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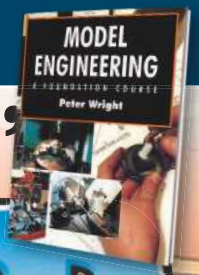

MODEL ENGINEERS' WORKSHOP

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Roderick Jenkins' and his ML7

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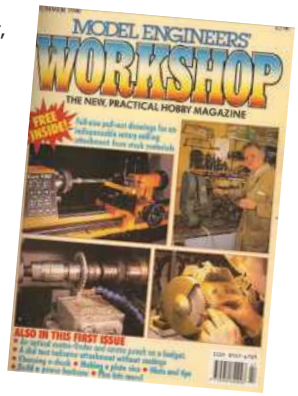
On the Editor's Bench

Happy New Year

A Happy New Year to all readers of *MEW* from all across the UK and around the world. I hope it brings you good fortune and many happy and productive hours in your workshops.

2015 is a significant year, our first issue was published in the summer of 1990, so we are celebrating 25 years of *Model Engineers' Workshop*. In that first issue Stan Bray set out his vision for an occasional magazine that had a very practical focus on tools and techniques, mostly in single-part articles. As the magazine evolved through being bi-monthly to thirteen issues a year, the new century saw more and longer series appearing.



It's planned to mark the anniversary with a separate 'special' featuring some of the best content from the magazine. I hope to feature some interesting snippets from past issues over the year in the magazine, particularly focusing on the early years. Do get in touch if there's something you would particularly like to see.

On My Bench...

Avid followers of the 'Mega Adept' saga may be following my progress with rebuilding this venerable machine tool on **www.model-engineer.co.uk**
I have made a new headstock from a lump of meehanite (a high grade of continuous cast iron). To this I've fitted a spindle with a bronze taper bearing at the front and a parallel bearing at the back, with roller thrust bearings either side for adjustment. My present task is completing an eccentric back gear arrangement, including cutting the gears. Hopefully by the time you read this the lathe will be working again, although there will still be a lot of work to add gear drive for the leadscrew and then bring the rest of the lathe up to scratch. I've also acquired a wonderful 'period' Parvalux fractional HP motor that has apparently been in a box for the last 25 years that will suit it down to the ground.

New Authors Wanted

While I have many really good articles lined up for 2015, I'm keen to hear from potential new authors. Just drop an email to **neil.wyatt@mytimemedia.com** letting me know of any ideas you have for an article, and I will send you the guidance for contributors.

SMEE Training Courses

The popular SMEE engineering training courses will be running again in 2014. The Basic Training Course that has introduced many new model engineers to the hobby is aimed at complete beginners. The next course runs over three Saturdays, starting on the 14 February – so perhaps your significant other will treat you!

All courses are held at Marshall House, SMEE's headquarters close to Loughborough Junction station in London, SE24. To book a place on the course, or the 'part 2 'Polly' course, or just find out more contact

Peter Haycock the course organiser on 01442 266050, email **haycock388@btinternet.com**, or visit the SMEE website **www.sm-ee.co.uk**

MODEL ENGINEER EXHIBITION

This issue will, hopefully, be landing on your doormat just ahead of the Model Engineer exhibition at Sandown Park on 12-14 December. You'll remember that I mentioned plans for an *MEW* 'open forum', this will be held between 2:30 and 3:30 on the afternoon of Friday 12. I'll be keeping it strictly to an hour to make sure that those who come along have plenty of opportunity to get around the show afterwards. It will probably happen upstairs near where the DoE models are on display, but please check the time and place as we may need to move it round a bit. I'll make sure the details come up on the monitors. I'm also bringing a few models along as loan exhibits, including my canal crane, pictured here. If you see me around the exhibition, do stop me and say hello!

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&
a Happy New Year

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Contents

Coming up...

in the February issue

THE URWICK METALMASTER

Mike Philpotts introduces one of the really radical innovations in manual lathe and machine tool design of the twentieth century in a special article to be accompanied by full details on our website.

PLUS Andrew Johnston describes the operation of the Anjest threading unit, Mark Noel explores the manifold possibilities offered by threaded inserts and Alastair Sinclair gives constructional details for his mini-lathe ball turning tool to ball turning.

Regulars

ON THE COVER

We're not sure what's puzzling Roderick Jenkins, but we are sure you'll enjoy the story of his ML7 on page 8.

Visit our Website

for extra content and our online forum

www.model-engineer.co.uk

The Model Engineers Workshop Free Plan Collection

Over the first few years following its launch in 1990, MEW regularly included a free pull-out plan. These plans covered a diverse range of tools, from a rotary table to a rear toolpost – now these plans are being made available again through our website!

FREE PLAN:

A Lathe Mounted Bandsaw

Back in the 90s it wasn't unusual to see bandsaws designed to mount on woodworking lathes! G. Gray needed a similar solution for his metalworking workshop, due to a shortage of space. He came up with this design for the Myfiord ML7, but it could easily be adapted for other lathes.

George Round's Home-Made Lathe

A special reprint for subscribers – George Round's six-part Model Engineer series on the building of a 3½ inch centre height lathe.

Stepperhead lathe Construction

As Alan Jackson's construction series on his award-winning lathe concludes, his technical notes are of interest to both constructors of the machine and anyone interested in making or modifying their own CNC machines.

Some of the other live topics on the forum include:

- Which Spray Gun – choosing one to paint a loco.
- Milling Machine Trammel – ways and means of setting it straight!
- Dore Westbury Mill – Finding suitable collets.

Together with plenty of live advice for beginners setting up a workshop.

One Man and his Lathe

Roderick Jenkins and his Myford Super 7

No other lathe is more closely associated with model engineering than the Myford Super 7. The basic design is now over sixty years old, but Rod Jenkins argues it is still the ideal machine for the home workshop.

My Myford Super 7.

I'm not sure whether I chose to own a Myford Super 7 lathe or it chose me. Perhaps it was destiny. Dad was an electrical engineer but I chose a scientific career path and didn't aspire to owning a lathe in my formative years. During my education I was, however, fascinated by the lathe (always a Myford) that lurked in various laboratory technician's cubby holes. In my twenties I started making stringed musical instruments as a hobby and, with the encouragement of a work colleague, decided that I wanted to make some instrument making tools. A Zyto lathe came my way. Some tools were made but gradually the means became the end and I started to make engineering models. My colleague, by now my model engineering mentor as well, had a Myford Super 7 lathe. Both of my neighbours at home had Myford Super 7 lathes. I became a regular reader of the Model Engineer. Those great authors of the period, Tubal Cain and George Thomas, both used Myford Super 7 lathes. This, surely, was the ultimate lathe for the model engineer. Sadly, one of those neighbours of mine died early into his retirement but I became the custodian of his, almost pristine, Myford Super 7 No. 102520, from the early 1970s (photo 1).

So, what is a Myford Super 7? The specification from the comprehensive 50 page manual supplied with the lathe tells us that it has: 3½ inch centre height and admits 19 inch between centres, can swing 10 inch diameter in the gap and has No.2 Morse tapers in both head and tailstock. The cross-slide has a boring table with 6 ½ inch travel and a topslide that can rotate though 360 degrees. Fourteen spindle speeds between 25 and 2,150 rpm are available, by changing the belt and/or using back gear, all of which utilise the full power of the ¾ HP single phase motor. Weight, including motor, is 245 pounds.

These bare facts, though, don't reveal how well the lathe was designed for ease of use. The guarding for the belt drive and change gears, so often an afterthought on lathes aimed at the amateur market, are hinged and retained by spring loaded catches. A single lever tensions the drive

Standard gearbox banjo showing the cluster gear in the middle which is reversed for fine feed and a 34t gear on the tumbler stud for a metric thread.

Turning a centre in silver steel held in a Myford Patent collet.

belt so that speed changing is quick and easy. The back gear is engaged by turning a key on the bull wheel and moving a lever. The spindle nose is threaded, so changing chucks is straightforward using the easily engaged spindle lock. All this may sound like so much advertising hype but it is the attention to these details that make the lathe such a pleasure to use. The weight seems to be just right. The lathe is rigid and can be set up to turn taper and chatter free by following the manufacturer's instructions yet I've moved this lathe between workshops 3 times now. With the motor removed and the tailstock and cross slide slid off it was readily handled by 2 people, even just my wife and I on one occasion!

The Super 7 was available with change gears or with a Norton type gearbox for thread cutting. My lathe was originally supplied with the change gears but was retro-fitted with a gearbox. Imperial threads from 8 to 56 tpi can be selected from the gearbox and fine feeds from 2 thou to 14 thou per revolution can be chosen by simply flipping the cluster gear: Possibly overkill, as I only ever use 2 or 4 thou. To complement the gearbox a replacement banjo was available with a set of change wheels to allow the cutting of metric threads, together with worms in both imperial diametrical pitch and metric module. These days I cut metric threads using the method that John Stevenson has popularised of simply the replacing the standard 24 tooth gear on the tumbler stud with either a 33 or 34 tooth gear (**photo 2**). However, I have found the addition of the metric screw cutting banjo together with all the original change gears to be very useful for cutting helical gears.

An enormous range of accessories is available for the lathe, including 2 types of vertical slide (fixed and rotating), a dividing head and various collet systems. I particularly like the Myford patent collets that fit directly in the No.2 Morse Taper in the spindle and are retained by a nut that screws onto the spindle nose (**photo 3**). I use these whenever I can and try to devise my machining procedures to incorporate a suitably sized spigot to fit into collet. My dividing head, a homemade unit based on the Timmins casting (**ref. 1**), incorporates a 2MT and spindle nose thread and register to match the lathe, thus making it easy to transfer work between the two, either in a collet or any of the other chucks.

The ubiquity of the Myford series 7 lathes in the model engineering world in the 1950s, '60s and '70s meant that many accessories were designed for the home engineer to construct themselves. Those by Jack Radford and George Thomas were, and still are, particularly popular. The 60-tooth bull wheel for the back gear lends itself very nicely to use for indexing and dividing and is easily accessible by lifting the pulley cover, which stays up when required to! Radford and Thomas' Headstock Dividing Attachment (**ref. 2**), together with a milling spindle mounted on the cross slide provides considerable extra versatility for drilling and light milling (**photo 4**). Even though I have a Sharp Mk II milling machine I often find it easier to mill on the lathe, particularly when headroom is an issue on the milling machine and I can use the lathe as a horizontal boring machine. The flat bed of the Myford has gone out of fashion now but it does mean that certain accessories such as milling attachments can be easily accommodated. George Thomas's hand rest (**ref. 3**) is a case in point, shown here supporting a graver used to round off the fins on a replica Dyno compression ignition engine (**photo 5**). The bed can even be used as a (rather long and thin) surface plate for marking out. A little after my lathe came out of the factory Myford introduced the Super 7B that had a powered cross feed driven from the feed screw. My Myford has a third party addition that provides the same function. Made by Warrington Model Engineering Developments this was available in the 1990s. After 30 years or so, the original single phase motor supplied with the lathe became rather noisy so I took the opportunity to replace it with a 3 phase motor with variable frequency drive. This is very useful with its infinitely variable speed control. It does, however, sometimes run out of torque at low speeds so the ability to easily move the belt to a different pulley ratio is still a convenience.

The top slide has a conical spigot on the base that fits securely in a hole in the cross slide. Other attachments can use this hole such as the Tubal Cain's Gibraltar toolpost (**ref. 4**), which he designed primarily for turning crankshafts, or a base for a milling spindle that is sized so that the spindle centre is on lathe centre height (**photo 6**).

The hole through the lathe spindle is only $^{19}/_{32}$ inch. This is certainly a restriction but one that I find mostly in theory rather than practise. The chucks, of course, will admit rather more and one can project into the 2 Morse Taper but for larger diameter pieces I have to cut them to a suitable length to avoid having too much projection from the chuck. Either that or they have to be supported in the fixed steady. I do end up with some stub ends but they generally come in useful for something. It is, though, very useful to be able to easily switch chucks, both on the lathe and on to my dividing head on the milling machine. This is something I would not be able to do if the chucks were that much bigger and heavier. I would certainly not be happy with screw on chucks that were very much larger and would want a more positive system, with the drawbacks that would entail. On balance, even if I was given the choice between the super 7 and it's big bore brother, I would stick with the 2 MT spindle.

So what do I do with my Myford Super 7 lathe? An interest in flying radio control model aircraft led me towards internal combustion engines and while the aircraft are long gone the interest in I.C. remains. These engines generally incorporate gears of some sort. I made a Eureka backing off device (**ref. 5, photo 7**) to relieve Brown & Sharpe type gear cutters which I made to cut the spur gears for a 10cc side valve 4 stroke engine (**photo 8**). These gears were cut by holding the gear blank in the lathe

Headstock Dividing Attachment and milling spindle.

Using a hand graver to round the fins on a Dyno replica cylinder head.

Milling spindle base fits in the topslide spigot hole.

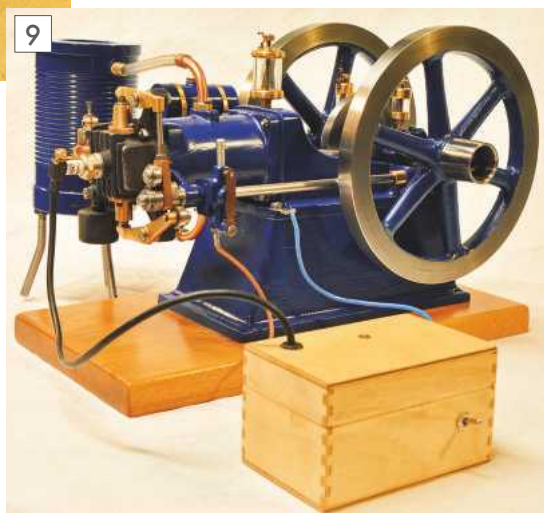
chuck. The Headstock Dividing Attachment was used to index the blank and the cutter was fastened to an arbour in the Arrand milling spindle (**ref. 6**) attached to the vertical slide. My latest completed project is a Wyvern gas engine to Edgar Westbury's design (**ref 7**, **photo 9**). All the usual turning functions were done on the Myford (**photo 10**). The cam shaft on this engine is driven by a pair of skew (helical) gears which I made (**photo 11**). When cutting helical gears you need to rotate the blank under the cutter at the correct helical pitch. Using the metric conversion banjo on the gearbox, change wheel combinations to give leads of up to 5 inch per revolution can be accommodated. In this case the gears, with 9 tpi selected on the gearbox, give a lead of 0.885 inch per revolution (**photo 12**). The gear cutter can be driven in a milling spindle mounted on the swivelling vertical slide that is set to the correct helix angle – making sure that an intermediate pulley system reduces the speed from the motor to an appropriate speed for the cutter. In this configuration the lathe spindle is rotated by turning the handwheel on the leadscrew (**photo 13**). The long T-slotted cross slide, standard on the Super 7, has plenty of room for fastening both the vertical slide and the pillar for holding the milling spindle drive. Normally my rear toolpost lives on the end of the cross slide.

What does the future hold? I'd like to make a beam engine but I will choose a model that has a flywheel that will fit in the gap. Similarly a hit and miss engine is on the cards and maybe a traction engine. If I want to build a locomotive then most designs up to 5 inch gauge can be built on a 3 ½ inch gap bed lathe. My overriding criterion is that I should be able to lift the resultant model so the Myford should be able to cope with anything I can. We seem to suit each other; I think the Myford Super 7 chose its owner rather well. ■

Eureka form reliever and gear cutters.

Cam drive gears.

Recently completed Wyvern gas engine.



Boring the Wyvern cylinder using a fixed steady and tool held in the Gibralter toolpost.

Helical gears driving the cam shaft on Wyvern gas engine.

Gearbox banjo set up to give a lead of 0.885 inches for cutting a helical gear.

Set up for milling a helical gear.

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6. Arrand, The Forge, Knossington, Leicestershire LE15 8LN. T. 01664 454566

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Jock Miller's shop-made vertical lathe.

A Vertical Lathe

Jock Miller in New Zealand describes an extraordinary self-built machine tool to find in a home workshop, with photos by Peter King.

Having visited many commercial workshops during a long career in mechanical engineering in NZ, UK, Japan and India, the idea of a small vertical lathe, sometimes described as a vertical borer, as an addition to my home workshop appealed (**photo 1**). A vertical lathe has usually a large faceplate rotating on a vertical axis, where work (usually of large diameter and short length) can be worked on by one or more cutting tools. Some machines are 40 feet diameter or greater. In these cases 'work setting is assisted by gravity'.

My workshop includes my late father's equipment and includes his L5 and M250 Harrison lathes and Pacera 2MT pillar drill as well as a number of machines he and I built or obtained over the years. My first machine tool was an 11th birthday present of a ¼ inch M.E. drill press all of 60 years ago, made by my father! Two machines that were critical for such a project as the vertical borer were a restored Henry Milnes two foot planer (circa 1920) and a Tom Senior Major milling machine. Let's start by looking at the specification for the machine:

Maximum work diameter: 24 inches
Table (face plate) diameter: 18 inches
Max work height: 14$^{5}/_{32}$ inches
Spindle bore: 3 inch diameter
Spindle speed –
variable (2 ranges): 7 to 260 rpm
Power feed – turning and facing (5 steps): 0.005 to .045 inch per rev
Horse Power (single phase) input: 1.5
Tooling – TIPCO M interchangeable (ex-Harrison lathes): 0.625 inch shank tools
Chucks: 10 inch 3 jaw Self Centering (TOS) recycled, now fitted with fine adjustment.
12 inch 4 jaw Independent (Chinese)
Boring Bar attachment – 4 MT boring bar holder on top-slide.

The design was facilitated by only one or two full scale rough layouts plus many 'back of envelope' sketches so no reproducible drawings could be made available – some metric, some imperial depending which side of the bed I got out of in the morning. I am indebted to some ideas in Joshua Rose's *Modern Machine Shop Practice*, of circa 1890, regarding details of the cross-slide / top-side saddle, especially regarding the power feed to the top-slide.

Construction

The machine was entirely constructed 'in house'. The structures are all weldments (150 square x 9mm RHS and smaller). As I have no access to stress relieving, care in weld assembly with ½ inch length of runs was used to minimise local heat build –up and distortion, i.e. weld appearance was secondary. Details followed accepted machine tool practice. Component assembly for the structure was by M12 H.T. caps-crews with machined surfaces at all joints (some cap-screws are inside the RHS components). The bed consists of twin 150mm square RHS bolted and welded together with the appropriate pads for the RHS side verticals, spindle assembly and spindle drive etc. All major

The lathe's large faceplate.

A chuck fitted to the backplate.

items can be up to 25 inches long as the Milnes planer is 'stretched to 25 inches'. The side verticals had 16 inch long twin pads for the cross rail/bridge or cross slide fixings. In using heavy RHS at least 9mm thick the maximum rigidity was achieved.

The cross-slide (bridge), see photo 1, is an S.G. iron casting, but stiffened on its back with an RHS. The top-slide is machined from a piece of scrap cast iron, while the saddle was formed from two slices of continuous cast round cast iron cut rectangular.

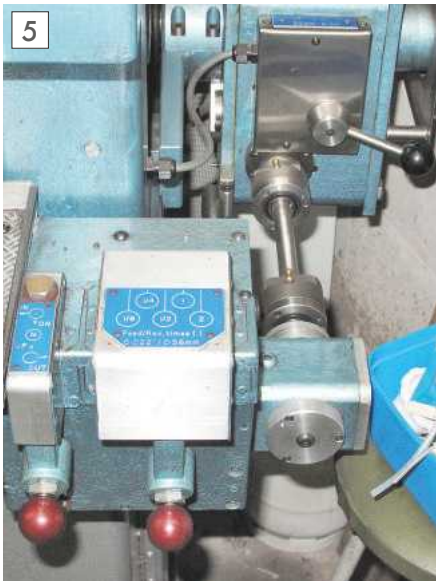
The headstock is a steel fabrication based on a piece of heavy walled tube large enough to contain the 100mm bore diameter pre-loaded taper roller bearings, and is bolted to the front of the bed. The spindle is a piece of 80mm I.D. heavy walled tube with a 25mm x 300mm dia. flange welded at one end. A lockable nut provides pre-loading of the bearings. The face-plate (table), **photo 2**, is machined from a slice of continuous cast iron 2 inches thick bolted to the spindle flange with 12 M10 socket head bolts and has 12 radial T-slots. The chuck is shown in **photo 3**.

The final drive is an ex-Bedford J4 small truck crown wheel and pinion of 5:33 ratio. This was almost new, donated by a friend who converted the truck to a camper van and changed the differential ratio. The gear surfaces were unmarked. The crown wheel is bolted to the underside of the table and the pinion shaft with taper roller bearings are in an oil bath housing fixed to the top of the bed.

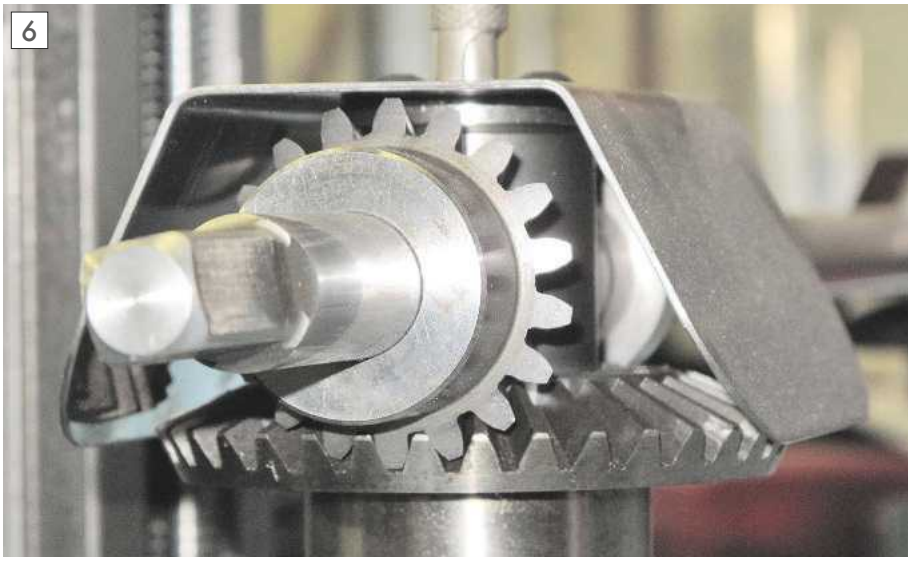
The power transmission consists of a 230v three phase 1.5 HP 6 pole ASEA TEFC motor, 'pig-a-back' on a purpose made 2-speed fabricated gearbox (**photo 4**) with constant mesh gears selected by 2 pairs of dog clutches with a hand lever. Ratios are 1:1 and 1:5, the input shaft of the oil bath gearbox is driven by a 2:1 reduction triplex set of M section V-belts. The drive from the gearbox output to the pinion shaft is via a shaft fitted with gear type couplings at each end where the gears have proprietary crowned teeth to enable any slight miss-alignment to be accommodated.

A worm and worm-wheel is fitted inside the output side of the main gearbox and this provides shaft rotation for the power feeds. By means of several pairs of right angle grease lubricated bevel gears (**photo 5**), feed power is provided to the RHS end of the cross-rail (bridge). Five stages of feed selection and reverse are provided by a written-off feed gearbox (**photo 6**) from a badly damaged new Chinese centre lathe, donated by the lathe merchant. Available feeds are 0.005 to 0.045 inch per revolution, reversible. This gearbox was inverted, cut down in length and arranged for oil bath lubrication. A spring loaded adjustable slipping clutch is fitted. Several shafts are ⅜ inch hexagon (**photo 7**) like the feed-shaft on the 'Harrison' M250. The

The motor sits above the gearbox.



The power feed gearbox.



Bevel gears in the feed gearbox.

cross-rail feed arrangement has a selector gear lever for turning or facing to either rotate the cross-slide feed screw or turn two more sets of bevel gears on the centre line of the top-slide bevel pivot for top-slide movement.

A matched pair of screws on either side of the machine, with bevel gears and a cross-shaft, allow the cross-rail to be adjusted up or down by hand crank after twelve M10 clamp bolts have been released (**photo 8**). A substantial fabricated base supports the machine with adjustable feet, storage lockers and the electric control containment and supports the swarf trays and table guards.

Early on in the design, the selection of a variable speed inverter drive simplified speed change. The inverter selected is of NZ manufacture (**photo 9**) and is set for 25 to 150Hz, a 0 – 10v output feeds a digital voltmeter to indicate RPM. Internal circuitry records time spent at an output less than 50 Hz, acting as a thermal overload indicator to assist in protecting the motor from overheating at low speeds. Kelvin Lewis, a fellow model engineer and electrical engineer sorted the electrics. A 0 to 10 ampere compressed scale meter has been installed in the incoming 230v supply (visible in photo 1) and this aids maximum metal removal without overloading. Two sets of push buttons have been provided – trip/reset, stop/start, inch and a toggle switch for reverse. All electric wiring has been concealed within the RHS members and where possible, power electrics have been segregated from control electrics to minimise R.F. effects.

The use of a Newall D.R.O. (**photo 10**) with the Microsyn 6mm diameter spars has enabled a neat installation and makes redundant the graduated feed screw dials and of course easy metric/imperial conversion.

The machine construction over a seven year period gave a lot of pleasure and plenty of challenges in both design and execution, especially to machine components within and outside the normal capacity of the machine tools available. One example was machining the feet of the two side frames on the 'Tom Senior' mill. Other challenges included:

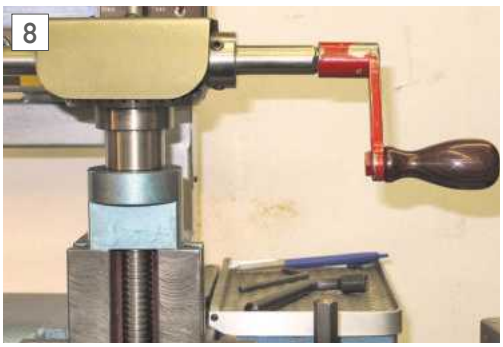
- Line boring the headstock fabrication to get 0.001/0.002 inch interference for the taper bearings outer races on the 'Tom Senior' mill.
- Machining the face plate blank in the gap of the L5 Harrison with only 1/16 inch clearance to the lead-screw.
- Screw-cutting the four square thread feed-screws (limited diameter to length).

Because of the weight of some components a system of Henderson door tracks was fitted to the workshop ceiling to enable transfer with a small chain block between bench/drill press/L5 Harrison lathe/Tom Senior Mill/planer etc. All fortunately without mishap, squashed fingers or the like.

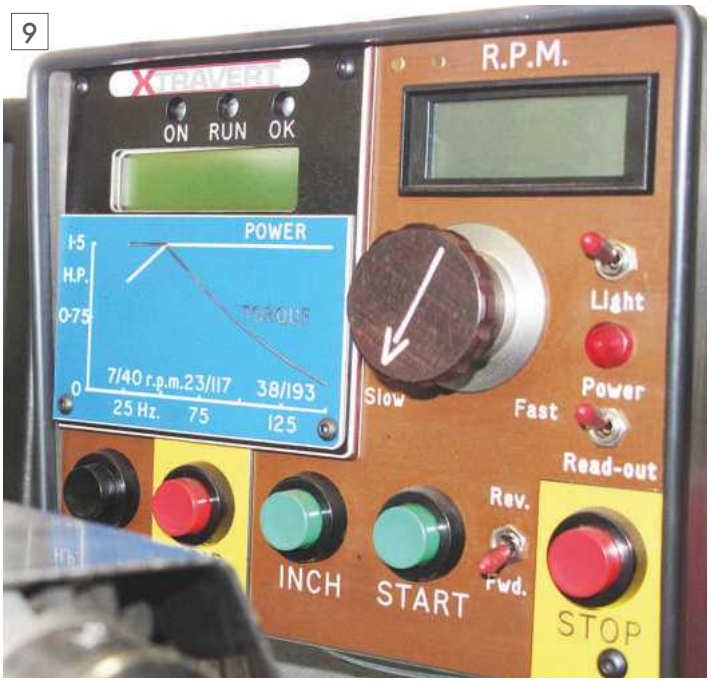
Jobs to date

Three noteworthy jobs done on the machine include a 7¼ inch gauge:
Berkshire 2-8-4 boiler smoke-box: A fellow model engineer is building this

A hexagon drive shaft.



The cross-rail adjustment crank.



The control panel.

Another view of the lathe showing the digital readout.

locomotive, the large boiler for which is a piece of 12 inch I.D. certified steam-pipe. The smoke box is to be 12 inch O.D. and manufactured by slitting and squashing a piece of the boiler barrel material, and welding. The length was 14 inches and when the cross-slide was raised there was only 5/32 inch clearance! With two lots of M12 tapped equispaced holes near each end and three tooling blocks 1inch square with holes and jack screws to suit the face plate T-slots machining commenced. Three passes to get circular O.D. from each end and with ends squared and one end recessed for smoke box door – job completed. This would not be an easy job in a conventional lathe.

Crane wire rope pulleys: A good friend, a civil engineer (he is a technical civil engineering contractor) is currently building a 'tilt slab' house with precast concrete wall/floor/ceiling panels, some of which are in excess of 10 tons. On site he has an old but good condition RB30 tracked crane with a lattice jib and 4 fall wires to the pulley hook lift block. To assist the delicate placing of these panels on the job a slower 6 fall wire system was preferred. The side panels for the new pulley block ex 1½ inch MSP were bored 65mm diameter for a new axle and six off 15 inch diameter cast steel wire pulleys required ⅜ inch removed from the central boss on each side – plus a light cut through the bronze bush bore to clean up for the 65mm diameter axle (originally 2½ inch).

7¼ inch gauge loco wheels: A possible future project is a 7¼ inch gauge locomotive *Lion*. Some years ago a set of wheel patterns were brought to NZ and aluminium patterns were cast from these. I was able to get a set cast from these in SG iron and I decided at this stage to proof machine and ended up completing them.

The machine construction over a seven year period gave a lot of pleasure and plenty of challenges in both design and execution, especially to machine components within and outside the normal capacity of the machine tools available.

Conclusion

The biggest advantage over a conventional centre lathe versus a vertical lathe is that set up is greatly facilitated. The job stays put till bolted down or clamped with no packers or bolts dropped into the swarf tray. Concentration is required if using the machine after working a standard centre lathe as the turning and facing motions are interchanged. When the ex-editor of *MEW* David Fenner was in NZ and visited some years ago, he suggested this epistle, so I trust readers will find it interesting and informative and perhaps be inspired to design and build their own machine. ■

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Heat Treating
O1 & W1 Tool Steels

Richard Rex has discovered that understanding the science behind steel leads to better results in the workshop.

Until a year or so ago all I knew about hardening carbon steels was summed up in the one-liner: 'Heat to cherry-red, then quench in water'. You then tempered the piece – reduced its brittleness – by heating it to a lower temperature and re-quenching. I learned that as a blacksmith's assistant (more accurately, gofer), and have applied it ever since making scrapers, chisels and – now and again – milling cutters such as D-bits and counterbores from O1 and W1 tool steels. Now and again says it all: I didn't make them regularly enough to be troubled by quality control. Some cutters would last forever, others died in a minute or two, oh well. That's how it stood until a couple of recent failures prompted a closer look. This article is the result.
It focuses on the O1 and W1 alloys because they are inexpensive, easily machinable in the model shop, and available overnight in a huge range of flat and round sections (especially O1).

Steel: what is it, exactly?

The spectrum of model shop machinists goes from the data-driven engineer who does the thing for a living, to those who wonder what on earth you're talking about, as in: 'steel is steel, what's your problem?' Most of us tend toward the engineering end because the projects we do often call for more than vague ideas.

The short answer to the question is: steel is an alloy containing 95% or more of iron (Fe); its other key ingredient is carbon (C), which can range from trace amounts to a little over 2% (higher amounts of carbon, 2% to more than 4%, are found in cast iron). One example from literally hundreds of alloys is 'mild steel' 1018, a steel you'll find in practically every shop; its carbon content is 0.18%, which tells you why it was designated 1018 (this numbering convention applies only to plain carbon steels). Some sources refer to 1018 as a 'low-carbon' alloy; others tell you that the low carbon range stops at 0.15%. Hardenable 'high-carbon' alloys such as W1 and O1 have a carbon content of about 1%. Other performance enhancing elements added to steel include manganese (**Mn**), silicon (**Si**), chromium (**Cr**), vanadium (**V**), Molybdenum (**Mo**), tungsten (**W**), cobalt (**Co**) and nickel (**Ni**). Phosphorus (**P**) and Sulfur (**S**) are almost always present as impurities. Amounts are always given as percentages by weight.

Readers outside North America may be confused by the O1 and W1 classification. As will be explained later in the article, 'W' indicates water hardening steel, like silver-steel, whilst 'O' indicates oil hardening and is the equivalent of gauge plate.

If you need further reading on steel – or any other topic – be on the lookout for misinformation, even from web sources that seem reliable. Some of the bad stuff out there is viral; if it's copied often enough in different places it achieves the status of fact. When fact-checking it was a good day when I found two sources that agreed.

Steel: a very brief history

Needless to say, the main motivation to find stronger, harder materials was weaponry. With a bigger, better sword you could force your neighbour to part with something he didn't want to. If you had a bronze sword and all he had was a club, no contest. But if he too had a bronze sword, what then? The answer to that, and countless other applications we take for granted, was iron. Iron and its close relative steel were indeed the 'great enablers'.

Iron has been around for thousands of years, judging by artefacts found in the Middle East, but any iron object from before (say) 2,000 BC would have been made from meteoritic iron – a very rare source that would make your iron dagger more valuable than its weight in gold. After that date iron was everywhere, not from meteorites but extracted from iron ores – plain old rocks – a truly pivotal discovery. From that point onward it was just a matter of time. By 500 BC, when the Roman conquests got underway, iron had completely replaced bronze as the dominant metal for armour, weapons and other tools.

Iron making from ores, a process called smelting, was a hit or miss process in those days, and it remained so for a very long time. For one thing, even with a bellows forcing air through burning charcoal and a pile of crushed ore it's very hard to get to the 2800˚F (1540˚C) melting point of iron; the best you could do might be 'bright yellow', about 2200˚F. There was no way then of achieving a homogeneous mixture from which you could separate the impurities; what you got instead was 'bloom', an accumulated mass at the bottom of the furnace containing, surprisingly, a good amount of pure iron aside from a lot of ash and who knows what. The bloom would then be refined by a repeated process of re-heating and anvil pounding until the product was recognizably 'wrought iron' of the shape and hardness you had in mind – a sword, perhaps. But what was in it? How much carbon? Who knew? This was a time of mystique, secret ritual, prayers to the gods. Quantification just wasn't possible: charcoal in the furnace might add carbon, but pounding would deplete it. Master blacksmiths got it right, but only some of the time.

Meanwhile, the Chinese and Indians had figured out centuries before how to melt iron, and were casting all kinds of products as a matter of routine. Unimpressed by this, or maybe unaware of it, the Europeans pressed on with their smelting, doing no iron casting until – by definition – they discovered how to get to the melting temperature. Whatever the reason for this technology advance in the late Middle Ages – iron cannonballs perhaps – various forms of iron became increasingly common from that time on. How to control its behaviour was still a mystery, though; it was not until the 1700's that it became clear that carbon content determines hardenability, and another 100 years went by before 'good' steel was produced on an industrial scale in the Bessemer converter. The idea of this was not to infuse carbon into the iron, but instead to burn it off by

›

Steel Micrographs

Steel under the microscope

To the unaided eye one sample of steel in the shop looks very much like another, giving few clues as to how it will behave; but with a microscope and a polished, acid-etched sample of the steel you can explore the steel's granularity – its microstructure – and thus predict some of its mechanical properties. Etching is the key factor: it creates a visible map of the grain boundaries by eroding pearlite, ferrite and cementite at different rates.

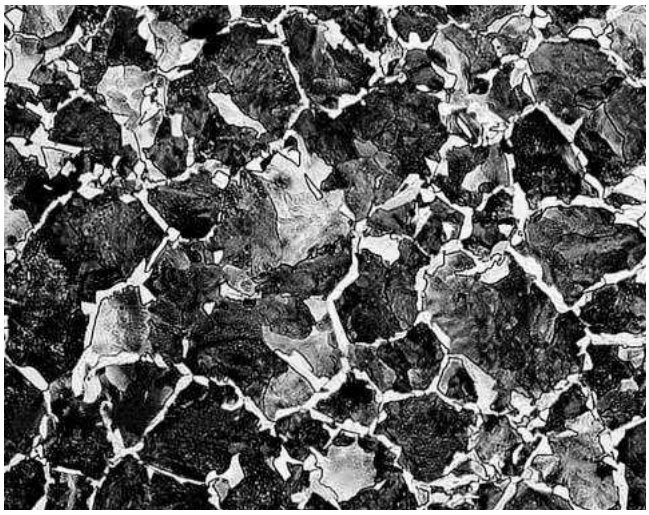
Micrograph 1 shows ferrite grains, light grey, outline the darker pearlite regions formed by cooling from austenite grains.

Looking at **micrograph 2**, we see ferrite/pearlite banding of the microstructure which occurs when cold or hot-rolled 'wrought steel' cools from the high temperature austenite region. In 1018 there is less carbon content than in 1060, so ferrite grains dominate (light grey).

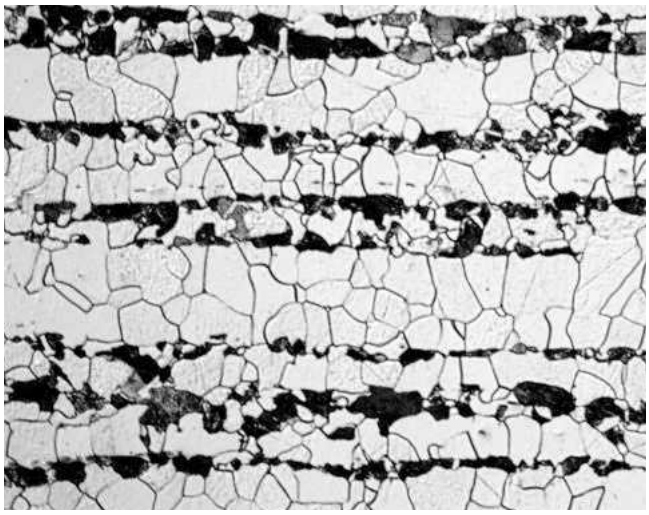
Quenching alters the picture

Quenching in oil or water – near-instantaneous cooling – causes dramatic changes in the higher carbon steels. These changes are highly visible with an optical microscope, even more so with an SEM (scanning electron microscope), (**micrograph 3**). In the quenching process pearlite begins to form on the previously austenite boundaries, followed by the formation of hard martensite (light grey), which stops the growth of pearlite.

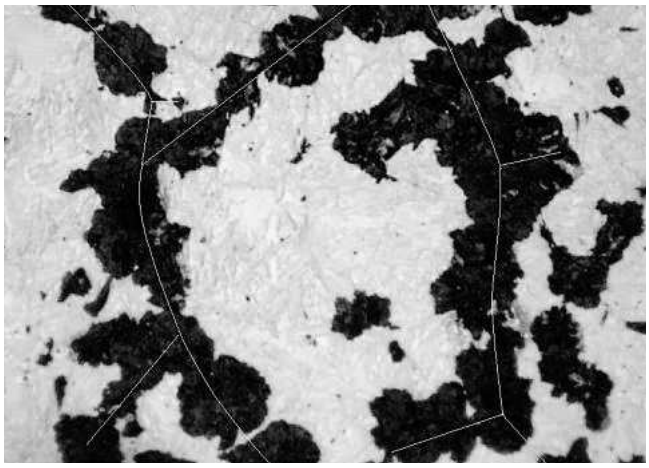
An optical microscope is limited to about 1,500x, but an SEM goes much further. **Micrograph 4** is an enlargement of a tiny portion of pearlite in the previous micrograph. This is 'fine pearlite', the result of rapid cooling, showing a ferrite/cementite plate spacing of about 50 nanometers.



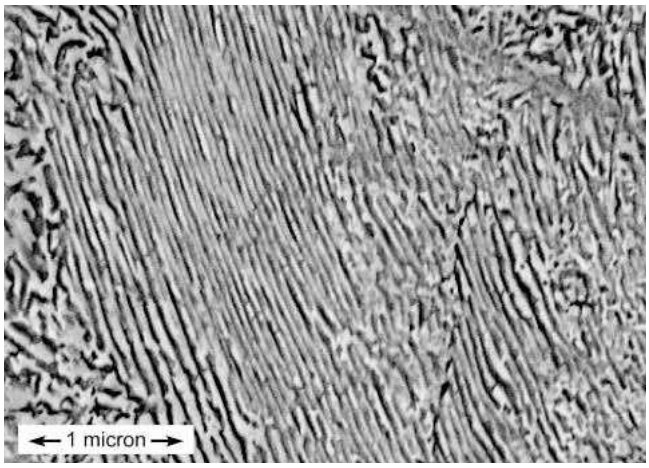
Micrograph 1: *Slow-cooled 1060 (450x).*



Micrograph 2: *Slow-cooled 1018 (240x).*



Micrograph 3: *Quenched 1095 tool steel (600x).*



Micrograph 4: *Close-up of pearlite (21,000x).*

Micrographs reproduced from Steel Metallurgy for the Non-Metallurgist, John Verhoeven, by permission of the author..

blowing air from below through molten 'pig iron', the highly variable product of smelting. By monitoring the colour of the furnace flame you knew how much carbon remained in the melt, and so could cut off the air supply at exactly the right point. And that is still the basic process used in steel production today. So much for the history of steel, millennia of development in a couple of paragraphs.

Back to the what's in it question

Closer to the home shop is the chemistry of steel, an understanding of why it behaves the way it does.

First, we need to think of steel as a ***solution***. What? Yes, solid states can be solutions, too. In the molten state, steel is a solution of carbon in iron, and it remains a solution – though with a different molecular structure – when the metal cools. Another word we need to re-define is **phase**, which usually suggests something to do with time. Not for us: 'phase' in steel chemistry means a specific state defined by its temperature and composition, which can be one of several crystalline structures ranging from pure iron to iron carbide, and everything in between. These states can be graphed in an **Fe-C phase diagram**, with temperature as the Y axis and carbon percentage the X.

A homely phase diagram

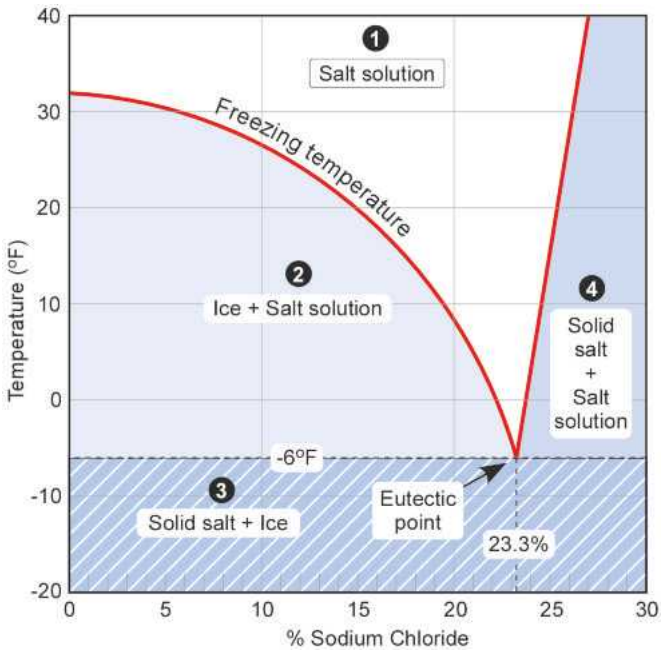
To make sense of the Fe-C phase diagram, imagine a solution of table salt in water. As we add salt, we lower the freezing temperature (**fig. 1**). But only so far: there is a specific concentration beyond which the addition of salt sharply raises the freezing temperature. This is the 'knee' on the graph, the so-called ***eutectic point***. There is a similar knee in the Fe-C phase diagram, too; it has nothing to do with freezing, but the underlying ideas are the same (but beware, in the context of steel chemistry this is the eutectoid point; there is also a ***eutectic*** point – but that occurs at white heat, with high carbon, so we won't talk about it here).

Getting back to iron ...

Unlike ice and salt, the building blocks of which are molecules (units of two or more atoms), **pure iron** is nothing but atoms. These are organized together to form randomly sized individual regions called **grains** (a.k.a. crystals), measuring on average about 25 µm (25 millionths of a meter) or 0.001 inch. (Using a high power optical microscope, say 100X, you can actually see the granular structure on the surface of a polished, etched sliver of iron.) Within the grains the atoms organize themselves in specific ways depending on temperature. First we have the 9-atom Body Centered Cubic structure, BCC, the only possible arrangement of pure iron atoms at low temperatures (**fig. 2**). This is called ferrite, or alpha iron, α.

If pure iron is heated to 1674˚F (912˚C), bright cherry red going to orange, the structure magically changes from 9 atoms to 14. It has become Face Centered Cubic, FCC, and is known as **austenite**, or gamma iron, γ (**fig. 3**). Don't look for beta iron, β, there's no such thing (actually there is another Greek phase, delta iron, which exists only at temperatures above 2540˚F

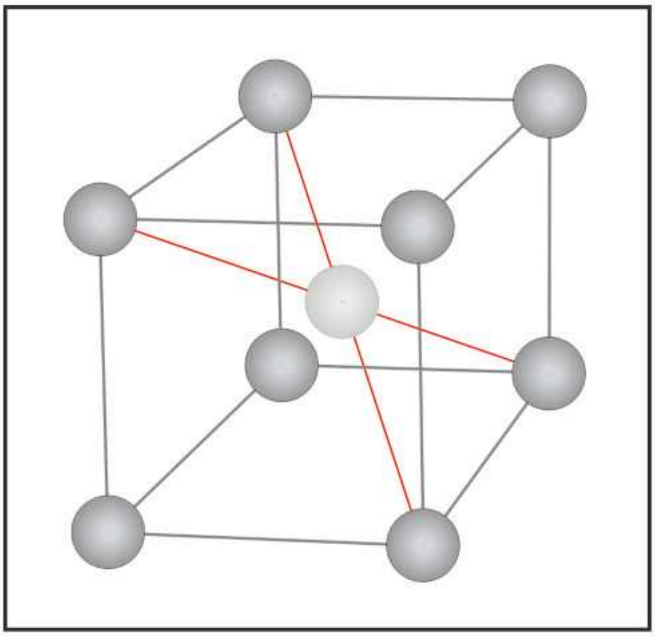
Fig. 1



Salt water phase diagram

*This is a map showing how composition of salt water varies with temperature and salt concentration. Region (1) is nothing more complicated than fully dissolved table salt in water. The freezing temperature is the temperature at which crystals begin to appear as the mixture is cooled. As more salt is added the freezing temperature goes down steadily [Region (2), ice + salt solution] until, at and below the eutectic point, the mixture is frozen solid [Region (3), solid salt + ice]. From that point, surprisingly, the addition of more salt apparently causes a sudden increase in the freezing temperature. What happens in Region (4) might seem less miraculous if instead you think of the sharply rising line as a measure of **solubility** – the temperature at which crystals of salt will appear when you cool a highly concentrated mixture (hot water can dissolve a lot more salt). Temperature-driven transitions from one phase to another, in this case and also in steel, are all to do with changes in solubility.*

Fig. 2



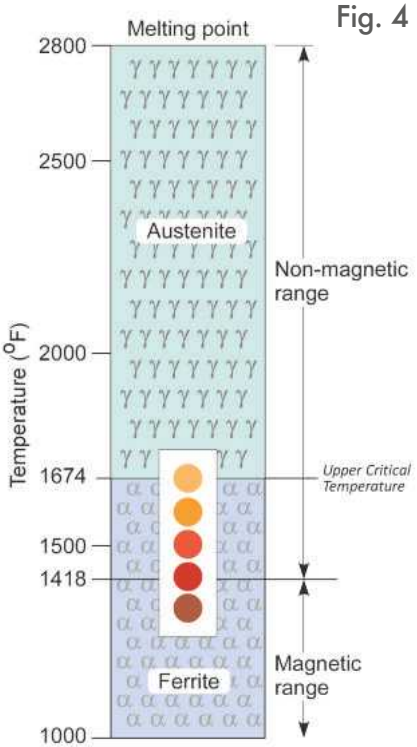
This is the BCC structure. At temperatures up to 1674˚F (912˚C), the atoms are arranged in tiny 9-atom cubes, one atom at each corner, one in the center – hence the designation 'Body Centered'. A single crystal of iron contains thousands of these cubic structures. For the size of an atom think in terms of one tenth of a nanometer (a billionth of a meter).

Iron atoms (Ferrite) at low temperatures

(1343˚C) – so that's the last you will hear of it here). One interesting thing about austenite is that it occupies a smaller volume; in other words – counter-intuitively – iron shrinks a little as it passes the 1674˚F **Upper Critical Temperature** (UCT). How can that be? Economy of atoms is the answer: two 9-atom BCCs placed side by side convert to a single FCC structure by sharing the 4 atoms at the interface, so we go from 18 to 14.

We've seen one magical change due to rising temperature – BCC to FCC. Here's another one, even more interesting to us in the shop because we can easily tell when it occurs. At 1418˚F (770˚C) steel ceases to be magnetic. This is known as the **Curie temperature**, a useful point of reference when hardening basic tool steels like O1 and W1. **Figure 4** and **table 1** may be useful for visualising these changes. This is the ages-old way of estimating the temperature of iron and steel. It is subjective, to say the least (color blindness can be a factor). Viewing conditions are also important, especially for the lower, near-black temperatures. Use shadow, or low-light when possible. Roughly speaking, the 'visible heat' range is 1000˚F (500˚C) and above.

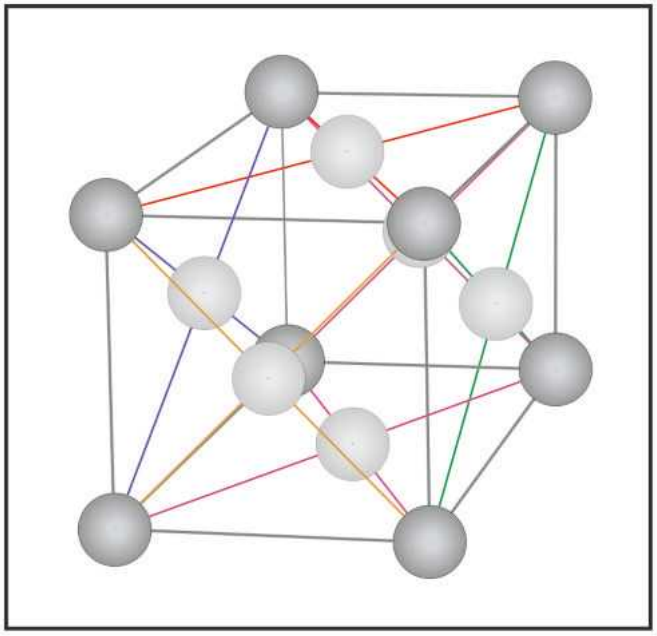
Fig. 4



Two important temperatures

The color dots give a rough visual idea of temperature. As pure iron is heated the ferrite (a) structure changes to austenite (γ) at the Upper Critical Temperature 1674˚F (912˚C - 'near-orange heat'). Along the way, at 1418˚F (770˚C - 'dark red heat'), it becomes non-magnetic (amazing!). This applies to steel as well as iron. When heat treating steel use a scrap magnet to detect the non-magnetic transition. A few degrees above that is the right temperature for quenching.

Fig. 4



When pure iron is heated to 1674˚F (912˚C), the cubic structure switches from BCC to FCC, in which the central atom goes away and is replaced by 6 atoms, one in each face of the cube – hence 'Face Centered'. Austenite is about 2% more dense than ferrite, so a given weight of iron occupies a smaller volume than it did as ferrite.

Iron atoms (Austenite) at high temperatures

Carbon enters the picture

Depending on what you want your ferrous metal to do, carbon is either a troublesome impurity, or a vital constituent – a hardening agent. It can be added to iron in several ways, the first being the most obvious: melt it. In its **molten** state iron dissolves a significant amount of carbon. It can also be **diffused** into solid iron by coating the metal with a source of carbon (graphite, say), then cooking it for a few hours at over 1800˚F (980˚C - 'orange heat'). This causes the carbon to disappear from the surface, becoming instead a **solid solution** in the iron – in other words, steel. Carbon atoms, which are much smaller than iron atoms, have in fact migrated into the austenite, squeezing themselves into the wide-open spaces of the FCC structure (just as they do when you case-harden by heating the metal to red with a molten, carbon-rich coating). Carbon can also migrate into the ferrite BCC structure, but only to a very small degree – only 0.02% carbon by weight, and that only at fairly high temperatures. Why? Simply because there is less space between iron atoms in BCC compared with FCC austenite, which can dissolve more than 2% carbon at temperatures above 2000˚F (1090˚C - 'yellow heat'). BCC ferrite is 99.98% pure with respect to carbon; in other words, it's practically pure iron. This accounts for the skinny region at left of the Fe-C phase diagram. In discussions to do with steel there are differences of opinion depending on the source. One minor example: some say that α ferrite is a solid solution of carbon in BCC iron; others regard it as pure iron. For practical purposes this doesn't matter.

The Fe-C phase diagram (**fig. 5**) tells us where the austenite and ferrite phases will occur, and also where we can expect to find mixtures of the two, along with other phases we've yet to meet. Pure iron transforms itself from ferrite to austenite as it is heated past its **Upper Critical Temperature**, UCT, which is 1674˚F (912˚C) at the zero-carbon point (the UCT is also referred to as the 'austenizing temperature'). The inverse transition applies as the metal cools, provided you don't rush it. This applies to everything in the Fe-C phase diagram, which depicts

Table 1: Using colour to gauge temperature

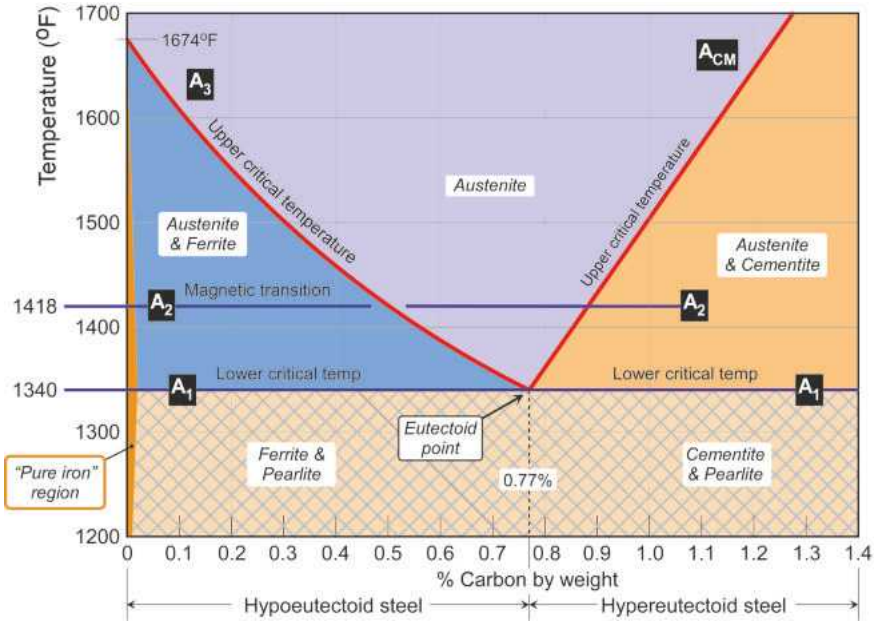
Colour	Temperature [˚F]	Temperature [˚C]
Black, hint of red	800 to 1100	425 to 600
Very dark red	1100 to 1300	600 to 700
Dark red	1300 to 1500	700 to 820
Cherry red	1500 to 1600	820 to 870
Bright cherry red	1600 to 1800	870 to 980
Orange	1800 to 2000	980 to 1090
Yellow	2000 to 2300	1090 to 1260
Yellow white	2300 to 2400	2400 to 1320
White	2400 +	1320 +

equilibrium, or steady state conditions – a point worth remembering, because hardening tool steels is a violent transformation, the very opposite of a leisurely steady state.

Simplifying the picture a little, you can say that at any location above the UCT you will find nothing but austenite, increasing in carbon content from left to right. With increasing carbon in the 'solid solution steel' the UCT decreases until – just like salt in water – more carbon increases the UCT sharply. This occurs at the eutectoid point, 0.77% carbon content (note the 'oid'). This is a big deal in metallurgy. Steels to the left and right of the eutectoid point behave quite differently.

The 'hypo' region left of the eutectoid point is not of much practical interest in tool making, but it does make the general point that two separate phases such as austenite and ferrite (between the LCT and UCT) can co-exist yet appear like a single phase. The same applies to the two-component region below the LCT, ferrite and **pearlite**. It also applies to the mixed region on the 'hyper' side, austenite and **cementite**. These two new 'ites' are discussed later. The 'A' references for temperature are included for completeness: they specify the temperature of phase changes at equilibrium (leisurely heating and cooling).

Fig. 5



The Fe-C phase diagram

*This is the low-to-medium-carbon end of the phase diagram, the complete version of which has a much wider range of carbon content. Bear in mind that at the temperatures diagrammed here everything is **SOLID** steel. Aside from the two new 'ites', cementite and pearlite, note that the upper critical temperature (UCT) changes dramatically with temperature. By contrast, the lower critical temperature (LCT), 1340°F (726°C), varies hardly at all. The knee on the UCT curve is at a specific carbon content (0.77%), which defines the break point between the two classes of steel, hypo- and hyper-eutectoid (think hypoxia = too little oxygen; hyperactive = over-active).*

Hypereutectoid steels

This is the 'tool steel' region, meaning any steel containing more than 0.77% of carbon (typically, but not exclusively – there are tool steels with less carbon). In this class, among dozens of others, you'll find O1 and W1. Both come in somewhat different formulations; W1 is said to be available in 4 grades from 0.8% to 1.2% carbon, which suggests a wide range of austenizing temperature, or UCT. (My ancient 23rd edition Machinery's Handbook gives an even wider range of carbon, from 0.6% to 1.4%.) How do you know one W1 from another? You don't, unless your supplier can tell you. For our purposes this isn't a real problem because most off-the-shelf W1 is 1% carbon, or close enough to it.

Cementite (= iron carbide)

6.7% carbon. Metallurgists call this ***cementite***, which co-exists with austenite below the UCT (why we need another name for iron carbide is a good question). As you might expect of a carbide, cementite is very hard and brittle. You might also expect cementite, with its very high carbon content, to play a major role in the hardening of tool steels. It does, but not directly; cementite develops mostly when 'quench-cooled' steel is tempered (stress relieved). Note that the UCT curve is labelled differently in the two regions – for hypo-eutectoid steel it's A_3 (the austenite-ferrite transformation line); A_{CM} (the austenite-cementite transformation line) for higher carbon, hyper-eutectoid steel.

Actually, cementite is present in all annealed, slow cooled steels at room temperature no matter what their carbon content (see 'Pearlite' below). From shop experience we all know there must be something in off-the-rack carbon steel that uses up hacksaw blades faster than 1018.

Depending on what you want your ferrous metal to do, carbon is either a troublesome impurity, or a vital constituent – a hardening agent. It can be added to iron in several ways, the first being the most obvious: melt it.

Think of the UCT as a plot of carbon solubility: as the metal cools, the UCT is the point at which the austenite can't hold all the carbon. So, almost by definition, a non-austenitic structure must be formed. In low carbon steels we get a mix of austenite and ferrite below the UCT. For steels to the right of the eutectoid point, what's ejected from the austenite is ***iron carbide***, Fe_3C, which has a fixed composition (unlike austenite) of

Pearlite (= ferrite + cementite)

Any steel cooled slowly below the LCT of 1340°F, (726°C - 'dark red') turns into a mixture of the two phases cementite, and ferrite, nearly pure α iron containing less than 0.02% carbon. More specifically, at the eutectoid composition of 0.77%C, only, that mixture is 100% **pearlite**, so called because at an electron microscope magnification of 10,000 or so it appears as alternate stripes of ferrite and cementite resembling the inner surface of a pearl shell (but note that this effect is also seen in fast-cooled, quenched steel, but the 'striping' is much finer). **All** basic carbon steels below the LCT down to room temperatures are some variant of this pearlite-type mixture, containing microstructures of varying proportions of the two phases. By heat treatment at the mill it is possible to **spheroidize** the steel so that the cementite (carbide) is formed in isolated grains as opposed to the mixture of thin cementite plates and ferrite plates present in a 'stronger' pearlite configuration. This makes for much easier machining. Most O1 and W1 steels available today are likely to have been spheroidized.

To be continued...

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TIP OF THE MONTH WINNER!

This month's winning tip from Matthew Shaw saves space and might help save you a strained back too! He wins £30 of Chester gift vouchers.

Space in most workshops is usually at a premium, so taking up a sizeable portion of your work bench with your surface plate isn't ideal. A good place to store it would be under the bench, however, with some plates weighing as much as a small child, it isn't an item you should be regularly lifting on and off the bench.

I have found a solution by putting my plate on drawer runners under the bench. This was achieved by fabricating a suitable drawer out of 1 inch timber with a ¾ ply top, then screwing the drawer runners into the side, as can be seen in the pictures, I then mounted them on suitable supports under the bench. An additional support leg was added to the front of the drawer which could be fabricated from many materials you have, but I used parts purchased from my local fishing tackle shop www.millingtonstackle.co.uk who have a good variety of adjustable legs and brackets which I found suitable.

If you do adapt this to your own workshop, please check the loading specifications of the runners you purchase to match the weight of your surface plate. Obviously this solution can be adapted to any other heavy items in your workshop.

I hope my fellow readers find this tip of use.

Dennis Kitson is our runner up this month, with a tip for making a pillar drill a little easier to use. Dennis can look forward to a Workshop Practice Series book to read in the New Year.

Sometimes when using the drilling machine it feels that a third hand is required. My answer was to use my foot. How? Well I installed a foot operated push on push off switch. In my 'it may come in handy box' I had such a switch rescued from a defunct vacuum cleaner. It not only gave me a 'third hand' it also gave me an emergency stop switch. I've used it now for many years and I would not be without it.

Workholding for CNC Users

John Pace offers some useful ideas aimed at making life easier for CNC machinists.

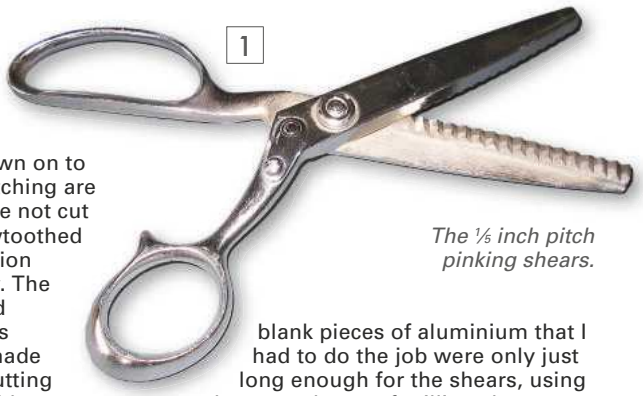
Sometimes when machining work holding can be a problem, whether machining manually or using cnc these little fixings could solve an otherwise difficult job.

It is a familiar tale when someone will say to you 'you have got some machinery', followed by 'is it possible to make?' On one such occasion a friend and fellow member of our model aero club, (Worthing and Littlehampton model radio control flying club) David Knott showed me some pinking shears owned by his wife. He builds and flies scale model aircraft to a very high standard and has represented this country flying in the GB team at the world championships.

He also competes every year at the nationals and has won 1st place in three consecutive years in the flying competition and 1st place in F4C main scale competition. In this level of competition the smallest detail can make the difference between winning or placing.

My friend's current project is a scale WW2 Hurricane, this is where the pinking shears come in. Fabric covered aircraft of this era have the covering material sewn on to the structure, covering the stitching are strips of material the edges are not cut straight but are cut with a sawtoothed edge. At this level of competition this kind of detail is necessary. The pinking shears that he showed me have a pitch of 5 serrations per inch (**photo 1**). They are made from stainless steel and the cutting edges are hardened and cut either cloth or paper to a clean serrated edge. At the scale of model he was building the serrations would need to be 20 per inch, I felt that this would be perhaps difficult to do but seemed a worthwhile challenge as he had also come around with a couple of boxes of ex-equipment stepper motors and other motors as a bribe I was prepared to give it a go.

1



The ⅛ inch pitch pinking shears.

First of all it was necessary to design the shears, this is not what this article is about but it illustrates the method of holding work, sometimes that is difficult to do. A pair of scissors is an everyday object and you would think that they would be easy to make. I used an old pair to get a feel of the job - separating the 2 halves makes it easier to visualise. I made the frames in aluminium and the cutting edges from gauge plate. I used CAD to draw them up and used this to produce a cutting file for the cnc mill.

Two aluminium blanks were made to the thickness required but holding them was a problem as they were about seven inches long and needed to be held clear of the table to allow the cutter to profile through the blank.

Using a vice to hold the material seemed a non-starter, as when the job is cut the grip of the vice is lost as the metal is cut through ending up with scrap. The blank pieces of aluminium that I had to do the job were only just long enough for the shears, using the normal type of milling clamps with step blocks would mean that the chuck would run very close when cutting. Using CNC does mean that you have to work out any job and exclude any problems before you start as you cannot stop and start to get around obstructions as you may be able to do when machining manually. After a little thought I came up with the fixtures in **photo 2**. These really proved to be a winner, being easy to make and the cost in time and material was little, **fig. 1** shows the fixtures.

2

The four support fixtures.

I have drawn these as the size I used but they can be made to any size within reason. Enough clearance must be allowed for where the job rests on the pillars and the top of the base parts to allow fitting of the bolts into the tee slots. The dowel is not fixed into the pillar but should fit without slop. You may thread inside the dowel M5 as this allows the dowel to be easily extracted when set up on a job. The best way to make them is to hold the base part in a vice and mill the bottom edge then drill the hole for the base of the pillar. It is almost guaranteed that the hole will be perpendicular to the table surface. It would also be an advantage to have the turned diameter at the base of the pillar machined at the same setting as the dowel hole so that the pillar dowel hole is also perpendicular. The dowels are made to the length required for the job in hand so that they are recessed below the surface so the clamping screws do their job. No great care need be exercised making the height of each fixture the same during assembly as when the Loctite has set they are all be clamped in a row on the mill and a cut taken across the tops to level them off. When setting out the positions of the fixtures this can be done at the same time as producing the CAD drawing and saving the hole positions as a separate file and using this to drill the hole positions first before the job is set up. Placing the fixtures to avoid the cutter

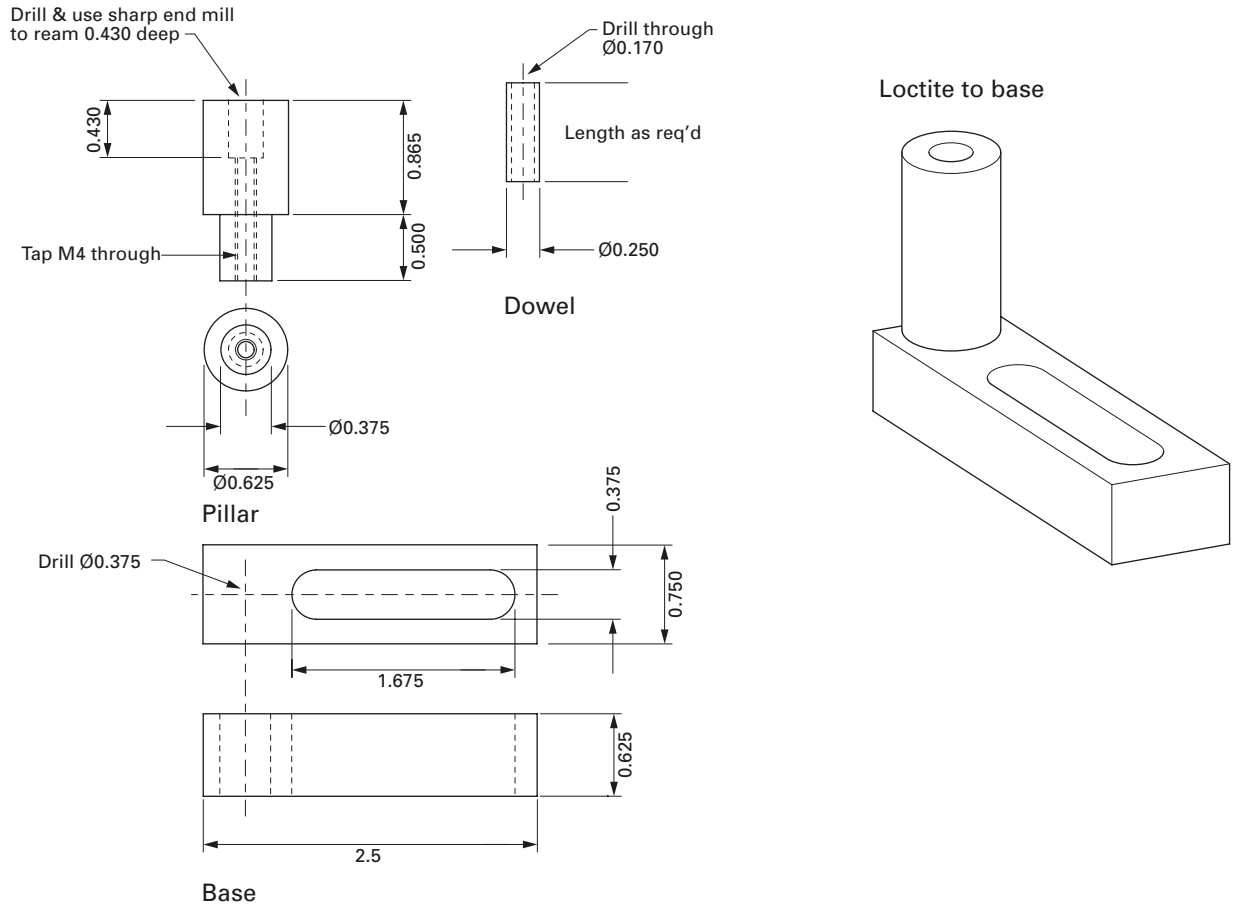


Fig. 1

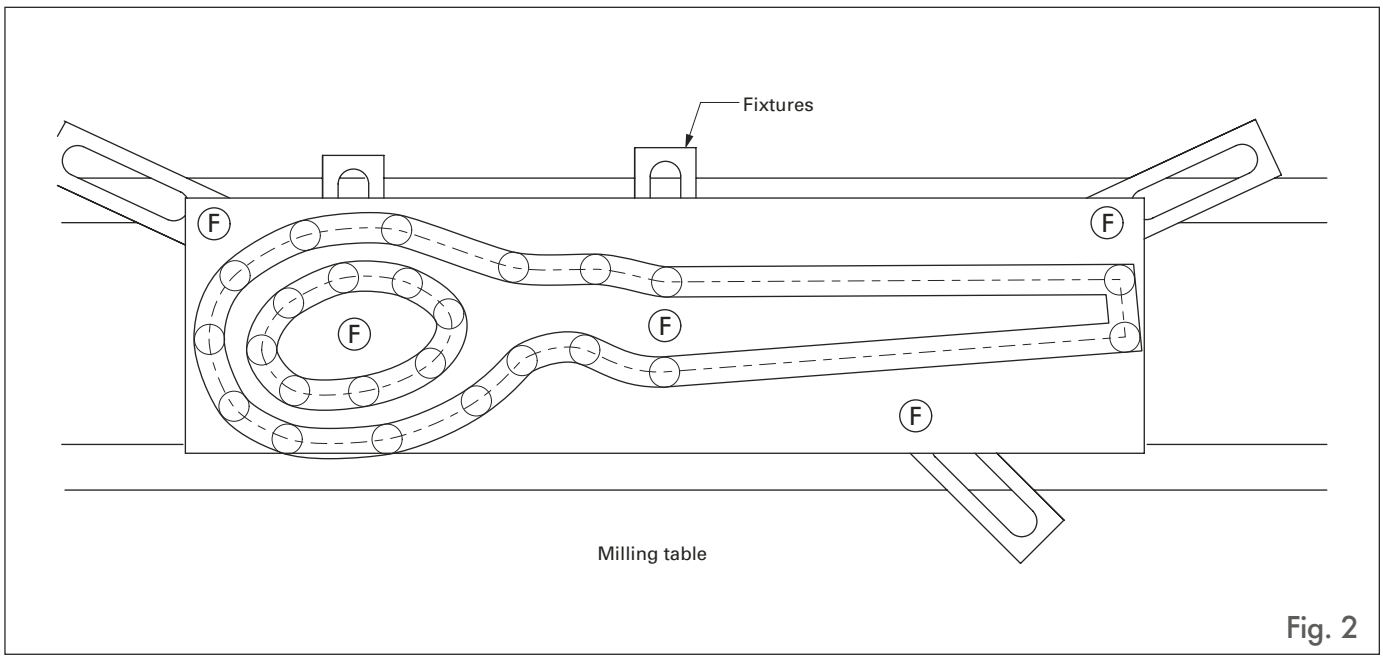


Fig. 2

paths. **Figure 2** shows a diagrammatic form of this, **photos 3** and **4** show the top and bottom halves of the shears, some of the original blank has been machined or has fallen away. The centre point of the job was the middle fixture where the pivot connection joins both halves together as can be seen the fixing bolt is lower down than the others. At the start of the job it was clamping the full thickness of the blank. A stop was made in the cutting file to remove this bolt and

Top half of shears.

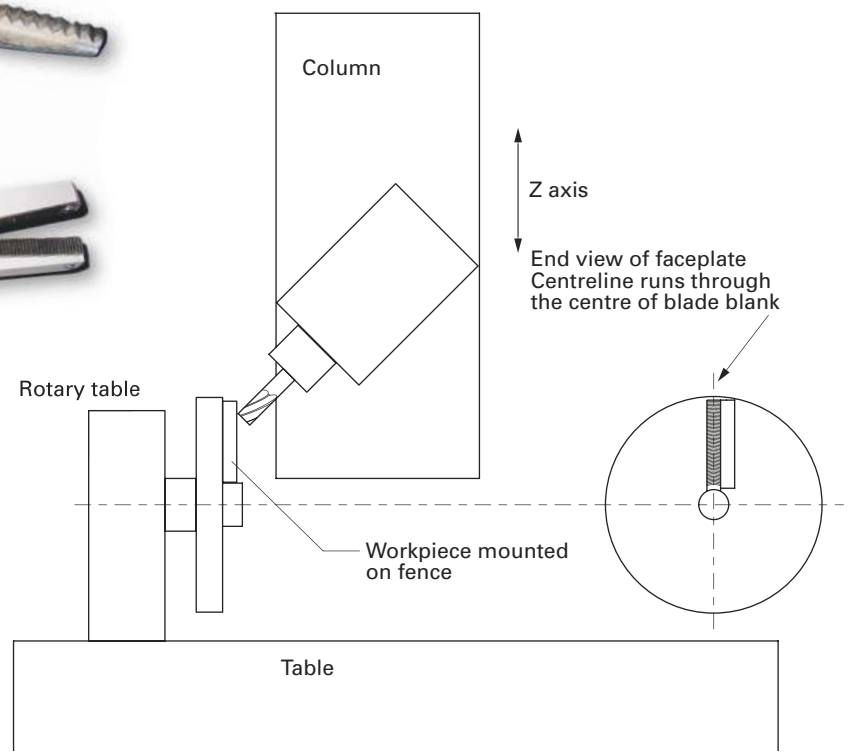
Lower half of shears.

5

The finished shears alongside originals for comparison.

started again to machine this feature. Then stopped again to replace the bolt and shorter dowel. I used the pivot point as my X & Y origin - 0, 0 point to set up and clock one edge parallel to the table. This ensures when setting up that the cutter path will miss the fixture and the object will fit within the available material. At various points around the profile the cutter is lifted to provide nibs keeping the halves attached to the blank until the machining is completed. The profile is finally removed just by sawing through when off the machine. Used like this the whole of the milling table becomes the fixture and the set up can be from the job. The pillars can be regarded as sacrificial, as can be seen top right in photo 2 the cutter has touched the edge of the pillar. This is of no consequence as they can all be levelled off again and reused and finally replaced by heating with a blowtorch to break the Loctite bond and renewed. **Photograph 5** shows the finished shears along with the original shears in photo1. For completeness I will explain how I made the cutting edges for the shears as this is an interesting machining operation. When I had made my conversion to CNC on my Dore Westbury mill I included as part of the project a rotary table. This can be used as a fourth axis for positioning or used as one of the three primary axes, It has a 90:1 ratio, 18000 steps per rev. **Figure 3** shows the general layout.

Fig. 3



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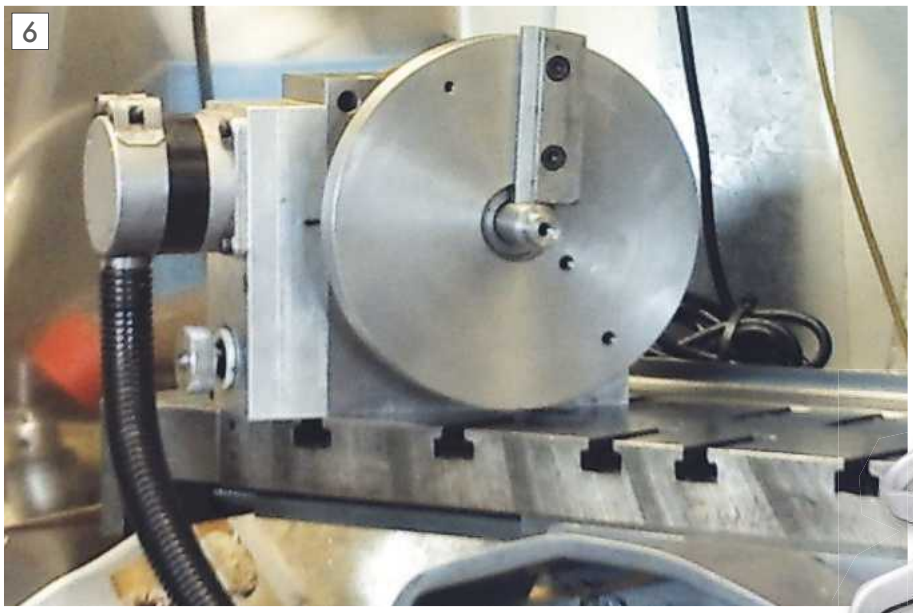
6



The cnc rotary table faceplate and fence to form the blades.

The head on my mill can rotate 90 degrees either way. The rotary table is mounted in vertical direction and is fitted with a purpose made faceplate on to its Myford nose. The plate has a split collar which locks the plate to the table and

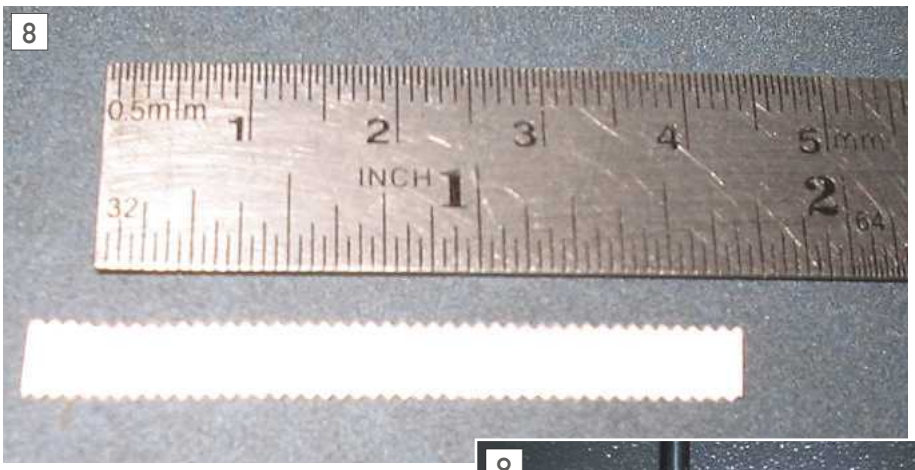
7

The finished shears showing the central location bush for the blades.

prevents it from becoming unscrewed, (**photo 6**). A fence is fixed to the table and the blank pieces of gauge plate can be fixed to produce a handed pair of cutting edges, the fixing holes are drilled into each of the blanks and are spaced at the same pitch. The hole positions are spotted through to the fence and drilled and tapped. The blank is fitted to the fence and the faceplate fitted to the lathe.

A location diameter is turned at the centre on both blanks. The faceplate is fitted to the rotary table, a Morse taper mandrel which has the same diameter as the location diameter previously turned is fitted to the table and the blank is fitted locating against this diameter. A small control file moves the table to and fro rotating the work past a sharp carbide milling cutter angled at 45 degrees to the work, moving down a pitch at every pass. The file stops at the completion of the first blank, to allow fitting the second and as part of the program moves the cutter down by half the pitch to do the second blank, the 2 blanks have to be made as pairs as the position may be lost if made as individual pieces. Therefore it is not important to have an accurate start point for the position of the milling head as the two blades only have to be correct relative to each other. After hardening the blades are fitted to the shears, in **photo 7** the centre pivot can be seen more clearly and as part of the assembly a bush has the same location diameter. The blades are fitted against this and holes are spotted through for fixing. The blades have a short section of concentric rings as their form this location diameter ensures that they are correctly located at the correct diameter and with respect to each other. **Photograph 8** shows a test strip cut by the shears, **photo 9** shows a fairly crisp cut at a higher magnification - the round object is the shank of a 1 mm drill. As for the new owner of these shears he was well pleased with them, the model is still being built, **photo 10** shows the assembled airframe with its builder. It is a truly magnificent piece of model building, many fine details are unable to be seen in these photos. **Photograph 11** shows the front view, a single cylinder 30 cc two stroke engine will power this ⅛ scale 96 inch model. ■

8



A cut strip showing the serrated edge.

9

The cut edge compared against the shank of a 1 mm drill.

10

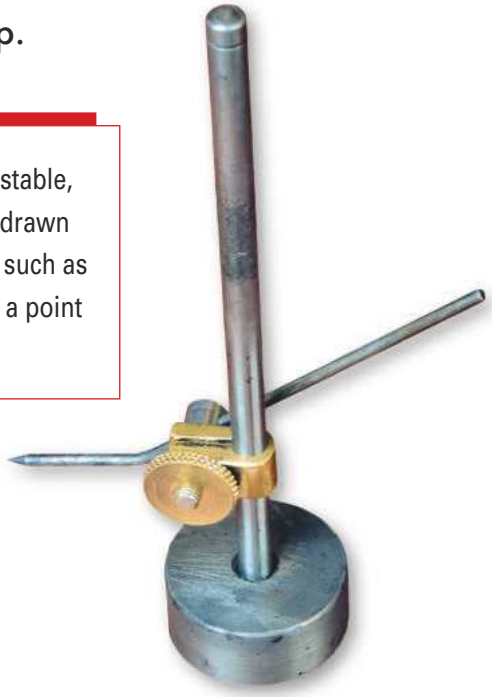
The WW2 scale Hurricane with builder David Knott .

11

Front view of Hurricane.

Stub Mandrel's Short End
A Simple Surface Gauge

Another 'made in a weekend' project from Stub's workshop.



A surface gauge is an essential aid to accurate marking out. What is needed is a stable, flat bottomed base with a pillar and clamp to hold a scriber, allowing lines to be drawn truly parallel with the top of a surface plate. Such a device has many other uses, such as helping set work in a four-jaw chuck or any other task where the ability to 'mark' a point in space with the end of a scriber is needed.

The best material for the base is steel or cast iron – it needs to be heavy for stability, and hard enough not to be easily damaged or worn. It does not need to be fully hardened – if cast iron or mild steel you can take a tiny skim off the bottom to true it up after 20 years or so. The hole for the pillar is best bored in the lathe. In truth, because a surface gauge has inherent accuracy the angle of the pillar doesn't matter a jot, but don't spoil the job for a ha'porth of tar. It's worth doing non-critical tasks to the best of your ability, so that when a critical job comes along you will be well prepared, so lets try to make this pillar vertical!

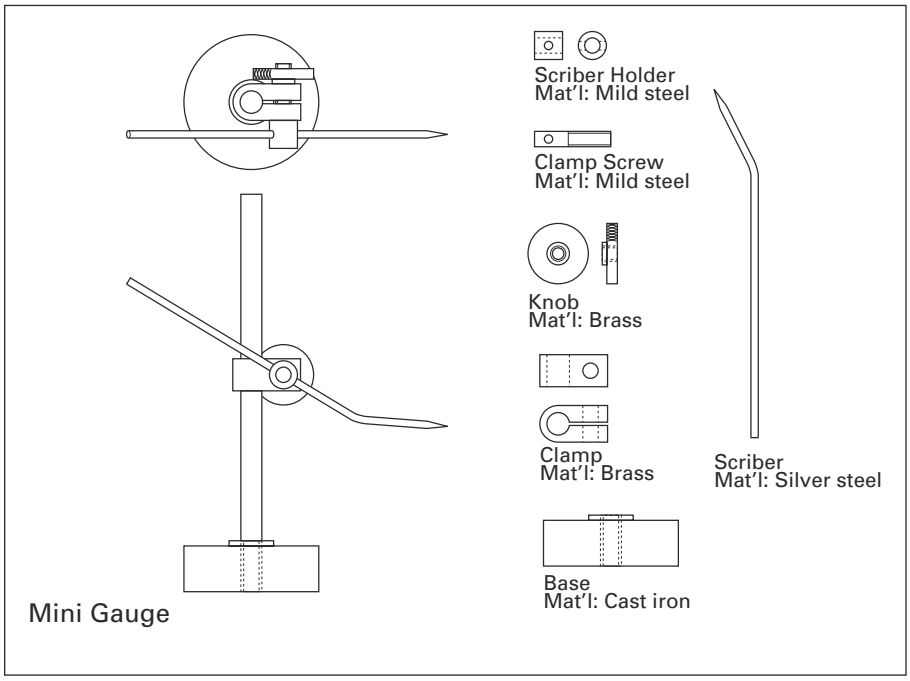
Silver steel of ¼ inch (or 6mm) diameter is fine for the pillar, do not harden it, as this may cause distortion. Precision ground mild steel would do just as well. Thread both hole and pillar in the lathe – ¼ inch BSW, 0BA or M6 will do fine. Carefully open out the upper part of the hole, so that some of the full diameter of the pillar enters the hole, holding it in line. You can also use a force fit, a retaining adhesive or even a set screw to fix the pillar in place, but in any case produce the hole in the lathe, not on the drilling machine.

If you have doubts, hold the assembled pillar and base in the three-jaw chuck and take a light skim to make sure it is both true and flat. Make sure it does not wobble when placed on a flat surface, such as your lathe's bed.

The simplest and best clamp for such a device is shown in the drawings. A central shaft is threaded at one end and has a hole for the scriber at the other. This is threaded through the body of the clamp, a sleeve fitted around the scriber end and the scriber inserted through both sleeve and shaft. Provided the clamp body is good fit on the pillar, then a simple knurled nut on the thread will pull the parts together with ample force to secure everything in place. Brass is a good material for the clamp body (it can be finished by draw filing), while the other parts of the clamp can be mild steel.

The scriber should be made from silver steel (3⁄32 inch or 2.5mm is good size for a small gauge), cut it to length and carefully turn a taper on each end, finishing with a tiny 60 degree point. If you use files to do this, take great care, making sure they have secure handles and that you wear safety goggles – if the file contacts the chuck jaws it can be thrown into your face. Bend the scriber about 30 degrees near one end – this will help when setting it low. Hardening such a long, thin piece can be difficult. It may be easier to heat it to a bright red along its length using a large gas cooker ring or a camping stove, rather than a blowtorch, picking it up at the centre with a pair of pliers and plunging it rapidly into a bowl of water. An alternative is to heat and quench each end separately, but this will leave the centre of the scriber soft, and it may bend in use.

Similarly there are two approaches to annealing the scriber. Heating the centre until the ends turn a straw colour will leave the ends hard and the centre less so, but again the centre will become soft and be easily bent. An easy alternative is to cook at gas mark 5-6 which gives a good colour and even temper along the whole length. Remember though, gas ovens are not precision instruments! I know my oven runs hot, so I suggest you put the work in at a low number, and then 'tweak' it up every ten or fifteen minutes, until you get the right colour. This works well for tempering cutters as well! ■



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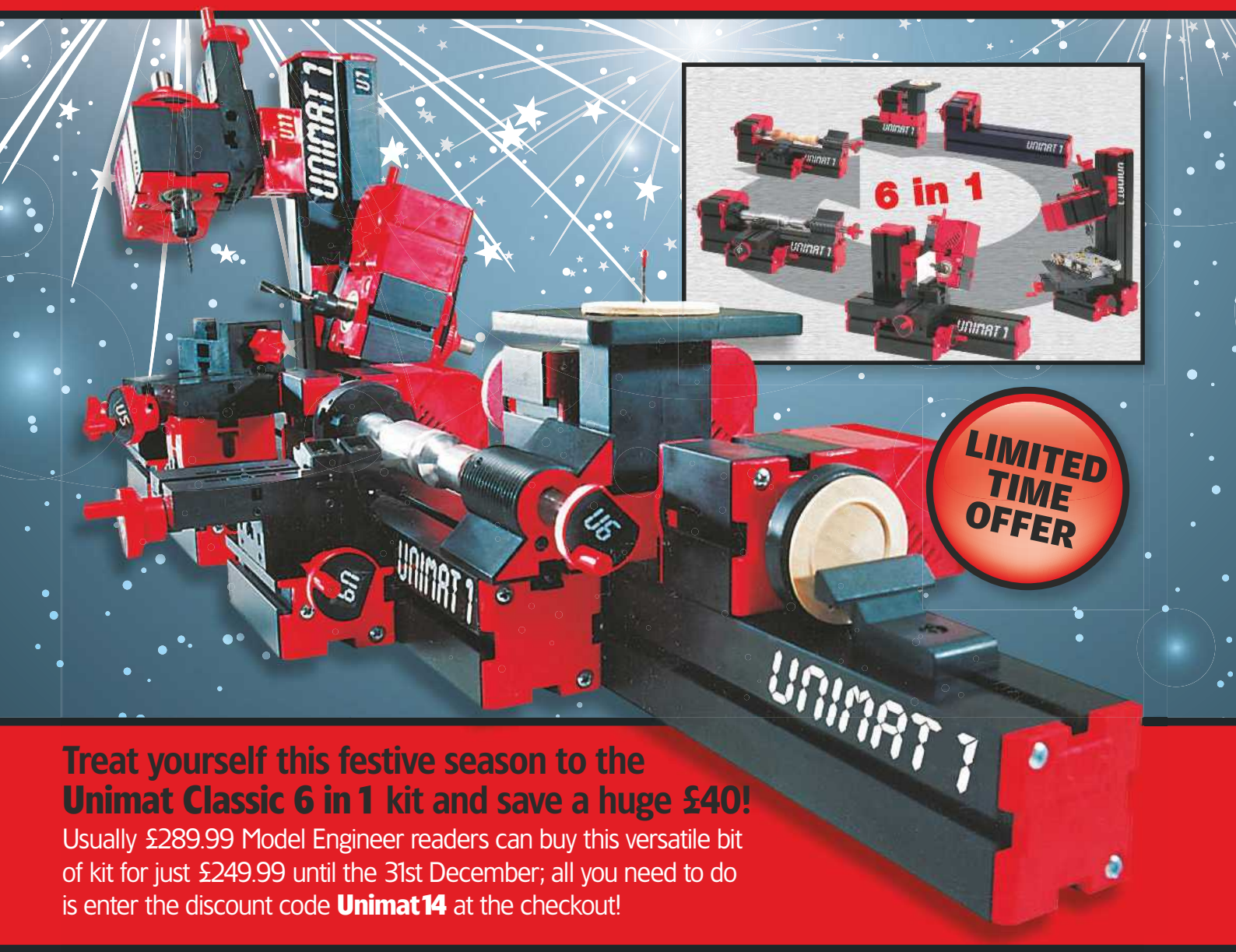

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Milling accessories for a Myford ML7 Lathe Part 2

Godfrey Greeves needed to mill work that was far too long for his standard vertical slide.

This article gives details of a purpose-made, narrow, long-travel vertical slide and plain-bearing MT2 milling spindle for an ML7 lathe. This is normally bolted at the rear of a long cross slide to provide a convenient and relatively robust milling spindle with minimum overhang and requires minimum overhang of slender work pieces held in the headstock chuck. This rear-mounted milling spindle does not need to be removed for normal turning and parting off operations or when work pieces are mounted on a standard Myford vertical slide at the front of the cross slide.

Purpose-made vertical slide and milling spindle.

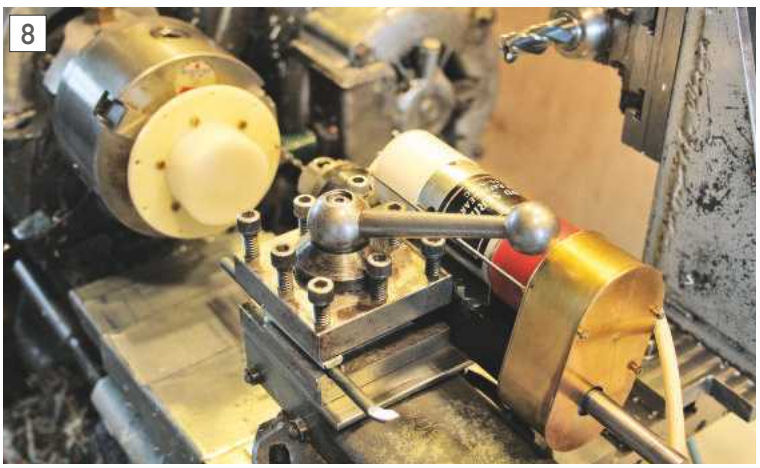
For axial milling the vertical slide is first set to the reference vertical height value, as explained above, and then the tailstock chuck or centre is used to engage the protruding rear end of the milling spindle. This is used in combination with a drill shank or steel rod in milling spindle chuck to engage the mandrel chuck or another reference in the headstock. This allows me to accurately set the plan view axis of the milling spindle to be exactly in line with the mandrel axis before bolting down on the cross slide. It also gives a reference cross slide reading for the milling spindle.

The milling operation being performed is a straight length followed by an arc using an end mill fitted in the milling spindle ½ inch chuck (ideally it should have been mounted in the ½ inch drawbar collet). The component is a curved support for the back of the front loader bucket of the tracked tractor.

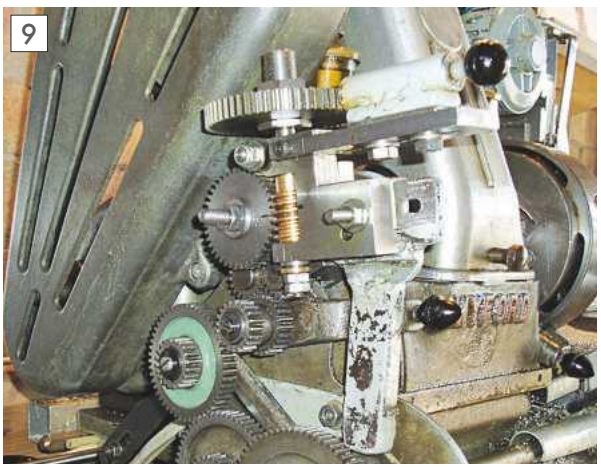
Photograph 8 shows another lighter milling/drilling spindle made for axial machining to obviate the need for moving the heavier milling spindle from the rear of the cross slide. This spindle has a simple ⅛ inch base plate that is clamped under a turret tool holder on the top slide. This milling spindle's housing is arranged so that the spindle axis is fixed and aligned at the centre height of the lathe mandrel. It has a ⅜ inch spindle fitted with a 5⁄16 inch chuck and is driven by a geared DC motor with a further reduction gear to the spindle below. The spindle protrudes from the rear. As above this spindle can be easily aligned with the lathe mandrel axis using a chuck in the tailstock and a rod in the spindle chuck, checking a centre line reference at the headstock end before clamping with the tool post clamp bolt. This also gives a reference centre line reading on the cross slide.

A transformer/rectifier is used to power the low voltage DC motor and is a standard item for power small tools. This provides variable speed control and I have fitted a reversing switch.

The milling spindle is being used to drill the holes that form the base of the acetal sprocket teeth for the tracks on the tractor. After this operation the other milling spindle on the rear of cross slide will be used to mill the sprocket teeth flanks and the flats needed between the teeth on the OD of the sprocket.



Another lighter spindle made for axial drilling/milling.



The completed dividing attachment fitted to the rear of the ML7.

Since this milling spindle is mounted on the top slide it can be used to drill/mill at an angle to the lathe mandrel axis by rotating the top slide. So in the above lathe set up it is being used as a 3-spindle machine.

The heavier-duty milling spindle described above can be unbolted from its vertical slide and mounted on the standard Myford swivelling vertical slide. This allows angled milling/drilling in various directions.

Purpose-made dividing head

Photograph 9 shows the completed dividing head fitted to rear of the lathe headstock mandrel. The dividing head comprises an attachment for simple dividing to which a further worm attachment can be fitted for more complex dividing.

For simple dividing a change wheel gear is fitted to the rear end of the lathe mandrel bore using an expanding spigot with an axial clamping bolt to lock it in position as shown in **photograph 10**. Normally a 60-tooth wheel is used for most simple dividing operations. The mandrel bore was not exactly concentric with the mandrel bearings etc. This was corrected in situ by slightly enlarging the rear end of the mandrel bore using a specially-made very long boring bar going right through the mandrel bore and held at one end in the tailstock chuck. The other end of the boring bar protruding at the rear of the mandrel was supported on three points (like a fixed steady) anchored to the rear of the lathe using the two change-wheel gear guard back-plate mounting bolts. With the lathe mandrel rotating the tool bit in the boring bar could be traversed by winding the tailstock in and out and a concentric bore produced at the rear end of the lathe mandrel.

A slotted bracket for mounting the plunger detent is secured by the two mounting bolts in the tapped holes at the end of the lathe bed that normally secure the change-wheel-gear guard back plate as shown in photo 10. The top of this slotted bracket is further stiffened in the lathe axial direction as shown in **photo 11**.

There is a U-shaped member that clasps the lower part of the mandrel rear-bearing housing by tightening a small grub screw against a short length of aluminium channel packing. This can be seen just to the left and below the white oil-thrower ring on the mandrel pulley. The top part of the slotted bracket is bolted to a tapped hole in the left face of the clasp. This arrangement provides a very rigid mounting for the slotted bracket. The plunger detent can be mounted in the slotted bracket to suit any size of Myford change-wheel on the rear of the mandrel. A modified change-wheel gear cover can be fitted to the lathe when it is in use for turning and screw-cutting operations.

For more complex dividing, such as gear cutting, an additional purpose-made worm dividing attachment as shown in **photo 12** is mounted on the slotted bracket instead of the plunger detent. This also shows the side of the worm dividing attachment with the two studs that bolt to the slotted bracket mounting described above instead of the plunger detent. The latter is transferred to and bolts to the slotted arm and acts on the change wheel division gear shown in photos 12 & 9. A change-wheel gear with any number of teeth may be fitted as a division gear.

The worm bearing, division gear and arm for the detent are a separate part that can pivot round the two-stud mounting piece in photo 12. The pivot is shown at the top where there is a Nylock nut on the right side with a spring washer. The face for the two clamping studs is machined at an angle to match the helix angle of the worm to ensure correct mesh with the change-wheel worm gear on the rear of the lathe mandrel.

Photograph 13 shows the opposite side of the attachment. There is an arced slot with stud and a clamping nut to lock the position of the worm bearing part round the pivot point, where the Nylock nut is fitted. In photo 9 both the worm gear fitted to the rear end of the lathe mandrel and the division gear at the top of the worm attachment can be a change-wheel gear with any number of teeth. The worm gear fitted is a relatively small 40-tooth change wheel for cutting a gear as described below.

Initially the adjustable pivoting and clamping of the worm bearing part of the attachment with the arced slot was to provide an easy way for setting a minimum backlash between the worm and the worm wheel. In practice it was found that the clamping stud nut in the arced slot could be left slack. The weight of the worm bearing part, division gear, slotted arm and plunger detent round the pivot was more than sufficient to ensure good contact and engagement between the worm and the worm-wheel teeth. Also, the backlash between worm and worm gear is then zero.

This allows very rapid indexing by lifting the worm bearing mounting up round the pivot, rotating the lathe mandrel as required and then lowering the worm bearing part to re-engage the worm gear teeth.

For both simple and more complex dividing a permanent felt-tip marker is used to mark the face of both the worm wheel and the division-plate gear to position these for the particular dividing job in hand. I think this provides a much more rapid and foolproof method of dividing than working with sector arms on a conventional worm dividing head. Where the worm is permanently engaged to a fixed number of teeth worm wheel and can require counting of a large or non-integer numbers of turns of the sector handle.

Also since any of the full range of Myford change-wheel gear tooth numbers can be fitted as a worm gear or a division gear this provides for most requirements in gear cutting. This provides a very convenient and flexible dividing attachment for the lathe mandrel.

Attachment made for simple dividing.

Gear cutting with a rack cutter

Gear cutters are expensive to purchase especially if several cutters are needed to cover the full range of tooth numbers from small pinions to large gears. Also I often need to make pinions with a very low number of teeth for which gear cutters may not be available. The technique I use is to generate the involute gear teeth *in situ* using home made rack-tooth-shaped

U-shaped clasp locating on the headstock rear bearing housing.

Purpose-made worm attachment for more complex dividing.

The opposite side of the worm attachment.

cutters. The technique I use does not require the complexity involved in a gear hob attachment.

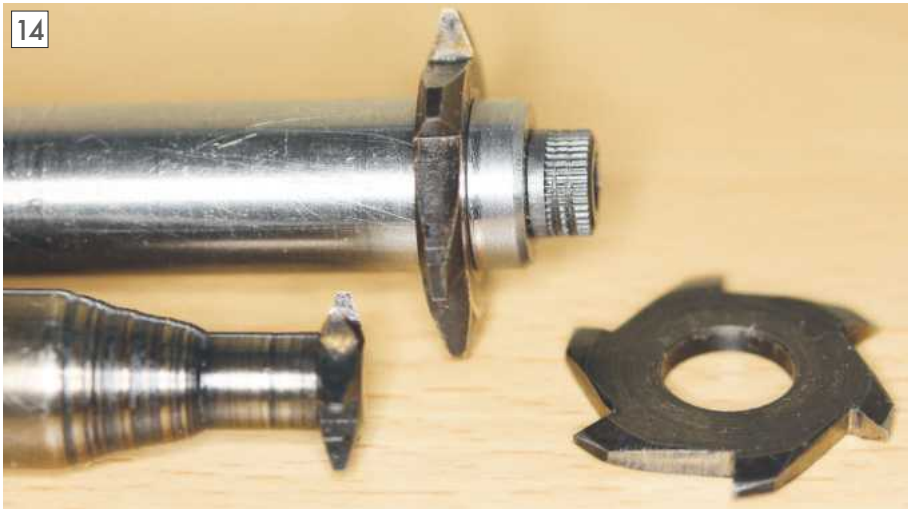
Photograph 14 shows three rack-form gear cutters made using the milling spindle and the dividing attachment described above. The material is silver steel rod or gauge plate. The tooth flanks are turned using the top slide set to the required tooth pressure angle. The cutter teeth are machined with an end mill in the milling spindle including relief on the OD behind each tooth tip leaving only a very small length of OD behind the tooth tip which can be further relieved with a slip-stone.

I have not found it necessary to provide any additional side relief behind each tooth since theoretically the side faces of the cutter curve away from the tangential direction of the cutter traverse. It is beneficial to machine the front face of each tooth so that there is some top rake (especially for cutting acetal gears) by end milling beyond a radial line. The cutter teeth are hardened and tempered to a light straw colour. The 3 rack-form cutters in photo 14 are for generating gears of module 1, 28 DP and 20 DP.

Photograph 15 shows the milling spindle mounted on the rear of the Myford long cross slide being used to cut the gear teeth on the OD of a brass flywheel for the glow-plug engine in the model tractor.

One of the rack-shaped cutters described above is mounted in the milling spindle. With the rack cutter positioned directly over the centre line of the lathe mandrel axis a lathe-saddle traverse of the rack cutter is made for the first pass. This is done for all of the required number of teeth on the flywheel. If the dividing head worm gear has the same number or a multiple of the required number of flywheel teeth, then advancing to the next tooth is very quick as described above.

After the first pass for all teeth, the next step is to rotate the mandrel clockwise by a small controlled angle using either the division gear teeth, the worm gear teeth or a combination. The cross slide is then moved in by the calculated distance required for a rack meshing with the flywheel teeth at its pitch circle diameter.



Rack-shaped gear cutters made on the milling spindle.

A lathe saddle traverse of the rack cutter is done at this second-pass setting for all of the teeth. This starts to shape one side of the tooth flank.

This process is repeated for further controlled amounts of angular rotation, until the rack cutter does not remove any more material from the tooth flank. Typically about 4 steps of controlled amounts of rotation are adequate with no visible signs of flats being formed on the tooth flanks.

Then all of the above is repeated but this time for anticlockwise rotation by controlled amounts of angular rotation with the cross slide moved out by the calculated amount - taking account of the cross slide feed-screw backlash which will be in the opposite direction.

This provides the means of generating involute-form straight spur gear teeth from the lowest number of teeth pinion to the largest gear using a single home made rack-form cutter. One rack cutter is all that is needed for each module or DP size. No need to purchase any expensive gear cutters!

In the above gear cutting procedure, it is important to check in advance with a dial gauge that the axial float of the milling spindle is minimised since the machining of the opposite flanks of the teeth will bias any end-float in the opposite direction. The collar described in photo 2 above is set to give an axial float of not more than 0.001 inch.

It is important to note that with the milling spindle mounted on the rear of the cross slide, the axis of the milling spindle needs to be above (rather than underneath) the lathe mandrel axis to cut the teeth on the relatively large gear blank in photo 15. This is for the gear cutters made for the normal direction of rotation. Consequently a relief of the brass rod stock behind the gear blank was machined so that the saddle traverse of the cutter could be from left to right. This is to avoid any problems with climb milling. This direction of traverse was only needed on the first pass cut and not for the subsequent passes that remove only a very small amount from the tooth flanks. For gear cutting small pinions or pinion rod the milling spindle vertical slide can go low enough to cut underneath and traverse towards the mandrel chuck directly into the stock rod, since it is not climb milling.

For gear cutting or end-milling operations of stock rod above the mandrel axis then a saddle stop can be used to set the saddle travel towards the mandrel chuck. Then each saddle pass is made away from the chuck after lowering the rotating milling spindle on the vertical slide by the next cut depth.

Gear cutting a brass model-engine flywheel using a 1 MOD rack cutter.

Finally

Unfortunately no drawings are available for the various attachments described in this article. But hopefully the article may help other readers of *MEW* to apply the ideas according to their needs and the lathes that they have available. The narrow long-travel vertical slide and plain bearing milling spindle would be easier to construct if a supplier could provide suitable machined castings.

The ML7 lathe and the attachments described here have been used extensively over many years and recently for building a radio-controlled ⅛ scale model tracked tractor with hydraulics. This is a complex experimental model with lots of working functions. Hopefully details of this model may be published later in *Model Engineer*. ■

A Top Slide Index Dial

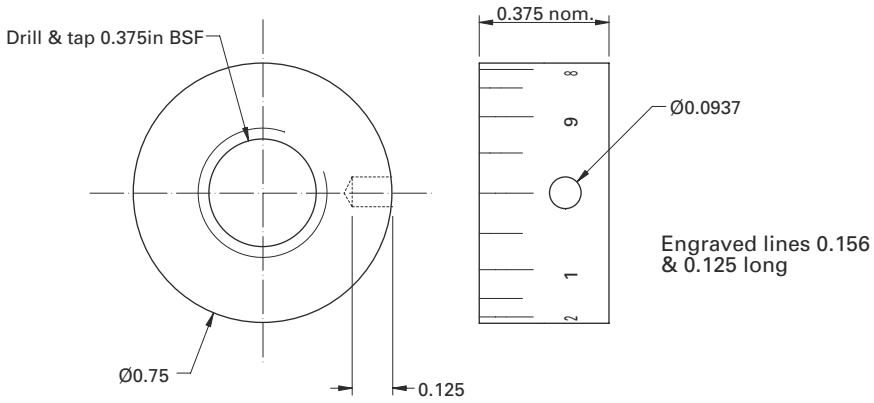
Geoff Walker describes and aid to precision for Myford and Drummond M type lathes.

The new dial attached to the top slide.

Removing the tapered pin in the handle.

The addition of feed screw index dials to an old lathe will often promote some serious debate as to their relative merits. Many old school turners will eschew such additions, considering them unnecessary whereas the less experienced, like myself, often see them as a positive which when made and fitted accurately are a real benefit.

Fig. 1



The Myford/Drummond M type lathe has an adjustable dial fitted as standard to the cross slide feed screw but no dials fitted to the lead screw and top slide. This short article is for the addition of a simple fixed top slide dial, easy to make and with all materials to hand could be made in less than a day. The dial is shown in place on the top slide in **photo 1**. This one is made from bronze, good for this application as it is easy to engrave and stamp.

The first task is to remove the top slide handle. This is secured to the feed screw with a single taper pin which when removed allows the handle to slide off the screw. Locating the ends of the pin may be difficult if the pin has been dressed over and after many years of use probably never been removed. I found that the centre ball on the handle needed to be thoroughly cleaned with emery cloth finishing off with a polishing grade. This highlights the ends of the pin so you can then pick out the very fine circular outline. Use a sturdy punch to loosen the pin which may be a little stubborn after being in place for many years. Ideally use an eclipse style pin punch, or as shown in **photo 2** an old centre punch ground at the end for a short length to match the pin diameter. Once the pin is loose a short length of silver steel will suffice to tap the pin out.

With the handle removed the lock nut, the adjusting nut and the thrust washer can be removed. The end plate will also need to be removed to engrave an index line on the top of the boss.

Of course if you only have one lathe the top slide really needs to be in use to make the dial. That's not a problem but when engraving the front plate, the top slide minus the screw can be locked with the gib screws. The lead screw and cross slide feeds can then be used to set the tool in the engraving position.

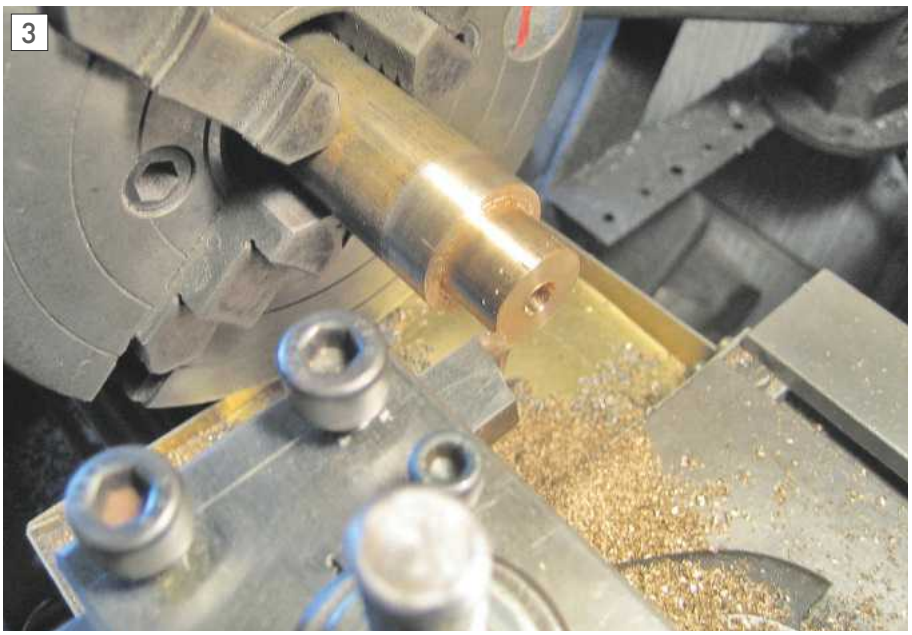
Fig 1 shows the dimensions for the new dial and **photos 3** to **5** show the initial stages. They are mostly self -explanatory but I would add the following points.

The thread in the dial, must be tapped square to the front and rear of the dial. For adjustment purposes the front of the dial

needs to be brought into close contact with the outer face of the end plate boss, therefore keeping the thread square is essential. Using the tailstock to guide the tap is a tried and trusted method of keeping the tap square.

With the removal of the thrust washer and the thrust/adjusting nut the new dial replaces both of them and is now used for adjustment and to take any thrust from the slide. On reassembly only the lock nut is needed. Adjust the dial width to suit your machine. ⅜ inch is shown as the nominal width.

The dial is engraved with 20 divisions (0.005 inch each, the screw being 10 t.p.i.). Indexing, shown in **photo 6**, is simple and direct from a standard 40 or 20t gear on the lathe spindle. The gear engages with the keyed and locked collar on the spindle and is indexed from an attachment secured to the quadrant. Do ensure that the gear and collar, when combined, are free from any circumferential play which may affect the accuracy of the indexing. The attachment you see in the photo has a spring loaded detent pin shaped to fit the gear spaces. This could be a much simpler arrangement with the square block drilled and tapped to accept a screw type detent. The engraving tool, which must be laid on its side, should have an included angle of about 50 degrees, no top rake and with just a small amount of clearance on the front and both sides.

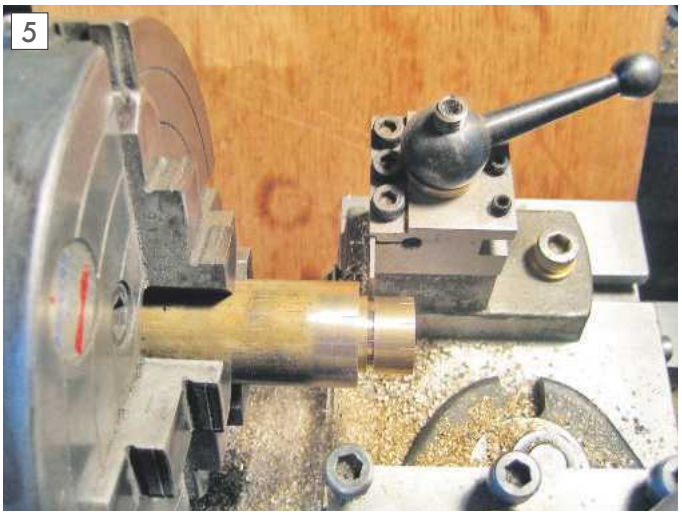


Engraving the dial.

Each line was engraved to depth of .010 inch with .002 inch the maximum incremental cut. The engraving process will create some swarf which may cling to the dial. Before parting off, wrap a piece of fine emery cloth around a small flat file and apply this to the rotating dial to improve the surface finish and remove any sharp edges.

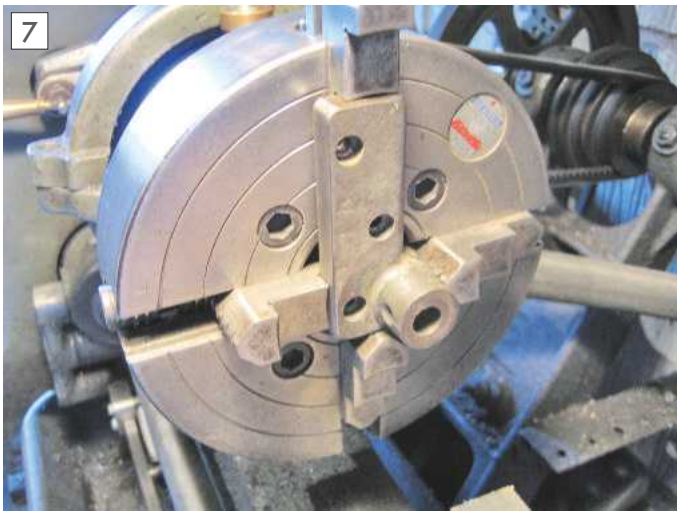
Photograph 7 shows a 4 jaw chuck set up for engraving the boss on the end plate. Engrave the line from the front face of the boss through to the countersink on the oil hole.

Threading the dial.



Parting off the dial.

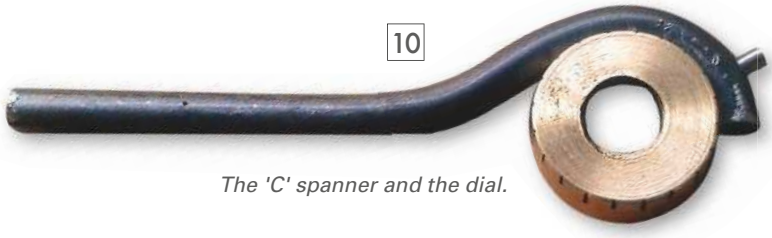
Direct indexing using a 40T gear wheel.



Engraving the end plate.

8

The stamp guide.



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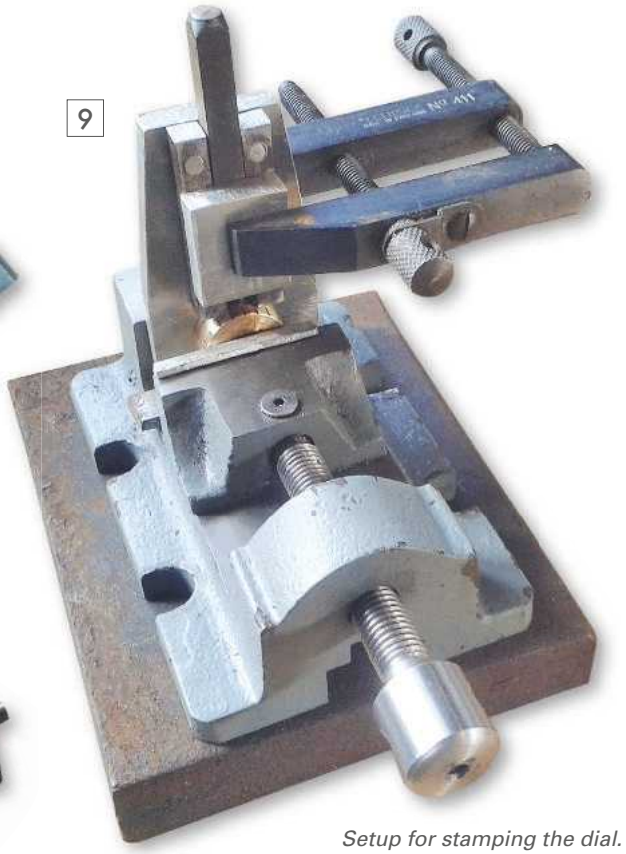
The 'C' spanner and the dial.



9

Setup for stamping the dial.

The number stamps size I used were 1/16 inch and the shanks of the stamps were ¼ inch square. With such a small dial I felt that accurate freehand positioning of the numbers would be difficult. **Photographs 8** and **9** show a small guide I used, which when combined with the vice, placed each number accurately on the dial. The back plate is made from a piece of alloy plate and the two guides from square stock. If you make the dial from bronze it is wise to protect the dial with aluminium alloy to prevent any bruising when the dial is gripped in the vice and also when the stamp is struck. For each stamp position, the engraved line just needs to be set centrally under the two guides.

I used stamps 1-9 at every tenth division. The '0' stamp is not used. Instead, at this position, a small hole is drilled 3/32 inch diameter and about ⅛ inch deep. The hole is for the 'C' spanner, shown located on the dial in photo 10. This was used on assembly to hold the adjusted position of the dial whilst the lock nut is tightened. The 'C' spanner was made from a length of ¼ inch mild steel bar and has a pin 3/32 inch diameter. With the lock nut tight the handle can be refitted taking care to correctly line up the tapered holes before replacing the taper pin. ■

In our Next Issue

Coming up in issue 225
On Sale 23rd January 2015

Andrew Johnston ⌃⌃ on automated screw threading

Alastair Sinclair's ball turning accessory ⌄⌄

Mark Noel on threaded inserts ⌃⌃

A Precision Machine Vice Part 2

Michael Checkley shows how you can make a solid and practical tool that also looks good in the workshop.

Designing and building a vice gives the opportunity for many personalised features to be incorporated in the design including mounting features for different vice orientation; endstops; and a variety of custom vice jaws for clamping different shaped parts.

Machine the T slots by starting from the bottom of the slot and cut a slot the full thickness of the cutter then take the finishing cut on the top surface of the slot. The top surface is the only working surface of the T slot and both slot top surfaces should be machined with the same height setting on the mill to ensure both surfaces are both parallel and coincident (**photo 11**).

The end face of the base, to which the fixed jaw attaches, needs to be perpendicular to the slideway channel therefore machine this face whilst the base is still mounted on the mill. Machine this face using the side of an endmill, milling to 0.2mm above full depth as to not machine the milling machine bed! This 0.2mm step is later removed during the machining of the 0.5mm chamfer which extends around the base (**photo 12**). Alternatively sit the block on a pair of parallels and clamp in place.

Now that the bulk material has been removed skim the top sliding surfaces to the final height. Try to achieve the best surface finish using a flycutter as any cleaning up using emery cloth will only risk degrading the flatness of the sliding faces. Aim for the tolerance on the drawing but any slight error can be compensated for in the machining of the sliding jaw. Chamfer the corners to remove the sharp edge.

Flip the vice base over on the milling machine bed and machine the 10mm chamfers on each corner. This isn't a high precision job so the 45 degree angle can be set by eye using a protractor (**photo 13**). Machine the 10mm chamfers on the corners and using the same fixture machine the 0.5mm chamfer on the base (**photo 14**). With the base now clamped square to the milling machine axis complete the chamfer all around the vice base (**photo 15**).

Align the base with the milling machine axis and drill the mounting holes to suite your milling machine bed (**photo 16**). I decided to use six counterbored M5 clearance holes positioned to allow the vice to be aligned with either the X or Y axis. This is the advantage of making our own vice and if the milling bed T slots require a different hole spacing the width of each flange can be adjusted on the drawing before machining begins.

Mark out the positions for the threaded holes on the end face (**photo 17**) and clamp the base upright against an angle plate and drill and tap the fixed jaw mounting holes. Centre the hole pattern on the channel to ensure that the leadscrew runs along the centre line of the slideways.

Machining the T slots.

Machine the base sides, careful not to touch the milling bed!

Mark out and mill the chamfers, no need for high precision!

Moving jaw (fig. 7)

The moving jaw is sized to match the final dimensions achieved when machining the vice base. Care needs to be taken to achieve the geometric tolerance specified as this will determine how smoothly the vice operates with the minimal amount of free play.

Machine a block of mild steel to overall size. The width of the block should match the final width of the base and the height and depth of the block should be machined to drawing but are not critical dimensions.

Machine the step in to the block to produce the mounting face for the bolt on jaws. This will be one of the reference faces for marking out the bore which houses the leadscrew nut.

Sit the previously machined mounting face on a parallel and align the block with the milling machine axis. It is importance the block is fixed on this face as the bore to house the leadscrew nut needs to be perpendicular to this face. If this bore isn't perpendicular the moving jaw will be driven in to the side of the base channel during operation jamming the moving of the jaw.

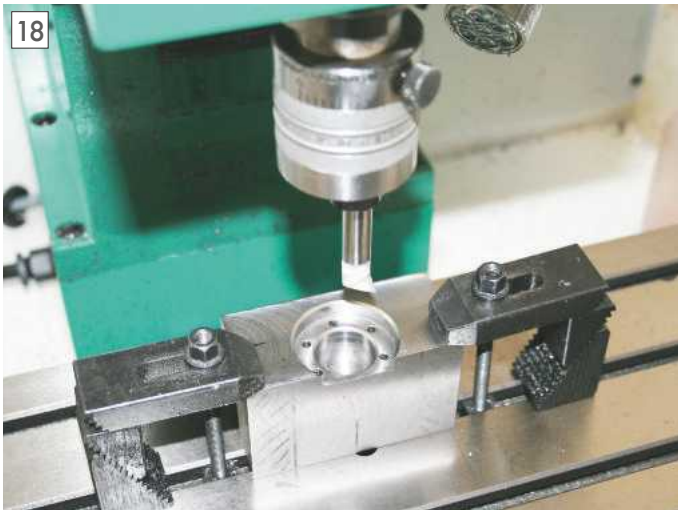
Locate the centre of the block and measure up from datum C. Drill through the block increasing in drill size up to Ø11mm. This isn't critical as the hole has clearance around the leadscrew and also gives a start for machining the bore to house the nut. Machine the bore to accept the leadscrew nut, aiming for a H7 fit as per the drawing to ensure the nut is accurately located. Ensure the inner shoulder of the bore is machined perpendicular to the bore axis as this is the face the nut will be clamped up to and thus determining how square the nut

Chamfer the edges.

Chamfer the edges.

Drilling the mounting holes whilst raised off the milling bed.

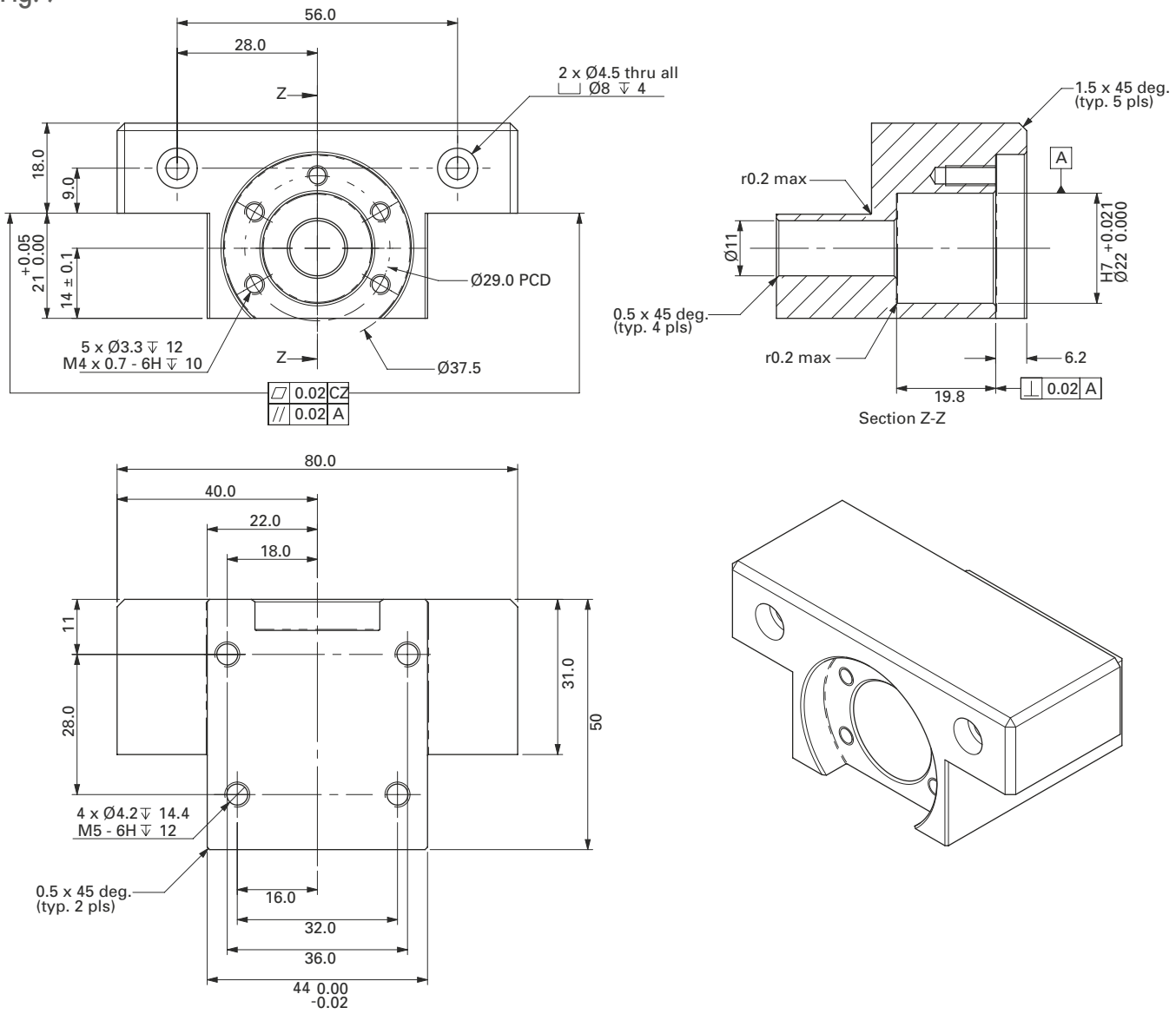
Marking out the mounting holes using a height gauge.



Boring the moving jaw for the leadscrew bush.

Measuring the slot height.

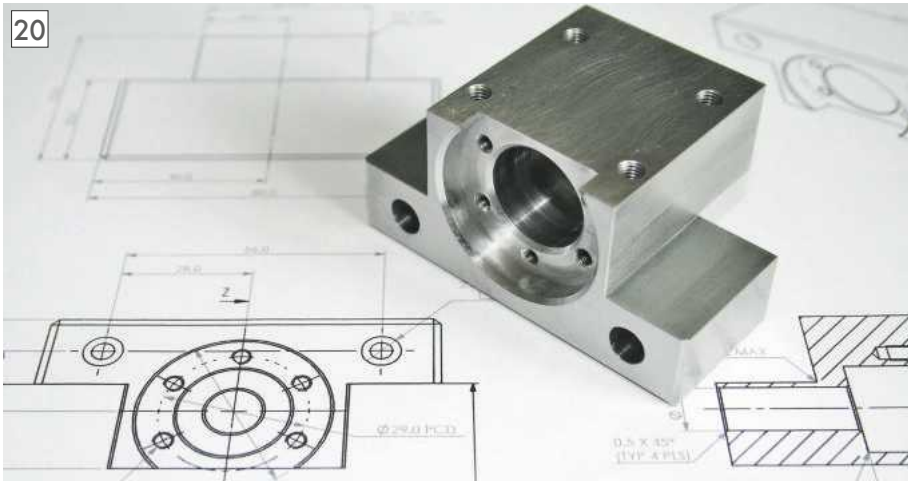
Fig. 7



sits within the moving jaw. The nut is supplied with a generous chamfer on each end but ensure that there is not a large radius at the bottom of the bore from the boring tool as this will prevent the nut from being seated properly. Machine the larger bore to give good clearance around the clamp ring. Chamfer the bore edges to remove any sharp edges and drill and tap the five M3 holes (**photo 18**). With the block still clamped in place and aligned on the milling machine drill and counterbore the clearance holes used for fixing the jaws.

Flip the block over on the milling machine to enable the machining of the sliding faces. Clamp the block in place and align with the milling machine axis. Machine the sliding faces to depth. This depth is measured from the final dimensions of the vice base (**photo 19**) and the sliding faces on the moving jaw should be machined to match. The width of the sliding jaw is machined to suite the final dimension of the channel in the vice base.

Machine the end faces with a sharp slot cutter and the side faces with an endmill trying to achieve the best surface finish possible. A small step in height of about 0.1mm to accommodate a change in cutter is fine as the base is well chamfered for clearance. With the block still clamped in place take the opportunity to drill and tap the four M5 mounting holes used to secure the clamping plate. Chamfer the sliding jaw and deburr to remove the sharp edges (**photo 20**).



The finished moving jaw.

To be continued...

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Disposing of a Home Engineer's Workshop

Roger Backhouse suggests we should all take a little time to plan for the inevitable.

It happens to all model engineers one day. Their workshops, perhaps built up over many years, have to go. This may be because of house moves, change of personal circumstances, acquiring new interests and worst, through illness or death.

There are several options for workshop disposal. That chosen may depend on personal priorities. Is it to obtain the maximum value for workshop contents? Is it to secure fast and easy removal? To obtain quick payment? Or to ensure that contents go to good homes, perhaps where other model engineers will appreciate and use the equipment? These objectives are not incompatible.

This article is really about planned disposal, but if you are in the unfortunate position of having to dispose of a workshop at short notice, here's some 'potted advice':

- Plan ahead if possible. Itemise principal items and give realistic values. Friends or family members would appreciate an idea of values, which are also useful for insurance purposes - your workshop may be worth more than you thought.
- If selling, take plenty of good photographs - they will help dealers or other potential buyers.
- Make a will but consult with potential executors and beneficiaries - the last thing they might want to deal with is a workshop!
- Consider your model engineering club or society as a good home for equipment - members might like your tools and metals.
- Remember other people's time in disposing of your assets, they might be pleased to do it but may not want the responsibility.
- Use dealers who advertise in *ME/MEW* if you want a quick no hassle sale.

Planning ahead

Ideally, though rarely possible, workshop disposal should be planned in advance. Those with disposal responsibilities would probably appreciate a note of workshop contents and guide prices to ask. This is particularly important when selling models, though this article concentrates on selling tools and equipment. Family or friends unused to model engineering may have little idea of values.

It is always advisable to leave a will and appoint executors, though unfortunately many people don't. Having a simple will made is not expensive. You can name an individual or an organisation to have your workshop should you wish.

A *Lasting Power of Attorney* drawn up in advance can also be considered. This allows a named person (or persons) to manage some or all affairs of someone who becomes incapable of managing their own financial or other business.

Family and friends

Family members may share interests and be ready to take workshop contents. Model engineers could have like-minded friends who can help. However, many of our friends are likely to be of similar age, perhaps with similar ailments and not always able to cope with the considerable demands of sorting out a workshop.

Advertisements

Model Engineer and *Model Engineer's Workshop* offer free adverts and many workshops have been sold through these magazines. Sensible pricing helps, and looking through to find the going rate for machinery will help fix a price that can attract buyers without pricing too cheaply. Both magazines are good sales outlets if you can plan ahead and have adequate time to make a workshop sale.

Adverts in local papers may produce sales but results are hit and miss. One engineer I knew bought a milling machine cheaply thanks to an advert in the local Yellow Advertiser. However, local papers do not usually reach a specialist market like model engineers.

Society sales

Model engineering clubs often help sell member's workshops. Many societies have notice boards where members advertise unwanted goods, or less usually ask for something they need. Others take adverts in club magazines.

Sometimes society members show their appreciation of the help and companionship found in a society and

Dennis Major's Myford ML7B lathe (rebadged Super 7) was left to Dockland and East London Model Engineering Society (DELMES). It was sold to a dealer and cleared the same week.

make bequests to help clubs. They may also want to see their workshop contents going to people they know will appreciate them. For example, Dennis Major, a founder member of Dockland and East London Model Engineering Society, bequeathed his workshop to the Society when he died in 2013. Fortunately Dennis had made a will and appointed executors.

Workshop contents included a milling machine, drill and Myford ML7B lathe in very good condition, plus stationary engine castings and other tooling (**photo 1**). It was quite a task for a small society to handle the sale but by contacting other societies locally the drill, milling machine, castings and tooling and some metals were sold, going to appreciative model engineers. They also organised a sale by their track in Belhus Country Park, near Thurrock, with surplus goods on a trailer and invitees from other local societies.

With the house on the market it was pressing to remove remaining equipment. *MEW* advertisers Home and Workshop Machinery stepped in to make a fair offer for the Myford lathe (to include accessories), removed it within three days and paid promptly.

SMEE Sales Service

The Society of Model and Experimental Engineers (SMEE) offers a service, holding regular rummage sales for members selling unwanted tools and metals (**photo 2**). If there is a workshop for sale they change this to a much larger disposal sale to sell workshop contents. They have a tightly organised workshop clearance system but it is considerable work for their volunteers (**photo 3**).

Using SMEE's services my neighbour Bob Buckle sold many tools and metals from his father's workshop, untouched for nearly 30 years after his death. Going through an untouched workshop is always sad. It is also dirty with oil film and dust. The SMEE team of Martin Cook and David Taylor rapidly sorted cupboards, drawers and boxes. They dismantled the drill and moved the massive vice downstairs, taking most contents in a morning's work. Martin Cook says it is worth spending time sorting through goods before a sale to remove scrap and rubbish. This helps boost buyer interest and takings.

Besides removing goods for the auction Maurice Fagg, a SMEE member and clockmaker, took a synchronome clock for sale at one of the specialist clock fairs held three times a year at Brunel University, making £150 for Bob, much more than he expected.

However, they wouldn't take patterns for castings as these wouldn't sell. Nor would they take the 1920's made IXL lathe, bench and grinder as these wouldn't sell either. A brazing hearth remained as the piping was unsafe.

An SMEE auction at Marshall House was enjoyable. About 30 members attended with the auctioneer, Peter Wardropper, rattling through the goods on offer. Speed is a secret of a good auction. Humour helps too. One bundle of polished metal was described as 'could be platinum' and when a clock kit came up for sale the society humourist had to ask 'Is it digital'? As a sale novice I enjoyed the afternoon, but in a fit of auction fever bid a whole £1

The thrill of the chase, SMEE members looking through goods for sale at a disposal sale in the meeting room at Marshall House. Rummage and disposal sales always bring out a range of goods.

Martin Cook clearing a workshop in readiness for a SMEE disposal sale. The SMEE team have this well organised.

for a box of miscellaneous nuts and bolts, few of which mate! Better, the unwanted bits and pieces I took in made a satisfactory £23.

As with any auction there is no knowing how much lots will make - there are good days and bad. SMEE charge 10% commission on sales for members. This one raised £400 for my neighbour, less commission and a charge for petrol used to transport the goods. Bob was well satisfied, and SMEE members enjoyed themselves. If a smaller society plans to hold an auction I suggest inviting members of other societies to boost the market.

Society auction sales seem a good way to sell metals and tools, though perhaps not larger machinery (**photo 4**). There are always club members looking to pick up metals, though one SMEE theory is that the same bits of unworkable metal are sold each time, to be returned to the next auction by an unhappy buyer!

Peter Wardropper thinks that interest in society sales is less than formerly and lathes in particular are more difficult to sell. Model engineers are now generally better equipped though Peter suggests rummage and disposal sales remain a good outlet for many tools and surplus metals.

Local Auctioneers

In 2013 the firm of Harry Ray and Co of Welshpool, Powys, advertised a complete workshop, sold as one lot at auction. This firm is a general auctioneer holding specialist machinery and farm sales when required. Some auction firms specialise in machinery auctions but these may take time to arrange. They are a possible outlet for machines and other equipment if you want to test the market, but may not attract specialist buyers.

Second hand machinery dealers

Tools and machinery dealers advertising in Model Engineer's Workshop and Model Engineer offer quick removal of workshop contents which can be vital where there is pressure to remove goods quickly. They also offer quick settlement, again this can be helpful.

Long established dealers advertising in *ME* and *MEW* include Home and Workshop Machinery of Sidcup, G and M Tools of Ashington, West Sussex, and West Point Machine Tools, of Hyde, Cheshire. These firms aim for fast turnover so are constantly in need of new stock.

Steve Holder of Home and Workshop Machinery says he can usually offer a price based on good photographs of the machinery and tooling offered. He quoted quickly after seeing pictures of Dennis Major's lathe and associated tooling, and cleared all within three days. They are highly experienced in clearing workshops, offering a professional service.

Tim Muddle of G and M Tools reckons to deliver a similarly quick service. His firm can travel to most parts of the UK if the tools offered are good enough. Like Steve he can make an offer based on photographs. Sadly he sometimes buys back workshops sold previously to model engineers who can no longer continue with their hobby.

West Point Machine Tools originally dealt in factory machinery but finds increasing business among model engineers. They prefer to value and sell whole workshops rather than individual machines. Like other dealers they pay promptly.

All these firms offer second hand smaller tools, though these are generally less important to them than machine sales.

Sometimes dealers are criticised for offering prices considered too low. This is not really fair. Look at the costs of running a second hand machinery business - there are rents and rates to pay, wages and insurance, transport costs (hiring a large truck can be £1000 a day), cleaning machinery for sale, advertising and of course the need to make a living. All these costs mount up so dealers need reasonable mark-ups just to cover costs, never mind make a profit. And some goods probably won't sell quickly but still add to storage costs.

Selling goods yourself or through a society may make more money but if costing time involved for family, friends or society volunteers then a dealer is a good option. Norman Dean of West Point Tools says that contrary to expectations a dealer can often offer more than a private buyer. They have turnover and financial organisation to offer ready money.

One risk is that a dealer may already be well stocked though *ME/MEW* advertisers are always ready for more stock. A local second hand dealer (who doesn't advertise in *ME/MEW*) had lots of measuring equipment for sale so when a retired toolmaker came in to sell Imperial micrometers he was politely refused. Luckily I could make an offer.


4

Auctioneer Peter Wardropper at a SMEE disposal sale. Speed is important to a good auction.

eBay

This has rapidly become the means of choice for many people wanting to sell unwanted items. Bob Buckle could not sell his father's 1920's IXL lathe though offered to south-eastern model engineering societies (**photo 5**). Despite being well built, carefully maintained, and used to produce models winning prizes at Model Engineer exhibitions, there is no demand for older non indexed lathes. Bob's son put it on EBay and received an offer of £127 which was gratefully accepted. Fortunately the buyer could collect promptly, obtaining a robust lathe with a good centre height.

Freecycle

Almost all areas have a Freecycle website where members can offer items free or request free goods. Obviously it is no good if you want paying but potentially useful if you want something moved quickly. People like something for nothing.

It is surprising what people take. I put three plastic air bricks on Redbridge Freecycle which were collected the same day. I tried my neighbour's old bench on Freecycle; there was interest but unfortunately potential takers were unable to remove it.

Conclusion

There are many options for workshop disposal. We all hope it doesn't happen, but the time will come. Planning ahead, consulting with family, friends and our societies, will all help make eventual disposal easier and help ensure that our valued tools and equipment go to those who will use and value them. ■


5

Older lathes like this are difficult to sell but this IXL sold through eBay for £127. The buyer obtained a robust, well maintained lathe with a 5 inch centre height.

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Care (and Feeding?) of Micrometers

Dear Neil, I notice that one of our Australian colleagues has raised the issues of lubrication and rust protection.

I apologise for missing lubrication. This was probably because most of my Customers do not have a problem. They are generally working 24/7, so the instruments are constantly in the working environment, and in reasonably steady temperatures.

When I have a need to lubricate, the need is to be sparing so as not to carry dirt into the instrument or clog it with lubricant that is too thick. I use ONE DROP only of clock oil, which is much thinner than most oils, on either the spindle thread or the mating internal thread.

Regarding rust protection, I use the rust inhibiting paper (VCI, VCR etc) of which I get plentiful supplies from customers who otherwise discard it. My tool storage drawers are lined with this paper, and instrument boxes are treated in the same way. There are various rust protection liquids, but I believe these have to be cleaned off before the tools can be used - useful if you lay up your workshop for a period, but not very practical.

There are also some substances that give off a rust inhibiting vapour for about two years. I have not tried any of these, and would be glad to hear from anyone with experience of them.

One problem that I do have is that digital instruments do not like industrial liquids like coolant. The only cure is to avoid getting them wet.

This leads me nicely on to my worst 'Room 101' hates - people who refer to Digital Vernier instruments. The words Digital and Vernier are contradictory, and do not belong together. An instrument can be digital or Vernier, but not both. I notice even dealers are guilty on this point.

Wishing all at MEW a very Happy Christmas and best wishes for 2015

Regards,
Bert Bishop

Shaper Back in Action

Dear Neil, I have had to sell my larger machine tools and house and move in with my daughter's family because I have cancer. I luckily had just completed a compact machining system for my grandson to inherit. I moved it to my daughter's house. I recently tried the hand shaper out.

It works. The shaper does not have a clapper box. I have to back away with the cross feed before making the successive cut. I added a couple of photos showing a current machining job with the shaper.

Ted Clarke

Thanks Ted, I hope being able to continue with the hobby helps you on the road back to better health – Neil.

Aluminium Extrusions

Hello Neil, Here's something you may wish to bring to the attention of readers.

Octanorm is a supplier of aluminium extrusions largely to the exhibition stand industry. I came across a reference to them on a woodworking website and found that some of their profiles would be useful for woodwork fences, tee slots and the like. They will also cut to length.

Dave Fenner

We would love to hear your comments, questions and feedback about MEW

Write to The Editor, Neil Wyatt, Model Engineers' Workshop, MyTimeMedia Ltd., Enterprise House, Enterprise Way, Edenbridge, Kent TN8 6HF. Alternatively, email: neil.wyatt@mytimemedia.com

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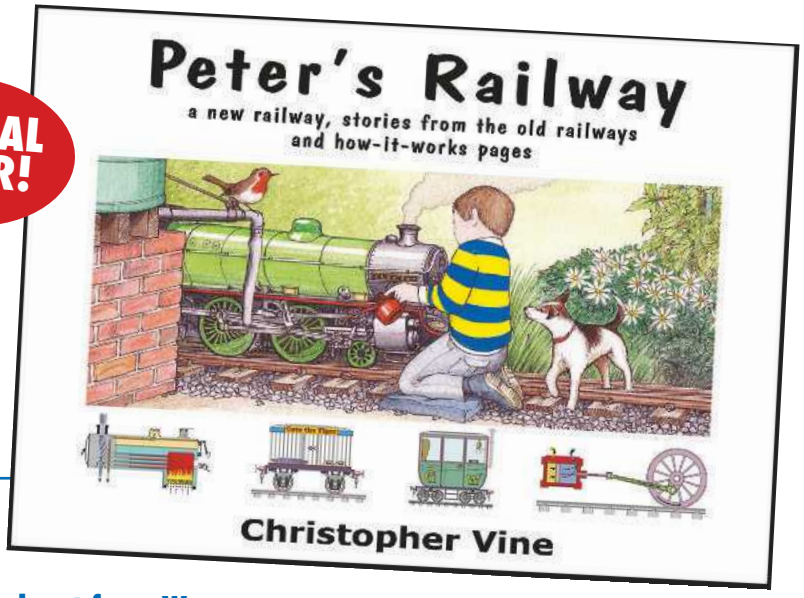


SPECIAL OFFER!

Peter's Railway Offer

Chris Vine has been in touch to let readers know about a special Christmas offer on Peter's railway book one – Peter's Railway. This excellent book is an ideal present for a bright youngster and at half price with free delivery, it's just £5.99, but you'll have to be quick! Visit **http://www.petersrailway.com/introduction.aspx** for details and ordering and also to download his free e-book Peter's Railway E-xtra!

Scarborough Model Engineering Group

Sadly the Scarborough and District Model Engineering Group, based at Yorkshire Coast College were short of members for their end of year programme. They are looking for new members to join them for an initial ten sessions in the New Year. They hire the workshop for two hour evening sessions and share the total cost. The workshop is very well equipped with big lathes and mills as well as welding equipment. There is plenty of friendly advice on hand. You can work on models or making your own tools and equipment for your home workshop – whatever takes your fancy. If you would enjoy the company of varied but like-minded fellow hobbyists, please contact Ted Fletcher via email **g4egb@yahoo.com** or on 01723 362537.

Rear Toolpost from Warco

Warco tell me that, due to customer demand, they have developed a flexible rear parting off tool and a vertical slide for their popular WM240/250 and 280 range of lathes.

A ground base plate locates on the cross slide tee slots, secured by a four point fixing. The base plate has a machined slot allowing the rear tool post tenon to engage, this arrangement ensures that the tool post remains rigid under load. The base plate also serves as a location for the vertical slide and an optional vice is available. Full details are available on **www.warco.co.uk**

The Midlands Garden Railway Show

Fans of the 'garden gauges' will be interested to hear of the 14th Midlands Garden rail Show to be held at Warwickshire Exhibition Centre, near Leamington Spa, on 14 and 15 March 2014. Regarded as one of the leading garden rail exhibitions in the UK, the Tyne and Wear themed layout, Hollowbeck Shed, has already confirmed attendance. Visit **www.largescalemodelrail.co.uk** for more details.

Machine DRO Engineers' Kits

Machine DRO have got some very nice measurement kits, featuring useful assortments of digital and traditional micrometers, callipers and other measuring equipment in very nice 'flight cases' as well as a couple of 'bundles' which had more items, but no case. Both the kits and the bundles are available with either their own brand tooling, or with top-notch Moore and Wright tools. The 'Digital Engineer Kit' contains a Moore and Wright digital set with a 150mm/6 inch digital caliper and a 25mm/1 inch micrometer. It's supplied in a fitted case for £95.89 (ex VAT).

Emergency Soft Jaws

Martin Gearing offers an inexpensive solution for awkward workholding.

As so often happens, this article came about because of my getting into a corner unexpectedly on a job with a tight deadline and budget. I'm sure it's not original but can't bring to mind seeing it in print elsewhere, and having used the method, found it so successful that I felt it would be of benefit to anyone requiring the occasional use of soft jaw facility for light work.

Nuts bored to fit over the existing chuck jaws.

Drilled and tapped for grub screws.

Soft jaws are a lifesaver whenever one has a repetitive job that has to run true and/or is of an awkward shape or section that makes it difficult or impossible to hold using conventional tooling. For the chucks found in most home workshops they are generally difficult to obtain, and even if available, relatively expensive, particularly when you consider that they are consumable in use.

To anyone that is wondering what soft jaws are and why anybody would want them? In brief they are jaws that fit to a 3 jaw self-centring chuck, but when new are rectangular in section (i.e. not having the stepped profile like the standard hardened jaws supplied) and as the description suggests are left soft. Because of these two features, it allows the jaws to be machined using standard tools to run perfectly true to any size within the capacity of the chuck and also to be machined to shape to suit specific needs.

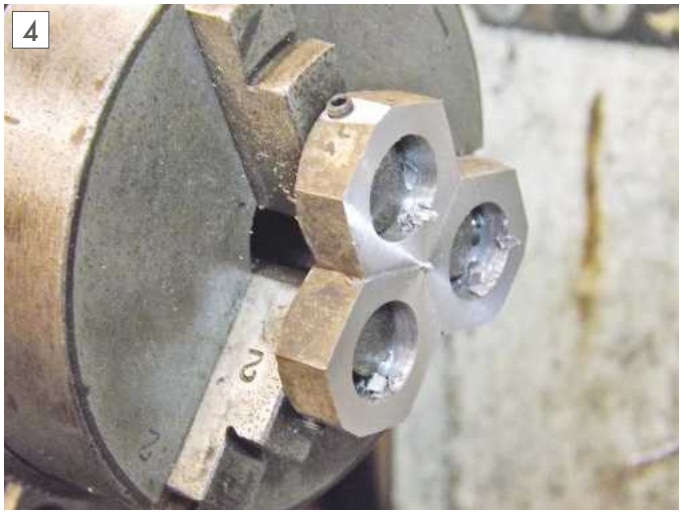
The procedure for making jaws to fit a 3 jaw was covered in an excellent article in *MEW* by Ken Thornton in issue 116. If one is organised and makes a number of sets when a bit of spare time is available, there is always a set in hand – but reality means I never have them. I'm not particularly organised and probably because of this never have any spare time!

The job that screamed 'Soft Jaws' was fitting phosphor bronze thrust washers to a pinion shaft to set the mesh and the end float. Eight were required in total, and the thickness varied between 3mm and 0.9mm. I'd turned the outside and inside diameters and made all of them to 3.5mm thick by parting off from the tubular blank. This guaranteed that they were all of uniform thickness and concentric, but the finish on the faces left a little to be desired.

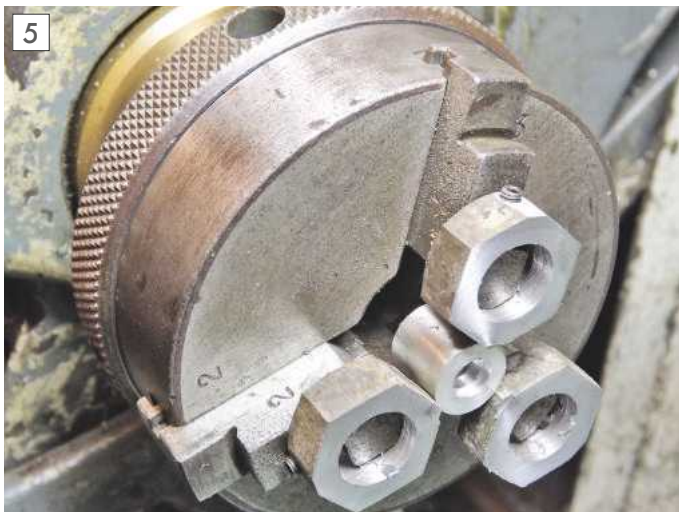
I now needed to hold them on the outside diameter to face off first one side to give a good finish, and then reverse the washer to face the second face off to size and give a good finish, whilst retaining a uniform thickness. This is why holding in soft jaws offered the fastest method of completing the task.

My method of adapting a standard chuck to give a soft jaw facility, was to take three nuts that were about two and a half times

Secured to the jaws and…



…faced to length.



Using a spacer to hold the jaws open.

Facing a washer held in the 'soft jaws'.

The job that screamed 'Soft Jaws' was fitting phosphor bronze thrust washers to a pinion shaft to set the mesh and the end float.

wider across the flats than the width of the jaws of the chuck I wanted to use.

These were bored out to a diameter about 1.5 times the chuck jaw width, and faced off square as in **photo 1**.

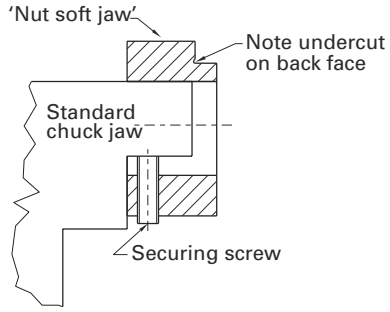
Taking each nut in turn, I filed a flat about 4mm wide, along the junction of two flats. Then 3mm in from the faced end, in the centre of the filed flat, centre punched, prior to drilling and tapping M3 (**photo 2**).

The nuts were then placed on the first step of the inside jaws. These are generally the most used - as they have the longest gripping face for holding on the outside diameter of small diameter round bar. After tightening down on the nuts, making sure that they had 'settled down' fully, 3M grub screws fitted in the previously threaded holes were tightened up fully (**photo 3**). Leaving the chuck tightened, the nuts were faced off all to the same length (**photo 4**).

The next operation was to open the chuck and check that all the nuts were still secure, before gripping a short length of round bar so that the jaws were opened to about 6mm less than the diameter of the thrust washers I intended to grip. This is necessary to ensure the scroll of the chuck is 'driving' the jaws in the same direction that they will be when holding the work, thus removing any backlash between the scroll and the teeth of the individual chuck jaws (**photo 5**).

A recess was then machined into the 'soft jaws' to the diameter of the thrust washer and to a depth of 0.8mm using a sharp boring tool. The diameter was taken in about 0.2mm further than the depth of recess, to produce an undercut. This meant that there was no radius left by the boring bar tip to prevent the face of the thrust washer seating firmly back against the face of the recess in the soft jaw (**fig 1**).

Finally, after removing the length of bar, the first washer was gripped in the recess and cleaned up on the first face, before turning around and facing off to the correct thickness (**photo 6**).



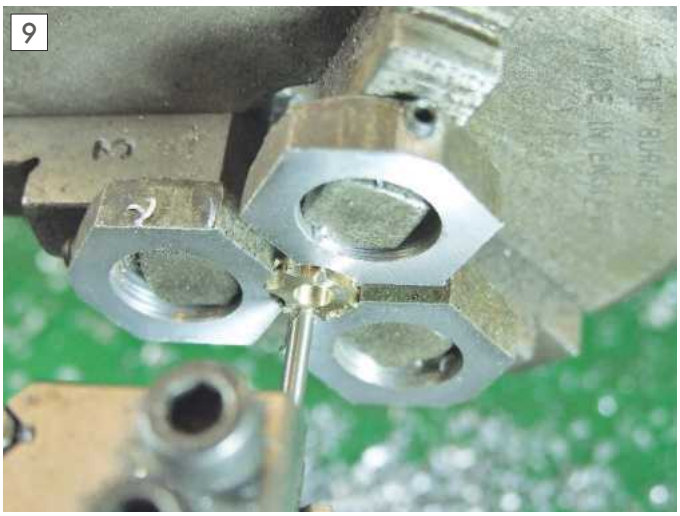
Recess On Back Face

Fig. 1

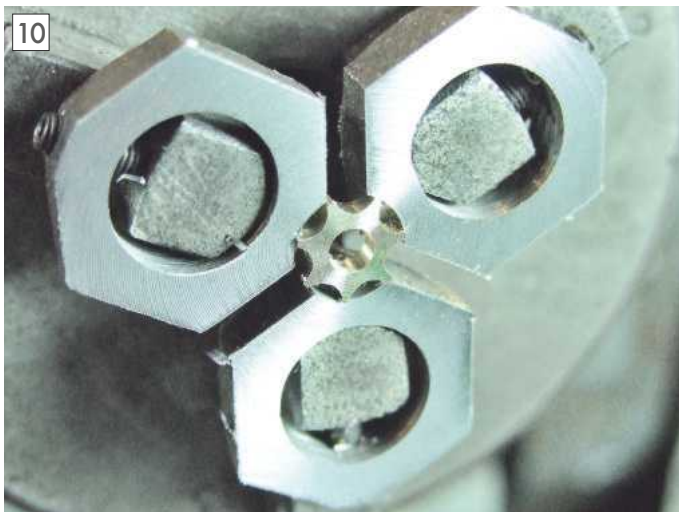
Later on the jaws were bored again using the same method for machining the recess to allow a pair of small seven tooth sprockets to be bored (**photo 7**). This time the ability to produce a recess with a diameter that was able to span two or more teeth meant that the bore was guaranteed to run true with the outside diameter of the sprocket teeth (**photo 8**). This was despite it having a number of teeth that were not divisible by three or four that would have enabled it to be held in either a 3 or 4 jaw chuck on or between the teeth (**photo 9**). The job took less than 10 minutes with excellent results (**photo 10**).

The tiny sprockets.

Boring a recess for the sprockets.



Boring a sprocket.



The end result.

Boring a washer to size.

Chamfering one of the spacers.

The two jobs took less than 20 minutes – a good deal less than it's taken to write about it!

A more common example of the use of soft jaws, were two jobs that cropped up a couple of days later. The first one being 40 washers, each requiring boring out to a larger size to suit a specific requirement.

Using the 'soft jaws' this job was painless, as after producing a suitable diameter and depth recess, it only required the washer setting in the recess against the back face before tightening up the chuck, and running the boring tool through. After adjusting to cut the correct size on the first one, the setting didn't demand any further attention (**photo 11**).

The second comprised 15 spacers that after having the outside diameter turned to size and drilled out undersize, prior to parting off, needed to be bored out concentric to the outside diameter. They also had to be made to a specified thickness and have a chamfer put on both inside and outside diameters at both ends. The soft jaws used in conjunction with a bed stop again made short work of the task. By virtue of the guaranteed concentricity and repeatability each machining operation was carried out in turn.

1) Each spacer was faced off one side.
2) The first spacer was faced off to the specified thickness, and when the size was achieved, the bed stop locked, and the remaining 14 faced off using the cross slide.
3) The boring tool was set to cut size on the first spacer, followed by each one in turn, in the same way the washers were machined.
4) A tool was set up to form the inside chamfer by feeding the saddle against the stop. When set, the remaining 27 chamfers where produced, simply by moving the saddle against the stop.
5) The tool was reset to form the chamfer on the outside diameter and the stop set before repeating the process for the remaining 27 (**photo 12**).

The two jobs took less than 20 minutes – a good deal less than it's taken to write about it! In case anybody noticed, the nuts I used were old wheel nuts retained from scrapped vehicles, but ordinary standard nuts produce exactly the same result. I used these as I have a drawer full and no vehicle to fit them!

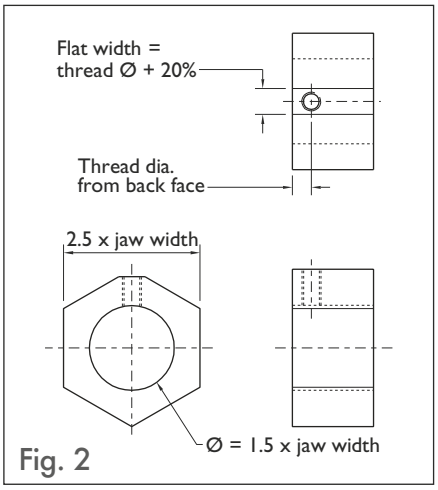


Fig. 2

As a general guide, I've included a drawing with proportions so that a nut of sufficient size can be selected but the dimensions are fairly tolerant (**fig 2**).

Provided common sense is applied regards depth of cut, the method is excellent for light machining, particularly of thin components, with the added advantage that if one, shall we say, 'pushes the envelope' and touches the soft jaw no damage is inflicted on the tool.

It is also applicable to large thin items if the 'Nut Soft Jaw' adaptation is fitted to the outer step of the outside jaw set. ■

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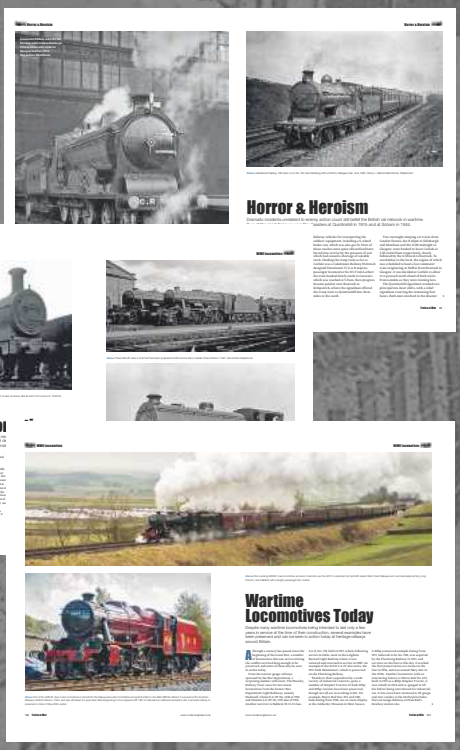

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Were you stumped by Peter King's Christmas posers? Fear not, here's how these challenges were tackled in real life.

1 The Big Bearing Race

Lay the ring on its side and level it as accurately as possible with shims and wedges. Find the centre and drill the concrete floor and fit expanding bolts to hold a suitable steel plate. Weld the plate to a column of 4 inch tube that has been precision ground. Shim the tube true vertical and central to the ring and bolt down, brace the top of the tube back to the floor outside the ring. Make a trussed arm greater in length than the radius of the ring with a sliding bearing to fit the vertical tube and means to micro adjust it up and down the tube. Make an attachment to accommodate a lathe grinding head, allowing fine feeds and adjustment for vertical and horizontal work. Set to grind the top face of the ring and put an apprentice to work pushing the arm slowly round in a circle, adjust grinder until top face is clean, flat and to final working width. Lift ring and turn over, re-centre and shim level. Set to again and grind the other face, then inside and outside of the ring whilst maintaining the air temperature to parameter. About 6 weeks for making each one.

2 Bend a Big Beam

Set up a simple jig with two supports and datum points to indicate the curve every 500mm, lowest in the middle. Set RHS in place centralized across the supports on edge. Get a gas torch and heat to dull red heat in bands starting from the ends. Expansion, stretching and its own weight will gradually form the RHS to match the datum points.

3 True a 400lb Flywheel...

Examine the flywheel and mark which side of what spokes needs to stretch. Take a ball pein hammer and peen the side that needs to be stretched, the blows should not be heavy, just lots sufficient to make a small mark. Rotate the flywheel with a DTI against the side of the rim from time to time to ascertain how much it has moved. Stop when it is true again.

4 ...or Take it off its Shaft!

Remove bearing caps, lift flywheel and shaft with a chain hoist clear of the bed. Put timbers under the shaft. Support the wheel with the chain hoist. Take one apprentice with tongs holding a brass tupp against the end of the shaft. Apply 14lb sledge hammer to tupp.

Blast from the Past

Engineering of the Future, Issue 1, Summer 1990.

Stan Bray, the first editor of MEW.

Editor Stan Bray 'visited a trio of major engineering exhibitions' in 1990 and was mightily impressed by the new technology he saw on offer. Here are a few highlights from his peek into a future which may now have arrived!

Stan was particularly struck by laser cutting: 'a tiny component, compared for size with a twenty pence piece, is cleanly cut and requires no further machining'. Although a lucky few have low-powered wood-cutting machines, metal cutting lasers are not yet a familiar sight in hobby workshops, however, many of us will have used laser-cut parts. Items such as the little gear sector that impressed Stan (**photo 1**) can now be obtained as one offs from specialist suppliers for little more than the cost of the raw materials.

This little laser cut part is still impressive today.

It was clear that computer-controlled machines had arrived in industry in a big way by 1990, and Stan reported that 'there were few machines on view that were not in one way or another electronically controlled'. Considering the importance of the 'digital workshop' today, there was a certain caution about the possibility of CNC invading our workshops: 'Fully computer controlled machines such as this lathe (**photo 2**) seem to have no direct application in the workshop – at the moment, at least…' on the other hand though he felt that 'digital read-outs on machines could be useful at home and this is something we hope to consider in future issues'.

Not everything reported on was computer controlled, 'plow-drills' raise a bush when forced through sheet metal and are still a specialist item rarely used by hobbyists. In contrast hand-held belt sanders are now easily obtained, although most of us seem to prefer 'Linisher-style' bench-mounted belt sanders. Finally, one exotic new technology was diamond files 'which retain their edge much longer than normal files'. Perhaps the glitter has rubbed off the diamond files, which now cost about the same as ordinary ones – I find them useful for intractable materials, but less pleasant to use than 'traditional' files.

One or two new innovations seem humdrum today – angle-adjustable v-blocks or magnetic bases for segmented coolant pipes are things to be found in every engineering supplier's catalogue.

So, looking back, perhaps this vision of the future in 1990 was reasonably accurate, but not particularly revolutionary. I wonder what a fuss a 3-D printer would have caused back in 1990? ■

This CNC lathe represented the future of engineering in 1990.

A Wall Mounted Chuck Holder

Barry Chamberlain offers a neat storage solution.

Changing chucks usually creates the problem of where to place or store the removed chuck.

Most lathe stands have storage shelves which require the user to bend down which, with a relatively heavy chuck and outstretched arms, is not ideal. The alternative is to place the removed chuck either on a shelf or on the work bench which, in my case, is normally somewhat short on space. Having toured other workshops I suspect this is the case for most model engineers and so I sought an alternative solution.

By trial and error I determined that a chuck holder set at 45 degrees and fitted at a comfortable height on the wall adjacent to my lathe would minimise lifting the chuck on removal/refit between the lathe and the storage holder.

Using four short lengths of 50 x 25 mm timber the holder was manufactured as per the drawing. The four pieces were clamped together and 3 mm pilot holes drilled to take three 90 mm long securing screws. The four pieces of wood were then glued together with Evo-Stik wood adhesive and secured, before the adhesive set, with the three screws.

The assembled holder was turned over and two wall mounting screw holes drilled 30 mm from the end as shown.

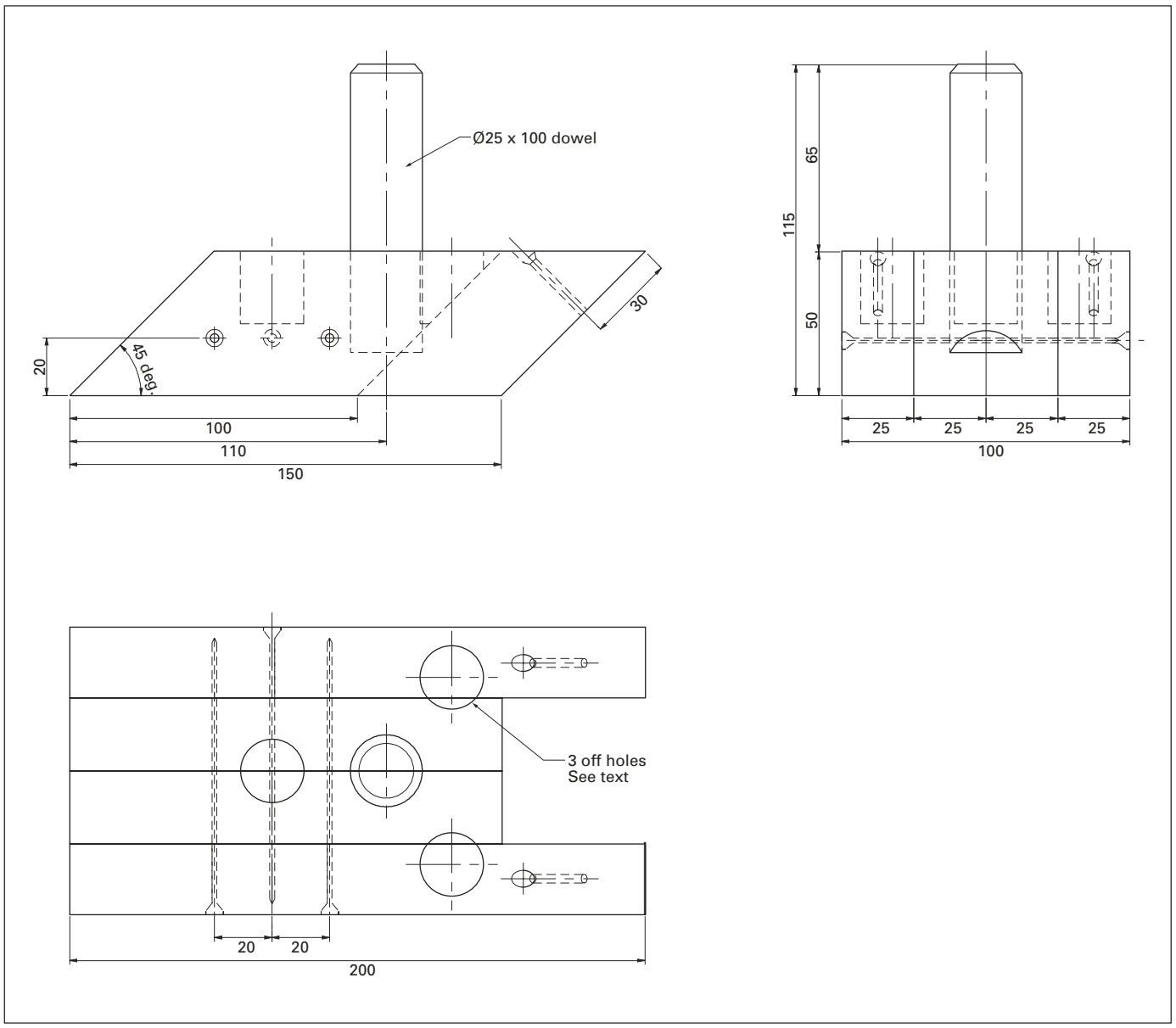
As per the drawing, a 25 mm diameter hole, 35 mm deep was drilled to receive the dowel. The dowel had been cut from a broom handle which, fortunately, management still hasn't noticed!

How the body is built up.

The dowel sits proud of the holder by 65 mm, sufficient that that the jaws of the chuck need to be partially opened when stored. Doing so ensures that the chuck will sit square and securely on the holder. Once the dowel was secured in place with Evo-Stik, the holder was held in the vice and the chuck was lowered over the dowel. The locations of the three mounting studs were established by witness marks on the wood. Noting the size of the mounting stud washers, three clearance holes were drilled sufficiently deep to clear each stud, washer and securing nut.

Finally after a bit of a rub down with sandpaper the holder was given a couple of coats of varnish to protect the wood from oil ingress. The holder was then screwed to the wall. The chuck key on my 3-jaw chuck has silicone covering the arms of the key which sits quite nicely against the wall, but the 4 jaw chuck key is plain so a couple of nails have since been added to hold the key clear of the chuck body.

Being narrower than the chuck the holder allows a comfortable and safe grip below the chuck body when handling the chuck. The drawing dimensions and prototype are based upon my 125mm chucks which should give a reasonable guide for producing similar holders for other chuck sizes. ■



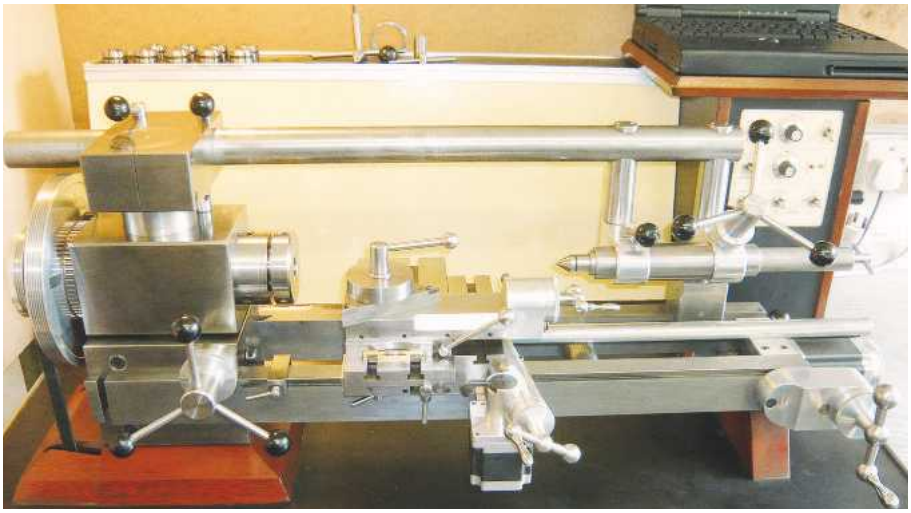
A holder showing key storage.

A finished Chuck Holder.

Stepperhead Lathe Construction Part 22

Alan Jackson's gold-medal winning Stepperhead Lathe series concludes with his reflections on using the machine.

This series details construction of my Stepperhead lathe although many aspects of the design could be incorporated into other lathes if so desired. The whole design is a series of modules or building blocks that can be adapted and used on other lathes.



The finished Stepperhead CNC lathe.

Assembly, Alignment and Set up

The general assembly is self-explanatory and has been referred to in the previous notes so I will concentrate only on particular details.

A 1 inch diameter test bar is required that fits into the mandrel and is concentric and in line with the mandrel axis. A piece of straight bright mild steel should be good enough, you have to be careful when you fit a steel bar snugly in a steel bore; lubricate it well before fitting. One of the worst circumstances is that it can scuff or pick up; virtually weld the two surfaces together. This can happen with other combinations of materials as well, it is difficult to quantify the actual conditions. Rough, dry surfaces in soft materials seem most liable and hard smooth lubricated the least. This is about all I know on the subject and this is not a treatise on it. So make sure the bore and test bar are good smooth lubricated surfaces. A few times it has happened to me when I have been turning something and trying it for a fit. It slides on just right then gets stuck; becomes difficult to separate because separation seems to increase the scuffing. Often later inspection shows only a small zone involved. So be careful.

With the saddle and crosslide adjusted and operational it is now possible to align the mandrel and overarm to the lathe bed. Ensure that the triangular gib is adjusted for a close sliding fit and use the top gib clamp screw to lock the column firmly in the bed block. A clock gauge with a magnetic base, preferably a tenths clock or the metric equivalent is mounted on the cross slide with the gauge set horizontally at the centre of the test bar. Adjust the mandrel bearings to run freely with no play at the test bar. I do not think you need to preload the bearings, this is always difficult to measure and overdoing it will lead to bearing failure as well as additional rotational resistance. Of course the headstock must be locked to the vertical column with the clamp screws just nipped up for this operation.

The mandrel pulley can then be added and its retaining nut fitted hand tight. The clock gauge is positioned on top of the overarm block to check the axial run out of the pulley. Rotate the pulley and check the axial run out. Tighten the three grub screws in the pulley nut in an order to minimise the run out until they are all nipped up. If you have machined it all carefully you should be able to get the run out down to about 0.005 inch or less. Replace the clock as before on the cross slide and run it along the horizontal length of the test bar noting the reading. The head stock clamps can now be slackened and given a tap axially to free them. A long piece of 1 inch steel bar is placed in the rear end of the mandrel.

The headstock can then be lined up with the bed by tapping it in the direction required with a mallet. Tighten the head stock clamps just enough to grip the column. Aim to get this alignment as good as possible; but remember that you can always return later to improve it. Once you are happy with this you can tighten the clamps and check finally that nothing moved.

Now check alignment with the clock along the top of test bar. This is an acid test on how good the headstock and vertical column have been machined at right angles to each other. It also is measuring the squareness of the bed bars to the vertical column. If it was machined dead square there should be little run out (less than 0.005 inch over say 10 inches or better). If it is more it should be corrected. It is difficult to determine were any error is. Either the mandrel is not square or the bed bars are not square or both. You could remove the triangular gib and rotate the headstock 180 degrees reposition the test bar in the other, (rear) end of the mandrel, and check the vertical alignment along the top of the test bar again. This will show that if the error is the same it's the bed bars that need correction by careful scraping at the dovetails. This all sounds rather drastic and will hopefully not be necessary. I was rather pleased to find that my machine had a vertical run out of about 0.002 inches over a 12 inch length, which I was very happy with.

Assuming the vertical alignment is ok. The next step is the overarm alignment.

The overarm should be extended with the tailstock bore holes vertical. The overarm clamps should be tight on the overarm and just nipped on the vertical column. The clock gauge is placed on the cross slide to check and adjust the overarm's horizontal alignment by traveling the accessible overarm's length with the clock contacting the side of the overarm. Aim to get as good an alignment as possible (Lowest movement of the clock needle) after which the overarm clamp block can be locked in position. Check again after tightening the locking screws to ensure nothing has changed. Then check the vertical alignment, which

again depends on the squareness in machining the two right angled bores of the overarm block.

When all is well it is now possible to assemble and Loctite the tailstock parts together and in line with the mandrel axis. I must confess I did not do it this way so you are getting the benefit of hindsight, but I wish I had. In my eagerness to see results I aligned and Loctited it more crudely and spent ages correcting the errors so be warned. It was only on reflection that it occurred to me this would be a much better way.

The tailstock barrel is fitted in the tailstock sleeve and clamped with maximum protrusion forward. The tailstock sleeve, with the front and rear members are assembled on the tailstock tubes to the overarm. The front and rear members will have already been Loctited in position and the bores for the clamp and rack machined. The tailstock vertical column and bed clamp block are installed in position with the bed and column clamps left loose. The tailstock assembly is then moved up close to the headstock by sliding the overarm along in its block and the tailstock barrel is slid into the mandrel bore. The vertical adjustment for the overarm will probably also need to be set by slackening the overarm block clamp screws to the vertical column and raising or lowering the overarm block.

You will probably need two pair of hands (That is a minimum of four hands) and a good supply of patience but that's the plan. The bed clamp is clamped to the bed and the tailstock vertical column rotated to get the best alignment. You will probably have to clamp and unclamp the various clamps as you adjust everything in order to get the desired alignment. The tailstock tubes can be rotated to align the barrel and the overarm can be unclamped at the main column to rotate the overarm to get the tailstock tube bores vertical. When you a happy with the alignment, mark the tailstock tubes (with a felt tip marker) so that they can be removed and replaced in the same positions.

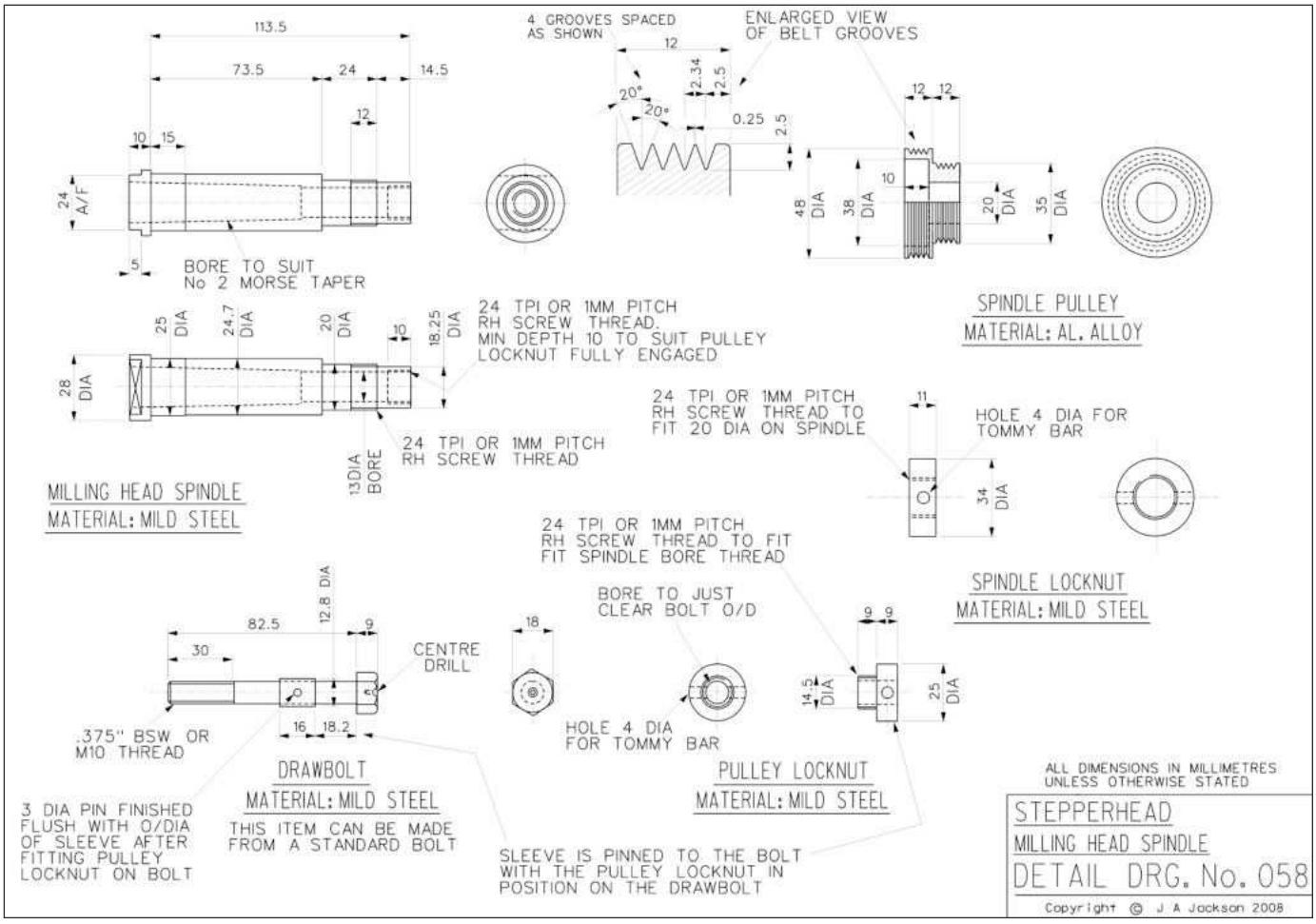
The assembly can then be retracted from the mandrel and dismantled for Loctiting. You should check the Loctite or equivalent data sheet for setting time etc. I used Loctite 603, which has a setting time around 10 to 30 minutes approx. So apply the Loctite and reassemble the parts then slide the overarm close up to the mandrel and insert the tailstock barrel into the mandrel bore. All the clamps should be tightened while the Loctite sets.

A final check should be made on the tailstock barrel by retracting the overarm and tailstock and checking the tailstock barrel for vertical and horizontal parallelism with a clock mounted from the cross slide via its magnetic base. Check to see if locking and unlocking the various clamps affects the alignment. Ideally there should be no input from clamping and unclamping. If a clamp does deflect the barrel too much it should be investigated and corrected.

Only when the main motor and inverter installed and the machine is up and running is it possible to finish machining the mandrel nose as shown in Drawing 16. The collet and other chuck back plates can then be finalised and mounted on the mandrel nose for finishing concentrically.

The collet chuck body is now machined to fit on the mandrel nose. This will be machined on your usual lathe. The 7 degree tapered recess should be carefully opened up to fit the mandrel nose. Check against the mandrel nose using marking blue to get a fit whereby the taper fits into the recess allowing only about 0.002 inch clearance at the flange faces which are nipped up when the chuck is fitted to the mandrel nose. You will have to remove the chuck and collet chuck body from your lathe mandrel or remove the mandrel from the Stepperhead headstock or pre-make a reference master to achieve this. The camlock fitting is fairly unforgiving and does require accurate machining to work correctly. There is little room for adjustment if the tapered bore is made too big, it will require a lot to be cut off the face to correct it. This procedure is required for each chuck fitting. So it is a good idea to machine all the chuck backplates at the same setting if at all possible. This of course means the expenditure of buying a 3 and four jaw chuck.

The collet chuck body, or backplate, is then drilled for the camlock chuck studs and retaining screws. The chuck studs are screwed into the body so that the body is retained firmly on the mandrel nose when the camlock lock pin is rotated clockwise from between a 100 degrees to 170 degrees from its unlocked position. Screw the camlock chuck stud in or out in full turn increments to achieve this. When you are happy with the result the M3 socket head cap screws are fitted to prevent the chuck stud from unscrewing.



The chuck stud does not fit tightly into the chuck body there will be some slight movement which is ok. If a particular stud will not adjust very well you can try swapping the chuck studs, this may well fix the problem. This procedure will be required for each chuck fitting.

A check can now be made for the cross slide squareness to the lathe bed.

Assuming that the mandrel is set parallel to the bed axis, a clock can be mounted in a chuck on the mandrel. An extended bar at right angles to the mandrel axis should allow the clock mounted on this bar to sweep over a reasonable arc. Note the clock reading in two points on the front face of the cross slide, which ideally should be the same. To correct any out of square errors the saddle will have to be removed and the inner face that contacts the bed bar scraped to achieve the desired squareness. Try to achieve somewhere between zero to 0.002 inch in the concave direction over say 100mm or better. This ensures that a turned faced off surface will not be convexed.

Setting up the Stepper Motors

This will depend to a large extent on the CNC system chosen. The CNC system will most certainly supply comprehensive set up procedures for the whole system and their recommendations should be adhered to. There is also extensive information available on the Internet where CNC forums discuss and give detailed instructions on methods and problem solving. This is your lifeline and support help desk.

Stepperhead Operation Notes

Until another Stepperhead is built you only have my biased opinion on its capabilities. I would say that it is surprisingly rigid compared to similar size lathes.

I think headstock and mandrel add much to this. I expected that the headstock being attached to the bed via the vertical column would be detrimental to the overall rigidity but I have not noticed it. Conversely one could argue that when the vertical column clamps are tightened, plus the additional stiffness of the overarm connecting to the bed, provides as rigid a mounting for the headstock as any conventional bolted arrangement. I have easily parted off 1 inch mild steel bar without any hint of distress or chatter and have purposely turned parts extended further from the chuck than is sensible with no hint of chatter. The saddle drive works very well, I can make a deep cut on manual or power feed and wind the tool slowly back without a fine additional cut being added due to spring (or saddle racking).

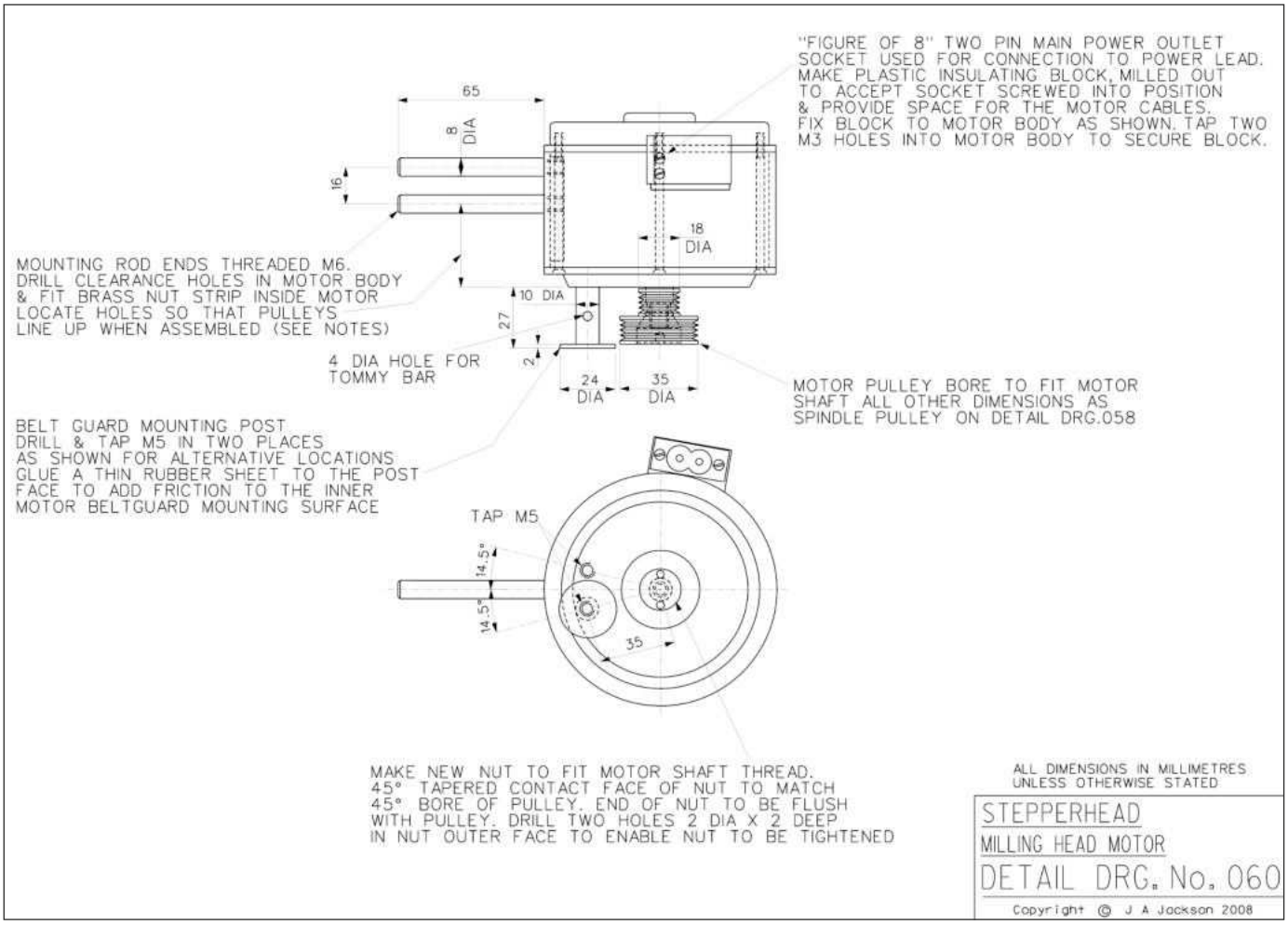
I am going to claim that this is due to the saddle drive leadscrew position moving the saddle without importing too much twisting moment although this is difficult to prove.

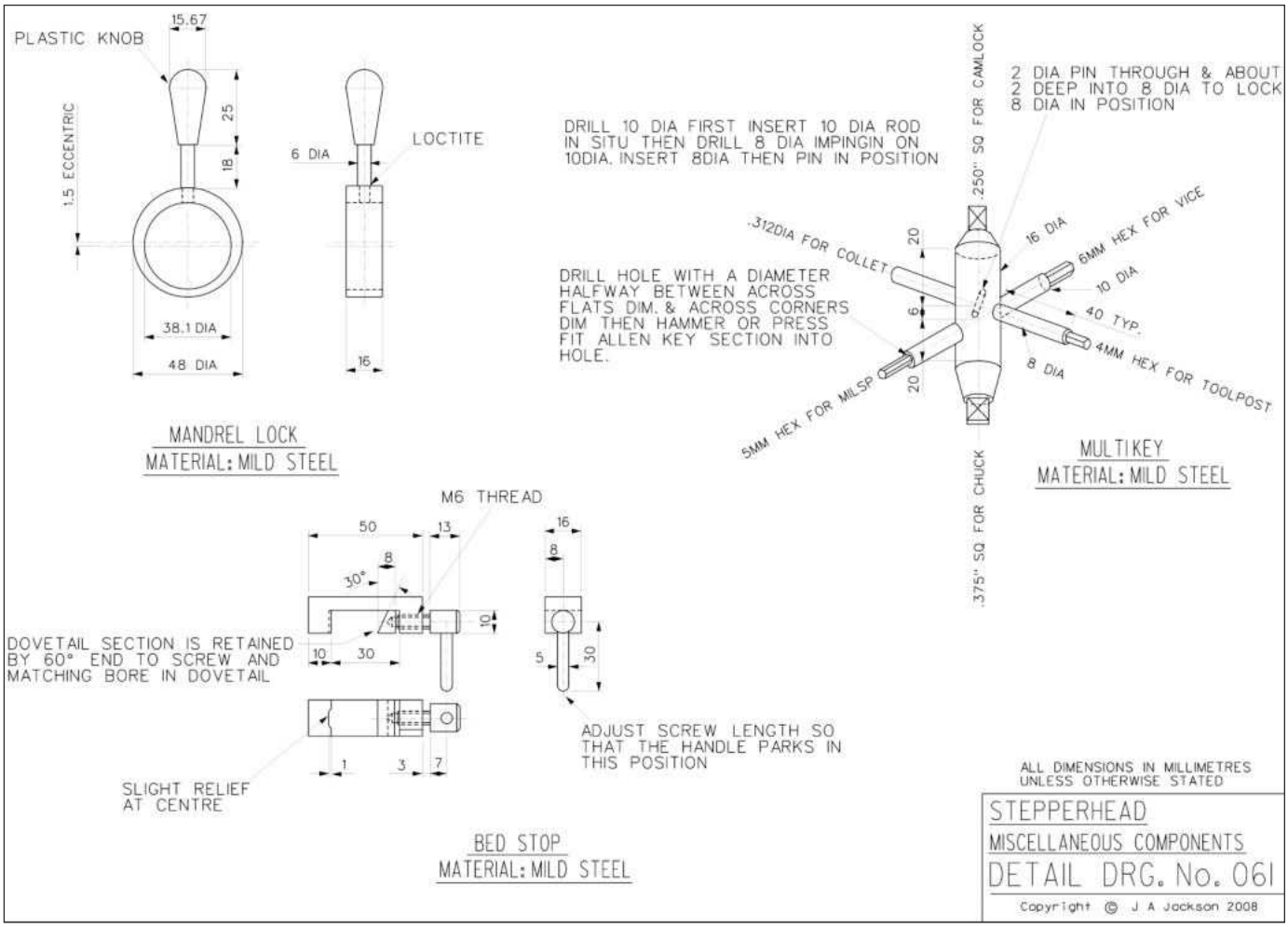
It is after all a test bed incorporating many untried and unconventional features and my first experience with CNC, stepper motors and electronic control. I have got used to the presence of the over arm, it does not seem to restrict or hinder operation. The overarm is also very useful for attachments etc. The gains in rigidity provided by the overarm being locked to the bed and headstock are quite palpable. The topslide can be moved anywhere on the cross slide. Full use of this is realised when say turning a steep taper. The topslide can be positioned so that the cutting tool is past the centre of the component being made and the lathe run in reverse. This enables easy access to the top slide handwheel whereas normally the topslide will be positioned awkwardly close to the chuck. One is spoilt for choice here because this same operation can also be done with CNC control by setting the X and Y axes to move in unison to generate the same taper and at a controlled feed rate if required.

I am very happy with the TurboCNC control programme. It can do everything I require. Although it is only a DOS programme and seemingly quite basic it is easy to operate and set up and it works well with the older and inexpensive lap top computers that have parallel port.

I have even evolved a screwcutting method whereby the CNC programme controls the screw pitch and length of thread but the screw thread depth control is manually applied ahead or during the cutting operation. This is very useful for one off operations, which are generally, for me, most of the time.

One comforting aspect of a Manual/CNC mix is to be able to set up for a CNC based operation and dry run through the program





with the cutting tool away from the material being cut. This can also be done on full CNC but the advantage is that when satisfied with the programmed operation, the tool can be gradually advanced to come into play with say the topslide handwheel. This gives a feeling of control over the electronic mindset rather than it doing what it wants without your permission. I am sure dedicated CNC people will laugh at this but it works for me.

The computer replaces the gear train and gearbox that normally drives the saddle and cross slide. The choice of feeds, screw threads, tapers etc. is infinite and instant. I like to think that it may also cross the learning gap between manual and CNC operation because of its cross gender multi-purpose features. (This assumes that manual and CNC operatives have genders – but let's not go there.)

The plus points are: The stepper motor driven headstock makes dividing easy and error free. The requirement for countershafts, clutches, back gears, lead/feedscrew gear trains, screwcutting/feed gearboxes, tumbler reverses and jockey pulleys are eliminated.

This allows the main drive motor to drive the mandrel only. Smoothly, quietly, without power loss and unwanted, secondary, inputs from ancillary drives, which can and do affect surface finish. The Taper roller headstock is grease lubricated avoiding constant attention.

Various attachments can also be to be added to increase Stepperhead's versatility. The overarm provides a useful attachment point for potential devices. I have added a boring and facing head and a keyway cutting attachment that also provides the basis of a ball turner and a rotary broach.

A small lever operated drilling attachment could also be very useful; perhaps using the existing milling head on a sliding base for instance and /or a third axis for a CNC milling head.

There are of course alternative permutations of this design. It would be quite feasible to fit the horizontal overarm and integral tailstock to a conventional fixed head lathe. The tailstock also gains in rigidity by being fixed to the lathe bed and headstock via the overarm. This would then provide a rigid horizontal arm to mount a milling head and other attachments. The saddle then gains additional movement along the bed under the tailstock barrel and avoids the saddle having a notched cut-out to clear the tailstock thus enabling more use of the lathe bed. The Stepperhead leadscrew, saddle and cross slide configurations could also then be used with advantage. The fixed height overarm/tailstock assembly would also add stiffness to the headstock and bed and tailstock, all good things for lathes.

At the 2012 M E Exhibition I entered the lathe as part of the SMEE Workshop. One of the many questions I was asked was why was the construction article so lacking in general description of the Stepperhead lathe. I could only reply that they look up *MEW* 151,152 & 153 published in 2009, where a complete description was published. So I tried to minimise repeating this text in the construction article.

Congratulations to anybody who builds a Stepperhead. I hope you will be pleased with the result, but of course cannot surmise how you will judge it - for me it's fingers crossed. I would like to thank *MEW* and it's editors for taking a risk and publishing this long construction series and beg for tolerance from all those who had no interest in this subject, clogging up their magazine. But you never know, it might have created a few converts. Looking through the advertisements in *MEW* of available lathes it seems to me that, apart from variable speed being available on some machines and chuck mounting improvements, little has changed in the design from about 1960. The available models still represent what was made for machine shops of that time and earlier, with hardly any accommodation for the variety of operations that a home workshop requires. I know I will be shot down for these last comments, but with the advances in technology that have been made since then, it would not be a bad thing for some of this to be incorporated into the new machines. In fact I think it would be a step ahead.

Further technical information on Stepperhead including CNC initialisation files, stepper motor settings and a materials list are available on our website at **www.model-engineer.uk** – select 'workshop' from the black menu bar, them choose machines from the drop down menu. Stepperhead will be near the top of the list of articles. ■

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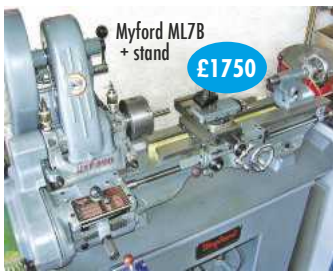
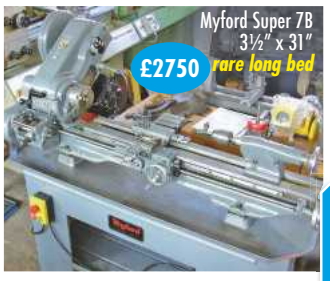
10 minutes from M25 - Junction 3 and South Circular - A205

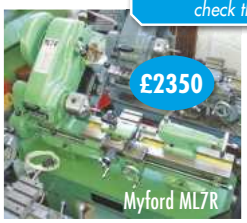


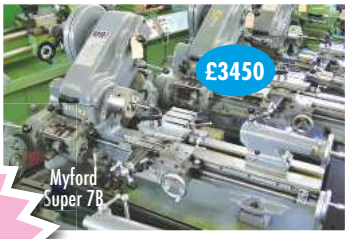


Models
- 3½" RobRoy chassis, castings, plans etc. £475
- 5" Pansey chassis, castings, plans etc. £750

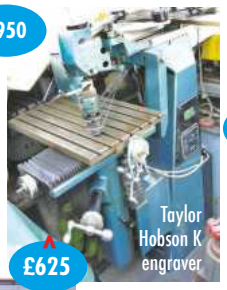
MYFORD GENUINE PARTS
Running out fast!!
Purchased from Nottingham
check the web site for full list!

A Perfect Christmas Gift!





OPEN DAYS
10am – 4pm
Monday 29th and Tuesday 30th December
Check our web site for details!



PLEASE PHONE 0208 300 9070 TO CHECK AVAILABILITY OR TO OBTAIN OUR LIST
DISTANCE NO PROBLEM! • DEFINITELY WORTH A VISIT • ALL PRICES EXCLUSIVE OF VAT
Just a small selection of our current stock photographed!
We are currently seeking late `Myford Super 7B´ & `Super 7 large bore´ model lathes!

SHIPPING WORLDWIDE

CHESTER
Machine tools

Clwyd Close,
Hawarden Industrial Park,
Hawarden, nr Chester
CH5 3PZ.

ORDER LINE: 01244 531631

For those who can not make it to our Winter Open Week (1st - 5th December), We will be at the London Model Engineer Exhibition at Alexandra Palace 16th - 18th January 2015

SOFT JAWS

80mm
Was: £35 NOW £29
100mm
Was: £38 NOW £32
125mm
Was: £41 NOW £35
160mm
Was: £47 NOW £39

Other Sizes Available

BANDSAW BLADES

Carbon, 14TPI to fit H80 £14.50
Bi Metal 18TPI to fit H80 £16
Carbon, 18TPI to fit H110 £12.60
Bi Metal, 14TPI to fit H110 £17.20

Other Blades Available

STRAIGHT SHANK TWIST DRILLS

Available In Metric 1mm - 12.5mm & Imperial 1/16" - 1/2"

END MILLS

Available In Metric & Imperial

5pc INDEXABLE REPLACEMENT TIPS

1/4" / 6mm Was £18.80 NOW £15.60
5/16" / 8mm Was £18.80 NOW £15.60
3/8" / 10mm Was £20.60 NOW £17.00
1/2" / 12mmWas £20.60 NOW £17.00
5/8" / 16mm & 3/4" / 20mm
Also Available

INDIVIDUAL STEEL FOR FLY CUTTERS

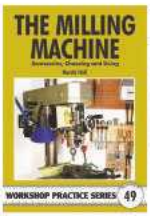
Was: £2.13 3/16" £1.80
Was: £3.92 5/16" £3.30
Was: £2.78 1/4" £ 2.30
Fly Cutters Sold Seperately

CONQUEST LATHE TOOLPOST HOLDERS

Was: £12.24
£10 each

SLOT DRILLS

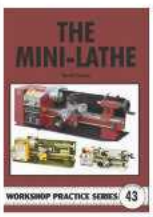
Available In Metric & Imperial



The Milling Machine

This book deals with the process of choosing & using a milling machine & its accessories. In addition to the machine itself, the accessories include cutters, cutter chucks, clamps, vices, angle plates, rotary tables etc.

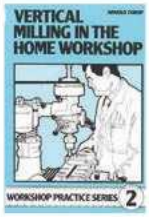
£ 6.95



The Mini-Lathe

This book is a complete course on using & improving this new generation of lathes. It explains everything from setting up & tuning the machine for best performance to using and 'tuning' the machine.

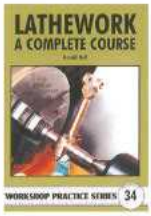
£ 6.95



Vertical Milling In The Home Workshop

This 3rd revised edition includes descriptions of many of the very wide range of operations possible with photographed examples, plus info on machines, accessories, sutters, chucks etc.

£ 7.50



Lathework, A Complete Course.

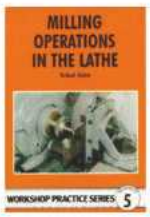
This book assumes no previous experience & using the medium of 12 lathe turning projects will lead prospective model engineers through all the basic techniques needed to tackle ambitious projects.

£ 8.75

Screwcutting In The Lathe

One of the most useful functions of the modern lathe is its ability to cut any form of extrenal & internal thread of any thread form, pitch or diameter within the overall capacity of the machine

£ 7.50



Milling Operations In The Lathe

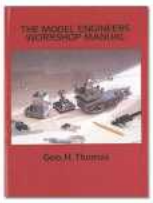
One of the most popular titles in model engineering books for almost 60yrs was milling in the lathe, which 1st appeared in the 1920's & continued in updated & revised editions until 1983. This book replaces it.

£ 7.50

Milling A Complete Course

All of the projects within this book are extensively illustrated & include full workshop drawings. Once followed through, the reader will have amassed a wealth of practical skills.

£ 7.50



The Model Engineers Workshop Manual

The 3rd book by highly respected author George Thomas will undoubtedly become the bible for both novice & experienced alike. containing over 300 pages on most aspects of machining.

£ 26.35

BELT & DISCS

1" x 5" Belt & Disc Sander
BELTS: Was: £8.40 NOW: £7.00
DISCS: Was: £12.00 NOW £10.00
Both available in 80#, 120#, 180#, 240# Grit

4" x 6" Belt & Disc Sander
BELTS: Was: £8.40 NOW £7.00
DISCS: Was: £8.40 NOW £7.00
Both available in 80#, 120#, 180#, 240# Grit

COOLANT

Coolant / Cutting fluids are used in metal machining for a variety of reasons such as improving tool life, reducing workpiece thermal deformation, improving surface finish and flushing away chips from the cutting zone.

1 Litre WAS: £10.36 NOW £8.60
5 Litres WAS: £30.34 NOW £25.00
25 Litres WAS: £157.24 NOW £131.00
(25-1 Mix)

Dont forget we also sell Coolant Systems, hoses & Hose Fittings

BI-METAL HOLE SAWS

Items below 32mm / 1-5/16" have a 1/2" 20UNF bore.
Items above 32mm / 1-5/16" have a 5/8" 18UNF bore.

9/16" / 14mm £2.38
5/8" / 16mm £2.53
11/16" / 18mm £2.81
3/4" / 19mm £3.06
13/16" / 21mm £3.18
7/8" / 22mm £3.35
15/16" / 24mm £3.48
1" / 25mm £3.67
1-1/16" / 27mm £3.79
1-1/8" / 28mm £3.98
1-3/16" / 30mm £4.32
1-1/4" / 32mm £4.47
1-5/16" / 33mm £4.76
1-3/8" / 35mm £4.89
1-7/16" / 37mm £5.09
1-1/2" / 38mm £5.20
1-9/16" / 40mm £5.33
1-5/8" / 41mm £5.54
1-11/16" / 43mm £5.67
1-3/4" / 44mm £5.86
1-13/16" / 46mm £6.07
1-7/8" / 48mm £6.31
2" / 51mm £6.53

E&OE