No.309

THE MAGAZINE FOR HOBBY ENGINEERS, MAKERS AND MODELLERS

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NOVEMBER 2021

Grinding Chuck Jaws to Restore Accuracy

Making a Finger Plate for Precision Work

INSIDE

COVER STORY

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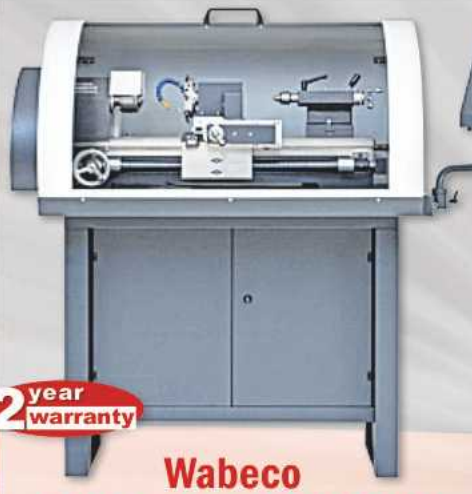

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Suite 25, Eden House, Enterprise Way,
Edenbridge, Kent TN8 6HF
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EDITORIAL
Editor: Neil Wyatt
Tel: +44 (0)1689 869 912
Email: neil.wyatt@mytimemedia.com

PRODUCTION
Designer: Andrew Tompkins
Illustrator: Grahame Chambers
Retouching: Andrew Tompkins
Ad Production: Andrew Tompkins

ADVERTISING
Business Development Manager: Angela Price
Email: angela.price@mytimemedia.com

MARKETING & SUBSCRIPTIONS
Subscriptions Executive: Beth Ashby-Njiiri
Email: beth.ashby@mytimemedia.com

MANAGEMENT
Group Advertising Manager: Rhona Bolger
Email: rhona.bolger@mytimemedia.com
Tel: 0204 522 8221
Chief Executive: Owen Davies

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On the Editor's Bench

Careful What You Wish For

Last month I made the mistake of looking forward to a good downpour to test my roof repairs! I got a couple, and real beezer of one last week. As you might expect I have tracked down a few more leaks – don't underestimate the power of a strong wind to blow rain between roofing sheets and up a slope, when it's a relatively small angle. It does appear to be sorted now, with the application of sealant and a few rolls of flashing tape.

Less welcome is the discovery that moisture is moving through the base of breeze-block walls on two sides where adjacent walls make rainwater puddle up and prevent any easy access. The good news is that where I have applied a thick coat of polymer/cement based waterproofer nothing has come through, but I need to get this all around the walls. I am, however, reconciled to the potential need to run a dehumidifier in damp weather, something my old workshop never needed.

Of course, the real frustration is how this has all slowed down progress to a crawl – the last thing I want to do is install wall, ceiling or floor linings and have to rip them up again.

Trigger's Guitar and the Bass of Theseus

Some may recall that as a 'lockdown project' I ordered an inexpensive bass guitar kit, which really turned out to be an exercise in spray finishing the wooden body. It turned out better than expected so I gradually replaced various parts, such as machine heads, pickups, knobs, scratchplate and other parts. Recently I obtained a wooden body with a 'quilted maple' top as a second at a 'knockdown price'. I am confounded if I can see the claimed minor fault in it, so I'm very happy. Having fitted this, I realised that the only parts from the original kit are the neck and neck mounting plate, tone control, jack socket and the screws.

A quick search online quickly tracked down replacements for the neck and other essentials for under forty quid. Now I'll be rebuilding a new bass on the original body... my greatest concern is, if I end up upgrading this one, where does it all end? And one for the philosophers - which is the original instrument?

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Brushless Mini Lathe WBL1835

SPECIFICATION:

Distance between centres: 350mm
Taper of spindle bore: MT3
Number of spindle speeds: Variable
Range of spindle speeds: 100 - 2250rpm
Weight: 43Kg

Price: £642

AMABL250Fx550

SPECIFICATION:

Distance between centres: 550mm
Taper of spindle bore: MT4
Number of spindle speeds: Variable
Range of spindle speeds: 50 - 2500rpm
Weight: 140Kg

Price: £1,732
With 2-Axis DRO - Price: £1,986

AMABL290VF Bench Lathe (11x27) power cross feed - BRUSHLESS MOTOR

SPECIFICATION:

Distance between centres: 700mm
Taper of spindle bore: MT5
Taper of tailstock quill: MT3
Motor: 1.5kw
Weight:230Kg

Price: £2,395
With 2-Axis DRO - Price: £2,787

AMAVM25LV

SPECIFICATION:

Model No: AMAVM25LV (MT3)
Max. face milling capacity: 63mm
Table size: 700 x 180mm
T-slot size: 12mm
Weight: 120Kg

Price: £1,354
With X-Axis Powerfeed - Price: £1,659
With 3-Axis DRO - Price: £1,723
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Model No: AMAVM32LV (MT3)
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Table size: 840 x 210mm
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Weight: 240Kg

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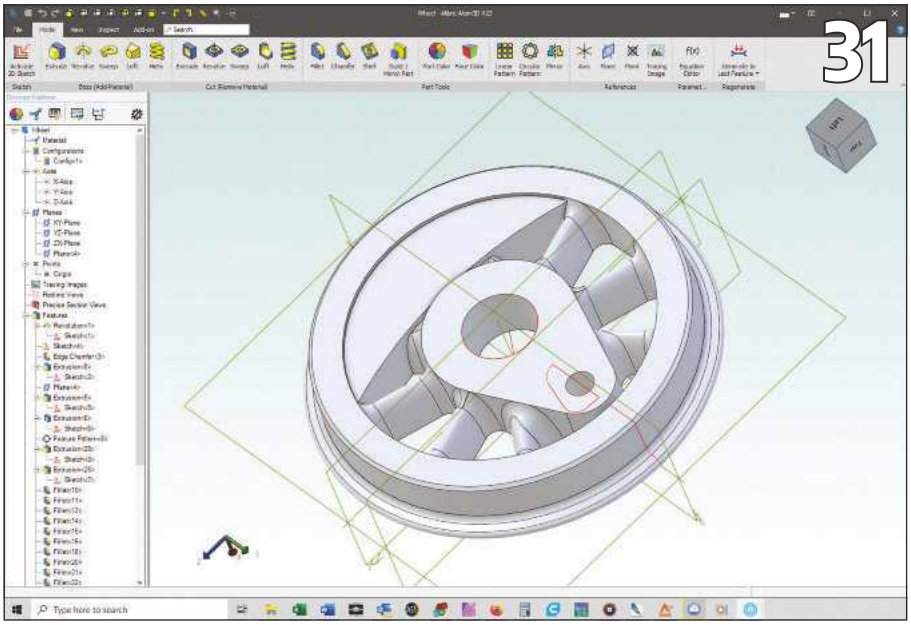
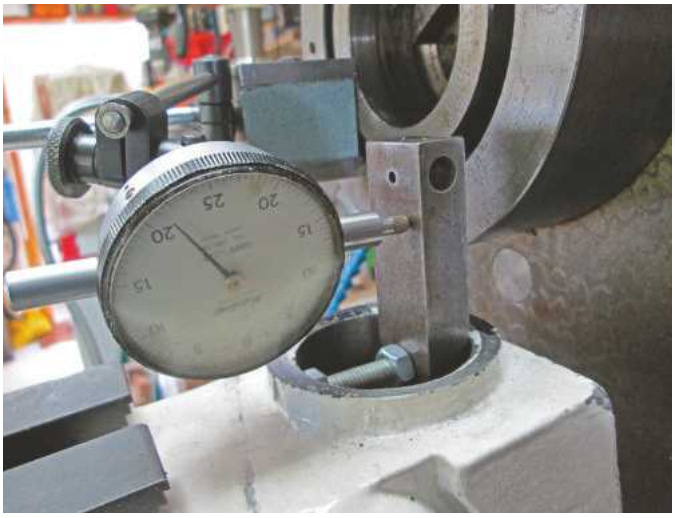


Coming up...

in our next issue

In our next issue Laurie Leonard improves his workshop drill press.



Regulars

ON THE COVER >>>

This issue sees the first part of John Fawcett's guide to making a very serviceable instrument vice in a project ideal for beginners and useful to old hands, see page 25.

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THIS MONTH'S BONUS CONTENT

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Discussion of Duncan Webster's version of Joe Noci's Electronic Lead Screw
It seems a few readers have struggled to find this thread. The correct address is: **https://www.model-engineer.co.uk/forums/postings.asp?th=126045**

Plus:
Antikythera Mechanism
Can you help solve the mystery of the holes?

Workshop lighting / energy costs
Experiences of workshop lighting in a post-fluorescent world.

Standard dead length Crawford collets
Interesting information on this workholding alternative.

Come and have a Chat!
As well as plenty of engineering and hobby related discussion, we are happy for forum members to use it to share advice and support. If you feel isolated by the lockdown do join us and be assured of a warm welcome.

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The GWR 61xx Class

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The 61xx Class were almost identical to the earlier 51xx and later 81xx Class. They did however, have an increased boiler pressure which resulted in a greater tractive effort.

The 61xx locomotives spent their working lives on the Paddington suburban services and were capable of hauling heavy trains at fast speeds due to their increased boiler pressure. In GWR days standard unlined green livery was carried. B.R. applied both lined black and lined green liveries to the class.

Summary Specification

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- 5" gauge
- 2 Outside cylinders
- Piston valves
- Stephenson valve gear
- Mechanical drain cocks
- Mechanical Lubricator
- Silver soldered copper boiler
- Multi-element Superheater
- Pole Reverser
- Boiler feed by cross head pump, injector, hand pump
- Etched brass body with rivet detail
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Mike Pavie

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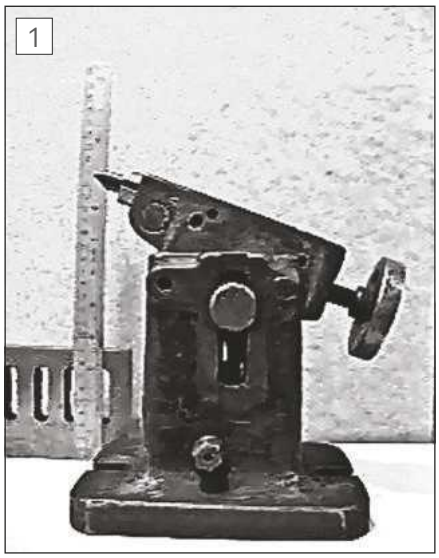
A Tailstock Tail

John Cuckson makes two useful items from an auction 'extra'.

How often do you not know you need a tool until you see it? This happened to me when I won an auction lot consisting of a splendid Italian made (and wonderfully named) "Paradisi" six-inch centre height universal dividing head that came, unfortunately, with a mismatched tailstock. Unlike the familiar lathe style tailstocks, industrial quality dividing head tailstocks can usually be raised, lowered and inclined in order to support work that may be held at an angle to the worktable, see **photo 1**. While I had a specific use for the dividing head (which is exceptionally rigid), I did not then see a need for the tailstock. But later I realised I had two unsatisfied needs: one for each major part of the unmatched tailstock.

Its housing was the first piece to be 'repurposed'. It made a perfect slotting support for the 10-inch Alba shaper,

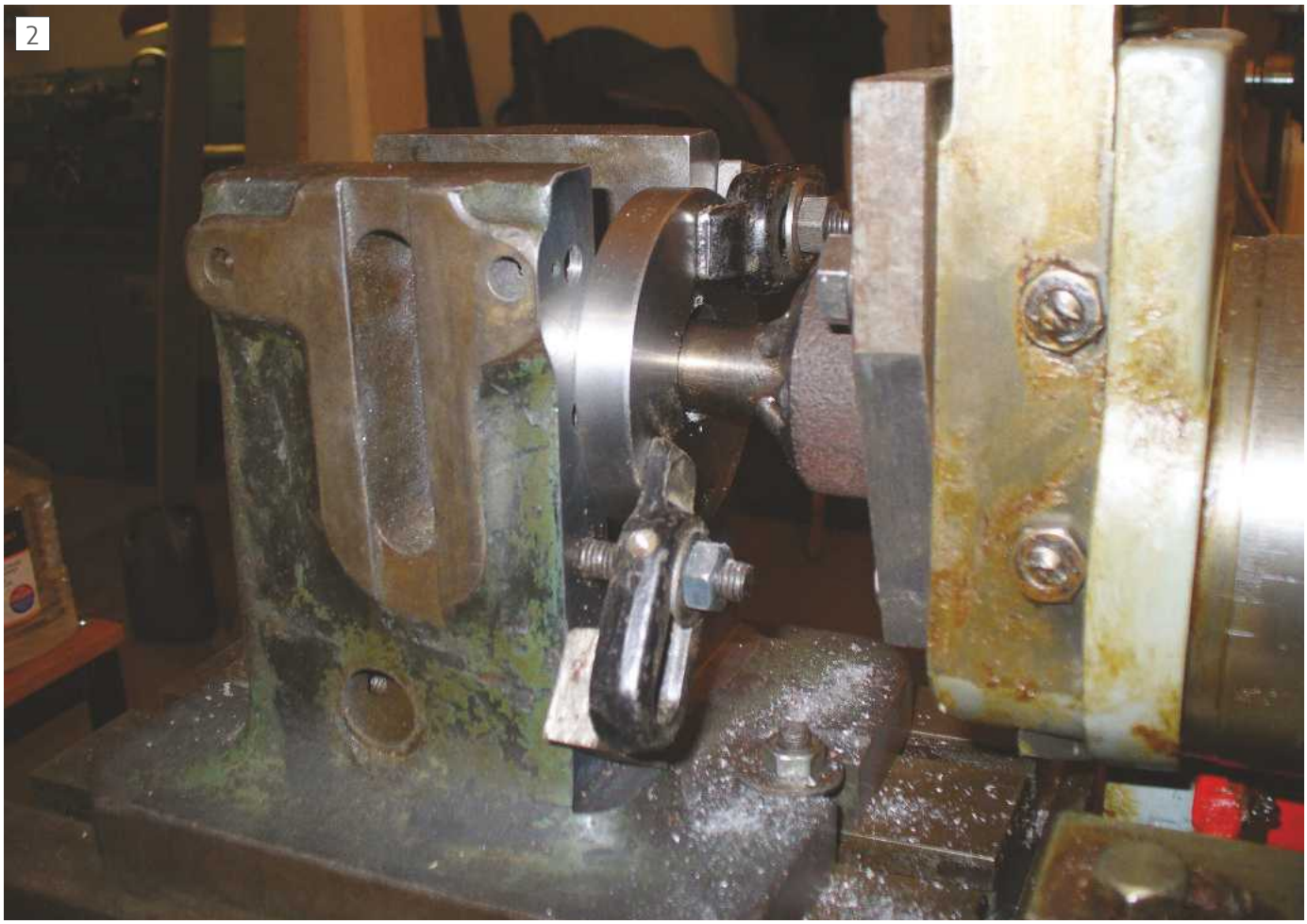


Cincinnati dividing head tailstock in original form showing vertical and angular adjustment

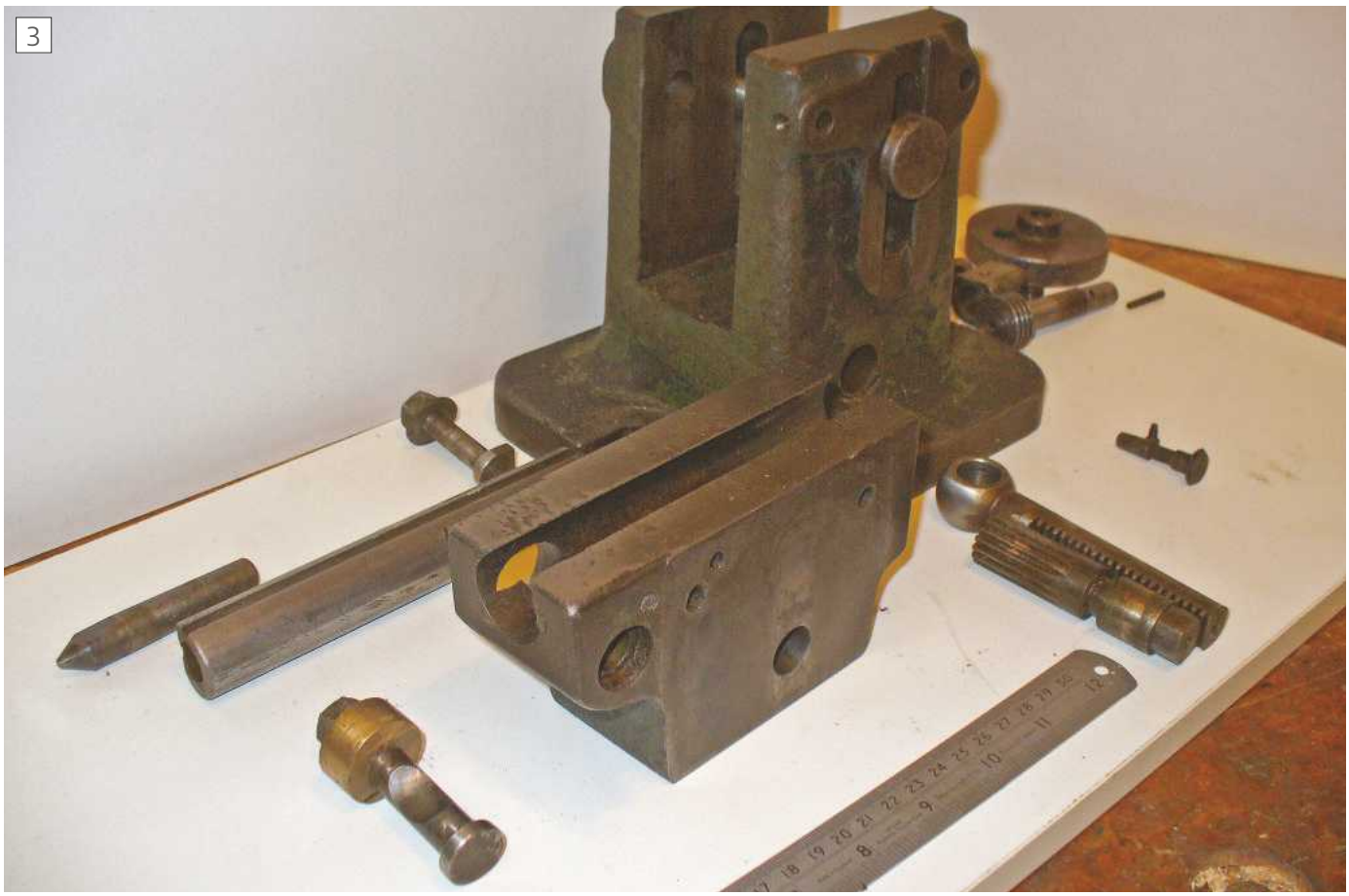
photo 2, and, being much stiffer than either an angle plate or a vice, it allows keyways to be cut at the top of the bore rather than the bottom which, I find, makes inspection far easier plus it is far more secure. A bit later, I realised the tailstock barrel assembly (foreground of **photo 3**) was about the right height to serve as a standard, fixed tailstock for the Reishauer dividing chuck on my Aciera F3 (right hand side of **photo 4**) which, surprisingly for such a generously tooled machine, never appeared as an original item. It also turned out that I could repurpose both parts of the tailstock without precluding their reuse for their original purpose.

Making the slotting support

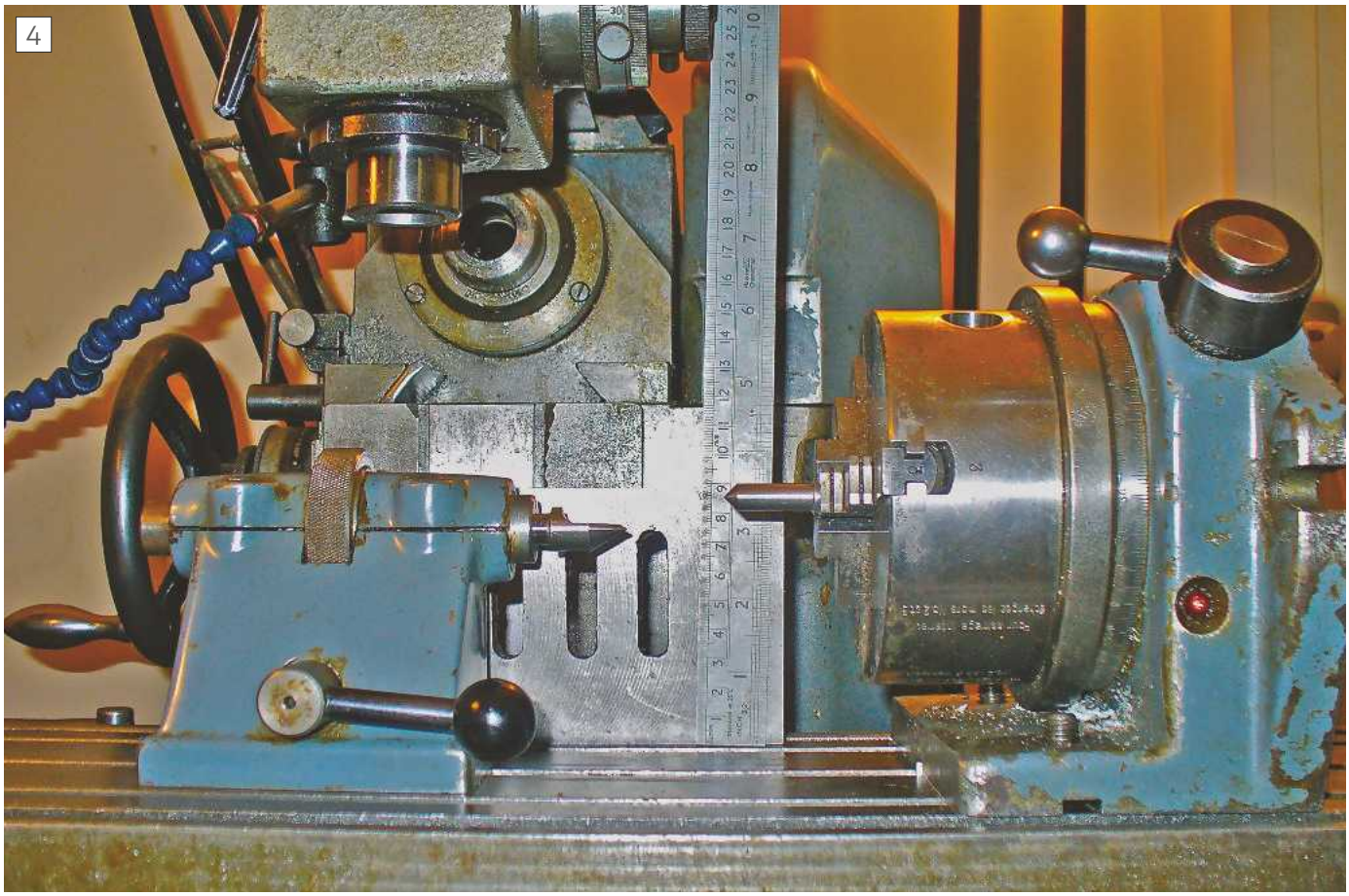
The only significant task was to machine one end of the base casting, along with



Housing used as slotting support on Alba shaper for cutting internal keyways



Dismantled Cincinnati tailstock showing components



Aciera F3 dividing chuck with Aciera dividing head tailstock showing mismatch

Housing modified as slotting support

the area surrounding the slot for the barrel assembly, truly square to the slot itself. A series of tapped holes around the newly machined end of the slot, **photo 5**, was then all that was needed to enable workpieces to be clamped securely at right angles to the axis of the slotting tool, **photo 6**.

Making the tailstock

The mismatched dividing head tailstock suffered a far tougher life than the almost unused 6-inch dividing head that accompanied it. Its top face was bruised and there were various gouges on the barrel and handwheel. But the most challenging task was to devise a means of fixing it to the milling machine table such that the centre line of the barrel was precisely in line with the centre line of the dividing chuck. I hoped to find a way that did not make the tailstock (with what now had become a slotting support) unusable for its original purpose. The minimally invasive approach uses the recess in the base of the barrel assembly that contained the original eccentric clamp, to accommodate a horizontal alignment system like that used for lathe tailstocks. Vertical alignment would then be assured by carefully machining the base of the barrel assembly parallel to the bore and attaching it to a suitably thick plate that would then be attached to the milling machine table. This particular dividing head tailstock was made by Cincinnati but all industrial dividing head tailstocks above

Close up of housing being used for slotting keyways on shaper (minus clapper box)

Preliminary checking of centre heights

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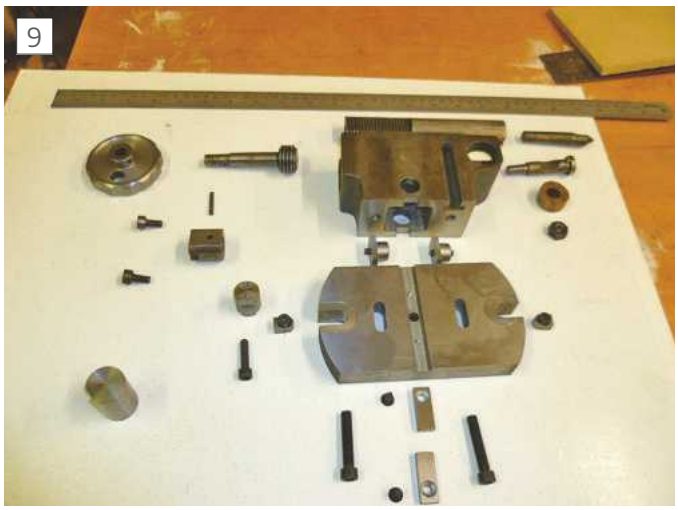
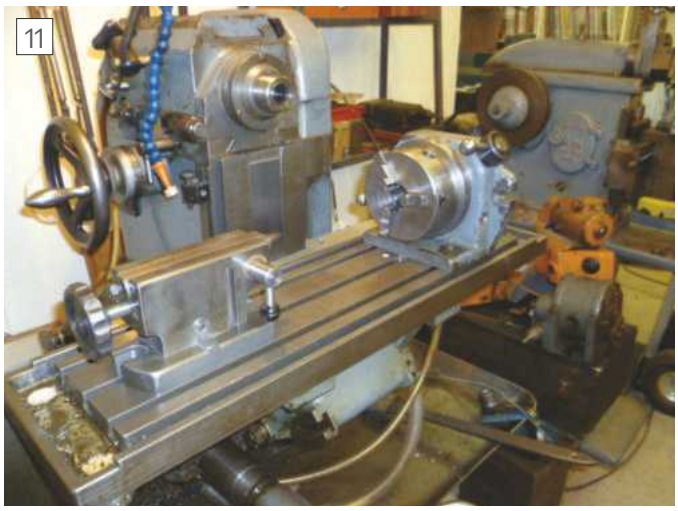
Enlarging recess in base of tailstock barrel assembly to fit alignment bushes



Components of new tailstock

Final horizontal and vertical alignment check



New tailstock in use

about 5-inch centre height have much the same features.

The first job was to establish a preliminary datum on the base of the barrel body which was milled parallel to the top surface of the tailstock which itself is parallel to the axis of the barrel. Comparing the centre height of the indexing chuck with that of the barrel, **photo 7**, indicated the approximate thickness of the base plate that would be needed, for which an offcut of cast iron was prepared. Setting the preliminarily machined barrel and base plate on the milling machine table with accurately ground pieces of bar in the barrel and in the indexing chuck, enabled their relative heights to be measured more precisely. This was done with a surface gauge and double checked with a dial test indicator acting as comparator relative to a stack of slip gauges. The decision could then be made how much material to take off the barrel assembly and how much off the base plate to arrive at a perfect vertical alignment. The chief constraint was to conserve as many of the original features of the Cincinnati barrel body as possible, in particular the transverse clamping spindle bore, while leaving enough thickness for tenon slots and counterbored securing bolts in the baseplate. The original circular recess in the barrel assembly was squared off and enlarged to locate two captive threaded bushes through which grub screws could push either side of a central stop on the baseplate thereby assuring horizontal alignment of the barrel, **photo 8**. It also determined the location of a couple of short transverse tenons to keep the barrel assembly perpendicular to the chuck axis while the barrel was adjusted laterally. The underneath of the base plate needed a longitudinal tenon carefully aligned with the barrel bore axis as well as fixing slots to suit the table tee slots. All these dimensions were set out on the barrel assembly and base plate which were then finish milled and ground leaving about 0.005 inches to be removed from final thickness following preliminary assembly. All the pieces are shown in **photo 9**, along with the final trial assembly in **photo 10**. This time the longitudinal and transverse tenons were installed along with the horizontal alignment screws and bushes and the whole thing tightened up. Again, using the ground bars in the barrel bore and dividing chuck, the vertical and horizontal alignment were measured as accurately as possible using a DTI and slip gauges. The assembly was then taken apart and the base plate ground to final thickness.

The final touches were to tidy up the handwheel and nose lock, mill a radius on the baseplate and remove sharp edges. **Photograph 11** shows the tailstock in use. I end up using this set up far more frequently than I anticipated because the centre height is somewhat higher than the universal dividing head on the Aciera F3 (as shown in photo 4) plus the Reishauer dividing chuck is much more robust and has a very secure rotary lock. It also preserves the beautiful Aciera universal dividing head for more delicate work. ∎

3D Images of Workshop Tools

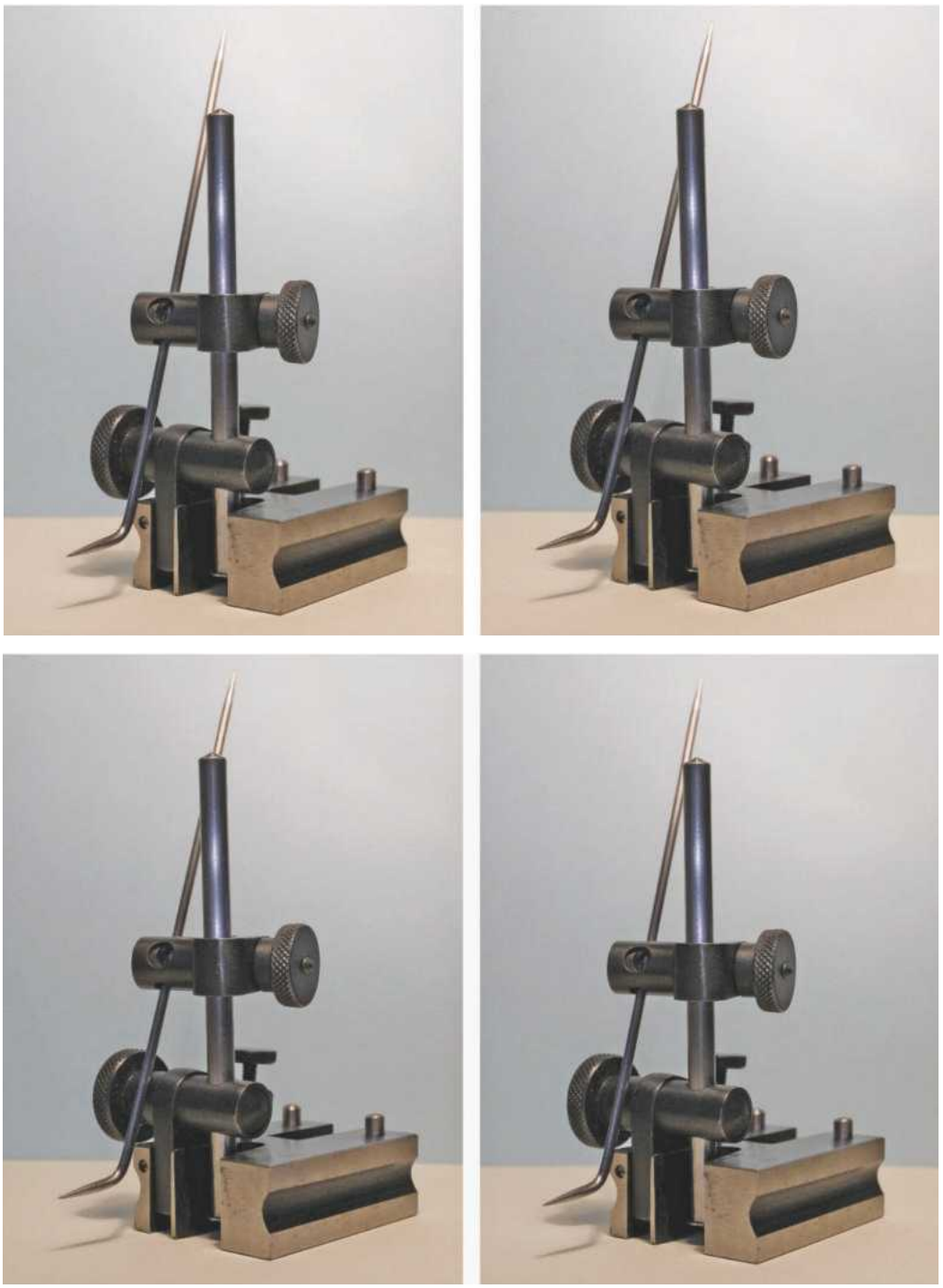
Nick Farr has produced some interesting stereo images

On the Model Engineer Forum, the thread Macro-photography has included some fascinating examples of 3D-images. Many of these have been produced by Nick Farr, who has taken the image below of a scribing block.

There are two ways to view images. The intuitive way, parallel viewing – with the upper image pair, is to hold the page at arm's length and look at the left image with your left eye and the other with your right eye. This requires you to relax your eyes until they form a 3D image in the middle.

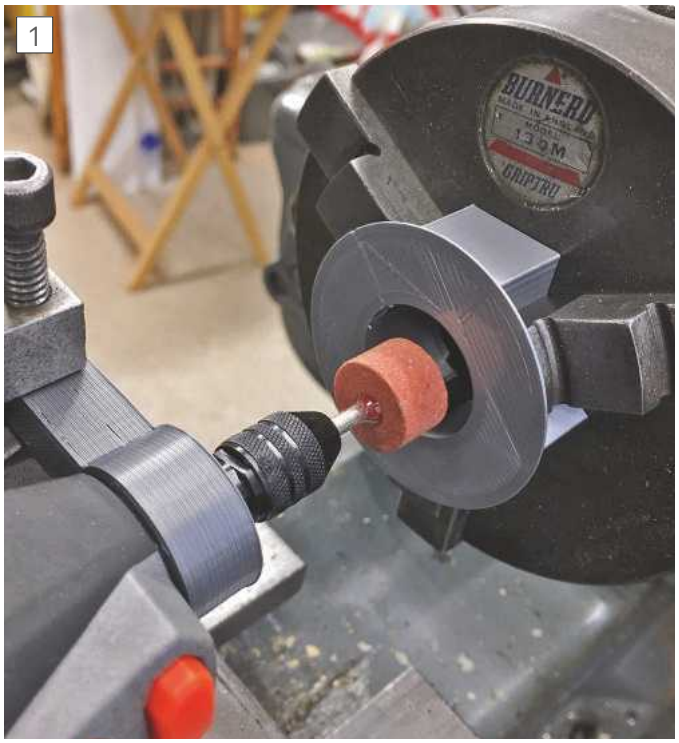
The other way, crossed viewing – with the lower image pair, requires you to cross your eyes so a 'third' 3d image appears in the middle. Many, but by no means all, people find this easier.

Most people find they can get one or other method to work, but some can do both and a few can't get on with either approach. Good luck, and many thanks to Nick for generating these images.

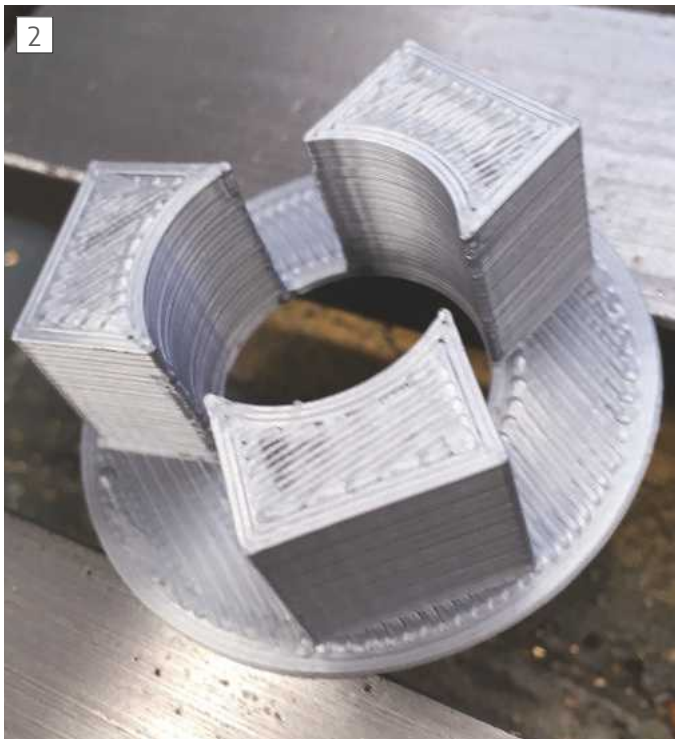


Chuck Grinding with a 3d Printed Jig

Adrian Rawson uses OpenScad and 3D printing to make components for truing up a 3-jaw chuck.



Mini grinder support and chuck jaw jig in action.



Chuck Jaw Jig.

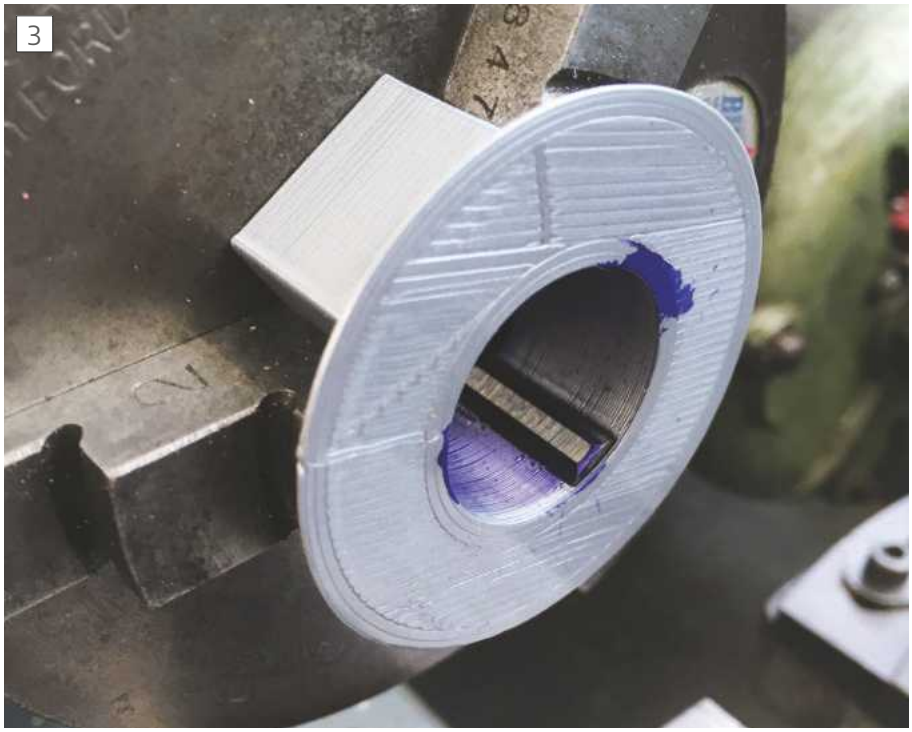
How many of us Myford lathe owners bought them second hand? I bought mine in the 1980s and according to its serial number it was already twenty or so years old. But I was assured by an experienced friend that it had one careful previous owner and was fairly low mileage. One advantage of buying second hand is that, more than likely, it comes with a load of extras. The disadvantage, of course, is that you buy it as seen, and unless you have been apprenticed in a machine shop have no idea what to look for. I had no idea what I was doing but loved the idea of one day making a working model of something. Over the years I put it to good use repairing stuff and making all sorts of adaptors and fixtures, none of which needed great accuracy. It was only in the last couple of years whilst engaged in making fine worm gears that I've felt there was something wrong. If I used my self-centring three jaw chuck to turn something and then drill a hole through it, the two, somehow, lacked concentricity. This showed up with a fine worm which would wander in and out of mesh with its worm gear. My solution was to drill the hole then cut the worm between centres. Basically, I lost confidence in the old 3-jaw chuck and wondered if self-centring was some kind of a rough guide statement to be ignored where accuracy was required. The chuck was set aside while I got on with the job in-hand.

Sometime later I was reading an article about grinding self-centring chuck jaws. I read that they can suffer uneven wear and eventually require trueing up. I started to hope that my 3-jaw chuck just required a bit of maintenance after fifty-odd years of abuse. My research told me that grinding the jaws must be done whilst they are gripping something, and a thread in MEW revealed a few solutions to this conundrum. They varied in nature from fiddly to expensive and I didn't have the necessary scrap (I mean stock) lying around to make anything meaningful. They did all have one thing in common though, and that was a mini grinder set at centre height to do the work.

I decided that printed plastic might offer a solution, so I made the two components shown, **photo 1**.

The mini grinder mount isn't the strongest of components, but it threaded straight on and mounted in the lathe's tool holder. I held another piece of steel in the toolholder running parallel to the grinder and fixed them together with a tie-wrap. This took the weight off the plastic fitting.

The other component was inspired by a solution that involved inserting three segments of tube between the jaw's side angles leaving the gripping faces exposed. After a couple of hours I had the component shown, **photo 2**.



Jig in place.

This was very easy to insert into the chuck as the segments are held in place by the front disc and it was solid enough to allow the jaws to grip firmly.

So, with everything in place, the lathe turning slowly in back-gear and the grinder spinning at speed I inserted the grinding wheel into the chuck advancing it with the cross slide until sparks were give off. In my case jaw 3 caught first followed by jaw 2 and then after some grinding, jaw 1.

Photograph 3 shows jaw 3 after all grinding was completed. Just in case it isn't obvious, at each setting of the cross-slide the grinder was plunged to the full depth of the jaws.

The result was a self-centring chuck that behaves as it should. Why didn't I do this before?

If you've got a 3D printer available it's a simple task to knock up these two components. All you need is a CAD system and a bit of ingenuity. But for those of you who need a bit of help I've included the designs in OpenScad. There are many ways to capture designs for 3D printing but my favourite is OpenScad. It has two major selling points for me: one it's free and the other is it is language based. The fact that it's free is an obvious benefit but the language element may put many people off. If you are used to writing code of any kind then OpenScad is worth a look. If you prefer drawing lines with a mouse, then leave it alone.

I decided for the purposes of this article to enhance my original code to make it more general purpose. The code shown, **fig. 1**, has parameters for throat radius, grip radius, number of jaws, height of jaws from front face and protrusion for grinding.

Taking a look at the code we can see that it is written as a callable module and the first section is a list of parameters and their default settings. The values set are those for a Myford 3 jaw self centring chuck. All measurements in OpenScad are in millimetres. Once the parameter list brackets are closed the module code starts in curly brackets. The first item is a setting to define the number of facets in drawn arcs. The higher the number the smoother they are. I nearly always set it to 100. Following that there is a bit of maths. The 'grip' value is used to calculate the size of the finished item. It is set to be 1.5 times the chuck throat size to make sure it sits nicely on the chuck face. The 'inradius' is the radius of a circle that is tangential to the lines connecting chuck jaw points. The chuck jaw points are on a circle which is described by 'holesize' see **fig. 2**.

Now we have calculated the size of the blocks and their distance from the centre we can create them.

OpenScad has a few 3D basic shapes, the simplest being cubes and cylinders. The way it manipulates them through addition, subtraction, translation and rotation soon becomes second nature. Additions are implemented as Unions and subtractions as Differences. The code shows a union nested inside a difference. That is simply because the supporting disc is added to the blocks (a union) before a hole is punched through the design (a difference) to accommodate the grinding tool.

The blocks are created by a for loop

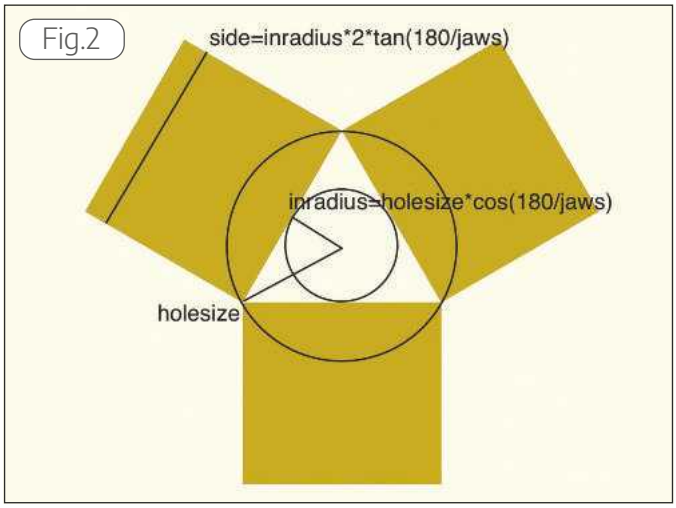
```
module chucker(     //PARAMETERS:- (Defaults shown are for Myford 3 jaw chuck)
    throat=12.7,    //Chuck throat radius in mm
    holesize=12,    //Jaws will be set to grip this radius in mm
    jaws=3,         //Number of jaws the chuck has
    jawheight=17.3, //The amount the jaws protrude from the chuck face in mm
    protrusion=3)   //Jaw protrusion for grinding in mm
{
    $fn=100; //Number of facets used to generate an arc
    grip=throat*1.5; //make sure item sits on chuck face
    inradius=holesize*cos(180/jaws); //internal radius of polygon
    side=inradius*2*tan(180/jaws); //polygon sides

    difference(){
        union(){
            //create the grip segments
            for (i=[0:360/jaws:360]){
                rotate([0,0,i])
                translate([-side/2,inradius,0])
                cube([side,grip,jawheight]);
            }
            //add the mounting disc
            cylinder(r=holesize+grip,h=1);
        }
        //subtract the centre hole
        translate([0,0,-1])
        cylinder(r=holesize+protrusion/2,jawheight+2);
    }
}
// Call the module here, substituting parameters as required
chucker();
```

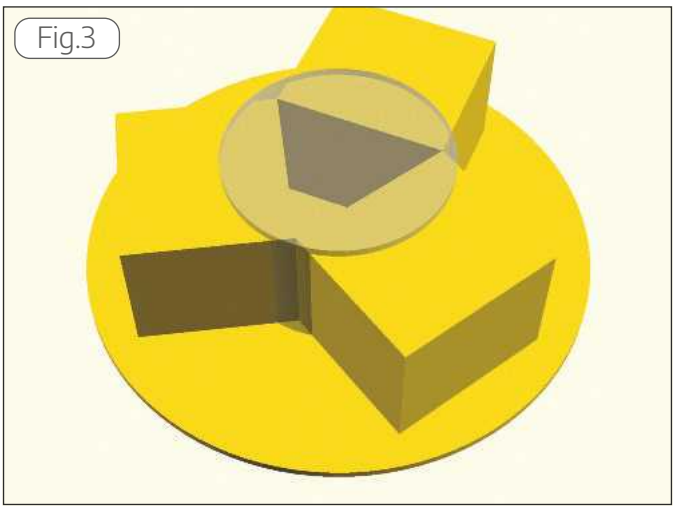
Fig.1

Viewport: translate = [0.00 0.00 8.65], rotate = [55.00 0.00 25.00], distance = 229.41 (729x466)

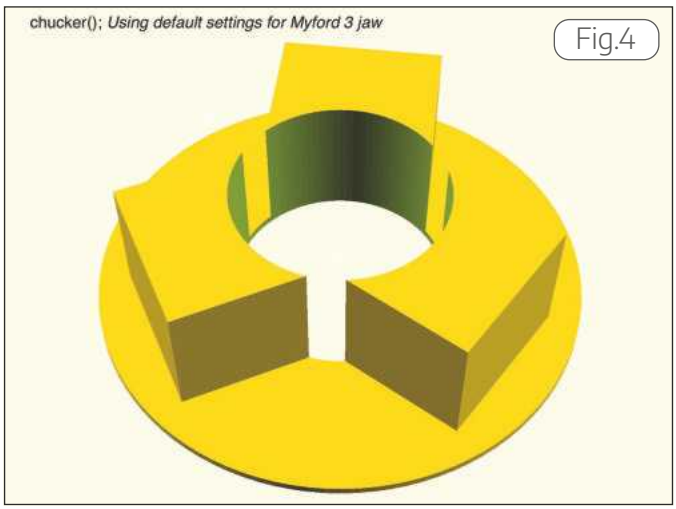
OpenScad code for chuck jig.



Geometry behind the jig.



Initial stages of designing jig.

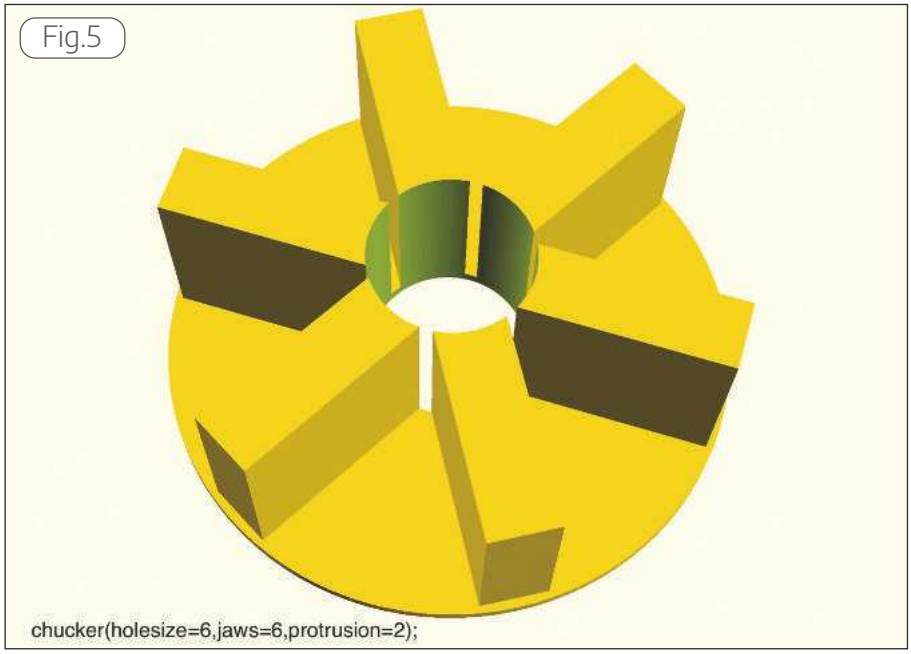


Render of final design.

which steps through the number of jaws. The size of each block is defined by the 'side', the 'grip' and the 'height' and these are translated away from the centre by the 'inradius' and set at their midpoint (side/2). Translations and rotations are in [x,y,z] format. Translations in millimetres and rotations in degrees. The mounting disc radius is calculated from the 'holesize' radius plus the 'grip' radius and has a thickness of 1 millimetre (h=1). The centre hole is then subtracted, its size calculated from the 'holesize' radius plus the millimetres of jaw protrusion required. The subtracted punch through cylinder is defined as 2 millimetres larger than the design and is translated to start from -1 millimetre in the z plane. This is to ensure that it goes completely through, it starts below and ends up above. If the line of code that generates the punch through cylinder has a '%' directive at its start then it can be displayed as shown in, **fig. 3**. This facility is very useful when defining differences.

The last line in the code is the call line. This calls the module, and if no parameters are given the defaults are used. The result is shown in **fig. 4** and an example of passing parameters is illustrated in **fig. 5**. It is important when making this item to keep the 'holesize' parameter smaller than the 'throat' of the chuck otherwise you could end up grinding the chuck as well as the jaws.

I hope that this illustration of OpenScad as a design tool encourages others to have a go. I've tried graphical tools and keep coming back to this as the one of choice. The rendering of a design is pretty instant so there is no frustration time in correcting errors and amongst other things it includes the ability to animate translations and rotations for movie making. Although I personally use macOS, it's also available for Windows and Linux.

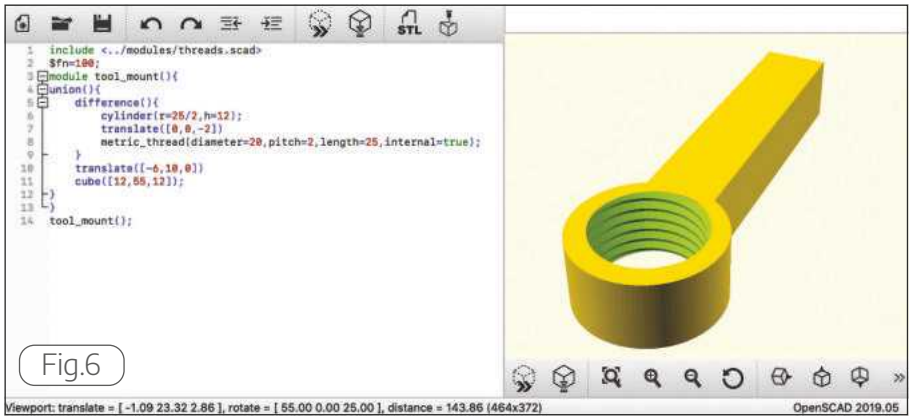


Version for six-jaws.

But not forgetting that this article is about grinding chuck jaws I've also included the code for generating the mini-grinder mount, **fig. 6**.

The first line is an 'include' statement and pulls in a threads library. There are many others available for download.

Drawing the design isn't the end of the story as there is still the slicing and printing to do. OpenScad outputs STL files ready for slicing. ■

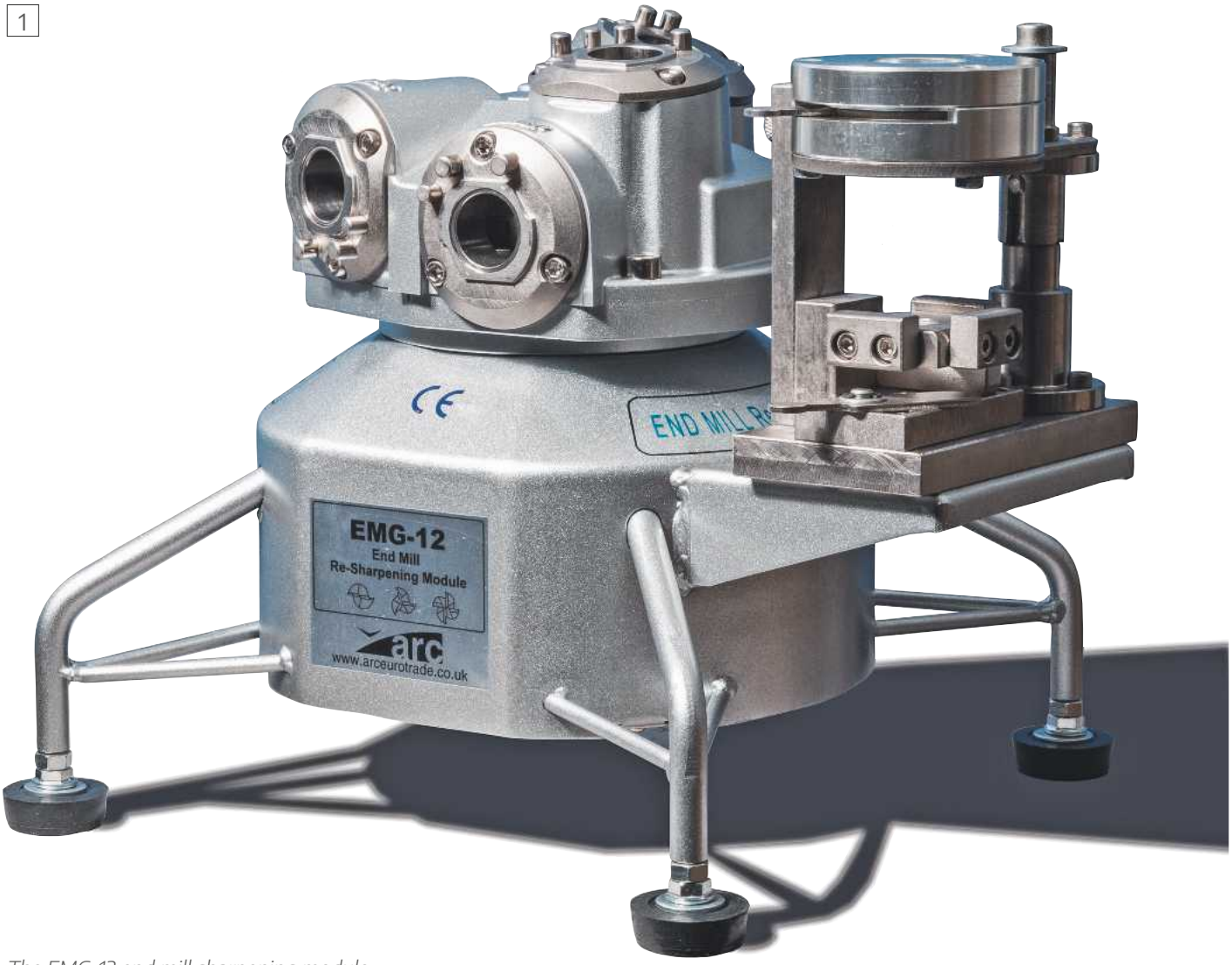


Mini-grinder mount.

Tool Grinding and Sharpening Machines

A beginner's guide to tool and cutter grinders.

1



The EMG-12 end mill sharpening module.

It goes without saying that metalworking tools have a hard life and sooner or later they will become dull, blunt-edged or even chipped. This does not mean they should be thrown away as they can usually be resharpened, so one basic tool that should find a place in every workshop is some form of grinder for sharpening tools. Even a basic bench grinder, as long as it has reasonably rigid work supports, can be used for basic tasks such as resharpening HSS lathe tools. With a degree of skill and practice, resharpening drills and even milling cutters is possible 'freehand', but the results are rarely, if ever, as good as those given by more sophisticated sharpening systems.

Things to watch with grinders of all kinds are ensuring the wheels are in good condition without cracks or defects, that you never run a wheel faster than its rated speed and that you always use guards and eye protection. It is also important to make sure the gap between tool rest and wheel is too small for the tool to be pulled down and jam the wheel.

The most basic of jigs can significantly improve your sharpening results. The simplest improvement is just making a metal table that can be positioned close

Multigrind – a flexible sharpening system base on a recycled food processor by Mark Noel.

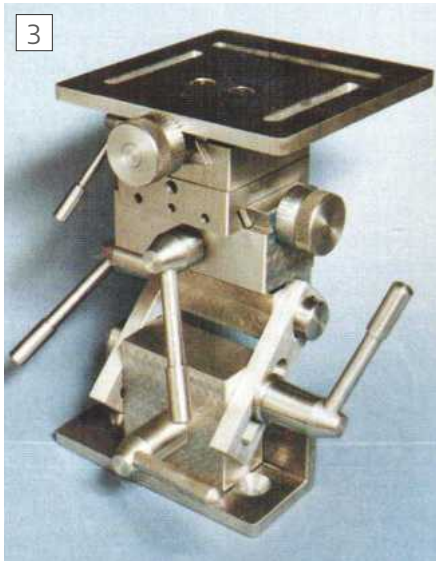
to the grinding wheel and angled to achieve best results.

Drill Grinding Jigs

There are various types of drill grinding jig available, broadly speaking these allow you to swing the drill point past the grinding wheel so as well as sharpening the cutting edges, it puts a conical relief on the drill to allow it to cut freely. It seems that the results users get with these drills generally depend on following the instructions, although sometimes a bit of experimentation with angles or with the amount by which the drill tip protrudes from the jig can bring improvements.

Other Tools

There are few other types of workshop tool for which there is a dedicated grinder. Exceptions being the EMG-12 and EMG-20 end mill grinders from Arc Euro Trade, **photo 1**, but these are expensive machines suited to a jobbing workshop or people who get through large numbers of end mills in a year. For most workshops, sharpening more complex tools will require some sort of multi-function tool and cutter grinder. There are off-the shelf T&C grinders from Clarkson and Vertex, for example, but more than any other type of machine they are a popular choice for building in the workshop, **photo 2**.



Harold Hall's grinding rest.

Harold Hall's Grinding Rest

One of the most popular construction articles ever published in Model Engineer's Workshop was Harold Hall's versatile grinding rest and its accessories. This rest is based around a small table with a guide fence that can be set up next to a standard bench grinder.

Although the rest, **photo 3**, is not capable of as wide a range of operations as a full-blown tool and cutter grinder, it is able to carry out most of the everyday sharpening tasks in the hobby workshop. Examples of tools it can sharpen, with appropriate accessories, include:

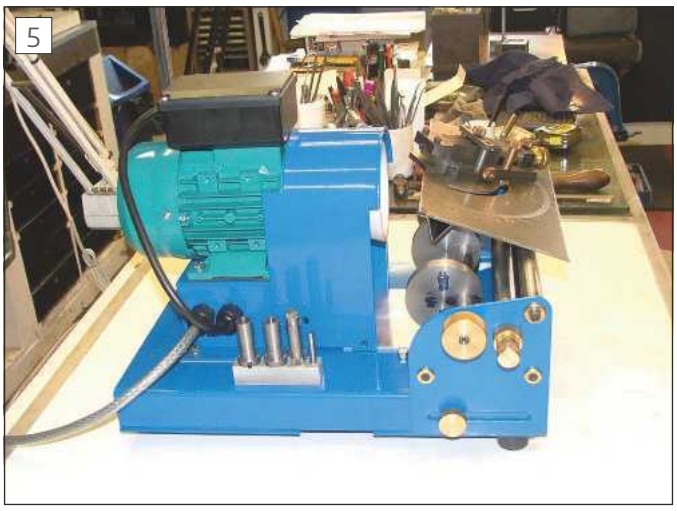
- Lathe tools
- End mills and slot drills
- Slitting saws
- Flat-ended screwdrivers

The Quorn

Probably the most versatile tool and cutter grinder for hobby use is the Quorn, although it was actually designed by Professor Dennis Chaddock as a production machine, but with amateur construction in mind, **photo 4**. The Quorn has a vast array of possible movements and adjustments as testified by an array of ball handles which have been known to deter some builders. Some builders have added even more features to the Quorn, such as the ability to grind drills.

Castings for the Quorn appear to be unavailable in the UK, but can be obtained in the USA and Australia, and unmachined sets appear second-hand from time to time. Even if not intending to build a Quorn, Professor Chaddock's

A very nice Quorn by Allen Berman of the Society of Model and Experimental Engineers.



A Worden Mk. 3 made from a Hemingway Kit..

book Building the Quorn is full of ideas and solutions potentially of use to anyone planning to build their own grinder from scratch.

The Worden

The Worden, **photo 5**, was designed as a simpler alternative to the Quorn based around a tilting table with a rotating work head. It is available from Hemingway Kits as a part-machined kit that is a much faster build than a Quorn. Like the Quorn builders have come up with various modifications and accessories that increase its usability and flexibility beyond that of the original design.

The Acute Sharpening System

The Acute system, from Eccentric Engineering, is a departure from traditional tool and cutter grinders. It uses a pantograph system together with an assortment of jigs and holders to present tools to an ordinary bench grinder while constraining movement to allow accurate sharpening, **photo 6**. One of its benefits is a very quick setup time when changing between different tools. The Acute system is available as a complete unit or as a part-machined kit with many laser-cut parts. ■

Demonstrating Eccentric Engineering's Acute Sharpening System at the model Engineer Exhibition.

A Supplementary Work Surface

Ted Joliffe makes a workshop aid for those fiddly little jobs you wish were a bit closer.

An overall view of the supplementary table mounted in the bench vice.

This idea is useful for fiddly little jobs where the gremlin who lives under most of our benches is eager to grab that irreplaceable small screw. This can be made in an hour or so but will get lots of use.

For me the first of these supplementary benches came about when I discovered that it was difficult to see the tiny screws used in a speedometer I was repairing during the period when my son and I built his kit car. Somehow the tiny screws on the bench top seemed miles away and I found it was much easier to work if I made a small tray out of some off cuts of timber and fixed this in the bench vice, gaining a few useful inches, and with a rail around the edges preventing small screws from rolling into inaccessible places, **photo 1**.

The current version was knocked up in a hurry when I kept getting asked to tighten up the frames on various lady friends' glasses. I had purchased the tiny vice on a whim and put it to good use in my case being a "sinister" (left-handed)). It was mounted on the left side of the device, it was later easily moved to the right side, as it made working from my perching stool easier.

I have found, through a few spiked fingers that when tightening up the hinge screws on spectacles it is as well to have somewhere firm to rest the underside of the hinge, hence the little device shown in the vice, an off cut from a broom handle with a couple of flats milled on the bottom to sit it in the voce, very useful, and helps to save the screwdriver slipping off and bearing into the fleshy part of a thumb of finger.

Making the device

This is so simple it needs little description. The base of mine was a piece of MDF, 14 x 7 inches, started life as the frame of a gas fire. The edging strip is plastic angle from one of the large DIY centres (called PVCU Edge Lipping in the catalogues). I confess that mine was some salvaged from a redundant kitchen worktop. The 'posh' way is to glue it to the edge of the board, the quick way was to use small oval nails, my choice. I like to work on a light surface so gave the MDF a coat of white paint.

I screwed and glued a strip of 1 x ⅝ in. Wood underneath about 2 in, in from one long edge, this allows me to fix the top where I want it, simply by sliding it along the large vice jaws. When I later started light filing operations, I found that the support allowed too much flexibility (the top wobbled), so I added a couple of lengths of the same timber to form a shallow H section. For speed I screwed and glued the pieces, ands this serves me well. Purists may feel that glue and dowels would be a better job.

Currently I am engaged in making 1 in to 1 ft. scale swords and arrows (I haven't yet tackled the longbow), for use with the miniature siege train I am building after the style of da Vinci, and the new surface is excellent to hold the pieces of old hacksaw blade while I shape them with a diamond file.

The mini vice mounted in the corner, **photo 2**, is a useful addition (mine came from a stall at an M.E. Exhibition). The piece held in the vice is a bit cut from a broomstick, which is a good rest for the base of the hinge when tightening the screws in spectacles. The broomstick has a couple of flats milled to give support and a good hold for the vice. The last thing wanted is for it to tilt and let the screwdriver pierce a finger or thumb.

Let me stress there is no magic in the sizes quoted, they were what I had to hand, and the job can within reason be any size to suit your work. A friend who has seen the thing in action made one half as big again for his work on electronic bits, I have since made another for use in the woodwork shop, my retreat when the weather is too inclement to venture up the garden to the metal shop.

Caution

I stress that this is only intended for light work, and for holding parts of work in progress, it is not rigid enough for heavy

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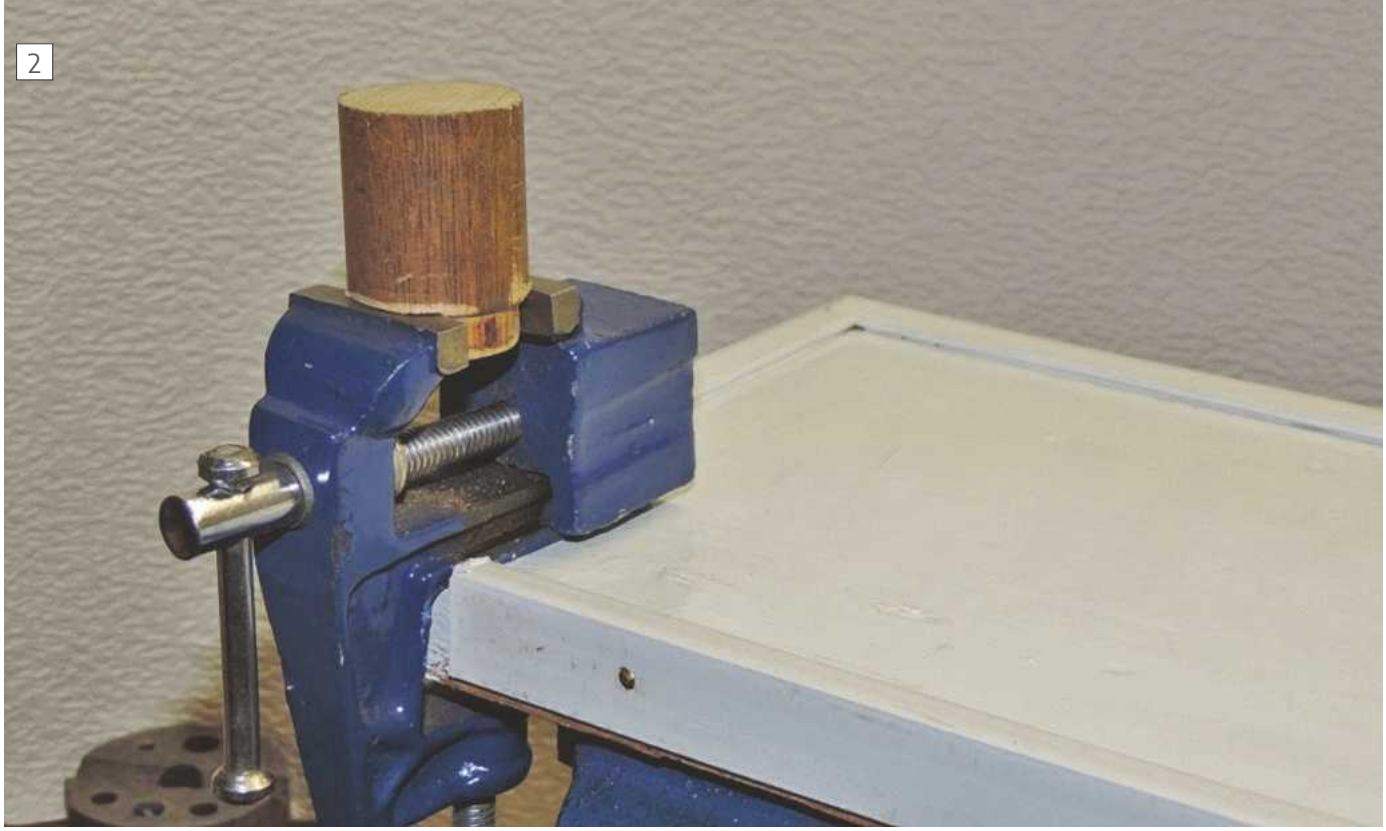

Mini Vice mounted on the corner of the table.

bashing with a hammer or carrying large loads. But when you have to strip small parts such as lubricators or injectors it is reassuring to know that all is in a safe place. Incidentally I keep a few old 'one portion' jam jars for use when working on parts which need cleaning, one of these half full of lighter fluid, white spirit or in the case of injectors "Kilrock" (largely formic acid and great for removing lime scale - watch it bubble) is usually enough to clean a small part, I upend these over a plastic tea strainer so the parts are trapped ready for final drying or washing as required.

I have when pressed made a new hinge for a pair of glasses and find it a boon when filing them up to have the work held closer to the eye in the mini vice.

It also comes in handy when I have a job spread over the bench top and need another surface for a more urgent task - often the boss's glasses.

Enjoy!! ∎

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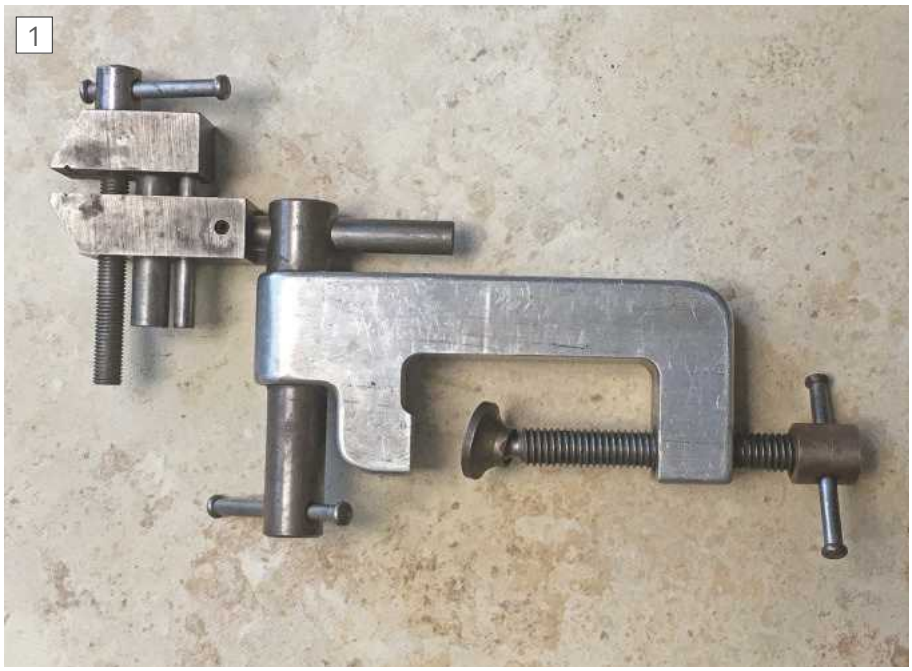
Making an Instrument Vice

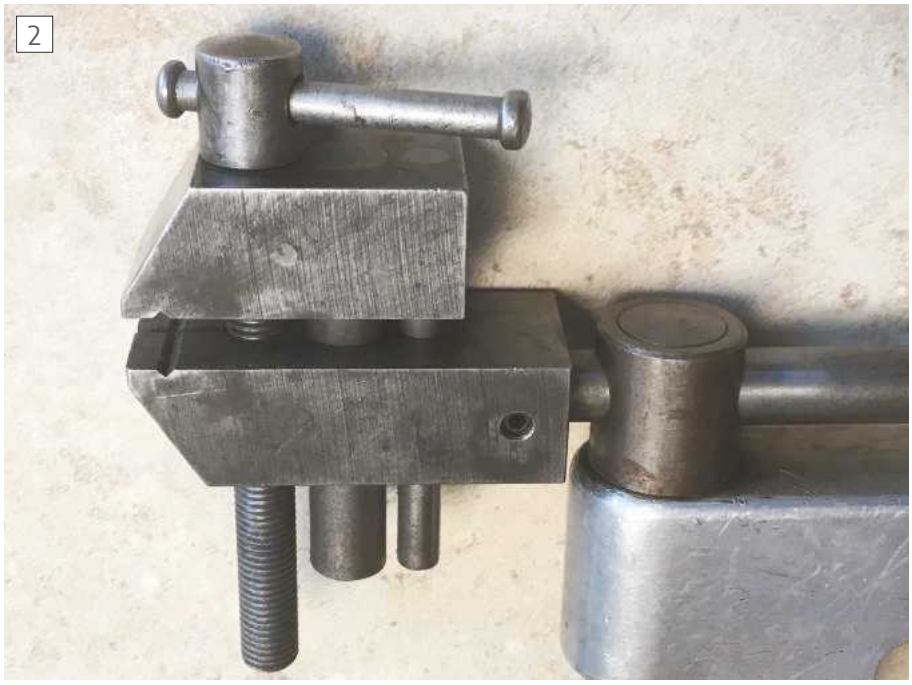
John Fawcett details his re-making of a vice, originally made 45 years ago.



Original vice LHS

Inspired by the commercial Eclipse vice I made my original vice, **photos 1** and **2**, over 45 years ago before I left my job in engineering and went self-employed. Realising a small instrument vice of this type would be particularly useful in my new venture, with my boss's permission I made the vice working after normal hours. An easy task having the run of a full machine shop, but it was made as a working tool and not to look pretty! The vice has been in everyday use ever since but became a "prisoner" in the company workshop even after I retired! I missed the vice on many occasions so decided to make another and here is the story - I hope you enjoy my ramblings.

There is no particular order in which any of the components need to be made, there are however in some cases a sequence of operations that are best adhered to. Some general machining. I will not dwell on in any detail such as squaring up the ends of the material on the mill, a simple task that needs no explanation.



Original Vice Closeup LHS

The Jaws Item 1, fig. 1.

I chose to machine the jaws first, one of the main reasons being that if need be you can make guide rods to suit the holes, if done correctly then standard round stock should be fine for these. The material I used was Gauge Plate, ground flat stock or 01 tool steel, available ground all round to 1" x ¾" I had some already but its widely available, This could be substituted with any suitable steel that can be hardened say EN9 but gauge plate is easy to source, very stable during heat treatment and will give a long service life.

First cut the material to length plus a small finishing allowance, set up in the mill and square the ends of both jaws. Next is to drill and ream the three holes for the two guide bars and the operating screw. These must be machined in a stack to ensure positional accuracy. I did this on our Bridgeport because the 4" vice on my Emco was not deep enough - the Bridgeport resides in a larger workshop at my sons house much too large to fit in my shop, **photos 3** and **4**. It's important to clock the vice true to the X axis, also note the slip of paper or very thin card between the moving vice

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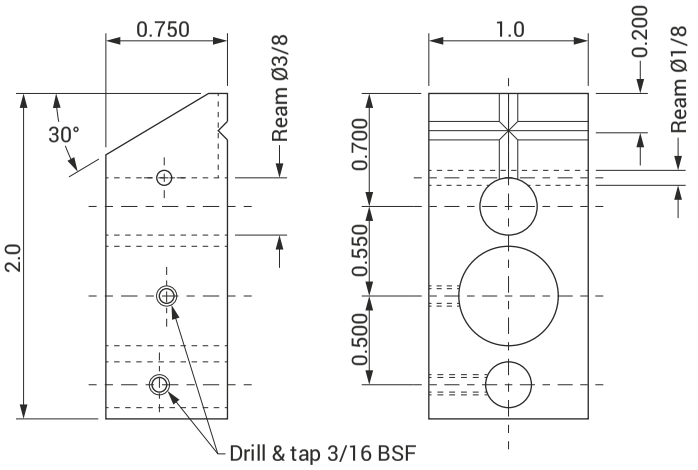
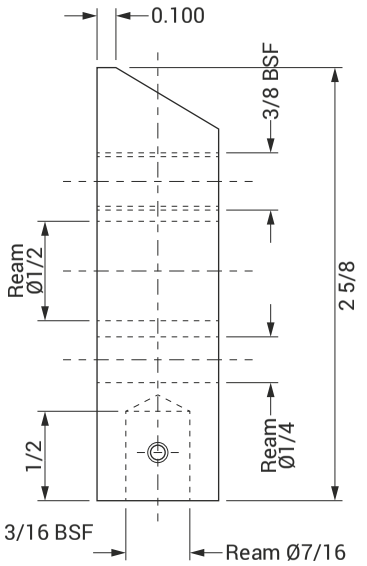
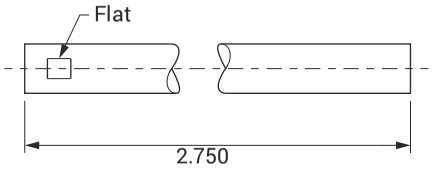
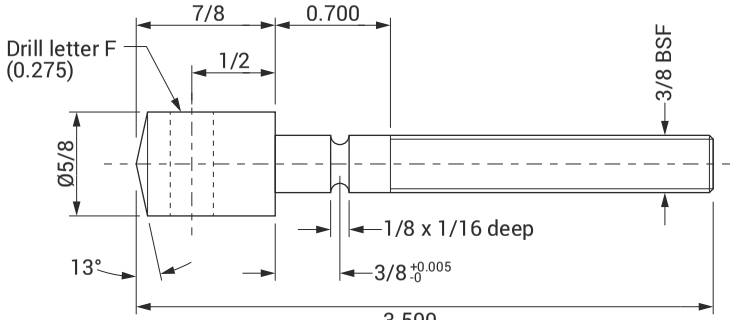


Item 1





Guide Bars
1 off each:
Ø1/4
Ø1/2
Ø7/16 x 3.0 long



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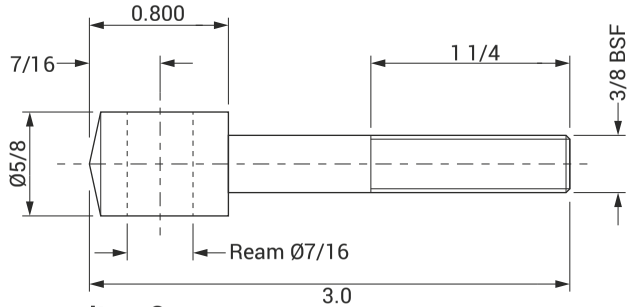
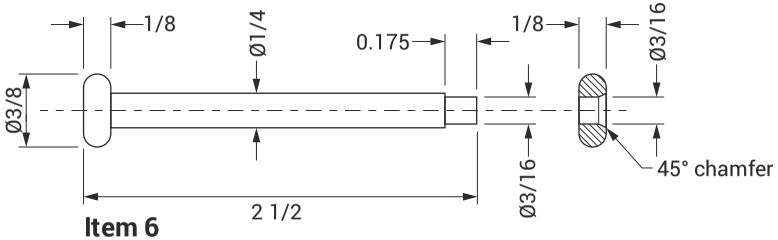
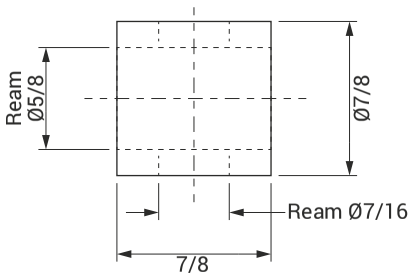


Item 3



Item 6
3 off



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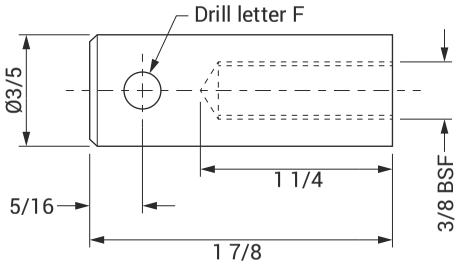


Item 5

Drill & Ream Jaws

Drill & Ream Jaws

jaw and the work pieces, this takes up any tiny dimensional difference between the two embryo jaws and ensures they are gripped so not to move during machining.

Make sure you stack the front shorter jaw on the top for this operation because the top hole for the operating screw you need to drill through with the tapping drill size for ⅜" BSF [or your chosen thread if you want to go metric]. Notice in the photos my deliberate mistake here! I stacked them the wrong way and had to do a mod to rectify my mistake later but that's another story, more later. Next open up the top shorter jaw to the size for reaming to ⅜" so drill 23/64" making sure you are through the full depth of the jaw by plus approximately 0.050" then ream ⅜" the extra 0.050" allows a small clearance for the start of the thread and ensures you can ream through the full depth required, the other two holes are straight drill and ream through both jaws, 1 x ½" and 1 x ¼".

Do not tap the thread at this point through the reamed hole — the tap will be slightly large on the O/D and will thus leave a "thread" in the reamed hole - tap the thread after separating the jaws but do make sure the thread is square to the jaw in both planes.

Another point is to mark the orientation of the jaws so that you can keep them correct as progress is made. I used a small centre pop mark in each jaw on the outer corner that will be machined away to form the 30 degree chamfer on the top of the jaws.

Next operation is to drill and tap the holes for the grub screws that lock the guide bars and the mounting bar together with the 7/16" hole in the bottom of the longer jaw for the mounting bar and drill & ream the ⅛" hole for the dowel pin that holds the vice spindle in place. A simple operation using co-ordinate positioning for the holes, **photos 5** and **6**.

First you need to make a slave pin to

D & T Grubb Screws

D & T Grub Screws

insert in the top ⅜" hole for the vice feed screw so the ⅛" dowel hole can be drilled & reamed true. I used BMS for this and faced it off carefully to be exactly the same length as the jaw thickness, **photo 7**. I then clamp the short front moving jaw in the machine vice with a slip of thin card to make sure the slave pin does not move and use whatever method you wish to pick up the end of the work piece. I used a dowel and a slip gauge - ¼" dowel plus 0.125" slip means the spindle centre is 0.250" from the edge of the work. Use coordinates to move to the positions required to make the holes as per drawing. I used 3/16 BSF grub screws because I have masses of them. I was a little lazy here using a dowel in my chuck rather than in a collet but I know my chuck runs very true and more than good enough in this instance — not looking for tenths here!

Drilling and reaming the 7/16" hole in the bottom of the long fixed jaw plus the tapped hole for the locking screw to drawing is a straight forward operation needing no further explanation.

Next to machine are the V grooves at 90 degrees to each other, you may notice in my original vice I made grooves in both jaws but on this one only in the fixed jaw. Two reasons, one if both jaws are machined the V's must align precisely, not too difficult but no problem if there is only one groove. The second more important reason is with only one V you can grip smaller diameters and no detriment for larger diameters. I simply marked the positions of the V's with a height gauge then with the jaw set in a V block in the milling vice, **photo 8**. I "picked up" the line with my cutter just kissing the work then with the cutter clear of the work lowered the head and moved the table to the drawing dimensions and cut the vertical V. The horizontal V was done similarly but using a 45-degree setting gauge it was held in the vice in a similar manner to **photo 9**.

Outer Jaw all holes D & T or Reamed

All that remains is to machine the top clearance chamfer at 30 degrees on the top of each jaw, **photos 10** and **11**, note the standard angular setting gauge used to position the work piece. The finished jaws were later heat treated, **photo 12**.

The Feed Screw Item 2

I would suggest this is made from something tougher and more wear resistant than mild steel. I used EN24T because I use this regularly and have it "in stock". It is a straight forward turning and threading operation. I used a collet chuck and supported the job with a running centre, the thread was cut with a Coventry die box but you could use an ordinary die providing it's in a tailstock die holder to ensure the thread is true, **photos 13** and **14**. It is also necessary to make the hemispherical ⅛" x 1/16"

Set in V block

Milling the V groove

Milling the chamfer

Heat Treated Jaws

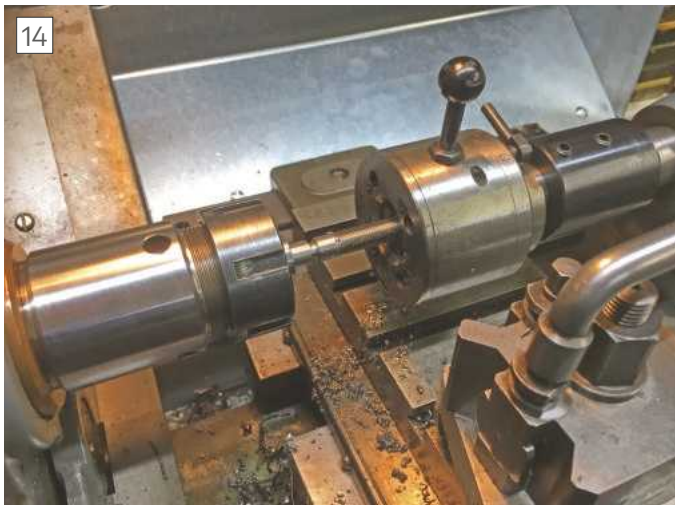
Milling chamfer

deep groove for the retaining dowel positioned as per drawing but see the mod later for the thrust washer.

The hole for the vice handle needs to be cross drilled and chamfered on both sides but I left this until all the other turning jobs were done because there are several cross-drilling operations to do. The hole does however need to be a clearance size for the handle so use a letter F [0.257"] drill, assuming Item 6 the tommy bar is made from ¼" diameter material.

●To be continued

Turning the spindle



Cutting the thread with die box

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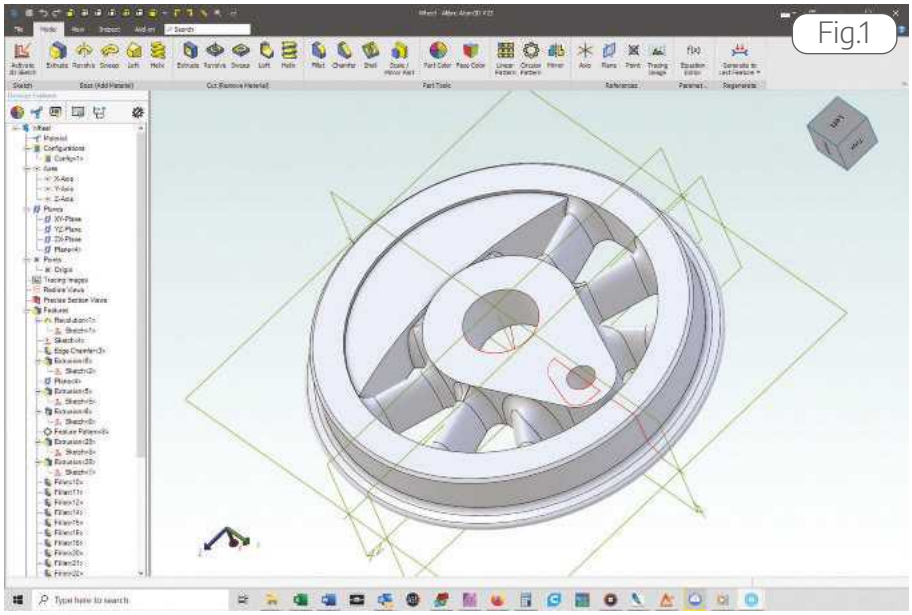
Tips for Designing in Alibre Atom 3D

Neil Wyatt describes his approach to design using this 3D CAD app.

I find the best way to approach designing any object in Alibre is to think through the sequence of creating the part, at least in outline, before I start. The most important step is identifying the ruling dimensions – those which set the proportions for everything else. For example, this might be the mounting points for a motor, the separation distance of two gears or the size of some other part. When making 'scale' models from limited information it's best to choose a large, well documented dimension to minimise errors when you are 'filling the gaps'. It is also worth having a clear idea of how you will make the part. If parts are to be machined, you may take a different approach for milled or turned parts. A turned part could be designed as a series of cylinders, or as a shape rotated around an axis; neither is the 'right' approach, but one may be better than the other for any given part.

It's important to think about tool access as it is easy to design parts that are impossible to machine because of poor access or difficulties in mounting parts. On the positive side, a program like Alibre helps you think about jigs and fixtures, for example planning a special steady, mandrel or locating fixture alongside the part.



This single-sided pattern for a locomotive wheel is designed flat on a plane, with a draft angle on all its vertical surfaces.

If designing for 3D printing, you must remain aware of the need to minimise support and of the preferred orientation of the final print, but with care you can create nested shapes that would be impossible to machine.

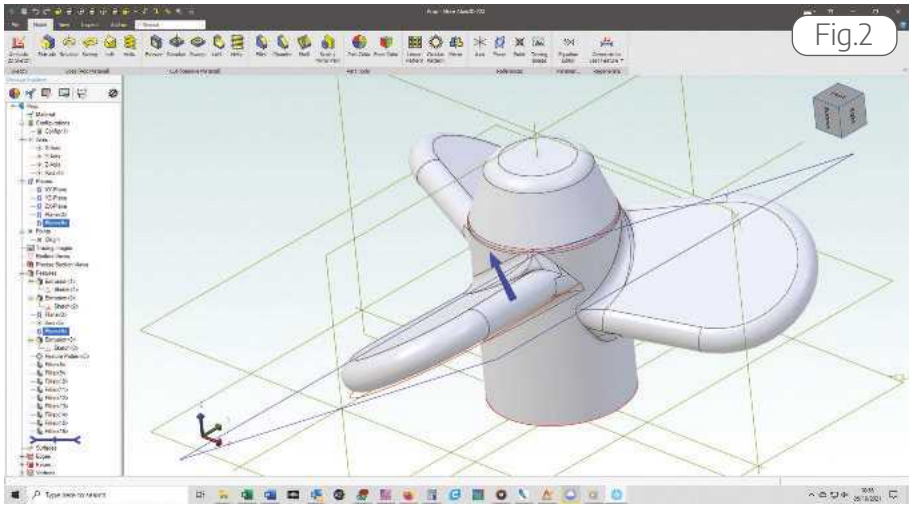
If a casting is the final aim, you need to think about both how the pattern will be made and allow for things like draft on the mould, **fig. 1**.

Like a building, its best to start from a firm foundation. In Alibre this means choosing a base plane that is not just convenient for setting up the initial steps but will also make it easy to place further planes or axes for later parts or assemblies, **fig. 2**. It's easy to assume a top-down view, or even a ground plan is best but often other views are better.

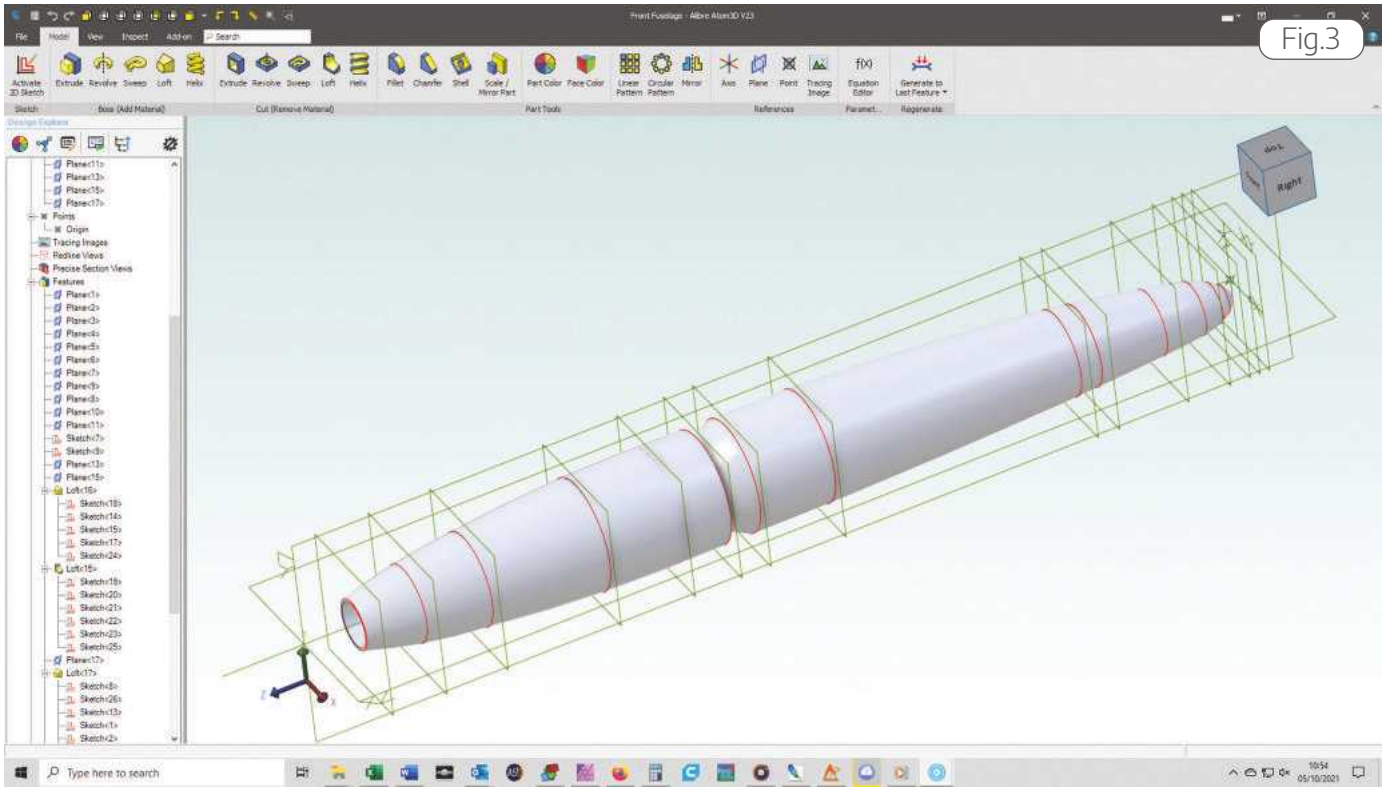
Many spindle-shaped objects, especially lathe turned parts or even spacecraft have an obvious main section and are made up of cylindrical or conical sections with clear discontinuities. One of these discontinuities often offers a useful reference plane to start from. They are often easier to build as a series of stacked extrusions than by rotating an outline.

Spindles with more complex shapes, like a candlestick, are better drawn as a half-section and created by rotating it around an axis. Be aware that the section must be accurately drawn along the axis (use the snap tools) as if there is a gap it will have a central hole, and if it overlaps the rotate process will fail.

For irregular flowing shapes like a



One angled blade for this simple propellor was designed on the highlighted plane, then copied around an axis.



The fuselage of this proposed WW2 jet has a complex, near-eliptical cross sections. After sketching each cross section on a separate plane, the smooth final shape was created by lofting.

aircraft or boat hulk, a good place to start is a cross section. Further cross sections can be added fore and aft and joined using lofting, **fig. 3**. I can't get lofting from a shape (e.g. an ellipse) to a point to work – my work-around is to use a tiny ellipse as the 'point'. Additional parts like superstructure and wings are often symmetrical and easy to add from the central plane.

The basic units of Alibre Atom 3D are sketches, parts, assemblies and drawings:

The fundamental unit is the 'part' which can be saved as a .part file. Parts are exactly what they sound like, each one is a discrete object. 'Sketches' are a subdivision of parts; the simplest part might be a single 'sketch', but most parts are many sketches combined with various operations to make them 3D and modify their shapes.

Two or more parts can be combined into an 'assembly'. Both parts and assemblies can be used to create 2D 'drawings'.

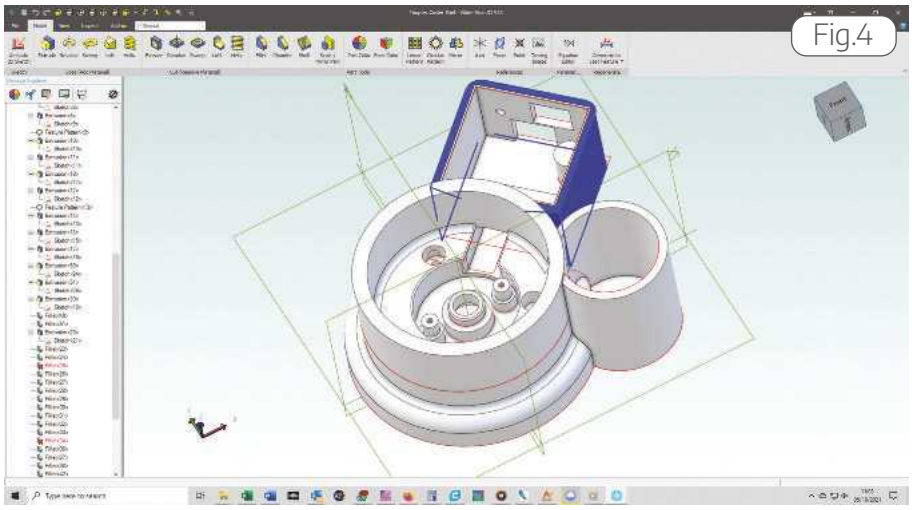
Sketches

A typical sketch is a 2D drawing that is then developed into 3D as a 'boss' or 'cut'. A typical part will have multiple sketches, each created on a plane or a face of an existing boss. They may be modified by mirroring or patterning and applying fillets and chamfers. The tools for drawing sketches include various shapes and line-drawing tools, as will as a text tool. A whole range of 'constraints' can be used to manage the relationships between the elements of a sketch (and any guidelines or even other sketches). One thing that confused me at first is that the rectangle tool only creates 'unrotated' shapes. An angled rectangle is created by drawing four lines – if you place these carefully the system automatically offers you 'snaps' to make the corners right angles and the opposite sides equal. It's fast, easy and intuitive once you have done it a couple of times.

Sketches can be as complex as you like, but if they are to be used for a boss or a cut they need to be 'closed' – that is made up only of continuous, non-crossing lines. Sketches to be used as a path or guideline do not need to be closed, although the system will give you a warning. If your shape appears closed but has errors, a 'helper' pops up when you try to close the sketch. Clicking on this identifies where the errors are and you can zoom in and correct them.

Bosses

Sketches are drawn in 2D, but Alibre



This housing for a cooled camera includes voids and holes created by extruding cuts.

Atom 3D offers several powerful ways to develop them into 3D by creating 'bosses'. The simplest way is to extrude a boss, this can be done in one or both directions with a number of different ways of setting the distances. A handy feature is being able to taper the boss, useful for designing patterns but obviously with many other uses – such as cones. Other bosses are:

Revolve – which creates circular shapes like spindles or rings.

Sweep – which follows a path, I've used this to simulate a pipe.

Loft – this creates a 3D shape by 'transforming' one shape into another shape, or a series of them. You can use a 'guideline' to tweak the process a which is great for creating elegant blends between accurately sized ends.

Helix – a very useful tool that comes into its own for 3D printing as you can create accurate working threads. It can also be used for other purposes such as decorative twists or Archimedean screws.

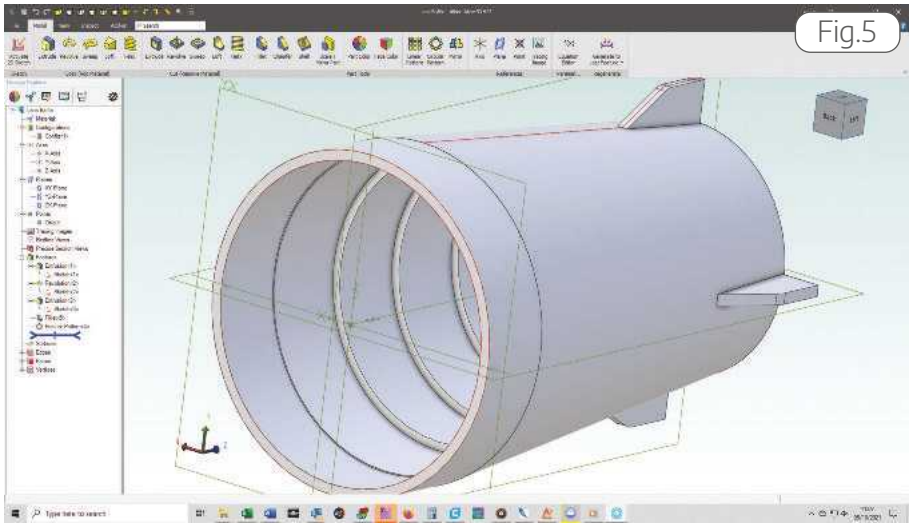
Cuts

Cuts are essentially 'negative bosses'. They work in exactly the same way, but instead of being added to the model they remove any existing volume that intersects with them. You can use all the same methods to create a cut as a boss. The 'through all' setting is a very quick and easy way to turn sketches into holes right through an object.

Imagine putting a thread around a cylinder -you can do this in two basic ways. One is to draw a cross section of the thread on the surface of the cylinder and extrude a helical boss along its axis. If instead the cross section is drawn inside the surface of the cylinder you can create the screw thread by extruding a helical cut. This might be useful when you have two cylindrical parts one inside the other, giving you the choice of using their shared surface as either the major or minor diameter of the thread.

Cuts can be used in some creative ways, **fig. 4**. Some useful examples are:

- Creating angled surfaces by creating a suitably angled plane, drawing a large polygon and extruding a cut to take the end off a part.
- Cleaning up a surface by drawing a polygon on it and extruding a cut – you could use this to remove an area of a pattern of rivet heads, for example.
- Breaking a long sketch into parts while keeping their integrity; for example, the centre part of a crankshaft could be a single cylinder with sections cut out for each throw, rather than as a series of aligned cylinders.
- Lightening 3D printed parts by creating internal cavities.
- A neat way to create matching cavities on both sides of a solid object is to draw a sketch on its centre line and then use the 'through 'all cut to make it into a hole. You can then do a symmetrical extrude on the same sketch to create a central 'plug'.

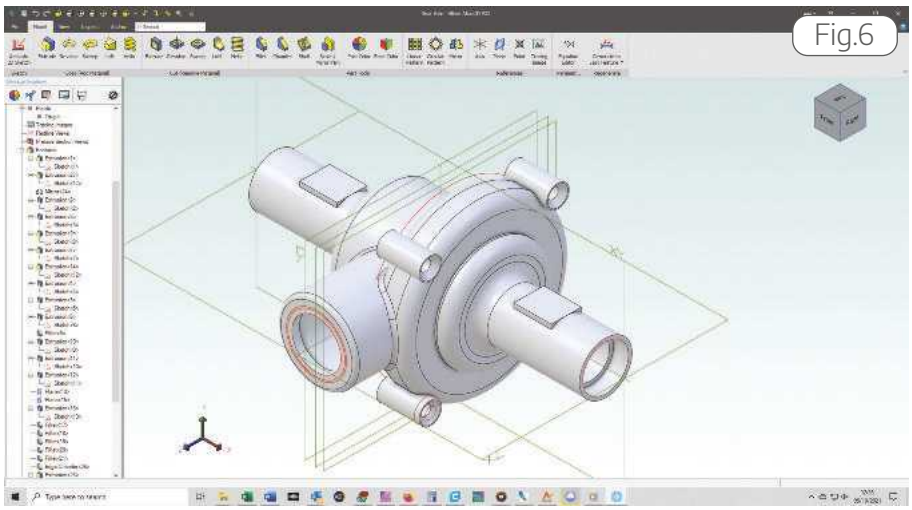


Centring this stepped tube on the XY plane made it easy to arrange the radial supports.

Combining Techniques

Naturally. It's possible to combine different approaches to achieve the final object. Here's an interesting example that looks fairly simple, but has a catch, **fig. 5**. It's a light baffle that has some supporting fins, but the tricky bit is making the internal anti-reflection ridges inside the tapered part. The part is intended for 3D printing and the obvious starting point is the large circular end as its end face is the datum surface, and its diameter is the most critical measurement. We start with a circle centred on the XY plane, the diameter of 59.6mm is chosen to give a push fit into a nominal 60mm tube. An inner circle of 56mm is chosen to give adequate thickness while maximising the open aperture. This ring is then extruded by 15mm to provide the section which locates the baffle in the tube.

The tapered part could be made as a series of stacked tubes, each narrower than the previous. This would then require the outer part to be removed with a conical loft to keep the weight down. Instead, the tapered section was drawn as a series of 'steps'. Note the use of the equal length constraint to keep the steps the same size. This allowed even steps to be achieved even though the exact size was not defined – the rightmost step is shown in red (position and magnitude undefined) but the other steps are orange (magnitude defined) as they are set to be equal to the right step. After ensuring it would be thick enough



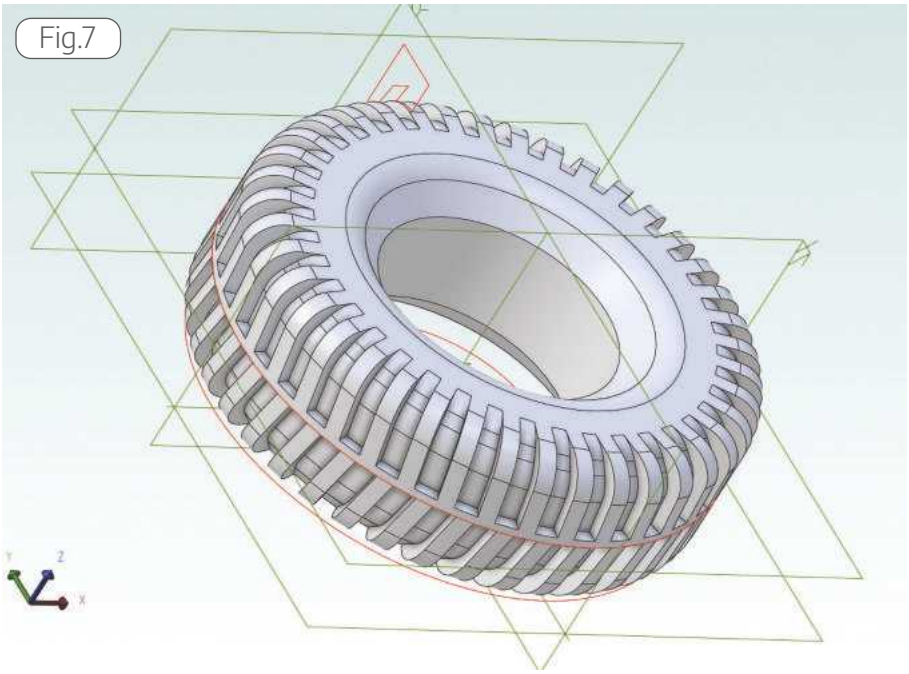
This differential housing is really just a series of cylinders and cylindrical holes, but good choices of fillets create a more pleasing and efficient 'organic' shape.

for strength, the stepped polygon was extruded using 'revolve boss' along the Z axis. This is why it was important to centre the initial part on the XY plane, otherwise we would have had to use that initial cylindrical extrusion to place a new axis to rotate around.

The final parts are the four stabilising 'fins'. Either of the YZ or XZ planes could be used to draw a section of one fin, which was then extruded using the 'mid plane' setting which ensure it is not offset to one side. Finally, the Circular Pattern tool was used to place four fins evenly spaced around the X-axis.

Incidentally, as the steps on the baffle needed to be sharp and to avoid the need to use support material, the baffle was printed large end up. Exported as an STL file, its natural orientation was large end down, but it was easy to rotate it 180 degrees in the slicing program.

Fig.7



This tyre uses rotated patterns to create a tread, to be 3D printed using TPU.

Fillets and Chamfers

These are hopefully self explanatory, with fillets being curved and chamfers being flat. They can be applied to an edge – adapting automatically to inside and outside corners, or to a surface, in which case the programs tries to apply them all around its perimeter. Alibre does an excellent job of blending them together, even if they have different sizes (you can even create asymmetrical fillets and chamfers). They do sometimes fail if the target is too small; for example, a 5mm radius fillet on both sides of a 10mm wide bar will not always work. I suspect this is when a rounding error means the bar is really infinitesimally smaller than 10mm. In such cases using 4.99mm solves the problem!

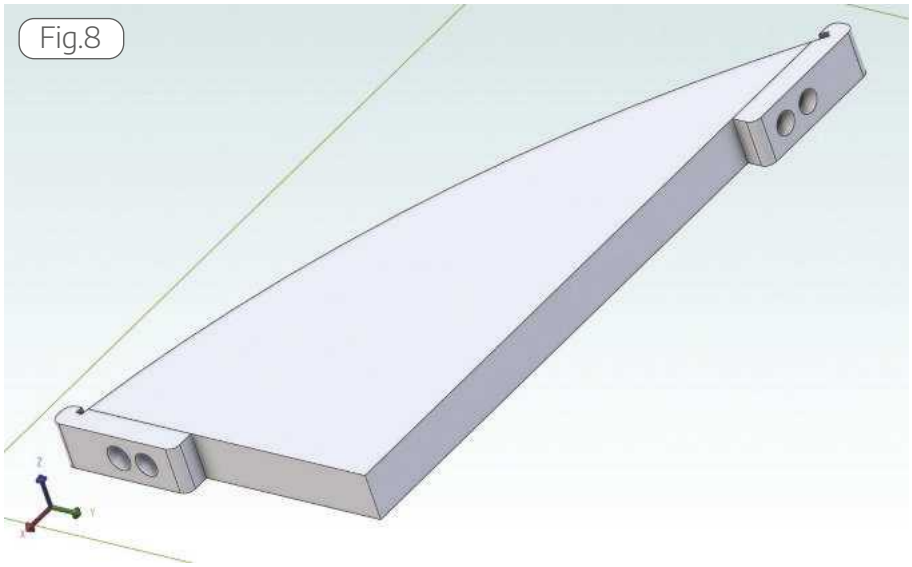
If find that, generally, it's best to design a part and add the fillets and chamfers as a final stage to tidy it up. A great tip is that very large fillets can be used transform blocky, functional designs into much more elegant ones, **fig. 6**.

Mirrors and Patterns

Mirrors and patterns are fairly self-explanatory operations that allow you to rapidly create copies of sketches to make more complex parts, **fig 7**. For example, you can create one rivet head and then just use a pattern to create a grid or circle of rivets. Selectively mirroring sketches and helps when making partially symmetrical parts. Note that you can mirror a cut or a pattern or even a whole sequence of sketches and operations – any group of items from earlier in the in the history.

When in sketch mode you can mirror or use linear and circular patterns, but they work in a different way. Rather than going in the history, they create new instances of the features mirrored or patterned and the action is 'forgotten'. This can be both helpful and irritating! You can create a grid pattern of holes in a sketch and then delete any holes you don't want. But if you want to change the spacing of the pattern, you have to either move each hole individually or use the undo button and start again. This is because the history works at the parts level, not at sketches level.

Fig.8



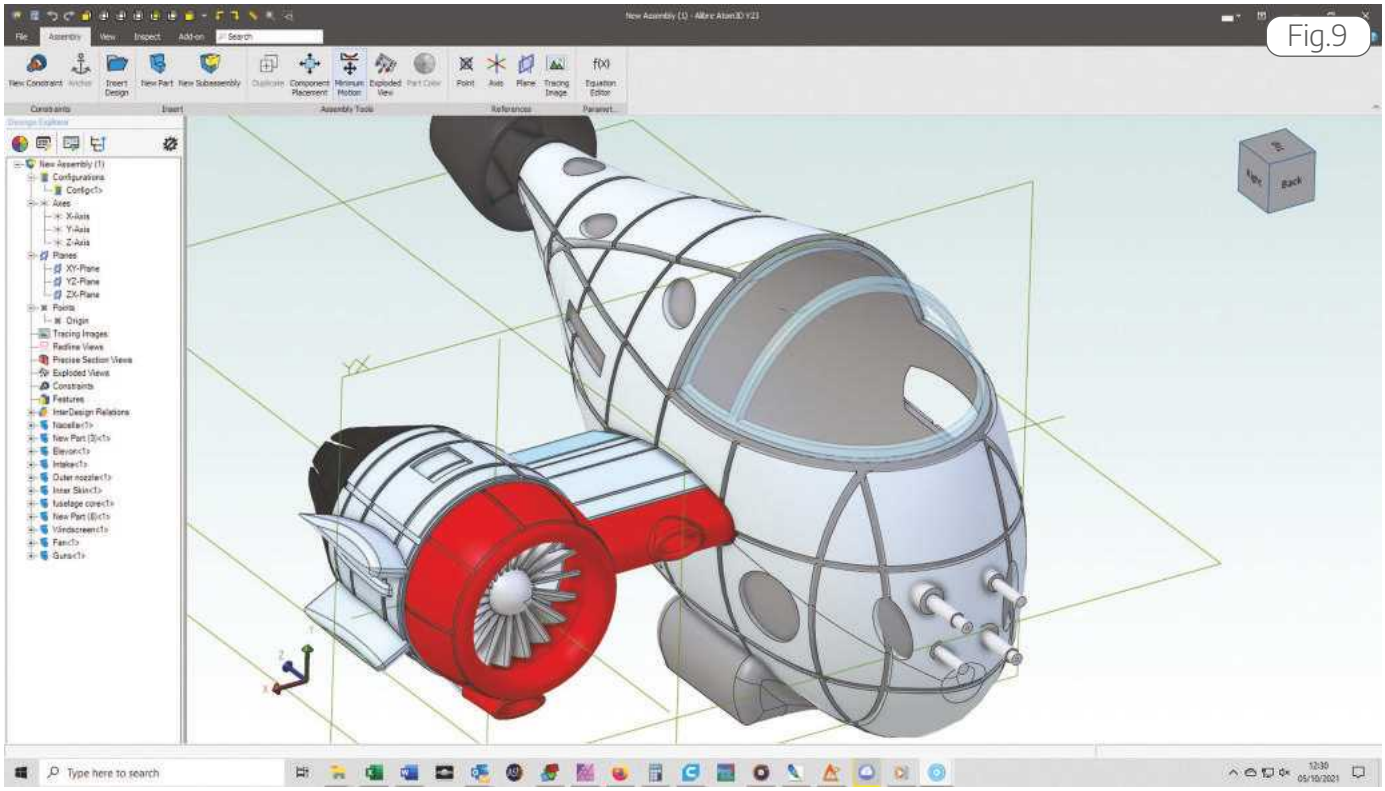
By 'building' these clips directly on the main part their notches perfectly match the angles at each end.

Shell

Shell is a really handy facility for making relatively delicate objects. Readers familiar with 3D printing may know the 'spiralise' option that turns a solid object into an open-topped 'vase'. The problem with this is that the resulting objects have a single layer thickness and are very fragile.

The 'shell' command is more flexible as rather than just removing the 'top' of a part it can be used to remove any one or more faces and you can also set the thickness of the shell to be left. A simple example of how this can work is to create a boat hull:

- Create a series of planes representing the hull sections.
- Draw the hull sections on the planes.
- Use the 'loft' command to join the sections into a 3D shape.
- Use the shell command to remove the



A complex assembly for a model 'spacecraft' made of eleven parts, each comprising multiple sketches.

top surface leaving an outer hull of appropriate thickness.

Naturally you could use sketches to add various additional elements, such as a propeller tunnel, before carrying out the shell command.

Finally, if you run shell without specifying any faces, it simply makes the part hollow, if you set a relatively thick shell this is an easy way to make large, light 3D prints with reasonable strength, but do bear in mind the difficulty of printing large unsupported surfaces.

The History

The biggest step up in my productivity came with using Alibre's history feature. The drawing window includes a list of all the sketches, extrusions, cuts, patterns, planes and axes you have used – in order. It's possible to delete (or suppress) any of these or re-order them.

You need to be aware that if a sketch depends on dimensions from another sketch and you reverse their order or delete the earlier sketch, then the dimensions will remain, but the dependency will be broken. This may not have an immediate effect but may cause problems later, as if it creates an undefined sketch you may not be able to extrude or cut it. The moral is to try not to change the order of parts if you can avoid it, or to take care when doing so.

On the other hand, it doesn't seem to cause problems if you go back in the

1 *A 3D printed model assembled from separately printed parts.*

history to create sketches at an earlier point, although these will be affected by any later cuts or extrusions.

Reordering can be very useful, for example you may have added a part and later realise that it is blanking off a fixing hole. Usually you can just move the fixing hole to a later point in the history, so it goes through all parts.

You can always use the 'suppress' option to hide a sketch or operation and observe the consequences or just to get a better view of the area you are working on. I also find that temporarily hiding operations like knurling or threading can speed up the rendering of a complex part.

Parametric 3D

Because Alibre is parametric, a handy feature that often goes unnoticed by beginners is the ability to use formulas and constraints to control dimensions. For example, you can make the diameter of a cap equal to the diameter of spigot plus a small allowance. If you later make the spigot larger, the cap will resize and keep the same fit. Similarly, careful use of constraints to keep the important parts of a drawing in the right relationships is a powerful approach. It can be tricky to get right, but an advanced example could be a design for a lathe, where you might change the between centres distance and centre height so the headstock and tailstock change in proportion but keeping all the parts in alignment.

Assemblies

Assemblies are a powerful aspect of Alibre. You create a new assembly around an existing part. You then have the option of creating new parts using the existing part as a base. For example, in **fig. 8**. you can see a curved sector that has two clips at each end. You can use the surfaces of the base part as guides for aligning the new part. The clips were 'built' on the flat ends of the sector, and using constraints allowed the slits to be exactly tangential to the ends of the curves.

The example of a lathe mentioned above would clearly be best be done using 'assemblies', where the starting point would probably be the lathe bed. The headstock would be a part created on the bed, and the spindle made to fit the headstock. The tailstock would also fit the bed but would take its centre height from the headstock. The same approach would be taken with each subsequent part, so that assembling the design would mirror the making of the full size object.

Closeup of an equatorial platform showing a 'sector' with a complex geometry.

The alternative approach of making each part separately, then 'assembling' them can be used, but this is much more likely to lead to errors or the need for adjustments. That said, if making a complex model, fig. 8 and **photo 1**, you will probably use a mixture of both approaches as repeated parts like fixings or wheels are likely to be designed separately and brought into the assembly.

Producing 2D drawings

One of the nice features of Alibre is that it can produce 2D drawings automatically from your 3D parts. This can be a little tricky at first, as it is not always obvious which views you are selecting in the 'chooser', but you can always select more views than you need and delete the unwanted ones. Dimensioning your drawing is simple. Choose a line or circle and pull out from it to place a length or radius. Choose two points to dimension between them – if they are not aligned vertically or horizontally moving the cursor swaps between the perpendicular and direct distance.

Text notes can be placed simply by clicking with the note tool, this seems to be the best way to fill most text boxes although a right click and edit allows you to enter data for the main field (drawn by, date etc.)

A 3D Sketchbook

Before using 3D CAD of any kind, I often used the back-of-an envelope (or dog-eared A4 pad) approach to setting out my assemblies. I usually have the final design 'in my head' but there is always the need to adjust the proportions to make the best use of stock materials, check clearances and just be sure that thinner sections and the like will have adequate strength without being clumsy.

I find that 3D CAD of any kind and Alibre in particular lends itself to this kind of 'sketching' with no need to elaborate a fully finished design. For example:

- Gears can be represented by discs whose diameter is the PCD of the gear.
- Trignometrical challenges can often be solved most easily using overlapping circles rather than by trying to juggle lines.
- Sometimes carefully placed and angled planes or axes are more useful than guidelines when trying to work out the placement of parts in three dimensions.

A good example of the last point was when I was designing a sector of a cone to move across a roller, **photo 2** – an evolution of the part in fig. 7. Traditionally this would either be a circular section on an angled roller, or a thin elliptical section that would move back and forth across a horizontal roller. By drawing the construction in Alibre I was able to make a conic section (a hyperbolic curve) in three dimensions, so it operated on a horizontal roller without moving back and forth. Exporting to an STL also enabled me to 3D print the sector that would otherwise have required a complex jig two feet wide and high to machine in wood or metal. ∎

Mini Project - Make an Elephant Foot

Gary Wooding explains a device to add accuracy when working with convex surfaces.

Most DTIs have a ball-ended probe which makes it very difficult to locate the high-point of a convex surface. What it really needs is a probe with a flat end. **Photograph 1** shows my DTI, which I have mounted on quick-change tool holder. The ball ended probe unscrews and can be replaced by a flat-ended probe called an elephant foot. **Photograph 2** shows the DTI with the new foot, with the ball ended probe in the background. This mini project shows how I made the elephant foot.

The first job was to carefully measure the salient dimensions of the ball-ended probe. In my case, the screw thread was 6BA, but I suspect that most modern DTIs use an M3 thread. I decided make mine from a piece of 10 mm stainless steel that I found in the scrap box, but it's certainly not critical. Based on that I drew up the plan shown in **fig. 1**.

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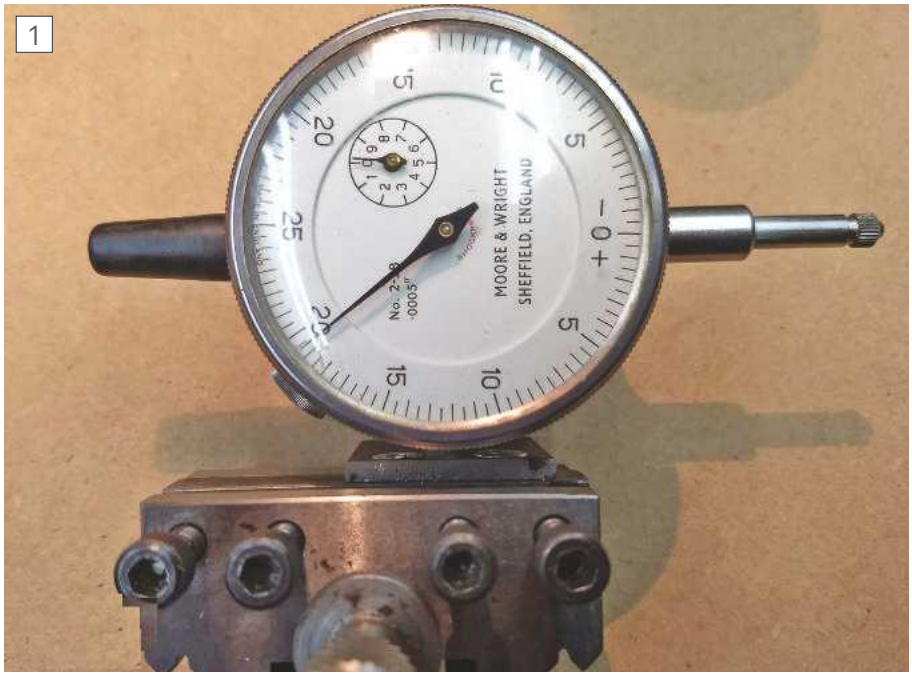
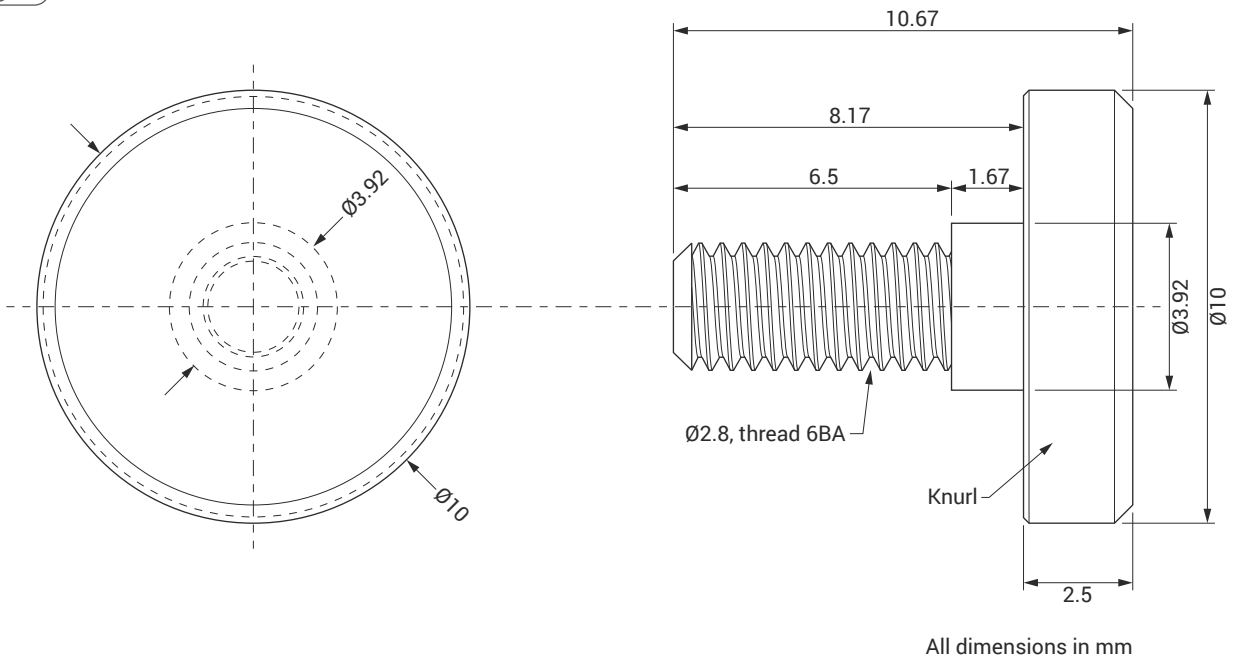


DTI with standard tip.

I decided to knurl the rim of new foot (it's certainly not necessary, but it does look the business), so I used my

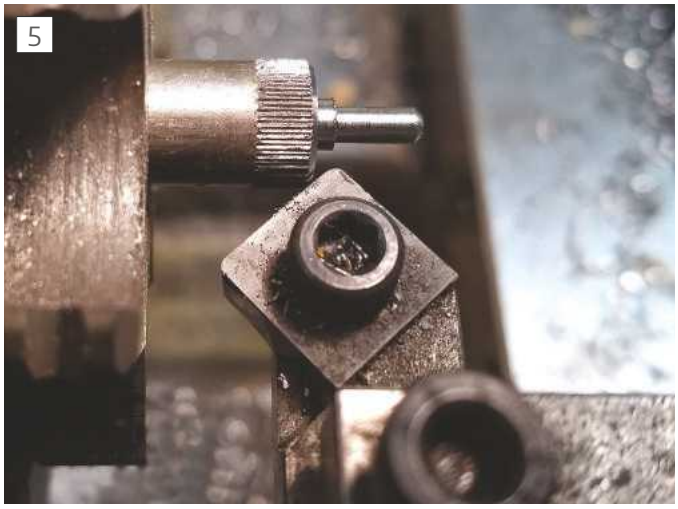
Fig.1



DTI with elephants foot.

Knurling bar for the foot.

Turning spigot.



Chamfering.

Tapping scrap bar.

Finishing outer end.

To ensure the tapped hole was accurate to the axis I used a tap holder supported by a spring tapping guide held in the tailstock drill chuck.

Completed elephant foot.

home-made scissor knurl with a pair of fine parallel knurling wheels, see **photo 3**. I then turned the end of the bar to the required dimensions, **photo 4**, chamfered the end and the edge of the knurl, **photo 5**.

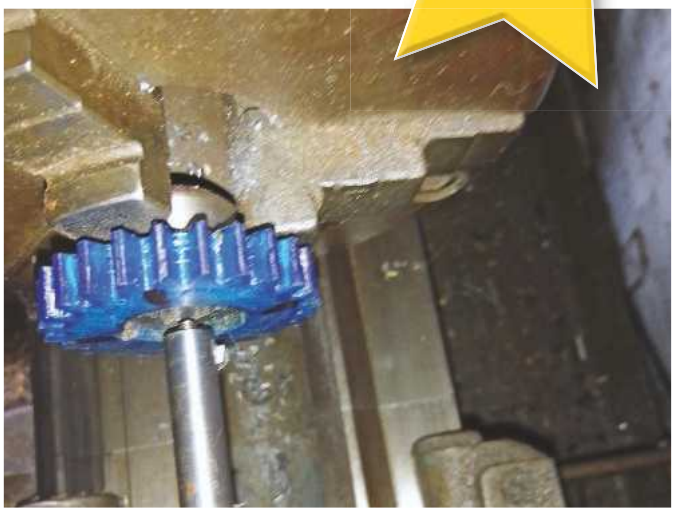
I then used a 6BA die to cut the thread. I used the end of the tailstock drill chuck to ensure that the 6BA die was square to the lathe axis. Because the die has a lead-in it didn't cut a thread up to the shoulder, so, after the initial cut I reversed the die in the holder and repeated the operation. After cutting off the partially finished foot, I had to hold it somehow in order to finish turning the end. The 3-jaw chuck would damage the screw thread, and the shoulder wasn't long enough to be gripped.

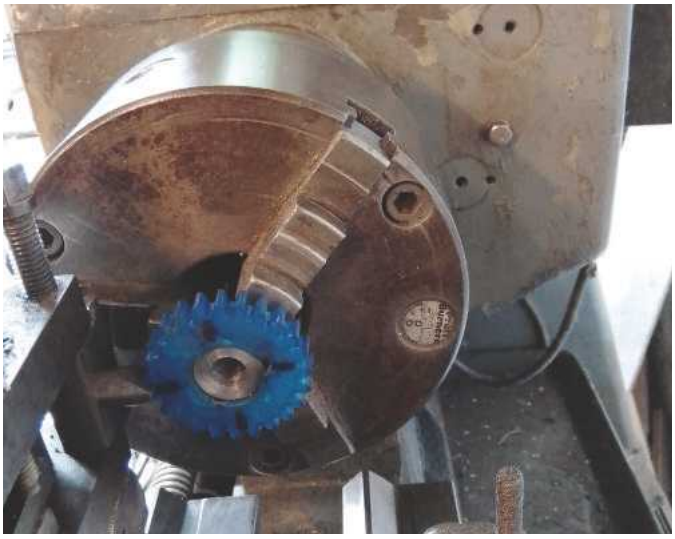
I took a piece of scrap ⅜" bar, faced the end, and drilled and tapped it 6BA. To ensure the tapped hole was accurate to the axis I used a tap holder supported by a spring tapping guide held in the tailstock drill chuck, **photo 6**. The new elephant foot was then screwed into the bar which allowed the end to be carefully faced and chamfered, **photo 7**. The foot was then complete, **photo 8**. ■

Readers' Tips

TIP OF THE MONTH WINNER!

Indexing Internal Splines





This month's winner is Geoff Andrews with a tip for simple indexing.
I needed to plane some internal splines using my lathe. I had no indexing facilities on the lathe so came up with this idea. I 3d printed a gear with the required hole and number of teeth. This gear was glued to the workpiece then the workpiece was chucked up as per photo. A simple indexing pin set at centre height in the tool post is then engaged with one tooth space. The spindle is the locked or the lowest gear engaged. The tool post is then spun around to present the cutting tool and the first spline is planed out. The tool post is the indexed around to present the indexing pin to the work. The chuck is then rotated around the required amount the indexing pin engaged the spindle locked, repeat as before until all splines are cut. When finished the gear or indexing ring is knocked off. I was pleasantly surprised by the accuracy of the spline spacing. This is another example of 3d printing as an aid in the workshop.

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

Please note that the first prize of Chester Vouchers is only available to UK readers. You can make multiple entries, but we reserve the right not to award repeat prizes to the same person in order to encourage new entrants. All prizes are at the discretion of the Editor.

The Basics of 230/400Vac Electricity in Simple Terms

Part two of a short series by Steve Skelton that covers various aspects of basic electrical safety in the hopes of making us all a little more secure in our workshops.

Overload – Protective Devices

There are a number of devices that are used in fuse boards, distribution boards and consumer units to prevent circuit overload. These are:

1: Rewireable fuses
2: Cartridge type fuses
3: MCBs or miniaturised circuit breakers

It must be remembered that these devices are used to protect the wiring in the installation from an overload (and to help protect the building from a potential fire) – they do not necessarily protect people from receiving an electrical shock or to protect appliances.

1 Rewireable fuses

These are historically very common and made up the vast majority of domestic and light industrial circuit protective devices in the 60's and 70's. They have the advantage of being relatively low cost to produce are technically straightforward and tend to be very reliable in use.

The disadvantage of these fuses is that when a fault occurs (or in the case of a lighting circuit, a lamp fails) the fusible element "blows", disconnecting the power to the circuit. The fuse, by its nature, has to then be manually rewired. Of course, it usually happens when it is dark, or the fuseboard is sited in an unlit under stairs cupboard making the process time consuming, awkward and potentially dangerous.

It is also important to determine that the cause of the original fuse failure has been rectified otherwise the rewiring process will again be necessary.

Another disadvantage is that the correct fuse wire to replace the "blown" wire is often not available or the person replacing the fuse wire is unaware of the different grades of fuse wire and thus puts in the incorrect grade with potentially disastrous results.

An example of rewireable fuses and the type of fuse board in which they are generally found are shown in **photos 1** and **2**.

On some occasions we have found the fuse carrier to have been rewired with a section of copper wire which would not "blow" until the cable, to which it was attached, over-heated and set fire to the building. We carried out electrical inspection and testing on one property in Taunton and found that the cable had become so hot, due to a fault, that the PVC insulation was charred and dripping from the cable – we are not sure how the house did not catch fire – all because someone had used a section of copper wire instead of the correct fuse wire.

Based on our experience we would recommend that fuse boards containing rewireable fuses are replaced with modern MCB types for safety reasons especially if the property is let – we have found that many tenants do not understand the need to replace fuse wire with the correct grade!

2 Cartridge type fuses

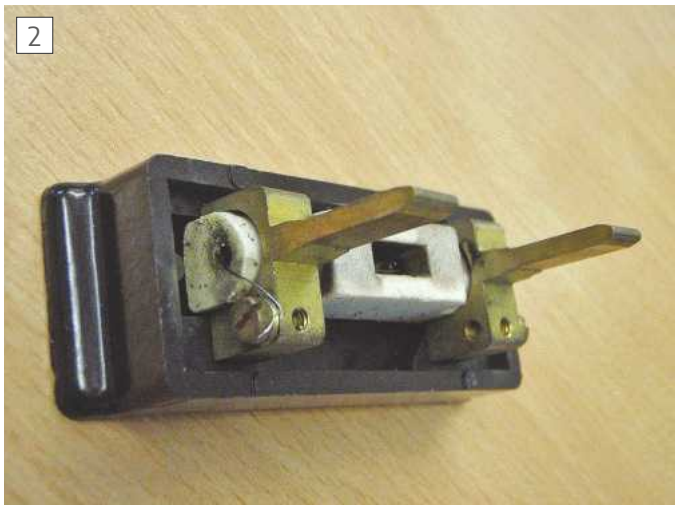
These are very similar in performance to rewireable fuses in that they are very straightforward and are very reliable in use. However, they do suffer from the same shortcomings as the rewireable types requiring the user to replace the fusible element. They are generally faster to replace than the rewireable fuses but again it relies on the user having spare fuses to hand (which is rarely the case), **photo 3**.

The fuses themselves are all of dissimilar sizes (in domestic applications) and therefore eliminate the potential of replacing with the incorrect size of fuse, **photo 4**.

3 MCBs or miniaturised circuit breakers

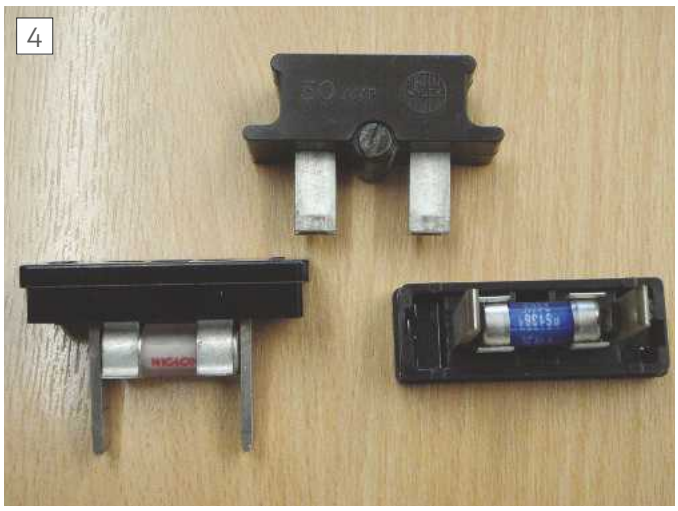
These are now the preferred choice in the majority of new domestic and

Old style distribution box with rewireable fuses.



Rewireable fuse.

Distribution board with cartridge fuses.



Cartridge fuse carrier.

commercial installations. They are relatively low cost and can be reset, although in a short circuit situation they can be overloaded and damaged. It is essential to ensure that the potential short circuit current at the board does not exceed the rated short circuit capacity of the MCB.

There are different versions of MCB and modern ones to BS EN 60898 are of B, C or D curve. I have not described them as Type B, C or D as there are devices called RCDs and RCBOs that come in different "Types" and there is often confusion between the two.

B curve MCBs are generally for normal use where the loads attached do not have high switching currents on start up and domestic type circuits generally fall into this category.

C curve MCBs are used in commercial or industrial circuits where switching surges can be quite high, for example banks of fluorescent lighting or equipment with motors.

D curve MCBs are not suitable for general use and are generally limited to equipment like X-ray machines or industrial welders.

Both C and D curve MCBs trip at the same constant current as a B curve when maintained for a significant period of time (can be up to an hour), the difference is the tolerance to varying start-up currents. The circuits to which each is attached have to be designed to cope with this start-up current. As an example, a D curve 32A breaker will withstand 200A for about 10 seconds whereas a B curve 32A breaker will "trip" immediately.

An example of a consumer unit and some MCBs are shown in **photos 5** and **6**.

To sum up – all of the devices above are designed to protect the wiring in the installation to prevent overheating and potential fires.

They are not there to protect appliances or their wiring (that's why plugs have fuses!).

It is important to ensure that the correct size of fuse or MCB is chosen for the wiring it is supplying. Lighting circuits are usually 1 to 1.5 mm² in cross section and are generally protected by up to a 6 A MCB or fuse. Radial power circuits are generally 2.5 mm2 and have up to a 20 A protective device and ring circuits in 2.5 mm2 a 32 A device.

Cables that run through or within insulation may have to be downrated to prevent overheating if they are unable to dissipate any resistive heating effects

Electrical leaks or faults that can lead to electrical shocks

Leakage is where an electrical current is passes down a path it is not intended to travel. This could be in an electrical installation or an appliance.

Some appliances are designed to have a certain level of leakage current to earth (usually in the order of 2 or 3 milli-amps maximum i.e. 2 or 3 thousandths of an amp or 0.002A) – these are usually power supplies to electronic equipment e.g. pcs.

If however a fault or damage to a cable causes a component to become live then there is a potential for leakage current to be pass through a person or animal.

To eliminate the possibility of dangerous leakage currents causing electrical shocks there are a number of safety features that should be incorporated into all installations.

Before looking at these it is important to look at the effect of electrical current passing through the human body.

Distribution board with MCBs.

- Current flowing through the body is detectable at a current of about 0.5 mA (ie 5 ten thousandths of an amp.
- At 1 mA a slight tingling is felt.
- When the current is about 5 mA a slight shock will be felt, it is not dangerous as a current but will have a startling effect on the body potentially causing a reaction accident.
- Above 6 mA the shock becomes more painful with increasing current. At 20 mA breathing difficulties are experienced and it becomes difficult to "let go" of the equipment that is causing the shock. As the current increases heart rhythm is affected and cardiac arrest is possible although the effects are reversible up to about 40 mA.
- Above 40 mA there is a risk of non-reversible disturbances to the cardiac cycle (ventricular fibrillation). Burns are now possible as is full cardiac arrest.

The above relates to a healthy person and the effects above are also exposure-time critical. The young and elderly are more seriously affected as are people in poor health.

The factors affecting the current and thus the level of the shock are dependent on a number of environmental and health issues:

Individual MCBs.

Damp skin conducts electricity more readily than dry skin and will increase the potential shock. Cuts and bruises will also increase the shock level as will the path of the current through the body. Assuming the path to earth is through the feet then the insulating properties of shoes and the floor construction will also have a bearing on the level of current that will pass. Wet leather soled shoes whilst stood in the garden will lead to a significantly higher potential shock current than rubber soled shoes on the floor of a typical dry carpeted room.

The above indicates how small a current has to be to cause a significant threat to life. 40 mA (that is 40 milli amps or 40 thousandths of an amp) is a serious shock – the smallest fuse or circuit breaker that is likely to be present in a fuse board or consumer unit is 5 A (5 amps or 5 thousand milli amps) – so at 125 times the shock level you can see that the 5 A fuse is not going to protect you by itself.

The next article will look at the systems and components used to prevent electrical shock. ■

In our Next Issue

Coming up in issue 310
On Sale 19th November 2021

Content may be subject to change

Look out for MEW 310, the December issue, helping you get even more out of your workshop:

Moving heavy machinery? **Will Dogget** gets his skates on.

Jacques Maurel makes a tool for internal turning.

Laurie Leonard makes some improvements to a drill press.

DON'T MISS THIS GREAT ISSUE - SEE PAGE 46 FOR OUR LATEST SUBSCRIPTION OFFER

Scribe a line

YOUR CHANCE TO TALK TO US!

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

Moxon Vices

Dear Neil, I enjoyed reading Laurie Leonard's article on making handles for his Moxon vice.

Although the Moxon double-screw vice is a 17th century invention, they have become popular in recent years partly because of the availability of kits for the metalwork. The perceived advantage of the heavy hand-wheels is said to be that they can be spun quickly to open and close the jaws. However, once the jaw separation is set for a particular job, I rarely find much need to change it. I don't like the usual arrangement because it leaves two long, heavy steel screws sticking out from the bench at just the right height to catch some tender bits of flesh.

I built mine with more conventional vice handles, which leave the screws at the back where they are much less likely to do me any harm. This arrangment also keeps everything better aligned and pretty much eliminates the tendency to racking which Laurie describes (I used bronze sleeves where the acme screws pass through the jaws, which is probably overkill) . I can wholeheartedly recommend lining one jaw with leather - gives a very strong grip with minimal tightening of the handles.

Norman Billingham, Brighton

New Model Engineering Society for North Yorkshire

Dear Neil, Like just about every club and society over the last 18 months has been affected by the social restrictions placed upon us all during the Covid pandemic. So, it may come as a surprise that plans are being developed to establish a new model engineering society in North Yorkshire; with opportunities to have a working association with the Wensleydale Heritage Railway, that operates between Scruton in the Vale of Mowbray to Redmire, in the spectacular Yorkshire Dales.

Plans are currently at an early stage. However, these are already supported by access to land for the development of facilities, the potential of track to begin building a combined 5" and 7 ¼" gauge layout, access to meeting facilities, and the logistical opportunities association with the Wensleydale Railway can bring.

Further potential opportunities for members will include options to become a Member of the Wensleydale Railway Association (Trust) Ltd., and the chance to volunteer at the Wensleydale Heritage Railway. Membership will also offer regular editions of the Wensleydale Railways' magazine, 'Relay'; along with discounted travel on normal timetabled trains.

As the societies founder, Cliff Almond, I am no stranger to establishing new societies: having been the founding member of the very successful East Somerset Society of Model & Experimental Engineers and was their first Chairman. He has also held the honorary posts of Secretary and Committee Member at two other Societies.

The society will be known as the Wensleydale Model Engineering Society (WMES); as welcomes enquiries for member from anyone interested in any facet of model engineering.

Anyone interested in joining the society are invited to email me at **clifford.almond@gmail.com**.

Cliff Almond, North Yorkshire

Scribe a Line is continued on page 56

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A Dodgy Ballscrew

John Scott does some problem solving on his milling machine.

A former colleague of mine was a director of a national company making railway switches (you'd call them points). He was recruiting graduates to work as junior engineers:

"I don't need railway enthusiasts, I need problem solvers, I've got a factory full of problems here."

I know exactly where he was coming from. Some people are fixers, some aren't. There are ways to approach problems which bring results... or you can just wade in.

I spent the thick end of my career solving problems in engineering and software

When the underlying cause of a problem becomes clear, when you just know you've got it, it brings a special satisfaction. In my experience, this often happens suddenly, you're working

Milling process.

Traditional milling machine.

CNC milling machine.

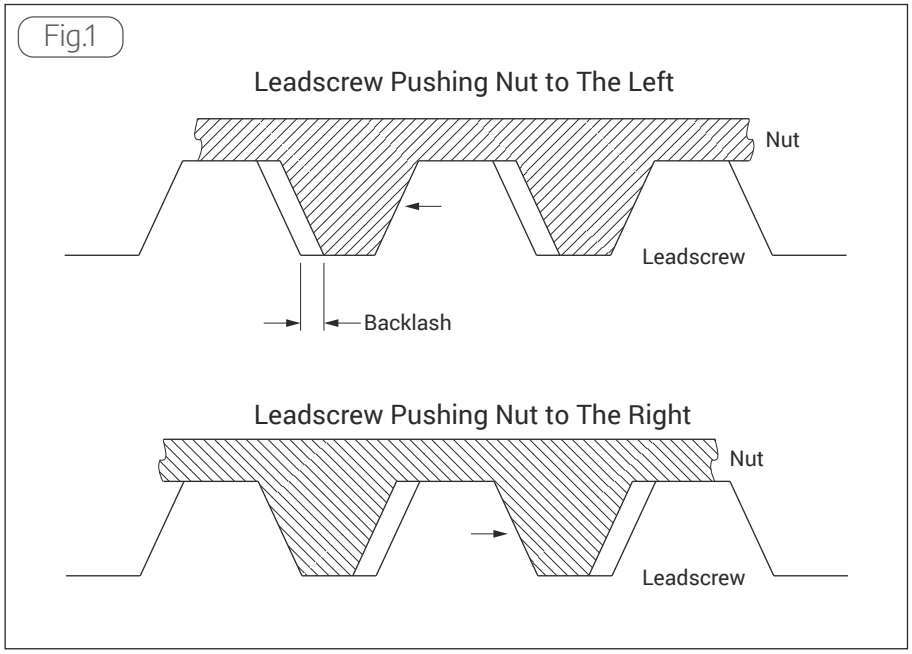
Y-axis ballscrew and swarf.

steadily at a problem. Maybe there are multiple symptoms, multiple possible causes. Then in a heartbeat, you've got it! No further doubt what's at the bottom of the problem, even if there's a load of work to be done to resolve, or even confirm it. It is truly special.

Sportsmen describe such a sensation on making a perfect stroke. I'm no golfer, but once, just once , I hit the ball impressively, a visceral feeling.

Anyway, this describes one such occasion, one eureka moment. Embarrassingly the root cause was my fault. No excuses could have been avoided. That root cause was simple to understand and fixing it was straightforward. It could be an anticlimax.

Getting to the problem, and repairing the damage was a considerable process. To describe the problem I've had to describe the context in some detail. I think that context is interesting, some people think I need to get out more...



Wider Context

This problem affected my hobby CNC milling machine. Forgive me if you know all this, but in case it's not a subject you think about constantly.

Milling is a metalworking process, using a rotating cutter that is typically cylindrical. **Photograph 1** shows some milling.

Adaptor mounted into leadscrew nut.

Split leadscrew nut.

Keeper sequence 1.

Keeper sequence 2.

Keeper sequence 3.

Keeper sequence 4.

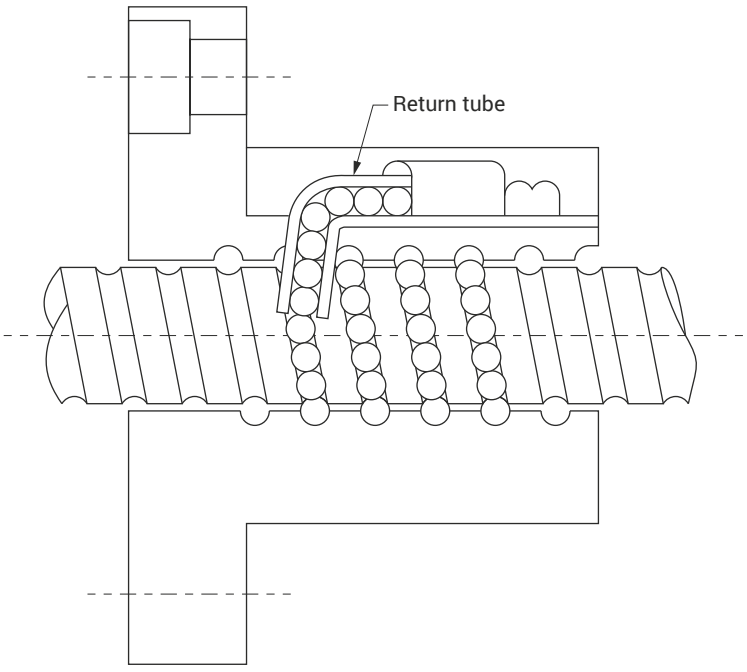
The traditional milling machine is hand operated requiring a skilled operator. **photo 2**. The alternative is to control the machine with a computer. **photo 3**, this technology is called CNC. The machines are typically very costly. When I was alive my job involved making CNC machines work. As a retirement project I have fitted CNC controls to a small hobby size milling machine using low-cost components. Much detail is available, inappropriate here.

Narrow context

Traditional machines use leadscrews to move when operators move control handles. That is, a screw thread that pulls or pushes parts of the machine as it is turned.

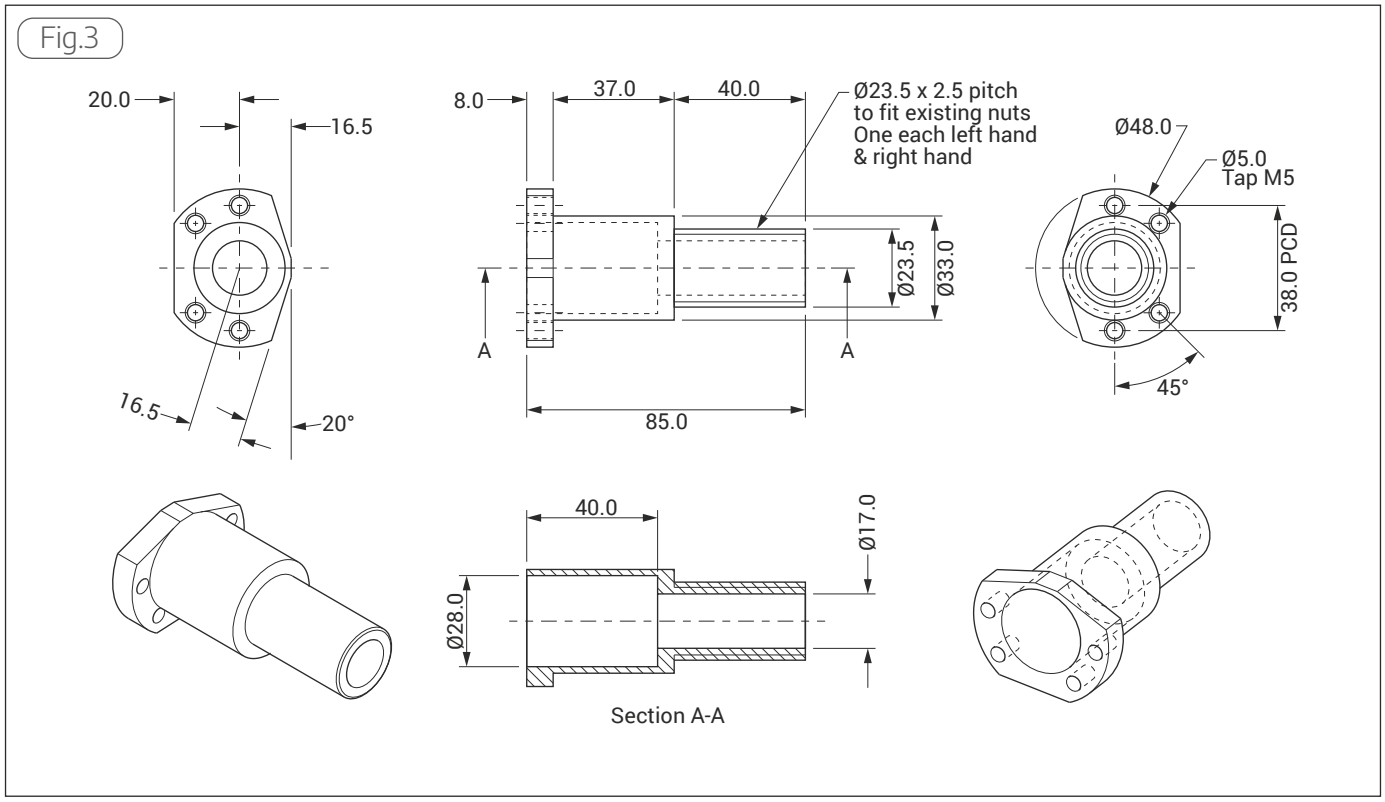
Leadscrews have inherent slack, known as backlash. Backlash means that, however accurate the control is when advancing unidirectionally, there will be an inaccuracy when the motion direction is reversed. Handling and overcoming that inaccuracy is part of the skill of operating a traditional, manual

Fig.2



Keeper sequence 5.

Slip-on centre.



machine. **Figure 1** shows backlash in a leadscrew.

CNC computer controls can't exercise that skill, so they use something called a ballscrew instead of a leadscrew.

A ballscrew is a bit like a ball-race that has had a fight with a spin drier. It does the same job as the leadscrew but has near zero backlash. **Figure 2** shows the structure of a ballscrew.

When I fitted CNC to my mill, I replaced leadscrews with ballscrews. The backlash was reduced from about half a millimetre to less than 0.1 mm. On a scale of one to what I do, that's more than fit for purpose.

Ballscrews used to be very expensive items. Large high precision ones as used in industrial machines still are. Recently, use in 3D printers and changes to the way they're manufactured has reduced prices of smaller ballscrews substantially.

Problem Symptoms

After nearly three years of reliable working, I detected some backlash in the Y-axis.

That was confirmed by measuring the position of the slide with an indicator and comparing the actual position with the programmed position as moves were made.

Unlike normal backlash, as found in a old fashioned leadscrew, this backlash was not uniform . It didn't occur to the same extent across the whole range of movement. Rotating the ballscrew by hand, I could feel a non-linear movement, not always in the

Ballscrew between centres

Tailstock and slip-on centre.

Bench grinder wooden stand 1.

Bench grinder wooden stand 2.

same position. This was puzzling, I was stumped.

Parts of the mechanism which drives the screw could cause a problem, they were checked and found ok.

The screw is visible underneath a rudimentary swarf guard, and there was no gross damage. Because of the design of the machine (a craftsman never blames his tools, but sometimes criticises) the screw is exposed at extremes of travel, and gets swarf and coolant on to it, which subsequently could find its way into the ballscrew nut.

It appeared that the ballscrew nut must be failing. I assumed it was failing because of swarf falling onto the screw and fritzing the ballnut. I was cross that I'd not improved the guarding to stop that happening (craftsman blames craftsman). **Photograph 4** taken during dismantling shows embarrasing swarf ingress on the Y-axis ballscrew.

Pivot for grinding wheel.

Portass compound slide for feed.

Indicator for displacement.

The rotary feed mechanism (as the ballscrew is being turned by hand not power the gloves pose no risk).

Ballnut replacement difficulties

Replacing the nut and the screw was not going to be particularly expensive, but was going to be a major undertaking for a number of reasons:

I've stated "I replaced leadscrews with ballscrews" earlier. This was not a matter of simply replacing parts with others using spanner and screwdriver. It involved some complexity to modify off-the-shelf parts and make adaptors. It's not possible to simply unscrew the ballscrew and pull it out, as you could with the original leadscrew. The ballscrew and nut assembly has to be taken out as one. It is deep inside the machine; every removable part has to come off. There's an extension on the driven end of the ballscrew, to adapt to the driving mechanism, that extension has to be removed to get the screw out.

And last but not least; the ballscrew end has to be machined to connect it to the extending adaptor.

The ballscrew is hard, it is manufactured by rolling the thread, which work-hardens the outer surface. That's good for its function and service life but makes it a nightmare to turn down. The screw is 16mm outside diameter, core diameter approx 14mm. To fit the adaptor, we need the crest of the screw machined down to 15mm. The core of the screw is just ok to turn, it's hard material but not impossible, but the threads are glass hard from the thread rolling.

I did the original screws on the engineering club lathe which is a substantial industrial machine. They were very difficult, only achieved after two falls and a submission. However, at replacement-time the engineering club was Corona-closed.

A brief trial of a screw offcut on my Atlas lathe showed that there was absolutely no hope, of machining it ... anyway the Atlas spindle won't pass 16mm, so it wouldn't fit on the lathe.

Meanwhile, eBay delivered a replacement ballscrew and nut in less than the time it took to prepare an alternative machining solution.

The root cause of the problem (a eureka moment)

I took the machine to bits to get the old nut-and-screw out. As well as the drive end extension adaptor which requires the 15 mm diameter, there's another adaptor to mount the ballnut onto the original leadscrew nut.

This is quite a neat design. I'd really like to take credit for it, but it is "reverse engineered" (copied) from a commercial product used on larger machines.

The original leadscrews are approximately 22 mm diameter. The ballscrews are 16 mm diameter. I made adaptors to mount the ballscrew nuts into the leadscrew nuts using the original leadscrew thread. **Figure 3** shows the adaptor which screws into the leadscrew thread.

Photograph 5 shows the adaptor

The vibration damper.

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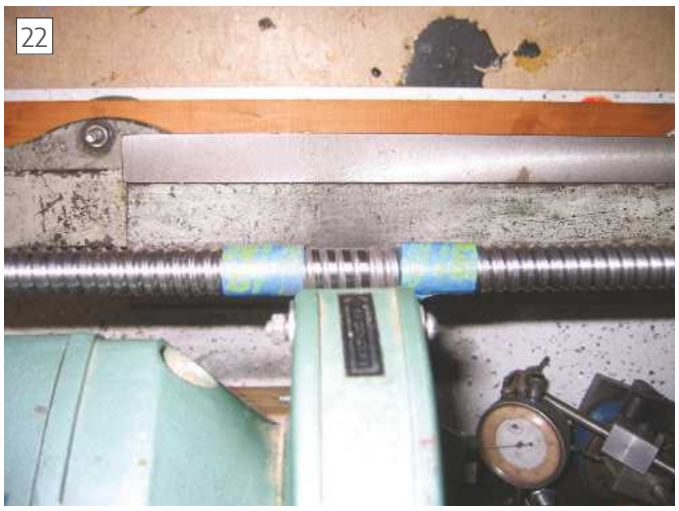


Proof of pudding 1.

Proof of pudding 2.

Drive end extension.

X-axis adaptor.

mounted into the original brass leadscrew nut.

The design I copied locks the adaptor into the original brass nut by tightening a screw which squeezes the split nut visible in **photo 6**. This was originally intended as a crude backlash adjuster for the leadscrew. It is used here simply to jam the thread, so it doesn't move.

While taking the ballscrew assembly off the machine, I spotted that the adaptor was not held firmly in the nut. It was able to rotate, stiffly and unevenly, by about ⅛ of a turn.

When this happens there's relative axial movement, the source of the backlash. As soon as this is understood, it explains everything!

It explains why the backlash didn't always manifest in the same axis position, it explains the slightly "mushy" feel in the movement when turning by hand, it explains why the screw movement was uniform after the error was finished.

This was my golf ball moment.

Fixing the unwanted rotation was going to be straightforward. In truth the old ballscrew might have continued to work adequately without replacement. However, the new one was on its way , the old one had spent its service life covered in swarf, and the drive end extension had been removed (not a straightforward job) in order to get at it. I decided to press on with a replacement.

Ballscrew Mod

The shortest replacement ballscrew was 500mm long with the ends pre-machined to standard patterns unsuitable for this application. One end needed to be simply cut off to length, but there was still the 15mm diameter requirement. The normal way would be to grind the shaft between centres. Three problems:

- You can't just unscrew the nut; the balls will fall out.
- The shaft didn't have centres in the end.
- I didn't have access to a cylindrical grinder (being Corona-grounded).

Three solutions:

- You can unscrew the nut if you use a keeper which matches the core diameter, **photos 7**,**8**,**9**,**10** and **11** show a home-made keeper saving the situation.
- I made some slip-on centres to fit the pre-existing end machining, **photo 12** shows one of them.
- My Portass Model S lathe was in bits, as part of another project. The bits included the lathe bed, the tailstock and a temporary tailstock-like dead centre mounted on the fixed steady (from yet another project).

Photographs 13 and **14** show this lot pressed into service to mount the screw between the slip-on centres. **Photographs 15** and **16** show a bench grinder mounted on a block crafted from precision wood(!) to position the wheel to reach the screw.

Pivoting the grinder and wheel was easier than trying to slide it in a controlled manner. **photo 17** shows the pivot. The Portass compound slide became the feed mechanism

Swarf guard.

Machine working.

photo 18 with an indicator to measure displacement, shown in **photo 19**

At this point I was nearly ready to grind the small section of shaft diameter, all that was needed was the manual "rotary feed mechanism" **photo 20** and the "vibration damper" **photo 21**, note the contrasting colour gloves.

Despite being a complete lash-up, this set up worked extremely well, if a little slowly. The outside diameter of the glass-hard screw was reduced to a uniform, specified diameter in a safe and controlled manner. Proof of the pudding here, **photo 22**, shows grinding dust on the lathe bed and **photo 23** shows the finished diameter.

Refitting the drive end extension

The drive end extension fits onto the end of the screw. **Photograph 24** shows how it joins on and reveals why 15mm diameter was needed. It uses a plumbing compression joint and olive, reinforced with Loctite 603 high strength cyanoacrylate. This joint has proved robust in service. Ultimately it can be separated by heating.

Resolving the root cause

The ballnut adaptor thread was separated, cleaned and reassembled with Loctite to prevent a recurrence. While the machine was in bits, I did the X-axis adaptor as well, **photo 25**.

Swarf Guard

To prevent swarf falling onto the leadscrew I made up an additional sliding swarf guard which lives under the existing flexible guard, and covers the gap exposed when the Y axis is at minimum full travel, **photo 26**.

Conclusion

I'm pleased to report that the machine was finally reassembled at the end of April (AKA mid-lockdown) and tested with no appreciable backlash in Y.

In case that sounds an anti-climax, **photos 27** and **28** are a couple of pictures which show it working under CNC control. ■

Another shot of the cnc mill in action.

On the Wire

NEWS from the World of Hobby Engineering

Midlands Garden Rail Show 2022

Meridienne Exhibitions are excited to announce the dates for their 2022 Midlands Garden Rail Show. The exhibition, held at Warwickshire Event Centre, is taking place on the 12th and 13th March 2022!

Attracting nearly 2,000 enthusiasts from all over the UK, the inspiring exhibition showcases a range of exciting railway layouts. Covering the larger gauges and scales the layouts will depict a variety of historical and fictional lines.

The exhibition is well supported by local and visiting clubs and layouts as well as leading suppliers,

Save the date now to avoid disappointment!

For further details on the exhibition and suppliers attending will be updated over the coming months at; **www.midlandsgardenrailshow.co.uk** and on Facebook Meridienne Exhibitions Ltd.

INTERMODELLBAU prepares for its winter show

INTERMODELLBAU has been an established event at Messe Dortmund for over 40 years now. Unique in its form and in the variety of subject matter covered, it reaches experienced model makers as well as newcomers, fascinates entire families and covers the whole range of aircraft, railways, ships and cars as well as working models and cardboard model making. Thanks to covid, the model-making community has had to endure a long wait for this trade show favourite, but that will soon be over as INTERMODELLBAU opens its doors from 17 to 20 November 2021. As well as a great many exhibitors across all segments, visitors can look forward to the ever-popular supporting programme where they can experience product highlights in action on the water, in the air and on the "roads". Tickets can be pre-booked in the online store.
For more information visit **www.intermodellbau.de/en/home/**

Scribe a line *Continued from page 45*

Chuck Remover

The picture shows my Clarkson Autolock chuck which came with my second hand Sharp Miller. You can see the boss at the base of the Morse taper. It is fitted to the chuck body by a left-hand thread. When you tighten it, it rises against the base of the spindle and disengage the taper. I have searched and cannot find a commercially produced similar item.

I assume the previous owner of the mill made the adaption. I have used it many times and it functions very well with one exception. The thread is very fine and if you are heavy handed the boss can lock on the threads. I would be interested if anyone has encountered a similar system?

Stuart McPherson, by email

Pinnacle PCD 3D Manual

Dear Neil, our "Mens Club" (Mates) here in sunny Scarborough, have been given a Pinnacle PCD 30 mill /drill we would like an instruction manual / parts list for this machine. These machines were around in !970/80 and might have been sold under a different name by sellers who might not be around now. Would you please put a note in letters to the editor or where you think our request will be best seen, asking a reader who has a Pinnacle PCD 30 to get in contact with me.

Ted Fletcher, Scarborough

If anyone can help Ted, please email me – Neil.

Workshop Tools

Dear Neil, with regard to your article on basic workshop tools, I find I have recourse to two in particular a surprising number of times. Wire Coat Hangers and Lolly sticks (all sizes). Joking apart, it often does seem that the simplest things are the best!

Jim Perry, by email.

BEGINNERS WORKSHOP
These articles by Geometer (Ian Bradley) were written about half a century ago. While they contain much good advice, they also contain references to things that are out of date or describe practices or materials that we would not use today either because much better ways are available or for safety reasons. These articles are offered for their historic interest and because they may inspire more modern approaches as well as reminding us how our hobby was practiced in the past.

Types of bearings

GEOMETER discusses the various types of bearing in common use and gives examples of their use

BEARINGS ARE THE means by which shafts are located, enabled to carry loads and transmit power. Ail machines necessarily employ them and all engineers must possess some knowledge of their design, construction, lubrication, adjustment, etc.

Every bearing must perform one of two functions, or a combination of both: (1) carry radial loads, as a journal bearing; (2) take end loads, as a thrust bearing; (3) take both journal and thrust loads.

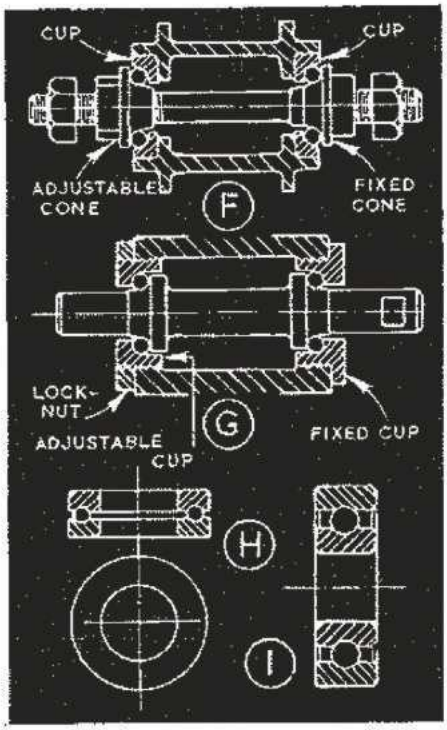
In some applications, usually of a heavy nature, where both kinds of loads are encountered, a bearing of each type (1 and 2) are fitted, though certain types of bearings combine the functions naturally. These are the plain conical and taper types, cup-and-cone ball bearings, standard journal ball bearings (1/3 of journal load as thrust) and taper roller bearings.

For a simple purpose, the ordinary plain journal bearing can be simply a drilled hole, though a reamed hole is preferred for superior accuracy and surface finish. Replacement when wear occurs can be made by bushing the hole *A*, the bush being the actual bearing and, if required, this can be in some more suitable metal than the housing.

To locate a shaft endwise, the bush can be flanged as is usually the case for crankshaft bearings. In some instances, where speed of rotation is secondary, no special provision is necessary to take quite heavy thrusts -other than a flange on the shaft. The screw of a vice B is a common example.

The halved (split-and-bolted) bearing, C, whether provided with brasses or a white-metal lining, admits of initial fitting and later adjustment to accommodate wear. In this connection, there may be shims in the joint (steel or brass foil in thicknesses from 0.0015 in. upwards), removal of one or more of which closes the halves to reduce running clearance.

Common types of ball-bearings



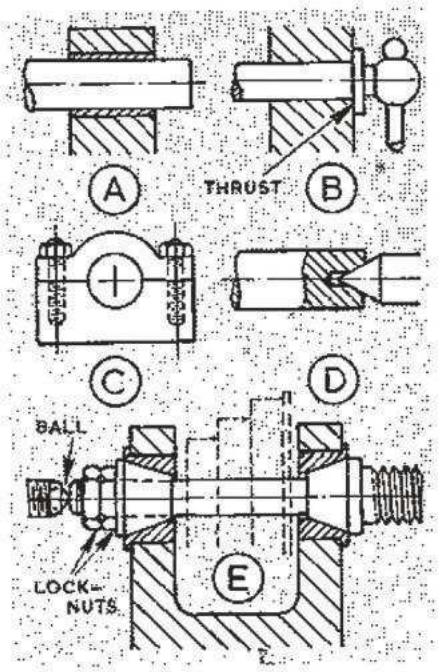
Conical bearings

Between-centre turning on a lathe furnishes the most common example of a conical bearing, *D*, though the same type is used on older lathes for treadle and countershaft bearings. Here the bearing is a hard pad in the end of the shaft, and the pointed adjusting screw is hardened too and fitted with a lock-nut.

More substantial bearings of this type are used for the spindles of older and precision lathes *E*. Locknuts admit of regulating the adjustment for the spindle to turn freely wtthout shake. Solid spindles can have a single ball thrust, though hollow spindles require a thrust in the form of a ring with a number of balls. A separate thrust is essential with this type of bearing for lathe use-to prevent seizing.

Ball bearings

Ball (and roller) bearings possess an advantage over plain types in that rolling is substituted for sliding action-reducing friction and obviating the tendency to seize present on occasion. Disadvantages are all parts of the bearing must be hard and point or line contact involves heavy unit loading. Chipping or scarring of running members can occur.



A selection of typical plain bearings

Such bearings, however, can carry both journal and thrust loads where neither is too heavy. Common examples are cycle wheel bearings *F*, and bottom bracket bearings G. On wheel bearings, the cups are pressed in the hubs, one cone is fixed on the spindle and the other adjustable. On bottom bracket bearings, the cones are formed on the spindle, one cup is fixed, and the other adjustable-held by a locknut.

Cups are filled with balls, (avoid wedging) and grease to hold them is essential for assembly. Complete new sets of balls must be used, not a mixture of old and new, as old may be undersize. Cycle head races furnish examples of thrust types H, these being adjustable from the top-held by a locknut.

The typical ball bearing or race which cannot be dismantled is shown at I. This consists of inner and outer members and a ring of balls located in a cage. A wide range of standard sizes provides for many applications. Outside diameters, bores and widths are held to close dimensions, and housings and shafts are made to light push or driving fits, to obviate rotation other than in the bearing itself.

Replacing a Mini-lathe Controller

David Drury uses a commercial motor control module to revive his mini-lathe

Introduction

I am new to the ME forum, and joined after I bought a second hand Clarke 300CL mini lathe as a 'nice to have toy' with no specific knowledge of machining, to make minor none-critical dimension parts for my grandkids' toys.

After a school-boy error, my lathe stopped turning, and being an ex-maintenance electrician, I thought I would have a go at repairing it.

Before going any further, I would like to point out that this is a description of how I got my mini-lathe running again – I am sure that other people will have their own ideas, and this description is only intended as guide for those who have the misfortune to have one of this type of lathe 'die' on them. If you do decide to have a go yourself, the work involves dealing with 230V AC and up to 200 V DC. These voltages are lethal and can kill you! If you do not have the skills to deal with these voltages, then do not attempt this work, find someone who does to do the work for you. The advice here is given in good faith. I take no responsibility for your accidents!

Some of the wiring may need to be replaced in order to reach the appropriate connection. You may find it easier to remove some of the wiring and replace it, if you have the skills and confidence.

Diagnosis

Not knowing if the motor or the controller board had failed and caused the problem, I found some information on YouTube about testing the motor and established there was a very good chance the motor would be OK. Using a 12 volt car battery it rotated slowly. I also checked for no short-circuits and the resistance between the armature segments, then cleaned the armature with a fibre pencil and made sure the brushes were free and a good length in the holders.

I asked forum members if others had this problem, and if a modern solution had been found. Several kind members

1

The Jinan Keya Controller

replied telling me where a new board could be purchased and also about an after-market controller for sale online. A replacement for the original board is available from Arc Euro Trade and other suppliers.

After discussing the matter via a Private Message with another forum member, we realized that a simple AC/DC converter should do the job. A search of the net produced the Keya Controller I ended up using, shown in **photo 1**. This produces a variable DC voltage, up to a nominal 220V DC, at up to 4 amperes, and came complete with the control potentiometer, for a very keen price. I also found the exact same unit offered by others for twice as much or more – so buyer beware! It is possible some suppliers do not provide the control potentiometer – in that case, you will need a 10 kohm, 2 Watt linear potentiometer.

2

The Controller Installed

Controller Description and Initial Testing

Testing with the unit as received, I found that the lathe spindle was rotating at over 2000 rpm as opposed to the approximately 1100 rpm required in the slow speed setting of these lathes. After some examination, I found there is a preset potentiometer under a hole in the cover for adjusting the output voltage – on my unit, this was unmarked. Measuring the output voltage across the terminals OUT- and OUT+ of the controller showed this was set to 220V DC, so it needed to be reduced to just over 180V DC, as in the original controller, using the preset. This procedure is described later.

After setting this voltage, a check using a simple app on my smartphone showed the motor running at around 1100 rpm in the slow speed setting, as per the original installation.

The controller also has two 'Inhibit' inputs, which have to be connected for it to operate – this could be used as an interlock loop to remove power from the motor when the reversing switch is operated – details will be shown in the schematic.

In addition, the Keya controller has preset controls to adjust the motor start-up speed for a 'soft start', also to adjust the available torque, and to adjust for smooth running under load.

It also has short-circuit protection, and will shut down if the output is short-circuit – this is indicated by a red LED alarm on the unit.

The unit seems to be well made, and as described above, seemed suitable as a replacement for the original controller, so I set about fitting it to the lathe.

›

IMPORTANT - Before Starting Work.

First a WARNING: this modification requires you to work with 230V AC and up to 200 V DC, which can be lethal. Take all necessary precautions to avoid touching potentially live wires, and ensure that all connections are securely made using the appropriate methods, and correctly insulated. Take extra care connecting the power to the STOP switch – it is easy to connect 230V AC to the wrong terminals on this switch, so check carefully.

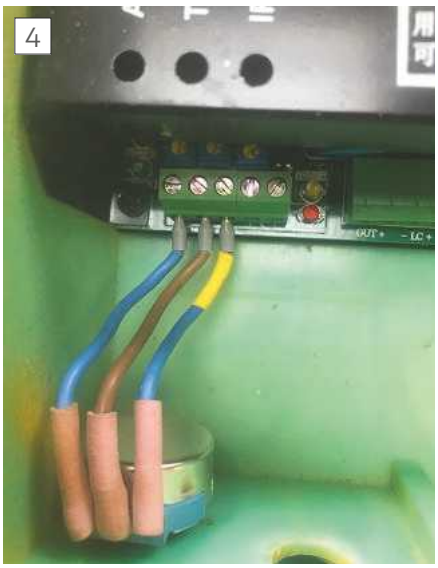
Note the small numbers on the back of the reversing switch and connect as shown – refer also to the drawings.

This description assumes you still have the original controller wired in place, and can identify its connections, as described below. I would advise reading these instructions through and understanding what you are doing before starting work.

Installation Procedure

Before doing anything else, it is easier to set the operating voltage before installing the controller, as follows:

Retaining the Controller



Installing the Potentiometer

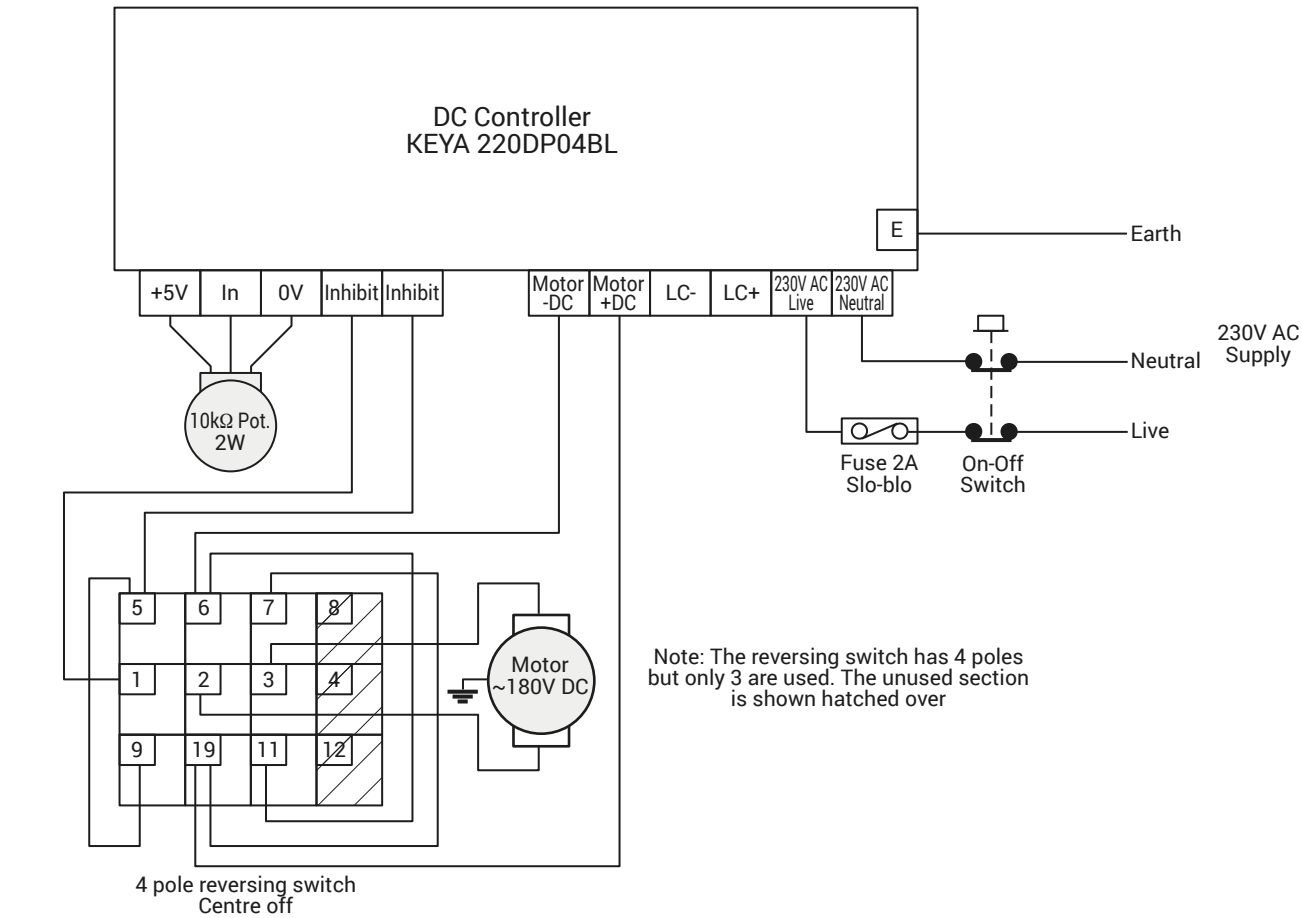
Have a small insulated screwdriver available to adjust the miniature potentiometer inside the unmarked hole on the front of the controller. This can be seen in **photo 2**, close to the "PWM DC Drive" label.

It is not necessary to connect the motor at this point.

Connect the 10KΩ potentiometer as shown in the diagrams and set it fully clockwise, (this would be maximum speed if the motor was connected).

1. With the AC power supply disconnected, connect 230V AC Live

Fig.1



Mini Lathe AC/DC Supply Connections For KEYA 220DP04BL Controller

Controller Earth Connection

and Neutral to the AC IN connections of the controller.

2. Connect a short piece of insulated wire between the two INHIBIT terminals.
3. Connect a DC voltmeter set to at least 250 VDC across the OUT- and OUT+ terminals, noting the polarity.
4. Apply the AC Power.
5. Taking care not to touch any of the high voltage points on the controller, carefully adjust the potentiometer (inside the hole in the case), until the voltmeter reads 180V +/- 5 Volts.

Once this is correct, then disconnect it from the power, and remove the link across the INHIBIT terminals. This procedure sets the voltage such that the motor will not run too fast when it is connected.

Mechanical Installation

It is necessary to remove the mounting posts for the old controller inside the box, then the controller can just be fitted inside the box, leaving enough space for the controls at the top of the box, photo 2. I milled these off so the inside of the case had no obstructions which would obstruct the controller.

The controller is fixed with a single 4 mm screw into the case, as shown in **photo 3**.

There is a plastic guard mounted just above the leadscrew inside the controller box, to prevent swarf entering and getting into the electronics. It also prevents the leadscrew catching any loose cables, particularly the ones fed through from the rear of the machine. It is advisable to leave this in place, but it will need reducing slightly in width by approximately 10mm so it doesn't foul the controller when the box is refitted to the lathe.

Electrical Connection

The circuit diagram of the Controller for use in the mini-lathe is shown in **fig. 1**.

The original speed control potentiometer should be removed and discarded and the 10Kohm potentiometer supplied with the new controller fitted in its place, **photo 4**. This is connected to the +5V – IN - 0V terminals of the Keya controller as shown in the circuit schematic, fig. 1.

You may need to enlarge the hole for the potentiometer to 10mm so the new one will fit.

The high voltage DC outputs from the original controller board (connected to terminals 6 and 10 of the reversing switch) must be connected to the OUT- and OUT+ terminals of the Keya controller (refer to the circuit schematic, Figure 1).

As shown in Figure 1, one pole of the reversing switch is connected through the INHIBIT input of the controller. The reversing switch has a 'centre OFF' position, which will break the INHIBIT loop, and remove power from the motor. Terminals 5 and 9 are connected together, and connected to one INHIBIT input, and the common terminal (1) is connected to the other INHIBIT input. This can be seen on the schematic drawing.

Finally, the incoming 230VAC power connections to the lathe, fed via the STOP switch and a 2A Slow-Blow fuse, should be connected to the AC IN terminals of the controller. A new earth connection must be made from the metal frame of the Keya controller, **photo 5**, to the earthing point on the lathe bed, usually below the headstock, and the incoming mains earth should also go to this point.

Note: there are NO connections to the two terminals on the controller marked LC- and LC+. These are used for motors having a separate field winding, which the mini-lathe motors do not have. (They use a permanent magnet).

Next set the preset controls to their preliminary positions – set the ACCEL and TORQUE presets to approximately 50%. The IR COMP adjustment can be left 'as is' at this stage. Additional information is available in the Specification Sheet, which can be downloaded from the Keya Site. (Link at end of article)

When all is complete, and you are sure that all connections are secure and not able to short-circuit, then set the controls so the lathe should rotate anticlockwise (normal operation), and the speed control potentiometer in the centre of its range, make sure there are no obstructions, stand clear, cross your fingers and apply the power.

If at this point, the motor is rotating backwards, switch off and disconnect the power, and swap the motor connections at the reversing switch (marked 2 and 3). If you now run the lathe again as above, it should rotate in the correct direction.

You can also check operation of the Reverse switch. Run the lathe forward at about half-speed, then operate the Reverse Switch. In the centre (OFF) position, the lathe motor should stop running, and in the reverse position, it should be running in reverse.

The Controller is manufactured by Jinan Keya type MMT-PWM DC DRIVE. Model number 220DP04BL, Input 220 volts AC and output up to 220 DC volts at 4 amps. A Specification Sheet is available for download on the Keya Site:

http://www.dcmotorkeya.com/220v-dc-motor-speed-control%204a.html ■

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Models

■ 7 ¼ gauge Petrol Driven SNCF (4-4-4). 6 ½ hp LONCIN ENGINE (Honda copy). Electric Start. Variable Hydraulic Drive. Hydraulic Disc Brake. Chain Drive to Centre Bogy. Comfortable seat. Good passenger hauler, has been used to haul passengers on the Cardiff track. Easy to drive Easy Controls. Comes with purpose-built trailer for transporting. Nearest offer to £3,000. Photos available. **T. 01792 898205. Swansea**.

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■ BOILER, copper, brand new professionally made for Stanier mogul. Ex works condition. £2800 Ono. Photos and details on request from seller. **T. 01670 517545. Newcastle on Tyne**.

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Wanted

■ 5 inch GWR Prairie Loco, either complete or well advanced construction. Kindly let me know what you have under the workshop table. Thanks. **T. 01566 86032. Launceston, Cornwall**.

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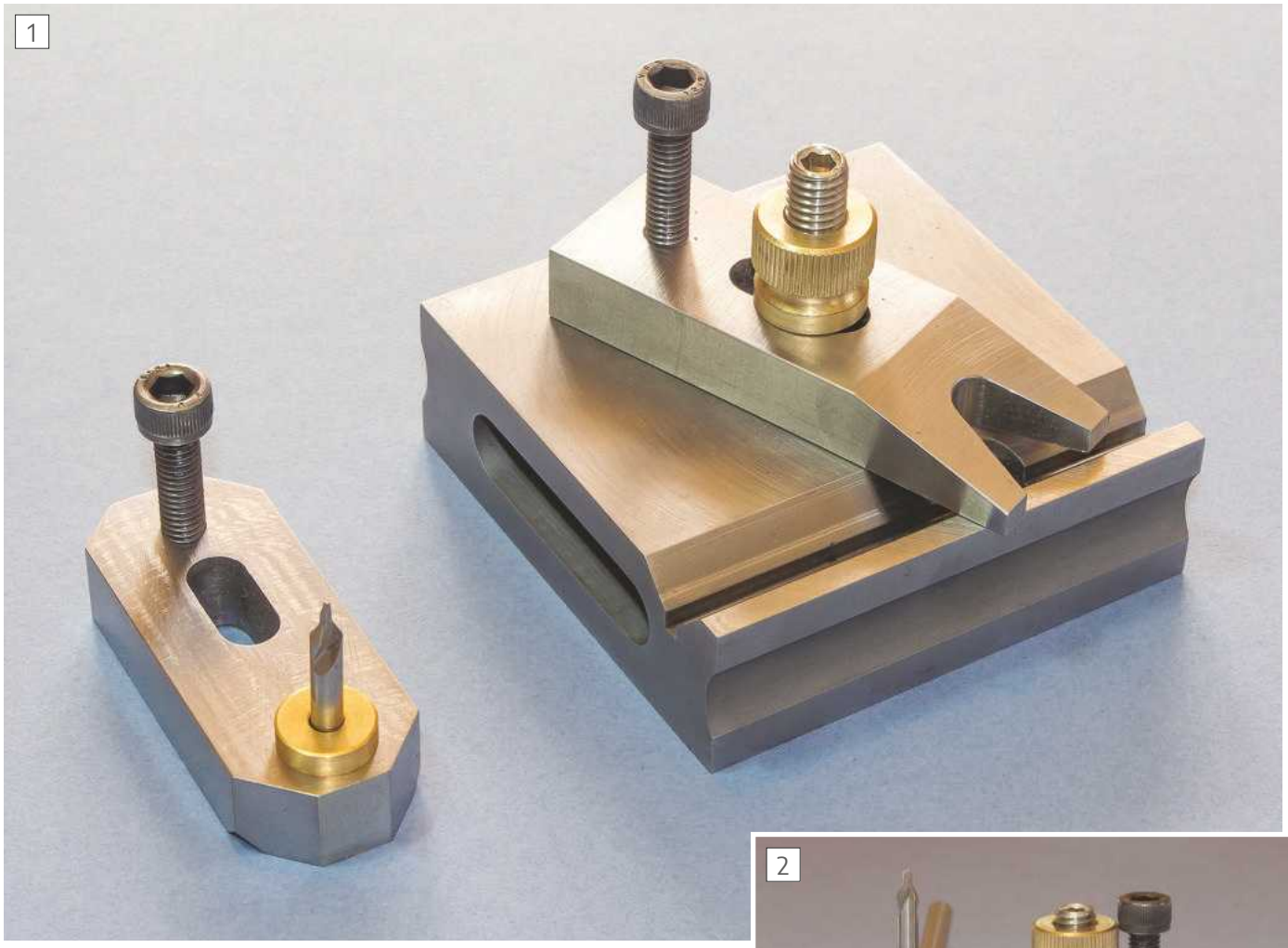
A Finger Plate

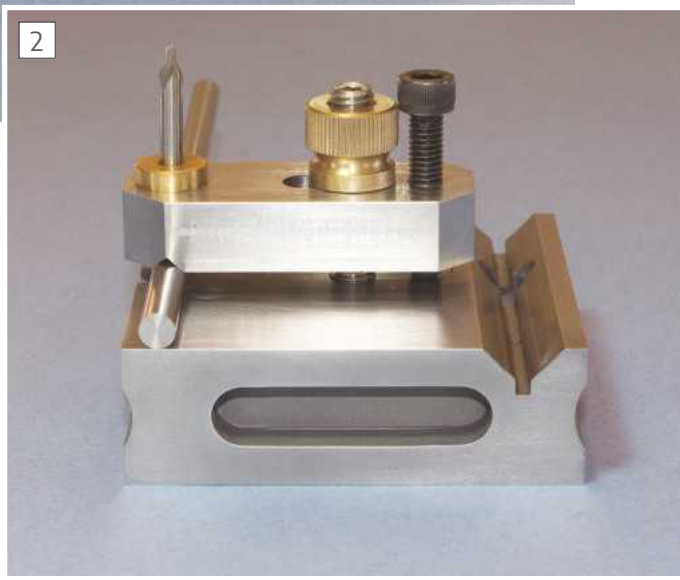
Vic Russell makes a very neat example of this traditional toolmaker's accessory



The finished finger plate.

I needed to cross drill a small shaft some years ago for a project I was working on and after a couple of attempts I was reasonably happy with the result. It did prompt me though to look at a more suitable solution for holding small parts for machining. I'd seen a Finger Plate, **photo 1**, in one of my engineering books and further searches yielded a large number of different designs all loosely based on the same basic idea. Searching through my scrap bin I found some inch thick steel plate of unknown composition that seemed a likely candidate for the base. After truing up on the mill I ended up with a plate 75mm square, 24mm thick. I taped an M6 hole for the post and fitted an M6 stainless steel stud that luckily already had a hex socket in one end. The post is locked in place by a short socket set screw from underneath.

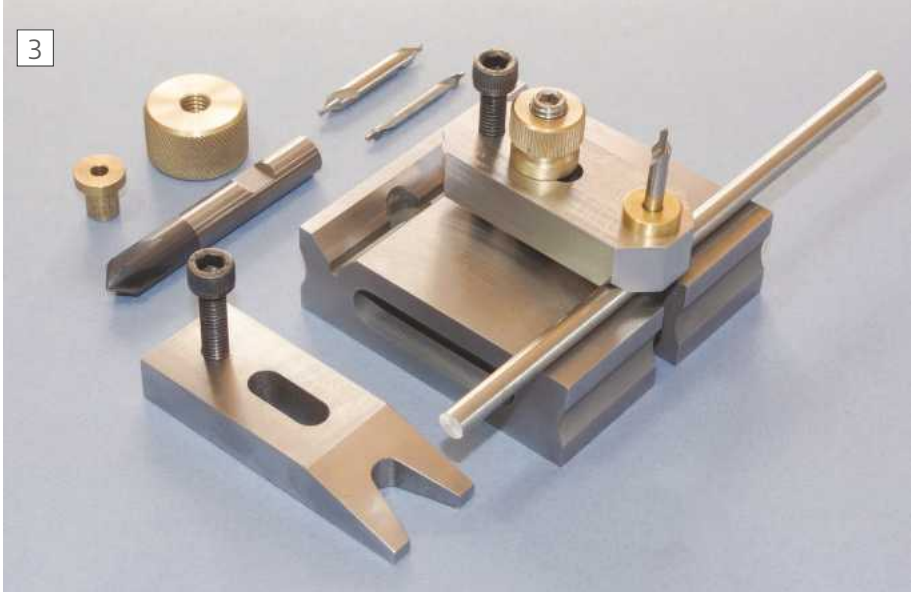
The next operation was cutting the V slot in the top, **photo 2**, and this gave me pause for thought as I wanted to ensure any holes drilled along the V were in perfect alignment. One of them in particular was to have a cross drilling button in it so alignment was paramount. In the end I hogged out the majority of the V by mounting the plate at 45 degrees using a conventional mill but I did finish off the final cut with a V router cutter. This enabled me to lock the Y axis on the mill for subsequent milling of the clearance slot and drilling. The two finger grooves I'd seen on one particular example didn't seem absolutely necessary but part way through the build I attended the London Model Engineering Show and happened upon a nice ¾" bull nosed end mill at a good price so it followed me home. I'm



Side view showing the v-slot.

glad I went to the bother of cutting the grooves as it really is much nicer to use when the plate is held in the hand. In practice the plate is held in my milling vice on most occasions but yet another example of a finger plate I'd seen had slots cut in the side of the base for step clamps so I added those as well.

The clamping arms, **photo 3**, themselves are self explanatory just having a suitable slot cut into them for adjustment and a threaded hole for a jack screw. One of them though has a V cut into the bottom with a through hole for brass drill bushes of different sizes to be inserted as required, this is my cross drilling jig. By this time I'd decided to acquire a proper Drill Mill which made aligning the hole much easier as once again I just locked the Y axis for milling and drilling.



Alternative arms (fingers?)

I already had a knurled brass nut for the post but this proved too large for most jobs so I made a smaller version. It seems though that my finger plate is still a "work in progress" as I've had a few other ideas like adding a couple of tapped holes down one side so that I can add a fence! ■

Theasby's Wrinkles

Radio tuning control

Geoff Theasby, G8BMI, achieves rotary precision

In some electronic applications it is necessary to use a heavier, if less attractive adjusting control than the usual plastic component. This is doubly helpful if it controls a rotary encoder, as there is nothing of substance behind the panel and the merest touch can alter it. To this end, I made one myself from 38 mm diameter aluminium rod, cut to length and blind drilled 6.5mm for a ¼ inch shaft, cross-drilled 2.5 mm, & tapped 3 mm for a retaining screw, preferably two. Not having a knurling tool, I fitted a rubber ring to the knob to aid grip and 'feel' when tuning. I had a bicycle inner tube that I found in the street a while ago, a short length of that proved just right. Alternatively, wrap self-amalgamating tape round the knob for a similar purpose. I wanted something different from the usual smooth, shiny appearance, so I found some relevant clipart and stuck it on. N.B. Pritt Stick does not work on aluminium, so I used Evostik. ■

Heavyweight aluminium knob.

A 'granite' place mat/chopping board from a supermarket makes an excellent surface plate, and placed upon your mill bed, offers a good surface with no slots, for use in tramming the head. They are heavy, sound like stone when tapped, but are limited to 100 degrees C.

For the electronics enthusiast, if you need heat sink grease in a hurry, use toothpaste, nappy rash cream, Germolene, heavy grease, lip balm, or Marmite. Nappy cream and Germolene contain zinc oxide, good for thermal conductivity, Marmite and lip balm are very high viscosity so don't drain away. I use lip balm. Toothpaste dries out after a few days.

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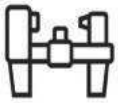

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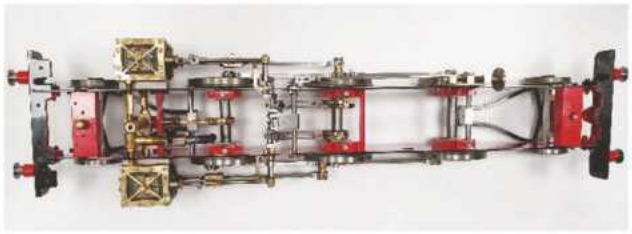

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