No.275

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- Making a custom cutter
- Arduino - Pandora's Box?

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On the Editor's Bench

Engineering and other Hobbies

Regular readers will know that I have several other interests. My hobbies of astronomy/astrophotography and electronics complement that hobby engineering and I find that these days most of my projects have brought at least two of them together. A recent example was 3D printing the panel for a power box for my astronomy kit. An interesting alternative to Alan Wood's novel approach to enclosures in this issue, for me an advantage was being able to incorporate captive connectors by printing holders behind the panel.

On the other hand, my other interests rarely overlap, although I can see ways in which they might be combined. For example, in the past I made a strange miniature bass guitar using hand tools alone and several big loudspeaker enclosures. There's always car maintenance as well!

From our forum at **www.model-engineer.co.uk** my impression is that as much of the time in our workshops is spent on projects other than models or making tools. I'd really like to hear more about what you do in your workshop, especially when you apply your skills to there hobbies and interests. Why not drop me an email with a picture of your work or, if your project has involved interesting or unusual machining and construction challenges, you might consider a short article on these.

A Belated Correction

Two year's ago, in MEW 242 we published a short article on 'Button Boring' under the by-line of *Georgineer*; it should have been credited to *'SimplyLoco'*, my only excuse is that the real-names behind the two pen-names are closely related! My apologies to both Jon Barrett (*SimplyLoco*) and *Georgineer* for the confusion.

Year of Engineering

The Year of Engineering is drawing to a close in a month or so. Hopefully the initiative has sparked an interest in engineering in thousands of young people, and hopefully some of them will go on to be professional or hobby engineers in the future. I'm aware that several model engineering clubs have used the year to promote their work through exciting hands-on events, for more information on what's happened over the year, visit **www.yearofengineering.gov.uk.**

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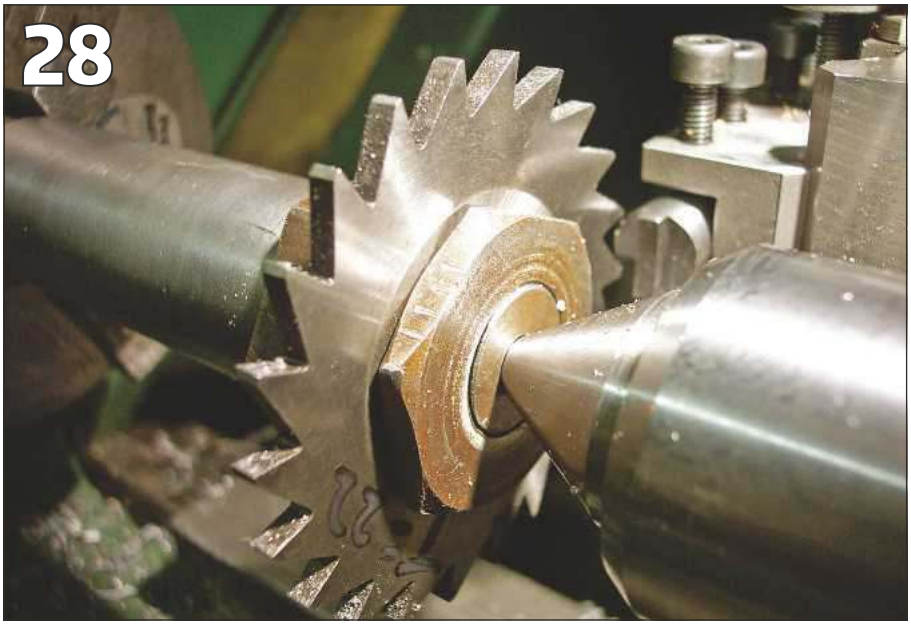

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Coming up...

in our next issue

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Regulars

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ON THE COVER

This month's cover shows Norman Billingham demonstrating silver soldering on the Society of Model and Experimental Engineers Polly course, photo: Richard Dedman. Read more about their 120 year anniversary on page 61.

Visit our Website

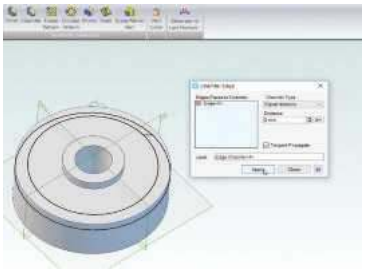
www.model-engineer.co.uk

Why not follow us on Twitter: twitter.com/ModelEngineers hashtag #MEW

THIS MONTH'S BONUS CONTENT

Log on to the website for extra content

Visit our website to access extra downloads, tutorials, examples and links to help you get the most out of your free Alibre Atom3D Licence: **www.model-engineer.co.uk/alibreatom3d**



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

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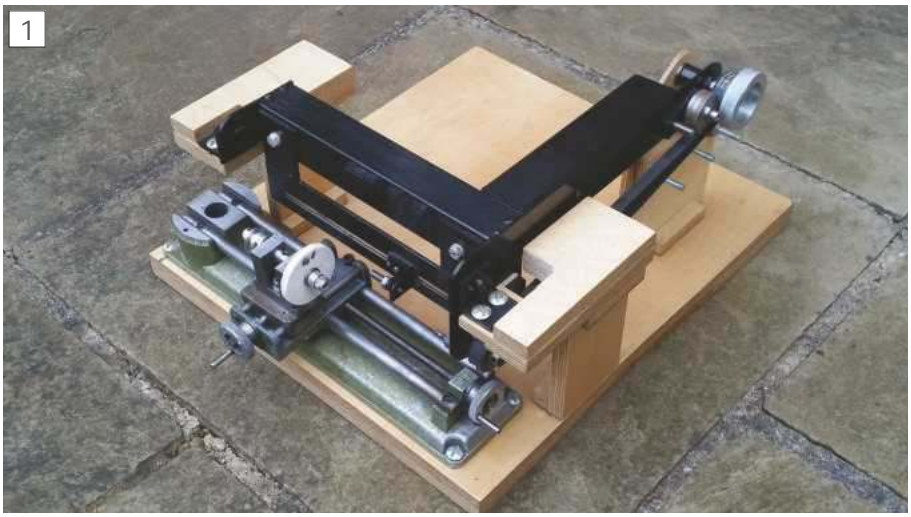
A Cam Grinding Machine

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

Introduction

The machine can grind single cams or multiple-cam camshafts. My machine was built as a means to an end using mostly materials from my scrap box. I used my old Unimat SL lathe to provide the precise X and Y movements needed for the grinding wheel. I suspect that in most cases the design will need to be adapted to suit available materials and equipment. I am therefore offering detailed drawings for the swing arm, which forms the main part of the machine, but I will describe the base and the use of the Unimat in less detail, on the assumption that prospective builders will modify these elements, **photo 1**.



General view of the cam grinding machine.

Background

I was working on a design and build project for a series of miniature four-stroke IC engines and was contemplating the best way to machine the cams. The project, ongoing at the time of writing, consisted of four single cylinder engines and one in-line four with alternative single and double overhead camshafts, giving a total of 24 cams to be made, **photo 2**.

Two methods for making miniature cams are generally cited. The first involves mounting the cam blank onto a dividing head of some type and milling the cam profile with the end teeth of an end mill. The approach is to rotate the cam blank in small increments, taking a cut of the appropriate depth with the end mill at each increment, setting the depth with the Z axis feed. The Z axis position must be calculated for each rotational increment. The resulting facets are then filed away by hand.

One of the part-built model engines which led to the cam grinding machine.

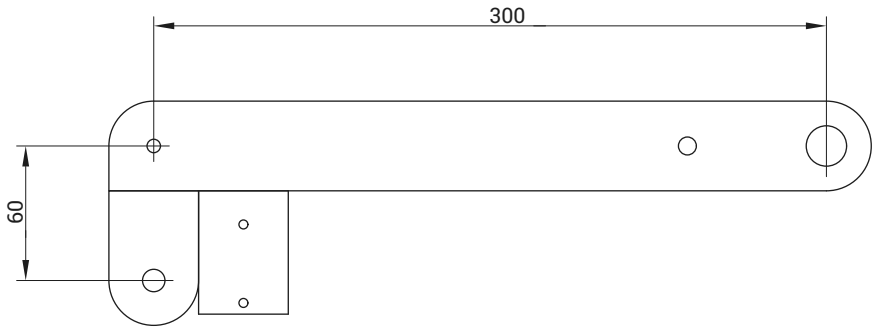
The second approach is to use a jig in the lathe which presents the cam blank to the cutting tool in such a way as to allow the cam flanks to be turned separately, further work being required to form the base circle and nose profiles.

Neither of these methods seemed at all satisfactory to me. The first would be prohibitively time consuming and prone to error, whilst still requiring the further work with a file. The second would give only an approximation of the required cam profile. Both methods are also only suitable for working on unhardened metal and both prevent the dimensions of the cam from being checked until the work is complete.

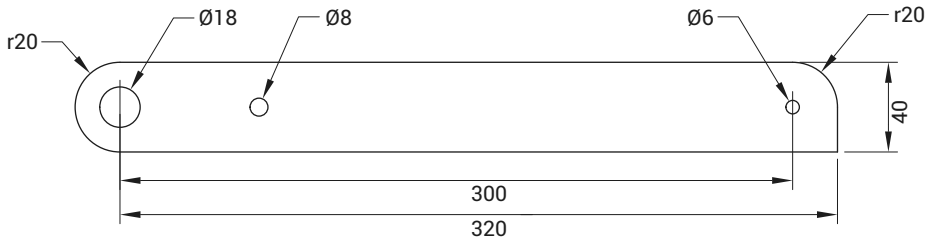
My solution was to design and make a simple cam grinding machine. Whilst requiring some time and effort to make, it would then overcome the disadvantages of the other two methods and allow cams to be turned out relatively quickly. The machine can grind hardened camshafts and allows the dimensions of the work to be checked whilst in progress, so that the cams can be roughed out and then finished accurately to size; this is not possible in any practical sense with the above methods. The machine also allows complex and asymmetric cam profiles to be easily made. Once the machine

›

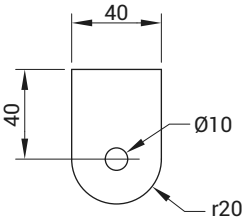
Cam design terminology.



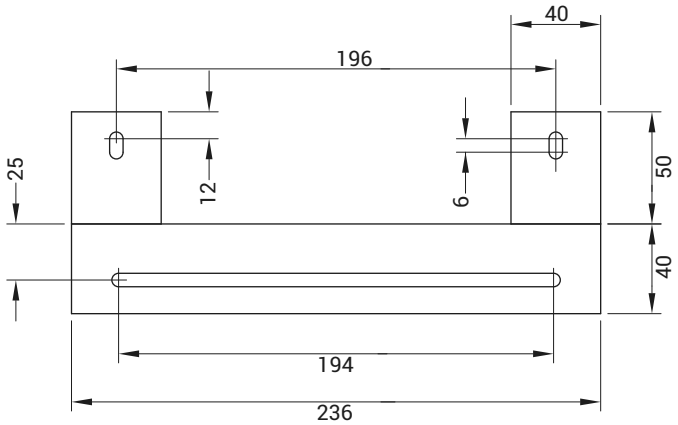
Frame Assembly
Critical dimensions



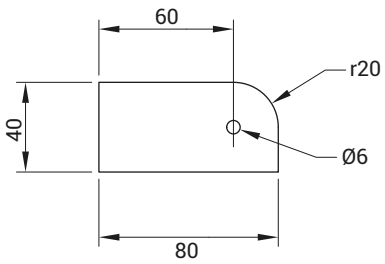
Part 1. Long Arm
Mat'l: 4mm steel plate



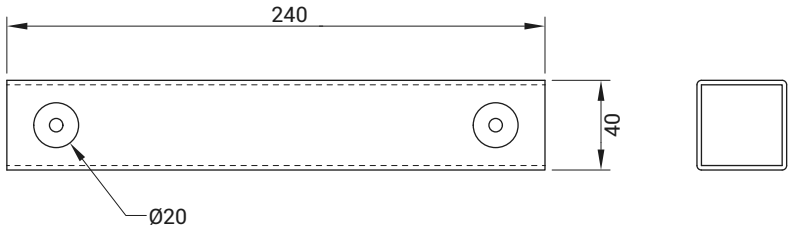
Part 2. Short Arm
Mat'l: 4mm steel plate



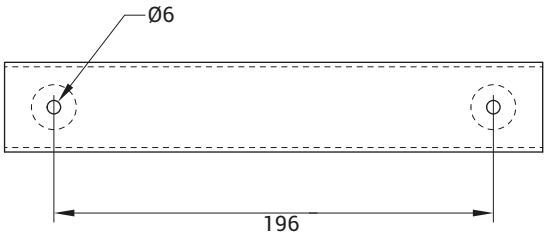
Parts 6 To 8. Slotted Plate
Mat'l: 4mm steel plate
Slots 6mm wide

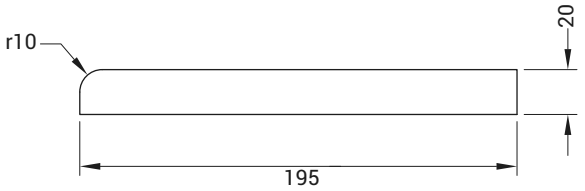


Part 4. End Plate
Mat'l: 4mm steel plate

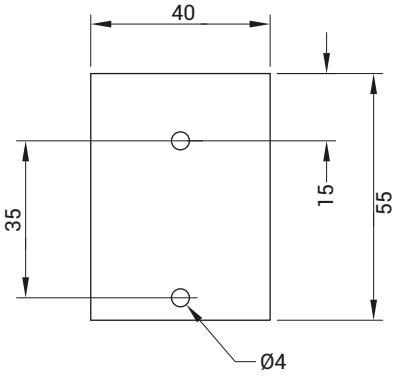


Part 3. Tube
Mat'l: Square section steel tube

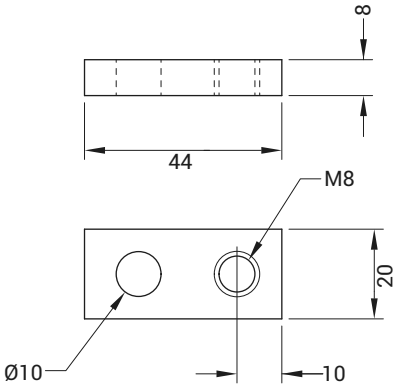




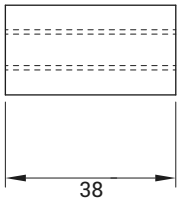
Part 5. Stiffener
Mat'l: 4mm steel plate

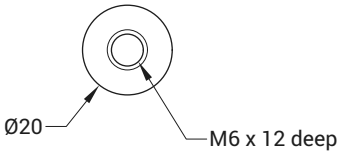


Part 9. Locking Plate
Mat'l: 4mm steel plate

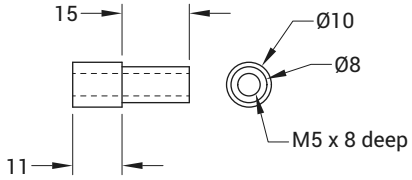


Part 37. Tensioner Arm

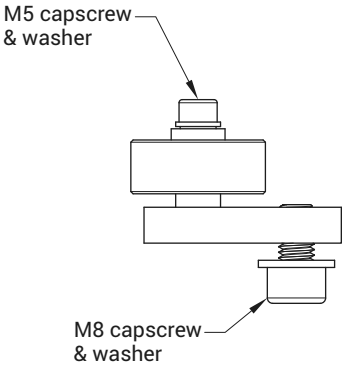




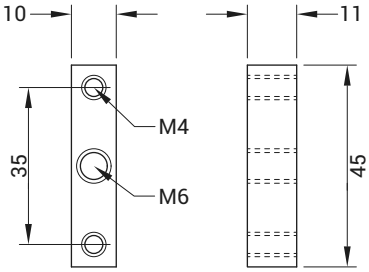
Part 35. Tube Bolt Bush
2 off



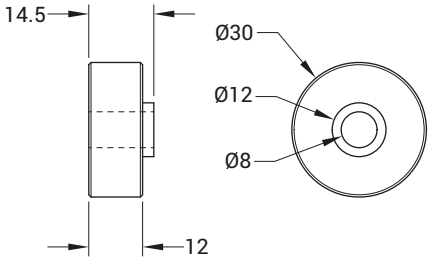
Part 38. Tensioner Axle



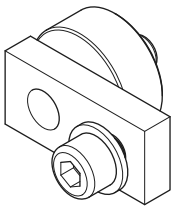
Tensioner Assembly

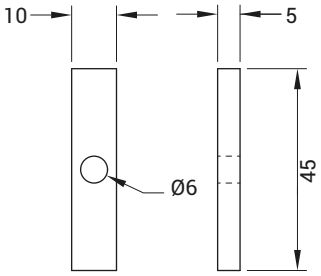


Part 10. Locking Block

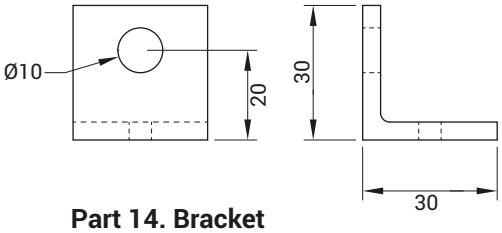


Part 39. Tensioner Wheel

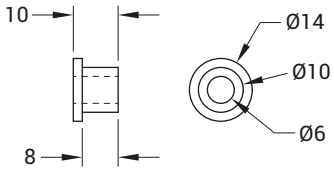




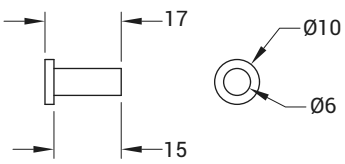
Part 11. Locking Bar



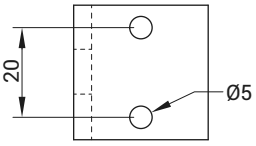
Part 14. Bracket
2 off

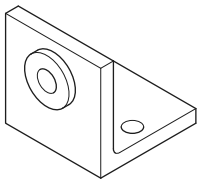


Part 13. Bearing
2 off



Part 12. Pivot Pin
2 off





Pivot Bracket Assembly

is complete, all that is required is to accurately make a master cam that is five times larger than the actual cams.

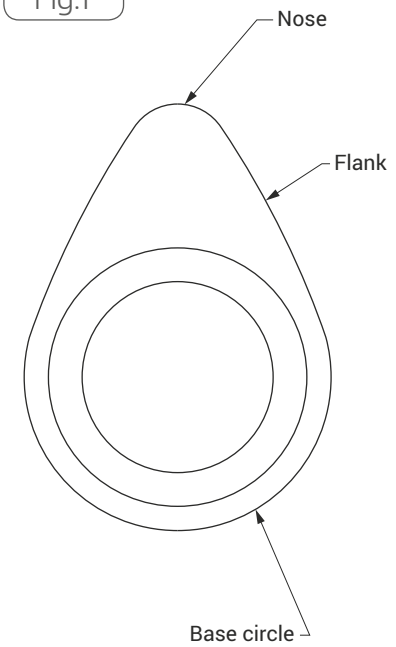
Machine Capacity

The machine will take cams with a base circle diameter of up to about 10mm and a maximum camshaft length of about 220mm. As an indication, my 10cc engine design has cams with a 7.5mm base circle diameter and a typical camshaft length for a 20cc in-line four-cylinder engine is about 125mm. There is no reason why the design cannot be scaled up if larger cams are required.

Cam Design Terminology

Before proceeding, a brief description of cam design terminology may help. A typical IC engine cam can be defined by its base circle diameter, flank radius and nose radius, **fig. 1**. The base circle is, of course, circular and concentric with the camshaft axis. The flanks are typically of constant radius and the ends of the flanks are tangential with the base circle and nose. The nose is also circular, so the nose radius may be defined. Cams are generally, but not always, symmetric about their vertical axis. The cam lift is the distance between the cam nose and the base circle. Some cam designs have different features and more complex profiles, but the above description is sufficient most cases.

Fig.1



3

Machining the ends of the tube square in the lathe using a faceplate fly cutter.

Design Principles

The basis of my machine is a lever with two arms of unequal length either side of a pivot, or fulcrum, that transfers the profile of a large cam pattern, or master cam, onto the cams for the miniature engine. The lengths of the lever arms are in the ratio 5 to 1, and so the master cam is five times larger than the cams being made.

The master cam is attached to an axle at the end of the longer lever arm, whilst the smaller cam or cams is held between centres on its camshaft at the end of the shorter lever arm. The master cam axle is connected via a toothed belt to the camshaft axle and so both rotate in synch together. The master cam is rotated against a fixed stop, causing the frame to pivot around its fulcrum and transfer the movement to the smaller cam, the movement at the end of the short arm being one fifth of the magnitude of the movement at the end of the long arm.

The cam profiles are ground with a grinding wheel which can be advanced towards the camshaft (Y direction) with measured precision and moved along the camshaft (X direction). To provide the X and Y movements required, the grinding spindle is mounted to and XY table, in my case the saddle of a small lathe – I used an Emco Unimat SL.

The long and short lever arms of the frame are at right angles to each other, forming an L shape, but with the longer side of the L horizontal and the shorter side vertical and pointing downwards. The pivot is at the intersection between the two. The arrangement is designed to ensure that the grinding wheel cannot be accidentally fed too far into the work as would be the case if the L was lying on its back. The master cam can be rotated with respect to the shaft on which it is mounted, to enable multiple cams to be ground on the same shaft with the correct angles between them. A protractor scale fitted to the end of the master cam shaft is used for this purpose.

The machine can also be used to precision-grind the cylindrical portions of a camshaft by rotating the camshaft against the grinding wheel without rocking the frame.

To use this machine, blank cams must either be turned integral with their camshafts, or temporarily fitted to a mandrel mounted between, both of which are mounted between the machine's centres. If centre holes are not desirable on the finished camshaft, the camshaft can be made over length and the portions bearing the centres removed when work

4

Clamping frame components together ready for welding.

Welding the stiffener using intermittent welds.

is complete.

Machine Construction and Materials

The frame is made from steel sections welded together. Most parts are cut from steel sections or machined from steel bar stock. I used thick, good quality birch plywood for the base, which has proved perfectly adequate, although any similar material would suit. The main bought-in components are the toothed timing belt and matching pulleys, grinding wheels and a handful of cap screws, nuts and washers of various sizes.

A motor to drive the grinding head will be needed, as will a suitable XY table on which to mount the grinding head.

Let's get building and make a start on the frame.

Frame

The main parts of the frame, or rocker, assembly are made from 4 x 40mm steel flat bar welded together around a length of 40 x 40 square section steel tube, **fig 2**. To maintain the design intent, it is important that the frame is accurately made, particularly that the relative positions of the holes for the pivots, master cam axle and cam axle are correctly positioned with respect to each other.

Start by cutting out all the frame parts and file joining edges square. Carefully mark out and then drill the various holes accurately using the drilling machine except for the hole in the short arm which will be done later. The length of the square tube is not critical, but its ends must be filed square with reasonable accuracy. I actually milled the ends of the tubes square using the lathe, which was an interesting machining exercise but probably overkill for this purpose, **photo 3**.

I used a powered bandsaw to cut off all the parts and filed the edges to finish. The rounded end of the long arm was made by milling using the rotary table but roughing out with a hacksaw and hand filing would be perfectly adequate.

The frame is welded together. I recommended that short intermittent welds are used to join the components. Continuous welds will almost certainly cause distortion unless you are an expert welder. I used a MIG welder. There is no reason why the frame should not be silver soldered together instead. During welding, the parts to be welded must be clamped securely together or clamped down to the work table using a sacrificial piece of scrap wood to avoid burning the work top. Tack weld first, then complete the weld, **photos 4** and **5**.

Grinding weld beads flat.

The set up used to cut the graduations on the protractor.

Weld the short arm (part 2) to the end of the long arm (part 1) then mark out and drill the hole in the short arm ensuring that it is exactly the right distance form the pivot hole in the long arm and such that the centres of the holes in the ends of the long arm and the hole in the short arm form a right angle.

Weld the long arm and the endplate (part 4) to the tube (part 3) ensuring that they are square and aligned. Next, weld the stiffener (part 5) and locking plate (part 9) in position.

Due to my welding skills being miserable at best, and out of practice to boot, I ground some of the welds flat for the sake of appearance and especially in

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Knurling the handle.

areas where the weld bead would have interfered with other parts, **photo 6**.

The tube bolt bushes receive the bolts or screws that secure the slotted plate to the frame. They are needed because the tube wall is too thin to take the screws. They are turned from steel with an M6 female thread tapped through the centre. They are then secured into the 20mm holes in the back of the tube, using tack welds, epoxy or Loctite.

Locking Plate

The locking plate (part 9), locking block (part 10) and locking bar (part 11) are used to clamp the timing belt into a locked position to prevent the headstock spindle rotating when adjusting the rotational position of the master cam. The components are easily made from scraps of square section steel milled to size as necessary and drilled and tapped to take the screws.

Slotted Plate

Cut out the three parts (parts 6 to 8) from 4 x 40mm flat bar and dress the edges with a file ready for welding. The various slots are produced on the milling machine either before or after welding the parts together, as you prefer. The shorter slots must align with the corresponding holes in the frame tube, their purpose being to allow the vertical position and alignment of the slotted plate to be adjusted when setting up the machine.

Master Cam Assembly

This assembly mounts the master cam to the frame, allowing it to rotate freely. Most of the parts are straightforward turning work, **fig 3**.

Protractor (part 27)

The protractor is turned from steel and is engraved with long 10 degree lines and short 5 degree lines. It is too small to allow numbers to be stamped onto it. It is secured to the outer end of the shaft with an M4 cap screw, which needs to tightened sufficiently to prevent the protractor from rotating with respect to the shaft. The engraved lines were cut using a slotting tool fitted with a pointed cutter ground from high-speed steel. For this job, the lathe was set up as a dividing head using a method of my own devising consisting of a disc fitted to the rear face of the lathe chuck and a locking device which grips the edge of the disc attached to the lathe headstock behind the chuck. The divisions for the job in hand are printed off using a CAD programme and stuck to the disc, the divisions being aligned by means of an aimer fitted to the front of the machine. The slotting tool set on the cross slide at the angle required to match the angled surface at the front of the protractor, **photo 7** shows the set up. Needless to say, the lathe is isolated from the mains for this operation.

Shaft (part 29)

This is a simple turning job, with a female M4 thread on one end and a male M6 thread at the other end. A flat is milled for part of the length of the smaller diameter for the pulley grub screw.

Inner sleeve (part 30)

This must be a close sliding fit on the shaft. Its purpose is to clamp the master cam in position against the protractor when the outer nut is tightened. Its outer surface forms a bearing against the bore of the outer sleeve, so a close running fit with the outer sleeve is also required. Use a boring tool followed by a reamer to finish the bore.

Outer sleeve (part 31)

The outer sleeve is another simple turning and boring job. It is permanently fitted into the corresponding hole in the outer end of the lever arm. I used Loctite with complete success, but silver soldering is an alternative, if more onerous, method. Bore and ream the bore as for the inner sleeve.

Spacer (part 32)

The spacer presses the inner sleeve against the master cam and protractor when the outer nut is tightened. The thickness of the spacer will depend on the thickness of the pulley you are using, so adjust to suit.

Handle (part 33)

The handle can be made from any suitable material. I used a piece of aluminium from the scrap box. Its diameter should be an easy fit between the fingers for turning the cam assembly with good feel. It is a simple turning job with no critical dimensions, so it can be made freestyle which is quite fun. The outer diameter is knurled to give a good grip, **photo 8**.

Pulley (part 36)

The pulley is a stock component. The bore will probably need to be machined to suit and the overall thickness may need to be reduced to match the drawing, otherwise adjustments to the dimensions of other components will be required. Two pulleys of the same diameter/tooth number are required, the other one being for the headstock shaft. I happened to have a pair of 18 tooth pulleys in the scrap box which suited. The headstock and master cam pulley must of course be the same diameter so that both shafts rotate at the same speed, and the tooth pitch must match the timing belt. The pulley is keyed to the shaft by means of the locking grub screw and the flat on the shaft (a proper key would be far better) but is free to slide along the shaft in order to transfer the force from the lock nut to the sleeve and hence lock the master cam in position against the protractor.

Timing Belt

I used a 9mm wide, 5mm pitch, round tooth timing belt (toothed belt) to match the 18 tooth pulleys I already had. This was ordered from bearingboys.co.uk and arrived very quickly. The length of belt required, in terms of number of teeth, was calculated from: (2 x half the number of teeth on each pulley) + (2 x distance between pulley centres).

I then selected the closest available size above this, which was 2 teeth more than the calculated number. The greater the excess, the more slack there will be to take up.

●To be continued

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Mike Pavie

Summary Specification

Length approx 72"

- Coal-fired live steam
- 2 Outside Cylinders
- Walschaerts valve gear
- Cast iron cylinder blocks (bronze liners)
- Steam operated drain cocks
- Mechanical lubricator
- Silver soldered copper boiler
- Multi-element semi-radiant superheater
- Reverser
- Boiler feed by axle pump, injector, hand pump
- Stainless steel motion and grate
- Sprung axle boxes with needle roller bearings
- Etched brass body with rivet detail
- Two safety valves
- Available in two liveries
- Painted and ready-to run

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Making a Special Cutter

Roger Vane needed a custom cutter. His approach should help anyone looking at making their own 'specials'.

Overview

Some time ago I needed to machine a number of semi-circular pockets in the bore of a component, for which I would normally use a Woodruff cutter. In this particular instance it was not possible to use a standard cutter due to the position of the pockets within the component, so I had to adopt a different approach which involved making a special cutter. This article describes how it was made.

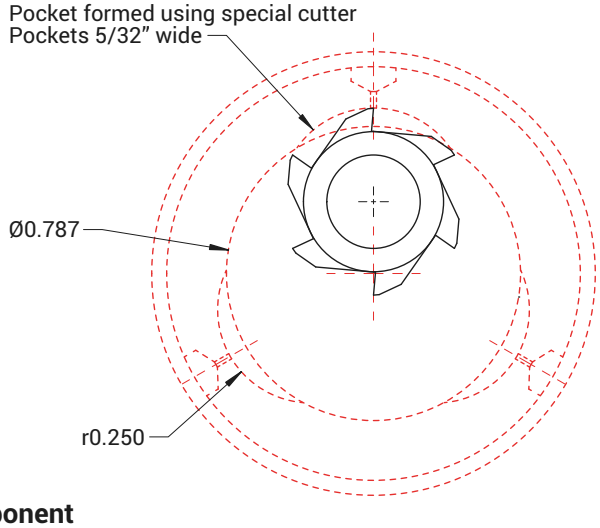
Introduction

The components in question were for an air bearing. They have 3 semi-circular pockets within the bore which are for air distribution, spaced at 120 degrees to each other. **Figure 1** shows the position of the pockets within the bore of the component, while **photo 1** shows one of the finished pockets.

Normally I would have used a 5/32" wide Woodruff cutter to form the pockets, but there were a couple of problems with this approach. Firstly, a cutter of suitable diameter (1/2") would need to have the shank ground down to 3/8" diameter for this particular job. My only available method for grinding the shank was to press my Quorn grinder into use, and this was an option that really didn't appeal to me. Secondly, the position of the pockets required the shank to be ground right up to the extent of the collet chuck to allow me to achieve the correct position (depth). When in the correct position for machining the pockets the collet chuck would obscure my view of the machining operation - the cutter really needed a longer shank.

The challenge was to machine the pockets in the bore of this component

Fig.1



Component
Mat'l: Meehanite

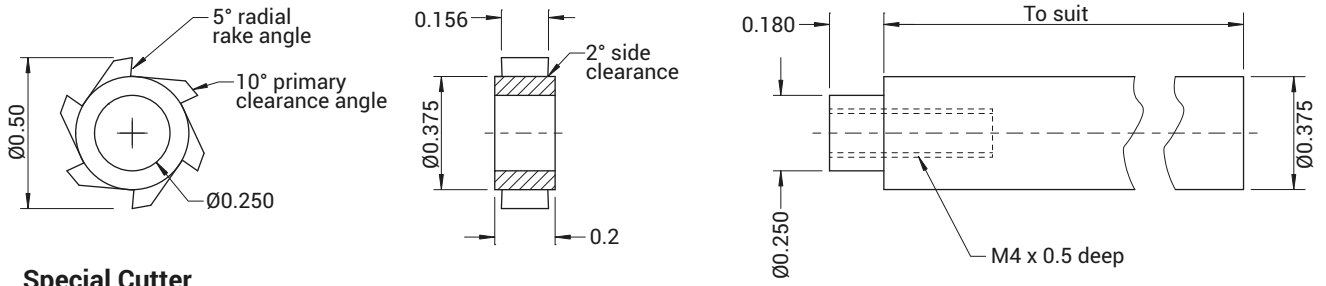
Making the mandrel

The first item needed is a simple mandrel to be used to turn the blank, mill the teeth and finally hold the cutter when in use. Made from 3/8" diameter mild steel, ideally it should it should be machined and used in a collet to ensure concentricity. The mandrel itself is a simple turning job with an M4 tapped hole for a capscrew used to hold the cutter in place, **fig. 2**. The choice of a 3/8" diameter mandrel gave me a reference when milling the teeth and also when the cutter was used - when the mandrel just touches the bore of the bearing full depth has been achieved.

Making the cutter blank

Once the mandrel has been made the cutter blanks can be produced. I chose to make a couple, just in case Mr Murphy decided to become involved. These were simply turned blanks with a central hole - just chuck a length of 1/2" diameter silver

Fig.2



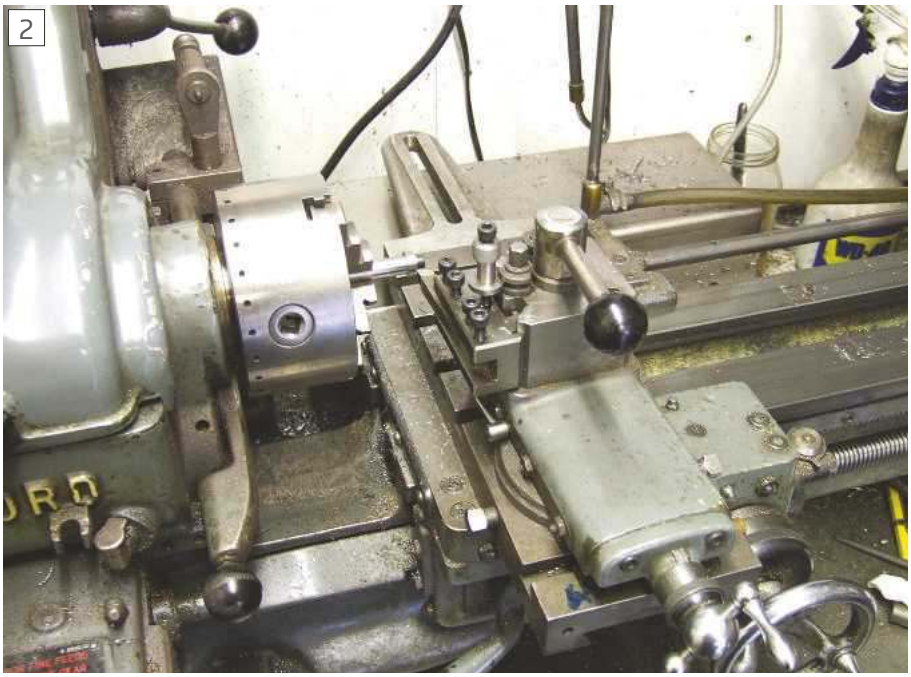
Special Cutter
Mat'l: Mandrel - mild steel
Cutter - silver steel

steel, drill and ream 1/4" diameter and part off blanks to just over 0.2" thick. The blanks should then be faced to thickness., maintaining the two faces parallel.

The side clearance can now be machined - set the blank on the mandrel and swing the lathe topslide around to machine the 2 degree side clearance while reducing the width of the teeth to size. **Photograph 2** shows the setup. Remove around 20 thou from the first face (taken at the tip) and then simply turn the blank around and machine the second face to leave the tooth width at 0.15", although on this particular job the width was not that critical.

Machining the teeth

Now that the turned blank has been completed it's time to cut the teeth, but firstly a few words about the design and geometry, **fig. 3**. The cutter has 6 teeth and these were milled using an indexing head with 24 divisions, which makes the milling reasonably straightforward. Terminology for the various angles seems



Machining the cutter to width and creating the 2 degree side clearance angle

Milling the radial rake angle (5 degrees)

to vary between sources, so I have adopted the what appears to make sense. In terms of geometry this is a fairly simple cutter and the machining procedure has been designed to give a radial rake angle of 5 degrees and a 10 degree primary clearance angle, which seem to be just about right for machining cast iron.

Before cutting the teeth there are a couple of things to do. Firstly, it is well worth coating the periphery of the cutter with marking blue so that the teeth are better defined during the machining process. The other job is to accurately establish a centreline for the indexing head spindle in relation to the milling machine spindle - this will provide a datum (zero) for positioning the milling cutter. The cutter blank and mandrel can now be fitted into the collet on the indexing head.

I used a 1/4" end mill, so once the datum had been established I could set the end mill relative to that. From this the milling cutter can easily be moved away 0.125"so that the tooth radius aligns with the centreline datum - the milling cutter can now be advanced to create the tooth offset

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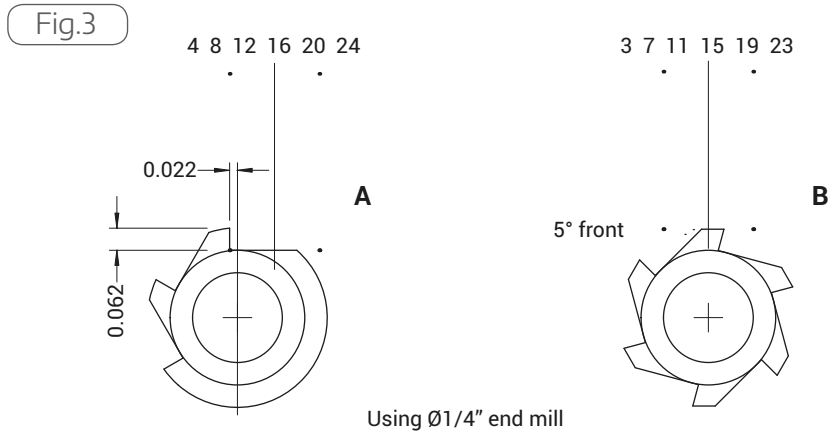
A useful tip when heat treating this cutter is to mount it on an old bolt (facing vertically upwards) which makes it easy to pick up for quenching in the oil.

Fig.3



24 Hole Circle Position

from the centreline of 0.022". It is this offset which will provide the 5 degree radial rake angle on the finished cutter.

Touch the top of the work to provide a datum and then after coming off the blank the cutter can be moved down by 1/16". The cutter will now be positioned for the first milling operation. Photograph 3 shows this operation under way, with a tooth just having been formed. For reference the hole numbers on a 24 hole circle are shown in **fig. 3A**

Without removing the cutter from the indexing head, the next operation is to mill the 10 degree primary clearance angle. This requires a different set of hole positions to be used, and these are shown in **fig. 3B**.

For this the end mill is carefully lowered onto the workpiece and the remaining original curved surface milled away until the flat so created blends with the flat of the radial rake angle. I say "carefully" because only minute amounts of material need to be removed. Rather than suggest a dimension, this is where the marking blue really becomes helpful as it is possible to see the cut 'advancing' towards the cutting edge as the depth of cut is increased but beware as this really is a small amount. The operation is shown in **photo 4**.

Milling the primary clearance angle (10 degrees)

Heat treatment

All we need to do now is to carefully deburr and then heat treat the cutters. I had recently read an article in 'Model Engineer' in which the author had heated a silver steel cutter to a "nice bright red, quenched in oil and not tempered", so I decided to follow suit and was quite happy with the result. A useful tip when heat treating this cutter is to mount it on an old bolt (facing vertically upwards) which makes it easy to pick up for quenching in the oil. A quick rub over the cutting edges with an oilstone completes the job. The finished cutters and mandrel are shown in **photo 5**.

Using the cutter

I used the cutter mounted on the mandrel which was held in a 3/8" collet. Once the position in the bore had been established in was simply a matter of touching to establish a datum and then feed in by a depth of 0.060". At the full depth position the mandrel just touched the wall of the bore without marking it.

In use I found that the cutter cut quickly and cleanly, and there was no sign of chatter. ■

The finished cutters and mandrel

Alibre Atom3D

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

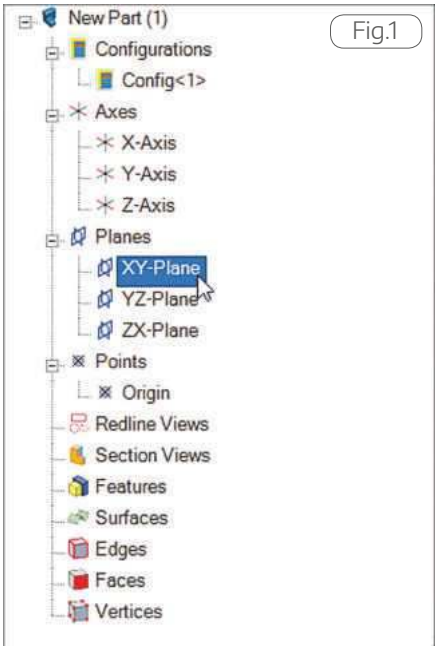
In the first article we looked at the basic interface of Alibre Atom3D, and how to create a simple part using the extrude tools. In this tutorial we will cover some more in depth sketching and demonstrate the use of the revolve cut tool to create the 'Vertical Column' component, then use the Assembly workspace to combine the new part with the base created last month.

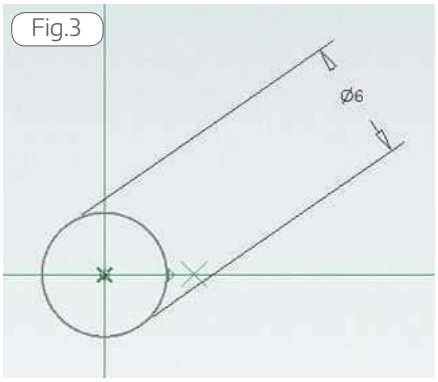
If you don't have the base component from the last article, a copy is available on the website at www.model-engineer.co.uk/AlibreAtom3d.

Create the Vertical Column component:

Open Alibre Atom 3D and click on the Part icon to start creating a new component.

We need to start off by creating a sketch on one of the pre defined sketch planes. In the previous article we selected this in the main view- sketch, planes can also be selected from the model tree on the left hand side as shown. Selecting



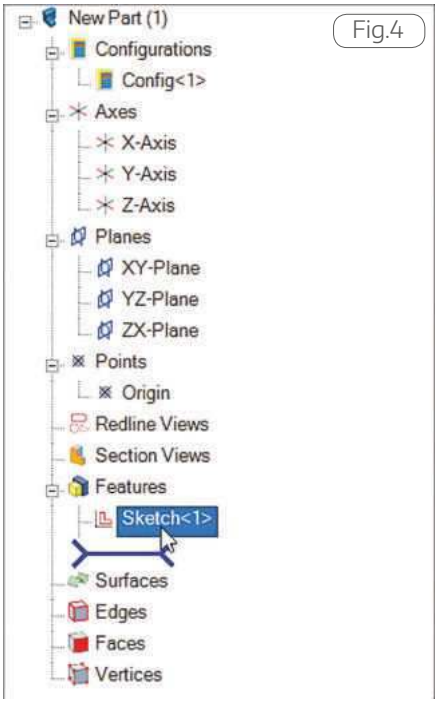


items from the tree can often be easier than finding something in the main view once a model becomes more complex.

Select the 'X-Y Plane' as shown in **fig. 1**, then click on 'Activate 2D sketch' to start a new sketch, **fig. 2**.

Create a circle around the origin and specify the diameter as 6mm as shown in **fig. 3**.

Click on the Deactivate Sketch button to exit the sketch.

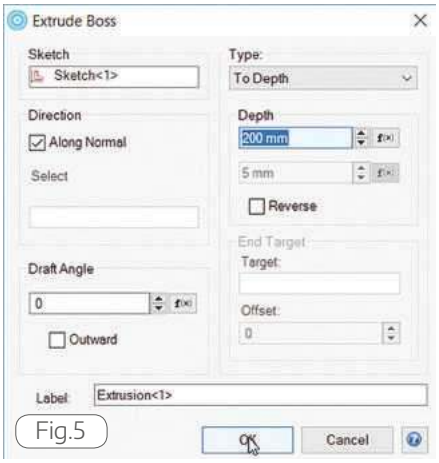


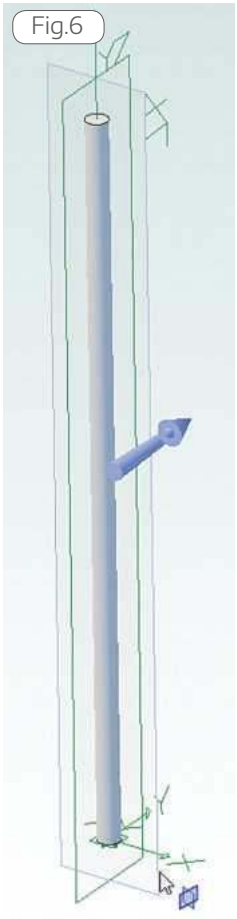
Sketches can also be selected from the model tree - select Sketch<1>, then create an extrusion using the Extrude command (located under the 'Boss (Add Material)' section of the main menu), **fig. 4**.

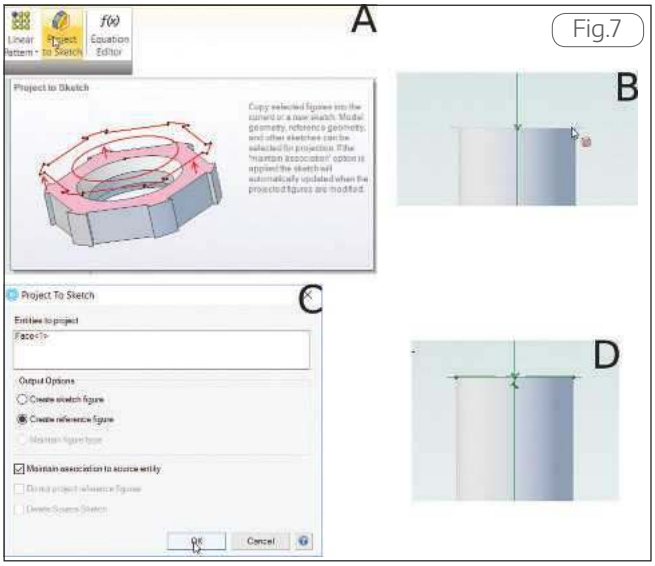
Set the depth to 200mm as shown in **fig. 5**, and click 'OK', fig. 5.

We now need to create a 2 degree taper on the end of the part, to match the tapered hole in the base component.

Rotate and zoom the main view so that you can see the whole part as shown in **fig. 6** (reminder, click and hold left and



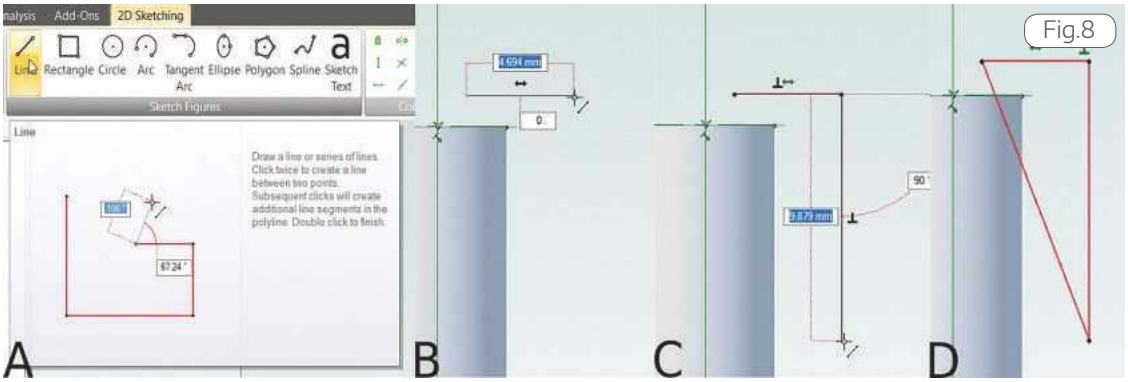




D: This creates a reference line on the end of the part that we can position/ dimension our sketch against.

Standard figures vs Reference Figures:

When creating sketches in Alibre Atom 3D there are two line types available. Standard figures (e.g. lines and circles) are used in the 3D functions to create features. These have strict rules, such as no gaps or overlaps. Reference figures are lines that are not used in the 3D functions, so do not have the same restrictions as standard figures. Reference lines are very useful when creating more complicated shapes. Figures can be switched between standard and reference by right clicking on the line and choosing either 'Convert to Reference Figures' or 'Convert to Regular Figures' option.



right mouse button to rotate, scroll the middle mouse wheel to zoom).

To create the taper we can use the 'Revolve Cut' command. The Revolve tools are used to create features which are rotationally symmetrical around an axis- think turned components. The tool requires a section sketch and an axis.

To create the section sketch:

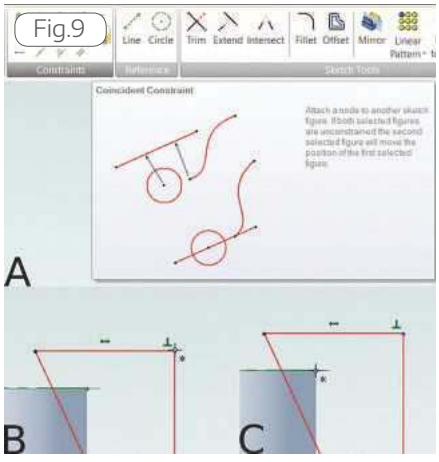
Select the XZ plane, then activate 2D sketch mode.

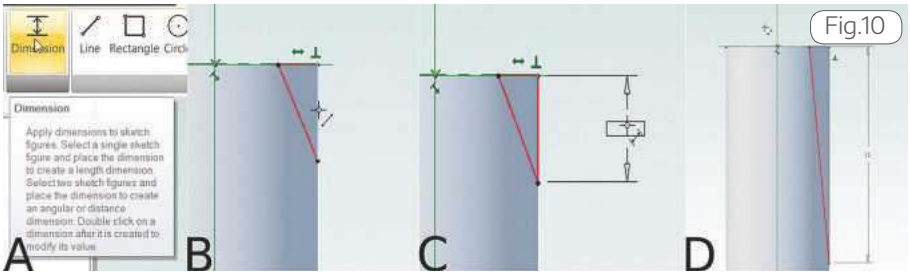
In order to position the cross section sketch, we need to create some reference geometry. To do this we can use the Project to Sketch function- which pulls information from the part into the sketch. Create a reference feature for the end of the rod as shown in **fig. 7**:

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

B: Click on the top edge of the rod- this will add the edge into the 'Entities to project' section of the tool.

C: Change the Output Option to 'Create reference figure' and tick the 'Maintain association to source entity' (this option links the created reference line to the part) then click OK.

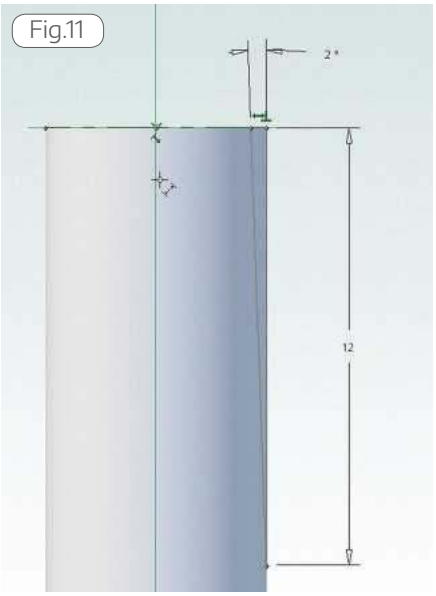


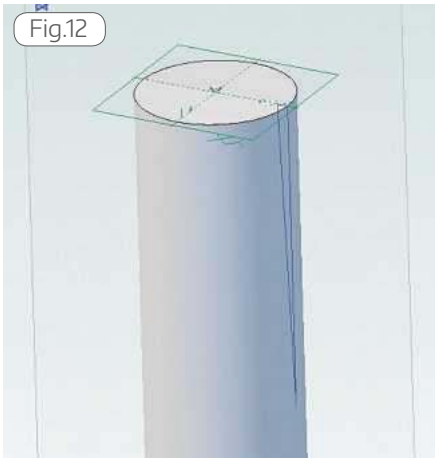


Now we can create the cross section for the cut, **fig. 8**.

A: Click on the 'Line' tool located under Sketch Figures.

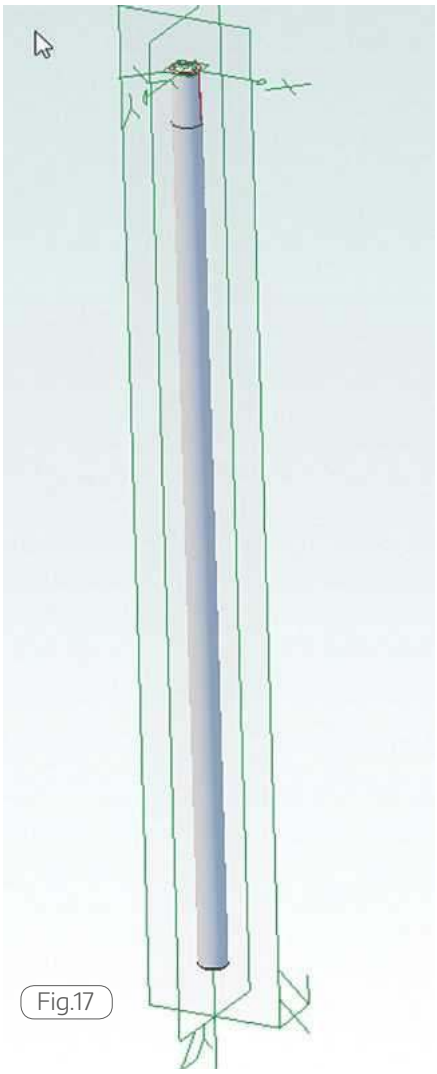
B: Left click to start a line (do not hold down the mouse button), then move to the right trying to keep horizontally aligned with the starting point. The software should automatically snap the line to horizontal (denoted by the black arrow symbol above the line). Left click again to finish the line.

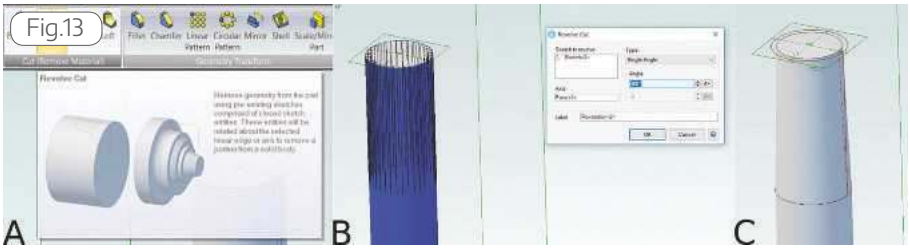


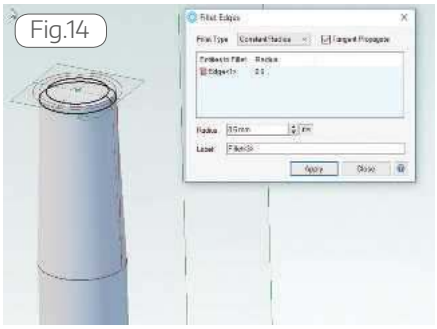


C: After clicking, a new line will start, connected to the end point of the first. Move the mouse directly down from this point, the line should snap perpendicular to the first as shown. Left click to finish the second line segment.
D: A third line will start, from the end of the second- move the mouse over the start of the first line (a little asterisk tooltip will show when you have the point selected) and left click to close the shape. As this is a closed shape the line tool will automatically finish.

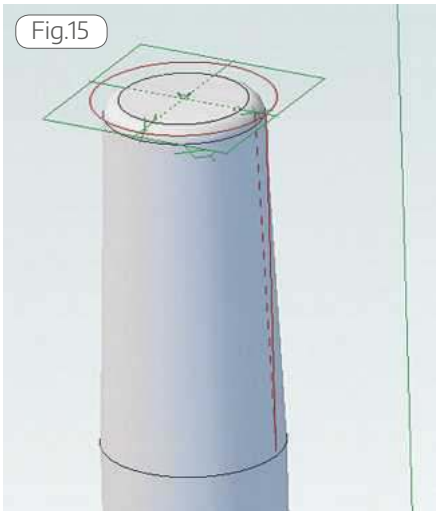
Note: If you only want to draw one or two lines, you can press the 'Esc' key to finish the line tool at any point.



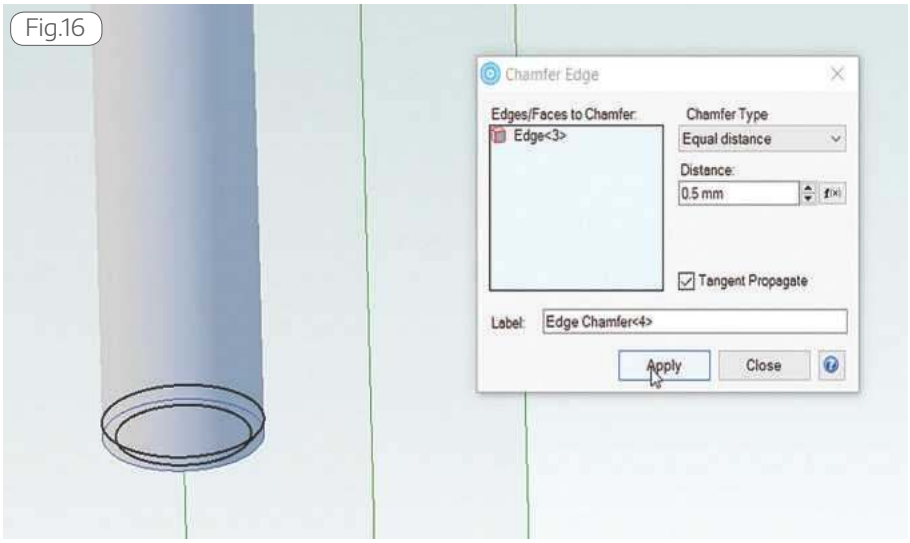


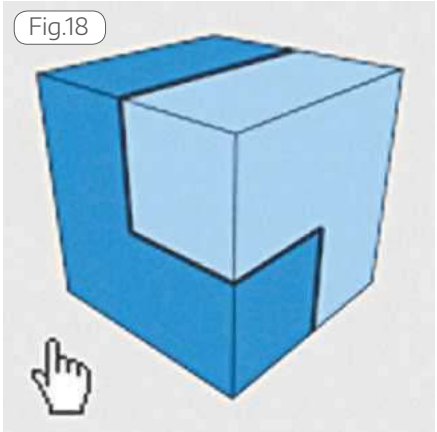


Now we have defined our basic shape, we can use a combination of constraints and dimensions to finish the sketch, **fig. 9**.
A: Left click on the Coincident Constraint option, located under the Constraints section of the tool bar. This tool allows us to connect points together.
B: Left click on the node in the top right corner of the section sketch.



C: Left click on the right hand node of the reference line created earlier. This will snap the section sketch to the corner of the rod.

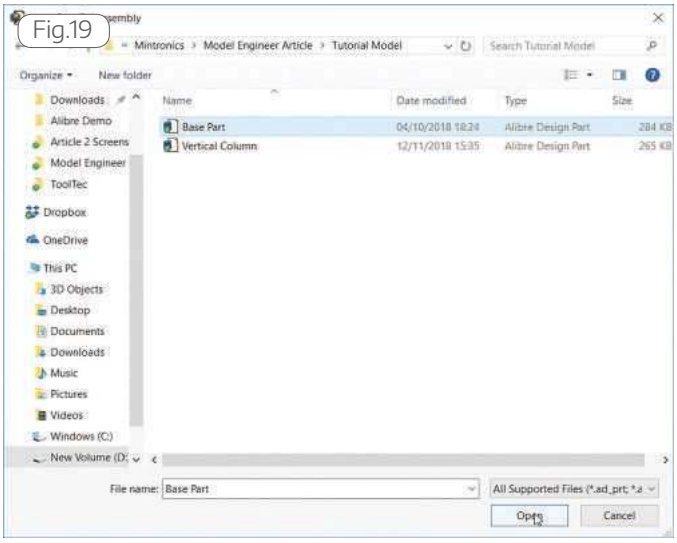


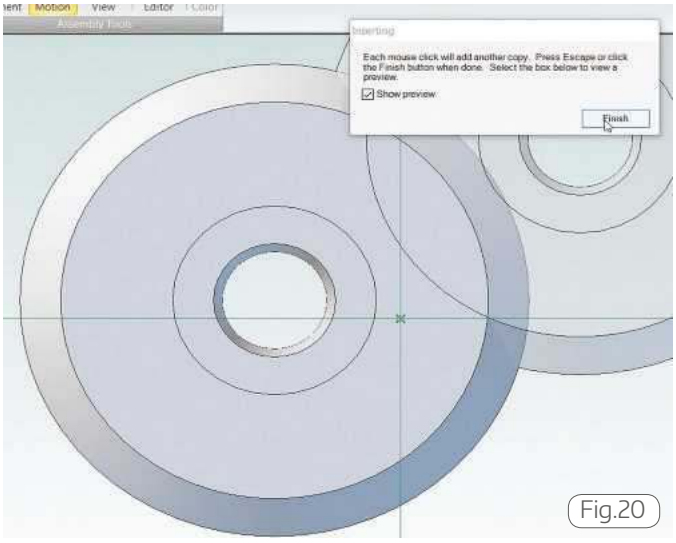


Alibre Atom 3D allows dimensions to be input whilst sketching (as we did when creating the Base component), however often it is easier to define the shape first and then manually add the dimensions in afterwards, **fig 10**.

To manually add a dimension:

A: Left click on the Dimension button.
B: Left click on the right hand edge of the section sketch.
C: Move the mouse over to the right (do not hold down the mouse button), then left click again the position the dimension- a dialogue will appear. Input a value of 12mm and press the enter key to





accept the value.
D: The finished dimension.

We also need to define the angle of the taper, **fig. 11**.

To dimension the angle:

1: Left click on the dimension tool
2: Left click on the vertical line
3: Left click on the long edge of the triangle
4: Move the mouse such that the cursor is positioned vertically above and between the two lines and left click again. Input a value of '2' into the dialogue and press Enter.

Figure 11 shows the finished sketch. Note that all lines are in grey to indicate that there are no remaining degrees of freedom left in the sketch.

Click Deactivate Sketch to exit sketch mode.

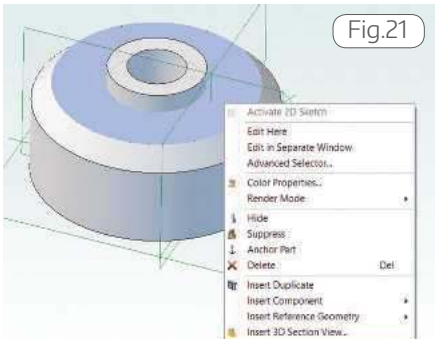
Rotate and zoom the main view as shown in **fig. 12**.

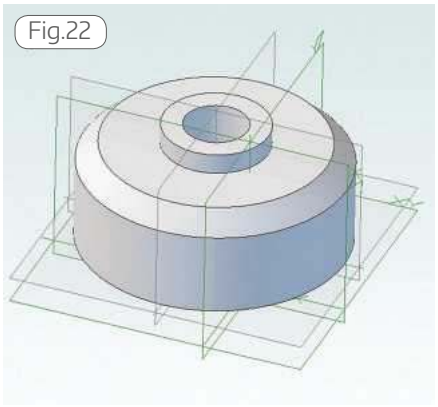
We can now create the taper using Revolve Cut, fig **13**:
A: Click on the 'Revolve' command located under the 'Cut (Remove Material) section of the main menu ribbon.
B: Make sure the section sketch is listed under the 'Sketch to Revolve' section of the tool, then left click in the 'Axis' box and select the outside cylindrical face of the rod, then click 'OK'.
C: This finished taper.

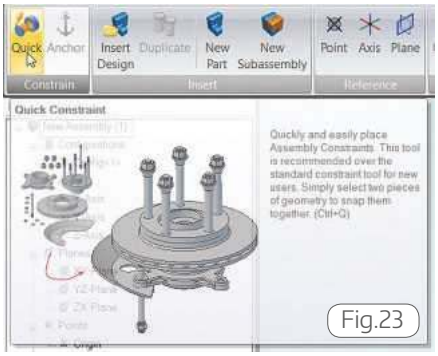
A few final details to finish the part:

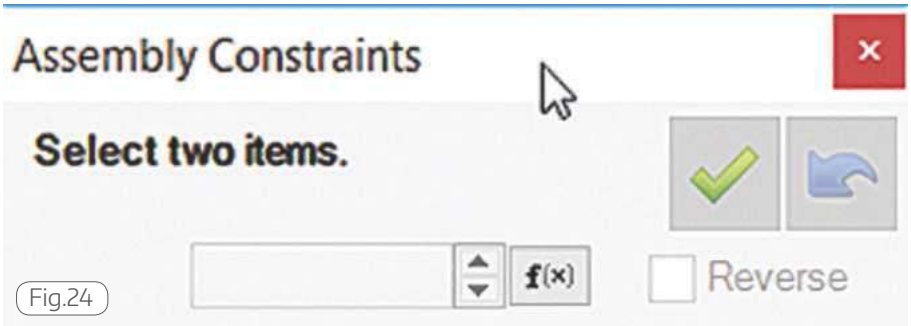
Create a 0.5mm fillet on the tapered end of the rod as shown in **fig. 14**. **Figure 15** shows the finished fillet.

Create a 0.5mm chamfer on the other end of the rod (note when changing the size of a fillet or chamfer, type the required size in the 'Distance box' and then left click in the 'Entities to Fillet' / 'Edges/Faces to Chamfer' box to apply the change in value), **fig 16**.









Save the part into the same folder as the base component created in the last article, use the file name 'Vertical Column'.

Figure 17 is the finished Vertical Column component.

Create an assembly to combine the base and vertical column components together:

Go back to the Alibre Atom 3D home window, then click on the assembly button (**fig. 18**) to open a new assembly workspace.

When starting a new assembly, Alibre Atom 3D will open the 'Insert Part / Subassembly' window, which allows us to bring in the parts previously modelled (by default the software should go to the folder where you last saved a part).

Left click on the 'Base' component and click the 'Open' button as shown in **fig. 19**.

This will now enter the assembly workspace and a preview of the part will follow the cursor. Left click once somewhere in the main view to place one copy of the base part (we don't need to worry about its position at this stage), **fig 20**. Then click the 'Finish' button to exit the part insert mode (note that when in this mode, each left click in the main view will place an additional copy of the part- which is handy when dealing with things such as fasteners that are often used multiple times in an assembly).

If you left click on the part in the main view and drag the mouse whilst holding

down the left mouse button, the part is free to move within the workspace. This needs to be fixed in position relative to the assembly co-ordinate system (the green planes / axis for the assembly as shown in **fig. 21**). To do this we need to use assembly constraints to lock all 6 degrees of freedom for the component.

Right click on the face of the base component to bring up the right click menu, then left click on the 'Show Reference Geometry' option.

This will make the construction planes the base part was built around visible, which are shown in light grey to denote they belong to the part rather than the assembly, **fig. 22**.

Click on the 'Quick' button located in the 'Constrain' section of the assembly toolbar as shown in **fig. 23**.

This will bring up the 'Assembly Constrain' tool, **fig. 24**.

We can now use the assembly constrain tool to create a constraint between the XY plane of the part and XY plane of the assembly as follows, **fig 25**:
A: Left click on the grey XY plane of the part.
B: left click on the green XY plane for the assembly (at this point the part will move so that the two planes are coincident with each other).
C: Click the green 'Apply' tick on the Assembly Constrain tool.
D: An 'Align' constraint has now been added to the assembly model tree on the left.

Fig.25

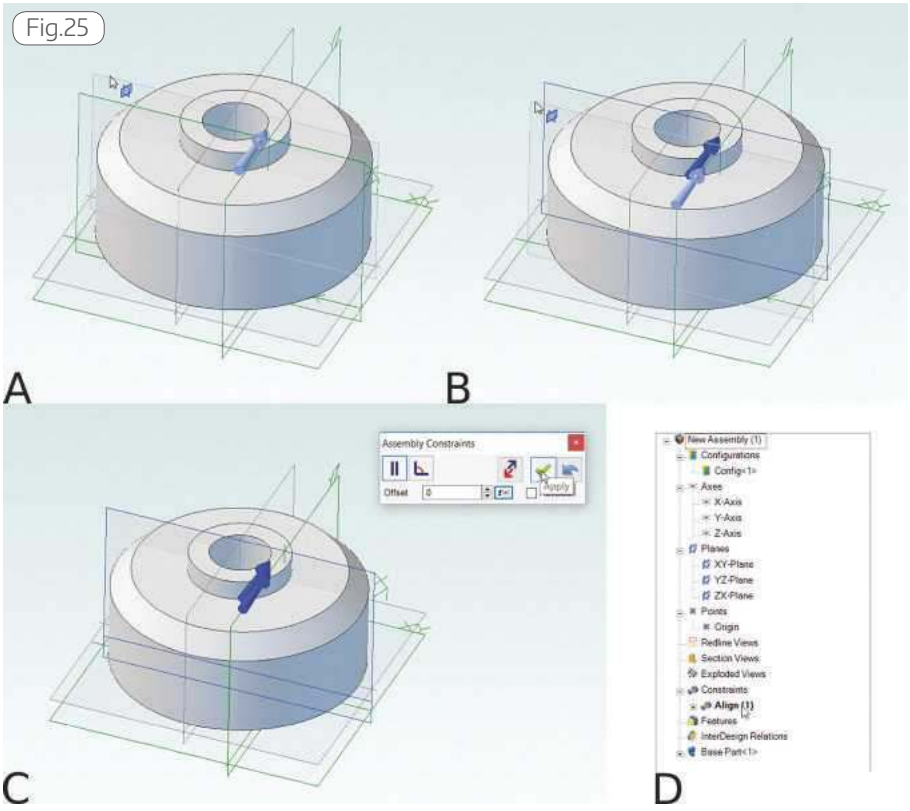


Fig.26

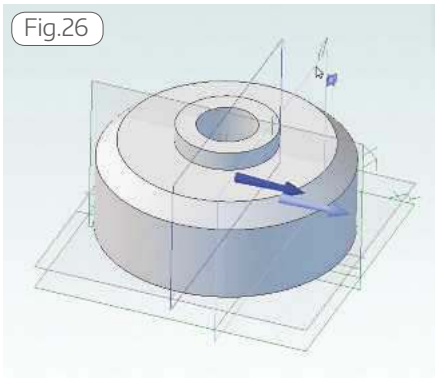
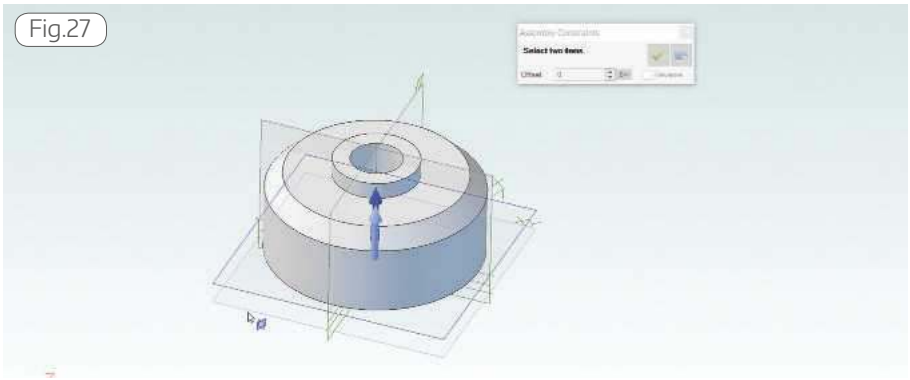


Fig.27



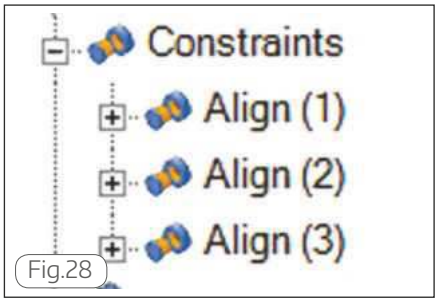


Fig.28

The Assembly Constrain tool will remain open to allow us to quickly move onto the next constraint.

Left click on the grey YZ plane of the part, then left click on the green YZ plane of the assembly and click the apply tick to accept the constraint, **fig. 26**.

The part will now be locked in place in all but the vertical direction.

Fig.29

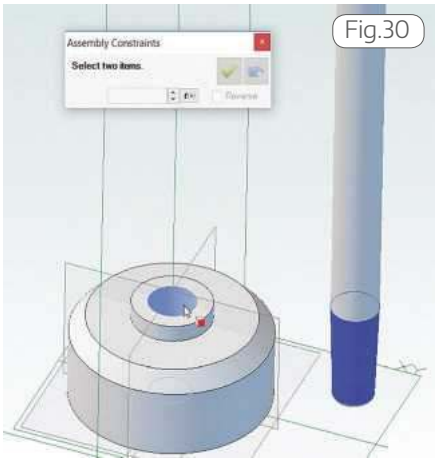


Fig.30

Left click on the grey XY plane of the part, then left click on the green XY plane of the assembly and click the apply tick to accept the constraint, **fig 27**.

The result should be 3 align constraints in the assembly tree as shown in **fig. 28**.

Click the red 'x' in the top right corner of the Assembly Constrain box to close the tool.

If you left click and drag on the part in the main window it should be fully fixed and will not move in any direction (applying constraints to 3 planes will lock all 6 degrees of freedom).

We can now bring in the Vertical Column component and position it in relation to the Base.

Left click on the 'Insert Design' button under the Insert section of the assembly ribbon as shown in **fig. 29**.

Select the Vertical Column component and click 'Open', then left click in the main window to place 1 copy of the part into the assembly and click 'Finish' to exit the insert part tool.

Open the 'Quick' constrain tool. Left

Fig.31

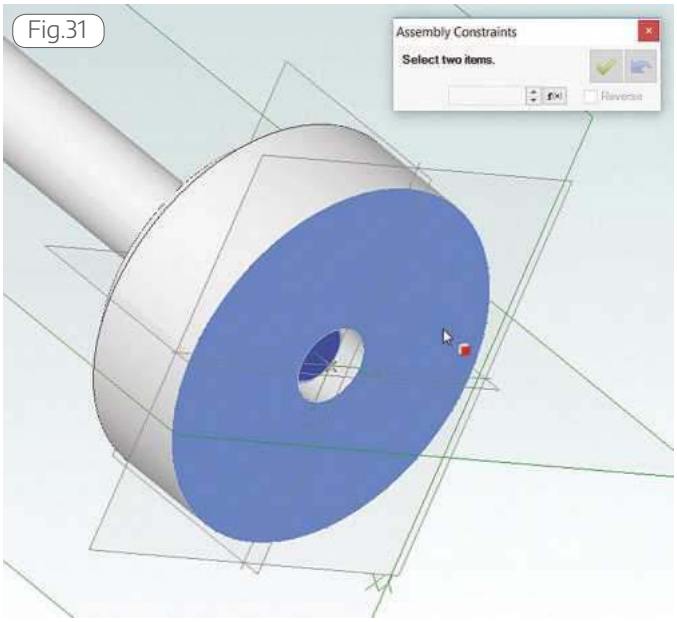


Fig.32

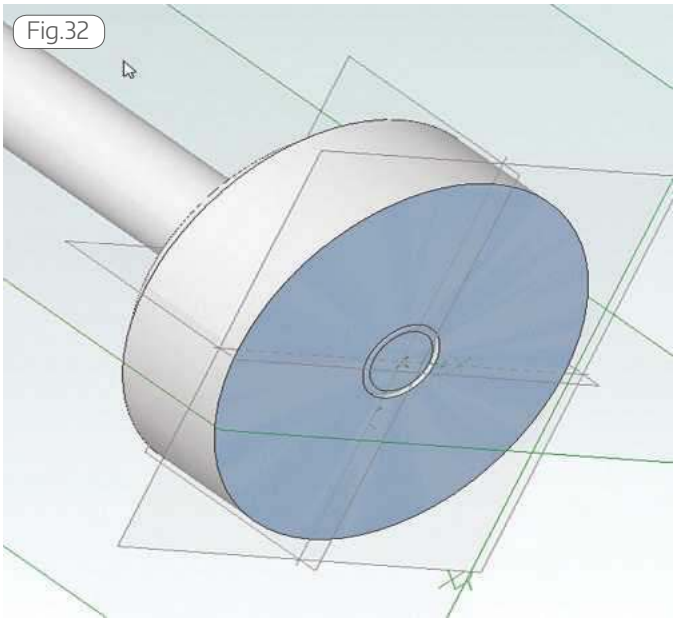


Fig.33

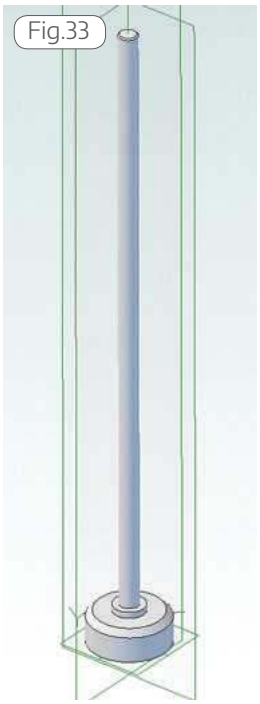
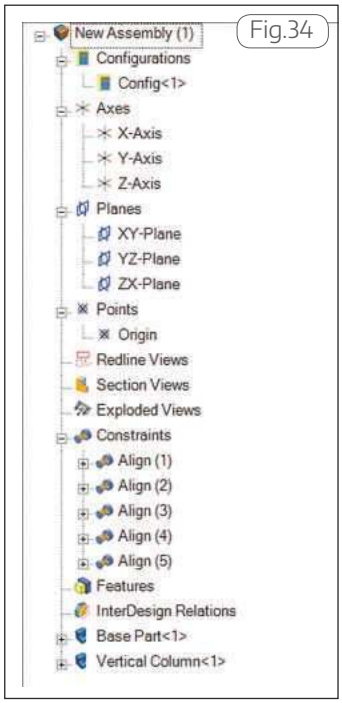


Fig.34



click on the outside surface of the taper at the bottom of the vertical column, then left click on the tapered surface of the hole on the base component as shown in **fig. 30**, and then click the apply button.

This will centre the column on the hole in the base component and add an 'align' constraint into the assembly tree.

Rotate the main view so that you can see the underside face of the base component and the flat face on the end of the vertical column.

Left click on the flat face on the end of the vertical column, then left click on the flat face on the bottom of the base component and click apply, **fig. 31**.

This will align the end of the vertical column with the bottom of the base as shown in **fig. 32**.

Figure 33 is a perspective view of the assembled components.

The assembly tree is shown in **fig. 34** - note that we now have 5 constraints defining the position of the parts, and both parts are listed at the bottom of the tree.

Save the assembly by clicking on the Atom roundel top left and then clicking 'Save'.

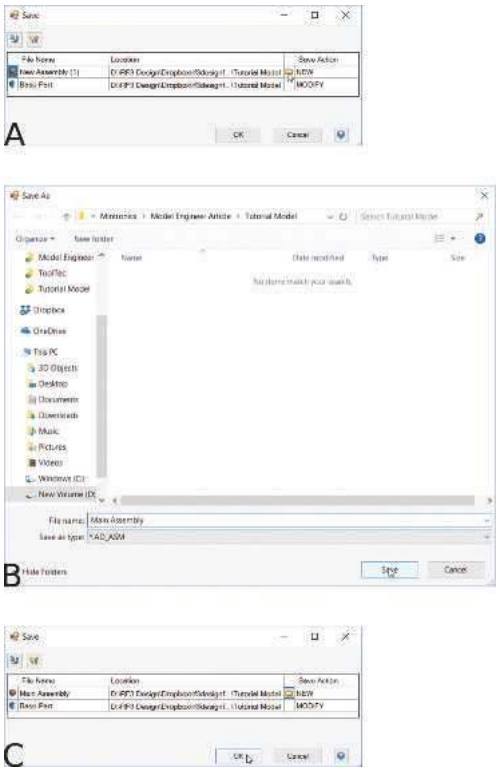
This will open the assembly save dialogue ('A in **fig. 35**). As assemblies deal with multiple parts, this dialogue indicates what changes are being made to each component. As the assembly is a new file, this is denoted as 'NEW' in the save action column and has a small folder icon next to it. Left click on the folder icon.
B: This brings up the standard save dialogue. Change the file name to 'Main Assembly' then click the Save button.
C: This will bring us back to the assembly save dialogue seen previously, with the file name and folder location information updated with the details just entered. Hit the 'OK' button to save the assembly.

Summary:

In this tutorial we have looked at some more in depth sketching, reference geometry and the revolve command, as well as the basics of assemblies. In next months article we will introduce some more modelling tools and an introduction to 2D drawings. In the meantime I suggest you continue working with Alibre Atom3D, explore some of the examples available at **www.model-engineer.co.uk/AlibreAtom3d** and experiment with creating some parts and assemblies of your own. ■

In next month's article we will introduce some more modelling tools and an introduction to 2D drawings.

Fig.35



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Readers' Tips

CHESTER MACHINE TOOLS

Transfer Screws

TIP OF THE MONTH WINNER!

This month our lucky winner of £30 in Chester gift vouchers is Terry McCabe; he's sent me a couple of examples of shop-made transfer screws, and they look very useful.

I recently required some transfer screws and previous experience caused me to rethink the idea. These screws are used to 'transfer' the position of threaded holes in one part to another, by creating a centred dimple. What I came up with is not earth shattering but is a handy way of dealing with the issue.

Take an allen screw of the appropriate size and make the little pin as in the enclosed sample. I have enclosed two samples (see the photos). Drop the pin into the threaded hole, and follow with the allen screw to create the dimple. The pin can be extracted using a magnet and of course the screw can be removed with an allen key.

Terry McCabe

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.

Brian Wood's **Dore Westbury Mk II Miller**

Brian Wood recounts the story of his adaptations to this classic home-build machine.

Mill work head supported on Dexion frame

The capstan

Photograph 14 shows the head thus supported leaving a void where the support used to be. Also visible top left in this photo is the shim, coloured blue for 0.003 inches thickness, on the face of the uppermost packing slab. **Photograph 15** is an inside view of the capstan after 9 years of service, but what cannot be seen and came as a bad shock was the state of the key, which is seen here in **photo 16**.

It was made in silver steel, hardened and tempered as directed in the build notes but clearly the loading has been too much for the design in that form and it was cracked right through with maybe only 45% of it left on the remaining side doing any useful work.

Returning to the motor drive, I was keen to avoid the risk of powering up the lift motor when the column was clamped, so I built in an interlock to isolate the motor while the column was clamped.

A flat was milled across the plain section of the lower clamp bolt to activate a proximity switch that was wired to isolate the live feed to the motor while the column is clamped. **Photograph 17** shows this part of the installation.

Two further precautions were taken against accidental power application by first unplugging the power lead when height adjustment was no longer needed and secondly by getting into the habit of leaving the change over switch in the central OFF position

I accept that with two clamp bolts it is not a completely fail safe situation, but with just myself using the mill I considered those precautions would be quite adequate.

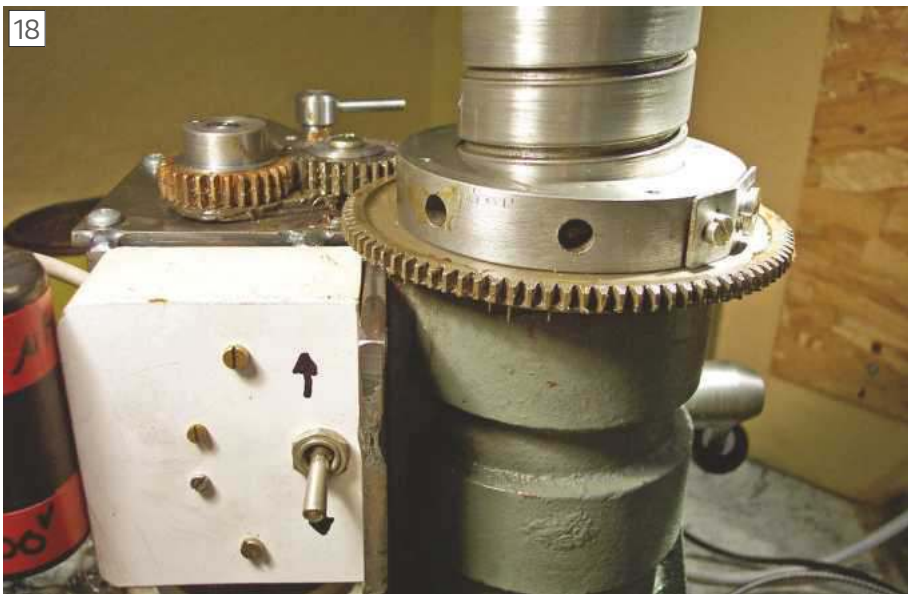
The cracked key

Even if a senior moment were to take place, it would be realised immediately and the power cancelled, with words like 'tut tut' being used. **Photograph 18** shows the gearing arrangement from the motor to the capstan. The lock down bolt, with the short tommy bar, to clamp the swing away idler gear carrier can also be seen here.

A pop riveted shroud protects the gears from the worst of the swarf that might get flung in that direction, seen here in **photo 19** together with the centre OFF two pole change over switch for motor reversal which completed the installation.

The performance of this modification has been all I could hope for, winding is smooth and jerk free in both directions and on manual testing, the thrust bearing has reduced the frictional loading at the joint between the column support and capstan to about 1/3 of what it had been. On a long lift those benefits are really very welcome.

Interlock fitted



Motor gearing arrangement

c) The cracked winding key

There had been no prior indication in use of a developing problem nor was there any clue from just looking at the key in situ while held in the capstan and only some instinct prompted me to take it out for a closer look; perhaps because this was a one off opportunity to do so or just simple curiosity, I'll never know which now. Whatever it was, I'm pleased I acted on it.

It is actually quite a tricky thing to engage and wind into the helix. I recall on initial assembly it seemed to have a perverse determination to rotate and thwart fitting, further frustration would obviously come from trying to do this upside down when the view is obscured.

The key as designed is normally held in place as an easy fit in one of the 5/16 inch diameter capstan holes, the two 'wings' that fit in the helix prevent it from coming back out through the hole, so once fitted and engaged in the helix, there is no way to access it for operational condition unless the capstan has been removed.

As has been amply demonstrated, taking this vital component out for inspection is just the sort of task which it is all too easy to put off to another day and then conveniently forget. The sheer effort involved in getting at it is quite considerable.

Gear cover fitted

Clearly, I was rather lucky to catch it before complete failure took place.

Who knows what damage might have occurred on sudden failure of what was left of the key with the weight of the milling head supported by it. There would be no other support below it to arrest a run-away release

After a cup of tea to think about the new situation (what else does that job so well in a crisis!) a practical solution came to me. **Photograph 20** shows the capstan centred on one of the winding holes and duly supported at the correct height, to allow drilling through on the lathe followed by reaming, as seen here, to leave a hole of ½ inch diameter.

A section of 1/2 inch diameter silver steel was machined to form a grooved step at one end and a new 1/8 inch wide blade section was milled at the other end with a keyway cutter using the rear tool post of the lathe to hold the key. That stage is shown here in **photo 21**.

An adjacent capstan hole was plugged, drilled and tapped for an appropriate screw to secure a suitably shaped finger plate as shown here in **photo 22** to hold the new key fully in contact in the column helix.

Photograph 23 shows the two keys compared. The new key now has much more support for the curved blade than was provided before.

This time the key was left unhardened and fitted in that state; it is now only a matter of moments to inspect it for damage.

it was taken out and checked before writing this article. I am happy to report it shows no sign of any distress after 10 years of duty, there is just a little polishing on the blade surfaces as might be expected.

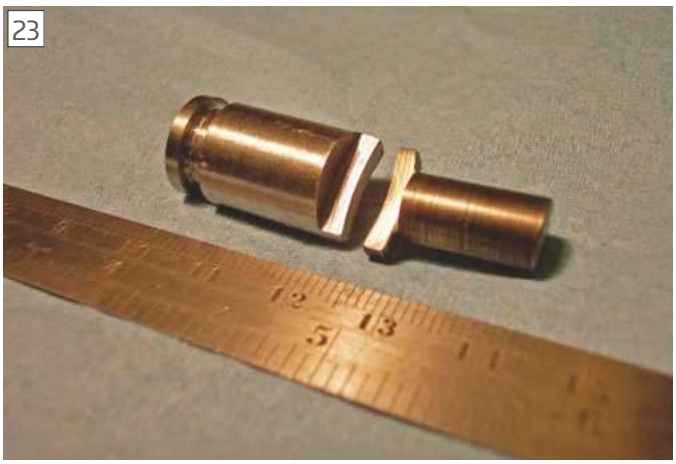
At the same time, the capstan was wound up on the column to take a look at the rolling surface on the lower of the flat washers on the thrust bearing and again, other than a little polishing on the track of the balls, which was to be expected, there was no indentation whatsoever. Clearly the washers are right up to the duty expected of them. **Photograph 24** shows how this looked.

Refitting the key now couldn't be easier, it is merely a case of rotating the capstan until

Final reaming after drilling

New key nearly complete

Key held in place



The two keys compared

Rolling track marks on thrust bearing washer

the column helix can be seen at midpoint through the hole, aligning the blade to fit into the helix and 'click' to engage.

This salvage has worked particularly well and without beating a drum I would recommend it to other owners to undertake as a precautionary measure and remove the threat of a potentially catastrophic failure, of which there could well be no warning.

On a similar basis to one in medical treatment taken in time for a potentially dangerous inherited condition, it has been well worthwhile.

3. The DRO installation

There has been plenty of correspondence exchanged on the ME Forum website concerning the installation of a digital readout on these mills and I think it would be unproductive to repeat a lot of that, so I will just include a resume.

I installed mine in 2003, after fitting another system to my Myford ML7B lathe the year before

The system I chose in both cases was made by Newall, a company to whom these smaller installations were rather unusual at the time and I was graced with a visit by Brian Mosley, the then Northern Regional Sales Manager to offer advice. For this mill he recommended a Topaz two axis display with the Pitch Circle Diameter [PCD] function, something I have since found most useful.

Microsyn 10 sensors and scales were fitted to both machines and both installations have behaved faultlessly since commissioning. The installation notes were very comprehensive, easy to follow and they described step by step, in English, the various functions of the readout displays and key functions in all the necessary detail.

Fitting the scales and readers is greatly aided by the generous supply of mountings provided; every conceivable mounting arrangement can be achieved with the minimum of surgical attachment. **Photograph 25** shows the surplus fittings I have left over after robbery for other unrelated things

All of my scales have been fitted so that the anchorage is single ended, the readers form the remote support and permit self aligning to occur during fitting to avoid any likelihood of strain on the scales in particular. It has to be said though that they are pretty rugged and made for industrial use, but giving them an easier time right from the start was surely beneficial.

Photograph 26 shows for example the end mounting for the cross slide scale on the mill which makes use of the aluminium shield to perform double duty.

Surplus Newall fittings

Just to complete this section, I later added a modestly priced scale and reader to cater for the Z axis on the mill; photo 27 shows how this was fitted. There was a small sacrifice to pay in fitting the bottom support bracket for it as it reduces the quill return by 6 mm, I considered that a small price to pay. The only real complaint I have with the digital scale is that if it gets traces of oil in the reader the display flashes and reads complete nonsense. Attention to cleaning puts that right; the only other gripe I have is remembering to turn it off after use as the small button batteries have a rather limited life.

4. Future plans

At the time of buying the mill kit I added the fairly expensive supplementary kit for powered traverse to the order, thinking that would be a valuable addition to the machine. I am still of that opinion, but not in the form that was offered at the time.

I did actually go to the trouble of building the double worm reduction gearbox for the system which was to be powered by a Parvalux fractional horsepower motor that was also supplied, but I was never really happy with the large space that fitting it all would occupy on the handle end of the table. For a start it would foul the swarf tray.

There were two small castings for example to provide 3 step external round belt shaft drives between the motor and gearbox which struck me as untidy. They remain as un-machined castings. What I really wanted was a much more compact package.

I have since earmarked what seems to be a suitable mains powered motor with built in gearbox that came out of a document shredder; it combines small size and suitable power to be used for this duty but it might be a bit noisy in use. We shall see.

I shall in due course replace the ½ HP Brook motor [bought for £2.00 with a broken cast foot in a farm sale, but otherwise brand new] with the variable frequency 3 phase motor system that came with the recent purchase of a Smart and Brown Sable lathe as a second machine.

I have elected to reinstate the original Crompton Parkinson motor that came with that lathe partly to restore it to original supply form but mostly to benefit from the variable speed on the DW mill where I think it will be more beneficial.

Overall impressions

I have been very pleased with the mill and having owned it from the castings and parts stage I know it intimately. The cracked winding key was a one off failure and perhaps a design mistake which can be forgiven, but that apart, the machine has worked very well for me.

The round column has been a mixed blessing when it has been necessary to alter the working height on a job on the table but the machine is one of the few small vertical milling machines available with a really useful operating quill range of greater than 105 mm

Scale end fitting mounted to shroud

Having said that I had an urgent workshop repair on my bandsaw recently where the round column allowed the machine to be used like a radial arm mill to swing the head over the job and carry out what was needed to be done on the gearbox.

The job is shown in photo 28 where the whole bandsaw frame has been mounted on the mill table with the work head swung over it to attack the gearbox.

The smaller dovetail column machines may well win hands down in preserving alignment if the work head has to be raised, but one of those would have struggled with this repair without having a long table to hold the job securely.

I shall be mounting a laser pointer off the mill in due course to shine through a remotely mounted slit onto a salvaged photocell with a voltmeter attached to get precision long range alignment of the head in future. ■

Digital readout for Z axis

Bandsaw Job

A Chuck Jaw Assessment Device

Ron Wright checks out his 3-Jaw.

Three jaw self centring chucks give excellent service for all general lathework but it is known that good though they are, their jaws do not close with exact concentric precision even when new, and with age and regular use wear occurs in the scroll and in the jaw slots in the body.

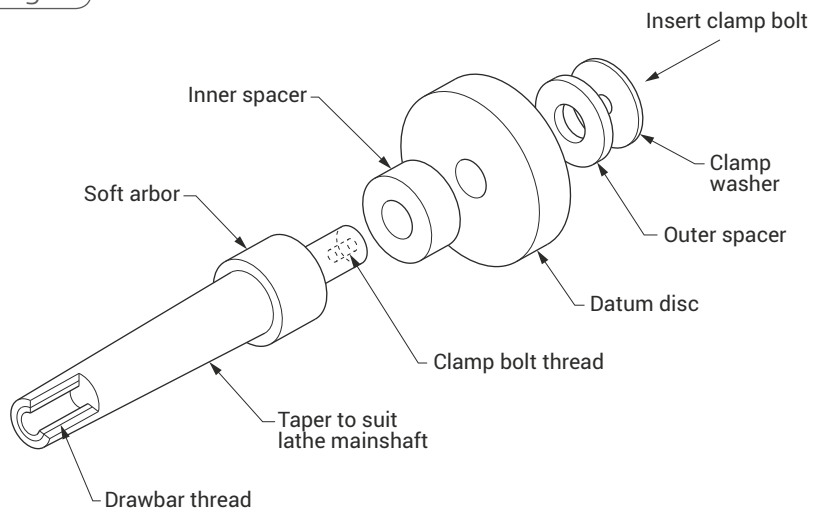
This obviously worsens the eccentricity of the jaws and renders the whole chuck less and less precise as time goes on. The problem can be rectified but it is first necessary to ascertain just how far out of true each jaw is, and the gadget described below, which is quite easy to construct and is shown in **fig. 1**, will enable accurate measurements to be taken quite straightforwardly.

It is probably best to start by machining the datum disc which in my case was power hacksawed from a 2in diameter chunk of mild steel bar and drilled centrally 12mm in the lathe. Following this the chuck is removed and the arbor fitted into the lathe mandrel using a drawbar to hold it firmly, and centrally, in place. The soft nose is then turned down to match the datum disc bore -with minimal play- and to a length suitable for the chuck front-to-back depth; about 25mm in the example shown in **photo 1** which is a posed shot. Finally the end of the spigot is drilled and tapped to accept a clamp bolt which in my case was M6.

The next step is to refit the chuck to the mandrel nose with the jaws removed and secure the datum disc to the spigot using spacers or distance washers as necessary (see fig. 1) to locate it just ahead of the chuck body and making sure that the clamp bolt holds the whole assembly firmly in place.

Now for the important operation; a light skimming cut is taken across the face of the

Fig.1



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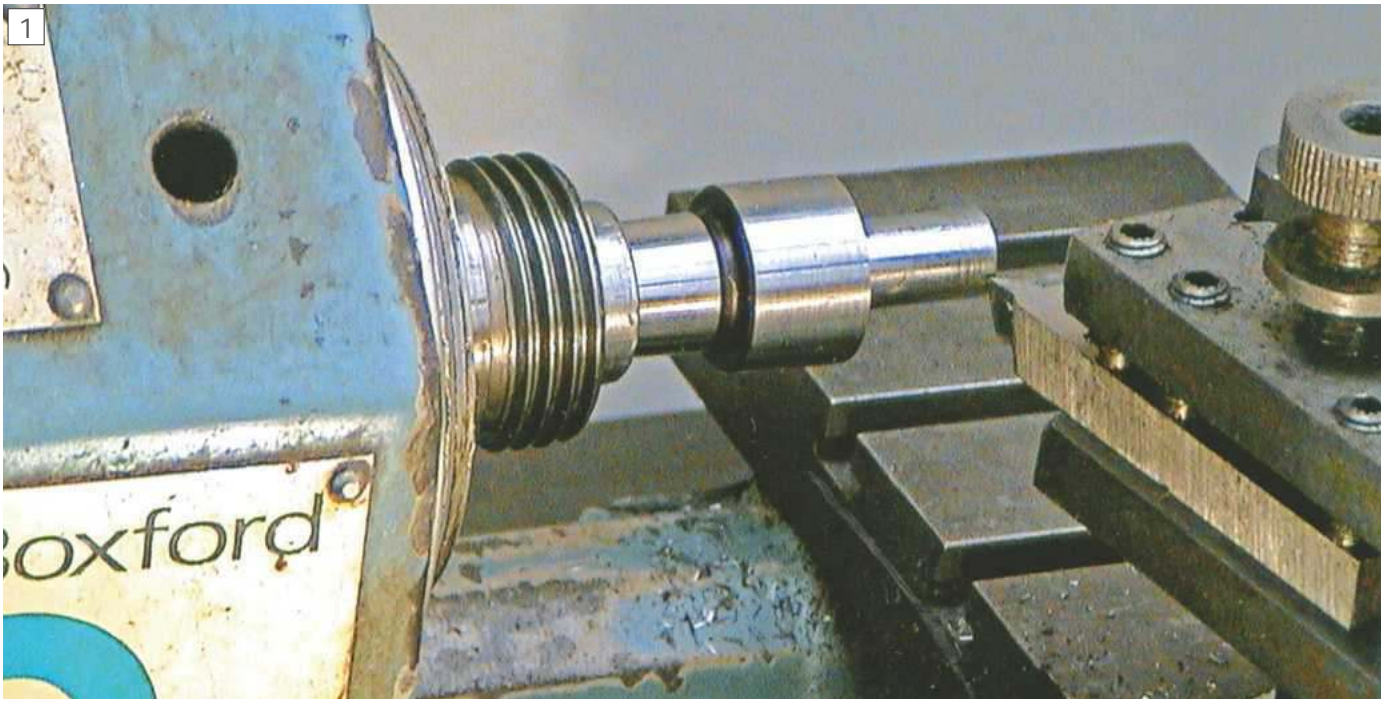
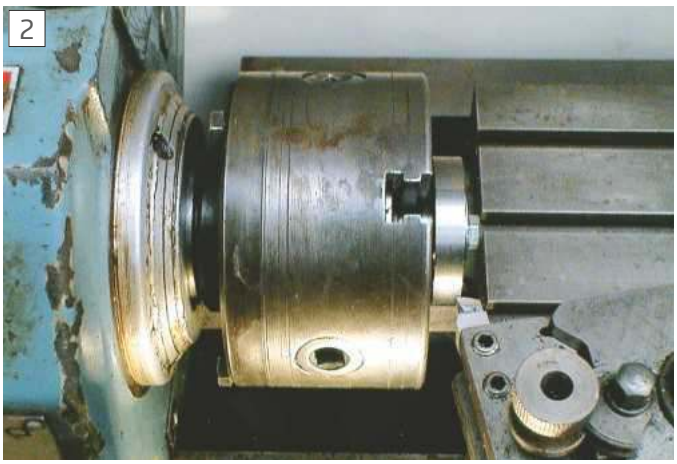


Turning spigot to match datum disc bore

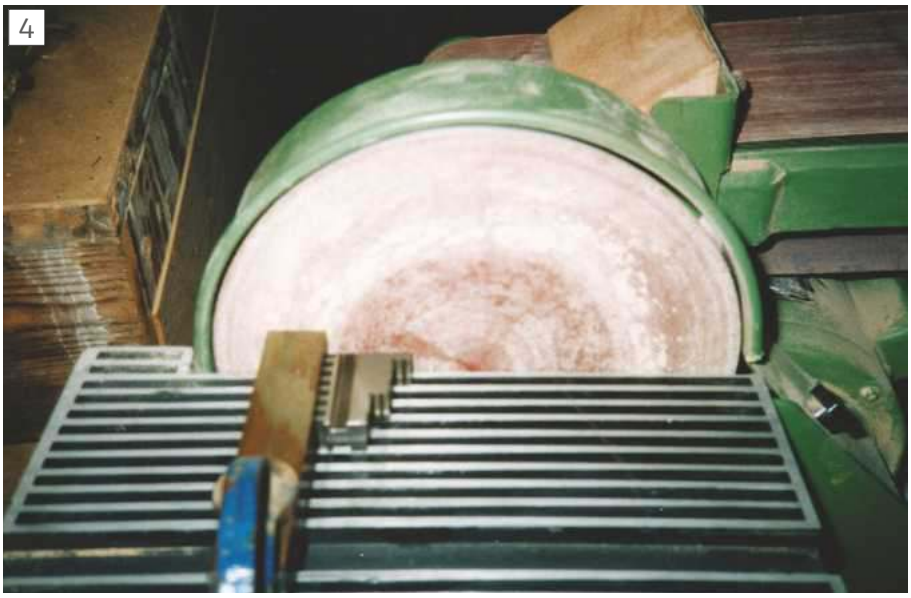


Skimming the disc

Checking for gaps with a feeler gauge

disc as shown in **photo 2** (posed) which will render the disc face exactly co-incident with the lathe centre line.

All that then remains to be done, as shown in **photo 3**, is to replace the jaws and clamp them reasonably firmly on to the disc and use a feeler gauge to locate any gaps. In my case as the photo shows I found a 0.04mm gap on one jaw thereby indicating probable wear on the scroll teeth of that jaw. Of course, the best remedy for this is to fit a new chuck but a reasonable compromise can be achieved by slightly "trimming" the faces of the other two jaws. This is something that I did some years ago and is shown in **photo 4** with a jaw face being held square against a woodworking disc sander, which actually worked very well indeed. But the best way to obtain absolute concentricity in lathe work is to use either a collet chuck, or split collets in the mandrel nose or the old toolmakers' trick of using soft chuck jaws bored to suit the workpiece. ■



'Trimming' a jaw

In our Next Issue

Coming up in issue 276

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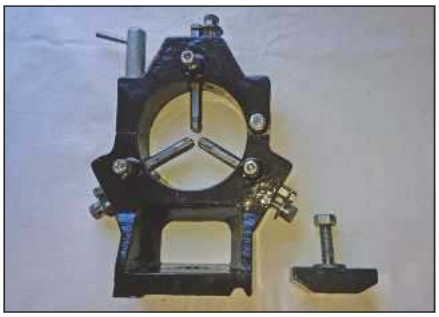
The January issue, number 276, of Model Engineers' Workshop welcomes the New Year:



Chris Gill makes a Fixed Steady for a Harrison lathe that can be easily adapted to suit many other machines.

Pete Barker makes worm gears for his Versatile Dividing Head.

Katrina Bhowruth reports on a skills workshop with Gateros Plating.

Scribe a line

YOUR CHANCE TO TALK TO US!

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

That Curious Machine 1

Dear Neil, the "Curious Machine" in MEW, Issue 274, is most probably a manual stitching machine used in securing the pages of publications that are "Stitched and Folded" in like manner to MEW. Brehmer machines are still used in the printing trade to "finish" magazines. "Stitching" is the industrial term for the staples that are inserted along the fold of the magazine, and they are formed from the roll of wire, cut off, bent and inserted by the machine. The length of the stitch can be adjusted to suit the number of pages being stitched, unlike preformed staples.

Andy Houston, Orpington, Kent

That Curious Machine 2

Dear Neil, to answer Terry Durham's question his 'curious machine' is a Brehmer hand operated wire stitching machine used in the printing industry. I believe they were made in Leipzig and imported.

To use it you would bolt it to a table close to the edge so that the operating handle can be pushed fully down. The flat horizontal table on the machine is removable by undoing a wing nut underneath it which will then leave a narrow saddle over which folded sheets of paper can be placed. The handle is then depressed and the wire will be formed into a 'n' shaped stitch (staple) which is forced down through the paper and is then clenched over from underneath making a little booklet. There is an adjustable wire grip at the right hand side which drives the wire from the reel as the machine is operated, the wire being then led through a small hole at the base of the stitching head. If not making a booklet, but simply stabbing flat sheets to make a pad then the table can be refitted and the sheets laid on top. It has a limited capacity determined by the thickness and rigidity of wire being used and the gap left under the stitching head when the handle is fully depressed.

Iain Crosbie, by email

That Curious Machine 3

Dear Neil, I have just received my copy of MEW so I guess by now you must have dozens of readers responding to the "Scribe a Line" question of the curious machine. It is what I called a Boston Stitcher. it was and is used for stapling magazines (like MEW) although I imagine that modern production processes do not involve manual handling for MEW. The machines could be hand operated as the one in the photo or mounted on a table and treadle operated. It offered either straight stapling of say a pile of papers with the staple or staples in the spine of a book or magazine in an unfolded format (i.e. a pile of A4 sheets). There was a back gauge so the staple always finished in the same position on the papers. However it was the best machine for stapling though the spine of a folded magazine so the folded staple (or stitch) appeared in the middle pages of the magazine and was completely flattened against the paper, unlike modern office stapling machines where the staple folding action is carried out by a curved foot to shape the closure of the staple. The operating table on the stitcher could be tilted down by 45 degrees to allow the open magazine to be place half inside the cast loop and half outside, these machines had a proper underside closing action and it could take different thicknesses of wire for different loadings of paper. I only used the manual version but I believe there were powered versions. It was not unknown to get jambs where the wire would break off inside the closing mechanism and it was a real pain to dismantle the head of the closure to clear the jamb. It was heavy, beautifully made and was the business if your world was stapling.

Jeff Gearing, by email

Thanks to everyone who got in touch to identify Terry's 'mystery machine'. My guess was wide of the mark! My apologies for those whose replies we don't have space to share – Neil.

Old Lathes in Tasmania

Dear Neil, attached are the photos of the old lathes I saw while on holidays in Tasmania. They are all located at Pearn's Steam World in the town of Westbury.

Photos 1 & **2** are of a small treadle lathe converted to electric drive. I could not find a maker's name on it anywhere. The lever sticking out from the front of the bed under the gap might make identification easier, but I could not find anything on Lathes.co to match it. This lathe appeared to have been recently used.

Photos 3 & **4** are of a mid-size lathe, located next to the small one. It has the makers name Smith Barker & Willson of England on the stand along with the supplier's name which was T McPherson & Son in Melbourne. It has an elaborate frame holding a high-level layshaft with fast and loose pulleys for the flat belt drive to the headstock, belt driven from a low-level countershaft which was also belt driven from an electric motor at floor level. It appears to be a much earlier model than those pictured under the Willson brand on Lathes.co.uk

Photos 5 & **6** are of a much larger lathe hidden away at the rear of the second building, behind some old agricultural machinery. It bears the name Jones Burton & Co, Liverpool. It appeared relatively complete but did not have any drive system attached to it. It would be similar in size to the one pictured on Lathes.co.

Anyone visiting Tasmania should call in to Pearn's if they have an opportunity. The display includes a number of traction engines of various makes and sizes, some quite rare, as wall as a comprehensive range of old tractors, farm machinery and earthmoving equipment. I was unable to find a web page but they have a facebook page (https://www.facebook.com/Pearnssteamworld/) and Tripadvisor has a number of reviews (search for Pearns steam world).

Geoff Perkins, Tasmania

Milling for Beginners

PART 8 - FLYCUTTERS, SINGLE POINT CUTTING AND SLITTING SAWS

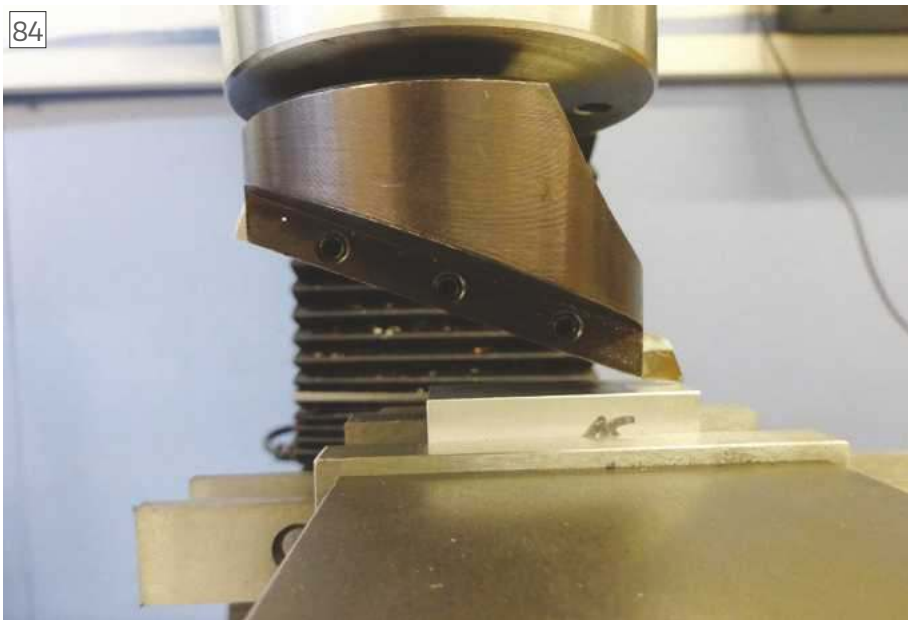
This month Jason Ballamy looks at how to use fly cutters and slitting saws plus what can be produced with a single point milling cutter.

Flycutters

Having used a fly cutter in the previous instalment to machine the rough block it seems right to look at them in a bit more detail this time. Where a large surface is to be machined the fly cutter is a good choice as it can cover the area in a single pass thus giving a uniform finish unlike using a smaller diameter cutter that will leave a series of visible lines on the surface which although they don't leave a physical step can look unsightly. They also work out to be quite economical in use as the one usually HSS tool bit will do a lot of cutting and is easily sharpened on a bench grinder unlike milling cutters that need expensive tool grinders or insert face mills where the cost of inserts can soon add up.

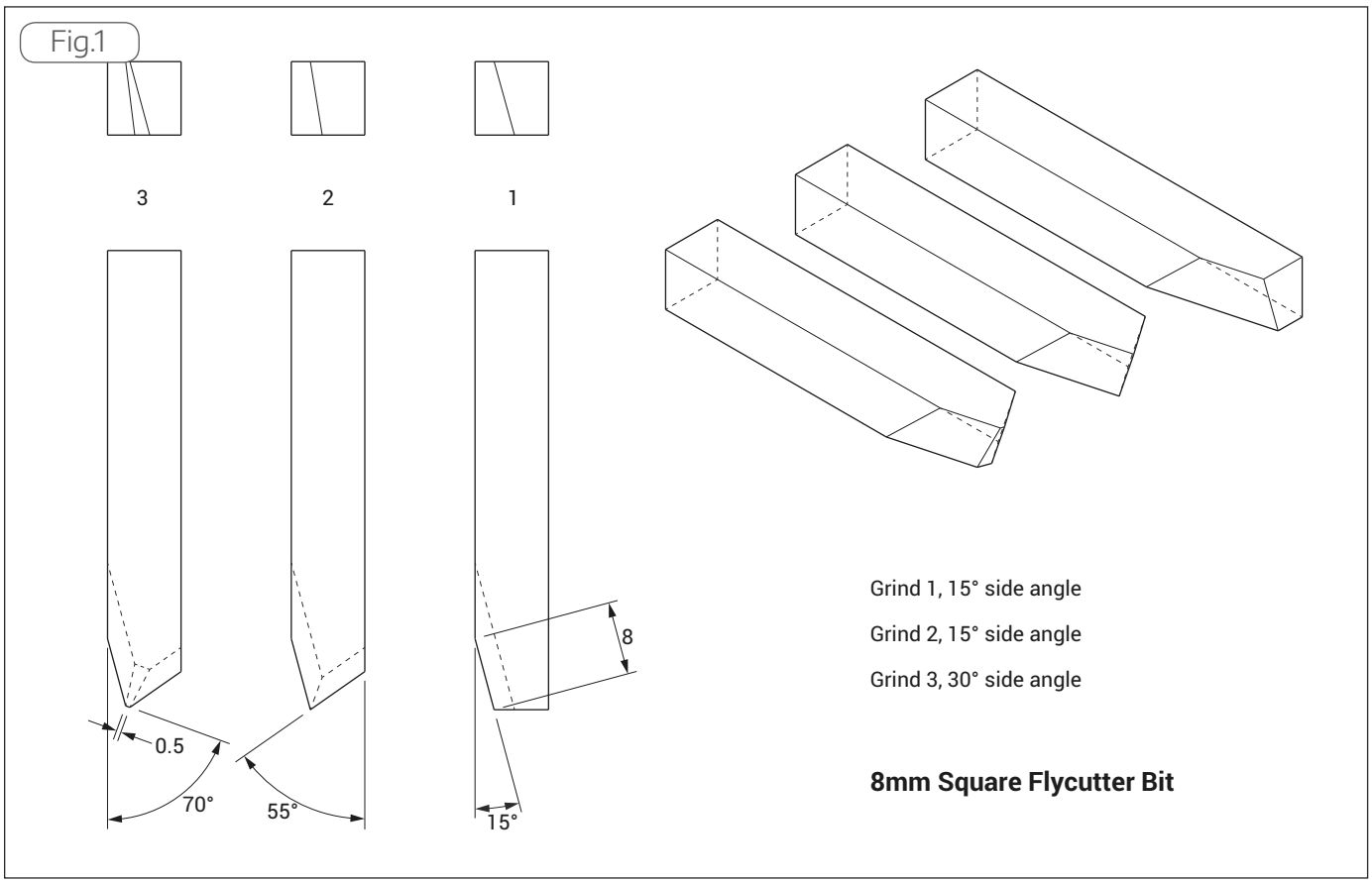
Most fly cutters take the form of a cylindrical head on a straight or tapered shank, the end of the head is cut at an angle and slotted to take a toolbit which presents the tool in such a way that it clears the work below the head. **Photo 84**. There are two or three grub screws to retain the toolbit in the slot. For very large areas or to machine a concave radius the head can take the form of a flat disc mounted on a shank and a toolbit can be held facing vertically downwards for surfacing cuts or protruding from the edge when used for cutting concave surfaces. Indexable fly cutters are also available and often take the form of a shanked body and adjustable arm that takes the insert, these are a bit on the large side for the average bench top hobby machine though a smaller version could be made. However, if you do want to go down the indexable route then it is often simpler to mount an indexable Left Hand lathe tool in place of the HSS bit.

Figure 1 shows the typical angles to grind a toolbit suitable for use in a 63.5mm fly cutter which is also shown in **photo 85**, the main thing to watch is that the back of the tool does not rub against the cut, so this may need to be altered if using a smaller diameter flycutter. As shown on the drawing with the small angled corner it will



Side of Flycutter

Suitably ground toolbit mounted in flycutter



To produce the first edge set your grinders rest to 15degrees and then holding the blank at 15degrees to the wheels face grind until the top edge is 8mm long. Now with the rest still at 15degrees swing the blank around so the other side is at 35degrees to the wheel and grind until this face meets the first. For the final cut set the rest to 30degrees and holding the tool at 70degrees grind the corner until there is a 0.5mm flat visible at the top (or swing the tool around if a rounded corner is desired. In use the first ground face should be towards the face of the work piece. These angles are not critical and can be eyeballed and the job done freehand.

be better suited for bulk metal removal. However, if the corner is ground with say a 1.0mm radius it will be better suited for producing a fine finish without having to reduce the feed rate.

If you do not feel up to grinding the tool from scratch our sponsor ARC Euro Trade should have stocks of ready ground HSS Cobalt cutters by the time this article is printed. ARC product codes:

060-280-99480 Pre-Ground HSS-Co5 Tool Bit 8x8x55mm for 38mm Fly Cutter

060-280-99485 Pre-Ground HSS-Co5 Tool Bit 8x8x80mm for 63mm Fly Cutter

In use it is important that the mill's spindle is truly vertical above the table or "trammed" as if the spindle leans too far from vertical a slightly concave surface will result. However, this can sometimes be used to advantage if the lean is very slight by using the higher edge of the circle that the tip of the tool swings in as the leading edge to remove the majority of the cut and then the trailing slightly lower edge will take of a finishing skim cut. Quite a few people also prefer the pattern that this leaves on the surface **photo 86** rather than the almost holographic look that a perfectly trammed machine will produce, **photo 87**.

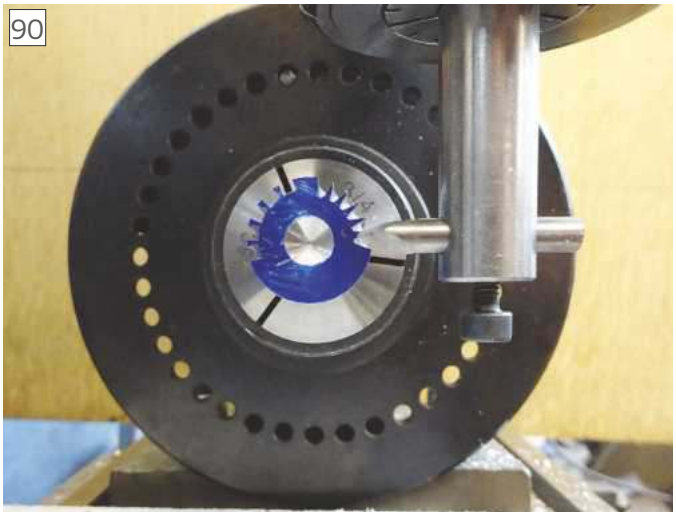
The fly cutter does not have to be restricted to machining large areas, they are equally at home on smaller parts, I

Single cut finish

Double cut "trammed" finish

Small fly cutter in use on narrow work

Profiles produced with single point fly cutters



Single point spline and gear cutting

Slitting a screw head with a fine toothed blade

often use them to bring rough bits of metal, particularly aluminium, brass and bronze, down to basic over all size as they can be kept sharp which these materials like and you don't end up wearing just the end of a costly milling cutter. For this sort of work the smaller straight shanked cutters that are often sold in sets of three are ideal as you can use smaller section toolbits that take less effort to grind and you don't waste a lot of time winding a big head clear of the work before putting on the next cut. **photo 88**.

Cutting speed can be worked out based on the diameter that the tip of the tool describes which on a 63.5mm cutter with say 10mm of tool sticking out would be 83.5mm. So for steel with an HSS tool that works out to around 125rpm for steel and 200rpm for aluminium. However, using a cutter of this diameter needs quite a lot of torque, a traditional machine will belt or geared speed reduction will have this torque but a variable speed machine may be found a little lacking at these slow rotational speeds. For this reason I find it better to run the spindle at a higher speed which also has the advantage of being able to feed the work faster so the job can be done quicker. So for a direct drive machine I would therefore start in the region of 300rpm for steel and 500rpm for aluminium with a HSS bit .

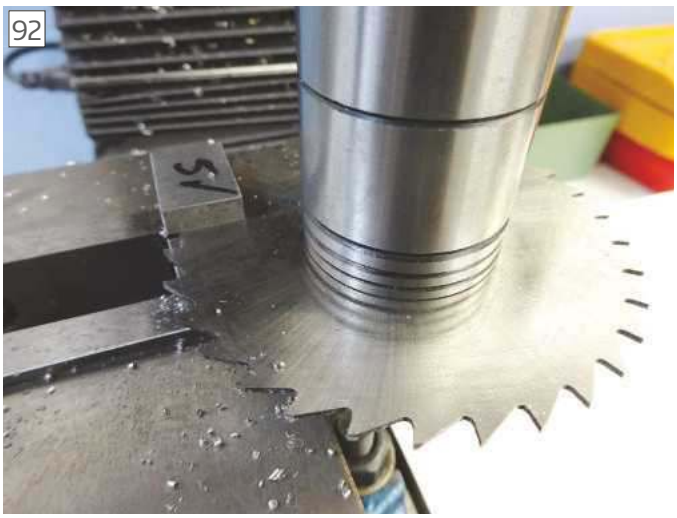
Single Point Cutters

Flycutters are really just a form of single point cutter and are generally associated with machining flat surfaces, however with a suitably ground toolbit the standard style fly cutter can make a good single point cutter for producing a variety of profiles where it may not be economic to buy a dedicated milling cutter for a one off job or the desired profile simply may not be available. **Photograph 89** shows both a raised pad with filleted internal corners and a cove moulding that would be ideal for those wanting to replicate a decorative cast engine base . One other advantage of this type of cutter is that it will remove the metal far faster than a bull nose cutter which can produce the same shape ever would. The Ogee corner moulding was also cut with a simple freehand ground tool bit. To the left of the picture are the two small bodied straight shank commercial fly cutters used to produce this sample part.

A suitable single point milling arbor can quickly be made up from a short length of bar with a cross drilled hole to suit a round HSS or carbide tool bit and a threaded hole in the end for a clamping screw. You are then really only limited by your imagination as to the shapes that can be cut. In **photo 90** I have shown some simple spline or keyway shaped cuts produced using a tool with a square ground profile, this would also be suitable for making toothed pulleys. If the tool is ground like a gear cutter then this method can be used to produce gearwheels, etc.

Safety

Finally, a word about safety, on these fly cutters and single point cutters it can be very hard to see the actual toolbit protruding from the head when it is turning at speed so keep fingers and lubricant brushes well out of the way and avoid having excess tool projection both at the actual cutting end and also the blunt end that sticks out the back. They will also throw the swarf a good distance across the workshop so use guards if you have them plus eye protection and try to arrange the direction of cut so that the swarf is thrown to the back of the machine rather than at the operator.



Part way through a full depth cut with coarse blade

Finish left on parts after completing the cut

Slitting Saws

Slitting saws can be used to cut an accurate thin slot in material that would otherwise need a very long flute small diameter milling cutter that would be too fragile for practical use. They also produce a thin well finished saw cut where there may not be sufficient material for a hacksaw cut and subsequent cuts to clean up the surfaces such a splitting an eccentric strap casting into two.

There are two types of saw generally available, fine tooth and coarse tooth. The fine ones are best suited to cutting thin sheet material or shallow cuts such as putting a slot into a screw head where it is best to have at least two teeth in contact with the work at any time. **photo 91**. For deep slots or cutting right through thick stock the coarse blades should be used due to the larger gullet being able to remove the increased amount of swarf that the longer cut length produces which helps prevent the blade from sticking or overheating which will, particularly on the thinner blades, tend to make the cut wander. **Photograph 92** shows a coarse toothed saw part way through slicing the top off a piece of 12 x 25mm stock and **photo 93** the smooth finish that the saw leaves that needs little if any further work.

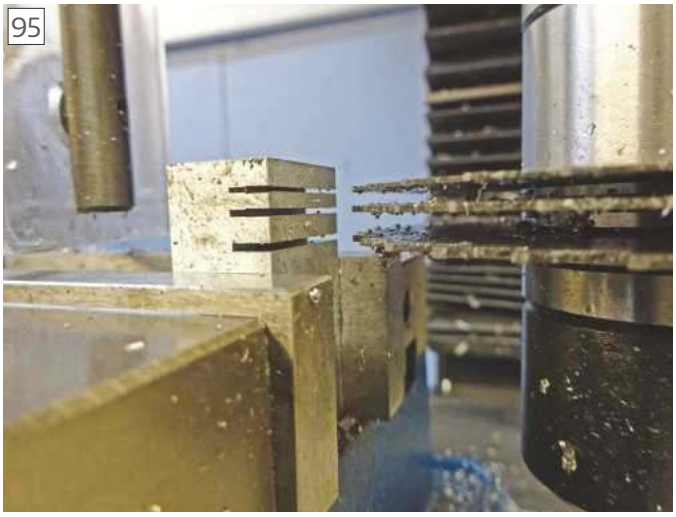
The saws should be held on a close fitting arbor but even then it is unlikely that the saw will run perfectly concentric so don't worry too much if it sounds like only part of the blade is cutting. Although a slot is provided in the saws to allow a drive key to be fitted there are two schools of thought about whether one should be used, **photo 94**. Those who don't use them say that it is preferable to allow the saw to slip on the arbor should there be a jam up especially on the thinner blades which can fracture. The other argument is that the keyway prevents the saw slipping if a heavy cut is used. This really only applies when using general purpose milling arbors which are provided with a keyway and suitable key, as dedicated slitting saw arbors don't seem to come with a keyway.

Several saw blades can also be ganged together on the same arbor to cut a series of slots. This can be a useful method for producing narrow cooling fins on internal combustion and sterling engines, where the use of a parting tool can cause one fin to deflect towards the kerf left by the adjacent parting cut. This method also suits engines with square or irregular shaped heads where the fins cannot be cut on the lathe with a parting tool. **photo 95** shows the cut from 3 blades ganged together just using the supplied spacers, for an even spacing it is necessary to turn up your own spacers to the desired thickness.

Speeds are much the same as the fly cutter being based on the diameter of the saw and again the variable speed machines will benefit from running faster than book speed. For an 80mm diameter saw of 1.0mm thickness as shown in the photos then something in the region of 200rpm for steel and 300 for aluminium will yield better results. ■

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

Arbor with key and keyway



Gang saw part

WARCO

2MT arbor Item No. 8139A **£12**

Keyed drill chuck B16 1 – 13mm
Item No. 8140 **£26**

Clamp type knurling tool
Item No. 9010 **£17.50**

Live centre
Item No. 8004
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NEW

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Selection of metric and imperial thread cutting through gear box. No more change gear selection. Only one 127T change gear necessary to switch from metric to imperial. This feature not usually found on smaller lathes.

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Power cross feed
Saddle controlled forward and reverse
Telescopic leadscrew covers
Tee slotted cross slide
Cam operated tailstock lock
Offset facility to tailstock
Bright LED light
Reversible leadscrew for left hand threading
Wide, double vee, hardened and ground bedways
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Adjustable tapered gibs to cross slide

Standard equipment includes:

Stand
Face plate
3 jaw self centre chuck with inside and outside jaws 125mm
4 jaw independent chuck 125mm
Fixed and travelling steadies
2 dead centres
Calibrated compound slide
Thread dial indicator
4 way indexing toolpost
Interlock chuck guard

Milling slide
Item No. 9628 **£130**

Centre drill set
Item No. 9053M **£10**

Indexable
lathe tools 12mm
Item No. 8947 **£79**

SPECIFICATION

Centre height	140mm
Maximum swing	280mm
Swing over cross slide	158mm
Distance between centres	600mm
Bed width	150mm
Longitudinal travel	560mm
Spindle taper	4MT
Spindle bore	26mm
Maximum tool size	12mm
Range of spindle speeds rpm (12)	45 - 2000
Range of metric threads	0.25 – 5.0mm
Range of imperial threads	4 – 96 tpi
Tailstock taper	2MT
Tailstock quill travel	60mm
Top slide travel	65mm
Cross slide travel	130mm
Headstock bearings	Taper roller
Compound slide swivel	360°
Chuck mounting	Flange
Motor	1.1kw
Power supply	240v
Dimensions L x W x H to end of handle grips	
1260 x 580 x 600mm Weight	160kg

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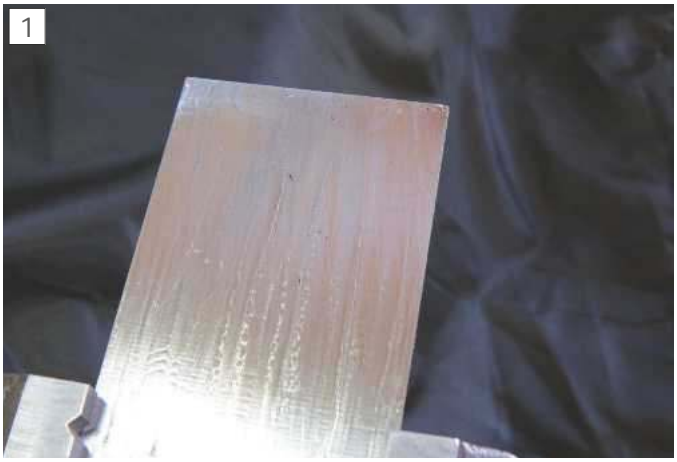
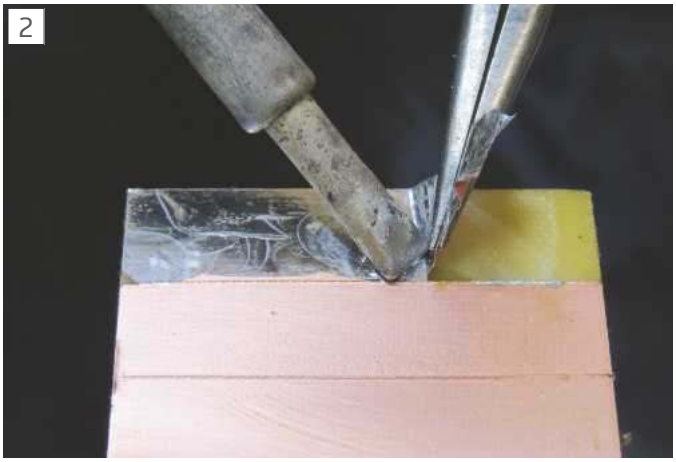
Printed Circuit Board as a Construction Medium

Alan Wood describes his unusual approach to making cases and enclosures from laminated copper boards.



Hand tinning



Copper stripping

Introduction

If you have ever tried to remove a large area of the laminated copper surface from a sheet of printed circuit board (PCB) you will know how tenacious the bonding is between the thin layer of copper and the fibre glass substrate.

This strength can be used to advantage in the fabrication of structures that emulate sheet metal but without the need for folding or welding to bond them together. All that is needed is single or double sided PCB sheet, an ability to cut to a size, flux paste, soldering iron and asbestos fingers. Using single or double sided PCB allows flexibility on whether joints are single sided or double sided. The resulting structure will be amazingly strong.

Process

1 Design your structure as if it was being made from sheet metal. Decide if single or double sided joints are needed to replace the folds on the sheet metal equivalent.

2 Copper clad board can be bought from RS, CPC etc but I would recommend a visit to a local PCB manufacturer and scrounge some off-cuts sufficient for your project needs. He will have pallets of scrap pieces going off to be recycled. Off-cuts are usually clean copper rather than tinned and will be in various industry standard thicknesses and these days are often multilayer making the material even tougher against flexing. I use 1.6mm (1/16") for my projects but it is useful to have other thicknesses to hand such as 1/32" and even 1/8".

3 Cut the PCB (either double or single sided) to the net shapes needed. These will all be flat pieces and the solder joints you will be making will replace

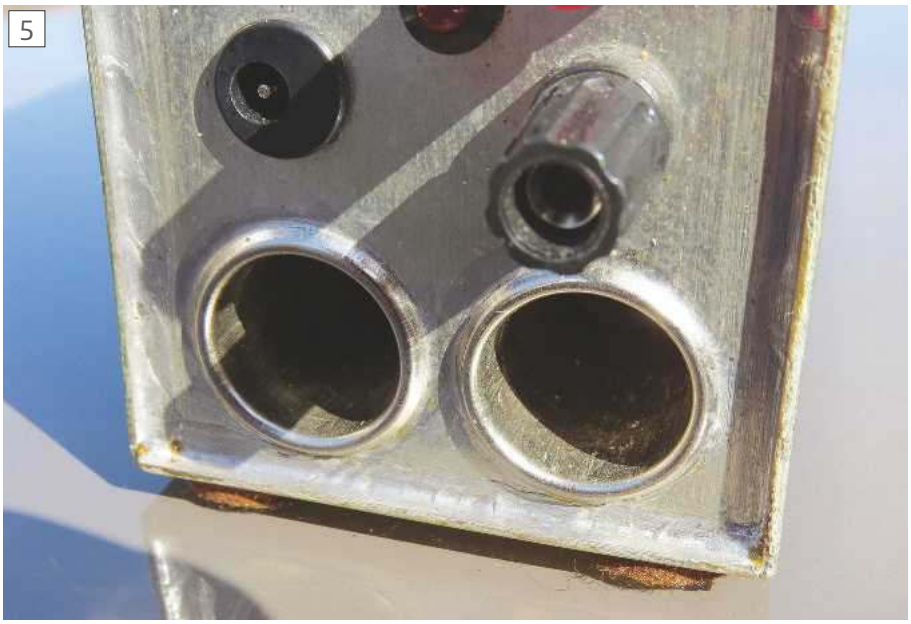
Battery box

the conventional sheet metal folds. The positive aspect of this technique is that you can get the finished article to fit exactly what you are trying to achieve. No allowances are needed for fold material etc and all holes for fittings can be made on the appropriate flat PCB sheet while still flat.
The Gabro 2M2 or similar notching guillotine is a real asset for cutting to size. The notched strips of PCB created by the guillotine blade are useful scrap to employ for ribbing.

4 Scrub clean the border surfaces to be soldered with an abrasive block or fine steel wool and then smear with flux paste. My preference is to use traditional Fluxite.

5 Tack solder the components together. I admit to preferring lead based traditional 60/40 Multicore for this work, although for regularly handled areas I suggest using lead free solder.

Front panel



Close up of front panel

Note that differential heat expansion will tend to 'pull' right angle surfaces over, so use a 123 block or similar to maintain the angle. Once tacked in place fully flow the seam joints using a large, high temperature iron bit with a copious solder feed. Keep pressure on right angle components even after tacking to avoid thermal pull over. You will soon pick up the knack for getting a smooth filet that is almost like a weld in appearance.

6 If fixings are needed (i.e. for removable lids etc) then sweat an appropriate brass nut to the copper surface on the body to pick up on matching fastener holes. Likewise, mounting holes can have larger nuts soldered in place in the manner of a sheet metal hank bush. When soldering nuts in place, hold them in position using steel screws smeared with a little MS4 silicon grease or similar so the screw doesn't get soldered into the nut.

7 Clean the finished seams with thinners or similar to remove the baked flux residues. If you want a bright finish, wash the completed joints with Swarfega or similar hand cleaner.

8 Paint and finish as required. Standard aerosol primer and finishing coats take well to the fibre glass and copper.

Other PCB Comments

If you ask the PCB maker he will quite often be prepared to tin the copper for you but some financial persuasion might be needed. This makes the look of the finished project better in that you don't have the distraction of a tinned solder seam at the edges with unfinished copper everywhere else.

The alternative is to hand tin. This is much easier than it sounds. Take the flat components of your project and scrub clean. Smear the copper all over with flux paste. Using a wide chisel bit soldering iron, simply run the iron up and down the copper in overlapping runs while feeding solder. Don't overfeed the solder or you will get ridges in the finish. It will look horrible until you wash off the flux. Best to use lead free solder for tinning, as you are likely to regularly handle the object.

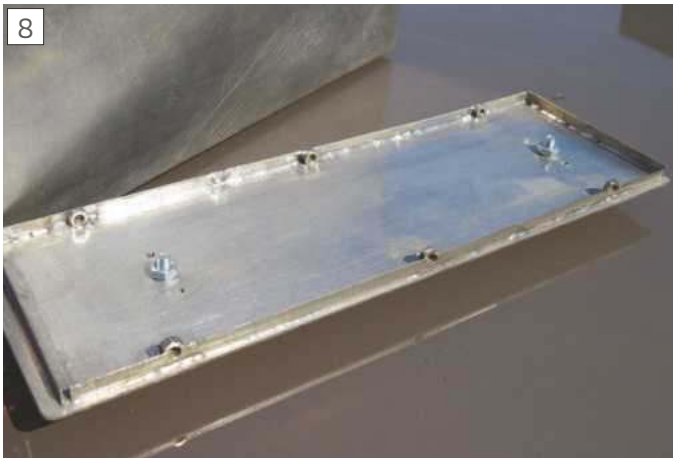
Use thinners first of all to remove the baked flux residues and then use Swarfega or similar hand cleaner to give the final polish. Once you get skilled at this process, the witness marks of your soldering strips will not be obvious after cleaning, **photo 1**.

Note this same hand tinning process can be used on home etched printed circuit board tracking. When applying solder in this way on thin tracks and lands, reduce the size of the soldering iron bit and keep the soldering iron movement high so as not to dwell and destroy the bond between the copper and fibre glass substrate.

Lid removed

›

Internal wiring



Underside of lid

If the project is electrical in nature, note that the copper surface can be easily isolated into electrical pads and conductors if required. The copper surface will, with design planning, be electrically conductive all the way through the fabrication so a negative supply return is automatically provided and the copper soldered to at any point. This is a big advantage over metal construction where there is a need to have bolted earth tags. Through links using 22SWG TCW or rivets can be used where conductivity between surfaces is not achieved in the soldered construction.

Cable forms can be held in place with a simple saddle of 22SWG or similar bridging the cable. Put some insulating sleeving on the saddle wire to stop the hot bridge wire from melting into the cable being held when soldering.

For those with engraving facilities you can engrave the front panels of projects by milling off the copper surface to reveal the contrasting bare fibre glass.

Items made with this PCB technique will be much lighter than a metal equivalent. This might be important for instance in airborne payloads. A further advantage is that the seams created in the described technique will be watertight.

Not totally related but useful to know is a technique for removing copper from PCB. With the common availability of surface mount devices (SMD) it is convenient to cut a prototype PCB as a series of lines and rectangles onto copper clad board with a scalpel or similar and to remove the intervening strips to isolate the conductors. When trying to lift the copper, if the board has un-tinned copper, the copper frustratingly tends to tear towards any nicks and come away in small pieces. If the section to be removed is tinned beforehand with the flux and iron technique it adds strength to the copper.

After tinning, lift one corner of the section to be removed and gripping with long nosed pliers, pull away from the PCB backing while slowing running the soldering iron ahead of the moving lifting point. The heat acts to degrade the epoxy bond between copper and fibreglass and the whole section will come away in one piece. Large areas can be stripped in this way but for ease of process, the strip sections should not exceed 10mm wide, **photo 2**.

Once the wanted conductors only are left on the prototype board, there will be burrs on the edges from the scalpel action. These should be scrub removed and then the remaining wanted conductors can be cleaned, fluxed and tinned as described earlier.

Definitely totally unrelated – do you have a persistent crack in a wall that no matter how many times you fill it and paint over it just comes back ? The chances are that there is some differential movement between the two sides of the crack. Cut some strips of PCB and brutally hammer them edge ways into the crack at regular intervals along the crack line. Make sure they are sub surface and then fill the crack and paint over. The PCB stops the differential movement between the two sides and the crack will not re-appear.

Constructed Example

Photograph 3 shows a universal 12V battery box completely fabricated using this technique. The box was made from 1.6mm single and double sided PCB.

The front panel is shown in **photo 4** and the zoomed image in **photo 5** shows how the 12V car socket outlets have been reflowed directly onto the panel copper.

Photograph 6 shows the lid removed and the wiring is shown in **photo 7**. Note the wiring held in place by wire saddles.

The lid is shown in photo 6 and has a nickel silver rib soldered in place onto which the lid retaining nuts are soldered as shown in **photo 9**. PCB strips could have been used rather than nickel silver.

Conclusion

The technique is clearly never going to produce items with similar strength to a steel equivalent. However, I think you will be surprised just how robust the finished items will be and how easy it is to quickly knock up custom boxes and structures using this method. ■

Nuts sweated inside lid

The Air2Go: simple and portable air dusting tools

Mark Noel shows how to create handy air-blasting tools from readily available items.

One of the most tedious jobs in the home workshop is cleaning machines and parts after a job is finished. A combination of rags, brushes and the vacuum cleaner are used to mop up the swarf, the worst debris being the fine brass dust and cast iron powder that seems to cling impertinently to every crevice. Some workshops are already equipped with a compressor and airline circuit useful for grit blasting, spray painting and for driving air tools. This article presents a project to make two portable air dusters, **photo 1**, that I have found useful for jobs such as shifting debris from tapped holes, carburettors, clock movements or model aero engines, **photo 2**. The project was completed in a day and combined a number of free, salvaged parts with a few items bought with my modest weekly pocket money.

In 2014 I rode a 125cc motorcycle to Mehamn in northern Norway, from where I hiked to the northernmost point in mainland Europe, Cape Nordkinn, a wilderness peninsular that projects into the Barents Sea. Anticipating the paucity of petrol stations on the way I invested in three Primus fuel bottles to provide an emergency provision of about 100 miles.

The completed mini air duster, left, and the maxi air duster, right. The Wolf compressor is shown fitted to the ATX power supply.

They were needed! These bottles are strongly made of thick-walled aluminium with a sturdy plastic stopper, sealed with an O-ring. One of these 1.5 litre bottles is used as the reservoir in my mini air duster. Other components comprise a Wolf tyre inflator, a DG10 air gun, an ATX computer power supply, a flexible steel-braided plumbing

Using the air duster to clean an old model aero engine.

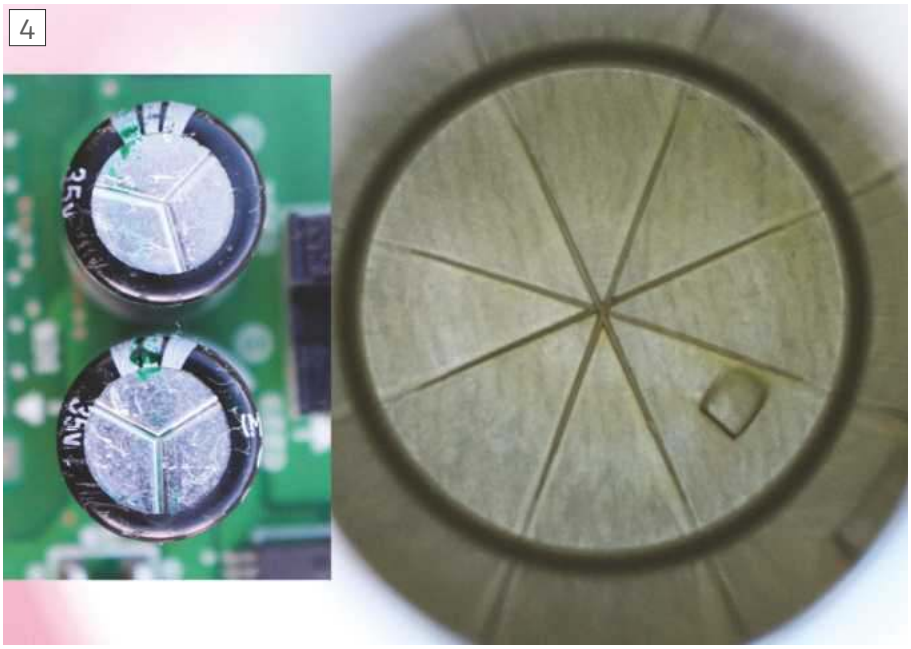
Components used to build the mini air duster tool.

'tail' and a Schrader tyre valve, **photo 3**. The last three items were salvaged at zero cost, while the remainder, including a brass collar and an aluminium plate totalled around £30. Oh, and I also spent about 10 pence on paint!

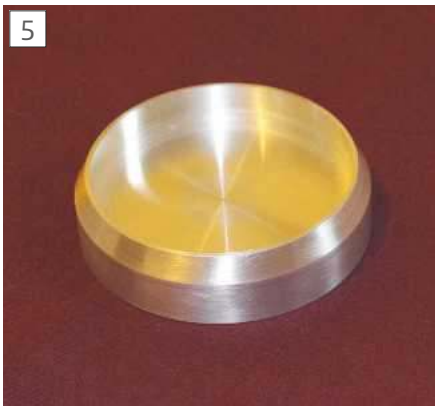
Peering into the Primus bottle, the base is seen to be pressed with an array of eight grooves which probably serve as 'burst creases', rather like those found on electrolytic capacitors where they act as a designed weak point to control a possible explosion, **photo 4**. To fortify this weakness in the bottle a 1" deep base plate was turned from 4" diameter aluminium bar and bonded to the bottom with Devcon 1 Ton epoxy, taking care to avoid bubbles in the space beneath that would compromise the support, **photo 5**. The bottle's plastic cap was modified and strengthened by removing the finger tang, then turning and fitting the two brass components, top left in **photo 6** that will sandwich the plastic cap via the M8 tang. A suitable O-ring from the scrap box shown in the photograph ensures an air-tight seal of these brass parts to the top of the bottle cap.

Final components that complete the assembly are a Schrader valve and 1" x½" BSP hexagon brass bush that connects to the flexible plumbing tail mentioned earlier. These parts enable charging of the bottle from the tyre inflator and feed pressurised air to the DG10 duster gun. At this point I had a choice of two types of valve scrounged from the local motorcycle shop. Uppermost in **photo 7** is the type bonded to inner tubes; below is the tubeless type that plugs into a tyre forming a seal. Various designs of valve insert have been devised over the years but in essence they all involve a tubular threaded part with a tapered plastic seal that screws into the rubber-bonded outer shell. This insert carries a sliding shaft with a tiny O-ring held in a cup. The shaft can be moved by a plunger to deflate the tyre, and reverses under pressure to seal the tyre via the mini O-ring. It seems extraordinary that one's life can depend on such a miniscule component!

The longer body of the tubeless type is best suited to our purpose, the problem



Burst creases in the base of the Primus fuel bottle. Inset: similar creases on the ends of electrolytic capacitors.



Aluminium turning used to strengthen the base of the Primus fuel bottle.

then being how to remove the bonded rubber? The bulk can be shaved away with a craft knife and the stubborn residue is best removed by unscrewing the internal components and then cremating the body. Time now for a vital tip! Under no circumstances burn off the rubber in the Temple of The Domestic Goddess. The fumes are persistent, and you will be found out! Instead I suggest using a blow torch or, as I did, roast the valve for one minute on the embers of the wood burner which will decompose the rubber to ash. Finally, buff up the brass body with wire wool ready for soldering, thus completing the manifold shown in **photo 8**.

In MEW 226 I described how a PC power supply can be used to provide a free or inexpensive high-current 12V source for a number of workshop projects. These units comply with the ATX standard that defines which wires and connectors are compatible with the computer's peripherals, and the manner in which the ATX unit is actually switched on. This is achieved by grounding the green 'PS_ON' by connecting it to a black earth line, **photo 9**, the unit's fan then starts and the ±3.3V, ±5V and ±12V lines become live. A small rocker switch on the ATX's case connects the unit to the mains. For more information about the ATX history and specifications visit the website listed at the end of this article.

The internals of the Wolf tyre inflator

Brass parts, O-ring and core of the Schrader valve that were used to adapt the Primus bottle screw cap (red).

Different types of Schrader valve: tubed, top and tubeless, bottom.

are quite sophisticated, comprising a 12V DC motor geared to a piston pump, a pressure sensor and control electronics for the pump, LCD panel and LED circuits, **photo 10**. The compressor input wire terminates in a plug that fits a car's cigarette lighter socket. With the decline in smoking this socket is now branded as a "12V auxiliary power outlet", with auto-makers only selling lighter modules as an accessory. This must explain why I have been unable to find a cigarette lighter anywhere on my Suzuki motorcycle.

By convention the 12V plug's centre terminal is positive, with the outer acting as ground. Take care to label the wires + and - before cutting from the plug, since in the case of the Wolf unit they are both the same shade of black. This make of compressor has no input polarity protection as I discovered to my cost when a cerebal malfunction turned my first purchase into a firework.

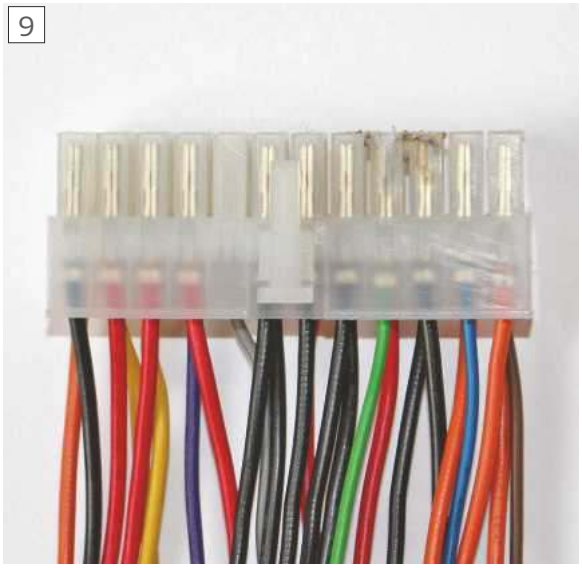
For our purposes we are only interested in drawing from the 12V output and immediately some confusion can arise. Most earlier ATX units have two 12V outputs described as 12V1 and 12V2 as seen in the upper example of **photo 11**. These two lines will be driven by separate 12V regulators which may differ slightly in their outputs, despite the fact that both deliver current to identical yellow wires on the bundle of various connectors (e.g. photo 9). Combining these lines in the hope of achieving higher net current can result in disaster, as the pair of regulators fight each other destroying the ATX supply. If using one of these older units it is best to use only one of the yellow 12V wires on only one of the connectors. Many of the latest ATX supplies have a single 12V line, presumably driven by just one monster regulator: these types can be identified by a type of label that lists only 12V, not 12V1 and 12V2, as per the lower example in photo 11. In such cases it should be OK to combine yellow wires from differing connectors to carry higher currents, although to play safe I would suggest sticking to the advice given earlier. Again, for further guidance on the matter refer to the website at the end of this article.

A few simple steps are all that is required to bring the ATX unit into service. First, cut off all the connectors with the exception of the large 24 pin one and shorten the wires to about 10cm. The ends should all be sheathed in shrink sleeve to make absolutely certain that any bare wires cannot make electrical contact, and these shortened tails can then be tucked away between components inside the power supply's case, taking care not to foul the fan. Next, do the same for the wires to the larger 24 pin connector, leaving aside

8

Modified Primus bottle cap, showing Schrader inflation valve and BSP union that connects to the braided tail.

9



24 pin ATX connector. Connect the green wire to one of the black wires (0V) to switch on the supply. 12V will then appear on the yellow wires when the mains is switched on.

10

Internals of the Wolf digital tyre pump.

11

Top: older type of ATX power supply that lists the two separate 12V1 and 12V2 outputs. Bottom: more recent supply that outputs only one 12V line.

Three low-profile rare earth magnets and four corner sockets glued to the ATX case comprise a simple detachable coupling between the pump and power supply.

The water connection manifold at the end of the Aquasystem expansion vessel.

two of the black wires (0V), the green wire (PS_ON) and one yellow wire (12V). Solder together one of the black wires to the green wire protecting the joint with shrink sleeve, thus permanently forcing the power supply to be ON whenever the mains is switched on. Finally pass the WOLF power lead into the case and solder the labelled +12V wire (black) to the yellow wire, and the labelled 0V wire (also black!) to the ATX black wire. Again, both joints must be sheathed in shrink sleeve and folded neatly inside the casing. Some strain-relief should be added at the entry point by means of a cable tie or grommet.

Now when the ATX is switched on via the rocker switch the pump comes alive and can be run by programming the set pressure and units according to the instruction leaflet. To complete this part of the project I added a simple coupling between the pump and the ATX using three rare earth magnets and locating sockets, **photo 12**. The bottle was pressure tested by filling it 90% with water then pumping to 80psi. Adding water reduces the air volume and hence the stored energy during the test, limiting the risk should an explosion occur. Happy with the result, I now operate the air gun with the bottle only ever pumped to 40psi, providing a minimum 100% safety margin. After a lick of paint, the mini air duster was completed and has been used for the smaller cleaning jobs, for example in the hands of the Domestic Goddess for dusting off her vintage doll's house interiors.

However, the capacity of the Primus air reservoir is obviously very limited and so I looked for a larger alternative as the basis for a maxi air duster. Possibilities considered included empty beer barrels, fire extinguishers, gas cylinders and water tanks but then my plumber suggested central heating expansion vessels, which are available in various volumes. These cylinders are designed to regulate the pressure within closed hot water systems by allowing the water to expand and contract against the pressure exerted by a rubber air bladder. Most of these

Gasket created by removing and trimming the rubber bladder from the expansion vessel.

cylinders are sealed units, precharged in the factory to an air pressure for a 'typical' heating circuit. However, I discovered that Aquasystem cylinders contain a removeable bladder plus a Schrader charging valve making them ideal for this application. I chose the AR24 unit with a capacity of 24 litres and maximum rated pressure of 10 bar (140 psi), more than adequate for this purpose, and available cheaply from Ebay. After removing the six bolts securing the endcap, **photo 13**, the rubber bladder was removed and trimmed to leave sufficient to form a gasket, **photo 14**. After smearing with Vaseline, the endcap was replaced using three longer bolts for attach a handle. A 2m long Draper airline hose was fitted to the vessel's port via various BSP fittings bought from my local plumbers' merchant. Finally, the cylinder was mounted in a posh stand made by cutting down a plastic plant pot, heating the rim and pressing down the cylinder to make a snug fit, **photo 15**.

All the components in the maxi air duster assembly are rated to pressures above 100 psi but in practice I find that a charge of just 40 psi is ideal for most applications. The larger unit is much easier to carry about than a heavy air compressor, does not need a mains electricity supply, and has been very useful for the removal of dust and debris from otherwise inacessible places, such as inside vintage radios, beehive frames, motorcycle engines and nest boxes. And don't forget, the air is free! ■

Resources

Aluminium fuel bottle: On ebay search for "1.5 litre Primus fuel bottle".
Pump: Search on Amazon for "Wolf digital tyre inflator" or similar products. Alternatively go to **www.ukha.tv** and search for "Wolf 3 in 1 Digital Tyre Inflator".
Aluminium disc cut from 4" bar stock: **http://www.m-machine-metals.co.uk/**
DG10 air gun: On Amazon search for "Am-Tech air duster".
Steel braided flexible pipe tail and BSP fitting: available from B&Q stores or plumbing merchants.
Aquasystem AR24 expansion vessel and Draper air line hose: find both on ebay.
Comprehensive guide to the ATX PC power supply: **http://www.playtool.com/pages/psumultirail/multirails.html**

The completed maxi air duster.

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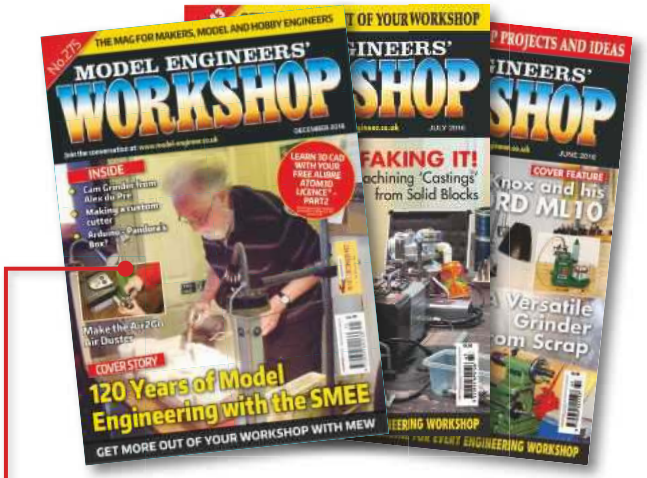

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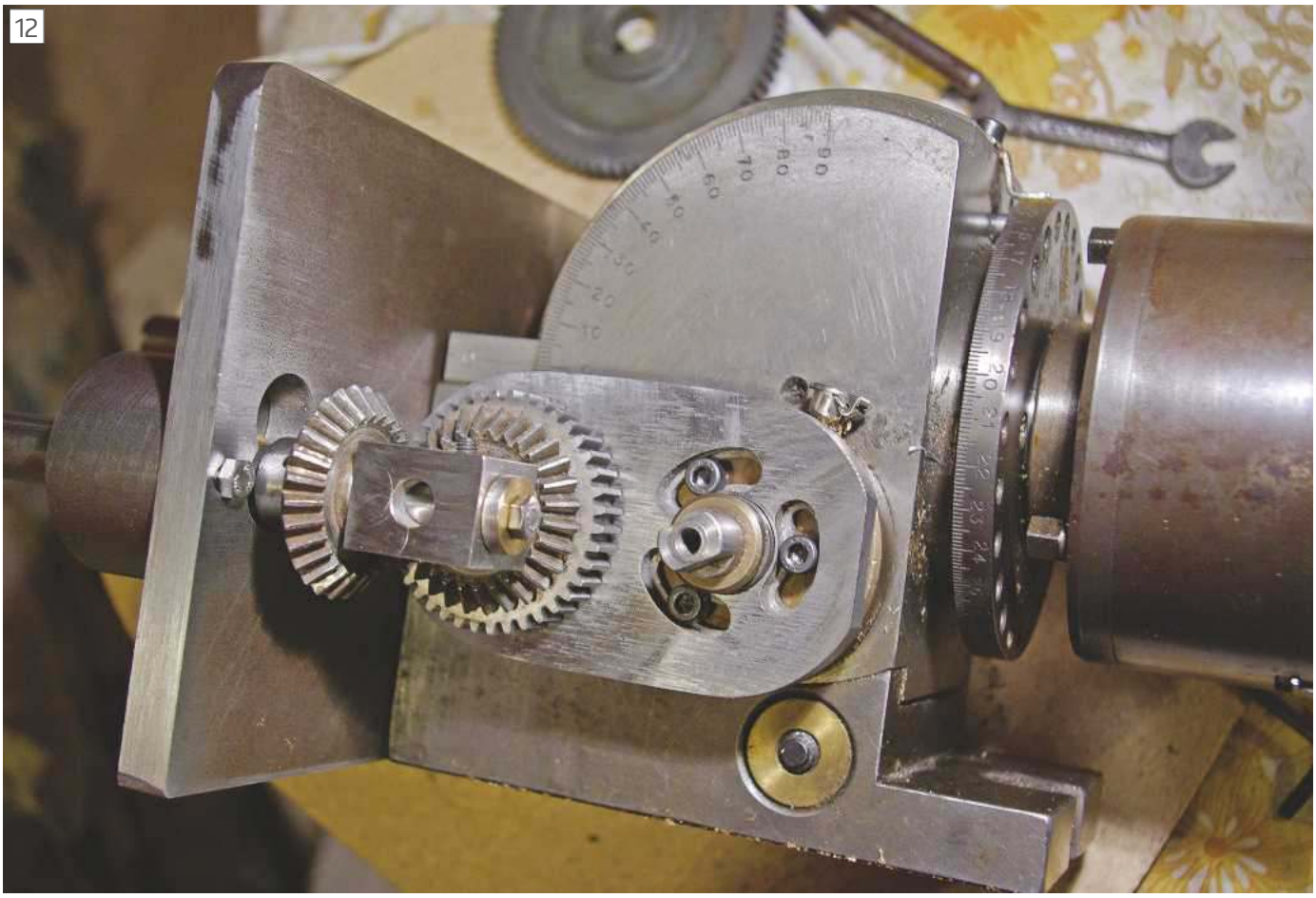
Differential Dividing

John Olsen makes an attachment to allow dividing awkward primes.



The 40 tooth gear can be removed again to nip up the mounting screws in the best position.

Assemble the bevel gear pin onto the bevel gear plate with the bevel gear and 40-tooth gear. Put the bevel gear plate on the boss on the Vertex and put the other 40-tooth gear in place. Check for correct mesh. If required, the hole for the pin can be elongated a little to give correct mesh, although of course we should ideally get the spacing correct in the first place. The gears should be free running but with very little backlash. Put the bevel gear block in place and assemble the other bevel gear and shaft onto it. Place on the bronze carrier and put the screws in loosely. Assemble the bevel gear shaft and block with the washer and screw. Again, check for free running and minimum backlash. The block determines how close the bevel gears can mesh and may be adjusted to reduce the backlash, but we also want free running so don't overdo this.

Put the main shaft in place, screwing the stud into the dividing head centre. When the shaft is assembled, it should align with the main axis accurately. I have never actually checked mine with a dial gauge, but it assembles and turns freely with the back plate in place, which is the acid test, **photo 12**. I assemble this with a little Loctite on each end of the thread for security, since if the extension shaft slips relative to the main spindle it will spoil the job.

Now a little bit of juggling. You need to slide the backing plate onto both shafts. There is some freedom in the bevel gear shaft if you leave all the screws a little loose, so it should be possible to get them both through their holes and then slide the back plate into place, **photo 13**. Once you have the back plate in place and the four screws in you can adjust the bevel gear plate up and down until everything is happily aligned and not binding. The boss can also tweak sideways to the best point. At this point you can tighten the three screws holding the bevel gear plate onto the bronze carrier. The two screws on the back plate boss can also be tightened when you are satisfied. Slip the other 40-tooth gear into place and the whole bevel gear assembly should be able to turn freely when the shaft is turned. Now put the shaft extension, the spacer, and the desired dividing plate together and slip them onto the boss. Put in the three

The block determines how close the bevel gears can mesh and may be adjusted to reduce the backlash, but we also want free running, so don't overdo this.

Table 4 Parts list

Part no	Description	Material	Quantity	Comments
1	Bevel Gear mounting plate	Steel plate 9mm	1	
2	Gear, 40 teeth, 20 DP	Steel or cast iron	2	FCMS or cast iron bar
3	Gear, 40 teeth, 20 DP	Steel or cast iron	2	FCMS or cast iron bar
4	Bevel gears	steel	2	See text
5	Spacer	BMS 50mm	1	
6	Input shaft extension	BMS 21mm	1	
7	Arm Retainer	BMS 28mm	1	
8	Bevel gear pin	BMS	1	
9	Bevel gear block	BMS	1	
10	Bevel gear shaft	BMS 5/8 inch	1	
11	Shaft end washer	Brass	1	
12	Back plate	BMS 12mm	1	
13	Boss	BMS 50mm	2	
14	Change wheel pin	BMS	2	Or use Myford items
15	Change wheel bush	BMS	2	Or use Myford items
16	Main shaft	BMS 5/8 inch	1	
17	Main shaft end boss	BMS	1	
18	Quadrant	BMS Steel 10mm	1	
19	Stud for main shaft	Steel M8 by 105 mm	1	Screw rod
20	Nut for bevel pin	Steel M8	1	
21	Washer for bevel pin	Steel M8	1	
22	Bevel plate cap screws	Steel M5 by 10mm	3	Use original Vertex screws
23	Dividing plate mounting screws	Steel M5 by 45mm	3	Cap screws
24	Dividing arm screw	Steel M6 by 75mm	1	Cap screw
25	Washer for dividing arm	Steel M6	1	
26	Grub screws for arm collar	Steel M5 by 5mm	2	
27	Grub screws for bevel block	Steel M5 by 5mm	2	
28	Screw for bevel gear shaft	Steel M5 by 10mm	1	Hex head
29	Screws for back plate bosses	Steel M5 by 15mm	4	Hex head
30	Back plate mounting screws	Steel M5 by 15mm	4	Hex head or cap
31	Bronze bushes for bosses	Bronze	2	
32	Quadrant mounting screws	Steel M5 by 15mm	2	Hex head
33	Quadrant gear pin nuts	Steel M8	2	
34	Quadrant gear pin washer	Steel M8	2	
35	Keys for change wheels	Steel	4	1/8 key steel or gauge plate
36	Collars for change wheels	Steel	2	Or use Myford items
37	Grub screws for change wheels	Steel M5 by 5mm	2	Or use Myford items
38	Screw for change wheels	Steel M5 by 10	2	Or use Myford items
39	Washer for change wheels	Steel M5 bore by 19mm	2	Or use Myford items

screws but do not fully tighten. Put on the dividing arms and their handle, and the long screw. Make sure everything is sitting happily and tighten the screws. When all is well it should all turn freely. Since it is going to be turning very slowly, it does not have to be totally friction free, but if there is binding there is some sort of trouble, most likely the bevel gear plate needs to be adjusted. Once all is well, set up your chosen gear train on the quadrant and gear the two shafts together. You can now set it up on the milling table. Set up your work piece and divide around it making marks with a height gauge, then count the number to check that you have the ratios set up correctly. Once you are happy, then you can actually cut the metal, and the scribed marks can also help to see that you are still getting the correct position when you go around with a cutter.

When dividing the normal advice is to make sure that you always go in the same direction to take up any backlash in the worm. This still applies with this device, so if you go too far, go well back and then re-approach the correct position from the original direction. To make things a bit more complex, you will want to make sure that you take up the backlash in the gears as you go around. I do this by holding the dividing plate back so that all the gears are

By always holding the dividing gear back as you rotate the input arm you should be able to always take this up in the same direction.

Table 5 Meaning of the symbols

Letter	Name	Full meaning
p	Plate	Number of holes on the division plate chosen
s	Step size	Number of divisions moved for each step
m	Main	Main shaft gear size (driver)
b	Bevel	Bevel shaft gear size (driven)
d	Direction	Sign of direction, e.g. +1 or -1
v	Virtual	Size of the virtual plate
r	Ratio	Worm ratio, 40 for the Vertex
a	Actual	Actual divisions achieved with this set-up

The backing plate is being fitted onto the two shafts.

driving it as I approach the next division hole. This does make the job pretty much like one armed paper hanging, since you are probably manipulating the dividing fingers at the same time. Some make a device that lets them lock the fingers to the plate. This would help us here, since we could lock the fingers by the pin at the old location, move the pin to the next hole, which will be by the other finger, then move the fingers again for the next hole. I have not made one of these yet but have used a simpler expedient. This involves using the dividing fingers to identify the next hole and making a mark beside it with a black felt tip pen. The pin can then be moved, and once the fingers are out of the way the old mark can be erased. You have to do this since otherwise you end up with many marks and will forget which one is the fresh one. On the backlash of the gears, remember that any error due to this will be divided by the worm ratio. If you have one degree of backlash in the gearing, this would reduce to 1.5 minutes of error in the angle on the job. By always holding the dividing gear back as you rotate the input arm you should be able to always take this up in the same direction. If your application requires extreme accuracy, use the differential set-up to make a master plate, then use a conventional worm-dividing set-up

The gears I have been cutting, no coarser than 20 DP, can be gashed out from cast iron or bright mild steel in one pass.

to divide onto the work piece using that master plate. In this way, any errors in the plate you have made will be reduced to one fortieth.

Since many of the applications for this device will involve making gears, a few words on the subject may be useful. I will not attempt to repeat what is already covered in many excellent books on the subject but would like to suggest that too many people make a really big deal out of gear cutting. Now, if you want spare gears for an automotive project, even a vintage one, then it certainly does get complex and demanding. We are not usually in a position as amateurs to harden and grind our gears or to cut them to the sort of limits needed for high speed high load applications. Bevel and helical gears obviously have their own requirements too. But for the sort of gears we are likely to want for our projects, home cut ones will often be more than adequate. I am thinking in particular of the sort of gears we want for a model traction engine, or special change wheels for a lathe or dividing project. Here the loads are such that they do not need to be hardened, and we can cut them with sufficient accuracy for our needs. The main ingredient is care and patience, and curiously enough I find the making of blanks and arbors the most tedious part. You will find that you must usually make a new arbor for each project, since they all have different bore sizes. The blanks should be a little oversize and are bored and faced in the lathe, then fitted to the arbor and brought accurately to diameter between centres. The arbor is then fitted to the dividing attachment and the teeth are cut. Since the blanks have been carefully sized, the cut can be found by bringing the cutter in to the proverbial piece of cigarette paper to find the starting point, then using the dial to feed in the correct cut. The gears I have been cutting, no coarser than 20 DP, can be gashed out from cast iron or bright mild steel in one pass.

It will be apparent that this device can only be used when the Vertex is set in the horizontal position. This limitation is also true of the Vertex differential-dividing configuration on the BS2 head. This should not be a problem in practice, since if you do require an unusual division with the head set to an angle, you can use the differential set-up to make a special plate, then use that plate with the normal worm dividing configuration. This is one reason why it was important that the dividing head should be able to be returned to its normal configuration easily.

Formulae for checking division trains.

When calculating a train, you have to make two arbitrary choices. The first is the choice of division plate to adjust from. The second is the pair of gears from the available set to give the ratio required. These do not lend themselves to putting into a simple formula, so to calculate a train follow the steps given above. Then check the result with the following formulae:

v = p * r – (p*d*m)/b

a = v/s

If the result "a" does not come out to what you thought you were going to get, check the working. **Table 4** explains the meaning of the symbols.

I look forward now to hearing of some interesting astronomical clocks using gears with really strange numbers of teeth to accurately predict the motion of the planets. ■

NEXT ISSUE

MODEL ENGINEER

- **Out and About**
  Edward George reviews the road steam scene during 2018.
- **LNWR 'D' Tank**
  Chris Rayward completes the valve gear for his 0-8-2T heavy tank locomotive.
- **Engineer's Day Out**
  Roger Backhouse visits the mills in Macclesfield.
- **Midlands Competitions**
  John Arrowsmith takes a look at the competition entries at the recent Midlands Model Engineering Exhibition.

Content may be subject to change.

ON SALE 7 DECEMBER 2018

An Ikea MT2 Holder

Mike Philpotts discovered a handy toolholder in an unexpected place!

My wife drags me around every charity shop she spots in a high street. A recent one was well worth the visit. I found an IKEA SOMMARLEK teapot warmer (Article no: 602.789.38) and it makes a great storage rack for MT2 taper tools, **photo 1**.

It costs £3.00 when new and has 35 holes in the top. These holes are dead on size (17.00mm) for MT2 taper tools. I got mine for £2.00 for two in the charity shop!

The height of the thing is just a little short to accommodate the full length of the morse taper shank so a little modification is necessary. Here's what I did. I cut the sides and determined what angle I wanted the top face to be. 20 Degrees seemed reasonable. Then I cut a piece of sheet material to the angle required and fixed the top along the edge at the desired slope. I used M3.5 nuts and screws. A few pop rivets would do the job just as well. Here is the finished result, **photo 2**, it beats buying storage racks at £20.00 or £30.00 a pop. ■

1

The Sommarlek tool holder, sorry Teapot Warmer.

2

Mike's Sommarlek in use after being extended with additional side panels.

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- Speed – 30 to 2300rpm
- Power – 1.4 KW
- Size – 1230 x 500 x 470mm
- Weight – 150kg

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Wabeco Lathe D4000

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- Centre Height – 100mm
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- Power – 1.4 KW
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On the Wire NEWS from the World of Hobby Engineering

5 Ways to Spray

Jason Ballamy looks at airbrushes that suit the needs of model engineers.

Anyone looking to buy an airbrush can be faced with a bewildering choice of what to get and if basing their choice on the fact that expensive equals best may end up with a very nice piece of kit that is sadly not really suited to their needs. For this reason, the long-established maker Iwata have come up with their "5 Ways to Spray" which breaks down their range into 5 main areas of use which makes it easier to decide of the right range of airbrushes that will best meet the users needs.

The five groups are: 1-Absolute Precision, 2-Total Control, 3-All-Star versatility, 4-Effortless Coverage and 5-Full Finish. The first two of these are not really suited to general model engineering use as they are intended more for very fine detail work which tends to use inks, liquid acrylics and dyes; these brushes would not handle the coarser pigments that tend to be found in enamels and acrylics. Full finish would be suitable for our paint types but only on sizable areas that tend to be found on the larger scale models.

That leaves categories 2 and 3 as being able to offer the model maker a good all-round airbrush as they can handle the typical paints used and cover both medium areas as well as give a fine line for small parts or weathering and paint effects.

Revolution BCR

The Iwata Revolution series falls into group 4 'Effortless Coverage' and is shown as being suitable for some fine work as well as wide but is best suited to medium coverage. There are nine different styles of airbrush in the Revolution range that start with small gravity fed, through top cup, side cup right through to bottom suction feed with single and dual-action variants. I have mentioned in previous articles the difference between single and dual-action, but briefly single action is simply press and spray where the amount of paint flow is adjusted separately and dual-action allows both paint and air to be controlled all by the finger trigger.

The subject of this review is the Iwata Revolution BCR which is a dual-action brush with a bottom suction fitting suitable for use with bottles from 1oz (28mls) upwards which will hold sufficient paint to cover a good size area without having to constantly refill. It has a 0.5mm nozzle so can handle the coarse pigments and higher viscosities of the usual enamels and acrylics as well as pearl and fine metallics. Packed in a firm foam insert inside a heavy card box with an outer sleeve the brush is supplied with a 1oz bottle and cap, lubricant and a spanner for removing the tip, **photo 1**.

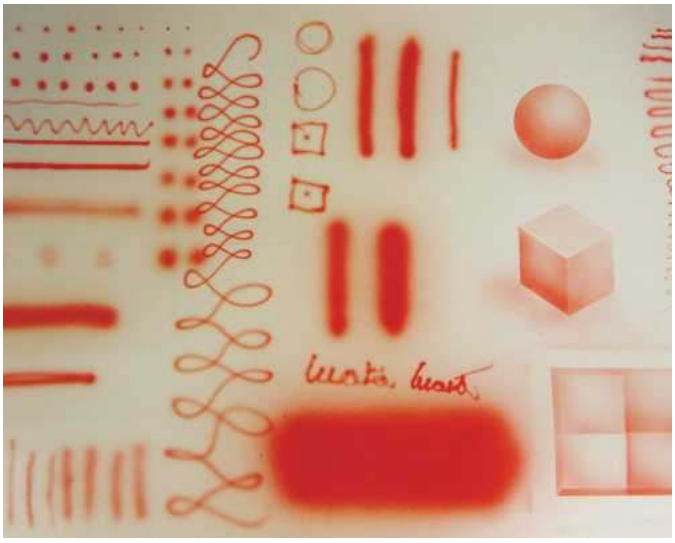
With a full bottle and the hose attached the revolution sits quite comfortably in the hand and can be used on horizontal surfaces with care but it is better if the work is angled or vertical so that you can get in closer for detail work without hitting it with the bottle or risking paint dripping out of the caps vent hole of tilted too far, **photo 2**.

I mixed up some of Precision Paints Traction Engine Vermilion enamel with about 50% of their quick air-drying thinners, set the compressor regulator to about 25psi and tried this out on some standard 80gsm copy paper. It gave good control of the paint flow from very little for close up detail work or general shading from a distance with fine even atomization, **photo 3**. With the trigger drawn back further and used at a greater distance from the sheet it was easy to fill in larger areas with an even solid coat.

It is possible to use this brush with the protective needle cap removed which makes it a lot quicker to clear any paint build up on the tip of the needle that inevitably happens though if you are not used to doing this it is best to keep the cap in place as it is all to easy to get a bit to close to the work and bend the needle.

As a test of something a little more like the surface of a model

›



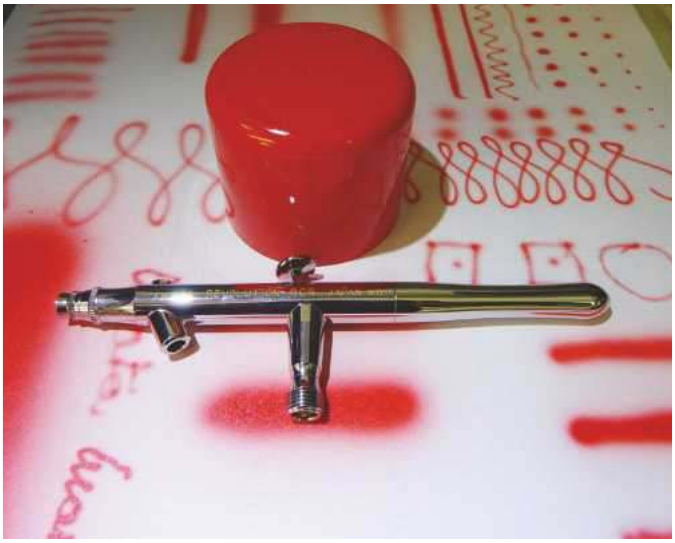
I took the clear plastic top from a spray can of lacquer and blew some paint over that. As airbrushes tend to produce much finer droplets in their spray pattern compared to something like an aerosol can it takes a little longer to build up the pigment but the quality and smoothness of the finish is worth it, **photo 4**.

This slower more controllable paint flow can be used to good advantage when painting intricate or hard to get to areas, if using a rattle can it is all too easy to get excess paint on the areas were you don't need more while trying to spray those where you want to cover, however the airbrush allows the paint to be directed to just where you need it and as the film thickness does not build up so fast there is a lot less risk of runs in the paint.

Conclusion

I was quite pleasantly surprised at the range of work that could be done with this airbrush particularly as it is placed towards the heavier end of the scale. Not only did it cover the larger areas that I had expected when initially choosing a brush to test but it also handles the fine close up and gentle shading very well. The Revolution would certainly suit someone with an interest in model making in general not just model engineering as it will do delicate weathering for small gauge loco and plastic kit modelling, custom painting for RC cars and aircraft, etc. at one end of the scale. At the other it is happy just blowing solid colour over castings or sheet metal be that for a small stationary engine up to say a 2" traction engine or 3.5" G loco.

Add to this the easy availability of spares should something get damaged or lost on the floor when cleaning, this is something you don't get with the cheap import copies. I would say the Revolution would be a good choice for an all-round jack of all trades airbrush.



For the full 5 Ways to Spray performance categories visit **https://www.iwata-airbrush.com/learn-the-5-ways-to-spray.html**

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The Revolution -BCR Retails for £125 and more details are available at **https://airbrushes.com/product_info.php?cPath=400_403_1_9_46&products_id=2**

Chester Open Day

Chester Machine Tools are having an open week on Monday the 3rd of December till Friday the 7th December. 8:30am till 5:00pm. We will have all Hobby machine on display and if you wish you can see the machine running as well. Along with Ex display machines and a bargain table with loads of parts and tools for all sorts of machines. There will be free tea and coffee available. So if you are at a loss end and looking for something to do fill free to put in. hope to see you there. **Visit http://www.chesterhobbystore.com/ for directions.**

Now SMEE is 120

Roger Backhouse marks 120 years of model engineering.

1

Haulage for SMEE's 120th anniversary Pullman dining train. The Bluebell Railway's No 65 is just two years older than SMEE! No 65 was built by the South Eastern Railway at Ashford works in 1896 (Mike Chrisp).

With a Pullman dining car lunch on the Bluebell Railway members of the Society of Model and Experimental Engineers (SMEE) celebrated the Society's 120 years in October 2018. Over the years SMEE has changed as members develop fresh interests and use techniques unknown to the founders but like Trigger's brush "with five new heads and three new handles" it's still the same organisation, **photos 1** & **2**.

Origins

SMEE was one of the earliest model engineering societies. Percival Marshall, editor of the new Model Engineer magazine, called a meeting on the 4th October 1898 to discuss forming a society for model engineers. Forty five people attended and they formally agreed to set up the Society of Model Engineers., changing the name much later to include experimental engineering. By the year end membership had reached 67 and in the following year branches opened in six British towns as well as in Sydney, New South Wales. Such was the influence of the new magazine and the need for clubs.

Members started activities quickly. They made an early visit to the London, Brighton and South Coast Railway's locomotive works. Soon after members heard a talk by W. H. Dearden describing techniques for sharpening the newly introduced twist drills.

By coincidence 120 years later a Society member, Professor Joerg Hugel of Zurich, published Twist drills: geometry and performance, a scientific study giving a detailed explanation of how these drills can work most effectively. (Obtainable from SMEE, cost £15)

2

Some of the SMEE members who enjoyed a dining car excursion pictured at Sheffield Park Station (Mike Chrisp).

Workshop

For some members the workshop is essential. It's in the basement of Marshall House, SMEE's London home since 1950. These facilities help members lacking a home workshop or needing specialist equipment providing a range of tools and equipment including some that members are unlikely to have at home, **photo 3**.

For example the Society has Jones and Shipman surface grinders and a Clarkson tool and cutter grinder in a room suitably equipped for dust extraction, **photo 4**.

Next door the machine shop has Colchester Chipmaster and Student lathes,

›

plus a Myford Super 7 B. The Tong lathe is suitable for larger work, **photo 5**. Milling machines include a Bridgeport vertical miller, photo 6, a Cincinnati horizontal milling machine and an EMCO mill. There are pillar drills, a power hacksaw and a chop saw plus work benches and some hand tools. Members have considerable interests in CNC work and a ORAC lathe was converted to CNC operation as a project using Linuxcnc and now upgraded to stepper motors.

The Society owns the prototype ML7 and Super 7 lathes, generously donated when Myford closed, but these are for display only.

A society workshop is about more than just machinery. Member Barry Taylor says "what's more important than the machines is the expertise of the members that use the equipment and how we bounce ideas about manufacture off one another. There are always competent engineers there to help each other out." Though members help each other and newcomers, the workshop isn't intended as a training facility and limited space means that only around four people can work comfortably at any one time. Barry Marshall adds "I really enjoy Thursday evenings in Marshall House whether I'm machining or not".

Talks and demonstrations

Monthly meetings held on Saturday afternoons cover a range of topics. Recent meetings have heard about 3D printing in the engineering workshop (talk given by the editor of Model Engineer's Workshop) , building a steam plant for a 9' battleship, the craft of making a replica and the life of William Fairbairn. Most are now shown on line so members don't have to travel to Marshall House to take part. There are also demonstrations including one on casting, **photo 7**.

Recent visits included trips on Thames Steam launches, courtesy of the owner Steve Bil, and to the Clockworks at West Norwood, specialists in restoring electric clocks, **photo 8**.

Part of SMEE's well equipped workshop (Mike Chrisp).

Jones and Shipman surface grinder with dust extraction equipment in a room devoted to grinding equipment (Mike Chrisp).

Digital Group

The SMEE Digital Group is a sub-group within the larger society that unites members with an interest in "digital" topics. It is now a highly popular and fast growing group. Typical Digital Group member themes are building and using CNC machines, using digital electronics within the workshop, and software for workshop and design use including modern 3D CAD applications.

One unique feature of the Digital Group is that all meetings are held online. Members use video conferencing software over the Internet to allow members to join in both formal presentation sessions and less formal "show and tell", discussion, or Q&A-style sessions. While most participants are in the UK, members join in from Europe and even a member holidaying in Australia

Tong lathe can handle large workpieces (Mike Chrisp).

Bridgeport vertical milling machine in the workshop, one of several millers (Mike Chrisp).

Noel Shelley from Norfolk demonstrates casting techniques outside Marshall House.

Society members visit historic testing equipment at Kirkaldy Works, South London.

Demonstrating the SMEE wire eroder at an exhibition. This was a group project by the Digital Group. An earlier plunger (or single access) spark eroder stands in front.

Theseus engines designed by Edgar T Westbury running at the London Model Engineering Exhibition at Alexandra Palace 2018. SMEE has displays at all major exhibitions.

participated! Members who live too far from SMEE Headquarters to attend meetings can easily be active members of the Digital Group community.

Group projects are important. These are generally undertaken by small teams comprising any member who would like to contribute. In the past these have been responsible for a digital tachometer design, and more recently a team has built a successful wire EDM (spark eroder) machine which has been shown at a number of exhibitions, **photo 9**.

Current projects are an autonomous maze-following "mouse" which is nearing completion, and a 5-axis desktop milling machine, requiring some challenging experimental work. Again, project teams communicate via the Internet using video conferencing where appropriate, allowing the maximum participation by "distant" members.

Membership

Membership is now over 450, making the society one of the largest in the UK. Members have a wide range of backgrounds from absolute beginners to professional engineers. Though most live in England membership is world wide. Women have been full members since 1943, a long time before Pall Mall clubs admitted lady members!

Library and archive

If members ever want to find that elusive back number of Model Engineer's Workshop SMEE has a full run in the library along with other major model engineering magazines. There is a good book collection and this is constantly added to. SMEE is unusual in having a Society Archivist, Ann Hatherill, to preserve and make known the rich heritage it has.

The Society's Journal is published every two months with a varied range of articles, advice, correspondence and reviews. Usually 44 pages long it has an enviable reputation for quality articles.

Experimental and model collection.

For obvious reasons models are kept off site but SMEE has acquired a collection of varied items including model stationary engines, **photo 10**, miniature locomotives, tooling, pumps, and an experimental steam turbine made by Professor Chaddock. The late Ian Bradley's workshop engine was restored by Allen Berman, the present Chairman, **photo 11**. Models are cared for by members of the Stationary Engines Committee. Specialist restoration is carried out by metals conservation students at West Dean College who have worked recently on Edgar T. Westbury's own engines.

Many members specialise in making tools and workshop equipment. Others specialise in clock making. A long running society fable has it that members spend so much time making tools they never get round to making models! While not strictly true there's no doubt many members enjoy this side of the hobby, **photo 12**.

Experimental engineering

Some members take experimental engineering seriously, a tradition kept up since the days of Jim Crebbin, a Bank of England employee who experimented with locomotive compounding as early as 1903 with his locomotive Cosmo Bonsor, **photo 13**. He knew G. J. Churchward and other leading locomotive engineers of the day, and travelled abroad extensively studying locomotive working.

Joerg Hugel is one of several modern experimentalists. Based in Switzerland he writes in the SMEE Journal particularly about electrical engineering and electronics, but readers may also have seen his beautifully made unbalance demonstrator on SMEE exhibition displays, **photo 14**.

Ian Bradley ("Duplex") was a leading model engineering writer of the 1950's and 1960's. He used this engine to power his workshop. Recently restored by SMEE Chairman Allen Berman. Part of SMEE's extensive library in the background.

Tracks

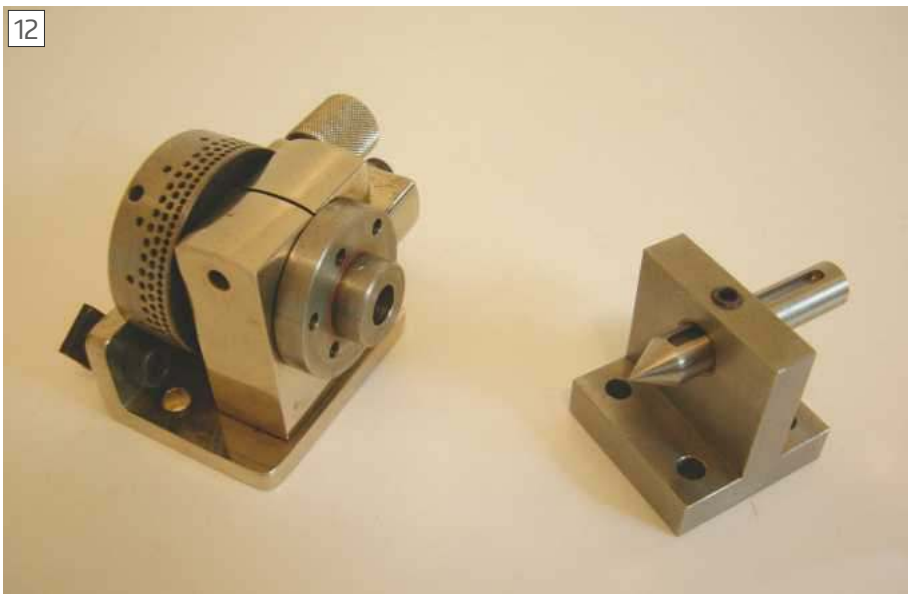
Though many members are interested in railways and build locomotives SMEE is not primarily a track operator, though it has a portable track used for local events, **photo 15**. A small but flourishing Gauge 1 group has a test track in Marshall House. The Society enjoys good relations with other clubs and sometimes takes part in their track days, notably with the Guildford Model Engineering Society. It is a member of the Southern Federation of Model Engineering Societies.

Training

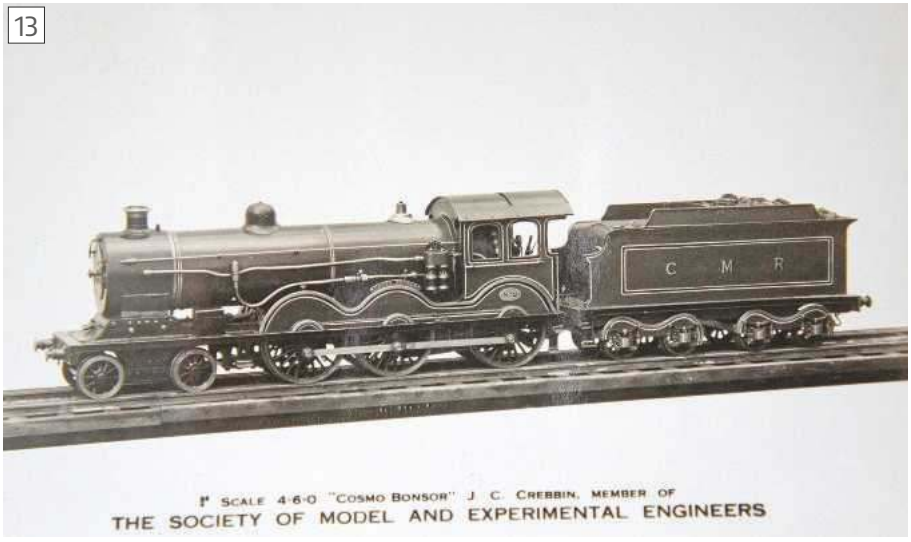
SMEE is near unique among model engineering societies in running training courses. It runs the Basic Model Engineering course over three Saturdays from February to April to introduce model engineering techniques. It follows with the Part 2 or Polly course where students are shown how to make Tubal Cain's "Polly" stationary engine, **photo 16**. These have introduced over a hundred students to model engineering, **photo 17**. SMEE also runs a milling course and a tool grinding course (this being a practical course is for members only), **photo 18**.

Given the growing interest the Digital Group has run training in Computer Aided Design using the Fusion 360 CAD tool. This is interactive using video-conferencing software and this sort of development looks to extend its reach vastly.

SMEE plans more one day courses. The latest course was aimed at new owners of steam locomotives and covered boiler



Indexing unit and tailstock for a Cowells Mill made by Mitch Barnes. Many SMEE members enjoy making tooling or workshop equipment (Mitch Barnes).



At one time probably the best known model locomotive in the world. SMEE's Cosmo Bonsor was built as an oil fired tandem compound 4-4-2 by founder member Jim Crebbin to test ideas about compounding. It will be displayed at a major exhibition in the National Railway Museum in Autumn 2019.

An unbalance demonstrator created by Professor Joerg Hugel of Switzerland, one of many items of experimental and demonstration equipment built by members.

One of the Society's youngest members Edward Crabb driving on the Society's portable track at a local festival in South London. Edward is now a fireman on the Talyllyn Railway.

Polly model made by a student on the Society's training courses. Well over a hundred students have learned basics of model engineering through SMEE.

Norman Billingham demonstrates silver soldering on the Polly course. SMEE is known for clear demonstrations with on screen projection of close-ups. (Richard Dedman).

Basic milling demonstrated by Roger Woollett. Training and demonstrations are carried out by enthusiastic volunteers.

management and maintenance. Feedback suggests it was well received.

Future

Current Chair Allen Berman says "We're proud of SMEE's history but we remain a welcoming and forward looking society . Member use techniques unheard of 120 years ago but our commitment to craftsmanship and learning together in an enjoyable atmosphere has never wavered. SMEE can look forward to another 120 years."

Thanks to SMEE members for help with information and photos. For information about SMEE please see the website or write to:

SMEE, Marshall House,
28 Wanless Road, London, SE24 0HW
Website **https://www.sm-ee.co.uk**
Membership Email memsec@sm-ee.co.uk

Look out for the SMEE teams who have stands at all major model engineering exhibitions.

Further information

One hundred years of Model Engineering: the Society of Model and Experimental Engineers 1898-1998. Published by SMEE. 1998. ■

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Arduino: Pandora's Box or Cool Box of Tricks?

Chris Gabel weighs up this popular approach to embedded electronics in the workshop.

In recent years MEW has covered several items featuring the Arduino family of mini- computer boards. The response to this is varied with a few suggesting Arduino bears little relevance to Model Engineering. Others have taken on the challenges of new processes and methods.

In this article, I will aim to see whether using Arduino within model engineering is a game too far or is a new resource to be embraced.

The task I had in hand was quite simple. I wanted to add a power lift to my XJ25 mill, **photo 1**. I did not have hanging space behind the mill, which precluded hanging counterweights down the back. Additionally, I have a CNC conversion in mind for some future time. This pointed me towards using a stepper motor as the lifting method. I acknowledge that this is probably the least economical method of powering the Z Axis, but given future plans, I deemed it a worthwhile expense.

I did have an understanding of a stepper motor system, gained from the leadscrew control I had attached to my 10" lathe. I knew I was into building a simple system comprised of a power supply, stepper motor driver, stepper motor, the mechanical connection to the mill's Z axis leadscrew, as well as a box to put it all in. But what about the basic control for the stepper? How do I start and stop the motor, change its direction and control the speed of ascent and descent?

My favoured stepper motor supplier is CNC4U. They have a Youtube video of a stepper motor lifting a 50kg weight up and down...exactly my task. **(https://youtu.be/-G2N-LaIu48)**. I phoned for advice and asked how to control the system without spending huge sums on CNC software. The reply was "It's easy. Just stick an Arduino on it." Right. I neither write code nor program. So, was this whole project a non-starter?

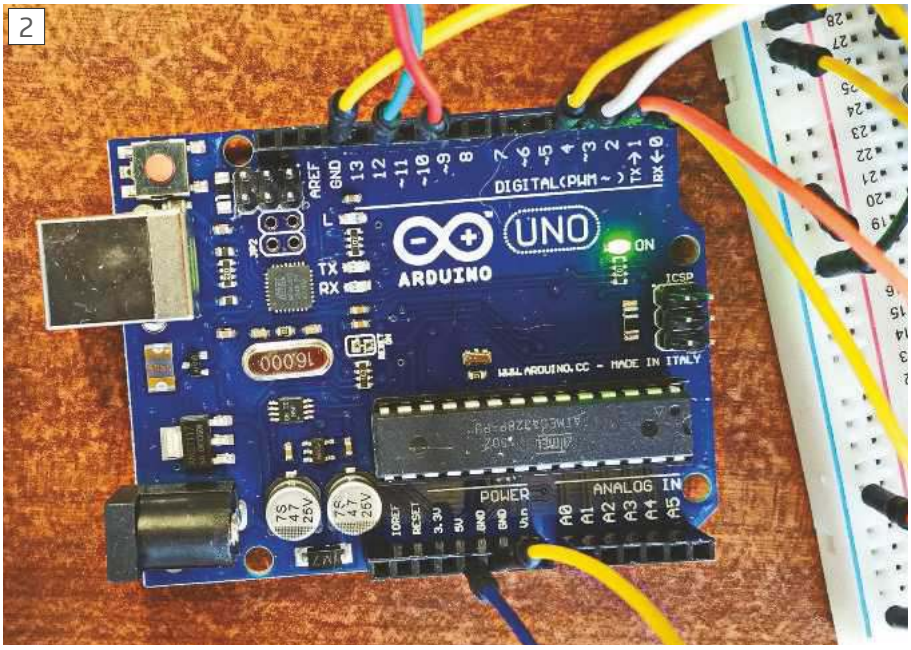
I did not want a whole new skillset to learn but thought I would give it an hour's reading time.

Stepper motor lift for mill Z axis

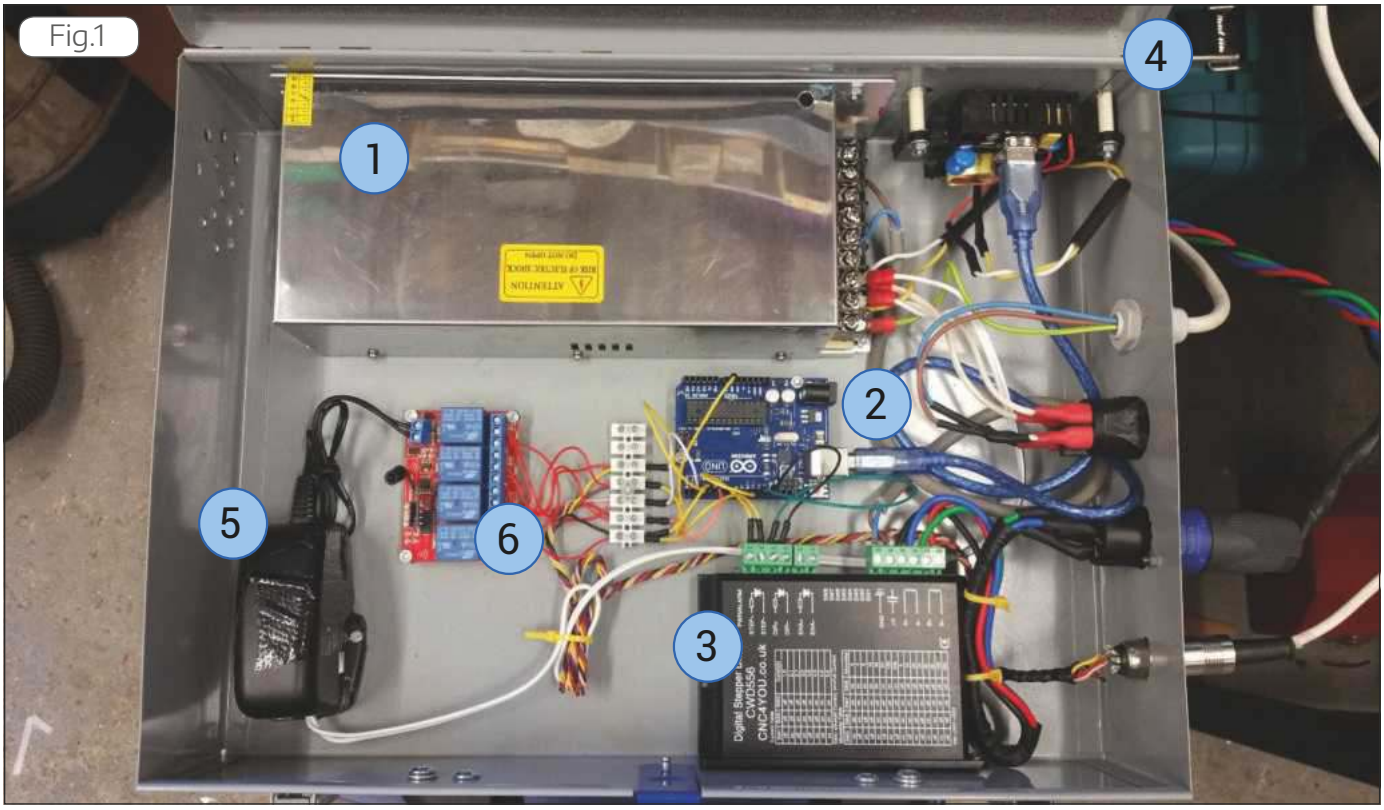
I found the whole Arduino project was designed as a teaching/learning system. It originally was conceived as a system that would rekindle the excitement and push for technology, control technology and computing that was put into the schools in the 1980's. 35 years later the web has evolved and now provides a superb way to learn and experiment. In a few minutes spent on the Arduino Website I understood the vocabulary and basic parts of the system. I simply had to download the Arduino PC software **(https://www.arduino.cc/en/Guide/HomePage)**. All the instructions and "how-to" were right there and were highly accessible.

Next, I needed to find how to make my mill go up and down. This brings in Google. A search for "Arduino Z axis control" produced many hits. I found an exact application that did exactly as I needed: Up fast, Up Slow, Down Fast Down Slow with top and bottom safety stops, all controlled by 4 buttons. And not only did it match but the program was already written and could be downloaded to the Arduino IDE site residing on my PC.

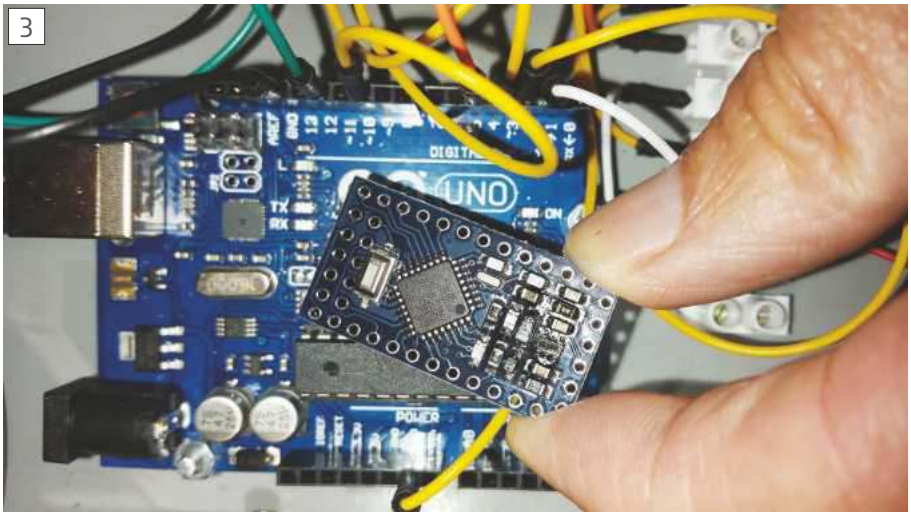
I bought an Arduino Uno, **photo 2**, which is the standard development board



Full size Arduino and breadboard



Control box components



Pro-Mini compared to Uno

most people start with. The Z Axis Control Youtube video said the author had used a very small Arduino called a Pro Mini So this was purchased as well, **photo 3**. The Pro-Mini is spectacularly miniaturised version of the Uno. It so small it even requires add-on boards to program. But all the easy to use bits have been stripped out. It is part of the Pro Series because advanced skills are needed to work with it. Great for miniaturization, but not for a first go. So right away we have an "not easy to use" hurdle and I feared that the tiny Pro Mini and its add-ons put it out of the easy to use category. I therefore rejected using the Pro-Mini, having read earlier that the full size Uno can be substituted for a Pro-Mini. It is a pin for pin replacement and worked on the first try. Connections were easily made on the larger Uno.

The usual project flow is that you build the system using a breadboard and jumper wires to see if it works. As there are only a dozen connections in the whole project, I built it, breadboard style, on my office desk and all functions worked as planned the first time. The next step was to find or build an enclosure suitable for the workshop environment. I found a ready-made box from ToolStation, **photo 4**. It is their middle-sized screw sorting case, and can contain the power supply and ultimately all three stepper motor drivers when I implement the full CNC system.

Figure 1 shows everything fitted into the case:

1: Ready Built Power Supply Unit 240 400W PSU 36V 11Amps
2: Arduino Board Uno Rev. 3
3: Digital Stepper Motor Driver
4: 240 to 5 volt USB charging module (for Uno)
5: 240 to 12 volt wall plug transformer for wireless relay module
6: 4 Channel Wireless relays

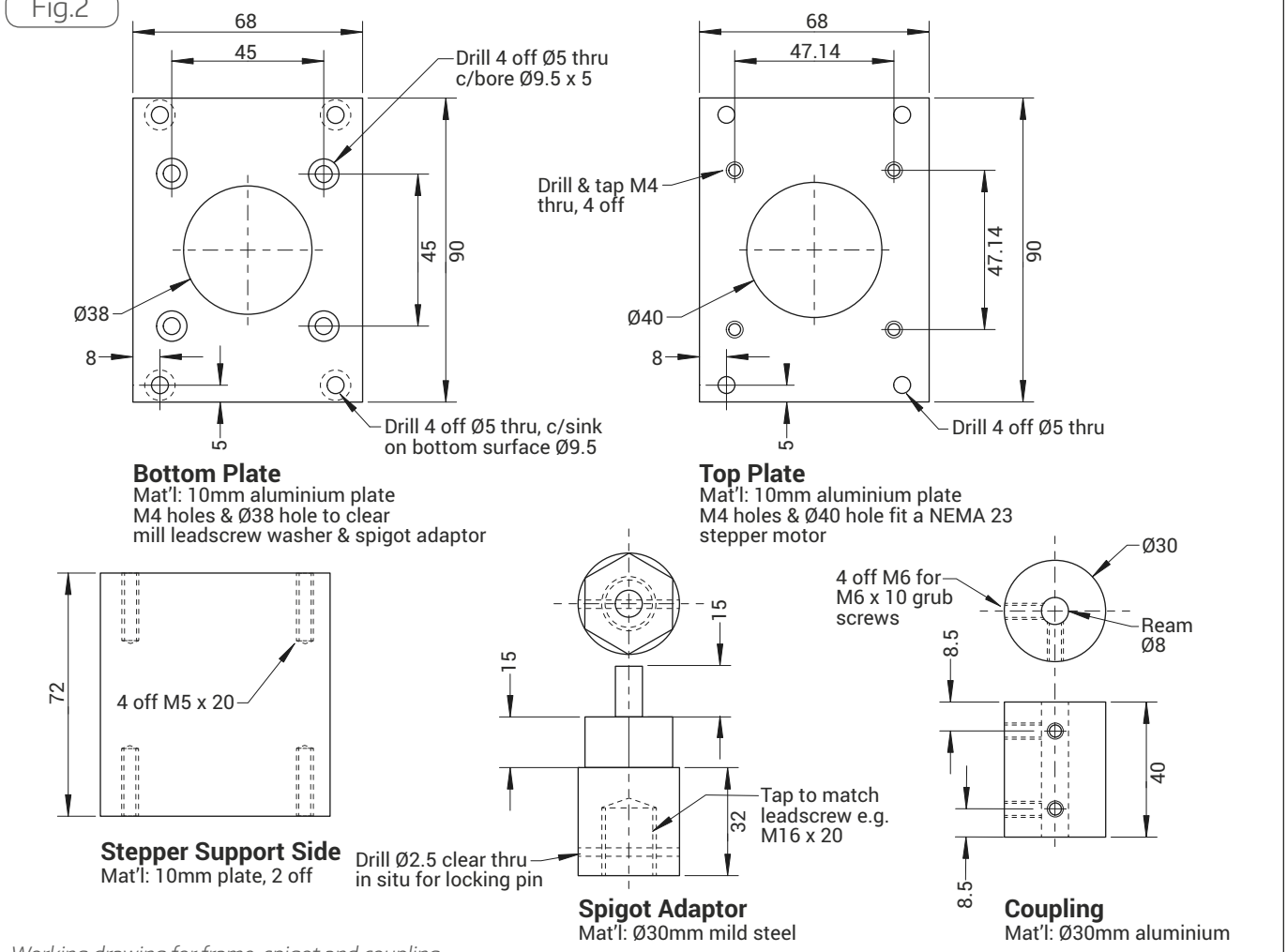
Powering the Arduino was quite simple. The Arduino can be powered using 5 volts dc directly to the board, or through the USB connector. I chose the USB connector. It is now common to find domestic wall outlets with USB charging ports built in. Inside this wall outlet is a 5volt power supply module. It is quite robust as it is designed to be "always on". If the wall outlet is disassembled, the module can be taken out as a free-standing unit. Alternatively, a USB plug-in wall charger works as well.

Note: The main Stepper PSU, the 12volt supply for the wireless module, and the 5volt USB supply are all connected to mains 240 volts. Make sure modules are insulted properly and that connections are sound. If you are unable to do this, find a competent qualified person.

Hardware: The stepper motor is quite easy to link to the Z axis leadscrew, **fig. 2**. Before modification, the leadscrew itself is held in place in my mill column with just one nut and washer, running in place supported by thrust washers. It extends about 20 mm above the top block of the column. It is necessary to replace the nut with a threaded spigot which screws onto the leadscrew **photo 5**.

It is tightened in place as was the nut. Once tightened, it is possible to cross drill the spigot to enable fixing of a locking pin, holding the spigot and leadscrew tightly together, **photo 6**. Note- on this mill, the z axis leadscrew is suspended from the nut and thrust washers and top block on

Fig.2

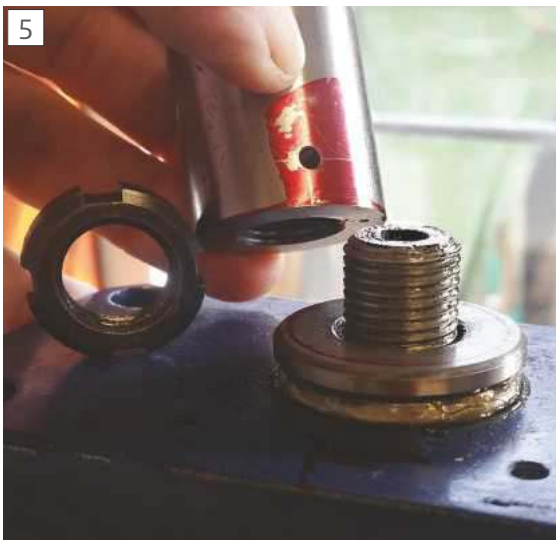


Working drawing for frame, spigot and coupling

4

Controller

5



Spigot attachment to the z-axis leadscrew

the mill column. If you undo the nut, the leadscrew and mill head will fall. Clamp the head and support it so this cannot happen.

After the spigot was in place, I made a coupling. The stepper shaft was ø8mm as was the spigot shaft. This meant a coupling could be easily made from ø30mm aluminium. I drilled and reamed the central hole. I drilled and tapped 2 M6 holes for each shaft, spaced at 90 degrees to each other. The holes were tapped M6 to receive M6 x 10 grub screws. The motor was coupled temporarily to the spigot shaft. This enabled height measurements to be determined for the stepper support frame. All 4 pieces of the support frame are made from 10mm aluminium plate stock.

As shown in **fig. 3**, connections are few, and straight forward and are described as follows:

Power Supply:
in: 240volts AC. Ground to controller box.
out: 35volts DC
"Common" goes to Stepper Driver "Ground" Terminal.
+V goes to Stepper Driver +V. terminal.
Arduino

Output pin 2 goes to one side of the Up Fast pushbutton
Output pin 3 goes to one side of the Up Slow pushbutton
Output pin 4 goes to one side of the Down Slow pushbutton
Output pin 5 goes to one side of the Down Fast pushbutton
The other side of each momentary pushbutton should connect to the Arduino ground when pushed. The pushbuttons were fitted in a project box, **photo 7**.
The Up Emergency Stop microswitch is normally open with one side connected to Arduino ground and the other to Arduino pin 7.
Down E Stop is connected to ground and pin 6.
The Arduino tells the Stepper Driver what to do and does this with 4 wires.
Arduino ground is connected to Step- and Dir-.

Step+ is connected to pin 10.

Dir+ is connected to pin 12.

Note that the Stepper Driver itself is controlling the DC voltage which comes from the Power Supply. The Stepper Driver GND is connected to the common terminal of the power supply. V+ is connected to V+.

Limit switches also function as emergency stop switches. Position a micro switch, in the normally open state, so that it is activated if the mill head goes up too high. The down limit switch is more problematic as it needs to be adjustable to be of use, as tooling can vary in length and position.

While still believing in "can't program won't program", when you download the Z Axis Sketch or program, you can see the lines of the program on the IDE editor. It is helpful to know that the first few lines of the program sketch always define the pin connections on the Uno. This makes a good check to see if you connected it correctly. **Photograph 8** shows how connections are defined in the Arduino sketch.

The stepper motor is configured as parallel bi-polar. There are 4 sets of paired wires, and these attach to the Stepper Driver A+ A- B+ and B-. Follow the diagram which came with your particular stepper motor. These are then connected to the A+ A- B+ B- terminals on the stepper driver.

I use quite heavy 12amp automotive wire, twisted together to form a robust cable.

8

ZAxis | Arduino 1.8.0

File Edit Sketch Tools Help

ZAxis

```
#include "TimerOne.h"

// Define the inputs and the outputs
#define UPFASTBTN 2
#define UPBTN 3
#define DNBTN 4
#define DNFASTBTN 5
#define DNSTOP 6
#define UPSTOP 7
#define PULSE 10
#define DIR 12
#define LED 13
```

Segment of Arduino program

This is visible in. I connect the cable to the control box using 4- conductor NL4FX Speakon connectors which rotate and click into place. Available from Farnell, Rapid Online and RS, both can be seen in photo 1.

Wireless: The mill goes up or down when a pushbutton connects the appropriate pin to negative or ground. However, there are inexpensive wireless relay units on Ebay which I could not resist. You push the controller keypad, **photo 9**, and a relay closes. It is simple to make that relay connect a designated wire to ground. So, by replacing the four pushbuttons with the wireless relay unit, hey presto, wireless remote control. The unit has considerable range, with the keypad able to make the mill move from three houses away down the block. Interesting, but obviously not very practical. A 12 volt wall transformer provides power to the relay module. This frivolous after-thought of making the control wireless has turned out to be one of the most convenient aspects of the system. Just up and down, no wires and the controller is always at hand!

6

Cross-drilling the spigot

7

Wireless and wired controllers

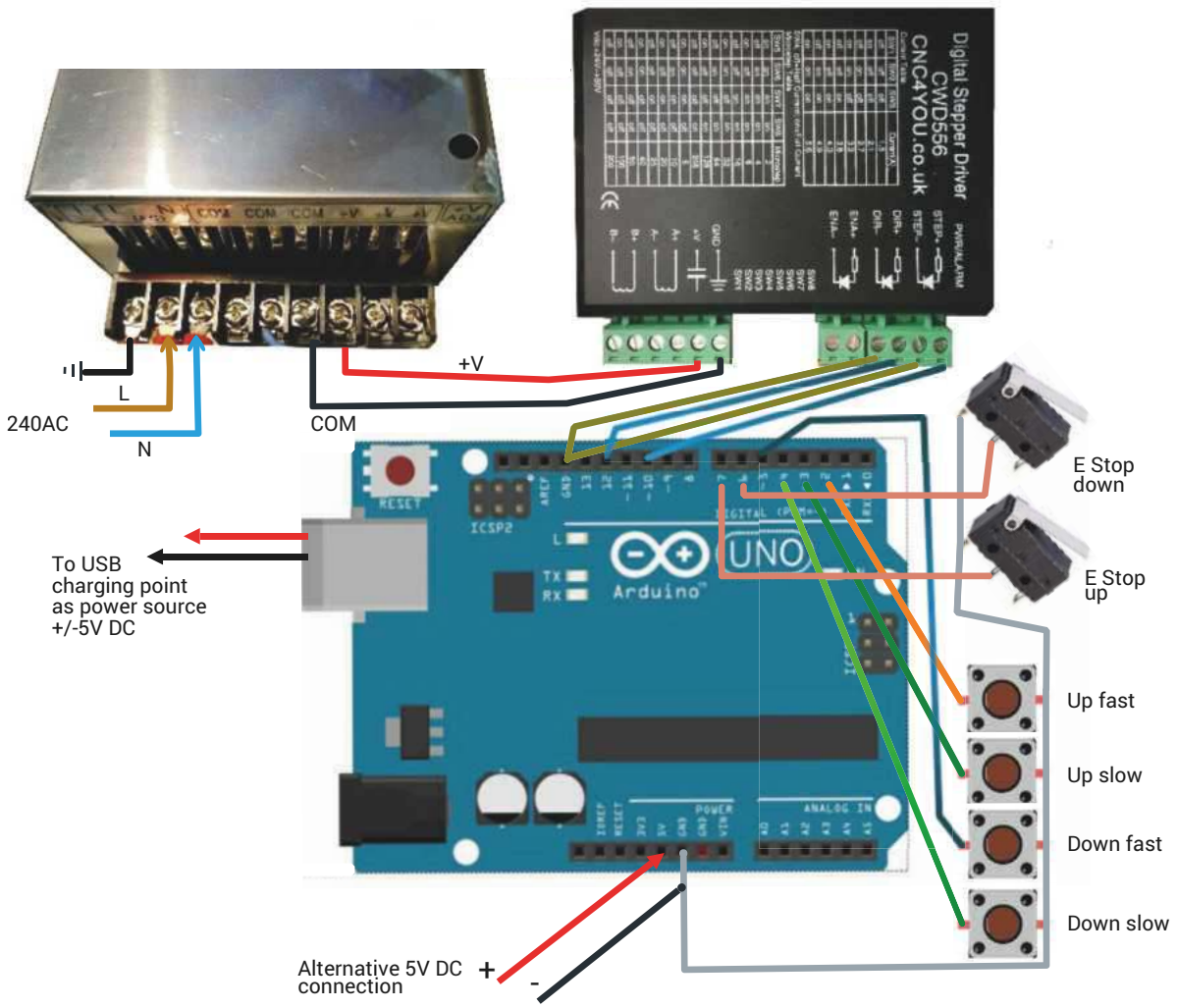
Conclusion

If you have a highly unique or complex control problem to solve, then that requires code writing and programming and that gets Geeky very quickly. It is definitely phone a friend time if you do not have those skills. I am told by power users that complex programs and applications are not always robust, and they often carry a spare programmed Arduino board, just to be sure.

However, using the Arduino as a simple controller is quite easy if you have an "off the peg" application or problem. It is inexpensive too, with an Arduino Uno starter kit containing all the parts I needed for under £12. If you are good at Lego Technic, you can make Arduino work. It may require good problem solving if your connections are dodgy or a wire comes loose. An understanding is needed of how powerful searches are on Google and how Google can supply answers to troubleshooting as well as just source materials and parts. An integral part of programming the Arduino Board is your home PC. So, it is necessary to know your way around the basic settings on your home computer. Information, help and online instruction are bountiful.

To answer my original question, making sophisticated, complex workshop robotic devices would be a step too far, requiring serious amounts of time and structured approach to learning code. But

Fig.3



Pin connection circuit diagram showing pin allocation

for simple control applications, Arduino is an economical and easy to implement solution. It is an excellent system and is easy to use, for at least simple control applications. ■

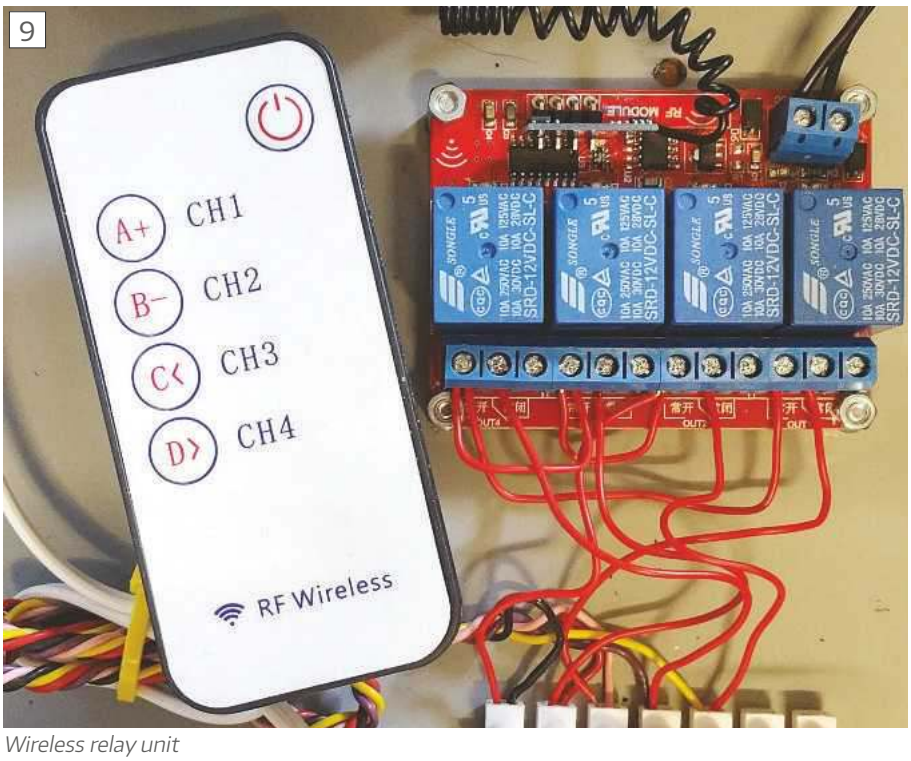
References

CNC4YOU
PSU: 400W PSU 36V 11A CNC Power Supply Stepper Motor
Product Code: 400W36V/11A
Stepper Driver Digital DSP Stepper Driver 5.6A, 50V CWD556
Product Code: CWD556
Stepper Motor 4Nm Nema23
Product Code: 60BYGH401-03

TOOLSTATION
Metal Case: Large Screw Case Single 440 x 330 x 66mm

Moore-Duino.co.uk
UNO Rev3 Board with Basic Essentials Starter Kit

Web and Youtube :
Z Axis Controller replacement - YouTube
http://msraynsford.blogspot.co.uk/2014/03/z-axis-controller-replacement.html



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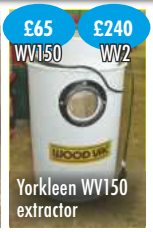

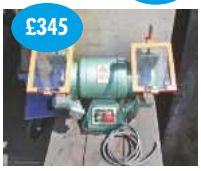

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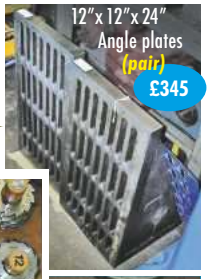

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