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- VFD for a Warco Lathe
- Convert a Wood Lathe to a Metal Lathe

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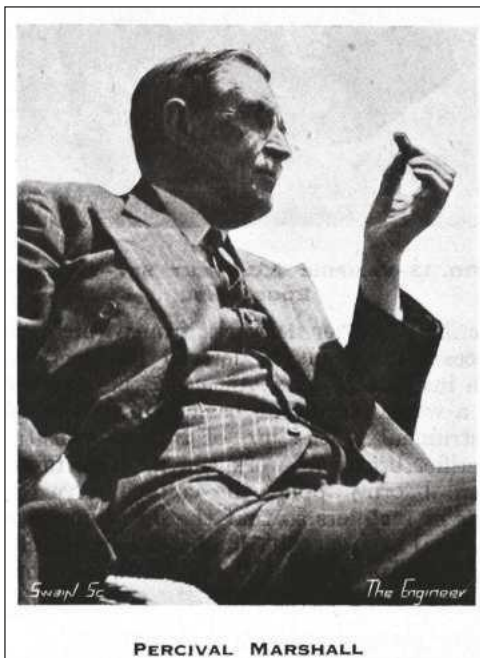
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On the Editor's Bench



Percival Marshall

This year marks the 60th anniversary of the death of Percival Marshall, this offers an opportunity to introduce some of the more recent converts to our hobby to this remarkable man.

Percival Marshall received lengthy obituaries in both his own magazine and the engineering press, evidence of how he was held in high regard across the engineering profession. Indeed, he was good friends with many of the leading engineers of the first half of the twentieth century. Here is a reduced version of his obituary in the *Journal of the Institution of Mechanical Engineers*:

PERCIVAL MARSHALL, whose death occurred on 10th April 1948, was well known in engineering circles and to an even larger section of the general public as the editor of "The Model Engineer", which he founded fifty years ago. During this long period, he made important contributions

to technical journalism and, moreover, by his enthusiasm did much to foster the art and science of model making.

He was born in London in 1870 and at the age of fourteen won a Mitchell scholarship at the Finsbury Technical College, where he spent two years in the mechanical engineering department under Professor Perry and obtained the College Diploma.

He continued his technical education at the Birkbeck Institute, the Manchester Municipal College of Technology, and at Owens College, Manchester, and subsequently gained practical experience in the shops of various firms, including Messrs. Alfred Herbert, Ltd., of Coventry.

After a period in the drawing office of Messrs. R. Furnival and Company, he returned to London to assist his brother in the manufacture of dynamos, motors, and arc lamps. But soon afterwards he went to France in order to obtain further practical experience and for some months was employed as a lathe hand in the works of Messrs. Hermet and Miquet. On his return to this country his thoughts turned towards journalism and he accepted an appointment as sub-editor of "The Hardwareman", one of the publications of his uncle, Sir Horace Marshall's firm. Later he became editor of "The Photographic News", and in 1898 published the first issue of "The Model Engineer". Since then his firm has produced numerous books on engineering and subjects connected with the workshop, which have proved their value to model makers and to those concerned with small engineering works. Other technical publications, which owed their inception to him, were "The Woodworker", "The Fine Art Trade Journal", "Experimental Wireless", and "The Engineer-in-Charge".

He was the founder, in 1898, of the Society of Model and Experimental Engineers, an event which led nine years later to the holding of the first Model Engineer Exhibition. In addition to all these activities Mr. Marshall took a leading part in the creation of the British Association of Trade and Technical Journals. He was also keenly interested in the work of the Junior Institution of Engineers and from 1900 to 1902 held office as Chairman of the Council.



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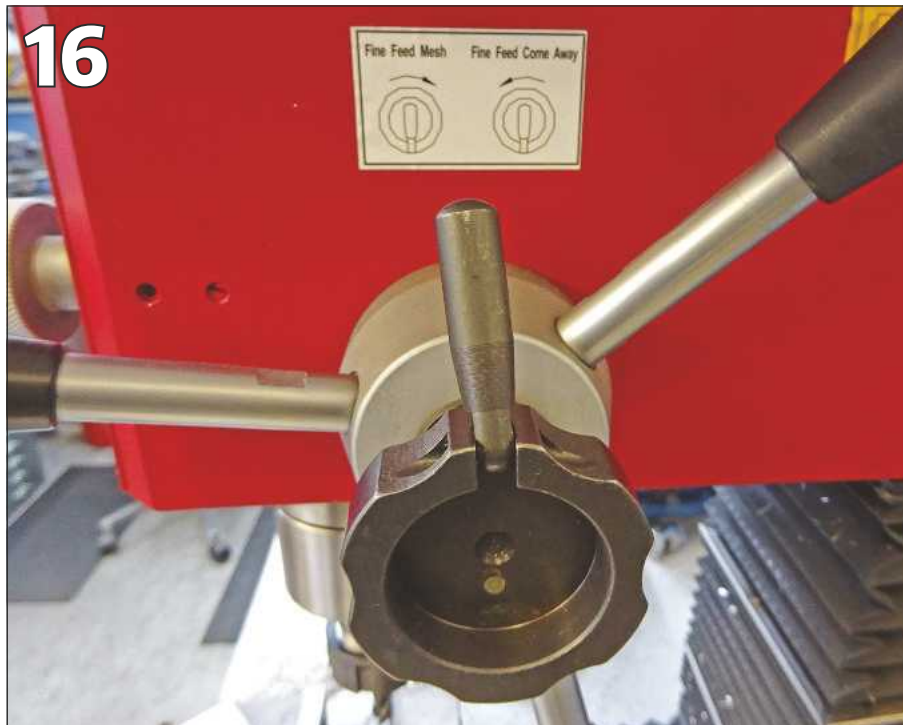
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in our next issue

Coming up in our next issue, MEW 272 another great read.



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ON THE COVER >>>

This month's cover features a Bridgeport milling machine with a large raising collar on the column. The job it is tackling weighs about 250kg! For more information on this unusual workshop task, see Ian Howitt's article Abuse to innocent Bridgeports on page 48.



HOME FEATURES WORKSHOP EVENTS FORUMS ALBUMS

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THIS MONTH'S BONUS CONTENT

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This month you can download a free plan for Bill Morris' Differential Screw Micrometer Head.



Any questions? If you are a beginner and you have any questions about our 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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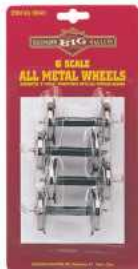
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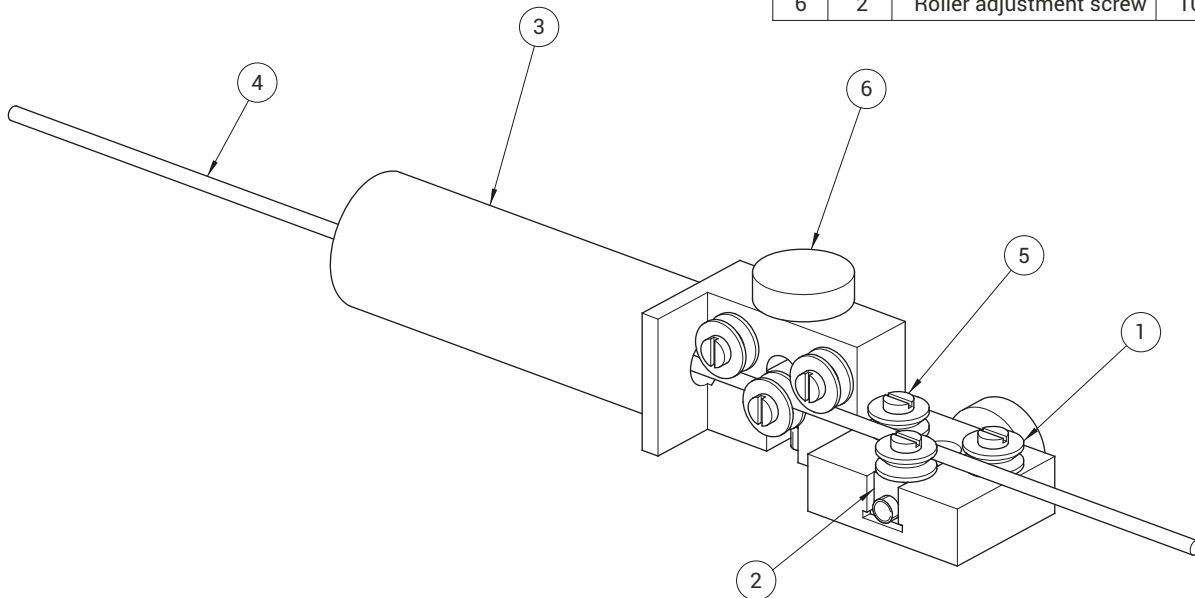
A Wire Straightener



This step by step guide from Mogens Kilde describes the construction of this useful device.

Fig.1

Component list			
I.D.	Qty.	Name	Part no.
1	6	Straightener roller	1026-01
2	2	Roller bearing	1026-02
3	1	Tool base	1026-03
4	1	Wire	-
5	6	Roller shaft	1026-05
6	2	Roller adjustment screw	1026-06



Often when you are working with soft wire, the wire needs to be straightened in order to obtain a satisfying result.

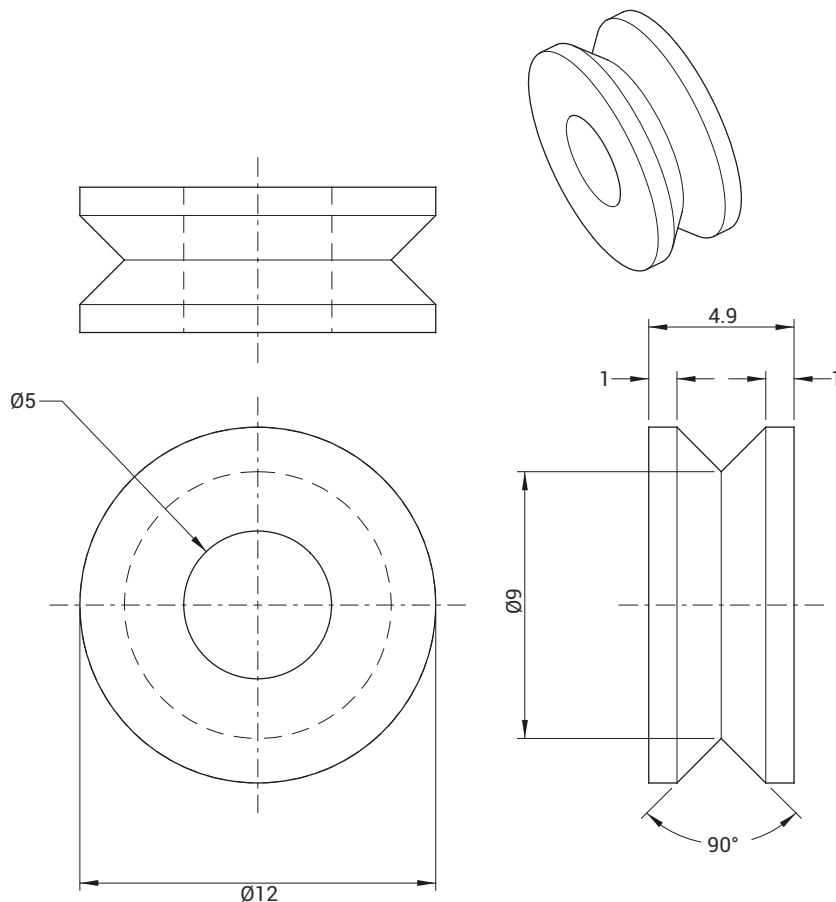
In this article you will find a description on how I built a tool for doing this straightening job, shown in the header photo. Please make reference to the general arrangement, **fig. 1**, throughout this description.

First part I made, **fig. 2** were the 6 rollers for guiding and forming the wire when the tool is in use. These rollers were made from UHB Arne, which is an oil hardening tool steel, you can of course use any kind of hardenable steel, I do recommend hardenable steel or at least some tough steel in order to make the rollers work for many years.

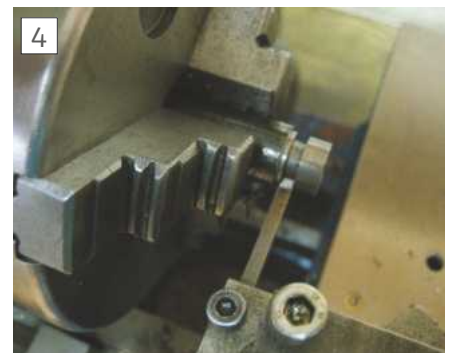
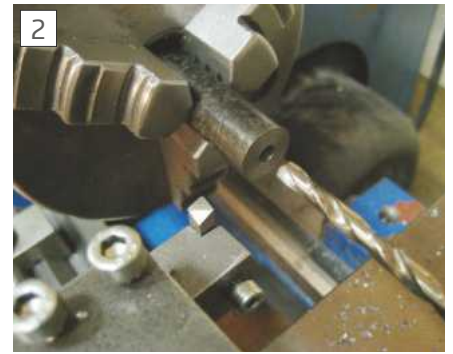
First job, **photo 1 and 2** was to centre drill and drill a hole in the work piece, the



Fig.2



Roller Wheel



hole where drilled to 4.8 mm and would later be reamed. Next the outer diameter, **photo 3**, of Ø12 mm was turned, the part was cut off, **photo 4**, at the length 4.90mm according to the drawing, next the roller was reamed to 5.0 H7 mm, **photo 5**, (H7 is the typical tolerance for easily available reamers and will give a suitable fit). After turning all six rollers as above, I made an arbor to hold the rollers, **photo 6**, when turning the 90° groove to a depth of 3.0mm.

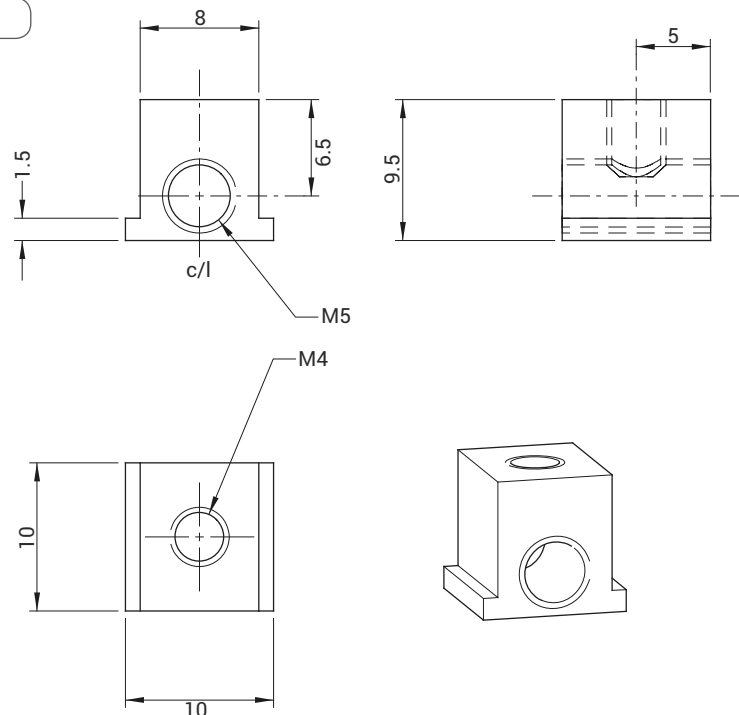
To finish the rollers, they were heated to bright red and dipped into some engine oil, **photo 7**.

To make the straightening force on the wire, it needs to be over bend in both the horizontal and vertical direction, the next part I made was a set of brackets that will enable one roller in each direction, to be moved more or less out of the straight line.

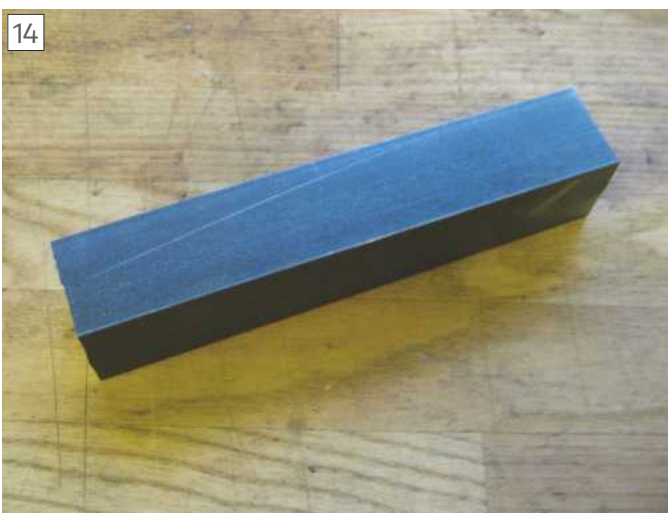
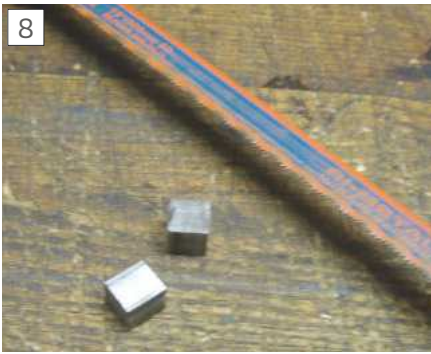
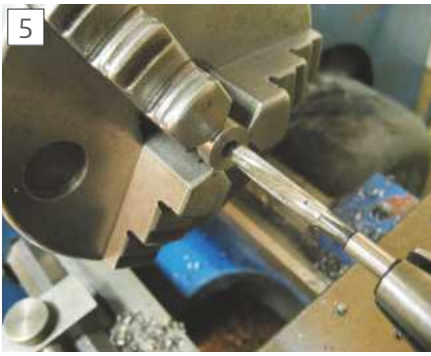
This part **fig. 3**, was made from mild steel.

First some blanks were cut off slightly over size, **photo 8**, and the outer T-shape was milled, **photos 9, 10**, using a fly cutter. Next the two threaded holes, M5 and M4, were drilled and tapped on the mill, **photo 11, 12**. The M5 will fit to

Fig.3



Roller Bearing



the adjustment screw and the M4 will hold the shaft for the roller, the finished brackets, **photo 13**, were put aside, so I could go on to the next part.

The next part I made was the base of the tool, **fig. 4**. The tool base was made from 30x30mm cold rolled steel bar, **photo 14**. After cutting off the material some 1.0mm oversize, the bar was

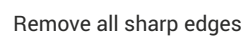
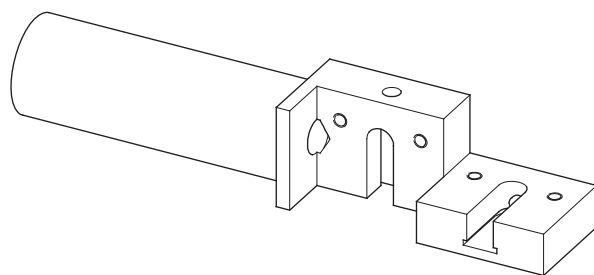
mounted onto the 4-jaw in the lathe. With very light cuts, because of the long overhang, the end was faced off and afterward a centre hole was made, now the work piece could be supported with a rolling centre, **photo 15**, and the outer diameter of $\varnothing 28\text{mm}$ could be turned, **photo 16**, according to the drawing.

Next the part was mounted in the mill

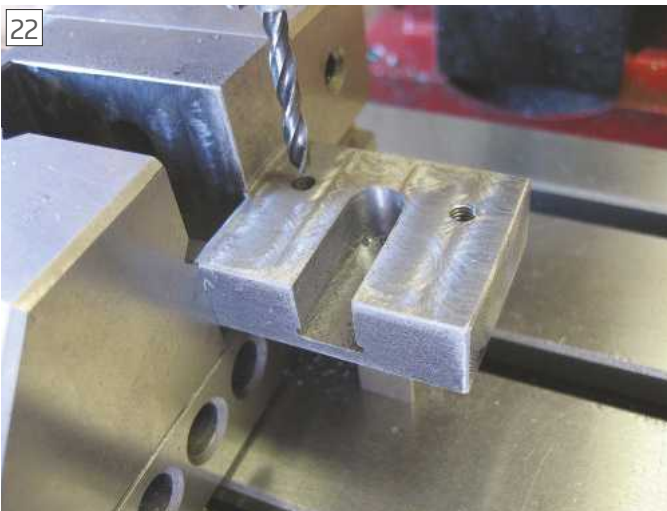
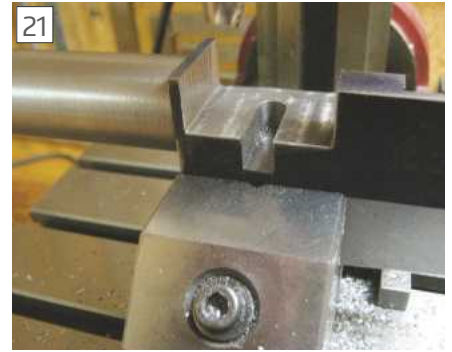
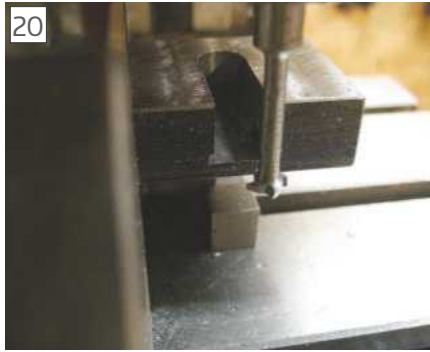
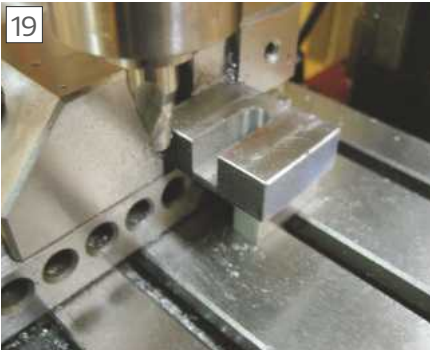
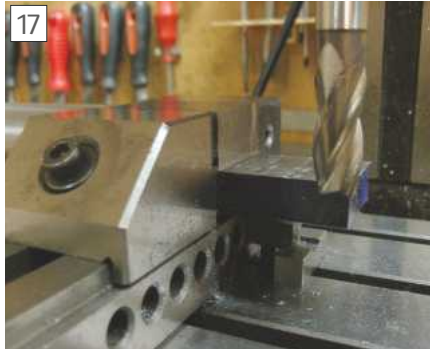
vice and the front portion of the part was milled, **photo 17**. This milling work along with centre portion of the part, **photo 18**, was a rather large job for my mini mill, but with sufficient patience the job was eventually done.

Next the 4mm radius slot for the roller bracket was milled, **photo 19**, in the front portion of the part, also the 5mm radius

Fig.4



Tool Base



lower section of the slot was milled, **photo 20**, the same was done in the centre portion of the part, **photo 21**.
Next the four M4 tapped holes that would position the fixed roller shafts, were

drilled and tapped in the mill, **photos 22, 23**.
The 5mm access hole for the adjustment screws, both in the front and centre portion of the part, was drilled next, **photo 24**.
To finish the tool base the 10mm

longitudinal centre hole was drilled in the bench drill, **photo 25**.

● To be continued

Readers' Tips



Milling a Curved Groove

**TIP OF
THE MONTH
WINNER!**



This month our lucky winner of £30 in Chester gift vouchers is forum-member Bob MC who sends us his solution for some decorative machining.

I am making Will Doggett's digital height gauge, see MEW issue 268, to make the grooves in the sides he mentions either milling using a ball cutter or a fly cutter in the lathe, however I don't have a ball milling cutter which would be expensive and possibly only used a few times. The flycutter I would have to make specially since it is quite a small radius.

However, whilst renovating/modifying my Dore Westbury it occurred to me that by setting the mill over at an angle, and with a 12mm cutter fitted I could cut the grooves easily.

I was surprised at how easily the mill cut these grooves, but a slow feed is needed on the x axis since the finish is not going to be smooth, however if the milled diameter is arranged to be similar to a piece of dowel with sandpaper wrapped and glued around it then it can be smoothed down by putting the dowel in the lathe and holding the work against it.



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!

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PART 6 - OPERATING THE SX2.7 CORRECTLY, MAKING SOME BASIC CUTS AND MARKING OUT AND MEASURING TOOLS

This month Jason Ballamy Looks at the correct operation of the SX2.7 and makes some swarf

Since the last instalment it has become apparent through the forum and discussions with the series sponsor ARC Euro Trade that some new owners of Sieg X2.7 & SX2.7 mills may not be operating them correctly which in some cases could be detrimental to the machines. Following the correct procedures detailed below should allow the user to get the best out of their machine without doing it any harm.

X2.7 and SX2.7 Quill Lock

On the lower left hand side of the head there is a recessed hex socket cap screw with the caption "loose - lock". This should be used to lock the quill and can be operated using the plastic handled hex



Quill Lock



Fine Feed Locking Knob

wrench provided. The quill should be locked when changing spindle tooling so that the quill will not move as the drawbar releases the taper. It should also be locked when a cut is being taken as this gives the most rigid set up and there is no risk of the quill creeping upwards during the cut, **photo 60**.

X2.7 and SX2.7 Fine Feed Engagement

The fine feed for the quill can be engaged at any point along its travel by turning the small black hand wheel in the centre of the down feed lever hub clockwise. The fold out handle on the hand wheel should be swung right out to give the required leverage as shown below in **photo 61** To disengage the fine feed hold one of the quill levers so the quill won't suddenly spring up and turn the black hand wheel anti-clockwise, then let the quill gently return to the retracted position. Do not use this hand wheel to lock the quill particularly when changing tooling as it will put undue load onto the rack and pinion feed.



Control Panel



Methods of holding vice to table

Quill Wrench

The Mills are supplied with a two pinned wrench, this is used to stop the spindle rotating while changing tooling or for example tightening the nut on an ER collet holder. There are two holes in the underside of the spindle that the wrench's pins locate in which may not be obvious when you first look at the machine.

Chuck Guards

On both the mills the chuck guard must be in place for the mill to run, they activate a micro-switch which will detect their position and prevent the machine from running if not in the closed position.

Correct turning on/off procedure. SX2.7

When you first plug in the mill and switch on at the wall socket the display screen on the front panel may or may not light up depending on the position of the safety switch when shipped. If the panel does not light then rotate the large red knob clockwise in the direction of the three engraved arrows, you will feel it spring outwards slightly and the panel will light up, if it does light up when the wall socket is switched on you don't need to touch anything, **photo 62**.

This large red button is the Emergency Stop Button and should only be used from now on in the event of an emergency. If you want to power the mill lathe down, then switch off at the wall socket and back on there when next in use.

To start the machine, ensure the chuck guard is in the closed position and press the oval shaped green button on the touch panel, the spindle will start to rotate slowly and the display will show approx 40rpm and forwards. If on the odd occasion you want to run in reverse now is the time to select it by pressing the button with the curved arrow, the spindle direction will change and the display will then show reverse.

With the spindle now turning the desired speed can be set by pressing the + or - buttons, holding one down will give a rapid change of speed or to change in 10rpm

increments briefly press the desired button.

To Stop the machine, press the oval shaped red button on the touch panel not the emergency stop button.

To start the machine back up press the green button again and the spindle will ramp back up to the previously selected speed, this is the main reason to use the small red one to stop, if you hit the e-stop then it will need resetting by turning, green button pressing and the previous speed setting will have been lost. Opening the chuck guard while the spindle is turning will have a similar effect to hitting the e-stop and you will have to set the speed again.

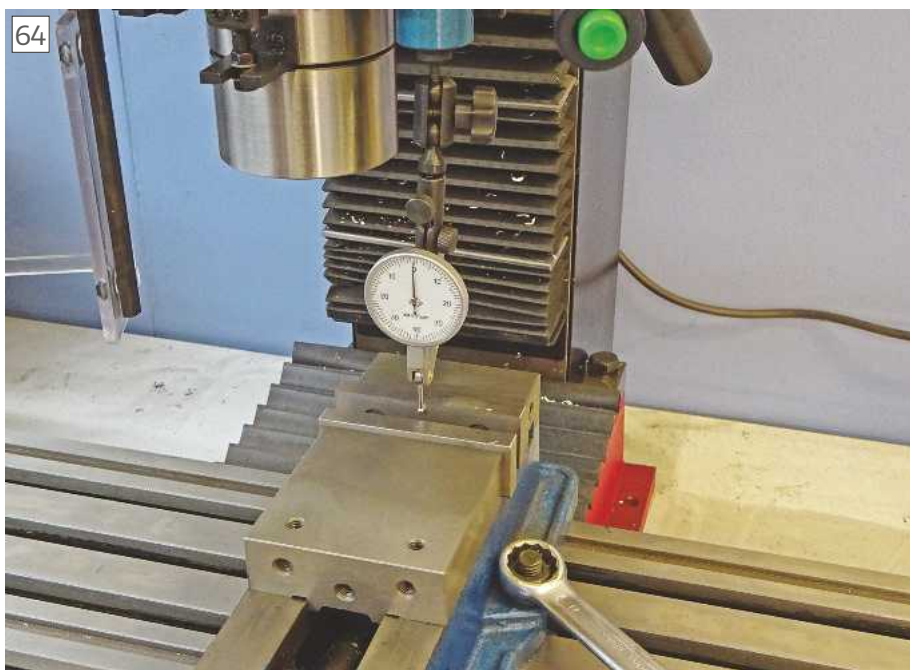
Selecting tapping mode (SX2.7 only)

Start the spindle turning as above by pressing the small green button, then press the tapping button which is the one above the +/- buttons and "tapping" will be displayed on the screen, next set the speed, there is a limit of 500rpm when tapping.

You will now have the spindle running forwards and the quill can be used to bring the tap down into the previously drilled hole, when the tap has threaded right through the hole press one of the buttons on the end of the quill downfeed levers and the machine will go into reverse and back the tap out of the hole. You can carry on changing between fwd/rev by continuing to press one of the green buttons. I would suggest that a very slow speed is used until you get the hang of using this feature.

Making some basic cuts Vice Mounting

Before cutting, a means to hold the work is needed, then mill vice is the most commonly used so a few words about mounting one would not go amiss. Wipe over the mill table to make sure there is no stray swarf and do similar to the vice base than slide it gently onto the table. If the vice has slotted mounting lugs at either side then Tee bolts and nuts or Tee nuts and



Setting Vice rear jaw true to x-axis

...it is a good idea to cut two pieces of 6mm ply or MDF to lay onto the mill table either side of the vice which will soften the landing of any dropped clutter.

short bolts can be used to hold the vice in place. If you are using a precision style vice then use either a cranked bracket or studs, nuts and a clamping bar, **photo 63**.

Just nip the nuts up so the vice won't slide about then use a lever type DTI against the fixed rear jaw while moving the table along the X-axis, gently tap the vice until there is no movement on the dial as the vice moves against the DTI then the nuts can be tightened. This will ensure that any cuts made in the Y direction will be at right angles to the fixed jaw which is used as a reference surface. I find that a small magnetic base stuck to the underside of the head is an easy way to hold the DTI, **photo 64**.

Cutter holding

Whether you are using a direct fitting collet, Weldon shank holder, ER or other collet system the method is much the same. Make sure both male and female tapers are clean and then place one into the other and



Correct cutter projection

tighten up the drawbar. Generally, the bar should be done up finger tight and then about 1/8th of a turn with a spanner, no need for excessive force.

If using direct collets, you will have to place the cutter into the collet at this time so that it closes down onto the tool as the drawbar pulls it into the taper. Weldon shank cutters should be inserted into the holder until the flat lines up with the grub screw which can then be tightened.

For ER type collets click the collet into the nut as I described earlier and then start the nut onto the holder's nose, Slip the cutter in leaving the minimum amount sticking out without actually gripping over the cutting edges and carry

on tightening the nut by hand. The nut should now be tightened with a suitable spanner while the spindle is locked. The suggested forces are quite high for the best running but as a guide as tight as you can get with the supplied spanner should do in most cases. If the cutter is not the same nominal size as the collet, as you may get if holding a drill, then you will have to juggle the spanner, spindle lock and stop the cutter dropping all at the same time, **photo 65**.

Similarly, when undoing a cutter make sure that it will not drop as the collet or taper releases, it is a good idea to cut two pieces of 6mm ply or MDF to lay onto the mill table either side of the vice which will soften the landing of any dropped cutter. The boards also help prevent the table from damage when tools are inevitably laid on the table, plus they help to keep the swarf out of the tee slots.

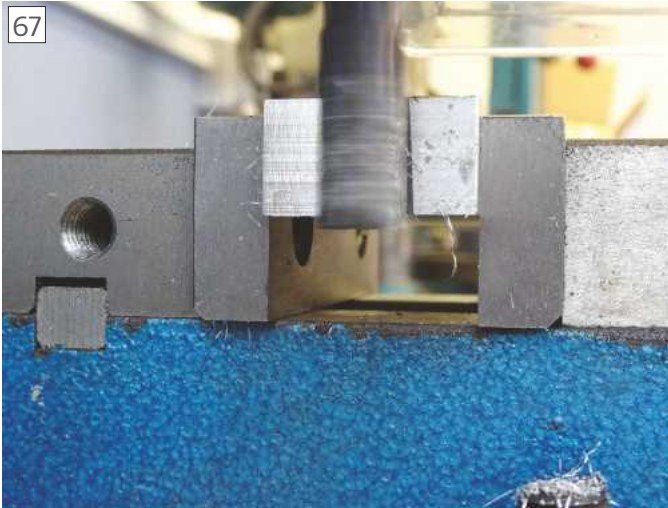
Using an End Mill (4 flute cutter) For Flat Surfaces

One of the common uses of these cutters is to remove material from the whole top surface of the work piece. If the work is quite small, using a cutter with a slightly larger diameter than the width of the work will do this in one pass with the cutter centralised over the part. If the work is wider then several overlapping passes will be needed, a good rule of thumb is make each cut 2/3rds the cutters diameter so for example if using a 12mm diameter cutter, then make each cut 8mm wide.

Speeds and feeds will be covered in more depth later but for a few practice cuts using say a 10mm diameter cutter, then 750rpm for steel and 1200rpm if aluminium. A feed rate of approximately one turn of the handle per second should



Mid way through the second pass of a facing cut



Edge cutting full depth



Cutting a rebate

be a reasonable rate to start off with.

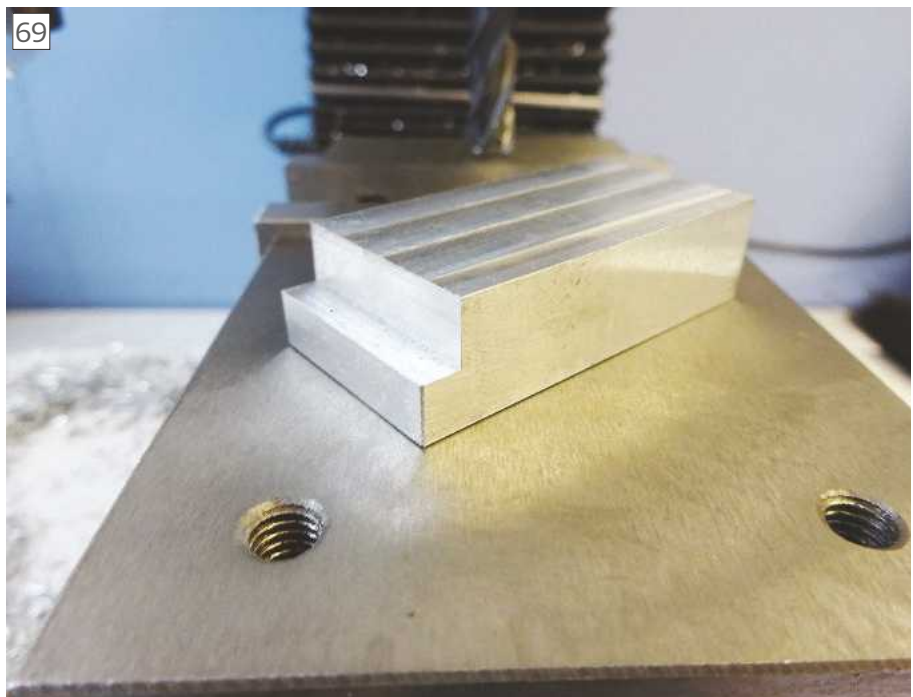
With the work firmly held in the vice with the minimum amount standing up above the jaws move the table so that the spindle axis is over the work and bring the head down until the end of the cutter is about 10mm above the surface. Now using the quill lever gently bring the cutter down until it just touches the work, lock the quill feed and zero the DRO or fine feed scale if no DRO is fitted. Raise the cutter slightly using the fine feed hand wheel and then move the work so that the tool is to the right of the work and 2/3rds of its diameter from the back of the work and then lower the cutter until the DRO reads 1.0mm, lock the quill and the y-axis gib lever.

The chuck guard can now be closed, and the mill started using the procedure described earlier and the speed set according to your chosen test material. Now turn the x-axis hand wheel anti-clockwise which will move the work from left to right into the spinning cutter and carry on until it clears the cutter on the other side. To make the next cut return the x-axis to your starting position then unlock the Y-axis and move the work 7mm away from you & lock the axis back up. Now make a second pass which will overlap the first. You can carry on like this until the whole surface has been machined. **Photograph 66** shows the cutter part way through the second pass.

Using an end mill (4 flute cutter) For Edge/End Cutting

Another use where the 4-flute cutters are more suitable is to profile the edge of plate material or squaring off the end of bar stock. Provided the thickness of the material is not excessive this can be done by cutting the whole thickness of the work but the depth of cut often has to be reduced as the thickness of the work piece increases.

With a small amount of the work protruding from the left-hand side of the vice position the work so that it is to the left of the cutter and slightly in front. Lower the



Completed Test Piece

quill until the bottom of the cutter is below the work and lock the quill. The work is then moved to the left to put on a cut, say 0.5mm, X-axis gib locked and then fed away from you into the rotating tool. Return the tool to the back of the work and put on another cut and then continue as required until the desired amount of metal has been removed. **Photograph 67** shows the cutter part way through the cut.

Using an End Mill (4 flute cutter) To Cut Rebates

If you need to cut a rebate out of the corner of a part then a similar method to that described above for edge cutting can be used. To get the most use out of the cutter it is better to use as much of its length as possible, so cut in from the side rather than wearing the corners by taking wider cuts coming down from above. **Photograph 68** shows the cutter on the second pass, note the longer swarf that is

generated when more of the side of the cutter is used.

The test piece after completing the three basic types of cut with a 4-flute cutter is shown in **photo 69**. By the time you read this there will be a video on the Model Engineer Forum showing these cutting operations in this thread: www.model-engineer.co.uk/forums/postings.asp?th=131318 ■

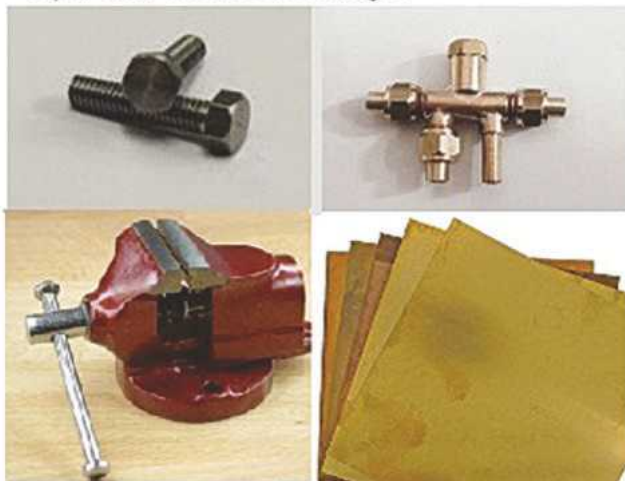
The items featured in this series are available from Arc Euro Trade, www.arceurotrade.co.uk, who also sell the X series of mills. See the accompanying thread on Model Engineer Forum www.model-engineer.co.uk/forums/postings.asp?th=131318 for more discussions about this series.



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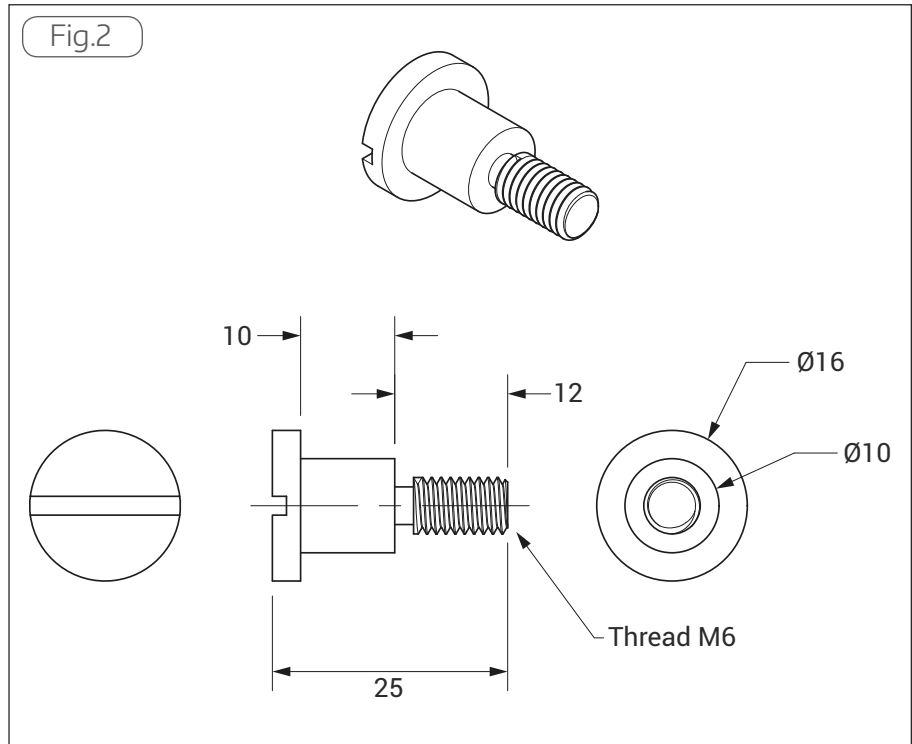
For those who find themselves facing a lot of repetitive machining tasks Alex du Pre describes his approach – Part 2.

Example 2 – Making Machine Screws

The next task is to make a number of steel machine screws as shown in **fig 2**. These feature a plain portion of larger diameter than the screw thread. This will require the use of the carriage multi-stop. This job will be tackled in two main stages. The first stage is to machine the parts with all the turning and threading complete and the second is to cut the slot in each screw. The steps are as follows:

Stage 1 – turning and threading

1. Prepare the four lathe cutting tools needed for this job. The first three are held in the QCTP. These are a right-hand turning and facing tool, a 45° chamfering tool and a recessing tool capable of cutting the thread run-out groove in a single plunge cut. The fourth tool is a parting tool fitted to the rear tool post.
2. Bar stock of equal diameter to the screw head could be used, but in this case a fully machined finish is required for the sake of appearance, so slightly larger



Using the knife tool as an end stop. The tool is positioned by the carriage multi-stop.

bar stock is selected. The bar stock is run through the lathe spindle bore and held in the three-jaw chuck. A sufficient length should protrude from the chuck to make one screw, ensuring clearance against the chuck for the parting off tool.

3. Face the end of the bar and stop the lathe. Advance the knife tool slightly and touch it against the end of the bar just faced. Set the carriage multi-stop first station to stop the carriage in this position, **photo 14**.
4. Set the second multi-stop station to allow the carriage to advance by 20mm from the initial position to give the position for the underside of the screw head. Set the third multi-stop station 10mm from the first position to cut the shoulder at the right-hand end of the plain portion.
5. Cutting can now begin. Turn the protruding length of the bar to the diameter of the head, noting the cross-slide dial reading when the correct diameter is achieved. Then, with the



The part in example 2 with all diameters machined, ready for threading before parting off.



Cutting the screw thread using a tailstock die holder.

multi-stop in position 2, turn the bar to the diameter of the plain portion whilst forming the shoulder under the screw head, again noting the dial reading. A number of roughing cuts will be required before using a finishing cut for the final diameter and the shoulder with the carriage against the stop.

6. Move the multi-stop to position 3 and cut the thread diameter and the shoulder at the end of the plain portion, noting the dial reading.
7. Fit the recessing tool and adjust multi-stop position 4 to cut the recess in the correct position, noting the cross-slide dial reading when the recess is at full depth. The shoulder could also be formed at this stage as an alternative.
8. Fit the chamfering tool and cut the chamfer on the outer end. Set multi-stop station 5 and note the cross-slide dial reading, **photo 15**.



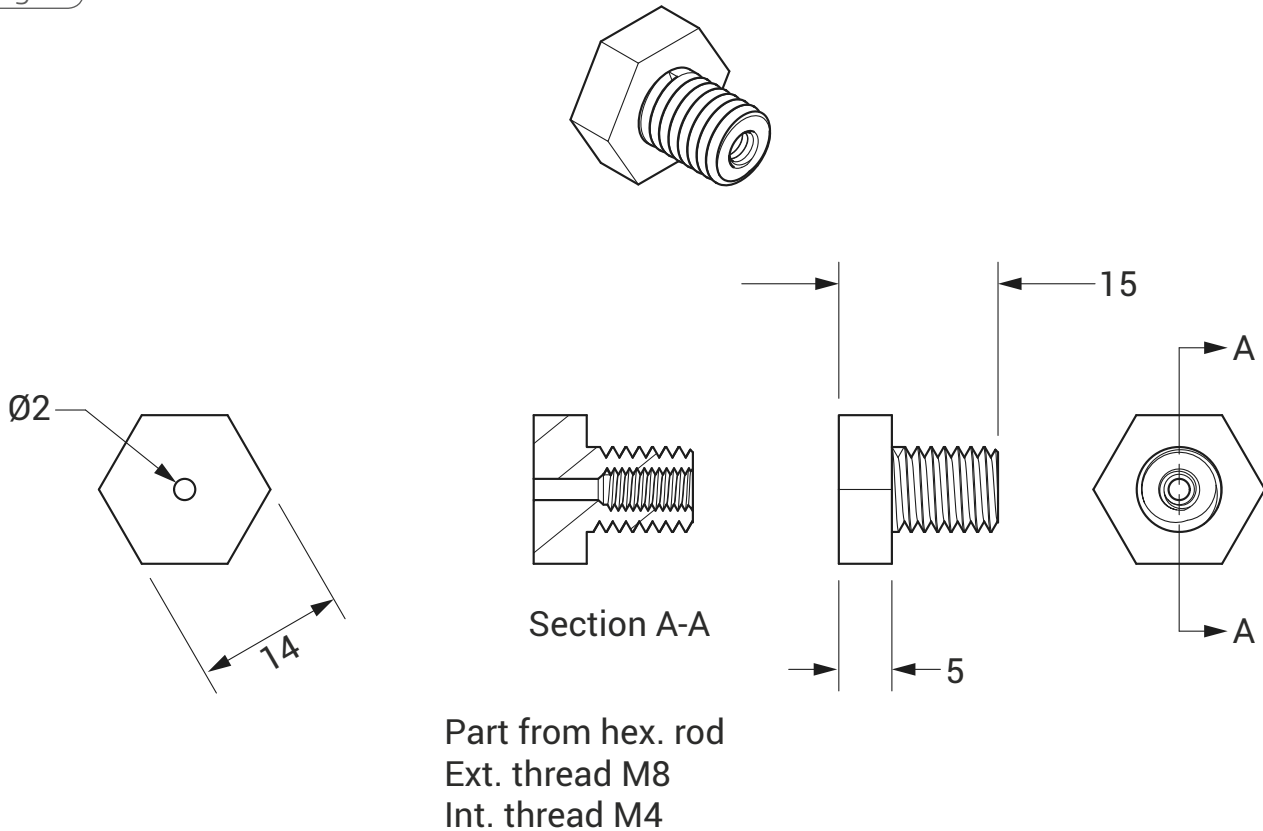
The multi stop with all six positions set.



The component parted off ready for cutting the slot on the milling machine.

9. Next, cut the screw thread using a tailstock die holder. It will probably be necessary to rotate the lathe by hand for this operation, or it may be done under power, with all due attention to safety aspects, if a slow lathe speed can quickly be selected, **photo 16**.
10. Finally, move the parting tool into position and set multi-stop station 6. In this case, let's assume that the finish from the parting tool is satisfactory and no further machining of the screw head is required. The parting tool and stop should therefore be set to finish the head to the correct thickness, **photo 17**.
11. Check the dimensions of the part and adjust the stops and cross-slide readings as required. The remaining screws can now all be completed to this stage relatively easily using the multi-stop and dial readings, with an occasional check on the dimensions to check for any necessary adjustments, **photo 18**.

Fig.3



Stage 2 – cutting the screwdriver slot

This is best done on the milling machine using a slitting saw. A suitable quick-release fixture should be devised to hold the screws in the correct position. Since this article is focusing on the lathe, I will not expand on this aspect.

Example 3 – Making a Pipe Fitting

The final example is the fitting shown in **fig. 3**. This fitting has been invented for the purposes of this example, but it resembles

a pipe fitting of some sort. This example will again use the carriage multi-stop and will also illustrate the use of the tailstock turret. It is quite a complicated part requiring many individual machining operations.

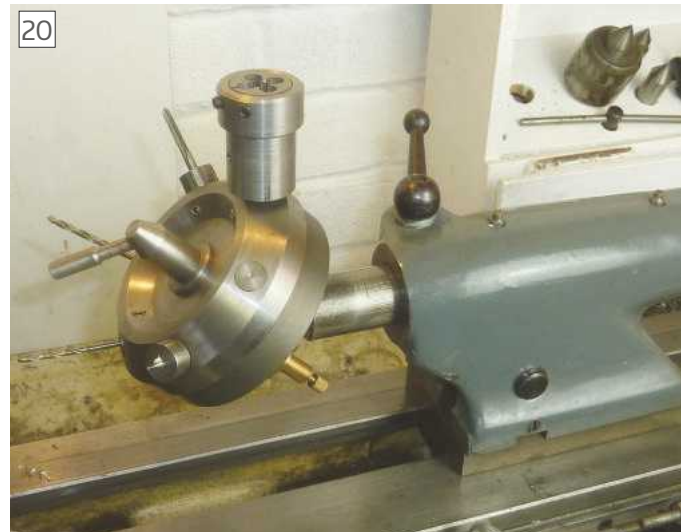
The part is made from hexagon bar stock. To machine it, we will require a right hand turning and facing tool, a chamfering tool and a parting off tool, all mounted in QCTP tool holders. The rear tool post won't be used on this occasion as it is likely to get in the way of the tailstock turret. The tailstock turret will need to be fitted with a centre drill, 2mm drill, M4 tapping size drill, M4 tap

and die holder with M8 die. Unlike the other examples, this part can be made in a single stage, provided the finish from the parting off tool is sufficient.

1. Prepare the lathe tools with their QCTP tool holders.
2. Fit the turning and facing tool and position the bar stock in the three-jaw chuck so that sufficient material protrudes to produce one part. Face the end of the bar and position the carriage and cross-slide so that the tool touches the end of the bar. Set the carriage multi-stop station 1 to stop



Outside diameter machined on component in example 3.



Tailstock turret set up with all tools required for example 3.



Centring the end of the part.



Drilling the smaller bore.



Tapping drill.



Tapping the bore, turning the lathe spindle by hand.

the carriage in this position. Fit the chamfering tool and form the chamfer on the outer end, noting the dial reading.

3. Turn the bar to the length and diameter required to form the external thread, setting the multi-stop station 2 to form the shoulder, **photo 19**.
4. Now fit the necessary tools to the tailstock turret in the order in which they will be used, namely centre drill in position 1, through 2mm drill, tapping drill, tap and die holder in position 5. It is helpful if all tools protrude a similar amount from the turret, although this is not always possible if long and short tools are used. At least ensure that tools are positioned so that the tailstock does not need to be slid along the bed, **photo 20**.
5. With the turret in position 1, centre drill the end of the bar, then rotate the turret to position 2 and drill the 2mm hole to a depth sufficient for one part. Drill tapping size to the depth specified. A collar fitted to the tapping drill will ensure the correct depth is achieved. Move the turret to position 4 and tap

the hole, rotating the lathe spindle by hand. Finally, use the die to form the external thread, **photos 21 to 25**.

6. The final job is to part off the finished component using the parting tool, setting multi-stop position 3 accordingly.
7. The batch of parts can then be produced by repeating the above steps, less the setting up, and using the stops, dial readings and tailstock turret in the correct sequence, **photo 26**.

The spare tailstock turret position could be used for a countersink. Countersinking the outer end of the hole would best be done before cutting the internal thread.

The tailstock turret shown in the photos features a locking handle which is tightened after rotating the turret to the required position. It greatly improves rigidity of the set up and prevents straining the delicate detent components.

Some Further Tips

Rapid production work is about minimising the number of steps required to machine the component and minimising the time spent changing tools. An excellent way of

achieving both of these objectives is to produce cutting tools that can perform two or more operations at one pass. A single cutting tool can be ground to perform a facing and chamfering cut or to chamfer and part off in one go. If, like example 2, the part is stepped, two lathe tools can be mounted side-by-side to cut both steps at once. Stepped bores can be produced by similar means, either with two boring tools or by grinding a suitable D bit or similar tool.

A final, valuable tip is to be even more

It would be more than unfortunate to produce a great pile of components only to find that you have misread one of the dimensions.



Cutting the external thread, turning the spindle by hand or using the back gear if available.



The finished component. Just another hundred to make!

careful than normal in checking the dimensions of the part at the setting up stage. It would be more than unfortunate to produce a great pile of components only to find that you have misread one of the dimensions. An occasional confirmatory check as you go will also check for any dimensions drifting out of tolerance.

Safety and Concentration

Working on a production run can become somewhat mindless. Just be aware that with lots of different tools being used, it is

all too easy to catch yourself on one of the many sharp edges. There may well also be tool changes going on in close proximity to a rotating chuck; this may be acceptable for the tailstock turret, but it is very unwise to change a lathe tool with the chuck running.

Concentration can easily drift, with forgetting to change the multi stop position being a common personal failing. This will quickly scrap a part or worse.

The trick is to work methodically and safely and take a break if you find your attention going.

Conclusion

I hope these examples have been useful. I have tried to illustrate some of the main principles and accessories involved in repetition work and hopefully given you an approach that can be adapted to suit whatever projects you are working on. As with most workshop tasks, there are many different ways of achieving the same outcome and it is a matter of making the most of the equipment you have available. ■

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Mystery Vice

Dear Neil, is this the strange vice of Trevor Jones? Found in a box of magazines given to me.

H. E. Setterfield, Margate



(Yet another!) Mystery Tool

Dear Neil, sometimes one of the special tools of yester-year appear in an unlikely place and often have uses long forgotten in these days of mass produced objects. They always interest me and sometimes, the knowledge gained can help do some simple DIY task that no "normal" folk would attempt. I am sure many MEW readers are in that category!

I happened to see this device at a car boot sale and out of sheer curiosity I bought it for a pound. (No wonder my sheds are full of junk).

I have not yet found anyone who can suggest what it was used for. It could be home made, although the short jaws at just two ends of the device look rather as if they were of factory origin. It measures about 6" long and is quite easy to squash the two parallels together by hand. One suggestion has been an extension vice, for holding small objects, after clamping it in another vice, But in reality that does not make much sense.

Perhaps a reader can come up with the answer?

David Dunn, Lincolnshire





Fire Brigade

Dear Neil, knowing the breadth of interests of our readers I wonder if anyone can offer an answer to this little poser.

A good friend has recently purchased, for preservation, a retired fire engine. George Lee from Peterborough is 28 years old, and I think that he must be, if not the youngest certainly among the youngest owners of such vehicles.

Unless, of course, anyone knows better?

The photo shows him with the engine at their first outing together in Basingstoke in May of this year. George grew up helping Dad, Steve with various locos and recently a traction engine and is also a very accomplished modeller in the smaller gauges, this beast is his first foray into full-size.

Ted Jolliffe, Bedfordshire

Screwcutting

Dear Neil, I hate to be critical of work done by other people and thought at first what a useful 'aide-memoire' the author was describing for rapid reference in setting up metric and BA pitches on a standard Myford screwcutting gearbox.

It was clear he had put a lot of work into it but, as I read the article through, several times, I couldn't help noticing a number of errors.

1. I was puzzled by the inclusion of Figure 10 which is labelled as a BA overlay in conjunction with a 24 tooth mandrel gear. The entry 7C is highlighted in red for a pitch of 0.49 mm. The maths is correct but that doesn't match a BA pitch. *(It's an approximation to 7BA at 0.48mm, although a better match is on the 20T overlay – Ed.)*
2. In Figure 7 for metric pitches there is an entry for a pitch of 0.73 mm at position 6C which is correct for a pitch of 3BA. Also I would have expected an entry for 0.80 mm at 5C for M5 coarse pitch threads.
3. Mike has not included overlays for a mandrel gear of 25 teeth, so other than listing M4 and M3.5 coarse threads in Table 1 the same visual treatment of these pitches for gearbox settings are absent
4. There are two incorrect entries in Table 3 for the pitches of 0.7 mm and 1.25 mm. These should be entered as 28T1B and 50T1B respectively. As listed, the gearings will yield pitches of 1.125 mm and 0.75 mm

Most UK readers will not be aware that Myford equipped North American export lathes with modified gearboxes that catered for 23 tpi threads instead of the 19 tpi pipe threads used here in the UK.

This means a North American owner of an export lathe, using his BA overlay in Figure 8 for a 20 T mandrel gear at position 5C, would cut a pitch of 0.460 mm instead of the expected 0.480 mm for 7BA.

Brian Wood, by email.

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Seeking Loco Enthusiasts in Scotland

Dear Neil, I work as a volunteer at the Grampian Transport Museum (www.gtm.org.uk) and we are looking into building a multi gauge model engineering track for locos at the museum to enhance our visitor experience and to give local model engineers a place to run their locos. We already have a small collection of live steam locos but nowhere to run them. I believe that there is no longer an Aberdeen or Dundee ME society. Is this correct? Before we embark on raising funds for the track I want to see if I can gauge the level interest in the north east or wider Scotland for such a facility. I'm looking for advice on the sort of numbers of locos, popular scales, the sort of facilities required etc. as well as a specification for track construction. I can be contacted at mikerazz@icloud.com or on my mobile **07968 196888**.

Mike Rasmussen, Aberdeen

Melbourne SMEE Show

Dear Neil, the Melbourne Society of Model and Experimental Engineers is having another exhibition, you can find more details at www.msme.org.au.

We have called it "Lets Make It" A name chosen to attract younger people, much needed to keep our special interest growing. The exhibition will run over 2 days. It will be a mixed; the usual model trains, boats, and stationary engines. Also, there will be 3D printing, epoxy machine building, Arduino projects and many others.

John McNamara, Melbourne, Australia.

An Indexing Head for the Unimat SL1000



Terry Gorin has devised a neat accessory that may inspire devices for other types of machine. Part 2

The Unimat gears referred to are a set of small module gears for use on my modified lathe and were never a Unimat product. The spindle adaptor enables both these and Myford gears to be mounted.

Brass keys were soft soldered to the spindle extension and adaptor, the bores of each cleared and any protruding solder was removed, and key heights adjusted by filing to achieve a sliding fit to the gear keyways. These small keys are not to resist machining thrust, only to prevent loss of index count, through gear rotation, if the locking nut should loosen.

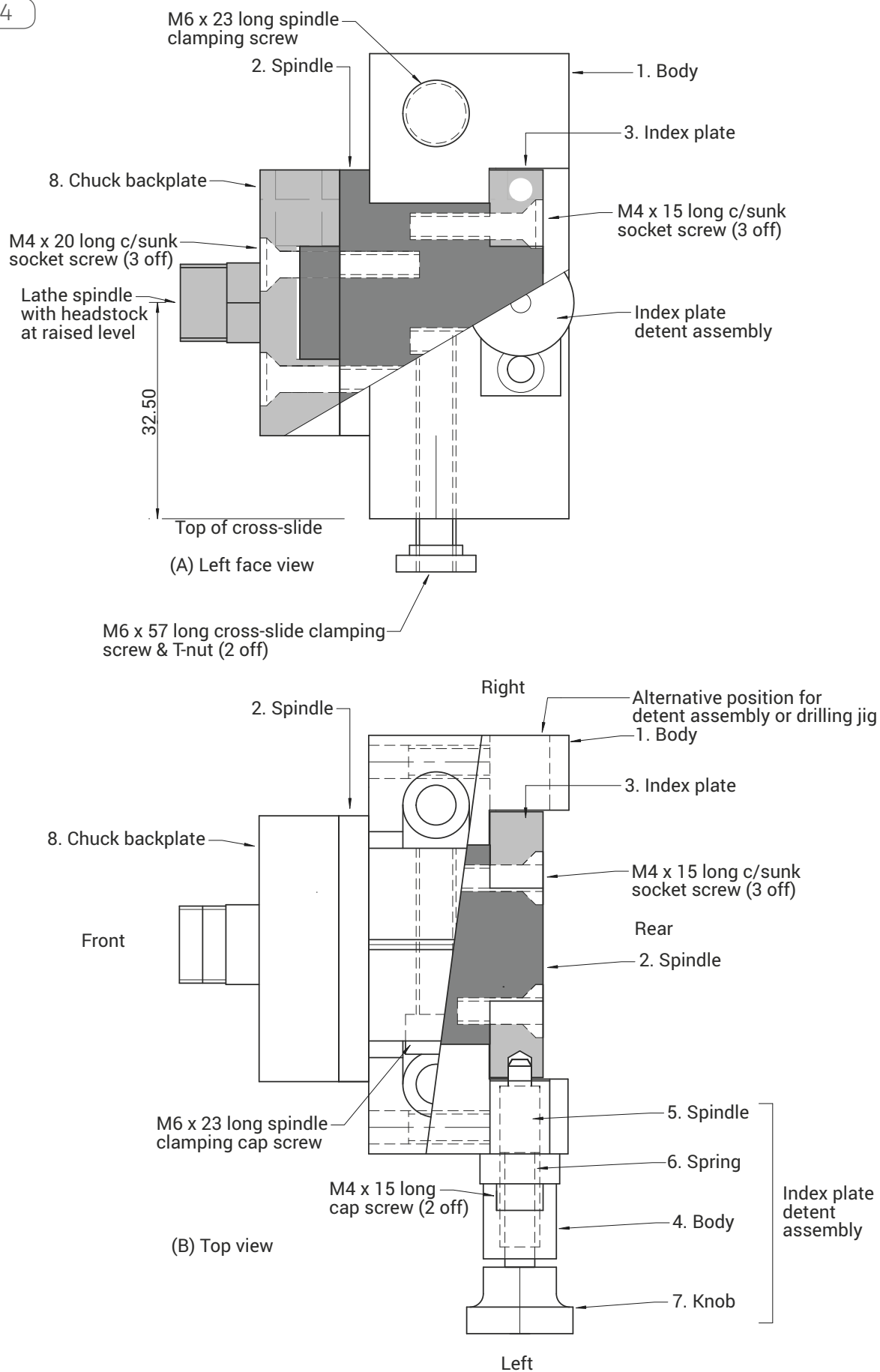
The positions of the 4mm diameter drilled holes above and below one of the 12mm diameter holes of the otherwise symmetrical and drilled and tapped gear detent holder were determined by drilling through the corresponding holes in the index plate detent body. A temporary adaptor ring 10mm long, not shown on the drawing, was turned to centralise the 9mm diameter spigot of the plate detent body



Using a change wheel for indexing

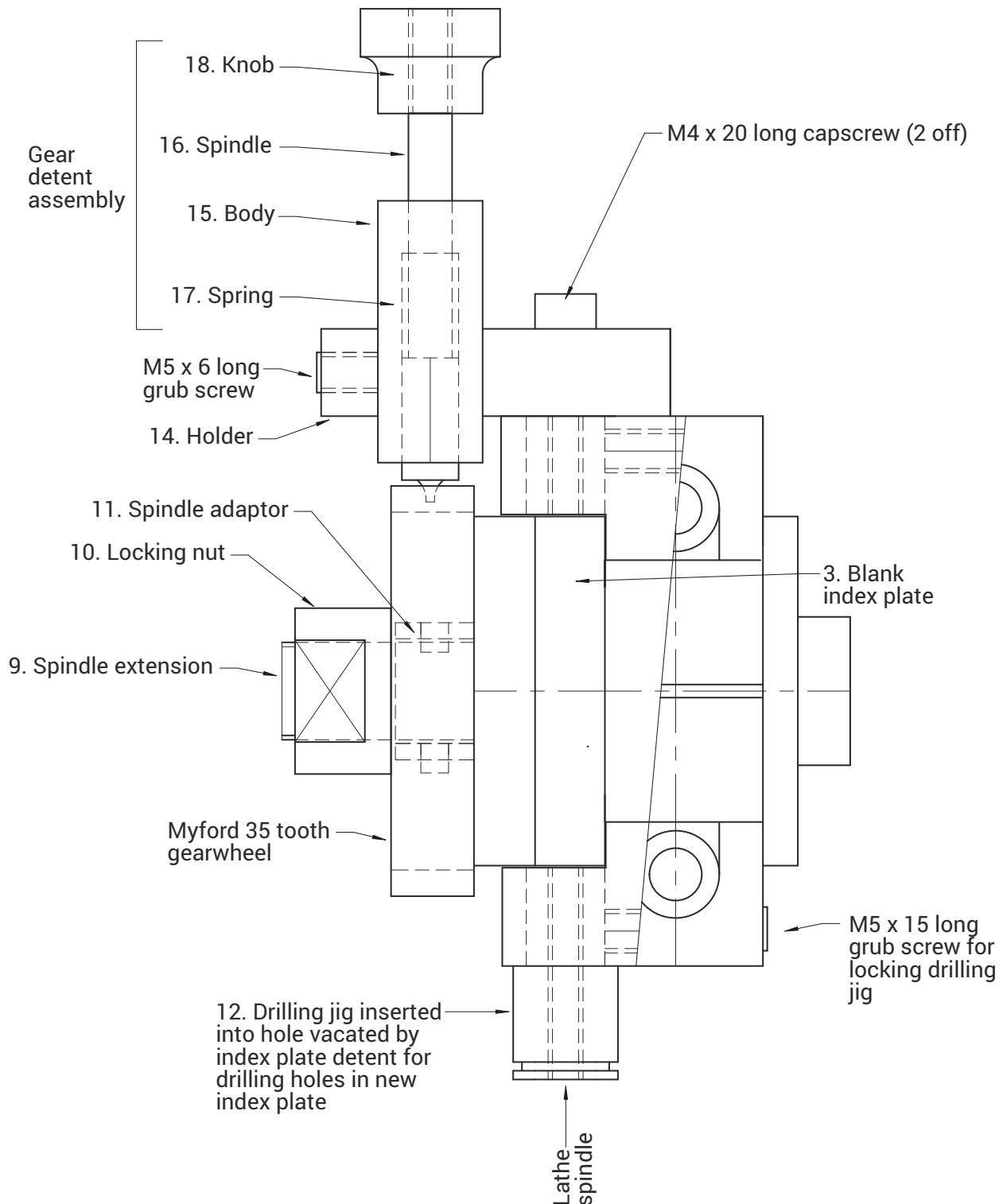


Fig.4

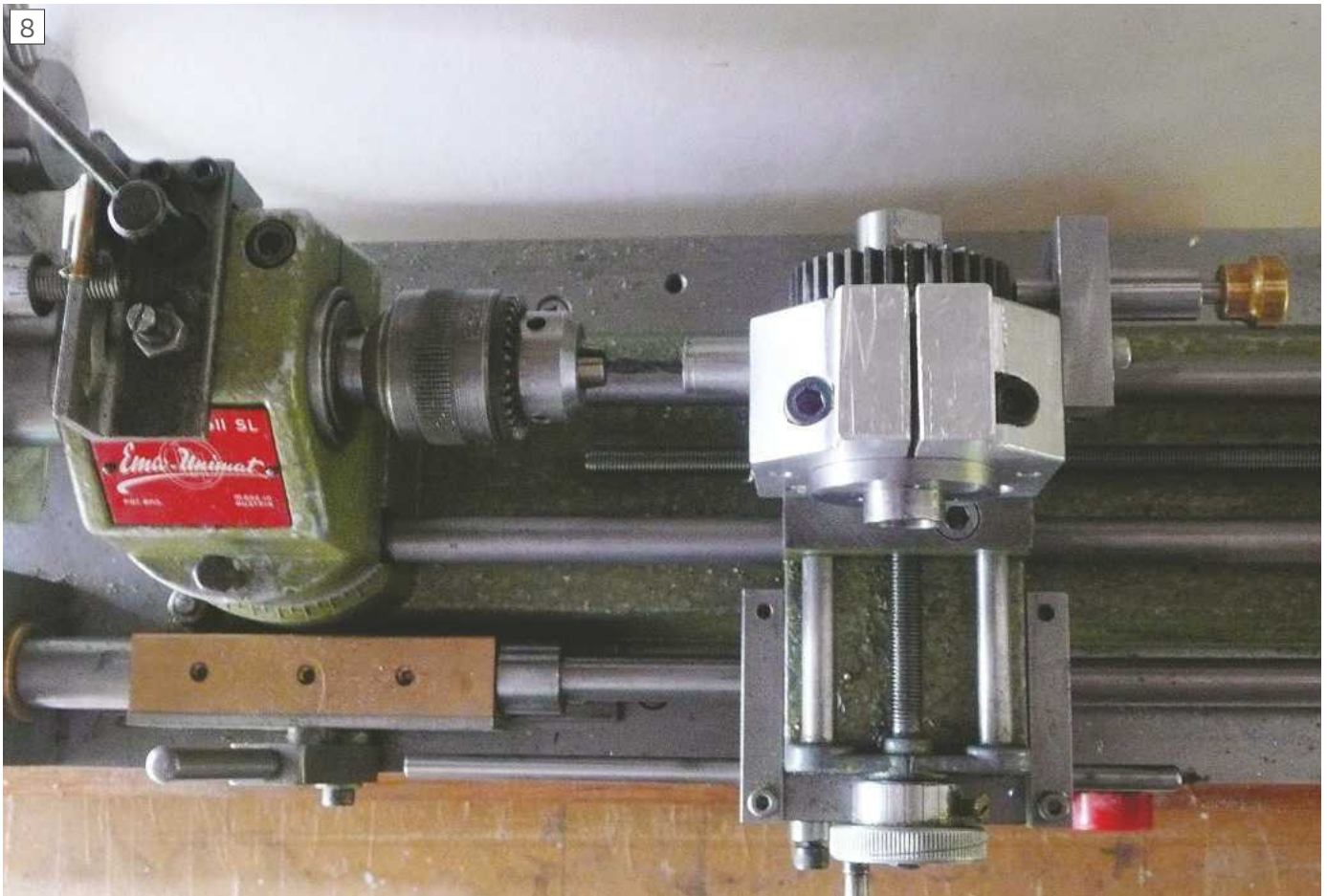


Index Head Assembly

Fig.5



Top Views Of Assembly Using Lathe Gears For Indexing



The indexing head mounted on the Unimat SL1000

within the 12mm diameter hole of the gear detent holder. With the guide holes of the upper body aligned with previously marked out vertical lines above and below the 12mm hole in the lower holder, both body and holder were clamped and the holes drilled through.

The drilling jig was a simple turning exercise to ensure a close sliding fit of the 9mm diameter spigot to the detent holes in the index body.

The gear detent is necessarily longer than the index plate detent but still of conventional design. The engaging end of the prototype spindle is, however, spherically tapered to suit both Unimat and Myford gears, an acceptable compromise, but if across teeth indexing is needed in the future either the spindle, or its engaging end, will need replacing.

Index Head Assembly (fig. 4)

The 'basic' head assembled with attachments is shown in **fig. 4** and **photo 7**.

This 'set up' shows that the spindle extension when bolted to the rear of the head spindle both clamps a blank index plate ready for drilling and provides a mounting for lathe gears for indexing. The drilling jig is located secured in one of the detent locations in block and the gear detent assembly located and secured to the opposite detent location. A Myford change gear is shown mounted

Probably obvious, but worth mentioning, if directly using lathe gears to index workpieces, instead of using internal index plates, the head can only be used in the vertical position.

for indexing a blank plate. The limited travel of the single slotted cross-slide, as mentioned, before, had identified the need for the two detent locations in body(1), shown in fig.1, and the head assembly for drilling needing to be as **fig.5**. An ongoing advantage being that the index plate detent assembly can now be positioned front or rear to suit individual machining set-ups when using the head in its basic form.

A 24 tooth Unimat change gear was chosen for drilling the first index plate, giving useful 2, 3, 4, 6, and 8 divisions.

At that point it occurred, that the blank plates being cheap and relatively quick to fabricate, why not have individual plates for each required division, immediately to hand, and thus avoiding the need to count and re-count hole positions to prevent possible dividing error.

Probably obvious, but worth mentioning, if directly using lathe gears to index workpieces, instead of using internal index plates, the head can only be used in the vertical position.

Finally, **photo 8** shows the 'extended' head mounted on the Unimat using the Myford 35 tooth gear for indexing the 5 division plate showing in photo 3.

Conclusion

This small head able to index in basic mode, using internal drilled plates, and useable vertically in 'extended' mode to drill additional blank plates, or index direct by lathe gear, is a modified and more versatile version of the original Unimat accessory on which it is modelled. With little dimensional alteration the head could find use on any small or even larger Lathe, as it will on my Myford. ■

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Mike's WORKSHOP



A mini-compressor system for the workshop.

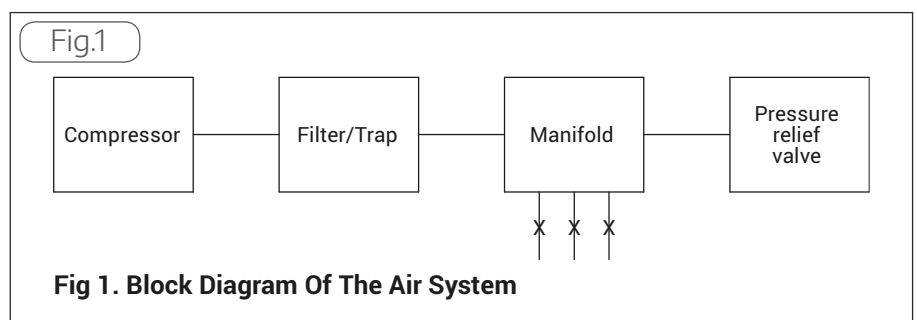
When I first set up my metal working workshop I already had a small 1.5 HP compressor with a 6-litre tank. Previously, this had been mainly used for tyre inflation and the occasional paint spray job. I installed this compressor in the room next to my metal working workshop and I used it for cleaning out blind holes after drilling and tapping as well as other cleaning operations. I did not like this system because the compressor was quite loud, even though it was situated in the next room, and it would switch on at random intervals to maintain the tank at pressure. These sudden start ups would sometimes startle me which was rather disconcerting when working close to fast turning machines. The other thing I disliked was the fact that when used with a blow gun there was simply too much air and particles of dirt and swarf would fly in all directions.



The original blow gun.



The original refrigerator compressor system.





The new compressor system on its trolley.



The front of the trolley showing the trap and manifold.

I had an old compressor sitting under the bench that I had salvaged many years before from a scrapped freezer and I wondered whether this could be used to operate a small blow gun. After a little playing around I managed to get the compressor up and running and I connected short piece of brass rod that had been drilled through with a 1 mm hole to the outlet. With the compressor running this produced a nice fine jet of air. A big plus point for this system was that the compressor was practically silent. I quickly rigged up a small trolley, **photo 1**, on which to mount the compressor and I used an old sodastream cylinder as a trap to catch any oil or condensate. This was a flow through system and the cylinder was not there to store air but simply to trap oil and water that was carried over from the compressor.

The blow gun, **photo 2**, was simply a length of copper tubing with a brass nipple with a 0.6 mm hole drilled in it sweated in the end. To use the blow gun the compressor was turned on, the cleaning operation was performed and the compressor then turned off.

Another advantage of the system is that compared with my 1.5 HP compressor the air flowrate is much lower which makes the blow gun much safer to operate. It is possible to just move particles of swarf around on a surface rather than to blast them everywhere in the workshop.

This system has served me very well for many years. More recently I have used the small compressor to run an air brush for small spraying jobs and I have also been

developing a system to spray coolant and air when using the milling machine. In this latter development I do not want to create a mist but more to spit small drops at the work being milled. For these last two applications it is necessary to be able to control the rate of flow of the air and I have been doing this by bleeding some air off through a small valve. This bleed off system

Fig.2

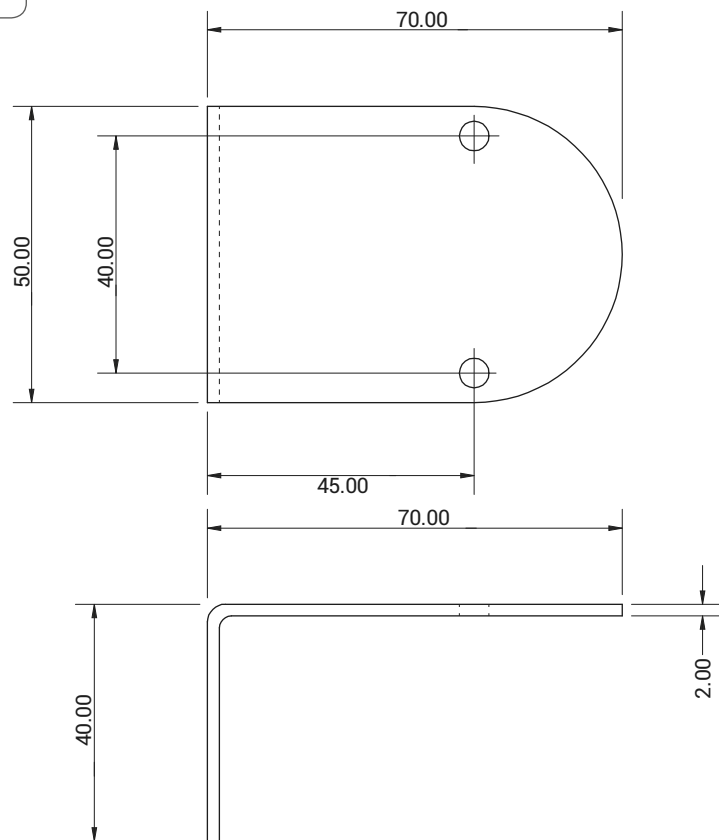


Fig 2. Filter Trap Bracket

was a bit makeshift and I decided to update the system and make a more engineered solution.

The new system.

A block diagram of the new system is shown in **fig. 1**.

The compressor feeds a new filter/trap. This was a commercially bought item with

a transparent polycarbonate bowl. This is advantageous because the condensate is visible so that it is easy to see when the trap needs emptying. The trap was purchased from Aim Tools (www.aimtools.co.uk) and it is listed as KATSU type QSL10 Large volume airline filter water trap.

The output from the trap goes to a manifold with three stopcocks. This was

Because there is no storage of high pressure air then the flow of air stops almost immediately the compressor is switched off.

purchased on ebay and it is designed for used with aquarium air supplies. One of the stopcocks is permanently connected to the blow gun. One is available for the air brush or coolant spray system and the third can be used to bleed off some of the air to control the flow.

The final component in the system is a pressure relief valve. This was made in the workshop. It is necessary because all three stopcocks on the manifold can be turned off and this would result in pressure building up in the system that would cause the hoses used to connect everything together to blow off the connectors.

The electrical system does several things. Firstly, there is a switch that turns the entire system off. The blow gun is hung on a hook when not in use and this hook is connected to a microswitch such that when the blow gun is lifted from the hook then the compressor starts. There is also a switch which over-rides the microswitch enabling the compressor to run continuously when the blow gun is on the hook. Because there is no storage of high pressure air then the flow of air stops almost immediately the compressor is switched off.

Construction.

Photograph 3 shows the new system. The compressor is mounted on the same trolley as used previously.

Photograph 4 shows the front panel with the new filter/trap mounted. The trap had 3/8 BSP threaded holes and two 3/8



The manifold as supplied.

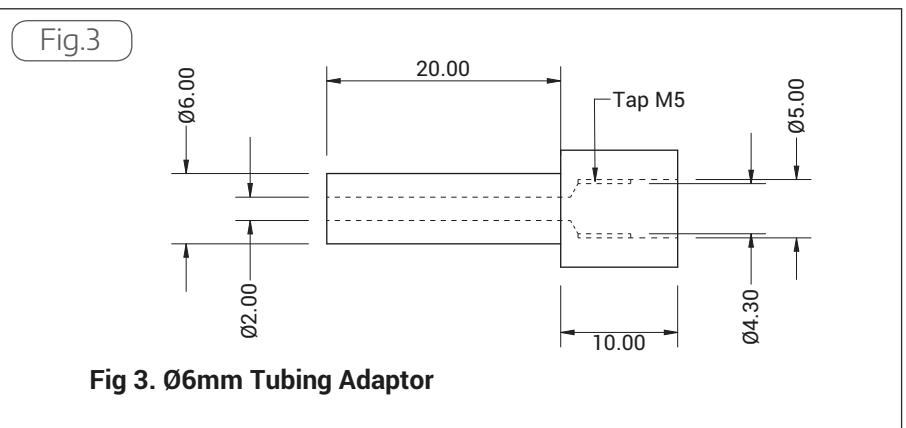


Fig 3. Ø6mm Tubing Adaptor

BSP to 6 mm connectors were bought and screwed into these using PTFE tape to make a good seal. A small bracket was made from 2 mm steel sheet, **fig. 2**, and this was fixed to the top of the trap using M4 button head screws. Again PTFE tape was wound onto the screw threads before the screws were inserted in order to make a good seal. The bracket with the trap were then fixed to the trolley.

Above the trap is mounted the manifold with three stopcocks. The manifold as supplied, **photo 5**, had 5 mm diameter ends designed accept push on 4 mm ID flexible tubing. An M5 die was used to cut a thread on each end. A 6 mm tubing adaptor was made for one end, **fig. 3**, using 10 mm

diameter aluminium. The aluminium was turned down to 6 mm for a length of 20 mm. the end chamfered and then parted off 30 mm from the end. The piece was remounted in the chuck by the turned down end and drilled through with a 2 mm drill. The end was drilled 4.3 mm for a length of 8 mm and drilled 5 mm for a length of 4 mm before tapping M5. The final operation was to skim the outside diameter and chamfer the end.

A pressure relief valve was made for the manifold, **fig. 4**. This was also made from 10 mm diameter aluminium. The aluminium was mounted in the lathe and the end faced. It was drilled through to half its length with a 2 mm drill. The end was then

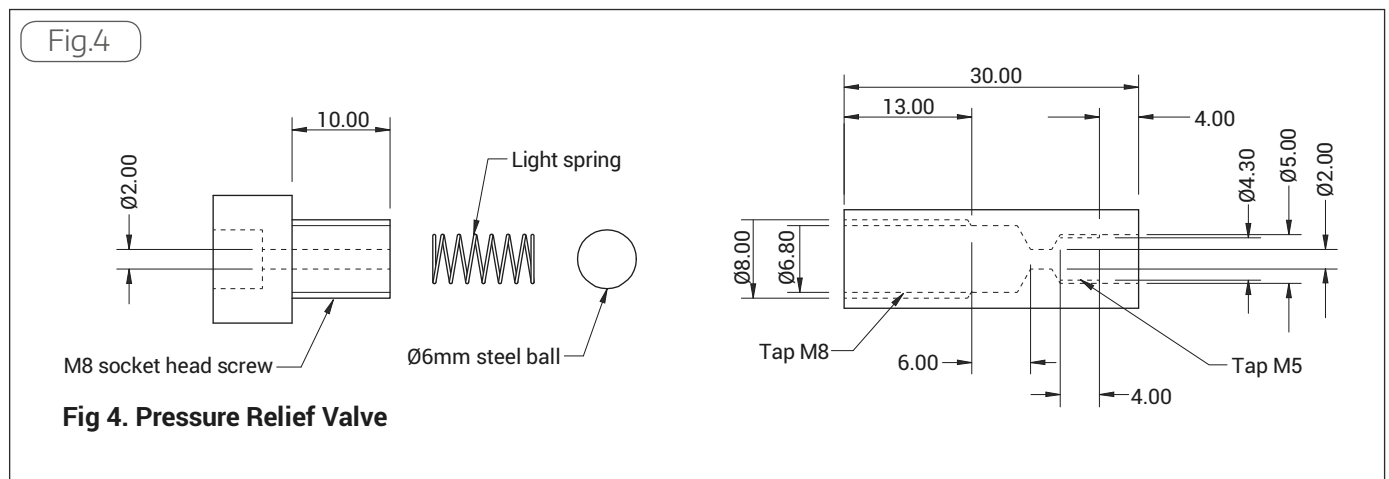


Fig 4. Pressure Relief Valve

drilled out to a depth of 8 mm with a 4.3 mm drill and to a depth of 4 mm with a 5 mm drill. The 4.3 mm section was tapped M5. It was parted off 10 mm from the end and the cut off piece remounted in the chuck and drill out from the other end to a depth of 19 mm using a 6.8 mm drill. The 6.8 mm section was tapped M8 to a depth of 13 mm.

The 6 mm steel ball shown in fig. 4 was one that was floating around in one of my junk boxes and I think it probably come from the bottom bracket of a bicycle. There is nothing critical about this component. The spring shown on the drawing was also from the junk box it was 10 mm long and 5 mm diameter and the wire diameter was 0.4 mm. Only very light pressure is required from the spring. The adjusting nut for the pressure relief valve was made from an M8 socket head screw. This was cut down to give a thread length of 10 mm. The end was faced off and the screw was then drilled through with a 2 mm drill. The hole is necessary for the air to escape.

The 6 mm tubing adaptor and the pressure relief valve were then fixed to the manifold.

The threaded ends of the manifold were lightly coated with epoxy resin and then the adaptor and valve were screwed on. Excess adhesive was carefully wiped off and the adhesive was allowed to set.

A small bracket, **fig. 5**, was made to



The manifold with the tubing connector and pressure relief valve mounted in the bracket.

mount the manifold onto the trolley. This was constructed from a strip of 2 x 30 mm steel sheet and a small block of 10 x 20 mm hot rolled steel. The 6 mm tubing adaptor fits through the 6 mm hole in the bent steel strip and the relief valve fits into the small block that is then screwed to the steel strip with a 3 mm countersunk screw. The manifold is prevented from rotating and sliding by another 3 mm

screw through the front of the block.

Photograph 6 shows the completed manifold with pressure relief valve and tubing connector mounted in the bracket.

The blow gun was made from a 250 mm length of 8 mm copper tube. A brass nozzle, fig. 6, was made from a short piece of 8 mm brass rod. This is a simple turning and drilling operation. The brass was chucked in the lathe and faced off. The outside

Fig.5

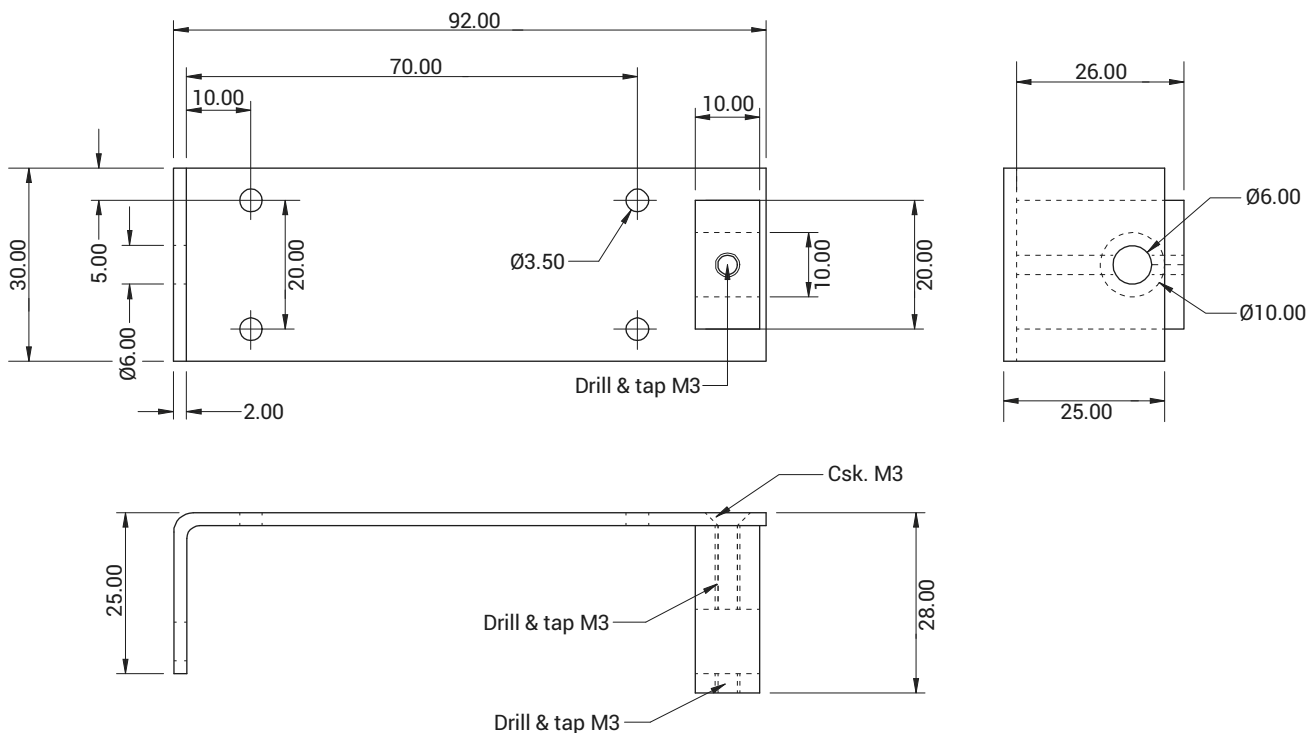


Fig 5. Mounting Bracket For The Manifold

When cool the tube and nozzle should be flushed with water to remove any flux. Failure to do this will result in rapid corrosion and possible blockage of the nozzle.

diameter was reduced to 6 mm for a length of 10 mm. The rod was then parted off 20 mm from the end. The parted off piece was gripped by the thick end and drilled out with a 2 mm drill to a depth of 17 mm. The drill was changed to a 0.6 mm drill and the drilling continued until a through hole was made. The drilling with such a fine drill must be made with the lathe running very fast, e.g. 2,500 rpm, and the drill must be withdrawn often to clear the flutes. The final operation was to reverse the piece in the chuck and with the cross slide turned through 30 degrees and the turn a taper on the end of the piece.

The nozzle was placed in the end of the copper tube with some active soldering flux in the joint. It was then heated up and soft solder applied to the joint. When cool the tube and nozzle should be flushed with water to remove any flux. Failure to do this will result in rapid corrosion and possible blockage of the nozzle.

The handle for the blow gun can be made from wood or any other suitable material. I happened to have a handle from a long-gone kitchen utensil which had a nice sculptured handgrip. The internal cavity was filled with a length of 16 mm dowel that had been drilled through 8 mm. The copper pipe was pushed through this and secured with a little contact adhesive.

Fig.6

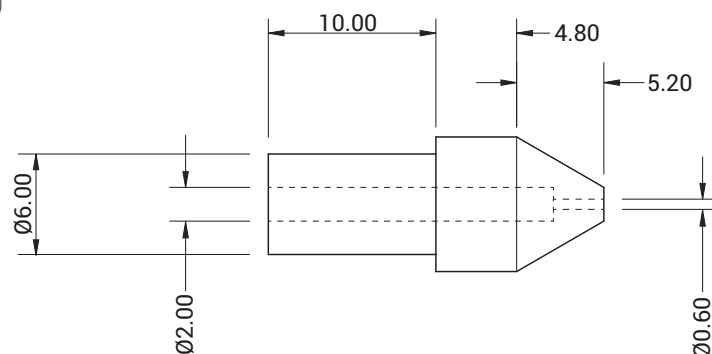


Fig 6. The Nozzle

A small adaptor, **fig. 7**, was made for the other end of the pipe to reduce the diameter to 5 mm. This was made from 10 mm diameter aluminium as shown in the drawing. The 6 mm end was then bonded into the end of the copper tube using epoxy adhesive.

The handle of the blow gun has a wire hanging loop so that it can be hung on a hook when not in use.

The finished blow gun is shown in **photo 7**. It has a 3-metre length of tubing linking it with the compressor and it can reach all corners of my little workshop. The excess tube hangs on a hook below the blow gun.

The connections from the compressor to

the trap and from the trap to the manifold were made using transparent 8 mm OD and 5 mm ID PVC tubing. This is difficult to force over a 6 mm metal tube in the cold but if the tube is dipped into boiling water first then it slips over easily and when cold it grips well. The connection between the manifold and the blow gun was made using 6 mm OD 4 mm OD PVC black tubing. This is also used for any other equipment that needs to be connected to the manifold.

Electrics.

The electrical schematic is shown in **fig. 8**. This is very simple there is an on/off switch to activate the system, a hook switch which

Fig.7

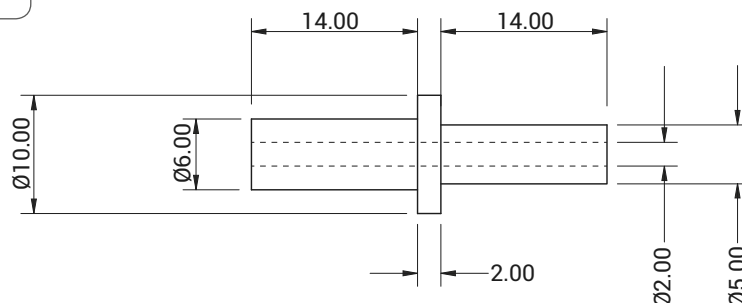
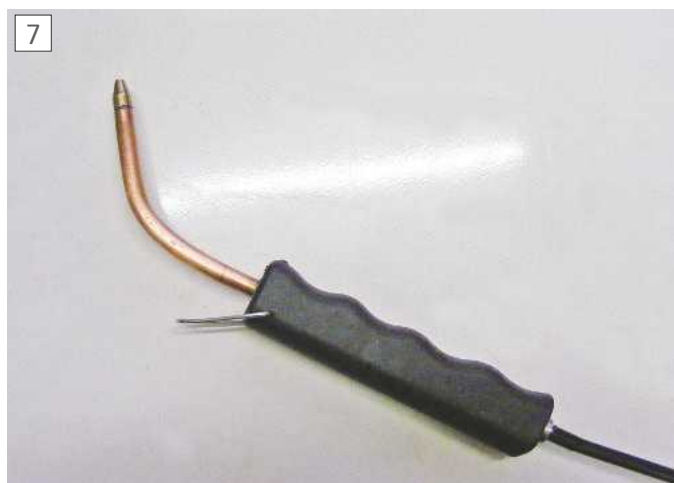


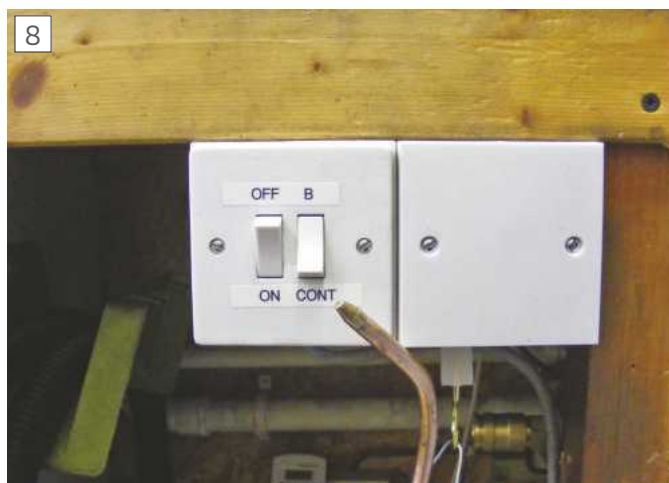
Fig 7. The Tubing Adaptor

7

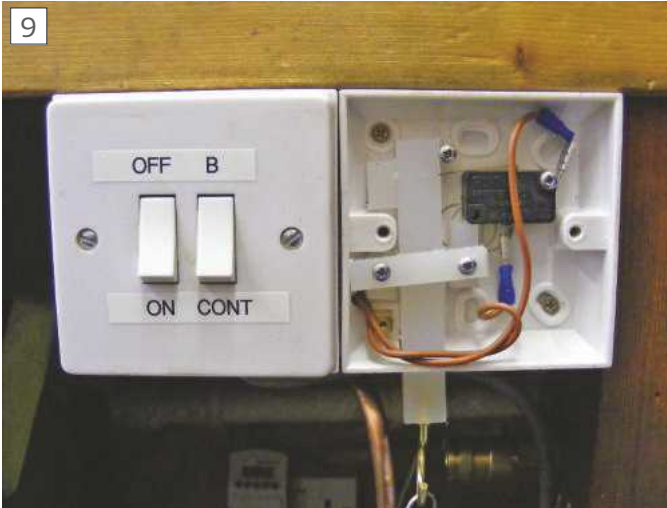


The blowgun with hanging loop. Note the thin, flexible air supply pipe.

8



The electrical controls.



The hook switch with the cover removed.



The back of the electric board showing the compressor socket.

turns the compressor on when there is nothing hanging on the hook and a bypass switch that overrides the hook switch if the compressor is to be used for purposes other than the blow gun. There does not appear to be an international symbol for a hook switch, so I had to invent one! The hook switch must close when the weight of the gun is removed from the hook. The control panel is shown in **photo 8**. The hook switch is inside the right-hand box.

Photograph 9 shows the inside of the hook switch box. The microswitch at the top right hand side of the box is activated by a bar of polyethylene, cut from an old kitchen chopping board. This bar is sized to pass through one of the cable knockouts of the switch pattress. A normal cupboard hook is screwed into the end of this bar. At the top of the bar is a slit into which the microswitch lever fits. Thus, pulling down on the bar operates the microswitch. The thickness of the plastic making up the back of the pattress varies because of the various cable knockouts and screw holes present. This makes finding secure fixing points difficult and explains why the screw positions and guides are not in straight lines. Some pieces are fixed in position with hot melt adhesive.

The switches are mounted on a piece of chipboard fixed to the workbench. The back of the small chipboard panel, **photo 10**, has a normal socket into which plugs the compressor.

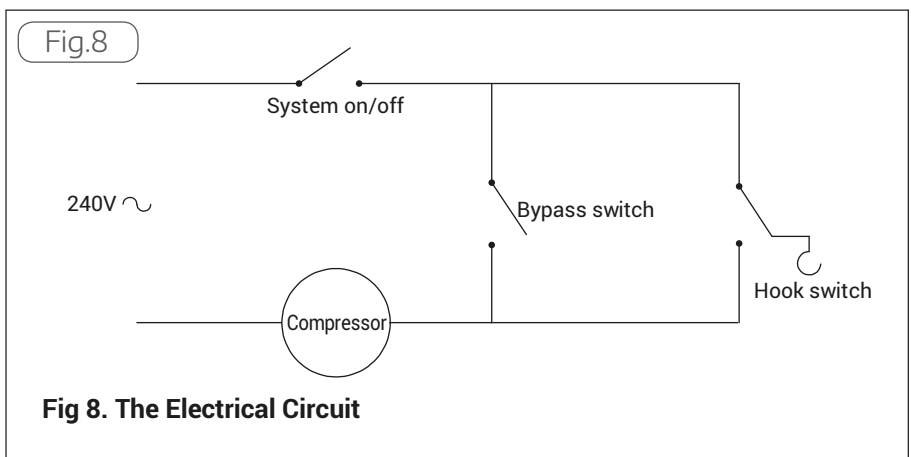


Fig 8. The Electrical Circuit

Operation.

When the system is first set up the stopcock on the manifold feeding the blow gun is open and the other two are closed. The compressor is then started using the by pass switch. The pressure relief valve is then adjusted until it just closes and all the air is coming out of the blow gun. The bypass switch is then turned off so that the blow gun automatically starts whenever it is lifted from the hook switch.

If the compressor is to be used to operate other devices then the blowgun stopcock is closed and the device is connected to one of the other stopcocks. The device stopcock stopcock and the unconnected stopcock should both be open and the compressor can be started using the bypass switch. The unconnected stopcock is then slowly closed until the flow rate through the device is satisfactory.

Benefits.

There are several benefits of this system in a small workshop:

1. The system is small and can easily slide under a bench or into a corner.
2. The compressor is almost silent.
3. The refrigerator compressors are very reliable and most refrigerators are scrapped with working compressors. They can therefore be obtained at minimum cost.

4. The airflow is more than sufficient for operating a blow gun, an airbrush, a mist lubricator etc.
 5. The system described here does not store gas and you do not have to wait for an enormous reservoir to fill before air is available. Air is available immediately the system is switched on.
 6. The hook switch that the blow gun hangs on is very convenient. You lift the blow gun and by the time you have brought the gun to the job the air is already flowing. The airline attached to the blowgun is light and flexible.
 7. The blow gun is very effective at removing swarf from holes and for cleaning work but the throughput is not so high as to cause particles to fly everywhere so it is intrinsically safer than the normal high pressure blowgun. However, I would still advise the use of safety glasses during any blowing operation.
 8. The manifold allows easy connection of other devices to the system and provides an easy way to bleed off air.
 9. The transparent trap allows a visual check on the quality of the air and is easy to empty when it collects condensate/oil carry over.
- Overall, I am very pleased with this system. ■

The airflow is more than sufficient for operating a blow gun, an airbrush, a mist lubricator etc.

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

The Holiday Makers

This summer, Year of Engineering partners are encouraging children across the country to get making, inventing and having fun over the holidays.

The Holiday Makers is a brand-new hub packed with fun activities and challenges that will help to entertain and inspire your children, keeping their minds sharp all summer long.

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International Model Boat Show 2018





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The International Model Boat Show is the only 3-day marine modelling exhibition dedicated to all aspects of marine modelling – an event not to be missed! It is widely regarded as one of the UK's leading marine modelling exhibitions and takes place from Friday 9th to Sunday 11th November at the Warwickshire Event Centre.

Organisers are expecting 3000+ visitors, who will be able to enjoy in excess of 600 models from over 25 clubs and societies, where some of the finest marine models will be on display. The excellent and varied displays include everything from early warships to modern power boats – all of which will be complemented by action on the large indoor boating pool.

The organisers are pleased to confirm that the HMS Ark Royal will be attending the 2018 exhibition. This model gained an overwhelming amount of attention at the Alexandra Palace show, where it was first unveiled in January this year. Built by Royal Navy veteran David Fortey over the course of 25 years, this magnificent model was created by working from original builders plans direct from the MOD.

The award for the best society/club display will be sponsored by our sister magazine, "Model Boats". Last year King Lear Model Boat Club came 1st, in 2nd place was Bournville Radio Sailing & Model Boat Club and in 3rd position was The Lifeboat Enthusiasts Society. Who will win this year?

Make a note in your diary now, tickets are also on sale at discounted prices from www.modelboatshow.co.uk





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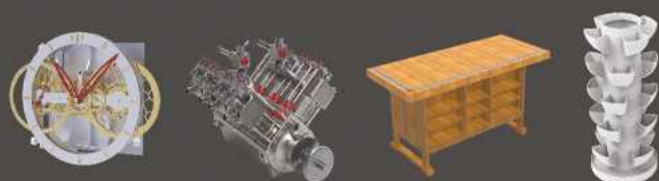


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Abuse to innocent Bridgeports



Having previously written about the versatility of the Bridgeport milling machine, with respect to building full size locomotives, I thought another short article would not go amiss – Ian Howitt.

Although we do a modest amount of steam engine work and are currently engaged in building a 2ft gauge Kerr Stuart 'Wren', our bread and butter work is sub contract machining of components, particularly for the oil industry.

This means that when buying machines, you are always looking for something that will do everything, and a general maxim is "the bigger the better". Obviously, being a small operation, money is always a deciding factor, but equally important is space available. In fact, it is just like most model engineers.

Being something of an enthusiast for machine tools there is always the excuse to go and buy another machine to do that special job and increase the ability of the shop in the future.

One job we were asked to quote for recently was to produce a pair of keyways in the 10" diameter bore of a component about 2 feet diameter and about 3" deep. The overall height of the job was 17" and it weighed about 4cwt (somewhat over 200kg if you work in the curse of Europe). Although we have a small slotter of about 8", stroke it was obviously far too small to tackle this job. Not liking to turn work away, however, it seemed that this was a job that we could not do and I was about to suggest someone I knew who had a 3ft stroke slotter. This is a serious piece of kit and would have eaten the job.

However, when the customer said it was a shame we could not do it as he felt that 64 of them would keep us quiet for a while, I said I would think again and started the hunt for a big slotter. As the job was not particularly accurate (the slots were for aligning the inner part down an oil well) I thought I could buy a cheap, large slotter for this job and have the machine for future use.

Obviously, you can never find a machine when you want one and I drew a blank. As I was thinking about this job over the next two or three days, it occurred to me that the right angle head on a Bridgeport would go down the bore of the job and we would be able to mill them. Just one or two problems to resolve. **Photograph 1** shows the overall size of the job and indicates the capacity of the machine



This is what is meant by 'pushing the envelope' of a machine.

The first was the headroom underneath the Bridgeport head and the second was the lack of power feed to the knee. Although the quill of the Bridgeport has three rates of feed derived from the head, the quill is not accurately restrained from rotation in the housing and moves around a fraction with the torque reaction of drilling. This is no problem when milling as you would always have the quill locked by means of the very effective split clamp arrangement. Again, when the right-angle attachment is in use the quill has to be locked. This obviously meant that the feed had to be by lifting the knee. For a one off it would just about be bearable to wind it by hand, but for 64 of this was a none starter.

There are several far eastern feed units made for Bridgeports and the various clones, at reasonable prices, mainly for the table long travel (x) although they are available for the cross (y) and knee elevation (z) as well. One of these would provide the power feed, but would it be powerful enough to lift the table and the job?

The manufacturers of wthe units

helpfully give the torque output of them and a few experiments with scrap loaded onto the table and a spring balance on the handle showed that we would be OK. I remember reading somewhere that the max table loading on a Bridgeport was about 500lbs so again we were just about OK.

As our existing Bridgeports were in a low shop with no craneage over them and were both fully committed work wise, it was a good excuse to buy another machine and put it in the no 2 shop where we had the headroom and more importantly an overhead crane to lift the jobs on and off. The latter is a homemade affair with a 1-ton hand chain block but is worth its weight in gold. There just remained the problem of the lack of height.

Bridgeport supply riser blocks in, I think, 4" and 8" depths and in theory you can keep adding them until you are high enough, just needing longer screws to hold it all together. Obviously, when I looked round to buy a spacer none were available (new price was daft) so I had a bit of 12mm plate cut and rolled and a couple



The job in progress

This was all fitted up and we awaited the delivery of the first components. They were coming from the customer directly from his newly acquired all singing and dancing CNC vertical borer and it seemed the singers and dancers could not get it together. However, they eventually started to arrive and we set about them.

The technique was to clamp the job onto the table and clock the right-angle head along the clocking strip until it was true to the axis of travel. A $\frac{3}{4}$ " ripper cutter was used for roughing, changed to a standard end mill for finishing. Although the slot was $\frac{11}{2}$ " wide it was felt that several passes with the smaller cutter was better than trying to use a bigger one. When the first slot was completed the head was rotated 180 degrees and clocked up again. We could have put a rotary table on but wanted to keep the height to a minimum. You can see the machined clocking strip on the side of the right-angle head. As remarked before the slots were not key ways in the accepted sense but were for aligning the mating part. The limits on the width were plus or minus 15 thou, and after the first one was done and the settings arrived at they all went through with no problems. **Photograph 2** shows the machining in progress

We got to the stage of doing two a day, which was slightly slower than using a slotter, but, bearing in mind the cheaper hourly rate on the smaller machine, meant it was a reasonably economical way of working and we also finished up with another Bridgeport to add to the collection. ■

of 25mm flamecut discs supplied from our usual profilers and we welded one up and machined it to suit.

Just as we were ready to assemble the spacer to the machine (another use for the crane) we got a drawing change showing the job was 1" higher than originally shown. Of course this was just too high to go under the newly increased head and so we made another riser, this time from a flange we had scrapped a month or two earlier. (Yes, we do make mistakes and also, like model engineers, we don't throw much away.)

By this time, we had received the two power feed kits, one for the table long and one for the vertical knee. As this was the

first time we had used these I wanted to see how they performed and if OK we would fit one to the cross feed in the fullness of time. I also decided to fit a cheapo Chinese digital readout to all three axes. Anyone who is working for money and does not use readouts wants his head examining. They save hours of time and prevent you forgetting where you are with the dials. Whilst we were at it we made a locating spigot to position the job on the table. This would mean that we would be able to set the readout up and they should all come out the same. Hopefully all correct! (Readout, like CNC enables you to make scrap that much quicker...)

ISSUE NEXT ISSU E NEXT ISSUE NEX MODEL ENGINEER NEXT ISSUE NEXT IS SSUE NEXT ISSUE

- **Sheffield Rally**
Geoff Theasby tells us about his day out at the Sheffield Steam Rally.
- **BR2 Aero Engine**
Having completed the cylinders, Mick Knights moves on to describe the crankcase of his aero engine.
- **LittleLEC 2018**
Geoff Bashall reports on this year's LittleLEC event at Worthing.
- **CNC for a Sieg Mill**
Graham Sadler describes how he converted a Sieg mill to CNC operation.
- **Vertical Boiler**
Martin Gearing flanges the plates for his vertical boiler.

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A Stepper Motor Driven Toolchanger for a Small CNC Lathe

In this new series, Simon Davies describes the development and construction of a CNC toolchanger for his Emco lathe. Part 3



Steel casing for the nut

An outer steel shell was then created **photos 54 and 55** and the nut inserted and Loctited into place as shown completed in **photo 56**. The steel shell allows a complicated spacer arrangement to be constructed which required greater dimensions than the phosphor bronze rod. The steel shell will eventually act directly onto a thrust bearing which in turn acts onto the block. The reason for this method was to minimise



Boring taking place

the tightening forces when tensioning the through bolt between the toolchanger plate and the body (via the cone).

The original design for the bolt tightener stepper motor was that it would be in line and acting directly on the nut. I swiftly realised that the torque required to solidly lock the cones together was far in excess of the available torque from the stepper. At this point I redesigned the arrangement such that a much more powerful stepper drove a belt reduction arrangement to increase the tightening torque. Later we will see that the electronics were also adjusted to further maximise available torque.

The shaft is a simple design and was machined between centres to the dimensions shown with an additional lump of steel again attached by Loctite and then screw-cut to match the nut. The left-hand thread can be seen in **photo 57**.

Steppers and their mounts

There are two stepper motors involved in the unit; one turns the locking nut and the other rotates the toolholder to the desired position when the locking bolt is released.

The locking bolt stepper has been upgraded twice from the original as well as maximising the available ratio that can be extracted from the timing gears and their combination of available space and belt constraints. This means that the locking stepper drives a commercial 15 tooth gear through a belt to a homemade 67 tooth



Nut Loctited firmly into the casing

gear. The toolholder stepper was easier and uses the original specification motor and belts and has proved to be perfect for the job. In this case the requirement is not on torque which merely needs to be adequate but on the positioning accuracy which defines how close to centre height a tool can be set to and how closely it can be returned to that point. This is achieved by a high reduction ratio and micro stepping the motor to gain yet more resolution without going to a point where that resolution cannot be repeated.

Both motors are mounted on CNC milled mounts incorporating slots for applying tension to the belts. The material is 6.5mm ground aluminium plate 'acquired' nearly 30 years ago which has been a useful source of material ever since. I assumed that it would have adequate stiffness but was rather surprised to see it flexing during some of the tests when the motor was stalling, and I may still add a further support at the other end of the locking stepper.

Machining was another CNC exercise where the size and shape and mounting holes were taken from the drawing of the block and transferred to a separate drawing. This formed the source of the mill's g-code instructions directing the path to follow. However, it also proves that CNC and CAD is not proof against carelessness as shown by the use of countersunk mounting bolts in place of the original socket head which solidly



Through bolt being machined



Commercial timing gear being bored for 1/4"



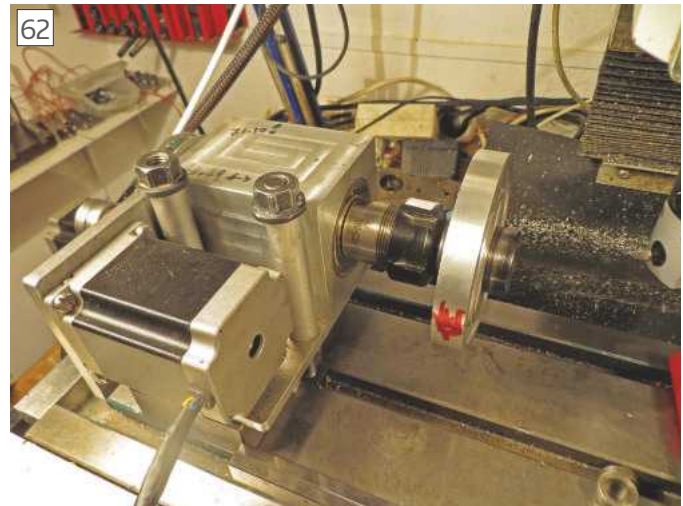
Big slice of aluminium being faced for the toolholder plate timing gear



Initial trepanning mark indicating where it will need to be cut later



Bored and mounted on a mandrel for machining to diameter. Note use of ER25 collet



4th axis on the mill also uses ER25 collets. Note witness mark on the side of the blank from setting up the cutter-blank distance

fouled the toolholder timing wheel.

The commercial 15 tooth timing gear came with a boss incorporating the locking screw which meant that the gear was too long. It also had a 6mm hole whereas the stepper had a 1/4" shaft. It was adapted by boring then machining away the boss, **photo 58**, and cross drilling through the gear itself for a suitable locking grub screw.

The other timing gear for the toolholder started life as a band-sawed slice of aluminium bar which was faced to size and bored for the centre hole. It was then mounted on an arbour and the outer

dimension machined to size before being transferred to the mill's 4th axis as seen in the sequence **photos 59 to 62**. I had previously made a fly cutter tool to suit the XL timing wheel dimensions and this was now installed in my boring head for convenience **photo 63**. Yet another CNC program was written to machine a single tooth gap and then rotate the wheel blank and repeat for the remainder of the wheel. **Photograph 64** shows an initial run with the cutter just skimming the blank as a sanity check and **photo 65** shows the full depth cut in action – note the temporary

screens to prevent the entire workshop disappearing under a carpet of aluminium snow.

Once completed, the timing gear was returned to the mill table and the bore centred to the mill head **photo 66**. The centre was then trepanned out using a CNC program to a near finished size as shown in **photo 67**. At the time I was not confident of the CNC mill's backlash and absolute dimensional capabilities, so I chose to CNC to a close but not final dimension. The boring head was then pressed into service as shown in **photo 68** to finish the bore to



Timing belt cutter mounted in a boring head for convenience



Part of the first run just checking that the correct numbers have been entered



65 Cutting to full depth on this pass



66 Centred on the table using a suitable shaft mounted in the mill ER25 collet



67 Roughing cut to remove the centre. Note the delicately placed clamps and the MDF sheet to protect the mill table



68 Small flycutter held in a boring head for the final boring of the gear

the final dimension. This was then loctited to the toolholder plate as can be seen in the later **photo 69**.

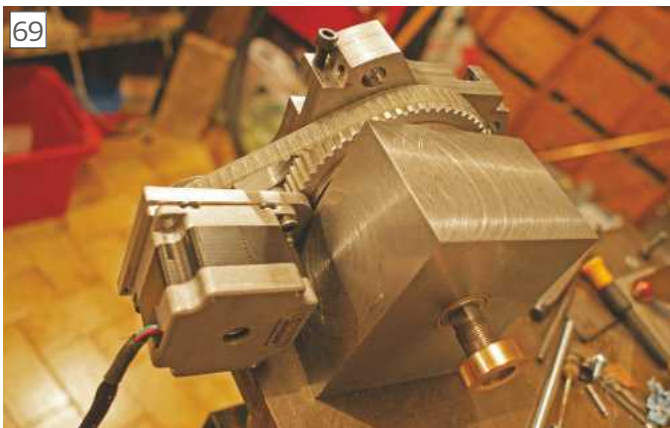
An index plate with one double width (index) slot and 7 tool position slots was milled from a piece of 3mm sheet as shown in the sequence **photo 70 to 72** and bored to also fit the toolholder plate.

The 62-tooth locking gear was manufactured in a similar manner although it started life as a roughly sawn piece

of 10mm aluminium plate which was subsequently made circular, **photo 73**, before having the teeth cut with the same cutter as shown in **photo 74** with the final version shown in **photo 75**. The centre was bored for the bronze nut which was subsequently loctited into place as can be seen in **photo 76**.

Often the biggest problem with CNC work is how to hold an object whilst it is being machined – moving and replacing

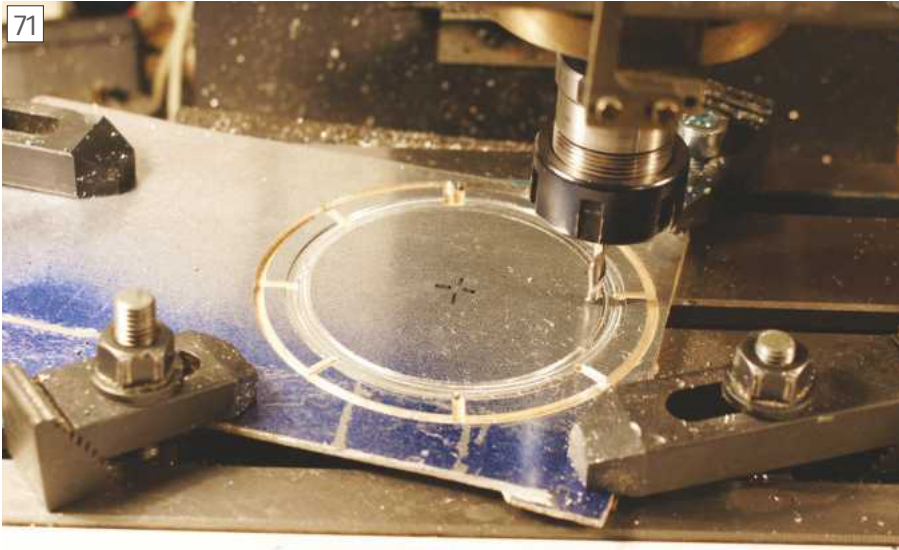
clamps in mid cut is 'not recommended' so I had to use different methods to profile the stepper motor mounting plates. A machining block was mounted on the mill table and several holes drilled and tapped into it – these corresponded to slots and holes needed in the final mounting plate. These can be seen ringed in red in **photo 77**. The plate was then clamped to this block and clearance holes (corresponding to necessary holes in the plate) cut as shown



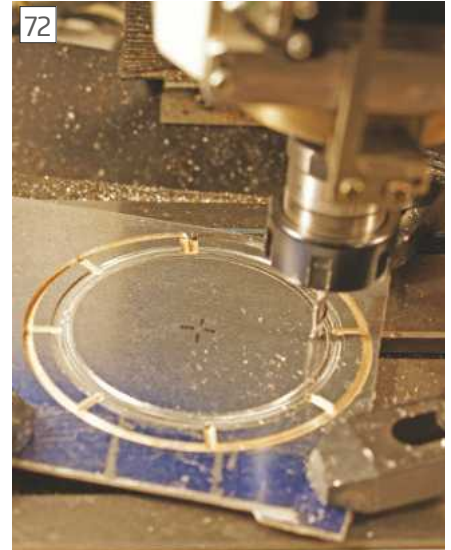
69 Installed in place for a sanity check. Note also the bronze nut on the through shaft



70 Milling out the index disk. The aluminium is glued to an MDF backing sheet



71 Milling the slots in the index - note the double width index at the top of the photo. This has now become the only slot used



72 Final work on the plate



73 Another out of round blank ready to become a timing gear wheel



74 Enough confidence this time around to cut immediately to full depth

in **photo 78** and the plate firmly bolted down and excess clamps removed. The profile of the plate was then cut as shown in **photos 79** and **80** where the clamping bolts can be clearly seen. One additional check needs to be made before starting to ensure that either the Z clearance plane (where the end mill is retracted to for any 'move' operations) is higher than the bolt head or that the bolts are not on a traverse path, otherwise it all gets swiftly messy. The

unstoppable meeting the immovable under CNC control is never good!

The original method for determining whether the nut was tight or not was based on the idea that when tight, the nut would stop rotating and that the stepper would stall repeatedly. I originally designed an opto detector in conjunction with yet another toothed wheel to detect this change in movement. The detector wheel can be seen in **photo 81** along with

the electronics box which contained the detector. Although the logic was sound, the actual operation of the lock and unlock was found to be unreliable and very difficult to determine what constituted 'stepper stalled and thus locked' as opposed to 'getting tight but not tight enough'.

This whole assembly has now been replaced by a commercial 600 pulse rotary encoder connected by tiny timing belt to the locking nut.



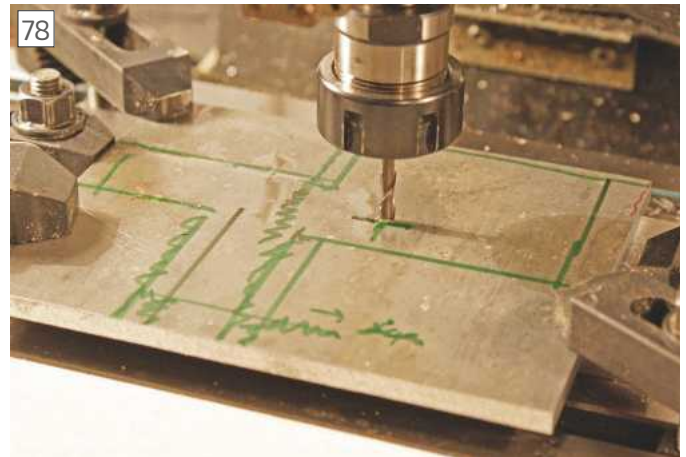
75 The finished locking timing gear



76 Bronze nut installed, awaiting a final cleaning cut



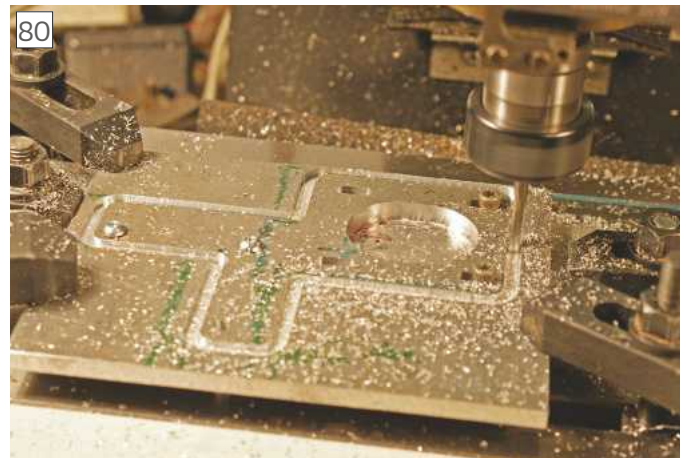
Sacrificial plate predrilled for hold down bolts



Stepper mount plate clamped in place and being drilled at hold down points



Profiling the stepper mount plate - note the hold down bolts



Another view of the profiling process - note the oval hole for the stepper reference dimension allowing some limited movement for tensioning



Stepper installed in the mount plate. Note the oval holes allowing some L6R movement



Rough initial 3D print



Version 2 alongside V1, note holes, bracing to the arms and a generally better finish

Since this is more than a little bit of an afterthought, the encoder bracket was made using a 3D print. If I had planned it in the original concept, then I would have incorporated it into the main stepper bracket but I couldn't face making yet another of these (I had to remake one early on when I made a mistake with the geometry). I also used my 3D printer to make the timing gears since they have no stress on them and can be made from plastic with no concern for wear. I initially expected to have obscure sizes as well to ensure that the available belts would allow the encoder to be installed in a sensible place but that turned out to be not the case so the 32 tooth gear on the encoder is

driven by a 60 tooth gear attached to the tightening gears. I used the 3D drawings I had made during the construction of the toolchanger and fiddled with a combination of the available belts and gears and eventually found a spot to install it. This was modelled using the 3D program and then uploaded to my 3D slicing program and a fast (and rough) print made. Twenty minutes later the prototype (lacking fixing holes) was being manoeuvred into place and tested, **photo 82**. A couple of minor dimensioning adjustments and the addition of fixing holes and additional bracing produced the second prototype as shown in **photo 83** with the original for comparison. This was deemed to function, and a final,

much finer print was made as shown in the next photo where the differences between 0.4mm and 0.1mm layers may be seen **photo 84**.

The bracket was attached to the encoder and the stepper mounting plate and the timing gears installed along with the belt. This was tensioned via the elongated hole designed into the encoder bracket.

Electronics box

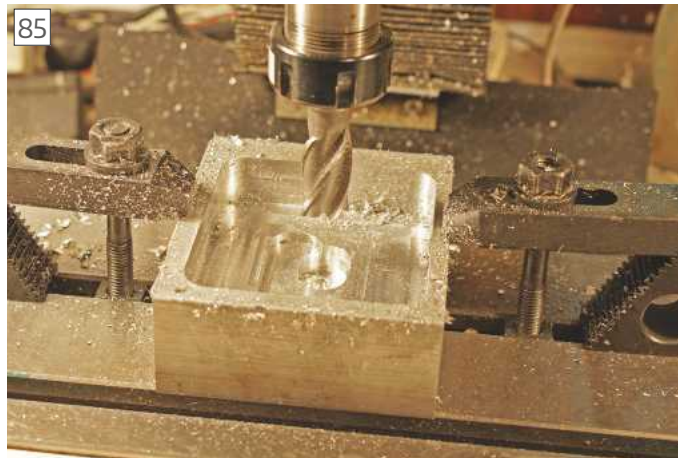
The electronics box houses the Arduino single board computer as well as the (originally two) optical detectors that detect movement and position of the two stepper driven components. Additionally, it contains the two drive circuits for the steppers and

84



Final version bolted onto the encoder

85



Carving as much aluminium out as possible with large end mill

86



Smaller end mill cleaning the corners and applying a final finish internally

87



Milling out the base leaving 4 mount points for the Arduino

the lid houses the manual controls and the information display.

In some ways this was a pure indulgence on my part since it could have been satisfied by the use of a commercial box. However, machining it using CNC allowed me to machine integral mounting bosses on the base rather than relying on washers and stand-offs, more on that later!

The other advantage of a metal box is that it provides electrical isolation from the motors, although having the high voltage drivers within the box negates some of that effect.

The drivers are postage stamp sized modules containing several ICs and which can drive up to 2A at 45V, originally equivalent to Pololu A4988 and then upgraded to DRV8825. Since I am driving them to the maximum, they need to have sufficient cooling to prevent them from switching to their over temperature mode and cutting out momentarily. On my bench tests I was confused why the motors would have ever increasingly long pauses whilst driving the steppers and spent some time looking at the software before realising that the over-temperature mode was kicking in. The box allows the control chip on the driver module to be in direct contact with the aluminium via heat transfer paste thus offering a direct heat sink further enhanced by the several kilos of steel forming the block. Since being mounted in the box, I

have had no further heat related problems. Because the chip is in the top of the module, they are mounted upside down with the connector pins sticking upwards allowing interconnection by standard connectors.

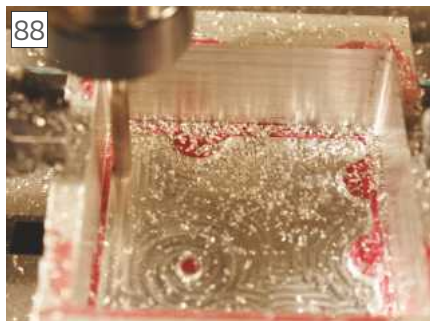
I initially machined a square hole to allow a reflective opto sensor (a transmitter and detector side by side able to measure the difference between dull and reflective surfaces) to be mounted as closely as possible to the detection disks for the toolchanger plate. This was however fraught with problems for the detection part so I replaced it with a simple opto-switch and made a 3D printed adapter to hold it in place of the original device.

The lid contains an Arduino display and a 5-way switch for manual operation of the unit through the Arduino.

Machining the box was a straightforward CNC exercise where a piece of aluminium was first hollowed out to the depth of the internal mounting bosses using the fastest process available as can be seen in **photo 85**. A smaller long series end mill then cleaned the inner face of the sides and removed the remaining 2mm leaving the bosses as islands in the box base, **photos 86 to 89**. Very satisfying until I uprated the driver modules which had the main chip in a different position but still needing a heat sink. This was solved by epoxying a small slice of aluminium onto the board with heat transfer paste between the chip and the slice. This allowed the new module to fit in the same place as the earlier version.

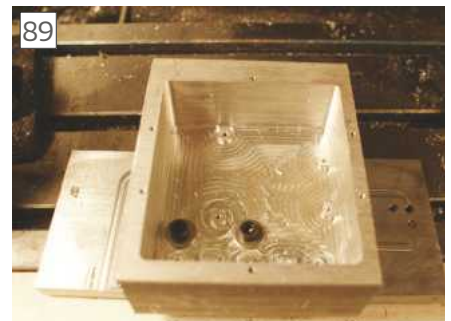
● To be continued

88



The mount points are clear in this shot

89



Box finished internally, bolted to a mount for finishing externally

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A Metal Turning Attachment



Stan Nesbitt modified an old Arundel Wood lathe for light metalworking duties.



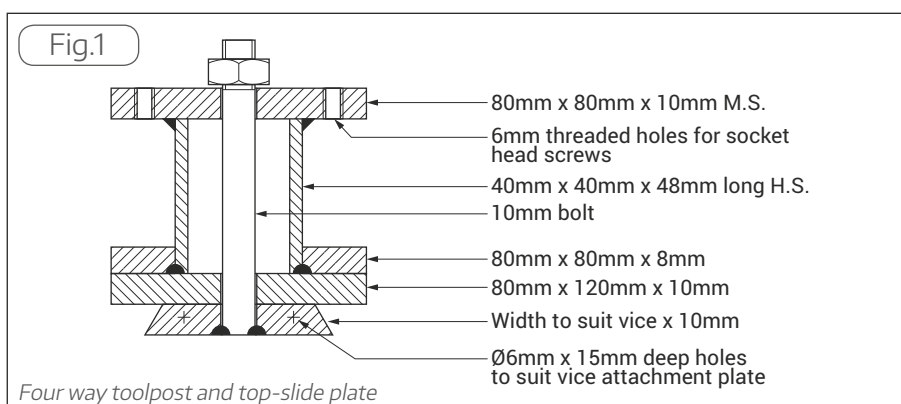
The converted Arundel wood lathe



Another view of the converted lathe

Wood turning lathes are generally of lighter build and when pressed into turning metal, patience and lighter cuts are necessary. Given such limitations this procedure may be useful in an emergency to get back into production. The lowest speed on a wood turning lathe may be rather high for metal turning but for smaller diameters, this is manageable.

Whilst I used an old 6-inch 3 jaw self centring chuck for work holding, turning between centres is also possible, **photos 1 and 2**. The 4-way tool post, **fig. 1**, was constructed with sufficient height to allow adequate packing for the cutting tool to be



The cross vice



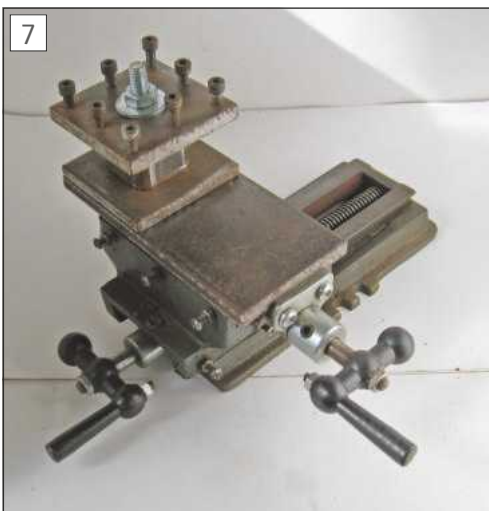
The base clamping system fits the lathe bed



Showing how the clamp assembles



The base plate



Four way toolpost assembled to vice



Underside view of the whole assembly



The top-slide base plate in position with toolpost removed

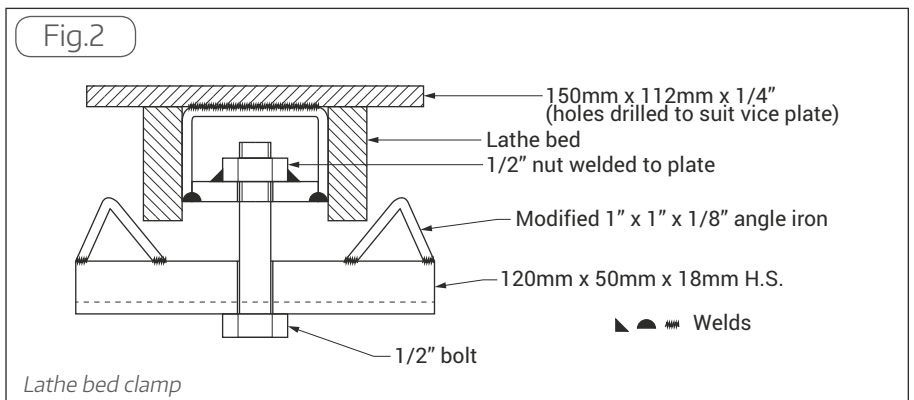
This design allows both the lathe and the cross-slide vice to be restored to their original condition when required.

set at the correct centre height, 6 inches for my Arundel lathe.

I utilized those materials readily available from my scrap box, including an old cross-vice, **photo 3**, of course others may vary the design to suit their own circumstances.

The basic concept is a clamping plate which can be fitted at any place along the bed, **photos 4, 5 and 6**. On this is mounted the modified cross vice to provide a cross-slide and a (fixed) top slide, **photos 7 and 8**. The topslide base plate, **photo 9**, operates in the vice dovetails.

The clamping system, **fig. 2**, is intended to squeeze the lathe bed ways together which ensures a very sturdy grip, but



without any damage to the lathe. Some of the welds need to be flattened with a file or angle grinder. I found it necessary to drill 10 mm holes through the dovetail plate to enable spot welds to the base plate at the bottom of each hole. With the flattened welds at both ends this additional welding ensures a very firm connection between the two surfaces.

This design allows both the lathe and the cross-slide vice to be restored to their original condition when required. Of course, this use of a wood turning lathe is limited to light plain turning and facing. ■



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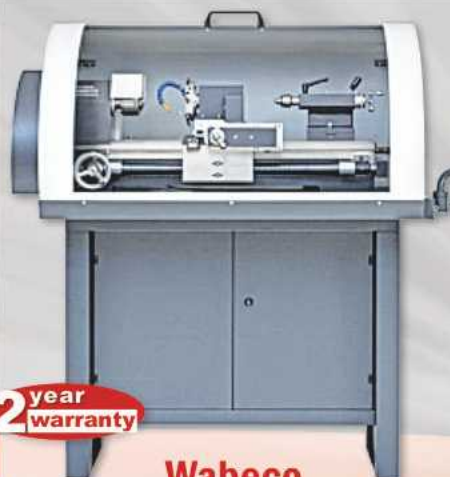
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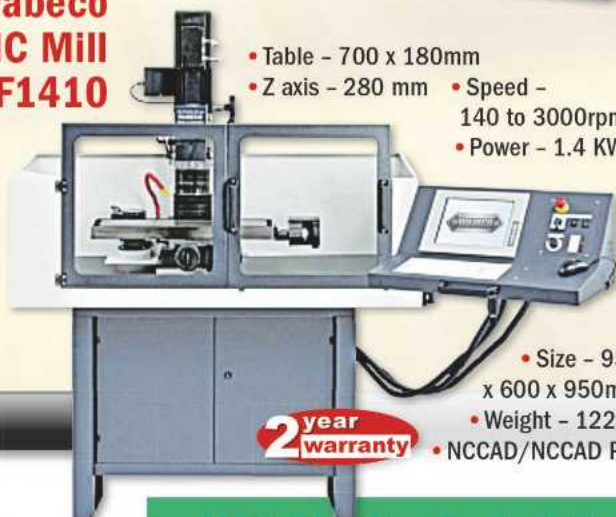
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Making a threading indicator for a lathe

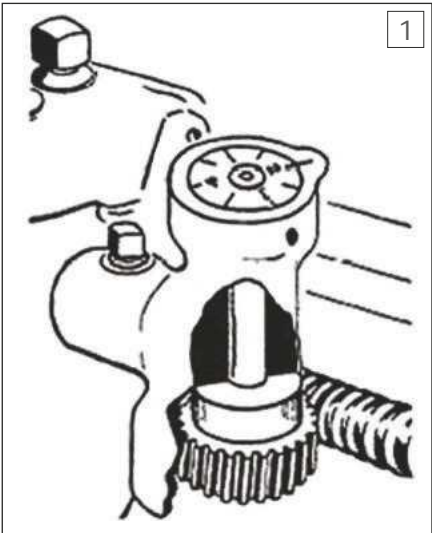


Christopher Robinson explains how to make an aid to screw cutting

We all know that if you want to produce an accurate screw thread precisely aligned to the axis of a part then the best way to accomplish this is to screw cut it on a lathe. Most of the time we can choose the thread we want from a standard range but quite frequently we have to make threads to fit existing parts where we have had no influence on the choice of thread. An additional complexity is two parallel thread systems, imperial & metric with different ways of specifying pitch, imperial in threads per inch and metric in mm pitch. When buying a lathe, there is a choice usually between imperial and metric. Having made the choice, it is cumbersome but quite feasible to produce metric threads on an imperial lathe and vice versa.

To make a thread quickly it is most helpful to disengage the lead screw and half nut, wind back the carriage and re-engage at a place where the tool is still indexed correctly to the thread being made.

If the thread has a pitch which divides nicely into the pitch of the lead screw, then the half nut can be engaged at any point and indexing is maintained. So, if we have an imperial lathe with a 4 tpi lead screw, this is the happy case for threads with any tpi count divisible by 4. Likewise, for a smaller lathe like a Myford with an 8 tpi lead screw this obtains for all threads with a tpi divisible by 8. It is probably no accident that the two pitches used in the Model Engineer series of threads, 32 & 40 tpi are both divisible by 8. For a metric lathe with a 6mm pitch lead screw this situation will obtain for any metric pitch which divides into 6 and produces a whole number, namely 0.2, 0.25, 0.3, 0.4, 0.5, 0.6, 0.75, 1, 1.5, 3 & 6mm. Smaller pitches also meet this criterion, but we are unlikely to screw cut a thread with a smaller pitch than 0.2mm very often.



Typical thread indicator

However, there are many thread pitches in common use which do not meet this criterion. If we look at imperial fastening threads up to one inch then 18, 14, 13, 11 & 9 tpi are used. Why the powers that be chose 26 tpi for brass threads as opposed to 24 is a puzzle. British pipe threads are even more perplexing with 19, 14 & 11 tpi being specified but American NPT/NPS takes the biscuit with 27, 18, 14 and 11½ tpi. In the metric world of fastening threads up to 25mm, apart from the pitches above, 0.35, 0.45, 0.7, 0.8, 0.9, 1.25, 1.5, 1.75 and 2.5mm are used.

Finally, there are equipment manufacturers who deliberately choose an obscure thread to encourage users to buy spares from them. The best example I know of this is the Swiss manufacturer of watch making lathes, Shaublin, who use a 12/3 mm pitch buttress thread for their collets. By the way, these are beautiful

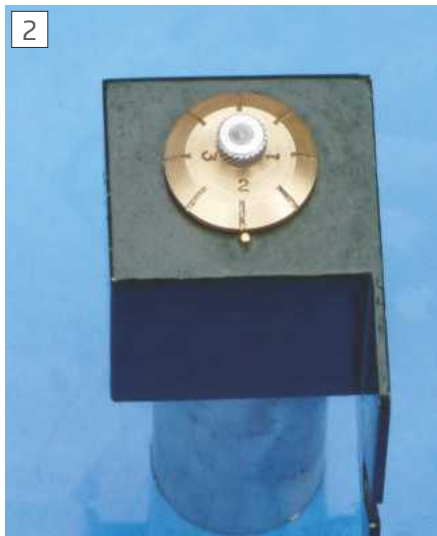
machines of the highest quality.

So, how can we get the speed of threading with these pitches which do not divide nicely into our lead screw pitch? The answer is a threading indicator.

Incidentally, to make metric threads on an imperial machine and vice versa involves a 127T gear or some approximation. In this case there will be no convenient point at which the lead screw can be re-engaged and indexing maintained. The only option is to keep the lead screw and half nut engaged throughout the whole process and reverse the lathe between cuts.

The threading indicator

Photograph 1 shows a basic threading indicator. A housing attached to the lathe saddle supports a shaft which is generally vertical, or near vertical. At the lower end of



Thread indicator for the Colchester Student - top view

Table 1: Rules for an imperial thread indicator

	Indicator gear teeth 4 x lead screw tpi	Indicator gear teeth 2 x lead screw tpi
Even number tpi threads	Reengage at any line (1/8 rev)	Reengage at any number (1/4 rev)
Odd number tpi threads	Reengage at any number (1/4 rev)	If 1 or 3, reengage at 1 or 3 (1/2 rev) If 2 or 4, reengage at 2 or 4 (1/2 rev)
"Something and a half" tpi threads	If 1 or 3, reengage at 1 or 3 (1/2 rev) If 2 or 4, reengage at 2 or 4 (1/2 rev)	Engage and reengage on same number only (1 rev)

Table 2: Thread indicator indexing for metric threads with lead screws from 1 - 6mm pitch**Indicator indexing with a 6mm lead screw**

Gear	Any line or halfway between (1/16 rev)	Any line (1/8 rev)	Any numbered line (1/4 rev)	Alternate numbers 1.3 or 2.4 (1/2 rev)
14				0.35, 0.7, 1.75, 3.5, 7
16	0.2, 0.25, 0.3, 0.4, 0.5, 0.6 0.75, 1, 1.5, 2, 3, 6	0.8, 4, 12	8	
18				0.45, 0.9, 4.5, 9
20			1.25, 2.5, 5, 10	
22				5.5, 11

Indicator indexing with a 5mm lead screw

Gear	Any line or halfway between (1/16 rev)	Any line (1/8 rev)	Any numbered line (1/4 rev)	Alternate numbers 1.3 or 2.4 (1/2 rev)
14				0.35, 0.7, 1.75, 3.5, 7
16	0.2, 0.25, 0.5, 1 1.25, 2.5, 5	0.4, 2, 10	0.8, 4	8
18				0.45, 0.9, 4.5, 9
22				5.5, 11
24		0.3, 0.6, 0.75, 1.5, 3	6	12

Indicator indexing with a 4mm lead screw

Gear	Any line or halfway between (1/16 rev)	Any line (1/8 rev)	Any numbered line (1/4 rev)	Alternate numbers 1.3 or 2.4 (1/2 rev)
14				0.35, 0.7, 1.75, 3.5, 7
16	0.2, 0.25, 0.4, 0.5, 0.8, 1, 2, 4	8		
18				0.3, 0.45, 0.6, 0.75, 0.9 1.5, 3, 4.5, 6, 9, 12
20			1.25, 2.5, 5, 10	
22				5.5, 11

Indicator indexing with a 3mm lead screw

Gear	Any line or halfway between (1/16 rev)	Any line (1/8 rev)	Any numbered line (1/4 rev)	Alternate numbers 1.3 or 2.4 (1/2 rev)
14				0.35, 0.7, 1.75, 3.5, 7
16	0.2, 0.25, 0.3, 0.5, 0.6 0.75, 1, 1.5, 3	0.4, 2, 6	0.8, 4, 12	8
18				0.45, 0.9, 4.5, 9
20			1.25, 2.5, 5	10
22				5.5, 11

Indicator indexing with a 2mm lead screw

Gear	Any line or halfway between (1/16 rev)	Any line (1/8 rev)	Any numbered line (1/4 rev)	Alternate numbers 1.3 or 2.4 (1/2 rev)
14				0.35, 0.7, 1.75, 3.5, 7
16	0.2, 0.25, 0.4, 0.5, 1, 2	0.8, 4	8	
18				0.3, 0.45, 0.6, 0.75, 0.9 1.5, 3, 4.5, 6, 9
20			1.25, 2.5, 5, 10	
22				5.5, 11
24			12	

the shaft a gear is mounted which meshes with the lead screw as it would with a worm. At the upper end of the shaft is a circular dial on which are marked regular graduations, usually 8 with every other mark bearing a number and a fiducial line on the face of the housing. There are other numbering systems for the dial but since this is by far the most used and generally accepted, this article will concern

itself with 8 divisions only. This gives 4 marks numbered 1 to 4 each with a mark between successive digits with no number. The housing can be swivelled to allow engagement or disengagement of the gear with the lead screw.

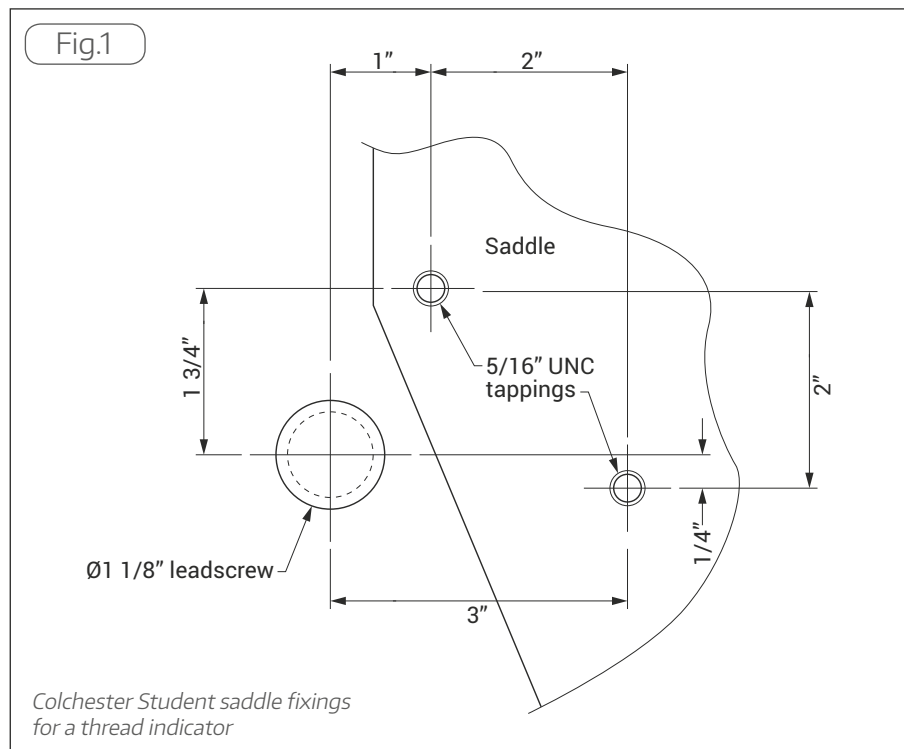
These indicators work best with the imperial system of threading. It is generally convenient to have a gear which has a tooth count of 2 or 4 times the tpi of the

lead screw. So, take a lathe with a 4 tpi lead screw, ie a 1/4" pitch, with a threading indicator having a 16 tooth gear, 4 times the lead screw tpi. As the saddle progresses the gear wheel will turn, and with it the dial. In turning a full revolution, the saddle will have moved a total of 16 pitches which is $16 \times 1/4 = 4$ inches. This means that between successive numbered lines which is a quarter of a revolution, the saddle will move

one inch, and between any two lines one half of an inch. For an indicator with a gear with a tooth count of 2 times lead screw tpi, say a 16-tooth gear with a 8 tpi lead screw, then all these distances will be halved.

Now, say we are thread cutting with a 4tpi lead screw and an indicator gear of 16T with the indicator engaged and have stopped at the end of a pass. If the indicator dial is now set to a particular line, say 1, the half nut disengaged, and the saddle would back to a position where any number is indicated, then this will always be a distance of an exact number of inches. If the half nut is reengaged at this point, then provided we are cutting a thread with a whole number of threads per inch the tool will always be indexed correctly with the thread being cut. Further if we are cutting a thread with an even number of threads per inch this will be true for every half inch, so the half nut can be reengaged at any of the 8 lines. Going a little further, with any thread number divisible by 4, this can be done not only at any line but also halfway between lines, ie every 1/4". As this is the lead screw pitch this means that for threads divisible by the lead screw tpi number, the half nut can be engaged at any point and the thread will be correctly indexed. So, with this condition, while a thread indicator is not essential, it still helps to quickly find the correct point rather than "feeling" for it with the engagement lever and carriage wheel. So, in summary, the general rules for an imperial thread indicator of this design are shown in **table 1**.

As was mentioned earlier the use of a threading indicator with metric threads is not quite as straightforward and this is due to the metric system of specifying linear pitch in mm rather than a number of threads per unit distance. As already established, if we are cutting a thread whose pitch will divide into the lead screw pitch yielding a whole number, then the half nut can be reengaged at any point. However, the indicator is still useful as it indicates exactly where to reengage and saves time. So, if we take the same design as above with a 16 tooth gear and a dial with eight graduations with a 6mm pitch



lead screw when cutting the following pitches, the half nut can be reengaged at any line or halfway between lines:

0.2, 0.25, 0.3, 0.4, 0.5, 0.6, 0.75, 1, 1.5, 3 & 6mm

However, if we wish to cut a thread having a pitch which does not meet this condition, say 0.7mm then we need an indicator gear having the factor 7 in it. The nearest to 16T is clearly 14T. Now consider the indicator with a 14T gear meshing with the 6mm lead screw. In one revolution it will have moved 14 pitches which equals $14 \times 6 = 84\text{mm}$. This is $84/0.7 = 120$, ie a whole number of threads being cut as well as a whole number 14, of lead screw pitches, so a whole rotation works. Now in half a rotation the carriage will move 42mm. This 60 thread pitches and 7 lead screw pitches to that works also. However if we take a quarter rotation then we will move 30 thread pitches and 3.5 lead screw pitches. as 3.5 is not a whole number the

lead screw will not engage, thus half a rotation of the dial is the best we can do.

Now take the example of common threads having the factor 5 but not divisible into the lead screw pitch, namely 1.25, 2.5 and 5mm. The indicator gears with a factor of 5 in the tooth number and near to 16 are 15 and 20. 20 works better because it also has a factor of 4 as opposed to 3 with 15. 4 works much better with the indicator with 8 divisions. With a 20T gear the carriage will travel $20 \times 6 = 120\text{mm}$ in one revolution. This is 96, 48, and 24 pitches of these three threads and 20 lead screw pitches. All these numbers can be divided by 4 and yield integers so a quarter of a revolution will work, ie any numbered line. We cannot go to 1/8 revolution because it would be only 2.5 lead screw pitches, so 1/4 rev is the best we can do. If you need threads with a factor of 9 in them then you need an 18T gear, for those with a factor of 11, a 22T gear.

Working through all the threads that are

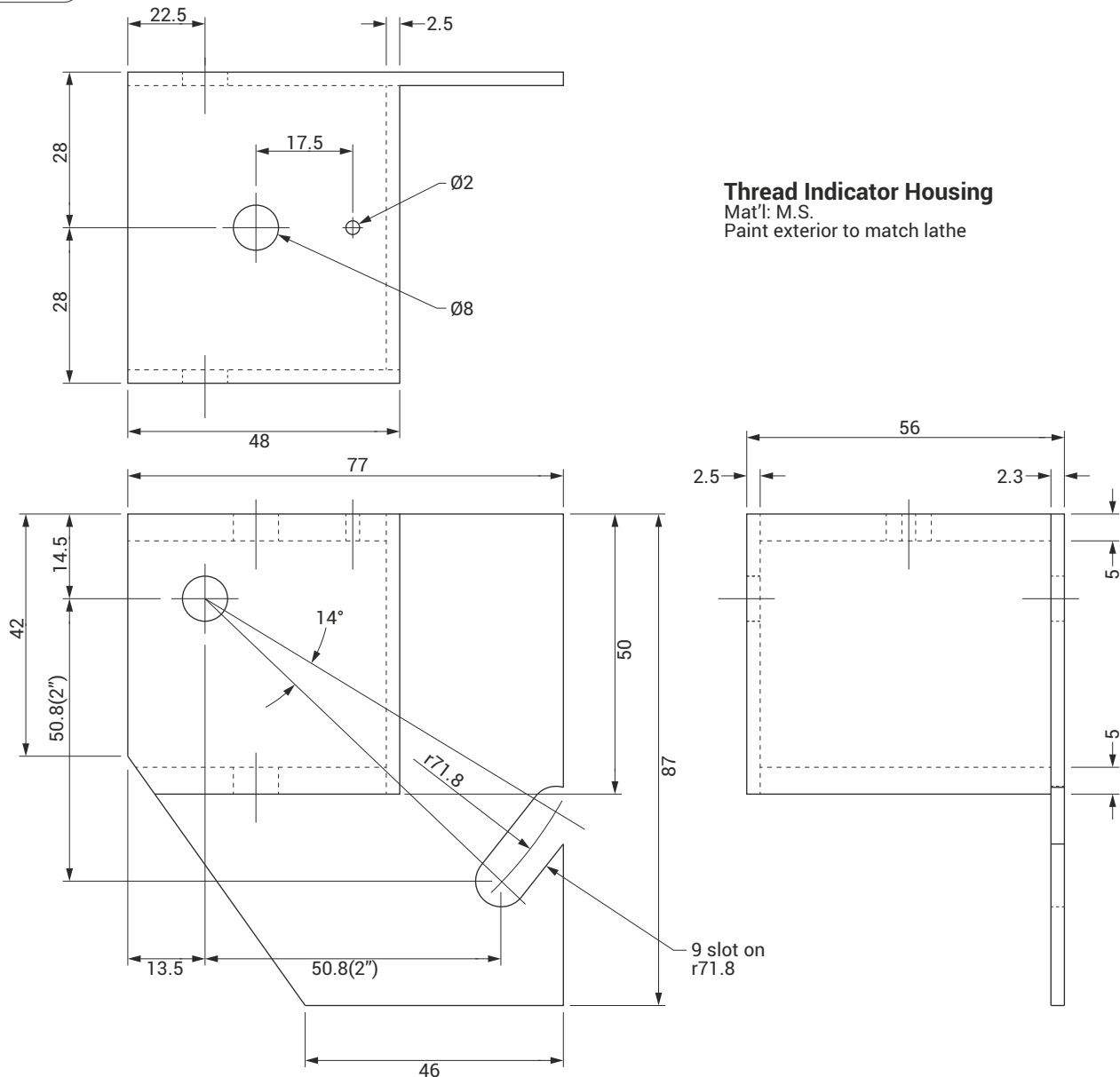


Thread indicator for the Colchester Student - side view



Indicator gears

Fig.2



likely to be needed you end up with the results shown in **table 2** for lead screws with pitches from 1 to 6mm in steps of 1mm.

Making a threading indicator

While the principle of an indicator is the same for all lathes, the details and mounting for different designs will differ widely. This section gives details of the design of an indicator for a Colchester Student metric lathe but can be adapted for other lathe designs.

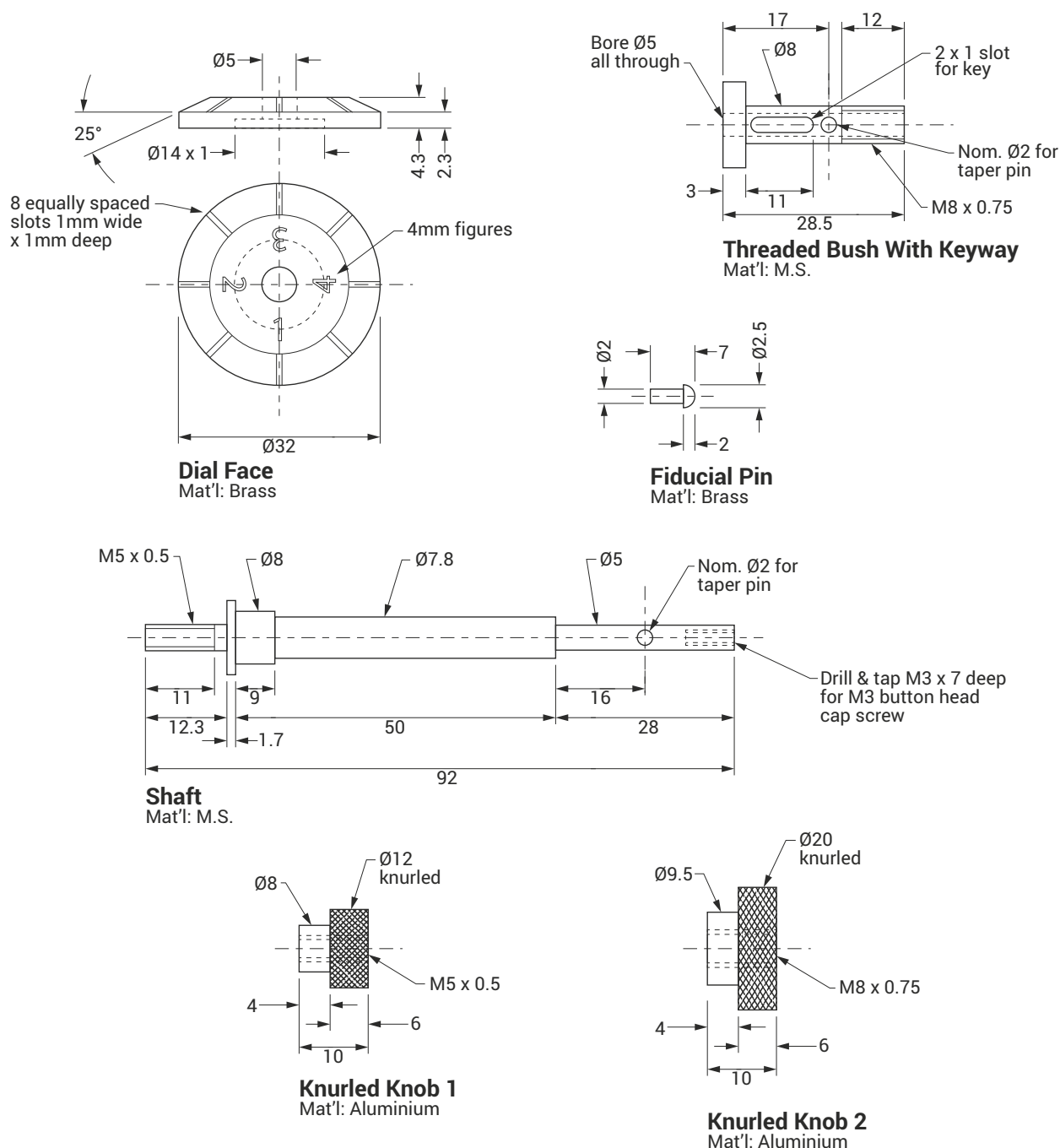
Figure 1 shows the details of the mounting points on the saddle of my lathe and their positions relative to the lead screw. The Student was originally designed as an imperial lathe and this shows in the dimensions of my lead screw which is 11/8 inch diameter x 6mm pitch. The flat face mounting on the saddle favoured a box type design of housing and this is detailed

in **fig. 2**. This was made from 2.5mm and 5mm MS sheet and fixed together with small screws but is also suited to a welded or brazed construction. Details of the shaft, dial and gear mounting are shown in **fig. 3**. The gears are keyed to the shaft and knurled knobs provided for quick gear changing and dial setting. **Figure 4** details the 5 gears of 6mm circular pitch. These were made in two parts, the gear blanks being made with a 16mm bore for ease of mounting on an arbor for gear cutting and were fixed to the boss with Loctite® retainer. It will be noted that as the gears get smaller they are offset further away from the housing as the lower end swings in towards the lead screw to keep the gear on the lead screw centre line. Knowing that Colchester used the same saddle with a 4 tpi lead screw for their imperial Student lathes, I have included the dimensions



Indicator mounted on the Student lathe

Fig.3



for a 16T gear with 1/4" circular pitch. As we have seen, this is the only gear you will need for an imperial indicator.

Photographs 2 and 3 show the assembled indicator and **photo 4** the five gears made in brass. **Photograph 5** shows it fitted to the lathe.

The gears

Making the gears is the only part of the project which is not straightforward. Gears to mesh precisely with the lead screw must have an involute form as generated by a rack conforming to the lead screw thread which usually of ACME or trapezoidal form.

While I am certain that nearly all imperial lead screws are ACME in form I expect some metric machines use the trapezoidal form. The only difference is an included angle of 29 degrees for ACME and 30 degrees for trapezoidal. The thread depth is 1/2 x pitch for both. For the purposes of an indicator the precise thread form is not so important as the gears are not transmitting any power, they only need to indicate position so a relatively simple approximation to the correct tooth form will do the job.

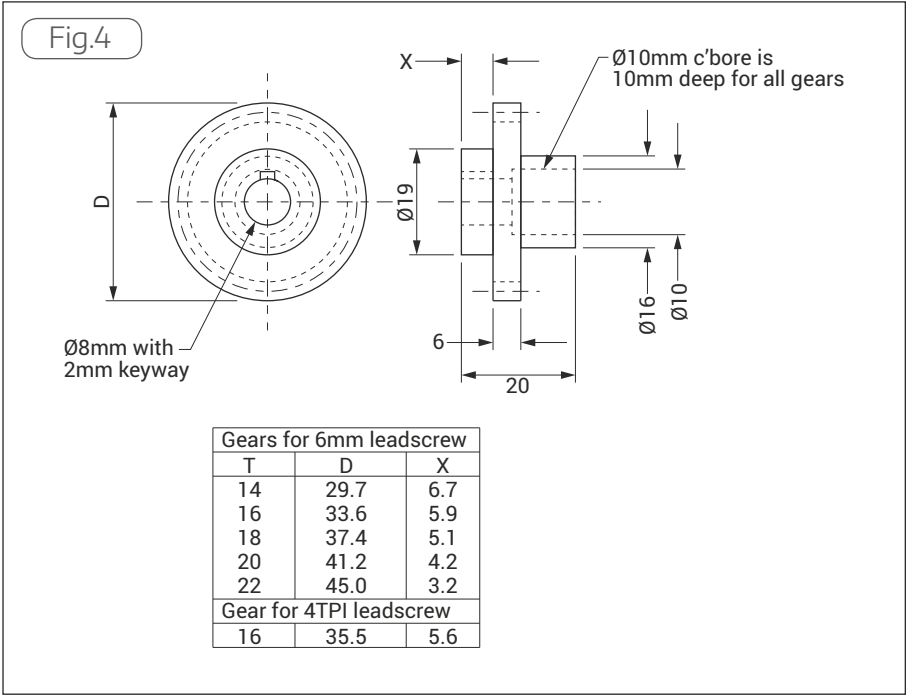
In my case I have a Jacobs gear hobbing machine and I found it an interesting exercise to hob the gears to the correct

form. First a hob was made by machining a thread the same as the lead screw (which in my case is 1.25" OD, 6mm pitch RH) in silver steel, gashing it to form teeth, relieving the teeth by milling the tips and carefully filing the flanks, and hardening. **Photograph 6** shows the finished hob with a 10mm bore. The gears were then hobbled as RH helical gears with a helix angle equal to the lead angle of the lead screw, 40 16'. The helical form of the gears can be seen in **photo 7**. An interesting aside here is that the gear PCD's do not need to be increased in the ratio 1/Cos(helix angle) as would usually be the case. The reason for this is that 6mm

is the pitch of the lead screw parallel to its axis, whereas the true normal pitch at right angles to the thread helix at the pitch circle is $6 \times \cos(4^\circ 16') = 5.983\text{mm}$. This is the pitch which would be specified when making a gear. So what we are actually making is 5.983mm CP gears with a $4^\circ 16'$ helix angle. If you divide 5.986, the true normal pitch, by the cosine of the helix angle you get 6.

At this point I can sense the reader thinking that there must be a simpler way of making satisfactory gears and there is. I have not tried it but I am fairly certain that a slotted wheel with the slots aligned with the lead screw lead angle and suitably tapered at their tips would work fine. The gears need not be as thick as I made them, and 2.5 to 3 mm should be sufficient for a 6mm or 4 tpi lead screw and thinner for smaller lead screws.

A better approximation can be achieved with involute gear cutters which are now freely available to the model engineer market at reasonable prices. Referring to **table 3**, in column 2 is listed the pitch in



Home made hob



View of the gears showing the helical teeth

mm of all the lead screws we have been considering; and the gears to mesh with them should have a circular pitch (CP), as close as possible to this. Most involute gears are specified by their Module (Mod) or diametral pitch (DP). Now the Module

of a gear is related to its CP in mm by $CP = \pi \times \text{Mod}$ or $CP = \pi \times 25.4 / DP$ so the exact equivalent module for each lead screw is listed in column 3. The closest readily available involute gear cutter, whether it be Mod or DP is listed in column 4 and

the Module numbers for all these close approximations (the DP's being converted to module by $\text{Mod} = 25.4 / DP$) are listed in column 5.

● To be continued

Table 3: Involute gear cutters for making the gears

Lead Screw 1	LS pitch mm 2	Module Exact 3	Best Fit 4	Mod Best fit 5	Depth of cut Involute gear 6	ACME Addendum 7	Inv gear Addendum 8	Difference 9	Required Depth of cut 10
6mm	6	1.910	2 Mod	2.000	4.31	1.50	2.00	0.50	3.81
5mm	5	1.592	16DP	1.588	3.42	1.25	1.59	0.34	3.09
4mm	4	1.273	20DP	1.270	2.74	1.00	1.27	0.27	2.47
3mm	3	0.955	1 Mod	1.000	2.16	0.75	1.00	0.25	1.91
2mm	2	0.637	40DP	0.635	1.37	0.50	0.64	0.14	1.23
1mm	1	0.318	80DP	0.318	0.68	0.25	0.32	0.07	0.62
4 tpi	6.35	2.021	2 Mod	2.000	4.31	1.59	2.00	0.41	3.90
8 tpi	3.16	1.011	1 Mod	1.000	2.16	0.79	1.00	0.21	1.95

Simple Tool Height Gauge



Brian Wood describes a truly simple tool height setting gauge for your lathe

Browsing the web recently, I came across a masterful demonstration on a black and white 1950's training film from the USA of a very competent lathe operator making a new 2 tpi worm on a two-inch diameter shaft for a lathe apron.

So what? I hear you say. It was the exceptionally simple centring aid for tool height adjustment he used that caught my attention, one I have not seen before.

Introduction

The lathe he was using looked to be a brand-new Monarch tool room lathe, a really magnificent machine. The gauge I was so impressed with was a built-in feature on the machine

It might have been a design feature of the lathe, an in-house workshop modification or even the operators' own work, the commentary made no comment on it.

Especially helpful in tool setting on American style lantern tool holders in particular, this job used two tools, a roughing tool to cut the bulk of the thread and a finishing tool made to a sizing gauge. Each took just seconds to set to height.

I have since modified my own Myford to include this feature; it is shown here in **photo 1** with the tailstock off the lathe to get the lighting right for the photograph.

In **photo 2**, the engraved mark is shown extended across the nose of the tailstock quill while things were all set up



Engraved mark on the side of a Myford tailstock barrel

and **photo 3** shows an ACME type tool set to working height.

It can also be used to set the height of a boring tool as shown in **photo 4** where the tool is shown deliberately below centre to emphasise the effect. The tool has to be swung round for setting, but that is all that is different.

The modification method

It really couldn't be easier. A really sharp

tool is needed set very carefully to the point on a dead centre in the tailstock. I used a brand new one, but even if the point on yours is slightly blunted it is not difficult to judge the mid-point.

I found a magnifier a really helpful aid to getting this stage correct. Having got it just so, wind out the tailstock barrel a little, touch the outside of it with the tip of the tool, add a little feed and traverse the apron towards the headstock.

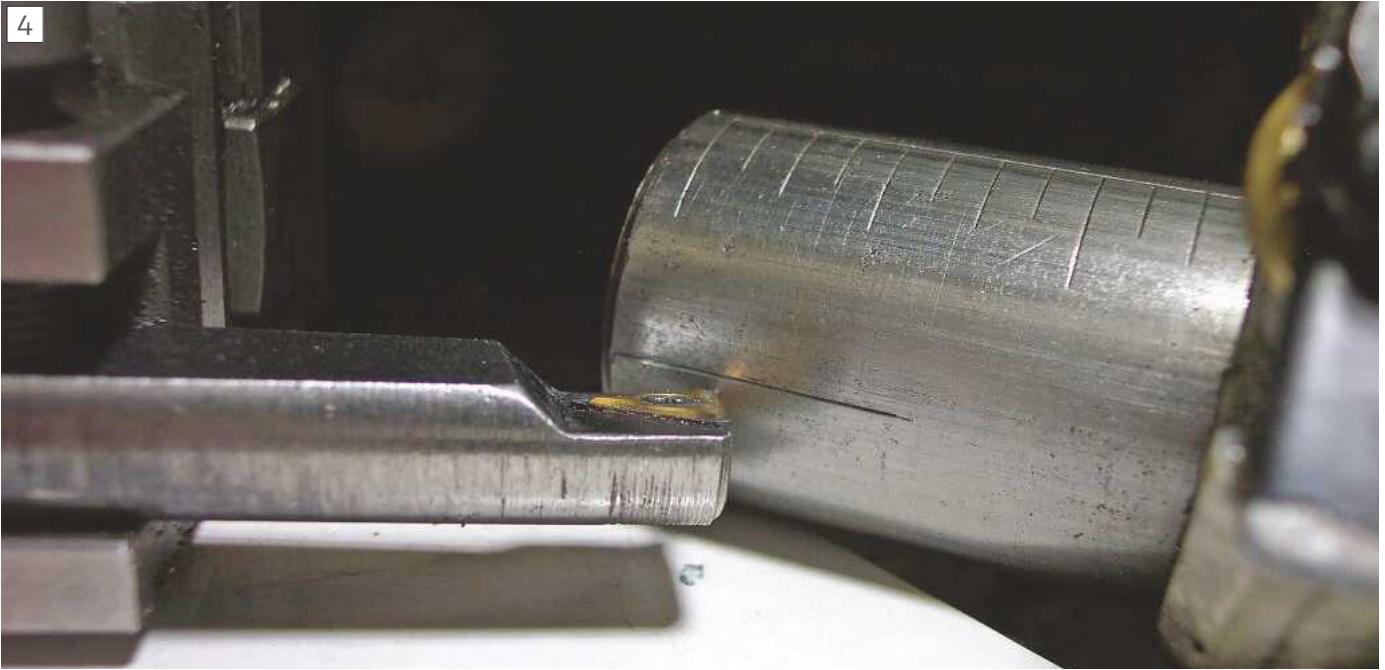


Mark extended across the nose of the barrel



An ACME type tool set up ready for work

4



A deliberately low set boring tool

Repeat with a little more in feed on the tool if the mark is too faint for your liking. Rub off any raised burr and that really is all there is to it. A black marker will help highlight the engraved mark.

The advantages as I see them are as follows:-

- Any lathe can be modified in this easy way.
- It very little time to do after the setting up.
- It is then a permanent feature of the lathe and instantly ready for use. Neither can it get lost nor hidden by the workshop gremlins!
- It is truly accurate depending on the care taken to engrave the mark in the first place.
- It renders all other methods such as height gauges, of whatever flavour whether mounted off the lathe bed or saddle, clip on plastic spirit levels and the like completely redundant. Above all, it costs nothing to do except taking up a few minutes of your time. What's not to like about that? ■

In our Next Issue

Coming up in issue 272
On Sale 7th September 2018

Content may be subject to change

The September issue, number 272, of Model Engineers' Workshop will be packed full of great articles:



Paul Buckley makes an Optical Centre Finder from microscope parts.



The REMAP awards 2018, with tales of ingenuity and invention.



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Converting a WARCO WM280V-F Lathe to 3 Phase Operation



Barry Chamberlain takes a look at fitting a variable frequency drive to a lathe, focusing on the practicalities involved.

This project started with what appeared to be a simple turning exercise. Sustained attempts to break through the hard skin of a 210mm diameter by 35mm cast iron disk were proving to be extremely difficult because the cutter continually dug into the material bringing the lathe to an abrupt halt. On each occasion the resultant current surge ruptured the 8amp front panel mounted fuse. As a direct result of the continual blowing and replacement of the fuse without waiting for the motor to cool between stoppages, the motor inevitably overheated and became unusable. Needless to say, this is neither a recommended nor a sensible way to operate a lathe!

The quandary was what to do next? Weighing up the situation the options were either to order a direct replacement 1.1kW D.C. motor from Warco or fit a more powerful motor with more torque in the low speed range - provided one of a suitable size could be sourced to fit within the available space. After much research it was decided to attempt to install an 80 frame size 1.5kW (2HP) 3 Phase Motor.



Ply backplate bolted to headstock, motor on blocks



Initial clearance checks between motor and ply backplate



Checking for 2mm minimum clearance from ply backplate

Preliminary Assessment

A full-scale end elevation of the chosen motor was produced on CAD and printed off. The change-gear cover was removed, and the paper outline assessed against the motor mounting backplate. It looked encouraging and, at that point, the drive belt and pulley were removed from the motor which was then released from the mounting frame and moved clear. Measurements of the backplate were taken, drawn up on CAD, and an outline profile produced out of 12mm plywood. The next step was to determine if sufficient space would be available for adjustment of belt tension.

The backplate was removed from the lathe body and replaced by the plywood mock-up using the two fixing bolts.

A 150mm square motor mounting plate was also produced out of 12mm plywood. The motor end elevation drawing was fixed to the motor mount, set on the ply backplate, and moved around to check clearances. This looked fine so four 7mm x 25mm long 45° slots were produced in the ply plate along with four motor M6 mounting holes and an 80mm diameter

clearance hole for the front of the motor.

The centres of the upper ends of the 45° slots were located and four undersize countersunk holes (sufficient to retain M6 bolts) drilled in the ply backplate. Countersunk bolts were fitted from the rear of the backplate. With the ply motor mount loosely fitted with washers and nuts, it became immediately obvious that only three of the four studs could be used as the fourth was sitting over the original backplate motor clearance aperture. This was not relevant at this stage as all that was being considered was motor clearance. With everything looking promising and unable to progress further without a motor, crunch point had been reached and a TEC motor was chosen as it looked like good value at £133 (2016).

Motor Installation

The ply mounting plate was attached to the motor using M6 studding. Moving the backplate relative to the motor mount indicated that there was sufficient clearance between the motor body and the backplate over the full range of movement afforded by the 45 degree slots, **photos**

4

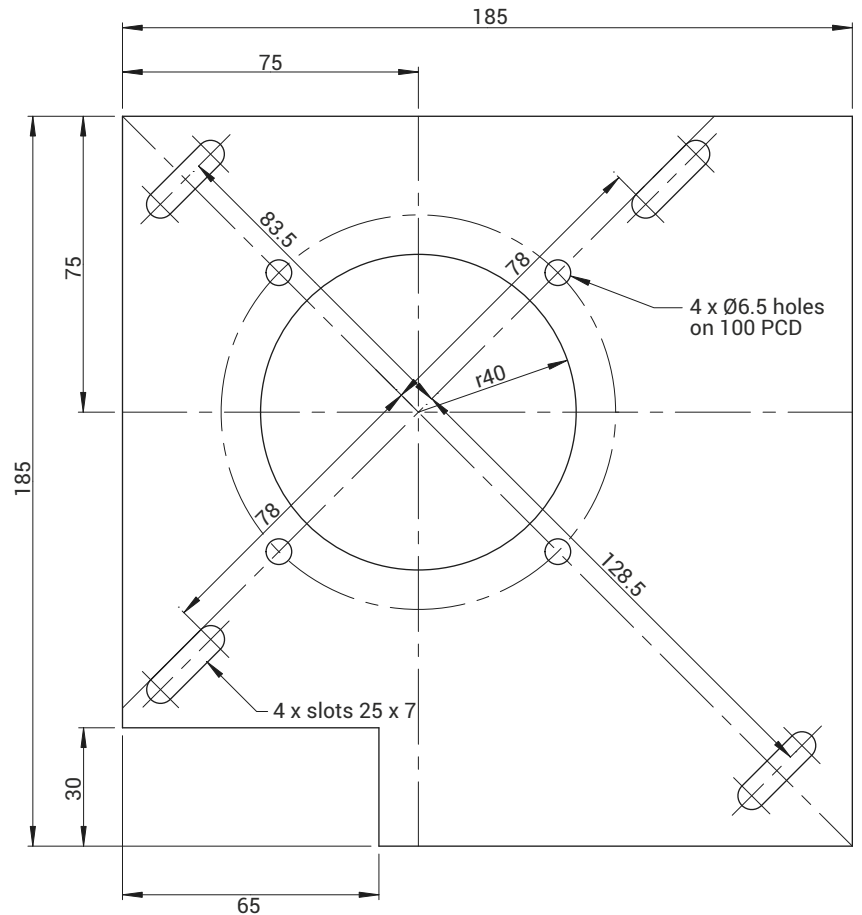


Old and new motors with their mounting plates

1 & 2. The ply back plate was then bolted to the headstock, (the motor weight being temporarily supported on blocks) and the ply motor plate bolted to the motor whilst overall clearances were checked between the motor and the headstock, **photo 3.**

The motor mount was redesigned with an extended bottom right hand corner to locate the lower right-hand stud over the backplate. The revised plate now measured 185mm square with a 65 x 30mm cut out at the bottom left corner to clear the change-gear cover micro-switch. Having the motor mounting plate laser cut was deemed to be cost effective so a dxf poly-line drawing was produced and emailed for manufacture, **fig. 1.** Note that poly line drawings are preferable as they give a continuous line so that the laser (or router) doesn't stop start as the cutting path is followed so producing

Fig.1



Motor Mounting Plate

a better cut. The metalwork arrived within 5 days. **Photograph 4** shows the old and new motors and mounting plates

Whilst awaiting the motor plate, the ply backplate was placed over the metal backplate. Where material was to be removed the area was covered with masking tape and the revised profile transferred to the backplate using an

automatic centre punch. The punched outline was scored with a scalpel and the excess masking tape removed to give a clear indication of the cutting line during the milling operation.

The backplate was firmly clamped to the mill bed above a sacrificial sheet of plywood. The combination was moved to the optimum position for each cut until the

5



Removing material from backplate

6



Motor mounting plate aligned 3mm in from edges of backplate



Motor supported in backplate – final check prior to fitting motor plate

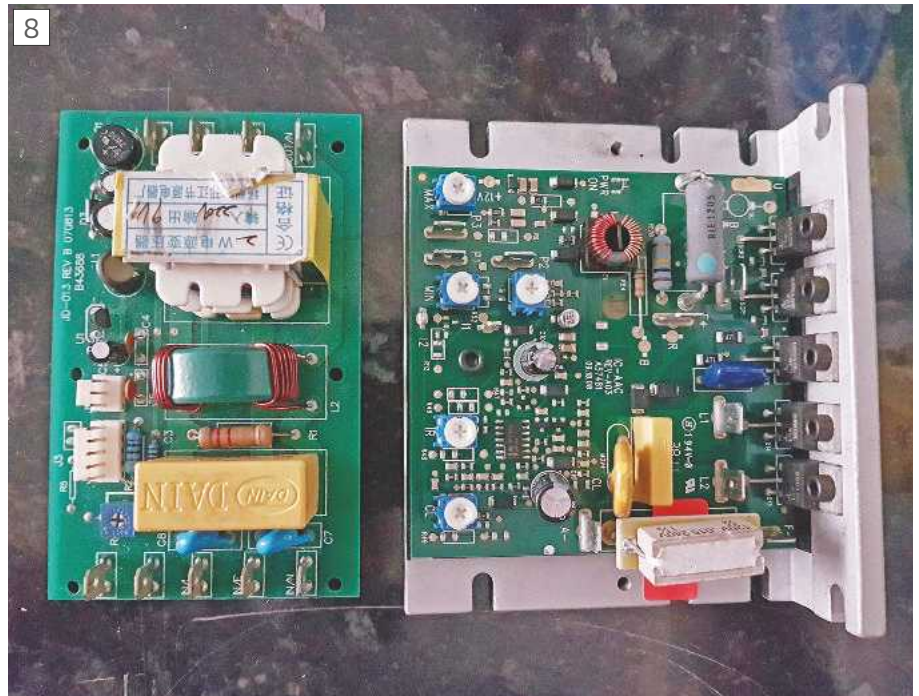
excess material had been removed using an indexable cutter, **photo 5**. This was, on reflection, not the most efficient way to remove the material. A plasma cutter or even chain drilling may have been a better alternative.

Attention now turned to the control panel assembly. After disconnecting the mains supply (by pulling the mains plug out) the rear cover panel was unbolted and the mains power lead disconnected from the internal wiring terminal block then set to one side. The previously released gear cover safety microswitch situated to the bottom left side of the backplate was, complete with its wiring loom, moved back towards the control panel.

The lathe front cover was released to gain access to the speed control potentiometer. Because the hole in the headstock casting was too small to allow the pot to pass through it was cut free from its wiring, the earth lead disconnected and the cover set to one side.

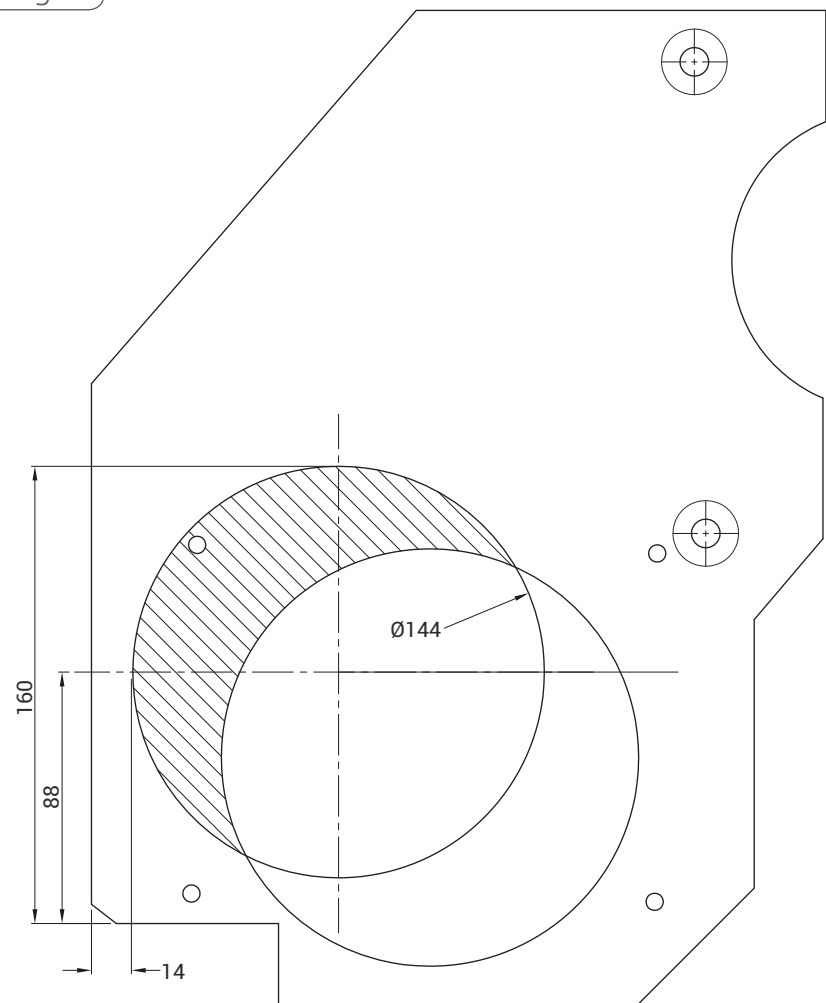
To improve access the switch panel was released and moved forward. The splash back panel was unbolted and moved clear. Left within the control panel column were two PCBs, the contactor and associated wiring. Next, the motor lead and headstock earth lead were disconnected. The 4 cap screws holding the control panel column to the rear wall of the headstock were removed after releasing the contactor from its DIN mounting frame and the column pulled clear of the lathe.

The motor was then supported on blocks at the correct height behind the backplate and secured to the new motor mounting plate with nuts fitted to temporary mounting studs. This showed the motor body was too close to the rear of the motor mounting plate in places, requiring further backplate material to be removed. The backplate was again clamped to the mill bed above a sheet of plywood and the extra



Removed Speed Control and Filter PCBs

Fig.2



Backplate

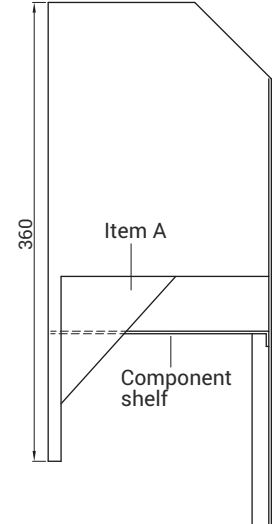
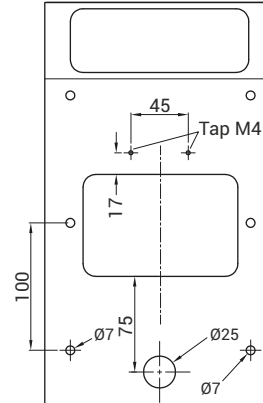
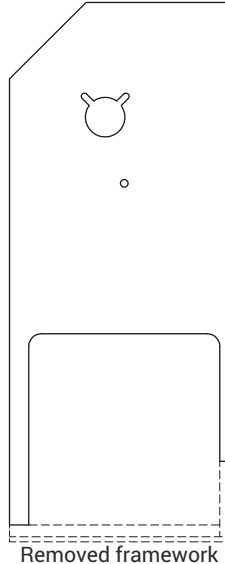
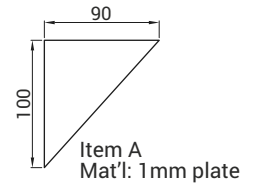
A green metal box with a large rectangular cutout, sitting on a wooden pallet. A yellow chair is partially visible to the right.

material removed using a roughing cutter, after which the edges were cleaned up. The area of material to be removed is shown on **fig. 2**.

The reworked backplate was clamped to the workbench. The laser cut motor plate was set 3mm from the left edge of the backplate and 3mm above the top edge of the cover microswitch cut-out then clamped firmly to the backplate. Using a 7mm transfer punch the upper right hand end of the four 45° slots were located and centres marked. The backplate was released and four holes drilled and tapped M6, **photo 6**. The backplate was temporarily fitted to the headstock for a final clearance check, **photo 7**. The backplate was removed, four 30mm long flanged M6 bolts inserted from the rear and tightened up. The motor mounting plate was installed over the bolt shanks and loosely secured with nuts and washers then the backplate was finally bolted to the headstock.

It was now clear that the motor would not fit within the existing lathe rear splash panel recess and that it too would require some remodelling work but that could wait until later. The primary objective was to resolve the clearance between the motor and the control column rear panel assembly.

With the motor moved to the worst case position it was not possible to re-locate and fit the control panel column as it was originally. However, by moving the panel up by 100mm the lower mounting holes could be used in conjunction with a second pair of 7mm holes drilled 100mm further down. This then became the plan and some reworking of the control panel frame work was required. The electrical equipment and wiring were removed from the control panel and set to one side, including the Speed Controller and Filter PCBs, **photo 8.**



17mm above the centre of the large forward facing opening then tapped M4 for the circuit breaker DIN rail. A 25mm hole was punched 75mm down from the lower edge of this opening to line up with the existing hole in the headstock for the speed control wiring, **fig. 3**.

The lower shelf of the control panel column was removed, marked up and the rear "legs" shortened to 360mm, **photo 9**.

from the lower shelf material and welded into position. This plate is necessary to prevent access to the electrical installation when the gear change cover is removed. A second plate was cut from the remains of the lower shelf to form a support bracket, Item B, and welded inside the rear of the control column assembly, **fig. 4 & photo 10**.

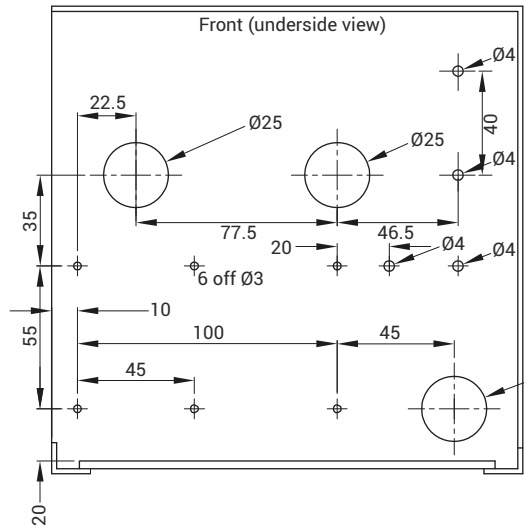
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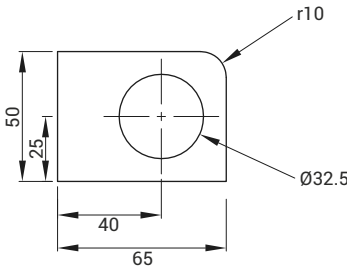
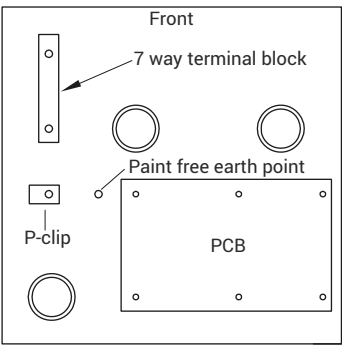
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Fig.4

Component Shelf

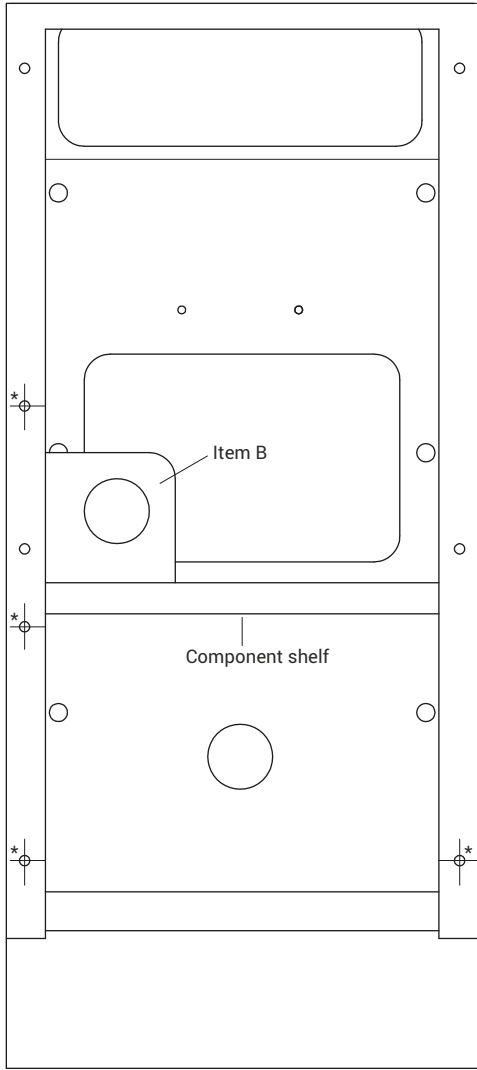


Component Shelf Layout (topside)

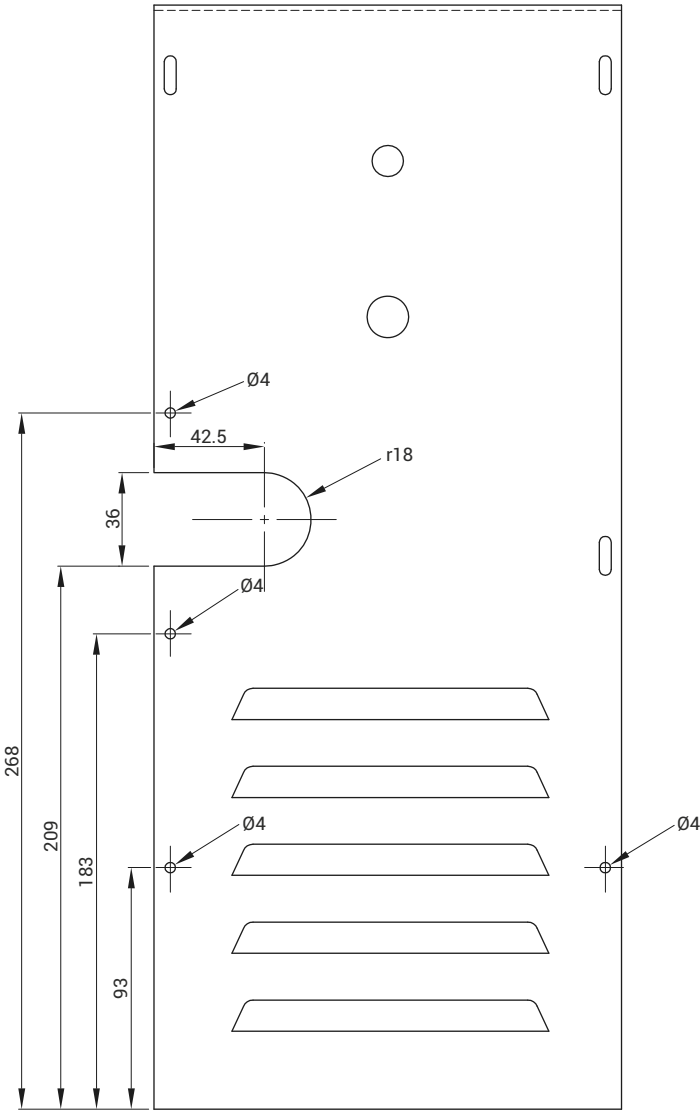


Item B
Mat'l: 1mm plate

Rear View



Rear Cover Panel



* 4 off M4 holes located through rear cover panel

Control Panel Rear

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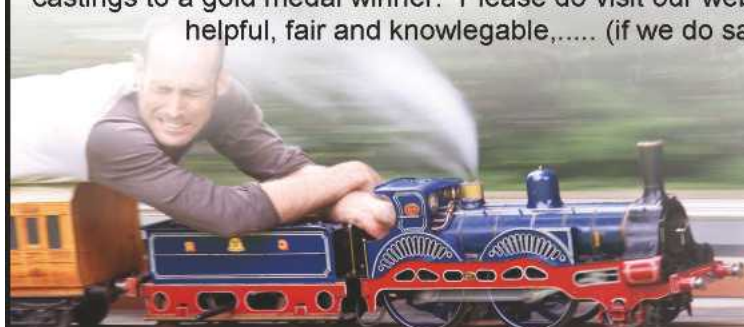
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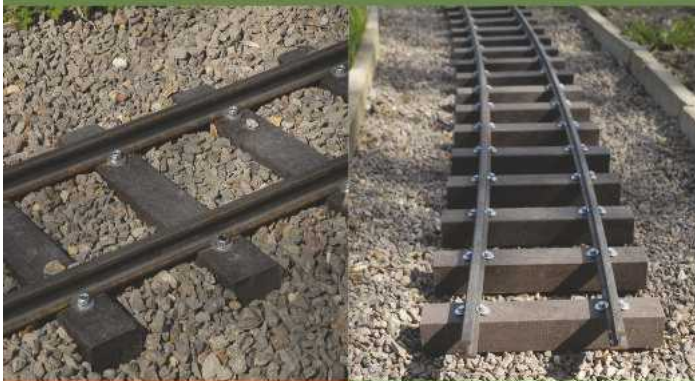
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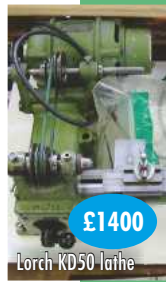
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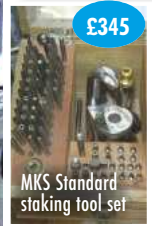
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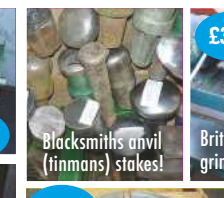
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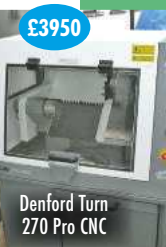
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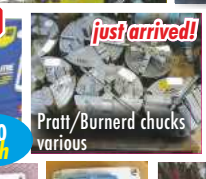
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