

No.277

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On the Editor's Bench

What Accuracy Do You Need?

In this month's Scribe a Line, a reader has offered some simpler gear train ideas for cutting diametric pitch gears, which need to approximate Pi, accepting that though they are not as precise they will be more than adequate for most purposes. We often debate ways of maximising the accuracy of our machine tools and setups, but rarely look at the practical consequences of any error. It seems the general assumption is that if you can measure or calculate an error, then it will adversely affect your results.

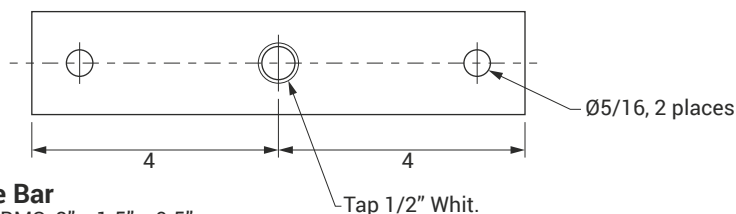
To see what this means in practice let's look at two examples. I made a rotary table with a 60:1 ratio and a handle with sixty graduations. This gives me 3,600 steps of 0.1 degrees, is this good enough for cutting 'ordinary' gears? Let's assume the biggest gear I want to cut is 50mm in diameter, and that I work out the location of each cut and round it to the nearest 0.1 degrees. This means the maximum position error will be 0.05 degrees at a radius of 25mm. A quick bit of trigonometry shows that this is equivalent to 0.022mm, or slightly less than a thou. That's good enough for making working gears for most purposes, as evidenced by several mechanisms I have made this way, which work perfectly well. Estimating the position to a half division gives a precision of about 0.01mm, which should be good enough for all but mechanisms requiring precise angular positioning. Ironically my hobby of astronomy often does demand such extra precision!

A second example is tramming a milling machine, another popular topic for discussion. A recent report showed a relative beginner was able to achieve an error of 0.0002" in 5" by shimming the column of his mill. In practice achieving that level of parallelism when actually milling a workpiece is optimistic, if you actually want to machine something to that accuracy, you will probably choose to use a surface grinder rather than a mill!

This isn't to suggest for a moment that if you can divide your angles to greater accuracy or tram your mill to perfection that you shouldn't do so. But when faced with a task you think may challenge your skills or equipment, calculate the actual precision required – you may well find that no more than working carefully and taking your time can give the results you need.

Drill Clamp

I'm afraid a production error substituted figure 2 for last month's very useful Drill Clamp with a repeat of figure 2. Thanks to reader MC Black for alerting me to this, here's the correct figure 3, although it is possible to work out what it should be like from the photos.



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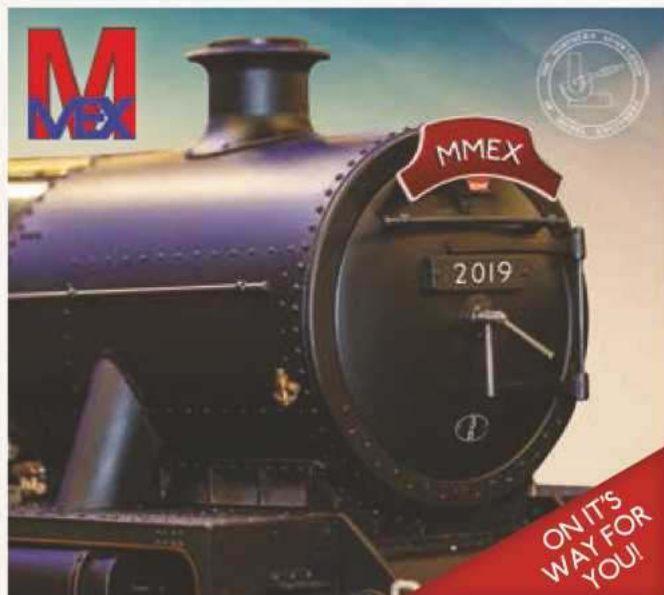
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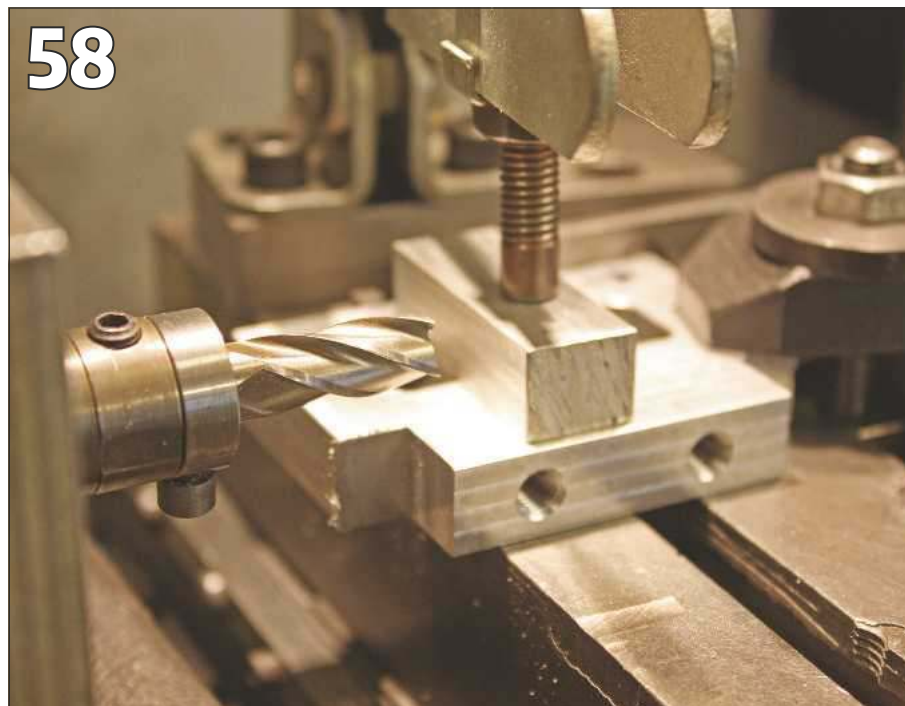
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Coming up in our March issue, number 278, another great read



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This month's cover shows the final stages of machining an internal step chuck, one of several useful designs explained by Brett Meacle in his two-part article which starts this issue.



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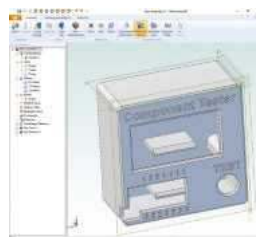


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Any questions? If you have any questions about our Alibre Atom3D, Lathework for Beginners or Milling for Beginners series, or you would like to suggest ideas or topics for future instalments, head over to www.model-engineer.co.uk where there are Forum Topics specially to support the series.

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What did you do Today 2019

Join in this year's big thread and share your workshop adventures, triumphs and tragedies!

Seized Drill Chuck in Tailstock

Lots of excellent advice on how to free a jammed Morse Taper without causing damage.

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Improved Low-Speed Torque for a Variable-Speed Lathe



Allan Wain gives his lathe some more 'low down grunt'.

When I eventually replaced my long-suffering Hobbymat MD65 with a larger lathe, I bought a Warco WM240. This was chosen over the 'belt drive' version (WM240B) despite misgivings resulting from stories of burnt-out motor control boards. In just about all respects, I was and still am very pleased with my choice but the lack of 'grunt' at low speeds quickly became apparent. Turning jobs that the old Hobbymat with its mere 1/3hp motor would take in its stride could stall the WM240 with its, quoted, 1.5hp (1.1kW) motor. After little over a year of use, the motor control board died when I failed to hit the stop button quickly enough during yet another unexpected stall.

I investigated the possibility of conversion to three-phase motor and variable frequency drive (vfd) but this seemed like a costly exercise, so I carried on with the replacement control board; waiting for my hand to be forced, I suppose. The situation eventually came to a head when cutting grooves in pulleys up to 114mm diameter for poly-vee belts. I managed, just, with aluminium because of the higher cutting speed but EN8 steel was a real struggle; EN8 simply because I have a ready supply for free. In desperation, I made a mandrel handle; something I never thought would be needed with 50rpm available under power. My arm provided more effort than the motor could produce at low speed,

I was, and still am, very pleased with my choice but lack of 'grunt' at low speeds quickly became apparent



Modified for two-stage speed reduction

but it is not easy feeding a steady plunge-cut with one hand whilst winding with the other. Before anyone writes in with the suggestion; yes, the cut was fed at half the 'V' angle, as for thread cutting.

When wishing (again) that I had gone for the belt-driven model, it occurred to me that further speed reduction at the belt would allow the motor to work at higher speed, where more power is being produced. A few rudimentary measurements confirmed that it would be straight forward to fit intermediate pulleys above the motor axis and an additional belt to the spindle. The large pulley diameter was dictated by the largest slice of aluminium I had available which, after cleaning up, yielded a diameter of 120mm. Calculations showed that a 120 to 35mm diameter pulley pair, driving the smaller 'high-range' spindle pulley, would give a speed reduction of approximately 11:1 instead of the existing low-range reduction of around 4:1. This would bring the motor speed to around 1100rpm for 100rpm spindle speed; higher up the

power curve and would also improve motor cooling at low spindle speeds. The resulting two-stage reduction is shown in **photo 1** and the original configuration in **photo 2**. No drawings were produced for the intermediate spindle, other than the sketch in fig. 1 specifically for this article. The pulley profiles, widths and separation replicate those existing on the lathe for the Gates Polyflex 7M series belt. On my lathe, the pulleys are 11mm wide with 2mm shoulders giving groove centres separated by 11mm. Readers deciding to make their own version must carefully measure the sizes, distances and separations on the subject lathe. Material and bearing dimensions are not at all critical, so long as the end result is a bracket sturdy enough to resist the forces that it will be subject to. The completed pulley bracket assembly is shown in **photo 3** and, sectioned, in **fig. 1**. The only alteration needed to the lathe is to drill and tap a hole in the motor mounting plate. The machining methods and sequences are just how I elected to carry them out. I have no doubt that they could be improved upon.

Bracket

My bracket was already half made for me, in the form of a clamp from a redundant articulating desk-mount monitor bracket. Essentially a 'U' section of 8mm thick plate with a 38mm diameter, 7mm wall thickness tube beautifully welded to one leg of the 'U'. After cutting sufficient plate, complete with tube, for a 100 x 50mm finished size from the rest of the bracket, the tube was cut off to the required length plus a bit for finishing. A similar fabrication could be produced with plate and bar, joined by whatever method is available: welding, brazing, or pressed into a bored hole in the plate. Until my ready-made part surfaced, I had planned to machine a step onto the end of round bar to fit a bore in the plate, and then MIG weld around the joint. I wouldn't think a professional welder would charge too much to do the welding for those who don't have the equipment. If choosing a welded fabrication, use mild steel or something like EN8 for the bearing housing because it welds easier. The bracket/bearing housing could even be made from a length of 50mm square bar, cut to an 'L' shape, and the housing diameter produced in the lathe. I already had the 32 x 15 x 9mm sealed bearings that seemed the most suitable for the tube size.

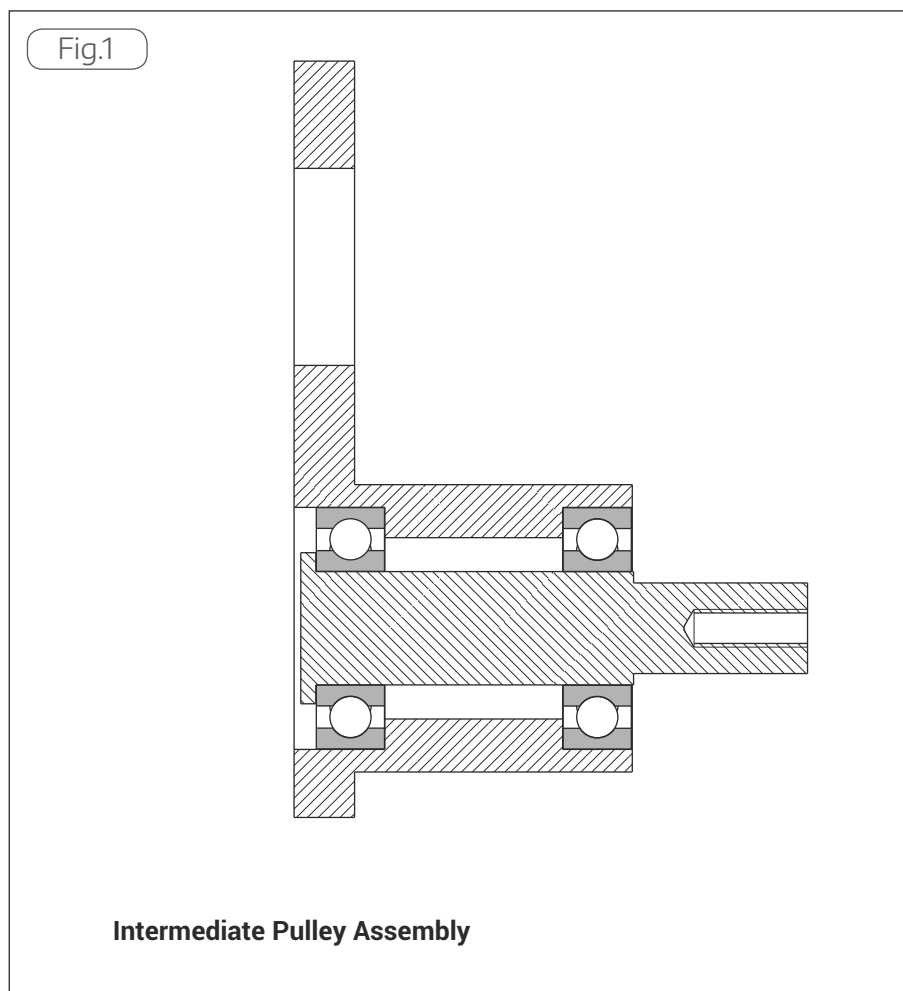
With the tube held in the three-jaw chuck, skim the rear face of the plate until flat, then drill large enough to start boring. Bore the tube and plate completely through, until uniformly cleaned up and at right angles to the rear face, then bore the rear bearing housing 32mm diameter x 12mm deep. This depth allows 9mm for the bearing, 2mm for the spindle end-flange and 1mm clearance.

Turn the bracket around and mount on a taper stub mandrel to turn the tube to the required length, and then bore the front bearing housing, this time 32mm diameter x 9mm deep. I deliberately machined the length of the complete bearing housing 1.5mm short of what my measurements suggested, with the intention of machining a spacer to fine tune pulley alignment.

Finish by milling or drill and filing the 25 x 8.1mm mounting slot.

Pulleys

I am fortunate to have access to the scrap bins in the machine shop of a factory in my area, so I have a decent selection of aluminium bar ends and slices in various diameters. I don't know what grade this is but it machines beautifully and is not at all 'sticky'. The large pulley diameter already mentioned finished at 120mm but the slice used was only around 16mm thick, so the pulley pair had to be made in two parts. A 40mm diameter piece of the same material turned to 35mm diameter and then a 12mm long stub to fit a 33mm diameter bore in the large blank. I had intended to pin the two parts axially along the joint to prevent



rotation but, instead, placed my trust in high-strength anaerobic adhesive. The pulleys could be manufactured as one piece but would produce a lot of waste.

Face the large blank one side, turn around in the chuck, then face and bore 33mm in one session; this gives a true face and perpendicular bore to mate with the small pulley. Lightly chamfer the edge of the bore. Mark this face for assembly reference with permanent marker pen.

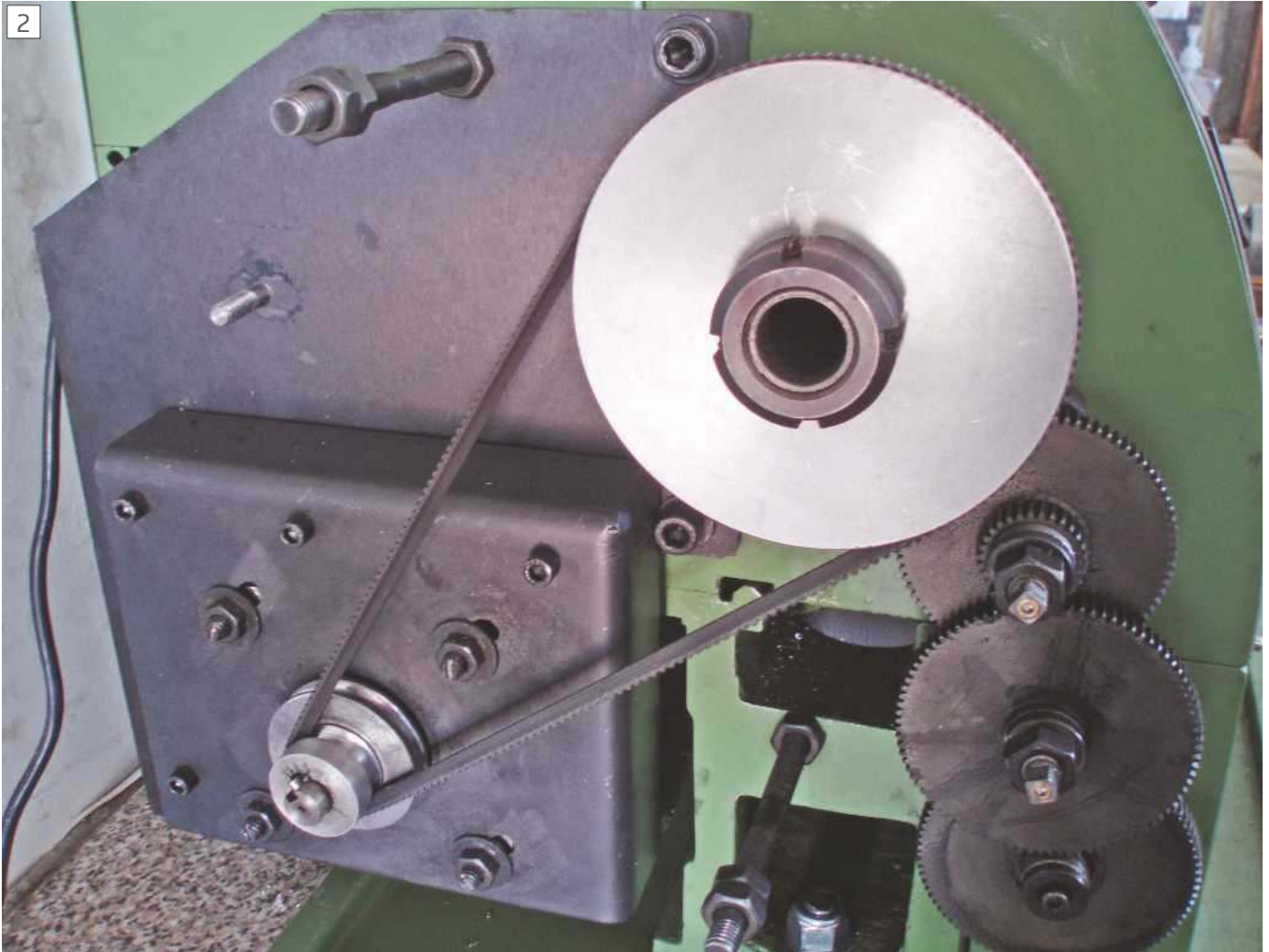
For the small pulley, chuck a length of 40mm diameter bar leaving about 30 to 35mm protruding. Face and centre drill, then reduce the diameter to 35mm almost to the chuck jaws. Support with a tailstock centre (preferably revolving). Machine the 60 degree groove to fit the Gates belt, with the edge of the right-hand flank 14 to 15mm in from the bar end; the groove should be 7mm wide. Turn a 33mm diameter spigot to exactly 2mm from the edge of the belt groove for a good push fit in the large pulley blank bore. Skim a band on the spigot 6mm wide and 0.025mm deep, centred at 5.5mm from the shoulder for adhesive. Remove the supporting centre and face the 33mm diameter spigot to 12mm long. Drill and ream 12mm diameter, approximately 30 to 35mm deep. Lightly chamfer the edge of the bore. Apply high-strength anaerobic adhesive and press the large pulley blank onto the spigot, reference-mark towards the headstock,

using a fully open tailstock chuck. Leave overnight to cure.

After curing, support again with the tailstock centre (against the lightly chamfered bore) and face the large pulley blank to 11mm wide, leaving a 1mm long, approximately 28mm diameter spigot around the bore. Finish machine the outer diameter to 120mm, then machine the 60 degree, 7mm wide groove for the Gates belt in the middle, leaving 2mm wide shoulders. Finally, cut off the chucking piece and mount the assembly onto a purposely-machined taper stub mandrel to finish the small pulley to 11mm wide.

Spindle

Chuck a piece of 20mm free-cutting steel bar. Face, centre-drill and support by the tailstock. Turn down for a fairly easy but slop-free fit in the bearing inner diameters for just longer than the combined bearing housing length and pulley width. With the bearings fitted into their housings, carefully measure the distance between the outer faces of the inner races; I used the depth facility of a digital calliper against a 'stop' across the 'bottom' bearing. This distance determines the final length of the through-bearings diameter. Reduce the outer end of the spindle to 12mm for a snug fit in the pulleys, leaving the pre-determined length of the through-bearing diameter. Support the outer end of the shaft with



Original drive belt configuration

a fixed steady whilst finishing the 12mm diameter to length equal to the thickness of the pulleys (23mm in my case). When the spacer is fitted, this length will be shorter than pulley width, ensuring that the pulley is firmly attached to the spindle. Drill 15mm deep and tap M6 for the pulley securing screw. Remove from the lathe, cut off the chucking piece, and re-chuck the reversed spindle. Face the rear of the spindle to leave a 2mm wide flange. The spindle shape can be seen in the section view, **fig. 2**.

Bracket stud, nut and washer

The nut used is a commercial M8 full nut but the stud and washer were custom made. The M8 stud has a shank 8mm long and 8mm diameter, and is threaded 8mm at the inner end and 15mm at the outer. The washer is 25mm diameter and 3mm thick.

Spacer

Because I duplicated the widths of the existing pulleys faithfully, the outer faces of the new large pulley and the outer face of the large spindle pulley are in the same plane. By aligning the pulley faces with a straight edge, the spacer length was determined by measuring the space between the small pulley inner edge and outer bearing face with feeler gauges. This, of course, has to be done after modifying

the motor mounting plate and fitting the pulley bracket.

Once the length is determined, the spacer is made by boring a short length of 20mm steel bar at 12mm diameter and parting off to length.

Pulley retaining screw and washer

The retaining screw is a 20mm long M6 socket cap screw shortened to 17mm long. The washer is custom made from 20mm diameter steel bar, faced, chamfered and drilled 6.1mm before parting off 3mm thick.

Belts

I had originally hoped to use the existing 7M730 (730mm) belt for the second reduction stage but this would have placed the intermediate pulleys too far to the back of the lathe. Instead, I had to purchase two 7M545 belts; this combination puts the pulleys nicely within the belt cover and clear of other hardware, as can be seen in photo 1.

Motor plate modification

With the pulleys and bracket assembled except for the spacer, place the two belts onto the pulleys: small new pulley to high-range spindle pulley; small motor pulley to

large new pulley. With the slotted bracket towards the rear of the lathe and horizontal, pull the new pulley pair upwards and rearwards to tension the belts and mark through the slot onto the motor plate. I covered the area in masking tape and used a short pencil around the inside of the slot to mark the position.

Before removing the motor, disconnect the lathe from the mains supply and unscrew the rear panel. Only undo the screws along the edges of the panel because the inner screws retain the motor control board. Carefully pull the panel rearwards and make a sketch of the wiring connections for reference on re-assembly. Disconnect the wiring and remove the panel and motor control board to avoid damage. On my WM240, the dc motor is mounted onto a secondary rectangular bracket screwed to pillars on the main 6mm steel motor plate. Remove this secondary bracket complete with motor, noting the route of the cable. This is a good opportunity to check the motor brushes. The main plate is held by two M5 socket cap screws from inside at the rear edge and two M10 socket cap screws at the forward edge of the plate.

Drill and tap the motor plate M8 in the centre of the marked slot position, and



screw in the short thread of the bracket stud. I used thread-lock on this to prevent inadvertent unscrewing in use. The stud can be seen fitted in Photo 2.

Re-assembly is straight forward, although starting the two rear M5 screws is a little fiddly. Leave screws loose until all are started into their recipient threads. Make sure the motor cable is not routed through the jumble of other wiring.

As an aside, with the motor plate removed, I noted that the two screws and nuts securing the auxiliary board were causing a pronounced bow in the circuit board. I corrected this by making two 6mm square plastic rails to support the long edges of the circuit board, assembled with longer screws. Maybe this will avert a future circuit board failure.

How does it perform?

A definite improvement at the lower speeds and the speed remains more constant when working hard rather than the tendency to increase rpm. Spindle speed over the full motor control range is 22 to 340 rpm.

To quantify the improvement in low speed torque, I made back-to-back test cuts of a piece of 90mm diameter EN8, using first the original low-range set-up, and then my speed reduction modification. All cuts made using a HSS tool, fine auto-feed and spindle speed set at 100rpm off load.

With the original set-up, 0.8mm depth of cut (doc) could be achieved without problem but the spindle speed increased to around 130rpm. At 0.85mm doc (1.7mm on diameter) the motor stalled.

Using the modified drive, a 1.3mm doc (2.6mm on diameter) provoked a spindle speed increase to around 106rpm. At 1.35mm doc, belt slip occurred but,



Intermediate pulley and bracket assembly

significantly, the motor did not stall. This could be because the new belts are still too stiff to optimise tension, or even the presence of moulding release agent on the belts. Any avoidance of motor stalling can only be good for the longevity of the motor and control board.

Although this modification may not be the answer for regular machining of large diameters, it does offer a far cheaper alternative to the three-phase and vfd route for users having only occasional need for that extra torque or lower spindle speed. This modification

should be straight forward to apply to other variable-speed lathes by adjusting dimensions accordingly.

Design review

Further improvement in torque should be possible by driving the low-range spindle pulley instead of the high-range as here. I haven't investigated this possibility, which would involve machining a replacement motor pulley group with a third groove, require a longer second-stage belt, and longer intermediate stage bearing housing and spindle. ■

ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE

MODEL ENGINEER

● Water Crane

Roger Davis completes his third scale GWR water crane by dealing with the water supply and the ground works.

● Polly Wog

Tony Bird begins the description of a model outboard racer, first described in the American magazine Popular Mechanics in 1933.

● Boiler Treatment

Bob Bramson explores the mechanism of corrosion within boilers and methods for preventing it.

● Tilting Table

Harprit Singh Sandhu solves the problem of cutting long bevels on a milling machine by constructing a tilting table.

● Niche Engineering

Julie Williams reviews a rather unusual branch of model engineering, on show at the recent Lowestoft exhibition.



Content may be subject to change.

ON SALE 1 FEBRUARY 2019

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Thanks to Forum Members

Hello Neil, I just wish to express my gratitude to members of the model engineers workshop forum. I recently had problems with my bench mill drill and requested advice the response was brilliant and the level of support for a non electronic person was much appreciated.

The support was mainly in emails (some outside the forum), offering 'let me know where you are and I'll pop over and give you the benefit of my experience' but distance and travel time ruled this out.

The solution became a series of idiots' guides covering one or two

sides of A4 with step by step instructions and over a period of 2-3 weeks, due mainly as to when I could get into the workshop in daylight as the fault caused me to lose power. I ended up today with a working mill.

What a fantastic group of people we share our hobby with. Many thanks to all.

John Millis, by email

The David Birkett Young Model Engineer Award

Dear Neil, the David Birkett award was started in 2006 by the family of the late David Birkett. David was a member of Bradford Model Engineers who unfortunately died in his early 40's. Clubs and Societies put forward young members from their midst and the David Birkett award is made to anyone between the ages of 18 and 25 chosen by the NAME officers.

The Northern Association makes a second award to model engineering society members younger than 18 with a small individual token and an amount of £100.

The award is presented at the National Railway museum followed by a "behind the scenes visit" for the lucky winners and their family.

The David Birkett award was made to Owen Pickering, a member of the Leicester Society of Model Engineers.

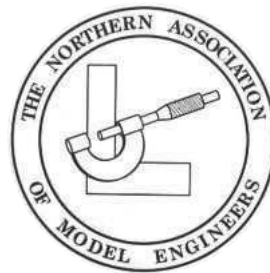
Owen started by doing work experience with the Leicester Society one one day a week from his college. He then joined the Society and helped out on public running days. The Leicester Society advise that he has become a very useful member. On public running days he is often first on site, sorting out the Club locos and rolling stock and then walks the track to check that all is in order. At their 2017 Santa Special run he arrived first and had cleared the station of snow before anyone else arrived. He is the creator of the Leicester Society's new website and has set up Facebook and Twitter accounts which he updates and answers on a regular basis.



The NAME Young Engineer went to Alex Peckitt a 15 year old who has been a member of the Sale Area Model Engineering Society since he was twelve. They say that he is an enthusiastic member assisting with getting out locos and passenger trucks (and putting them away), installing the signal sets and then helping take fares at the station and ensuring that the passengers board safely.

It is wonderful to see that, despite many Clubs not encouraging young members and, in some cases, actively discouraging young persons from joining, we are still able to make an annual award to these youngsters!

Allan Budd, Northern Association of Model Engineers Secretary



Alibre Atom

Dear Neil, a couple or so days ago I downloaded the "Alibre Atom 3D" 6 month freebie. I had a copy of the earlier version 5 or 6 years ago but one day it just 'died'. This was about the time that the ownership changed and despite much checking no trace of it could be found in my computer or the 'server' and there was no on-line service. I finally just 'shrugged my shoulders' and left it.

When the new 'Alibre' had loaded – very slowly, I was stunned to see some of my drawings of 5 – 6 years ago on screen – as to where the new program found them in either my desktop computer or in the office 'server' is anyone's guess, as a search under 'Alibre' 5 years ago did not find anything and all was assumed lost. We have rather a lot of storage as there are multiple 600Gb and 4Tb hard discs and the new programme spent about 25 minutes 'loading' and presumably 'searching'.

I am now embarking on a fresh 'learning curve', with the advantage that some of the techniques are coming back to mind. I am finding the 'new' programme much easier to use than the original as the screens are rather more intuitive. The only annoyance is that some of the original drawings are 'there' and appear on screen but are not editable due to the new programme taking exception to 'circles' in some of those drawings.

Peter King, New Zealand

Hello Peter, I'm glad you are finding the new version easy to use. If old drawings include features from the professional versions, the 'hobby' program acts as a viewer. Do visit the forum at www.model-engineer.co.uk if you have any questions, Neil.

Record Vice Mod



Dear Neil, my favourite milling vice is this slightly modified Record vice because jaw lift is totally eliminated. The second photo shows the modified jaw keep on the underside.

I have a couple of them and I've never found any purpose built milling vice that works as well. I think the idea will be of interest to your readers.

David Tredenick, Brisbane, Australia

A Piece of Pie

Hi Neil, with reference to Peter King's gear-combination offering as his solution to the generation of π in lead-screw drives (MEW 274, page 27), a very effective solution.

Also, these high-order fractions will also deliver up accurate solutions:

(i) 355/113 Factored: $(71 \times 5)/113$

(ii) 377/120 Factored: $(29 \times 13)/(3 \times 40, 6 \times 20, 10 \times 12, \text{etc})$

Anyone game enough to take on gear-cutting the 'magical' 127 tooth gear for metric thread-cutting will be unfazed by the prime-gears required for these combinations.

However, for the more timid or the plain impatient who just want to get on with their project and not be diverted into gear-cutting there is a simpler gear combination that avoids odd-ball gears and utilises easily obtained tooth-counts:

(iii) 80:20 | 55:70 or, expressed mathematically: $4 \times (55 \div 70) = 3.142857$

Error compared to $\pi = 0.00126$, not as accurate as Peter's but more than sufficient for many amateur applications. In other words, analyse and assess your allowable tolerances before committing. Likewise, this combination:

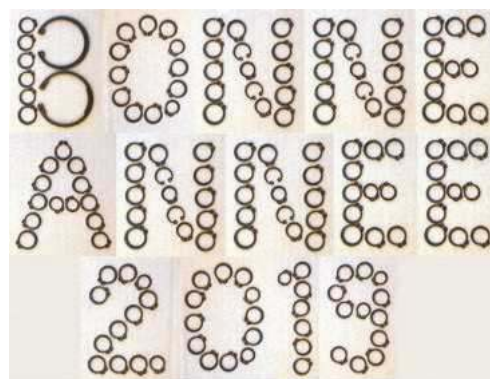
(iv) 55:35 | 40:20

The 40:20 provides a 2:1 gear ratio so any gear combination available that produces 2:1 can be substituted. The 'root' fraction from which the above two combinations derive is the well known 22/7.

Andre Rousseau, Auckland South, New Zealand

Thanks for the contribution of these ratios, Andre. I always recommend calculating the actual error in tooth spacing with given setup, you will often find that apparently crude approximations still give results well within machining tolerances. Neil.

Happy New Year



Dear Neil, Happy new year and best wishes for you and all MEW readers, with snap rings this year!

Regards

Jacques Maurel

A Drummond M-Type and Astrophotography

Dear Neil, like you I am an amateur astronomer, interest mainly on deep space astrophotography. I designed and made my own German equatorial mount (GEM) with the idea to optimise my mount for astrophotography using outmoded Vixen SS2K motors and handset. This mount has been sited in a metal hut in my back garden for some years now and makes setting up for a nights imaging very easy as there is little time spent switching on and opening up the roof.

I am making a new mount which will be a GEM fork type which does not need to do a meridian flip, this means uninterrupted tracking during a nights imaging.

I was most interested in the article by Geoff Walker on tool holders for the Drummond M Type. I have a 1946 vintage long bed Drummond M Type lathe which I inherited from my wife's cousin some years ago. I am in awe of the capabilities of this wonderful machine, for its years it is very easy to use and extremely accurate, I work to very close tolerance for making concentric accurate worms and wheels. I would be interested to see more of Geoff's ideas in the toolmaker department in the future.

Keep up the good work and clear skies.

James Wood, by email

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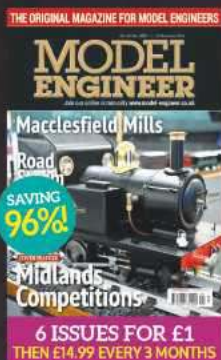
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Prototype Tooling System Large Boring Bar

Richard T. Smith describes a further addition to the range of options for his tooling system.

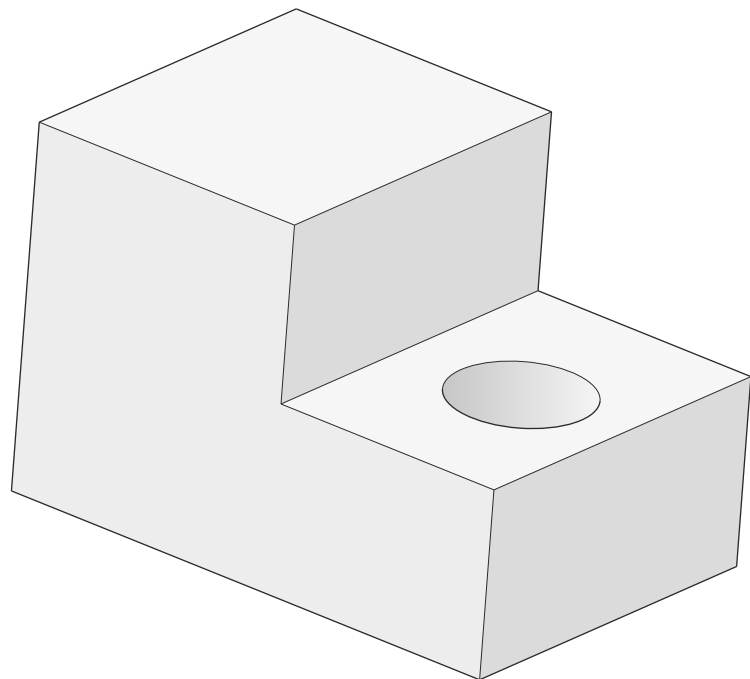
When I started this prototype tooling system project one of my main aims was to be able to see the tool tip clearly without having to lean over the lathe and peer around a chunky toolpost. The other aim was quick change.

As one of the initial prototypes I made a holder for my existing 10mm diameter boring bar. This is a block which clamps directly to the adaptor plate and which was bored clamped in position and wound up 26.5mm thick (the pillar height for the insert holders is 25mm) so the cylindrical nut has to be wound out an extra turn, but the handle still clamps in the usual position. This is hardly noticeable in practice – but is still not quite quick change.

I wanted to make a holder for a larger diameter boring bar which would need a much thicker block. There is a limit to how much extra the screw/nut combination can accommodate, and multi-turns would definitely not be quick change.

I have some 50 x 50mm which I intended as the basis of the holder and my first thought was to simply cut a step in the block, **fig. 1**. By making this slightly higher than 25mm I could reposition the clamping position back clear of the thick end of the

Fig.1



First attempt still obscures the work

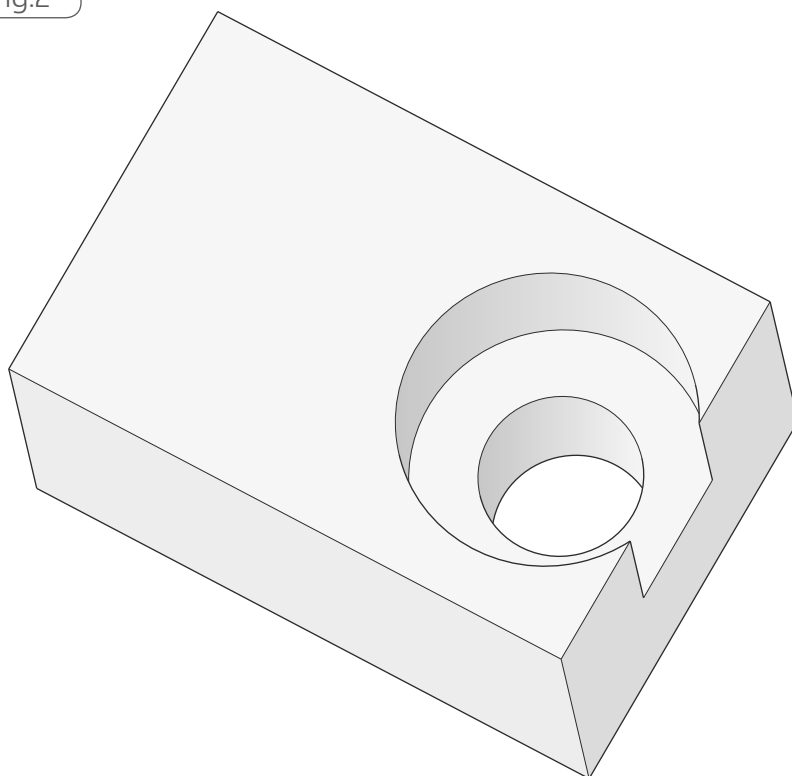


Facing block

...one of my main aims was to be able to see the tool tip clearly without having to lean over the lathe and peer around a chunky toolpost.

block. My next thought was to make a longer cylindrical nut with two cross holes for the locking handle for block heights of both 25 and 50 mm. This seemed a very simple attractive idea so I made just such a nut and tried using it with my existing insert holders. It proved to be visually in the way and I was back to peering around it! **Photograph 1** shows the problem. So back to the step. The step height will be a critical value, the screw pitch is 1.5mm so for instance an additional 0.5mm will move the operating arc of the handle back by 120 degrees. I settled on a height of 25.4mm. A bore of, say, 31mm diameter down to this height would be entirely within the block and the height would not be directly measurable. After the washer

Fig.2



had been put on the bore would have to be increased as the end of the handle sticks out, so by increasing the bore to 36mm diameter it breaks out of the

end, **fig. 2**, making it possible to directly measure the remaining height during machining. There still needs to be space for the handle to swing in so cutaway



Squaring up the block in 4-jaw



Clamp pieces from scrap



Arrangement to balance faceplate



Skimming spacer

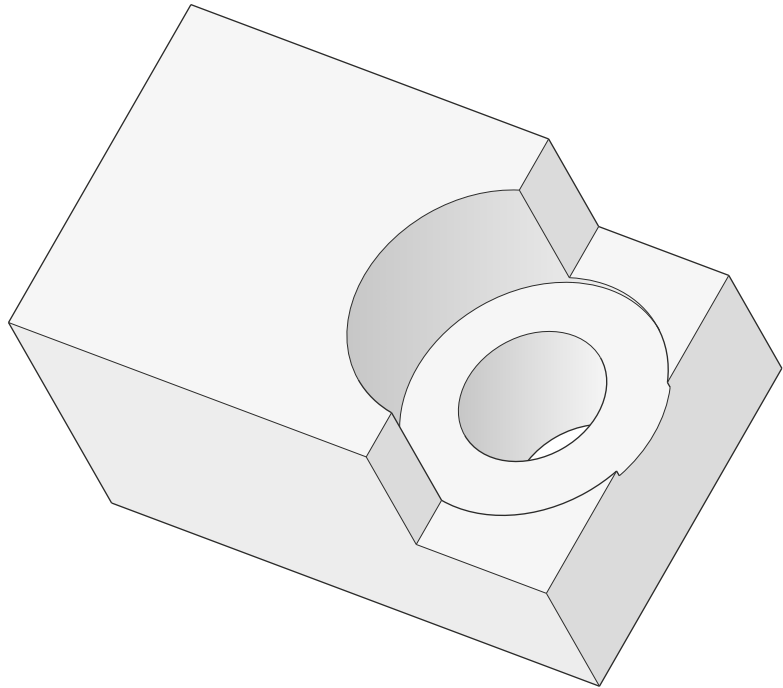


Use of clamps

some more, **fig. 3**. The cutaway does not need to come down to the bored face to clear the handle and can finish just above it so no risk to the critical dimension. The handle can now swing as shown in **fig. 4**. Compared with the simple step in fig. 1, this version also adds two significant ribs.

To start I cut a piece of 50 x 50 mm BMS and faced the ends in the four jaw chuck – **photo 2**. I had decided on a block height of 36 mm so sawed off most of the surplus then faced the cut side also in the four jaw chuck **photo 3**. In order to be able to measure the step while boring the bottom face has to be held off the faceplate enough to get the micrometer under it so the block has to be clamped to a spacer which is clamped off centre to the faceplate. First up I made a pair of clamps from some scrap, **photo 4**. Next, I found a suitable piece for the spacer which spanned two slots in the faceplate at about the right off centre position and drilled and tapped two M10 fixing holes. Then I laid out everything on the faceplate on the bench including a brass lump as a potential balance weight **photo 5**. Satisfied that the micrometer would go under and that the 20 mm through hole could be bored

Fig.3



Setup after skimming to give a true surface



Block clamped by tailstock



Boring in progress



Test of lever clamping



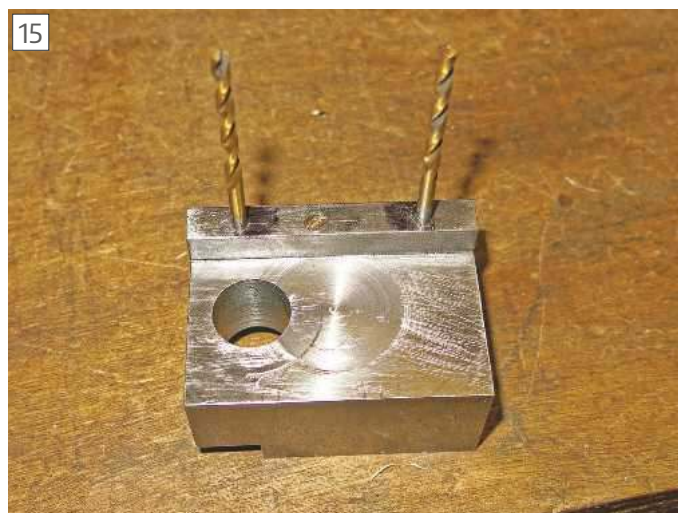
Setting block square



Guide lightly clamped to block

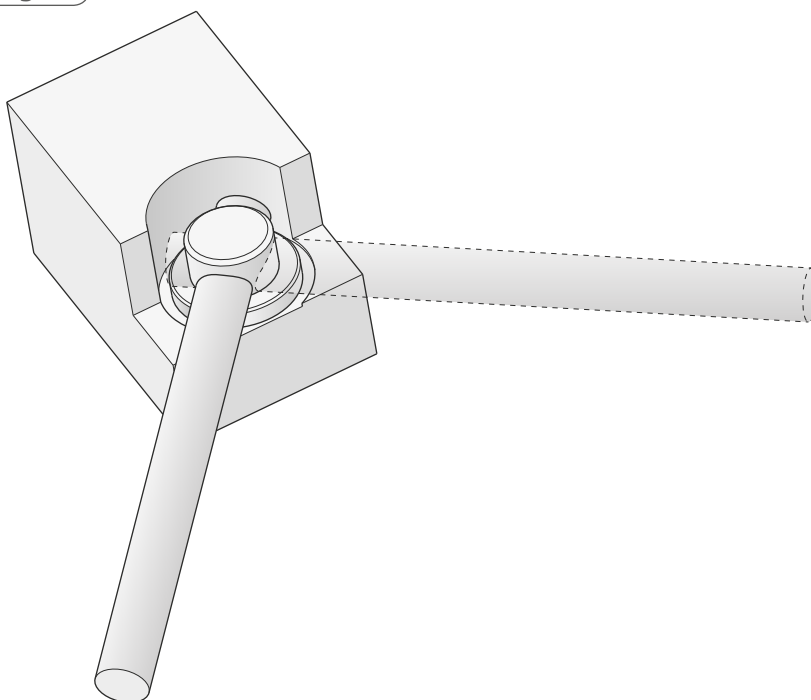


Guide secured with toolmaker's clamps



Using drills as guide pins

Fig.4



I skimmed one side of the spacer **photo 6**. I drilled and tapped two M10 holes for the clamps and checked the grip **photo 7**. The spacer was bolted from the back of the faceplate with the skimmed side down together with a thinner piece of scrap as a balance. **Photograph 8** shows the setup after skimming to give a true mounting surface. **Photograph 9** shows the block being clamped using the tailstock to locate the marked out centre position and **photo 10** shows boring in progress. Finally, I milled the handle clearance and tried it on the toolpost. Clamps fine with the handle action moved as intended, **photo 11**.

You will notice that the block overhangs the adaptor plate and this is where a guide was to be attached as I wanted the boring bar to line up with the lathe axis when fitted. The adaptor plate is normally kept square to the axis so I checked it first and then set the block square as well **photo 12**. To make the guide I clamped the piece cut off from the block (to reduce its thickness) to the mill table and reduced a strip at a long edge to be just greater than the overhang and then sawed it off. This could then be fitted under the block with the cut surface down and clamped



Drilling block



Finished mounting block



Base and bush...



... to set first angle

in position **photo 13**. Now the guide was clamped to the block at each end with toolmakers clamps **photo 14**. The block was then taken to the mill and two 4mm diameter holes drilled through the guide into the block for locating pins. A deliberately off centre hole was drilled and tapped for a countersunk retaining screw. **Photograph 15** shows the result with two 4 mm drills acting as temporary guide pins. I turned a pair of pins and loctited them into the guide. The block was mounted in position and the hole for the boring bar was drilled out to 17.5 mm diameter **photo 16**, and then taken to the mill to drill and tap the clamping screws and finally slit. An extra tapped hole is for a jacking screw if ever one is needed. **Photograph 17** shows the finished block mounted and with the start of the boring bar clamped in it.

Now we come to the boring bar. I wanted one to bore 20 mm diameter and upwards holes. I have 3MT drills sized 17.5, 18.0, and 18.5 mm diameter available so I had chosen to make the boring bar 17.5 mm diameter to be used with an 18.5 mm diameter starting drilled hole. I also wanted to use the same triangular inserts as before. The inserts have 7

degrees clearance and if mounted with the top level on the centreline this is not enough to avoid fouling in the hole. To get around this, commercial tools tip the insert by typically 8 to 10 degrees to give

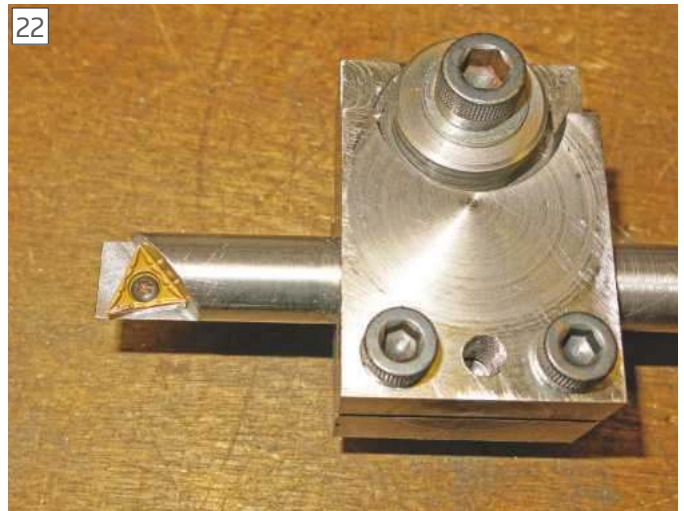
something like **fig. 5**. When this is rotated with the insert horizontal the top of the insert is seen to be not on the centreline of the bar. The red section in **fig. 6** shows the part of the insert above the centreline.



Setting seat angle



Machining the angle



Attaching insert



Setting up for finishing cut



Completed bar end

The greater the angle of the insert the more the top is above the centreline. The second angle to consider is the tip relative to the bar axis. I decided to position the

60 degree tip midway.

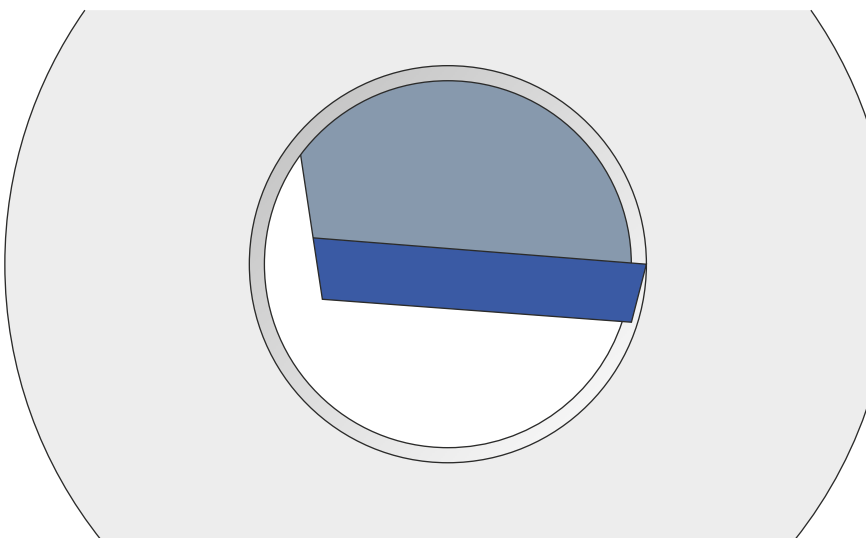
To enable the angles of the seat to be cut I held the bar in the block and attached the block to another small block

(serving as a base) with an M10 tapped hole using a caphead screw through a 20 mm diameter bush I turned to fit in the block, the parts are shown in **photo 18**.

Photograph 19 shows how the small base was gripped in the vice and the block swivelled to mill the angled seat face. The bar was set level with the table. The thickness below the cut face was the measured value. Without disturbing the block to base setting the block was then angled to cut the 7 degree sloping side of the seat to match the insert **photos 20** and **21**. With the seat levelled the insert was located so that the tip was just fully supported and firmly against the inclined face and an M4 fixing hole drilled and tapped **photo 22**. All that remained was to machine off the surplus in front of the insert so the dial gauge was used to line up on the edge by rotating the block on the base and base inclined in the vice to set the 7 degree angle, **photo 23**. The result is shown in **photo 24**.

Commercial bars have the head slightly offset to leave a clearance between the bar and the bore for the swarf to pass through. I have not done this so was concerned that the swarf could get jammed here. With the idea of preventing

Fig.5



25



Long series drill

26

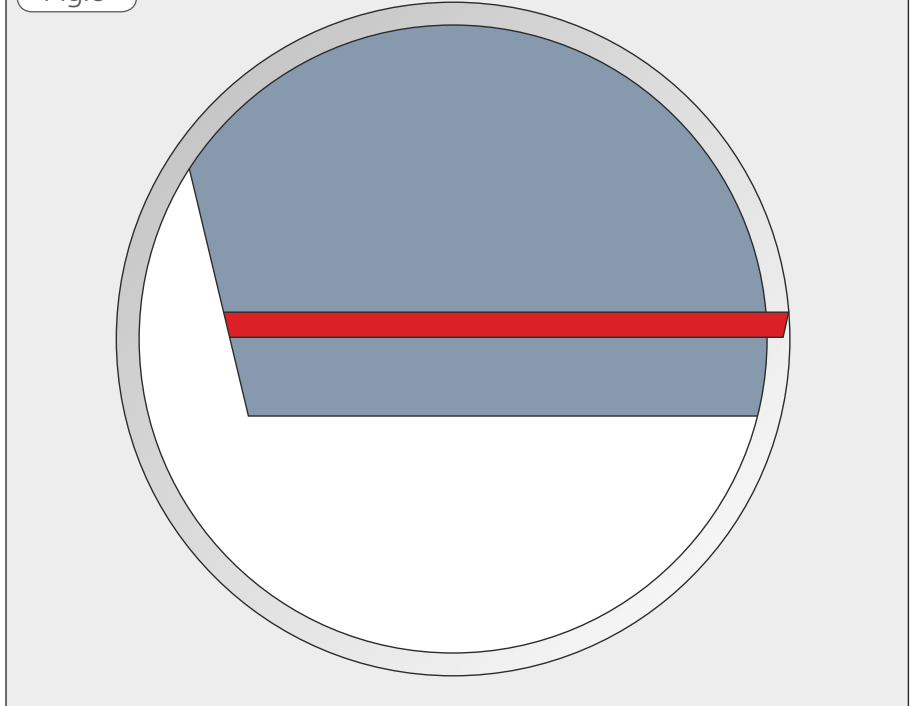


Drilling angle hole to meet blind lengthways hole

this I decided to arrange an air blast at the insert. To do this I bought a couple of long drills. **Photograph 25** shows the 5 mm diameter one alongside the cut to length boring bar. These are described as worm pattern and drilled a 5mm diameter blind hole along the bar with no difficulty at all. There is room in the face the insert locates against to drill a 3 mm diameter hole perpendicularly through into the centre hole, **photo 26**. This is not ideally aimed, and I was not sure if it would do anything worthwhile. I added a pneumatic push in fitting to the other end to feed air to it through a valve. The bar had to be rotated to set the tip on centre height. To do this I faced a scrap and lined the tip up with the pip, **photo 27**, and tried it out.

The bar will just enter an 18.5 mm diameter hole and can effectively bore

Fig.6



from 19 mm diameter up and will cut a face at the bottom of a hole. An example with a through hole, a facing cut and an interrupted bore is shown in **photo 28**, which was done with this tool.

I have found the air blast very useful

sometimes and no doubt coolant would have the same swarf clearing effect. I have used the tool quite often now and the only problem is me deciding when to change the insert (I tend to wait too long!). ■

27



Setting tool height

28



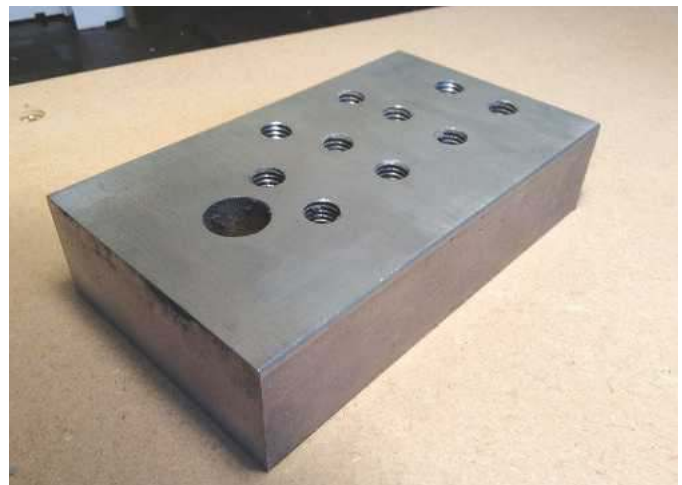
Example bore cut with the tool

Readers' Tips



**TIP OF
THE MONTH
WINNER!**

Bandsaw Clamping Block



This month our lucky winner of £30 in Chester gift vouchers is Shaun O'Sullivan, who offers some advice on workholding for horizontal bandsaws.

A variety of ideas have been published to circumvent the shortcomings of the vice on the popular 3.5inch horizontal bandsaw. These have included replacing the jaws or adapting a smaller vice to enable small workpieces to be held.

My take on this problem is to use the clamping set that I have for my mill. I obtained a scrap block of aluminium size approx. 130x75x30mm. It had a few holes in it, but these do not get in the way. This is big enough to be held firmly in the vice, but shorter than the rear jaw which can thus act as a fence for the workpiece.

I used the milling machine to tidy up each face and make them square to each other. I then drilled an array of 8.5mm diameter blind holes, 15mm deep and tapped them M10. This enabled me to insert the threaded bars of the clamping set and use the step blocks and clamping bars to securely hold small workpieces. If you have a suitable clamping set, this solution costs almost nothing and works really well for holding small items that the main vice jaws cannot.

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.chestershobbystore.com to plan how to spend yours!

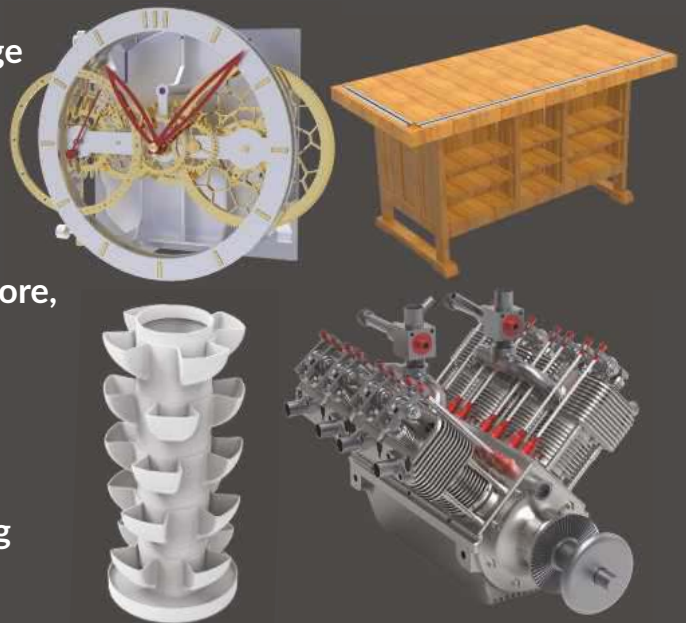
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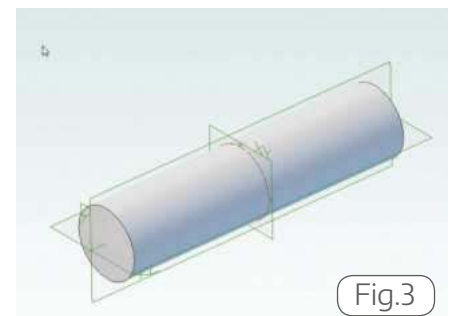
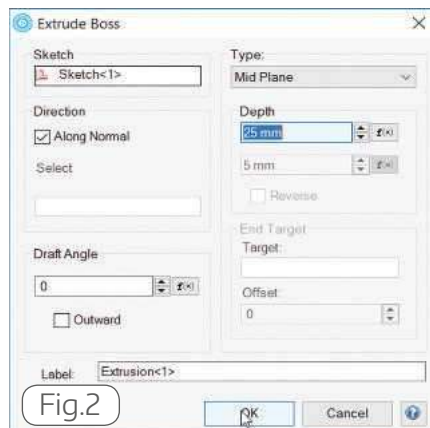
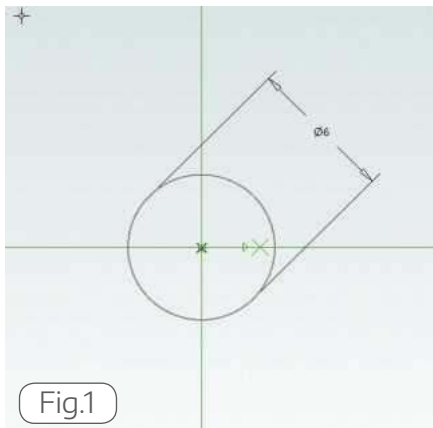
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To accompany the free six-month license available to every MEW reader, Robert Footitt starts a tutorial series to introduce you to working with Alibre Atom3D. If you haven't downloaded your free licence yet, visit www.alibre.com/MEW For extra information on the series including files to support the tutorials, other examples and links to useful resources visit www.model-engineer.co.uk/alibreatom3d



In the last article, we created the 'Clamp' component and looked at the basics of 2D drawings in Alibre Atom 3D. In this article we are going to create 2 new components, the 'Clamp Pin' and 'Thumbscrew', including accurate M6 threads and a knurled pattern around the outside of the "Thumbscrew" part. This tutorial requires the latest version of Alibre Atom 3D (Version 2018.2 at time of writing), as some of the tools covered were not included in the first release of the software.

To check for updates:

- Make sure your computer is connected to the internet
- Open Alibre Atom 3D and click on the 'Utilities' tab- Click on the 'Check for updates' link to open the update tool

A note about threads: Accurately modelling threads greatly increases the complexity of the model, which

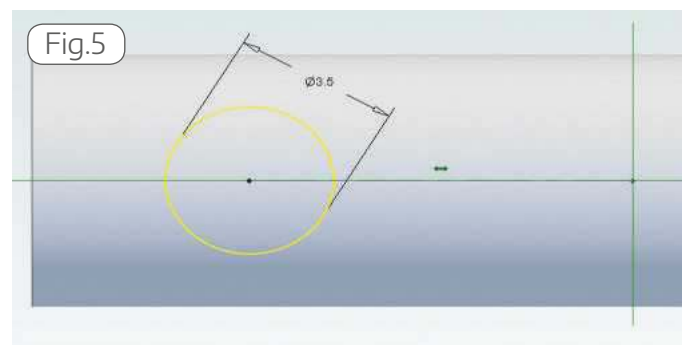
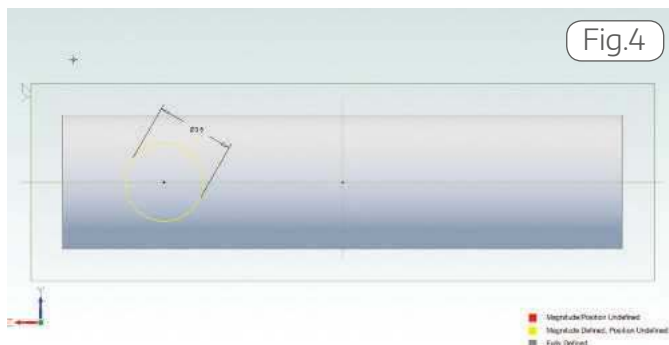
can slow down graphics performance and significantly increase load times. I would only recommend modelling them if you intend to directly manufacture a component from the 3D model (for example on a CNC lathe or a 3D printer). In instances where the thread is to be cut manually or for reference components, such as fasteners in an assembly, then the best option is to annotate the thread details on a 2D drawing.

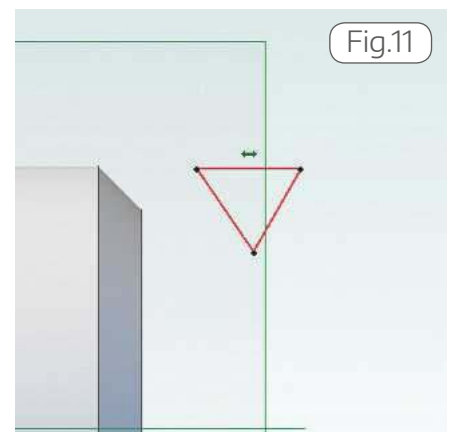
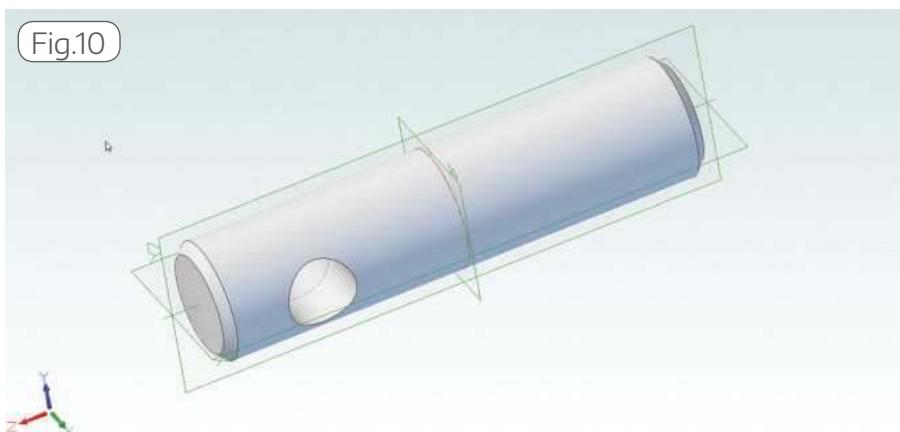
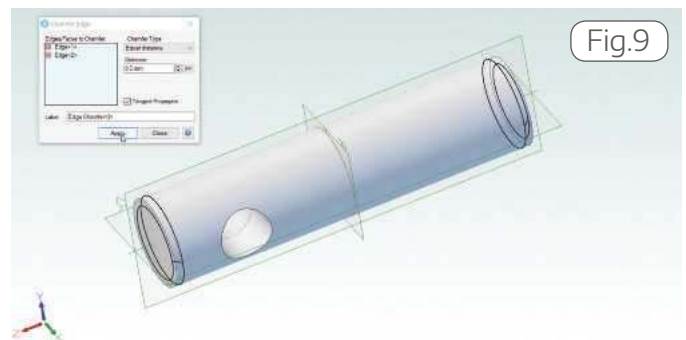
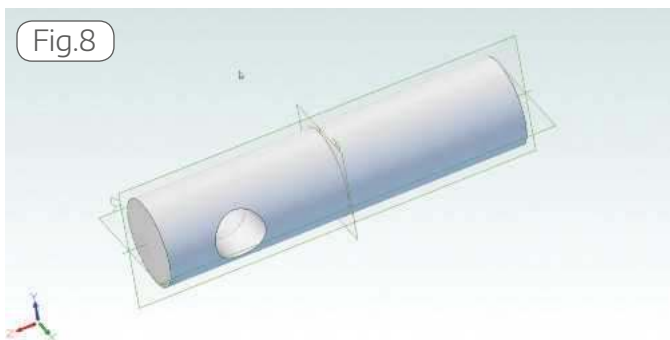
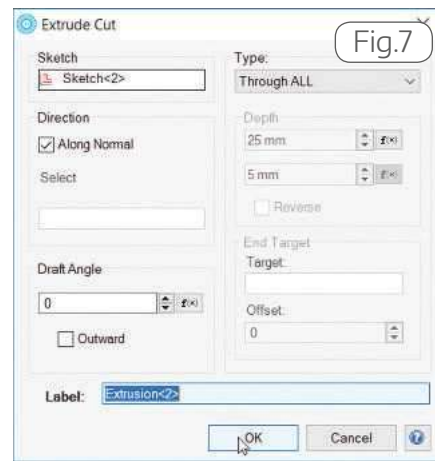
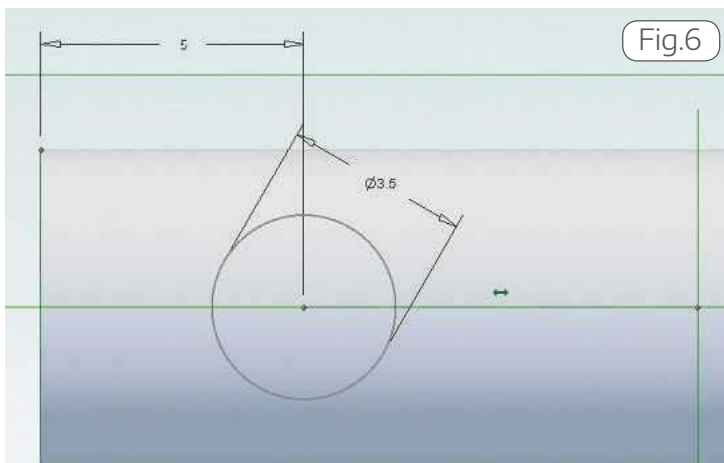
Create the 'Clamp Pin' component:

Create a new part, select the XY plane and activate 2D sketch. Create a 6mm diameter circle, centred on the origin as shown in **fig. 1**. This should be a fully defined sketch. Deactivate 2D sketch, then click on the 'Extrude' button under the Boss (add material) section of the main menu.

Change the 'Type:' option to 'Mid Plane', set the Depth to 25mm and then click 'OK' as shown (see **fig. 2**). The mid plane option makes the extrusion symmetrical around the sketch plane as shown in **fig. 3**. Select the YZ plane, then start a new sketch.

Create a 3.5mm diameter circle to the left hand side of the part, in line with the origin as shown in **fig. 4** (you will get a red guide line once you get the centre point of the circle in line with the origin point). Next, create a reference line (located under the 'Reference' section of the ribbon) between the origin and the centre point of the circle. Alibre Atom 3D should automatically create a horizontal constraint on the reference line, assuming the circle was lined up with the origin in the previous step (if no horizontal constraint is created, add one manually by selecting the reference line, then clicking the horizontal constraint button located under the 'constraints' section of the ribbon), **fig. 5**. To finish the sketch, create a dimension between the centre point of





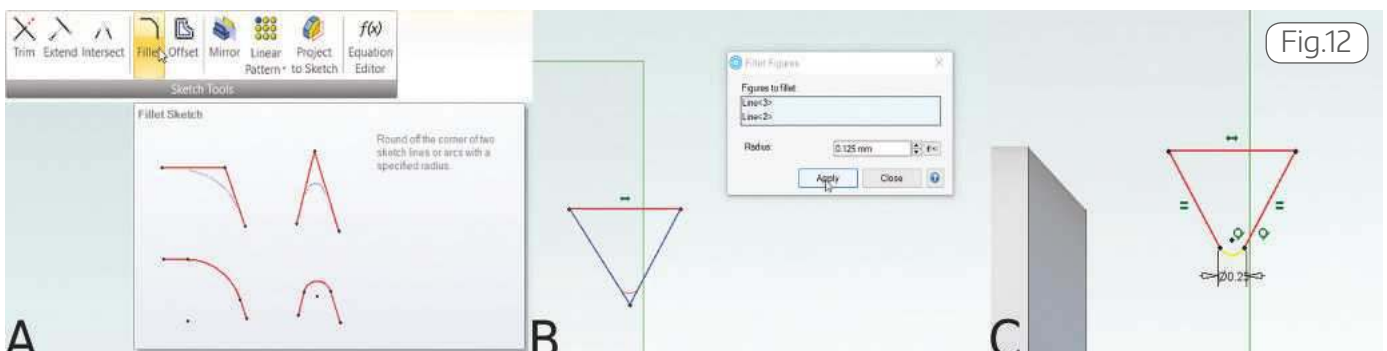
the circle and the left hand edge of the part as shown in **fig. 6**, set the distance to 5mm, then deactivate sketch.

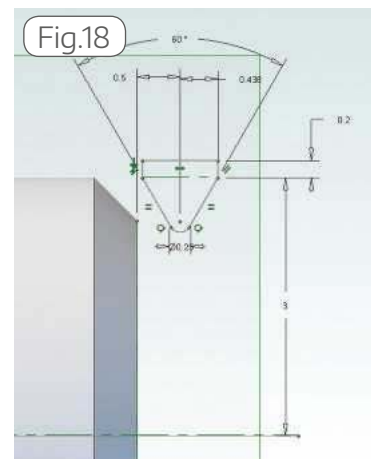
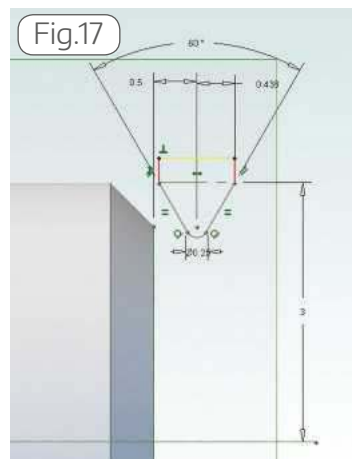
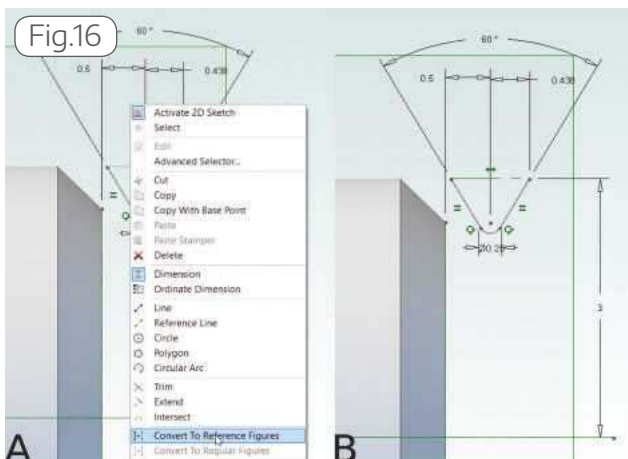
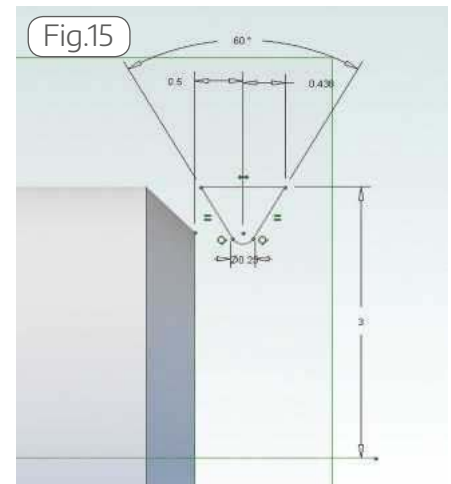
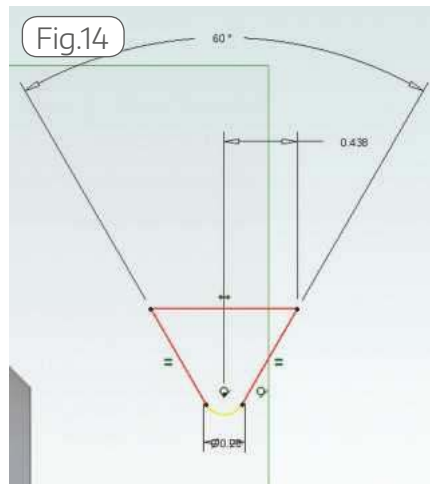
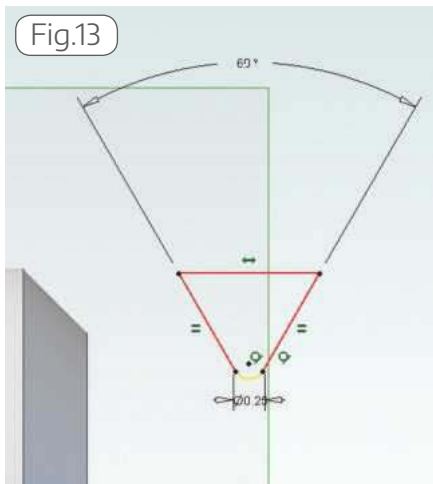
Click on the 'Extrude' option located under the 'Cut (remove material)' section of the ribbon. Change the Type to 'Through ALL', then click 'OK' as shown in **fig. 7**. **Figure 8** shows the finished cut. Click on the Chamfer button (located

under the 'Geometry Transform' section of the ribbon). Set the size to 0.5mm, then click in the 'Edges/Faces to chamfer' box to apply the value. Select the circular edges at both ends of the part, then click 'Apply' as shown in **fig. 9**. Then close the tool. **Figure 10** is the finished base component.

We can now create the M6 thread on

the part using the Helix tools. The Helix tools in Alibre Atom 3D are very straight forward, all that is required is a cross section sketch and everything else can be specified in the tool itself. The Helix cut function is ideal for threads, whilst the Helix boss function is the easiest tool to create wire forms such as springs. To create our section sketch for the





thread:

Select the YZ plane, and activate 2D sketch. Using the 'line' tool draw a triangle just off the right hand end of the part as shown in **fig. 11**. Create a fillet to define the root of the thread using the fillet tool as shown in **fig. 12**:

A: Select 'Fillet' located under the 'Sketch Tools' section of the ribbon.

B: Set the radius to 0.125mm, then click in the 'Figures to fillet:' box and select the two lower lines of the triangle as shown, then hit 'Apply'

C: The finished sketch fillet.

Using the dimension tool, create the 60 degree angle as shown in **fig. 13**. Make sure there is an 'equal' constraint between the

left and right hand sides of the triangle as shown. Create a dimension of 0.438mm between the centre point of the radius and the top right corner of the thread profile as shown, **fig. 14**. Position the sketch with the following dimensions:

- 0.5mm from the end of the part to the centre of the radius
- 3mm from the centre axis of the part to the upper horizontal line as shown, **fig. 15**.

This is now a fully defined sketch. Unfortunately, the outer radius of our thread form is exactly the same as the radius of the base part we are cutting, which can lead to artefacts after the cut operation. In order to avoid this issue, we can extend the section profile to be bigger

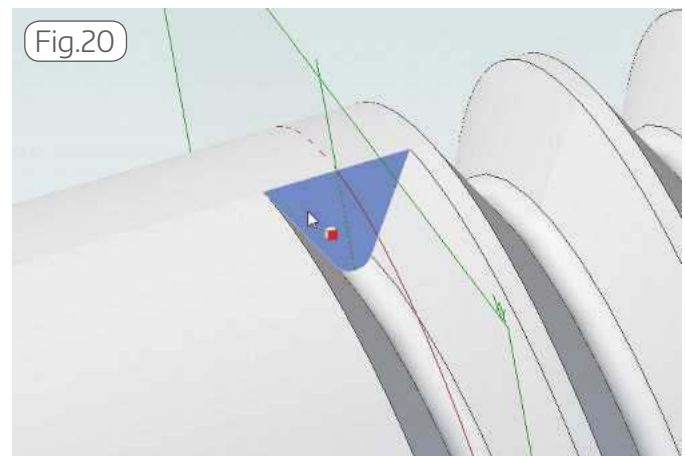
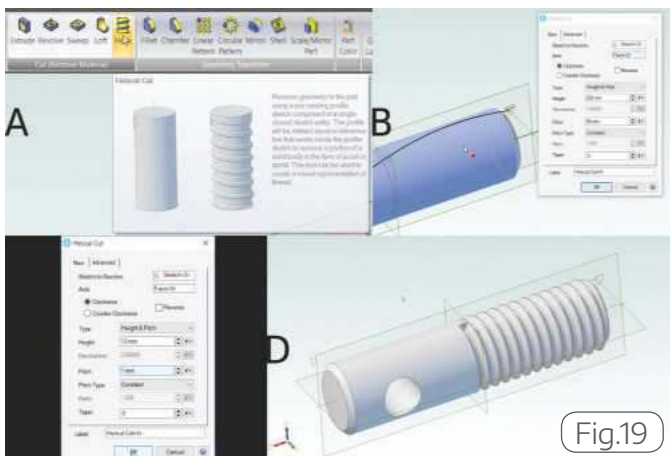
than the radius of the part.

Firstly, we need to convert the top horizontal line to a reference figure as detailed in **fig. 16**:

A: Right click on the horizontal line, then click on 'Convert to Reference Figure'

B: This converts this line segment from a standard figure to a reference line.

Next, using the 'Line' tool draw an extension to the shape as follows: Starting at the top left corner point, go up vertically, horizontally across to the right and then down to the other corner to close the shape as shown in **fig. 17**. Finally create a dimension of 0.2mm between the reference and standard horizontal lines as shown in **fig. 18**. This should now be fully defined



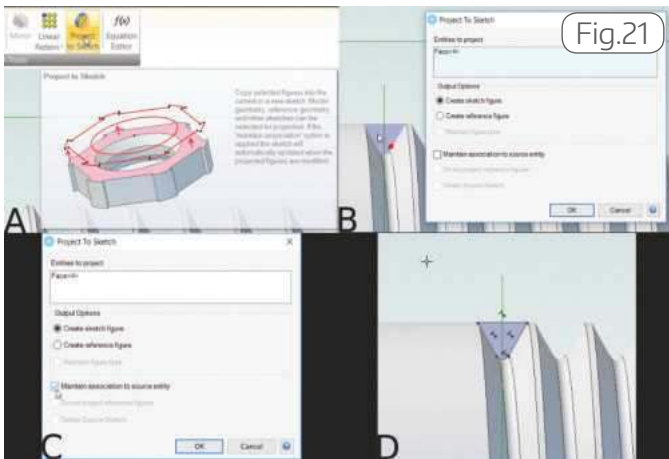


Fig.21



Fig.22



Fig.23

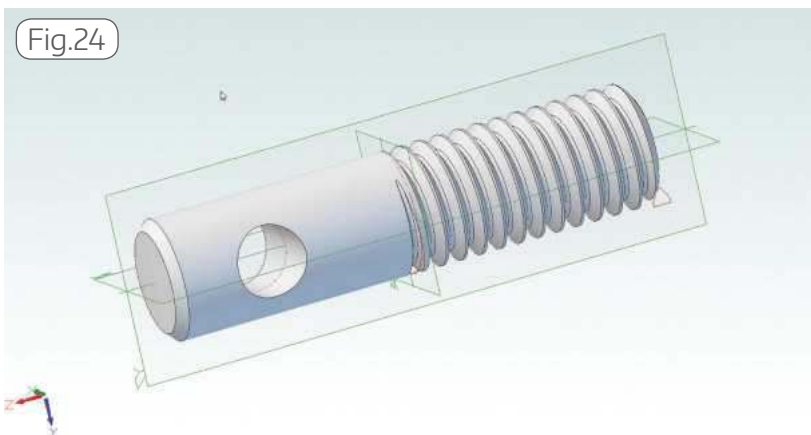


Fig.24

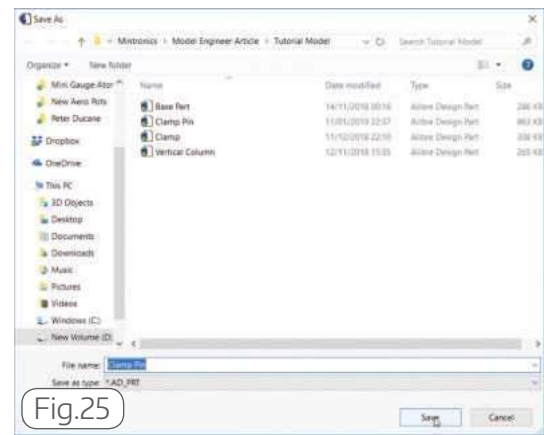


Fig.25

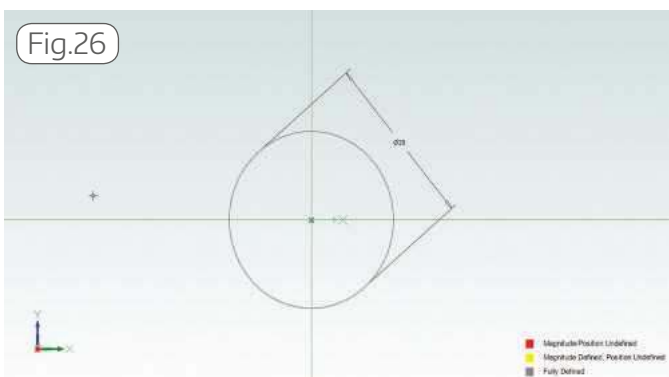


Fig.26

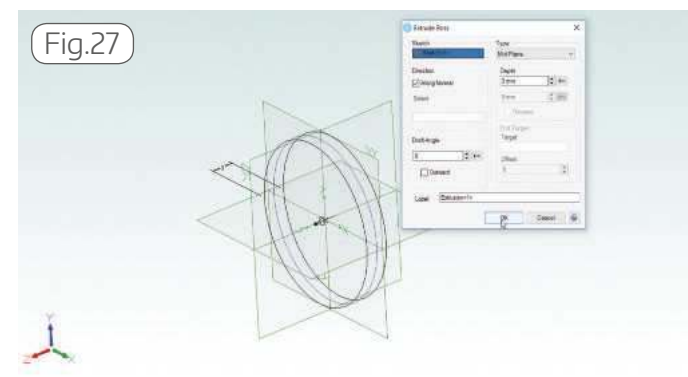


Fig.27

sketch. Deactivate sketch mode.

Create the helix cut as detailed in **fig. 19**:

A: Click on the Helix tool located under the 'Cut (remove material)' section of the menu.

B: Click in the 'axis' box in the helix cut tool, then select the outside surface of the

pin as shown.

C: Make sure the type is set to 'Height and Pitch'. Set the Height to 13mm, and set the Pitch to 1mm, then click 'OK'

D: The finished cut.

To finish the thread we now need to deal with the termination. To do this we

can create a second helix cut with a taper which will neatly blend out the thread. Select the flat face at the end of the thread as shown in **fig. 20**, then activate a 2D sketch.

Instead of drawing the cross section again, we can use the 'Project To Sketch'

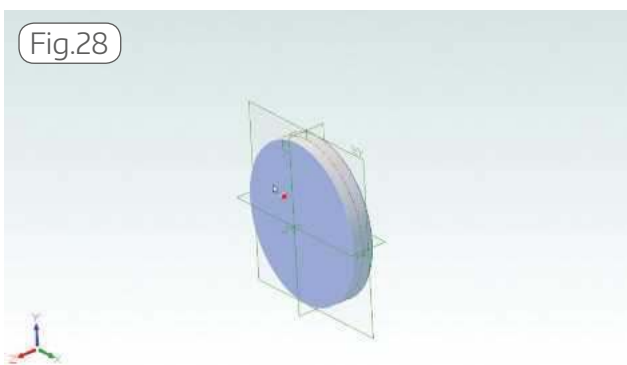


Fig.28

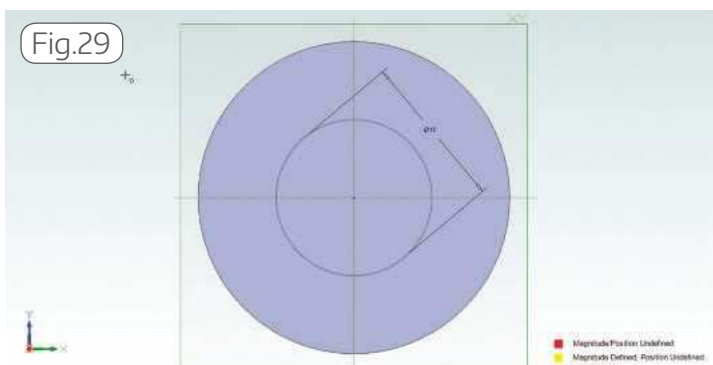
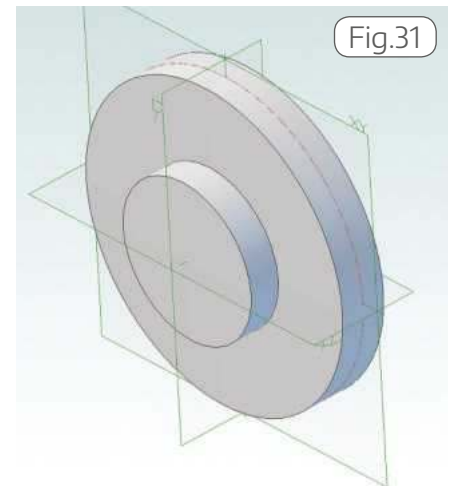
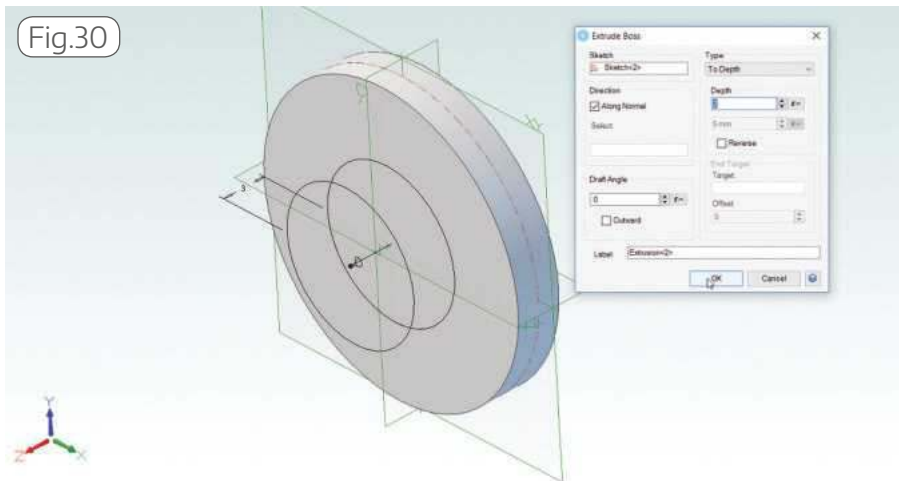


Fig.29



function to duplicate the face as detailed in **fig. 21**:

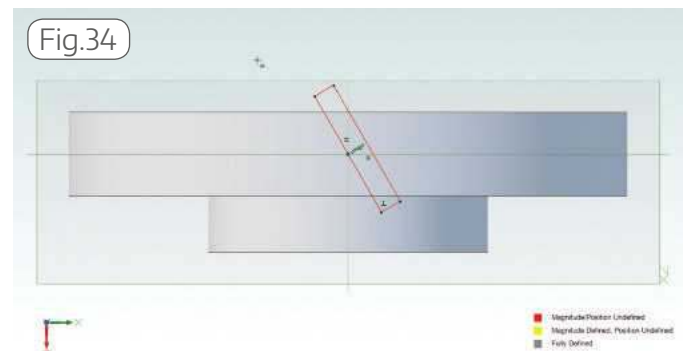
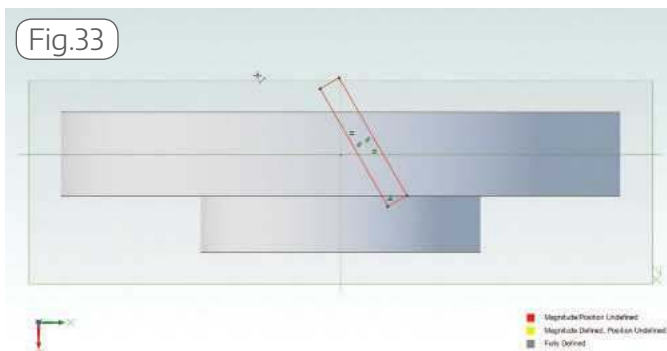
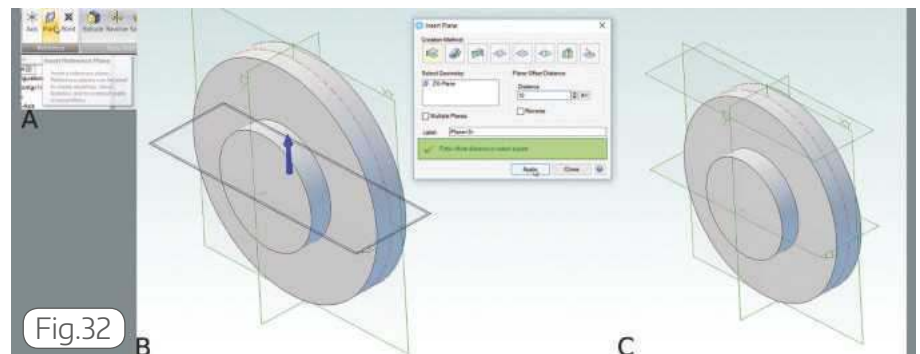
A: Click on the 'Project to Sketch' button located under the 'Sketch Tools' section of the ribbon.

B: Click in the 'Entities to project' box, then click on the face at the end of the thread.

C: Check the 'Maintain association to source entity' check box, then click 'OK'

D: This duplicates the edges of the face, creating a fully defined section sketch.

Deactivate 2D sketch.



Create a second Helix cut, and set the axis to the outside face of the pin. Change the Type to 'Revolution & Pitch' as shown in **fig. 22**. Set the 'Revolutions' value to 0.5mm, the 'Pitch' to 1mm and the 'Taper' to 60 degrees, then click 'OK' as shown, **fig. 23**. The large taper angle ensures that the cut will neatly blend out around the edge of the pin. **Figure 24** is the finished thread.

Save the part into the same folder as the parts created in the previous articles, set the File Name to 'Clamp Pin' and click 'Save', **fig. 25**.

Create the 'Thumbscrew' component:

Create a new part, then start a 2D sketch on the XY plane. Create a 20mm diameter circle, centred on the origin point as shown in **fig. 26**. Deactivate the sketch.

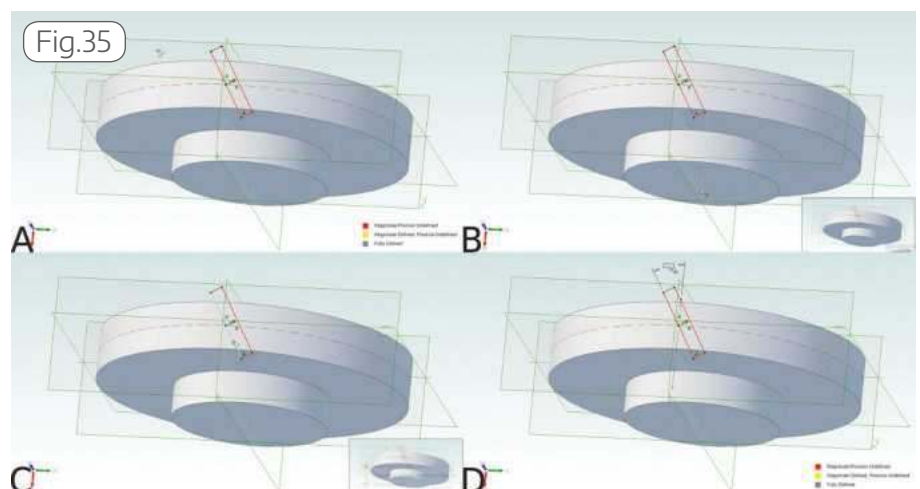
Create an extrusion, set the type to 'Mid Plane' and the depth to 3mm as shown, **fig. 27**, then click 'OK'. Select the flat face of the part as shown in fig. 28, then activate 2D sketch mode. Draw a 10mm

diameter circle, centred on the origin point as shown in **fig. 29**, then deactivate 2D sketch.

Create a second extrusion, set the type as 'To Depth' and make the depth 2mm, **fig. 30**, then click 'OK'. **Figure 31** is the

finished base shape for the thumbscrew.

We will now create a grip around the edge of the thumbscrew using a cut and the circular pattern function. Note- as with threads, patterns can add a lot of complexity to a model reducing



performance. To create the cut feature on the cylindrical outer face of the thumbscrew, we will first need to create a reference plane to work on, as detailed in **fig. 32**:

A: Click on the 'Plane' button located under the 'Reference' section of the ribbon.

B: Select the XZ plane (either by clicking in view or by selecting from the model tree) and change the 'Distance' value to 10mm, then click 'Apply'

C: This will create a plane that sits on the edge of the thumbscrew (note the plane will be added into the model tree on the left with the name 'Plane<1>').

Select the reference plane we have just created, then activate 2D sketch.

Use the line tool to draw an angled rectangle as shown in **fig. 33**. Alibre Atom 3D should automatically add in

• The linear width

After clicking on the line to dimension it, move the mouse around the line to specify which dimension you need. This should now be a fully defined sketch, **fig. 38**. Deactivate 2D sketch.

Create an extrude cut feature, set the type as 'To Depth', the depth to 0.1mm and make sure the 'Reverse' box is checked, then click 'OK' as shown in **fig. 39**. We can now use the 'Circular Pattern' tool to copy the cut feature around the outside surface of the thumbscrew as detailed in **fig. 40**:

A: Click on 'Circular Pattern' located under the 'Geometry Transform' section of the ribbon.

B: Under the 'Circular Feature Pattern'



Fig.36

Article continued on page 70

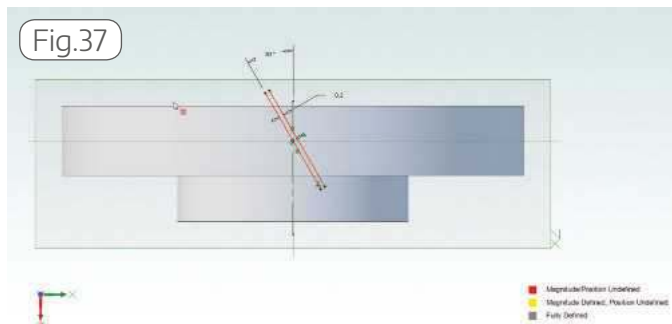


Fig.37

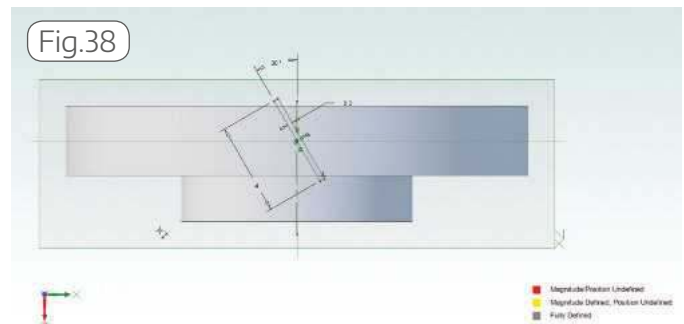


Fig.38

perpendicular / parallel constraints as you draw the shape. Next, use the 'midline' constraint (located under the 'constraints' section of the ribbon) to centre the left hand long edge of the rectangle onto the origin point as shown in **fig. 34**.

We now need to apply an angle dimension to the shape. We can dimension from the model 'Z' axis, however this isn't selectable from the 2D sketch view so we have to work in 3D as shown in **fig. 35**:

A: Whilst still in 2D sketch mode, rotate the view slightly by dragging the mouse whilst holding down the left and right mouse buttons at the same time.

B: Click on the dimension tool, then click on the Z axis, which is now selectable.

C: Click on the long left hand edge of the rectangle.

D: Click above the shape and just to the left of the Z axis to place the dimension, and make the angle 30 degrees.

We can now switch back to a 2D sketch view by clicking on the blue 'Reset View' button, located to the left side of the ribbon as shown in **fig. 36**. Create a dimension of 0.2mm between the long edges of the shape as shown in **fig. 37**. Finally dimension the length of one of the long edges- make this 4mm. Note- when dimensioning the length of an angled line, the software can give you one of 3 possible dimensions:

- The linear height
- The overall length (i.e. the length that is parallel with the selected line)

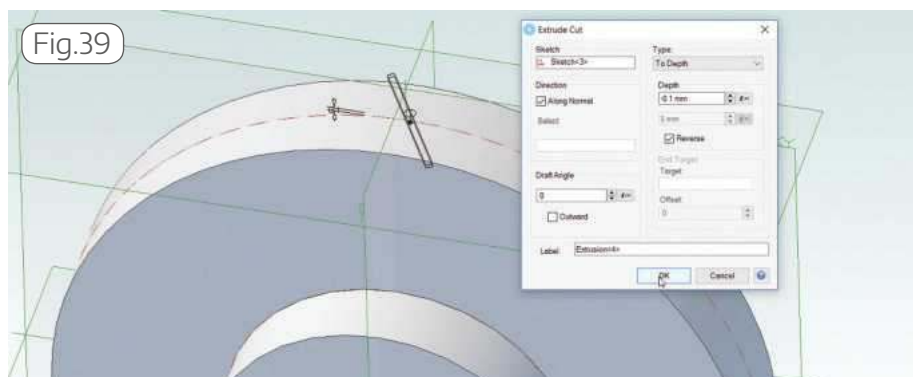


Fig.39

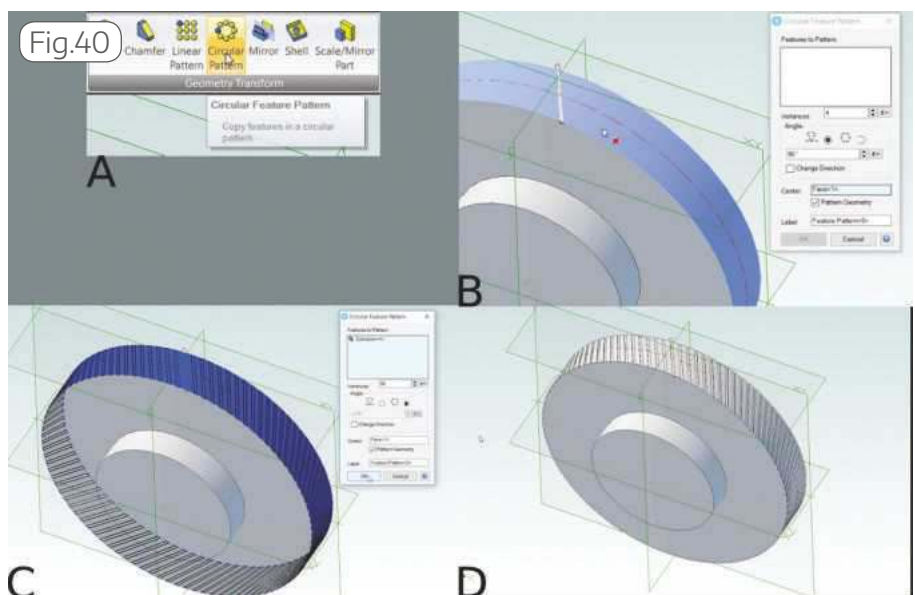


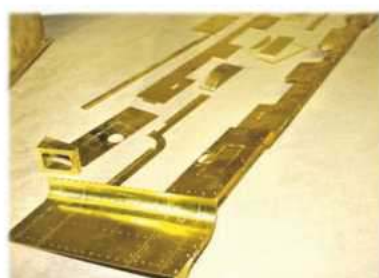
Fig.40

Practical Scale

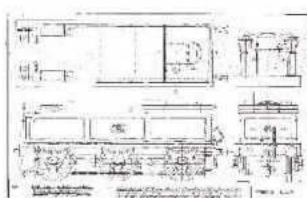
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Unusual Chucks From The Past



Brett Meacle looks at making a set of step collets – and shows you how to make your own.

When I first got my lathe and discovered MEW, I began to learn about all the machining possibilities that could be done with just a lathe. I went on a buying spree purchasing a number of the classic books and reading up on everything machining. This was pre-Internet / You Tube days and books and magazines were king if you wanted to learn stuff. Particularly so if you didn't have access to a time served tradesman who could instruct you.

As I started using my lathe, I learnt that three jaw chucks although quick and easy to use, had concentricity issues if the work required refitting in the chuck. When planning a job, doing as much as possible at the initial chuck setting is best but not always possible. Second operation work accurately in a three jaw chuck has its limitations.

I then started to use a four jaw independent chuck for all my machining. Setting up a four jaw becomes second nature after a little practice and is just another skill that can be mastered. Setting up the chuck depends on the level of accuracy you are looking for, it can range from quickly setting by eye, old timers a piece of chalk, comparing the point of the tool to the work or for best accuracy a dial indicator. When setting up accurately for subsequent machining work on a partly finished workpiece, a dial indicator is the best method.

For some jobs I was machining a one-off



Master Chuck and selection of Slaves.

jig e.g. threaded shaft, bar with a tapped hole, mandrel with a step etc. to do the required machining, but setting up the jig up again at a later time, accuracy was not totally assured.

One of the books in my library was "Workholding in the lathe" by Tubal Cain, No.15 in the Workshop Practice Series. In it the Master and Slave Chuck was described, in his words 'a useful accessory that had

seemed to have been forgotten'. It consists of a body that screws onto the lathe spindle with an accurately bored hole that various slaves are fitted into. Each slave is made to suit the component you are machining. Once made the slave can be reused in the future and when refitted in the Master chuck will always be concentric and to the exact length, **photo 1**.

The Step Collets were also described



Small Internal and External Collets.



Large Collet Chuck and Drawbar.



Dummy Spindle and Threaded Chuck Body.

in the same book, and are a common item used on watch makers lathes. I saw a use for both the internal and external step collets for holding thin and fragile workpieces, components hard to set up in normal chucks. Washers, thinning down components, boring holes and chamfering hard to hold components or whatever other second operation is required.

Once the decision was made to make the Master and Slave Chuck, I scaled it to match the Spindle of my lathe. When thinking about what slaves to make, I included an internal step collet chuck, then decided to add an external step collet set up as well. These were in keeping with the original smaller work holding sizes 6-26mm that these collets come in, **photo 2**.

As I realized how handy these step collets were for holding work, it was decided to scale up the design to make a stand alone collet chuck to fit the lathe spindle with a set of 4 collets to hold material ranging from 25mm to 60mm, **photo 3**.

Chuck Bodies

I won't go into exact sizes as your lathe will be different, I have included some drawings, but they are not fully dimensioned. You can modify the design to suit, I hope you take the ideas and stamp your own mark on them, just as other writers have inspired me to do in the past. This is the process I followed when making these chucks.

The machining of the embryo chucks starts with machining the thread and register to fit the spindle. To make the job easier a dummy spindle and a plug gauge of the register is first made and used to test for the fit correct. It is an as accurate copy of your spindle as you can make it, **photo 4**.

Chuck the cast iron billet in the lathe. I decided on cast iron as it is easy to machine and is a little easier on the spindle than steel. Continuous cast iron billets are readily available and it machines beautifully.

Face the material to a good finish. Drill an undersized hole through the billet, this helps when you are sizing important internal diameters. If you are using a plug gauge to check a blind hole for size, the trapped air can build up pressure and only when the hole is oversize will the gauge enter freely. Another thing to remember is to always clean the bore before checking for fit as the cast iron dust will give a false



Toolbit to machine the runout groove.



Setting toolbit square using Screw cutting Gauge.



Improvised strap wrench.



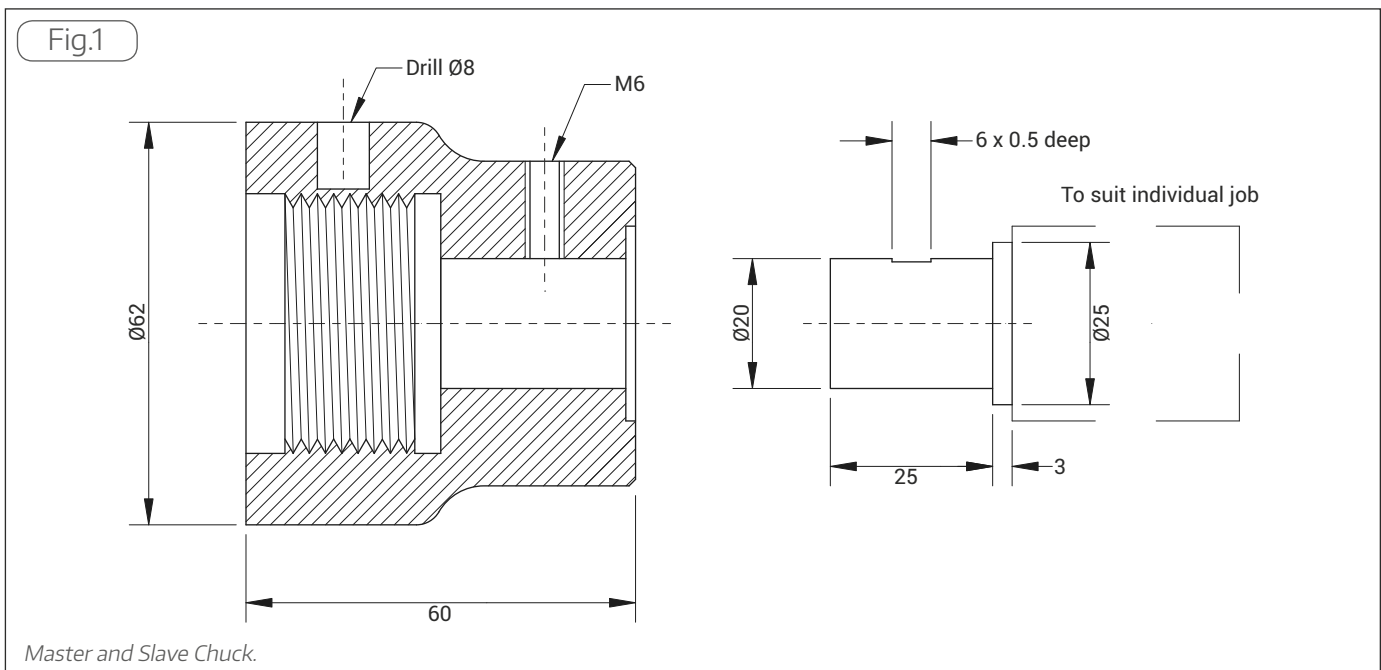
Retracting topslide set up for screwcutting the thread.



Strap wrench removing Master Chuck.



Centering workpiece under drill spindle.



Reaming tommy bar hole.



Threaded Knurled Component being machined using a threaded slave.



Topslide set up to machine closing taper.

reading or at worse seize the components together.

Bore a recess for the ID of the thread. Make the bore large enough to ensure binding of the thread crests won't occur. The thread can be a little loose but you want a good fit on the register and face. To allow the threading tool to finish in the blind hole, a runout groove is required.

Photograph 5 shows the boring bar and toolbit I used to machine the groove at the bottom of the bore.

Set up the lathe to screw cut the spindle thread. My lathe Spindle is 40 x 2.5mm pitch but yours will be different. "Screwcutting in the lathe" by Martin Cleeve WPS No.3 is also another excellent book for learning about screwcutting, the tools and setting up the lathe for various threads.

As the chucks have a short coarse thread in a blind hole, screwcutting under

power will be a bit nerve-wracking unless you have Graham Meek's Screwcutting Simplified clutch fitted. I recommend using a mandrel handle to do the job. This is a handy accessory to have for other reasons, even if only helping with changing chucks. Hold the loose chuck in one hand and wind it off/on the spindle with the mandrel handle. **Photograph 6** shows my screwcutting setup, because I was using a GHT Retracting Topslide, the threading tool was mounted upside down to cut on the rear of the bore.

For cutting the thread you could use one of the cranked end threading toolbits or a boring tool with a round screwcutting bit ground to the correct angles. **Photograph 7** shows setting the threading bit at 90 degrees to the bore use one of those Screw Cutting gauges.

Machine the thread to be a nice smooth

fit to your dummy spindle and hopefully your lathe spindle too. Finish bore the register to size, with a fine finish using the plug gauge to get a close fit.

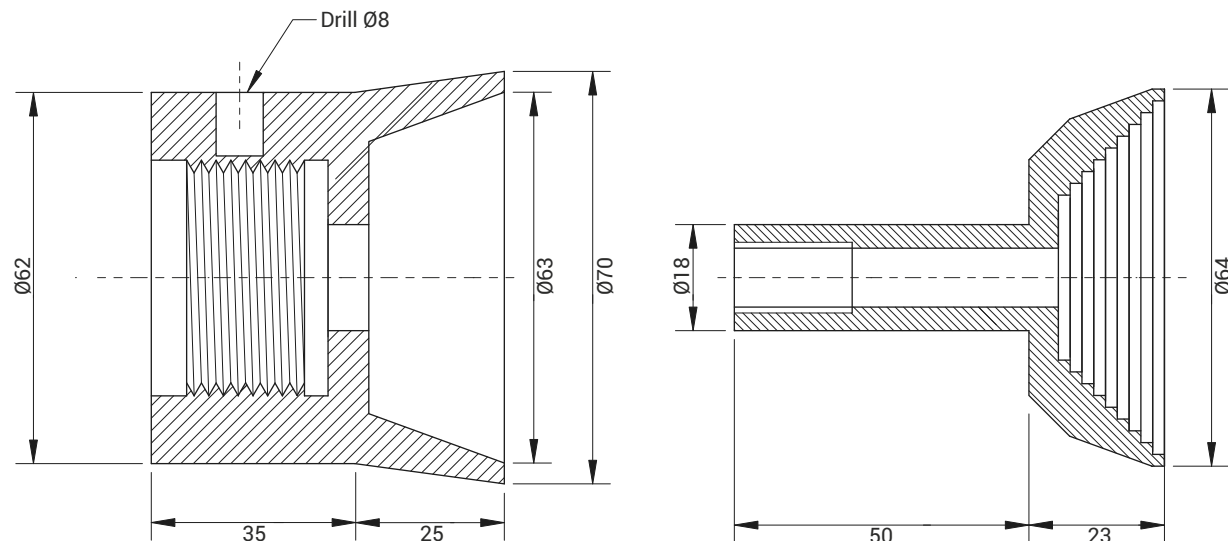
Once you are in the groove, so to speak, do the billet for the large step collet closer and as many other spindle accessories as you need, maybe even a couple of spare back plates for the future.

Once you have machined the threads, you can do all of the machining on the chucks then clean up the lathe of all the cast iron dust before you start work on the steel components.

Master Chuck

The master chuck only requires fitting to the spindle and shaping the external dimensions to suit your machine and preferred look. The pre-drilled hole is then opened up to the size of the slave shanks

Fig.2



Large Collet Chuck.

and a recess made on the front face to protect the bore from damage. I used a boring bar to get a nice close sliding fit and finish on a 20mm plug gauge. Whatever method you use all the slaves are made to the final dimension of your bore anyway, **fig. 1**.

To finish the chuck a setscrew hole needs to be drilled and tapped, and a hole reamed to allow a tommy bar or C spanner to be used remove the chuck from the spindle when you have finished using it. That brings up a small problem of removing the chuck the first time before the holes have been drilled. A handy tool in the workshop is one of those webbing strap wrenches used for changing oil filters on vehicles. It can be wrapped around the nearly finished chuck to remove it from the spindle, **photo 8**. An impromptu strap wrench can be made from a length of webbing strap and cutting a slot in a large size bolt, **photo 9**.

Set the chuck up in a vice on your drill press or mill to machine the tapped hole and the reamed hole. **Photograph 10** shows a quick and easy method of finding the centre of a round workpiece that is accurate enough for most jobs, trap a ruler/length of thin steel between the work and a spotting/centre drill, when the strip is parallel to the vice jaws it is in the center, **photo 11**.

Work holding Slaves

The slaves are made from a suitable size material to turn the shank to closely fit the bore with a shoulder to locate on the face precisely every time it is used. The working end is machined to suit each job in hand. A number of blank slaves were made for use as required in the future. Machining the slaves is mostly simple lathe work, just ensure the shanks are an accurate fit in the bore.

The only other thing to do on the slave shanks is to mill a flat for the locating



Machining External collet expanding taper.

setscrew to mate with. This is important to ensure the slave is mounted in the chuck in the same location every time but also any burrs raised will not damage the shank of the slave or the bore of the master. At worst you might not be able to remove the slave because of the burr. The setscrew itself benefits from being faced and chamfered to also minimize damage.

You can machine the business ends as need arises. Some can be a simple as a tapped hole, a spigot or a recess, an expanding mandrel, others for operations on internally threaded components can be a screw cut shaft. **Photograph 12** shows a threaded knurled component being work on. Any method of holding your work piece can be made and every time the slave is used, it fits back in the chuck with the same concentricity as when it was first made.

Another useful addition is a 60-degree center for between centers work that may be too close to the chuck using a normal center in the headstock.

One of the slaves made was a lantern chuck for shortening and modifying small screws. This is in essence a threaded rod that holds a lantern with a drilled hole to suit the screw being worked on. I have found the rigidity of the lantern chuck is a little on the weak side, but a design for a "Universal Screw Modification Fixture" by John Ashton published recently in MEW 250-251 would make a good addition to the set.



Machining chucking recesses in large collet head.

Large step collet chuck

After machining the billet to fit the spindle, the chuck can be fitted to the lathe and almost all the machining can be completed with the exception of finishing the closing taper, **fig 2**.

Machining of this chuck is similar to the master, complete the outside to suit your preferences then bore the through hole a close fit on the collet shanks. Rough out the large recess and machine the closing taper leaving a little for final finishing. The taper on both the chuck and the collets need to match and be machined at the same setting.

Remove from spindle and ream a hole for the tommy bar or C spanner. I didn't see any need for a keyway in the collets with a matching pin in the chuck. To ensure concentricity the chuck and each collet was marked as it was machined and the collets always put back into the chuck with the marks lined up.

The taper is the same for all the collets, both internal and external. The topslide is set to 20 degrees to get a 40-degree included angle taper. Once this is set do not change it until your collet closer and all the collets to fit it are machined. When setting the topslide, I angled it towards the front of the lathe, **photo 13**. It's easier to wind the handle and it also moves the cutting tool closer to the work.

Because you do not want to change the angle of the topslide until after all the chucks and collet seats are machined, and because of the workholding methods, some of the working is on the front side of the work and some on the rear. The internal closers are normal taper turning but the collets need machining from the rear.

You can accomplish this in a couple of ways. If your lathe has a reversible motor, you can run the lathe in reverse, being mindful of using light cuts and the possibility of screwed on chuck coming undone. Another option is to turn the cutting tool upside down, setting the cutting edge at centre height and using the normal motor direction.

Small Internal and External Collet chucks

These are made from suitable sized steel, the outside dimensions are normal turning to suit your tastes, **fig 3**.

Machining the shanks is the same as all the other slaves. Mount in the master chuck, Ream the 8mm hole for the collet shanks, I chose 8mm as this is a standard collet size but 10mm would also be suitable. The internal closer is the same machining steps as the large chuck.

The external collets expand to grip the inside diameter of workpieces. To machine this taper, you have to set the tool up on the rear side of the work, **photo 14**. Once the tapered nose is machined the reamed hole for the shank is enlarged slightly for a short distance into the bore to allow the shank to flex outwards.



Components trial assembled without flux.



Silver soldered collet.



Rough machining of large collet taper.

Finish Machining

When you have finished all your collet chucks. Ensure the topslide is set accurately to the 40-degree included angle. Fit a sharp toolbit and do the final machining of the tapers to a smooth finish.

Remember do not change the topslide angle until your collets are machined to match the closing taper.

We can now clean up the lathe and prepare to make the collets.

Stepped collets

These are used on many watchmakers' lathes and are available to purchase but the price seems to be high and availability secondhand is a bit scarce. I thought it would be a good exercise to make some for myself.

Watchmakers' sets seem to have a set of 4 or 5 collets but I decided to use three collets to cover 6-26mm in the small sets increasing in 1mm steps, **fig 3**.

Collet 1 6-9-12-15-18-21-24
Collet 2 7-10-13-16-19-22-25
Collet 3 8-11-14-17-20-23-26

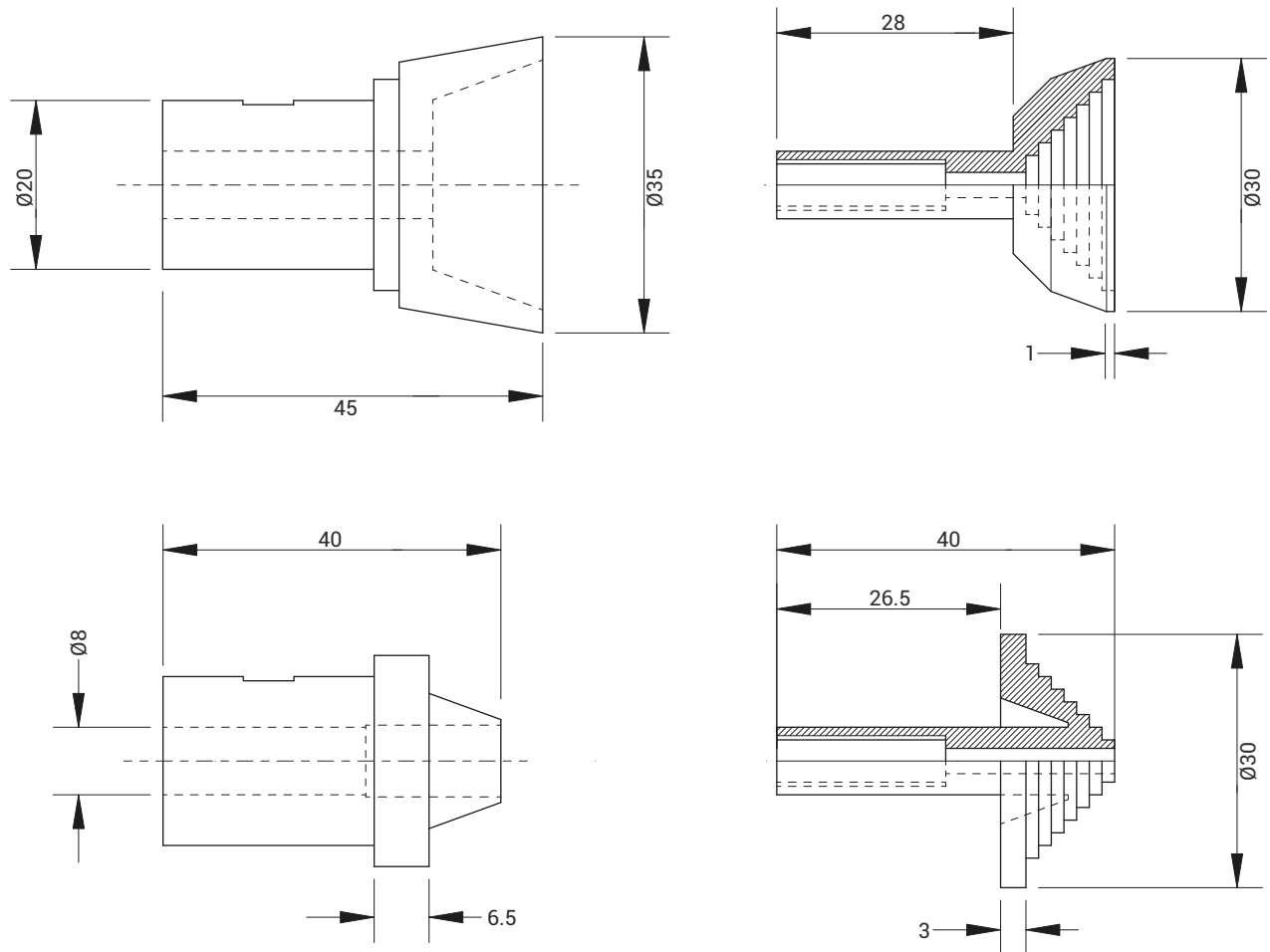
Each step in the smaller collets is 1.5mm x 1.5mm deep to allow the workpiece to be held.

The larger collets use a 2 x 2mm step arrangement to cover a range from 25mm to 60mm in 1mm increments. This required the use of 4 large collets to cover the range. I work in metric but if you work in imperial you can decide your size range and increments required.

Commercial collets are hardened for long life but as these are only for light duty jobs, I decided to make them from 070M20 steel (EN3b). So far, they have held up well to the jobs thrown at them.

The smaller collets were made from solid using 30mm steel, but the larger ones were fabricated with 2 pieces silver soldered together. To make the larger collets in one piece would waste a lot of material and time. I don't like wasting material so think how to make components from different

Fig.3



Step Collets For Master Chuck.

sections joined together. Various methods can be used depending on the final use of the item, welding, silver soldering, riveting, occasionally Loctite products but I use a lot of shrink fits. A shrink fit involves making a shaft slightly larger than the hole it is to fit into. Cooling the shaft and heating the component with the hole, then if the universe is smiling on you, assembling them together swiftly for a permanent fit.

A shrink fit would not work on the collets because they are slit into 3 segments to allow them to close and grip the work, so a shaft was silver soldered into the head of the collet.

Large Collet Fabrication

As I had decided to fabricate the larger collets, an action plan was required to ensure the job went smoothly. A little time spent on planning can pay dividends saving more time and mistakes as the job progresses.

Cut the material for the collet bodies, leave a couple of millimetres of extra length to help with the machining. I used some 65mm diameter stock, 25mm thick for the large collets, insert in the four

jaw and face one end. Turn around in the four jaw and face the second side. Drill a through hole to allow the shank to be silver soldered into position. Machine a recess in the front 24mm diameter x 18mm deep then a second larger recess 35mm x 9mm deep. This is to give the internal jaws of your chuck something to grip when you are finish machining to outside of the collets, **photo 15**.

Remove from lathe and deburr the holes and anything else that might cut you.

To prepare the shaft, leave a small amount of material for final finishing once it is silver soldered to the collet body. You need some clearance for the silver solder to flow into the joint, so reduce the end of the shaft to create this clearance. This also stops the shaft falling through the head during the silver soldering operation.

Silver soldering

The two components are cleaned and covered in a suitable flux and assembled. A length of silver solder is cut and formed into a ring, this is slipped over the shank, **photo 16** and then covered with flux. The job is then heated up from the underside of the larger component as you don't

want to apply too much flame directly onto the flux. As everything heats up the flux will bubble and flow cleaning the joint, then as the components get up to temperature, the ring of silver solder should melt and flash around and into the joint. That's what the text books say and hopefully it will be so, **photo 17**.

Once the large collets are fabricated the machining steps are the same for all of them. Only the size and holding method is different for the larger collets, for example no chucking pieces

To make life easier, you can remove most of the excess material from the large collets now. **Photograph 18** shows holding them by the shank and use normal turning methods to machine the taper, leaving a small amount for finishing.

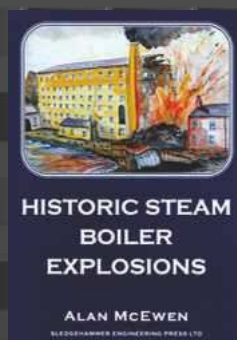
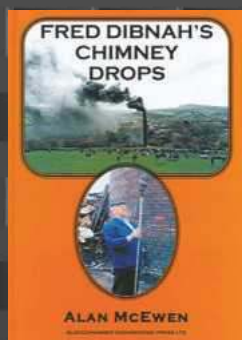
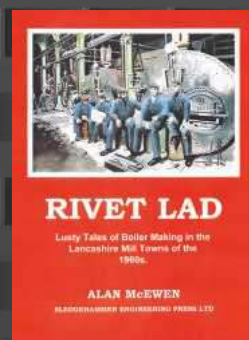
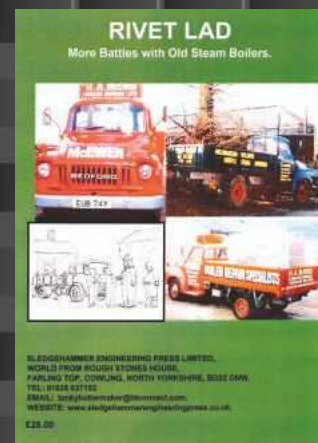
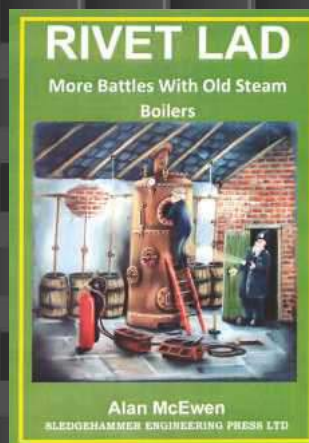
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On the **Wire** **NEWS** from the World of **Hobby Engineering**

Manchester Exhibition Competition

As an added interest to visitors, exhibitors at the 2019 Manchester Model Engineering Exhibition are being encouraged to show operating models. All running models will automatically be entered for the MMEX Trophy. There is no limit to the number entries per club or individual.

Axminster Tools are sponsoring the competition, and the prize will be an Axminster Model Engineer Series Seig CO Micro Lathe, a cash prize to the exhibiting club and a trophy to be retained in perpetuity by the model maker.



Brimarc announce New Proxxon Belt Sander

The Proxxon RBS/A Tube Belt Sander is perfect for grinding, cleaning or putting a brushed finish on pipes or tubes. It is particularly effective in places difficult to reach using "regular" power tools. The RBS/A greatly reduces time-consuming refinishing by hand in restricted areas. It is suitable for sanding, brushing and cleaning steel, non-ferrous metals and especially stainless steel.

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aluminium housing. The head can be angled by up to 60° at the push of a button. There is a dust extraction outlet for connection to a vacuum cleaner for clean working. The main body of the machine is glass-fibre reinforced polyamide with a rubberised grip for comfort and greater control.

The sander is supplied with four abrasive belts (two of 80g, two of 180g) and two satin-finishing belts. The RBS/A includes Li/A (10.8V) battery and rapid battery charger in a virtually unbreakable polypropylene case with a handle and two snap closures.

The Beginner's Tale

Mike Aireton recalls his hobby engineering journey.

I have always enjoyed the articles entitled "One man and his lathe" but have never considered myself a likely candidate for the series. All I have is an old Myford Trilever and a more recent X3 milling machine. mundane in the extreme!

But, you see, I live on the tiny Channel Island of Alderney, well away to the North of the larger Islands. This means that my efforts to use a Lathe evolved solely from what I could read in books. I had nobody to show me what to do.

So, although my equipment is mediocre it could be that my engineer's learning curve will be of interest. It is a pathway littered with broken cutters, echoing with loud bangs and wailed imprecations yet interspersed here and there with the occasional success.

So how did it all begin?

When I was nine years old my father owned a garage in Poole and held the Austin franchise for the area. At one end of the workshop was an old and tatty lathe of indeterminate vintage. I began turning odd bits of wood and promptly fell passionately in love with the whole concept of making things on a lathe. However, my pleas to try turning something metal were rejected and the garage was sold soon afterwards. I never saw another lathe for more than twenty years.

In my early twenties, I secured a job at the Microbiological Research Establishment at Porton Down. Arriving for my first day at work I was taken on one side and apologetically told that there had been an error. I could not start work for another week. I had to go to the library and entertain myself there until my clearance to enter the laboratories was finalised. The library was huge but contained material which was so exclusively erudite as to be unintelligible to anyone with an IQ of less than 170.

There were two glorious exception. I stumbled across copies of Laurence Sparey's "The amateurs Lathe" and Len Mason's "Using the Small Lathe"

During that week, I read those books as though they were gripping thrillers. Then I read them again and again.

Then another ten years went by. I still had no lathe. There were visits to the Model Engineer Exhibitions of course, but no lathe until one day I happened to visit a scrap yard and there, still just about in one piece, was an ancient Colchester Lathe. I bought it for ten pounds and bore it home in triumph. It was far too big for my needs. It had a flat belt drive rigged up via a Morris



Oxy-hydrogen torch

8 gearbox (could this be the lathe once featured in Model Engineer that had such an arrangement? – Ed.), a stripped half nut on the leadscrew and no change wheels. There was a three-jaw chuck which, on a fair day, could hold a bar concentric to plus or minus a quarter of an inch, and a small four-jaw chuck which could be held – somewhat precariously – in the outside jaws of the larger chuck. It was ghastly, but I loved it dearly.

And so, another ten years passed, during which I often played with the Colchester but never made anything of significance apart from the occasional bush, pin, spacer or monumental pile-up. My attempts to make simple cutters and harden them for use were a blasphemous failure. I didn't discover HSS tool blanks for some years.

Then came that tide in the affairs of men which reshaped the destiny which I was so roughly hewing for myself. My parents retired to Alderney in the Channel Islands and I followed them soon afterwards, taking the Colchester with me. The house which my parents bought had previously belonged to a model engineer and although he had taken most of his workshop with him he left behind a Murad Bormillathe. I was in seventh heaven. I began to make simple replacement parts for our car or domestic appliances *which actually worked*. This was DAY ONE. It was the day on which my Odyssey into the enchanted world of model engineering began.

I now had a lathe with a full set of change wheels, so I could start cutting threads. However, I did not have a chart showing the

required combinations for a given thread. Various handbooks from the library gave the necessary tables but these were useless because the Murad change wheels advance in steps of FOUR not FIVE. I had just bought one of the early Amstrad computers which came with a rudimentary Qbasic program so I wrote a simple number-cruncher to work out the combinations for me. It would work out any combination, for metric or imperial threads. It worked beautifully, but it took over forty hours to run. I must here depart from my time-line to say a few words about this program.

Inevitably my computers moved with the times and when Windows 95 came along I feared that the old Amstrad program would be incompatible, but there were no problems at all – and the program ran through in 95 minutes. Then Windows 98 arrived and reduced the run time to an hour. Windows XP only just deigned to speak to the program and only with a limited window in the middle of the screen, but now with a run time of 35 minutes. When I offered the program to windows 7 it was disdainfully spurned. Ultimately, I discovered and downloaded Basic-256 and a cut and paste operation transferred the data from Qbasic. The program now gives me my answer in just 15 seconds. Here is the program:

```
cls
INPUT "Input required TPI ", w
INPUT "Input deviation ", z
x = w + z
y = w - z
FOR a = 20 TO 75 STEP 5
```

```

FOR b = 20 TO 75 STEP 5
FOR c = 20 TO 75 STEP 5
FOR d = 20 TO 75 STEP 5
if a = b then goto skip
if a = c then goto skip
if a = d then goto skip
if b = c then goto skip
if b = d then goto skip
if c = d then goto skip
  IF a * b * 8 / c / d < x AND a * b * 8 / c / d
  > y then print c;" "; a;" "; d;" "; b;" "; a * b *
  8 / c / d
skip:
next d
next c
next b
next a
print "DONE"

```

And that's all there is to it. The above layout is for a Myford. For the Murad I needed {a=20 to 100 step 4}. For a 10TPI leadscrew I would alter the line to {IF a * b * 10 / cetc}. Try it and see.

So, back to the time-line.

With the Murad, I was at last equipped with a machine on which I could turn out reasonably accurate work but my skills and experience were so limited as to leave mediocrity way beyond my grasp. Practice makes perfect they say, but in my case practice made morose. However, there were now glimmers of light at the end of my tunnel. So long as I remained non-ferrous I began to produce some useful items, such as a replacement for a broken brass spray bar for a model aero engine, oddments for the old car and sundry aluminium items for domestic appliances, but as soon as I went ferrous I went GRAUNCH!

Then two friends retired to the Island, both bringing extremely well-equipped workshops. Ray is a retired shop steward from Westland Helicopters and Professor Dick Stephen is a retired scientist. Dick may be well known to some of your readers as he has had numerous articles published in ME and MEW.

Ray was the first to arrive on the Island and I helped him to set up his workshop. It was here that, for the first time in my life, I saw somebody else using a lathe. I saw him put a piece of steel in the chuck of his Myford and start turning.

PSSSSSSSSSS.....
What the...? Why couldn't I do that? I was using the same HSS tool that Ray was using and it was sharp enough to shave with. I was evidently running the job at about the right speed and his cut and feed were about what I was attempting. I went home to try again. I put a piece of steel in the Murad and tried to replicate exactly what Ray had been doing.

GRAUNCH GRAUNCH GRAUNCH. Red hot swarf. Barbed wire finish on the job. I tried again with a much lighter cut. Not much better. It was one of those occasions when I bitterly regretted being almost teetotal.



Horse on frame

Dick arrived soon afterwards. I had never met him before, but I was greeted at his new home with great enthusiasm. He showed me round his magnificent workshop which he was still unpacking and setting up. Then I saw some of the clocks he had made, and I struggled to keep breathing. It would have been demeaning to describe them as merely magnificent. "I could never begin to make anything like that" I gasped. "Of course you could" he replied, "all you have to do is have a go. You will find that you can do it". I described to him my continued failure

to turn anything worth having out of a piece of steel. He promised to visit me the next day.

When he walked into my workshop and caught sight of the old Colchester he shied like a startled mustang (Who wouldn't?), but the rest of the workshop met with his enthusiastic approval. I had a piece of steel in the Murad and demonstrated my abilities. GRAUNCH GRAUNCH GRAUNCH.

Dick smiled. "Where did you get that steel?" he asked. When I told him that it was a piece of lorry half shaft he nodded wisely. He explained that the clever metallurgists in the motor industry produced very tough and durable steel that was never intended to be turned on a lathe. Basically, all production was done by precision grinding. He solemnly produced a piece of steel from his pocket and said "Here, try this. It is EN1A steel". I put it in the Murad, switched on and fed in the cutter.

PSSSSSSSSSSSSSSSSSSSS.....

AAAAAAAAAAAAAARGH!!!!!!

Forty years of banging my head against a wall simply because there had been nobody to tell me where I was going wrong. I gave up being a cheapskate and bought some surprisingly inexpensive EN1A steel, since when all has been sweetness and light in the workshop.

"I bought some EN1A..." So, what is so special about that? Just go to a steel stock holder, pay for what you want and chuck it in the back of the car? True, but don't forget I live on a little Island, with 65 miles of sea and an international boundary between me and the Isle of Wight. Anything that I buy has to be obtained via the internet or by mail order. That is where the rot sets in.

The Channel Islands are not part of the EU. As far as the UK is concerned, we are as "Foreign" as Mexico or Indonesia. Goods sent to us from England are thus



Frozen horse ready for drilling

exported from the UK so if any supplier charges VAT on the exported orders they are breaking the law. Dealing with the big boys is no problem. As soon as their automated shopping carts detect a Channel Island post code the VAT defaults to zero. But you would never believe the confusion that can arise when a supplier is less familiar with trading overseas. Just one fairly typical scenario: an order placed on line accepted my address and payment details, then issued an invoice inclusive of VAT. I phoned the Company and was told that I had to reclaim the VAT from customs. I explained that this was incorrect and so was referred to the boss. I gave the boss chapter and verse – HMRC VAT direction notice 703 etc. – but was told that he had no time for people who “Try it on”. I had to buy elsewhere. Numerous other variants of this theme have provided endless hours of exasperated entertainment over the years.

After the cowboys come the Indians – the couriers. Some are good but some of them are absolute bas – bandits. Again a one off example: I wanted a set of allen keys, price £3.85 less VAT. Carriage £29. (Yes really, twenty-nine pounds carriage.) This was from one of the well-known big boys. A phone call elicited, with profuse apologies, the information that their deliveries were exclusively contracted out to a courier and they were thus precluded from using the Royal Mail.

Now, to cheer myself up, here is another story. One Monday morning I ordered a bandsaw, weighing 60kg, from Axminster tools. My Channel Island post code immediately defaulted the VAT to zero. The saw arrived on the boat that Thursday. Carriage and customs charges were just ten pounds total. There are some very good friends out there if you can find them.

So, there I was with my EN1A steel and a determination to make something really worthwhile. Dick's continued encouragement persuaded me to have a go at a simple clock, but I realised immediately that the Murad's limited facilities were insufficient for my needs. Ray and I got together and bought two X3 milling machines at a very advantageous rate. Then, under Dick's guidance, we converted them to CNC, using the article which Dick had already published on the subject. This conversion took about a year of tinkering about but was ultimately successful.

At about this time I was offered a Myford Trilever from the estate of a recently deceased island resident. It was in a rather unkempt condition and had not been used for quite a few years but was offered at an unmissable price. I gave the Murad away to a friend and put the Myford in its place. There followed a full strip down and clean. There was a nasty ding in the bed, but a scraping session restored a smooth saddle travel.

Then the only really serious problem became evident. The mandrel should have contained a No. 2 Morse taper. It didn't. It contained a ragged three-quarter inch



The stallion restored

hole. Some clown had wanted some extra depth behind the chuck and acted accordingly! I was determined to reinstate my taper. I began by using a boring bar to skim out a cobweb of swarf from the hole to give me a clean true bore. I then turned up a steel plug (EN1A!), fixed it in place with Loctite and drilled a pilot hole. Back to the boring bar with the topslide set to a (sort of) Morse taper angle and bored out to nearly there. Finally, I fed in a No.2 profile reamer to finish off and all ran true and happy. I was a bit concerned that the tapered bore might be a bit soft but after six years of almost daily use of No.2 draw-in collets everything remains clean and true.

And so, to the clock. Dick was there offering enthusiastic encouragement and all the advice anyone could wish for. I was adequately equipped to produce



The clock

sufficiently accurate work but still needed to extend my facilities. I made a dividing head fitted with a stepper motor drive. I bought a good quality worm and wheel for it and cast the components using my home-made gas furnace. No, I am not going to be side tracked by talking about the furnace. It is a much-modified Dave Gingery design and I made it from two LPG gas cylinders which I found on our local rubbish tip (do not try this at home). It terrifies the neighbours but does a splendid job.

The clock has a Graham deadbeat escapement which was made according to Dick's method. There are two tungsten Carbide pallets silver soldered to a steel escapement arm. Doing the silver soldering was problematic. Both pallets have to be held in exact alignment with the arm while they are soldered. A propane torch applies a diffuse heat which melts the solder on both sides at once and you end up herding cats. I needed a very small spot of intense heat with which I could solder one side at a time – I needed oxy-acetylene.

I used to have an oxyacetylene Portapac set, but the annual cylinder rental was astronomical. In addition, when I needed a refill, perhaps once every two years, the empty cylinders had to be shipped off to Guernsey (£15 each) and the filled cylinders had to be shipped back (£15 each) – in short, an absolute nonsense. I terminated my contract with BOC and bought an excellent little oxy-acetylene set with disposable cylinders which was more than adequate for anything I would ever need it for.

Sadly, I was again nabbed by my cheapskate psychosis. The little cylinders did not last long and the refills from Guernsey again cost £30 carriage to obtain so I started messing about with oxyhydrogen generators. This was terrific fun, surrounded by fizzes, splashes of corrosive liquid and frequent flamboyant explosions which reduced the dogs to uncontrolled trembling whenever they passed the workshop. A trawl through YouTube showed that quite a few people had made torches for use with oxyhydrogen. Whilst some were unable to get past the light-back stage the successful ones proudly displayed their ability to melt holes in tin cans but showed no serious application for anything useful such as welding or silver soldering. Nevertheless, after some initial hairy experiments to determine jet size I designed and made a fountain pen sized welding torch and a set of jets for use with my generator. It is a great success and I am very pleased with it, **photo 1.**

Now that I had finished my workshop refinements, I was able to spend more time on the clock itself. Or so I thought. The word had gone around! The consequences of this were so profound that I wanted to change the name of our house to 'Kudujust' but was outvoted by my wife who held the casting vote. Mike, kudujust turn up a shear-pin for my boat? Mike, kudujust skim a bit off my

steering shaft and make a new bush for it? Mike, kudujust reface the cone bearings for my bike? Mike, kudujust – kudujust – kudujust. To be honest I thoroughly enjoy it all. Every request needs a bit of thought as to how best to do the job and sometimes leads to a burst of genuine ingenuity – Bev's horse for example:

This was a broken chess knight from a rather substantial bronze chess set. It took the form of a rearing horse and had shattered both its back legs. The only way to repair it was to drill a hole up through the base and into the belly of the horse so that a brass rod could be fixed with Loctite. The broken limbs could then be rebuilt around the rod. The difficulty was that the base and the horse had to be fixed firmly in exact alignment while the hole was drilled through both components. There was a sizeable gap between the base and the horse which would eventually be bridged by the rod and by the rebuilt legs. First, I drilled the hole through the base for the brass rod. Then I drilled and tapped an inconspicuous M3 hole in both the base and the horse. I was then able to build a small scaffolding of slotted steel plates whereby I could hold the two pieces in exact alignment, setting this up by temporarily placing the broken legs in position, **photo 2**.

Now came the ingenious bit. Cords were affixed so that the whole assembly could be suspended upside down in a polythene pot. Water was added to just cover the base and then everything was put into the deep freeze overnight and frozen solid, **photo 3**. The following morning a long M3 drill was fed through the previously drilled hole, on through the ice and into the horse. After thawing and drying the rod was fixed in place, scaffolding removed and the rebuild completed. I returned the knight to Bev advising her to apply some matt black paint to the reinforcing rod, otherwise she would give a whole new meaning to the words "stallion" and "Viagra", **photo 4**.

Whilst I was rebuilding the fragments of the horse's legs I used several mixes of two-part epoxy adhesive and as I did so I thought of the "good ideas" series. OK, here is my way of using two-part epoxy adhesives. I used to squeeze out a portion of resin and hardener, do the job and then throw most of the mix away. Now I push a cocktail stick into the resin tube and another into the hardener tube. Withdraw the sticks, mix the adhesives together on the sticks and use as required. For a rather larger mix, use kebab sticks. For an even smaller mix, use pins. (My cheapskate psychosis strikes again – hardly any waste at all).

Grim determination – keep to the subject – the clock!

As I said, Dick's method of making the escapement entails making two pallets of Tungsten carbide. Obviously, this requires quite a bit of grinding and polishing with diamond wheels. If you want to know anything about this, go and read Dick's articles. Actually, it is surprisingly easy,

but since copious amounts of water are used in the processes there is a lot of splashing – I often ended up with a black vertical stripe down my shirt front. I reasoned that since this water contained microscopic particles of tungsten carbide it must be very abrasive and I didn't want it to find its way into the slides of the saddle, cross slide etc.. I thought of the barber throwing a cape over me during my biennial shearing so I did the same for my lathe using a sheet of thousand-gauge polythene held strategically in place with half a dozen small magnets. Incidentally a magnet can likewise be used to fix a temporary pointer or hold a sticky pin.

The clock! Yes, I must tell you about the clock...

I remember that I was just setting up to cut one of the clock frames when my neighbour Franco turned up holding a casting from his motor-bike gearbox. There was a bush which he wanted to replace, but he was not sure how to remove a bush from a blind hole. Your "good ideas" series had already described how to make a plunger, fill the hole with grease and whack in the plunger forcing the bush out hydraulically but since my plunger was a very sloppy fit I feared that the grease would give me a liberal squirting. I had read somewhere that the lad's way back in the golden age had often used this method but they did not use grease, they used glaziers putty. I tried it and it worked – and I didn't need to change my shirt.

Concentrate Mike – THE CLOCK...

After about ninety hours work the clock was nearing completion and I was delighted to find that I could actually get it to run. However, since the escapement was a first attempt the angles of the locking and lifting surfaces were just a little bit – shall we say – approximate. When properly adjusted everything ran smoothly and accurately, but the adjustment was a bit critical. In particular the depth of engagement of the escapement pallets into the escapement wheel had to be minutely adjustable. In order to achieve this, I made the escapement arm bearings slightly eccentric so that by rotating them in the frame I was able to fine-tune the depth of engagement. So on went the four jaw chuck...

My four-jaw chuck is exasperating. I take it out of the cupboard, screw it onto the



Grasshopper project

mandrel and there it is, always – always! – with the jaws the wrong way around and screwed right in. There follows a tedious session of chuck key twiddling during which I always fumble the wretched thing, drop it and lose it under the cupboard. Eventually I beat the system. I found a square steel bar which would fit the chuck jaw sockets, turned one end down to a cylinder and put it into my electric screwdriver. Now I just whisk the jaws in and out in moments and only use the key for the final adjustments and tightening.

And so now the clock is sitting on our mantelpiece keeping fairly good time and is a constant reminder that I really can do it if I try, **photo 5**. I am now well on with a twin pendulum grasshopper escapement remontoir-wound figment of my own fevered imagination, **photo 6**. I am still learning all the time and have hopefully crept past mediocrity towards indifferent competence. It has been a very steep learning curve.

At last, after fifty odd years, I can turn something true to half a thou and take pride in doing so.

What took me so long? Well I have just told you, haven't I? ■

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Milling for Beginners



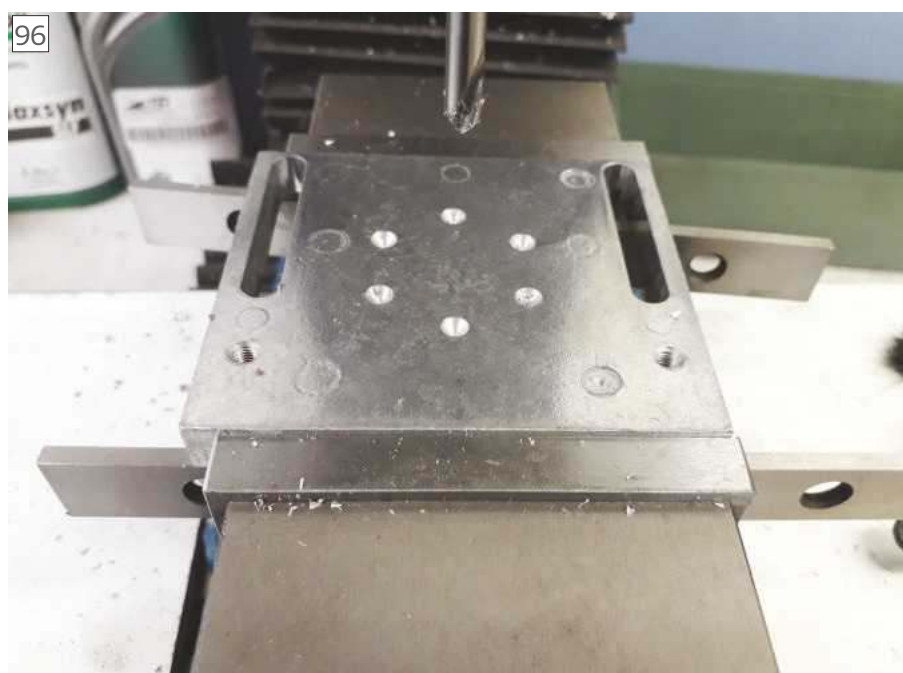
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PART 9 - DRILLED HOLES, COUNTERSINKS AND COUNTER BORES.

This month Jason Ballamy looks into making holes

The mill makes a very good drilling machine, particularly when equipped with a quill which the vast majority of modern imported bench top mills are. With just a bench drill the usual method is to mark out the hole positions with scribe, rule and square then dot punch, inspect the dot to make sure it is accurately placed (and pull it over if not) then go over the positions again with a centre punch before transferring the work to the drill and locating each mark under the spindle. This can lead to some inaccuracies and does not readily lend itself to easy placement of holes defined with decimals of an inch or less than 0.5mm increments because as a rule they cannot be easily read below that.

However, the mill's hand wheels or better still a DRO (Digital Read Out) can be used to accurately position the spindle relative to two datum edges or a datum point. For machines with just a hand wheel the far rear edge and the left hand side are best located and used as the datum then all subsequent positions will be positive numbers which reduces errors problems caused by any backlash in the feed screws/nuts. For DRO equipped machines you can be a bit more flexible in what you use as a datum, some parts will



Six spotted holes on a PCD

be better suited to using the same edges as above, others may be better if the "half" function is used from each edge and then the two central axes used as the datum.

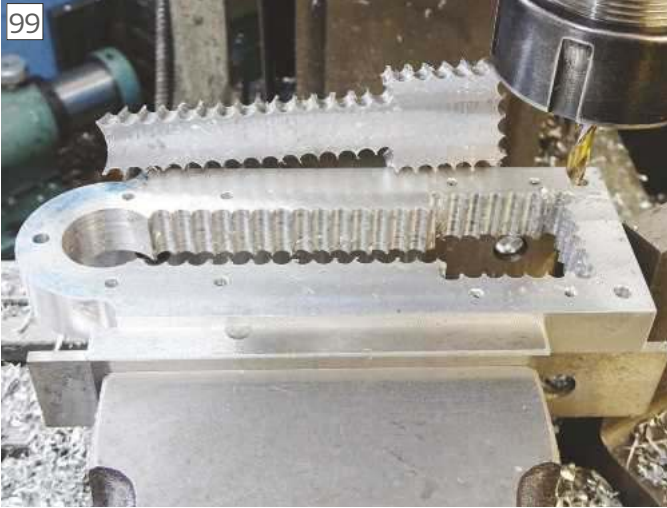
If using standard jobber drills which have a non-cutting portion between the two main cutting edges they will tend to skate about on the surface when starting



Clean edge around subsequently tapped holes



Split-point and standard drill bit ends



Stitch drilling straight lines



Stitch drilling round holes

the cut without a punch mark so a small dimple needs to be produced first for the end of the bit to locate in. In the past a Slocumb or centre drill was used for this but the use of spotting drills is now filtering down from CNC machining and becoming more popular for home workshop use, **photo 96**. The main advantage of a spotting drill over a centre drill is that they are far more robust, so no risk of breaking off the small diameter pilot of a centre drill, also if sized correctly so that the hole they produce is a little over the final drill size they will chamfer the edge at the same time which saves going back to deburr the hole. If used for tapped holes they will prevent the slight raising of the surrounding area you can get when tapping into soft materials, **photo 97**. Having said that, there is no real need to go out and buy a whole range of different size spotting drills I find I can get away with just 3mm and 6mm which seem to cover most things.

An alternative to having to go around the hole positions and spot them all is to use a "split point" or "four facet" drill bit which has a second angle ground just behind the cutting edge which reduces the central "dead" area so that they will locate themselves. It is still best to initially bring them down slowly into contact with the work and let them find their own position before increasing the feed to complete the hole, **photo 98**. For commonly used sizes it is worth getting some stub length drills as these combined with split points will have even less tendency to wander and their shorter length has the added bonus of not having to keep cranking away on the z-axis hand wheel to lift the head so that longer standard length drills can be used.

Holes up to 6.0mm diameter can be drilled in one go but as you get bigger than that it is usually best to go up in stages as it puts less load on the machine and the drills will cut faster, so there is not that much time lost over using just one. The only time this method may give you problems is when drilling materials that



Long Series Drill in use

tend to grab the drill bit such as brass, bronze and copper where it is better to leave larger steps between drill sizes or, as I often do, use the fine feed to control the second and subsequent drills rather than the quill handle as there is far more resistance to the bit being pulled into the work. Other ways to avoid this is with special slow helix drills, stoning the

edge of the drill to reduce the rake of the cutting edge or using a 2 or 3 flute milling cutter rather than a drill.

Care should be taken to make sure that swarf is regularly cleared from the hole by raising the bit out of the work which is known as "pecking" and should be done more frequently as the drill's diameter decreases, a simple rule of thumb is one diameter's depth then retract the bit. As with milling cutters as the diameter of the drill goes down the rotational speed should go up to keep the correct cutting speed for the material being machined.

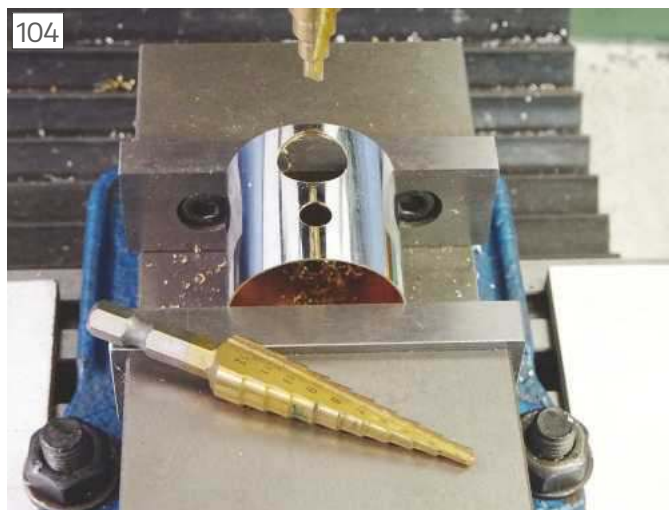
The mill's ability to easily place holes in exact positions can be made good use of when "stitch drilling" which is the use of a series of almost overlapping holes just inside the final cut line to cut out waste material where a saw can't easily get in. Using a stub length split point drill of a suitable diameter, such as 6.0mm on a metric machine, the work can easily be moved in 6mm increments by two or three turns of the hand wheel depending on the leadscrew pitch. If done right the work will literally drop out, though may need slight encouragement with a hammer. For imperial machines a 1/4" diameter drill at 0.250" pitch works just as well with two and a half turns of the usual 0.100" pitch leadscrew, **photo 99**.



Stub, Standard, Long and Extra Long bits and an extended drill



Deburring tools



Step drills in use on 0.5mm wall tube



Starting a drill on an angled surface



Set of countersink bits showing unusual sizes

The use of a suitable CAD package such as Alibre makes it easy to work out a suitable pitch circle diameter (PCD) and number of holes to suit a chosen drill diameter then co-ordinates can be produced or the details entered into the mill's DRO so that circles can also be stitch drilled, **photo 100**.

Drilling deeper Holes

There are odd occasions where a standard length jobber drill will not reach far enough, for times like this long series and even extra long series drills are available which are made in the same way except they have a much longer fluted section. It is best to use a stub or standard length bit of the same diameter to get the hole started on as straight a path as possible and only when that can't reach any further change to the longer version, don't be tempted to skimp on clearing the flutes when using these drills which will often require the head raising or knee lowering as the quill won't have enough movement to lift the bit clear of the hole, **photo 101**.

If a long drill is required due to only having to reach into an inaccessible place, then a home made extension can be used. This is simply a length of straight rod 2

or 3mm larger in diameter than the bit that can be faced off and drilled in the lathe and then the shank of the drill can be bonded into the hole with a suitable Loctite or similar retainer and once set it can be used to drill the hole. After use grip the end of the drill in the vice with soft jaws and gently heat the end of the rod while twisting and pulling it until the retainer fails and the two come apart, **photo 102**.

Cleaning up the Burrs

Drilling will raise a small burr around the entry point of the drill and usually a larger one on exit, the top entry one can be removed by using a countersink bit while the job is still on the mill or deburred along with the underside once removed. For small to medium size holes a hand-held countersink type deburring tool can be used either with a solid or cranked handle that just needs a quick turn or two to clean things up. Larger holes are better tackled with a hook type deburring bit that is pulled around the edge of the hole to cut off the burr, **photo 103**. If you find you are throwing up large hard to remove burrs then it is a good sign that your drill is starting to become blunt and should be

attended to, the same applies to milling cutters too.

Drilling Through Thin Materials

When drilling thin sheet or tube the usual two fluted twist drills can snatch or produce a tri-lobed hole rather than the round one that is desired. One way to avoid these problems is to use a stepped drill. These still have two flutes, but they have very little or no helix to the cutting faces which reduces the tendency to be drawn into the work and their stepped shape means the hole is cut in increments up to the desired size. In use they can be treated much the same as a normal drill but be prepared to reduce the speed as you work your way through due to the increasing diameters giving an ever increasing cutting speed, also watch out as you get to the final step that the drill does not break through too abruptly so that you start cutting with the next step! **Photograph 104**.

Angled Surfaces

There are times when the hole needs to start on an angled surface or off to one side of a round part, unless this is a very shallow angle, even a spotting or centre drill will struggle to start the hole without it tending



Holes from different size countersinks



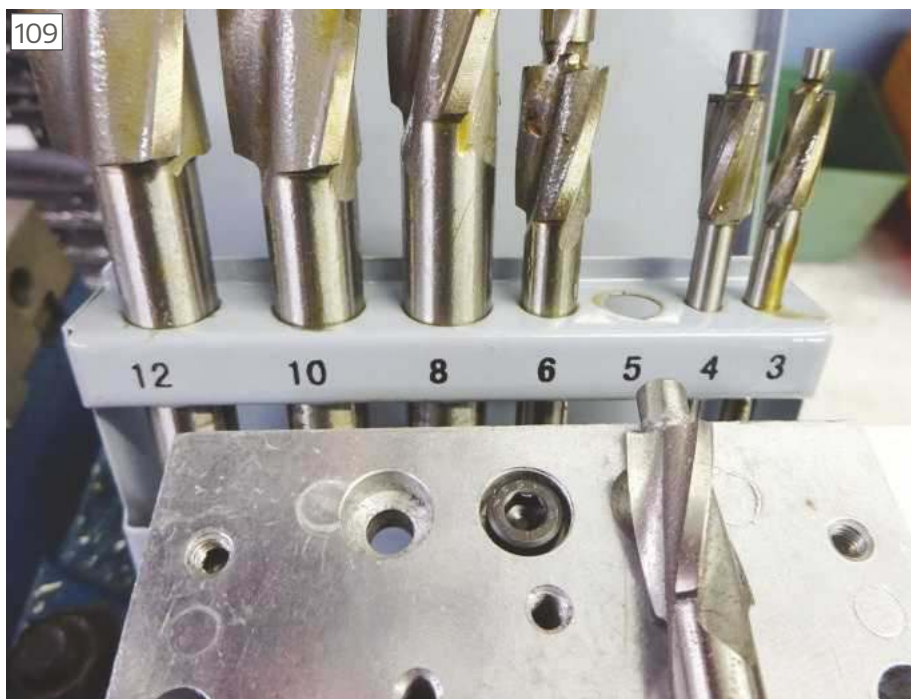
Different forms of countersink

to drift down the slope. In cases like this there are two options, the first is to use a ball nosed milling cutter of a similar size to the drill bit and use that to form a dimple that the end of the drill bit will settle into or if you don't have a ball nose cutter then a centre cutting standard one can be used to form a pocket or just enough of a flat area that a spotting drill can be started on to start the drill into, photo 105 shows a dimple produced with a ball nose cutter on the left and the flat and spotting drill method on the right.

Countersinks

To get you started a single 90-degree countersink bit around 12mm or 1/2" diameter will do for most work such as putting a neat chamfer onto the edge of drilled holes as well as recessing for countersunk screws and rivets. These bits are best run at quite a low speed which helps to stop them from chattering and gives a clean round edge to the countersunk hole. Over time you may find the 12mm CSK a bit restricting when trying to use it for holes that are close to a feature sticking up from the surface or have a need to CSK larger holes in which case other sizes can be bought as required. Some of the sizes offered may seem a bit odd at first being neither whole millimetre or metric conversions of inch sizes, photo 106, but they are sized to suit the heads of hex socket countersunk screws where the whole diameter of the bit is used so that the CSK hole goes down vertically for a short distance before sloping in towards the hole. **Photograph 107** shows two countersunk holes, the top one has been done with the correct size bit and the lower with an oversize one.

Photograph 108 shows some of the different forms of countersink available, the multi fluted ones as not used so much these days as they are prone to chattering and giving a wavy edge to the hole. The single and three flute forms are a good all round choice and the cross hole type are particularly good for softer metals and plastics. All are available in different



Counterbores in use

angles but 90-degree ones are the most commonly used.

Counterbores

In part seven I showed that a milling cutter can be used to counterbore a hole to enable the head of a bolt or screw to be recessed below the surface, but this can also be done with dedicated counter bores which would be worth investing in if you have a need to do this on a regular basis. There are two main types, those with an integral pilot which guides the cutter in a generous clearance size hole for the fixing with the main body of the cutter being sized to suit cap head fixings. Or you can get cutters that take a range of different size pilots which have the advantage of allowing a bigger counterbore for a given hole size which is useful if you want to recess a hex head fixing and also have room to fit a socket over the head. As with the countersinks these are best run

at fairly low speeds particularly in the larger sizes as they take off quite a wide cut and can chatter if run too fast, **photo 109**. These bits can also be used for spot facing which produces a flat area around a hole that has been drilled into an uneven surface such as that of a casting so that the head of the fixing has a flat area to bear against. ■

The items featured in this series are available from Arc Euro Trade, <http://www.arceurotrade.co.uk>, who also sell the X series of mills. See the accompanying thread on Model Engineer Forum <https://www.model-engineer.co.uk/forums/postings.asp?th=131318&p=1> for more discussions about this series.

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An Alternative Motor Controller for The Mini-Lathe

Mike Cox takes a different approach to speed control for his machine.

The standard Sieg mini-lathe has a variable speed power controller. The speed is varied using a control knob and once set the controller is designed to maintain a constant speed irrespective of the load on the motor. Thus, if the motor starts to slow down then the controller increases the power to the motor to restore the speed. This constant speed function works very well but the electronics are rather delicate and there are many instances recorded on the mini-lathe user groups where the lathe has been heavily loaded to the extent that the controller ceases to function altogether. A replacement controller board is quite expensive at typically around a 20% of the price of the lathe.

I have not blown my controller board through mechanical abuse of the lathe. However, after having my mini lathe for about 2 years I was using it and turned the speed control down to zero and there was bang and the speed control potentiometer did not stop at zero but continued to rotate anticlockwise. The lathe ceased to function. After dismantling the potentiometer from the control box, it was apparent that the potentiometer had failed mechanically. A new potentiometer was ordered and fitted but the board still would not work.

At this time, circa 2004, there was little



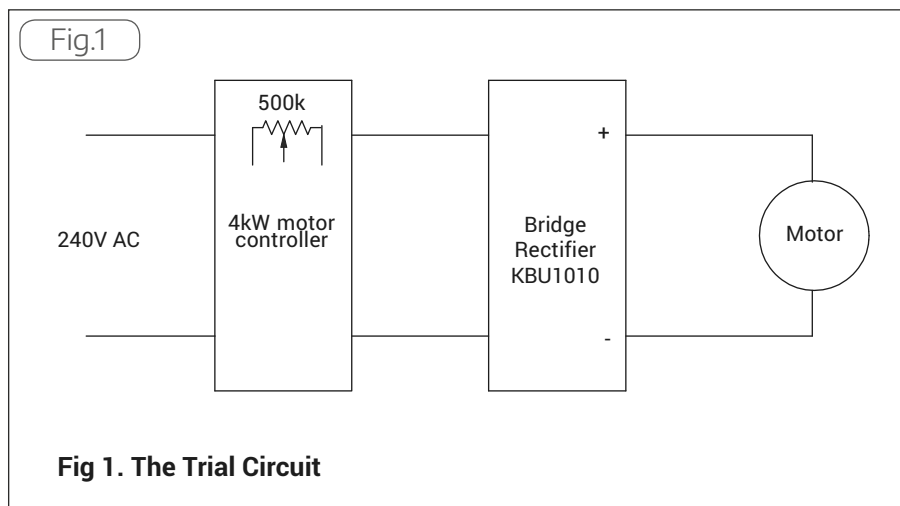
The 4kW motor speed controller.

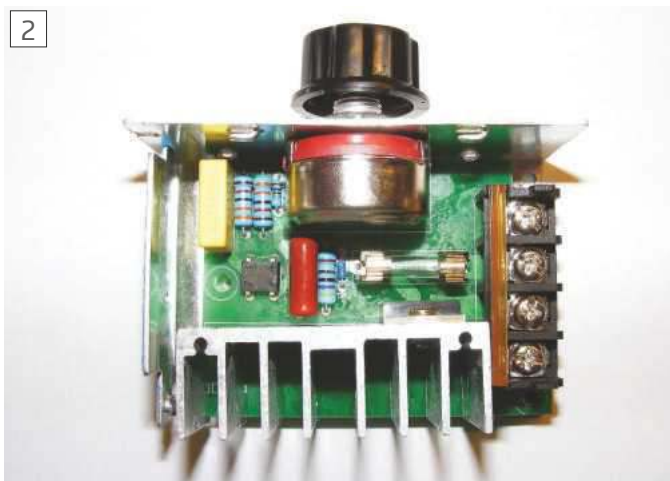
information in the public domain on the controller circuit. There were a few basic tests reported on the littlemachineshop website (**ref. 1**). This has since changed thanks to the sterling work of John Swift on the Model Engineer website who has reverse engineered the board. There was a site in the USA run by a Native American

with the name Rabid Wolf who undertook repairs to mini-lathe boards for a flat rate of 50 USD (about £35 in those days) so I sent my board to him. It was returned about 4 weeks later repaired. However, the final bill was over £60 by the time the cost of post and packing, taxes and the Post Office collection charge for the said taxes were included. Sadly, Uncle Rabid, as he was known affectionately on the Yahoo website, has passed away but others offering repair services have replaced him.

Whilst the board was away for repair, I pondered whether a much simpler speed controller would work at least as a temporary measure. The lathe motor is a DC motor with a specification of 350 W and rated for a voltage of 180 V. Many common power tools have an AC motor the speed of which is regulated by a simple triac controller. What I envisaged was a simple triac power controller giving a phase angle controlled AC output feeding a bridge rectifier to convert this to DC which then connected to the lathe motor.

I had a triac power controller to hand and a bridge rectifier and gave the idea a try. It worked after a fashion, but the low

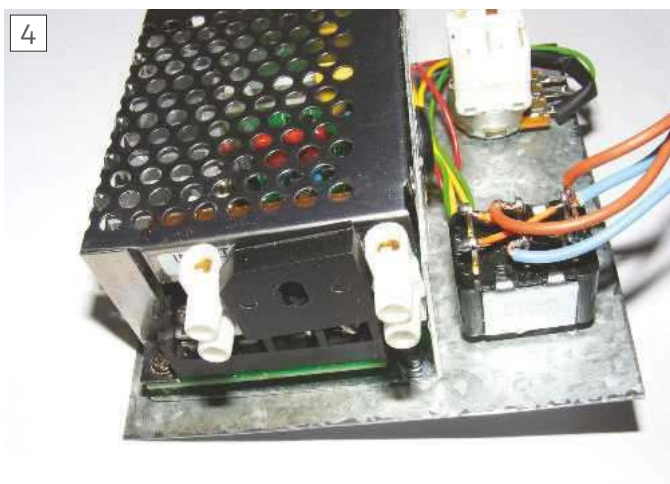




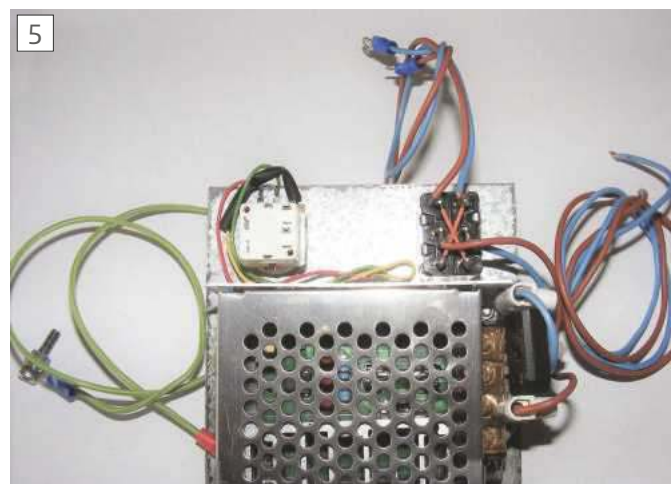
Inside the controller.



The controller panel. Note the flying leads to the new potentiometer.



The KBU 1010 bridge rectifier mounted on the controller output terminals.



The panel nearly complete. Note the earth wire on the left hand side that is fixed to the controller mounting screw.

speed performance was bad. Turning the controller up and the motor would burst into life and run instantly at medium speed. Turning the control back the speed would reduce but any load would stall the motor.

I recently purchased a second hand Clark CLM300 lathe. This was cheap because the lathe had a faulty speed control board and it would not run. The motor worked fine, and it would turn over when connected to a 12 V plug in DC power supply. My intention is to trouble shoot and repair the speed control board with the help of John Swift's notes on the ME website.

However, in the meantime I stumbled on a youtube video by bigclivedotcom entitled "Inside a "4kW" eBay power controller with schematic", **ref. 2**, in which he discusses a Chinese 4kW triac motor controller with superior low speed performance. I thought it would be interesting to test out this controller with a bridge rectifier as a controller on the secondhand lathe. The controller was cheaper than the components can be purchased in the UK. I ordered one of these from an ebay company called "bigfashionmarket" and it arrived about 2 weeks later. I shall not discuss the detailed electronics of the

controller here since this is well covered in bigclive's video and in the Littelfuse application note AN1003 that he refers to.

Photograph 1 shows the external appearance of the controller and **photo 2** shows an inside view once the case was removed. There are relatively few components. However, note the small square black component below and to the left of the potentiometer. This is a small bridge rectifier and it is this component that improves the low speed performance. These 4kW motor speed controllers are available from many suppliers on ebay but not all of them have the bridge rectifier. The control knob actuates a 500k potentiometer. There is a scale under the knob marked 0 - 10 that corresponds to the angle of rotation.

The first test of the motor speed controller was made using the simple circuit shown in **fig 1**. When this was connected to the mains then as the control knob was turned up the motor would start to rotate at a scale setting of 2.4 and with increasing rotation the speed increased smoothly. On turning the control down the speed reduced smoothly and the motor stopped at a scale setting of 2.4. There was thus no hysteresis in the stopping point. In this

test the maximum speed was potentially very fast because the motor was running on 240V DC whereas it was rated at 180V DC. To prevent damage to the motor the maximum speed was not attempted.

In a second test I attached a reflective strip to the lathe chuck so that I could record the speed of rotation using a non contact optical tachometer. I set the speed lever on the back of the headstock to 'High' and then slowly turned to control knob up until the speed reached 2,000 rpm. The scale reading at this speed was 6.5.

The usable range of the potentiometer to give a speed control from 0 - 2000 rpm was thus 2.4 - 6.5. Bearing in mind that the potentiometer has a maximum resistance of 500k then the required resistance range is from:

$$500k \times 2.4/10 = 120k \text{ to } 500k \times 6.5/10 = 325k.$$

Thus, if the 500k potentiometer were replaced by a 120k fixed resistor in series with a 205k potentiometer then the required range would be covered. The nearest preferred size potentiometer is one of 220k.

The final circuit for the controller is shown in **fig 2**. The mains is fed first through an emergency stop switch and then it passes through a 2 Amp fuse. This

Fig.2

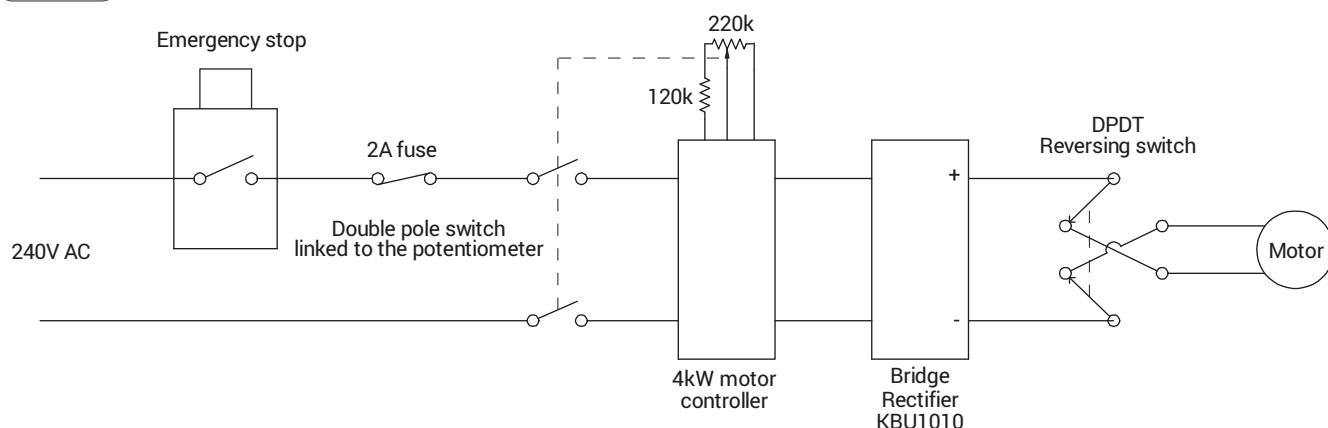
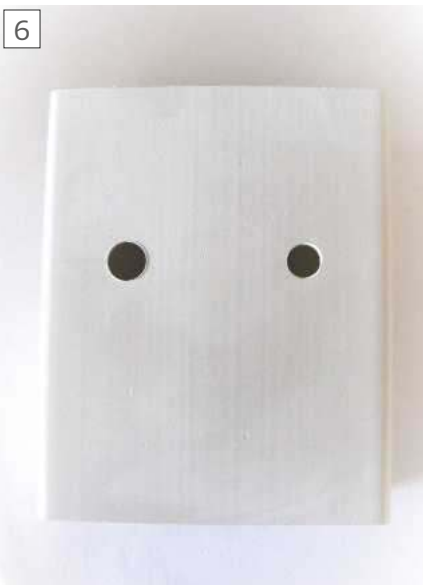


Fig 2. The Controller Circuit

is to protect the motor if the current draw become excessive. It then passes to a double pole switch which is linked to the potentiometer. This ensures that when the potentiometer is turned to zero then no current is supplied to the controller. After the switch is the 4kW triac controller. Note that the internal 500k potentiometer has been replaced by an external 120k resistor in series with a 220k potentiometer. After the controller is the KBU1010 bridge rectifier that converts the AC from the controller into DC. The final component before the motor is a double pole double throw switch wired at to enable the polarity of the output to be reversed thus allowing the motor to run forwards and backwards.

It should be noted that all the components are very overrated for driving a 350 watt motor. This has a rated current draw of 1.4A. The controller is rated at 4 kW so it can supply 16 amps of current which is a safety factor of more than 10. The rectifier is rated



The plastic case made from ventilation duct.



The back of the case.

8



The top of the case with the e-stop and fuse holder mounted.

at 10 amps giving a safety factor of 7. The only under rated component is the reversing switch which was rated at 250V AC and 2A. Such switches have a much lower current rating when used to switch DC voltages. However, in this application the reversing switch should only be used when the controller is turned to zero when there is no current flowing, so it is no problem.

Construction.

The first operation was to remove the potentiometer from the circuit board. Because there are three potentiometer tabs soldered to the board it is very difficult to unsolder and the easiest way is to cut off at least one of the tabs using wire cutters. Once the potentiometer is removed flying leads can be attached to the circuit board. These leads can exit the controller case through a grommet fitted in the old potentiometer mounting hole. The controller was then mounted onto a piece of 0.7 mm steel 100 x 100 mm which is also used to mount the potentiometer and the reversing switch, photo 3. The



The bottom bracket fixed to the headstock.

flying leads then connect to the new 220k potentiometer via 120K resistor which is inside the black sleeving attached to one of the potentiometer terminals.

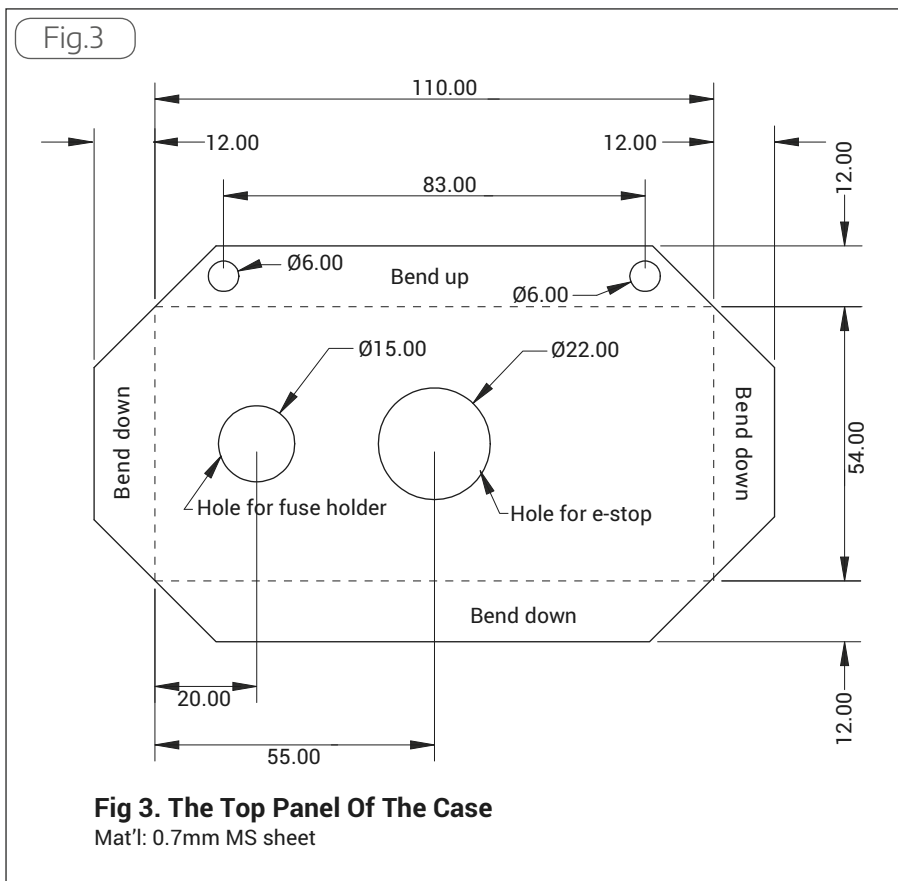
The bridge rectifier is attached directly to the output terminals of the controller, **photo 4**. No heat sink is required because the dissipation is only around 2 watts at maximum the DC terminals are bent up and connected to the reversing switch using connectors.

Photograph 5 shows all the wiring completed on the steel panel. Note particularly the earth wire on the left hand side which is fixed securely under the mounting screw of the controller module. For safety it is very important that the steel panel is earthed.

The steel panel fits inside a plastic case made from a 135 mm length of 110 x 54 mm ventilation ducting. The case is drilled to take the control knob and the reversing switch on the front face, **photo 6**. The back of the case is cut away, **photo 7**, to facilitate connections to the earthing screws on the headstock and for access to the motor and mains leads.

The fuse and emergency stop button are mounted on a top for the plastic case that is bent up from 0.7 mm steel sheet, **fig. 3** and **photo 8**. This is also drilled out to enable attachment to the head stock. The steel top is attached to the plastic case by two self tapping screws at the side.

The plastic shelf that supports the cables over the leadscrew was replaced by a metal shelf 80 mm wide and 70 mm deep that was bent up from 0.7 mm steel sheet, **Fig 4** and **Photo 9**. This was drilled out and attached to the headstock. The front end was bent up and the bottom of the plastic case attached with a single self tapping screw. The new shelf is not quite as wide as the plastic case so that there is some air flow through the case.



The completed controller mounted on the headstock.

The final unit after connecting everything up and fitting to the lathe is shown in **photo 10**.

Performance.

This speed controller provides the same range of speeds as the standard Sieg controller. When making a heavy cut the speed does slow down noticeably compared with the standard controller. However, the lathe is perfectly usable, and all the normal turning, facing and drilling operations are possible.

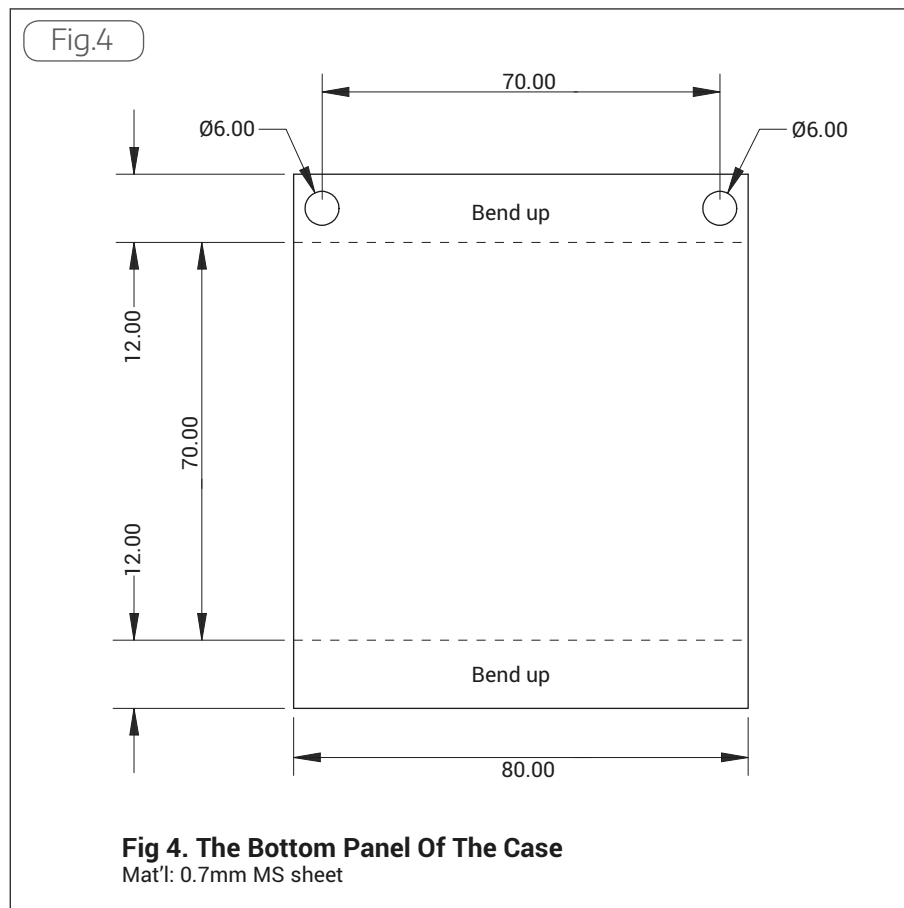
The total cost of the components is very low, very much cheaper than a standard controller board. In the event of a damage by overload the only likely components that could be damaged are the speed controller itself and bridge rectifier listed.

There is only one thing to be careful of. Never operate the reversing switch whilst the motor is running so always turn the speed control to zero first. Sudden reversal of the motor whilst it is running will cause large transient currents to flow in the controller which could damage the triac or bridge rectifier.

The controller can be made and assembled very quickly from cheap readily available parts so would be ideal as a stopgap controller if the original controller board becomes damaged. ■

Safety.

This project involves testing and handling components at potentially lethal AC mains voltages and DC voltages. Every care should be taken to ensure safe working practices are followed and that the final version is appropriately and adequately earthed so as to pose no risk to potential users. If you



are not experienced and competent to work with such voltages, see the help of someone who is.

References.

1. <https://littlemachineshop.com/Reference/>

- DriveTroubleshooting.pdf
2. Bigclivedotcom -Inside a "4kW" ebay power controller with schematic.
https://www.youtube.com/watch?v=_4PwYm_7HKg&t=38s

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The March issue, number 278, of Model Engineers' Workshop has a great:



Joseph Noci describes his journey to resurrect an Alba shaper and brining it under computer control.



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Centec 2 Vertical Head Attachment.



Peter Worden describes and the ups and downs of taking on a major workshop project.

The second idea was to put the bevel gears in a box enabling the countershaft to be positioned lower and the vertical spindle to be driven via a vertical shaft and pulleys. This would enable smaller bevels to be used but the vertical shaft would be long and unsupported, **fig.1B**.

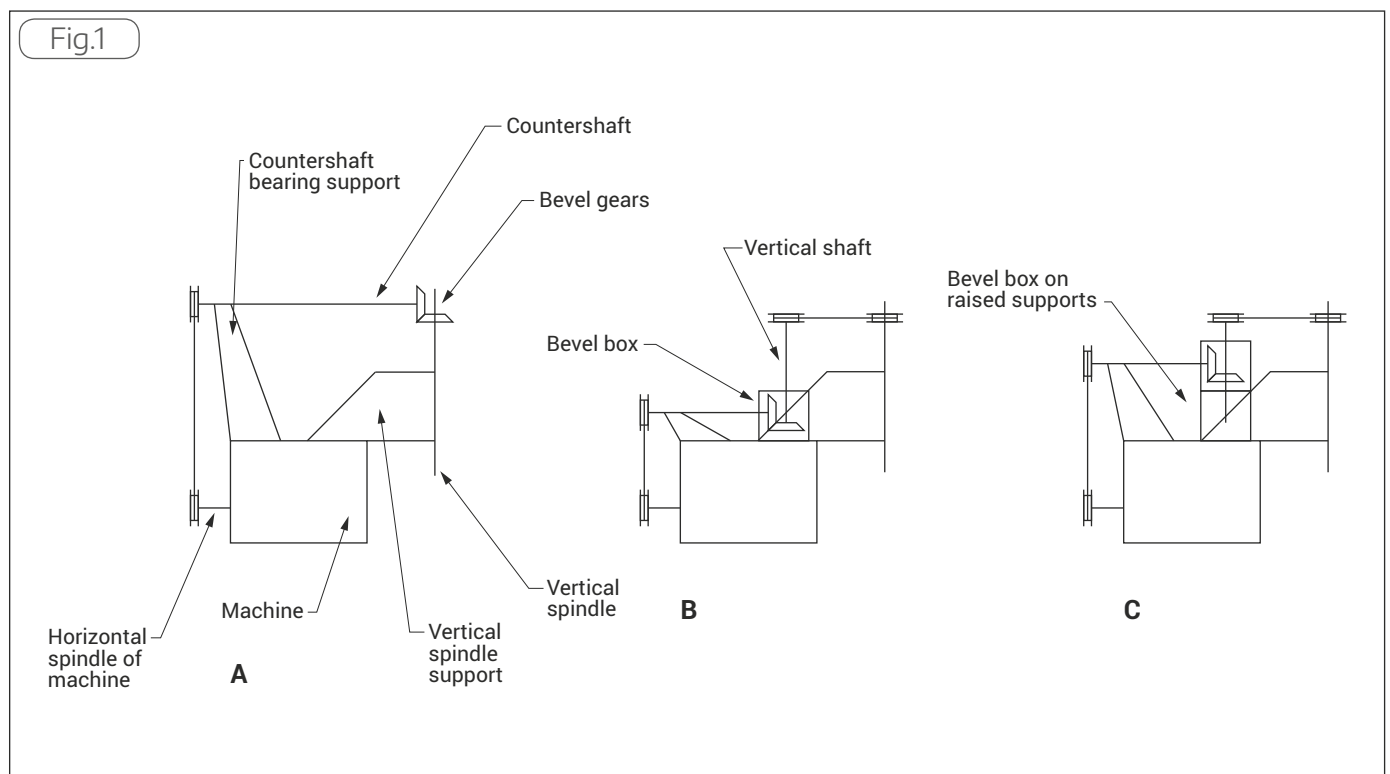
The third idea was a compromise of the first two. The bevel box was raised and supported on spacers giving the countershaft and vertical shaft hopefully enough support, **fig. 1C**.

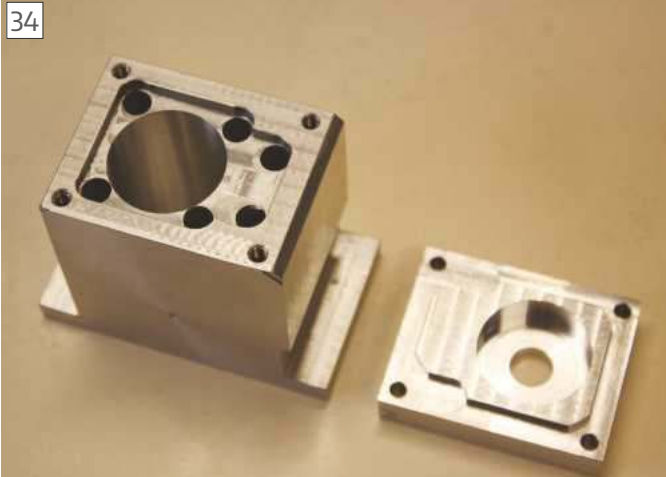
Bevel Box.

The bevel box was made from the largest billet of aluminium that was available, **photo 33**.

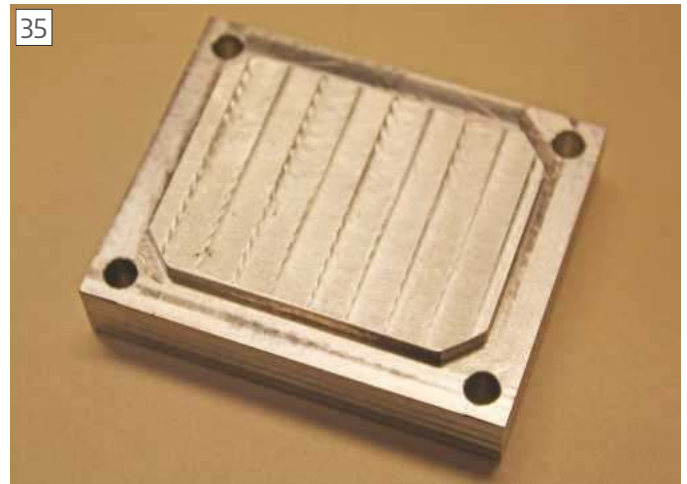


Off-cut billet of Aluminium that was used to make the bevel box.

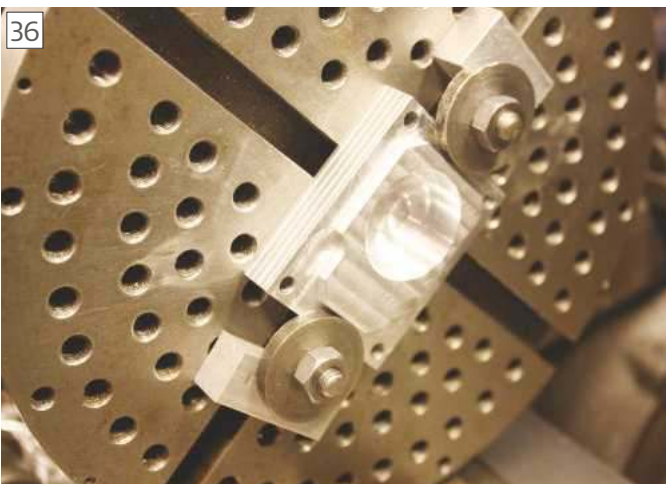




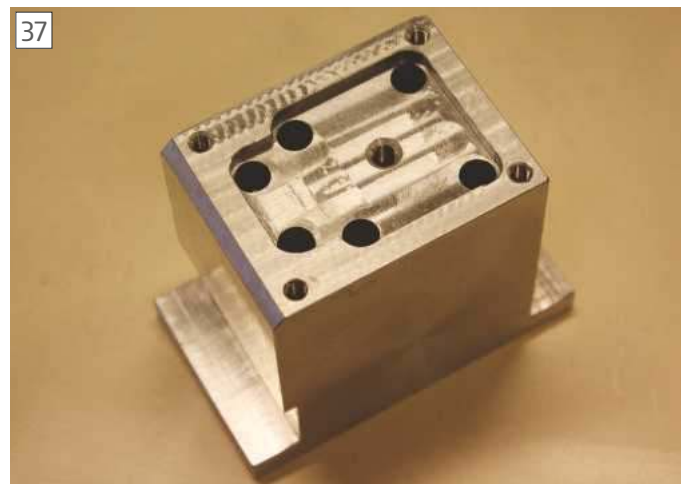
Bevel box top on the right.



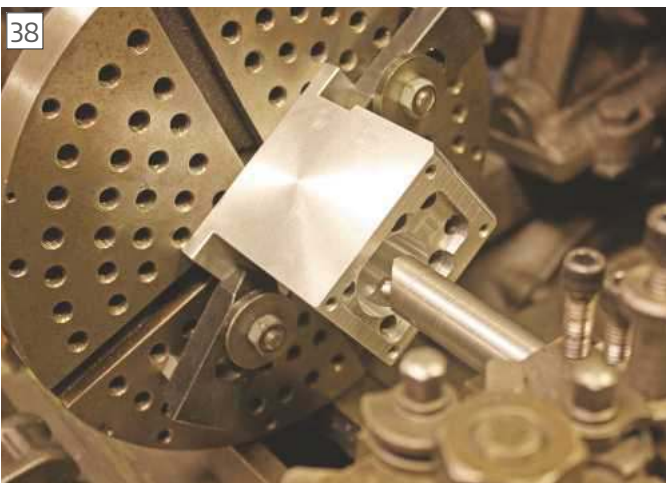
Part finished bevel box top.



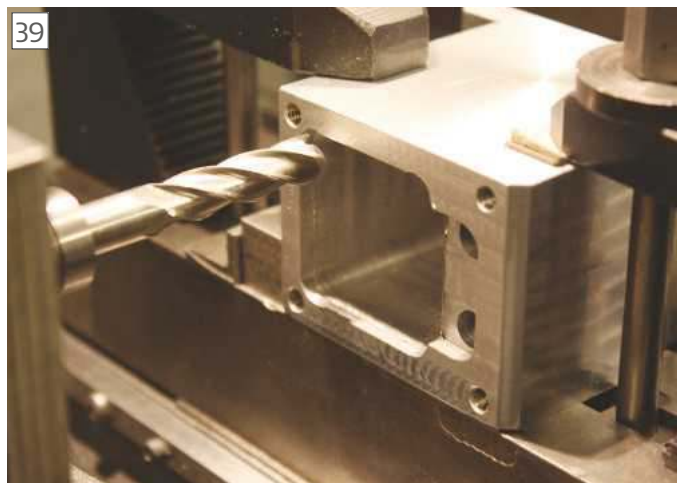
Bevel box top clamped to faceplate after bearing location was bored.



The bevel box with 2BA holes tapped on the corners, before the bearing location was bored.



Boring the bearing location in the bevel box.



Milling the inside of the bevel box.

The bevel box top (on the right in **photo 34**) was made first to enable it to be used to set up the bevel box for boring the vertical shaft lower bearing location. Once the box-top reached the stage as at photo 35 the raised portion was reduced one end to match the shape that will be inside the bevel box. A setting button was positioned accurately and

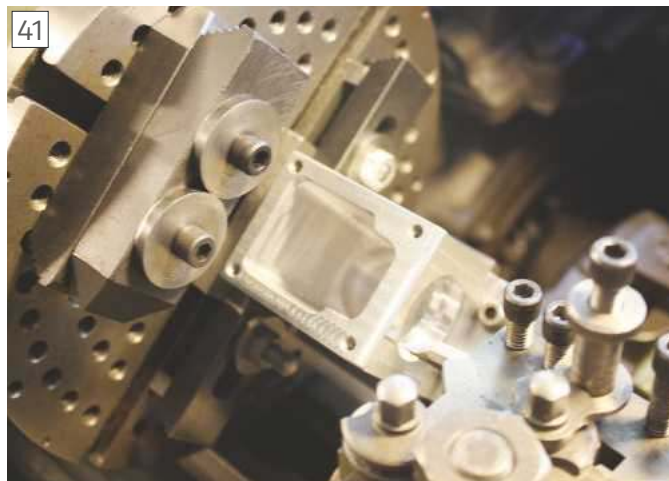
the box-top was clamped to a faceplate on the lathe and the button was clocked with a DTI until running true. The button was removed and a clearance hole for the vertical shaft was bored through. The box-top was reversed and located by the clearance hole on a mandrel held in the collet to maintain concentricity and the hole was then opened out on the

underside to form a housing for the upper bearing, **photo 36**.

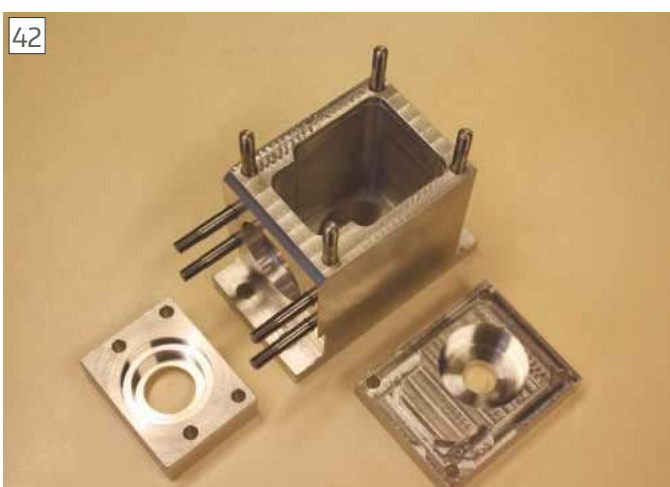
The bevel box itself was milled all round to get the outside shape. The top of the box was milled accurately to the shape of the raised portion on the box-top to a depth enough to allow the box-top to seat properly. Four holes were spotted on the corners on the top of the box



Inside shape of the bevel box complete.



Countershaft bearing location being bored in the bevel box.



Completed bevel box with top and countershaft bearing retainer.



The countershaft and vertical shaft.



The two bevel gears.



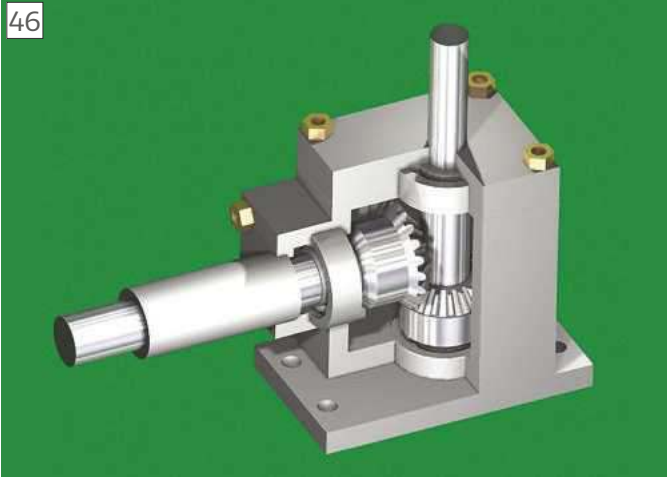
The vertical shaft with bevel gear and bearings mounted in the box top.

using the box-top as a jig, and drilled and tapped 2BA, **photo 37**, then the box-top was fixed with screws. The box, complete with its top, was clamped to the faceplate and a clock was used on the clearance hole in the box-top to run true. The box-top was removed and a hole was bored in the box to the required depth to a diameter that would accept the lower

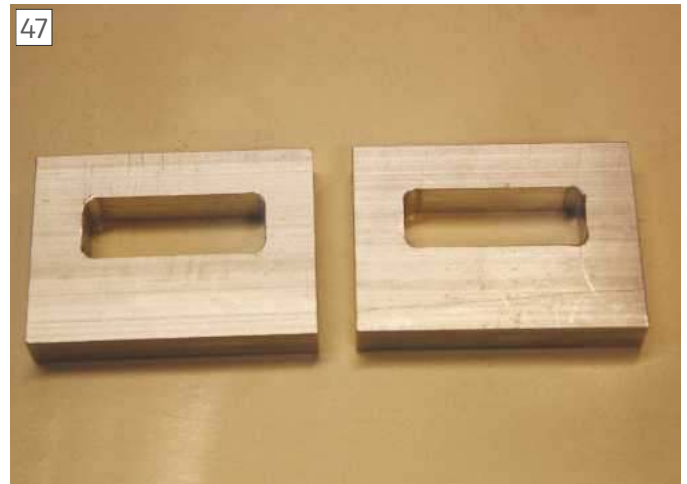
bearing with a tight fit, **photos 34 and 38**. The reason for boring the hole before milling out the box is that it is easier to measure it where it can be seen rather than trying to do it deep inside the box. The inside shape of the box was then milled out to the required depth, **photos 39 and 40**.

The box was re-mounted on the

faceplate via a small angle plate and the countershaft bearing location was bored in the side of the box, **photo 41**. This operation used a setting button, as before, to position the bearing location accurately. A bearing retainer was made from an oblong piece of aluminium (bottom left **photo 42**). A hole was counterbored to locate the bearing and



A computer-generated cut-away showing the workings of the bevel box.



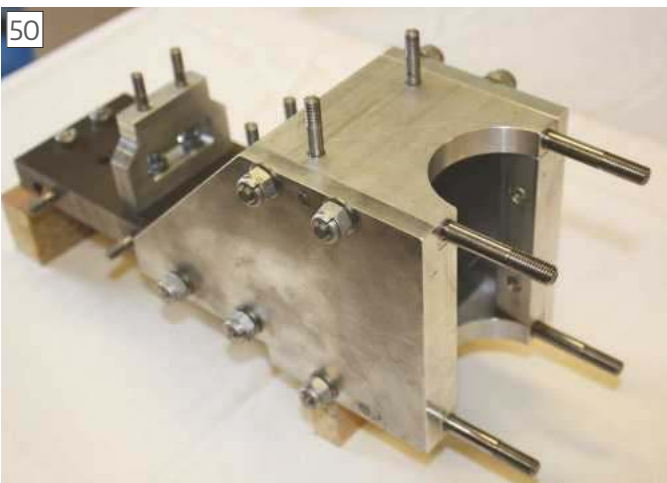
Part made bevel box supports.



Milling bevel box supports.



Milling angle on bevel box supports.



Bevel box supports at left in picture.



Rear pulley and spacer.

a further counterbore was made to take an oil seal. Four 2BA clearance holes were drilled at the corners and when the bearing was pushed in to the bevel box and the retainer slid over the bearing the four holes of the retainer were used to spot the bevel box to be drilled and tapped 2BA. The reason for the reduced section in the internal shape of the bevel

box was to allow deeper fixing holes for the retainer to be tapped in the side without breaking through into the inside of the box alleviating any chance of oil leaks through the threads.

The countershaft and vertical shaft, **photo 43**, were made from stainless steel, mainly because I had more of that at the right size than I had mild steel (again

using what's available).

The two bevel gears, **photo 44**, were purchased and modified to fit the shafts, **photo 45**, shows the sub-assembly of the vertical shaft fitted with the bevel box-top, top and bottom bearings and vertical bevel gear.

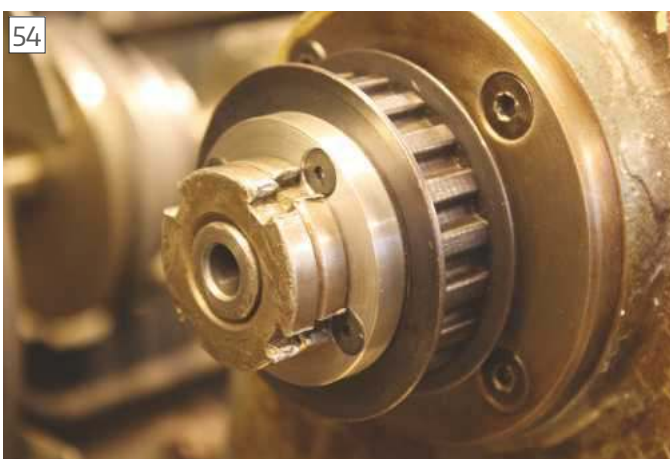
A computer-generated picture showing a cut away view of the complete bevel box



Assembly of rear pulley and spacer.



Rear of horizontal spindle showing woodruff keyway.



Rear pulley and spacer mounted on horizontal spindle.



The two larger pulleys with lightening holes.



Computer-generated view showing how spreader fits.



The spreader Parts.

assembly is shown in **photo 46**.

Bevel Box Support.

The bevel box supports were made from the same material source as the tube camps, namely 1/2" thick aluminium.

Two oblong blanks were milled and then the inside relief was milled out, **photo 47**. Two 1/4" diameter holes to correspond with the fixing studs that hold the clamping plate to the base plate were drilled in the narrow section in

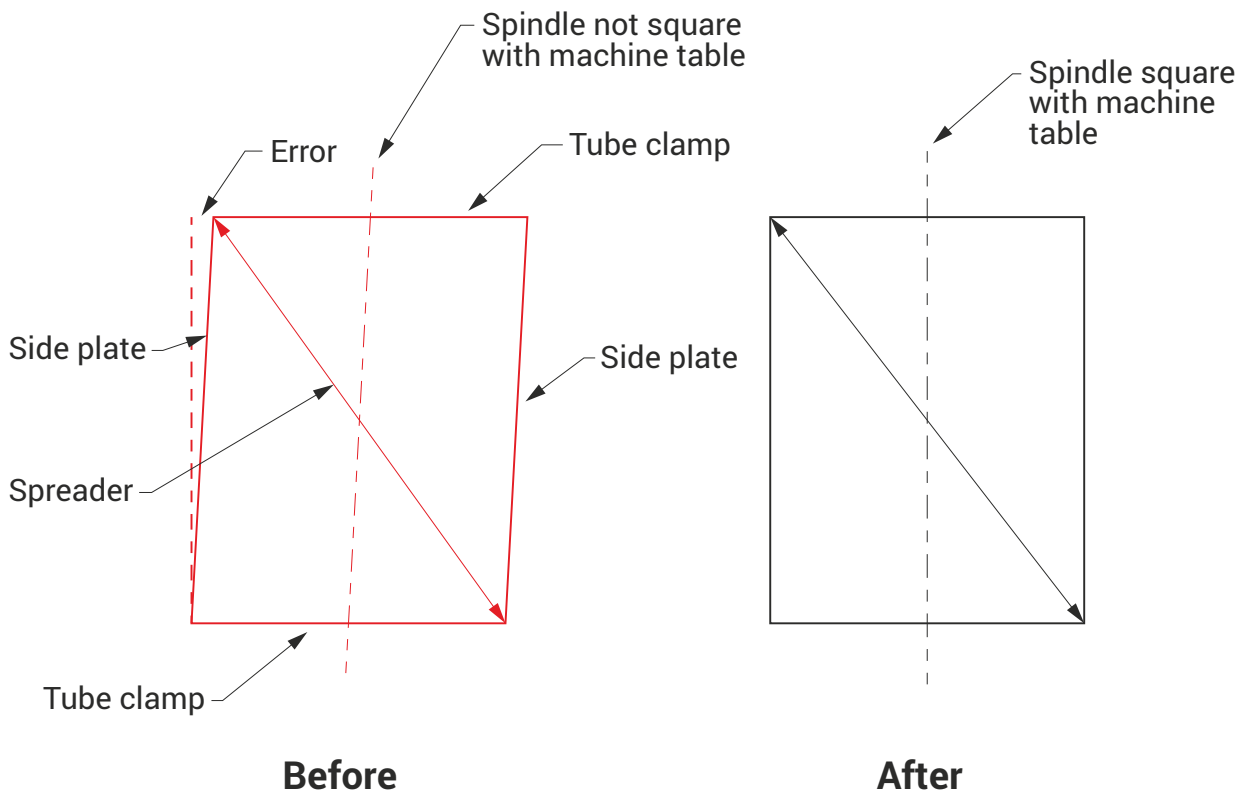
each support. Two holes corresponding with the fixing holes in the base of the bevel box were drilled and tapped 1/4" Whitworth in the wider section of each support. A step was milled on either side of each support, **photo 48**. This was finished off with a 45° angle, **photo 49**. Two studs with a 1/4" Whitworth thread on one end and 1/4" BSF on the other were screwed into the shorter side to mate with the bevel box. A finished support can be seen to the left in **photo 50**.

Drive Train.

The drive train, as mentioned before, consists of a belt drive from the horizontal spindle of the machine to a countershaft, through two bevel gears to a vertical shaft, then via another belt drive to the vertical spindle.

It was decided, to give the bevel gears an easier time at top speed, that it would be better to reduce the speed of the drive by gearing it down from the horizontal

Fig.2



spindle to the countershaft and then gearing up from the bevel-box to the vertical spindle. Timing belts and pulleys were used to maintain grip with the help of two jockey pulleys to put enough tension on the belts without straining any of the bearings.

The first job was to fix a pulley onto the end of the horizontal spindle of the machine. It wasn't going to be an easy job as there was not much of it protruding from the machine. Just the two adjusting nuts and a short section of a spacer, the rest of which disappeared inside a cover. The cover was removed and discarded, as it did not seem to be doing much, and showed a bit more of the spacer. The problem now was to fix the pulley to the spacer but as this was only clamped on the spindle by the adjusting nuts it could be possible for it to rotate on the spindle as the nuts could not be tightened too much as this would cause the taper roller bearings to be too tight. There wasn't enough length on the visible part of the spacer to have a boss on the pulley and anchor it to the spacer with a grub screw so it was decided to make a new spacer with a flange to bolt through a bossless pulley, **photos 51 & 52**. The removal of the adjusting nuts and spacer revealed a woodruff keyway cut in the spindle, **photo 53**. If I could cut a corresponding

keyway in the new spacer this would solve the problem of it revolving on the spindle. I found a woodruff key the right size but now I had to see if I had a broach the right size to cut the keyway. Well Lady Luck was shining on me yet again as I found the very thing in my collection of broaches. All I had to do was make a

guide to fit in the bore of the spacer and we were in business. The broach was a short push type which was used on the afore mentioned home made arbor press and had a set of shims of 5, 10 and 15 thou thickness so that cuts could be made in 5 thou steps. Everything was assembled and ended up looking quite a reasonable



The spreader assembled.

job, **photo 54**. I did think afterwards that maybe I could have put a keyway in the pulley but the material that was used in the purchased item was not of high quality, in fact it was rather hard, so trying to broach it might have been a bigger problem.

Another look in the bearing collection produced a suitable double shielded job to support the rear end of the countershaft. The two rear bearing supports were made from the same 3/8" Aluminium plate as the spindle side plates.

The larger pulleys were a bit on the heavy side, one was in steel and the other was cast iron. To reduce the weight to make the attachment easier to lift on and off the machine a series of holes were bored on a PCD (Pitch Circle Diameter) in each pulley, **photo 55**.

Testing

A test was made to see how the attachment worked. I clamped a piece of



Shows the spreader mounted in the attachment.



The spanner used to adjust the spreader before modification.

Aluminium, about 2" x 3", in a vice on the machine table and set up a flycutter in the spindle and took a light cut. The leading edge of the flycutter provided a good finish but the trailing edge cut deeper, only about a thou or two but it indicated that the spindle wasn't quite square with the table. A bit of thought had to be put into how it would be possible to rectify this. I finally had the idea that as the tube clamps and the side plates formed a box what if I placed what I would call a spreader in two opposite corners inside the box and expanded it, it might have the effect of straightening the spindle, **fig. 2, photo 56**.

The individual parts of the spreader are shown, **photo 57**, and assembled, **photo 58**, and mounted in the attachment, **photo 59**. The spindle had to be removed to get the spreader in as it could only be done from the front. The spindle was then replaced. There wasn't much room inside the box to make any adjustments as open ended spanners could only make small movements. What I needed was a 12-point ring spanner but there was no

way I could get one in there. I found a thin ring spanner which I didn't use for anything else, **photo 60**, and thought that if I could cut a section out, **photo 61**, wide enough to slip over the screw part of the spreader and engage on one of the hexagons it might do the trick, and it did.

I unscrewed the spreader to take up the slack until it settled into each corner via a couple of rollers. I opened it up a bit more with a tiny movement of the spanner and open ender on the other end and took a cut with the flycutter. It was still cutting deeper on the trailing edge but with a session of trial and error I eventually got the finish I wanted, a criss-cross pattern of tool marks indicating that the spindle was now square with the machine table... success!!

At top speed it's a little noisy, mainly it is the timing belt engaging the small pulley on the top of the spindle, but I think I can live with that.

It's taken me 2 1/2 years on and off making this attachment but I can now get back to my original project of building a 1/4 scale 4 cylinder petrol engine without getting neck and back ache, but it's been 2 1/2 enjoyable years well spent. ■



The spanner after modification.

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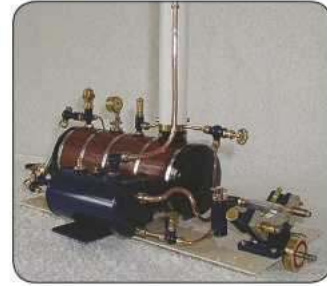
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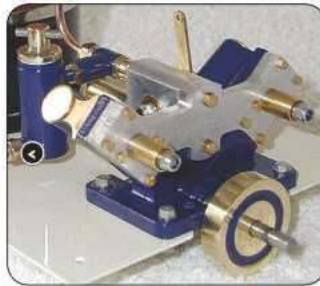
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A Cam Grinding Machine

Alex du Pre describes a machine for grinding the cams of miniature internal combustion engines or any application requiring small cams to be ground to precise size and shape.

Cambelt Tensioner

This is a simple swing arm and idler wheel arrangement, **fig. 6**. None of the dimensions is critical, except for those which place the idler in line with the timing belt. The swing arm (part 39) is a block of steel, milled to the required dimensions. It is bolted to the frame with relatively hefty 8mm cap screw as it needs to be solidly fixed to the frame in use. The axle (part 38) is a simple turning and tapping job and is fitted to the swing arm with Loctite, **photo 16**. The idler wheel (part 39) was turned from a steel offcut. Its reamed bore runs directly on the axle. A steel to steel bearing would not normally be ideal, but in this case, the rotational speeds are so slow that it is of no consequence, although the axle should be oiled of course. The wheel is retained on the axle with an M5 cap screw and washer, **photo 17**.

This completes the frame assembly, **fig. 7**.

Cam Mandrel

When making individual cams, they must be mounted on a mandrel between centres in the machine. It is critical that the cams do not rotate on the mandrel under grinding forces, as they are all too inclined to do, otherwise they will be scrapped. To prevent this, the small nut that clamps them onto the mandrel must be very firmly tightened, so the mandrel and the nut must be made from high tensile steel which will not yield under the clamping forces.



Fixing the idler axle to the swing arm with Loctite. A high temperature grade was used as I had it in stock, but a low temperature grade will be fine for this application.

Base

A heavy, rigid, flat base is needed that will absorb vibration and prevent flex. This was made from two layers of 15mm birch plywood, measuring approx 42 x 44cm, glued together with wood glue, weighted and temporarily screwed down onto the flat work bench to keep the base as flat as possible. Before gluing, the top layer was marked out and drilled for the Unimat hold-down bolts. The four holes were spotted through onto the lower layer in way of the Unimat, and these were drilled through 18mm using a spade drill. These four holes

give a recess for each of the hold-down nuts, leaving the underside flat, **photo 18**.

The swing arm pivots are supported on two raised platforms. Rigidity is important, so reinforcing strips were added. The uprights were made from two identical rectangles of birch glued to the base and held vertical with squares whilst allowing the glue to dry. These were reinforced additional glued strips of wood and with three countersunk woodscrews from underneath once the glue had dried. The platforms were glued on top of the uprights, with screws and reinforcements

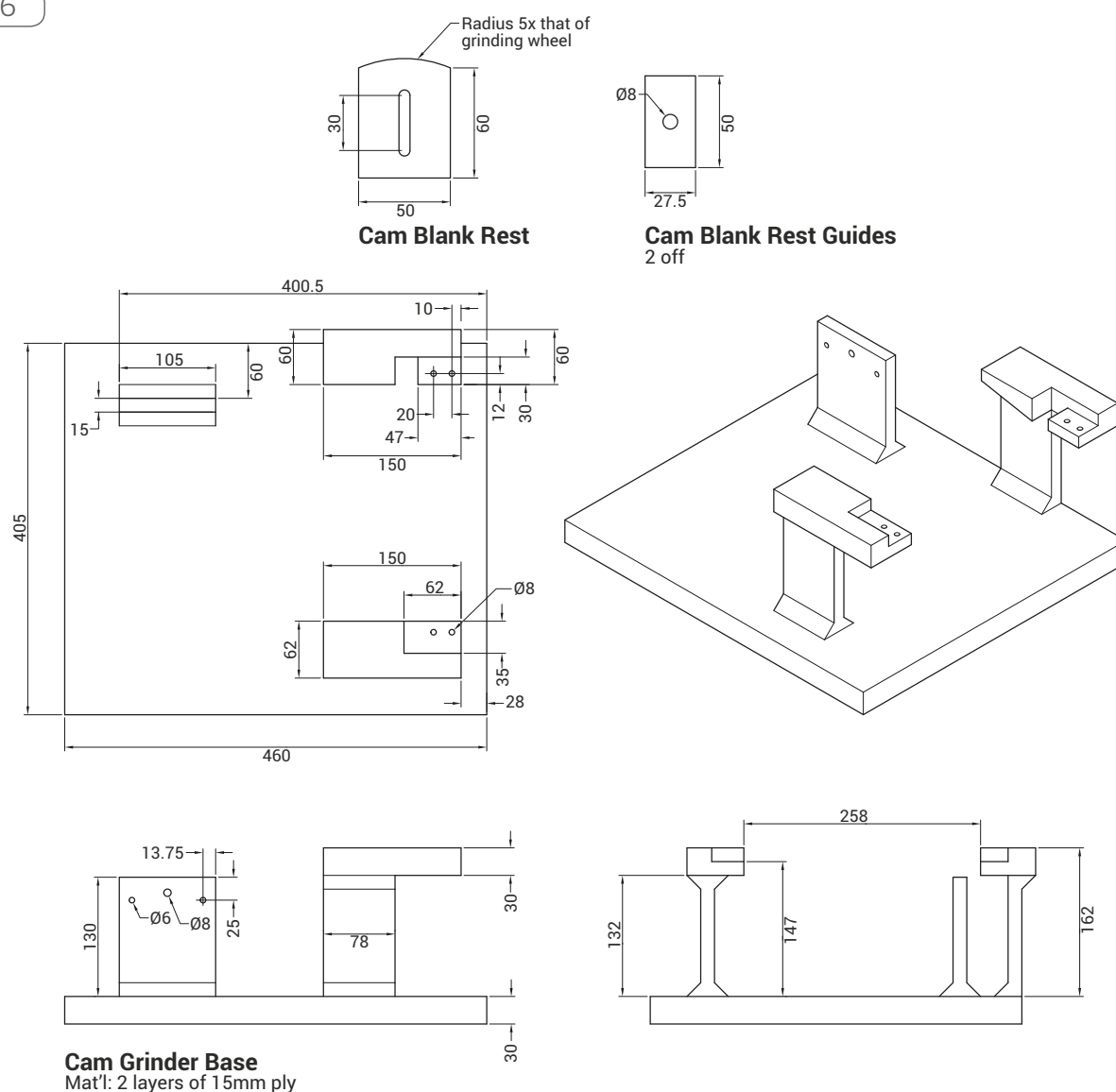


Belt tensioner components.



Building the base around the Unimat and frame. The base was made to fit these components and was not built to a plan.

Fig.6



as before. A strip of ply was temporarily clamped across the top of the platforms to keep them flat and level. The platforms were extended forwards with a second piece of wood and a reinforcing piece glued on top. This was an afterthought needed to bring the swing arm into the correct longitudinal

position in relation to the Unimat.

The exact height of the swing arm over the base is not critical as it can be shimmed up, as can the grinding spindle attached to the Unimat cross slide. It is as well to get it as close as possible though. There is provision for some fore-and-aft adjustment in the

swing arm position too, but it is important that the tops of the platforms are equal heights above the base.

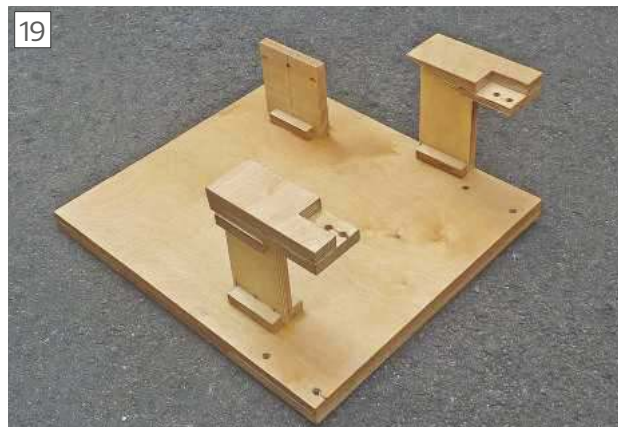
The platform in way of the timing belt had to be cut away slightly to give clearance over the belt, **photo 19**.

● To be continued

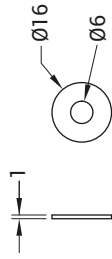
Fig.7



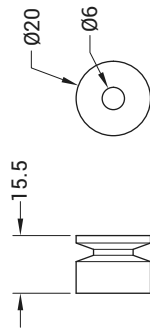
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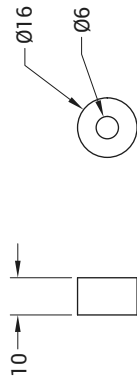
The completed base.



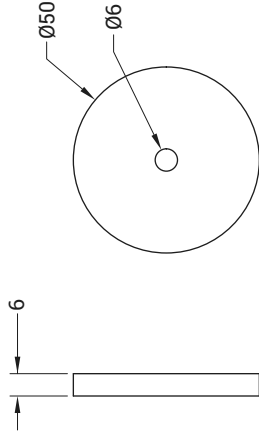
Part 53. Washer
2 off, place either side of grinding wheel with card pads between



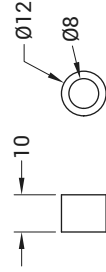
Part 50. Pulley
Machine groove to match drive belt
Tap boss M4 for grub screw



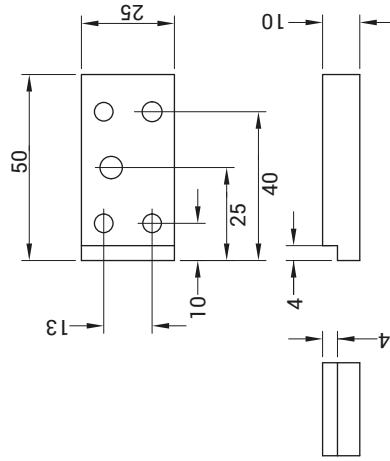
Part 52. Spacer



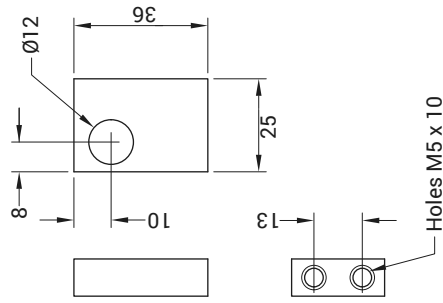
Part 51. Grinding Wheel



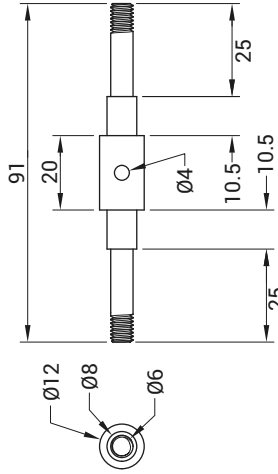
Part 48. Bush
2 off, phosphor bronze



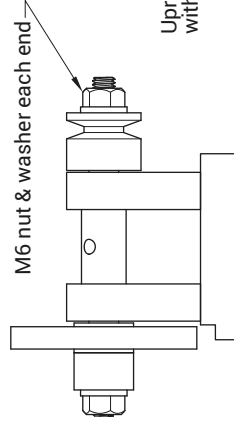
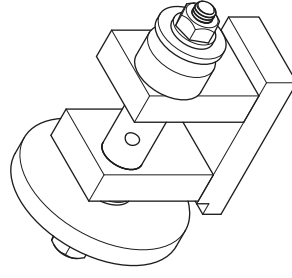
Part 45. Base



Parts 46 And 47. Uprights



Part 49. Spindle



Uprights attached to base with 4 off M5 cap screws

Grinding Head Assembly

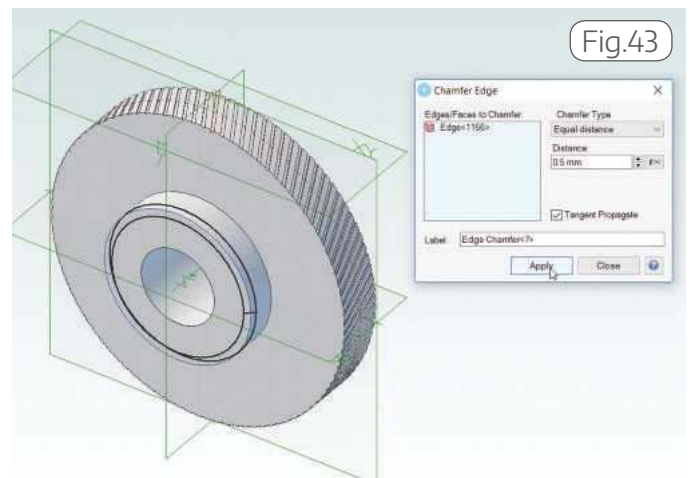
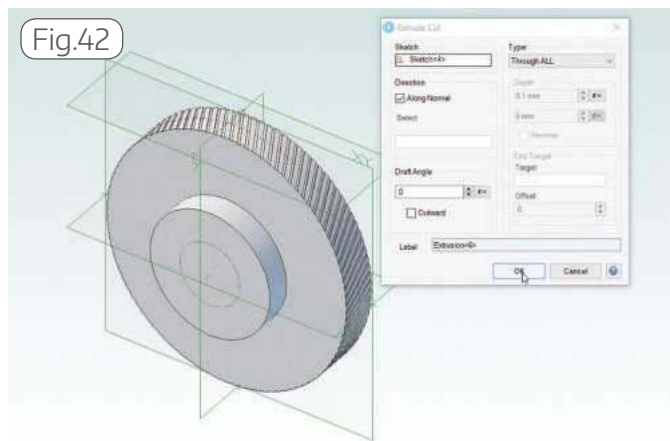
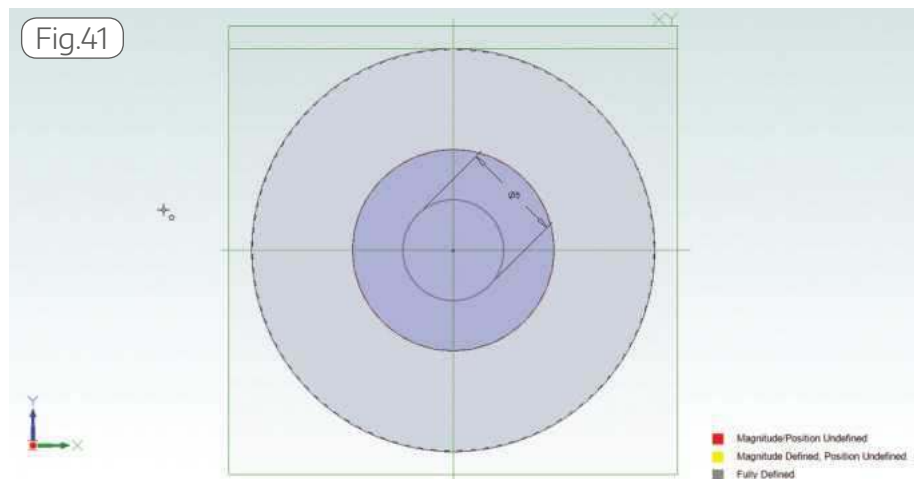
Alibre Atom3 continued from page 31

tool, click in 'Center' and then select the outside cylindrical face of the component as shown.

C: In the 'Instances' box, change the value to 96, and in the 'Angle' section, change to the right hand radio button (this option evenly spaces the specified number of instances around 360 degrees) and click 'OK'

D: The finished grip pattern.

Select the flat face on the end of the smaller protrusion and activate 2D sketch mode. Draw a 5mm diameter circle, centred on the origin as shown in fig. 41. Deactivate sketch mode. Create an extrude cut feature, set the type to 'Through All' and click 'OK' as shown in fig. 42. Click on the



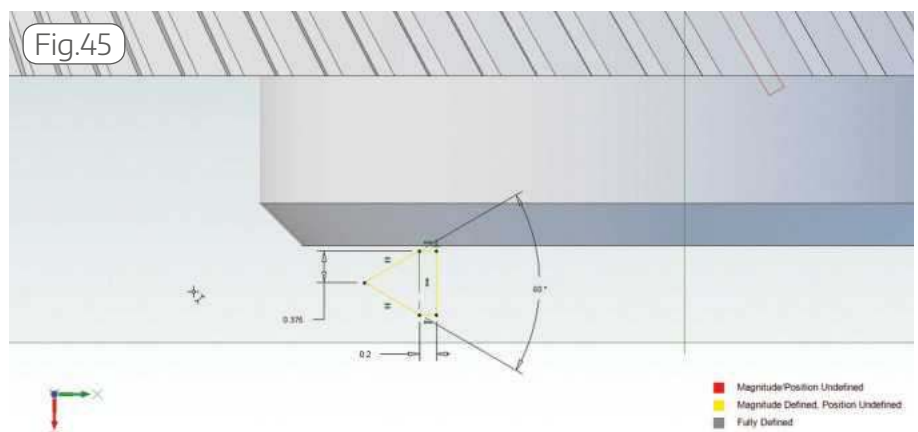
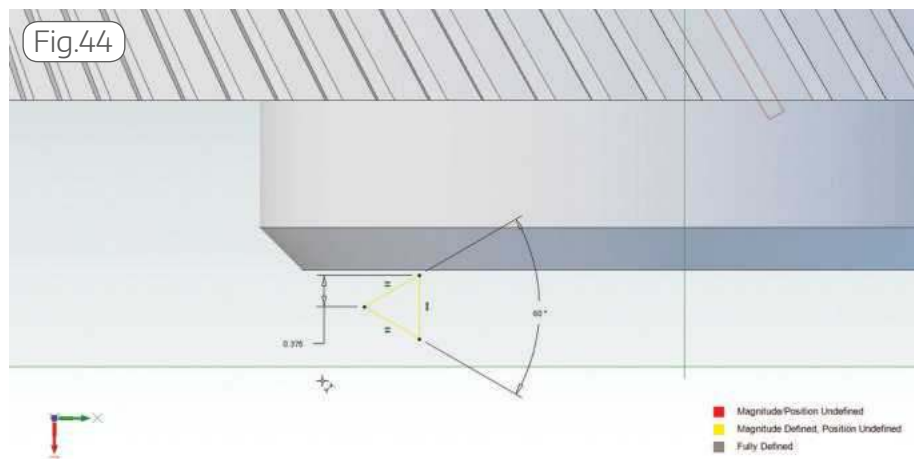
Chamfer button (located under 'Geometry transform'), set the size to 0.5mm and select the front edge of the smaller protrusion as shown (see fig. 43), then click 'Apply'.

Create the female M6 thread:

Select the 'XZ' plane and activate 2D sketch mode, fig. 43. Draw a triangle using the line tool, positioned just below the thumbscrew to the left hand side of the 5mm hole we just created. Apply an equal constraint to the upper and lower angled edges of the triangle and create a 60 degree angle between them. Make sure the right hand edge of the triangle has a 'vertical' constraint. Create a dimension of 0.375mm from the left hand tip of the triangle to the top of the shape as shown in fig. 44.

Change the right hand edge of the triangle to a reference figure (this option is found under the right click menu), then extend the shape with the line tool and set the distance to 0.2mm as shown in fig. 45. To position the section, create a 2.5mm dimension between the origin point and the vertical reference line as shown in fig. 46.

Use a 'coincident constraint' (located under the 'Constraints' section of the ribbon) to snap the top of the triangle to the bottom edge of the part. This should now be a fully defined sketch, deactivate the sketch. We can now create the thread as shown in fig. 47:



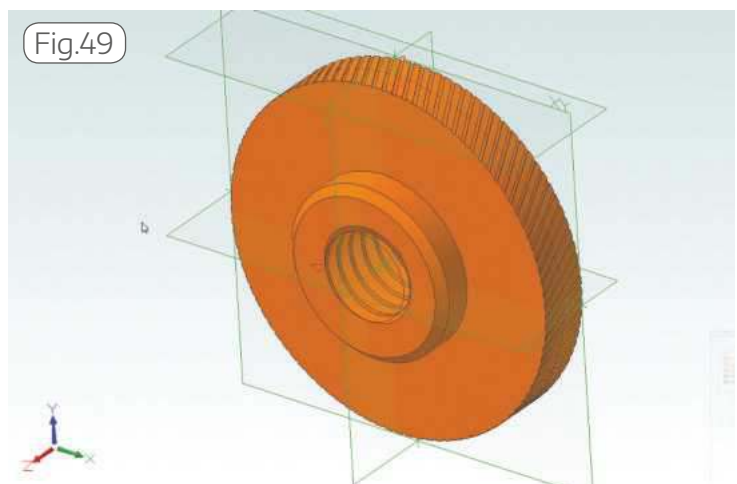
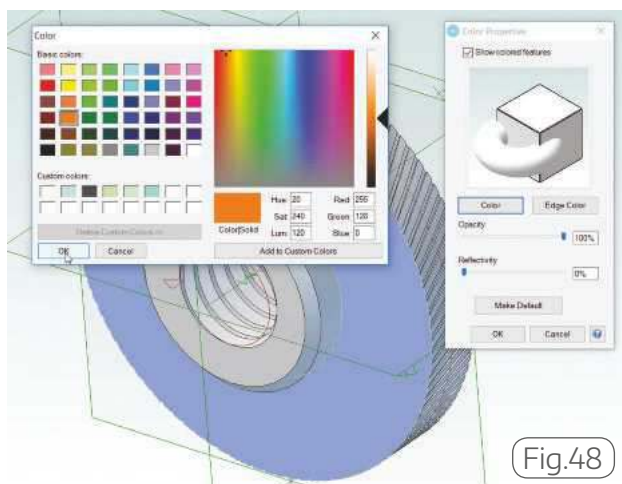
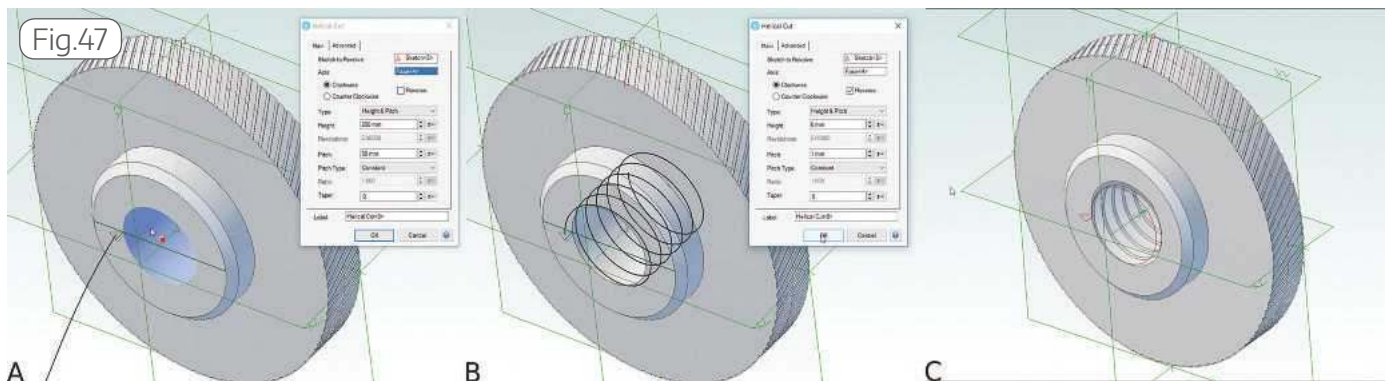
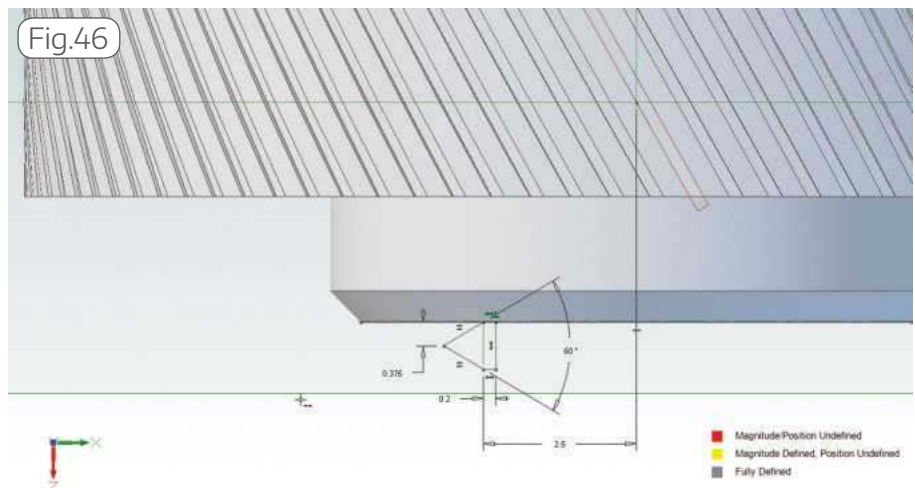
A: Click on the 'Helix' tool located under the 'Cut (remove material)' section of the ribbon. Click on 'Axis' and then select the inner cylindrical face of the hole as shown.

B: Make sure the type is set to 'Height and Pitch'. Set the height to 6mm and the pitch to 1mm. If the preview shows the thread path moving away from the part, check the 'Reverse' option, then click 'OK'.

C: The finished thread.

As this is another brass component, set the colour to orange as follows:

- Right click on the part
- Click on 'Color Properties...'
- Click on the 'Color' button in the 'Color Properties' dialogue
- Change the colour to orange in the 'Color' dialogue



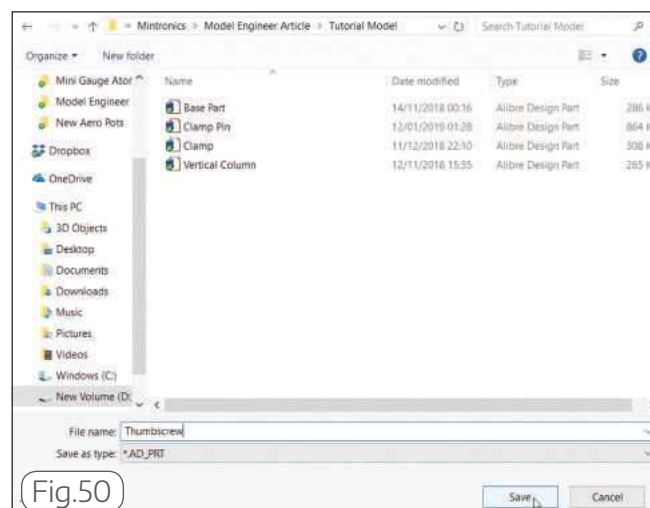
- Click 'OK' on both dialogues, **fig. 48**.

Figure 49 shows the finished thumbscrew component.

Save the part into the project folder, use 'Thumbscrew' as the file name and click 'Save', **fig. 50**.

Summary:

In this tutorial we have covered the creation of threads and patterned features. In the next article we will look at creating a component using the 'sweep' tool and complete the assembly. In the meantime I suggest you continue working with Alibre Atom3D, explore some of the examples available at www.model-engineer.co.uk/AlibreAtom3d and experiment with creating some parts and assemblies of your own. ■



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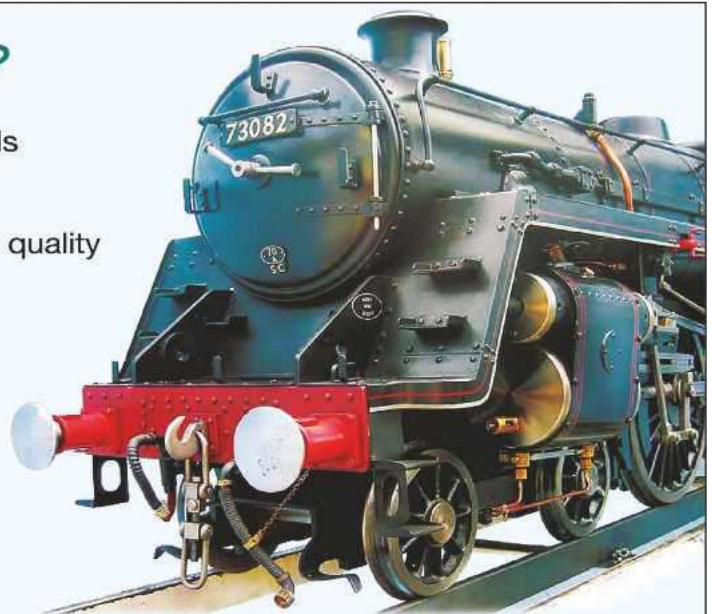
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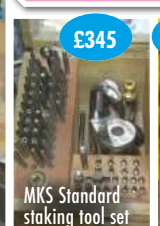
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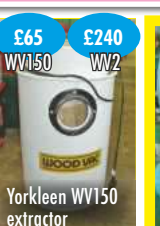
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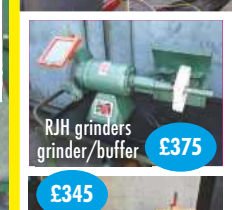
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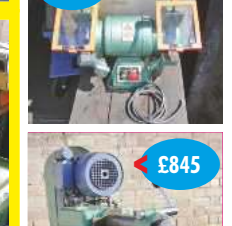
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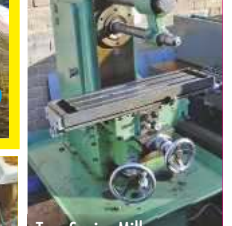
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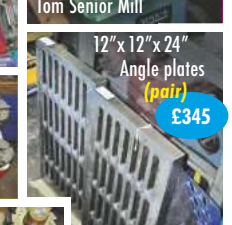
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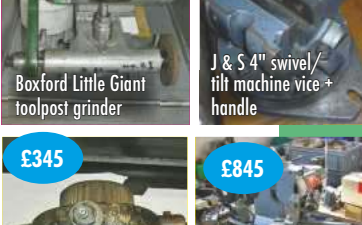
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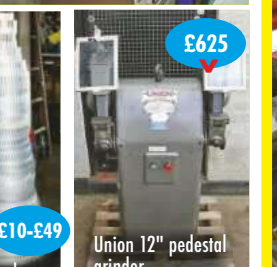
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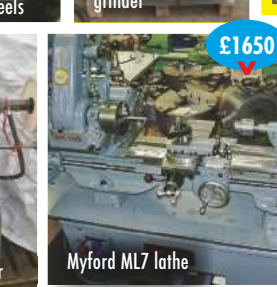
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