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SEPTEMBER 2016

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A complete guide

CNC

Complex shapes with Marcus Bowman

COVER FEATURE

ROD JENKINS ON THE LAMMAS HARDNESS TESTER

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MODEL ENGINEERS' WORKSHOP

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On the Editor's Bench

Dr Giles Parkes

Giles Parkes died recently aged 83. Giles was a General Practitioner, following in his father's footsteps, in a practice near Crewe until ill health forced him to retire early and concentrate on his many interests in engineering.

Many readers will remember Giles demonstrating gear cutting and hob relieving on workshop stands at several annual exhibitions, Donnington, Leamington Spa etc. He was always patient: willing to answer questions and explain what he was doing with his much modified Jacobs Gear Hobber. This machine started as a set of castings supplied by Helix Engineering, owned by John Buckley, but over the years it became more and more complex as he strove to make improvements, particularly to cut accurate helical gears.

Giles had some involvement in making gears for the 12-year reconstruction of the Bletchley Park Bombe, a war time mechanical code breaker which finally ran in July 2007. There were timing problems when the machine was first run and a stroboscope revealed some of the gears, cut with a dividing head, were not accurate enough. This machine now runs almost daily and there were fears that it would wear out. Giles was asked to make a backup set.

Over the years Giles wrote a number of articles for this magazine on Gear Hobbing and making gear hobs. He made many "specials"; both hobs and gears and was generous in the gifts of his time and products to help restorers of clocks, cars etc.

Giles latterly had an extensive workshop near Newbury, mostly equipped with British machines. His pride and joy, however, was a wartime import, a USA Barber Coleman Gear Hobber, which he got going again. He was a member of SMEE and the Andover and District Model Engineering Society.

Mike Haughton

On My Bench

I haven't yet done any machining of the kittiwake castings although I have made a start by painstakingly reconstructing the drawings from scans of the very delicate old blueprints and, as mentioned last time, cleaning up the castings. Many of the castings had a dark, hard layer of corrosion, treatment with a nonacidic/alkaline corrosion removed helped a bit but still left me with the most resistant parts requiring mechanical removal. On flatter surfaces I was able to make slow, slow progress with a Scotchbrite pad assisted by the corrosion remover. I then tried a rotary brass brush in a Dremel. A steel brush is no good; as well as being too harsh bits of steel would have embedded in the alloy and later corroded. This worked quite well, but was still rather slow – after half an hour's work one half of the crankcase looked better, but still had bad contamination in all the nooks and crannies the brush could not reach. It was also unpleasant work requiring both googles and a facemask to keep the aluminium dust at bay.

Fortuitously, I was asked by Alan Ward of Allendale/Machine-DRO to try out one of their ultrasonic cleaning tanks. There will be more detail of this machine in the next issue, but for now it will suffice to say that the combination of an aluminium-compatible corrosion remover and ten minutes in the ultrasonic tank was sufficient to get the castings looking like they had just come out of the mould. I wasn't able to detect any damage to machined surfaces, the only negative being that some small patches of porosity appeared where bits of sand were dislodged from the casting.

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DIGITAL CALIPER WITHIN 100mm
OPERATING INSTRUCTION

Coming up...

in the October issue

Once you have enjoyed this issue, look out for the next, packed full of more tools and techniques!

Regulars

ON THE COVER

Reader Rod Jenkins made this fine example of the Lammas Hardness tester, see the full story on page 28.

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Many amateur astronomers may be surprised to learn that the inventor of the Crayford Focuser wrote a constructional article , with plans, for Model Engineer, having decided not to patent it. Read the article at: **http://www.model-engineer.co.uk/news/article/the-crayford-telescope-focuser/23813**

Hot topics on the forum include:

■ **CNC'ing an SX2P Mill**
John Stevenson blogs a CNC conversion from the Bodger's Lodge.

■ **What is this please?**
Can you help identify these mystery tools inside their neatly made cases?

And:

■ **Stafford Mobile Pup Auto Scooter**
Never heard of one? There may only be a handful left in existence but one of our forum members has two and would like to track down the others.

PLUS:
Visit **http://www.modelengineershow.co.uk/** for the latest news about the 2016 Model Engineer Exhibition at Brooklands.

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CNC in the (Model Engineers') Workshop

In this instalment Marcus Bowman looks at using CNC to produce irregularly shaped curves – an area where CNC excels.

CNC in the Workshop part 10

This series of articles started from fundamentals and covers many aspects of CNC programming and machining. The series is not specific to one make or model of machine tool. There is a support website for the series at www.cncintheworkshop.com

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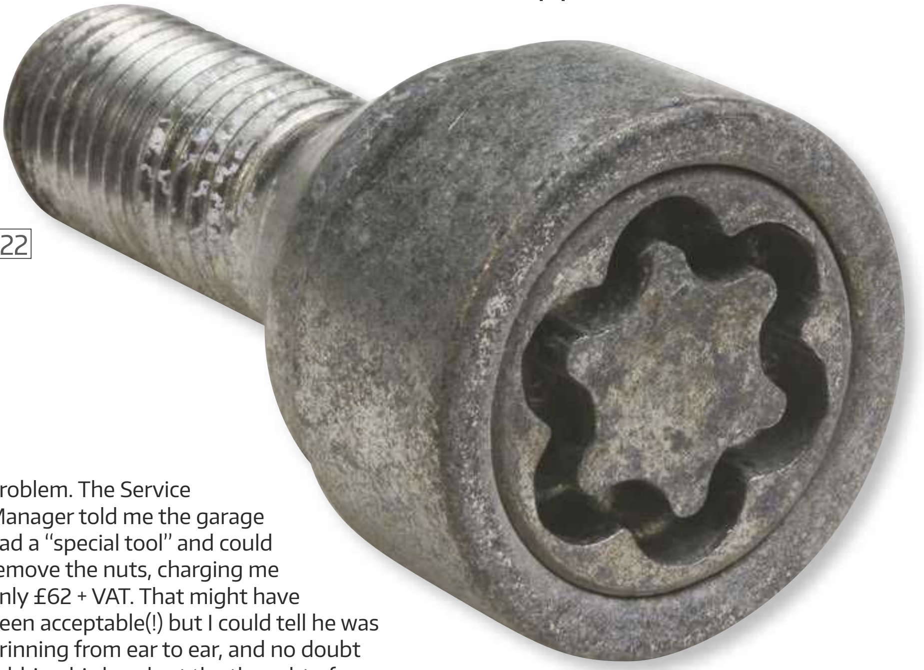

A locking wheel nut. The key has a projecting ridge which matches the groove in the nut.

Wheel Nuts and Soleplates

It is easy enough to draw a machining path when the precise dimensions of a piece of work can be read from a plan. It is also relatively straightforward to draw a machining path if you can accurately measure an existing object you want to copy. It's not so easy to copy a shape which is difficult to measure, or where a mating component is impossible to reach. In those cases, some work-arounds may help capture the shape of the object, and a scanner may allow a machining path to be seen and drawn. This can help with some awkward jobs.

Unlocking nuts

My wife's car was due a service and an MOT, so, the night before it was due at the garage, I tidied up inside to make it look as though it had been cared for. As I walked away I noticed it needed two new front tyres. No surprise there. But as I looked at the tyres, I realised the wheels had locking nuts, **photo 122**. A quick look in the boot and the glove compartment did not reveal the unlocking socket, and panic quickly set in. In fact, neither my wife nor myself could remember being given the unlocking socket when we bought the car which was some 18 months old at the time. It has been for a service and an MOT before, so there are a number of possibilities which might explain why we now had no means of removing the wheels.

The following morning, I phoned the garage, to be told this was a familiar problem. The Service Manager told me the garage had a "special tool" and could remove the nuts, charging me only £62 + VAT. That might have been acceptable(!) but I could tell he was grinning from ear to ear, and no doubt rubbing his hands at the thought of more easy money from yet another careless customer. Sorry; not this time. Not every customer has a CNC mill. So, how did I solve the problem, impress the family, and gain a far-from-quiet sense of satisfaction when I turned up at the garage later that week, locking nuts having been removed without damage to the wheels?

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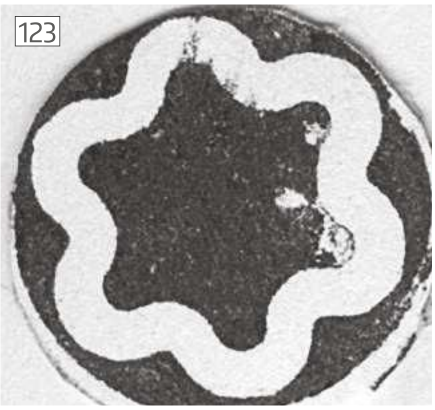


Painting the face of the nut with layout blue then pressing a paper disc onto the nut resulted in a clear image of the groove

Capturing the shape

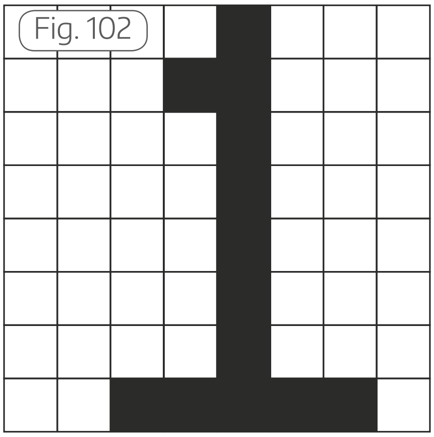
The locking wheel nuts are flat ended and carry a thin irregular groove in the end face, **photo 122**. The unlocking "key" needs to carry a matching projecting ridge.

The nuts were on the wheels, and sat in a deep recess, so that the only real means of removing them was to use a key. They were too deep for a hacksaw, a punch or a chisel, and the recess was too narrow to allow a stud to be welded to the face.

What I needed was an accurate drawing of the groove, so I cut a small circular disc out of thin card, and glued it to the end of a piece of dowel. I painted the end face of the nut with marking blue, then carefully pushed the card firmly against that face and withdrew it as cleanly as I could, leaving me with an accurate record of the shape of the groove, **photo 123**.

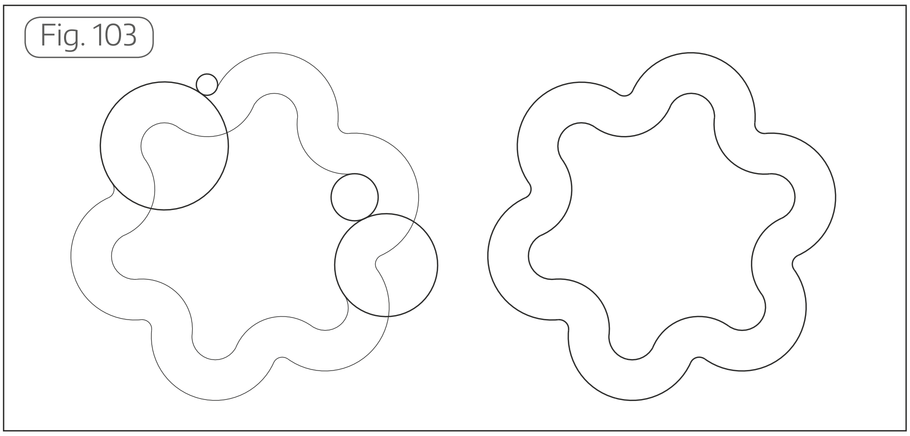
I removed the card and glued it to a larger piece of paper, then scanned the shape as a black and white image. At that stage, the image was a bitmap. Bitmaps

Fig. 102



A bitmap of the digit 1, using pixels to represent ones (black) and zeroes (white)

Fig. 103



Initially using circles to represent lobes (shown on the left), then cutting those and drawing connecting lines between the circular arcs (shown on the right) resulted in a close match for the curved edges required on the ridge for the key.

simply use pixels (dots on the screen) to represent information about the image. In a black and white image, each pixel is a dot representing black or white at any given point. **Fig. 102** shows how an area of the screen might use pixels to represent the digit 1. I like to think of bitmaps as being crude pointillist paintings, proving that art inspires computer science. It would be possible to use the information in a bitmap to identify positions where a cutter might drill straight down into the work, and a groove could be produced that way; in theory at least. Drill down if a pixel is black; do not drill if it is white. Unfortunately, that would produce a very rough-sided groove with scalloped sides, not accurate enough to fit the matching groove in the nut, so the bitmap is not directly useful. Magnifying the bitmap by scaling the image up would make things even worse, because there is information about each pixel, but nothing about what lies between pixels. Scaling up a section of the curve simply scales the size of each pixel, which is perhaps why the term "pixellation" has passed into common language as a term implying loss of contours and loss of the resolution of an image. Bitmap images are usually stored in file types ending in bmp, jpg, gif, tiff, or png and images generated by imaging programs like Adobe Photoshop, Corel Paint, Paint and GIMP are bitmaps (sometimes also referred to as "raster" graphics). For CNC purposes, bitmaps are not terribly useful except as an intermediate stage in a process leading to a file in a more useful format. There are a couple of exceptions, though, and we will look at those later in this series, as they can lead to impressive results using very specific techniques in particular applications.

What we require is that an image file contains a description of the path a cutter

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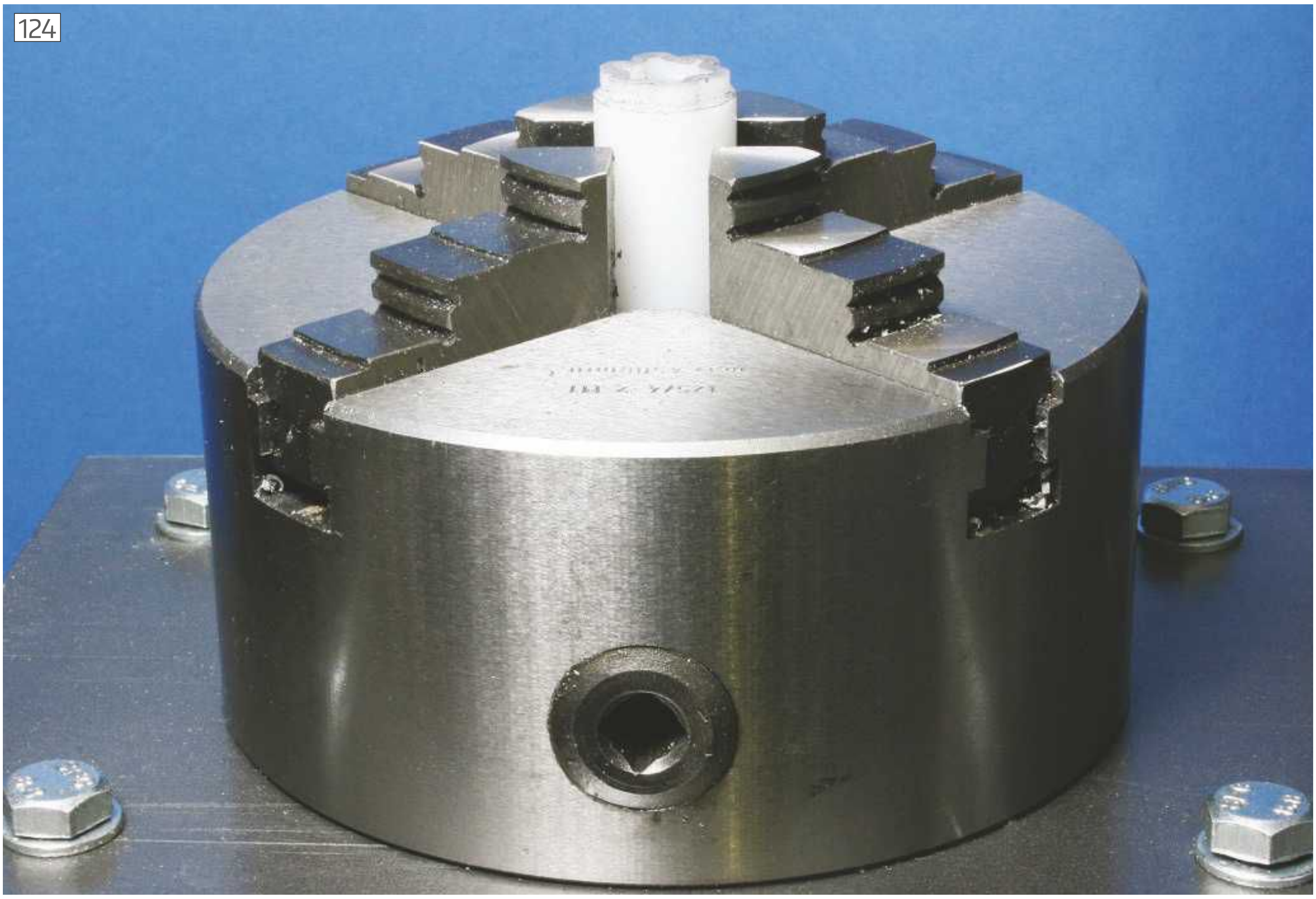

A test piece was cut in Acetal gripped in an upward-facing chuck bolted to the mill sub-table should follow, and that is best obtained from a vector graphics program. A vector image is constructed from a mathematical description of a path. In the case of a visual image, this will be a path along which the computer should draw a line. It is easy to translate that to a path the Controlled Point (CP) should follow. One of the benefits of a vector image is that it is resolution independent, and can be scaled up or down without losing the path information. A line drawn 1cm long, for example, describes a continuous path for a line. Magnifying the drawing by 100 results in the same resolution (level of detail) as the line becomes 1m long. Scaling the 1cm down by a factor of 10 results in the same resolution even though the line is now only 1mm long. That's because the lines are drawn using essentially the same instructions, which, in one format are:

<line fill="none" stroke="#000000" stroke-miterlimit="10" x1="170.079" y1="283.464" x2="328.819" y2="283.464"/>

The line fill, stroke, and stroke-miterlimit can be ignored for the moment, leaving the co-ordinates of the first point and the co-ordinates of the end point. Scaling the image up results in the instructions:

<line fill="none" stroke="#000000" stroke-miterlimit="10" x1="170.079" y1="283.464" x2="1757.484" y2="283.464"/>

Line fill, stroke, stroke-miterlimit and the co-ordinates of the first point are unchanged, and it is only the end point which is moved further away.

The same procedure is used to construct both lines, (before and after scaling) and the pixels on screen are not scaled up. The longer line simply makes more of them black.

Vector graphic images use formats like EPS, SVG, Gerber, CMG, and a number of proprietary (commercial) formats associated with specific programs, like "ai" (Adobe Illustrator), "CDR" (CorelDRAW), "ODG" (Open document graphics) and "HPGL" (Hewlett Packard's printer language).

Drawing programs usually use vector graphics to construct and display images.

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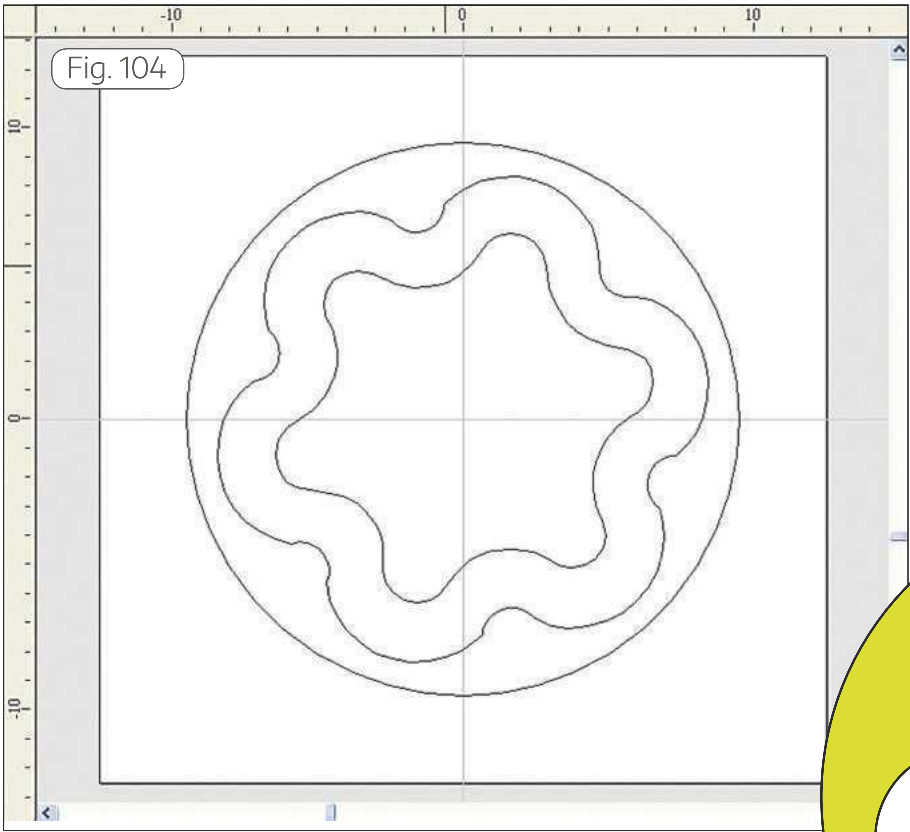
The completed test piece

For my wheel nut task, I needed a smooth path for the cutter, so I imported the image into Illustrator as a template, created a new layer lying on top of the template, and drew two lines to represent the edges of the groove. This was not entirely straightforward, with all those curves, so I drew circles to match the lobes on the groove, then used the scissors tool to cut those, and joined the cut ends of adjacent curves with other short curves, using the pen tool, **fig. 103**.

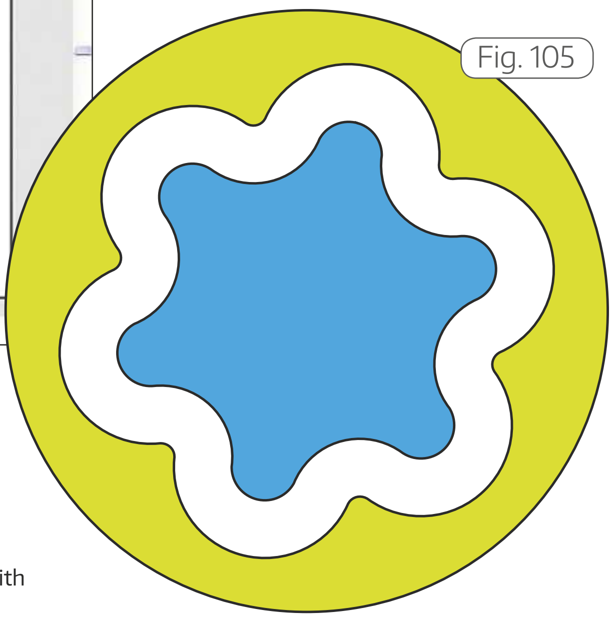
I removed the template layer, then saved the file in AI format (native to Illustrator) and, using a belt and braces approach, exported the file in EPS (Encapsulated PostScript

Fig. 104

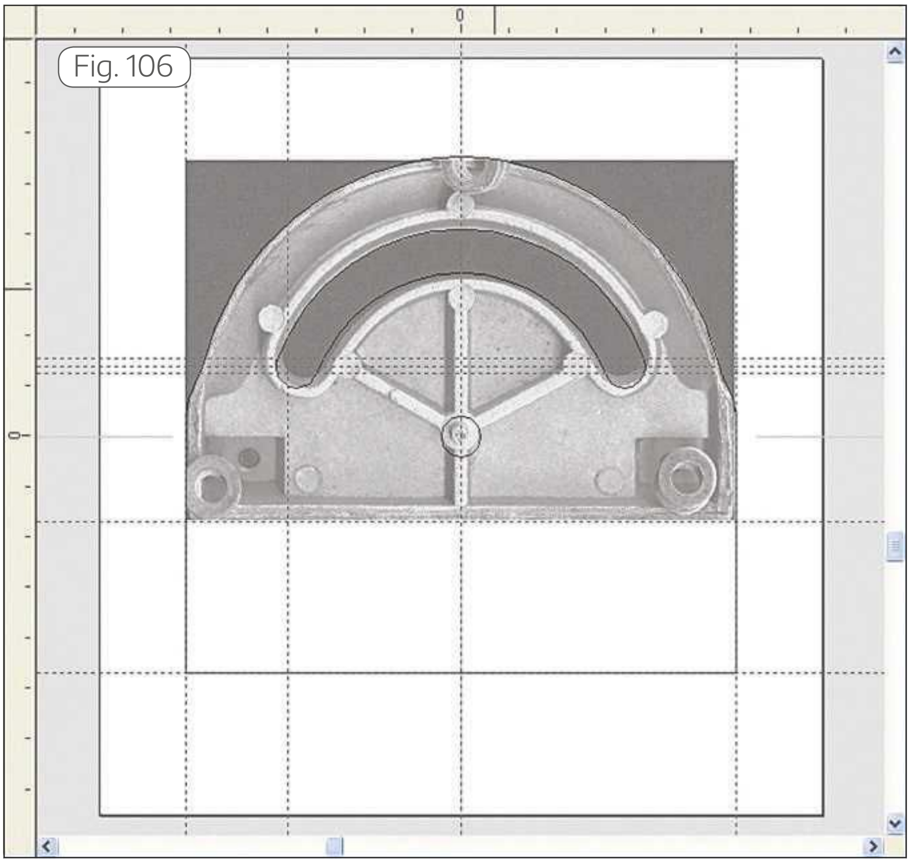


The EPS file for the groove was transferred into Cut2D

Fig. 105



The ridge is created by machining away two areas. The yellow area is a pocket containing an island (the white + blue areas). The blue area is also a pocket.



Using the bitmap as a template, the outline of the shape was drawn on a new layer, and an additional section added.

format). EPS files use the PostScript language to describe the appearance of a single page, and can contain text, graphics and raster (bitmap) images in any combination. EPS is commonly used as a means of transferring vector graphics files form one program to another.

Creating a machining path and a test piece

The next stage was to use the EPS or Illustrator file to create a path for the CP to follow, and this was done using Vetric's Cut2D. I created a new document in Cut2D, defining the size of the workpiece as a square large enough to accommodate the diameter of the bar I would use, then imported the Illustrator file directly into that document, and centred the image in the workpiece, **fig. 104**.

There are two areas to be removed to leave the upstanding ridge: the pocket inside the inner edge of the ridge; and the area outside the outer edge of the ridge, **fig. 105**. In Cut2D, the inner pocket (area 1 in fig. 105) can be created using the pocket tool. The outer area needs a bit of thought, though. In the end, I drew a circle slightly larger than the diameter of the bar from which I intended to cut the key, then used the pocket tool to create a pocket between that circle and the outer edge of the ridge (area 2 in fig. 105), leaving the ridge and the inner area as an island. I used this technique to ensure that the cutter cleared the whole area outside the outer edge of the ridge. Otherwise, it might only have cleared the width of a single pass of the cutter, leaving a set of small uncut areas opposite the places where the cutter moved inwards towards the centre of the work.

My strategy was to cut a test key in Acetal, so that I could produce a result quickly, to see if the method worked and the key fitted the nut. If that was successful, I would repeat the job using mild steel. This would mean using the same tool, but appropriate speeds and feeds for each material. I intended using the largest tool possible, and that was determined by the smallest radius on the paths, which was a shade over 2mm, so I chose a 2mm cutter. My mill has a top speed of 3000rpm, so that set the speed of the cutter, which is well below the ideal theoretical cutting speed for a 2mm diameter cutter machining either Acetal or mild steel. That, in turn determined the feed rate I could use for each material.

For Acetal, a decent cutting speed would be approximately 125M/min, giving a spindle speed = cutting speed(mm/min) / (3.14 x cutter diameter), or 400000/(3.14 x 2) = 19904rpm. Setting the spindle speed to its maximum of 3000rpm was the best I could do. There is a challenge with hard plastic anyway, and that is keeping the work sufficiently cool, to avoid the plastic welding itself to the cutter, so 3000rpm is on the right side for air cooling alone.

Feed rate is spindle speed (rpm) x no. of teeth x chip load per tooth, and the recommended feed rate per tooth is between 0.25mm (roughing) and 0.05mm

The finished steel key

The proof of the pudding

(finishing), so taking a middle figure of, say, 0.1mm per tooth, the feed rate should be 3000 x 3 x 0.1 = 900mm/min. That's pretty fast, but lowering the speed too much will cause heat build up, with a further risk of melting the plastic. Note that I used my actual spindle speed for this calculation, rather than the theoretical speed initially calculated.

Using a two-tooth rather than a three-tooth cutter would mean a feed rate of 600mm/min, and using a finishing cut instead of a roughing cut would mean a chip load of 0.05 and a feed rate of 300mm/min. A typical depth of cut might be half the diameter of the cutter, so the full depth of cut (3.2mm) can be achieved in 4 cuts of 0.8mm each.

Because this was a small cutter I settled on a conservative feed rate of 200mm/min and 0.5mm depth of cut. I chose a 2mm end mill from the cutter library, and redefined the cutting speed and feed rate to suit.

I let Cut2D calculate the cutting paths by using the Mach3 Arcs postprocessor, then saved both paths.

I then cut a short length of Acetal rod and held it vertically in a self-centring 4-jaw chuck mounted on a flat backplate, sitting on the mill sub-table, **photo 124**.

Next, I transferred the saved cutting paths to my CNC directory, and loaded the first path into Mach3 (the inner pocket path in my case; although the order in which you cut the paths doesn't matter). I calculated the speed and feed for the cut, set the spindle speed and machined the pocket.

Then I loaded the outer path and machined that.

Removing the rod from the chuck, **photo 125**, I can scarcely tell you how chuffed I was to find that it fitted the groove in the first locking nut perfectly. Tea and biscuits all round.

Having proven the paths, it was time to cut the key in steel.

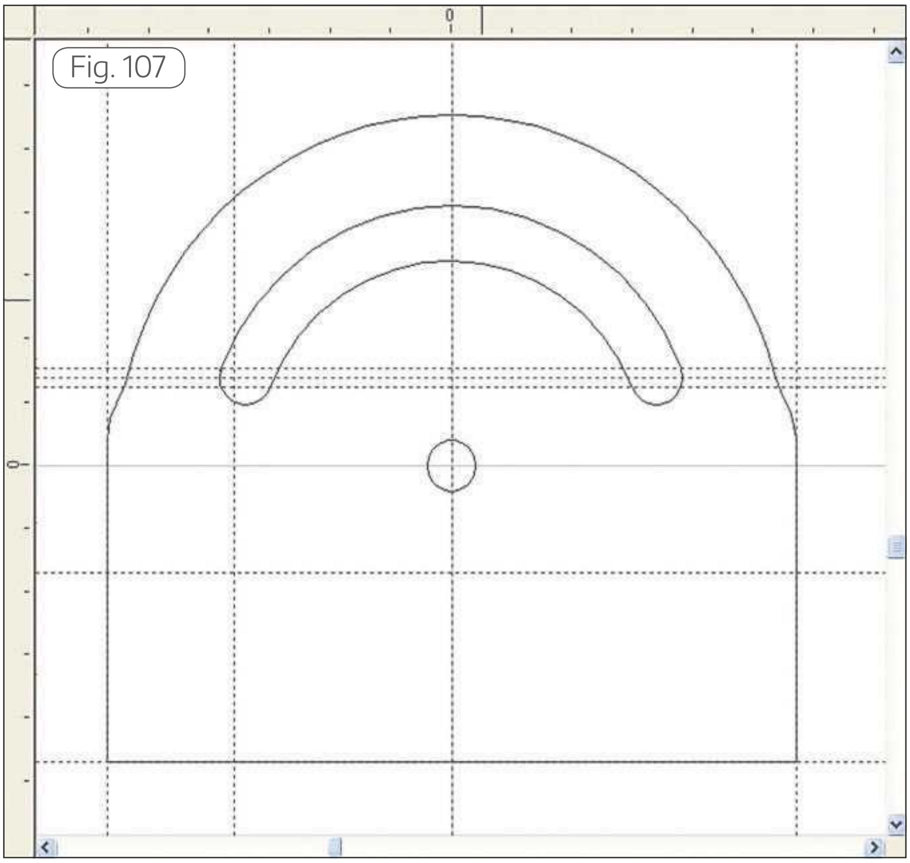
First, I used the lathe to cut a slice of 22M07 bar, and held it in the chuck on the mill table, pointing upwards. I used Cut2D to create two paths to cut a hexagon around the bar, 17mm across the flats (A/F). These both created a hexagon, but the first path included an allowance to make the hexagon 0.2mm oversize, while the second used an allowance of zero to bring the A/F dimension to size. I used my roughing end mill, so the finished hex had what I might charitably call a working finish, but that's all I required.

I transferred the workpiece to the lathe and drilled right through with an 8.5mm drill, simply to reduce the work the end mill would have to do to produce the inner pocket. That was not an essential step, but I find that making life easy on small cutters can save breakage, disappointment and consequent cost.

The workpiece was transferred back to the mill and the hexagonal end was gripped in the chuck so that the blank end pointed upwards towards the cutter.

I modified the cutter speed and feed rates in Cut2D to produce another program to mill the slot in the steel workpiece. Because the feed rate and depth of cut at each pass were both much lower than for Acetal, the work progressed much more slowly. The danger with this cut is that the cutter is crowded in the groove, with no side clearance, and there is a real danger the cutter jams and snaps. Generous quantities of neat cutting oil were dispensed using a toothbrush. Once the inner pocket had been completed, the outer path was cut in just the same way. I did pause for some time after cutting the inner pocket, to allow the

Fig. 107



With the bitmap layer turned off, the drawn shape was used to produce the machining path and G code program

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An angle-setting accessory for a bench grinder motor, cutter and workpiece to cool.

The end result was wondrous to behold, **photo 126**, with an excellent finish to the walls of the ridge, and, like its Acetal predecessor, the key fitted the nuts snugly and precisely, **photo 127**.

You have no idea how I felt after removing all four locking nuts; just no idea!

The key was cut in steel, but was relatively soft, so the key was held in a socket attached to an extension bar which was supported by an axle stand, to try to ensure the key was subject to a turning torque but not a downward force. Pushing very firmly inwards, to keep the ridge in the groove, and applying steady force did the trick.

This just goes to show what you can do when you feel you are being taken for a mug.

The final task was to mount the key and the locking nuts on a block of wood, and sit it on the workshop windowsill as a constant reminder of the capabilities of the mill. Wondrous.

You will never guess what I discovered, in a safe place, about a month later...

A soleplate for a grinder accessory

The scanner proved so useful when bringing the shape of the wheel lock nut into the computer that I later tried the same technique when I wanted to make a soleplate for an angle-setting accessory for my bench grinder. A typical scanner is designed to make an accurate scan of a flat object in full contact with the glass of the scanner, so this accessory posed a challenge because the base incorporated a projecting pin and so could not sit flat and in direct contact with the glass. The basis of the accessory is an existing item from a woodworking circular saw, **photo 128**. The top carries a set of scale markings and other features, while the underside has a cast-in pin, **photo 129**. Because the original item is made of a relatively soft aluminium alloy, it requires a 3mm thick steel soleplate. Adding the soleplate protects the alloy from wear, but also allows for an additional ledge to be incorporated. The challenge was in replicating the shape of the underside of the object, then modifying it.

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Underside of the angle-setting accessory

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A preliminary scan of the underside of the object

Although the object would not sit flat on the scanner, it sat comfortably on three piles of washers, with the base of the object parallel to the glass of the scanner. A greyscale scan seemed to give a good image, **photo 130**, but closer examination showed that the projecting pin (left of centre) seemed tilted to one side, and the deep wall on one side of the curved slot was visible while the other side appeared as a simple profile. A scan looking directly at the underside would show the end of the pin but not its sides, and the same amount of wall beyond each side of the curved slot. When an object lies flat and in full contact with the scanner glass, the fact that the optics take a slightly sideways look at the object does not matter much, but the further away the object is from the glass, the more the effect of non-vertical sight lines; and that is what is producing the problem with the pin. The scan may also contain significant reflections but if these are outside the boundary of the object they can simply be ignored. All of this suggests there may be a problem with distortion. This is, after all, a flatbed scanner, and although we usually abbreviate the name, the term flatbed is significant. Flatbed scanners work by using a travelling light to illuminate the item being scanned, and the reflected light is bounced off at least one mirror, then sent through a prism to turn it and separate it into red, green and blue colours. Because the light moves in one direction and hits a thick feature such as a projecting pin or a deep slot at an angle, it can produce an image of one side better than the opposite side, tending to distort the image.

I experimented by moving the object so that the pin was located more centrally over the glass, and scanned it again until the effect seemed to be reduced (but not removed).

The resulting image was saved, then imported into a drawing program, and rotated until the base line was horizontal. The image was then cropped, leaving just a little of the surrounding black colour outside the outline of the object. It was then imported into Vectric VCarve Pro as a bitmap image (but could have been dealt with in Cut2D in just the same way).

Creating a new layer then using the drawing tools, a line was drawn around

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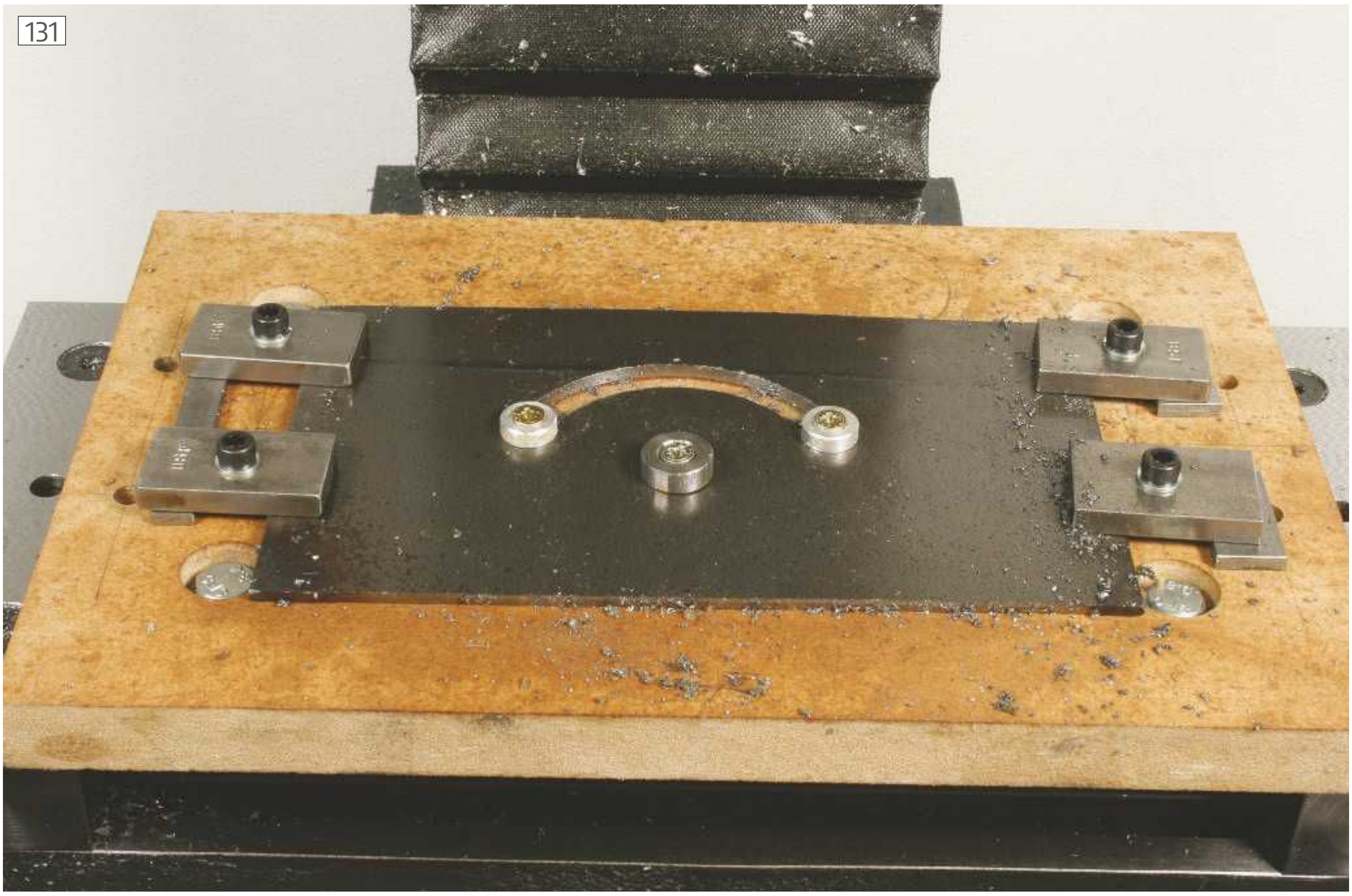

After machining the arc and the hole for the pin, stepped washers were used to secure the section of the plate which would be cut free when the outline was machined

the outline of the object and the curved slot. The basic outline was then extended by adding a rectangular area on one side. **Figure 106** shows the composite image, with the drawn layer on top of the bitmap. The dotted guidelines were used to ensure that, as far as possible, the shape was symmetrical and corresponded to sizes physically measured on the original. The main non-symmetrical parts were the blending curves on the casting between the straight parts of the sides and the main curve of the scale. The layer containing the original scanned image was then turned off, leaving the shape shown in **fig. 107**. That was then used as the basis for creating three pairs of machining paths to cut the plate, a hole for the cast-in pin, and the integral slot out of 3mm sheet steel. Each pair of paths consisted of a roughing path and a finishing path. Both were calculated from the same section of the drawing, but the roughing path used a conventional milling cut direction and was given an Allowance offset to move the cutter out 0.2mm. The finishing paths took a climb cut to final size with no Allowance. In each case, both paths in a pair were saved as one composite G code file, so that the mill would cut the roughing path and immediately follow with the finishing path. With a piece of steel sheet clamped on a sacrificial plate and secured to the mill sub-table, the pin hole and the curved slot were created first. Washers with close-fitting projections were added to provide security for the next stage, **photo 131**, and the profile of the soleplate was then cut, to produce the finished shape, **photo 132**. Comparison with the outline of the existing casting showed that the outlines matched very closely. All that remains is to clean up the plate and secure it to the existing casting.

So; a basic flatbed scanner is capable of a range of work, even on non-flat objects, and understanding its limitations allows it to be used for some jobs which are outwith its designed range of applications. ■

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The completed soleplate

A Look at Drill Sharpening

informed by 3D CAD

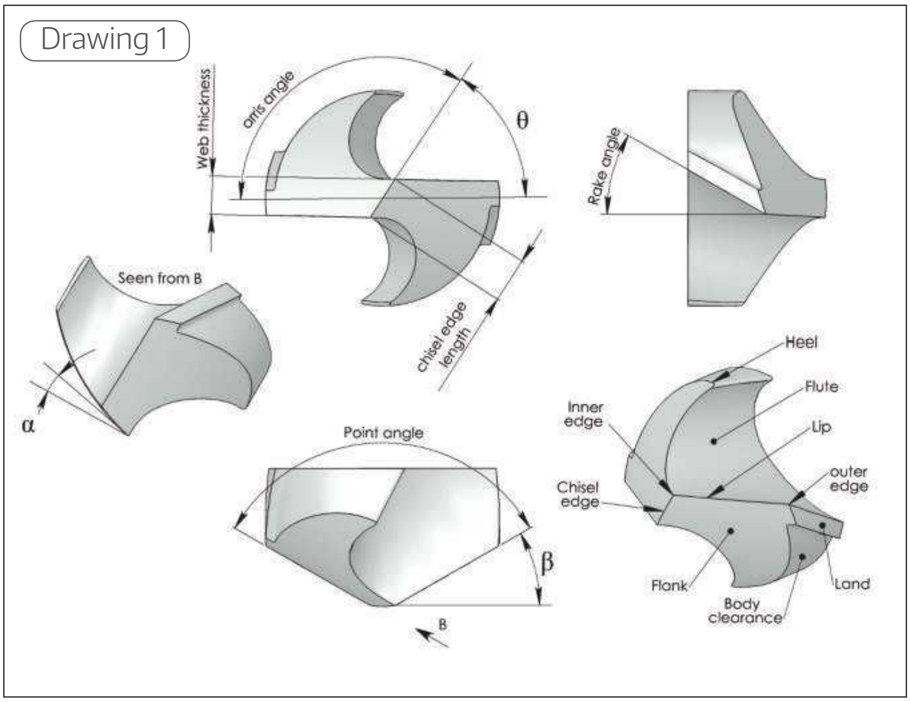
Jacques Maurel takes a detailed look at the constraints on the geometry for drill tips, and describes a jig for drill grinding with concave wheels.

I will pass on some information about drill point geometry that could be of some help when drill sharpening, as we are more efficient when we know what we do.

We want to grind 2 symmetrical lips at the right angles with no rubbing of the drill heel at the bottom of the hole to be drilled**,** see **drawing 1** for drill point definition.

To test the clearance (for not rubbing) I used 3 D CAD for the following process (see **drawing 2**):

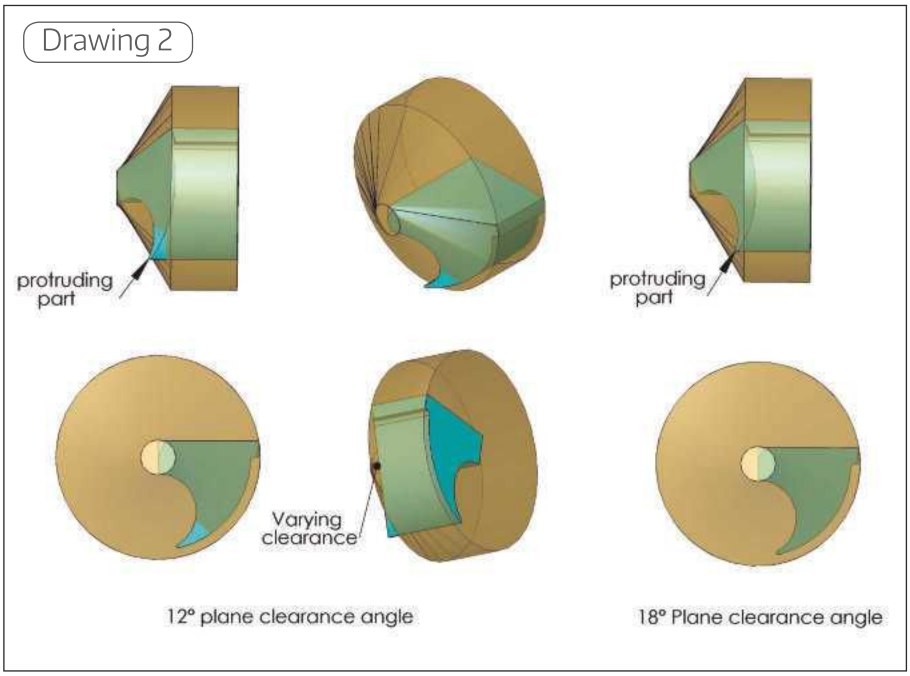
I made a model of the drilled hole, but in negative (as if some molten material had been cast inside), yellow colored. It can be noted that the bottom of the hole is not a conical surface, but a hyperboloid one, because of the web thickness which causes the (straight lines) cutting lips not to cut on the drill axis (the center part made by the chisel edge will be dealt with later). I made a model of the corresponding drill point, blue colored, with straight flutes (far easier to make than the helical ones, and of the same use for studying the clearance); the 2 pieces are then 'assembled' in a working situation.



Drawing 1

If there is any blue protruding from the yellow, rubbing will occur, moreover, the hole can be made translucent so you can see the drill through and hence judge the behavior (increasing or decreasing) of the clearance.

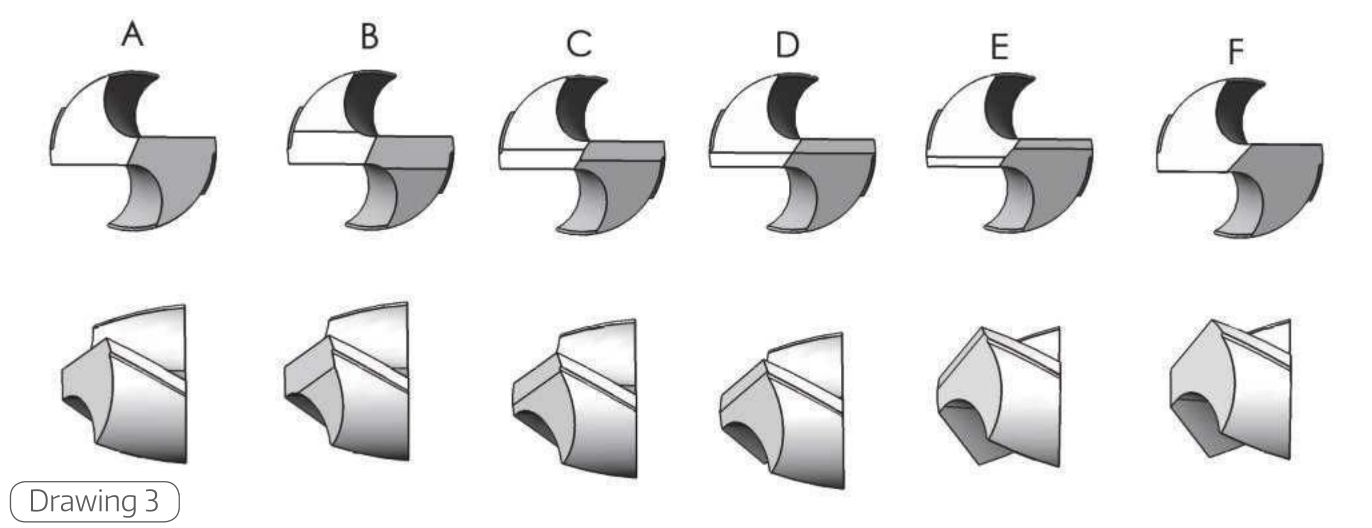
This drill model is the standard one with 120°point angle; 0.16xD (diameter) web thickness, only one flute has been made for a clearer drawing.



Drawing 2

Using a plane (or planes) as clearance surface(s)

Refer to drawing 2. The first idea is to use a plane as clearance surface with 12°clearance angle, you can see that this clearance is not satisfactory as the heel is protruding out from the "hole". For no rubbing, a 20° clearance would be necessary, a nearly adequate 18° clearance is shown on the drawing, just a very small part of the drill heel is protruding here. It can also be seen that the clearance is first increasing (when you are looking from the outer edge of the drill to the heel) then decreasing after, until the heel emerges through the hole bottom.



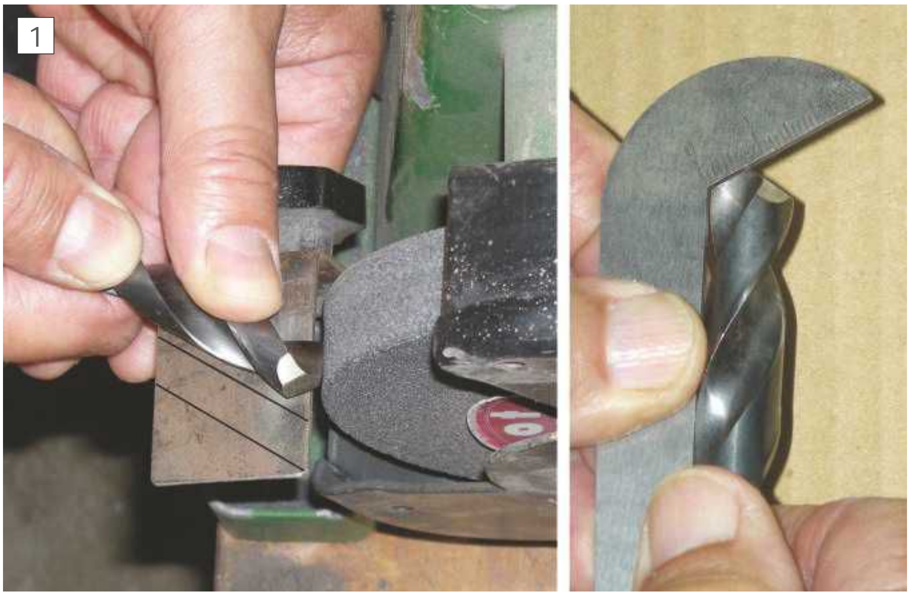
Drawing 3

Hence the idea of the 4 facet point having 12° and 25° clearances**.**

Drawing 3 shows 6 drill points, as more and more of the tip is ground away at the 25° clearance angle: (the side views under the face ones are oriented for the chisel edge to be in the drawing plane).

- **point A** having a single12°clearance (not satisfactory).
- **point B** with 25°secondary clearance just sufficient to prevent heel rubbing.
- **point C**: here the secondary clearance has begun to cut the web.
- **point D**: the clearance planes are meeting in one point giving a self-centering capability. **Drawing 4** shows more views of this 4-facet drill point.
- **Point E**: the secondary clearance has exceeded the "meeting point".
- **point F**: a single 25°clearance, too big and the chisel edge being too long.

While these 4 facets could meet in a single point to give self-centering property (**point D**), this is not at all necessary, and as this secondary clearance has no contact with the workpiece, it can be done by hand with no inconvenience (**point B**).



1

2a

This is I think the easiest method for drill sharpening when no jig is available. Furthermore, you'll very often have to rough out the drill point by off hand grinding before using a jig (the lands are sometimes scored or worn near the lips, and the point must be ground off before resharpening. If this roughing out has been done accurately, just a small amount of material will have to be removed by jig grinding, and the smaller the better.

Roughing the point by off-hand grinding:

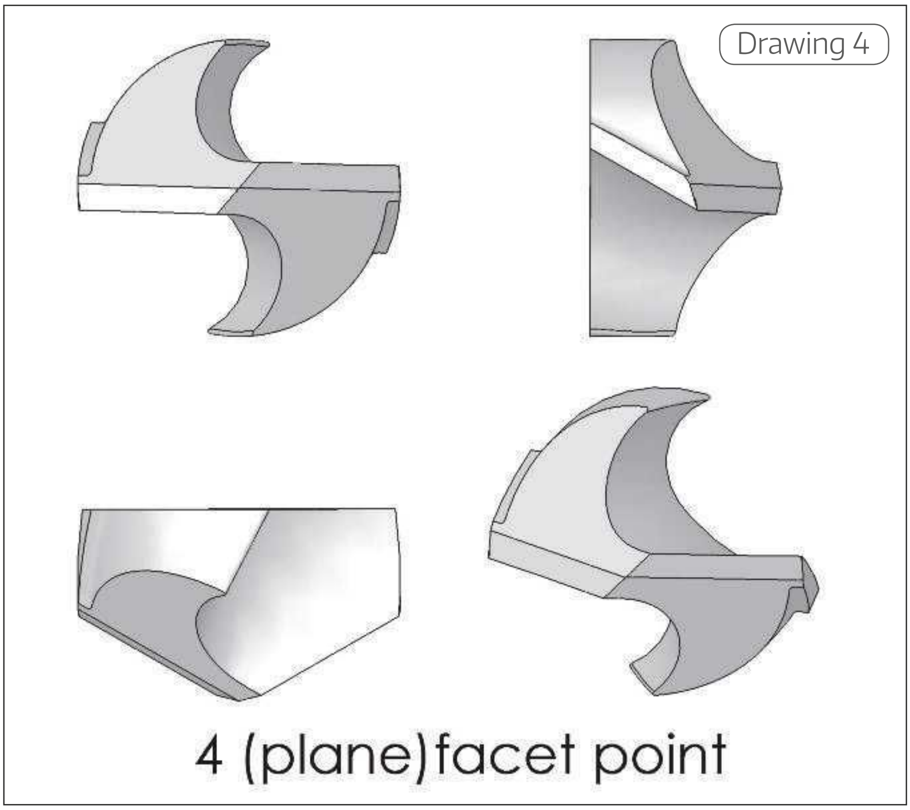
The first clearance is easy to make using the standard grinding rest (set at the first clearance angle), and a drill gauge to control the point angle and the lip length, the lines marked out on the grinding rest help keeping a good point angle), **photo 1.**

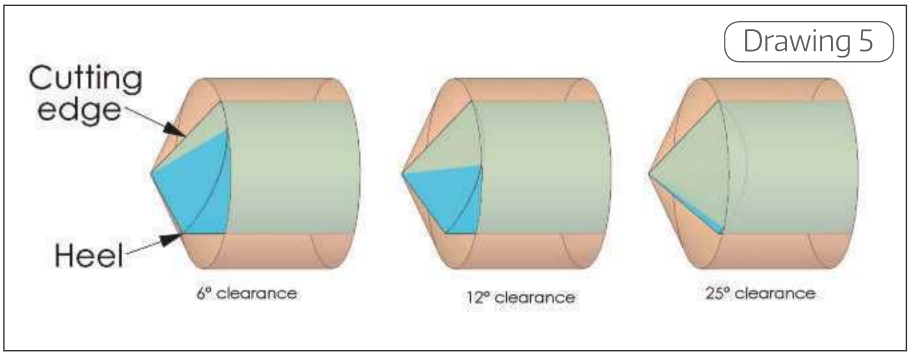
Be careful when grinding the secondary clearance not to score the opposite lip (**point C** to **point E** on drawing 3) if so you'll have to keep the symmetry for the secondary clearances too; it's easier to regrind the first clearance slightly.

Large Drills

For drills more than Ø10mm it's easier to grind a conical surface first by turning the drill against the wheel, because the contact

2b





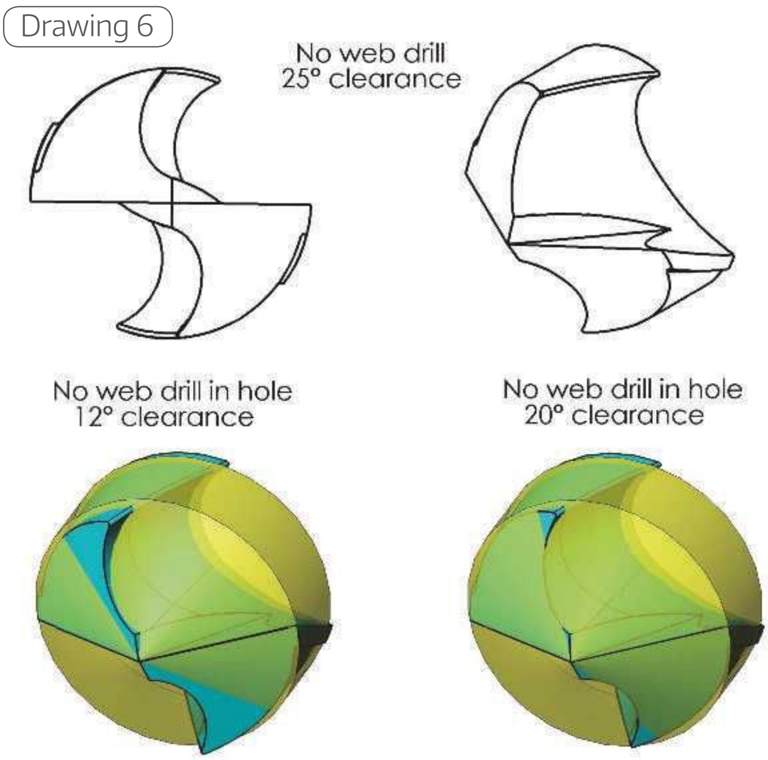
surface is smaller, and then make the flat ones after.

For drills more than say Ø16 mm, it's not necessary to grind right to the point (that won't be used if you use a pilot hole) as grinding a big drill is long and boring. Grind half the diameter of the drill, the point being kept flat (see **photos 2a &2b** showing a Ø21mm drill). In this case the symmetry of the lip length must be controlled with a graduated rule from the outer edges of the drill to the back, the drill gauge working only for the point angle.

Web Thickness:

Imagine a drill the half of which is one quarter of a cylinder (so no web) this could be possible by grinding inside the flutes **(drawing 6),** only near the point of course. The bottom of the hole will be here a perfect conical surface. It can be clearly seen on **drawing 5** that the protruding part goes from the center to the heel of the drill. To avoid rubbing you need a clearance angle greater than 25°(when 120°point angle).

So the help given by the web thickness is that only the heel is protruding - as the lip is above the drill axis, the heel is moved backwards **(drawing 7).**



It is possible to find the limit of the clearance angle giving no rubbing (if no web) **(note 1)**:

$\alpha > \tan^{-1}(\sin\beta)$

α = clearance angle, β = lip inclination = (180° - point angle)/2

Results:

For β = 0° (180°point angle) → α > 0°
For β = 20° (140°point angle) → α > 19°
For β = 30° (standard drills, 120°point angle) → α > 26.56°
For β = 45° (90°point angle) → α > 35.26°
For β = 60° (center drills, 60°point angle) → α > 40.89°

It is clear that for drill point angles less than 90° (center drills) it is not convenient to use a plane as clearance surface (a sort of helical surface has to be used).

It can be seen that the problem is less acute for a great point angle. But in that case, the risk of drill wandering is increased, so the compromise of 120° (or 118° is chosen).

For the standard drills (with 118/120°point angle), the web thickness is usually 16% of the diameter. In this case, the CAD model shows that 20° clearance is sufficient, so 25° is typically used for the secondary clearance, moreover the heel diameter is smaller than the drill one due to body clearance, and also the heel is ending at an angle smaller than 90° from the lip edge.

For drills having a thick web (deep hole drills, or some recent drills) the web thickness can reach 40% of the drill diameter, moreover, the heel of these drills is often shortened (see photo3 showing cut off of these drills). In these cases, a 12°clearance is sufficient to avoid rubbing but some sort of web thinning is of absolute necessity.

The chisel edge:

This can be easily studied assuming that the chisel edge is a straight line (the clearance surfaces being planes), there is a relation between the angles defined in **drawing 1** (also see note 2):

$\alpha = \tan^{-1}(\sin\beta/\tan\theta)$
α = clearance angle
β = lip inclination= (180°- point angle)/2
θ = chisel edge inclination = (180°- arris angle)

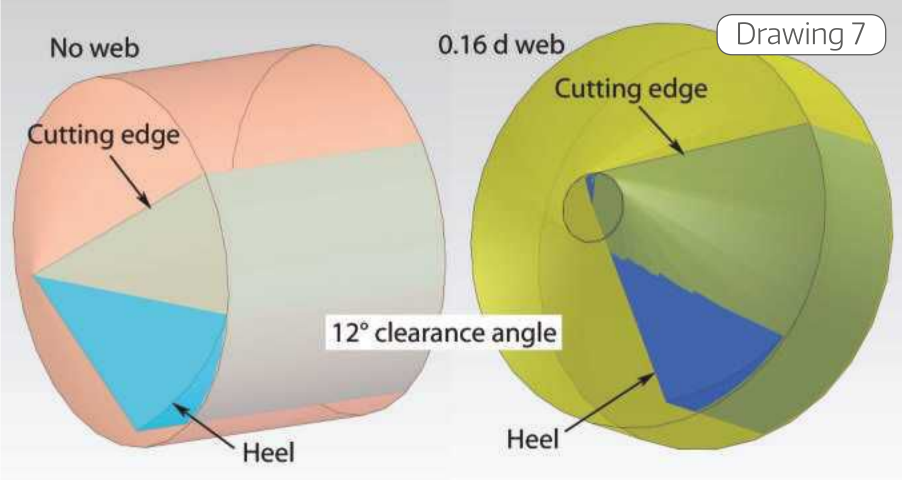
Results for a standard drill (120°angle point):

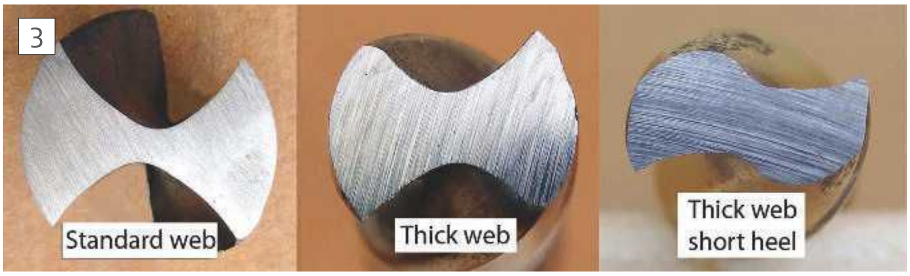
arris angle	clearance angle
130°	22°
125°	19.3°
115°	13.12°
110°	10.3°
105°	7.6°
100°	5°

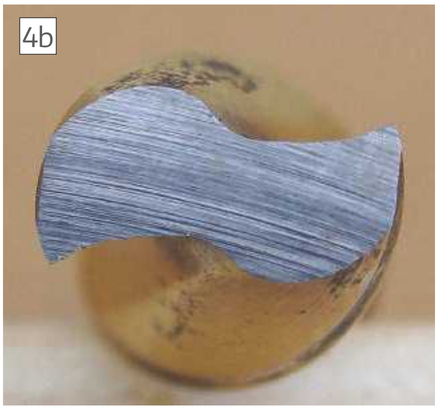
These results can't be used if the relief surfaces are not planes (i.e. cones or cylinders) as in that case the chisel edge is a curve and the actual relief angle is slightly smaller than the one given by the formula.

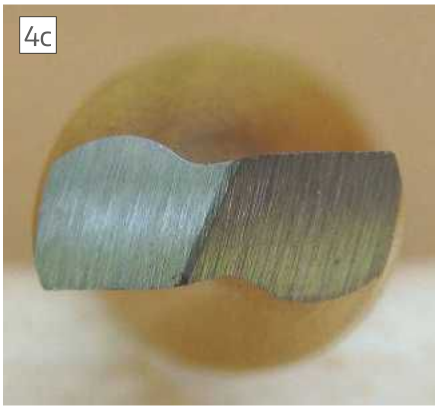
So you can know the clearance angle by measuring the arris angle (using a protractor, or an angle graduated magnifying lens for small drills).

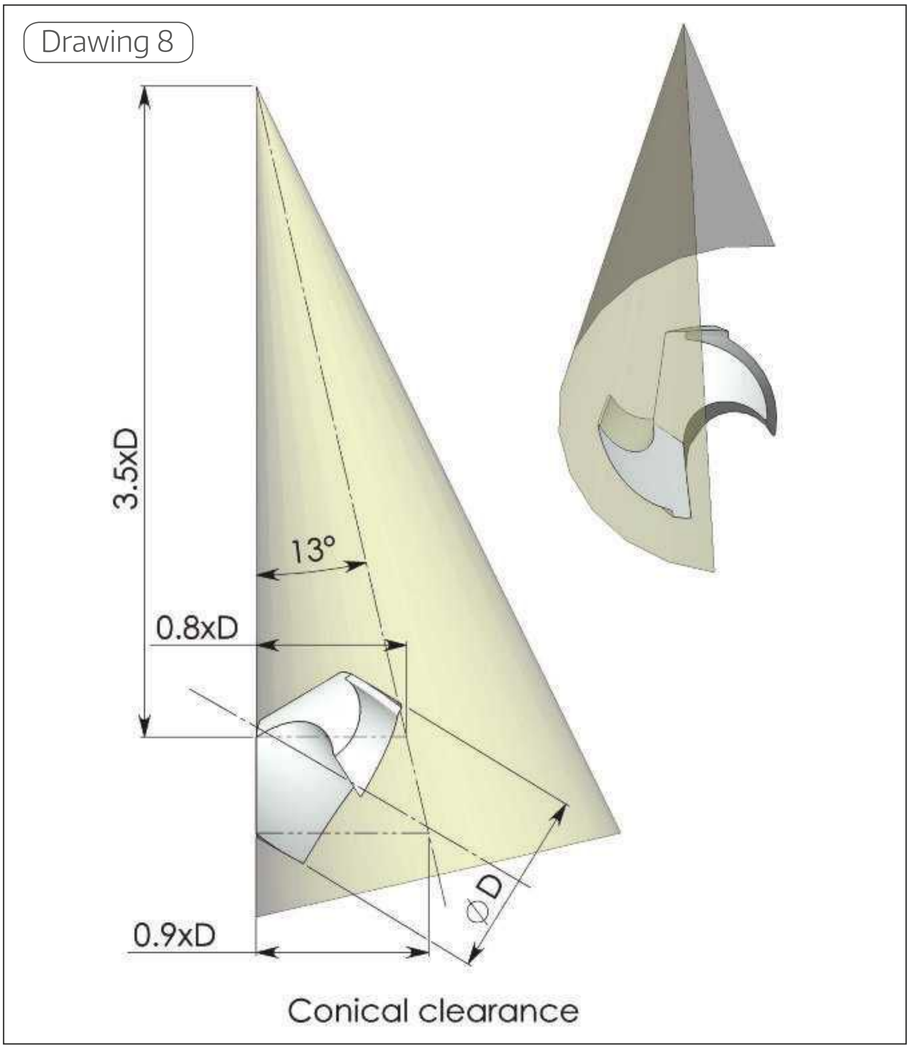
It can be noted that the chisel edge length increases with the clearance angle, and this is a problem as this edge has no cutting action. For a thick web drill, the

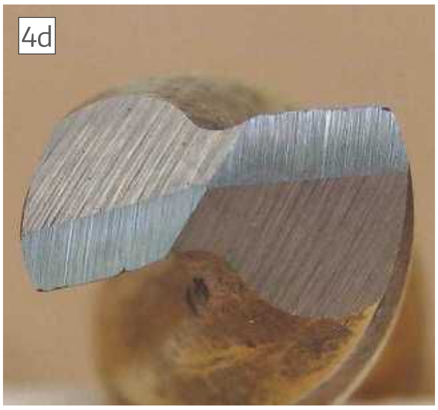


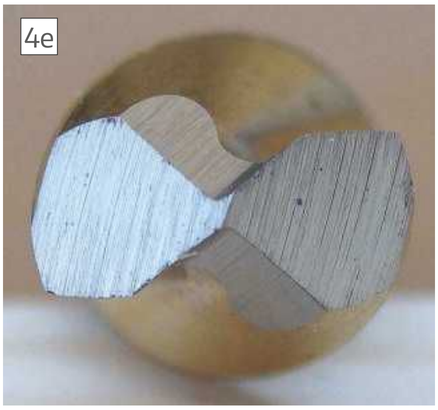


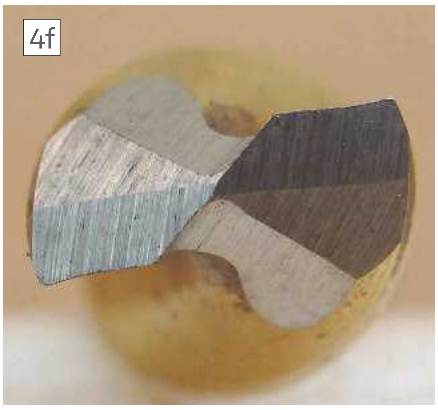












chisel edge length is often half the drill diameter! So there is the necessity for web thinning in that case.

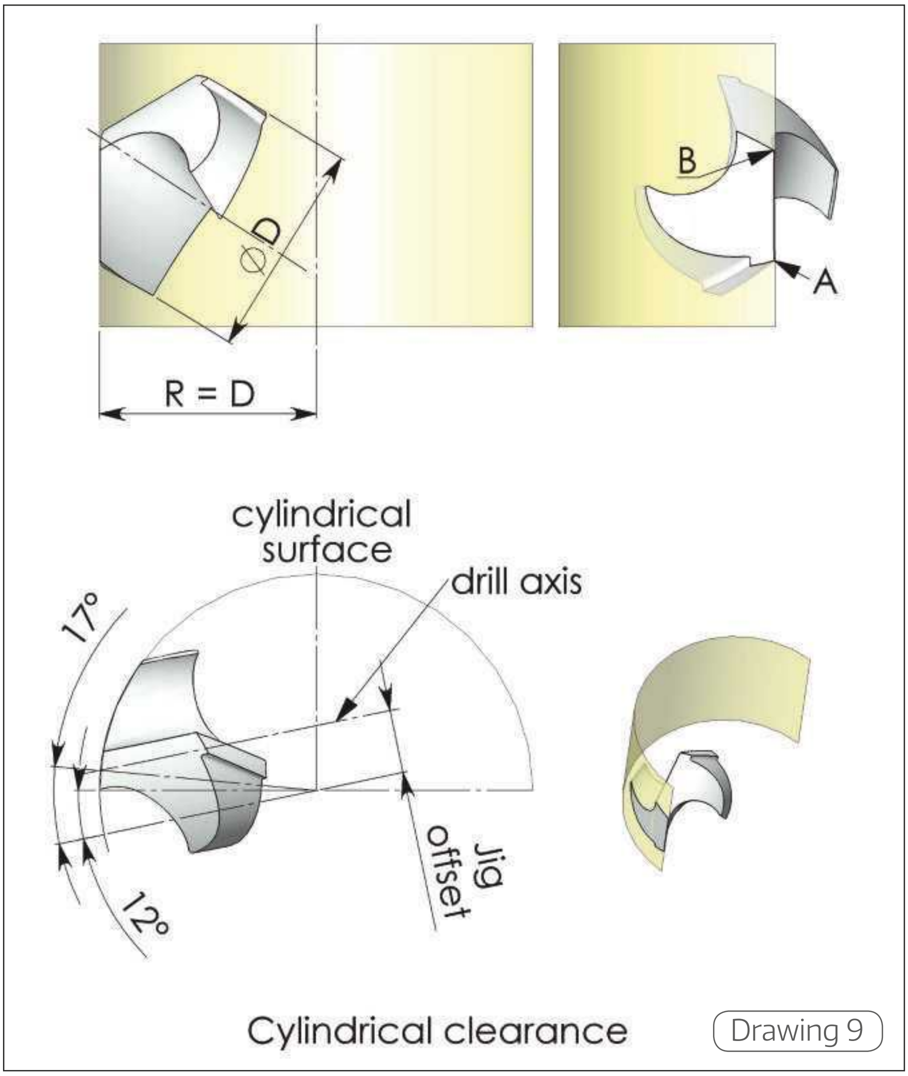
Photographs 4a to 4f showing a thick web (e = 0.3d) and short heel Ø7.5mm drill:

Photograph 4a drill as supplied, 4b cut-off, 4c with 2 facets, 4d with 4 facets (the chisel edge is so long that drilling will be impossible with points 4c and 4d) and the split points (Split pointing will be described in a further article), photo 4e 2 facets split point with the self centering property, photo 4f 4 facets split point.

Using a cylinder (or a cone) as clearance surface

Drawing 8 shows almost the same thing as a cone, which can be seen as a variable radius cylinder because in the usual jigs the difference between the radius at the outer edge (0.9 D) and at the inner edge (0.8 D) of the lip is small (the cone dimensions of drawing 8 were found in the book: The Grinding Machine by Mr I Bradley, Model and Allied Publications,1973, p46 & 47).

If the cone angle was larger and the center of the drill nearer from the cone apex, the clearance angle would be greater at the inner edge of the lip than at the outer, but as the chisel edge length increases with the clearance angle, this is of no interest.



The clearance is due to the fact that there is a distance (offset) between the drill axis and the axis of rotation of the jig (cone axis).

Drawing 9 is showing a cylindrical clearance, the radius of which being the drill diameter D. It must be noted that (because of the web thickness) the clearance angle is diminished at the cutting edge: on the drawing, the actual clearance is 12°, but would be 17° with no web, and only 5° for a thick web drill (0.4xD). It's common practice to modify the offset by turning the drill around its axis when sharpening; this will be sensible at point A, but negligible at point B! Furthermore, the clearance wouldn't be set in a plane perpendicular with the cutting edge. I think that the best way for increasing the offset (for thick web drills) is to put some packing between the drill and the Vee bracket of the sharpener.

Calculation of the clearance angle:

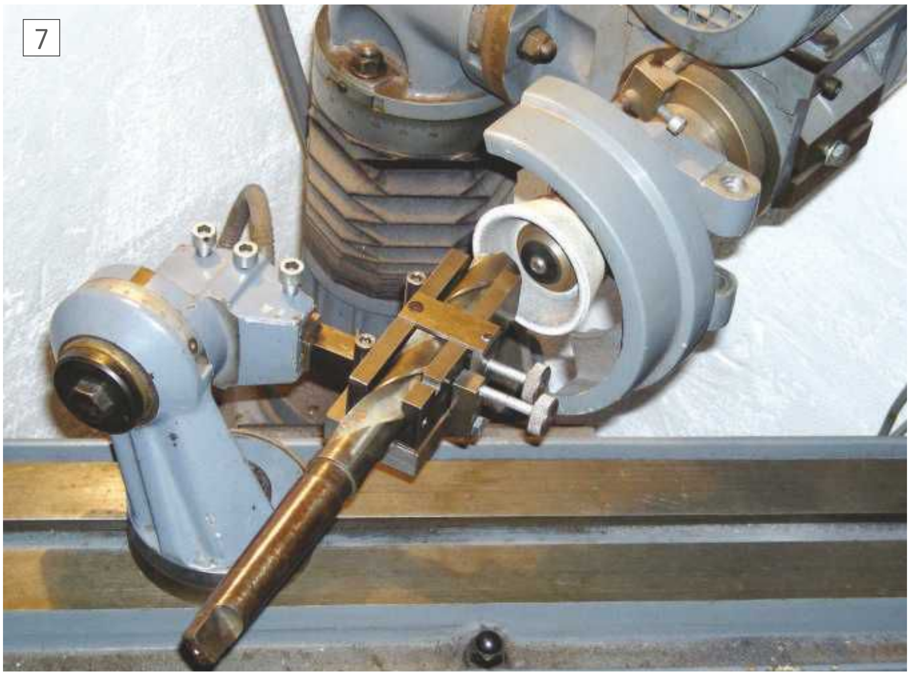
If **h** is the jig offset, **e** the web thickness and **R** the cylinder radius (**note 3**).

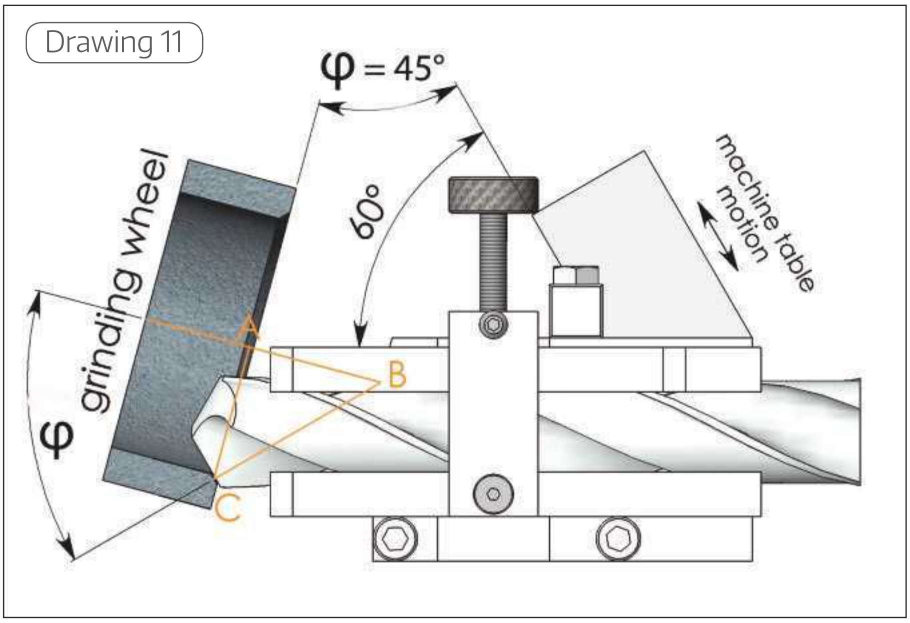
$\alpha = \sin^{-1}((h-e/2)/R)$

or if you want h from α:

$h = R \sin \alpha + e/2$

The CAD test for a standard drill (diameter D,120° angle point, 0.16D web thickness, 12°relief angle) shows that the maximum





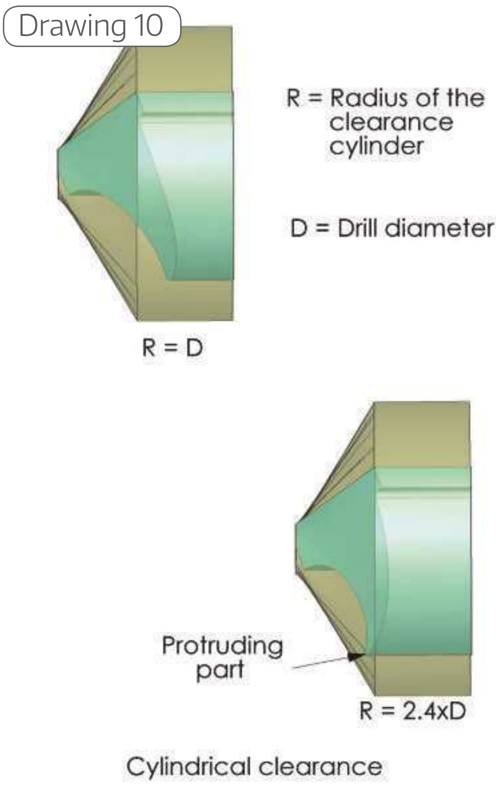
limit radius of the clearance (see **drawing 10**) cylinder is:

R = 2.2xD (for no rubbing).

Analysis of a popular jig:

The clearance surface of the jig in **photo5** is a cone but very nearly a cylinder as the pivot axis is almost vertical.

Here the offset between drill axis and jig axis is about 4mm and the radius (for a standard drill 118°point angle) about R = (10 + D) mm, D being the diameter of the drill (D being the length of drill protruding out from the vee).



So the clearance angle is decreasing while the drill diameter is increasing (about 17° for Ø3mm to about 7.5°forØ13mm) this is not a bad thing. It's possible to alter this angle by packing under either side of the Vee and/or by varying the radius R (the drill protrusion).

Again, I think that the best way to increase the offset for thick web drill sharpening is to put packing between the drill and the Vee.

Some more sophisticated jigs use a vee inclined by 12°, so the clearance angle is maintained when the drill diameter varies (**photo 6**) I use it for my big drills (from Ø27 to Ø31mm).

A new conception for a drill sharpening jig

The previously described concept has 3 drawbacks :

You need a plane surface for grinding (typically the side of the standard wheel.

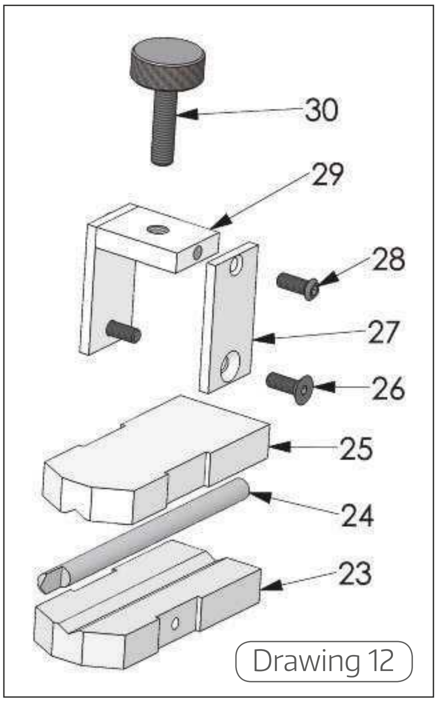
Dividing is difficult using the lip index, particularly for small sized drills.

Dividing is also difficult because the drill is very close to the grinding wheel.

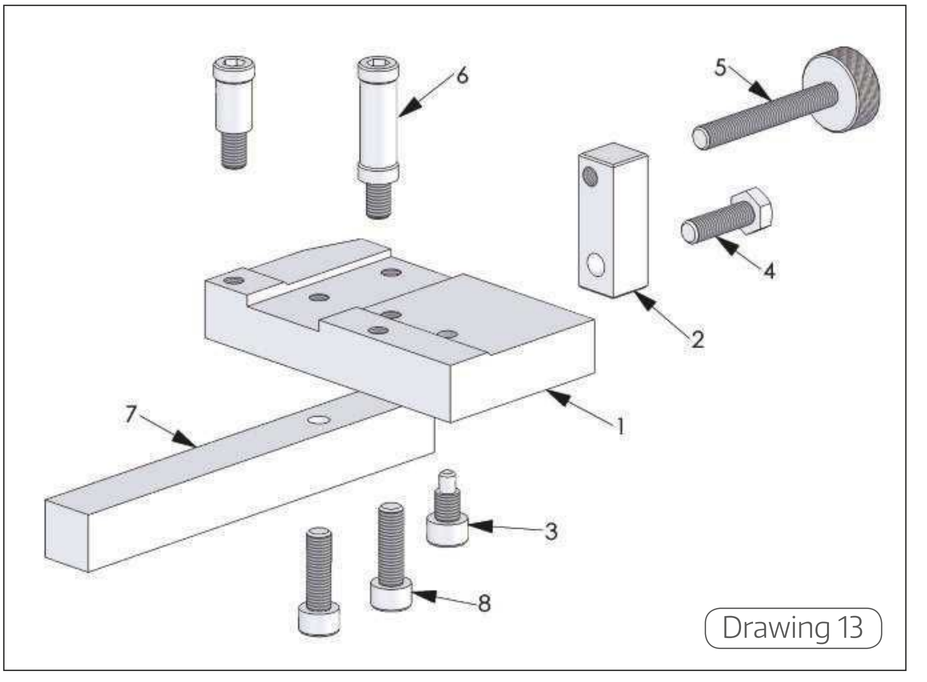
To overcome these problems, I use a different concept, see **photos 7 & 8** and **drawing 11.**

The clearance surface is still a concave cylinder, but of a fixed diameter, for this, the drill is moved inside a cup (or saucer) grinding wheel.

The direction of the drill rectilinear motion is at ϕ = 45° from the grinding wheel axis, the contact with the drill is part of a circular arc or of a narrow conical surface so equivalent to a cylinder (a 0° angle would give a plane clearance; for 90° angle R = r (internal radius of the cup wheel but this is not a convenient situation due to a deep penetration of the drill inside the wheel and a great contact surface); thus the



Drawing 12



Drawing 13

equivalent internal cylinder radius "R" is:(on drawing 11, AC = r; BC = R; AB is the wheel axis) (**note 4**).

$R = r/\sin\phi = 1.414xr$

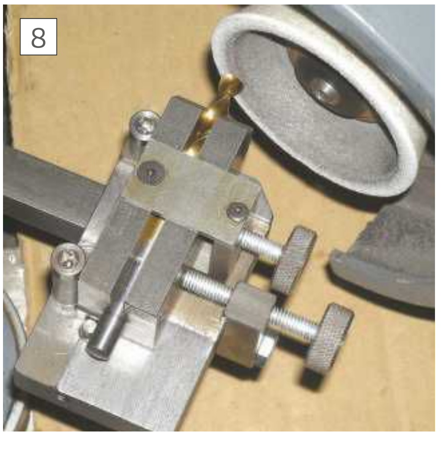
(r is the internal radius of the cup wheel).

The drill is held in a dividing block, three different dividing blocks are used for holding drills from 1.5 to 27mm in diameter **(photo 9).** The dividing blocks are set and locked on a bracket.

This jig can be adapted to a 3 axis T&C grinder (like the Stent for example) but it can be also adapted to more simple grinding rests (drawings 12, 13 & 14 and next issue).

What advantages are to be expected:

The dividing is easy to do (even for the smallest diameter:1.5 mm) and far from the


8

grinding wheel.

It is very easy to make a 4 facet point (see later).

The same attachment can be used for web thinning (described in a further article).

The main inconvenience is that the wheel internal diameter is relatively great (60mm for my machine) so I must use a 4 facet point for small drills, but it is very easy to make. Some professional machines using this principle use cup wheels of 19 mm internal diameter for small drills (such as the SRD machine, see MEW aug-sept 1992 issue p. 30).

Grinding the primary clearance:

Adjust the offset "h" (distance between drill axis and wheel axis) using the adjusting pin set in the medium size dividing block, **photo 10**:

$h = 1.414 \times r \times \sin\alpha + e/2$

r = internal grinding wheel radius;

α = clearance angle.

(h = 9mm on my machine for12°clearance, e/2 is neglected here as e<<r).

Set the drill in the convenient dividing block (see **photo 9** and **drawing 15**) the protrusion should be from 1.5x diameter for the biggest drill, to 3x diameters for the smallest.

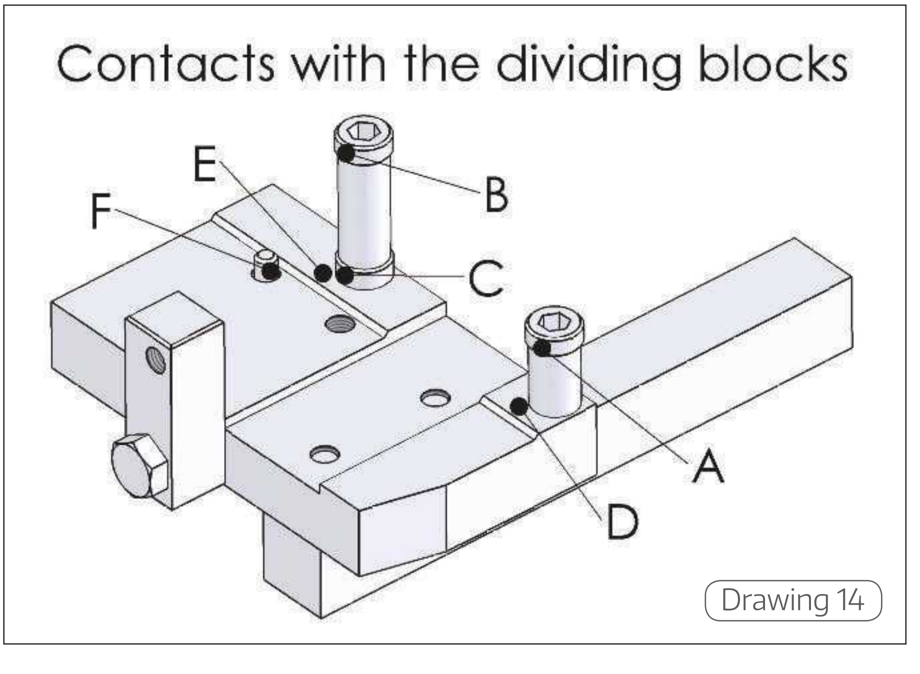
Machine the 2 lips until completely ground, the dividing being made by turning over the dividing block.

Grinding the secondary clearance:

Don't disturb the drill, just increase the offset (same formula, giving 18 mm on my Machine, 3 turns of the hand wheel to go from the12°clearance to the 25°one).

Machine the 2 lips until their meeting at the center of the drill.

Here again, if you don't want the centering point, the secondary clearance can be made only for "clearing the heel" (**point B in drawing 3**). It has usually already been made when roughing out the point. ■



Drawing 14

To be continued...

On the Wire NEWS from the World of Hobby Engineering

New Clark drill range from Machine Mart

The components of the machine are well packed

My trusty helper...

The robust table mounting arrangement

For many years one of the most used machines in my workshop has been an entry level Clarke bench drill, it was literally the cheapest machine in the range. Whilst it is not perfect, it has nevertheless more than earnt its keep. That said, I often felt I would be better off with a larger one to speed up bigger jobs. A larger, more rigid machine is also better suited to tasks like reaming that I would normally carry out on my milling machine.

I was therefore pleased to be asked by Machine Mart to try out one of Clarke's new range of pillar drills specifically designed for heavy duty engineering and workshop with tilting and swivelling tables. There are floor standing and bench models, we agreed that the CDP302B would be best suited to my needs, **photo 1**.

I wasn't prepared for just how big the machine was, let alone the huge and very heavy box it arrived in, weighing in at 43kg. The machine is supplied broken down into its major components, as is usual for drill presses. All the parts were securely packaged – it was clear the box was unopened and machine had not been assembled previously, so it was exactly as despatched form the factory, **photo 2**.

Unpacking, I was surprised by the quality of finish of the castings; the base casting was even painted a contrasting colour on the inside. Assembly was reasonably straightforward although my glamorous assistant, Luna, wasn't much help, **photo 3**.; the one minor exception being fitting the rack to the pillar. The pinion had a rather desultory lump of grease, so I added a bit more. The rack itself fits into a groove around the base of the column and another in a ring which is fitted to the column, **photo 4.** People who have mills using this arrangement will know that it is not a precision system, but more than adequate for raising the table. Once locked the table is very solid. I checked the horizontal alignment of the table using digital angle gauge, I zeroed the gauge on the table, then attached it (magnetically) to the column and it read 90.0 degrees. Repeating the test with a bar in the chuck showed that the spindle is also accurately at 90 degrees to the table.

Final assembly is just attaching the head to the top of the column, best done when in final position as I found when I tried to move the whole thing!

Unlike smaller drills, the CDP302B and other machine in the range have an MT2 taper socket. It is supplied with a big 16mm capacity MT2 chuck, **photo 5** – a release wedge is included in the fixings pack. The advantage of this is that you can easily swap the big chuck for smaller ones to suit the job in hand, or use accessories such as a centre or spotting drill permanently fixed in an a MT2 holder.

The supplied 16mm capacity MT2 chuck

Photos of the machine on its own really don't show how much larger it is, as all the parts are bigger in proportion; in fact, I had to cut the end off a shelf in order to fit the machine in a sensible place. **Photograph 6** shows just how much larger the CDP302B is than my five-speed drilling machine.

Machines in this range come with either a round table or a square t-slotted one; as I don't use flood coolant for drilling the round table is better for me as it can be rotated simplifying some tasks like chain drilling around a curve. The table is like a giant faceplate with six radial slots and held in a hefty clamp on the cantilever arm. The slots match the clamping set for my milling machine which is handy, although my preferred a setup for everyday work is to use a drill vice. Readers may be interested in my drill vice setup – I have one M10 screw and nut that holds the vice down loosely, while; a second screw just drops through into a slot. This is enough to prevent the vice spinning or lifting off the table under light loads yet it is easy to reposition it quickly – the rotating table helps here. For larger holes, I have a quick-release clamp that works like a mole grip designed to reach around obstructions. Always kept next to the drill it is the work of moments to use it to clamp the vice securely in place, **photo 7**.

All drill presses share the issue of having a high centre of gravity and a

Syd and Eddie?

Drilling a 13mm hole in cast iron

small footprint, making them potentially unstable. The drill was not supplied with fixing bolts, but it is essential to securely fix it to the bench. I used two lengths of M10 studding, this was a little small for the holes in the base despite being more than adequate for a bench mounted machine, so I used a couple of big washers, **photo 8**. There's no special reason for the wing nuts – I just couldn't find any clean M10 nuts!

The built in work light is very effective, despite being at the back it provides good illumination and saves me having to turn the lamp above the lathe every time I drill a hole. The guard is of the two-piece design common to just about all drilling machines and seems to be well proportioned and works well enough. When flipped up it can contact the light switch and turn the lamp on or off.

Secured to the bench

As a 16-speed machine the drill has two belts and three pulleys. The sheer number of configurations shown on a chart inside the flip-up lid (which has a safety interlock) is a bit daunting, **photo 9**. Unlike a five-speed drill, you really do need to look up the best arrangement on the chart, but changing is quicker than you might expect; undo two locking thumb-nuts and the tension is relieved, reposition the belts, pull a lever to restore tension and tighten at least one of the thumb nuts.

Some of the commonest criticisms of imported pillar drills are quill slop and lack of rigidity. I was pleased to find that, even when fully extended, I couldn't get the quill to show any detectable slop at all.

Despite appearances, belt changing only takes about a minute.

As for rigidity, the usual test is to check for tilt in the table while winding a chuck down against a block of wood on the table while pulling hard on the feed lever. I tried this and movement was virtually undetectable. Naturally the heavy cantilever arm for the table helps, but this also shows that the table clamps are secure. Some trials showed the machine made quick work of drilling holes in steel bar with a 13mm four-facet drill. Swapping to a 10mm Jacobs brand chuck I had no problems on a quick test making sub-millimetre holes in a printed circuit board, so despite its size, this drill press is an all-rounder.

The CDP302B costs £203.98 including VAT. You can see the full range of Clarke drill presses from hobby and light workshop to industrial types at **www.machinemart.co.uk**.

The Clarke CDP302B is a sizeable bench mounted drilling machine

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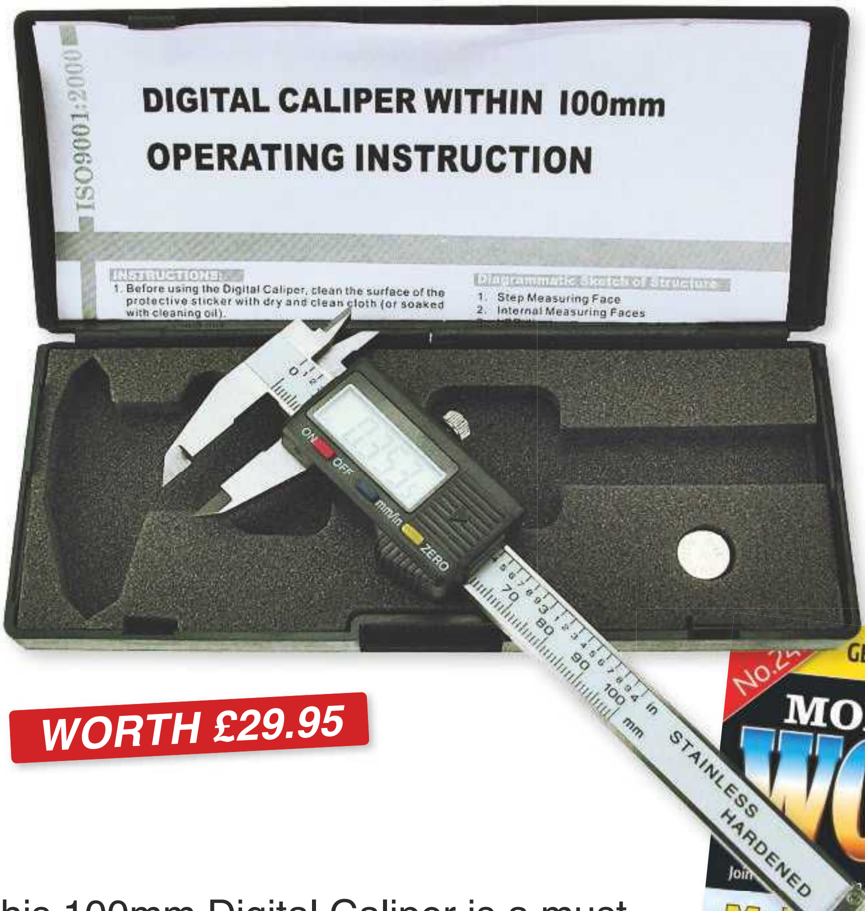

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Making the Lammas Hardness Tester

Rod Jenkins builds a design featured in Model Engineer in the 1980s

The ability to actually measure hardness rather than just do a "is it or isn't it" test with a file, whilst not essential to the home engineer, is certainly useful. Not just on carbon steels either: Most aluminium and copper alloys can be heat treated to change their physical properties. A hardness tester is a good way to test those properties.

The advent of low cost manufacturing in the Far East has meant that many items that model engineers used to make for themselves are now available relatively cheaply and I have taken advantage of this to provide my workshop with a small electric muffle furnace and, thanks to the generosity of my old work colleagues, a nice binocular microscope. The ability to quantify my attempts at heat treatment by hardness testing appealed to the scientist in me. The cost of hardness testers, even from the East, has not yet reached a level that I could justify but fortunately, back in 1989, Dave Lammas introduced a hardness tester in Model Engineer that could be manufactured in the home workshop, ref. 1. Mr Lammas comprehensively described the making of his splendidly compact design so I will not attempt to repeat his instructions. However, things have changed in the intervening 25 years and I will mention the way that I chose to make some of the items that Dave didn't fully describe, in the hope that it may be of help to other constructors of this worthwhile addition to the workshop.

There are various methods of hardness testing but the most reliable and accurate method is by applying a weight to a point resting on the specimen to be tested and then measuring the resultant indent. These days, in engineering at least, the most common hardness measurement scale for hardened steels seems to be Rockwell C. This involves using a conical indenter that undergoes a small pre-load and then a load of 150Kg. The depth of the indent can be measured and has the advantage that a DTI with a suitably modified scale can give a direct read out of hardness. The manufacture of the indenter, the complication of the two different weights and the sensitivity of the DTI required present some difficulties to home manufacture. The alternative, and British!, method is the Vickers system. This uses a pyramidal indenter and a weight of 120kg. The size of the indent is measured optically and the resultant hardness is read off from a table. Using a second table it is easy to convert Vickers results to Rockwell C, or any other scale, if so required. The

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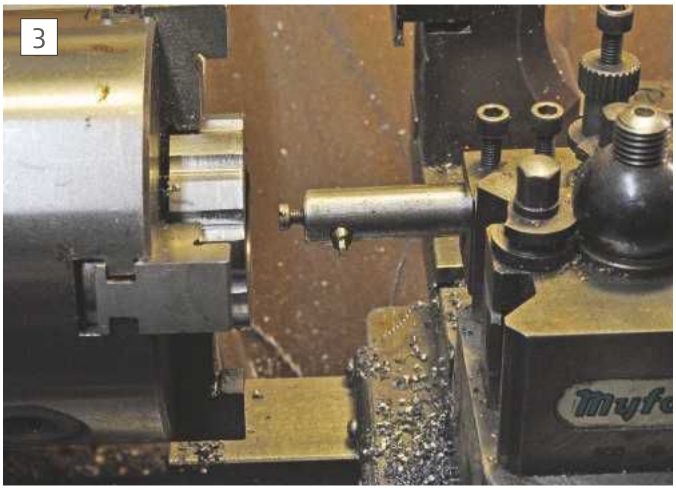
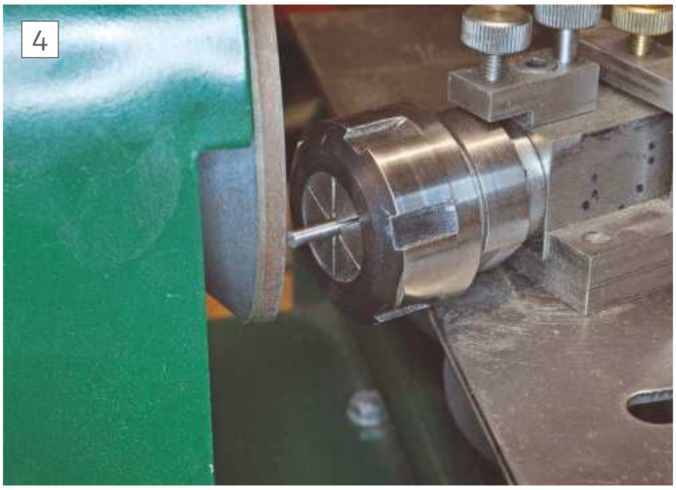
Castings as received from Blackgates

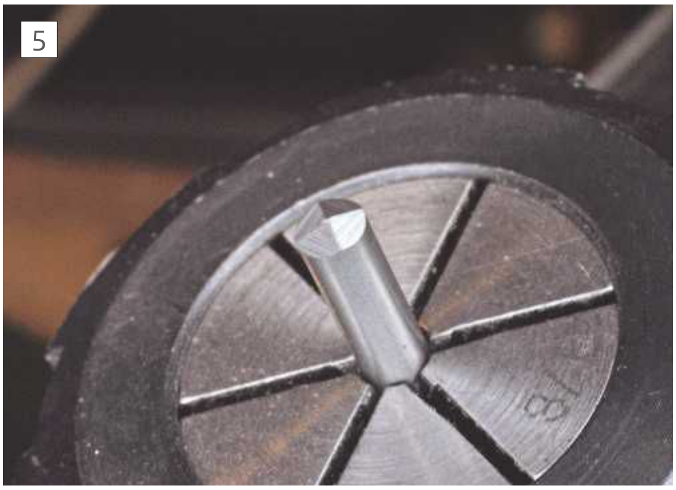
Square thread cutting tool



Same toolbit used for cutting an internal thread



Grinding the indentor on a worden



Finished indentor

Vickers system has the advantage that the indenter can be used on softer materials whereas Rockwell B or Brinell, yet another system, use a ball rather than a conical diamond. So, the Vickers system is the one that Dave Lammas used for his design and is really quite straightforward: A double lever system gives 24 times multiplication of the 5kg lead weight to provide the force on the indenter. Provided the spacing of the pivots is reasonably accurate and the pivots themselves move freely there is very little to go wrong. Ideally, the indenter would be diamond but Dave Lammas showed that a tungsten carbide indenter is perfectly satisfactory for testing materials that are as hard as the hardest steels and this can be easily made from a broken tungsten carbide tool using a "green grit" or diamond grinding wheel.

Blackgates, ref. 2, sold me the castings, drawings and re-prints of the original ME articles. Three iron castings were supplied, **photo 1**. These were nice quality with no hard spots. The flow lines on the surface of the castings give a rather pleasing "leather look" to the finish. When machining castings, I like to try and follow industrial practise and only mill or file those surfaces that are needed for functionality. I followed this mantra for most of the milling, drilling and reaming of the upright but found that the best way to make the holes for the indenter holder was to lay it on its back and for this I ended up milling the rear surface. In retrospect I recommend doing this at a very early stage and using that machined surface as a reference, whatever machine tools you use. The pivoting arms are straight forward milling tasks. I used my DRO on the milling machine to position the pivot holes and spotted, drilled and then reamed in situ.

Making the square thread on the specimen holder was a novel experience for me. The 8tpi thread needs a nominal 1/16-inch wide tool. I made my cutter from a 3/16-inch diameter HSS tool blank held in a square holder. This was ground in my Worden tool and cutter grinder with 2 degrees relief all round, **photo 2**. I made the width slightly less than 1/16-inch wide to ensure that the cutter wouldn't jam in the cut and rotated the tool just a tad in the holder so that the tool gave some relief at the helix angle. I used the topslide to shave the trailing edge of the thread until it was 0.063 inches wide as measured with my digital calliper. I was able to use the same tool in a cross wise holder to cut the matching female thread in the adjusting nut, **photo 3.**

The indenter was made from a broken 1/8-inch tungsten carbide slot drill. I have made a ER25 collet holder for the Worden with 12 hole indexing, ref. 3, so it was a simple task to set the Worden table horizontal and the tool holder to the required angle to grind each face by rotating the collet by 3 holes for each face. I roughed out the shape first, **photo 4**, and then finished off with a final cut for each face at the same depth, just turning the collet between traverses, to ensure that the facets were even, **photo 5**.

Perhaps the most daunting task to we metalworkers is the wooden base. Although I have made a few musical instruments from wood, the joints used are all pretty crude – mostly butt joints with the addition, for true period authenticity, of the odd nail! The wood for the base was not a problem – I have some mahogany salvaged from an old chest of drawers that was the correct thickness but the concept of hand cut dovetails, as recommended by Dave Lammas, is beyond me. I have an old Black and Decker router and dovetail jig that I bought many years ago at a tool sale. I tried a practise piece and failed: depth setting on the router is very crude and the jig is for timber rather thicker than I was using. However, modern glues are pretty forgiving, even on end grain. I cut the timber up for the two long sides, the two short sides that would go between

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the long sides for the ends and the top on my bandsaw. This, fortunately, is pretty accurate and gives a good finish so no further work was necessary. An alternative to getting some nice square parts is to finish them in the milling machine which makes a surprisingly good job of cutting wood, particularly hardwoods. The top needs to have clearance holes for the specimen support column and for the weights. While I have a wood drill that will cut the clearance hole for the column, the weight orifice is way beyond my drill sets. The mill again came to the rescue and my boring head made a good job of this hole, **photo 6**. Note the use of a piece of sacrificial timber under the job to ensure that the exit of the hole is nice and clean. The blue hold down clamp usually lives on my drill press. The end grains of the short end pieces were anointed with Titebond glue and they were clamped between the long sides, **photo 7.** This assembly was then placed onto the top and weighed down with some cast iron dumbbell weights that I'd been given, **photo 8**. After trimming the slight overlaps, I finished the base by chamfering the corners and wiping on 2 coats of Danish oil.

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Boring the hole for the weights

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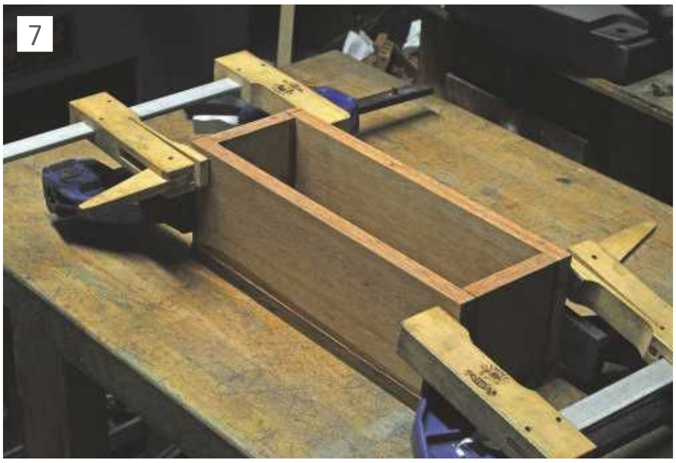

Base sides clamped to end pieces

8

Base frame glued to top

One of the other important features that Dave Lammas wasn't able to fully cover was the manufacture of the weights. I convinced the domestic authorities that our lean-to garden shed needed re-roofing and this time it should be done properly with some lead flashing. By amazing coincidence there was just enough left over to make the weights for the hardness tester! I also managed to get an angle grinder, for chasing out the mortar for the flashing, from the same budget. I melted the lead with a blowtorch directly in a stainless steel soup ladle and cast it into aluminium soft drinks cans (dear readers, please take all required precautions when casting lead, not only is the molten metal hazardous, but it gives off poisonous fumes – Ed.). I was able to peel the aluminium away when the weight had cooled but, if you can make a good job of tidying the ends, then it would be neater to leave the aluminium in place and paint it. Cutting the slot in the weights was somewhat fraught: Lead is not easy stuff to either hold or machine. I held a weight in a 3 jaw chuck and then centred the free end by eye against a lathe tool. I was then able to drill the central hole very slowly using loads of cutting oil. Once this was done I was able to use a rotating centre to more firmly hold the weight for tidying up one face before reversing in the chuck for the other face. The hole in the weight needs to be opened out into a slot so that it can be easily slid on and off the carrier. I didn't fancy my chances of being able to mill this slot in lead so resorted to sawing by hand with an Eclipse general purpose saw, which has quite a wide kerf, and then opening the slot out with a wood chisel. This palaver is only really necessary to provide some flexibility in the use of the hardness tester. If you are going to stick to the Vickers system, then the weights can be threaded on to the carrier and left there – no slot required. If I were doing it again that would be my option. I tested my weights on the digital kitchen scales, which weighs to 1 gram. The weight for the carrier was adjusted by spot drilling some craters until the assembly was the correct weight. The two other weights

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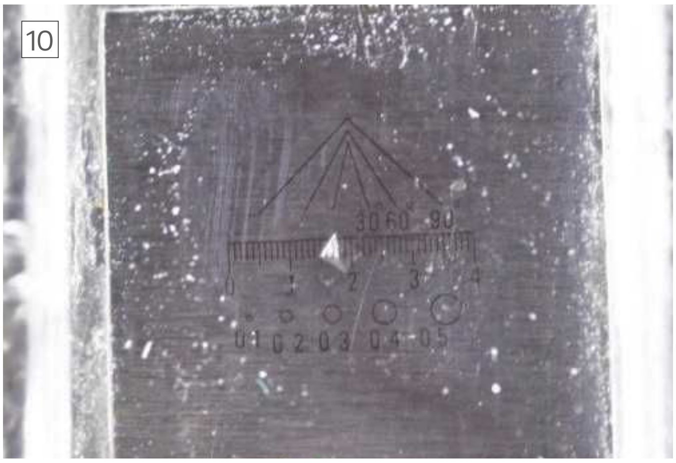
Measuring loupe

10



Indent seen through loupe

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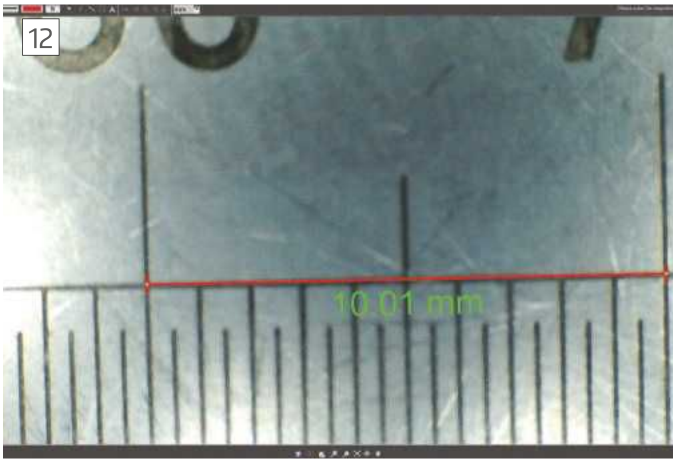
USB microscope

12



USB microscope scaling

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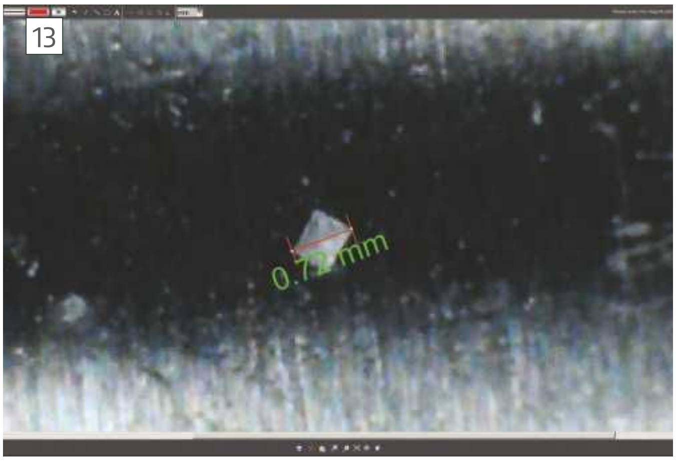


Indent measurement with the USB microscope

were both undersized – the amount of lead I had left from the flashing was marginal. I made a couple of steel discs, slotted them to match the weights and then fastened them to the lead with short countersunk wood screws. The weights were then adjusted by spot drilling the steel.

When assembled and with the weight in the parked position, the lever arms should be neutrally balanced. The drawings give a general shape for the arms with no indication of the various angles. When I assembled mine I found that the smaller arm was too heavy but I was reluctant to reduce the dimensions because the accuracy of the machine depends on the rigidity of the whole structure. My solution was to add some weight, in the form of a piece of BMS screwed to the underside of the larger arm.

As we have seen, in the Vickers system, the indent is a square pyramid. The hardness is determined by measuring the length of the diagonals of the indent, averaging these by adding together and dividing by two and then looking up the hardness figure from the tables. I have a rather neat little measuring loupe that I bought at the last Sandown MEX, **photo 9**. In use the loupe is placed over the indent and positioned so that the diagonal length can be measured, **photo 10**. An alternative not available to Dave Lammas is to use one of the cheap USB microscopes that are now readily available, **photo 11**. This microscope came with a simple image capture and measurement program. In order to use the microscope for measurement it is necessary to first calibrate the system. This is achieved by taking an image of a scale, in this case a steel rule. The scale bar is then dragged across a known distance, **photo 12**. In the top right hand corner of the screen view is the calibration number which is adjusted until the scale reads the correct distance. With this program the calibration can only be changed in whole numbers so the nearest I could get was the 10.01 mm with a scaling factor of 19 as shown in the image, which was perfectly satisfactory. If you do require greater accuracy then Zeiss have made a version of their very comprehensive "Axiovision" microscope analysis program available for free, ref. 4. Once the calibration factor has been determined then the indent can imaged at the same magnification and the size measured, **photo 13**.

Having made the machine, I was keen to determine how accurate the hardness measurements are. Fortunately, I came across some Rockwell hardness standards on Ebay for a good price and chose one in the middle range, 46.4 HRc. This test block can be seen under the USB microscope. On testing, the average diagonal of the indent measured 0.70mm which comes out at a Vickers hardness of 454. A conversion table for Vickers to Rockwell C, ref. 5, gives a reading between 45 and 46.7 HRc which was very pleasing. However, too much self-congratulation is not really justified. The Lammas design is straight forward and depends only on having accurate spacing between the pivots, to the nearest thou, and accurate weights, to the nearest gram, to be sure of an accurate machine. The engraved scale on my Worden grinder would also seem to be accurate enough to produce an indenter that gives the right answers. I was very happy with the resultant machine – all the tools in the workshop now seem to have little diamond shaped dents in them. ■

References:

Model Engineer Vol 163, 1989
Blackgates Engineering, Unit 1 Victory Court, Flagship Square, WF12 7TH
Model Engineers' Workshop No 189, 2013
www.zeiss.com/microscopy/en_de/downloads/axiovision.html
www.taylorspecialsteels.co.uk/pages/main/conchart.htm

How to Make Small Helical Springs

This neat tip for making small compression springs from G. E. Coupland first appeared in Model Engineer Volume 86, 2138, April 30 1942.

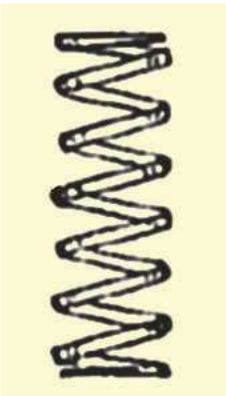
THE MODEL ENGINEER

Vol. 86 No. 2138

Percival Marshall & Co., Limited
Cordwallis Works, Maidenhead

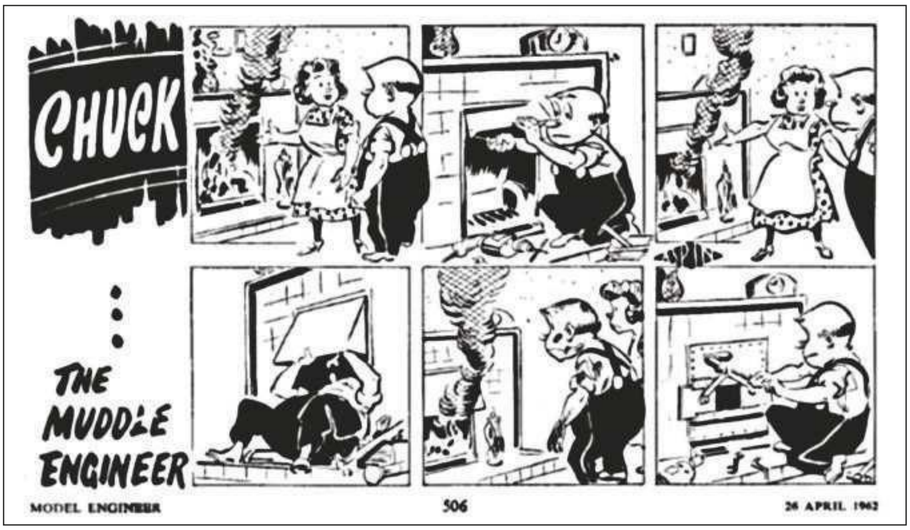
April 30th, 1942

Small helical (spiral) springs used in model locomotive construction for safety—valves, axle—bxes, buffers, etc., and for many other purposes in model making, need to be correctly made if they are to function properly. If they are to be used in compression, as they mostly are, it is a mistake to close-wind them on a metal rod and afterwards stretch or pull them out to the required length. Using. that procedure, you may, by luck, produce a spring with equally-spaced coils and axially straight, but the odds are against it.



A much better plan is to use a former to space the coils evenly when winding. Choose a suitable wood screw, cut off the head, and use it as a former, by gripping it in the vice or s.c. chuck and winding the wire tightly in the thread of the screw. The coils will spring back a little on being released, and a few trials with different sized screws will show the right size of screw to use to produce a spring of a definite diameter. As the working range of such springs is in most cases very small, there is no need to harden and temper them if made of hard "piano" wire, but it is important that the ends should be ground off in a plane perpendicular to the axis. Push in a match—stick (for very small springs), skewer or any bit of wood that will fit tightly inside the spring and dab the spring squarely against the side of a revolving grinding wheel. The end coil of the spring will immediately become red-hot and will be pressed down nearer to the coil below and at the same time be ground off to a tapering point. The operation is so quick that the heat has no time to travel down the spring and spoil its 'temper. Reverse on the stick and do the other end in the same way.

Test the spring by standing it on its end on a smooth level surface. If right, it should stand upright like a ninepin. If it tumbles over or looks like the leaning tower of Pisa, the grinding has not been correctly done, and must be repeated until right. If the spring is too long, cut a bit off and regrind. If too short, it may be stretched slightly, although it is better to make another one a little longer and try again. Springs of hard brass or p.b. wire can be made in the same way, for use in positions where steel would rust. The sketch shows how the spring should look if correctly made and ground. ■

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Simple Dividing

TIP OF THE MONTH WINNER!

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

Please note that the first prize of Chester Vouchers is only available to UK readers. Other prizes are at the discretion of the Editor.

Our winning tip from David Nye might come in handy for people wanting to do basic dividing without a dividing head.
I am in the process of restoring my Fordson Super Major tractor and needed to fabricate a couple of missing control knobs for the hydraulics. One was an easy turning job even for a beginner like me and was quickly knocked up out of an old bolt, drilled and tapped 3/8 UNF. You can see it shining in the background of the second picture.

The second hydraulic flow control knob was a bit harder as in the workshop manual it showed it having milled grooves around it, not a problem if you have a dividing head and know what you are doing, I have a Warco Mill Drill but no dividing head and also haven't used it yet for milling. So I was stumped until I had an idea;

I had a new 1/8th end mill which looked about the right size for the grooves so I worked out the circumference of the aluminium bar that I was using for the knob - 75.4mm, divided it by 10 which conveniently came to roughly the sum of the 1/8th mill plus the width of the lands that wanted to leave protruding. I know this is a mishmash of metric and imperial but that is how I work jumping from one to the other for convenience sake.

I then drew10 x 7.6mm apart lines on a 25mm wide strip of paper and tried it for size round the bar, it was nearly perfect but needed a little tweaking to get the spacings right. Once I was happy I stuck it on with Sellotape, you can just make it out in **photo 1.**

The next corner was cut by clamping the bar direct into one of the tee slots, I figured that they must be true to the milling head so that would eliminate another setting up mistake. I put a fixed stop behind the bar so that as I rotated it it stayed put. Finally I clamped a steel rule to the table and used that as my reference point for the lines on the paper.

I zeroed the cutter onto the knob blank and marked the depth of cut I wanted on the fine feed of the quill with a bit of masking tape and pencil so that I didn't forget the depth of cut and off I went taking very shallow and slow cuts, just in case.

The finished knob can be seen in **photo 2**, it is aesthetically fine but I make no claims on this method for replacing the need of a proper dividing head. However, if like me you are new to this game and want to make something that doesn't have to be 100% perfect, and also like me, you don't have a dividing head here is a simple dodge that you can use and have some fun along the way.

David Nye

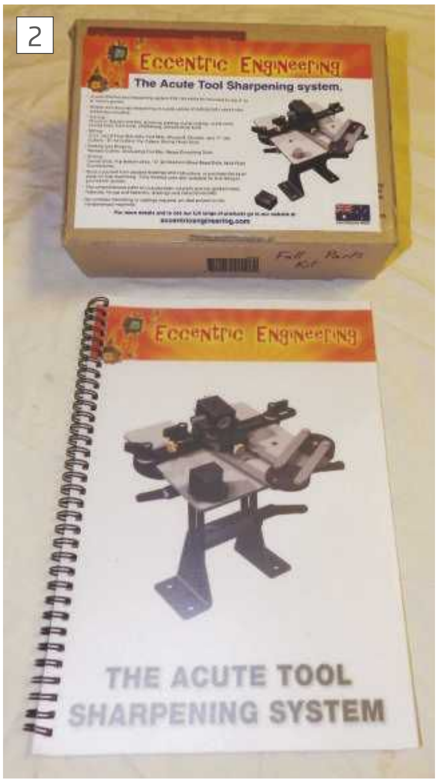
Machining and Building the Acute Tool Sharpening System

John Ashton describes how he built this versatile sharpening system from Eccentric Engineering's kit, including some useful jigs that will be helpful to anyone following his example.

Photograph 1 shows the completed 'acute tool sharpening system', with an extra table unit, fitted to my grinding head, which is a standard 6-inch (150mm) bench grinder I modified to use specifically with the 'acute' tool system. It is based on the grinding head used in the eccentric engineering's demonstration video. While I was machining and building my grinding head the eccentric engineering's acute tool sharpening system kit with the additional table kit arrived.

Photograph 2 shows the boxed kit and manual, the boxed kit was well packaged. The spiral bound a4 manual is a well illustrated document with easy to read drawings, each drawing also has

The completed Acute system



The kit box and manual as supplied

a 3d model illustration of the finished component or sub-assembly for extra clarity also each component and sub-assembly has an individual part number for ease of identification, an example is shown in **photo 3**, and there is a list of the tools required to complete the kit. Finally, the manual has a note page at the back for recording any data or information you may need to refer to at a later date.

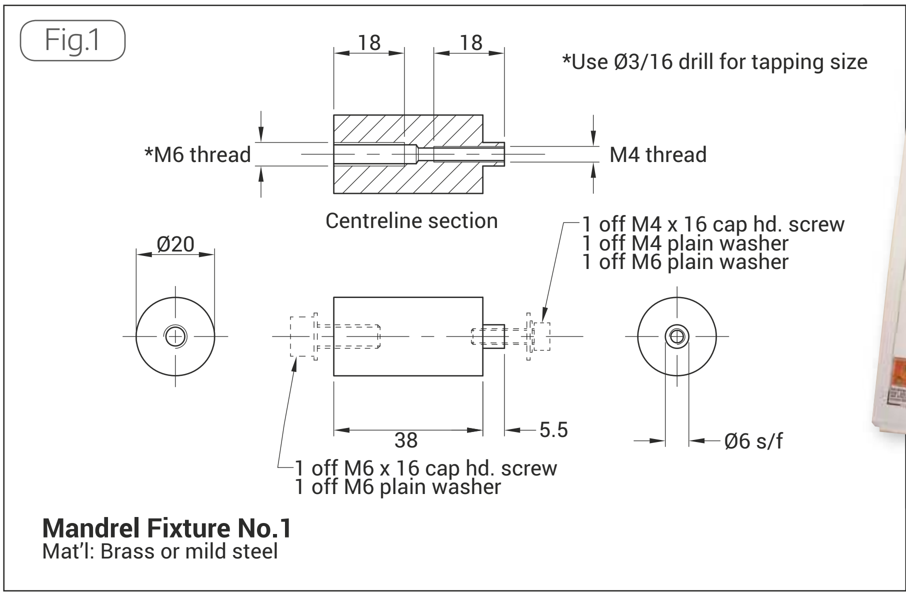
Photograph 4 shows the full kit of parts. Most of the laser cut components are pre-spotted or have pilot holes avoiding a lot of complex marking out. The instruction dvd was not available at the time I built my acute tool sharpening system so it was important to read the manual of drawings thoroughly to familiarise myself with what machining was required for each component and how the various assemblies worked together and anything I didn't understand or I had a question, regarding the machining or functionality of any component, gary sneesby at eccentric engineering was only an email away.

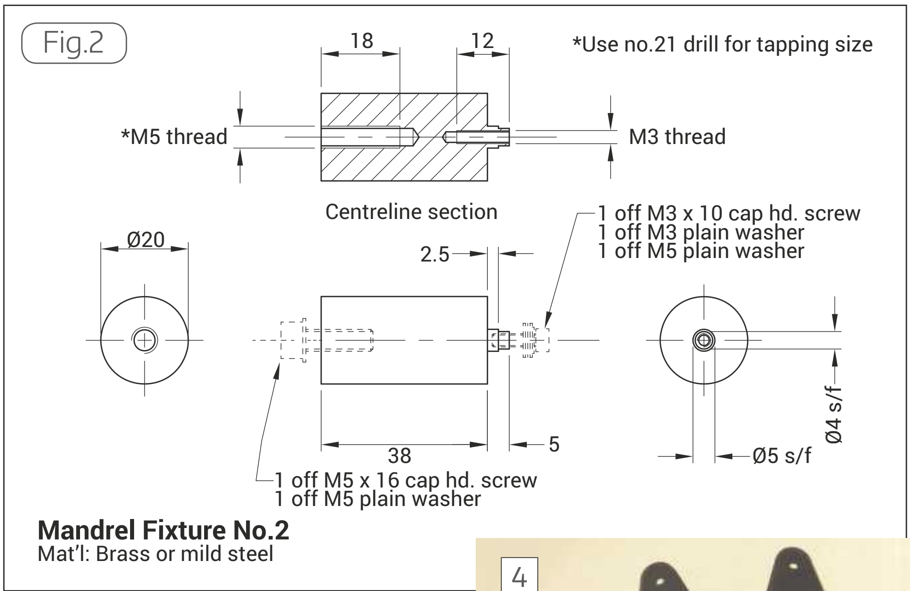
Special tooling

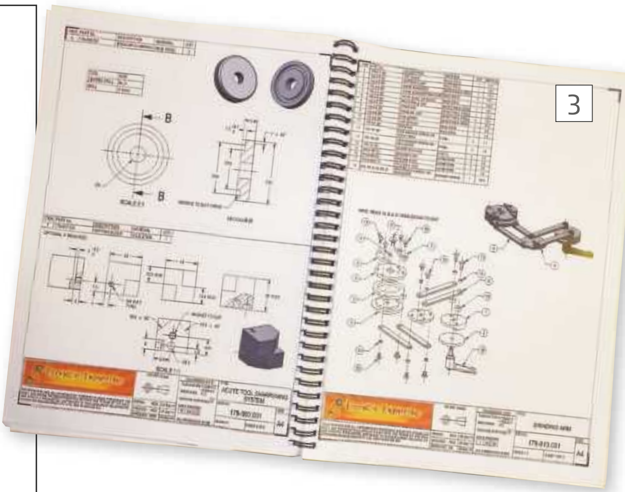
To help machine some components I machined tooling aids to hold components during some operations as follows;

A) mandrel fixture 1 – **fig. 1**.
B) mandrel fixture 2 – **fig. 2**.
C) riveting dolly – **fig. 3**.
D) turning fixture – **fig. 4**.

I kept the tapping size for the threaded ends of the mandrel fixtures as close to the core size of the threads as possible to minimise any eccentricity. However, this leaves little or no clearance for the taps, therefore, great care must be taken when tapping, slow and patient. **Photograph 5** shows the complete set of special tooling fixtures used during the build.







An example page from the manual

You can, of course, cut the whole slot out with a hacksaw and file to size.

Top bracket & bracket bottom

The top and bottom brackets are already finished apart from the 5mm diameter pilot hole, which has to be opened up to 6mm diameter on one side and 5.8/5.9mm diameter on the other, this is to keep the fit to the pivot bolts as tight as possible on both the shank and thread section of the pivot bolts because the thread diameter of a bolt is normally slightly smaller than the shank. However, the shank and thread diameters of the bolts supplied with the kit happened to be the same size 5.87mm diameter. So what I did was to drill them all 5.8mm diameter then I used the tapered part of a 6mm diameter hand reamer to ream from each side of the brackets to size the holes to suit the pivot bolts. **Photograph 8** shows one set of

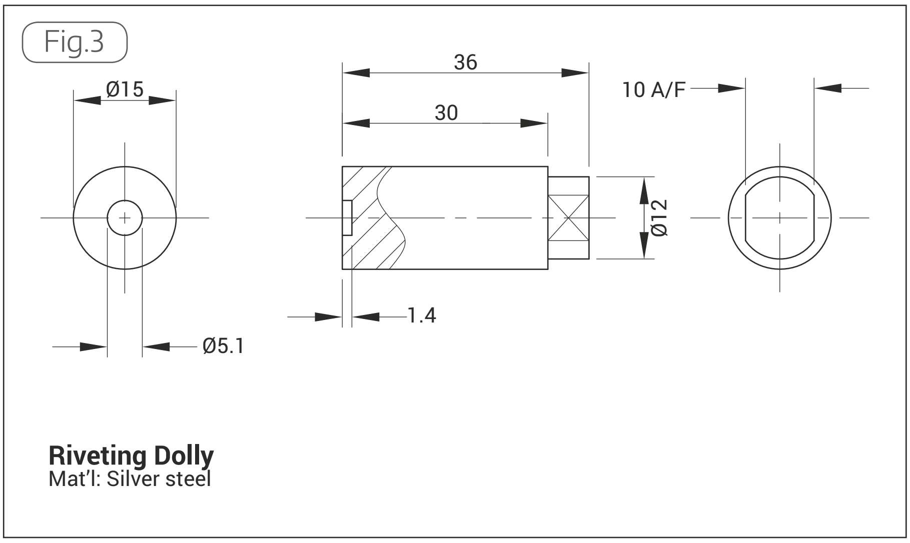
Component parts and assembly of the base table

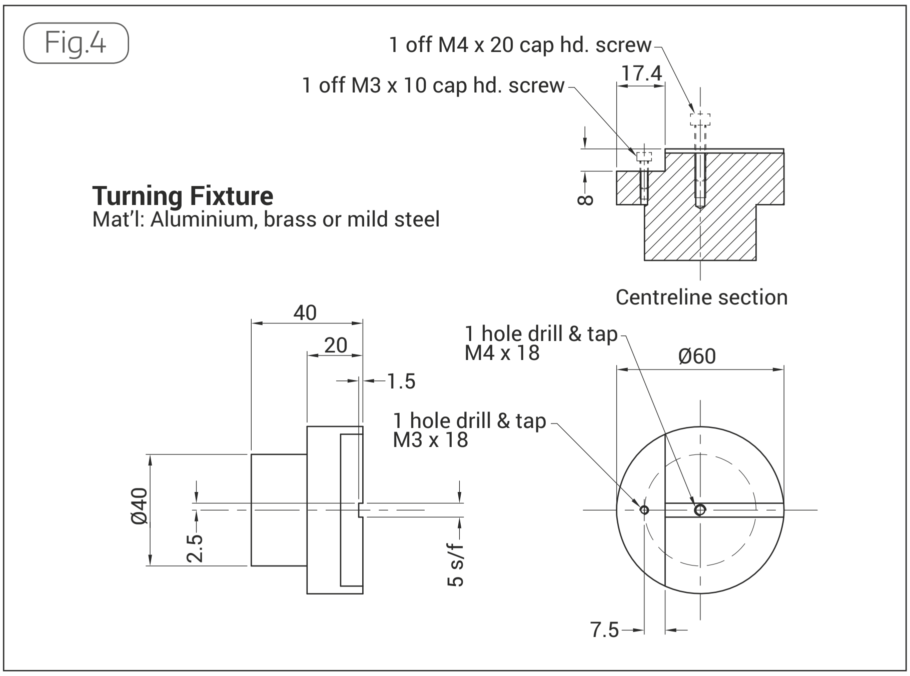
As my system consists of two base table units the component parts for the base table were doubled up on the basic kit.

Work table

The work table is already tapped for the top brackets and has two laser cut slots large enough to take a standard hacksaw blade positioned 30mm from one edge and 45mm from the opposite edge this is to make it easier to complete the machining of the slot required to clear the grinding wheel, **sketch 1** shows the dimensions of the clearance slots I required to clear the grinding wheels of my grinding head and **photo 6** shows the finished work tables. You will need to machine the slot to suit your own grinding head setup. After marking out the slot positions, I machined the slot sides using a slitting saw on my milling machine, see **photo 7** show my slitting saw setup and machining. I then hacksawed between the slots and finished off by filing the hacksawed edge to size.

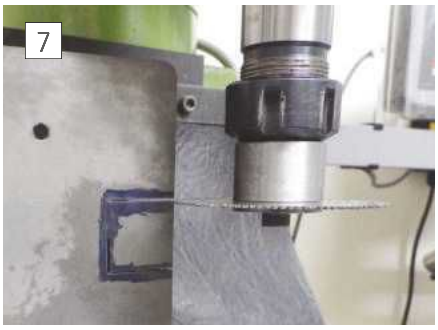
The parts as supplied





John's special jigs and fixtures

The work tables



Slitting saw set up

completed brackets and sliding links.

Sliding link

Like the top and bottom brackets the sliding links are already finished apart from the 5mm diameter pilot hole, which I drilled and reamed out to 6mm diameter.

Base spacer

The base spacer blanks are supplied from 1-inch diameter aluminium bar stock; the drawing shows the diameter to be 25mm. As the outside diameter of the spacers are in free space I decided to leave the diameters at stock size. I used my 5c collet chuck setup on my lathe to face off the spacers to 60mm length and drill the pivot bolt holes 6mm diameter. I used a 5c collet backstop to a set depth for machining the length then removed the backstop to drill the 6mm diameter hole. **Photograph 9** shows a completed pair of spacers.

End cap clamping

These are supplied as 5mm thick laser cut discs. The first operation was to hold the disc squarely in the 3-jaw chuck of my lathe to drill and ream the central 6mm diameter hole. The reason for reaming the hole was so I could use it as a tooling aid to complete the machining of the end caps.
To complete the end cap, I used mandrel fixture 1 (fig. 1) to hold the end cap on the 6mm diameter spigot end for the rest of the machining operations. The next operation was to machine the outside diameter and the chamfer. I turned the end cap around on the mandrel fixture to machine the 'o' ring groove. The 'o' ring groove can either be machined on a lathe or milling machine.
I decided to machine the 'o' ring grooves using my rotary table setup on my milling machine. Using the rotary table setup, I used an edge finder to centre the end cap.
I machined the 'o' ring grooves with a 2mm diameter slot drill, in accordance with the drawing, see **photo 10**. **Photograph 11** shows the machined 'o' ring groove and **photo 12** shows an end cap with the 'o' ring fitted. The 'o' rings create a slight tension

Brackets and links


9

Spacers


10

Machining o-ring grooves


11

Groove in end cap...


12

...and o-ring fitted


13

Completed base tables

against the sliding links to prevent the table collapsing to the deck when the handles are loosened to adjust the table position.

The top and bottom brackets and sliding links are 'blackodised' so I decided to blackodise the end caps to give the table assemblies that professional touch plus some extra protection.

Assembly of base tables

The base tables were assembled in accordance with the assembly drawing. The M6 x 90mm long pivot bolts had to be shortened by 5mm. **Photograph 13** shows the completed assembled base tables.

Blackodising

I have a blackodising kit I bought from a company called pixel-plus. The kit is called black-it and consists of four solutions;

1) Degreaser.
2) Conditioner.
3) Blacking solution.
4) Dewatering oil

The whole process is carried out at room temperature and takes 18 to 21 minutes plus 45 minutes drying time. I have the standard kit, which is a 500ml system. The cost is £40, this may sound a lot but the solutions are reusable and seem to last for years. I have had the kit for 2 years now and the solutions are as good as the day I bought them.

The website is **www.black-it.co.uk**, **photo 14** shows my blackodising setup, the size of the solution containers to suit your components. Small components can be hung on a wire and dipped directly into the solution bottles.

Component parts and assembly of grinding arm

Top clamp

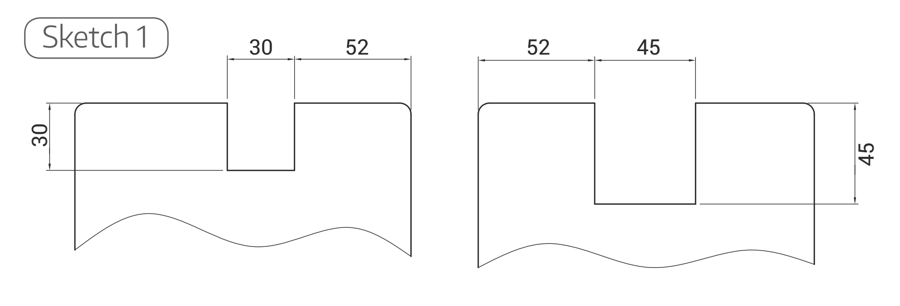
The top clamp is supplied as an 8mm thick laser cut disc with the centre M6 and two M4 hole positions pre-spotted. The first operation was to hold the disc squarely in the 3-jaw chuck of my lathe to drill and tap the M6 centre hole, for this I used my tapping head detailed in issue 233, autumn 2015 addition, titled a tapping dilemma. With the top clamp assembled to the M6 threaded end of mandrel fixture 1, fitted in my 5c collet chuck of my lathe, I machined the outside diameter. Next, again using the mandrel fixture I clamped the assembly in my toolmakers vice setup on my milling machine to drill and tap the M4 holes, this operation can also be performed on a pedestal drill. The final operation was to machine the 4mm deep rebate. I fitted two cap head screws in the M4 holes to hold the top clamp in my toolmakers vice, see **photo 15**, then I used an edge finder to centre the top clamp, then machined the rebate to drawing, **photo 16** shows the finished part prior to blackodising.

Bottom clamp

The bottom clamp is supplied as a 4mm thick laser cut disc. The first operation was to hold the disc squarely in the 3-jaw chuck of my lathe to drill and ream the centre hole. Once again I used the spigot end of mandrel fixture 1 to hold the bottom clamp in my 5c collet chuck setup of my lathe to machine the 40mm outside diameter, **photograph 17**.

Work head base

The work head base is supplied as a 5mm thick laser cut blank with the external profile already finished to size, the bore is cut undersize for finishing to size and hole positions are pre-spotted. The first operation was to machine the bore to size, due to the asymmetric profile the work head base was held squarely in the 4-jaw chuck of my lathe, see **photo 18**. Next I drilled and tapped the two M4 tapped holes, this I did on my mill, this operation



Positions Of Machined Clearance Slots In Work Tables

Metal blacking kit

can also be carried out on a pedestal drill. **Photograph 19** shows the finished part prior to blackodising.

Work head bottom plate

The work head bottom plate is an 8mm thick laser cut disc. The first operation was to hold the disc squarely in the 3-jaw chuck of my lathe to drill and tap the centre threaded hole. Next I used my 5c collet chuck setup with the threaded end of mandrel fixture 1 to machine the outside diameter. With the same setup I machined the 3.5mm deep register to locate in the work head base, this needs to be a close slide fit in the work head base, see **photo 20**, then I undercut into the face of the register to eliminate any corner radius interference. The final operation was to machine the slot to locate the fence, again this needs to be a close slide fit. To machine the slot I clamped the work head bottom plate in my toolmakers vice setup on my mill and centred it with an edge finder. I did not machine the reamed hole shown on the drawing, at this stage, the reason for this will be explained later. **Photograph 21** shows the fence positioned in the slot of the work head bottom plate.

Work head top plate

The work head top plate is a 5mm thick

Using screws to locate part in vice

laser cut disc. The holes are pre-spotted. With the disc held squarely in the 3-jaw chuck of my lathe I drilled and reamed the centre hole then, with a 12mm diameter spot drill, I machined the countersink to take the M6 countersunk head screw, supplied in the kit, ensuring the screw head was just sub-flush. Next I used my 5c collet chuck setup with the 6mm diameter spigot end of mandrel fixture 1 to machine the outside diameter, to do this I mounted the work head top plate with the countersink against the mandrel fixture face, so that with the same setup I could machine the register to locate in the work head base, this needs to be a close slide fit in the work head base, similar to the work head bottom plate, reference **photo 20**, then I undercut into the face of the register to eliminate any corner radius interference. Next I turned the work head top plate around on mandrel fixture 1 and mounted the assembly in my toolmakers vice setup on my mill, using an edge finder to centre the setup. I then drilled and reamed the hole that locates the stop pin and drilled and tapped the four holes to locate the adjustable way and fixed way in accordance with the drawing. These operations can also be carried out on a pedestal drill. I did not machine the second 3mm hole, the reason for this will be explained later. **Photograph 22** shows the component with the un-machined hole position.

Adjustable way

The adjustable way is supplied as a 4mm thick laser cut circular segment. The positions of the two mounting holes are pre-spotted. The adjustable way is fixed to the work head top plate with the two M4 hex screws, the clearance between the 5mm diameter mounting holes and the M4 screws allows for the adjustment of the adjustable way. The drawing dimension from the hole centres to the guide face is 5mm, the centres of the spotted positions of the laser cut guide face measured approximately 5.5mm. Therefore, before drilling the mounting holes to 5mm diameter I carried out the following operations to machine the guide face and rebate to guide the feed guide assembly and tool block assembly.

First I drilled and reamed the spotted positions to 4mm diameter, the reason I didn't drill the mounting holes 5mm diameter straight away was because I happened to have some 4mm diameter dowels which I used to support the adjustable way between two toolmakers 1-2-3 blocks to confirm the amount to be removed, with my height gauge I measured off the top of the dowels to the guide face, which measured 3.5mm this meant that 0.5mm needed to be removed, with the dowels still fitted I set up on the mill to machine the guide face to size. With the same setup I used an edge finder to set the datum for machining the rebate that locates the feed slide. Next, I machined the 45° chamfer on the base of the rebate, for this I used a spotting drill, I find them brilliant to use as a chamfer cutter. Finally, I opened the mounting holes out to 5mm diameter. The adjustable way was put to one side until the fixed way was ready for the final machining of the outer radii of both parts.

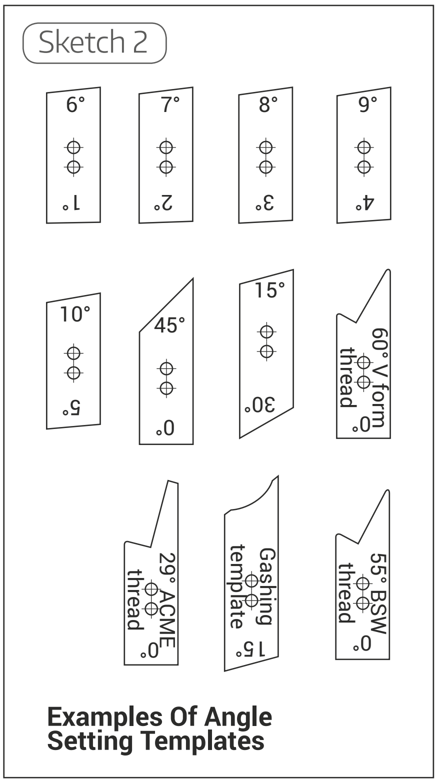
Fixed way

The fixed way was supplied as a 4mm thick laser cut circular segment, holes are pre-spotted. The dimension of the M4 countersunk holes to the guide face is 5mm. The measured distance was 5.4mm. I first drilled, reamed and countersunk the mounting holes, and then I confirmed the

Top clamp

Bottom clamp

Boring work head base



Finished base

Bottom plate on mandrel

amount to be removed from the guide face, similar to the adjustable way. Next I machined the guide face and chamfer to size. As with the work head top and bottom plates I did not machine the reamed hole at this stage. Next I secured the fixed way and the adjustable way to the work head top plate with the screws supplied in the kit, ensuring that the tool block was a slide fit in the slot produced, and then fitted the assembly to the spigot end of fixture 1. Next, using my 5c collet setup on my lathe, I machined the outside radii flush with the outside diameter of the work head top plate, see **photo 23**.

Machining the work head line up hole

It is now time to drill and ream 3mm diameter reamed holes in the fixed way, work head top plate and work head bottom plate. The purpose of the hole through the three parts of the work head is so that you can set the tool block slot at 90° to the fence slot. Just use a 3mm diameter pin, drill shank or drift, which is a slide fit, located in the hole to set it. Another advantage of locking the top and bottom plates together is that you can now use an angle template in the tool block slot to set the fence at a specific angle to the grinding wheel. The top and bottom slots can also be rotated independently of each other with the pin removed.

Photograph 24 shows the parts required for assembly to machine the line up hole, although it's not required for this operation I left the adjustable way assembled. First I set the fence slot and tool block slot 90° to each other and tightened the M6 screw, the radial position of the work head base does not matter. Using my mill setup, I lined up the pre-spotted position on the fixed way clamped the assembly in position then drilled and reamed the hole through. **Photograph 25** shows the machined assembly. It is important that the hole does not encroach on the bore diameter of the work head base; as this will prevent the parts rotating independently of each other, see **photo 26**.

Parallel links

The parallel links are supplied as 3mm thick laser cut pre-shaped blanks so the only operation to do is drill and ream the pre-spotted holes, which can be carried out on the mill or pedestal drill. **Photograph 27** shows the finished parts prior to blackodising.

Link joiner

The link joiner is a 4mm thick disc. The positions of the four holes are pre-spotted. With the disc held squarely in the 3-jaw chuck of my lathe I drilled and reamed a 6mm diameter centre hole, this hole is purely for work holding and is not part of the functionality of the link joiner. Next I used my 5c collet chuck set-up with the 6mm diameter spigot end of fixture 1 to machine the 40mm outside diameter. Next I transferred the link joiner and mandrel assembly to my mill set-up and used an edge finder to centre the link joiner, I then lined up one of the pre-spotted hole positions then drilled and tapped the hole, I then rotated the link joiner to the next position and repeated the operation until all four holes were drilled and tapped. Photograph 28 shows the finished link. ■

To be continued...

Fence fitted in slot

Scribe a line

YOUR CHANCE TO TALK TO US!

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

E.T. Westbury

Dear Neil, the timing of your editorial leader-piece (MEW July, 2016) is fortuitous as it coincides with my reading of Frank Whittle's autobiography "JET - Story of a Pioneer".

What's the connection? ... the tantalising suggestion that both famous individuals were linked together through chance and circumstance, see page 17 *(the page in question describes the construction of a large model aircraft at Cranwell, the engine being made by a 'laboratory assistant' named Westbury – Ed.).*

Could it be that the 'Westbury' Whittle refers to only by surname is the one and the same all model engineers know by the pre-appendage Edgar T.? The circumstantial aspects of the story strongly suggest it. Perhaps another more knowledgeable reader may be able to confirm the link?

Andre Rousseau. Papakura,
NEW ZEALAND

It is indeed the ETW "to whom we doff our caps". During the 1920s Westbury was an RAF Instructor at Cranwell and he made the Atom Minor engine with which model aircraft pioneer, Colonel CE Bowden powered several of his aircraft. For example, in 1936 Bowden's Blue Dragon established an endurance record powered by the Atom Minor. There is evidence that he knew both Whittle and 'Lawrence of Arabia'. What is most interesting about the extract is that it claims Whittle, not Bowden, was responsible for the design of the airframe of one of Bowden's machines. Perhaps one day, someone will write the biography of ETW! – Neil.

Into the Jaws of...

Dear Neil, just a suggestion for followers of the '4 jaws made easy' articles – I have always followed the NSEW method from earliest days. With the large lathes at work using two chuck keys was not a problem, but at home now, with my elderly Myford, there just isn't enough room to use the second key at the back of the chuck. The solution was to make a new key 12 inches long to be clear of all obstructions.

The snap shot shows how easy it is now to keep control of where we want the needle on the dial to be.

Colin Murdoch, by email

PS the card at the window was needed to balance the light up a bit (also hide the Oster and the oil on the window) – the dust sheet was to avoid distractions not relevant to 4 jaws (like be an unholy mess that will get sorted some day)!

Grist to the Mill

Dear Neil, I've recently bought an Amadeal XJ12-300 Belt-drive Milling machine. It seems fine for what I want to do.

My question (and I'm only asking because I just cannot find the answer in any forum) is:

What is the best way to make certain a scribed line across a work piece is at right angles to the compound table? Set-squares are a little awkward and not that precise, as I have to hold the set-square while attempting to arrange the work-piece and it is especially difficult as the machine has an X-way measurement strip that stands proud of the machined bedway. I'm thinking about just cutting down a small machinists set-square to fit (and then gluing some niobium magnets to it so that it remains attached to the table while I adjust the work-piece) or making a bespoke tool to do the job - although not sure how well I'd get the right-angle to be correct.

Colin Lloyd, Wantage, Oxfordshire

Hello Colin, I assume you don't have any square faces to work from, so perhaps you could use a laser edge finder and run that along the line using the mill's y-movement? I'm sure readers will have some other good ideas. - Neil

Praise for our Authors

Dear Neil, I have been subscribed to mew for just over one year. I really enjoy the magazine and looking thru the archives I live in the US and I am greatly impressed by the quality of work and the scope of the projects your authors take on. In my humble opinion MEW is a much better magazine than American counterparts keep up the good work.

Steve Phillips, USA

We would love to hear your comments, questions and feedback about MEW
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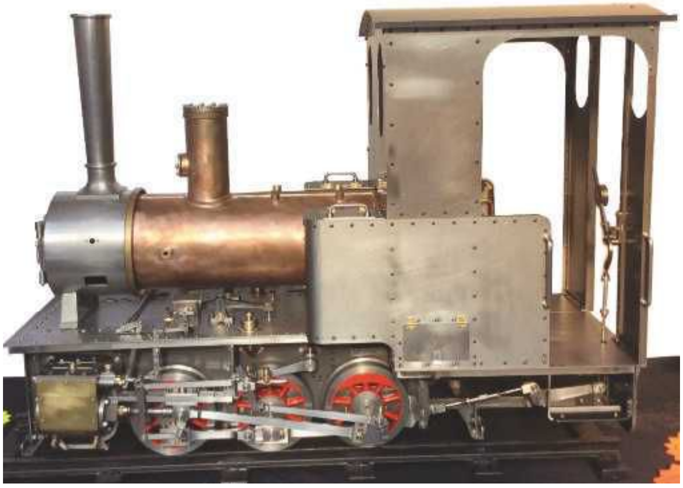
7 ¼” gauge GWR Collett Goods Doncaster 2016



7 ¼” Narrow Gauge Koppel 0-6-0 under development based on Ken Swan Design.



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Drummond M Lathe Extension

Do you ever wish you had a machine five-feet between centres? Alan Hearsum increases the capacity of his long-discontinued but still popular machine.

This article has been written to appeal to small lathe users not just those who own a Drummond M lathe. Much has already been written on increasing the diameter of work that can be machined in a small lathe using lifting blocks under the headstock, saddle and tailstock. Another worthwhile increase in the capacity of a home workshop can be achieved by an extension to the lathe bed of a smaller lathe, particularly if the extra distance between centres is used, say, once or twice a year.

Is this the longest Drummond M in the world?

Photograph 1 shows the completed project extending the bed of a Drummond M lathe in order to machine shafts that are up to 5ft long between centres and up to 1½ inches in diameter. Screw cutting is a requirement in this project for journals that can be turned at the extreme ends of a shaft, that is, those nearest to the tail stock end on the lathe bed extension. Parallel turning of the full length of the shaft is also a requirement, but a rare need, using an existing power fine feed and a combination of lathe change wheels connecting the leadscrew to the spindle.

My existing Drummond M lathe uses a single to three phase inverter drive and is capable of screw-cutting threads using a range of change wheels for imperial and metric threads. I always use the half nut fully closed throughout for the whole of the screw cutting operation as the most accurate method of screw cutting. Reversing the lathe spindle is then needed and in my case using a reverse switch on my inverter drive allows me to return the cutting tool to the start point of the thread. A temporary fixed half nut requires the need to reverse the spindle and, in turn, the leadscrew.

A flat belt brake is used to accurately stop the lathe spindle even though there is a facility in my inverter drive to activate a DC braking function. The DC braking system, when activated allows the inertia of the spindle and chuck to act like a flywheel and overrun rather than stop immediately. The flat belt brake on the spindle uses the largest flat belt pulley on the existing lathe headstock connected to an air cylinder tensioning the belt onto the pulley. A foot controlled pneumatic valve positioned on the floor allows the lathe operator to stop the lathe accurately and then as normal winding the screw cutting tool out from the work using the cross slide hand wheel.

This article, however, concentrates on the fabrication and machining of the slide ways or shears of the bed extension using steel components, also fitting an extension of the leadscrew and rack. The lathe extension is only used when a long shaft is machined, and on completion, the lathe bed extension is capable of being separated from the lathe. My lathe extension is fitted onto an existing woodworking bench in order to fully utilize space in my workshop. It is a heavy duty wooden bench originally used in a school woodworking classroom. The first task after the design of the lathe extension was to fix a piece of 3mm plate onto the top of the bench using countersunk woodscrews that are flush with the surface of the plate. The bench was already level standing at the right hand side of the existing Drummond M lathe, but was checked again for level.

I can continue to use my bench for wood working when the lathe extension is removed and pushed to the back of the bench. I temporarily screw a piece of plywood onto the new steel 3mm sole plate then add temporary small beech 'stop' blocks at different heights to hold wood when I am machining with a hand planer or sander.

I am sure readers have their own ideas on how they safely screw cut threads in their lathes so I am leaving my controls to a future article that will concentrate on remote controls.

Fabricating the lathe extension bed

Photograph 2 shows the extension bed fabrication with the 30 degree angle

End view of the extension bed

Locations of the fixing screws

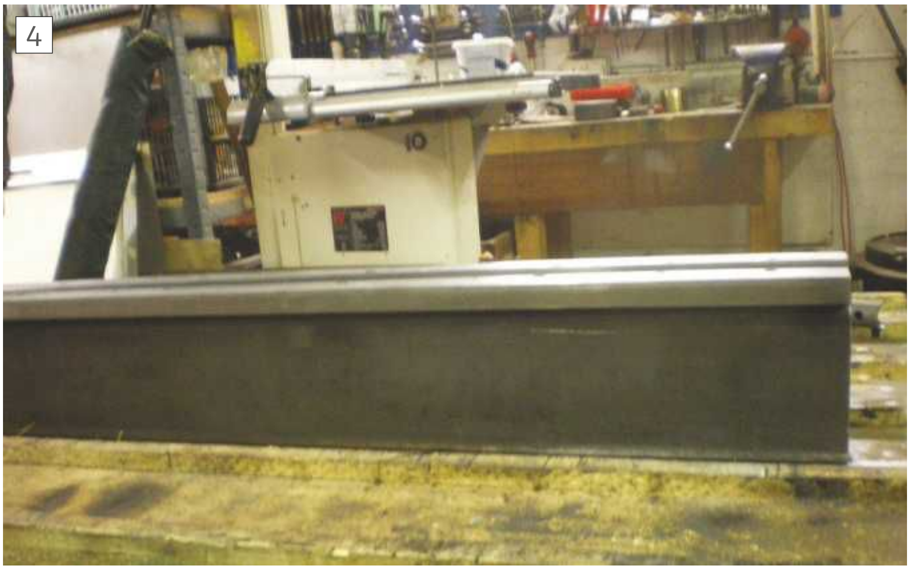
machined on one of the shears matching the shape of the existing lathe bed. The extension is made from a 4 ft. length of box section steel 80mm x 120mm x 5mm wall thickness. The two shears are the same size as the existing Drummond lathe shears. The shears are made from 1½ x ¾ inch bright mild steel bar. When ordering from your steel supplier it is wise to explain what you are attempting to do so they let you have pieces of steel that are straight.

The BMS bars to form the lathe extension shears were clamped together with four temporary steel blocks 3 x ¾ inch long used as spacers. One block at each end and the other two blocks at five ninths of the overall length to optimize deflection. The two blocks at each end had a G-clamp across the shears and then a G-clamp at each end holding the composite structure temporarily to the steel box section bed. The dimensions for this composite structure matches the shears on the Drummond lathe in size and shape.

It is important that the composite structure of the shears is positioned on the box section an equal distance along its length and this was achieved using a micrometer depth gauge measuring from the edge of a shear to the front edge of the box section bed. An external micrometer was also used to check the measurement across the shears at several positions.

The shears are attached to the box section with ¼ BSF socket head cap-screws. Spring roll pins ¼ inch diameter were used to avoid any movement of the shears. Where there is a difference using the micrometer measurements this was noted with a permanent marker pen and written on the box section. These measurements were used later to decide where to remove metal through light grinding, filing and scraping of the shears. The metal removal required was in thousands and not fractions of an inch to fit the components together as a sliding fit.

Photograph 3 shows the positioning of the socket head cap-screws and the roll pins. First the roll pins holes were drilled and then a clearance hole for the ¼ BSF cap-head screws. The depth of the drilled clearance hole was critical to produce a full thread in the 5mm thick box section. The clearance drill was ground and sharpened with a shallow angle and a depth collar held in place with grubscrews and constantly checked to make sure it had not moved up the drill. A tapping drill for ¼ BSF was then used drilling through the box section. A counterbore drill then formed the hole for the head of the cap-head screw in the shear. The holes were then tapped and cap-head screws tightened to pull the shears onto the box section thus forming the extension



Front view of the fabrication

Cutting the shear with an Evolution Rage saw

End view of the cutting jig

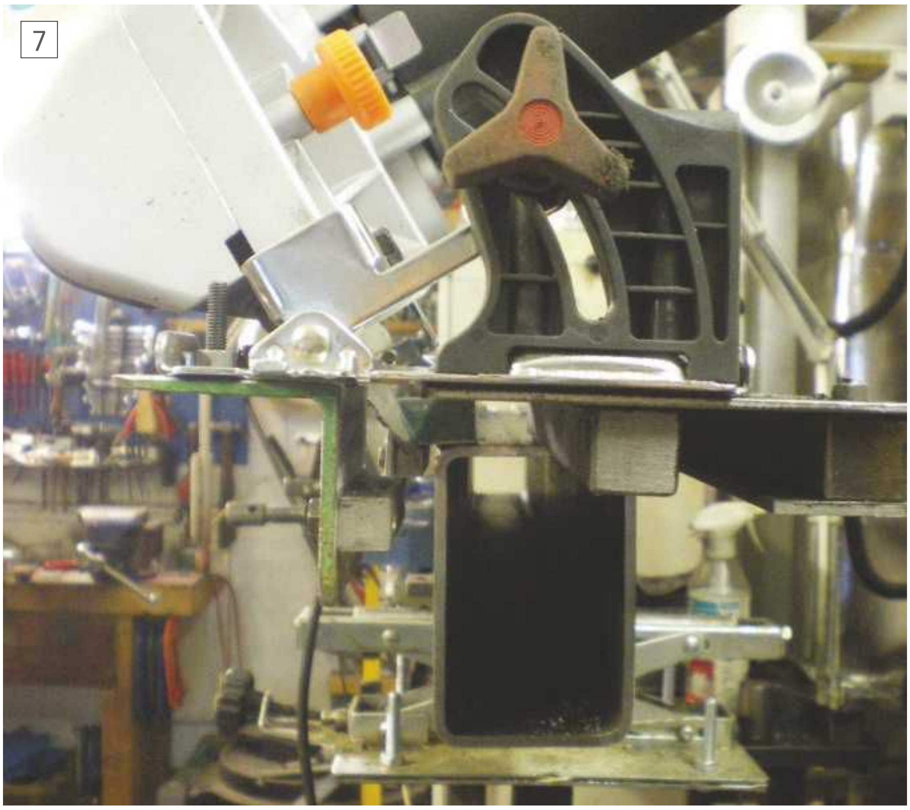
lathe bed. All the drilling and tapping was done in my milling machine with one end supported on a special purpose floor stand set to carry long lengths fabricated using a scissor lift adjuster bought from Axminster tools some years ago.

Photograph 4 shows a front view of the completed fabrication. This was successful and did not need any shims to correct the level of the shears.

Machining the angle on the shears

My initial reaction was to use a dovetail cutter in a vertical milling machine to produce the 30-degree angle on the shear. I tried this and it would have taken for ever to do the business. I decided to use my carbide tipped Evolution Rage circular saw because of the excessive amount of metal to be removed with my small milling machine. It was not possible to make the cut free hand using the saw as the final angle would unlikely be accurate throughout its length. **Photograph 5** shows the saw finishing its cut leaving the shear on the extension bed. You will notice this has a jig which guides the saw fixed to the base of the saw and fits closely to the two oblong bright mild steel shears along its length. **Photographs 6 and 7** provide more information on the jig. This jig behaves similar to a lathe saddle being held onto the pre machined shears with keep plates adjusted to provide a smooth sliding motion. Pressure has to be applied on top of the saw as well as very slowly pushing the circular saw along the bed guided by the pre-machined shears. Evolution Rage saws are designed to cut mild steel not to produce excessive sparks in comparison to cutting with a disc grinder.

This cannot be a rush job and requires physical stamina to do the task manually in one complete operation. I learned that it would have been advantageous to order and use a piece of box section and bright mild steel sheers 12 inches longer so that the jig could hold the saw whilst the 4 ft. length was supported throughout the required length. Fortunately, it was possible to hold the saw steady whilst it cut at the start and the last few inches with only one part of the jig holding the saw upright at the 30-degree angle on entry and exit from the sawing operation.



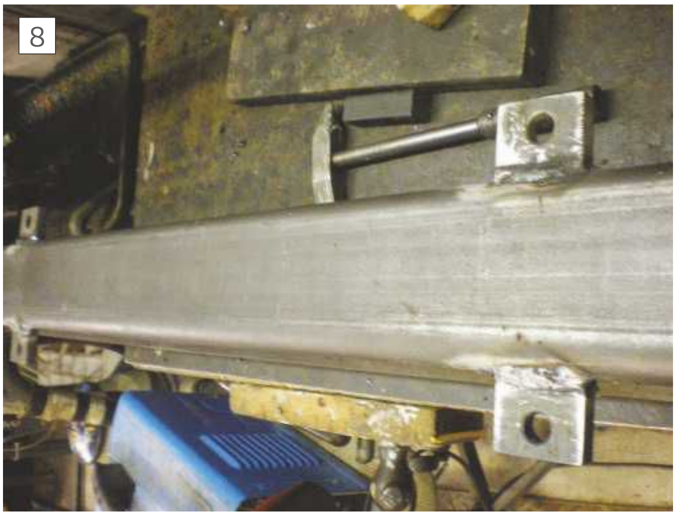
A side view of the jig

Welding Plates to hold adjustable feet to align extension to existing lathe bed

Photograph 8 shows four plates welded onto the box section at equal distance four ninths of the length of the bed. These plates are 50 x 50 x 10mm with holes to suit the adjustable feet. I obtained these from Axminster Tools. Machine Mart do a similar type that have a vibration resistance element to them. A first alignment of the existing lathe bed and the lathe extension was achieved using a fixed steady as a temporary clamping bridge bracket. The clamping operation was achieved by tightening the taper gib and clamp plate onto the shears. A number of Drummond M lathe parts were obtained from eBay and from people who had spares for sale to avoid transferring the existing saddle, cross-slide and top slide onto the lathe extension from the existing lathe. The duplication sounds a bit excessive but it worked well for me, at an extra cost of course.

Aligning and filing and scraping the shears on the extension bed

Photo 9 shows the blued marks where the bed has been scraped to fit the saddle and tail stock when sliding up and down the shears on the extension bed. Initial filing and scraping was done using the permanent marker pen to record measurement notes in writing along the



Foot mounting plates

Using engineer's blue to guide scraping of the shears

bed as described above, for example + 0.005 or -0.002 etc. Where there was a lot of metal to be removed an angle grinder was used prior to scraping. The saddle and the tailstock were fitted to smoothly move along the 30-degree shear and the oblong shear. Several hand scrapings were needed before the 30-degree shear was a satisfactory fit. The lathe saddle was fitted on the front 30-degree shear; the oblong back shear primarily holds the saddle to the bed with keep plates and shims to avoid a clamping action when the setscrews are tightened. A check for accuracy was done with a precision straight edge using engineers blue and further scraping carried out of the shears.

The extension bed was finally lined up using a tailstock with a rotating centre on the extension bed and the tailstock of the existing lathe, **photo 10**. Raising and lowering the adjustable feet brought the extension bed up to the correct height which had to be level along the bed and across the two shears to match the position of the shears on the existing Drummond M lathe. At this point in the project the shears had been checked for straightness using a precision level and a 4 ft. long precision straight edge. The precision level was also used with feeler gauges and later engineers blue to check the position in height of the two shears as related to each other. Some filing and scraping was needed. This operation was done in conjunction with fitting the saddle as described above.

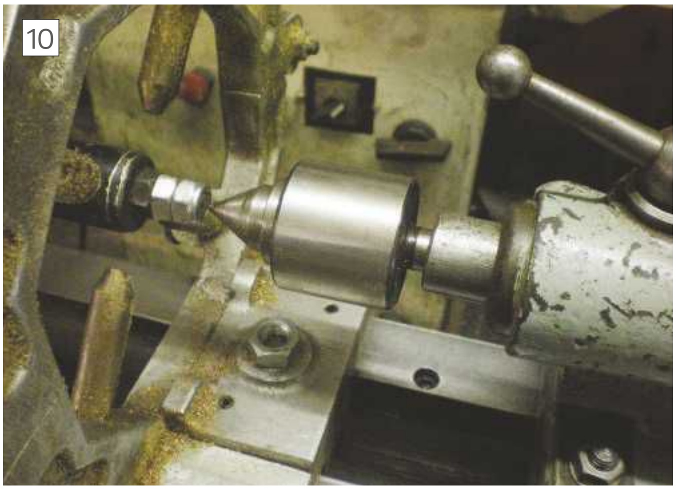
Once the bed was level the temporary fixed steady was replaced with a permanent joining bridge as shown in **photo 11**. This was made from a piece of bright mild steel 3 x 7 x ½ inches. A Gibb block was made 3 inches long, the same shape as the 30 degree Gibb block on the Drummond lathe saddle. The actual angle had to match the front shear even though it may be slightly different from the existing lathe shear. In other words, a bespoke fitting. The rear of the bridge piece was held in place with a similar fixing to the tailstock. A bright mild steel flat plate 10mm thick with two studs in the bridge plate and nuts holding the keep plate in place gripping under the rear shear.

Shims were used to ensure the saddle was allowed enough clearance to slide up and down the bed. Now the correct height had been decided using the adjustable feet more permanent feet were designed to hold the extension bed to the 3mm thick sole plate. **Photograph 12** shows these feet in position prior to being welded to the box section extension. The two brackets were positioned equal distance along the lathe bed. Initially the brackets were screwed to the sole-plate but this did not provide flexibility of movement in aligning up with my existing lathe. The final method was clamping the feet in case the Drummond Lathe moved on my workshop concrete floor. Only a light tack weld was used to secure the feet brackets to avoid distortion of the box section bed.

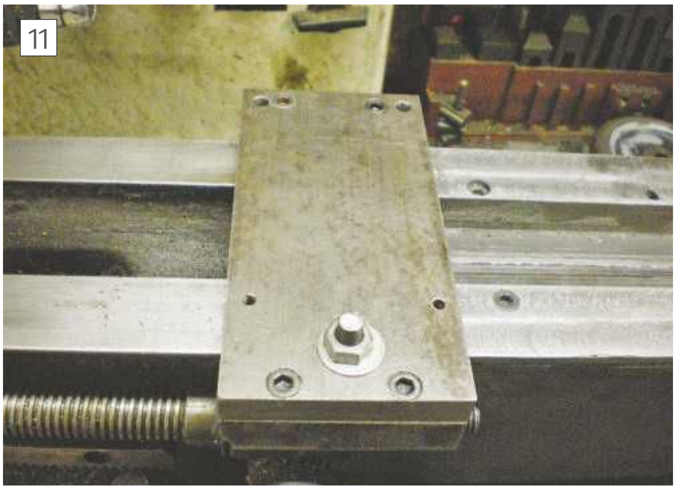
Positioning and fixing the rack

Photograph 13 shows the rack in place along the extension lathe bed. The rack is positioned on a 10mm x 40 mm plate. The plate was temporarily held in place on the box section with G-clamps positioned by measuring from the top of the shear and aligning with the position of the rack on the existing lathe. The rack was made up from several racks from breakers of Drummond M or Myford M lathes bought on eBay over time, with this project in mind.

The rack on the lathe extension was made up from three individual racks cut to size based on the required rack and was clamped onto the 10mm x 40mm plate and the composite rack and plate roll pinned onto the box section bed. The rack was drilled and tapped for caphead setscrews in a similar way to the fixing of the shears described above. It was essential that the



Rotating centre used as a gauge for setting centre height



The joining bridge

distance from the top of the shears was maintained to ensure engagement of the spur gear driven from the apron handwheel.

The fixing and positioning of the rack related to the position of the saddle was achieved by accurate measuring and not a 'hope for the best' methodology. The final test in the fitting of the rack was when the saddle was traversed with the spur gear engaged and the hand wheel free to turn efficiently without any jumping of the spur gear in contact with the rack. There was some adjustment available on the spur gear in contact with the rack by a modification; cantilevering the spur gear on an arm from the apron.

Machining the leadscrew in the extended lathe

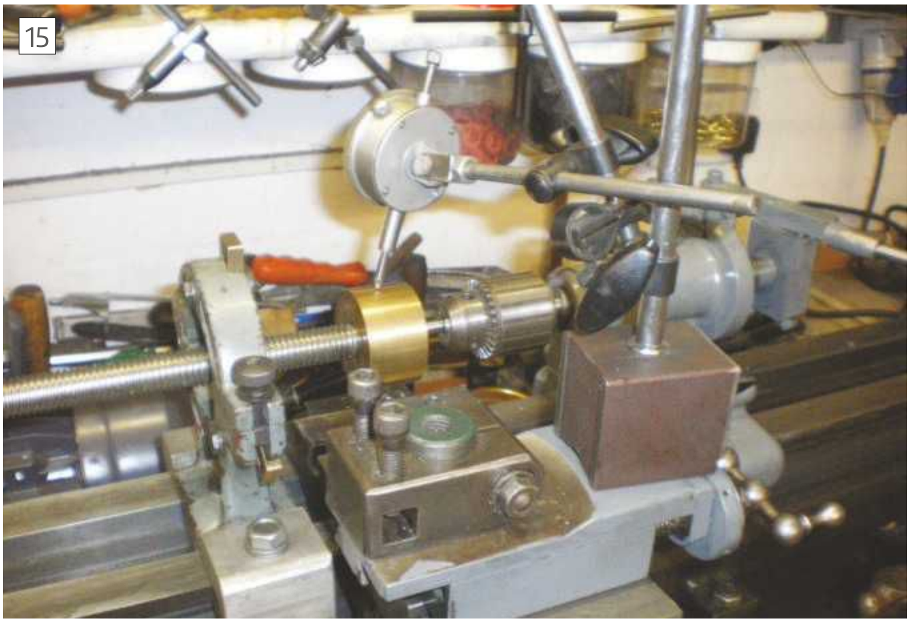
A 5 ft. length of ¾ inch diameter acme leadscrew the same pitch as the square threaded leadscrew on the existing Drummond M lathe and a nut was also purchased from Kingston Engineering in Hull. This was cut to length in a machine saw, the measurement taken from the extension bed, allowing for one Myford ML7 bracket with Oilite bush to hold the leadscrew in place and one outrigger bracket. The extension leadscrew is joined to the Drummond lathe leadscrew, when the journals had been machined. The outrigger bracket was only needed to prop up the extension leadscrew when not connected to the existing Drummond Lathe. The leadscrew on the extension was provided with its bearing at the connection using the existing lathe leadscrew bearing.

Photograph 14 shows the leadscrew held in a four jaw chuck at one end and in a fixed steady at the other end. Photograph 15 shows how the nut from Kingston Engineering was helpful in aligning up the leadscrew using a dial test indicator. Once the leadscrew was running true then it was drilled with a 60-degree centre drill to provide support for the leadscrew using a rotating centre, when turning the journals. **Photograph 16** shows the machining of the journal that has to fit the purchased

Positioning the permanent feet

Rack fitted in place

Set up for machining the ends of the leadscrew



Using the matching nut as an aid to alignment

16

Machining the leadscrew to fit a Myford journal on the tailstock end

17

Machining the journal for the joint end

Myford ML7 bracket with its bearing shown in the finished project **photo 1**.

Photograph 17 shows the machining of the journal that holds the bush which connects the leadscrew to the leadscrew of the existing Drummond M lathe. **Photograph 18** shows the screw cutting of the thread which holds the hand wheel onto the leadscrew which was purchased on ebay. The hand wheel has a slot in it which connects with a roll pin in the leadscrew in a similar way to the roll pin located in the leadscrew journal on the existing lathe. I will not go into detail as your small lathe may have a different leadscrew connection.

Conclusion

The project was a success and I have already used the extended lathe to machine its own leadscrew and two new shafts for an agricultural machine. It will never be used every week but it adds capacity to a small engineering workshop when needed. I have already mentioned the need to add an additional further length to the composite lathe bed extension to provide a method of keeping the Evolution saw and its jig on an upright straight path when machining the 30 degree angle on one of the shears. The extra length can then be cut off at each end to finish at 4 ft. knowing the whole length required on the lathe extension is more precise and accurate through less freehand cutting of the shear at the end and beginning of the sawing operation.

The design of the lathe extension could of course have been made simpler if the leadscrew had not been added. In retrospect most of the work I envisage being done on the Drummond lathe with its extension will be parallel journals and these would not need the use of a leadscrew. Similarly, the accuracy of the bed would not have been necessary as no accurate sliding motion of the saddle would have been needed as the top slide can deal with 4 inches of parallel turning.

Someone has explained, since I machined the 30 degree shear, that extruded bright mild steel can be purchased with a 30 degree angle on it. This definitely needs to be explored. There may also be brass extruded sections as a useful alternative for the steel shears. Easy to be wise after the event, but useful for others to check this out before commencing with this project. Of course it is through reflection that we progress.

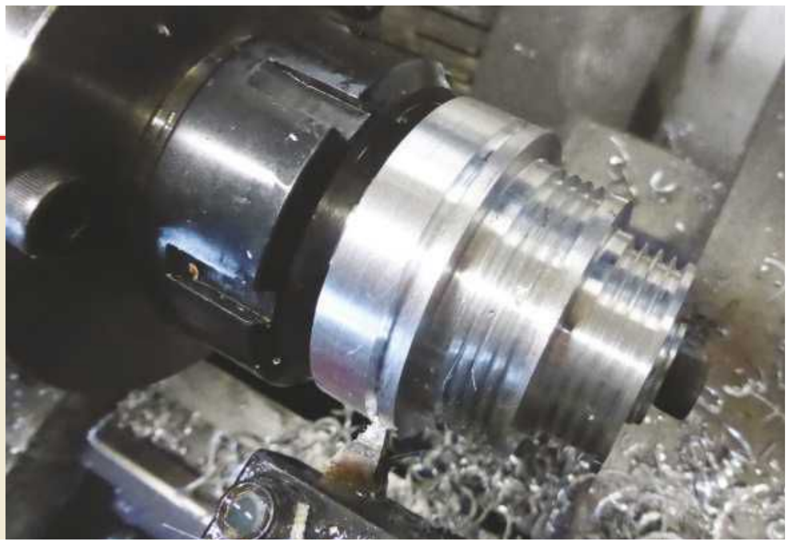
Finally, in conclusion a cast iron bed or beds could have been added from redundant Drummond M or Myford M lathes to form a composite lathe extension. The ideal would have been a bespoke machined casting and not a steel fabricated bed, but his is perhaps a bit over the top if the extension is only going to be used once or twice a year. ■

Threading the end of the leadscrew for a handwheel.

MODEL ENGINEER

Coming up in Issue 4541...

- **Mike Haughton explains the benefits of poly-v drive and how to make your own poly-v pulleys.**
- **A brief biography of the German engineer Georg Schelsinger by Alan Bester.**
- **A top-slide angle setter from John Hinkley**



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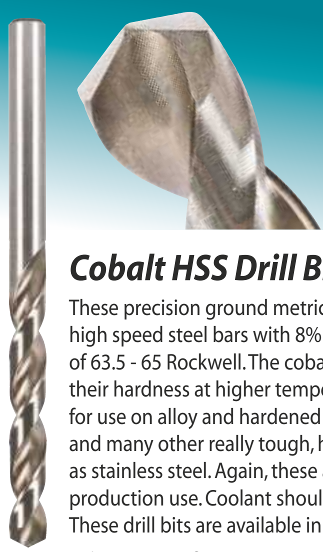

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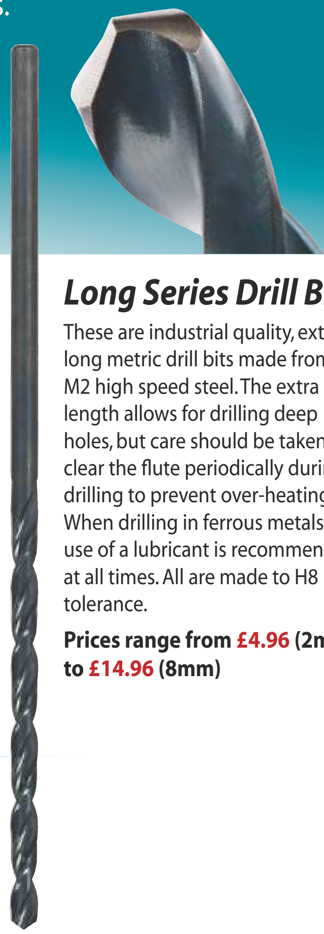

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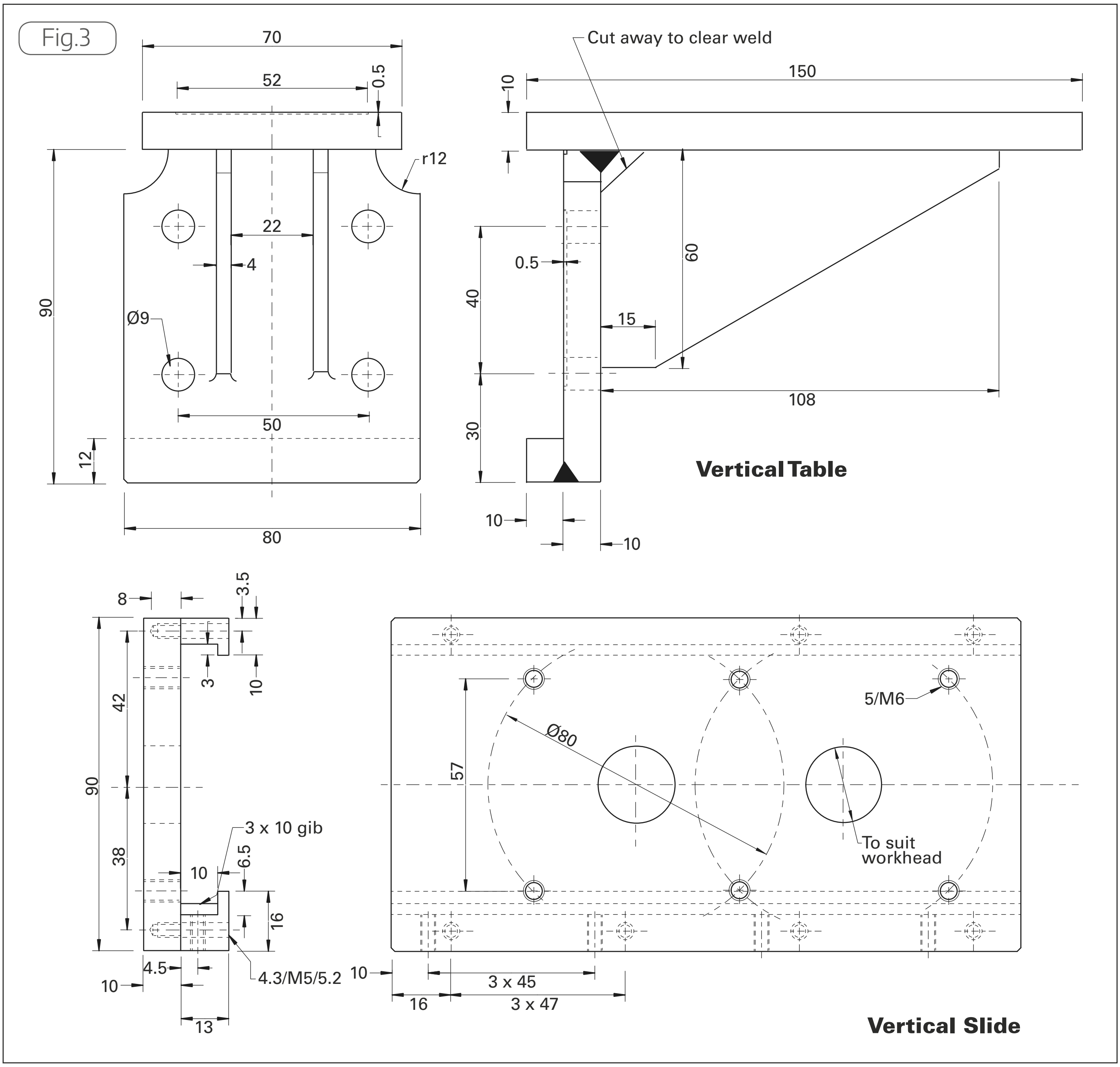
Gear Cutter

Alan James Aldridge describes a flexible machine for the production of gears in the home workshop – part two



Vertical Table

The second table is the vertical slide **(fig 3)** which has a welded construction. The essential requirements for this table is that it stands square to the rotating table, and the rotating table and the long table have to be made to a high standard so this happens. The vertical table is constructed from a mixture of plain and bright section steels with latter forming the vertical face. The base is in ordinary steel which has to be machined, as I do not feel I can get a truly 100 % perpendicular arrangement of slide and base by any other way. The base has to be pre-machined for the holding screws set by the rotating table layout. So, one waits for the rotating table to be made or transfers the square pattern of the slide to the rotating table when it comes to the slotting of the arcs.

On the vertical slide the angle forces the design to employ two parts welded together. The vertical plate has to be left alone though inevitably there will be a need for final machining of the base and the vertical slide arrangement demands that it has parallelism down its length to provide the required contact to the slide to the vertical table. In **photographs 5** to **8** the process of building the angle is shown. The process requires the vertical plate to join the base using only a normal square to set the angle. The welding is likely to pull

Setting the parts of the angle square

operation. With a boring head on the lathe spindle the sweep of the cutter has to be set out and with a Myford lathe the cutaway will accommodate a full circular cut. For lathes like my present one the work may have to be held higher up above the cross slide. For those without a boring head the face skimming can be achieved with the older and cheaper way, but no less adequate one, of mounting a tool on the lathe face plate in a simple holder far enough out on the face plate to skim a full circle over the rectangular base. One difficulty with the face plate mounted tool is that it is not easily reset to new diameters, but if the recessed base is required then the resetting is essential.

The facing speed should be fairly low as the diameter cut is large. Ideally one wants to have a constant speed but that might not be easily done with hand operation. One also wants both a flat and fine finish. The drawing shows one way out with a

Checking alignment after initial weld

Bracing piece tacked in place

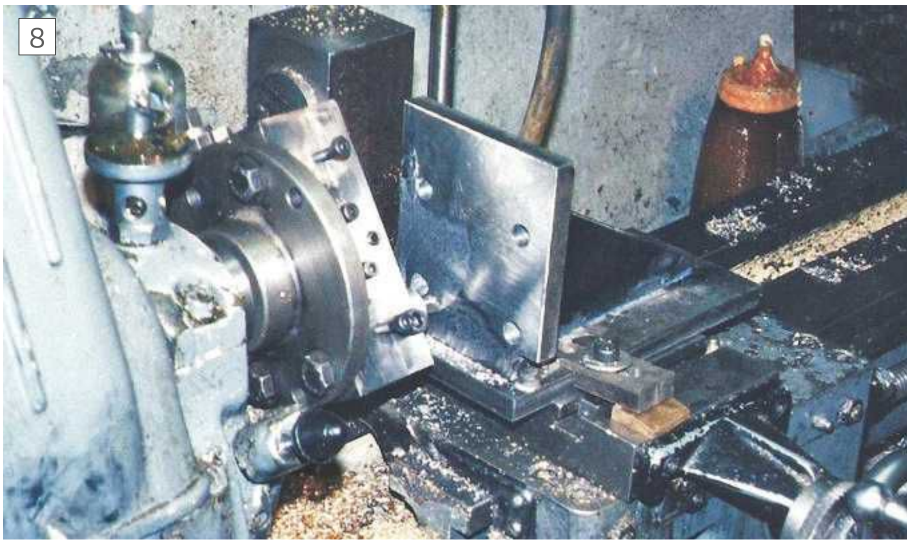
the vertical plate and base a small amount which can be offset by welding both sides of the plates alternately. The weld needs cleaning off which I would do with an angle grinder. The gussets are put in to brace the construction.

For the final machining the work is put vertical face down on the lathe cross slide and held by screws, tee strongbacks or whatever is suitable for the cross slide. The base sits over the cross slide edge and about 50 mm in front of it. The angle has to lie along the line of the lathe and here it took some time to work out a simple method. It will require hunting around for a piece of 10 x 10 or 12mm aluminium bar, preferably still with a protective paper coating, about 250 mm long which sits against the outside of two of the four jaw chuck jaws and is clamped by a third. The bar by this time has the paper coat taken off! The bottom edge of the bar is just off the cross slide, which then can move unhindered under it, with other parallel slips. A check can be made with dial indicator on the cross slide running on the bar to see the degree of parallelism. Instead of bringing the bar and vertical slide hard up to each other, I believe it better to use feeler gauges to judge the lie of the bar and slide. The slide can be secured only on one side at present but as soon as the bar is out of the way the other side is pulled down.

The base is machined off with a boring stepped base line, which needs only a fairly narrow line with a high finish. It will be, however, a dirt collector.

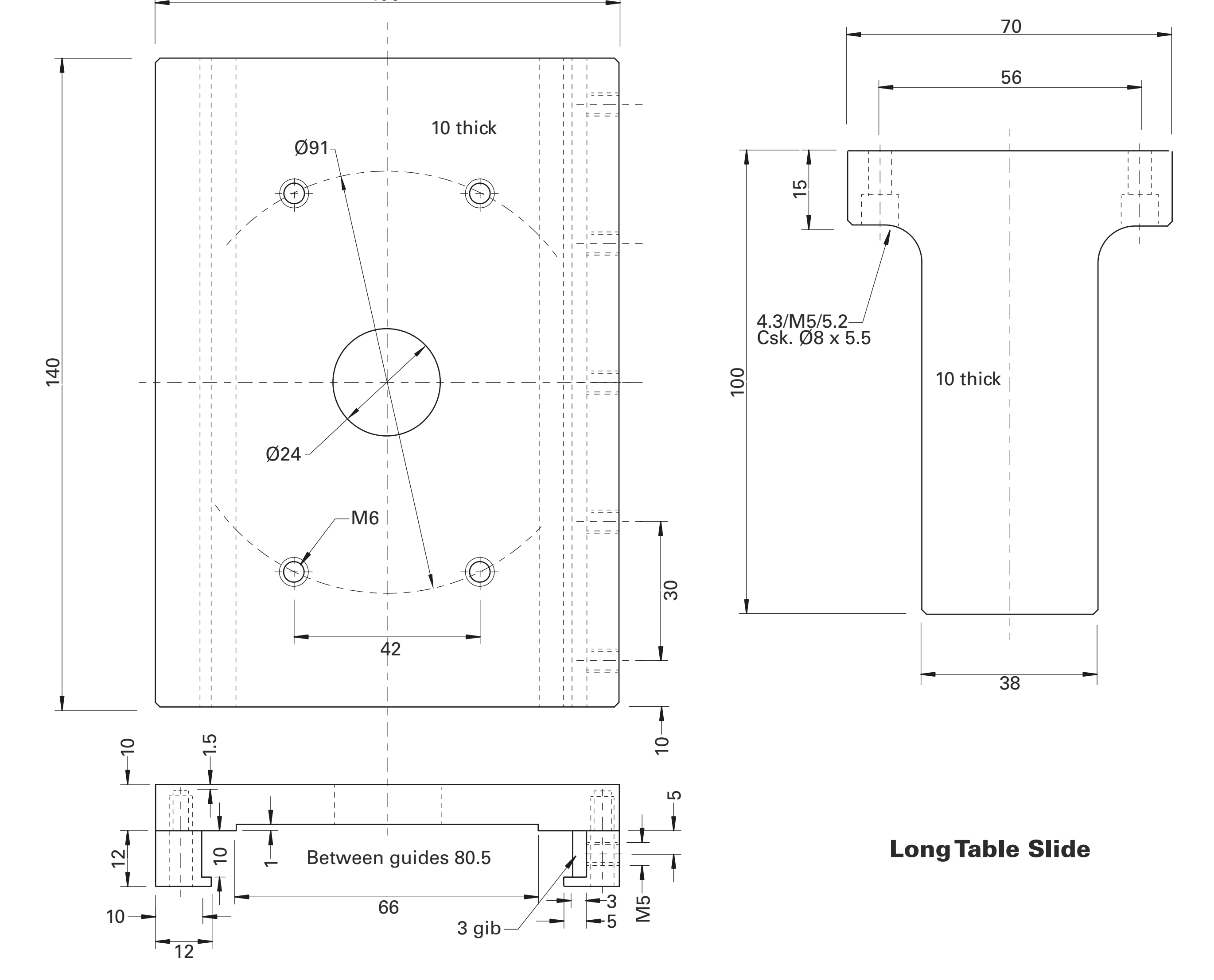
Long table

The long table **(fig. 2)** does not follow the



Facing off the bracket.

Fig.4

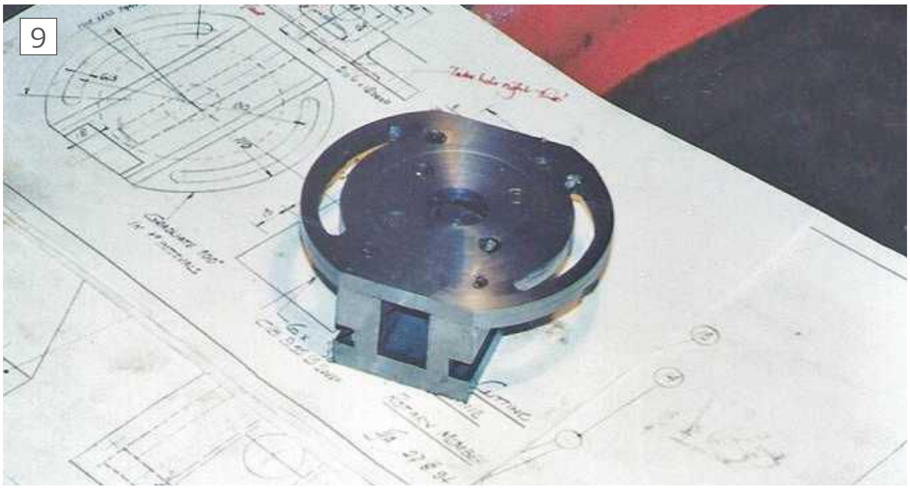


methods applied to the other two. As it is mounted on the baseplate the screws cannot come upwards into the top plate but have to go down into the baseplate. The screws are cut short of coming right through the base. The top ends are countersunk into the top plate. Sealing is required around the base line to stop coolant leakage. It is essential that the long table is parallel to the stand baseplates which is almost guaranteed by the use of bright steel but needs checking and thin slips to make it so.

Slides

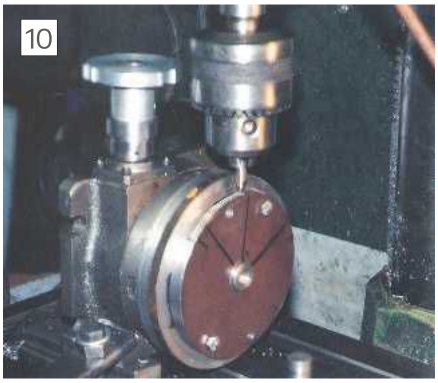
Each of the tables bears a slide constructed from bright steel sections so machining can be cut down as far as possible. The machining of slideways was seen as a difficult operation in a workshop with very limited facilities at the time the project was started. Industrially, machines have taken out hand work to lower costs and obtain very high repeatable accuracies part to part. There is still some work for the skilled man and I like to think of the model engineer as being one of these who can machine and hand work to accuracies similar to those gained by present day machinery systems. Cost of one's time is not really a factor in our work. It is then my submission that flat guides and adjusting strips can equal the traditional v-way.

Though the guideways are long and normally would require milling, built up guideways will get round this operation which might be too much for a small lathe. The basic material is 10 mm key steel which has a superb finish but check that what the supplier offers is straight in all planes. The square steel is clamped to the



9

The rotating table



Graduating in the mill

slide with a string of small screws. Under the key steel will be a thin plate, say, 2 or 3 mm bright steel which is also part of the bolted assembly. The expectation is that the slide will partly move down the table and then stick. The sticking can be in three places, the table top or side and the underside on the thin strip. To some extent the side connection can be checked with the key steel alone with lightly bluing the table edge and moving the key steel a few millimetres back and forward. It will need some judgement as to how the touch point will affect the running of the table and slide. But if the picture shows an 80% contact I would accept it as satisfactory, however, the bluing has to be from end to end with odd missing spots. There cannot be a good bluing to one end and nothing at the other. If the latter is present then the most likely situation is that the key steel has a slight bowing. It should be possible to measure this gap with shims or feelers.

In fitting the key steel to the slide the bolt holes in the key steel have to have sufficient clearance, so a bolt, when inserted, does not lie too close to the hole edge, enough to bow the key steel. The bolts will clamp the slide and key steel but two or three dowels will set the position. The bolt positions can be marked out now, then drilled and tapped into and through both slide and the key steel, respectively. With the first side, the one without a gib strip, bring the key steel and slide together over the table getting the edges coincident

Punching numbers on the dial

along their length. Clamp the position tight over the full length which will pull the key steel straight. Run in the bolts to hold the position. Drill the dowel holes and install the three roll pins. One can now take out the bolts and put up the closer at the bottom. The most likely situation is that the closer is just too tight to the table for free running which can be remedied with a thin shim, say, 0.04 mm brass, which must not have any wrinkles. Once again pushing the slide along the blued table will pick up sticking points which are marked and then examined. It may require some scraping work and one will again have to make an educated guess as to which part is scraped. It tends to be obvious.

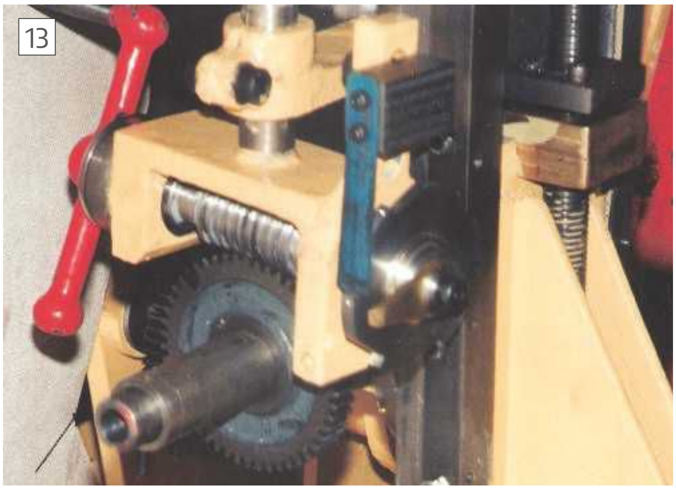
On the other side of the first part of the new sub-assembly is exactly the same as the first, except that the gib, a 3 x 10 mm piece of bright steel or key steel with a temporary backing along the whole length of thin card, is also in place. The end product should provide a slide that will need a two finger and thumb push to set it gliding down the table without any noticeable wobbling. It is possible to set the assembly up on the work bench with the table held to the bench and a dial indicator touching the slide edge, following the motion. In my own work I can consistently manage a run out of less than 0.07 mm over 100mm. The only downside with this work is that it will take three to four hours do the work on one table and slide assembly. The gib side requires several forcing screw holes to be drilled and tapped along with the normal bolt and dowel holes. The card backing to the gib can then be thrown away and the gib cleaned up.

Long Slide

This slide (**fig. 4**) can be tighter on the gib strip that the others as the slide is not used while cutting a gear, so once the alignment has been found then the gib is locked up tight. It has to be a failing in many of the attachments employed on small lathes that they have too much 'resilience', caused by poor jointing at bolted surfaces, slide to table contact and, in some, insufficient metal to resist bending. Tight gibs go some way to taking some of the resilience out.

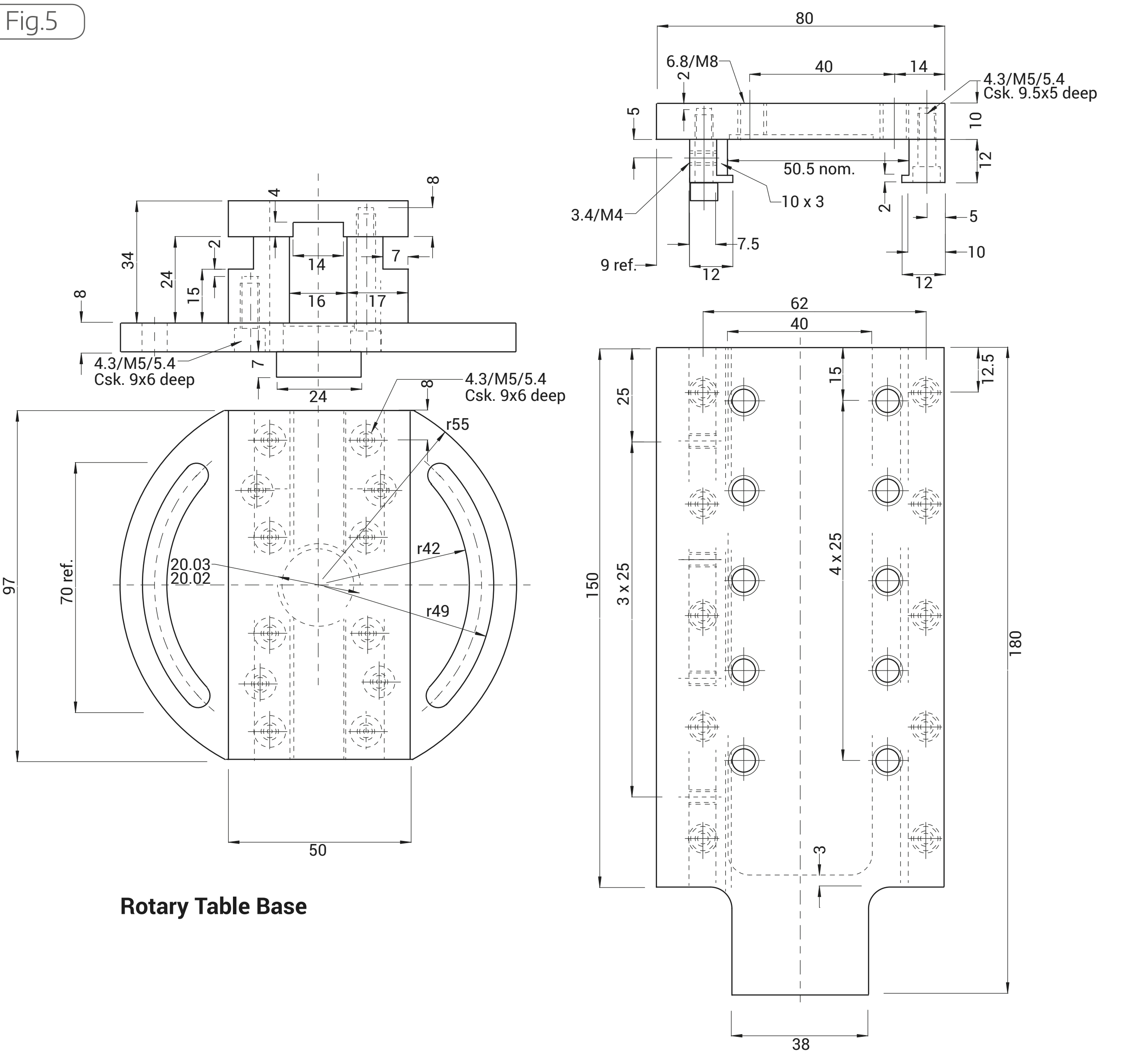
On all the slides the underneath is recessed so the slide bears down on the table at its sides which aids a good contact surface at the best place. It is an unwanted but I think necessary job though one that does not demand much on dimensions or finish. A slide will be possibly be too big for the lathe's vertical slide. It will have to sit on edge on the lathe cross slide with strongback arrangement to hold it in place, as close to perpendicular to the lathe centre lines as is possible. Other work on the slide will have to wait the arrival of the rotating table from which the pitching of its holding screws will be plotted. Once available, the screw centres can be plotted and one way of doing this is to mark off the holes on the slide, set the slide on the table, clamp up the gib screws and drill from slide to table with a pilot hole, say, 5 mm. These are opened out to M6 or M8. Further holes will require the slide to be shifted back to pick up the last set of two holes and so on.

Dividing arrangement.



Ratchet arrangement for worm and wheel.

Fig.5



Rotary Table Base

Rotary Table Slide

Rotating Table/ Vertical Slide

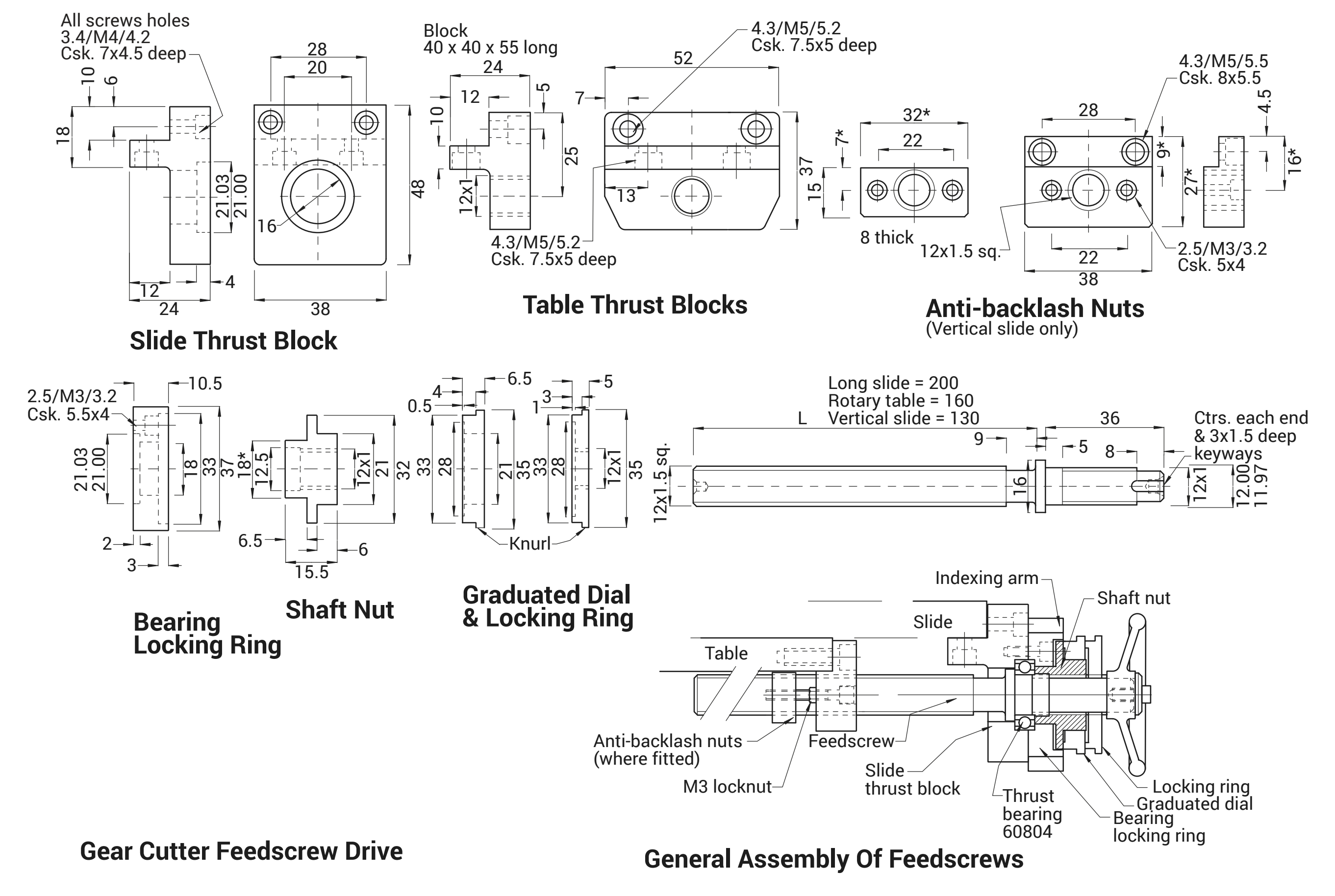
In general the rotating table and vertical slide **(fig. 5)** follows the same principles as the long slide but there are exceptions which apply to the handle ends and their attachment, and general sizing and attachment to the rotating slide in the case of the vertical slide. The actual work is straight forward once the first table and slide is made, as it then becomes repetitious work.

The rotating table (**photo 9**) is built up from bright steel sections and though that will reduce the amount of machining work there has to be some to gain the necessary clearances on awkward dimensions that arise from having guiding strips on tables or slides. The build of the base is really about siting the bolting, which holds everything together, making sure the outer diameter, the arcs and the centre are concentric and ensuring that the screw holes do not breech the top surfaces of slides and later on the graduating of the dials. The top plate is cut from stock and faced in the four jaw chuck, with jaws reversed, to required depth and finish.

It may appear to be the wrong way round but the base disc of the rotating table was made first with the disc having been turned in the lathe four jaw chuck held by two or four screws to a backing plate. The screws are set on the centre line diameter of the arcs. In the picture the backplate is a round piece of steel which is not the way to do the job. The backing plate should be rectangular or square as that will so much easier to align for future stages of machining. The backing plate just has to bridge all the screws. Four extra bolt holes are required towards each corner for a later use. For the centre hole in the rotating table base plate we require a plug-in pin or button with no more than 0.025 mm slack running through table and backing plate. Also scribe a full circle lightly to indicate the centre line of the arcs. In my own work the graduating was done early on but on reflection it would be advisable to leave this work until the point where the arcs are fully cut. The arcs are milled out. The two long arcs allow the table to swing around on the long slide and to lock down on to the latter.

The milling machine offers the best approach to the work but it does require a dividing head or rotating table to hold the workpiece. Working the right way around the backing plate and workpiece attached to it are put up on the rotating table for milling the slots, which are marked off on the bench and do not require to be absolutely accurate. The milling work starts with picking up the arc centre line which

Fig.6



I do with a purpose made pointer. Mark off the end points with a marker pen or scriber and begin cutting with a 5 or 6 mm slot drill. One can pre-drill a chain of 5 mm holes to remove much of the waste before milling. Take cuts appropriate to the milling machine capacity. Marking the backplate is not an issue. I opened out the cuts which were a little ragged after the full cut and ran a 7 mm cutter around on the same centre line with a full depth single, but very slow cut. Alternatively the table could be machined with a lathe and vertical slide.

Graduating

Photograph 10 illustrates the graduating being done with the indexing attachment on milling machine in a vertical stance, set to stand square to the line of the advancing cutting tool. The first job is to set out the limits of the graduations to match the arcs. The arc should permit a rotation of 90 degrees, but the graduations will run for 50 degrees either side of the centre of an arc. I reckon one can actually get very close to the exactness required. Only one side of the base plate is graduated and this will be the side that sits upwards on the vertical slide, towards the operator. In the milling machine the rotating table holding the workpiece has its own graduations so finding the arc centre is not difficult. On the vertical slide it is not quite so easy.

The graduating cutter can be a normal high speed tool on its side and sharpened to a narrow and very sharp point. There are rotating engraving tools and similar available from suppliers, such as Dremel, today so that is possibly a better option. One can see from the photograph of milling graduations that the cut is ragged, due no doubt to the type of tool employed, and the surface will have to be cleaned up later with turning the graduated surface in the lathe four jaw chuck by clocking the centre button and then lightly machining off the surface.

Some sort of trial run should be run, if graduating is a foreign subject, to gauge the depth, the feed and getting the length right. The latter can be set by a mechanical stop. The scales have the 100 degrees cut to a common length then the fives are re-cut a little longer, then the tens, a little longer still, starting from a centre zero. The lengths of the stripes is regulated by stops which can take many forms and a simple block bolted to the table with stop screw running through and double-nutted will do all that is required. The marking of the tens with a number punch set, for which I have a simple tool is shown in the **photo 11**.

The work sits under the punch on something soft to avoid marking the scales, such as a hard plastic block.

The tool does not have any system for turning the work exact angles and it would still require some resetting by hand to accommodate the step from tens to

Boring the small bearing housing

hundreds, so find a magnifying glass. The double numbers are stamped each side of a long graduation. Striking the punch needs to be with much the same force each time to make sure the lines all look alike. For reference, I have shown in **photo 12** a vertical slide on the lathe and a dividing attachment straddling it.

The base plate should be cut back, the edge lies 90 degrees round from the zero on the scale, and it is necessary to get this as true as possible. There is a little compensation to accommodate any error, but the emphasis is on little. The first side to be cut has to have the zero mark below it where a square can reach the mark and set the alignment. The depth of cutting is determined by exact measurements and a little arithmetic. ■

To be continued...

Out of the Frying Pan...

... and into the fire with Des Bromilow, who describes some workshop inventiveness with wider applications.

Clearly essential in Aussie kitchens, the frypan may be unfamiliar to many readers.

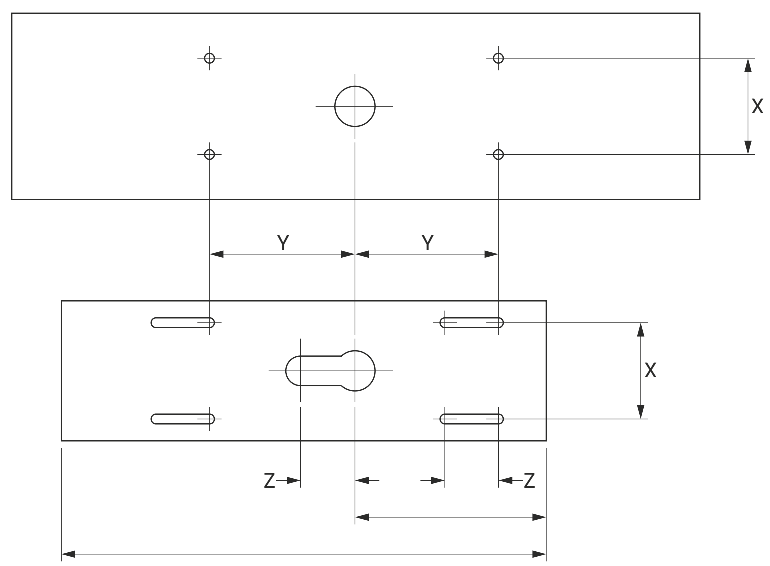
The Problem

An expensive electric frypan became damaged over several years of use. The damage was restricted to the threads of the base retaining screw coupling stripping out due to use and effects of heating cycles. But why replace when the fix is only an hour or two of work?

Photograph 1 shows the frypan (lid removed) in normal orientation, and **sketch 1** illustrates the amount of damaged thread in the retaining nut.

Method of repair:

The damaged knob was removed from the pressed metal sheet in the base of the frypan, leaving a hole of approximately 18mm which passed straight through the base. This hole can be seen in **photo 2**.



Baseplate And Keeper Plate

Fig.1

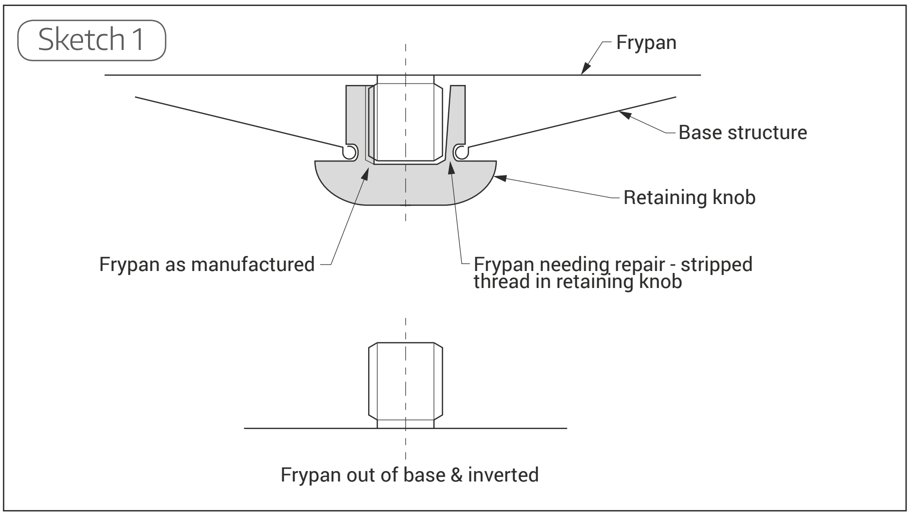
Top view of base

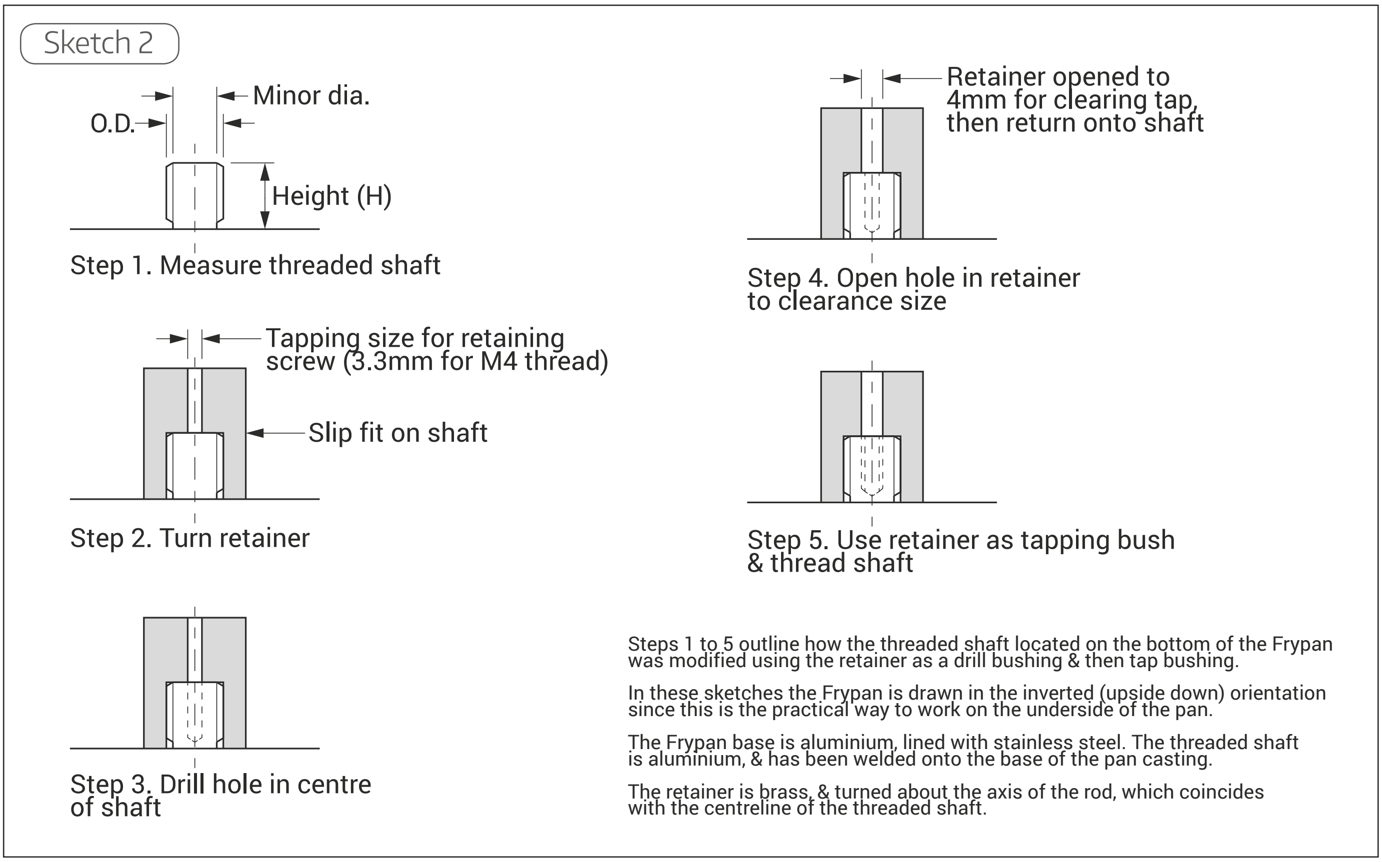
The new baseplate

The frypan threaded spigot was measured to determine the length and external diameter of the threaded section, **sketch 2-1** These measurements were used to bore a slip fit hole in the brass rod. The brass rod I used was a slip fit through the 18mm hole, so external turning was not required in this case.

An effort was made to measure the minor diameter of the spigot thread in order to establish the diameter of solid metal in the core of the pieces. It was estimated to be approximately 6.5mm (1/4"). Based on this, it was decided that a 4mm thread could be placed inside the screw thread core leaving about 1mm of solid wall between the two threads in the minimum.

The brass rod was drilled through with the tapping drill for the 4mm tap (3.3mm),





and the brass piece slipped over the threaded spigot, **sketch 2-2**.

The drill bit was then marked so it would stop 2mm short of the length of the threaded spigot and then chucked into a handheld drilling machine. The hole into the core of the threaded spigot was drilled using the brass rod as a drill bushing/guide, **sketch 2-3**.

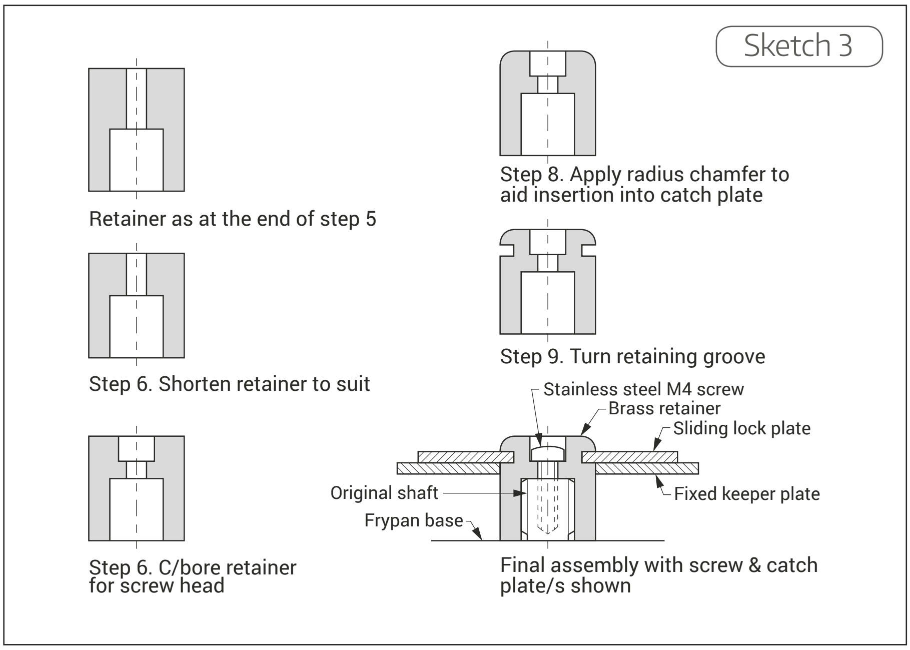
The brass rod was returned to the lathe and the 3.3mm hole was drilled out to 4mm, the clearance size for the 4mm thread, and then returned back over the threaded spigot on the frypan, **sketch 2-4**. The brass piece was again utilised as bushing/guide to align the 4mm tap, and the hole was threaded for M4 threads for the depth of the hole, **sketch 2-5**.

The base of the frypan was inverted, and a base plate was fabricated from 3 x 50mm flat bar, **figure 1**. This base plate can be seen in **photo 3** (bottom view, general arrangement) with a clearance hole drilled through it to coincide with the hole in the middle of the original base. Since my frypan had some circular steps pressed into the sheet metal base, I used one of those steps as a dimension, and filed the base plate to fit into that step for location.

I then marked and drilled 4 holes sized for 1/8" aluminium pop rivets, but did not rivet the base plate in. I used longer "un-popped" rivets as locating dowels for the subsequent operations.

With the frypan inverted, the retaining piece was placed over the threaded shaft, and the frypan base lowered over it with the base plate in place.

This allowed me to mark the retaining piece where it protruded through the retaining plate. Knowing that my keeper plate would be made from the same 3 x 50mm flat bar, I was able to then mark out the slot, and chamfer needed to complete the piece.



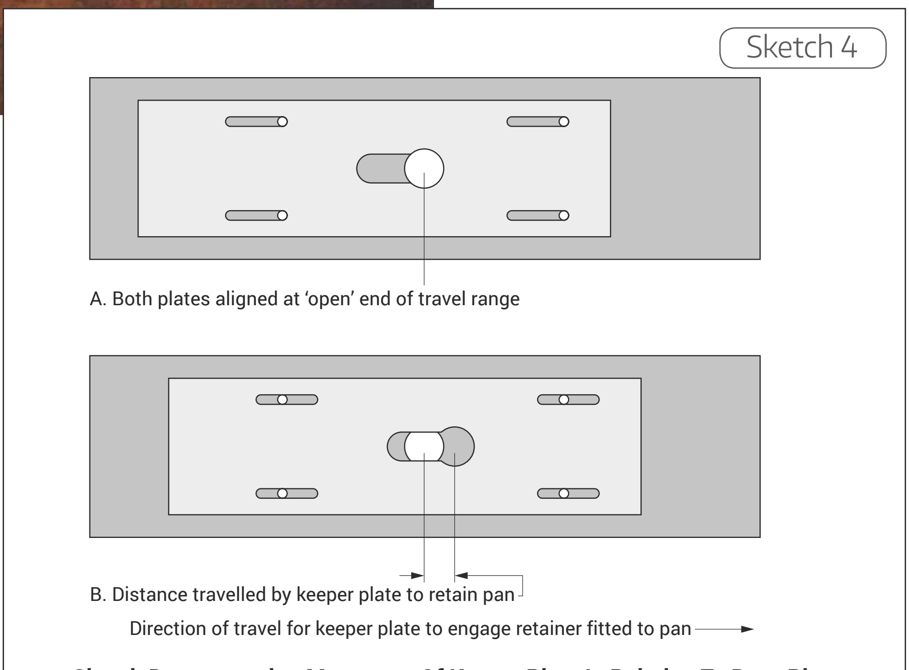
M4 screw fitted in retainer

Sketches 3-1 through to **3-9** illustrate how those markings were used to shorten the piece, turn a rounded chamfer, use a parting tool to cut a retaining slot, and counter bore the end so the screw head would not protrude at the bottom. The slot cut with the parting tool was cut to 3mm depth so there was sufficient depth for the engagement of the keeper plate (still to be described).

A suitable M4 stainless steel machine screw was selected, and adjusted for length so it did not bottom out in the threaded hole. The retainer is shown in **photo 4**.

The retaining piece was left screwed to the bottom of the frypan, and the base plate left in location.

A short piece of 3 x 50mm flat bar was marked and drilled with a 18mm clearance



Sketch Demonstrating Movement Of Keeper Plate In Relation To Base Plate

5

Clearance allowing the keeper plate to move in and out of engagement.

hole on the centreline. A 12.5mm hole had been marked 25mm along the centreline, and also drilled out, with parallel sided slot cut joining the two holes.

A set of 8 holes were marked near the corners. 4 holes were marked and drilled with the 5mm drill. With the keeper plate located with the 18mm hole on the retainer (the open position) the holes were spotted through to the base plate.

The second set of 4 holes were marked 25mm along the long axis of the keeper plate, and drilled through at 6mm. The original 5mm holes were opened to 6mm once the keeper plate had been removed from the base plate, and the holes joined to form slots. The operation and orientation of these holes and slots is shown in **sketch 4**.

The 5mm holes spotted through on the base plate were drilled through at 5mm, then tapped for M6 metric thread.

A handle was bent up from 3 x 20mm flatbar, and welded to the keeper plate so it could be accessed whilst the frypan was in its normal orientation. This handle is visible in the photos already shown in this article.

Some short 6mm bolts (with matching nuts) were used to fix the keeper plate to the base plate. Some shims were used to provide the basic clearance as the bolts were tightened into the threaded holes in the base plate, then the hex nuts were used to lock the bolts in place. The shims were then removed so the keeper plate could slide easily. The resulting clearance is evident in a side view photo of the plate assembly, **photo 5**.

The plate assembly was then spray painted to match the base of the frypan, and once dry, riveted into position using aluminium pop rivets.

Photographs 6 and **7** show how the keeper plate restrains or releases the retainer in normal operation. The repair has been in regular use for over 2 years, and still functions as well as the day it was made.

Whilst this article describes a repair for this electrical appliance, I feel certain that people can see the potential use of this mechanism or repair method for many other applications. Is it due to this versatility that I have omitted many dimensions from the description, and drawings. ■

6

Plate engaged...

7

...and disengaged

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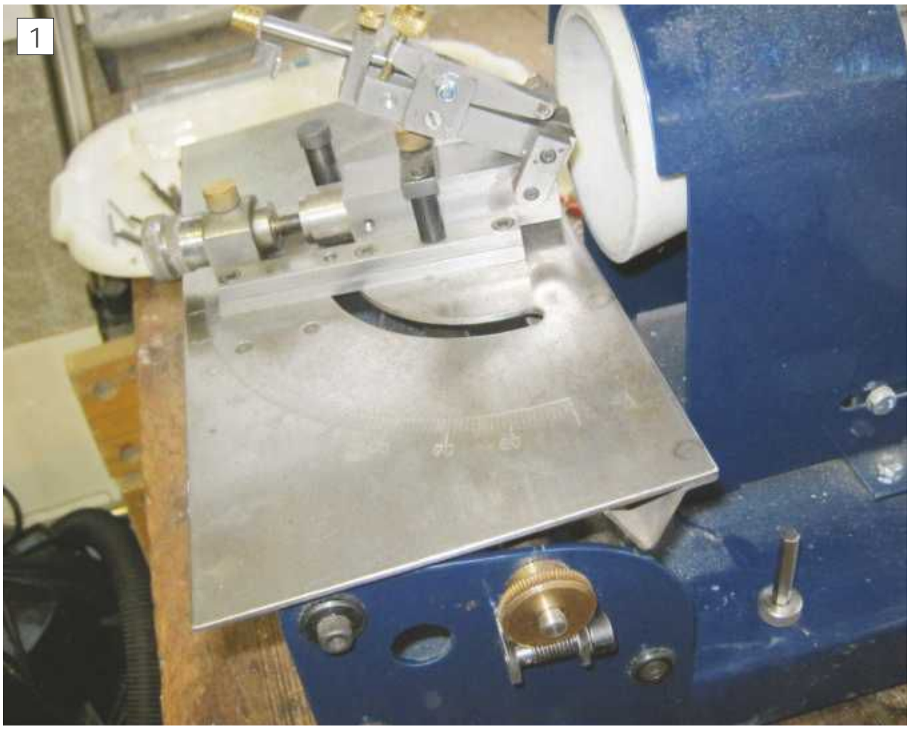
Modifications to a Woden Tool and Cutter Grinder

Laurie Leonard details some improvements to this popular tool and cutter grinder.

A number of years ago I purchased a kit from Hemmingway for a Woden Tool and Cutter Grinder. Wanting to be able to sharpen twist drill bits I also purchased the kit for the Four Facet sharpening jig. I actually purchased two: a mark I which did not get made and the Mark II which came out after my original purchase and was simpler to construct. It is the latter which is in use. **Photograph 1** shows a general view of Woden with the drill sharpening jig mounted on the table.

The table tilt angle on the Woden is adjusted by cams attached to a shaft which has a knob on one end and a locking arrangement at the other. I found it difficult to set the angle as the table weight loads the shaft and tightening the locking knob can also upset the angle. This does not help setting the angle when grinding the second set of facets on the drill which is done by sighting the space between the drill bit and the grindstone. A fine adjustment facility that is not affected by the weight of the table was required. The solution – a worm and wheel. The photographs are based on the prototype: the production model has yet to be constructed!

1



Woden Grinder with drill sharpening attachment mounted

Design Considerations

Serious thought should always be given before modifying any piece of equipment to try and alleviate future problems. I also prefer to carry out minimal work that can not be reversed.

Whilst a worm and wheel gives fine control it also requires a serious number of turns of the worm to get any appreciable angle of rotation of the worm wheel so it was concluded that the design had to permit the withdrawal of the worm to enable quick rough setting of the table angle with subsequent re-engagement to provide the positive positioning and fine adjustment.

Some means of operating the worm was required that did not interfere with other areas of the grinder. A detachable knob was chosen as suitable means that did not clutter the grinder but had an extended spindle to give finger access.

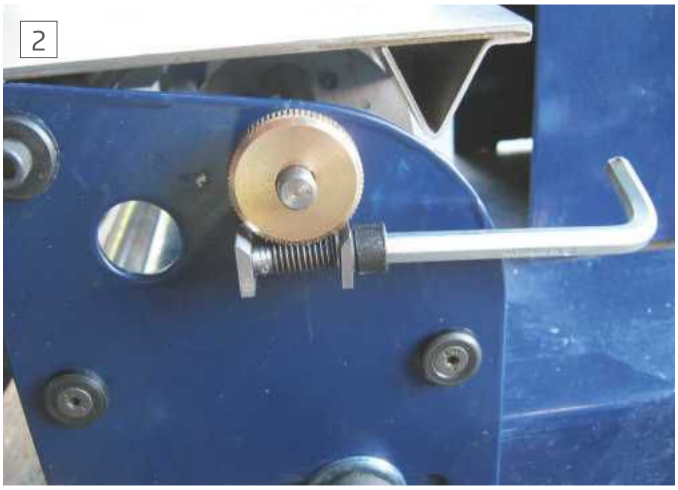
Photograph 2 shows a general view of the parts added for the modification with an Allen key used as a temporary adjuster (it also shows the runs you get when painting in a cold shed in winter!).

Constructional Comments

It is not intended to provide a blow by blow account of construction but to provide some notes to assist a constructor.

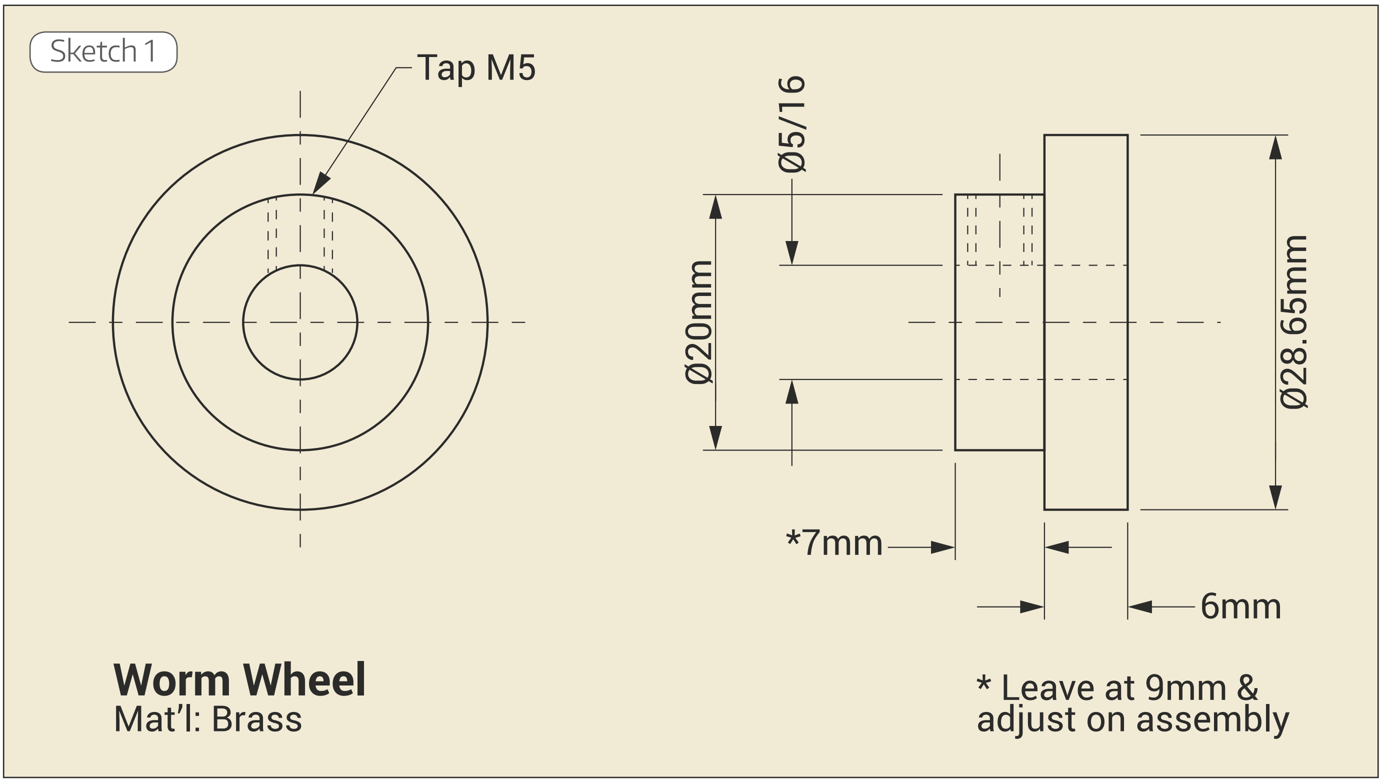
A while ago I came across a procedure for making worm wheels using a tap as a hob and decided to use this procedure to fabricate the worm wheel. The basis of the method is the use of a tap held and rotated in the lathe chuck to hob a wheel blank which is fixed but free to rotate about its axis.

A fixture was made that could be clamped to the cross slide using tee nuts. This fixture was equipped with an axle which was a good rotating fit in the worm wheel blank to be cut, **photo 3**. Not seen in

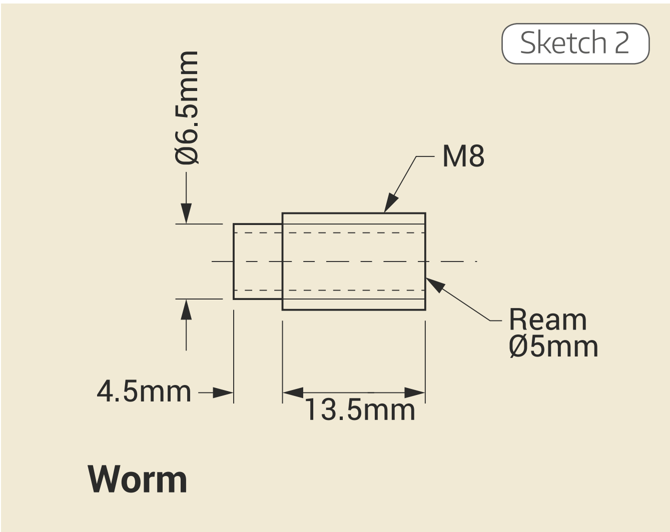


General view of the parts added for the modification

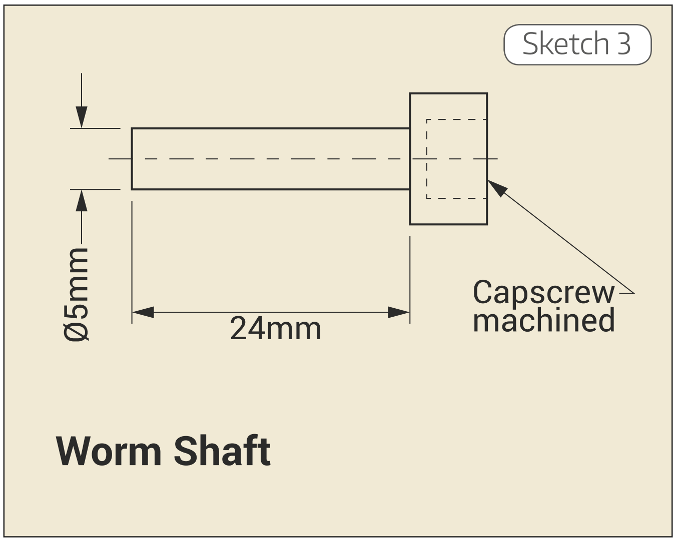
Fixture to carry the worm wheel whilst hobbing



Worm Wheel



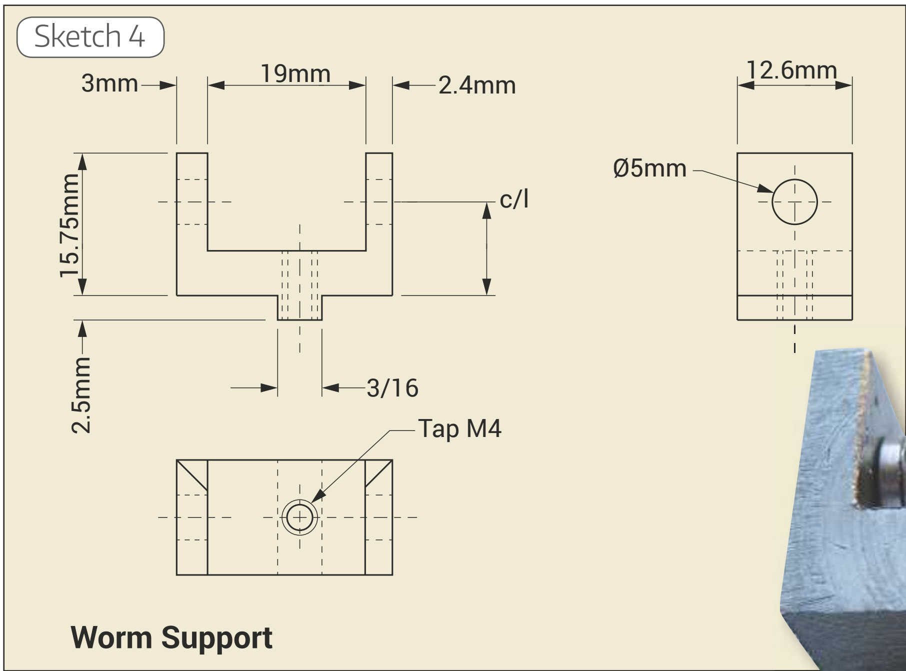
The Worm



Worm Shaft

Worm wheel hobbing in progress

the photograph is a large diameter spacer under the wheel that was sized to put the rim of the blank on the lathe centre line. **Photograph 4** shows the wheel being cut with the tap. In practice a "cut" was put on by advancing the cross slide until the tap bit and the lathe run at low speed. The cross slide was further advanced until the teeth looked good and a nice feel to the engagement with a bolt was obtained.



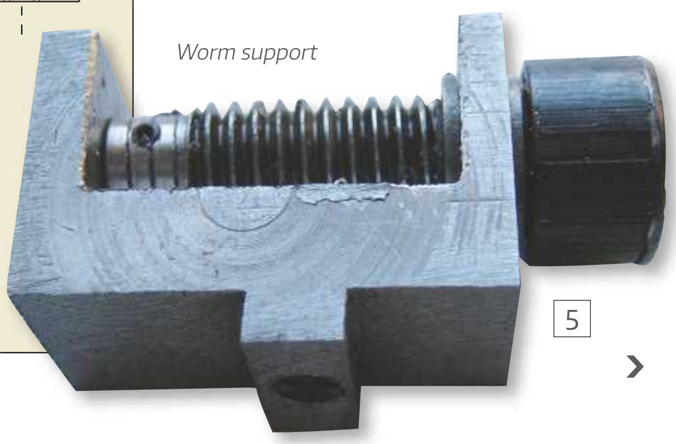
Worm Support

Sketch 1 shows the Worm wheel.

A piece of M8 stud bar was chosen to form the basis of the worm as an M8 tap was available but it was necessary to check the dimensions to ensure that there was enough meat left under the thread after the shaft hole had been drilled through the centre. This was machined as in **sketch 2** to make the worm

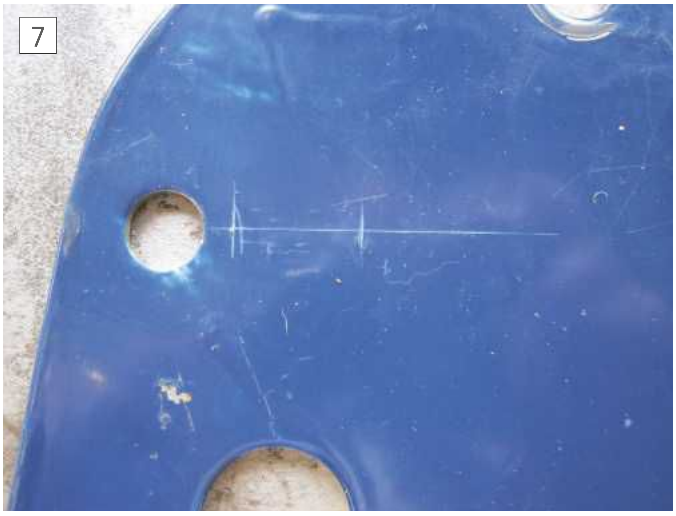
An Allen screw was used to make the worm shaft as this provided a hex recess for the removable knob to engage in, **sketch 3**.

A support for the worm was designed, **sketch 4**. This was to be located in a slot cut into the side plate of the Woden. The slot was sized to permit the worm carrier



Worm support

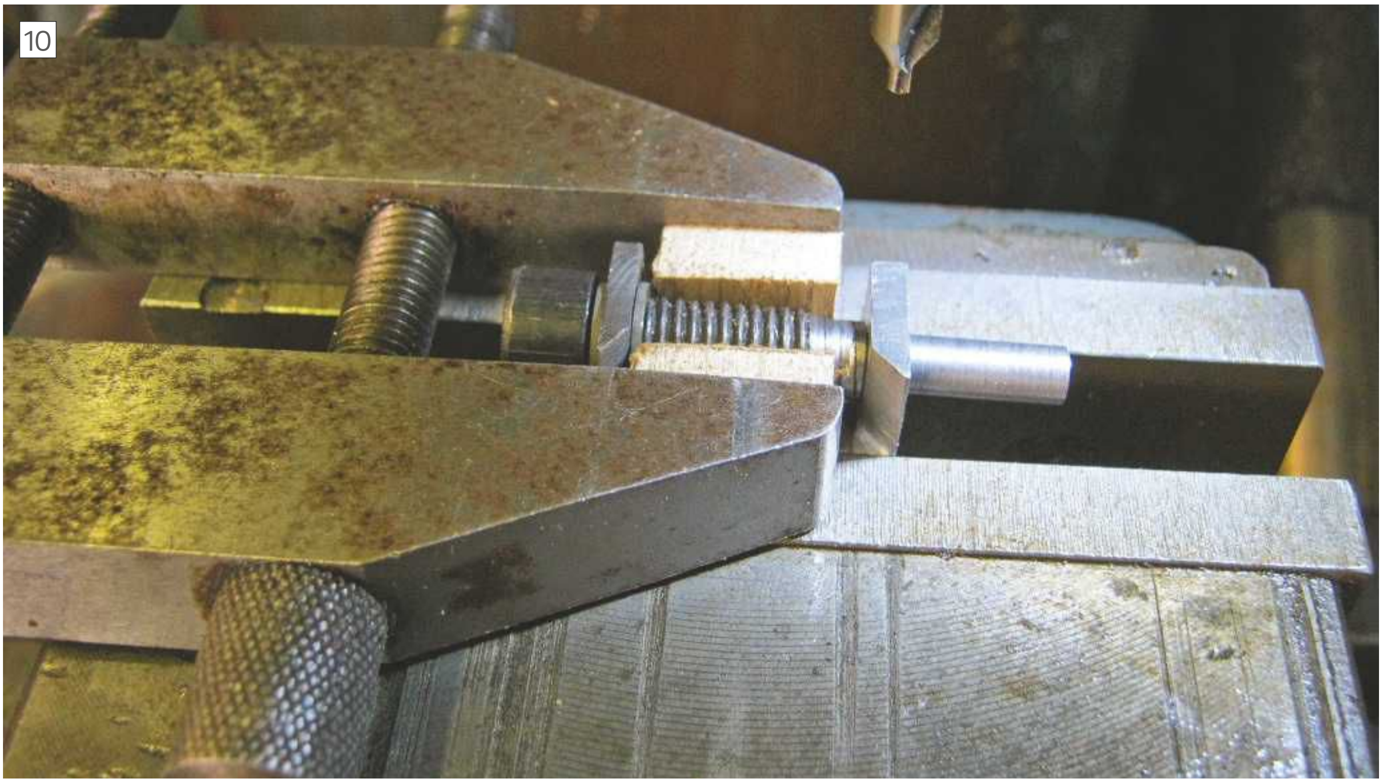
Checking worm wheel dimensions



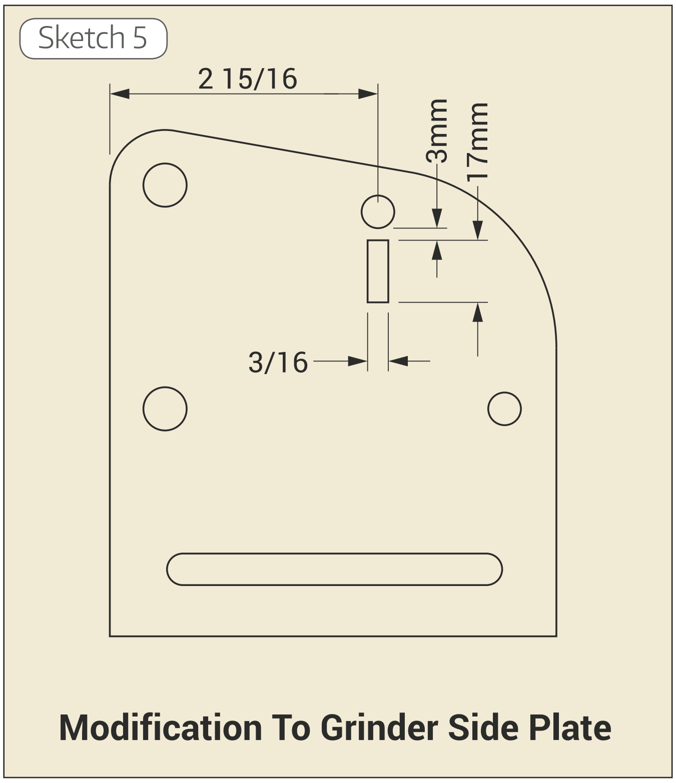
Marking the side plate for machining the slot

Setting milling machine to cut slot

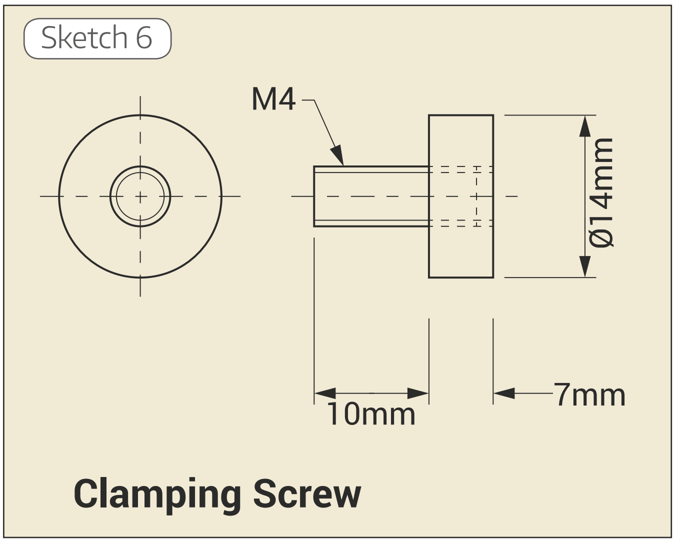
Slot cut, ends squared



Worm in its support ready for drilling to accommodate the roll pin.



Side plate modification



Clamping screw

> *"...tightening the locking knob can also upset the angle."*

to be lowered to enable it to be disengaged from the wheel so that free rotation of the cam shaft is available if required. The worm support (before final cleaning up) is shown in **photo 5**.

The worm wheel was drilled and then reamed to fit over the existing table cam spindle where it fits up to a shoulder after it has passed through the side plate of the machine. Thus the centre line of the hobbed gear is at a fixed distance from the side plate. In practice the hobbing process left the teeth on the worm wheel slightly off the blank centre line so a digital height gauge was used in conjunction with the reamer to calculate the position of the actual centre line, **photo 6**. A good "feel" was used to locate the worm in the worm wheel teeth prior to measuring. The worm wheel boss was adjusted to compensate for the discrepancy.

It was necessary to machine a slot in the Woden side plate as in **sketch 5**. This was marked out as in **photo 7** and was done on a milling machine, **photo 8**. **Photograph 9** shows the machined slot with the ends squared, burs still to be removed.

Moving on to assembly, the length of the worm was adjusted to be a snug fit in the support with a washer on either side. The worm was fastened to its shaft with a roll pin. **Photograph 10** shows the set up ready for drilling the hole in the worm and shaft for the pin. Clamping the worm via wooden chops prevented it turning during the drilling operation but it was necessary to clamp the shaft with self grip pliers to stop it turning as the drill went in. (The toolmaker's clamp made at Derby Tech circa 1970 showing the ravages of a life in the shed).

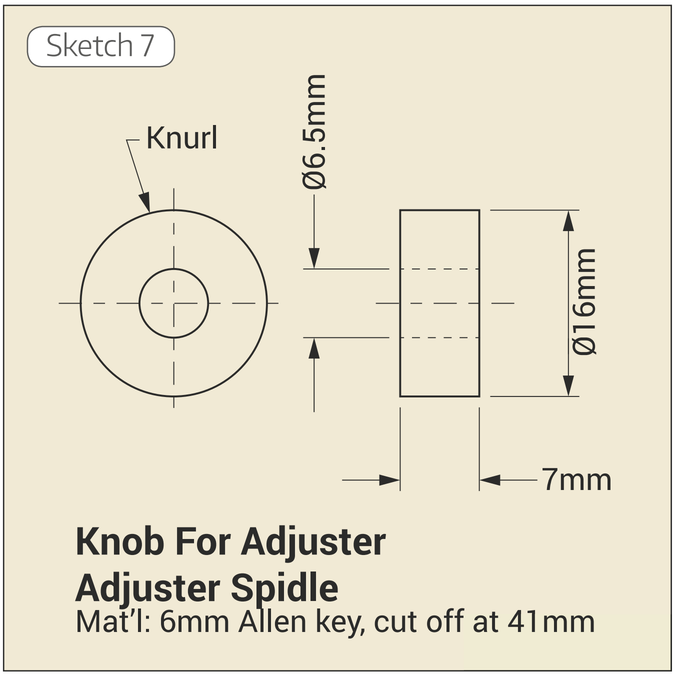
The worm wheel replaced an existing knob, **photo 11** (note extended locking screw fitted to get leverage to tighten the locking arrangement on the cam shaft). The worm wheel, **photo 12**, had guide marks scribed on the circumference to give an indication of the table tilt. The marks were scribed in line with the original Woden constructional notes.

11

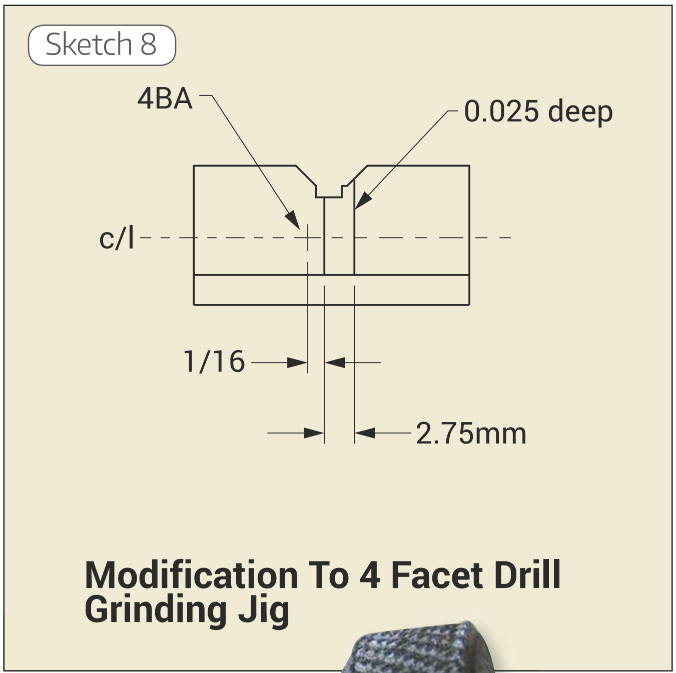
Original cam shaft knob

12

Graduations scribed on worm wheel



Knob for adjuster



Modification to Four Facet drill grinding jig

A knurled clamping screw was made, **sketch 6**, which locates in a tapped hole in the worm support and is tightened to fix the worm support against the side plate with the worm either in mess or out of mesh as required. A fibre washer was introduced between it and the inside of the grinder side plate to assist gripping

13

Adjuster

14

Using a vice to force the knob onto its Allen key shaft on the painted surface.

The adjuster, **photo 13**, was made from a knurled knob, **sketch 7**, and a piece of Allen key cut with a metal cutting disc, the Allen key should be hardened, and then forced into a drilled hole in the knob using a vice, **photo 14**.

Photograph 15 shows the parts as manufactured for the worm and wheel addition.

Conclusion

It works! The mod performs as design and the ease of fine adjustment is very noticeable. The slight downside is that the clamping screw is not very accessible and could really be of larger diameter to provide more leverage. Thinking cap on on this aspect.

Addendum

I thought it may be useful to include basic information on a couple of mods I made to the Four Facet jig.

Photograph 16 shows a modification I made to the drill stop arrangement. The original design had a 1/16 inch diameter peg with a flat filed on it located in a hole in the jig bed. The peg was designed to rotate so that the flute of the drill to be sharpened rested against the flat on the peg. I had trouble getting it to rotate and positioned at the right height from the bed so I utilised a craft knife blade located in a milled slot in the end of the jig as shown in the photograph and **sketch 8**.

Also shown in the photograph is the small block of metal located on the round drill clamping bar. I found that the round bar tried to sit in the flute and had a tendency to rotate the drill, despite the stop, as it did so. The flat lower face of the added metal sits on top of the drill to overcome this. ■

15

Manufactured parts for the worm and wheel addition

16

Modified drill stop on four facet jig

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Viceroy 240V 16" grinder £425
£1475 Wadkin 10" AGS saw bench 240 volts
£875 Eagle Model 3 surface grinder
from £75 Bench vices
£3250 Tom Senior ELT 36" x 8" table
Baileigh AP5; 5Ton press £475
Colchester Mastiff 1400 fixed steady £425 less clamp
£375 Meddings LF1 ped. drill
£170 Precision Stanier 55mm machine vice from New Zealand
£450/£725 Quorn tool and cutter grinders
£40 Trolley wheels (heavy duty) sets of four
Faceplates various from £75
£1250 240 volts Colchester Student
Set of rolls geared 5 to 1 £525
£65 each Trolleys Various!
£400 Meddings LFFS1 ped. drill
Prince 6075 grinder £12000
Tap/Die holders from £10
£1425 Bench milling machine + stand tooled
J & S arbor press 8" x 15½" height £425
£10-£49 Myford non standard wheels
WD-40 £20 each
Speedex (metal cutting) bandsaw £825
Colchester Triumph Fixed Steady £425
Micrometers Various!
Micrometers 0-16"/ 300mm
Clarke 50T (50 ton) garage press choice £750/£1150
MYFORD GENUINE PARTS
Running out fast!
Purchased from Nottingham
Check the web site for full list!
£525 RJH late buffing machine
£375 New Minor 4" linisher
Myford Super 7B + Sino DRO & Tesla £3950
Q and S 6" hacksaw £345
£15 each Just arrived! DP/MOD gears
Steel EN3B (mild steel) £7 each
Angle plates +surface plates various!
Special 5 for £20 Myford ML7/ Super 7 Rifle/ Bridge bed felts
£90 Tripus (German) on/off switch
£425 Boxford Little Giant toolpost grinder
£1850 BRL mower grinding machine
£3450 Weiler lathe + collets... lovely!
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
New even easier to use Web site!