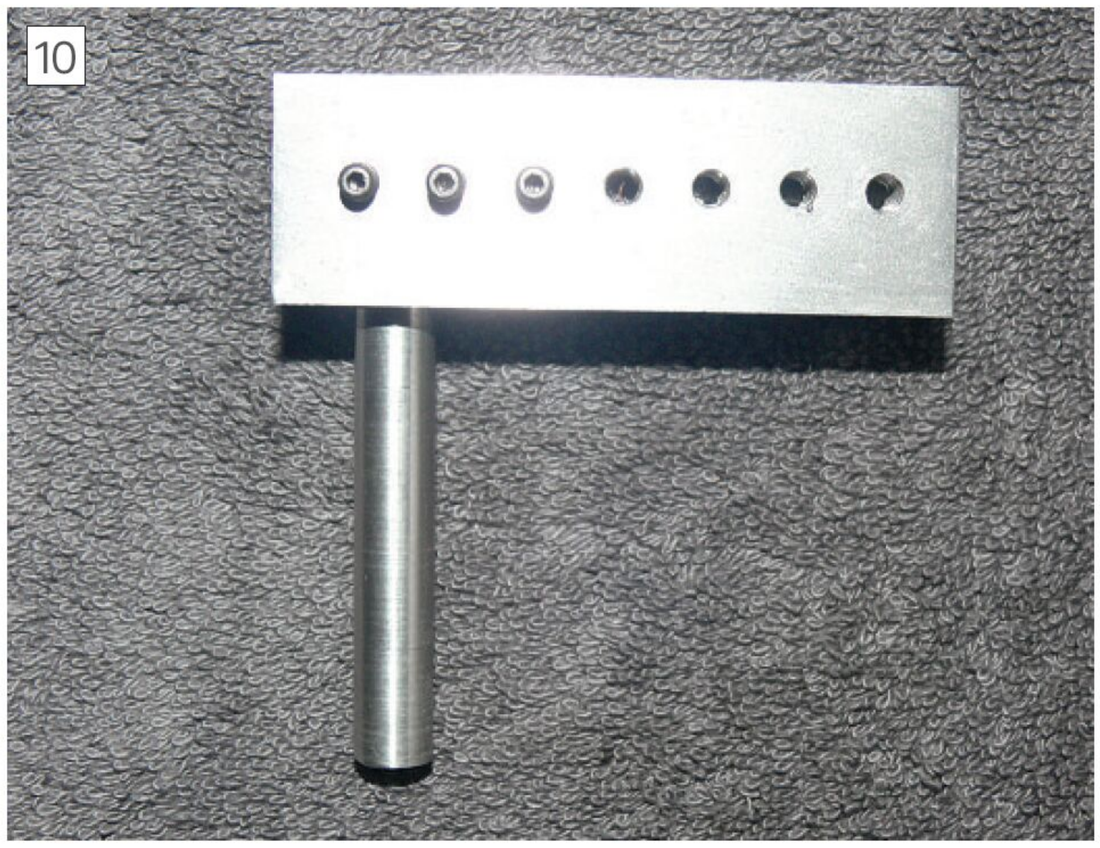
The final small job was to turn up a thrust pad, with a 3/8" stub to fit into holder 1, with a short counterbore to take the thrust screw from the

Holder 1, drilled and tapped.

Holder 2 and the spigot.

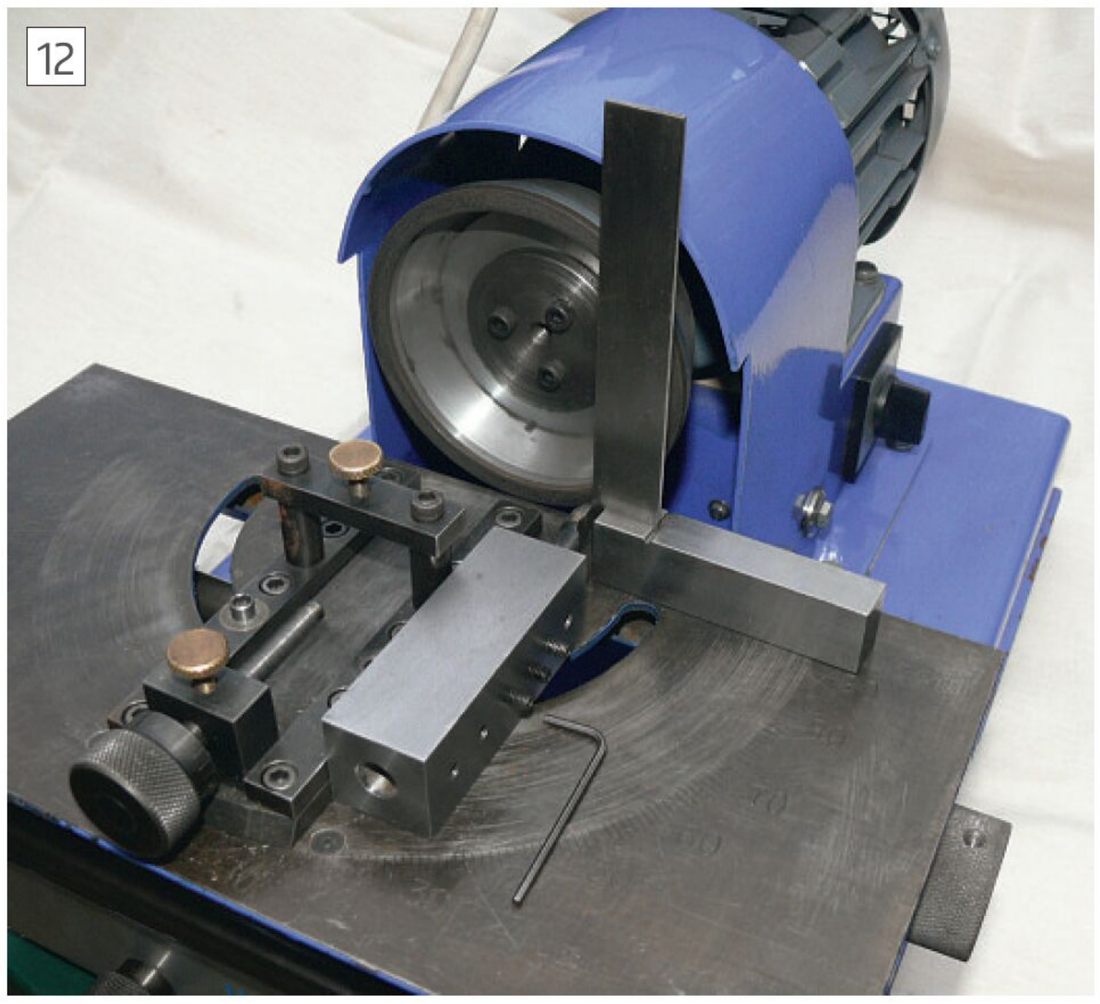


Holder 2 with both spigot tappings.

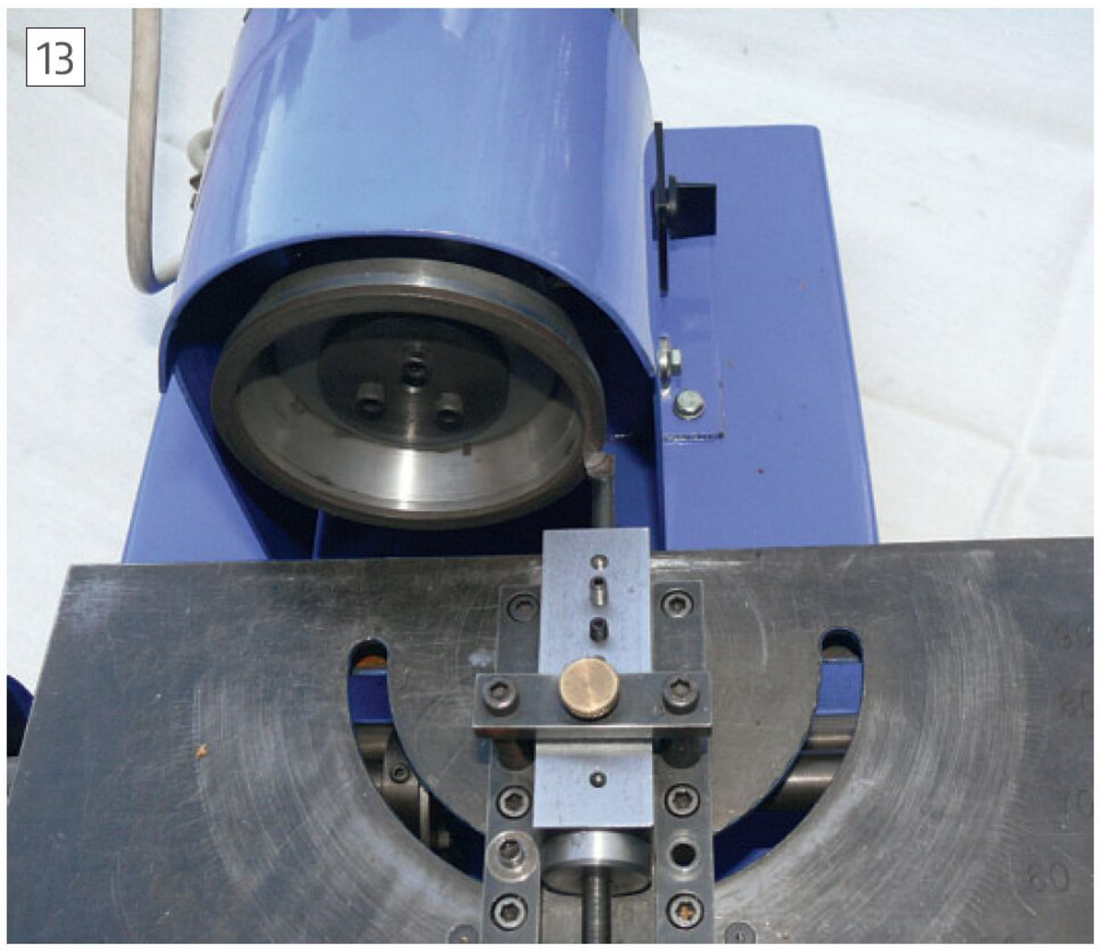


Holder 2 with spigot positioned for the right-hand side of the Worden.

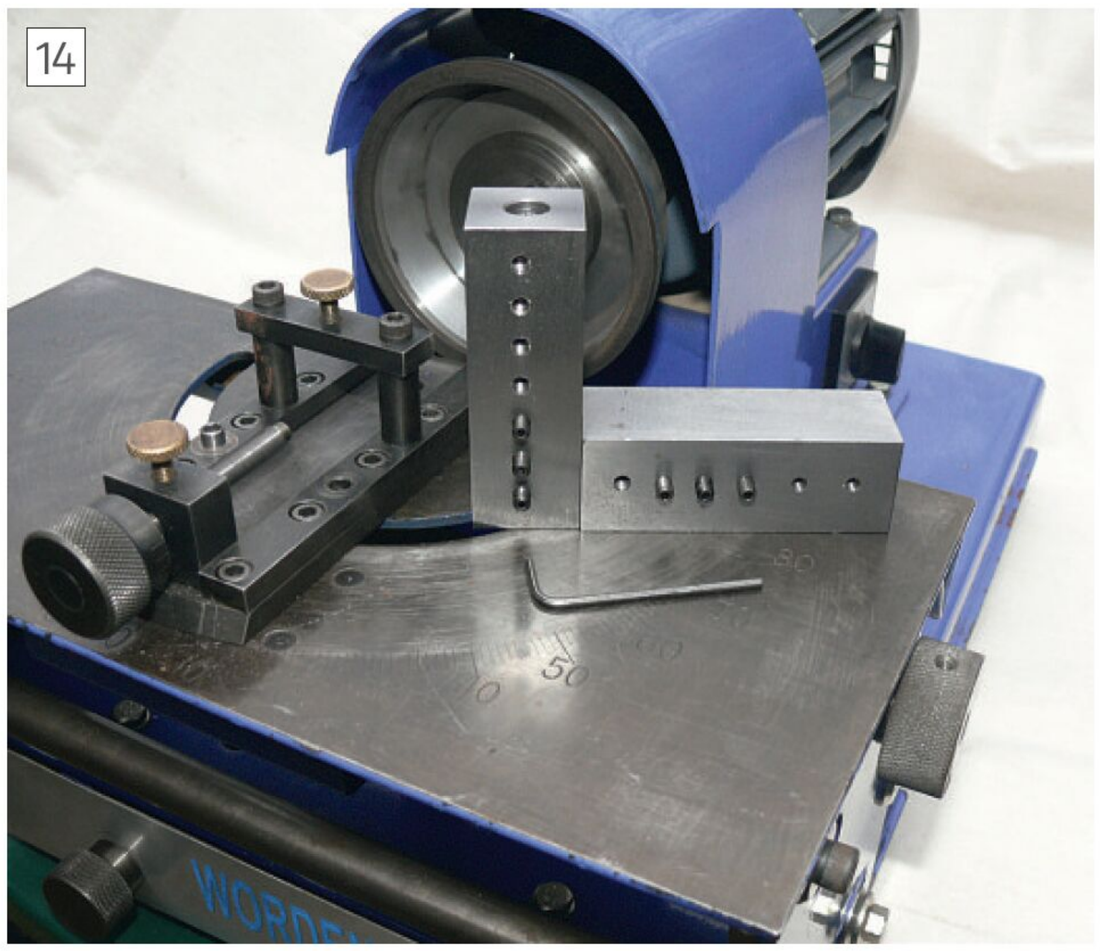
Holder 2 with spigot positioned for the left-hand side of the Worden.



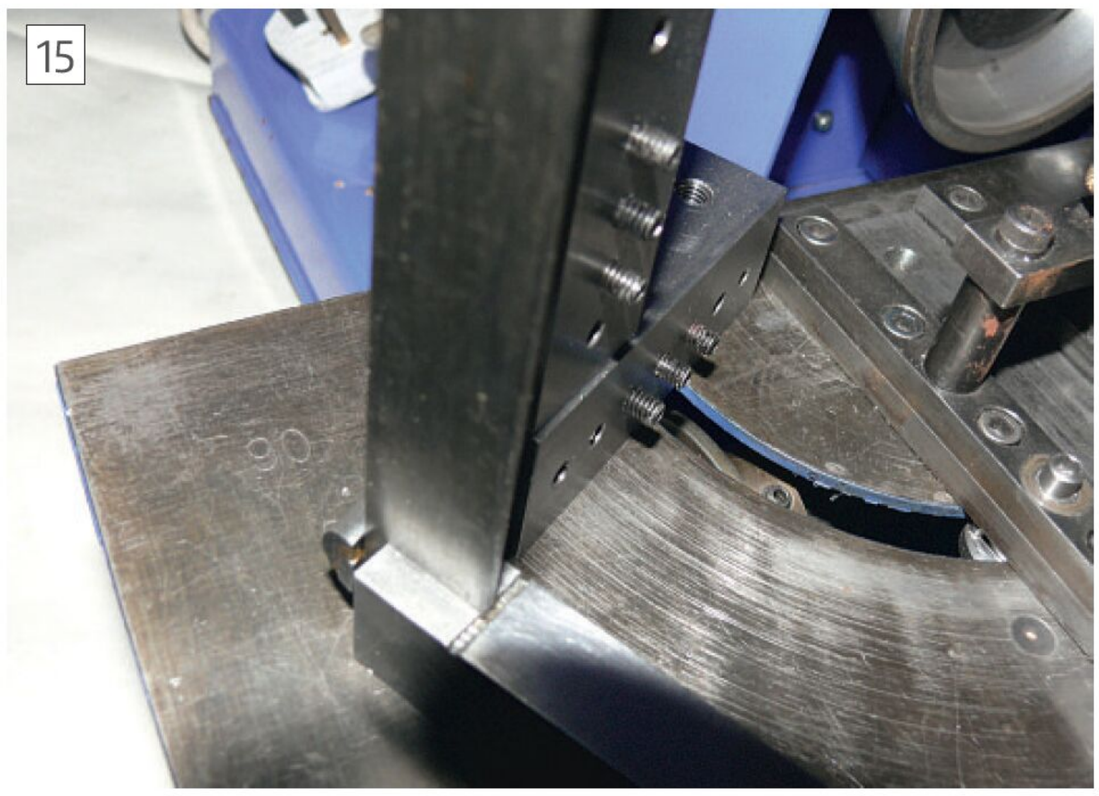
Setting the top face vertical.



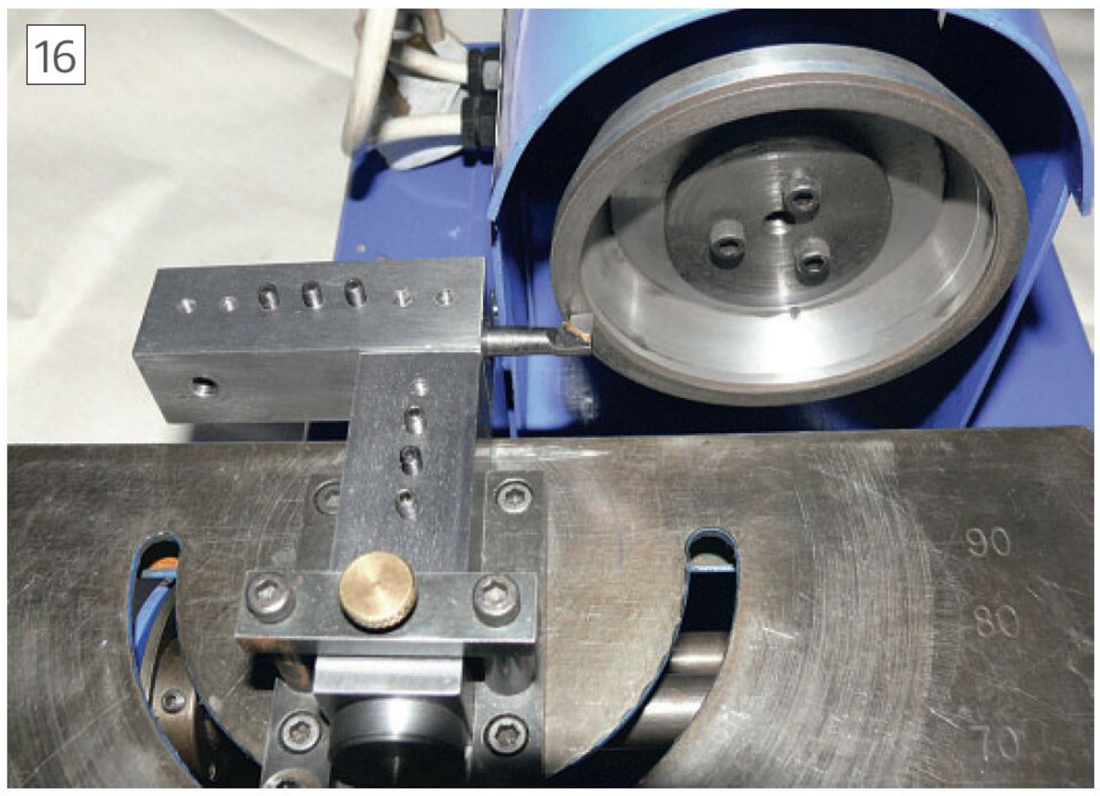
Grinding the front face of the cutter .



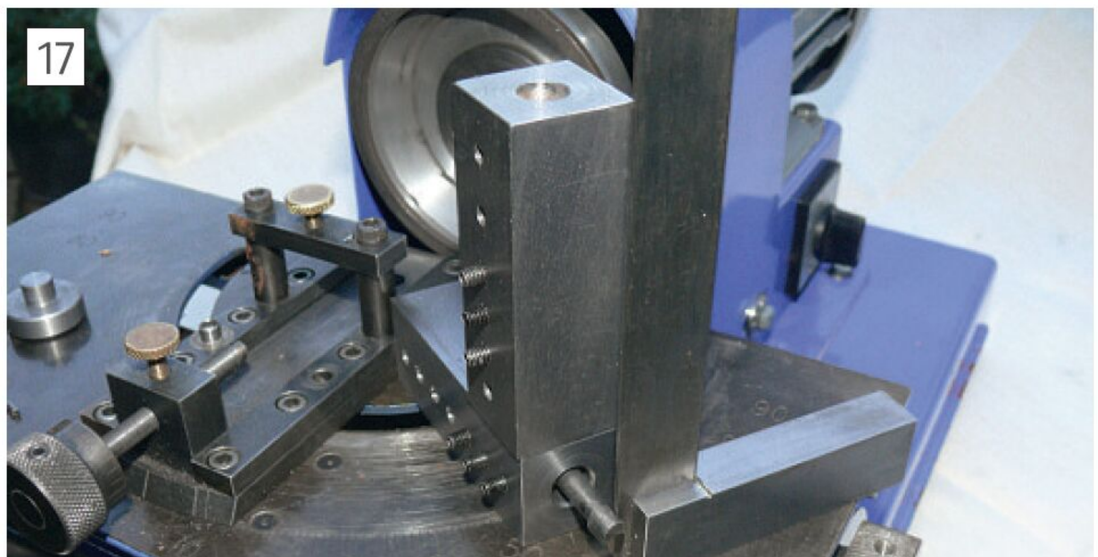
Setting the two holders square.



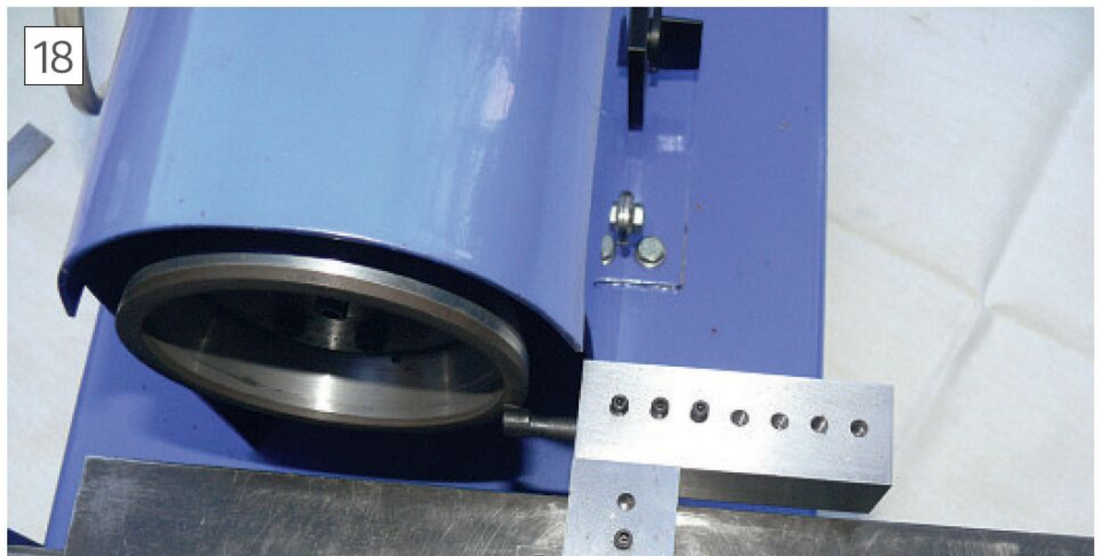
Setting the cutter top face vertical for grinding on the left side..



Grinding the side face (left side).



Setting the cutter top face vertical for grinding on the (right side)..



Grinding the side face (right side).

fixture. This can be seen lying on the table of the Worden, in one of the later pictures. It may be that a second, longer thrust pad will need to be made for some operations, **photo 9**.

Grinding the Cutters

By screwing the 3/8 inch spigot into holder 2, at either end**, photos 10** and **11,** it was possible to fit it to holder 1 for use on either the Right or Left side of the Worden Cutter Grinder.

The cutter was prepared for grinding by setting the top face vertical, before being clamped in holder 1, when it had been rotated 90 degrees "in advance" of the position to be used. This sets the cutter for zero top rake, ready to be traversed across the face of the diamond wheel to grind the front face, **photo 12**.

Initially the table was set square to the face of the wheel, before it was angled upwards towards the wheel to set the clearance angle. The holder slide was set, initially to 5 degrees.

Because the diamond wheel is a fine one, material removal rates are low. So that where the cutter was badly worn, or chipped, as much material as possible was removed by hand using a coarse diamond file.

The diamond wheel was used for the final polish and to set the clearance angles. To maximise the material behind the cutting edge, large clearance angles were avoided. Clearance angles were initially set to 5 degrees, in both planes, but this was later changed to 10 degrees, **photo 13.**

For the side face of the cutter to be ground, holder 2 was set into holder 1, ensuring that the two holders were square to each other, **photo 14**. If the left hand position were to be used to grind the side face the top face would need to be set vertical, **photo 15**, so that it can be ground, **photo 16**

In the left-hand position, the side face could be ground with the table set to the same angle as for the front face, pointing upwards towards the wheel. If the right hand position is used, the cutter is inverted, and the top face set vertical, **photo 17,** so that the side face can be ground**, photo 18.** For this operation, the table would need to be angled downwards towards the wheel to set the clearance angle.

In both these instances, the cutter protrusion from holder 2 needs to be carefully adjusted so that the cutter tip can traverse beyond the face of the wheel, before the table reaches the limit of its travel. Care also needs be taken to ensure minimal risk of the holder colliding with the wheel and being damaged when traversing in the other direction. This means that when grinding the side face of the cutters, using holder 2, the table travel will be very small.

European Space Agency Metal 3D Prints Return from Space

NASA and the European Space Agency expected to receive scientific research samples and hardware as a SpaceX Dragon spacecraft departed the International Space Station on Thursday, December 5, for its return to Earth.

Two specimens printed with ESA's (European Space Agency) Metal 3D Printer, will go to researchers for post-processing and analysis. Researchers will compare the specimens printed in microgravity with those printed on Earth (see the photo). The goal is to demonstrate the capability to perform metal deposition, or the layering of metals, in 3D under sustained microgravity conditions and manufacture test specimens. Researchers aim to understand the performance and limitations of the chosen technology and become familiar with crewed and remote operations of the instrument onboard a space habitat.

The Metal 3D printer was launched aboard a Northrop Grumman Cygnus Vehicle and installed in the ESA European Drawer Rack Mark II (EDR2). EDR2 provides the Metal 3D printer with power, data, and cooling, as well as a venting and N2 connection.

Upon arrival and unpacking aboard the Columbus Module, the Metal 3D printer was opened and configured for a printing sequence. Configuration is done by the crew and involves removing the launch locks (for the first print only), placing a HEPA filter and the substrate (on which the sample is printed), and feeding the printing material wire in its feeder.

Following the configuration, the Sealed Container is placed in EDR2, and connections to the EDR2 Utility Distribution Panel established. Commissioning of the Metal 3D printer, as well as printing operations, are performed by the User Support Center CADMOS in Toulouse, France. No crew time is required in this phase.

Prior to printing, the oxygen (O2) level is reduced to 0.1 % by a number of cycles flushing the printing environment with nitrogen (N2) and venting the printing environment. During printing, apart from housekeeping data, print-related data is downlinked for monitoring of the printing process and progress. This data includes photos and videos of the printing progress, as well as data of the printing environment such as pressure, temperature, and O2 level.

After the printing is concluded, the crew is tasked with retrieval of the Sealed Container Assembly from EDR2 and – after opening the printing environment – retrieval of the printed specimen, attached to the initial substrate from the Additive Machine and pack for return of the printed specimen.

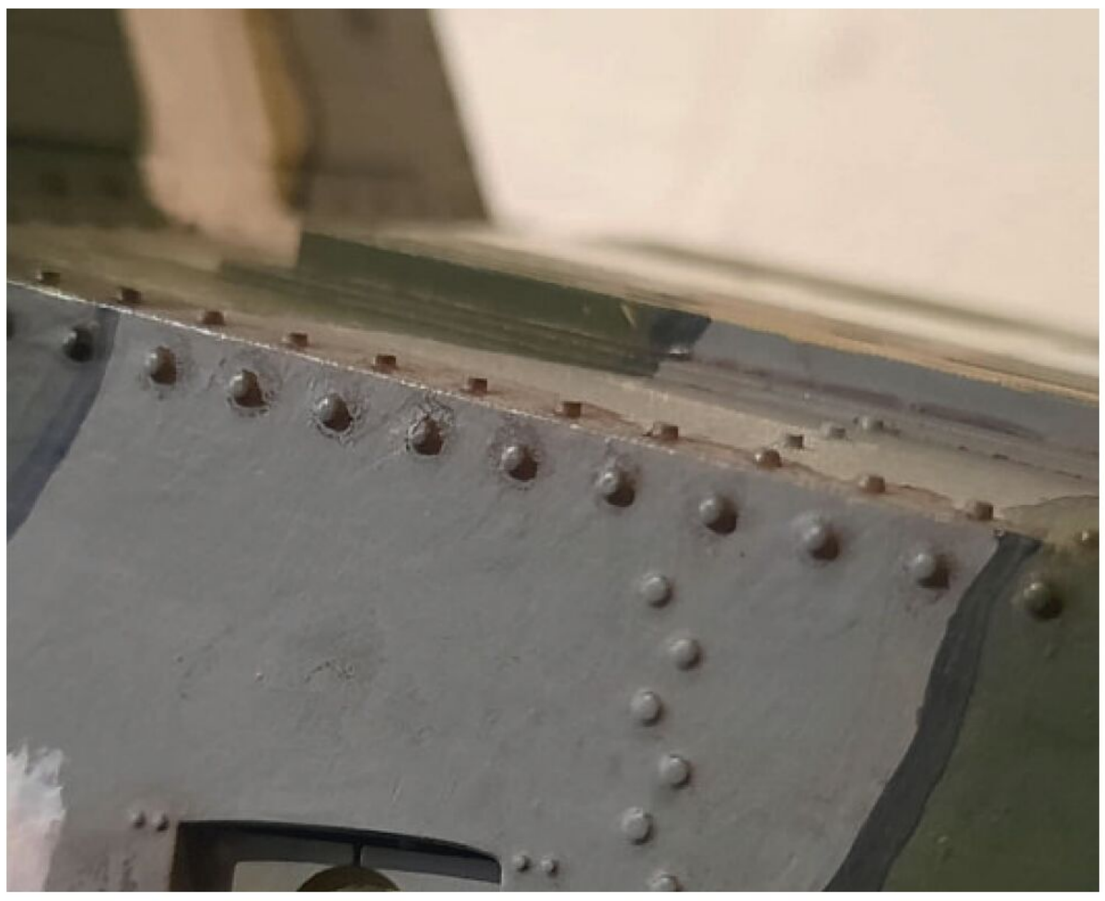
After retrieval of the printing specimen, the Metal 3D Additive Manufacturing machine is reconfigured for the printing of a new specimen, closed, and placed in the EDR2 again. Four specimens are planned to be printed with the Metal 3D printer and returned to Earth for processing and analysis.

The Midlands Garden Rail Show

Plans are "on track" for the 2025 Midlands Garden Rail Show taking place on Saturday 1st & Sunday 2nd March for one of the leading model railway events dedicated to garden rail At Warwickshire Event Centre.

This event features the larger gauges of O Gauge, G Scale, Gauge 1, 16mm and more. There will be over 15 layouts and clubs at the event. Plenty of inspiration if you are planning your own garden railway be it live steam, gas or coal fired.

Lifecolor Liquid Pigments



If you are someone who likes to 'weather' your models for a more realistic appearance, then the Lifecolor Liquid Pigment range, from Airbrushes.com may be just what you need. The "Tanks & Vehicles" detail emphasiser set contains five pigments that are applied to a wet model, and run to fill in corners, panel lines and emphasise details. They are easily removed with water or the supplied cleaner or can be fixed with a coat of suitable spray lacquer. The effect need not be exaggerated or 'cartoonish' – in the example we've highlighted the horizontal line of rivets, but not the vertical one. Visit airbrushes.com for more details.

Readers'Tips

CHESTER MACHINE TOOLS

Choosing Alternative Screws

TIP OF THE MONTH WINNER!

UNC screw size	nearest metric screw size
2 - 56	M2 / M2.5
4 - 40	M3
6 - 32	M3.5
8 - 32	M4
10 - 32	M5
1/4 - 20	M6
5/16 - 18	M8
3/8 - 16	M10
7/16 - 14	M10 / M12
1/2 - 13	M12

This month's winner is Keith Keen with a tip in a different format this month. He's put together an 'equivalence table' for substituting Metric and UNC threads.

I am putting together some CAD drawings in metric dimensions for a Stirling Engine, based on an American design which is shown in Imperial dimensions. The American drawings show various tapped UNC screw threads which I would change for near size metric threads. To do this, I have made a table of metric screw sizes which are near(ish) to UNC threads, and which might, perhaps, be useful to other readers doing the same thing.

Keith Keen

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.

RAILWAY MUSEUM

YOUNG RAILWAY PHOTOGRAPHER OF THE YEAR

CALL FOR ENTRIES

Win prizes and the chance to be exhibited at the National Railway Museum

youngrailphotographeroftheyear.co.uk

Image: 'Kings Cross reflected', Bradley Langton, 2021

The Midlands Model Engineering Exhibition 2024

Neil Wyatt, MEW Editor, concludes his report with a closer look at tooling at the Show.

It's a long time since I last saw a Rodney Milling Attachment.

There were several lathes around the show this year, and as far as I could see they were all Myford lathes, mostly Super 7s. Myford themselves were present with a wide range of spares and accessories as well as new machines. A great relief for those who worried that this important name in model engineering could disappear after the original company's troubles several years ago. As well as the two machines loaned to SMEE by 'new' Myford, there were also several second-hand Myford machines including what I think was a Speed 10, and fitted to a Super 7, one of the rater scarce Rodney Milling Attachments, **photo 23**.

There was plenty of materials and tooling on sale, new and second-hand, **photos 24, 25, 26** and **27**. On the Blackgates Engineering stand I

An impressive selection of used tooling on one of the trade stands.

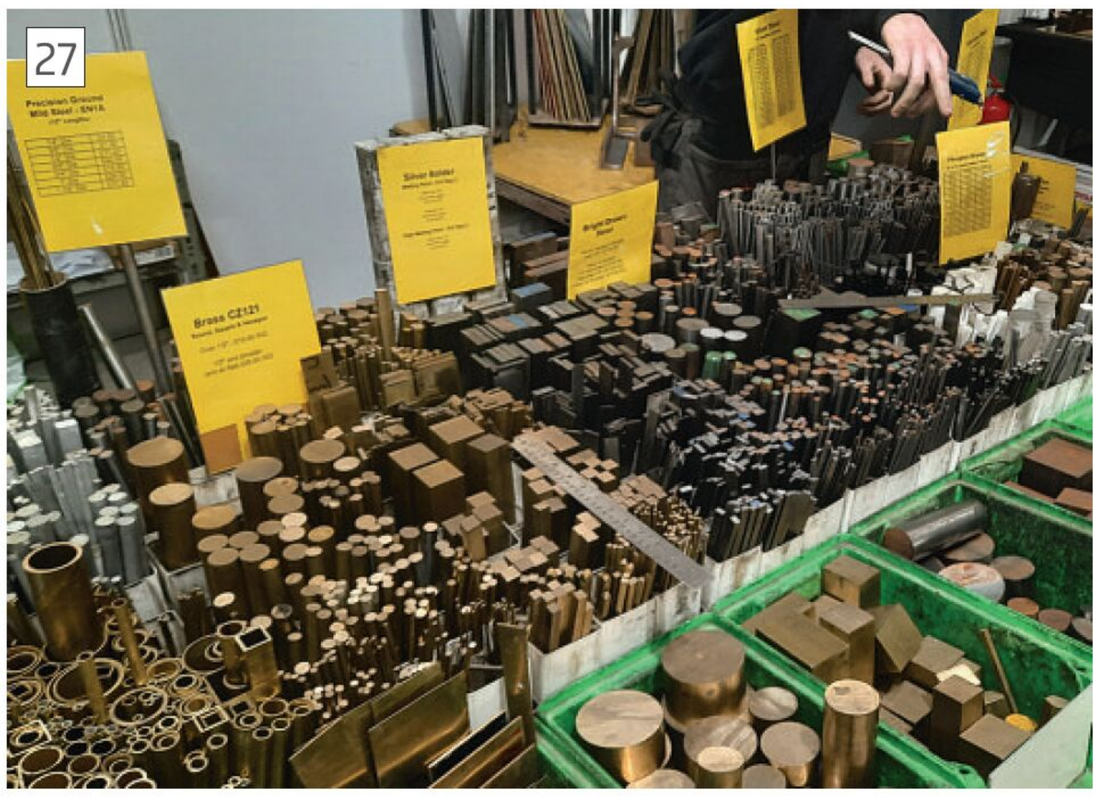
25

EKP Supplies had a large selection of fixings.

26

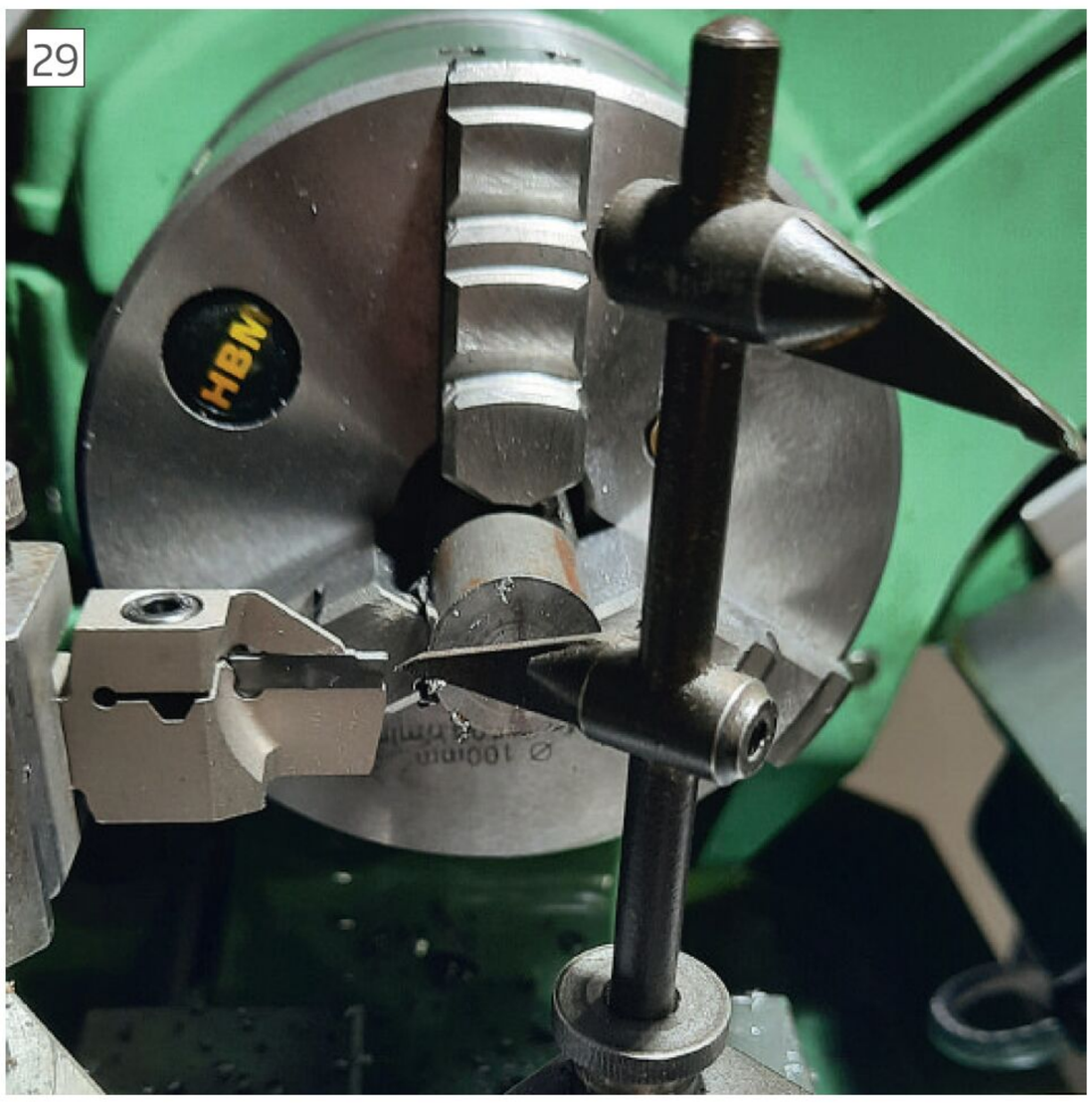
RDG Tools had a large and well-stocked selection of new tooling.

27



An impressive selection of raw materials.

29



A rather neat height setting gauge.

28

The 'Chobert' blind riveting tool.

›

A large gauge locomotive wheel quartering jig.

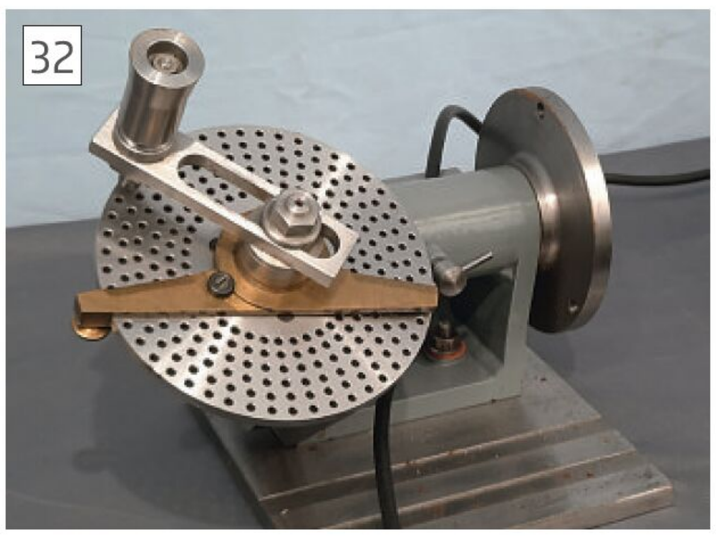
This design for a taper turning attachment caught my eye.

was intrigued by a Second World War "Chobert" blind riveting set, **photo 28**. This looked very different from the much simpler 'pop-riveting' tools am familiar with. Having done some research, I was surprised to learn that the blind-riveter was invented as long ago as 1916 by Hamilton Wylie!

Of particular interest were the tools made by hobby engineers like us! **Photograph 29** shows a height setting gauge by Alan Hopwood being used to set a parting off tool for an SMEE demonstration. The tool was held in a Dickson-type quick-change toolholder that had been machined away underneath to allow it to be lowered sufficiently, something I've had to do for one or two of my own tools. A robust quartering jig for locomotive wheels by Peter Fairhurst was to be found on the Melton Mowbray and District MES stand, **photo 30**.

A taper turning attachment for a 5" Raglan lathe was exhibited on the Wolverhampton MEW stand, **photo 31**. If anyone can put me in touch with the builder, I would be interested in an article as this design looks both relatively straightforward to build and easily modified to fit other lathes. Other nice tooling on the same stand were a knurling tool by I.D Priest and a slotting tool by K. Breeze.

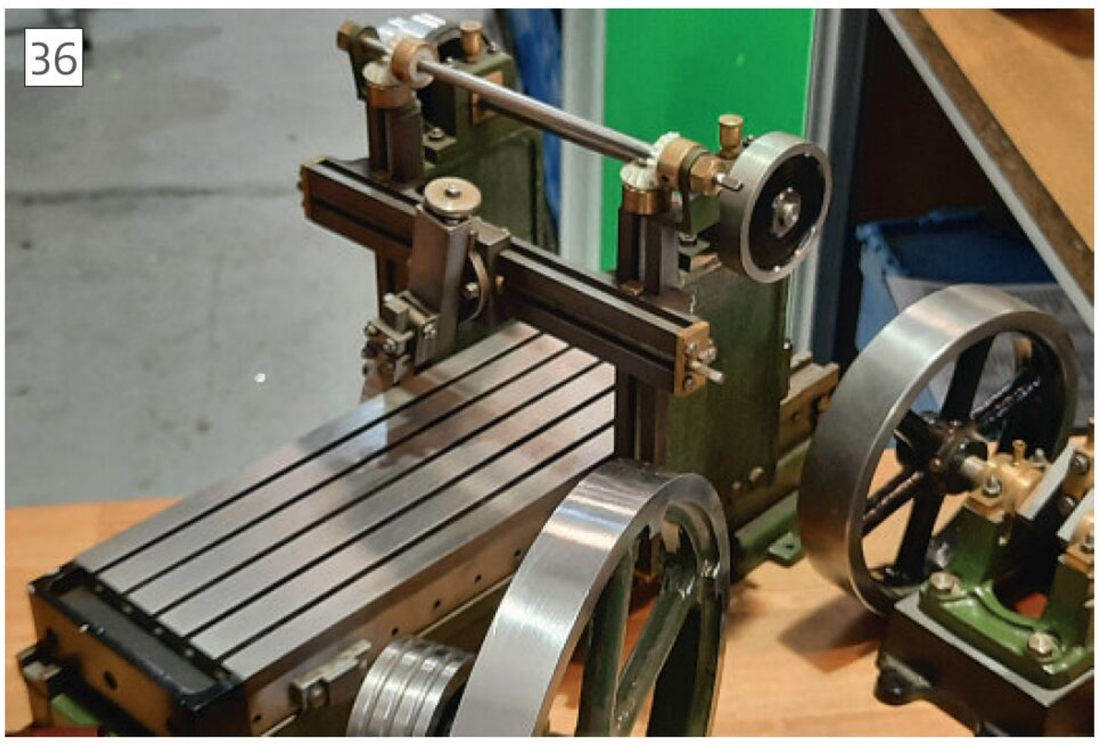
Photograph 32 shows a more traditional dividing head on the Erewash Valley MES stand, a lovely, neat tool. The Society of Ornamental Turners were doing some fascinating demonstration of their craft, which creates ornate pattern and shapes using complex chucks, reciprocating spindles and more, **photos 33** and **34**. Their stand included a fascinating display of 'modern copies of antique equipment' by Tony Brooks, **photo 35**.



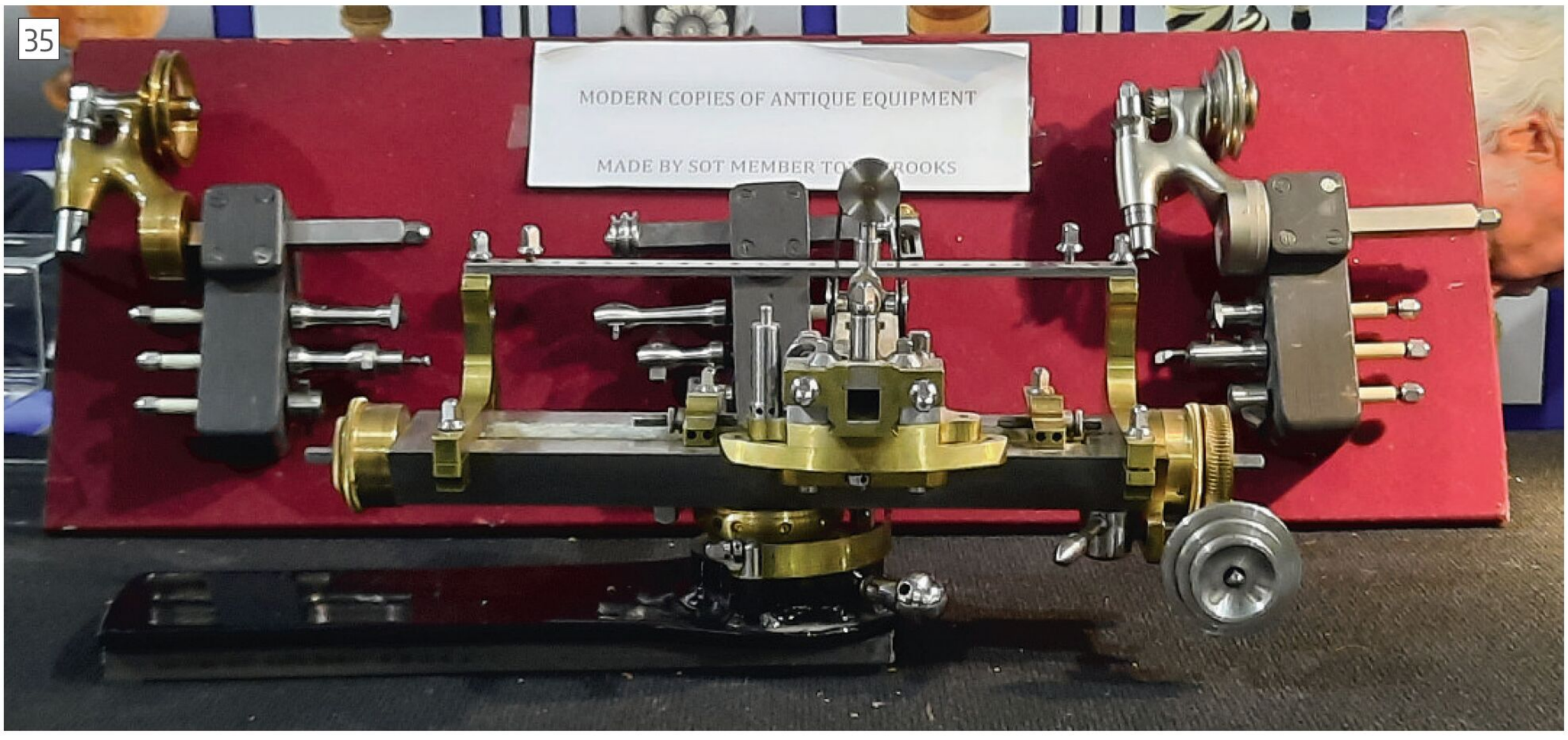
A very nice dividing head on the Erewash Valley MES stand.

Rose turning.

The ornate pattern created in African blackwood combining just three patterns on the rose engine.



Working model planer on the Stuart Models stand.



This display showcased some of the unusual tools used by ornamental turners.

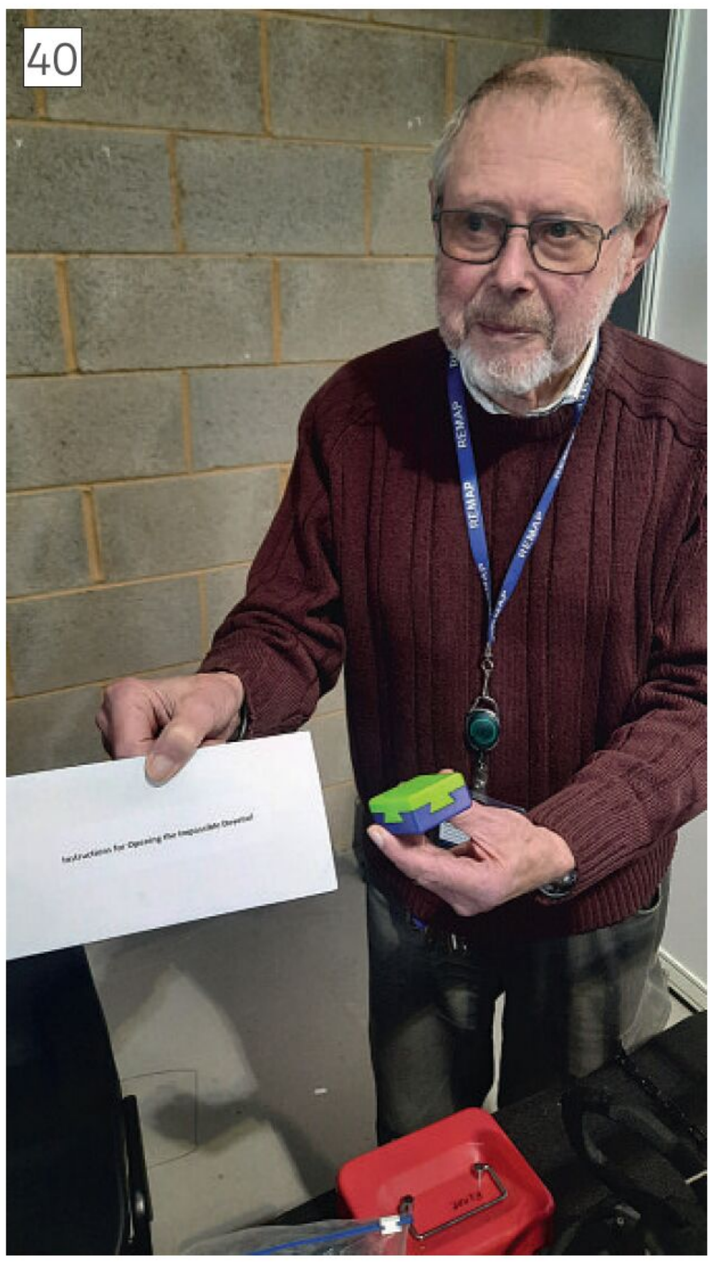
Excellent work by a young engineer on the Herefordshire MEWS stand.

Wally syke's tool and cutter grinder.

Three nice pieces of tooling by Wanda Sykes.

Noel Shelley's mystery tool.

Another view of the mystery tool.



The Impossible Dovetail on the REMAP stand.

There was plenty of shop made tooling this year, but models of tooling were a little scarce this year. The miniature planer (like a shaper but the bed and the work moves instead of the tool) in **photo 36** was rather noble exception, on the Stuart Models stand; it is fully working and castings are available.

The award for the best club stand went to Herefordshire MES, who as always were showcasing some of the outstanding work by their junior engineers, **photos aa** and **as**. The youngsters are mentored by club members including Wally Sykes who exhibited an impressive 'Quorn-inspired' tool and cutter grinder, making good use of hydraulic ram parts, **photo 38**. His wife, Wanda Sykes, is also becoming skilled in the workshop, exhibiting two nicely finished fly cutters and a wobble broach for square holes, **photo 39.**

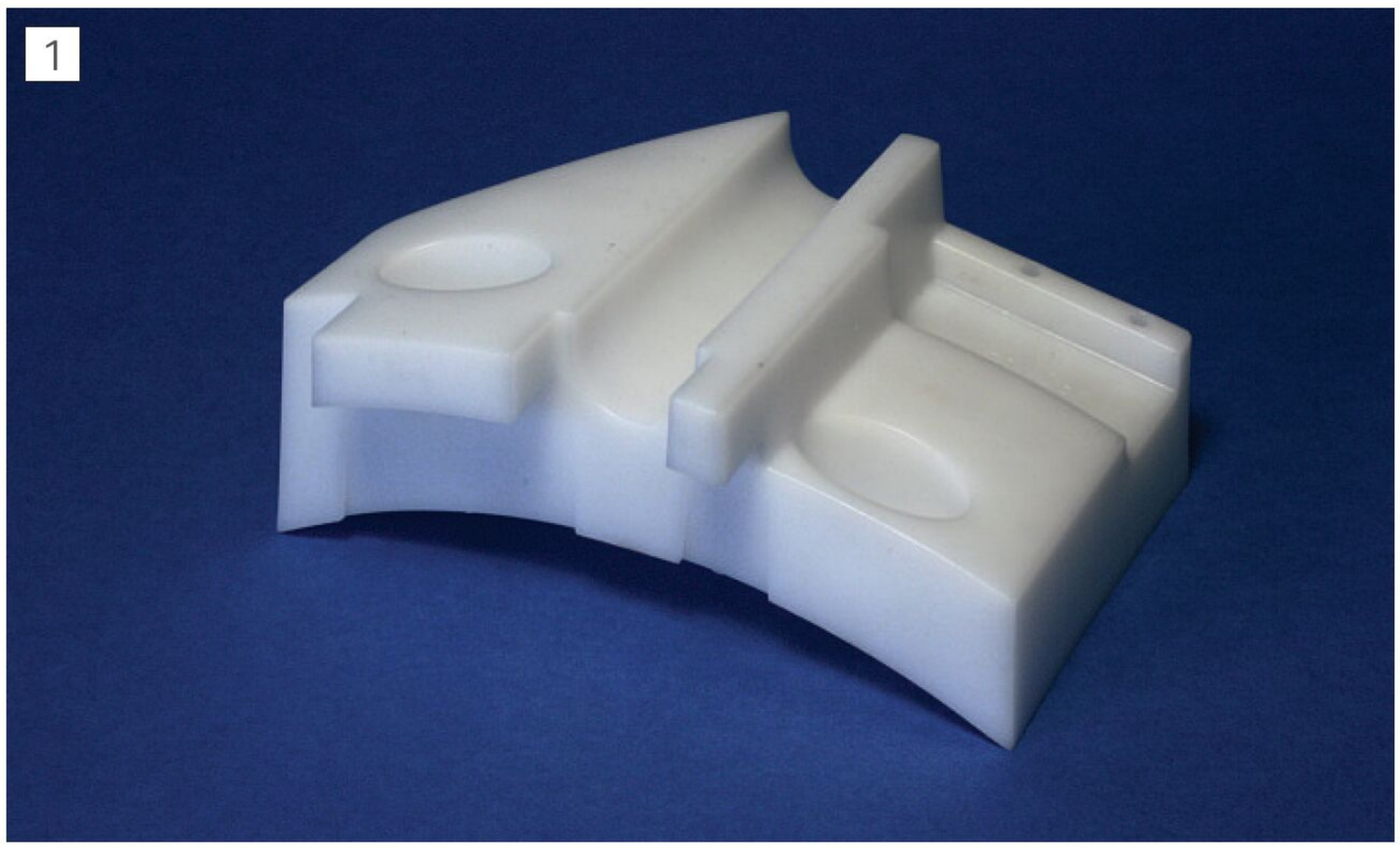
Finally, some fun items. REMAP's stand featured a 3D printer and the blue and yellow object in **photo 40,** which was an "impossible dovetail" that could only be opened with a special technique, written down in a sealed envelope! I could share the solution with readers, but where would the fun be in that? I'm sure most readers will be familiar with REMAP as the charity whose volunteer engineers help people with disabilities overcome challenges with custom adaptations and equipment. **Photographs 41** and **42** are two views of a device Noel Shelley was challenging showgoers to identify. I can be smug as I successfully identified it, having needed to bodge a similar too in the past. If you know what it is and especially if you have a tale to tell about its use, send an email to me for Scribe a Line. For those in the dark, I'll reveal the identity of this mystery tool in the next issue.

I have plenty more photos from the exhibition, but space has run out. I must finish by saying that this year it felt like the exhibition was fully back on its feet after the disruption of covid. It's a shame that other exhibitions have not been able to recover, so please come along to MMEX next year, and any other local exhibitions. If nothing else, they are a great way to get some inspiration and meet other hobbyists. I hope to meet you there in October 2025.

A Guide Block Challenge

Asked to produce some special parts with an awkward shape, Marcus Bowman made use of new technology to make a series of jigs for the task.

I'm sure you know the situation. Once your friends know you have a workshop, its not long before someone arrives at the door with a "Could you just..?" So it was no great surprise to get a request to help out on an urgent job which appeared deceptively simple. **Photograph 1** shows a finished item which is one of three identical guide blocks for a large diameter tube which forms part of an entry barrier. **Photograph 2** shows that the guide blocks are attached to the outer surface of the tube and engage with three 25mm diameter guide bars which keep the tube vertical as it rises and falls. The timescale was, as usual, for 'yesterday' - oh, and there are three of these assemblies, so the job is for nine guide blocks. There's nothing like a challenge, right?

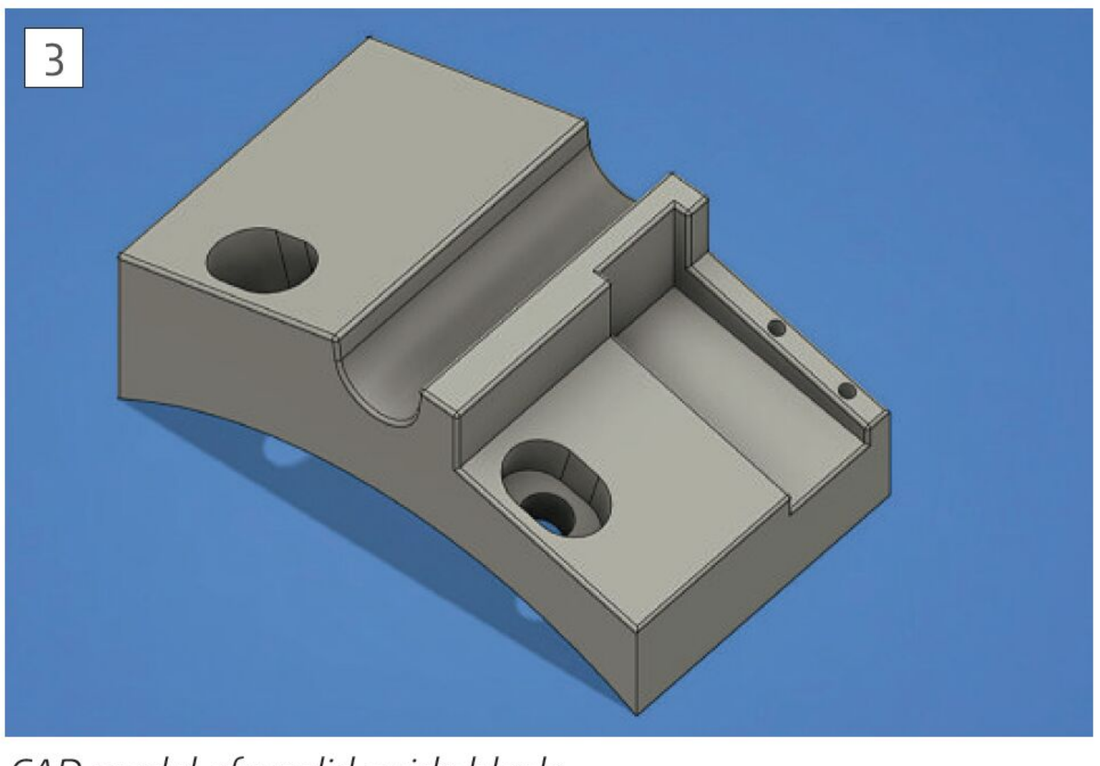


An uprated injection moulded guide block.

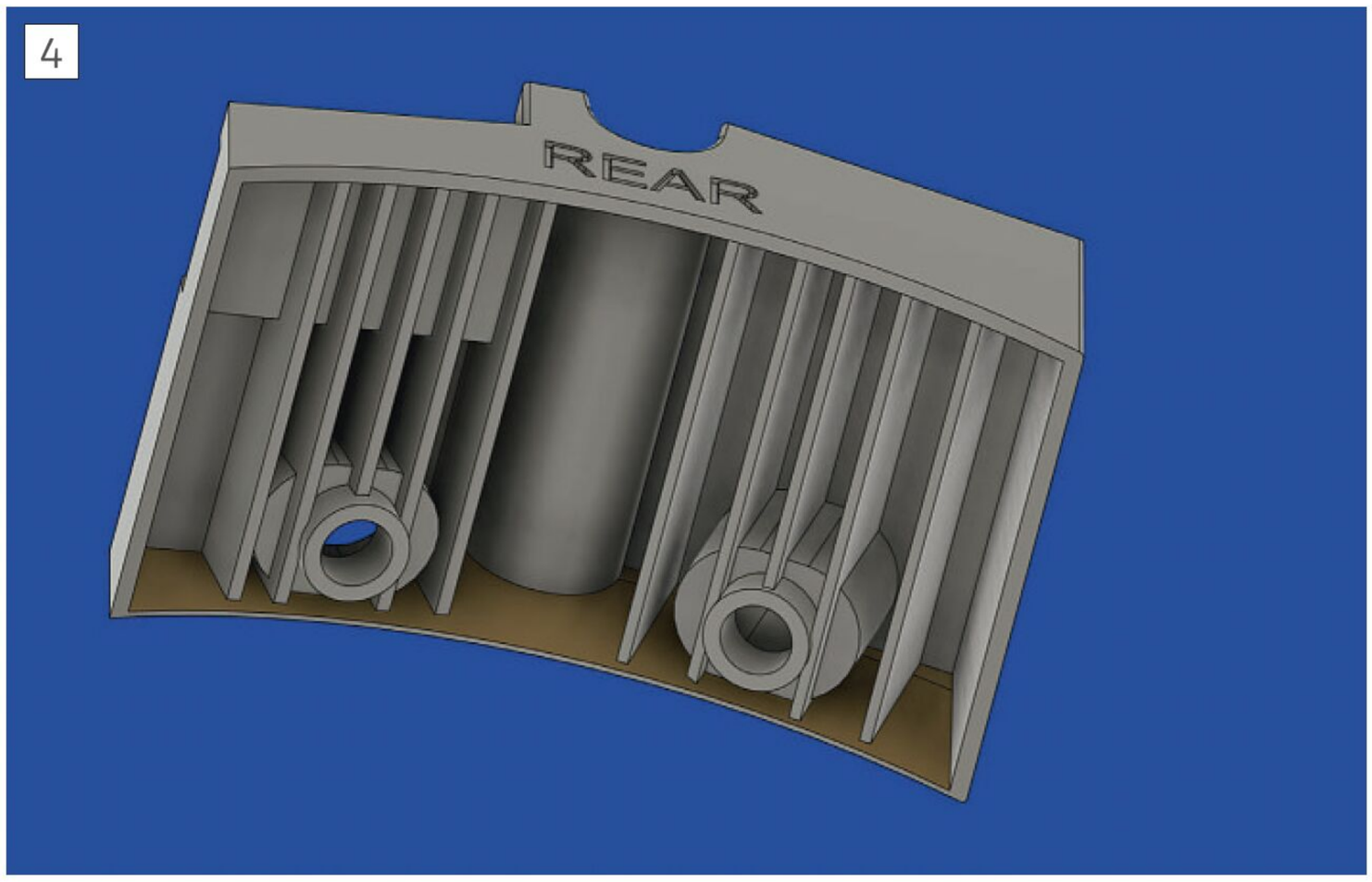
Design

The problem with this installation is that the tubes, guide bars and guide blocks are located in a set of leaky concrete tubes below ground level in an area with a high water table and operate in a thick sludge which acts as a very effective abrasive. The original blocks were tiny, roughly the size of my thumb, and had to be renewed at regular intervals. Each renewal involved a road closure, a crane, a jet washer and three men; so not a trivial undertaking. A manufacturer's upgrade provided a much larger wearing surface (as in photo 1) but this had been produced by injection moulding, and had relatively thin walls. The lead time for supply was several months, and one of the barriers had already been removed requiring urgent repair, so time was pressing. In this case, the operating environment suggested that solid blocks would be required to withstand the hostile abrasive conditions for a more reasonable time interval between repairs. After measuring the tube and the vertical rods, a solid guide block was drawn in Fusion 360 and designed to allow manufacture on the milling machine with standard cutters, **photo 3**. Drawing in CAD does tend to reveal the significance of particular features, like the oval pockets for the bolt heads, which prevent the heads from turning as the nuts are tightened from inside the column; the sloping sides to release the moulding from the mould – not required on a block milled from solid; and the recess to hold the magnetic position sensor. CAD

Guide blocks in position between the central tube and the guide bars.



CAD model of a solid guide block.



CAD model showing the underside of the test print, open underneath, and with reinforcing ribs. The brown face has a built-in slope.

also allows dimensions to be altered easily. In this case, the tricky part was determining the exact radius of the large curve so that the finished block would sit snugly against the side of the tube. Careful measurement and the use of a cardboard test piece showed that the tube was of a standard diameter (274mm). Six of the blocks were to be identical, and the other three had additional arms protruding from the front face.

Bearing in mind the hostile abrasive environment in which the guide blocks must operate, acetal (often referred to as POM-C) was chosen as the most practical material for the blocks.

The test piece

To create a test piece, I took the solid CAD object and used the SHELL command to create a hollowed-out version, then the RIB command to help add some internal ribs connecting the top and bottom faces, **photo 4**. I exported the CAD design as an STL file and 3D printed one block using a resin printer, to allow the design to be tested in place on the column. I chose to print using resin rather than filament, because the accuracy and finish would more closely resemble the final machined surfaces of a block. The downsides are that resin printing is slightly more expensive, requires an additional clean-up, and takes longer than printing with filament. The test block was printed with a 3mm skin supported by ribs but omitted the large, curved surface on the underside, to speed up the printing process, to minimize the amount of resin required, and to make the print as light as possible. In a resin printer, the print hangs downwards from the build plate and a solid print of this size may be sufficiently heavy for gravity to pull it off the build plate, causing the print to fail. The print was orientated so that the flat 'rear' side was against the build plate (to avoid having to create supports for parts of the face which did not touch the build plate). On the CAD drawing it would be easy to do the logical thing and retain the 'bottom' curved surface which enclosed the ribbed interior but printing it that way would require drain holes through the lowest face, to allow uncured resin to escape from the inside during printing. After printing, the partially-cured resin must be fully cured by direct exposure to UV light, but resin inside a closed interior will not be exposed and will not cure fully, so it will have reduced strength.

In theory, the block could have been printed with one of the side faces against the build plate. However, that would have resulted in the ribs lying horizontally, which gives rise to another type of problem. When the print reaches the first rib, that layer is attached to existing edges on two sides and the 'top' of the block, but the other ('bottom') edge is unsupported. Because of the length of the rib, and the thin layer of resin that will lie against the bottom of the tank, distortion is likely as the build plate rises and falls. That edge of the new layer will tend to move as it is pulled through the resin, upwards then down again to just above the bottom of the tank. There is a real danger that the edge is not stable when the next (adjacent) layer is cured, and the rib will be malformed. To avoid this kind of effect, it is better to orientate this type of feature vertically rather than horizontally.

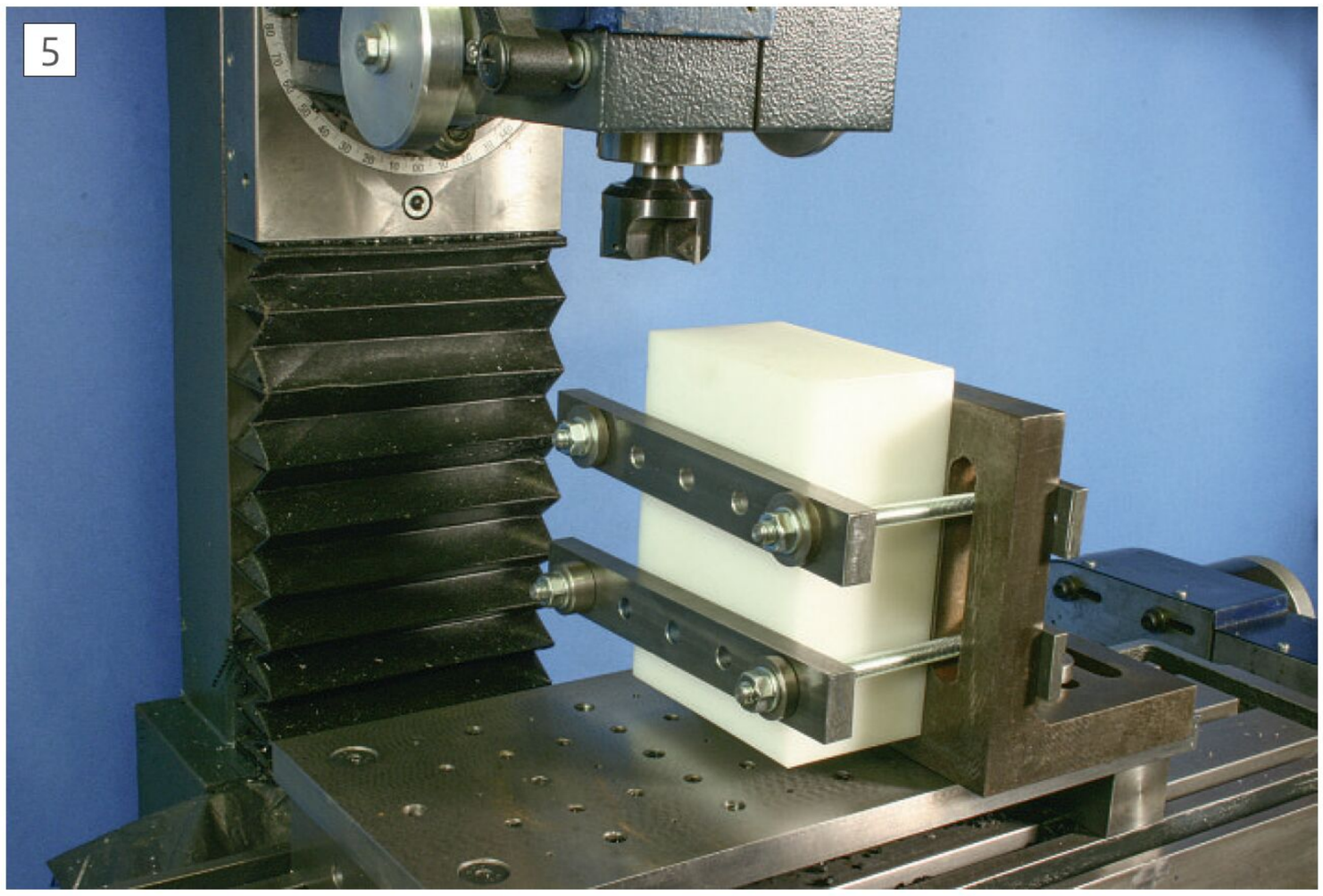
The lowest face (coloured brown in **photo 4**) is tapered inside, from 3mm thickness at the inside corner, to 1mm on the outside edge. That encourages the resin to run off that face, which would otherwise be a horizontal ledge. Leaving the block on the printer for a few minutes once printing has finished allows uncured resin to drain back into the vat, and the taper on the lower inner face helps. That kind of feature is easy to incorporate at the drawing stage.

The workholding challenge

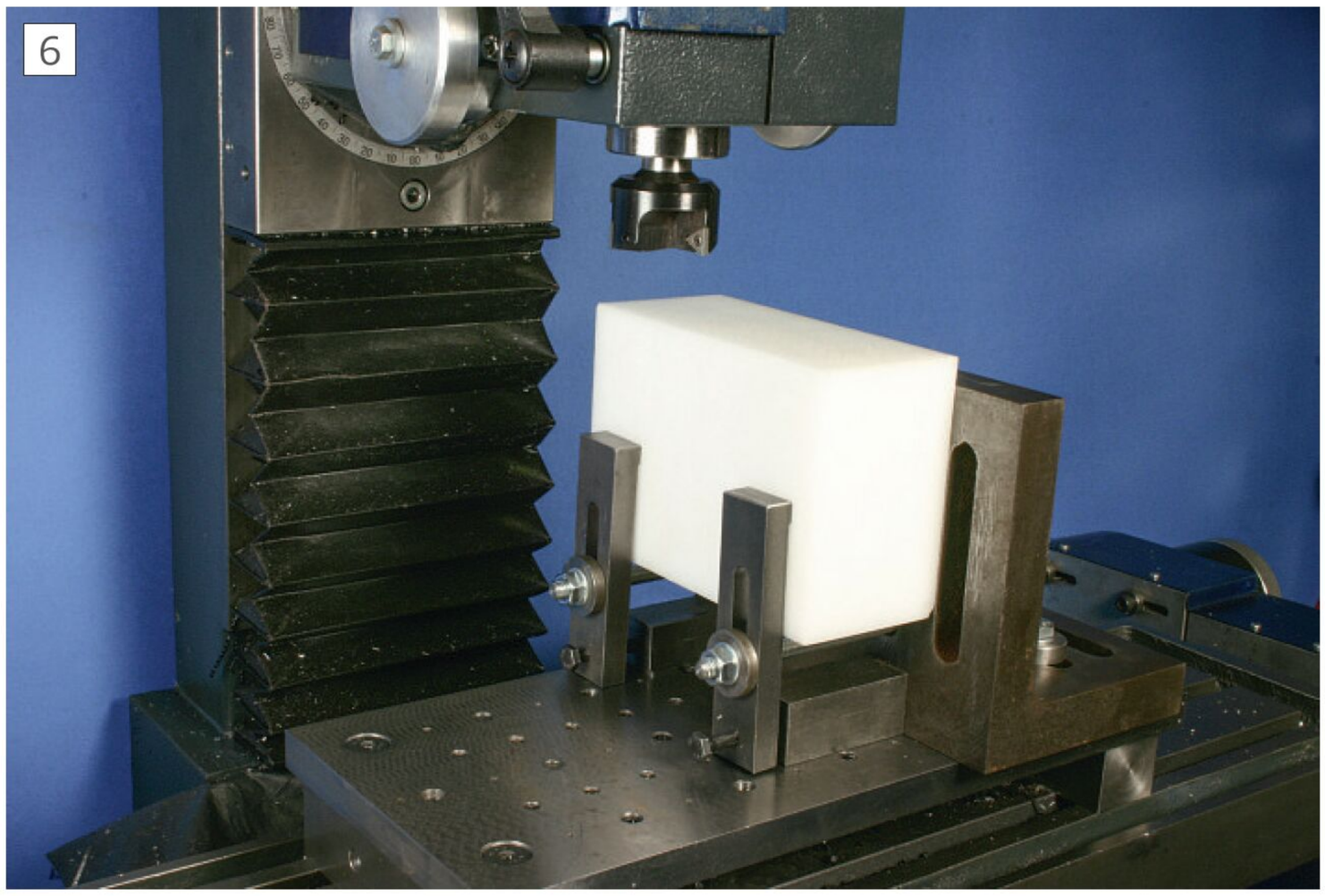
The drawing process was quite straightforward, but there were challenges in manufacturing the shape.

Firstly, large blocks of Acetal are not easily obtained, so I had to buy two long strips sawn from a 60mm thick sheet, then cut those into 10 pieces, giving me one spare. This is not a cheap option. Acetal is easily cut on the reciprocating ('donkey') saw, or a bandsaw. The blade must be razor sharp with a coarse pitch, and 10TPI works well because the coarse pitch allows a rapid rate of cut that avoids softening the plastic and causing the saw blade to bind. A 6TPI blade cuts more quickly, but it tends to be more difficult to start a cut without stalling the saw. In theory, Acetal can be cut with a hand-powered hacksaw, but good luck finding a 10TPI blade. A wood saw should do the job, but modern coarse pitch 'hardpoint' wood saws don't have enough kerf and tend to bind as the cut progresses. That's a problem when cutting wood too, of course.

Secondly, each guide was made from a block measuring 60 x 110 x 150mm and the problem was going to be holding the work on the mill table for some operations, particularly after the



A block mounted on an angle plate to allow the 'left' end to be skimmed at right angles to the 'bottom' face.



A block mounted so that the 'front' face can be skimmed at right angles to the 'bottom' face and to the 'left' face.

large curve had been cut. The 110mm dimension meant there would be little Y axis travel to spare, and insufficient room for decent clamps. The angled faces would involve holding the block tilted at 14 degrees to machine one face, or at a 12.5° tilt to machine a second face, all while ensuring the block was held securely during cutting.

The third challenge was going to be producing the large-radius curve on the underside, and the upper groove with the semi-circular bottom.

A lesser problem would be the radial holes for the bolts, and the shaped pockets for the bolt heads, because these could be machined while the block was tilted so that the sloping sections of the top face were horizontal.

Finally, producing the slot between the protruding lugs on three of the blocks meant standing the workpiece on its end, which presented its own workholding challenge.

All in all, this looked nothing like a straightforward job.

Overall holding strategy

The block is a cuboid, so we need 3 reference faces, and I chose the bottom, left side, and front face, marking those with a pencil. If each block uses the same reference faces, we can locate the work easily and set the positions of the various features consistently from those faces. The bottom surface was one of the as-supplied finished surfaces of the sheet, this was flat enough to be used as a reference. The left side and front faces are cut surfaces, so those need to be cleaned up to set them at right angles to the bottom, and to each other.

Given the size of the block, skimming the faces was a job for a conventional cast iron angle plate, **photos 5** and **6**.

Left and right end faces

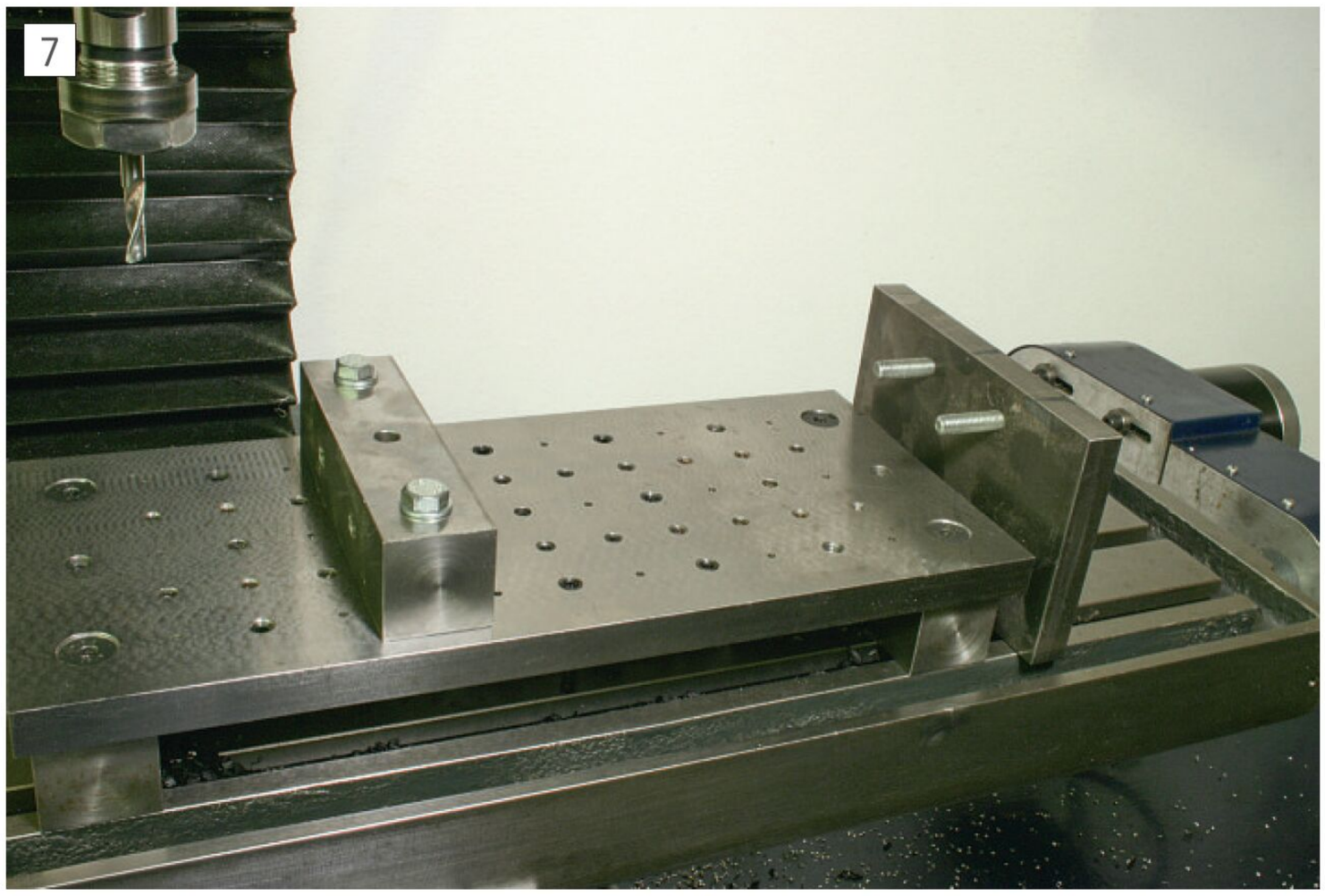
Set the angle plate parallel to the Y axis; put the 'bottom' reference face of the block against the plate, and clamp the block lightly, keeping the lower face a few millimetres above the table. Use a square to set the as-yet-unmachined side face approximately vertical, tighten the clamps, then skim the upper surface to create the 'left' end reference face. Turn the block end-for-end, putting the 'left' end face on the mill table and the 'bottom' face against the angle plate, then skim the uppermost 'right' end to bring the block to length.

Front and rear faces

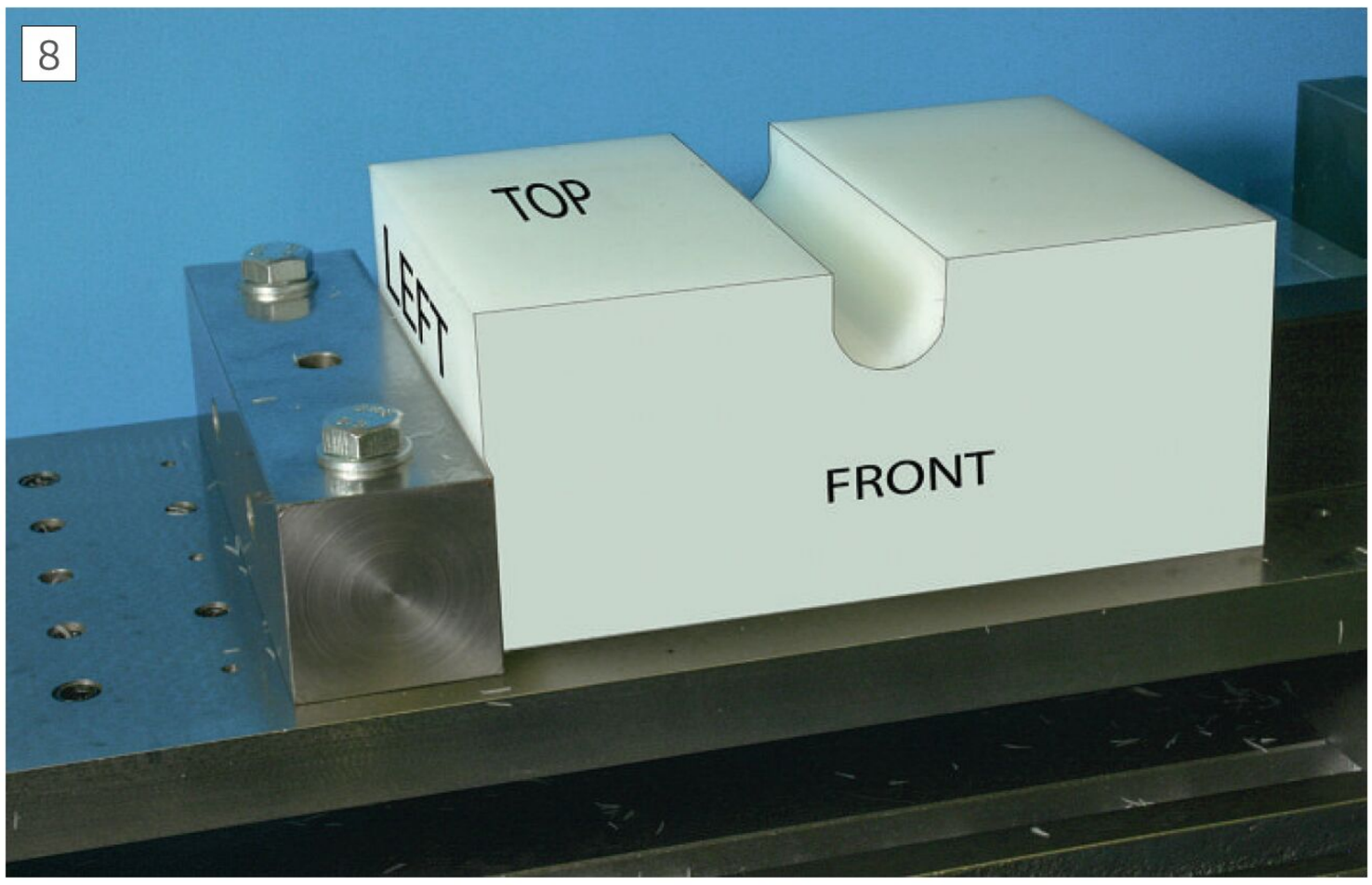
The front and rear faces can be machined using the same basic sequence. Set the 'bottom' reference face against the angle plate, set the 'left' reference face vertical, then skim the upper surface to form the 'front' reference face. Keeping the 'bottom' face against the angle plate, turn the block end-for-end and set the 'left' end vertical. Machine the uppermost face to create the 'rear' face and bring the block to the correct front-to-rear dimension.

Use a clamping system

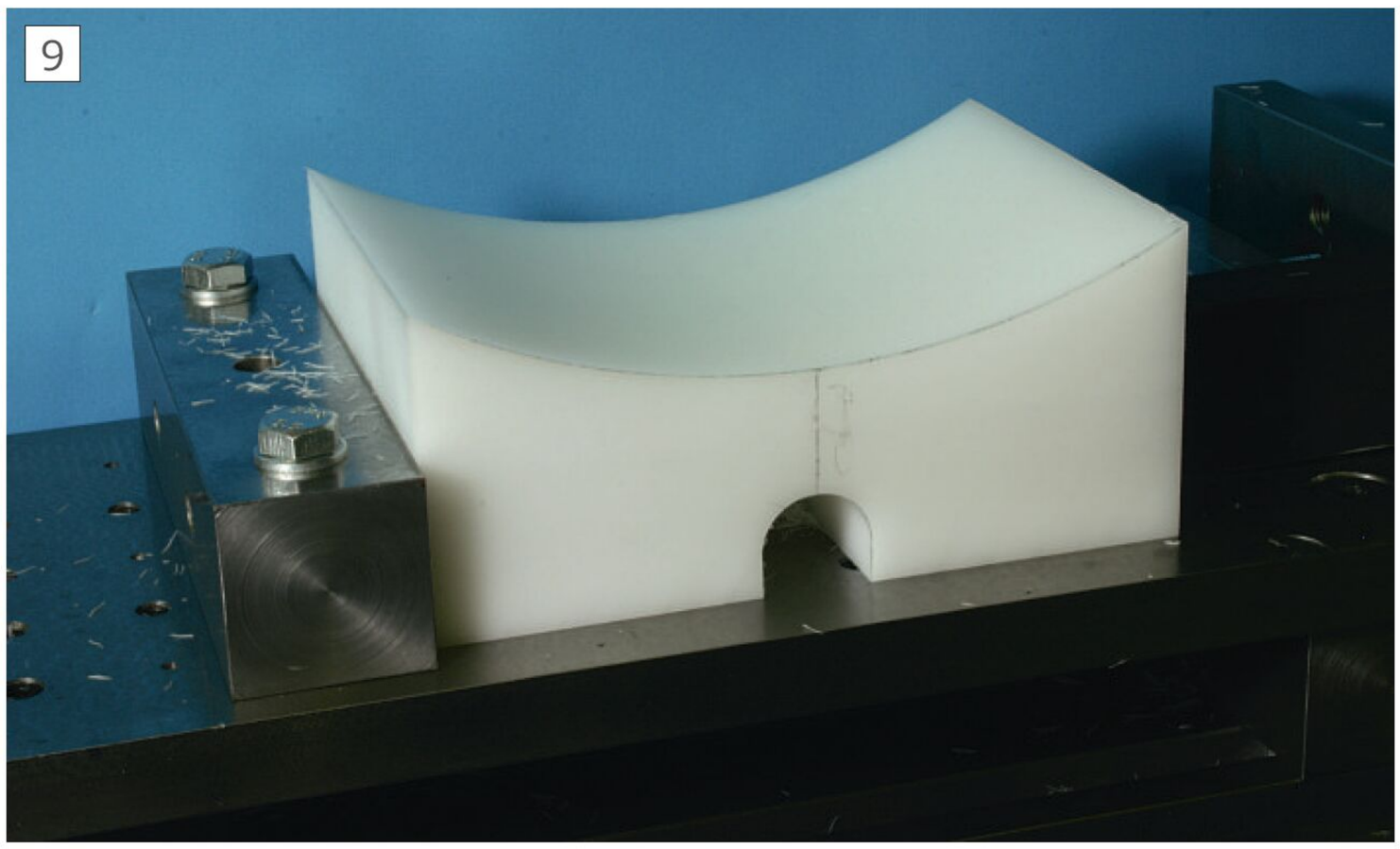
In some orientations, the block can be held by conventional clamps, but in this job each setup must be repeated nine times, so it is useful to have a way of speeding the process of aligning each block ready for machining. The blocks are too large for my vice, but I have met ›



Mill sub-table, left hand reference block, and pressure plate on the right hand end.



The channel with the semi-circular bottom can be machined parallel to the Y axis.



The large diameter curve can be machined on the bottom of the block.

this problem before, and **photos 7, 8** and **9** show a sub-table with a reference stop mounted towards the left-hand end, parallel to the Y axis, and a vertical plate with pressure screws mounted on the right-hand side, to act rather like a giant vice. The sub-table is not essential, it just lives more or less permanently on my mill and is peppered with a regular pattern of screwed holes to make mounting or clamping work easier. The reference stop has a 35mm square section, with vertical clearance holes to match the pattern of holes on the sub-table. The front face of the sub-table is set parallel to the X axis of the mill and the reference stop is set at 90 degrees to that front edge so that it is parallel to the Y axis. The sub-table sits on 35mm square-section blocks which have tapped holes in their sides to allow accessories like the vertical plate to be attached.

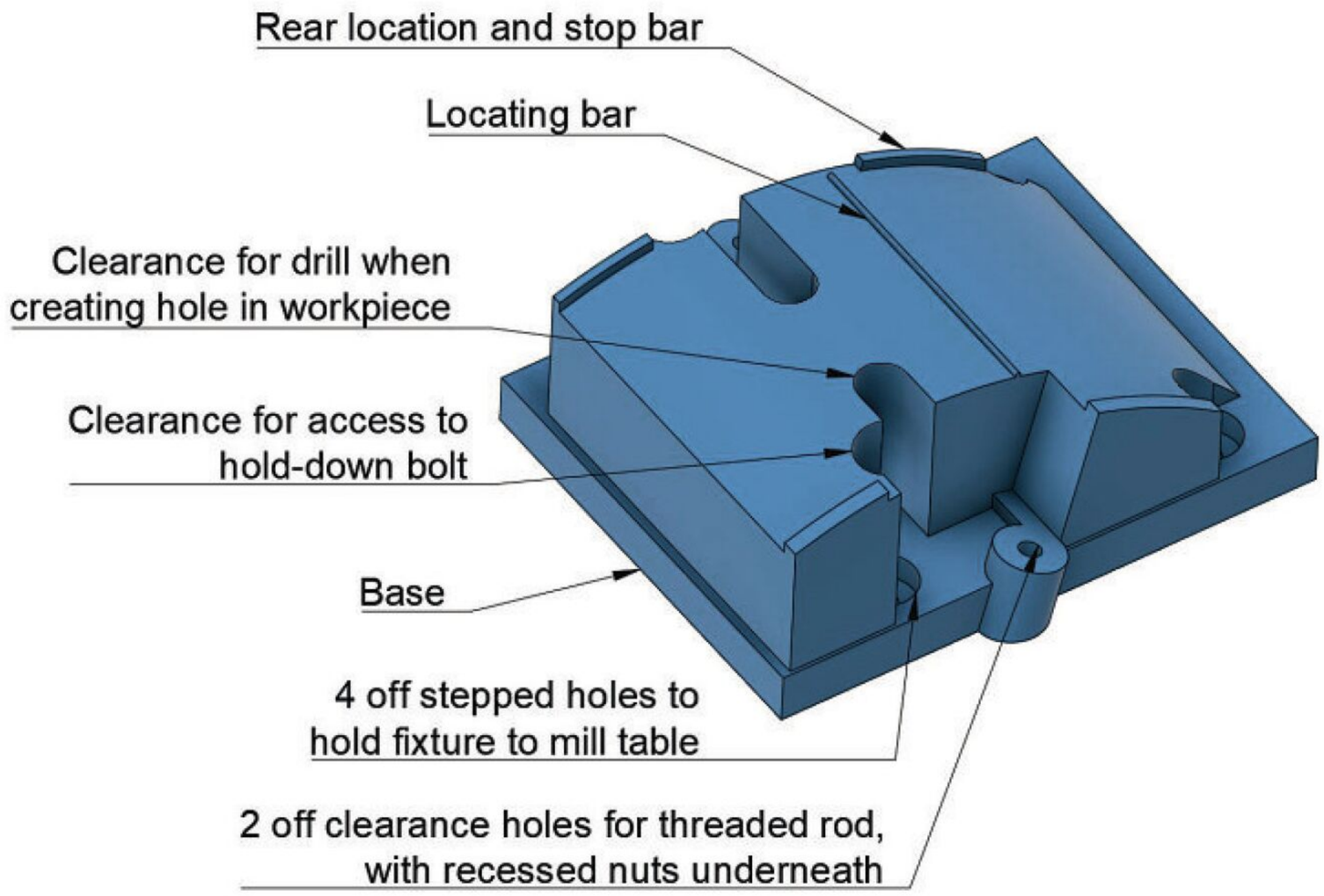
Clamping the guide block with its bottom face down and with the left face against the reference stop allows the top face to be skimmed parallel to the bottom to set the thickness of the block, and the groove with the semi-circular bottom can then be machined, **photo 8**.

Turning the block over, so that it is top down and keeping the left face against the reference stop allows the large curve on the underside to be machined, **photo 9**, followed by the small location groove. After that, we run out of ways to use conventional clamps.

Using 3D printed fixtures

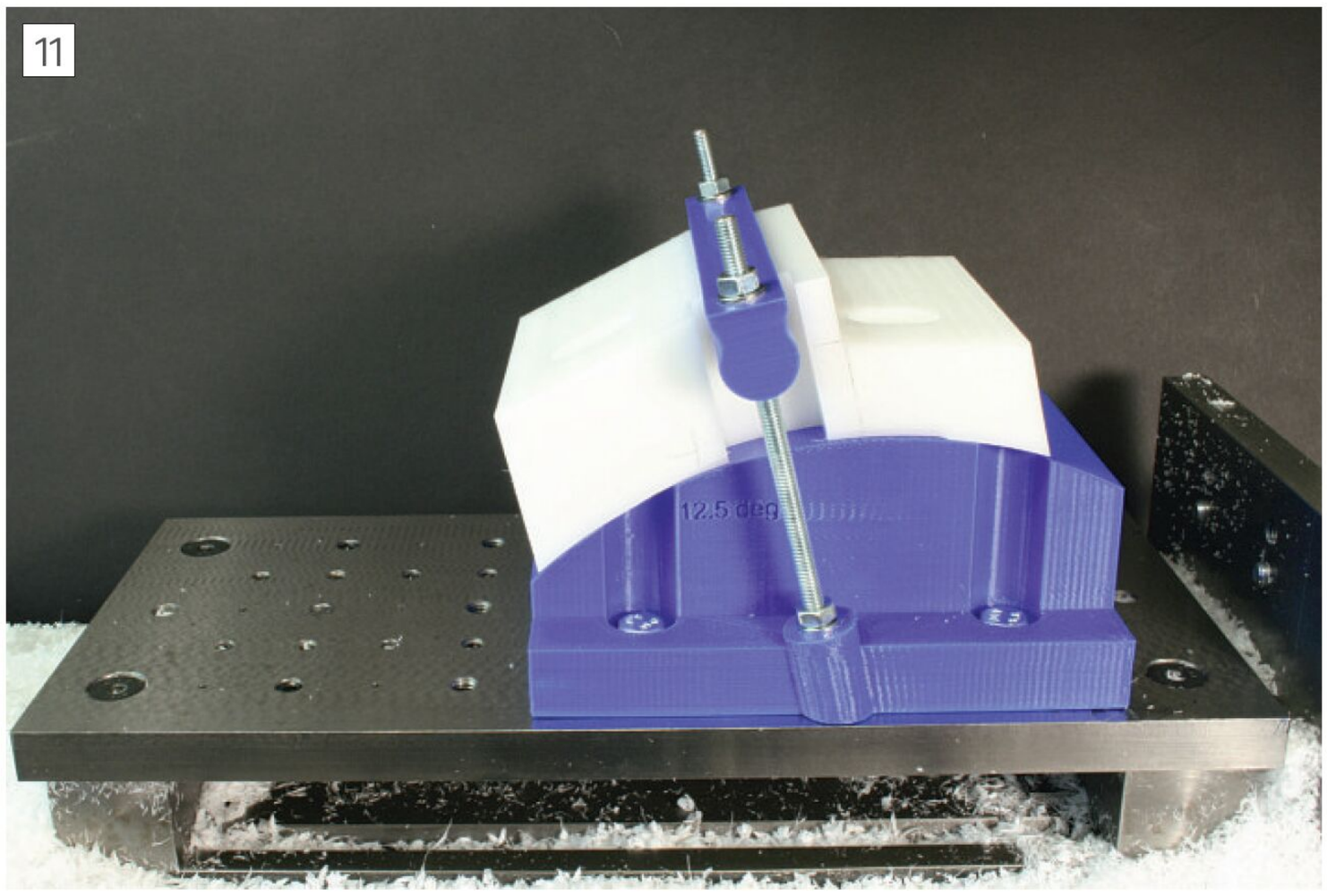
The sloping upper faces can be produced by clamping the block onto a 3D printed fixture. Two of these were created using a filament printer; one to hold the block tilted at 12.5° from the horizontal and the other to hold the block at 14 degrees. **Photograph 10** shows the essential features of these fixtures, while **photos 11** and **12** show that the blocks locate on the large radius and the small slot. A small lip at the rear of the fixture acts as a stop to position the block on the Y axis. A 3D printed bar locates in the existing top slot and clamps the block in place using lengths of threaded rod set at an angle to match the slope of the face which will be machined. The base of the fixture has holes for attachment bolts, located to suit the spacing of the holes in the

10



Features of the two tilted fixtures.

11

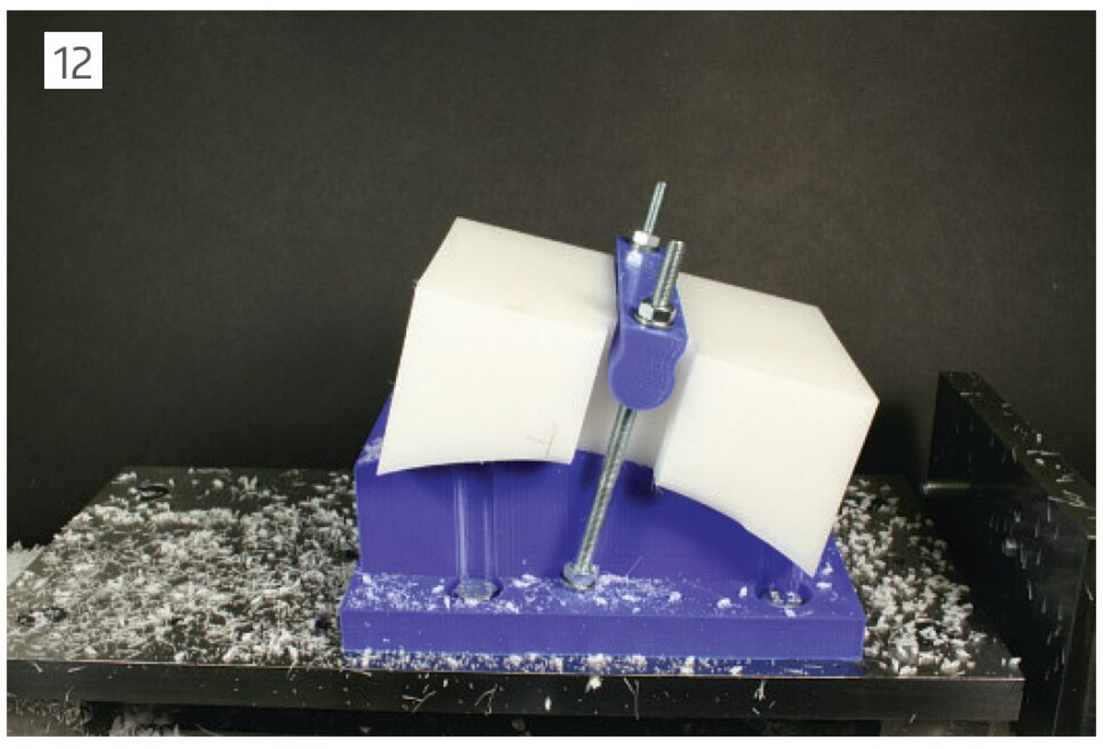


Block mounted on the 12.5° fixture

mill's sub-plate. Photographs 11 and 12 show early development versions of the fixtures which differ from photo 10 as they had not yet been given the clearance holes associated with drilling for the block's attachment bolts.

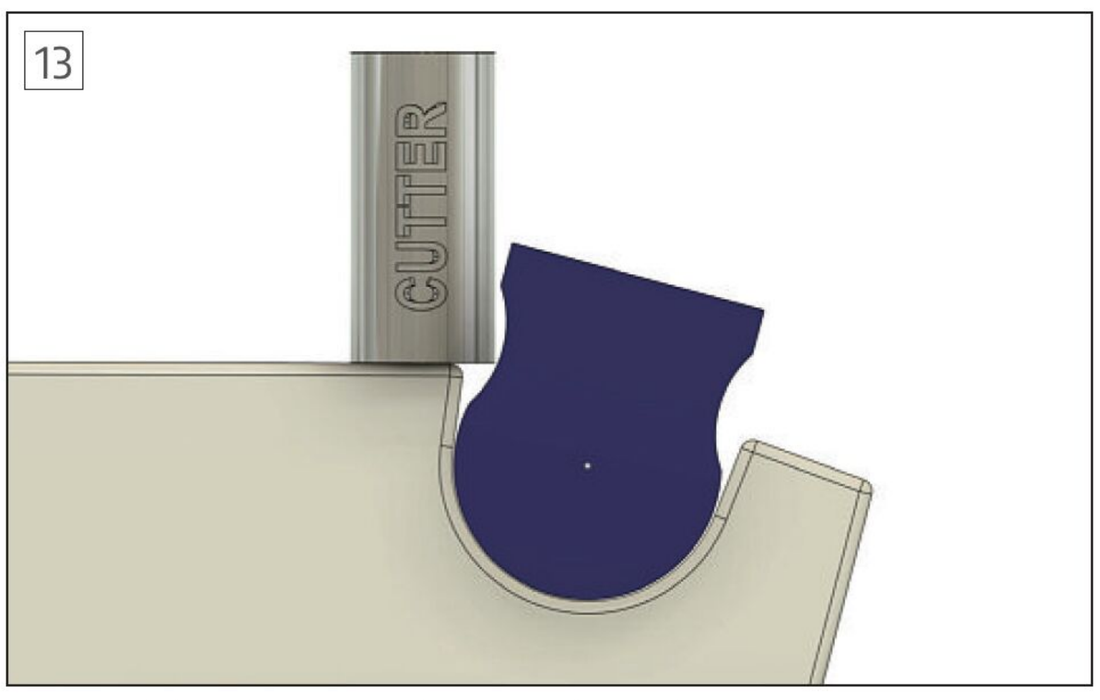
The 3D printed clamp bar has a semi-circular lower face to match the curve at the bottom of the machined slot, and a flat top for nuts and washers to bear against. The surface of the bar curves inwards just beneath the flat top face, **photo 13**, to allow a milling cutter to be positioned with a small overhang as it machines the angled face where it meets the upper groove on the block. It's easy to draw this kind of detail at the design stage and involves no extra work when printing.

12

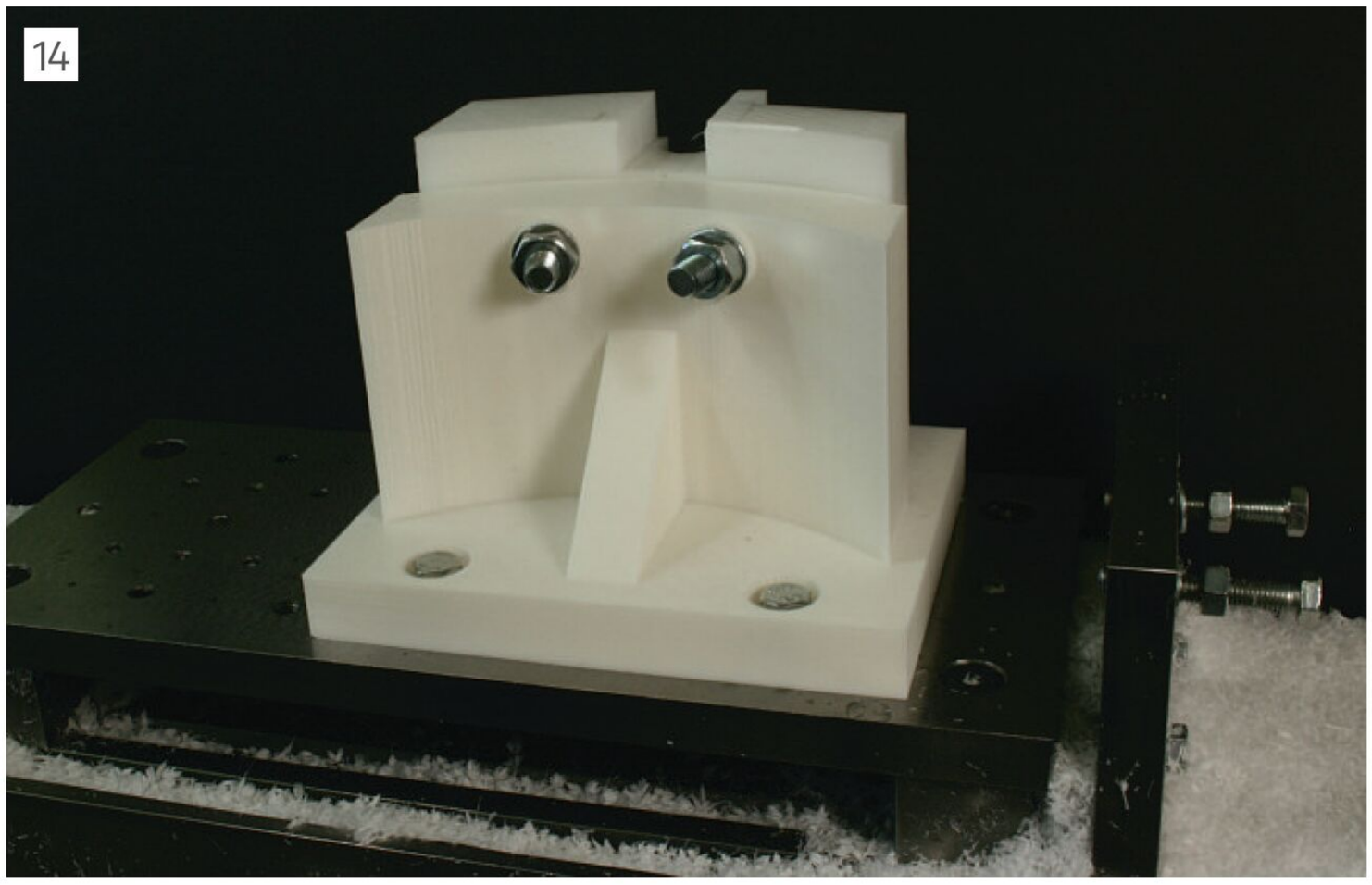


Block mounted on the 14° fixture.

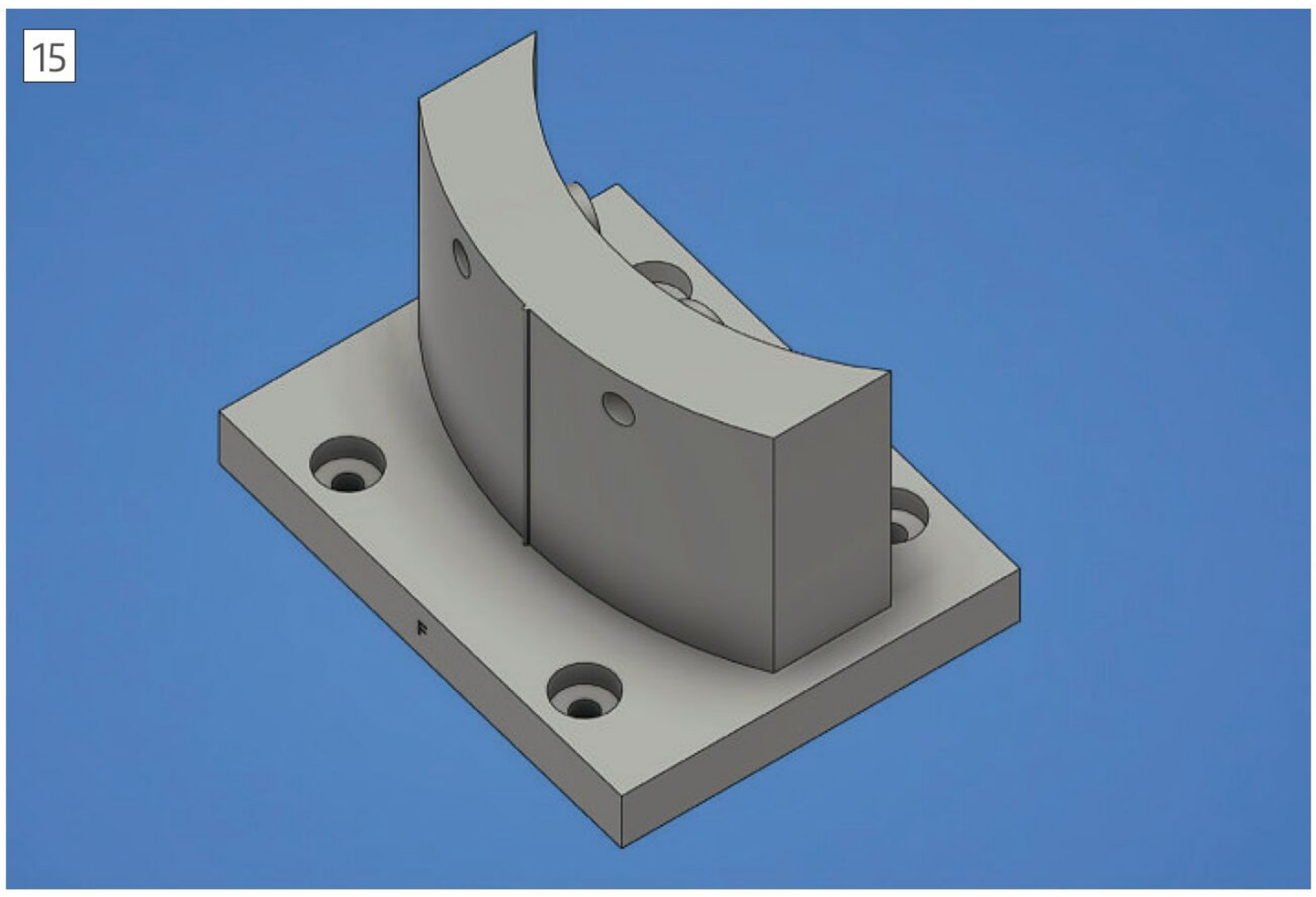
13



Detail of the clamp bar, showing the undercut to allow cutter overhang.



Angle plate style fixture.



CAD model of the angle plate style fixture showing the locating ridge.

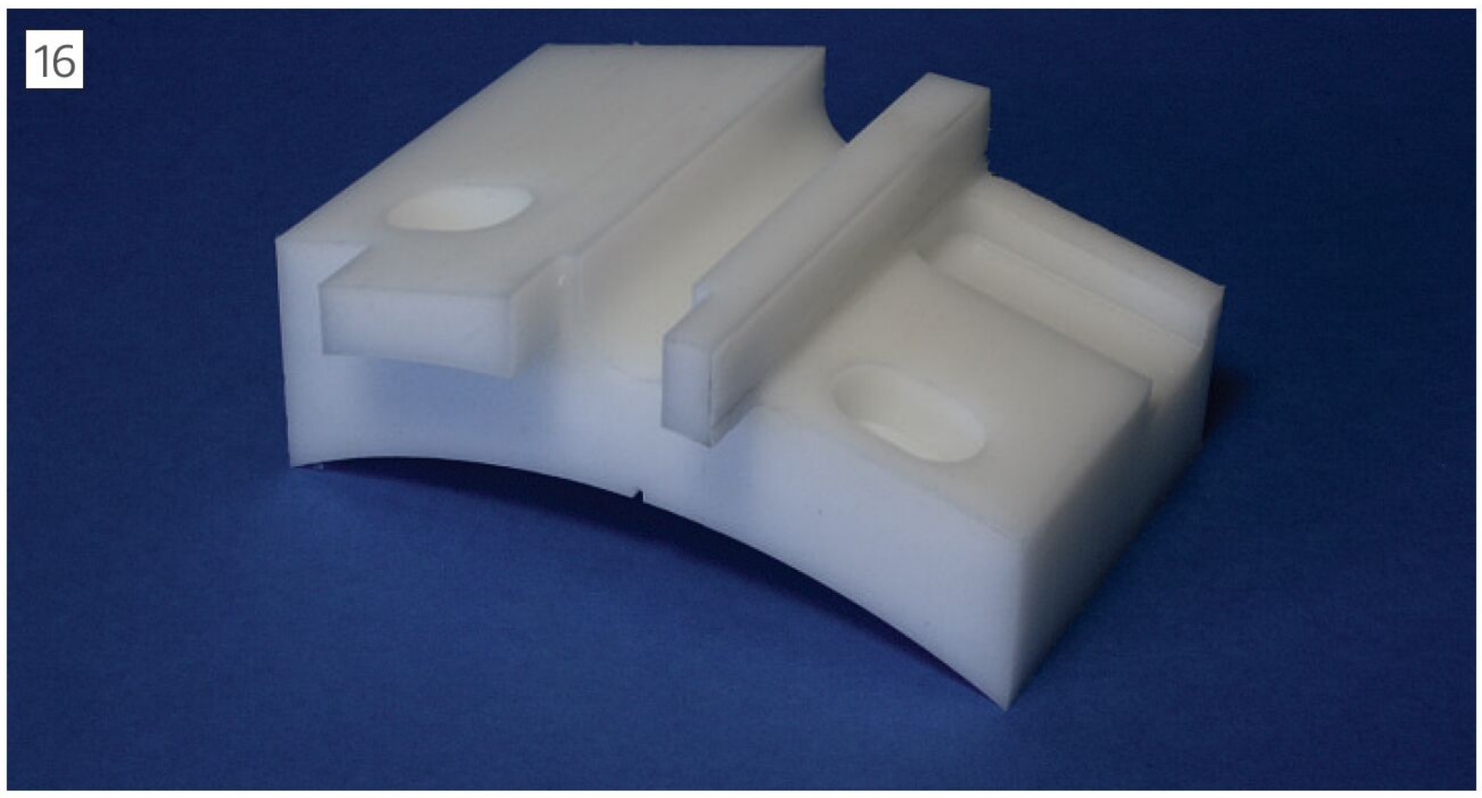
In the main body of the fixture, each threaded rod is held at the bottom by a nut on the outside and a nut sitting in a hexagonal recess lying at an angle on the underside. This is another detail which is easy to draw and to print, but which can simplify assembly. Another easily added feature, visible in photo 11, is the angle of tilt embossed in the side of the fixture.

Filament printing was used for these fixtures, for three reasons. First, these fixtures are larger than the capacity of the resin printer. Second, the internal structure of the fixture can be controlled so that these fixtures are not solid. The CAD drawing is imported into a 'slicer' program which prepares the sequence of layers of filament required to print the object beginning with the bottom layer and adding layers vertically upwards until the object is complete. By changing a setting, the slicer will automatically hollow out the inside of the object then insert a pattern of supports which look like honeycomb or intersecting cards. This makes the object lighter while retaining a surprising degree of strength. The fixtures were printed with 25% infill, using PLA+ filament, so 75% of the inside of the fixtures is air. The wall thickness of the outer shell was 1mm, and each layer was 0.2mm thick. Third, filament does not require curing, so the fixtures can be used as soon as the print finishes. Besides, filament is available in a much wider range of colours than resin, and I like printing most of my fixtures in this attractive blue.

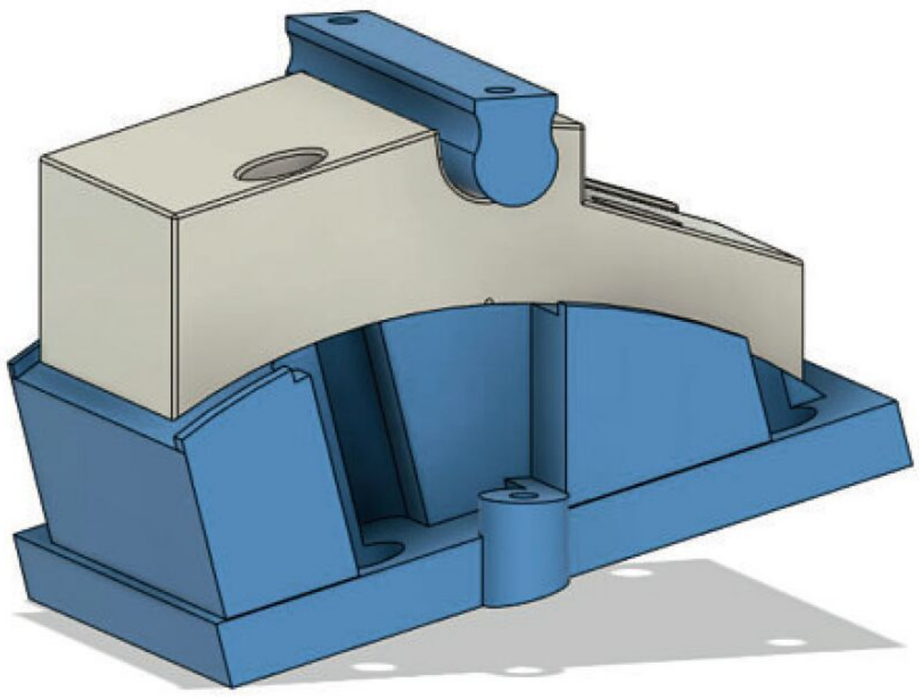
To produce the protruding arms on three of the Acetal blocks requires each block to stand on its rear face. It would be very inconvenient to use conventional clamps in this situation, because each block would have to be carefully aligned each time, and the clamps would have to be repositioned part way through machining to allow the area under the clamps to be cut away. The curved and angled faces make it difficult to hold the machined guide blocks on a conventional angle plate, so a third fixture was used to allow the cutter to access the whole of the 'front' surface. That fixture took the form of a 3D printed angle plate with a curved face to match the radius of the large curve of the block, **photos 14**. A central vertical protruding rib locates in the machined slot in the large curve, **photo 15**. The curve allows radial bolts to be used in the machined pockets to clamp the block to the angle plate. The plate can be reinforced by a rib behind the curved face, photo 14 – another feature which is easy to draw and incorporate into the print. Although there were only three of the blocks with arms, it was still worth making a fixture to ensure ease of use, accuracy and repeatability of positioning of the blocks.

Photograph 16 shows a finished guide block – one of the three with protruding arms.

Drawing the fixtures is relatively straightforward, as all the various dimensions of the block were now known. However, rather than starting from scratch, one way of ensuring an exact match between work and fixture is to use the concept of 'bodies' and draw the fixture in position on the existing drawing of the block, **photo 17**. Toggling the visibility of individual bodies allows you to see just the guide block, just the fixture, or the block and fixture in position one against the other. If you are using Fusion 360 remember Rule #2: name your bodies and components as soon as you create them. That way, it is obvious which body's visibility to toggle at any time. I cloned the drawing of the guide block twice, using the 'save as' command to give me three identical drawings. I added a left-tilted fixture and clamp bar to one drawing; a right-tilted



A finished block; one of the three with protruding arms.



Composite CAD model of fixture and guide block.

Crack in the lug supporting the threaded rod for the clamp bar.

fixture and clamp bar to the second drawing; and an angle plate-style fixture to the third drawing. In the first two drawings I used three bodies: block, fixture and clamp bar. In the last drawing I used tho bodies: block and angle plate.

Alternatively, you can create separate 'components' (one block, each fixture, one clamp bar, and one angle plate style fixture) then create a different 'assembly' for each combination of blocks and fixtures.

3D printed fixtures like these ones are not without their particular challenges. The strength of the attachment points for the threaded rods caused problems because the first version of the fixtures had too little strength around the mounting points for the threaded rod, causing the fixture to crack as the threaded rods tried to pull themselves out of the base of the fixture, **photo 18**. Fortunately, that did not happen until machining the last block, and did not affect the outcome. The position of the crack gives a clue as to the cause. A filament printer creates layers of plastic by laying down horizontal 'threads' of hot filament. Photograph 18 shows that although the rod is not vertical, and the pulling force it exerts is not vertical, the crack is horizontal. That indicates that the crack lies between two layers of filament, because the force is sufficiently strong that it can overcome the bond between layers. One solution might be to print the fixture using a greater percentage infill and/or a thicker outer shell. An alternative solution might be to print the fixture in a different orientation. Printing the fixture on its end, for example, would result in layers which were vertical when the finished fixture sat in its normal working orientation as shown in the photos. Similarly, printing the fixture tilted so that the hole for the rod was vertical would produce layers running parallel to the rods, which should be much stronger. Printing with the fixture tilted is likely to require additional supports created by the slicer software. That's fine, but those supports must be removed after printing, so it is then tricky to ensure that the base of the fixture is flat. Another alternative would be to modify the design of the attachment holes, perhaps by incorporating a recess on the base for a loose bar like the top clamp bar. The threaded rods would then squeeze the two clamp bars, pressing the block onto the fixture. That would avoid putting the filament layers of the fixture in tension.

All of this underlines the importance of the design process and the relative ease with which changes can be made using 3D CAD software, as well as the usefulness of 3D printing both for test pieces and for working fixtures. ▮

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

DENT and BULGE removal

IN SHEET-METAL WORK repairs, involving shapes with double curvature, the principles resemble those in panel beating in regard to obtaining the desired contour-stretching, shrinking or compressing the metal, planishing and finishing.

In some instances, repairs may seem more difficult than straightforward hollowing or raising of a sheet, owing to constraint to a given shape, and to the metal often being rolled iron or steel which flows less easily than annealed brass or copper. The presence of paint may also be a complicating factor, as may the difficulty or impossibility-owing to space limitations-of directing on to the damaged area just the type of blow required.

Simple damage, as to a car mudguard or panel, starts as a dent; but should the metal require considerable working to remove the dent, the result is generally a bulge, in turn demanding removal.

A moderate-sized dent-not too small-on a well-defined double curvature is sometimes very easily removed. The metal having retained a tendency to the original contour will spring out again, as an oil. can bottom, when a discreet blow is struck from behind with a wood or rubber mallet. Supporting with a small sandbag or rubber block from behind, the perimeter of the dent-if still visible-may be lightly tapped round with a small hammer or mallet, though care is necessary if the paint is undamaged.

Where a direct blow may be difficult to strike, a piece of wood, shaped to approximate curvature at the end, may on occasion be used as a " punch " with a hammer, or in conjunction with a jack, to push the dent **out**-a method which usually does not damage the paint on the outside. A dent too small to spring out may also respond to this treatment.

A fairly large shallow dent, A, may be driven out with a mallet, supporting from the opposite side with a block of wood covered with cloth. Then with the metal at approximate curvature, it is necessary to avoid producing numerous small bulges on the outside-though the difficulty is to know where to strike. Bend a stick of solder as a curvature gauge and from this shape a block of wood. Wrap emery cloth over this and use from below to rub the area and reveal the " high spots "-dents from above-which should be tapped with a small panel hammer.

Severe damage

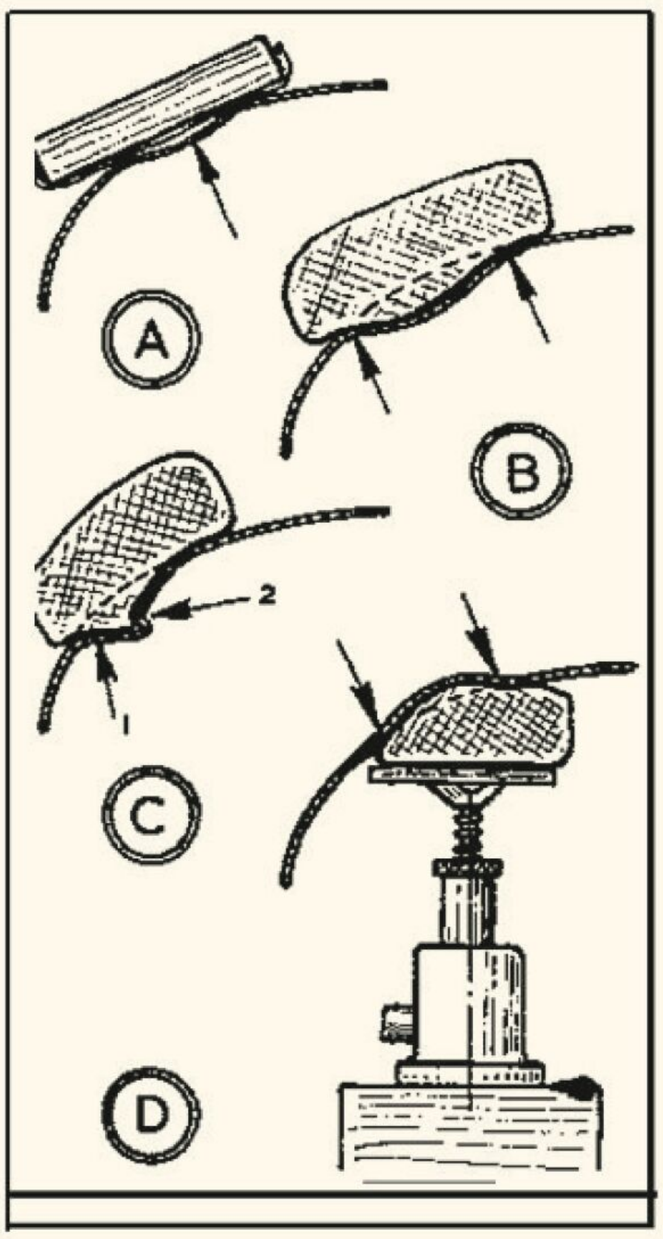
When damage is considerable and repainting required afterwards, knocking out should be on a panel-beating principle. Instead of directing blows to the centre of the area and so producing bulges or even sharp bends, to stretch or crack the metal, a sandbag should be placed on top and a start made at the outside edges, *B*, to bring the shape back gradually, working in diminishing circles to the centre.

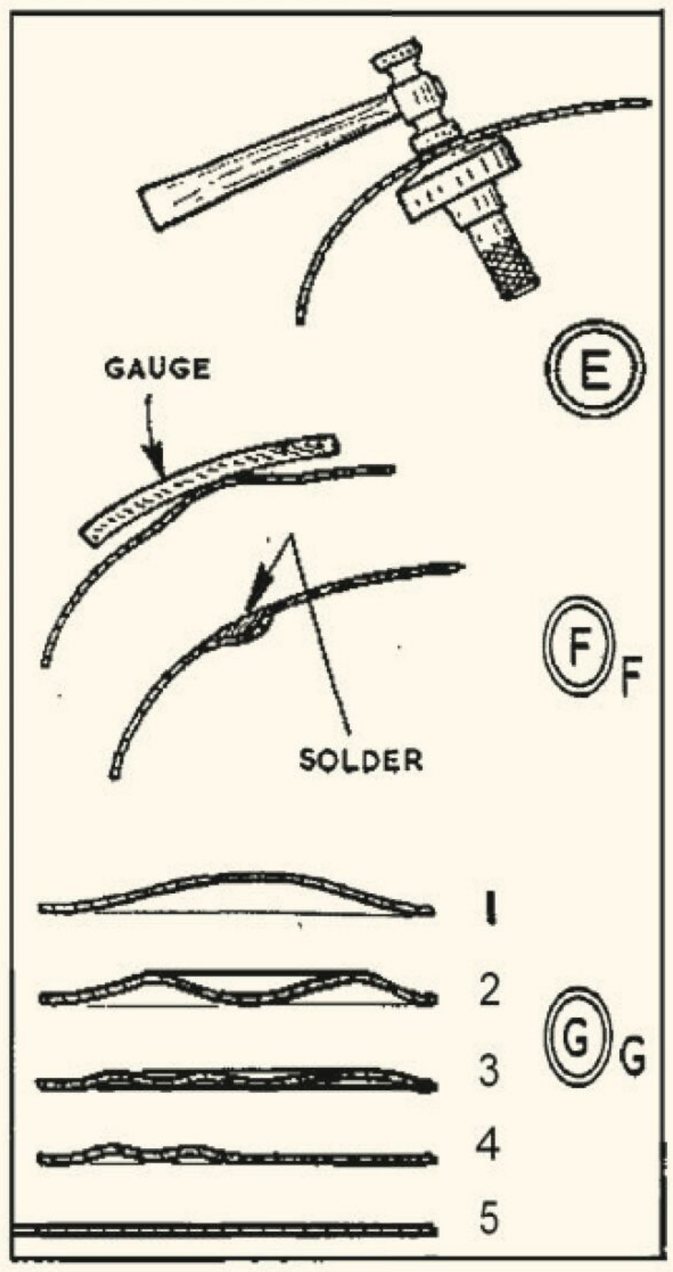
When metal has been pushed in acutely, C, it is weakened at the apex of the bend, if not actually cracked, and if struck at that point will fold or break. Hence blows are advisable as at (1) to begin to restore the curvature, then as at (2) to continue the process, supporting from the top with a sandbag.

To eliminate a bulge due to the metal's stretching, support from behind or below with a sandbag is necessary; and on a car mudguard, a jack and block can be used *D*. Work should proceed from the perimeter to the centre of the bulge in diminishing circles.

Planishing to remove small marks requires a flat hammer and a steel block of approximate curvature *E;* and the whole area should be gone over lightly to avoid stretching. In all working, a check can be kept with a gauge of bent solder, and if necessary low areas filled in, *F*.

Shrinkage of a bulge can be hastened when it is possible to apply concentrated heat from a welding torch. Beginning at G (l), the top of the bulge is heated bright red then knocked down with the mallet, and after a time cooled with a wet cloth. This leaves a circular crater (2), which is heated all round at the top, knocked down (3) and cooled; after which, the metal is planished (4) and (5) using a hammer and block, *E*. ■





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Combination Door Bolt

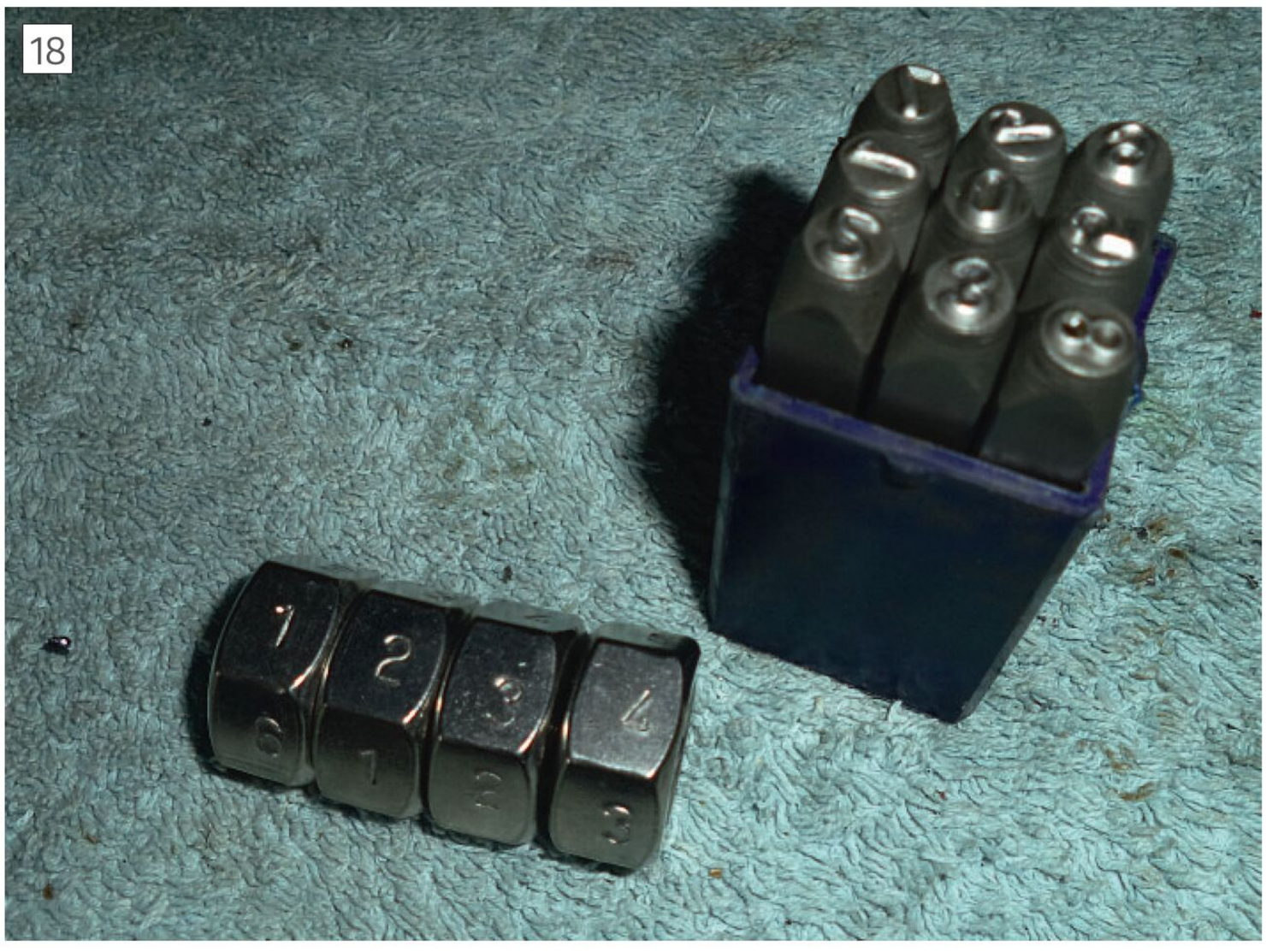
Stewart Hart finishes off this a security bolt for your workshop.

Tumbler 4 is thinner so you will have to touch the front of the nut and re zero the dial and advance the tool to a new position. You will need to take care to get the orientation correct for the next machining operation to ensure you keep the groove in the correct position so mark the datum face with felt tip. The 19.8mm diameter step is the same for tumblers 1,2 and 3 again using the back stop the process is similar to the grooving. Tumblers 2,3 and 4 all have a similar 20mm bore so again using a boring tool the process will be similar with a suitable adjustment for the thinner tumbler 4. It's important for the lock to work smoothly that all the burs and sharp edges are removed from the bore, this was done using emery cloth wrapped around a lapping stick**.**

The axial groove in the tumbler is milled using a 3.5 slot drill fed vertically down, **photo 16**. The tumblers can be

Milling groove in tumbler.

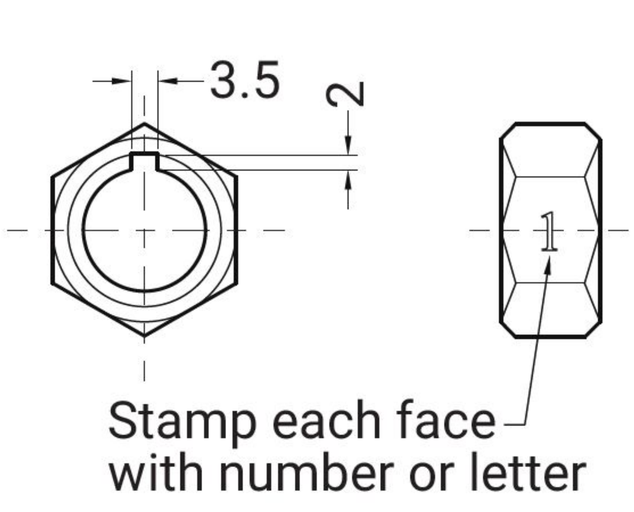
Stamping tumbler. Note support from round bar.

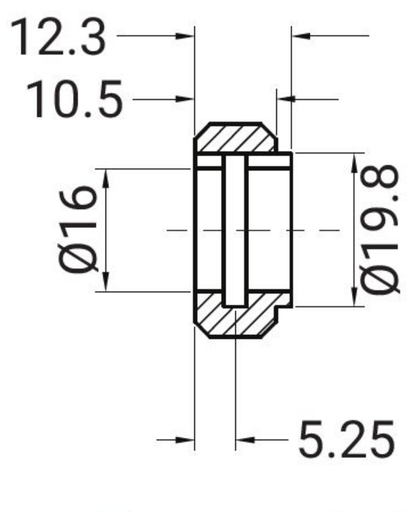


Stamps and tumblers.

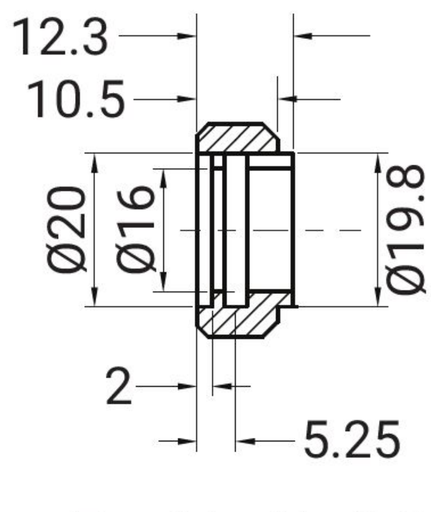
stamped with numbers or letters. The relationship with the slot will determine the combination so it's important that you carefully orientate the slot and make a note of the combination as you stamp it. To carry out the stamping process I supported the tumbler on a piece of round bar so that it didn't get distorted. You need to give the stamp a heavy blow with a decent sized hammer, so that it is done with one clean blow as it is difficult to give it a second blow and not get a double stamp, **photos 17** and **18.**

The bolt, fig. 2 (previous issue), and wards, **fig. 3**, are made from 16mm diameter free machining S303 stainless steel. The wards are TIG welded in place. It's important that the wards don't stand out too far and that they are nicely rounded off. The wards should be positioned so that they

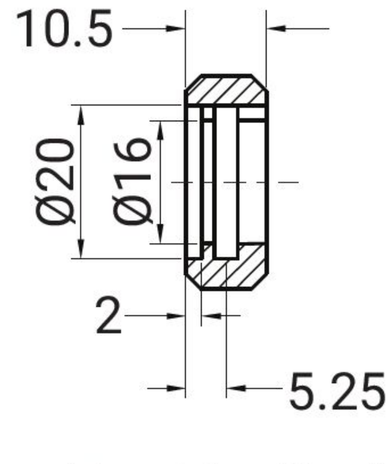




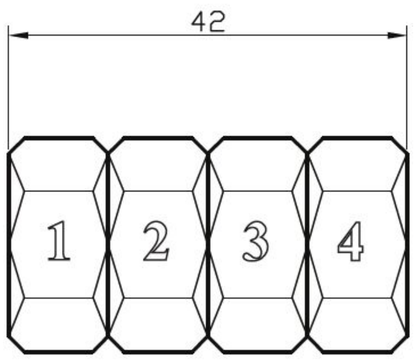
Tumbler No.1



Tumbler No.2 & 3

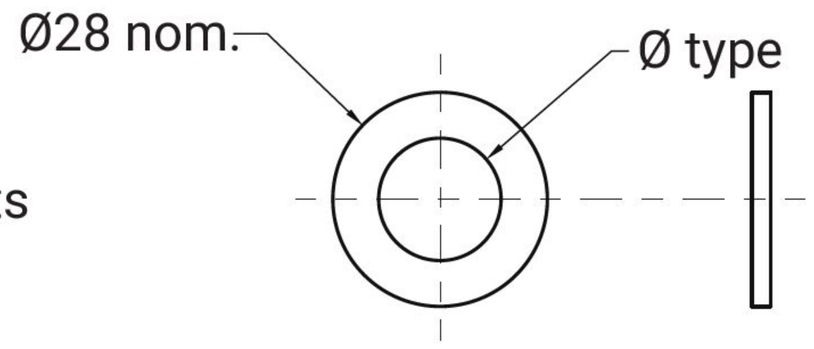


Tumbler No.4



Tumbler Assembly Sequence

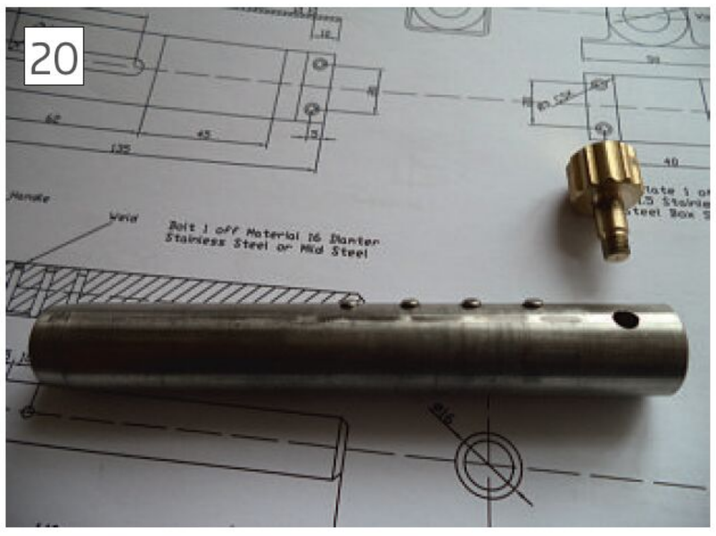
Tumblers
Mat'l: M16 stainless steel nuts
4 off



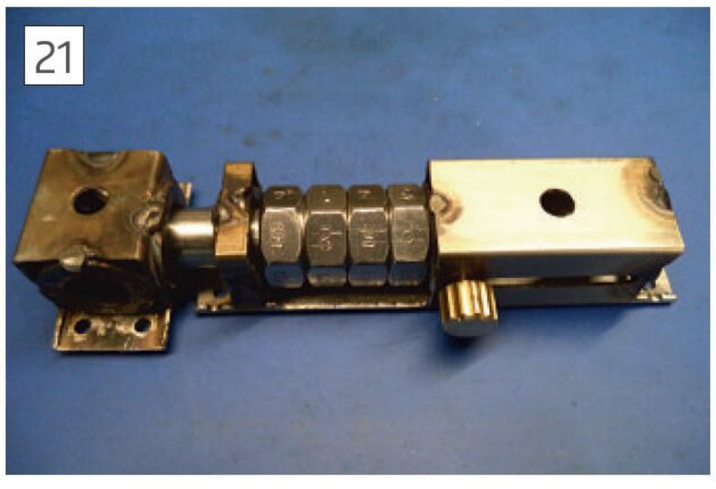
M15 Washers
Mat'l: Stainless or mild steel
7 off
Bore type 1 - Ø17mm
Bore type 2 - Ø18mm
Bore type 3 - Ø16mm

Figure 3

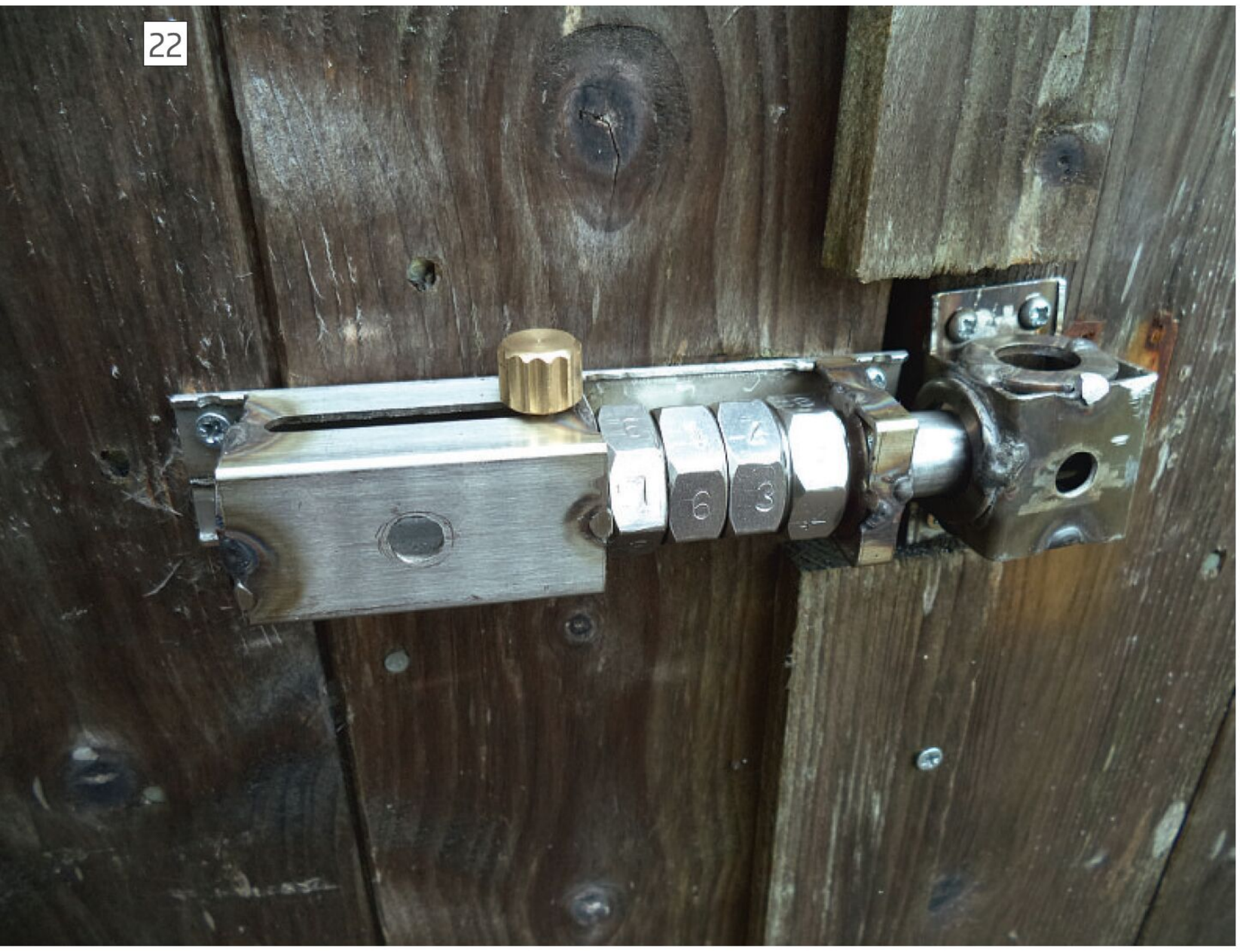
Machining lead on bolt.



Completed bolt and handle.



Completed lock.



Bolt on garden shed.

are next to the door so that they are hidden from view, this depends on how you orientate the combination and how you position the lock on the door the position of the handle also influences this orientation. It's important that you spend some time working out the orientation to suit your application. The best way to do this is not to drill and tap the bolt for the handle, fig. 2, until you've carried out a trial assembly and checked that everything works OK, and then drill and tap to give you the orientation you require. The actual machining of the bolt and handle is straight forward and doesn't need any further explanation, with the handle fixed in place with thread lock after final fitting and testing, **photos 19, 20** and **21.**

That's it completed its now fitted to a garden shed hopefully deterring any would be thieves and avoiding frantic searches for lost keys. Now what was the number again? ▮

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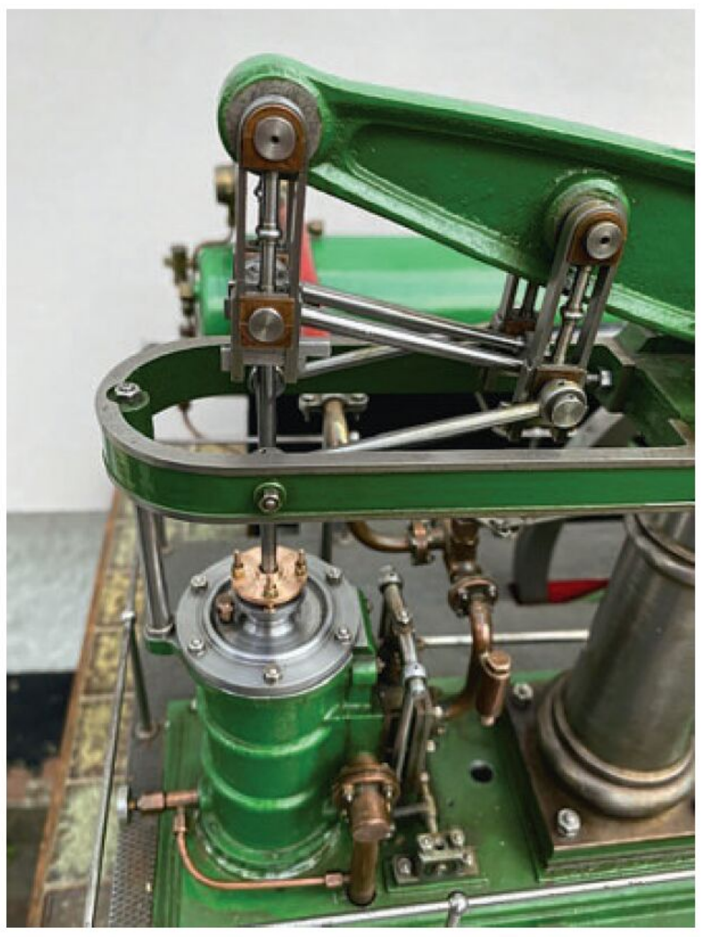

Beam Engine
Mitch Barnes completes the restoration of a nicely made but rather decayed ME beam engine.

Steam Engine
Ron Fitzgerald explains how Richard Trevithick failed to exploit his hight pressure steam engine patents effectively.

Flying Scotsman
Peter Seymour-Howell completes the construction of the rather complicated reverser for his 5 inch gauge *Flying Scotsman*.

Space Toys
Henk-Jan de Ruiter looks back at the toys produced at the height of the space race 50 years ago.

Youth
Peter Kenington exploits a ready source of enthusiastic labour to construct a railway.

The Next Issue of Model Engineer is issue 4758, December 27 2024

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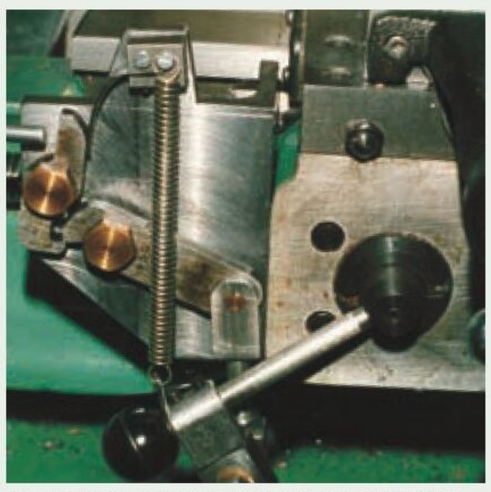
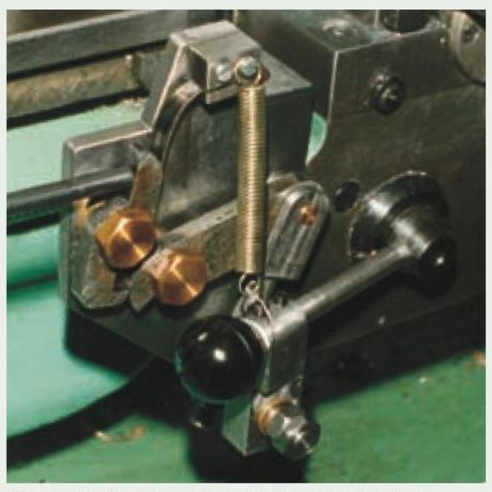
From the Archives

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.

This interesting article by Rowland Lowe explains his quick-release half-nut mechanism for Myford 7-series lathes. From Model Engineer 4183, Vol. 189, 29 November 2002.



The half-nut quick-release mechanism fitted to the Author's lathe. Here the unit is shown with the half-nuts engaged with the leadscrew.



The unit with the half-nuts disengaged. The mechanism locks the half-nuts together during engagement. Release is by way of a spring.

The actuator rod which triggers the release lever is screwed to the front of the lathe, only suitable when no quick-change gearbox is fitted.

QUICK-RELEASE HALF-NUT MECHANISM

Rowland Lowe
describes a device designed for Myford Series 7 lathes which, once made, will convince most builders of its usefulness when machining to a shoulder and screwcutting.

The device to be described has been found to be a very effective accessory for my Myford Super 7 and would be equally applicable to most of the Series 7 range. A trigger mechanism holds the leadscrew half-nuts engaged, and when this contacts the adjustable stop, the nuts are rapidly released.

Experience has shown that disengagement takes place with a very good degree of repeatability and that the machine can be run with confidence at relatively high speeds with power feed to the leadscrew.

Two important applications have been extensively used. The first is machining up to a shoulder at a constant feed for optimum finish. This has proved much faster than hand feeding using the leadscrew handwheel to determine the manual disengagement point, not only because of the higher speed, but the point of disengagement is determined by the stop and is constant in relation to the workpiece. If the leadscrew handwheel is used to determine the shoulder position, disengagement of the half-nuts may upset the relationship of the leadscrew to the half-nuts and affect the handwheel reading.

Such errors cannot occur with a fixed stop. Avoiding mistakes by withdrawing the tool and leaving the half-nuts engaged while reversing the leadscrew by its handwheel rather than the apron traverse loses much time. The exact positioning of successive shoulders can be ensured by use of the stop collar shown on the stop rod in the photograph, and minor adjustments can be made by use of the top-slide index.

The second main application is in screwcutting, especially up to internal and external shoulders. In these cases a runout groove is normally made with a parting tool to allow manual disengagement with some allowance for variation. As the width of this groove is limited, speed needs to be restricted to avoid errors and spoilt work. Another disadvantage, especially when the threaded length is short, is that a significant length may be sacrificed to the runout groove. With the mechanical method, this is not necessary. When the leadscrew is released, the tool continues to cut a runout groove around the work without traversing further, and on the final cut the work is left with a runout groove of the minimum size, the same width as one thread.

The fitting has proved so useful that it is left permanently in place on my lathe. If not required, it can easily be isolated by temporary removal of one of the 5BA bolts from the top spring block, unhooking the tension spring attached to it, and slipping the trigger behind the leaf spring to relieve this tension — quicker done than described! The clasp nut lever then operates normally. Construction is shown in the sketches and photographs.

Materials come from the odds and ends box and partly depend on what is available. The bracket was from a piece of scrap angle, the only major adjustment being the fly-cutting of a small flat on the inner face to give a suitable surface for the head of the mounting bolt to sit truly. The method of mounting on the lathe is not seen in the

QUICK RELEASE MECHANISM FOR MYFORD SERIES 7 LEADSCREW
FIRST ANGLE PROJECTION

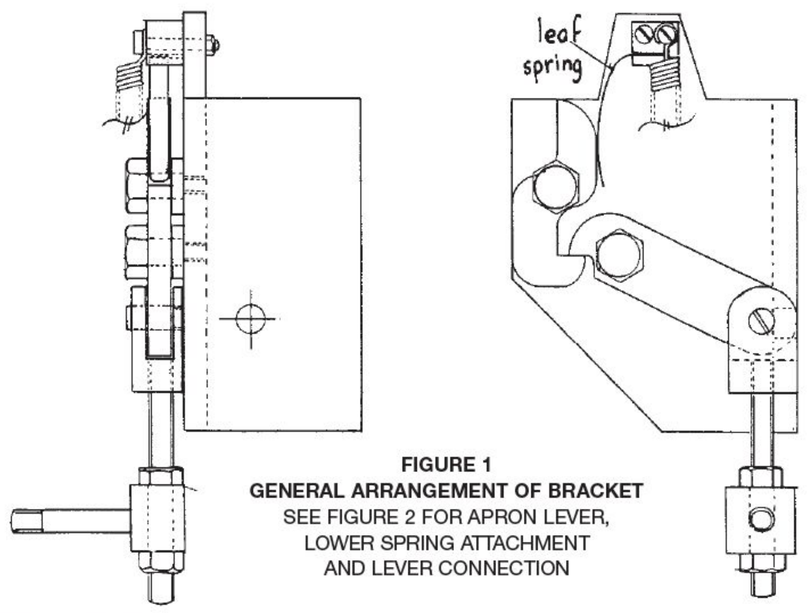


FIGURE 1
GENERAL ARRANGEMENT OF BRACKET
SEE FIGURE 2 FOR APRON LEVER, LOWER SPRING ATTACHMENT AND LEVER CONNECTION

STANDARD ITEMS REQUIRED:

3 x 1/4in. BSF NUTS, 7/16in. A/F
1 x LEAF SPRING FROM CLOCK SPRING OR STEEL SHIM STOCK
1 x TENSION SPRING 1 3/4in. FREE LENGTH
1 x 2BA GRUB SCREW 2BA x 3/16in. LONG
2 x 6BA GRUB SCREWS 6BA x 1/8in. LONG TO FIX LEAF SPRING
2 x 5BA x 1in. LONG BOLTS & NUTS .

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photographs but is simple, being by the single 5/16in. BSF bolt detailed. On the left hand side of the apron is a 5/16in. BSF tapped hole for a socket screw (Myford part No. LA58), which is far enough into the hole to leave sufficient thread to engage the fixing bolt.

The stop rod itself and mounting are not detailed. The stop is a plain rod about 1/4in. dia. mounted as convenient to strike the trigger. On a change wheel machine, as can be seen in the photograph, it can be mounted in the holes drilled in a block secured by screws in the holes provided in the bed for mounting a quick-change gearbox. An alternative would be necessary for a gearbox machine.

Final adjustments to the trigger mechanism should be made on trial assembly. For the best operation, the cocked trigger should be set vertical with its trip face horizontal and the corresponding face on the lever also horizontal.

You'll not need much use of this fitting to convince yourself of its usefulness!

QUICK RELEASE MECHANISM FOR MYFORD SERIES 7 LEADSCREW
FIRST ANGLE PROJECTION

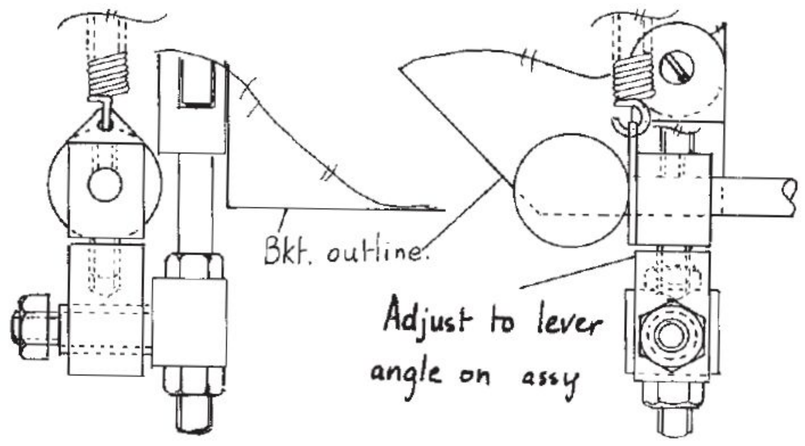


FIGURE 2 - GENERAL ARRANGEMENT OF LEVER LINKAGE AND ASSEMBLY TO BRACKET

QUICK RELEASE MECHANISM FOR MYFORD SERIES 7 LEADSCREW - FIRST ANGLE PROJECTION

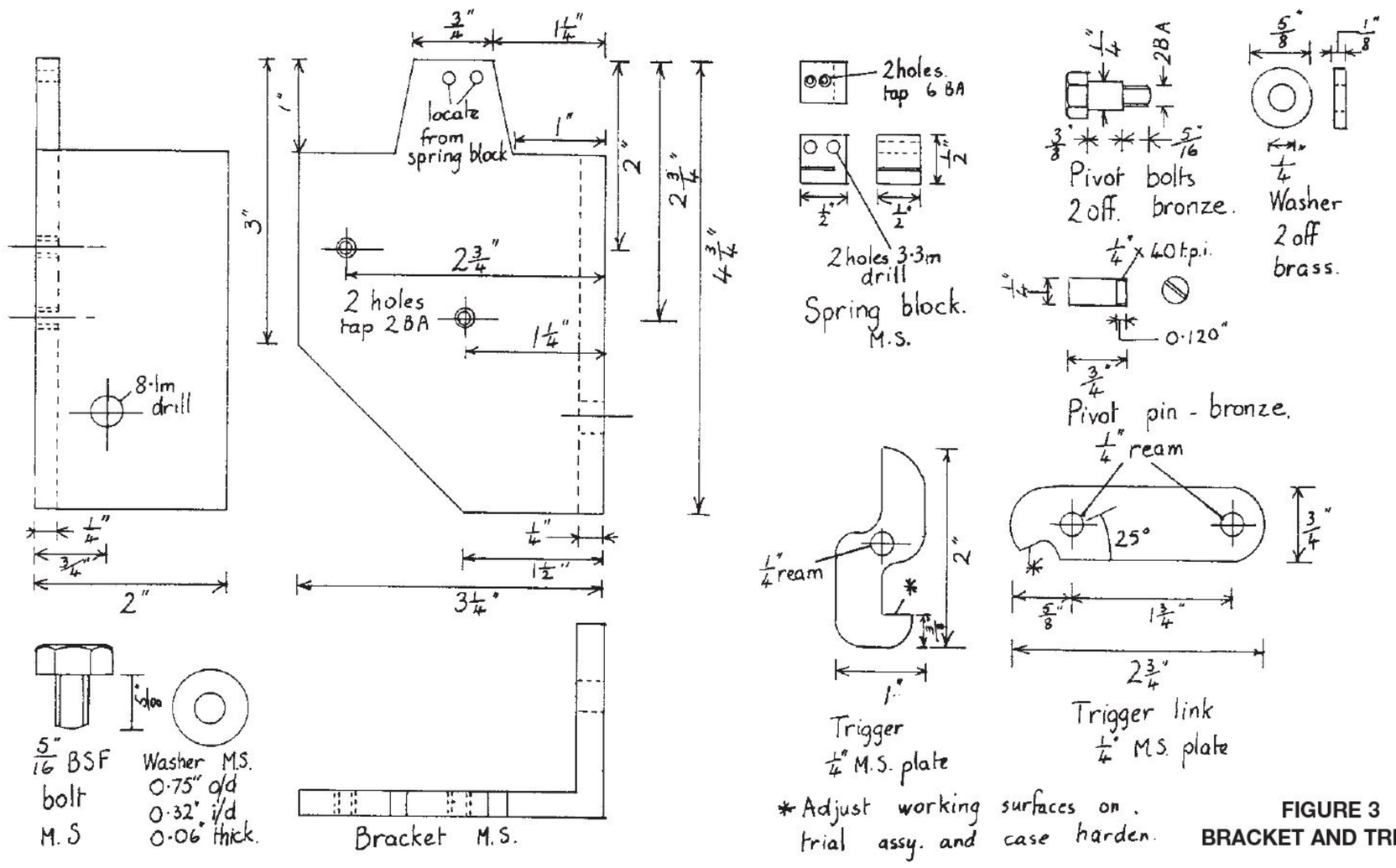
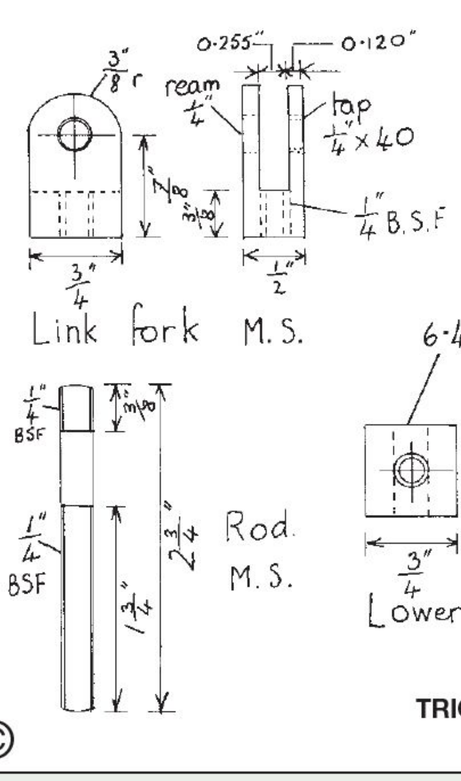


FIGURE 3
BRACKET AND TRIGGER

QUICK RELEASE MECHANISM FOR MYFORD SERIES 7 LEADSCREW FIRST ANGLE PROJECTION



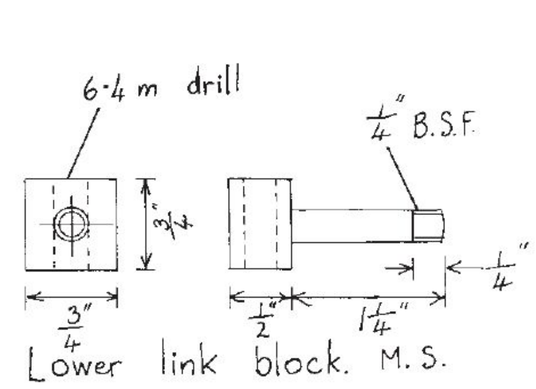
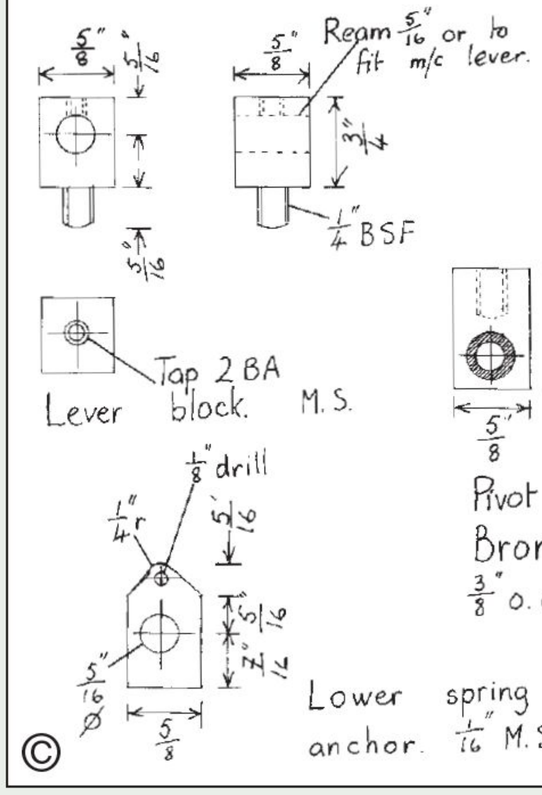


FIGURE 4
TRIGGER TO LEVER LINKAGE

QUICK RELEASE MECHANISM FOR MYFORD SERIES 7 LEADSCREW FIRST ANGLE PROJECTION



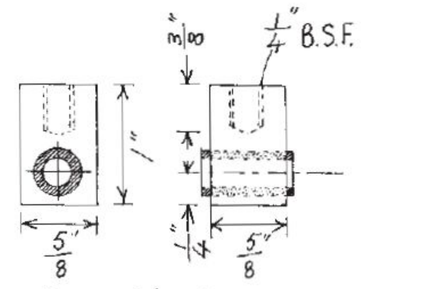


FIGURE 5
LEADSCREW LEVER LINKAGE

Reversing Time

This Christmas, Humphrey Park has drunk too much sweet sherry to go into the workshop to escape all the re-runs of old movies, so he shares his thoughts on the march of time instead.

I read Paul Tiney's letter (Scribe a line, MEW No.344) concerning his lack of time in the Workshop. I too have been thinking about problems of a lack of time, which I am sure affects many other model engineers in a similar way. I decided that some research into this problem might prove beneficial. I have concluded that the real problem with time is all about its perception. I find that all my little bits of available time cannot be swept up and joined together using temporal glue, so I have developed a method of breaking jobs down into little bits which fit neatly with the bits of time. As an example, I am rewinding a motor at the moment, so putting on one turn of wire at a time would use only one tiny amount of time, so eventually the job would get done without piecing the bits of time together in one long period. Working on this principle, after seven weeks I now have 43 turns on one of the coils with only 2597 turns to go. I have left instructions in my will as to how my executors can complete the winding if I don't finally get around to it.

I am sure a lot of fellow model engineers find that they spend a lot of time correcting errors whilst making items in their workshops. Here is where the ability to undo something would save enormous amounts of time. My computer has an "undo" command by using <CTRL>+<Z>, but after drilling a hole in the wrong place, I discovered that my drilling machine is not fitted with <CTRL> and <Z> keys, so the only way to correct it would be to either fit these keys to the drilling machine or reverse time. As the drilling machine was built in the 1960s before home computers were available, fitting such keys would be difficult. However, further analysis of my use of time and its availability led me to the conclusion that a method of reversing time would be good as there are many other benefits to accrue from such a capability. Typically one could go back and un-drill the incorrect hole or have a second go at turning a shaft to the correct diameter when you have taken too much off.

My initial thought was to try something simple, such as reversing the drilling machine. I thought that this might allow for the metal that had just been removed to be replaced, using the drill as a 'hole-filling' drill rather than a 'hole-making' drill. This did not seem to work, and I concluded that the drill needed sharpening the other way round, so I thought about making a 'putting-on' tool on the lathe having previously turned a shaft just a bit too small. Running the lathe in reverse might be necessary, but when I tried this, the chuck unscrewed and fell off, fortunately missing my foot when it hit the floor.

Then I realised that I was not actually reversing time, as the clock in the workshop was still ticking away in the right direction. In view of that, I decided to remove the battery and replace it in the reverse position, thus hoping to make the clock go backwards. This did not work, and neither does the clock now. However, there is a good side to the clock not ticking any more. When I tell my wife that I am going into the Workshop 'for a moment' it doesn't seem to matter how long I am out there or what I am doing, and I can achieve a lot in no time at all. My wife's perception of time does not seem to be the same as mine when I go into the workshop. I will let you know in a previous issue of *Model Engineers' Workshop* if I ever get round to reversing time in my workshop. Naturally, such reversal of time would have to be restricted solely to the workshop and its occupant at the time, as being able to reverse time on a global scale could lead to such problematical things as Presidential elections which might be reversed and who knows to where this might lead?

However, help is at hand for those short of time as many years ago I saw a shop selling "Round Tuits" which seemed even better than re-organising time, as you can no longer put things off by saying that you will do it when you get a Round Tuit. Although I have several square and hexagonal tuits, round tuits seem unobtainable now and as my lathe is now missing its chuck, I have no chance of turning my hexagonal or square tuits into round tuits. ▮

An Eccentric Turning Chuck

It's no surprise that several readers have asked for more details of Bernard Towers' nicely made eccentric chuck, with which he won the 2024 Stevenson Trophy. Here he describes how he made the tool.

This is not a piece of tooling, **photo 2**, that is regularly seen in home workshops as this type of work is usually done in a 4 Jaw chuck or on a faceplate. I thought that just as a project alone it might be quite interesting and in the end would give me an interesting tool for future use.

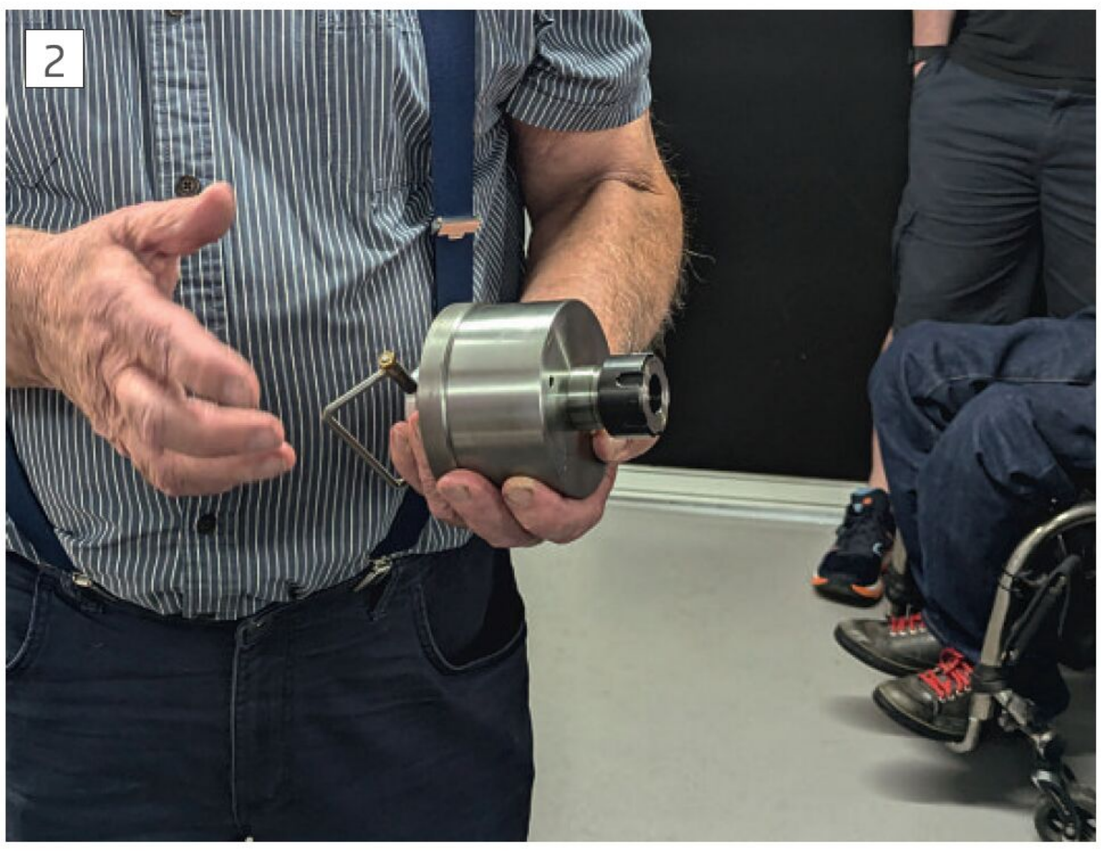
The one I made has a Myford backplate, but this can be substituted for one of your choice. The amount of eccentricity really determines the overall dimensions of the chuck which worked out to be close to four inches and gives me an eccentric amount of approximately 1 ¼", so as far as crankshafts are concerned your engine could have a 2 ½" stroke. As I was thinking about using this for small IC engines this amount is more than adequate.

Unfortunately, this design requires two hefty lumps of material, one is 4" diameter by 2" long and one 2 ½" diameter by 3 ½" long. Cast iron would be nice for the larger piece, but I had a four-inch doorstop in steel begging to be used, and the smaller piece of steel as well.

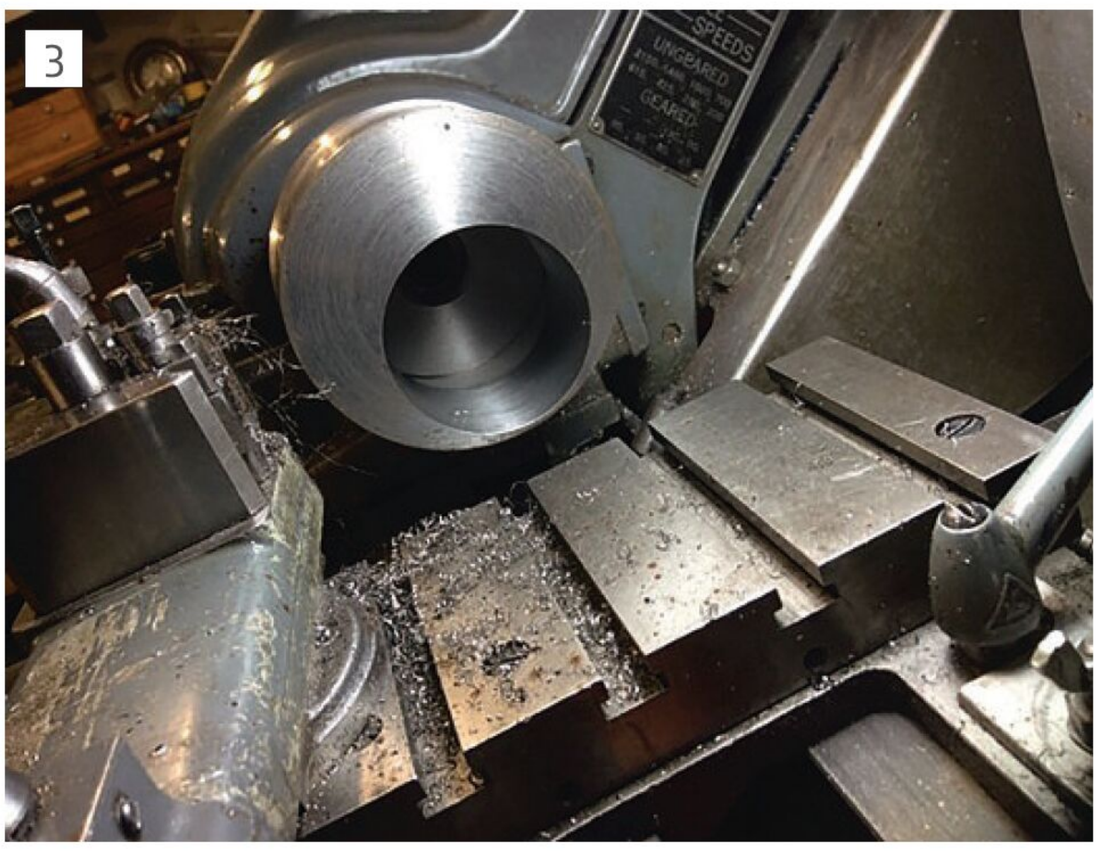
The amount of material to be removed is quite daunting and fills the swarf bucket quite quickly, the eccentric hole in the larger piece is turned off centre after first marking out and centre punching, **photo 3**.

The next thing to do is to machine the off-centre hole used for locking the chuck in the set position. If like me you use 16mm brass for this then the cross hole needs to be offset from the centre dot mark by 1.700" and when done a piece of 16mm brass has to be locked in place in this hole, before we start to bore the 2.500" hole this means that this machines the correct curve in the brass insert which is to be used for the locking process, the hole and the insert can be seen in **photo 4**. Once boring is completed the brass insert is drilled through then cut across the narrowest part. A screw is fitted which can be tightened to pull the two halves together for locking.

Bernard Towers with the Stevenson Trophy



The finished chuck on its Myford backplate.



After boring the eccentric hole in the body.

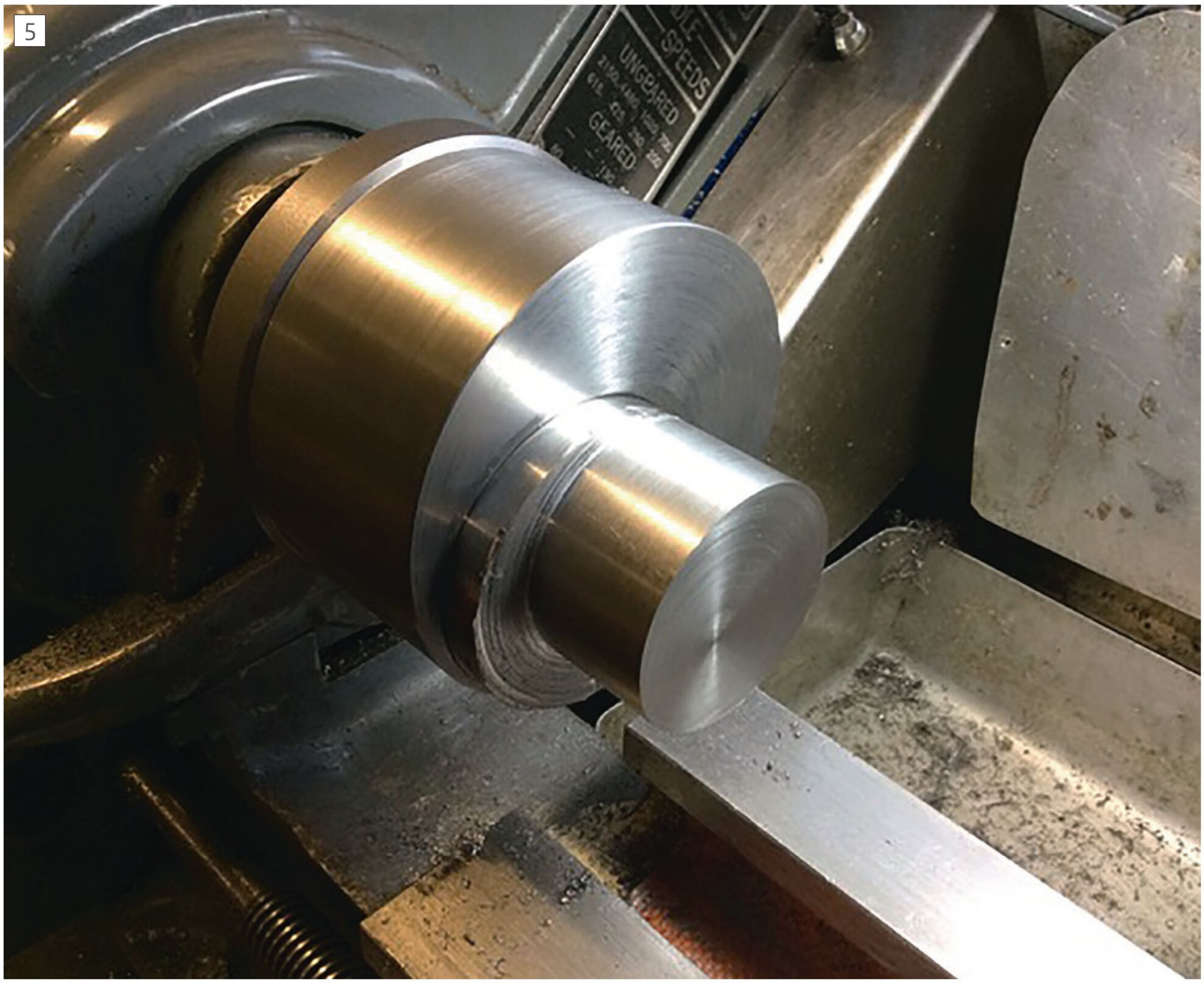
The finished chuck showing the hole for the brass locking piece which is just visible in the hole.

Then set up on the faceplate with 6mm spacers to allow the boring bar to exit the end of the material. It was clocked into position with a between centres wobble bar. The hole was finished bored a few thous under the 2.5" measurement to allow me to machine the 2.5" blank exactly to size. Aim for as good a finish as you can possibly get, it will make it smoother in operation.

The four-inch blank can now be reversed and mounted in a 4-jaw chuck to have a shallow (~1mm deep) register socket machined ready to be mated with a backplate of your choice. Three fixing socket head screws are used, two strategically placed either side of the eccentric hole. Once this is done a cut can be taken from the outside diameter to clean the blank up and a skim across the front.

If the 2 1/2" piece is fitted and the pinch bolt is tightened securely you can now commence to turn the outer diameter for the collet chuck dimensions, **photo 5**, and drill and bore a hole all the way through the blank, making sure the hole is slightly smaller than the lathe bore! Make sure the 2 1/2" blank is pushed all the way to the backplate before this operation is done which means you can finish the piece flush with the main body.

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, **photo 6.** It does involve a fair bit of interrupted cutting. The tapers and threads you use are up to you, but keep the tolerances as tight as you can, mine has a commercial ER25 ball bearing nut and I used that as the thread gauge.



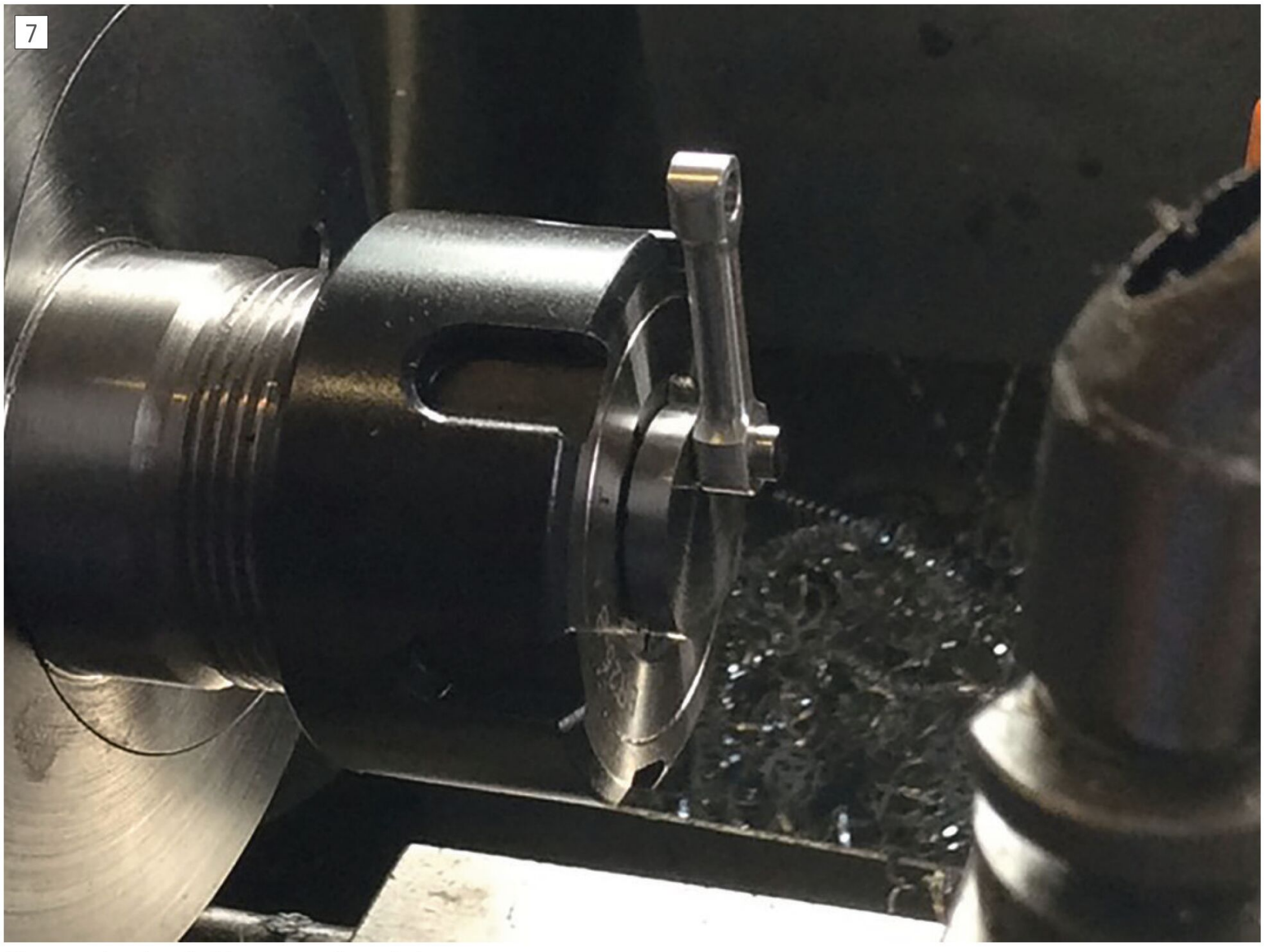
The movable piece fitted in the hole with the spigot roughed out.

The moveable piece after finishing as a collet holder.

To set up I use a DTI with a flat piece of smooth steel screwed to the stem at right angles and with a dowel in the collet chuck and the DTI will show the full stroke, see photo 4. This can be adjusted by using a collet spanner to turn the eccentric part of the chuck within the body, or if it takes your fancy, I have a hole drilled in the face of the insert and make a pin spanner to suit. It is possible to get one thou accuracy with patience. **Photograph 7** shows a piston rod fitted to a crankshaft turned using the chuck.

One of the advantages of this style of chuck is that it is able to have a crankshaft approximately 4 ins long which is not always possible if you have a large throw crank and a small bore lathe although the Keats style of fittings do allow this.

Although this is a heavy piece of kit, I think it is in its favour as it turns very smoothly enabling a good finish to be obtained a necessary thing for a big end bearing. ▮



The completed tool with an example workpiece.

Funding Model Engineering Part 2

Martin Berry concludes his thoughts on how to make our hobby more affordable, he starts by looking at supermarket tools and bargain buys.

Many years ago, I was recommended to make disposable tools out of cheap imported tools. This applies to many things available, and the low-cost supermarkets are one source of such cheap items, many of which can be applied to applications not originally intended. For instance, I turned a set of training weights into a pulley block to assist with moving my surface grinder to the workshop which is at the bottom of my garden (see MEW Issue 289 – January 2020).

Occasionally, the budget supermarkets sell branded electric tools at extremely competitive prices such as small drill presses or band saws and the like. If these suit your needs then a decent saving can be made., sometimes as much as 30% on the national trade orientated vendors. However, they don't go on sale very often, so you will need to be very patient. If you are super lucky and the stock does not sell, especially if there is some damage, they get sold off even cheaper to clear.

Think Twice or Maybe Three Times

Expensive purchases should not be made on the spur of the moment. If something stretches your budget, wait, maybe the seller can't get rid of it (continual re-listing on auction sites is a good example) and this provides an opportunity to step in with a low offer.

On eBay, I bid on a Meddings fretsaw about 100 miles from where I live, but it sold for more than I was prepared to pay after considering the cost of going to get it. A couple of months later, I saw another advertised which appeared to be the same but only 20 miles away, so similar that I decided to do check

My bargain Meddings fretsaw.

on the original sale, only to establish that the current seller had bought the machine I had originally bid on, **photo 5**. It being bought by a small business which had established that it was not, in the end, suitable for what they wanted to use it for. Despite bidding a similar sum to that I bid originally, no one else bid, and I got it for the starting price which was half what I bid – a bargain.

Moving your Purchases

If buying machine tools, the cost and effort of moving it has to be factored into the purchase price. If you need to hire a van and pay for fuel and a hired help, then consider having a professional machine mover quote for moving it for you. Sometimes, if you are prepared to wait, they will add it to another job and offer you a worthwhile saving, especially if cash in-hand. Having moved machinery myself and also had machinery delivered, I would prefer the latter even if it costs more. Personal safety and convenience are worth a lot.

Make it if You Can

Sometimes even cheap tooling may stretch the budget and making your own may be the only short-term option, especially if you already have the (scrounged/recycled) materials in stock. I made a ER40 collet chuck for my lathe and one for my son's lathe, although making the nut was not considered worthwhile so was purchased. The making or modifying of a relatively unique tool may be considered as a potential revenue earning MEW article, so take pictures at the outset.

Make and Sell Widgets

Sometimes you have a good idea for a widget, either for the workshop or the household in general and consider that this might sell and make you untold riches, or maybe just a few pounds. To make it worthwhile, you need to make a number of widgets in a production environment, then you need to sell them. After selling no more than three, it may dawn on you that it was not the product to set the world on fire! And yes, I did try it once, and all I will say is that I got my money back – just!

Clubs & Societies

Model engineering clubs and societies have a collection of like-minded individuals who will be happy to buy and sell used tooling and surplus materials through personal contact or through club sales. Recently I bought a clone of a Deckel D-bit grinder from a fellow club member at a bargain price – he just wanted shot of it because he'd just finished building a Quorn tool and cutter grinder.

Some clubs can get good deals on materials by buying in bulk and selling on to members at a reasonable price, while benefiting club funds as well.

Publish in MEW or ME

Write up your experiences and inventions; MEW pays for good articles large or small and the same applies to more model engineering related articles for Model Engineer and I expect publications for other modelling hobbies have similar arrangements for contributors.

Articles require an element of preparation, photos of setups on tidy machines, and sometimes dimensioned drawings, so it's best to think about what you intend to do some time in advance. It takes a lot longer to write an article that it first appears. Even though I have extensive report writing experience through my employ, I still end up re-writing articles several times, and that's before my wife gets her editorial eye on it. Where an article covers the manufacture of an item with dimensioned drawings and pictures of setups, extensive cross-checking is needed to ensure that the final drawings, photos and text agree so that anyone who decides to make your invention does not come unstuck half way through their attempt at manufacture.

Articles are not a quick source of income and payment is only made when the article is published and this could be many months after your original submission. My first article took over a year before it was published. It was written retrospectively, and I was lucky I had taken some pictures at the time as a memento. I now consider whether a project might be suitable material for a MEW article and quite often draft out the text of the article before I've even cut any metal. This gives me a starting point and chance to consider the machining steps before producing any swarf. Not that I always follow the original idea as implementation often throws up new ideas or complexities as you proceed. At present I have several articles on the go, some in concept stage, others waiting for workshop time to implement the next stage, some waiting for photographs or drawings and some nearing completion. I may start a project and then put it down for a while, depending on my immediate priorities or while I try to work out a solution to a problem. The oldest part-completed article is coming up for ten years old, with little expectation of completing it to a satisfactory standard within the next six months; maybe it will never be completed. Indeed, several articles have been then abandoned for one reason or another.

The actual time required for me to write an article is such that the earning rate (£/hour) is less than the national minimum wage, but I don't do it for a living. A further consideration is that the Inland Revenue deems this as an income and, as such, this revenue stream falls within income tax rules so potentially devaluing the financial benefit. (For most people their first £1,000 of income from self-employment, such as writing articles, falls under the 'trading allowance' and is tax free - Ed.)

Become an Actor and Director

If you fancy making, and possibly starring in, you own production, YouTube, one of several video streaming services, provides an opportunity to convey your ideas and experiences to a greater audience. If you are making something and are happy to video what you're doing as you go along, then YouTube provides a payment mechanism for videos, based on the advertising attached to them. Model engineering is a minority market and your audience and therefore viewing figures are going to be relatively small, so any revenue generated is going to be microscopic compared to those modelling fashion and cosmetics to teenagers. It appears that some YouTubers are not getting acceptable revenues from their creations and are turning to the Patreon and other financing routes, where viewers pay a fixed monthly

Accumulation of scrap for future casting projects.

My last major self-financed acquisition.

subscription to the video producer. I would suspect that you will need to offer a good service to your viewers and this then turns more into a business with a level of commitment to keep publishing and supporting your videos, so detracting from normal model engineering activities.

I'd consider that writing publishable workshop and model engineering articles offers a better financial return than YouTube, unless you find that magic component that goes viral and makes you an internet millionaire (dream on!).

Let Your Friends and Work Colleagues Know What You Do

If friends and work colleagues know your interest, they might be inclined to let you know of something which which they consider you might be interest in. A manager once asked me if I was interested in a small machine – it turned out to be a baby Kennedy hacksaw, which belonged to his father. I made him a fair offer; he was delighted to just get rid of it. Another colleague gave me a small toggle press and one sold me some Moore and Wright measuring equipment.

If you get known for mending things or sharpening tools etc., small cash jobs may come your way.

Model Engineering builds a much more comprehensive tool set than most DIY'ers and this combined with all the skills developed in turning lumps of metal into things of beauty, puts the workshop owner in a good position to sell his skills and facilities to aid friends and family with odd projects. This may be a simple as freeing something seized or repairing a domestic appliance.

Never be afraid to ask for some form of payment, but always suggest a modest cost in advance; some people can be so pleased with your achievements that you might get a bonus. Often a trade can be made for something which would be useful to yourself and which the owner would be more than happy to dispose of, even a favour using their skills in return. I do odd jobs for my retired neighbours, but don't like to charge, knowing they will always help us out with other favours like house sitting, but often still get a bottle or two of wine for my troubles.

Have a Fund and Don't Spend Beyond it

I keep an allocated pot of money put aside, which is just dedicated to the workshop, whether this be for tools or materials. My pot (my slush fund) is fully self-financing; if I sell something the money goes into the pot and if I want to buy something and I have nothing in the pot, then I have to do without. My pot is a literal one and I keep records of revenue streams and purchases on a spreadsheet. Sometimes a sale results in cash in-hand, which is a nice feeling, but most purchases are made using the debit card, or Paypal, so an electronic trading system requires an electronic (or paper) logging system. There is nothing to stop you putting a fixed monthly contribution from your conventional earnings into the pot if you have nothing to sell.

Epilogue

It is now almost 10 years since I entered into a focused view on financing my hobby. Over that period, my employment status held firm for a few years, until redundancy finally hit me and then retirement. But the Wabeco milling machine has a new inverter and I've bought one machine tool and sold two others. With this, I've had eight articles published in MEW and my stock of saleable items is largely depleted with most of the money I've raised being ploughed back into tools or materials. I still have a few bob in the slush fund and this allows me to buy bits and pieces when I need without having to ask myself whether I can afford them. I bought and fitted out a small lathe for my son and my experiences on this will be written up in time, hopefully to be published in MEW. I have one machine to sell, and this will pay for other machines to be brought into operation or buy some new tools/tech. I still keep my eyes open for real bargains to stock my own workshop or as a refurbishment and re-sell opportunity.

As for the pile of scrounged/recycled materials – after sorting through and classifying my piles of scrap, I've embarked on a mass reprocessing programme, **photo 6,** to turn it into useful ingots of aluminium, brass and copper with a view to actually doing some casting or, if times get really hard, maybe it will be a trip to the scrappy to realise the financial benefit of my years of squirrelling.

It is important to remember not to become obsessed with the desire to accumulate wealth in an effort to buy more or better tools, **photo 7**, as the list is never ending and enjoyment of the hobby has to be the first objective, something I hope I've achieved. ▮

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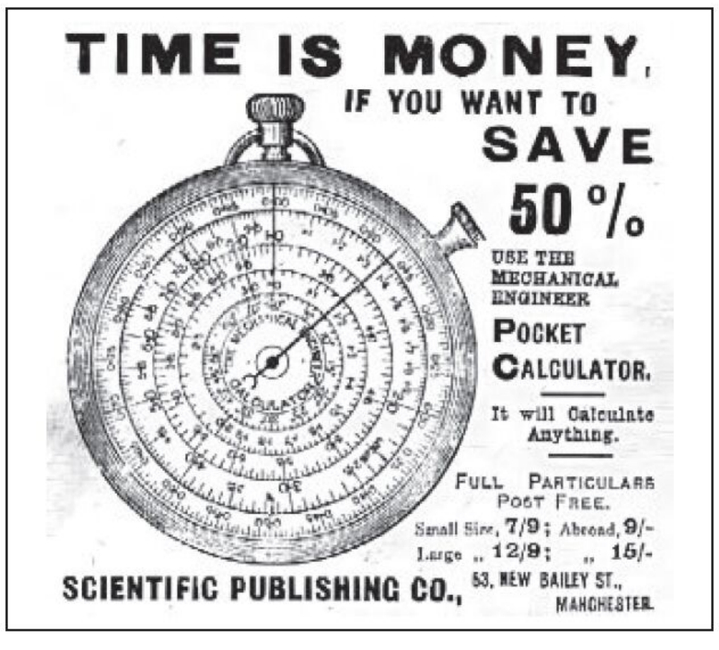

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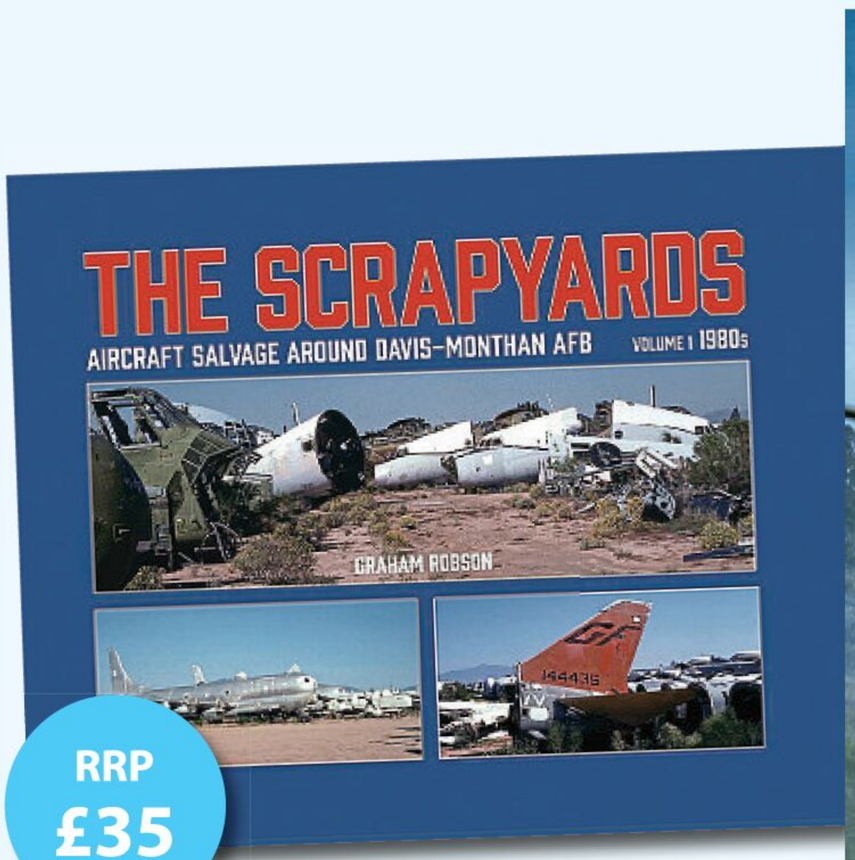

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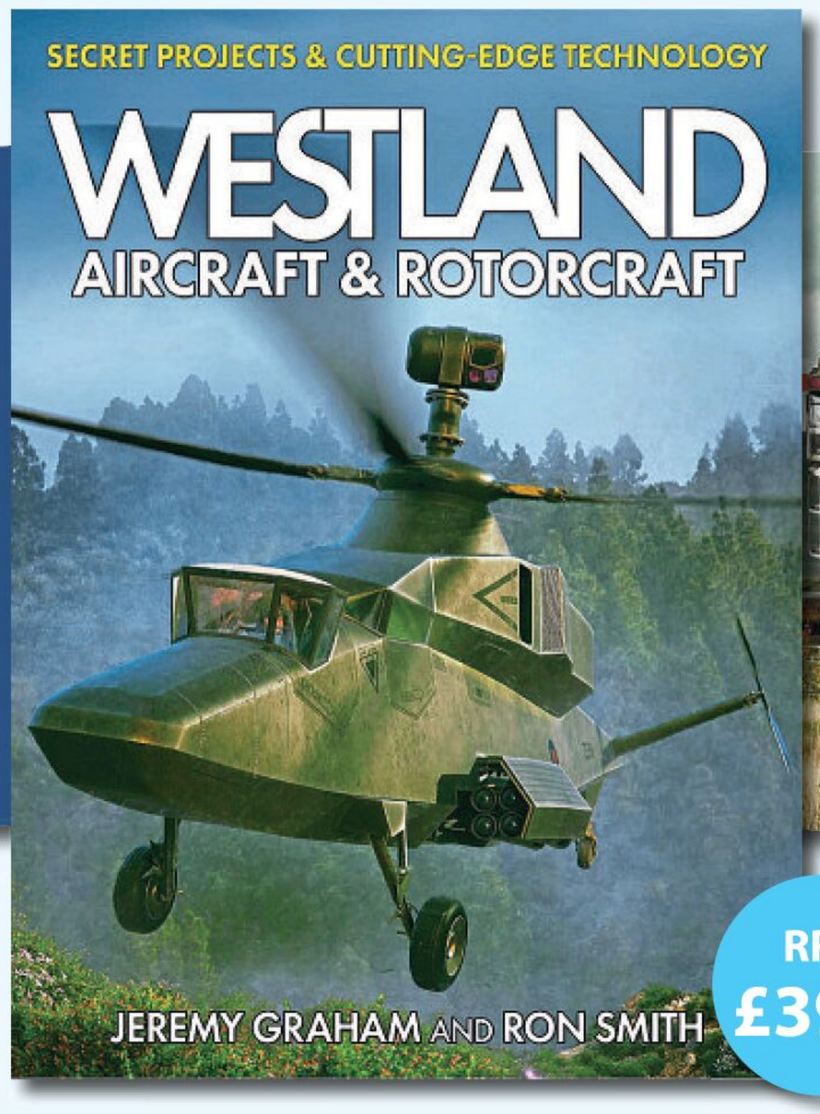

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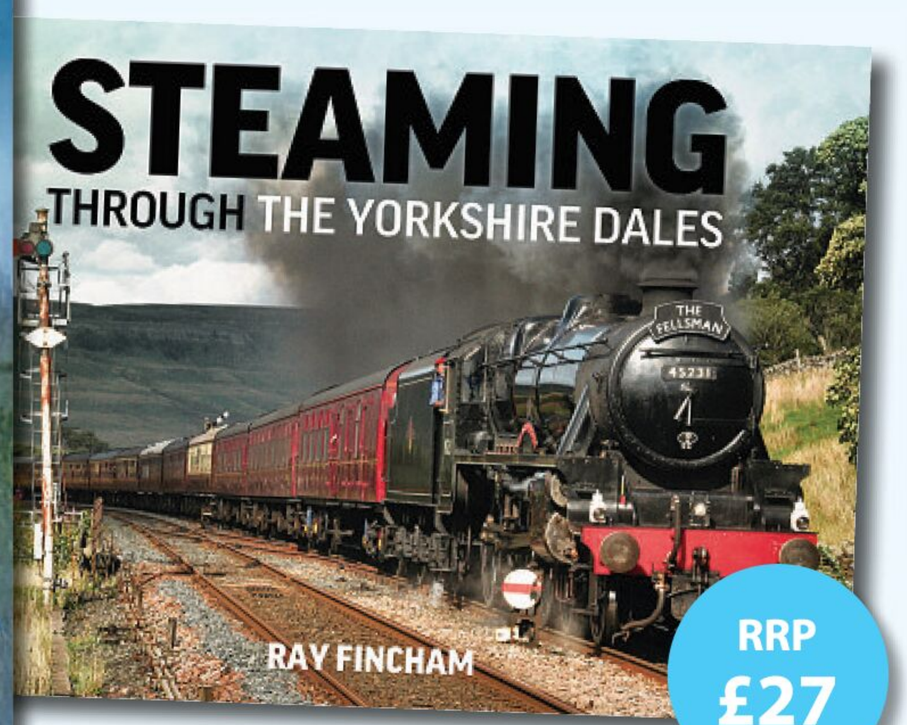

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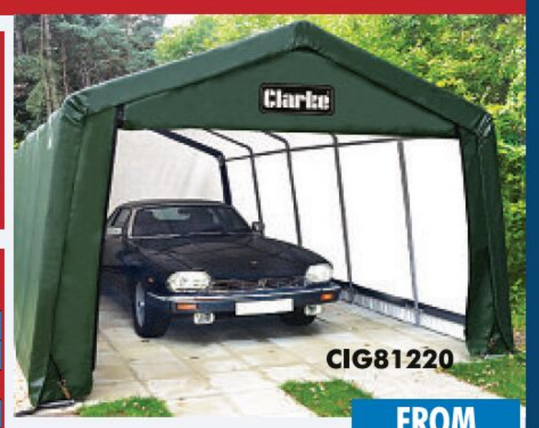

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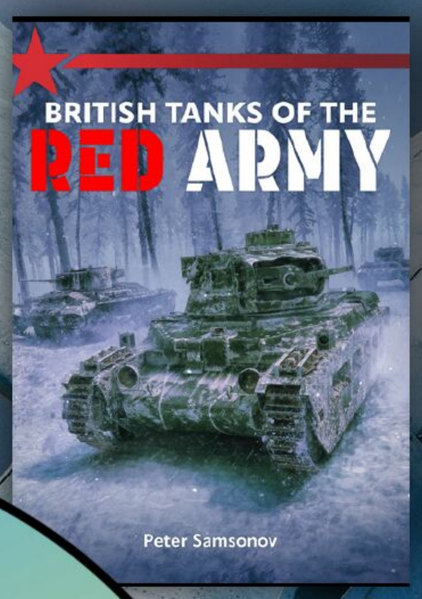

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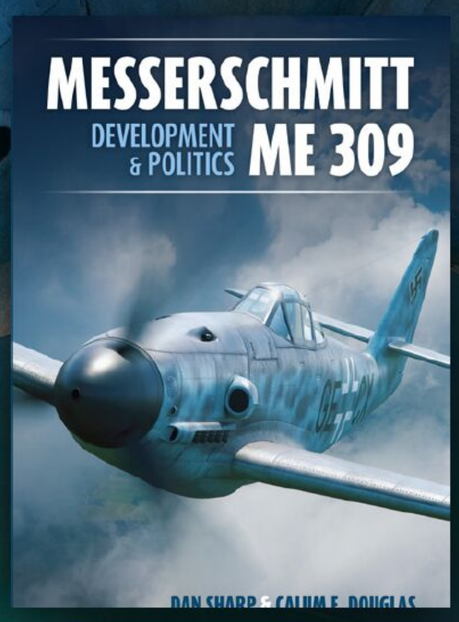

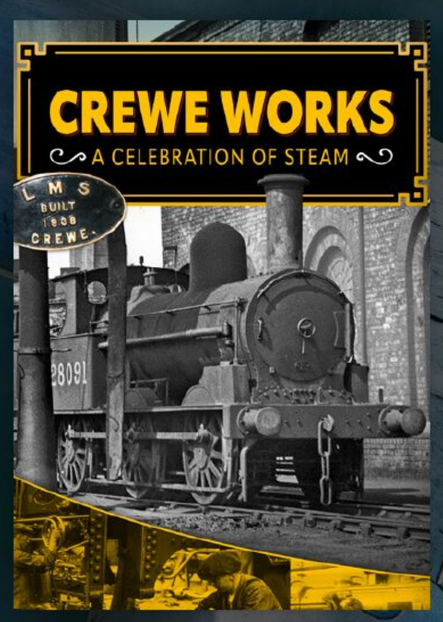

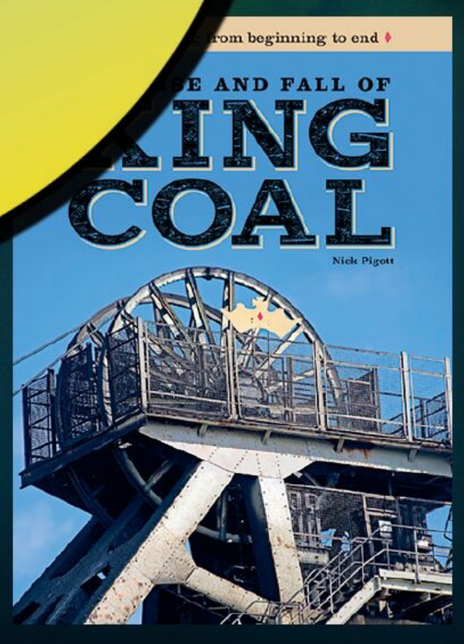

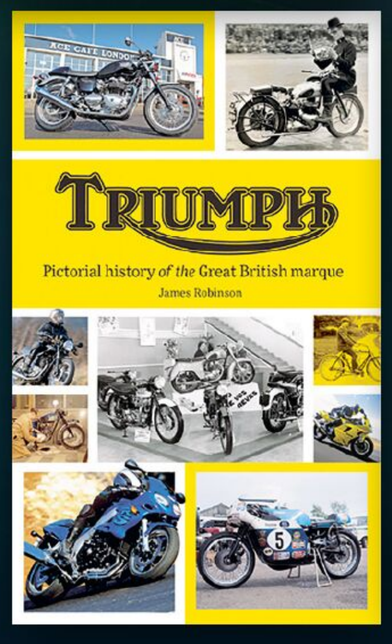

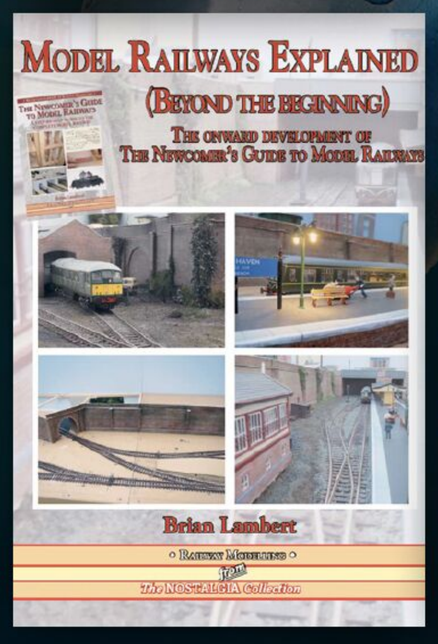

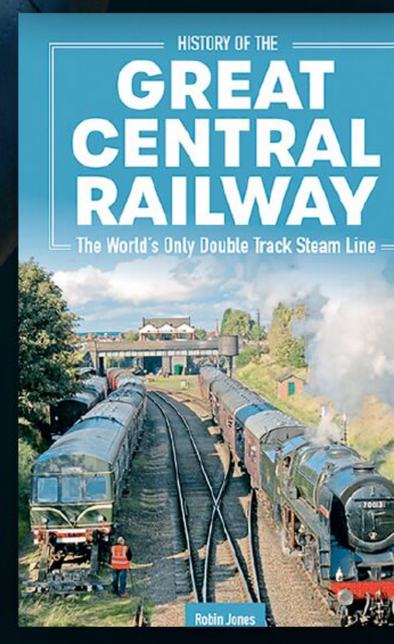

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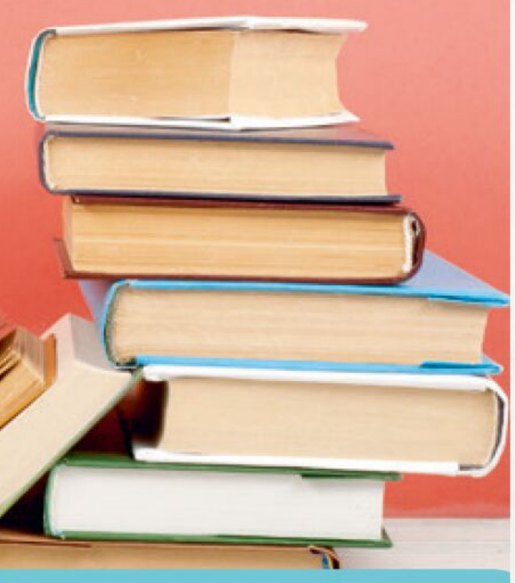

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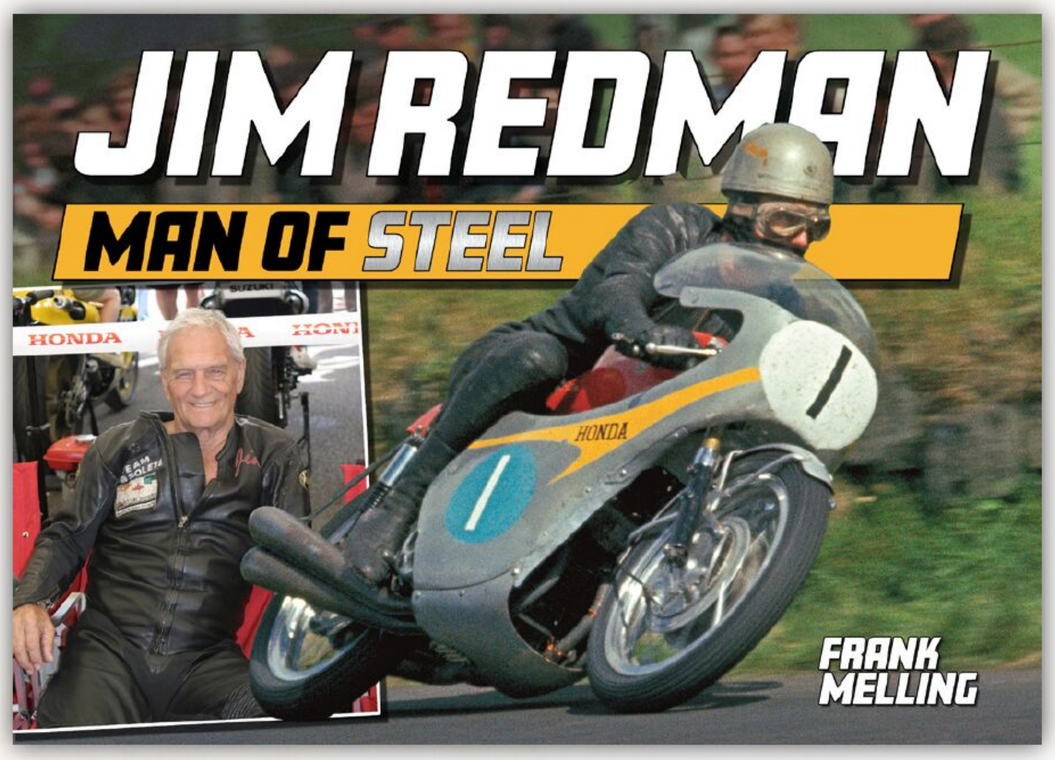

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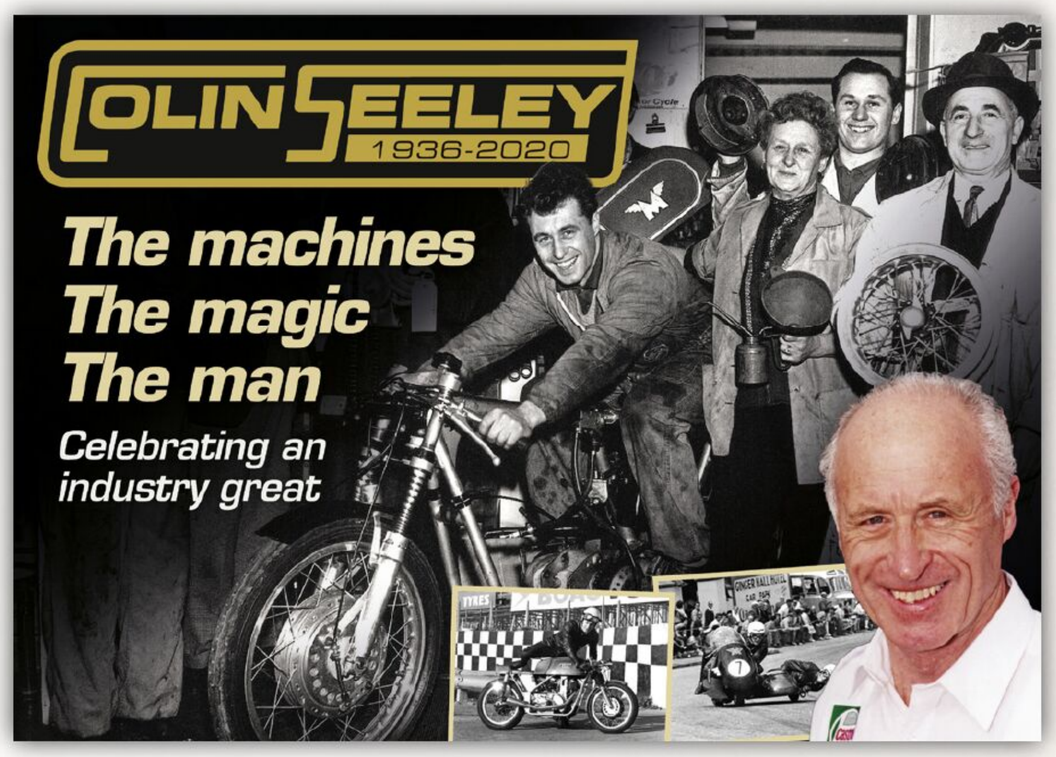

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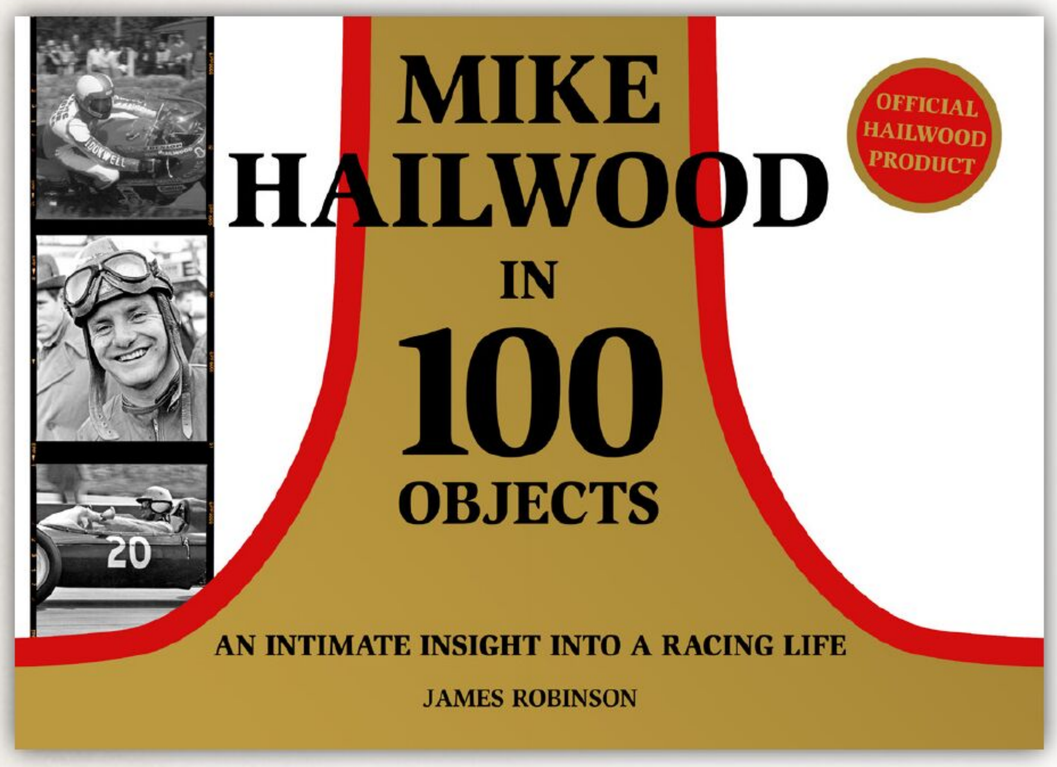

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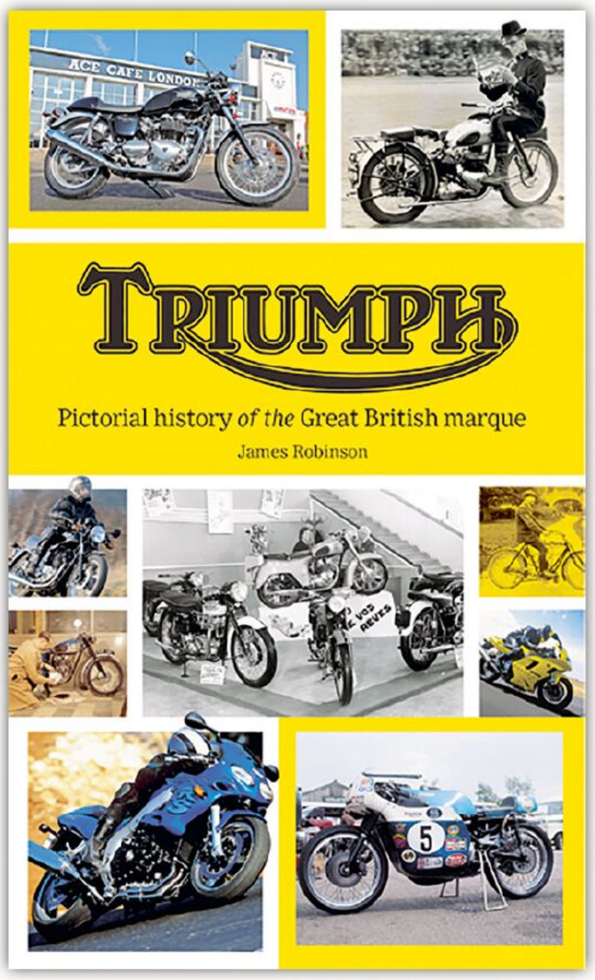

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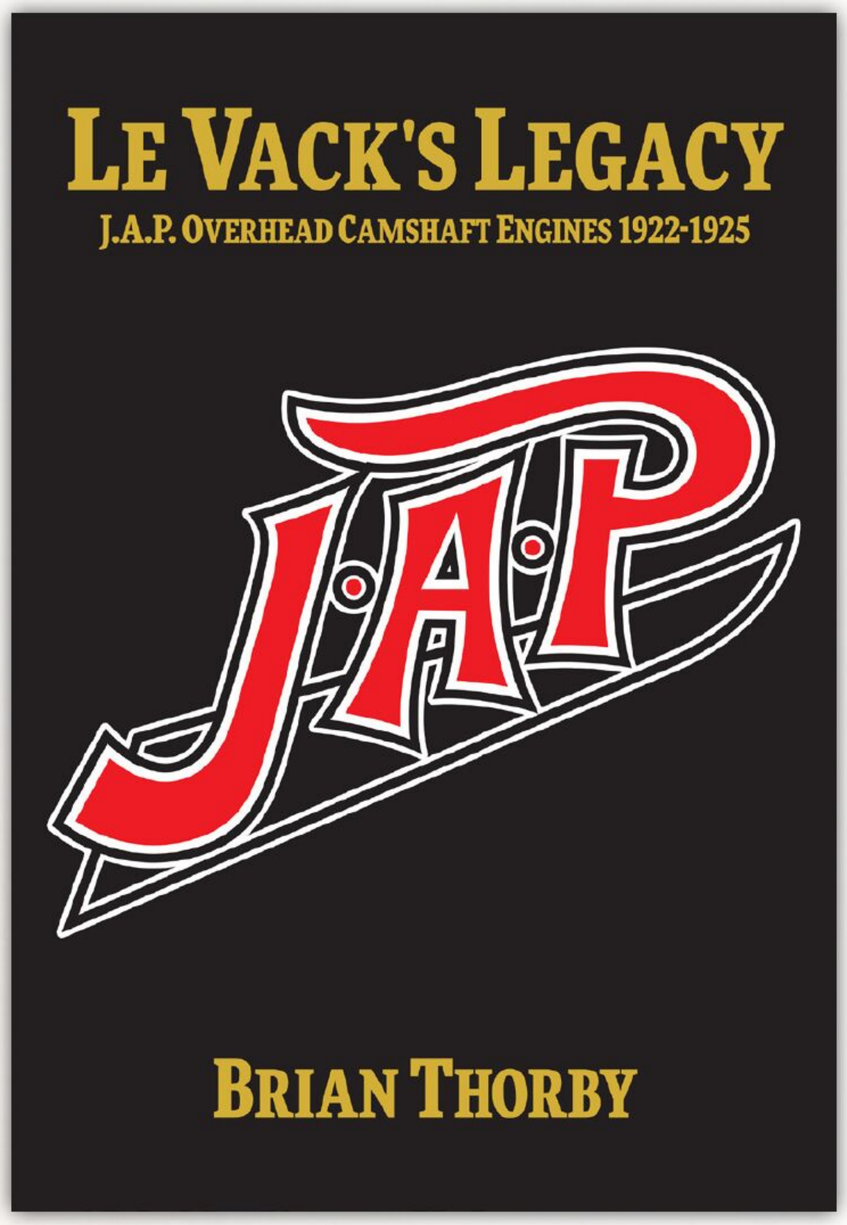

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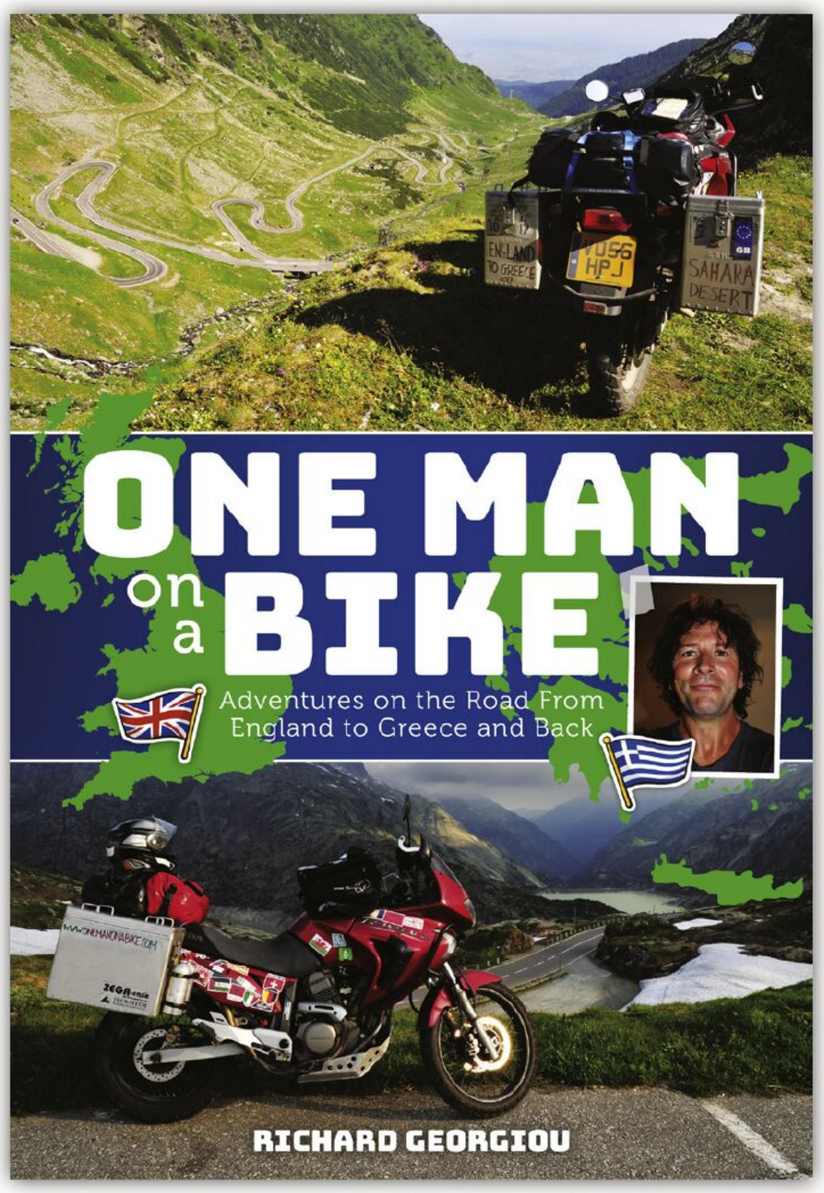

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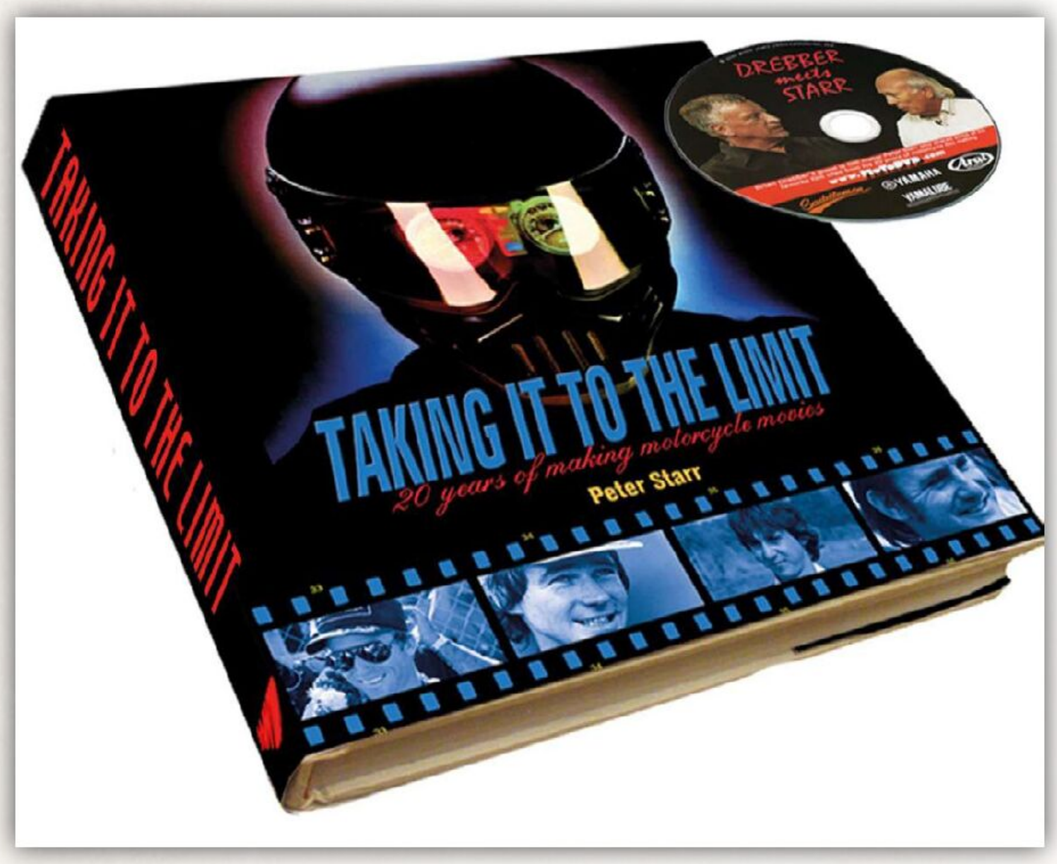

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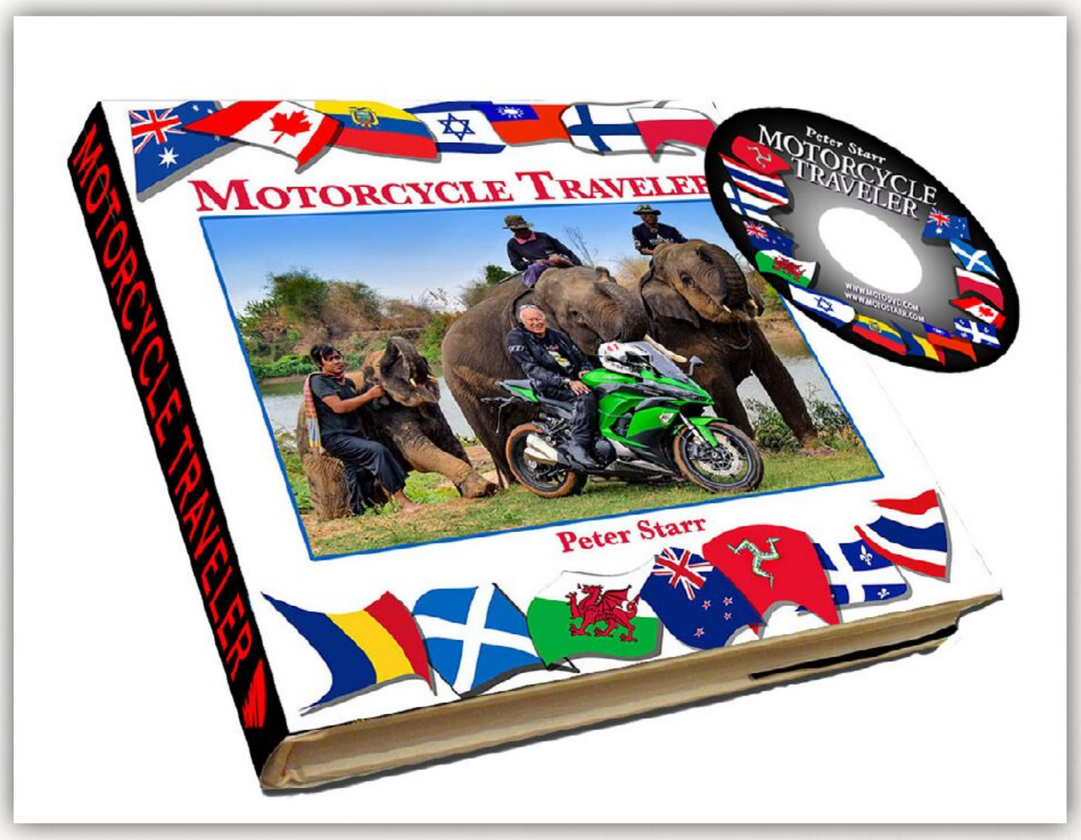

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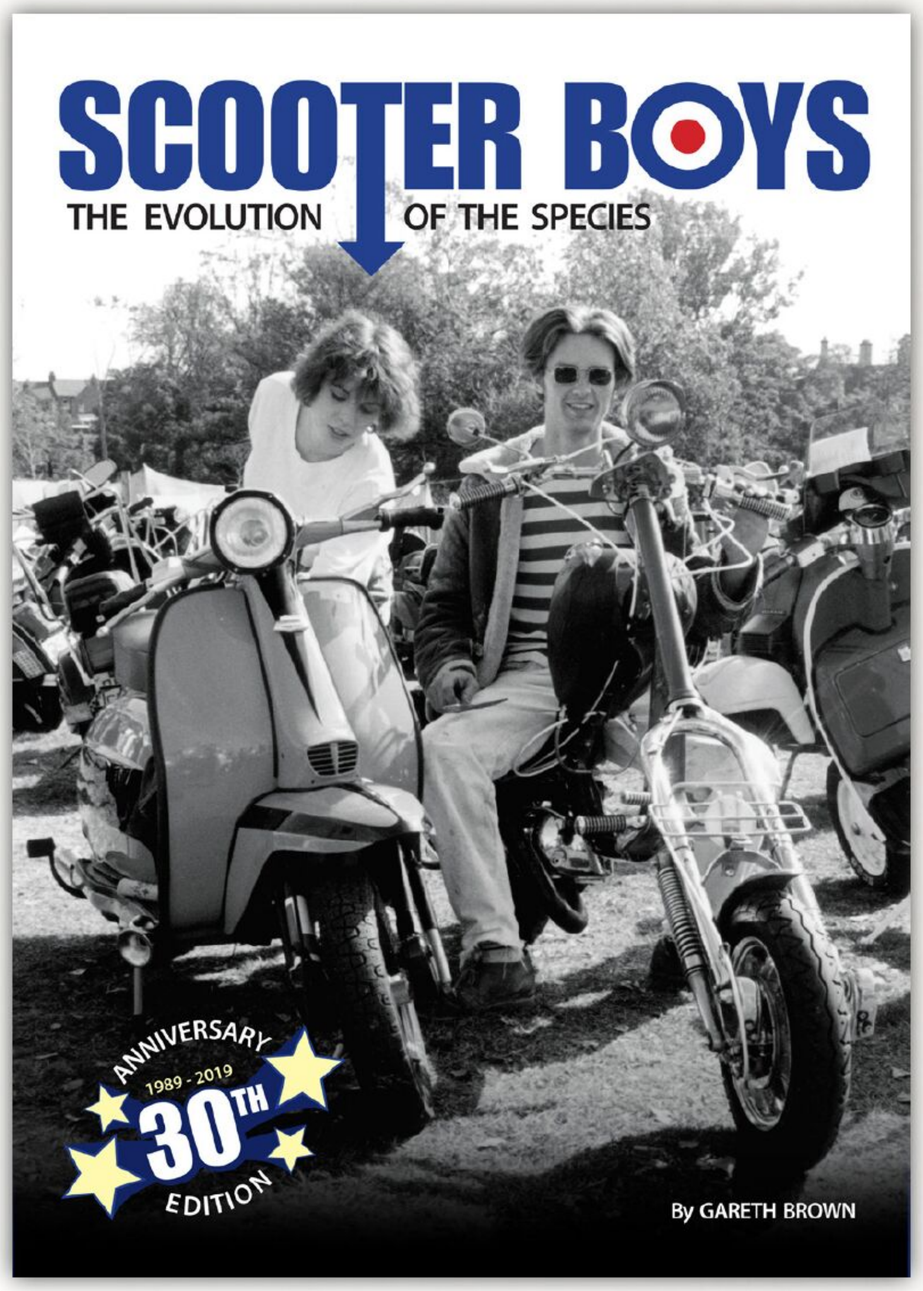

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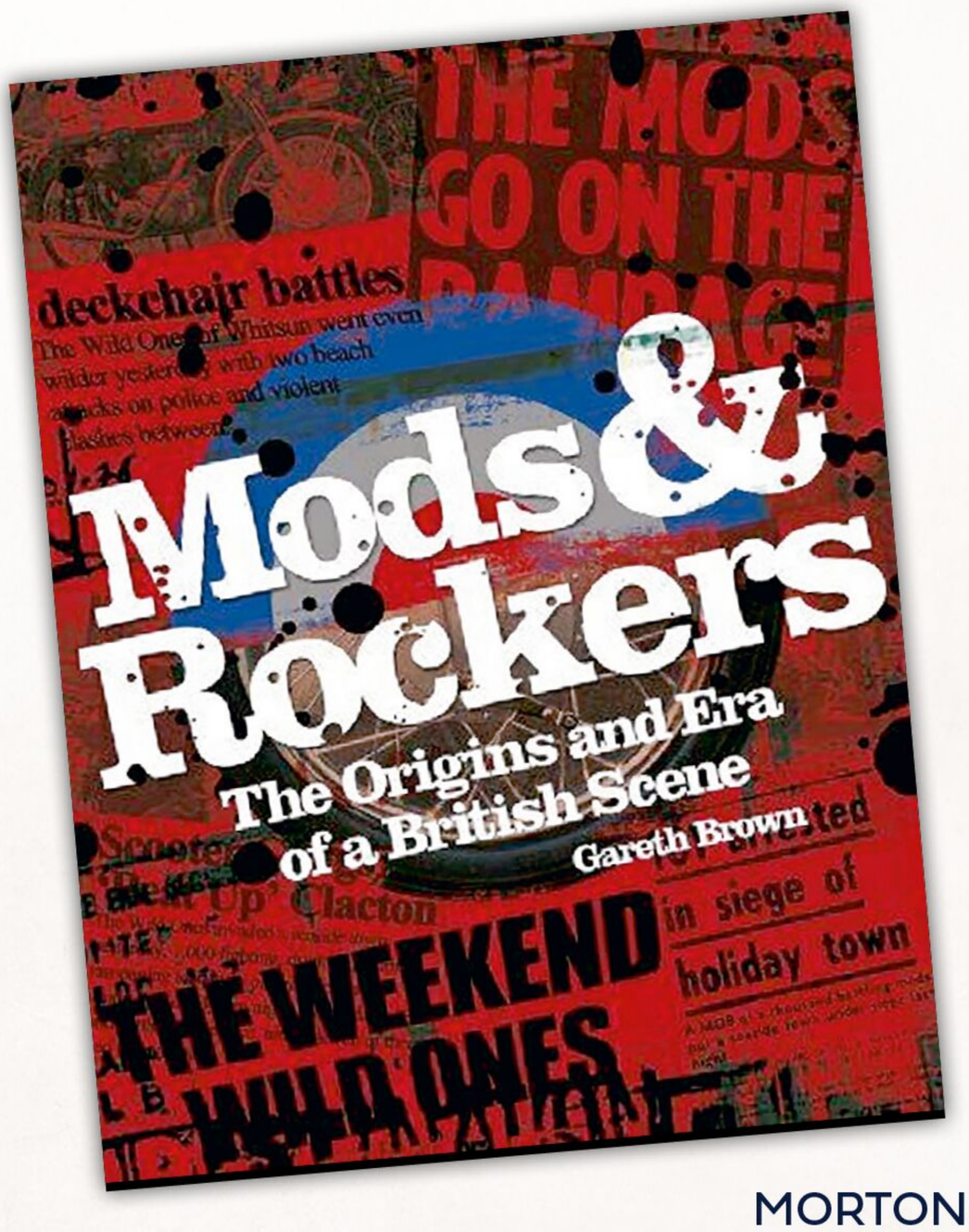

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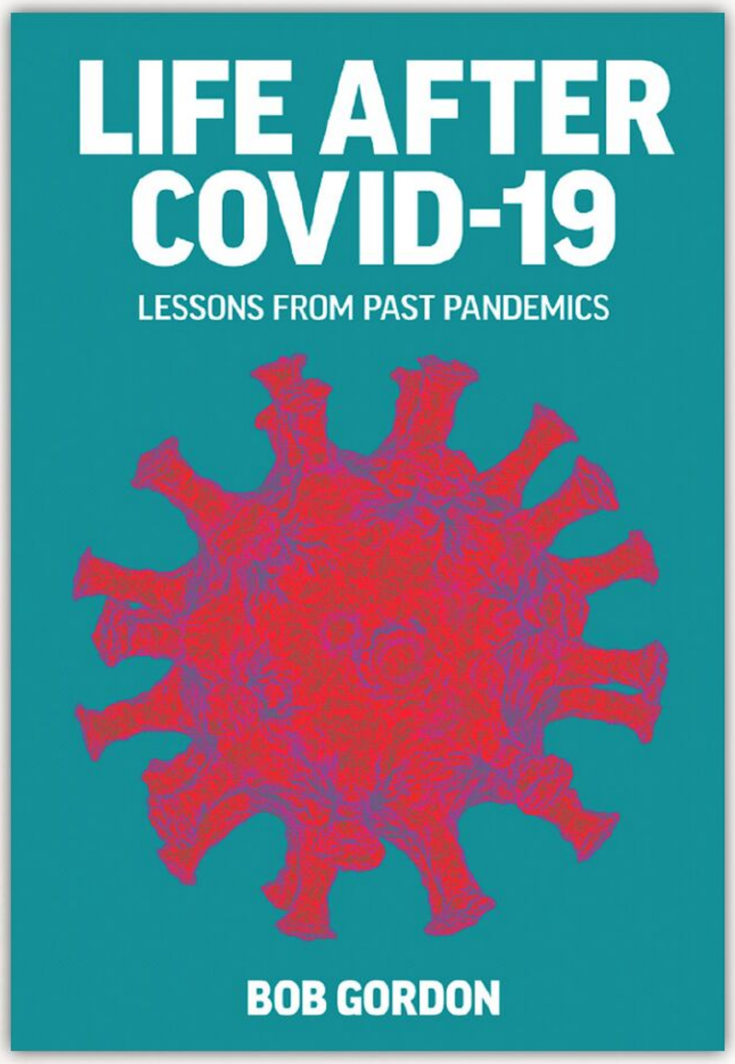

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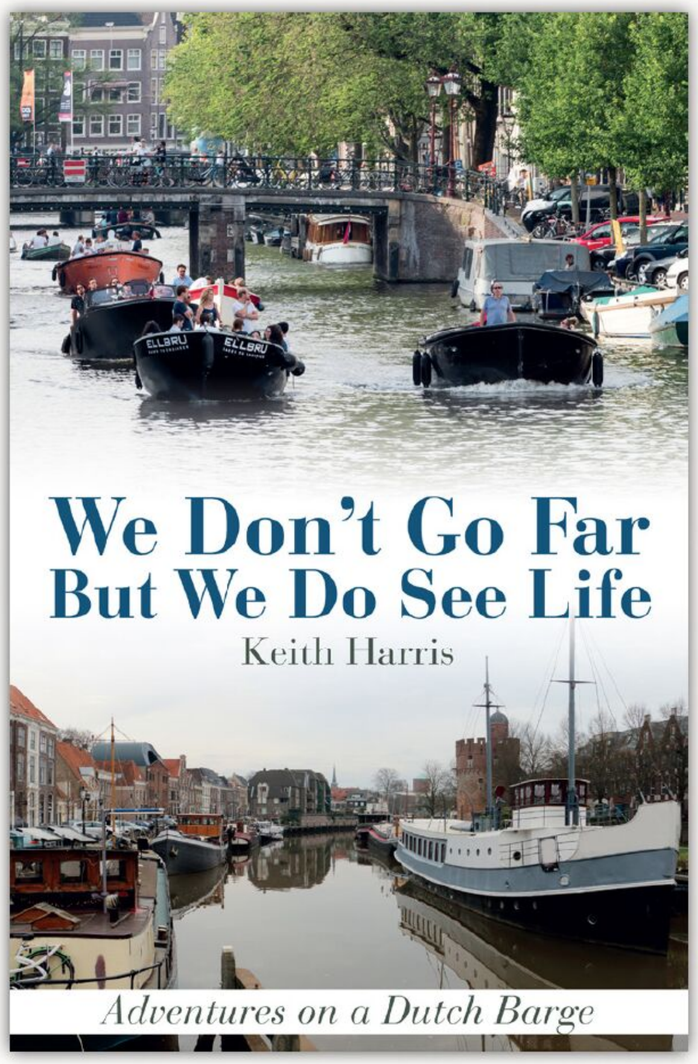

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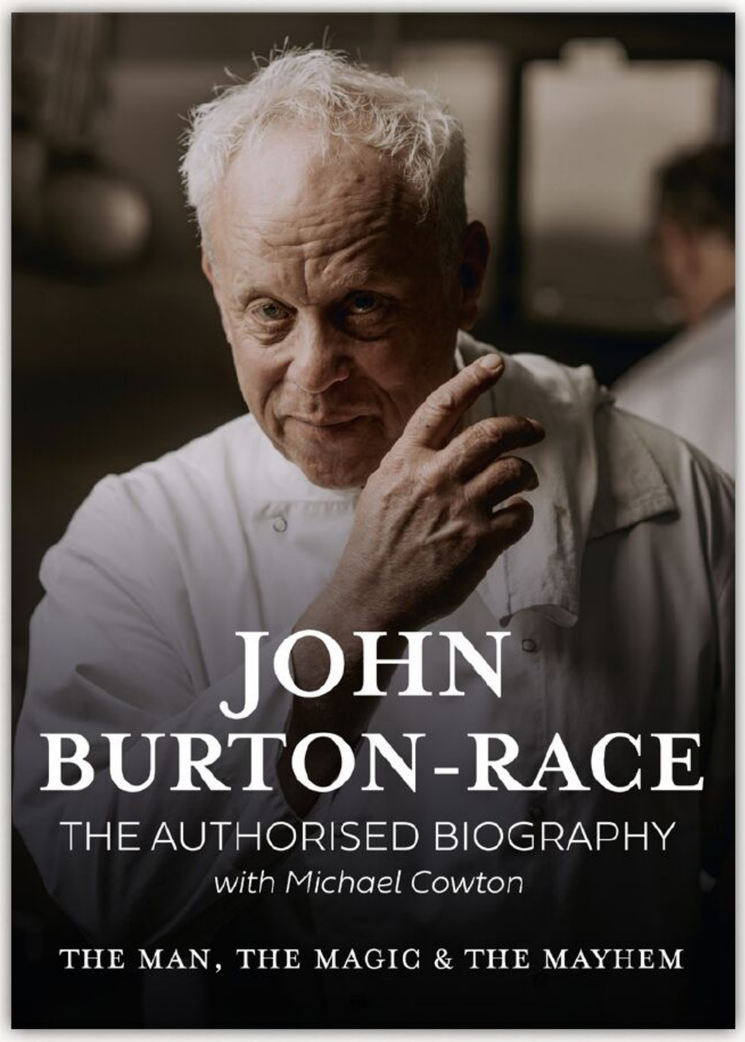

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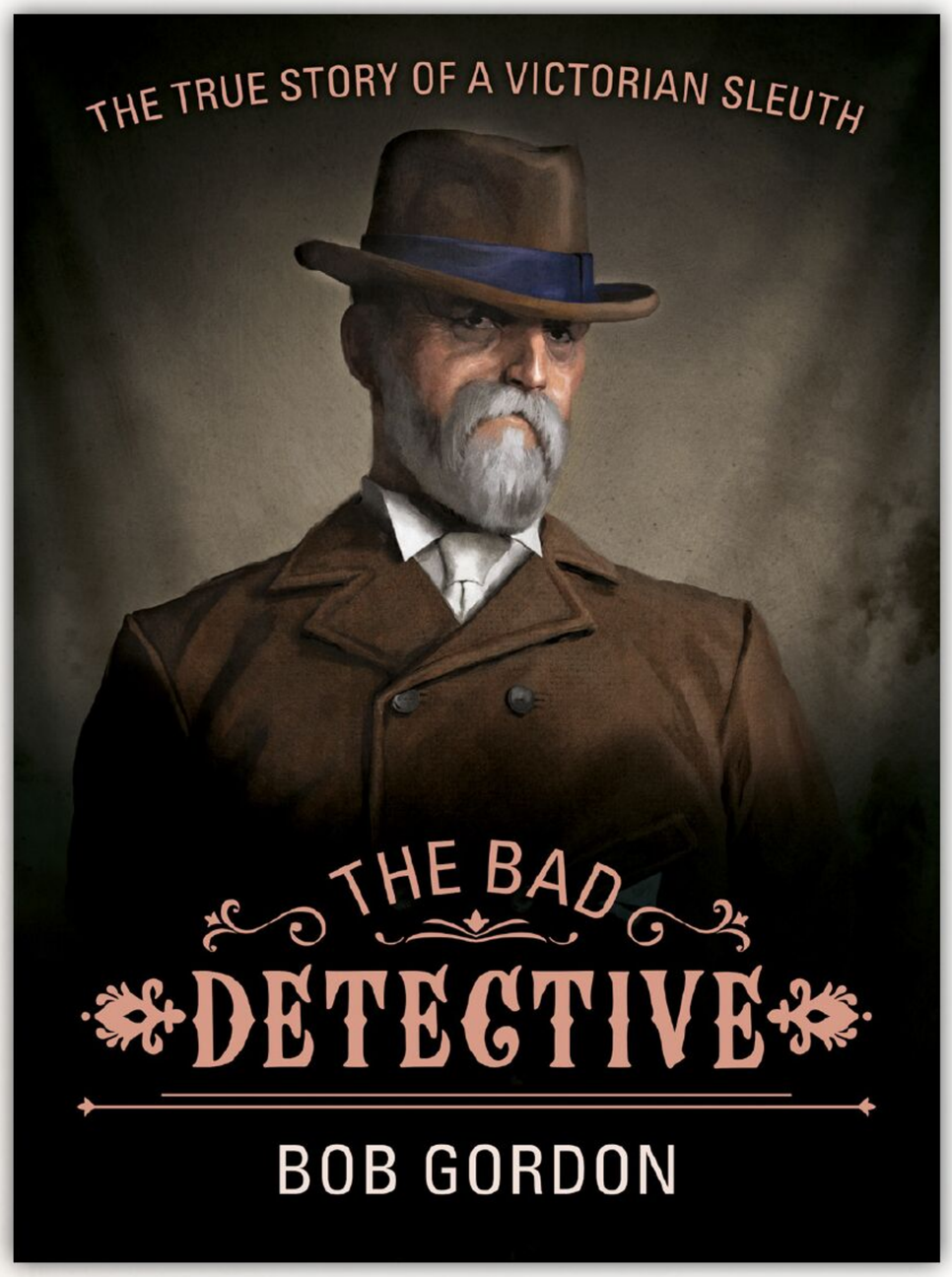

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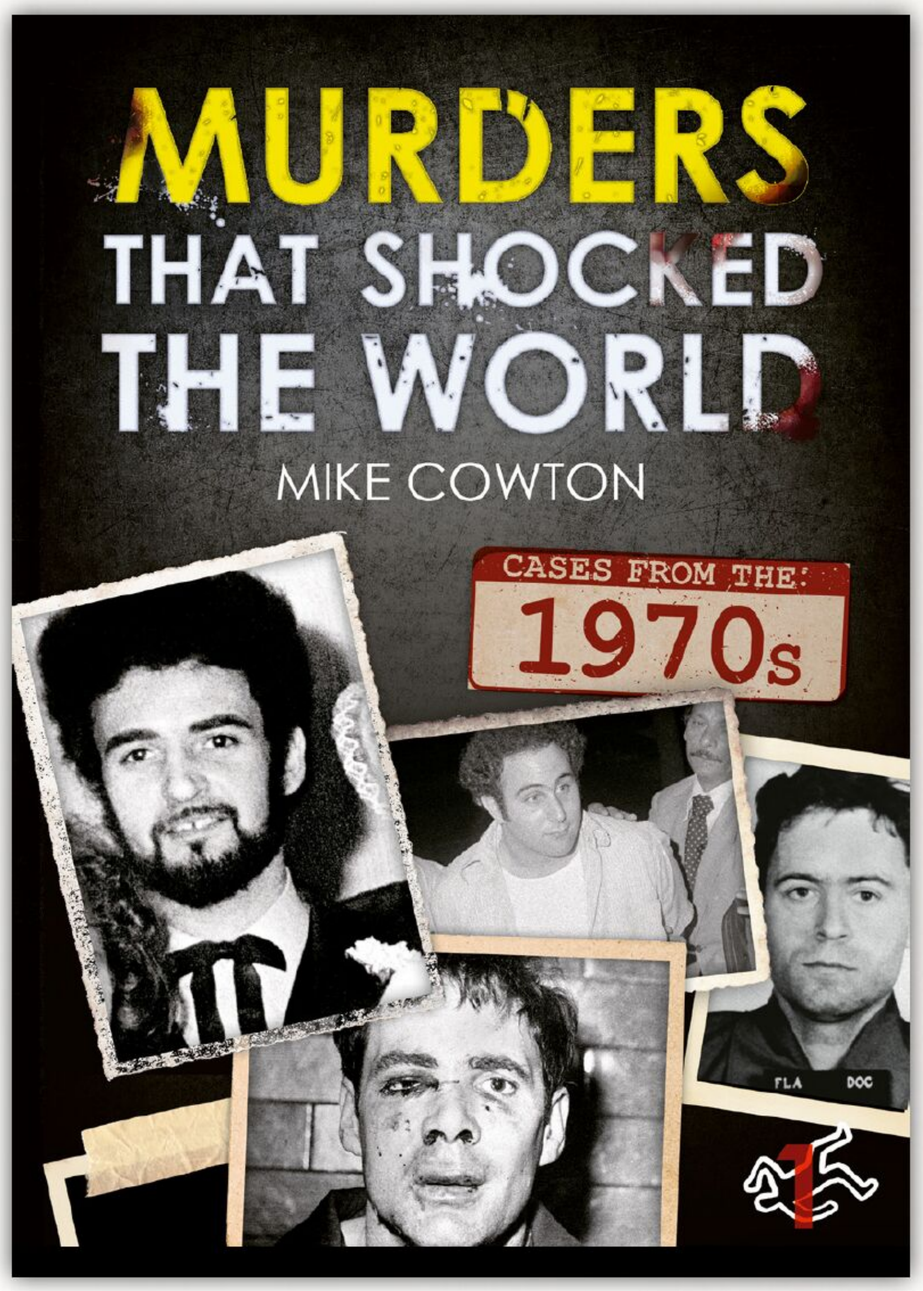

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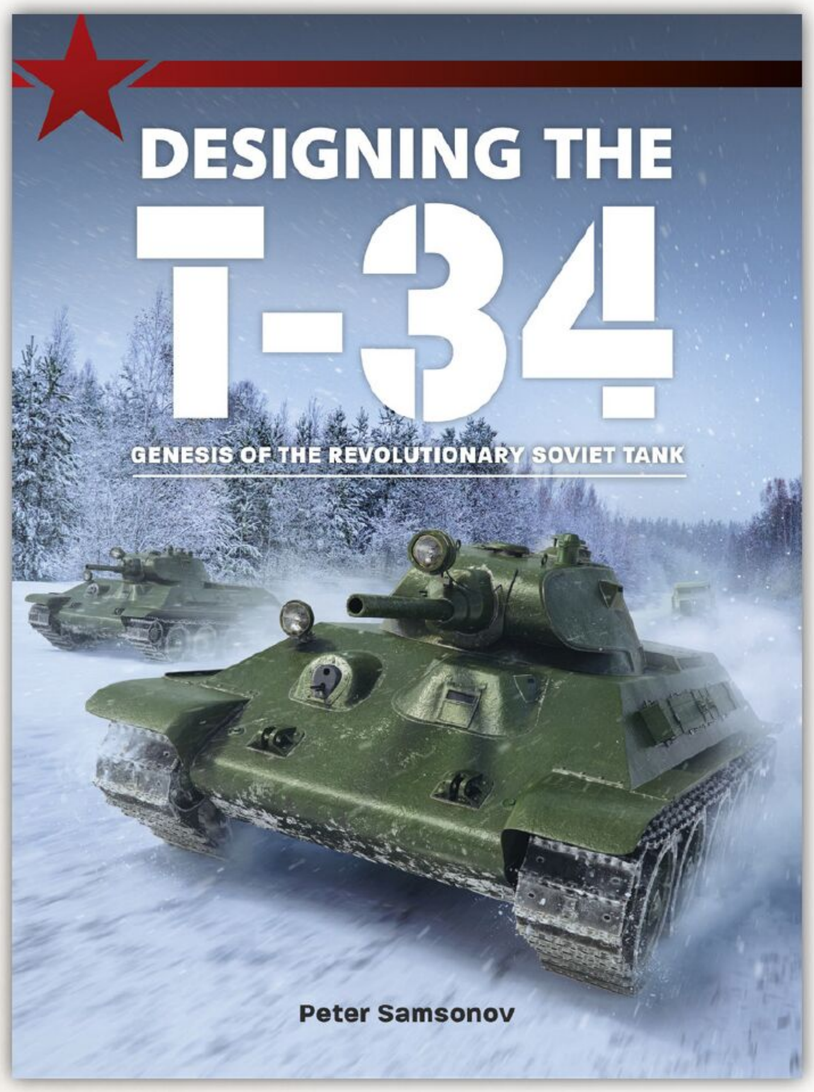

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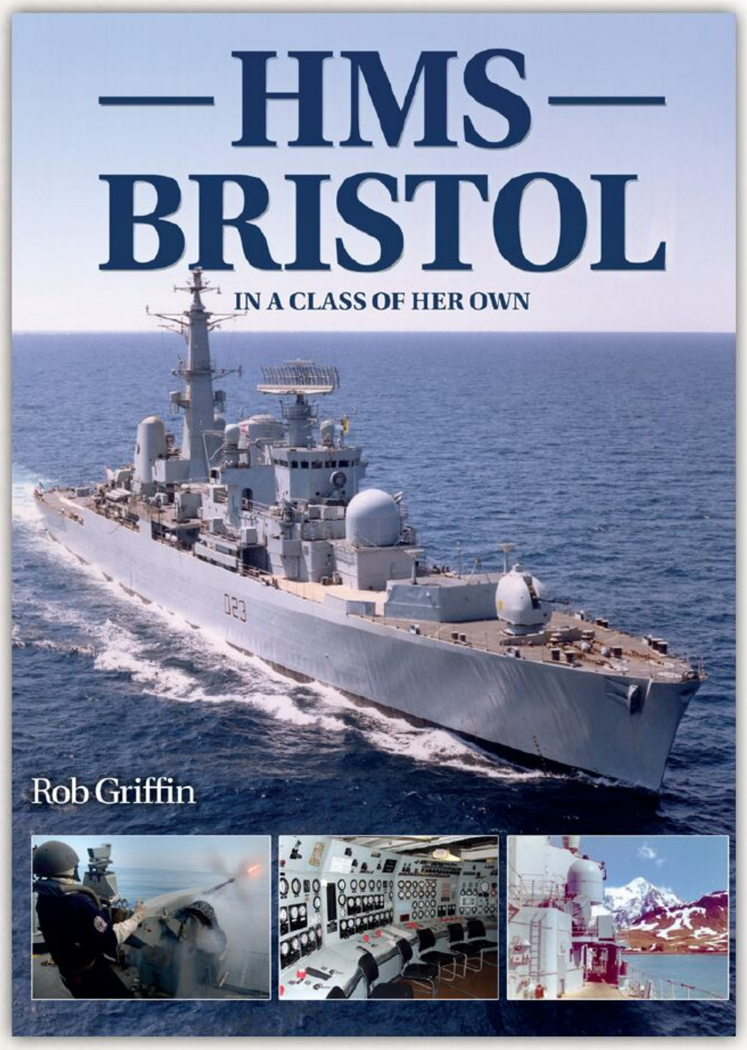

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The first encounter between British armour and the Red Army was not on friendly terms – with the British sending surplus tanks to reinforce the pro-monarchy White Army in the Russian Civil War. When the Reds won, war trophy Mark V heavy tanks as well as medium Mk.A Whippets and Mk.B Hornets entered service with the RKKA. As the political landscape changed during the 1920s, the Red Army assessed British designs available for export and a licensed copy of the Vickers Mk.E entered production in 1931 as the T-26.

During the early days of the German invasion of the Soviet Union, armour losses were huge and the Red Army once again looked abroad to acquire new fighting vehicles. A large-scale programme of military aid to the USSR began in August 1941, with the US and Britain offering help under separate terms – though not for free. A deal was struck and Convoy PQ-1 with the first 20 British tanks for the Red Army left for Arkhangelsk on September 29, 1941. These tanks arrived in time to take place in the Battle of Moscow and as shipments continued, British armoured vehicles would remain in service with the Red Army until the conclusion of the Second World War nearly four years later.

A wide range of British vehicles served under the Red flag during the war – ranging from Matildas and Valentines to Churchills and even Tetrarch light tanks.

In British Tanks of the Red Army, tank expert Peter Samsonov presents a history of British tanks in the Soviet Union and provides a detailed account of their use on the battlefield, including what the Red Army tankers thought of them.

Locomotive No 32 Tamerline became the first steam locomotive to be completed at Crewe Works on 10 March 1843. One hundred and fifteen years later BR 9F No 92250 became the 7,331st steam locomotive to be built at the Cheshire works, when completed in December 1958. This publication is a tribute to the thousands of people employed there during the steam locomotive building era.

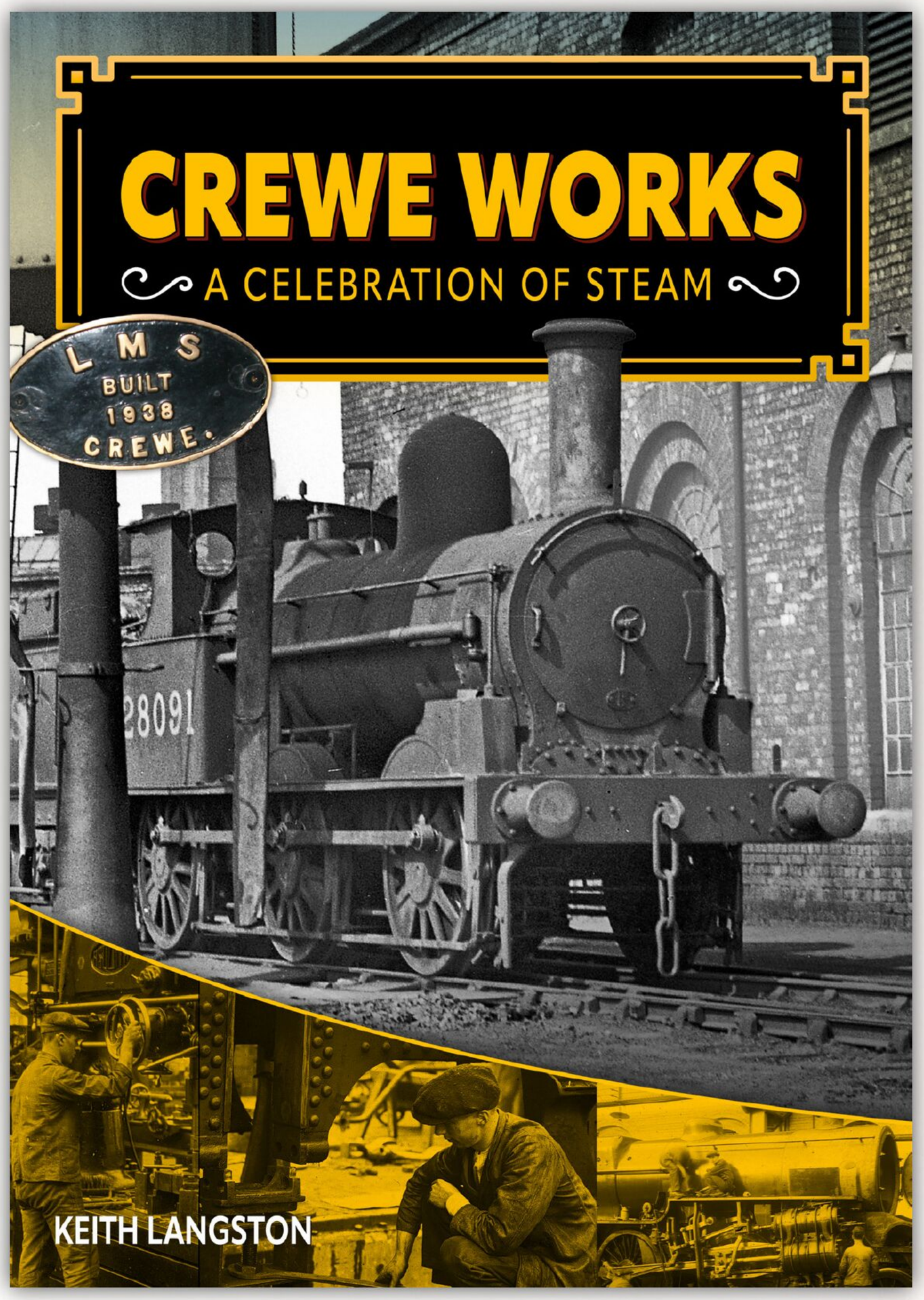
In 1913 The Railway Magazine proudly described Crewe as "the most famous railway works in the world". Indeed, railways throughout the world benefited from adopting 'best Crewe practice'. Many who worked at Crewe in its heyday, first under the London & North Western Railway and later the London Midland & Scottish Railway, held the firm belief that the works was the 'beating heart' of the Cheshire town.

Back in those days you would be hard put to find a local family without some kind of connection to that vast engineering enterprise. In earlier times the works not only provided the steadily growing town with employment, but furthermore supplied the town with both gas and domestic water. For example, the consumption of the gas produced at the works in the 1940s was assessed as 30% to the works, 20% to Rolls-Royce and 50% to the town. Those statistics are a great example of the many close ties that existed between the works and the town.

After the post-war Trasport Act, steam locomotive construction and maintenance continued under the newly created company British Railways. From 1948 under Nationalisation in addition to locomotive building, BR Crewe Works was responsible for the maintenance of some 2,779 steam locomotives. However, even as the Standard Locomotive building programme got underway plans for a future railway system without steam traction were being drawn up.

The timeline of this publication highlights those steam locomotive classes which were listed as being built by Crewe Works (in any time period) but importantly included in the BR January 1948 stock list. It also includes BR Standard class locomotives built at Crewe post 1951. Steam traction did return to the works, albeit in only a token manner during the occasion of the September 2005 Great Gathering.

Crewe Works – A Celebration of Steam by Keith Langston is not intended to be a source of detailed steam engineering practices, but is a comprehensively illustrated record of steam locomotive building and maintenance at Crewe Works. Fortunately, important engineering work was still carried out at Crewe Works in 2023. Given the reduced size of the works, and reduction in numbers employed, it would not be unfair to say that the once 'beating heart' of the town is at least a 'discernible pulse'.



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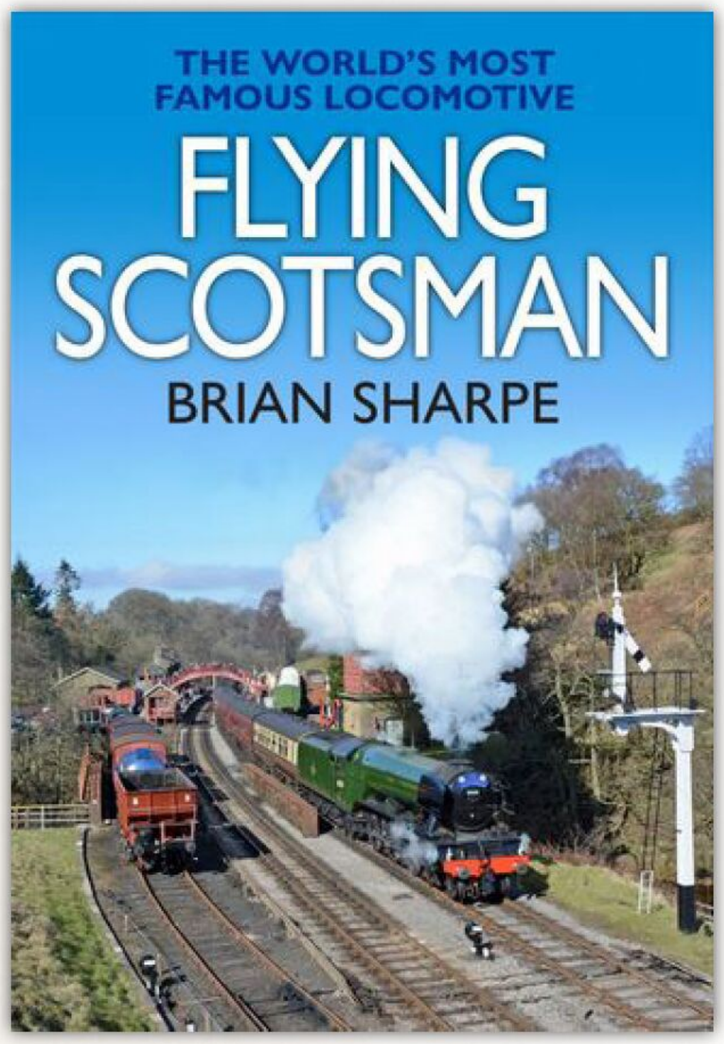

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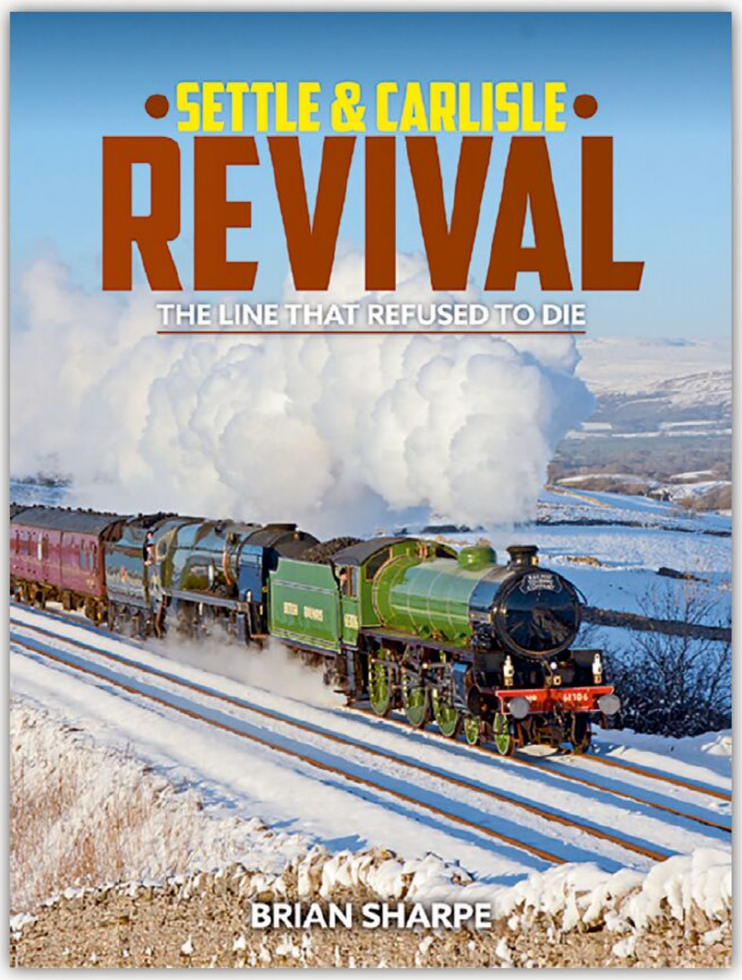

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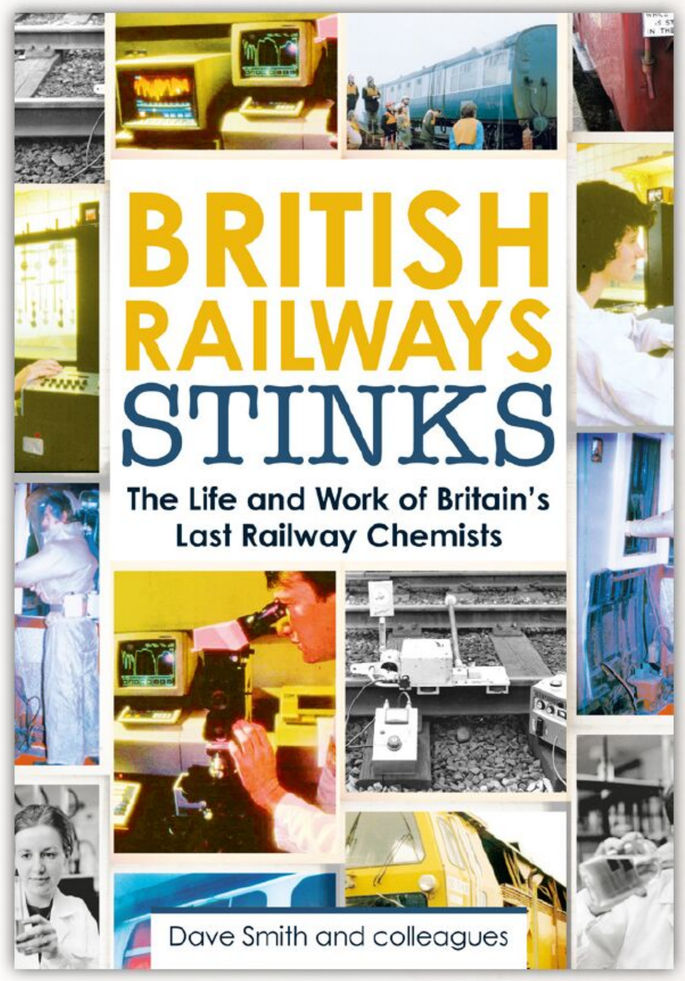

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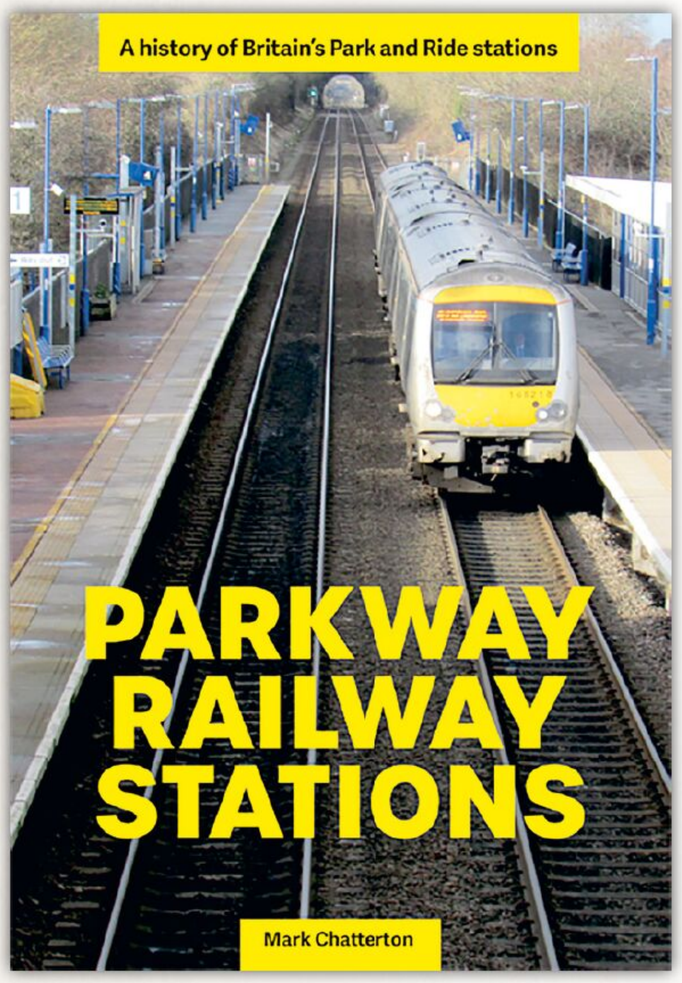

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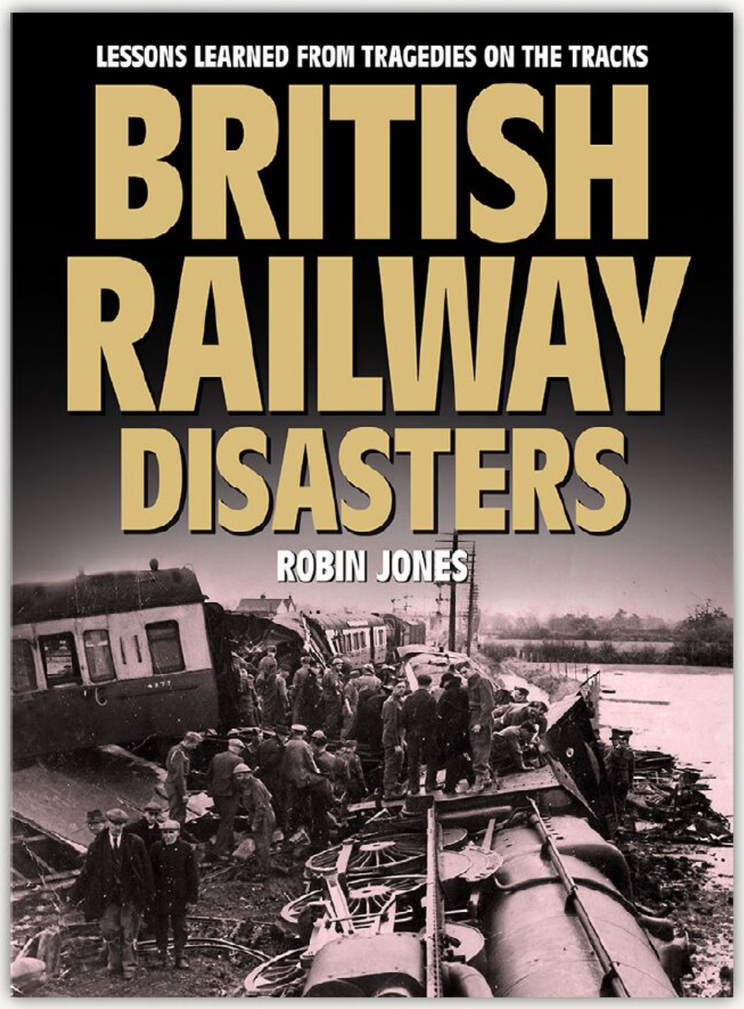

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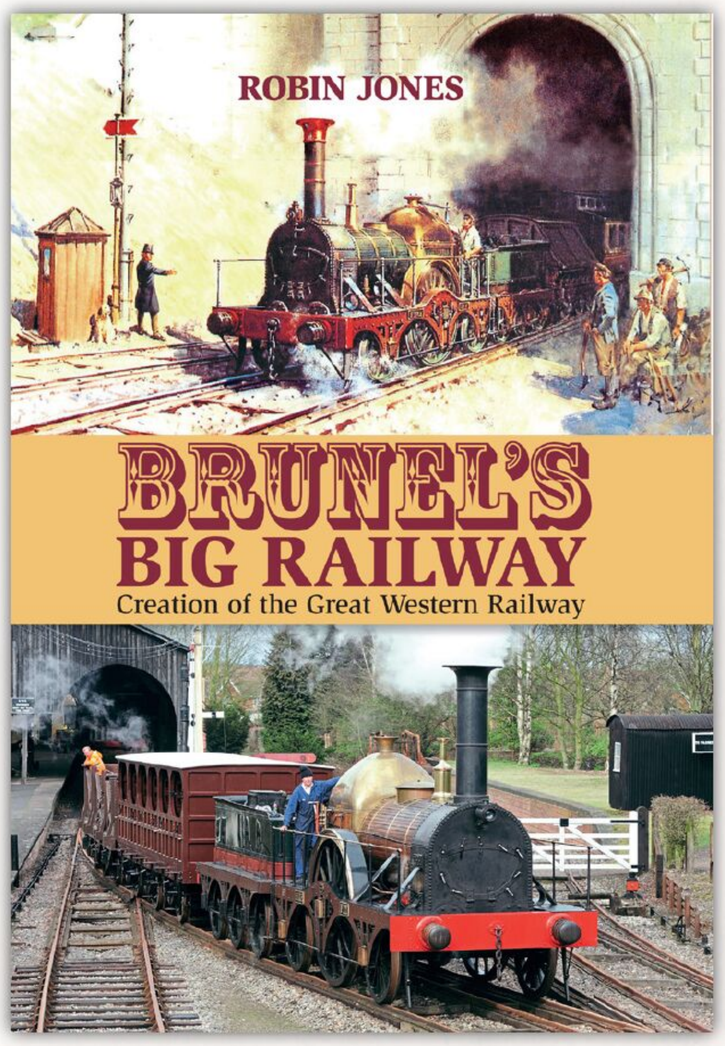

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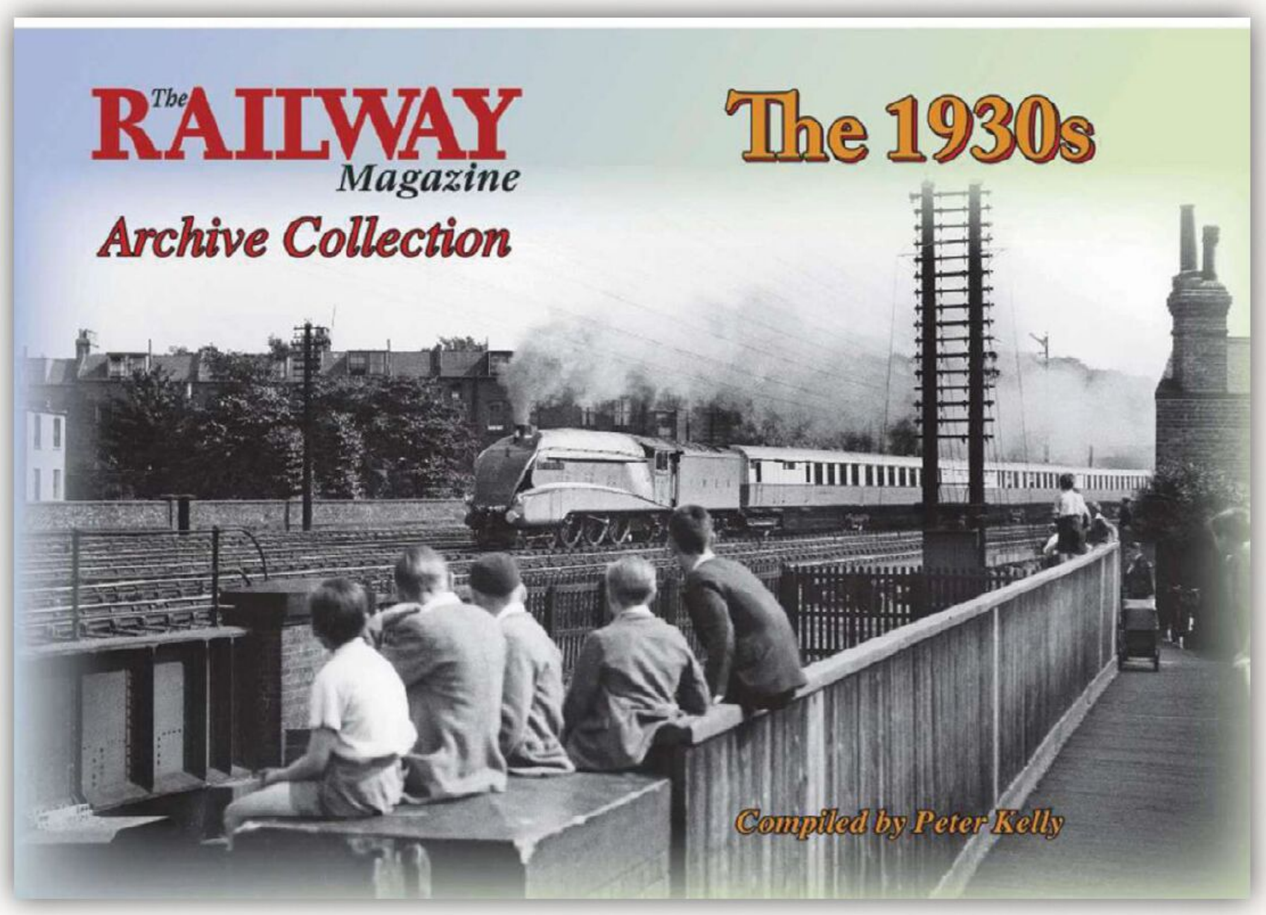

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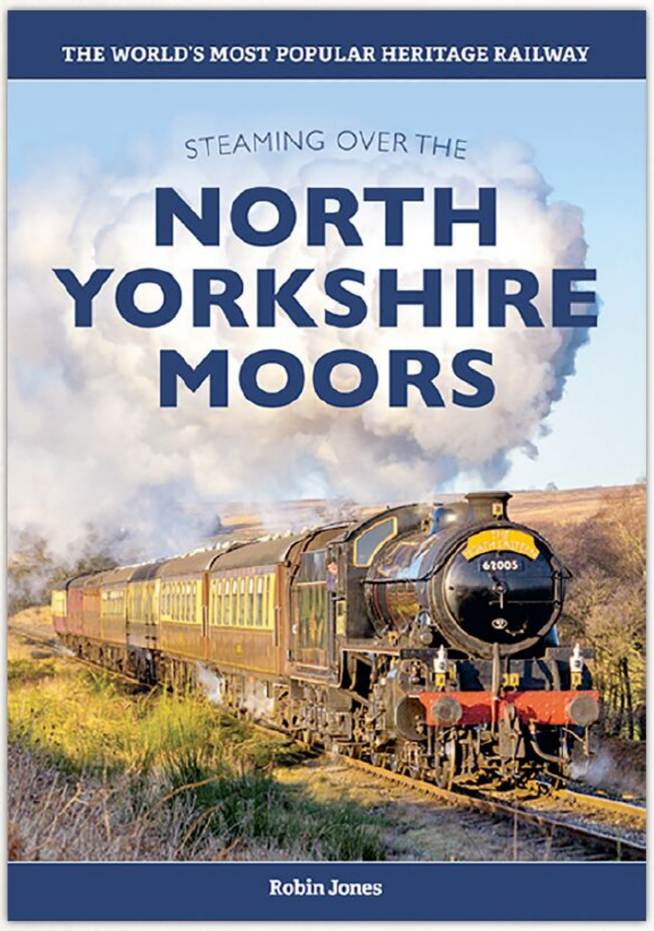

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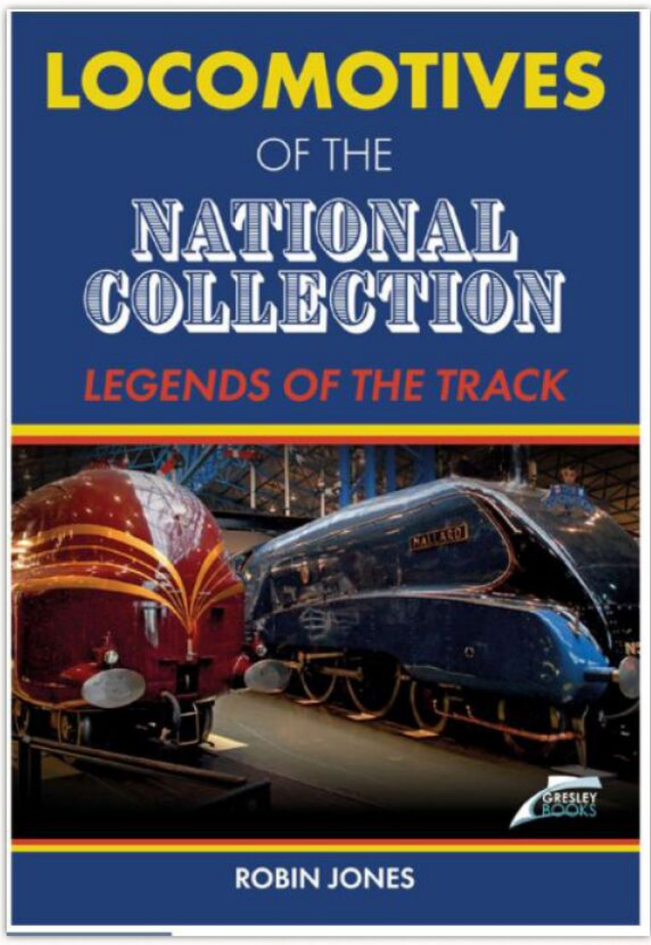

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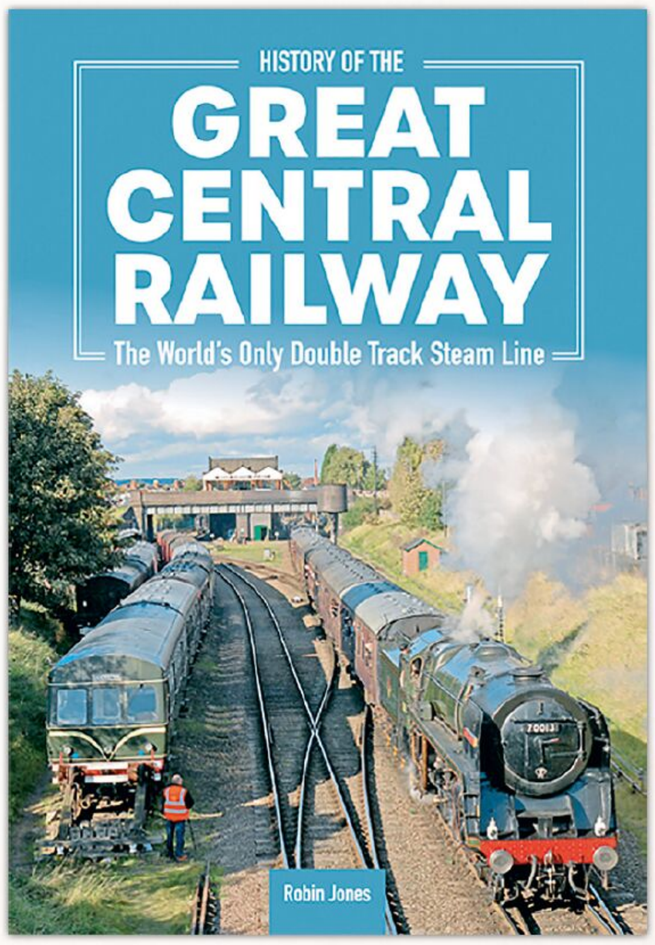

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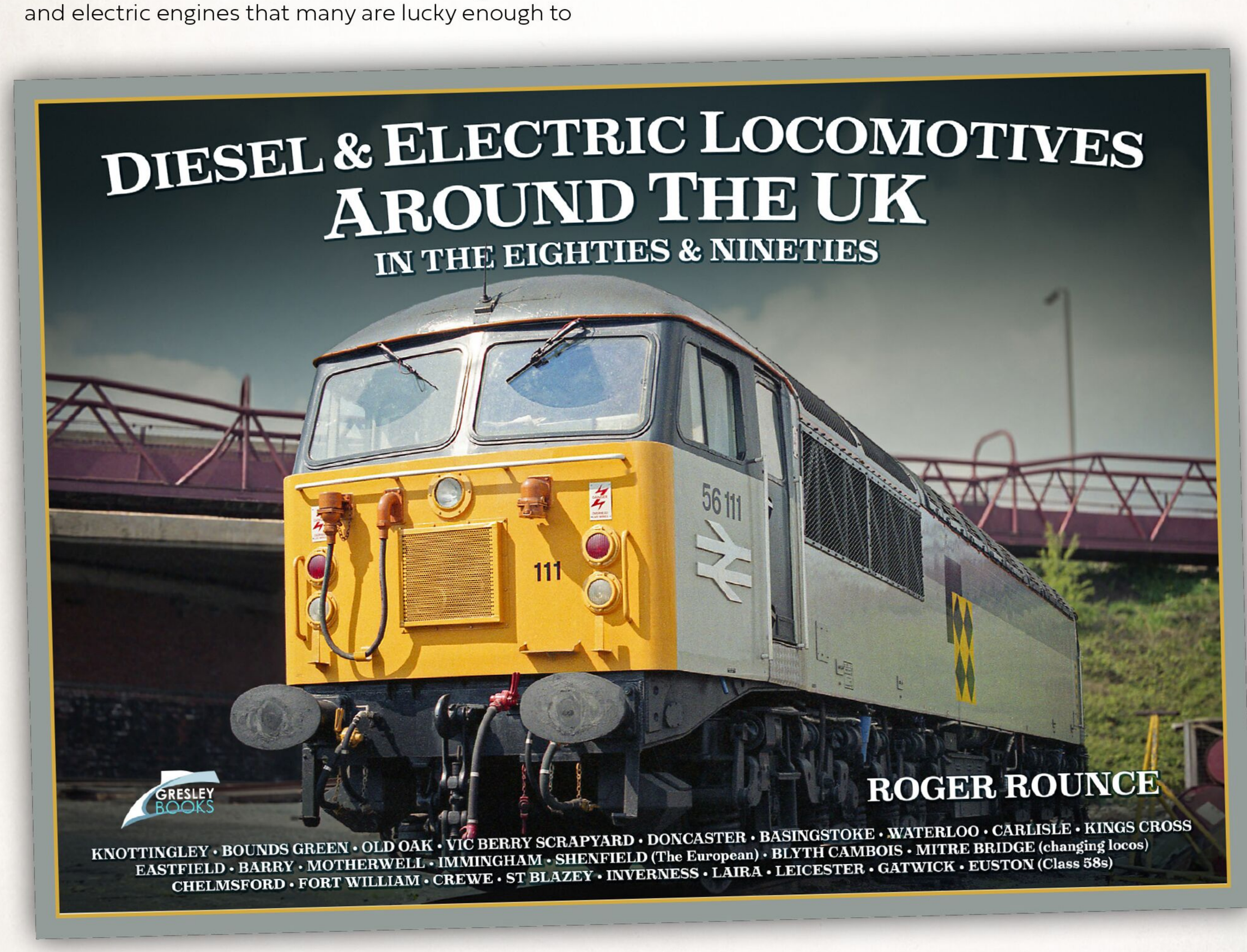

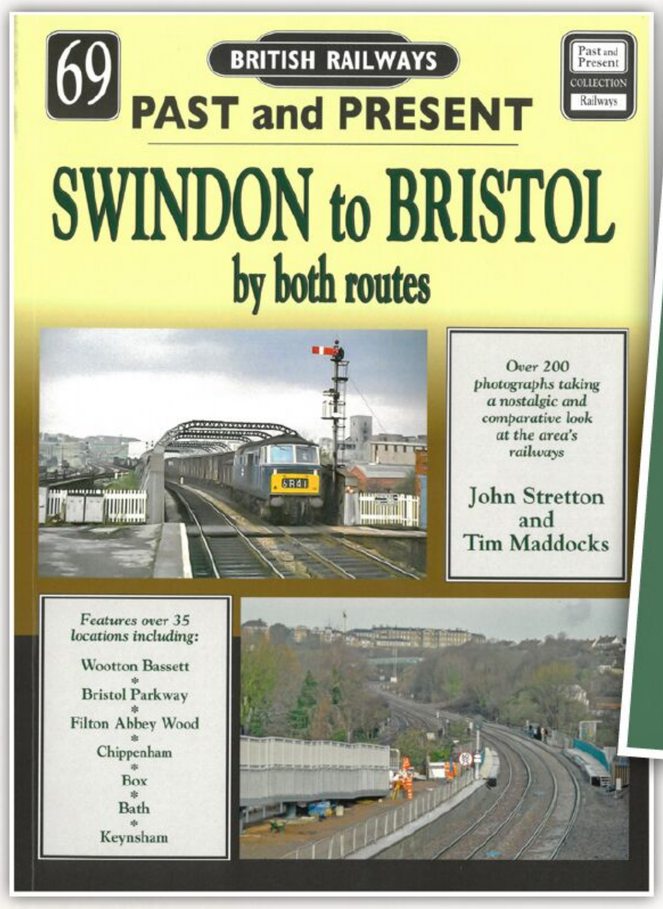

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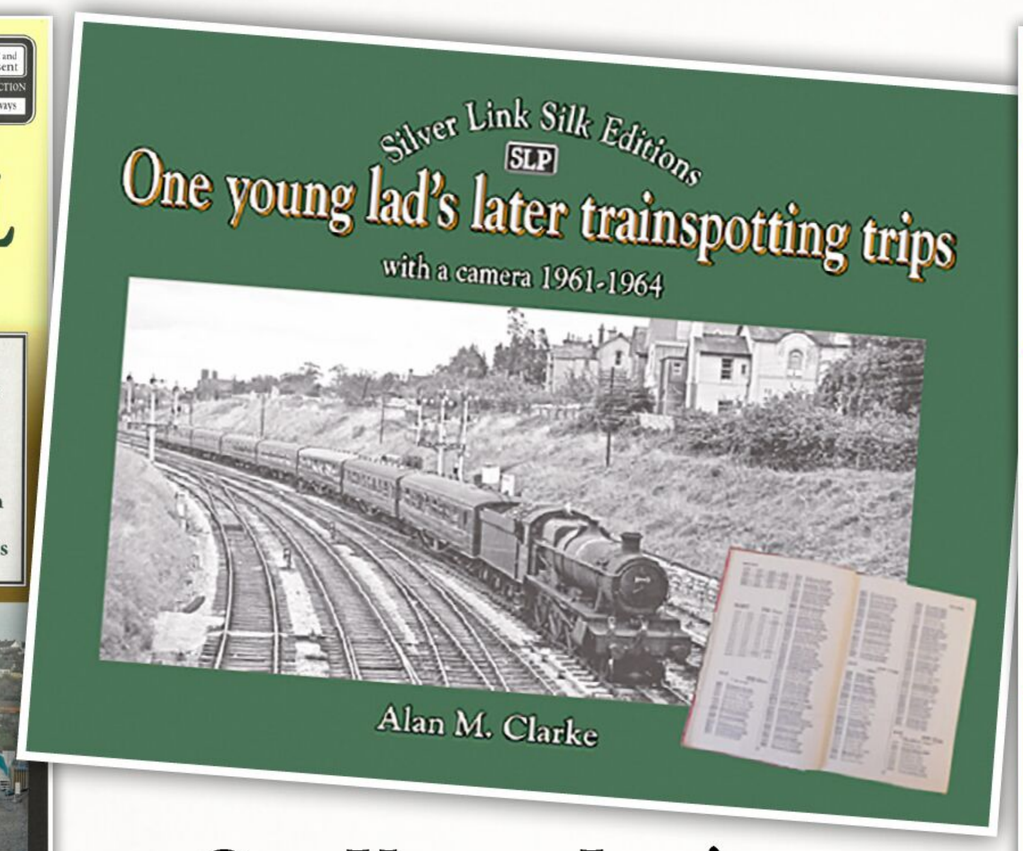

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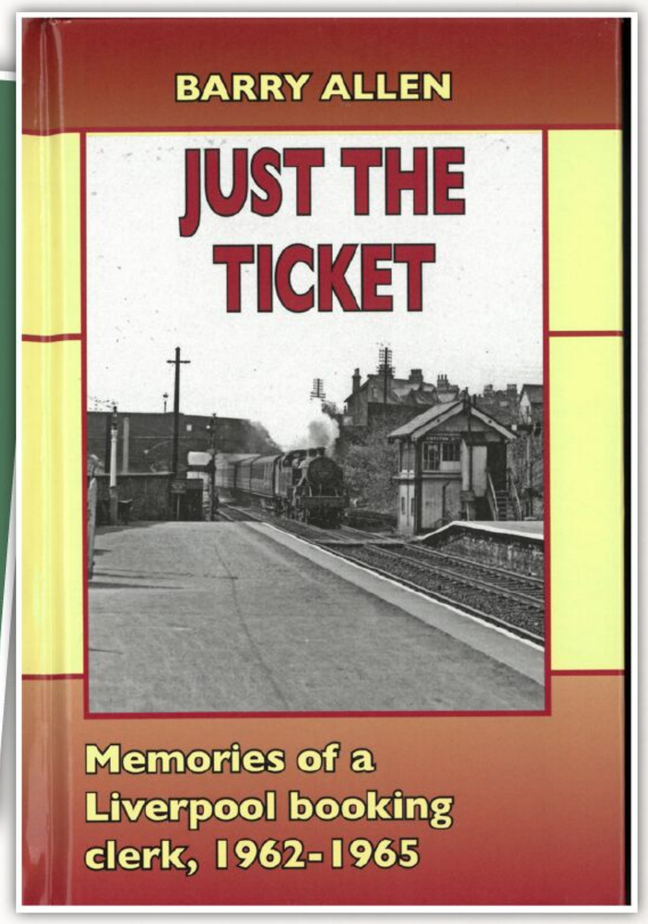

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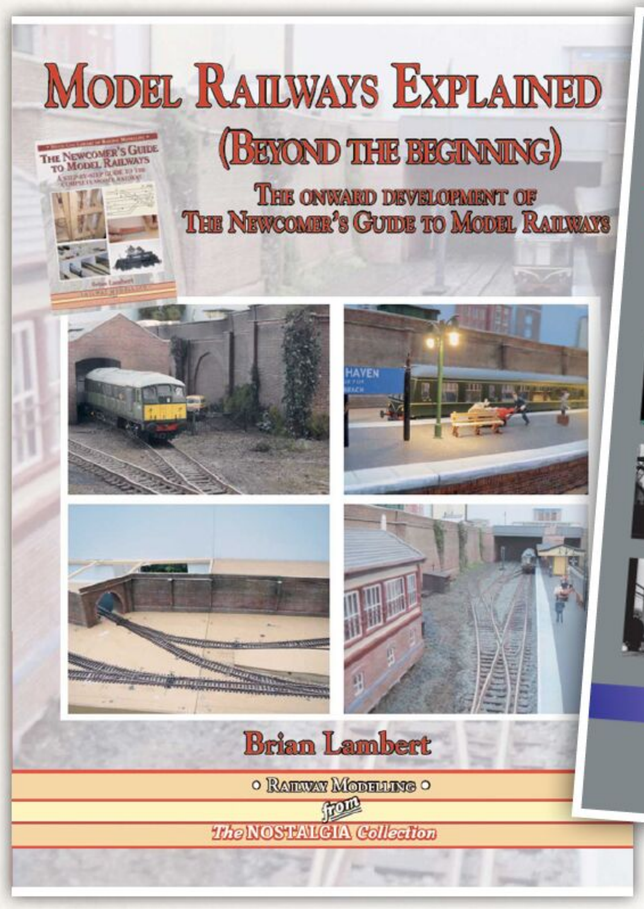

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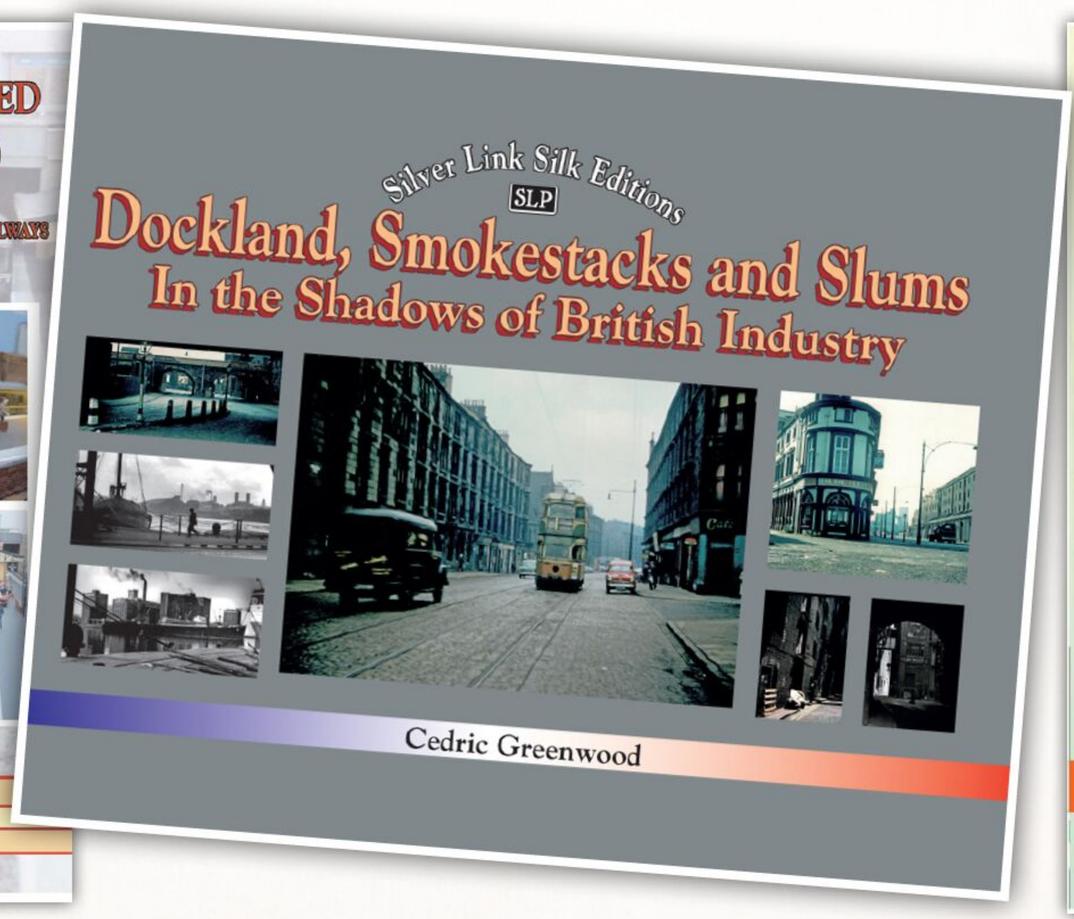

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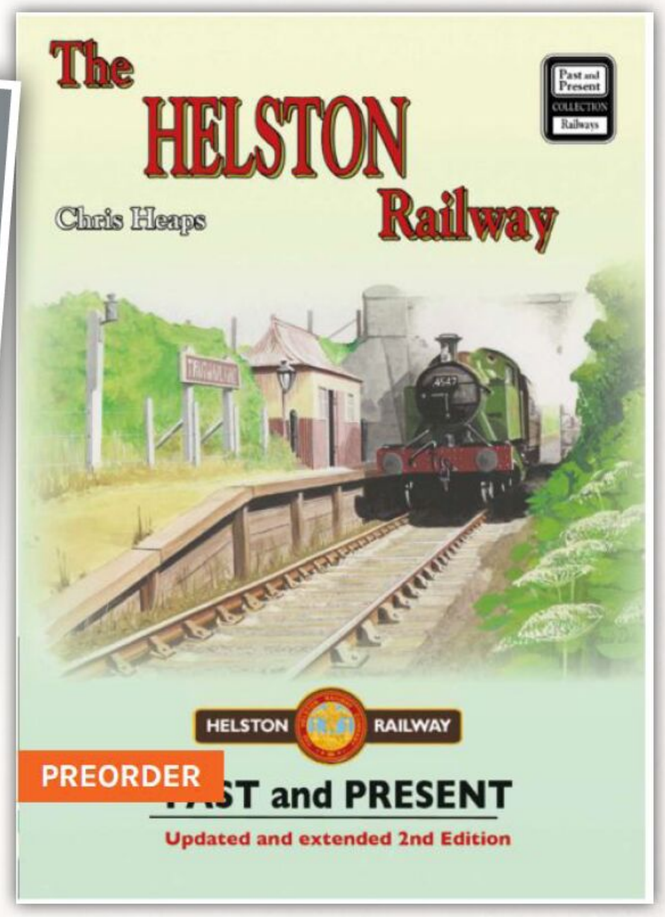

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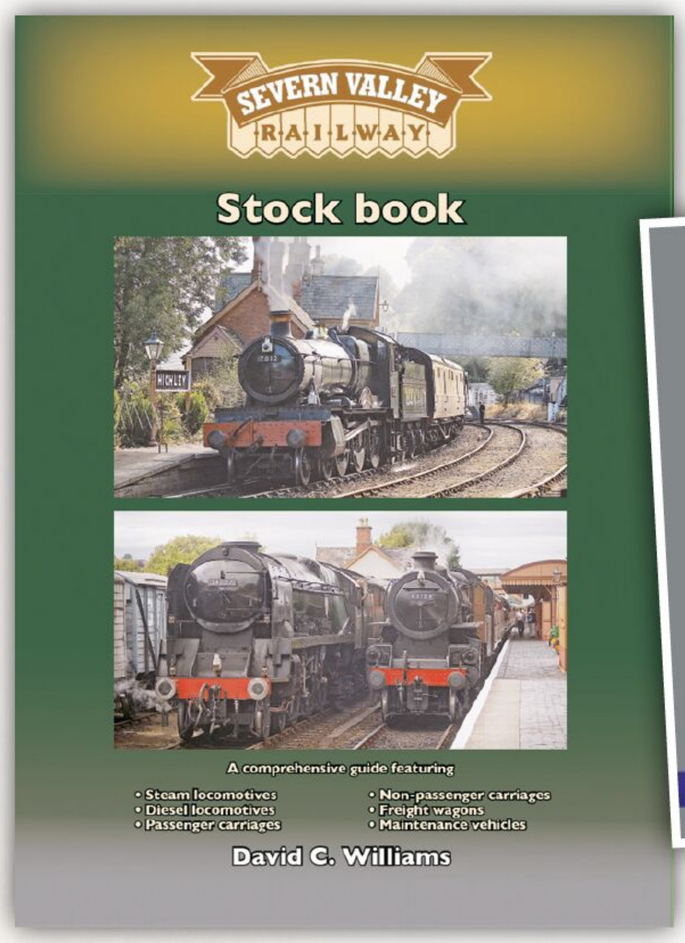

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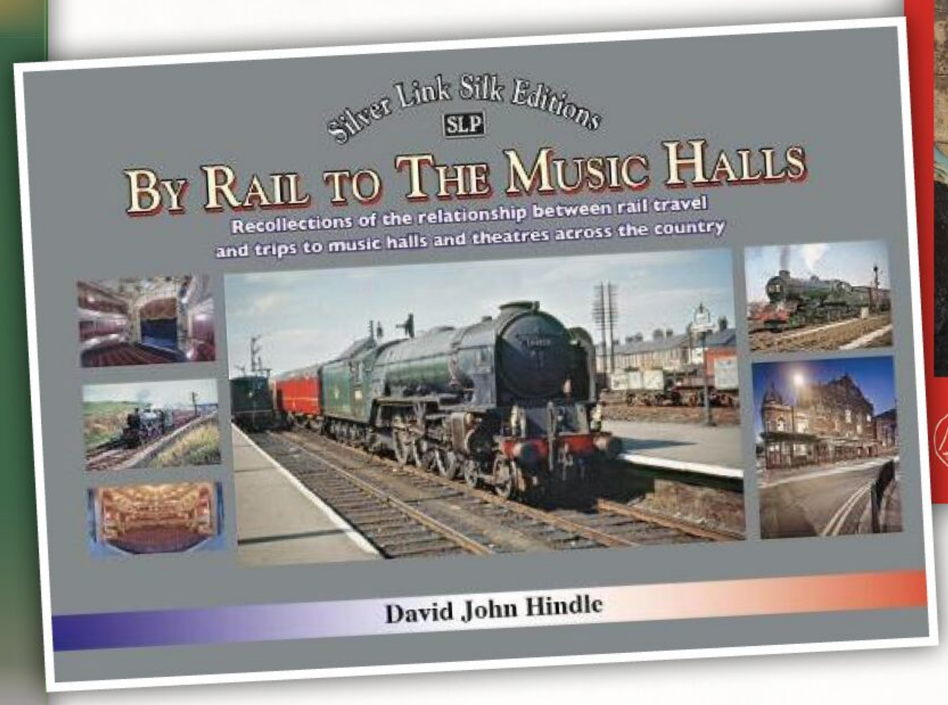

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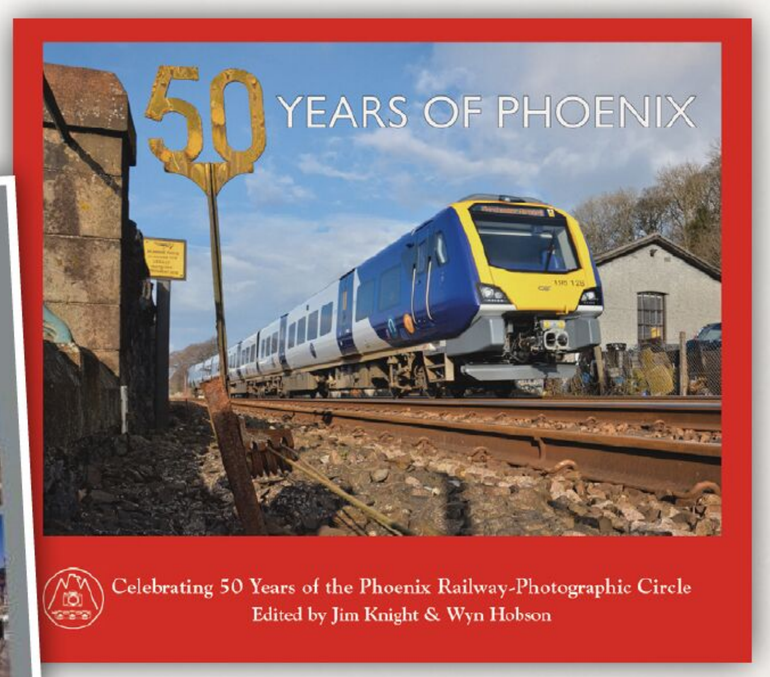

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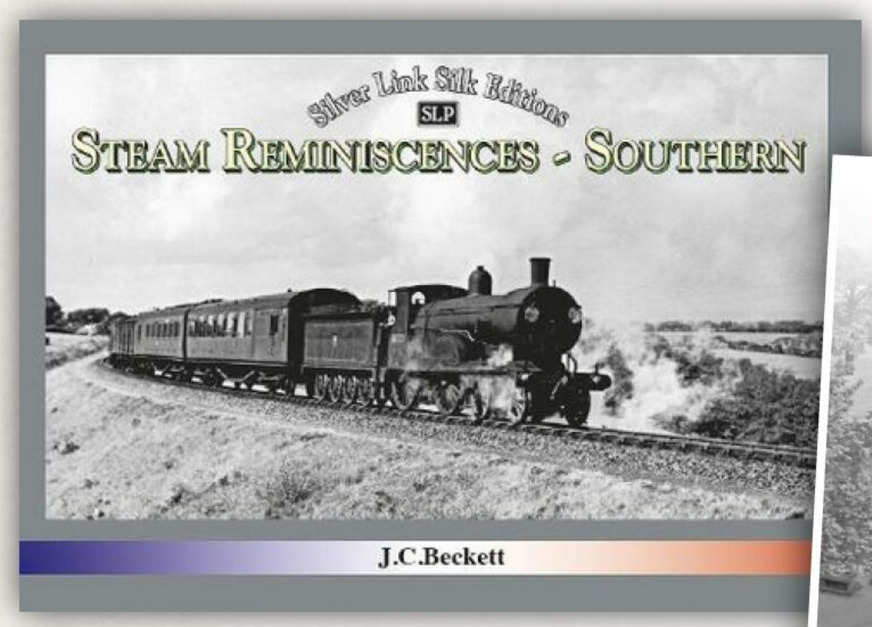

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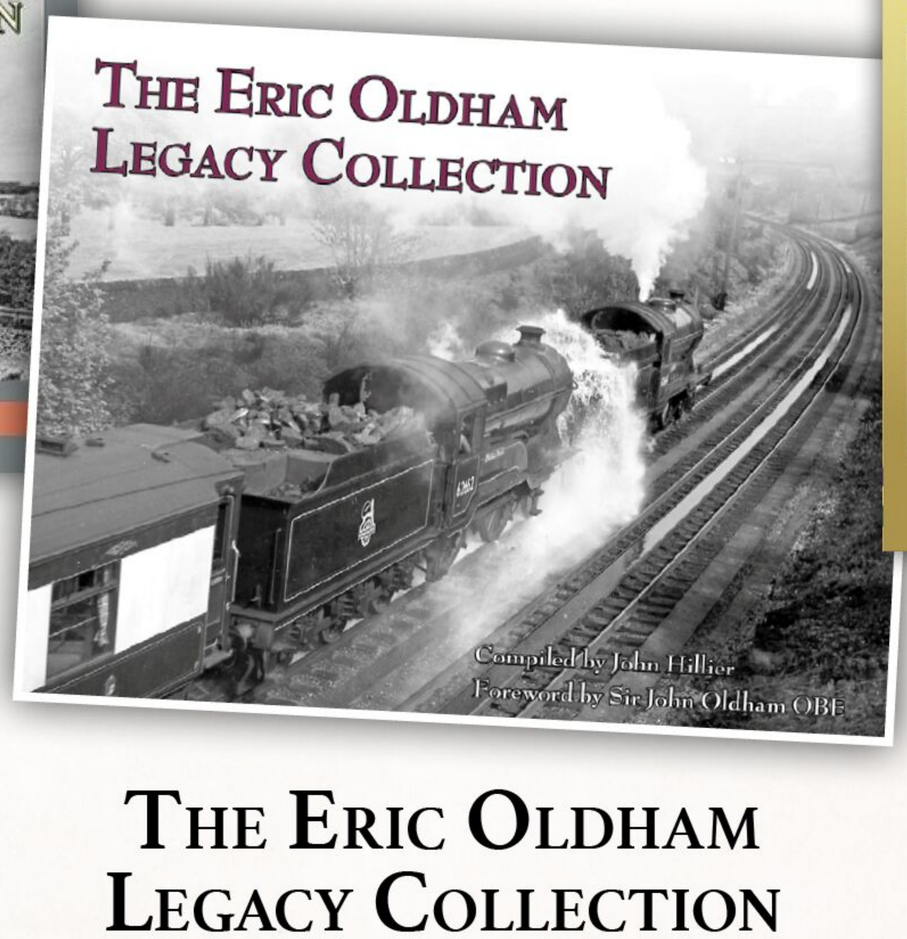

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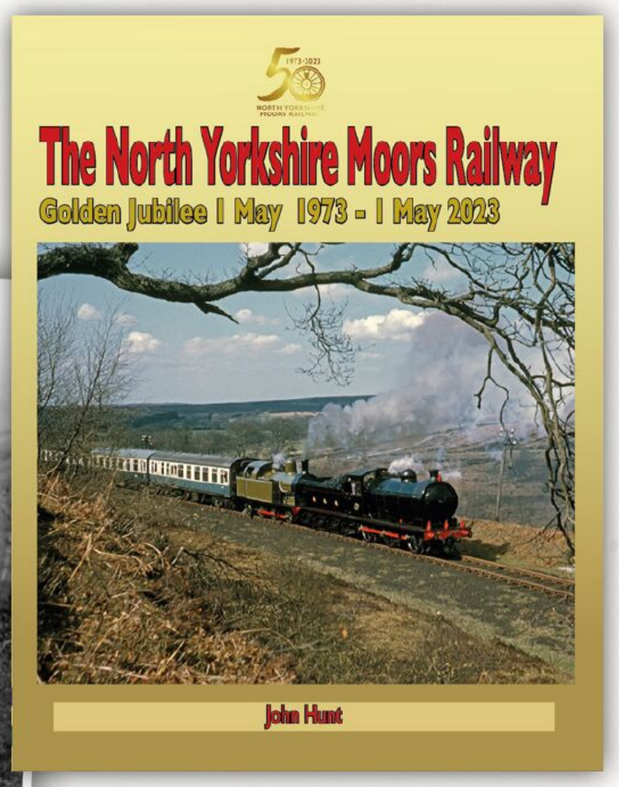

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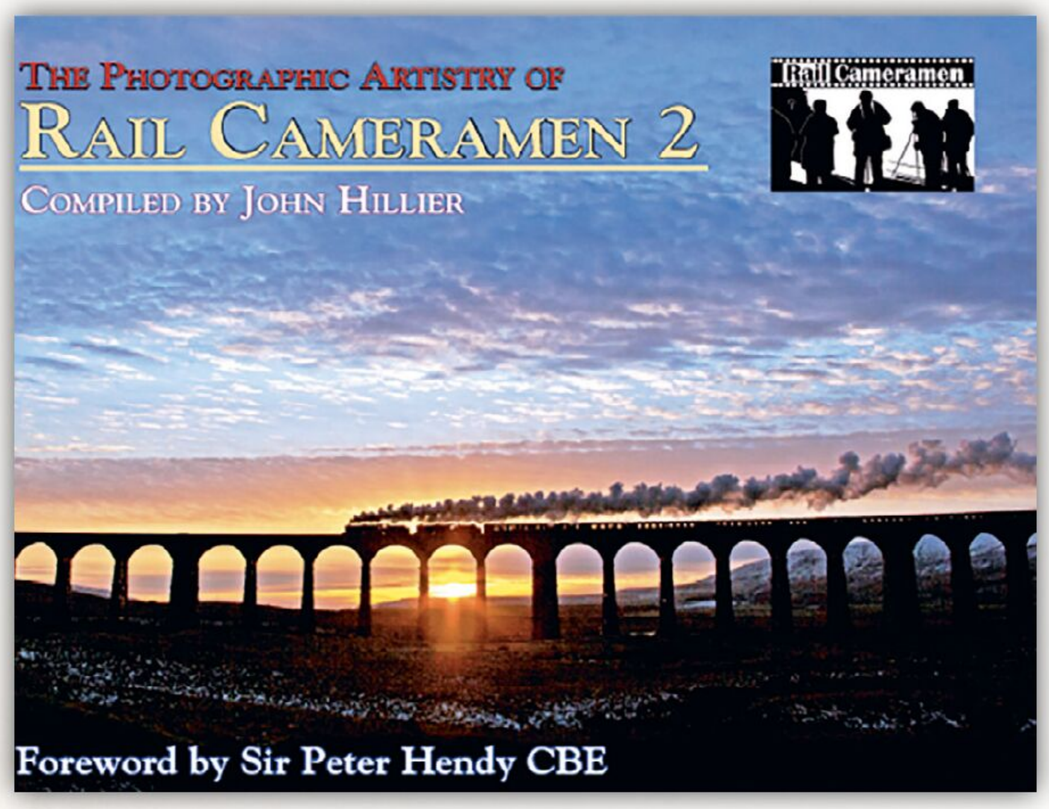

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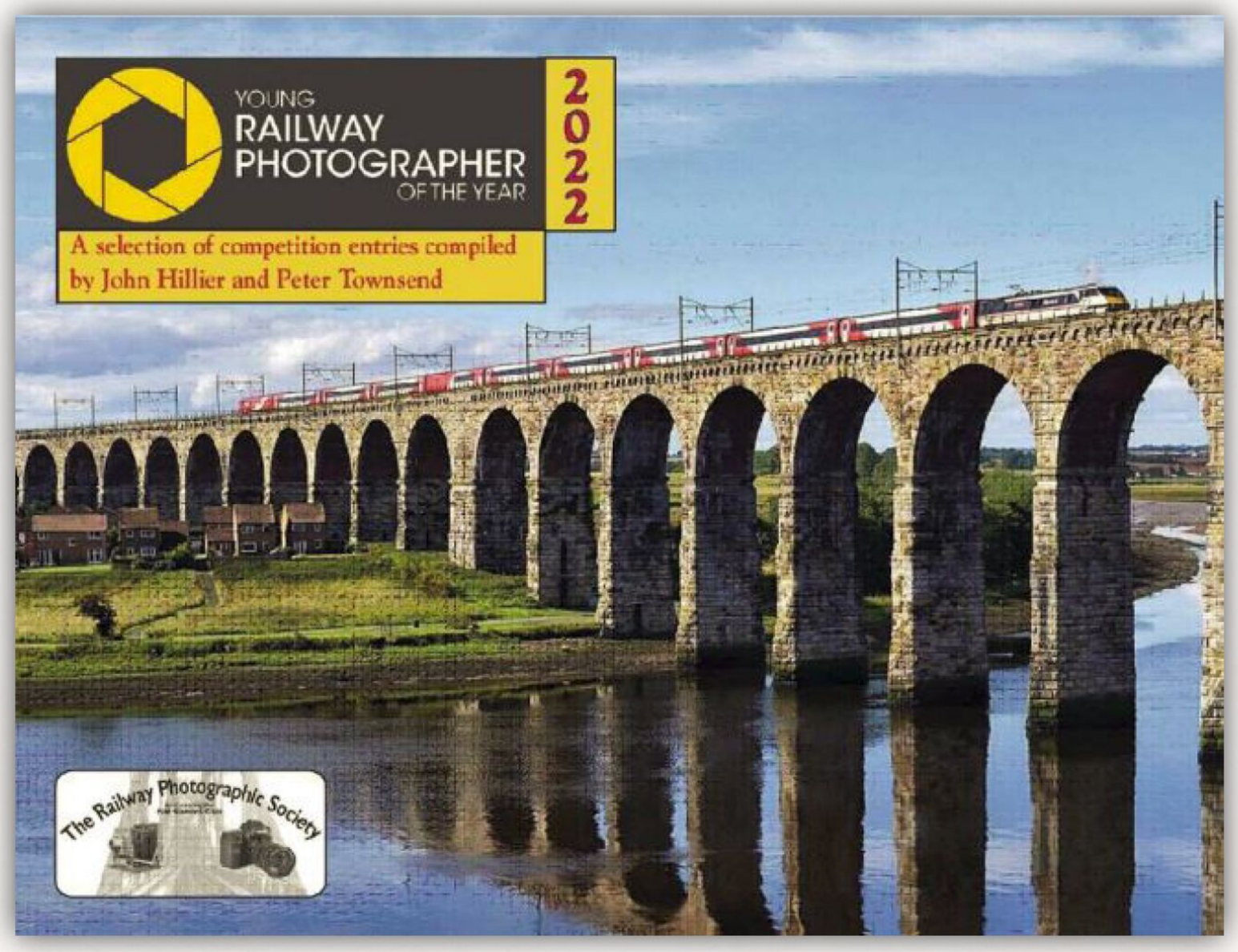

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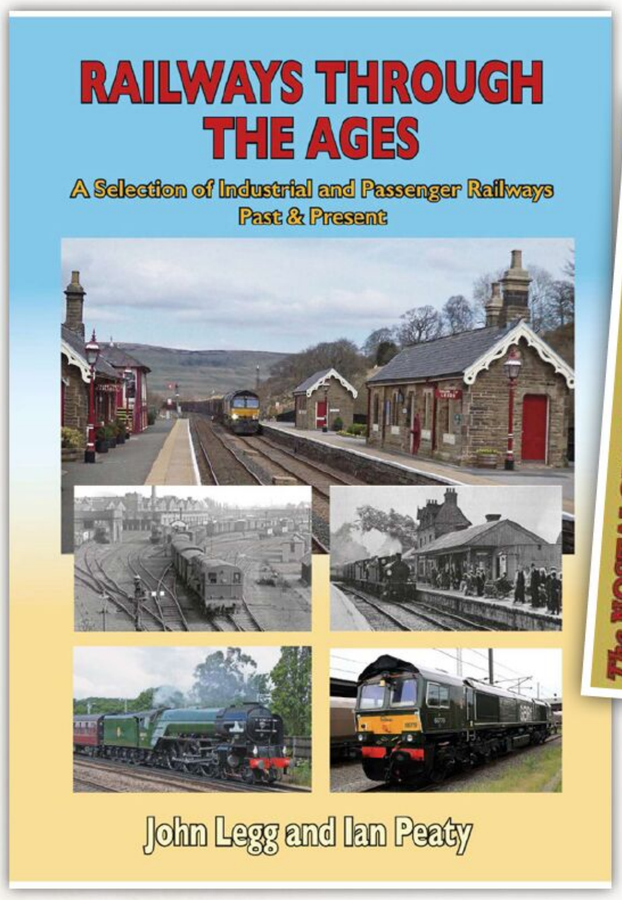

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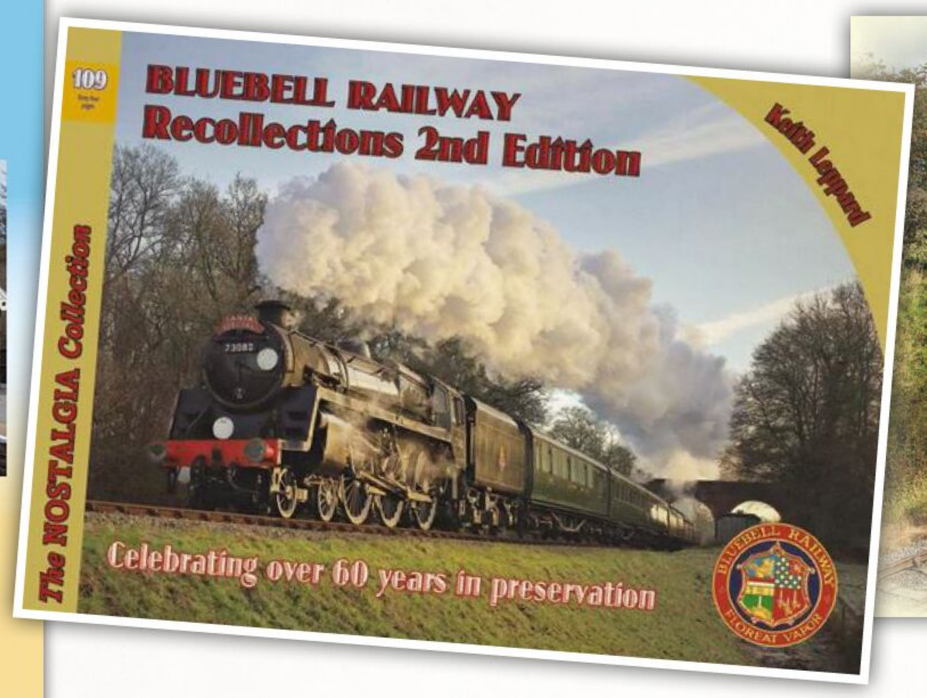

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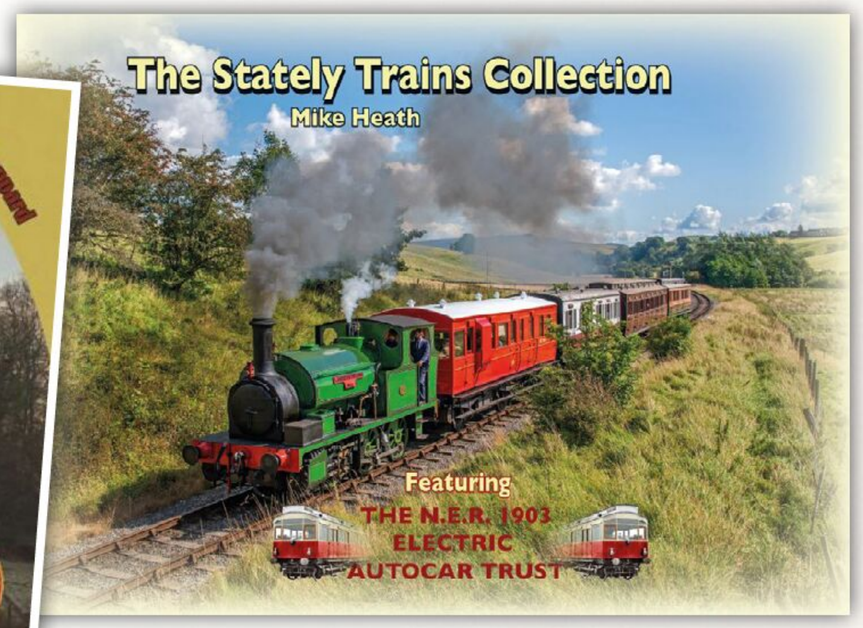

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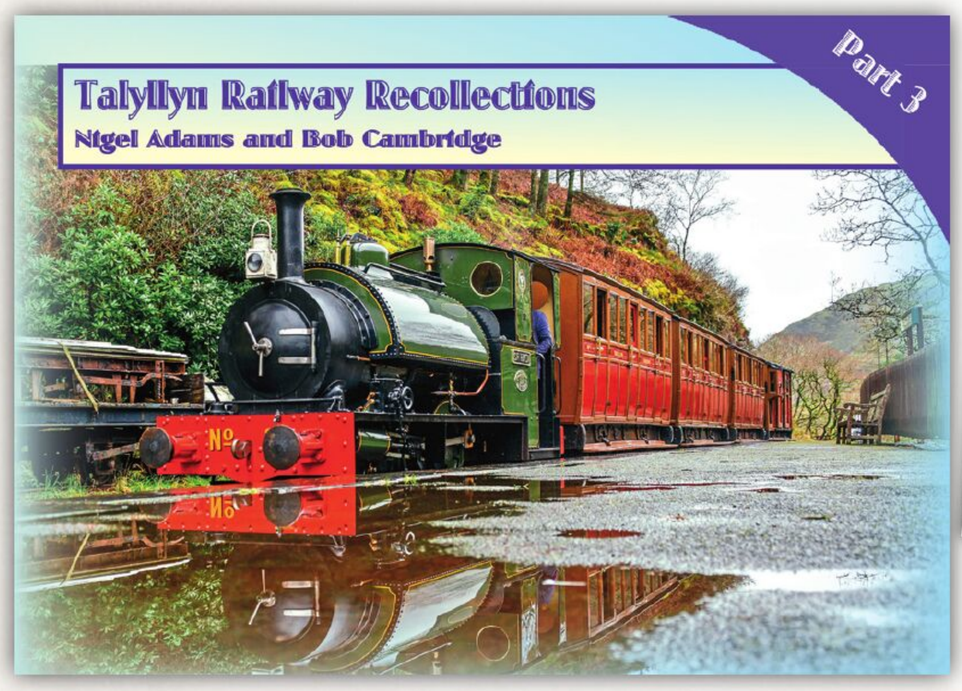

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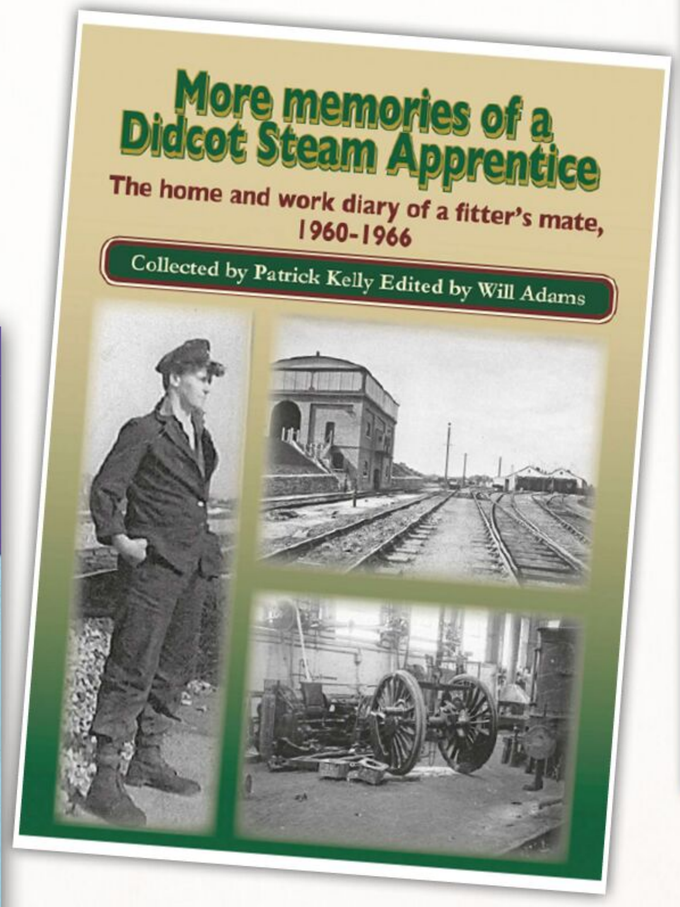

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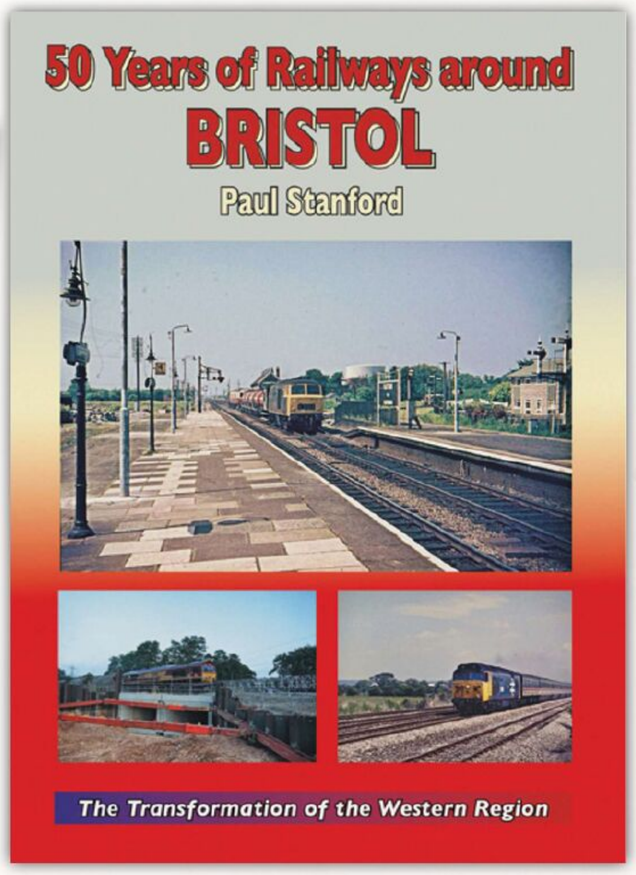

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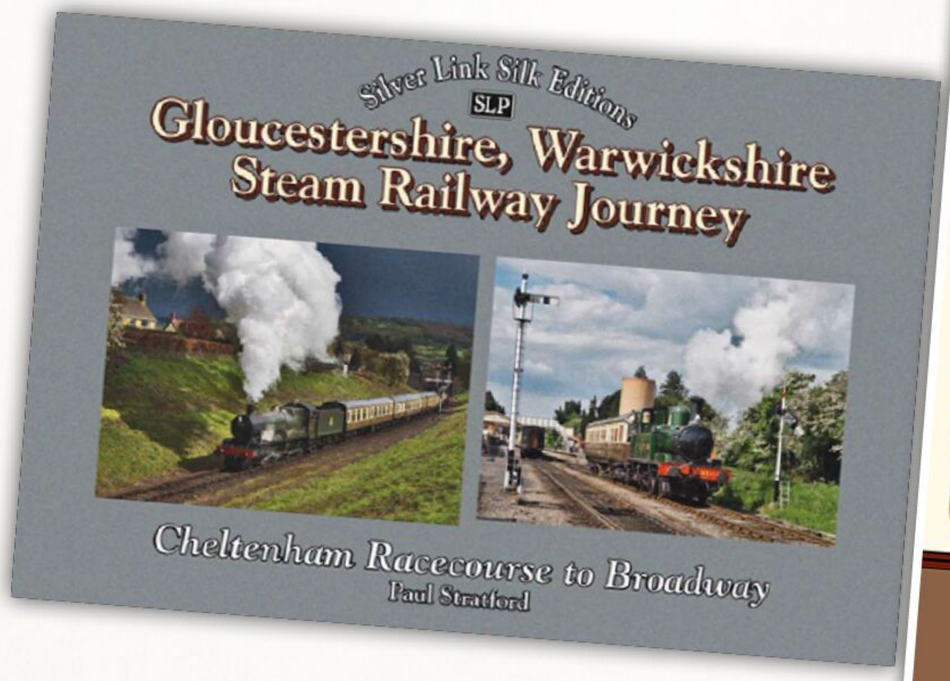

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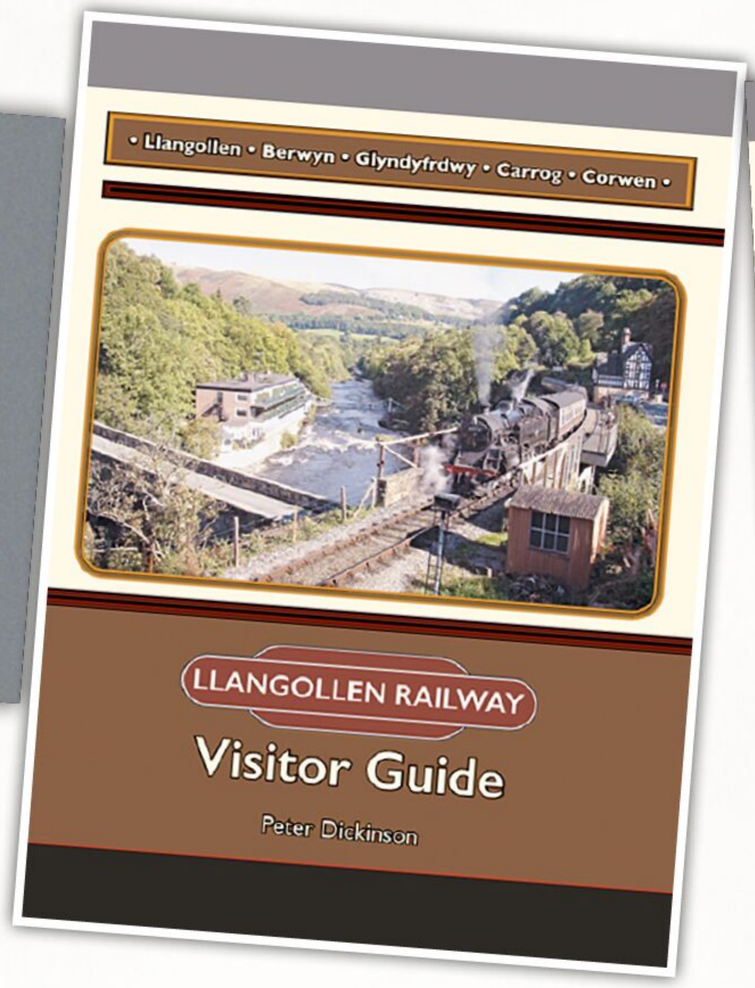

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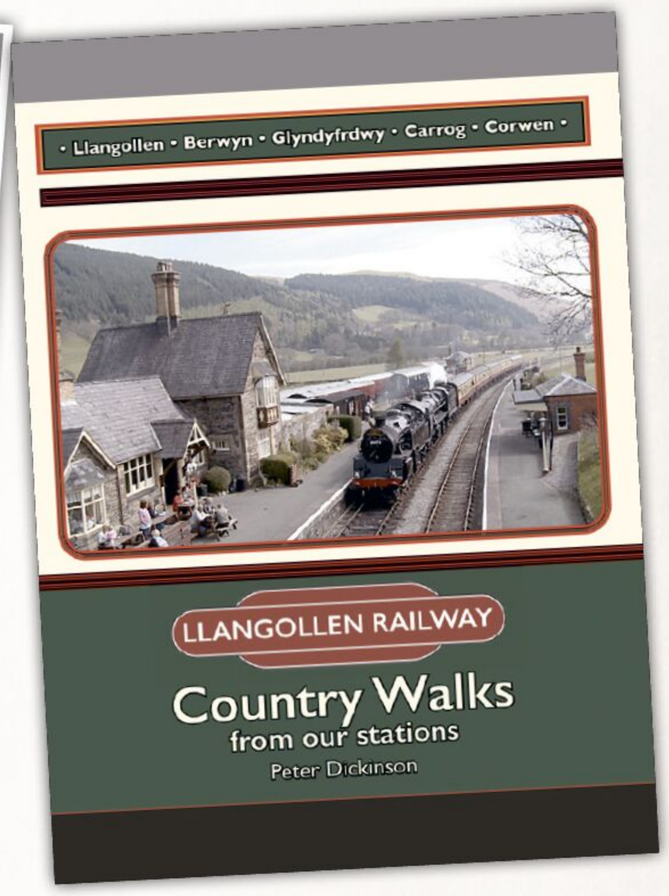

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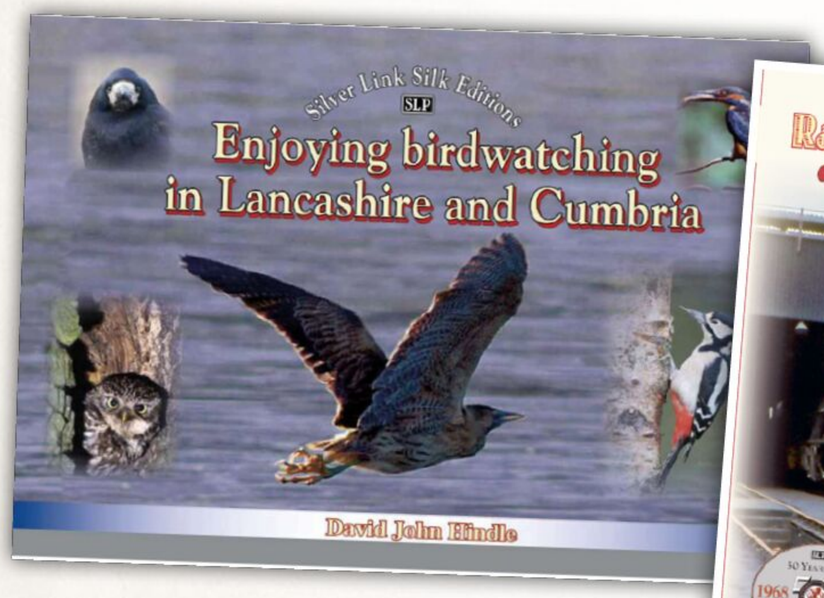

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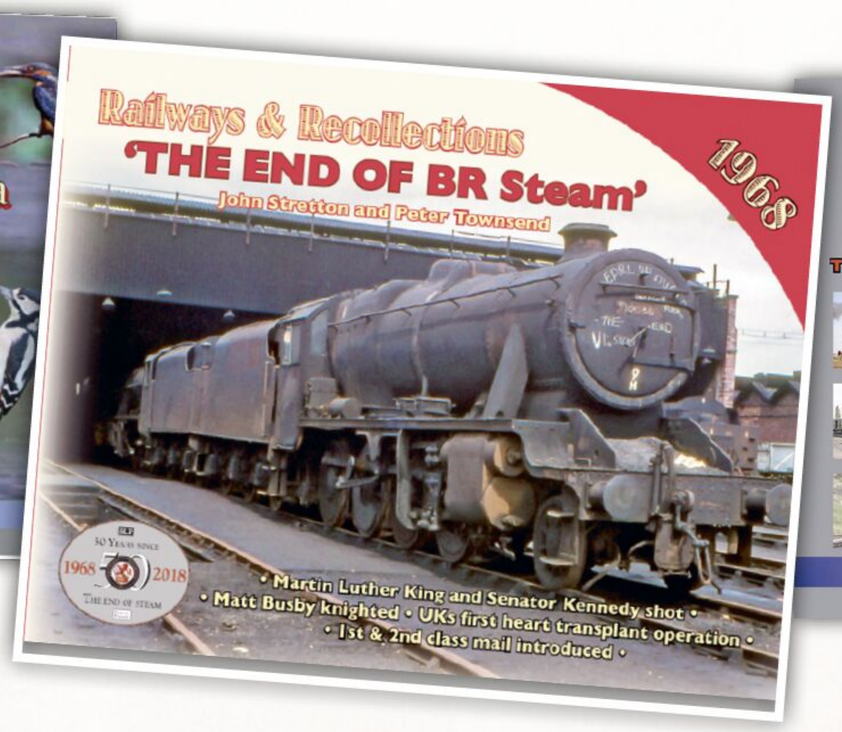

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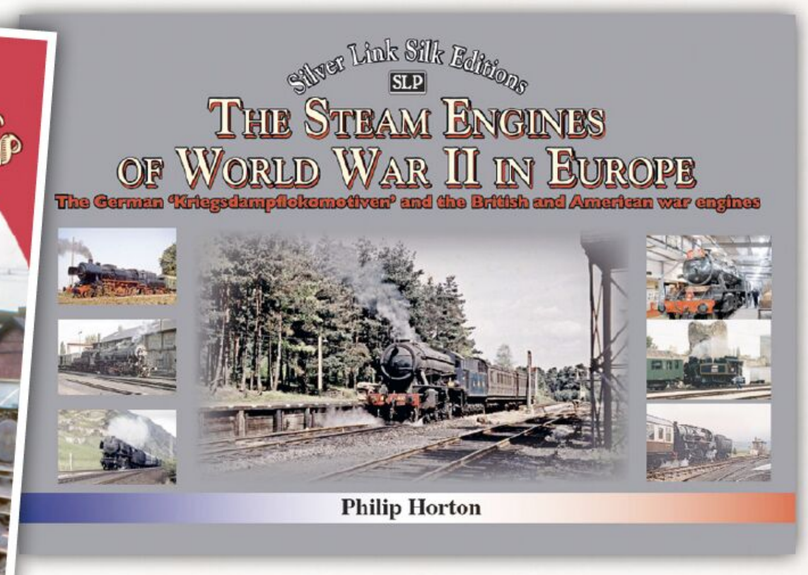

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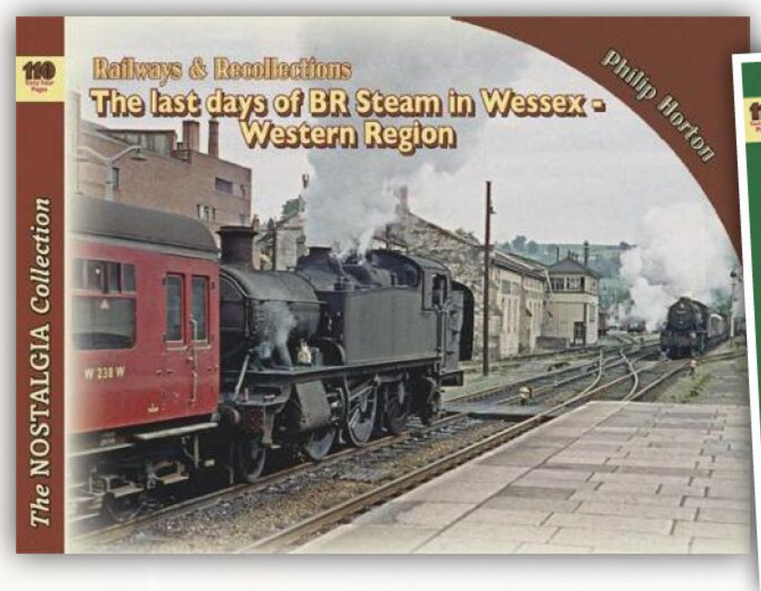

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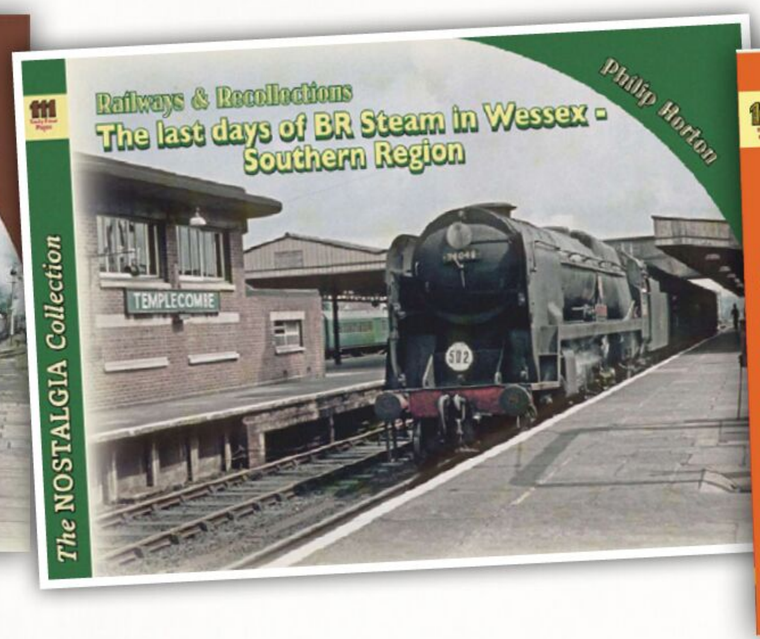

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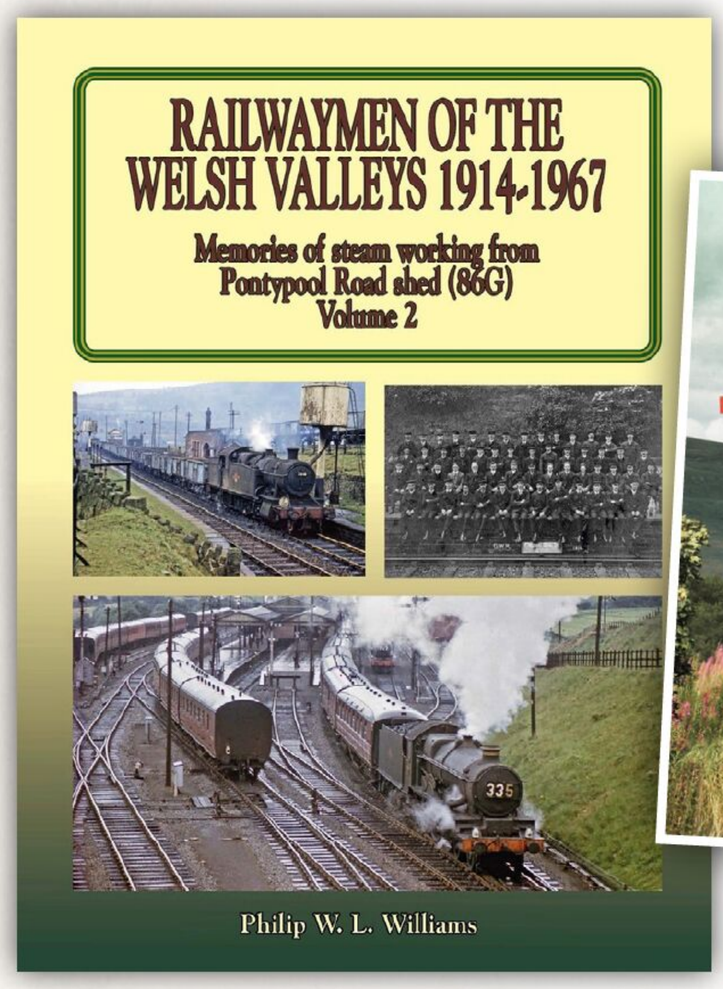

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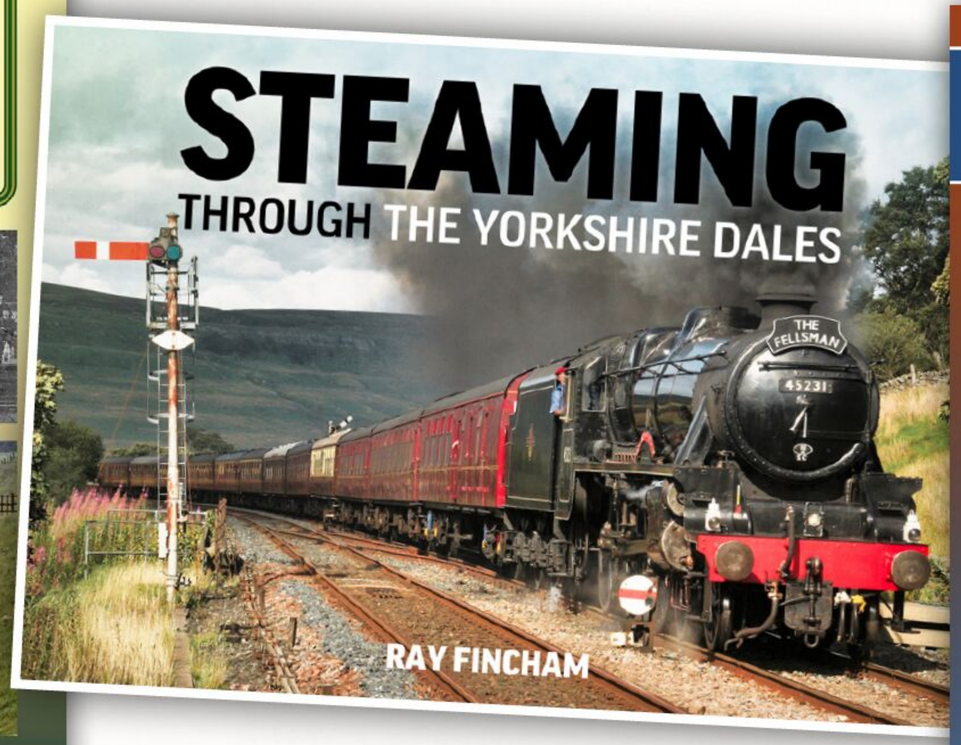

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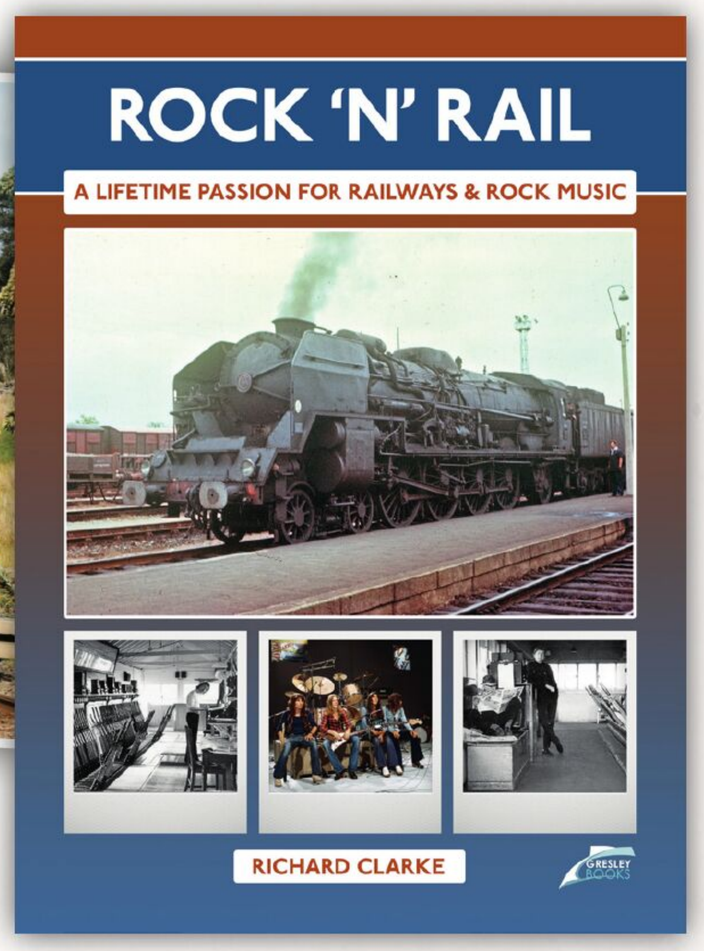

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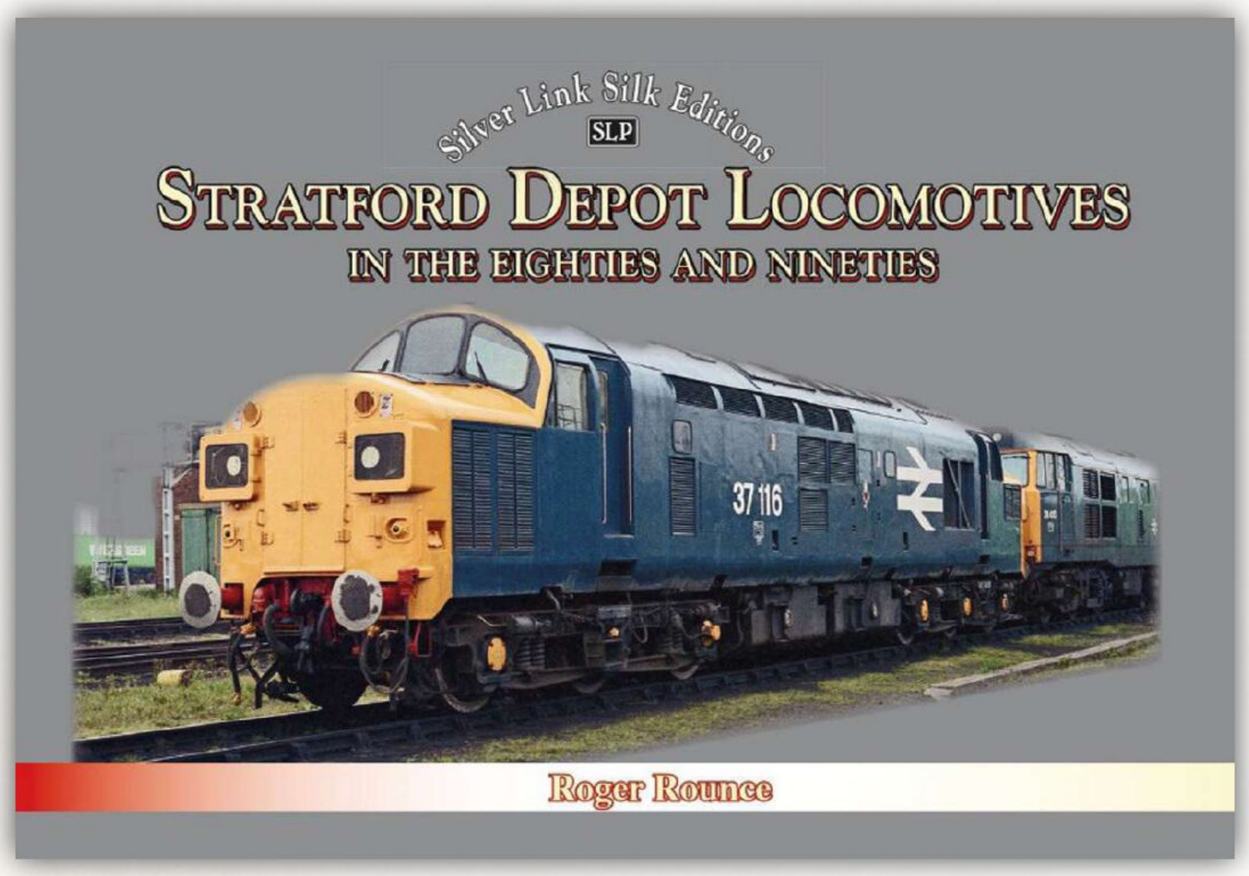

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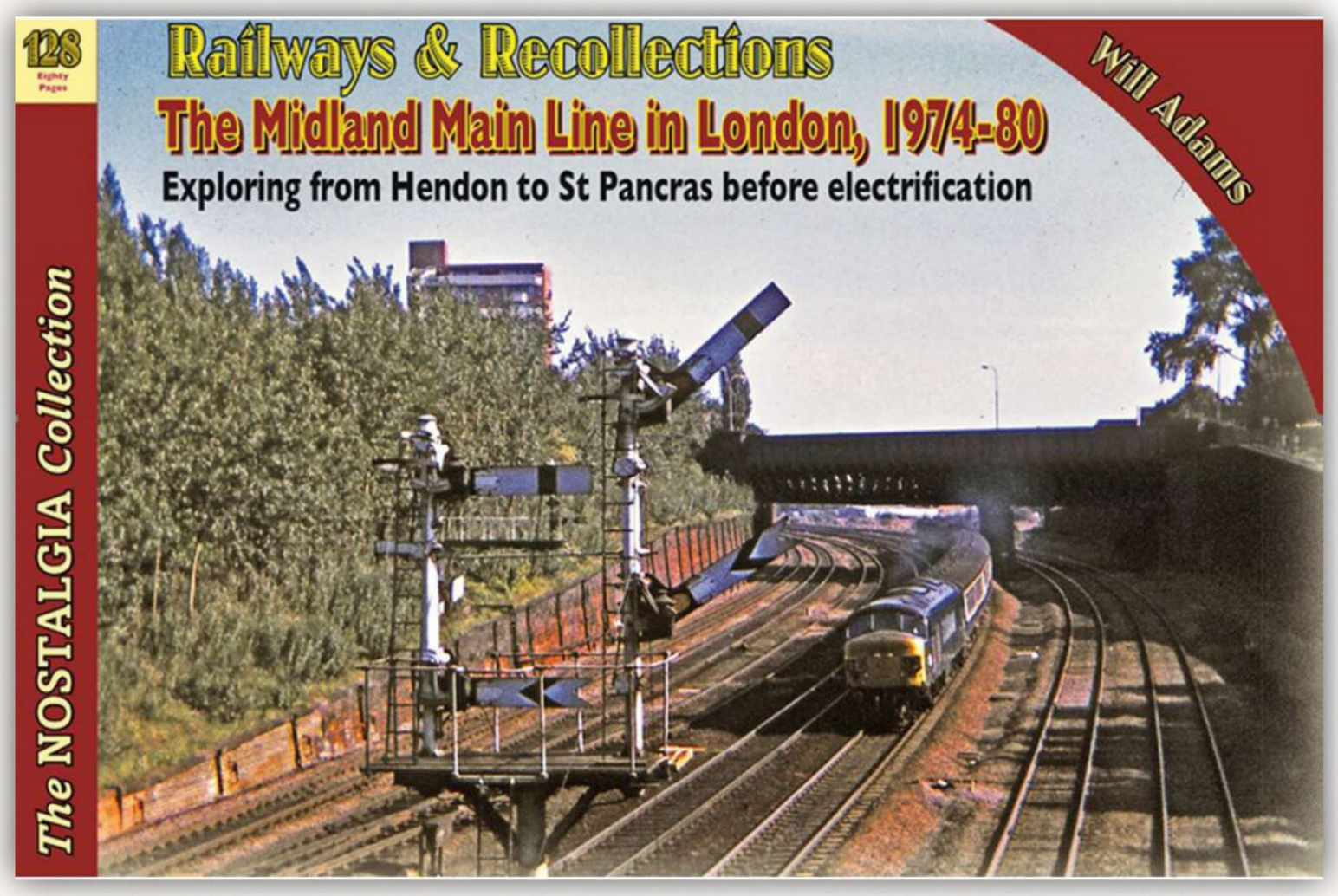

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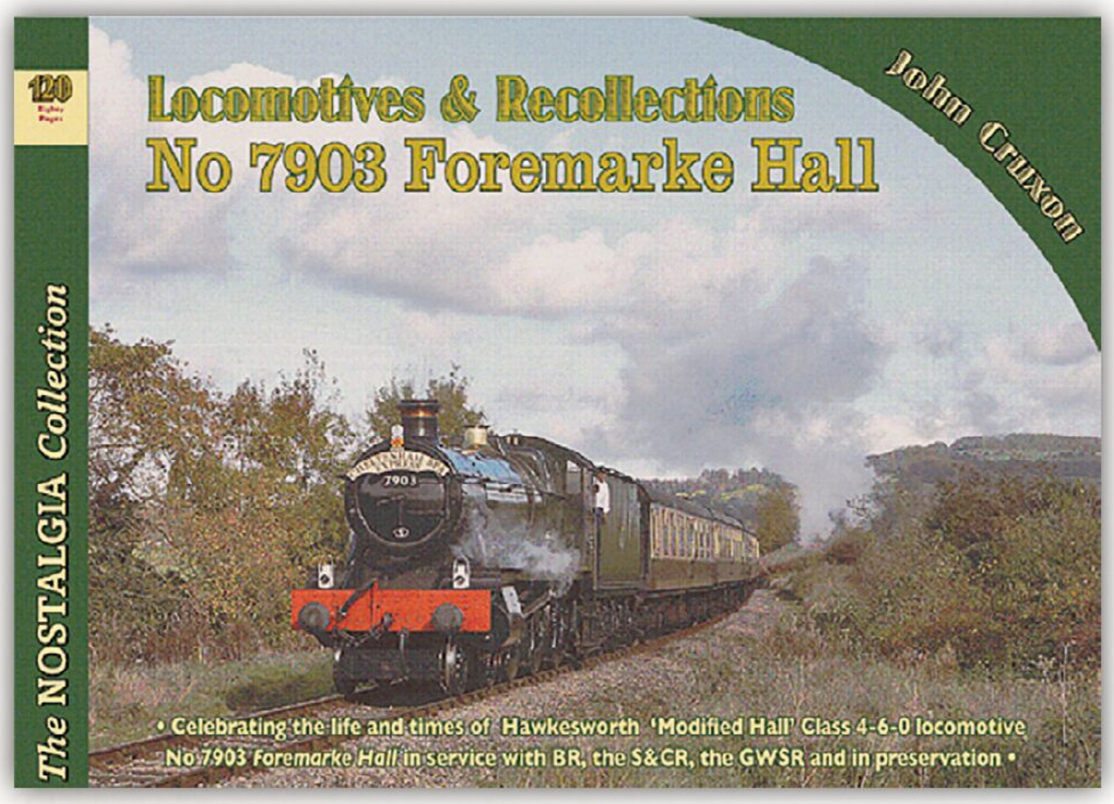

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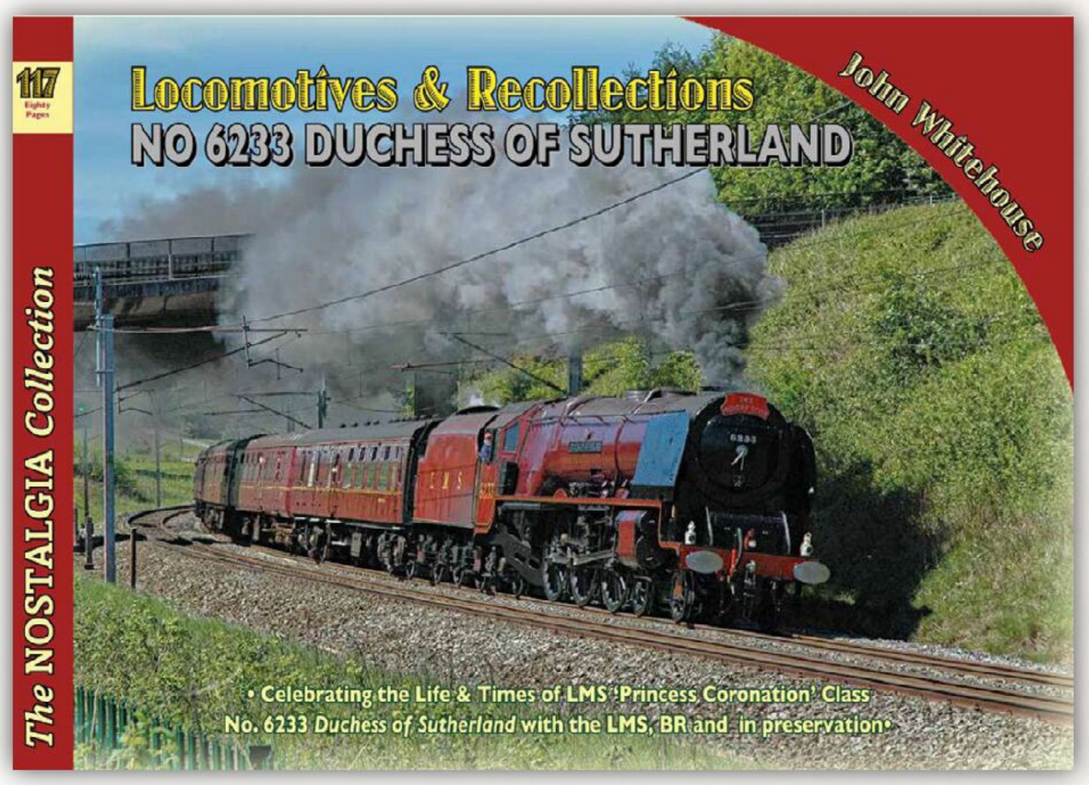

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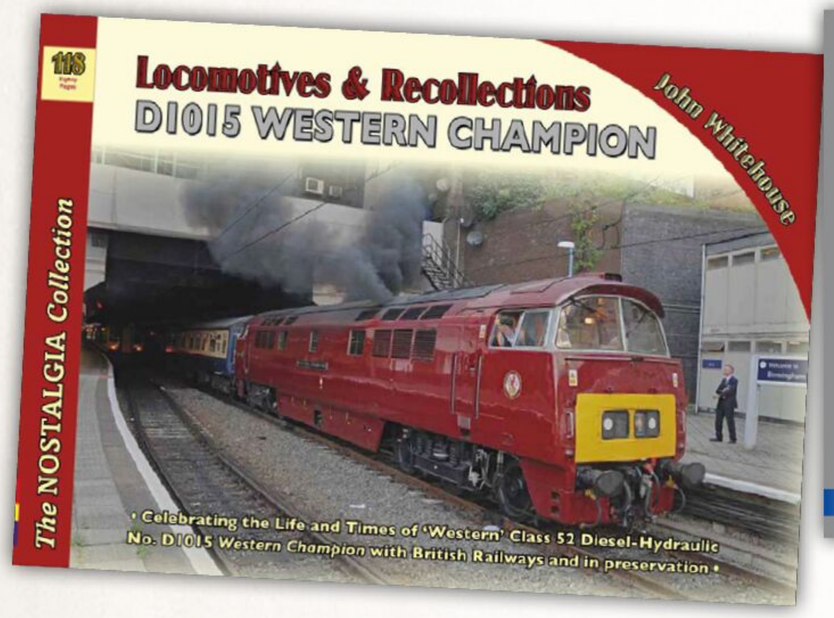

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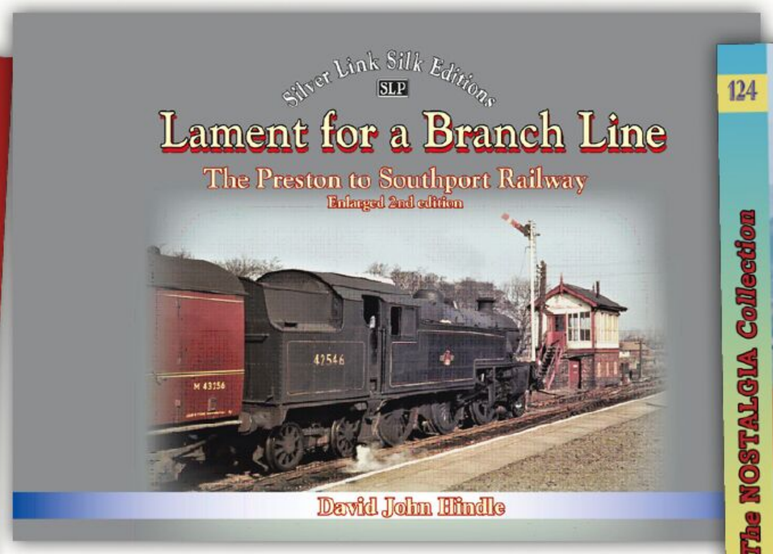

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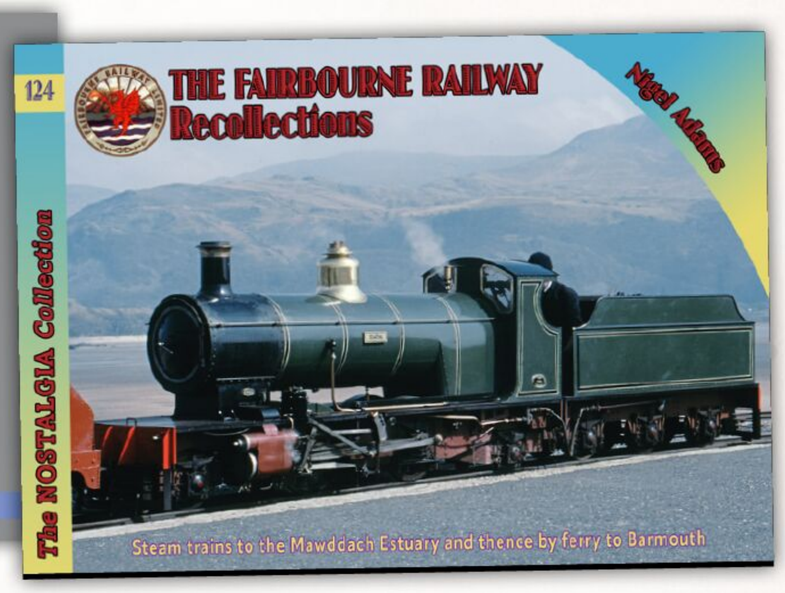

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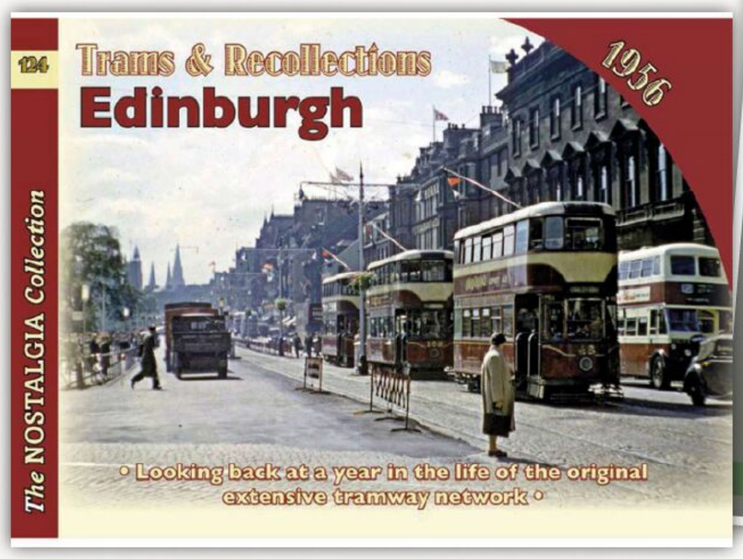

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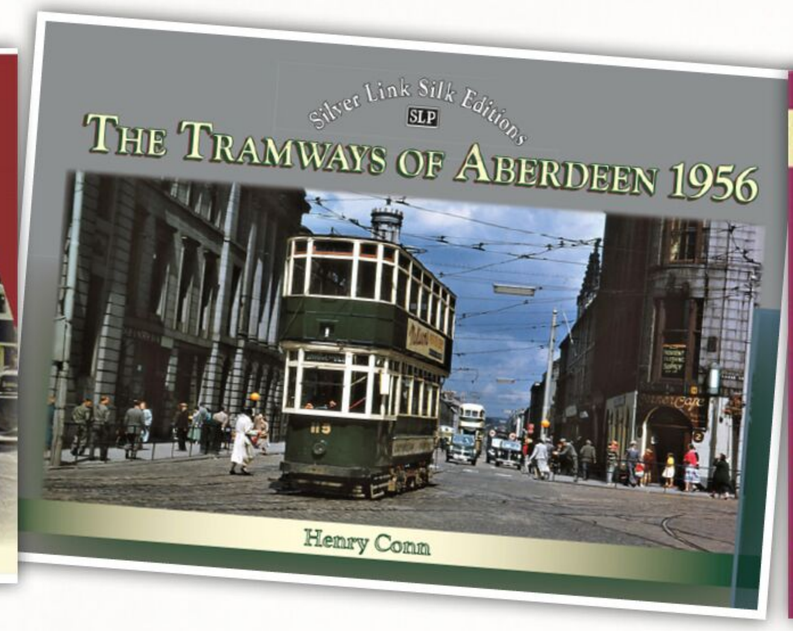

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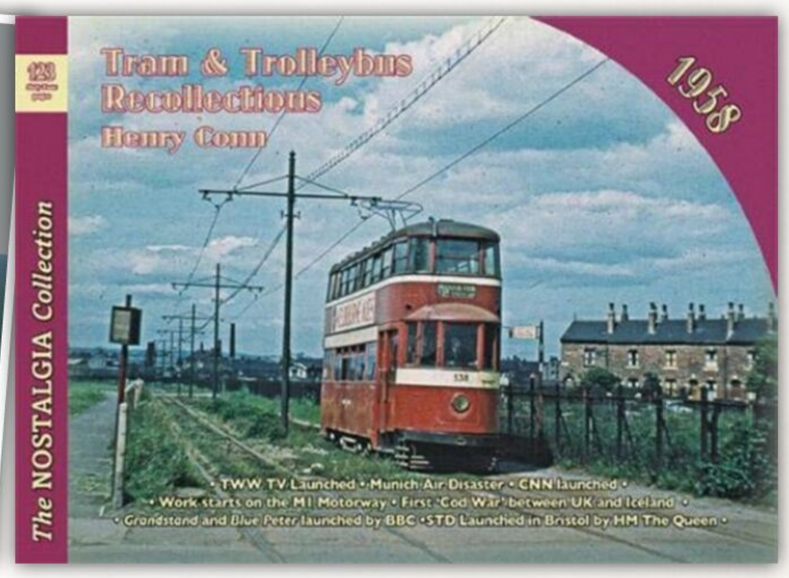

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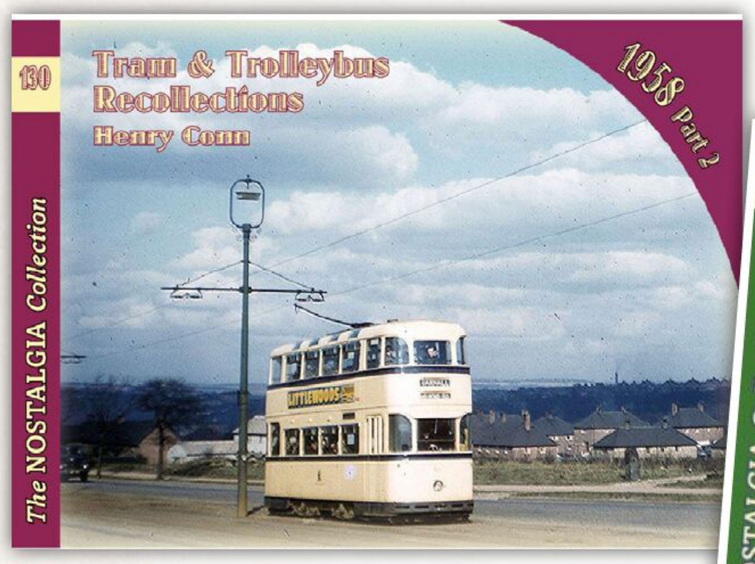

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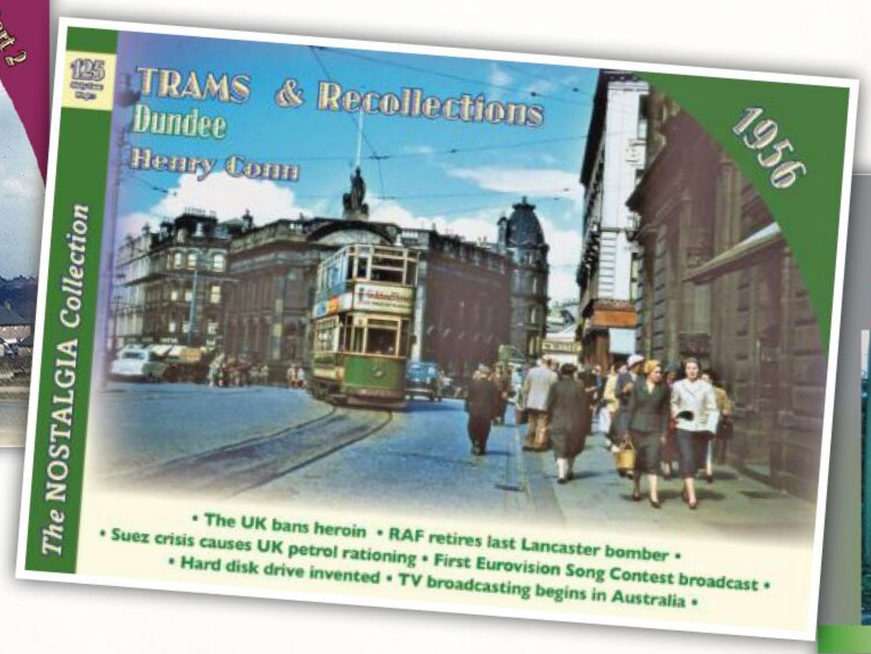

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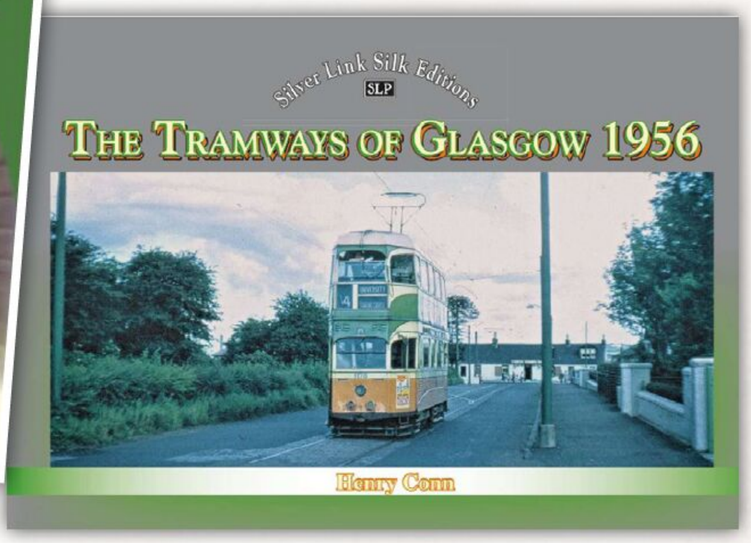

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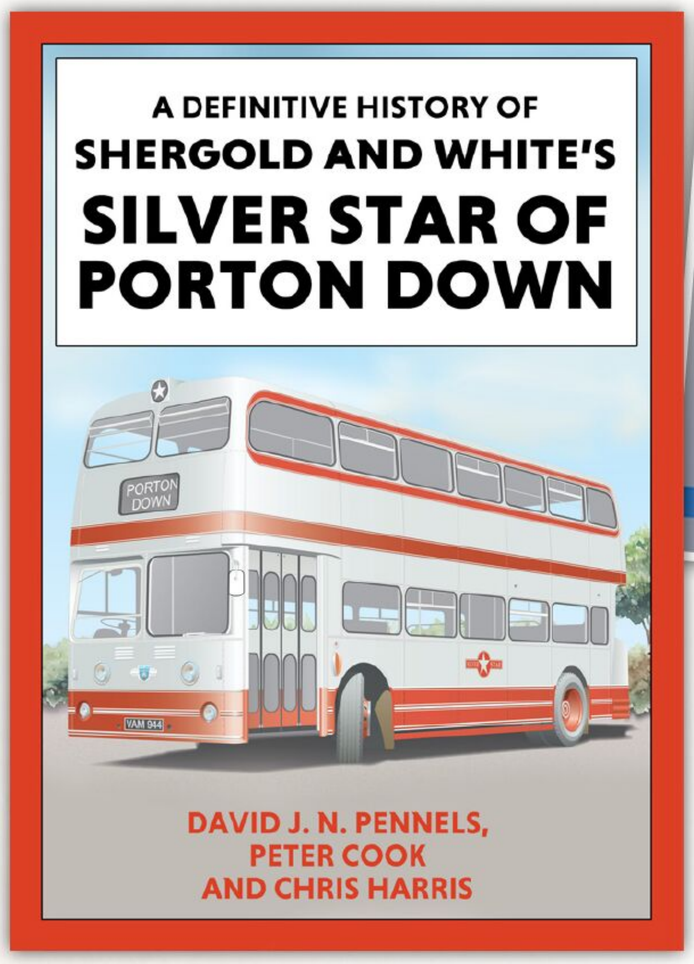

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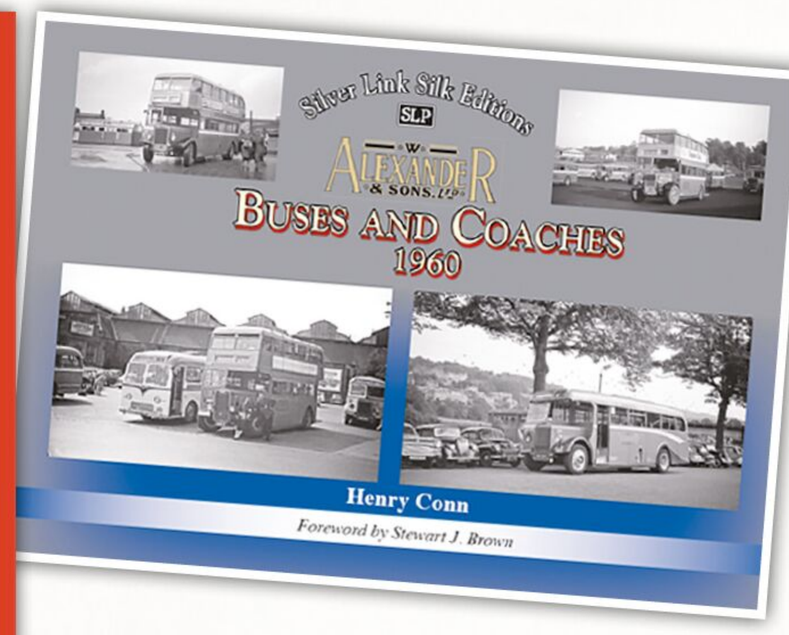

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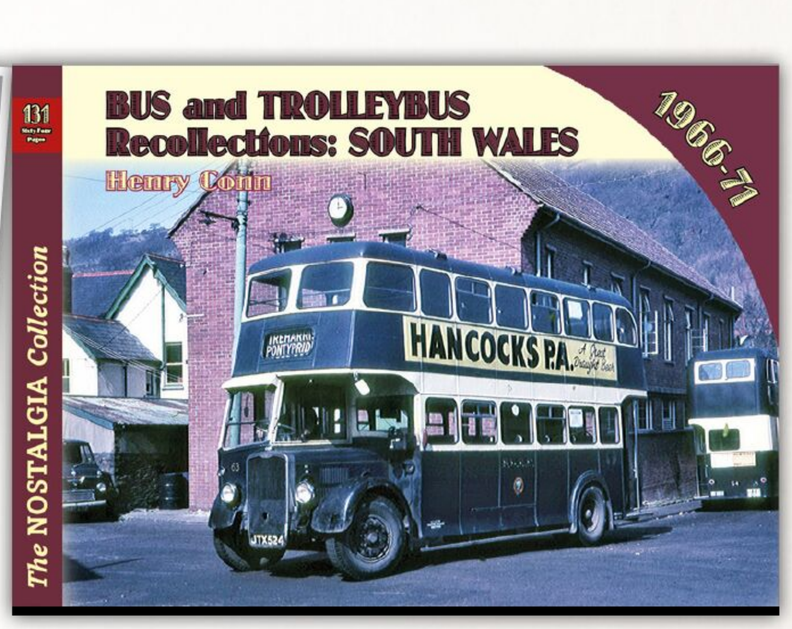

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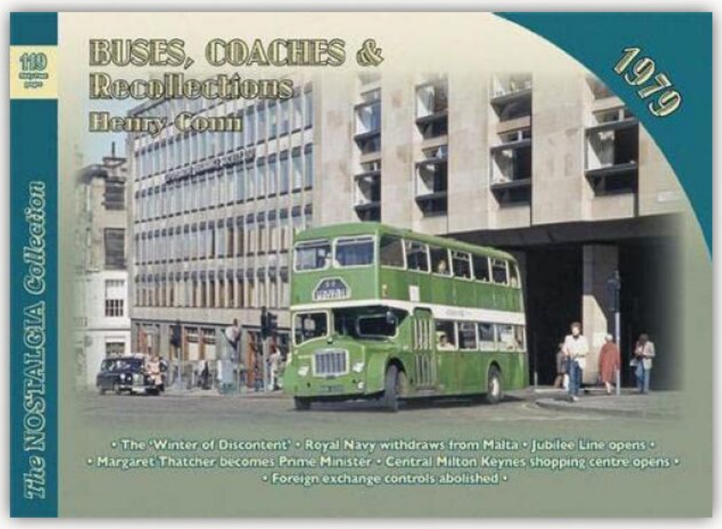

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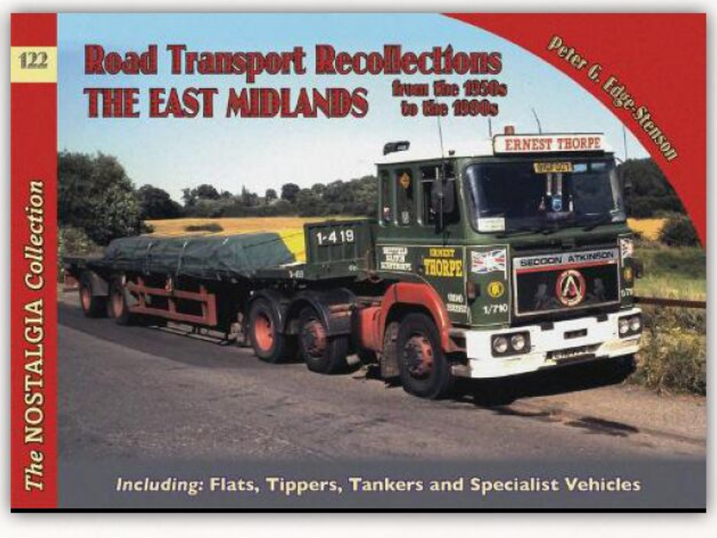

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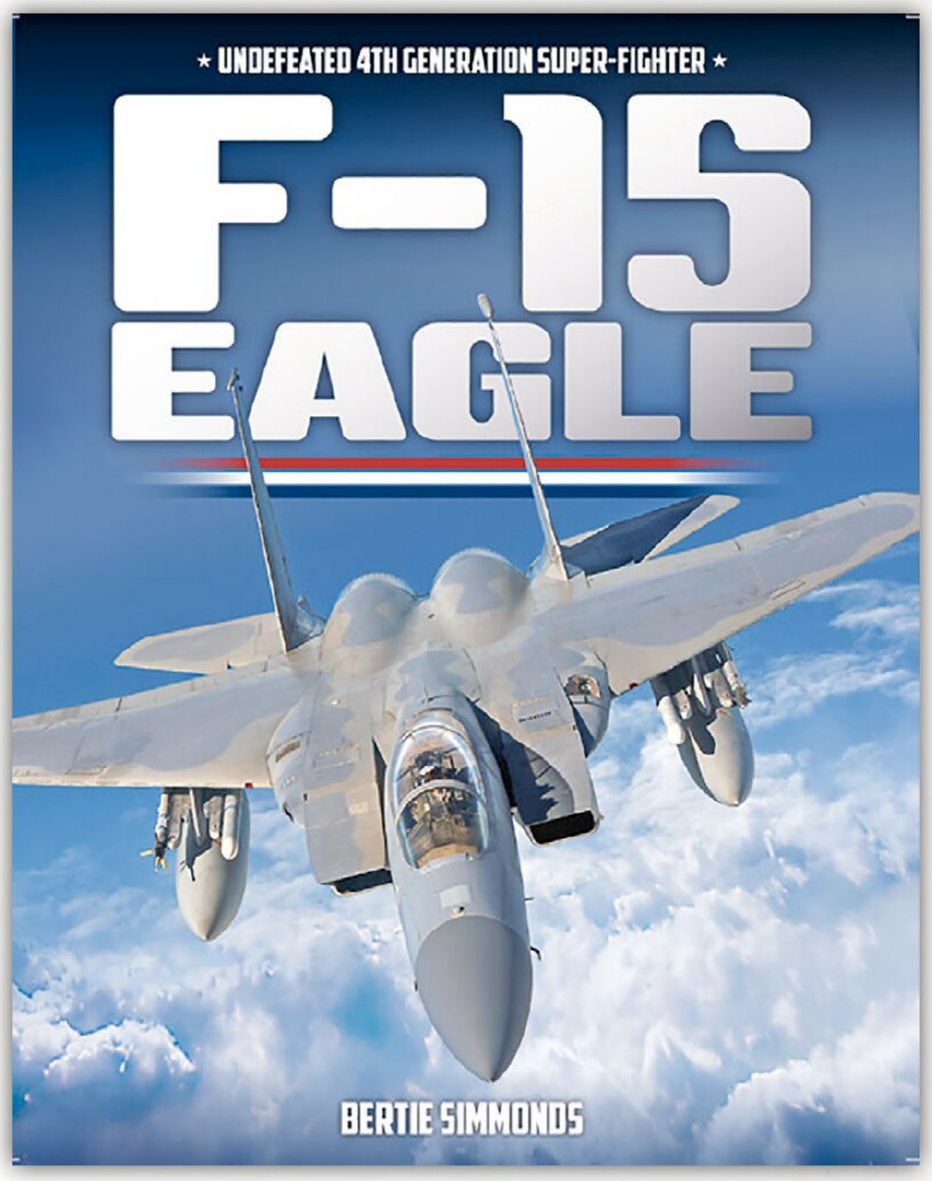

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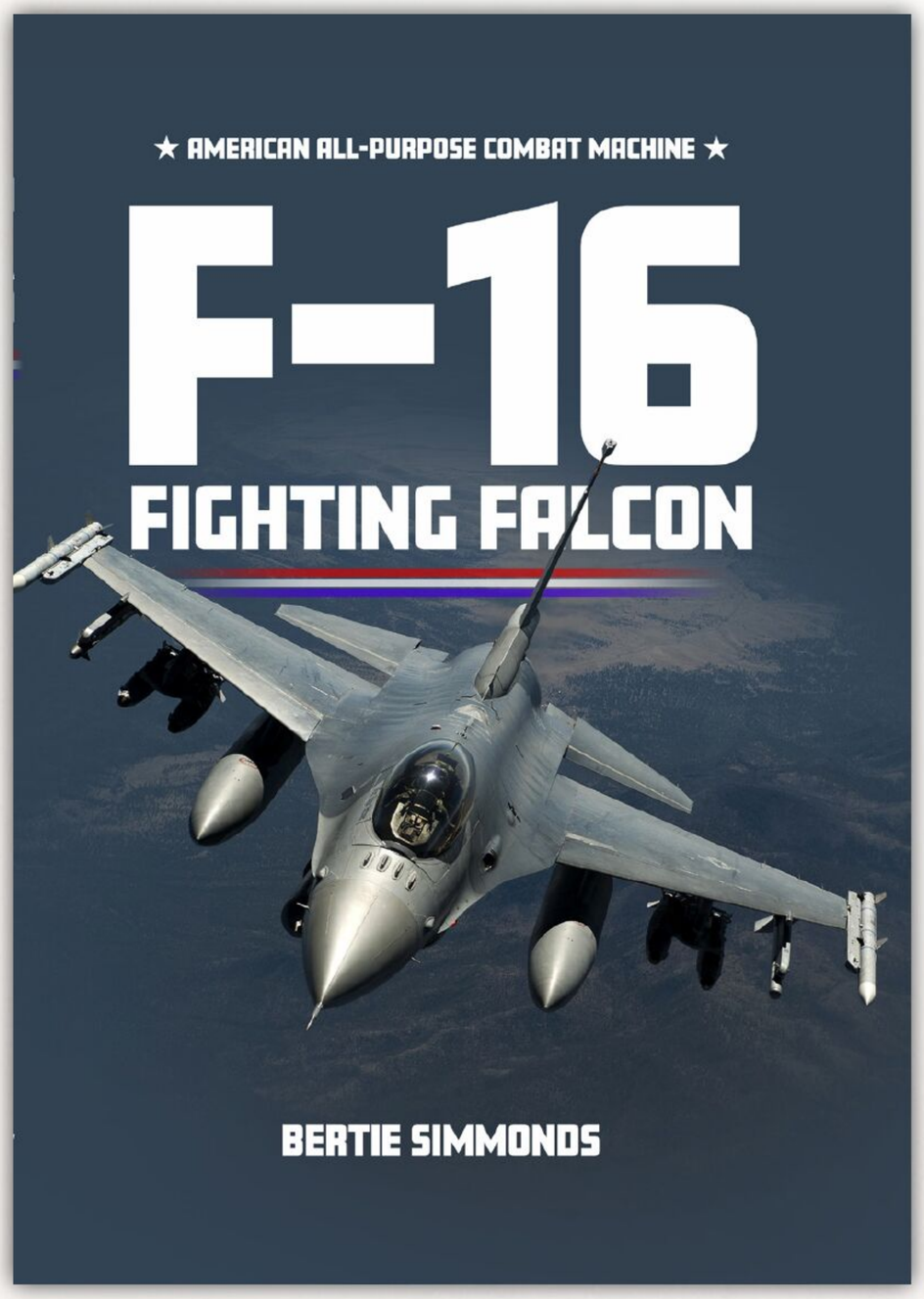

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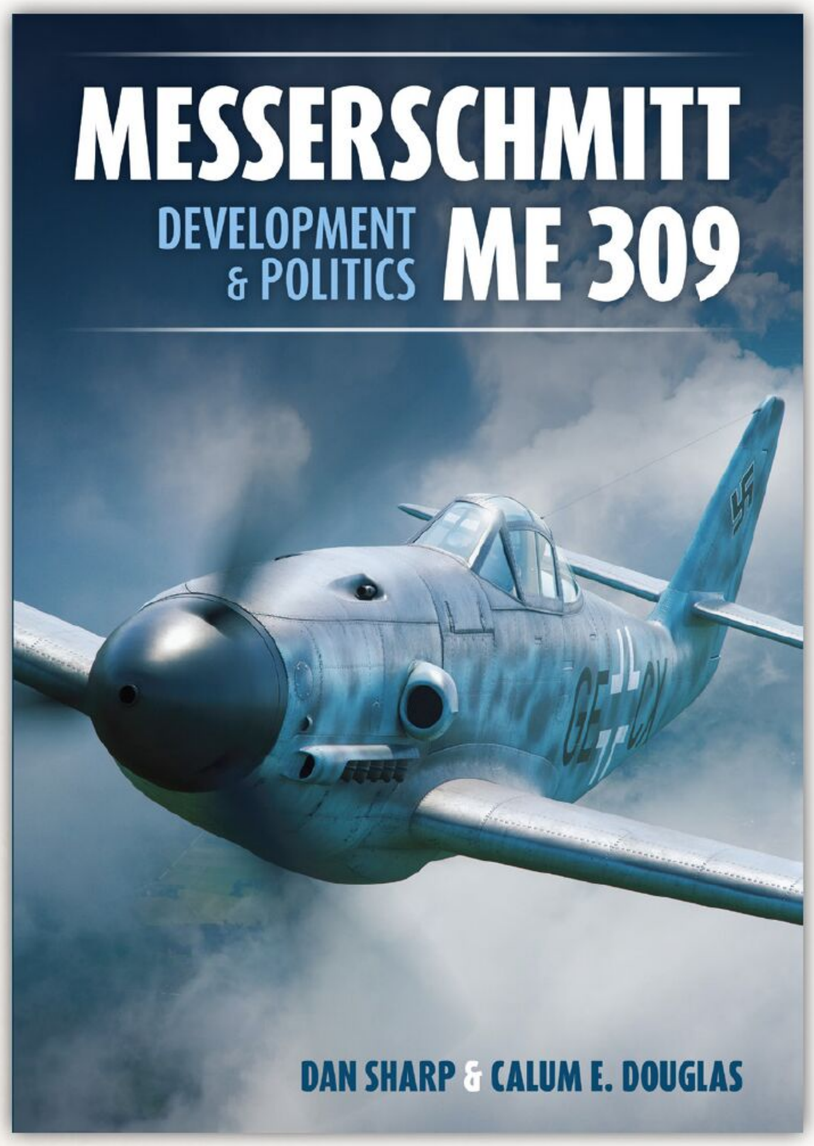

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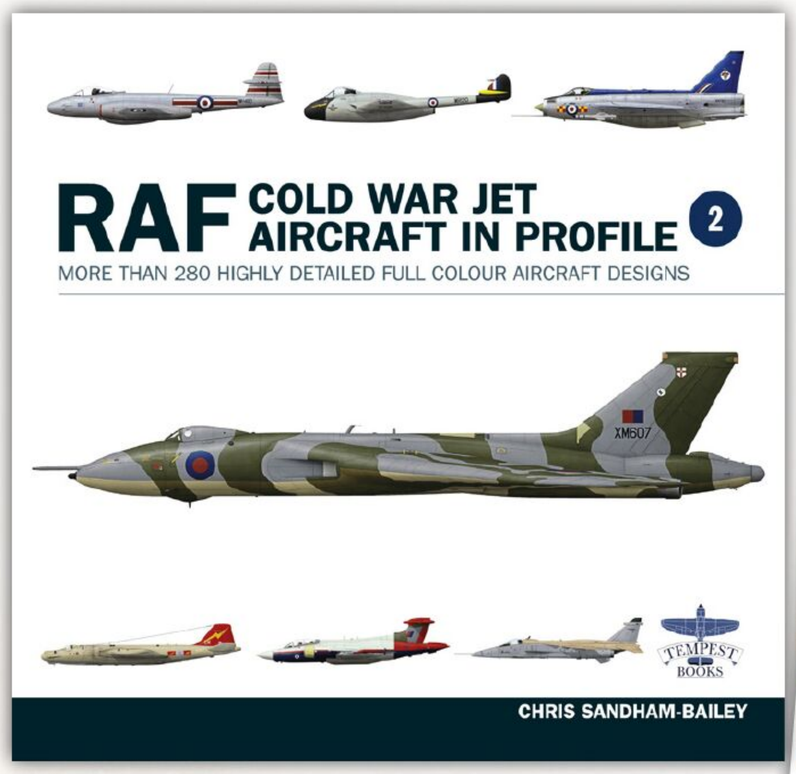

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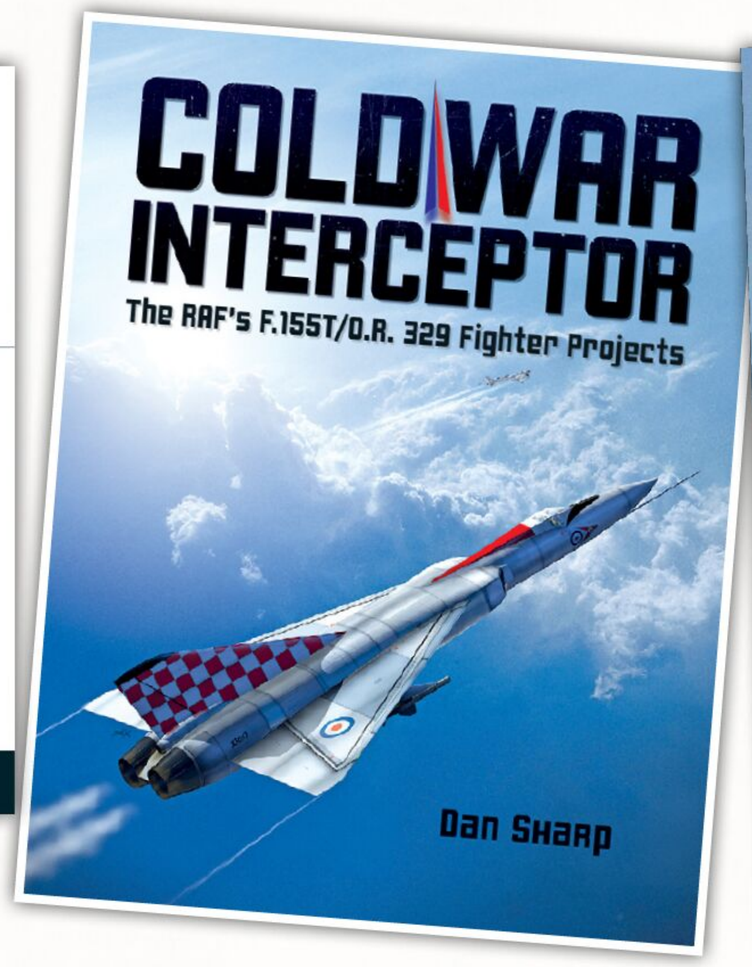

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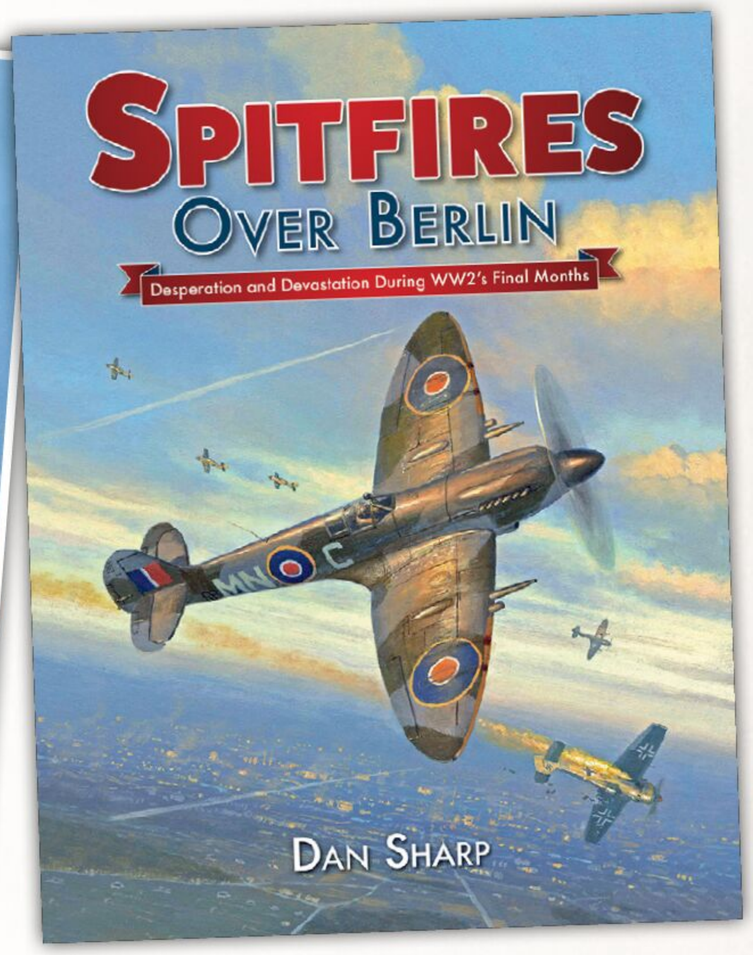

Spitfires Over Berlin

DAN SHARP

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The Battle of Britain Memorial Flight (BBMF) is a standing reminder of the heroism and sacrifice of countless British and Commonwealth aircrew who flew and fought during the Second World War.
Formed at RAF Biggin Hill on July 11, 1957, as the Historic Aircraft Flight, today the BBMF's incredible collection of aircraft includes six Spitfires, two Hurricanes, one of only two airworthy Avro Lancaster bombers in the world, a Douglas C-47 Dakota and two de Havilland Chipmunks.
The Flight's Second World War aircraft have survived against the odds to exist in flying condition today and this book charts each of their careers over the last seven decades or more. Author and illustrator Chris Sandham-Bailey has meticulously reproduced every known paint scheme worn by each of the aircraft – as well as gathering together an unrivalled collection of photographs to show how the appearance of the aircraft has changed. Never before have all of the BBMF aircraft liveries from the war's end to the present day been catalogued and illustrated in one publication. This book is a must for anyone with an interest in the BBMF aircraft and their histories.

Battle of Britain Memorial Flight in Profile

CHRIS SANDHAM-BAILEY

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Messerschmitt Me 262: Development and Politics

DAN SHARP

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ISBN: 9781911658276

The first jet fighter to enter service and see combat anywhere in the world, the Messerschmitt Me 262 was a deadly technological marvel – yet it was also difficult to produce, dangerously unreliable and extremely vulnerable during takeoff and landing. Despite these flaws, its graceful swept wings, aggressive shark-like profile and undoubted combat abilities made it a legend. The aircraft underwent rapid development during its short front line career and numerous unusual variants were designed and produced. German Secret Projects: Messerschmitt Me 262 Versions examines unusual production models alongside one-offs and drawing board projects. More than 30 designs are detailed, including the Me 262 A-1a/U1-5, Me 262 A-1b, Me 262 A-2a/U1-2, Me 262 B-1a, Me 262 B-1a/U1, Me 262 B-2a, Me 262 C-1a-3a, Me 262 D-1, Me 262 E-1 and E-2, Me 262 HG I-III, Me 262 W, Me 262 Mistel, P 1099A-B, P 1100, Me 262 Interzeptor I-III, Aufklärer I-II and Schnellbomber I-III.

Messerschmitt Me 328 Development & Politics

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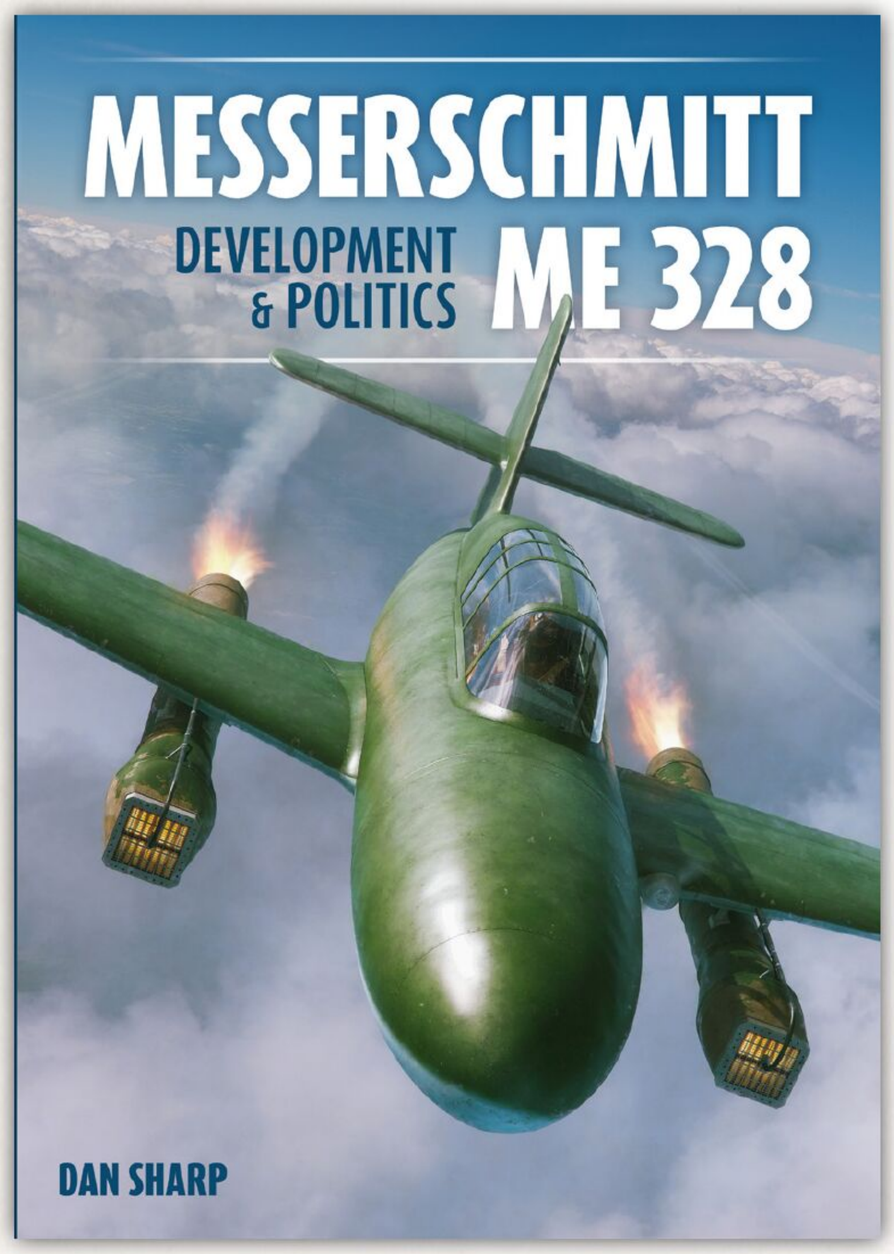
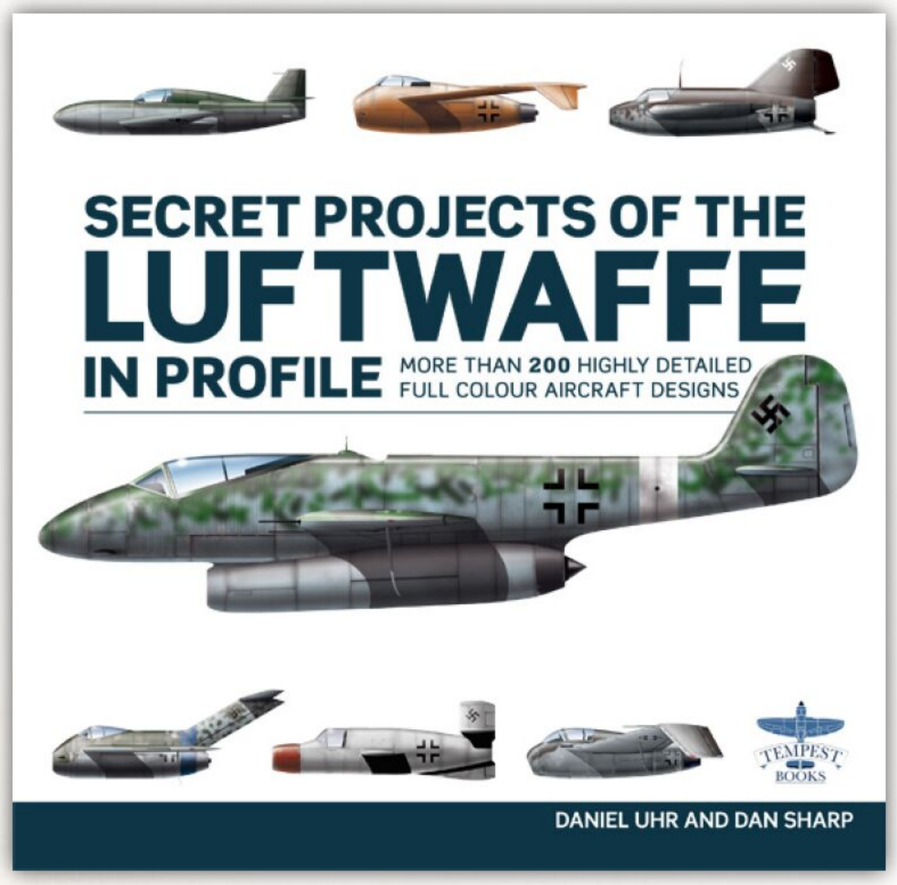


Conceived as a multirole combat aircraft based on promising early data from pulsejet tests, the Me 328 was arguably Messerschmitt's most controversial wartime project. Early projects imagined the compact machine as a fighter, a bomber, a reconnaissance platform or even a parasite aircraft – detaching from large bombers in mid-air to conduct operations before returning to the mothership. Enthusiasm was high, prototypes were built and extensively flight tested, with and without pulsejets, but it soon became clear that the airframe, the pulsejets and even the operational procedures mapped out for the Me 328 were proving far more troublesome than anticipated.

The type was cancelled – but then revived with a darker purpose: as a suicide bomber. Famous test pilot Hanna Reitsch and her cadre of fanatics chose the Me 328 as their vehicle for 'self-sacrifice' missions, where idealistic young pilots, plied with drugs to remove their inhibitions, would fly the aircraft, laden with bombs, directly into high-value Allied targets such as warships, bridges or command posts.

In Secret Projects of the Luftwaffe: Messerschmitt Me 328, German WW2 aircraft development specialist Dan Sharp presents the first ever book dedicated to the type and explores its history and purpose as far as surviving documentation allows.



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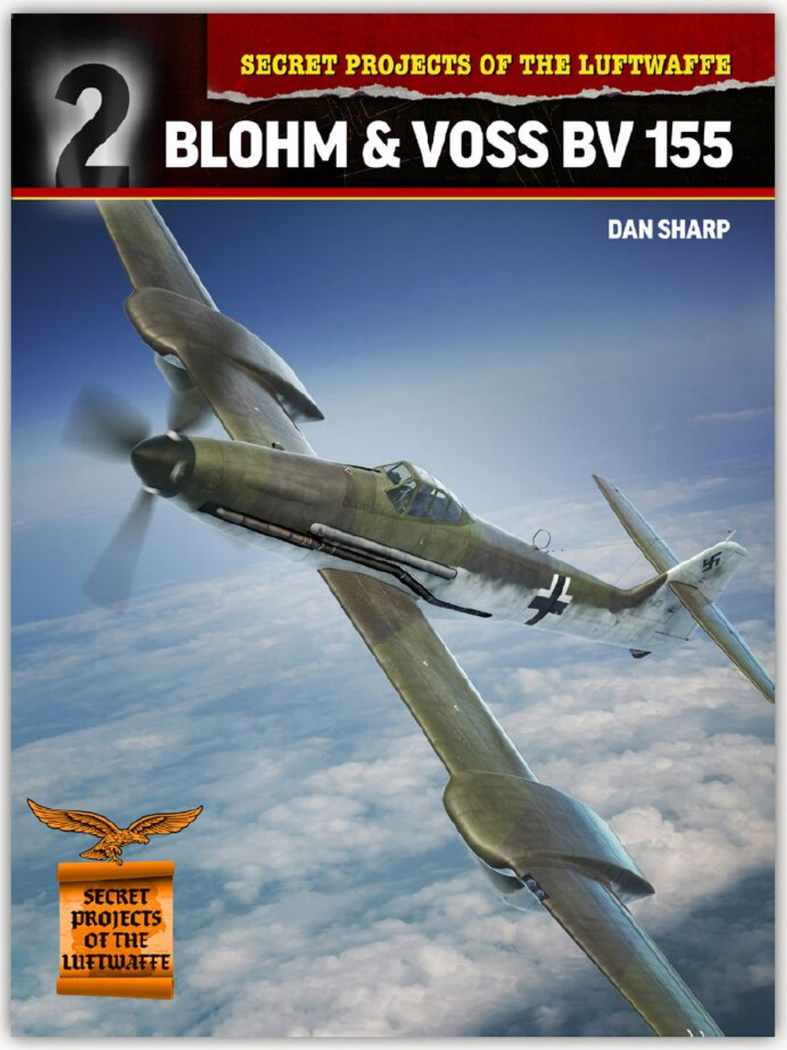

Secret Projects of the Luftwaffe: Blohm & Voss BV 155

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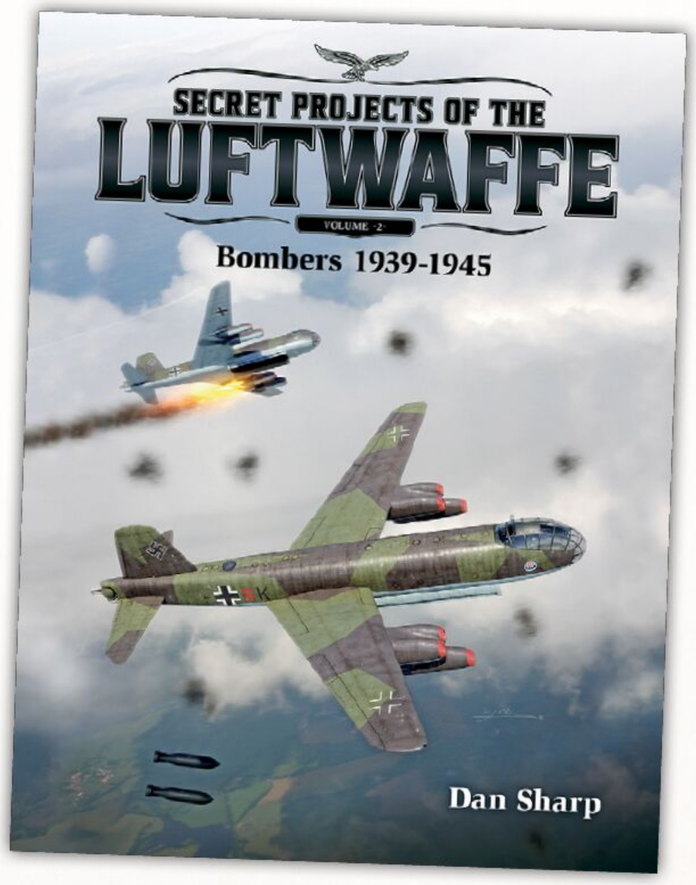

Secret Projects of the Luftwaffe - Vol 2 - Bombers 1939 -1945

DAN SHARP

On sale: SEPTEMBER 20, 2024

Softback **£39.99**

ISBN: 9781911658092

Secret Projects of the Luftwaffe: The Fastest Bomber

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HOTOL: Britain's Spaceplane

DAN SHARP

On sale: SEPTEMBER 27, 2024

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ISBN: 9781911704294

The start of Space Shuttle operations in 1981 marked a new era in spaceflight – with the five orbiters launching numerous satellites, interplanetary probes and the Hubble Space Telescope. But Shuttle was only partially reusable, its external fuel tank being expendable and its solid rocket boosters having to be recovered from the ocean and refurbished. Putting a satellite into orbit using a rocket was even more wasteful – with boosters such as Ariane being one-shot only. The costs were astronomical.

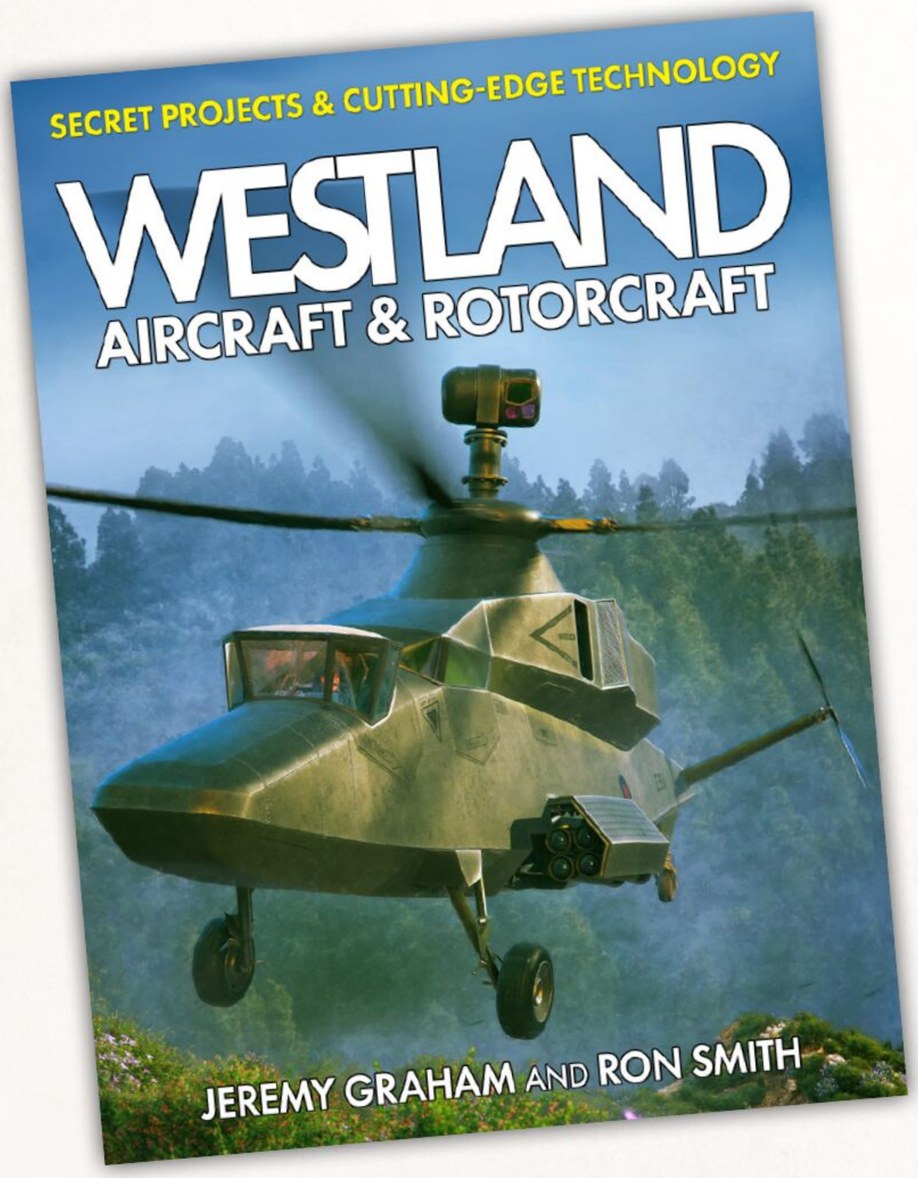
So when rocket scientist Alan Bond and aerospace engineer Bob Parkinson attended a British Interplanetary Society lecture on the proposed non-reusable Ariane 5 rocket in 1982, they began to discuss possible alternatives and concluded that the best solution was... an aerospaceplane.

The concept was deceptively simple – a vehicle able to take off from a conventional runway using airbreathing engines, switch to pure rocket propulsion at high altitude, fly up into space, complete its mission, then fly back down and land. Bond and Parkinson believed it could be done and HOTOL – HOrizontal Take-Off and Landing – was born.

By 1983 both British Aerospace and Rolls-Royce were backing the project. A broadcast on ITN's New at Ten in 1984 made HOTOL famous overnight, with the whole nation now aware of its existence. The Government agreed to match-fund the companies' financial commitment in 1985 and the work ramped up into high gear, with some of Britain's best engineers engaged in making this remarkable vehicle a reality.

Two years later, Minister of State of Trade and Industry Kenneth Clarke withdrew funding – signalling the beginning of the end of HOTOL, though there were attempts to revive it as an air-launched vehicle atop an Antonov An-225 as Interim HOTOL.

HOTOL: Britain's Spaceplane by Dan Sharp covers the full story of HOTOL's development in detail from beginning to end, drawing on the BAE Systems archive, the personal archives of the project's creators and extensive interviews with those involved. It includes new artwork plus hundreds of contemporary diagrams and illustrations, ranging from full colour brochures and publicity material – both used and unused – to previously unseen diagrams and schematics of HOTOL's numerous configurations.



Westland Aircraft & Rotorcraft: Secret Projects & Cutting-Edge Technology

DR RON SMITH AND JEREMY GRAHAM

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ISBN: 9781911658955

Half Century, Baby! - Fifty Years of the Grumman F-14 Tomcat

DAVID PARSONS, MADS BANGSO

AVAILABLE NOW Softback **£40.00**

ISBN: 9781911658924

Half Century, Baby! marks the 50th anniversary of the first two Grumman F-14A fleet squadrons (VF-1 and VF-2) receiving their first Tomcats during the summer of 1973. This lavishly illustrated volume tells the story of the aircraft from the beginning to its sunset of service with the US Navy in 2006; the longest operational career of any Naval Fighter to date. Preeminent Tomcat historian and former Tomcat RIO Dave Parsons explains the history of the F-14 decade by decade through the words of the aircrew who flew it. Artist Mads Bangsø brings his superlative illustration talents to the forefront with more than 120 F-14 profiles as well as highly accurate fully rendered recreations historical events featuring the Tomcat, highlighting the interesting markings of the aircraft (including helmets) as well as other aircraft associated with the Tomcat Community. The book features pertinent colour photography throughout, interwoven with the illustrations to complement the text.

Half Century Baby Volume II

DAVID PARSONS, MADS BANGSO.

On sale: SEPTEMBER 12, 2024

Softback **£40.00**

ISBN: 9781911704232

Bomber Command Gardening Operations - The Invisible Campaign 1940-1945

JANE GULLIFORD LOWES

On sale: OCTOBER 18, 2024

Softback **£19.99** ISBN: 9781911704287

Aerial mining by RAF Bomber Command was a vital part of the Allied war effort – claiming far more tonnage of Axis shipping destroyed than direct attack by either Coastal or Bomber Command itself. Minelaying operations commenced in April 1940 and expanded dramatically as the war progressed, yet today this vital campaign and its wide-ranging achievements against Axis merchant vessels, Kriegsmarine ships and U-boats are virtually unknown. Invisible Campaigns, based on Air Ministry and Admiralty archival material, together with squadron records, veteran accounts and logbooks as well as contemporary publications and press releases, provides the most detailed account of Bomber Command's minelaying operations and their effects ever written.

Historian Jane Gulliford Lowes looks at the aims of the campaign and how it was implemented, together with the measure of its success and how it compared against the mining operations implemented by the Luftwaffe and Kriegsmarine. The role of Arthur 'Bomber' Harris in overseeing minelaying operations is assessed and the experiences of the men who delivered the campaign, particularly the hazards they faced, are explored.

Invisible Campaigns sheds new light on a little-discussed but important and ultimately highly successful aspect of Bomber Command and is a must-read for anyone interested the RAF's in wartime bombing operations.

The Battle of Britain Memorial Flight in Photos

LISA HARDING

AVAILABLE NOW Softback **£39.99**

ISBN: 9781911704249

This collection of more than 150 high-quality images offers a unique perspective on the historic aircraft and hard-working personnel of the unique Battle of Britain Memorial Flight based at RAF Coningsby in Lincolnshire.

Photographer Lisa Harding has spent many years photographing the flight and now presents some of her finest work – chronicling winter maintenance, when the aircraft undergo extensive checks and repairs if required; out-of-season practice displays and some spectacular 'hot starts'. Ground crew can be seen performing their duties both indoors and out while pilot training provides views rarely seen by the public.

A collection of notable displays showcases memorable moments from the past decade, including the gathering of three Lancaster bombers at East Kirkby, the last two airworthy Lancasters flying together down the Derwent Valley, the RAF100 Buckingham Palace flypast and the Dambusters 80th anniversary.

The images are presented with commentary from the author, providing both background and technical details on how the shots were taken.

The Battle of Britain Memorial Flight in Photos offers a wealth of previously unseen views of the flight in incredible colour, detail and clarity – a must for any warbird enthusiast.

Messerschmitt Bf 109 Origins and Evolution

LYNN RITGER

On sale: SEPTEMBER 30, 2024

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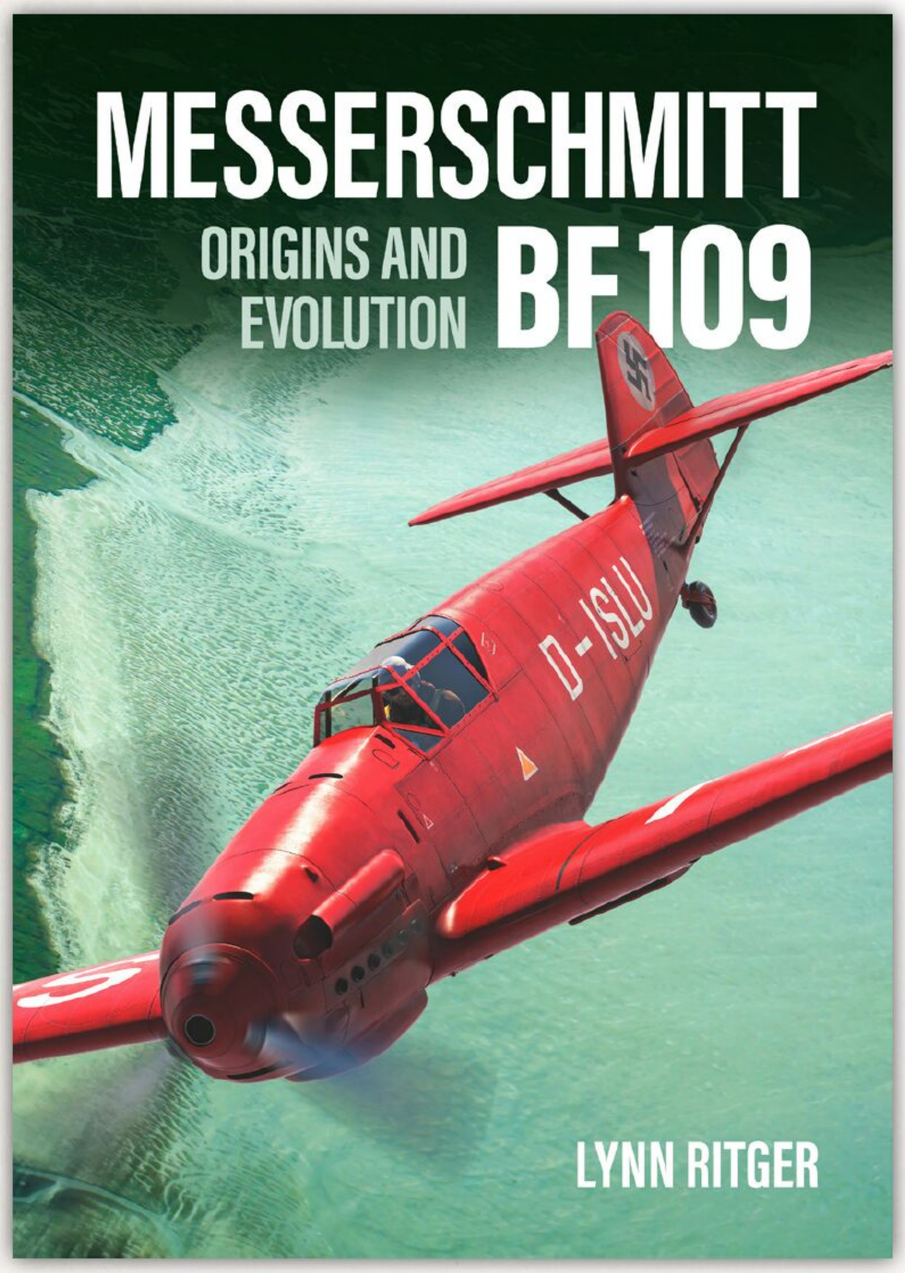

The most produced fighter aircraft in history, and arguably the single most important German aircraft of the Second World War, the Messerschmitt Bf 109 was unquestionably the most advanced fighter in the world when it first flew in May 1935. The scale of the development and production effort by Messerschmitt and its subcontractors over the next ten years to fulfil the operational needs of the Luftwaffe resulted in a seemingly endless variety of modifications to every aspect of the aircraft, from engines and weapons down to radios and tailwheels. Political gamesmanship and often heated discussions between Luftwaffe leaders and Messerschmitt company representatives, striving to keep their most successful product relevant in the face of ever-increasing Allied threats, also had a role to play in the developmental history of the Bf 109.

In Messerschmitt Bf 109 – Origins and Evolution, historian Lynn Ritger examines in detail the development of the Bf 109 family across its entire lifespan, from the first flight of the Bf 109 V1 to the last operational flight of a Spanish Hispano Ha 1112 M in 1965. Drawing upon original documentation from archival sources, including RLM meeting minutes and planning documents, intelligence reports, production records, factory handbooks, and front-line unit reports, Ritger traces the technical history of the Bf 109, illustrating prototype and service variant development, production batch differences, internal and external equipment and ordnance fitment, factory specific equipment and finish details, postwar variants developed in Czechoslovakia and Spain, and unrealised design proposals.

Fleet Air Arm Legends: Supermarine Seafire

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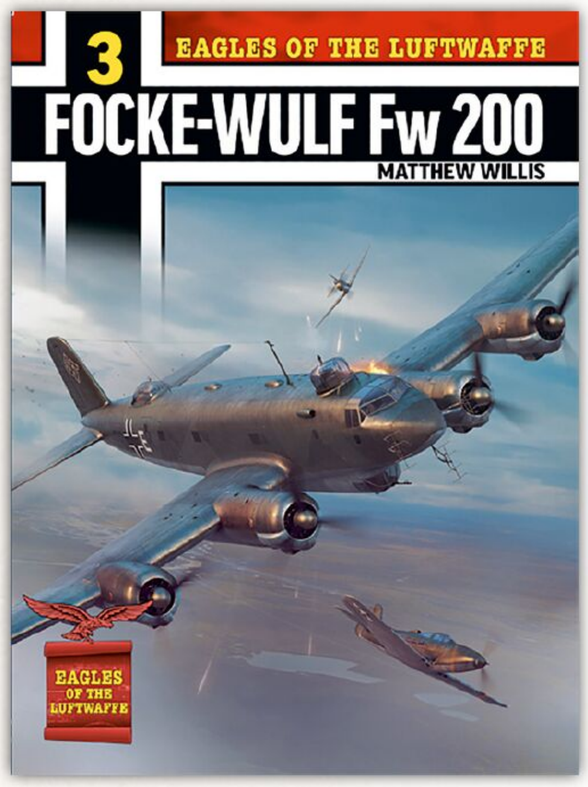

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Eagles of the Luftwaffe: DFS 230

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Snooperbase Waddington

MICHAEL HILEY

On sale: AUGUST 23, 2024
Softback **£16.99**
ISBN: 9781911704218

The air base at Waddington has been home to the RAF's most valuable surveillance, intelligence-gathering, communications and electronic warfare assets for more than three decades.

During the 1990s, Boeing E-3D Sentry AWACS and Hawker Siddeley Nimrod R1 signals intelligence platforms became familiar sights in the skies over Lincolnshire as ISTAR (Intelligence Surveillance Target Acquisition and Reconnaissance) assets were brought together at RAF Waddington.

The Raytheon Sentinel R1 followed and more recently the base has become home to the RAF fleet of Beechcraft Shadow R1s, Boeing RC-135W Rivet Joints and General Atomics MQ-9 Reapers – as well as the Red Arrows aerobatic team and units experimenting with future drone technology.

Most recently, the base has received its first General Atomics Protector RG Mk 1s to take up the roles performed by the now 15-year-old Reaper fleet.

In Snooperbase Waddington, author and photographer Michael Hiley chronicle's the history of the RAF's ISTAR hub – including the aircraft flown, their known equipment and their operational use as far as the Official Secrets Act will allow.

Ronny Barr Profiles - British Two Seaters of the Great War

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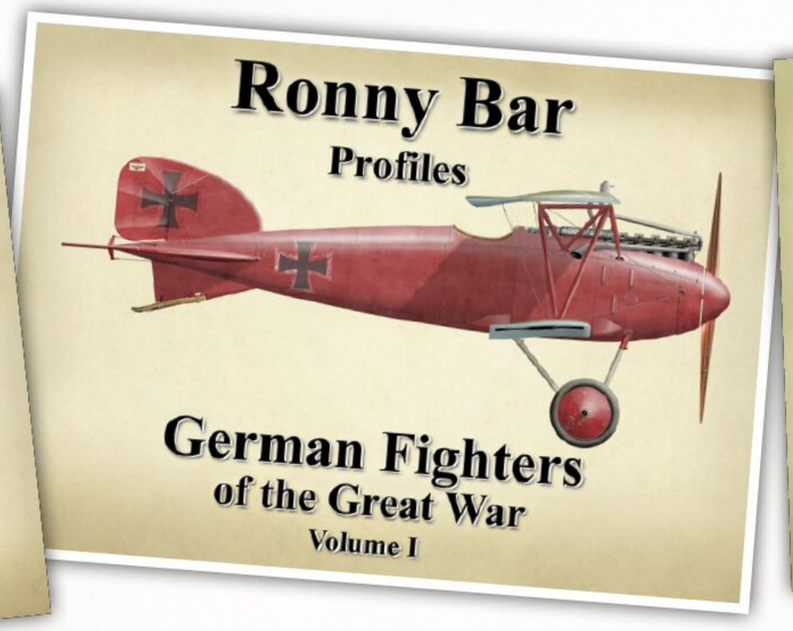

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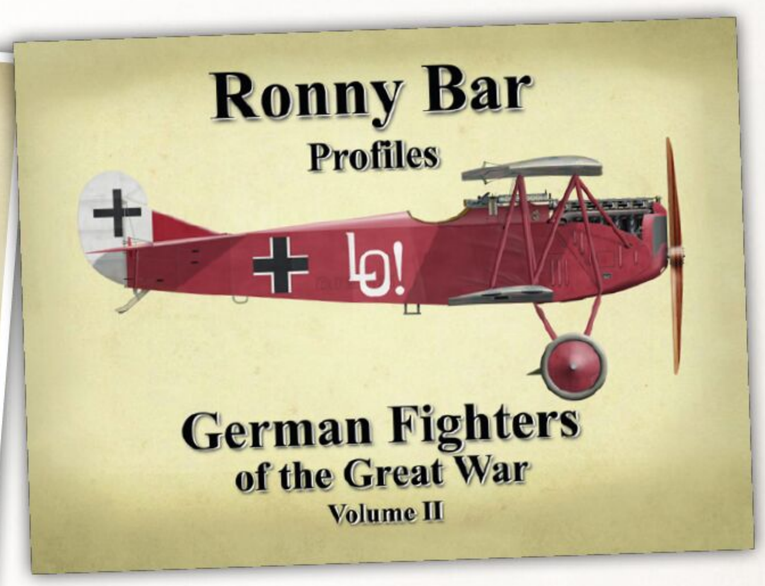

Ronny Bar Profiles - German Fighters of the Great War Vol 2

RONNY BAR

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Supermarine's iconic Spitfire needs little introduction – its graceful lines and remarkable combat record during the Second World War speak for themselves. Rolls-Royce Merlin-powered Spitfire Mk Is fought their way through the Battle of Britain during the summer and autumn of 1940 with the Mk II, incorporating a more powerful Merlin, being introduced in the meantime.

As the war progressed, the Spitfire underwent an intensive programme of upgrades and enhancements as well as modifications to expand its capabilities. Unarmed Merlin-powered photo reconnaissance Spitfires flew hazardous missions over occupied Europe and Germany, while the Seafire, a navalised Spitfire, was operated from Royal Navy carriers in the Far East. In Europe, the Mk Is and IIs gave way to the Mk V and then the world-beating Mk IX before the last major Merlin-powered Spitfire, the Mk XVI, was introduced. While some later marks of Spitfire would receive Rolls-Royce Griffon engines, it is undoubtedly the Merlin variants that bore the brunt of the action and which are the most fondly remembered today.

In Ronny Bar Profiles – Spitfire The Merlin Variants, renowned profile artist Ronny Bar presents an exciting and colourful selection of more than 350 highly detailed artworks, most created specifically for this book, showcasing the full range of Rolls-Royce Merlin-powered variants from the original Type 300 prototype, K5054, to the late-war Seafires. Aircraft of RAF aces including Robert Stanford Tuck, Alan Deere, 'Sailor' Malan and Douglas Bader are included as well as colour schemes worn by Spitfires in service with Allied forces around the world. Bar's love of Spitfires clearly shines through in his incredible attention to historical accuracy throughout this fascinating and illuminating collection.

Ronny Bar Profiles - Spitfire the Merlin Variants

RONNY BAR

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Boeing B-47 Stratojet and B-52 Stratofortress: Origins and Evolution

SCOTT LOWTHER

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Mikoyan-Gurevich MiG-31 Foxhound

SERGIO SANTANA

On sale: AUGUST 30, 2024

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ISBN: 9781911704140

With a top speed approaching Mach 3 and equipped with both powerful sensors and air-to-air weaponry, the two-seater MiG-31 interceptor has proven to be one of the Cold War's most formidable survivors – finally coming into its own during the Ukraine War. Development began in 1975 with a design based on that of the MiG-25 Foxbat and progressed to the point where, although it bore a superficial similarly to its forebear, it was largely a new aircraft. The MiG-31, NATO reporting name Foxhound, entered service in 1981 and more than 500 were built.

Several dozen examples remain in service today with both the Russian and Kazakh air forces – and throughout 2022 and 2023 Foxhounds using R-37M long-range AAMs operated virtually unopposed against Ukrainian fighters, which lacked the speed, range, altitude and firepower to engage them. MiG-31s have also provided a valuable platform from which to launch Kh-47M2 Kinzhal hypersonic missiles against Ukraine while remaining within Russian airspace.

Author Sergio Santana details the aircraft's early development, its long operational history and its most recent operations in this all-new look at one of the world's deadliest combat aircraft.

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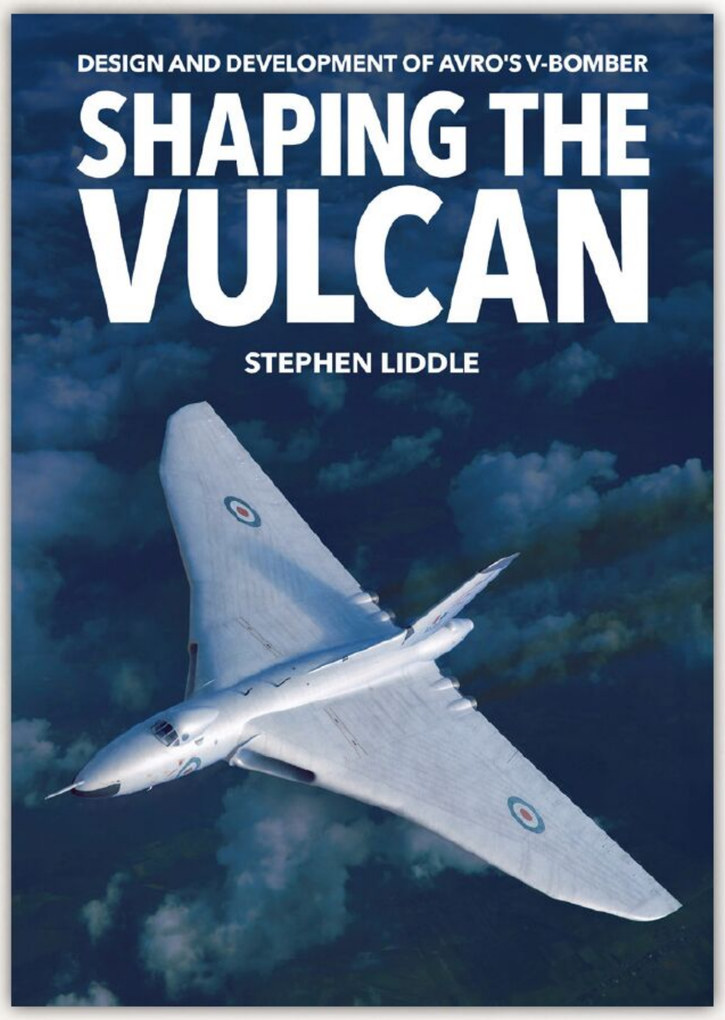


Shaping the Vulcan

STEPHEN LIDDLE

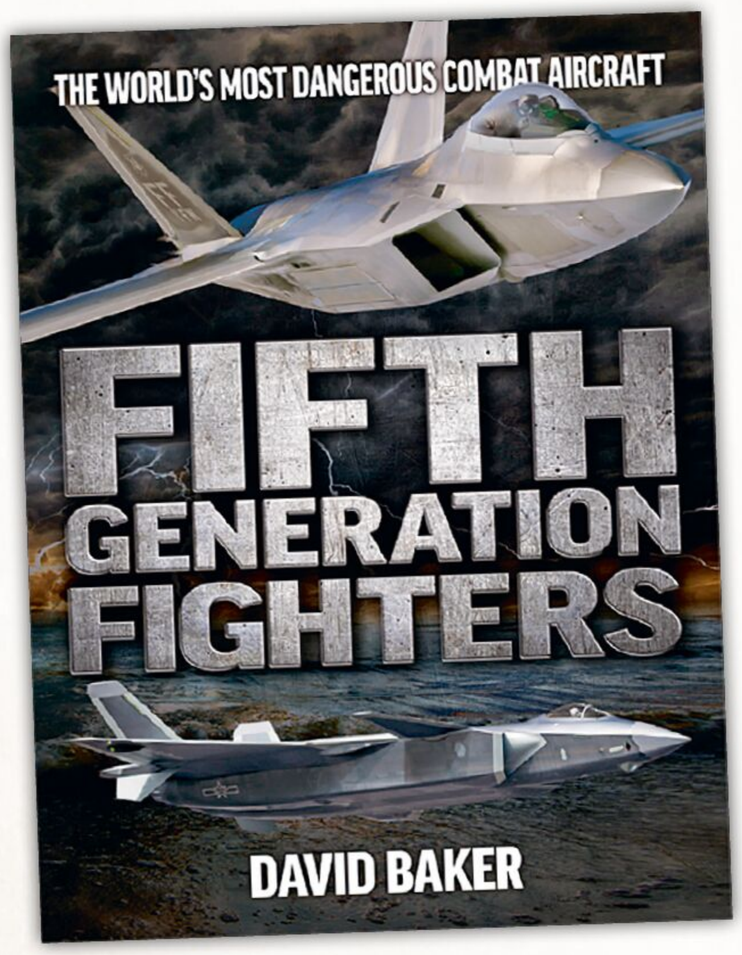
On sale: AUGUST 30, 2024 Hardback **£35.00**

ISBN: 9781911704072

The Avro Vulcan is one of the most striking aircraft ever made – its enormous wing stretching back from an improbably thick leading edge marked by cavernous wing root engine intakes. Perhaps even more incredible, its first flight was made just over ten years after the introduction of the piston-engined Lancaster during the Second World War. Within a decade, technology had taken a giant leap from straight-winged slow-moving conventional bombers to this vast delta designed to carry a nuclear payload.

But what led to such a radical configuration and what was the technology that enabled such an ambitious design? What possessed Avro to offer the Air Ministry such a futuristic aircraft and what prompted the Ministry to approve its development and entry into service?

Formula 1 racing team aerodynamicist and Vulcan to the Sky trustee Stephen Liddle presents a full history of the Vulcan's development and assesses the technological and engineering breakthroughs which underpinned the construction of this unparalleled aircraft.



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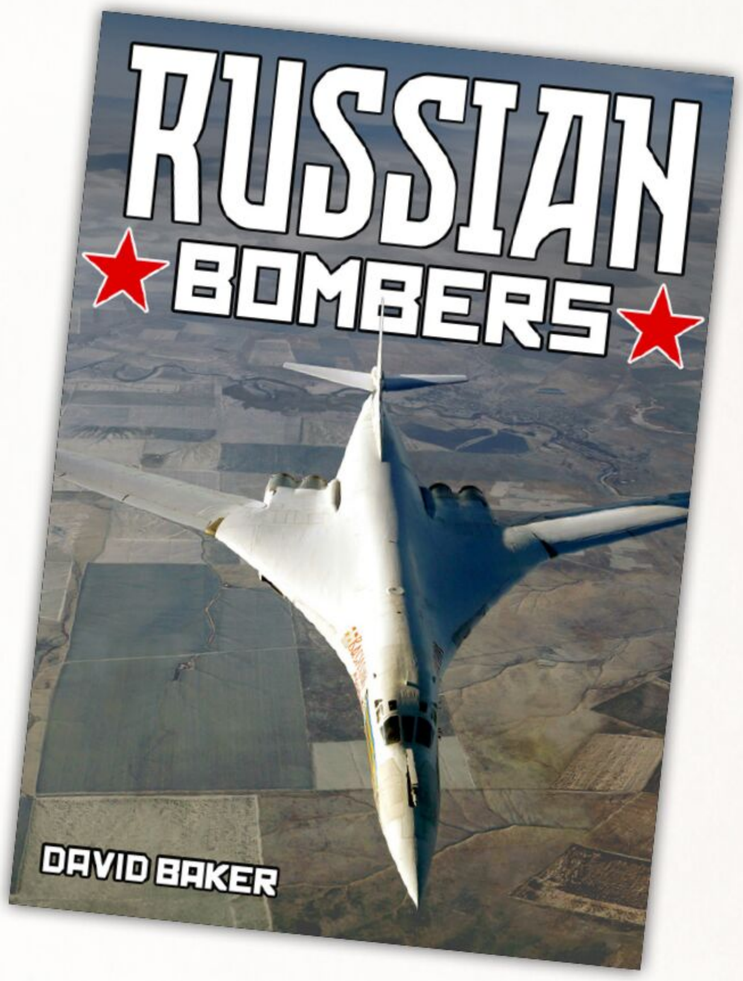

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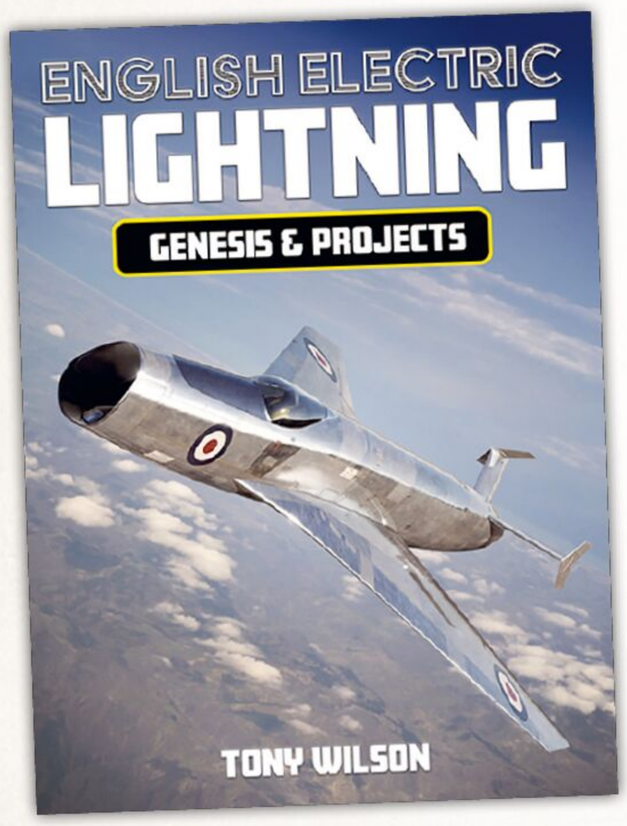

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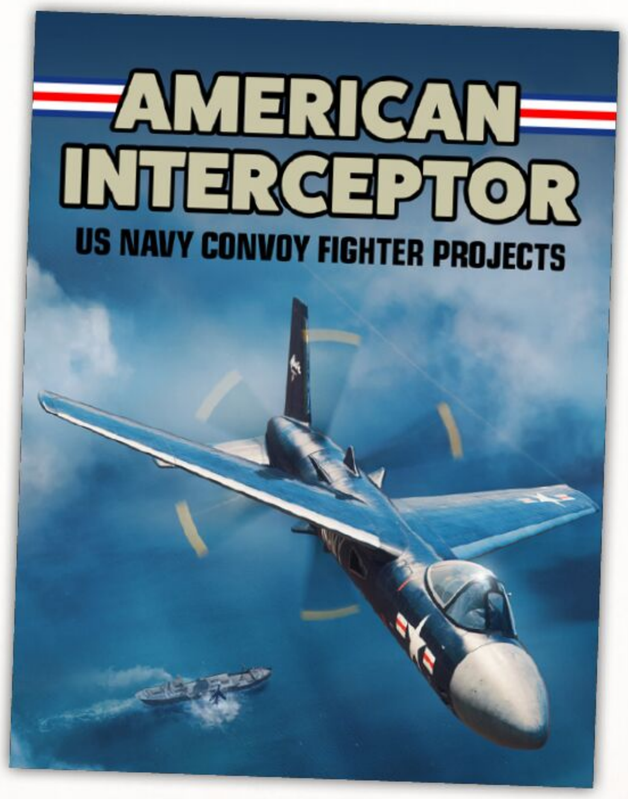

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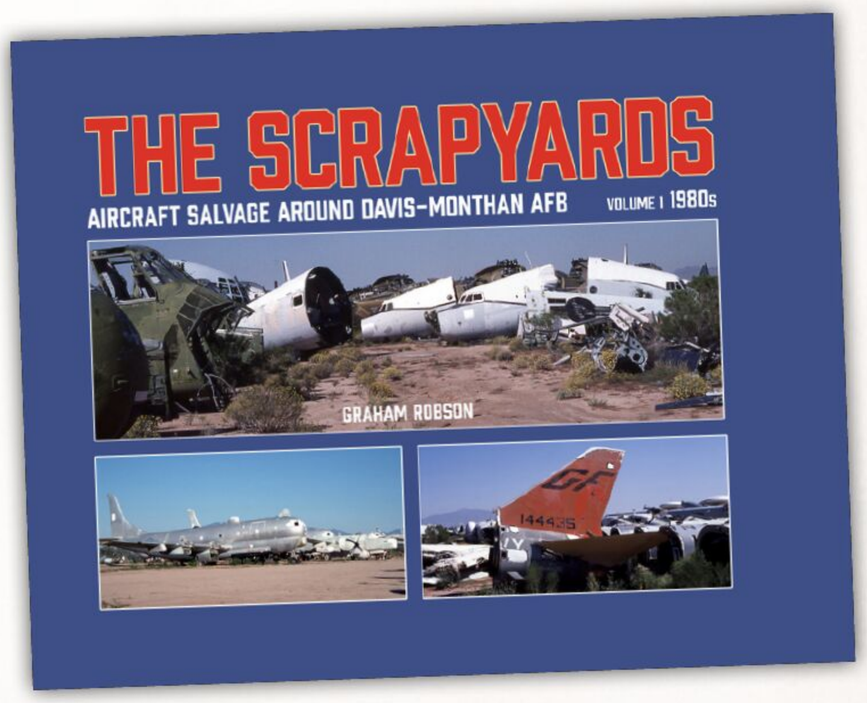

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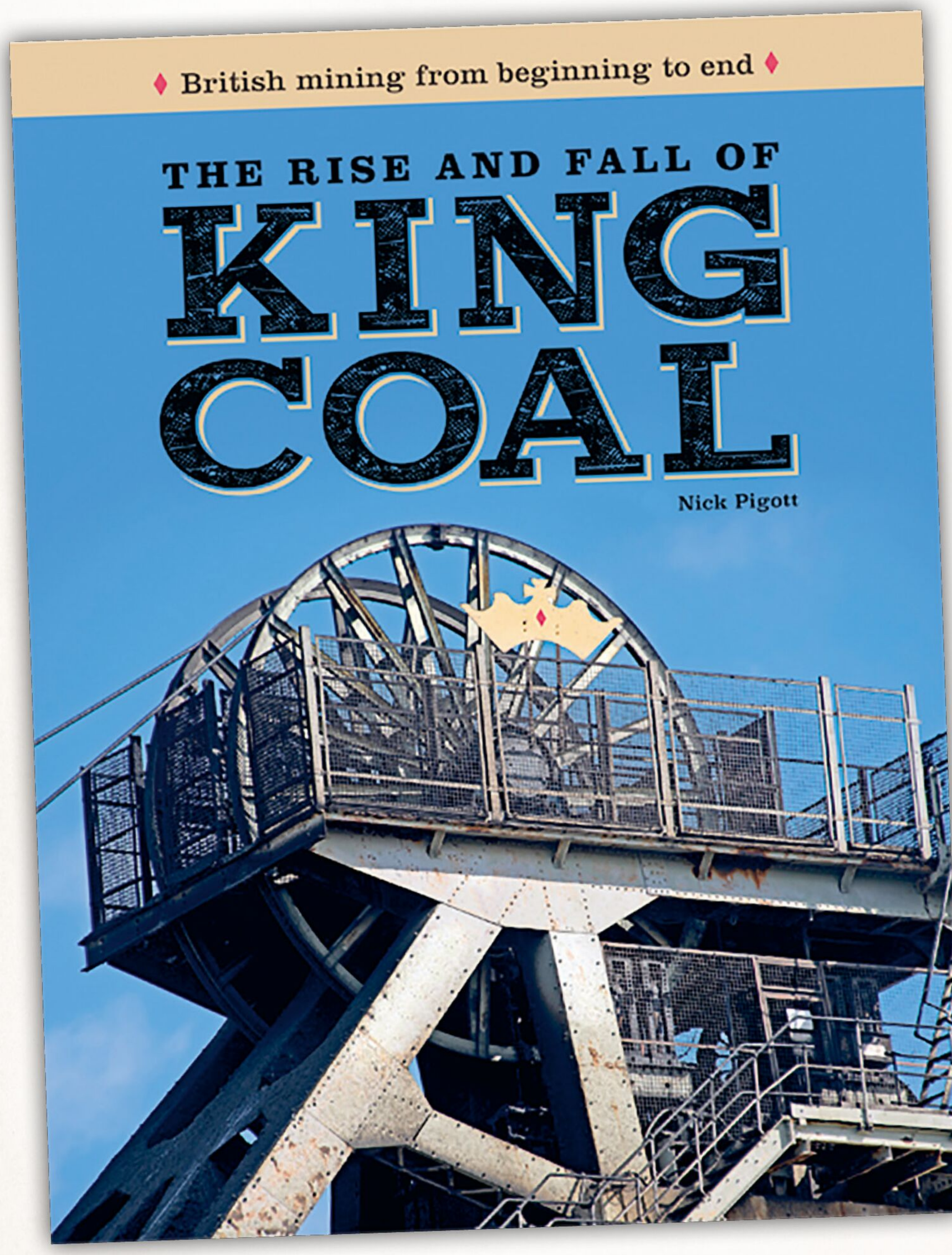

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