No.250

A HAPPY NEW YEAR WITH OUR LANDMARK 250th ISSUE

MODEL ENGINEERS' WORKSHOP

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JANUARY 2017

INSIDE

POWER FEED FOR A CENTEC MILL

One man and his SEVEN lathes!

COVER FEATURE

Stephen Wessel on making patterns for complex castings

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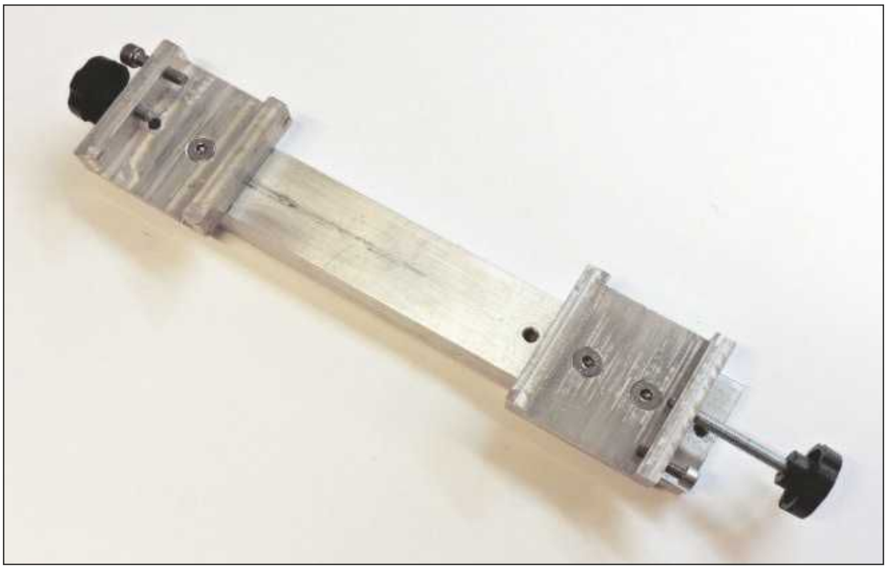
On the Editor's Bench



On My Bench

Astronomy and model engineering fit together nicely, at least they do for me. I have made lens adaptors, finderscope rings, gearboxes for my mount and all sorts of other hand bits and pieces – I even turned a plastic end cap to replace one I accidentally sued for something else! At the moment I'm making a long dovetail bar to fit my mount, with two dovetail holders fitted to it – this will let me put two telescopes on my mount at the same time. Making 75-degree external dovetails by milling wasn't difficult, but making internal dovetails was more of a challenge. I tried putting the block at 15-degrees so I could use a 60-degree dovetail cutter, but the cutting edge wasn't long enough to let me get to the corner. A long end mill could have done the cut, but would leave a 90-degree groove at the base and the external dovetails are recessed and need to be supported right into the corner.

Then the light bulb moment! Only a few months ago I picked up an Adept Number 2 hand shaper. It took a while to select the right holes to get the correct stroke length, and a bit longer to adjust the vice so the block was level and aligned, but only a moment to set the shaper head at 75 degrees, The tricky bit was getting the right tool. I experimented with different shapes as I roughed out the dovetail, the work getti8ng easier as the tool got better! In the end I ground some HSS with a 60-degree point at the corner, with plenty of front and side relief and lots of top rake. For the final cut, I used a diamond slip top make a flat at almost the dovetail angle on the tip of the tool and used a cut that just took a tiny shaving. The result was very smooth and quite shiny. Admittedly this was aluminium alloy, but even so I was surprised how little effort was needed once the tool was right. This nice old machine has already earned its place in my workshop as the item I've made would cost more to buy new than I pad for the shaper!

If you still have some vintage tools earning their keep in your workshop, why not send me a description and some photos?

Wilder Paints

Anyone who saw my loco, Southam, at the Model Engineer Exhibition will have noticed it's been weathered. I've been sent a couple of samples of Wilder brand paints by the Airbrush Company, www.arbrushes.com. One is a pink masking fluid that would be very handy for masking off moving or bright metal parts when painting models. The other is 'maroon shadow' weathering oil. It's a runny, fast-drying oil paint that dries completely matt. I've only had a quick look at it, but it seems quite an intense pigment and easy to use with a 'dry brush' technique.

Contents

See page 60 for details.

Coming up...

in the February issue

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

Regulars

ON THE COVER »»

This month's cover shows Stephen Wessel, author of our castings feature (p. 9) clearly enjoying relaxing in his workshop. This excellent photo was taken through an open window!

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DOWNLOAD A FREE PLAN: A Top Slide for the Unimat 3. This little topslide by D. Scroggins uses a novel approach to the dovetail slides. It first appeared in MEW issue 16, April/May 1993. Just sign in at www.model-engineer.co.uk and click 'articles – article reprints' on the black stripe

Hot topics on the forum include:

- **Arduinos and Microcontrollers**
  Follow up discussion of last month's two articles.
- **How do you measure your holes?**
  Techniques for measuring small bores.
- **3½" Small Boilered Tich**
  Follow progress thorough Ryan Norton's well photographed build log.
- **Brian's 1" Minnie Traction Engine**
  Prefer road locos? Take a look at Brian Abbott's excellent work.

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Casting and Pattern Making Techniques

Stephen Wessel describes his approach to producing complex castings for a large-scale model of an aero engine.

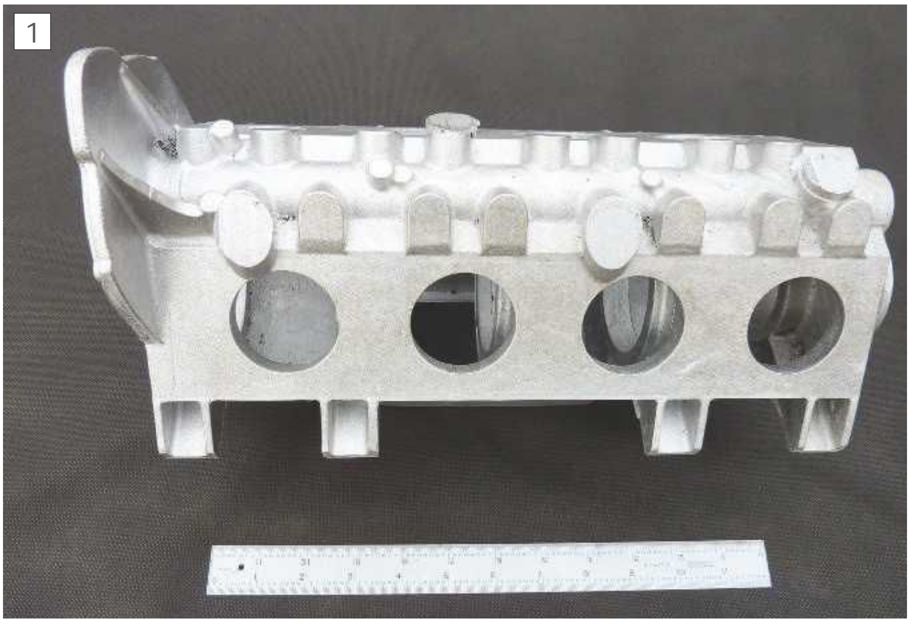
Introduction

I was reminded recently by an old childhood chum that our mutual interests in all things practical probably began in our sandpit. Aged from three onwards we mucked about endlessly with stuff found in our fathers' garages. Later on we discovered that some metals, such as lead, could be melted rather easily and then poured into holes made in the sand; such experiments suggested its use for making things we wanted like little wheels without resource to proper tools, which we hadn't got. The excitement was much enhanced by the need for a good fire at the bottom of the garden helped along with bellows and of course, total secrecy. Even in those days parents could be desperately boring. Some years later, as part of my student apprenticeship in engineering, I was sent to a foundry where I learnt the rudiments of pattern making and could watch iron being poured into my own moulds.

More recently I became interested in large scale vintage aero engine models and am currently working on my third, an ENV water-cooled type dating from 1910. This one, and a radial made a few years ago, both required aluminium castings. So, I had to learn how to make the necessary patterns and find no less than three foundries willing to use them and pour the metal. One can of course watch many examples on Youtube of foundry work being done at home in the back yard but despite my childhood experience I felt quite unable to do this with any chance of success given that all the castings would be complex and thin walled. A job best left to the experts. The castings would in any case all require heat treatment before machining and this too is not easily done at home.

So why bother with castings at all? Many model engineers take pains to avoid them altogether and it has to be admitted that modern machining techniques do allow complex shapes to be hacked out of the solid. For a one-off job this may be more economic and would certainly avoid many of the uncertainties involved in casting, such as shrinkage, distortion, blow holes

1



The raw casting prior to heat treatment. Sprue removal not complete.

2

The 5 parts of the upper half of the pattern. Constructed mainly from 12mm PVC plate.

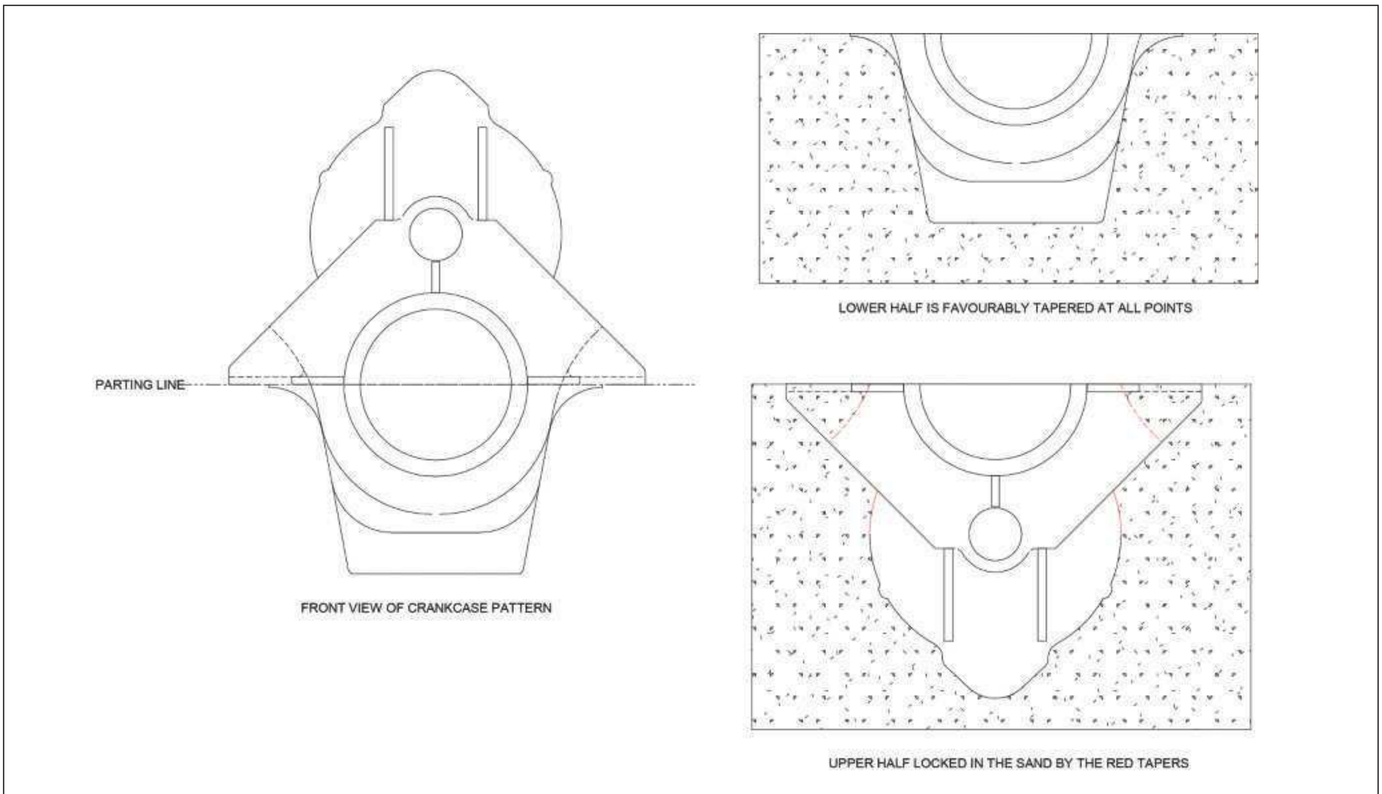
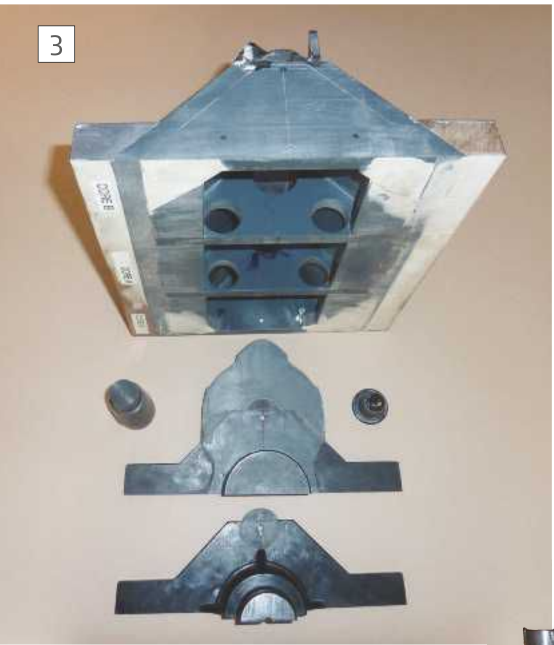


FIG 1



3

Another view. The wood side blocks form prints for the external bracket cores.

and all the rest. Even without a CNC set-up it is not difficult to produce something that looks quite like a casting, especially in aluminium. Bits can be brazed on using one of the low temperature alloys now widely available; subsequent shot blasting can produce a suitable finish. All the same, if the model is to be truly authentic it should, in my opinion, involve castings if they were used on the original.

Perhaps the geometrical and surface imperfections of cast metal give it a look that is more pleasing than the perfectly machined replica. In the case of my own work, machining from solid would have been quite impossible without major design change. So castings they had to be.

This article is divided into three parts each describing a different foundry technique as may be appropriate for the job in hand. The basic pattern-making will be the same or similar throughout, but the way in which those patterns will be used depends on foundry method. In the first part I will describe the most traditional route in which the patterns are used directly to form cavities in sand. In the second I will talk about a modern variation of this in which the patterns are made from rubber and the sand replaced by a ceramic plaster; this is a technique highly suited to complex shapes involving undercuts and results in very smooth cast surfaces. In the final section I will cover investment casting. Both the second and third sections will draw on my experience in building the Lynx radial engine while the first is illustrated by the latest project. I should emphasise that I am no expert in the subject, aiming to demonstrate only what I have actually done in my very average home workshop so the whole article is more of an *example* than a lesson.

Most model engineers will know the basics of sand casting whether they have actually used it or not so I am going to assume some prior knowledge here amongst my readers and show how I tackled something fairly complicated. **Photograph 1** shows the one piece crankcase successfully cast in Gloucester that forms the body of my half size ENV aero engine. It is about 15'' long and has a general wall thickness of only 3.5mm (I think imperial but the foundry thinks metric!). In case anyone is already wondering how the crankshaft can be installed I will just say that it runs in ball races and the bearings are all assembled on the shaft before the whole caboodle is slid into the rear end. The 8 separate cylinders bolt on to the inclined faces and the cam shaft passes through a long chamber just below the apex of

4

The main part of the upper pattern.

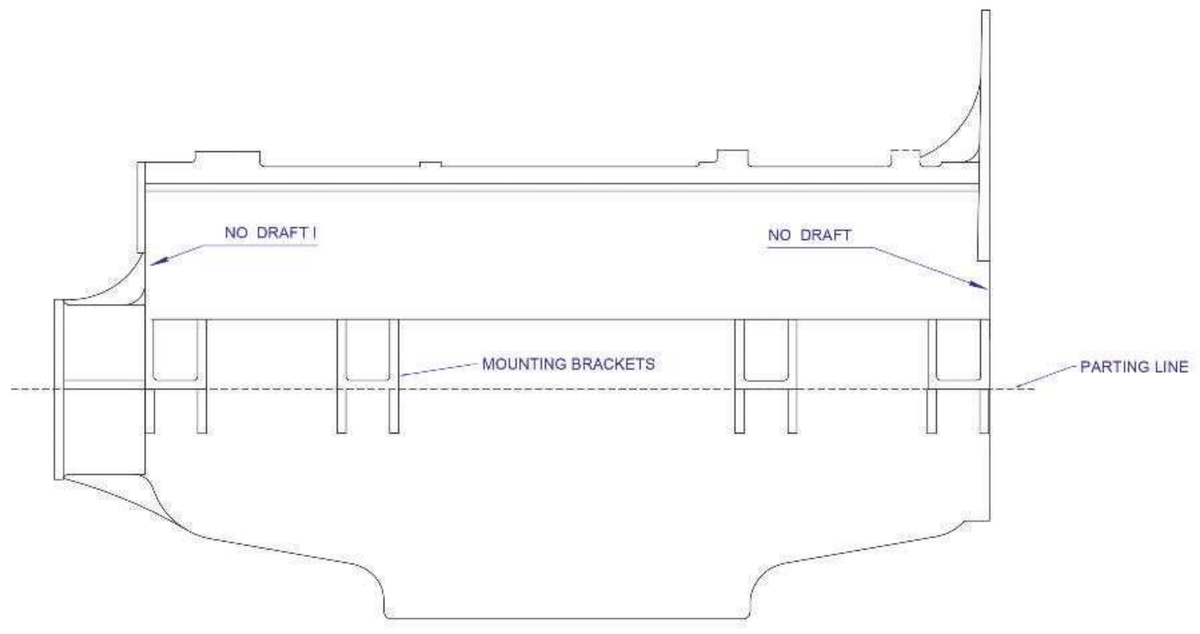


FIG 2

SIMPLIFIED ELEVATION

these faces. The interior of this box is really more complex than the outside, which is why it could not be made from the solid.

The general principle to be followed would be to make a pattern for the exterior shape and several cores for the interior. The first decision was where to make the parting line between the upper and lower parts of the mould, the cope and drag boxes respectively. Anyone who has made a sand castle will understand the need for a taper, or draft, on the bucket that allows the sand to come out cleanly. So it is with a pattern: it must be removable from the sand cavity. In this case, it seemed fairly obvious that the parting would lie on the crankshaft centre line. Both shapes, above and below, are generally tapered. There was, however, a problem with the upper half, clearly shown in **fig. 1**.

The red lines represent shapes that taper the wrong way: in other words, these areas would lock the pattern firmly into the sand. **Figure 2** shows a further difficulty in that the required casting has no draft at its ends. This is how the original engine that I am replicating was designed; so how was it done? Parting lines are not visible on the original so I had to work out something for myself.

The cope pattern would need to be built from several components each of which could be removed separately from the sand. **Figure 3** shows this pattern turned upside down as though it were in the sand and **photos 2** and **3** show the various parts. **Photograph 4** shows the main part the right way up. The end plates were made separately and mate with the main body of the pattern along a tapered face; three screws accessible from inside hold each

5

Lower half of pattern. Made chiefly of wood laminations with PVC core prints at each end. The 16 little buttresses are also plastic. Each one is given draft.

plate in position together with the core prints for the camshaft chamber. Drawing the pattern from the mould therefore implied three things:

1. The body of the pattern would be hollow to allow access to the screws.
2. Having removed these screws the founder would lift out the main body vertically, then ease out the end plates sideways and finally pull out the core prints, one in towards the cavity and the other outwards through the sand and a special hole in the mould box.
3. The engine mounting brackets would be formed by "external" cores placed in the sand cavity after removal of the pattern.

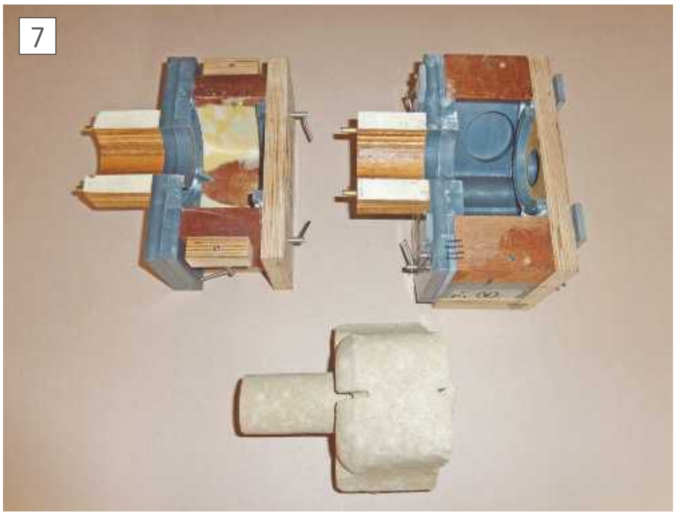
This last point needs clarification. The word "core" strongly suggests something internal and is usually a sand entity inserted into the main mould designed to define the inside shape of the casting. There may be several and they register with core "prints" that extend outwards from the pattern. My external cores were required to define parts of the exterior of the casting, namely the mounting brackets with their annoying negative taper. I call them cores because they are sand entities made in core boxes.

I am pleased to say that the foundry was happy to try this with the proviso that all components be clearly labelled and fit together in only one possible way.

Pattern materials

It is now time to talk about suitable materials for patterns. Traditionally they have nearly always been of wood, a close grained stable timber such as yellow pine, lime, mahogany or jelutong; relatively cheap, easily worked and glued. The trouble with wood though is its grain and if the pattern has many cylindrical elements it means an awful lot of wood turning that the model engineer might not want to get into. Far better is to make use of plastic, particularly PVC sheet and bar. This

One of the main core boxes. This one is in two halves to make ramming easier.



Upper section of the same box taken apart. The white fillets are Milliput filler. The central block is common to all three boxes.

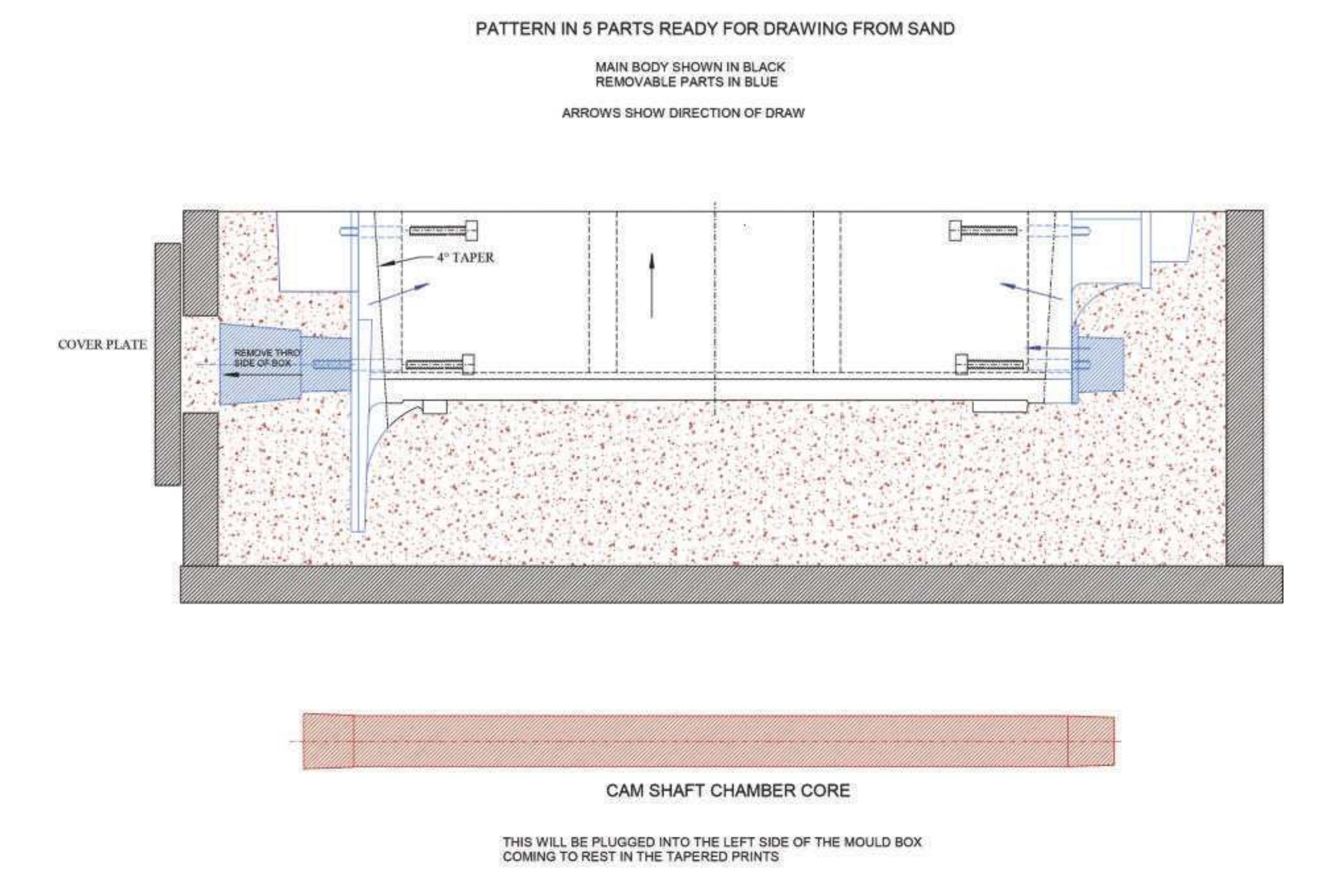


FIG 3

is a perfect material available online in all thicknesses and diameters. It is stable and can be rapidly joined with either solvent cement or superglue. It can be worked to a high accuracy with either metal or woodwork tools, allowing the use of a planer-thicknesser, circular saw or milling machine as appropriate. For a smallish job you don't need much and online companies will happily supply what you need, unlike a timber yard that will start you off with an enormous 1" or 2" board most of which will remain unused.

The one feature of wood that is useful however is its carvability. The lower half of my crankcase pattern, photo 5, was partly made by laminating some ½" mahogany boards which were subsequently carved like a ship's hull; harder to do in plastic.

The other very important material you need is a fine filler. This is used to form all the fillets needed around the glued joints. I use mainly Milliput (no business connection) as it is dead smooth, sticks well to PVC and can be worked as a sort of thick paste using water. Full instructions will be given in Part 2.

Finally, the patterns may need painting. PVC is grey, filler is usually white. It is surprisingly difficult to see whether the filler has properly blended curves into flat areas until both are the same colour. Several coats may be required with some slight sanding in between before a nice even surface is obtained. The paint also offers a more slippery surface to the sand. There are standard colours in use for the

The two halves put together for a final ram. Notice the founder's notes to herself!

My home made core to test the box

various parts of a pattern but my foundry was quite unconcerned that I use them so I made use of what was in stock, all quick drying aerosols.

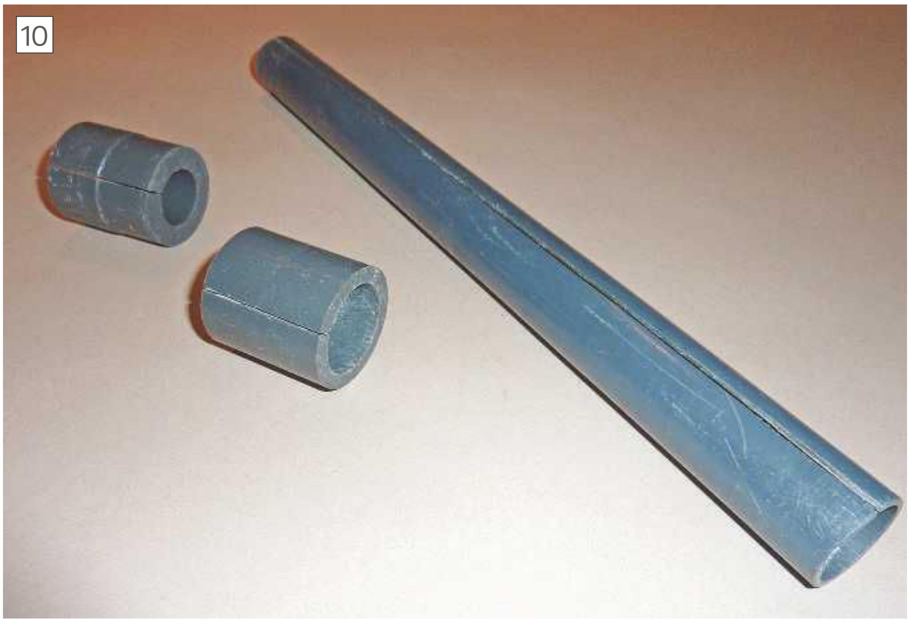
Foundry matters

Before starting any casting project, it is prudent to talk to the foundry. Nowadays they mostly prefer to work directly from a 3D drawing and make all the tooling themselves. I was very lucky to find companies willing to work with an amateur wishing to construct the tooling himself. Forming a friendly relationship and capturing their interest from the start was vital. It rapidly became clear to me that foundry work is something of a black art in which experience is king. There are many variables and success often seems to rest on a knife edge between opposing constraints. I got the message about draft early on, followed by the need for reasonably constant wall thickness. I let them decide on the exact alloy, LM25, and of course the runner and feed system. I also learned that both the main mould and the cores would be of hardened sand; a cold curing resin is mixed with the sand and takes about half an hour to harden it. Cores no longer have to be cooked in an oven so the boxes they are made in can be of plastic or wood. Some foundries use sodium silicate (waterglass) mixed with the sand and harden it with injected CO2. Both methods allow the resulting moulds to be handled more easily and less likely to collapse during the pour.

Tooling handed over to a foundry must be foolproof. Cores are particularly important to get right. They must be assembled into the mould in only one possible way with precision and no fuss. I would not be around to advise or get in the way but any snags would directly affect my pocket.

Cores

By far the biggest design task for this engine was to work out the interior shape of the crankcase and then turn it into sand cores. Take for example a stiffening rib, of which there are many: call this a positive entity. It will be formed by the corresponding



Camshaft chamber core box.

negative entity in the sand core. To make the core therefore you need a pattern, this time in the general shape of a box, the insides of which will replicate those positive entities. The box must be constructed in sections dowelled together such that the hardened core can be removed without breaking bits off. It must also be designed so that it can be filled with sand and rammed. A good founder will know how to do this, getting the sand to compact properly around all the little features inside, some of which she may not even be able to see clearly. Needless to say, every single entity needed draft in the direction that it would be pulled. **Photos 6,7** and **8** show the components of one of the three main boxes, made with a mixture of plywood, PVC and mahogany. Coloured discs indicate how it is to be assembled and some of the parts are common to the two other boxes. There are some special pins that ensure certain parts can only be fitted in one way.

All this required a great deal of imaginative head work. The bath was a good place to do it. But it would have been very difficult indeed without CAD. My starting points for the whole project were a surviving engine locked up in the Science Museum storage facility at Wroughton, a tiny sectional drawing in a book and some grainy photos on the Net taken from Flight magazine in 1910. The surviving engine has been partly sectioned at one end, offering a glimpse into the interior but much detail needed to be filled in by a mixture of engineering common sense and guesswork.

Before handing them over, the core boxes were all tested at home. I got some bone dry fine sand and mixed in a small quantity of Cascamite wood glue plus just enough water to get it to set. This worked well for a demo but would not have been suitable for the foundry, **photo 9**.

The other core box I will describe is the one used to core out the camshaft chamber. This is seen in **photos 10** and **11**. A long cylindrical core was needed with a tapered print at each end where it would rest in the main sand cavity (fig 3). The only sensible way to make this was to use a plastic tube (PVC again) split down the middle to allow ›

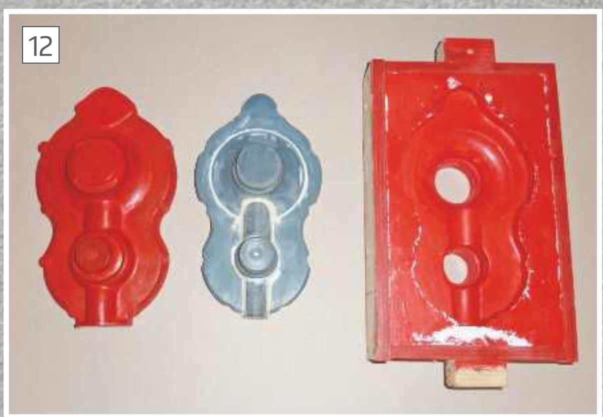
Core box assembled with hose clips ready for sand.

it to open out a little and release the sand core. I needed a fairly precise diameter for this to allow for the smallest machining allowance on the final casting; long narrow holes are no fun to bore when bits of sand may still be around inside. Once again, I found a supplier online offering rigid tube in every conceivable size. The split width was calculated such that when completely closed up the ID would become the core diameter I needed and then a suitable splitting saw selected. The tapered print "boxes" were turned from solid bar, split and simply pushed on. Jubilee clips held the tube closed during ramming while a 6mm steel rod down the centre provided necessary reinforcement. Luckily this very slender core did not need any central support and was easy to install by feeding it through the side of the mould box. Extra sand was rammed in behind to lock it in place.

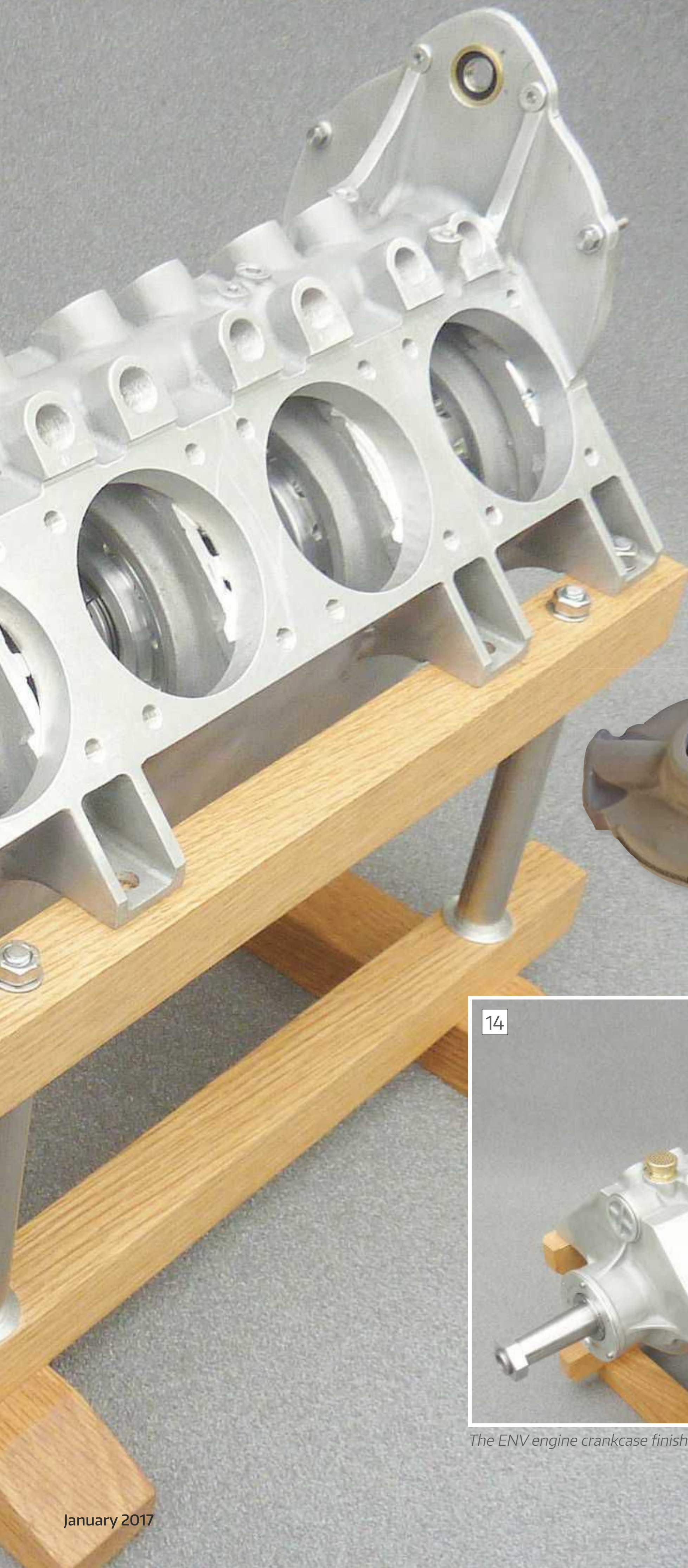
A second much simpler casting was needed for the crankcase rear cover. Similar methods were employed but this time because the core surfaces were all curved an extra stage was needed. I began by fabricating a solid plastic model of the core. This I considered easier than making the "negative" version. A Plaster of Paris mould was taken of it and when completely dry given a couple of coats of paint. This was then used by the foundry to make the sand core. It incorporated a shallow print to allow registration in the main cavity, **photos 12** and **13**.

Heat treatment

Some alloys require this, others don't. LM25 was chosen for its fluidity in the mould and ultimate strength. It is the alloy of choice for modern engine builders. Another reason for leaving the foundry work to the professionals is that your casting will be true to specification, unlike anything melted down from scrap. You will know what alloy it is and therefore what heat treatment it will need. In the



End cover plate patterns. Left: external pattern. Centre: plastic core. Right: plaster cast ready for core sand



untreated state this particular alloy is quite unusable. It cannot be properly machined and is soft. After treatment, it is a different material altogether. Distortion during the process is unlikely but very careful handling is vital and it is well that the company be accustomed to small precision work.

Finishing

Sand castings by nature will have a roughish finish depending on the grade of sand. Mine turned out pretty well but with rough spots in the corners and along the fillets. When it comes to model work surface texture can be considered a scalable quantity and without knowing exactly how I would go about it I decided to go over the whole thing with various sanders and see what turned out. I used carbide burrs to get into the corners and a vibrating sander to deal with flat areas. The idea was to produce an even, smooth look but not a polish. A final blast with 400 grit in the blast cabinet followed by a rub with old sump oil, gave exactly the appearance I wanted.

13

Rear cover plate casting

14

The ENV engine crankcase finished.

Two New Chucks for An Old Myford Lathe

Mike Haughton fits and tests some new accessories for his machine.

This article describes how I mounted, tested, adjusted and use a 125mm dia. 4-jaw self centring chuck on my aged Myford Super Seven lathe. Specifications supplied with the chuck, described as Model K12 size 125, indicate Chinese manufacture by Fuerda. A HBM ER32 collet chuck, bought at the same time, is also described and its accuracy and usefulness evaluated; as are a number of "legacy" chucks that came with the lathe and "orphans" from workshop clearances. Avoiding errors in mounting chucks on back plates are also discussed. How does your lathe and its chucks compare? My Super Seven is a fairly early one dating from 1960.

It wasn't so long ago that a 4-jaw self centering chuck was a rare and expensive addition to a home workshop lathe. The recommended "standard" equipment for smaller British lathes was traditionally a faceplate, a catch plate for between centres driving, and 3-jaw self centering and 4-jaw independent chucks. If you were very fortunate you might have a 3-jaw chuck with adjustment to reduce the run out such as a Pratt Burnerd Griptru, Easyset or similar adjustable scroll chuck.

The arrival of Asian imports has gradually changed all that. Most western manufactured chucks became too expensive for the average Home Workshop. The manufacturers, especially US, but even the Swiss and Germans, have increasingly had their chucks, collets and so on made in Asia, usually China. Alternatively, one can look for good condition, used, known western manufactured brands, avoiding dealers, who have their own profit motives.

Imported 4-jaw self centering chucks and ER series collet chucks are readily available from a number of UK suppliers; as are a host of other lathe accessories that were previously out of reach on price for hobby use. Things like collets and collet chucks, chucks with interchangeable screw on top jaws, soft chuck jaws, quick change tool posts etc. One has to be aware that there can be quality issues with imports and return anything that doesn't measure up to the supplier and get a replacement. Another, riskier, route is to personally import direct from China, OK for small cost and low weight items, like collets. I note quite a lot of Import stuff now coming from UK based Chinese companies, so the import duties, vat and delivery charges are hidden.

In my opinion you have to be equipped and willing to test the accuracy of chucks to get the best out of any purchase.

HBM 4-jaw self centring chuck

The HBM 4-jaw self centring Chuck

You may believe, as I did, that you don't do enough work in the lathe on square stock so the standard independent 4-jaw chuck will suffice. Having used this 4-jaw SC chuck for some time I have now revised my opinion, it saves a lot of time and seems to grip round bar more tightly than a 3-jaw. An unexpected bonus is easy mounting on my 150mm rotary table, without a backplate, see later.

A friend made me a batch of about 2 dozen square head M5 screws from 1/4" square rod for some quick change tool holders that had been supplied with hex head cap screws, the heads of which annoyingly filled up with swarf. His Myford, with a 4-jaw SC chuck did the job in quick time and encouraged me to look for a similar new chuck at the 2012 Midlands ME Show. I found a number of suppliers at the show offering 60, 80, 100 and 125mm body diameter 4-jaw SC chucks, both branded and unbranded. Eventually I bought a HBM branded 125mm unit with recessed back and a machined Myford fitting cast iron back plate from RDG. I also bought a Myford fitting ER32 collet chuck which I will include later in my accuracy comparison measurements. The 125mm body diameter may seem a little large for a Myford Super 7; as the chuck bore (30mm) is considerably larger than the bore through the lathe spindle, but I also intended to experiment with the same chuck on my larger lathe, the Chester Craftsman with a 12" swing and 36mm bore.

RDG supplies a range of HBM branded stuff. HBM is apparently a Dutch importer of Asian, mostly Chinese, machines and tooling. Herman Buitelaar Machienenfabriek, www.buitelaar.nl if you right click on the webpage and select translate you will be able to read the pages in your language. The units, as supplied, are shown in **photos 1** and **2**.

As you can see both chucks are very well presented. The 4-jaw SC chuck was complete with inside and outside jaws and can be bolted to a back plate via the front (four M8 x 65 screws) or through the back

HBM ER32 collet chuck

plate from the back, (three M8 x 25 screws). I would have preferred a chuck with bolt on reversible top jaws. These are listed in the chuck manufacture's literature, but UK home workshop suppliers don't seem to have cottoned on to this style yet. They are quite widely available in the US. The chuck manufacturer also offers 6 jaw SC chucks of the type one used to see on precision tool grinders; also, good for work on thin walled tube.

The overall appearance of all the chuck parts was excellent and the jaws fitted smoothly with no shake. The slots and jaws were all position marked but the jaw sets, inside and out had different serial numbers and the body appeared to have no serial number at all. On a quality unit one might expect the jaw sets and body to have matched numbers? Or is that just old fashioned thinking?

I removed the 4 small retaining screws to remove the cover from the back of the chuck to reveal the crown wheel on the back of the scroll and 2 pinions. There was no machining swarf and very little lubrication, just the thin anti corrosive oil that covered the whole unit. I added a little Rocol MTS 1000 (an EP grease containing molybdenum disulphide for slow moving parts) to provide more lubrication, it did seem smoother afterwards. A minor point, two of the four back cover retaining screws had eccentric heads, a design feature? I doubt it, just sloppy assembly/manufacture.

There has always been an argument over what to lubricate chuck internals with. If you use grease it collects swarf, if you leave it dry it wears faster and is more difficult to adjust, if you use oil it is spun out, everywhere. I used to use a dry lubricant, powdered graphite. Whatever you use, you should dismantle chucks regularly and wash out the swarf. Notice in photo 1 the manufacturer has thoughtfully included a grease or oiling point in the front face! Pratt-Burnerd (600 group) supply a chuck lubricant for manual and power chucks that is a grease containing molybdenum disulphide. They should know what they are doing so we could follow them.

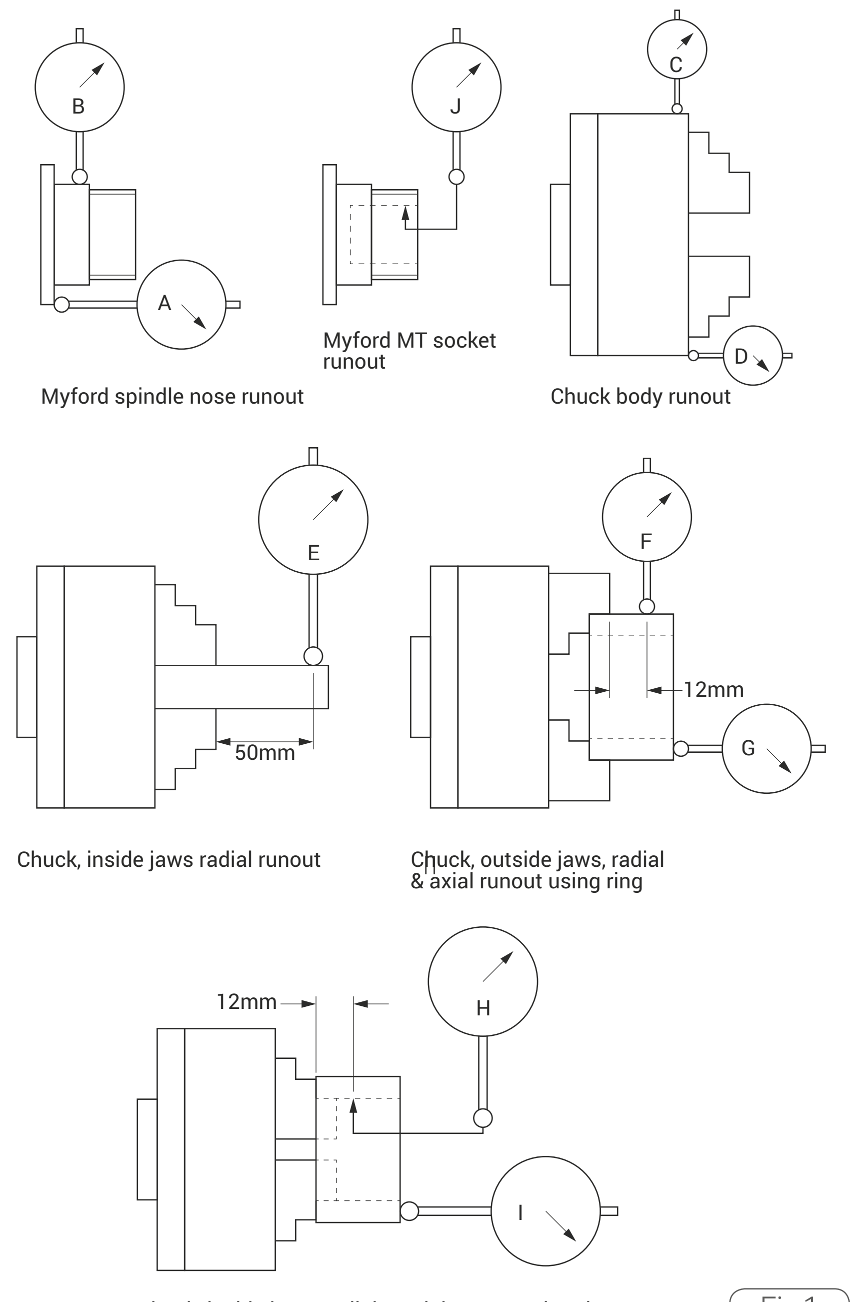


Fig.1

Mounting the chuck

Figure 1 shows my radial and axial measuring positions to help explain the measurements that follow.

I started with the Myford spindle nose and measured the total indicated run out TIR axial A=0.004mm, radial B=0.005mm, see **photo 3** of the measurement setup. Making the QCTP "clock" holder was described in MEW 192, page 39. **Figure 2** is the Myford sized clock holder and can easily be modified to suit individual indicators.

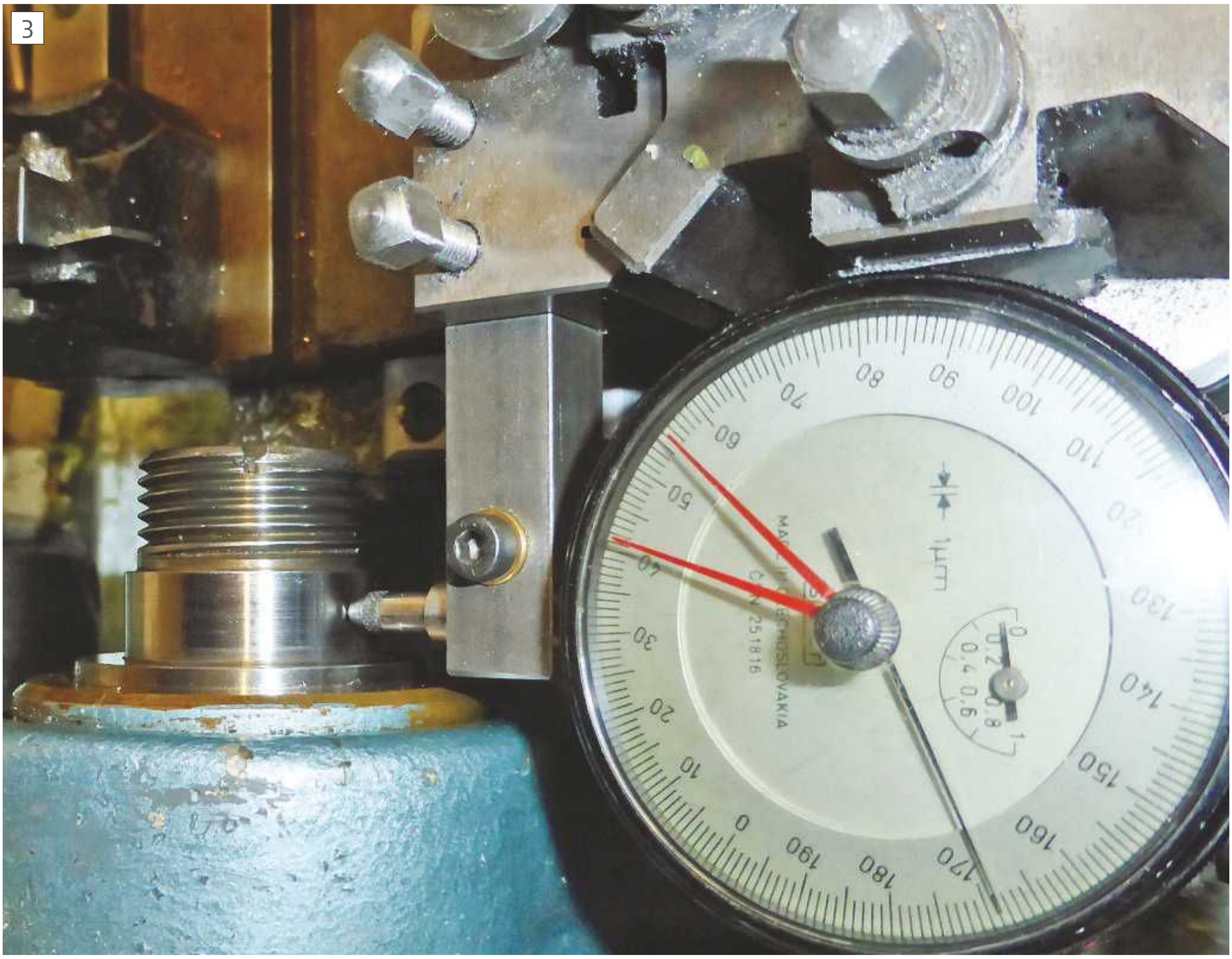
Note the damage to the threaded part of the spindle nose, not me! It doesn't seem to cause problems; the tread isn't the critical part of the chuck registration process.

I decided to do the same measurements on the spindle nose of my Chester Craftsman 12" lathe. **Photograph 4** shows measurement of the radial run out using a probe extension piece.

On this bigger lathe A=0.008mm and B=0.007mm. I suspect these numbers are significant, but, after all, these are Home Workshop machines not precision "Tool Room" equipment. However, if you get any larger numbers it's a good time to find out and rectify before you turn to mounting back plates and chucks. Equally, large movements in the reading brought about by tugging on the belts might indicate hidden problems with the spindle bearings and should be investigated now. In the Bison literature 0.003mm TIR is called for to get the best precision from their chucks.

Microns

A Micron is 0.001mm. I know that many don't or won't relate to microns (I'm afraid we've changed all the runout measurements to mm, as that's the convention for MEW as it was dropped by the SI system in 1967, although it's still widely used in some specialist fields – Ed.) 1 Micron is one millionth of a metre, 0.001mm or 0.4 of a "tenth". Since I last wrote about using a micron resolution dial Gauge ArcEuro have started stocking them. I always regard these high-resolution gauges as delicate and don't use mine on any surface that is powered. That is, I just rotate the chuck by slowly pulling on the belts when measuring run out. Should you have a geared head lathe a spindle handle might be called for? Jogging isn't a good idea. These dial gauges won't measure the run out of a Morse taper socket: for that I use a "Verdict T500" finger gauge with 0.00005" (1.3micron) resolution. The Myford 2MT measured J=0.0001" (2.5micron) and the



Radial runout on Myford S7

Chester 5MT measured barely 0.00005" (1.3micron). I cross checked both measuring clocks with brass shim and against another Mercer 0.0001" dial gauge. The "Verdict" finger clock required a different mounting method as it has a dovetail at the back, **photo 5**.

I prefer a QC tool post mounting over a magnetic base as I think it's considerably more rigid. Figure 2 shows the indicator mounting. You will have to adjust the dimensions to suit the indicator you are using. The spit clamp bore overlaps the indicator bore by about 1mm. I made a separate bar to hold the Verdict finger (lever) DTI as it has a 3/8" mounting for the dovetail.

It's also a good idea to lock your cross slide before taking measurements. On my old Super7 this isn't possible, no lock on early models, so following a suggestion from Chris Hallaway, who had already built one, I made a version of a friction lock first shown in MEW 109 Oct 2005 by John McIntosh. Figure 3 gives the details, there were no drawings with the original article.

Mounting the new 4-jaw SC chuck on its back plate.

The cast iron, part machined, 125mm back plate supplied by RDG was thoroughly

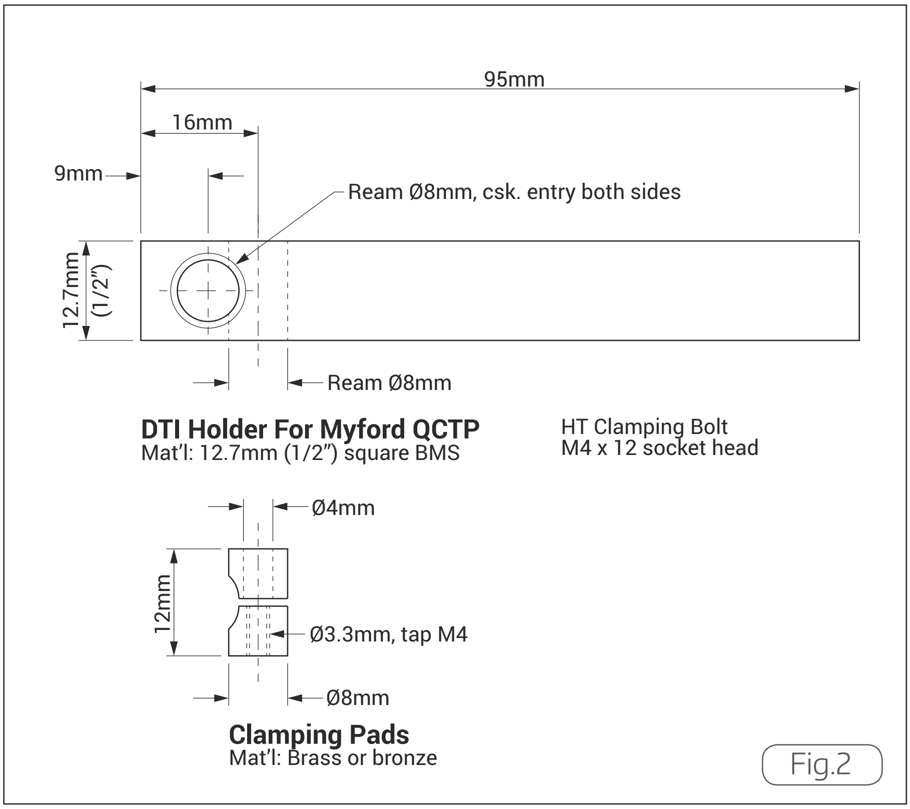
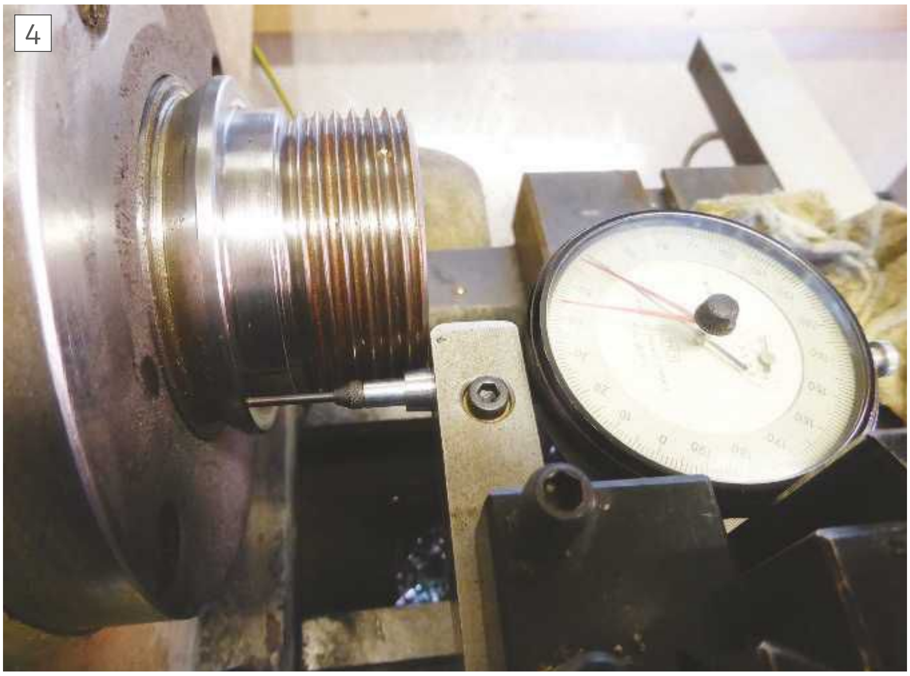


Fig.2

degreased with white spirit and fitted to the Myford spindle, also very carefully cleaned.

The pre-machined RDG 125mm cast iron back plate screwed on smoothly without much shake on the thread. The back plate ran without visible eccentricity (Usually about 0.002" run out) and a dial indicator gave a TIR (total indicated run out) of C=0.040mm on the outer diameter, radial, and D=0.010mm, axial, on the face. As in C and D in figure 1, but with the chuck removed. Pretty good I thought. Removing the back plate from the spindle and refitting it gave the same results i.e. good repeatability. Examining the back of the back-plate boss, the critical region for an accurate fit showed it was mating hard up against the spindle shoulder. Truing the two faces with a lathe tool gave C=0.020mm and D=0.005mm respectively and quite a lot of surface roughness left by the cutting tool was shown by the indicator. The shallow spigot was turned down to be a close fit in the chuck body, more on this later. Caution! Not all 125 mm dia. chucks use the same spigot diameter, check before



4

Radial runout on Chester lathe with probe extension

5

Indicator mounting for Myford MT2 runout

you buy to avoid a mismatch.

By way of comparison, a well used Myford standard 7" face plate that came with the lathe gave a radial TIR of C=0.090mm and an axial TIR of D=0.035mm. I didn't skim it as there isn't much metal there and the lathe doesn't have power facing! A new Myford copy 7" faceplate from RDG (Show special, 2014, £12.50) measured C= 0.020mm and D=0.030mm. It had much more metal in it than the Myford original and skimmed down gave C=0.015mm and D=0.010mm. Surface roughness of these cast iron machined surfaces was improved when I used an 8mm square shank indexable carbide lathe tool, Glanze DCMT and followed it up with a burnish with very fine 1200 carborundum paper. The faceplate boss that fits into the back of the chuck body was then machined for as close a fit as I could manage. Purists say this should be a very close fit, microns ideally, and that's quite difficult/impossible to achieve, later I eased the fit by a tiny amount to allow for tap adjusting of the chuck. The chuck body must be flush against the back plate at its outer edge, it's the diameter of the backplate spigot that has to be turned very slightly undersize for the recess in the back of the chuck.

I decided to mount the new chuck with screws through the chuck body as the chuck can be used as an indexing plate by spotting through the chuck holes with a drill that just fits the chuck body holes, 9.5mm. See **photo 6**. I did this on the drilling machine.

The drill bit on the table is to stop the backplate toppling off its boss. It would have been better to bolt the chuck to the table through its centre. The drill point is fed down just sufficiently to make a small dimple in the backplate. I then removed the chuck body, fixed the backplate by a

Spotting through chuck onto backplate

stud through its centre and drilled the 4 dimples right through with an M8 tapping size drill. (6.8mm). Because the chuck body is so deep it's very important to get the tap absolutely perpendicular or the bolts may foul the sides of the holes in the chuck body and the adjustment process to be described later is unlikely to work. Many M8 taps are too short to allow tapping through the chuck body, but I was fortunate in having a spiral tap 80mm long below the drive square, **photo 7**. An alternative method would be to use a tap guide or start the tap off in the drilling machine, manually.

Once the chuck was mounted on its backplate and the two parts marked with a punch to help repositioning after cleaning and to indicate the "nominated" key position. Nominated is the chuck key position used for final tightening up if you are after the highest accuracy. Incidentally, this chuck only has two chuck key holes, most have 3. Run out on the chuck body was measured at C= 0.090mm and D=0.020mm. At this point I noted where the body was closest to me and marked the chuck body plus with felt tip pen. The variation in the reading C was a smooth increase followed by a smooth decrease with one high point and one low point. Several high and low points indicate a badly machined or damaged chuck body. I once found a hair line crack in a chuck body this way! You should be prepared for the run out to reduce over the first few turns; this is simply the indicator ball point clearing debris out of its track.

D was measured close to the outer edge with the chuck jaws removed and inevitably was interrupted by the mounting holes and jaw slots. Tapping the chuck body with a lead hammer or a bronze bar and hammer at the high point changed the DTI reading even with the bolts quite well tightened up. I remove the DTI before tapping. How hard to tap is something you will have to learn. I was able to reduce the radial runout, C to 0.020mm; the axial runout, D didn't change at all. Indicating the chuck is hard back against the backplate.

A 20mm Titex HSS cnc spotting drill and a new 3/8" round HSS tool blank were used for initial testing and the run out E measured. E=0.095mm but would tap down to 0.020mm with the 20mm test piece and the 3/8" started at 0.080mm and tapped down to 0.025mm. I found that the chuck had to be adjusted for the lowest run out for each test piece. Adjustable chucks like the Pratt-Burnerd Griptru also have to be optimised for each test diameter, but are then reproducible to about 0.013mm (0.0005"), they claim, with work pieces of the same diameter.

To be continued...

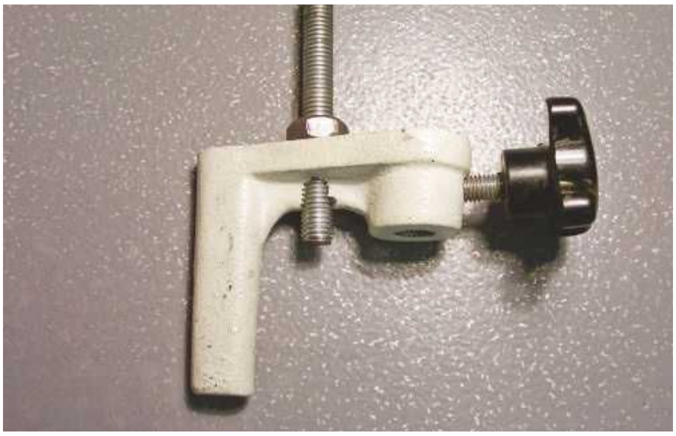
Tapping M8 holes square

Readers' Tips

CHESTER MACHINE TOOLS

Double Top

TIP OF THE MONTH WINNER!



Our winning tip from Brian Wood is actually two short ones, he wins this month's Chester Vouchers!
I was cutting repeated short lengths of finished parts from a bar yesterday and cursing the intractable design of the length stop that came with my bandsaw. A light bulb moment and 10 minutes' work later with an off-cut of M10 all thread and the problem was solved. The picture is self–explanatory.

The second tip helped me greatly in removing the arbour from my Senior mill; it saves all that agro on belting away with a drift through the drawbar hole, in my case there is very limited space to swing a hammer.

File Under Tools

Our runner up tip is again two little ones, these from Brett Manners in Western Australia, he gets a lucky dip from the editorial bran-tub!

Like most people space is tight in my workshop and I have found that using old metal filing cabinets for storage quite good. They can be found cheap second hand, are strong, store lots of things and even come with a lock/key.

The second tip is to use a rice bag to store the chain from a chain block. I have a chain block hanging from a beam in the workshop roof and when I am not using it I use a small bag to hold the chain up out of the way.

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.

An Arduino in my toolbox

***Silly Old Duffer* describes how a Jan Ridders Coffee-Cup Stirling engine was instrumented with an Arduino Uno Micro-controller programmed to be a Data Logging Triple Thermometer and Pressure Gauge.**

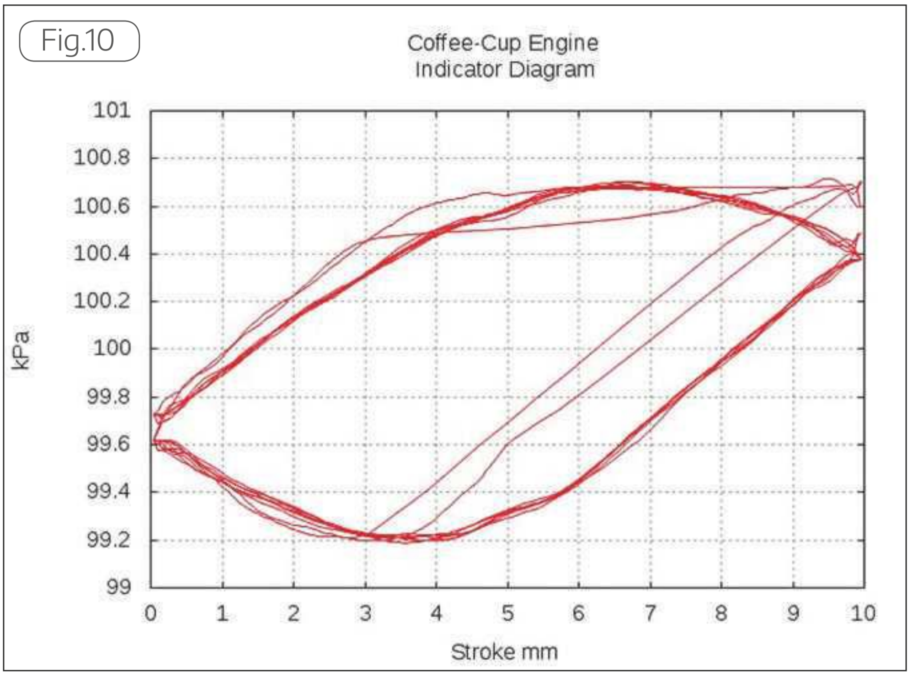


Fig.10

Example loops

Figure 10 was taken when the engine was mostly debugged: it shows the engine behaving well apart from two suspicious aberrations. These are probably caused by a leak.

Figure 11 was taken after a disappointing rebuild that made the engine noticeably worse. The indicator diagram confirms that there's a problem!

By design the Displacer Piston should be 90 degrees out-of-phase with the Power Piston. This build was carelessly reassembled with the two pistons closer in phase than that, at rather less than 80 degrees. As there were also problems with the power piston at the time, I cannot guarantee that the flattened loop is due to the relative motions of the power and displacer pistons being mistimed. But it seems like a good explanation to me. Later on I will experiment with different phase settings to confirm that 90 degrees really maximises power output.

In a project like this it's necessary to be aware of the possibility that the computer program or interface electronics are producing spurious results. This PV-Loop example in **fig. 12** isn't an engine fault, rather it was caused by an inefficient program keeping the Arduino too busy during a backstroke to collect new pressure readings whilst sending data to the PC, taking temperatures, and being a thermostat.

The Set-Up

The Coffee-cup engine normally runs on a mug of hot water and this is how the measurements were taken, **photo 8**.

Wire the sensors to the prototype board and link the prototype board to the Arduino as shown in the circuit earlier.

Connect the Arduino to a powered up PC using a USB cable. Put a powered USB hub between the Arduino and the PC if the display is dim or data corrupted.

The Arduino will display zero readings for the first few seconds after switch-on. After that the display should show reasonable values for pressure, rpm and temperatures. To save space pressure is displayed "raw" as a number about 820.

On the PC start the putty terminal program and set the logging on to capture "All Session Output". The log file name should be "putty&Y&M&D&T.log". Set putty to "Serial" with the speed set to 115200 baud. The settings may be saved for future use. After clicking the "Open" Button a terminal screen with scrolling numbers should appear. These numbers represent data captured from the sensors and will be captured in a date-stamped log file.

Although putty works in much the same way on Windows, MAC and Linux, it will store the log file in a differently named folder on each system. Finding out where the logfile went is part of the fun!

Allow putty to capture data until the engine stalls. Then stop putty. A copy of all the data will be kept in the logfile.

Next run the Python3 script "enganal. py". Python is a command-line language normally run from a shell such as bash or cmd.exe. In that mode the script allows some additional options, not normally needed. You may find it easier to run the script from the Python IDE, idle3. "enganal.

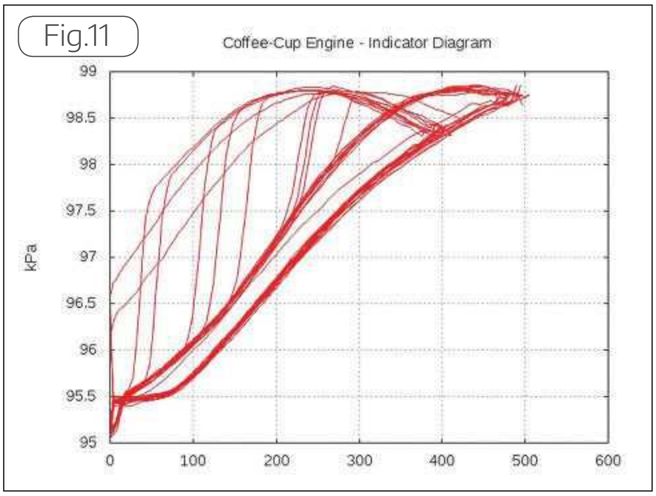
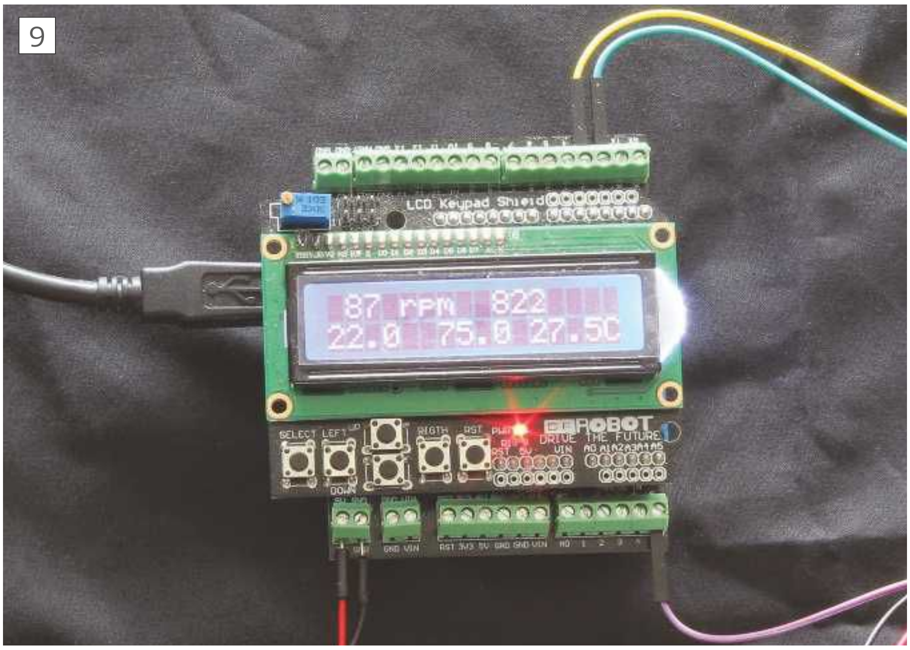


Fig.11

8

The engine during a test

9



The Arduino in Action

py" automatically finds the most recent putty logfile and uses it to calculate engine performance and to make the files needed for graphing.

Once the necessary files have been generated by "enganal.py" graphs may be drawn with gnuplot scripts. They are:

- cycles.gnu graphs a sample of engine pressure cycles
- engplot.gnu graphs rpm, atm, cylinder pressure, temperatures, hot-cold plate over a run
- ipvst.gnu graphs Plate Temperature Difference vs Indicated Power
- engind.gnu graphs an individual PV-Loop
- ipwr.gnu graphs Indicated Power for each Cycle over a run

After "enganal.py" has created the necessary output files, a second script called "indicators.py" can be run. "indicators.py" uses the available data files to automatically create a jpg image for each cycle. jpg images are digital photographs. Normally they are examined one at a time with a viewer but other treatments are possible. It was an easy job for a video editor to turn the list of images into a video clip. I used Open Shot. The animated effect is like watching a "What the Butler saw machine", or Mutoscope if you're posh.

Results

Initial testing of a mostly debugged engine showed it to be quite "sticky". For rather a long time the engined maxed out at 60 rpm, then as it loosened up top speed gradually rose to 120 rpm, **photo 9**.

The first graph drawn, **fig 13**, is of cylinder pressures changing inside the engine. There is intelligence to be obtained from the graph: firstly, the waveform isn't a true sinusoid; secondly the waveform isn't centred above and below atmospheric pressure meaning the engine does more work on cooling than on heating; thirdly every fifth cycle is truncated, which indicates some kind of repetitive fault.

Run-time varies considerably, probably due to known issues with the engine. The best naturally cooled run lasted 52 minutes at 18C room temperature. With a fan-cooled Cold Plate, and room temperature at 21C, the run lasted 56 minutes.

Assuming I got the Maths right, the average Indicated Power of my Coffee-cup Stirling is about 2 milliwatts, **fig 14**.

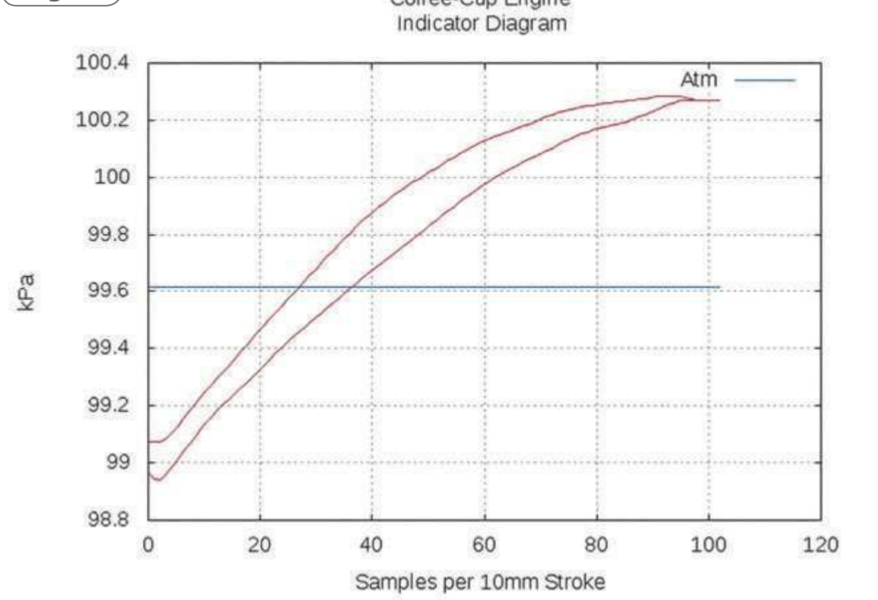
An average of 2mW Indicated is typical over many runs: the highest recorded average was 2.1mW, the lowest 1.7mW. Graphing the indicated power developed in each cycle of a run is more encouraging. **Figure 15** shows power rising to 4.4mW as the engine accelerates early in a run before finally slowing to a stall at 0.8mW.

My debugged and run-in engine spins for 35 – 42 minutes on 0.4 litres of hot water in an insulated mug. The starting temperature of water straight from the kettle is 98C and the naturally cooled engine stalls when the water is at 66C. (Measurement taken at 20C room temperature.)

I also ran the engine in reverse by replacing the coffee mug with a large bowl of crushed ice. I didn't really expect the engine to run backwards this arrangement, but it did! The engine ran for two minutes with the lower plate at 4.5 C and room temperature at 22C. It wasn't a glorious success because the engine stalled as soon as the top plate cooled to 21 C. My engine isn't able to absorb enough heat from the air to run reliably.

Thermodynamic theory says that a heat engine will convert heat into mechanical work and that the conversion will be accompanied by a temperature drop. I

Fig.12



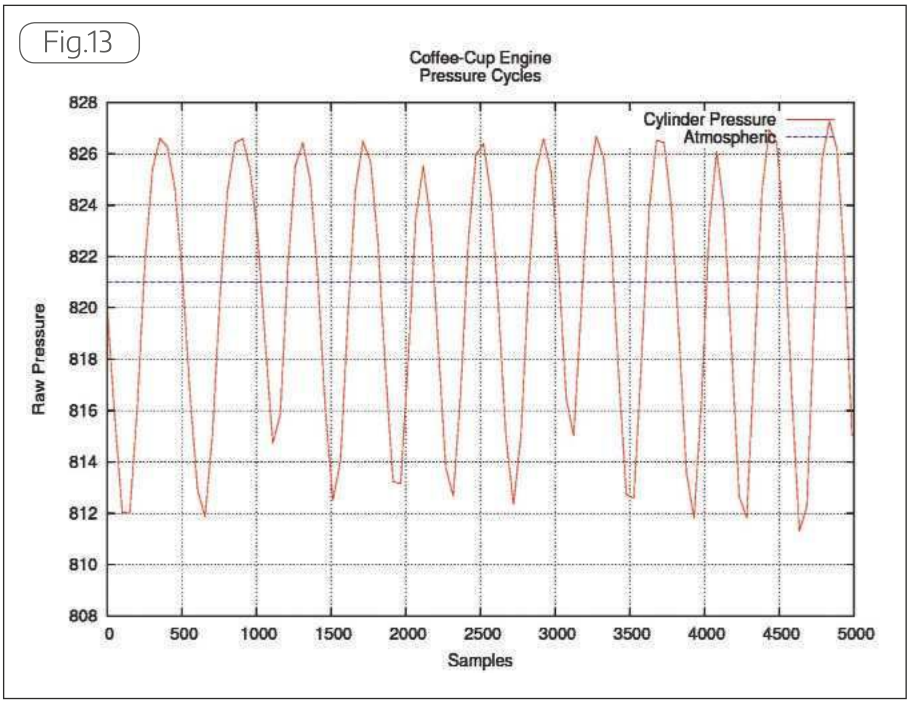


Fig.13

tested this by comparing the temperature drop that occurred with the engine stopped (i.e. deliberately not started) with the equivalent temperature drop with the engine running normally. As can be seen from **fig 16** the hot water cools faster when the engine is running. It seems that thermodynamic theory is correct!

I had hoped to demonstrate that the Stirling cycle is reversible by rotating my unheated engine with a small electric motor and observing a temperature drop on the lower plate. Sadly my measurements show no such effect. I put this down to the cooling effect being very small due to the miniscule power of the engine, low precision thermometry and poor insulation. Good insulation is essential to stop the wanted heat loss being replaced immediately with heat from the environment. My engine is a long way from Carnot's ideal!

Theory also predicts that a larger temperature difference between the Hot and Cold Plates will increase engine power. **Figure 17** shows this relationship in the real engine.

The graph shows that, at room temperature, my engine needs the Hot and Cold plate temperatures to differ by at least 13 degrees C before it will run. The slope of the graph (about 3.7 x temperature difference + 7) allows the Indicated Power of this engine to be calculated for any difference between plate temperatures.

Improvements to The Engine

My first build of the Coffee-cup Stirling engine came with a lot of mistakes. They are the most likely explanation between the difference in performance claimed for this engine as described in Model Engineer 4329 (300rpm) and my engine (120rpm). My Displacer Gland Bearing is off-centre which makes it hard to assemble the engine without the Displacer Piston rubbing against the Displacer Cylinder. At the same time bearing friction will be increased due to the displacer assembly being unbalanced. This may also explain why the Displacer Piston rotates back and fro a few degrees at the end of each downstroke. A ticking noise noise occurs at high speed and is likely caused by the Lower Displacer Flange just touching the Hot Plate. The crank assembly is not quite true and the resulting imbalance is likely to put the Connecting Rods at a slight mechanical disadvantage. The Flywheel isn't quite true either. All these bugs need to be fixed!

Although I took a lot of care with the Power Piston and Cylinder fit, the Displacer Piston Rod and Glide Bearing are just as they came off the lathe, unpolished and slapdash.

Heat flows undesirably from the Hot Plate to the Cold Plate through the six steel Plate Fixing Spacers that hold the engine together. Jan's design calls for the pillars to be drilled through and tapped, an arrangement that is noticeably less conductive than simply passing stainless steel bolts end to end across the engine.

Grooving the pillars helped reduce unwanted heat flow and I guess making them from M4 stainless studding or plastic would be superior. Jan Ridders suggests gluing the engine together so that the pillars are omitted entirely.

The engine should perform even better with both Cold and Hot plates roughened and blackened. Simply painting them isn't ideal: zinc black or anodizing would be advantageous.

A solid silver Cold Plate would be worth trying. Perhaps after I've been paid a gigantic sum for this article!

Fig.14

```
Enter raw atmospheric pressure: 820
Using /home/dave/putty20160526152115.log
Analysis of /home/dave/putty20160526152115.log

Samples = 46422
Bad data lines rejected = 1
Bad rpm rejected = 0
Good data lines accepted = 46420
Indicator Diagram Files Output = 151

Area of piston face 132.71 sq mm
Stroke 10 mm

                    Pressures
        Max     Avg     Min     Atm
kPa 100.270   0.605  98.206  99.618

        Max      Avg
RPM     117     71.79
RPS   1.950 :   1.196

Run-time: 2.10 minutes ( 126.05 seconds )

Heater on for: 122.85 Watt Seconds

Average Plate Temperatures
Lower 88.43C  Upper  24.68C  Difference 63.74C

Calculated Power
      SI: Mean Pressure 0.61 kPa @ 71.8 avg rpm -> 0.00192 W
      Engine Watt Seconds 0.24 / 122.85 = 0.20%
```

Improvements to The Electronics

The Arduino measures the voltage

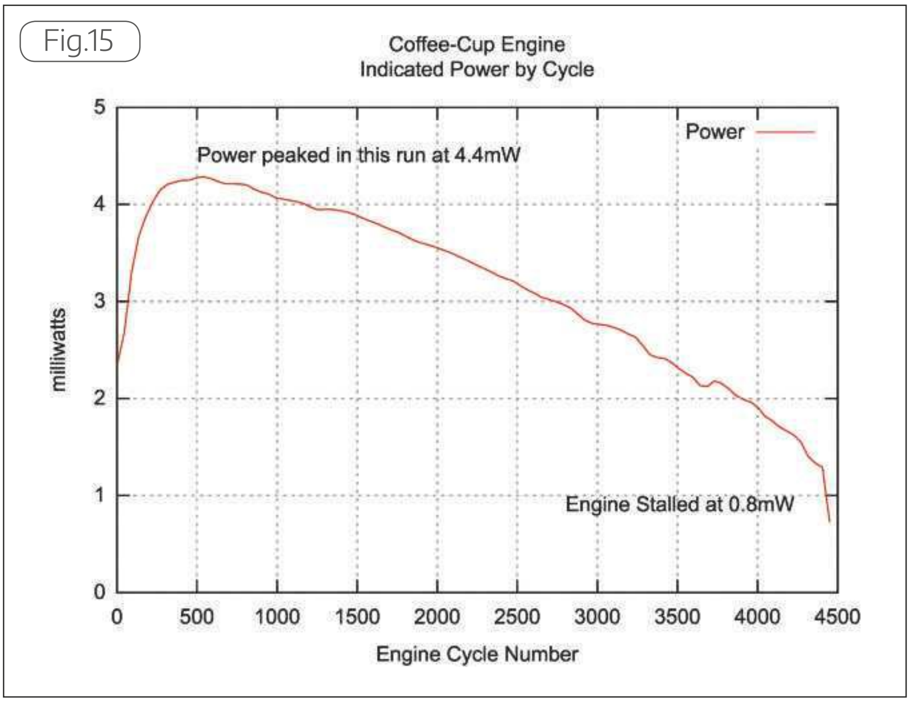


Fig.15

output of the pressure sensor on an analogue pin with a 10-bit resolution - 1 part in 1023. This limits the smallest detectable voltage change to about 4.9mV. Consequently, the smallest pressure change that can be detected by my set up is about 0.1kPa, which isn't impressive. It is possible to improve the sensitivity of the pressure readings with an Operational Amplifier configured to remove the voltage offset whilst amplifying the wanted range by a fixed amount. Texas Instruments Application Report SLOA097 explains how this might be done.

I experimented with the circuit in fig. 18 to improve the sensitivity of the pressure measurements without much success. I hit a rock called calibration. Unfortunately, the resistor values required are non-standard and have to be tuned for accuracy. I ran out of enthusiasm!

Another way to improve resolution would be to use an external 12 bit Analogue to Digital Converter (ADC).

One obvious improvement is to move the temperature sensors inside the cylinder. Doing would make it possible to get more meaningful results on how quickly the engine heats up, to find the lowest running temperature, and to find if there's an optimum plate difference.

Unfortunately, the "engine on mug" arrangement is far from ideal when taking measurements because the whole apparatus cools off an uncontrolled rate. Nothing is constant and the data is harder to analyse. More accurate measurements could be taken with the engine warmed by a steady heat source. We should also thermostatically control the temperature of the Cold plate as it's temperature also varies with environmental conditions. To prove that it can be done the Sketch includes the code necessary to allow the Arduino to control an electric heater via a relay and also a 5 volt electric cooling fan. In tests, after settling, the Arduino thermostat maintained the Cold and Hot plates within a degree of the target temperatures. On an electric heater my engine seems to run best with the Hot Plate at 90 degrees Celsius and the Cold Plate at 25 degrees Celsius, that is just above room temperature. The result is suspect because I haven't had time to try many temperature combinations. In the interest of keeping the article short the additional complexity is not described here.

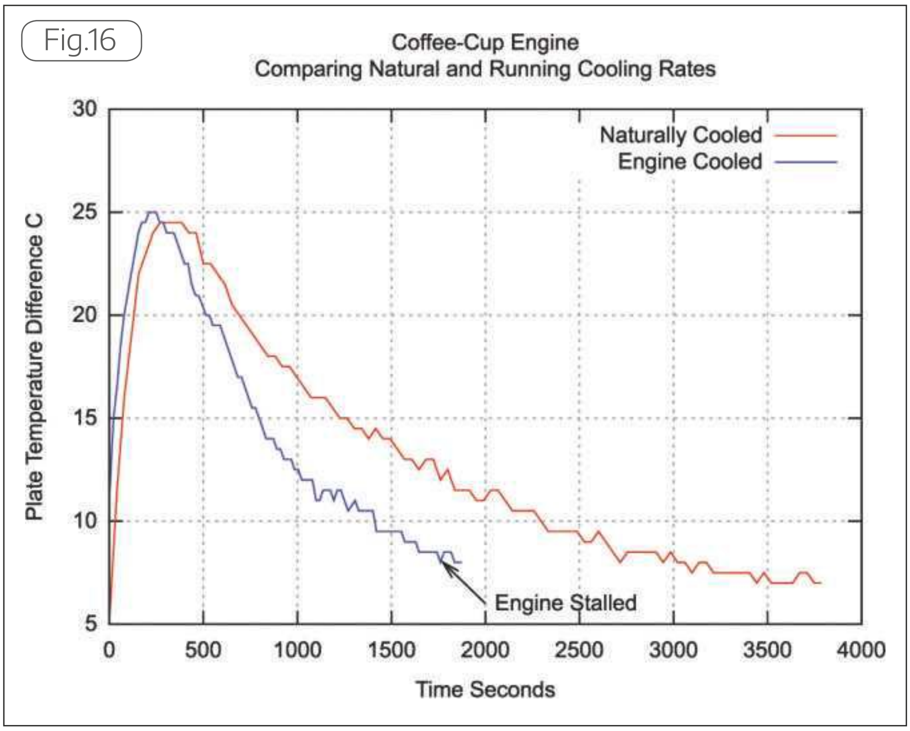


Fig.16

Improvements to The Arduino

It's fairly obvious that the Arduino sketch I used to instrument my Coffee-cup engine would need only minor changes to become:

- A weather station measuring wind speed, indoor and outdoor temperatures and barometric pressures.
- A stand-alone Indicated Power meter. The Arduino could easily calculate the mean cylinder pressure, and, knowing the cylinder dimensions, it could display indicated power directly on the LCD.
- A camera trigger, set off at tdc, or any value of RPM, cylinder pressure or temperature.
- An altimeter.
- A thermostat.
- A more general engine monitoring tool by using the DF-Robot LCD's control buttons to let the user alter settings without having to recompile the sketch each time a parameter is changed.
- An Engine Management Unit

For cheapness I used a 2 row by 16 column LCD which limits the amount of information that can be displayed. Bigger LCDs are available. A 4 by 20 LCD would allow more information to be shown. To save space I only displayed raw pressure values, when it would be friendlier to convert pressure readings to a meaningful unit such as kPA or PSI. A larger display area would tempt me to display mean pressure and indicated power as well, thus giving a direct impression of engine performance without the bother of connecting a PC.

My sketch does not use all of the Arduino's digital and analogue pins. It would be straightforward to add a second sensor to continually record atmospheric pressure throughout test runs.

The OneWire Bus makes it easy to add more temperature sensors, for example an obvious improvement is to take temperatures inside the displacer cylinder.

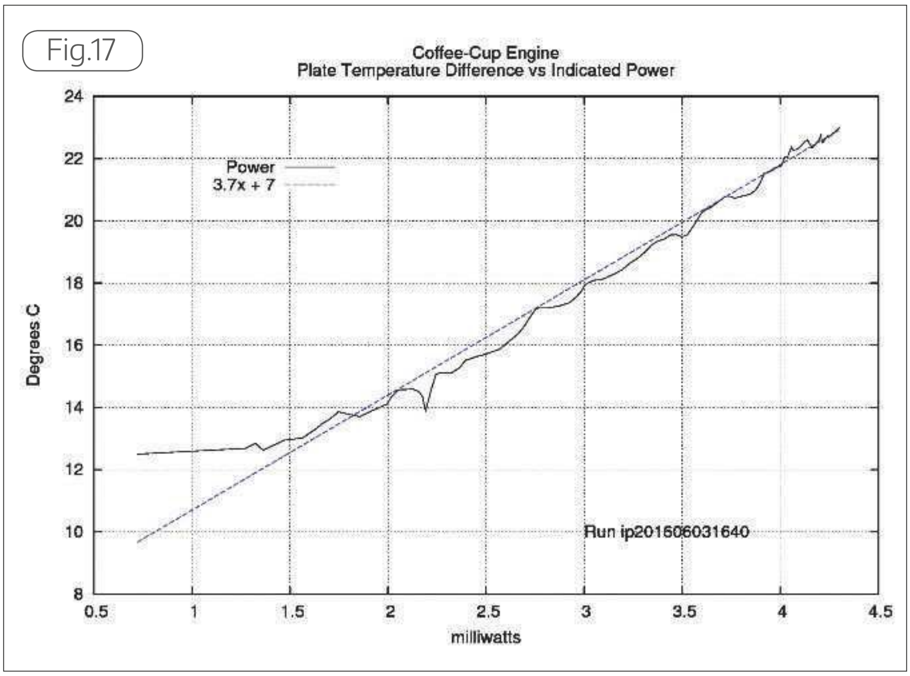
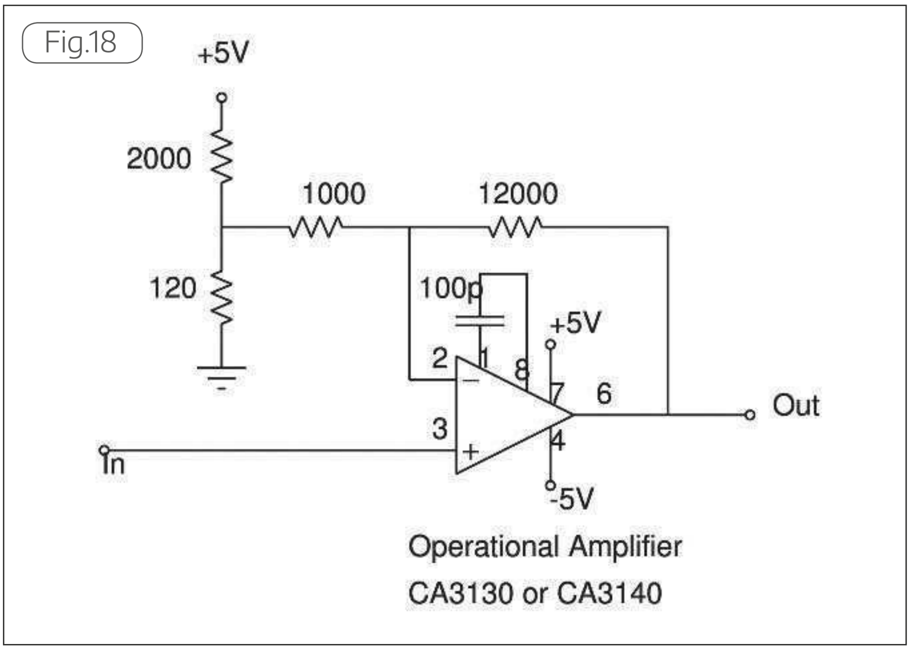


Fig.17

Author paranoia

Not false modesty but my limited mathematical and workshop skills were both stretched by this project. I have good reason



to fear that my audience will spot a serious mistake or three. Please be gentle with me!

Conclusions

Availability of equipment able to see inside the operation of the Koffiekop Stirling makes it possible to ascertain the effect of design changes with some precision. It's possible to detect small changes in RPM, power and run-time from a given heat input. This opens up the possibility of optimising the engine in various ways. For example, although the gap between the Displacer Piston and Displacer Cylinder is not critical, there must be an optimum value. What is it? Likewise, there must be an optimum ratio between the volumes of the power cylinder and the displacer cylinder. Again, what is it? How about the thicknesses of the Hot and Cold Plates? Or the dimensions and weight of the flywheel? Or the phase angle between the Power and Displacer Pistons? Although it's unlikely that the performance of the engine would be radically improved, accumulating several small optimisations might well be worthwhile.

It is possible that similar analytic tooling might benefit Model Engineers developing small engines today. Back copies of Model Engineer show that the design, materials and building of model steam engines has not changed much for several decades. It may be that "best practice" has long since been achieved, or then again perhaps it hasn't! Today we have access to tools, techniques and information beyond the imaginings of our forebears: possibly it's worth another look at the state of the art.

Theory discourages professional scientists and engineers from looking closely at the size of heat engine typically built by model engineers because it is obvious from thermodynamics that big heat engines can be made far more efficient than small ones. There have been many unresolved arguments over the years between those adamant that super-heating a model locomotive is beneficial and those equally convinced that super-heat is a complete waste of time. I suggest that the reason the argument remains unsettled is because 'our' size engines operate in a zone of uncertainty that's poorly understood partly because full-size practice deliberately avoids it.

Perhaps using modern techniques it might be possible to come up with a good looking model steam engine that's not only powerful and reliable, but cheaper and easier to build than existing designs.

Experience gained building the engine has been most valuable to me. I have started to make another one and find that my workmanship has improved with fewer blunders. I hope the next version will perform better. With a better engine ticking over on my dining table I will try to make a dynamometer sensitive enough to measure the output power of the Koffiekop engine. Knowing the indicated and actual power outputs will allow me to calculate the engine's efficiency. Making a suitably sensitive dynamometer looks to be a serious challenge that may well turn out to be beyond me, but watch this space...

Acknowledgements

Many thanks to Jan Ridders for making available plans for an engine that's so suitable for this experiment. I did not find any mistakes in the plans, all the build errors are mine.

Thanks also for the help and advice freely given to me by contributors to the Model Engineering Website. Our exchanges are in the "Jan Ridders Coffee-Cup Stirling" thread.

No thanks at all to my daughter's cat who "helped" by tap dancing on my computer keyboard. ■

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Dallas DS18B20 Data Sheet

Maxim A3144 Data Sheet

Freescale MPX4115AP Data Sheet

HARDWARE AND SOFTWARE

Arduino Uno

Solder-less Breadboard

Screw Terminal Strip Shield for Arduino (Optional)

Three DS18B20 Temperature Sensors

One A3144 Hall Effect Switch

One MPX4115APX Pressure Sensor

Personal Computer (Linux, MAC or Windows)

Powered USB Hub

DF Robot Keypad Shield

One USB Cable Type A/B (Computer to Printer)

Small niobium magnet.

30mm Silicone Tube 3mm diameter bore

Some glue or modelling clay.

Two wooden clothes pegs.

Python3 scripting language

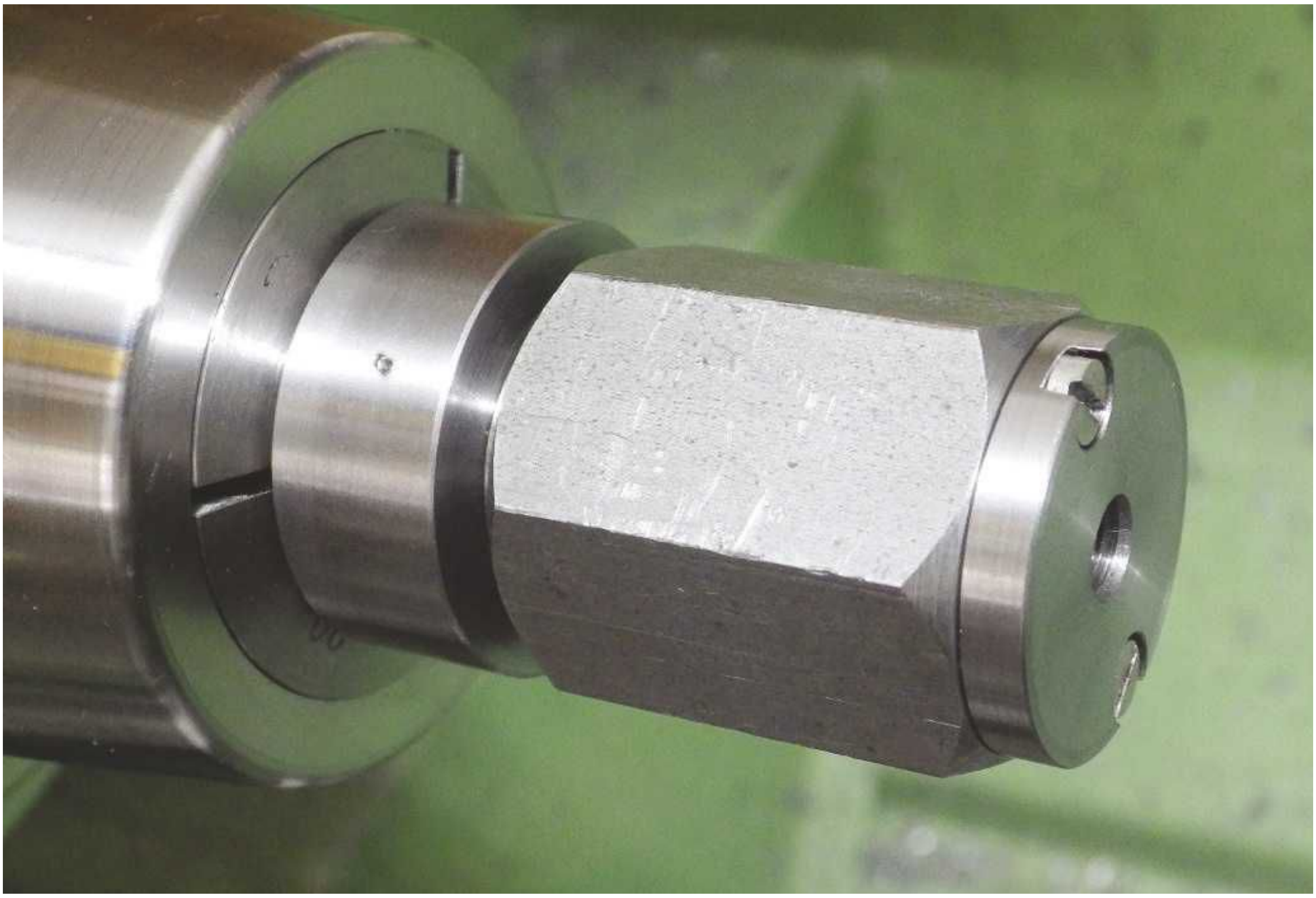
IDLE3, the Python3 IDE

Arduino IDE

gnuplot, graphing package
putty, terminal emulator

Universal screw modification fixture

John Ashton describes a useful device to simplify the holding of screws for machining.



The Finished Fixture

I'm sure you are aware of how difficult it is to hold any machine screw to modify it, especially very small ones, and in particular countersunk one's. I believe the universal screw modification fixture, I have developed, addresses most of the known problems. For this article, I have used an M6 size thread to explain the principles of the fixture and its manufacture, but any size thread can be accommodated, up to the limits of the fixture.

Design concept

The fixture can be entirely manufactured using a lathe, with a little help from a pedestal drill or milling machine, and can be held in either a three-jaw chuck or collet.

It is capable of accepting all types of machine screws, including shanked screws (bolts) and it does not rely on driver or head type for securing in the fixture, which means you can also modify studs and all-thread, even nuts. It can be scaled up or down to accept a specific range of thread sizes, depending on your requirements.

Photograph 1 shows a 3d model, exploded view, of the fixture components; **photo 2** shows a cutaway section view of the same model, showing the assembled fixture ready for use, while photos 3 and 4 show cutaway views of set-up examples for modifying a screw head and shanked screw (bolt).

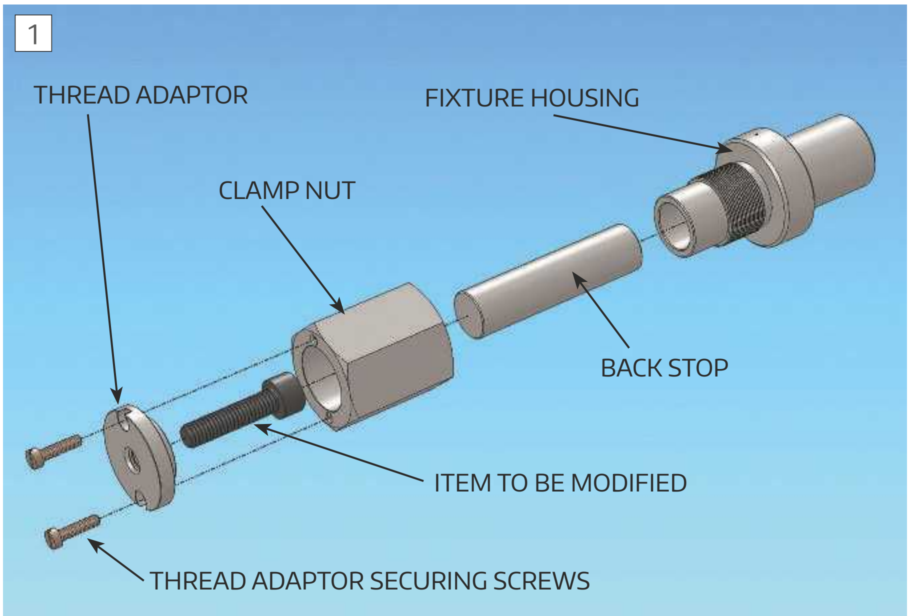
The fixture has four main components;

1. fixture housing
2. clamp nut.
3. interchangeable thread adaptor – specific to thread size and type.
4. interchangeable back stop.

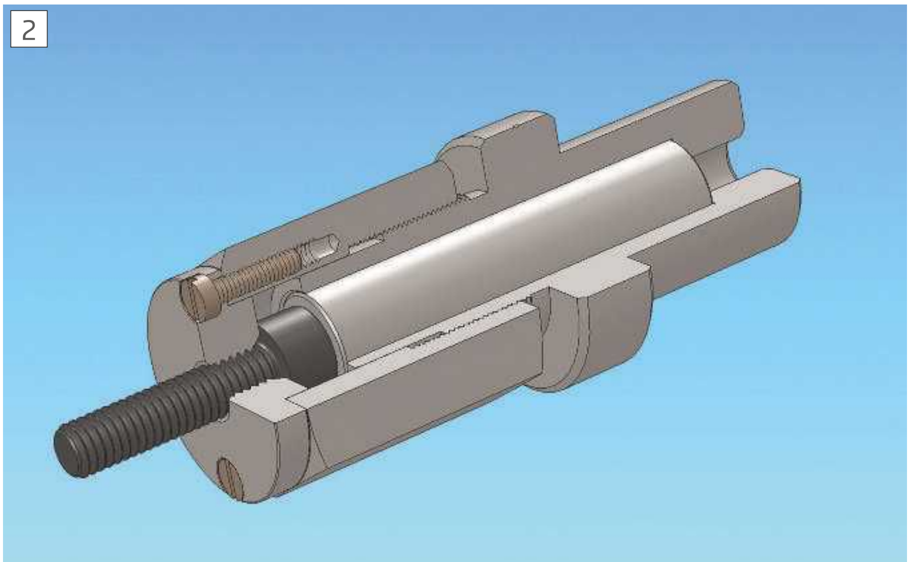
Other ancillary components include spacer sleeves, various back stops, etc., for special setups, as shown in **photos 3 & 4**.

How does it work?

It works because the process of machining the screw being modified causes the screw to try to unscrew itself from the thread adaptor and clamp nut, but because the screw head is sandwiched between the thread adaptor and back stop all it does is to tighten itself against the back stop. This simultaneously creates a reactionary torque load on the thread adaptor and clamp nut that forces the clamp nut to tighten itself onto the fixture housing. You could



Exploded View of Universal Screw Thread Adaptor Assembly



Section View of Universal Screw Thread Adaptor Assembly

device in a bench vice when hacksawing off excess thread from a screw before transferring to the lathe to finish the modification. The fixture can also be held in a machine vice, 'v' block, dividing head, spin indexing fixture, etc. For drilling cross-holes for split pins, R-clips, locating pins, etc.

The concentricity accuracy and closeness of fits of the fixture component parts are very important, especially when dealing with very small threads and diameters. The smaller you go the greater the error due to clearances of mating component parts. Therefore, the fit between the component parts of the fixture need to be as close as you can get them while ensuring that you can repeatedly assemble the component parts without them seizing up. Another important factor is that the back face of the screw to be modified needs to be perpendicular to the axis of the screw, otherwise when you tighten the clamp nut, of the fixture; the screw will be forced to skew over within the clearance between the screw and the thread adaptor.

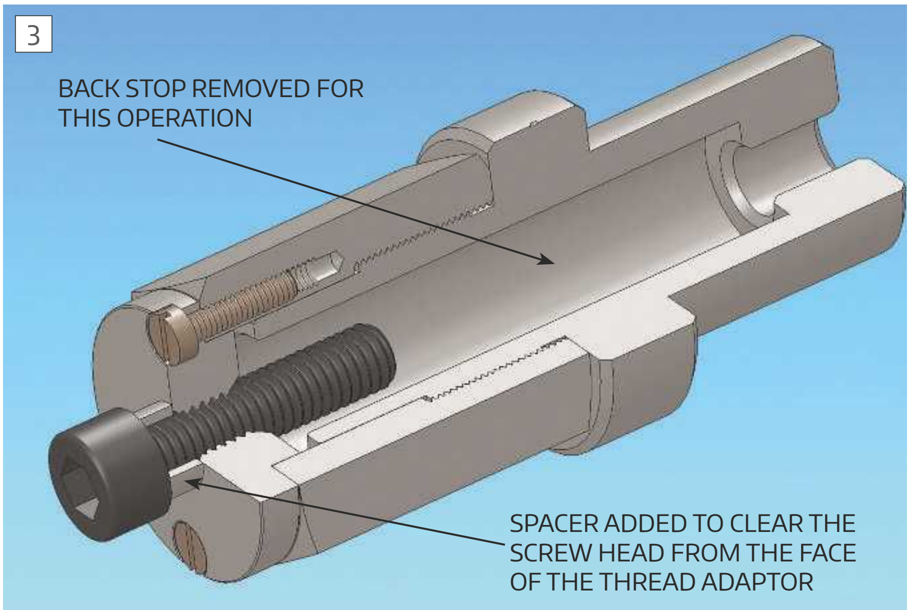
One problem I did encounter, when developing the fixture, was the inaccuracy of some low-cost machine screws, which are normally manufactured using the "heading or upset forging" process. This is a mass production process which enables the manufacturer to use a smaller diameter stock bar than the head diameter of the screw being manufactured (usually around the effective diameter of the thread size), depending on the type of forging machinery, the bar stock is either billeted off, to length, before the forging process or cut-off to length after. The process name comes from the fact that the protruding end of the bar stock is literally forced into the head shape of the screw or bolt being produced, complete with its driver type, between a set of forging dies. This can be a hot or cold process depending on size and material type. The thread is then roll formed onto the remaining shank, completing the

say it's a double whammy preventing the screw from turning in the fixture. It doesn't matter what the thread type, size or driver type the screw being modified cannot turn independently of the fixture.

You can create any form you like on the end of a screw, within the limits of the screw dimensions, for example; machine it to a specific length, chamfer the end, machine a spigot, a circlip groove, a bore in the end of the screw and anything else you can think of.

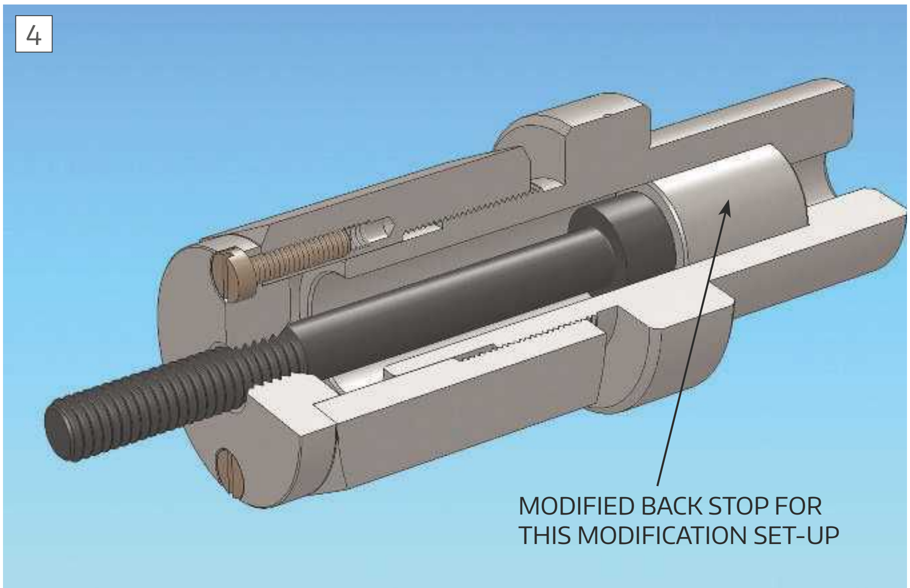
Photograph 5 gives some examples, from left to right, a hexagon socket cap head screw with a reduced head diameter and cone end, a hexagon socket cap head screw with a spigot end, a hexagon socket countersunk head screw with a spigot end, a hexagon socket button head screw with spigot end and location groove (could be machined as a circlip groove), a hex nut with a washer face and a hexagon head bolt with a washer face. **Photographs 6** and **7** show a couple of machine set-up examples.

You can also use the fixture as a holding



Section View Set-up Example for modifying the Head of a Screw

4



Section View Set-up Example for modifying a Bolt

5

Some modified examples

screw or bolt.

The process has three main advantages: there is little or no wastage of material (no swarf compared with standard machining processes); high volume production at a fraction of the cost of other processes; and the grain structure of the bar stock follows the head and thread form adding to the tensile strength of the screw or bolt, allowing the use of cheaper specification materials.

However, this process does not produce screws or bolts as accurate as machined screws and bolts manufactured on screwcutting lathes and the like.

The problem I encountered was that not all of the back faces of the heads of screws and bolts manufactured using the heading or upset forging process were perpendicular to the screw thread axis. As soon as I tightened the screw against the back stop, of the fixture, the screw skewed over, the longer the screw the greater the eccentricity problem. I tried sandwiching a soft washer between the back face of the screw and the fixture back stop, no good. I tried holding the screw in the fixture thread adaptor with a couple of locknuts; this worked but would be no good when modifying very short screws. In any case these improvised methods went against the principles of the fixture philosophy. Luckily the shoulder face of the screw heads were accurate, so the answer turned out to be simple enough. I removed the fixture back stop, located the screw in the fixture thread adaptor, with the head outermost, and faced off the back face of the screw head making it perpendicular to the thread axis, job done! See **photo 8**.

Manufacture

The fixture I made takes up to M6 or 1/4" thread screws and some types of m8 or 5/16" threads screws. The bill of materials, listed in **table 1**, is based on material requirements for the fixture I manufactured.

Clamp nut, fig. 1

The clamp nut is the first component to be machined, as it can be used as a gauge for the machining of the fixture housing. First, I had to decide what thread type and size to use for the main clamping thread. Any size and type will do as long as the core diameter is larger than the largest head diameter of any screw to be modified. I have a ¾ inch x 40 tpi tap set, so that's what I decided to use, however, I did find this pitch a bit fine, I had to be careful not to cross thread the nut on the housing. If I were starting again I would choose a coarser thread, probably 32 or 26 tpi imperial, or 1mm pitch metric.

I decided to machine the clamp nut from a billet, cut from 1 inch hexagon mild steel, this allowed me to run the boring tool through without hindrance to machine the parallel through bore required for location, billet length 35mm. With the billet positioned in the 3-jaw chuck of the lathe, I first faced off and chamfered the billet face. I then centre-drilled, drilled and bored the location bore to size, ø17.0mm.

6

Set-up showing the modification of a Screw

7

Set-up showing the modification of a screw Head together with a Nut being modified with a washer face

Table 1 – bill of materials

Description	Qty	Size (mm) unless otherwise stated	Material	Remark
fixture housing	1	Ø30 x 70 lg	En 1a Bright mild steel	machine from bar stock
clamp nut	1	1" or 25 a/f x 35 lg Hexagon bar	En 1a	machine from a billet
thread adaptor	1	Ø 26 x 10 lg.	En 1a Bright mild steel	one per thread size Machine from bar stock
back stop	1	Ø 1/2" x 21/8" lg.	En 1a Bright mild steel	machine from bar stock
thread adaptor securing screws	2	6ba x 7/16" lg. Or m3 x 12lg. Slotted cheese head screws	Plain carbon steel zinc or cad plated	purchased item

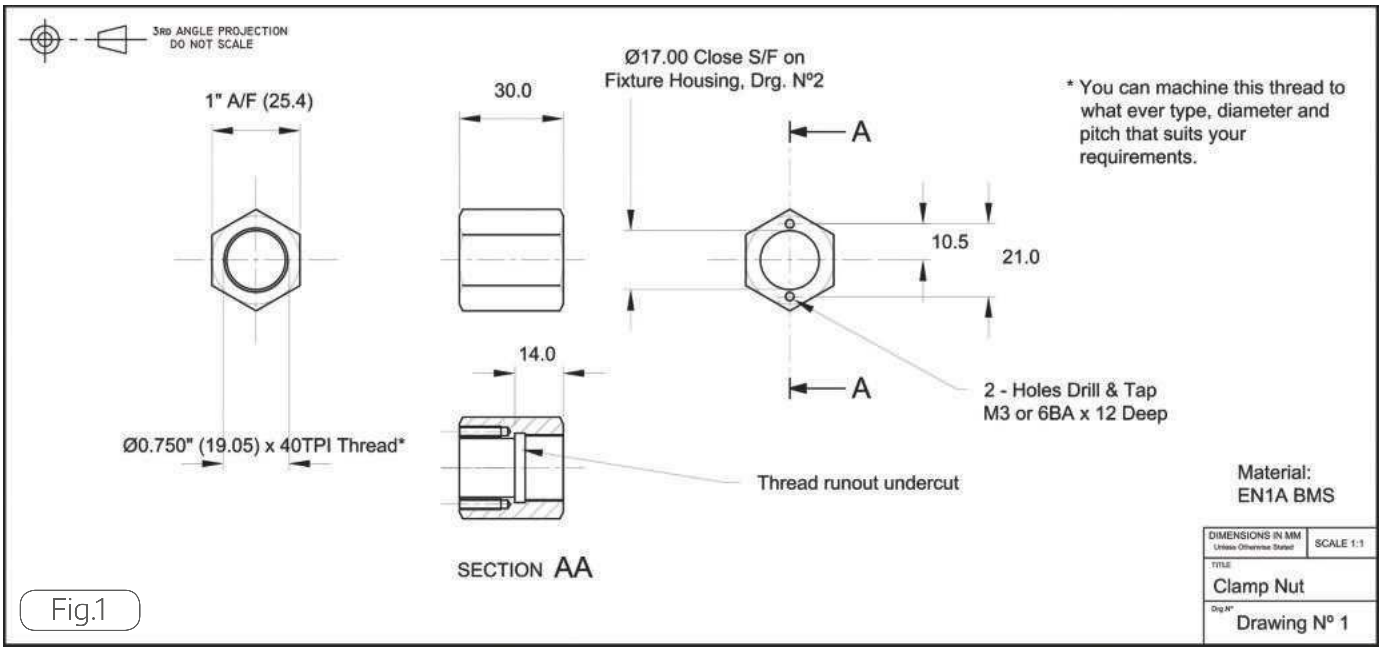
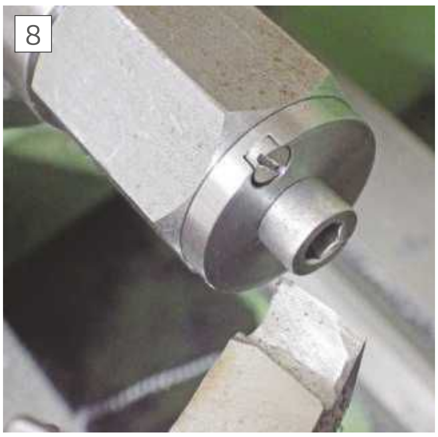


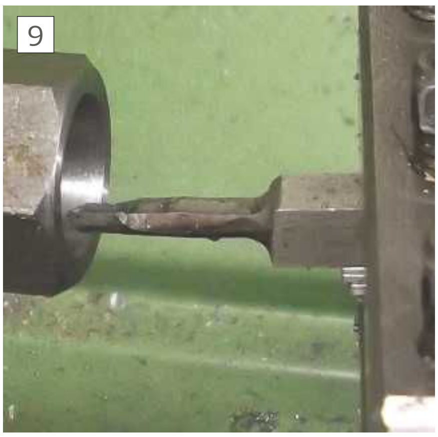
Fig.1

Next I counterbored in 14.0mm from the face to produce the core diameter of the thread, in this case ø18.3mm, see **photo 9**. The reason for machining the bore to the minor diameter and not the tapping size, which allows clearance on the tap, is because I want to keep the thread clearance to a minimum, to maintain minimal axial clearance. You just have to be careful, when tapping, that the tap doesn't bind too much. I tapped the thread, using the tapping head adaptor I described in a previous article entitled 'a tapping dilemma', see **photo 10.**

To be continued...



Facing off a Screw Head perpendicular to the screw axis



Counterboring the nut

Tapping the nut

A "Nutty" Problem

In the curious, but long-standing, MEW tradition of detailing challenging repairs to aged furniture, Brian Moseley tackles an unusual screwcutting task.

Sat at the computer one night, there was bang and suddenly I found myself six inches lower than I was meant to be. I was sitting on an antique piano stool, (over 100 years old, see **photo 1**), when the screw height adjustment collapsed underneath me. Subsequent dismantling revealed that the brass 'nut' part of this adjustment system had worn, to the point where what remained of the threads had stripped, and down I went with a bang. No problem I thought, make a new nut, simple - but it wasn't! What I found when the thing was dismantled was a steel 'leadscrew', which although showing minor signs of wear, was in pretty good condition given its age. The brass 'nut', essentially had no thread left at all, with my weight on the lead screw having simply pushed the remnants of the thread out the through the bottom, **photo 2**, the lead screw with the new nut screwed on, and **photos 3** and **4**, the new and old nuts side by side.

It was at this point my ego said - 'No problem, make a new nut!' So, I set out to dimension this 'new nut' and that's when the problems began to emerge. I referred to the male section earlier as a 'leadscrew' and essentially that is what it is. It has a square section thread at 4 threads per inch, (tpi), with an outside diameter, on the upper unworn section, of 0.725". I have a Myford Super 7 lathe with a screw cutting gearbox so I didn't envisage any major problems until I looked at the gear change selector plate on the machine itself, **photo 5**. The coarsest tpi the quick-change gear box can cut as standard is 8tpi; and therein lay just one of my problems.

It can be seen in photo 3 that the original nut is a brass, (or maybe bronze), casting, with a hexagonal outside cross section. Unfortunately, it was not a symmetrical or parallel hexagon - there is an average 0.030" taper on all 6 sides of the hexagon. Looking down the mahogany column of the stool I could see that this nut sits in a notionally hexagonal, tapered hole and is not fixed in any other way - body weight on the top of the stool simply locks the tapered nut into the tapered hole such that it can't move any further down and the hexagonal shape stops it rotating as the stool rotates in use. Measuring this rather rough casting to decide on the dimensions of the new version had to be a series of compromises. The sides where somewhat concave and the across flats dimensions were different on all 3 pairs both at the top and bottom, i.e. no symmetry of any description. I eventually came up with some averages, erring on slightly oversize if anything, on the basis I could shave the wooden hole if necessary albeit with some difficulty due to its depth down inside the column. In the extreme, my thoughts were, I could make a steel replica of the new outside shape, heat it to cherry red and gently 'burn' the hole profile to my averaged but now symmetrical shape. In the event, this extreme solution wasn't necessary.

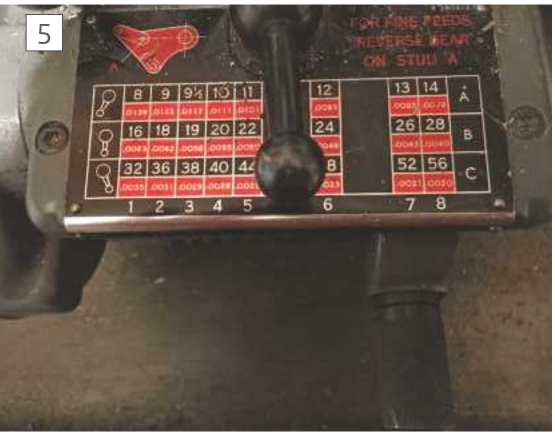
Having decided on some reasonable averages the next issue was how could I cut an internal 4tpi thread on the Myford. On the first page of the Myford quick change gearbox handbook is a warning that '... the cutting of unusually coarse pitches in excess of 0.125", (8tpi), exerts excessive pressure on the lathe's leadscrew and gear mechanisms'. It then goes on to say great care should be taken in these circumstances. By implication therefore, my guess was it should be possible. When I spoke to Jack Peovey at Myford he had not heard of this being done before, but

The Problem Stool.

The 'Leadscrew' with the new 'nut' finished and fitted.

The old and new 'nuts' side by side.

Another view of both 'nuts'.

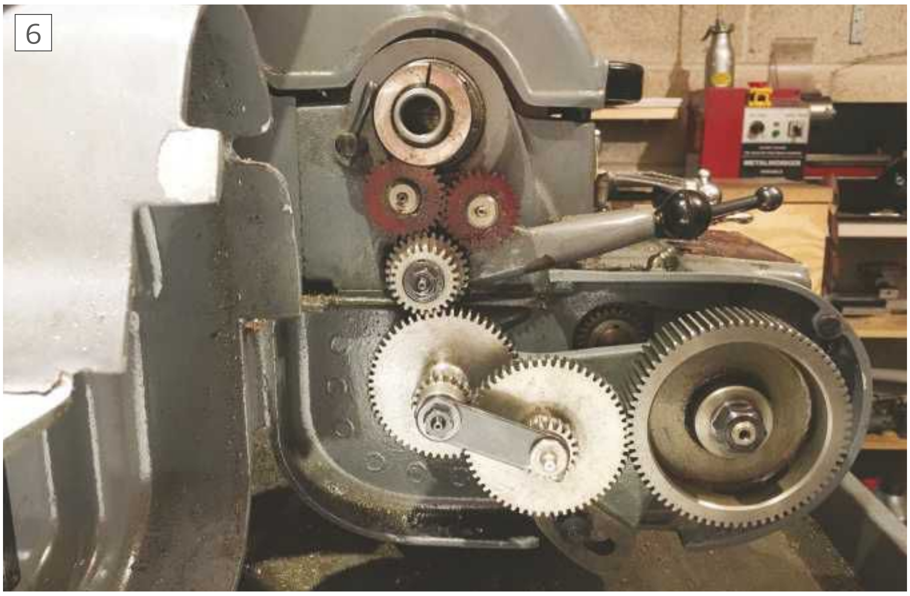


The Myford Gear Box selector plate.

did comment that he had experience of changing the standard 24 tooth gear on the Tumbler stud for a 12 tooth, to give finer feeds and smaller pitches. This results in a reduction in pitch by a factor of 2, so, fitting a 48-tooth gear in this position would have the opposite result and increase the pitch by a factor of 2 - the effect would be to double the output speed from the quick change gearbox; that is when set to 8tpi the thread cut would be 4tpi. In **photo 6**, which shows the standard Myford gear train used to input the screw cutting gearbox, the 24 tooth gear on the tumbler stud is the outer one of the pair, just below the 2 leadscrew reversing gears.

The quadrant on which this gear assembly is mounted is specific to the quick-change gearbox and has 2 long studs at fixed centres - these carry the 2 big double gears below the tumbler stud seen in photo 6. I needed to mount a 48-tooth gear on the tumbler stud but retain the remainder of the gear train. However, whilst the quadrant can be rotated about the gearbox input shaft, to adjust the gear backlash, there is not enough downward movement to take the larger 48 tooth gear I needed on the tumbler stud.

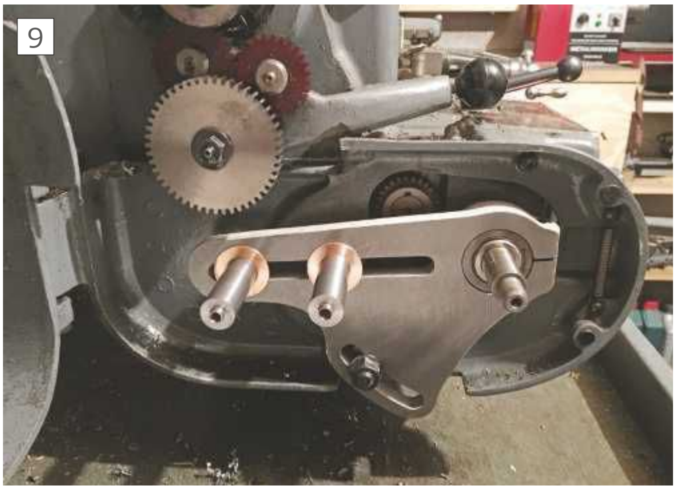
As it happens I have a Myford Metric conversion set which includes a slotted quadrant, (as used with change gears), but the studs, which are part of that setup, are to short to take the 'long bore' double gears from the quick-change gearbox arrangement. I therefore needed to make some adjustable 'long studs' the detail of which is shown in **fig. 1** and **photo 7**. Making these 'long studs' was a fairly simple exercise. A length of ¾ inch diameter mild steel was held in the 3 jaw chuck, (preferably EN1A - free machining, gives a better finish). The end with the 2BA thread was machined and finished first, including centre drilling oversize for use later. The bar was then reversed in the chuck and the M10 end completed, taking care to get the length of the 0.625" dia. section correct at this stage. The chuck was removed from the lathe without disturbing the work piece and transferred to a vertically mounted rotary table for milling the flats. It will be noted from fig. 1 that the across flats dimension needed is less than the Imperial diameter needed for M10. In order to assemble the new long studs into the slotted quadrant it is necessary to clean off the tops of the M10 thread by some



The standard gear train input to the gear box.

The two new 'long studs'.

Finish turning a 'long stud' between centres.



The new studs assembled onto the slotted quadrant.

0.007" on each side. This is easily done as part of milling the flats and will have no detrimental effect on the M10 thread. Once complete to this stage it was set up between centres in the lathe and the 0.625" section finish-turned to a good finish and a nice sliding fit in the 'long gears', **photo 8**.

Photographs 9 and **10** show this slotted quadrant, front and back respectively, just prior to fitting the rest of the gear train. The 48-tooth gear can be seen in photo 9 fitted as the outside gear of the tumbler stud pair. Note the 'washer' in photo 10. In order to properly align the 48-tooth gear with the rest of the train, a spacer is needed on the clamping stud behind the slotted quadrant; on my machine this needed to be 0.140" thick, made to the same overall dimensions as a standard 3/8" dia. washer. Even with this washer in place there is very little space behind the quadrant. I found the nuts on the studs were just clear of the rear gear casing but this needs checking. If there is any suggestion they foul, the nuts and the threaded ends of the long studs need to be thinned down until they are clear.

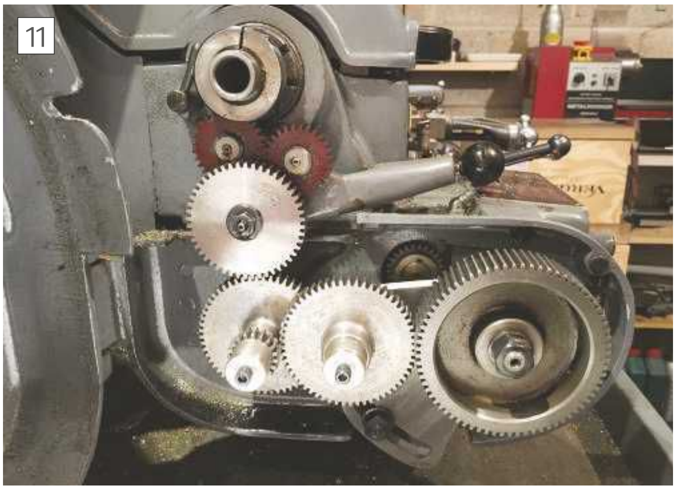
Photograph 11 shows the 48-tooth gear and the rest of the train assembled and fitted to the Myford, ready to start making the new nut. With the gear box set to cut 8tpi, a trial run with a pointed tool on a length of bar was done to check that the tpi was in fact 4tpi with the new setup - it was, **photo 12**.

Before starting the new nut, the first job was to make a small plug gauge from EN1A to make sure I got the bore spot-on to the target diameter - a simple turning job turned to 0.596 inch diameter with the first 1/4 inch undersize by about 0.003". This undersize front end gives you a warning when cutting the bore that you are very close to where you want to be.

A length of 1.250" diameter brass was held in the 3-jaw chuck, skimmed to clean up, centre drilled and drilled 1¾" deep at 14mm

10

Rear view of the assembled slotted quadrant.

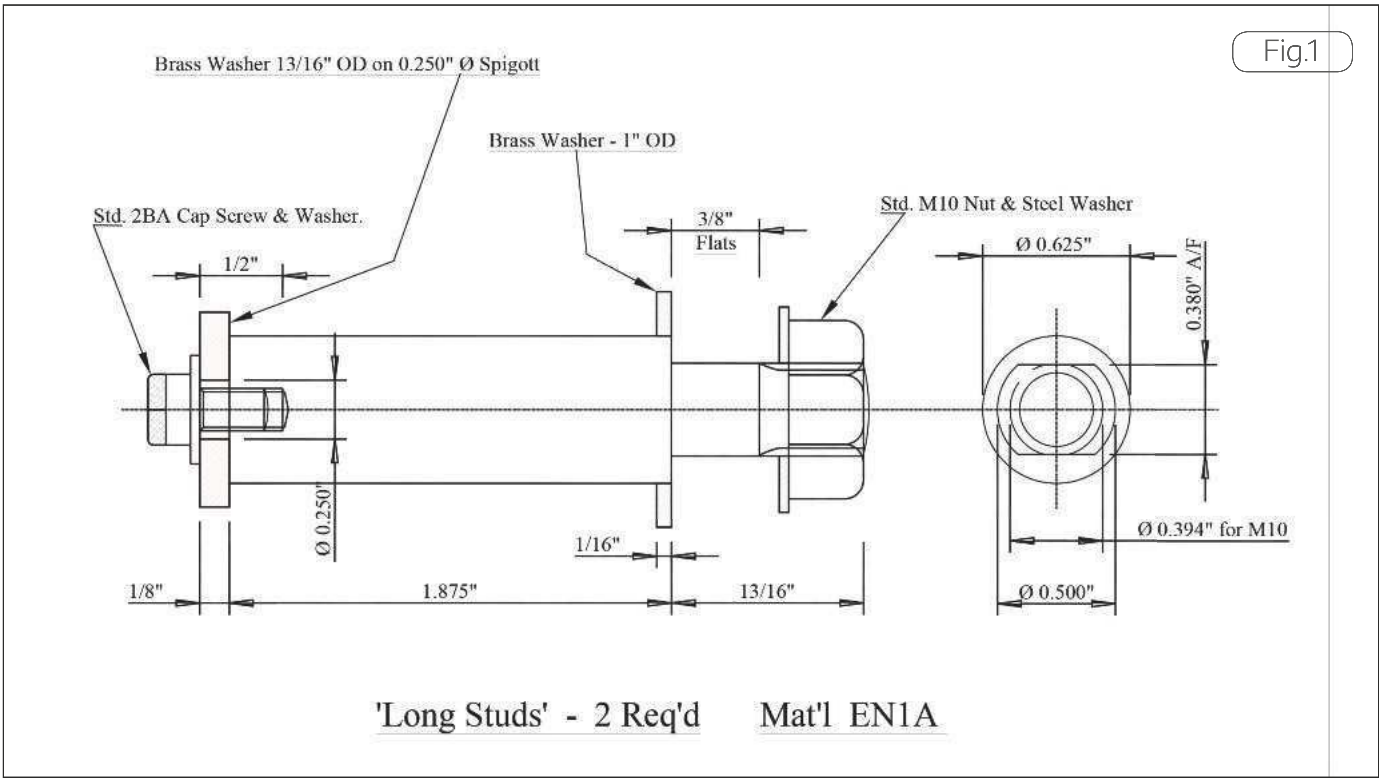


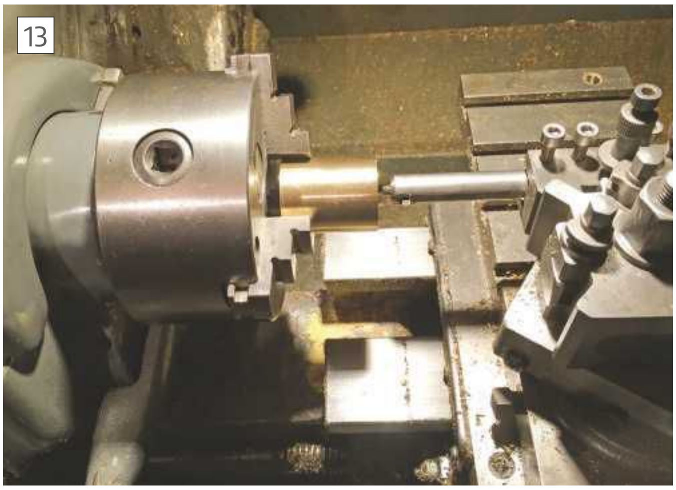
11

The new gear train with the 48 tooth gear in place.

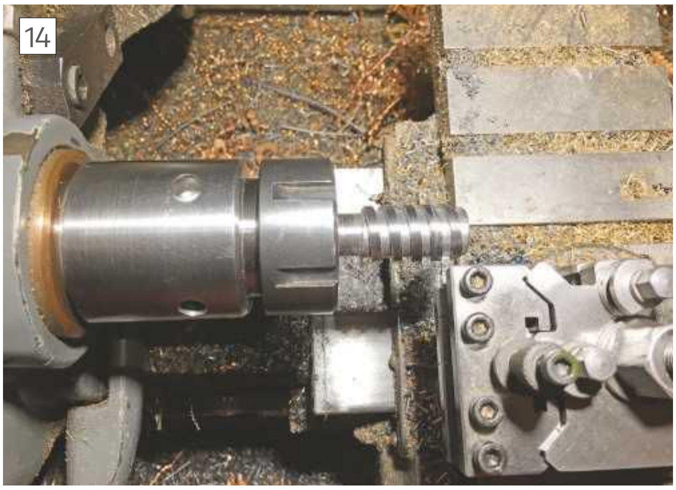
12

The test piece confirming 4tpi.




13

The blank nut ready for screw cutting, note the construction of the boring bar and the HSS tool.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Screw cutting the 4tpi tap.

diameter, this was the nearest under size drill I happened to have, and parted of 1.625" long. **Photo 13** is the setup ready for screw cutting and shows the blank in the 3-jaw chuck ready for boring etc. The purists would have used soft jaws bored to the outside diameter of the blank, but my 3-jaw is pretty concentric and given the inaccuracies in the original cast nut, any minor eccentricity in its replacement was not going to be an issue. I then bored the pre-drilled 14 mm hole to 0.596", (the core diameter of the thread less a small clearance), the previously made plug gauge was a tight push fit, see **fig 2**. So far, so good!

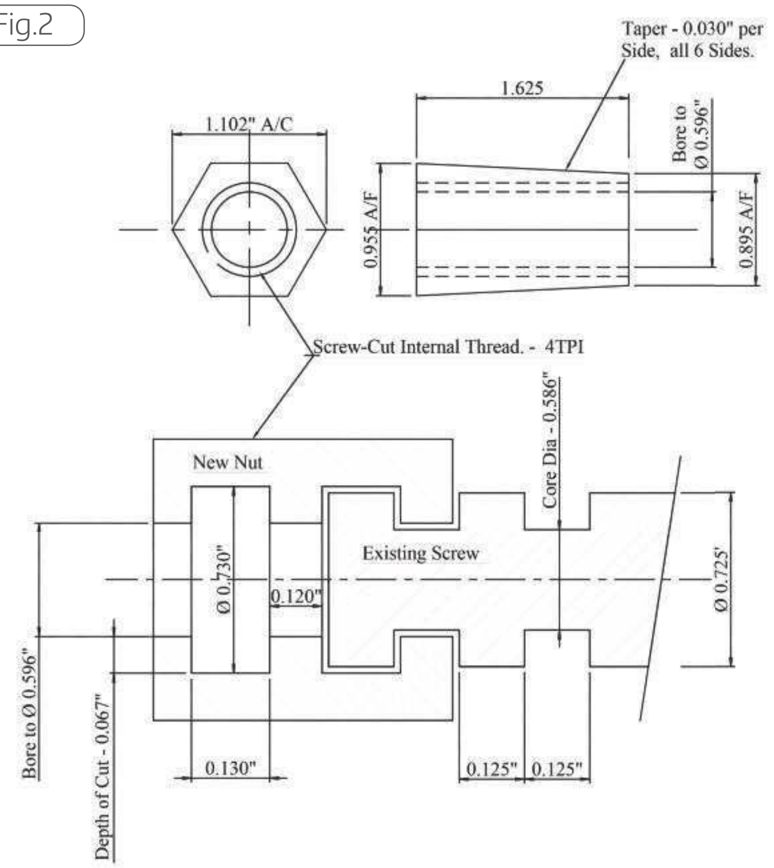
The test piece noted earlier proved 2 things, yes the new gearing does cut to 4tpi, but at even very low spindle speeds, engaging the lathe's leadscrew nut results in the saddle fairly flying along the bed. Clearly, this is where the high pressure referred to in the Myford handbook comes from, obviously stress on the lathe but, as I found out, also on me as the machinist. Disengaging the leadscrew nut at the end of the cut has to be precise, every time - clear of the end of the work piece but not running into the chuck or the spindle nose on the lathe.

In my setup I had about ¼" to spare. I found the best way was to have the boring bar protruding from the quick-change tool holder at just the right length so that with just a fraction of clearance between the tool holder and work piece I could disengage very quickly and know the cutting tool was clear of the internal end of the thread but not running into anything.

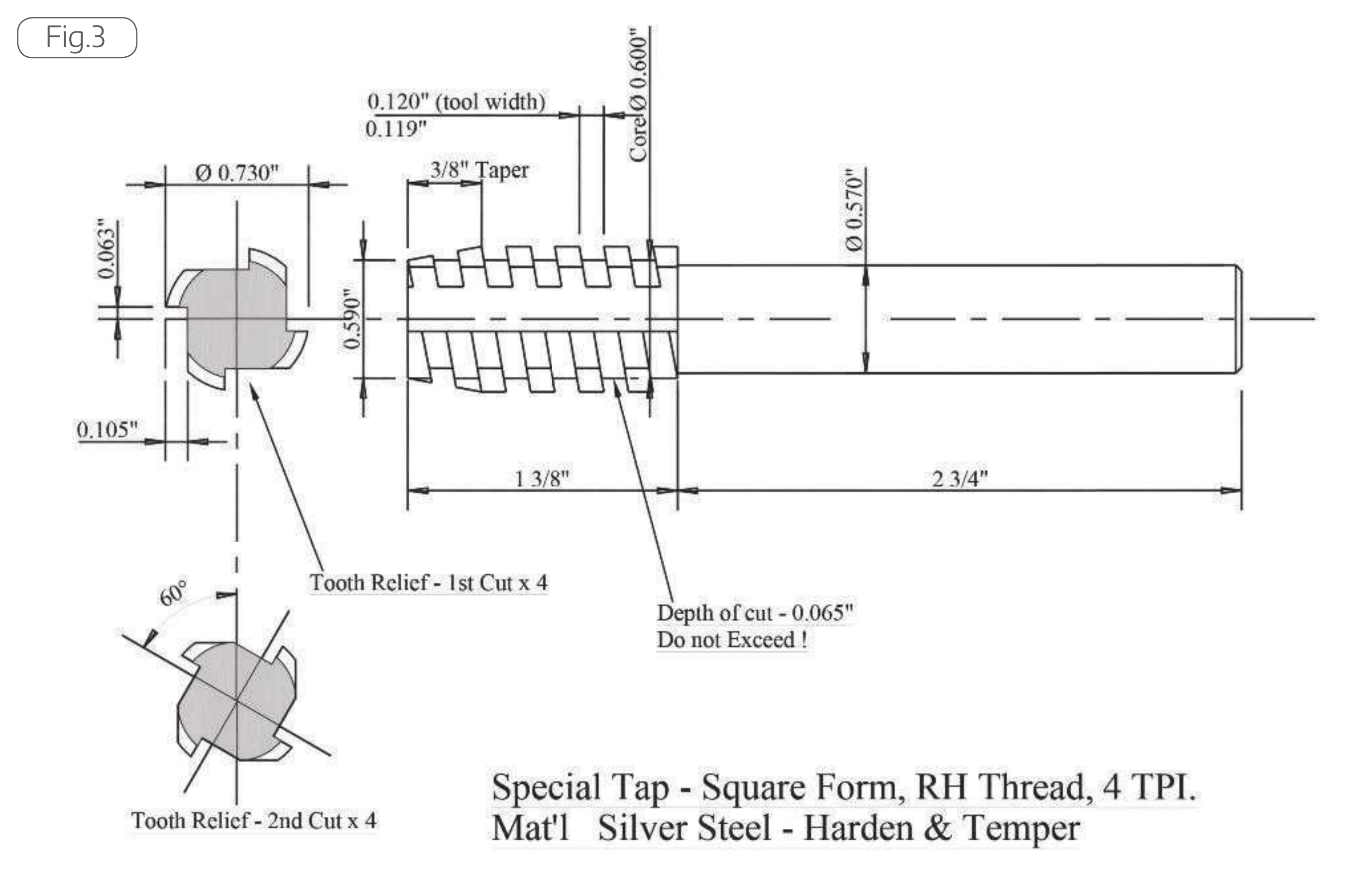
If you don't have a boring bar suitable for the square shaped cutting tool needed for this job, its easy enough to make one as I did from a piece of ½" steel bar, (EN1A if you can). Drill and tap one end at 2BA and cross drill and ream for a 3/16 inch diameter HSS tool bit. File or mill a flat on the bottom of the bar to give a good seating in the tool holder. For 4tpi, the tool then needs grinding to as close to 0.125" wide as you can with a good relief on both sides. If it's 0.001" or so under, don't worry. I found I needed a higher front rake than I expected for it to cut freely and ended up at 14 degrees. Cutting brass, this was fine, in carbon steel I'm not so sure it would have lasted very long. The measurement from tool tip to the back of the bar cannot be any greater that the bore diameter, obvious but just thought I'd mention it. Photograph 13 shows the setup ready to go, however I made one change very early on in the process which is therefore not right in this photo - I reset the top slid to zero, i.e. exactly parallel to the bed, (explanation as to why comes later).

After some practice runs to get the feel of my new 'high speed saddle' it was obvious back gear was going to be essential. In the end, I cut the whole nut at 39 rpm - the slowest but one speed available on

Fig.2



Dimensions for New Nut - 4TPI
Material - Brass



the Myford, any faster and disengaging the leadscrew nut at exactly the right moment would have been nigh impossible. Bearing in mind the Myford warning about excessive pressure I only used cuts of 0.001" or 0.002" each time and after every 3rd cut ran the tool through without advancing. With a depth of cut of 0.067" that's a lot of passes, it took forever but seemed to go well.

When I was happy, continued passes were not removing any more material, I advanced the top slid. 0.001" and ran another cut. I repeated this several times to give a theoretical 0.005" side clearance on the width of the new thread groove visa-vis the thread width on the screw. So, if your cutting tool was under 0.125" wide, no matter, run these final cuts parallel to the bed enough times to give a finished width of 0.130". This is why I reset the top slide parallel to the bed as noted earlier.

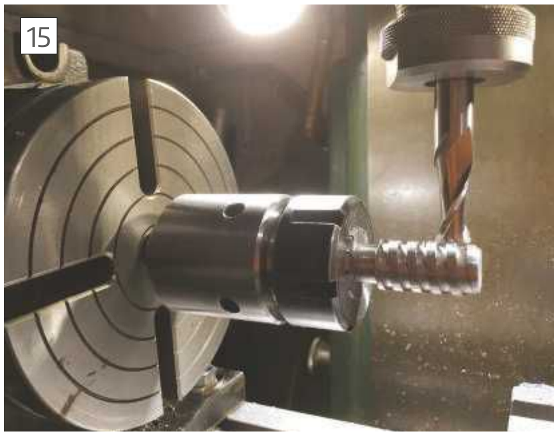
When I tried the screw into the new nut it entered about 1 turn and went so tight it became stuck. I didn't know what the problem was or what to do about it! Was the bore too small? was the depth of cut not enough? or was it the width of the groove that was to narrow?

It is of course impossible to measure the later two of these, so whichever was the problem, it was as a result of all the dead reckoning and not being able to measure as I went along or indeed now, after the event. A big suspect had to be my original measurements of the core diameter which determined the bore. I had had problems with this, it being a very difficult measurement to make due to the pitch of the threads. At that point I gave up for the day and slept on the problem.

After some thought, I was very nervous about just cutting away more brass, virtually indiscriminately, not knowing where the problem lay. The only low risk option I could see was to make a 4tpi tap, which I could measure. This would potentially be a lot less traumatic than screw cutting the nut had been. The downside was that I would have to remove the nut from the lathe to make the tap, thereby loosing concentricity, and if it didn't work for any reason my only option might be to start all over again and make another nut from scratch with no guarantee that this would be any better.

The tap dimensions I finally decided on are shown in **fig. 3**. These are only a few thou' above my original target dimensions; any more and I was worried the force needed to push the tap through my 'tight' nut might be to high. I reckoned that if this still left the nut to tight, I could always make another tap slightly larger still. The OD I left the same as my target dimension for the nut - I could measure this accurately on the 'leadscrew' and

Clearance of + 0.005" seemed about right on virtually ¾" dia. The target core diameter was already 0.010" bigger than what I had measured the screw at, so rounding this up to 0.600" for the tap root diameter, should, I felt, be a little more clearance than ought to be necessary. With the width of the thread



Milling the teeth into the tap.

my target was 0.005" clearance and again, if everything else was 'at target', then this should have been adequate. Overall I had the opinion that the target dimensions were OK and that, with the exception of the difficulties in measuring the core diameter of the 'leadscrew' any other problem was most likely to be in the execution and not in the design. So the only real difference I was building into the tap deign was a 0.004" increase on the core diameter which would have the effect of increasing the 'bore in the nut. Running a tap through should of course correct any errors in my making of the nut.

Making the tap is not a particularly difficult process. Using 5/8" diameter silver steel, I first turned a blank to the shank end dia. of 0.570". If I had to make this again I would make this shank end longer than I did, such

16

The finished tap after hardening an tempering.

that the tap could be screwed right through the nut and exit from the other side; this is reflected in the dimensions given in fig. 3 and why the the finished tap might appear a bit short.

I then mounted the shank in an ER32 collet chuck on the Myford and finish machined the tap end outside diameter to size including the short taper on the front end. **Photograph 14** shows screw cutting in progress. This time disengaging the lead screw nut was not so fraught, with plenty of space and a clear sight line. The tool was made from a short length of 1/8" square HSS, again with side relief, but this time a standard front rake of 7 or 8 degrees. I ground the width of the tool to 0.120" wide as the 'teeth' on the tap will be cutting the groove in the nut and I wanted to maintain the 0.005" side clearance on the screw. It sounds double-dutch I know, but the narrower the groove on the tap, the wider the groove in the nut - think about it!

Being carbon steel, silver steel is not free cutting in any way, and very light cuts of 0.001" were used with alternate cuts not being advanced at all. Once down to the target core dia. repeat the last cut several times until no more material is being removed. I took great care not to the exceed the 0.065" depth of cut as this would have reduced the effect of increasing the bore diameter of the nut.

I then needed to create the 'teeth' on the tap and the ER32 collet chuck was transferred to the rotary table mounted vertically on the milling machine. I had bought a 'Myford nose' adapter for the rotary table some year ago and the ability to make this switch whilst maintaining concentricity is very useful on lots of projects. The 'first relief' was milled out to the profile shown in fig. 3, some 0.040" into the core diameter. This creates the cutting edge needed to enlarge the core diameter of the nut. Cutting the teeth back to an over centre position, gives a small positive rake to the teeth. After cutting this 'first relief' in four places, each down the full length of the tap, I rotated the rotary table through 60 degrees and milled the 'second relief', also shown in the figure, on each of the sides of the Tap. Finally, everything was 'deburred' and polished as far as possible. Be careful in the cleaning up process, not to round off the cutting edges, these need to be kept as keen as possible. The fished tap was then hardened at cherry red, re-polished, lightly tempered and then polished again.

Now came the moment of truth. I mounted the new nut in the bench vice and inserted the tap. The tapered section went in OK, all-be-it somewhat tight, as you might expect, plus at best about a quarter of a turn of the full thread. I removed the tap, applied liberal amounts of cutting oil to both the tap and the nut, and then, with a 14-inch pipe wrench, started to work the tap into the nut. Progressively working the tap clockwise and then anti-clockwise and removing it completely as it got excessively tight to clean off the cuttings, I eventually pushed the tap into the nut as far as it would go with the shank being as short as it was. I then turned the nut over and did the same thing from the other side. I repeated this exercise from both ends and then washed the nut out with paint brush cleaner, (I didn't have any paraffin or I would have used that rather than turps substitute).

It was with some trepidation that I offered the screw into the nut. It was tight-ish, but it went in except for a couple of threads right at the very top of the screw. After some gentle filing and attention to a minor burr or two, it went the last bit, although still a touch tight. This top part of the screw obviously had not had as much wear as the lower section and so the tightness at that point was understandable. I was one happy bunny!

The next job was to mill the outside faces to the required tapered, hexagonal profile. The machine vice was setup square and flat on the mill table and the new nut gripped as shown in **photo 17**. By subtraction of the required finished large end across flats, (A/F), dimension of 0.955" from the skimmed diameter of the nut, the amount to be removed from each side was calculated as 0.014". Having finished the first side to this depth, the work piece was rotated and set to 60 degrees against the new flat with a vernier protractor, again as shown in photo 17, and the second cut made. This was repeated until all 6 sides were completed. I then had a parallel hexagon at 0.955" A/F. Creating the taper was the next job.

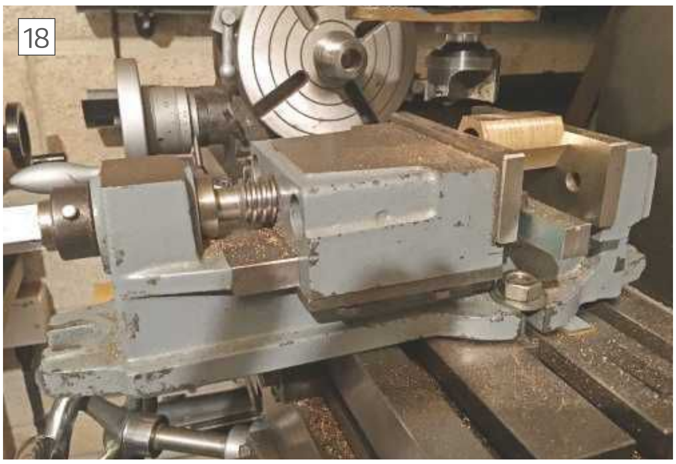
Photograph 18 shows the same set-up as before, but the close observer will note some packing under the front end of the machine vice. This has the effect of tipping the front end up, but leaving the back of the vice hard onto the table. Careful experimentation will establish the right amount of packing to give 0.030" of taper per side over the 1.625" length of the nut. Starting with zero cut, the 0.030" taper was then milled on each flat, resetting the 60 degree angle each time as the nut was rotated - 'fiddly', but it worked!

Photographs 1 and 2 showed the finished Stool back in pristine condition and the screw with its new nut fitted, prior to assembly into the central column. In the event the guesstimated symmetrical shape of the new nut fitted pretty well and no additional fiddling with the woodwork was necessary. After a few days use at the computer, the screw and the nut had bedded nicely together and it is now a smooth operation, up down and around, without the previous wobble. The end result was well worth the effort but not without some trauma on the way !

My thanks go to Jack Peovey at Myford for suggesting the solution to the 4tpi issue - the usual disclaimer applies. ■

17

Milling a parallel hexagonal side and setting the angle for the next side.



18

Packing under the front of the vice to generate the necessary taper.

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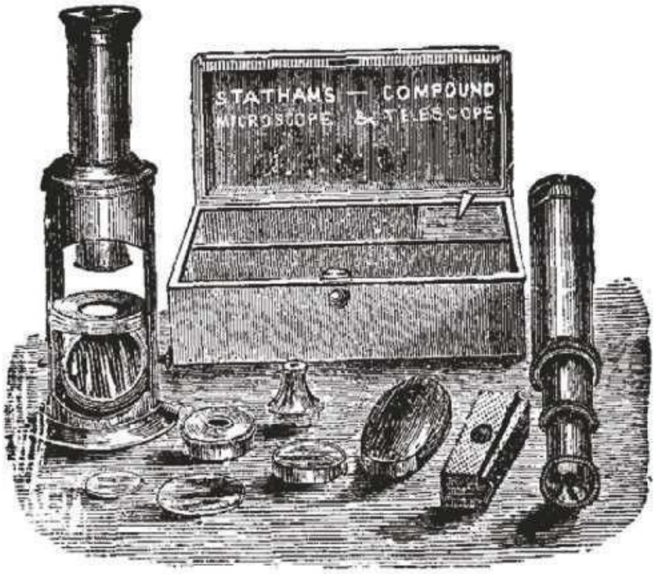

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Modifications to a Myford 7 Series Lathe

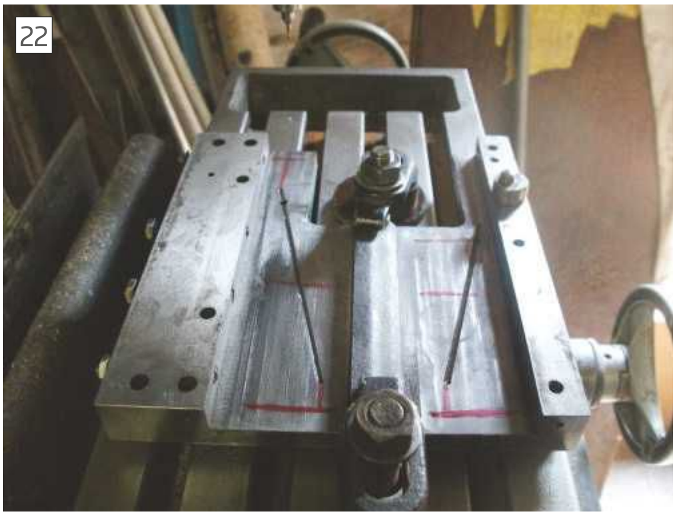
Concluding this series, Inchanga, in South Africa, describes work carried out on the carriage of his lathe.

Carriage modification

The carriage assembly of the Myford gives very little trouble but there is one worthwhile modification that will extend the life of the bed and the carriage. This regards the oil grooves. The oil grooves appear to be cast into the body of the carriage and extend over a major portion of the length. However, they stop well short of the front and back and these areas get little or no oil. The ability to flood the working surface with oil to flush out tiny pieces of swarf and grit is an essential part in keeping things running sweetly. Consequently, whilst the writer had his Super 7 in pieces to clean up the carriage and bed it was decided to extend these oil grooves whilst the carriage was on the milling machine table. Having read Alan Hearsum's article on renovating the ML7 lathe I was spurred onto finally doing something about my Super 7. Some previous owner had the bed reground but the end result was to say the least shoddy workmanship. I decided to follow Alan Hearsum's article and stripped the bed and carriage to work on them.
My bed was essentially straight and true but had very minor deviations along the vertical shears that meant the carriage and tailstock did not run freely all the way along the bed, but tightened up at the extremes of travel. The worst-case error along and across the bed was just less than 1-thou on any bearing surface, so it was almost perfect. Very minor honing with a small slip stone corrected the tight spots. But the bottom surface of the carriage where it ran on the bed was also heavily scored just like the tailstock, because of swarf trapped between the slides. The front of the carriage had the worst wear and it was obvious the felt wiper fitted was not doing a very good job. I had purchased several felt wipers and changed them every 6-months or so, but they soon wore out and swarf got under them. Once trapped they had no way of being removed, apart from physically

21

Finish ground carriage



22

New oil groove positions marked out

23

New oil grooves cut in carriage

Carriage front felt wipers and cover

Profiling the new wiper plate

Old and new wiper plate

stripping the carriage off the bed. This is not a 5-minute job and entails a lengthy process to adjust all the shims etc when things are replaced, so it is often avoided.

The wear pattern on the front of the carriage surface looked like corduroy trousers with many tiny score marks and minute pieces of brass noticeable. The carriage was stripped and set up on the vertical milling machine and clocked all round to ensure it was truly level. The wear thickness was 3-thou at the front of the carriage and about 2-thou at the rear. I decided to rip off 5-thou all over to get down to solid unscored metal. (If I had to take any more off then I would need to remove some material off the front and rear gib plate bolting areas and that meant more work. I finally opted to not trim these and make up the difference with the shimming on reassembly, which worked out fine as it happened). I used a large diameter shell end mill cutter and made the cut in one pass across each half of the carriage. After the milling I changed the collet chuck to a drill chuck and fitted a small grinding stone. This covered about half the face width of the area to be ground. With the spindle speed on the milling machine set to Warp Factor 5 (2100 rpm) and with a flood of coolant I adjusted the down feed for 0.5-thou of cut. The grinding wheel was moved up and down the surface several times until I had a reasonably smooth surface. This was repeated on the other half without changing the down feed setting and the end result was acceptable. The final machining was to extend the oil grooves. The final ground finish is shown in **photo 21** before hand lapping on the bed.

For this I used a 2mm FC3 cutter and went in about 1mm deep starting with one of the oil feed holes. **Photograph 22** shows the rough position of the oil grooves extensions marked in crayon as a guide to work to. The exact position is not too critical; the front grooves should extend to about ½-inch from the front face so these get a plentiful supply of oil when flushing out swarf. The sideways cut needs to come close to the vertical shear rubbing area so these get plenty of oil. The current oil grooves starve these areas at present.

When the oil grooves had been cut, **photo 23**, I removed any burring with a small slip stone to get a smooth surface. The final operation was to mount the carriage back on the lathe bed and to lap the two together with some very fine metal polish. This produced a super finish close to a fully ground one but matt. This leaves millions of tiny oil pockets to retain the oil that is vital for smooth running. Remove the carriage and ensure you wash off all the abrasive on the carriage and the bed, as we don't want this to undo all our hard work! After that it only remained to fit the rear and front gib plates and to adjust the shimming to the correct amount of vertical float. I find it best to get the rear plate adjusted correctly first and then to set the front shims. The last operation was to slide in the front gib strip and adjust the screws for optimum running. All these adjustments are performed with a dry bed and carriage, so a little bit of clearance exists. It should move smoothly but without too much effort to push it along the bed. Note that the apron with the hand wheel for the rack is not fitted so you can better assess how much effort is needed to slide the carriage along the bed. Now we flood the bearing surfaces with the oil gun at the front

Two strips of draught excluder glued together and rear nipples and see the oil emerge all around the surfaces. If it felt smooth before it should now feel silky smooth and a pleasure after all the hard work. Fit a new felt wiper onto the front of the carriage and soak this in oil before fitting. Bolt the apron front back in place on the carriage and make any adjustments to the leadscrew nut mechanism and we are ready to get back to work on our as good as new lathe.

Carriage Felt Wipers

The carriage has a felt wiper fitted to the front edge that is designed to stop swarf getting between the carriage and the bed. This works fairly well when the felt wiper is new but the writer got the distinct impression that when the wiper is older it works more like a one-way valve, allowing the carriage to Hoover up dirt and swarf but not allowing it to escape from under the carriage. The other noticeable fact is that the felt material is too compressible. Over a period of time the clamping pressure of the screws causes this felt to become too thin to work effectively. Another failing is that the centre gap and the two inner shears have no protection from the felt wiper pad, there is a huge space where dirt can enter the carriage-bed area because of this gap. The dirt and swarf can still get under the shears and then into the carriage-bed interface. The writer devised an improved version for his Super 7. **Photograph 24** shows a new felt wiper and two that had been removed. The thickness of the new pad and the recently removed one shows a marked difference, it is almost squashed flat but the other wiper, removed some years ago, has almost returned to its original thickness. The metal cover for the existing wiper was used as a pattern to make the new cover from a piece of 30mm wide by 3mm thick aluminium. Steel sheet as used in the original would be preferable but none was to hand. The salient points of the new wiper cover are that it contains a centre piece that fits in the inner gap and it has short spacer tubes on the 4 fixing screws to maintain the thickness so the material is not compressed too much. The wiper material was also changed from felt


28

New wiper profile

to closed cell plastic-rubber foam, the sort that is used for draught excluders on doors. This is considerably thicker and spreads out better when compressed, so pressing firmly on the bed top and inner shears. It also springs back quickly when the pressure is released. The draught excluder strip to hand was 6mm thick and 25mm wide and has a self-adhesive backing with a peel off paper cover. It is easy to cut with scissors and a hobby knife to the required shape. It is supplied in 5m long lengths, sufficient to fit an average door, and is inexpensive compared to the felt wipers. A piece of the new material is shown in photo 24 above the original cover plate. **Photograph 25** shows the new wiper plate being profiled on the vertical milling machine using a 2.5mm FC3 cutter. **Photograph 26** shows the old and new wiper plate. The two ends on the new plate extend further down than the original plate and the reason will be explained later.

The draught excluder strip I had was not wide enough to reach down to below the bottom shears so I glued two pieces in parallel on the edges to make a piece 50mm wide by peeling off the backing paper and sticking them to a piece of thin cardboard. **Photograph 27** shows the two pieces glued together.

No doubt different widths are available but the piece I had was left over from making resilient pad-strips to stop fibreglass removable body panels on a race car from rubbing on the monocoque tub and rattling at high speed. The shape of the new wiper worked out has the inner shears portion looking like an inverted T so the sides rub on the vertical portion and the bottom portion rubs on the bottom of the two inner vertical shears with a wiping action. The two outer parts are similar but L shaped to rub on the sides and bottom of the outer vertical shears to keep them clear of swarf. **Photograph 28** shows the new wiper profile and **photo 29** shows it fitted on the Super 7 carriage. Unfortunately cutting the sandwich of rubber and cardboard proved to be more difficult than I first imagined. Using a sharp scalpel and wetting it with water still left a ragged cut. However, when a very sharp 1-inch wide wood chisel was used with a hammer and


29

New wiper fitted to carriage front


30

Rear of carriage showing area for new wiper

Cardboard template for rear wiper

hole nearest the front just happens to break into one of the apron cap screw holes, so if a much longer than standard screw is used it may cause a problem. I found the standard 4BA screws a little short when trying to fit them, as you have to compress the rubber quite a bit before the screw will start in the hole. I replaced the standard screws with ones about 3mm longer, which solved the problem.

The part of rural Kwa-Zulu Natal I live in mostly has untarred roads and the dust from these is a persistent nuisance. As the prevailing wind blows from the

Grinding tailstock base plate

piece of wood to support the work piece I got a lovely clean cut. I had to forgo the planned bottom wiping sections. If the wiper is made by a die-cutter then all the finer details could be incorporated and the wipers smacked out in one hit.

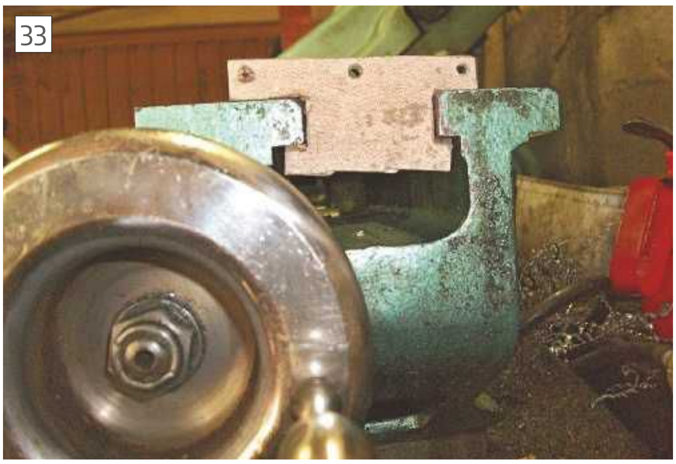
One very important point to note about the wiper fixing screws. The 4BA tapped

road towards the house keeping things clean is a never-ending job. Not only does it settle on the furniture forming a thin film it adheres to any oily surface and forms an effective grinding paste.

The back of the carriage has no wiper pad and this is also a potential source of entry for fine dirt and swarf particles. The back of the carriage is cut away to provide clearance for the tailstock so it is a rather difficult shape to fit a wiper to. However, with a little ingenuity one was devised that gave at least some protection, which is better than no wiper at all. **Photograph 30** shows the area of interest. There is not a lot of clearance between the cut out portion and the tailstock when slid forward up to the carriage so the attachment method needs to be thin in section. Of course, if a bit was machined off the tailstock width there could be more room made available, but that is more work.

Clearly it is not going to be possible to drill and tap into the two inner sides but the backward facing surfaces can take screws to attach a wiper-backing strip. The solution is to make the backing strip from some thin material and to form small lips on the top part that goes around the corners to take some countersunk screws tapped into the two top surfaces. It is also desirable to extend the wiper across the two back faces and down onto the vertical shears so they wipe the front and rear outer vertical shears clear of dirt and swarf. The area around the carriage rack gave some problems. After experimenting with some pieces of cardboard a workable solution was arrived at as **photo 31** shows. Of course, this meant I had to remove the carriage from the bed again, to drill and tap some holes, after going through the entire shimming adjustments etc, but it should be still correct when it is replaced provided I don't mix up the shims! Such is the way with experimental apparatus. I discovered you could in fact slide the entire assembly off the tailstock end of the bed, like the tailstock. To do this (having first dropped the apron by removing its four cap screws) you remove the hand-wheel on the end of the leadscrew and remove the two cap screws holding the leadscrew end bearing and let it dangle downwards. This is a great time saver and means you don't need to disturb the carriage shims, just slacken off the front and rear gib plates bolts and the carriage front gib screws a couple of turns to give a little clearance.

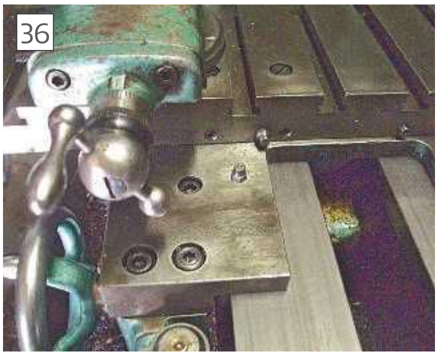
The cardboard template was used as a guide to cut a piece of sheet metal to



Tailstock wiper in end of bed to check the fit

Tailstock wiper in place

Tailstock wiper producing a ploughed clear area



Rear oil nipple position

Front oil nipple showing it fouling with blanking plug

form the wiper-backing fixture. Aluminium sheet about 1.5mm thick or mild steel about 1mm would be ideal, but as luck would have it I didn't have any at the time, so I cut a strip of brass off a larger piece of 20SWG (≈1mm thick) plate.

Tailstock wiper

Having added the new front carriage wiper, I decided to add a similar wiper to the front of the tailstock. This proved to be quite an easy task as it turned out. Whilst I had the milling machine set up for machining the carriage it was not much effort to do the tailstock. I didn't take a cut off the bottom but I did grind the base plate sliding surfaces using the same method as the carriage. The one thing I should have done was to take a trimming cut off the front face of the casting as this in the earlier Myford 7s is slightly curved, but the gradual curve could be accommodated. **Photograph 32** shows the finish ground tailstock base. I took a very small amount off the gib strip and the opposite side to make sure they were true and presented a smooth surface to the bed shears by just kissing them with the side of the grinding wheel.

The wiper plate was measured up and cut from 30mm wide by 3mm aluminium as for the carriage. The wiper again needed slightly more width than the 25mm draught excluder strip so another two lengths were stuck to the cardboard backing and glued together. Having now changed to using wood chisels to cut the rubber it went quite well. **Photograph 33** shows the roughly cut wiper offered up to the end of the bed to check the fit. In this wiper I was able to get the bottom section to wipe the underside of the inner shears. I will remake the carriage wiper using this method.

The front face of the tailstock base was drilled and tapped to take M3 cap screws to clamp the wiper plate in place. **Photograph 34** shows the finished wiper attached to the tailstock base.

Finally, I have included a picture of how effectively the tailstock wiper works. **Photograph 35** shows the bed surface after the tailstock has been pushed up to the headstock and returned to the end of the bed. You can see how the wiper has acted like a plough to move the dirt forward. Using a flash on the camera hides this detail but taken without the flash using the natural light it is quite clear.

Cross slide front locking screw

Cross Slide modification

Having dealt with the tailstock and carriage lubrication improvements I thought a look at the long cross slide was in order. Although this seems not be a problem area the lubrication on my Super 7 seemed to have been overlooked. By winding the cross slide feed screw so the slide is fully out one can easily pull the cross slide with the top slide attached off the carriage. Be warned this is a heavy lump and I dismounted the top slide to make things easier. Turning it over we see the gib strips are in two pieces and a small gap exists between them. An ideal place to apply the oil via a 2BA standard oil nipple. So the slide was marked out and a 2.5mm hole drilled so it broke through the casting between the two gib strips. The outer portion of the hole was drilled to 2BA tapping size and the end tapped about 6mm deep to take an oil nipple. **Photograph 36** shows the position of the oil nipple.

The opposite side was treated the same way, but here I had a senior moment that I didn't spot until I replaced the cross slide. The oil nipple is too low and it fouls the bolt that fits in the tapped hole to take the travelling steady. This is shown in **photo 37**, it needed to be plugged with a flush 2BA stub of brass with a screwdriver slot and this is removed when the oil nipple needs to be fitted. The time between application of oil gun is quite long; every month should be adequate. For the rear nipple, I used the same height as the gib screw adjuster screws and on this side there is no problem with clearance. Where the oil hole breaks through into the V-slide the ragged edges need carefully smoothing with a needle file so it doesn't upset the operation.

Finally, a personal gripe about the cross slide locking screws. Many do not know they exist but there are two fitted to my Super 7 cross slide, one at the front and one at the rear. The long cross slide version of the ML7-R uses the same cross slide. The rear locking screw is fairly obvious, because it sticks out from the side of the cross slide. You can see it in photo 36 at the right just before the carriage locking bolt head. The normal gib strip adjusters are M5 x 16mm grub screws, which have no lock nuts, as they are special self-locking screws, and normally sit just below the surface of the slide face. The two locking grub screws are M5 x 20mm and hence sit about 3mm proud of the back face. The front locking screw is concealed beneath the top slide; below the ½-inch square headed bolt that locks the top slide rotary movement, **photo 38**. Like the carriage front oil nipple it seems Myford went out of their way to hide this away from prying eyes. Unless you get on your hands and knees you might not spot it! Whether this has been changed on the later versions I do not know, but it would be simple to move the locking screw forward so it was visible from above without much effort.

Observant readers may notice that the rack lubricating oil nipple is missing from its hole, I borrowed it to fit to the rear cross slide for the modification. As this point doesn't need frequent lubrication I fitted another 2BA plug and remove this and screw in the correct nipple when it is time to use the oil gun. When I can obtain some new oil nipples it will get replaced. ■

Axminster self centring vice

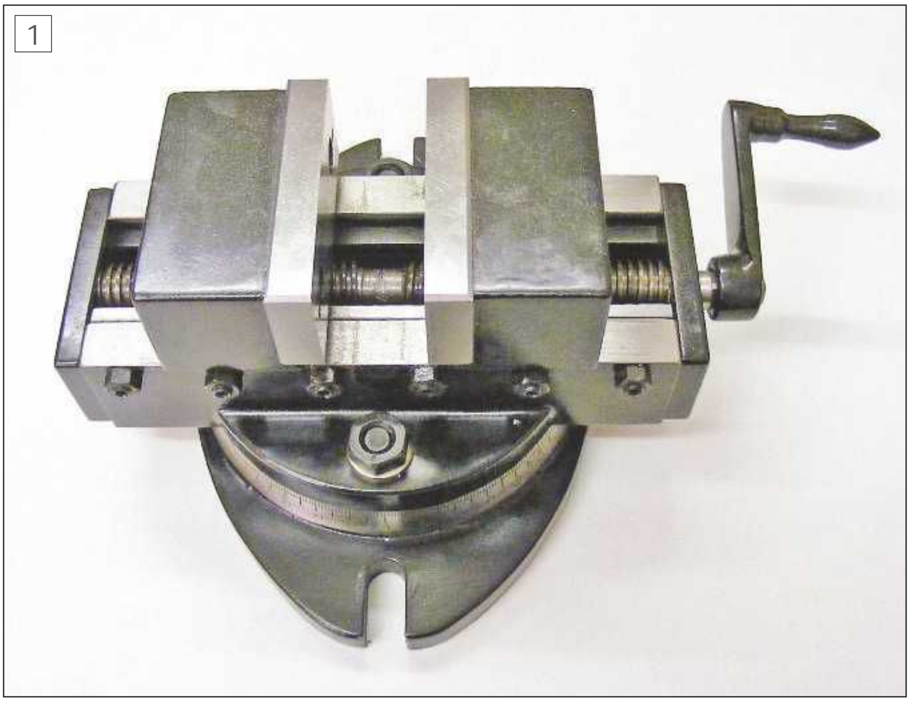
Mike Cox reviews an interesting new milling vice from Axminster Tools.

Axminster Tools have introduced a range of self centring vices to their product range. They are available in three sizes 50, 75 and 100 mm. This review relates to the 50mm vice.

The vice, **photo 1**, is very substantial, weighing in at 8.2 kg. The jaws are hardened steel and are 76 mm wide and 40 mm deep. The maximum jaw opening is 78 mm. The height of the top of the jaws above the mill table is 110 mm including the swivel base but this comes down to 83 mm if the swivel base is removed. There is a removable handle at the front of the vice.

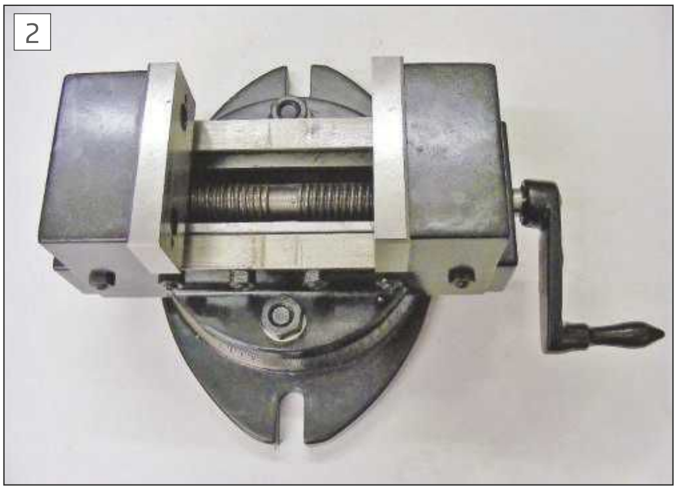
Both jaws slide in dovetails machined into the base and there is a very substantial gib strip on the left hand side together with a row of six gib adjusting screws. These are clearly visible in Photo 1.

Photograph 2 shows the vice with the jaws wide open to show the screw. The end of the screw closest to the handle is threaded with a left hand, 3.2 mm pitch, acme thread whilst the far end is threaded with a right hand, 3.2 mm pitch, acme thread. Thus when the screw is rotated clockwise then the far jaw is pulled in towards the middle of the vice and the near end is pushed in, both by the same amount. If the jaws are closed and set to line up with the mill axis and then a piece of parallel side bar is clamped in the vice the rotation axis of the mill will be down the centre line of the bar. This is a very handy feature for drilling holes or milling slots down the centre of bars.



A general view of the vice.

In order to test the accuracy of the self centring the vice was mounted on the milling table and the jaws adjusted parallel to the x axis using a dial indicator. A short piece of 10 mm silver steel was mounted in the mill spindle using an ER32 collet chuck, **photo 3**. This rod was lowered down between the jaws and the jaws closed onto it whilst adjusting the table feedscrews to keep the rod centralised between jaws. This roughly centralises the jaws on the mill axis. The jaws were then opened and a piece of 75 x 6 mm plate was gripped between the jaws just below the rod, **photo 4**. The distance between the jaws and the rod was measured both at the front of the



The jaws are fully open to show the screw.

The vice clamped around the silver steel rod.

vice and at the back of the vice using a digital calliper. The position of the table was adjusted until the distance from the rod to the rear jaw was the same as the distance of the front jaw from the rod. The table was then locked in position.

A series of metal plates were then clamped in the vice jaws and the distances between both jaws and the central rod were recorded. The measurements were repeatable to within 0.03 mm. These results are shown in **table 1**.

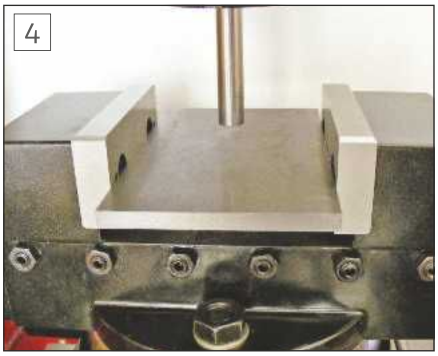
The results show that the difference between the front and rear measurements goes not exceed 0.11 mm over the entire range of jaw opening and thus the vice does provide a reasonably good self centring action.

The swivel base is clearly graduated over a +/- 90 degree range, see photo 5. Note the barely visible indicator mark on the upper casting.

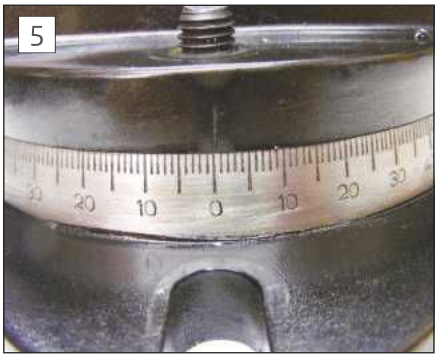
Conclusions.

The Axminster self centring vice is a very well made rugged piece of equipment and it has good accuracy and repeatability.

My only gripe is that the indicator mark for the angular scale on the swivel base is very faint and in some light it is barely visible. However, this is a trivial complaint since the visibility has been improved by just smearing a little white paint into the existing mark.



The vice jaws clamped to the 75 mm steel plate.



The swivel base scale and index mark.

Width of plate mm	Distance from front jaw to the rod mm	Distance from rear jaw to the rod mm
75	32.65	32.66
50	20.52	20.58
40	15.81	15.75
32	11.07	10.96
28	9.36	9.38

Table 1. Centring measurements

In our Next Issue

Coming up in issue 251
On Sale 27th January 2017

In the next packed issue of Model Engineers' Workshop:

Nick Thorpe tells the story of his Boxford lathe.

Jacques Maurel describes how to make and use a wishbone sharpener for small drills.

Warren Jacobs improves a tool height gauge.

Centec Mill Power Feed

John Harris automates the table travel on his milling machine

Although the company that made Centec milling machines went into liquidation over forty years ago in the early 1970's they are still a very sought after machines. Well made, accurate and originally aimed at industrial use; it is well worth the effort of improving what is a very useful machine. I count myself as lucky to have a late model Centec 2B with the fine feed quill vertical head.

Centec did offer a power feed option but my machine wasn't fitted with one when I bought it. The power feeds rarely appear for sale and when they do they are expensive. They also have a disadvantage, for me, in that the power feed motor is 3 phase and so would require an inverter or a new motor.

Having power feeds on both the leadscrew and the cross-feed on my lathe has made me appreciate what a boon power feeds are. After several years of plans to make a power feed, which got waylaid by more urgent jobs, the power feed is now a reality.

My design had to incorporate, in no particular order, these points; it had to be mounted in such a way as to not restrict access for T-nuts; it had to have controls in positions that didn't restrict the capacity of the mill; it had to have a drive shaft and dog clutch that could engage / disengage whilst the motor was running; it had to allow the milling machine to revert back to original if needed; it had to not to restrict manual operation; it had to be made as much as possible from materials 'in stock'!

At the time I first contemplated making a power feed my son was working as a workshop supervisor in a garage and was able to find me some 12 volt DC motors, windscreen motors and the like. One of these was a new seat motor, which would have otherwise gone into the skip. It was taken from a replacement seat being fitted to a van which was not wired for a seat motor. As it happened this design of motor was fortuitous in that it eased making a dog clutch which met my criteria.

I must acknowledge the ideas and information I gleaned from the Centec Owners Forum whilst I was designing my power feed, especially the idea of using a socket to transfer motion from the driveshaft to the leadscrew.

Photograph 1 is the plain bearing for the end of the leadscrew and the nylock nut which retains the leadscrew and adjusts any backlash. This is the only place where any power feed can be readily attached to the leadscrew. Instead of modifying the original bearing holder I made a new one, which also doubled as the support for the motor and drive shaft. An often used method to attach a drive to the end of the leadscrew is to replace the original nut with two thin locknuts, using the outer nut to attach to the drive motor. In my opinion there is a disadvantage with this method; I consider the nuts would be too narrow to have enough threads engaged to make a good attachment point for the drive. Also, due to the surface friction between the plain bearing face and the nut, they are likely to undo under stress. This is what happened to me with my first design.

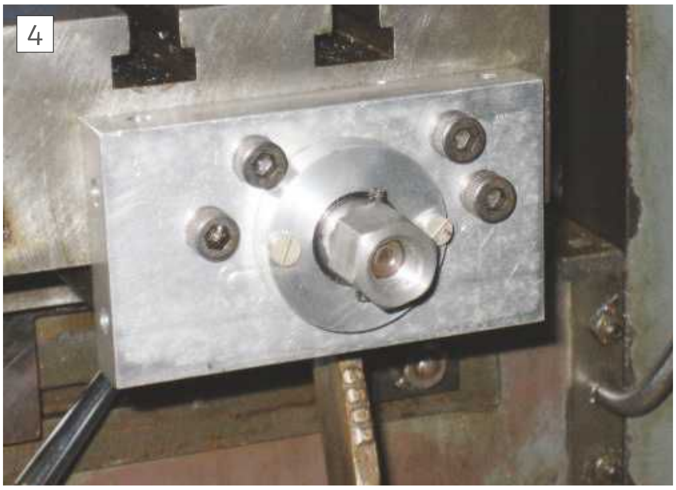
Photograph 2 is of 'toolmakers points' given to me by an ex toolmaker. These were invaluable in making the bearing cum support plate. The original leadscrew bearing was held in place by two 2BA screws but it appears the power feed models used four screws, which I think is preferable, taking in to account the weight of the motor and driveshaft to be supported.

I used a piece of 1/2" thick aluminium plate for the bearing plate. I bored a hole in the horizontal centre the same size as the leadscrew. I then made a dummy

Original bearing

'Toolmaker's Points'

The support plate

4

The finished plate

5

Motor end plate

leadscrew end which was used to align the original bearing plate over the new bearing cum support plate. The two holes for the existing 2BA screws were spotted through and two close fitting holes drilled. Two of the 'toolmakers points' were screwed into the two extra screw holes in the end of the table, using the modified Allen screws as screwdrivers. The points protruded about 30 thou from the end of the table. The new bearing plate was fitted over the end of the leadscrew and the two original screw holes used to pull the plate tight against the table. The 'toolmakers points' accurately marked the position for the second pair of holes.

Photograph 3 features the bearing-cum-support plate and bearings. As mentioned previously, friction between the bearing and a nut screwed on to the leadscrew can cause the nut to undo so I decided to reduce the friction as much as possible by using a ball race for the nut to pull up against. A thrust race and a ball race would have been better but there was not enough room. The plate was bored out to take the plain bearing I made from phosphor bronze. This bearing was held in place by a grub screw. Unfortunately Centec used what is a common practice of using odd sizes for their bearings, a practice which is intended to make spares only available from the makers! The leadscrew bearing is 15/32" ID and ball bearings of that size appear to be unobtainable in the UK. Luckily 12 millimetres is within 4 thou of the size I needed, so with the aid of Loctite 'bearing fit' I could use a metric bearing, obtainable over the counter at the local bearing stockist. A bearing support ring was made together with a short length of double diameter shaft (15/32" and 12mm) to ensure that the ball bearing lined up with the plain bearing. The bearing holder was held in place with two 4BA screws from 'stock'. There is a mixture of Imperial and Metric fasteners used on this project as I used what was 'in stock'!

Photograph 4 shows the finished support plate and the nut which transmits power to the leadscrew. The hexagon of the nut was made to fit an available 5/8" AF socket which is attached to the driveshaft. The nut is reduced at the bearing end so it only comes into contact with the inner race of the ball bearing. To make sure the nut would drive the leadscrew it was cross drilled and tapped 6BA. Two grub screws were used to clamp the nut to the leadscrew. To avoid damaging the threads on the leadscrew, when the nut had been adjusted to eliminate leadscrew backlash, the grub screws were removed one at a time and a sharp drill was employed to drill into the thread of the leadscrew, giving clearance for the 'dog point' on the grub screws. If I need to adjust the leadscrew backlash in the future I will have to modify the leadscrew by turning away the threads where the grub screws locate.

Photograph 5 is of the end plate of the seat motor and the conversion ring used to adapt it to become a power feed motor. The conversion ring was needed to provide a mounting point for the motor. As standard the motor didn't have any suitable mounting points. The end plate of the motor is made from steel so could be welded/brazed. The body of the motor gearbox is plastic. Odd lugs and protuberances were cut off the end plate and the paint was stripped. The mounting ring was made to be a snug fit over the motor output shaft bearing, leaving about 5/16" protruding. The two parts were brazed together and then painted.

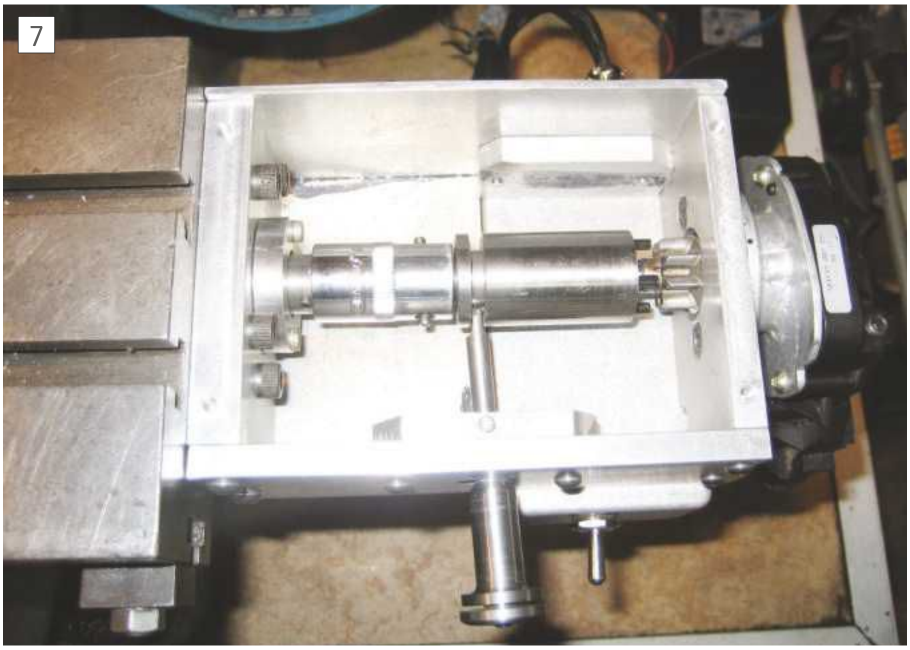
Photograph 6 shows the completed motor conversion. The motor mounting end plate of the power feed is a simple rectangle of 5/16" aluminium. A hole, which is good sliding fit for the motor output bearing housing, was bored. This hole had to line up with the hole in the bearing cum support plate. Two clearance holes for 5mm screws were drilled in the motor mounting plate and spotted through onto the motor conversion ring, and then the conversion ring was drilled and tapped 5mm.

Photograph 6 also shows the parts of the 1" diameter driveshaft with the motor. The length of the driveshaft was decided by the depth of the motor output gear which was to be part of the dog clutch; the length of the socket; the length of the driveshaft support bar; the movement needed to operate the dog clutch.

The output of the converted seat motor is a gear, the centre of which is tapped 6mm. This feature helps to support the driveshaft. A length of 3/8" steel bar was reduced and threaded 6mm at one end and the opposite end was rounded and polished. The driveshaft was drilled

6

The completed conversion



The internal mechanism

The power supply please note the wires at the bottom are 12V DC the mains supply is pre-wired and enters at the top.

and reamed to 1/2" and a 3/8" ID 1/2" OD Oilite bush was pressed in. This keeps the driveshaft in line with the motor output shaft, assisting the smooth operation of the dog clutch.

The PCD of the gear wheel was calculated. The driveshaft was centred in a four jaw chuck which was then mounted on the rotary table. Four 1/8" diameter holes were drilled 1/4" deep in the end of the driveshaft on the PCD. Then four 1/2" long roll pins were driven in. This is the driven part of the dog clutch. The driveshaft slides on the support bar and the four roll pins engage/disengage with the motor output gear. The other end of the driveshaft is reduced to 1/2" and the 5/8" AF socket is attached with a roll pin. With the dog clutch engaged this socket drives the nut on the end of the leadscrew and thereby moves the mill table. The socket also supports the end of the driveshaft.

Photograph 7 shows the finished internal mechanism. The length of the side plates of the power feed were determined by the driveshaft length. The dog clutch operating lever is mounted on the centre line of the driveshaft. It is a length of 1/4" steel bar pivoted midway along its length. The inner end of the operating lever is reduced to 1/8" in the mill, taking 1/16" from each side and the end is radiused and polished. The width and depth of the slot in the driveshaft was calculated by measuring the arc that the end of the lever would have to travel to move the dog clutch in and out of engagement and, importantly, not come out of the slot. The calculation produces a wider and deeper slot than a guess would have given! The outer end of the lever was threaded 1/4" BSF and a sprung loaded handle was made. The slot in the side plate for the operating lever was shaped with a ball end milling cutter to provide positive location for the handle.

Photograph 8 Shows the power supply.

Finished power feed

This is an AC transformer with a 5amp output that I had in stock. A friend supplied the rectifier to provide the DC current that is needed. He also explained a crude but effective way of discovering what amperage I would need from a power supply. This involved having an ammeter in a 12 volt DC feed to the motor, such as a car battery, and grasping the output shaft of the motor with water-pump pliers. The idea is not to stall, or burn out, the motor but to slow it in the same way a load on a power might occur. The ammeter will give a reading which will indicate the size of fuse the motor will need.

The wiring layout is very simple, the 12 volt DC feed comes via a 5 amp fuse to a three position, OFF – ON - OFF double pole switch and thence to the motor. The switch and fuse is mounted in an aluminium box that was 'in stock' which is screwed to the bottom of the power feed mechanism. The switch lever points in the direction the bed moves.

Photograph 9 is the finished power feed. I am pleased with the power feed and it is a definite improvement to the mill. It meets all of the conditions I set at the outset; I can slide T-nuts into their slots with no trouble; the mechanism does not interfere with the size of things I put on the mill; the dog clutch works as smoothly as I hoped; the motor is not stressed.

There is only one 'but' and that is the speed. The motor revolves at 42 rpm and with a 10 TPI leadscrew that is only four inches of travel a minute. This is great for a finishing cut but a bit slow when, say, returning the table. If I was starting again I would look for motor with a spindle speed of 300 rpm and use a Pulse Width Modulator to control the speed.

However, there is a big plus with this design, it works and it can be modified to go faster. The seat motor output gear and shaft is a large enough diameter to accept another motor driving it. On eBay there are numerous 12 volt motors which could be used. I can feel another project coming on! ■

One Man and His Seven Lathes

Jock Miller in New Zealand describes a selection of unusual machines, illustrated with photos by Peter King.

Over the last few years, readers of MEW have been treated with numerous articles describing various owner's views on commercial lathes, the refurbishment of them and descriptions of their workshops; all most interesting.

This article describes the original and six descendants of a locally built small 'bench lathe' all constructed in Canterbury in the South Island of New Zealand, 12,000 miles from the U.K.

'Bench Lathe' – if readers care to obtain or view a copy of Lindsay Publications' 1987 reprint of *Modern Toolmaking Methods*, 1915, by Franklin D. Jones, (ex-Camden Booksellers) - Chapter 14 has many illustrations of the use of a 'bench lathe' in the USA. Hardinge and Cincinnati were among the many manufacturers of these high accuracy small machines that generally had many special attachments and were used for the manufacture of small high value components.

Today CNC lathes probably supersede these machines which were generally labour intensive in industry. However, for those that want to advance their skills in machining even though it is 100 years old the above volume is very informative.

So "One Man and His Seven Lathes". Early history is a little vague unfortunately; in Timaru (a town today of about 35,000), 160 kilometres south of Christchurch. An elderly Model Engineer was to tell me of his meetings as a schoolboy with "Bill Atkinson" - the machinist who built the first machine - but he had passed away before that happened.

1

The first machine, lathe 'A'

The story starts with "Bill Atkinson" setting up a small machine shop in downtown Timaru in the basement of a professional photographer, a Mr Kingham probably in the early 1930's.

We believe Mr Atkinson came to N.Z. from the Midlands U.K. in the early 1930's and was commissioned by Mr Kingham to build and equip a small 'Bench Lathe' (3" centre height by 12" between centres) to facilitate camera repairs. Both Messrs Atkinson and Kingham died before WWII.

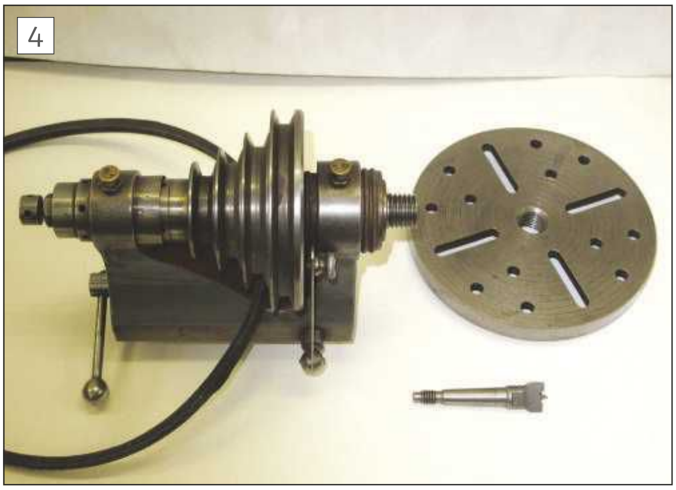
About 1946 this lathe, 'A', **photo 1**,

2

Headstock of lathe A

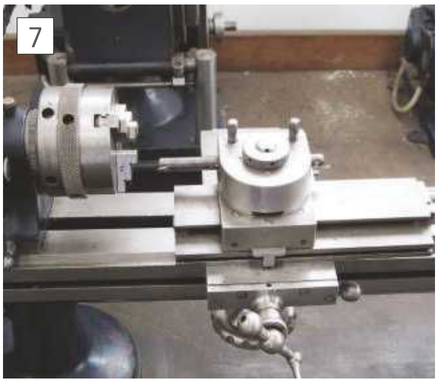
3

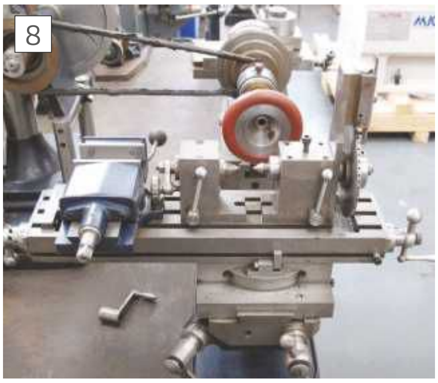
Carriage of lathe A, note the cantilever bed design


The original headstock of lathe A, later re-used in the first incarnation of Lathe


Lathe D, now a 'museum piece'


Drive arrangements for lathe D


Compound slide of lathe D


Horizontal mill table at headstock end of lathe D

surfaced and my father, the late J.O.S Miller, was able to purchase it. Dad had no hesitation in buying it from Mr Kingham's estate, as early in WWII he obtained a very good heavy 10" travelling head hand shaper built by Bill Atkinson, probably in the early 1930s. This machine I still have and with a cut in steel of 1/8" x 1/32" and 270° of the rack pinion and handle, about 25 strokes and a rest was required! It is still within 0.001" parallel to the table in 10 inches.

The lathe (as purchased by my father) was set up on a good bench as a treadle machine with a 16" diameter 3 step flywheel for a ¾" wide leather belt. The lathe, flywheel, attachments and small tools were all contained in a strong Kauri "Sea Chest" complete with two sets of drawers containing a mass of small tools including a set of "P & W" Whitworth taps and dies 3/32" to 1/4" in 1/64" steps and several pitches.

Initially Dad motorised the treadle in 1947 and then made a separate drive with a double ended "Hoover" ¼ H.P. four-pole motor with two A-section belts to a lay-shaft where the belt pulleys run free on ball-races. A dumbbell double ended dog-clutch picks up the fast or slow speed to the lay-shaft. A four-step "M" section belt pulley then drives the headstock. A lever with a cam plate can elevate the back of the unit to facilitate belt changing.

Very soon the original headstock, a brilliant piece of toolmaking with hardened steel conical bearings, **photo 4**, was replaced with a heavier hollow spindle, **photo 2**, with 1 1/8" dia pre-loaded angular contact ball bearings at the chuck end and plain 1" bore ball bearings at the outer end.

The hollow spindle (5/8" bore) is actually bigger than a Myford ML7, has a Myford ML7 nose, a 40° taper for collets and a large index wheel with 60 and 100 holes. The bed is 25" long and has full length "T" slots on top and sides, with the top edges bevelled at 45°.

The compound, **photo 3**, has an adjustable square locating on the front 45° bevel of the bed and clamped to the bed by a handle underneath. This type of machine has a long top-slide with degree graduations for tapers. Both slides have 3/8" dia x 10tpi square thread feed screws.

The tailstock is conventional and has a knock out rod for centres and other tools. The lathe bed has been extended to provide a parking place for the tailstock when not in use and as an aid to using the top-slide.

This machine is now operating amongst


Spare steady for lathe at right...


10

The author's Lathe, version E


11

Drive arrangements for lathe E


12

Drawer of accessories for lathe E


13

Another cupboard full of accessories

the extensive collection of machine tools by a professional mechanical engineer, John Thompson, at his residence on Banks Peninsula. John helps in keeping the Air New Zealand national airline airliners from 'losing their wings'.

Now for The Beginnings Of Multiplication

A Timaru Model Engineer, George Martin junior, was foreman in the tool-room of a local industrial pottery factory (porcelain fuse holders, street pole insulators and the sole source during WWII of New Zealand Railway (NZR) railway cups and saucers). He had built a 6" centre height lathe and a 3 ½" gauge NZR Ab Pacific Loco in 1947. When he saw the original 'A' lathe, he decided that he would construct three more – 'B', 'C' & 'D', with some variations in design. He made one for himself, one for his father, George Senior - a pattern maker, and one for another Model Engineer in Timaru. Castings were produced and five sets were made. He machined five beds on a 12' planer at the foundry. All three (B, C & D) were each set up on a bench with drawers underneath and with his version of the head-stock plus a complete small milling machine using the left-hand end of the lathe spindle and his own style of drive unit from a single phase motor. Additionally, a ¼" diameter capacity M.E. drill press plus a hand vice were set up on the benches.


14

Lathe F

Lathe B, we understand is in Auckland where George Junior retired as he had family there. Lathe C we understand is somewhere in East Christchurch. D is now an exhibit in the Machine Tool Showroom of the local machine tool supplier Scott Machinery. This was George Martin Senior's machine, **photos 5,6,7,8** and **9**. Note the spare fixed steady for the little lathes and a Pallas horizontal mill in very good condition, (the Rev. Ian Strickland should appreciate it!)

We now come to lathe 'E', **photo 10**. As I was becoming interested in engineering so Dad purchased one of the five completed beds and the raw castings for the tailstock and the compound (for £5-00 NZ). As the original redundant headstock, in photo 4, was available and a drive was 'bodged up' from the temporary treadle drive I was able to set up my lathe and by borrowing Dad's compound carry out a little turning. The compound ball handles were turned freehand at the age of 13 years, about 1950. As time went by a new tailstock and the compound were manufactured as a 'father and son' project (using the hand shaper!) Later while an engineering student I was able to machine a new headstock to Dad's design, except the spindle nose is like the 'L' Series (on some Colchester Lathes) with the cone 35° and 5/8" bore spindle with 40° taper for collets. The back-plates have a key-way and a 2 3/16" x 12 tpi external thread and a captive nut. I designed a new drive, **photo 11**, with a Newman 1/3HP 4 pole single phase motor driving a purpose built 4:1 variable speed belt drive to an oil filled gearbox with 19/60 and 19/60 14 DP steel and Tufnol gears and a selection lever –which at 1:1 and 10:1 gives 800-3000 and 80-300 rpm at the spindle. Duplex "M"


Drive arrangements for lathe F


Lathe G, note the different bed

belts 2:1 drive to the headstock. The spindle has a 7/8" dia. extension at the non-chuck end, this was made in about 1958.

As time went by many attachments have been made or accumulated, **photo 12** and **13**:

(a) Thread chasing using a pair of small 4 track linear bearings with master screws on the mandrel for 19 to 40 tpi and 0.6 to 1.5 mm pitch. For threading up to 40 mm long.
(b) Vertical slide and vice.
(c) Tool-post indexing 8-way (3/16" SQ HSS).
(d) 4 way rotary stops on the compound for cross and long travel (like on a Herbert capstan.
(e) 5 way tailstock turret for 3/8" dia tooling.
(f) Worm and worm-wheel (60:1) index on the spindle in addition to the 60 holes in the belt pulley.
(g) Various chucks – 3 ¼" and 4", Griptru 3 jaw, 3" TOS 4 jaw S.C. independent 4 jaw 4 ½" Burnerd, and more recently a pair of Swiss Reishauer 80mm diameter step chucks
(h) A fixed steady.
(i) Simple indexing attachment, centred on the lathe axis either radial or parallel to the lathe axis using the Headstock collets and other fittings.
(j) 6" diameter faceplate.
(k) ER 25 and ER 50 collet chucks.

The gearbox now has a Coventry Gauge and Tool multi-plate clutch which saves single phase motor multi-starts. As an indication of my use of the machine I last year replaced the worn feed screws in the compound slide.

Lathe 'F', **photo 14**, the fifth of the 5 sets of castings was made up by the father of the current owner of 'A' and is now not operational. It used my father's spindle design, photo 15.

Lathe 'G' is shown in photo 16; the late Frank Currie, a tool maker, self-employed general engineer and then president of the local Model Engineer Club decided to build one. He constructed the bed from a cast iron printer's roll, used Dad's pattern for the headstock and made a pattern for the tailstock. He then got the castings and machined them, purchased bearings


Accessories for lathe G

and a 3 jaw self-centring chuck and other bits, photo 17, but unfortunately passed away before completion. Kelvin Lewis a professional electrical engineer and Model Engineer completed it with a 1:1 and 5:1 version of my gearbox driven by a 3-phase motor and V.F.D. using the modern poly-V belts, photo 18, and my version of the chuck back-plates, it was completed in 2000.

VFD drive control system for lathe G

Conclusion

All the clones have been completed to a high standard and are all capable of good work. My father completed a 3 ½" gauge four-cylinder LMS Princess Royal, a 5" gauge Caledonian Railway 4-4-0, Dunalastair III, as well as other models.

I have completed a 3 ½" gauge Lion and am currently building a 7 ¼" gauge NZ Canterbury Railways 1873 Neilson 0-4-0 broad gauge locomotive.

Now before the armchair safety experts start jumping up and down, the old-style open belt final drive to the lathe spindles have not proven a hazard (after 65 years I still have all my fingers undamaged). In fact, when the power is off or the clutch disengaged a great facility is to turn the spindle to use and back-off small B.A/ taps and dies without damage and position the chuck for easy access for the key operation and work set-up etc. Safety is learned by good practice, common sense and education not by a proliferation of rules extra guards; safety switches etc! ■

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YOUR CHANCE TO TALK TO US!

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

Dear Neil, I enjoyed and agree with your reviews and findings in your article on Digital Calipers in MEW248.

My "workhorse" Digital Caliper on the mill is a 4 inch or 100mm Caliper. I find that anything larger is hard to use as it won't "fit" under the milling head. I also have a Mitutoyo 200mm Digital Cailper for other jobs.

I once bought a nice Chinese pair of Digital Calipers through eBay, I think they cost about AUD$30. They were beautiful to use and very smooth in operation but after a while I found that the Caliper readings did not agree with movement of the table as shown on the Mill Digital readout. I eventually worked out that as the battery in the Digital Caliper ran down the Caliper gave an incorrect measurement. As it is impossible to know when the battery was going flat I threw them out.

I now always use Mitutoyo Digital Calipers as they have always given correct readings and have never let me down and the battery lasts about 4 to 5 times longer than in the cheap Calipers. In my opinion the Mitutoyos are worth the extra money.

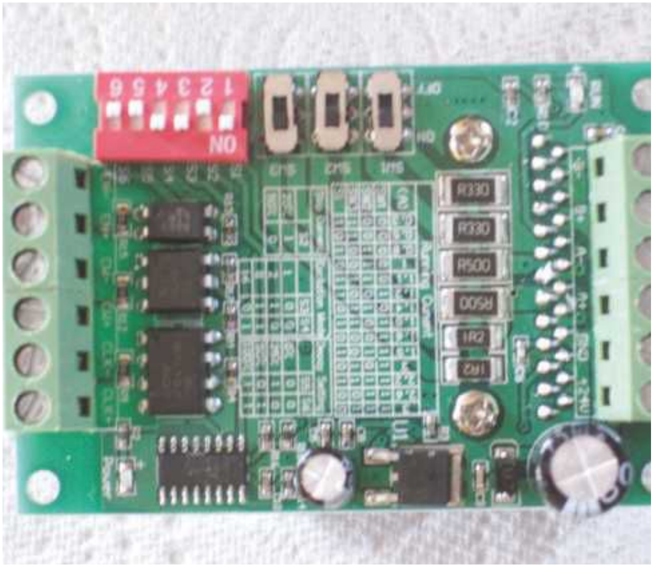
Peter Darveniza, Ballarat, Victoria, Australia

Arduino Rotary Table

Dear Neil, The photo shown is captioned as Toshiba TB6960 Driver Board (MEW 249). I have only been able to find a TB6560 Driver Board matching the photo.

Colin Binnion, by email

Carl confirms the correct number for the board is TB6560, head for www.-model-engineer.co.uk for enthusiastic discussion of both the Arduino projects in our last issue – Neil.



Camera Adaptation

Dear Neil, just a few words in reply to Victor J Croasdale's letter in the Nov issue (MEW248) regarding my disabled camera adaption.

Victor gives a great solution to the inability to use a tripod, but unfortunately the user would not be able to assemble the camera onto any other device or tripod due to her disabilities. But I am tempted to use Victors suggestion for when I use the camera, because it will save me the bother of dismantling the device.

It is a one-off adaption, but I hope it inspires others to develop solutions for their less able bodied family members or friends.

And those woodworking router bits work okay on aluminium too!

Ian Johnson, by email

Hexagone

Dear Neil, I have just read the letter in your October issue about milling a hexagon from round bar.

Can I suggest another way?

Clamp the round stock bar in a vice or straight onto the bed using a tee slot to align it. Then machine the two opposite sides to give the correct "across the flats" size you require and then using an engineers protractor simply re-clamp the bar at 60 degrees to the machined surface and repeat the machining operation, repeat for the last two sides.

This is the way I used to do it when in a hurry!

John Knight, Goulceby, Lincolnshire

Cone-fusion

Dear Neil, I am grateful to Henk Slinggerland for correctly pointing out an unfortunate error in my article on cones, in MEW issue 241. This seems to have arisen because of an omission in fig. 3, and my own lack of concentration. I apologise if anyone has tried to make a cone using the calculation in that article, as they will have found it doesn't measure up to expectations. The cones shown in the article were made to correctly calculated sizes, and fitted perfectly. Tidying up the calculations at a later date, for publication, was clearly not as perfect.

Good old fashioned technical drawing uses the concept of a 'true length', and that applies to a situation where the various lengths and angles are calculated, just as much as to a drawing. If fig. 3 had included the true length of the cone, as I had intended, the problem might have been avoided. There is much to be learned from cones, so I hope I might be permitted a future explanatory article to clarify the key concepts. My sense of embarrassment may eventually subside.

Marcus Bowman, by email

I have asked Marcus to prepare the explanatory article, which will cover other useful points about preparing such drawings - Neil.

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

Write to The Editor, Neil Wyatt, Model Engineers' Workshop, MyTimeMedia Ltd., Suite 25, Eden House, Enterprise Way, Edenbridge, Kent TN8 6HF. Alternatively, email: neil.wyatt@mytimemedia.com

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Protecting Hobby Workshops and Equipment

Sadly, a small proportion of readers have their workshop burgled or affected by fire or flood. We've asked insurance specialists AXA to produce this useful guide for MEW readers.

- 95 per cent of the UK population says they have a hobby which uses equipment both inside and outside the home2
- One in four AXA home insurance claims are for accidental damage both inside and outside the main home1
- Thirteen per cent of all home insurance claims are due to forcible entry or exit, while 11 per cent are for accidental loss
- AXA discusses home insurance cover for model engineers looking to protect their workshops

Model and hobby engineers spend years searching for, purchasing, bidding-on and maintaining their equipment, however some may not know that they are inadvertently putting their workshops at risk by not having the right type of insurance policy.

One in four AXA home insurance claims are due to accidental damage, whilst forcible entry or exit and accidental loss make up 13 and 11 per cent of claims respectively, showing just how vulnerable the pride and joy of model engineers can be.

To help matters, AXA Insurance has put together a handy guide to show you where to start when it comes to protecting your workshop, tools and equipment, as well as information on what items may not be covered and how you can you work with your insurer to provide peace of mind.

Photo: Lyndon Baugh

Your Model Engineering Workshop

No two workshops are the same, which is why it's so important that you get to know yours from a protection point of view so that you can try to cover your equipment as much as possible. Even small items such as tools, storage and models can all hold certain value, especially if you add up how much you spent on them over the years.

To help matters, make a list of everything in your workshop so you know exactly what needs to be covered and their relative costs, that way you won't find that you're missing out on cover just when you need it most.

Storing your tools

It's extremely common for model engineering enthusiasts to have their own workshops at home, whether they are in the main home or an outbuilding such as a garage or garden shed. The important thing to keep in mind is that your home insurance policy may provide varying levels of cover depending on where your tools are stored.

At AXA Insurance we offer our customers three levels of cover to suit differing budgets and requirements. HomeSmart is the most basic level of cover, followed by HomeSure and HomeSafe.

One thing you will notice regardless of the level of home insurance cover you choose from AXA is that contents cover inside the home has a higher maximum sum insured (HomeSmart: £75k, HomeSure: £85k, HomeSafe: £100k) than contents in outbuildings (HomeSmart: £2.5k, HomeSure £2.5k, HomeSafe: £5k)3. If you are unsure whether your workshop constitutes as an "outbuilding" then it's important you talk to your insurance provider.

Single Valuable Limits

One thing to keep in mind when it comes to home insurance is that there is often a difference between your contents cover limit and your "single valuable" limit. Put simply, your contents cover is the total amount that can be paid out should the insured contents of your property be stolen and/or damaged, whilst a single valuable limit is how much a single, "valuable" item is covered for4.

With AXA Insurance, "valuables" are classified as jewellery, items containing gold, silver or other precious metals, watches, paintings and other works of art, stamp collections, coins and medals. Therefore, your tools and equipment are unlikely to be determined as "valuables" (even though they may be to you!) unless they contain gold, silver or other precious metals.

The good news is that this means that your tools and/or equipment may not be subject to a single valuable limit – however don't forget other limits in your policy may still apply, so always check to be sure.

Using your Tools for Business Purposes

Throughout 2016 AXA Insurance has been promoting their Live Boldly campaign which encourages people to take up new hobbies from sports to crafts to pastimes such as model engineering. Throughout the campaign, we have noted that the UK is a nation of keen hobbyists, with 95 per cent of the population saying they have a hobby.

One thing that also became aware throughout the campaign was the fact that some people choose to turn their hobbies into professions, and model engineers are no different. However, if you do use your tools for business purposes (such as making models and then selling them online), you must make sure you have specialist business insurance.

Even though AXA's contents cover

provides a certain amount of protection for business equipment, this is for "clerical items" only (e.g. computers, modems, keyboards, monitors and printers), so if you do decide to turn your passion into a business you will likely require a separate business insurance policy, as customers who run businesses from their homes aren't always eligible for AXA home insurance policies.

Jyoti Bird from AXA Insurance says "Model engineers are extremely dedicated, often spending thousands of pounds investing in specialist equipment, which is why it's so important that you protect your workshop whether it is inside or outside the home.

"Unfortunately, some people forget that they need to take special care when it comes to protecting their workshops, so to help customers AXA offers three levels of home insurance cover. However, the most important thing to always keep in mind is that you check your policy so that you know exactly what is covered and how. If you are ever in doubt, make sure you call your provider for more information."

Accidental Damage Contents Cover and Personal Possessions Cover

If you are looking to extend your home insurance policy so that you are covered for even more eventualities, then you may want to look into adding accidental damage or personal possessions cover.

If you have not heard of these types of cover before, the simple definition is that the former protects your contents from accidental damage, whilst the latter protects items that you take outside of your property5. However, as with contents cover, the amount your possessions are covered for either with accidental damage and/or personal possessions cover will vary depending on your policy, where your tools and equipment are stored and how you intend to use them.

For instance, it's important to note that in many cases accidental damage cover does not include mechanical or electrical breakdown or failure. At the same time, personal possessions cover enables you to take your contents outside the home anywhere in Europe for as long as your policy is in place.

With AXA, accidental damage contents cover and personal possessions cover are included in our HomeSafe policies and can be added to our HomeSmart and HomeSure policies as optional extras.

Summary

With AXA receiving hundreds of thousands of home insurance claims every year, you can see why it's so important to pay close attention to your home insurance policy as it enables you to not only protect your workshop but also your passion.

After spending so many years investing in your workshop, the last thing you want is to find out that you're not covered for as much as you thought. Your home insurance policy documents will include information on the cover that is provided depending on your circumstances, so if in doubt always look to these first.

There are often a number of options to choose from when it comes to home insurance, so make sure you explore all your options to help keep your workshop and its contents safe.

To find out more, including where you can compare levels of AXA Insurance's home insurance cover as well as read full policy details, please visit: http://www.axa.co.uk/insurance/personal/home/

NOTES

1. Statistics from AXA home and motor insurance claims for policies incepted or renewed between January 2014 and December 2015. Data only includes settled claims with an incurred amount where loss date is before 1st July 2016 and within 365 days of policy year start date.
2. Research commissioned by AXA of 2002 UK residents. The research was carried out by Opinium in May 2016.
3. Terms & conditions, limits and exclusions apply for all levels of contents cover (HomeSmart, HomeSure, HomeSafe) and cover limits.
4. Terms & conditions, limits and exclusions apply for all levels of contents cover (HomeSmart, HomeSure, HomeSafe) and single valuable limits.
5. Contents cover required for accidental damage and personal possessions cover. Subject to a valid claim, excesses applies, repair or cash may be offered. For full terms & conditions, limits and exclusions, please visit: http://www.axa.co.uk/insurance/personal/home/ ■

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- **A visit to the French n/g Railway Museum in Friossy**
- **Tales from the SMEE Collection:** Professor Chaddock's Experimental Steam Turbine Plant
- **A redesigned cab for the 7¼ inch gauge GWR 14XX**
- **Under type Hot Air Engine – Developments**
- **BollAero .49**

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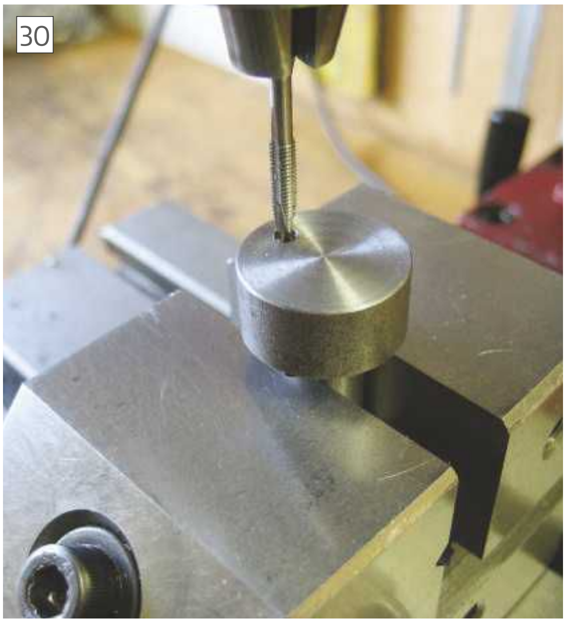
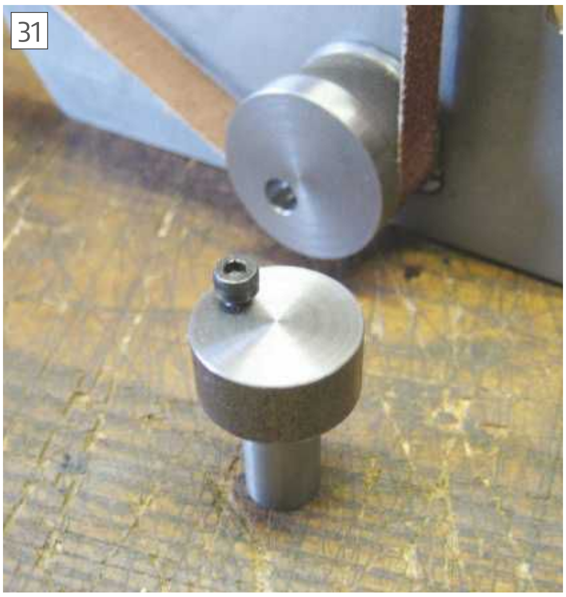
ON SALE 6 JANUARY 2017

A Miniature Belt Sander for your Lathe

This step-by-step guide from Mogens Kilde explains this a useful addition for any workshop.

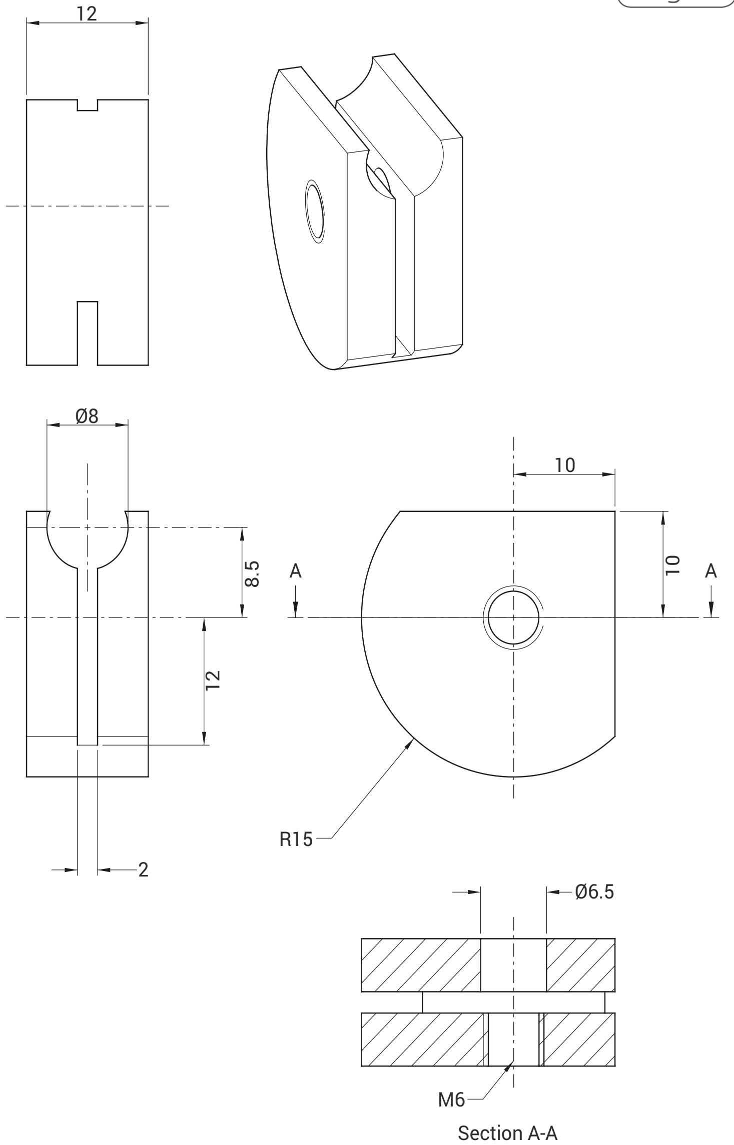


The part was placed on the bed of the bench mill and after zeroing in the part, the M3 tapped hole was drilled and tapped, **photo 30**.



A M3mm bolt was mounted and the driver was ready for action, **photo 31**.

Fig.8

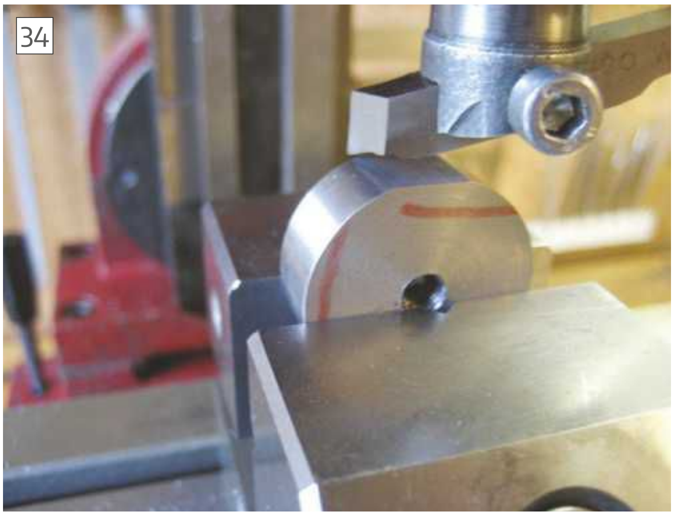


Adjusting Bracket

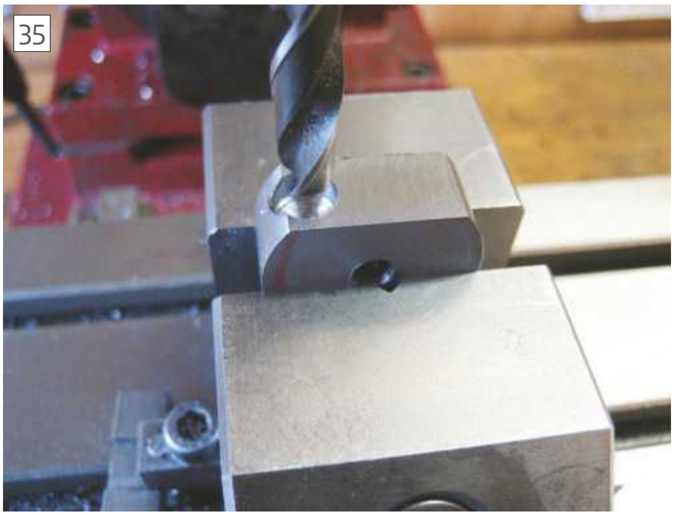
The next part made was the bracket that was going to support the grinding plate, **fig. 8**.

This part was made from 30mm diameter free machining steel. First, the M6 tapped hole was drilled and tapped in the lathe and the 6.5 clearance hole was drilled, **photo 32**.

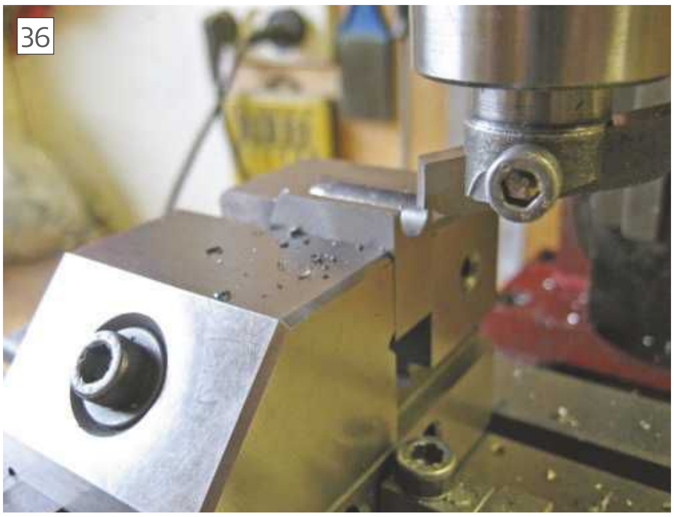
Next the part was cut a little oversize with a hacksaw and the part was faced off to a final dimension of 12mm in width, **photo 33**.



Next the upper face was milled, **photo 34**.



An 8mm hole was drilled perpendicular to this face, **photo 35**.



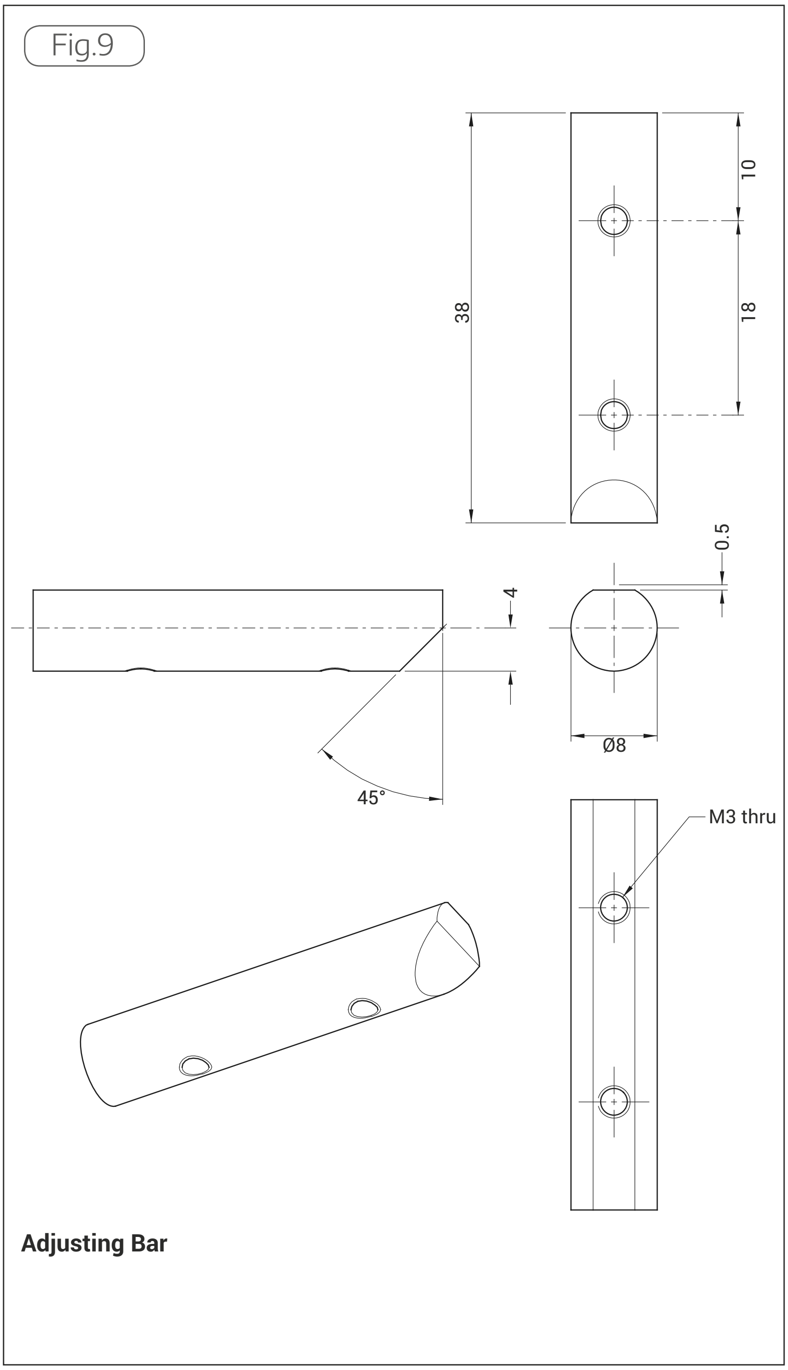
The part was turned over in the mill vice and the next face was milled according to the drawing, **photo 36**.

Final job on this part was to mill out a 2.0mm wide slot, this slot would enable me to lock the grinding plate in any wanted position when using the tool, **photo 37**.

This bar was made from 8mm free machining steel. After cutting off the bar a little over size according to the measure in the drawing and faced off to final length in the lathe, the part was taken to the mill and the upper face was milled, **photo 38**.

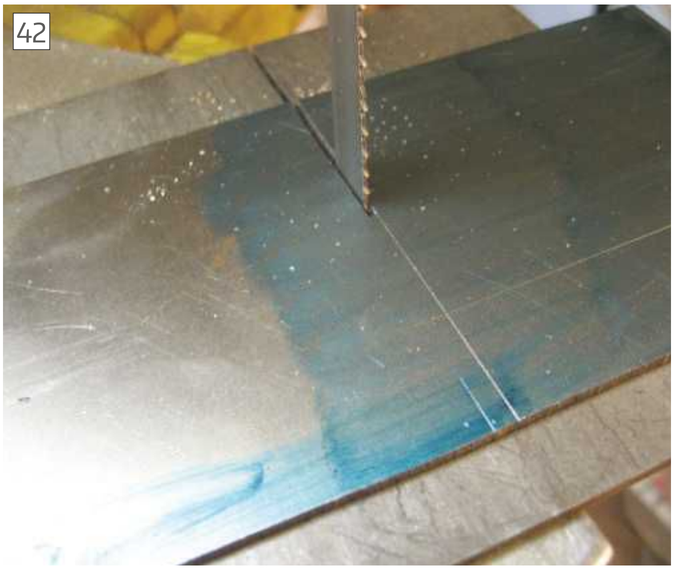
The two M3 tapped holes where drilled and tapped, **photo 39**.

Finally, the 4 x 45° chamfer in one end was filed, **photo 40**.

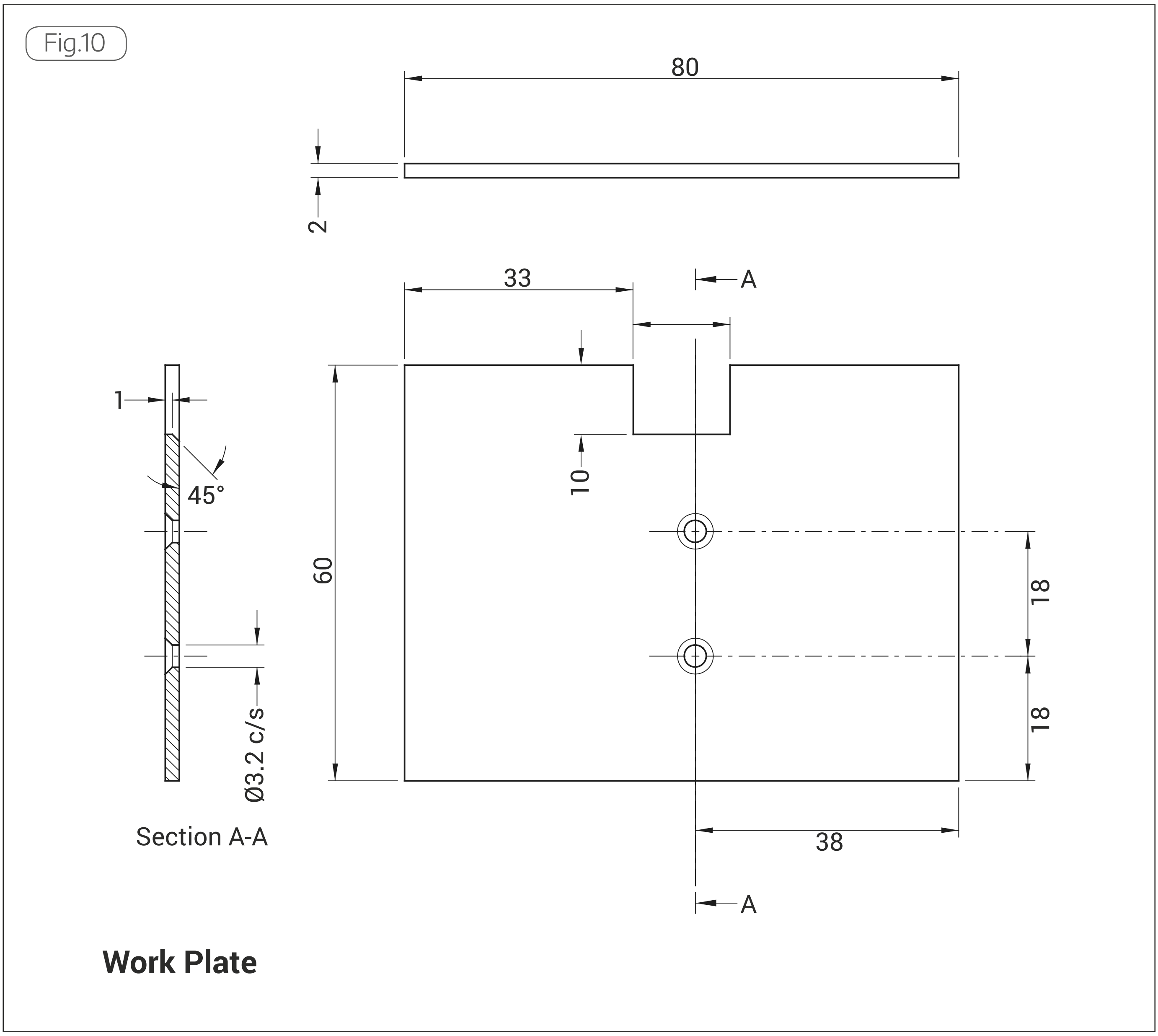


The next part was the sliding bar for the grinding plate, **fig 9**.

The bar was mounted in the grinding plate bracket and the adjusting and locking function could be tested, **photo 41**.

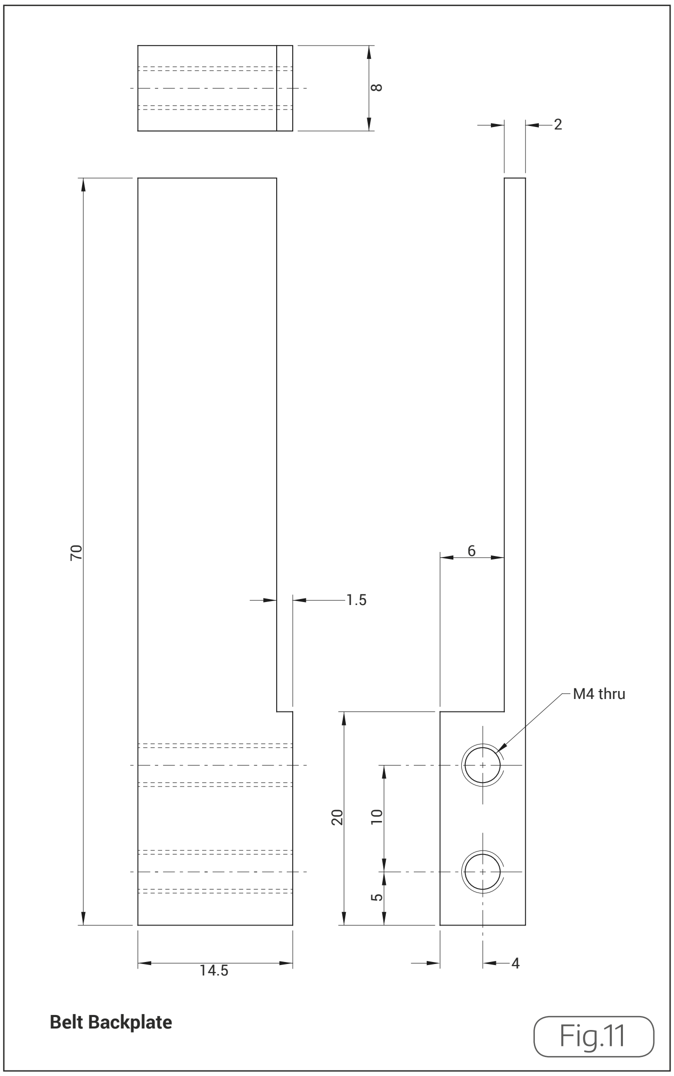


The grinding plate was made from 2.0mm mild steel plate. After marking the outline on the plate, the shape was cut roughly on the band saw, **photos 42 & 43**.



Next part in the project was to make the grinding plate, **fig 10**.

And the final outer shape was finished using appropriate files, **photo 44**.



Belt Backplate

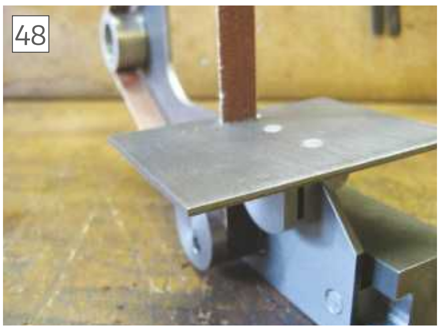
Fig.11

Next the two counter sunk 3.2mm holes were marked and centre punched, **photo 45**.

The final part I made was the back plate for the grinding belt, **figure 11**. This part was made from 8mm mild steel plate.

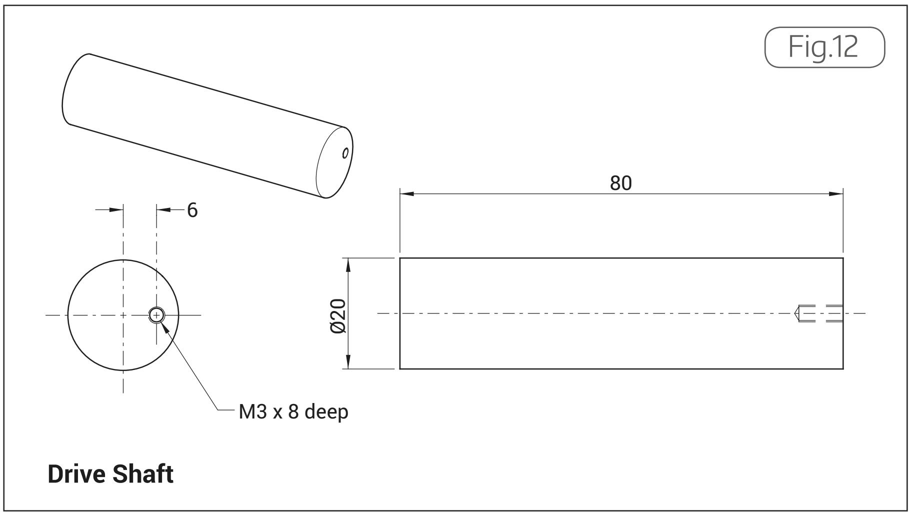
The holes were drilled and chamfered in the drill press, I worked carefully to get the correct depth of the chamfer to ensure that the head of the screws was exactly flush with the upper face of the grinding plate, otherwise the work piece to be ground would not move smoothly over the plate when using the grinder, **photo 46**.

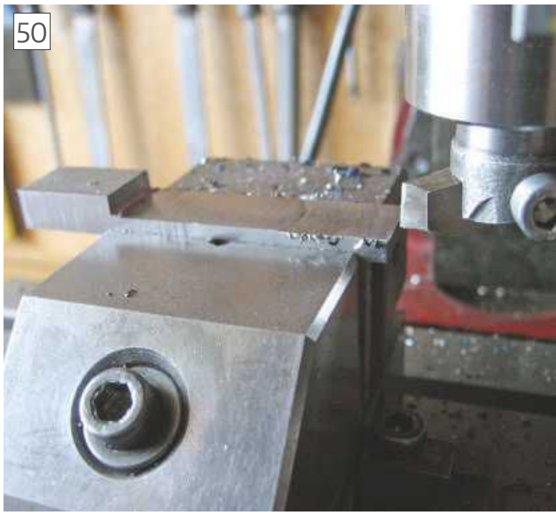
Finally, the grinding plate was assembled with the adjusting bar and the counter sunk screws were cut and filed off, this to make sure they weren't protruding from the adjusting bar, this way the bar would slide smoothly in the adjusting bracket, **photo 47**.



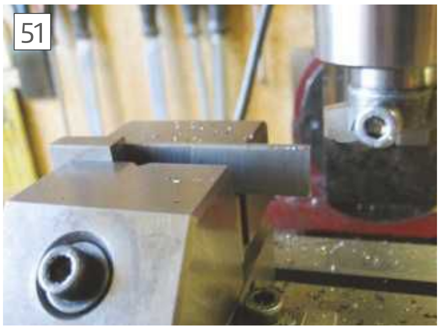
The grinding plate was mounted to the grinding tool and the function of adjusting the plate in accordance to the grinding belt could be tested, **photo 48**.

After a rough cut out, the part was milled to correct outer measurements according to the drawing, **photo 49**.





The final part I made was the back plate for the grinding belt, **figure 11**. This part was made from 8mm mild steel plate.



The 6 x 50mm section of the part was milled out using a fly cutter, this to obtain a nice smooth surface, also the 1.5mm cutout was milled, **photos 50 & 51**.

Finally, the work piece was turned over once again and after zeroing the part, the two M4 tapped holes were drilled and tapped, **photo 52**.

To conclude the project, the back plate was mounted onto the grinding tool and a test run could be made, **photo 53**.

I hope you will be tempted to make this nice little tool for your lathe. I sure had fun making it and I'm sure this tool will be used a lot in future projects in my workshop.

Please note! When working any kind of grinding job on your lathe, it is vital that you cover your bed ways with some kind of cloth or cover, as the grinding dust can damage the bed ways. ■

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